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CONSOLIDATED ANNUAL ACTIVITY REPORT 2020

22 June 2021

In accordance with Article 20 of the Statutes of the S2R JU annexed to Council Regulation (EU) No 642/2014 and with Article 23 of the Financial Rules of the S2R JU.

The Annual Activity Report will be made publicly available after its approval by the Governing Board.

Contents

FACTSHEET

Name	Shift2Rail Joint Undertaking (hereinafter S2R JU or S2R)
Objectives	The Shift2Rail Joint Undertaking is a public-private partnership in the rail sector, providing a platform for cooperation that drives innovation in the years to come. The S2R JU pursues research and innovation (R&I) activities in support of the achievement of the Single European Railway Area and should improve the attractiveness and competitiveness of the European rail system. The S2R JU contributes to: • a 50 % reduction of the life-cycle cost of the railway transport system (i.e. costs of building, operating, maintaining and renewing infrastructure and rolling stock), • a 100 % increase in the capacity of the railway transport system, • a 50 % increase in the reliability and punctuality of rail services (measured as a 50 % decrease in unreliability and late arrivals). The S2R JU shall propose innovative solutions to be explored, tested and demonstrated in operational environment and/or "zero on site" to achieve market uptake. Beyond that, with the deployment of its innovative solutions the S2R JU will foster connections between people, regions, cities, and businesses, supporting the socioeconomic objectives of the Union
Founding Legal Act	Council Regulation (EU) No 642/2014 of 16 June 2014 establishing the Shift2Rail Joint Undertaking[1] (S2R Regulation)
Executive Director (ED)	Mr Carlo M. Borghini, as from 16 May 2016
Governing Board (S2R GB) **As at end of Jan 2021**	***European Commission (EC) members***: • *Henrik HOLOLEI, DG MOVE* ***EC alternate:*** • *MOVE DDG 2* *Elisabeth WERNER,* • *RTD D* *Rosalinde.VAN DER VLIES,* ***Industry members:*** • *ALSTOM* *Nicolas CASTRES-SAINT-MARTIN* • *AZD Praha* *Vladimir KAMPIK* • *BOMBARDIER TRANSPORTATION* *Massimo SIRACUSA* • *CAF* *Imanol ITURRIOZ* • *DEUTSCHE BAHN* *Hans Peter LANG* • *EUROC* *Thomas PETRASCHEK*

[1] OJ L 177, 17.6.2014, p. 9

	• *HACON* *Lars DEITERDING* • *HITACHI RAIL STS* *Antonella Trombetta* • *INDRA* *Javier Rivilla LIZANO* • *KNORR - BREMSE* *Hans-Christian HILSE* • *NETWORK RAIL* *Robert AMPOMAH* • *SIEMENS* *Roland EDEL* • *SMARTDEMAIN* *Henk SAMSON* • *SMARTRACON* *Michael Meyer zu HÖRSTE* • *SNCF* *Carole DESNOST* • *THALES* *Yves PERREAL (Industrial Spokesperson)* • *TRAFIKVERKET* *Bo OLSSON* • *VVAC+* *Filip KITANOSKI* ***Industry alternates:*** • *ALSTOM* *Sophie PERROCHEAU* • *AZD Praha* *Michal PAVEL* • *BOMBARDIER TRANSPORTATION* *Richard FRENCH* • *CAF* *Jorge DE CASTRO* • *DEUTSCHE BAHN* *Ralf MARXEN* • *EUROC* *(to be appointed)* • *HACON* *Rolf GOOßMANN* • *HITACHI RAIL STS* *Claudio MONTI* • *INDRA* *Javier Rivilla LIZANO* • *KNORR - BREMSE* *Jasmina BRACKOVIC* • *NETWORK RAIL* *Felicity OSBORN* • *SIEMENS* *Jürgen SCHLAHT* • *SMARTDEMAIN* *Javier Bonilla DÍAZ* • *SMARTRACON* *Jaizki MENDIZABAL* • *SNCF* *Christophe CHERON* • *THALES* *Alberto PARRONDO* • *TRAFIKVERKET* *Christer LOFVING* • *VVAC+* *Erik STOCKER* ***Other participants:*** • *Carlo M BORGHINI* *Executive Director of the S2R JU* ***Observers:*** • *Josef DOPPELBAUER (ERA)* • *Anna GIGANTINO(ERA)* • *Ny Tiana TOURNIER (ERA)* • *Angela DI FEBBRARO (SC Chair)* • *Sarah BITTNER-KRAUTSACK (SRG Chair)* • *Miroslav HALTUF (SRG Vice Chair)*
Other bodies	Scientific Committee (SC)

	States Representatives Group (SRG) Innovation Programmes' Steering Committees (IP SteCos)
Staff	24 at 31 December 2020 including 2 Seconded National Experts (SNEs) and including one exceptional recruitment (cf. 2.6)
2020 Budget	The initially adopted budget was not amended in 2020. By year end, the Executive Director had proceeded with several transfers in terms of commitment and payment appropriations within Tile 1 and Title 2, in accordance with S2R JU FR art.6.5. In addition, the Executive Director had also transferred 4m€ in payment appropriations (in agreement with the Governing Board as per minutes of the meeting of 19 November) and 330k€ in commitment appropriations from Title 3 to Title 4 in order to be made available immediately to the S2R JU AWP 2021. As a result, the Final Adopted Budget amounted to EUR 89.7 million in commitment appropriations, of which EUR 80.5 million for operational expenditure, EUR 3.6 million for administrative expenditure and EUR 5.6 million of unused appropriations not required in the financial year but needed to meet early 2021 commitments. In payment appropriations, the Final Adopted Budget was EUR 80.3 million, of which EUR 72.2 million for operational expenditure, EUR 3.6 million for administrative expenditure and EUR 4.5 million of unused appropriations not required in the financial year.
Budget implementation	Based on the above, the Budget implementation in terms of commitment appropriations is at 100% and, in terms of payment appropriations at 81% (both excluding the unused appropriations not required in the financial year). The payment appropriations' implementation is stable in comparison to previous years (78.6% in 2017, 82.3% in 2018 and 89% in 2019). A decrease compared to 2019 is mainly due to the non-payment of one Call 2020 pre-financing due to the grant signature delayed to May 2021 at the request of the Consortium (and the pre-financing of EUR 6.3 million executed beginning of June). The implementation of Administrative budget was EUR 3.6 million in commitment appropriations and EUR 3.4 million in payment appropriations, respectively representing 100% and 96% of budget execution. Applying sound financial management, the JU makes use of multi-annual framework contracts in particular in Title 2. The Administrative budget corresponds to approximatively 4% of the JU Budget. The Operational Budget was implemented at EUR 80.5 million in commitment appropriations (100%) and EUR 57.7 million (80%) in payment appropriations.
Grants	In July 2020, the S2R JU awarded 19 grants as a result of the 2020 Call launched on 7 January 2020 based on the Annual Work Plan (AWP) 2020. All topics have been covered. All but one, as already mentioned, grant agreements were signed between September 2020 and December 2020, allowing the timely start of the projects. The remaining grant agreement was signed in May 2021 as a result of the Consortium request to reorganize the proposal between the different work packages. In total, the awarded grants will fund Research and Innovation activities up to EUR 75.3 million against a total value of EUR 147.7 million. In this respect, it should be noted that the Founding Members other than the Union and the Associated Members (jointly referred to as the "Other

	Members") agreed to limit their requests for funding to 44.44% of the total project cost.
Strategic Research Agenda	In accordance with the S2R Regulation, the strategic research and innovation agenda of the S2R JU is described in the Multi-Annual Action Plan (MAAP) adopted in its latest version in November 2019, with GB Decision N° 9/2019; The original MAAP of 2015 is maintained as a reference document.
Call implementation	The Call 2020 was implemented already at the beginning of the year. The award of the Call 2020 took place during the Governing Board meeting of 17 July 2020. With an exceptional commitment and effort, the Other Members and OC together with the JU were able to reach the signature of 18 grants related to the Call 2020 by year end and one grant signature is expected to be finalised in Q1 2020. The AWP2021 was amended in April 2021 to include an additional new Call for Proposal under the current MFF 2014-2020.
Participation, including SMEs	Under the 2020 Call, 87 Small and Medium enterprises (SMEs) participated to the 2020 Call (21.4%); 46 SMEs were retained for funding (52.9%). SMEs represent 29.1% of the entities selected in the Open Calls projects.

EXECUTIVE SUMMARY

The S2R JU was officially established on 7 July 2014, following the adoption of Council Regulation (EU) No 642/2014 of 16 June 2014 establishing the Shift2Rail Joint Undertaking (S2R Regulation).

The Shift2Rail Joint Undertaking (S2R JU or S2R) is a public-private partnership under the Horizon 2020 Framework Programme[2] established to manage and coordinate mission-oriented Research and Innovation (R&I) activities for a major transformation in rail systems in Europe.

The S2R strategic objectives and targets remain more than valid also within the framework established by the new "Sustainable and Smart Mobility Strategy" adopted by the European Commission on 9 December 2020[3].

2020 has been an unprecedented year, heavily marked by the COVID-19 pandemic crisis, its successive waves and uncoordinated responses that imposed restrictions in Europe and around the World; in June 2021, at the moment of writing this report, the situation is not yet addressed. During such critical periods, rail has demonstrated its role as backbone of the European economy: in a multimodal approach, it has ensured the transport of goods – from food to protective and critical equipment –, supported the management of sanitary critical transfers but also continued meeting the needs of citizens, to commute for working or essential reasons. This thanks to the rail workers and the innate strengths of rail.

Passenger numbers are dramatically low, more for cross-border traffic, with 2020 total turnover losses estimated by CER at EUR 24 billion for passenger services (-42%) and at EUR 2 billion for cargo (-2%) compared to 2019 values. Especially for rail passenger services, including urban transport, health safety expectations will have to be managed.

Programme Status

During 2020, the S2R JU has further progressed in delivering the S2R Programme, although operational activities have been affected by the COVID-19 Pandemic; the internal control system in place has ensured effective and efficient sound financial management.

In this context, the work of Members', other beneficiaries and of the S2R staff shall be commended because they have collectively and individually ensured the progress of the research and innovation activities in such complex conditions, not only with paper-work or lab developments but with concrete demonstration activities on the rail network.

This AAR 2020 is impregnated with the achievements of the S2R projects: successful pilot line tests, including with requests of derogations at national level, were performed for Automated Train Operation over ETCS at GoA2 both for passenger (in UK) and for freight operations (in CH). Additional line tests were performed on digital automatic couplers (DAC) in Germany and in Sweden, on enhanced switches and crossings installed in Austria, with a multi-modal travel companion/trip tracking/social services for passengers in Spain, Portugal, the Netherland and Greece resulting in a validation of technology that has been used for a public transport COVID-19 tracking app, and many

[2] Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020), OJ L 347, 20.12.2013 and Council Decision (EU) No 2013/743/EU of 3 December 2013 establishing the specific programme implementing Horizon 2020 (2014-2020), OJ L 347, 20.12.2013, p. 965.

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789

other R&I activities performed around Europe by multiple companies were successful and demonstrated the commitment of the rail sector to deliver the major digital transformation of Rail, paved and steered by the Shift2Rail programme.

Shift2Rail projects progressed towards delivering higher TRL levels and prepare for Technological Demonstrators that will be presented at InnoTrans 2022.

By the end of 2020 the Programme delay, still considered substantially contained, is estimated to be up to 6 months, although the evolving of the situation combined with additional scattered restrictions may further impact the progress of the activities.

The ongoing projects have been affected in different ways by the COVID-19 pandemic. Although projects at lower TRL levels or where collaboration was possible via digital communication progressed largely in line with their planning, projects requiring collaborative activities in situ at different sites in Europe suffered from delays due to different limitations.

Since the early months of the pandemic, the Programme Team has worked with the Project Coordinators to establish a detailed risk analysis and identify mitigating action as early as possible.

By the end of 2020, the Programme reached pivotal milestones in term of Programme implementation:

- almost all S2R resources are committed for the Programme activities,
- at least 60% of the Programme has been realized in view of reaching the TRL6/7 operational demonstrations planned for conclusion during 2023. Also the R&I activities of the Call 2020 started, with the exception of one grant agreement signed in May 2021. In total, it is estimated that the Total Value of the activities performed in 2020 amounts to EUR 119.4 million, of which EUR 110.3 million delivered by the Members other than the European Union (hereinafter Other Members).

During 2020, the S2R JU assessed its R&I activities through a third Control Gate exercise[4]. This exercise took into account the deliverables and reports submitted in the context of the Annual Review of the active Projects coordinated by the Other Members. The S2R JU also ensured through this process that the recommendations made during the previous Control Gate Assessment had been properly applied. The overall result is that the Programme benefited from such feedback, built upon also external expertise.

The quality of some deliverables was below standard and the S2R JU requested several re-submissions of deliverables and suspended technical and financial reports. This process is still particularly demanding for the Members and the JU, and the Executive Director requested the Programme Team to rethink the approach for 2021.

The overall Programme monitoring realized through the quarterly meetings of the Innovation Programmes (IPs) appears more and more to be a coordination/information exercise that will require corrections for the S2R successor.

[4] In accordance with the procedure set in the S2R Governance and Process handbook, transparently published on the S2R website: https://shift2rail.org/wp-content/uploads/2017/12/S2RJU-Governance-and-Process-Handbook_20171010_v11_Cleanv-nd.v2.pdf

The S2R JU Programme Team conducted also projects review meetings for non-S2R Members during 2019. The request of such projects to better interact with the reviewing experts and the S2R Programme Managers will have to be considered at the light of the future staffing of the JU.

This Programme assessment allowed the S2R JU to confirm that overall the progress of the activities has been in line with the expectations. In addition, the launch of the system approach activities within IPx allowed providing additional coherence and consistency between the interdependencies of the implementing Projects.

The status of the progress of the TDs is reported in Section 1.7. Only few TDs show delays compared to the initial scheduling, mostly due to availability of resources and external factors. In such cases, the JU has requested the concerned Project Teams to put in place the necessary mitigating measures.

- **IP1**

In 2020, IP1 TDs progressed unevenly and overall reached 83% of the estimated work planned in 2020. Beside TD1.5 which show a significant progress in term of overall implementation for the innovative braking system and TD1.8 (started in 2018) which is now running full speed for the HVAC demonstrators with CO2 refrigerants, most of the other TDs activities concentrated in the preparation for the high-TRL demonstrations. TD1.3, TD1.6 and TD1.7 were impacted by an initial non-alignment of the complementary project Carbodin, which ultimately led to a mitigation measure in agreement with the JU that will be put in place in 2021, including the externalization of a stream of work via a JU procurement procedure.

It is worth noting the potential savings highlighted by different TDs in IP1: a standardised approach to virtual certification showed a reduction of validation test of about 20%, for example for traction system. Several works of IP1 contribute to the CCA activities on both energy and noise reduction, e.g. the running gear works which, with active suspension and new materials, estimate a reduction of the rolling noise of -2dB. Furthermore, within TD1.5 a proposal for consideration of wheel/rail adhesion management solutions within ETCS braking curve calculation has been made and discussed with ERA.

- **IP2**

Significant progress has been reported on all TDs that on average have reached 98% of the estimated work planned in 2020; all IP2 TDs started between 2016 and 2017 have been working on the preparation of demonstration activities. On the contrary, TD2.8 on “virtual coupling” only started at the end of 2018, having therefore reached an overall implementation maturity at 45% by the end of 2020. Similarly, the activities of TD2.4 has shown a slower progress in term of TD overall advancement; this is due to the fact that an activity has been added in 2020 with R&I works on a stand-alone train positioning on top of the previously ongoing works on virtual-balises.

Notable results are the successful pilot line tests performed for Automated Train Operation over ETCS at GoA2 both for passenger (in UK) and, together with IP5, for freight operations (in CH). The positive assessment of these test results allow the safe introduction of such novel technology in the Technical Specifications for Interoperability (TSI) for enhancing the capabilities of ERTMS, as they will complement the feedback on specifications issued by S2R in 2019 (further to interoperability tests performed on the Reference Test Bench) provided to ERA and the rail sector.

TD2.8 – virtual coupling, which is not planned to reach a high TRL under the S2R programme, has shown through an analysis of sample scenarios that the Virtually coupled Train set has the

potential to improve the line capacity compared to a mechanical coupling: +29.7% in high-speed operations (that includes coupling of trains) over 300km with 3 stops and + 41.1% on regional operations (that includes coupling of trains) over 70km with 15 stops. These results, together with a potential increased flexibility of operations, call for pursuing such innovation.

Overall, the results achieved are key milestones for the market uptake of the solutions of this IP and prepare the integration of functions and its specifications in the Control Command and Signalling TSI, in the next revision, currently targeted by 2022, and its further evolution. The work performed in IP2 will show how R&I will feed the new regulatory framework and become a test bed for the future deployment of S2R innovative solutions.

- **IP3**

As in the previous years, also this IP showed of an uneven progress between TDs. On average IP3 has reached 84% of the estimated work planned in 2020, but TDs 3.2, 3.4 and 3.5, overall, did not progressed as expected. Next generation of switches and crossings, next generation of track and bridges and tunnels activities are showing a delay in their overall implementation: although many diverse activities have been initiated the progress is estimated at less than 50%. This results from a combination of factors, availability of resources, reorganization of activities and companies but also contractual aspects with linked third parties.

The S2R JU has worked together with the related projects to implement mitigation measures, as reported in IP3 section of this AAR, although they were not sufficient to close the gap. Early 2021, additional meetings, also in the light of the launch of the last IP3 project, will help to enhance the situation and prioritize further.

In general, IP3 R&I activities are moving towards the operational environment demonstrators. In 2020, enhanced Switches and crossings tests have started both in Austria and France contributing to a significant progress (compared to 2019) in TD3.1. A slower progress needs to be reported for the Asset Management activities (TDs 3.6 to 3.8), which are over the 50% implementation but mainly thanks to the important progress achieved in 2019. Energy management (TDs 3.9 and 3.10) and the Future Stations (TD3.11) have been progressing well.

- **IP4**

IP4 TDs on average have reached 80% of the estimated work planned in 2020. Progress has been affected by TD4.1 performances issues of the Interoperability Framework that required major interventions for the correct implementation in a pilot scenario; works on developing a new architecture and, in the short-term, on solving existing bugs have been put into place late 2020 for this essential TD that enable interoperability and multi-modality.

Notwithstanding the Interoperability Framework issues, in 2020, IP4 started the pilots in different European locations: Spain, Portugal, the Netherlands and Greece. The following features were tested for the passenger:

- Travel companion: applies behavioural analytics and AI techniques to provide a seamless door-to-door experience that suggests solutions and available options when they are necessary during a journey;
- Trip tracking services: help guide passengers from A to B;
- Social Market service: enhances provider interactions with passengers during trip, offering additional products and services like discounted transport, leisure activities and Wi-Fi access.

In addition, the following feature was tested for transport operators:

- Web-based interface for operators: collects past passenger data to improve and adjust services to each traveller's individual needs and preferences, ensuring compliance with GDPR.

It is worth noting that, the open call project My-Track, building upon the technology developed within the S2R IP4 ecosystem was funded by the EIT Urban Mobility to develop a COVID-19 app (Co-APS), launched to help reduce the spread of the virus by managing density in public transport and public spaces.

- **IP5**

In 2020, the TDs reached an average implementation rate of 73%, but especially delivered some key results, such as

- the ATO freight demonstration in coordination with IP2,
- static tests in Germany for Distributed Traction and long trains
- and the essential prototype development of the European digital automatic coupler and its tests.

The 50% milestone of overall progress has been reached, showing an overall progress with the activities in 2020 compared to 2019; in particular, major focus on the preparation of the upcoming demonstration activities.

The R&I work of IP5 in 2020 has also been instrumental for creation of the modular Automatic Coupling prototype that went beyond its initial scope of only being validated in the test bench. This prototype is, in fact, now tested at TR7 (operational conditions) within the framework of the European DAC Delivery Programme, been installed in real wagons and compared with other type of DAC (based on proven couplers market solutions).

The acceleration in some of key aspects of IP5 may require additional resources to achieve market impact - resources not yet available for rail freight in the S2R Programme.

- **CCA**

The Cross Cutting Activities after a catch-up of the delays in 2019 faced some new delays in 2020, with 79% level of implementation of planned activities for 2020.

The S2R KPI works achieved a milestone with the tender "Long-term needs & socio-economic research" completion of the S2R KPI tool which has been launched in the S2R website during the S2R Innovation Days in October 2020.

The WA3.2 progressed slowly in 2020 achieving both a yearly and total implementation of 50% and being able to deliver the version 4 of the Standardisation Rolling Development Plan (SRDP) at the beginning of 2021. Another work area shows a slow implementation pace; the WA6 on Human Capital suffered from internal allocation of resources. WA 5.2 on Noise and Vibration impacted by delayed measurement campaigns due to the COVID restrictions which are fundamental for achieving the objectives defined in the MAAP.

WA3.5 and WA4.1 successfully ended their activities. The first provided general recommendations for a mixed virtual/experimental certification process, which shall ultimately lead to a significant reduction of certification costs and duration. The second more concretely resulted in the development of a macroscopic simulation tool which supports the timetable and operational

planning with information on the operational impact of disturbances, delivering calculated results within minutes instead of hours compared state of the art tools.

- **IPX**

The investment of the Members and the S2R in designing and launching the IPX activities related to the concept of operations and functional system architecture, started delivering: the first version of the railway Functional System Architecture by the project Linx4Rail is now ready and under approval. This is major milestone achieved by the sector working together moving away from silos initiatives, setting the basis of the System Pillar in the successor of the JU.

TER4RAIL provided a useful Rail Innovative Research Observatory and mapping of running EU funded projects that have potential content synergies with the S2R Programme activities. This output is now used by the Programme team to engage with a possible collaboration and synergy with those other R& projects including with non-rail stakeholders.

Also Flex-Rail provided a comprehensive inventory of innovations and trends that was made available in an interactive public webpage, inspiring possible future R&I works.

And finally S2R launched in 2020 the HYPERNEX project which is tackling the topic of innovation in new and emerging guided transport system, looking for sharing of technological know-how with rail and ensuring a coherent European approach. In addition, it has to be noted that the JU supported DG MOVE to keep regular contacts and organise meetings (4 in 2020) with hyperloop promoters and Member States (1 meeting in 2020). S2R has contributed to ongoing technical discussions (e.g. preparation of a document on hyperloop functional definition) and has provided useful advise on the study commissioned by DG MOVE on a EU Regulatory Framework for Hyperloop, which was finalised in March 2021.

Programme Management and MAAP

In terms of Programme Management, 2020 was the first year during which reviews of Lump Sum projects took place. Experience so far has shown that from an operational perspective the use of Lump Sum for members' projects does not only result in an administrative simplification, but also effectively bundles efforts in the project review to focus on the achievements of results. The fact that the proof of concluded work packages (hence related focus on deliverables and milestone approval) provides the basis for the reimbursement of costs has allowed the JU and consortia to focus their efforts in an effective way in order to ensure the delivery of the projects.

2020 Programme Management has been influenced by the need to continue monitoring projects affected by the pandemic restrictions. According to the Commission guidelines, the S2R JU applied a fast track procedure to requests for amendments justified by reasons related to C-19 pandemic, for up to 6 months. The S2R Programme Office supported the projects in implementing mitigating measures as needed. However, delays in the submission of deliverables, in particular in the case of the demonstration activities, will have to be mitigated once the current pandemic restrictions are lifted. Nevertheless, thanks to the ambitious S2R 2019 planning to have all activities finalised by end 2022, the delays caused by the pandemic restrictions will still allow the JU to target a conclusion of its R&I Programme by mid-2023, well within the S2R JU mandate ending in 2024.

With a holistic approach, the role of the S2R JU is also to ensure that interactions between the various IPs are adequately considered and managed, as technological developments in one part of the system could lead to changes in performance, or even create barriers, in other parts. In addition, cross cutting activities include research on long-term economic and societal trends such as customer needs and human capital and skills, which must be taken into account by the different IPs.

In 2020, the programme management could also benefit from the active exchange with the ED Programme Board which took up its activities following the ED Decision on a renewed Programme Governance and Change Management, and endorsed by the GB. Several change requests have been processes, ensuring among other sectorial coherence of initiatives, notably with the integration of relevant concepts from OCORA or RCA into the S2R R&I activities that will deliver concrete demonstrations.

At the end of 2020 the ED Programme Board also discussed the first release of the S2R Functional System Architecture, which is setting the basis for an increase sectorial competence for system of systems modelling in view of enabling and accelerating the integration of new technologies and processes in the rail system.

R&I activities launched in 2020 and prepared for 2021

In July 2020, the S2R JU Governing Board selected for funding 19 proposals as a result of the 2020 Call launched in January 2020 based on the amended Annual Work Plan (AWP) 2020, covering in its entirety the topics and scope of the call.

18 grant agreements were signed between September and December 2020; at the request of the Consortium, taking into consideration the need to reorganize the project allocations between work packages, one grant agreement signature was postponed and signed in May 2021. In total, the project proposals selected for funding will result in Research and Innovation activities funded up to EUR 75.4 million against a total value of EUR 147.7 million. The CFM part of the Call was implemented through the Lump Sum approach.

As in the case of the previous years and for the full duration of the Programme, excluding the S2R light-house projects launched by the Commission in 2014, the Founding Members other than the Union and the Associated Members (jointly referred to as the “Other Members”) of the S2R JU agreed to a funding rate of maximum 44.44% (this would mean a net 41.44% for an Other Member after having considered its obligations), demonstrating a strong commitment to deliver the most ambitious Railway R&I Programme for a major transformation to rail systems, once deployed.

In total 242 participants, of which 29% were represented by SMEs in the Open Call projects, were retained for funding in the 19 R&I topics under the 2020 Call. The applications represented participants from 30 countries, of which 19 EU Member States and 3 Countries associated to the Horizon 2020 Framework Programme where retained for funding (See Annex C for details).

A slight increase of underrepresented Member States’ participants has been noticed in the 2020 Call, thanks to the efforts made by the S2R JU and the increase of TRL of the Programme with a total of 20 participants versus a previous average of 13; in order to attract a wider representation from underrepresented Member States, it will be important to integrate successful S2R R&I results with longer-term demonstration activities, to bridge the way towards future deployment.

Additionally, the S2R JU used for the first time the "prize" as an instrument to accelerate innovation into the market and respond to a specific Union need.

During the Shift2Rail Innovation Days on 22-23 October, the "Unique Train" Prize was launched. The Prize is aimed at the development of an implementable single solution that will allow the tracking of all commercial freight trains, from all railway undertakings, covering the whole European network.

The applicants have one entire year to develop the solution and the winner will be awarded €400.000, while the runner-up will receive €100.000 EUR.

The European DAC Deliver Programme under the leadership of S2R JU

In July 2020, the Governing Board of the S2R JU endorsed the European DAC (Digital Automatic Coupler) Delivery Programme proposed by the Executive Director, voicing the request of the railway sector. Building upon the outcomes achieved in Shift2Rail's freight related R&I activities (Innovation Programme 5), this Programme brings together the rail sector beyond the Membership to bridge the research work with innovation, including migration planning, towards the deployment of a European DAC solution, built on open and transparent standard specifications. This activity constitutes a major step ahead of the digital rail freight, enabling new operations and services that will contribute meeting the expectations of the Sustainable and Smart Mobility Strategy of the European Commission.

Today the European DAC Delivery Programme is a reality and it integrates, with an independently managed delivery programme, projects like DAC4EU, funded by the German Federal Ministry of Transport and Digital Infrastructure, as well as relevant results from S2R projects under its Innovation Programme 5 on European rail freight.

Following the task provided by S2R Governing Board to the S2R Head of Research and Innovation, an effective programme management system has been set-up to ensure the proper and timely delivery of the expected results. The EDDP has been structured in seven different Work Packages and two decision-making bodies (Supervisory Board and Programme Board), with the Programme Manager playing a pivotal role; Mr Mark Topal, CTO of OEBB, was identified and appointed the European DAC Delivery Programme Manager supported by the Co-Manager Jens Engelmann, owner of railiable.

The programme's objectives cover technological assessments of the available solutions, testing and demonstrations, definition of migration plans, assessing the interfaces with other programmes, business cases, and communication and dissemination, aiming to facilitate the deployment of the DAC in Europe. Concretely, it will include:

- the selection of an open, functional, operationally tested, safe and sustainable European DAC model ready for industrialisation and deployment;
- the delivery of a final open design of the selected model, based on use-case considerations in 2021, and its interoperability and safety requirements which could be incorporated into the TSI, Green Deal and Digitalization Package in 2022;
- the identification of migration and business plans compatible across Europe (subject to the results of the ongoing business case analysis), as well as the necessary resources to match them

The European DAC Delivery Programme is an open programme which looks forward to active participation from stakeholders, who are invited to submit their interest through the dedicated application form on the EDDP webpage, established under S2R website in autumn 2020, where additional and up to date information about the programme is available.

With regard to the budget appropriations set aside for this activity in 2020, the necessary procurement procedures were launched and contract are expected to be signed by Q1 2021 in accordance with the JU Financial Rules.

Activities aligned to feed the successor of the S2R JU

The current activities of the S2R JU are progressing towards their demonstrations in 2022 and 2023, paving the way to the R&I activities to be undertaken by the S2R successor. This will ensure a proper phase out and phase in between the two Programmes. The S2R technological demonstrators are the building blocks of a more systemic railway transformation which is strategically driven by the European Commission's European Green Deal, the Digitalisation Agenda and more recently the Sustainable and Smart Mobility Strategy.

During spring 2020, the JU further supported the development of a High Level Paper on the S2R successor, the candidate European Institutional Partnership "Europe's Rail JU". As part of its preparations to set new R&I European partnerships under the next research and innovation framework programme, Horizon Europe, the European Commission had asked the rail sector (EIM, CER with the technical support of UIC, UNIFE, UITP, ERRAC, etc.) in autumn 2019 to develop the key features of a future European partnership. Following the submission of the first version of the High Level Paper in December 2019, the S2R JU, in its role of sectorial stakeholders' integration, continued the coordination of the various inputs in the first half of 2020. The final version of the Draft Partnership Proposal was sent to the Commission by the sector in early July 202 and was published on the DG Research & Innovation website for the presentation of candidates for European Partnerships in climate, energy and mobility[5].

This preparation work has also been an opportunity for the S2R JU to re-assess the maturity level expected to be reached by the different streams of work, the potential in terms of market take up of R&I outputs, and indicate the areas of improvements to foresee for the next generation of R&I projects, the so called "transforming projects".

The preparations for the future European Partnership for the rail sector were also part of several events during 2020.

During August 2020, the European Commission launched its Invitation for entities to manifest the interest to become candidate founding member of the Europe's Rail JU. This process was formally concluded in the very end of 2020 with the Commission's notification to entities of their status as Candidate Founding Members of the new Partnership. First exchanges took place in early 2021 to prepare for the new partnership and develop the priorities of the successor programme.

Other activities

In order to provide administrative support to the Programme execution, the JU has progressed in the recruitment of staff filling budgetary open positions; at the end of the year, 24 position were filled, including 2 SNEs and one short term exceptional recruitment to cover a long leave absence. The JU is subject to high turnover mostly due to the fact that other Union JUs and Agencies are in the position to offer Temporary Agent posts (TA) instead of Contractual Agent posts (CA). In fact, contrary to almost

[5] https://ec.europa.eu/info/horizon-europe/european-partnerships-horizon-europe/candidates-climate-energy-and-mobility_en

all other Union Institutions, Agencies and JUs, the S2R JU has a Staff Establishment Plan with 25% TAs positions and 75% CAs positions; in almost all other cases, these percentages are reversed!

With regard to communication and dissemination activities, the S2R JU continued its efforts to promote the activities of the programme during 2020, while adapting to the challenges imposed by the Covid pandemic. 2020 communication and dissemination activities were marked by the first digital edition of the S2R Innovation Days, that to a certain extent compensated the lack of larger physical events (like InnoTrans 2020) which gathered on 22-23 October more than 600 participants interested in discovering the R&I discoveries of the S2R projects.

During 2020, the S2R JU also continued its efforts to increase cooperation in Member States as well as with international parties. On 22 January 2020, the S2R JU signed a Memorandum of Understanding (MoU) with the Basque Region. This was followed by the signature of two additional Memoranda in October: during the Shift2Rail Innovation Days, a Memorandum of Understanding was signed with the Canadian Urban Transit Research & Innovation Consortium (CUTRIC), a non-profit innovation consortium whose vision is to make Canada a global leader in low-carbon smart mobility, by focusing on technology development, integration and standardisation vis-à-vis low-carbon propulsion systems, smart vehicle systems, data-driven analytics in mobility, and cybersecurity in transportation. Moreover, the signature of a Memorandum of Understanding with the Permanent Secretariat of the Transport Community took place on Monday 26 October, during the Transport Community Ministerial Meeting. The Transport Community is an International Organization established by the Treaty establishing the Transport Community that was signed on 9 October 2017 and comprises the European Union and the South East European Parties being the Republic of Albania, Bosnia and Herzegovina, the Republic of North Macedonia, Kosovo, Montenegro and the Republic of Serbia.

In addition to the efforts on stakeholder involvement, the JU further continued improving its internal organisation as to provide continuous support to its Members and beneficiaries. By implementing adopting and implementing a new internal control framework, performing defined control activities as well as assessing and managing risks, the JU has continued to ensure the sound financial management of EU funds.

With regard to the Discharge in respect of the implementation of the Budget of the S2R JU for the financial year 2019 and the European Parliament resolution, the present report provides in its different sections the answers requested by the Budgetary Authority. All actions stemming from audit recommendations have been implemented without delay, thus reinforcing the internal management and control system of the S2R JU.

Suggestions from the SRG and the SC to improve the present report have been taken into account.

Thanks to the commitment of both Members and Programme Office, 2020 has seen the S2R JU further continuing its important progress towards delivering the Programme.

European Green Deal, the United Nations Sustainable Development Goals (SDGs) and the Sustainable and Smart Mobility Strategy

The European Green Deal was presented in December 2019, setting out a clear vision of how to achieve climate neutrality in Europe by 2050[6]. Transport accounts for a quarter of the EU's greenhouse gas emissions, and still growing. To achieve climate neutrality, a 90% reduction in transport emissions

[6] European Commission (2019). The European Green Deal. COM(2019) 640 final, Brussels

is needed by 2050. As a matter of priority, a substantial part of the 75% of inland freight carried today by road should shift onto rail and inland waterways.

"To transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use." (European Green Deal, p. 2).

Priority areas include accelerating the shift to sustainable and smart mobility: *"Automated and connected multimodal mobility will play an increasing role, together with smart traffic management systems enabled by digitalisation. The EU transport system and infrastructure will be made fit to support new sustainable mobility services that can reduce congestion and pollution, especially in urban areas" (European Green Deal, p. 10).*

The European Green Deal is also an integral part of this Commission's strategy to implement the United Nation's 2030 Agenda and the 17 Sustainable Development Goals (SDGs).[7] Shift2Rail JU has been reporting on its contribution to the SDGs since 2018 in its Annual Activity Reports. Shift2Rail's Multi-Annual Action Program sets out key goals to strengthen the role of rail in the transport system, given rail's inherent advantages in terms of environmental performance, land use, energy consumption and safety.

Shift2Rail's unique R&I work concretely contributes to the following goals, and related sub targets:

Goal 9: Building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

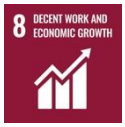
SDG 12: Ensure sustainable consumption and production patterns

Goal 13: Take urgent action to compact climate change and is impacts

The SDGs are not 17 individual goals, but are strongly interconnected, whereas progress in one goal can unlock progress in another. Shift2Rail's R&I programme also indirectly contributes to the following SDGs, and related sub targets:

Goal 5: Achieving gender equality and empower all women and girls

[7] United Nations General Assembly (2015). Transforming Our World: The 2030 Agenda for Sustainable Development. Draft resolution referred to the United Nations summit for the adoption of the post-2015 development agenda by the General Assembly at its sixty-ninth session. UN Doc. A/70/L.1. New York



SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reserve land degradation and stop biodiversity loss.

A few Horizon 2020 Key Performance Indicators common to all JUs are aligned with the broader objectives of the SDGs, for example, growth and job creation in participating SMEs or percentage of women participants/coordinators in H2020 projects (Annex C, Table I). The same holds for the Key Performance Indicators specific for the S2R JU, for example reducing the life-cycle cost of the railway transport system and reducing the negative externalities linked to railway transport (Annex C, Table III). The Shift2Rail JU is continuously improving its KPI model data.

Besides its contribution with its R&I programme, the Shift2Rail JU continues to further improve its business operations, and highlighted in the AWP 2020 its plans to reduce the Carbon Footprint of its activities on the basis of a specific action plan. Due to the Covid pandemic, the development of the Carbon Footprint Action Plan has been postponed, but it remains a priority in particular when the participation to events under and related to the programme will start returning to pre-Covid levels.

Moreover, the new Sustainable and Smart Mobility Strategy of the Commission, launched in December 2020, includes more concrete milestones for the railway sector to enhance a smart and sustainable future. Its underlying Action Plan of 82 initiatives lays the foundation for how the EU transport system can achieve its green and digital transformation and become more resilient to future crises. In particular, it provides the visionary ambitions that the next rail R&I Programme will have to contribute to insofar as possible and notably:

- By 2030 the high-speed rail traffic will increase of 50%; the scheduled collective travel of under 500 km should be carbon neutral within the EU and automated mobility will be deployed at large scale.
- By 2050 rail freight traffic will double; high-speed rail traffic will triple and the multimodal Trans-European Transport Network (TEN-T) equipped for sustainable and smart transport with high speed connectivity will be operational for the comprehensive network.

Additionally, rail transport will also need to be further electrified; wherever this is not viable, the use of hydrogen should be increased. And the roll out of the European Rail Traffic Management System (ERTMS) will be pursued including further efforts to develop train automation, for instance through joint undertakings (JUs).

Furthermore, the draft proposal for the Europe's Rail JU published in July 2020 presents also the sector commitment towards an ambition research and innovation programme for the decade, meeting the expectations of the Union policies and Sustainable Development Goals. These two documents pave the way for the Shift2Rail's successor to more concretely monitor how it's R&I programme is contributing to broader objectives of the Union to meet its sustainable development targets.

Finally, the European Parliament decision on discharge in respect of the implementation of the budget of the Shift2Rail Joint Undertaking for the financial year 2019 called upon the Commission to address via a legal framework the issue of Intellectual Property Rights in all contracts which may produce an intended outcome or result of the performance, in order to safeguard the rights of individual creators but also provide details on how the rights will be used in the future. In this respect, the S2R JU

highlights the focus it provides to transparency of results and access to results, inter alia through the inclusion of the specific IPR provisions in the standard Grant Agreements, as well as through the public access to results – not only via de EC CORDA system, but also directly via the S2R JU website (by TDs/WAs - https://projects.shift2rail.org/s2r_matrixtd.aspx), thereby contributing to the simplification of transparency of results implementing the S2R Multi-Annual Action Plan (MAAP) with individual S2R JU grant agreements.

The next sections of this AAR 2020 present in details the achievements, risks and opportunities and evolution of the JU during the past year.

INTRODUCTION

The S2R JU was established by Council Regulation (EU) No 642/2014 of 16 June 2014 (S2R Regulation) with, in Annex I, the S2R Statutes.

The S2R JU is a public-private partnership in the rail sector established under Article 187 of the Treaty on the Functioning of the European Union, providing a platform for the rail sector as a whole to work together with a view to driving innovation in the years to come. Inter alia, the S2R JU shall manage all rail-focused R&I actions co-funded by the Union.

The S2R JU is a mission-oriented Programme delivering a major system transformation, bringing railway at the centre of advanced integrated mobility.

The Vision of S2R JU is

TO DELIVER, THROUGH RAILWAY RESEARCH AND INNOVATION, THE CAPABILITIES TO BRING ABOUT THE MOST SUSTAINABLE, COST-EFFICIENT, HIGH-PERFORMING, TIME DRIVEN, DIGITAL AND COMPETITIVE CUSTOMER-CENTRED TRANSPORT MODE FOR EUROPE.

The mission statement of the S2R JU is

"*Shift2Rail: moving European railway forward*"

Rail R&I conducted within the S2R JU must contribute to addressing the challenges faced by the rail sector, through a comprehensive and coordinated approach to R&I focusing on the needs of the rail system and of its users, including in Member States that do not currently have a railway system within their territory.

This is part of a clear legal framework, where the European Commission, DG MOVE in particular, inter alia defines the transport and mobility policies, the S2R JU contributes to delivering and challenging them through its R&I Programme and ERA acts within its regulatory mandate under the 4th Railway Package.

In addition to the Union, the S2R JU has eight Founding Members other than the Union[8] and nineteen Associated Members. The latter were selected following a call for expression of interest to become Associated Member of the S2R JU[9] [10].

In this respect, its main objective is to implement the S2R Programme, R&I activities in the railway sector in Europe, through the collaboration between stakeholders in the entire railway value chain, also outside the traditional rail sector, with particular attention to SMEs, research and technology centres and universities.

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[8] Consisting of rail equipment manufacturers Alstom Transport, Ansaldo STS, Bombardier Transportation, Construcciones y Auxiliar de Ferrocarriles (CAF), Siemens AG, Thales and infrastructure managers Trafikverket and Network Rail

[9] Commission Decision N° C(2014) 7084 final

[10] AERFITEC consortium, Amadeus IT Group SA, AZD Praha s.r.o., CFW consortium, Deutsche Bahn AG, DIGINEXT, EUROC consortium, Faiveley Transport, HaCon Ingenieurgesellschaft mbH, Indra Sistemas S.A., Kapsch CarrierCom, Knorr-Bremse GmbH, MER MEC S.p.A., Patentes Talgo S.L., Railenium Swi'TRACK'EN consortium, Smart DeMain consortium, SmartRaCon consortium, SNCF, Virtual Vehicle Austria consortium+

The Union tasked the S2R JU with its Regulation and Statutes, *to manage all rail- focused research and innovation actions co-funded by the Union, ensuring coordination among projects and providing all stakeholders with relevant and available information on projects funded across Europe*.

This task is complemented by the request of the Union to the S2R JU *to establish and develop — and ensure the effective and efficient implementation of — a strategic Master Plan (the 'S2R Master Plan')*, which has been endorsed by the Council[11], and which provides a high-level view of what needs to be done; it explains why and by when. It sets the framework for the research and innovation (R&I) activities to be performed within and beyond the S2R Programme and the deployment activities to be carried out by all operational stakeholders, coordinated to achieve the Single European Railway Area.

The S2R JU has developed, together with its Members and advisory bodies, the S2R MAAP, which translates the S2R Master Plan into detailed, result-oriented R&I activities to be performed to start delivering the S2R partnership vision as from 2014 onwards. The current version of the S2R MAAP was adopted by the Governing Board at the end of 2019[12]. Overall, the S2R JU shall:

- contribute to the implementation of H2020 Regulation and in particular part of the Smart, Green and Integrated Transport Challenge under the Societal Challenges pillar of Decision No 2013/743/EU;
- contribute to the achievement of the Single European Railway Area, to a faster and less costly transition to a more attractive, user-friendly (including for persons with reduced mobility), competitive, efficient and sustainable European rail system, and to the development of a strong and globally competitive European rail industry;
- play a major role in rail-related R&I, ensuring coordination among projects within its overall Programme. It provides all stakeholders with relevant and available information on R&I activities funded across Europe. It shall also manage all rail-focused R&I actions co-funded by the Union;
- actively promote the participation and close involvement of all relevant stakeholders from the full rail value chain and from outside the traditional rail industry. In particular, it fosters the involvement of small and medium sized enterprises (SMEs), as defined in Commission Recommendation 2003/361/EC (8);
- develop demonstration projects in interested Member States including those that do not currently have a railway system established within their territory.

The S2R Joint Undertaking shall, more specifically, seek to develop, integrate, demonstrate, and validate innovative technologies and solutions that uphold the strictest safety and security standards and the value of which can be measured against, inter alia, the following key performance indicators:

- a 50 % reduction of the life-cycle cost of the railway transport system, through a reduction of the costs of developing, maintaining, operating and renewing infrastructure and rolling stock, as well as through increased energy efficiency;
- a 100 % increase in the capacity of the railway transport system, to meet increased demand for passenger and freight railway services;
- a 50 % increase in the reliability and punctuality of rail services (measured as a 50 % decrease in unreliability and late arrivals);

[11] http://ec.europa.eu/transport/modes/rail/doc/2015-03-31-decisionn4-2015-adoption-s2r-masterplan.pdf
[12] https://shift2rail.org/wp-content/uploads/2019/12/GB-Decision-9-2019_MAAP-Part-B.pdf

- the removal of remaining technical obstacles holding back the rail sector in terms of interoperability, product implementation and efficiency, in particular by endeavouring to close points which remain open in Technical Specifications for Interoperability (TSIs) due to lack of technological solutions and by ensuring that all relevant systems and solutions developed by the S2R Joint Undertaking are fully interoperable and fitted, where appropriate, for upgrading;
- the reduction of negative externalities linked to railway transport, in particular noise, vibrations, emissions and other environmental impacts.

R&I activities are performed by the Other Members and any other eligible entity. They are co-funded or procured by the S2R JU in accordance with its budget availabilities and in compliance with the H2020 Regulation[13], its Rules of participation[14] and the S2R Financial Rules. To this end, the S2R JU shall organise calls for proposals and/or for tenders for supporting the R&I activities.

a. As specified in Article 17 of the S2R Statutes, up to 40 % shall be allocated to founding members, other than the Union, and their affiliated entities
b. up to 30 % shall be allocated to associated members and their affiliated entities;
c. at least 30 % shall be allocated by way of competitive calls for proposals and calls for tenders.

As for the "open and competitive calls" (point c. here above), also the award of the R&I activities to the Other Members (a. and b. here above) is through competitive calls in compliance with H2020 Rules of Participation and/or calls for tenders, under the relevant eligibility criteria.

THE JU'S APPROACH TO MANAGING THE CHALLENGES OF THE PANDEMIC

JU's general management response: administrative management

As a result of the COVID19 pandemic which was declared by World Health Organisation (WHO) on 11/03/2020 and in line with the risk assessment by the European Centre for Disease Prevention and Control (ECDC), the European Commission decided to activate, on the request of its President, both business continuity plans and special teleworking arrangements.

The JU followed the EC approach and implemented special measures designed to protect staff by decreasing physical contacts between colleagues, while ensuring that essential tasks of the JU could continue to be carried out. As of 16/03/2020, remote working became mandatory for all JU staff with the only exception of critical functions.

These measures were subject to regular review depending on the evolution of the situation specifically in Belgium, in line with the European Commission guidelines.

The JU also established a dedicated working group composed of the Head of Administration and Finance, the HR Officer, the Chief Communication Officer and a representative of the Staff Committee. This working group has been mandated to monitor the situation and provide to staff information published by different entities (EC, Belgian National Authorities as Host Country etc.), as well as

[13] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0104:0173:EN:PDF
[14] http://ec.europa.eu/research/participants/data/ref/h2020/legal_basis/rules_participation/h2020-rules-participation_en.pdf

clarifying mitigating measures during weekly staff meetings. Moreover, a dedicated mailbox was set-up enabling staff to contact the working group with specific questions or concerns.

In June 2020, on the basis of the proposal of the S2R JU, the 6 JUs located in the White Atrium building adopted a joint "return to office" guidelines with the aim of providing a common exit strategy to the crisis. In order to do this, the JU provided surgical masks and hydro-alcoholic gel and reconfigured the offices to allow occupation by only one person at a time.

In accordance with the medical protocol published by the Medical Service of the European Commission, all suspected/confirmed cases of COVID19 in the staff were duly monitored in order to ensure staff safety and the continuity of activities at all times. Nevertheless, the situation has not evolved in such a manner to implement the "return to office" guidelines and remote working continue remaining the rule. S2R JU staff is present to the office on exceptional basis or a need to be present basis, on a voluntary basis to be agreed by the line manager or up to the Executive Director. Monitoring instruments have been put in place

Beyond the pure "physical aspects" related to the impact of pandemic, it became clear that staff "mental health" constitutes a key element at personal level but also to ensure the functioning of the organization.

It is for this reason that, in autumn 2020, the JU put in place a *wellbeing training programme,* as part of a framework contract led by the EC. The aim of this programme is to support all staff throughout the crisis and propose a wide range of wellbeing activities in order to help the staff gain a deeper awareness of their own physical, mental and social well-being, manage their own emotions in order to prevent potential risks and get to know the impact of lack of physical, mental and social welfare in the workplace. The programme was deployed around 5 main activities: webinars on wellbeing, meditation sessions, mindfulness sessions, individual coaching sessions, and specific sessions dedicated to managers. The programme is foreseen to be deployed until spring 2021.

In terms of remote working, the ICT architecture and concepts that the S2R JU has brought forward, including converging on it the other JUs, has allowed ensuring continuity of operations since the beginning of the pandemic, without extremely rare disruptions.

Covid-19 impact on the JU's activity 2020 and mitigating measures

a) Management of the Programme and financial impact: Call – H2020-S2RJU-2020

On 7 January 2020, the S2R JU published and opened the yearly call for grant for proposals (Call for members and open call) with deadline 21 April 2020.

Following the COVID-19 outbreak and the request received from different participants, the JU proposed to the Governing Board, who agreed, to extend the deadline to 27 May 2020.

Given the exceptional circumstances, the evaluation of the call ran fully remote. All staff members involved in the evaluation process attended a training session on remote evaluation provided by the Research Executive Agency, to ensure a smooth execution of the consensus meetings. The consensus meetings took place via conference call system with the independents experts, the moderators, the rapporteurs and the observer. The Commission ICT tool used for calls evaluations has been enhanced and integrated with a new functionality to allow the experts to sign the panel report electronically.

b) Management of the Programme and financial impact: Grant Agreements management and S2R Programme impact

The S2R JU has conducted a risk management exercise in order to define a series of fast-track amendment procedures framing favourable measures to alleviate the difficulties potentially encountered by S2R JU GA beneficiaries due to the COVID-19 outbreak. The beneficiaries had been allowed to request an extension of the duration of up to 6 months of the initial project durations through the fast track amendment process.

Around 20 amendments were processed specifically based on COVID-19 requests (mainly extensions of grant duration).

The S2R Programme team carried out a risk assessment exercise and presented its first results already at the S2R Governing Board of March 2020, covering the ongoing 80 projects at that time. An impact assessment based on the ability of each Programme Technological Demonstrators to reach TRL7 was made, the delays assessed and mitigation actions put in place.

Together with the Members and the other beneficiaries, the following aspects were analysed in a live monitoring document:

- Technical impact on deliverables and milestones, including interdependencies with complementary projects
- Impact on projects dissemination and communication activities
- Impact on projects financial and technical reporting periods
- Overall TD progress impact, including ongoing field tests demonstration and final planned high TRL demonstrations
- Impact on InnoTrans2020 demos (*ultimately cancelled during 2020, and replaced by additional JU virtual events participation, notably with the setup of the S2R Innovation Days*).

The initial S2R JU assessment made during the first COVID-19 wave indicated a contained general delay on the activities of around 2 to 3 months, thanks to the readiness of the S2R JU Members and project beneficiaries to swiftly implement mitigation measures following the S2R Programme team recommendations.

The analysis showed that on the one hand, projects at lower TRL levels or where collaboration was possible via digital communication progressed largely in line with their planning, possibly accelerated; on the other hand, projects requiring collaborative activities in presence in different sites in Europe, suffered from delays due to travel restrictions or other limitations.

Nevertheless, the second wave further complicated the possibility of R&I activities requiring field tests, and by the end of 2020 the Programme delay, still considered substantially contained, is estimated to be up to 6 months.

In this respect, the work of Members' and other beneficiaries, S2R staff shall be commended to ensure the progress of the research and innovation activities in such complex conditions, not only with paper-work or lab developments but with concrete demonstration activities on the rail network: for example, successful pilot line tests, including with request of derogations at national level, were performed for Automated Train Operation over ETCS at GoA2 both for passenger (in UK) and for freight operations (in CH). Additional line tests were performed on digital automatic couplers (DAC) in Germany and in Sweden, on enhanced switches and crossings installed in Austria, with a multi-modal travel companion/trip tracking/social services for passengers in Spain, Portugal, the Netherland and Greece resulting in a validation of technology that has been used for a public transport COVID-19 tracking

app, and many other R&I activities performed around Europe by multiple companies were successful and demonstrated the commitment of the rail sector to deliver the major digital transformation of Rail, paved and steered by the Shift2Rail programme.

c) Management of the Programme and financial impact: Yearly Members Annual Total Project Costs(TPC)/IKOP and IKAA declarations and certifications

In accordance with article 4(3) of the S2R Regulation, "*the members of the S2R Joint Undertaking other than the Union shall report by 31 January each year to the Governing Board of the S2R JU on the value of the contributions referred to in paragraph 2 made in each of the previous financial years*". In addition, the Other Members should provide the JU with audit certificates on these contributions (TPC/IKOP and IKAA) by 30 April of each year.

Following the COVID-19 outbreak and the request received from some Members to have their annual audit certificates provided later in the year, the JU accepted to extend the deadline for some of them, in duly justified cases. More than half of the Members submitted the audit certificates by 30 of April, while the remaining ones proceeded with submission between May and November 2020. Consequently, all the Members complied with their obligations and the reported figures are available in the section 1.11 of the present document.

In conclusion, as much as the pandemic has adversely affected the personal and professional life of the women and men working as staff, Members and/or beneficiaries in S2R and their organizations, at the same time, the S2R Programme has demonstrated resilience and has progressed towards delivering its objectives as reported in the following sections of this report.

1. IMPLEMENTATION OF THE ANNUAL WORK PLAN 2020

1.1. Key objectives 2020 and associated risks

In 2020, the S2R JU activities were driven by the overarching objective to progress the S2R R&I Programme according to the revised MAAP and detailed in the AWP 2020. Despite the Covid-19 pandemic, which affected the implementation of selected activities, the programme continued in delivering its operational objectives.

The main operational achievements in 2020 can be summarized as follows:

Delivery of Programme R&I activities

During 2020, through operational activities the Programme Office continued the supervision of the implementation of the 105 Projects and operational contracts of the S2R Programme[15], awarded and signed since 2016, for an estimated R&I Total Value of EUR 717.2 million. Details are provided in Section 1.6.

The Programme supervision and monitoring was implemented through 37 specific Control Gates (18 project reviews of 18 CFM projects, 19 project reviews of 19 OC projects) and 104 specific issue reviews (45 specific issue reviews of 18 CFM projects, 59 specific issue reviews of 30 OC projects) in order to continuously assess the submitted technical deliverables with the support of external experts (in the specific field of the deliverables) when needed. The continuous assessment of deliverables has

[15] 4 Light house projects (2015) not included.

allowed the S2R JU to be efficient in providing timely feedback to the projects for an effective implementation of recommendations and/or requests for changes.
The continuous assessment of deliverable process consists in engaging for each output of the project a swift review, which may need the support of external technical expertise and in that case the S2R JU will trigger a specific issue review. This process allows the S2R JU to provide an in depth technical feedback to the project not linked only to the reporting period review (our control gates) but during the lifetime of the action, allowing a better tuning of the activities towards the objectives.

Similarly to 2019, also in 2020 has been marked for being at the apex of the overall operational activities with 71 running projects, representing a significant workload for the JU staff. Additionally, work has been performed on the elaboration of some CCA activities, on KPIs and Standards in particular, the management of 6 quarterly IP Steering Committees and the follow up of the grant implementation (amendments, reporting, etc.).

Signature of grants related to the 2020 Call for proposals

In 2020, the S2R JU awarded 19 grants for a Total value of EUR 147.7 million, and signed 18 of them, on:

- topics (RIA and IA) open to S2R JU Other Members with a total value of the actions of EUR 125.7 million (max S2R funding EUR 55.4 million);
- topics (RIA and IA) where the S2R JU Members are excluded from participation, with a total value of the actions of EUR 22.0 million (max S2R funding EUR 20.0 million).

All call topics have been covered by applicants, thus allowing the Programme to fully implement the activities foreseen in AWP 2020 and closing the R&I needed to implement the S2R MAAP.

For more details, related to call for tenders, procurement and contracts concluded and/or launched in 2020 see section 1.8- 2.4.

Stakeholder management and external relations have been maintained through a close collaboration with the European Union Agency for Railways (ERA) in different areas, with the European Railway Research Advisory Council (ERRAC), as well as with the different International and European organizations and associations. A continuous and constructive exchange took place with other Union bodies and agencies, such as GSA, FCH JU, SESAR JU, CleanSky JU, EASA and others.

In addition, the S2R JU signed a Memorandum of Understanding (MoU) with the Basque Region on 22 January 2020 as well as with the Canadian Urban Transit Research & Innovation Consortium (CUTRIC) and the Transport Community on 23 and 26 October respectively.

The JU has also enhanced its communication efforts through the participation – mainly through virtual means - in specific activities, workshops and events in order to promote the S2R Programme participation and inform worldwide the achievements of the S2R JU Partnership.

The following sections describe how these objectives have been achieved, the activities performed and the resources used. In Annex C performance is measured against the set of agreed KPIs.

Risks

During 2020, the JU carried out an in-depth risk assessment to identify and evaluate operational and non-operational risks for the achievement of objectives. The corresponding risks associated with the Programme activities and the financial administration of the JU, requiring continuous ED (and when relevant GB) attention, as well as the corresponding risk mitigation actions have been communicated via the S2R JU AWP 2021.

The annual risk assessment performed allowed to conclude that the average Shift2Rail risk profile presents a moderate/high net criticality. No risk appears as having a very high or unacceptable net criticality score. With regard to C-19 pandemic, reference is made to the mitigating measures put in place as the risks associated to it materialized during 2020.

In the context of this report, only those risks which require continuous attention and treatment by the ED and, when relevant, by the S2R GB, because of their criticality level assigned, are reported. They are summarised in the table below together with an update on mitigating actions.

The results of the risk assessment exercise are reflected in the present table.

Risk identified	Action plan	Update 2020
Cross-project collaboration required to achieve the programme objectives may not be achieved due to 'silo-project management' or restrictions related to 'licenses', 'patents', 'IPR Member's sharing policies' or 'accessibility of past OC project results'. Therefore, individual grant agreement implementation may lead to inefficient knowledge exchange across projects and IPs and may also impact the Programme outputs at system level.	- ED Programme Board in place (IP coordinators meets) - decoupling IP structure from AWP topics - further fostering the use of a common S2R JU Cooperation Tool and sharing functionalities - dedicated cross-IP meetings - TD leaders ad-hoc meetings - focus on the GAP phase on technical part of COLA between OC/CFM - end of project letter from the S2R JU to project and IP coordinators to ensure project results use within the Programme - models and guidance from the S2R JU - simplification of legal structure for collaboration. A S2R JU Common Collaboration Agreement (Common COLA, or 'CCOLA') is under preparation. - in order to ensure connection with national activities, the S2R JU will consider signing specific collaboration agreements with other European and international Organizations, Regions and Member States.	- Actions implemented as foreseen.

Risk identified	Action plan	Update 2020
Efficiency of operations is impacted by high staff turnover together with difficulties for S2R JU to attract new people which may result in positions being filled in with delays, shortage of resources especially (during peak moments), and as a consequence leading to difficulties in getting the work done or achieving the JU's objectives (continuity); this may include a negative impact on other on employees' motivation.	- This risk is intrinsic to the S2R JU Staff establishment plan. Nevertheless, within the budget constraints, a career plan for staff has been prepared and business continuity is ensured. In 2018, the S2R JU GB adopted a revised decision on Learning and Development; implementing policy was adopted in April 2018 by the ED. - Enhancing the planning of activities will allow for better risk management. - Recruitment of short term resources (interim or trainees) has been extended.	- Actions implemented as foreseen. - In particular, the option of recruiting short-term resources was used.
Impediments during a project (e.g. changes in regulation/ non-achievement of harmonised requirements/unforeseen planning difficulties in resource planning etc.) might lead to the project not being executed in a timely and/or adequate manner preventing S2R solutions to reaching the market. This may in particular include force-majeure events (e.g. COVID) of longer duration which may lead to difficulties in obtaining the necessary authorisation(s) to organise project demonstrations, resulting in non-completion of such activity in the project concerned.	- Ensure appropriate implementation/exploitation plans in GA and at TD/IP level + national migration strategies + investigate possible instrument to support deployment at EU level and implement JU strategy/support+regular follow up of S2R standardisation roadmaps + coordination with RASCOP, and also directly with ERA, CEN/CENELEC/ETSI + regular follow up at IPSteCo/SIWG + regular updated with EURID WG + follow up of regulatory environment - change management approach (EDPB) - continous risk management and risk response (e.g. regular Covid risk assessment at project level)	- actions implemented as foreseen. - In particular, risk assessment at project and IP levels was carried out to adopt mitigating actions to correspond to the impact of the Covid-pandemic.
Coupling Reporting Period with the technical assessment of the project progress of the work and associated deliverables leads to inefficient and ineffective implementation of the action.	- continuous assessment of deliverables decoupled from the Periodic Technical Reporting - sufficiently wide and qualified expertise from pool of experts	- actions implemented as foreseen.

The risks listed here above take in particular consideration the situation of the S2R Programme, which enters in its final phases as from 2021; hence, many risks listed in the past are no longer relevant.

As regards the involvement of UK participants to the programme following the transition period, the S2R JU will implement activities in accordance with the instructions issued by the competent Commission services.

1.2. R&I activities: the S2R Programme

The S2R MAAP translates the S2R Master Plan into detailed, result-oriented R&I activities to be performed with the objective of delivering the S2R vision as from 2016 onwards.

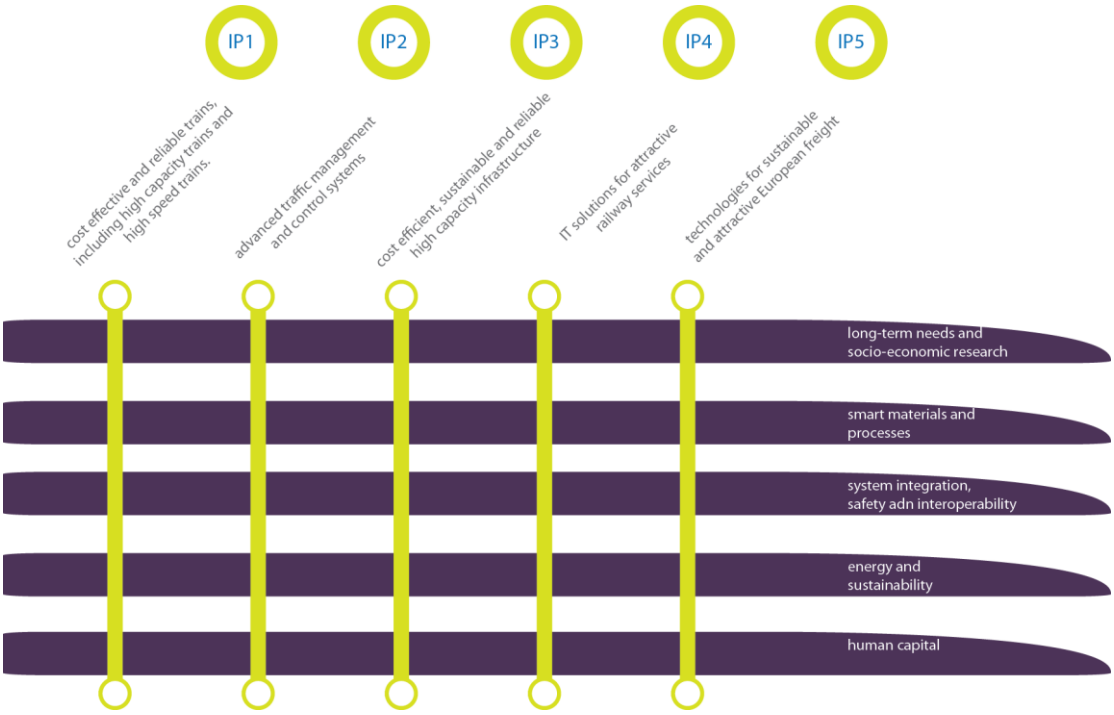
Addressing through R&I the challenges as they are detailed in the MAAP Executive View opens three opportunities for the railway:

- To become the backbone of current and future mobility concepts (e.g. mobility as a service-MaaS) and on-demand future logistics, through integrations with other modes in view of reaching a climate neutral European economy by 2050;
- To identify and establish new market segments for exploitation;
- To enhance the overall competitiveness of the industry, both in Europe and globally.

This is what the Regulation tasks the S2R JU to do when requesting it to manage all rail-focused research and innovation actions co-funded by the Union. Developing the Innovation Capabilities requires a coordinated effort among different rail and non-rail stakeholders to drive innovation at all levels in Europe. The S2R JU and its Programme are designed to make a decisive contribution to delivering the essential knowledge and innovation that will provide the building blocks to develop the Innovation Capabilities.

The work conducted within the S2R framework is structured around five asset-specific Innovation Programmes (IPs), covering the different structural (technical) and functional (process) sub-systems of the rail system. These five IPs are supported by work in five cross-cutting areas (CCA) covering themes that are of relevance to each of the projects and which address the interactions between the IPs and the different subsystems:

- IP1: Cost-efficient and Reliable Trains, including high-capacity trains and high-speed trains
- IP2: Advanced Traffic Management & Control Systems
- IP3: Cost-efficient, Sustainable and Reliable High-Capacity Infrastructure
- IP4: IT Solutions for Attractive Railway Services
- IP5: Technologies for Sustainable & Attractive European Freight.



S2R introduced in the updated MAAP also some IPx activities, R&I designed to look beyond currently planned technology applications (of the Technology Demonstrators) and how to integrate the S2R TDs with new operational concepts. IPx activities will help to realise the global optimal approach for this

System of Systems, which is railway mobility, by starting to build a railway Functional System Architecture and a Conceptual Data Model (CDM).

In addition, in 2020 the S2R JU set up the European DAC Delivery Programme, to bridge the gap towards future industrialization and deployment of a European DAC solution, building upon the work delivered in IP5 on DAC (see the following sections).

With a holistic approach, the role of the S2R JU is also to ensure that interactions between the various IPs are adequately considered and managed, as technological developments in one part of the system could lead to changes in performance, or even create barriers, in other parts. In addition, cross cutting activities include research on long-term economic and societal trends such as customer needs and human capital and skills, which must be taken into account by the different IPs.

Different types of activities contribute to the Programme development, including:

- studies, fundamental and "blue-sky" research (TRL 0 – 2),
- scientific/applied research and laboratory demonstrations (TRL 3 – 6)
- operational demonstrations and innovation activities (TRL 6-7)
- other supporting activities.

In addition to these activities, which are co-funded by the S2R JU and conducted within the scope of the S2R Programme, the Other Members are required to conduct Additional Activities with a view to leveraging the effect of the overall R&I. These Additional Activities are not eligible for financial support from the S2R JU but must contribute directly to the broader objectives set out in the Master Plan.

In 2020, the management of the programme could benefit from the regular activities of the ED Programme Board. The ED Programme Board was established as a formal advisory support to the ED and has the role of:

- monitoring the progress of the Programme,
- identify risks and opportunities and related mitigating actions,
- providing strategic guidance and making recommendations with regard to the management Programme,
- advise the Executive Director in solving issues escalated to his attention in accordance with the S2R Regulation on Programme implementation and propose a way forward,
- advise the Executive Director on the need to complement the Programme with specific expertise to be contracted as needed,
- assist and advise the Executive Director in any matter of relevance,
- the ED Programme Board works by consensus;
- the Executive Director shall report to the Governing Board about the work performed by the ED Programme Board.

The ED Programme Board forms part of the renewed Programme Governance and Change Management, adopted by ED Decision in the end of 2019 with the objective of fostering the integration of innovations and subsystems making use of a new functional (or better service-oriented) system architecture.

Through its monthly advisory meetings with S2R's Executive Director, the Programme Board has actively supported reflections on and integration of new concepts, ideas, solutions that impacted the programme. Several change requests have been processes, ensuring among other sectorial coherence

of initiatives, notably with the integration of relevant concepts from OCORA or RCA into the S2R R&I activities (projects) that will deliver concrete demonstrations.

Additionally, at the end of 2020 the ED Programme Board discussed the first release of the S2R Functional System Architecture, which is setting the basis for an increase sectorial competence for system of systems modelling in view of enabling and accelerating the integration of new technologies and processes in the rail system.

The ED Programme Board proved to provide clear benefits to the overall Programme management, anticipating risks and opportunities, ensure higher integration and synergies, addressing issues to avoid negatively impacting a delivery oriented approach.

The progress of the programme was shared with a wide range of stakeholders during the S2R Innovation Days in the end of October 2020. More than 700 participants had the opportunity to hear about rail's crucial role in the mobility and transport recovery effort, as well as recent developments with regard to Shift2Rail's successor and the upcoming European Year of Rail in 2021.

1.3. Call for proposals and grant information

Considering the annual budget availabilities and the R&I activities planned in the S2R MAAP, the S2R Programme is implemented through combined and interdependent multi-annual Projects. This structured interdependence of the S2R Projects reflects the Technological Demonstrators (TD) and Work Areas (WA) approach set within the Programme and each IP and CCA.

The following table summarises the amounts and topics available under the 2020 Call, against Budget Commitments of 2020. This Call, based on the Annual Work Plan 2020 (AWP 2020), was launched on 7 January 2020 and awarded by the JU following the Decision of the S2R GB of 17 July 2020[16].

It is presented showing the values of the topics open to Other Members (CFM) and those excluding them (OC).

Call	Type	Estimated S2R JU funding	Number of topics
H2020-S2RJU-2020	CFM	55.5 M€	8
	OC	20.0 M€	11

The total number of proposals received in response to the call for proposals was 43:

Call	Type	Number of proposals received	Number of topics
H2020-S2RJU-2020	CFM	8	8
	OC	35	11

The total S2R JU contribution requested by all the submitted proposals amounted to EUR 111.7 million compared to EUR 75.5 million available for funding:

[16] Governing Board Decision No 07/2020 of 17 July 2020: https://shift2rail.org/wp-content/uploads/2020/07/S2R-GB-Decision-07-2020.pdf

Call	Type	Requested S2R JU funding	Estimated S2R JU funding available
H2020-S2RJU-2020	CFM	55.4 M€	55.5 M€
	OC	56.3 M€	20.0 M€

On 17 July 2020, the S2R GB agreed with the proposal of the ED to award grants, which resulted in the following data:

Call	Type	Total Project Cost	S2R Funding	IKOP	Other contributions to R&I
H2020-S2RJU-2020	CFM	125.7 M€	55.4 M€	70.3 M€	
	OC	22.0 M€	20.0 M€		2 M€[17]
	TOTAL	**147.7 M€**	**75.4 M€**	**70.3 M€**	**2 M€**

The S2R JU Other Members submitted project proposals to cover eight call topics open to them.

The value of activities to be performed by the S2R JU Other Members in the coming years in respect to the amounts awarded and signed of this call corresponds to EUR 125.7 million that will be funded by the S2R JU up to EUR 55.4 million. These projects normally started on 1 December 2020; however, for some projects an earlier start date was agreed to guarantee continuity with previous R&I activities.

Following the projects selected for funding by the S2R Governing Board resulting from the call 2020 and the four calls from preceding years (2016-2019), the overall value of Other Members ongoing projects is EUR 616.6 million which are expected to be co-funded by the S2R JU up to EUR 271.3 million.

The applicants to the OC covered all 11 topics open to them. The value of the activities to be performed by the awarded consortia amounts to EUR 22.0 million: EUR 20.0 million to be funded by the S2R JU up to 100% or 70% of the eligible direct costs, subject to respectively being RIA or IA actions. The overall OC amount of ongoing projects awarded in the 2016-2020 calls is EUR 102.1 million. The S2R GB on 17 July 2020 approved the list of actions selected for funding proposed by the Executive Director; evaluation result letters were sent to all applicants on 28 July 2020.

Call topics open to S2R JU Other Members: Awarded and signed projects

Topic	Acronym	Title	Project value € M	Grant € M	In kind contr. € M	Start date	End date
S2R-CFM-IP1-01-2020	PINTA3	IP1 Traction TD1– Phase 3 and HVAC TD8	19.4	8,6	S2R-CFM-IP1-01-2020	01/12/2020	31/05/2023

[17] This is the difference between the Research and Innovation activities declared by a beneficiary and the funding received from the JU.

Topic	Acronym	Title	Project value € M	Grant € M	In kind contr. € M	Start date	End date
S2R-CFM-IP1-02-2020	CONNECTA-3	CONtributing to Shift2Rail's NExt generation of high Capable and safe TCMS PhAse 3	9.0	4.0	S2R-CFM-IP1-02-2020	01/12/2020	31/07/2023
S2R-CFM-IP2-01-2020	X2Rail-5	Completion of activities for Adaptable Communication, Moving Block, Fail safe Train Localisation (including satellite), Zero on site Testing, Formal Methods and Cyber Security	33.9	14,8	S2R-CFM-IP2-01-2020	01/12/2020	31/05/2023
S2R-CFM-IP3-01-2020	IN2TRACK3	IN2TRACK3	26.7	11,8	S2R-CFM-IP3-01-2020	To be signed in Q1 2021	
S2R-CFM-IP4-01-2020	ExtenSive	Extending the attractiveness of transport for end user and extending IP4 to SaaS solutions.	11.3	5,0	S2R-CFM-IP4-01-2020	01/12/2020	30/06/2023
S2R-CFM-IP5-01-2020	FR8RAIL IV	Use-centric rail freight innovation for Single European Railway Area	17.6	7,8	S2R-CFM-IP5-01-2020	01/07/2020	31/03/2023
S2R-CFM-IPX-01-2020	TAURO	Technologies for Autonomous Rail Operation	4.6	2.0	S2R-CFM-IPX-01-2020	01/12/2020	31/05/2023
S2R-CFM-IPX-CCA-02-2020	LINX4RAIL 2	SYSTEM ARCHITECTURE AND CONCEPTUAL DATA MODEL FOR RAILWAY, COMMON DATA DICTIONARY AND GLOBAL SYSTEM MODELLING SPECIFICATIONS	3.2	1,4	S2R-CFM-IPX-CCA-02-2020	01/12/2020	31/05/2023
TOTAL			**125.7**	**55.4**	**70.3**		

For the CFM projects, the respective grant agreements were signed in November and December 2020 and with the exception of IN2TRACK3 signed in May 2021 all the activities started between 1 December 2020 and January 2021.

Open call topics for S2R JU non-Members: Awarded and signed projects

Topic	Acronym	Title	Project value € M	Grant € M	Start date	End date
S2R-OC-CCA-01-2020	SILVARSTAR	SoIL Vibration and AuRalisation Software Tools for Application in Railways	1,0	1,0	01/11/2020	31/10/2022
S2R-OC-IP1-01-2020	RECET4Rail	Reliable Energy and Cost Efficient Traction system for Railway	2,3	2,3	01/12/2020	31/05/2023
S2R-OC-IP1-02-2020	Safe4Rail-3	Advanced safety architecture and components for next generation TCMS in Railways	6,1	4,6	01/12/2020	31/07/2023
S2R-OC-IP1-03-2020	Gearbodies	Innovative Technologies for Inspecting Carbodies and for Development of Running Gear	2,4	2,4	01/12/2020	31/12/2022
S2R-OC-IP2-01-2020	PERFORMINGRAIL	PERformance-based Formal modelling and Optimal tRaffic Management for movING-block RAILway signalling	1,3	1,3	01/12/2020	30/06/2023
S2R-OC-IP2-02-2020	AB4Rail	Alternative Bearers for Rail	0,4	0,4	01/01/2021	31/12/2022
S2R-OC-IP3-01-2020	IN2ZONE	The Next Generation of Railway Transition Zones	1,3	1,3	01/12/2020	30/05/2023
S2R-OC-IP3-02-2020	DAYDREAMS	Development of prescriptive AnalYtics baseD on aRtificial intElligence for iAMS	1,7	1,7	01/12/2020	31/05/2023
S2R-OC-IP3-03-2020	STREAM	Smart Tools for Railway work safEty and performAnce iMprovement	2,7	2,7	01/12/2020	31/05/2023
S2R-OC-IP4-01-2020	IP4MaaS	Shift2Rail IP4 to support the deployment of Mobility as a Service	2,5	2,0	01/12/2020	31/05/2023
S2R-OC-IPX-01-2020	HYPERNEX	HYPERNEX: IGNITION OF THE EUROPEAN HYPERLOOP ECOSYSTEM	0,3	0,3	01/12/2020	30/11/2021
TOTAL			**22,0**	**20,0**		

For the open call projects, the respective grant agreements were signed in November and December 2020 and all the activities started between 1 November 2020 and 1 January 2021.

1.3.1. Progress against KPIs / Statistics (Annex C)

The Key performance Indicator results for the year 2020 are presented in Annex C. The JU has taken into its scoreboard all Horizon 2020 indicators, which have been established for the entire Research family by the Commission, to the extent they can be applied to the JU in view of providing meaningful results.

Comments to some indicators are provided in the table in the Annex or in the related section of the report, to which the indicators refer. In addition, the S2R JU is presenting more detailed results of its performance monitoring in specific areas, e.g. key figures provided in the section dealing with the call for proposals and the following evaluation process.

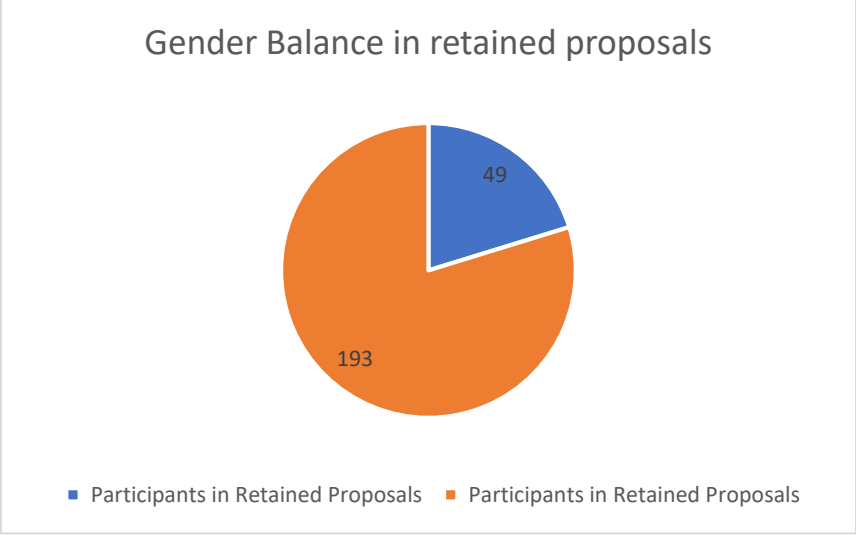
Within the context of the CCA activities, during 2020 the S2R JU continued the work to maintain the 'S2R 2030 Impact Forecast Model' ensuring the next Release, resulting from the update of the data input from the different projects and TDs. The latest version is shown in Annex C Table IV of the present report provides the figures (Release 3.1). The KPI tool is fully available to the public on the S2R website (https://kpi.shift2rail.org/Dashboards/Dashboard/41)

1.3.2. Evaluation: procedures and global evaluation outcome, redress, statistics

The evaluation process took place from 28 May to 1 June 2020. The proposals were evaluated by 39 external experts from 13 different Member States (with a gender balance of 26 males and 13 females). Evaluations were conducted in 7 panels. Seven independent experts performed the task as recorder, supporting the evaluators. These experts, also selected from the EC database, facilitated the drafting of consensus reports as dedicated rapporteurs but did not assess proposals. An independent observer was appointed to monitor the whole process. Each panel covered between 1 and 8 topics from the AWP 2020. The CFM proposals were evaluated as part of one specific panel, with 6 experts covering the entire field of needed expertise. The OC proposals were evaluated in six specific panels reflecting technical domains and each containing 3 to 5 experts. The European Commission/DG MOVE representatives, the European Agency for Railways representatives and the European GNSS Agency were invited to be present at the panels' meetings. For the evaluation of the Lump Sum Grant proposals, three independent financial experts provided support to the experts in charge.

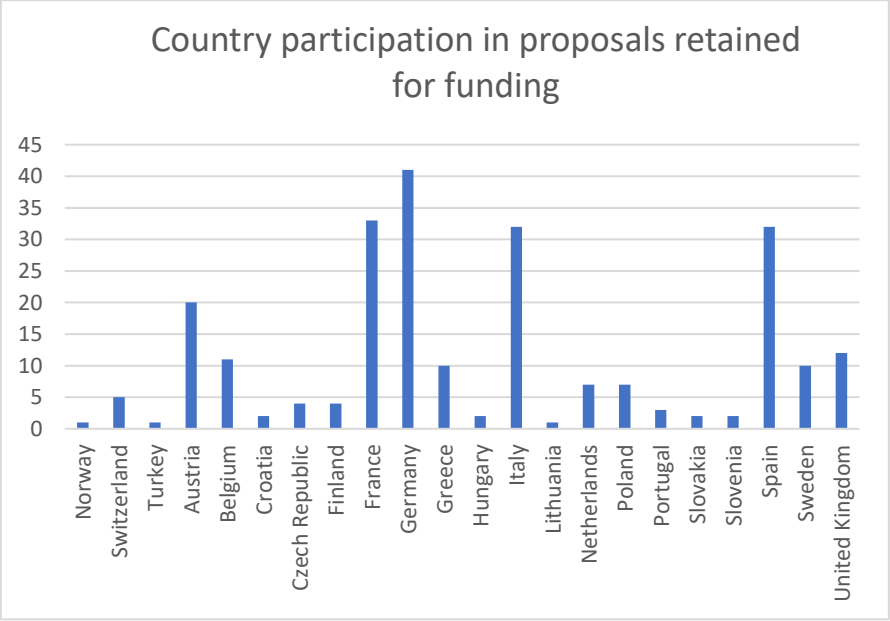
Due to the situation of the pandemics, the consensus meetings in the end of June to beginning of July 2020 were organised fully online. They were moderated by staff from the S2R JU via web-conferencing tools and attended as well by the IP Coordinators, representatives of European Commission, European Agency for Railways and European Global Navigation Satellite Systems Agency as additional observers. While the process as such saw no change, specific provisions were made, in line with guidance provided by the Commission, to reflect and comply with additional requirements stemming from an online organisation of the meetings.

The total number of proposal evaluated was 42: 19 were retained for funding with a success rate of 45.2%. The number of participants in the evaluated proposals was 406, represented by 87 female, 318 male and 1 with no gender information provided. 242 participants were retained for funding with a success rate of 59.6%. Out of the retained participants in terms of co-signatory of proposals, 49 were female (success rate 56.3%), 193 were male (success rate 60.7%) and 1 with no gender information provided. Out of the 19 retained proposals for funding with 19 coordinators involved, 4 were female (success rate 40.0 %) and 15 were male (success rate 46.9 %).



SMEs participating were 87 and 46 were retained for funding, with a success rate of 52.9 %. SMEs represent 21.4% of total participation and 19.0% of retained participants for funding. In the OC projects, SME's represent 26,7% of total participation and 29.1% of the entities selected for funding.

From a geographical perspective, 30 countries participated to the call, 23 were from the EU Member States, 5 from Associated Countries[18] and the United Kingdom. After the evaluation, the participating countries to the retained project for funding were 22 in total out of which 19 from EU and 3 from Associated Countries, as well as the United Kingdom (see details in ANNEX C).

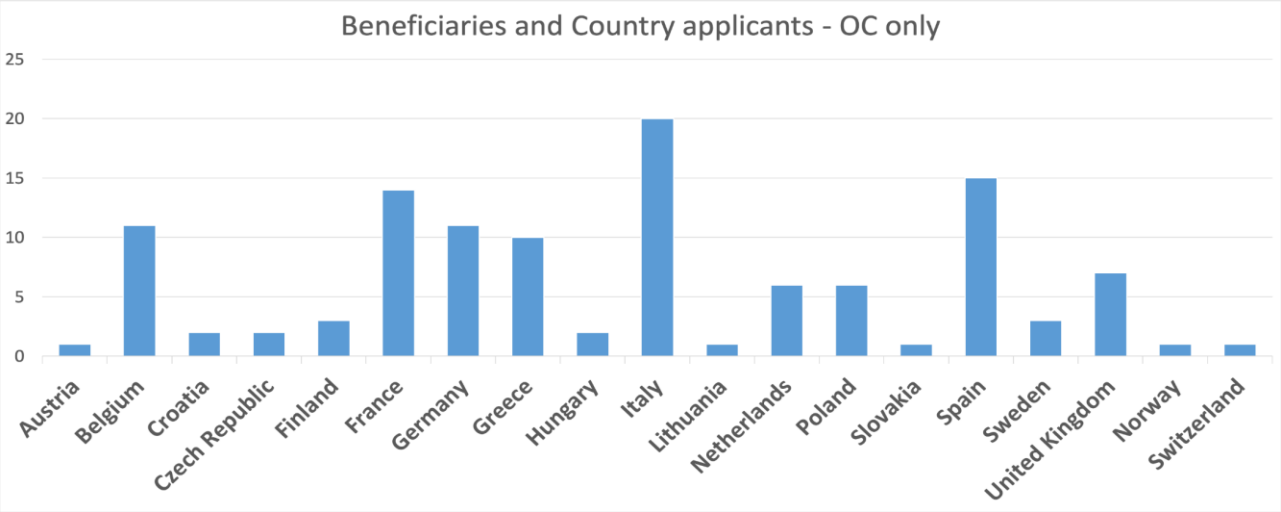


The majority of the participation to the Call 2020 is from the EU-15 Member States. Although a slight increase of EU-13 Members participation has been noticed in the last call of S2R thanks to the efforts made by the S2R JU and the increase of TRL of the Programme, representing a +54% compared to the

[18] EU Member States include the United Kingdom given status at the time of the launch and evaluation of the call.

average from all the previous S2R calls (with a total of 20 participants versus a previous average of 13), to facilitate a future stronger participation from the under-represented Member States, it will be important to integrate successful S2R R&I results with longer-term demonstration activities, to bridge the way towards future deployment.

For the Open Calls, the beneficiaries are from the following countries:



1.3.3. Activities carried out in Grant Agreements

On 31 December 2020, taking into consideration activities reaching their completion and recently awarded projects, 72[19] projects were ongoing (36 CFM and 36 OC): 55 projects were distributed on the 5 Innovation Programmes, 9 projects on the Cross Cutting Activities and 8 projects in IPx, as follows:

IP1: Cost-efficient and Reliable Trains, including high-capacity trains and high-speed trains

Project Title	Call Reference	Period	Project Value (signed GA)
PIVOT	S2R-CFM-IP1-01-2017	01/10/2017 - 31/12/2019	€ 17 432 048
CONNECTA-2	S2R-CFM-IP1-02-2018	01/10/2018 - 31/03/2021	€ 9 687 622
PINTA-2	S2R-CFM-IP1-01-2018	01/09/2018 - 30/11/2020	€ 28 534 184
SAFE4RAIL-2	S2R-OC-IP1-01-2018	01/10/2018 - 30/04/2021	€ 3 991 632
PIVOT2	S2R-CFM-IP1-01-2019	01/10/2019 - 31/12/2022	€ 40 155 405
CARBODIN	S2R-OC-IP1-01-2019	01/12/2019 - 30/11/2021	€ 3 549 291

[19] Four Lighthouse projects (2015) not included. One Open Call project, Dynafreight in IP5, has been finalised.

Project Title	Call Reference	Period	Project Value (signed GA)
NEXTGEAR	S2R-OC-IP1-02-2019	01/12/2019 - 30/11/2021	€ 2 573 877
PINTA-3	S2R-CFM-IP1-01-2020	01/12/2020- 31/05/2023	€ 19 446 251
CONNECTA-3	S2R-CFM-IP1-02-2020	01/12/2020- 31/07/2023	€ 8 973 663
RECET4Rail	S2R-OC-IP1-01-2020	01/12/2020- 31/05/2023	€ 2 300 036
SAFE4RAIL-3	S2R-OC-IP1-02-2020	01/12/2020- 31/07/2023	€ 6 132 399
GEARBODIES	S2R-OC-IP1-03-2020	01/12/2020- 31/12/2022	€ 2 419 969

IP2: Advanced Traffic Management & Control System

Project Title	Call Reference	Period	Project Value (signed GA)
X2Rail-1	S2R-CFM-IP2-01-2015	01/09/2016 - 30/04/2020	€ 40 878 154
X2Rail-2	S2R-CFM-IP2-01-2017	01/09/2017 - 31/08/2020	€ 30 152 828
X2Rail-3	S2R-CFM-IP2-01-2018	01/12/2018 - 30/11/2021	€ 38 728 459
X2Rail-4	S2R-CFM-IP2-01-2019	01/12/2019 - 28/02/2023	€ 41 109 700
X2Rail-5	S2R-CFM-IP2-01-2020	01/12/2020- 31/05/2023	€33 890 375
MOVINGRAIL	S2R-OC-IP2-01-2018	01/12/2018 - 31/12/2020	€ 1 299 135
GATE4RAIL	S2R-OC-IP2-02-2018	01/12/2018 - 30/11/2020	€ 1 019 994
EMULRADIO4RAIL	S2R-OC-IP2-03-2018	01/12/2018 - 31/05/2020	€ 748 097
4SECURAIL	S2R-OC-IP2-01-2019	01/12/2019 - 30/11/2021	€ 549 875
OPTIMA	S2R-OC-IP2-02-2019	01/12/2019 - 28/02/2023	€ 2 249 897
PERFORMINGRAIL	S2R-OC-IP2-01-2020	01/12/2020 - 30/06/2023	€ 1 335 359
AB4Rail	S2R-OC-IP2-02-2020	01/01/2021- 31/12/2022	€ 349 926

IP3: Cost-efficient, Sustainable and Reliable High-Capacity Infrastructure

Project Title	Call Reference	Period	Project Value (signed GA)
In2Track	S2R-CFM-IP3-01-2016	01/09/2016 - 30/04/2019	€ 6 531 900

Project Title	Call Reference	Period	Project Value (signed GA)
IN2SMART	S2R-CFM-IP3-02-2016	01/09/2016 - 31/10/2019	€ 16 405 563
In2Stempo	S2R-CFM-IP3-01-2017	01/09/2017 - 31/08/2022	€ 13 439 981
S-CODE	S2R-OC-IP3-01-2016	01/11/2016 - 31/10/2019	€ 4 999 771
ASSETS4RAIL	S2R-OC-IP3-01-2018	01/12/2018 - 31/05/2021	€ 5 506 631
FUNDRES	S2R-OC-IP3-01-2019	01/12/2019 - 30/11/2021	€ 749 540
In2Track2	S2R-CFM-IP3-01-2018	01/11/2018 - 30/04/2021	€29 676 014
IN2SMART2	S2R-CFM-IP3-01-2019	01/12/2019 - 30/11/2022	€ 23 091 203
In2Track3	S2R-CFM-IP3-01-2020	12/05/2021- 30-12-2023	€ 26 689 979
IN2ZONE	S2R-OC-IP3-01-2020	01/12/2020- 31/05/2023	€ 1 349 974
DAYDREAMS	S2R-OC-IP3-02-2020	01/12/2020- 31/05/2023	€ 1 709 875
STREAM	S2R-OC-IP3-03-2020	01/12/2020- 31/05/2023	€ 2 700 000

IP4: It Solution for Attractive Railways Services

Project Title	Call Reference	Period	Project Value
CO-ACTIVE	S2R-CFM-IP4-01-2015	01/09/2016 - 31/05/2019	€ 7 621 915
CONNECTIVE	SR2-CFM-IP4-01-2017	01/09/2017 - 30/06/2022	€ 7 906 243
COHESIVE	S2R-CFM-IP4-02-2017	01/09/2017 - 30/06/2022	€ 4 039 492
My-TRAC	S2R-OC-IP4-01-2017	01/09/2017 - 30/09/2020	€ 3 494 476
SPRINT	S2R-OC-IP4-01-2018	01/12/2018 - 31/12/2020	€ 1 999 500
SHIFT2MAAS	S2R-OC-IP4-02-2018	01/12/2018 - 31/12/2020	€ 1 499 906
MaaSive	S2R-CFM-IP4-01-2018	01/11/2018 - 31/05/2021	€ 11 692 236
RIDE2RAIL	S2R-OC-IP4-01-2019	01/12/2019 - 31/05/2022	€ 2 999 993
ExtenSive	S2R-CFM-IP4-01-2020	01/12/2020- 30/06/2023	€ 11 308 529
IP4MaaS	S2R-OC-IP4-01-2020	01/12/2020- 31/05/2023	€ 2 507 081

IP5: Technologies for Sustainable & Attractive European Freight

Project Title	Call Reference	Period	Project Value
ARCC	S2R-CFM-IP5-02-2015	01/09/2016 - 31/10/2020	€ 3 600 360
FR8HUB	S2R-CFM-IP5-01-2017	01/09/2017 - 31/08/2020	€ 9 900 990
FR8RAIL	S2R-CFM-IP5-01-2015	01/09/2016 - 31/08/2019	€ 7 826 783
FR8RAIL II	S2R-CFM-IP5-01-2018	01/05/2018 - 30/04/2021	€ 12 438 174
M2O	S2R-OC-IP5-01-2018	01/12/2018 - 31/12/2020	€ 599,955
LOCATE	S2R-OC-IP5-01-2019	01/11/2019 - 31/10/2021	€ 1 499 072
SMART2	S2R-OC-IP5-02-2019	01/12/2019 - 30/11/2022	€ 1 708 737
FR8RAILIII	S2R-CFM-IP5-01-2019	01/09/2019 - 31/08/2022	€ 13 061 601
FR8RailIV	S2R-CFM-IP5-01-2020	01/07/2020- 31/03/2023	€ 17 604 534

IPX:

Project Title	Call Reference	Period	Project Value
FLEX-RAIL	S2R-OC-IPX-01-2018	01/12/2018 - 30/06/2021	€ 1 099 230.00
TER4RAIL	S2R-OC-IPX-02-2018	01/12/2018 - 30/11/2020	€ 499 992
B4CM	S2R-OC-IPX-03-2018	01/12/2018 - 30/11/2021	€ 124 951
MVDC-ERS	S2R-OC-IPX-03-2018	01/12/2018 - 30/11/2021	€ 125 000
LINX4RAIL	S2R-CFM-IPX-CCA-01-2019	01/12/2019 - 30/11/2022	€ 5 216 494
RAILS	S2R-OC-IPX-01-2019	01/12/2019 - 30/11/2022	€ 299 954
TRANSLATE4RAIL	S2R-OC-IPX-02-2019	01/12/2019 - 30/11/2021	€ 248 094
LINX4RAIL2	S2R-CFM-IPX-CCA-02-2020	01/12/2020- 31/05/2023	€ 3 228 829
TAURO	S2R-CFM-IPX-01-2020	01/12/2020- 31/05/2023	€ 4 559 803
HYPERNEX	S2R-OC-IPX-01-2020	01/12/2020- 31/11/2021	€ 250 000

CCA: Cross Cutting Activities

Project Title	Call Reference	Period	Project Value

FINE1	S2R-CFM-CCA-02-2015	01/09/2016 - 31/10/2019	€ 3 017 282
IMPACT-1	S2R-CFM-CCA-01-2015	01/09/2016 - 30/04/2018	€ 674 958
IMPACT-2	S2R-CFM-CCA-01-2017	01/09/2017 - 30/08/2022	€ 7 096 428
PLASA-2	S2R-CFM-CCA-01-2018	01/09/2018 - 31/10/2020	€ 1 853 384
TRANSIT	S2R-OC-CCA-01-2019	01/12/2019 - 30/11/2022	€ 1 308 718
FINE2	S2R-CFM-CCA-01-2019	01/12/2019 - 30/11/2022	€ 8 179 973
SILVARSTAR	S2R-OC-CCA-01-2020	01/11/2020 31/10/2022	€ 949 999

Closed Projects related to Call for member topics for S2R JU Members

TOPIC	ACRONYM	TITLE	PROJECT VALUE	GRANT	START DATE	CLOSURE DATE
H2020-S2RJU-CFM-2015-01-1	ATTRACkTIVE	Advanced Travel Companion and Tracking Services	5,5	2,2	01/09/2016	14/04/2020
H2020-S2RJU-CFM-2015-01-1	FFL4E	Future Freight Loco for Europe	3,9	1,4	01/09/2016	07/02/2020
S2R-CFM-CCA-03-2015	PLASA	Smart Planning and Safety for a safer and more robust European railway sector	1,2	0,3	01/09/2016	07/06/2019
H2020-S2RJU-CFM-2016-01-1	PINTA	IP1 Traction TD1 and Brakes TD5 – Phase 1	29.2	12,6	01/09/2016	02/01/2020
H2020-S2RJU-CFM-2016-01-1	CONNECTA	CONtributing to Shift2Rail's NExt generation of high Capable and safe TCMS and brAKes. Phase 1.	11,5	5.1	01/09/2016	08/10/2019

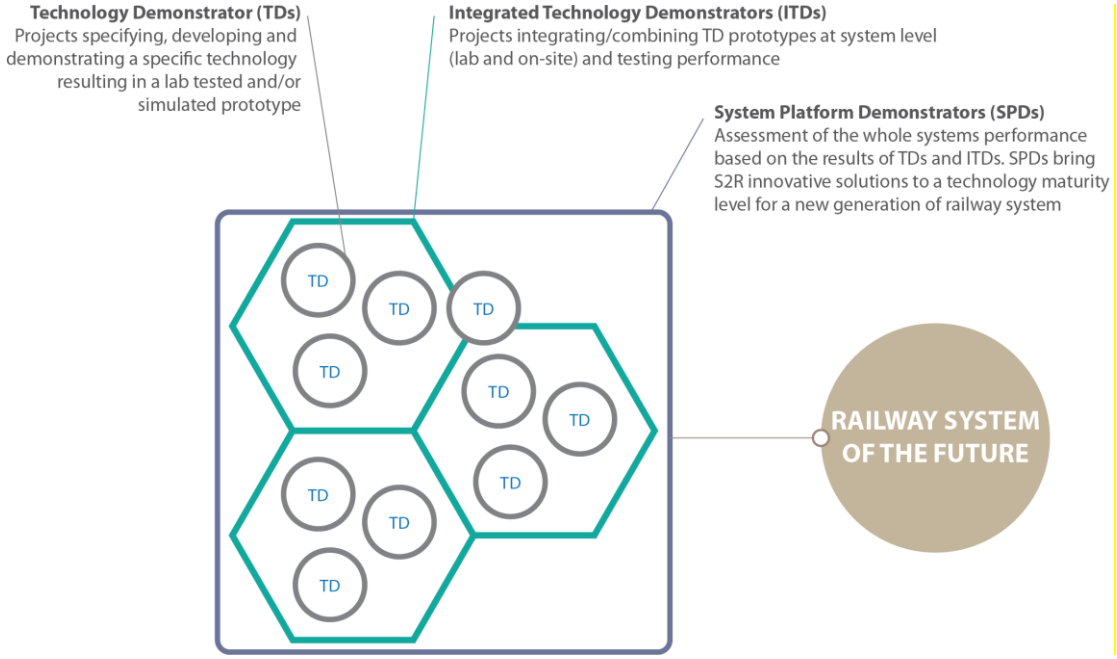
Closed Projects related to Open call topics for S2R JU non-Members

TOPIC	ACRONYM	TITLE	PROJECT VALUE	GRANT	START DATE	CLOSURE DATE
S2R-OC-IP2-01-2015	CYRAIL	Cybersecurity in the RAILway sector	1,5	1,5	01/10/2016	16/11/2019
S2R-OC-IP2-03-2015	MISTRAL	Communication Systems for Next-generation Railways	0,5	0,5	01/11/2016	28/06/2019
S2R-OC-IP4-01-2016	GoF4R	Governance of the Interoperability Framework for Rail and Intermodal Mobility	1,8	1,8	01/11/2016	10/10/2019
S2R-OC-IP4-02-2016	ST4RT	Semantic Transformations for Rail Transportation	1,0	1,0	01/11/2016	19/04/2019

TOPIC	ACRONYM	TITLE	PROJECT VALUE	GRANT	START DATE	CLOSURE DATE
S2R-OC-CCA-01-2015	NEAR2050	NEAR2050 - future challenges for the rail sector	0,4	0,4	01/10/2016	21/09/2019
S2R-OC-CCA-03-2015	DESTINATE	Decision supporting tools for implementation of cost-efficient railway noise abatement measures	1,0	1,0	01/11/2016	19/07/2019
S2R-OC-IP5-02-2015	Dynafreight	Innovative technical solutions for improved train DYNAmics and operation of longer FREIGHt Trains	0,9	0,9	01/11/2016	11/12/2018
H2020-S2RJU-OC-2015-01-2	GoSAFE RAIL	GoSAFE RAIL- Global Safety Management Framework for RAIL Operations	1,3	1,3	01/10/2016	14/07/2020
H2020-S2RJU-OC-2015-01-2	INNOWAG	INNOvative monitoring and predictive maintenance solutions on lightweight WAGon	1,5	1,5	01/11/2016	22/06/2020
H2020-S2RJU-OC-2015-01-2	OPEUS	Modelling and strategies for the assessment and OPtimisation of Energy USage aspects of rail innovation	0,7	0,7	01/11/2016	17/08/2020
H2020-S2RJU-OC-2015-01-2	VITE	Virtualisation of the testing environment	0,9	0,9	01/11/2016	14/04/2020
H2020-S2RJU-OC-2016-01-2	SAFE4RAIL	SAFE architecture for Robust distributed Application Integration in roLling stock	6,7	6,7	01/10/2016	19/06/2020
H2020-S2RJU-OC-2017	IN2DREAMS	Intelligent solutions 2wards the Development of Railway Energy and Asset Management Systems in Europe	2,1	2,1	01/09/2017	19/08/2020
H2020-S2RJU-OC-2017	Mat4Rail	Designing the railway of the future: Fire resistant composite materials and smart modular design	3,5	3,5	01/10/2017	14/04/2020
H2020-S2RJU-OC-2017	MOMIT	Multi-scale Observation and Monitoring of railway Infrastructure Threats	0,6	0,6	01/09/2017	14/07/2020
H2020-S2RJU-OC-2017	OPTIYARD	Optimised Real-time Yard and Network Management	1,4	1,4	01/10/2017	08/12/2020
H2020-S2RJU-OC-2017	RUN2Rail	Innovative RUNning gear soluTiOns for new dependable, sustainable, intelligent and comfortable RAIL vehicles	2,5	2,5	01/09/2017	14/07/2020
H2020-S2RJU-OC-2017	SMaRTE	Smart Maintenance and the Rail Traveller Experience	1,0	1,0	01/09/2016	14/06/2020

TOPIC	ACRONYM	TITLE	PROJECT VALUE	GRANT	START DATE	CLOSURE DATE
H2020-S2RJU-OC-2017	ASTRail	SAtellite-based Signalling and Automation SysTems on Railways along with Formal Method and Moving Block validation	1,8	1,8	01/09/2017	21/03/2020
H2020-S2RJU-OC-2017	ETALON	Energy harvesTing for signAILing and cOmmunicatioN systems	1,7	1,7	01/09/2017	22/10/2020
H2020-S2RJU-OC-2017	FAIR Stations	Future Secure and Accessible Rail Stations	1,2	1,2	01/09/2017	10/12/2020

The practical demonstration of S2R R&I activities is being carried out using a combination of single technology demonstrators (TDs), integrated technology demonstrators (ITDs and resulting into the Innovation Capabilities) and system platform demonstrators (SPDs).



The following sections illustrate the progress achieved in the Technology Demonstrators at the end of 2020. The contributions from the TDs to the delivery of the innovation capabilities (as mentioned in the MAAP (part A) were elaborated in the MAAP (part B), adopted by the GB in November 2019.

1.4. Towards delivering the S2R Programme

This section presents by Innovation Program the progress of ongoing projects implementing the R&I activities measured through the achievements in the development of Technology Demonstrators. A market correspondence table per TD was published in the MAAP (draft Part B) in May 2019.

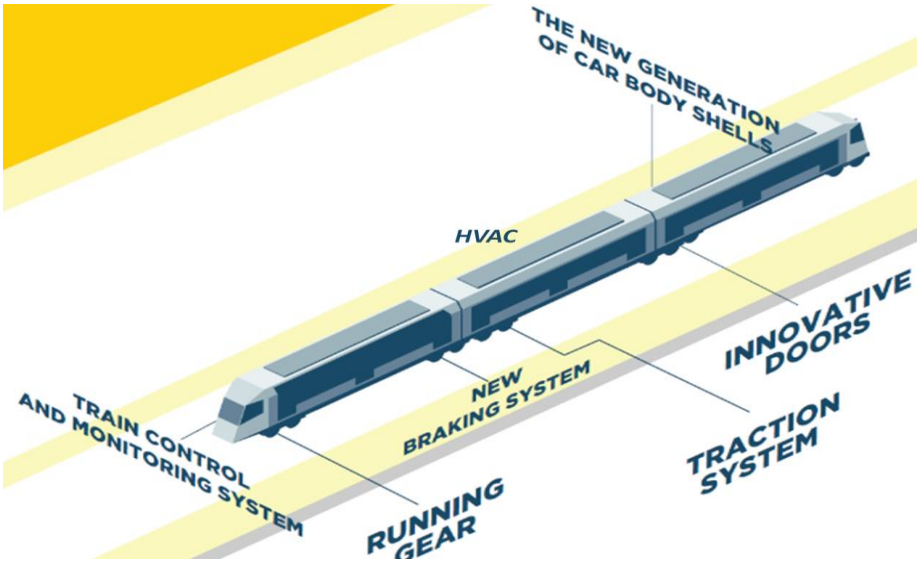
An overview of demonstrators with a Technology Readiness Level reaching at least 6 (technology demonstrated in relevant environment) is displayed below, together with the provisional planning for test end.

IP	Research Area	Specific Technological demonstration of	characteristics					Overall high level focus/objective
			Market	Testing time - YEAR start	Testing time - YEAR end	Country	TRL	
IP1	TD1.4 Running Gear	Optimised Materials	High Speed	2020	2021	ES	6	Composite runnning gear from for independently rotating wheels
		Bogie Control	Generic	2019	2021	DE	6/7	Innovative wheelset guiding based on proven hydraulic actuators minimizing active control
			High Speed	2019	2021	ES	6	Active suspension to improve passenger comfort and vibration reductions
	TD1.8 HVAC	HVAC-Technology with natural gases	Regional	2020	2022	DE	7	Test within a climatic chamber and in real operation of new soltuion and compatibility of Standardisation of interfaces, Reduction of climatic impact, Reduction of energy consumption and costs.
IP2	TD2.2 Automatic Train Operation	feasibility of GoA2 solution	Urban/High Speed/Regional	2019	2021	UK, CH	6/7	For GoA2, to check the behaviour of the system (ATO on board and ATO trackside) in a real pilot line.
	TD2.9 Traffic management system	Conflict Detection and Resolution	Generic	2020	2022	DE	6	Business service applications for the detection of future conflicts, the presentation of the results to the operator and conflict resolution measures and integration into workflow.
		Application Modules		2020	2022	DE	6	Interaction between the TMS providing indication of asset failure on the Integration Layer + selected features of Operator workstation with 3rd party application HMI
IP3	TD3.1 Enhanced Switch & Crossing System Demonstrator	RAMS optimised S&C	Generic	2019	2023	AT	6/7	Monitoring programme foe S&C including: Geometry and overrunning, casting, novel rail grade, resilient pads, rail fastening system, base plates, switch roller system, etc.
		Joint Welding of bainitic components		2020	2023	FR	5/6	Experimental evaluation of fatigue of cast manganese-crossing for welding technology to join bainitic with pearlite steel components.
	TD3.2 Next Generation	Materials and Components	Generic	2019	2023	UK, SE, FR	4/7	Next generation S&C materials and components tests (*i.e.* adjustable fastening systems)
	TD3.3 Optimised Track System	Transition zone	Generic	2019	2023	SE	5/6	tests on improvement of the transition between open track and bridges, open track and S&C, ballasted track and slab track
		new slab track		2019	2023	SE	7	test of a Modular Slab track solution reducing maintenance costs
		Innovative use of materials		2019	2023	AT	5/6	test of innovative use of materials and advanced manufacturing techniques
		Laser clad coating on rails		2020	2023	AT	5/6	test of laser clad coatings on rails nearby and on rail joints; laser hardening and laser cladding of worn rail zones
	TD3.4 Next Generation Track System	Rail Defect Repair	Generic	2020	2023	UK	7	Thermocouple instrumented trials on process for different rail steel grades
	TD3.5 Proactive Bridge and Tunnel Assessment, Repair and Upgrade Demonstrator	Tunnel improvements		2020	2023	FR, UK	7	Reduce track and tunnel closure by offsite manufacturing and increase quality
				2020	2023	AT	7	Predict calcite clogging over time
		Bridge improvements	Urban/Suburban	2020	2023	DE	6	Efficient monitoring of noise emission and installation of passive noise dampers.
			Generic	2020	2023	UK	7	Extend bridge service life by lowering fatigue
			High Speed	2020	2023	SE	7	Make high speed traffic possible on existing bridges with proven dynamic properties
IP4	Integrated TDs of all IP4 ecosystem	Integrated multimodal ecosystem	Multimodal (rail, bus, metro,…)	2020	2020	PT (Lisbon), ES (Malaga), Central East Corridor	5/6	Demonstration of functional ecosystem, including integrated functionalities (operator Portal, CMMP, Journey Planning, Offer Building, Booking and Ticketing, Access to Ansilary Services, Trip Tracking, Location Based Experiences) within the different scenarios. Through the application show how to plan (booking,shopping, tracking, navigation, notification…) and perform the trip. Different corridors (Lisbon, Malaga and central east) will be presented with a specific use cases for each one covering business or family travel. Integration with a third-party application.

IP5	TD5.1 Fleet Digitalization and Automation	Automatic coupling	Freight	2020	2022	SE	6/7	Telematics and electrification, digital automatic coupling of TD5.1 will be tested. Test in extreme winter conditions. These testing activities will contribute to the compilation of enough evidence so final EU DAC Product specification can be standardised and safety/interoperability requiments updated in the TSI
		Condition based maintenance		2020	2022	DE	6/7	End-to-end solution for predictive maintenance, including processes, data handling, analytics and dashboards, for locomotives and wagons.
		ATO-application for industrial Freight trains		2020	2021	CH	6/7	Freight ATO (GoA2) use cases on ETCS Level 2 track in the open network, using ATO modules of IP2.

1.4.1. IP1 Cost-efficient and Reliable Trains, including high-capacity trains and high speed trains

The pictures below gives a visual perception on where the TDs will introduce improvements



TD 1.1. Traction systems Demonstrator

The TD develops new traction components and subsystems using mainly silicon carbide (SiC) technologies leading to new architectures. The activities aim at producing SiC Technology Traction Demonstrators to be implemented into a tramway, a metro, a sub-urban train, a regional train and also a traction system based on independently rotating wheels to be demonstrated on a high-speed train. The SiC application opens up many Key Performances Indicators (Life Cycle Cost and technical) improvements. Besides improved energy efficiency, maintenance costs, it gives additional optimisation possibilities enhancing customer value, such as noise reduction and efficient cooling.

TD progress

TD1.1 builds on the progress made by the Roll2Rail and PINTA projects and ongoing action PINTA2. PINTA3 and RECET4Rail (OC project) were launched in December 2020.

The main objective for 2020 was the manufacturing and static tests of prototypes of Traction components at TRL5-6 levels, preparing further validation for the future trains testing (TRL7) in PINTA3 (Dec 2020-May 2023).

The work carried out in 2020 has given the following main results:

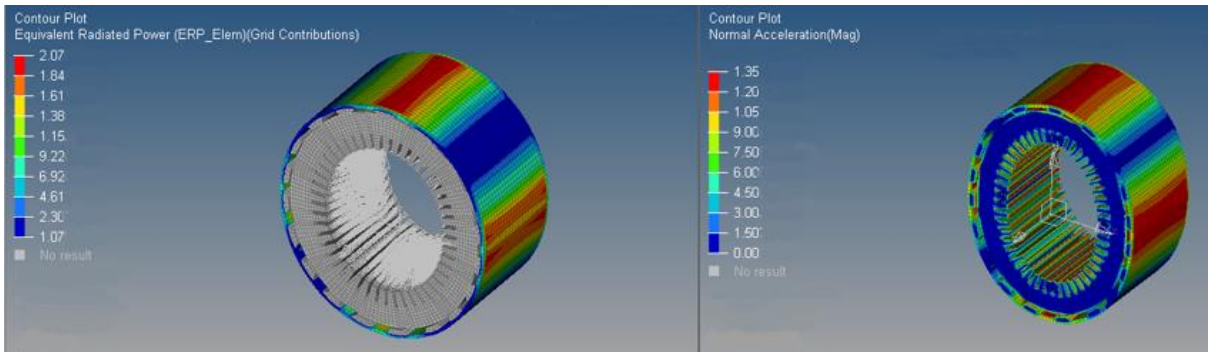
- Prototypes manufacturing and tests in lab environment of SiC based Traction components for tramways, metro, sub-urban and regional trains.
- Demonstration of SiC Traction system on a Siemens tramway in Germany.
- Preparation of further demonstration on trains for Metro (CAF), Regional (Alstom) demos.
- On HST the development of a wheel motor prototype is continuing, targeting further manufacturing and on train demonstration in PINTA3.
- Seven KPIs have been updated: The KPIs progress confirms that most of the targets defined for the end of S2R are achievable. The main benefits of the newly developed traction and brakes components are described in the following chart:

		LCC reduction						Reliability		Train Capacity				Line Capacity	
Train/application	Development partner	Cost		Energy Cost		Mainte-nance Cost		Reliability		Weight Reduction		Volume Reduction		Noise reduction	
Tramway	Siemens	0%	2	-7%	4	0%	1	5%	2	-4%	2	-5%	2	Reduction of noise tonality	4
Metro	CAF	2%	3	-7%	2	-7%	2	6%	2	-25%	4	-25%	4	-3%	2
Sub-urban	BT	0%	2	-5%	3	0%	1	5%	2	-5%	3	-10%	3	-5%	3
Regional	Alstom	2%	3	-13%	2	-14%	2	11%	2	-16%	4	-5%	4	-3%	2
High Speed	Talgo	2%	1	-3%	2	-5%	1	12%	1	-3%	2	-2%	2	0%	1
Application	Development partner	Commissi-oning Cost				Mainte-nance Cost		Reduction of braking distance elongation							
Adhesion Management	FT	-50%	1			-15%	1	-40%	3						
Adhesion Management	KB	-50%	1			-15%	1	-40%	3						

The number in % are representing progress compared to the classical Si Traction baselines (tramway, metro, sub-urban, regional trains). The accuracy of quantification is described from 1 to 4, as defined at S2R level by the KPIs consolidation project IMPACT-2. 1 is expert estimation; 4 is demonstrated on a train.

The main point to be underlined is that major energy savings have been demonstrated. It opens the path toward less CO2 trains emissions, both for electric trains and diesel-electric trains as the SiC technology can be used in all train types. The SiC technology is a good solution to better fight climate change and open promising possibilities for further R&D action in the next decade if we use this technology for decarbonised alternative Traction systems like Hydrogen hybrid or Batteries powered trains.

On Acoustic noise, the prediction of noise of electro-magnetic origin from traction motors progressed significantly: the development of methods to couple electrical, magnetic and mechanical models accurately and efficiently has been done, studies to improve capabilities of existing tools have been done (e.g, computation time reduction)



Examples of simulation results on a simplified stator model

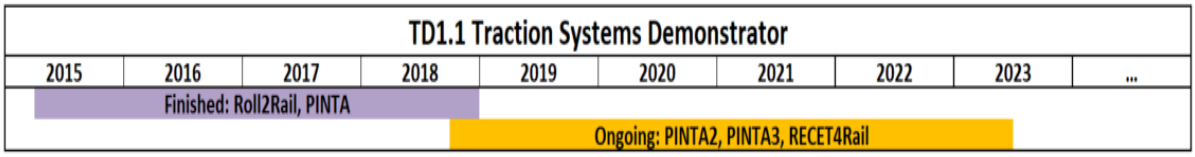
On EMI emissions, the test system to measure magnetic field emission affecting ATP systems operating below 100kHz has been validated.

On traction reliability, the work on power semiconductor lifetime models for the forecasting of device lifetime continued with on train's measurements campaigns. It will be used in future predictive maintenance algorithms to reduce maintenance costs. Activities to improve the environment requirement specification for power semi-conductors used in railway traction have been continued through the ECPE (European Center for Power Electronic) with the TD members and major high-power semi-conductor suppliers. Pending the results from the activities, a *Technical Guideline* may be released and following the S2R approval procedure could be proposed to standardisation bodies e.g. CENELEC or IEC as an input for a New Work Item.

On virtual validation and certification, work focused on simulation quality justification and virtual validation & certification approaches acceptance by operators. A standardised approach to virtual certification has been discussed and the reduction of validation test by -20% is still considered realistic. The cooperation with the Cross Cutting Activity "Virtual Certification" has led to the organisation of an interesting workshop with other IP1 train sub-systems.

The Traction TD is ongoing and according to schedule, apart from minor delays (about 3 months) due to Covid-19 disturbance.

The availability of power semi-conductors at affordable price remains a topic to be monitored carefully, and having a European credible supplier would be positive for price reduction. Due to this unavailability of high power semi-conductors, the development of the e-transfo was stopped. The deletion of such activities provided additional resources to manufacture consumables prototypes components for the future on train SiC Traction Regional demonstration.



During 2020, 11 deliverables were planned out of which 7 were released. TD1.1 has reported having accomplished 95% of the planned work up to the end 2020, which represents around 59% of the overall TD.

The TD Traction work, in the PINTA2 project, will be completed before end of February 2021 (delivering the 9 remaining Reports) with the same objectives of paving the way for future TRL 7 on trains demonstrations in PINTA3 to finish the S2R programme.

Concerning TRL7 demos, the global situation on Traction is the following:

- TRL5 SiC Traction on tramway is ongoing in Germany
- TRL7 SiC Traction demos on Metro and regional trains are planned on 2021
- TRL7 Wheel Motor demo is planned on 2022

TD 1.2. Train control and monitoring system (TCMS)

The development of a new-generation TCMS (Train Control and Monitoring System) will allow overcoming current bottlenecks caused by physically coupled trains. The new drive-by-data concept for train control, along with wireless information transmission, aims at making new control functions possible; it involves interaction between vehicles and consists, providing high safety and reliability levels with very simple physical architectures.

TD Progress

The TD1.2 builds on the progress made by CONNECTA and Safe4Rail and the work in progress being made by CONNECTA-2 and Safe4RAIL-2 projects. CONNECTA-3 and Safe4RAIL-3 projects were launched in December 2020.

After having reached in previous years the definition of general specifications for the next generation TCMS, including a comprehensive list of use cases and the corresponding high level system architecture, and its validation via prototypes, during 2020 different IT deployments based on the specification were made. The setting up of laboratory demonstrators and the definition of the test cases to be used in 2021 to validate the Next generation TCMS were also performed.

The maturity of aforementioned pillar technologies up to TRL4/5 is in progress with some important milestones already achieved:

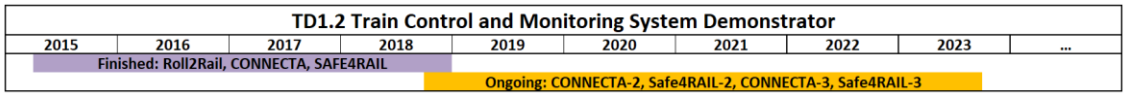
- Two different implementations of Functional Distributed Framework (FDF) have been deployed, one based on Autosar Adaptive Platform and another based on Integrity RTOS.
- A common HVAC application deployed by Safe4RAIL-2 has been integrated and validated in both FDF implementations, demonstrating the cross-platform interoperability based on a common Application Profile and common API.
- Different Drive-by-Data(DbD)-compliant ETBN, Consist Switches and PCIe cards for End Devices have been validated, including them in urban and regional demonstrators. Additionally, remote interoperability tests have been carried out for testing functional validation, connecting remotely

the laboratory demonstrators from CAF, Bombardier and Siemens. These remote interoperability tests have allowed to overcome some of limitations derived from the current COVID-19 pandemic.

- The low-level telegrams for the Functional Open Coupling (FOC) for HVAC and Doors applications have been specified and deployed. This definition has allowed the project to start with the calculation of ETB-level TSN resource allocation for future FOC functions.
- The Simulation Framework (SF) allowing software and hardware in the loop simulations have been built and tested. This SFs will be used in 2021 for carrying out the defined Test Cases in order to validate Next Generation TCMS.

Moreover, TD1.2 has issued the specification of the standardisation ATO-TCMS interface. This last interface standardisation is a long-path process which includes up to GoA4, being the current work focused on GoA2. Moreover, this work is being made following a cooperation with OCORA. This TD has actively participated in the ERA TWG ARCHI, together to LinX4Rail on the topics related to a Common Bus.

The running projects of this TD, CONNECTA-2 and Safe4RAIL-2, have also deployed and perform interoperability tests of the evolved Wireless Train Backbone (WLTB) based on direct communications and the Wireless Consist Network adapted to the Next Generation TCN architecture. This interoperability tests have served to validate two parallel implementations of the Adapted ETBN compliant with the new WLTB specification made in 2019. Additionally, Safe4RAIL-2 has been developing LTE-based communication devices which will be integrated in the interoperability tests, together with AETBNs at the end of 2020.



In 2020, 6 deliverables out of 7 planned have been delivered. The overall progress is in line with the plan. TD1.2 have accomplished around 90% of the planned work up to end 2020, which represents 62% of the overall TD progress. The work accomplished along 2020 paves the way to achieve successfully the High TRL Demonstrators planned to 2022 and 2023 when the TRL of these technologies will be scaled up.

TD 1.3 Car body shell

The new generation of car body shells using composite or other lightweight materials will lead to significantly lighter vehicles that carry more passengers within the same axle load constraints, using less energy and having a reduced impact on rail infrastructure.

TD Progress

The TD1.3 builds on the progress made by the project Roll2Rail, Mat4Rail and PIVOT, and currently from the running project PIVOT2 and Gearbodies (launched in Dec 2020).

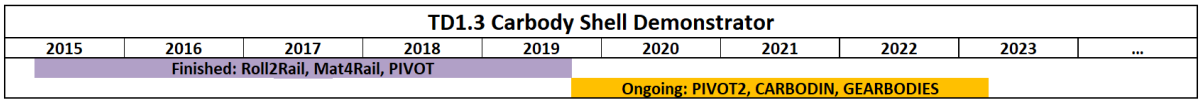
In 2020, the TD1.3 detailed design activities have been completed with the analysis of the structures of the four different demonstrators. Detailed design including 3D and 2D drawings were developed to allow the manufacturing of the moulds at the beginning of 2021. In addition, a functionalization of the different structures was performed to match the conductivity requirements and EMC including

metallic mesh on the laminates. Finally, Finite Elements Analysis (FEA) was conducted to validate the 3D model according the structural load cases.

The results show that the reduction in weight is greater than 15% in all the cases, reaching 1 t reduction in the full carbody of a HST according with the expectation defined in PIVOT.

In addition, in view of closing the designs, during 2020 several manufacturing scale tests have been performed. The aim of the manufacturing test is to check the feasibility and quality of profiles, lay-ups and configurations on a reduced scale before developing the 1:1 scale moulds. These manufacturing lab samples have been used additionally to test at subcomponent level different requirements set in the specifications. In parallel, the activities of the manufacturing metal components and testing were run.

Regarding standardisation activities, the activities of the working group in CEN have started in order to establish a new "Process standard for the introduction of new materials" defined in 2019 with active contribution of TD1.3.



During 2020, 10 deliverables were planned out of which only 1 was released due to the rescheduling of tasks between PIVOT2 and CARBODIN. TD1.3 has reported having accomplished 85% of the planned work up to the end 2020 considering the above mentioned circumstances, which represents 49% of the overall TD. The high TRL demo, a full high speed intermediate coach, according the demo plan, will be finished in the last part of 2022. It will be tested in Spain before the end of 2023.

TD 1.4 Running gear

TD 1.4 develops innovative combinations of new architectural concepts, new actuators in new lighter materials leading to innovative functionalities and improved performance levels.

The TD1.4 builds on the progress made by the project Roll2Rail, Run2Rail and PIVOT, and currently the running projects PIVOT2, NEXTGEAR and Gearbodies (launched in Dec 2020).

- *Sensor and health monitoring functionality*

  Based on the results of PIVOT in 2019, a prototype of wayside system capable to monitor bogie imbalance, suspension status and the condition of wheel has been installed and tested. A framework for machine learning model development is currently under construction - first models for detection of anti-yaw damper fault were developed. The integration procedure with TCMS and the reduction target of 5-15% running gear maintenance cost has been defined.

- *Active Suspension and control technology*

  Control algorithms for active curve steering have been developed which significantly reduce wheel and rail damage in curves. Blended control algorithms including signal from both carbody and bogie frame for improvement of vertical and lateral ride comfort are developed.

  In the Open Call project NEXTGEAR a high safety integrity level (SIL4) controller has been designed and manufactured. Initial testing is underway and a test system has been set up to allow a vehicle model to be controlled in realistic 'Hardware in the Loop' conditions to be undertaken. Initial results are promising showing that the controller can run at close to the frequencies required with SIL4. Furthermore, an innovative actuator has been developed.

- *Noise and Vibration reduction*

  A comprehensive methodology to predict the transmission of noise and vibration from the running gear to the carbody has been started. The newly developed models have been used to assess the effect of the developments on the running gear on noise and vibration. In particular, an initial assessment has been launched to study the effect of novel lightweight materials and active suspensions systems and an optimisation strategy for controlling the structure-borne noise transmission. A reduction of the rolling noise has been estimated, establishing a target of -2dB.

- *Optimised Materials*

  A composite frame for an independent rotating wheel running gear with high structural requirements has been manufactured using composites material and high strength alloys (steel and titanium). The first results showed a weight reduction of 46% for the whole frame in the prototype.

  A light-weight axle was developed to reduce the weight of the axle by up to 26 %. In addition, the light-weight axle should decrease maintenance costs by reducing wheel exchange time. The axle is already being tested in a freight-wagon application. The test results will be used to convert the light-weight axle into a metro application.

  In NEXTGEAR a state-of-the-art analysis for composite material suitable for rail wheelsets and related manufacturing was carried out. Three concepts for wheelsets with composite axles were developed and their advantages and disadvantages analysed. The lowest achievable mass is 80 kg compared to 198 kg for the benchmark steel axle.

  Carbon fibre composite frame for the proposed single axle running gear has been designed. The design phase is finished. The total weight including metallic inserts will be around 120 kg. The frame will be manufactured at the beginning of 2021.

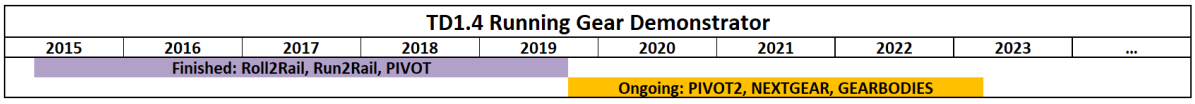
  Seven potential components have been identified and each of them was assessed against a set of criteria for additive manufacturing process. An aerial bracket for a metro vehicle has been selected. A detailed design for additive manufacturing has been carried out using a load case which was prepared from measured data provided by Metro Madrid. The weight could be reduced by 60% compared to the reference component.

- *Virtual certification*

  The methods currently used in the railway sector and assessment of current methodology were investigated following the guidelines established by EN 14363:2016. In 2020, a benchmark on existing different approaches around the world has been performed

- *Universal Cost model 2.0*

  The Universal Cost Model from the Roll2Rail Lighthouse project has been further developed. During 2020, the main work consisted of updating the technical modules such as the infrastructure module, energy and noise module and the vehicle module. Moreover, work on cost calculation models has been started.



During 2020, 3 deliverables were planned out of which 2 were released. TD1.4 has reported having accomplished 95% of the planned work up to end 2020, which represents 51% of the overall TD.

The overall status of the high TRL demos in 2020: TD1.4 could reach several milestones on the way to providing the demonstrators. The new health monitoring systems and condition-based maintenance of the track with novel sensor system (hardware) were able to produce a prototype which will get

tested during the next period. Control algorithms for active curve steering have been developed which significantly reduce wheel and rail damage in curves. A composite frame for an independent rotating wheel running gear with high structural requirements has been manufactured and will be tested in the next steps. A light-weight axle was developed. The axle is already being tested in a freight-wagon application. The test results will help to convert the light-weight axle into a metro application during the next year. Finally, work on way to validate a virtual certification model has begun and to be continued during the demonstration activities.

TD 1.5 Brakes

The main objective of Technical Demonstrator 1.5 Brakes is to develop novel braking systems and contribute to the achievement of overall Shift2Rail's mission of increasing the attractiveness of railway by:

- improving the performance, reliability and punctuality,
- increasing line capacity
- reducing lifecycle costs.

Building on the results made in already completed projects Roll2Rail, CONNECTA, PINTA and PIVOT, the focus of TD Brakes in 2020 was on developing innovative solutions in five areas:

1. Ability to implement brake control functions on electronic platform compliant with safety integrity level SIL 3 and 4
2. Innovative friction pairing solutions that would reduce weight, noise and dust emissions
3. Electro-mechanic braking system to replace conventional pneumatic and hydraulic technology
4. Methods and tools for virtual validation and certification of braking system
5. Improved adhesion management systems for traction and braking; improved virtual testing for WSP systems

TD Progress

High SIL electronics

To ensure the safety of passengers and goods and achieve required safety integrity level (up to SIL4) for certain braking functions, modern railway vehicles rely on conventional technology, i.e. pneumatic signals and brake control. Development of electronic brake control function compliant with high safety integrity level (SIL3/SIL4) will provide more accurate control and reduction of overall vehicle weight.

In 2020, the task force specified, designed and implemented laboratory test bench that simulates an existing EUSKOTREN train equipped with developed high SIL electronics. First laboratory trails were conducted to validate the performance of high SIL electronics against the performance of conventional braking control electronics. The scope of the simulation was also to confirm the capability to easily integrate high SIL electronics in the existing TCMS interface.

Innovative friction pairings

This research area focuses on development and design of a new generation of disc and friction material to reduce noise and braking dust and improve braking performance. Furthermore, by reducing the wear of the materials, longer lifetime is possible, which reduces LCC costs.

In 2020, different calculations have been performed to investigate possible approaches and test the feasibility of innovative combination of components. As a result, the first prototype has been manufactured and treated to reach the targets.

The new friction pair concept is based on an innovative approach for the brake disc and the brake pad. In order to reduce brake dust and noise emissions the brake disc uses an ambitious idea, a special material treatment. The application of this new technology offers the possibility to reach different targets:

- brake dust reduction
- brake noise reduction (today estimated at -5 db)
- wear reduction
- LCC improvement
- weight reduction

The reduction of brake dust emissions and noise by a similar technology is a concept already established in the automotive world but new in the railways field. Moreover, due to the potential high wear reduction it is possible, on the one hand, to conceive a brake disc with a lower weight and, on the other hand, to reach an increase of the LCC because of the longer brake disc life. First tests at dynamometer have been carried out in order to have preliminary results about the brake disc behaviour under different test conditions (e.g. speed, clamping force, environment). Based on these first trials we expect a reduction of brake noise and dust emissions between 5% and 15%.

On the other side, several solutions have been investigated in order to proper pair the treated disc material. Some brake pad prototypes have been produced and preliminary tested on dynamometer for the feasibility validation. Several optimizations and of course tests will be required to assess the benefits, including noise and emissions reduction, during 2021.

Electro-mechanic braking system

Currently railway vehicles deploy either pneumatic braking system in form of purely pneumatic systems, electro-pneumatic system or electronically controlled pneumatic braking systems. Technological trends like electrification and vision of airless train together with the urge to reduce vehicle weight and lifecycles costs drive the development of electro-mechanic solution. Effective transfer of braking signal, better diagnostics and fewer components and thus significant reduction of system weight, energy consumption and lifecycle costs are just some of the advantages of electro-mechanic braking systems.

In early 2020, the members of the EM-Brake working group joined for a kick-off meeting of PIVOT-2 project. The group exchanged opinions and documents about the applicability of mandatory rules and regulations, e.g. TSI LOC PAS and EN15595 (WSP). Knorr-Bremse successfully finished the brake calculation for the EMB brake and provided a comparison with an EMU equipped with pneumatic brake. This document was delivered as Deliverable *D9.2 EM-Brake Brake Calculation.*

Wabtec's work within PIVOT-2 WP9 Subtask 9.2.3 focused on the identification of the main standards and norms to be considered for the transition to the new technologies, where a conceptual step from pneumatic to electric is required. Special attention was given to the energy management and the transition of the train architecture "from pipes to wires".

Virtual validation and certification

One of the major cost drivers for the authorization of braking systems currently stems from the necessity to perform comprehensive laboratory and on-train test as a final validation of the system performance. Building on the work of Roll2Rail and PIVOT, the main objective of this task is to propose improvements to reduce homologation costs and shorten the time necessary for putting rail vehicles in service by using simulation.

In 2020, specifications for virtual validation and certification process and simulator have been prepared. This was supported by extensive dialogues with DAkkS, NBRail and ERA. Focus was on

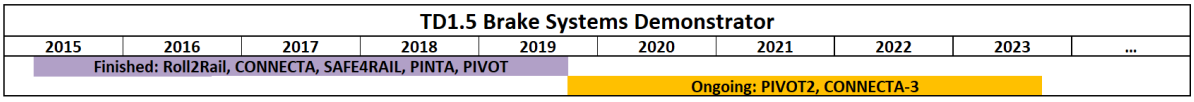
achieving credible simulations integrating the approach into CSM-RA and CCA WA3.5 generic framework.

Adhesion management

Unpredictable physical phenomena in wheel-rail contact make exact determination of braking distance very difficult and hinder all efforts in increasing capacity by taking sufficient braking distance reserves into account. The main objective of this task is development of solutions (and testing methods) capable of better management of adhesion condition variation to significantly reduce braking distance and torsional vibration during traction and increase capacity and punctuality.

In 2020, multiple trials on the solutions for the adhesion management during degraded adhesion condition were conducted on Knorr-Bremse's 1:1 scale roller rig ATLAS and Faiveley's roller rigs. The validity of developed concepts is confirmed and results are published in PINTA-2 Deliverables D15.3, D16.3 and D16.4.

Furthermore, a proposal for consideration of wheel/rail adhesion management solutions within ETCS braking curve calculation has been made and discussed with ERA and other project external stakeholders. The discussion will be continued within PIVOT-2 where TRL5-6 is expected to be reached.



During 2020, 18 deliverables were planned out of which 10 were released. TD1.5 has reported having accomplished 85% of the planned work up to end 2020, which represents 68% of the overall TD. By the end of 2022, TD1.5 Brakes is expected to deliver 6 demonstrators of TRL 4-6:

- Full brake system including new generation high SIL brake control equipment (on field demonstrator)
- Innovative friction pairing solution (on field demonstrator)
- Field test of adhesion management solutions
- Field test with EM brake (one bogie)
- EM brake solution completely hydraulic free (laboratory validated prototype)
- Laboratory validated demonstrator for virtual validation and certification

TD 1.6 Doors and Access Systems Demonstrator

The challenge of the TD is to provide seamless and flexible access to the train for the public including persons with reduced mobility, while reducing the weight and the cost, improving the comfort features (acoustic attenuation, thermal insulation, etc.), and adding more functionality to the door and access systems toward self-managed and autonomous door for automated train operations till GoA4.

TD Progress

The TD1.6 builds upon the progress made by PIVOT, Mat4Rail, and ongoing PIVOT2 and Carbodin projects.

Door leaves design for acoustic attenuation, thermal insulation and weight reduction.

- Metallic door leaves: In 2020, work focused on the development of the new type of structural profile (assembly, characterisation for mechanical calculation, ageing tests...) for thermal insulation, the development of the new structure of the door leaves filling for acoustic attenuation (complex arrangement of rigid and flexible materials inside the door leaves instead of rigid foam for improved sound attenuation through the door leaves) and the improvement of the door leaves sealing also for acoustic attenuation.
- Composite door leaves: In 2020, the detailed design of a ones-block composite door leaf compliant with the selected manufacturing process (press-moulding) was performed and the specifications of the mould were defined. 1/3 scale manufacturing tests have been prepared to check the feasibility of innovative mould. Specific actions have been performed aiming the improvement of the acoustic attenuation which have been degraded by the weight decrease.

Accessibility

At the end of the PIVOT project, it became clear that the development cost of the adaptive boarding aid proposed by the PIVOT project and the resource requirements necessary for its development are excessive. Furthermore, the development risks are very high considering the following aspects: the train reliability should not be degraded by the system despite its complexity; its deployment time would be sometimes excessive; an autonomous access to persons with reduced mobility cannot be guaranteed when its adjustment requires too important slopes; and finally its implementation inside the vehicle creates a lot of constraints to the vehicle layout and would create sometimes disturbances to the passenger flow.

For those economic and technical reasons, the development of adaptive boarding aid which would allow level access for boarding and alighting has not started. So, the TD has focused its efforts in 2020 to the improvement of the door threshold , especially for sliding doors, removing or reducing offsets and slopes between the bridging plates and the vestibule floor. The door sealing is also considered in the study for acoustic attenuation. The solution will be implemented on a door mock-up and tested in 2021.

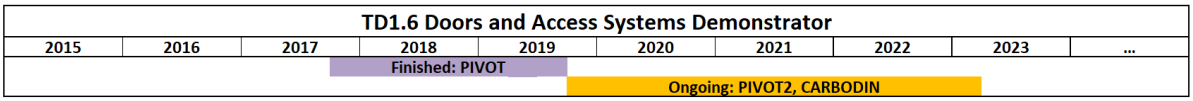
Door surveillance and safety

In 2020, PIVOT2 has implemented a laser sensor for contactless passenger detection on a sliding-plug door mock-up and tested a capacitive sensor specifically improved for that application. The development of the functions using a camera like platform detection, platform position measurement, virtual pushbutton, contactless obstacle detection, passenger detection on bridging plates or ramp, surveillance of the door area during train departure has been started based on image analysis or artificial intelligence. The target is to prepare a first on-line experiment in autumn 2021 validating laser and capacitive sensors solutions, collecting data for the improvement of the functions using artificial intelligence and image analysis, improving the algorithms in a second stage and validating a first stage of development of the functions.

Integrated door and demonstration

PIVOT2 has worked on the integration of the solution and on the global improvement of the entrance system, especially in 2020 for single sliding-plug doors. Endurance tests are on-going for testing new swinging arm developed for weight reduction and load withstanding. A second mock-up will be studied in 2021 integrating the new functions, the new swinging arm, the new metallic door leaves and other features.

The integrated solutions (double sliding plug doors) with composite door leaves and with metallic door leaves will also implemented in 2022 on a SNCF static train.



During 2020, 15 deliverables were planned out of which only 1 was released due to the rescheduling of tasks between PIVOT2 and CARBODIN. TD1.6 has reported having accomplished 65% the planned work considering the circumstances mentioned above, which represents 47% of the overall TD.

The TD works on implementing the results in demonstrators or operating tests. The main demonstrators planned deal on the one hand with communicating doors where a test in operation should start in Autumn-2021 with a gradual improvement of the functions (for example, mainly the collection of images at the beginning) and on the other hand with the implementation of doors equipped with improved door operators and optimized door leaves (metallic door leaves and composite door leaves) in a static regional train in 2022.

TD 1.7 Train Modularity in Use (TMIU)

The TD develops new modular concepts for train interiors that allow operators to adapt more quickly and at a lower cost the vehicle layout and atmosphere to the actual usage conditions. The objective is to give better opportunities to the operators to be flexible to the demand: improve passenger flows, optimise the capacity of the vehicle, test new interiors design without waiting the milestone of the mid-life of the rolling-stock.

TD Progress in 2020

The TD1.7 builds on the progress made by PIVOT, Mat4Rail and running projects PIVOT-2 and Carbodin.

INTERIORS:

Based on the opportunities identified by the Design to Cost study done in 2019, in 2020 the interiors design pre-studies started:

1- Ideation Phase: 6 main items were split into 2 sub items and each sub item has been noted with 5 level of performance.

   i. Attractiveness: Aesthetic / Uses
   ii. Innovation: New / Value offered
   iii. Maintenance: Vehicle / part replacement
   iv. Modularity: Layout / Atmosphere
   v. Cost: Tool / Process
   vi. Technical: Feasibility / Studies

   Four mains general ideas have been selected compared to the results of the notation.

2- Pre-concept Phase. 4 pre-concepts to simplify fixing/defixing equipment with taking into account lighting.

   In December 2020, the first drafts of the 4 pre-concept have been done with 3D model and preview (« white mock-up ») to allow the technical pre-studies.

   Two of these pre-concepts will be selected in 2021 to go further in the studies and be integrated in the demonstrator scale 1:1 of the TD1.7.

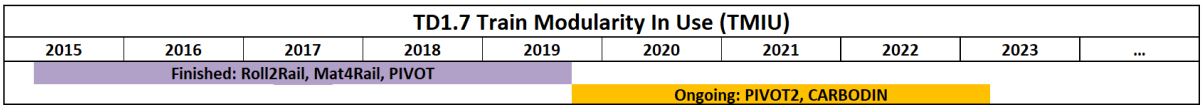
CABIN:

The topic driver's cabin has progressed with the analysis topic by topic: state of the art and opportunities of new design.

1- State of the art: technologies / Define the GOA for railways / Define the future role of driver / Overview of European driver's cabin and equipment.

2- Opportunities of new design: analysis of cost / analysis of weight / analysis of kind of sounds.

In 2020 the TD has defined the overview of the current driver's cabin and the data to start European surveys. These Surveys will be done in 2021 and help the TD to validate the level of acceptance of drivers for new HMI before starting the new design itself.



During 2020, 15 deliverables were planned out of which only 3 were released due to the rescheduling of tasks between PIVOT2 and CARBODIN. TD1.7 has reported having accomplished 65% the planned work considering the above mentioned circumstances, which represents 47% of the overall TD.

For Interiors, the objective for 2021 will consist of finalising the concepts and start to build the moulds to produce the prototypes in 2022.

In 2021, to validate the technical studies, first technical mock-ups and pre-dimensioning by numerical simulations will be realised to test few new design and technologies: electric panel without cable, soft plug&play systems and hardpoint systems, for example. In 2021, the bricks of the Virtual Reality demonstrator will be done to prepare the final demonstrator for InnoTrans 2022.

TD 1.8 HVAC

Conventional "Heating, Ventilation Air conditioning and Cooling" systems (HVAC) within rail vehicles use artificial refrigerants that have a very high impact on the global warming (e.g. R134a). In order to limit the climatic impact from HVAC systems the European Union introduced in 2014 regulation Nr. 517/2014 which aims to reduce the use of artificial refrigerants within the EU according to a fixed time schedule. Hence, there is a strong need to develop HVACs using natural refrigerants such as air or CO_2.

Within TD1.8 two HVAC demonstrators with CO2 refrigerants will be specified, developed and tested in real operation (TRL7). At the end of the project these HVAC units are ready for application within new trains and for the refurbishment of existing trains.

Further activities are the pre-standardisation of mechanical, electrical and control interfaces of HVAC-units as well as fundamental work on alternative refrigerants.

The activities are carried out within PIVOT2 and PINTA3 projects.

TD Progress

In 2020, requirements for HVAC systems were provided by the railways operators (about 1000). The requirements were analysed with respect to the relevance for changing the refrigerant to CO2. These CO2-relevant requirements were reviewed by the HVAC suppliers with respect to technical acceptance.

In 2020, this TD carried out simulations, adopted their HVAC units to the refrigerant CO2 and carried out a laboratory test.

Pre-standardisation work was carried out in collaboration with all partners:

- Classification of HVAC units
- Clarification of the mechanical and electrical interfaces
- Pre-standardisation work for control interfaces in collaboration with the Shift2Rail project CONNECTA-2 (TD1.2 TCMS). For this work the future TCMS with one central controller and a functional distribution network is considered. The HVAC control will be one task carried out by the central controller.

Fundamental work was carried out on the following topics:

- Alternative refrigerants
- Risk analysis
- Definition of the KPIs

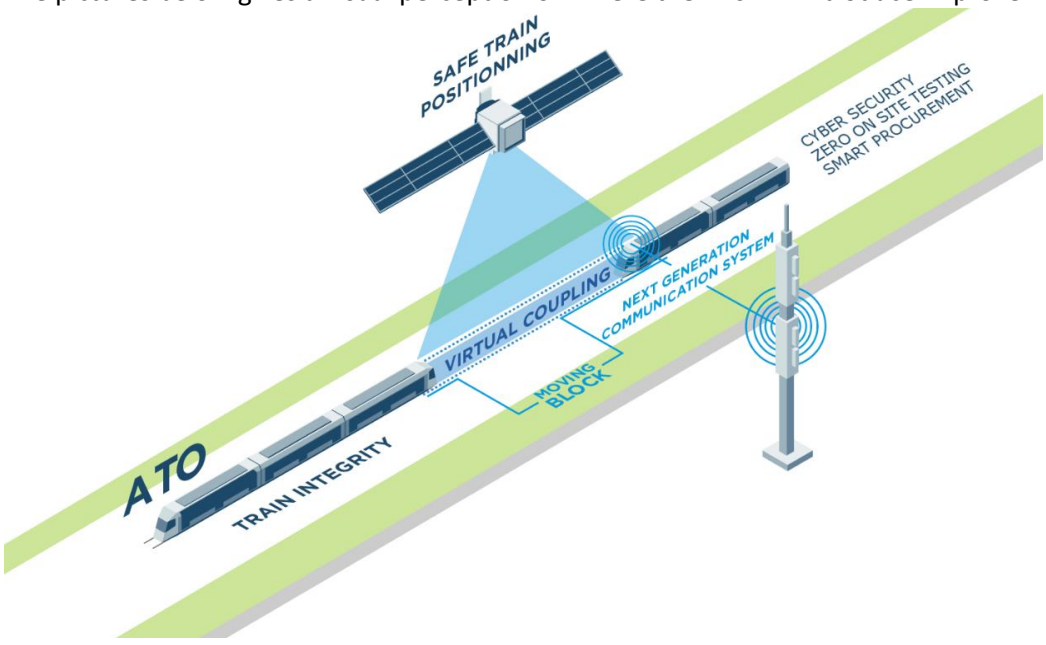
The TD-work will be continued with two technical demonstrators, where the HVAC units will be tested in real commercial operation for one year (TRL 7). The test results as well as the work on pre-standardisation and performance of CO2 HVAC units will be reported in the final public deliverable (PINTA3 D8.1) in October 2022.

TD1.8 HVAC									
2015	2016	2017	2018	2019	2020	2021	2022	2023	...
					Ongoing: PIVOT2, PINTA3				

During 2020, 9 deliverables were planned out of which only 4 were available in drafts and not officially reported due to delays incurred within PIVOT2 deliverables submission. TD1.8 has reported having accomplished 80% of the planned work up to end 2020, which represents 30% of the overall TD.

1.4.2. IP2 Advanced Traffic Management and Control System

The pictures below gives a visual perception on where the TDs will introduce improvements.



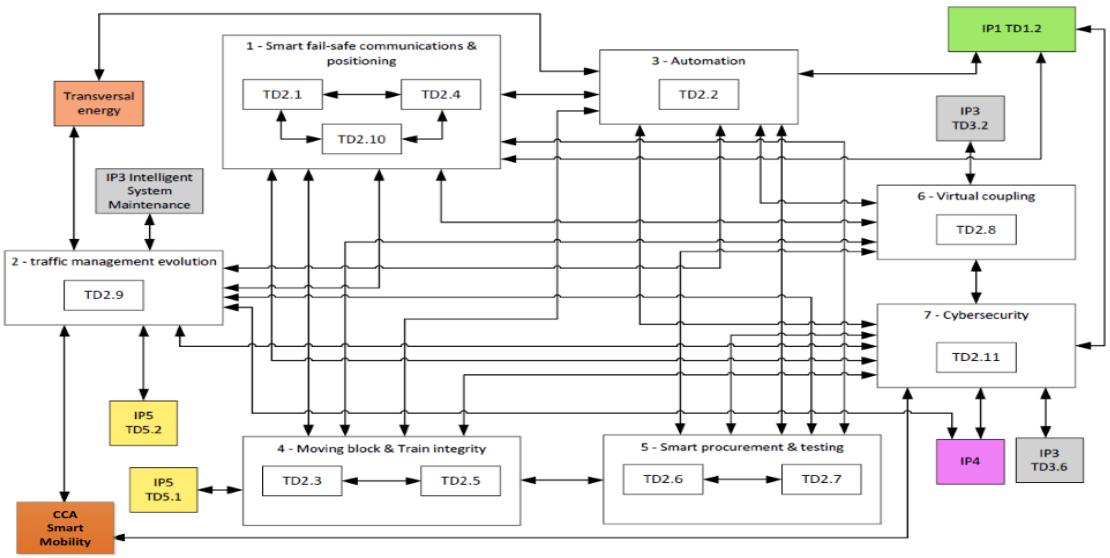
The aim of IP2 is to design and develop a control, command and communication systems that goes beyond being only a contributor to the control and safe separation of trains, and to become a flexible, real-time, intelligent traffic management and automation system.

IP2 builds on ERTMS, that, although deployed in Europe to a limited extent, including on core rail corridors, is a worldwide dominant solution for railway signalling and control systems. Current ERTMS systems do not sufficiently take advantage of new technologies and practices, including use of satellite positioning technologies, high-speed, high-capacity data and voice communications systems (Wi-Fi, 4G/LTE), automation, as well as innovative real-time data collection, processing and communication systems. These have the potential to considerably enhance traffic management (including predictive and adaptive operational control of train movements), thereby delivering improved capacity, decrease traction energy consumption and carbon emissions, reduce operational costs, enhance safety and security, and provide better customer information - all in all, the potential for achieving major cost efficiency results for railway operations.

Key Technology Demonstrators under development in IP2 will contribute to the new release of the CCS TSI, planned in 2022. Those TDs will contribute to the ERTMS Game Changers (ATO, FRMCS, Moving Block/ETCS Level 3 and train positioning). Coordination work has started in 2019 and is expected to continue beyond 2020.

In December 2019, LINX4RAIL, a S2R IPX project, was launched with the objective to create the first common rail Functional System Architecture The project will gather input across all IPs, external initiatives, such as RCA, OCORA, EULYNX, railML, and harmonise the way solutions are designed, developed and integrated. The common approach will allow to lower the life-cycle costs by enabling modularity, develop new business models, and overall increase the efficiency of the railways with seamless data exchange. The outputs of the two work streams, System Architecture and Conceptual Data Model (CDM), will trigger the implementation of the suggested changes into running S2R initiatives. The existing IP2 projects, and X2Rail-4, started in December 2019, will be one of the first S2R initiatives in which this common vision will be implemented.

The picture below shows the TDs connections and dependencies within IP1 and with other IPs and CCA.



TD 2.1: Adaptable communications for all railways

The purpose of this TD is design, develop and deliver an adaptable train-to-ground communications system using packet switching/IP technologies (GPRS, EDGE, LTE, Satellite, Wi-Fi, etc.) for supporting digital train control applications in all railway market segments. The system will facilitate migration from existing systems such as GSM-R, providing enhanced throughput, safety and security functionalities to support the current and future needs of signalling systems and well beyond; it will be resilient to interference and open to further developments in radio technology.

TD Progress

This TD builds on related activities within the following projects: X2RAIL-1, X2RAIL-3, X2RAIL-5, EMULRADIO4RAIL and AB4RAIL. The project MISTRAL was completed in October 2018.

The main achievements during 2020 are the following:

- Delivery of the Updated Prototype development report
- Delivery of Technology Demonstrator Lab Test Report
- Delivery of Field Test Strategy for the field tests of the demonstrators planned in scope of X2Rail-5
- Delivery of Antenna System Specifications for adaptable communications in Railway Environment
- Update of User Requirements Spec and System Specification of the Adaptable Communication System (ACS)

Based on the development activities before, three demonstrators have integrated prototypes, covering the Railways Segments High-speed/Mainline, Regional/Freight and Urban/Suburban.

Tests were performed on a basis of a laboratory tests plans tailored for the different market segments. Interconnection between different partners' laboratories and using simulators and emulators (including the one developed by the open call projectEMULRADIO4RAIL) allowed the companies to perform all the planned tests. Remote access to the different laboratories was also key to be able to do the tests in 2020, due to the COVID pandemic.

The results have shown that the technical concepts described in the System Specification of the ACS have been validated successfully. Communication at application level was independent from the underlying radio technology. Different options for an application interface for the ACS were evaluated. In cooperation with the Cybersecurity TD, IT security requirements were defined in a security profile and first validation was performed as part of the test plan.

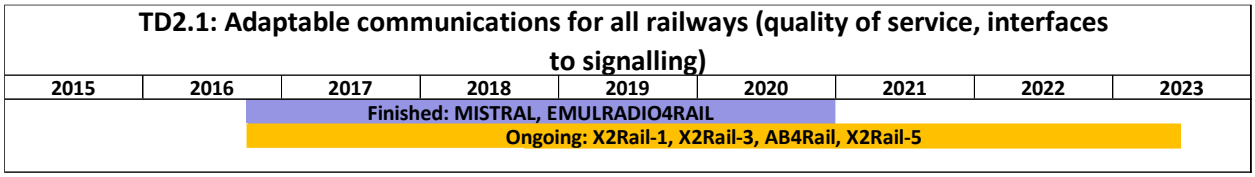
In addition to the demonstrator laboratory tests, integration tests were performed together with the IP1 Project CONNECTA (TD1.2 – Wireless TCMS (Train Control and Monitoring System)) to prove the interworking between the future TCMS and the ACS.

In preparation for the next planned step in X2Rail-5 (CFM 2020), the field test strategy was discussed, agreed and described in the Field Test Strategy document[20].

[20] D3.3 of X2RAIL-3 (Field test strategy) available on the S2R website : https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-3

Specification of an antenna system was written, taking into account the increased complexity and functionality of the ACS compared to legacy communication systems. This activity has not only been focused on the train antenna system, but has also taken into account requirements for trackside antenna systems. It encompasses both electromagnetic considerations and requirements such as spectrum bands, bandwidth, radiation pattern and re-configurability, polarisation, system adaptability, combination and integration of different radio technologies, as well as mechanical requirements such as platform integration, positioning, size, height, weight and lifetime. The objective was to study, assess and specify on-board and ground-based antenna systems.[21]

Last but not least, the Technology Demonstrator continued its cooperation with the UIC project "FRMCS" (Future Railway Mobile Communication System) which led to further updates of the User Requirement Specification document and the System Specification of the ACS. This cooperation will continue in 2021 in order to ensure full alignment within the sector, ahead of the preparation of integration of the results in the Control Command and Signalling Technical Specifications for Interoperability (CCS TSI). The System Specification from TD2.1 was discussed in detail with the FRMCS project and will influence the Functional Requirements Specification as well as the System Requirement Specification for FRMCS in 2021/2022.



In 2020, all planned deliverables were delivered. The overall progress is in line with the plan. TD 2.1 has reported having accomplished 100% of the planned work up to the end 2020, which represents 70% of progress of the overall TD.

TD 2.2: Railway network capacity increase (ATO up to GoA4 – UTO)

ERTMS/ETCS, the current generation of main line signalling, faces a growing challenge to provide the performance improvements and increases in line capacity needed by (European) Main Line operators.

Using Automated Train Operations (ATO) with ETCS is an answer to this challenge. This technology is already vastly deployed in urban transport where different grades of automation are implemented including driverless and unattended operation. The objective of this technology demonstrator is to develop and validate a standard ATO up to GoA3/4 over ETCS, where applicable, for all railway market segments (mainline/high speed, urban/suburban, regional and freight lines).

TD Progress

This Technology Demonstrator currently builds on the following projects: X2RAIL-1, launched in 2016 and X2RAIL-4 and SMART-2, both launched at the end of 2019. ASTRail, launched in 2017 and completed at the end of 2019

Regarding ATO over ETCS GoA1/2, in 2020, the change requests issued by S2R in 2019 (further to interoperability tests performed on the Reference Test Bench in January 2019) have been addressed

[21] D3.4 of X2RAIL-3 (Antenna Specification for the ACS) available on the S2R website : https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-3

with ERA in EECT meeting. Most of GoA2 specification documents have already been addressed: SUBSET_125, SUBSET-126, SUBSET-126 Appendix A, SUBSET-130, SUBSET-143. The following documents have not yet been addressed: SUBSET-139, SUBSET-140 and SUBSET-141.

The formal ERA approval is expected for June 2021.

In addition, TD2.2 has successfully performed pilot test on NR facilities in United Kingdom at ENIF[22] on a class-313. The following configurations have been tested:

1. ATO-OB from ALSTOM connected to ATO-TS from SIEMENS;
2. ATO-OB from AZD connected to ATO-TS from THALES.

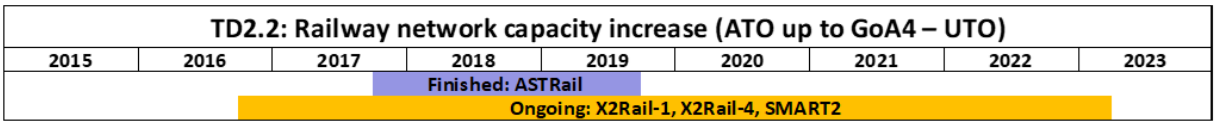
The pilot tests report will be delivered before March 2021.

Finally, TD2.2 has supported the pilot tests of S2R IP5 ARCC project led by DB. The following configurations have been tested in Switzerland:

1. ATO-OB from ALSTOM connected to ATO-TS from SBB;
2. ATO-OB from HITACHI connected to ATO-TS from SBB;
3. ATO-OB from AZD connected to ATO-TS from SBB;
4. ATO-OB from SIEMENS connected to ATO-TS from SBB

In parallel, the TD has continued working on the requirements for Automatic Train Operations up to Grade of Automation 4 (unattended train operations), further elaborating on the following documents that will we delivered in full in May 2021:

1. Operation Requirement Specification which includes:
   - The operation contexts and the associated actors
   - The operation Use Cases (modelised by sequence diagrams)
   - Logical Architecture
   - Interface definition
   - Users interface principles
2. System Requirement Specification which includes:
   - The functional requirements allocated to the Logical Architecture
   - Interface specifications (FIS level) between the Logical Components.



In 2020, the TD has delivered all three expected deliverables. TD 2.2 has reported having accomplished 100 % of the planned work up to the end of 2020, which represents 50% of the overall TD. The overall progress appears is in line with the plan, despite the initial delay in execution of the pilot tests in the United Kingdom.

[22] ETCS National Integration Facility, Hitchin

TD 2.3: Moving Block

Improving line capacity by decoupling the signalling from the physical infrastructure, and removing the constraints imposed by trackside train detection is the key objective of this technology demonstrator. This will allow the transit of more trains on a given (main) line, especially for high-density passenger services. The system is expected to be compatible with existing ERTMS specifications and will enable progression towards CBTC (Communication Based Train Control) functionalities for urban applications.

TD Progress

This TD currently builds on the following projects: X2RAIL-3 and MOVINGRAIL, both launched in 2018. ASTRAIL was completed in the year 2019 and was supporting the development on the hazard analysis. X2RAIL-1 and X2RAIL-3 is developing moving block operational and engineering rules, system specifications as well as the application analysis while MOVINGRAIL supported the validation work of those rules and system specifications.

In 2020, the TD completed the X2Rail-3 deliverables for the Testing of Moving Block systems, updated System Requirements, Operational and Engineering Rules and Safety Analysis, and created report on Future Moving Block systems:

- The updated System Requirements reflect validation of the work from X2Rail-1 via examination of a number of "Use Cases", and examination of number of specific topics, including Track Status and Margins. There are now much more clearly described in the updated documents
- The updated Safety Analysis now includes the results of Risk Analysis
- The report on the Future Moving Block systems is a summary of the work in progress to move beyond the assumed baseline in the other documents, which is ETCS Baseline 3 Release 2 plus Change Request 940 on Train Integrity.

In addition, there has been work on four Moving Block demonstrators by supplier members of the TD, with an X2Rail-3 deliverable to report on the results.

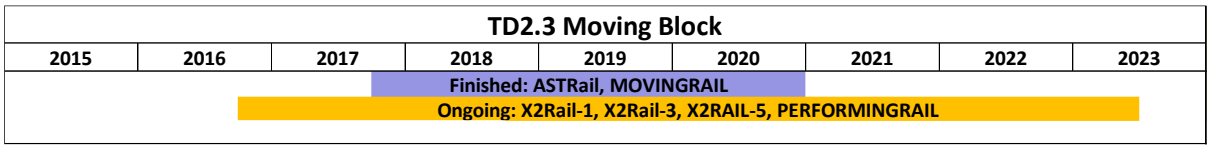
The work in the TD will continue in X2Rail-5, with further refinement of the Requirements, Operational and Engineering Rules, and any work required for the CCS TSI 2022.

The MovingRail project has delivered an assessment regarding the testing of Moving Block systems, based on a literature survey, and a workshop collection information from suppliers and railways.

User requirements for Moving Block testing have been collected during the May 2019 workshop and reviewing the outcomes of previous and on-going projects on ETCS level 3 developments. The results from the May 2019 workshop have been used to formulate a Moving Block Signalling Test Strategy, which will be issued as a deliverable in early 2020.

Taking as input the information from the key stakeholder interviews and a literature review, the project described Moving Block fundamentals, including the differences from traditional signalling systems, propose changes that might result in easier application of Moving Block signalling or their evolution to a different traffic management approach, and assessed Moving Block Operational and Engineering Rules. Various operational situations were defined to which the Operational and Engineering Rules were tested using serious gaming.

The TD developed a testing architecture to highlight the important issues relating to test automation, such as apportionment of effort and testing time.



In 2020, the TD has delivered 4 out of the 4 expected deliverables. TD 2.3 has reported having accomplished 100 % of the planned work up to the end of 2020, which represents 75% of the overall TD. The overall progress appears to be in line with the plan.

TD 2.4: Fail-Safe Train Positioning (including satellite technology)

This Technology demonstrator aims at developing two key new innovations for the signalling system. On one side, a fail-safe, multi-sensor train positioning system based on the Virtual Balise concept, applying Global Navigation Satellite Systems (GNSS) technology, as a functional block of the current core of ERTMS/ETCS. On the other side, an enhanced, safe, multi-sensor, stand-alone train positioning subsystem that calculates the train travelled distance, speed and absolute train position including the analysis and solution of the track discrimination problem.

They will enable the use of new technologies or sensors to boost the quality of train localisation and integrity information, while also reducing the overall life cycle costs, in particular by enabling a significant reduction in all conventional trackside (train) detection systems, such as balises, track circuits or axle counters.

TD Progress

This TD currently builds on the following projects: X2RAIL-2 and the complementary open call project GATE4RAIL. It also builds on the open call ASTRAIL, completed in 2019.

X2RAIL-2 focuses on the development of the specifications, proof of concepts, and testing. GATE4RAIL aims at providing a GNSS automated virtualized test environment.

Regarding the first work stream (virtual balise), based on the guideline specifications for the preparation of demonstrators of a GNSS based positioning system defined in 2019, the TD, in 2020, focused on activities related on:

- Deepening and clarifying the technical solutions proposed by the guideline specifications (e.g. signal measurement, coasting approaches, map survey, etc.) which are candidate at being part of the technical demonstrators;
- The developing of proof of concepts (PoC) as well as the first iteration of definition of laboratory environments and test specifications.

The target for the above activities was to reach TRL 4 for development and specifications.

Internal labs activities have been carried out in order to check the functionalities of PoC and the suitability of the test environment for lab testing activities.

As a complement to these activities, both requirements and a first iteration of reference values for the Minimum Operational Performances for the Virtual Balise Solution in the railway environment have been proposed.

As regards the second work stream (stand-alone train positioning), requirements and guideline specifications for the preparation of the technical demonstrators have been defined, together with activities for the definition of the lab environment, proposal for PoCs and finally test specifications for the future Verification & Validation (V&V) activities.

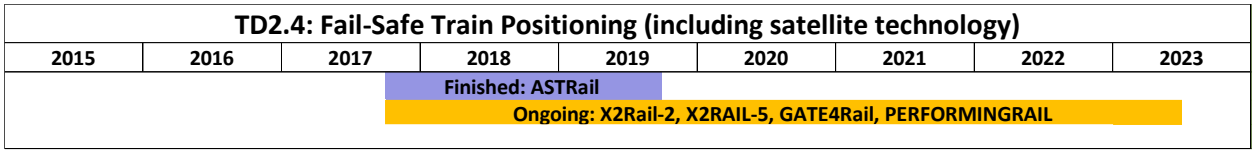
In parallel, the open call project GATE4RAIL, which aims at designing a comprehensive framework for the simulation of a realistic characterization of the railway environment, to allow evaluating the performances and properties of GNSS-based fail-safe train positioning in nominal and faulty conditions, has delivered the following outputs in 2020:

- the definition of the methodology and the associated tools able to characterise the GNSS performance into the railway scenarios selected in the project;
- the detailed design of a simulation and verification infrastructure.

These achievements will feed TD2.4 and will contribute to the higher TRL activities foreseen to start from 2021 in the follow up project, X2RAIL-5.

The TD also started discussions in 2020 to launch a collaboration with the ERTMS Users Group (EUG) regarding the definition of an interoperable solution for Fail-Safe Train Positioning, including two key building blocks, «digital map» and «augmentation». They are considered as key enablers for the introduction of innovative technologies in the (train localisation) system (e.g. GNSS or Inertial Measurement Unit – IMU) to provide better accuracy and further improvements in terms of safety, performance, cost saving, and (trackside) asset reduction, which is the ultimate goal of TD2.4.

Globally for the TD2.4, objectives and roadmaps have been defined for upgrading the TRL to which will then allow to progress to TRL6 in subsequent activities, which will also focus on reaching, by end of the TD, interoperable solutions.



In 2020, the TD has delivered all twelve expected deliverables. TD 2.4 has reported having accomplished 100 % of the planned work up to the end of 2020, which represents 55% of the overall TD.

TD 2.5: On-board Train integrity

This Technology Demonstrator aims at specifying and prototyping an innovative on-board train integrity solution, capable of autonomous train-tail localisation, wireless communication between the tail and the front cab, safe detection (SIL4) of train interruption and autonomous power supply

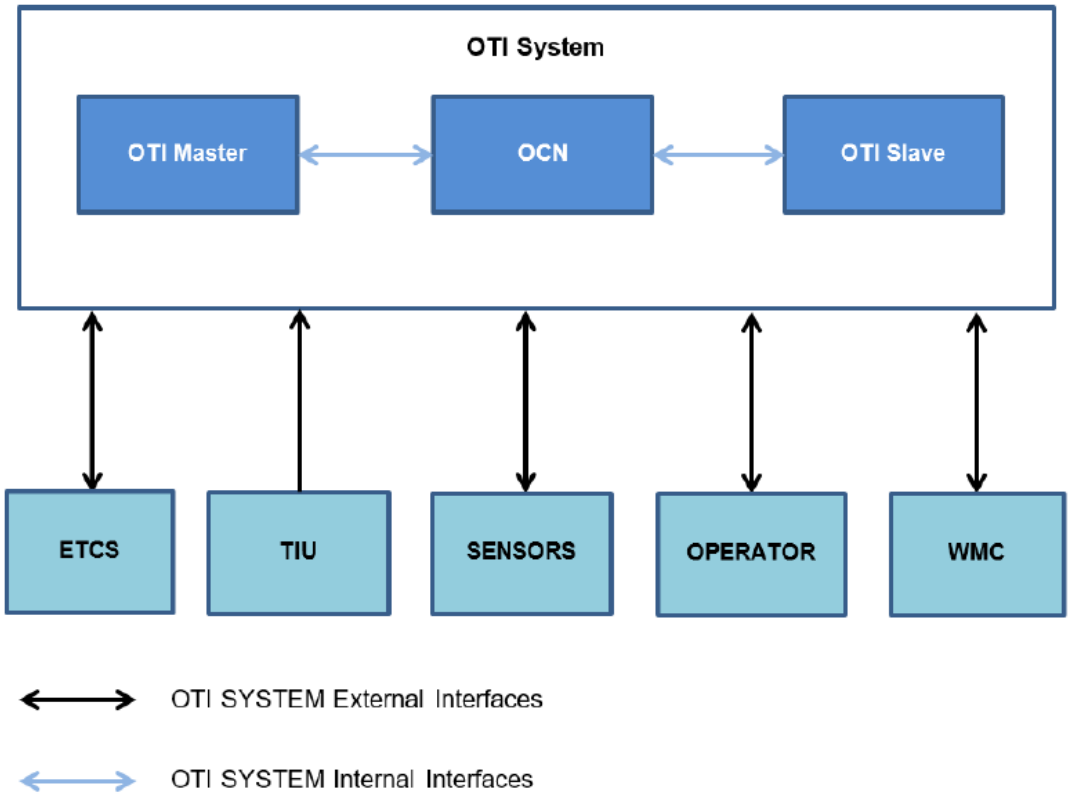
functionality without the deployment of any fixed trackside equipment. This functionality will be developed for those market segments (e.g. freight and low traffic lines) lacking such functions.

TD Progress

This TD currently builds on the following projects: X2RAIL-2 started in September 2017, X2RAIL-4 started in March 2020 and ETALON, completed in 2019. Respect to the original scope of work, the definition of requirement for train length determination has been to the scope of the Technology Demonstrator in 2020.

The main achievements for in 2020 include:

- Delivery of the system architecture specification for on-board train integrity)
- Issue of the cost-benefit analysis for on-board train integrity
- results of preliminary feasibility studies and preliminary laboratory tests for candidate technologies selection and adaptation of existing solutions for on-board train integrity



Functional architecture and interfaces

Regarding the definition of requirement for train length determination, achievements in 2020 include:

- functional requirements for train length determination
- functional architecture and interface specification for train length determination
- functional testing specification for train length determination
- system architecture specification for on-board train integrity and for train length determination

- candidate solutions [23] and impact analysis at product level for train length determination

RODUCT CLASS ID		SPECIFIC REQUIREMENTS		INTERCITY HIGH-SPEED	REGIONAL	URBAN SUB-URBAN	FREIGHT
1	A	COMMUNICATION	WIRED	X	X	X	X
		ETCS AT TRAIN TAIL	YES				
		TAIL ODO/POSITION SENSORS	NO				
		ENERGY HARVESTING	NO				
		FUNCTIONALITY	TRAIN INTEGRITY MONITORING				
	B	COMMUNICATION	WIRED	X	X	X	X
		ETCS AT TRAIN TAIL	NO				
		TAIL ODO/POSITION SENSORS	NO				
		ENERGY HARVESTING	NO				
		FUNCTIONALITY	TRAIN INTEGRITY MONITORING				

OTI product classes 1

[23] Solution 1 is based on one WSN node per wagon.

RODUCT CLASS ID		SPECIFIC REQUIREMENTS		INTERCITY HIGH-SPEED	REGIONAL	URBAN SUB-URBAN	FREIGHT
2	A	COMMUNICATION	WIRELESS				X
		ETCS AT TRAIN TAIL	NO				
		TAIL ODO/POSITION SENSORS	YES				
		ENERGY HARVESTING	NO				
		FUNCTIONALITY	TRAIN INTEGRITY MONITORING CARGO/WAGGON DIAGNOSIS				
	B	COMMUNICATION	WIRELESS				X
		ETCS AT TRAIN TAIL	NO				
		TAIL ODO/POSITION SENSORS	YES				
		ENERGY HARVESTING	YES				
		FUNCTIONALITY	TRAIN INTEGRITY MONITORING CARGO/WAGGON DIAGNOSIS				

OTI product classes 2

PRODUCT CLASS ID		SPECIFIC REQUIREMENTS		INTERCITY HIGH-SPEED	REGIONAL	URBAN SUB-URBAN	FREIGHT
3	A	COMMUNICATION	WIRELESS				X
		ETCS AT TRAIN TAIL	NO				
		TAIL ODO/POSITION SENSORS	YES				
		ENERGY HARVESTING	NO				
		FUNCTIONALITY	TRAIN INTEGRITY MONITORING TRAIN COMPOSITION DETERMINATION SAFE TRAIN LENGTH DETERMINATION CARGO/WAGGON DIAGNOSIS				
	B	COMMUNICATION	WIRELESS				X
		ETCS AT TRAIN TAIL	NO				
		TAIL ODO/POSITION SENSORS	YES				
		ENERGY HARVESTING	YES				
		FUNCTIONALITY	TRAIN INTEGRITY MONITORING TRAIN COMPOSITION DETERMINATION SAFE TRAIN LENGTH DETERMINATION CARGO/WAGGON DIAGNOSIS				

OTI product classe with train length determination – (product classes 3)

TD2.5 activities continued also in X2R4 WP6 including in 2020 the following achievements:

- TRL4 demonstrators for passengers and freight application domains with wired and wireless communication technologies.:
  - AZD demonstrator for OTI Product Class 1
    - OTI Finite State Machine implementation and functional testing in host environment for mastership, inauguration and monitoring states.
  - HITACHI demonstrator for OTI Product Classes 1 and 2
    - Design for OTI real target
    - OTI dashboard implementation in host environment for OTI status information visualization and for start/reset command acquisition aimed ad reconfiguring OTI system in joining/splitting procedures

        - OTI Finite State Machine implementation and functional testing in host environment for mastership and inauguration states, joining/splitting procedures and monitoring state based on odometry data from real trains and simulated loss of integrity
        - OTI Finite State Machine implementation and functional testing in real target for mastership, inauguration and monitoring states with real OTI Master and real OTI Salve boards
    - INDRA demonstrator for OTI Product Classes 3
        - OTI Finite State Machine implementation and functional testing in real target with real cabin equipment and four real OTI slave devices. Implementation includes train composition discovery, communication with TMS for train composition acquisition, composition visualization on OTI dashboard for confirmation from the driver, train integrity monitoring based on radio signal strength sensors.
    - MERMEC demonstrator for OTI Product Classes 1 and 2
        - OTI Finite State Machine implementation and functional testing in host environment with two virtual machines for mastership, inauguration and monitoring states.

- Performance analysis
    - RANSS simulator adaptation and set-up for train integrity functionality with wired and wireless communication in different architectural solutions (e.g. tail-head or coach-coach communication), IMU, GNSS and composition sensors. Tracks selected for simulations: Zurick-Brugg and Hannover-Wurzburg.
    - sensitivity analysis for OTI configuration parameters related to timers and thresholds with OTI Finite State Machine transitions (e.g. non-regular state, recovery mechanism).

Sensitivity analysis has shown what parameters and factors should be taken into consideration in order to understand the evolution of some indicators such as probability of false alarm, number of reported unknown integrity status and detection time of loss of integrity. The work highlighted the impact of the quality of service of communication network, in terms of loss of message rate, on the OTI performance. It provides a policy to choose the system configuration parameters, mainly, the OTI timers ensuring an acceptable level of availability as well as the safety. One of the considered timers is T_OTIM_L which represents the period of time where the master waits for slave status information before reporting a loss of integrity status. This analysis has shown the impact of T_OTIM_L and message loss rate on the performance indicators for product class 1 and 2. This study will be carried out in future work to analyse the impact of other configuration parameters.

- Safety analysis
    - RAILENIUM: quantitative evaluation for OTI system tolerable hazard rate, based on input data provided by the IMs (i.e. loss of integrity events observed in real operation over 10 years)

- Costs-Benefits Analysis
    - Cost analysis for SIL4 and SIL2 OTI systems
    - Capacity analysis in the nodes

TD2.5: On-board Train Integrity								
2015	2016	2017	2018	2019	2020	2021	2022	2023
			Ongoing: X2Rail-2, ETALON, X2Rail-4					

In 2020, the eight expected deliverables have been delivered. In conclusion, TD 2.5 has reported having accomplished 100% of the planned work up to the end of 2020, which represents 70% of the overall TD.

TD2.6: Zero on-site testing (control command in lab demonstrators)

The development of a new laboratory test framework comprises simulation tools and testing procedures for carrying out open test architecture with clear operational rules and simple certification of test results. It aims at minimising on-site testing (with the objective of zero on-site testing) by setting-up full laboratory test processes, even when systems comprise subcomponents of different suppliers. The test framework will also allow remote connection of different components/subsystems located in various testing labs.

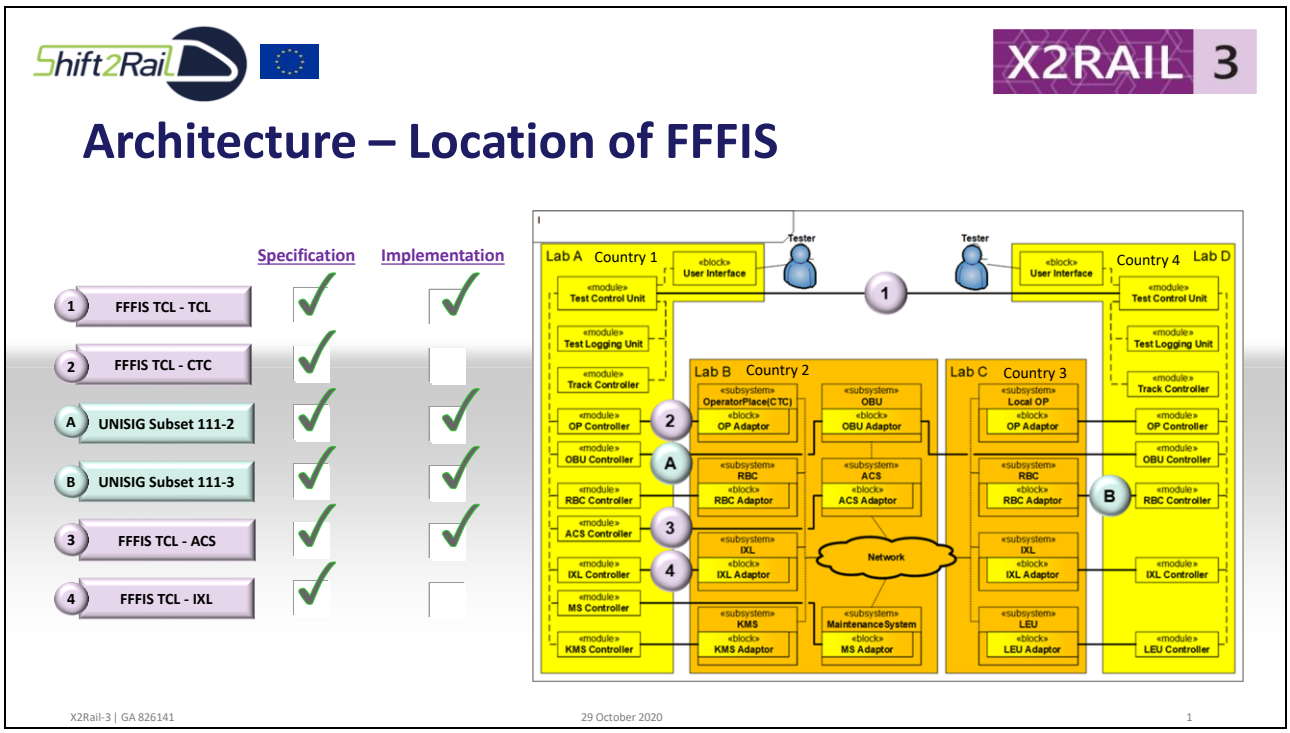
TD Progress

The activities related to this TD were started in X2RAIL-1 and the first results have been ready since December 2018. These results include a benchmarking analysis, the description of the test process and the definition of a full system test architecture for the necessary test environment to support shifting testing from the field to the lab. In this timeframe the results of the VITE open call have been jointly analysed and taken into account.

The TD continued the activities started in 2019 as part of the X2Rail-3 and GATE4RAIL projects working on the following milestones finishing in 2020:

- definition of a generic communication model,
- data modelling for the test environment and
- validation of data with formal methods

In 2019, the generic communication model has been defined. In this generic communication model, several different interfaces and adapters are specified down to the level of FFFIS (Form Fit Functional Interface) specifications. They will make part of an important cornerstone for the implementation of the prototypes in 2020, the following picture shows which Interfaces had been specified and which of these specified interfaces are implemented and tested in 2020:



An initial data model to set up the common prototypes was finally agreed in 2020 and the analysis using formal modelling for verification of this data has been completed (D5.2).

For the above shown UNISIG and FFFIS interfaces various prototypes were implemented by the partners of TD2.6. In 4 different prototypes these interfaces were tested and a common verification report including the test results (D5.3) was delivered.

The collaboration with the complementary project GATE4RAIL was deepened with workshops in 2020 to exchange the results of the projects in order to

- align automated update of test environments due to multiple Changes made by TD2.6
- align the concept for continuous integration as well as automated test repetition and automated evaluation of tests, taking the safety aspect into account.

In addition to the collaboration with GATE4RAIL also an exchange with open call project MOVINGRAIL was performed to take into account and discuss the different results/approaches on testing on the example of Moving Block.

The integration of the “game changer” technologies like ATO, Moving Block should be the focus. In addition to that the identification/evaluation of the technical boundaries of a distributed lab are also in the focus. Related to test automation the group will be working on a demonstration of an integrated test environment for running automated testing scenarios.

TD2.6: Zero on-site testing (control command in lab demonstrators)								
2015	2016	2017	2018	2019	2020	2021	2022	2023
		Finished: VITE						
		Ongoing: X2Rail-1, X2Rail-3, X2RAIL-5, GATE4Rail						

In 2020, the TD has delivered all three expected deliverables. TD 2.6 has reported having accomplished 100 % of the planned work up to the end of 2020, which represents 60% of the overall TD.

TD2.7: Formal methods and standardisation for smart signalling systems

Formal methods (FMs) provide the means to establish correctness of a system model with respect to given properties, to improve verification, certification, and authorisation processes, while reducing the need for extensive field tests in the future. To verify safety is considered one of the most compelling use cases for FMs. FMs and standard interfaces aim to contribute to reduced life cycle cost and time-to-market, increased market competition and standardisation, and improved interoperability and reliability. While standard interfaces are orthogonal to formal methods (one can use one without the other), they help increase competition, and enable more efficient use (and reuse) of formal methods.

TD Progress

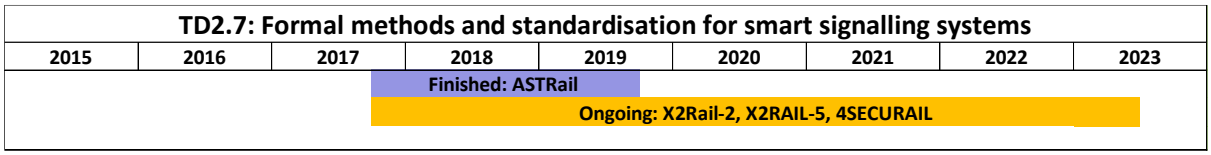
This TD built in 2020 on X2RAIL-2, 4SECURail (which started end of 2019) and ASTRAIL (completed in 2019). The open call 4SECURAIL will run in parallel with TD2.7 also in X2RAIL-5, and is expected to provide a cost benefit analysis (CBA) for FMs, assessment of key topic 'learning curve', and perform a case study (for an RBC/RBC handover interface, based on UNISIG specifications SUBSET-039 and SUBSET-098).

TD2.7's survey and classification of FMs (the FMs taxonomy deliverable in 2018) defined relevant use cases to apply FMs and semi-FMs for development and V&V of railway signalling systems ("FMs use cases"). Key activities during 2020 for TD2.7 included two case studies applying all FMs use cases, to enable comparison and evaluation, and to reach further in conclusions and recommendations:

- Two FMs use cases in process to create and define a standard interface (EULYNX process).
- Four FMs use cases in development and V&V of software for a railway level crossing subsystem using a standard interface, based on a recent tender specification.

A main achievement has been that all FMs use cases defined were applied, including a variety of different state-of-the-art methods and tools, providing a concrete basis to assess the potential of FMs and standardisation for rail control. These results are described in three deliverables produced by TD2.7 in 2020; one for each case study, plus the deliverable providing the business case for FMs and standardisation.

This TD has during 2018-2020 focused on the subsystems level. Within X2RAIL-5, this TD will pivot to the system-of-systems perspective, with modular architecture and the whole system development process. Further benefits of FMs, but also new challenges, can be expected in this context.



TD 2.7 has reported having accomplished 100% of planned work up to the end of Nov 2020, which represents 69% of the total calendar time planned for TD2.7 in X2R-2 and X2R-5.

TD2.8: Virtually – Coupled Train Sets (VCTS)

This technology demonstrator targets the enabling of 'virtually coupled trains', capable to operate much closer to one another, within their absolute braking distance, and to dynamically modify their own composition on the move (virtual coupling/uncoupling of train convoys), while ensuring at least the same level of safety as currently provided.

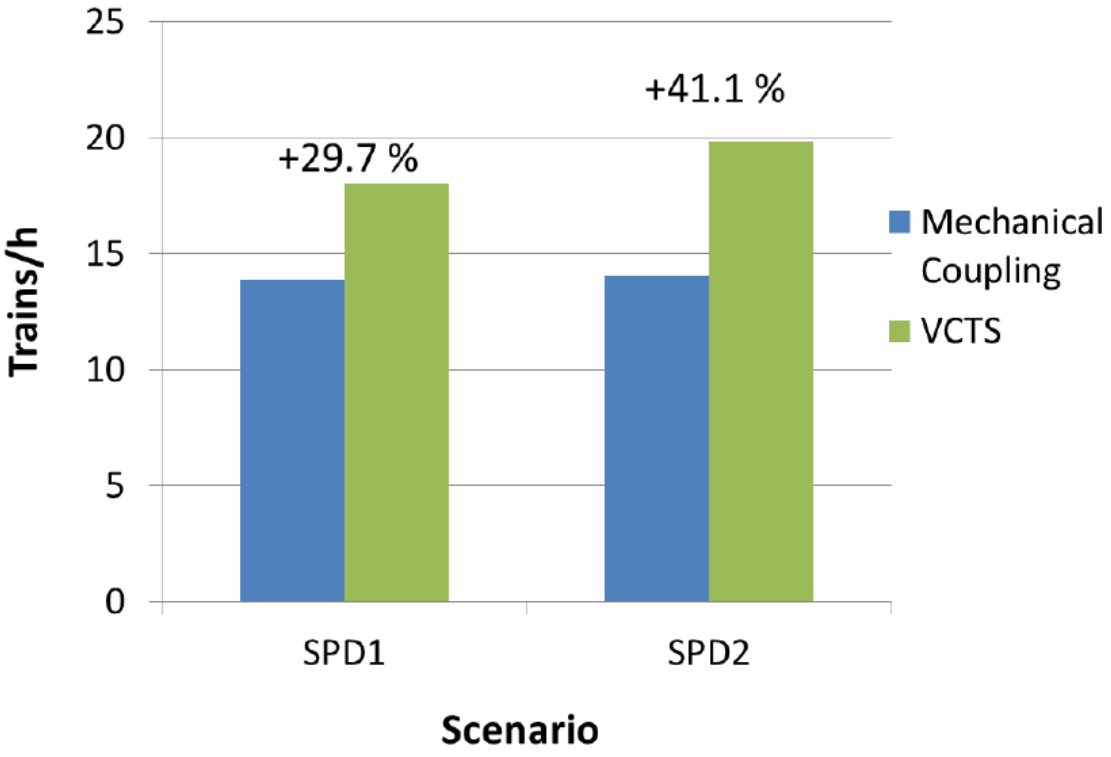
TD Progress

This Technology Demonstrator currently builds on X2RAIL-3 and the open call MOVINGRAIL, both launched at the end of 2018.

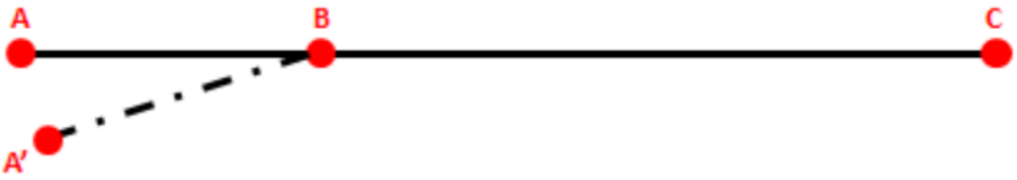
After dedicating 2019 to develop the overall operational concept of VCTS, in 2020, activities have been focused on 3 main streams of work:

- The finalization of the safety analysis, based on the Functional Requirements Specification (FRS) that have been drafted in the system concept. Specifically, the system concept has been further elaborated in the details of a FRS, in order to develop a safety analysis that replicates the CENELEC workflow (e.g.: EN50126/8/9 norms) by identifying hazards and therefore address safety targets to the VCTS functions. A meaningful level of detail has been achieved especially by identifying approx. 50 main hazards and associated mitigations.

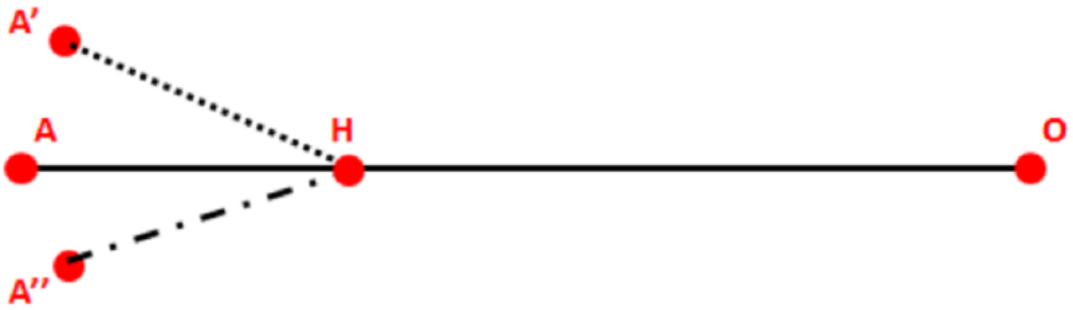
- A structured analysis through sample scenarios of operations (shared with the TD TCMS, IP1 project CONNECTA-2) in order to determine the achievable increase of performances thanks to VCTS. The analysis has taken as main key performance indicator the improvement in terms of trains running per hour in a specific section of track, showing as main result that VCTS does improve the line capacity:



SPD1 corresponds to high speed operations: 300km with 3 stops. At station B, every train coming from Station A is virtually coupled with a train coming from station A'.



SPD2 corresponds to regional operations: 70km route including 15 stops. Stations H is used to couple trains coming from A, A' and A''.



- It also highlighted another main benefit that sits in the flexibility of operations allowed by removing the mechanical coupling procedures.

- As last deliverable of 2020, the feasibility study, that has gone through all the available technologies and relying also on synergies with other work streams of both TD2.8 and other S2R TDs or external initiatives[24], in order to determine the gaps between the current state of the art of each technology (radio communication, odometry, brake interface, etc…) and the needs of VCTS in terms of performance and safety especially.

As a meaningful remark on the outcomes of activities from 2020, the work performed by MOVINGRAIL has been essential as regards work on performance evaluation.

The final set of activities from 2020 has moved the focus in detailing the implementation of the VCTS into an SRS. Especially, from the FRS initially drafted in the system concept, the SRS targets to develop in detail the functional items of VCTS with a structured attention to the hazards identified in the safety analysis.

For this reason, at the moment a preliminary SRS has been developed, whilst the focus is now to rely on proper tools allowing tracing towards other inputs to VCTS like safety analysis, FRS, or other input elements. The Tool Capella is now being used to structure the SRS of VCTS in order to rely on an automatic methodology to have traceability matrix implemented and to ensure full coverage of the system definition.

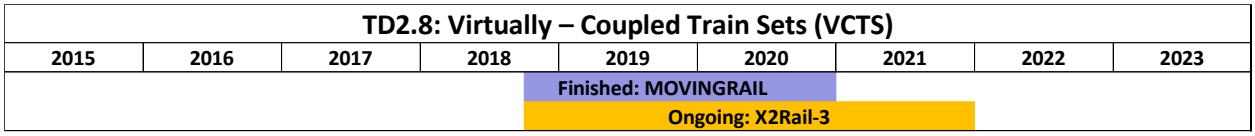
As a summary of the findings in year 2020 regarding VCTS:

- It has been shown how the VCTS can actually improve performances of the line in terms of headway, but this seems to be only one of the main benchmarks determining the convenience of VCTS. Especially, figures show how the procedure for splitting/joining trainsets is the key element that determines VCTS advantages: the more the operations require splitting or joining of trains, the more VCTS is convenient. Moreover, VCTS adds, from a qualitative perspective, a tangible advantage in terms of flexibility, as it clearly simplifies the operations in changing trainset composition;
- The advantages of VCTS come anyway at a cost, that is a number of hazards introduced in the operations that have to be mitigated through technical solutions or procedures. The main outcome is that the VCTS therefore cannot limit its scope to an on board-centered technology, as hazards have been identified requiring solutions on wayside (e.g. RBC or Interlocking) to be mitigated.
- From a feasibility point of view, the outcome has shown how the convenience of VCTS also relies in the performances achievable with the technology. The study carried out has shown not only the gaps that current state of art of technology has to match VCTS requirements (e.g. performance of braking systems for distances below absolute braking distance, clear VCTS requirements for communication, length constraints at stations and number of passengers allowed on platforms)[25], but also that the current roadmap for the evolution of these technologies has necessarily to take account the VCTS needs to ensure its efficacy in application.

The system requirement specifications and the system functional architecture will be the next focus of the activities in 2021.

[24] TD1.2, TD1.5, TD2.2, TD2.4 TD2.6, TD2.7, TD2.9, EULYNX, EUG,

[25] Minimum requirements for VCTS performance: allowing driving below the absolute braking distance, reducing time and effort for de-coupling compared to mechanical coupling, reaching same of higher safety level compared to current operation and providing compatibility with existing infrastructure and independence from signalling system.



In 2020, all five of the expected deliverables were delivered. TD2.8 is reporting having accomplished 100% of the planned work up to the end of 2020, which represents 45% of the overall TD.

TD2.9: Traffic management evolution

The goals of an advanced Traffic Management System are to improve traffic management operations with automated processes for data integration and exchange with other rail business services and to develop new or optimized business functionalities. Parallel to the development of a scalable, interoperable and standardized communication structure is the implementation of a Platform specific Data model (PSM) for Traffic Management applications and data integration following the general guidelines of the generic Canonical Data Model. New business service applications are specified and developed comprising ATO, Dispatching and planning functionalities, conflict detection and resolution algorithms and others targeting increase of rail operations performance and customer satisfaction.

TD Progress

This TD currently builds on the work performed in X2RAIL-2, for which the TD was expected to be completed by February 2020. The activities will then continue in X2RAIL-4 and the complementary action OPTIMA (open call) whose was launched in December 2019.

The main achievements are system requirement specifications for a new communication Backbone (Integration Layer), a WEB- Interface to link external and internal clients, an Application Framework to host Business service applications and a standardized operator work station.

The activities to define or re-define core applications for the TMS meeting the requirements to increase the efficiency of traffic execution, reduce of OPEX for rail transportation, increase passenger comfort and to deliver the required environmental contributions has successfully been finalized.

Specific focus was to enable a significant increase of digitalization and automation for these new functionalities based on an application of the new specified communication network (Integration Layer) in parallel with the implementation of a standardized Data Model.

In addition to the integration processes to manage ATO and Moving Block, the scope of the works covered applications/process definitions for future automated Traffic Management (see Figure 1) validated through an extensive benchmarking process against the new strategic concept developed from Deutsche Bahn (Digitale Schiene).

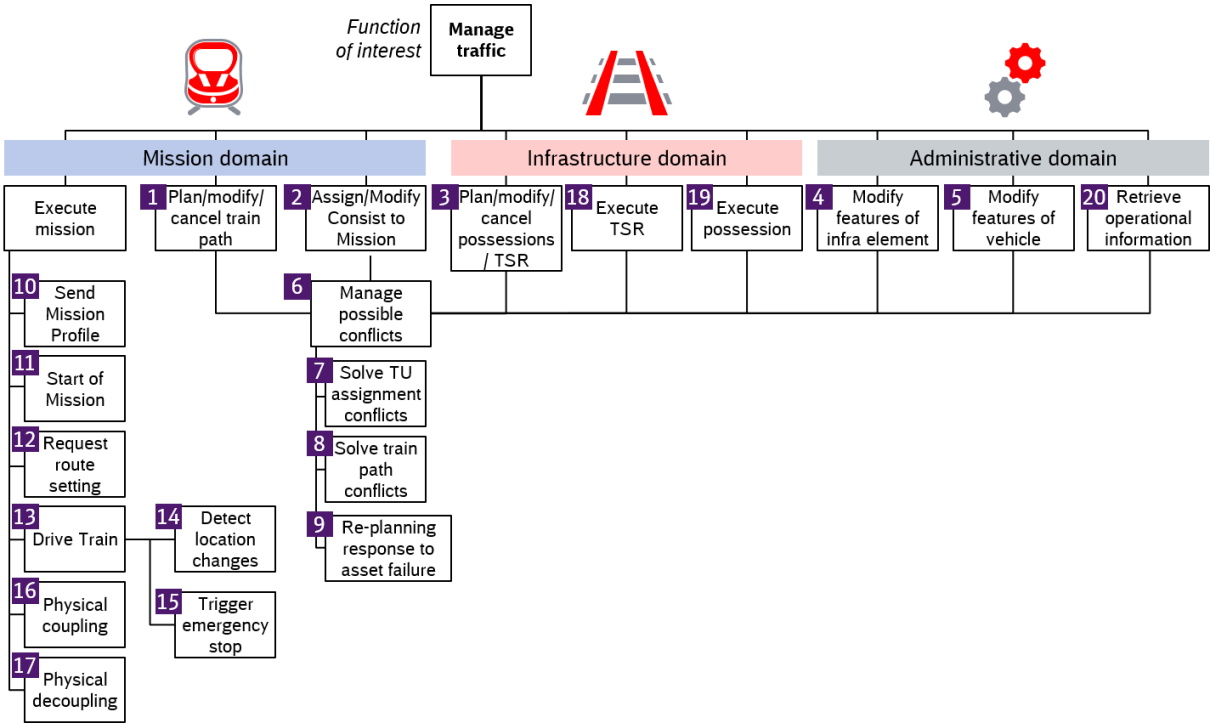


Figure 1: New advanced TMS Applications – reference: X2RAIL-2 D6.3

Development of Demonstrators have started and a guideline how to structure and report the development process has been established. The design of the prototypes will continue (up to TRL6) inside X2RAIL-4.

The TD continued with the design and specification of new Traffic Management functionalities and algorithms for specific processes based on use cases of D6.3 of X2Rail2 focusing on further updates of the generic Use cases including degraded mode scenarios.

Processes in the use for state-of-the-art automated conflict handling solutions has been selected to a benchmark based on requirements structures delivered from the involved IMs between algorithms in practice and those developed in academia is in progress.

Works to define large scale optimization methods have started and are progressing. Involved partners are providing high level descriptions of their algorithms and test environments.

The prototypes in development at TRL4 comprise Wayside ATO, a centralized Driver Advisory Functionality, Conflict detection and resolution applications, Field asset integration and other planning and dispatching processes.

Experiences gained throughout the development of the demonstrators will lead to an update of the SRS for the Integration Layer in terms of necessary Data Elements to be represented on the communication network.

A TMS Platform Specific Data Model (PSM) covering the needs of the prototypes has been established. In 2021 the prototypes will be scaled to TRL6.

TD2.9 Traffic Management Evolution								
2015	2016	2017	2018	2019	2020	2021	2022	2023
			X2R2, X2R4, OPTIMA					

In 2020, the TD has delivered seven of the nine expected deliverables. TD 2.9 has reported having accomplished 77 % of the planned work up to the end of 2020, which represents 56% of the overall TD.

TD2.10: Smart radio-connected all-in-all wayside objects

The objectives of this technology demonstrator are to develop an autonomous, intelligent, maintenance free smart equipment ("box") able to connect with any signalling wayside object and communicating device in the area (wireless), guaranteeing safety and security, by the definition of a common architecture and of requirements and interface specifications. The TD will develop concepts for locally derived power, for the overall reduction of power consumptions and required cabling as well as to specify interfaces with control, power**,** diagnostics and maintenance systems using both low and high capacity wireless links.

These "intelligent" objects - knowing and communicating their status conditions - would not only provide opportunities in terms of cost reduction and asset management improvement, but also establish new means for management and control of railway network information.

TD Progress

This TD currently builds on the following projects: X2RAIL-1, ETALON (completed in 2019), and X2RAIL-4, launched in December 2019.

In 2020, the TD focused in the definition of demonstrator specifications and test strategy and the starting of the Development and Verification of selected demonstrators.

The Definition of demonstrator specifications and test strategy used the results of the deliverables of X2Rail-1 WP7 as inputs for the generation of the D11.1 "Specification and Test Strategy": Matrix of requirements from D7.2 "Railway requirements and Standards application conditions", System Architecture defined in D7.3 "System architecture definition and interfaces definition" and Planning and description of the demonstrators from D7.4 "Structured planning of overall system demonstrator".

In this Definition of demonstrator specifications and test strategy, the overall demonstrator concept has been defined, the requirements from previous deliverables have been identified and the test strategy has been specified for Smart Wayside Object Controller demonstrator to be developed in the X2Rail-4 project WP11 and WP12 scope. The goal is to cover the majority of objectives and requirements of the demonstrator. Due to the huge number or requirements, they have been split in different prototypes that will be developed by the selected participants.

As a result of the previous process, the D11.1 "Specification and Test Strategy" contains: the description of the overall demonstrator's concept, including a brief description of each prototype, the identification of the requirements that will be covered by the demonstrator, in order to guarantee

that all the significant requirements for a SWOC will be implemented and validated by at least one prototype, and the description of the test strategy to be used for testing demonstrator.

For the Development and Verification of selected prototypes a test report model has been agreed for monthly reporting of the demonstrator progress.

TD2.10: Smart radio-connected all-in-all wayside objects								
2015	2016	2017	2018	2019	2020	2021	2022	2023
		Ongoing: X2Rail-1, ETALON, X2Rail-4						

In 2020, the planned deliverable was delivered on time. The overall progress was in line with the plan. TD 2.10 reports having accomplished 100% of the planned work up to the end of 2020, which represents 65 % of the overall TD.

TD2.11: Cybersecurity

The interconnected digital railway network at European level is constantly growing and will keep on growing, which will increase the number of risks associated to security. There is therefore a growing need for handling these cyber-security threats in railway systems. This technology demonstrator aims at achieving the optimal level of protection against any significant threat to the signalling and telecom systems in the most economical way (e.g. protection from cyber-attacks and advanced persistent threats coming from outside).

TD Progress

The activities of the TD are addressed via the projects X2Rail-1, X2Rail-3, and the recently launched, X2Rail-5. The open call project 4SECURAIL was launched at the end of 2019 and has provided its first initial results (on C-SIRT) in 2020.

The following activities were completed in 2020:

- Optimisation of the risk assessment process compliant to IEC 62443
- Risk assessment of railway generic signalling architecture using the optimised risk assessment process on selected zones
- Security by Design guidelines interdependencies based on 62443 4-1 and IEC 62443 4-2 requirements
- Generic Cybersecurity architecture and shared security services
- Definition of generic railway protection profiles
- Guideline for security of Legacy system
- Modelling of ERTMS Threat analysis for balise to train connection
- Analysis of the cybersecurity challenge of IoT introduction

During the X2Rail-1 project, a risk assessment process compliant with IEC 62443 has been issued. This one has been optimised and simplified in the X2Rail-3 project. This new risk assessment process has been validated through its application to some of the security zones of the generic signalling architecture defined during the X2Rail-1 project.

One of the other main questions raised by the TD is “how to design cyber secured railway component”. Due to the specificities of the railway sector (small sector with very long development and life cycle, and high level of certification), it has been decided to investigate the interdependencies that could impact the implementation of “security by design” at product supplier level through the analysis of

the requirements specified in the IEC 62443-4-1 and IEC 62443-4-2 and their potential interdependencies with the railway specific standards.

The TD defined also the basis for technical interoperability for cybersecurity in the rail automation domain. This resulted in the definition of mandatory shared security services such as system-wide time service, central logging, security incident and event management, intrusion detection, identity and access management, backup and asset inventory and two highly recommended services: public key management and central software update. Further interoperability is achieved through the agreement on protocols to these shared security services (NTPv4, syslog over TLS, CMP, OPC UA SC…).

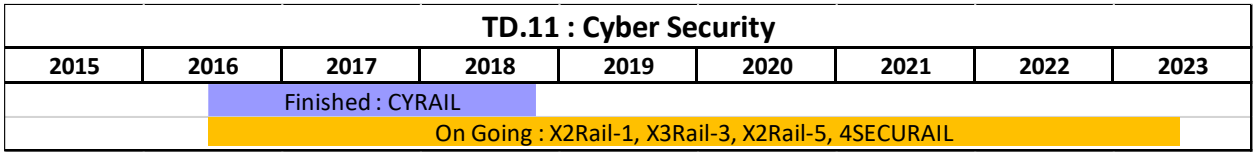
This TD produced a list of requirements for rail automation components in the form of protection profiles. Three protection profiles have been produced for trackside, on board and adaptable communication system components.

The applicability of cybersecurity to legacy systems was analysed covering areas such as threat analysis, implementation of IEC 62443 requirements and compensating counter measures.

The TD performed an in-depth analysis of the operational risks related to the current implementation of the balise to train connection in the ERTMS system for Level 1 and Level 2 operations. This analysis provided also some approaches for mitigations and countermeasure implementation.

The TD also analysed the cybersecurity challenges associated with introducing the Internet-of Things into the railway. It starts with an overview of the main concepts and architectural patterns of IoT as well as associated cybersecurity challenges. An analysis of associated cybersecurity risks has been made and recommendations are provided that can facilitate addressing cybersecurity challenges specific to IoT.

For 2021, the dissemination to EU standardisation groups and regulatory bodies (ERA) is planned.

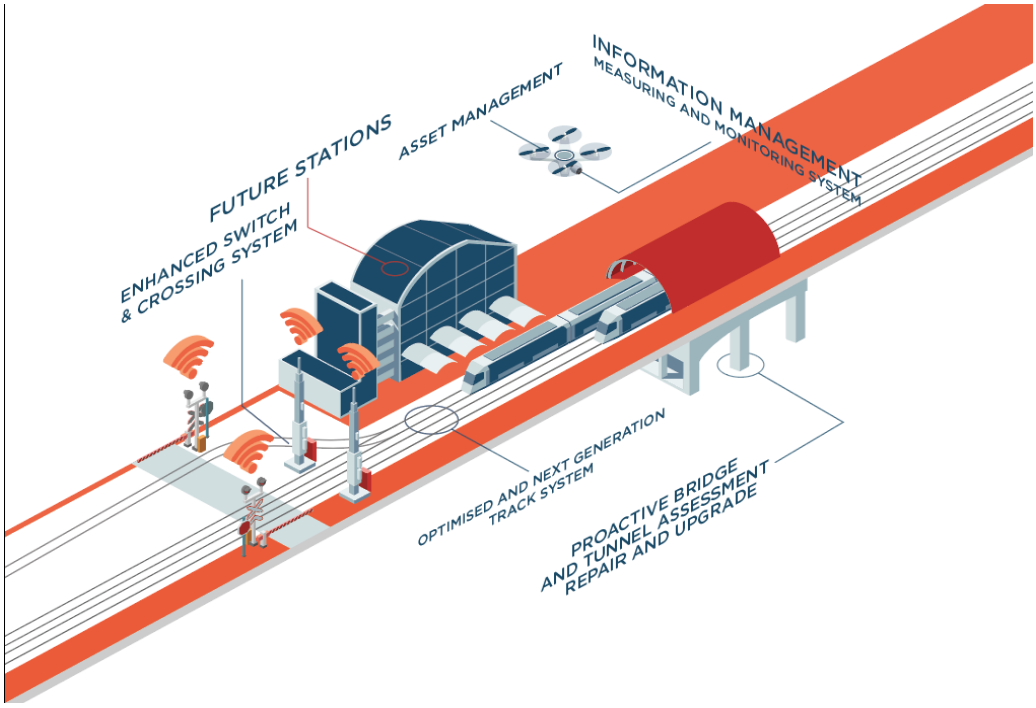


In 2020, the 3 planned deliverables were delivered on time. The overall progress is in line with the planned activities. The TD has reported having accomplished 100% of the planned work up to the end 2020.

In addition to these activities, the TD participated actively to the standardisation and the coordination of the cybersecurity approaches for railway at European level. This was embodied by the participation as member or as guest to the following groups: RASCOP, ESCO, ER-ISAC, TC9X/WG26 (cybersecurity) and Railsec platform.

1.4.3. IP3 Cost Efficient and Reliable High Capacity Infrastructure

The picture below provides a visual of the TDs where improvements are expected.

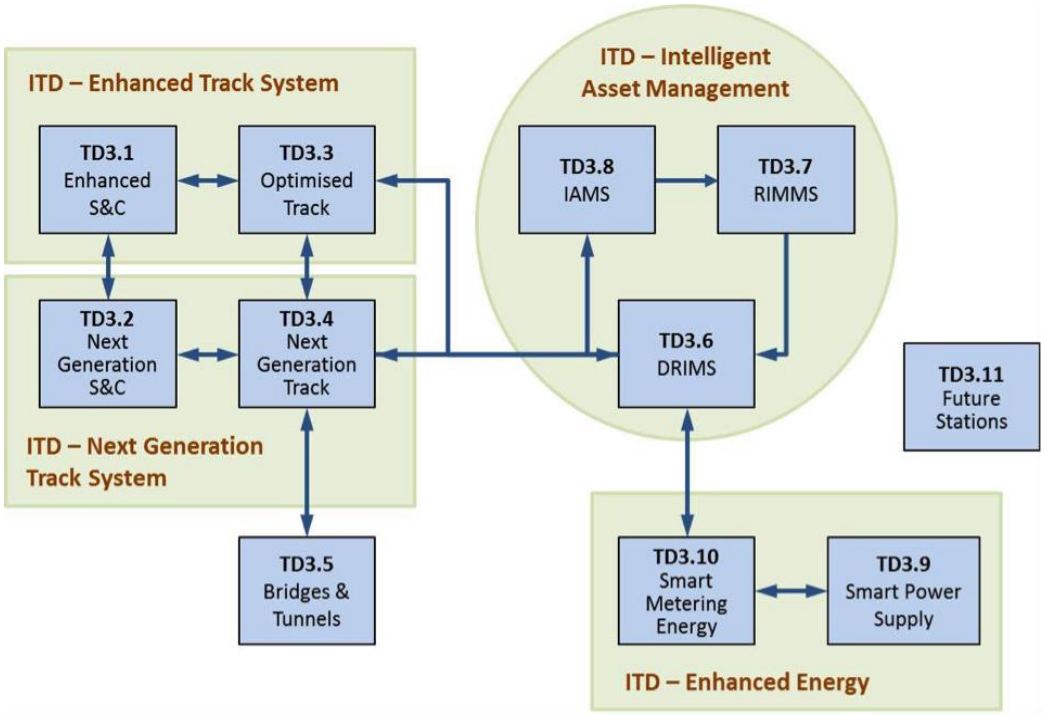


The design, construction, operation and maintenance of rail network infrastructure have to be safe, reliable, supportive of customer needs, cost-effective and sustainable. In order to deliver the benefits of market opening and interoperability and to reduce the life cycle costs of rolling stock and on-board signalling systems, the network diversity needs to be eliminated, notably through a migration towards common high-performing infrastructure system architecture.

Activities that can support the reduction of infrastructure maintenance costs, such as simplified procedures or automation, need to be led in priority. They should propose solutions that can be rapidly and efficiently deployed. Furthermore, the infrastructures have to be managed in a more holistic and intelligent way using lean operational practices and smart technologies that can ultimately contribute to improving the reliability and responsiveness of customer service, as well as the capacity and the whole economics of rail transportation.

In order to be competitive with other modes but also integrated with them, compatibility between different modal infrastructures (including multimodal hubs, changing points and stations) needs to be ensured and based on principles of interoperability and standardisation.

The picture below shows the connections and dependencies within the IP3.



TD3.1 Enhanced Switch & Crossing System Demonstrator

TD3.1 aims at improving the operational performance of existing Switches and Crossings (S&C) designs through the delivery of new S&C sub-components with enhanced Reliability, Availability, Maintainability and Safety (RAMS), improved Life Cycle Cost (LCC), sensing and monitoring capabilities, self-adjustment, noise and vibration performance, interoperability and modularity.

TD Progress 2020

TD3.1 builds on the project's activities of IN2RAIL and IN2TRACK (past projects) and IN2TRACK-2.

In 2020, the whole system modelling approach for virtual evaluation and design of S&C was enhanced by further modules. The description the material behaviour was added, supporting the development of models which are capable of describing the influence of microstructural properties on the plasticity and RCF related fatigue behaviour of S&C materials. For track settlement predictions the Vehicle-Track-Interaction model, and for RCF predictions the wedge model was developed and applied. Changes of S&C sub-systems or components and their influence in context of system of systems can then be assessed and the S&C system performance for pre-defined deterioration and system functions analysis can be shifted to fully virtual environment and hybrid-testing significantly, which decreases the time-to-market and innovation cycles by up to 30%.

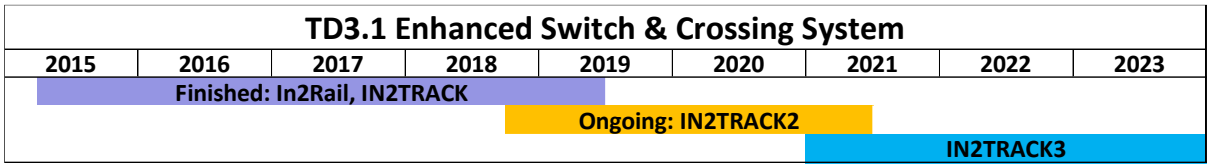
Condition monitoring approaches and monitoring procedures around acceleration (triggered by vibrations), temperature (triggered by time interval) and monitoring actuators of the switch (triggered by switch movement) have been validated under controlled environment. Existing data from operators and the in-track demonstrator will be used in 2021 for the validation of the technologies in operational environment, raising the maturity level of the solutions. Data sources were integrated using the railML and SensorML data formats. Due to the complexity and limitations of these data formats, continuous collaboration with IPX is needed to benefit from the work on the CDM workstream.

Electromechanical Impedance Technique for the deterioration inspections of Cast Manganese Crossings have been investigated. EMI was identified as a potential method for early detection and continuous monitoring of discontinuities in the crossings. The technology was validated and tested under controlled environment in laboratory. On-field validation did not occur in 2020, as initially planned, due to restrictions resulting from the COVID19 pandemic.

Two enhanced S&C demonstrators were produced and installed in track for evaluation in 2020:

- An enhanced manganese crossing combined with bainitic steel was validated in laboratory environment, demonstrating the expected fatigue performance of the system. Two of the novel enhanced design prototypes have been installed in track for tests under operational environment. The final assessment is planned in 2021/2022- Specific high-frequent track with high tonnage was chosen for validation purposes.
- A fully re-design of the VARS enhanced switch & crossing, including enhancements on several subsystems such as: the switch geometry / rail profile, whole system stiffness / support, modular bearer joints, optimized rail steel grades was produced and built into the network of the Austrian Railways ÖBB close to Vienna, in one of the highest capacity track. Benchmarks between the current VARS solution and the new S2R designs were integrated in 2020 in the field and equipped with sensors. Based on test procedures and test plan, a data acquisition system was designed and commissioned. In 2020, first data were successfully gathered, enabling the kick-off of the on-site tests.

As next step, meaningful data and information will be gathered and analysed out of these demonstrators as part of the in-field measurement campaign in operational environment, to validate and quantify the impact of the proposed enhanced S&C solutions.



During 2020, 1 deliverable was planned but not released. TD3.1 has reported having accomplished 80% of the planned work of 2020, which represent 50% of the overall TD3.1.

TD 3.2 – Next Generations Switch & Crossing System Demonstrator

TD 3.2 aims to provide radically new system solutions that deliver novel methods for directing trains between tracks to unlock additional network capacity, while reducing maintenance needs, traffic disturbances and life cycle costs. This will enable a change from current design forms to a radical shift to a new approach in transferring trains between tracks in a +40 year horizon view.

TD Progress

TD3.2 builds on the project's activities of IN2RAIL, S-CODE (past projects) and IN2TRACK-2. In 2020, TD3.2 has reported progress on the following topics:

- Development of a BIM model (still on-going) to complement the digital twin development for S&C: with no BIM standard currently available for railways, IFC rail has been used as a basis

for the development. This initiative will form the basis for feeding the BIM information into the digital twin which will, once fully developed, provide a detailed system monitoring and health architecture.

- Development of an integrated embedded sensor system for S&C with completion of structural and functional modelling of S&C unit to aid robust fault detection: this will support the development of the whole system approach to combining the output of sensors placed in the ALD (Actuation, Locking and Detection) system and at predetermined locations within the track element of the switch and crossing unit. The information from these sensors will be combined to provide a method of assessing and identifying as far as possible the root cause of S&C defects as opposed to symptoms of the cause.
- A further development of the Discrete Defect Repair (DDR) with the design of the Crossing Repair Machine (CRM): this system is designed to excavate in a predetermined area of a crossing wheel transfer zone to repair defects and wear, back to an as new profile through the deposition of weld material to rebuild the crossing and wing rail profiles.
- The use of drones to carry out inspections of S&C continues to be developed with a view to produce a process template of how the drone and point cloud footage can be utilised to carry out basic visual inspection of S&C.
- A prototype of fault tolerant Actuation, Locking and Detection system has been delivered. The switch control system (SCS) architecture has been designed to incorporate feedback loops and redundancy configurations for a CPU (Central Processor Unit) and actuator boards within the whole SCS system. This will enable the ALD system to operate in a degraded mode of operation, improving the availability of the S&C and reducing service affecting failures.
- Ranking the requirements identification for the new system and the concept design selection considering known failure modes have been performed as part of the whole system design for next generation S&C concept. This includes ALD types, novel component concepts and new monitoring technologies.
- A single multidisciplinary model using MATLAB software and capable of carrying out Boolean operations similar to CAD software has been developed. The tool will create track models for multibody simulations and CAD files for S&C manufacturers to use to recreate the modelled profiles. This model will form the basis for optimising a NR56V crossing profile (the method of which can be transferred to other crossing types and designs) to facilitate crossing profile optimisation to minimise impact loading and make an incremental change in the design of crossing running profile.
- Additive manufacturing techniques have been investigated to reproduce S&C components in alternative materials.
- A solution for the next generation kinematic system is being progressed from the Repoint concept that has been initially developed outside the Shift2Rail project.
- Conceptual design work to develop improved transition support conditions for the next generation switch and crossings has resulted in the development and completion of a methodology for integrating FEM and MBS models with variable soil properties. Work has included the development and trial of a superposition algorithm to calculate stresses in track substructure and calculate sleeper settlements. This methodology is being further developed to include the non-linear track behaviour in case of hanging sleepers. The benefits from this modelling work will be to minimise the rate of change of the support system stiffness and prevent the settlement issues associated with transitions between S&C and plain line track.
- Work on the Modular Continuous Support (MCS) concept has continued in 2020 with the development and qualification of a new fastening system for the MCS for S&C through testing to EN 13146 Pt4 (*Railway applications - Track - Test methods for fastening systems).* This technology development offers a smaller footprint to standard fastening systems with the capability of lateral adjustment to accommodate gauge variation.

During 2020, 1 deliverable was planned and also released. Due to delays in resourcing some workstreams and the added problems caused by the effects of the COVID pandemic, TD3.2 has reported having accomplished 70% of the planned work up to the end 2020, which represent 45% of the overall TD.

TD3.3 Optimised Track System

The TD challenges track construction assumptions, currently implicit in track design, and explores how innovative solutions in the form of products, processes and procedures can provide enhanced reliability, availability, sustainability, less capacity consumptions together with LCC savings. The aim is to derive medium-term solutions thus requiring harmonisation with current solutions and regulations. The TD pays also attention to the wheel/rail interaction that needs to work properly for good performance of the entire railway system. The environmental aspect are also involved in his TD.

TD Progress

TD3.3 builds on the project's activities of IN2RAIL, IN2TRACK (past projects) and IN2TRACK-2. The description below summarises the most important results achieved during 2020.

New bainitic rail solution for higher performance is under field validation and the current monitoring shows good results of the rail in terms of resistance of rolling contact fatigue. This higher performance is due to improved material structure in the rail that are less crack prone, that will lead to less grinding activities, which will extend the life of the rail, contributing to LCC improvement.

More understanding has been obtained during 2020 in the area of rail steel behaviour (rail anisotropy) that has been deformed by the rolling contact, just below the surface, and how the fabrication of test samples needs to be performed to be representative of a real rail section. Crack growth behaviour in rails has been investigated and new methodology to predict rail breakage caused form defected wheels has been performed, resulting in new knowledge on how to deal with wheel defects and to refine the risk management on track.

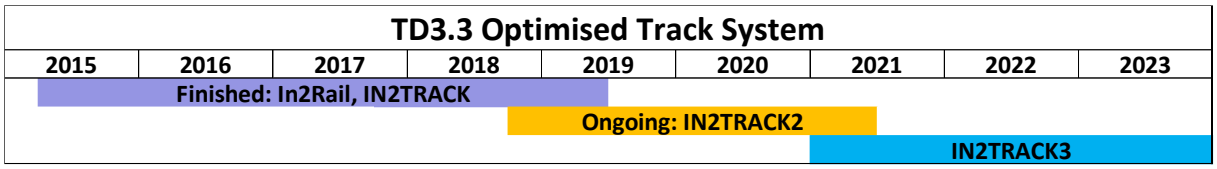
A new concept of rail grinding combining conventional whetstone grinding with oscillating grinding has been developed to fit into the demanding environment and requirements that are prescribed in urban network and tested in real condition in a tramway network during 2020 with initial promising results. Investigations have also demonstrated that the European standard for rail machining can be improved to some extent for some of the key operational parameters of machining rails.

Field activities of how friction modification can be used to reduce wear and N&V has been performed. This investigation also looks into how the dosage of friction modification can impact the adhesion between wheel and rail. Wheel squeal mitigation has been performed by test rig and by simulations with great success, more knowledge has been drown that can be used to mitigation actions out in field. The results are planned to be demonstrated during 2021.

Progress has been made in the knowledge of the wheel/rail system conditions in terms of how the wheel profile will impact the stability on track for high speeds vehicles. Furthermore, a proposal for novel measure of the wheel profile that that can be used for evaluation of the status of the wheel in terms of riding performance has been obtained. New knowledge has been acquired as to how the system of wheel and rail are linked to vehicle stability.

The preliminary results from field test of transition zones show a reduction of the dynamics impact on the track between two areas with different stiffness. However, field tests need to be exposed to more traffic before conclusions can be drawn. Thanks to simulation, progress has been made in understanding how settlement in transitions zones grows and how this can be mitigated.

A parametric study on noise reduction for slab track reduction has demonstrated that the pad stiffness impact the sound radiation, and increasing rail pad stiffness decrease the radiated sound power.



During 2020, 1 deliverable was planned and has been released. TD3.3 has reported having accomplished 90% of the planned work up to the end 2020, which represent 50% of the overall TD.

TD3.4 Next Generation Track System

TD3.4 aims to provide solutions which improve the plain line track system substantially, targeting a time horizon of around forty years beyond current state-of-the art. The improvements are planned for delivery through development of novel sub-systems and components, combined with more efficient and targeted inspection and maintenance processes. Step-change solutions are prioritised over short-term incremental improvements and as such, a longer-term implementation timescale is envisaged for the majority of technologies developed.

TD Progress:

TD3.4 builds on the project's activities of IN2RAIL and IN2TRACK (past projects), IN2TRACK-2 and IN2ZONE (started December 2020).

Asphalt track solution:

- The use of asphalt as a formation treatment was further developed. An asphalt layer with transitions was designed for incorporation within a standard ballasted track renewal. Modelling showed significant stress reduction on the subgrade with the inclusion of an asphalt layer. However, extreme weather on the weekend of the planned installation prevented construction of the asphalt section, although a range of instrumentation was installed on site, which will be used to collect data for monitoring the conventional renewal.

Rail defect repair technology suitable for autonomous operation:

- An innovative fully automated solution for the discrete defect repair of rail using a low preheat process was further developed and demonstrated for R260 rail, with full automation of the entire process from profile measurement to reprofiling following repair. High repair integrity has been demonstrated, with controlled microstructure, uniformity of hardness for resistance to wear and good resistance to bending fatigue.

Progress of other work within 2020 is as follows:

Next generation track system, sub-systems and components:

- High level functional requirements have been defined for the next generation plain line track system and efficient numerical simulation models have been developed, for use in optimising, validating and certifying potential slab track solutions.
- Development of a plain line track system digital twin (DT) started, with definition, prioritised high-level requirements and process steps for creation of the DT completed. Work has been carried out on the development of a Building Information Modelling (BIM) demonstrator for plain line track, which is scheduled for completion in mid-2021.
- Development of advanced numerical modelling of the train-track-ground system has been carried out, including development of advanced dynamic models and selection of appropriate degradation models for the system components. Work has commenced on optimisation of transition zones taking into account the train-track-ground interaction, which will be continued into 2021.
- Modelling has been completed to investigate different materials and locations for an off-rail design for noise shielding close to the rail. Initial results show that the absorptive panels can

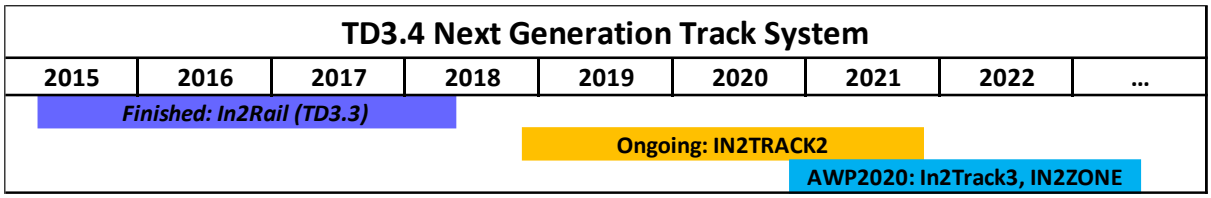
give a reduction of 2.5 to 5 dB in the rail noise, depending on the distance between the panels and the rail.

- 60E2 and 49E1 profile bainitic rail has been manufactured and installed in plain line track. Monitoring of the performance of the rail has commenced on site and further monitoring site visits and analysis of rail samples is scheduled for early 2021.
- Experimental and numerical investigations have been conducted into the formation of anisotropy and its effect on rail integrity. Also, numerical assessment has been carried out on the loading of rolling contact fatigue cracks close to rail surface irregularities, to investigate rail crack propagation.
- Development and laboratory testing of a fibre reinforced mortar has been carried out, to allow more efficient replacement of slab track sections following deterioration or damage, reducing the time to remove and replace slab track sections compared to traditional methods of demolishing concrete structures.
- Several types of smart fibre-based soil reinforcing solutions have been developed and tested in the laboratory. In particular, proof of concept has been provided for a smart cementitious based material which can provide self-sensing capabilities.
- Drainage solutions for next generation track have been investigated and a novel system exploiting the process of evapotranspiration and capillary action, to control water in track subgrade has been selected for further development to proof of concept during early 2021.

Track inspection, monitoring and maintenance:

- Initial development of a predictive model for forecasting track performance over time has been carried out. Further development and validation using a case study is planned for completion in early 2021.
- A method of train borne track stiffness measurement has been developed, to monitor the rate of change of track stiffness over time due to component degradation. Modelling has been validated by laboratory tests and development of algorithms to extract the track stiffness from axle box acceleration measurements has commenced. These models will lead to improved decision-making, supporting more predictive and preventative maintenance strategies.
- Investigation has been carried out into the effect of out-of-round wheels on loading of track and running gear through laboratory experiments, numerical simulations and field tests. Investigation has been carried out into the effect of out-of-round wheels on loading of track and running gear through out-of-roundness measurements, numerical simulations and field tests. A parametric study was performed where wheel–rail impact loads and axle stresses were computed for different sizes of tread damage and different train speeds.
- Laboratory and field tests were carried out for a novel configuration of sensors for non-destructive measurement of thermal rail stress. Initial results have been promising, showing a good correlation between strain and flight time in the laboratory. Work will continue in 2021, to analyse the results of the field trials and develop a prototype sensor measurement system.
- A contactless ultrasonic method of identifying rail head defects of less than 5mm depth using electro-magnetic acoustic transducers (EMAT) has been developed. This has been demonstrated, with the detection of synthetic (controlled) defects of varying depths in a section of rail. This technology overcomes the problem of current ultrasonic rail testing solutions not being capable of detecting rail head defect development under 5mm in length.
- Initial development of a method of rail head repair using cold spray additive manufacturing has been carried out. Further work is planned for early 2021, to use and test the process on rail defects in a laboratory.

During 2020, 1 deliverable was planned out of which 1 was released. Due to delays in resourcing some workstreams and the added problems caused by the effects of the COVID pandemic, TD3.4 has reported having accomplished 75% of the planned work up to the end 2020, which represent 35% of the overall TD.



TD3.5 Proactive Bridge and Tunnel Assessment, Repair and Upgrade Demonstrator

The main objective of the TD is to improve inspection methods and repair techniques in view of reducing costs, improving quality and extending the service life of existing structures. A main objective also consists of reducing the cost for new bridges regarding bridge dynamics. Reduction of noise and vibrations are also among the prioritised objectives.

TD Progress

TD3.5 builds on the project's activities of IN2RAIL, IN2TRACK (past projects), ASSETS4RAIL and IN2TRACK-2.

Despite some postponed site installations due to C-19 pandemic, significant steps towards the demonstrations have been taken in 2020:

The previous developed components of an autonomous image-based tunnel lining inspection system using high definition images of tunnel lining paired with ground penetrating radar, and lidar scanning have been mounted on a tailored vehicle for future pilot tests.
Functionality and robustness of fibre optical distributed sensors have been tested in laboratory and operational environment, and a robust solution for tunnel installation has been developed to be demonstrated as part of a tunnel health monitoring system solution.

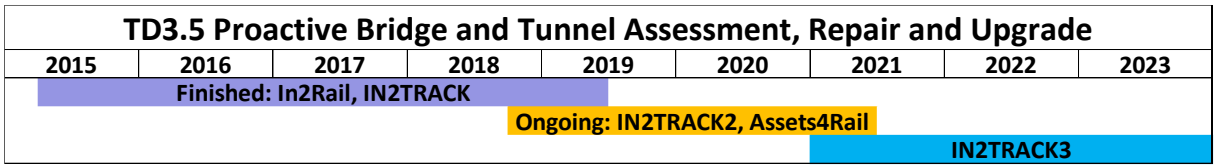
Additionally, laboratory tests on new materials and solutions for drainage pipes in tunnels have also been tested.

Optical measurement methods - ground based and un-manned aerial vehicle (UAV) mounted - have been used to test the applicability of several image-based technologies in the creation of digital twins, detection of damage and identification and tracking of changes in geometry and structural behaviour of bridges. Initial evaluation of the technology has been performed as a first iteration of implementation and basis for development of requirements.

Regarding Bridge health monitoring system, a solution to monitor fatigue consumption of bridges has been developed, including track quality effects, on-board monitoring prototypes and algorithms for enhanced load effect on structural components.

Methods for structurally strengthen bridges in shear without disturbing traffic have been developed and tested in laboratory.

Regarding bridge dynamics for high speed, several full-scale test have been undertaken to study bridge dynamics including resonances, damping and bridge soil interaction. The results will form the basis for proposal of improvement codes for bridge dynamics that will reduce cost, and increase safety. An existing bridge has been tested with tailored dampers to improve structural dynamical behaviour in order to allow for higher speeds hence improving bridge performance and allowing for extended use and increased service life. The initial full scale test showed promising results.



TD3.5 has reported having accomplished 75 % of the planned work up to the end 2020, which represent 45 % of the overall TD. The progress in this TD is expected to be significantly accelerated during 2021, as delayed installations will be performed. By end 2021, the TD3.5 is expected to be on schedule.

TD3.6: Dynamic Railway Information Management System (DRIMS) Demonstrator

The TD defines an innovative system for the management, processing and analysis of railway infrastructure data obtained from TD3.7 (Railway Integrated Measuring and Monitoring System (RIMMS) Demonstrator). The aim is to provide high-quality input to TD3.8 Intelligent Asset Management Strategies (IAMS). The main goal of these three TDs is to create new and optimised strategies, frameworks, processes and methodologies, tools, products and systems for the implementation of a step change in risk based, prescriptive and holistic asset management in the rail sector.

TD Progress

TD3.6 builds on the project's activities of IN2RAIL, IN2SMART and IN2DREAMS (past projects), IN2SMART-2 and DAYDREAMS (started December 2020).

During 2020, the work related to this TD has been performed within IN2SMART2, project that started in December 2019 and built around various use cases showing an integration of the three TD's associated to IAMS.

Work on the development of data analytics tools has started, aiming to optimize and mature the previous work done in IN2SMART (prototype level). Due to COVID-19 pandemic restrictions, limitation in accessing both laboratories and sites slowed down the TD's development: site installations were stopped and they have been delayed by several months. Moreover, this affecting not only the data collection but also the data study and analysis.

The main developments regarding TD3.6 are the following:

- Big Data platform definition and first implementation: system architecture has been designed for most of the Use Cases (e.g.: the Decision Support System and analytics framework and the IT architecture has been designed and accepted by the IM for the Use Case on the Italian Urban Metro System IAMS; Conceptual architecture has been designed for the Use Case on the Remote Condition Monitoring Maintenance Reduction Interventions and Decisions), , defining the main tools to be used.

- Implementation of the Big Data platform and start of the data acquisition occurred for some of the UCs (e.g in the data collection for track and bridges started in the UC for Integrated Assets Management for Civils)
- Algorithms developed in IN2SMART have been optimized by adding new data sources, such as weather data, in the analysis and increasing the acquisition frequency of data in various assets (e.g.: track circuits, switch&crossing, bridges, track).
- A set of analytics modelling approaches has been implemented (e.g. decision forest, DBSCAN) for use cases not been relying on new installations.
- In case of lack of real data, due to COVID-19 situation, research started with the use of historical data and/or data simulators based on some data samples previously collected.

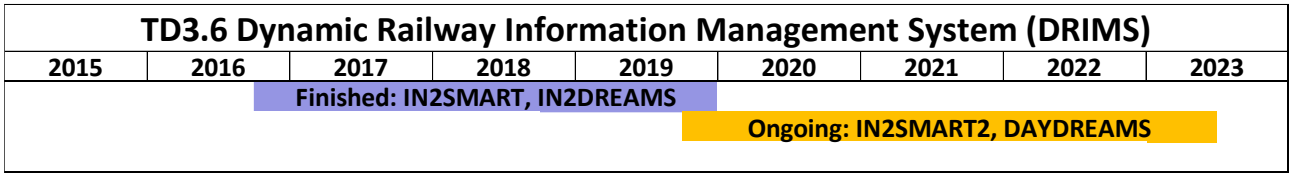
Additionally, the TD achieved the following tasks:

- Extract relevant maintenance infrastructure-related information from measurement data by the development of smart data processing methods for decision supports of maintenance activities. This includes the development of Algorithm for sensor system to support track geometry monitoring, Algorithm for wayside computer vision system, Algorithm for data collection system and Methodology for maintenance decision support and impact assessment of condition monitoring.
- Appropriate storage and management of generated data/information, considering big data solutions and standardized interface, to allow further data mining and transmission of data to other management systems. This includes Data handling solutions for sensor system to support track geometry monitoring, Data handling solutions for wayside computer vision system and Data handling solutions for data collection system.

In December 2020, the Open Call DayDreams started. The main objectives of the project are to develop:

- Prescriptive data analytics tools to implement a Decision Support System
- Multi-objective decisions' optimization tools for IAMS
- Sensitivity analysis methodologies to be applied to both prescriptive analytics and optimization tools
- Context based dynamic human machine interface supporting the DSS operators to manage prescriptive analytics and optimization tools.

The output of the project will be validated within one of the Use Case of IN2SMART-2, assessing the overall benefit of the results at programme level.



During 2020, 6 deliverables were planned out of which 2 were released. TD3.6 has reported having accomplished 85% of the planned work up to the end 2020, which represent 55% of the overall TD.

TD3.7: Railway Integrated Measuring and Monitoring System (RIMMS) Demonstrator

The TD aims at providing innovative tools and techniques to capture information on the current status of infrastructure assets in a non-intrusive and fully integrated manner. To this end, the TD focuses on infrastructure asset status data collection in close interaction with TD3.1 Enhanced Switch & Crossing System Demonstrator and TD3.5. Proactive Bridge and Tunnel Assessment, Repair and Upgrade Demonstrator.

TD Progress

TD3.7 builds on the project's activities of IN2RAIL and IN2SMART (past projects), IN2SMART-2 and ASSETS4RAIL

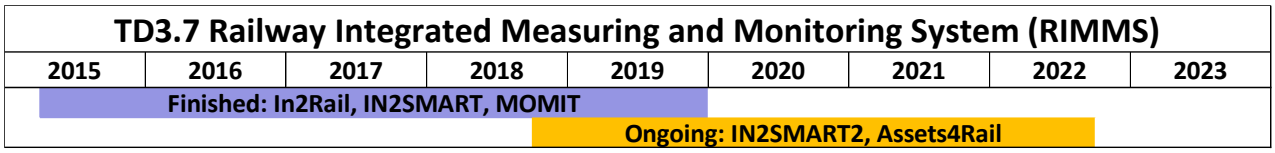
The main developments regarding TD3.7 are the following:

Regarding the TD3.7 contribution to the Integrated IAMS Demonstrators : Installation sites have been identified and confirmed for most of the Use Cases and installation has been completed for some of them (e.g. Track scan has been installed on a hi-rail vehicle in order to monitor track parameters optimizing maintenance inspection and anomaly detection). To mitigate the restriction of site access due to C19, an intermediary step of validation has been added with development and installation of sensors in a representative environment (e.g. lab or depot) waiting for the real installations to be performed (e.g. the low cost monitoring system is currently tested in lab condition).

The goal is to finalize the full installation phase in the first half of 2021.

Additionally, the following objectives have been achieved:

- A functional hardware prototype of Train-borne sensor system to support track geometry monitoring has been developed and deployed for data collection. The prototype is under improvement for the final demonstration in 2021. The developed sensor system can be combined with accelerometers to monitor the lateral and vertical track geometry parameters on in-service vehicle. This will reduce the investment costs for track geometry measurement and increase the data availability, which finally increases the track reliability and availability
- Investigation, implementation, testing of Radio-Frequencies Identification applications for a wayside computer vision system for monitoring rolling stock occurred and functional hardware prototype has been developed and tested in the laboratory. Apart from the standard application of RFID for vehicle identification, it can also be used to track MRO (maintenance, repair and overhaul) components in the rolling stock maintenance process. This functionality of the stereo camera based wayside training monitoring system is more flexible for installation and calibration, and more accurate for depth measurement of failures than the standard 2D cameras. This will have an impact on automatic identification of the critical bogie faults, reducing human intervention, saving maintenance costs and improving rolling stock and track reliability. At the current stage of the data collection, the data availability is not yet sufficient for the development of failure detection algorithm. Final conclusions cannot be drawn now. The prototype is ready for testing in the railway environment (delayed due to C19 – results expected in 2021)
- Hardware design, safety analysis and software platform development have been performed to collect Data from safety-critical components (signalling); implementation of the HW and tests foreseen in 2021.



During 2020, 13 deliverables were planned out of which 4 were released. TD3.7 has reported having accomplished 85% of the planned work up to the end 2020, which represent 55% of the overall TD.

TD3.8: Intelligent Asset Management Strategies (IAMS)

The vision of the TD is a holistic, whole-system approach of asset management employing collected and processed infrastructure data provided by TD3.7 Railway Integrated Measuring and Monitoring System (RIMMS) Demonstrator and TD3.6 Dynamic Railway Information Management System (DRIMS) Demonstrator. This includes translating long-term strategies into day-to-day execution of the maintenance and other short term maintenance activities. It also includes new and advanced working methods, tools and equipment and logistics solutions, supporting the LEAN execution of intelligent maintenance processes.

TD Progress

TD3.8 builds on the project's activities of IN2RAIL and IN2SMART (past projects), IN2SMART-2 and STREAM (started December 2020).

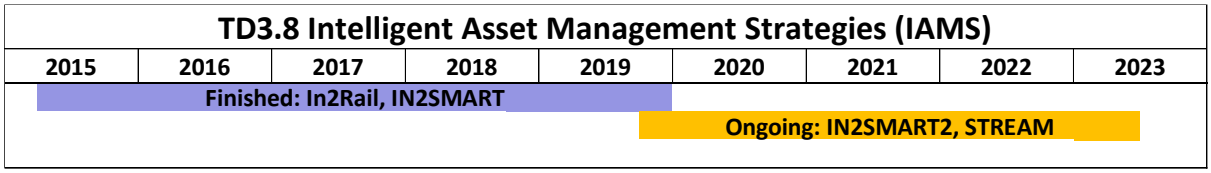
In the decision-making uses cases first prototypes and system set-up are being made (e.g. in the Use Case for the Italian Urban Metro System IAMS) but as there is a dependency on installations of sensors to acquire data, delays occurred due to lack of access to work sites (COVID-19).

Regarding LEAN execution,

- Implementation of architecture & ROS software modules of basic functionalities and delivery of railway vehicle platform were in progress but not finalized in 2020.
- Implementation of a mobile system of a Water Jet Cutter has been done and demonstration of a start of work at the correct location following analysis and work order has been achieved, with rail guidance system for starting work on two rails at the same time. First results should be evaluated in 2021 to confirm whether the water cutting jet technology use case can fully support the demonstration of LEAN execution as described in the MAAP.

Additionally, the project STREAM started in December 2020, it will focus on advanced working methods, tools and equipment and logistics solutions, supporting the LEAN execution of intelligent maintenance processes. More specifically advanced tools and equipment for:

- A Collaborative robot in alignment with the work of In2Smart 2 around the robot platform with focus on the used principles for the control platform (Robot Operating System).
- Wearable mobile machines, with the implementation/validation of a Modular Multitasking Powered Exoskeleton (MMPE) in railway environment



During 2020, 7 deliverables were planned out of which 2 were released. TD3.8 has reported having accomplished 85% of the planned work up to the end 2020, which represent 55% of the overall TD.

TD3.9: Smart Power Supply Demonstrator

The global objective of the Smart Power Supply Demonstrator (TD3.9) is to develop a railway power grid in an overall interconnected and communicating system. This will enable improvements and optimizations regarding train traffic capacity, energy losses and costs, energy supply security and availability for the railway system and environmental impact.

TD Progress

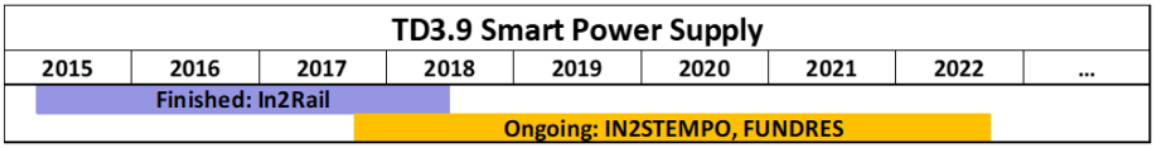
In 2020, the TD3.9 builds on the progress made by IN2STEMPO to finalize the demonstrators defined in In2Rail, and FUNDRES.

The demonstrator on a transportable switchgear panel is been manufactured and the installation of demonstrator equipment will start beginning of 2021, paving the way to the upgrading of the station control systems within 16,7 Hz railway networks, introducing IEC 61850 and process bus. Especially process bus is a new communication network type, installed between Intelligent Electronical Devices (e.g. protection devices) and Merging Units (measuring devices for voltage and current). Process bus reduces the wiring effort significantly and enables new protection concepts. It has not been used so far for railway station control systems.

Necessary adjustments on other standard control components, for coordinated work with demonstrator equipment and functionality is ongoing. Demonstrator equipment will be ready for tests beginning of 2021.

In regards to the second TD demonstrator (proof of concept for Flexibles-AC-Transmission-System – FACTS – in 50 Hz railway systems), the simulator for Smart AC traction power system was extended to Hardware in the Loop simulations to do complete investigations in realistic use cases. The demonstrator conducts various simulation models to investigate the application (operational behavior, control strategies, interaction with the railway network) of several FACTS on 50 Hz railway systems. In the process, FACTS already used for 16,7 Hz railway networks are adapted for 50 Hz network application and new types (unknown in Europe) are introduced. The demonstrator will lead to application guidelines, enabling 50 Hz railway network operators not just to choose the most suitable solution for an individual use case, but also how to maximize the benefits form the technology.

The TD started to investigate in 2020 a new DC power supply system with an increase of nominal voltage to 9kV. The technical concept of such a system and the necessary components have been defined. As results of the studies, the system achieves the same capacity as the standard AC systems with 25 kV/50hz voltage using the benefits from DC-traction. The concept of a Solid-State-Transformer based on Multilevel-Inverters, usable for integration in the DC power supply, is developed and the use case “reinforcement of 1,5 kV DC-System by 9kV feed wire” demonstrated thanks to simulation an efficiency increase of 5% - simulation also demonstrated that a complete change to 9kV would increase the efficiency of traction power supply by 10%. The developed solution will enable higher capacities and high speed operation in existing DC networks. The use cases for high speed lines in 3kV DC and of reinforcing 1,5 kV DC-lines are under further preparation.



During 2020, 2 deliverables were planned out of which 2 were released. TD3.9 has reported having accomplished 100% of the planned work up to the end 2020, which represent 60% of the overall TD.

TD3.10: Smart Metering for Railway Distributed Energy Resource Management System Demonstrator

The objective of the Smart Metering Demonstrator (TD3.10) is to achieve a fine mapping of energy flows within the entire railway system, as a basis of any energy management strategy.

TD Progress

TD3.10 builds on the project's activities of IN2RAIL and IN2DREAMS (past projects), and IN2STEMPO.In 2020, the work has been carried out on all three use cases of the Smart Metering concept as defined in the MAAP:

- Use case 1: Commercially Operated line (CO-OP) Use Case on a line in commercial operation south of London.
- Use case 2: Stationing and Maintenance facilities operation (STM-OP) Use Case in the Saragossa tramway depot.
- Use case 3: Electrical Infrastructure monitoring (IN-OP) Use Case on the London North Westcoast mainline.

In the CO-OP use case, issues have been fixed on Smart Metering systems installed in 2019 on three different sites: Chiddingstone and Bletchingley Tunnel substations and Crowhurst Junction switchgear. The robustness is now improved, especially in terms of data acquisition and transmission to the cloud. Dashboards have been set up to visualise recorded data and identify weak points on the network, as a first step of applications that will be developed next year.

In the STM-OP use case, installation of sensors and acquisition system has been finalised in the Saragossa tram depot. A large variety of measurements is available, from 750V traction substations, to 400V auxiliaries and event environment values such temperature and wind velocity. This brings a detailed view of energy sharing and will enable an energy improvement plan in the future.

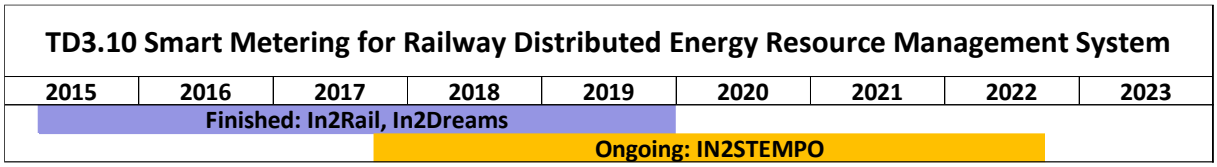
For the first two use cases already implemented on site, temporary data storage and user dashboards have been set up in order to assess the quality of measured data. The ODM (Operational Data Management) platform has been set up as a centralized platform and prepared to suit the needs of the three use cases. This data platform is now able to host and read data from all use cases.

In the IN-OP use case, the equipment's to be installed on site has been specified in order to meet the requirements of this use case: fast voltage and current acquisitions, to detect fault events and enable harmonic analysis. The detailed design of the Smart Metering architecture was then achieved, combining on-the-shelf products and custom development. Equipment installation on the first site Acton Lane, close to London, is expected at the very beginning of 2021.

In this use case, the transmission system has also been designed to send data through two different streams. The first stream will send data flow on the ODM, used for all 3 use cases. The second stream

will send data to another data platform, part of the ITD Enhanced Energy, thus linking TD3.10 to TD3.9 in the next 2 years. The aim of the latter is to demonstrate that the Smart Metering concept is an open system, able to connect to several platforms for different usage.

Partnership established in previous H2020 projects has brought new cooperation in the first and the third use cases. In particular, a brand new gateway has been developed in the third use case, to enable data transmission in real time, from high sampling rate measurements.



During 2020, 2 deliverables were planned out of which none was released. TD3.10 has reported having accomplished 85% of the planned work up to the end 2020, which represent 60% of the overall TD.

TD3.11: Future Stations

The primary objective of the TD is improved customer experience at stations increasing thus the number of customers that will use rail as their preferred transport mode. The TD is organised around four identified key functional demands; two demands relate to improving capacity, safety and security in large stations, one demand relates to the design of small stations with the objective of reducing whole life costs and standardising design where possible and the final demand relates to platform to train accessibility.

TD Progress

TD3.11 builds on the project's activities of FAIRSTATIONS (past project), and IN2STEMPO.

In context with Video Content Analytics (VCA) a comparison between traditional VCA (density computation) and Machine learning (people counting) was performed and demonstrated the advantage of Machine learning by providing information on the actual number of people framed that is difficult to process with traditional video analysis. With the derived results a scenario has been developed in a demonstrator to forecast, train and better react to crowd incidents.

Concerning "Improved Station Designs and Components", progress on the specifications for materials, components, smart solutions, digitalization and ticketing technologies for small stations design is reported and should be finalized in 2021 for the Demonstrator Platform Jurata Station in the north of Poland.

Concerning the improvement accessibility to Trains, the analysis of specifications defined in various existing standards at EU and national level regarding PTI technical background was finalized and development of proposals of solutions to improve the accessibility to trains in four areas (platform based, rolling stock, cultural/behavioural, technological) was further developed in collaboration with TD1.6. Persons with Reduced Mobility will be involved in the presentation and development proposal of various solutions.

TD3.11 Future Stations								
2015	2016	2017	2018	2019	2020	2021	2022	2023
			Finished: FAIR Stations					
			Ongoing: In2Stempo					

During 2020, 3 deliverables were planned out of which 3 were released. TD3.11 has reported having accomplished 95% of the planned work up to the end 2020, which represent 60% of the overall TD.

1.4.4. IP4 IT Solutions for Attractive Railways Services

In order to become more attractive, rail must respond to customer needs to support seamless door-to-door multimodal journeys encompassing different modes of transport. Rail must achieve interoperability with other transport modes and mobility services, within different regions, cities and across borders. In view of this objective, rail needs to take due advantage of the ever growing connectivity of people and objects, the availability of European Global Navigation Satellite System (GNSS) based location and other means of localisation, the advances in cloud computing, Open Data and Big Data Analytics and the wide dissemination of Internet and social media. Multimodal integration will also take benefit from existing rail standards as FSM and TAP TSI.

The pictures below represents the areas where IP4 Technological Demonstrators will introduce improvements.

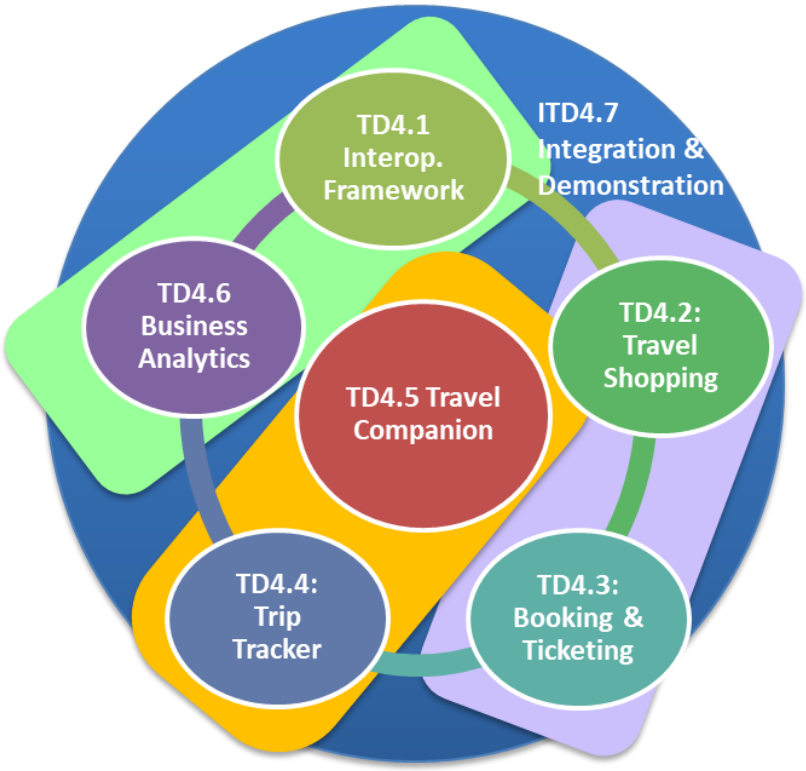
To achieve this the IP4 ecosystem aims to integrate and make interoperable all possible transport modes and travel services: rail, urban transport (metro, tram, and buses), airlines, private cars (such as the use of toll roads and parking, which have an associated price) and also shared modes (cars and bikes). Thus, multimodality and the use of public transport are being fostered, making it easier for travellers to connect with rail stations and airports, regardless of where and how they start their journey. For the future, Demand Responsive Transport and Ride Sharing will be included in the

ecosystem to ease the access to everyone to long distance trips, even to those living in not well connected areas.

IP4 Ecosystem has also evolved to implement at European Level the new Mobility-as-a-Service (MaaS) paradigm, which considers the mobility system as a whole in order to achieve an optimal and sustainable transport scheme. This way, the IP4 ecosystems facilitates the task to create formal contracts that could involve the agreements, business rules and financial compensation that shall occur between the different stakeholders when combining their services into a joint product. In the future, this component will evolve to be used also to create MaaS Packages that integrate a variety of transport services that could include multiple Transport Service Providers.

IP4 is organised around 7 Technological Demonstrators within three priority research and innovation areas as shown in the graph below.

- Technical Framework: Interoperability Framework and Business Analytics
- Multimodal Travel Services: Travel Shopping and Booking and Ticketing
- Customer Experience Applications: Travel Companion and Trip Tracker



IP4 projects are contributing to develop innovations in each TD. All the outcomes of IP4 project will contribute to one single Integrated Technological Demonstrator (iTD4.7), which will merge all the developments.

TD 4.1 Interoperability Framework

The aim of the TD is to facilitate multimodal travel in a highly diverse environment and with many transport modes. Interoperability at the semantic level defines formal and explicit models of the transportation domain in an open, standard, machine-readable language that is exchanged

automatically by computers, therefore allowing seamless access to all transport data and services in a multimodal and distributed environment. Hence, TD 4.1 is a key technology enabler for a complete transformation of the European transportation ecosystem.

TD Progress

The TD covers different aspects of the Interoperability Framework, including the implementation of components with basic capabilities, definition of architectural principles, analysis of the state of the art with respect to ontology conversion tools and reference ontology, and the understanding of current and future demand for the Interoperability Framework.

The efforts of previous projects and years in this TD have resulted in a first complete demonstration of the IP4 ecosystem as part of the ALPHA RELEASE (2019). Projects that contributed to the Alpha release were CONNECTIVE and ST4RT, which demonstrated the first converter using semantic interoperability. Thanks to the IF, it was possible the integration of the different TSPs into the IP4 ecosystem and the connection with the software developed by IP4 projects, which was crucial to demonstrate end-to-end functionalities for booking, ticketing etc. In 2020, activities continued with enhancements and deployments within 2 projects, CONNECTIVE and SPRINT, to be demonstrated in the next release.

Activities have continued in relation to the evolution of the architecture, which was previously based on IT2Rail architecture, but started to be improved in 2019 in order to provide more flexibility and better performance. The work of improvement of the architecture has continued during 2020. This new architecture, takes the advantages of the use of microservices and new technologies to minimize the coupling among components, to facilitate the creation of components and the connection to the ecosystem, and to allow an easier adaptation to the changes in the ontology. Moreover, new requirements from other TDs were incorporated to allow connecting partial Trip Trackers (pTT) with the Trip Tracking orchestrator. This requires that the IF is ready to receive information from the pTT when an event is detected, and not only as a response to a specific query sent by the orchestrator (such as a booking request) which is the only type of interactions allowed previously by the IF. The first implementation of this new architecture has been done, and tests and refinements are ongoing.

Special emphasis has been made in the processes that allow TSPs to join the ecosystem, register their data, and make their services available to the IP4 ecosystem. This data (for example GTFS files containing routes and timetables) and access to services are needed by other TDs in order to calculate end-to-end multimodal routes or trip prices. The first version of the Operator Portal, that was designed last year, has been implemented and it is the main interface among TSPs and the ecosystem, acting as a unified access point to allow registration of TSP and access to several services, including those offered by other TDs. For this, it implements Identity Management and Access Management through single sign-on.

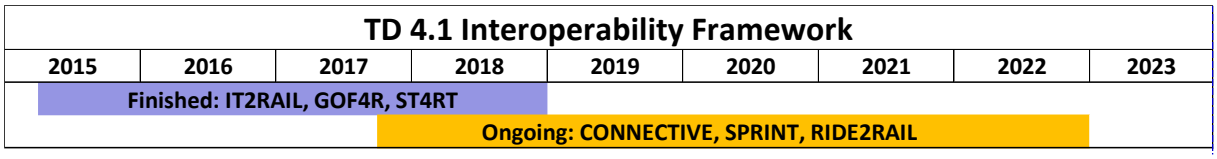
The Asset Manager component is equally important as relevant to offer an open ecosystem to which TSP can join to offer their services. As a result of this year's developments of this component, a TSP can now use the Asset Manager to include easily their service information (for example timetable information) and this information is accessible to the entire ecosystem applications. This implies data being automatically converted in semantic resources based on the use of ontologies, which are stored in a RDF[26] repository, another component of the IF that is being enhanced.

Apart from GTFS, other standards and data models are being considered, with the objective to convert the existing monolithic ontology used until now in a modular ontology divided into subgroups of

[26] https://www.w3.org/RDF/

different aspects or topics (for example one for static infrastructure and other for real-time data) with links among them.

TD 4.1 has also worked in alignment with the results of its composing projects Shift2MaaS, My-Trac and Ride2Rail, in order to integrate the TSPs developed in those projects.



During 2020, 12 deliverables were planned in relation to the IF in the active projects. Eight of them were released as expected and the others are ongoing. The results of the deliverables produced this year contribute to the Additional Release of the architecture, which is the 2nd release of the 3rd proposed for the programme. Since the beginning, TD4.1 has accomplished 80% of the planned work up to the end 2020, which represents approximately 60% of the overall TD objectives.

TD 4.2 Travel Shopping

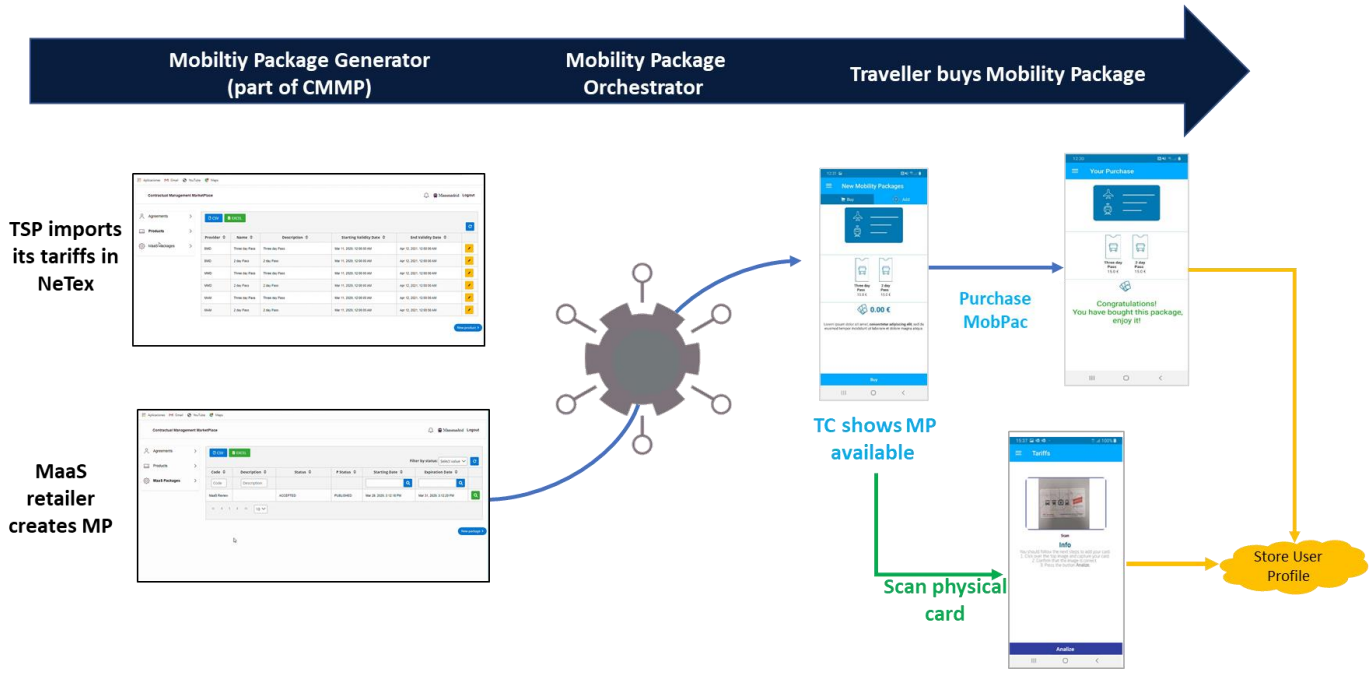
The concept of TD 4.2 Travel Shopping is both to enable and to respond to an emerging single European multimodal transport market place within a Single European Transport Area (SETA). The IP4 approach will promote the integration of distributed travel operators' data and services and the orchestration of services such as expert journey planning and offer building for all modes. It will benefit from the Interoperability Framework that enables applications based upon different interfaces, standards or coding lists, to communicate meaningfully but without costly application adaptations with the existing legacy systems of all stakeholders. The TD4.2 contribution to IP4 System is to enhance the technical facilitation of a one-stop-shop capability, to enable comprehensive choice of itineraries and offers from modes/operators able to respond to customer mobility requests, especially through the use of existing services from all stakeholders by interfacing their legacy systems.

TD Progress

The basic idea of the travel shopping system was designed within IT2Rail (Lighthouse Project) using a distributed architecture. This decentralized approached was enhanced within the project Co-Active. That effort continues throughout MaaSive. RIDE2RAIL, which started in 2020, will contribute to add the Ridesharing functionalities to this Technical Demonstrator. The main technical outcomes in 2020 are:

- Addition of TSPs (for Malaga and Lisbon, partially CEC) to the Travel Shopping process
- More automation in the Meta-Network building process
    - Connect automation with developments done in Connective
    - Use Hacon's TPSI during the Meta-Network building
- Improved Travel Shopping process to better integrate new mobility services
    - The Meta-Network Explorer now uses additional modes of transport, such as shared mobility with the help of the newly introduced Service Area Checker
- Travel Shopping now uses the Travel Service Resolver to identify TSPs that may contribute to the Travel Shopping result

The CMMP (Contractual Management Market Place) is a component developed with the objective of facilitating the creation and management of agreements among all TSPs of the IP4 ecosystem. The main functionality is to allow the creation of multimodal discounts of two TSPs, in case both TSPs are involved in the same offer. In 2020, this component has been improved regarding user interface and its functionalities. Now it allows the creation of Mobility Packages (MP) including MaaS, which is possible due to two new functionalities deployed in 2020: (1) TSPs are able to upload tariffs (2) retailer of MaaS operator are able to create a Mobility Package by combining existing tariffs uploaded to the system by TSPs.



Workflow to create Mobility Packages (MP) within the CMMP developed in MaaSive

During 2020, MaaSive supported My-TRAC with the integration of the Travel Shopping API (MaaSive) into the Personal Application (My-TRAC). This collaboration was concluded in December 2020 with the final event of My-TRAC project.

TD4.2 Travel Shopping								
2015	2016	2017	2018	2019	2020	2021	2022	2023
Finished: IT2RAIL, Co-Active								
			Ongoing: MaaSive, RIDE2RAIL, Extensive					

During 2020, two important technical deliverables were submitted D1.1 – TD4.2 CREL Specifications and D1.2 – TD4.2 CREL Implementation Report. Within MaaSive, deliverable D12.1 –CREL Implementation report is still ongoing. We also contributed to D9.1 CREL Contractual Management Specifications and D9.2 CREL Contractual Management Implementation Report, both Deliverables have been approved in 2020. D2.1 – FREL Specifications and D10.1 – Contractual Management FREL Specifications are planned for a delayed delivery and will be provided in 2021.

To be noted also the evolution of MyTract that, thanks to the additional funding provided to the project by the EIT Urban Mobility, became one of the solutions used to address crowding in public transport.

Since the beginning, TD4.2 has accomplished 80% of the planned work up to the end 2020, which represent 85% of the overall TD.

TD 4.3 Booking & Ticketing

Today, even within a given mode of transport (air, rail, urban, etc.), the rights to travel have, in the best case, a limited interoperability between the various travel service operators; and this interoperability is almost non-existent between the modes themselves. The aim of this TD is to orchestrate multiple but parallel interactions with several booking, issuing, payment and ticketing engines, including the all-important roll-back activities. This will radically simplify the traveller's life, by abolishing uncertainties and complexities associated with 'behind-the-scenes' multiple booking, issuing, payment and ticketing processes.

TD Progress

The efforts of previous projects and years in this TD allowed to reach a first implementation and integration of all components with other IP4 TDs, which was demonstrated during the ALPHA RELEASE demonstration in 2019 with a number of Travel Service Providers (TSP) covering different transport modes.

Activities in 2020 have progressed on this implementation as part of the MaaSive project, by enhancing the existing components, creating new ones and starting the integration of new modes of transport (such as transport on demand) and paradigms (such as MaaS). RIDE2RAIL project will enhance the Booking and Ticketing TD by including features to perform a multimodal Travelling. Moreover, at the end of 2020, Extensive project started, which will continue the work started in MaaSive

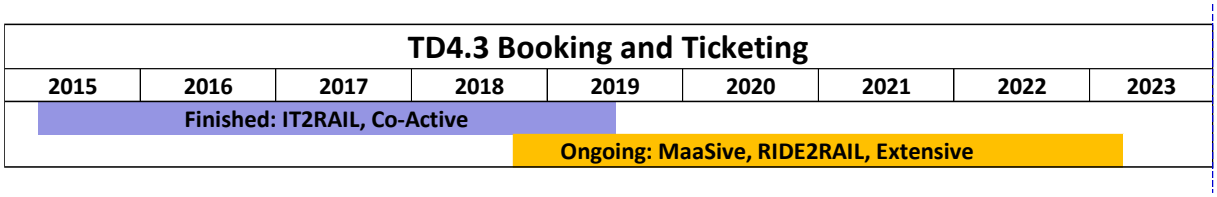
In 2020, the orchestrators developed in previous projects (booking, ticketing, ancillary services etc.) were enhanced with new functionalities and to cover MaaS needs. All of these software components contribute to the interoperability between the different TSP, orchestrating parallel interactions of different booking and ticketing engines in a seamless way for the passenger. During 2020, a new orchestrator was created to manage Mobility Packages. Following current MaaS approaches, one of the objectives of MaaSive was to include within the different flows of the IP4 ecosystem the concept of Mobility Package as a kind of subscription or travel card that combines a number of transport products that could include different modes and operators. Thus, the possession of a Mobility Package by a user needs to be taken into account for example when calculating the price of the offer. By enabling the creation and consumption of these Mobility Packages, IP4 aims at changing traveller's behaviour towards more sustainable modes, offer better service and affordable mobility to reduce car ownership, but at the same time assuring the flexibility and convenience of a car. The new Mobility Packages orchestrator manages of the lifecycle of Mobility Packages, since its creation using the Contractual Management Marketplace (presented in TD4.2) and its purchase through the Travel Companion, to its use at shopping and travelling time.

Secondly, other activities have advanced in the integration of legacy equipment for ticket validation of different TSPs. A new generic token toolkit for operators has been develop. This token toolkit allots two things: configuration of new entitlements for existing TSPs or the configuration of an entitlement that could be adopted by different providers. This could facilitate intermodal ticketing experiences. At the moment a first implementation of this generic token toolkit for TSP using the S2R environment has been develop and will be tested in Ride2Rail and IP4MaaS project. This generic token toolkit consists of a Web Portal and a Configuration API that allow TSP to configure their own metadata (or use the generic metadata structure proposed) and embodiments. A metadata compiler will interpret the

metadata, and feed token generation and validation modules in order to do the serialisation and deserialization of the entitlement metadata.

To design the module, an analysis phase has been performed in order to take into account different transport modes for the generation of the token. The deployment was supported by an analysis phase of data fields and data classes to be taken into account in the generation of the tokens, analysing different transport modes. Moreover, an implementation of a ticket inspection application has been accomplished, which allows new and simplified ways to inspect the tickets provided via the ecosystem and with the interaction to the traveller apps in close vicinity. The inspection app also enables the inspector to block the ticketing function of the traveller apps in close vicinity for the time of inspection in the vehicle as a fraud protection mechanism.

Another area of work aims at providing the ecosystem with Customer Relationship Management (CRM) capabilities to improve the management of user information and to allow managing customer claims and passenger rights. A CRM Web Portal has been developed with this aim, integrated with other existing components of IP4 such as the Cloud Wallet and the Operator Portal. Functionalities accessible through this module are being gradually integrated in the IP4 ecosystem. For example, at the moment, an Operator is able to consult specific users' information and manage several types of user complaints. Moreover, a new Passenger Rights Orchestrator is being deployed that pre-computes information about the claimed offer related to delays on trips for each TSP involved, facilitating information to the CRM a faster decision making process.



In 2020 two deliverables have been submitted, corresponding to the specifications and implementation done for the Core Release. A third deliverable was expected for this year, related to the Final Release specifications, although it will be delayed for 2021.

Since the beginning, TD4.3 has accomplished 70% of the planned work up to the end 2020, which represents approximately 85% of the overall TD.

TD 4.4 Trip Tracker

The overall objective of the Trip Tracking system is to assist a traveller throughout his multimodal journey in respect to any obstacles that might occur during his trip. Technologies which accurately and timely notify the traveller of those unforeseen difficulties on individual trips will be used. In cases they arise alternative routes will be provided to limit any impacts on them. When a disruption occurs, Trip Tracker will provide assistance by calculating with a multimodal approach both entire new itineraries door to door, and from the current position or even only single legs. It will analyse and correlate available static data (such as timetables), dynamic data (mainly real time data) and passenger data (like preferences, locations). The architecture of Trip Tracking foresees not only to easily remove service providers and / or event sources but as well to add new and upcoming services is it a transport service provider or specific event sources bringing benefit to the travellers.

TD Progress

The basic idea of a trip tracking system was designed within IT2RAIL (LP) comprising the activation, disruption detection and alternative managing of an itinerary. Shift2Rail IP4 project ATTRACkTIVE

expanded the architecture of this trip tracking system to a modular one consisting of the Tracking Orchestrator, different partial Trip Trackers and the corresponding Event Source Management. Results were demonstrated through the final release of ATTRACkTIVE which is as well the Alpha release of COHESIVE on the final event of that project.

In 2020, the project MaaSive has continued the work of ATTRACkTIVE. The main focus was on further improvement of the architecture of Trip Track system marking an additional step forward to gain even more flexibility in respect to add new service providers and event sources. The architectural adaptation is the integration of the Interoperability Framework between the Tracking Orchestrator and the partial Trip Trackers. In addition, the Interoperability Framework between partial Trip Tracker and Event Sources has been designed. This enhancement is the base to easily include additional partial Trip Tracker and Event Sources and thus brings more flexibility in the whole Trip Tracking System.

As a new functionality Trip Sharing has been implemented and integrated into the ecosystem. Nowadays, there are applications that allow the user to share the plan of the trip or the location in a map at a given moment. The Trip Sharing, enables a traveller (the Sharer) to share every step of the multimodal trip with someone (the Follower). After sharing a trip, the follower will receive all Trip Tracker information related to all the corridors of the shared trip. In this way you can find out, for example, whether someone is arriving later than originally planned.

An additional step forward is the integration of machine learning systems to take travellers behaviour into account. In the first step an analysis took place how this information can be gained from travellers. Implementation of this function is as well done. Thanks to this function, the Shift2Rail ecosystem learns the travelling behaviour through machine learning algorithms, which propose trips to the traveller. If the traveller accepts the proposed trips, those trips are stored in the Shift2Rail ecosystem which also automatically activates the trip tracking. The next step now consists of testing the entire function on base of the IP4 ecosystem. As part of the improvement of Event Sources to further help travellers, a vehicle average speed modelling has been started. This development is still ongoing and will be finished in 2021.

Finally, attention was laid on the enhancement of rules for the Complex Event Processing. Instead of having a fixed rule engine as part of the partial Trip Tracker, an interface was designed and developed to modify these rules. A web platform provides a user interface to modify these rules.

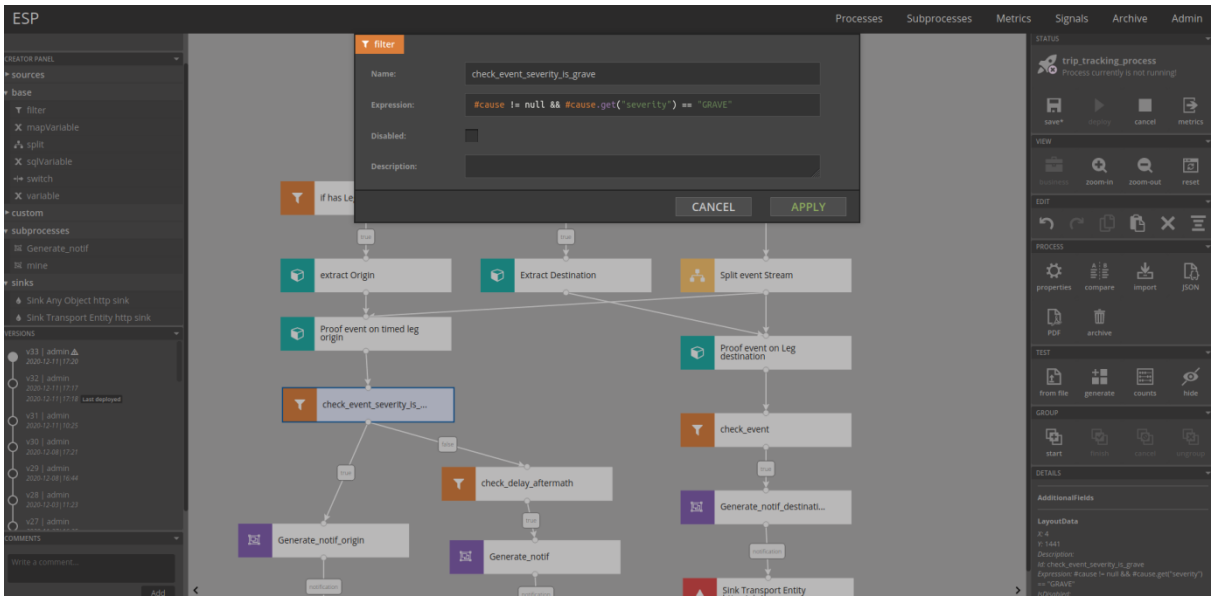


Figure 2: CEP rule definition tool interface

This rule authoring tool is supposed to be accessible by TSP operators in charge of maintaining the live running pTTs, helping them to increase with agility the accuracy level of the Trip Tracking business logic.

Already in 2019 several partial Trip Tracker have been integrated into the IP4 ecosystem to demonstrate the independency of interfaces. These systems are still running and are used to proof the design and performance of the system. It was planned to demonstrate this on the InnoTrans 2020 which had to be cancelled due to Covid 19.

In 2020 the Trip Tracking architecture should have integrated the Real Time information provided by the Open Call My-TRAC, although in the course of the R&I it was discovered that Real Time information based on the foreseen transport operator was not available. As a result, the decision was taken to not develop a dedicated partial Trip Tracker for the My-TRAC system.

TD4.4 Trip Tracker								
2015	2016	2017	2018	2019	2020	2021	2022	2023
Finished: IT2RAIL, ATTRACkTIVE								
			Ongoing: My-TRAC, MaaSive, RIDE2RAIL, Extensive					

Regarding the progress, three projects have contributed to the development of TD4.4 during 2020: Connective (integration of the Interoperability Framework), My-TRAC and MaaSive (IF integration, Data and Event handling). The overall progress is in line with the plan in the S2R MAAP.

The Open Call My-TRAC was finalised in 2020. Its results, mainly the work for GDPR issues, are important for Trip Tracker functionalities as well.

The Trip Tracker Demonstrator targets TRL 6/7. Since the beginning, TD4.4 has accomplished 80% of the planned work up to the end 2020, which represent 75% of the overall TD.

TD 4.5 Travel Companion

The overall objective of the TD 4.5 Travel Companion is to research, implement and evaluate a seamless and interoperable platform offering new levels of interaction between travellers and

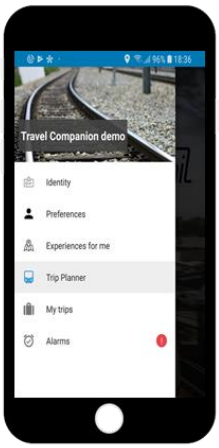
transport stakeholders along with an innovative ubiquitous adaptive front-end to the global transportation service ecosystem.

Thanks to their own personal and secured 'Travel Companion' travellers will have access to all travel services needed for the journey (shopping, booking, ticketing, trip tracking, preferences, cancellation, ancillary services as well as novel forms of experiences) which will extend and transform the journey to a real door to door experience.

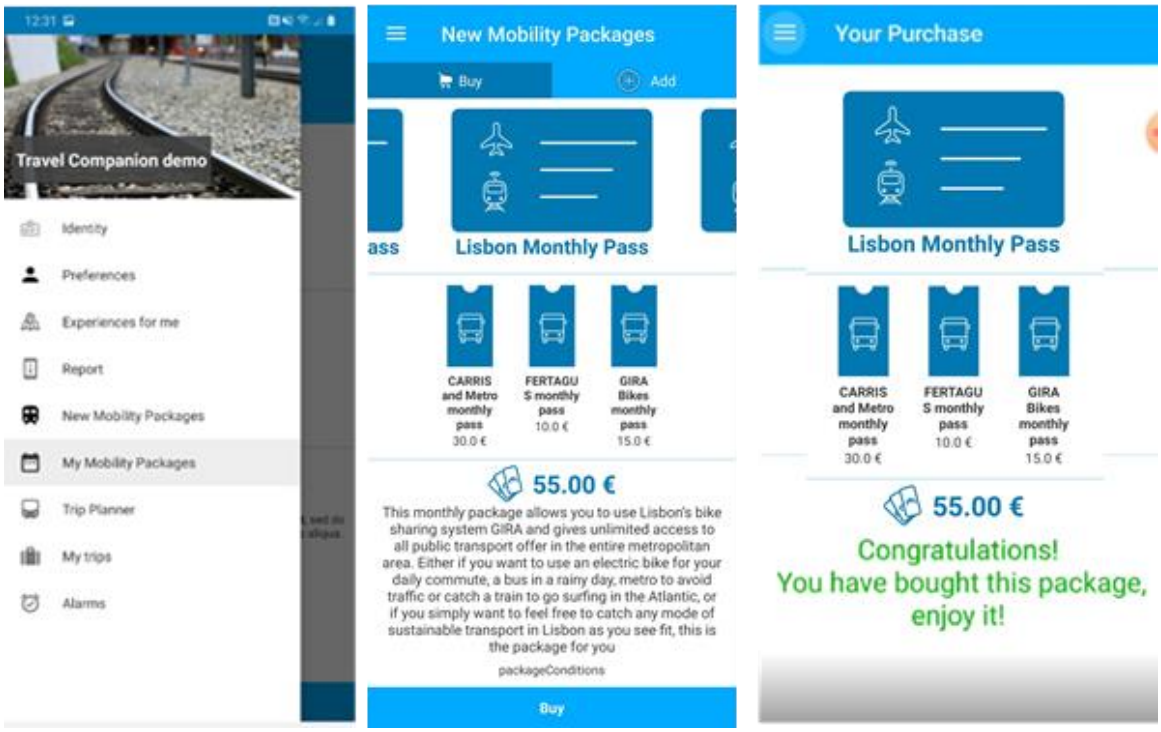
TD Progress

During 2020, the project partners have focused on updating the work carried out in the ATTRACkTIVE project by integrating the solutions planned into MaaSive CREL. In addition, the project My-Trac, the objective of which consisted of developing and piloting an independent Travel Companion front end, using services developed by CFM project ATTRACkTIVE, finished this year.

During this period, in order to respond to users' needs and to propose a solution compliant with the MaaS approach, different works have been carried out and a wide range of modules have been developed. With this in mind, such as multi-modal entitlement management, a trip informer system as well as the mixed reality devices solutions were carried out.
All these new modules represents an improvement that will be integrated on the Travel Companion personal application to provide the user with an enhanced version.



During this year, the technical developments integrate mobility as a service approach to the IP4 framework, enabling the management of entitlements and tokens in order to allow the traveller to retrieve them for validation and inspection purposes. Capabilities such as fraud control, to prohibit users to issue offers during the inspection, and management of Mobility Package (MP) where user can add a MP that he already has purchased externally to the IP4 ecosystem, or can purchase a MP through the IP4 ecosystem were developed.



One of the achievements of MaaSive during this year is the Token activator. This Token activator is a new solutions handling the entitlements and tokens produced in order to allow user to retrieve them for validation/inspection purposes through the Travel Companion Personal Application.

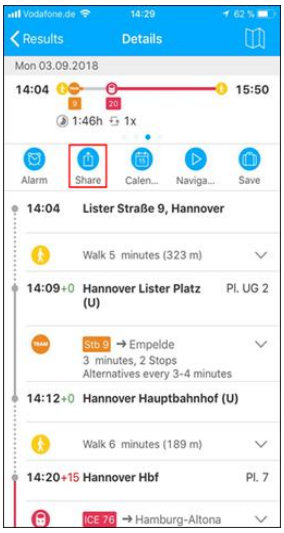
This new solution allows detecting the next leg in the trip, based on logical position, and showing the token needed at each travel episode, shielding him from the need of selecting the appropriate one at each stage in cases were multiple tokens are needed.

When a person travels they often use different Mobility Package for different parts of our journey provided by different operators. Thanks to the achievements of MaaSive project, the TD is now able to manage these Mobility Packages.

Indeed, contrary to what exists today, this Mobility Package combines a number of transport products that could include different modes and operators. This solution is more adapted to the travellers' needs who often use different modes of transport for the same journey.

Through the Travel Companion Personal Application this module allows to select among available Mobility Packages or purchase a new Mobility Package. The user can even scan his or her physical Mobility Package by applying Optical Character Recognition (OCR) so that he or she can easily use it later on, which is automatically linked to the traveller's profile for future orders.

This mobility concept has been extended in order to ensure a novel Travel Informer module for both the travellers as well as the stakeholders that enables a continuous tracking of the travellers. Thanks to this new functionality, allowed people (parents willing to be kept informed of the travel status of their kids travelling to their grandparents' home) can be informed of a traveller's status.



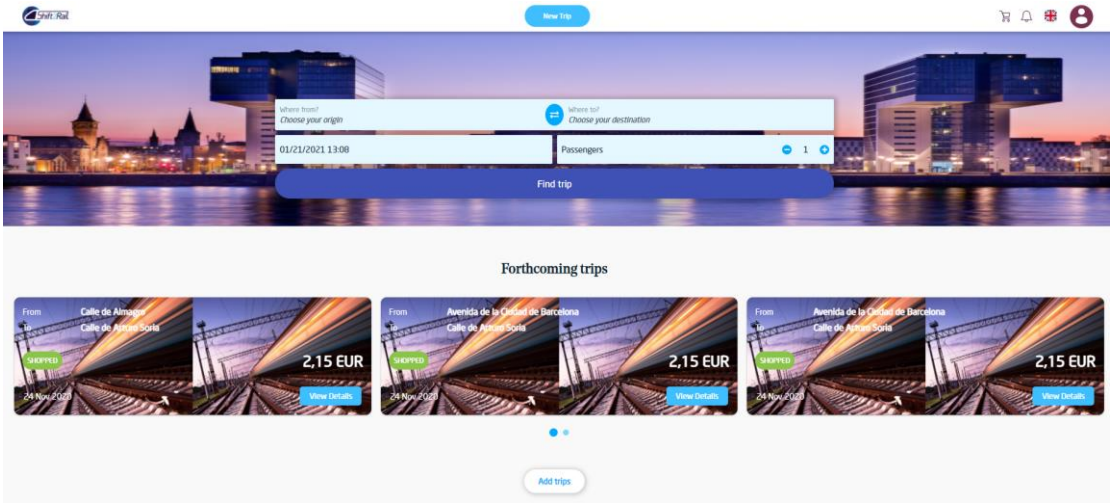
Indeed, nowadays there are some application that allow the travellers to share their position on a map or their GPS location at a specific time.

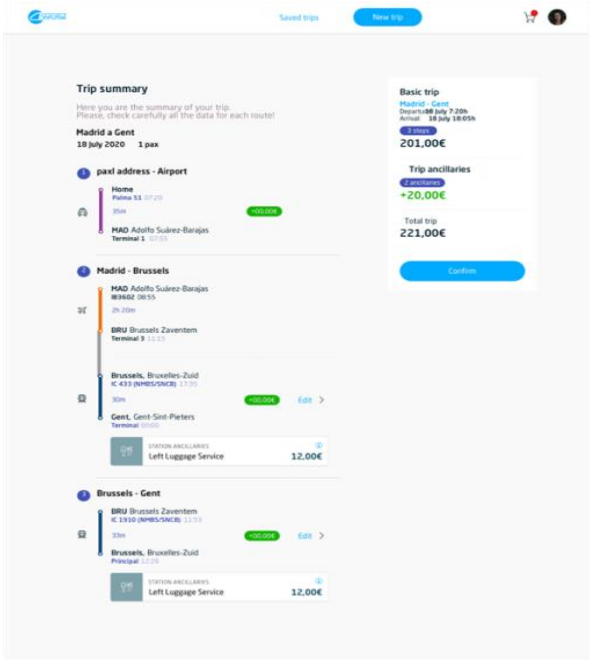
The MaaSive achievements in 2020 allow the traveller using the Travel Companion Personal Application to share with someone the different parts of his multimodal trips.

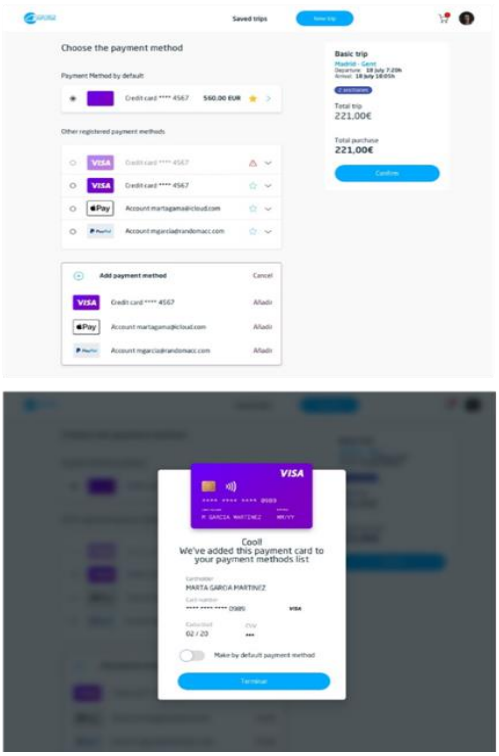
- The “sharer” selects a trip
- The sharer enters the email of a follower
- The follower is informed by Push notification about the information related to all the corridors of the shared trip

In contrast to existing solutions, this function allows the follower to have information in real time, which allows parents to follow the route of their children who are travelling alone in a serene way. Moreover, this allows the follower to know at any time where they can find each other, even if the traveller arrives later than expected. This solution is not limited to just providing a position at a given moment, but allows the follower to have a constant and real time follow up of the route and to be informed as the journey progresses.

Beside the improvements of the Travel companion personal application, a Travel Companion Web Front End (see figure below) has been setup to allow users to access “IP4” services using a web browser allowing the traveller to prepare his journey on his or her computer.







Once the trip planned on the web browser, the traveller could use his/her Personal application to perform his trip.

In addition, the Travel Companion has been updated to allow the integration and support of new devices such as watches and Mixed Reality glasses. The TSPs or the station managers are now able to create easily and publish Location Based Experiences (LBE) on the travel companion as well as on MR glasses.

This achievement will save time for the application creators, so they can in few clicks create easily mixed reality applications without any technical skills, publish them on the travel companion as well as on the HoloLens so they can provide attractive solutions and promote the local shops.

From travellers' point of view, they will experience a door-to-door journey through mixed reality devices connected to their Personal Application. Using these new devices, travellers will see their environment augmented with virtual elements that can help (travel information, guidance…) as well as entertain them. This will be particularly beneficial to the travel and transportation industry to encourage customers to visit local sights and shops and to improve the traveller journey.

In addition, particular attention was paid to carrying out tests in order to be able to deliver a functional version of the application, to be tested by the S2M project and used during their scheduled pilots in December 2020 in Lisbon and Malaga.

My-TRAC performed during 2020 the 2nd pilots between September 2020 and November 2020.
Thanks to My-track pilots IP4 started the pilots in different European locations: Spain, Portugal, the Netherlands and Greece. The following features were tested for the passenger:

- Travel companion: applies behavioural analytics and AI techniques to provide a seamless door-to-door experience that suggests solutions and available options when they are necessary during a journey;
- Trip tracking services: help guide passengers from A to B;

- Social Market service: enhances provider interactions with passengers during trip, offering additional products and services like discounted transport, leisure activities and Wi-Fi access.

And the following feature was tested for transport operators:

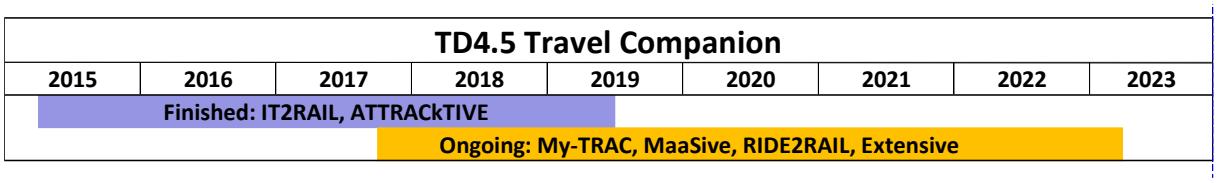
- Web-based interface for operators: collects past passenger data to improve and adjust services to each traveller's individual needs and preferences, ensuring compliance with GDPR.

As already mentioned, it is worth to note that the open call project My-Track used the technology developed within the S2R IP4 ecosystem to develop a COVID-19 app (Co-APS), launched to help reduce the spread of the virus by managing density in public transport and public spaces.

My-TRAC travel companion had a range of enhancements such as the integration of the following models: mode, time of departure, route and activities and recommendation models. Furthermore, a UI/UX personalization model was implemented to assist people with visual impairments to use the application.

My-TRAC developed their analytics tool, connected with the landing page of My-TRAC that allows live access to the status of the app's usage http://www.my-trac.eu/stats/

Furthermore, during this year work was carried out by the CFM partners to integrate the activities into the IP4 travel companion. Thanks to the LBE (Location Based Experience) you can now have access through the Travel Companion Personal Application (TC PA) to the list and then information of the different POI around you.



During 2020, only one deliverable is planned for TD4.5 that cover the FREL specification of MaaSive and it is due for December 2020. Regarding the progress, four projects have contributed to the development of TD4.5 during 2020: MaaSive, Shift2Maas, My-TRAC and COHESIVE. Since the beginning, TD4.5 has accomplished 85% of the planned work up to the end 2020, which represent 81% of the overall TD.

TD 4.6 Business Analytics

The TD will provide a common business intelligence foundation for all products and services transport providers based on the access to open-ended web of transportation data offered by the Interoperability Framework (TD4.1).

Based on descriptive, predictive and prescriptive analytics using multimodal data sets generated by the Travel Service Providers and by the services developed in IP4, the TD will help the passenger carriers to better adapt their level of service to the passengers' demand and to optimize their operations. TD4.6 will also provide interactive and dynamic visualization capabilities.

Data privacy is also an important issue in transportation: European GDPR – General Data Protection Regulation is effective since May 2018 and before GDPR adoption, other regulations were applied in a transportation context. In this context, anonymization services will be developed to guarantee privacy and confidentiality.

TD Progress

The TD R&I activities in 2020 relies on works performed in CONNECTIVE project.

The TD adopts two approaches to develop Business Analytics. The first approach is a top-down approach: it aims to identify what information operators would value, regardless any existing implementation and any data availability. This approach is complemented with a bottom-up approach which aims at managing real data from real operators, to be able to build robust big data platforms and to propose rich algorithms.

For the top-down approach, interviews with stakeholders (Shift2MaaS, MaaSive, Rail Delivery Group and Rail Safety and Standards Board in UK) have been held to understand the S2R landscape, stakeholders and drivers. From these interviews and the resources provided by stakeholders or publicly available, top-down approach identified a multitude of use cases that cover a wide range of situations and consume many kinds of data. Next steps will be the prioritization of these use cases, based on questionnaire and interviews with stakeholders. On the other hand, bottom-up use cases have been built with transport operators with the data they can share. These bottom-up use cases helped to develop Business Analytics platform, algorithms and visualizations.

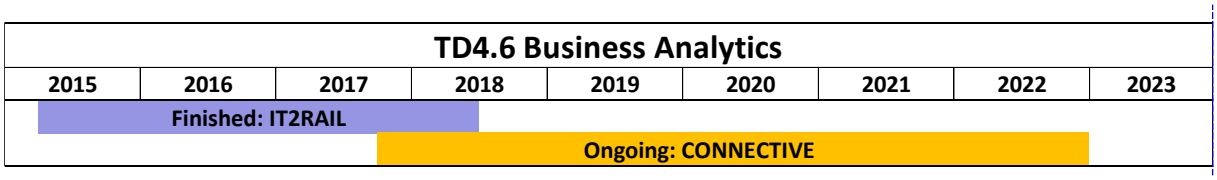
The Business Analytics platform is based on a common architecture across the partners, with different implementations done by each partner, to allow testing and benchmarking of a large variety of components. In 2020, the three big data platforms have been enriched and tested with the data collected and development done in the different use cases. Ontologies, functional and non-functional requirements, some standardisation of the data to facilitate visualization, have been defined to give a common view of all the developments done on the platforms. These works will continue in 2021 and the goal is to integrate the platforms into the Operator Portal (defined for the other TDs), which is aimed to be the unique access point for TSP to join the ecosystem.

In 2020, Descriptive and Predictive Analytics have continued with models aiming at better understanding transport demand and some analyses have been also done in relation to covid-19 impact on transportation. These works have been combined with works on Prescriptive Analytics. The goal is to help transport operators with: decision support tools to optimize timetables and to adapt dwelling time in station, regarding the predicted demand; to optimize bus route planning; to minimize impact of maintenance activities on the railway attractiveness.

Last, new visualization components have been added, to allow more dynamic visualizations, and virtual reality has been enriched with real data. Works will continue in 2021.

In 2020, three deliverables have been produced for the AREL.

Work in this TD will continue until 2022, supported by the activities of project CONNECTIVE.



With Covid-19 situation in 2020, the overall progress of the activities is a bit delayed compared to its schedule. Since the beginning, TD4.6 has accomplished 80% of the planned work up to the end 2020, which represents approximately 60% of the overall TD objectives.

ITD 4.7 Integrated Technical Demonstrator

At the core of the ITD lies the objective of opening the transportation ecosystem to new business actors, able to rejuvenate the transportation ecosystem technologies and business models, thus achieving the goals of European leadership in the market. The ITD will release, on a regular basis and for all TDs, successive versions of enriched deliverables, from early conceptual prototypes to the final version. It will act as the orchestrator of other TDs' developments, and will ensure the systems approach to integrate the different TDs' results.

ITD Progress

During 2020, the ITD continued to address intermediate activities to support internal technical, to guarantee consistency and to coordinate the interface between the CFM projects and the Open Call projects aiming to have integrated coherent demonstrations. The regular tasks such as activity planning and follow-up, definition and production of the technical management documentation used to guarantee effective monitoring and control of activity and its progress were also included.

Activities in ITD4.7 are mainly handled and managed by the project COHESIVE supported by the other CFM projects (CONNECTIVE, ATTRACkTIVE, Maasive and Extensive) (providing technologies) and by Shift2MaaS Open Calls (preparing pilots).

Practical integration activities started in 2018, taking over similar activities developed in IT2RAIL and during 2019 the results of ATTRACkTIVE and Co-Active projects supported the integration of modules and components by COHESIVE in the Alpha release, including the definition of the demonstration, use cases, test cases, integration, testing of integrated components and the Demonstration itself performed in November 2019.

During 2020 there were different targets for the ITD7:

- Perform a successful demonstration on TRA2020
- Perform a successful demonstration on Innotrans2020
- Integrate CREL results from MaaSive project
- Identify performance issues and improve ecosystem performance
- Prepare Demonstration environment
- Support Shift2MaaS OC pilots

In 2020 due to Covid-19 pandemic, most of the dissemination goals had to be adapted due to the cancelation of the main live events foreseen. The two demonstrations were thus replaced by online events with the support of the Shift2Rail JU.

The first online event was held in May 2020 and divided by two webinars, the first one focused on the Innovations from the Travellers' perspective and a second one dedicated to the Transport service providers. Those events were prepared with the collaboration of all CFM and OC projects running (COHESIVE, Connective, MaaSive, Shift2MaaS, My-Trac and SPRINT), demonstrating different use cases for each technology presented. For the first time was possible to expose all IP4 outcomes on the same event in a systematic way. Those webinars may be seen again online in the following links:

- Travellers' perspective > https://www.youtube.com/watch?v=HuTT3FxgDMY&t=
- TSPs' perspective > https://www.youtube.com/watch?v=-SpLT7aL4N0

In October 2020, a second online event was hold replacing the participation on Innotrans2020, and the opportunity was taken to realize CFMs mid-term events. These events were presented during the S2R Innovation Days 2020, where the CFM projects and results and their collaboration activities with OC projects were presented. In addition, a set of self-explanatory videos were prepared to this event, being presented on a virtual space prepared by the S2R JU. The videos can still be seen on the following link:

- https://shift2rail.org/innovationdays/station/ip4

Both online events had good levels of participation having more than 100 attendees during most of the time.

To perform those demonstration events, the TD had to prepare an intermediate release to be ready for those demonstrations, including the integration of new technologies on the ecosystem, such as the:

- Inclusion on new transport modes on the ecosystem (DRT);
- Creation of Mobility packages and their integration on the orchestration layers (TD4.2 and TD4.3) and the Travel companion (TD4.5);
- New validation and inspection technologies;
- Mixed reality experiences available on the Travel companion;
- Multi-user capabilities;
- First version on the web version of the Travel companion.

Some of these functionalities are still partially integrated and will be improved to be included in MaaSive final results (FREL) in 2021.

On all demonstrations preparation integration and testing phases were held, guaranteeing the best results possible for the Webinars and Innovation days events.

One of the already detected issues on the ecosystem was related to the performance of the Travel Companion requests to the backend services. Most of the services were improved and tested to guarantee acceptable levels of performance for the final user.

Two important components from IP4 ecosystem had significant updates on their architectures and internal processes (Interoperability Framework-TD4.1 and the Cloud Wallet-TD4.5). Those updates were done between June and December 2020 and were essential to the preparation of a demonstration environment with an acceptable level of performance.

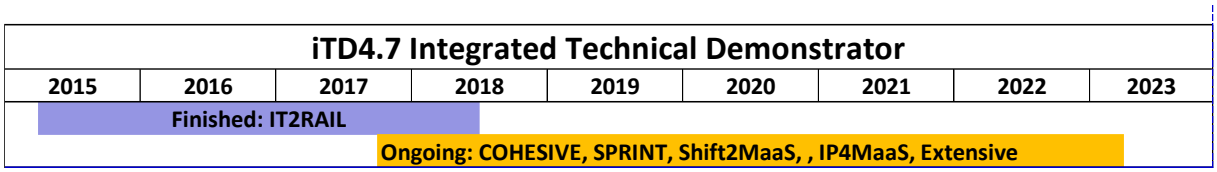
During 2020, considerable effort was also made to ensure the IP4 ecosystem infrastructure could work on two parallel environments:

- Test and Integration – to be used for new components updates testing, new functionalities deployment and testing and functionalities validation. This environment is not intended to have big performance or capacity as it is limited to the partners' developers and testers.
- Demonstration – to be used on public events as TRA or Innotrans, or to be used for Pilots in real operational environments. This environment will only receive functionalities previously validated on the Test and Integration environment. This environment should be always available to demonstrate IP4 technology at any time without big efforts associated to this.

The collaboration between the pilot project Shift2MaaS and the other technological providers' projects have been coordinated by this TD, with focus on:

- Preparation and execution of the Shift2MaaS first pilot phase, dedicated to test TSP tools (CMMP, Mobility packages creation and Asset Manager)
- Transport service providers services integration
- Preparation and validation of second pilot phase, dedicated to test the Travel Companion application and the ecosystem behind it
- Managing pilots expectation due to limitations on scope (affected by Covid-19 pandemic)

In 2020 a joint IP4 Advisory Board was established, having a first exposition of result in May 2020, and a first dedicated meeting on the 2nd of October with Advisory Board members.



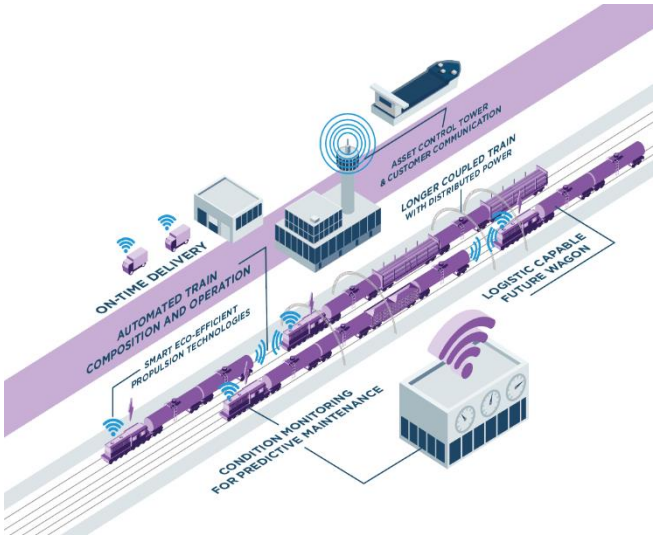
During 2020, the project was able to recover from late documents' delivery and catch-up the timeline. A total of six new deliverables were submitted, still having one more planned until the end of 2020. Also four deliverables were re-submitted or updated.

An amendment process is also in place for the COHESIVE project, aligning the project milestones with the other CFM project timelines, which will postpone the Beta release phase to first half of 2021 together with the two deliverables associated to this phase.

Since the beginning, iTD4.7 has accomplished 85% of the planned work up to the end 2020, which represent around 60% of the overall TD.

1.4.5. IP5 Technology for Sustainable and Attractive European Rail Freight

The picture below gives a visual perception on where the TDs will introduce improvements.



This IP aims to improve the cost competitiveness and the reliability of freight services of the rail sector in order to meet the ambitious objectives of almost doubling the use of rail freight compared to 2005. This will allow achieving the White Paper objective of a shift of 30% of road freight over 300 km to modes such as rail or waterborne transport by 2030, and more than 50% by 2050. Rail freight must be in a position to offer a cost-effective, attractive service to shippers that helps to take freight away from the already-congested road network. Work focus on different market segments with specific technical and operational characteristics and needs.

TD5.1 ***Fleet Digitalisation and Automation***

This TD targets the adoption of two global megatrends for freight rolling stock: Condition Based Maintenance and automation based on DAS/ATO and Digital Automatic Coupling for freight trains. DAC is an important boost in competitiveness of the rail freight market, not only delivering increased capacity in the system, but also enabling digitisation of rail freight, which leads to smart, connected rail freight that offer the necessary information for improved services. The TD focuses on areas such as condition-based and predictive maintenance of locomotives and wagons and wagon monitoring systems, automatic coupling and freight DAS and ATO, the latter is developed in close collaboration with IP2.

TD progress

This TD currently progresses through the ongoing work performed in ARCC, FR8RAIL, FR8HUB, FR8RAIL II, FR8RAIL III and FR8RAIL IV as well as the Open Calls projects, LOCATE and SMART II. These projects built on the initial work carried out in INNOWAG and SMART all closed by 2020.

In the area of CBM the overall ambition can be summarized as followed:

- Development of a condition-based and predictive maintenance strategy and roadmap, as umbrella for all asset intelligence projects in IP5
- System engineering incl. data crunching, modelling, behavioural research & development of mass data infrastructure for live pattern recognition and recommendation of measures
- Process conceptualization, testing, validation and change management in implementation

In 2020, the CBM achieved significant progress by producing and testing a suit of sensors that will be the first tier of the CBM architecture, capturing from actual vehicles key data for vehicle maintenance.

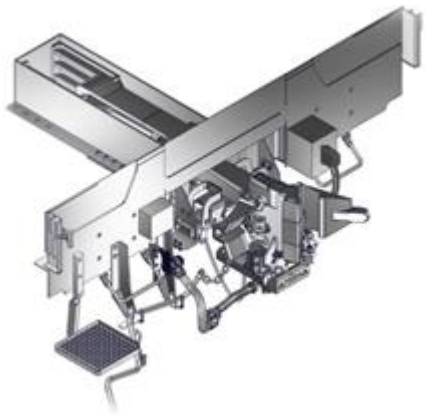
In this context, the innovation in developing specific locomotive sensors to capture health status of lubricated system within the fluid stream shall be highlighted. These sensors were installed and tested in different Deutsche Bahn diesel locomotives and now form key part of maintenance dashboards where parameters like temperature, electrical conductivity and permittivity, water content, and corrosiveness are being recorded. Whilst diesel locomotive dashboards have been the main focus, there are plans to extend it to axle bearings and transformers. Vehicle sensoring for wagons is also present in the CBM maintenance strategy; and in 2020 the focus has been on modelling and capturing

data over wagon springs conditions and bogie performance, where a set of KPI have been identified and modelled, and making progress on defining admissible thresholds. Two different sets of EU wagon fleets - DB Cargo and FGC - have been used for the analysis. Work on the relevance of CBM use cases for European countries has progressed by checking the adaptability of 28 CBM use cases for 4 locomotive fleets in France (BR 186, Cl. 77, Gravita) and Poland (BR 170). These CBM use cases and business opportunities aim to determine unused value levers and pain points. The use cases are currently still adjusted within the programme in order to better reflect maintenance costs and asset availability.

In order to ensure an effective and efficient analysis, a funnel methodology was established and used when categorizing the use cases. The use cases were evaluated with different degrees of severity and divided into different phases according to progress (starting with simple ideas for use cases up to operationally implemented use cases). With this method, the ideas for possible use cases are currently evaluated and sorted. This allows new, untapped use cases to be analysed and, at the same time, new business opportunities in connection with CBM to be identified. This work will continue in 2021.

2020 has been an important year for the Automatic Coupling, not only because of the start of the prototyping and validation phases, but also for the establishment of a common European approach to the matter with the European DAC Delivery Programme. Up to 2019, there had been separate initiatives in Europe, oriented to the definition and test of different coupler solutions. Although common discussions existed, there had been a lack of alignment in the timing and in roadmap for the migration in Europe.

The TD5.1 R&I work has led to the creation of an innovative and modular Automatic Coupling prototype that has not only been validated in the test bench. Thanks to a collaboration with the German-funded project DAC4EU, this prototype has also been installed in real wagons, involved in a test campaign close to real operational conditions, with different loads and speed levels.



FR8RAIL DAC DESIGN

The technical requirements for automatic couplers elaborated in this TD, have been upgraded in collaboration with TIS (Technical Innovation Circle for Rail Freight Transport) and now integrated in the works of the European DAC Delivery Programme.

ATO / DAS

For ATO the goal consisted of reaching a mature set of technical documentation for final ATO test runs in a demonstrator to apply ATO acceptance test protocols. After some delays year, 2020 has been successful, and after an effective coordination with IP2 R&I works, the specification for the architecture

and interface for the demonstrator, was delivered as design freeze by February 2020. Test runs were defined to be within SBB.

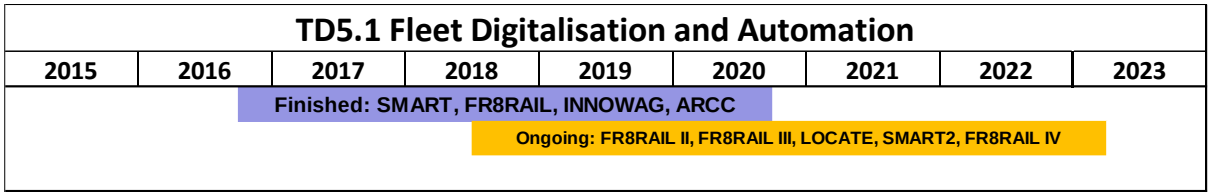
ARCC 2020 Tests BR 185.1 cabin with AZD ATO DMI & ETCS cube with different ATO modules

All field tests successfully happened in Q4 2020, on ETCS level 2 track in Switzerland. Certain issues regarding TCMS and Swiss ATP delayed testing activities. COVID also meant a difficulty for all necessary field activities that were delayed. Nevertheless, testing activities concluded with positive results and demonstrated that certain initial goals were achieved:

- **Ensuring (network) interoperability and interchangeability:** The DB Cargo locomotive used as the mobile testbed of the GoA2 Demonstrator (a TRAXX AC 1 locomotive) ran on an operational ERTMS L2 test track which is part of the operational Swiss rail network (SBB). The vehicle was equipped with ATO OB systems from various suppliers. Data exchange with trackside equipment was executed according to SUBSET 126 (version 0.1.16) requirements.
- **Establishing interface standardization between TCMS and various ATO on-boards:** the ATO OB provided by the involved suppliers, was connected to the vehicle Train Control Management System (TCMS) via the standardized interface SUBSET 139. Furthermore, these units were connected to the ETCS SUBSET 026 version 2.3.0d compliant on-board unit via the standardized interface SUBSET 130 (SUBSET 130 has been realized by ETCS to ATO proprietary gateway).
- **Solving human factor:** Test sequence output provided, among others, indications for improvement of automated driving style and vehicle guidance requirements as handled by the human today. Test results can be used to enhance driver handling of ETCS and ATO enabled rolling stock in general and the ATO equipment specifically.
- **Increasing specification maturity:** Test output will allow to improve the robustness, quality, correctness and completeness of the ATO specifications which will support a harmonized demand by RU's to the supply industry, reducing the need to design and engineer specific solutions.

Driver Aid Systems made progress in 2020 by delivering a working prototype of Driving Aid System connected with the IM Traffic Management System, so Locomotive driver can be informed of the kind of traffic ahead and behind, so the speed can be managed accordingly and be more efficient. After initial successful tests this prototype was released and installed in a bigger fleet (more than 50 Locomotives) to follow up and test the validity of the solution. Results showed that the months under test trials have been the months with the best results in terms of energy saving. Moreover, it was

shown that the number of unplanned stops were reduced, which is one indicator for energy savings. Furthermore, the train drivers who have been using the function F&R (Front and Rear Traffic view) gave predominantly positive feedback in terms of usability and support for anticipatory driving.



2020 was a successful year for the TD; yet, it was heavily impacted by COVID which not only limited field test trials and lab test availability but also led to a reduction of the number of working hours. TD5.1 has increased its workload with FR8Rail III and recently added FR8RAIL IV which is the largest project under IP5 program. This tow projects have added new tasks and deliverables which were particularly impacted by COIVD. Overall, the TD has achieved 60% of the planned work in the year and is half way through of the planned work up to the end of the programme.

TD5.2 Digital Transport management

This TD targets the digitisation of processes to optimise service planning and operation thanks to real-time data gathering, steering, operation and coordination of intermodal transport at higher speed. This supports better utilisation of available capacity, by optimising access and operation of local hubs which are essential but cost-intensive subsystems for rail freight business. The TD looks into ways of improving the effectiveness in marshalling yards and terminals operations with the introduction of innovations for real time information management (e.g. intelligent video gate). The key challenge is to improve the interaction between yards/terminals and the network, thus reducing the lack of information and adding new decision tools that will increase the punctuality and capacity.

TD progress

This TD currently progress through the ongoing work performed in ARCC, FR8RAIL FR8HUB, FR8RAIL II, FR8RAIL III and FR8RAIL IV. These projects build on the initial work carried out in INNOWAG, SMART and OPTIYARD which were all closed by 2020.

The TD5.2 is built around the following building blocks

- Intelligent Video Gate Terminals
- Improved methods for time table planning & Real Time management
- Real-time yard management & SWL system

Intelligent Video Gate

The work on IVG for 2020 is based on the successful prototype concept developed in FR8HUB which has been continued within the framework of FR8RAIL III.

A Requirements definition and IVG preliminary installation report was Prepared. A full scale demonstration has been installed in the vicinity of the Port of Gothenburg, Sweden, and work is currently carried out regarding the image processing of tag identifiers in wagons and the integration of the TU in the logistic /network part of the port dealing with Data sharing easying and digitalizing the freight multimodality.

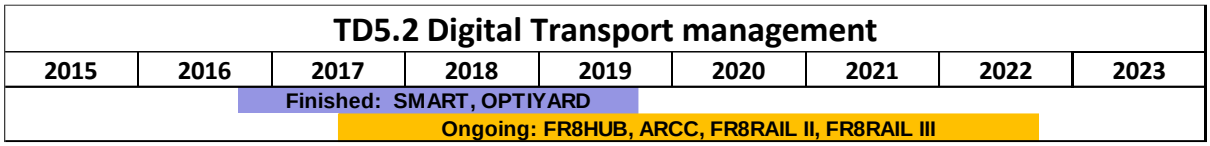
So far, the main focus has been around IA and machine learning for images captured from cameras. This work is built upon the results of FR8HUB for wagon and container identification and matching with other data (such as RFID) also providing new functionalities based on images processing and information collected by the sensors, including automatic recognition of damages and defects.

Improved methods for time table planning & Real time Management Terminal and Yards

Progress has been made by delivering a conceptual demonstrator for advanced real time network management for freight rail traffic. The emphasis has been on the coordination between traffic control, train drivers and yard management, three essential parts in the real time management of a rail freight network. The demonstrator concept outlined an Intelligent planning module M2 – Timo and a macrosimulation module Proton. Simulations were made taking as a reference Hallsberg – Malmö rail traffic; and scenarios took into account infrastructure maintenance work and infrastructure errors.

The intelligent planning module includes one part with data handling, timetable viewer, optimisation support. Timo is a timetable modifier based on optimisation. TIMO uses a conflict regulated timetable and modifies timetables in a desired way, for example, to change the departure and/or arrival time of one or more trains, to change a train's vehicle characteristics related to runtimes or to add a completely new train. The concept and planning is developed step by step. Next step is to further develop timetable planning and yard – network interaction into a real Demonstrator.

Also a Hallsberg Malmo combined simulation-optimization demonstrator was developed using railML for timetable optimization and using Railsys for micro-simulation. A timetable visualization-tool, and a graphical user interface were developed as front end showing its capacity to re-plan many freight trains.



During 2020, overall the TD has achieved 89% of the planned work in the year and has completed 70% of the planned work up to the end of the programme.

TD5.3 Smart freight wagon concepts

This TD has the objective of delivering technical demonstrations of next generation running gear and wagons for freight. The next generation freight wagons will improve the competitiveness of rail freight logistics by providing more flexible and reliable high-capacity assets at competitive costs. This will be achieved by means of the technological outputs to be delivered by this TD consisting of low-noise, lightweight, high speed & track friendly freight running gear, intelligent freight wagon 2020 for core market share increase & extended markets able to provide information such as status and location.

TD progress

This TD currently progress through the ongoing work performed in FR8RAIL FR8HUB, FR8RAIL II, FR8RAIL III and FR8RAIL IV. These projects built on the initial work carried out in INNOWAG all closed by 2020

The TD5.2 is built around the following building blocks:

- Running gear and Core Market Wagon (CMW)

- Extended Market Wagon (EMW)
- Telematics and Electrification

Running gear and Core Market Wagon (CMW)

In 2020, the work related to Core Market Wagon (CMW) has focused on the CMW bogie and on the CMW wagon. CMW bogie has been optimised with regards to the cross-coupling - the shape will be changed to a U-frame and all technical calculations and initial tests were conducted. Moreover, coordination activities have been covered among different partners to cover fully the bogie: wheelset, brakes and Telematics & Electrification.

This first bogie is based on the Y25 family which is the most spread bogie type for freight wagons in Europe.

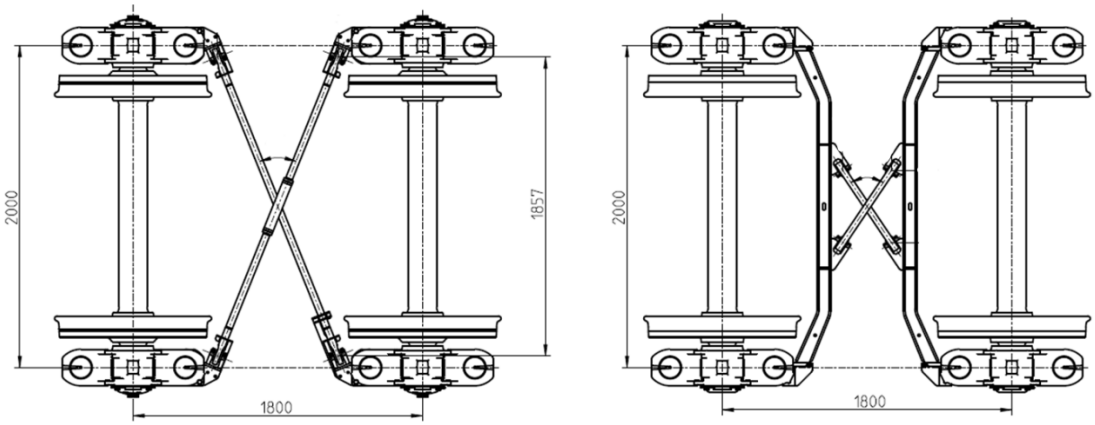
On the other hand, the Y25 family bogies are also well known for their significant lateral forces - sometimes close to the limit of Y/Q ratio and their instability at higher speeds. The challenge therefore consisted of eliminating these disadvantages.

Lots of multibody simulations, analyses of broad range of applications like performance analysis of complete vehicle, bench tests and track tests were performed, on the basis of which a new guiding of the wheel has been designed. The double-sided Lenoir link in combination with cross-coupling (to ensure radial adjustment of the wheelsets in the curves) gave the basis for a new track friendly bogie developed on the basis of Y25.

Other improvements have been defined in the FR8Rail II bogie with regard to reliability as well as running characteristics and increase of the maximal operational speed. These improvements relate mainly to change of wheelset connection design, which provides radial adjustment of the wheelsets in a curve, but it also contributes to improvement of running stability at higher speeds. Moreover, the wheelset wheel base underwent a fundamental change; it expanded from the original 1,800mm to 2,000mm. This change has an effect mainly on the increase of stability at maximum operational speed of 140 km/h, which is one of the key parameters to fulfil 5L requirements.

With regard to the development of a new cross-coupling, the following activities were performed:

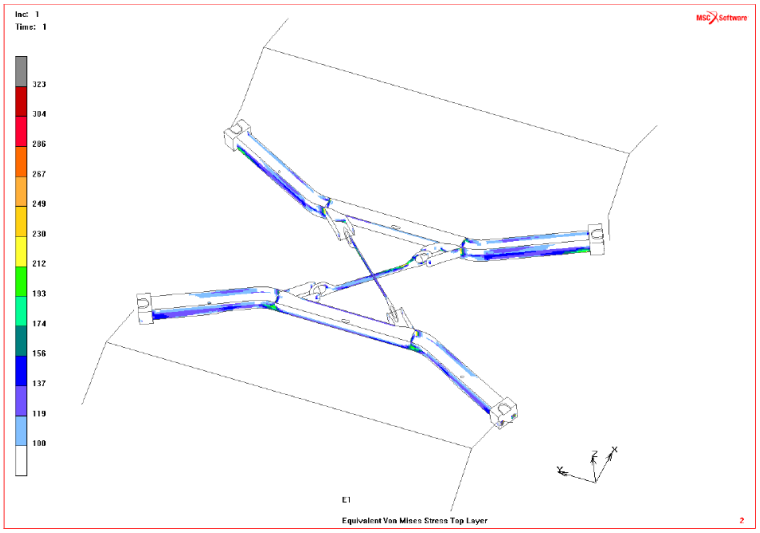
- Validation and Verification test of the running behavior - cross coupling
- Redesign of the cross coupling - Concept of U-Frame
- Validation and Verification test of the running behavior - U- Frame
- Tests according EN 13749 - CMW



Kinematics of wheelset connection mechanism of the bogies FR8RAIL I vs. FR8RAIL II

The next step was a design proposal for the individual mechanism. Three important requirements had to be considered for designing:

- Large stiffness of construction for providing high effectiveness of longitudinal movement transmission,
- For reduction of stresses of components of wheelsets equipped with bearings,
- And all that with maintaining low weight.



FR8Rail II Bogie – U Frame – FEM Analysis according EN 13749

As this is a dynamically stressed component and also a safety element, the strength FEM calculations were performed in accordance with the standard EN 13749, which defines the loading conditions and methodology for a fatigue test of bogie frames but also of their components.

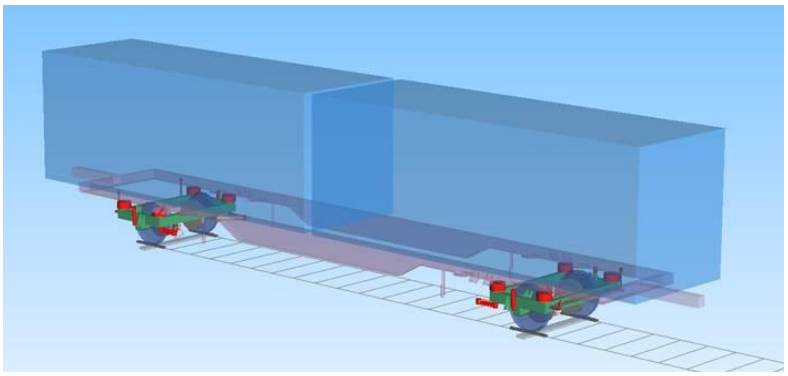
In this development stage, the results from the simulation calculations needed to be proven, or verified by means of simplified running test.

In 2020, the CMW – demonstrator was verified by tests in test circuit. Torsional stiffness test, static tests, curve negotiation test, safety against derailment and many other tests confirmed the appropriate direction of development. The wagon is manufactured, fully functional and ready for next tasks and activities during 2021-2022.

Extended Market Wagon (EWM)

In 2020, the work related to the Extended Market Wagon (EWM) continued with the development of concepts of the wagon with a central automatic coupling and a wheel disc brake integrated into a single axle running gear. Wagon simulations, measures and optimizations for aerodynamic drag reduction and a life cycle costs analysis has been an integral part of the design process. Final wagon specifications for prototypes of the EMW have been defined, including definition of the mechanical design and the covering of the car body, definition of the running gear with selection of all components regarding wheel, bearing, suspension and damping

The running behaviour has been studied with Multi-Body-Simulation. More than 10 variants in principal design have been modelled.

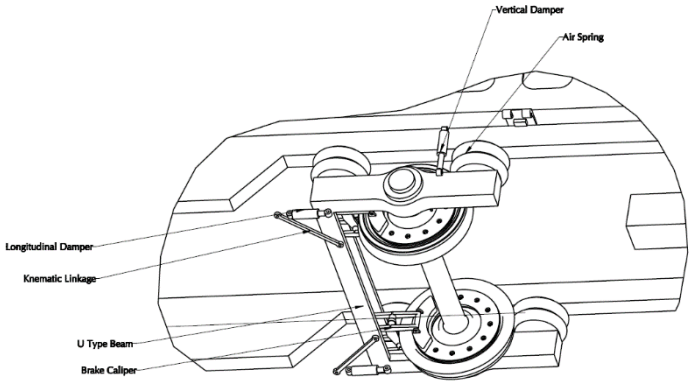


Multibody simulation model of EMW

Eventually a design solution has been developed which is aligned with the requirements. The solution for EMW shows stable running behaviour within the higher speed range for future intermodal operation on the bases of an efficient 2-axle wagon concept. This concept will be the bases for the prototype of the EMW, which will be developed in future project.

On the component level progress has been achieved within:

- Detailed design of the wheelset including disc brake and bearing set.
- Specification of damping and suspension for the running gear.

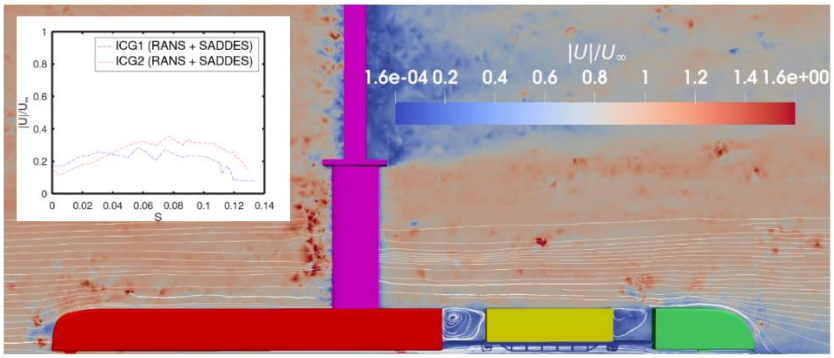


Design of the wheelset including disc brake and bearing set.

A design problem has been found while dealing with the future integration of the automatic coupler within the EMW. In order to integrate the coupler, the distance between the wagons platforms respectively have to be reduced to approximately 800 mm. This is far below the level which the standard UIC rules indicate (1350 -1400 mm). For using the Shift2Rail SA3 DAC or any other solution the height of the coupling layer must be reduced below 1000 mm. A further reduction is necessary for the transport of high cube Container on G2-Profile lines. Overall, the coupling layer will be about 250 mm lower than the current UIC standard. This feature will not be an issue for a block train configuration - envisaged as main use of this wagon - as locomotive and wagon sets are determined to operate in dedicated trains. Shunting locomotives will not be necessary either. For the prototype manufacturing – programmed to happen in 2022 – some adaptations may need to be performed for the test runs the wagon in combination with a standard locomotive as these operate at the standard coupling height of UIC. This will be addressed in 2021.

In 2020, two large scale wind-tunnel models have been developed. The first model has been created to focus on the investigation of the influence of the intercar-gap to the overall drag of a freight trains. The second model allows for the investigation of concrete measures on the chassis for better performance. Simulations have been performed according to the guidelines for CFD in EN 14067-6 using RANS (Reynolds-averaged Navier-Stokes). Based on the experimental and numerical results of

this second model, fairings in the vicinity of the running gear have been identified as a solution for optimized aerodynamic performance, drag reduction and therefore better energy management.



Sample result of CFD showing the impact of the intercar-gap (ICG) on the flow topology.

Telematics and Electrification 2020

The TD has also progressed in the activities related to telematics and electrification with the aim of building up the intelligent freight wagon. During 2020, activities related to the definition of general architecture of the system have been concluded.

This architecture has been evolved from a previous operational analysis and refined to build a complete System Architecture using Model Based System Engineering (MBSE). This architecture definition focuses on what the system has to accomplish for the Users, by defining how the system can satisfy the previous operational needs and requirements established in FR8RAIL project.

Concerning the interfaces, a data model has been proposed for rail freight market and a first approach to the specification of the interfaces between the wOBU and the different subsystems along the freight composition has been defined. This will allow the future integration of the different subsystems with the wOBU, following the Use Case Requirements and the Business Needs defined in previous years and embodied in the design of the System Architecture.

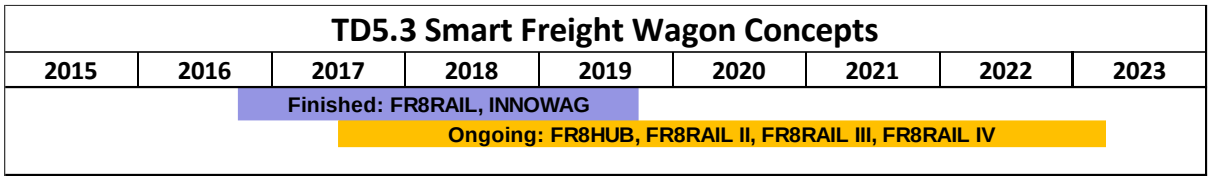
In addition to this, other complementary activities have been covered such as Energy budget and safety analysis. An energy budget including a preliminary analysis of the power needs of the different subsystems have been done, that helps to identify what subsystems can be installed in electrified or non-electrified wagons. A safety analysis has been defined for the different use cases focusing on the identification of the different safety functions related to the different Use Cases analysed.

Finally, during 2020, foreseen demonstration activities have been defined in advance with the aim of paving the way for its deployment. The demonstration activities definition takes into account the corresponding system architecture and subsystems of the Intelligent Wagon, as well as the interaction with other TDs and are linked to the Use Cases defined for the intelligent wagon. In order to define the demonstration activities, a list of test scenarios, technological demonstrators, partners' contribution and the corresponding demonstrator plan have been defined. Three different test scenarios were considered, with the main one the test scenario in Sweden in the route Eskilstuna, Luleå, Malmö and Stockholm, where the technological demonstrators are expected to be deployed. As back-up locations, Issoire in France and Hannover-Würzburg in Germany have also been defined.

This activity will continue with the final development of the subsystems to deploy the demonstrators.

During 2020, the overall progress is delayed due to different reasons, such as underestimation of the time required for design, difficulties in the interaction, unavailability of testing sites and above all COVID has had impact lowering the number of available hours.

Since the beginning, TD5.3 has reported having accomplished 80% of the planned work up to the end 2020, which represent 50% of the overall TD (even though some activities are have covered a higher percentage).



TD5.4 New freight propulsion concepts

The target of this TD is to provide more attractive rail freight services to the final customer, with competitive rail solutions maximizing flexibility and efficiency while reducing the operating and maintenance costs. The focus of this TD is on improving the overall performance of today's locomotives by adding and integrating additional functionalities and technologies. Future locomotives will provide extreme flexibility for operation in non-electrified and in electrified lines, allowing private and public operators to offer broaden rail freight services according to demand without the need of changing the locomotive or allowing the new production concepts. Future locomotives will feature remote control for distributed power, thus, allowing the increase of the train length up to 1500m and consequently improving the cost efficiency of rail transport. Moreover, other areas of work include: reduced LCC, braking energy recuperation, operational efficiency increase by automating various activities such as train start-up, train preparation, start of mission, stabling and parking, generally shunting.

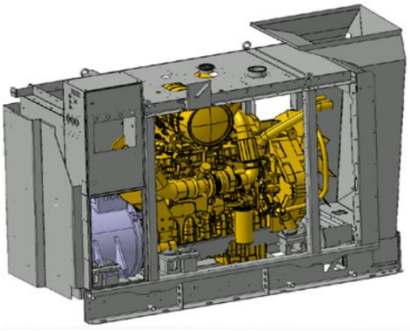
TD progress

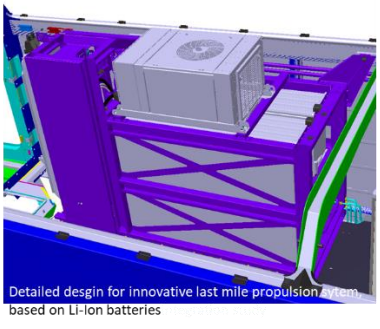
This TD in 2020 builds on the progress made with the member call projects FR8HUB, FR8RAIL II and FR8RAIL III and open call M2O which take into account the work delivered by the already finished projects FFL4E, DYNAFREIGHT. The main goal of this TD was to run the second demonstrator of a Li-Ion based last mile propulsion system, to continue with the development of on-board energy storage system and work on the specification of intelligent approaches to further improve the energy efficiency of the rail operations, such as e.g. power peak shaving, intelligent mission manager , or new auxiliary concepts . Due to Covid-19, most of the activities have been delayed by approx. half a year.

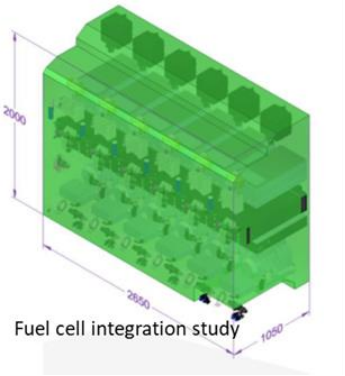
In the area of last mile, the TD has done an analysis of various energy sources for last mile application, looking at different diesel engines, fuel cells, batteries, flywheels, etc., concluding that a diesel engine remains still offers the best energy density vs cost rate show although not so good CO2 footprint. Within this framework, the most efficient and future oriented approach, is a last mile battery. During 2020, relying on the results achieved in FFL4E, a new water-cooled LI-Ion based last mile battery has been designed. The lab demonstrator, which is expected to be finalized by February 2021, will be a full functional system with an 800V 105kWh battery, a DC/DC converter, a thermal conditioning unit, all integrated in a cubicle which today houses a last mile diesel propulsion engine.

The system is ready for the integration of another 105kWh. The full system with 210kWh will, depending on how the battery blocks are connected together, provide enough power (in the range of several hundred kW) to pull heavy freight trains on their last mile. The study on how to implement an

innovative mission manager for last mile application has been started and is expected to be finalized by mid-2021.



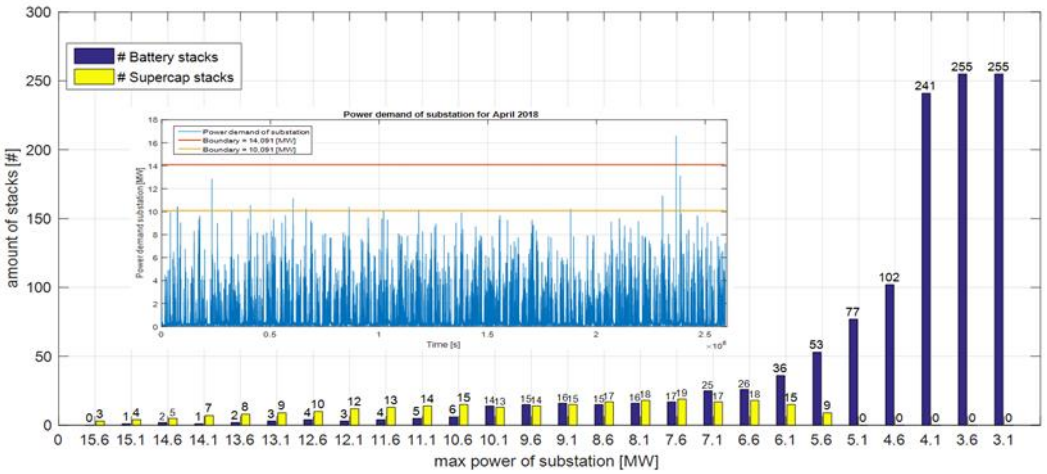




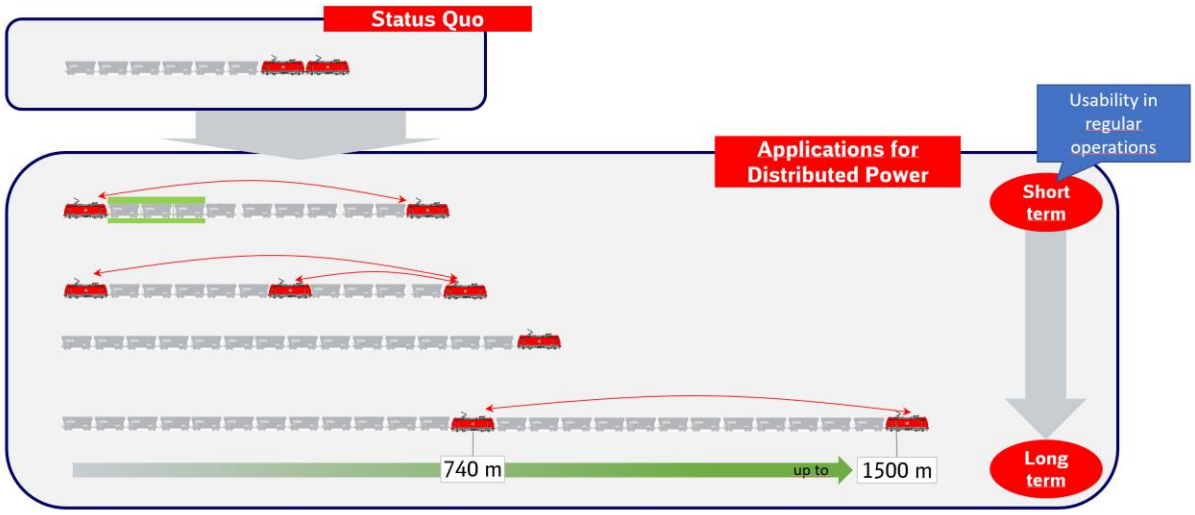
For the topic “freight loco of the future” the work on the hybridization of freight locomotives has been continued, deep diving in the definition of the architecture and the development of energy storage systems. The analysis and simulations on hybrid (diesel and battery) propulsion system showed, that fuel consumption can be reduced by up to 23% with respect to the baseline.

In 2020 new design concepts around auxiliary power converters such as for instance medium frequency converters are studied. These converters may make use of new switching technologies that will enable a significant reduction of the weight and therefore a great reduction on energy consumption. First results are expected in mid-2021.

The work on power peak shaving has been finalized - report is due by 02/2021 - showing that by introducing larger energy storage systems, such as for instance also a last mile battery, power peaks can be reduced effectively. Implemented to a full extend, over a complete fleet of train, may help to reduce complexity and costs on the infrastructure side.

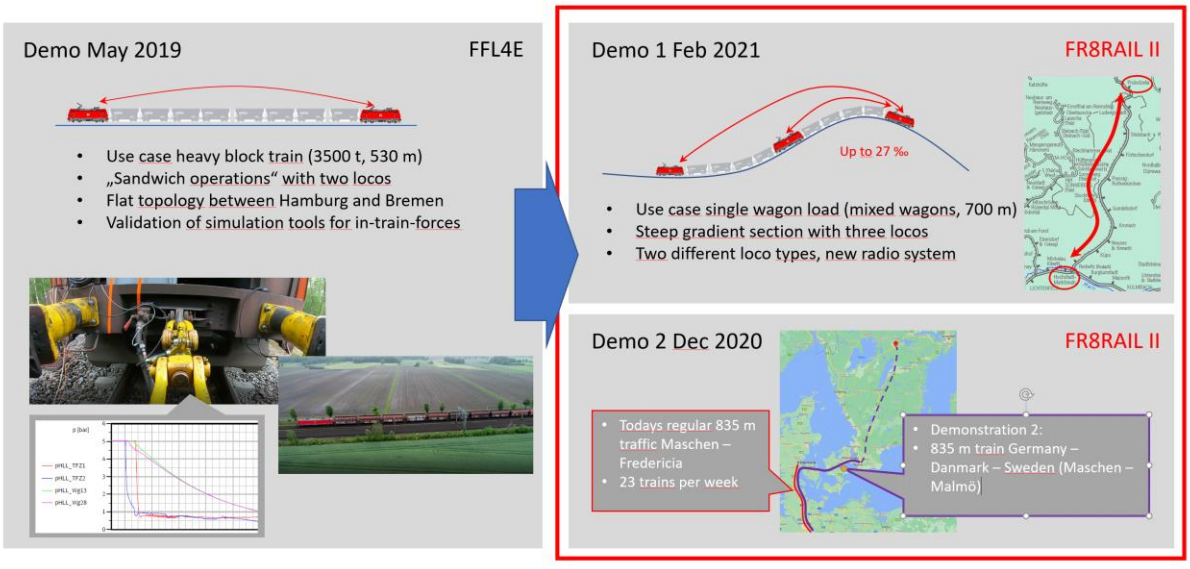


Long Trains is one of the most efficient leverages to increase productivity and competitiveness of rail freight. Distributed Power is the key technology to realise train lengths of up to 1,500 m.
The use cases of Distributed Power are diverse: also in trains up to 740 m Distributed Power helps to overcome the restrictions from coupling hook load limits and enable RUs to run much heavier and longer trains than in the status quo:



Within FFL4E in May 2019 a first prototype of a heavy block train with one locomotive at each train end has been successfully tested. Based on this FR8RAIL II has in 2020 refined the Distributed Power Technology. Several additional functionalities have been developed and tested in the labs of Bombardier and Faiveley. Together with the Open Call Consortium M2O a prototype of Distributed Power for three locos within a train consist has been developed. LTE as a bridge technology to FRMCS was used to steer the two guided locos in the train. Safety Concepts were developed and the upcoming longitudinal forces within the train were simulated in all relevant operational manoeuvres.

As the much more complex test scenario the steepest infrastructure in Germany has been selected for the next test campaign. In addition, a mixed train as an example for the single wagon load and intermodal section was selected. From the technology perspective the challenge was to steer three locos within the train via LTE (due to its limitations and is not considered therefore a suitable long term solution, the R&I focus has been therefore now shifted to the use of 5G) and to integrate two different loco types. The retrofitting of the three locos was successfully finished within 2020 so that the test campaign in Feb 2021 can take place.

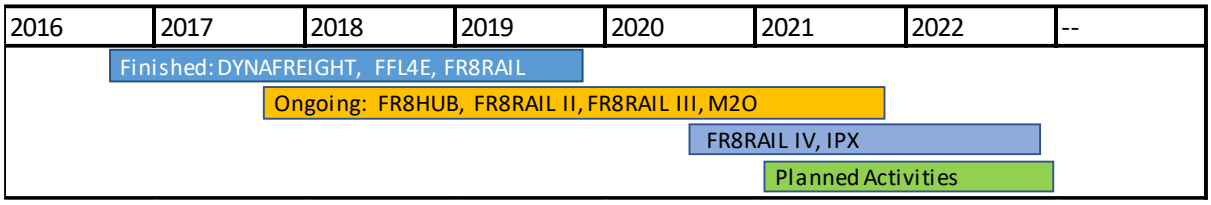


FR8RAIL II – Contract No. H2020 - 826206

During 2020, 13 deliverables were planned; some were postponed to be submitted in 2021, due to the Covid-related extension of the projects. The overall progress appears to be in line with the plan (including planned amendments), with some deviations. Since the beginning, TD5.4 has reported

having accomplished 60% of the planned work up to the end 2020, which represent 50% of the overall TD.

TD 5.4 New Freight Propulsion Concepts



TD5.5 Business analytics and implementation strategies

This TD ensures that IP5 develops technologies in line with the market needs and with sound plans for introductions into the market. This is provided by migration plans for implementing new technology solutions on a large scale, identifying market segments and developing specifications and Key Performance Indicators for freight.

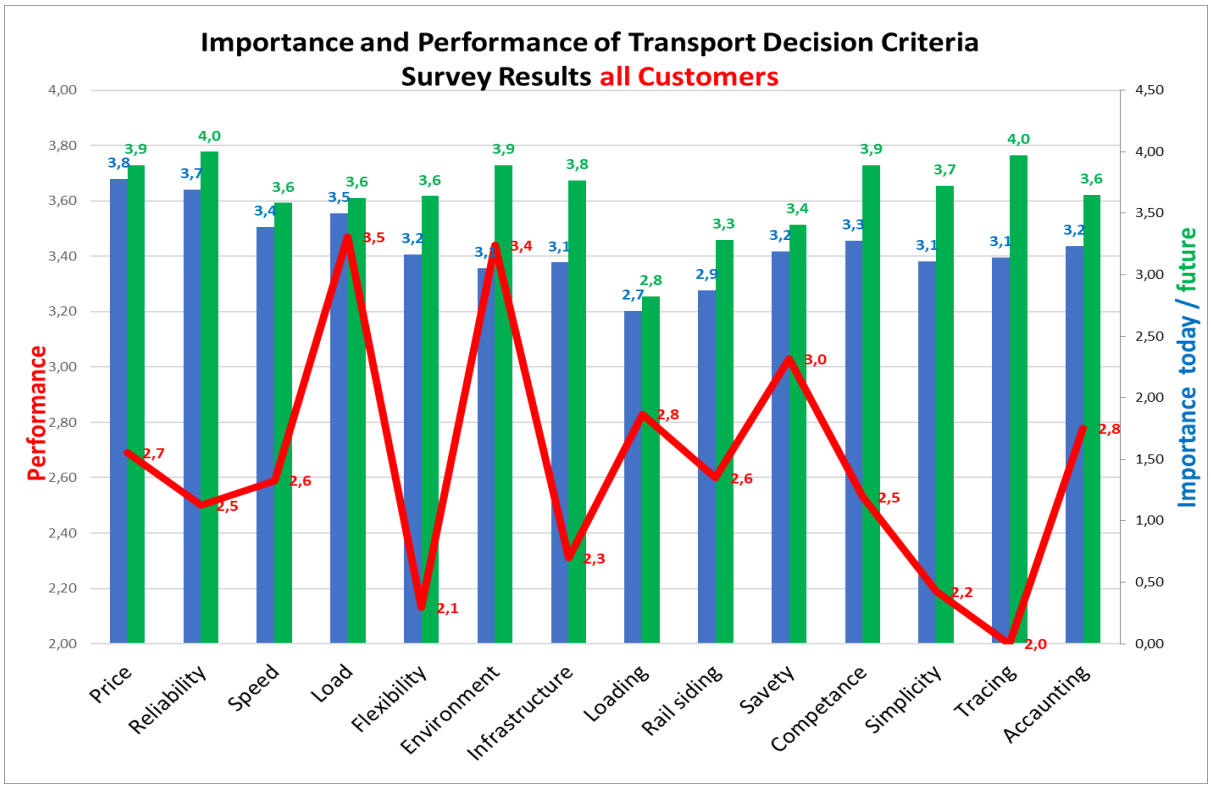
TD progress

TD 5.5 works in areas of identification of market segments, development of (high level) specifications and key performance indicators (KPIs), and in the area of migration plans.

Already 2018 TD 5.5's goal was to establish KPIs for freight and for that, cooperation have taken place with the CCA IMPACT II project and top-level requirements have been one target to reach. Fine tuning work as well as workshops with business analysis and migration have taken place during 2020.

The work on market segments and top level requirements for wagon applications have had a central position in the TD 5.5 whereas first deliverable was finished in late 2018. Planning for demonstration of the wagons CMW and EMW have started 2020 and will most likely take place in FR8RAIL IV.

The TD also worked 2020 in quantifying the estimated benefits of new technologies in the form of KPIs based on model calculations and interviews/survey carried out in teamwork with IMPACTII under a work named *Freight Metrics*. This baseline of freight metrics was done on one hand with a questionnaire/surveys for the TD leaders and technical experts and secondly with investigating project proposals and so far published deliverables. So, the improvement potentials of individual technologies, their dependencies and the operating modes were incorporated into the calculation model of IMPACT-2 in order to calculate the impact and benefit development.



The content of the work and approach he TD works in areas of identification of market segments, development of specifications and key performance indicators (KPIs), and in the area of migration plan(FR8HUB), was challenged and elaborated in a workshop with a lot of stakeholders in February 2020, Berlin.

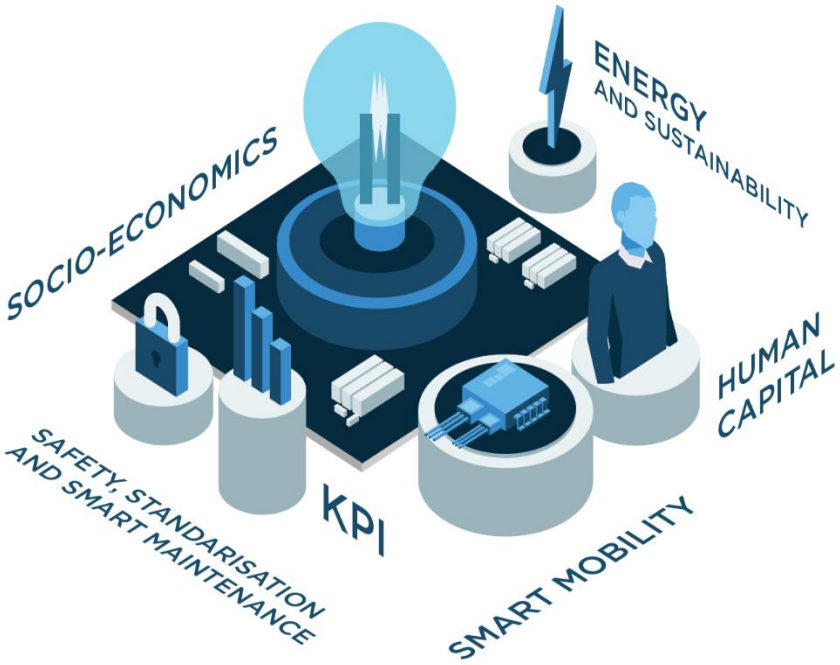
The aligned results with ***Freight metrics*** was with great success presented in a freight workshop and not at least at the Innodays in October 2020.

TD 5.5 – Business analytics and implementation strategies								
2015	2016	2017	2018	2019	2020	2021	2022	2023
Finished: SMART-RAIL, FR8RAIL, INNOWAG								
			Ongoing: FR8HUB					

This TD was expected to end by 2020 but with COVID and its associated limitations it will end by March 2021. Since the beginning, TD5.5 has reported having accomplished 75% of the planned work up to the end 2020, which represent 75% of the overall TD.

1.4.6. CCA Cross Cutting Activities

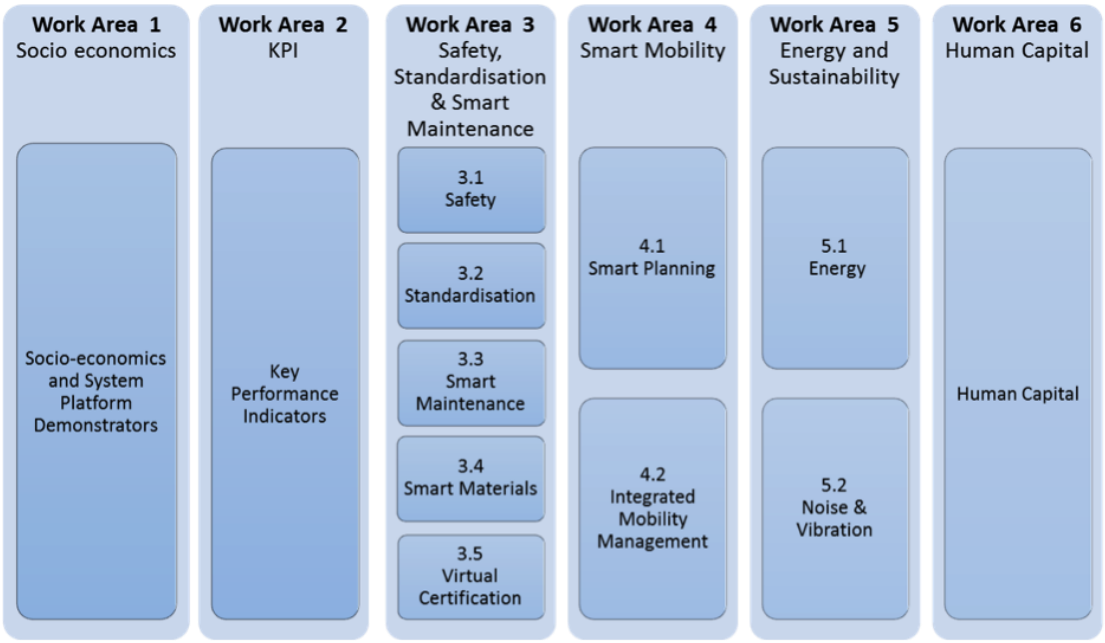
An overview of the various work areas in the CCAs is shown in the figure below.



Cross Cutting Activities are relevant to the different sub-systems of the five IPs taking into account the interactions between these sub-systems.

These Cross Cutting Activities ensure that the R&I activities within the different Innovation Programmes are closely aligned in terms of their objectives and their requirements, as well as the methodologies for evaluation and assessment of impacts. The Cross Cutting Activities facilitate a coordinated approach in order to avoid duplication and guarantee consistency.

CCA work is organised so as to achieve the objectives of the following areas:



Below a summary of the activities performed in the CCA Work Areas (WA). Activities under WA 3.4 (Smart Materials) have not started; some activities on this subject will be carried out in the dedicated Innovation Programmes.

WA1 Long-term needs and socio economic research

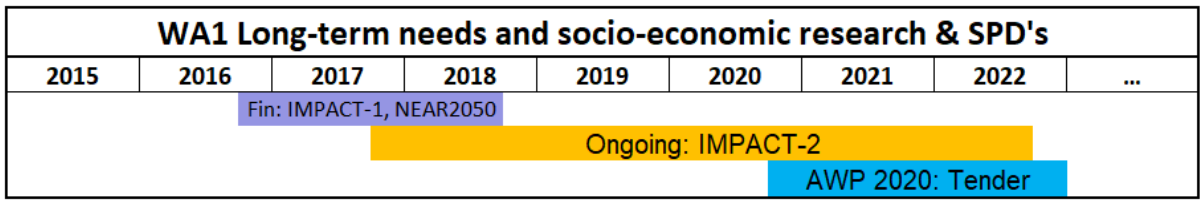
The objective of WA1 is to analyse the areas and the expected improvements that the works deployed under Shift2Rail bring to the European context in terms of social and economic benefits.

The work area is addressed in the CFM projects IMPACT-1, IMPACT-2 and complemented by the OC project NEAR 2050.

The first phase IMPACT-1 focused on customer needs and mobility behaviour of passengers and is followed in IMPACT-2 by a second phase (2018-2022) concentrating on customer requirements and scenarios for the railway freight sector which also includes the non-rail bound first and last mile of supply chains. The decision criteria for transport mode choice in the freight business were ranked by freight business stakeholders and completed. In 2020, the customers were asked for the actual performance of the rail bound transport. Transport decision criteria matrix shows that areas with high importance and current low performance are the obstacles which have to be improved to attract more customers. The main obstacles are inflexibility, no tracking possibility, complexity, unreliability, low speed and high price. In cooperation with the Freight Innovation Programme (IP5), the contribution of the Shift2Rail technologies was analysed and assessed in order to mitigate the given obstacles. Based on the logistic megatrends developed in 2019, for each trend the impact on the future rail freight transport is described. Finally, in dependence of the implementation of the success factors, future freight scenarios were developed.

Work on identifying and calculating the benefits of Shift2Rail for the society as a whole progressed, the quantification is expected to be available by mid-2021. The modelling of the system platform demonstrators progressed (SPD) with the completion of the implementation of the mode choice corridor models for high-speed passenger rail, regional passenger rail, metro, and rail freight.

Calibration to baseline situation before introduction of Shift2Rail innovations and sensitivity analysis of the models were also carried out. The next step consists of applying the mode choice models to future scenarios and of calculating potential effects on modal split and consumer surplus. The effects of Shift2Rail innovations are then tested in four complementary future scenarios, selected during 2020, that include improvements in competing modes, i.e., moderate/optimistic electrification/automation of cars and trucks. In 2020, a literature review and the methodological approach has also been developed for societal benefit calculation. The social benefits will be calculated as consumer surpluses from person transports (including external effects and wider economic benefits) and cost changes for freight transport, and the net of changes in external effects and wider economic benefits/agglomeration effects. A first draft of the "Rail as a design tool" was produced.



During 2020, 4 deliverable were planned, 1 has been released, one is slightly delayed and two will be submitted with an agreed delay in 2021. WA1 has reported having accomplished 90% of the planned work up to the end of 2020. The current work represents 60% of the overall WA.

WA 2 –KPI (Key Performance Indicators) method development and integrated assessment

The objectives of the Work Area 2 are to capture the impacts of the TDs and to assess how they contribute to the key Shift2Rail targets by defining and quantifying key performance indicators for their results.

This objectives of this Work Area are achieved through the following projects:

- CFM-Projects IMPACT-1, IMPACT-2,
- Long term needs tender focused on the support for KPIs development.

The main objectives for 2020 were to consolidate the KPI model, to develop an accuracy level definition and to collect the updated improvement values from the technology demonstrators. All the parameters have been fed into the model and an updated set of quantified values for the master plan targets "LCC", "Capacity" and "Punctuality" has been computed.

To ensure coherent results from the model, an Accuracy level definition has been developed and collected from the TDs during 2020. To ensure an efficient approach qualitative scales ranging from "Level 1 - Expert Estimations" up to "Level 4 – Physical Prototype" for technical values or "Level 4 – Based on Market" for cost values were defined.

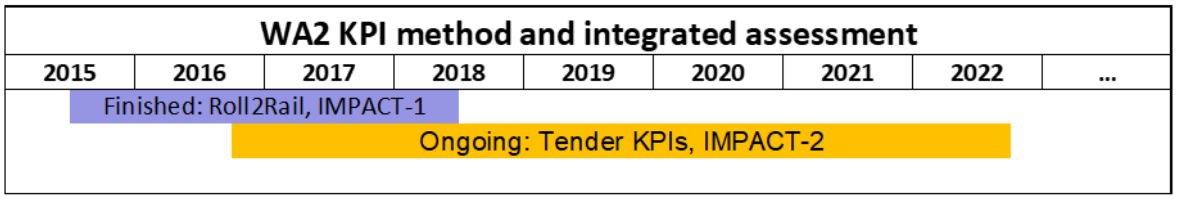
The IP2 control command and signalling (CCS) architecture changes from the baseline scenario to the future scenario, e.g. the functionality of the train integrity is done via trackside elements in the baseline, while this will be done via on-board units in the future. Therefore, the approach of a percentage change cannot be directly applied. A different modelling approach has been developed for the CCS subsystem compare to the other subsystem such as rolling stock and infrastructure with the collaboration of IP2 in 2020 and to be completed early 2021. The capacity simulation for 3 S2R SPDs (high speed, regional and freight) have been fully delivered. The punctuality values have been completed for all S2R SPDs by the ATO and TMS TDs.

The collaboration and exchange process with the TD regarding their input to the KPI models was continued on the basis of previous years. The release 3.2 of the KPI model is based on the results of 2019 which was presented in the S2R Governing Board and is included in Annex IV. Some of the TDs submitted new improvement values and initial accuracy values were given by most of the TDs.

A validation and verification process have been introduced for the different steps and input values of the quantitative KPI model in 2020. For the validation of the baseline values, a data collection process has been developed where the baseline data has been obtained and compared by different sources such as RU, IM, public data sources, and data from European authorities. In a second step, these data have been revised by the KPI experts to ensure validity across Europe.

The customer experience model has been further developed for the IP4-related values and the initial integration of the other Shift2Rail-related improvements resulting from the other IPs such as noise, station and vehicle design has been integrated in 2020.

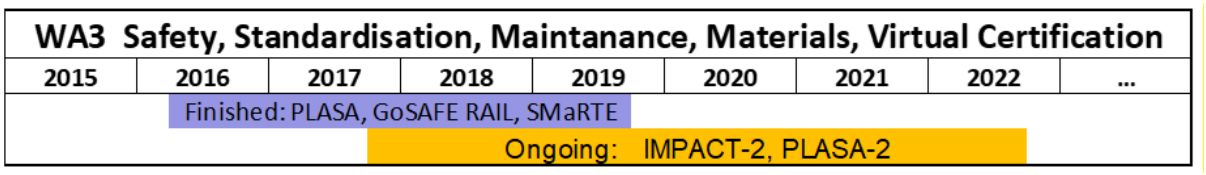
Under the tender "Long-term needs & socio-economic research", the S2R KPI tool has been completed which has been launched in the S2R website during the S2R Innovation Days in October 2020. The KPI tool aims at visualising the impacts of the S2R innovations by using the KPI model and there is a possibility to visualise the impacts of one or many groups of S2R Technology Demonstrators by using the Technology filter function.



During 2020, two deliverables were planned and both deliverables have been released. WA2 has reported having accomplished 90% of the planned work up to the end of 2020, some activities have been moved to 2021 such as the validation process of the model. The current work represents 90% of the overall WA.

WA 3 Safety, Standardisation and Smart Maintenance

Work Area 3 builds on the activities of the projects Plasa/Plasa 2, GoSAFE RAIL, IMPACT2 and SMaRTE, the graph below refers to all the activities performed in the whole WA. WA 3.4 (Smart Materials) has not been launched in the S2R Programme. The activities in Safety (WA3.1) and Smart Maintenance (WA3.3) concluded in previous years. The active work areas are Standardisation and Virtual certification. The latter concluded its work in 2020. The conclusions on these WAs can be found under the relevant section.



WA 3.2 – Standardisation

The main objective of WA3.2 is to foster the transfer of Shift2Rail results and outcomes of innovation activities into standards or regulatory documents when needed and beneficial. It aims to provide a coordinated approach across the S2R research activities and to develop optimised pre-standardisation aligned processes with the relevant standardisation bodies, standard setting organisations, as well as ERA.

The Standardisation work area is covered in the IMPACT-2 CFM project, which started in September 2017.

In 2020, the investigation on standardisation potential of the S2R outcomes was continued across the different projects, leading to issuing version 4 of the Standardisation Rolling Development Plan (SRDP) at the beginning of 2021. Regular exchanges with the Commission, the European Railway Agency and with CEN and CENELEC railway TCs highlighted the need for more accurate and clear information. In consequence, a major restructuration of the SRDP was undertaken, while it was continuously enriched up to version 4.

Based on SRDP version 3, contributions were provided to the work ongoing under the lead of the European Commission by the RASCOP Ad Hoc Group on Standardisation Request. This S2R contribution aims at identifying and expressing the standardisation needs from the research results of the S2R Programme for their future implementation in the market, as well as highlighting where and when some significant input can be expected from the research outcomes to revise or develop the standards that will be identified. This activity will continue the first half of 2021.

A preliminary process to take the S2R output into standardisation was developed in which the sector representatives are consulted and thus play a role in the assessment, prioritisation of standardisation topics related to S2R activities linked to standardisation. At the end of the process, standardisation trajectories are defined.

In early 2021, effort will be put on the contextualisation of the standardisation needs and proposal, to describe how the S2R contribution to standardisation meets the sector's needs and engagement in standardisation. It will focus on a selection of topics of major importance for the sector and for their support of European Regulation. This work will be based on ad hoc topical meetings including sector representatives, standardisation stakeholders and Shift2Rail experts. This task has begun end 2020 with Virtual Validation and TCMS topics.
Due to the originally planned low efforts and lack of resources, the activities in this work area progressed slower as planned in 2020. Activities were shifted to the first half of 2021 and the members are looking solutions to ensure sufficient resources for the next year.

During 2020, 1 deliverable was planned which is delayed and will be published in 2021. WA3.2 has reported having accomplished 50% of the planned work up to the end of 2020. The current work represents 55% of the overall WA.

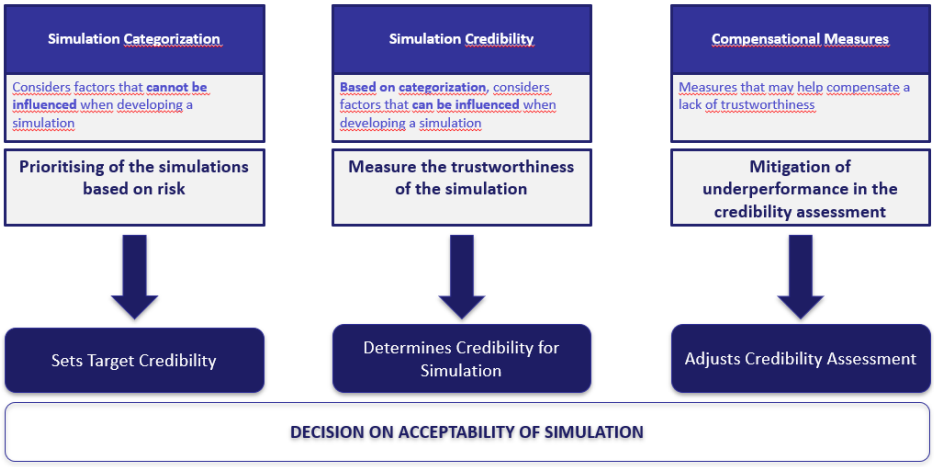
WA 3.5 – Virtual Certification

Virtual Certification is covered by the CFM project Plasa-2 which started in November 2018. The objective of virtual certification within S2R's CCA is to provide recommendations for a mixed virtual/experimental certification process, which shall ultimately lead to a significant reduction of certification costs and duration.

The analysis of the state of the art on methods and processes, as well as the identification of the main barriers and the benefits brought by virtual testing to the process of authorizing a new or modified vehicle to circulate, were accomplished in 2019. This work was complemented during the first three months of 2020 by the development of a streamlined approach which enables to quantify the reduction of duration and cost when simulation is used. Assessments are made for an entirely new rolling stock (commuter trains and high-speed trains) and for an extension of an existing approved train. The potential benefits were given as ratios against the total cost and duration of a total process and were mainly based on experts' estimations. Some figures from previous European projects, such as Acoutrain or PINTA2, were also collected. Estimations show that time reduction could be increased to approaching 40% in cases for extension of existing approvals for a new rolling stock and cost reduction could reach 22% through the application of Virtual Testing.

A generic approach for introducing virtual testing in the approval process was developed without downgrading the level of safety. The generic method can also help in harmonizing the methods used today in the different technical fields. For the generic method, stakeholder engagement was carried out to ensure wide acceptance in the sector.

This generic framework consists in defining a three steps process to assess virtual testing and determine if it is acceptable for use in the authorisation of a system. First of all, a categorisation is achieved based on the criticality of the design to be approved, targets on simulation credibility are defined (the higher the design criticality is, the higher the targets are). The second step consists in determining the simulation credibility, various factors (verification and validation of simulations, quality of input data, management process of the entity performing the simulation, etc.) are ranked from level 1 to 4 to verify whether the overall simulation credibility meets the targets. Finally, compensational measures can be performed, if needed. At the end, a decision can be made whether simulations can be accepted as a proof of compliance to the requirements.



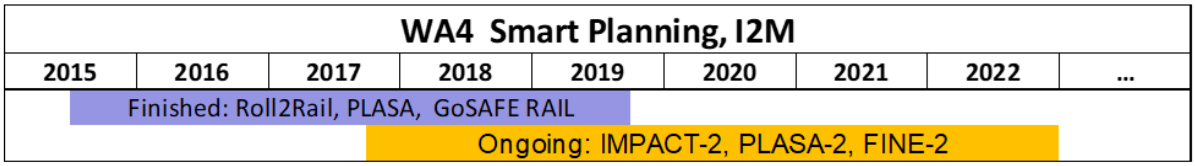
The objective of the WA is to provide its outcome to the CEN WG55 with a first proposal of a generic framework based on which WG55 will write a new standard.

Following recommendations set by the WA, the future standard should be probably voluntary and not mandatory. The CCA WA3.5 also suggested that IP1 should consider to test during the implementation of its demonstration activities the generic framework to assess how it could be applied to specific technical fields.

During 2020, two deliverables were planned and both deliverables have been released. WA3.5 has reported having accomplished 100% of the planned work up to the end of 2020. The current work represents the overall objective of this WA.

Work Area 4 SMART MOBILITY

Work Area 4 builds on the results of the Roll2Rail (LP). Relevant activities were completed in the projects Plasa and GoSAFE RAIL. In December 2020, Plasa-2 project also completed its work, concluding the Smart Planning WA. Activities on these areas are ongoing in IMPACT-2 and FINE 2.



Work Area 4.1 – Smart Planning

The aim of Smart Planning is to enable railway stakeholders to make the best decisions for the overall system, for example concerning schedules and the availability of rolling stock and staff, based on up-to-date operational data, taking into account all essential information in order to ensure quality promised is delivered to customers. The work area also enables optimum allocation of funds by using knowledge of all relevant system parameters and their interaction to promote the best possible use of existing capacities.

This work area was completed by the end of 2020. The key result of this work area was the development of a simulation tool (PROTON) which supports the timetable and operational planning with information on the operational impact of disturbances. Contrary to current state-of-the-art railway simulations which take hours to deliver the results, PROTON is a macroscopic railway simulation capable of simulating a large network within a short runtime (~min) while at the same time leading to realistic results which represent a typical day of operation. The simulation relies on sampling from probability distributions (Monte Carlo simulation) and allows to quickly evaluate the effects of different options as an important input in railway timetable planning.

Within the framework of this activity, it was analysed whether PROTON simulation delivers accurate enough results compared to RailSys, the current standard for railway simulations at Trafikverket, especially for the use case of freight trains running ahead of schedule. Both simulation methods seem to correspond satisfactorily, implying that PROTON can be used for some simulations with the benefit of runtimes reduced by multiple orders of magnitude.

Regarding the resources that are needed to run a train (e.g. rolling stock, staff) was tackled by implementing an explicit handling of dynamic resources in PROTON. Previously, resource effects were only treated in PROTON by using historic stochastic data. The explicit implementation of these dependencies allows addressing new use cases related to resource plans and thereby extends the scope of applicability of PROTON.

Within this WA, it was also explored how some microscopic information (e.g. the detailed position of signals) could be flexibly incorporated into the infrastructure model used within PROTON when it is available, without substantially increasing the running time and without demanding for complete microscopic infrastructure information. The preferred solution with respect to running time and realistic representation of the real-world is to augment the macroscopic infrastructure model by

microscopic information, in such way that the representation of the railway network remains mostly the same, but the properties of the nodes and edges are more fine-grained.

Examples of dispatching actions commonly employed by different railway operators were collected and summarized. The systematic analysis of these actions forms the basis of future implementations of dispatching rules in PROTON. Some low-level dispatching rules such as deviation from the timetable, deadlocks, crossings on single track line, have already been implemented, and were evaluated in a case study on the German railway network. The results demonstrate that the dispatching rules lead to satisfactory results for passenger traffic, but refinement for freight traffic needs to be further investigated.

During 2020, four deliverables were planned and all deliverables have been released with an agreed delay. WA4.1 has reported having accomplished 100% of the planned work up to the end of 2020. The current work represents the overall objective of this WA.

Work Area 4.2 – Integrated Mobility Management

WA4.2 aims to integrate the data exchange between Traffic Management Systems, Freight operations and Asset Management Services using a unified data exchange mechanism (the "Integration Layer" or IL) to develop new business service applications.

In 2020, WA4.2 built on the work of IMPACT-2 Work Package 7 and the FINE-2 project, which had started in December 2019.

WA4.2 delivered the specification of data to be broadcasted via the Integration Layer, supporting our defined use cases for advanced freight operation. This will be comprised in the Conceptual Data Model (CDM), developed under the S2R IPX project LinX4Rail.

The Work Area successfully collected requirements for Freight Operation Systems; enabling the finalisation of the new applications (use cases) in Traffic Management Systems to be implemented.

Cost Models have been designed for the existing Use Cases relating to Advanced Freight Operations. The development activities to create demonstrators of these use cases continued e.g. applications related to timetable/Node Management and Freight Transport Monitoring.

A first version of the interface specification for the communication between traffic management, and freight operation services via the integration layer has been established.

The definition of initial Platform Specific Data Models (PSM) for Infrastructure, Timetables and Rolling Stock, has begun. Final alignment is dependent upon the availability of a final Platform Independent Data Model, delivered in LinX4Rail.

Use Cases for Conflict Management have been defined, the specification of an API developed, and the design of associated demonstrators has begun. Similar activities have taken place for a prototype addressing the safe management of dangerous goods on the railway e.g. the definition of an API, data structures, etc. relating to the IL, and the development of this demonstrator has started.

A prototype has been developed that demonstrates qualitative benefits of data exchange utilising the IL. This shows the communication of a 'train ready to depart' message between a Traffic Management system, Container Management system, and Rolling Stock and Crew Management System, to optimise the train path in line with the various constraints of these systems. This substitutes manual processes,

such as phone calls, and provides a route to process automation. A conceptual Test HMI interface to view data on the S2R Integration Layer for validation of the prototype has also been developed.

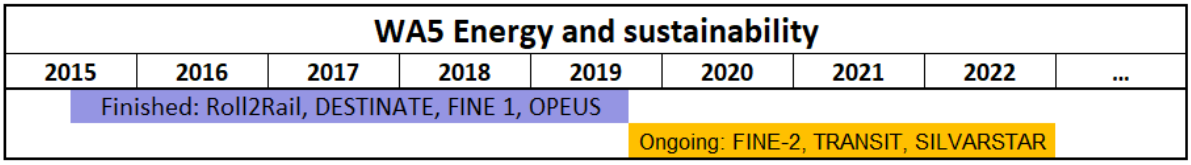
New Use Cases and interface specifications for what constitute Advanced Business Services (ABS) have been defined. These primarily look at Traffic Management System applications addressing improved traffic prediction, real-time control of the operation, maintenance planning, and operational decision support features.

One full proof-of-concept (POC) of an ABS has been developed. In collaboration with Transport for Greater Manchester this demonstrates how data integration can enhance the visualisation of operational issues, through features such as automatic prioritisation, and seeks to improve the response to incidents that impact multiple transport modes by taking data currently seen on different monitors and providing a unified view. The POC will also enable remote access to the information, whereas currently all staff members are needed to be physically present in a control room. Activities to determine the quantifiable impact are planned for 2021 when trials of the system begin. An initial proof-of-concept was also developed, integrating a 3rd party Rolling Stock and Crew system with a partner Traffic Management system, using the IL. This develops the aforementioned activities linking these systems.

During 2020, all 6 of the planned deliverables of I2M subarea and four of them were successfully submitted. WA4.2 has reported having accomplished 67% of the planned work up to the end of 2020. The current work represents 50% of the overall WA. The planned prototype developments are up to TRL3 and 4, these prototypes will be available during the 2nd half of 2022.

Work Area 5 Energy and Sustainability

Work Area 5 builds on the results of the ROLL2RAIL (LP). Relevant activities were completed in the projects FINE 1, OPEUS and DESTINATE. Activities on these areas are ongoing in the projects FINE 2 and TRANSIT and started in SILVARSTAR end of 2020.



WA 5.1 Energy

The overall objective of this work area is to develop a standardised methodology for estimation of energy consumption by simulation and measurement enabling the standardised specification of energy efficient railway systems.

The Energy work area is covered in one ongoing member's project FINE-2, launched in December 2019.

With regards to the S2R energy labelling proposal, a questionnaire was created for railway stakeholders with the objective to gain an impression of stakeholders' experience and opinion on energy labelling of rolling stock. Liaison with the UNIFE LCA (life cycle assessment) topical group was established to facilitate exchange of experience in the field of labelling and create synergies on the relevant activities.

The activity on gathering data to the energy KPI continued and first inputs were received. These inputs will be fed into the overall Shift2Rail KPI models and provide relevant information mainly to the LCC calculation.

Energy reduction potentials of specific technologies were identified and the following activities were carried out in these areas in 2020:

- The development of base line values for battery drives was planned together with PINTA 3 (carbon-free mobility). The base line values will be specified in Q1 2021. Base line values mean the technical parameters of the rolling stock that the new solution (rolling stock with battery drive) will be compared to for investigation of energy / fuel consumption impact. The comparison results obtained in the future can then be included in the S2R energy KPI assessment.
- State of the art HVAC (heating ventilation and air conditioning) solutions were analysed and by liaison with PIVOT-2 a cross-check of findings was carried out. The cross-check showed/ensured that both PIVOT-2 and FINE-2 work with consistent technical parameters of HVAC systems in order to ensure consistency in the energy KPI used in the S2R KPI model. This will be the basis for assessing the energy consumption reduction potential of the HVAC system. Key finding of these preliminary work shows that in conventional (EMU) vehicles, maximum power consumption (maximum cooling demand) is not very relevant for energy cost but partial load at moderate conditions is what should be optimized with first priority.
- Validation simulations for a thermal car-body model were performed with the goal of validating a thermal car-body model which shall be used later on to study HVAC energy saving potentials with smart control (e.g. stocking thermal capacity in the train with the production of heat when electricity is available from the catenary and reducing HVAC demand while the train is running on battery).
- Measurement was performed to assess the energy improvements due to Hybrid Silicone Carbide (SiC) converters.
- State of the art analysis on running resistance was carried out and the test protocol for measuring energy improvements due to Driver Advisory Systems implementation was carried out which will be used for measurements in 2021.

During 2020, 4 deliverables were planned and 2 deliverables submitted. WA5.1 has reported having accomplished 70% of the planned work up to the end of 2020. The current work represents 76% of the overall WA.

WA 5.2 – Noise and Vibration

The overall objective of this work area is to reduce the annoyance and exposure to noise and vibration (N&V) related to the railway sector in Europe and to provide the necessary system approach and leverage the results from all the IPs by applying effective noise control in the different technical demonstrators. The N&V work area further supports the development of simulation capabilities for exterior noise at standstill and pass-by, based on existing tools stemming from ongoing and past projects, as well as the prediction of ground-vibrations by passing trains. The outcomes will further improve the acoustic certification process for new trains e.g. during TSI homologation as well for impact studies on vibration prediction during the Environmental Impact Assessment for new or upgrading railway lines.

The Noise and Vibration work area was covered in the previous CFM project FINE 1 and in the OC project DESTINATE, which were accomplished in 2019, and during 2020 continued in part of FINE-2

project as well as the corresponding OC-project TRANSIT. In November 2020, a further OC project SILVARSTAR was launched as a complementary project to two main activities of FINE-2.

For the exterior noise tools development, the first objective was to choose the 5-6 noise sources and train integration to be measured and simulated to have a global view of all scenarios typical for the railway industry. A validated procedure for source characterization based on equivalent monopoles and tests involving generic sources were developed. Since the tested sources represent the three basic sources (monopole, dipole, quadrupole) from which any real sources can be built up, it is considered that the method would also be accurate with real sources. The measurements and simulation requirements were also defined. The preparation and organization of measurement campaigns with advanced techniques with source stand-alone and installed on the train are ongoing.

Regarding Noise sources separation, the work progressed on the development of innovative techniques to separate the noise sources of the train from other external noise sources (for example, the noise emitted by the rail) during the passing of a train at constant speed. The final goal for the future is to use these techniques for the pass-by homologation test as a partly virtual certification in contrast to the extensive and costly field measurements for today.

The state of the art and strategies for new separation techniques investigated on and inspired by the former Roll2Rail project were further improved. The developments focus on microphone array techniques combined with Advanced Transfer Path Analysis (ATPA), Pass-by Analysis (PBA) and TWINS-based transfer functions, but also hybrid approaches considering the interfaces of the methods.

Towards the end of the year 2020, different test campaigns had been planned to check the previously identified separation innovative techniques. These activities were impacted by the COVID pandemic and the schedules of these campaigns have been shifted to 2021.

With regards to the ground vibration prediction tool, the requirements specification were completed. In addition, the collection of models describing the influence on vehicles, tracks and soils on the vibration emission started.

A feasibility study of new concepts and approaches is carried out on innovative materials and design tools for improved interior sound control and acoustic comfort for passengers. Several noise sources that are major contributors to interior noise were selected and an inventory and assessment of innovative solutions and materials to reduce sound transmission to the interior were performed. The identified focus areas are “Increasing sound absorption in HVAC systems, near-field sound absorption for traction systems, reducing airborne and structure-borne sound transmission from pantographs and reducing the transmission of horn noise into the driver’s cabin”. Thanks to the fruitful cooperation between universities, which provide new ideas and basic knowledge about the working principles, on the one hand, and the train manufacturers, which provide practical necessities and restrictions on the other, promising approaches can be identified for a more detailed investigation in the next phase of the project. New approaches such as the application of metamaterials, acoustic black hole effects and duct systems using ultra-thin low-frequency resonators are candidates for further investigations.

As a result, five possible scenarios were proposed: (1. Design of a simplified Ultra-thin Low-frequency (UTLF) resonator array to maximize sound transmission loss in railway air-conditioning ducts, 2. Frame design based on acoustic black holes (ABH) to reduce vibration transmission for the pantograph to the roof, 3. Roof plate design based on ABH to potentially reduce both airborne and structure-borne sound caused by the pantograph, 4. Modify horn directivity by means of resonant antennas and 5. Design panels and/or covers based on locally resonant meta-materials to increase the sound transmission loss from the horn to the driver cabin). The next step is to select the two most promising scenarios for

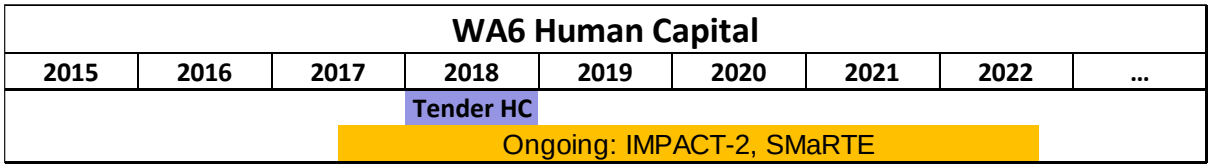
detailed investigation using numerical predictions and measurement campaigns for model validations and assessment of reduction potentials in comparison to classical solutions.

During 2020, 9 deliverables were planned, and 5 deliverables have been released, the other deliverables were impacted by the COVD pandemic. WA5.2 has reported having accomplished 56% of the planned work up to the end of 2020. The current work represents 55% of the overall WA.

Work Area 6 - Human Capital

The objective of WA 6 is to analyse the impact of future innovations resulting from the S2R IPs on the human factor in the rail system. The requirements and future needs of the humans in the system need to be taken into account in order to fully benefit from the advances in technology, for the workforce, but also for railway customers. The focus of the investigation lies on the impact on railway staff while also considering the impact on the customer.

WA6 is addressed in the CFM-project IMPACT-2 and SMARTE. The SMaRTE project already finished in 2019.



During 2020, the focus was on continuing and completing the work on skill profiles and agile organizations.

Occupational groups and positions that are expected to be greatly affected by technology development have been identified. With the help of an interview survey, the significance of technology development on the competence need of personnel employed in the industry sector related to rail infrastructure in Sweden has been assessed. Railway contractors emphasize the importance of their profitability and the built-in incentives in maintenance contracts, for the pace at which new technology is adopted. Both the infrastructure manager and railway contractors describe a future need for increased engineering capability primarily in the area of information technology.

In 2021, an assessment of the impact of new technologies on train dispatchers working conditions and skill profiles will be analysed. The next step is to assess transferability of the Swedish findings into a European example by receiving feedback from other infrastructure managers involved in the project.

Operators need agile organizations that adapt to disturbances and deal with uncertainties ensure continuity of service and production while preserving the workforce and users of our system. A study on the creation of a Crisis Management Team is developed. The example selected is based on a tumultuous incident 1999 at a station in Paris where people had to be evacuated and the station closed. The inception of the team and its gradual maturing within an ordinary organisation is being analysed. As preliminary results, five features seem be decisive in the agility to manage crisis: matching workload/worker availability, localization of the team, skills, link with the rest of the organization and organization and perennial. Pros and cons of two different models of agile organization were then compared based on that analysis grid: a professional group model and a network of experts. Consolidated conclusions and recommendations for organisational design will be made in the final report.

Due to the originally planned low efforts and lack of resources, the activities in this work area progressed slower as planned in 2020. As a consequence, 1 deliverable was planned which has been delayed to 2021; members are looking for solutions to ensure sufficient resources for the next year.

WA6 has reported having accomplished 30% of the planned work up to the end of 2020. The current work represents 86% of the overall WA.

1.4.7. IPx activities

IPX was introduced in S2R Annual Work Plan 2018. Its forward looking activities, in which disruptive technologies or thinking and exploratory research is performed, aim at accelerating the pace towards radical rail system innovation and transformation. Besides various research themes, such as Artificial Intelligence and Blockchain, IPX activities also initiated the works on a common rail Functional System Architecture, following a system-of-systems approach, and a Conceptual Data Model (CDM), further enhancing data flow between rail subsystems and beyond.

Exploratory research
The Ter4Rail project - Transversal exploratory research activities for railway to identify new opportunities for innovative research and facilitate the cross-fertilisation of knowledge from other disciplines – started in December 2018. The project has close links with the European Rail Research Advisory Council (ERRAC). It concluded in November 2020 and delivered a comprehensive map of the state-of-the-art and major tendencies of innovative research in rail technology and key stakeholders in the R&I of rail related activities.

The project has identified non-rail actors to assess the potential for synergies, and used it as a basis for the Rail Innovative Research Observatory delivered at the end of the project. Ter4Rail also provided a detailed report on the features of urban scenarios 2050 and technologies influencing the development of rail transport. Finally, it launched a successful video contest for the younger generation. The goal of the video contest was to engage and motivate a broad and young audience to use their own words and images to explain, support and create awareness around the promotion of the railways in Europe. The video contributions are available at http://www.eurnex.org/video-contest/

The project's final event presentations and a recording of the event are available at https://ter4rail.eu/2020/11/20/final-conference-of-the-shift2rail-cca-ter4rail-project-held-remotely-on-19-november-2020/ .

FLEX-RAIL is another IPX project dealing with exploratory research. It has a vision to target a lean, integrated and flexible railway system, which will stimulate further innovation within the rail sector and will ensure that rail services can address the future user needs. The project is forecasting the evolution of key fundamental technologies, identifying technical risks and of potential blocking points, studying future user needs, formulating technological concepts of future rail system and will finally deliver recommendations and implications for the S2R activities. In the first phase, the project delivered a review of trends, transport sector innovations and blue sky projects. This comprehensive inventory of innovations and trends was made available in an interactive webpage (http://flexrail.org/). In 2020, FLEX-RAIL defined and prepared a dedicated framework used to assess the impact of the defined rail technology scenarios and transition pathways. It further worked on identifying gaps between future user needs, competitiveness requirements and technology potential with the status quo in the rail sector, including required paradigm shifts and the development of a future rail system scenario based on an open innovation participatory process involving general

public and stakeholders was developed, to first decide which paradigms are holding back the rail sector.

In a second stage FLEX-RAIL generated new paradigm solutions for a future rail system. These paradigm solutions are defining draft scenario packages that have been evaluated within different perspectives leading to final scenario packages. These will constitute the basis for the final scenario of "rail in a sustainable and user-oriented (multi-modal) system", describing the key functionalities, potentials and possibilities and alignments within the paradigm solutions.

Artificial Intelligence (AI)

Artificial intelligence is seen as one of the key technologies contributing to the transformation of the rail system. In IPX AI is tackled within an open-call project called RAILS and call for members' project TAURO.

RAILS is a S2R funded PhD research investigating Artificial Intelligence for rail automation, predictive maintenance and defect detection, traffic planning and capacity optimisation. The researchers are investigating ways to transfer existing Artificial Intelligence developed in other sectors, in particular transport, which can support a fast take up of this technology in railways. RAILS started in December 2019, but the COVID-19 situation caused significant delays and difficulties in conducting the research activities as planned.

Despite the difficulties the project delivered a definition of a reference taxonomy of AI in railways and in September 2020 organised an on-line workshop on AI in Railways.

TAURO, launched in December 2020, deals with Advanced Functions towards Autonomous Trains. Its high-level objective is to identify, analyse and finally propose suitable founding technologies for the future European automated and autonomous rail transport. The work will focus on the use of AI for perception of external environment (developing a common database for artificial sense training) and on train internal perception (demonstrator), remote driving and command (standardisation input), to further advance on train-to-ground communication, automatic status monitoring and diagnostic for autonomous trains and to accelerate the deployment of ATO over ETCS.

Blockchain

Despite the wealth of new data provided by sensors on the infrastructure and vehicles, the deployment of next generation traffic management systems that allow real-time management of the system, and the provision of mobile applications for passengers and staff, the railways are still struggling in their aspiration to be an information-led industry due to a lack of traceability of information usage, and the commercial barriers between stakeholders.

The B4CM (Block chains as a Distributed Ledger for Attribution of Remote Condition Monitoring Data in Rail) project is a PhD research that will identify key use cases for the technology within the railways, deliver a blockchain-based testbed that enables the benefits of the technology to be formally evaluated, and demonstrate the value of blockchains in the attribution of data costs across organisational boundaries within the European rail sector. The developed testbed will enable future developers to extend the tools produced based on a known working configuration.

Due to difficulties in allocation of resources faced by one beneficiary, the project started its activities in late 2019. An effective 5 months into the 3-year programme of work, the B4CM team have begun developing a set of formalised use cases for the deployment of a blockchain-based condition monitoring framework in rail, initially building on the findings of the RSSB's T1010 work programme

on possible commercial arrangements for sharing of data between industry stakeholders. A toolchain has been selected based around the Hyperledger Fabric framework, which will provide a permissioned platform on which the B4CM tools will be delivered.

New and emerging land mobility
HYPERNEX is the 2020 project, launched in December 2020, answering the topic on 'Innovation in guided transport'. It plans to gather all promoters, at least European, of technologies around hyperloop and together define the enhanced / innovative modes in terms of concept of operations, safety cases, functional specification and operational conditions and testing methodologies / environment and in addition also identify the potential transferability and synergies with Railways solutions, processes and procedures in general, and in particular from a technological perspective with the S2R innovations (Technology Demonstrators and IPX activities).

Human-machine interface Translate4Rail is a project tackling language barriers by utilising advanced technologies and human-machine interface. The project started in December 2019 and is on track to offer drivers a fully comprehensive set of predefined standardised messages which encompass all the necessary for the exchange with an infrastructure manager traffic controller in normal or exceptional operational situations, in a country where they do not understand nor speak the local language.

The project will implement an IT tool to enable the driver and the traffic controller to understand each other even though each of them speak in their own native languages. In August 2020, the Translate4Rail partners developed a prototype solution to solve the language barriers. Since October 2020 the partners have been testing the solution under laboratory conditions. Work will continue in 2021 with field tests in the border region between Italy and Austria.

Innovation in power supply
A project on flexible medium voltage DC electric railway systems (MVDC-ERS) is a PhD research that started in December 2018 with the objective to produce ground breaking knowledge on the next generation of railway power supplies and on-board traction systems to propel electric rail transport into the era of distributed generation. Based on a comprehensive literature review of converters suitable for MVDC railway electrification in 2019, the project provided the grounds for future project work on comparative evaluation of topologies of static converters for the supply of medium voltage DC rail electrification networks. Building on this knowledge, in 2020 the project reviewed of converter topologies for MVDC transformers, comparing several modular topologies for MVDC transformers to identify the most suitable for the application to railway traction.

Rail System Architecture and Conceptual Data Model (CDM)
During 2020, LinX4Rail ran a series of workshops with all rail-relevant stakeholders in order to rethink the rail system and to introduce a common vision and build the first version of a rail Functional System Architecture. These workshops allowed collecting knowledge from other sectors, refining iteratively common understanding on the concept of an architecture for the railway system and implementing a structured approach based on use cases. LinX4Rail produced in November 2020 the first preliminary version of the rail System Architecture. The proposed architecture is based on 3 layers: Services, Operations and Resources layers as illustrated below:

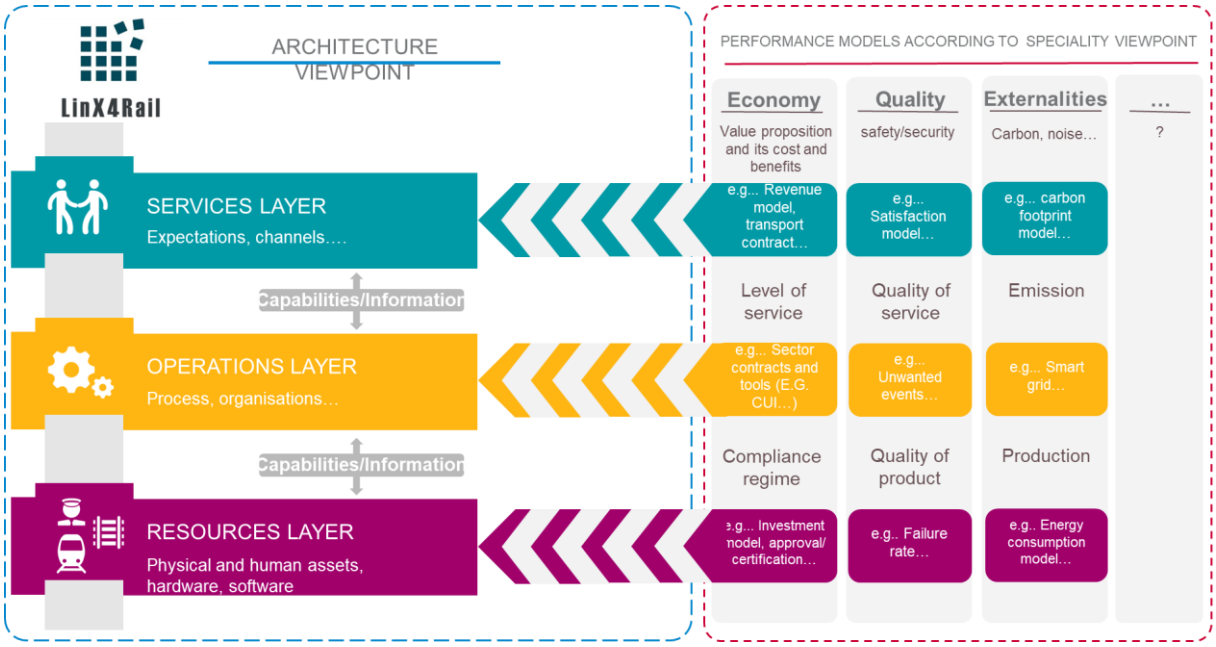


Figure 1: LINX4RAIL's proposed architecture

The 3-layer concept was assessed and developed on two use cases: "running a train from A to B" and "maintenance" (infrastructure and rolling stock). An internal release of the Functional Railway System Architecture is planned for end of May 2021. The second public release of the architecture will be done in November 2021. Both will consider additional use cases, in particular ones identified in EXTENSIVE project and considered within LINX4RAIL-2. This last one started in December 2020 and aims at ensuring a wider uptake of results from LinX4Rail.

Parallel to building the System Architecture, the assessment and alignment of some of the currently existing initiatives was carried out in a dedicated task, following a positive assessment based on Change Management process and endorsement of the change subjects by the Executive Director's Programme Board (EDPB). In particular, alignment between the S2R works on the common on-board communication system in the IP1 project CONNECTA and the initiative OCORA promoted by some RUs was carried out, along with alignment between the S2R works on Smart Wayside Objects Controller (SWOC) in IP2 project X2Rail and the initiative EULYNX/RCA promoted by some IMs. Furthermore, following the consideration of the subject "Harmonisation of operational rules", it was decided to write and publish a white paper on harmonizing the operational requirements for ERTMS with no trackside signals. This document results from the work of a group, constituted with LINX4RAIL's members and experts nominated by IP2 members and ERA. Its purpose is to describe how and in which areas of operational harmonisation would have the intended impact (White Paper: Harmonisation of Operational Requirements).

For the CDM workstream, a functional specification of the appropriate ontology was produced from a review of the existing ontology approaches (IFC, RailTopoModel now RailSystemModel, RailML, EULYNX). Based on the Railway Ontology to be developed in the project, the representations in these existing models will be put into a coherent framework. From this approach, the target CDM vision was developed. Having in view shorter term implementation in Shift2Rail projects, the concept of a short-term version of the CDM was developed. Agreement was reached in June 2020 to support both Intermediate UML based solution and long-term ontology based solution, therefore the project runs two parallel workstreams. It will be tested on the identified project use cases "Running a train from A to B" and "Maintenance". The chosen approach envisages the possibility for CDM users to extend the model to fulfill their use cases if the required entities are not included in the short term CDM.

The CDM, both in shorter and longer term visions, is then adaptable by design to contributions of actors of the railway sector, inside or outside Shift2Rail. A core development team is now in place to carry out the implementation work during the remainder of the project.

1.5. Operational calls for tenders and prizes

With regard to the implementation of procurement activities, the S2R JU has complied with the principles of the EU Financial Regulation and the guidance provided in the European Commission Procurement Vademecum. This resulted in the implementation of activities obtaining the best value for money.

The values established for the different procurement procedures, which are below any materiality level considering the total value of the R&I activities and the Programme, result from the collective knowledge of involved staff and their experience in previous private and public organizations.[27]

In 2020, the S2R JU awarded the "**Railway operators, staff and passengers' expertise" framework contract** (Implementation of a 4-year framework contract with a total estimated value of EUR 2 Million):

- LOT 1 - Expertise in European railway operations;
- LOT 2 - Expertise in European railway human capital aspects;
- LOT 3 - Expertise in European railway passenger aspects.

The estimated budget for 2020 amounts to EUR 1.35 million (specific contracts for 2020).

In addition, in 2020 the S2R JU launched the call for tenders **- Strategic support to the S2R JU.** The total value of the framework contract over four years is EUR 3 300 000:

- LOT 1-strategy advice; Lot 1 covers the provision of strategy advice on the content and structure of the activities of the S2R JU or/and the S2R JU Programme and the future S2R JU remit.
- LOT 2- support to programme management; The objective of this lot is to support the S2R JU with the implementation of the applicable programme management processes and procedures, adapted to the specific S2R JU Programme business needs. This lot is about the execution of recurring defined programme management processes/procedures that support the S2R JU Programme Management operations.
- LOT 3-legal assistance: The objective of this lot is to support the S2R JU with the provision of services concerning legal support and assistance in different EU legal fields, such us public procurement, grant management, data protection, intellectual property rights (including copyright issues), pre-litigation and litigation support

It is worth noting that for the tender "**Strategic support to the S2R JU**" (open procedure - framework contract), the dispatch of the notification letters and signature of the FWCs for the 3 LOTS will take place in January 2021. The award decision was however signed in December 2020.

At the end of 2020, the JU also published its first "**Call for Expressions of Interest – Senior external experts to assist the Shift2Rail Joint Undertaking with high level support and advice in relation to**

[27] Also in answer to point 15 of Discharge 2016 of EP, reference P8_TA-PROV(2018)0173.

the R&I activities (S2R.20.CEI.01)" to avail itself with senior/high level experts in the fields related to the Programme implementation to enhance its activities.

In 2020, the implementation of the framework contract "**Support to ERTMS European Action Plan to pave the way for the deployment of the future S2R Innovative Solutions**" continued - Implementation of a 4 year framework contract with a total estimated value of EUR 8 Million. The objective of this tender is to ensure the establishment of the essential baseline for the deployment of the future S2R Innovative Solutions through the support to the coherent deployment of European Railway Traffic Management System, a horizontal priority aiming at ensuring in the interoperability of the EU railway system. The action is a part of a global project on deployment of ERTMS in the European Union, as defined in the TEN-T Guidelines and the MoU signed between the EC and the European Railway Associations in 2016. The estimated budget for 2020 amounts to EUR 3.0 million (specific contracts for 2020).

In 2020, Shift2Rail launched its first call for **Prize, under Horizon 2020**. Taking the opportunity of a dedicated event of innovation, the S2R Innovation Days, the "Unique Train" Prize was launched at the end of October. The Terms of References for the Prize have been developed based on a Union need and following an expert workshop held on the 5th of May 2020, where around 20 experts contributed to better shape further the objectives of the Prize, as well as the relative criteria. The Prize is aimed at the development of an implementable single solution that will allow the tracking of all commercial freight trains, from all railway undertakings, covering the whole European network. The winner will be awarded €400.000, while the runner-up will receive €100.000 EUR. The deadline for applications is 21 September 2021.

As stated in point 3.3 of the Annex I of the Financial Regulation 2018/1046, the S2R JU, as a contracting authority, shall publish a list of contracts on its website no later than 30 June of the following financial year for specific contracts under a framework contract. In 2020, the specific contracts implementing the FWC were published here: https://shift2rail.org/participate/recipients-shift2rail-funds/

1.6. Dissemination and information about projects results

The S2R JU disseminates the project results at the heart of its R&I programme. Dissemination activities mainly target the European scientific and academic community working in the mobility field, and specifically rail, but not exclusively. Dissemination therefore plays an essential role within the S2R Programme, being a core ingredient of its success. Due to the Covid-19 pandemic, most communication and dissemination activities were concentrated online in 2020.

All JU dissemination activities are designed to consolidate the S2R JU as the key European platform for R&I in the railway sector, where all interested parties, including manufacturers, infrastructure managers, rail operators and regulators can exchange in helping move European railway forward. The S2R JU website hosts Call for Members Projects activities and links to Open Call Projects' websites and dissemination activities, as well as the Lighthouse Projects and other related projects (See also section 2.1).

Dissemination of project results was a prominent element of various Shift2Rail events during 2020, most notably at the Shift2Rail Innovation Days (22-23 October), the JU's major communication event in 2020. This event was conceived as a platform to promote Shift2Rail results and to bring the sector together to discuss progress and future plans, in the absence of major events in the usual rail community calendar, including TRA 2020 and InnoTrans 2020, due to the health pandemic. The event

was also considered a successful way of attracting a larger audience for the dissemination of the final results of projects rather than the small-scale individual final events of projects which to date have gained little attention from participants outside of the organisations involved in the projects. During the Shift2Rail Innovation Days, the results of 17 projects at their completion stage were discussed in dedicated webinars during the Shift2Rail Innovation Days, with an average participation rate of 120 people per webinar. Furthermore, a dedicated 3D results area on the event website allowed participants to navigate each of Shift2Rail's Innovation Programmes and explore the innovations being developed under each, with the latest results made accessible. In the interest of further dissemination, the 3D results area of the event platform has been embedded into Shift2Rail's corporate website so that it is now permanently accessible from the homepage and can be updated as results evolve.

Dissemination of project results in Innovation Programme 4 also took place via dedicated webinars organised by Shift2Rail on seamless door-to-door travel from the travellers' and service providers' perspective. Moreover, project results were also presented and discussed at a number of external events participated in by Shift2Rail staff, Members and project partners. More details on these events are available in Section 2.1.1.

2020 also saw an increased use of shared dissemination information among projects coordinated by the Shift2Rail Communication Team. In the past years the tool has had a multiplier effect as we have seen an increase on social media and in newsletters of the promotion of results by organisations working with Shift2Rail as well as external parties. This was especially visible in 2020 as the Covid-19 pandemic led to an increased online presence of our projects, especially in terms of social media and online event organisation. The cross-projects collaboration of communication activities pushed by S2R JU, has allowed for a more efficient promotion of this increased activity and a global overview of all project dissemination, ensuring we are able to promote results in a timely and effective manner. It also has enabled monitoring and the possibility to advise projects in the dissemination of their work in order to ensure they support the programme approach and contribute to the overarching Shift2Rail communication strategy.

Project Final Conferences in 2020:

25 February – ETALON Final Event, Brussels, Belgium
22 October – FR8HUB Final Event (during Shift2Rail Innovation Days), Online
22 October – GoSafe Rail Final Event (during Shift2Rail Innovation Days), Online
22 October – PLASA-2 Final Event (during Shift2Rail Innovation Days), Online
22 October – X2RAIL-2 Final Event (during Shift2Rail Innovation Days), Online
23 October – Sprint Final Event (during Shift2Rail Innovation Days), Online
19 November – TER4RAIL Final Conference, Online
8 December – MOVINGRAIL Final Conference, Online
11 December – EMULRADIO4RAIL Final Conference, Online
14 December – My-TRAC Final Event, Online

1.7. Operational budget execution

In 2020, the S2R JU Budget, adopted by the Governing Board on 14 November 2019, was kEUR 89 677 in commitment appropriations and kEUR 80 255 in payment appropriations.

By year end, the Executive Director had proceeded with the transfers needed to maximize the use of the commitment and payment appropriations available within Tile 1 and Title 2, in accordance with S2R JU FR art.6.5. In addition, in agreement with the Governing Board as per minutes of the Governing Board meeting of 19 November, the Executive Director had also transferred 4m€ in payment

appropriations and 330k€ in commitment appropriations from Title 3 to Title 4 in order to be made available immediately to the S2R JU AWP 2021. At year-end, kEUR 33.9 were re-inscribed in the budget 2020 from Members projects that release this overall amount due to efficiencies in the resources consumption or from minor administrative contracts. This amount is recorded as assigned revenues. Following these changes, the total budget commitment appropriations for 2020 amounted to kEUR 89 711, of which KEUR 80 505 for operational expenditure, and kEUR 80 289 in terms of payment appropriations, of which KEUR 72 204 for operational expenditure.

Based on the above, the Operational Budget Title3 was implemented at KEUR 80 505 in commitment appropriations (100%) and kEUR 57 657 (81%) in payment appropriations (both excluding the unused appropriations not required in the financial year). The payment appropriations' implementation is stable in comparison to previous years (78.6% in 2017, 82.3% in 2018 and 89% in 2019), with a decrease compared to 2019 which is mainly due to the non-payment of one pre-financing payment from the call 2020 (grant signature delayed to Q1 2021).

This Operational budget corresponds to approximatively 90% of the overall S2R JU Budget.

1.8. In-Kind Contributions

In accordance with article 4(3) of Council Regulation (EU) No 642/2014 of 16 June 2014 (hereinafter the S2R Regulation), "t*he members of the S2R Joint Undertaking other than the Union shall report by 31 January each year to the Governing Board of the S2R JU on the value of the contributions referred to in paragraph 2 made in each of the previous financial years*".

Article 4(2) of the S2R Regulation establishes that the total contribution to be provided by the Other Members[28] and totalling EUR 470 million shall consist of:

IKOP[29] **(in-kind operational)**: at least EUR 350 million, including at least EUR 200 million from the founding members other than the Union and their affiliated entities, and at least EUR 150 million from associated members and their affiliated entities. In accordance with Article 16(3)b of the S2R Statutes, IKOP consists "*of the costs incurred by them [the Other Members] in implementing indirect actions less the contribution of the S2RJU and any other Union contribution to those costs*".

IKAA (in-kind other activities): of at least EUR 120 million, of which at least EUR 70 million from the founding members other than the Union and their affiliated entities, and at least EUR 50 million from associated members and their affiliated entities. These contributions shall consist of the costs incurred by them in implementing additional activities outside the work plan of the S2R Joint Undertaking, which are complementary to this work plan and contribute to the objectives of the S2R Master Plan. Other Union funding programmes may support those costs in compliance with the applicable rules and procedures. In such cases, Union financing shall not substitute for the in-kind contributions from the members other than the Union or their affiliated entities.

The aforementioned In-Kind Contributions, which consist of financial expenditure executed by the Members – salaries, assets, operations, etc. – to achieve the S2R Programme and its Projects, are in addition to the cash contribution of the Other Members to the 50% of the running costs of the JU.

[28] The "Other Members" consist of the Founding Members of the JU, with the exclusion of the Union, and the Associated Members.

[29] As laid down in Article 16(2) and Article 16(3)(b) of the Statutes.

Other Members' reporting for 2020

The Other Members of S2R submitted their reporting on IKOP and IKAA to the JU by 31 January 2021 with the exception of 3 Members (EUROC, SmartRacon and SNCF).

The Lighthouse projects are excluded from this reporting as assimilated to open calls and within the administrative management of the European Commission.

This report covers IKOP related R&I activities as from Sept 2016 till Dec 2020; in terms of IKAA the activities are considered eligible as from the date of acceptance by the Other Members of the S2R JU Statutes, by means of their respective letters of endorsement.

In accordance with Article 4(4) of the S2R Regulation, the Other Members shall have the costs related to IKOP and IKAA certified by an independent external auditor appointed by the entity concerned.

IKOP and IKAA Certification

By 30 April 2020, the Other Members have provided the JU with audit certificates on the IKOP and IKAA costs declared for the year 2019[30]. After due examination of the relevant certification and, in particular, the audit standards applied to the issuance of the "audit certificates", the acceptable corresponding IKOP contributions have been "validated" by the Executive Director and will therefore be accounted towards the obligation set in Article 4(2) of S2R Regulation to the Other Members as well as recorder as Net Assets of the Joint Undertaking in the Annual Accounts 2020.

With regard to the Final Annual Accounts of S2R, all IKOP contribution reported but not validated in 2020 will be accounted for "to be validated" considering that:

- 65% of the IKOP reported "to be validated" is supported by the relevant certification; the rest is expected to be certified by year end;
- in accordance with the accounting principles, IKOP of year n-1 will be accounting for only in year n accounts, if and once validated in year n.

Additional information

IKOP

The progress and acceleration realized since the end of 2016 is confirmed and is well in line with the usual Programme Management S-Curve (with 52% of linear time consumed since September 2016 and with 62.3% of the IKOP objective reported).

As indicated under the definition of IKOP, these costs represent the difference between the Total Project Value and the S2R JU co-funding (or estimated).

The 2020 IKOP is the cumulative result of the activities awarded by the S2R JU to the Other Members:

[30] Following the COVID-19 outbreak and the request received from some Members to have their annual audit certificates provided later in the year, the JU has accepted to extend the deadline for some of them and based on justification provided. More than half of the Members submitted the audit certificates by 30 of April. The others did between May and November 2020. Consequently, all the Members have complied with their obligations and the reported figures are available in the section 1.11 of the present document.

EUR million	R&I activities			
	awarded and signed	realized		%
	Sept 16 - Dec 20	2020	Sept 16 - Dec 20	
Total Value	**616.6**	**110.3**	**356.4**	*57.8%*
S2R co-funding	271.3	38.5	141.4	*52.1%*
IKOP	**345.3**	**71.8**	**215.1**	***62.3%***

In order to allow the S2R JU to be in the position to sign the relevant grant agreements, the Union provided the necessary Commitment Appropriations to match the S2R co-funding of EUR 271.3 million above (excluding OC), against the Other Members' commitment of EUR 616.6 million. In terms of Union Payment Appropriations, they were used to provide the pre-financing up to 45% till 2019 and 55% for the call 2020 (to maintain cash flow in the current economic negative situation created by the C-19 pandemic) of the estimated funding in accordance with the relevant provisions of the grant agreements.

It should be noted that the estimated requested co-funding included in the 2020 Other Members' declarations is within the limits of the provision of the relevant Membership Agreements. In fact, Article 2.2 of each Other Member's Membership Agreement signed with the S2R JU establishes that "*the Member agrees to limit its reimbursement request in indirect actions funded under Article 3(1)(a) of the S2R JU Regulation to an amount not exceeding 44.44% of the Member's total eligible costs in implementing indirect actions. In case of research and innovation activities delivering the expected results through a series of intertwined actions throughout successive S2R JU Annual Work Plans, and without prejudice to the provisions concerning co-funding rates established in the S2R JU Annual Work Plans, this 44,44% threshold shall be applied cumulatively taking into account the final amount of reimbursement requested at the end of the last action implementing the specific intertwined research and innovation activities".*

The percentage resulting from the cumulative declarations in 2020 is 39.7%, within the maximum level of 44.44%.

However, it is to be noted that the intermediary reports of the following Members show the most important deviation with respect to an IKOP rate below 55.56%: Network Rail, Siemens, AZD Praha and EUROC.

This will be brought to the attention of the Governing Board for any remedial action to be taken and followed up by the S2R JU in 2021 and in any case will result in a grant final payment which will correspond in a cumulative rate not exceeding[31] 44.44% rate. The interim and final payments of the 2020 grants, which are participated by the listed members, will be reduce accordingly to match the target of 44.44%.

IKAA

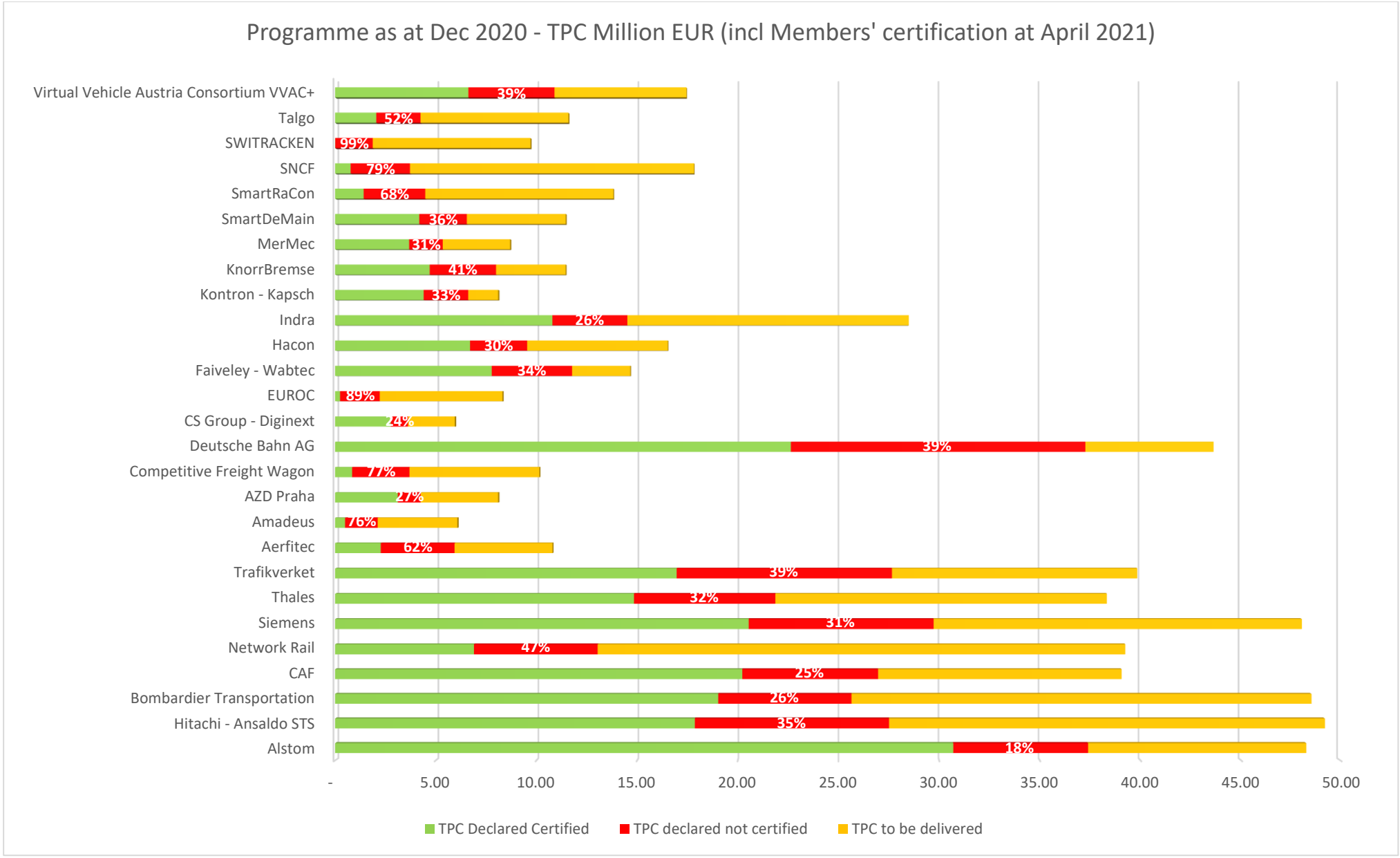
[31] In this respect, the Governing Board adopted Decision 16/2018 amending the Other Members' model Membership Agreement.

In terms of IKAA, the total expected contribution by the end of the S2R Programme is now estimated, subject to certification, at EUR 205.0 million, **71% above** the regulatory obligation of minimum EUR 120 million. Out of this amount, EUR 165.5 million were already certified at 1 May 2021.

On 1 May 2021, based on the audit certificates received and the Projects' cost statements, the situation of IKOP and IKAA is as following:

	TPC/IKOP REPORTING											
	TOTAL PROJECT COST				CO-FUNDING			IKOP				
Other Members	AAR 2016 - AAR 2019	AAR 2020	TOTAL	of which CERTIFIED	AAR 2016 - AAR 2019	AAR 2020	TOTAL	AAR 2016 - AAR 2019	AAR 2020	TOTAL	*Validated as Net Assets*	*To be validated*	*Deviance as per MA Art 2(2)*
Alstom	30,702,510	6,694,059	37,396,570	***30,701,775***	13,483,373	828,178	**14,311,551**	17,219,138	5,865,881	**23,085,019**	*19,258,929*	*3,826,090*	*38.27%*
Hitachi - Ansaldo STS	17,868,682	9,644,562	27,513,243	***17,868,681***	7,936,154	4,214,118	**12,150,272**	9,932,527	5,430,443	**15,362,971**	*9,943,152*	*5,419,819*	*44.16%*
Bombardier Transportation	19,055,148	6,591,177	25,646,324	***19,029,954***	7,857,582	2,780,735	**10,638,317**	11,197,565	3,810,442	**15,008,007**	*11,188,378*	*3,819,630*	*41.48%*
CAF	20,216,727	6,751,523	26,968,250	***20,224,220***	8,433,135	2,725,977	**11,159,112**	11,783,591	4,025,547	**15,809,138**	*11,991,610*	*3,817,528*	*41.38%*
Network Rail	7,758,689	5,279,258	13,037,947	***6,896,761***	3,946,104	2,220,978	**6,167,082**	3,812,585	3,058,281	**6,870,866**	*3,265,909*	*3,604,957*	***47.30%***
Siemens	20,711,843	9,013,030	29,724,874	***20,540,798***	9,179,206	5,069,332	**14,248,539**	11,532,637	3,943,698	**15,476,335**	*6,196,061*	*9,280,274*	***47.93%***
Thales	14,064,717	7,800,391	21,865,109	***14,844,676***	6,302,570	3,301,928	**9,604,498**	7,762,147	4,498,463	**12,260,610**	*726,210*	*11,534,401*	*43.93%*
Trafikverket	17,604,092	10,053,360	27,657,453	***16,964,663***	6,568,269	3,244,116	**9,812,384**	11,035,824	6,809,245	**17,845,068**	*10,789,395*	*7,055,673*	*35.48%*
Founding Members	**147,982,408**	**61,827,361**	**209,809,770**	**147,071,527**	**63,706,394**	**24,385,361**	**88,091,755**	**84,276,015**	**37,442,000**	**121,718,015**	**73,359,644**	**48,358,371**	
Aerfitec	2,795,095	3,140,229	5,935,324	***2,269,498***	1,242,140	1,290,242	**2,532,382**	1,552,955	1,849,987	**3,402,942**	*1,138,318*	*2,264,624*	*42.67%*
Amadeus	2,231,940	- 114,317	2,117,623	***498,185***	586,385	- 42,653	**543,731**	1,645,555	- 71,664	**1,573,891**	*267,999*	*1,305,893*	*25.68%*
AZD Praha	3,118,116	1,135,321	4,253,437	***3,118,116***	1,377,796	742,080	**2,119,876**	1,740,320	393,241	**2,133,561**	*1,740,320*	*393,241*	***49.84%***
Competitive Freight Wagon	2,837,289	857,366	3,694,655	***845,407***	1,276,437	332,398	**1,608,835**	1,560,852	524,968	**2,085,820**	*470,508*	*1,615,312*	*43.54%*
Deutsche Bahn AG	22,636,478	14,624,506	37,260,983	***22,636,478***	6,417,891	1,714,147	**8,132,038**	16,218,586	12,910,359	**29,128,946**	*16,722,109*	*12,406,837*	*21.82%*
CS Group - Diginext	2,763,151	859,182	3,622,333	***2,763,151***	1,227,944	379,425	**1,607,369**	1,535,207	479,757	**2,014,964**	*1,548,808*	*466,156*	*44.37%*
EUROC	2,213,642	6,623	2,220,265	***251,079***	961,547	161,088	**1,122,634**	1,252,095	- 154,465	**1,097,630**	*116,540*	*981,090*	***50.56%***
Faiveley - Wabtec	7,889,793	3,879,224	11,769,016	***7,780,063***	3,129,287	1,311,475	**4,440,763**	4,760,505	2,567,748	**7,328,254**	*4,272,821*	*3,055,433*	*37.73%*
Hacon	6,702,395	2,836,003	9,538,398	***6,702,395***	2,978,249	1,164,030	**4,142,279**	3,724,146	1,671,973	**5,396,118**	*3,725,253*	*1,670,866*	*43.43%*
Indra	10,785,129	3,730,360	14,515,489	***10,794,700***	4,788,442	1,442,876	**6,231,319**	5,996,687	2,287,483	**8,284,170**	*6,213,767*	*2,070,403*	*42.93%*
Kontron - Kapsch	4,401,138	2,213,931	6,615,069	***4,401,138***	1,955,865	851,703	**2,807,568**	2,445,273	1,362,228	**3,807,501**	*2,445,273*	*1,362,228*	*42.44%*
KnorrBremse	4,699,186	3,294,110	7,993,296	***4,699,186***	1,916,680	1,107,122	**3,023,802**	2,782,506	2,186,988	**4,969,494**	*2,777,554*	*2,191,940*	*37.83%*
MerMec	3,562,328	1,787,469	5,349,797	***3,678,895***	1,582,444	729,655	**2,312,099**	1,979,884	1,057,814	**3,037,698**	*2,076,283*	*961,415*	*43.22%*
SmartDeMain	4,372,314	2,172,424	6,544,738	***4,183,592***	2,057,887	695,160	**2,753,047**	2,314,427	1,477,264	**3,791,691**	*117,658*	*3,674,033*	*42.07%*
SmartRaCon	4,248,640	228,360	4,477,000	***1,419,483***	1,691,831	139,885	**1,831,716**	2,556,809	88,475	**2,645,284**	-	*2,645,284*	*40.91%*
SNCF	2,938,702	779,440	3,718,142	***773,736***	1,457,021	158,619	**1,615,640**	1,481,680	620,821	**2,102,501**	-	*2,102,501*	*43.45%*
SWITRACKEN	1,139,331	728,382	1,867,712	***10,322***	495,281	305,063	**800,344**	644,049	423,319	**1,067,368**	*38,537*	*1,028,831*	*42.85%*
Talgo	2,048,561	2,194,991	4,243,553	***2,048,561***	1,043,437	360,417	**1,403,854**	1,005,124	1,834,575	**2,839,699**	*1,006,596*	*1,833,103*	*33.08%*
Virtual Vehicle Austria Consortium VVAC+	6,771,219	4,125,286	10,896,505	***6,621,353***	2,958,664	1,302,055	**4,260,718**	3,812,555	2,823,231	**6,635,786**	*3,904,401*	*2,731,385*	*39.10%*
Associated Members	**98,154,444**	**48,478,889**	**146,633,333**	**85,495,340**	**39,145,229**	**14,144,784**	**53,290,014**	**59,009,215**	**34,334,105**	**93,343,320**	**48,582,744**	**44,760,575**	
Total	**246,136,853**	**110,306,250**	**356,443,103**	**232,566,867**	**102,851,623**	**38,530,146**	**141,381,769**	**143,285,230**	**71,776,104**	**215,061,334**	**121,942,388**	**93,118,946**	**39.66%**

	IKAA REPORTING			
Other Members	**In-Kind Additional Activities as at 30 September 2020***	**In-Kind Additional Activities as at 30 April 2021**	**TOTAL**	***of which Certified as at 30 April 2020***
Alstom	11,912,418	-	**11,912,418**	*11,912,418*
Hitachi - Ansaldo STS	5,062,272	2,083,589	**7,145,861**	*5,794,531*
Bombardier Transportation	15,688,168	-	**15,688,168**	*15,688,168*
CAF	8,946,296	-	**8,946,296**	*8,946,296*
Network Rail	2,220,203	-	**2,220,203**	-
Siemens	8,100,000	2,850,000	**10,950,000**	*10,950,000*
Thales	7,865,105	-	**7,865,105**	*7,865,105*
Trafikverket	25,159,312	-	**25,159,312**	-
Founding Members	**84,953,774**	**4,933,589**	**89,887,363**	***61,156,518***
	0			
Aerfitec	2,331,032	237,416	**2,568,448**	*1,848,984*
Amadeus	17,496,678		**17,496,678**	*17,496,678*
AZD Praha	1,600,558	1,251,642	**2,852,200**	*2,852,200*
Competitive Freight Wagon	631,132		**631,132**	*141,239*
Deutsche Bahn AG	29,084,129		**29,084,129**	*29,084,129*
CS Group - Diginext	990,000	206,244	**1,196,244**	*530,000*
EUROC	3,880,016		**3,880,016**	-
Faiveley - Wabtec	4,562,939	156,274	**4,719,214**	*4,562,939*
Hacon	13,992,866	3,617,511	**17,610,377**	*17,610,377*
Indra	2,646,140	2,078,273	**4,724,412**	*2,552,140*
Kontron - Kapsch	3,653,879	326,956	**3,980,835**	*3,653,879*
KnorrBremse	9,293,079	53,585	**9,346,664**	*9,346,665*
MerMec	2,246,245	320,000	**2,566,245**	*2,566,245*
SmartDeMain	2,982,376	511,345	**3,493,721**	*2,782,822*
SmartRaCon	992,453		**992,453**	*553,618*
SNCF	934,632		**934,632**	*404,414*
SWITRACKEN	211,892		**211,892**	*2,461*
Talgo	2,886,321	20,000	**2,906,321**	*2,906,321*
Virtual Vehicle Austria Consortium VVAC+	5,886,907		**5,886,907**	*5,403,795*
Associated Members	**106,303,275**	**8,779,247**	**115,082,522**	***104,298,907***
Total	**191,257,048**	**13,712,836**	**204,969,885**	**165,455,425**


Programme as at Dec 2020 - TPC Million EUR (incl Members' certification at April 2021)
Virtual Vehicle Austria Consortium VVAC+
Talgo
SWITRACKEN
SNCF
SmartRaCon
SmartDeMain
MerMec
KnorrBremse
Kontron - Kapsch
Indra
Hacon
Faiveley - Wabtec
EUROC
CS Group - Diginext
Deutsche Bahn AG
Competitive Freight Wagon
AZD Praha
Amadeus
Aerfitec
Trafikverket
Thales
Siemens
Network Rail
CAF
Bombardier Transportation
Hitachi - Ansaldo STS
Alstom
39%
52%
99%
79%
68%
36%
31%
41%
33%
26%
30%
34%
89%
24%
39%
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26%
35%
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5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
TPC Declared Certified
TPC declared not certified
TPC to be delivered

1.9. Synergies with the Union Programmes, Funds and national funded R&I

During the first months since its autonomy, the S2R JU started some activities and participated to Regional events organized by the Committee of the Regions and European Economic and Social Committee to consider how to make use of activities planned in other Union Programmes and Funds in relation with the Railway sector, in particular EFSI, Regional and Cohesion Fund. This work stream further developed during 2020.

In terms of national funded R&I activities in the Railway sector, the S2R JU invites the relevant Member States to present their programmes and projects in the context of the meetings of the SRG. This allows discussion on ways to interconnect the different activities and ensure that resources are leveraged to achieve the best results. This is an ongoing process, which becomes increasingly relevant in view of standardisation processes and market uptake.

During 2020, the ongoing work on collaboration agreements, in the form of a Memorandum of Understanding (MoU) or cooperation agreement, which the S2R JU may sign with various European regions and Member States, European and international organizations and bodies was pursued.

In particular, the negotiations with the Basque Region were successfully concluded and a MoU was signed on 22 January 2020.

This was followed by the signature of two additional Memoranda in October: during the Shift2Rail Innovation Days, on 23 October, a Memorandum of Understanding was signed with the Canadian Urban Transit Research & Innovation Consortium (CUTRIC), a non-profit innovation consortium whose vision is to make Canada a global leader in low-carbon smart mobility, by focusing on technology development, integration and standardisation vis-à-vis low-carbon propulsion systems, smart vehicle systems, data-driven analytics in mobility, and cybersecurity in transportation.

Moreover, the signature of a Memorandum of Understanding with the Permanent Secretariat of the Transport Community took place on Monday 26 October, during the Transport Community Ministerial Meeting. The Transport Community is an International Organization established by the Treaty establishing the Transport Community that was signed on 9 October 2017 and comprises the European Union and the South East European Parties being the Republic of Albania, Bosnia and Herzegovina, the Republic of North Macedonia, Kosovo, Montenegro and the Republic of Serbia.

In addition, the JU also further explored synergies with other JUs. The collaboration with the Fuel Cell and Hydrogen (FCH) Joint Undertaking started in 2018, with the co-tendering of a Study on the use of Fuel Cells and Hydrogen in the Railway Environment. This resulted in three reports being jointly presented and published on the respective websites[32]. The cooperation FCH JU / S2R JU came to the attention of the European Parliament and led to a joint presentation, notably on February 4th during the 11th European Innovation Summit in the EP conference session “Shift2Rail, Shift2Green”. Due to COVID a panel on “hydrogen in traffic” planned for 16th March in the European Parliament has been postponed to 2021.

This collaboration sets the basis for the future alignment of the respective programmes in view of the hybridization of rail systems making use of the FCH technologies.

Furthermore, because of this identified synergy and following the study recommendations for R&I, FCH JU inserted in their AWP2020 a R&I call on Extending the use cases for FC trains through innovative

[32] https://shift2rail.org/publications/study-on-the-use-of-fuel-cells-and-hydrogen-in-the-railway-environment/

designs and streamlined administrative framework, as Innovation Action with a funding of maximum 10 million euros.

The S2R JU enhanced its collaboration with the SESAR JU on the matters related to traffic management and functional system architecture, inviting the experts to present their approaches in the S2R project Linx4Rail which aims to create an innovative rail functional system architecture.

The S2R Programme Office and Executive Director also regularly exchanged best practices and ideas for future synergies mainly with SESAR JU and CleanSky JU at programme level and with all other JUs at administrative level.

In terms of synergies with other Union Programmes, the S2R JU works closely with the other Joint Undertakings sharing the same building, infrastructure, etc. maximising the opportunity for collaboration in terms of administrative and operational activities.

1.10. Launch of Calls for Proposals and Tenders during 2021

On 19 November 2020, the S2R GB adopted the AWP 2021 and budget that resulted from the work performed by the JU with its Members, partners and Bodies during large part of 2020. The focus of the work in 2021 will be on delivering the programme activities/

On a proposal of the Executive Director, at its meeting in March 2021 the Governing Board agreed to launch a final call in 2021.

2. SUPPORT TO OPERATIONS

2.1. Communication activities

The S2R JU continued to promote the activities of the programme during 2020, while adapting to the challenges imposed by the Covid-19 pandemic. Shift2Rail communication activities in 2020 were focused on the continued promotion of the S2R programme, and bringing as much visibility as possible to the results of its R&I activities. Promotion of the 2020 Call for Proposals was as usual a major focus of the yearly communication activities, with regional information days held in different European capitals, including Vienna, Ankara and Prague at the beginning of the year. The 2020 Call for Proposals was widely promoted through Shift2Rail's website, newsletter and social media channels, and this promotional content was successfully re-shared by Members and partners as well as reported on in the press (see Annex E).

While most physical meetings and events were cancelled, S2R JU held a series of online events throughout the year and created a dedicated webinar library on its website (https://shift2rail.org/webinars/). These webinar recordings have also been made available on Shift2Rail's YouTube channel. Additionally, S2R JU staff participated to numerous online meetings and events throughout the year.

In parallel to the key events organised and participated in by Shift2Rail during 2020, the JU continued to build its audience and stakeholder mailing list by revamping its website and consolidating its presence on social media. Moreover, press relations were also strengthened in 2020 resulting in a significant media presence in specialised rail press (particularly in the Railway Gazette, International Railway Journal, Global Railway Review, and Railway Pro – all press articles are listed in Annex E). For

more detailed information and statistics covering Shift2Rail's communication channels please refer to the dedicated section 2.1.2.

During 2020, Shift2Rail published 4 publications: The Multi-Annual Action Plan, the Annual Activity Report 2019, the updated Shift2Rail Factsheet, and the Innovation in Action brochure. The consolidated edition of Multi-Annual Action Plan (MAAP) was a key communication output in 2020. The publication consists of two parts – Part A and Part B and gives a detailed overview of Shift2Rail's research and innovation programme, including a demonstration plan for the various technology demonstrators in the years to come. Part A provides an executive view of the updated Multi-Annual Action Plan, clarifying the S2R vision and its contribution to delivering EU societal goals; it identifies the associated set of 12 new capabilities that S2R will help the railway to develop and bring to market. Part B introduces a demonstration plan for the various technology demonstrators and incorporates new ideas, solutions and technologies that have become relevant for the S2R Programme since the last edition of the MAAP. It also summarises the major demonstrations and technological developments resulting from the research and innovation work.

The JU's visual identity was updated in 2020 to give it a greener and smarter look in alignment with the European Green Deal, reinforcing the message that rail is an important means through which to reach its goals. The updated logo retains the main elements of the original logo to ensure it is recognisable, while giving it a relevant, modern look.

On 23 December 2020, the European Parliament and the Council of the European Union adopted the Decision to designate 2021 as the European Year of Rail. Shift2Rail is a member of the #EUYearOfRail taskforce together with colleagues from the European Commission's DG MOVE and has been working on the preparation of the year together with stakeholders since February 2020. A teaser video promoting the European Year of Rail was produced by S2R JU and launched on 21 October during the European Week of Regions and Cities. A longer video has been also developed for further dissemination in 2021. Several events are also being planned for the upcoming year, including a hackathon for young people and startups as well as the next edition of the Shift2Rail Innovation Days.

All event and communication activities were supported under the Shift2Rail Communication Framework Contract implemented by 20 Seconds to Midnight.

In 2020 the Shift2Rail Joint Undertaking (S2R JU) made additional efforts to ensure that relevant stakeholders are aware of its mission, activities and achievements, by taking the following measures:

1. **Promotion of Shift2Rail's 2020 Call for Proposals**: Following the Info Day it held in December 2019, S2R ensured the launch of the Call was effectively communicated to all relevant stakeholders in January 2020, including stakeholders across the entire railway value chain, with a particular attention to SMEs, research and technology centres and universities. Subsequently, the Call's participation and final results were also widely promoted through all S2R corporate channels, primarily through digital means due to the pandemic.

2. **The first edition of the Shift2Rail Innovation Days** ensured that the progress of the programme was shared with a wide range of stakeholders on 23-24 October 2020. More than 700 participants had the opportunity to hear about rail's crucial role in the mobility and transport recovery effort, as well as recent developments with regard to Shift2Rail's successor and the upcoming European Year of Rail in 2021.
   The Innovation Days were an opportunity to hear from high-level representatives from the European Commission, including European Commissioner for Transport, Adina Vălean, and from S2R Members and partners about rail's crucial role in the mobility and transport recovery

efforts, Shift2Rail's successor and the European Year of Rail in 2021. A hybrid format was chosen, comprising live studio sessions and Zoom webinars. Several sessions about S2R's Innovation Programmes dedicated to running projects were held. Furthermore, a virtual exhibition area was on display throughout the event allowing visitors to see the latest developments of the technological demonstrators.
Shift2Rail also used this occasion to launch the Unique Train Prize

3. **The organisation and participation in specific activities, workshops and events** (mainly through virtual means) in order to promote the S2R Programme participation and inform about the achievements of the S2R JU Partnership worldwide. One example is the ALICE and Shift2Rail workshop on Freight customers' needs held on 13 February 2020, in Vienna, where rail freight customers gathered to express their needs to selected stakeholders from the rail industry and supply chain. The workshop facilitated a better understanding of what is expected from the railway system to meet client expectations, so that approaches and solutions can be delivered through targeted research and innovation. The conditions imposed by the pandemic also created new opportunities to reach more interested stakeholders online and to engage with them in relation to our work. A webinar library was also developed on the S2R website to meet the need for a central hub for the various webinars Shift2Rail hosted and participated to during this year of intense online event activity. A full list of events organised and participated in by Shift2Rail to ensure stakeholder engagement is available in section 2.1.1. and Annex E of the Annual Activity Report 2020.

4. **The European DAC Delivery Programme**, launched at the end of 2020 and enabled by Shift2Rail, offers a unique European platform for cooperation and collaboration between railway undertakings, infrastructure managers and wagon keepers, as well as the rail supply industry, entities in charge of maintenance, concerned sector organisations, rail research centres and national and European political institutions. The programme is aimed at building upon R&I results and pilots to ensure the necessary actions for a fast, technically and economically feasible European-wide roll-out. A dedicated area of the website was created for the newly established European DAC Delivery Programme, and Shift2Rail is working closely with the dedicated dissemination group to ensure effective communication of this initiative, open to all interested stakeholders, that has already received significant media attention.

5. **The Decision to designate 2021 as the European Year of Rail** was adopted on 23 December 2020 by the European Parliament and the Council of the European Union. Shift2Rail is a member of the #EUYearOfRail taskforce together with colleagues from the European Commission's DG MOVE and has been working on the preparation of the year together with stakeholders since February 2020. A teaser video promoting the European Year of Rail to citizens was produced by S2R JU and launched on 21 October during the European Week of Regions and Cities as well as during the Shift2Rail Innovation Days later the same month. Several targeted events are also currently being planned in 2021 under the European Year of Rail:
    a. Shift2Rail exhibition coach and related participation at events throughout the Connecting Europe Express' journey across Europe, visiting 26 countries in 36 days from 2 September – 7 October 2021 –> Stakeholders targeted: European citizens, the rail sector, national and European policy makers;
    b. Shift2Rail welcoming event and high-level panel for the arrival of the Connecting Europe Express in Brussels on 4 October 2021 –> Stakeholders targeted: High-level participants from the rail sector, national and European policy makers;
    c. Shift2Rail and Siemens Hackathon –> Stakeholders targeted: Startups and young people

d. 2021 edition of the Shift2Rail Innovation Days –> Stakeholders targeted: The rail sector, national and European policy makers, and European citizens

6. **Targeted communication through Shift2Rail corporate channels** has allowed the JU to continue to build its audience and stakeholder mailing list. In 2020 this included revamping the S2R website and strengthening the S2R presence on social media. The S2R JU increased its online presence significantly and dedicated time and resources to improve the content and frequency of its posts across its social media accounts – Twitter, LinkedIn, Facebook, YouTube – to engage with the rail community, aiming to constantly inform established stakeholders while also reaching out to new interested stakeholders in order to ensure a growing audience for Shift2Rail activities. In 2020, the average number of tweets per month was 35, while in 2019 the average number was 25, showing a significant increase in social media activity. Moreover, Shift2Rail has also increased its presence on its YouTube channel. Efforts have been made to publish videos showing our innovations as well as recordings of our online events to ensure that even those who were unable to join can access the content.
   Moreover, press relations were also strengthened in 2020 resulting in a significant media presence in specialised rail press (particularly in the Railway Gazette, International Railway Journal, Global Railway Review, and Railway Pro). More detailed information and statistics covering Shift2Rail's communication channels are available in section 2.1.2. of the Annual Activity Report, and all press articles are listed in Annex E.

7. **Increased communication partnerships with DG MOVE, DG RTD, ERA, INEA and other EU-institutions** progressed in 2020 and have been further consolidated in 2021 under the European Year of Rail. This has included the sharing of editorial plans and outputs for mutual dissemination through corporate channels, helping to spread and reinforce the Union's policy objectives in the mobility and transport area.

8. **Providing access to public information on the ongoing process for the Shift2Rail Successor, Europe's Rail** via a new dedicated web page on the S2R website, in agreement with the European Commission and following requests from the sector stakeholders.

9. **Stakeholder management and external relations** have been maintained through a close collaboration with the European Union Agency for Railways (ERA) in different areas, with the European Railway Research Advisory Council (ERRAC), as well as with the different International and European organizations and associations. A continuous and constructive exchange took place with other Union bodies and agencies, such as GSA, FCH JU, SESAR JU, CleanSky JU, EASA and others.

10. **Cooperation in Member States as well as with international parties** was also increased in 2020:
    a. On 22 January 2020, the S2R JU signed a Memorandum of Understanding (MoU) with the Basque Region during the Basque Railway 2020 conference in San Sebastián, bringing together over 400 rail professionals from across the sector. The objective of this new cooperation is to identify common priorities and potential synergies between the funding instruments that are available at the European Union, national and regional levels to move rail Research & Innovation forward and crucially promote market deployment.
    b. During the Shift2Rail Innovation Days on 23 October 2020, an MoU was signed with the Canadian Urban Transit Research & Innovation Consortium (CUTRIC), a non-profit innovation consortium whose vision is to make Canada a global leader in low-carbon smart mobility, by focusing on technology development, integration and

standardisation vis-à-vis low-carbon propulsion systems, smart vehicle systems, data-driven analytics in mobility, and cybersecurity in transportation.

c. The signature of a Memorandum of Understanding with the Permanent Secretariat of the Transport Community took place on Monday 26 October, during the Transport Community Ministerial Meeting. The Transport Community is an International Organization established by the Treaty establishing the Transport Community that was signed on 9 October 2017 and comprises the European Union and the South East European Parties being the Republic of Albania, Bosnia and Herzegovina, the Republic of North Macedonia, Kosovo, Montenegro and the Republic of Serbia.

2.1.1. Events

The S2R JU participated in a number of institutional events (i.e. led by the European institutions), external and internal meetings and conferences, as well as webinars. Due to the COVID-19 pandemic, major events have been postponed to 2021 or 2022 or cancelled, including Innotrans and TRA.

Nevertheless, the conditions imposed by confinement created new opportunities to reach more interested stakeholders online and to engage with them on our work.

Institutional events

EUvsVirus Hackathon and Matchathon – 24-26 April 2020, online

The European Commission, led by the European Innovation Council and in close collaboration with the EU member states, hosted a Pan-European Hackathon and Matchathon to connect civil society, innovators, partners and investors across Europe in order to develop innovative solutions for coronavirus-related challenges. The Shift2Rail JU staff took actively part in the Matchathon. For 48 hours, 1,264 international teams, developed ideas around health, transport as well as business continuity challenges, to bring breakthrough responses to a global pandemic. Shift2Rail widely promoted the event through all communication channels.

European Research and Innovations Days - 22-24 September 2020, online

The R&I Days brought together thousands of participants who benefitted from high-level discussions about the future research and innovation landscape. Shift2Rail's project Ter4Rail had a stand at the 'Science if Wonderful!' exhibition with live sessions four times a day. Additionally, Shift2Rail's Head of Administration and Finance participated to a debate dedicated to lump sum.

European Week of Regions and Cities – 20-21 October 2020, online

During the 18th European Week of Regions and Cities, Shift2Rail co-organised two online rail events with the European Commission's Directorate-General for Mobility and Transport. We discussed how rail connects regions and generates growth and opportunities. The first session titled 'Workshop on the role of rail for a smart & green recovery' focused on the needs of the regions and railway systems of the future, the promotion of transport and tourism in remote regions, safety, jobs and skills in the rail sector, in anticipation of the European Year of Rail 2021.
The second session titled 'Exhibitor's pitch on the regions' role in the European Year of Rail' demonstrated how the rail community will play a major role in driving sustainable mobility by highlighting Shift2Rail's R&I results and plans for the European Year of Rail, aimed at delivering a

climate-neutral mobility and transport system for European citizens and businesses, with a special focus on regions' and cities' active participation.

European Green Week – 19-23 October 2020, online

Shift2Rail participated to the European Green Week. As a partner of the initiative, Shift2Rail widely promoted the event through all communication channels to reinforce the message of rail as a sustainable and green mode of transport. Shift2Rail's Innovation Days was also branded as a partner event of the campaign, receiving high visibility on the European Green Week's website.

Joint Social Media campaign of the Joint Undertakings

For the first time, a coordinated social media campaign was organised by all Joint Undertakings to showcase why Europe needs Joint Undertakings and the value they bring to society. The social media campaign was built around the common key messages formulated jointly by the JUs and published in the Innovation in Action brochure. Additionally, Shif2Rail used the campaign to promote rail-specific key messages to its audience. The social media campaign was organised to promote the value of Joint Undertakings to the European Parliament in particular, during a year when the successor programmes were being intensely debated. The campaign was moved online as the onsite event at the European Parliament originally foreseen was unable to take place due to the pandemic.

1st Hydrogen Inter-Partnership Assembly Meeting – 9 December, online

The European Commission organised the first meeting of inter-partnerships for discussing hydrogen applications and R&I. Shift2Rail Joint Undertaking was represented by the Head of Research and Innovation who presented the excellent collaboration with FCH JU started in 2018 and resulting in a common study of market applicability of fuel cells to hydrogen applications. Following the published results in 2019, FCH JU launched a call for proposal in 2020 addressing through R&I the bottlenecks identified in the common study.

S2R JU events

Shift2Rail Innovation Days – 22-23 October, 2020, Brussels, Belgium and online.

The Shift2Rail Innovation Days brought together over 700 participants and were an opportunity to hear from high-level panellists about rail's crucial role in the mobility and transport recovery effort, Shift2Rail's successor, the European Year of Rail in 2021, and much more.

The event focused on the big issues facing the future of rail, featuring high-level representatives from the European Commission, as well as participation from our Members and partners across Europe. The varied programme allowed the European railway community the chance to come together to discuss the challenges and opportunities that lie ahead for the rail sector.

The welcome address was delivered by Adina-Ioana Vălean, Commissioner for Transport, who highlighted Shift2Rail achievements so far, the key objective of transferring innovations to the market and the 3 new priorities for the next Shift2Rail programme: automation, digitalisation and freight.

Around 650 participants got first-hand access to the latest results coming from across Shift2Rail's Innovation Programmes in sessions dedicated to our running projects.

A virtual exhibition area was developed allowing participants to see Shift2Rail's latest technological demonstrators and the progress we are making in bringing innovative solutions to the market.

The event was also used as the occasion to launch the Unique Train Prize which aims to develop an innovative solution that will allow tracking all commercial freight trains, from all railway undertakings, covering the whole European network.

Additionally, during the event Shift2Rail signed a Memorandum of Understanding with the Canadian Urban Transit Research & Innovation Consortium (CUTRIC).

ALICE and Shift2Rail workshop on Freight customers needs ***– 13 February 2020, Vienna, Austria***

During the ALICE (Alliance for logistic innovation in Europe) event on "Roadmap Towards Physical Internet as well as the PI implementation monitoring" priorities for research & innovation were also discussed. S2R participated and co-organised a dedicated interactive workshop session gathering rail freight customers in expressing their needs and issues with selected stakeholders from the rail industry and supply chain. The workshop was facilitated by the Shift2Rail's Executive Director, Head of Research and Innovation and IP5 Programme Manager resulting in a better understanding of what is expected from the railway system to meet client expectations, so that approaches and solutions that can be delivered through targeted research and innovation.

Shift2Rail Freight Rail Innovation workshop ***– 7 October 2020, online***

Shift2Rail organised a focused discussion that will contribute to shaping our R&I agenda, involving key representatives of the logistic value chain, from the end users to the service providers. The workshop was designed as a collaborative online discussion, facilitated by the S2R's Head of Research and Innovation and the IP5 Programme Manager, following up the key customer requirements identified during the previously organised Vienna's workshop. This workshop concluded on prioritised requirements and potential services, solutions and technologies that will enable rail freight to achieve the desired modal shift.

Webinar: Shift2Rail innovations from the travellers' perspective ***– 12 May 2020, online***

The Shift2Rail JU organised a webinar investigating the traveller's perspective on door-to-door travel. The webinar brought together around 200 participants from across Europe and beyond and demonstrated the current results of key projects working under Shift2Rail's Innovation Programme 4, dedicated to digital services facilitating mobility as a service in rail. The webinar explored multimodal journey planning, offer building, booking, issuing, ticketing, validation and location-based experiences from the travellers' perspective.

Webinar: Shift2Rail innovations from a transport service provider's perspective ***– 14 May 2020, online***

The Shift2Rail JU organised a webinar investigating the transport service provider's perspective on door-to-door travel. The webinar brought together around 150 participants from across Europe and beyond and demonstrated the current results of key projects working under Shift2Rail's Innovation Programme 4, dedicated to digital services facilitating mobility as a service in rail. The webinar explored multimodal journey planning, offer building, booking, issuing, ticketing, validation and location-based experiences from a transport service providers' perspective. Watch the recordings of the event here.

The Shift2Rail JU together with other entities organised **regional information days across Europe and beyond*:***

- **Austrian S2R Info Day: Shift2Rail JU together with representatives from Austria organised a regional information day** on 10 January 2020. Participants were able to find out about Shift2Rail Call for Proposals 2020.
- **French S2R Info Day:** On 14 January 2020 a French-language information session on the Shift2Rail 2020 Call for Proposals was hosted by Shift2Rail's associated member SNCF.
- **Turkish S2R Info Day:** A Shift2Rail regional Call for Proposals 2020 Information was organized by NCP Transport in Ankara on 22 January 2020. The event aimed to clarify the principles and practical aspects of the Shift2Rail JU 2020 Calls.
- **The Czech Republic S2R Info Day:** The event, co-organised by the Czech Ministry of Transport, took place on 10 February in Prague and introduced the Call for Proposals 2020 as well as discussed the recent developments in Czech railways.

External events

In 2020, the Shift2Rail JU participated to major rail, transport and research events, presenting concrete results achieved by Shift2Rail JU Members together with other key stakeholders. A selection of the most high-profile and relevant events are listed below, while a full list of external events can be found in Annex E.

"Shift2Rail, Shift2Green" of the 11th European Innovation Summit - 4 February, European Parliament, Brussels

The 11th European Innovation Summit was an event organised by Knowledge4Innovation - K4I addressing Horizon Europe including the future partnerships. The event will also be linked to the "Green Deal" and a session was organised on "Shift2Rail, Shift2Green" in order to discuss about the future rail partnership and future partnerships that could be connected to the rail one (e.g. future FCH partnership). Shift2Rail Head of Research and Innovation, Giorgio Travaini, presented in the European Parliament how through an R&I and a systemic approach to it, including decarbonisation, automation and digitalization, Europe can achieve over the goals of sustainability and attractiveness for passengers and freight connecting cities, regions, economic centres and beyond.

European Startup Prize for Mobility kick-off – 20 February, Berlin, Germany

As an Ecosystem Partner, Shift2Rail helped launch the 3rd edition of the European Startup Prize for mobility on 20 February in Berlin. Shift2Rail is sponsoring for the first time the third edition of the European Startup Prize for Mobility – a public-private initiative co-founded by the European Parliament's Transport and Tourism Committee Chairwoman, Karima Delli, Boston Consulting Group and Via ID. The competition is supported by both the European Parliament and the European Commission, as well as influential partners, and invites mobility startups from around Europe to participate. The aim of the prize is to recognize future mobility champions over the course of the competition.

OBB H2 closing event – 23 November, online

ÖBB held and event about the pioneer project in Austria, investigating the usage of hydrogen rail vehicles for passenger traffic has just finished. The project included three months of demonstration operations in passenger traffic with one hydrogen train on the ÖBB-Infrastruktur AG rail network. As

partners of the project, Shift2Rail participated to the project closing event on 23 November and talked about the current progress of the Shift2Rail programme with a particular focus on hybrid solutions for rail transport.

***CAE Conference* – 30 November, online**
Shift2Rail's Executive Director gave a keynote speech at the 36th International CAE Conference and Exhibition on 30 November 2020. Mr Borghini opened the Automotive and Transportation Session and spoke about the importance of digital innovation in transport. It was a great opportunity to find out more about the Shift2Rail contribution and the other technical sessions.

***RAIL LIVE 2020* – 1-2 December, online**
Rail Live 2020 took place on 1-2 December in a fully digital format. Shift2Rail's Executive Director Carlo Borghini moderated a panel to discuss creating infrastructure that can act as the pivot for the digitally connected transport industry of the future. Shift2Rail's IP4 Programme Manager participated to a panel discussion investigating how we can shape the future of mobility with end to end mobility services. Additionally, Shift2Rail had its own virtual exhibition stand at the event. It was an opportunity to find out more about the work we are doing and to get in touch with the Shift2Rail team.

***Canadian Smart Rail Technology Conference* – 13-14 November, online**
Shift2Rail's Executive Director participated to the Canadian Smart Rail Technology Conference on 13-14 November. It was a great opportunity to further discuss collaboration between Shift2Rail and CUTRIC following the Memorandum of Understanding recently signed at the Shift2Rail Innovation Days. Moreover, it was a chance to take the conversation further on how autonomous and connected technologies can make rail safer and faster.

***World Passenger Festival* – 18 November, online**

Shift2Rail's Head of Research and Innovation participated in the World Passenger Festival on 18 November in a panel debate on agile innovation and the role of technology in shaping the future of passenger experience. He helped answer the question 'What role will technology play in supporting the recovery of public transport operators around the world?'

***International Railway Summit* – 20 February, Warsaw, Poland**

Shift2Rail's Executive Director, participated in the 9th International Railway Summit in Warsaw, Poland on 20 February. He moderated a panel focusing on smart multimodality.

***Post-COVID: What will be the new normal for rail travel?* – 2 June, online**

Shift2Rail's Executive Director moderated a webinar titled Post-COVID: What will be the new normal for rail travel? The webinar was organised by the International Railway Summit and held on 2 June. The webinar answered may questions: "After the lockdown is lifted, will passengers come back? What are the medium- and long-term impacts for rail operators, governments, and the supply industry? What are the lessons to be learnt? How can the sector come out of the tunnel and continue the journey of growth we have seen in recent years?"

***ETNA 2020 Webinar: Transforming Europe's Rail System* – 9 June, online**

Shift2Rail's Executive Director Shift2Rail participated to an online event on Transforming Europe's Rail System, organised by ETNA 2020. It was an opportunity to discuss more about Shift2Rail's future under Horizon Europe.

***InnoTrans Business Days* – 24 September, online**

On 24 September Shift2Rail's Executive Director participated in an online business talk on the future funding for rail transport technology. It was an opportunity get an in-depth information about the future of rail research and innovation under Horizon Europe.

***Accelerating Railroad Transport in the Chemical Industry conference* – 15 September, online**

Shift2Rail's Executive Director participated to an online conference about Accelerating Railroad Transport in the Chemical Industry organised by Lineas. The Executive Director talked about Shift2Rail's role in innovation and digitisation of the rail industry in Europe.

***Transport Innovation Summit* – 21 September, online**

Shift2Rail also participated to the Transport Innovation Summit on 21 September focusing on Shift2Rail's R&I activities concerning rail freight, including the potential of digital solutions and how innovative technology can help create a modal shift.

XV Edition of the Annual Assembly of the Spanish Railways Technological Platform – ***26 November, online***

The XV Edition of the Annual Assembly of the Spanish Railways Technological Platform (PTFE) was organised online and Shift2Rail's Head of Research and Innovation, Giorgio Travaini, opened the annual Assembly with a presentation of Shift2Rail towards the next successor programme, highlighting also the main sector priorities as described in the High Level Sector Paper for Transforming Europe's Rail system as well as on the draft ERRAC Strategic Innovation Agenda.

2.1.2. Communication

Website

In 2020, the Shift2Rail website was enhanced with new content. A dedicated area of the website was created on the newly established European DAC Delivery Programme. Moreover, in agreement with the European Commission and following the requests from the sector stakeholders, a new web page was created to provide public relevant information on the ongoing process for the Shift2Rail Successor. A webinar library was also developed to meet the need for a central hub for the various webinars Shift2Rail hosted and participated to during this year of intense online event activity. Additionally, the 3D environment showcasing technical demonstrators developed for the Shift2Rail Innovation Days was permanently added to the website homepage.

These developments were mostly done in-house at short notice to meet needs in an efficient manner. A web development contract has been planned in early 2021 to request our communication framework contractor to improve the website's responsiveness in view of the new content added so as to maximize the website's user friendliness.

R&I content

Significant efforts and improvements have been made on the R&I content that a user can get from the S2R website. In January 2020, following the work done in 2019, the new Technological Demonstrators (TDs) View interface was launched. The updated website interface allows visitors to find information and public results (deliverables) on the concrete innovations co-funded by S2R through a new

Technical Demonstrator overview, allowing to see more clearly how Shift2Rail individual projects work together and how they nurture the TDs ambitions and allow the Programme progress beyond the state of the art..

Data protection

In cooperation with the ICT officer, legal officer, who is the JU's Data Protection Officer, and two contractors managing the shift2rail.org and projects.shift2rail.org domains, Shift2Rail's communication team continued to work on making the website compliant with the data protection regulation based on the instructions provided by the European Data Protection Supervisor. In 2020 we created a database for "online consent" and GPDR with automatic process that allows to unfollow/delete data. We ensured that the website platform and applications are compliant with the GDPR and EUDPR Regulations. In particular, our contractor ensured that a privacy management platform is used. Furthermore, the website cookie management was improved. All passwords were encrypted and a more secure method with unique hashed key and frequent backup was developed. A backup content database that is not on the same server as the website was created.

As a result of this work, Shift2Rail's website is considered compliant with the data protection regulation that also helped the domain to substantially improve its position in the EU Privacy Score Tool.

User statistics

Shift2Rail's website was visited by 91 073 unique visitors in 2020, which is a significant increase compared to 79 628 unique visits in 2019. Most visitors (44 825) were based in Europe, followed by North America (33 872 visitors) and Asia (6822 visitors). The largest number of visitors by country were based in the United States, followed by Germany, the United Kingdom, France and Spain. Shift2Rail's website was mostly visited by people using a personal computer (79,437 visitors), second most popular device being smartphone (10,275 visitors). A very low bounce rate (6%) on the Shift2Rail website indicates that visitors find the website content interesting and informative. Average time spent on the Shift2Rail website in 2020 was 3 minutes.

Newsletter

Since January 2020, Shift2Rail's Communication Team has been fully managing the production of the monthly newsletter, without relying on an external contractor, which has significantly improved efficiency and the team's flexibility in being able to respond to last minute news input from colleagues and external parties. The monthly newsletter offers readers an overview of the most important news and events, while giving visibility to our projects.

The 2020 editions continued to include more project news and results deriving from the Projects Communication Spreadsheet that is filled in by project coordinators and partners themselves. This not only gives visibility to projects but also helps to fill the newsletter with relevant and fresh content about the results coming from across the entire Shift2Rail R&I programme. Additionally, 2020 saw an increase of articles per newsletter. The average number of articles per newsletter has increased to 10 in 2020, in comparison to 8 in 2019.

The readership of the Shift2Rail newsletter has steadily increased throughout 2020 from 1,402 in January 2020 to 1,576 at the end of 2020, reaching +12.5%. Various factors have fed into the growth of the audience including Shift2Rail's participation to numerous events, improvements to the Shift2Rail website offering more visibility to the newsletter, more promotion of the newsletter by staff through their meetings and networks, and increased promotion of the newsletter and its individual articles on Shift2Rail's corporate social media channels.

Social media

In 2020 due to the COVID-19 pandemic the S2R JU increased its online presence significantly and dedicated time and resources to improve the content and frequency of its posts across its social media accounts – Twitter, LinkedIn, Facebook, YouTube – to engage with the rail community, aiming to constantly inform the already-converted while also reaching out to new interested stakeholders in order to ensure a growing audience for Shift2Rail activities. In 2020, the average number of tweets per month was 35, while in 2019 the average number was 25, showing a significant increase in social media activity.

The audiences Shift2Rail targets on social media depend on the channels. While on Twitter Shift2Rail is followed by a wide audience with different backgrounds, LinkedIn attracts a more specialised community interested rather in technical details and longer in-depth articles. Shift2Rail's Communication Team creates different content in order to tailor the message to these different audiences. On Twitter Shift2Rail shares daily events, short articles and posts illustrated with images and videos. On LinkedIn, however, the audience expects longer, more thought-provoking material including technical details about our innovations. While Twitter posts tend to be more popular, LinkedIn posts stimulate more online discussion, so these two channels complement each other very well ensuring we communicate at high and more granular levels.

Shift2Rail has also increased its presence on its YouTube channel. Efforts have been made to publish videos showing our innovations as well as recordings of our online events to ensure that even those who were unable to join, have access to the content.

Shift2Rail has increased the number of followers on all its social media channels during 2020. The largest increase in the number of followers was on LinkedIn where Shift2Rail got an impressive 1,500 new followers. The total number of followers on LinkedIn is now 4,156. LinkedIn therefore has the biggest audience out of all Shift2Rail's social media channels. On the other hand, Shift2Rail's Twitter account has 3,480 followers out of whom 570 started following the Shift2Rail account in 2020.

Throughout 2020, Shift2Rail has put more effort into long term social media planning to make sure that all relevant news is promoted through our social media platforms in a timely and effective manner. Shift2Rail also focused in 2020 on engaging more intensively with other relevant stakeholders on social media (DG MOVE, DG RTD, INEA and other EU-institutions; Members and key associations) that help to support the dissemination of Shift2Rail messages and vice-versa. We have had an especially successful collaboration with DG MOVE who have posted and re-shared Shift2Rail content on their Twitter account, which has 47,000 followers. This collaboration will be continued and further intensified in 2021 to promote the European Year of Rail.

In 2020, Shift2Rail also had at the heart of its strategy the promotion of Shift2Rail project results through its social media channels (see also section 1.1. Dissemination and information about projects results). Thanks to the collection tool developed by Shift2Rail, projects are able to directly propose content for organic or re-shared posts, through the Projects Communication Planning Sheet. This has proved a successful tool in providing fresh and up-to-date content to fuel S2R channels, allowing an increase in the number of posts and a larger visibility to our audience concerning what is happening on the ground to build the rail solutions of the future.

After the various events Shift2Rail organises or participates to, social media highlights are created to showcase the most successful tweets from Shift2Rail and participants' accounts. This gives our audience the possibility to get an overview of the opinions trending during the event and promotes

further engagement, acting as a complementary post-event communication tool to wrap-up videos and photo galleries.

Press

Shift2Rail published seven press releases in 2020, covering the Shift2Rail 2020 Call for Proposals, the establishment of the European DAC Delivery Programme, and the signing of Memorandums of Understanding with the Basque Country, CUTRIC, and the Permanent Secretariat of the Transport Community of the Balkans (full details of all press releases are available in Annex E).

In 2020, the S2R JU was featured in articles in a range of magazines, industry press and online media. Shift2Rail's Communication Team has continued to build relations with journalists and editors from different media outlets to find ways for cooperation and offer ideas for stories. Shift2Rail's Communication Team has created a directory of over 70 journalists who often publish Shift2Rail related content. Additionally, we have developed an especially fruitful collaboration with journalists from the Railway Gazette, International Railway Journal, RailTech, Global Railway Review and Railway Pro.

In addition to Shift2Rail's news about the Call for Proposals (which have also been widely covered in different media outlets in previous years), some of the most widely covered stories about Shift2Rail include the launch of the DAC Delivery Programme, the various MoUs signed in 2020 and the Shift2Rail Successor. Various articles about Shift2Rail featured in the media in 2020 were popular and these have been monitored and archived as well as featured in the monthly Shift2Rail newsletter.

In 2020, journalists have also been targeted by Shift2Rail on social media which has proved effective as well. The fact that the Programme continues to become better known and the interest in its results progressively increases is reflected in a broader media coverage of Shift2Rail compared to previous years.

2.2. Legal and financial framework

In 2020, the S2R JU legal framework refers predominantly to:

- Council Regulation (EU) N°642/2014 of 16 June 2014 establishing the Shift2Rail Joint Undertaking (OJ L 177, 17.6.2014, p. 9)[33],
- The Delegation Agreement between S2R JU and the EC,
- The General Financial Regulation (EU, Euratom) 2018/1046[34], subject to any specific provisions of the Financial Rules of the S2R JU and the establishment act.

[33] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R0642

[34] Regulation (EU, Euratom) 2018/1046 of the European Parliament and of the Council of 18 July 2018 on the financial rules applicable to the general budget of the Union, amending Regulations (EU) No 1296/2013, (EU) No 1301/2013, (EU) No 1303/2013, (EU) No 1304/2013, (EU) No 1309/2013, (EU) No 1316/2013, (EU) No 223/2014, (EU) No 283/2014, and Decision No 541/2014/EU and repealing Regulation (EU, Euratom) No 966/2012. OJ L 193, 30.7.2018, p.1.

- The Financial Rules of the S2R JU[35], adopted by the Governing Board Decision N° 11/2019 of 20 December 2019[36] and entering into force on 1 Jan 2020
- The S2R JU GB Decisions adopted since its establishment, which frame the functioning of the S2R JU within the boundaries of the S2R Regulation and its Financial Rules, in particular the AWP to be approved by the GB (draft budget, Staff Establishment Plan, Scientific Priorities, calls, tenders, etc.). As indicated in the GB rules of procedure, once adopted the GB decisions are published on the S2R JU web site[37].

In addition:

- Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 — the Framework Programme for R&I for the period 2014-2020 and repealing Decision No 1982/2006/EC (OJ L 347, 20.12.2013, p. 104), as well as Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in Horizon 2020 (OJ L 347, 20.12.2013, p. 81) is applicable to the grants awarded by S2R JU;
- The Staff Regulations of officials and the conditions of employment of other servants of the European Union are applicable to the staff of the S2R JU.

Additional reference documents may be found on the S2R JU's dedicated webpage: http://shift2rail.org/about-shift2rail/reference-documents/.

2.3. Budgetary and financial management

At the year-end 2020, the JU had implemented 100% of its commitment appropriations made available in its active budget. The payment appropriations were executed up to 81% of the active funds. The implementation when compared to the full S2R budget (including Title 4) was 94% in commitment and 76% in payment appropriations.

In GB Decision 08/2019 on 14 November 2019, the S2R Governing Board adopted the initial Annual Work Plan and Budget for 2020. No amendment to this document was adopted during the year 2020.

As a response to the COVID-19 crisis, the Executive Director executed his rights in accordance with Article 10 of the S2R Financial Rules and reassigned appropriations within his remit in the course of the year to correspond to the re-prioritised administrative and operational needs. In addition, due to the crisis, some payment requests initially foreseen by year-end are expected to become due only in 2021. The JU is taking the necessary measures to ensure that the payment appropriations are available for re-activation to the following year. This is mainly valid for one grant agreement of the call 2020 which was not signed in December as planned, and, consequently, with 6.5m€ of pre-financing not paid at year-end.

To support the planning of re-activating credits, the JU is making use of Title 4 in its budget. This Title is of technical nature and, in accordance with the S2R Financial Rules, shows the appropriations

[35] By Delegated Regulation (EU) 2019/887, the Commission adopted the model financial regulation for public-private partnership bodies to ensure sound financial management of Union funds and to enable public-private partnership bodies like S2R JU to adopt their own financial rules. The model financial regulation should be consistent with the provisions of Regulation (EU, Euratom) 2018/1046. The S2R JU shall adopt its financial rules in accordance with this model financial regulation.

[36] https://shift2rail.org/wp-content/uploads/2020/01/S2R-JU-Financial-Rules.pdf

[37] https://shift2rail.org/about-shift2rail/structure-of-shift2rail-initiative/governing-board-2/

available for applying n+3 rule on the following budgetary years. It is used to increase transparency and accurate reporting of the JU. By allocating the appropriations in Title 4, they were identified as being used in the following years to meet the JU's legal obligations on payments and the JU could re-activate them as part of the initial budget 2021.

In particular, kEUR 5 630 of unused commitment appropriations and Keur 4 510 of unused payment appropriations, recorded under Title 4 in S2R budget 2020, have immediately been re-allocated to the S2R budget 2021 in accordance with the GB Decision 08/2020 of 19 November 2020, adopting the Annual Work Plan and budget for 2021.

Following this, the active S2R budget available for 2020 amounted to kEUR 84 081 in commitment appropriations and kEUR 75 779 in terms of payment appropriations.

	Commitment appropriations (including reactivations)					*EUR '000*
Title	**Initial budget adopted**	**Amending budget**	**Transfers**	**Final adopted budget**	**Commitments made**	**%**
	(1)	(2)	(3)*	(4)=(1)+(2)+(3)	(5)	(6)=(5)/(4)
1	2 477	0	(50)	2 427	2 427	100%
2	1 065	0	82	1 147	1 147	100%
3	80 834	0	(328)	80 506	80 505	100%
Total	**84 376**	**0**	**(295)**	**84 081**	**84 079**	**100%**
4	5 301	0	329	5 630	0	0%
GRAND TOTAL	**89 677**	**0**	**34**	**89 711**	**84 079**	**94%**

* The positive balance of kEUR 34 on column Transfers represent recovered credits related to previous years

	Payment appropriations (including reactivations)					*EUR '000*
Title	**Initial budget adopted**	**Amending budget**	**Transfers**	**Final adopted budget**	**Payments made**	**%**
	(1)	(2)	(3)*	(4)=(1)+(2)+(3)	(5)	(6)=(5)/(4)
1	2 477	0	(50)	2 427	2 393	99%
2	1 065	0	82	1 147	1 034	90%
3	76 203	0	(3 999)	72 204	57 657	80%
Total	**79 745**	**0**	**(3 967)**	**75 779**	**61 083**	**81%**
4	510	0	4 000	4 510	0	0%
GRAND TOTAL	**80 255**	**0**	**34**	**80 289**	**61 083**	**76%**

* The positive balance of kEUR 34 on column Transfers represent recovered credits related to previous years

Title 1 and Title 2 of the S2R Budget were executed up to 100% in commitment appropriations, demonstrating a reliable budgetary planning.

Title 1 - Staff Expenditure was mainly used for the salaries of the JU staff. During the year, the JU made also use of external support, in view of filling staffing gaps during recruitment processes on staff as well as coping with the important workload stemming from JU activities.

The execution rate of the payment appropriations for Title 1 and 2 was 96% (96% also in 2019), showing a steady implementation of payment appropriation in relation to the previous budgetary year, which demonstrates the JU's ability to react to changing circumstances in 2020.

Due to the COVID-19 crisis, a significant part of the budget for missions was reallocated to support digital meetings and events, the enhancement of digital services to support staff and the implementation of a specific training programme to accompany the staff in such critical period. The Executive Director has executed his rights in accordance with Article 10 of the S2R Financial Rules and reallocated these funds to answer the specific needs of the JU for the year. In addition, the payments related to the Press & Information budget were not executed due to the rescheduling of events such as TRA and Innotrans, for example, which have been postponed to the year 2022.

Title 3 Operational Expenditure

Title 3 of the S2R Budget constitutes the JU's Operational Budget. The vast majority of the JU's budget falls under this category representing 96% of the active and 90% of overall budget (including Title 4). The budget category covers the JUs Calls for proposals, operational procurement and expert fees incurred linked to the evaluation process.

The execution rate of the operational budget in both commitment and payment appropriations was respectively 100% and 80%. The majority of the payment appropriations were used for the pre-financing of the grants resulting from the 2020 calls for proposals. As mentioned earlier, one project of the call 2020 was signed in May 2021, with the pre-financing payment (for 6.56m€) becoming due only in 2021, which causes the lower execution rate in comparison to the previous year (89%). In order to ensure that no project suffers from the current situation, and in agreement with the Governing Board, the pre-financing levels related to the Call 2020 have been increased of 10 basis points, after the necessary financial viability checks.

The reported execution also includes kEUR 144 relating to the Expert Evaluators which is managed by the REA Services.

Title 4 Unused appropriations not required in current Year

The amount included under Title 4 – Unused appropriations not required in current year has been established to support a transparent implementation of S2R JU Financial Rules Art.6.5, the so-called n+3 rule. In accordance with the Financial Rules and the general practice of the JU, these appropriations will be reactivated in the future year budget(s) of the following year and used first.

As detailed above, the Executive Director has executed his rights in accordance with Article 10 of the S2R Financial Rules and reassigned appropriations within his remit to Title 4. kEUR 328 in CA and kEUR 4 000 in PA of the operational budget has been transferred to Title 4.

After this transfer, the total unused appropriations available of kEUR 5 630 of unused commitment appropriations and kEUR 4 510 of unused payment appropriations, recorded under Title 4 in S2R budget 2020, have immediately been re-allocated to the S2R budget 2021 in accordance with the GB Decision 08/2020 of 19 November 2020, adopting the Annual Work Plan and budget for 2021.

2.4. Procurement and contracts

In order to reach its objectives and adequately support its operations and infrastructures, the S2R JU continued in 2020 to allocate funds to procure the necessary services and supplies. In the interest of sound financial management and to the possible extent, the S2R JU made use of Service Level Agreements (SLAs) with relevant Commission services and EU Agencies (ICT, training, payroll, mission, experts reimbursements, interim staff, etc.) and participated in inter-institutional framework contracts (e.g.: IT, audit, office furniture, insurance, human resources services) by signing Memoranda of Understanding. In addition, the S2R JU led or participated in inter-JUs framework contracts (e.g.: IT and data protection services), also with the objective to enhance synergies.

In 2020, the S2R JU implemented the following framework contracts (FWCs) awarded at the end of 2019: Provision of integrated information and communication campaigns, event organisation and public affairs services.

When for specific services or supplies SLAs or a framework contract were not available, the S2R JU resorted to middle and low-value contracts.

In 2020, the S2R JU did not launch any negotiated procedure without prior publication of a contract notice (point 11.1(b) of Annex 1 to the EU Financial Regulation 2018/1046).

The procurement contracts awarded in 2019 were published in the "Recipients of Shift2Rail Funds and Annual List of Specific Contracts" at the following web page: https://shift2rail.org/participate/recipients-shift2rail-funds/

In order to establish the maximum values of procurement contracts, where necessary, the JU makes use of the collective experience of its staff involved in it, its Members and experts as necessary, driven by the principle of sound financial management. Although this was not formally documented in formal acts, audit trails are available also in the exchanges between the staff and the procurement sector to finalize the call for tenders before approval by the Executive Director.

In 2020, the S2R JU launched the first call for tenders (open) procedure using the e-tendering and the e-submission platform available from the TED e-Tendering website and accessible on the Funding and Tenders Opportunities portal[38].

During 2020 several guidance and templates for procurement procedures were updated by the Chief Legal Officer (i.e.: calendar, tender specifications, opening and evaluation of tenders, award procedures for low value contracts, etc.) in order to adapt them to S2R JU needs and in particular to the e-submission procedure. In addition, the register of framework contracts, SLAs and Memoranda of Understanding has been regularly updated to ensure a proper follow-up of the SLAs and FWCs in force.

2.5. IT and logistics

The S2R JU focus is on the core activities: since its creation, the JU has been one of the most active promoter of a single approach for all the JUs to the ICT environment, reducing costs, outsourcing and increasing performance.

[38] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/home

In this respect:

a. Use of European Commission applications and framework contracts

The S2R JU has implemented common ICT tools designed and made available by the EC for the financial management and Horizon 2020 call management. These tools are updated and maintained on regular basis by the EC; they require continuous input from the side of the JU, on the one hand, to correct the multiple and repetitive mistakes and, on the other hand, in terms of future developments to meet the expectations of the partnership. The follow-up of these processes absorbs multiple resources of the JU.

In order to ensure the correct usage and implementation of these applications, S2R JU makes use of the training services offered by the EC on these applications.

For the execution of the call for proposals in the AWP 2020, the Horizon 2020 IT systems were used throughout the entire process: for the publication of the call, for the submission and evaluation of the proposals as well as for grant preparation. The EC IT systems "e-submission"/"e-tendering" have also been used for the first time in 2020 for one of the JU operational tender procedure.

In addition to the extended use of the Commission financial applications, the S2R JU adopted the EC's ICT systems for HR (Sysper) and daily document management (ARES) to leverage the EC's proven working technology solutions already in place, but also to streamline and further harmonize the processes, workflows, procedures of record management, document archiving and electronic document cataloguing, secure storage and document access.

The JU continued to make use of the Commission's ICT framework contracts to procure all ICT services required to run its activities.

b. Use of European Agencies' framework contracts, including with or on behalf of other JUs

In addition, the S2R JU participates to the joint strategic ICT plan of the JUs located in the White Atrium building. Since 2018, the S2R JU shares its virtual IT infrastructure that is hosted by a private cloud computing provider, in synergy with these other JUs. In 2020, the connectivity to the EC tools has also been migrated to this private cloud, which provides a full mobility and independence from the S2R JU premises and confirmed as efficient during the Covid-19 pandemic. The S2R JU has integrated also other agencies to benefit from these services, such as ERA, BEREC, etc. building upon a unique know-how of synergies' service model.

In 2020, on behalf of all the JUs, the S2R JU commissioned a Data Protection Impact Assessment (DPIA) and security risk assessment on the migration to Microsoft Office 365 public cloud environment, as required by the recently adopted EU regulation on the protection of personal data by EU institutions and bodies (Regulatio (EU) 2018/1725). The DPIA identified the inherent risks that can be mitigated through a series of identified measures with the conclusion that the residual risks are qualified as "under control". The S2R JU started in 2020 to work in synergy with the other JUs to implement these mitigation measures. The mitigating measures and the O365 services will be progressively implemented in the course of 2021.

2.6. Human Resources

In 2020, the S2R JU was fully staffed and did therefore not need to proceed with any recruitment of statutory staff in accordance with the establishment plan. One financial assistant left the JU at the end of the year and will be replaced beginning 2021, via a new selection procedure. The JU also made use of a contract agent to replace a TA on long-term absence in order to ensure the continuity of operations, after having distributed some functions to other staff, considering the need to comply with the separation of duties.

Considering the exceptional temporary CA recruitment, in 2020, the S2R JU team consisted of 24 staff members, including 2 SNEs, (see ANNEX B Establishment plan).

Moreover, for the fourth year, the S2R JU welcomed Bluebook Trainees in accordance with the SLA signed with DG EAC.

In addition to recruitment activities as well as daily HR administration not provided by the Commission central services, particular attention was given to the swift implementation of HR-related decisions adopted by the S2R GB (Implementing rules).

For the first year, the JU carried out a staff survey with the aim of measuring the temperature in terms of staff engagement and of monitoring the extent to which S2R JU predefined internal control framework was already embedded in the staff behaviours. This survey was carried out by an external contractor in order to ensure full independency in the implementation of the project as well as in the analysis of the survey. The outcome of the survey was presented to the staff as well as to the Governing Board.

An action plan has been drawn up in order to address the key aspects resulting from the staff survey and prioritise the actions to be implemented in the JU. This action plan resulted in three main responses:

a. the “well being training programme” to accompany the staff at personal and professional level during the pandemic situation; the training is ongoing and expected to be concluded in the first half of 2021;
b. a dedicated training programme to redefine the “bond” between the staff at all levels, focusing on three main concepts “Perform (deliver) – Inspire (people) – Engage (stakeholders)” that will be running till summer 2021 and whose impact will be re-assessed during the second staff survey;
c. a dedicate assessment of the processes and procedures put in place to run the programme in view of the launch and management of the S2R successor, engaging also with the S2R industry members.

Furthermore, the fourth reclassification exercise of the JU was successfully carried out during 2020. The JU also organised in-house trainings on different topics as foreseen by the JU’s Learning and Development Policy (cf. Annex 2 Learning Paths), such as a trainings on some implementing rules adopted by the S2R Governing Board (annual appraisal exercise, reclassification etc.) .

Due to the COVID19 outbreak, the JU was unable to organize team-building activities as usual. However, in order to provide the staff with an adequate support to best address the new challenges caused by the COVID19, the JU has put in place a wellbeing programme. The program was developed by the winning contractor of lot 2 “HR activities” of Framework contract N°HR/R1/PO/2019/024. This

program will be deployed throughout several months and will propose different activities such as webinars on psychological and physical wellbeing, meditation exercises, mindfulness, individual coaching sessions etc.

2.7. Data protection

The S2R JU continues to implement the EU data protection policies and legal framework. As regards the processing of personal data, the S2R JU applied the current EU Data Protection rules (Regulation (EU) 2018/1725[39]) that entered into force on 11 December 2018. In particular, the S2R JU Data Protection Officer (DPO) followed the recommendations and guidance provided by the European Data Protection Supervisor (EDPS), attended the different data protection meetings and networks, coordinated his work with the other DPOs and provided guidance to S2R JU staff on data protection issues

To ensure compliance with the data protection principles and synergies with the other Joint undertakings (JU), the S2R JU took the following actions:

- as a "leading contracting authority":
  - continued the monitoring of a common inter- JU central on-line register of records of activities processing personal data (article 31(5) Regulation (EU) 2018/1725) tailor made to the needs of the JUs.
  - coordinated an inter-JU data protection impact assessment (DPIA) and action plan for the migration to Office 365;
  - proposed a common template for implementing rules concerning the DPO function
- continued representing the other JUs in a working group on "Joint Controllership" within the Research & Innovation Family for personal data processing operations in the "Funding and Tenders Portal".
- closely followed up the introduction of a "joint controllership" clause and a joint controllership arrangement (Article 28(1) of Regulation 2018/1725) in the replacement of the standing SLAs with the European Commission.
- continued to update privacy policies in order to provide transparent information, communication and modalities for the exercise of the rights of the data subject (articles 14 to 16 of Regulation (EU) 2018/1725).
- adopted the "S2R JU video surveillance policy" after having consulted the EDPS

As in the previous year, the role of the Data Protection Officer was exercised by the S2R JU's Chief Legal Officer during 2020.

3. GOVERNANCE

3.1. Governing Board (GB)

In accordance with the S2R Regulation, the S2R JU GB continued its work steering the JU through the adoption of decisions to be implemented and executed by the ED. Three meetings of the Board were

[39] Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free movement of such data, and repealing Regulation (EC) No 45/2001 and Decision No 1247/2002/EC

convened in 2020, as well as one extraordinary GB meeting to approve the list of actions selected for funding under the S2R JU call for proposals H2020-S2RJU-2020. These GB meetings dealt with both operational and administrative aspects. Important decisions were taken, such as the approval of the list of actions proposed by the ED selected for funding under the 2020 Call, the approval of the amended Membership Agreements between the S2R JU and some of the members other than the Union, the adoption of the AAR 2019 and the AWP 2021, and the endorsement of the ED proposal on the European DAC Delivery Programme.

The Governing Board endorsed the proposal of the Executive Director on the European DAC Delivery Programme, federating the different rail sector interests, with IP5 in a central role steering the research and innovation activities, whilst ensuring inclusiveness and allowing for independent experts' involvement. More specifically, the Governing Board:

- took note of the European DAC Delivery Programme to complement the S2R R&I activities of IP5 and the freight R&I in a S2R successor;
- endorsed the approach to ensure that the results of IP5, specifically S2R DAC, would be supported towards TRL 9 in order to pave the way to the future deployment;
- confirmed the strategic role of IP5 and its Members in steering S2R Research and Innovation towards the achievement of the objectives defined in the Multi-Annual Action Plan May 2019 toking into consideration the feedback and interaction with the European DAC Delivery Programme; support an active role of IP5 in this Programme;
- and took note of the impact on the S2R resources of the European DAC Delivery Programme

Moreover, the Governing Board requested the Executive Director to ensure that an Interim Working Group is set up under the responsibility of the Head of Research and Innovation, together with the future DAC Programme Manager, as well as to duly integrate independent expert views and the Member States in the process.

The activities started under Shift2Rail, which will provide some programme support within existing contracts and involve the key role of Innovation Programme 5, and are expected to expand substantially under its successor.

The Governing Board was also informed of the implementation of the new Internal Control Framework following the adoption of the ED Decision as well as of the action plan established as a follow-up from the staff survey carried out in the JU in this context.

Furthermore, a number of decisions were adopted concerning administrative and personnel issues (adoption by analogy of rules of employment of staff of the EU).

A number of changes of the legal status of Governing Board members were reported on:

- The merger between Thales Ground Transportation Systems UK Ltd and Thales Transport and Security Ltd.
- France's New Railway Pact called for a unified, publicly owned rail transport and mobility group to be created on 1 January 2020, bringing three EPICs (Établissement Public Industriel et Commercial)—SNCF, SNCF Mobilités and Réseau—and their subsidiaries together. On the 1st of January 2020, three state-owned entities and their subsidiaries became one publicly owned group consisting of a parent company plus four subsidiaries, Keolis and Geodis. The three state-owned enterprises have become five companies within a single group: SNCF (our parent company), SNCF Réseau, SNCF Gares & Connexions, Fret SNCF and SNCF Voyageurs. SNCF is owned by the French State, which may not sell its shares in the company. SNCF owns all of the

other companies in the Group, directly or indirectly, and may not sell its shares in SNCF Réseau and SNCF Voyageurs. Geodis and Keolis, formerly subsidiaries of SNCF Mobilités EPIC, are now linked to SNCF, the parent company.

- The merger between Diginext and CS Système d'Informations
- The merger between Nottingham Scientific Limited (NSL) with GMV Innovating Solutions Limited and the creation of a new company named GMV NSL.

Moreover, after the entry into force of the new S2R Financial Rules of GB Decision n° 11/2019 on 01/01/2020, the publication on the S2R JU web site of the Annual Declarations of Conflict of Interest of the GB members and observers became mandatory (Art 27(4) of GB Decision n°11/2019), in addition to the current rules on the prevention and management of conflicts of interests for S2R bodies as embodied in GB Decision n° 07/2018), according to which names and CVs of GB members should be published on the S2R JU web site

Consequently, the following actions were undertaken by the S2R JU:

- GB members and observers[40] who had not yet provided the declarations on conflict of interest and CVs were requested to submit them. The DPO verified no personal data information are included
- The declarations on conflict of interest and the CVs are included in a DPO internal register for a period of 5 years as per GB decision N° 07/2018

In total, 20 annual declarations out of 43 current active (not former) representatives, alternates and observers were submitted, which represents about 47% of the total:

In percentage of Annual declaration of interest received:

- *Union members (EC) = 33%*
- *Industry members (GB Representatives, Alternates and Observers) = 47,5 %*

Consequently, 12 out of 43 current active (not former) representatives, alternates and observers have not submitted their declaration on conflict of interest, and 28% of the CVs are missing.

*In percentage of the **CVs received** – 30 out of 43:*

- *Union members (EC) = 33%*
- *Industry members (GB Representatives, Alternates and Observers) = 72,5 %*

In light of the European Parliament's Discharge for the Financial Year 2019, calling on the Joint Undertaking to publish the CVs and the declaration of interest of the Governing Board in compliance with the transparency framework and to guarantee user-friendly access to them, it is suggested – based on the Financial Regulation - to consider non-submitted declarations of conflict of interest as *de facto* cases of conflict of interest, leading to an exclusion from Governing Board votes.

3.2. Executive Director (ED)

According to Article 10 of the S2R Statutes, the ED is the chief executive responsible for the day-to-day management of the S2R JU in accordance with the decisions of the S2R GB. The ED is the legal representative of the S2R JU. The ED is accountable to the S2R GB. He is supported by the JU staff organized in a Programme Office.

[40] NB: Observers take part in the GB deliberations and give opinions (i.e.: AAR, AWP, etc). Therefore they are also subject to the "public scrutiny" as per the European Parliament's resolutions on the budgetary discharge

The S2R JU ED was appointed on 16 February 2016. He took up his duties on 16 May 2016.

During the 26th GB meeting of 19 November 2020, the Chair informed the Board that it has launched its internal procedure in view of the extension of the term of office of the Executive Director. The current ED's mandate will expire on the 16th of May 2021, and in line with Article 8 (J) of the Statutes of S2R JU, this term can be extended once for a period of 5 years and will be subject to a formal decision of the GB after the Commission's internal procedure is finalised. The Chair highlighted that the Commission feels vindicated in proposing an extension of 5 years to the current mandate of the S2R Executive Director. The Chair requested that potential comments from Board members be submitted bilaterally to her.

The ED is supported by the Head of R&I and the Head of Finance and Administration. The Programme Office under his responsibility followed, in 2020, the Governance and Process Handbook which describes in detail the processes and procedures to monitor the performance of the projects that will be implementing the Programme through an integrated Programme Management approach.

Moreover, following the provision to the ED of a mandate to establish relations with European regions and other European and international organizations, the cooperation with regions and international organizations has been fostered. In this respect, the ED signed an MoU with CUTRIC on the 23rd of October at the S2R Innovations Days, with a focus on sustainability, intelligence and hybridization, as well as an MoU with the Western Balkans Transport Community on the 26th of October 2020. The MoU with CEN/CENELEC was sent to the GB for consultation and the MoU with UIC is in its final drafting stage.

Furthermore, 2020 saw the consolidation of the ED Programme Board, striving to ensure that barriers experienced in the integration of new concepts in the S2R R&I activities are duly addressed, as well as to ensure that a more encompassing future system architecture would not find obstacles in their integration in the specific R&I projects.

3.3. States Representatives Group (SRG)

To date, 32 countries have nominated representatives to this group. During 2020, the SRG held its twelfth meeting on 4 March in Brussels, preceded by a Workshop on the SRG Recommendations for "Transforming Europe's Rail System" on 3 March 2020. One of the main tasks in both meetings was the consultation with the Member States and the Associated Countries on the JU's AAR 2019, discussions on the sector paper on "Transforming Europe's Rail System" and on the S2R successor preparatory process, information on ongoing/planned railway research and innovation activities, as well as the update on Brexit and the transition period.

Following the SRG workshop on S2R2 held on 3 March 2020, the S2R JU launched a written procedure, on behalf of the S2R JU Executive Director, and in accordance with article 12 of the SRG Rules of Procedure ("At the request of a SRG member, the SRG may amend these Rules of Procedure following approval by decision of the SRG") and article 8 on written procedures, on the proposal for amendment of Article 11 of the S2R Rules of Procedure on resources. The written procedure was approved by the SRG representatives and the amended Rules of Procedure were subsequently published on the S2R website.

In the thirteenth meeting, which took place via remote connection on 25 September 2020, the SRG discussed the latest developments and ongoing activities - including information on call 2020 award and S2R JU communication activities, as well as the proposal for the creation of the SRG DAC subgroup

within the context of the European DAC Delivery Programme. A presentation as delivered on the Innovation Programme Results: IPx (L4R system architecture) and IP5. Moreover, discussions also focused on the S2R successor programme.

Regarding the creation of the SRG DAC subgroup, the ministries of transport underlined the importance of changing rail freight in the next decade and highlighted the importance of rail freight with DAC as a key element and a major enabler. A link with the ministries of transport should therefore be ensured to guarantee awareness concerning the progress. This dedicated WG should consist of representatives of the Ministries of Transport or others with knowledge of the type of activity, in order to ensure the link with national programmes. Member States were called upon during the meeting to appoint representatives to this group to ensure the liaison with the European DAC delivery programme and the activities of MS, thereby mobilizing a strong connection between the national and European levels to arrive to a concrete justified migration plan within the next decade. Member States' involvement is a key condition for the DAC success story.

Furthermore, taking into account the fact that the mandates of the current SRG Chairperson and Vice-Chairperson ran until 1st January 2021, a proposal for extension of the current mandates was submitted as follows:

- Extension of the mandates of the Chairperson and Vice-Chairperson up to the start of the S2R successor programme, e.g. extension of 6 months to maximum 9 months;
- Alternatively, should the launch of the S2R successor be postponed to after January 2022, the election of the new SRG Chairperson and Vice-Chairperson will take place at the Extraordinary SRG meeting of 5 February 2021, in line with Art. 2 of the Rules of Procedure ("*Elections shall take place at the last meeting of the SRG under the chairpersonship of the outgoing Chairperson"*).

A written procedure was launched on this matter in accordance with article 8 of the Rules of Procedure on written procedures and article 2 on the mandates of Chairperson and Vice-Chairperson. The SRG representatives agreed to the written procedure.

In all meetings, participants were informed in detail about the ongoing and planned activities of the JU.

3.4. Scientific Committee (SC)

The SC is an advisory body to the S2R JU focusing on the long-term research and identifying scientific and technological achievements and development priorities.

A Workshop on SC Recommendations for S2R KPIs was organized on 5 March 2020, with discussions focusing on KPIs models and attractiveness and mode choice model. Moreover, a Workshop on SC Recommendations for S2R2 was organized in Brussels on 6 March 2020, focusing on the SC feedback on 'transforming Europe's rail system', on SC role in the governance structure, as well as a brainstorming for KPIs in the S2R successor programme.

The S2R JU SC held its thirteenth meeting on 29 April 2020 in Brussels. The meeting developed on the SC contribution to the definition of KPIs for the S2R successor, as well as initial comments on the AAR 2019.

The fourteenth meeting of the S2R JU Scientific Committee was held on 23 September 2020 in Brussels. Discussions focused, inter alia, on the results of the S2R JU 2020 call and the publication of the GB Decision n°07/2020 on the call results, the AWP 2021, the S2R2 preparatory process and Horizon Europe state of play, as well as on the SC involvement in the European Year of Rail.

The members provided specific comments on the different topics in order to contribute to the document finalisation of the draft AWP 2021.

3.5. Innovation Programme's Steering Committees (SteCos)

The SteCos convened regular meetings (four meetings in total in 2019) and their role was to ensure the necessary coordination of activities within each IP and to provide input in assisting the JU in the planning of its future activities (i.e. input for the AWP 2021, the Demonstrations activities planning, the MAAP review, etc.). As from the signature of the first OC grants, the coordinators of the OC projects were invited to participate to the SteCo meetings in order to present their plans in a way to ensure coordination of actions and to maximise synergies among projects.

During 2017, the S2R JU together with the IP Coordinators work towards the evolution of the IP meetings more on technological and operational content than administration. This was further enhanced in 2018 and continued since then, focusing on TDs results and adding IPs' joint meetings on specific thematic areas (e.g. automation, digitalization, telecoms, cyber-security, integrated traffic management).

3.6. European Union Agency for Railways (ERA)

Article 12 of the S2R Statutes clarifies the areas of cooperation between the S2R JU and ERA. In order to ensure that strong cooperation is established with ERA, the rules of procedures of all relevant groups established by the S2R JU foresee the participation of representatives from the ERA (either as observers or direct members of these groups); this ensures that the Agency is duly prepared to take into account the results of the Programme in its activities.

As a result, staff members of ERA have been participating in meetings of the S2R GB (cf. 3.1) and the IP SteCos, but also in the groups which were tasked with the drafting of the MAAP and contributing to the S2R JU AWP.

The S2R Governance and Process Handbook[41] clarifies the way ERA can access the R&I activities performed within the S2R Programme in the areas of their competence, interoperability and safety. It worth to mention that the S2R JU provided to ERA in 2018 the ATO over ETCS GoA2 specification and in 2019 the Moving Block (MB) system specification, MB operational and engineering rules as well as the MB preliminary safety analysis, all as input of the possible game changers integration in the next release of the CCS TSI. During 2020 the tender launched following and awarded by S2R in 2017, an ERA request to close a TSI open point, on "Pantograph – Overhead Contact Line Interaction – Dynamic Behaviour and Quality of the Current Collection" concluded its technical activities and ERA could accede to all results, formally provided to the Agency at the administrative closure at the beginning of 2021.

[41] https://shift2rail.org/wp-content/uploads/2017/12/S2RJU-Governance-and-Process-Handbook_20171010_v11_Cleanv-nd.v2.pdf

Through the S2R Framework Contract to support the ERTMS Deployment action, Shift2Rail had issued service contracts formulated with ERA and the European Commission for the maintenance of the ERTMS specifications as well addressing the technical updates for integration of the game changers into the regulation by the ERTMS system authority.

In addition, regular coordination meetings have been organised between the two EDs, operational staff and communication staff. The overall objective is to ensure that the R&I innovative solutions that will be delivered by the S2R Programme will be considered in the pipeline of ERA activities in order to avoid any step back in the future market uptake.

The role of ERA in the context of 4th Railway Package, is another asset to facilitate the deployment of the S2R Innovative Solutions.

In addition, with the objective to avoid overlapping activities, the S2R JU assess the requests for R&I coming from ERA and ensure their implementation to maximize the use of public funding. Building upon parallel structures would constitute a waste of resources.

The S2R JU also supported the EC in its ERTMS Deployment Action Plan, participating to the ERTMS Policy Board meetings and advertising the ERTMS Deployment Action Plan Consultation on its website.

The S2R JU is also participating together with ERA to the Rail Standardisation Coordination Platform for Europe (RASCOP) chaired by the European Commission (DG Move). S2R is actively contributing providing to the group of standardisation setting organisations and the ERA the S2R standardisation rolling development plan, a comprehensive document anticipating the possible need for changes or creation of standards and regulations as a result of successful outcomes of the S2R R&I Programme.

On the coordination on standardisation and regulation issues, the S2R JU has been also participating in the EU Rail Security Platform providing expertise (also to the ERA) based on the R&I outcomes on cybersecurity applied to ERTMS.

The S2R JU has also ensured along the year the contribution of its projects to ERA Topical Working Groups in view of the revision of the TSIs 2022 Package; such important work is paramount to accelerate the market uptake of the innovative solutions.

4. INTERNAL CONTROL FRAMEWORK

4.1. Financial Procedures

The S2R JU Financial Rules applicable as from 1 Jan 2020 were adopted on 20 December 2019 by the S2R JU Governing Board (Decision N°11/2019), in order to align them to the General EU Financial Regulation 2018/1046 entered into force on 18 July 2018.

The Financial Rules do not depart from the model Financial Regulation for public-private partnership bodies referred to in Article 209 of the Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012. Since its budgetary autonomy, the S2R JU has been using ABAC (accounting system of the European Commission) for its financial management. As already mentioned, the new JU Financial Rules entered into force on 1 January 2020.

The S2R JU Manual of Financial Procedures has been prepared in line with Article 20 of the Financial Rules of the S2R JU and incorporated. The main purpose of the document is to identify actors, describe the financial circuits and detail procedures regarding the implementation of the S2R JU Budget. The financial circuits take into account the structure of S2R JU and the risks associated with the management environment.

The Financial Rules of the S2R stress the need to differentiate between the initiation of a financial transaction and the verification of the same transaction in order to guarantee the principle of segregation of duties.

The S2R JU budget in respect of this document has been divided mainly into two types of expenditure;

- Administrative Expenditure covering both; Titles 1 and 2 of S2R Budget, and
- Operational Expenditure covering Title 3 of the Budget.

A Title 4 is dedicated to account for un-used appropriations.

Due to their nature and the difference in ICT tools implemented at the S2R JU to manage them, the financial circuits between these two expenditure types are different.

The Manual of Financial Procedures describes in detail financial circuits the S2R JU implements per type of transactions and the roles and responsibilities of each actor involved. To a less extent, it also describes the basic principles on main procedures (grants & procurements). In 2017, this document has been reviewed to streamline and improve the internal financial processes.

It should be noted that the specific S2R JU financial procedures are complemented by *vademecum* established for the overall Horizon 2020 research family as well as by S2R JU Programme Handbook.

The S2R GB formally appointed the Accounting Officer of the Commission as the Accounting Officer of the S2R JU on 18/03/2016.

4.2. Ex-ante Controls on operational Expenditure

The S2R JU adopts the standard financial circuits in ABAC Workflow for the commitments and payments. The circuit has a three-step authorisation performed by the following financial actors:

- Initiating Agent (OIA and FIA)

- Verifying Agent (OVA and FVA) and
- Authorising Officer (AO).

Staff members designated by the AO to verify financial operations are chosen on the grounds of their knowledge, skills and appropriate professional experience.

The S2R JU financial circuits comply with the requirements of the four eyes principle, segregation of duties and the independence of the verifier. In addition, in view of the limited staff, they also provide the flexibility necessary to ensure the continuity of operations.

For the operational expenditure of the JU, S2R JU recognises two different types of transactions: ones solely performed in the ABAC Workflow and ones with the initiation and verification functions outside the ABAC environment in a tool called SYGMA. This tool is also linked to ABAC which allows real time controls over the budget and its implementation.

The nature of the transaction defines the system where the initiation and verification is performed:

- ABAC for all procurement related transactions and
- SYGMA for any transactions related to grant management

In all transactions, whether initiated in SYGMA or ABAC, the AO will give his/her authorisation in ABAC only.

A key element of the ex-ante controls is the "*Guidance Horizon 2020 ex-ante controls on interim & final payments*" adopted by the CSC Steering Board on 15 Dec 2016 and applicable as such to the S2R JU. The main consequence of this simplified ex-ante control approach is that the limited details asked to beneficiaries to be provided in each periodic report do not allow the S2R JU to check most of the conditions for the eligibility of costs. Ex-ante controls in Horizon 2020 are therefore trust-based, focusing on whether:

- the work has been done (as described in the periodic reports)
- the reported effort and use of resources is reasonable and in accordance with the plan
- sufficient explanation and justification are provided for any substantial deviations (see Section 2.5).

In practice, the assessment involves comparing the Description of the Action (DoA) and the budget earmarked with the work actually carried out, as explained in the periodic report, and the costs being claimed in connection with it.

Certain elements (such as risk factors or deviations) are less in evidence when checking interim periodic reports than when assessing final reports. Moreover, since CFS are required only as part of the final reports, ex-ante controls in final periods will be more in-depth. Moreover, officers may take a more flexible approach to ex-ante controls in interim periods by asking beneficiaries for additional clarification in the ensuing reporting period. However, by the time the final payment is made, all outstanding issues should have been dealt with.

4.3. Ex-post Control of Operational Expenditure and Error Rates Identified

Ex-post controls are defined as the controls executed to verify the financial and operational aspects of finalised budgetary transactions in accordance with Article 22 of the S2R JU Financial Rules.

The controls are the last stage of the JU's control strategy in the project life cycle. This stage includes the ex-post audits as well as the recovery/correction of any amounts found to have been paid in excess of the sum due.

Ex-post Control of Operational Expenditure at S2R JU is covered by the Horizon 2020 Audit Strategy. The implementation of the Horizon 2020 Audit Strategy falls under the responsibility of the Common Audit Service (CAS).The role of the CAS is defined in the Commission Communication of 18 September 2013 establishing the Common Support Centre (CSC)[42]. The CAS has been designated as the single entity for implementing the H2020 audit campaign on behalf of the CSC stakeholders such as S2R JU.

The main objective of the Horizon 2020 Audit Strategy is to provide the ED with the necessary elements of assurance in a timely manner on the Horizon 2020 budget for which they are responsible by contributing to:

- assessing the legality and regularity of Horizon 2020 project payments;
- providing an indication of the effectiveness of the related ex-ante controls;
- providing the basis for corrective and recovery mechanisms, if necessary;
- attaining residual error rates at an acceptable level at the closure of Horizon 2020, once the financial impact of all audits, correction and recovery measures has been taken into account[43].

The actions identified to realise these objectives include:

- the gradual achievement, in a cost effective-way, of quantitative multi-annual targets in terms of audited participations;
- the closure and communication of audit findings and extension of audit findings to those responsible for their implementation providing the basis for corrective and recovery activities, if necessary.

Different indicators are calculated to provide a comprehensive view of legality and regularity:

Overall Detected Error Rate: this is the error rate derived from the results of all audits, whether audits on a representative sample of beneficiaries or audits implemented for other reasons (large beneficiaries, preventive audits, risk factors, etc.). Its value is cumulative and can be calculated for a specifically to S2R JU or for the whole Research and Innovation Family.

Representative Error Rate for the Framework Programme: this is the error rate derived solely from the results of the CRS on the whole Research and Innovation Family, extrapolated to the overall population and calculated for each FP as a whole. This error rate provides an estimate of the level of error in the given Framework Programme at the time of the audits, but does not factor in the follow-up and corrections/recoveries undertaken by Commission services after the audit, nor does it provide information on the net final financial impact of errors.

[42] Communication on the delegation of the management of the 2014-2020 programmes to Executive Agencies SEC(2013)493 of 18 September 2013, section 5.1.2

[43] Legislative Financial Statement as part of the 2011 Commission proposal for the Regulation on H2020 (COM/2011/809) of 30 November 2011, pages 98-102

Residual Error Rate: the residual error rate, on a multi-annual basis, is the extrapolated level of error remaining after corrections/recoveries undertaken by S2R JU following the audits that have been made. The calculation of the residual error rate is made in accordance with the H2020 Audit Strategy and is based on the following assumptions:

- all errors detected will be corrected;
- all non-audited expenditure is clean from systematic material errors so that the residual error rate can be estimated to be equal to the non-systematic error rate (for expenditure subject to extension of audit findings this is only assumed when the respective extension procedures have been closed).

The residual error rate develops over time and depends on the assumptions set out above. This indicator is reliable and acceptable for the purposes for which it was intended, i.e. as a legality and regularity indicator on the progress made, through its ex-post audit strategy, in dealing with errors over a multi-annual basis. However, it remains an estimate as long as not all cost claims have been received and not all cases of extension of audit findings have been fully implemented yet.

Ex-post controls of the Horizon 2020 programme globally in 2020

In year 2020, the Commission re-defined its methodology for calculating the Horizon 2020 error rates in line with the European Court of Auditors' observations in its 2018 and 2019 Annual Reports. As of January 2020, the application of the revised methodology on 790 samples resulted in an error rate higher, on average, by 0,41 % in comparison to the error rate calculated by applying the methodology used in the past on the same 790 samples. Consequently, the detected error rate for 2020 calculated according to the methodology used in the past has been corrected by adding 0.41%. This results in the following error rates for Horizon 2020[44] on 31 December 2020:

- Representative detected error rate: 2,95%[45],
- Cumulative residual error rate for the Research and Innovation Family DGs: 2,16 % (2,24 % for DG Research and Innovation),

The error rates presented above should be treated with caution. Since not all results of the three Common Representative Samples are available yet, the error rate is not fully representative of the expenditure being controlled. Moreover, the nature of expenditure in the first years of the programme may not be totally representative of the expenditure across the whole period.

Since Horizon 2020 is a multi-annual programme, the error rates, and especially the residual error rate, should be considered within a time perspective. Specifically, the cleansing effect of audits will tend to increase the difference between the representative detected error rate and the cumulative residual error rate, with the latter finishing at a lower value.

[44] The Horizon 2020 audit campaign started in 2016. At this stage, three Common Representative Samples with a total of 467 expected results have been selected. By the end of 2020, cost claims amounting to EUR 24.3 billion have been submitted by the beneficiaries to the services. The audit coverage for Horizon 2020 is presented in annex 7. In addition to the Common Representative Samples, Common Risk Samples and Additional Samples have also been selected. The total of all samples represents 4 047 participations. The audits of 2 906 participations were finalised by 31/12/2020 (out of which 790 in 2020). This sampling accommodates special needs of certain stakeholders with regard to audit coverage and selection method. In addition, top-ups, which are participations of selected beneficiaries and which are added to the selected participations, are included in the total participations selected.

[45] Based on the 334 representative results out of the 467 expected in the three Common Reprentative Samples.

As was the case last year, there is evidence that the simplifications introduced in Horizon 2020, along with the ever-increasing experience acquired by the major beneficiaries, affect positively the number and level of errors. However, beneficiaries still make errors, sometimes because they lack a thorough understanding of the rules, sometimes because they do not respect them.

Given the results of the audit campaign up until 2020, and the observations made by the European Court of Auditors in its 2018 and 2019 Annual Reports, the CIC, in close cooperation with DG BUDG, SecGen and the IAS, are defining actions aiming at reducing further the multiannual error rate of Horizon 2020.

Ex-post control 2020: S2R JU Specific sample

Given the relatively small share of the S2R JU's budget (less than 1%) compared to the overall H2020 budget, the number of projects selected for ex-post audit by the CAS via the common representative sample is limited. Therefore, S2R JU in line with Annex 1 to the H2020 audit strategy, planned for additional audit sampling (i.e. JU's specific sample) in order to ensure sufficient ex-post audit coverage and allow a representative error rate on S2R JU expenditure to be calculated over time. This is necessary to provide reasonable assurance to the JU's Executive Director in view of his declaration of assurance and the separate discharge procedure for the JU. There were no S2R JU cost claims selected as part of the Common Representative Samples for the H2020 research family, selected by the CAS in years 2016 and 2017; in the third Common Representative Sample, two S2R cost claims were selected. Four risk based audits on S2R JU cost claim have been launched as result of implementing the H2020 Audit Strategy: the first one was finalised in 2018; two more audit were concluded in 2020, one also with zero adjustment and one with minor negative adjustments.

In 2017, in addition to the risk based audit detailed above, the JU launched representative audits covering 15 additional cost claims. After launching the representative audits, the total coverage raised into KEUR 1 324 representing 40% of the all cost claims validated in that year. With the additional audits launched during 2019, the direct coverage of the S2R JU launched audits into KEUR 7 404 (10%) and in-direct coverage into KEUR 39 96216 757 (52%).

By 31 December 2020, S2R validated cost claims for a cumulative total of EUR 115,126,105.19 covering 59 projects. In 2020, the JU selected 25 additional representative audits on its population as well as two risk-based audit following its own risk assessment. This brought the direct coverage of the S2R JU launched audits into EUR 6,830,350 (6%) and in-direct coverage into EUR 68,466,576.68 (59%). The overall status of these audits is shown below.

Batch	Audit launch year	Launched	On-going	Finalised	Of which	
					Representative	Risk-based
1	2017	15	0	15	14	1
2	2018	15	1	14	14	1
3	2019	26	11	15	14	1
4	2020	18	18	0	18	0
Total		**74**	**30**	**44**	**60**	**3**

Numbers referenced in terms of cost claims

Total Number of Cost Claims validated at 31/12/2020	1134
Total Cost Accepted by S2R JU (cumulative) (A)	115,126,105.19
Total cost audits launched 2020 (B)	6,830,350
Total cost Audits finalised 31/12/2020 (C)	6,111,389
Direct coverage of total audits (B / A)	6%
Direct audit coverage of the finalised audits (C / A)	5%
In-direct coverage* of the total audits	59%
In-direct audit coverage* of the finalised audits	43%

* taking into account the audited entity's participation on other S2R projects contributing to the sum in (A)

At 31 December 2020, 39 final audit reports from the representative sample were available to the JU. These participations represent 5% of the direct and 43% of in-direct coverage in S2R JU accepted cost claims.

Overall detected error rate based on 63 participations: by applying simple average is 1.60% and by applying weighted average is 2.89%.

Representative Error Rate based on 60 participations: by applying simple average it is 1.70% and by applying weighted average 2.90%.

S2R JU Residual Error Rate: by applying simple average is 0.85% and by applying weighted average is 1.99%.

A sufficient audit coverage in finalised audits will be ensured via the selection of the ex-post audits in 2020 and after to be completed and reported in future years. The results becoming available after 31.12.2020 will be reported accumulatively in the Annual Activity Report 2021 and after.

S2R JU has reported the respective error rates in terms of both, simple and weighted average. The nature and characteristics of the population determine which one of these two methods provide more representative characteristics of the results. At the cut off 31.12.2020.

The reported error rate is below the targeted threshold of 2% under the two methodologies applied, simple and weighted average.

4.4. Audit of the European Court of Auditors

The European Court of Auditors (ECA) with its mission of November 2020 completed its work which resulted in S2R JU Annual Audit Report for the year 2020, in accordance with the ECA mandate as defined in the TFEU.

During 2020, for the 2019 Financial Year, the European Court of Auditors released the following opinions:

Opinion on the reliability of the accounts

"*In our opinion, the accounts of the JU for the year ended 31 December 2019 present fairly, in all material respects, the financial position of the JU at 31 December 2019, the results of its operations, its cash flows, and the changes in net assets for the year then ended, in accordance with its Financial Regulation and with accounting rules adopted by the Commission's accounting officer. These are based on internationally accepted accounting standards for the public sector*."

Opinion on the legality and regularity of revenue underlying the accounts

"*In our opinion, revenue underlying the accounts for the year ended 31 December 2019 is legal and regular in all material respects*."

Opinion on the legality and regularity of payments underlying the accounts

"*In our opinion, payments underlying the accounts for the year ended 31 December 2019 are legal and regular in all material respects*."

For the year 2020, the ECA reported no findings for S2R JU in its draft preliminary observations report.

Furthermore, it is confirmed that the corrective actions taken by the S2R JU in response to the Court's observations from previous years were mostly completed, while the status of one action is ongoing:
From year 2017: In response to the recommendations raised by the evaluators, the Joint Undertaking prepared an Action Plan adopted by the Governing Board on 28 June 2018. While not all recommendations raised in the Interim Evaluation will be addressed under the current Financial Framework Programme, some actions included in the Action Plan have already been initiated, while others, in accordance with their nature and the current legal framework, are expected to be implemented in the period 2018 to 2020.The final ECA report on FY 2020 is expected to be published at Q4 2021 and will include a consolidated view of the audit and finding for all the Joint Undertakings. Chapter 3 of the report regroups the individual Statements of Assurance for each JU; section 3.8 being the one specific to S2R JU.

4.5. Internal Audit

The Internal Audit Service (IAS) of the EC performs the role of Internal Auditor of the S2R JU and, in this respect, it reports to the S2R GB and the ED indirectly.

The first audit mission consisted in establishing a risk profile of the S2R JU with the objective of establishing a triennial audit plan. The IAS Strategic Internal Audit Plan 2017-2019 had been presented to the S2R GB in June 2017.

In accordance with this audit plan, the IAS performed in 2019 an audit on grant process (from the identification of the call topics to the signature of the grant agreement) in the S2R JU. In its Final Audit Report of 21 October 2019, the ongoing efforts made by the JU to monitor strictly the duration of the grant preparation phase aiming at ensuring that the H2020 'time to grant' target is respected were recognised. During 2020, the JU took measures on the basis of its action plan to implement the four important recommendations which had been raised by the auditors and related to the following topics:

- *Participation of Member representatives as observers in the evaluation process*
- *Application of evaluation sub-criteria and scoring*
- *Reporting on H2020 indicators*
- *Call topic development procedure*

In October, the IAS confirmed on the basis of additional documentation provided that it considers the first three recommendations as implemented. The final recommendation on the call development procedure has been implemented and reported back to the IAS in the beginning of 2021. The IAS informed the JU in January 2021 that all recommendations are considered as implemented.

In mid-June, the IAS performed an in-depth risk assessment in the S2R JU as to develop a new Strategic Internal Audit Plan covering the period 2021-2023. The assignment was carried out as desk review complemented by interviews with selected staff members, on the basis of which the IAS has defined envisaged audit topics over the coming years. Taking also into consideration the Risk Management processed performed by the JU, the IAS considered that the main JU process is grant management and that main risks related to this process. In addition, IAS highlighted key risks already identified by the S2R management in relation to the continuity of the activities in relation to the MFF 2021-2027, market uptake of innovative solutions and finally high staff turnover. On these basis, the Audit Plan 2021-2023 will focus primarily on H2020 grant implementation and closing and Performance Management.

4.6. Risk management and conflict of interest

The S2R JU implements a risk policy to manage risks and opportunities related to the execution of the S2R Programme. The S2R JU follows the principles of the recognised international standards and aligns to the requirements of the EC as indicated in the Communication SEC (2005) "*Towards an effective and coherent risk management in the Commission services*".

Risk is defined as "*any event that could occur and adversely impact the achievement of the S2R Joint Undertaking strategic and operational objectives. Lost opportunities are also considered as a risk*".

The Risk Management system aims at enabling informed decision making with the objective of optimising the ratio between the level of acceptable risk by the S2R JU and the use of the relevant resources by anticipating and proactively identify, analyse, treat, control and monitor risks and opportunities.

With regard to programme specific risk management, the S2R Cooperation Tool as well as the relevant grant agreements related to the different projects provide for the framework to manage both risks and opportunities, with the possibility of escalating them to the proper level of the ED and S2R GB.

For the purpose of implementing the requirements of Article 23 of its constituent act pertaining to the prevention of conflicts of interest, the S2R JU has adopted rules governing conflicts of interest in respect of its members, bodies, staff and seconded staff, as well as its S2R GB members. The responsibility on conflict of interest is within the competencies of the ED.

4.7. Anti-Fraud Implementation and Indicators

During 2020, the JU continued to implement the Shift2Rail Anti-Fraud Strategy 2017-2020[46], a tailor-made anti-fraud strategy complementing the Horizon 2020 strategy, including an assessment of its risks and opportunities.

In accordance with the S2R Anti-Fraud Strategy, five indicators are used to report on the results of fraud prevention and detection activities. At the end of 2020, the following results are reported:

	Indicator	Result
1	Number and value of contracts subject to close monitoring or additional controls due to an assessment of a high risk of fraud.	0
2	Number (and trend in number) of files sent to OLAF for investigation.	0
3	Time elapsed between receipt by staff or management of first information on alleged internal fraud and transmission to OLAF.	NA
4	Time elapsed between OLAF requests for information and date when information is provided to OLAF.	NA
5	Time elapsed between receipt of an OLAF report and the decision on recovery or disciplinary sanctions by the S2R JU	NA

The Anti-Fraud Strategy also includes an Action plan designed to implement this strategy, which covers the different stages of the anti-fraud cycle: prevention, detection, investigation and corrective measures. During 2020, fraud awareness and fraud risks were covered through the staff survey, carried out following the adoption of a revised internal control framework, and the risk assessment respectively.

As defined by the strategy, the Action Plan is reviewed on a biannual basis: the first review during 2020 took place at the end of the second quarter, a second review at the end of the fourth quarter. These updates are available on the S2R website.

In addition, given the upcoming transition to a new partnership, the JU decided to extend its Anti Fraud-Strategy 2017-2020 for one year, with the objective of adopting a new strategy once the future partnership has started (i.e.: covering the period January 2022 till December 2025).

[46] https://shift2rail.org/about-shift2rail/reference-documents/

4.8. Compliance and effectiveness of Internal Control

In 2020, the JU adopted a revised Internal Control Framework which is designed to provide reasonable assurance regarding the achievement of the following objectives:

- Effectiveness, efficiency and economy of operations;
- Reliability of reporting;
- Safeguarding of assets and information;
- Prevention, detection, correction and follow-up of fraud and irregularities;
- Adequate management of the risks relating to the legality and regularity of the underlying transactions, taking into account the multiannual character of programmes as well as the nature of the payments concerned.

The revised Internal Control Framework was implemented during 2020 by the Executive Director, with the support of the Internal Control Coordinator as well as across all functions in the organisation.

A first annual self-assessment of the JU's revised internal control framework has been performed in order to evaluate the compliance and effectiveness of Internal Control. The internal assessment has been carried out on the basis of a set of indicators defined for each Internal Control principle and has in particular taken into account relevant information available to management as well as the reports of the internal and external auditors and the follow up of audit recommendations.

Internal control deficiencies that were identified, after due assessment, were considered as minor. One deficiency consists of the delay in the publication of Conflict of Interest Declarations and CVs from GB Members on the S2R website, which is mandatory as per the S2R Financial Rules and hence required for 2020. GB Members will be reminded, again, on these requirements during the next GB meeting in March 2021. In addition, the JU's Exception and Non-compliance register includes two internal control deficiencies for 2020. Both events are results of human error; and the JU has defined additional measures to reinforce controls. No financial impact was involved.

Given the minor nature of the deficiencies identified, all internal control principles were assessed as effective.

Moreover, the JU has continuously followed up on audit recommendations from the internal and external audit reports. All recommendations raised by the IAS in previous audits have been confirmed by the former as implemented.

On this basis, it can be concluded that the S2R JU's control system is working efficiently and effectively.

5. MANAGEMENT ASSURANCE

5.1. Assessment of the Annual Activity Report by the Governing Board

The ED submits the draft AAR to the S2R GB for assessment and approval. Once approved by the S2R GB, the AAR is made publicly available. No later than 1 July of each year the AAR together with its assessment shall be sent by the ED to the ECA, to the Commission, to the European Parliament and the Council.

The S2R GB takes note of the results achieved and recommends the JU to continue improving its effectiveness and efficiency with the Members' stronger support.

5.2. Elements supporting assurance

In addition to the specific supervisory activities of the ED, the main elements supporting the assurance are:

- the Certificate of the Accounting officer,
- the information received from the Head of R&I, the Head of Administration and Finance, the Data Protection Officer,
- the assessment of the Internal Control System carried out by the JU's Internal Control Coordinator,
- the results of the audit of the ECA,
- audits performed by the Internal Audit Service,
- the overall risk management performed in 2020 as supervised by the ED,
- the key performance indicators in place,
- the dedicated ex-ante controls of the JU's operational and administrative expenditure,
- the results from ex-post audits carried out by the Commission services,
- the Other Members' reporting of in-kind contributions,
- the follow-up and monitoring of Call process,
- the exceptions reported in the "*exception and non-compliance register*" and the remedial measures put in place.

5.3. Reservations

The ED is not aware of any element that would bring him to introduce a reservation in the AAR 2020.

5.4. Overall conclusion

Not applicable.

6. DECLARATION OF ASSURANCE

I, the undersigned, Carlo M Borghini, Executive Director of Shift2Rail Joint Undertaking

In my capacity as authorising officer by delegation

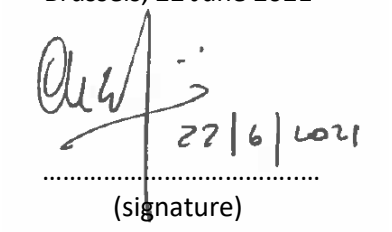
Declare that the information contained in this report gives a true and fair view[47]*.*

State that I have reasonable assurance that the resources assigned to the activities described in this report have been used for their intended purpose and in accordance with the principles of sound financial management, and that the control procedures put in place give the necessary guarantees concerning the legality and regularity of the underlying transactions.

This reasonable assurance is based on my own judgement and on the information at my disposal, such as the results of the self-assessment, ex-post controls, the work of the internal control coordinator, the observations of the Internal Audit Service and the lessons learnt from the reports of the Court of Auditors for years prior to the year of this declaration.

Confirm that I am not aware of anything not reported here which could harm the interests of the Joint Undertaking.

Brussels, 22 June 2021



……

(signature)

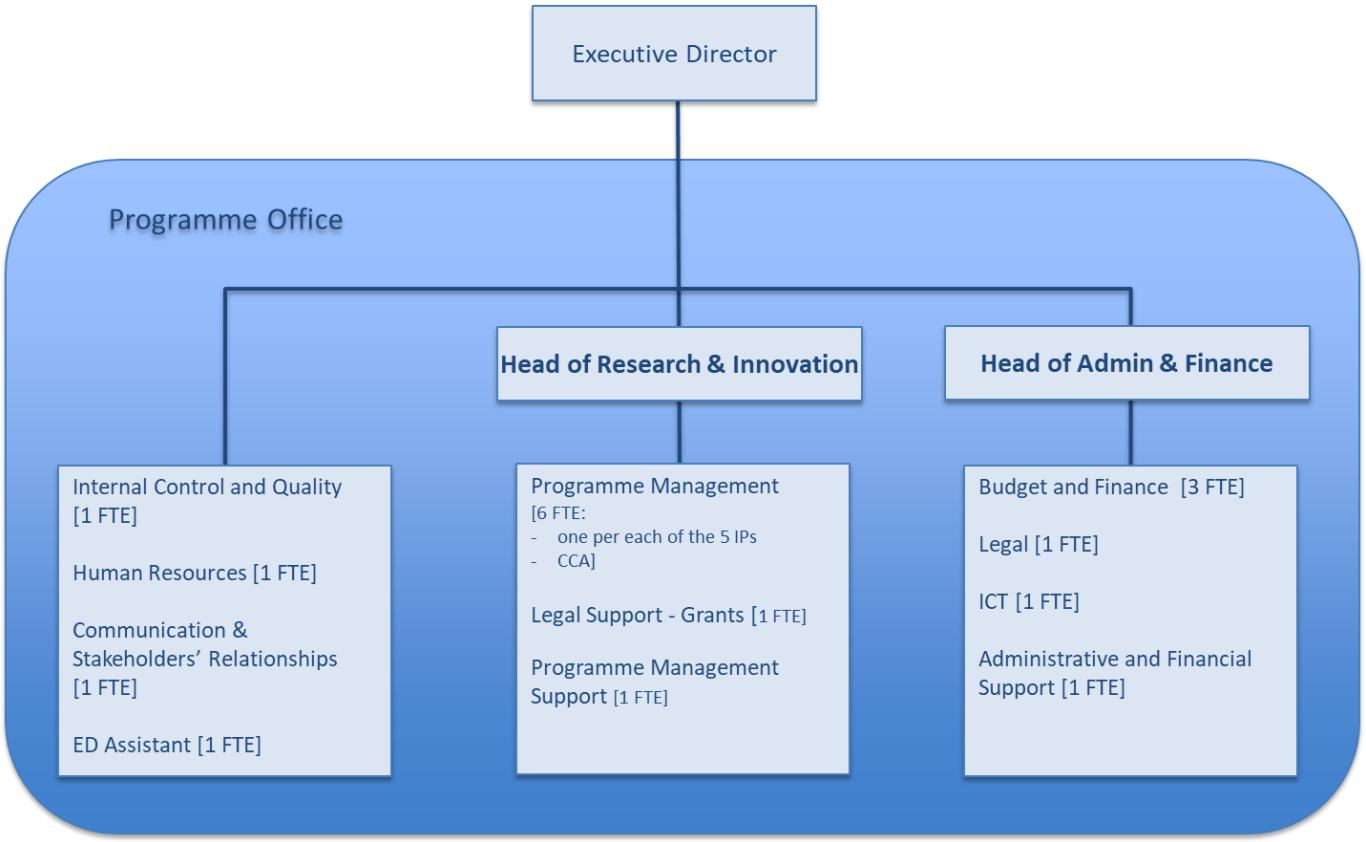
carlo m borghini,
Executive Director

[47] True and fair in this context means a reliable, complete and correct view on the state of affairs in the Joint Undertaking.

7. ANNEXES[48]

[48] It should be noted that the Annexes related to publications from Projects, patents from Projects, materiality criteria are not included considering that the Projects' activities started only 1 September 2016.

ANNEX A Organisational chart of the S2R JU



ANNEX B Establishment plan

Function group and grade	Temporary agents					
	2018		2019		2020	
	Authorised under the EU Budget	Filled as of 31/12/2018	Authorised under the EU Budget	Filled as of 31/12/2019	Authorised under the EU Budget	Filled as of 31/12/2020
	Temporary posts	Temporary posts	Temporary posts	Temporary posts	Temporary posts	Temporary posts
AD 16						
AD 15						
AD 14	1	1	1	1	1	1
AD 13						
AD 12						
AD 11						
AD 10						
AD 9	2	2	2	2	2	2
AD 8	1	1	1	1	1	1
AD 7	1	1	1	1	1	1
AD 6						
AD 5						
AD TOTAL	5	5	5	5	5	5
AST 1-11						
AST TOTAL						
AST/SC 1-6						
AST/SC TOTAL						
TOTAL	5	5	5	5	5	5
GRAND TOTAL	**5**	**5**	**5**	**5**	**5**	**5**

Contract agents	Authorised 2018	Filled as of 31/12/2018	Authorised 2019	Filled as of 31/12/2019	Authorised 2020	Filled as of 31/12/2020
Function Group IV	11	10	12	13[49]	12	13[50]
Function Group III	3	3	3	3	3	2
Function Group II	2	2	1	1	1	1
Function Group I						
TOTAL	**16**	**15**	**16**	**17**	**16**	**16**

	Authorised 2018	Filled as of 31/12/2018	Authorised 2019	Filled as of 31/12/2019	Authorised 2020	Filled as of 31/12/2020
SNE	2	3	2	3	2	2

[49] 1 additional FG IV is included for initial period of one year, with possible extension for one additional year. Such recruitment is within the budget availability of S2R to replace the activities covered by a TA, absent due to a serious long term sickness leave, with a new contract running from December 2019 to December 2020. It is important to mention that the associated tasks could in no circumstances be wholly or partly allocated to any internal staff (segregation of duties and conflict of interest) nor be covered by an external interim agent or consultant in compliance with the EU Financial Rules.

[50] 1 additional FG IV renewed for an additional 1 year-period

ANNEX C Indicators and Scoreboard of KPIs

TABLE I - Horizon 2020 Key Performance Indicators[51] common to all JUs

	Correspondence to general	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2020
INDUSTRIAL LEADERSHIP	12*	SME - Share of participating SMEs introducing innovations new to the company or the market (covering the period of the project plus three years);	Based on Community Innovation Survey (?). Number and % of participating SMEs that have introduced innovations to the company or to the market;	Number of SMEs that have introduced innovations;	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	50%	Yes	121 (47%)
	13	SME - Growth and job creation in participating SMEs	Turnover of company, number of employees	Turnover of company, number of employees;	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	to be developed based on FP7 ex-post evaluation and /or first H2020 project results	Yes	n/a
SOCIETAL CHALENGES	14*	Publications in peer-reviewed high impact journals in the area of the JU	The percentage of papers published in the top 10% impact ranked journals by subject category.	Publications from relevant funded projects (DOI: Digital Object Identifiers); Journal impact benchmark (ranking) data to be collected by commercially available bibliometric databases.	H2020 beneficiaries through project reporting; Responsible Directorate/Service (via access to appropriate bibliometric databases)	n.a. [new approach under H2020]	[On average, 20 publications per €10 million funding (for all societal challenges)]	Yes	280

[51] (based on Annex II to Council Decision 2013/743/EU)

	Correspondence to general	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2020
	15*	Patent applications and patents awarded in the area of the JU	Number of patent applications by theme; Number of awarded patents by theme	Patent application number	H2020 beneficiaries through project reporting; Responsible Directorate/Service (via worldwide search engines such as ESPACENET, WOPI)	n.a. [new approach under H2020]	On average, 2 per €10 million funding (2014 - 2020) RTD A6	Yes	4
	16*	Number of prototypes testing activities and clinical trials	Number of prototypes, testing (feasibility/demo) activities, clinical trials	Reports on prototypes, and testing activities, clinical trials	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	[To be developed on the basis of first Horizon 2020 results]	Yes	221
	17*	Number of joint public-private publications in projects	Number and share of joint public-private publications out of all relevant publications.	Properly flagged publications data (DOI) from relevant funded projects	H2020 beneficiaries through project reporting; Responsible Directorate/Service (via DOI and manual data input-flags)	n.a. [new approach under H2020]	[To be developed on the basis of first Horizon 2020 results]	Yes	28
	18*	New products, processes, and methods launched into the market	Number of projects with new innovative products, processes, instruments, methods, technologies	Project count and drop down list allowing to choose the type processes, products, instruments, methods, technologies	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	[To be developed on the basis of first Horizon 2020 results]	Yes	37

	Correspondence to general	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2020
EVALUATION	NA	Time to inform (average time in days) all applicants of the outcome of the evaluation of their application from the final date for submission of completed proposals	To provide applicants with high quality and timely evaluation results and feedback after each evaluation step by implementing and monitoring a high scientific level peer reviewed process	Number of days (average)	Joint Undertaking	H2020		Yes	all calls (TTI): average 95 // Maximum 176 2020 call (TTI) : 62
	NA	Time to inform (average time in days) successful applicants of the outcome of the evaluation of their application from the final date for submission of completed proposals		Number of days (average)	Joint Undertaking	H2020		Yes	all calls (TTI): average 95 // Maximum 176 2020 call (TTI) : 62
	NA	Redress after evaluations	To provide applicants with high quality and timely evaluation results and feedback after each evaluation step by implementing and monitoring a high scientific level peer reviewed process	Number of redresses requested	Joint Undertaking	H2020			1
GRANTS	NA	Time to grant measured (average) from call deadline to signature of grants	To minimise the duration of the granting process aiming at ensuring a prompt implementation of the Grant Agreements through a simple and transparent grant preparation process	Cumulatively in days Average under H2020 (days) TTG < 270 days (as %of GAs signed)	Joint Undertaking (automatized)	H2020		Yes	all calls (TTG): average 191 (in2Track 3 signed in May 2021) 2020 call (TTG) : 195

	Correspondence to general	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2020
	NA	Time for signing grant agreements from the date of informing successful applicants (average values)		Average under H2020 (days)	Joint Undertaking	H2020		Yes	all calls (TTS): average 92 (in2Track 3 signed in may 2021) 2020 call (TTS) : 133
AUDITS	NA	Error rate		% of common representative error; % residual error	CAS	H2020		Yes	representative error of 1.99% (weighted average 3.74%) for the JU; residual error of 1.10% (weighted average: 2.90%)
	NA	Implementation of ex-post audit results		Number of cases implemented; in total €million; ´of cases implemented/total cases	CAS	H2020		Yes	50 implemented cases, EUR 0.2 million 85% of total cases

	Correspondence to general	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2020
PAYMENTS	NA	Time to pay (% made on time) -pre-financing - interim payment -final payment	To optimize the payments circuits, both operational and administrative, including payments to experts	Average number of days for Grants pre-financing, interim payments and final payments; Average number of days for administrative payments; Number of experts appointed	Joint Undertaking	H2020	-pre-financing (30 days) - interim payment (90 days) -final payment ((90days)	Yes	Operational: Pre-financing: 18 (100%) Average number of days: 12 Interim/final: 48 (98%) Average number of days: 77 Administrative: Interim/final: 548 (98.5%) Average number of days: 13
HR	NA	Vacancy rate (%)		% of post filled in, composition of the JU staff [52]	Joint Undertaking	H2020			96%

[52] Additional indicators can be proposed/discussed with R.1 and/or DG HR

	Correspondence to general	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2020
JU EFFICIENCY	NA	Budget implementation/execution: 1. % CA to total budget 2. % PA to total budget	realistic yearly budget proposal, possibility to monitor and report on its execution, both in commitment (CA) and payments (PA), in line with sound financial management principle	% of CA and PA	Joint Undertaking	H2020	100% in CA and 90% in PA	Yes	CA: 100% PA: 81%
	NA	Administrative Budget: Number and % of total of late payments	realistic yearly budget proposal, possibility to monitor and report on its execution in line with sound financial management principle	Number of delayed payments % of delayed payments (of the total)	Joint Undertaking		H2020	Yes	8 late payments 1.5%

NOTES:

12,14,15,16,17,18*: The upcoming Control Gates (April) and project Reviews could generate improved data for this KPI which is cumulative on the S2R running projects in 2017.
18*: This indicator is not a legally compulsory one, but it covers several additional specific indicators requested for more societal challenges by the services in charge.

TABLE II - Indicators for monitoring H2020 Cross-Cutting Issues[53] common to all JTI JUs

Correspondence in the general	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2020
2	Widening the participation	2.1 Total number of participations by EU-28 Member State	Nationality of H2020 applicants & beneficiaries (number of)	H2020 applicants & beneficiaries at the submission and grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes	376 applicants from 24 Member States 235 beneficiaries from 19 Member States
		2.2 Total amount of EU financial contribution by EU-28 Member State (EUR millions)	Nationality of H2020 beneficiaries and corresponding EU financial contribution	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes	62.6M from 19 Member States (with one Grant agreement pending for signature)
NA		Total number of participations by Associated Countries	Nationality of H2020 applicants & beneficiaries (number of)	H2020 applicants & beneficiaries at the submission and grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes	At the submission: 29 applicants from 5 countries In the signed grant agreements: 6 Beneficiaries from 2 countries (with one Grant agreement pending for signature)
NA		Total amount of EU financial contribution by Candidate Country (EUR millions)	Nationality of H2020 beneficiaries and corresponding EU financial contribution	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes	2 Associated countries beneficiaries 0.8 M€ (with one Grant agreement pending for signature)

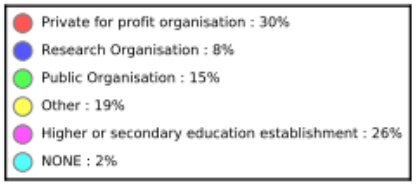
[53] (based on Annex III to Council Decision 2013/743/EU)

Correspondence in the general	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2020
3	SMEs participation	3.1 Share of EU financial contribution going to SMEs (Enabling & industrial tech and Part III of Horizon 2020)	Number of H2020 beneficiaries flagged as SME; % of EU contribution going to beneficiaries flagged as SME	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes	41 Beneficiaries are SMEs and they benefit of 8.32% of the total contribution (with one Grant agreement pending for signature)
6	Gender	6.1 Percentage of women participants in H2020 projects	Gender of participants in H2020 projects	H2020 Beneficiaries through project reporting		YES	Yes	21.43% of applicants 20.25% among beneficiaries
		6.2 Percentage of women project coordinators in H2020	Gender of MSC fellows, ERC principle investigators and scientific coordinators in other H2020 activities	H2020 beneficiaries at the grant agreement signature stage		YES	Yes	21.83%
		6.3 Percentage of women in EC advisory groups, expert groups, evaluation panels, individual experts, etc.	Gender of memberships in advisory groups, panels, etc.	Compiled by Responsible Directorate/ Service /Joint Undertaking based on existing administrative data made available by the CSC		YES		S2R JU Governing Board : 16% of representatives are female in the GB members only and 19% including alternates - S2R JU States Representatives Group 33% of representatives are female - S2R JU Scientific Committee : 33% of members are female
7	International	7.1 Share of third-country participants in Horizon 2020	Nationality of H2020 beneficiaries	H2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	NO	Yes	1 (0%)

Correspondence in the general	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2020
		7.2 Percentage of EU financial contribution attributed to third country participants	Nationality of H2020 beneficiaries and corresponding EU financial contribution	H2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	NO	Yes	0%
9	Bridging from discovery to market [54]	9.1 Share of projects and EU financial contribution allocated to Innovation Actions (IAs)	Number of IA projects	Project Office – at GA signature stage he/she will be required to flag on SYGMA. Responsible Directorate/Service (WP coordinator)/Joint Undertaking - via tool CCM2	JU AAR RTD Monitoring Report		Yes	42% (Share of Projects) 78% (share of financial contribution)
		9.2 Within the innovation actions, share of EU financial contribution focussed on demonstration and first-of-a-kind activities	Topics properly flagged in the WP; follow-up at grant level	Responsible Directorate/Service (WP coordinator)/Joint Undertaking - via tool CCM2	JU AAR RTD Monitoring Report		Yes	100%
NA		Scale of impact of projects (High Technology Readiness Level)	Number of projects addressing TRL[55] between…(4-6, 5-7)?	Joint Undertaking	JU AAR RTD Monitoring Report		No	TRL 4-6 (incl. projects up to TRL 4): 4 TRL 5-7: 14 Total: 18

[54] This indicator (9.2) is initially intended to monitor the Digital Agenda (its applicability could be only partial)
[55] TRL: Technology Readiness Level

Correspondence in the general	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2020
11	Private sector participation	11.1 Percentage of H2020 beneficiaries from the private for profit sector	Number of and % of the total H2020 beneficiaries classified by type of activity and legal status	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes	153 beneficiaries 55% of the total beneficiaries
		11.2 Share of EU financial contribution going to private for profit entities (Enabling & industrial tech and Part III of Horizon 2020)	H2020 beneficiaries classified by type of activity; corresponding EU contribution	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes	63% of the total contribution
12	Funding for PPPs	12.1 EU financial contribution for PPP (Art 187)	EU contribution to PPP (Art 187)	Responsible Directorate/Service	JU AAR RTD Monitoring Report		Yes	81.8M
		12.2 PPPs leverage: total amount of funds leveraged through Art. 187 initiatives, including additional activities, divided by the EU contribution	Total funding made by private actors involved in PPPs - in-kind contribution already committed by private members in project selected for funding - additional activities (i.e. research expenditures/investment of industry in the sector, compared to previous year)	Joint Undertaking Services	JU AAR RTD Monitoring Report			127% 227%

Correspondence in the general	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2020
13*	Communication and dissemination	13.3 Dissemination and outreach activities other than peer-reviewed publications - [Conferences, workshops, press releases, publications, flyers, exhibitions, trainings, social media, web-sites, communication campaigns (e.g radio, TV)]	A drop down list allows to choose the type of dissemination activity. Number of events, funding amount and number of persons reached thanks to the dissemination activities	H2020 Beneficiaries through project reporting	JU AAR RTD Monitoring Report	YES	Yes	1752 Dissemination and outreach activities other than peer-reviewed publications People reached: 601.417
14	Participation patterns of independent experts	14.2 Proposal evaluators by country	Nationality of proposal evaluators	Responsible Directorate /Service/Joint Undertaking in charge with the management of proposal evaluation				26 experts (25 from 12 EC Member States + 1 from Associated Countries)
		14.3 Proposal evaluators by organisations' type of activity	Type of activity of evaluators' organisations	Responsible Directorate /Service/Joint Undertaking in charge with the management of proposal evaluation				Extract from S2R Experts Pool statistics 

Correspondence in the general	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2020
sNA	Participation of RTOs and Universities	Participation of RTO[56]s and Universities in PPPs (Art 187 initiatives)	Number of participations of RTOs to funded projects and % of the total Number of participations of Universities to funded projects and % of the total % of budget allocated to RTOs and to Universities	H2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes	25 participations of RTOs 10% of total 38 participations of Universities 16 % of total 17% of total budget allocated to RTOs and Universities
NA	Ethics	The objective is ensuring that research projects funded are compliant with provisions on ethics efficiently	% of proposals not granted because non-compliance with ethical rules/proposals invited do grant (target 0%); time to ethics clearance 5target 45 days)[57]	Responsible Directorate /Service/Joint Undertaking	JU AAR RTD Monitoring Report			0%

Notes:

*H2020 applicants - all those who submitted H2020 proposals

*H2020 beneficiaries - all those who have signed a H2020 Grant Agreement

13*: The upcoming Control Gates (April) and project Reviews could generate improved data for this KPI which is cumulative on the S2R running projects in 2017.

[56] RTO: Research and Technology Organisation

[57] Data relates to pre-granting ethics review. This time span runs in parallel to granting process.

TABLE III - Key Performance Indicators specific for the S2R JU

#	Key Performance Indicator	Objective	Data to be provided by	Baseline at the start of H2020	Target at the end of H2020	Automated	Result 2020
S2R							
1	% reduction in the costs of developing, maintaining, operating and renewing infrastructure and rolling stock and increase energy efficiency compared to "State-of-the-art"	Reduce the life-cycle cost of the railway transport system	JU	"State-of-the-art" 2014	> 50 %	No	See table IV
2	% increase the capacity of railway segments to meet increased demand for passenger and freight railway services compared to "State-of-the-art" 2014	Enhance the capacity of the railway transport system	JU	"State-of-the-art" 2014	100%	No	See table IV
3	% decrease in unreliability and late arrivals compared to "State-of-the-art" 2014	Increase in the quality of rail services	JU	"State-of-the-art" 2014	> 50%	No	See table IV
4	Reduce noise emissions and vibrations linked to rolling stock and respectively infrastructure compared to "State-of-the-art" 2014	Reduce the negative externalities linked to railway transport	JU	"State-of-the-art" 2014	> 3 - 10 dBA	No	TD3.4 2.5 to - 5 dB from the rail noise thanks to absorptive panels TD1.4 Running gear works which,that with active suspension and new materials,

#	Key Performance Indicator	Objective	Data to be provided by	Baseline at the start of H2020	Target at the end of H2020	Automated	Result 2020
							estimate a reduction of the rolling noise of -2dB. TD1.5 “multi-material” brake pad type - 5 DB
5	Addressing open points in TSIs, compared to "State-of-the-art" 2014	Enhance interoperability of the railway system	JU	"State-of-the-art" 2014		No	One open point of the TSI Infra (tender and IN2TRACK-2) and open point TSI ENE (tender pantograph overhead contactline)
6	Number of Integrated Technology Demonstrators (ITDs) and System Platform Demonstrations (SPD)	Improve market uptake of innovative railway solutions through large-scale demonstration activities	JU	Multi-Annual Action Plan	4 SPD	No	ITD 4.7 - COHESIVE Alpha Release
7	Share of the fund allocated to the different Innovation Programmes and to cross-cutting themes	Ensure that funding covers the railway system as a whole	JU	n.a.	> 80%	No	100% of the operational funding
8	Percentage of topics resulting in signature of GA	Ensure a sufficiently high call topics success rate	JU	n.a.	> 90%	Yes	signed 18 of 19 94%
9	% of resources consumption versus plan (members only)	WP execution by members - resources	JU	n.a.	> 80%	Yes	*

#	Key Performance Indicator	Objective	Data to be provided by	Baseline at the start of H2020	Target at the end of H2020	Automated	Result 2020
10	% of deliverables available versus plan (members only)	WP execution by members - deliverables	JU	n.a.	> 80%	No	91.8% - 2015-2020 71.3% - 2020

TABLE IV – Initial Estimation – Release 3.2 - of the Key Performance Indicators of the Shift2Rail Programme

SPD	LCC	Capacity	Punctuality	S2R KPI
Target	-50%	+100%	+50%	
High speed	-20%	62%	35%	
Regional	-37%	74%	53%	
Metro	-18%	25%	n / a	
Freight	-39%	94%	57%	

One of the objectives of the Shift2Rail Joint Undertaking defined in its regulation is to seek developing, integrating, demonstrating and validating innovative technologies and solutions that uphold the strictest safety standards and the value of which can be measured against, inter alia, 3 quantitative Key Performance Indicators (KPIs). The targets defined are the following: reduction of LCC by 50%, improving the reliability & punctuality by 50% and doubling the capacity.

As the railway system is a very interlinked and complex system, it is required to have specific tools and methods to evaluate the effect of technological developments. This question is highly relevant for Shift2Rail as the technologies, which are developed, are to be evaluated with respect to four scenarios

called System Platform Demonstrators (SPDs). Hence an approach of estimating the above mentioned KPIs applied on the four generic SPDs based on the market segments high-speed rail, regional rail, metro and freight rail[58] has been applied which were defined in the S2R Master Plan[59].

As some of the Shift2Rail technologies (e.g. Innovation Programme on IT Solutions for Attractive Railway Services) are targeting to increase modal share of rail within the transport sectors by satisfying the customer's travel experience, those innovations cannot be taken directly into account in the three quantitative KPIs, only via an increased load factor. Therefore a dedicated model on the improvement of the attractiveness of the rail system is developed independent from the model discussed here (see also explanations to "demand effect").

In 2020, the Release 3.2 of the KPI model was published. In this version, the Scenarios for the SPDs are continuously stabilised due to a process involving a variety of sources and expertise and it also includes the improvements coming from Innovation Programme 2. Hereby it was identified that the Freight SPD has the highest potential for improvement, among others due to a more flexible operation concept for the SPD.

The Accuracy of the improvement data was developed to increase the robustness of the model. A qualitative scale of four different levels was defined and applied. The accuracy levels for more than 85% of the improvement values were reported. More than 50% of the reported improvements were classified as Level 1 "Expert estimations" while another significant part of the reported accuracy level is based on Level 3 "tested in simulation or labs".

The LCC and the capacity models were adjusted in order to capture the positive effect of weight reduction and thanks to this, measure the benefits related the increased number of passenger capacity. In addition, the LCC improvements were revisited with more accurate values while in previous KPI version conservative estimations based on the estimation of cost for prototypes were considered.

The Punctuality KPI has been completed and the main finding is that the ATO GoA4 will lead to a significant operational improvement with respect to punctuality by 13% up to 19%. The Traffic Management Systems will provide a significantly faster recovery from disturbances in the operation. Nevertheless, the railway operation suffers from more than 90% "other causes" which are coming from outside of the railway technology. For the Metro SPD there is no Punctuality result reported, because it was identified that a reasonable data base to do so could neither be found within Shift2Rail nor in any other accessible source.

[58] IMPACT-1 – D4.1 "*Reference Scenario*" – 2018, Issue 1
[59] Shift2Rail - *Shift2Rail Master Plan (MP)* – 2015

Key Performance Indicators - KPI

The KPI Life-Cycle-Cost (LCC) is defined as the cost for the railway undertaking over the lifespan of the systems. Hence they are the investment cost, operative cost like maintenance, labour or energy cost and, where applicable, the dismantling cost.

The KPI Capacity is defined as the maximum possible capacity, which is the maximum number of transportable passengers in one peak hour for the passenger transport scenarios and the maximum of tonne-kilometres in 24 hours for freight.

The KPI Reliability and Punctuality is measured as a 50% decrease of late arrivals mainly caused by unreliability of technologies.

System Platform Demonstrators - SPDs

The reference scenarios (state of the art technologies in 2013) described in the deliverable D4.1 “Reference Scenarios” of IMPACT-1 and were further developed in IMPACT-2. The data for this scenarios were collected from various sources whereas usually there could only one source for each certain parameter be found. The coherence check is scheduled for the next iteration of the model.

Further there are aspects for the four different market segments of the SPDs, which need to be kept in mind, when reviewing the result table. Those aspects are due to the inherent structure and specificities of the different market segments:

For the High Speed passenger transport (SPD1), relatively new or constantly upgraded vehicles and lines are taken into account, which are more or less best of class in Europe. Therefore, it is on the one hand a much elaborated basis to start from and on the other hand it can be assumed that effects at less developed railways will show much higher results.

The main relevant KPIs for typically Regional Rail (SPD2) lines are LCC and punctuality. Hence the challenge is here to provide a punctual service at lower cost.

Concerning Metro Rail (SPD3), there are few activities dedicated directly on Metro in direct relation to the specific S2R JU objectives in the short term. Therefore, the results for Metro are mainly based on positive effects of the innovations developed for High Speed or Regional trains as e.g. reduction of energy consumption or improved maintenance. They are not optimised for this special form of rail transport, but can help to reduce LCC and improve capacity.

Because SPD4, Freight rail, is not focussing on passenger transport, but freight transport, it differs in some definitions and focus points from the other three SPDs. Further the modelling has not only to consider technological improvements, but also operational optimisation for rail freight transport. Moreover, as generally the introduction of innovations in freight rail operation takes more time than in passenger transport, the technology level in execution is quite

moderate. Taking both into account, the more legacy basis to start from and the technological and operational effects, the achievable benefits are much higher than for the other three SPDs.

Further some innovations cannot show their full potential, because there is only one scenario per market segment. Those scenarios are optimised to show the majority of positive effects, but cannot be set to show every effect of every Shift2Rail innovation.

Demand effect

As already explained in the background, large parts of positive effects especially for the passenger transport (SPD1-3) are not adequately measurable through LCC, capacity and punctuality, e.g. new IT solutions (IP4), effects of other innovations such as noise mitigation, customer oriented services and better quality, increased comfort for the customers, better governance etc. Those will be included in the attractiveness model. Therefore, the increase of demand is not considered in the results for the passenger SPDs, yet, meaning that for the first results there is no change in the load factor and therefore in the demand included. For the freight SPD, a demand increase could already be considered and therefore also it positive effect of the contribution margin.

In line with the reporting requirement detail in FR 2018 Article 130.4, the Financial Framework Partnerships >4 years are reported under section 1.6 of this document.

BALANCE SHEET

EUR '000

	Note	31.12.2020	31.12.2019
NON-CURRENT ASSETS			
Intangible assets		*2*	*0*
Property, plant and equipment	*2.1*	*183*	*197*
Pre-financing	*2.2*	*50 271*	*44 980*
		50 456	**45 177**
CURRENT ASSETS			
Pre-financing	*2.2*	*46 049*	*33 756*
Exchange receivables and non-exchange recoverables	*2.3*	*40 598*	*26 316*
		86 646	**60 072**
TOTAL ASSETS		**137 102**	**105 249**
CURRENT LIABILITIES			
Payables and other liabilities	*2.4*	*(97 465)*	*(80 746)*
Accrued charges and deferred income	*2.5*	*(44 413)*	*(36 963)*
		(141 878)	**(117 710)**
TOTAL LIABILITIES		**(141 878)**	**(117 710)**
NET ASSETS		**(4 776)**	**(12 462)**
Contribution from Members	*2.6*	*428 922*	*298 570*
Accumulated deficit		*(311 031)*	*(190 081)*
Economic result of the year		*(122 667)*	*(120 950)*
NET ASSETS		**(4 776)**	**(12 461)**

STATEMENT OF FINANCIAL PERFORMANCE

EUR '000

	Note	2020	2019
REVENUE			
Revenue from non-exchange transactions			
Recovery of expenses	*3.1*	*136*	*30*
		136	**30**
Revenue from exchange transactions			
Other	*3.2*	*33*	*4*
		33	**4**
Total revenue		**169**	**34**
EXPENSES			
Operational costs	*3.3*	*(119 355)*	*(117 459)*
Staff costs	*3.4*	*(1 914)*	*(1 684)*
Other expenses	*3.5*	*(1 568)*	*(1 842)*
Total expenses		**(122 836)**	**(120 984)**
ECONOMIC RESULT OF THE YEAR		**(122 667)**	**(120 950)**

CASHFLOW STATEMENT[60]

EUR '000

	2020	2019
Economic result of the year	*(122 667)*	*(120 950)*
Operating activities		
Depreciation and amortization	*52*	*53*
(Increase)/decrease in pre-financing	*(17 584)*	*(17 843)*
(Increase)/decrease in exchange receivables and non-exchange recoverables	*(14 282)*	*3 441*
Increase/(decrease) in payables	*16 719*	*11 535*
Increase/(decrease) in accrued charges & deferred income	*7 450*	*12 278*
Increase/(decrease) in cash contributions	*77 054*	*64 529*
Increase/(decrease) in in-kind contributions	*53 298*	*46 972*
Investing activities		
(Increase)/decrease in intangible assets and property, plant and equipment	*(40)*	*(15)*
NET CASHFLOW	**–**	**–**
Net increase/(decrease) in cash and cash equivalents	–	–
Cash and cash equivalents at the beginning of the year	–	–
Cash and cash equivalents at year-end	–	–

[60] Following the appointment of the Accounting Officer of the Commission as the Accounting Officer of S2R JU, the treasury of S2R JU was integrated into the Commission's treasury system. Therefore, S2R JU does not have any bank accounts of its own. All payments and receipts are processed via the Commission's treasury system and registered on intercompany accounts which are presented under the heading exchange receivables.

STATEMENT OF CHANGES IN NET ASSETS

EUR '000

	Contribution from Members	Accumulated Surplus/ (Deficit)	Economic result of the year	Net Assets
BALANCE AS AT 31.12.2018	**187 070**	**(78 305)**	**(111 776)**	**(3 011)**
Allocation 2018 economic result	*–*	*(111 776)*	*111 776*	*–*
Cash contribution	*64 529*	*–*	*–*	*64 529*
Contribution in-kind	*46 972*	*–*	*–*	*46 972*
Economic result of the year	*–*	*–*	*(120 950)*	*(120 950)*
BALANCE AS AT 31.12.2019	**298 570**	**(190 081)**	**(120 950)**	**(12 461)**
Allocation 2019 economic result	*–*	*(120 950)*	*120 950*	*–*
Cash contribution	*77 054*	*–*	*–*	*77 054*
Contribution in-kind	*53 298*	*–*	*–*	*53 298*
Economic result of the year	*–*	*–*	*(122 667)*	*(122 667)*
BALANCE AS AT 31.12.2020	**428 922**	**(311 031)**	**(122 667)**	**(4 776)**

ANNEX E Overview of publications and events

SHIFT2RAIL 2020 PUBLICATIONS

Title	Publication Date	Link to the Publication
Multi-Annual Action Plan	8 September, 2020	https://shift2rail.org/wp-content/uploads/2020/09/MAAP-Part-A-and-B.pdf
Annual Activity Report 2019: Executive View	21 October, 2020	https://shift2rail.org/wp-content/uploads/2020/10/Annual-Activity-Report-2019-Executive-View.pdf
Shift2Rail Factsheet	21 October 2020	https://shift2rail.org/wp-content/uploads/2020/10/S2R_Factsheet_October-2020.pdf
Innovation in Action brochure	16 November, 2020	https://shift2rail.org/wp-content/uploads/2020/11/JU-Brochure_WEB-1-003.pdf

SHIFT2RAIL 2020 PRESS RELEASES

Title	Publication Date	Link to the Publication
Shift2Rail publishes its Call for Proposals 2020	8 January, 2020	https://shift2rail.org/press-releases/shift2rail-publishes-its-call-for-proposals-2020/
Memorandum of Understanding signed between Shift2Rail Joint Undertaking and the region of the Basque Country	24 January, 2020	https://shift2rail.org/press-releases/memorandum-of-understanding-signed-between-shift2rail-joint-undertaking-and-the-region-of-the-basque-country/
Shift2Rail Call for Proposals 2020: Participation Results	29 May, 2020	https://shift2rail.org/press-releases/shift2rail-call-for-proposals-2020-participation-results/
Shift2Rail's Governing Board gives ''green light'' for the set-up of the European DAC Delivery Programme	23 July, 2020	https://shift2rail.org/press-releases/shift2rails-governing-board-gives-green-light-for-the-set-up-of-the-european-dac-delivery-programme/
Shift2Rail awards 19 grants for its Call for Proposals 2020	28 July, 2020	https://shift2rail.org/press-releases/shift2rail-awards-19-grants-for-its-call-for-proposals-2020/
Memorandum of Understanding signed between Shift2Rail Joint Undertaking and the Canadian Urban	23 October, 2020	https://shift2rail.org/press-releases/memorandum-of-understanding-signed-between-shift2rail-joint-undertaking-and-the-canadian-urban-transit-research-innovation-consortium-cutric/

Transit Research & Innovation Consortium (CUTRIC)		
Memorandum of Understanding signed between Shift2Rail Joint Undertaking and the Permanent Secretariat of the Transport Community	27 October, 2020	https://shift2rail.org/press-releases/memorandum-of-understanding-signed-between-shift2rail-joint-undertaking-and-the-permanent-secretariat-of-the-transport-community/

SHIFT2RAIL 2020 NEWSLETTER

Title	Publication Date	Link to the Publication
Apply for Shift2Rail Call for Proposals 2020	31 January 2020	https://mailchi.mp/s2r.europa.eu/idkjg938qg
Shift2Rail at TRA 2020	28 February 2020	https://mailchi.mp/s2r.europa.eu/februarynewsletter
#S2RCall2020 – Deadline Extended!	31 March 2020	https://mailchi.mp/s2r.europa.eu/s2rmarchnewsletter
Moving Around Europe Seamlessly – Join our Webinars!	28 April 2020	https://mailchi.mp/s2r.europa.eu/s2raprilnewsletter
Call for Proposals 2020: Participation results now out!	29 May 2020	https://mailchi.mp/s2r.europa.eu/maynewsletter
Register now for the Shift2Rail Innovation Days!	30 June 2020	https://mailchi.mp/s2r.europa.eu/junenewsletter
Shift2Rail Innovation Days: LET'S RECONNECT!	30 September 2020	https://mailchi.mp/s2r.europa.eu/september2020newsletter
Shift2Rail Innovation Days-the highlights at your fingertips!	29 October 2020	https://mailchi.mp/s2r.europa.eu/october2020newsletter
Apply now! Unique Train Prize	30 November 2020	https://mailchi.mp/s2r.europa.eu/november2020newsletter
Delivery of new smart maintenance concept & global safety framework!	17 December 2020	https://mailchi.mp/s2r.europa.eu/december2020newsletter

PRESS ARTICLES ABOUT SHIFT2RAIL PUBLISHED IN 2020

Press outlet	Title	Link to the Publication

Railway Gazette	Shift2Rail invites 2020 research proposals	https://www.railwaygazette.com/research-training-and-skills/shift2rail-invites-2020-research-proposals/55500.article
	European Rail Partnership to succeed Shift2Rail	https://www.railwaygazette.com/research-training-and-skills/european-rail-partnership-to-succeed-shift2rail/57184.article
	EU ministers commit to foster freight corridors	https://www.railwaygazette.com/freight/eu-ministers-commit-to-foster-freight-corridors/57415.article
	Research project starts work on FRMCS demonstrator	https://www.railwaygazette.com/research-training-and-skills/research-project-starts-work-on-frmcs-demonstrator/57778.article
	Digital automatic couplers on test	https://www.railwaygazette.com/freight/digital-automatic-couplers-on-test/57021.article
	Urban transport industry news round-up	https://www.railwaygazette.com/news/urban-transport-industry-news-round-up/57760.article
	Freight ATO demonstration on track	https://www.railwaygazette.com/freight/freight-ato-demonstration-on-track/57632.article
	Latest Shift2Rail call for proposals attracts strong market interest	https://www.railwaygazette.com/news/latest-shift2rail-call-for-proposals-attracts-strong-market-interest/56653.article#.XtUI0Ox8KKQ.twitter
	Automatic operation of regional passenger trains to be tested	https://www.railwaygazette.com/technology/automatic-operation-of-regional-passenger-trains-to-be-tested/56606.article
	Research: We need to focus on the vision	https://www.railwaygazette.com/in-depth/research-we-need-to-focus-on-the-vision/56153.article
	SmartRail Europe attracts global rail professionals	https://www.railwaygazette.com/news/smartrail-europe-attracts-global-rail-professionals/55823.article
Global Railway Review	Shift2Rail publishes its Call for Proposals 2020	https://www.globalrailwayreview.com/news/94948/shift2rail-call-for-proposals-2020/
	A shared vision towards the future of rail: Shift2Rail at InnoTrans 2020	https://www.globalrailwayreview.com/article/96310/carlo-borghini-looking-ahead-to-innotrans-2020/
	Shift2Rail signs MoU with the region of the Basque Country	https://www.globalrailwayreview.com/news/95686/shift2rail-mou-basque-country/
	“2020 must be the year of rail”: Philippe Citroën, UNIFE Director General	https://www.globalrailwayreview.com/article/96050/2020-rail-philippe-citroen-unife/
	Rail Baltica: Capturing the greenfield and transforming mobility	https://www.globalrailwayreview.com/article/109669/rail-baltica-capturing-the-greenfield-and-transforming-mobility/
	Green Cargo to test digital automatic coupling to improve efficiency	https://www.globalrailwayreview.com/news/113269/green-cargo-digital-automatic-coupling/
	EU-funded 5GRAIL project for development of FRMCS officially launched	https://www.globalrailwayreview.com/news/112804/5grail-project-frmcs-officially-launched/
	IN2STEMPO: How smart maintenance could help support	https://www.globalrailwayreview.com/article/111652/in2stempo-smart-maintenance-decarbonisation-rail/

	the decarbonisation of our rail network	
	Europe's rail industry joins to support deployment of Digital Automatic Coupling	https://www.globalrailwayreview.com/news/109296/rail-freight-digital-automatic-coupling-dac/
	Slovenian Railways' new SEPA international reservation and ticketing platform	https://www.globalrailwayreview.com/article/107422/slovenian-railways-sepa-ticketing-platform/
	Shift2Rail's Governing Board gives go-ahead for European DAC Delivery Programme	https://www.globalrailwayreview.com/news/105061/shift2rail-dac-delivery-programme/
	Shift2Rail awards 19 project grants for its Call for Proposals 2020	https://www.globalrailwayreview.com/news/105398/shift2rail-project-grants-call-for-proposals-2020/
	Shift2Rail releases its Call for Proposals 2020 participation results	https://www.globalrailwayreview.com/news/101223/shift2rail-call-for-proposals-2020-results/
	COVID-19 and its impact on the European rail supply industry	https://www.globalrailwayreview.com/article/98741/covid19-european-rail-supply-industry/
International Railway Journal	Shift2Rail invites submissions for 2020 research projects	https://www.railjournal.com/technology/shift2rail-invites-submissions-for-2020-research-projects/
	German mainline ATO trials to commence in 2021	https://www.railjournal.com/signalling/german-mainline-at o-trials-to-commence-in-2021/
	Testing and development of digital automatic couplings launched	https://www.railjournal.com/fleet/testing-and-development-of-digital-automatic-couplings-launched/
	IRJ 2020 Innovations Showcase: Bombardier retrofits AGC fleets for electric power by	https://www.railjournal.com/innovations-showcase/bombardier-retrofits-agc-fleets-electric-power/
	Next-generation railway radio reaches key milestone	https://www.railjournal.com/opinion/next-generation-railway-radio-reaches-key-milestone
	Voith to deliver additional CargoFlex couplers to SBB Cargo	https://www.railjournal.com/freight/voith-to-deliver-additional-cargoflex-couplers-to-sbb-cargo/
	ÖBB launches passenger trials with hydrogen train	https://www.railjournal.com/passenger/main-line/obb-launches-passenger-trials-with-hydrogen-train/
	FRMCS project takes key step forward	https://www.railjournal.com/telecoms/frmcs-project-takes-key-step-forward/
	European operators urge policymakers to prioritise rail freight in Covid-19 recovery	https://www.railjournal.com/in_depth/european-operators-policymakers-prioritise-rail-freight-covid-19-recovery
	Innovative rail policy needed to decarbonise European transport	https://www.railjournal.com/opinion/innovative-rail-policy-decarbonise-european-transport
	Shift2Rail calls for freight train tracking solution	https://www.railjournal.com/freight/shift2rail-calls-for-freight-train-tracking-solution/
	Shift2Rail approves €75.4m funding for 19 projects	https://www.railjournal.com/financial/shift2rail-approves-e75-4m-funding-for-19-projects/
	Unife and CER call for rail to be included in EU recovery plan	https://www.railjournal.com/policy/unife-and-cer-call-for-rail-to-be-included-in-eu-recovery-plan/

	Shift2Rail signs agreements with CUTRIC and Western Balkan countries	https://www.railjournal.com/regions/europe/shift2rail-signs-agreements-with-cutric-and-western-balkan-countries/
	German mainline ATO trials to commence in 2022	https://www.railjournal.com/in_depth/german-mainline-ato-trials-commence-2022
	Rail freight industry leaders sign digital coupling MoU	https://www.railjournal.com/freight/rail-freight-industry-leaders-sign-digital-coupling-mou/
	Covid-19 brings new opportunities for rail	https://www.railjournal.com/opinion/covid-19-opportunities-for-rail
	Shift2Rail call for proposals receives 43 requests worth €113.3m	https://www.railjournal.com/regions/europe/shift2rail-call-for-proposals-receives-43-requests-worth-e113-3m/
	Next stop: the station of the future	https://www.railjournal.com/in_depth/next-stop-the-station-of-the-future
	Will ERTMS ever reach critical mass in Europe?	https://www.railjournal.com/in_depth/will-ertms-reach-critical-mass-europe
	Reopening the Plum Railway	https://www.railjournal.com/policy/uic-uitp-unife-public-transport-post-covid-19-world/
	EU publishes guide for restoring transport services	https://www.railjournal.com/policy/eu-publishes-guide-to-restoring-transport-services/
Railway Pro	Shift2Rail 2020 call for proposals opened	https://www.railwaypro.com/wp/shift2rail-2020-call-for-proposals-opened/
	19 projects selected under Shift2Rail 2020 call for proposals	https://www.railwaypro.com/wp/19-projects-selected-under-shift2rail-2020-call-for-proposals/
	S2R JU and the Transport Permanent Secretariat to develop rail in Western Balkan region	https://www.railwaypro.com/wp/s2r-ju-and-the-transport-permanent-secretariat-to-develop-rail-in-western-balkan-region/
	Shift2Rail signs MoU for international collaboration	https://www.railwaypro.com/wp/shift2rail-signs-mou-for-international-collaboration/
	S2R JU approves the European DAC Delivery Programme	https://www.railwaypro.com/wp/s2r-ju-approves-the-european-dac-delivery-programme/
	Calls for a new European rail research partnership	https://www.railwaypro.com/wp/calls-for-a-new-european-rail-research-partnership/
FerPress	Shift2Rail pubblica la sua Call for Proposals 2020. Saranno finanziati progetti per un valore di 146,6 mln	https://www.ferpress.it/shift2rail-pubblica-la-sua-call-for-proposals-2020-saranno-finanziati-progetti-un-valore-1466-mln/
	5GRAIL Horizon Program: prototypes for Future Railways Mobile Communication System are underway	https://www.ferpress.it/programma-horizon-5grail-al-via-prototipi-per-future-railways-mobile-communication-system/
	UIC: the speech by Castelli (Fs), the Covid-19 task force, the 5G for rail transport at the center of the 96th General Assembly	https://www.ferpress.it/uic-discorso-castelli-fs-la-task-force-uic-covid-19-5g-trasporto-ferroviario-al-centro-della-96a-assemblea/
	Shift2Rail: 43 proposte per un valore totale di 185,8 mln al suo invito a presentare proposte per il 2020	https://www.ferpress.it/shift2rail-43-proposte-un-valore-totale-1858-mln-al-suo-invito-presentare-proposte-2020/

El Mercantil	Shift2Rail destina más de 146 millones de euros para fomentar la innovación ferroviaria en 2020	https://elmercantil.com/2020/01/13/shift2rail-destina-mas-de-146-millones-de-euros-para-fomentar-la-innovacion-ferroviaria-en-2020/
CORDIS	Innovating railways for tomorrow's freight transport	https://cordis.europa.eu/article/id/413243-innovating-railways-for-tomorrow-s-freight-transport
Railway Technology	Horizon 2020: a look at the EU's flagship rail projects	https://www.railway-technology.com/features/horizon-2020-rail-projects/
	Rail Baltica II: three lessons we learned from the IRS webinar	https://www.railway-technology.com/features/rail-baltica-three-lessons-we-learnt-irs-webinar/
	The eye of the storm: boosting railway resilience in the UK	https://www.railway-technology.com/features/railway-resilience-in-the-uk/
	Could remote sensing improve railway infrastructure monitoring?	https://www.railway-technology.com/features/remote-sensing-to-monitor-railways/
	Consortium of European partners chosen for new EU Shift2Rail Programme	https://www.railway-technology.com/news/consortium-european-partners-eu-shift2rail-programme/
Strukton	Lean Tamping implemented in maintenance operation	https://strukton.com/en/articles/news/2019/12/lean-tamping-in-maintenance-operation
British Plastics and Rubber Magazine	AIMPLAS takes part in project to help replace metal railway parts with lighter composite materials	https://www.britishplastics.co.uk/News/aimplas-takes-part-in-project-to-help-replace-metal-railways/
Baltic Times	Rail Baltica presents project status and benefits to European partners	https://www.baltictimes.com/rail_baltica_presents_project_status_and_benefits_to_european_partners/
Inter Empresa	Siete socios desarrollarán el nuevo proyecto '4SECURail' de Shift2Rail para la seguridad y ciberseguridad ferroviaria	https://www.interempresas.net/Ferrocarril/Articulos/267113-Siete-socios-desarrollaran-proyecto-4SECURail-Shift2Rail-seguridad-ciberseguridad.html
Rynek Kolejowy	Javier Goikoetxea z Shift2Rail na Europejskim Forum Taborowym	https://www.rynek-kolejowy.pl/mobile/javier-goikoetxea-z-shift2rail-na-europejskim-forum-taborowym-95490.html
Le Soir	Charleroi, locomotive du train sans conducteur	https://plus.lesoir.be/280087/article/2020-02-14/charleroi-locomotive-du-train-sans-conducteur
Spoor Pro	Europese Commissie: Spoorsector moet haast maken met digitalisering	https://www.spoorpro.nl/spoorbouw/2020/02/25/europese-commissie-spoorsector-moet-haast-maken-met-digitalisering/?gdpr=accept
	Minister: neem internationaal personenvervoer per spoor op in de Green Deal	https://www.spoorpro.nl/spoorbouw/2020/02/24/minister-neem-internationaal-personenvervoer-per-spoor-op-in-de-green-deal/
	Van Veldhoven is polling European colleagues for international rail top	https://www.spoorpro.nl/management/2020/12/02/van-veldhoven-polst-europese-collegas-voor-internationale-spoortop/
International Railway Summit	The European Green Deal – an opportunity for rail	http://www.irits.org/the-european-green-deal-an-opportunity-for-rail/

	After Coronavirus: An opportunity for green mobility in Europe	http://www.irits.org/after-coronavirus-an-opportunity-for-green-mobility-in-europe/
Railway News	Masats Involved in the European Project Shift2Rail	https://railway-news.com/masats-involved-in-the-european-project-shift2rail/
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	EC to Establish New Partnership on Rail Research and Innovation	https://railway-news.com/ec-to-establish-new-partnership-on-rail-research-and-innovation/
	Through the Storm and Forward: Rail Transport at the Time of COVID-19	https://railway-news.com/through-the-storm-and-forward-rail-transport-at-the-time-of-covid-19/
Rail Technology Magazine	RIA 'Digital Journeys' - Day Four Webinar Series	https://www.railtechnologymagazine.com/Rail-News/ria-digital-journeys-day-four-webinar-series
Gonews	Rendere standard i sistemi europei di gestione del traffico ferroviario: il Sant'Anna partner del progetto europeo "optima"	https://www.gonews.it/2020/04/24/rendere-standard-i-sistemi-europei-di-gestione-del-traffico-ferroviario-il-santanna-partner-del-progetto-europeo-optima/
InToscana	'Optima', un software per migliorare il traffico dei treni	https://www.intoscana.it/it/articolo/software-circolazione-treni/
Ansa	Trasporti:S.Anna studia software migliore circolazione treni	https://www.ansa.it/nuova_europa/it/notizie/rubriche/infrastrutture/2020/04/24/trasportis.anna-studia-software-migliore-circolazione-treni_356c0314-3555-4da2-afdd-cbf9df40888d.html
ETNA 2020	Transforming Europe's Rail System	https://www.transport-ncps.net/wp-content/uploads/2020/05/N13_Etna2020Newsletter.pdf
Alstom	World-first: Automatic Train Operation for regional passenger trains to be tested in Germany	https://www.alstom.com/press-releases-news/2020/5/world-first-automatic-train-operation-regional-passenger-trains-be
RegionalHuete.de	Automatischer Zugbetrieb soll in unserer Region getestet werden	https://regionalheute.de/automatischer-zugbetrieb-soll-in-unserer-region-getestet-werden-1590602723/
Treinenweb.nl	Alstom gaat proeven met ATO uitvoeren in Braunschweig	https://www.treinenweb.nl/nieuws/8404/alstom-gaat-proeven-met-ato-uitvoeren-in-braunschweig.html
Eleconomista	La ingeniería española, en auge en los proyectos de transporte en todo el mundo	https://revistas.eleconomista.es/transporte/2020/mayo/la-ingenieria-espanola-en-auge-en-los-proyectos-de-transporte-en-todo-el-mundo-FE2969362
Rieles	OPERACIÓN AUTOMÁTICA DE TRENES PARA TRENES REGIONALES DE PASAJEROS A PRUEBA EN ALEMANIA	http://www.rieles.com/front/operacion-automatica-de-trenes-para-trenes-regionales-de-pasajeros-a-prueba-en-alemania/
	The railway is the most sustainable means	http://www.rieles.com/front/el-ferrocarril-es-el-medio-mas-sostenible/
Mobilita.org	Alstom, assegnato dal Ministero dell'economia tedesco il Premio per l'innovazione	http://mobilita.org/2020/05/28/alstom-assegnato-dal-ministero-delleconomia-tedesco-il-premio-per-linnovazione/

Ferrovie.it	Anteprima mondiale per l'Automatic Train Operation di Alstom in Germania	http://www.ferrovie.it/portale/articoli/9578
Money and Tourism	Announcements by the European Commission for Air Transport, Ships, Trains and Transport	https://money-tourism.gr/oi-anakoinoseis-tis-eyropaikis-epitropis-aerometafores-ploia-trena-metafores/
Luxinnovation	Shift2Rail Innovation Days 2020 – Save the date	https://www.luxinnovation.lu/event/shift2rail-innovation-days-2020-save-the-date/
Errac	Research and innovation – enablers of strong and resilient rail services	https://mailchi.mp/c55545f5767c/press-release-research-and-innovation-enablers-of-strong-and-resilient-rail-services?e=eaa67029a9
Railways Africa	Giving Public Transport a Central Place in the World of Tomorrow	https://www.railwaysafrica.com/news/giving-public-transport-a-central-place-in-the-world-of-tomorrow
	Indra Will Develop The Traffic Management System Of The Railway Network In Estonia	https://www.railwaysafrica.com/news/indra-will-develop-the-traffic-management-system-of-the-railway-network-in-estonia-for-18-4-million-euros
	Shift2Rail Awards 19 Grants For Its Call For Proposals 2020	https://www.railwaysafrica.com/news/shift2rail-awards-19-grants-for-its-call-for-proposals-2020
Assembly Magazine	High-Speed Rail Demands Light Railcars	https://www.assemblymag.com/articles/95730-high-speed-rail-demands-light-railcars
Agefi	Swisspod tackles the Hyperloop standard in Europe	http://www.agefi.com/home/entreprises/detail/edition/online/article/la-firme-de-monthey-integre-linitiative-hyperloop-development-de-la-commission-europeenne-nee-de-la-participation-de-ses-fondateurs-a-la-competition-californienne-spacex-hyperloop-swisspod-497291.html
Heidi News	EPFL's Hyperloop project becomes a start-up supported by Europe	https://www.heidi.news/sciences/exclusif-le-projet-hyperloop-de-l-epfl-devient-une-start-up-soutenue-par-l-europe
Diario de Castilla y Léon	An 'app' on wheels in the backpack	https://diariodecastillayleon.elmundo.es/articulo/innovadores/app-ruedas-mochila/20200608214920011028.html
Forbes Romania	Swisspod, a startup co-founded by Denis Tudor, joins the European Commission's initiative to build ultra-fast Hyperloop trains across Europe	https://www.forbes.ro/swisspod-startup-cofondat-de-catre-denis-tudor-se-alatura-initiativei-comisiei-europene-pentru-construirea-trenurilor-ultra-rapide-de-tip-hyperloop-toata-europa-170270
Rynek Kolejowy	Meeting with the EC on financing European railways	https://www.rynek-kolejowy.pl/mobile/spotkanie-z-ke-nt-finansowania-europejskich-kolei-97236.html
Mreza	In addition to aviation, the EU railway also receives satellite navigation	https://mreza.bug.hr/uz-avijaciju-i-eu-zeljeznica-dobija-satelitsku-navigaciju/
Robotics and Automation News	Alstom to test fully driverless trains in Germany	https://roboticsandautomationnews.com/2020/06/04/alstom-to-test-driverless-trains-in-germany/32772/
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Interempresas	Alstom probará por primera vez en el mundo un tren regional completamente autónomo	https://www.interempresas.net/Ferrocarril/Articulos/305766-Alstom-probara-769-por-primera-vez-en-mundo-tren-regional-completamente-auto-769-nomo.html
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Trasporto Europa	Le ferrovie europee verso un unico gancio automatico	https://www.trasportoeuropa.it/notizie/ferrovia/le-ferrovie-europee-verso-un-unico-gancio-automatico/
Swiss Info	Hyperloop projects inch closer to reality	https://www.swissinfo.ch/eng/hyperloop-projects-inch-closer-to-reality/45925150
Financial Mirror	Cyprus mulls trams, railway network	https://www.financialmirror.com/2020/09/22/cyprus-mulls-trams-railway-network/
Ferrovie Info	Railways, Austria: regular service test for the hydrogen Coradia iLint	https://ferrovie.info/index.php/it/13-treni-reali/15597-ferrovie-austria-test-in-servizio-regolare-per-il-coradia-ilint-a-idrogeno
Automotive World	Voith participates in test phase for Europe-wide introduction of automatic freight coupler as part of DAC4EU	https://www.automotiveworld.com/news-releases/voith-participates-in-test-phase-for-europe-wide-introduction-of-automatic-freight-coupler-as-part-of-dac4eu/
Progressive Railroading	Rail supplier news from Voith, Granite, Quandel, STV, Stridas and LRW	https://www.progressiverailroading.com/people/news/Rail-supplier-news-from-Voith-Granite-Quandel-STV-Stridas-and-LRW-Oct-7--61773
DEC Research News	Railway Management System Market Detailed Analysis of Current Industry Figures with Forecasts Growth By 2024	http://news.decresearch.com/railway-management-system-market-detailed-analysis-of-current-industry-figures-with-forecasts-growth-by-2024/
Galicia Press	A Galician technology center participates in a project that seeks to reduce maintenance costs of the railway system	https://www.galiciapress.es/texto-diario/mostrar/2110919/centro-tecnologico-gallego-participa-proyecto-busca-reducir-costes-mantenimiento-sistema-ferroviario
Alkas	How we will drive in the future: harmonious, safe, green and driver-free	http://alkas.lt/2020/10/23/kaip-vaziuosime-ateityje-darniai-saugiai-zaliai-ir-be-vairuotoju/
i-Doprava.com	AŽD Praha is testing the ATO system in Switzerland. It is similar to the Czech AVV	https://i-doprava.com/2020/10/27/azd-praha-uspesne-expanduje-do-svycarska-narusil-silne-vazby-zapadu-se-siemensem/
Sciencebusiness.net	Way to run a railway: new partnership aims to lead the industry to a green and digital future	https://sciencebusiness.net/news/way-run-railway-new-partnership-aims-lead-industry-green-and-digital-future
Mynewsdesk	Green Cargo tests digital automatic couplers for more	https://www.mynewsdesk.com/se/greencargo/pressreleases/green-cargo-testar-digitala-

	efficient freight traffic by rail in unique European cooperation	automatkoppel-foer-effektivare-godstrafik-paa-jaernvaeg-i-unikt-europeiskt-samarbete-3049992
Il Denaro	"Unique Train Prize", call for 500 thousand euros: innovative solutions for rail transport	https://www.ildenaro.it/unique-train-prize-call-da-500mila-euro-soluzioni-innovative-per-i-trasporti-ferroviari/
Market Screener	CER Community of European Railway and Infrastruc : New EU Strategy for Sustainable and Smart Mobility gives pivotal role to rail	https://www.marketscreener.com/news/latest/CER-Community-of-European-Railway-and-Infrastruc-New-EU-Strategy-for-Sustainable-and-Smart-Mobilit--31972301/
Rinnovabili.it	Hydrogen trains, between advantages and challenges	https://www.rinnovabili.it/mobilita/veicoli-ecologici/treni-ad-idrogeno-vantaggi-sfide/
Leadersnet	ÖBB successfully completes test operation with hydrogen train	https://www.leadersnet.at/news/47336,oebb-schliesst-testbetrieb-mit-wasserstoffzug-erfolgreich-ab.html
Energate	Hydrogen train passes practical test by ÖBB	https://www.energate-messenger.de/news/207697/wasserstoffzug-besteht-praxistest-der-oebb
ElEspañol	Modular molds to manufacture lighter and more sustainable trains in the future	https://www.elespanol.com/invertia/disruptores-innovadores/autonomias/cataluna/20201201/moldes-modulares-fabricar-trenes-ligeros-sostenibles-futuro/539946506_0.html
Rynek Kolejowy	Nevomo financed by Shift2Rail	https://www.rynek-kolejowy.pl/wiadomosci/nevomo-z-finansowaniem-z-shift2rail-99832.html
La Vanguardia	Eurecat will contribute to the manufacture of "lighter and more sustainable" trains	https://www.lavanguardia.com/vida/20201130/49808147614/eurecat-contribuira-a-la-fabricacion-de-trenes-mas-ligeros-y-sostenibles.html
Z.DoPravy.cz	Hydrogen as the railway drive of the future? Research, development and innovation activities in VUZ in 2020	https://zdopravy.cz/vodik-jako-pohon-zeleznice-budoucnosti-vyzkum-vyvoj-a-inovacni-cinnost-ve-vuz-v-roce-2020-67808/
En Directe a Radio 4	Discover the Co-Aps Project	https://www.rtve.es/alacarta/audios/en-directe-a-radio-4/co-aps-upc/5734618/

EXTERNAL EVENTS PARTICIPATED TO BY SHIFT2RAIL IN 2020

In 2020, the Shift2Rail JU participated to major events across Europe and beyond, presenting concrete results achieved by Shift2Rail JU Members together with other key stakeholders.

Basque Railway 2020 Event, 4th International Railway Conference – 22 January, San Sebastian, Spain
Shift2Rail signed a Memorandum of Understanding with the Basque government. The Memorandum of Understanding, signed between Shift2Rail and the region of the Basque Country on 22 January at the Basque Railway 2020 Event in San Sebastián, will allow for synergies between the funding instruments available at the European Union and regional levels to move rail Research & Innovation forward and crucially promote market deployment.

11th European Innovation Summit ***– 4 February, Brussels, Belgium***
The 11th European Innovation Summit was an event organised by Knowledge4Innovation - K4I addressing Horizon Europe including the future partnerships. The event will also be linked to the

"Green Deal" and a session was organised on "Shift2Rail, Shift2Green" in order to discuss about the future rail partnership and future partnerships that could be connected to the rail one (e.g. future FCH partnership). Shift2Rail's Head of Research and Innovation, Giorgio Travaini, presented in the European Parliament how through an R&I and a systemic approach to it, including decarbonisation, automation and digitalization, Europe can achieve over the goals of sustainability and attractiveness for passengers and freight connecting cities, regions, economic centres and beyond.

ALICE and S2R workshop on Freight customers needs ***– 13 February 2020, Vienna, Austria***

During ALICE event on "Roadmap Towards Physical Internet as well as the PI implementation monitoring" priorities for research & innovation where also discussed. S2R participated and co-organise a dedicated interactive workshop session gathering rail freight customers in expressing their needs and issues with selected stakeholders from the rail industry and supply chain. The workshop was facilitated by the Shift2Rail's Executive Director, Head of Research and Innovation and IP5 Programme Manager resulting in a better understand what is expected from the railway system to meet client expectations, so that approaches and solutions that can be delivered through targeted research and innovation.

Low-Carbon Mobility: Making Modal Shift Desirable ***– 13 February 2020, Brussels, Belgium***

Shift2Rail's Programme Manager for Cross-Cutting activities gave a key note speech at the UIC event on Low-Carbon Mobility, highlighting how Shift2Rail innovations contribute to energy efficiency in the rail system.

Mafex Steering Committee ***– 20 February, Brussels, Belgium***
Shift2Rail's Head of Research and Innovation, participated in the Spanish railway association steering committee delivering a presentation on S2R results and the current status on its possible successor programme.

International Railway Summit ***– 20 February, Warsaw, Poland***
Shift2Rail's Executive Director, participated in the 9th International Railway Summit in Warsaw, Poland on 20 February. He moderated a panel focusing on smart multimodality.

European Startup Prize for Mobility kick-off ***– 20 February, Berlin, Germany***
As an Ecosystem Partner, Shift2Rail helped launch the 3rd edition of the European Startup Prize for mobility on 20 February in Berlin. Shift2Rail is sponsoring for the first time the third edition of the European Startup Prize for Mobility – a public-private initiative co-founded by the European Parliament's Transport and Tourism Committee Chairwoman, Karima Delli, Boston Consulting Group and Via ID. The competition is supported by both the European Parliament and the European Commission, as well as influential partners, and invites mobility startups from around Europe to participate. The aim of the prize is to recognize future mobility champions over the course of the competition.

Open ENLOCC network Talks ***– 6 May, online***
Shift2Rail's Head of Research and Innovation, participated to the European network of logistics competence centers, whose main task is the international exchange of experience and knowledge between its participants and the promotion of a higher level of cooperation with European institutions. He delivered a presentation on the "Shift2Rail opportunities and rail transport challenges for the next programming period".

Post-COVID: What will be the new normal for rail travel? ***– 2 June, online***

Shift2Rail's Executive Director moderated a webinar titled Post-COVID: What will be the new normal for rail travel? The webinar was organised by the International Railway Summit and held on 2 June. The webinar answered may questions: "After the lockdown is lifted, will passengers come back? What are the medium- and long-term impacts for rail operators, governments, and the supply industry? What are the lessons to be learnt? How can the sector come out of the tunnel and continue the journey of growth we have seen in recent years?"

ETNA 2020 Webinar: Transforming Europe's Rail System ***– 9 June, online***

Shift2Rail's Executive Director Shift2Rail participated to an online event on Transforming Europe's Rail System, organised by ETNA 2020. It was an opportunity to discuss more about Shift2Rail's future under Horizon Europe.

ERCI's freight and transport logistics webinar ***– 10 June, online***

Shift2Rail's Executive Director discussed how to boost a modal shift to rail and current trends in multimodality during ERCI's freight and transport logistics webinar.

Rail Freight Transport in the Public Interest ***- 2 September, online***

Shift2Rail's Executive Director presented a broad overview of the R&I activities done by S2R under the Horizon 2020 to contribute to the achievement of the Single European Area (SERA) and discussed the Catalogue of Solutions. Watch the recordings of the event here.

Accelerating Railroad Transport in the Chemical Industry conference ***– 15 September, online***
Shift2Rail's Executive Director participated to an online conference about Accelerating Railroad Transport in the Chemical Industry organised by Lineas. The Executive Director talked about Shift2Rail's role in innovation and digitisation of the rail industry in Europe.

Innovative Rail Transport, Connecting, Sustainable, Digital – 21 September, online

Shift2Rail's Executive Director participated to the online event and delivered a presentation on the next generation of rail research and innovation.

Transport Innovation Summit ***– 21 September, online***
Shift2Rail also participated to the Transport Innovation Summit on 21 September focusing on Shift2Rail's R&I activities concerning rail freight, including the potential of digital solutions and how innovative technology can help create a modal shift.

InnoTrans Business Days ***– 24 September, online***

On 24 September Shift2Rail's Executive Director participated in an online business talk on the future funding for rail transport technology. It was an opportunity get an in-depth information about the future of rail research and innovation under Horizon Europe.

TRA VISIONS 2020 Award Ceremonies ***– 29 September, online***

Shift2Rail's Executive Director announced the winners of the Young Researchers Competition in the field of rail competition.

Dutch Rail Forum ***– 5 October, online***

Shift2Rail participated to the Dutch Rail Forum and gave a presentation on results of S2R and an outlook towards the successor programme.

Eurnex General Assembly ***– 6 October, online***

Shift2Rail participated to the Eurnex General Assembly and gave a presentation the status of S2R and opportunities for the future.

Shift2Rail Freight Rail Innovation workshop ***– 7 October 2020, online***

Shift2Rail organised a focused discussion that will contribute to shaping our R&I agenda, involving key representatives of the logistic value chain, from the end users to the service providers. The workshop was designed as a collaborative online discussion, facilitated by the S2R's Head of Research and Innovation and the IP5 Programme Manager, following up the key customer requirements identified during the previously organised Vienna's workshop. This workshop concluded on prioritised requirements and potential services, solutions and technologies that will enable rail freight to achieve the desired modal shift.

RAILCON 2020 ***- 15-16 October, Nis, Serbia and online.***

Shift2Rail's Executive Director presented the activities of S2R and its impact on the European rail system.

TCT Ministerial Meeting – 26 October, online

Shift2Rail signed an MoU with the Permanent Secretariat of the Transport Community.

World Passenger Festival **– 18 November, online**

Shift2Rail's Head of Research and Innovation participated in the World Passenger Festival on 18 November in a panel debate on agile innovation and the role of technology in shaping the future of passenger experience. He helped answer the question 'What role will technology play in supporting the recovery of public transport operators around the world?'

Canadian Smart Rail Technology Conference **– 23-24 November, online**
Shift2Rail's Executive Director participated to the Canadian Smart Rail Technology Conference on 13-14 November. It was a great opportunity to further discuss collaboration between Shift2Rail and CUTRIC following the Memorandum of Understanding recently signed at the Shift2Rail Innovation Days. Moreover, it was a chance to take the conversation further on how autonomous and connected technologies can make rail safer and faster.

OBB H2 closing event ***– 23 November, online***
ÖBB held and event about the pioneer project in Austria, investigating the usage of hydrogen rail vehicles for passenger traffic has just finished. The project included three months of demonstration operations in passenger traffic with one hydrogen train on the ÖBB-Infrastruktur AG rail network. As partners of the project, Shift2Rail participated to the project closing event on 23 November and talked about the current progress of the Shift2Rail programme with a particular focus on hybrid solutions for rail transport.

XV Edition of the Annual Assembly of the Spanish Railways Technological Platform – ***26 November, online***
The XV Edition of the Annual Assembly of the Spanish Railways Technological Platform (PTFE) was organised online and Shift2Rail's Head of Research and Innovation, Giorgio Travaini, opened the

annual Assembly with a presentation of Shift2Rail towards the next successor programme, highlighting also the main sector priorities as described in the High Level Sector Paper for Transforming Europe's Rail system as well as on the draft ERRAC Strategic Innovation Agenda.

CAE Conference ***– 30 November, online***

Shift2Rail's Executive Director gave a keynote speech at the 36th International CAE Conference and Exhibition on 30 November 2020. Mr Borghini opened the Automotive and Transportation Session and spoke about the importance of digital innovation in transport. It was a great opportunity to find out more about the Shift2Rail contribution and the other technical sessions.

RAIL LIVE 2020 ***– 1-2 December, online***

Rail Live 2020 took place on 1-2 December in a fully digital format. Shift2Rail's Executive Director Carlo Borghini moderated a panel to discuss creating infrastructure that can act as the pivot for the digitally connected transport industry of the future. Shift2Rail's IP4 Programme Manager participated to a panel discussion investigating how we can shape the future of mobility with end to end mobility services. Additionally, Shift2Rail had its own virtual exhibition stand at the event. It was an opportunity to find out more about the work we are doing and to get in touch with the Shift2Rail team.

Politico Sustainable Future Summit ***– 2-3 December, online***

Shift2Rail's Executive Director participated on 2 and 3 December in various panel discussions, including one on the Green Future of Inter-European Travel and one on Financing the Green Transition- how public-private partnerships are key to achieving a sustainable economic model.

1st Hydrogen Inter-Partnership Assembly Meeting – 9 December, online

The European Commission organised the first meeting of inter-partnerships for discussing hydrogen applications and R&I. Shift2Rail Joint Undertaking was represented by the Head of Research and Innovation who presented the excellent collaboration with FCH JU started in 2018 and resulting in a common study of market applicability of fuel cells to hydrogen applications. Following the published results in 2019, FCH JU launched a call for proposal in 2020 addressing through R&I the bottlenecks identified in the common study.

Rail Industry Meetings ***– 9-10 December, online***

Shift2Rail's Executive Director participated on the 9 December in the Rail Industry Meetings and presented about 'Delivering the Shift2Rail: Preparing the next Rail R&I Programme'.

Rail Freight Day 2020 ***– 10-11 December, Vienna, Austria and online***

Shift2Rail's Executive Director participated to the Rail Freight Day on 10-11 December 2020 and contributed to a session dedicated to safety & interoperability.

Decarbonising Transport in Europe – 10-12 December, online

Shift2Rail's Monique van Wortel participated on 11 December in a panel discussion "Non-urban passengers: results, feasibility and policy implications".

ANNEX F LIST OF ACRONYMS

Abbreviation	
ABAC	Accrual Based Accounting
ADI	Austempered Ductile Iron
AO	Authorising Officer
ATO	Automated Train Operation
AWP	Annual Work Plan
AAR	Annual Activity Report
CA	Commitment Appropriation
CAS	Common Audit Service
CAPEX	Capital Expenditure
CBM	Condition-Based Maintenance
CBTC	Communication Based Train Control
CCA	Cross Cutting Activities
CEN	European Committee for Standardisation
CENELEC	European Committee for Electrotechnical Standardisation
CFM	Call for Members
COVID-19	'CO' stands for corona, 'VI' for virus, and 'D' for disease. Formerly, this disease was referred to as '2019 novel coronavirus' or '2019-nCoV.' The COVID-19 virus is a new virus linked to the same family of viruses as Severe Acute Respiratory Syndrome (SARS) and some types of common cold.
CRS	Common Representative Sample
CREL	Core Release
CSA	Coordination and support action
CW	Cloud Wallet
DOI	Digital Object Identifier
DRIMS	Dynamic Railway Information Management System
EC	European Commission
ECA	European Court of Auditors
ED	Executive Director
EDPS	European Data Protection Supervisor
EDV	Electronic Distributor Valve
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EN	European Norm
ERA	European Union Agency for Railways
ERRAC	European Rail Research Advisory Council
ERTMS	European Rail Traffic Management System
ETCS	European Train Controlling System
EU	European Union
EUG	ERTMS Users Group
FACTs	Flexible AC Transmission Systems
FFFIS	Form Fit Functional Interface Specifications
FIS	Functional Interface Specifications
FREL	Final Release

GA	Grant Agreement
GDPR	General Data Protection Regulation
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GoA	Grade of Automation
H2020	Horizon 2020, EU framework programme for Research and Innovation
HST	High-Speed Train
IA	Innovation Action
IAS	Internal Audit Service
LP	Lighthouse Project
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IKAA	in-kind contributions to additional activities
IP	Innovation Programme
IPR	Intellectual Property Rights
ISO	International Standardisation Organisation
IT	Information Technology
ITD	Integrated Technology Demonstrator
JTI	Joint Technology Initiative
JU	Joint Undertaking
KPI	Key Performance Indicator
LCC	Life Cycle Cost
LIDAR	Light Detection and Ranging
LTE	Long-Term Evolution (standard for wireless communication)
MAAP	Multi-annual Action Plan
MaaS	Mobility as a Service
MB(S)	Moving block (System)
MC	Mission Critical
MNO	Mobile Network Operator
NaaA	Network as an Asset
NaaS	Network as a Service
NLOS	non-line-of-sight
NTP	Network Time Protocol
OC	Open Call
ODM	Operational Data Management
OMTS	On-board Multimedia and Telematics Services
OPEX	Operating Expenditure
PA	Payment Appropriation
RCA	Railway Command Control and Signalling Architecture
R&I	Research and Innovation
PPP	Public Private Partnership
PRM	Persons with Reduced Mobility
PTC	Positive Train Control
PTI	Platform Train Interface
QoA	Quality of Service

RAL	Unpaid amount
RAMS	Reliability and Maintainability System
RBC	Radio Block Centre
RFID	Radio Frequency Identification
RIA	Research and innovation action
RoI	Return of Investment
S2R	Shift2Rail
SC	Scientific Committee
SDG	Sustainable Development Goals
SETA	Single European Transport Area
SiC	Silicon Carbide
SLA	Service Level Agreement
SME	Small and Medium Enterprise
SNE	Seconded National Expert
SPD	System Platform Demonstration
SRG	States Representatives Group
SWL	Single Wagon Load
TAF	Telematic Application for Freight
TAP	Telematic Application for Passengers
TCMS	Train Control and Monitoring System
TCO	Total Cost of Ownership
TD	Technology Demonstrator
TL	Train Load
TMS	Traffic Management System
TRL	Technology Readiness Level
TSI	Technical Specifications for Interoperability
TSP	Travel Service Provider
UAV	Unmanned Aerial Vehicle
UG	User Group
UN	United Nations
WA	Work Area
WP	Work Package
WSP	Wheel Slide Protection

Founding Members

Associated Members

Virtual Vehicle Austria Consortium (VVAC+)

European Rail Operating community Consortium (EUROC)

Swi'Tracken Consortium

Smart DeMain(SDM) Consortium

AERFITEC

Competitive Freight Wagon Consortium(CFW)

Smart Rail Control (SmartRaCon) consortium

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