SP TACS Analysis of Standardisation potential for Interfaces to field devices

1 Introduction

The interfaces defined by SP TACS/EULYNX are the standardised points of interaction of Trackside Assets Control and Supervision subsystems within the CCS system, designed to ensure that components from different manufacturers can work together seamlessly.
The standardised interfaces:

- Enhance Interchangeability : Allow different signalling equipment from various manufacturers to work together, reducing dependency on single vendors.
- Reduce Costs: Standardised interfaces can lower development and integration costs by simplifying the design and implementation processes.
- Improve Safety and Reliability: Consistent standards help ensure that safety-critical systems operate reliably and can be maintained more effectively.

The modular architecture allows for integration of subsystems of Trackside Assets Control and Supervision according to standardised interfaces. The following interfaces are already specified:

- Standard communication interface (SCI): The process data interface which contains process and other information necessary for the exchange between the system Traffic CS and the subsystems of Trackside Assets Control and Supervision. The specification of the process data interface is supplier independent. This interface is also applicable for the exchange with digital interlockings/RBCs and provides an important future proof migration step until the target system Traffic CS will be developed.
- Standard diagnostic interface (SDI): The interface required for transmitting non-safety relevant diagnostic information.
- Standard maintenance interface (SMI): The interface required for updating the engineering and configuration data, as well as software data of the subsystem.
- Standard security interfaces (SSI): The interface required for managing functionality related to IT security.

The already installed base of field devices, such as point machines, light signals, train detection, level crossings and generic input/output devices, is very diverse and influenced by historic developments. This creates a strong brownfield environment, where standardisation attempts have to be carefully analysed. This presents the opportunity for further standardisation.
The focus of this report is to evaluate the potential for long term interface standardisation of connected field devices, referred to as control interfaces.
The control interface is used for control and supervision of the external systems in the field (field devices), connected to the Trackside Assets subsystems (object controllers). Currently, the specification of the control interfaces is largely supplier dependent (the control interface may be a bus interface, DC interface etc.).
The goal is to investigate the potential for standardisation of the control interfaces, and conclude the analysis with recommendations for further standardisation steps.

2 Summary of previous work

EULYNX standardisation:
The aspects for different levels of standardisation of the signalling system were defined. These aspects were proposed to be standardised with the given priority.
Prior to starting the work on control interface standardisation, the goal was to find (partial) alignment on method of safety analysis and reach common numerical requirements for RAMS requirements for each field element subsystem, as a precondition for specifying a common interface to the field device.
An inventory of technical characteristics of the field element interfaces has been prepared in 2019, but no further analysis was carried out. The inventory data may be reused and enriched for the analysis within this activity.
It was also concluded that the following norm must be considered - EN50125-3 Railway applications - Environmental conditions for equipment Part 3: Equipment for signalling and telecommunications.

3 Alignment with common business objectives

The standardisation of the field device control interfaces aligns with the following Common Business Objectives of the System Pillar:

Business objective	Explanation
Reduced costs	Produce solutions that are economically attractive: • Harmonised and standardised interface specifications lead to reduction of Capex + Opex from railways and suppliers' points of view. • For suppliers, these enable reduction of country specific product portfolios to one generic European product portfolio allowing important cost reductions for development as well as for the lifecycle management. • For railways, these enable decoupling the life cycles of trackside assets from the interlockings. This reduces cost of projects and adds flexibility for migration. • Market size is importantly increased, from national specific solutions to standard components for the full European market (and beyond)
Harmonised approach to evolution and greater adaptability	Standardize architecture: • Standardisation with modular architecture at European level, considering standardising power supply interfaces

4 Candidate interfaces

The proposed scope is to evaluate opportunities to harmonise the control interface between the Trackside Assets subsystems and related field objects: Point / point machines, Generic IO / adjacent systems including consideration on application libraries, Level Crossing / level crossing protection facilities, Light signal / signals e.g. light spots, Train Detection System / wheel sensors.

The respective control interfaces with reference to the current architecture are the following:

- Subsystem – Point: Interface to point machine
- Subsystem – Generic IO: Input and output interfaces to Adjacent IO systems
- Subsystem – Level Crossing: Interface to Level crossing protection facility
- Subsystem – Light Signal: Interface to train driver via light spots
- Subsystem – Train Detection System: Interface to wheel via wheel sensors

5 Alignment with granularity concepts and principles

A guideline was prepared for developments within the ERJU System Pillar to determine levels of granularity and modularisation. Applicable principles shall be analysed for consideration of the standardisation of interfaces to field devices.
Concerning the point machine interface, since this would be a standardisation of an existing interface in the current architecture, no further decomposition is proposed. Moreover, the target architecture includes the Point / Point Machine as a key element of railway. The evaluation related to the point machine interface is carried out from perspective of harmonisation of current national specific or proprietary interfaces.
The justification for decomposition would be required in case of further decomposition related to Light Signals, Level Crossing Protection Facility (LCPF) and Train Detection Systems with Wheel Sensors. The evaluation was carried out as an example for the further decomposition of Train Detection System.

Both evaluations are listed in following sections.

5.1 Subsystem – Point: Interface to point machine

The base reference for the evaluation below is a situation in which there is no harmonised interface between Subsystem – Point and the point machine. The point machine interface may be partially standardised on a national level.

Objective	Position	Comment
6.1 Interoperability for cross border operation / open network access	Not applicable	Not relevant for cross borders
6.2 Cost reduction at the LCC level	Neutral / Positive	Standardisation can enable access for new suppliers or improve the applicability of one product to many markets
6.3 Creating open markets for sub-systems and ensure competition	Neutral / Positive	Same as 6.2
6.4 Create broader supplier base	Neutral / Positive	Same as 6.2
6.5 Support integration of new systems into existing environments	Positive	Standardisation allows simple integration of new technologies into existing field element types
6.6 Support Migration	Neutral / Positive	Standardisation can facilitate future migration, but it must be rolled out first. This may mean replacement or adaptation of existing systems.
6.7 Long term sustainment of the service	Positive	Same as 6.5
6.8 Manage different lifecycles of systems	Positive	Same as 6.5
6.9 Interchangeability	Positive	Same as 6.5
6.10 Exchangeability	Positive	Same as 6.5
6.11 Independent changeability for non-safe and safe sub-systems	Not applicable	Interface between safety sub-systems, no further decomposition

Objective	Position	Comment
6.12 Different Performance or RAM requirements of sub-systems	Not applicable	Same as 6.11
6.13 Independent changeability of shared functionality	Not applicable	Same as 6.11
6.14 Maintain and upgrade legacy systems not supported by the original supplier	Positive	Same as 6.5

Table 1

5.2 Subsystem – Train Detection System: Interface to wheel via wheel sensors

A first evaluation of position in case of standardisation for an internal TDS interface (axle counter evaluator - wheel sensor) is reported below for chapter 6 (table 2) and chapter 7 (table 3) of Granularity concepts and principles. The base reference for the evaluation below is a situation in which there is no harmonised interface between Subsystem – TDS and the wheel sensor. The wheel sensor interface is proprietary/supplier specific.

Objective	Position	Comment
6.1 Interoperability for cross border operation / open network access	Not applicable	Not relevant for cross borders
6.2 Cost reduction at the LCC level	Neutral / Negative	Technological differences between wheel sensor principles make it difficult to harmonise this interface. It is therefore questionable whether new wheel sensor suppliers will join the market.
6.3 Creating open markets for sub-systems and ensure competition	Neutral / Negative	Same as 6.2
6.4 Create broader supplier base	Neutral / Negative	Same as 6.2

Objective	Position	Comment
6.5 Support integration of new systems into existing environments	Neutral / Negative	Same as 6.2
6.6 Support Migration	Neutral / Positive	Standardisation can facilitate future migration, but it must be rolled out first. This may mean replacement or adaptation of existing systems.
6.7 Long term sustainment of the service	Neutral	Today evaluation unit and wheel sensors are deployed as an entity, unclear whether the separated parts will have different life span.
6.8 Manage different lifecycles of systems	Neutral / Positive	Same as 6.6
6.9 Interchangeability	Neutral / Positive	Same as 6.6
6.10 Exchangeability	Neutral / Positive	Same as 6.6
6.11 Independent changeability for non-safe and safe sub-systems	Not applicable	Interface between safety sub-systems
6.12 Different Performance or RAM requirements of sub-systems	Neutral	Clear apportionment needed between wheel sensor and evaluator. This may invalidate existing integrated solutions.
6.13 Independent changeability of shared functionality	Neutral / Positive	Same as 6.6
6.14 Maintain and upgrade legacy systems not supported by the original supplier	Neutral / Positive	Same as 6.6

Table 2

Rule ID and Title	Position	Comment

Rule ID and Title		Position	Comment
SPT2ARC-1283 Interface only with justifiable data	Neutral	Rule can be applied, no positive nor negative position	
SPT2ARC-1282 Avoid mixing functions of different quality attributes		Neutral	Same as 6.12 in table 2
SPT2ARC-1279 Isolate optional functions		Neutral	Same as SPT2ARC-1283
SPT2ARC-1278 Ensure independent life-cycles		Neutral / Positive	Same as 6.6 in table 2
SPT2ARC-1276 Aim at realizing functions in software		Not applicable	Interface related to trackside asset
SPT2ARC-1275 Aim for balanced integration effort		Negative	The integration effort might be increased (currently no real integration since it is internal interface within Axle Counter product)
SPT2ARC-1271 Aim for balanced maintenance effort		Neutral / Positive	Same as 6.6 in table 2
SPT2ARC-1272 Aim for a strict separation of hardware and software		Not applicable	Same as SPT2ARC-1276
SPT2ARC-1281 Effort of changing products only for harmonisation		Negative	Same as SPT2ARC-1275
SPT2ARC-1280 Evolution vs. stability of interfaces		Neutral	Same as SPT2ARC-1283
SPT2ARC-1274 Consider current granularity specifications		Neutral	Same as SPT2ARC-1283

Rule ID and Title	Position	Comment
SPT2ARC-1273 New major enhancements as separate sub-system	Neutral	Same as SPT2ARC-1283
SPT2ARC-1603 Avoidance to decompose sub-systems for already established sub-systems retrospectively	Negative	Same as SPT2ARC-1275
SPT2ARC-1277 Critical mass of a sub-system	Not easy to evaluate	Current market is bundled
SPT2ARC-1289 Evaluation to use parametrisation	Neutral	Same as SPT2ARC-1283
SPT2ARC-1288 Avoidance of options	Negative	The current variability of technology in the interface might lead to high number of options
SPT2ARC-1287 Ontologies to define semantics	Neutral	Same as SPT2ARC-1283
SPT2ARC-1607 Harmonisation for functional apportionment	Negative	Standardisation only to FIS level can already be complex and limit innovation in wheel detection technology, see also SPT2ARC-1288
SPT2ARC-1606 Independent changeability of interfaces	Negative	Same as SPT2ARC-1607
SPT2ARC-1605 Decomposition only if linked to a harmonisation level	Neutral / Positive	Same as 6.6 in table 2
SPT2ARC-1593 Avoidance of SRACS	Negative	Same as SPT2ARC-1275

Rule ID and Title	Position	Comment
SPT2ARC-1594 Separation of shared functionality	Negative	Same as SPT2ARC-1275
SPT2ARC-1595 Consideration of proven in use solutions	Negative	Proven in use solutions for wheel detection will need adaptation
SPT2ARC-1598 Reduce railway specific requirements	Neutral	Same as SPT2ARC-1283
SPT2ARC-1597 Reduce interfaces between safety relevant subsystems	Negative	Same as SPT2ARC-1275
SPT2ARC-1599 Adapt the environment or existing sub-systems for newly defined interfaces	Negative	Same as SPT2ARC-1595
SPT2ARC-1602 Harmonised requirements	Neutral	Same as SPT2ARC-1283
SPT2ARC-1627 Intermediate step for migration	Not easy to evaluate	No cost/benefit analysis performed. Con: Existing evaluation units and wheel sensors need adaptations and cannot be re-used. Pro: Costs of new harmonised axle counter systems may go down. Unknown: Support of SP target architecture not clear
SPT2ARC-1626 Common ontology for data element in a domain architecture	Neutral	Same as SPT2ARC-1283

Table 3

6 Analysis

6.1 Analysis for the interface to the point machine

The expert opinion, consolidated within the SP TACS group, is that the first valuable area of standardisation is the one for the point machines (P3 interface). This opinion is supported by following arguments :

- The IMs wish to have independent life-cyclelife cycle for Point Object Controllers (typically part of Interlocking procurement) and Point Machines (typically part of individual procurement or part of point / turnout).
- Typical life-time of Point Machine differs from Point Object Controller (10 years vs 15-25 years).
- The 4-wire interface is a quasi-standard already in use byin several IMs. It combines driving and detection in the same wires.
- IMs that are currently using other interfaces with separate wires for drive and detection are unlikely to accept this loss of functionalitythe loss of separate driving and detection circuits. Nevertheless in most IMs, there is already one national standard for the PM interface.
- The 4-wire quasi-standard is not fully identical and exchangeable between IMs. There are differences in the electrical properties and some other physical parameters. Standardisation would bring benefit in the interchangeability.
- Reducing the number of variants used for the point machine interface will increase the market size for these fewer variants.

One possible counter-argument is that there may be a tendency in which Point Object Controllers will be more closely integrated with the point machines. If this is the case, there is less added value of a standardised (supplier-independent) interface. It is common opinion that this tendency will be observed in specific cases, for example in mostly green field projects , and it is not going to be a recurrent schema. In brown field projects, IMs will not be able to use the standardised interface because the existing point machine does not support it. IMs in general prefer to keep the separation between point machine and Point Object Controller.

It has been identified that at least two variants are proposed for standardisation:

- Mixed drive and detection (“4-wire” interface in EULYNX BL4 terminology)
- Separated drive and detection (“non-4-wire" interface)

It is still possible to identify sub-variants depending on additional technical constraints or functions such as number of wires, internal circuits of point machine, detection of trailing, etc. A collection of key characteristics is launched with the IMs.

A mandatory precondition to launch the task of specifications development is to confirm the business improvement that additional standardisation would bring. The possible criteria to measure it is the saving on integration activities each time a Point Object Controller or a Point Machine is replaced by one of another vendor.

It is not easy to define a quantitative saving benefit. A proposed list of benefits has been discussed:

1. Decoupling of life cycle point & point machine vs point controller (only in those cases where there is no national standard yet in use)
2. Smoother integration between different vendors
3. Capability for new vendors to enter in the market or capability to address same product for larger market scope

The level of benefits of bullets 2 and 3 strongly depends on how much reduction in the total number of variants can be achieved.

As input for the proposed analysis, limited data has been collected about the number of points installed / foreseen and the associated typical lifecycle. For a total of 5 IMs that use point machines with the “non-4-wire” interface, the number of point machines in operation is a bit over 60 000. The typical lifetime of these point machines is between 10 and 30 years.
The collection of data on the number of points installed / foreseen with the “4-wire” interface has not been concluded yet.

6.2 Analysis for the interface to the wheel sensors

The interface between subsystem TDS and wheel sensor is concluded as unlikely to benefit from standardisation. The interface is currently internal to axle counter products, in each case vendor specific and is expected to contain a wide range of differences on functional, physical and data layers. Harmonisation would most likely need to introduce several options, and caution would be required to not limit innovation. It is also needed to define the safety related application conditions on the interface, which increases the complexity of the system integration.

The analysis of the granularity criteria for the interface between TDS and wheel sensor shows an

overall negative evaluation.
No further standardisation of this interface is proposed.

6.3 Analysis for the remaining interfaces

The input/output interfaces of the Subsystem – Generic IO may be future candidates for standardisation as these interfaces are already functionally specified. Only electrical physical properties would need to be added. However, the benefit of additional electrotechnical harmonisation is not clear, as there are a lot of variants today, which would need to be aligned. Due to lower priority, these interfaces may be addressed in a later stage, in particular in combination with a common application library for the defined use of the IO channels of connected adjacent systems (to be determined which connected systems will need to be supported by the target system).

The interface between subsystem Light signal and signals/light spots is concluded as unlikely to benefit from standardisation at the current stage. Signals are highly dependent on power supply, nationally defined signal aspects, wayside deployment strategy (object controllers close to signals or deployed in centralised locations). In the target system reference architecture there will be a limited number of signals, potentially mainly shunting signals. The analysis can be resumed once further harmonisation is reached on the use of light signals in the future target system.

Level Crossing Protection Facilities are currently highly dependent on national standards/regulations and are not considered as likely candidates for harmonisation. Due to lower priority these may be addressed in a later stage.

It is agreed to postpone the analysis of standardisation of other field element control interfaces than the point machine interface.

7 Results with proposals

The results of the analysis are summarised below.

7.1 Conclusions

The qualitative assessment did not provide conclusive evidence or strong justification for further harmonisation of the point machine interface. Full harmonisation towards a single standard interface is not feasible due to the fundamental difference between mixed or separated drive and detection. While there are potential benefits in standardising variants for both configurations, these advantages are offset by migration costs from existing national standards.

The assessment of the interfaces to the wheel sensor had concluded that there will not benefit from further standardisation. These interfaces remain as unharmonised national or supplier specific interfaces, with no further work to be undertaken within the System Pillar.

It is proposed to defer the standardisation analysis of interfaces to the IO adjacent system, signal/light spots, and the Level Crossing Protection Facility, as these have lower priority and limited harmonisation potential.

7.2 Final decision

Based on the discussions with the Core Group, we propose concluding the report at this stage. In light of the inconclusive findings and low stakeholder interest, further economic analysis of life cycle cost benefits for a single European standard interface to the point machine is not recommended. The significant effort and resource constraints do not justify this assessment, given the absence of clear qualitative evidence supporting harmonisation.

It is recommended to formally conclude the analysis at this stage, with the expectation that these topics will be closed unless further compelling arguments or sector-wide interest emerge. Future analysis of the IO adjacent system, signal/light spots, and Level Crossing Protection Facility interfaces should only resume after the conclusion of potential harmonisation activities related to the point machine interface and in response to renewed interest from stakeholders.