SP TACS Analysis of Standardisation potential for Power Supply and Power Management of Trackside Assets subsystems

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 focus of this report is to evaluate the potential for long term standardisation of the power supply and related interfaces, as well as explore the potential power management functions with the goal to reduce power consumption.

2 Summary of previous work

Smart Wayside Object Controller:

SWOC builds its concept on providing an independent power supply from energy harvesting sources with limited and managed amounts of energy, possibly shared by several SWOCs in the same area, and a prescription for reducing power consumption with features such as the use of a “sleep mode”.

Following suggestions to be considered:

- Consider the inclusion of the power supply subsystem inside the EULYNX standardisation system, allowing several arrangements to be used (one power supply for several OCs, one for each OC, one centralized power supply, etc.)
- Include in the OCs functions and interfaces to manage intelligently these resources.
- Add sleep mode / power saving functions in the OCs with the possibilities outlined in SWOC specifications: switch to sleep mode automatically or on demand, switch off selected parts of the SWOC or even the field elements themselves, etc. Modify the EULYNX interfaces to enable the integration of those functions in the EULYNX standardisation system.

Requirements from the SWOC project will be considered as inputs for this analysis.

3 Alignment with common business objectives

The standardisation of the power supply interfaces and power management functions 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)
More sustainable and resilient transport	Manage more efficient energy consumption: • Advanced power management solutions can contribute to reduction of energy consumption of trackside assets

Business objective	Explanation
Harmonised approach to evolution and greater adaptability	Standardize architecture: • Standardisation with modular architecture at European level, considering standardising power supply interfaces

4 Power Supply

The goal of standardisation is to define a single standard power supply interface valid for the Trackside Assets control devices in the CCS system of the Single European Railway Area.
This will define the harmonised physical and electrical properties of the interface between the power supply system and the control devices that implement the SP TACS EULYNX field element subsystems.
This interface shall be suitable to provide power needed by the controller devices to run themselves but also the power needed to control the connected field devices (e.g. point machine, signal lamps, axle counting heads). It does, however, not cover the power properties of the control interface of the controlled field devices themselves.
Ideally, a single standard power supply interface can be used to provide power to all types of Trackside Assets control devices, including Point, Light Signal, Train Detection System, Level Crossing and Generic IO. In this way, all CCS control devices can be fed from the same power distribution system.
If the analysis shows that the type of power needed for one or more types of Trackside Assets differs significantly from the others, a separate specific power supply interface may be defined.

5 Power management functions

The overall power use of Trackside Assets control devices can be reduced when (parts of) devices can be turned off for the time that they are not needed to allow train movement. Especially on lines with low traffic density (max. 1 train per hour per direction) and/or lines with longer train-free periods (e.g. several hours during the night), savings may be interesting.
A lower overall power consumption can help to make power provision with local renewable energy sources (solar, wind) in combination with a battery more feasible. This removes the need for a power distribution network, which may be a significant cost saving for remotely located field

devices.

6 Alignment with granularity concepts and principles

A guideline was prepared for developments within the ERJU System Pillar to determine levels of granularity and modularisation.
The preliminary analysis with all parties dismissed the harmonisation and specification of the power supply interface, therefore the strict application of the qualitative criteria of the granularity concepts was not required and not applied.
The analysis of power management functionality does not impact granularity and modularisation, no further system decomposition is foreseen. The application of the granularity concepts was not required.

7 Analysis

7.1 Analysis for power supply interface

Information has been collected on the properties of the currently used power supply interfaces by different IMs. The completeness of the collected information so far is quite limited, for some types of field devices, information is only available from 1 or 2 IMs.

7.1.1 Light Signal

Information collected from 5 IMs. The most commonly used power type is 110V AC, used by ProRail, TRV and NR. This type is not used by DB (used 48V DC) and SNCF (uses 127V AC). Industry partners indicate that also 230V AC is common. It should be noted that the frequency of AC systems sometimes differs from 50 Hz.

7.1.2 Point

Information collected from 7 IMs. The most commonly used power type is 400V AC 3-phase, used by DB, ProRail, SBB, SNCF and FTIA. This type is not used by TRV (used 230V AC) and NR (uses 110V DC).
Industry partners indicate that also 230V AC is common.

7.1.3 Level Crossing, Generic IO, TDS (axle counter and track circuit)

Information collected from 2 to 5 IMs. Limited indication of convergence.
Level crossing: 3 IMs use 24V DC, 1 IM uses 48V DC and 1 IM uses 400V AC 3-phase
Generic IO: 1 IM uses 24V DC, 1 IM uses 400V AC 3-phase
TDS (axle counter): 2 IMs use 24V DC, 1 IM uses both 230V AC 1-phase and 400V DC 3-phase
TDS (track circuit): 1 IM uses 24v DC, 1 IM uses 110V AC 1-phase (75Hz)

7.1.4 General remarks

There could be some potential to define 400V AC 3-phase as a standard for all types of field devices. This type of power is widely used to power industrial devices on the general market, outside of railways. Another candidate would be the standard household power of 230V AC 1-phase, which may be more readily available and cheaper to generate from batteries.
In Network Rail, the reason to use 110V AC is also related to maintenance procedure and management of personnel. The lower voltage allows more maintenance tasks to be allowed on a live system. The fact that the voltage differs from the standard used outside of railways prevents competition on skilled staff with sectors outside of the railways.

The economic benefits of defining a single harmonised interface are considered as limited. Field element controller products can be delivered with different power adapters, depending on national needs. This variability is not a significant cost driver for suppliers.

7.1.5 Overview of pros/cons for power supply interface

Con: No obvious candidate for harmonisation, large variability between IMs
Con: Limited economic benefit, the existing variability is not an important cost factor

7.2 Analysis for power management use cases

Two level of ‘sleeping mode’ can be distinguished with different characteristics and operational consequences.

1. Sleep: Field device off, controller on
2. Hibernate: Field devices and controller off, only network card on

A field element device can be woken up from ‘sleep’ mode by a command from the EIL/TPS, as the safe communication remains available. Diagnostic, Maintenance and Security interfaces are available as normal in this mode.
A field device can be woken up from ‘hibernate’ mode only via a ‘wake on LAN’ functionality available on Ethernet. The origin of the ‘wake on LAN’ trigger must still be defined. In ‘hibernate’ mode there is no safe communication with the EIL/TPS and Diagnostic, Maintenance and

Security interfaces are also not available.
Per field device type, a feasible operational scenario is described and a rough estimate of potential saving is made.

7.2.1 Point

The saving potential of 'sleep' mode is very limited. With a single point machine interface, the power consumption of the detection circuit is much less than the consumption of the controller device. Only in case of long points with at least 4 or 5 point machines, a reduction around 50% could be reached in this mode.
The saving potential of the 'hibernate' mode is more significant. In normal situations, no supervision of the point position is needed when no train movement is expected. The last registered point position is usually guaranteed by the physical properties of the point machine (physical locking). Depending on train speed, it is enough to wake the point controller from 'hibernate' mode between 1 and 5 minutes before the expected train passing.
Points that provide flank protection can be in 'hibernate' mode as long as there are no train movements expected neither on the point themselves nor on the neighbouring track to which they provide flank protection.

7.2.2 Light Signal

The saving potential of 'sleep' mode is very limited for light signals equipped with LED light spots. When the most restrictive signal aspect consists of a single light spot, the power consumption of the lamps is much less than the consumption of the controller device. Only in case of incandescent lamps, a higher saving could be reached in this mode. It is assumed that light signals with incandescent lamps will be phased out in the Single European Railway Area.
The saving potential of the 'hibernate' mode is more significant. In normal situations, no indication of any signal aspect is needed when no train movement is expected. It is enough to indicate and confirm the indicated aspect shortly before a train comes within sighting distance of the signal. It is enough to wake the light signal controller from 'hibernate' mode about 1 minute before the expected train passing, as signal based movement authority will not be used at high speeds.
An additional advantage of turning off the light spots needed for the Most Restrictive Signal Aspect when no train movement is expected is that this can significantly extend their expected life time, as it significantly reduces their burning hours.

7.2.3 Generic IO

The saving potential of ‘sleep’ mode is very limited. The power consumption of the physical output channels is much less than the consumption of the controller device. Only for devices controlling many physical output channels, a more significant reduction could be reached in this mode.
The saving potential of the ‘hibernate’ mode is more significant. In normal situations, it should be acceptable to set all physical output channel to ‘off’ when no train movement is expected, as this is the same as the initial state of outputs.
Whether it is acceptable to have no supervision of the input channels when no train movement is expected will strongly depends on the characteristic of the adjacent IO system. For devices like an avalanche detector, you may want to have this information available also when no trains are expected anytime soon. Which input channels from adjacent IO systems represent ‘crucial’ information which must be supervised constantly also when there is no train traffic needs to be defined by the IMs operational practices.
If the subsystem Generic IO controls 'crucial' input, the 'hibernating' mode is not possible. The benefit of 'sleep' is limited.
If the input channels from the adjacent IO system convey other less critical information, the ‘hibernate’ mode is possible and can bring a reduction of the power consumption. It is enough to wake the Generic IO controller from ‘hibernate’ mode between 1 and 5 minutes before the expected train passing.

7.2.4 Train Detection System with axle counters

The saving potential of the ‘sleep’ mode can be quite significant, depending on the number of axle counting heads supervised by the overall TDS controller. The saving may depends on the physical architecture of the complete controller subsystem, which may consists of separate devices such as evaluation units and central communication.
When there are no vehicles present within the complete supervision area of the TDS controller and no train movement is expected, it is acceptable to supervise only those counting heads that are at the boundary of the supervision area. All other counting heads can be turned off and the whole supervision area will be evaluated as a single TVP section. Before train movement is expected, all counting heads can be turned back on and the supervision area is subdivided back into the configured topology of TVP sections. The consequence is that if an axle passing has been detected on one of the boundary counting heads during ‘sleep’ mode, all section in the supervision area will inherit the non-vacant state (occupied/disturbed) after waking up. This must be avoided.
Railway operators must ensure that appropriate operational rules and procedures are in place in the areas where the ‘sleep’ mode of the TDS system is used as described, based on a risk analysis. Risks related to on-railing and off-railing of maintenance vehicles must for example be

considered . Operational and/or technical measures, for example providing flank protection, must be considered to avoid unintentional rolling wagons to enter the area in 'sleep' mode.
The saving potential of the 'hibernate' mode could be bigger, but the operational feasibility is more limited. When waking up from 'hibernate' mode, all TVP sections supervised by the TDS controller will be in the safe state 'disturbed' and need to be reset to vacant by operational procedures. If the complete absence of vehicles in the supervision area can be guaranteed by operational procedure, an unconditional Force Clear can be acceptable. This may be similar to the existing practice at the end of engineering works. But it is questionable whether such procedure are acceptable as part or regular operation at the end of a (short) period without trains.

7.2.5 Train Detection System with track circuits

The saving potential of the 'sleep' mode can be quite significant, depending on the number of track circuit sender and receiver units supervised by the overall TDS controller. In normal situations, no supervision of the occupancy of sections is needed when no train movement is expected. Track circuit systems have the advantage that the presence and absence of vehicles will be reliably detected after waking up also if no supervision was active for some time.
The saving potential of the 'hibernate' mode is somewhat bigger than in 'sleep' mode, the difference depends on the ratio between track circuit sender and receiver units and central controller devices. The operational context of waking up from 'hibernate' is similar to 'sleep' mode. As the power saving is higher, the use of 'hibernate' mode seems preferable.

7.2.6 Level Crossing

The saving potential of the 'sleep' mode is negligible. It is assumed that even without train movement certain detection circuit are still needed to supervise that the barriers remain in the upwards position, as they otherwise pose a risk to road traffic. The only devices that may consume superfluous power in the 'deactivated and idle' mode could be the detection devices.
The saving potential of the 'hibernate' mode could be somewhat bigger, but the operational feasibility is limited. Supervision of the Level Crossing Protection Facility is needed, as it must be ensured that barriers remain up to not impede road traffic safety. An exception could be 'on-demand' level crossings, which have the default state with barriers down. This is considered to be a very rare use case.

7.2.7 General concerns

This use of ‘hibernate’ mode means that unforeseen events that may negatively impact train operation will only be detected very shortly before the train passing, reducing the re-planning options. This may include internal (technical failures) or external (weather, vandalism, security breach) events that lead to a loss of the required safe functionality of the field element device.
There are indications that the reliability and durability of electronic systems is much better when the components are supplied continuously with power, compared with multiple on-off activations for power. A check would be needed to ensure that the repeated on-off cycles don’t have negative effects on the overall life expectancy of controllers and its components.
Operators needs to consider mitigations of these general concerns when defining the operational context of going to and coming out of both ‘sleep’ and ‘hibernate’ modes.

7.2.8 Overview of pros/cons for power management use cases

Pro: Savings in the power consumption are operationally feasible in a ‘hibernate’ mode for subsystems Point, Light Signal, Generic IO and TDS with track circuits.
Pro: Savings in the power consumption are operationally feasible in a ‘sleep’ mode for subsystem TDS with axle counters
Con: Additional functionality is needed in the field element subsystems to handle ‘sleep’ or ‘hibernate’ modes. Uncertain whether the power consumptions savings outweigh the development costs.
Con: Additional functionality is also needed in other components of the overall CCS architecture. This includes at least the EIL/TPS, but likely also the traffic management and planning systems.
Con: Reduced time for mitigating unforeseen events when using ‘hibernate’ mode
Con: Physical manipulation of the control interfaces may remain undetected if occurring during ‘hibernate’ mode (e.g. wrong connection of point machine wires)

It is worth noting that the EU Ecodesign for Sustainable Products Regulation, in force since 18 July 2024, sets rules for efficient power use. Any future analysis regarding power management functions may still contribute to discussions in that context.

8 Results

The results of the analysis are summarised below.

8.1 Conclusion regarding power supply interface standardisation

The qualitative assessment did not yield conclusive evidence that harmonising the power supply interface would provide substantial benefits. Given this, no further work will be undertaken within the System Pillar, and further harmonisation of these interfaces is not proposed at this stage.

8.2 Conclusion regarding power management functions

The initial analysis of additional power management functionality aimed at achieving power consumption savings did not result in a clear direction for further development steps. While some advantages were identified, they were offset by significant disadvantages. Additionally, there was no strong indication from stakeholders that further efforts in this area would be beneficial.

Since the economic assessment was originally proposed not based on a clear qualitative indication but rather to find supporting arguments, this step will be omitted due to the substantial effort required for such an analysis. Consequently, further analysis of economic aspects will not be pursued unless compelling new arguments or stakeholder interest emerge.

8.3 Final decision

Based on the discussions with the Core Group, we propose concluding the report at this stage. The findings indicate that further development or harmonisation is not justified at this time.