# Future S-network

## Market Dialogue/FS.TL.01

**FS.TL.01**

**Summary of Request for Information (RFI) 2019-2022**

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# 1. Background

## 1.1. Background on the S-network

The S-network is an urban heavy railway system covering central and greater Copenhagen. It was introduced in 1934 and has gradually been extended since then. Today the S-network includes 170 km of double track with 7 branches and 86 stations, a workshop in Høje Taastrup and a small workshop in Hundige. The S-trains carry 350,000 passengers on a busy weekday. It is free to bring bicycles on the train, and 7.3 million bicycles are brought on the S-train each year.

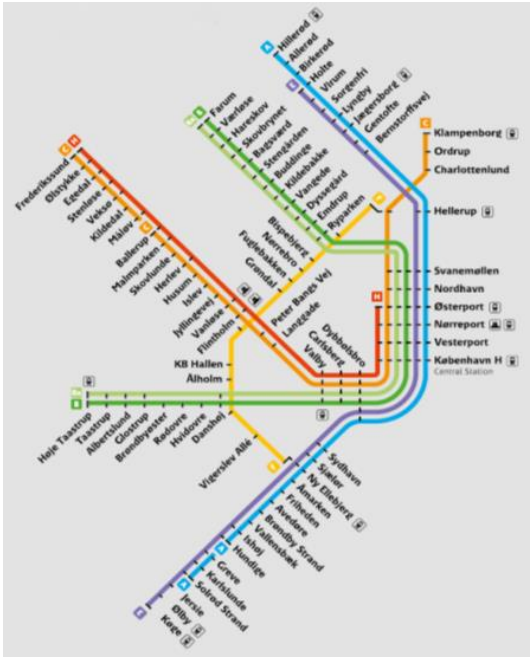

Figure 1 Copenhagen S-network

## 1.2. Background on the Future S-network (FS)

The Future S-network programme is the outcome of a political agreement called "Future Train services in the Capital Area"[1], which was entered into in December 2017 by the former government and supporting parties. The agreement entails a conversion of the 89-year-old Copenhagen S-network into a fully automated train operation and thus requires procurement of new fully automated rolling stock, necessary technologies for obstacle detection and supporting systems, infrastructure updates and the establishment of the future S-network organisation.

## 1.3. Background on the RFI Process

Throughout 2019, 2020, 2021 and 2022 DSB has engaged with the wider market in order to create the basis for contract structures and tender materials for the Future S-network. A key part of this market investigation was a Request for Information (RFI), providing DSB with a deeper understanding of the products and capabilities available in the rolling stock and rail related technology market, as well as suppliers' views on the organisational setup, procurement model and transition plan proposed by the DSB.

The RFI process was open to all interested suppliers through an invitation via the European public procurement journal, Tender Electronic Daily (TED). DSB has conducted eight RFI Workshops:

1. Workshop 1 in 2019
2. Workshop 2 in 2020
3. Workshop 3 in 2020
4. 5G Workshop in 2021
5. Distributed Acoustic Sensing Workshop in 2021
6. Obstacle Detection System Onboard Train and Distributed Acoustic Sensing Workshop in 2021
7. Unattended Measurement Systems Workshop 2022
8. Rolling Stock and Supporting Systems Workshop 2022

A large number of companies from the rolling stock, infrastructure, operation, technology, railway diagnostics & signalling and advisory markets participated in the process and attended at least one of the workshops. The attendance for the market dialogues is as following:

[1] https://www.regeringen.dk/media/4521/aftaletekst-fremtidens-togtrafik-i-hovedstadsomraadet.pdf

Workshop 1: Aarsleff Rail AS, Acciona Construcción S.A, Alstom Transport AB, Atkins Danmark AS, Bosch Engineering GmbH, Construcciones y Auxiliar de Ferrocarriles (CAF), CRRC ZELC Verkehrstechnik GmbH, Euromaint Rail AB, F-Secure Consulting, Go-Ahead Sverige AB, IDOM Consulting, MTR Nordic AB, Régie Autonome des Transports Parisiens (RATP), Siemens Mobility AS, Stadler Rail AG, Strukton Rail AS, Sweco Danmark AS and Thales S.A.

Workshop 2: Alstom Transport AB, AP Sensing GmbH, ClearSy, Delkor Rail Pty. Ltd., ELTA IAI, Fokus Tech, Masats, MTR Nordic AB, OptaSense Ltd., Optex Co. Ltd., RailVision, SICK AG, Siemens Mobility AS, STRAFFIC Co. Ltd., Thales S.A., VIVERIS and Woori Technology Co. Ltd.

Workshop 3: Alstom Transport AB, Bosch Engineering GmbH, Construcciones y Auxiliar de Ferrocarriles (CAF), CRRC ZELC Verkehrstechnik GmbH, ITK Engineering, MTR Nordic AB, Régie Autonome des Transports Parisiens (RATP), Siemens Mobility AS, Stadler Rail AG, Strukton Rail AS and Thales S.A.

5G Workshop: Cellnex Denmark ApS, TDC A/S, Telenor A/S and Telia Company Danmark A/S

Distributed Acoustic Sensing Workshop: Alstom Transport AB, AP Sensing GmbH, CEMIT AB, ITK Engineering GmbH, OptaSense Ltd. and Sensonic GmbH.

Obstacle Detection System Onboard Train and Distributed Acoustic Sensing Workshop: Alstom Transport AB, AP Sensing GmbH, Bosch Engineering GmbH, Construcciones y Auxiliar de Ferrocarriles (CAF), CEMIT AB, ELTA IAI, ITK Engineering GmbH, OptaSense Ltd., Rail Vision and Sensonic GmbH.

Unattended Measurement Systems Workshop: Alstom Transport AB, Balfour Beatty plc, DMA Torino, MERMEC S.p.A, Ricardo plc, Siemens Mobility AS and Tyréns AB.

Rolling Stock and Supporting Systems Workshop: Alstom Transport AB, Construcciones y Auxiliar de Ferrocarriles (CAF), CEMIT AB, DB Engineering & Consulting GmbH, FOKUS TECH d.o.o., IVU Traffic Technologies AG, Siemens Mobility AS, Stadler Rail AG and Thales S.A.

The RFI process took place from August 2019 to June 2022 and covered eight rounds of market involvement. The first three rounds covered the overall programme and tender strategy, while the last five dived deeper into specific topics. More specifically Workshop 1 focused on rolling stock, train-borne technology, infrastructure, enhancements and civil works, safety approvals, maintenance, operator, transition and organisation and contract strategy. Workshop 2 was purely centred around technologies with a particular focus on platform protection, track protection, gap fillers, platform screen doors (PSD) and object detection systems (ODS). Ultimately, workshop 3 of market involvement dug deeper into rolling stock, transition topics, organisation, and contract strategy as well as a specific ODS system, ODS Train-borne (ODS-T). The topics discussed during the workshops 4-8 followed the above-mentioned headings.

Most of the rounds of market dialogues consisted of two stages: An RFI questionnaire stage where the suppliers provided their written responses to an extensive RFI questionnaire and a workshop stage for the suppliers who provided relevant and in-depth information in their RFI responses. Due to COVID-19 the workshops for 2021 was held as virtual meetings, and the lessons from the virtual meeting made us introduce hybrid meeting with some attendees in the DSB headquarter and some with virtual attendees. Distributed Acoustic Sensing market dialogue and Unattended Measurement Systems market dialogue in 2021 only consisted of an RFI questionnaire stage with suppliers written responses and no workshop stage.

A consistent process and methodology across all three market dialogues ensured that all market players were provided with an equal opportunity to engage with the Future S-network programme and bring forth their perspectives, whether this was done in writing or at the workshops. The input from the market has subsequently been assessed in great depth relative to the programme aspirations for the future UTO network.

All information shared in the RFI process has been shared on a "without prejudice" basis. In the following, DSB has made a short summary of the topics and key findings discussed in the RFI process. As the information shared in the RFI process has been subject to a confidentiality declaration, the summary has been made with respect of this obligation.

# 2. Summary

## 2.1. Tender Model

A key question for DSB during all the market dialogues was how to design an optimal procurement setup for the entire S-network system. The input from the market has played a key role in the development of the agreed tender and contract strategy, called the Market Model.

In the first round of market dialogue, the suppliers were presented with the Hybrid Model that was developed as part of the Rambøll/Quartz report in 2018. The suppliers unambiguously responded that they had little or no appetite for a such model, encouraging DSB to develop an alternative. One of the key arguments for this was that the model posed too many risks, i.e. by not considering the central role of the existing CBTC contract (Signalling) with Banedanmark.

Based on the input from the market, several iterations on the Hybrid Model were foregone, which ultimately resulted in the Market Model. The Market Model is based on the following key input from the market:

- All suppliers but one agreed that ODS-T should be procured as part of the rolling stock tender to reduce the integration risk and allow the train manufacturer to have control of the onboard systems. The same goes for the (hardware) onboard systems such as CCTV, passenger information systems (PIS), etc. and maintenance of all systems and the rolling stock itself.
- All suppliers recommended that DAS was procured as a separate tender to allow specialised suppliers to bid
- All suppliers agreed that all platform UTO supporting systems should be procured as a separate tender package incl. maintenance.

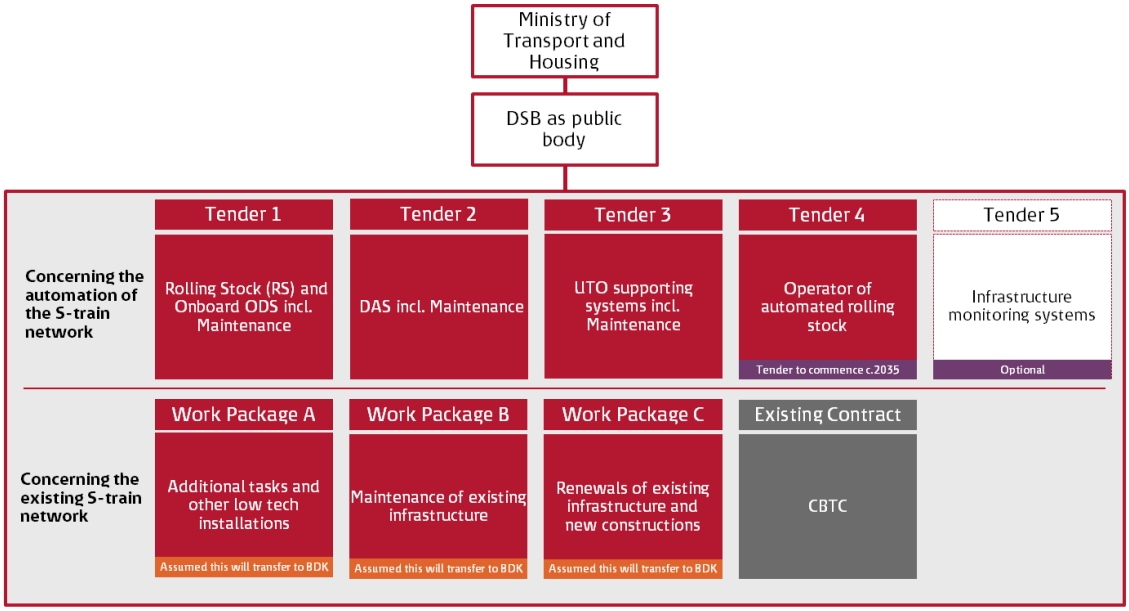


Figure 2 Market Model 2020

Some suppliers raised the concern that the proposed model did not include early operator involvement to make sure adequate UTO experience and integration knowledge was transferred into DSB. These suppliers proposed that DSB entered a joint venture setup with an experienced operator. However, DSB

expressed that they would prefer to include this knowledge in other ways, e.g. by the use of advisors, and instead involve the operator through a separate tender post transition, as the Market Model shows (Tender 4). The majority of the suppliers agreed to the importance of having a clearly defined party on the customer side.

After the market dialogue in 2021 and 2022 it was clear that the ODS-T and DAS solutions was not matured enough to the timeline of the Future S-network. The suppliers' range for ODS-T was not far enough for the use of the Future S-network (section 2.4.1) and also issues with curves lead the conclusion that ODS-T was not a feasible solution. The DAS solution had some high-risk uncertainties related to both installation and capability that would increase the cost (section 2.4.2). Instead of ODS-T and DAS tenders, it was decided to use full fencing between stations and a series of UTO supporting systems at platforms.

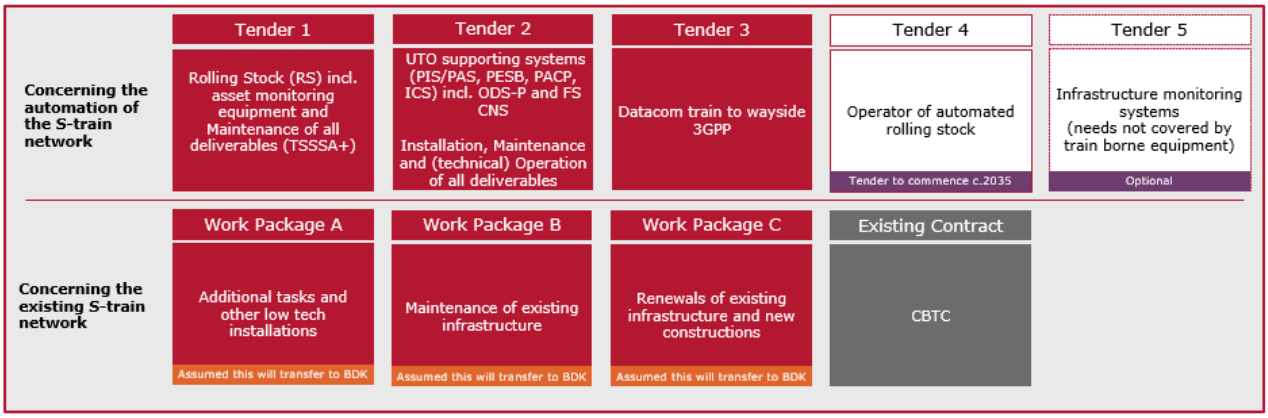


Figure 3 Market Model 2022

## 2.2. Tenders, Work Packages and Existing Contracts

During the 2022 market dialogue figure 3 above was presented as DSB wanted to explore if the split of tenders were suitable for the suppliers.

Please note that the rolling stock tender (Tender 1) was published on the 12th of May 2023 and that there can be differences between what was presented in the market dialogue 2022 and the actual tender. To access the published tender please go to EU Supply Supplies - 293430-2023 - TED Tenders Electronic Daily (europa.eu).

### 2.2.1. Tender 1 – Rolling Stock

The tender for new rolling stock was in the market dialogue 2022 expected to include design, build and maintenance of a new automated train fleet of approximately 200-220 electrical trainsets. For the maintenance a TSSSA+ (Technical Support & Spare part Supply Agreement) framework was anticipated, where DSB will provide the DSB Maintainers and the maintenance facility. The "+" indicates that the supplier is expected to maintain responsibility for the performance of the trainsets throughout the term of the contract. Hardware and associated onboard systems for PIS/PA, CCTV and PCP onboard the trains were expected to be supplied by the Rolling Stock Supplier whilst the CBTC onboard unit will be provided by DSB but installed and integrated into the train by the Rolling Stock supplier.

### 2.2.2. Tender 2 – Supporting Systems

The tender for UTO supporting systems (also referred to as "SuSy") was in 2022 expected to include design, build, maintain and technical operation of a portfolio of subsystems:

- Obstacle Detection System at Platforms (ODS-P) enabling surveillance and detection solution of tracks and platform edges and trigger stop in case of obstacles in track/movement across the
- platform edge
- Platform Emergency Stop Bottom enabling "manual" stop in case of obstacles in track/movement across the platform edge
- CCTV (Closed Circuit Television) enabling surveillance of platforms in general
- PIS/PAS (Passenger Information/announcement System) enabling information to passengers
- PCP (Passenger Call Points) enabling passengers to contact DSB for information and/or emergency situations
- ICS (Integrated Control System) allowing the traffic control centre to monitor functionality and operate all SuSy sub-systems (and operate PIS/PA, CCTV and PCP in trains and other train-borne sub-systems
- The on-board supporting systems CCTV, PCP and PIS will be interfaced and managed in TCC from a landside system delivered by the SuSy supplier

This tender is expected to include all hardware at platforms, back-end systems as well as one front-end system for operating the PIS/PA, CCTV and PCP functionality in the traffic control centre covering both platforms and in trains.

### 2.2.3. Tender 3 – Data Communication, Train to Wayside 3GPP

As there will be ongoing data exchange between the Rolling Stock and the landside systems, such as the systems included in the Supporting Systems package – and this is not within the scope of any of the technology suppliers DSB is expecting to procure the data connectivity via a separate tender.

### 2.2.4. Tender 4 – Operator of Automated Rolling Stock

Given that DSB has been given the task to plan and execute the entire conversion including implementation of the new technologies, new organisation and operation of the entire system during the transition phase, this tender will not be relevant at this point in time. It is expected that it will be subject to political decision a later point in time once the transition into the new fully automated system has been completed.

### 2.2.5. Tender 5 – Infrastructure Monitoring Systems

This tender was in 2022 expected as optional as the optimal solution is still under investigation. Some measurement equipment for monitoring the infrastructure will be installed on the new trainsets procured via Tender 1, however there may be need for additional equipment (wayside or specialised vehicles) which will then be tendered out separately as indicated with this Tender 4.

### 2.2.6. Existing Contract – CBTC

The new automated system (GoA4) will be based on the CBTC signalling system delivered by Siemens and currently implemented for GoA2. The CBTC is today owned by Banedanmark and it is expected that this contract will be transferred to DSB. From there DSB will exercise an option in the contract for upgrade of the CBTC to GoA4. Furthermore, the CBTC onboard units for the new train fleet will be procured by DSB in order to ensure that all suppliers in the Rolling Stock tender is treated equally.

### 2.2.7. Work Package A – Additional Tasks and Other Installations Related to Conventional Railway Infrastructure

This work package covers works to be performed on Banedanmark owned infrastructure and it is expected that these works will be specified by the FS Programme and subsequently executed and

tendered as applicable by Banedanmark as part of their project portfolio in order to harvest synergies with similar works on the main line network. Currently the following tasks are anticipated:

- Preparatory works at stations covering installation of fibre cable between all stations at the S-bane network, establishment of technical object housings at stations which will serve as access points of the Supporting Systems supplier and modifications on platforms as applicable.
- Establishment of fencing along the S-network ensure that nobody unintentionally accesses the guideway
- Establishment of fauna passages as applicable as a consequence of fencing along the S-network

#### 2.2.8. Work Package B – Maintenance of Existing Conventional Infrastructure

As a consequence of DSB taking the full sector responsibility for the future S-network whilst the ownership of conventional existing infrastructure such as tracks, catenary, bridges, vegetation and drainage etc. will remain at Banedanmark, DSB and Banedanmark will enter into a contract for maintenance of this infrastructure. The maintenance works will be executed and tendered as applicable by Banedanmark as part of their project portfolio in order to harvest synergies with similar works on the main line network.

#### 2.2.9. Work Package C – Renewals of Existing Conventional Infrastructure and New Constructions

This work package covers works to be performed on Banedanmark owned infrastructure and it is expected that these works will be specified by the FS Programme and subsequently executed and tendered as applicable by Banedanmark as part of their project portfolio in order to harvest synergies with similar works on the main line network. Currently following tasks are anticipated:

- Establishment of a new turn-back track at Carlsberg station (already part of the decided Infrastructure Plan 2035)
- Extension of the S-network to Roskilde and hence conversion of parts of the existing mainline infrastructure between Høje Taastrup and Roskilde into S-infrastructure
- Potential establishment of new cross overs to ensure flexible future operations.

DSB asked during the 2022 market dialogue the suppliers if this split of tenders (as stated above) were compatible with the suppliers' products and ability to develop a solution. The suppliers confirmed that the market model with two main tenders (Tender 1 and Tender 2) is the most optimal solution. However, the suppliers had some concerns regarding the future division of responsibility and ownership of conventional infrastructure (as well as rework/renewals of it in relation to Work-packages) and which entities of employees DSB will take over from DSB.

### 2.3. Requirements for Rolling Stock

During the market dialogue DSB asked the suppliers about their ability to meet a number of specific requirements for the rolling stock, because the Future S-network is an adaptation of current S-network and to make sure the anticipated solution for the Future S-network is available and feasible from the suppliers' perspective.

#### 2.3.1. Platform Height and Wheelchair Accessibility

Most of the stations consist of either island platforms i.e. rails on both side of the platforms, or classic platforms i.e. two platforms for each direction with several tracks in between. At terminals and hubs, there may be several tracks and platforms, depending on local conditions. The network consists of 87 stations with 132 platforms.

The platform height is 920 mm with some deviations. The platform length is between 165 – 240m, except for the Ring line where the length is between 90 and 155m.

The curvature along the platforms varies from radius 300m to straight track. The worst case of curved platforms is the following:

- Flintholm: Radius 300m
- Ny Ellebjerg: Radius 313/317m
- Vesterport: Radius 325/375m

DSB asked the suppliers for a suitable solution to wheelchair users, because of the GAP between platform and train. The solution on the current fleet is that the train driver unfolds an access ramp and is therefore able to support the user. The current solution cannot be used in the future because there is no driver.

To ensure the GAP between the platform and the train is minimized most of the suppliers suggest a sliding step installed on the train and that will move out towards the platform.

### 2.3.2. Speed of 120 km/h

The maximum operational speed of the S-network is 120 km/h over most of the network, except for three tunnels. There are no level crossings except for staff crossings at some stations.

The suppliers confirmed that 120 km/h is possible, but because the current S-network is a mix between metro operation and regional train operation it will require customisation of the train compared to a classic metro train.

### 2.3.3. Width of Car-Bodies

Today's fleet consists of 104 8-car and 31 4-car vehicles. The cars are short (10m) and wide (3.6m measured on the outside) and the train design is based on single axles running gears. It is free to bring bicycles onboard the train, which requires a large flex area designed to match this service and hence wider car bodies than applied in most train designs.

To fit the above-described specificity of the S-train, DSB asked the suppliers about their abilities to meet specific design metrics. Among the key topics were the discussion of the optimal combination of length and width, in which DSB asked for the suppliers' ability to meet 3.4m width and 3.6m width, respectively. Some suppliers could, in principle, meet the 3.6m requirement, but in most instances, this would require significant changes to their recommended product platform entailing a significant cost and risk increase for DSB. The suppliers generally agreed that a 3.2 – 3.4m wide train would be a more feasible solution and ensure optimised costs in terms of both CAPEX and OPEX (e.g. not designing an entirely new train, optimal numbers of bogies etc.), capacity (allowing bicycles onboard) and reduced risk (utilizing vital some parts of existing product platforms).
DSB opted for a minimum (outside) width of 3.2 m for the car-bodies.

### 2.3.4. Capacity and Trainset Length

Regarding length of the train, most suppliers stated that if the width of the train remained in the range of 3.2 – 3.4m, they would be able to meet DSB's length requirements (illustrated in the below graphic). The majority of the platforms in the network have a length of approx. 170m, except for the platforms in the inner Ring Line, which are approx. 90m long.

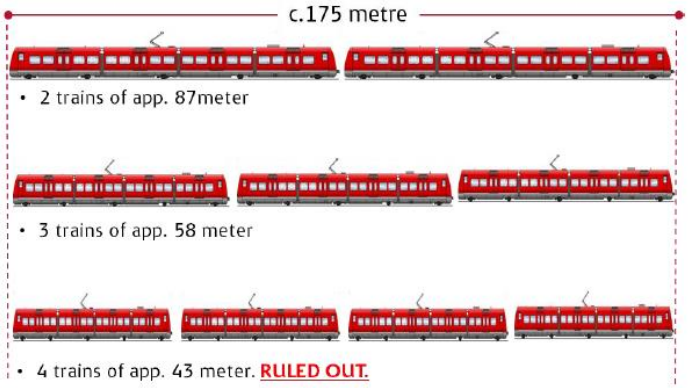


Figure 4 Proposed Trainset Length

In addition to the length and width of the train, DSB was also curious to understand the maximum seating capacity achievable. To ensure future capacity needs are met, a 3+3 seating arrangement was preferred, but this was not something the suppliers could easily satisfy. The majority of suppliers had a preference for a 3+2 or even 2+2 seating arrangement in a 3.2-3.4m wide train, as their opinion was that a 3+3 solution would not be fully utilised anyhow due to the limited leg room on the window seats and further entail a significantly more costly solution for DSB.

In the market dialogue in 2022 DSB had analysed that the most optimal solution was a train with a maximum length of 56 m and a possibility to couple up to 3 trains taking into account all platform length, stopping accuracy etc.
The seating layout should be a 2+2 vis-a-vis and with the capacity of minimum of 450 passengers (including both sitting and standing), a minimum of 16 bicycles and 2 wheel-chair spaces per train (full train based on more coupled trainsets). The suppliers confirmed that it would be possible to accomplish but would require some customisation.

### 2.3.5. Driver Cabin

Another topic discussed with the suppliers was the possibility to have driver cabins installed in retrospect, should reliable GoA4 operations not be possible for some reason. The majority of the suppliers indicated that they could install a driver cabin in retrospect, although this solution would be significantly more costly compared to having it installed as part of the initial train design. It was, hence made clear by all suppliers that DSB should be clear on this requirement from the beginning and make sure that the option to include a driver cabin was included in the rolling stock contract from the very beginning.

### 2.3.6. Maintenance Model FSA vs. TSSSA+

For maintenance of rolling stock, the key finding from the workshops was that the responsibility should lie with the rolling stock manufacturer. The majority of the suppliers confirmed that this would provide DSB with the best opportunity to ensure hands on and rolling stock specific maintenance, which is essential considering the relatively high degree of modification needed. A few suppliers (none-Rolling Stock suppliers) did propose that maintenance of rolling stock should be bundled with operation in an operation and maintenance tender.

Further on in the RFI process, DSB specifically asked the suppliers about two different maintenance models: A full-service agreement (FSA) and a Technical Support and Spare part Supply Agreement (TSSSA+). In particular, DSB asked for the suppliers' experience with and preference for the two models. While all the suppliers had experience with and could do both models, the majority preferred FSA. The

main argument for this was that FSA ensures an end-to-end responsibility for the train performance being held in one place. However, one supplier specifically recommended a TSSSA+.

A few other topics regarding maintenance of rolling stock were also discussed with the market i.e., the split between different maintenance types. Some suppliers forecast a split of 60 % being preventive maintenance, 30 % being overhauls and fixed schedule maintenance and 10 % being corrective maintenance.

Additionally, the contract length for maintenance of rolling stock contracts was discussed. The market's response was an estimation of 15 years with the possibility to review/withdraw every 5-7 year however with the right contractual setup also a full lifetime contract could work (30 years).

Lastly, the sharing of the maintenance facilities with DSB during a transition where DSB would still need to maintain the existing S-train was discussed with the suppliers, showing that the majority of suppliers had no problem in doing so, as long as well-established boundaries and agreements were in place.

In the 2022 market dialogue DSB indicated that the TSSSA+ model was the preferred model due to the long transition period where both old and new trains are to be maintained within the same facility, and therefore asked the suppliers for their opinion and experience on this model.
The suppliers explained that they had experience with the TSSSA model and that it would be possible to work with but would require that DSB managed the interface between DSB and the supplier very strictly.

### 2.4. Obstacle Detection Systems

Securing the safe route to the driverless S-train has been a priority for the programme and led this topic to become key in the market dialogue. It was articulated early on that upgrading all platforms with platform screen doors (PSDs) was not a feasible solution for the DSB due to the extensive need for infrastructure upgrades and associated cost impact compared to any tangible benefit of having PSDs (e.g. safety). As a result, and due to the open status of much of the S-network, the suppliers recommended the programme to explore the market for Object Detection Systems (ODS), which is considered the future for intrusion detection technology for both track and platform areas by many suppliers. Some driverless systems around the world already exist with such a concept, however mainly in closed environments (tunnel).

The second round of the market dialogue focused on testing the market's technology capabilities, i.e. within platform/track protection (Platform or Trackside ODS) and ODS-T (Train-borne ODS), from which the outcome was no supplier currently offered a technology mature enough to act as a standalone product. This suggested that a combination of technologies was needed in order to achieve the required level of safety and punctuality for the S-network.

On the basis of this and further analysis, DSB presented the suppliers with the intention of procuring the intrusion protection system for the Future S-network as a combination of a Distributed Acoustic Sensing system (DAS) and an ODS system onboard the train (ODS-T). This procurement setup was discussed in detail with the suppliers in conjunction with the commercial approach.

In the latest market dialogue in 2022 DSB had come to the conclusion that DAS and ODS-T were not developed enough to be part of the automated S-network. Therefore, DSB opted for a solution with fencing between stations and obstacle detection systems at platforms (ODS-P), which the market was asked further into in 2022 in order to further explore maturity and availability as well as suggested technologies of such solutions.

### 2.4.1. Train-borne Obstacle Detection System (ODS-T)

The early identification of ODS-T as a possible technology to deploy has allowed DSB to dive deeper into the maturity and capabilities of this market. Throughout the first three rounds of market dialogue, it became apparent that although no solution is currently able to match the requirements of the Future S-network, suppliers are investing heavily in research and development to improve their offerings, although on short term mainly as driver assistance systems only. Most solutions are either in final stages of testing or awaiting pending patents, with multiple suppliers stating they would have a mature solution at a point in time.

In the last market dialogue regarding ODS-T in 2021 the market's roadmaps for GoA4 commercial products was challenged compared to the timeline of the Future S-network. In the market there are no commercial ODS-T in service for GoA4 operation with passengers yet – however it already exists for GoA2 operation and as demonstrator for GoA3. The market dialogue confirmed that ODS-T is considered as the future common solution for GoA4 operation, and several major suppliers (train manufactures and specialised companies) already have ongoing development with defined roadmaps and goals as well as ongoing Proof of Concept. The suppliers' range for ODS-T is between 100 m and 1000 m for small size objects, for medium size objects the range is between 100 m and 1500 m and for large objects the range is up to 2000 m on a straight stretch of tracks. On the S-network there are curved stretches hence the detection range will not be as long as for a straight stretch which may cause severe speed limitations in order to manage the braking distance of the trains. For now, there are no common ODS-T norms and standards, which are still under development in international forums (such as Shift2Rail, Sensors4Rail etc.).

### 2.4.2. Distributed Acoustic Sensing (DAS)

The market dialogue showed there are numerous companies offering Distributed Acoustic Sensing (16+) technology with many focusing on the oil and gas industry but at least seven have deployed some form of DAS in rail environments. DAS was first considered – in combination with an on-board obstacle detection system installed in the front area of each train (ODS-T) - as a possible solution to detect unauthorised intrusions into the track area by persons, animals or large objects. DAS was considered in particular suitable for the open line stretches between stations.

After the market dialogues the DAS system was put on hold as an intrusion detection system, mainly for the following reasons:

- The required fibre optics cables on both sides of the track area combined with high requirements for the exact position of the cables would increase the cost for installation beyond the initially expected amount and would make DAS less competitive compared to fencing.
- There is no reference application yet for a DAS system which is reporting obstacles in the track area to the signalling system with an automatic reaction of the latter to the event.
- Suppliers were uncertain about the false alarm rate from a DAS system used of for obstacle and intrusion detection.
- Suppliers were not able to guarantee any safety level for the DAS system as an intrusion detection system.

All these reasons would create a high risk and uncertainty on the overall project. Instead of the combined ODS-T and DAS solution, DSB identified a solution where the tracks between stations are protected by fences and the stations are equipped with a wayside obstacle detection solution (ODS-P) as the most feasible solution.

### 2.4.3. Fencing

In the first three round of market dialogues DSB asked the market for technologies regarding to support foreign obstacle detection between platforms in areas with no fences. An example of foreign objects includes persons, fallen trees, larger animals that are crossing the tracks, thrown shopping carts and bicycles from bridges etc. In general objects with a size that can potentially cause damage to the trains, cause derailment and thereby harm the passengers on-board. The rail network is already fenced to some degree by line side fencing, noise barriers, dams, vegetation etc., - but not entirely.

After a deeper analysis into the current fencing around the S-network tracks DSB concluded that the most feasible solution in terms of controlling both risk and costs would be to full fence the area between stations and add fauna passages for animals and vegetation where needed.

### 2.4.4. UTO Supporting System and Obstacle Detection Systems for Platforms

In the market dialogues DSB presented DSB's intention of bundling several platform-based supporting systems for Future S-network driverless operation (GoA4). The ODS-P system is expected to be a central part in the safety set-up as it must secure that persons and objects in the track at platform areas are detected to avoid damage on persons or trains or even derailment of train. The ODS-P is expected to have a simple interface to the CBTC system enabling the train to brake based on alarms from the ODS-P. The alarm shall be simple and not specify the object in the track. DSB wanted to explore an ODS-P based on Smart CCTV. To reduce the numbers of false alarms it was anticipated that the system must have built-in intelligence allowing to disregard e.g., trains, paper and plastic bags flying in the air. Furthermore, alarms must be directed to the traffic control centre (TCC) to support manual actions by TCC staff calling assistance from stewards or supplying passenger announcements to specific platforms. The ODS-P must support video recording, storage, and playback.

DSB suggested the supporting systems package to include design, build, maintain and technical operation of a portfolio of subsystems such as:

- Obstacle Detection System at Platforms (ODS-P) enabling surveillance of tracks and platform edges and trigger stop in case of obstacles in track/movement across the platform edge
- Platform Emergency Stop Bottom enabling "manual" stop in case of obstacles in track/movement across the platform edge
- CCTV (Closed Circuit Television) enabling surveillance of platforms in general
- PIS/PAS (Passenger Information/announcement System) enabling information to passengers
- PCP (Passenger Call Points) enabling passengers to contact DSB for information and/or emergency situations

The market agreed that the systems are off-the-shelf products, except for the ODS-P system. The ODS-P solution is not available as an off-the-shelf product and has do be developed and matured in close cooperation with DSB for the specific application even though the basic technologies are well known. The suppliers were reluctant to take the full risk in terms of costs and commitments to performance requirements mainly due to the level of development needed for use in outdoor environment. The suppliers asked for DSB to consider making the suppliers choose the technologies for the ODS-P solution instead of DSB specifying a certain technology. Furthermore, the suppliers asked for a clear specification of level 1, 2 and 3 maintenance responsibility for the entire Supporting Systems package.

According to the market the expected lifecycle of the hardware and software within the Supporting Systems package are 8-10 years, due to fast changing developments in the areas, especially regarding artificial intelligence (AI). Under certain conditions the market can accept a contract op to 30 years including responsibility for the performance of the systems.

## 2.5. Automatic Asset Monitoring Equipment on Commercial Trains

DSB wanted to explore the possibilities of including requirements about train-borne infrastructure monitoring systems for the new S-network rolling stock. DSB was specifically interested in real time monitoring systems that are easily integrated with the train design process especially infrastructure monitoring technologies that are light-weight, small and have few and standardised interfaces to the rolling stock itself. DSB was, as a minimum, interested in monitoring technologies directed towards the condition of tracks, rails and overhead catenary in order to prevent/reduce service disruptions on the S-network. In 2022 DSB asked train suppliers regarding the possibility to include such infrastructure monitoring systems on the rolling stock.

The suppliers answered that they do offer train-borne solutions for infrastructure condition monitoring such as tracks, rails and overhead catenary. The solutions are near-real time monitoring, but an interface to the landside is needed. The suppliers noted that the integration of such solutions will increase the complexity of the design process by adding time, interface management and potential 3rd party integration. The variety of solutions to be integrated will define the complexity and the required efforts.

## 2.6. Onboard Data System Hardware

It was DSB's expectation, that the Rolling Stock supplier also would deliver the following hardware and required onboard software as part of the train delivery, even though most back-end systems are going to be delivered as part of the Supporting Systems package (Tender 2):

- all on-board network equipment incl.
- CCTV, Passenger Call Point (PCP), Passenger Emergency Stop Bottom (PESB), Passenger Information and Announcement System (PIS/PAS), Passenger Counting system
- equipment for a bi-directional data transmission to support data communication between train and wayside during full operation at 120km/h across the complete S-bane Network

The suppliers confirmed that they are familiar with installing hardware as CCTV, PCP, PESB and PIS/PAS. The connectivity to the wayside data although should be handled by MNO (mobile network operator) in contract with DSB, and where DSB is in charge of the integration between the Rolling Stock supplier and the MNO.

## 2.7. Wireless Data Communication

In the 2022 market dialogue DSB asked the suppliers whether it was possible for the rolling stock supplier to handle a standard network 3GPP (3rd Generation Partnership Project) based on a contract with the Danish MNO (mobile network operator) as part of the data communication solutions. DSB wanted the rolling stock supplier to handle this contract in order to avoid unnecessary interfaces.

None of the rolling stock suppliers wanted to handle this type of contract because they are no used to it. They believed it would be a major cost driver and could be a possible showstopper for bids. Instead, the suppliers recommended that the rolling stock supplier provides hardware and DSB supplies SIM-cards and connectivity.

DSB therefore anticipate a separate tender for data communication train to wayside based on 3GPP. This will require that DSB oversees the interface management.

## 2.8. Delivery Rate and Time Scales for Rolling Stock Project

Regarding commissioning of trains, some suppliers recommended a delivery schedule of 25 trains per year (equal to 1 train bi-weekly), while others suggested weekly commissioning. Most suppliers confirmed that a delivery rate of 2 trains per month would be feasible.

## 2.9. General Market Situation

In the latest market dialogue, some of the suppliers raised concern regarding the situation of the market, that could impact the tender process. First of all, the train industry has generally experienced many train tenders over a period of time – and still is - and therefore the order book is full for many of the companies. The process for ordering and building trains are consequently longer.
Secondly, the business landscape has changed extraordinarily since 2020 due to COVID-19, war in Ukraine, increased energy costs, rising interest rates and semiconductor shortage. In consequence the rail industry experiences the following macro trends:

- Increased delivery times
- Extraordinary price volatility
- Extraordinary price increases
- Uncertainty on future inflation projections
- Inability to negotiate fixed prices with suppliers, and the traditional indexation is at risk
- Increased foreign exchange rate volatility
- Rolling Stock suppliers generally reluctant to commit to short delivery schedule

These conditions have led to extended supply chains which means the train supplying companies cannot commit to short delivery times and force majeure does not solve the issues experienced. Furthermore, the contracts need to reflect the changed situation in order to be interesting for the market.


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