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1 **Vehicle**  
 1.1 **Vehicle Boundry conditions**  
 1.1.1 **Physical limits**  
 1.1.1.1 **Infrastructure compatibility**

| Id           | Requirement   | Referring to   |
|--------------|---|--|
| A2:1.1.1.1.a | <p><b>M</b> The Trainset shall comply with all functional and process requirements required by the Norwegian Railway Authority in the vehicle regulation (Kjøretøyforskriften) FOR-2016-12-19-1846 to be compatible with the Norwegian national railway network, except the Flåm Line.</p> <p><a href="https://www.sjt.no/andre-valg/regelverk/">https://www.sjt.no/andre-valg/regelverk/</a></p> <p><a href="https://lovdata.no/dokument/SF/forskrift/2016-12-19-1846">https://lovdata.no/dokument/SF/forskrift/2016-12-19-1846</a></p> <p>The Trainset shall minimum comply to referred TSI unless otherwise specific Norwegian requirement is specified.</p> <p>The functional requirements for integration in the Norwegian national railway network are set out in the vehicle regulation with reference to detailed information in the infrastructure managers “Network Statement” and “Technical requirements rolling stock”</p> <p><a href="http://networkstatement.jbv.no/doku.php?id=2021">http://networkstatement.jbv.no/doku.php?id=2021</a></p> <p><a href="https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations">https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations</a></p> | <p>Kjøretøyforskriften<br/>           TSI LOC&amp;PASS<br/>           TSI SRT<br/>           TSI PRM<br/>           TSI NOISE<br/>           TSI ENERGY<br/>           TSI CCS<br/>           Network Statement 2021</p> |
| A2:1.1.1.1.b | <p><b>I</b> The Trainset must comply with the Norwegian track gauge 1435mm.</p>   |  |
| A2:1.1.1.1.c | <p><b>I</b> The Trainset must be within Norwegian NO1 Dynamic gauge</p>   |  |
| A2:1.1.1.1.d | <p><b>M</b> The power supply for the Trainset shall be 15kv 16 2/3 Hz.</p>  |  |
| A2:1.1.1.1.e | <p><b>M</b> The Trainset shall have ETCS BL3 installed</p>  |  |

## 1.1.1.2 Electric network compatibility

| Id           | Requirement   | Referring to   |
|--------------|---|--|
| A2:1.1.1.2.a | <p><b>K</b> Power factor shall be as close as possible to 1 and adjustable in relation to primary voltage and direction of power complying with EN 50388 and Bane NOR Technical Regulations Chapter 8, Appendix d, section 4.3.5 P5.</p> <p><a href="https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations/Appendix/Requirements_on_rolling_stock_in_Norway_and_Sweden_regarding EMC_with_the_electrical_infrastructure_and_coordination_with_the_power_supply_and_other_vehicles">https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations/Appendix/Requirements_on_rolling_stock_in_Norway_and_Sweden_regarding EMC_with_the_electrical_infrastructure_and_coordination_with_the_power_supply_and_other_vehicles</a></p>   | <p>EN 50388<br/>Bane NOR technical regulations/Chapter 8/Appendix d</p>  |
| A2:1.1.1.2.b | <p><b>M</b> Trainset shall function satisfactorily with the power supply of the electrical railway infrastructure and the other vehicles existing on the Norwegian railway network and without adversely affecting the other parts of the railway system. In this regard, the trainset shall comply with:</p> <ol style="list-style-type: none"> <li>1) TSI LOC&amp;PAS clause 4.2.8.2 Power supply</li> <li>2) Kjøretøysforskriften chapter 8</li> <li>3) Bane NOR technical regulations, chapter 8, appendix d.</li> </ol> <p><a href="https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations/Appendix/Requirements_on_rolling_stock_in_Norway_and_Sweden_regarding EMC_with_the_electrical_infrastructure_and_coordination_with_the_power_supply_and_other_vehicles">https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations/Appendix/Requirements_on_rolling_stock_in_Norway_and_Sweden_regarding EMC_with_the_electrical_infrastructure_and_coordination_with_the_power_supply_and_other_vehicles</a></p> <p>4) Bane NOR Network Statement</p> <p><a href="http://networkstatement.jbv.no/doku.php?id=2020">http://networkstatement.jbv.no/doku.php?id=2020</a></p> <p>Special attention shall be paid to Annex 3.3.2.6 <a href="http://networkstatement.jbv.no/doku.php?id=vedlegg:elektrifiserte_linjer">http://networkstatement.jbv.no/doku.php?id=vedlegg:elektrifiserte linjer</a></p> | <p>TSI LOC&amp;PAS 4.2.8.2<br/>Kjøretøysforskriften chapter 8<br/>Bane NOR technical regulations/Chapter 8/Appendix d<br/>Bane NOR network statement</p> |

*The Tenderer shall demonstrate compliance with the requirement by presenting relevant documents, e.g. simulation studies, with the Tender documentation.*

# Exhibit A02: SOW Technical

## 1.1.1.3 Technical summary

| Id           | Requirement  | Referring to  |
|--------------|--|---------------|
| A2:1.1.1.3.a | <p><b>K</b> A technical summary of the Trainset main data is requested.</p> <p><i>The Tenderer shall fill in the sheet "Technical sheet"</i></p> | Appendix A2-1 |

## 1.1.2 Environmental condition

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:1.1.2.a | <p><b>M</b> The Trainset shall comply to EN 50125-1 and the following ranges:</p> <ul style="list-style-type: none"> <li>• Altitude A1</li> <li>• Temperature T2</li> <li>• Snow level S3</li> <li>• Solar radiation R1</li> </ul>   | EN 50125-1   |
| A2:1.1.2.b | <p><b>E</b> No components shall be damaged or encounter reduced functionality if an unheated Trainset is exposed to a climatic condition with temperatures as low as -40°C for a longer period.</p> <p><i>The Tenderer shall describe the consequences of exposing an unheated Trainset to temperatures as low as -40°C and how the Trainset will be made operational again.</i></p>   |              |
| A2:1.1.2.c | <p><b>E</b> The Trainset shall be designed to avoid extensive repair after collisions with large animals (e.g. moose, deer and wild boars).</p> <p><i>The Contractor shall describe the following aspects of the projected aftermath following a collision between the Train running at high speed and an adult moose:</i></p> <ul style="list-style-type: none"> <li>• <i>the expected damages on the Train</i></li> <li>• <i>the expected damages on the railway infrastructure</i></li> <li>• <i>the needed repair, including duration and required Spare Parts.</i></li> </ul> <p><i>Description shall be done for 160km/h and 200km/h.</i></p> <p><i>Frequency of collision with large animals may happen 2-3 times per trip on Nordlandsbanen.</i></p> |              |

## 1.1.3 External Command and Control and signalling

| Id | Requirement | Referring to |
|----|-------------|--------------|
|    | NA          |              |

## 1.1.4 Maintenance provisions

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:1.1.4.a | <b>I</b> Requirements can be found in referred Exhibit. | TBD          |

## 1.1.5 Electromagnetic compatibility (EMC)

### 1.1.5.1 General

| Id           | Requirement  | Referring to                         |
|--------------|--|--------------------------------------|
| A2:1.1.5.1.a | <b>K</b> The electrical components mounted on the Trainset shall comply with EN 50121-3-2.   | EN 50121-3-2                         |
| A2:1.1.5.1.b | <b>K</b> The electromagnetic emission of the Trainset shall comply at least with EN 50121 and Kjøretøysforskriften clause 8.4 .  | EN 50121<br>Kjøretøysforskriften 8.4 |
| A2:1.1.5.1.c | <b>K</b> The Trainset shall be compatible with the track circuits within the limits of TS 50238-2.   | TS 50238-2                           |
| A2:1.1.5.1.d | <b>K</b> The Trainset shall be compatible with the axle counters according to TS 50238-3. Testing of the compatibility of the trainset with axle counters shall be done according to EN 50592. | TS 50238-3<br>EN 50592               |

### 1.1.5.2 Electromagnetic fields

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:1.1.5.2.a | <b>E</b> Values for human exposure to electromagnetic fields shall be as low as possible following at least the ICNIRP (International Commission on Non-Ionizing Radiation Protection) guidelines.<br><br><i>The Tenderer shall state their values.</i> | ICNIPR       |
| A2:1.1.5.2.b | <b>K</b> Magnetic and electric fields with respect to human exposure shall be measured according to EN 50500.   | EN 50500     |
| A2:1.1.5.2.c | <b>K</b> Interference with, or effects on, active implantable medical devices such as cardiac pacemakers shall be avoided.  | ICNIPR       |

## 1.2 Vehicle Performance parameters / boundry conditions

### 1.2.1 Operational conditions

| Id         | Requirement   | Referring to               |
|------------|---|----------------------------|
| A2:1.2.1.a | <b>I</b> Requirements can be found in referred Exhibit. | A1:3.5 Operator experience |

# Exhibit A02: SOW Technical

## 1.2.2 Operating performance

| Id         | Requirement   | Referring to               |
|------------|---|----------------------------|
| A2:1.2.2.a | <b>I</b> Requirements can be found in referred Exhibit. | A1:3.5 Operator experience |

## 1.2.3 Weight

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:1.2.3.a | <b>E</b> The Tenderer shall calculate the Trainset weight distribution according to EN 15663 Vehcile category M-I and the weight shall be as low as possible.<br><i>The Tenderer shall present the Trainset preliminary weight distribution calculation.</i> | EN 15663     |

## 1.2.4 Vehicle dynamics and gauging

### 1.2.4.1 Ride comfort

| Id           | Requirement   | Referring to                |
|--------------|---|-----------------------------|
| A2:1.2.4.1.a | <b>I</b> Requirements can be found in referred Exhibit. | A1:3.6 Passenger experience |

### 1.2.4.2 Track forces

| Id           | Requirement   | Referring to                          |
|--------------|---|---------------------------------------|
| A2:1.2.4.2.a | <b>M</b> Locomotives and possible train configurations shall have documented and verified vehicle dynamic behaviour to satisfy the requirements of EN 14363 and "Teknisk Regelverk - Bane Nor". Ref "Rolling stock_Supplementary information and regulations".  | EN 14363                              |
| A2:1.2.4.2.b | <b>M</b> Maximum dynamic lateral force during all possible operation on relevant parts of the Norwegian Network shall be 100kN. Ref Appendix J.2 in EN14363 regarding measurements and required filtering.  | EN 14363                              |
| A2:1.2.4.2.c | <b>M</b> Dynamic track forces shall be verified on Norwegian track with a rail inclination of 1/20, on straight sections as well as in curves.<br>The vehicle dynamics assessment shall be documented to be representative of the contact characteristics of the relevant sections in Norway.   |                                       |
| A2:1.2.4.2.d | <b>M</b> Locomotives and possible train configurations shall be able to run into a 1-metre high snow drift at a lateral distance of 1.6 metres from the track centre line and 0 metre at the track centre line without risk of derailment.<br><br>The Contractor shall deliver calculations demonstrating satisfactory derailment safety (Y/Q) when running into specified snow drift. First edition shall be delivered as part of the preliminary design review. | TSI 4.2.2.5<br>EN 15227<br>EN 50125-1 |

# Exhibit A02: SOW Technical

## 1.2.4.3 Roll angle coefficient

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:1.2.4.3.a | <b>M</b> For coaches fitted with a pantograph, the maximum roll angle coefficient shall be $\leq 0.2$ .  | EN 14363     |
| A2:1.2.4.3.b | <b>K</b> The roll angle coefficient shall be kept as low as possible and preferably be $< 0.20$ .<br><i>The roll angle coefficient shall be specified for all coaches.</i> | EN 14363     |

## 1.2.4.4 Wheel unloading

| Id           | Requirement   | Referring to    |
|--------------|---|-----------------|
| A2:1.2.4.4.a | <b>M</b> For locomotives, cars and coaches the load difference between the right and left wheel of each axle shall be within +/-5% from the measured axle load.<br><br>For locomotives the load of the wheels measured on one side of the vehicle shall not differ by more than +/- 4% from the average of the measured wheel loads on both sides. (EN 15528 og TSI)<br><br>All wheel- and axle load requirements shall be verified with a type test. | EN 15528<br>TSI |

## 1.2.5 Acoustics and Vibration

### 1.2.5.1 Internal noise

| Id           | Requirement   | Referring to                |
|--------------|---|-----------------------------|
| A2:1.2.5.1.a | <b>I</b> Requirements can be found in referred Exhibit. | A1:3.6 Passenger experience |

### 1.2.5.2 External noise

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:1.2.5.2.a | <b>E</b> External noise of the Trainset shall be as low as possible.<br><i>The Tenderer shall present the values.</i>                                  |              |
| A2:1.2.5.2.b | <b>E</b> External noise of the Trainset during Stabling and Parking mode shall be as low as possible.<br><i>The Tenderer shall present the values.</i> |              |

# Exhibit A02: SOW Technical

## 1.3 Vehicle Performance parameters

### 1.3.1 Aerodynamics

| Id         | Requirement   | Referring to   |
|------------|---|--|
| A2:1.3.1.a | <b>K</b> The Trainset shall be verified regarding aerodynamic effects according to NS-EN 14067-1:2003, NS-EN 14067-3:2003, NS-EN 14067-4:2013, NS-EN 14067-5:2006+A1:2010, and NS-EN 14067-6:2018.  | NS-EN 14067-1:2003<br>NS-EN 14067-3:2003<br>NS-EN 14067-5:2006+A1:2010<br>NS-EN 14067-6:2018 |
| A2:1.3.1.b | <b>K</b> There shall be no speed restrictions from pressure pulses arising from tunnel operations or from train encounter.  |  |
| A2:1.3.1.c | <b>K</b> There shall be no speed restrictions due to crosswinds up to 102 km/h (28,3 m/s) under the following conditions: <ul style="list-style-type: none"> <li>• Maximum trainset speed</li> <li>• Train running at a tangent and levelled track with a non-compensated lateral acceleration of <math>a_q</math>: 0 m/s<sup>2</sup></li> <li>• TBR ground configuration</li> <li>• Tare load condition</li> </ul> |  |

### 1.3.2 Thermodynamics

| Id         | Requirement  | Referring to                |
|------------|--|-----------------------------|
| A2:1.3.2.a | <b>E</b> Thermal bridges between the outside and inside of the Trainset shall be avoided.<br><i>The Tenderer shall describe how the thermal bridges are avoided.</i> |                             |
| A2:1.3.2.b | <b>I</b> Additional requirements   | A!:3.6 Passenger experience |

### 1.3.3 Structural mechanics

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:1.3.3.a | <b>K</b> The Carbody Shell shall fulfill the requirements of EN 12663 category P-II  | NS EN 12663  |
| A2:1.3.3.b | <b>K</b> For topics not covered by EN 12663, UIC 566 requirements apply.   | UIC 566 OR   |
| A2:1.3.3.c | <b>K</b> Critical components/systems (e.g. body, bogie frame, axles, wheels) shall be designed for loads in excess (up to 5 %) of that required for the delivery. This is to facilitate modifications that might entail a weight increase. |              |

## 1.3.4 Rescue and recovery

### 1.3.4.1 Towing the train

| Id           | Requirement  | Referring to         |
|--------------|--|----------------------|
| A2:1.3.4.1.a | <p><b>K</b> A defect Trainset shall be towable by another UIC vehicle that can control the mechanical brakes through main brake pipe connection while upholding the full braking capacity even when all electronic and electrical systems (including battery systems) are down.</p> <p>See also: TSI LOC&amp;PAS 4.2.4.10 and Norwegian regulation "Kjøretøyforskriften 4.9 Bremskrav ved berging"</p> | TSI LOC&PAS 4.2.4.10 |

### 1.3.4.2 Towing other trains

| Id           | Requirement                      | Referring to               |
|--------------|----------------------------------|----------------------------|
| A2:1.3.4.2.a | <b>I</b> Additional requirements | A1:3.5 Operator experience |

## 1.3.5 Power distribution and management

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:1.3.5.a | <p><b>E</b> The Tenderer shall calculate the Trainset electric auxiliary (400V AC) load and it shall be as low as possible with sufficient margin.</p> <p><i>The Tenderer shall present the electric auxiliary (400V AC) load calculation for the Trainset including the percentage used of full capacity for each consist configuration.</i></p> |              |
| A2:1.3.5.b | <p><b>E</b> The Tenderer shall calculate the Trainset battery (110V DC) load and it shall be as low as possible with sufficient margin.</p> <p><i>The Tenderer shall present the battery (110V DC) load calculation for the Trainset including the percentage used of full capacity for each consist configuration.</i></p>                       |              |

## 1.3.6 Energy consumption

| Id         | Requirement  | Referring to                 |
|------------|--|------------------------------|
| A2:1.3.6.a | <p><b>K</b> The energy consumption of the Trainset shall be calculated by performing simulations and finally validated by doing measurements for the specific pre-defined service profile, environmental and loading conditions stated in Exhibit A5-2 SOW LCC and in compliance with EN 50591.</p> <p><i>The Tenderer shall demonstrate compliance with the requirement by presenting relevant documents.</i></p> | NEK EN 50591<br>Exhibit A5-2 |

# Exhibit A02: SOW Technical

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:1.3.6.b | <p><b>E</b> The Trainset shall be designed in a way that ensures optimized energy consumption in all modes of operation, independent of where power is supplied from: catenary, external power supply, or traction batteries (if present).</p> <p><i>The Tenderer shall deliver a description of how the Trainset is designed and can be operated to have minimized energy consumption in all modes of operation, defined in section 12.2 Operational concept.</i></p> |              |

## 1.3.7 Industrial design (interior and exterior aesthetics) and ergonomics

| Id         | Requirement   | Referring to                |
|------------|---|-----------------------------|
| A2:1.3.7.a | <b>I</b> Requirements can be found in referred Exhibit. | A1:3.6 Passenger experience |

## 1.3.8 Environmental protection

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:1.3.8.a | <b>I</b> Requirements can be found in referred Exhibit. | TBD          |

## 1.3.9 Safety

### 1.3.9.1 Product safety

| Id           | Requirement   | Referring to  |
|--------------|---|---|
| A2:1.3.9.1.a | <b>M</b> The Trainset shall be designed for category B train (according to TSI SRT) and operation category 3 (according to EN 45545-1).                     | TSI SRT<br>EN 45545-1   |
| A2:1.3.9.1.b | <b>M</b> Electrical safety of the Trainset shall be assured in accordance with EN 50153, TSI LOC&PAS clause 4.2.8.4. and Kjøretøysforskriften clause 8.3.4. | EN 50153, TSI LOC&PAS § 4.2.8.4, Kjøretøysforskriften § 8.3.4 |
| A2:1.3.9.1.c | <b>K</b> All Electronic equipment on the Trainset shall comply with EN 50155 and all safety related electronic systems shall comply with EN 50129.          | EN 50155<br>EN 50129  |
| A2:1.3.9.1.d | <b>K</b> The Trainset crashworthiness should be designed according to EN 15227, and shall fulfill the requirements of EN 15227 Category C-I.                | EN 15227  |

### 1.3.9.2 Perceived safety

| Id           | Requirement   | Referring to                |
|--------------|---|-----------------------------|
| A2:1.3.9.2.a | <b>I</b> Requirements can be found in referred Exhibit. | A1:3.6 Passenger experience |

# Exhibit A02: SOW Technical

## 1.3.9.3 Traffic safety

| Id           | Requirement   | Referring to                           |
|--------------|---|--|
| A2:1.3.9.3.a | <b>I</b> Requirements can be found in referred Exhibit. | Exhibit I_ Traffic safety and security |

## 1.3.10 Security

### 1.3.10.1 IT Security

| Id            | Requirement   | Referring to    |
|---------------|---|-----------------|
| A2:1.3.10.1.a | <b>K</b> If the Contractor processes personal data on behalf of Norske tog in connection with this Contract, the Contractor shall process data in accordance with instructions from Norske tog, this Contract and applicable data protection laws.  | Contract clause |
| A2:1.3.10.1.b | <b>I</b> The security of the IT assests is of utmost importance in the digital world. Threats against IT assets are set to increase and this risk increases for Norske tog as the majoroty of the IT systems onboard and on the Wayside are connected and online. The aim of the IT Security requirements in this section is to ensure a safe, reliable and secure operation of the fleet as well as the confidentiality, integrity and availability of the IT System onboard and on the Wayside.   |                 |
| A2:1.3.10.1.c | <b>I</b> It is envisaged that the Supplier will have their own Security Operations Center (SOC) or similar function that may or may not be dedicated for the fulfillment of the contract and that this function will work in close cooperation with Noske tog.<br>Continual scanning of IT assets is a key tool within Norske tog's operations to address the IT threats which Norkse tog and the operators are subject to. It is the intention that this practice of continual scans is extended to the Trainsets via the Supplier's obligations. The continual scans are to be supplemented with deeper scans that can be carried out for example on a Trainset that is not in service. |                 |
| A2:1.3.10.1.d | <b>K</b> The Train IT System and Wayside IT System and their external interfaces shall be secured against malicious attack, manipulation, eavesdropping, intrusion or accidental access in such a way that the correct, safe and reliable operation of Trainsets can be ensured.<br><br><i>The Contractor shall demonstrate compliance by describing how the IT system has been secured and the design principles used during the design of the system. The description shall include how the requirement in this section is to be fulfilled</i>  |                 |

# Exhibit A02: SOW Technical

| Id            | Requirement  | Referring to          |
|---------------|--|-----------------------|
| A2:1.3.10.1.e | <p><b>K</b> The Contractor shall apply an information security management system (ISMS) in accordance with the applicable version of ISO27001, EN 62443 or equivalent (national or international) recognized standard, based on a risk management process accepted by Norske tog.</p>  | ISO 27001<br>EN 62443 |
| A2:1.3.10.1.f | <p><b>K</b> The Supplier shall apply a Risk Management process for information security when fulfilling the contract. This process shall be based on a documented and continuously updated risk assessment and shall ensure that:</p> <ul style="list-style-type: none"> <li>• The risk assessment shall include the Deliverables and the parts of the Supplier's business that may affect the information security of the Deliverables.</li> <li>• The risk assessment shall be updated as a minimum twice a year.</li> <li>• The risk assessment shall be updated on Norkse tog's request to include a specific threat in the risk assessment, including but not limited to results of changes in Norkse tog's own risk assessment and or instructions from Norske tog with regards to processing of data</li> <li>• The risk assessment shall take into account the GDPR regulation and any risk to the rights and freedoms of natural persons who are subject to video surveillance.</li> <li>• The Supplier without undue delay provide Norkse tog with the Supplier's current risk assessment upon request.</li> </ul> |                       |

# Exhibit A02: SOW Technical

| Id            | Requirement   | Referring to |
|---------------|---|--------------|
| A2:1.3.10.1.g | <p><b>K</b> The Supplier shall as part of the ISMS (see 1.3.10.1.e) comply with the specific organizational (process) requirements listed below.</p> <p>In this regard the Supplier shall:</p> <ul style="list-style-type: none"> <li>• Apply an IT security governance framework</li> <li>• Apply a process for managing the implications of relevant legislation, laws and regulations, including alignment with recognized industry Standards for information IT Security such as ISO/IEC 27001/27002 and IEC 62443 and other relevant Standards and certification</li> <li>• Apply a process to ensure segregation of duties related to the fulfillment of the contract. That is ensuring that the organization is set up with specific user controls such that the responsibility for fulfilling critical tasks such as authorizations, software changes and auditing is shared among several persons minimizing the risk that one person can exert potential damage.</li> <li>• Apply a process for securely managing IT related assets to be used when fulfilling the contract including acquisition, Maintenance, decommissioning and secure destruction according to NIST Special Publication 800-88</li> <li>• Apply an IT Security awareness process covering the Supplier's or Sub-Suppliers' employees who participates when fulfilling the contract.</li> <li>• Apply a process to handle Information security events which have or may have impact on the Deliverables.</li> <li>• Apply appropriate technical measures for processing of information in accordance with Norske tog and the Operators classification of information.</li> <li>• Apply a process for managing the recommendations from Audits and risk assessments including enhancements and risk mitigation actions and how these are to be reported to Norse tog.</li> <li>• Apply an incident management process for the Supplier's IT Delivery that includes identification, response, recovery and review of information security incidents including how this minimizes operational impacts and ensures operational continuity in response to incidents.</li> <li>• Apply a process for and action plan to support Norkse tog's management decisions on actions to be taken to bring an IT security crisis related to the contract e.g. a virus infection, back to an acceptable level of risk.</li> <li>• Apply a process for Identity and Access Management (IAM) covering all users relevant to the systems or devices involved in the Supplier's solution, including urgent creation and deletion of identities and/or access rights. This also includes logical and physical access as well as process of logging user activity within the Supplier's IT Delivery. (For the sake of clarity, this requirement shall not in any way limit the rights and obligations of the Parties under the contract concerning confidentiality)</li> <li>• Apply a process for conducting periodic reviews, as appropriate, to validate that individual users' access within the Supplier's IT Delivery as well as programmable devices, programs and libraries is appropriate</li> <li>• Apply a process for vulnerability scanning (continual scans focusing on configuration changes and deep scans</li> </ul> |              |

## Exhibit A02: SOW Technical

| Id | Requirement   | Referring to |
|----|---|--------------|
|    | <p>focusing on all vulnerabilities), patching, intrusion detection information, leakage protection, protection against malicious code and virus and malware protection including periodical reporting to Norske tog</p> <ul style="list-style-type: none"><li>• Apply a process for backup and storage in accordance with the risk assessment above</li><li>• Apply a system development life cycle (SDLC) process for the Supplier's IT Delivery within scope of the contract.</li></ul> |              |

# Exhibit A02: SOW Technical

| Id            | Requirement  | Referring to |
|---------------|--|--------------|
| A2:1.3.10.1.h | <p><b>K</b> The Supplier shall ensure that the ISMS (see 1.3.10.1.e) complies with the specific technical requirements listed below.</p> <p>The Supplier shall:</p> <ul style="list-style-type: none"> <li>• Taking the applicable risk assessment (see 1.3.10.1.f) into account, apply as necessary cryptographic solutions for all types of communications including communication within the Trainset, WiFi Solution and communications to and from the Wayside e.g. using encryption, public key infrastructure, digital signatures or biometrics; .</li> <li>• Apply relevant IT Security functions and features, relevant special configurations, separation of networks and internal gateways in accordance with the applicable risk assessment .</li> <li>• Apply appropriate technical measures for processing of information in accordance with Norkse togs classification of information.</li> </ul> <p>For the sake of clarity, this requirement shall not in any way limit the rights and obligations of the Parties</p> <ul style="list-style-type: none"> <li>• Apply IT Security hardening and testing thereof of hardware and software components applied in the fulfillment of the contract</li> <li>• Apply a protection system for Mobile Devices delivered within the scope of the Deliverables, e.g. laptops, tablets and smartphones against unauthorized modification or disclosure of content, loss and theft</li> <li>• Apply formalized methods (e.g. 2 factor authorization) to restrict access to data , software components (including backups) and hardware applied in the fulfillment of the contract, e.g. business applications, Mobile Devices, systems, networks and information to authorized individuals for specific business purposes, and to ensure that granted access privileges is in line with the user role.</li> <li>• Apply functionality to monitor the various networks including detection of suspicious traffic, alarming and access tracking.</li> <li>• Design physical, wireless and voice networks so that they e.g. can be characterized by being secure, reliable, resilient and encrypted.</li> <li>• Differentiate protection between various data classes/information types handled in as part of the Deliverables</li> <li>• Apply a continual scan function on all systems and equipment and a method for providing daily vulnerability scan reports via the IT Security reports, to Norske tog within the agreed time frame. Deep scans shall be carried out at least once a week in addition to continual daily scans. These scans shall be informed by the vulnerabilities identified in the vulnerability watch.</li> <li>• Apply an End Users monitoring function on service accounts, users, system administrator activities of the Supplier's IT Delivery for unauthorized access (including multiple logins (access and rejected) where possible) and monitor, review and respond in a timely and appropriate manner to access violations.</li> <li>• In relation to the Deliverables, ensure an ongoing implementation and Maintenance of comprehensive and up-to-date malware protection software and a process for dealing with malware infections, supported by an awareness</li> </ul> |              |

# Exhibit A02: SOW Technical

| Id            | Requirement  | Referring to |
|---------------|--|--------------|
|               | campaign targeted at the Supplier’s employees, which contribute in the fulfillment of the contract.  |              |
| A2:1.3.10.1.i | <p><b>K</b> The Supplier must regularly update the ISMS if the Supplier's risk assessment (see 1.3.10.1.f) implies a need for an update. The Supplier shall deliver written notice of such updated/amendments to Norske tog by not less than 30 (thirty) calendar days’ notice prior to the amendments take effect.</p>  |              |
| A2:1.3.10.1.j | <p><b>K</b> The Supplier shall at every Design Review provide a process description of how the IT System and other Supplier owned systems to be used to maintain and operate the Trainsets will be managed. The process description shall contain at a minimum information covering the compliance with the specific organizational and technical requirements as specified in the above requirements.</p>   |              |
| A2:1.3.10.1.k | <p><b>K</b> The Supplier shall present and discuss the output from the risk assessments to Norske tog and other Operators and together agree on an action plan for mitigation of the identified risks. Where the output of the risk assessment indicates that penetration tests are required to validate the security of the IT Assets the Supplier shall present a suitable third party for approval to carry this out.</p>   |              |
| A2:1.3.10.1.l | <p><b>K</b> As part of the TSSSA+ the Supplier shall ensure that the ISMS, see 1.3.10.1.e, complies with the specific organization interface requirements listed below.</p> <ul style="list-style-type: none"> <li>• Apply a process for regular updates and interfacing to the Norske tog's Security Operating Center (SOC) for among others the reporting of vulnerabilities.</li> <li>• Apply a process for electronic communication (dedicated email, SMS alerts) between the Supplier’s operations and Norske tog's SOC.</li> <li>• The Supplier shall carry out a vulnerability management review (continuous monitoring of the market) and report relevant vulnerabilities that may have an impact on the Deliverables to the Norske togs SOC.</li> <li>• Report within 48 hours report any vulnerabilities identified as part of the vulnerability management review, see above, via electronic means and call for a meeting to create an action plan for mitigating the risk of the identified vulnerability.</li> <li>• Regularly update the ISMS if the Supplier's risk assessment (see 1.3.10.1.e) implies a need for an update. The Supplier shall deliver written notice of such updated/amendments to Norske tog by not less than 30 (thirty) calendar days’ notice prior to the amendments take effect.</li> </ul> |              |
| A2:1.3.10.1.m | <p><b>K</b> The payment solution for the catering solutions within the Trainset shall be compliant to both PCI PTS and PSD2 SCA (Strong Customer Authentication)</p>   |              |

## 1.3.10.2 GDPR

| Id            | Requirement  | Referring to |
|---------------|--|--------------|
| A2:1.3.10.2.a | <p><b>I</b> Regulation (EU) 2016/679 of the European Parliament and the of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation – “GDPR”) is an EU regulation which has the intent to strengthen and unify data protection for all individuals within the European Union (EU). The requirements in this section is to ensure that Norkse tog and the Operators together with the Supplier, work together to develop a Technical Solution that complies with the regulation. A specific process for GDPR compliance is envisaged as the method for achieving this.</p> <p>The key document for demonstrating compliance will be a GDPR compliance report (doc no) that will be updated throughout the duration of the contract. A further document that will be an outcome of the process is the Data processing agreement. The Data processing agreement will as a fundament, specify what data processing is done by the Supplier's systems and to what extent this is personal data. How the processing of the personal data and to what extent the Supplier's systems provide compliance (e.g. privacy by default and privacy by design) with the GDPR is to be detailed in the GDPR compliance report.</p> <p>This section shall be read in conjunction with GDPR compliance check list which provides a checklist to assist the Supplier achieving compliance with the requirements in this section</p> |              |
| A2:1.3.10.2.b | <p><b>K</b> The Supplier shall develop and continuous update a GDPR compliance report for the supply contract period. The GDPR compliance report shall demonstrate how the Supplier will comply with the GDPR, the Norwegian Data Protection Act, and any other applicable provisions concerning protection of personal data.</p>  |              |
| A2:1.3.10.2.c | <p><b>K</b> The Supplier shall at every Design Review</p> <ul style="list-style-type: none"> <li>• Update and provide the GDPR compliance report 1.3.10.2.b with an updated description of how the IT System and other Supplier owned systems (including the Supplier's Wayside IT Deliverables) is to comply with the GDPR regulation to the extent that data processing including of personal data is done by the Supplier's systems</li> <li>• Review the GDPR compliance check list and ensure that the IT System and other Supplier owned systems complies with the relevant requirements stated in GDPR compliance check list to the extent that the Supplier's systems are processing personal data.</li> </ul>   |              |
| A2:1.3.10.2.d | <p><b>K</b> The Supplier shall ensure that as part of the Variation Order Process throughout the duration of the Supply Agreement, where the IT System and other Supplier owned systems (including the Supplier's Wayside IT Deliverables) are impacted by a change that an updated GDPR compliance report is delivered as part of the Variation Order</p>   |              |

# Exhibit A02: SOW Technical

| Id            | Requirement   | Referring to |
|---------------|---|--------------|
| A2:1.3.10.2.e | <b>K</b> As part of the TSSSA+ the Supplier shall <ul style="list-style-type: none"> <li>• Ensure that the GDPR compliance report is updated</li> <li>• Ensure that as part of the Variation Order Process throughout the duration of the Agreement, where the IT System and other Supplier owned systems (including the Supplier's Wayside IT Deliverables) are impacted by a change that an updated GDPR compliance report is delivered as part of the Variation Order</li> </ul> |              |

## 1.3.11 Health protection

| Id          | Requirement   | Referring to               |
|-------------|---|----------------------------|
| A2:1.3.11.a | <b>I</b> Requirements can be found in referred Exhibit. | A1:3.5 Operator experience |

## 1.3.12 Visibility and Audibility

| Id          | Requirement   | Referring to                          |
|-------------|---|---------------------------------------|
| A2:1.3.12.a | <b>I</b> Requirements can be found in referred Exhibit. | A2 External lighting<br>A2 Air supply |

## 1.3.13 Winterization

| Id          | Requirement  | Referring to |
|-------------|--|--------------|
| A2:1.3.13.a | <b>K</b> The Trainset shall be equipped with snow ploughs or similar snow clearing equipment which meets the requirements of EN 15227  | EN 15227     |
| A2:1.3.13.b | <b>E</b> The geometry of the Trainset front and snowplough shall ensure that axle load on leading axles are not reduced to a hazardous level when driving through snow.<br><br><i>The Tenderer shall provide detailed description of the snowplough dimensions, including distance to top of rail and coupler face, and simulations of the snow clearing capability at snow conditions as specified in A2:1.2.4.2.d.</i> | A2:1.2.4.2.d |
| A2:1.3.13.c | <b>E</b> All ducts and cabinets, etc. containing water pipes or water tanks, etc. shall be kept frost free during operation or normal stabling.<br><br><i>The Tenderer shall describe their solution.</i>  |              |

## 1.4 RAM/LCC - (ILS)

| Id       | Requirement   | Referring to            |
|----------|---|-------------------------|
| A2:1.4.a | <b>I</b> Requirements can be found in referred Exhibit. | Exhibit A05-1 and A05-2 |

# Exhibit A02: SOW Technical

## 1.5 Vehicle Transverse elements

### 1.5.1 Equipment and tools

| Id         | Requirement   | Referring to               |
|------------|---|----------------------------|
| A2:1.5.1.a | <b>I</b> Requirements can be found in referred Exhibit. | A1:3.5 Operator experience |

### 1.5.2 Preparation for technical investigations

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:1.5.2.a | <b>E</b> In connection with pantograph, running gear and similar systems provisions shall be made for easy mounting of cameras, sensors, wireless receivers etc enabling observations of the system. The system shall be as simple as possible such as a threaded hole or hole with two side access for fixing the equipment. The placements shall ensure protection of the equipment and clear view of the observed system. A prepared route for cabling between the position and the interior must be provided. Mounting of equipment and cabling shall be possible without any need for cutting, drilling, etc.<br><br><i>The Tenderer shall describe their provisions.</i> |              |

### 1.5.3 De-icing

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:1.5.3.a | <b>E</b> It shall be possible to accelerate the rate of ice melting by external means of de-icing.<br><br><i>The Tenderer shall state which de-icing procedure that may be used in the different parts of the Trainset, e.g.:</i> <ul style="list-style-type: none"> <li>• De-icing fluid</li> <li>• Steam</li> <li>• Hot water</li> <li>• Etc.</li> </ul> |              |

# Exhibit A02: SOW Technical

## 1.5.4 Software

| Id         | Requirement  | Referring to                          |
|------------|--|---------------------------------------|
| A2:1.5.4.a | <p><b>I</b> All software and components shall be designed, developed and manufactured in accordance with generally acknowledged railway industry standards regarding i.a. architecture, development and maintainability. All software and components shall be designed so as to communicate via open interfaces and to facilitate interchangeability, extensibility and interoperability with standard software and components as far as this is applicable and possible (both from a technical and a commercial point of view) having regard to the proposed system design of the Delivery as described in the system specification of the Contractor.</p> <p>All relevant software of the Delivery, both safety-related and non-safety-related, shall be designed, developed and tested according to EN 50657. All other software that does not contribute to, and is segregated from, rolling stock operational functions shall be designed tested and verified according to generally acknowledged and applied railway industry standards.</p> | Exhibit I_Traffic safety and Security |
| A2:1.5.4.b | <p><b>K</b> Development of software used in electronic systems shall comply with EN 50657.</p>   | EN 50657                              |

## 1.5.5 Redundancy

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:1.5.5.a | <p><b>M</b> Compressed air shall be supplied by at least two redundant compressors with separate air dryers.</p>   |              |
| A2:1.5.5.b | <p><b>K</b> The Trainset shall have redundant pantographs, while only minimum number shall be used in normal operation. Disconnection of individual pantograph shall be possible.</p>  |              |
| A2:1.5.5.c | <p><b>K</b> Traction system shall incorporate redundancy to ensure that no individual fault in the system may cause the trainset to halt or seriously reduce its performance. It is, however, acceptable that the available traction power is reduced on the occurrence of a single fault, with no limit on the driving range.</p> |              |
| A2:1.5.5.d | <p><b>K</b> Auxiliary power unit shall incorporate redundancy to ensure that no individual fault may cause a stoppage. It is however acceptable for individual faults to cause reduction of traction power or comfort, with no limit on the driving range.</p>   |              |
| A2:1.5.5.e | <p><b>K</b> Battery unit and charging shall incorporate redundancy, to ensure that no individual fault may cause a stoppage. It is however acceptable for individual faults to cause reduction of traction power or comfort, with no limit on the driving range.</p>   |              |
| A2:1.5.5.f | <p><b>K</b> Return power circuit shall incorporate redundancy to ensure that no individual fault, e.g. on an earth brush, may cause a hazardous situation</p>  |              |

# Exhibit A02: SOW Technical

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:1.5.5.g | <b>K</b> Signal- and control systems shall incorporate redundancy. No individual fault should cause a stoppage. It is however acceptable for individual faults to cause reduction of service/comfort.   |              |
| A2:1.5.5.h | <b>K</b> Driver's desk screens shall incorporate redundancy to ensure that important functions are routed to the remaining screens in case of a fault.<br>This requirement is not relevant for safety systems like ETCS and GSM-R radio.  |              |
| A2:1.5.5.i | <b>E</b> A single component failure shall not compromise the triangular light at the front, nor the red taillight.<br><i>The Tenderer shall describe how redundancy in external lighting has been considered in both components and the feeding and control systems to make the Trainset always distinguishable as a train.</i> |              |
| A2:1.5.5.j | <b>K</b> Speed transmitters shall incorporate redundancy. Should the speed transmitter for a certain system malfunction, the system shall be able to pick up a speed signal from another transmitter.   |              |

## 1.5.6 Standardisation

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:1.5.6.a | <b>I</b> Requirements can be found in referred Exhibit. | TBD          |

## 1.5.7 Quality management

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:1.5.7.a | <b>I</b> Requirements can be found in referred Exhibit. | Exhibit D    |

## 1.5.8 Requirement management

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:1.5.8.a | <b>I</b> Requirements can be found in referred Exhibit. | Exhibit D    |

## 1.5.9 Verification and validation

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:1.5.9.a | <b>I</b> Requirements can be found in referred Exhibit. | Exhibit D    |

## 1.5.10 Authorization

| Id          | Requirement   | Referring to |
|-------------|---|--------------|
| A2:1.5.10.a | <b>I</b> Requirements can be found in referred Exhibit. | Exhibit D    |

# Exhibit A02: SOW Technical

## 1.5.11 Cooling

| Id          | Requirement  | Referring to |
|-------------|--|--------------|
| A2:1.5.11.a | <p><b>E</b> All cooling air inlets for technical ventilation shall preferably be placed at roof height due to whirling of snow powder generated by the train's movement.<br/>This requirement does not limit the possibility to place heat exchangers and similar items directly under the floor or in the side or end walls.</p> <p><i>The Tenderer shall describe their solution.</i></p>          |              |
| A2:1.5.11.b | <p><b>E</b> All cooling air for technical ventilation shall have provision to eliminate the intrusion of snow and water.</p> <p><i>The Tenderer shall describe their solution.</i></p>   |              |
| A2:1.5.11.c | <p><b>E</b> Cooling air for technical ventilation of sensitive equipment that may be harmed by water and dirt shall have means to prevent water and dirt from coming in contact with the sensitive equipment. This may be by use of filters, heat exchangers or similar approaches.</p> <p><i>The Tenderer shall provide detailed information regarding their offered approach to equipment.</i></p> |              |
| A2:1.5.11.d | <p><b>E</b> Blocking of the air inlets and outlets by snow and ice shall be prevented.</p> <p><i>The Tenderer shall describe their solution.</i></p>   |              |

## 1.5.12 Cabling and harnesses

| Id          | Requirement   | Referring to |
|-------------|---|--------------|
| A2:1.5.12.a | <p><b>I</b> Operation, parking and stabling in severe conditions are common in Norway.<br/>The following design principles has proven to work in Norway:</p> <ul style="list-style-type: none"> <li>- Cables between body, bogie and axle box specially protected against the loads that arise from running in icy/snowy conditions.</li> </ul> <p>Regarding maintainability:<br/>The following design principles has proven to work in Norway:</p> <ul style="list-style-type: none"> <li>-Cables with different voltage levels (such as auxiliary power 230V/400V and battery circuit) colour coded. For the battery, different colours used for plus and minus poles.</li> <li>-Cables laid in a way which ensures ease of replacement.</li> </ul> |              |
| A2:1.5.12.b | <p><b>K</b> All cable installation in the Train shall comply with EN 50343.</p>   | EN 50343     |

# Exhibit A02: SOW Technical

| Id          | Requirement   | Referring to |
|-------------|---|--------------|
| A2:1.5.12.c | <p><b>E</b> The cabling in the Train shall have a robust design based on proven and standardized solutions fit for purpose during all climate conditions, all operating modes and maintenance activities.</p> <p><i>The Supplier shall describe how the cabling is designed to ensure full functionality, including worst climate condition, the descriptions shall include but not be limited to:</i></p> <ul style="list-style-type: none"> <li>- Cable standards being used</li> <li>- Cable routing with respect to separation of cable classes and EMC.</li> <li>- Cabling design with respect to fire safety</li> <li>- Cabling design in underframe and bogie areas</li> <li>- How ice and snow build up causing heavy loads is avoided</li> <li>- Design with respect to heavy condensation in tunnels</li> </ul> <p><i>The Supplier shall describe how the cabling is designed to ensure maintainability, the descriptions shall include but not be limited to:</i></p> <ul style="list-style-type: none"> <li>- How cables with different voltage levels are easily distinguishable, (preferably using colour codes)</li> <li>- Cable routing with respect to replacement and future modifications</li> </ul> |              |
| A2:1.5.12.d | <p><b>E</b> All channels, ducts and conduits running through the body shell shall provide spare capacity. The intension of the requirement is to reduce the need for cutting, welding, and structural calculations, etc. in connection with future upgrades.</p> <p><i>The Tenderer shall describe the size of provided spare capacity.</i></p>   |              |
| A2:1.5.12.e | <p><b>K</b> Cable ducts shall be filled to no more than 70% of their full capacity.</p>   |              |
| A2:1.5.12.f | <p><b>E</b> Cable looms shall included spare cables for future functions.</p> <p><i>The Tendere shall describe their cabling concept.</i></p>   |              |

# Exhibit A02: SOW Technical

| Id          | Requirement  | Referring to |
|-------------|--|--------------|
| A2:1.5.12.g | <p><b>E</b> The Trainset will have flexible car configuration that will be used frequently, therefore it shall be easy and fast to perform changes in the trainsets. NT foresee that the design and number of intercar connections enables quick updates of the Trainset.</p> <p><i>The supplier shall describe the solution for intercar connections and how a change of the Trainset configuration is performed. The descriptions shall include but not be limited to:</i></p> <ul style="list-style-type: none"> <li>- Number of connecting cables</li> <li>- Connector types</li> <li>- Mechanical interfaces</li> <li>- Lifetime for connectors (nr of connections)</li> <li>- Handling and time needed for changes in the car configuration of the trainset</li> </ul> |              |

## 1.5.13 Diagnostics diagnostic concept

| Id          | Requirement  | Referring to |
|-------------|--|--------------|
| A2:1.5.13.a | <p><b>K</b> The diagnostic management system shall have a diagnostic collection and storage functionality that shall support the maintenance concept and RAM targets set out within this procurement. Detailed system functionality and definitions shall be agreed in cooperation with Norske tog during the design phase.</p>  |              |
| A2:1.5.13.b | <p><b>K</b> All train diagnostic intended for onboard train crew shall be provided in at least English and Norwegian language.</p>   |              |
| A2:1.5.13.c | <p><b>K</b> Diagnostic data shall be able to be stored on the Trainset for for the period of time needed when not possible to transfer data to the Wayside.</p> <p><i>The Tenderer shall demonstrate compliance by describing how the system achieves this detailing the storage medium, how long the data can be stored on the Trainset and process for preventing accidental deletion.</i></p> |              |
| A2:1.5.13.d | <p><b>E</b> The diagnostic system shall support the use of condition based maintenance.</p> <p><i>The Tenderer shall describe how the diagnostic system support condition based maintenance, how the values from the sensors are available for future online monitoring system and how the system can be interfaced by Norske tog and the Operators.</i></p>                                     |              |

# Exhibit A02: SOW Technical

## 1.5.14 Piping fluids (liquids and gases)

| Id          | Requirement  | Referring to |
|-------------|--|--------------|
| A2:1.5.14.a | <p><b>E</b> To avoid potential hazardous leakages the use of piping fluids shall be minimized</p> <p><i>If applicable the Tenderer shall describe what liquids and gases are used as well as their purpose and the safety measures in case of a leakage.</i></p> |              |

## 1.5.15 Fire safety

| Id          | Requirement   | Referring to |
|-------------|---|--------------|
| A2:1.5.15.a | <p><b>E</b> The Trainset shall be equipped with a fire warning system to alert driver and conductor in case of fire. The fire warning system shall also be able to transmit an alarm out of the train.</p> <p><i>The Tenderer shall describe the proposed solution.</i></p> |              |
| A2:1.5.15.b | <p><b>E</b> The alert shall be transmitted to the driver via the diagnostic system, and to one of the conductor's mobile units (i.e. GSM-R or tablet).</p> <p><i>The Tenderer shall describe the proposed solution.</i></p>   |              |
| A2:1.5.15.c | <p><b>K</b> Fire detectors shall be self-monitoring – so-called AI detectors (Intelligent).</p>   |              |
| A2:1.5.15.d | <p><b>E</b> Firefighting – fixed equipment. The Trainset shall be equipped with fixed equipment for firefighting in high power technical cabinets, both inside and outside the carbody.</p> <p><i>The Tenderer shall describe the proposed solution.</i></p>                |              |
| A2:1.5.15.e | <p><b>K</b> Fire extinguishers shall not be harmed by temperatures according to climate conditions requirements, section 1.1.2.</p> <p><i>NT would like Tenderer to consider Presto PG 6 due to standardisation of maintenance, training and spare parts.</i></p>           | A2:1.1.2     |

# Exhibit A02: SOW Technical

## 1.5.16 Displays

### 1.5.16.1 IDU User interface

| Id            | Requirement  | Referring to  |
|---------------|--|---------------|
| A2:1.5.16.1.a | <p><b>E</b> The IDU shall support the driver and onboard crew for diagnostic monitoring purposes as well as interface to relevant Trainset operation data and operational commands.</p> <p><i>The Tender shall demonstrate compliance by describing the solution, including description of the graphical user interface and how it supports during Trainset operation, including multiple.</i></p> |               |
| A2:1.5.16.1.b | <p><b>K</b> The performance and design of the IDU shall support NS-EN 16186-3 or equivalent.</p> <p><i>The Tender shall demonstrate compliance by describing the solution of the performance and design of the IDU.</i></p>  | NS-EN 16186-3 |
| A2:1.5.16.1.c | <p><b>E</b> The IDU shall have different roles for different user groups. All IDUs shall support all roles.</p> <p><i>The Tender shall demonstrate compliance by describing the different roles and how they are supported in different modes of operation.</i></p>  |               |
| A2:1.5.16.1.d | <p><b>E</b> The Diagnostic text used by the diagnostic system shall be easily edited or replaced by Norske tog without involving the Tenderer.</p>   |               |

## 1.5.17 Labelling

| Id          | Requirement  | Referring to                |
|-------------|--|-----------------------------|
| A2:1.5.17.a | <p><b>I</b> Requirements can be found in referred Exhibit.</p> | A1:3.6 Passenger experience |

## 1.5.18 Locking

### 1.5.18.1 Operator access system

| Id            | Requirement  | Referring to |
|---------------|--|--------------|
| A2:1.5.18.1.a | <p><b>K</b> Limitations to access shall be implemented according to the specific requirement for safety or security from regulations and safety assessments.</p> |              |

# Exhibit A02: SOW Technical

| Id            | Requirement  | Referring to |
|---------------|--|--------------|
| A2:1.5.18.1.b | <p><b>E</b> The lowest level shall be based on RIC square key.</p> <p><i>The Tender shall describe the offered solution.</i></p>   |              |
| A2:1.5.18.1.c | <p><b>E</b> Higher levels shall be based on a proven in use electronic “key” concept with low maintenance cost and a high degree of flexibility.</p> <p><i>The Tender shall describe the offered solution.</i></p>   |              |
| A2:1.5.18.1.d | <p><b>E</b> “Keys” shall be personal with the possibility of excluding lost “keys”.</p> <p><i>The Tender shall describe the offered solution.</i></p>  |              |
| A2:1.5.18.1.e | <p><b>E</b> It shall be possible to remove or add rights without physically accessing the locks or keys.</p> <p><i>The Tender shall describe the offered solution.</i></p>   |              |
| A2:1.5.18.1.f | <p><b>E</b> It shall be possible to update rights for groups of keys and similar functions aiding efficient transfer of trainsets between different operators as well as organizing locks in groups.</p> <p><i>The Tender shall describe the offered solution.</i></p> |              |

## 1.5.18.2 Passenger access system

| Id            | Requirement  | Referring to                |
|---------------|--|-----------------------------|
| A2:1.5.18.2.a | <p><b>I</b> Requirements related to locking of Sleeping compartments can be found in referred Exhibit.</p> | A1:3.6 Passenger experience |

## 1.5.19 Panels and cases

### 1.5.19.1 Technical cabinets

| Id            | Requirement   | Referring to |
|---------------|---|--------------|
| A2:1.5.19.1.a | <p><b>E</b> Electric and pneumatic components should be located appropriately with respect to passengers and crews, e.g.</p> <ul style="list-style-type: none"> <li>-accessible during operation without disturbing passengers</li> <li>-accessible for maintenance personell</li> <li>-not hazardous to passengers</li> </ul> <p><i>The Tenderer shall describe their proposed solution.</i></p> |              |
| A2:1.5.19.1.b | <p><b>E</b> Low energy, long-life LED lighting should be provided in technical cabinets where train crew or maintenance staff have regular or emergency tasks.</p>  |              |

# Exhibit A02: SOW Technical

| Id            | Requirement   | Referring to |
|---------------|---|--------------|
| A2:1.5.19.1.c | <b>E</b> The lighting should be automatically activated when the cabinet is opened. The on/off switch for cabinet lights is preferably operated by cabinet door or hatch. |              |

## 1.5.20 Fixings

| Id          | Requirement   | Referring to |
|-------------|---|--------------|
| A2:1.5.20.a | <b>K</b> To avoid loosing components fixed to the train exterior the joints shall provide failsafe design, if their mass is above approx. 100 kg. |              |

## 1.5.21 Surface treatment/coating

| Id          | Requirement   | Referring to |
|-------------|---|--------------|
| A2:1.5.21.a | <b>E</b> Exterior surface treatment shall provide the necessary protection against corrosion. It is emphasized that operation in Norway is in a corrosive climate.<br><i>The Tenderer shall present their solution and present a reference where it has been used.</i>  |              |
| A2:1.5.21.b | <b>E</b> Surfaces shall be well protected against vandalism / graffiti.<br><i>The Tenderer shall present their solution and present a reference where it has been used.</i>   |              |
| A2:1.5.21.c | <b>E</b> Level of protection shall allow for at least five applications of strong graffiti removal chemicals, and an infinite number of applications of mild graffiti removal chemicals such as cleaning agents based on citric acid. The same requirements apply for exterior marking and signage.<br><i>The Tenderer shall present their solution and present a reference where it has been used.</i> |              |

## 2 Carbody, Doors, Interior and Lighting

### 2.1 Carbody

#### 2.1.1 Carbody shell

| Id | Requirement | Referring to |
|----|-------------|--------------|
|----|-------------|--------------|

|            |  |  |
|------------|--|--|
| A2:2.1.1.a | <b>E</b> The Tenderer shall give a general system description. |  |
|------------|--|--|

*The Tenderer shall describe their solution in detail and as a minimum include the following:  
system design, main components and function and vehicle integration*

#### 2.1.2 Crash energy absorption

| Id | Requirement | Referring to |
|----|-------------|--------------|
|----|-------------|--------------|

|            |  |  |
|------------|--|--|
| A2:2.1.2.a | <b>E</b> The Tenderer shall give a general system description. |  |
|------------|--|--|

*The Tenderer shall describe their solution in detail and as a minimum include the following:  
system design, main components and function and vehicle integration*

#### 2.1.3 Aerodynamic System

| Id | Requirement | Referring to |
|----|-------------|--------------|
|----|-------------|--------------|

|            |  |  |
|------------|--|--|
| A2:2.1.3.a | <b>E</b> The Tenderer shall give a general system description. |  |
|------------|--|--|

*The Tenderer shall describe their solution in detail and as a minimum include the following:  
system design, main components and function and vehicle integration*

#### 2.1.4 Windows

| Id | Requirement | Referring to |
|----|-------------|--------------|
|----|-------------|--------------|

|            |   |  |
|------------|---|--|
| A2:2.1.4.a | <b>I</b> Items to consider during the design:<br>Norwegian climate and infrastructure have an impact on what is the ideal design for side windows. The number and length of tunnels have some special conditions that cause considerable damage to windows in winter /spring. The long days of sunlight combined with a relatively low sun give a high amount of heat radiated through the windows in the summer. |  |
|------------|---|--|

|            |  |  |
|------------|--|--|
| A2:2.1.4.b | <b>K</b> NT shall be allowed to contribute with experience in all stages of the design process for the side windows. |  |
|------------|--|--|

|            |   |  |
|------------|---|--|
| A2:2.1.4.c | <b>E</b> Exchange of Side windows shall be fast and easy in all temperature conditions. |  |
|------------|---|--|

*The tenderer shall describe their solution.*

# Exhibit A02: SOW Technical

| Id         | Requirement   | Referring to  |
|------------|---|---|
| A2:2.1.4.d | <b>K</b> It shall be possible to open emergency exit side windows without the use of tools, etc. Emergency hammers are accepted only if they are fixed with wire, kept in a cabinet or similar. |   |
| A2:2.1.4.e | <b>E</b> Side windows shall reduce radiated heat by min. 50% and light transmittance shall be minimum 65%.<br><i>Value should be stated in the offer.</i>                                       |   |
| A2:2.1.4.f | <b>I</b> Additional requirements  | A1:3.5 Operator experience<br>A1:3.6 Passenger experience |

## 2.1.5 Windscreens

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:2.1.5.a | <b>E</b> The Tenderer shall give a general system description.<br><i>The Tenderer shall describe their solution in detail and as a minimum include the following: system design, main components and function and vehicle integration</i> |              |

## 2.2 Doors

### 2.2.1 Exterior doors

| Id         | Requirement   | Referring to                 |
|------------|---|------------------------------|
| A2:2.2.1.a | <b>K</b> The side entrance system shall comply with NS-EN 14752, and additional/specific requirements given in NOR_RS_0001 Norske tog AS standard scope of work / Specification for Side entrance systems.  | NS-EN 14752<br>Appendix A2-2 |
| A2:2.2.1.b | <b>K</b> Driver, train crew and passenger operation/interface shall be similar to existing Norske tog trainset and shall be decided in cooperation with Norske tog.   |                              |
| A2:2.2.1.c | <b>K</b> Side entrance system shall be electrically operated.   |                              |
| A2:2.2.1.d | <b>K</b> Vehicle control and door control interaction – there shall be provision for selecting any door(s) in part of train to stay blocked while the rest are released for opening. This function shall be operated from the driver’s cab. This is due to stations with short platforms. | Exhibit A2: 7.1.4.3          |
| A2:2.2.1.e | <b>I</b> Additional requirements  | A1:3.6 Passenger experience  |

# Exhibit A02: SOW Technical

## 2.2.2 Interior doors

| Id         | Requirement  | Referring to                |
|------------|--|-----------------------------|
| A2:2.2.2.a | <p><b>E</b> The Tenderer shall give a general system description.</p> <p><i>The Tenderer shall describe their solution in detail and as a minimum include the following: system design, main components and function and vehicle integration</i></p> |                             |
| A2:2.2.2.b | <b>I</b> Additional requirements   | A1:3.6 Passenger experience |

## 2.2.3 Loading system

### 2.2.3.1 Bistro and Cargo loading door system

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:2.2.3.1.a | <p><b>E</b> The Tenderer shall give a general system description.</p> <p><i>The Tenderer shall describe their solution in detail and as a minimum include the following: system design, main components and function and vehicle integration</i></p> |              |

## 2.3 Interiors

### 2.3.1 Floors and stairways, vestibules

| Id         | Requirement  | Referring to                |
|------------|--|-----------------------------|
| A2:2.3.1.a | <p><b>E</b> The Tenderer shall give a general system description.</p> <p><i>The Tenderer shall describe their solution in detail and as a minimum include the following: system design, main components and function and vehicle integration</i></p> |                             |
| A2:2.3.1.b | <b>I</b> Additional requirements   | A1:3.6 Passenger experience |

### 2.3.2 Compartments

| Id         | Requirement  | Referring to                |
|------------|--|-----------------------------|
| A2:2.3.2.a | <b>I</b> Requirements can be found in referred Exhibit.  | A1:3.6 Passenger experience |
| A2:2.3.2.a | <p><b>E</b> The Tenderer shall give a general system description.</p> <p><i>The Tenderer shall describe their solution in detail and as a minimum include the following: system design, main components and function and vehicle integration</i></p> |                             |
| A2:2.3.2.b | <b>I</b> Additional requirements   | A1:3.6 Passenger experience |

## 2.3.3 Toilet/Sanitary system

| Id | Requirement | Referring to |
|----|-------------|--------------|
|----|-------------|--------------|

# Exhibit A02: SOW Technical

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:2.3.3.a | <p><b>I</b> Operation, parking and stabling in severe winter conditions are common in Norway. The following design principles has proven to work when operating in Norway.</p> <ul style="list-style-type: none"> <li>-Automatic drainage of the system to prevent damage due to frost. If drainage of parts of the system is not possible, design to resist freezing in combination with rapid defrosting when power supply is available.</li> <li>-External tubes, pipes and tanks are insulated and heated to ensure that the system will not freeze under the worst climate conditions.</li> <li>-All drainage points and water outlets are heated, to ensure that the system will not freeze under the worst climate conditions.</li> <li>-“Tube in tube” solutions are used as much as possible. Leaks to the inner tube are led out of the train. Leaks are indicated by e.g. some sort of collection/inspection point.</li> <li>-Cables for heating of water tubes runs between the inner and outer tubes of "tube in tube" solutions to provide proper heating and allow for easy replacement.</li> </ul> <p>Norske Tog has experienced that the following approach gives the best results related to providing freshwater without and hazardous microorganisms.</p> <ul style="list-style-type: none"> <li>-Hygienic barriers by a combination of carbon filtering and UV-light (in a configuration where the UV-light also protects the outlet side of the carbon filter) close to water tap/usage point has proved to be a good solution for in operation in Norway. This solution does not apply to water used to flush the toilet bowl.</li> <li>-Regular cleaning by a mix of water and H2O2 at a temperature &gt; 70° C circulated through the entire system. With circulation and temperature regulation managed by an external system connected at couplings accessible from the outside of the Trainset provides effective cleaning.</li> </ul> <p>Water in Norway has a low content of lime, but limestone still cause system degrading and malfunctions, and Norske Tog has the following expectation related to cleaning of the toilet and sewage system.</p> <ul style="list-style-type: none"> <li>-Connections for external equipment for flow-through acid cleaning of the entire toilet system including sewage-piping and -tank with connections accessible from outside the Trainset.</li> </ul> <p>Norske Tog has the following expectation with regards to leakage</p> <ul style="list-style-type: none"> <li>-provisions to limit the spread of a leak into other parts of the train is part of the design</li> </ul> <p>When reference is given to toilet(s) it is also to be understood that related piping and tanks are included.</p> |              |

# Exhibit A02: SOW Technical

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:2.3.3.b | <p><b>K</b> The toilet and water systems of the train shall</p> <ul style="list-style-type: none"> <li>-be fully operational, including servicing and parking/stabling in worst winter conditions</li> <li>-be possible to park/stable without power supply without any permanent damage in worst winter conditions as specified in A2.1.1.2.a</li> </ul>   | A2.1.1.2.a   |
| A2:2.3.3.c | <p><b>E</b> The water system of the Train shall be proven in use and verified in real operation in similar climatic conditions as in Norway, including worst winter conditions, with regards to:</p> <ul style="list-style-type: none"> <li>-operation in worst climate condition, including filling/emptying tanks, by means of for example heated outlets/inlets for fresh and waste water</li> <li>-no damage of piping and tanks used for fresh water, waste water and any other type of water when parking/stabling with and without access to power supply, by means of for example, automatic drainage, "tube in tube" solutions heated drainage points and sewage tanks that can resist freezing</li> </ul> <p><i>The Supplier shall describe how the water system is designed and proven in use and verified in real operation in similar climatic conditions as in Norway with regards to</i></p> <ul style="list-style-type: none"> <li>-full functionality without freezing in operation in worst climate condition.</li> <li>-how damage due to parking/stabling (with or without power supply) in worst climate condition is avoided, the descriptions shall include but not be limited to:               <ul style="list-style-type: none"> <li>a) how freeze of tubes, pipes and tanks are avoided</li> <li>b) how drainage of pipes and tanks is ensured</li> <li>c) how the waste water tank and other tanks/tubes/pipes that may freeze are designed in order to withstand freezing</li> </ul> </li> </ul> |              |
| A2:2.3.3.d | <p><b>E</b> It shall be a short start up time for the water system, including any frozen pipes and tanks, when power supply is restored after the Train has been stabled for some time without access to power/heating of the water system.</p> <p><i>The Supplier shall describe how a short startup time for piping and tanks are ensured and state the start up time from (typical case).</i></p>  |              |

# Exhibit A02: SOW Technical

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:2.3.3.e | <p><b>E</b> Damage to the Train in due to leakage or overflow of water piping and/or water tanks shall be minimized, including</p> <ul style="list-style-type: none"> <li>-leakage shall be led out of the Train</li> <li>-leakage shall be indicated/visible</li> <li>-leakage or overflow shall not reach other parts of the train or penetrate into the inaccessible parts of the floor and walls.</li> <li>-provisions for collecting any spill of bio-hazard materials when disconnecting modules and other maintenance work</li> </ul> <p><i>The supplier shall describe how leakage and overflow is managed and how any damage is avoided or minimized.</i></p> |              |
| A2:2.3.3.f | <p><b>E</b> Water filling level for water tanks shall be monitored and available in the IDU. In minimum following different levels shall be registered:</p> <p>Fresh water tank: decreasing filling levels detection (in minimum 3 different levels, more preferred), i.e. at 100% (full), 50% 25%</p> <p>Waste water tank: increasing filling level detection (in minimum 3 different levels), i.e. at 50%, 75% and 100% (full)</p>   |              |
| A2:2.3.3.g | <p><b>E</b> The freshwater system shall be designed to allow for effective and efficient cleaning.</p> <p><i>The supplier shall describe how the freshwater system is cleaned, including considerations taken to ensure effective and efficicne removal of lime stone.</i></p>   |              |
| A2:2.3.3.h | <p><b>E</b> All point for tapping of water (excluding toilet flushing) shall provide water without any hazardous microorganisms.</p> <p><i>The supplier shall describe how it is ensured that all points for tapping of water (excluding toilet flushing) provides water without and hazardous microorganisms.</i></p>   |              |
| A2:2.3.3.i | <p><b>K</b> It shall be possible to adjust the time for self closing of the automatic water tap.</p>   |              |
| A2:2.3.3.j | <p><b>K</b> Wastewater from hand wash basins shall be collected.</p>   |              |
| A2:2.3.3.k | <p><b>E</b> Toilet systems shall be fitted with diagnostics. Full diagnostic information shall be transferred to the Trainset diagnostic system.</p> <p><i>The Supplier shall describewhich information that is provided by the diagnostic system, such as e.g vaccum/pressure etc.</i></p>  |              |

# Exhibit A02: SOW Technical

| Id         | Requirement   | Referring to  |
|------------|---|---|
| A2:2.3.3.l | <p><b>E</b> The toilet system should consist of components with low risk of deteriorated function due to limestone or other deposits.</p> <p><i>The Supplier shall describe how deterioration due to lime stone is minimized or avoided.</i></p>  |   |
| A2:2.3.3.m | <p><b>E</b> The tank system and toilet shall be designed for efficient maintenance e.g. consist of separate and exchangeable modules.</p> <p><i>The Supplier shall describe the maintainability of the toilet and tank systems.</i></p>   |   |
| A2:2.3.3.n | <p><b>E</b> The toilet-bowl should have a durable surface/surface treatment which is as easy as possible to flush clean with a small amount of water. This may be by a permanent coating or chemical treatment (Nano technology).</p> <p><i>The Supplier shall describe the material and coating of the toilet bowl and how high durability and easy cleaning is ensured.</i></p> |   |
| A2:2.3.3.o | <b>K</b> Toilets shall be fitted with safety glass mirrors.   |   |
| A2:2.3.3.p | <b>K</b> Toilets shall be fitted with plugged floor drain.  |   |
| A2:2.3.3.q | <b>I</b> Additional requirements  | A1:3.5 Operator experience<br>A1:3.6 Passenger experience |

## 2.3.4 Catering/Galley

| Id         | Requirement  | Referring to                |
|------------|--|-----------------------------|
| A2:2.3.4.a | <b>I</b> Requirements can be found in referred Exhibit.  | A1:3.6 Passenger experience |
| A2:2.3.4.b | <p><b>E</b> The Tenderer shall give a general system description.</p> <p><i>The Tenderer shall describe their solution in detail and as a minimum include the following:<br/>system design, main components and function and vehicle integration</i></p> |                             |
| A2:2.3.4.c | <b>I</b> Additional requirements   | A1:3.6 Passenger experience |

# Exhibit A02: SOW Technical

## 2.3.5 HVAC

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:2.3.5.a | <p><b>I</b> The operation around Oslo with many tunnels and throughout Norway in general gives very challenging operational conditions for the HVAC system. Operation, parking and stabling in severe winter conditions are also common in Norway.</p> <p>The following design principles has proven to work when operating in Norway and are therefore preferred by Norske Tog.</p> <ul style="list-style-type: none"> <li>-Emergency heating that ensures that even if the HVAC system main controller, supply air fan, heating battery or its converter is faulty</li> <li>-Manual activation of emergency heating</li> <li>-Frost in the duct after the evaporator is avoided</li> <li>-Hot-gas bypass is avoided as energy saving method during capacity regulation of AC unit</li> <li>-Environmental friendly natural type refrigerant media</li> <li>-Optimized COP (Coefficient of Performance) of the AC (Air Conditioning) plant during all operating conditions</li> <li>-Operation is optimised based on available data generated by other systems in the Trainset</li> </ul> <p>Furthermore Norske Tog requires to regard following design criteria:</p> <ul style="list-style-type: none"> <li>-It is possible in a railroad workshop to remove the HVAC unit from the Trainset and replace it with a spare unit without taking the Trainset out of service an extensive time</li> <li>-It is possible and easy to perform maintenance and testing of the HVAC unit when it is removed from the train</li> <li>-All hatches in connection with the HVAC system is designed for a high number of openings and closings. It is possible to get access to all components in the HVAC system through the hatches. Tool less hatch lock solutions is used</li> <li>-The HVAC unit is generally and especially if roof mounted designed for easy access for air filter change. It is be possible to do a filter change without removing the HVAC unit's main hatch or unscrewing covers</li> <li>-The maintenance SW for the HVAC system is easy to use and enable the maintenance personnel to perform system testing and component testing and to read all main parameters of the system (including system pressures and component status).</li> </ul> |              |
| A2:2.3.5.b | <p><b>E</b> Norske Tog shall be involved in defining the HVAC system control to bring in Norske Tog's experience into HVAC regulation under these special conditions.</p> <p><i>The Tenderer shall describe how the involvement of Norske tog will be secured.</i></p>  |              |

## 2.3.5.1 HVAC technical requirements

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:2.3.5.1.a | <p><b>E</b> The HVAC system shall have a robust design based on proven and standardized solutions fit for purpose during all climate conditions and all operating modes including tunnel passage.</p> <p><i>The Tenderer shall describe their solution in detail and as a minimum include the following:</i></p> <ul style="list-style-type: none"> <li>-system design, main components and function and vehicle integration</li> <li>-supply air, return air and exhaust air concepts</li> <li>-pre-heating and pre-cooling times</li> <li>-fresh air control</li> <li>-minimum passenger compartment temperature during emergency heating</li> <li>-minimum temperature that will be maintained by the trainset during Stabling mode</li> <li>-temperature range that that the Trainset temperature will be within during Standby mode</li> <li>-type of manual emergency heating activation</li> <li>-the relation between HVAC units if a single coach have more than one unit</li> <li>-how the system operation and comfort is secured in tunnels</li> <li>-how to adjust the interior temperature setpoint individually for a single coach</li> <li>-the temperature range in which the AC unit runs without capacity limitation</li> <li>-minimum supply air duct temperature after the evaporator in cooling mode</li> <li>-the selected refrigerant media</li> <li>-how the HVAC system is operated when the Trainset is stabled externally connected to 1000V or 400V power or when the Trainset is stabled connected to overhead catenary via the pantograph</li> <li>-the pressure protection solutions for good passenger comfort</li> <li>-the overpressure range within cars/Trainset</li> </ul> |              |

# Exhibit A02: SOW Technical

| Id                          | Requirement  | Referring to                   |
|-----------------------------|--|--------------------------------|
| A2:2.3.5.1.b                | <p><b>E</b> The HVAC system shall be energy efficient during all climate conditions and all operating modes including tunnel passage, by means of for example:</p> <ul style="list-style-type: none"> <li>-air handling that includes heat recovery.</li> <li>-air handling that includes active regulation of fresh air amount based on real passenger load. (Signal for real passenger load could be, e.g. T-pressure from the braking system or CO2 and moist measurement.)</li> <li>-heating by means of heat pump</li> </ul> <p><i>The Tenderer shall describe how an energy efficient HVAC system is realized and further to which extent the energy efficient function/components are proven in use.</i></p> <p><i>The description shall also as a minimum include the following:</i></p> <ul style="list-style-type: none"> <li>-the energy saving method during AC capacity regulation</li> <li>-how the lowest total energy consumption possible is achieved during all possible operating conditions</li> <li>-how input data from other systems is used to optimise HVAC operation and present calculation of expected energy savings</li> </ul> |                                |
| A2:2.3.5.1.c                | <p><b>E</b> The HVAC system shall have a robust design based on proven and standardized solutions regarding easy service and maintenance.</p> <p><i>The Tenderer shall describe their solution and as a minimum include the following:</i></p> <ul style="list-style-type: none"> <li>-how the design is adapted for easy maintenance on a removed HVAC unit</li> <li>-how the hatches are designed and how access to all parts are secured from these hatches and what kind of tool less hatch lock that will be used</li> <li>-how the air filter exchange is done in an easy manner</li> <li>-how the HVAC maintenance software is easily used for system and component testing</li> </ul>  |                                |
| A2:2.3.5.1.d                | <p><b>I</b> Additional requirements</p>  | A1:3.6 Passenger experience    |
| <b>2.3.5.2 Driver's cab</b> |  |                                |
| Id                          | Requirement  | Referring to                   |
| A2:2.3.5.2.a                | <p><b>K</b> The Trainset shall be fitted with HVAC systems for the driving cabs that comply with NS EN 14813-1 category A Zone III and general requirements given in this and other chapters. The HVAC system shall be tested according to NS EN 14813-2 TL-2.</p>   | NS EN 14813-1<br>NS EN 14813-2 |

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| Id                        | Requirement  | Referring to               |
|---------------------------|--|----------------------------|
| A2:2.3.5.2.b              | <b>K</b> Driver cab's HVAC unit shall be independent from the HVAC system for passenger compartments.  |                            |
| <b>2.3.6 Driver's cab</b> |  |                            |
| Id                        | Requirement  | Referring to               |
| A2:2.3.6.a                | <b>E</b> All relevant requirements and recommendations specified in UIC 651 shall be met.<br><i>The Tenderer shall describe the layout of the Driver's Cab</i>   | UIC 651                    |
| A2:2.3.6.b                | <b>K</b> A mock-up of the driver's desk shall be presented latest at the Preliminary Design Review (PDR).  |                            |
| A2:2.3.6.c                | <b>E</b> Driver's desk shall be according to Appendix A2-3 "Description of Traction and Brakes Control Devices and Functionality of Driving Modes".<br><i>The Tenderer shall describe the layout of the Driver's desk</i>  | Appendix A2-3              |
| A2:2.3.6.d                | <b>K</b> The driver's desk shall be equipped with a master controller of vertical design to control both traction force and speed. The master controller shall provide redundant signals for positions necessary to operate the Trainset. The different positions of the master controller shall be notched and it shall be placed on the left side on the driver's desk. For more information see document: "Traction & Brakes", Chapter: "Master controller (traction and speed controller)" | Appendix A2-3              |
| A2:2.3.6.e                | <b>K</b> A maximum power limiting selector shall be provided to limit the maximum power between 50% and 100%. The power limiting selector shall be placed adjacent to the master traction controller on the left on the driver's desk. See document: "Traction & Brakes" Chapter: "Maximum power limiting selector"  | Appendix A2-3              |
| A2:2.3.6.f                | <b>K</b> An analogue gauge displaying the catenary voltage in kV shall be installed on the driver's desk. See document: "Traction & Brakes", Chapter: "Catenary Voltage Gauge"   | Appendix A2-3              |
| A2:2.3.6.g                | <b>K</b> An analogue gauge displaying the tractive effort in kN shall be installed on the driver's desk. See document: "Traction & Brakes", Chapter: "Tractive effort gauge"   | Appendix A2-3              |
| A2:2.3.6.h                | <b>I</b> Additional requirements   | A1:3.5 Operator experience |

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## 2.4 Lighting

### 2.4.1 Interior lighting

| Id         | Requirement   | Referring to                |
|------------|---|-----------------------------|
| A2:2.4.1.a | <b>I</b> Requirements can be found in referred Exhibit. | A1:3.6 Passenger experience |

### 2.4.2 Exterior lighting

#### 2.4.2.1 Departure signal - intermittent

| Id   | Requirement   | Referring to  |
|--|---|---------------|
| A2:2.4.2.1.a   | <b>K</b> One intermittent amber departure light shall be mounted on each side of the Trainset end cars (distinct amber light).  |               |
| A2:2.4.2.1.b   | <b>K</b> Lights shall be fitted to the sides of the Trainset, clearly within the view of the driver and train crew. At least one indicator light shall remain clearly visible in the dark as well as in bright sunlight from the driver's cab and from a distance of 200 metres from the light, five metres outwards, even if the platform is crowded.  |               |
| A2:2.4.2.1.c   | <b>K</b> Intermittent on-off cycle shall be 40% on, 60% off, approx. 60 per minute.   |               |
| A2:2.4.2.1.d   | <b>K</b> Lights shall never dazzle the driver.  |               |
| A2:2.4.2.1.e   | <b>K</b> Driver shall be able to activate departure indicator via a push button on the driver's desk when the train is ready to leave. Indicator lights on either side of the end coach from which the signal is given shall be activated; it is preferred that the indicator lights on the Trainset opposite end coach is activated as well. In multiple operations all coupled trainsets shall activate the departure signal indicator. | Appendix A2-3 |
| A2:2.4.2.1.f   | <b>K</b> The departure indicator activation push button shall be placed to the right on the driver's desk adjacent to the door push buttons.  | Appendix A2-3 |
| A2:2.4.2.1.g   | <b>K</b> It shall be possible to de-activate Indicator lights in two ways: <ul style="list-style-type: none"> <li>• Automatically at train start-up.</li> <li>• Manually from driver's desk</li> </ul>  |               |
| A2:2.4.2.1.h   | <b>E</b> Faulty lights should be easily detected by the driver.   |               |
| <p><i>The Tenderer shall demonstrate compliance with the requirement by explaining how the faulty lights will be detected by the driver.</i></p> |   |               |

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| Id   | Requirement   | Referring to    |
|--|---|-----------------|
| A2:2.4.2.1.i                               | <p><b>E</b> The system shall remain functional under all weather conditions (snow accumulation) and shall never be affected by electromagnetic interference or similar.</p> <p><i>The Tenderer shall describe their solutions for both above-mentioned problems.</i></p>  |                 |
| <b>2.4.2.2 Head, marker and tail lamps</b> |   |                 |
| Id   | Requirement   | Referring to    |
| A2:2.4.2.2.a                               | <p><b>K</b> The external lights: Head, marker and tail lamps shall fulfill EN 15153-1</p>   | EN 15153-1      |
| A2:2.4.2.2.b                               | <p><b>E</b> 1-2, preferably two, additional upper head lamp shall be installed.</p> <p><i>The Tenderer shall describe their solution.</i></p>   |                 |
| A2:2.4.2.2.c                               | <p><b>K</b> Head lights shall have settings for high and low (dipped) beam in which the head light glare shall be controlled according to "Option (2)" presented in EN 15153-1:2020, clause 5.3.4.</p>  | EN 15153-1:2020 |
| A2:2.4.2.2.d                               | <p><b>K</b> There shall be a light mode selector and a push button to switch between high/low beam. The light mode selector switch shall be placed to the right on the vertical panel of the driver's desk and the push button for high/low beam shall be placed to the right on the driver's desk grouped with other push buttons.</p> | Appendix A2-3   |
| A2:2.4.2.2.e                               | <p><b>E</b> Headlights, marker lights and taillights shall be based on high-performance long life low energy light sources, e.g. LED.</p> <p><i>The Tenderer shall describe their proposed lamps for headlights, marker lights and taillights including their solutions to snow and ice accumulation.</i></p>                           |                 |
| A2:2.4.2.2.f                               | <p><b>K</b> During daylight hours, it shall be possible to rely on the marker lights.</p>   |                 |
| A2:2.4.2.2.g                               | <p><b>K</b> The luminous intensity of the head light shall comply with the requirements stated in EN 15153-1 and it shall be within the upper 25% of the limits given in the norm.</p>  | EN 15153-1:2020 |
| A2:2.4.2.2.h                               | <p><b>E</b> It should be possible to replace the lamps for external lighting easily and without new adjustment of the light angle.</p> <p><i>The Tenderer shall demonstrate compliance with the requirement by explaining how the external lamps can be easily replaced without new adjustment of the angle.</i></p>                    |                 |

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| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:2.4.2.2.i | <p><b>E</b> Faulty lights should be easily detected by the driver.</p> <p><i>The Tenderer shall demonstrate compliance with the requirement by explaining how the faulty lights will be detected by the driver.</i></p>  |              |
| A2:2.4.2.2.j | <p><b>E</b> The system shall remain functional under all weather conditions (snow accumulation) and shall never be affected by electromagnetic interference or similar.</p> <p><i>The Tenderer shall describe their solutions for both above-mentioned problems.</i></p> |              |

**3 Guidance**  
**3.1 Running gear**  
**3.1.1 General**

| Id         | Requirement   | Referring to  |
|------------|---|---|
| A2:3.1.1.a | <b>K</b> Elastomer based mechanical parts (e.g. limit stops, damper end-mountings, suspension components, etc) in bogies shall comply with EN13193.   | EN 13913  |
| A2:3.1.1.b | <b>K</b> Welding shall be according to EN 15085.<br><i>The Tenderer shall describe the proposed solution.</i>   | EN 15085  |
| A2:3.1.1.c | <b>K</b> Trailer bogie design including mounted components shall be according to UIC 515-0 and UIC 515-1 and ensure operation on the complete Norwegian Network according to "Teknisk Regelverk - Bane Nor". Ref "Rolling stock_Supplementary information and regulations"; chapter 3.<br>This means the following deviation from chapter 1.7 in UIC 515-0:<br>- All possible train configurations shall handle:<br>- Rmin = 130m<br>- S-curve with R=150m and 6m straight track<br>- S-curve with R=180m<br><i>The Tenderer shall describe proposed trailer bogie solution in order to verify possible operation on the Norwegian Network. Special focus shall be put on demonstrating ok wheel/rail contact conditions.</i> | TSI 4.2.3.5.1<br>EN 13749 , 6.2 , Annex C<br>EN 12663<br>UIC 515-0<br>UIC 515-1<br>Teknisk Regelverk - Bane Nor |
| A2:3.1.1.d | <b>K</b> Motor bogie design including mounted components shall be according to UIC 615-0 and UIC 615-1 and ensure operation on the complete Norwegian Network according to "Teknisk Regelverk - Bane Nor". Ref "Rolling stock_Supplementary information and regulations"; chapter 3.<br>This means the following deviation from chapter 2 in UIC 615-0:<br>- All locomotives and possible train configurations shall handle:<br>- Rmin = 130m<br>- S-curve with R=150m and 6m straight track<br>- S-curve with R=180m   | TSI 4.2.3.5.1<br>EN 13749 , 6.2 , Annex C<br>EN 12663<br>UIC 615-0<br>UIC 615-1<br>Teknisk Regelverk - Bane Nor |
| A2:3.1.1.e | <b>E</b> It should be possible to monitor the gearbox oil quality by means of a CBM-system. (Condition Based Monitoring)  |   |

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| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:3.1.1.f | <p><b>E</b> It should be possible to monitor the status of all rotating bogie components (e.g. bearings and gearbox teeth) by means of a CBM-system. (Condition Based Monitoring)</p> <p><i>The Tenderer shall describe the proposed solution.</i></p>   |              |
| A2:3.1.1.g | <p><b>K</b> It shall be possible to turn / reprofile wheels both on dismantled wheelsets and bogie-mounted wheelsets by use of existing workshop lathe facilities in Norway.<br/>This means that the axle box design must allow a tool to hold the wheelset during lathe reprofiling.</p> <p><i>The Tenderer shall describe the proposed solution.</i></p> |              |
| A2:3.1.1.h | <p><b>K</b> It shall be possible to lift complete locomotives/coaches/units without having to dismount the bogies first.</p>   |              |

## 3.1.2 Primary and secondary suspension

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:3.1.2.a | <p><b>M</b> The primary suspension design shall tolerate all Norwegian weather conditions and allow all planned operations for possible train configurations, empty and max loaded, at max speed with fulfilment of all relevant running dynamic requirements (track forces, safety against derailment, stability, passenger comfort, etc.).</p>   |              |
| A2:3.1.2.b | <p><b>E</b> The primary suspension system will be evaluated regarding:</p> <ul style="list-style-type: none"> <li>- Ability to tolerate Norwegian winter conditions: <ul style="list-style-type: none"> <li>- Snow and ice packing should not be a problem</li> <li>- Proposed springs, dampers and rubber elements should not experience functionality degradation due to expected temperature range and/or presence of snow and ice</li> </ul> </li> <li>- Expected lifetime: <ul style="list-style-type: none"> <li>- Proposed springs, dampers and rubber elements should experience minimum property- and functionality-degradation over time.</li> </ul> </li> </ul> <p><i>The Tenderer shall describe proposed solution so it is possible to evaluate listed requirement issues</i></p> |              |
| A2:3.1.2.c | <p><b>E</b> Proposed solution for the emergency spring will be evaluated. It should be serial, which means that the emergency spring is located below the air spring.</p> <p><i>The Tenderer shall describe proposed solution.</i></p>   |              |

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| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:3.1.2.d | <b>M</b> The secondary suspension design shall tolerate all Norwegian weather conditions and allow all planned operations for possible train configurations, empty and max loaded, at max speed with fulfilment of all relevant running dynamic requirements (track forces, safety against derailment, stability, passenger comfort, etc.).  |              |
| A2:3.1.2.e | <b>E</b> The secondary suspension system will be evaluated regarding: <ul style="list-style-type: none"> <li>- Ability to tolerate Norwegian winter conditions: <ul style="list-style-type: none"> <li>- Snow and ice packing should not be a problem</li> <li>- Proposed springs, dampers and rubber elements should not experience functionality degradation due to expected temperature range and/or presence of snow and ice</li> </ul> </li> <li>- Expected lifetime: <ul style="list-style-type: none"> <li>- Proposed springs, dampers and rubber elements should experience minimum property- and functionality- degradation over time.</li> </ul> </li> <li>- Simple and practical handling of possible operational faults like for example one broken (deflated) air bellow</li> </ul> <p><i>The Tenderer shall describe proposed solution so it is possible to evaluate listed requirement issues</i></p> |              |
| A2:3.1.2.f | <b>K</b> The emergency spring design shall ensure no safety related reduction in train speed with deflated air spring (due to running dynamic- or comfort issues).   |              |
| A2:3.1.2.g | <b>K</b> Proposed helical steel suspension springs shall be designed according to EN 13298.  | EN 13298     |

## 3.1.3 Bogie frame

| Id         | Requirement  | Referring to              |
|------------|--|---------------------------|
| A2:3.1.3.a | <b>M</b> Bogie frame steel shall be according to EN 10027-1 and EN 10025.  | NS-EN 10027-1<br>EN 10025 |
| A2:3.1.3.b | <b>M</b> Bogie frames shall be designed and verified according to EN 13749 | NS-EN 13749               |

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| Id                      | Requirement  | Referring to             |
|-------------------------|--|--------------------------|
| A2:3.1.3.c              | <p><b>K</b> The bogie frame design shall allow:</p> <ul style="list-style-type: none"> <li>- crane lifting</li> <li>- use of jack equipment during rescue operations after derailments (standard solution is two jack locations per bogie side)</li> </ul> <p><i>The Tenderer shall describe proposed solution and procedure for lifting and use of jack equipment in case of derailments.</i></p>   |                          |
| <b>3.1.4 Wheel sets</b> |  |                          |
| Id                      | Requirement  | Referring to             |
| A2:3.1.4.a              | <p><b>M</b> Wheel sets shall follow these norms:</p> <ul style="list-style-type: none"> <li>EN 12080 Railway applications – Axle boxes – rolling bearings</li> <li>EN 12082 Railway applications – Axle boxes – Performance testing</li> <li>EN 13103-1 Railway applications – Wheel sets and bogies – Non-powered axles – Design method</li> <li>EN 13260 Railway applications – Wheel sets – Product requirements</li> <li>EN 13261 Railway applications – Wheel sets and bogies – Axles – Product requirements</li> <li>EN 13262 Railway applications – Wheel sets and bogies – Wheels – Product requirements</li> <li>UIC 510–5 Technical approval of solid wheels.</li> </ul> |                          |
| A2:3.1.4.b              | <p><b>M</b> Axles and wheels shall be designed according to maximum axle load / wheel load and maximum dynamic lateral force.</p> <ul style="list-style-type: none"> <li>- For axle loads &lt;20t minimum 100kN lateral force shall be tolerated.</li> <li>- For axle loads &gt;20t minimum 110kN lateral force shall be tolerated.</li> </ul>   | BaneNOR Krav and NT-krav |
| A2:3.1.4.c              | <p><b>E</b> Required preventive ultrasonic testing of proposed wheelset / axle design will be evaluated regarding possible interval length and how this correspond with expected lifetime of other wheelset components. Preferred interval length should be 500 000 km or higher.</p> <p><i>The Tenderer shall describe required testing method, provide references verifying specified interval for ultrasonic testing and elaborate on how this correspond with the lifetime of other wheelset components.</i></p>   |                          |
| A2:3.1.4.d              | <p><b>K</b> Wheels shall be shrink fit on the axles according to EN13260, chapter 3.1 Assembly of components.</p>  | EN 13260                 |

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## 3.1.5 Axles

| Id         | Requirement   | Referring to           |
|------------|---|------------------------|
| A2:3.1.5.a | <b>M</b> Axles shall be designed in accordance with the guidelines provided in EN 13103-1   | EN 13103-1             |
| A2:3.1.5.b | <b>M</b> Axle tensions shall be measured in Norway (for empty and loaded train) and comply with relevant limit-values specified in EN13103-1. | EN 13261<br>EN 13103-1 |
| A2:3.1.5.c | <b>M</b> Axle material shall be made of steel grade EA1 or EA4T   |                        |
| A2:3.1.5.d | <b>K</b> Axle numbering and identification shall be according to Norske tog standard.   | Appendix A2-5          |
| A2:3.1.5.e | <b>K</b> There shall be an axle protection against flying ballast and ice.<br><i>The Tenderer shall describe proposed solutions.</i>          |                        |

## 3.1.6 Wheels

| Id         | Requirement   | Referring to                |
|------------|---|-----------------------------|
| A2:3.1.6.a | <b>M</b> Wheels shall be designed according to maximum axle load / wheel load / dynamic lateral force and all possible train operations on the Norwegian Network.   |                             |
| A2:3.1.6.b | <b>K</b> Wheels shall comply with requirements in "Teknisk Regelverk - Bane Nor" regarding minimum wheel diameter in relation to maximum axle load. Ref "Rolling stock_Supplementary information and regulations"; section 3.3.3.2 and appendix 3.e.  | Teknisk regelverk - BaneNor |
| A2:3.1.6.c | <b>M</b> Wheels shall be design according to the standard high-conicity P8a wheel profile.  | Appendix A2-4               |
| A2:3.1.6.d | <b>K</b> Minimum hardness for proposed steel wheel grade shall be according to EN13262.   | EN 13262                    |
| A2:3.1.6.e | <b>E</b> Proposed wheel solution will be evaluated regarding expected wear/life time and diameter size and . Preferred diameter for unworn wheels is 920mm.<br><i>The Tenderer shall specify wheel max and min diameter for proposed wheels and provide LCC data regarding wheel wear for three relevant reference projects with use of similar wheels (same steel quality and flange profile).</i> |                             |

## 3.2 Running gear connection

| Id       | Requirement   | Referring to |
|----------|---|--------------|
| A2:3.2.a | <b>E</b> The Tenderer shall describe the interface between the bogie and the carbody, |              |

## 3.3 Running gear auxiliary components

### 3.3.1 Flange lubrication

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:3.3.1.a | <p><b>K</b> Flange lubrication grease shall be suitable for Norwegian conditions and preferably be Tramlub R234 Mod2 which is the present standard for NT rolling stock.</p> <p><i>Flange lubrication grease of different type than Tramlub R234 Mod2 shall be verified suitable for Norwegian condition.</i></p>  |              |
| A2:3.3.1.b | <p><b>M</b> Leading bogies in Trainset shall be equipped with a flange lubrication system.</p>   |              |
| A2:3.3.1.c | <p><b>E</b> Proposed flange lubrication system will be evaluated regarding:</p> <ul style="list-style-type: none"> <li>- Ability to provide optimized flange lubrication in sense of satisfactory amount of lubrication grease equally distributed to all wheels despite of different tube lengths, etc.</li> <li>- The system shall be easy to control, adjust and maintain.</li> </ul> <p>Today it is an experienced problem with too much grease on one wheel side and no grease at all on the other wheel side.</p> <p><i>The Tenderer shall describe the proposed solution and clarify how optimized lubrication for each wheel is ensured.</i></p> |              |
| A2:3.3.1.d | <p><b>K</b> Lubrication grease tanks and all necessary controls shall be located in the carbody or in enclosed boxes in the carbody underframe.</p> <p><i>The Tenderer shall describe proposed solutions.</i></p>  |              |
| A2:3.3.1.e | <p><b>E</b> Proposed solution for flange lubrication grease tanks and necessary control equipment in the underframe will be evaluated regarding:</p> <ul style="list-style-type: none"> <li>- size (no filling shall be necessary between minimum inspection interval)</li> <li>- location (safe place, but easy to access during refilling and inspection)</li> <li>- protection against stones, snow and ice</li> <li>- easy and quick lubrication filling</li> <li>- indicating of filling level (at least full tank indicator)</li> <li>- wheel nozzles should be easy to height adjust to correct height after wheel turning</li> </ul>             |              |
| A2:3.3.1.f | <p><b>E</b> The grease tank level should be possible to monitor from the IDU.</p>  |              |

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| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:3.3.1.g | <p><b>K</b> A safeguard mechanism shall prevent grease from entering the compressed air system.</p> <p><i>The Tenderer shall describe the proposed solution.</i></p> |              |

## 3.3.2 Sanding

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:3.3.2.a | <p><b>M</b> All train configurations shall have a sanding system for both driving directions with sanding facilities on the leading axles with traction.</p>  |              |
| A2:3.3.2.b | <p><b>E</b> A system for IDU-monitoring of the sand level in the sand boxes, with a minimum level warning should be provided.</p> <p><i>The Tenderer shall describe proposed monitoring system.</i></p>   |              |
| A2:3.3.2.c | <p><b>K</b> Sanding rate shall be speed dependent.</p>  |              |
| A2:3.3.2.d | <p><b>K</b> Sand boxes shall be mounted in the carbody or in the carbody underframe.</p>  |              |
| A2:3.3.2.e | <p><b>E</b> The sandbox solution will be evaluated regarding:</p> <ul style="list-style-type: none"> <li>- Dimensioning (no filling should be necessary between the shortest inspection interval)</li> <li>- Design regarding easy and practical filling from outside the trainset with sufficient fall from the filling point.</li> <li>- Solution for manual inspection of the sandlevel</li> </ul> |              |
| A2:3.3.2.f | <p><b>K</b> Sanding shall be conducted with directionally adjustable steel nozzles connected to carbody sanding pipes by flexible hoses.</p>  |              |
| A2:3.3.2.g | <p><b>K</b> The complete sanding system shall tolerate Norwegian weather conditions, and special considerations shall be taken in order to avoid problems due to snow and ice and/or freezing:</p> <ul style="list-style-type: none"> <li>- Robust design</li> <li>- Protection against snow and ice</li> <li>- Heating and airing</li> <li>- Sealing (against water intrusion)</li> </ul>            |              |

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| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:3.3.2.h | <p><b>E</b> Proposed sanding system from carbody mounted sandboxes to the sanding nozzles will be evaluated regarding special considerations taken in order to avoid problems due to snow and ice and/or freezing:</p> <ul style="list-style-type: none"> <li>- Design</li> <li>- Mechanical protection</li> <li>- Protection against corrosion</li> <li>- Heating and airing</li> <li>- Sealing</li> </ul> <p><i>The Tenderer shall describe all special sanding system considerations taken in order to ensure satisfactory winter-performance without problems due to snow and ice and freezing.</i></p> |              |

## 3.3.3 Rail guard

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:3.3.3.a | <p><b>M</b> Leading bogies shall be fitted with rail guards with redundant fixation (e.g. with more than one bolt)</p>   |              |
| A2:3.3.3.b | <p><b>E</b> Proposed rail guard solution will be evaluated regarding:</p> <ul style="list-style-type: none"> <li>- fixation redundancy</li> <li>- mounting/dismounting</li> <li>- adjustment possibilities (should be easy and practical to height adjust correctly after wheel turning, preferably in fixed steps)</li> <li>- ability to handle hits of heavy objects without causing damage to underframe mounted components or the rail guard fixation</li> </ul> <p><i>The Tenderer shall describe proposed solution so it is possible to evaluate listed requirement issues</i></p> |              |

## 4 Energy supply and Propulsion

| Id     | Requirement  | Referring to                 |
|--------|--|------------------------------|
| A2:4.a | <p><b>I</b> Operation, parking and stabling in severe conditions are common in Norway. The following design principles has proven to work in Norway:</p> <ul style="list-style-type: none"> <li>- Protection of electrical equipment against dirt and dampness, either through positioning or through guard/seal in order to minimize the need for special cleaning of electrical equipment</li> </ul>   |                              |
| A2:4.b | <p><b>E</b> The electrical equipment and electrical systems of the Train shall have a robust design based on proven and standardized solutions fit for purpose during all climate conditions, all operating modes and maintenance activities.</p> <p><i>The Supplier shall describe how the electrical equipment and systems are designed to ensure full functionality, including worst climate condition, the descriptions shall include but not be limited to:</i></p> <ul style="list-style-type: none"> <li>- Standards used</li> <li>- Design with respect to fire safety</li> <li>- Design with respect to climate aspects</li> <li>- Design with respect to heavy condensation in tunnels</li> </ul> <p><i>The Supplier shall describe how damages or disturbances due to parking/stabling (with or without power supply) in worst climate condition is avoided, the descriptions shall include but not be limited to:</i></p> <ul style="list-style-type: none"> <li>- Avoidance of possible freeze damages</li> <li>- Avoidance of dirt and dampness</li> </ul> |                              |
| A2:4.c | <p><b>K</b> Low voltage electrics shall comply to NEK 400 "Electrical low voltage installations" or IEC 60364 "Low voltage electrical installations".</p>  | <p>NEK 400<br/>IEC 60364</p> |
| A2:4.d | <p><b>K</b> In order to have an overview of energy-efficient operation of the whole electric system of the Trainset, at least the following parameters shall be logged by the Trainset: energy consumed in propulsion and auxiliary systems (230V/400V and battery network) such as heating, ventilation and lighting and also energy recovered to the catenary.</p>   |                              |

4.1 Energy supply  
 4.1.1 Main energy  
 4.1.1.1 High voltage

| Id           | Requirement   | Referring to   |
|--------------|---|--|
| A2:4.1.1.1.a | <b>M</b> Trainset shall be built for 15kV 16 2/3 Hz system voltage as in accordance with Nasjonalt Jernbanenett "Kjøretøysforskriften", TSI and Bane NOR Network statement 2021 Fagområde kontaktledning kap 8 Appendix d "Requirements on rolling stock in Norway and Sweden regarding EMC with the electrical infrastructure and coordination with the power supply and other vehicles"   | Kjøretøysforskriften<br>TSI LOC&PASS<br>Bane NOR Network statement 2021<br>IEC 60850 |
| A2:4.1.1.1.b | <b>K</b> The Trainset shall be equipped with earth switch to facilitate connection of HV circuit to earth at the both sides of the main circuit breaker.  |  |
| A2:4.1.1.1.c | <b>K</b> In the case of loss of catenary voltage when parked, the main circuit breaker shall trip automatically and when the line becomes re-energized, it shall reclose automatically with random time delay complying section 11.3 of EN 50388. The time duration in which the auto-reclosure action can take place shall be agreed with NT during the Design Phase.<br><br><i>The Tenderer shall describe the proposed solution.</i> | EN 50388 section 11.3  |
| A2:4.1.1.1.d | <b>K</b> Due to severe winter conditions high voltage components on the roof and roof-mounted isolators shall be designed and arranged for 25kV system voltage with respect to air isolation distance and isolator creep distances.<br><br>Same applies for the Surge arrester, but it shall be functionally designed for 15kV.   |  |

# Exhibit A02: SOW Technical

| Id           | Requirement   | Referring to  |
|--------------|---|---|
| A2:4.1.1.1.e | <p><b>K</b> In general, pantographs shall comply with TSI LOC&amp;PAS clause 4.2.8.2.9 and EN 50367 "Railway applications - Current collection systems - Technical criteria for the interaction between pantograph and overhead line". The pantograph physical characteristics shall comply with the information presented in Tables B.1, B.3, B.5 and Figure B.5 given in EN 50367. Moreover, pantographs shall comply with clauses 8.2.2 and 8.2.3 of Kjøretøysforskriften and Bane NOR technical regulations:</p> <p>1) "Approval of new trains Pantographs and pantograph-overhead contact line interaction"<br/> <a href="https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations/Appendix/Approval_of_new_trains._Pantographs_and_pantograph-overhead_contact_line_interaction">https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations/Appendix/Approval_of_new_trains._Pantographs_and_pantograph-overhead_contact_line_interaction</a></p> <p>2) "Kontaktledning/Prosjektering og Bygging/Mekanisk utforming"<br/> <a href="https://trv.banenor.no/wiki/Kontaktledning/Prosjektering_og_Bygging/Mekanisk_utforming">https://trv.banenor.no/wiki/Kontaktledning/Prosjektering_og_Bygging/Mekanisk_utforming</a></p> | <p>TSI LOC&amp;PAS<br/>           EN 50367 Kjøretøysforskriften 8.2.2 and 8.2.3<br/>           Bane NOR technical regulations</p> |
| A2:4.1.1.1.f | <p><b>M</b> The length of pantograph head shall be 1800 mm.</p> <p>More information about the geometrical characteristics of the pantographs can also be found at Bane NOR.</p> <p><a href="https://trv.banenor.no/wiki/Kontaktledning/Prosjektering_og_Bygging/Mekanisk_utforming#Str.C3.B8mavtakere">https://trv.banenor.no/wiki/Kontaktledning/Prosjektering_og_Bygging/Mekanisk_utforming#Str.C3.B8mavtakere</a></p>  | <p>Bane NOR technical regulations</p>   |
| A2:4.1.1.1.g | <p><b>M</b> Pantographs shall be equipped with Automatic Dropping Device (ADD) complying with the features presented in EN 50367 and Bane NOR technical regulations (above).</p>  | <p>EN 50367<br/>           Bane NOR technical regulations</p>   |
| A2:4.1.1.1.h | <p><b>K</b> Distance between pantographs shall comply with Nasjonalt Jernbanenett "Kjøretøysforskriften", TSI and Bane NOR Network statement 2021 Fagområde kontaktledning kap 8 Appendix e Approval of new trains.</p>   | <p>Kjøretøysforskriften<br/>           TSI LOC&amp;PASS<br/>           Bane NOR Network statement 2021</p>                        |
| A2:4.1.1.1.i | <p><b>E</b> Active pantographs shall be minimized to reduce maintenance on the carbon strips and the overhead line.</p> <p><i>Specify number of active pantographs for the different train configurations</i></p>   | <p><i>It is expected that the Tenderer explains the possible pantograph configurations and their consequences.</i></p>            |

# Exhibit A02: SOW Technical

| Id           | Requirement  | Referring to                   |
|--------------|--|--------------------------------|
| A2:4.1.1.1.j | <p><b>E</b> Pantographs for redundance operation is required to avoid performance reductions due to faulty pantographs.</p> <p><i>Describe how the pantograph redundancy is solved for the different train configurations.</i></p>   |                                |
| A2:4.1.1.1.k | <p><b>E</b> The pantograph rising capability shall not be impaired in severe winter conditions and heavy snowfall.</p> <p><i>When the train has been parked with pantograph in folded position, ice and heavy snow on the pantographs may cause problems when rising the pantograph. The tenderer shall describe the proposed solution.</i></p>  |                                |
| A2:4.1.1.1.l | <p><b>K</b> The function to rise/lower the pantograph shall be integrated into the key switch. See document: "Traction &amp; Brakes", Chapter: "Pantograph Up and Down devices "</p>   | Appendix A2-3                  |
| A2:4.1.1.1.m | <p><b>K</b> An emergency mushrom button for power disconnection with rapid pantograph drop function shall be provided. The button shall be placed near the instrument for catenary voltage. See document: "Traction &amp; Brakes", Chapter: "Electrical emergency mushrom button with rapid pantograph drop function"</p>  | Appendix A2-3                  |
| A2:4.1.1.1.n | <p><b>K</b> Main transformer shall comply to IEC 60310 "Railway applications - Traction transformers and inductors on board rolling stock".</p>  | IEC 60310                      |
| A2:4.1.1.1.o | <p><b>K</b> The Trainset shall be designed in such a way to not facilitate climbing to the roof in order to protect the third party against electric shock.</p> <p>More information is provided in Bane NOR's document "Guideline on vehicle protection against electrical hazards to third party climbing"</p> <p><a href="https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations/Appendix/Guideline_on_vehicle_protection_against_electrical_hazards_to_third_party_climbing">https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations/Appendix/Guideline_on_vehicle_protection_against_electrical_hazards_to_third_party_climbing</a></p> | Bane NOR technical regulations |
| A2:4.1.1.1.p | <p><b>E</b> The Trainset should be equipped with a camera to show live view of the pantographs. The picture/film should be available on the driver's IDU screen.</p> <p><i>The Tenderer shall describe the proposed solution.</i></p>  |                                |

# Exhibit A02: SOW Technical

| Id           | Requirement   | Referring to  |
|--------------|---|---|
| A2:4.1.1.1.q | <p><b>K</b> The Trainset shall be able to run through phase separation sections (neutral sections) after receiving a signal from the driver, while the power transfer is kept to zero through the section and passenger comfort not compromised, complying with TSI LOC&amp;PAS clause 4.2.8.2.9.8, Kjøretøysforskriften clause 8.2.2.9 and Bane NOR technical regulations/Chapter 8/Appendix d/4.3.4 P4: Neutral sections. After passing the neutral section the train shall automatically retrieve power from the catenary.</p> <p><a href="https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations/Appendix/Requirements_on_rolling_stock_in_Norway_and_Sweden_regarding EMC_with_the_electrical_infrastructure_and_coordination_with_the_power_supply_and_other_vehiclesReview">https://trv.banenor.no/wiki/Rolling_stock/Supplementary_information_and_regulations/Appendix/Requirements_on_rolling_stock_in_Norway_and_Sweden_regarding EMC_with_the_electrical_infrastructure_and_coordination_with_the_power_supply_and_other_vehiclesReview</a>:</p> | <p>TSI LOC&amp;PAS 4.2.8.2.9.8<br/>Kjøretøysforskriften 8.2.2.9<br/>Bane NOR technical regulations/Chapter 8/Appendix d/4.3.4 P4:<br/>Neutral section</p> |
| A2:4.1.1.1.r | <p><b>E</b> It should be possible for the Trainset to monitor the infrastructure electric power quality and mechanical properties of the catenary by means of relevant tools and sensors. It is acceptable that the monitoring equipment is installed on at least 15% of the Trainsets.</p> <p><i>The Tenderer shall describe their proposed solution for monitoring the power quality and the mechanical properties of the catenary.</i></p> <p><i>Catenary monitoring can be:</i></p> <ul style="list-style-type: none"> <li>· <i>Geometry: stagger, height, inclination --&gt; height and inclination can be measured/calculated from the pantograph uplift</i></li> <li>· <i>Mechanical properties: stiffness/elasticity, hard points (number and intensity)</i></li> <li>· <i>Electrical properties: voltage, current, harmonics and % of arcing</i></li> <li>· <i>Contact properties: contact force, panhead accelerations</i></li> </ul>   |   |

# Exhibit A02: SOW Technical

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:4.1.1.1.s | <p><b>E</b> It shall be possible to measure mechanical properties of the track by means of relevant tools and sensors. It is acceptable that the monitoring equipment is installed on at least 15% of the Trainsets.</p> <p><i>The Tenderer shall describe their proposed solution for monitoring the mechanical properties of the track.</i></p> <p><i>Track monitoring of mechanical properties can be:</i></p> <ul style="list-style-type: none"> <li>· <i>Geometry: displacement, gauge, track position irregularities, track surface irregularities (possible with lidar technology)</i></li> <li>· <i>Mechanical properties: stiffness (especially important in transition zones)</i></li> </ul> |              |

## 4.1.1.2 Energy meter

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:4.1.1.2.a | <p><b>K</b> An energy measurement system with energy meter devices shall be installed and comply with EN 50463 and Bane NOR requirements.</p> <p><a href="https://trv.banenor.no/energiavregning/Krav_til_energim%C3%A5leutstyr">https://trv.banenor.no/energiavregning/Krav_til_energim%C3%A5leutstyr</a></p> <p><i>The Tenderer shall describe the proposed energy measurement system.</i></p> | EN 50463     |
| A2:4.1.1.2.b | <p><b>E</b> It should be possible to have a maintenance agreement with online condition monitoring of the energy measurement system to provide accurate functionality and continuous energy data transfer to Erex.</p> <p><i>The Tenderer shall describe their solution for the maintenance and condition monitoring of the energy measurement system.</i></p>                                   |              |

## 4.1.1.3 External connection

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:4.1.1.3.a | <p><b>M</b> The shortest train configuration that is parked/maintained shall have EN50546 connections for external power supply three-phase 400V 50 Hz 125A, that may be used in parking areas and workshops.</p> <p><i>According to Bane NOR, the Trainsets will be normally supplied by the catenary in the parking areas; however, it shall be possible to have 400 V external connections as a backup solution and for workshop use.</i></p> |              |
| A2:4.1.1.3.b | <p><b>K</b> There shall be plugs for external power supply 400V on both ends, left and right sides, of the shortest train configuration that is parked/maintained, i.e. in total 4 plugs.</p>  |              |
| A2:4.1.1.3.c | <p><b>M</b> The Trainset (or shortest train configuration that is parked/maintained) shall have UIC-552 connections for external power supply 1000V 16/2/3 Hz or 50 Hz, that may be used in parking areas and workshops.</p> <p><i>More details (e.g. connector types and power levels) and references are found in Kjoretöy föreskrift section 11.2.3, that in turn refer to TSI and Network statement:</i></p>                                 |              |
| A2:4.1.1.3.d | <p><b>K</b> There shall be plugs for external power supply 1000V on both ends, left and right sides, of the shortest train configuration that is parked/maintained, i.e. in total 4 plugs.</p>   |              |
| A2:4.1.1.3.e | <p><b>K</b> When connected to external power supply high voltage roof equipment shall not be energized.</p>  |              |

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| Id                            | Requirement   | Referring to                                      |
|-------------------------------|---|---|
| A2:4.1.1.3.f                  | <p><b>E</b> When the Trainset is supplied by external power supply, systems applicable for the actual operation mode shall be active or possible to activate. E.g. It shall be possible but not limited to</p> <ul style="list-style-type: none"> <li>• charge the batteries, including traction batteries (if present)</li> <li>• have internal lighting</li> <li>• have heating/cooling/ventilation</li> <li>• energize the 230V power outlets</li> <li>• provide compressed air if needed for cleaning or maintenance activities.</li> </ul> <p><i>The tenderer shall describe the solution for external power supply (both 1000 V and 400V) and the different scenarios and functionality when external power supply is used.</i></p> <p><i>The descriptions shall include but not be limited to:</i></p> <ul style="list-style-type: none"> <li>- Onboard connectors for external power supply (type and placement)</li> <li>- Onboard electrical system overview</li> <li>- Connected/activated onboard systems during external supply</li> <li>- Power/current consumption during external supply</li> <li>- Possible different modes of operation</li> <li>- etc</li> </ul> |   |
| A2:4.1.1.3.g                  | <p><b>E</b> It shall be possible to measure the energy consumption of the Trainset when the Trainset is supplied by the external power supply (400V or 1000V).</p> <p><i>The tenderer shall describe the solution for energy measurement</i></p>  |   |
| <b>4.1.2 Auxiliary energy</b> |   |   |
| Id                            | Requirement   | Referring to                                      |
| A2:4.1.2.a                    | <p><b>K</b> The Trainset auxiliary power network shall be based on a standard 400V 50 Hz 3-phase system complying with CLC/TS 50534 and EN 50533.</p>   | CLC/TS 50534<br>EN 50533                          |
| A2:4.1.2.b                    | <p><b>K</b> The auxiliary power converters shall comply with CLC/TS 50535.</p>  | CLC/TS 50535                                      |
| A2:4.1.2.c                    | <p><b>K</b> A single-phase 230V, 50 Hz (socket supply system) shall be included in the Trainset auxiliary power network to feed the power outlets specified in A1:3.6 Passenger experience.</p>   | CLC/TS 50534 4.5.3<br>A1:3.6 Passenger experience |

# Exhibit A02: SOW Technical

| Id         | Requirement  | Referring to                                      |
|------------|--|---|
| A2:4.1.2.d | <b>K</b> Auxiliary power network shall provide selective protection to ensure that isolation triggered by a fault is restricted to the faulty part of the system.                                      |   |
| A2:4.1.2.e | <b>M</b> 230V socket supply system shall be equipped with over voltage and earth fault protection systems.<br><br>230V socket supply system feeds the sockets specified in A1:3.6 Passenger experience | A1:3.6 Passenger experience                       |
| A2:4.1.2.f | <b>M</b> 230V socket supply system shall be galvanically isolated from the main power supply (HV) system.<br><br>230V socket supply system feeds the sockets specified in A1:3.6 Passenger experience  | CLC/TS 50534 4.5.3<br>A1:3.6 Passenger experience |

## 4.1.3 Energy storage

| Id         | Requirement  | Referring to         |
|------------|--|----------------------|
| A2:4.1.3.a | <b>K</b> Battery and battery box shall be positioned and designed in a manner which ensures that a potential battery explosion will cause no damage to passenger compartments or driver's cabs.  |                      |
| A2:4.1.3.b | <b>K</b> The battery network (LV DC distribution grid) shall have standard 110V system voltage complying with CLC/TS50534. Voltage characteristics and tolerances of the 110V LV DC system shall comply with EN 50155.   | EN50155, CLC/TS50534 |
| A2:4.1.3.c | <b>K</b> The auxiliary batteries shall comply with EN50547.<br><br><i>Today's battery solution for auxiliary power system in passenger trains in Norway is NiCd.</i>   | EN 50547             |
| A2:4.1.3.d | <b>E</b> The batteries shall have easy access for maintenance.   |                      |
| A2:4.1.3.e | <b>K</b> The auxiliary batteries shall be protected on both its poles. Supervision of the battery network supply shall be available to identify and generate warning of abnormal battery power consumption in the network.<br><br><i>The Tenderer shall describe how they provide selective protection for the battery network, both primary and secondary circuits, to ensure a proper fault isolation in the system.</i> |                      |
| A2:4.1.3.f | <b>K</b> Battery network power consumption shall be supervised and logged in the TDS system.<br><br><i>The purpose is to have information about spare capacity in case of installation of new or modified battery consumers.</i>   |                      |

# Exhibit A02: SOW Technical

| Id  | Requirement  | Referring to |
|---|--|--------------|
| A2:4.1.3.g  | <b>K</b> The LV DC distribution grid (battery network) shall be insulated from earth.  |              |
| A2:4.1.3.h  | <b>K</b> The battery circuit shall have an earth fault detection system with automatic warning to diagnostic system.                                   |              |
| A2:4.1.3.i  | <b>K</b> There shall be a central refilling system per battery, if the battery liquid needs to be refilled.  |              |
| A2:4.1.3.j  | <b>E</b> Monitoring of relevant parameters shall be done for efficient battery charging, keeping battery capacity and status control when discharging. |              |
| <p><i>Supplier shall present parameters to be measured and their function in charging or status control, or when maintenance is required. Such parameters can be but is not limited to:</i></p> <ul style="list-style-type: none"> <li>- Voltage</li> <li>- Current</li> <li>- Temperature (battery)</li> <li>- Liquid level</li> </ul> |  |              |
| A2:4.1.3.k  | <b>E</b> Battery boxes should accommodate a future battery capacity increase of approximately 30%.   |              |
| A2:4.1.3.l  | <b>K</b> The battery box and its surrounding area shall be protected against corrosion from leaking battery liquid if present.                         |              |

## 4.2 Propulsion

| Id   | Requirement   | Referring to |
|--|---|--------------|
| A2:4.2.a   | <b>K</b> All traction parts shall be described in the Tender document and they shall comply with IEC 60077 "Railway applications - Electric equipment for rolling stock". | IEC 60077    |
| <p><i>The tender documentation shall include the schematics and preliminary system description of the Trainset traction and auxiliary systems , including traction/braking curves. In addition, the technical characteristics (at least types, rated and maximum voltage and power, rated efficiency and temperature rating) of the main components in the traction chain i.e. pantograph, surge arrester, main circuit breaker, transformer, traction and auxiliary converters, traction motors, and their cooling systems shall be included in the tender documentation.</i></p> |   |              |

# Exhibit A02: SOW Technical

| Id       | Requirement  | Referring to     |
|----------|--|------------------|
| A2:4.2.b | <b>K</b> Traction motors shall comply with IEC 60349-2 "Electric traction - Rotating electrical machines for rail and road vehicles - Part 2: Electronic converter-fed alternating current motors".  | IEC 60349-2      |
| A2:4.2.c | <b>E</b> The Trainset shall be fitted with wheel slip protection and wheel slide protection systems that maximize the utilisation of available adhesion.<br><br><i>The Tenderer shall describe how the utilisation of available adhesion is maximized. The description shall include all different traction and brake modes.</i>   |                  |
| A2:4.2.d | <b>E</b> It should be possible to monitor the high voltage and traction system for fault diagnosis.  |                  |
| A2:4.2.e | <b>E</b> The Trainset shall have lithium-ion type traction batteries complying with NEK EN IEC 62928, dimensioned for reaching at least 2 km range with maximum speed of at least 30 km/h on a straight track with no gradient and without curves when there are no passengers onboard..<br><br>The application of such batteries is:<br><br>- low speed movement without passengers such as shunting and running through the washing equipment<br>- rescuing the train with passengers from dangerous situations in the case of power outage.<br><br><i>The Tenderer shall describe the traction battery solution, including but not limited to capacity and constraints.</i> | NEK EN IEC 62928 |

## 5 Braking and Air supply

### 5.1 Braking

#### 5.1.1 Winterization

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:5.1.1.a | <p><b>M</b> All pneumatic and brake components shall tolerate Norwegian weather conditions, and special considerations shall be taken regarding design, material properties, location of components, extra protection, special draining- and ventilation-solutions, use of heating, etc in order to avoid problems due to snow and ice and/or freezing.</p>   |              |
| A2:5.1.1.b | <p><b>E</b> Proposed pneumatic and brake solutions will be evaluated regarding special considerations taken regarding design, material properties, location of components, extra protection, special draining- and ventilation-solutions, use of heating, etc in order to avoid problems due to snow and ice and/or freezing.<br/>E.g wet snow shall not collect on exhaust outlets and brake cylinder rubber bellows shall be protected against flying rocks and ice lumps. Also rubber parts inside proposed components and grease for valves and mechanical assemblies shall be considered.</p> <p><i>The Tenderer shall describe special considerations taken in order to ensure satisfactory winter-performance without problems due to snow and ice and freezing.</i></p> |              |

#### 5.1.2 Brake functionality

##### 5.1.2.1 UIC Functions

| Id           | Requirement  | Referring to  |
|--------------|--|---|
| A2:5.1.2.1.a | <p><b>M</b> The air brake shall be a standard UIC-brake with through-going brake pipe:<br/>Ref EN14198 regarding trains hauled by a locomotive (chapter 5.1.4 UIC brake system)<br/>Ref EN15179 regarding brake system of coaches (chapter 5.3 and fig H.1 in appendix H)<br/>Ref EN16185 regarding EMU/DMU-units (chapter 5.1.1 with ref to UIC architecture as described in EN14198)</p> <p>The through-going brake pipe shall be dimensioned according to UIC 541-1 which means internal diameter 32mm.</p> | <p>EN14198 (chapter 5.1.4 UIC brake system)<br/>EN15179 (chapter 5.3 UIC and fig H.1 in appendix H)<br/>EN16185 (5.1.1 UIC)</p> |

# Exhibit A02: SOW Technical

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:5.1.2.1.b | <p><b>K</b> A button for overcharge and assimilation functionality according to UIC 541-03 shall be placed near the driver's brake handle.</p> <p><i>The Tenderer shall describe the proposed solution.</i></p>  | UIC 541-03   |
| A2:5.1.2.1.c | <p><b>K</b> A solution shall be provided that inhibits the replenishing of the pressure in the main brake pipe when testing the tightness of the main brake pipe at standstill. A warning system in order to avoid running with blocked brake pipe refilling shall be included.</p> <p><i>The Tenderer shall describe the proposed solution.</i></p> |              |

## 5.1.2.2 Functionalities to be provided

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.2.2.a | <p><b>E</b> The blending strategy between Automatic Brakes, EP-brakes and ED-brakes should be optimized for energy saving and reduction of wear.</p> <p><i>The Tenderer shall describe the proposed solution.</i></p>   |              |
| A2:5.1.2.2.b | <p><b>K</b> All possible train configurations shall be prepared for operation with automatic speed regulation with a driver selected fixed brake deceleration rate. Preferred fixed deceleration rates are 1.0, 0.9, 0.75 and 0.6 m/s<sup>2</sup>.</p> <p><i>The Tenderer shall describe the proposed solution.</i></p> |              |
| A2:5.1.2.2.c | <p><b>M</b> Brakes for roll back prevention and holding / immobilization shall be dimensioned to hold all train configurations in 35 o/oo gradient with max passenger load.</p>   |              |
| A2:5.1.2.2.d | <p><b>M</b> The holding brake function shall be engaged and released automatically.</p>   |              |
| A2:5.1.2.2.e | <p><b>K</b> It shall be possible to deactivate the holding brake function from the driver's cab.</p> <p><i>The Tenderer shall describe the proposed solution for automatic activation and de-activation of the holding brake and possible driver de-activation.</i></p>   |              |
| A2:5.1.2.2.f | <p><b>E</b> All train configurations should be prepared with an automatic brake test facility.</p> <p><i>The Tenderer shall describe proposed solution for automatic brake test.</i></p>  |              |

## 5.1.2.3 Operating elements and functionalities

| Id           | Requirement   | Referring to           |
|--------------|---|------------------------|
| A2:5.1.2.3.a | <p><b>E</b> The operation of the brakes, brake related functions and design principles of the control devices should be kept as equal as possible to the rest of the Norwegian passenger rolling stock (e.g. train classes 72, 73, 74 and 75). This is mandatory for safe operation and the ease of educating the drivers.</p> <p>Placement and functionality of handles and other operational elements related to safe operation should be chosen to avoid handling errors by the driver when changing from another train owned by Norske tog.</p> | See also Appendix A2-3 |
| A2:5.1.2.3.b | <p><b>K</b> The driver's brake handle for controlling the main brake pipe pressure shall be of vertical type with position dependent design and UIC functionality according to UIC 541-03.</p>  | UIC 541-03             |

## 5.1.2.4 Load braking

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:5.1.2.4.a | <p><b>K</b> Pneumatic brake (disc brake, combined disc- and block brake) shall be load compensated separately for each bogie. Design and functionality of the load compensating relay-valves shall be according to EN15611.</p> <p><i>The Tenderer shall describe proposed load compensation system.</i></p>   | EN15611      |
| A2:5.1.2.4.b | <p><b>E</b> The load compensated brake performance should be adjustable for possible future changes of weight and/or brake demands.</p> <p><i>The Tenderer shall describe planned upper and lower margin for proposed load compensation solution.</i></p>  |              |
| A2:5.1.2.4.c | <p><b>K</b> If the load compensation for the service brake is done electronically, adjustment shall be made possible for the Trainset owner by changing parameter settings rather than having to reprogram the brake system.</p> <p><i>The Tenderer shall describe proposed solution for adjustment of the service brake load compensation.</i></p>  |              |
| A2:5.1.2.4.d | <p><b>E</b> Where train software is dependent on the load compensated brake settings, the parameters should be adjustable in the software for the train. The changing of settings should be available only for dedicated personnel.</p> <p><i>The Tenderer shall describe and specify train software dependencies of load compensation settings and clarify possible adjustment by parameter changing.</i></p> |              |

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## 5.1.2.5 Pneumatic control components

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.2.5.a | <p><b>E</b> Proposed carbody mounted pneumatic sub-systems and bogie mounted brake assemblies will be evaluated regarding the possibility to exchange faulty single components at first line maintenance. Some example systems to be described are brake panels, disc-brake units, track brake assemblies, etc.</p> <p><i>The Tenderer shall describe possible first line maintenence activities regarding exchange of single components on sub-systems and assemblies.</i></p> |              |

## 5.1.2.6 External brake indicators

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.2.6.a | <p><b>M</b> Each car/coach/unit in the trainset shall have separate external pneumatic brake indicators on both sides for indication of local status of pneumatic brake and parking brake. The parking brakes shall show the 3 states: Released, applied and uncertain. Design and functionality of the brake indicators shall comply with EN15220.</p> | EN15220      |

## 5.1.2.7 External brake markings

| Id           | Requirement   | Referring to         |
|--------------|---|----------------------|
| A2:5.1.2.7.a | <p><b>K</b> External brake markings on locomotives, train-sets and coaches shall comply with EN 15877-2 and UIC545.</p> | UIC 545<br>EN15877-2 |

## 5.1.2.8 Monitoring

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:5.1.2.8.a | <p><b>K</b> All relevant pressures in the pneumatic system shall be monitored by pressure sensors connected to the TCMS for diagnostics.</p> <p><i>The Tenderer shall describe the proposed solution.</i></p>  |              |
| A2:5.1.2.8.b | <p><b>K</b> All train configuration shall have a solution for making data from all brake system pressure sensors available for future OCM functionality. (Operational Condition Monitoring)</p> <p><i>The Tenderer shall describe the proposed system.</i></p> |              |
| A2:5.1.2.8.c | <p><b>M</b> All relevant pressures in the pneumatic system shall be possible to measure by use of external manometer connected to installed test fittings.</p>   |              |

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| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.2.8.d | <b>K</b> For locomotives and fixed trainsets (EMUs and DMUs) all brake cylinder pressures shall be readable from the driver's IDU-screen.   |              |
| A2:5.1.2.8.e | <b>E</b> For locomotive and coach solutions all coach brake cylinder pressures should be readable from the driver's IDU-screen.<br><i>The Tenderer shall describe proposed system.</i>  |              |
| A2:5.1.2.8.f | <b>E</b> It should be a system for automatic measurement and indication of remaining brake pad thicknesses with an indication/alarm when it is time to plan for brake pad exchange.<br><i>The system and concept for the monitoring of the brake pad wear shall be described in the tender.</i> |              |

## 5.1.3 Emergency brake control

### 5.1.3.1 Emergency brake principle

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.3.1.a | <b>M</b> The emergency brake shall be based on mechanical brake (disc brake or combined disc- and block brake and magnetic track brake) activated by ventilating or depressurizing (from 5 to <2bar) the main brake pipe. |              |

### 5.1.3.2 Drivers emergency brake

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.3.2.a | <b>M</b> The driver shall have at least one possibility to directly empty the main brake pipe mechanically/pneumatically without electrical dependency. |              |
| A2:5.1.3.2.b | <b>M</b> The main traction control handle shall initiate the emergency brake when pulled backward to the end position close to the driver.              |              |

### 5.1.3.3 Passenger emergency brake

| Id           | Requirement  | Referring to         |
|--------------|--|----------------------|
| A2:5.1.3.3.a | <b>K</b> The passenger emergency brake shall work with delay function and meet the requirements in the TSI LOC&PAS 4.2.5.3.<br><i>The Tenderer shall describe the proposed solution.</i> | TSI LOC&PAS 4.2.5.3. |

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## 5.1.3.4 Warming up brake

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.3.4.a | <p><b>M</b> It shall be an automatic warming-up facility for the disc brake for keeping the brake discs warm (not hot) during cold winter conditions in order to prevent snow and ice to build up between discs and brake pads. Satisfactory functionality shall be demonstrated by disc temperature measurements on a trainset during Norwegian winter conditions.</p>   |              |
| A2:5.1.3.4.b | <p><b>E</b> The automatic warming-up facility for the disc brake will be evaluated regarding:</p> <ul style="list-style-type: none"> <li>- Activation/de-activation possibilities. It should be automatically activated at low out-door temperature, but possible to switch off by the driver. It should also be possible for the driver to switch it on manually.</li> <li>- It should be possible to adjust the warming-up capacity (brake application) by parameter adjusting by maintenance personnel.</li> </ul> |              |

*The Tenderer shall describe the proposed solution.*

## 5.1.4 Disc brakes

### 5.1.4.2 Brake discs

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:5.1.4.2.a | <p><b>K</b> The preferred disc brake solution is steel brake discs and sintered brake pads. Solutions with cast iron brake discs and organic brake pads have to be demonstrated suitable for Norwegian conditions regarding thermal capacity, winter properties and wear/lifetime (especially hollow wear and cracks in the brake discs)</p> |              |

*For all suggested disc/pad solutions the Tenderer shall provide the following brake disc information:*

- *References for experienced winter use*
- *References, tests etc demonstrating ok thermal capacity for operation in Norway*
- *References, etc demonstrating expected wear and lifetime*

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## 5.1.4.3 Brake pads

| Id           | Requirement  | Referring to     |
|--------------|--|------------------|
| A2:5.1.4.3.a | <p><b>K</b> The preferred disc brake solution is steel brake discs and sintered brake pads. Solutions with cast iron brake discs and organic brake pads have to be demonstrated suitable for Norwegian conditions regarding thermal capacity, winter properties and wear/lifetime (especially hollow wear and cracks in the brake discs)</p> <p><i>For all suggested disc/pad solutions the Tenderer shall provide the following brake pad information:</i></p> <ul style="list-style-type: none"> <li>- References for experienced winter use</li> <li>- References, tests etc demonstrating ok thermal capacity for operation in Norway</li> <li>- Data sheet with information about max short time and long time temperature and coefficient of friction as function of speed, pad-pressure, etc</li> <li>- Results from dry and wet testing according to UIC 541-3.</li> <li>- References, etc demonstrating expected wear and lifetime</li> </ul> | UIC 541-3        |
| A2:5.1.4.3.b | <p><b>K</b> All brake pads shall be of 200cm<sup>2</sup> divided format as depicted in UIC 541-3 attachments A1 or A3, and shall fit into standard UIC brake pad holders with dove tail groove.</p>  | UIC 541-3 A1, A3 |
| A2:5.1.4.3.c | <p><b>K</b> Brake pads shall be of at least 32mm thickness, and preferably 35mm in order to be able to optimize inspection intervals and reduce wasted material to a minimum.</p>  |                  |
| A2:5.1.4.3.d | <p><b>M</b> There shall only be one single type of brake pad within each bogie unless the bogie has both driven and not driven axles. Interchangeable brake pad types can be mixed, but not on the same disc.</p>  |                  |

## 5.1.4.4 Verification of friction materials

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:5.1.4.4.a | <p><b>M</b> At least one of the homologated brake pad materials shall have successfully been in use in Finland, Sweden or Norway the last three years prior to concept review.</p> |              |
| A2:5.1.4.4.b | <p><b>M</b> The trains braking percentage shall be stated for the homologated pad and disc combination that gives the longest brake distances.</p>                                 |              |

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## 5.1.5 Block brakes and conditioners

### 5.1.5.1 General

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:5.1.5.1.a | <p><b>M</b> Block brakes, if fitted, shall only be equipped as a supplement to disc brakes or as cleaning brakes. No axle shall have block brakes only.</p> <p>If installed, block brakes shall not take more than 15% of any axle's brake energy when decelerating from 120 km/h to standstill.</p> <p>Max 15% block brake per axle shall be verified by a brake calculation.</p> | UIC 544-1    |

### 5.1.5.2 Brake blocks

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.5.2.a | <p><b>K</b> Brake blocks shall be classed suitable for winter conditions according to UIC 541-4.</p> <p><i>The tenderer shall provide documentation (test results, operator experience, etc) that verifies that proposed brake blocks are suitable for norwegian winter conditions.</i></p> | UIC 541-4    |

### 5.1.5.3 Conditioners

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.5.3.a | <p><b>K</b> Driven wheels without block brake, shall be equipped with a wheel conditioning (cleaning) block brake.</p> <p><i>The Tenderer shall describe proposed solution.</i></p> |              |

### 5.1.5.4 Conditioners brake blocks

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.5.4.a | <b>K</b> Brake blocks for the conditioning (cleaning) brake shall be of P10 cast iron material. |              |

## 5.1.6 Brake mechanics

### 5.1.6.1 General

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.6.1.a | <b>E</b> All brake cylinders should be equipped with diagnostics regarding degraded pad force capacity and faulty slack adjuster functionality. |              |

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## 5.1.7 Dynamic brakes

| Id  | Requirement   | Referring to |
|---|---|--------------|
| A2:5.1.7.a  | <b>M</b> Locomotives and fixed EMU / DMU-units shall be equipped with an Electro-Dynamic brake. Regarding EMUs and DMUs see EN16185-1 chapter 5.2.2.                          |              |
| A2:5.1.7.b  | <b>E</b> Proposed electro-dynamic brake will be evaluated regarding capacity and regeneration capability.   |              |
| <i>Description of the dynamic brake system is to be provided with the tender documentations</i>                             |   |              |
| A2:5.1.7.c  | <b>M</b> The dynamic brake shall have priority over the mechanical service brake, but not during ETCS service braking or emergency braking.                                   |              |
| A2:5.1.7.d  | <b>K</b> If the Trainset or part of it is equipped with additional block brakes for cleaning purposes, the cleaning brake shall be activated during dynamic braking.          |              |
| <i>The Tenderer shall describe proposed automatic activation/de-activation of the cleaning brake during dynamic braking</i> |   |              |
| A2:5.1.7.e  | <b>K</b> It shall be possible to switch off the dynamic brake with a push button on the driver's desk. The button shall be illuminated when the dynamic brake is deactivated. |              |
| A2:5.1.7.f  | <b>K</b> Variation and/or losses in the dynamic brake effort shall be compensated by the brake blending system through the EP brake.  |              |
| <i>Blending curves for different driving modes and load conditions shall be provided.</i>                                   |   |              |
| A2:5.1.7.g  | <b>M</b> The braking force of the dynamic brake shall not be calculated into the emergency brake performance.   |              |

## 5.1.8 Parking brakes

### 5.1.8.1 General

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:5.1.8.1.a | <b>M</b> Each locomotive / coach / unit possibly shunted alone, shall be fitted with a parking brake which complies with TSI Loc&Pas. | TSI Loc&Pas  |

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| Id           | Requirement   | Referring to          |
|--------------|---|-----------------------|
| A2:5.1.8.1.b | <p><b>K</b> The parking brake shall be able to permanently hold both single vehicles, units and all possible train configurations in a 30 o/oo gradient with load condition "Design mass - Normal design payload" (as per EN 15663). Safety against both rolling and sliding with safety factor 1.1 shall be verified by both parking brake calculations according to UIC 544-1 and a type test.</p> <p><i>Tender documents shall include descriptions and drawings with main dimensions for parking brake cylinders and callipers.</i></p> | EN 15663<br>UIC 544-1 |

## 5.1.8.2 Functionality

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:5.1.8.2.a | <p><b>M</b> For locomotives and fixed EMU/DMU-units the parking brake shall be of type automatically applied spring brake at no air in the pneumatic release system.</p>   |              |
| A2:5.1.8.2.b | <p><b>M</b> It shall be possible to release spring applied parking brake units without air in the pneumatic release system.</p>  |              |
| A2:5.1.8.2.c | <p><b>E</b> The system for mechanical release of spring applied parking brake cylinders shall be reliable during all Norwegian weather conditions and experienced used during operation in tough winter conditions. The system shall be designed in a way that prevents mechanical release by unauthorised personnel.</p> <p><i>The Tenderer shall describe the proposed solution.</i></p> |              |
| A2:5.1.8.2.d | <p><b>M</b> For all train configurations with spring applied parking brake solutions there shall be a monitoring system for parking brake application/release (during standstill and running). Applied parking brake on one or more coaches shall result in traction cut out and driver warning.</p>   |              |
| A2:5.1.8.2.e | <p><b>E</b> For train configurations including coaches with manual screw brakes there should be a monitoring system for parking brake application/release on train level. Applied parking brake on one or more coaches should result in traction cut out and driver warning.</p> <p><i>The Tenderer shall describe proposed monitoring system on train-level.</i></p>                      |              |

## 5.1.9 Magnetic track brakes

| Id         | Requirement   | Referring to                    |
|------------|---|---------------------------------|
| A2:5.1.9.a | <p><b>M</b> The Trainset shall be fitted with electro-magnetic track brake with functionality in compliance with UIC 541-06 and EN 16207.</p> | UIC 541-06 and<br>EN 16207:2014 |

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| Id         | Requirement  | Referring to           |
|------------|--|------------------------|
| A2:5.1.9.b | <p><b>M</b> The additional effect of magnetic track brake shall be verified by emergency brake testing according to UIC 544-1. For fixed EMU / DMU-units the additional effect of magnetic track brake shall not be included in the brake weight percentage. For locomotive and coach solutions with different brake groups the brake weight percentage shall be presented for all relevant brake groups (P, R and R+Mg).</p>  | UIC 544-1              |
| A2:5.1.9.c | <p><b>K</b> For locomotives and single coaches at least one bogie shall be fitted with a magnetic track brake. Minimum brake capacity (R+Mg) for coaches in load condition "Design mass - Normal design payload with 2 standing per m2 in passenger area" (as per EN 15663) shall be according to UIC 541-06 (minimum 208%).</p> <p>For fixed EMU/DMU-units the available magnetic track brake capacity for all possible train configurations shall comply with EN 16185 and fig A.2 regarding brake capacity R+Mg. Minimum brake capacity (R+Mg) for load condition "Design mass - Normal design payload with 2 standing per m2 in passenger area" (as per EN 15663) shall be according to diagram "2" ("R+Mg3") in fig A.2.</p> <p><i>The Tenderer shall describe proposed magnetic track brake solution and provide necessary brake calculations for all possible train configurations.</i></p> | UIC 541-06<br>EN 15663 |
| A2:5.1.9.d | <p><b>K</b> The Magnetic Track Brakes shall be fitted with a diagnostic system that detects failures in the system. The system shall be able to detect typical faults including touch-down failure and lost magnetization.</p>   |                        |
| A2:5.1.9.e | <p><b>E</b> All diagnostic messages should be published to the train's diagnostic system.</p> <p><i>The tenderer shall describe proposed diagnostic system.</i></p>  |                        |
| A2:5.1.9.f | <p><b>K</b> The magnetic track brakes shall be automatically activated during emergency braking, but manual activation via a switch on the driver's desk shall also be possible for testing purposes.</p>  |                        |

## 5.1.10 Wheel slip control WSP/ABS

| Id          | Requirement   | Referring to           |
|-------------|---|------------------------|
| A2:5.1.10.a | <p><b>M</b> The wheel slip protection system (WSP) for both dynamic, mechanical and mixed brakes shall fulfill EN 15595 and UIC 541-05.</p> | EN 15595<br>UIC 541-05 |

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| Id          | Requirement  | Referring to                   |
|-------------|--|--------------------------------|
| A2:5.1.10.b | <p><b>K</b> The complete WSP system with all active components shall have been homologated and successfully operated on other trains at least 3 years prior to concept review.</p> <p><i>The Tenderer shall describe proposed system and provide relevant references.</i></p>  |                                |
| A2:5.1.10.c | <b>K</b> The WSP systems shall control each axle individually.   |                                |
| A2:5.1.10.d | <b>K</b> In order to minimize the consequence of faults the mechanical WSP system shall be divided into multiple control units with one unit per car / coach / unit.   |                                |
| A2:5.1.10.e | <b>K</b> The WSP system shall send all generated fault codes to the Trainset's TCMS system.  |                                |
| A2:5.1.10.f | <b>M</b> For any data transfer between the WSP and the train, the transfer protocols, formats and codes shall be 100% documented to Norske tog.  |                                |
| A2:5.1.10.g | <b>K</b> The wheel speed sensors for WSP mechanical brake shall be of standard interchangeable form and not an integrated part of another component, such as wheel bearings.   | UIC 541-05 (4.2.4.3 og 4.2.10) |
| A2:5.1.10.h | <p><b>K</b> The complete installation including cabling and tubing for the WSP system shall be specified, tested and approved by the sub-supplier of the WSP system.</p> <p>The WSP-functionality during low-graded adhesion wheel/rail shall be verified by practical testing according to UIC 541-05 with verifications of fulfilled requirements.</p> |                                |

## 5.1.11 Brake performance

### 5.1.11.1 General

| Id            | Requirement  | Referring to          |
|---------------|--|-----------------------|
| A2:5.1.11.1.a | <b>M</b> Brakes shall comply with the UIC 546 leaflet.   | UIC 546               |
| A2:5.1.11.1.b | <p><b>M</b> Brake weight and brake weight percentage shall be calculated and verified according to the emergency brake testing procedure specified in EN16834 and UIC 544-1.</p> <p>Calculated brake weight percentages shall consider worst case efficiency degradation of the brake system during planned overhaul interval.</p> <p>Valid/official brake weight percentages for brake group P, R and R+Mg, shall be based on obtained test results for initial speed 120 km/h, but tests shall also be carried out for other speeds, at least for 160 and 200km/h.</p> | EN 16834<br>UIC 544-1 |

## 5.1.11.2 Minimum brake percentage

| Id            | Requirement  | Referring to                                       |
|---------------|--|--|
| A2:5.1.11.2.a | <b>M</b> The minimum required brake weight percentage in the brake tables for running at line speed is 151%.   | Brake Table1, 2, 3 and 4 for the Norwegian Network |
| A2:5.1.11.2.b | <b>K</b> The target brake percentage for the mechanical brake in emergency brake for all possible train configurations shall be between 155% and 165%. | UIC 546<br>UIC 544-1                               |

*The Tenderer shall specify estimated brake weight percentages for proposed locomotives, coaches and units.*

## 5.1.11.3 Friction utilization

| Id            | Requirement  | Referring to  |
|---------------|--|---|
| A2:5.1.11.3.a | <b>K</b> The utilization of friction wheel/rail shall be in accordance with the German Eisenbahn Bundesamt document: Ergänzungsregelung Nr. B 007 zur "Kraftschlussausnutzung" rev. 3.0 vom 2016-02-10 | Ergänzungsregelung Nr. B 007 zur "Kraftschlussausnutzung" rev. 3.0 vom 2016-02-10 |

*Kolla krav i Operator Experience*

## 5.2 Air supply

### 5.2.1 General requirements

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:5.2.1.a | <b>M</b> A collected and structured description of the overall compressed air supply concept shall be delivered with the tender.<br>The description shall include but not be limited to:<br>- Details of compressor and air dryer type.<br>- Pneumatic diagram (with part list) for compressor and air dryer system.<br>- Preliminary air consumption calculation<br>- Functional description accompanying the diagram explaining working principles. |              |
| A2:5.2.1.b | <b>K</b> Compressors shall be of oil free type.   |              |

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| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:5.2.1.c | <b>M</b> Each compressor in the trainset shall have redundant air production capacity so it is possible to run the trainset with one faulty compressor.  |              |
| A2:5.2.1.d | <b>E</b> Time for filling up the main reservoir pipe system (including all air-reservoirs) from 0 to max operating pressure should be as short as possible and less than 15 minutes for worst case train configuration.<br><i>The Tenderer shall provide preliminary air consumption calculation for worst case train configuration indicating possible filling time.</i>  |              |
| A2:5.2.1.e | <b>E</b> Special considerations should be made for clean air and sufficient cooling for the compressors, as high compressor temperatures typically have been a recurring problem area on similar projects. The air temperature at the compressor inlet should not exceed 40°C.<br><i>The Tenderer shall describe proposed compressor / compressor-compartment solution, describe special considerations taken in order to comply with this requirement and if possible, refer to similar solutions in use.</i> |              |
| A2:5.2.1.f | <b>E</b> Care should be taken in order to prevent noise and vibrations from the compressors and noise from the dryer and water draining system to enter passenger compartments.<br><i>The Tenderer shall describe proposed compressor / compressor-department solution, describe special considerations taken in order to comply with this requirement and if possible, refer to similar solutions in use.</i>   |              |

## 5.2.2 Control

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:5.2.2.a | <b>K</b> Each compressor unit shall be equipped with an hour counter with display that counts the cumulative running hours of the compressor. The hour counter shall follow the compressor when mounted/dismounted from the train.  |              |
| A2:5.2.2.b | <b>K</b> The compressor control system shall ensure same average utilization and running time for all compressors   |              |
| A2:5.2.2.c | <b>E</b> During parking of an active Trainset, the air pressure in the high pressure system should be reduced to the required minimum pressure in order to save energy and reduce leakage.<br><i>The Tenderer shall describe proposed solution for reduced main reservoir pipe pressure for a parked active trainset.</i> |              |

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| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:5.2.2.d | <b>K</b> The activation status of all compressors shall be monitored by the TCMS so the driver can monitor the status in IDU.   |              |
| A2:5.2.2.e | <b>K</b> The Trainset shall have a monitoring system providing automatic warning (diagnostic system) of air filter and oil filter (if oil-lubricated compressor) malfunctioning.<br><i>The Tenderer shall describe proposed monitoring system and provide references to systems in use.</i>   |              |
| A2:5.2.2.f | <b>M</b> The driver shall have the possibility to force a compressor to run and stop independent of the automatic compressor control by measured main reservoir pipe pressure.  |              |
| A2:5.2.2.g | <b>E</b> There should be an automatic shutdown of a compressor/air drier-unit (including pneumatic isolation) in case of detected un-satisfactory dew-point temperature in produced air (measured after the air-drier). The driver should be alarmed and have the possibility to override the shutdown. He should also have the possibility to manually activate a shutdown and pneumatic isolation in case of a big air leakage in the air-drier, etc.<br><i>The Tenderer shall describe proposed shutdown solution.</i> |              |

## 5.2.3 Verification of compressor compartment temperature

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:5.2.3.a | <b>E</b> There should be a monitoring system for the compressor compartment temperature and relevant internal compressor temperatures in order to detect and avoid possible overheating problems and stop malfunctioning compressors.<br><i>The Tenderer shall describe proposed monitoring system and provide references to systems in use.</i> |              |

## 5.2.4 Air dryer

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:5.2.4.a | <b>M</b> Each compressor shall have its own air dryer.  |              |
| A2:5.2.4.b | <b>K</b> The air dryer shall fulfil dew point requirements for main reservoir pipe air under all normal operational conditions: -30°C or below at 8.5-10 bar in the main reservoir pipe system. |              |
| A2:5.2.4.c | <b>K</b> The water exhaust and drainage from the air dryer shall be secured against frost.<br><i>The Tenderer shall describe the proposed solution.</i>   |              |

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## 5.2.5 Dew Point Measuring

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:5.2.5.a | <b>M</b> In the pneumatic system after each compressor/air-drier unit it shall be installed a dew point temperature sensor . The compressed air dew point temperature shall be sent and displayed in the TCMS and diagnostic system. It shall be easy to check indicated dew point temperature by connecting an external instrument to a test fitting next to the installed temperature sensor. The dew point sensor shall be easy replaceable by use of an isolation cock with ventilation installed prior to the temperature sensor. |              |

## 5.2.6 Auxiliary Compressor

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:5.2.6.a | <b>M</b> The Trainset shall be equipped with an auxiliary compressor that has sufficient output capacity to raise the pantograph and, if applicable, turn on the high voltage breaker when the main reservoir pipe pressure is too low. |              |
| A2:5.2.6.b | <b>K</b> The engaging of the auxiliary compressor shall be automatically controlled by the Trainset. It shall also be possible to start the auxiliary compressor from the IDU screen.   |              |

## 5.2.7 Tubes and hoses

| Id         | Requirement   | Referring to       |
|------------|---|--------------------|
| A2:5.2.7.a | <b>K</b> Pipes for brakes and compressed air distribution generally shall be of stainless-steel quality ANSI 316 and NS-EN 10088-1 or 1.4301 DIN 2391 (German standard) or equivalent.  | EN10088            |
| A2:5.2.7.b | <b>M</b> Pipes shall be routed to avoid accumulation of condensation in bends. If this is impossible due to the design of the carbody or underframe, the pipes must be fitted with condensate separators with drain cocks at the lowest point of each pipe depression. Sharp bends in pipes shall be avoided. |                    |
| A2:5.2.7.c | <b>K</b> Copper pipes shall fullfill the requirements of one of the following EN norms:<br>EN 12449 Nahtlose Rundrohre zur allgemeinen Verwendung<br>EN 12451 Nahtlose Rundrohre für Wärmeaustauscher   | EN12449<br>EN12451 |
| A2:5.2.7.d | <b>M</b> Safety related systems shall not incorporate plastic piping or permanent hose connections made from meltable or flammable materials which may lose their functional capacity within 30 minutes of local over-heating or fire.  |                    |
| A2:5.2.7.e | <b>M</b> Flexible hoses on roof shall be protected against sunlight.  |                    |
| A2:5.2.7.f | <b>K</b> Pipe couplings and fitting shall be of standard DIN EN ISO 8434  | EN ISO 8434        |

# Exhibit A02: SOW Technical

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:5.2.7.g | <b>K</b> All air brake and air distribution couplings shall be easily accessible for leakage testing and tightening without having to remove equipment for access. |              |
| A2:5.2.7.h | <b>M</b> Tube connections in the compressed air distribution shall not be welded or soldered.  |              |

## 5.2.8 Air reservoirs

| Id         | Requirement   | Referring to       |
|------------|---|--------------------|
| A2:5.2.8.a | <b>K</b> All reservoirs shall be manufactured with non-corrosive materials (stainless steel ANSI 316 L or aluminium) according to EN286-3 or EN286-4.   | EN286-3<br>EN286-4 |
| A2:5.2.8.b | <b>K</b> Individual air reservoirs shall be of reduced size in order to fulfill $p \cdot V < 1000$  |                    |
| A2:5.2.8.c | <b>M</b> All air reservoirs, except those with reservoir air for the distributor and RLV valves (R-reservoirs), shall be fitted with drain cocks in positions which ensure that no water may remain in the tank after draining. R-reservoirs shall be fitted with screw plugs suitable for normal draining in case of detected water in the main reservoir pipe system. |                    |
| A2:5.2.8.d | <b>K</b> All air reservoirs shall be accessible for inside inspection without having to dismount other components.  |                    |

## 5.2.9 Air horn (Audible warning devices)

| Id         | Requirement  | Referring to             |
|------------|--|--------------------------|
| A2:5.2.9.a | <b>K</b> Signalling horns shall fulfill EN15153-2:2013 and UIC644 with frequencies 370Hz and 660Hz.                        | EN15153-2:2013<br>UIC644 |
| A2:5.2.9.b | <b>M</b> The driver shall have the possibility to activate the horns via a foot pedal and via button on the driver's desk. |                          |
| A2:5.2.9.c | <b>K</b> A button to activate the horn shall be reachable for the instructor in seated and standing position.              |                          |
| A2:5.2.9.d | <b>K</b> The horns shall be mounted so that snow and ice does not assemble and prevents the function.                      |                          |
| A2:5.2.9.e | <b>K</b> The horns shall be heated in cold weather.  |                          |

## 6 Information and communication

| Id     | Requirement  | Referring to |
|--------|--|--------------|
| A2:6.a | <p><b>I</b> In order to improve operational effectiveness, reduce Maintenance downtime amongst others the Trainset needs to be in constant communication with systems on the Wayside that can deliver real time and updated information. The onboard and Wayside communication equipment are key elements to delivering online services. They form the link between the Trainsets and the Wayside.</p> <p>A key part of the Train external communication is the concept of mobile carrier bundling. This technique is used to ensure seamless coverage especially in rural areas through the utilization of several Mobile Network Operators (MNOs).</p> <p>Norske tog or the Train Operator will be responsible for the SIM cards that will provide the needed connectivity between the Trainset and the Wayside to support the Contractor's solution. The requirements in this section ensure that a reliable, secure and constant connection can be established to and from the Wayside.</p> <p>The Trainset Communications Gateways and the Wayside Communications Gateway are key to delivering this service. They form the link between the Trainsets and the Wayside see the System Architecture Diagram. In Norway coverage from the three current Norwegian Mobile Network Operators are bundled together to ensure the maximum connectivity.</p> |              |

### 6.1 On-board train communication

| Id       | Requirement  | Referring to |
|----------|--|--------------|
| A2:6.1.a | <b>K</b> All safety-related data communication shall comply with EN 50159. | EN 50159     |

# Exhibit A02: SOW Technical

## 6.1.1 Public Address System (PA)

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.1.1.a | <p><b>I</b> The requirements in this section focus on the system functions needed for audible information to be provided to the passengers.</p> <p>One example is the possibility to adjust the volume of the PA system so that PA announcements can be heard in all interior areas of the Trainset in case of an emergency situation where the background noise may be higher than normal.</p>  |              |
| A2:6.1.1.b | <p><b>K</b> The onboard crew shall be able to select where the announcements should be heard, at least all of the below shall be selectable:</p> <ul style="list-style-type: none"> <li>• On the outside</li> <li>• On the inside</li> <li>• Both inside and outside</li> <li>• Only to a part of the Trainset</li> <li>• The complete Trainset</li> <li>• Specific Trainsets in multiple</li> <li>• Only inductive loop</li> </ul> <p>Manual announcements shall by default be transmitted everywhere except outside.</p> |              |
| A2:6.1.1.c | <p><b>K</b> It shall be possible to play announcements from the Wayside. Either as pre-recorded audio or with the onboard text to speech function.</p> <p><i>The Tenderer shall demonstrate compliance by describing their solution to this requirement, highlighting the communication path from the Wayside Interface to the Trainset as well as how the target for the announcement is selected on the Wayside.</i></p>   |              |

# Exhibit A02: SOW Technical

| Id         | Requirement   | Referring to          |
|------------|---|-----------------------|
| A2:6.1.1.d | <p><b>K</b> The public address functionality shall at least enable:</p> <ul style="list-style-type: none"> <li>• Manual operation with microphone</li> <li>• Intercom operation from driver's cab and conductors cab (if present) to driver's cab and conductors cab (if present)</li> <li>• Manual operation from GSM-R radio system (driver's phone, conductor's handheld phone and central train dispatcher)</li> <li>• Broadcasting of predefined audio notifications</li> <li>• Broadcasting of text as speech</li> <li>• Automatic operation</li> </ul> |                       |
| A2:6.1.1.e | <p><b>K</b> The public address system shall have the possibility to present audio information in multiple languages for the same information. At least Norwegian and English.</p>   |                       |
| A2:6.1.1.f | <p><b>K</b> The Trainsets shall be equipped with an inductive loop or equivalent communication solution with the equivalent level of accessibility as an inductive loop, to provide hearing assistance to hearing-aid users. The communication solution shall be available in all passenger areas.</p> <p><i>The Tenderer shall demonstrate compliance by demonstrating the inductive loop and coverage within the Trainset.</i></p>  |                       |
| A2:6.1.1.g | <p><b>K</b> Public address (PA) quality and specification shall follow the guidelines of UIC 568.</p>   | UIC 568               |
| A2:6.1.1.h | <p><b>E</b> The spoken information shall have a minimum STI-PA level of 0.60 for all relevant operating conditions (e.g. with few/many passengers, inside/outside of tunnels, etc.) for the Trainset, in accordance with the specification in NEK IEC 60268-16:2011.</p> <p><i>The Tenderer shall demonstrate compliance by stating the minimum STI-PA level and detail how the solution addresses different background noise levels across the Trainset.</i></p>   | NEK IEC 60268-16:2011 |
| A2:6.1.1.i | <p><b>E</b> The Tenderer shall propose a solution to attract the passengers attention when manual or automatic information of high importance are announced.</p> <p><i>The Tenderer shall describe the solution, detailing especially how the attention of passengers using noise cancelling equipment are attracted.</i></p>   |                       |

# Exhibit A02: SOW Technical

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:6.1.1.j | <p><b>K</b> The Supplier shall at every Design Review provide a sub-system description for the public address system containing at a minimum the following information:</p> <ul style="list-style-type: none"> <li>• System design, main components and functions</li> <li>• List of Standards and parts of Standards that the public address system comply to</li> <li>• Trainset and Vehicle integration of the public address system</li> <li>• Integration to the Trainset IT System and Wayside IT System including operation when coupled in multiple operation</li> <li>• System hardware layout showing the location and connection of all integrated parts e.g. microphones, loudspeakers, amplifiers, controls etc.</li> <li>• System software building blocks including user interfaces for Driver, Crew, maintainers, etc. including used protocols for data transfer.</li> <li>• System functionality including possibilities and any limitations for making manual and automatic announcements</li> <li>• Description of how location information for automatic announcements are obtained and the accuracy of the location information</li> <li>• System performance including speech intelligibility, timing and accuracy of automatic announcements</li> <li>• System functionality including possibilities and limitations provided by the system in normal service and fault modes</li> <li>• Concept for hardware and software updates, including description of the possibilities to do remote updates</li> <li>• How background noise is taken into consideration when designing and when testing the system</li> <li>• Redundancy concept</li> <li>• Integration between the public address and PIS system including any fall back functionality</li> <li>• Description of the text to speech functionality, including the quality of the text to speech spoken voice in regard to phonetics, articulation and prosody, ensuring a natural and fluent sounding speech in standard language</li> </ul> <p><i>The Tenderer shall demonstrate compliance by submitting a preliminary system description at least containing the information requested in this requirement</i></p> |              |

## 6.1.2 DAB+ radio

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.1.2.a | <p><b>I</b> DAB+ radio is standard equipment for driver and onboard crew as part of the onboard working environment. Good praxis is to provide automatic muting of the radio from the GSM-R, PA and PIS system and alsot that it is possible to operate the DAB+ radio from the driver's seat. A feature with added value for the drivers is if the DAB+ radio have the possibility to connect a Bluetooth streaming device.</p> |              |

# Exhibit A02: SOW Technical

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:6.1.2.b | <p><b>K</b> Each driver's cab and conductor's compartment (if present) shall be equipped with DAB+ radio with an external aerial. The radio shall also support FM signals.</p> <p><i>The Tenderer shall demonstrate compliance by delivering a preliminary system description</i></p> |              |

## 6.1.3 Wi-Fi solution and internet access for passengers

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.1.3.a | <p><b>I</b> Internet access via WiFi on board the Trainsets is part of the commercial strategy to provide an enhanced journey experience for passengers. The WiFi is to be a complete end to end solution including any network services required on the Wayside to perform any needed functionality to connect to the internet including traffic aggregation and policy enforcement.</p>  |              |
| A2:6.1.3.b | <p><b>K</b> The Trainset shall include a secure onboard WiFi Solution for providing internet access for passengers onboard.</p>  |              |
| A2:6.1.3.c | <p><b>E</b> The onboard WiFi Solution shall provide network and internet access in all areas where passengers and Operational Personnel have access.</p> <p><i>The Tenderer shall describe how the system can provide WiFi coverage throughout the Trainset with the minimum of equipment. The Tenderer's solution is to provide always on connectivity with quality, Reliability and speed. The Tenderer is to provide a preliminary drawing(s)/heat map showing the intended coverage of the WiFi Solution</i></p> |              |
| A2:6.1.3.d | <p><b>E</b> The number of wireless networks as part of the onboard WiFi Solution should be scalable.</p> <p><i>The Tenderer shall describe how the system is scalable and is flexible enough to provide multiple separate networks even within the same Vehicle</i></p>  |              |
| A2:6.1.3.e | <p><b>E</b> The number of simultaneous connections to the onboard WiFi Solution should be scalable.</p> <p><i>The Tenderer shall demonstrate compliance by describing how the scalability and capacity of the onboard WiFi solution relates to the Trainset passenger capacity.</i></p>  |              |
| A2:6.1.3.f | <p><b>K</b> The onboard WiFi Solution shall be independent of the Trainset Operation network.</p> <p><i>The Tenderer shall demonstrate compliance by providing a description of how the WiFi Solution can be separated and secure.</i></p>   |              |
| A2:6.1.3.g | <p><b>E</b> The WiFi solution shall be compatible with Trains external communication such that it can benefit from the operator bundling</p>   |              |

# Exhibit A02: SOW Technical

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.1.3.h | <b>E</b> The WiFi Solution shall be compatible with existing WiFi on the Norske tog FLIRT (Class 74/75/76) fleet |              |

# Exhibit A02: SOW Technical

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.1.3.i | <p><b>K</b> The Supplier shall at every Design Review provide a sub-system description for the onboard WiFi Solution that contain at a minimum the following information:</p> <ul style="list-style-type: none"> <li>• System design, architecture, main components, power, connectors and functions</li> <li>• List of Standards and parts of Standards that the onboard WiFi Solution complies to</li> <li>• Trainset and Vehicle integration of the onboard WiFi Solution</li> <li>• Integration to the Trainset IT System and Wayside IT System including operation when coupled in multiple operation</li> <li>• How the onboard WiFi Solution supports industry standards allowing for high capacity bandwidth and roaming WiFi including any backward compatibility (currently hotspot 2.0 - 802.11 a/b/g/n/ac on both 2.4Ghz and 5GHZ bands)</li> <li>• How the onboard WiFi Solution can be centrally managed remotely from the Wayside.</li> <li>• Which functionality the WiFi Solution shall provide including details on the following DHCP and authentication services, network address translation functionality, throttling available throughput per End User or per service/application type and providing traffic quotas per End User and whether this onboard or at the Wayside</li> <li>• Description of how the WiFi Solution supports the ability to differentiate between applications, meaning that application types can be assigned different levels of priority to optimize the bandwidth consumption and End User experience</li> <li>• Description of lawful interception capabilities to meet the requirement of the Danish authorities</li> <li>• Description of how the system ensures a seamless experience for the End User even if the End User is moving through the Train (client roaming)</li> <li>• Ability to support single SSID to all Vehicles and Trainsets and in the case of several SSIDs segregate the traffic from each SSID and max number of SSIDs that can be created</li> <li>• Description of supported open authentication (currently WPA2-PSK and WPA2- Enterprise solution or better)</li> <li>• Description of supported efficiency or effectiveness techniques for the WiFi technology (e.g. MIMO or equivalent)</li> <li>• Description of the flexibility of the system for expansion to adapt to increased passenger numbers including power and bandwidth estimations</li> <li>• How several End Users and systems including passengers and Operational Personnel can securely use the WiFi Solution without impacting each other or creating security issues.</li> <li>• Description of the fair sharing mechanism that ensures equal access (in terms of data consumption and speed) for all End Users.</li> <li>• Description of how the WiFi Solution will support Traffic Shaping including incorporating DSB's requests for changing Differentiation and shaping patterns</li> </ul> |              |

# Exhibit A02: SOW Technical

| Id | Requirement  | Referring to |
|----|--|--------------|
|    | <ul style="list-style-type: none"> <li>• Description of how the 3G and 4G coverage along the railways in terms of signal strength and SNR for each cellular carrier can be collected and the results provided on a map (e.g. Google Map) using positioning information.</li> <li>• Description of future expansion for 5G, the readiness for potential expansions and modem replacements and the associated procedures</li> <li>• Description of the functionality to power down the access points when Train is undergoing Maintenance in the Maintenance Facility, in order not to interfere with the Maintenance Facility WiFi infrastructure.</li> </ul> <p><i>The Tenderer shall demonstrate compliance by submitting a preliminary system description at least containing the information requested in this requirement.</i></p> |              |

## 6.1.4 Communications Gateway

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.1.4.a | <p><b>I</b> Communications to the Wayside is via multiple public cellular networks provided by several private telecoms companies. This means that communications to the Wayside is reliant on the carrier/company that has the strongest signal especially in the rural areas. Mobile carrier bundling is another technique used to ensure seamless coverage especially in rural areas. This is currently done through a multi SIM solution to cover the areas with minimum coverage. The requirements in this section are to ensure that despite multiple connections and disconnections of the communications to the Wayside due to the use of multiple mobile operators, a seamless communications link can be achieved.</p> <p>Within this chapter the word ‘real time’ has been used to indicate the lack of delay for the action to occur. As an example, in the case of a system, real time has been used to indicate the fact that there is no delay between when the system generates data and when that data is transmitted and or received by the receiving system. This lack of delay is independent of how often or the frequency of which the data itself is generated.</p> |              |
| A2:6.1.4.b | <p><b>K</b> The Trainset shall be equipped with a Trainset Data Communications Gateway that allows for real time communications at all times via concurrent mobile networks (at least 3) as well as WiFi connections.</p> <p><i>The Tenderer shall describe their solution.</i></p>  |              |
| A2:6.1.4.c | <p><b>K</b> The Supplier shall, on the Wayside, deliver a Wayside Operations Communications Gateway that allows for real time communications at all times via concurrent mobile networks (at least 3) as well as WiFi connections to each Trainset in the Fleet.</p>   |              |

# Exhibit A02: SOW Technical

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:6.1.4.d | <p><b>K</b> The Trainset shall be equipped with a Non Trainset Data Communication Gateway that allows for real time communications at all times via concurrent mobile networks as well as WiFi connections.</p> <p><i>The Tenderer shall describe their solution.</i></p> |              |
| A2:6.1.4.e | <p><b>K</b> The Supplier shall, on the Wayside, deliver a Wayside Internet Service Communications Gateway that allows for real time communications at all times via concurrent mobile networks to each Trainset in the Fleet.</p>   |              |

## 6.2 On-board train information

### 6.2.1 Passenger Information System (PIS)

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.2.1.a | <p><b>I</b> The requirements in this section focus on the visual and audio aspect of how the passengers will receive information.</p>  |              |
| A2:6.2.1.b | <p><b>K</b> The passenger information system shall include all necessary hardware and software to store, manage and easily edit visual information as well as applications for control and broadcasting of this information via internal and external displays.</p> <p>All delivered software shall offer a user friendly interface and compatibility with latest revision of commercially available operative systems in order to accommodate easy management of the passenger information system.</p> <p>It shall be possible for Norske tog to forward the necessary software to the Train Operator for their operations.</p> |              |
| A2:6.2.1.c | <p><b>E</b> Passenger information content like text, video and audio shall be easily edited and transferred to the on-board passenger information system by Norske tog or the Train Operator.</p> <p><i>The Tenderer shall demonstrate compliance by describing how content is created/edited and transferred to the passenger information system, including pre-defined messages and how these can easily be edited.</i></p>  |              |
| A2:6.2.1.d | <p><b>E</b> The passenger information system shall have the ability to send manual and pre-defined messages from the Wayside to any Trainset or Trainsets in multiple to be played in the speakers and shown on the information displays.</p>  |              |

## Exhibit A02: SOW Technical

| Id         | Requirement   | Referring to                       |
|------------|---|------------------------------------|
| A2:6.2.1.e | <p><b>K</b> The passenger information system shall have a text to speech functionality that allows text to be announced as audio and it shall be available for use onboard and from the Wayside.</p> <p><i>The Tenderer shall demonstrate compliance by describing how this functionality will work both on board and on the Wayside highlighting how the voice and sound libraries can be updated.</i></p>   |                                    |
| A2:6.2.1.f | <p><b>E</b> The control of each display shall be independent from other displays (Individual addressing of displays) to enable unique information on one display or a group of displays e.g. all displays in one Train or Coach.</p> <p><i>The Tenderer shall demonstrate compliance by describing how the displays can be individually controlled to enable different information in different areas of the Train, even in coupled Trainsets.</i></p>  |                                    |
| A2:6.2.1.g | <p><b>K</b> The passenger information system shall be able to provide both audible and visual information in multiple languages, where information in one language is presented after the other. It shall be possible to use colors and pictograms. At least Norwegian and English language shall be supported.</p> <p><i>The Tenderer shall demonstrate compliance by describing how both visual and audible information in several languages is presented.</i></p>  |                                    |
| A2:6.2.1.h | <p><b>K</b> The displays shall at least be able to show the letters and characters included in character set ISO 8859-15 and ISO 8859-4 or UTF-8 or equivalent for Norwegian, Sami, and English and all other Western European languages.</p> <p><i>The Tenderer shall demonstrate compliance by describing which character sets that are supported.</i></p>  | ISO 8859-15<br>ISO 8859-4<br>UTF-8 |
| A2:6.2.1.i | <p><b>K</b> It shall be possible to customize the colors, background, and layout, etc. of the information screens/display to support the need of different Train Operators and their design program. The customization shall be possible to install from the Wayside. It shall be possible for Norske Tog or the Train Operator to do this without support from the Contractor.</p> <p><i>The Tenderer shall demonstrate compliance by delivering examples of possible customizations and how these relates to the TSI PRM.</i></p> | TSI PRM                            |
| A2:6.2.1.j | <p><b>E</b> It shall be possible in the Trainset to test centrally the displays, loudspeakers, system functionalities and automatic route information.</p>  |                                    |
| A2:6.2.1.k | <p><b>K</b> When information is announced both visually and audibly, the visual information shall be synchronized with the audio regardless if the audio is triggered by manual, pre-programmed (i.e. pre-defined) or automatic operation.</p>  |                                    |

# Exhibit A02: SOW Technical

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.2.1.l | <p data-bbox="376 268 1727 336"><b>E</b> The Operational Personnel shall be able to trigger pre-defined messages stored in the passenger information system the following ways:</p> <ul data-bbox="423 341 853 443" style="list-style-type: none"><li data-bbox="423 341 577 371">• Only audio</li><li data-bbox="423 376 853 406">• Both audio and visual information</li><li data-bbox="423 411 725 443">• Only visual information</li></ul> <p data-bbox="423 464 1800 528"><i>The Tenderer shall demonstrate compliance by describing the functionality of pre-defined messages and stating the limitations of the number of messages the system can handle.</i></p> |              |

# Exhibit A02: SOW Technical

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.2.1.m | <p><b>E</b> The Contractor shall at every Design Review provide a sub-system description for the passenger information system containing at a minimum the following information:</p> <ul style="list-style-type: none"> <li>• System design, main components and functions</li> <li>• List of Standards and parts of Standards that the passenger information system comply to</li> <li>• Trainset and Vehicle integration of the passenger information system</li> <li>• System software building blocks including user interfaces for Driver, Crew, maintainers, etc.</li> <li>• Interfacing the Norske Tog and Train Operator functions using data service for timetable, Train position, arrival/departure etc.</li> <li>• System functionality including possibilities and limitations provided by the system in normal service and fault modes, including how joining and splitting Trainsets are handled.</li> <li>• How automatic and manual system initialization works</li> <li>• How it is ensured that the system is always using the newest version of the Train timetable and how it can be updated while running</li> <li>• System performance including a preliminary visibility study of interior and external displays, timing and accuracy of automatic broadcasts triggered by e.g. location, speed etc.</li> <li>• System integration with other relevant systems for passenger information e.g. PIS, seat reservation, passenger counting</li> <li>• Description of how priority between different information from different sources is handled</li> <li>• Description of legibility at different distances and in different light conditions</li> <li>• Concept for hardware and software upgrades</li> <li>• Concept for update of Master Data in the system</li> <li>• Concept for Maintenance of the system, including update of software and update of e.g. new automatic announcements, updated pre-recorded messages, adding station names, update of automatic announcement triggers, etc.</li> <li>• Description of the redundancy concept</li> <li>• Description of text to speech functionality including the quality of the spoken voice in regard to phonetics, articulation and prosody ensuring a natural and fluent sounding speech in standard language</li> <li>• How the system supports the passenger experience and wayfinding</li> <li>• Visual concept that shows all displays and describes what type of information can be shown on each display type without scrolling and location of each display.</li> </ul> |              |
|            | <p><i>The Tenderer shall demonstrate compliance by submitting a preliminary system description at least containing the information requested in this requirement.</i></p>  |              |

# Exhibit A02: SOW Technical

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.2.1.n | <p><b>E</b> Delivered software for content creation like timetable information shall be able to import infrastructure information and timetable information in the railML_nor format.</p> <p><a href="https://www.railml.org/en/">https://www.railml.org/en/</a><br/> <a href="https://www.jernbanedirektoratet.no/no/om-oss/railml/railml/">https://www.jernbanedirektoratet.no/no/om-oss/railml/railml/</a></p> <p><i>The Tenderer shall demonstrate compliance by describing how the solution is achieved and maintained.</i></p>   | railML       |
| A2:6.2.1.o | <p><b>E</b> .... Norwegian SIRI 2.0 profile, part of SIRI/NeTEX, ....</p> <p>Estimated Timetable (ET)<br/>           Situation Exchange (SX)<br/>           Vehicle Monitoring (VM)</p> <p><a href="https://enturas.atlassian.net/wiki/spaces/PUBLIC/overview">https://enturas.atlassian.net/wiki/spaces/PUBLIC/overview</a><br/> <a href="https://enturas.atlassian.net/wiki/spaces/PUBLIC/pages/637370420/Norwegian+SIRI+profile">https://enturas.atlassian.net/wiki/spaces/PUBLIC/pages/637370420/Norwegian+SIRI+profile</a></p> <p><i>The Tenderer shall demonstrate compliance by describing how the solution is achieved and maintained.</i></p> | SIRI/NeTEX   |

## 6.2.1.1 PIS exterior displays

| Id           | Requirement   | Referring to                |
|--------------|---|-----------------------------|
| A2:6.2.1.1.a | <p><b>I</b> To avoid light disturbance from the Trainset at night, the external displays shall only show information when the Trainset is nearby a station area with a planned stop. Information on the displays shall be activated/deactivated a predefined configurable distance before/after a planned stop.</p> |                             |
| A2:6.2.1.1.b | <p><b>E</b> The Tenderer shall give a general system description.</p> <p><i>The Tenderer shall describe their solution in detail and as a minimum include the following:<br/>           system design, main components and function and vehicle integration</i></p>   |                             |
| A2:6.2.1.1.c | <p><b>I</b> Additional requirements</p>   | A1:3.6 Passenger experience |

# Exhibit A02: SOW Technical

## 6.2.1.2 PIS interior screens

| Id           | Requirement   | Referring to                |
|--------------|---|-----------------------------|
| A2:6.2.1.2.a | <b>E</b> The Tenderer shall give a general system description.<br><i>The Tenderer shall describe their solution in detail and as a minimum include the following: system design, main components and function and vehicle integration</i> |                             |
| A2:6.2.1.2.b | <b>I</b> Additional requirements  | A1:3.6 Passenger experience |

## 6.2.2 Wayfinding

| Id         | Requirement   | Referring to                |
|------------|---|-----------------------------|
| A2:6.2.2.a | <b>I</b> Requirements can be found in referred Exhibit. | A1:3.6 Passenger experience |

## 6.2.3 Seat Reservation System (SRS)

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.2.3.a | <b>I</b> Possibility to reserv seats and sleeping beds   |              |
| A2:6.2.3.b | <b>K</b> All seats and sleeping beds, including folding seats and locations for wheelchairs shall have seat numbering for the seat reservation system.<br><i>The Tenderer shall demonstrate compliance by describing how the seat number is visualized.</i>                                |              |
| A2:6.2.3.c | <b>E</b> All seating places shall have an indication if the seat or sleeping bed is reserved or not.<br><i>The Tenderer shall demonstrate compliance by describing the solution for informing passengers about seat reservation.</i>   |              |
| A2:6.2.3.d | <b>E</b> The Trainset shall have possibility to reserv place for bicycles and prams, with numbering from the seat reservation system.<br><i>The Tenderer shall show compliance by describing how the place reservation number for bicycles and prams is visualized for the passengers.</i> |              |

## 6.3 Train external communication

| Id       | Requirement   | Referring to |
|----------|---|--------------|
| A2:6.3.a | <b>I</b> A key part of the Train external communication is the concept of mobile carrier bundling. This technique is used to ensure seamless coverage especially in rural and mountainous areas through the utilization of several Mobile Network Operators (MNOs). In Norway coverage from the three current Norway Mobile Network Operators (currently Telia, Telenor and ICE) are bundled together ensure the maximum connectivity |              |

### 6.3.1 IT-Connectivity

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:6.3.1.a | <b>K</b> The Trainset IT System shall ensure that all onboard Train functionality shall operate irrespective of whether there is a connection to the Wayside or not.   |              |
| A2:6.3.1.b | <b>K</b> The Trainset IT Systems shall have the functionality to handle packet loss and communication interruption in real time such that communications (in particular but not limited to voice and video communication) are not interrupted for connection loss of up to 30 seconds.   |              |
|            | Note, the real time in this case focuses that action is taken without delay.   |              |
| A2:6.3.1.c | <b>E</b> The Trainset IT Systems shall have open interfaces based on generally accepted standards and formats (e.g., LTE, 5G, RailML, SIRI 2.0 Norwegian Profile etc) for the communication interface between the Trainset and the Wayside to exchange real time information such as timetable, Trainset status, seat reservation etc. |              |
|            | <i>The Tenderer shall describe their solution for this requirement stating which format(s) their solution will use. Any compression or bundling shall be described.</i>  |              |

## 6.3.2 Communication design and integration

### 6.3.2.1 IT System Infrastructure

| Id           | Requirement  | Referring to  |
|--------------|--|---------------|
| A2:6.3.2.1.a | <p><b>I</b> This chapter refers to the physical IT network on the Trainset and on the Wayside containing the switches, cables, routers, gateways etc. This infrastructure supports the implementation of an architecture where the functionality described in this technical specification can be implemented. Please see an example of a generic IT System Architecture in System Architecture Diagram (Appendix A2-7) that should help understand the grouping of requirements within this document. This architecture also shows one of many ways how trainset functionality can be grouped /separated based on various assessments allowing for flexibility for future updates and upgrades. The System Architecture Diagram shows an architecture with an onboard network that is separate to the Trainset network and is referred to as Operator Network. This network is intended for functions that are independent from the Train operations such as WiFi and Operator specific functionality such as control of certain onboard systems as well as ticket checking and connecting to Norske tog Wayside services. It is Norske tog intention to utilize contracts with multiple available mobile operators (at least 3) to support the data transfer of all data from the Trainsets to the Wayside. This intention is shown in a System Architecture Diagram (Appendix A2-6).The requirements in this section aim at ensuring an IT System that is modern, contains a flexible architecture, and integrates technical solutions addressing common railways issues.</p> | Appendix A2-7 |
| A2:6.3.2.1.b | <p><b>K</b> The Contractor shall deliver an integrated IT System, consisting of software and hardware, that encompasses both the Trainset and the Wayside and shall monitor and manage the functions of the Trainset to deliver the functionality as specified in this specification.</p> <p><i>The Tenderer shall demonstrate compliance by delivering a system description.</i></p>  |               |
| A2:6.3.2.1.c | <p><b>E</b> The Contractor shall deliver an IT System for the Trainset that is flexible, robust, simple, secure, efficient and with a future-proof design enabling future upgrades.</p> <p><i>The Tenderer shall demonstrate compliance by describing the principles and building blocks of the solution. The Tenderer shall note that this requirement is focused on the security of the IT System itself with regards to the design and robustness.</i></p>  |               |
| A2:6.3.2.1.d | <p><b>E</b> The Trainset IT System onboard should support a service-oriented approach for sharing of data and services between the systems.</p> <p><i>The Tenderer shall demonstrate compliance by describing how the IT System supports a modular approach to design and integration of the various systems (principle of loosely coupled systems)</i></p>  |               |

# Exhibit A02: SOW Technical

| Id           | Requirement  | Referring to       |
|--------------|--|--------------------|
| A2:6.3.2.1.e | <p><b>E</b> The Trainset IT Systems should have a margin in the performance to ensure that all systems within can be fully functional fulfilling the requirements without limitations.</p> <p><i>The Tenderer shall demonstrate compliance by providing a detailed description including as an example the calculation of the bandwidth required, spare capacity and describing why the available bandwidth is enough. Any limitations must be clearly described</i></p>   |                    |
| A2:6.3.2.1.f | <p><b>K</b> The Trainset IT System shall be designed in a way that supports changes and updates of non-safety related functionality without effect on trainset homologation.</p> <p><i>The Tenderer shall demonstrate compliance by describing how the implemented functionality within the Trainset IT System has been risk assessed and separated within the implementation. As an example, what type of separation has been used (physical or logical) and motivation for this or how station names can be changed in the PIS system without extensive retesting.</i></p> |                    |
| A2:6.3.2.1.g | <p><b>E</b> The Ethernet back bone for the Trainset IT System shall have the capability of deploying VLANs across the whole Trainset.</p> <p><i>The Tenderer shall demonstrate compliance by providing a description of their system including any limitations.</i></p>  |                    |
| A2:6.3.2.1.h | <p><b>E</b> The Trainset IT System Infrastructure shall be built using proven technology as well as supported and standardized hardware and software environments.</p> <p><i>The Tenderer shall demonstrate compliance by describing what standard hardware and software environments are used in the proposed Trainset IT System Infrastructure and why these are considered proven. The Tenderer shall describe if the hardware or software can be replaced by a similar product from another supplier.</i></p>  |                    |
| A2:6.3.2.1.i | <p><b>E</b> The Trainset IT System shall contain a separate network with wireless connectivity that is independent of the Trainset Operation Network.</p> <p><i>The Tenderer shall demonstrate compliance by describing the Trainset IT System Infrastructure showing how this separate private network is independent from the Trainset Operation Network and how it can be used for non-operational services such as public WiFi.</i></p>  | Exhibit A2: 16.1.5 |

# Exhibit A02: SOW Technical

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:6.3.2.1.j | <p><b>K</b> The Contractor shall at every Design Review provide a system description of the Train IT System that contains at a minimum the following information:</p> <ul style="list-style-type: none"> <li>• A preliminary product breakdown structure including all IT components in the Trainset including features, scalability, capacity, security (physical and IT), databases, networks, development status etc. technologies used, including ethernet, hardware, software, etc.</li> <li>• A systems architectural drawing showing the complete Train IT System including networks and interconnections. The drawing must show how systems with different safety integrity are separated in order to avoid operational disturbance and how data exchange between these groups of systems is managed and made secure</li> <li>• How the Train IT System can be supported and serviced at any time during the Trainset Design Life. in accordance with the Supply Agreement.</li> <li>• The proposed bandwidth required to deliver the stipulated performance, and also detailed calculation showing expected bandwidth utilization in particular for communications to the Wayside</li> <li>• How the Train IT System is designed to ensure Availability and Reliability including any implemented redundancy features</li> <li>• Description of the flexibility in the Train IT System including how different architectures can be implemented on the same infrastructure</li> <li>• How the infrastructure can be extended in such way that additional functionality, systems and components can be added, updated or replaced after delivery of the Trainset and during the Design Life</li> <li>• Description of what functionality can be updated, upgraded, changed and how. In other words, the future proofability of the system. This description shall include how the individual parts of the system can be exchanged and updated over the Design Life without impacting the whole system (i.e. carrying out homologation again).</li> <li>• Stating start-up time for the Train IT System including a description of all involved timings and what functionality is available at what time during start up.</li> </ul> <p><i>The Tenderer shall demonstrate compliance by submitting a preliminary system description at least containing the information requested in this requirement</i></p> |              |

## 6.3.2.2 IT Governance and Data Management

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:6.3.2.2.a | <p><b>I</b> The management, collection and analysing of data can serve to support a more efficient trainset operation, realization of energy efficiency, achieving the Maintenance and diagnostic goals. The requirements in this section are to ensure that train operations are efficient and remote management is possible.</p> |              |

# Exhibit A02: SOW Technical

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:6.3.2.2.b | <p><b>K</b> Data produced by the Trainset shall be transferred to the Wayside and be available for Norske tog.</p> <p><i>The Tenderer shall demonstrate compliance by providing a description of what data the Trainset produces. The description must include what kind of data is transferred to the Wayside automatically and what data needs to be requested from the Trainset by the Wayside.</i></p> <p><i>If some data is not available or possible to request, the description shall include an explanation why the data is not available on the wayside and how the data can be transferred to Norske tog.</i></p> |              |
| A2:6.3.2.2.c | <p><b>E</b> The Data Management System on the Trainset should make it possible to refresh data in real time without shutting down/restarting any systems.</p> <p><i>The Tenderer shall demonstrate compliance by providing a detailed description of how the IT System fulfills this, highlighting systems where this may be complicated or not recommended.</i></p>  |              |

## 6.3.2.3 IT Operations

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:6.3.2.3.a | <p><b>I</b> The requirements in this section focus on the operations of the Trainset IT System and Wayside IT System.</p>   |              |
| A2:6.3.2.3.b | <p><b>K</b> The clock of both the Trainset IT System and Wayside IT System shall synchronize both with each other and with a verified global time server via the network time protocol (NTP).</p> <p><i>The Tenderer shall demonstrate compliance by providing a description of how the Trainset IT System and Wayside IT System acquires and maintains its time.</i></p> |              |
| A2:6.3.2.3.c | <p><b>K</b> All systems under control/management of the Trainset IT System shall synchronize their time with the clock of the Trainset IT System.</p> <p><i>The Tenderer shall demonstrate compliance by providing a description of how all systems under control/management of the Trainset IT System acquires and maintains their time.</i></p>                         |              |
| A2:6.3.2.3.d | <p><b>K</b> All systems under control/management of the Trainset IT System and Wayside IT System shall be capable of automatically compensating for daylight saving time.</p>   |              |

## Exhibit A02: SOW Technical

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:6.3.2.3.e | <p><b>E</b> The Trainset IT System and Wayside IT System should ensure easy access to sufficient logging- and trace-functionality for any Fault finding or audit activities of the system. The log must be protected against unauthorized changes and deletion.</p> <p><i>The Tenderer shall demonstrate compliance by providing a description of the logging system. This description shall also include how the logs from the various systems are combined to single source with keys that allow for combination.</i></p>   |              |
| A2:6.3.2.3.f | <p><b>E</b> The Trainset IT System shall provide central connection point(s) on-board where services (including but not limited to maintenance, troubleshooting, functional tests, data monitoring and analysis, downloading of failure logs and statistic reports, and software upgrading) on the various onboard systems can be carried out without connecting to each system individually. Norske tog acknowledge that upgrade of some of the software components (e.g. software for safety critical devices) is only possible locally in the Trainset. This requirement is valid for all subsystems except the repeater subsystem, ref X.</p> <p><i>The Tenderer is to demonstrate compliance by describing the service concepts for the various sub systems detailing remote functionality, local functionality, and systems where this is not possible including the justification. The Tenderer shall describe how the safety and security level is preserved.</i></p> |              |
| A2:6.3.2.3.g | <p><b>E</b> The Trainset IT System and Wayside IT System Architectures shall ensure that data on the performance of the network is available in real time.</p> <p><i>The Tenderer shall demonstrate compliance by providing a description of the system highlighting which performance parameters are available. Clarification of real time in this context shall be included.</i></p>  |              |
| A2:6.3.2.3.h | <p><b>K</b> The Trainset IT System and Wayside IT System shall have the functionality for self-testing and reporting of errors.</p> <p><i>The Tenderer shall demonstrate compliance by describing the various levels of errors in the system.</i></p>   |              |
| A2:6.3.2.3.i | <p><b>E</b> The Trainset IT System and Wayside IT System Architectures shall ensure that errors in one part of the system do not propagate and transfer to another part of the system.</p> <p><i>The Tenderer shall demonstrate compliance by describing the system functions that ensure that functional failures in one part of the network does not spread.</i></p>  |              |

## Exhibit A02: SOW Technical

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:6.3.2.3.j | <p><b>K</b> The Contractor shall deliver all test and condition monitoring software, and any special equipment required to send, receive, process, configure, print and interpret system and test data, test, fault diagnosis and repair of the Trainset IT System and Wayside IT System.</p> <p><i>The Contractor shall demonstrate compliance by describing what special tools are needed to carry out, review and interpret test data.</i></p> |              |

### 6.3.2.4 Interface to third party systems

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:6.3.2.4.a | <p><b>E</b> The Contractor should provide a description of how the Supplier intends to manage the interface to third party systems.</p> <p><i>The Tenderer shall demonstrate compliance by describing the Verification and Validation process for functions that involves a third party outside the Supplier's scope. The description shall include the need for any equipment for end-to-end testing including to Norske Tog Wayside systems.</i></p> |              |
| A2:6.3.2.4.b | <p><b>E</b> Application life cycle management should be applied to the various software within the IT System.</p> <p><i>The Tenderer shall demonstrate compliance by describing how they have and intend to apply a software management process for all software within the delivery.</i></p>  |              |

### 6.3.3 On-board repeater stations

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:6.3.3.a | <p><b>I</b> Development of infrastructure along the tracks and implementation of onboard repeater system will give travellers the expected coverage and capacity of telecommunication onboard the trains.</p>   |              |
| A2:6.3.3.b | <p><b>K</b> The Supplier shall deliver a repeater system in the trains that shall ensure that the cellular phone service currently available (including (3G), 4G, GSM-R and 5G is available to a suitable level for making calls all the cellular operators (Currently Telia, Telenor, ICE (operators with physical networks))</p> <p><i>The Tenderer shall deliver a presentation and drawing of the repeater train infrastructure according to the requirement. The train infrastructure installation documentation should include specifications of: Outside pickup antennas and cabling. Leaky feeders/indoor antennas. Cables and connections through cars. Installation of power supply and cabling. Preparation of mounting place for repeater(s).</i></p> |              |

# Exhibit A02: SOW Technical

| Id                             | Requirement  | Referring to  |
|--------------------------------|--|---------------|
| A2:6.3.3.c                     | <p><b>K</b> The repeater system shall support all current frequency bands in Norway (700MHz(Q2-2021), 800MHz, 900MHz/900GSMR, 1800MHz, 2100MHz, and 2600MHz) as well as the future technologies</p> <p><i>Information about frequency allocations and future frequencies can be found at Norwegian communications authority (Nkom) frequency compass is a roadmap for frequency bands for mobile communication and 5G</i><br/> <a href="https://www.nkom.no/teknisk/frekvens/frekvensstrategi/frekvenskompass/_attachment/34516?_ts=163d3b267b2">https://www.nkom.no/teknisk/frekvens/frekvensstrategi/frekvenskompass/_attachment/34516?_ts=163d3b267b2</a></p>   |               |
| A2:6.3.3.d                     | <p><b>K</b> The Contractor shall at every Design Review provide a system description of the Repeater System that contains at a minimum the following information:</p> <ul style="list-style-type: none"> <li>• MiMo capability</li> <li>• How the system can be upgraded in the future</li> <li>• How the system supports filtering including Software-Defined Digital Filtering</li> <li>• How the system supports non-contiguous Sub-bands (200kHz-20MHz) per band and per repeater.</li> <li>• Technical datasheet including power settings, isolation and gain settings, signal quality level, Fast Automatic Gain Control,</li> <li>• Synthesized Frequency Hopping, GPS Dynamically Controlled Settings, propagation delays etc</li> </ul> |               |
| <b>6.3.4 GSM-R Radio (CCO)</b> |  |               |
| <b>6.3.4.1 General</b>         |  |               |
| Id                             | Requirement  | Referring to  |
| A2:6.3.4.1.a                   | <p><b>I</b> The Trainset shall be fitted with equipment delivered approved GSM-R train radio to enable voice communication between the train crew, traffic control and train crews in other trains. This includes:</p> <ul style="list-style-type: none"> <li>- Central Cab radio (radio to be used by the train driver)</li> <li>- DMI (Driver-machine Interface module in drivers cabin)</li> <li>- Roof antennas</li> <li>- RF cabling</li> <li>- Cab radio-DMI cable connections</li> <li>- Power supply</li> </ul>  |               |
| A2:6.3.4.1.b                   | <p><b>M</b> The Contractor shall install and integrate all delivered GSM-R Cab radio onboard equipment in Trainset.</p>  | Appendix A2-8 |

# Exhibit A02: SOW Technical

## 6.3.4.2 Installation requirements

| Id           | Requirement  | Referring to   |
|--------------|--|--|
| A2:6.3.4.2.a | <p><b>E</b> The Tender shall document compliance with the requirements for the cab radio systems interfaces:</p> <ul style="list-style-type: none"> <li>• UIC 568: Passengers addressing and intercom,</li> <li>• Ethernet LAN</li> <li>• Digital input - digital output</li> <li>• Service and diagnostics interface</li> </ul> <p><i>The Tenderer shall document the interface specifications for:</i></p> <ul style="list-style-type: none"> <li>• Power interfaces central unit</li> <li>• MMI interface</li> <li>• Backplane interface central unit</li> <li>• Antenna connections</li> <li>• UIC interface</li> <li>• PA interface</li> <li>• I/O ports</li> <li>• RS ports</li> <li>• OTA</li> <li>• Service and diagnostic interface</li> <li>• Bus/Ethernet interfaces</li> <li>• Train interfaces</li> </ul> | UIC 568  |
| A2:6.3.4.2.b | <p><b>E</b> The Tenderer shall install the cab radio systems accordig to environmental standards:</p> <p>EN/IEC 60068-2-3 Damp, heat, steady state<br/>           EN/IEC 60068-2-6 Vibration ( sinusoidal)<br/>           EN/IEC 60068-2-27 Shock<br/>           EN/IEC 60068-2-29 Bump</p> <p><i>The Tenderer shall document compliance with the requirement.</i></p>   | EN/IEC 60068-2-3<br>EN/IEC 60068-2-6<br>EN/IEC 60068-2-27<br>EN/IEC 60068-2-29 |

# Exhibit A02: SOW Technical

| Id           | Requirement   | Referring to   |
|--------------|---|--|
| A2:6.3.4.2.c | <p><b>E</b> The Tenderer shall install the cab radio systems according to electromagnetic immunity standards:</p> <ul style="list-style-type: none"> <li>EN 50121-1 General</li> <li>EN 50121-3-1 EMU- Train and complete coach</li> <li>EN 50121-3-2 EMU- Apparatus</li> <li>EN 50121-4 Emission and immunity of signalling and telecommunications apparatus.</li> </ul> <p><i>The Tenderer shall document according to standard</i></p> | <p>EN 50121-1<br/>EN 50121-3-1<br/>EN 50121-3-2<br/>EN 50121-4</p> |
| A2:6.3.4.2.d | <p><b>E</b> UIC- leaflet 651 Layout of driver's cabs in locomotives, railcars, multiple unit EMU and driving trailers.</p>  |  |

## 6.3.4.3 Maintenance requirements

| Id           | Requirement  | Referring to            |
|--------------|--|-------------------------|
| A2:6.3.4.3.a | <p><b>E</b> Maintainability requirements to be delivered:</p> <ul style="list-style-type: none"> <li>- Spare parts delivery for maintainability requirements.</li> <li>- Service and maintainability instructions and documentation</li> <li>- Operations manual</li> <li>- Operating tool for Configuration, Update and diagnosis</li> <li>- Specific and / or principal requirements, minimum inspection interval, time consumption for inspection and replacement.</li> <li>- Specification for SIM card administration and SIM card swap for maintenance.</li> </ul> <p>This requirement shall be read in conjunction with Exhibits A05-1 to A05-5.</p> <p><i>The Tenderer should deliver according to the maintainability requirements, and document: OTA capability, Software update procedures, Configuration settings, Surveillance of performance and fault detection, Operating functions.</i></p> | Exhibits A05-1 to A05-5 |

## 6.3.4.4 Approval

| Id           | Requirement  | Referring to           |
|--------------|--|------------------------|
| A2:6.3.4.4.a | <p><b>K</b> Approval of the Railway-dedicated onboard communication system</p> <p>The railway-dedicated onboard communication system requires APIS approval from European Railway Authority. All necessary documentation for this approval must be delivered.</p> <p><i>The Tenderer shall deliver approval and all necessary documentation for ERA APIS approval.</i></p> | Appendix A2-8 clause 8 |

## Exhibit A02: SOW Technical

| Id           | Requirement   | Referring to |
|--------------|---|--------------|
| A2:6.3.4.4.b | <p><b>K</b> Commissioning documentation must be sent to Bane NOR, SIM-card provider.<br/>Bane NOR will approve the installed prototype enrolment in GSMR network, and this approval will document certificate of National approval<br/>The installation on each vehicle must be enrolled in Bane NOR's GSMR network<br/>Installation documentation like manufacturing record book (reports from each as built installation) where validation of the installation must be documented.</p> <p><i>The Tenderer shall deliver documentation according to requirement. The Tenderer shall deliver National approval.</i></p> |              |

## 7 Train control

### 7.1 Train Control and Management System (TCMS)

| Id       | Requirement   | Referring to |
|----------|---|--------------|
| A2:7.1.a | <b>E</b> The TCMS shall use open or known (made available for the customer) protocols for communication.<br><i>The Tenderer shall describe the protocols being used to integrate all devices in offered solution.</i>   |              |
| A2:7.1.b | <b>K</b> The Trainset shall be able to manage permanent and temporary failure in sub-systems.<br><i>The Tenderer shall demonstrate compliance by describing the redundancy concept, exclusion of functionality at failure and what impact loss of functions have on Train in operation.</i> |              |

#### 7.1.1 Train state data

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:7.1.1.a | <b>E</b> Basic trainset status shall be logged onboard and made available in real time on the Wayside to enable tracking and understating of the Trainset status.<br>Basic trainset data shall include at least, but not limited to: <ul style="list-style-type: none"> <li>• Positioning information including source and quality information</li> <li>• Trainset ID</li> <li>• Speed</li> <li>• Time</li> <li>• Last station</li> <li>• Next station</li> <li>• Status for subsystems</li> <li>• Battery voltage for each battery</li> <li>• Inside temperature for each coach in the Trainset</li> <li>• Outside temperature</li> </ul> <i>The Tenderer shall describe their solution for this requirement detailing data that can be provided by the offered system. The Tenderer shall also describe how the data is made available on the Wayside.</i> |              |

## Exhibit A02: SOW Technical

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:7.1.1.b | <p><b>E</b> The transfer interval for each train state data or groups of data shall be configurable from the Wayside. A configurable transfer interval can be omitted if all train state data is transmitted to the Wayside in near real-time and with a low utilization of bandwidth.</p> <p><i>The Tenderer shall describe and justify their solution for this requirement stating the transfer interval and which train state data that is sent to the Wayside.</i></p>   |              |
| A2:7.1.1.c | <p><b>E</b> All diagnostic or event data shall at least be tagged with environmental information that provides additional insight into the event. All diagnostic events shall also be tagged with a general set of environmental data equal for all events.</p> <p>Environmental information data onboard shall include at least, but not be limited to:</p> <ul style="list-style-type: none"> <li>• Time stamp (occur and disappear)</li> <li>• Outside temperature</li> <li>• Positioning information</li> <li>• Trainset ID</li> <li>• Train running number</li> <li>• Master controller position</li> <li>• Requested and achieved traction effort</li> <li>• Requested brake and achieved brake</li> </ul> <p><i>The Tenderer shall demonstrate compliance by providing a description of which data can be delivered by the offered solution as well as clarify how information such as Trainset ID, train running number and trainset configuration can be deduced from the diagnostic data provided.</i></p> |              |
| A2:7.1.1.d | <p><b>K</b> The on-board system shall be equipped with a system equipment for determining positioning information both in open air and tunnels. The system shall support at least 2 positioning information systems available in Norway.</p> <p><i>The Tenderer shall describe the solution to meet this requirement and which systems are supported, noting that the proposed routes have several tunnels and areas where satellite positioning information is not available, and providing details of how this is handled and which positioning systems are supported.</i></p>   |              |

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| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:7.1.1.e | <p><b>E</b> All positioning information (location data) shall be sent to the Wayside and be available in close to real time.</p> <p><i>The Tenderer shall demonstrate compliance by providing a description of how often the positioning information is sent to the Wayside and if the interval is configurable.</i></p>  |              |
| A2:7.1.1.f | <p><b>E</b> The format of the position data (location data) including but not limited to, orientation, driving direction, train running number, speed and the distance from last station of the Trainset shall be defined during the Design Phase.</p> <p><i>The Tenderer shall demonstrate compliance by describing the protocol, file format and transfer mechanism used.</i></p> |              |

## 7.1.2 Train data recording

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:7.1.2.a | <p><b>K</b> All Trainsets shall be equipped with a Train data recording device (“Black box”), separate from the ETCS juridical recording unit, that is compliant to EN 62625-1</p> <p><i>The Tenderer shall demonstrate compliance by describing the solution and stating the Standard, version of the Standard and any deviations from the Standard that the train data recording comply to. The Tenderer shall state any deviations between the used Standard and EN 62625-1:2013+A11:2017 (i.e. including Amendment A11) if another Standard is used.</i></p> |              |
| A2:7.1.2.b | <p><b>K</b> The final list of data to be recorded shall be defined during the Design Phase.</p>  |              |
| A2:7.1.2.c | <p><b>K</b> The Contractor shall deliver Equipment (special hardware and/or software tool if necessary) to download the train recorder data and make the data available throughout the lifetime of the train recorder.</p>   |              |
| A2:7.1.2.d | <p><b>E</b> The recorded data shall be transferred wirelessly to the Wayside.</p> <p><i>The Tenderer shall demonstrate compliance by describing the wireless transmission of the train data recording data, including if the data is transferred immediately or in batches including the frequency.</i></p>  |              |

## 7.1.3 Coach Configuration System

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:7.1.3.a | <p><b>I</b> The Coach Configuration System (CCS) is to meet the Trainset need to be flexible and easy adapt to different operational scenarios and coach configurations during the day, in terms of e.g. PA volume and content, lighting level and temperature.</p> <p>This makes a shorter time when preparing the Trainset after re-configuration (de-coupling/coupling).</p> |              |

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| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:7.1.3.b | <p><b>E</b> The Coach Configuration System (CCS) should adapt the passenger experience and optimize the comfort for the passengers in respective Coach, e.g. by customizing and adapting the: passenger information, interior lighting, temperature, PA and advertisement.</p> <p><i>The Tenderer shall demonstrate compliance by describing how the Coach configuration system can be adapted and which adaptations are possible with the offered solution.</i></p>  |              |
| A2:7.1.3.c | <p><b>K</b> The Trainset shall be capable of offering a Coach Configuration type per coach.</p> <p><i>The Tenderer shall describe how the Coach Configuration types that can be configured.</i></p>   |              |
| A2:7.1.3.d | <p><b>E</b> It should be easy to modify the parameters defining the Coach Configuration type from the Wayside or a mobile app.</p> <p><i>The Tenderer shall describe the procedure for modifying Coach Configuration parameters, the flexibility and any restrictions.</i></p>  |              |
| A2:7.1.3.e | <p><b>E</b> There should be either a fixed or mobile solution for updating the coach configuration onboard such that the train personnel does not have to move coaches to adjust the parameters in a coach except in the case of a redundancy is activated</p>  |              |
| A2:7.1.3.f | <p><b>E</b> Changing the Coach Configuration System in each coach should not require any hardware modifications and be possible to perform from the Wayside or onboard, multiple times each day.</p> <p><i>The Tenderer shall describe how the Coach Configuration System will be configured both from the Wayside and onboard in case of loss of communication to the Wayside. In addition, state how the Coach Configuration System will be controlled and how long it will take to re-configure.</i></p> |              |

### 7.1.4 Operational concept

#### 7.1.4.1 Modes of operation

| Id           | Requirement  | Referring to               |
|--------------|--|----------------------------|
| A2:7.1.4.1.a | <p><b>I</b> Requirements can be found in referred Exhibit.</p> | A1:3.5 Operator experience |

## 7.1.4.2 Side view, rear view and front-facing cameras

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:7.1.4.2.a | <p><b>I</b> Side- and rear view cameras together with front-facing cameras viewing the tracks is used during operation of the Trainset and during shifting movements. The system is a part of the Trainset IT System</p> <p>In addition, a front-facing camera shall be mounted in each driver's cab showing the track at the front of the Trainset similar to the driver's view</p>   |              |
| A2:7.1.4.2.b | <p><b>K</b> The Trainset shall be supplied with side-view cameras to view the sides of the Trainset. In addition, a front-facing camera shall be mounted in each driver's cab showing the track at the front of the Trainset similar to the driver's view.</p> <p><i>The Tenderer shall demonstrate compliance by describing the solution. Including how the content of the screen can clearly be seen under all external light conditions and how the light brilliance of the display can be adjusted.</i></p>  |              |
| A2:7.1.4.2.c | <p><b>E</b> It shall be possible for the driver to select which camera or cameras that will provide a live picture on the screen mounted in the active and non active driver's cab. The frame-rate shall be of sufficient quality for face recognition and clearly viewable on the display under any external light condition.</p> <p><i>The Tenderer shall demonstrate compliance by describing the solution. Including but not limited to how many live streams can be shown simultaneously on the IDU, what framerate the system delivers and how the content on the IDU is viewable in all light conditions. Any limitation must be clearly described.</i></p> |              |

## 7.1.4.3 Selective door operation (SDO)

| Id           | Requirement  | Referring to |
|--------------|--|--------------|
| A2:7.1.4.3.a | <p><b>E</b> The vehicle shall be equipped with a function that shall ensure that doors located outside the platform is prevented from being opened.</p> <p>It shall be possible to update this system from the Wayside</p> <p><i>The Tenderer shall demonstrate compliance by description of solution of function for selective door operation, that only doors located within the platform is released, and how safety is achieved.</i></p> |              |

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## 7.2 Automatic Train Control (ATC)

### 7.2.1 ERTMS (incl GSM-R) General

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:7.2.1.a | <p><b>I</b> The objective of this comprehensive Automatic Train Protection System is to constantly monitor the train speed and compare it to the maximum values that are sent by trackside signalling. ERTMS is the European standard for ATP that achieves interoperability throughout Europe. It allows trains equipped with an ERTMS onboard system to run on track sections equipped with supplier independent ERTMS trackside signalling system</p> <p>ERTMS consists of two systems.<br/>The ETCS - (European Train Control System), a train control standard, based on onboard equipment able to supervise train movements and to stop it according to the permitted speed at each line section, along with calculation and supervision of the maximum train speed at all times. The driver's response is continuously monitored, and if necessary the emergency brakes would be taken under control. This communication that is needed between onboard and trackside will be provided by means of GSM-R radio connection (operation Level 2). GSM-R (Global System for Mobile Communications - Railways) is the second ERTMS system, the European radio communications standard for railway operations. Based on GSM radio technology, GSM-R uses exclusive frequency bands to communicate the train with traffic control centres, devices beside the track, etc.</p> <p>The migration from the old ATP system, ATC (Automatic Train Control) towards ERTMS (both for Norway and Sweden) will be through a STM unit (Special Transmission Module) so that it will be possible to run trains on infrastructure implemented with both ATC and ERTMS systems.</p> <p>ERTMS onboard equipment will be delivered according to Contract NO.K0112099</p> |              |

### 7.2.2 Alstom ERTMS onboard system (incl GSM-R Radio)

| Id         | Requirement  | Referring to   |
|------------|--|--|
| A2:7.2.2.a | <p><b>M</b> The Contractor shall install and integrate all delivered ERTMS onboard equipment in Trainset.</p>  |  |
| A2:7.2.2.b | <p><b>M</b> The Contractor shall install and integrate in Trainset the free delivered material according to ENIO-ALS Equipment only Attachment 1 - Product Breakdown Structure and ENIO-ALS-GA-D200-SPE-000008_B Installation constrains.</p> <p>The products and datasheets for the Alstom onboard ERTMS system are listed in:<br/>ENIO-ALS Equipment only Attachment 1 - Product Breakdown Structure</p> | <p>Appendix A2-9.1<br/>Appendix A2-9.2<br/>Appendix A2-9.3<br/>Appendix A2-9.4</p> |

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| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:7.2.2.c | <b>K</b> The Trainset shall be able to operate with ERTMS in depot area when divided in Train halves for shunting and workshop purposes. |              |

## 7.2.2.1 ERTMS Cubicle

| Id   | Requirement   | Referring to |
|--|---|--------------|
| A2:7.2.2.1.a   | <b>I</b> ERTMS onboard cubicle will be delivered to train manufacturer for implementation in Trainset as described in Contract NO.K0112099  |              |
| A2:7.2.2.1.b   | <b>K</b> The ETCS equipment inside the Trainset is installed in a cubicle. The electronics of ERTMS are installed in 19-inch racks, and there must be allocated space for these.<br>There are two options for cubicle installation:<br>A. Vertical cubicle<br>B. Modular cubicle<br>Ref. attachment A2-7 – Architectural Description of the ENIO System chapter 5.2 - Draft Cubicle<br>The power supply voltage of all the ETCS components is 24 VDC (nominal).<br>The cubicle shall be supplied with 3 DC/DC converters. |              |
| <p>The Contractor shall install and integrate in trainset the free delivered material according to ENIO-ALS Equipment only Attachment 1 - Product Breakdown Structure and ENIO-ALS-GA-D200-SPE-000008_B Installation constrains.</p> |   |              |
| <p><i>The Tenderer shall deliver documentation on how the ENIO onboard system will be installed and integrated.</i></p>  |   |              |

## 7.2.2.2 Driver Machine interface

| Id           | Requirement   | Referring to    |
|--------------|---|-----------------|
| A2:7.2.2.2.a | <p><b>E</b> The Contractor shall install and integrate in Trainset the free delivered material according to: ENIO-ALS Equipment only Attachment 1 - Product Breakdown Structure</p> <p>The driver's machine interface, DMI, will be delivered to train manufacturer for implementation in trainsets as described in Contract NO.K0112099<br/>The driver's machine interface consists of:</p> <ul style="list-style-type: none"> <li>• 10" display referred to as DMI</li> <li>• Acknowledge button</li> <li>• ETCS isolation switch</li> <li>• STM isolation switch</li> <li>• ETCS reset button</li> <li>• Loudspeaker</li> </ul> <p>The driver's cabin equipment is listed in attachment: Appendix A2-9.2 chapter 5.9<br/>The design of the driver's dashboard must facilitate for allocation of a DMI and components with consideration given to ergonomics, and with reference to Appendix A2-1</p> <p><i>The Tenderer shall deliver documentation on how the ENIO onboard system will be installed and integrated.</i></p> | Appendix A2-9.2 |
| A2:7.2.2.2.b | <p><b>E</b> The installed driver's machine display and IDU must provide readability for the driver with regards to visibility, reading angle, and contrast in all external light conditions.</p> <p><i>The Tenderer shall demonstrate compliance by describing the visibility of the DMI and IDU. This shall include, but is not limited to:</i></p> <ul style="list-style-type: none"> <li>- <i>Visibility,</i></li> <li>- <i>Visible range,</i></li> <li>- <i>Ambient light conditions</i></li> <li>- <i>Brightness</i></li> <li>- <i>Resolutions</i></li> <li>- <i>Reading angle DMI</i></li> <li>- <i>How the light of the display can be adjusted</i></li> </ul>   |                 |

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## 7.2.2.3 The GSM-R sub-system

| Id  | Requirement  | Referring to   |
|---|--|--|
| A2:7.2.2.3.a  | <p><b>E</b> The ERTMS Onboard Sub-System GSMR will be delivered to train manufacturer for implementation in trains as described in Contract NO.K0112099</p> <p>The Tenderer shall deliver implemented equipment and all documentation of installation.<br/>The GSM-R subsystem consists of:</p> <ul style="list-style-type: none"> <li>• GSM-R radio module (installed in the vertical cubicle or in the radio module for modular cubicle).</li> <li>• Two roof antennas</li> <li>• RF cables and connections</li> </ul> <p>Ref. ENIO-ALS Equipment only Attachment 1 - Product Breakdown Structure and ENIO-ALS-GA-D200-SPE-000008_B Installation constrains.</p> | <p>Appendix A2-9.1<br/>Appendix A2-9.2<br/>Appendix A2-9.3<br/>Appendix A2-9.4</p> |
| <p><i>The Tenderer shall deliver documentation on how the ENIO onboard system will be installed and integrated.</i></p> |  |  |

## 7.2.2.4 The eurobalise antennas

| Id  | Requirement  | Referring to   |
|---|--|--|
| A2:7.2.2.4.a  | <p><b>E</b> The euroantenna/balisedata to the ERTMS system will be delivered to train manufacturer for implementation in trains as described in Contract NO.K0112099</p> <p>One antenna shall be mounted under the train body at each end of the vehicle.<br/>The Contractor shall install and integrate in Trainset the free delivered material according to:<br/>ENIO-ALS Equipment only Attachment 1 - Product Breakdown Structure and ENIO-ALS-GA-D200-SPE-000008_B Installation constrains.</p> | <p>Appendix A2-9.1<br/>Appendix A2-9.2<br/>Appendix A2-9.3<br/>Appendix A2-9.4</p> |
| <p><i>The Tenderer shall deliver documentation on how the ENIO onboard system will be installed and integrated.</i></p> |  |  |

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## 7.2.2.5 The odometry sub system

| Id           | Requirement  | Referring to   |
|--------------|--|--|
| A2:7.2.2.5.a | <p><b>E</b> The Odometry sub-system will be delivered to the train manufacturer for implementation in trains as described in Contract NO.K0112099.</p> <ul style="list-style-type: none"> <li>• The Odometry sub-system consists of:               <ul style="list-style-type: none"> <li>• Two wheel sensors</li> <li>• GPS antenna (included in GSM-R antennas</li> <li>• IMU and accelerometers (part of cubicle)</li> </ul> </li> </ul> <p>The Contractor shall install and integrate in Trainset the free delivered material according to: ENIO-ALS Equipment only Attachment 1 - Product Breakdown Structure and ENIO-ALS-GA-D200-SPE-000008_B Installation constrains. Ref. ENIO-ALS Architectural Description of the ENIO System, chapter 5.12</p> <p><i>The Tenderer shall deliver documentation on how the ENIO onboard system will be installed and integrated.</i></p> | Appendix A2-9.1<br>Appendix A2-9.2<br>Appendix A2-9.3<br>Appendix A2-9.4 |

## 7.2.2.6 Data recording sub system

| Id           | Requirement  | Referring to   |
|--------------|--|--|
| A2:7.2.2.6.a | <p><b>E</b> The Contractor shall install and integrate in Trainset the free delivered material according to: ENIO-ALS Equipment only Attachment 1 - Product Breakdown Structure and ENIO-ALS-GA-D200-SPE-000008_B Installation constrains. Ref. ENIO-ALS Architectural Description of the ENIO System chapter 5.13</p> <p>The sub-system recording juridical and diagnostic events, will be delivered to train manufacturer for implementation in trains as described in Contract NO.K112099. External JRU has no interface to the ERTMS system and is not part of the requirement.</p> <p><i>The Tenderer shall present how the installation of the ENIO system are done and describe the placements of components.</i></p> | Appendix A2-9.1<br>Appendix A2-9.2<br>Appendix A2-9.3<br>Appendix A2-9.4 |

## 7.2.2.7 Vehicle interfaces

| Id           | Requirement  | Referring to  |
|--------------|--|---|
| A2:7.2.2.7.a | <p><b>K</b> The vehicle interfaces on the trainset must be compliant with the delivered ENIO onboard system, according to Contract NO.K0112099.</p> <p>The Contractor shall install and integrate in Trainset all free delivered material according to vehicle interface requirements as defined in: ENIO-ALS Equipment only Attachment 1 - Product Breakdown Structure and ENIO-ALS-GA-D200-SPE-000008_B Installation constrains.</p> <p>The interfaces are described in Ref. ENIO-ALS Architectural Description of the ENIO System chapter 5.14</p> <p><i>The Tenderer shall deliver documentation on how the ENIO onboard system will be installed and integrated</i></p> | <p>Appendix A2-9.1</p> <p>Appendix A2-9.2</p> <p>Appendix A2-9.3</p> <p>Appendix A2-9.4</p> |
| A2:7.2.2.7.b | <p><b>K</b> Approval of the ERTMS system</p> <p>The ERTMS onboard system requires APIS approval from European Railway Authority. All necessary documentation for this approval must be delivered.</p> <p><i>The Tenderer shall deliver approval and all necessary documentation for ERA APIS approval.</i></p>   |   |
| A2:7.2.2.7.c | <p><b>E</b> The Tenderer have to fulfil the system and functional specification in EIRENE standard for railway safety systems to document the reliability.</p> <p><i>The Tenderer shall document the reliability with reference to the EIRENE standard for railway safety systems.</i></p>   |   |
| A2:7.2.2.7.d | <p><b>I</b> See all documents in Exhibit A05 with respect to maintainability requirements.</p>   | Exhibits A05-1 to A05-5   |
| A2:7.2.2.7.e | <p><b>K</b> The Tenderer shall deliver National approval.</p> <p>The installation on each vehicle shall be enrolled in BaneNOR's ERTMS system.</p> <p>Part off the MRB.</p> <p><i>The Tenderer shall deliver documentation according to requirement.</i></p> <p><i>Installation documentation like manufacturing record book (reports from each as-built installation) where validation of the installation must be documented.</i></p>  |   |

## 7.2.3 Train Integrity Monitoring System (TIMS)

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:7.2.3.a | <p><b>I</b> To enable operations under ETCS Level 3 each Trainset must monitor its integrity. This section focuses on the requirements for Train Integrity Monitoring System.</p> |              |

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| Id         | Requirement  | Referring to   |
|------------|--|----------------|
| A2:7.2.3.b | <b>E</b> The Trainset shall be equipped with a Train Integrity Monitoring System (TIMS)<br><i>The Tenderer shall demonstrate compliance by describing the concept for the Train Integrity Monitoring System.</i> | Appendix A2-10 |
| A2:7.2.3.c | <b>E</b> The TIMS shall interface the ERTMS onboard system delivered by Alstom   | Appendix A2-10 |

## 7.2.4 Automatic Train Operation ATO

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:7.2.4.a | <b>I</b><br>Consequences of an introduction of ATO for the operational functions, driver desk and for the brake/traction functions to be discussed.<br><br>The train control system and its interfaces shall make it possible to integrate ATO features on a later stage without changing major component and/or hardware or the core control system of the train. |              |
| A2:7.2.4.b | <b>K</b> The Trainset shall be prepared for future ATO over ETCS with minimum grade of automation 2 (GoA2). The Contractor shall deliver TCMS with at least the implementation of subset 139.<br><br><i>The Tenderer shall demonstrate compliance by describing the solution and how the Subset-139 can be implemented for this project.</i>                       |              |
| A2:7.2.4.c | <b>E</b> Tenderer shall explain how the train builder as an option will make preparations and design the train for future grades of Automatic Train Operation (GoA2-GoA3).   |              |

## 8 Coupling and interconnection

### 8.1 Consist coupling

#### 8.1.1 General

| Id         | Requirement  | Referring to |
|------------|--|--------------|
| A2:8.1.1.a | <b>M</b> For fixed units automatic central couplers shall be mounted in both ends of each unit. For locomotive and coaches the coupler solution shall be automatic central couplers. |              |
| A2:8.1.1.b | <b>M</b> Within max specified train length it shall be possible to couple and uncouple all variations of fixed units and coaches.  |              |

#### 8.1.2 Central couplers

| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:8.1.2.a | <p><b>M</b> The central couplers shall be designed and dimensioned to handle all possible train configuration couplings considering:</p> <ul style="list-style-type: none"> <li>- Norwegian weather conditions</li> <li>- All possible passenger loads</li> <li>- All possible train operations</li> </ul> <p>Satisfactory protection against snow and ice is required.</p> <p>The couplers shall be fitted with a system for energy absorbing (non-deformable energy-absorbing elements, permanently deformable elements, gas/hydraulic elements which are able to absorb a certain amount of energy without being damaged).</p> <p>Coupling and un-coupling shall be possible to control from the driver's desk, but manual operation shall also be possible.</p> |              |

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| Id         | Requirement   | Referring to |
|------------|---|--------------|
| A2:8.1.2.b | <p><b>E</b> Proposed coupler solution will be evaluated regarding the ability to ensure satisfactory functionality during all possible operational conditions in Norway including tough winter conditions with snow and ice, low temperatures, collisions with animals and attempted coupling to rolling stock with non-compatible coupler interface:</p> <ul style="list-style-type: none"> <li>- Couplers should be provided with a hatch or similar as cover and protection for mechanical and electrical parts. The coupler hatch or guard should also prevent snow and ice from entering the coupler.</li> <li>- Use of heating in order to avoid freezing problems should be considered.</li> <li>- Electric and data transmission contacts should be protected, have reliable functionality during all operating conditions and be easily pushed away in case of attempted coupling to a non-compatible interface.</li> <li>- Couplers should be fitted with non-deformable energy-absorbing elements, combined with permanently deformable and gas/hydraulic elements which are able to absorb a certain amount of energy without being damaged. The coupler's coach attachment device should be an easily replaced permanently deformable element.</li> </ul> <p>Preferrably the couplers should be of same type (or similar) as the couplers in use on Norske tog's existing fleet today because they are especially adapted to Norwegian winter conditions and experienced in use.</p> |              |
| A2:8.1.2.c | <p><b>M</b> It shall be impossible to uncouple Trainset-units and Trainsets in multiple operation as long as the automatic brake pipe pressure is higher than 2.5 bar. Full pneumatic brake on separate Trainset-units / Trainsets must be ensured before uncoupling is permissible.</p>  |              |
| A2:8.1.2.d | <p><b>M</b> The pneumatic uncoupling cylinder system designed to prevent uncoupling, shall include a leakage nozzle to ensure complete ventilation of the system after use</p>  |              |
| A2:8.1.2.e | <p><b>E</b> Proposed coupler solution will be evaluated regarding automatic and manual coupling procedure for coaches, trainset-units and trainsets. Preferrably trainsets and trainset-units should have an automatic coupling mode with speed control. It should be able to adjust the speed on driver's IDU in 0.5 km/h steps up to max 3-5 km/h.</p> <p><i>The Tenderer shall describe proposed solution so it is possible to evaluate listed requirement issues</i></p>  |              |

## 8.2 Vehicle coupling

### 8.2.1 Intermediate couplers

| Id  | Requirement   | Referring to |
|---|---|--------------|
| A2:8.2.1.a  | <p><b>M</b> Intermediate couplers of type semi-permanent couplers (short couplers), simplified automatic couplers or articulated connections shall be fitted between coaches inside fixed units.<br/>           These couplers shall be designed and dimensioned to handle all possible train configuration couplings considering:</p> <ul style="list-style-type: none"> <li>- Norwegian weather conditions</li> <li>- All possible passenger loads</li> <li>- All possible train operations</li> </ul> <p>Satisfactory protection against snow and ice is required.<br/>           The couplers and included brackets shall be strong enough to carry the gangway between coaches.</p>                                  |              |
| A2:8.2.1.b  | <p><b>E</b> Proposed intermediate coupler solution will be evaluated regarding the ability to ensure satisfactory functionality during all possible operational conditions in Norway including tough winter conditions with snow and ice, low temperatures, collisions with animals, etc:</p> <ul style="list-style-type: none"> <li>- Couplers should be provided with necessary protection for mechanical and electrical parts, and snow and ice should be prevented from entering the coupler.</li> <li>- Electric and data transmission contacts should be protected and have reliable functionality during all operating conditions.</li> <li>- Couplers should be fitted with energy-absorbing elements.</li> </ul> |              |
| <p><i>The Tenderer shall describe proposed solution so it is possible to evaluate listed requirement issues</i></p>   |   |              |
| A2:8.2.1.c  | <p><b>E</b> Proposed intermediate coupler solution will be evaluated regarding manual uncoupling (splitting of a fixed unit) and coupling. The solution should be simple and practical.</p> <p>Uncoupling/coupling include:</p> <ul style="list-style-type: none"> <li>- mechanical uncoupling/coupling including removal/ remounting of gangway, gangway bellow, etc</li> <li>- pneumatic uncoupling/coupling</li> <li>- electrical uncoupling/coupling.</li> </ul>  |              |
| <p><i>The Tenderer shall describe proposed solution so it is possible to evaluate listed requirement issues. In addition max uncoupling and coupling times including mechanical, pneumatic and electric disconnection/connection, shall be specified.</i></p> |   |              |

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## 8.3 Gangway

| Id       | Requirement  | Referring to |
|----------|--|--------------|
| A2:8.3.a | <b>I</b> In case Intermediate automatic couplers are used it is good practise that the Gangway bellow enclose the coupler to avoid issues when the Trainset is running in Norwegian winter conditions.   |              |
| A2:8.3.b | <b>E</b> The Tenderer shall give a general system description.<br><i>The Tenderer shall describe their solution in detail and as a minimum include the following:<br/>           system design, main components and function and vehicle integration</i> |              |

## 9 Wayside IT

| Id     | Requirement   | Referring to |
|--------|---|--------------|
| A2:9.a | <p><b>I</b> The Wayside IT is critical component of the smooth operation of the Trains. The basic operational concept is based on the the real time communication between the Trainsets and the Wayside. This means that the majority of the functionality can be done on the Wayside that allows for a more flexible operation including real time update of journey data such as timetables, passenger information and seat reservations.</p> |              |

### 9.1 General

| Id       | Requirement   | Referring to |
|----------|---|--------------|
| A2:9.1.a | <p><b>K</b> All systems under control/management of the Wayside IT System shall synchronize their time with the clock of the Wayside IT System.</p> <p><i>The Tenderer shall demonstrate compliance by providing a description of how all systems under control/management of the Wayside IT System acquires and maintains their time.</i></p>  |              |
| A2:9.1.b | <p><b>K</b> The Wayside IT Systems shall have the functionality to handle packet loss and communication interruption in real time such that communications (in particular but not limited to voice and video communication) are not interrupted for connection loss of up to 30 seconds.</p> <p>Note, the real time in this case focuses that action is taken without delay.</p>  |              |
| A2:9.1.c | <p><b>E</b> The Wayside IT Systems shall have open interfaces based on generally accepted standards and formats (e.g., LTE, 5G, RailML etc) for the communication interface between the Trainset and the Wayside to exchange real time information such as timetable, Trainset status, seat reservation etc.</p> <p><i>The Tenderer shall describe their solution for this requirement stating which format(s) their solution will use. Any compression or bundling shall be described.</i></p> |              |
| A2:9.1.d | <p><b>K</b> The Contractor shall provide a Wayside controller on the Wayside which shall form Norske tog's and the operators control interface to the Trainset (Supplier's Wayside controller).</p>   |              |
| A2:9.1.e | <p><b>K</b> The Contractor shall provide an interface on the Wayside which shall form Norske tog's and the operators interface from and to the Trainset (Supplier's Wayside Interface).</p>   |              |

## Exhibit A02: SOW Technical

| Id       | Requirement   | Referring to |
|----------|---|--------------|
| A2:9.1.f | <p><b>K</b> The details of the various interfaces on the Wayside to Norske tog systems and any third party (Operators) is to be agreed during the Design Phase.<br/>The identified main interfaces are shown in the System Architecture diagram</p> <p><i>The Tenderer shall show compliance by describing and documenting The interfaces so that future Train Operators can connect their operational systems to the Wayside interface.</i></p>  |              |
| A2:9.1.g | <p><b>E</b> The Contractor shall deliver an IT System for the Wayside that is flexible, robust, simple, secure, efficient and with a future-proof design enabling future upgrades.</p> <p><i>The Tenderer shall demonstrate compliance by describing the principles and building blocks of the solution. The Tenderer shall note that this requirement is focused on the security of the IT System itself with regards to the design and robustness.</i></p>  |              |
| A2:9.1.h | <p><b>E</b> The Wayside IT System onboard should support a service-oriented approach for sharing of data and services between the systems.</p> <p><i>The Tenderer shall demonstrate compliance by describing how the IT System supports a modular approach to design and integration of the various systems (principle of loosely coupled systems)</i></p>  |              |
| A2:9.1.i | <p><b>E</b> The Wayside IT Systems should have a margin in the performance to ensure that all systems within can be fully functional fulfilling the requirements without limitations.</p> <p><i>The Tenderer shall demonstrate compliance by providing a detailed description including as an example the calculation of the bandwidth required, spare capacity and describing why the available bandwidth is enough. Any limitations must be clearly described as well as how this will be implemented with 3 or more operators with different functionality .</i></p> |              |
| A2:9.1.j | <p><b>E</b> TheWayside IT System Infrastructure shall be built using proven technology as well as supported and standardized hardware and software environments.</p> <p><i>The Tenderer shall demonstrate compliance by describing what standard hardware and software environments are used in the proposed Trainset and Wayside IT System Infrastructure and why these are considered proven. The Tenderer shall describe if the hardware or software can be replaced by a similar product from another supplier.</i></p>   |              |

# Exhibit A02: SOW Technical

| Id       | Requirement   | Referring to |
|----------|---|--------------|
| A2:9.1.k | <p><b>E</b> The Data Management System on the Wayside should make it possible to refresh data in real time without shutting down/restarting any systems.</p>  |              |
|          | <p><i>The Tenderer shall demonstrate compliance by providing a detailed description of how the IT System fulfills this, highlighting systems where this may be complicated or not recommended.</i></p>  |              |
| A2:9.1.l | <p><b>E</b> The Wayside IT System shall provide central connection point(s) on the Wayside where services (including but not limited to maintenance, troubleshooting, functional tests, data monitoring and analysis, downloading of failure logs and statistic reports, and software upgrading) on the various onboard systems can be carried out without connecting to each system individually. Norske tog acknowledge that upgrade of some of the software components (e.g. software for safety critical devices) is only possible locally in the Trainset.</p> |              |
|          | <p><i>The Tenderer is to demonstrate compliance by describing the service concepts for the various sub systems detailing remote functionality, local functionality, and systems where this is not possible including the justification. The Tenderer shall describe how the safety and security level is preserved.</i></p>   |              |

# Exhibit A02: SOW Technical

| Id       | Requirement   | Referring to |
|----------|---|--------------|
| A2:9.1.m | <p><b>K</b> The Contractor shall at every Design Review provide a system description of the Wayside IT System that contain at a minimum the following information:</p> <ul style="list-style-type: none"> <li>• A preliminary product breakdown structure including all IT components on the Wayside including features, scalability, capacity, security (physical and IT), databases, networks, development status, etc. for technologies used, including Ethernet, hardware, software, etc.</li> <li>• A systems architectural drawing showing the complete IT System including networks and interconnections. The drawing must show how systems with different safety integrity are separated in order to avoid operational disturbance and how data exchange between these groups of systems is managed and made secure</li> <li>• The proposed bandwidth required to deliver the stipulated performance, and also detailed calculation showing expected bandwidth utilization in particular for communications to the Train</li> <li>• How the IT System is designed to ensure Availability and Reliability including any implemented redundancy features</li> <li>• Description of the flexibility in the IT System including how different architectures can be implemented on the same infrastructure</li> <li>• How the infrastructure can be extended in such way that additional functionality, systems, and components can be added, updated, or replaced after delivery of the Trainset and during the Design Life</li> <li>• Description of what functionality can be updated, upgraded, changed and how. In other words the future proofability of the system. This description shall include how the individual parts of the system can be exchanged and updated over the Design Life without impacting the whole system (i.e. carrying out homologation again)</li> </ul> <p><i>The Tenderer shall demonstrate compliance by submitting a preliminary system description at least containing the information requested in this requirement</i></p> |              |

## 9.2 Availability

| Id       | Requirement   | Referring to |
|----------|---|--------------|
| A2:9.2.a | <p><b>I</b> Availability for Wayside Functions is measured as a property of the Wayside Operations Communications Gateway even though a Wayside Function itself covers the complete function between the Trainset and the Wayside: Only the Availability of the service levels will be measured and tracked and any failure of a Wayside Function will affect the service level that the function belongs to.</p> |              |

# Exhibit A02: SOW Technical

| Id       | Requirement   | Referring to |
|----------|---|--------------|
| A2:9.2.b | <p><b>K</b> Availability for service levels shall be measured by:</p> $\text{Availability} = (\text{Tp}-\text{Td})/\text{Tp}$ <p>where<br/>           Tp = planned uptime in minutes excluding any planned down time.<br/>           Td = downtime outside planned downtime in minutes for the measured period.</p> <p>E.g. Measured period 24hrs, planned down time 4hrs, Unplanned down time 2hr.<br/>           Tp = (24-4)*60 = 20hrs*60 = 1200mins<br/>           Td = 2hr *60 = 120mins<br/>           Availability = (1200-120)/1200 = 1080/1200 = 90%</p> |              |
| A2:9.2.c | <p><b>K</b> Wayside Functions are Trainset functionality and data that can be accessed from the Wayside and is used in delivering an efficient fleet operation and Maintenance Operations. An example of a Wayside Function is the access key functionality, where the onboard list of approved persons that can access and operate the Trainset can be updated from the Wayside. Each onboard system can have one or more Wayside Functions.</p>   |              |
| A2:9.2.d | <p><b>K</b> As there are many Wayside Functions, it is necessary to group the functions into service level groups: operational critical and Maintenance. This grouping means that only 2 measures are to be tracked. The performance of a Wayside Function is thus described by the service level of that function. Each service level is defined by an availability commitment.</p>  |              |
| A2:9.2.e | <p><b>K</b> The operational period for the Wayside Communications Gateway shall be 24/7/365 with the exception of planned downtime in accordance with XX.</p>   |              |
| A2:9.2.f | <p><b>K</b> The Supplier shall only be allowed to plan downtime for the Wayside Communications Gateway on the Wayside between 02:00-04:00 am once (1) each calendar month to perform Maintenance. If additional downtime is needed, the Supplier shall make a request to Norske tog in writing.<br/>           Norske tog will attempt to accommodate such requests and respond within X hours to any written request for planned downtime limited to the 02:00 – 04:00 am period</p>   |              |
| A2:9.2.g | <p><b>K</b> Availability for Wayside Functions with classified service level</p> <ul style="list-style-type: none"> <li>• Operations shall be at least 93 %</li> <li>• Maintenance shall be at least 90 %</li> </ul>  |              |

# Exhibit A02: SOW Technical

| Id       | Requirement  | Referring to |
|----------|--|--------------|
| A2:9.2.h | <p><b>K</b> Unavailability of Wayside Functions that can be attributed to Defects on the Trainset shall be excluded from the service level availability measurements.</p>  |              |
| A2:9.2.i | <p><b>K</b> The Availability for the Wayside Communications Gateway (including the Supplier's Wayside Interface) shall be at least 99%.</p> <p>Name: Wayside Operations Communications Gateway (Availability WOG1)<br/>           Definition: This service level measures the Availability within the measurement period<br/>           Service level: At least 99 %<br/>           Measurement method: Reported downtime either via diagnostics or reports to help desk.<br/>           Measurement Period: Monthly, calendar month<br/>           Reference document for non compliance:TBC</p>  |              |
| A2:9.2.j | <p><b>K</b> The Availability for the WiFi service in each Trainset shall be at least 98%. The purpose of this key performance indicator is to monitor the Availability of WiFi service in the Trainsets.</p> <p>Name: WiFi service Availability in all Trainsets (Availability WiFi1)<br/>           Definition: This service level measures the Availability in each Trainset of the WiFi service within the measurement period<br/>           Service level: At least 98%<br/>           Measurement method: For each Trainset; the time in service of the Trainset and the WiFi downtime (Reported downtime either via diagnostics or report to help desk).<br/>           Measurement period: Monthly, calendar month<br/>           Reference document for non compliance:TBC</p> |              |
| A2:9.2.k | <p><b>K</b> The Supplier shall ensure that no preventive maintenance activity takes more than two (2) hours for the Wayside Communications Gateway</p>   |              |
| A2:9.2.l | <p><b>K</b> The Supplier shall provide diagnostics data from the Wayside Communications Gateway to the Supplier's Wayside Interface.</p>   |              |

## 10 Technical options

### 10.1 Driver Advisory system (DAS)

| Id        | Requirement   | Referring to  |
|-----------|---|---|
| A2:10.1.a | <p><b>I</b> The purpose of the driver advisory system is to assist the driver to operate the Trainset in the most energy efficient way while keeping the timetable.</p> <p>The driver interface of the driver advisory system should not duplicate information or required actions that are already provided to/from the Driver by other means.</p> <p>The driver advisory system should record each journey, both the system advice and the driver inputs, to enable evaluation and enhancements of the system.</p> <p>The driver advisory system provides accurate advisory information and notifies the driver and stop providing guidance if the data used by the driver advisory system cannot be authenticated. The driver advisory system should automatically resume guiding the driver when the flow of information and the data is authenticated again.</p> <p>NT informs that the Contractor will have to define and agree upon any required interfaces between the DAS and ERTMS onboard system together with the ERTMS onboard supplier.</p> |   |
| A2:10.1.b | <p><b>K</b> The Trainset shall be equipped with a driver advisory system.</p>   | <p><i>The Tenderer shall demonstrate compliance by submitting a description of the driver advisory system</i></p> |
| A2:10.1.c | <p><b>K</b> The advice of a target speed from the driver advisory system shall not exceed the speed from ETCS or the maximum allowed speed for the Trainset.</p>  |   |
| A2:10.1.d | <p><b>E</b> The driver advisory system should provide accurate advisory information and notify the driver and stop providing guidance if the data used by the driver advisory system cannot be authenticated.</p>   |   |
| A2:10.1.e | <p><b>E</b> The driver advisory system should automatically resume guiding the driver when the flow of information and the data is authenticated again.</p>   |   |

## Exhibit A02: SOW Technical

| Id        | Requirement   | Referring to |
|-----------|---|--------------|
| A2:10.1.f | <p><b>E</b> The driver interface of the driver advisory system should be user-friendly and intuitive and should support the driving task while keeping driver distraction to a minimum.</p>   |              |
|           | <p><i>The Tenderer shall demonstrate compliance by submitting description of the driver interface of the driver advisory system</i></p>   |              |
| A2:10.1.g | <p><b>E</b> The driver advisory system should limit the driver's actions by providing automated control of the Trainset.</p>  |              |
| A2:10.1.h | <p><b>E</b> The driver advisory system should assist the Driver in stopping at the correct location at the platform.</p>  |              |
|           | <p><i>The Tenderer shall demonstrate compliance by submitting a description of methods and precision of the system providing this functionality</i></p>   |              |
| A2:10.1.i | <p><b>K</b> It shall be possible for the driver to suspend the driver advisory system.</p>  |              |
| A2:10.1.j | <p><b>K</b></p> <p>The Contractor shall provide a list of all necessary data and data sources (including data from external actors like e.g. infrastructure manager) required by the driver advisory system to enable the system to provide full functionality. Technical documentation of data exchanged shall also be included in the description.</p> <p><i>The Tenderer shall in the tender demonstrate compliance by submitting a description of the functionalities of the driver advisory system and what information is needed from Norske tog by the driver advisory system to provide full functionality. Including how the information is to be supplied by Norske tog</i></p> |              |

## 10.2 Video Surveillance System

| Id        | Requirement   | Referring to |
|-----------|---|--------------|
| A2:10.2.a | <p><b>I</b> The requirements in this section focus on the system functions needed for video surveillance in different parts of the Trainset.</p> <p>In the vestibules high resolution cameras are needed. This is for possibility of face recognition in case of incident where identification of a person may be needed. In the bistro this can also be needed as there may occur theft or other incident.<br/>Coverage by luggage-, toilet- and sleeping area to view incidents and to not get too crowded in these areas, is also needed.</p> <p>Onboard the train the VSS streams should be possible to view in the driver's cab and in the crew compartment to have a good overview of the passengers on the Trainset. It could be beneficial if the onboard personell also have a mobile app to view live video streams.</p> <p>For better security in case of emergency and aid to the onboard personell and driver the VSS streams should also be viewable on the Wayside, both live and possibility to analyze recordings.</p> |              |
| A2:10.2.b | <p><b>K</b> All Trainsets shall be equipped with a color video surveillance system that complies with the requirements in IEC TS 62580-2:2016.</p> <p><i>The Tenderer shall demonstrate compliance by describing how and to what extent the video surveillance solution offered has been proven in use as a system and how it is integrated in the Trainset IT System and Wayside IT System.</i></p>  |              |
| A2:10.2.c | <p><b>K</b> The system shall include necessary tools to be used both wayside and onboard the vehicle for managing and reviewing both recorded and live video with at least the following functionality:</p> <ul style="list-style-type: none"> <li>• Selecting single cameras or groups of cameras for time synchronized viewing and reviewing, for both live and recorded video.</li> <li>• Searching recorded video based on metadata such as time, camera number, Trainset number and Train location and Train state data.</li> <li>• Possibility to set manual and automatic tags to identify video material for future analysis.</li> </ul> <p><i>The Tenderer shall demonstrate compliance by describing the tools provided for managing and reviewing recorded data and live video outside the Trainsets and how this can assist with the location of relevant data.</i></p>   |              |

# Exhibit A02: SOW Technical

| Id        | Requirement   | Referring to |
|-----------|---|--------------|
| A2:10.2.d | <p><b>E</b> Defined alarms and events should result in an automatic display of the most relevant camera view on the monitors/IDUs in active cab and conductor's room. Defined alarms and events should include but not be limited to:</p> <ul style="list-style-type: none"> <li>• Activation of emergency brake handle</li> <li>• Activation of emergency communication unit (call for aid)</li> <li>• Door alarms</li> <li>• Fire alarm</li> </ul> <p><i>The Tenderer shall demonstrate compliance by describing the concept for automatic camera viewing due to defined alarms and how multiple alarms are handled. The Tenderer shall further clarify how alarms can reach Operational Personnel not in a cab but working elsewhere in the Train.</i></p> |              |
| A2:10.2.e | <p><b>E</b> Inside video surveillance cameras shall be mounted to cover the passenger area inside the Trainset.</p> <p><i>The Tenderer shall demonstrate compliance by delivering coverage diagrams to show all areas covered by the VSS system.</i></p>  |              |
| A2:10.2.f | <p><b>E</b> Image quality shall be sufficient to use automatic face recognition on the recordings. According to IEC 62676</p>   | IEC 62676    |
| A2:10.2.g | <p><b>E</b> All video recordings should be stored encrypted in the onboard video surveillance system (VSS) and transferred to Wayside no later than 5 days after the recording took place.</p> <p><i>The Tenderer shall demonstrate compliance by describing how the video recordings are protected from unauthorized access.</i></p>   |              |
| A2:10.2.h | <p><b>E</b> It should be possible to centrally control access to the recorded video from a wayside system. It should be possible to define access control for per train. The process to set access control should be user friendly.</p>   |              |
| A2:10.2.i | <p><b>E</b> The video surveillance system (VSS) shall at least comply to the following minimum requirements:</p> <ul style="list-style-type: none"> <li>• Lowest framerate 12fps</li> <li>• Lowest resolution 1080p</li> <li>• Light sensitivity better than 1 Lux</li> <li>• Storage capacity for at least 5 days of continuous recording at highest framerate and resolution.</li> </ul>  |              |
| A2:10.2.j | <p><b>E</b> It should be possible to view live video from the Trainsets from the Wayside, including Trainsets in multiple operation.</p>  |              |

# Exhibit A02: SOW Technical

| Id        | Requirement  | Referring to |
|-----------|--|--------------|
| A2:10.2.k | <p><b>K</b> The Supplier shall at every Design Review provide a sub-system description for the video surveillance system containing at a minimum the following information:</p> <ul style="list-style-type: none"> <li>• System design, main components and functions</li> <li>• Description of the quality of the images, including update frequency, and justification on the level and if it can be used for face recognition.</li> <li>• List of Standards and parts of Standards that the video surveillance system comply to</li> <li>• Trainset and Vehicle integration of the video surveillance system</li> <li>• Integration to the Trainset IT System and Wayside IT System including operation when coupled in multiple operation</li> <li>• Layout drawing showing video surveillance system coverage</li> <li>• How data tags, watermarks, metadata and original recording are maintained when the recordings are downloaded or transferred</li> <li>• How unauthorized removal or dismantling of cameras, memory units, etc., is prevented</li> <li>• How obscuring or blinding of the cameras is detected including operation in smoky conditions</li> <li>• How the quality and capacity of making new recordings are not affected by monitoring, downloading and reviewing of recorded images</li> <li>• Description of the encryption used for protecting all recorded material, copied recordings and during download of recordings from the Trainset</li> <li>• Description of redundancy concept and under which Trainset modes the VSS is operational and recording video</li> <li>• Concept for hardware and software upgrades</li> <li>• System configuration methods for metadata and data tags</li> <li>• Methods for data authentication and data confidentiality</li> <li>• The functionality available to the VSS user per location/user (i.e. driving, non-driving cab, Operational Personnel etc.)</li> <li>• How the recording is impacted when there is a temporary loss of power for example at neutral sections</li> <li>• How automatic processing of the video can be done in real time to identify predefined actions and triggers a response to the operator</li> </ul> <p><i>The Tenderer shall demonstrate compliance by submitting a preliminary system description at least containing the information requested in this requirement</i></p> |              |

## 10.3 Passenger Counting System

| Id        | Requirement  | Referring to |
|-----------|--|--------------|
| A2:10.3.a | <p><b>K</b> The passenger counting system shall collect and store in real time, data about the number of passengers per Coach, per Trainset and per Train as well as the distribution of passengers within the Train for each journey. The transmission shall be such that the actual distribution of passengers within the Train is available on the Wayside for Norsketog at all times.</p> <p><i>The Tenderer shall demonstrate compliance by a description of how the passenger counting data is made available on the Wayside as necessary such that the data, including passenger distribution within the Trainset, can be used in combination with other data to display updated passenger distribution within the Train at the next station before the Train arrives</i></p> |              |
| A2:10.3.b | <p><b>E</b> Every registration of passenger movement shall be labelled with metadata that at least enables statistical analysis. The metadata shall include but not be limited to:</p> <ul style="list-style-type: none"> <li>• Location information</li> <li>• Trainset number</li> <li>• Coach number</li> <li>• Door number</li> <li>• Door status</li> <li>• Train route (train running number)</li> <li>• Date and time</li> <li>• Station name</li> <li>• Travelling direction</li> </ul> <p><i>The Tenderer shall demonstrate compliance by stating the available metadata that is stored with each count within the proposed solution</i></p>  |              |
| A2:10.3.c | <p><b>K</b> The passenger counting system shall be able to differentiate between humans, bikes and prams, and deliver separate counting for each. It shall also be able to differentiate between humans below or above a configurable height.</p>  |              |
| A2:10.3.d | <p><b>E</b> The data shall be transmitted to the Wayside in an open and platform independent format.</p> <p><i>The Tenderer shall demonstrate compliance by describing how the Tenderer's solution ensures that the data transferred to the Wayside can be used by several different systems to analyze travel patterns.</i></p>   |              |

# Exhibit A02: SOW Technical

| Id        | Requirement  | Referring to |
|-----------|--|--------------|
| A2:10.3.e | <p><b>K</b> The passenger counting system shall have an accuracy of +/- 5% for the total count per Trainset averaged over a year.</p>  |              |
|           | <p><i>The Tenderer is to demonstrate compliance through previous test reports detailing how accuracy is measured, error spread is addressed, how the system is set up to handle coupling and uncoupling in service and resetting of the system.</i></p>  |              |
| A2:10.3.f | <p><b>K</b> The passenger counting system shall have an accuracy of +/- 2% for the count of persons boarding and alighting from the Trainset over a journey.</p>   |              |
|           | <p><i>The Tenderer is to demonstrate compliance through previous test reports detailing how accuracy is measured and describing how cumulative counting errors are handled.</i></p>  |              |
| A2:10.3.g | <p><b>K</b> The Supplier shall at every Design Review provide a sub-system description for the passenger counting system containing at a minimum the following information:</p> <ul style="list-style-type: none"> <li>• System design, main components and functions</li> <li>• List of Standards and parts of Standards that the passenger counter system comply to</li> <li>• Trainset and Vehicle integration of the passenger counting system</li> <li>• Integration to the Trainset IT System and Wayside IT System including operation when coupled in multiple operation</li> <li>• Description of how the passenger counting data is used for different functions</li> <li>• Assessment of the system accuracy</li> <li>• Concept for Maintenance and upgrades</li> <li>• Development possibilities</li> <li>• System configuration of data tags and metadata</li> <li>• Methods for data authentication and data confidentiality</li> <li>• How the system handles Faults or missing counts for certain doors</li> <li>• How counts are handled when Trainsets are joined, split or renumbered during the journey.</li> <li>• How automatic start-up/initializing is done and manual procedures if automatic start-up fails.</li> <li>• Assessment of the system accuracy including performance level for Trainset average during a single passenger exchange</li> </ul> |              |
|           | <p><i>The Tenderer shall demonstrate compliance by submitting a preliminary system description at least containing the information requested in this requirement.</i></p>  |              |

# Exhibit A02: SOW Technical

## 10.4 Advertising

| Id        | Requirement   | Referring to |
|-----------|---|--------------|
| A2:10.4.a | <b>I</b> The requirements in this section focus on providing relevant advertising information for passengers.   |              |
| A2:10.4.b | <b>K</b> The Trainset shall have a digital method for visual advertising.   |              |
|           | <i>The Tenderer shall demonstrate compliance by describing a concept for digital advertising onboard the Trainset.</i>  |              |
| A2:10.4.c | <b>E</b> The advertising presented shall be configurable and location dependent as well as Trainset independent.  |              |
|           | <i>The Tenderer is to demonstrate compliance through describing their solution to this requirement specifying how the advertising system is integrated into the Trainset IT System and Wayside IT System.</i>   |              |
| A2:10.4.d | <b>E</b> Advertising content shall be wireless updated and managed from Wayside.  |              |
|           | <i>The Tenderer is to demonstrate compliance through describing their solution.</i>   |              |
| A2:10.4.e | <b>E</b> The Supplier shall at every Design Review provide a sub-system description for the advertising system containing at a minimum the following information: <ul style="list-style-type: none"> <li>• System design, main components and functions</li> <li>• List of Standards and parts of Standards that the advertising system comply to</li> <li>• Integration to the Trainset IT System including operation when coupled in multiple operation.</li> <li>• System hardware layout showing the location and connection of all integrated parts e.g. controllers, displays.</li> <li>• System software building blocks including types of advertising video, still images etc.</li> <li>• System functionality including possibilities and any limitations.</li> <li>• Description of interfaces for location and other information.</li> <li>• System functionality including possible integration to the passenger information system to deliver audio.</li> <li>• Concept for hardware and software updates, including description of the possibilities to do remote updates</li> </ul> |              |
|           | <i>The Tenderer shall demonstrate compliance by submitting a preliminary system description at least containing the information requested in this requirement</i>   |              |

## 10.5 Infotainment System

| Id   | Requirement   | Referring to |
|--|---|--------------|
| A2:10.5.a  | <p><b>I</b> The requirements in this section focuses on providing infotainment for passengers. It can be possibility to show/play extended information/audio inside the Trainset, such as:</p> <ul style="list-style-type: none"> <li>• Tourist information from e.g. places along the route</li> <li>• Multimodal traffic information</li> <li>• News</li> <li>• Weather forecast</li> <li>• Entertainment</li> <li>• Music and radio broadcasting</li> <li>• Streaming of audio and video either live or stored on board</li> </ul> |              |
| A2:10.5.b  | <p><b>K</b> The Trainset shall have a digital method for infotainment onboard.</p>  |              |
| <p><i>The Tenderer shall demonstrate compliance by describing a concept for digital infotainment onboard the Trainset.</i></p> |   |              |

## 10.6 Test solution for PIS and Advertising contents

| Id   | Requirement   | Referring to |
|--|---|--------------|
| A2:10.6.a  | <p><b>I</b> The purpose of the test solution is to provide a controlled test environment for verification of onboard train information content for Norske tog and the Train operators, to test implemenated changes and fault-finding during the lifetime of the Trainset.</p> <p>In the test solution it shall be possible to visualize all the different visual components used on board the Trainset, and simulate e.g. Wayfinding and Zone concept.</p> |              |
| A2:10.6.b  | <p><b>K</b> The Tenderer shall deliver a test solution for the passenger information, seat reservation and advertisement system that is capable of simulating the systems on board the Trainset.</p>  |              |
| <p><i>The Tenderer shall demonstrate compliance by describing the test solution, detailing any limitations compared to the systems onboard the Trainset.</i></p> |   |              |

# Exhibit A02: SOW Technical

## 10.7 Test rack PIS and Advertising system

| Id        | Requirement  | Referring to |
|-----------|--|--------------|
| A2:10.7.a | <b>K</b> NT shall have the option to purchase a test rack for on board passenger information and advertising Systems<br><i>This is linked to an Information, and not a requirement</i> |              |

## 10.8 Simulator

| Id        | Requirement  | Referring to |
|-----------|--|--------------|
| A2:10.8.a | <b>K</b> NT shall have the option to purchase a Simulator<br><i>This is linked to a heading, and not a requirement</i> |              |