Clean European Rail-Diesel

D 1.5.1 – Application Characterisation (Mission Profile, SBS)

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Start date of project: 01/06/2009  Duration: 48 months

Instrument: Large-scale Integrated Project
Thematic priority: Sustainable Surface Transport
EXECUTIVE SUMMARY

The scope of this document is to provide the characterization of the Mission Profile of the different types of vehicles considered in CleanER-D and the Set Up of Configuration Management.

In general, RAM, Maintenance and LCC Models are heavily affected by the conditions of use and operation of the system they refer to. Such conditions represent the so called Mission Profile of the system and are composed of:

- Environmental Conditions (e.g. climatic, mechanical, electrical);
- Operating Conditions (e.g. duty cycles);
- Maintenance Conditions (e.g. periodical inspections).

The mission profile sets up the external constraints to be considered to be able to perform effective and meaningful RAM, Maintenance and LCC analyses devoted to set up Requirements, to demonstrate their achievement and to evaluate performance of a system. In the specific case, the typical Mission Profile for all the different types of vehicles dealt with in the project will be characterised to the purpose of building consistent RAM, Maintenance and LCC Models (DMU, Light Loco, Heavy Haul Loco, Shunter).

Moreover defining the system configuration, in terms of System Breakdown Structure (SBS), is a fundamental step for properly organising data for RAM analyses and for dealing with issues related to maintenance programmes and plans. Furthermore, the SBS will represent the basic framework to build the LCC Model of the different types of railway vehicles equipped with NRMM compliant engines. The task will identify, within a hierarchical structure, all the objects making part of a NRMM compliant railway vehicle, according to the possible solutions and to an appropriate extent of detail to be agreed with the Engine Manufacturers. In principle, the breakdown will be developed according to the following hierarchical levels:

- Level 0 - System (for DMT proposed by different suppliers);
- Level 1 - Subsystem (Line Replaceable Unit – LRU);
- Level 2 - LLLRU (Lowest Level Replaceable Unit).
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Instrument: Large-scale Integrated Project

Thematic priority: Sustainable Surface Transport
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1. INTRODUCTION

Modern railroad locomotives are complex vehicles containing multiple operating systems including sophisticated computerized controls responsive to a large number of input variables.

A typical diesel railroad locomotive requires some type of power transmission system to couple the output of the prime mover to the driving wheels.

Locomotives are assembled in a number of different configurations so as to satisfy one or more respective mission requirements served by a railroad. One may appreciate that the operational requirements for over-the-road hauling are significantly different than those for switchyard operation. For example, a switcher locomotive generally moves a relatively small number of cars across a mostly flat area at low speeds, whereas road-hauling locomotives must be capable of moving a train at relatively high speeds across terrain that may include significant changes in topography. A switcher locomotive may also spend a significant amount of time idling, whereas road locomotives must operate for long periods at high power levels.

Railroad mission requirements are affected by numerous variables including customer demand, weather, equipment availability, personnel availability, government regulations, etc., and it is often impossible for a railroad dispatcher to make available the best-suited locomotive for a particular mission. For example, even a single mission as simple as moving a train from point A to point B may involve mission demands that vary significantly with the geography of the railroad track, such as different government emission regulations at different points along a railroad track. As a result, a locomotive originally assembled with the configuration suited for an initial intended mission will provide less-than-optimal configuration when placed into service for another and different mission, and typically the best a dispatcher is able to do is to provide a locomotive that presents a good compromise of capabilities to meet a range of different (and often competing) mission requirements.

1.1 TYPES OF VEHICLES

In the following sections, are reported the different types of vehicles considered in CleanER-D.

1.1.1 DMU (led by ATOC)

Operational sub-project which deals with a typical application of a low power engine (320kW) for passenger transportation on an urban/commuter service. The vehicle concerned is a Diesel Multiple Unit (DMU) in service in the UK. Specificities making significant this application deal with the particular location of the engine in the vehicle (under floor) and to the fact the application is developed in UK where gauge constraints are the most restrictive in Europe.

1.1.2 Railcar (led by CD)

The subproject deals with a railcar, a vehicle similar to a DMU, but composed of just one unit, in service in the Czech Republic, operated by CD. The vehicle is a class 842 railcar. The vehicle is equipped with two very low power engines (212kW) and the extremely restrictive space constraints make the application really challenging for manufacturers willing to fulfil IIIB
requirements. Such space constraints are, among the others, due to the need of having all auxiliary onboard equipment all under the vehicle floor together with the traction engine.

1.1.3 Heavy Haul Locomotive (led by VOSSLOH)

An application on a heavy haul locomotive is really significant because dealing with high power engines (>1.800kW) whose railway market is limited in volumes since the demand is for approximately 100 engines per year. The costs related to development and operation of a large engine will be a critical factor to be experimentally evaluated thanks to this operational Sub Project. Main issues will refer to maintaining the weight per axle under the infrastructure limits, reliability and durability of after-treatment, extra installation costs, performance changes, operation and maintenance costs changes related to engine and vehicle modifications to comply with IIIB requirements for a vehicle of this size. The concerned vehicle is the Vossloh EURO4000 diesel-electric locomotive equipped with a diesel engine in the size of 3.000kW. Another particular interest of this sub-project is that it deals with the move to IIIB on an already IIIA compliant locomotive.

1.1.4 Light Weight Locomotive (led by MTU)

A mainline light weight locomotive is dealt with in this SP. The vehicle, a V218 DB diesel hydraulic locomotive, is intended for freight service and the traction power is 1.500kW. Criticalities are similar to those related to heavy haul locomotives dealt with in SP4, but the lower engine size and lower weight per axle of the locomotive, as well as the hydraulic transmission, meaning different load factors for the engine, does imply different technical solutions to solve similar problems.

1.1.5 Shunter (led by MTU)

This application is significant mainly due to the completely different usage profile of a shunting locomotive compared with conventional vehicles, as well as the particular limited volume available in this “narrow hood” type of locomotive design. This specificity is justifying an experimentation to test the behaviour of a large power IIIB compliant engine, in the range of 1.000kW, in such a specific usage. The vehicle concerned is the SNCF BB66000 diesel-electric shunting locomotive.
2. MISSION PROFILE

The mission profile defines the function and operating conditions of the sub-system with what was recognized in the supply technical specifications, environmental conditions (thermal, mechanical, meteorological, electromagnetic, human behaviour, etc..) in which the subsystem performs its mission, Preventive Maintenance Plan and the need to ensure compliance with the requirements of durability and reliability.

This description is intended to determine, together with the RAM requirements, the criteria for mission success, failures that result in failure, the intrinsic availability of subsystems and therefore the effects of faults on system performance when the engine is mounted (locomotive).

The operating systems of a locomotive include also a plurality of end use devices. The end use devices may include fuel pumps, valves, lamps, semiconductor devices, switches, motors, compressors, resistance grids, energy storage batteries for hybrid locomotives, etc. These end use devices are part of respective operating systems of the locomotive, such as the fuel system, engine cooling system, braking system, diagnostic systems, operator control panels, etc.

Realistic mission profiles represent a challenge for the lifetime prediction of complex devices and systems. In the reliability field a mission profile is defined as the specific task, which must be fulfilled by an item during a stated time under given conditions.

The lifetime of a system is necessary to established the average running distance.

The average running distance (ARD) for a single rail vehicle must be determined using the mission profile for which the rail vehicle is used or designed for, according to the following formula:

\[ ARD[km] = \frac{\text{Track length}[km] \times \text{Number of runs per year} \times \text{Years of intended service life}}{\text{Number of rail vehicles for the mission}} \]

It is possible to distinguish the rail vehicles in function of their activity:

- **Passenger rail vehicles**

  The main function of a passenger rail vehicle is the transportation of a given number of passengers over a predefined distance. The functional unit chosen to quantify the main function is transport of 1 passenger for 100 km.

  The total number of passengers shall be calculated, according to the EN 12663 standard, for the rail vehicle in its configuration.

- **Freight rail vehicles**

  The main function of a rail vehicle for freight transportation is the transportation of a given amount of goods over a predefined distance. The functional unit chosen to quantify the main function is the transport of 1 ton for 100 km.

  The total weight taken into consideration shall include the weight of the locomotive, all rail-cars, and the weight of the cargo.
General parameters describing the mission profiles of the locos and the railcars, according to their application classes, can be derived from the SAM F015, issued by EPSF. They are reported in Table 1.

<table>
<thead>
<tr>
<th>Type of Rolling Stock</th>
<th>Average daily duration of the operation or mission duration (hours)</th>
<th>Number of mission days per year</th>
<th>Average annual path (km)</th>
<th>Maximum speed by default (km/h)</th>
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<tr>
<td>High speed train</td>
<td>8</td>
<td>355</td>
<td>500000</td>
<td>300</td>
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<tr>
<td>Propelled commuter</td>
<td>12</td>
<td>325</td>
<td>100000</td>
<td>140</td>
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<td>Propelled regional</td>
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<td>325</td>
<td>150000</td>
<td>160</td>
</tr>
<tr>
<td>Passenger locomotive</td>
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<td>345</td>
<td>250000</td>
<td>160</td>
</tr>
<tr>
<td>Freight locomotive</td>
<td>10</td>
<td>340</td>
<td>250000</td>
<td>140</td>
</tr>
<tr>
<td>Shunting locomotive</td>
<td>6</td>
<td>325</td>
<td>200000</td>
<td>100</td>
</tr>
<tr>
<td>Passenger car</td>
<td>7</td>
<td>355</td>
<td>200000</td>
<td>160</td>
</tr>
<tr>
<td>Wagon</td>
<td>6</td>
<td>150</td>
<td>according to type of operation</td>
<td>-</td>
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</table>

Table 1: Typical mission profile

Starting from this approach, the specific mission profiles for the loco/railcars which are object of the Project can be specified by means of the scheme reported in Table 2.

<table>
<thead>
<tr>
<th>Loco</th>
<th>Track Length</th>
<th>Max track slope</th>
<th>Number of runs per year</th>
<th>Number of rail vehicles</th>
<th>Engine type</th>
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<td>DMU</td>
<td></td>
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<td>Railcar</td>
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<td>Light Weight Locomotive</td>
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<tr>
<td>Shunter</td>
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Table 2: Mission profile for different suppliers unit

This information is useful to characterize in terms of performances each system and the aspects which are relevant for the Mission Profile and RAM Requirements definitions. Then their applicability to each subsystem (i.e. Operator, Car and Engine) has been considered in other deliverables.
3. SYSTEM BREAKDOWN STRUCTURE (SBS)

A system breakdown structure (SBS) is a systematic hierarchical representation of equipment, grouped into its logical system, sub-systems, assemblies, sub-assemblies, and component levels. It provides a schematic view of the subsystem and related process, their constituent assemblies and components and allows for the whole range of reliability analysis, from reliability prediction through reliability assessment to reliability evaluation, to be summarised from process or system level, down to sub-system, assembly, sub-assembly and component levels.

The various levels of a systems breakdown structure are normally determined by a framework of criteria established to logically group similar components into sub-assemblies or assemblies, which are grouped into sub-systems or systems. This logical grouping of the constituent parts of each level of an SBS is done by identifying the actual physical design configuration of the various items of one level of the SBS into items of a higher level of systems hierarchy, and by defining common operational and physical functions of the items at each level.

Thus, from a process design integrity viewpoint, the various levels of an SBS can be defined:

- a process consists of one or more systems for which overall availability can be determined, and is dependent upon the interaction of the performance of its constituent system;
- a system is a collection of sub-systems and assemblies for which system performance can be determined, and is dependent upon the interaction of the functions of its constituent assemblies;
- an assembly or equipment is a collection of sub-assemblies or components for which the value of reliability and maintainability relating to their functions can be determined, and is dependent upon the interactions of the reliabilities and physical configuration of its constituent components;
- a component is a collection of parts that constitutes a functional unit for which the physical condition can be measured and reliability can be determined.

Several different terms can be used to describe an SBS in a system engineering context, specially a systems hierarchical structure, or a systems hierarchy.

Generally the object of the LCC analysis must be defined with precision. In fact start from the design stage, the object is assigned a code identifier and a hierarchical decomposition of the elements that component (part list).

Configuration management object, both the hardware and software part, updates properly configuring (and possibly identification) considers the amendments to the project in subsequent revisions.

Physical objects that derive from the process of hierarchical decomposition should be represented in functional and/or reliability diagrams as part of project documentation, by conventional graphic symbols that will be accompanied by an identification of the same and a brief description of it represents.

This type of representation, adopted from the outset of the project should be kept updated in line with the phases of implementation and operation of installations. In fact, the Configuration Management the physical objects can be manage through the allocation to each element of a symbol, i.e. the unique identification of the object (Part Number) and description.

In the decomposition are generally considered two levels of detail than: LRU and LLRU.
LRU (Line Replaceable Unit) is an object that can be entirely removed during first level of the maintenance.

LLRU (Lowest Level Replaceable Unit) is an elementary component identifiable as LRU replacement part of a minimum level.

The process of hierarchical decomposition stops normally at LRU, including those of physical interface (usually cables and connectors) that must be identified so as to identify the LRU subsystems which you connect.

Generally in the hierarchical decomposition is appropriate to refer to levels of hierarchy encoded. You can find No. 8 levels of hierarchy:

- **Part**: One piece of equipment, which has no function of its own. An assembly of several pieces, which cannot be disassembled without destroying it, is also considered a "part".
- **(Sub-)Assembly**: A combination of parts and/or other (sub-)assemblies, in which the components can be replaced/removed separately. The distinction between assemblies and subassemblies is essentially arbitrary. A (sub-)assembly is not used independently from other equipment.
- **Unit**: A combination of parts and (sub-)assemblies, which is capable of independent operation on its own or can be used as a component of groups, sets or systems. Examples include: a hydraulic motor, power supply, diesel engine, alternating current generator, or radio receiver.
- **Group**: A collection of units, assemblies, or subassemblies which is not capable of performing a complete operational function. A group may be a subdivision of a set or may be designed to be added to or used in conjunction with a set to extend the function or the utility of the set. For example an antenna group may be "used with" or "part of" a radio set.
- **Set**: A combination of one or more units, together with associated groups, (sub-)assemblies and parts, which performs an operational function. An example could be a radio terminal set or sound measuring set, which includes parts, assemblies and units such as cables, microphone and measuring instruments.
- **Subsystem**: A combination of sets, groups, units, etc., which forms a part of a system and is a major subdivision of the system.
- **System**: Combination of several subsystems, sets, etc. which work together to perform one or more operational functions. The components of a system may be physically separated.

For each object on the division of the system shall be specified technical conditions of operation, they reference the estimated reliability, and in particular:

- Conditions of the system (environment, methods and frequency of use, period of life, etc.).
- Operating Conditions.
- Conditions of maintenance.

So the SBS is a tree structure, which shows a subdivision of effort required to achieve an objective; for example a program, project, and contract. In a project or contract, the SBS is developed by starting with the end objective and successively subdividing it into manageable components in terms of size, duration, and responsibility (e.g., systems, subsystems, components, tasks, subtasks, and work packages) which include all steps necessary to achieve the objective. The SBS provides a common framework for the natural development of the overall planning and control of a contract and is the basis for dividing work into definable increments from which the statement of work can be developed and technical, schedule, cost, and labour hour reporting can be established.
A SBS permits summing of subordinate costs for tasks, materials, etc., into their successively higher level “parent” tasks, materials, etc. For each element of the SBS, a description of the task to be performed is generated. The SBS is organized around the primary products of the project (or planned outcomes) instead of the work needed to produce the products (planned actions). Since the planned outcomes are the desired ends of the project, they form a relatively stable set of categories in which the costs of the planned actions needed to achieve them can be collected. A well-designed SBS makes it easy to assign each project activity to one and only one terminal element of the SBS. In addition to its function in cost accounting, the SBS also helps map requirements from one level of system specification to another, for example a requirements cross reference matrix mapping functional requirements to high level or low level design documents.

In accordance with the technical Annex I, the breakdown will be developed according to the following hierarchical levels:

- Level 0 - System (for DMT proposed by different suppliers)
- Level 1 - Subsystem (Line Replaceable Unit – LRU)
- Level 2 - LLRU (Lowest Level Replaceable Unit)

### 3.1 SBS Coding Scheme

It is common for System Breakdown Structure elements to be numbered sequentially to reveal the hierarchical structure. For example 1.3.2 Rear Wheel identifies this item as a Level 3 SBS element, since there are three numbers separated by a decimal point. In Figure 1 is shown a typical loco unit with some sub-system.

![Loco/Engine sub-item system](image)

**Figure 1: Loco/Engine sub-item system**

### 3.2 SBS Part Description

The system configuration, in terms of SBS, is a fundamental step for properly organising data for RAM analyses and for dealing with issues related to maintenance programmes and plans.
The task will identify, within a hierarchical structure, all the objects making part of a NRMM compliant railway vehicle, according to the possible solutions and to an appropriate extent of detail to be agreed with the Engine Manufacturers.

In principle, the breakdown will be developed according to the following hierarchical levels (Figure 2, Figure 3), divided into functional sub-assemblies.
EC Contract No. FP7 - 234338

Instrument: Large-scale Integrated Project
Thematic priority: Sustainable Surface Transport

Figure 2: Loco/Engine Stage IIIA levels

Figure 3: Loco/Engine Stage IIIB levels
3.2.1 Stage IIIA Equipments

It has been suggested the following hierarchical breakdown inherited from engines which are previous to the IIIB stage. This hierarchical structure can be considered the starting point for RAM, Maintenance and LCC Models analysis and the source to determinate the delta improvement of stage IIIB. These item were shared and discussed with the engineers teem of the project.

1 - CRANKCASE SYSTEM

- 1.1 CRANKCASE
- 1.2 CRANKCASE DOORS
- 1.3 EXPLOSION RELIEF VALVE
- 1.4 CYLINDER LINERS
- 1.5 SPRING DRIVE
- 1.6 CRANKCASE DRAIN PIPEWORK
- 1.7 ENGINE PIPEWORK
- 1.8 FLEXIBLE CONNECTIONS

Figure 4: Crankcase System

2 - POWER SYSTEM

- 2.1 BEDPLATE
- 2.2 BEDPLATE DETAILS
- 2.3 AV MOUNTING
- 2.4 CRANKSHAFT
- 2.5 CRANKSHAFT OIL SEAL
- 2.6 MAIN BEARINGS AND BOLTS
- 2.7 MAIN BEARING CAPS
- 2.8 PISTON
- 2.9 CONNECTING ROD
- 2.10 FLYWHEEL GEAR RING (SPLIT TYPE)
- 2.11 FLYWHEEL COUPLING DETAILS
- 2.12 TORSIONAL VIBRATION DAMPER
- 2.13 BARRING GEAR
- 2.14 AUXILIARY DRIVE CASING STUDS
- 2.15 BEDPLATE/CRANKCASE STUDS

Figure 5: Power System
### 3 - CYLINDER HEAD SYSTEM

- 3.1 CYLINDER HEAD
- 3.2 VALVE GEAR
- 3.3 CYLINDER HEAD COVERS
- 3.4 CYLINDER PRESSURE RELIEF VALVE
- 3.5 CAMSHAFT
- 3.6 CAMSHAFT DRIVE
- 3.7 CAMSHAFT DAMPER – A BANK
- 3.8 CAMSHAFT DAMPER – B BANK
- 3.9 DAMPER GUARDS
- 3.10 CAMSHAFT END PLATES

#### Figure 6: Cylinder Head System

### 4 - ENGINE CONTROL UNIT (ecu)

- 4.1 GOVERNOR
- 4.2 GOVERNOR CONNECTIONS
- 4.3 OVERSPEED TRIP
- 4.4 OVERSPEED TRIP SPRING
- 4.5 MAGNETIC PICK UP

#### Figure 7: Engine Control Unit

### 5 - INDUCTION/EXHAUST SYSTEM

- 5.1 TURBOCHARGER
- 5.2 AIR INLET DUCTING
- 5.3 AIR INLET BEND
- 5.4 AIR INTAKE ADAPTOR
- 5.5 BOOST BYPASS VALVE & ACTUATOR
- 5.6 INTERCOOLER
- 5.7 INTERCOOLER WATER PIPEWORK
- 5.8 EXHAUST MANIFOLD
- 5.9 EXH UPTAKE ADAPTOR
- 5.10 EXHAUST LAGGING/INSULATION
- 5.11 EXHAUST DUCTING

#### Figure 8: Induction/Exhaust System
6 - FUEL SYSTEM

- 6.1 FUEL TRANSFER PUMP
- 6.2 FUEL INJECTION PUMP
- 6.3 PUMP ASSEMBLY
- 6.4 FUEL INJECTION PUMP DRIVE
- 6.5 FUEL INJECTOR
- 6.6 FUEL FILTER
- 6.7 FUEL CONTROL MECH
- 6.8 MICROSWITCH
- 6.9 COMPOUND LEVER
- 6.10 FUEL PIPEWORK STANDARD
- 6.11 FUEL OIL PIPEWORK ADDITIONAL
- 6.12 FUEL LEAKAGE SWITCH & P’WK

Figure 9: Fuel System

7 - LUBRICATING SYSTEM

- 7.1 LUB OIL PUMP – INJECTION PUMP DRIVE
- 7.2 LUB OIL PUMP
- 7.3 LUBRICATING OIL PUMP DRIVE
- 7.4 LUB OIL INJECTION PUMP
- 7.5 LO SUCTION STRAINER
- 7.6 LUBRICATING OIL GALLERY
- 7.7 SUMP LEVEL ALARM
- 7.8 FILTER – CENTRIFUGAL
- 7.9 LUB OIL PRESSURE RELIEF VALVE
- 7.10 LUB OIL DIFF RELIEF VALVE
- 7.11 LUB OIL PRIMING PUMP
- 7.12 CRANKCASE BREATHER
- 7.13 LUB OIL PIPEWORK – STANDARD
- 7.14 LUB OIL PIPEWORK – ADDITIONAL
- 7.15 LO PIPEWORK SUMP DRAIN
- 7.16 LUB OIL FILLER PIPEWORK
- 7.17 LO FILTER P’WK – CENTRIFUGAL
- 7.18 LO MIST DETECTOR PIPEWORK
- 7.19 LO METAL DETECTOR P’WK
- 7.20 LO DISTRIBUTOR & PIPEWORK
- 7.21 AIR CHEST DRAIN PIPEWORK
- 7.22 CRANKCASE BREATHER PIPEWORK
- 7.23 MIST PURE PIPEWORK

Figure 10: Lubricating System
8 - COOLING SYSTEM

• 8.1 SEA WATER PUMP
• 8.2 LTC WATER PUMP
• 8.3 HTC WATER PUMP
• 8.4 WATER PUMP DRIVE – HTC/SW
• 8.5 WATER PUMP DRIVE - LTC
• 8.6 JACKET WATER PIPEWORK
• 8.7 SEA WATER PUMP OUTLET ADAPT

Figure 11: Cooling System

9 - STARTING SYSTEM

• 9.1 START MOTOR A + B BANK AND BRKTS
• 9.2 STARTER LUBRICATOR
• 9.3 AIR START PIPEWORK
• 9.4 AIR PRESSURE REGULATOR

Figure 12: Starting system

10 - CONTROL AND INSTRUMENTATION SYSTEM

• 10.1 ENGINE WIRING
• 10.2 INSTRUMENT PANEL
• 10.3 TACHOMETER
• 10.4 SHUT DOWN SWITCH – JW TEMP
• 10.5 THERMOMETER – AIR
• 10.6 THERMOMETER – OIL/WATER
• 10.7 THERMOMETER
• 10.8 PYROMETRY
• 10.9 OIL MIST DETECTOR ALARM
• 10.10 METAL PARTICLE DETECTOR
• 10.11 MAIN BEARING TEMP SENSORS

Figure 13: Control and Instrumentation System
11 - PROPRIETARY ITEMS

- 11.1 RW THERMOSTATIC VALVE
- 11.2 LO THERMOSTATIC VALVE
- 11.3 COOLER 3 PORT VALVE
- 11.4 CENTRAL PLATE COOLER
- 11.5 RW HEATER MODULE
- 11.6 INTERCOOLER HEATER MODULE
- 11.7 DUPLEX LO FILTER
- 11.8 SW FLAP VALVE
- 11.9 EXHAUST DOUBLE BELLOWS
- 11.10 EXHAUST BELLOWS
- 11.11 AIR INLET BELLOWS
- 11.12 CARDAN SHAFT
- 11.13 FLEXIBLE COUPLING
- 11.14 GOVERNOR ACTUATOR
- 11.15 DIGITAL CONTROL UNIT
- 11.16 DUTY/STANDBY MODULE
- 11.17 BAKK UP FEEDBACK MODULE
- 11.18 GOVERNOR CABLES
- 11.19 STARTER PANEL
- 11.20 START AIR FLEXIBLE
- 11.21 FO INLET FLEXIBLE
- 11.22 FO DRAIN FLEXIBLE
- 11.23 WI LEAKAGE FLEXIBLE
- 11.24 VALANCE DRAIN FLEXIBLE
- 11.25 JW VENT FLEXIBLE
- 11.26 LO PRIMING PUMP FLEXIBLE
- 11.27 BREATHER FLEXIBLE
- 11.28 FLEXIBLE MOUNT
- 11.29 FLEXIBLE MOUNT
- 11.30 LT WATER OUTLET FLEXIBLE
- 11.31 LT WATER INLET FLEXIBLE
- 11.32 JW OUTLET FLEXIBLE
- 11.33 JW INLET FLEXIBLE
- 11.34 LO OUTLET FLEXIBLE
- 11.35 LO RETURN FLEXIBLE
- 11.36 SW INLET FLEXIBLE
- 11.37 SW OUTLET FLEXIBLE
- 11.38 OIL MIST DETECTOR HEADS
- 11.39 OIL MIST DETECTOR MONITOR
- 11.40 LO NON RETURN VALVE
- 11.41 JW NON RETURN VALVE
- 11.42 JW HEATER NON RETURN VALVE
- 11.43 MIST PURE DEVICE
- 11.44 MAG PICKUP AMPLIFIERS
- 11.45 ENG SPEED AMPLIFIER
- 11.46 CHARGE AIR TEMP TRANSDUCER
- 11.47 JW & LO TEMP TRANSDUCER
- 11.48 MAIN BEARING SENSOR CABLE
- 11.49 MAIN BEARING PIPELINE CABLE
- 11.50 COMPENSATING CABLE
- 11.51 TEM TRANSDUCER AMPS
- 11.52 TURBO SPEED PICK UP

Figure 14: Proprietary Items
12 - LOCO BUILDER SUPPLY ITEMS

- 12.1 FUEL STORAGE TANK & PIPEWORK
- 12.2 COOLING WATER RESERVOIR & PIPEWORK
- 12.3 WATER SUCTION STRAINER & PIPEWORK
- 12.4 WATER DISCHARGE VALVE & PIPEWORK
- 12.5 EXHAUST SILENCER
- 12.6 CRANKCASE VENT PIPEWORK

Figure 15: Loco Builder Supply Items
3.2.2 Stage IIIB Equipments

Technical solutions for stage IIIB engine phases are necessary for the introduction of new NRMM directive on emission limits for diesel locomotives and railcars. Starting from the suggested hierarchical breakdown of IIIA engine equipments, in the following breakdown there are the new items added in order to comply with the IIIB requirements. These item were shared and discussed with the engineers team of the project.

13 - EXHAUST GAS RECIRCULATION (EGR) SYSTEM

- 13.1 NEW EXHAUST DUCTING
- 13.2 LIFTING PRESSURE PUMP
- 13.3 COOLER
- 13.4 SCRUNNER
- 13.5 AIR MANIFOLD DUCTING
- 13.6 TEMPERATURE CONTROL UNIT
- 13.7 PRESSURE/FLOW CONTROL UNIT

Figure 16: Exhaust Gas Recirculation

14 - MODIFIED INDUCTION/EXHAUST SYSTEM

- 14.1 TURBOCHARGER
- 14.2 AIR INLET DUCTING
- 14.3 AIR INLET BEND
- 14.4 AIR INTAKE ADAPTOR
- 14.5 BOOST BYPASS VALVE & ACTUATOR
- 14.6 INTERCOOLER
- 14.7 INTERCOOLER WATER PIPEWORK
- 14.8 EXHAUST MANIFOLD
- 14.9 EXH UPTAKE ADAPTOR
- 14.10 EXHAUST LAGGING/INSULATION
- 14.11 EXHAUST DUCTING

Figure 17: Modified Induction/Exhaust System
**15 - AFTERTREATMENT SYSTEM**

- 15.1 DIESEL PARTICULATE FILTER
- 15.2 DUCTING AND VALVES
- 15.3 BURNER AND FUEL SUPPLY
- 15.4 NEW SILENCER
- 15.5 COOLING ADDITIONAL REQUIREMENT
- 15.6 HEALTH AND SAFETY EQUIPMENTS

**Figure 18: After-treatment System**
4. CONCLUSIONS

This document represents the D 1.5.1 of the WP 1.5 and has been issued to describe the Mission Profile and to present the System Breakdown Structure applicable to the Engine of the CleanER-D project.

In section § 2, the mission profile and its importance within the RAM activities have been introduced. Then, an input description for the mission profiles of the loco/railcars according to European Standards is presented. These values can be reviewed standing the specific mission profiles of the loco and railcars used in CleanER-D project. According to this objective, the input tables have been defined in the last section of the chapter.

In section § 3, the System Breakdown Structure has been created. The model represents the general scheme for a railway diesel engine comprehensive with additional parts to reach the IIIB stage requirements. This description will constitute the basis for the RAM activities, object of the other deliveries of the WP 1.5.