DA1.6: Implementation of the PLM Process model for the Demonstrator

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ABSTRACT	This deliverable (DA1.6) summarises the implementation of the PLM process model for the demonstrator, in terms of scenes, PROMISE components and technology implemented, as described in DA1.3 and DA1.4. The motivation for eventual discrepancies is given, together with the detailed results of the activities performed for the implementation.

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Abbreviations

Abbreviations used in this document:

BOL	*Beginning of Life*
BOM	*Bill of Material*
DSS	*Decision Support System*
ECU	*Electronic Control Unit*
ELVs	*End of Life Vehicles*
EOL	*End of Life*
IMDS	*International Material Data System*
MOL	*Middle Of Life*
OBD	*On Board Diary*
OEM	*Original Equipment Manufacturer*
PDKM	*Product Data Knowledge Management*
PEID	*Product Embedded Information Device*
RFID	*Radio Frequency Identification*
TCP/IP	*Transmission Control Protocol/Internet Protocol*
UPnP	*Universal Plug and Play*
WH	*WareHouse*

1 Introduction

1.1 Purpose of this deliverable

This deliverable (DA1.6) summarises the implementation of the PLM process model for the demonstrator, in terms of scenes, PROMISE components and technology implemented, as described in DA1.3 and DA1.4. The motivation for eventual discrepancies is given, together with the detailed results of the activities performed for the implementation.

1.2 Objective of demonstrator

The domain of the Application Scenario A1 is the End of Life (EOL) phase of the product lifecycle[1]. It specifically deals with the take back of End of Life Vehicles (ELVs) by dismantlers so that they can be reprocessed: this strategy allows for both the feedback of vital information (design information, usage statistics on components etc.), and the materials / components themselves to the Beginning of Life (BOL) stage of the product lifecycle; as well as the take back of selected components into the Middle of Life (MOL) phase of the product lifecycle as second-hand parts (both recycled or remanufactured).

2 Description of the demonstrators

The following figure and table (from DA1.4) summarise the workflow, actors, events of processes of the A1 demonstrator. The scenes described in DA1.3 have been slightly modified into the processes described in DA1.4 and reported in the table below.

The following paragraphs will describe these scenes/ processes.

[1] The PROMISE A1 Demonstrator objectives has been fully described in Deliverable DA1.1 and DA1.4 (see References).

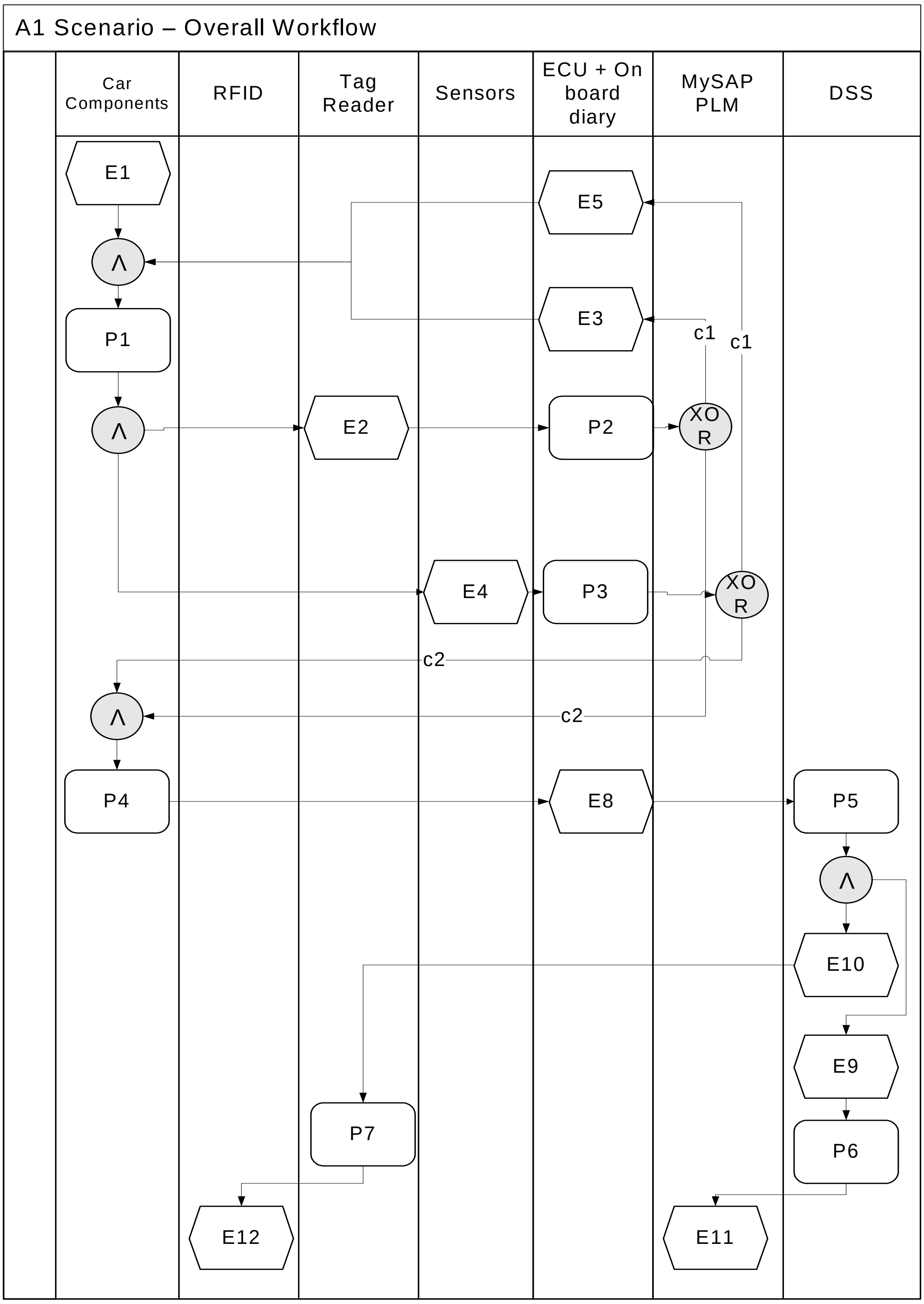

Figure 1: EPC Level-1 (overall workflow) diagram

Modelling components		Description
Process	P1	Customer uses the car
	P2	ECU memorises list of components
	P3	ECU stores data
	P4	Customer brings the car to dismantling site
	P5	DSS analyzes data
	P6	DSS updates list of components on PDKM
	P7	Tag Reader writes residual value and other information on RFID

Table 1: EPC diagram (overall workflow) for decision support at EOL

2.1 Scenes implemented

The scenes have been implemented on a CRF vehicle, in a test setting: the vehicle (a FIAT Grande Punto) status has been assessed at the beginning of the test sessions, and regularly evaluated during the test period (6 months).

In the following we report the discrepancies in the scenes implemented with respect to the plan.

Scene	**Discrepancy (None-L-M-H) with respect to**	Settings	Location	Actor	**Impact on relevance (None-L-M-H)**
Customer uses the car	L	None	None	The car has been driven by professional drivers, not real clients	None: the routes selected are representative of the real missions profiles.
ECU memorises list of components	None	None	None	None	
ECU stores data	None	None	None	None	
Customer brings the car to dismantling site	L	L	The dismantler site has been simulated by a CRF garage.	L (as above)	None: the hardware and software used are the same which would be used at the dismantler's.
DSS analyzes data	None	None	None	None	
DSS updates list of components on PDKM	None	None	None	None	
Tag Reader writes residual value and other information on RFID	H: the writing back of the information on the tag has not been given high priority with respect to the other scenes and has not been implemented	None	None	None	Low: writing back on tags is a simple action and does not add much value to the demonstrator: the important aspect was to "close the loop": accumulation of data during lifecycle, aggregation and support for decision

2.2 PROMISE components used

The components described in DA1.3 and DA1.4 have been used in the scenes presented above.

2.3 Eventual other modifications with respect to DA1.3 and DA1.4 (e.g. workflow)

No discrepancy.

3 Analysis of results obtained in the Activities in A1.6

In the following sections we report the activities for the implementation of the A1 demonstrator. The activities scheduled in the Dow in **Task TA1.6** are described, along with the technical problems and limitations encountered in each of these activities.

4 Test portfolio of stand-alone RFID solutions in machine environment

We report in the following the major tagging solutions tested in the PROMISE project are the following:

1. Solution 1: Passive RFID tags
2. Network of ZigBee tags

Taking into account the objectives presented in section 2, the A1 demonstrator is aimed at implementing an "on-board diary" able to assess the health of vehicles components, in order to facilitate the process of identification of components worth being re-used. This diary has to collect information about the usage of the vehicle and it has to be capable to quantify the efficiency of the main vehicle subsystems / components at the moment of deregistration. The physical components (PC) and software / support systems (SS) of the solution are briefly described below:

Name	Physical Component Software/Support System	Functionality	Interfaces
PC1	Tag on identified component X[1]	Uniquely identify component X	Wireless communication with SS1 included in PC4, using PC5
PC2	Sensor measurements	Continuously measure some vehicle parameters (eg: outside temperature)	Link with PC4
PC3	Component X	Depending on X	Supports PC1
PC4	Electronic Control Unit (ECU)	Manage in real-time vehicle electronics	Wireless link with PC1 through PC5, wired link with PC2, hosts SS1, wired link with SS2
PC5	Tag reader	Get info from PC1	Link between PC1 and SS1
SS1	On board diary	Store X statistics. Perform basic calculation on sensor data.	Communication with PC5, PC2 and SS2
SS2	Back-end decision support system	Download info from SS1, get component age from PC4	Retrieve data from SS1, SS3, SS4
SS3	Back-end international material data system	Manage info about X, from its ID	
SS4	Other database	Contain the components selling prices, availability of products, destination	

Table 2. Physical Components (PC) and Software / Support Systems (SS) of the A1

A 1-metre read distance between the tags PC1 and the tag reader PC5 is required. Indeed, the ultimate objective is to be able to read several tags attached to several parts with a single antenna. It implies that the distance between a tag and the reader can reach 1 metre.

This following focuses only on the physical components and on the potential solutions available to meet the requirements of the A1 demonstrator.

The main issue regarding those technologies is the surrounding metal environment. Wireless communication is difficult in heavy-metal environment. The influence of metal on those technologies and more specifically on RFID is explained below. Another issue is the size of the equipment. A car hood is already occupied by many parts and there is no space to add large components. Lastly, the car engine environment is a harsh environment, there is heat, humidity and dust. This may lead to difficulty in attaching tags on the parts.

4.1 Passive RFID tags in machine environment

RFID is an automatic identification technology whereby digital data encoded in an RFID tag is captured by a reader using radio waves. RFID systems can work at various radio frequencies, such as:

- Low Frequency (LF): 125/134 kHz
- High Frequency (HF): 13.56 MHz
- Ultra High Frequency (UHF) : 868/915/950 MHz
- Microwave: 2.45/5.8 GHz (more in use for active tags)

Passive RFID tags have no internal power. The electrical current induced in the antenna by the incoming radio frequency signal provides just enough power for the integrated circuit in the tag to power up and transmit a response. The response of a passive RFID tag is not just an ID number (Electronic Product Code): tag chip can contain non-volatile memory for storing data, which can be written and updated. Since passive tags do not require batteries, they can be small (less than 1 cm x 1 cm for the smallest, average 1 cm x 10 cm) and, providing they are not damaged by a harsh environment, their life span is rarely a constraint.

Figure 2: Different forms of passive tags
(source: Emerson & Cuming, www.eccosorb.com/rfid)

Metal and RFID do not mix well. The magnetic field generated by the RFID reader causes eddy current in the metal. Those eddy currents create a magnetic field that is perpendicular to the metal surface. In the vicinity of the reader antenna this perpendicular magnetic field absorbs RF energy, thus reducing the overall effectiveness of the RFID field. For a far field system, the consequences are different.

Metal can also detune both reader and tag antenna, causing reduced system performance: the electronic "friction" from the metal causes energy drain. Finally, at some frequencies, the energy reflected by metal creates interference between the tag and the reader. RFID in heavy metal environments can mean reduction in actual read and write rates, ranges and reliabilities far below those experienced in a clean lab environment.

4.1.1 Preliminary tests performed in a lab

In order to perform a preliminary study, a test site was set-up in a Cambridge lab. The potential parts of the engine that could be tagged were: the clutch, the AC compressor, the battery, the starter, the transmission, the catalyser, the gear box. The clutch was selected for its high value on a potential second hand market and its position in the engine. However, the clutch was not tagged directly. The clutch is protected and is difficult to access. The housing of the clutch, also in metal, was tagged instead. It was considered to be relevant enough, considering the purpose of the tag: identify the part tagged. Indeed, the clutch cannot be tampered with without removing the housing. To that extent, to tag the housing means to tag the clutch.
The tag was stuck on the housing as shown on figure below.

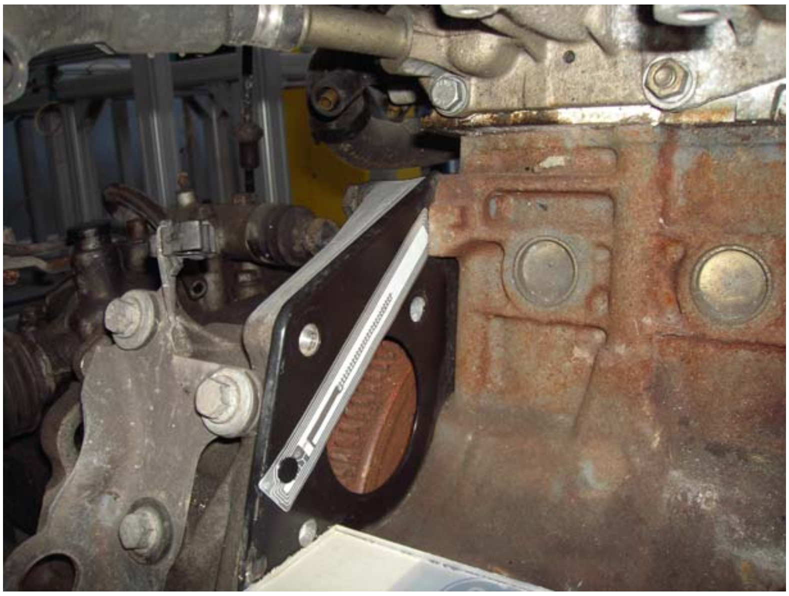

Figure 2. The tag on the clutch's housing

4.1.1.1 Reference experiment

The purpose of the reference experiment was to evaluate the performance of the RFID equipment used in a non metal environment, in terms of read range: distance of the reader from the tag, vertical range, for different angles. It was also designed to verify whether the tag used had an influence on the results.

The maximum read distances for each angle are summarised in the table below.

Angle	Maximum Read Distance
0°	21 centimetres
30°	16 centimetres
60°	7.5 centimetres
90°	15 centimetres

Table 3. Maximum read distance with respect to angle

4.1.1.2 Summary of experiments on Engine

According to the literature, a way to reduce the influence of metal on radio waves is to isolate the RFID tags from the metal. The decision was made to verify if the use of spacers could enhance the performance of RFID tags attached to the engine.

Three types of spacers were designed and shaped in the Auto-ID Lab. Another experiment was done with an air gap. The spacers had the following specifications:

- Material: foam ; 145 millimetres long, 20 millimetres large and 3.2 millimetres thick
- Material: cardboard ; 145 millimetres long, 20 millimetres large and 3.4 millimetres thick
- Material: plastic ; 145 millimetres long, 20 millimetres large and 3.2 thick

The tag was then stuck on the spacer, and the spacer attached to the engine. To create an air gap between the tag and the metal two small pieces of foam (3.2 millimetres thick) were placed at the ends of the tag, between the tag and the metal. The same protocol was then followed for each spacer.

Without any spacer, the maximum read distance drops to 5 centimeters. It must be compared to the 21 centimetres reached in a nice environment.
With spacers, the maximum read distance is 7 centimetres with plastic. It represents an increase of 40% from the situation without spacer. It appears that plastic is the best material to isolate. The performance of the tag is enhanced significantly.

4.1.1.3 Summary of experiments in laboratory

In this experiment, it appears that the shapes of the read area in a nice environment with two different tags and for an angle of 0° are close but not completely the same. There are small differences, that can be explained by three facts: firstly, in the protocol defined, the precision of the measures was 5 millimetres. Secondly, the design of the tag may be slightly different.
Thirdly, even though care was taken, the tags may not have been attached on the plastic board in the exact same position. All those reasons can account for the small differences. However, they were not important enough to be taken into consideration in the engine experiment. As a consequence, all the results given in this report are considered to be independent from the tag used.

The results show that the metal badly influences the performance of RFID. When the tag is directly on the metal, the maximum read distance drops by 76% compared to the non metal environment. The eddy currents in the metal absorb RF energy and create their own magnetic field. Only a close reader can provide enough energy to read the tag.

The use of spacers definitely enhances the performance of RFID. The maximum read distance can rise by 40% compared to the situation without any spacer. This improvement is due to the fact that the tag is further from the metal and, thus, from its magnetic influence. The spacers are in material that do not conduct metal and do not add any magnetic perturbation. It is the same for the air gap.

However, despite the same thickness, it is clear that all the spacers do not give the same results. Those differences may be linked with the fact that some material (cardboard, foam) are more suitable to retain water. Water reduces RFID performance. Generally speaking, RFID do not work well next to liquids due to the propensity of liquids to absorb RF energy. Thus, a material with high moisture content affects RFID performance. For instance, a spacer made of green wood is likely to isolate the tag from the metal influence, but may also affect the RFID performance because of its high moisture content. Thus plastics tend to produce better results than cardboard or foam.

The study was deemed satisfactory enough to continue in the direction of passive RFID tags, increasing the maximum read range to meet the requirements of the PROMISE demonstrator. The following section reports tests performed with UHF passive tags.

4.1.2 Tests of a pad used for tags reading

The objectives of the activity were to automate the ID capture solution in a cost effective way and in a dense metallic environment. Furthermore the material used ensured a quick implementability, by using commercially available and EU compliant equipment.

Radio-Frequency Identification (RFID) tags, each with its own unique identification number, are attached to the car's engine parts. The vehicle is then driven at low speed over a one-metre square servicing pad, which is fitted with an Ultra-High Frequency reader and four antennae.

Figure 3. The FIAT vehicle used of the tests

The architecture for demonstration of the capture of ID's consisted in:

- A RFID infrastructure within a deployable service pad, including the following technology:
  - Passive UHF RFID at 866 MHz
  - Alien Technology ETSI compliant 4 port reader
  - 4 Circular polarised antennas
  - QinetiQ Omni-ID Tags (on-metal tags) at 866 MHz.
- Components on a car engine: chassis, gearbox, starter motor, alternator, hydraulic pump and cooling fan motor.

Figure 4. The service pad developed by the University of Cambridge

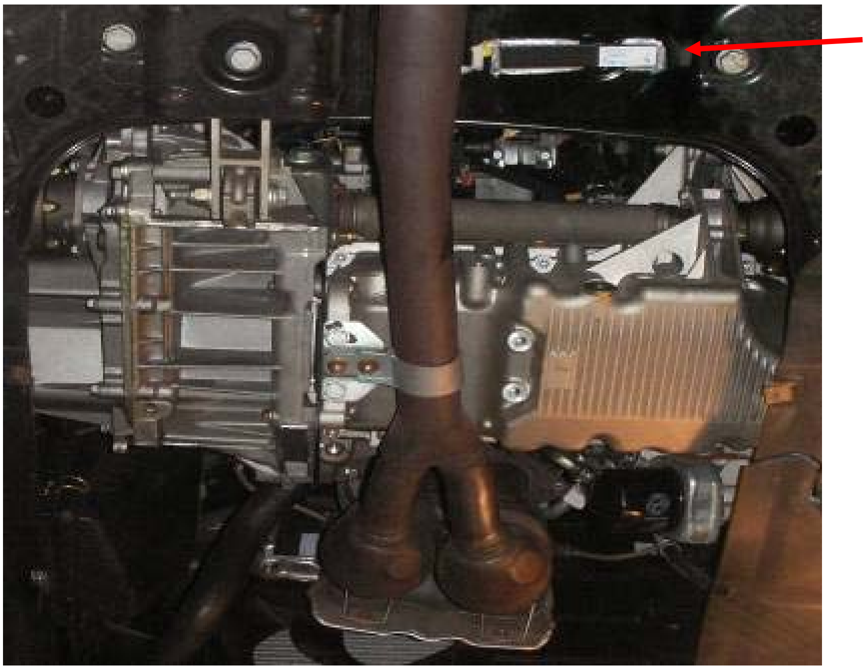

Figure 5. Tags attached to the engine (example)

As the car passes over the pad, the readers transmit the ID number from the electronic tags to a computer. By cross-referring this information with a computerised database – for example one showing the parts' date and manufacturer – mechanics are able to identify those parts that needed to be checked for wear at the click of a mouse.

Technical feasibility

The tests ensured that components distributed through out the engine bay are readable from a distance up to 1 meter. The system is also operational with the vehicle engine running, which was is not a requirement for the demonstrator but which enables a slightly different scenario and business model.

Figure 6. Tags reading and identification of components in the vehicle

Business scenario enabled

In fact in this case the pad is resident at the garage and the vehicle is driven to the garage, whether for maintenance or for pre-defined events (i.e. scheduled maintenance, periodic checks). This configuration has the following advantages:

- Enable a periodic check whether the components are still on-board or have been substituted (with non-tagged, non-original equipment);
- Enable battery or tag substitution, in case the battery is not running/ the tag has been damaged.

Drawbacks include the cost of installing pads in each of the official FIAT garages (1000+).

In synthesis, from a business point of view, the opportunity enabled by this configuration would be viable if and only if another business model could be coupled to End-of-life assessment: for example maintenance, ECU software modification or update. In the current situation, where the FIAT Group is already committed to maintenance using a telematics platform, enabling direct transmission from the vehicle to the service provider and the OEM, this business scenario is not forecast.

4.2 Test of networks of Zigbee tags in machine environment

4.2.1 Overview

ZigBee is a published specification set of high level communication protocols designed to use small, low-power digital radios based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs) [19, 20]. The technology is designed to be simpler and cheaper than other WPANs such as Bluetooth. There are three different types of ZigBee devices:

- ZigBee coordinator: It is the most capable device. It might bridge to other networks, and forms the root of the network tree. It is able to store information about the network. There is exactly one ZigBee coordinator in each network.
- Full function device (FFD): It can act as an intermediate router, passing data from other devices.
- Reduced function device (RFD): It is just smart enough to talk to the network; it cannot relay data from other devices.

ZigBee technology works on 2.4 GHz, 915 MHz and 868 MHz ISM bands. The devices require battery power but were designed to have lower consumption than Bluetooth. For this reason, ZigBee is a good candidate for industrial applications.

Wireless sensors networks are on the agenda of many automotive OEMs. Frost and Sullivan expect Zigbee to substitute Bluetooth by 2009 for applications such as diagnostics. Regarding the monitoring of components and the tracking of valuable items in the car (in our case valuable components), they are expected to be the most important areas of applications in the same period (2005-2011).

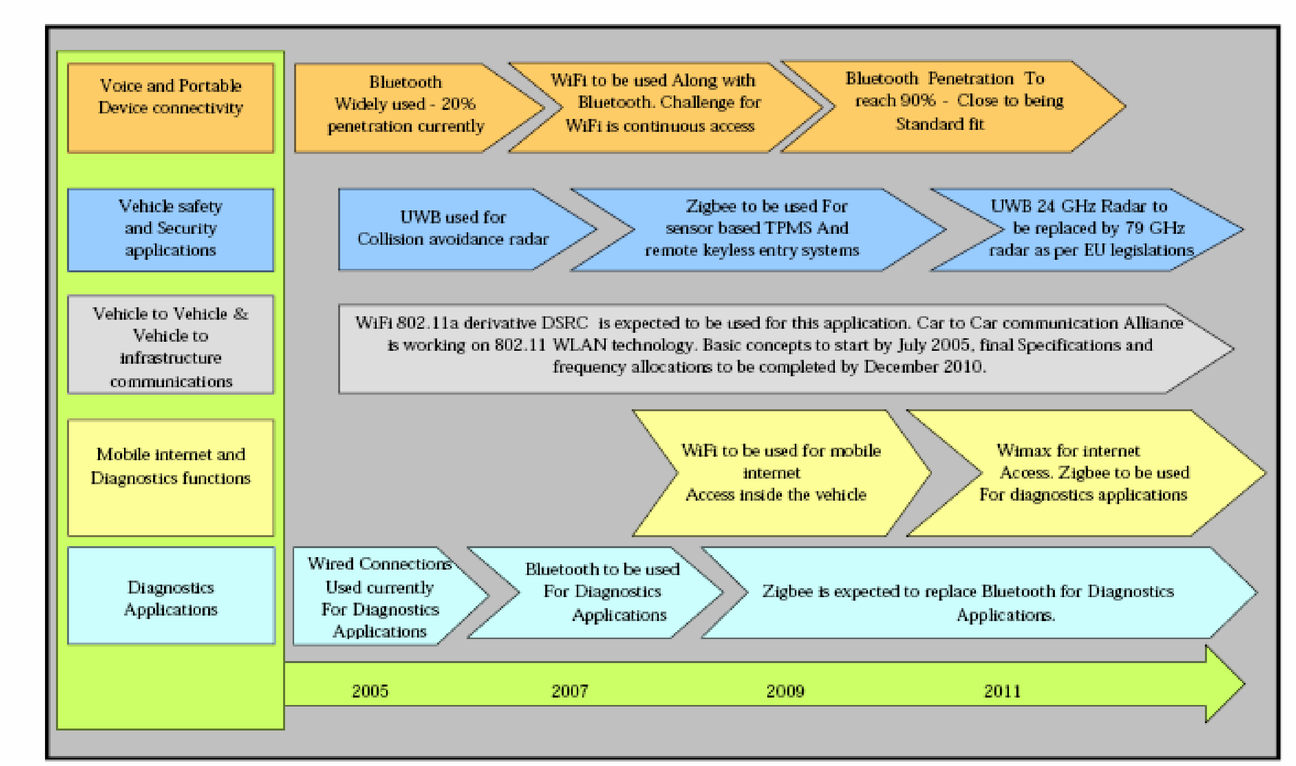

Figure 7. Frost and Sullivan - Automotive Wireless Technologies Market: Roadmap of Different Technologies (Europe), 2005-2011

Application Areas	Order of Importance
Sensor based Industrial Monitoring and Control Applications	
Tire pressure monitoring and Remote Keyless entry	1
Using Zigbee for tracking valuable items in a car	2
Deploying Zigbee enabled monitoring device for Rental Cars	3
Wireless home automation—personalization	

Figure 8. Frost and Sullivan - Automotive Zigbee market: Applications area (Europe), 2005

In the automotive sector, and in particular for the FIAT Group Sectors, potential gains include:

- Wiring simplification substituting existing sensors/devices with wireless one, generating a reduction in installation time and weigh, a standardisation in cabling and components;
- Dynamic handling of optional and after-sales components
  - To adapt vehicle life time to technology evolution and user needs
  - To potentially introduce functions not justified for high volumes (e.g. cameras)
  - To introduce optional features in different timescales with low impact on security
- Introduction of new sensors in parts not reachable by wire, such as brake sensor, TPMS evolution and intelligent wheel, Mission remote programming, and finally an:
- Opportunity to create interaction between vehicle and external components.
  - Development of “intelligent sensor” with wireless interface for diagnosis
  - Wireless diagnosis interface (maintenance tool)
  - Wireless vehicle interface to standardize fleet equipment and reduce connectivity interface
- Communication on a higher distance (e.g. between vehicle and cargo), difficult to realise by wire
  - Mechanical status monitoring
  - Environmental monitoring
  - Cargo monitoring
  - Diagnostic tools
  - Mission remote update (tools programming and settings – short range)

Thus, to take into account these trends of introduction and to create synergies with other applications of Zigbee tags, in terms of new applications based on a structure which will take off in the next future, it was decided in PROMISE to assess a solution in which components are tagged with Zigbee tags, including wireless sensors.

In order to evaluate the impact of introducing the Zigbee technology in a vehicle, it is necessary to evaluate both quantitatively and qualitatively some factors, which include:

- Quality of communication from different locations in the vehicles, to identify best and worst cases for installation of wireless tags and sensors, and consider eventually the multi-hop;
- Interferences with the on-board electronic devices;
- Possibility to create an interface with the on-board CAN-busses;
- Evaluation of cost/ benefits for the implementation and industrialisation of the solutions.

Below we report the following:

1. Technological evaluation (zigbee tags and WSN in automotive);
2. Set-up of a demonstrator vehicle;
3. Results of experimentation.

The technological evaluation include two aspects equally important:

- The development of sensor nodes, including hardware and software, able to retrieve and communicate the relevant information (ID, physical values, e.g. temperature), following the technology specific protocols;
- The development of the wireless network between the nodes and the analysis of performance:
    - robustness
    - reliability
    - reconfigurability
    - complexity
    - compatibility with legacy systems
    - others

We summarise the results of experiments using the TELOS hardware (from Crossbow), with communication frequency 2.4 GHz. The major advanteages include:

- Integration of sensors which may prove useful for the demo
- Integrated antenna to enhance the performance of the “communication link”
- Peripherical (I/O, CAN, ….) useful for realising a demonstrator
- ZigBee compliant.

4.2.2 Experiments

The scope was to evaluate the quality of the communication link on the vehicle, evaluating interferences due to the other on-board instruments.
During the experiments, different locations have been tested, including inside and outside the engine hood.
The architecture tested is composed of:

1. 1 receiving node (RX), connected to the Convergence on-board of the vehicle. This node is powered with batteries and transmits information coming from the other nodes;
2. 3 transmitting node (TX), which have been fixed in different location in the vehicle. These nodes were powered by batteries. For these tests a message was sent every 5s with a payload of 28 Byte (one for the packet ID).

The evaluation of the connection link is based on:

- The number of sent packets (2nd column);
- The number of received packets (3rd column);
- The percentage of lost packets (4th column)
- The mean value of signal lowering [-30dBm ÷ -105dBm] (5th column)

- The total time of transmission

The experiments were performed on a FIAT Grande Punto dedicated to this activity. The vehicle is equipped with the Blue&Me telematics platform, which is used as a Gateway towards the CRF database and towards the PDKM.

The table below summarises the tests performed in the two different sessions of tests.

Table 4. Test results using TELOS and MICAz

Location 1						
Tipo di modulo	Pkt inviati	Pkt persi	%pkt persi	Potenza media	Tempo tx	Intervallo singoli pacchetti
Micaz	5110	1	0,02	-75,09	24946	4,88
Telosb	4779	0	0,00	-79,70	23333	4,88
Location 2						
Tipo di modulo	Pkt inviati	Pkt persi	%pkt persi	Potenza media	Tempo tx	Intervallo singoli pacchetti
Micaz	5088	0	0,00	-73,54	24836	4,88
Telosb	4962	0	0,00	-67,65	24225	4,88
Location 3						
Tipo di modulo	Pkt inviati	Pkt persi	%pkt persi	Potenza media	Tempo tx	Intervallo singoli pacchetti
Micaz	7368	0	0,00	-76,39	35972	4,88
Telosb	4998	0	0,00	-74,93	24405	4,88
Location 4						
Tipo di modulo	Pkt inviati	Pkt persi	%pkt persi	Potenza media	Tempo tx	Intervallo singoli pacchetti
Micaz	5631	1620	28,77	-87,07	32497	5,77
Telosb	5325	0	0,00	-70,19	25987	4,88

Location 5						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	4620	0	0,00	-80,47	22562	4,88
Telosb	5874	0	0,00	-78,22	28671	4,88

Location 6						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	4857	606	12,48	-86,44	23714	4,88
Telosb	4853	14	0,29	-79,09	23694	4,88

Location 7						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	4983	0	0,00	-70,18	24325	4,88
Telosb	5301	0	0,00	-63,42	25898	4,89

Location 8						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	5328	0	0,00	-62,42	26017	4,88
Telosb	5007	0	0,00	-54,02	24455	4,88

Location 9						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	5226	0	0,00	-60,51	25517	4,88
Telosb	5373	0	0,00	-56,12	26228	4,88

Location 10						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	5352	0	0,00	-71,36	26138	4,88
Telosb	4962	0	0,00	-71,23	24224	4,88

Location 11						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	5004	0	0,00	-48,66	24435	4,88
Telosb	4734	0	0,00	-43,55	23103	4,88

Location 12						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	5346	0	0,00	-62,71	26097	4,88
Telosb	4851	0	0,00	-47,65	23694	4,88

Location 13						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	7105	1	0,01	-55,29	34689	4,88
Telosb	4578	0	0,00	-53,91	22352	4,88

Location 14						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	6456	0	0,00	-54,75	31516	4,88
Telosb	4878	0	0,00	-46,87	23814	4,88

Location 15						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	4992	0	0,00	-66,88	24375	4,88
Telosb	4881	0	0,00	-65,37	23835	4,88

Location 16						
Tipo di modulo	**Pkt inviati**	**Pkt persi**	**%pkt persi**	**Potenza media**	**Tempo tx**	**Intervallo singoli pacchetti**
Micaz	4665	0	0,00	-67,94	22773	4,88
Telosb	4716	0	0,00	-74,96	23023	4,88

The results highlight the better performance of Telos modules, with mean lowering of signal always inferior to MICAz.

In synthesis communication inside the vehicle is considered as very satisfactory, with mean lowering not inferior to -54dBm (even with passengers).

Under the hood, the communication link is considered satisfactory, and enable the transmission of information, including ID. CRF has analysed with the hardware supplier the results of the tests and the requirements for the system: with the expected use of the system in this application (3 transmissions of data per week: one for data, two for control) the required lifetime of 3 years for such batteries has a 90% probability of being met.

4.3 Development and test of the stand-alone DSS

The development and tests of the stand-alone DSS are reported extensively in deliverable DR8.8 and DR8.9. The integrated DSS is presented in DR8.11 The reader should refer to these documents for any detail on the DSS. The following paragraph recalls the components integrated in the demonstrator and presents some snapshots of the final system.

4.4 Integration

Integration of the following components (in bold the components specifically developed in PROMISE) has been performed:

1. Sensors and Embedded devices on-board of the FIAT Grande Punto: the hardware is off-the-shelf (Telos, MicaZ) and the **software** has been developed to create the network and interface with the Convergence®;
2. Data busses on-board of vehicles (B-CAN): collect on-board data on the real use of the vehicle, which enable to compute the residual life of the components;
3. A1-specific **algorithms for residual life**, developed by CRF;
4. Convergence®, the proprietary telematics platform of the FIAT Group: acts as a repository for lifecycle data; aggregates data; calculates residual life of components using the algorithms mentioned in point 3 above; updates the list of on-board components;
5. A1-specific **database** developed by and hosted in CRF: collects data coming from the vehicle at End-of-Life;
6. A1-specific **PMI** developed by Trackway: transfers data towards PDKM
7. **PDKM**, developed by Inmediasp and hosted by SAP: acts as a repository of lifecycle data, enables computation in DSS;
8. **Algorithms for decision making at End-of-Life,** developed by Cambridge and CIMRU: calculates the optimal decision for recycling/ remanufacturing/ reusing;
9. **DSS**, developed by Cognidata and hosted by SAP: integrates the algorithms mentioned in point 8 above;
10. DSS and PDKM **GUI** developed by SAP: creates the interface with the user.

We report some snapshots of the integrated system.

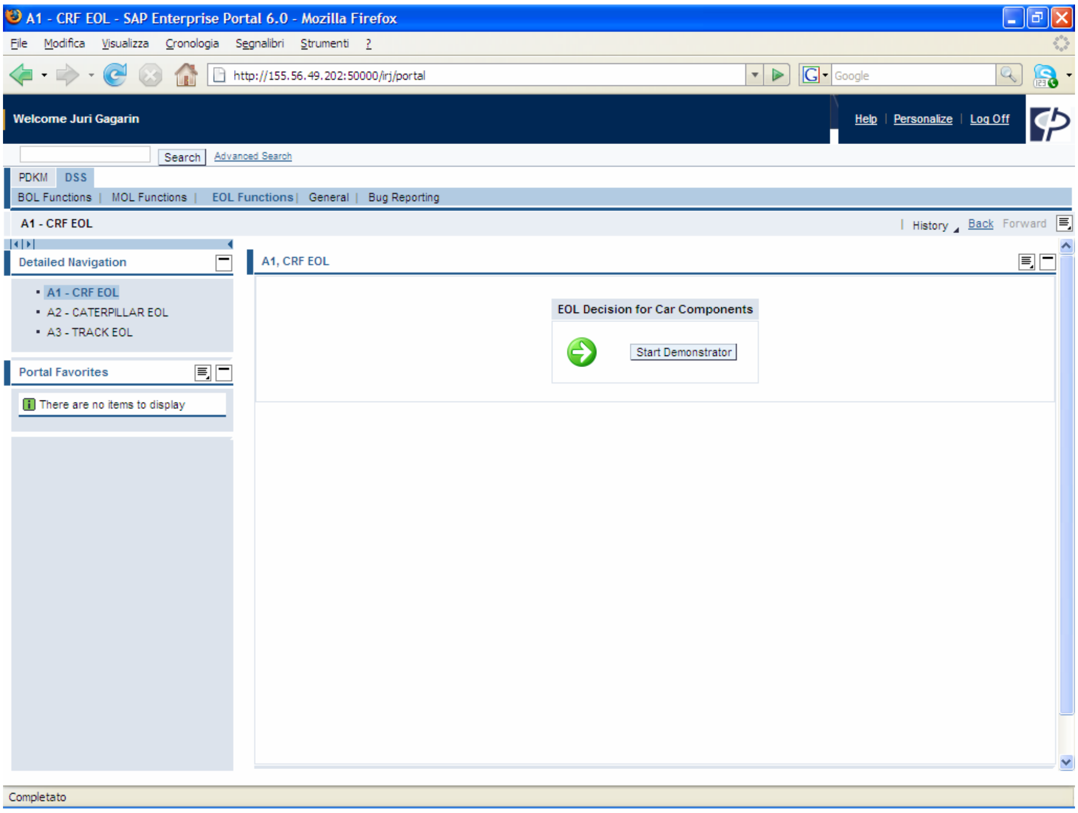

Figure 9. Start of the DSS

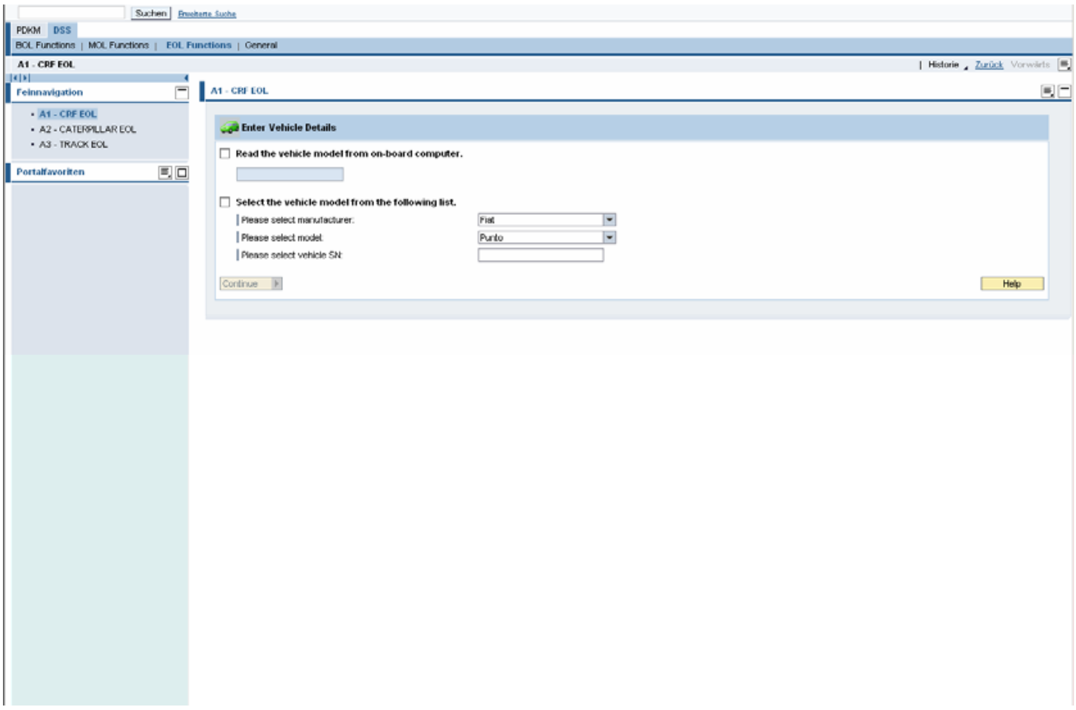

Figure 10. Selection of the vehicle

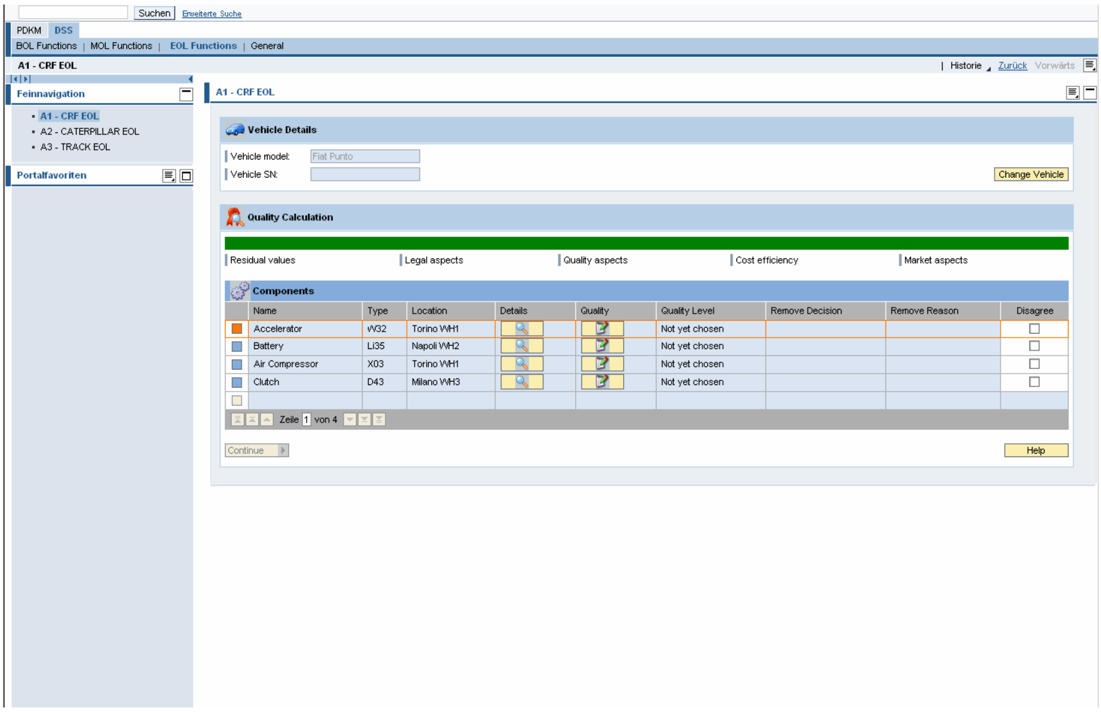

Figure 11. List of components (details)

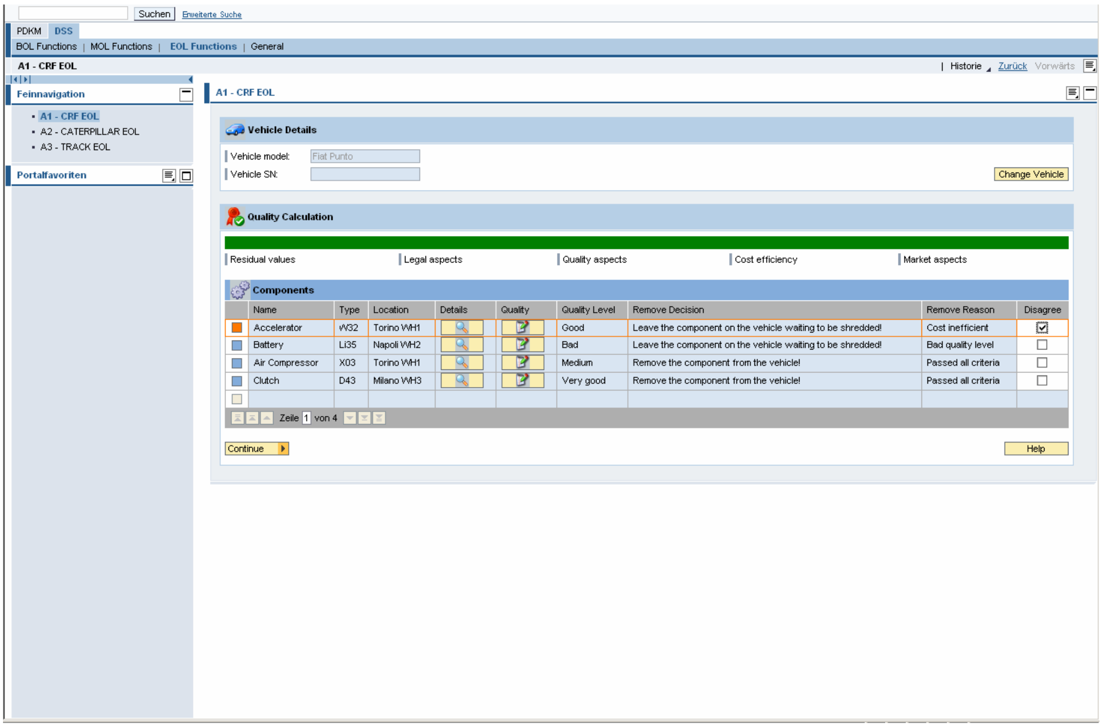

Figure 12. Final list of actions

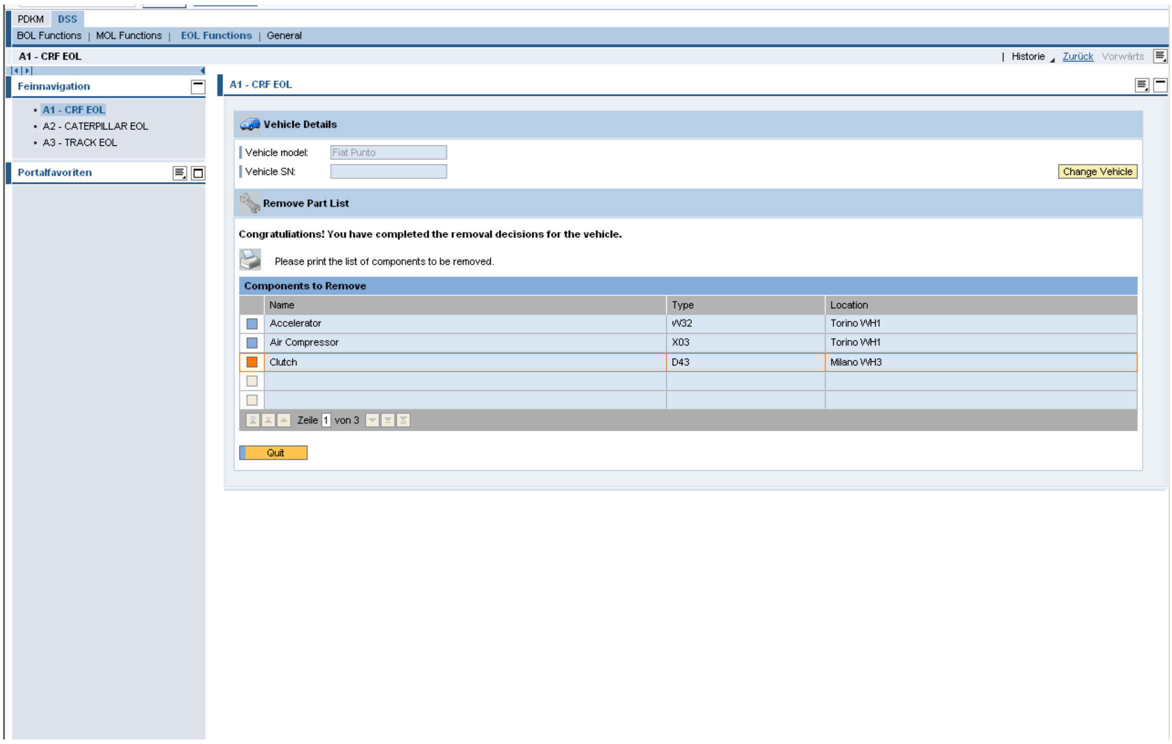

Figure 13. Completion of decision process

5 Conclusion

The present deliverable report the results obtained in implementing the PROMISE A1 demonstrator. The demonstrator shows the integration of all PROMISE components in order to solve the issue at stake: the decision support for decommissioning of End-of-Life vehicles. A portfolio of tested technical solutions is ready for further implementation.

The main technology issues to be solved were the communication in harsh environment, the battery life and the coexistence with existing systems on-board. Regarding communication, two of the three technical solutions were considered satisfactory, with different cost-efficiency ratios, maturity and timeline for implementation. Regarding battery life, the tests and analysis performed by the supplier are satisfactory. Regarding integration and eventual interferences with on-board system (such as Bluetooth), the integration has been fully performed and tests have not reported major problems.

One of the major issues, which was to integrate the PROMISE components with the (mainly on-board) existing infrastructure is thus fully addressed. In particular the demonstrator builds on existing vehicle on-board systems, reducing the effort for industrialisation. Business issues will be addressed in Deliverable DA1.7.

In synthesis, the objectives of the demonstrator have been fully met.

6 References

DA1.3: Design of the EOL Demonstrator on Deregistering of ELVs, N. Francone, J. Mascolo, CRF, May 12th 2006.

DA1.4: Process model workflow description for the demonstrator, Julien Mascolo, Francesca Bandera, CRF, Celal Dikici, BIBA, Nov 20th 2006.

"A Study of the Behaviour of RFID in a Car Engine Environment", Fabien Delahaye, thesis for the Master of Philosophy in Industrial Systems, Manufacture and Management, Institute for Manufacturing, University of Cambridge, May 4th 2006.

DR8.9. Testing and Evaluation of the DSS demonstrator (Version 3), Coordinator COGNIDATA, March 15th 2008.

DR8.11. Refinement and Improvement of the decision support demonstrator (Final version), Coordinator COGNIDATA, May 15th 2008.

Annexe A PMI for A1 - Example


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