



Handbook for Usage of the PROMISE decision support technology (Version 1)

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Abbreviations:

BOL	Beginning Of Life
BOM	Bill Of Materials
DfX	Design for X
DHW	Domestic Hot Water
DPN	Degradation Priority Number
DSS	Decision Support System
DOW	Description Of Work
ECC	Error Correction Code
EEE	electrical and electronic equipment
EIS	Enterprise Information System
ELV	End of Life Vehicle
EOL	End Of Life
GUI	Graphical User Interface
HTML	Hyper Text Mark-up Language
HTTP	Hyper Text Transfer Protocol
JDK	Java Development Kit
JSPs	Java Server Pages
LCC	Life Cycle Cost
MOL	Middle Of Life
MTBF	Main Time Between Failures
ORM	Object-Relational Mapping
PDKM	Product Data and Knowledge Management
PEID	Product Embedded Information Device
RAM	Reliability, Availability, Maintainability
RDBMS	Relational Database Management System
SAP	Systems Analysis and Product
SQL	Structured Query Language

1 Purpose of this document

This report contains the PROMISE WP R8 Deliverable DR8.6 “Handbook for Usage of the PROMISE decision support technology (Version 1)”. Its purpose is to give new users a handbook about how to use the DSS.

Hence, this document involves two main issues: (i) the installation of the first prototype of PROMISE DSS and (ii) the description of the how to apply the different strategies. Currently, the document includes the application scenarios A1, A4 and A6. In version 2 of the document the remaining application scenarios will be added.

2 Introduction

2.1 Objectives of work package R8

According to *PROMISE Description of Work* the goal of this work package is to provide the analytical basis of the PROMISE project. This WP concentrates on predictive maintenance, diagnosis and analysis of use patterns, which rely on algorithms originating from the fields of statistics, data mining, pattern recognition and computational intelligence. Based on the PROMISE research clusters 1, 2 and 3 and the PROMISE application clusters, this work package specifies decision-making systems supported by automatic identification systems, product embedded information devices, mobile reader devices, associated software and user interfaces. In a second step, methods and algorithms for beginning of life (BOL), middle of life (MOL) and end of life (EOL) decision-making systems will be developed for the evaluation in the application clusters.

2.2 Objectives of Deliverable DR8.6

As described in PROMISE_DoW (M30-M42), the main goal of Task TR8.6 is to give each new applier of the PROMISE technology a document that makes him understand, what part of the technology he can directly reuse, what part needs specific extensions developed by him and where the major obstacles in a successful application lay. In TR 8.6 we generate a handbook that guides new users in an instructive way.

2.3 Structure of Deliverable DR8.6

The rest of this document is organized as follows:

- In Chapter 3 an introduction into the DSS is given.
- Chapter 4 gives information which technical environment is needed in order to run the DSS.
- Chapter 5 explains how to start the DSS.
- In Chapters 6-8 it is shown how the different strategies can be executed within the DSS.
- Finally, Chapter 9 summarizes the content of the document and mentions next steps.

3 Introduction to the Decision Support System

This chapter provides an overview of the architectural concepts upon which the DSS is based. It can be used in two ways: On the one hand, as a stand-alone system including its own database and GUI. On the other hand, the DSS can be integrated as part of the PDKM system.

Decision Support System

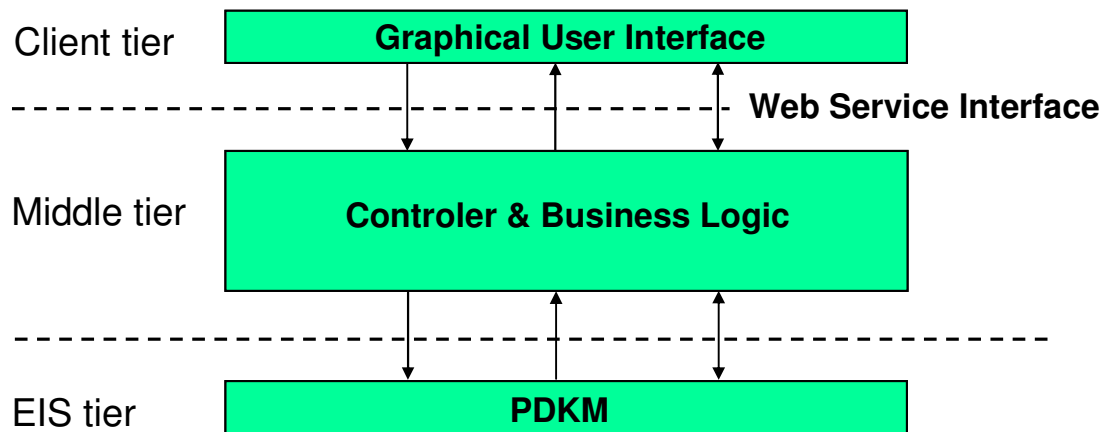


Figure 1: PROMISE DSS architecture

The PROMISE decision support system is designed as a browser-based 3-tier architecture. The EIS tier (also called the data tier or the bottom tier) maintains data pertaining to the decision support system. This tier stores data in a relational database management system (RDBMS). In the integrated solution DSS algorithms access data that is stored in PDKM. The middle tier implements presentation logic, controller logic and business logic to control interactions between the application's clients and the application's data. The middle tier acts as an intermediary between data in the EIS tier and the application's clients.

The middle-tier presentation logic then processes data from the application layer and presents the content to the client in form of JSPs and Servlets. The controller-action architectural pattern can be understood as a model manager. The controller itself is implemented as a web service which separates the presentation logic from the business logic.

The PDKM/DSS GUI (Client tier) development is carried out in form of iViews. iViews are web applications based on JSP that can be directly integrated into the SAP NetWeaver Portal, which provides the runtime environment for the PDKM GUI. This environment only supports JDK 1.4. Yet, the DSS includes several 3rd-party libraries and frameworks which require JDK 5.0. However, due to the separation of the presentation logic from the business logic each part can run in its own Java environment and is therefore not limited in its functionality. Furthermore, it has the advantage that only one GUI for PDKM and DSS can be developed. From the end-user's point of view it is transparent whether DSS or PDKM functionality was called.

4 Technical Information

The PDKM prototype bases on the PLM system mySAP PLM and on SAP EP. The following software versions have been used:

- SAP ECC 5.0 (including mySAP PLM)
- SAP NetWeaver 2004 with
 - SAP EP 6.0 SP 9
 - SAP WebAS 6.40
 - SAP J2EE-Engine 6.40 (realising J2EE 1.3)
- JRE 1.4.2
- MaxDB 7.5 as databases for SAP ECC and SAP NetWeaver

The PROMISE decision support system development is carried out with Java-based technologies.

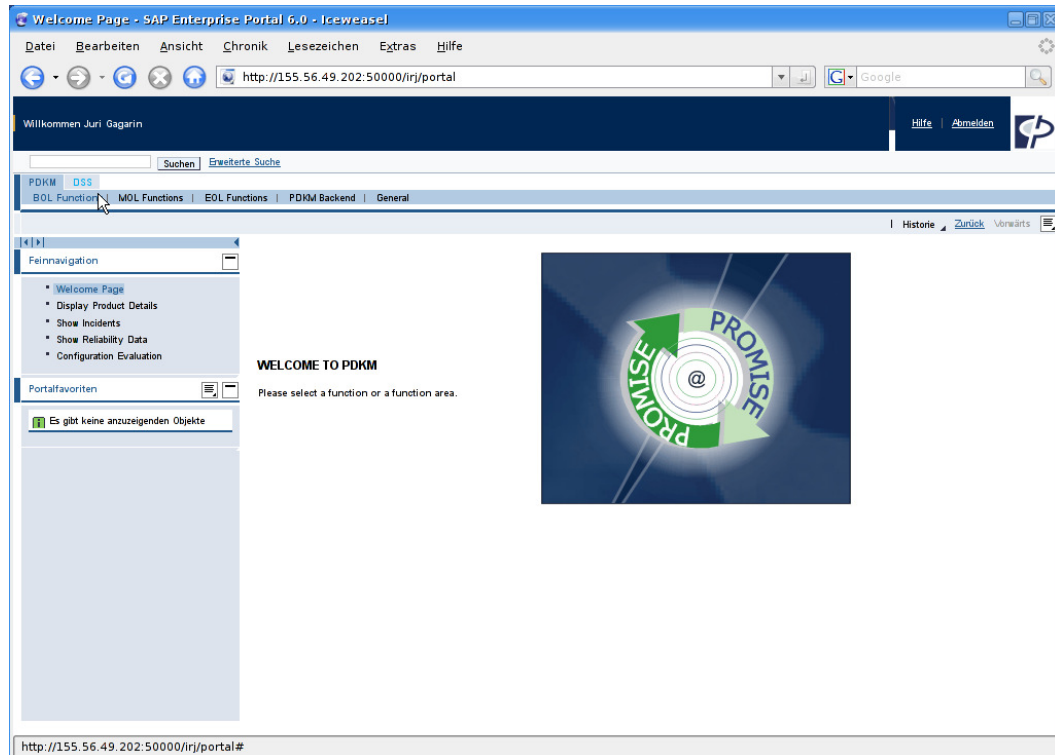
The development environment consists of the following components:

- Sun Java 2 Platform Standard Edition 5.0 Development Kit (JDK 5.0)
- Apache Tomcat 4.1.31 Servlet/JSP Container
- Eclipse 3.1.2 + WTP plug-in + Hibernate Tools plug-in
- Hibernate 3.1.2
- Commons-Math: The Jakarta Mathematics Library, Version 1.1
- MaxDB 7.5 (temporary database)

Using only platform independent components PROMISE DSS can be installed on multiple OS platforms.

5 Starting the DSS

After starting the DSS the system carries out a user login procedure and continues with the main screen:

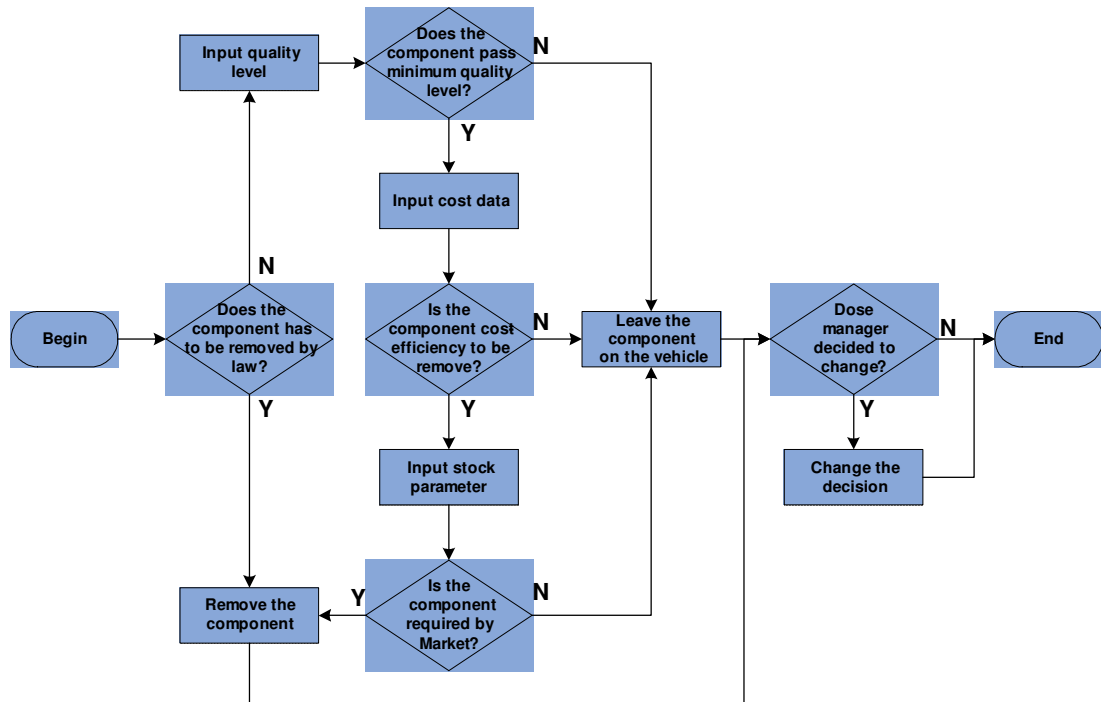


From here the user can start or administer the different decision support strategies.

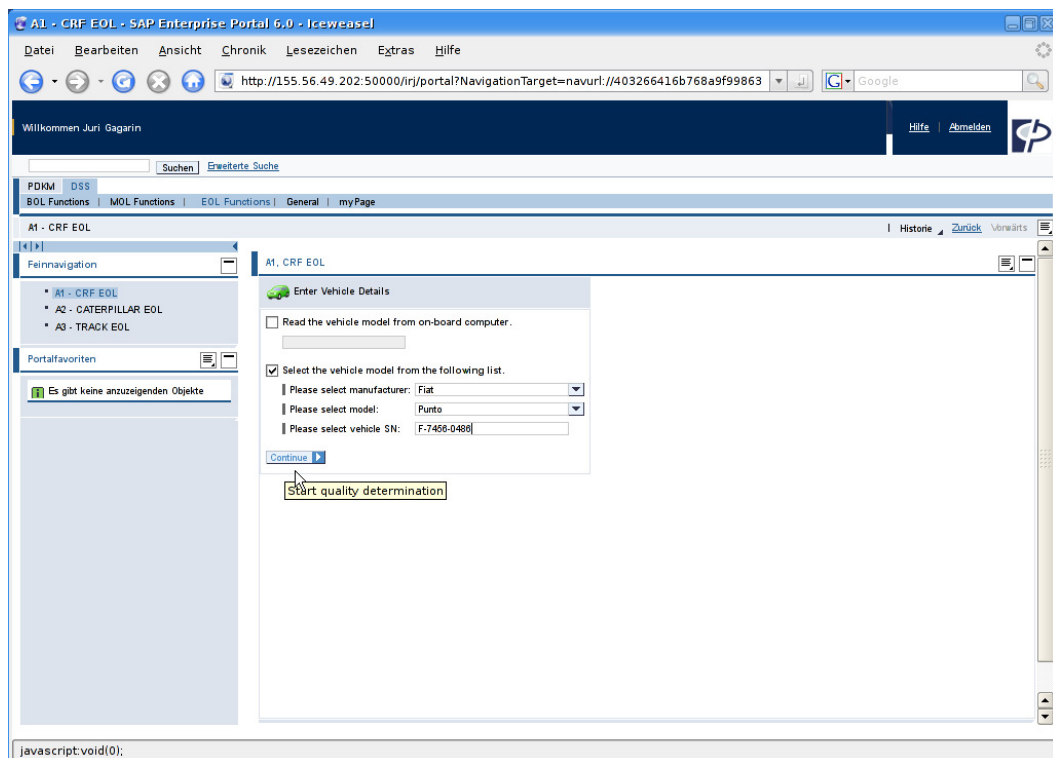
6 Strategies for End of Life

6.1 Example A1: Decision support for disassembly

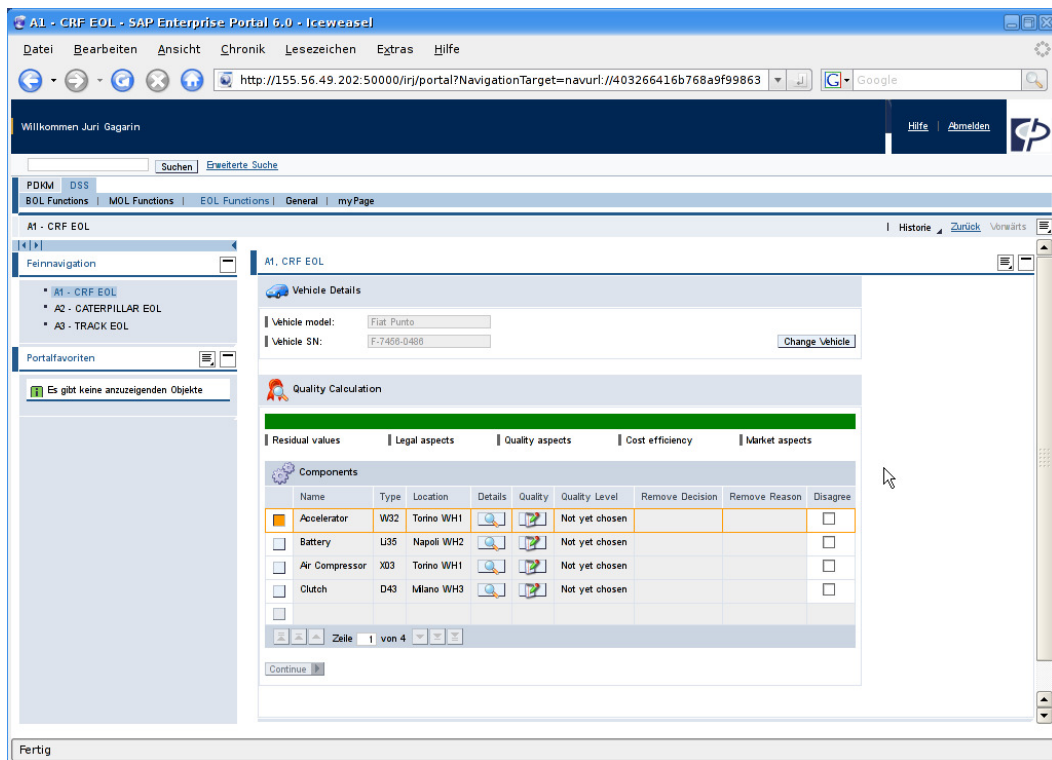
The ELV (End of Life Vehicle) directive (EU/2000/53) forces car manufacturer to increase their efforts in reuse, recycling and recovery of materials from ELVs. The DSS has therefore implemented a strategy that guides motor mechanics through the process of decommissioning ELVs. In the next figure the decision process is depicted.



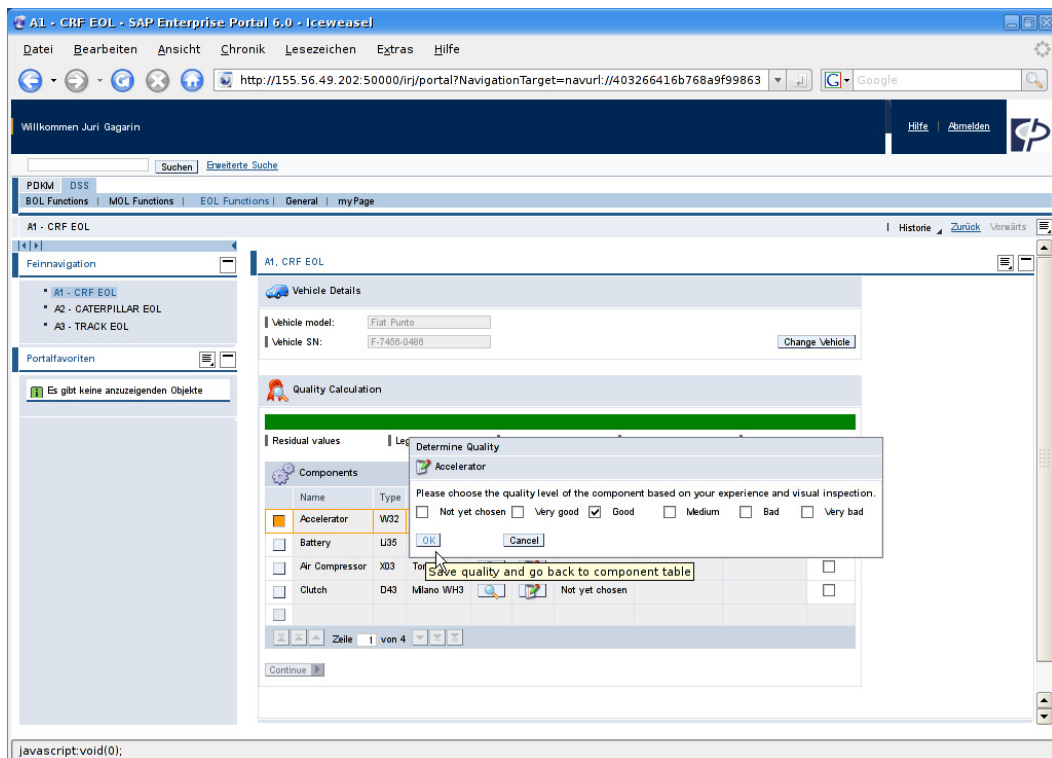
The DSS supports this process. By pressing the respective button for the decommissioning strategy “A1 CRF EOL” the process starts. At first the present car has to be identified, either by downloading information from the car or by typing the serial number manually.



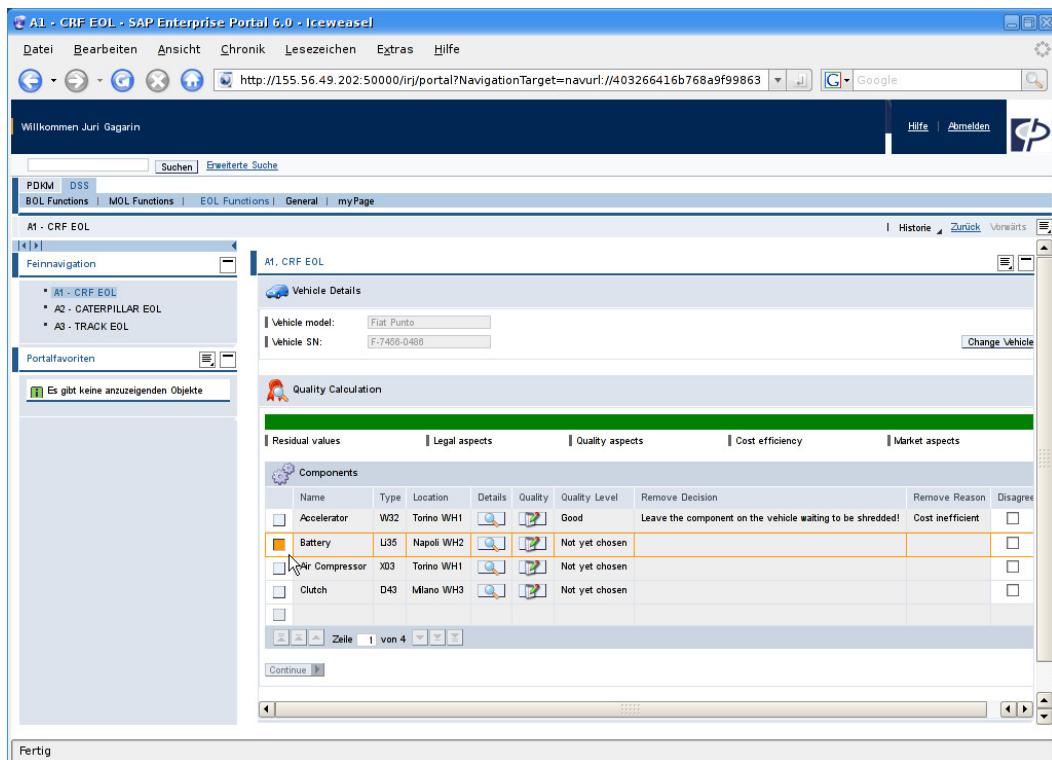
Afterwards the system displays the list of components which either have to be removed or to be shredded.



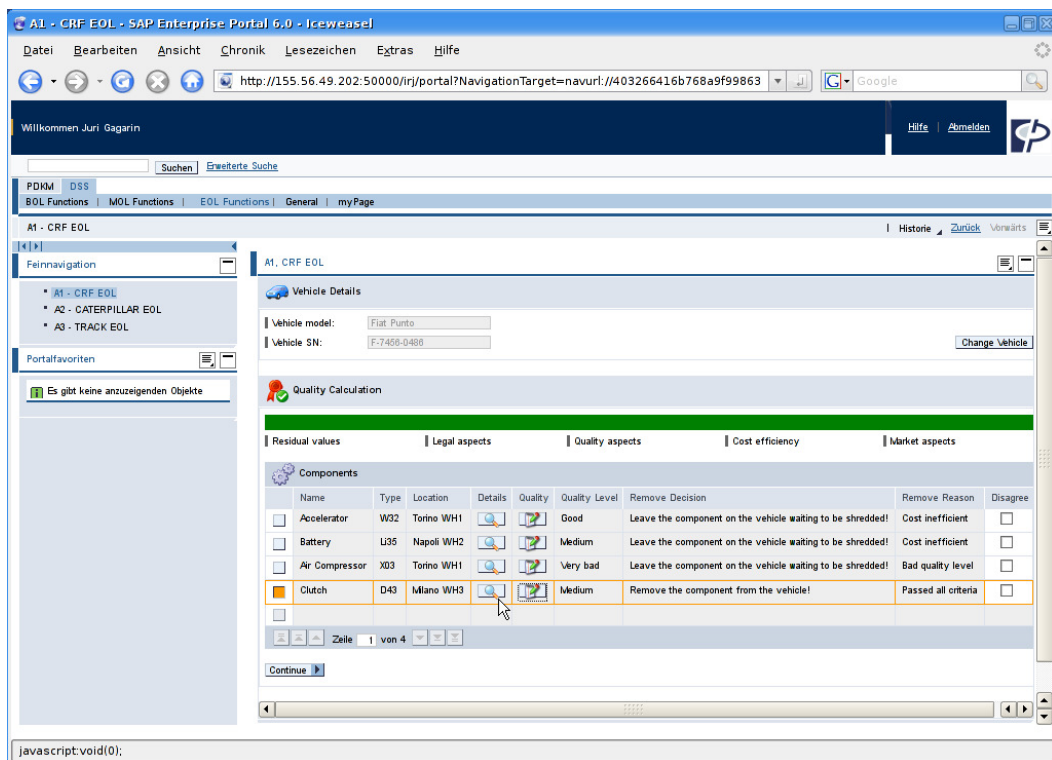
The mechanic has to go over each of these components and has to meet the correct decision. In each line a number of functions can be executed. By typing “Details” important information out of the back office is presented, by typing “Quality” the mechanic can enter its own estimation of the state of the component. In the next figure this can be seen.



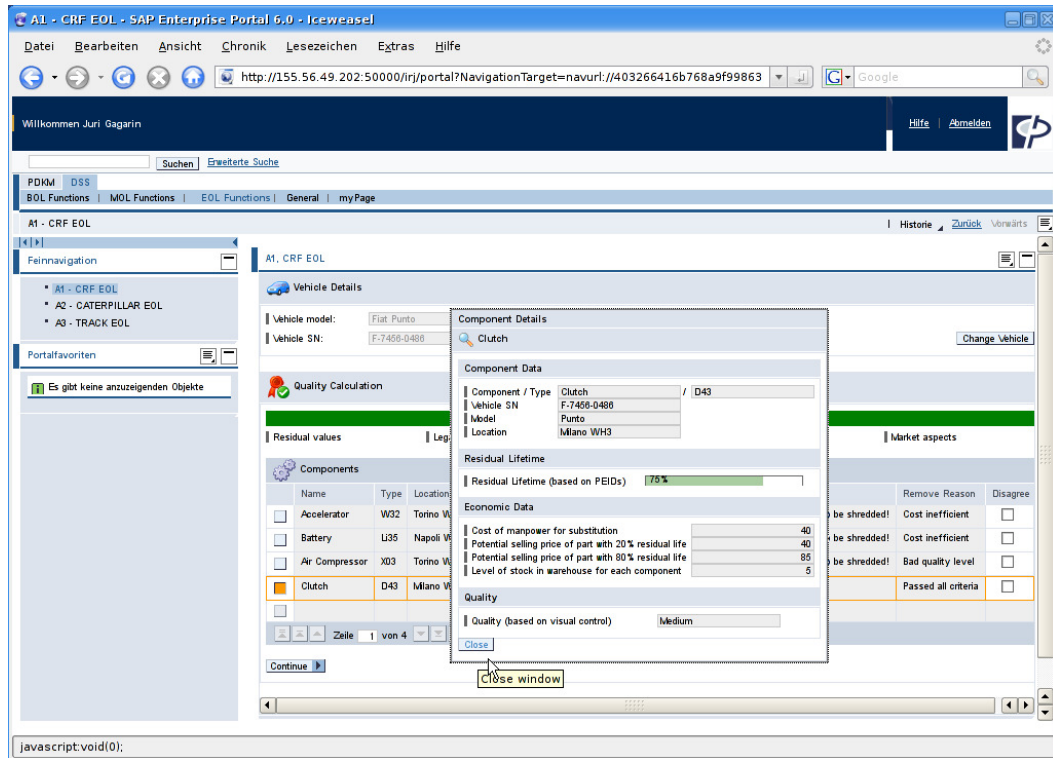
Depending on the actual own assessment of the component the mechanic chooses one of the 5 options. Closing the window with “ok” leads back to the overview list which displays the chosen option under “Quality Level”.



The process ends when all components are processed.



In case the mechanic wants to see the underlying information on which the decision was based, s/he can press the respective “Details” button.



In the “Components Details” screen the computed residual lifetime is given. This value is computed as the average lifetime of such components, taking also care of previous repairs or received sensor data. However, nobody took a look on the physical component.

In addition there is financial information about the possible second hand prices and the labour hours for substituting the component. Finally, the number of pieces in the inventory is given. Altogether the mechanic can now decide whether it makes sense to remove the component from the car.

Having finished the analysis the mechanic can review the decisions. If s/he wants to overrule the decision the “Disagree” button has to be clicked.

The next two screens display the list of decisions.

Vehicle Details

Vehicle model: Fiat Punto
Vehicle SN: F-7456-0488

Last Decision

Accepted Usage of Components

Components	Name	Remove Decision	Remove Reason
<input checked="" type="checkbox"/>	Accelerator	Leave the component on the vehicle waiting to be shredded!	Cost inefficient
<input type="checkbox"/>	Battery	Leave the component on the vehicle waiting to be shredded!	Cost inefficient
<input type="checkbox"/>	Air Compressor	Leave the component on the vehicle waiting to be shredded!	Bad quality level
<input type="checkbox"/>	Clutch	Remove the component from the vehicle!	Passed all criteria

Queried Usage of Components

Components	Name	Remove Decision	Remove Reason	Leave	Remove
<input type="checkbox"/>					
<input type="checkbox"/>					
<input type="checkbox"/>					
<input type="checkbox"/>					

Continue

Show parts to remove from vehicle

At the end the mechanic might want to print the list of parts which have to be removed, in order to walk to the car.

Remove Part List

Congratulations! You have completed the removal decisions for the vehicle.
Please print the list of components to be removed.

Components to Remove

Name	Type	Location
<input checked="" type="checkbox"/> Clutch	D43	Milano WH3
<input type="checkbox"/>		
<input type="checkbox"/>		
<input type="checkbox"/>		

Out

7 Strategies for Middle of Life

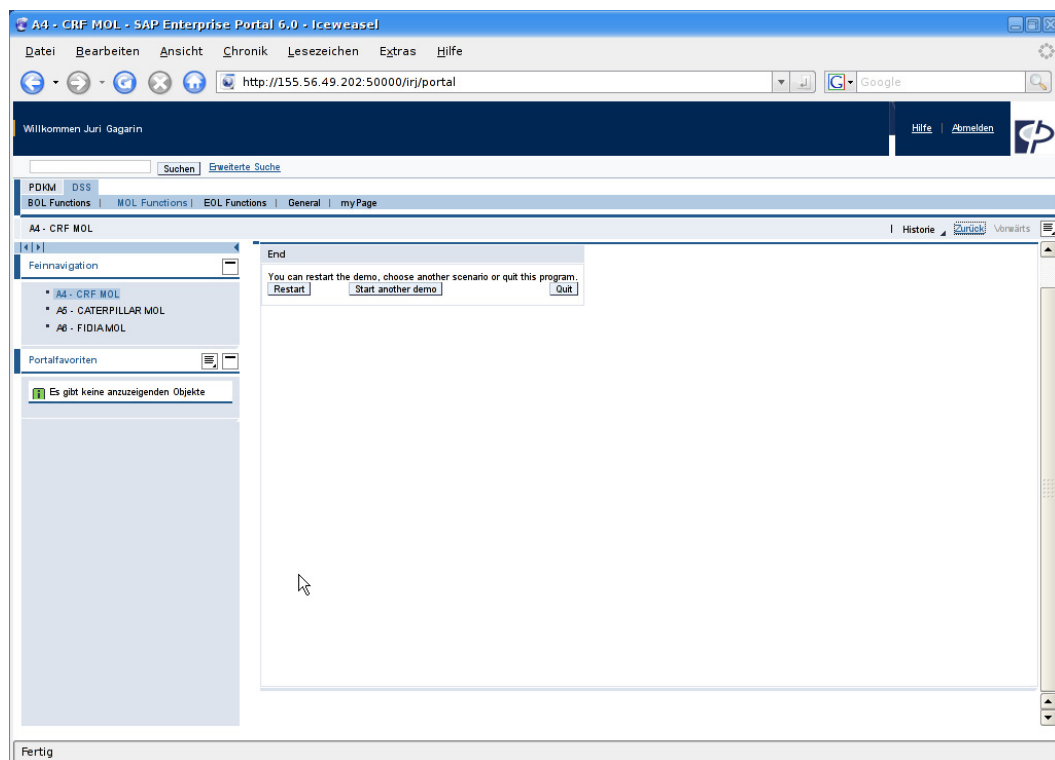
7.1 Example A4: Maintenance of a fleet of trucks

In this example the DSS is used to support the maintenance of a fleet of trucks, optimising the maintenance plan and increasing the overall availability of the trucks. This will improve the knowledge about the customer habits and the mission profile of the vehicle and finally enable to:

- Reduce the number of vehicle stops for maintenance
- Minimize the overall lifecycle costs of the components
- Avoid component breakdowns
- Take into account vehicle availability while planning maintenance interventions
- Take into account maintenance crew availability for performing maintenance

The idea behind predictive maintenance is the identification of slow degradation trends in the performance of specific systems in order to identify with reasonable warning the need of an intervention. This allows the optimisation of maintenance intervention with the implementation of a customised maintenance policy and contributes to make explicit the residual life of the component in order to better manage the total Life Cycle Cost (LCC).

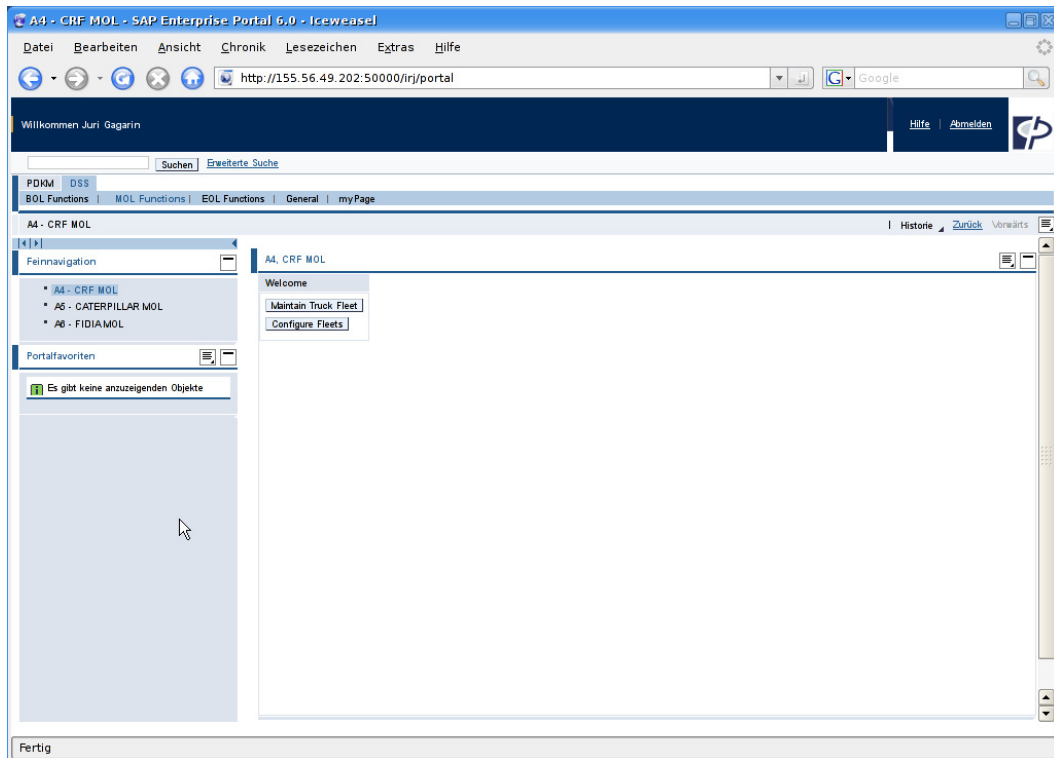
In the DSS the user navigates to the A4 use case:



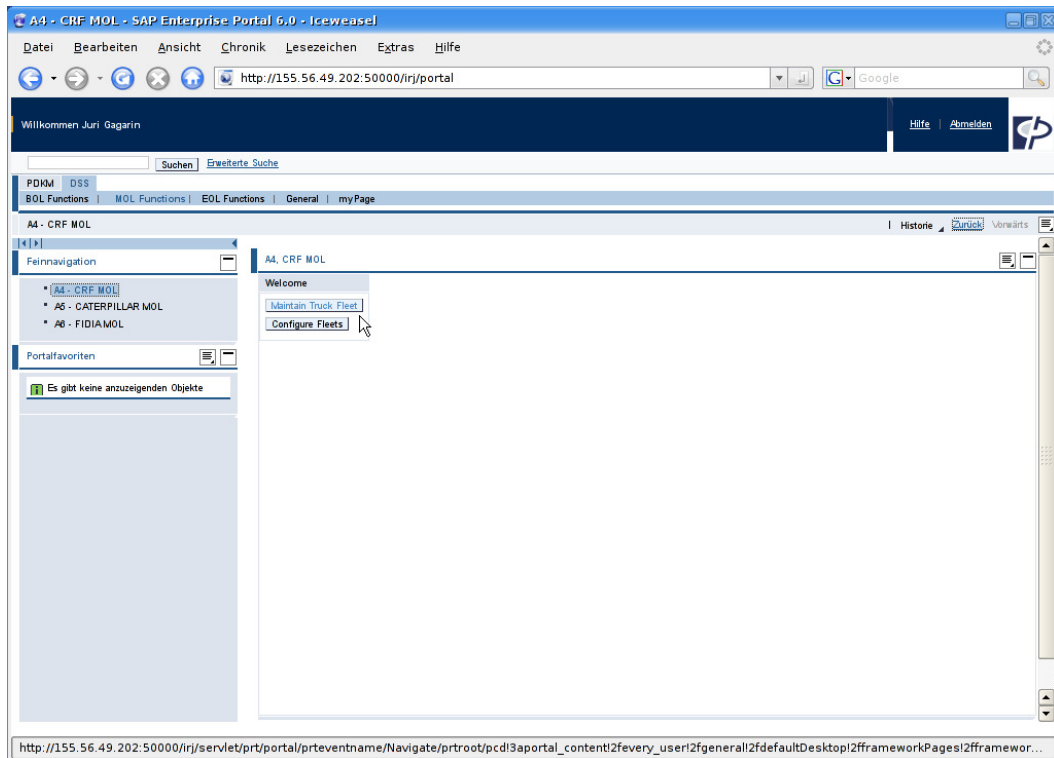
Then the user has two options:

- Getting support for decision making or

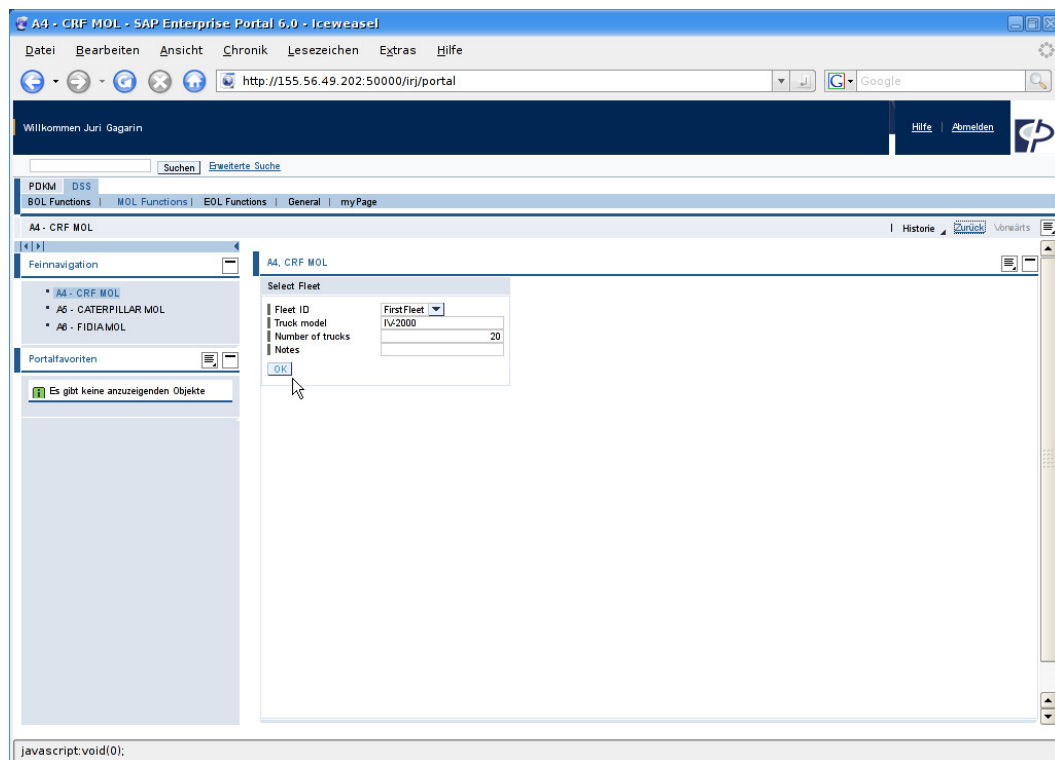
- Configuring the DSS.



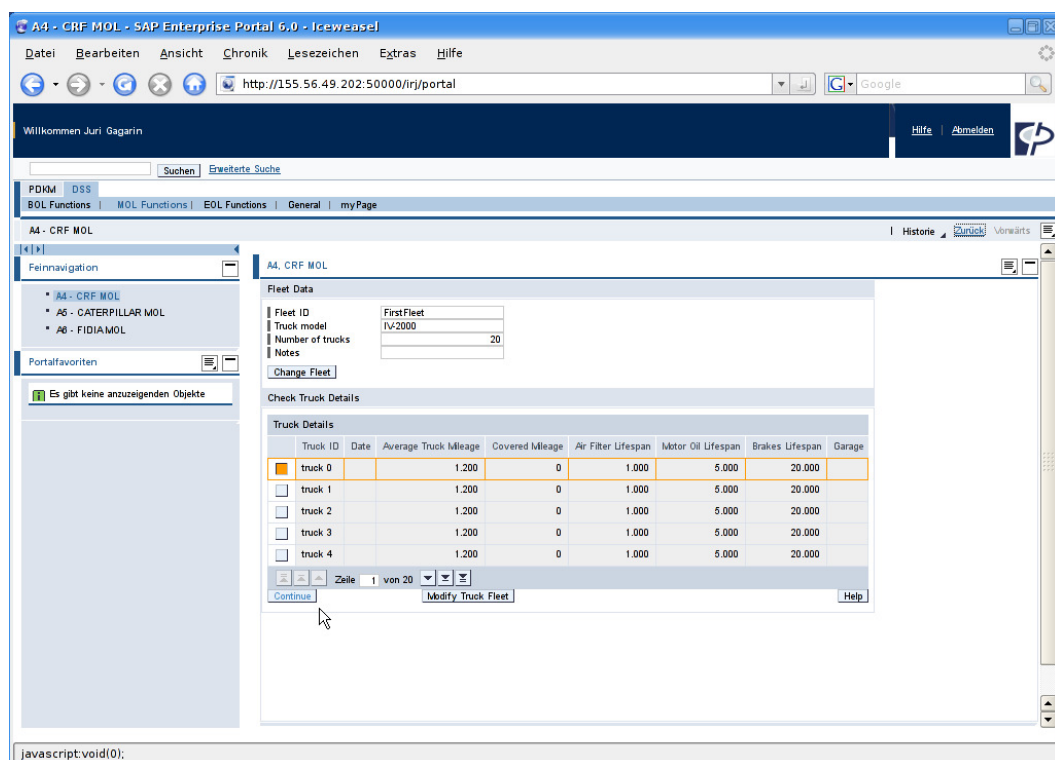
If the user selects the option “Maintain Truck Fleet” the system will support the decision process.



At first the user has to identify the truck fleet s/he wants to analyze.



The system will display the list of all trucks in the fleet with corresponding important attributes.



The system allows the user to see the underlying truck fleet parameter for the decisions.

A4 - CRF MOL - SAP Enterprise Portal 6.0 - Iceweasel

Willkommen Juri Gagarin

Suchen Erweiterte Suche

PDKM | BOLD Functions | MOL Functions | EOL Functions | General | myPage

A4 - CRF MOL

Feinnavigation

- A4 - CRF MOL
- A5 - CATERPILLAR MOL
- A6 - FIDIAMOL

Portalfavoriten

Es gibt keine anzuzeigenden Objekte

A4, CRF MOL

Fleet Data

Fleet ID: FirstFleet
 Truck model: IV2000
 Number of trucks: 20
 Notes:
 Change Fleet

Static Data Input

Generic Data

Cost of truck unavailability (€ / 1 day)	0,8575429316714287
Truck average mileage (km)	0,1254224406431398
Engine average mileage (km)	0,0423985209541055
Fuel price (€ / liter)	0,20755819127517475
Fuel consumption (liters / 100km)	0,46510587576084335

Air Filter

Maintenance intervention

Cost of air filter (€)	0,7280025809720517
Man-hours for replacement (h)	0,7529287417412002
Filter disposal (€)	0,06091078485548398
Air filter average mileage (km)	0,08737288097781056

Motor Oil

Maintenance intervention

Cost of motor oil (€ / liter)	0,02384489901505718
Motor oil amount (liters)	0,9444387384799181
Man-hours for oil replacement (h)	0,3075426991713177
Oil disposal (€ / liter)	0,8217110011271374

Problems due to intervention delay

Cost of engine (€)	0,5393865732551630
Man-hours for engine replacement (h)	0,31487337348897883
Motor oil average mileage (km)	0,5879218458552948

Brakes

Maintenance intervention

Cost of 1 brake pad (€)	0,4882272965288334
Man-hours for replacement (h)	0,07315127058074333

Problems due to intervention delay

Cost of 1 brake disc (€)	0,12155283024420315
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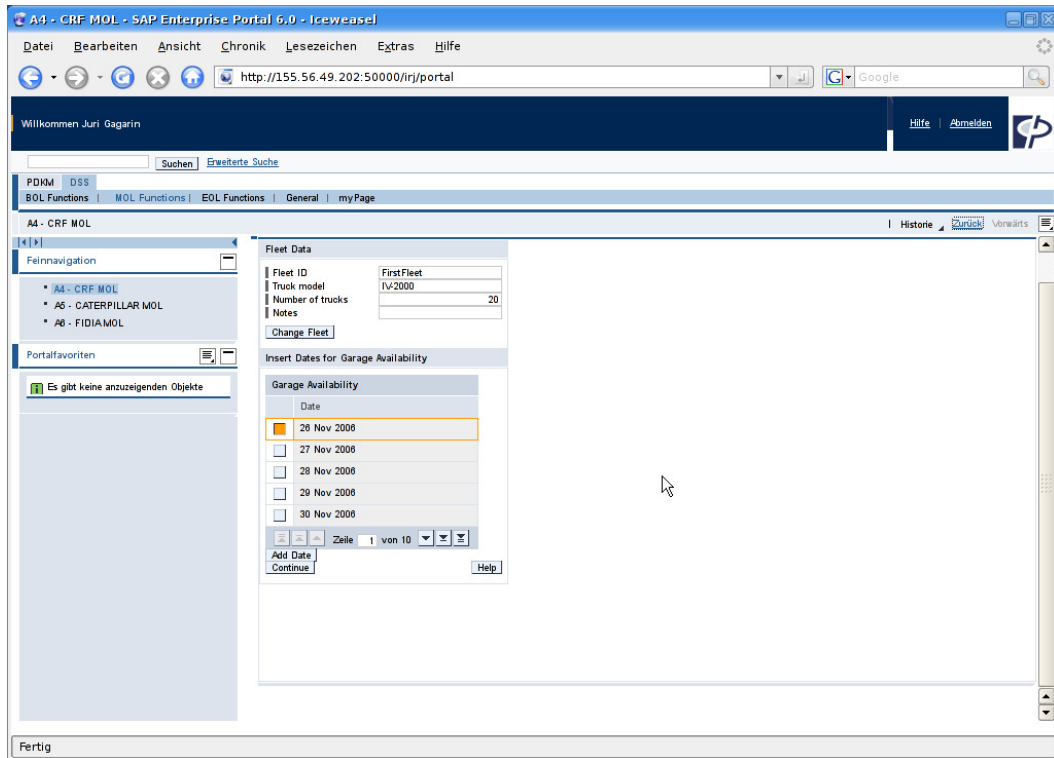
Fall/Uer with potential hazard for vehicle and/or people

Cost resulting of failure (€)	0,07030438312551013
Brake pad average mileage (km)	0,35846103839725374

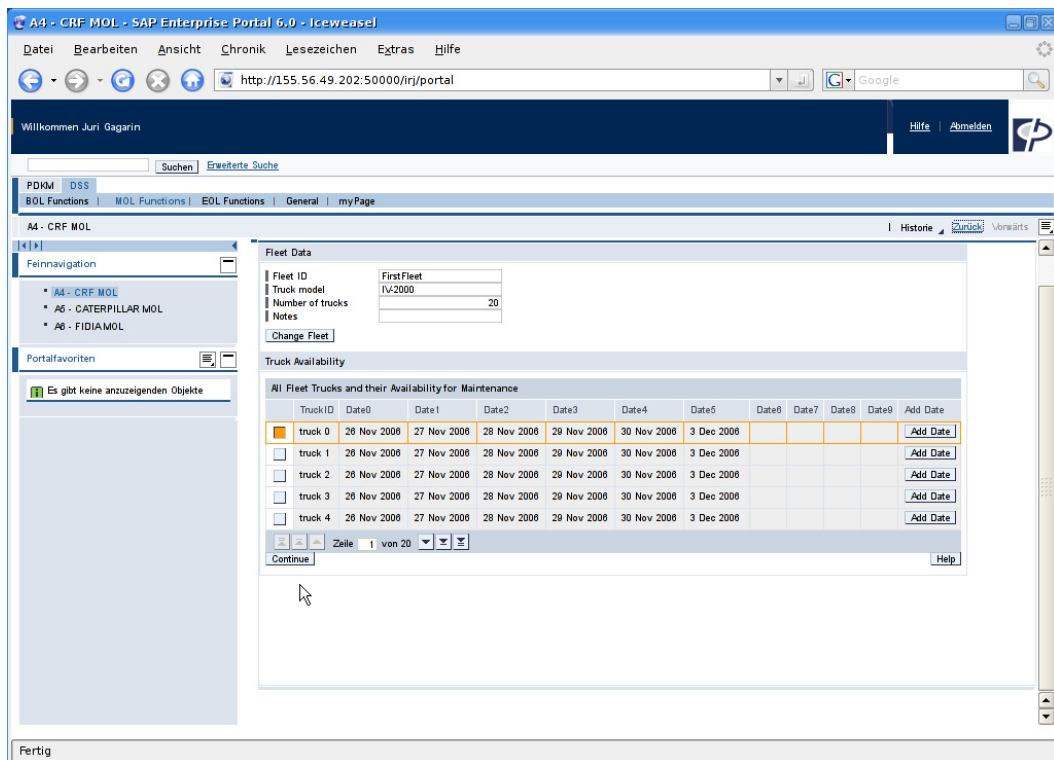
Continue Help

Fertig

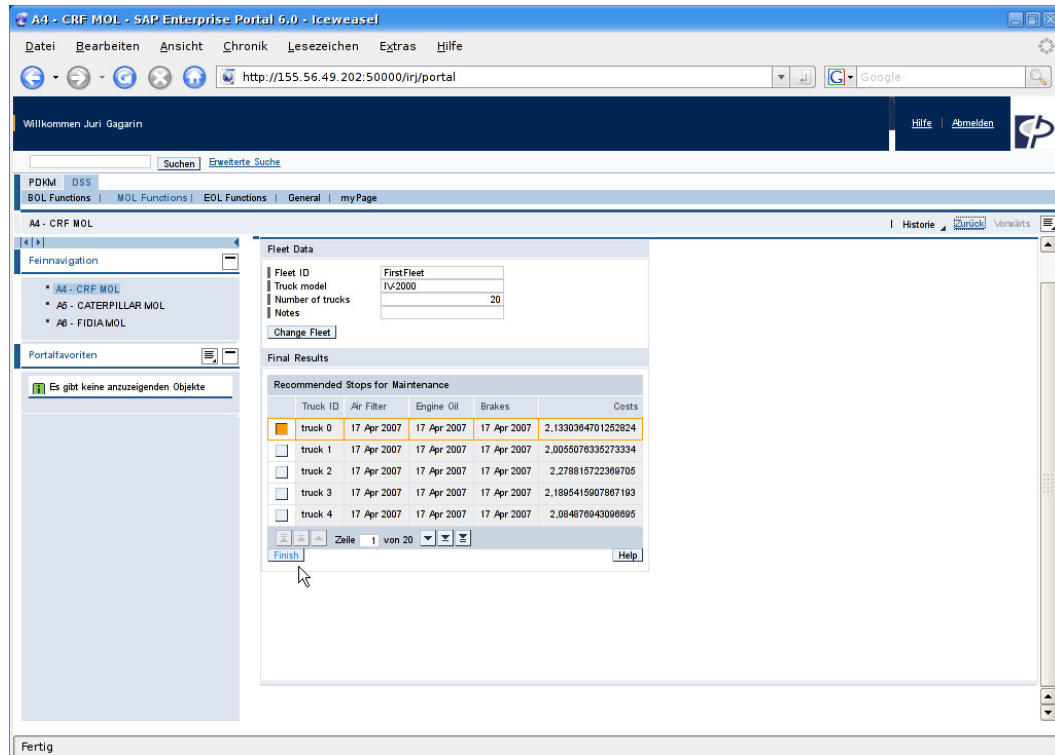
With an interface to the garage schedule the system is able to optimize the maintenance schedule.



The user can get an overview over the truck availability and possible maintenance days.



Finally the system can compute the cost of maintenance for a given choice for the day.



7.2 Example A6: Predictive Maintenance of machine tools

Periodic diagnostic tests on the milling machine provide indicators on the “health state” of its mechanical components. The A6 DSS is made of two components: the aging module that provides the residual life of the mechanical monitored components and the maintenance cost management module that provides a list of suggested interventions that can be performed on the machine tool when the residual life of these mechanical components of the axes is under a certain fixed threshold. Residual lifespan of each axis is provided by the DSS aging module running on each CNC on board the milling machine. The DSS maintenance cost management module is centralized on the central server at FIDIA service.

The application starts by showing the three axes with their main attributes.

Machine Data

Machine: FIDIA_001
Date: 25 Apr 2007 10:02:42 GMT

Please select the axis for which the recommended maintenance actions shall be computed.

Axis	Screw	Bearings	Nut
<input checked="" type="checkbox"/> Ais X	22	22	43
<input type="checkbox"/> Ais Y	34	43	34
<input type="checkbox"/> Ais Z	34	43	34

Continue

This kind of analysis needs a substantial amount of static data about screws, nuts and bearings.

Static Data

Screw	Nut	Bearing
Cost of screw: 19	Cost of nut: 17	Cost of bearing: 15
Cost of screw substitution: 33	Cost of nut substitution: 12	Cost of bearing substitution: 14
Average life of screw: 6	Average life of nut: 4	Average life of bearing: 3
Time for replacement: 23	Time for replacement: 23	Time for replacement: 23

Machine	Further Costs for Replacement	
Hourly cost of the machine: 20	Cost of replacement: 0	Cost of man power: 48
Machine average lifespan: 30	Cost of material: 45	Cost of waste disposal: 0
Cost of machine: 70		

All data can be modified. The button "Continue" updates the database.

Continue Back

The same counts for static data about material and labour costs and all kinds of costs generated by failures.

Production Data

Costs		Duration Indicators		Product Rejection & Productivity Reduction	
Cost of raw material	46	Productive hours	354	Average number of rejected products	64
Cost of dismantling	35	Average hours of reworking	354	Probability of product rejection	450
Cost for refunding customer	5	Hours of unplanned maintenance	354	Probability of product reworking	67
		Mean working time for a product	354	Threshold for reworking	67

These data are given by the user. If present defaults are provided by the database.

Buttons: Continue, Back

Based on the static data and the sensor data the system computes then which of the three decisions, replace, modify or continue, are the best choice from a financial point of view.

Results

Machine: FIDIA_001
Axis: X
Date: 25 Apr 2007 10:02:42 GMT

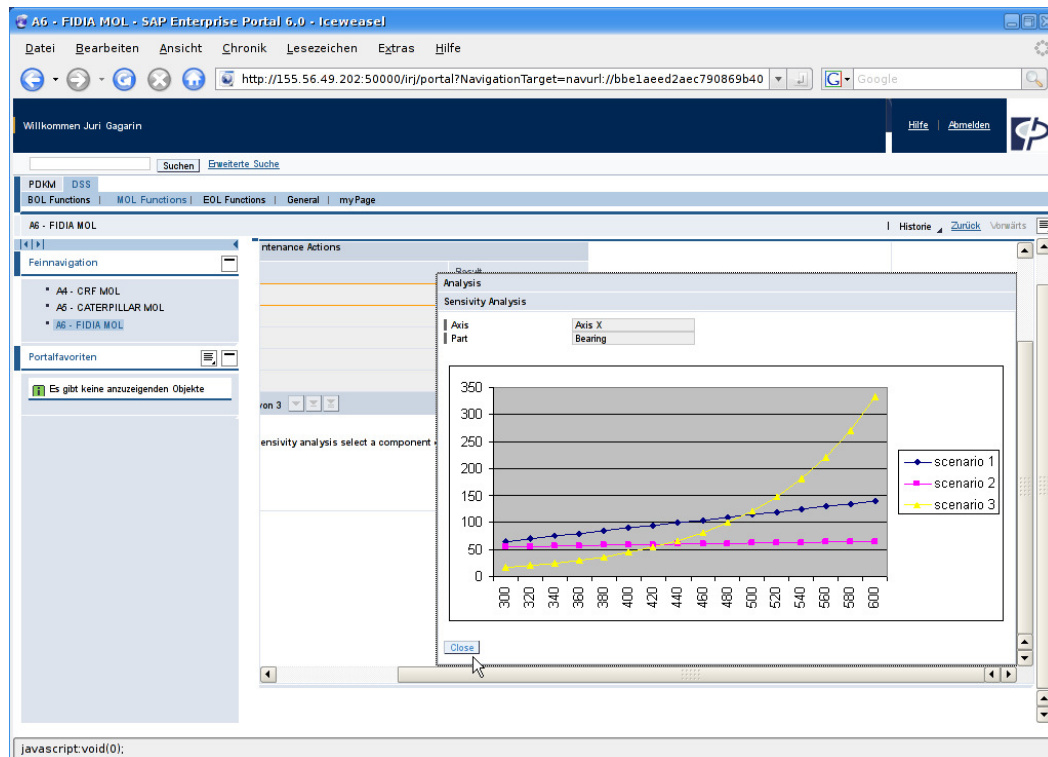
Congratulations! You have completed the maintenance decisions for this axis.

Recommended Maintenance Actions

Component Name	Result
<input checked="" type="checkbox"/> Bearing	Modify
<input type="checkbox"/> Nut	Modify
<input type="checkbox"/> Screw	Modify

Buttons: Sensitivity Analysis, Out, Back

In case the analyst wants to see the cost curves, s/he can press on the button “Security Analysis”.



8 Strategies or Begin of Life

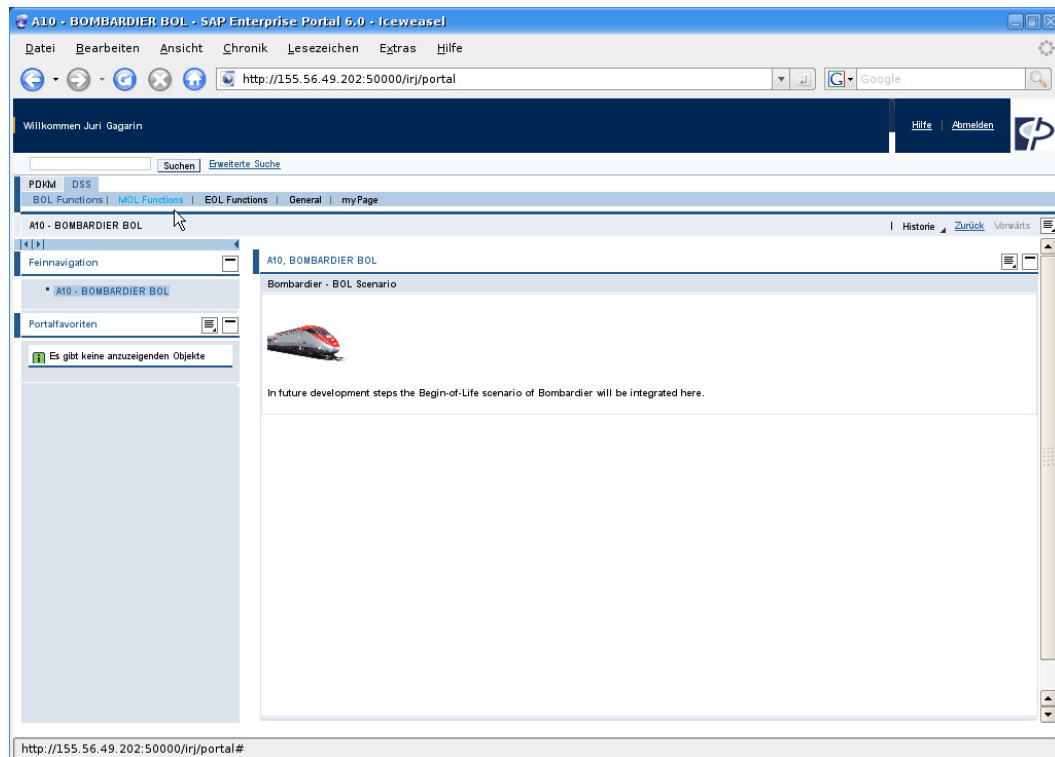
8.1 Example A10: Decision Support for Design for X

The main objective of the decision strategy of the DfX demonstrator is to provide decision methods and algorithms that allow transforming product lifecycle data into DfX knowledge where “X” stands for:

- RAM/LCC (reliability, availability, maintainability / life cycle cost);
- Safety;
- Environment.

The DfX decision strategy implemented in the first prototype of A10 DSS is composed of two main steps: (i) information generation, and (ii) knowledge generation. The purpose of the information generation step is to determine how well is the component/subsystem/system performing with respect to the design aspect considered and the purpose of the knowledge generation step is to determine the main causes behind the level of performance achieved with respect to the design aspect considered in order to aid designers in improving the next generation of locomotives from the point of view of the design aspect considered.

The application starts by pressing the A10 button.



9 Conclusion

The present document contains the first version of a handbook for the DSS. It includes a survey of the DSS, technical information and the application of the decision support strategies. Currently, three different decision support strategies are treated.

In Version 2, the remaining strategies will be added.