MONET2

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Generation of New Projects from Deliverable A2

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1. Introduction

1.1. Purpose of this Document

The purpose of this document is to further investigate the areas of interest drawn up in Deliverable A2 'An Outline of the Areas for Potential New Projects to Formulate Solutions to Agreed Problems and the Advantages for European Automotive Players in doing so'. A2 specified several project areas that the Automotive Industry felt would have considerable benefit. This document revisits those areas and includes the information and experiences of the Task Group and its Industrial contacts over the intervening time. Each of the topics was discussed by a panel of experts and their opinions and those of their contacts are noted in this document.

For one topic a proposal was submitted to the European Commission, but it was only partially successful: it passed the evaluation but it has not been funded. The panel discussed the comments from the Commission which led to a better formulation of the problem and of the industrial needs.

2. TOPIC 1: Tools for Knowledge Management of Technical Knowledge via Models

Co-ordinated by ESG GmbH and ROSE GmbH.

2.1. Original Concept

A huge amount of knowledge is used at different stages in the development process for vehicles. These pieces of knowledge are often heterogeneous, not formalised and in different formats, which therefore prevents sharing, reusability and consistent updates. The list of problems to be addressed is as follows;

1. Knowledge is often only informally documented, e.g. technical documents in natural language, which can lead to ambiguity in interpretation and which prevents automated use of the knowledge contained in these documents.
2. Even when partially formalised, they often do not share the same format or the same ontology. This heterogeneity prevents large-scale sharing of the knowledge.
3. Almost no two cars are exactly identical: there are differences in engines, countries' specifications, comfort equipment, customer configurations, etc. These variants should be handled from a common core of knowledge; this is not presently the case. The same is true for variants corresponding to small enhancements throughout the vehicle life cycle.
4. For any given system, different knowledge and information has to coexist. These may correspond to many different parts of the system; to different views (e.g. structural, functional, etc.), different granularities, different tasks to be achieved on the system (e.g. design, test, diagnosis, etc.). Most often these pieces of knowledge are independent and not related, which prevents the complete sharing of useful information along the development or life cycle of the vehicle (for example, knowledge from design is rarely available at the diagnosis stage).
5. There is no common format for knowledge. This complicates and severely hinders the exchange of information between different groups working on the

global manufacturing process. This is especially true of communications between manufacturers and suppliers.

This lack of knowledge sharing along the life cycle of the vehicle (from design to production, test and maintenance), results in far too much intervention by human beings. This leads to the duplication of work and the problem of constant updating of information. All these factors have a high impact in terms of cost and development time.

2.2. Topic One Evaluation

ROSE stated that this topic is of particular interest, they have had these topics raised by their customers frequently and there is, therefore, obviously a great need for this technology. One of the main problems with this topic is that the work would require a vast range of sector knowledge, not just Automotive. This is however, a very important area and the way forward for this topic, encouraging links with other sectors, may be a very positive step to take for the technologies as a whole. If the project is to be aimed at producing a set of domain standards then our group would obviously require input from a vast range of players, however if the project is to develop tools to achieve this then the focus of the topic needs to be broadened.

This topic is very focused on model-based technologies and this could be another potential weakness, however we could aim to demonstrate how we are looking to develop this and include other technologies. Although this may face issues of a cross-sectoral nature; BMW have suggested that this area is specific to their own processes and so would prove very difficult to standardise. However, we must remember that there are no standards for these tools as yet and it is the interface from the suppliers and OEM’s where adherence to standards could be most effective. Therefore, an initiative to try to focus suppliers on standards, by getting them to describe their standards and finding common goals, could be of significant use to the Industry as a whole.

The panel feel that the topic is interesting but agree it is difficult to make it graspable and find solutions that can be integrated into Industrial processes. Thus, we need to look at tools that are integrated from the very beginning of the process i.e. we should not be developing ‘new tools’ but integrating these technologies into the back end of existing tools. Another issue is that the word ‘tool’ suggests something that is ‘a new tool’ but we need to look at the use of existing tools and utilise this as a starting point. We should specify what the ‘knowledge’ should be applied to: the previous EU Call makes reference to ‘integration and standardisation of tools’ not the development of new tools. It would therefore seem to suggest that their research also points to the background ‘plug-in’ as being the best way forward with this issue.

Industry state that they need details from suppliers and they feed these requirements into their tools. What they do **not** want are full models from suppliers, just specific details to set their own models by. This problem is compounded by the fact that the ‘details’ that one manufacturer may need are not the same as those of the next manufacturer and even within a company different components interface with other components in different ways.

Another problem arises from distributed modelling. The information comes from suppliers (as it, of course, should) but the interfaces are not necessarily the same. This extends to the fact that suppliers may even use the same words for different processes or vice versa, the process is not an established one and everyone does this the way in which they have always done it.

2.3. *Conclusion*

There is a need for this area of research and the potential benefits are great.

3. TOPIC 2: On-board Systems; Integration of Control and Diagnosis; Software Solutions for the Deployment of Model-based Diagnosis On-board

Co-ordinated by LIPN and LAAS.

3.1. *Original concept*

The Modern European Car Industry is experiencing a globalisation of its markets. The training levels of technicians in the different workshops cannot meet the same required high quality standard of competence. Hence the complexity of the technology that is required to be housed ‘on-board’ a car is increasing. Technological complexity is also increasing for environmental and safety reasons.

In the vehicle after sales service arena it is thus necessary to improve the efficiency and quality of service diagnostics for European manufacturers on a global scale.

On-board diagnostics are more capable of observing the vehicle since, due to their higher degree of availability, they can monitor intermittent failures in their context. On-board diagnostics therefore reduce the need for specific diagnostics tools.

There are also further systems which require more on-board diagnostics;

- Multiplexed vehicle electrical architectures
- X-by-wire systems
- Safety related systems

The challenge is to leverage on-board diagnostics in a way which makes them capable of finding the replaceable parts, i.e. the error root causes. It is thus necessary to increase the on-board diagnostic intelligence of the vehicles.

A possible means for achieving this goal is to use model-based or model derived diagnostics with the components on-board the vehicle.

3.2. *Topic Two Evaluation*

The basic idea behind this topic was not to invent something but to emphasise the process of deriving onboard diagnosis and to deploy that on ECU’s. We already have demonstrators on PC’s and on ECU’s but Industry required the technology to go beyond this and derive a process, tools and a methodology (etc.) for on-board diagnosis. This area, which was investigated in the IDD Project[1], has proved to be a ‘bottle neck’ for model-based techniques in the past. The way forward may be to find a ‘mission statement’ i.e. clearly define what we mean by this topic. This must include

[1] The FP5 Project ‘Integrated Design Process for Onboard Diagnostics’

the fact that we must also provide the technical solution to the problems as well as the process to achieve this solution.

The panel feel that this topic is one they wish to continue developing, although we should look at gaining the input of the Control engineering sector. One area that could be added is a requirement for autonomy. At an initial stage this may be focused on ‘messages to driver’ to inform them to ‘return to garage’. But later this system could be used to transmit information to the garage so they are already prepared to deal with the problems that specific driver has upon their arrival. We know that Renault is very interested in this issue. This process should also be capable of linking to the part suppliers; so any part the driver needs is already waiting for them at the garage. This information could then also be traced to investigate wear and tear on parts and areas of the car in order to re-plan future services. Thus the challenge is presenting a global approach to this issue not just a focused technological approach.

FIAT has stated that they are having difficulty with distributed diagnosis; they are currently capable of achieving this for Control, but not for Diagnosis. Thus if this topic is to be continued it would involve the integration of Control and Diagnosis. Porsche are looking into the issue of using many ECU’s to fix one problem and Ford are also interested in this topic.

It has been suggested that on-board diagnosis should be included within this topic. However, there are in fact three topics that could usefully be covered under this area:

- Integrated control and diagnosis
- Homogenous approach to tele-diagnosis on / off board
- Distribution of localised diagnosis

The problem with approaches to this is that, in the past, many techniques have assumed that all components are working correctly. However, some manufacturers are now looking at ensuring accurate results under all circumstances, and this would include situations where one / some components are not working. There are also approaches that are designed to deal with control but then do not take the information and use it for diagnosis; although diagnosis is taken into account by engineers doing fault tolerant control. The main work on this topic is based heavily in academia and is not in current practice in Industry.

DaimlerChrysler suggest that usually they only do model-based diagnosis if they discover a fault signal; maybe we should look into a set of tests that run on-board to get more information out of electronic control systems in order to do better diagnosis.

3.3. Conclusion

This is still an important issue and the topic does have a long list of interested partners. This work should be continued but we should consider how we might wish to reshape this topic.

4. TOPIC 3: Model-based Testing of Embedded Systems

Co-ordinated by AUDI AG and OCC'M GmbH.

4.1. *Original Concept*

AUDI stated that the current situation has the model being generated only in the brain of engineers. This has several problems, i.e.

- No ability to re-use models
- Large number of system variants
- Team work is difficult
- Tests are missed
- No auto linking

Therefore there is a need for a model-based testing tool for model generation (one which could cover every project). This tool must also be generic, online, etc. AUDI's aim is to eventually be able to produce one model for the whole production plant.

This topic also fits very well with the global view discussed in the topic above.

4.2. *Evaluation*

This project involves engineering a system that can provide more information on how to test a complex system. Even an average car can have 50 – 60 ECU's on-board and the technology does not yet exist that makes it possible to test all of these processors in all possible scenarios. The need is to design tools that can generate tests to investigate many more such scenarios. AUDI have stated that they see it as a 'Company goal' to achieve this. This is an important topic as it is strongly related to issues such as reliability and safety.

AUDI have also spoken to rail companies about this issue and they have stated that they face the same problems and believe it would be advantageous to collaborate with them in this area. The topic was also discussed at the Munich European Automotive Forum yesterday (12^{th} February 2004) and several other manufacturers (including DaimlerChrysler and BMW) have expressed considerable interest in this area. We are also aware that this is a problem for telecommunications companies.

On a practical level, AUDI has tried to investigate the possibility of automating the checking process by predicting the response of the system from a model and generating tests that check for these responses in the real system. This process is currently in operation but it is done by humans and thus can be prone to errors.

AUDI already has automated testing, however the input of data and prediction of the results is not automated. In short they want to be able to automate the process of 'deciding' what tests to use to test a system. This is not to be used for the testing of cars in the workshop but to develop designs before production and implementation. The information that currently exists about designs is informal and in natural language; it is from this information that a human operator decides what to test. Their decision must also include software engineering issues. In order to have a verification process that is trustworthy you need a model of the system that you wish to test; currently you only have a specification of requirements in natural language form. There is also the problem of assessing the interaction of different systems; this is very difficult to do manually and thus also prone to error.

The goal of this task would be to produce a complete tool, incorporating hardware and software and the requirement specifications, in order to successfully identify (and run) tests that are designed to give a complete insight into the verification of the design. The ‘system’ to be looked at in the long run could be the whole car, however this could also be used for testing the statements of this software, for example, in order to check the state machines specifications all agree and do not contradict each other. The problem is that if you only test the system as described in the specifications, the fault may not be avoided in the product. The traditional assumption is that the specifications are ‘correct’ and thus we look at the details of the tests drawn from them. If we can put the specifications themselves into a tool the errors (if any) will be found.

Engineers in some fields have been trying to automate the testing of specifications for 20 years and have so far failed to achieve anything. Maybe the applied technologies of MBS&QR could be the way forward in this respect. There are tools that exist to do this at very low levels but the problem of abstraction to larger levels remains, also the higher the level of abstraction the more problems are usually encountered.

These methods could also eventually be used to check a wide variety of hardware specifications and could thus be used to check if final production delivers acceptable levels of results. The results could then be used to ensure the best coverage of tests and these could then be linked throughout the entire product lifecycle.

4.3. Conclusion

There is a great deal of interest in this area but we will obviously require other parties in this consortium. This topic also compliments the ‘active diagnosis’ topic above.

5. TOPIC 4: Preventive Diagnosis

Co-ordinated by Turin University

5.1. TOPIC Four Evaluation

A lot of work has gone into this topic and it has developed into a project, this was not successful in Call Two but it should be maintained and we should learn from the evaluation process.

5.2. Abstract of the Submitted Proposal

As intelligent as vehicles are today, it still takes a human operator to asses what faults 'may' occur in the future. This needs not be the case. European co-operation can lead to a breakthrough in the technology and produce results way beyond the State of the Art. This ambitious project will develop an embedded 'Diagnostic Brain' for a vehicle that actually 'knows' if there are any potential faults, that consequently proposes preventive inspection or maintenance actions to be taken and that has the knowledge management and communicational capacity to report this clearly and distinctly.

Thus a ‘preventive diagnosis’ is performed that enhances essentially automotive vehicles availability, thereby having a deep impact on effectiveness of transportation, mobility, safety, costs and international competitiveness of Europe's Automotive manufacturers.

We aim:

- to minimise unexpected faults and down-times and thus to increase the availability of vehicles
- to detect wear or faults at an early stage and thus to avoid capital faults/ damage with raised impact on availability, safety, costs and material usage
- to estimate the risk for down-times (having detected early faults/ wear), and thus to give a decision support for preventive actions to be taken
- to perform maintenance (for many components) on an ‚as needed basis‘ and thus to avoid unnecessary replacement of components

The solutions focus on beyond State of the Art methods for the detection of wear / faults at a very early stage and on risk analysis methods for proper decisions about preventive inspection or repair actions to be taken. We will exploit and integrate both knowledge-based (e.g. model-based) and data-driven (statistical, data mining) techniques.

With the following proponents:

Participant no.	**Participant name**
1 (Coordinator)	Daimler Chrysler AG
2	Centro Richerce Fiat
3	Actia,
4	R.O.S.E Informatik GmbH
5	OCC’M Software GmbH
6	ClearSy System Engineering
7	Laboratoire d’Analyse et d’Architecture des Systèmes - National Center for Scientific Research
8	University of Aberystwyth
9	University of Torino
10	University of Paris Nord XIII
11	Institut National de Recherche en Informatique et en Automatique, Rennes
12	University of Munich
13	University of Valladolid

An analysis of the comments we received led to a reformulation of the project objectives, which is now to create ‘A new generation of vehicles and transport systems with intelligent capabilities for preventive maintenance and diagnosis’.

Currently maintenance is performed on deadline. Specific maintenance and replacements are performed at predefined times. In many cases this leads to the replacement of components that could still operate without major problems. On the other hand, anomalous wear due to peculiar uses of the vehicle may lead to unexpected failures before the deadline.

This leads to costs for all actors involved:

- for the user
  - unexpected downtime and availability of vehicle
  - cost for replacing components which are not needed
- for the manufacturer
  - cost for doing maintenance (in terms of resources, time, …)
  - customer satisfaction
- societal
  - replacements which are not needed led to cost and may have an environmental impact (waste of materials/resources)
  - if wear is not recognized at early stage then expensive, environment-charging capital damages may occur

The solution should guarantee the following requirements

- prevention of perceivable damage/faults of components/systems
- prevention of capital expensive/environment charging damages
- maintenance performed on a situation-based base generalized to many components/systems
- detection of wear and potentially critical situations at a very early stage
- Solutions applicable to design phase, on-board algorithms and after-sale service
- Management of fleets

This may lead to the following benefits

- improvement of vehicle safety and availability
- reduction of down-time and costs
- reduced environment impact, clean maintenance
- wider applicability (not only automotive)

5.3. Conclusions

The plan is to re-organize the proposal according to the objectives listed above and to present

6. Other Topics

6.1. Open Systems Architectures

Open systems architectures for the development, testing, implementation and maintenance of new software for electronic systems. This approach should be based on standard modules and standard interfaces, which are defined and used jointly.

6.2. Multiplexed and Distributed Architectures

Multiplexed and distributed architectures include;

- Distributed monitoring
- Control and diagnosis
- Study of efficient approaches to performing such tasks in a distributed way
- Handling massive exchange of information between the different ECUs

- Avoidance and analysis of alarm and error code cascades between multiple ECUS
- FMEA of multiplexed architectures.

7. References

N/A

8. Document History

Version	*Date*	*Changes made to document*	*Changed by*
1.0	19th February 2004	Draft written up from topic discussion at Automotive Task Group Meeting Munich Friday 13th February	RIR
1.1	1st March 2004	Minor corrections	RIR and JNT
1.2	14th April 2004	Approval Received for Release	RIR

9. Annex One - TOPIC 1: Tools for Knowledge Management of Technical Knowledge via Models

Introduction

This section describes a proposal for a European Project in the context of the Sixth Framework Programme, with the objective of building a research project on the topic of 'Tools for Knowledge management of technical knowledge via models'.

1. The problem

In the development process for vehicles, a huge amount of knowledge is used at different stages. These pieces of knowledge are often heterogeneous, not formalised and in different formats, which therefore prevents sharing, reusability and consistent updates. The list of problems to be addressed is as follows;

1. Knowledge is often only informally documented, e.g. technical documents in natural language, which can lead to ambiguity in interpretation and which prevents automated use of the knowledge contained in these documents.
2. Even when partially formalised, they often do not share the same format or the same ontology. This heterogeneity prevents large-scale sharing of the knowledge.
3. Almost no two cars are exactly identical: there are differences in engines, countries' specifications, comfort equipment, customer configurations, etc. These variants should be handled from a common core of knowledge; this is not presently the case. The same is true for variants corresponding to small enhancements throughout the vehicle life cycle.
4. For any given system, different knowledge and information has to coexist. These may correspond to many different parts of the system; to different views (e.g. structural, functional, etc.), different granularities, different tasks to be achieved on the system (e.g. design, test, diagnosis, etc.). Most often these pieces of knowledge are independent and not related, which prevents the complete sharing of useful information along the development or life cycle of the vehicle (for example, knowledge from design is rarely available at diagnosis stage).
5. There is no common format for knowledge. This complicates and severely hinders the exchange of information between different groups working on the global manufacturing process. This is especially true of communications between manufacturers and suppliers.

This lack of knowledge sharing along the life cycle of the vehicle (from design to production, test and maintenance), results in far too much intervention by human beings. This leads to the duplication of work and the problem of constant updating of information, all these factors have a high impact on cost and development time.

2. Industry requirements

The main requirement for this domain is to achieve standardisation of knowledge, and for this standardisation to be based on models. This means the ability to:

1. Integrate or build communication interfaces between different tools using models
2. Exchange (pieces of) models in standard formats
3. Build ontology and founded semantics for models
4. Ensure consistency of different models
5. Build tools for maintaining, editing and handling models

3. The foreseen solution

The solutions to this issue will rely mainly on knowledge engineering techniques and a model-based reasoning framework, as developed in AI. (Data mining and information extraction from texts, which are also AI topics, may also be used.)

More specifically, solutions will be developed for:

1. Model-based representation relying on well-founded semantics, and definition of standard languages
2. Content management
3. Handling of different views on a model (e.g. granularity, level of abstraction, task orientation, domain) and specification of model transformations
4. Definition and management of libraries of models; re-use of models; evolution and update of models; model composition
5. Meta-modelling definition of ontology's
6. Model Data Warehouse; Data Mining
7. Definition of end-users interfaces

4. Benefits

We expect that the project can lead to very important social benefits such as:

1. Reduced cost on the overall product cycle
2. Shorter development time and time to market
3. Better products and higher quality
4. Increased availability, accessibility and circulation of knowledge across departments
5. Improved circulation of knowledge between manufacturers and suppliers
6. Re-use of knowledge
7. Systematic approach to different tasks
8. Wider applicability (not only automotive)

All of these can considerably improve the competitiveness of (worldwide) European Automotive Sector, but the results of the projects have a wider applicability (not only automotive purposes).

5. Type of project and potential Partners

We foresee the project as a STReP (which could become in the future an IP involving industrials of other sectors than automotive) involving the following partners:

- Audi-VW, Germany
- Seat, Spain
- Clearsy, France
- OCC'M, Munich, Germany
- R.O.S.E GmbH, Heidenheim, Germany
- ACTIA, Toulouse, France
- U. Turin, Italy
- U. Paris 13, France
- U. Aberystwyth, UK
- TU Munich, Germany
- + others

6. Reference to FP6 Work Programme

IST: 2.3.1.7, Semantic-based knowledge systems
Surface transport: Goal 2.1

10. Annex Two - TOPIC 2: On-board Systems; Integration of Control and Diagnosis; Software Solutions for the Deployment of Model-based Diagnosis On-board

Concerning the problem
The Modern European Car Industry is experiencing a globalisation of its markets. The training levels of technicians in the different workshops cannot meet the same required high quality standard of competence. Hence the complexity of the technology that is required on-board cars is increasing. Technological complexity is also increasing for environmental and safety reasons.

In the Vehicle after Sales Service arena it is thus necessary to improve the efficiency and quality of service diagnostics for European manufacturers on a global scale.

On-board Diagnostics are more capable of observing the vehicle since, due to their higher degree of availability; they can monitor intermittent failures in their context. On-board Diagnostics therefore reduce the need for specific diagnostics tools.

There are also further systems which require more On-board Diagnostics;

- Multiplexed vehicle electrical architectures
- X-by-wire systems
- Safety related systems

The challenge is to leverage On-board Diagnostics in a way which makes them capable of finding the replaceable parts, i.e. the error root causes. It is thus necessary to increase the on-board diagnostic intelligence of the vehicles.

A possible means for achieving this goal is to use model-based or model derived diagnostics on-board the vehicle components.

In this proposed Project (STReP) we would like to address the following industry requirements

- Having standard processes to derive on-board SW
- Integrate control / diagnostics on-board
- Scalability of solutions
- Integrate on-board and off-board diagnosis - plus - automatic suggestions of tests to be performed off-board
- Dealing with sporadic errors and with faulty fault codes
- Adapt to the vehicle life
- Automatic SW development

Our foreseen solution is

- Define and develop a process to automate or support the development of SW that really goes on-board based on models (MBD + FDI)
- Possibly using / integrating other technologies (NN, CBR, etc.) to achieve optimal diagnostic systems and to suggest tests to be performed for diagnosing a system
- Develop and produce tools for the developers supporting this process

Benefits

- Increased efficiency / quality of service diagnostics
- Reduce cost to develop diagnostics for complex systems
- Increased safety
- Wider applicability (not only automotive sector)

Type of Project / Potential consortium (companies)
STReP

- BMW
- AUDI-VW
- DC
- FIAT
- TRIALOG
- CLEARSY
- ACTIA
- OCC'M
- ROSE
- U. Paris
- U. Torino
- U. Aberystwyth
- TU Munich
- + Ask other BRIDGE Task Group Members

Link to the Call
IST: E-safety
SURFACE TRANSPORT - GOAL 2.2, 4.13

11. Annex Three - TOPIC 3: Model-based Testing of Embedded Systems

1) The Problem

All European car manufacturers face the problem of attempting to test embedded systems in a networked architecture. This task gains importance with the development of safety critical x-by-wire technology. Current practice is based upon the manual development of test procedures which leads to the following problems;

- High cost of the manual generation of test cases for a large number of system variants
- No re-use of the test engineer's work for other projects
- No guarantee for coverage of test cases
- Risk of incompleteness in particular for distributed architectures
- No automatic linking of requirements and versions to the test procedures

2) Industrial Requirements

To address these problems, computer support or automation of the test generation process is required. In detail, this means;

- Automatic suggestion of tests
- Handling of variants and re-use of previous work
- A standardised, formal description of system specifications as a basis
- An interface to requirement management tools
- Ensuring coverage and minimality of sets test cases
- Support for testing of networked architectures
- Easy-to-use tooling
- Traceability through the whole development process

3) Foreseen Solution

The solution exploits model-based technology. In this case, the model represents the system specification and is used to automatically generate test cases that check the monitored system behaviour against the specification. This includes;

- Import of requirement specifications from other tools
- The generation of a model from the requirement specification, for both general and system-specific requirements
- The aggregation of subsystem models and a communication model into a model of a network
- The automated generation of test cases covering all relevant potential faults from this model
- Algorithms for minimising the number / costs of test cases
- The automatic application of the test cases and the interpretation of their results

4) Benefits

A successful result will improve competitiveness of European industries (not confined to automotive industries) due to;

- Reduced time and costs for test generation
- Reduced time and costs for testing
- More reliable and safer systems
- Reduced time to market

5) Type of Project / Potential consortium
STReP

- AUDI
- SEAT
- BMW
- ROSE
- OCC'M
- (U. Paris
- U. Torino
- U. Aberystwyth
- TU Munich

6) Relevant Objectives of the Call
Main research domain is SURFACE TRANSPORT - GOAL 2.2.
Secondary links are;

- SURFACE TRANSPORT - GOAL 2.1, 4.13
- IST: E-safety

12. Annex Four - TOPIC 4: Preventive Diagnosis

Introduction
This section describes a European Project in the context of the Sixth Framework Programme, with the objective of building a research project on the topic of ‘Preventive Diagnosis’.

1. The problem
The main motivation and interest of these partners, in the context of preventive diagnosis research activities, is to contribute to an improvement of automotive vehicle safety and availability in order to reduce down-time and costs and thus to increase customers satisfaction.

Thus subsequent customer perceived damage, or faults of components and systems, will be efficiently prevented, which in turn ensures safety and the availability of the car and its functions.

Today problems within automotive systems, e.g. mechatronic, mechanic, hydraulic systems are;

- Failures can occur unexpectedly during operation time with the consequence of unexpected downtime and reduced availability of vehicles
- Frequently, wear is not recognised at an early stage, this may lead to environment-charging or expensive capital damage
- Maintenance for many components is done on a regular basis so that in many cases working components are replaced even if this is not necessary, leading to a waste of material / resources / costs which can impact on the environment
- On the other hand components which will have a short life-time are not detected, which may lead to unexpected downtimes and potentially dangerous situations

From these overall motivations the following more specific goals are derived.

- Prevention of perceivable damage or faults of components and systems; potential hazards will be envisioned before they occur in order to allow for repairs to be carried out in time
- Prevention of capital, possibly dangerous / expensive damage
- Maintenance should be performed on an 'as needed' basis rather than on a regular basis. In other words, preventive diagnosis will eventually ensure that the vehicle becomes able to predict the next maintenance action especially in cases when major problems have to be expected

2. Industry requirements
The main objectives of the project are to develop new methods for the detection of component wear and faults at a very early stage. Once component wear begins or faults are detected, by means of risk analysis methods, one should be able to make proper decisions about the appropriate preventive refit / repair actions to be taken.

The industrial requirements needed to reach these goals are as follows;

- Prevention of perceivable damage / faults of components / systems
- Prevention of capital expensive / environment-charging damage

- Maintenance performed on a situation-based base which can be generalised to many components / systems
- Detection of wear and potentially critical situations at a very early stage
- Solutions should be applicable to all phases of the vehicle life cycle, i.e. design phase, on-board algorithms and after-sales service.

3. The foreseen solution
The goal of this project is to develop and implement new solutions and technologies for the detection of wear and faults at a very early stage. Furthermore, this information should supply risk analysis methods for proper decisions about preventive refit or repair actions to be taken.

The solution should apply to the whole life cycle of the vehicle where different approaches for preventive diagnosis can be adopted as shown below.

Preventing Faults

Design Phase - Design for reliability, fault tolerance. Guidelines for Maintenance. Indicators for Predictive Maintenance.

On-Board - Predictive Diagnosis. Early Warning Systems.

After Sales / Service - Statistical analysis of fault / wear information. Risk analysis for proper actions to be taken. Support for preventive maintenance.

In order to implement these solutions we foresee the integration of different techniques such as the use of models and model-based reasoning techniques (taking into account the simulation of system and wear models), pattern recognition, statistics, data mining, CBR.

4. Benefits
We expect that the project can lead to very important social benefits such as;

- Reduced environmental impact and cleaner maintenance
- Improvement of vehicle safety and availability
- Reduction of down-time and costs
- All of these can considerably improve the competitiveness of (worldwide) European Automotive Sector, but the results of the project have a wider applicability (not only automotive purposes).

5. Type of project and potential Partners
We foresee the project as a STReP involving the following partners;

- ACTIA, Toulouse, France
- DaimlerChrysler AG, Stuttgart / Esslingen, Germany
- Fiat Centro Richerce Fiat, CRF, Torino, Italy
- FirstEarth, Aberystwyth, United Kingdom
- R.O.S.E GmbH, Heidenheim, Germany
- U. Turin
- U. Paris
- U. Aberystwyth
- TU Munich
- + others

6. Reference to FP6 Work Programme
The project is relevant for at least two programs

We refer to the paper "Thematic Priority, 1.6. Sustainable Development, Global Change and Ecosystems, 1.6.2: Sustainable Surface Transport, Work Programme 2002 - 2006" [1].

1. The Project Partners regard the proposal as an essential contribution to Objective 4: "Increasing road, rail and waterborne safety and avoiding traffic congestion" (cf. section 3.4).
2. Especially the objective of increasing vehicle safety and availability by preventing faults, thus minimising unexpected faults / down-time and possibly dangerous situations (cf. chapter 3.4.2).
3. Research Domain 4.13 "Developing integrated safety systems which are reliable and fault tolerant [preventive, active and passive] taking into account human-machine interface concepts focusing on the system implementation".
4. Research Domain 2.5 "Development of strategies and processes for clean maintenance, dismantling and recycling of vehicles and vessels. Emphasis will be put on clean, cost and energy effective processes, autonomous systems for maintenance and inspection, innovative dismantling and recycling operations.".

Relevant also to IST: E-safety.

7. Work Program
Partners propose the following basics of a work program;

- Identify one or several key applications together with key manufacturers
- Analyse them and their specific requirements
- Develop the concept of the ‘to be’ situation or the vision
- Develop the steps needed to achieve the ‘to be’ state from the present situation
- Devise, design and develop methods and algorithms for the latter
- Prove the methods and algorithms in the selected cases