MOBILE

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PROJECT INFORMATION:

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Acronym: MOBILE

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2 Project Execution

2.1 Publishable Executive Summary

2.1.1 Summary Description of Project Objectives

Two higher-ranking objectives are characterizing the MOBILE Project:

Objective 1 – Design and Development of an advanced sliding bearing system to overcome future support requirements: Since the first artificial bridges were built, the evolution of bridge engineering was characterized by the performance of available materials, state-of-the-art of the construction techniques and the technology of support systems. The MOBILE project is a major step forward in respect of durability, capability and serviceability of bridge bearings as well as its installation handling and production. The developed support system should catch up with the advancement of materials and construction.

Objective 2 – Europe-wide launch of the new generation of sliding bearings: For SMEs not only the product development stated in objective 1 but also a rapid product launch is essential for overall project success. For this reason main examinations which are necessary for European approval and also product dissemination and demonstration for customer approach will be part of the project. After the start for Europe-wide launch of the advanced sliding bearings within the project, the participating manufacturers plan to proceed with international marketing strategies.

The project objectives are realised by the creation of corporate task forces which are dedicated to current technological lacks. These task forces are operating in form of workpackages which output is going to be integrated in an “advanced sliding bearing system” prototype.

Research in the project covers the development, testing and validation of the advanced sliding bearing and gives an optimum lifecycle, reduced investment and annual costs and an improved Reliability, Availability, Maintainability and Safety (RAMS) performance.
2.1.2 Project Consortium

The research project MOBILE is under strong industrial leadership and aims at creating high added value in the advanced sliding bearing system, from design, construction and operation to maintenance, including components manufacturing.

The project consortium consists of four bridge bearing manufacturers namely Mageba, Maurer Söhne, Reisner & Wolff Engineering and RW Sollinger Hütte supported by the Institute of Structural Engineering (IKI), Material Testing Institute University of Stuttgart and the Vienna Consulting Engineers. A close collaboration with a high number of involved end users ensures customer-driven development of the new generation of sliding bearing systems.

The diversity of the experience, the balance of needed know-how as well as the agreeing research approach among all participants will lead to a successful technology and product development. The consortium is aware of the potential in cost reduction and technical performance of sliding bearing systems when proper materials, sophisticated design and facilitated manufacturing technology is available.

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2.1.3 Work performed and Results achieved

An informative Current Practice Workshop was held and Current Practice Reports were established to indicate the expertise and technology available within the project consortium. The major aim is to identify the gap between current technologies and future technologies and to make all needed resources for the development available.

New materials were tested as substitute to currently used sliding materials. Four samples of material compositions of polyoxymethylene (POM), polytetrafluoroethylene (PTFE) and polyethylene (PE) have been investigated in friction tests (range -35° to 35° Celsius) and load tests.

A product was identified as material to meet the requirements for the “advanced sliding bearing system”. The product is a very high interest for the consortium since a European approval is available for the sliding material.

Laboratory tests with the material have been implemented with mating so-called anti-friction coatings (AF-coating) were very promising results have been achieved. The AF-coating should be used as counter material to replace expensive and problematic austenitic steel sheets.

A further aspect which has been investigated within the scope of WP 3 and WP 4 is the application of pre-cast elements of fibre reinforced concrete instead of steel plates as sliding plate. The study was done in form of a numerical model. The idea is to prove fibre reinforced concrete as cost efficient alternative to heavy and expensive steel plates.

Deficiencies and solutions for potential enhancements of sliding bearing have been identified by the consortium. After further investigation considerable approaches have been selected and incorporated into the work planning of the project.

As system engineering concept was established within WP 4 to improve the design and production process.

A concept for a Monitoring system was set up for the measurement based assessment of stress of sliding bearing due to load resulting from traffic. A software tool for measurement documentation and for specification of support condition as well as structural information was developed. Evaluation software and measurement hardware will be finalized in year 2.

In the midterm meeting at the beginning of this reporting period it has been decided to continue the works as planned.

In WP2 a new material has been identified. A powder coating fulfills the requirement of performance. 12 samples have been prepared.

Tests following the current specification in DIN have been performed with the new material at MPA in Stuttgart. The result has been inspected and discussed during a meeting at MPA in May 2008. It has
been decided that the performance is satisfactory. A construction of a prototype and further testing in WP6 has been recommended.

In WP3 it has been decided to simulate and model the replacement of the steel parts of the bearings by polymer concrete elements. The analysis and modeling job has been completed with the result that this material is feasible.

In WP4 the application of this new material for real elements has been investigated. Constructability has turned out to be very good and economic and depending on the number of elements produced. The approach has been found feasible.

In WP5 a monitoring system has been developed, built and tested. The conception has been explained to the Consortium and a test case has been identified immediately. The Hagestein Bridge in the Netherlands has been tested with success. Comments from the bridge owners have been received which will be incorporated. The development has been rated successful.

In WP6 several prototypes have been built. The most innovative is the bearing consisting of polymer concrete elements which have been successfully tested at the end of the project. The minor weakness of the material, the lack of tensile strength, can be eliminated by a variation of the design and eventual reinforcement. This is a task to be performed after the project before the product can go into the market.

In WP7 several demonstrations have been performed for example in front of a large community (at Milano Politec in April 2009 or at demonstrations on site at various occasions). The response of the owners has been very positive. The objectives of MOBILE have been named very valid and important.

In general it is stated that all the objectives have been achieved and all activities have been completed.
2.2 Project Objectives and Major Achievements

2.2.1 General Project Objectives

- Investigation of Current Practices and evaluation on the State-of-the-Art was implemented in a short period of 3 months in the very beginning of the project. The output was the identification of the gap between current technology and of the future support requirements to be met by the “advanced sliding bearing system”. The objective is subject to workpackage 1, its deliverables and milestone 1.

- The development of new material with improved specification is a core task within the MOBILE project. PTFE (Teflon®) is used for sliding bearings since more than thirty years. The material has an excellent friction parameter if properly lubricated but does not fulfil the future requirements in respect of surface pressure, sliding velocity and accumulated sliding path. The identification or development of a proper material is scheduled to be finished in month 12 (milestone 2). The testing in respect to the new requirements (according to milestone 4) of the material has to be finalised within month 18 (milestone 3).

- Intensive investigations on product requirements and stress simulation have two major objectives. On the one hand to obtain clear and real specification for the new material and product and on the other hand leads proper Quality Function Deployment (QFD) to a reduction of costs and time for the material and system development. This objective is achieved when a comprehensive product specification of the “advanced sling bearing system” is available scheduled at month 12 as milestone 4.

- Another objective is a detailed numerical model (Finite Element Model) of the prototype based on the requirements available from workpackage 3 (milestone 4) and the prototype design from workpackage 6 (milestone 10). FE-models support the laboratory tests especially in respect of the system initial and boundary conditions by sensitivity analyses. The developed simulation model will be a sustainable design tool for future projects of the manufacturer and can be updated from monitoring data.

- Consideration of constructability in the development of the “advanced sliding bearing system”. The motivation is to turn the job shop production of sliding bearing systems into flow shop production by introducing a modular system of the “advanced sliding bearing system”. Consideration of constructability facilitated manufacturing processes. In respect to modern production management every simplification has major impact for better cost efficiency, shorter deliver periods and easier total quality management. This objective is subject of workpackage 4 and is schedule to be finalised at milestone 7 (=Successful system engineering concept for production and quality control).

- The maintainability of the “advanced sliding bearing system” has to ensure the extended lifetime and reduction of life-cycle costs after the product installation. The improvement of maintainability is achieved within two steps. The first partial result is scheduled at month 6
(milestone 6) where all deficiencies of sliding bearing maintainability have to be identified and a proposal how to overcome these shortcomings is established. The second partial result is aligned with milestone 10 where a conceptual design of the MOBILE prototype exists.

- A strategic objective for lifetime extension and life cycle-cost reduction is the development of a monitoring system for the “advanced sliding bearing system”. Such monitoring systems enable the new approach of integrating the RAMS factors (reliability, availability, maintainability and safety). The monitoring system will be development within workpackage 5 as concept by month 12 (milestone 8) and running system scheduled at month 18 (milestone 9).

- A further objective and necessity for the project is a professional data acquisition and data management system which will provide data for research and development tasks such as needed in WP 3 (simulation and modelling). The monitoring system has to allow proper system identification and bearing supervision during operation. (milestone 7)

- Development and testing of an totally reconsidered “advanced sliding bearing system” (MOBILE prototype) which:
  
  - is capable to meet the future requirements to support systems
  - fulfills the new aspects of constructability in bearing manufacturing (modular concept)
  - has improved maintainability
  - has higher performance and therefore reduces the life cycle-costs by at least 30 %
  - gives the SMEs a competitive edge due quality and costs

- Design of the prototype (milestone 10) and its construction and testing (milestone 11) is performed within workpackage 6.

- For a long-lasting exploitation of the project results the demonstration of the “advanced sliding bearing system” to end user is a necessity for Europe-wide product launch within the project and international launch afterwards. Efforts for scientific acceptation will be done due to dissemination of information about the new technology, materials and product performance to relevant institutes, science and interested parties (milestone 12).
2.2.2 Major Achievements

The achievements are explained following the milestones given in the description of work.

**M1** – Joint Knowledge on Current Practice

An informative Current Practice Workshop was held and Current Practice Reports were established to indicate the expertise and technology available within the project consortium. The major aim is to identify the gap between current technologies and future technologies and to make all needed resources for the development available. The output of the Current Practice Workshop was a list of approaches for further study within the workpackages. As result many contacts and individual groups (WPs) for intense collaboration were established of its own volition. The result is subject to workpackage 1.

**M2** – Identification or Finalised Development of Material with the Defined Specifications

New materials were tested as substitute to currently used sliding materials. Four samples of material compositions of polyoxymethylene (POM), polytetrafluoroethylene (PTFE) and polyethylene (PE) have been investigated in friction tests (range -35° to 35° Celsius) and load tests. The materials haven't met the standard of products currently used for sliding bearings. The consortium agreed to stop further development efforts with these materials. However the analysis of the test results will be done in year 2 as such consolidated findings are very valuable for later project work.

**M3** – Successful Material Testing and Improvement

Various materials have been selected and the optimum solution has been found. Material tests have been conducted at the partners own laboratories and the 4 selected samples were then transferred to MPA Stuttgart. After the 1st standard tests 1 material has been appointed for further testing which includes a long term test (50.000 m). All tests have been successfully completed and a suitable material is available.

**M4** – Finished Investigation of Future Requirements and Stress Analysis, Comprehensive product specifications

The investigation has been finished.

**M5** – Finite Element Model of the MOBILE Prototype

Various models have been tried in a feedback process with testing. Any new recorded phenomena has been analyzed and implemented into the model. At the end of the project the prototype has been tested to the ultimate limit and such the model has been verified. The anticipated weakness, namely local tensile forces from cross tension have been found. A solution for this problem will be developed after the project.
M6 – Identification of all Deficiencies of Sliding Bearing Maintainability

Deficiencies and solutions for potential enhancements of sliding bearing have been identified by the consortium. After further investigation considerable approaches have been selected and incorporated into the work planning of the project. This step was closed with Milestone 6 represented by Deliverable 4.1.

M7 – Successful System Engineering Concept for Production and Quality Control

As system engineering concept was established within WP 4 to improve the design and production process considering the technological enhancements for sliding bearing from MOBILE project. The concept is introduced in Deliverable 4.2 and fulfils Milestone 7.

M8 – Concept of the Monitoring System is Enabled

A concept for a Monitoring system was set up for the measurement based assessment of stress of sliding bearing due to load resulting from traffic. A software tool for measurement documentation and for specification of support condition as well as structural information was developed. Evaluation software and measurement hardware was finalized in year 2. The concept can be studied in Deliverable 5.1 (Milestone 8). The system was tested in month 18.

M9 – Data Acquisition for Monitoring

To proof the concept developed in the 1st year (M8) it was necessary to collect data at various occasions. The most interesting case has been Hagestein Bridge in the Netherlands, where a long problem history is well documented. This measurement campaign has been performed and the results elaborated and discussed in the Consortium. Minor adjustments to the procedure will be implemented after the project ends. Of particular interest is the approach with a cheap identification campaign, which sorts out those structures where a deep investigation is justified.

M10 – Design of the Prototype

The design of the prototype which has been started in the previous reporting period has been finalized. It shall be mentioned that the material tests suggested that the polymer concrete elements might also take over the sliding function due to their smooth surface. This additional objective will be subject to future investigations. The prototype has not only been designed but also built by the partners. A final test at the end of the project showed its capacities and applicability.

M11 – Construction and Testing of the Prototype

As mentioned in the previous milestone a full scale prototype has been produced for testing. A total of 4 samples have been made available which underwent the various tests for qualification. These tests were carried out in the partner’s laboratories until the end of the project, where a destructive test was performed at RWSH in Uslar. It has been recognized that this development is well worse bringing it to a level where it can be marketed.
M11 (12?) – Finalization of the System and Prototype

The prototype design has been discussed in the various progress and technical meetings held every 3 months during the project. Such the progress has been carefully controlled. Meetings were always organized in order to discuss the latest results and decide about new steps. With the introduction of a new European regulation changes had to be introduced which led to an elongation of the project for 6 months. Within this period the additional work has been completed.

M12 – MOBILE Workshop and Dissemination

Overall a number of workshops have been organized. This comprises mainly the dissemination activities towards the enlarged Europe, where the respective technology is not yet well known. With the various partners in the new member states a frequent exchange of information and direct dissemination activities have been arranged by the partners. A large workshop has been organized at Milano Politec in April 2009 to introduce the new concept of the development. In general it can be stated that every owner and user has been very interested in the development because it perfectly touches their concerns.

M13 – Consortial agreement established, schedule and resource management implemented, setup of a project secretariat

Completed

M14 – Midterm Assessment, Mid Term Reporting

Completed

M15 – Final Meeting

A Final Consortium Meeting has been conducted in July 2009 at MPA Stuttgart to prepare a careful end of the project and to fulfill all the Commission’s requirements. The last tests were running at this occasion and visited by the Consortium. It has been decided to complete the tests before the end of July (= end of the project). Further collaboration on this subject after the end of the project has been agreed.
2.2.3 Problems in the Reporting Periods

No problems occurred within the first reporting period (year 1 – month 1 to month 12).

No major deviation between actual and planned costs/schedule.

A minor problem has been found during execution of the work in year 2. A new regulation issued by the European Commission, which particularly influenced the design and proof procedures for these materials caused a necessary change in the plans. A letter has been written to the Commission to ask for a 6 months extension of the project, which has been granted. The work plan has been adapted accordingly and the testing procedure has been changed. After the extension the objectives have been achieved in full. It has been demonstrated that the Consortium was flexible enough to deal with the new situation and successfully implement the necessary changes.

The elongation had a minor influence on the costs which have been increased due to the elongation of the project and additional tests necessary. Nevertheless all partners have been aware and willing to bear this additional burden for the success of the project.
2.3 Workpackage Progress

2.3.1 WP 1 – State-of-the-Art and Current Practice

2.3.1.1 Summary of the specific WP Objectives

WP 1 is the investigation of the state-of-the-art is the basis of every successful research project. Although all of the participants are experts in the field of sliding bearings and sliding materials the WP1 facilitates the setting of the objective details. An own workpackage for state-of-the-art has proven to be a very effective method for building on new projects to increase identification and commitment.

The specific objectives of this WP are provide the state-of-the-art on:

- Technical standards of bridge bearings
- Evaluation and analysis on damages of sliding bearing systems
- Technologies of sliding materials
- Current practice in bridge life-cycle management

2.3.1.2 Overview of technical Progress

By deliverable D 1.3 a detailed report on the current practice in bridge life-cycle management is given. The report reflects the historical development of inspection activities in engineering. The current regulations given by different international standards and guidelines are reviewed in detail and summarised to outline this important information basis for modern life-cycle management of bridges. Recent developments in inspections including modern monitoring systems have been included to give an outlook to future possibilities to fulfil this demanding task. In order to analyse the discussed methods in a broader sense inspection management and evaluation methods have been included. Based on this general overview special requirements for the maintenance and inspection of bridge bearings were analysed. Starting from the evaluation of experiences with the description of defects and damages on bridges going to damages specifically related to bridge bearings. Finally possible damage preventions by bridge design were given.

Dated 16th of May 2007 a workshop was conducted at the Univ. of Natural Resources Applied Life Sciences to evaluate the current practice and future chances for movable bearings. Diverse solutions for general design aspects as well as more detailed solutions for specific demands have been elaborated. The workshop itself was reported resulting by deliverable D 1.4. Teams for specific investigations and/or the development of innovative ideas have been established.
The work package was finished in the first year and no further work was required in period 2.

All activities of the work package have been fulfilled as planned.

2.3.1.3 Comparison of planned Activities and actual Work

The establishment of a detailed questionnaire to collect the in house knowledge of all partners was rejected, as the majority of this knowledge can be assumed to be shared by all partners or was discussed in the meetings accompanied by representatives with detailed practical experiences. All other activities of the work package have been fulfilled as planned.

2.3.1.4 Deliverable List and Milestone List

All deliverables and milestones due in reporting period year 1 were finalised. The workpackage led by IKI is closed.

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2.3.2 WP 2 – Material Development and Testing

2.3.2.1 Summary of the specific WP Objectives

The specific objectives of this WP are:

- Development of new materials for the “advanced sliding bearing system” to
  - ensure the targeted extension of product lifetime
  - enable a sustainable reduction of LCC
  - meet technical requirements (higher loads, higher velocity, long sliding path)
  - meet environmental requirements (low temperature, aggressive water and air)
  - Utilization of modern materials and production technologies in the construction sector.

- The development of new material systems with improved specification is a core task within the MOBILE project. PTFE (Teflon®) is used for sliding bearings since more than thirty years. The material has an excellent friction parameter if properly lubricated but does not fulfil the future requirements in respect of surface pressure, sliding velocity and accumulated sliding path.

- A successful material development, testing and validation are ensured by the participating scientific Material Testing Institute University of Stuttgart (MPA.USTUTT) and bearing manufacturers. The new high-performance material will have major impact on the extension of the product lifetime and infrastructure life-cycle costs.

2.3.2.2 Overview of technical Progress

In this work package the suitability of new materials for the use as sliding elements in bridge bearings has been investigated. A detailed report is given in deliverable D 2.2. The report describes investigations on three new sliding materials and three new mating surfaces. In case of mating surfaces the focus has been put on lubrication varnishes. After several pre-tests in total 22 extensive and sophisticated main-sliding tests, each with a test duration of about 24 hours have been performed.

Objective: Development of new materials for the “advanced sliding bearing system”

The MOBILE-Consortium approached a company that is experienced in developing materials for sliding systems. The company supplied three different sliding materials including corresponding grease. Each investigated sliding material is based on different chemical composition. These sliding materials were tested following the European standard EN 1337-2 for sliding elements in structural bearings. The test conditions were chosen identical to the test conditions for PTFE, which is the standard sliding material for structural bearings at the present time. Figure 1 shows the sliding characteristic of the three investigated sliding materials in comparison to the current sliding material PTFE. The results show that the maximum coefficients of friction of the three investigated sliding materials are much higher than the corresponding ones of the current sliding material PTFE. Figure 2
shows the maximum coefficients of friction depending on the temperature; additionally the comparable values of the current sliding material PTFE in virgin state and after 10 km of accumulated slide path (allowable values corresponding to EN 1337-2) are plotted. To summarize the investigations on the three new sliding materials it can be stated:

- The maximum coefficients of friction of the three new sliding materials is much higher than the corresponding ones of the currently used sliding material PTFE. The coefficients of friction of new pairings even exceed or are the same range than the allowable coefficients of friction for PTFE after the total slide path of 10 km as specified in EN 1337-2.
- The three new sliding materials are especially not suitable for cold temperatures.

Figure 1: Maximum coefficients of friction of the three investigated sliding materials in comparison to the current standard sliding material PTFE
Further investigations showed that this behaviour is not mainly caused by the special lubricant, which had been supplied. Because of the unfavourable friction behaviour of the three new sliding materials the MOBILE-Consortium decided not to continue the work on those materials.

**Objective: Development of new material systems by means of the mating surface**

First investigations are related to the performance of bonded coatings as alternative to conventional austenitic steel sheets corresponding to EN 1337-2. Economical advantages are to be expected, if the use of bonded coatings as mating surfaces for sliding elements of bearings results in comparable or even better performance in relation to austenitic steel.

In order to meet the increasing high requirements of sliding systems the high-performance sliding material has been chosen for the first tests. Currently this material is the only one, which is approved for the use in bridge bearings (ETA-06/0131) in addition to PTFE.

First results show that the level of friction with a special selected bonded coating as mating surface is in acceptable order of magnitude. Therefore the MOBILE-Consortium decided to deepen the research of bonded coatings.
Investigations are related to the performance of lubrication varnish as alternative to the conventional mating surfaces austenitic steel or hard chromium corresponding to EN 1337-2. Economical advantages are to be expected, if the use of bonded coatings as mating surfaces for sliding elements of bearings results in comparable or even better performance in relation to the conventional mating surfaces. In order to meet the increasing high requirements of sliding systems the high-performance sliding material MSM\textsuperscript{®} which is approved for the use in bridge bearings acc. to ETA-06/0131 has been chosen for the tests.

The results on the three investigated mating surfaces G1, G2 an G3 show clearly that the mating surfaces G2 and G3 are not qualified for the use in sliding bearings; the coefficients of friction are too high (see Figure 3) and also the appearance of the sliding elements after testing show abnormalities. However, the mating surface G1 shows very promising results; the coefficients of friction are in the desired range and the sliding elements after testing show no abnormalities. Due to these results the further investigations were concentrated on the mating surface G1 in combination with the sliding material MSM\textsuperscript{®} and the lubricant silicone grease.

![Figure 3: Maximum coefficients of friction of the three investigated lubrication varnishes](image)

Since the first investigations on the mating surface G1 in combination with the sliding material MSM\textsuperscript{®} and the lubricant silicone grease has been very promising further investigations concerning the influence of the following parameters on the sliding behaviour have been performed: temperature, contact pressure, surface quality of G1 and lubrication. The results show the known characteristic non-linear dependence of the coefficient of friction of polymers on temperature and on contact pressure. Under the desired contact pressure of 60 MPa the sliding behaviour within the temperature range from
–35 to +21°C is nearly comparable to those of the standard sliding combination acc. to EN 1337-2 with a contact pressure of 30 MPa, see Figure 4. Even in the extended temperature ranges -50°C and +48°C acceptable coefficients of friction have been found. Further investigations of the surface quality of G1 showed that the deviations in coating thickness and surface roughness within the supplied test specimens have no significant influence on the sliding friction behaviour. Furthermore, investigations show that friction is strongly influenced by lubrication and that initial lubrication results in much better values than using no lubrication at all. The results without any lubrication show the worst coefficients of friction that can occur depending of the temperature.

Additionally a first test shows that the new mating surface G1 could also be suitable as mating surface in combination with the standard sliding material PTFE. However, this has not been completely verified yet.

![Coefficient of friction vs temperature](image)

**Figure 4:** Comparison of the coefficients of friction between the new sliding combination and the standard sliding combination

In conclusion it can be stated that the mating surface G1 in combination with the sliding material MSM® and the lubricant silicone grease showed in all performed investigations a favourable short term sliding behaviour. Due to this reason the partners of this research project decided to investigate the long-term behaviour of this sliding combination (see deliverable 6.3). The other investigated mating surfaces and sliding materials show results which are not satisfying for the use as sliding materials in bridge bearings, therefore no further investigations on these materials have been done.

Surface material G1 is tested in respect to its durability characteristics already by the developing company – but answering their own questions and using their own methods and standards. So after a
long discussion with the responsible officer of the notified body for a certified approval it proved to be necessary do some more tests to show the specific suitability in respect to resistance, corrosion stability and long service expectancy. A test program was decided, which has to be started after finishing all the friction investigations, and the project partner agreed to execute this even after the end of the project and at their own expense.

2.3.2.3 Comparison of planned Activities and actual Work

The activities as specified in the elaborated plan (description of work)

- research and development of new materials
- testing of materials
- definition of research emphases
- improvement of the material (if necessary)
- evaluation of current materials
- material specification

have been completed successfully.

Concerning the issue “Resource management within the WP” it is important that long-term tests on sliding materials will require about 5 to 6 months per material and that only a limited number of long-term tests can be performed within the period of time of the project because of the limited testing resources.

2.3.2.4 Planned Activities for the next Period

The work package has been finished.
Additional durability tests will be done as necessary for a certified approval at the partners own expenses.

2.3.2.5 Deliverable List and Milestone List

The deliverable 2.1 and milestone 2 was under the leadership of MS with input and close collaboration from the whole consortium. The tasks scheduled for year 2 concentrate on laboratory testing and therefore in hand of the workpackage leader MPA.USTUTT.

<table>
<thead>
<tr>
<th>No</th>
<th>Deliverable title</th>
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<td>Innovative material for the “advanced sliding bearing system”</td>
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### 2.2 Laboratory testing of innovative materials for sliding bearing

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<th>Lead contractor</th>
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<tr>
<td>2</td>
<td>Identification or finalised development of material with the defined specifications</td>
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<td>month 12</td>
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<tr>
<td>3</td>
<td>Successful material testing series are applied and improvement to the material finished if necessary</td>
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<td>month 18</td>
<td>month 18</td>
<td>MPA. USTUTT</td>
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</table>
2.3.3 WP 3 – Analysis of Requirements, Stress Simulation and Product Modeling

2.3.3.1 Summary of the specific WP Objectives

Intensive investigation on conditions and requirements for sliding elements has two major objectives. On the one hand to obtain clear and real specification for the new material and material combinations and on the other hand proper Quality Function Deployment (QFD) leads to a reduction of costs and time for the material and system development. A numerical product modelling supports the laboratory tests especially in respect of the system initial and boundary conditions by sensitivity analyses. The developed simulation models will be a sustainable design tool for future projects of the manufacturer.

The specific objectives of this WP are:

- Clear and intensive analysis of conditions for sliding elements
- Clear and intensive analysis of requirements for sliding materials and sliding material combinations
- Laboratory tests of materials simulating real conditions of sliding bearings
- Laboratory tests of appropriate materials to show long service life and stability
- Provide numerical models of the new material and product by Finite Element Method implementing effects of nonlinearities and contact
- Apply System Identification techniques
- Perform sensitivity studies
- Update numerical models by measurement data
- Prototype numerical simulations under real conditions

2.3.3.2 Overview of technical Progress

Based on the state-of-the-art described in European Standard EN 1337 ("Structural bearings") part 2 ("Sliding elements") the analysis of the change of conditions show clearly that the basically restricting bottleneck of sliding bearings is formed by the tribological system. The main problem is the stability and the long term behavior of the generally used sliding material "Polytetrafluoroethylene" (PTFE).

Size and design of large bridges change and the speed of the bridge passing (railway) traffic and the amount of the loads increase dramatically. As a result the amplitudes of the displacements of the bearings rose while the time span of the deflection of the structure related to a single passage of a load was reduced. Both factors result in an increase of the sliding speed.
To demonstrate the suitability of PTFE as sliding material in structural bearings it gets tested with sliding velocities up to 2 mm/s - while in reality displacement velocities are known of more than 15 mm/s.

As it is known that PTFE is not suitable for velocities like these - wear increases dramatically - the first and main objective was to obtain an alternative material which meets the following main requirements:

- suitability for displacement velocities of at least 15 mm/s,
- load-bearing capacity higher than that of PTFE to reduce size and cost of bearings,
- friction values within the limit values according to EN 1337-2 (down to -50°C),
- life time considerably higher than that of PTFE,
- elasto-plastic behavior similar to that of PTFE.

**Development of a new Sliding Material and a new Sliding Partner**

Several materials known form machinery construction which are based on PAS-LXY, PAS-PTFE + K25 and PAS-PEEK (modified) have been modified for high pressure and combined with optimized sliding grease. Theses sliding partners have been tested against austenitic steel at the MPA Stuttgart with poor results of the sliding behavior. The results are presented in Deliverable 2.2.

A material on Polyethylene basis fulfilling all these demands was found and is available now for all the participants and economically usable for the industrial partners of the project. For details see the following diagrams showing the much higher mechanical stability (Figure 2), low friction values (Figure 3) and the wear-free result (Figure 4) of a 50 km long term test of SSM (Special Sliding Material) specimen tested in a 50 km long term test with double load and 7.5 times higher sliding speed than for PTFE suitable.
Figure 2 Material stability

Figure 3 Friction values
The next important objective was the development of an alternative sliding surface instead of the known austenitic or hard-chromium countersurface to optimise tribological, corrosion and economic. Several different raisin based coatings have been tested together with the "Special Sliding Material" in a temperature range of -50 to +50 degrees Celsius. The total sliding path of the long term test was 50 km. The promising results are presented in Deliverable 6.3.

**Development of an advance Sliding Bearing based on alternative Materials**

Besides specifications to sliding materials calculations for structural behaviour and performance have been conducted for different new solutions of movable bearings described in the report of deliverable D1.4. Limitations of these new solutions to provide the freedom of rotation were analysed regarding their remaining friction and restrains. Detailed non-linear finite element method analysis were performed for sliding plates made of high performance fibre reinforced concrete to evaluate their stiffness development up to ultimate load state conditions. First investigations for the implementation of sophisticated material models for the sliding system have been elaborated. For details see Annex 2 of deliverable D1.4.

Besides the development of new sliding materials a main objective of this part of the project was the investigation of alternative materials for the main structural parts of the bearing. The requirements are:

- low material costs
- low processing costs
The calotte and the sliding plate are mainly exposed to compression. Therefore these parts seemed suitable to be manufactured from fiber reinforced concrete or polymer concrete.

In a first step a study on the behavior of high performance fiber reinforced concrete has been carried out. The parametric study was based on finite element analysis using nonlinear material definitions on simplified models of the sliding plate. The objective was to evaluate the influence of the material stiffness and the dimensions on the deflection (see Deliverable 3.2). Based on this results more sophisticated numerical models of complete bearings have been developed. To obtain realistic results special attention was put on nonlinear effects from contact definitions as well as on the consideration of the creep behavior of the PTFE sheet.

The results of this study showed clearly the usability of polymer concrete for the sliding plate and the calotte. The use of fiber reinforced concrete was decided to be critical as a possible corrosion of the steel fibers could influence the performance. In addition to that the high quality of the polymer concrete surface suggests the use as sliding surface only with additional coating but without an additional steel sheet.

2.3.3.3 Comparison of planned Activities and actual Work

In technical respect the work done on advanced materials meets the targets of the project plan in a high degree – but time was lost mainly because of the unexpected early start of the project. Seen from the actual point of view it will not be possible to finish the work packages 2 and 3 (they are highly connected) in the foreseen schedule meaning within the next half year.

Because of this and because of the very promising results concerning the advanced sliding material as the main element of advanced sliding systems the processing time of the project should become prolonged due to ongoing collaboration of the consortium (without any additional costs). Prove the long term stability of the advanced sliding system (which can be done only as the last testing package) will take much more time than being planned before the beginning of the project.

2.3.3.4 Deliverable List and Milestone List

Milestone 4 is represented in Deliverable 3.1 prepared by MS. Milestone 5 is represented in Deliverable 3.2 prepared by IKI.
<table>
<thead>
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<td>bearing system”</td>
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<td>3.2</td>
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<td>Finished investigation of future requirements and stress analysis, Comprehensive</td>
<td>3</td>
<td>month 12</td>
<td>month 12</td>
<td>MS</td>
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<td></td>
<td>product specifications</td>
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<td>5</td>
<td>Finished Finite Element model of the MOBILE prototype</td>
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<td>month 18</td>
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2.3.4 WP 4 – Constructability and Maintainability of Sliding Bearings

2.3.4.1 Summary of the specific WP Objectives

The specific objectives of this WP are:

The main objective is to turn the job shop production of sliding bearing systems into flow shop production by introducing a modular system of the “advanced sliding bearing system” for higher quality and better cost efficiency. Constructability is the integration of construction knowledge and experience in the planning, design, procurement, and construction phases of projects consistent with overall project objectives.

Purpose: To provide a forum for the communication and discussion of topics related to the constructability of civil engineering projects; advance the engineering and construction industry's knowledge and state of practice of constructability; and act as an industry resource for constructability information, education, and research

2.3.4.2 Overview of technical Progress

A system engineering concept for an advanced sliding bearing of the two new concepts replacement of the stainless steel sheet with a powder or a liquid lacquer coating and the replacement of steel parts with parts of high performance concrete were developed.

The development considers both advantages in performance, cost, lifetime and durability but also environmental effects due to recyclability of the materials.

There were no external contractors involved, work was done with the support of the other project partners.

Deliverable D 1.3 gave an important input for the discussion of need related to the maintainability of bearings. These findings gained broadening by first approaches to categorize the requirements of different types of bridges regarding their specific demands to the wear of sliding bearings. Different approaches to ease the maintainability of the bearings were developed and analysed, such as indicators of the state of wear of the sliding system or sliding tests of built in bearings.

Constructive details:

- Analysis for anchorage parts (enhancements, assembly simpleness, …) (RW/RWSH)
- Concept of function separation for vertical / horizontal loads (RW/RWSH)
- PE-blocks (IKI, Mageba) – tests, analysis not followed up a matter because of the results
- Analysis of combination pot- and sliding bearing (Mageba) – tests, analysis not followed up a matter because of the results
Design:
  o Generation of a concept for determination of stress types (MS, IKI) – deepened in WP 5

Maintenance:
  o Analysis of indicators (pressing indicator, colour indicator in bottom of lubricant pockets) (IKI) – Power point presentation; not followed up a matter, main focus on other parts
  o Mechanical measurement amount of sliding path (methods, information content) (IKI) – Power point presentation; not followed up a matter, main focus on other parts
  o Concept of an enhanced sliding gap indicator (IKI) – Power point presentation; not followed up a matter, main focus on other parts
  o Concept and integration of drag indicators (path/temperature) in sliding bearings (RW/RWSH)
  o Possibilities of exploitation of the results (RW/RWSH)
  o Possibilities of periodic and permanent monitoring of sliding bearings (VCE, MS) – deepened in WP 5
  o Influence of the bearing concept for dynamic system engineering (VCE) – deepened in WP 5
  o Feasibility study of damage identification on sliding bearings as a result of dynamic construction analyses (VCE) – deepened in WP 5

2.3.4.3 Comparison of planned Activities and actual Work

Possibilities with new materials like PE-blocks were analyzed and tested, but because of the results considered as not reasonable. Same applies for combinations of pot- and sliding bearings. The edge deepening of the recess seems to be worth to deepen the work, which is intended for WP 6.

From the technical point of view the objectives were fulfilled, because as a whole the intended improvement of existing design solutions was reached.

No deviation to the work programme occurred.

External contractors were not necessary, work was done within the group of project partners.

Design and maintenance parts were deepened in WP 5.
2.3.4.4 Deliverable List and Milestone List

Milestone 6 and 7 was reached due to input of other workpackage results provided by the consortium. The collection and integrated concept design presented in Deliverable 4.1 and Deliverable 4.1 was established by RW and Mageba respectively.

<table>
<thead>
<tr>
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<th>Deliverable title</th>
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<tr>
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<td>Maintainability of sliding bearings (deficiencies and enhancement)</td>
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<td>month 6</td>
<td>month 9</td>
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<td>4.2</td>
<td>System engineering concept for an “advanced sliding bearing system”</td>
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<td>Mageba</td>
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<th>Delivery Date</th>
<th>Lead contractor</th>
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<tr>
<td>6</td>
<td>Identification of all deficiencies of sliding bearing maintainability, proposal how to overcome the shortcomings in sliding bearing maintainability</td>
<td>4</td>
<td>month 6</td>
<td>month 9</td>
<td>RW</td>
</tr>
<tr>
<td>7</td>
<td>Successful system engineering concept for production and quality control</td>
<td>4</td>
<td>month 12</td>
<td>month 12</td>
<td>Mageba</td>
</tr>
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</table>
2.3.5 WP 5 – Development of a Monitoring System for Sliding Bearings

2.3.5.1 Summary of the specific WP Objectives

This WP will develop a monitoring system for the “advanced sliding bearing system” to enable the new approach of the integration of RAMS factors (reliability, availability, maintainability and safety). The monitoring system has to allow proper system identification which will be the bases for further development of sliding bearings.

A further objective and necessity for the project is a professional data acquisition and data management system which will provide data for research and development tasks such as needed in WP 3 (simulation and modelling).

2.3.5.2 Overview of technical Progress

Monitoring data directly related to the movement of bearings was analysed in detail. This information provided by an existing permanent monitoring system reflects the present load history of a full set of bridge bearings since their installation to the “Ponte 25 de Abril” in Lisbon. Conclusions were deducted for the bearings, as well as for the entire structure. Problems of such a permanent monitoring system were discussed and recommendations for improvements were given.

An applicable technology was identified and a concept for the prototype of the monitoring system was established taking into account:

- Possibilities for the permanent and periodic monitoring of sliding bearings
- Consideration of the influence bridge support conditions
- System identification of sliding bearings using dynamic structure investigations

Software for documentation of periodic and permanent measurements with information on bridge bearings support conditions was finalised and tested.
The analysis procedure was tested with measurement records of structural dynamic of bridges. The analysis software and measurement hardware development is under preparation which will be implemented in year 2.

Deliverable 5.1 – Concept of the monitoring system was written and submitted in the reporting period.

A concept for a monitoring system suitable for the respective applications has been developed, designed and implemented. The principles are described in deliverable 5.2 which gives a conclusive summary of the procedure, the used hard- and software. Respective modules have been development for application.

Verification of the development has been done through application on various real projects. In particular the Hagestein Bridge in the Netherlands has been used, where major problems with the bearing systems are evident. Monitoring campaign has been conducted by VCE and other partners to the bridge to install the monitoring system and evaluate the data. This comprises the milestones number 8 and 9. The results of the campaign have been discussed in the last 3
meetings of the Project and approved by the Steering Committee. Further collaboration on this subject after termination of the project has been decided among the partners.

A demonstration of the monitoring system has been given to bridge owners in Switzerland and Korea to the highest satisfaction. The conclusion is that the prototype is mature and can be finalized for economic application.

2.3.5.3 Comparison of planned Activities and actual Work

Milestone 8: Concept of the monitoring system is established (hard- and software) was fulfilled in month 12. The overall progress is in line with the planned activities.

All deliverables are available and all milestones have been met. There has been no deviation of the actual work from the planned activities and everything has been completed within the time-frame of the project.

2.3.5.4 Deliverable List and Milestone List

In the reporting period deliverable Nr. 5.2 (prototype of the monitoring system for bridge sliding bearings) has been completed, presented to the Consortium, updated and finally submitted to all partners. Milestone Nr. 9 (data acquisition and evaluation started for sliding bearing monitoring) has been achieved early in the project and has been completed in month 18. All targets have been met.

<table>
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<tr>
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<th>Deliverable title</th>
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<td>month 18</td>
<td>VCE</td>
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<td>8</td>
<td>Concept of the monitoring system is established (hard and software)</td>
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<td>month 12</td>
<td>VCE</td>
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<td>9</td>
<td>Data acquisition and evaluation started for sliding bearing monitoring</td>
<td>5</td>
<td>month 18</td>
<td>month 18</td>
<td>VCE</td>
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</tbody>
</table>
2.3.6 WP 6 – Prototype Design and Testing

2.3.6.1 Summary of the specific WP Objectives

Produce a sample system appropriate to the practise.

The manufacturing of a prototype is an essential aim of the project since it has to be seen as the integration of the results of the first five workpackages. The idea of the prototype is explicated in the “Strategic objective addressed”

2.3.6.2 Overview of technical Progress

WP 6 started shortly before the end of reporting period year 1. The actual goals and tasks were discussed and defined in the technical session of the midterm meeting. Two different technical solutions were analysed. At first the use of anti-friction coatings instead of stainless steel sheets should be tested. In the first step a powder coating was used for long term sliding tests. At the same time a model for the use of liquid lacquers was build.

The second technical solution was to replace steel parts with high performance concrete bearing parts. IKI provided a FE-analysis that was adapted with the help of mageba. Based on this FE-calculation mageba provided a first drawing of the prototype that was provided to the project partners. A test of the prototype was arranged by RWSH in Uslar.

2.3.6.3 Comparison of planned Activities and actual Work

Two possibilities of the conception and design of the advanced sliding bearing were shown. For both solutions prototypes were produced and tested in laboratories. The use of anti friction coatings should be practicable and leads to a better durability and is more economic then the use of stainless steel sheets. According to the FE-analyses the use of concrete parts instead of steel should be possible. In year two a test of the compressive strength was done. As the test was not successful further analyses are necessary and will follow.
2.3.6.4 Deliverable List and Milestone List

Milestone 10 and 11 is scheduled in the next reporting period.

<table>
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<tr>
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<td>month 15</td>
<td>month 15</td>
<td>Mageba</td>
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<td>6.2</td>
<td>Prototype of the advanced sliding bearing system</td>
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<td>month 24</td>
<td>month 24</td>
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<td>10</td>
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<td>11</td>
<td>Construction and testing of the prototype finished</td>
<td>6</td>
<td>month 24</td>
<td>month 24</td>
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2.3.7 WP 7 – Demonstration and Dissemination

2.3.7.1 Summary of the specific WP Objectives

- Demonstrate the "advanced sliding bearing system" to end user
- Disseminate information about the new technology, materials and product performance to relevant institutes, science, interested parties and end users

For a long-lasting exploitation of the project results the demonstration of the "advanced sliding bearing system" to end user is a necessity for Europe-wide product launch within the project and international launch afterwards. Efforts for scientific acceptance will be done due to dissemination of information about the new technology, materials and product performance to relevant institutes, science and interested parties.

2.3.7.2 Overview of technical Progress

WP 7 started in year 2 with the task to elaborate a presentation based on first results of the tests and experiences of the other project partners.

2.3.7.3 Comparison of planned Activities and actual Work

The Planned Activities:

- Establishment of a dissemination schedule
- Establishment of a dissemination platform (internet)
- Preparation of documents and information materials
- Organisation of a workshop
- Creation of an operator/end user register

The following steps were made in comparison to the above mentioned activities:

- a dissemination schedule was drafted and had as cornerstones a workshop in Bratislava and two seminars in Sweden in Borlänge and Stockholm
- a dissemination platform (internet) could not be established as this is only reasonable on basis of the results now given
- documents and information materials were prepared, presented and handed over to the participants in workshop and seminars

- a workshop was organized and held at Pezinok/Bratislava Slovakia in Nov. 2009

- operator/end user register could not yet be installed, as there are still coordination processes within the project partners required

2.3.7.4 Deliverable List and Milestone List

Milestone 12 and the workpackage deliverables have to be finished at the end of the year 2 under the leadership of RW.

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<td>Demonstration activities and dissemination literature</td>
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<td>7.2</td>
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<td>7.3</td>
<td>Results of Experiments with the bearings components &quot;Spherical Segment / Calotte&quot; and &quot;Sliding Plate&quot; of polymer concrete MG</td>
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<td>Completion of the MOBILE workshop and dissemination initiative started</td>
<td>7</td>
<td>month 24</td>
<td>month 24</td>
<td>RW, RWSH</td>
</tr>
</tbody>
</table>
2.3.8 WP 8 – Project Management

See Chapter 2.4

2.3.8.1 Deliverable List and Milestone List

Milestone 13 and 14 is reached in time by efforts of the Coordinator and all Contactors. Lead contractor was the workpackage leader VCE (Coordinator). Deliverables are submitted in time.

<table>
<thead>
<tr>
<th>No</th>
<th>Deliverable title</th>
<th>WP No.</th>
<th>Due Date</th>
<th>Delivery Date</th>
<th>Lead contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1</td>
<td>Project presentation</td>
<td>8</td>
<td>month 12</td>
<td>month 12</td>
<td>VCE</td>
</tr>
<tr>
<td>8.2</td>
<td>Plan for using and disseminating knowledge (first version / final document)</td>
<td>8</td>
<td>month 12/24</td>
<td>month 12/24</td>
<td>VCE</td>
</tr>
<tr>
<td>8.3</td>
<td>Reporting (first year)</td>
<td>8</td>
<td>month 12</td>
<td>month 12</td>
<td>VCE</td>
</tr>
<tr>
<td>8.4</td>
<td>Reporting (second year)</td>
<td>8</td>
<td>month 30</td>
<td>month 30</td>
<td>VCE</td>
</tr>
<tr>
<td>8.5</td>
<td>Final Technical Report</td>
<td>8</td>
<td>month 30</td>
<td>month 30</td>
<td>VCE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No</th>
<th>Milestone title</th>
<th>WP No.</th>
<th>Date</th>
<th>Delivery Date</th>
<th>Lead contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Consortial agreement established, schedule and resource management implemented, setup of a project secretariat</td>
<td>8</td>
<td>month 1</td>
<td>month 1</td>
<td>VCE</td>
</tr>
<tr>
<td>14</td>
<td>Midterm assessment, mid term reporting</td>
<td>8</td>
<td>month 12</td>
<td>month 12</td>
<td>VCE</td>
</tr>
<tr>
<td>15</td>
<td>Final reporting, project ending activities</td>
<td>8</td>
<td>month 30</td>
<td>month 30</td>
<td>VCE</td>
</tr>
</tbody>
</table>
2.4  **Consortium Management**

2.4.1  Tasks and Achievements of the Project Management

The Project Management has a vertical structure having

- a Steering Committee at the top with SME participants in the leading role (Strategic Level) and
- a detailed Technical Management which will be carried out by the Workpackage Leaders (Operational Level).
- Both levels are coordinated and supported by the Project Coordinator.

The project planning was performed by the Steering Committee which decisions were mainly based on identified potential enhancement during the Current Practice Workshop (WP1).

After continuative studies the most promising technical approaches were selected to for R&D efforts within the MOBILE project and to be incorporated into the MOBILE prototype.

The planning and building works for the prototype have been the task of the industrial partners. Nevertheless in order to avoid competition the management played a steering role and distributed the work load accordingly to achieve balanced contributions. Wherever unbalanced activities were found agreement among the contractors has been reached.

Implementation of the tasks on operational level was managed by the Workpackage Leaders according to the DoW – Annex 1 of the contract. Technical meetings were organised to share and discuss relevant items of the Workpackages. Additional bilateral meetings within the workpackages groups were held to bundle resources and organise the tasks.

The Midterm meeting was used to introduce the WP progress by the workpackage leader and to analyse the results from project year 1. Based on this status quo all major tasks for year 2 have been defined.

In the 2nd year of the project a new regulation has been issued by the European Commission. This regulation is asking for a different testing procedure for materials which are also involved in the development of the MOBILE project. Therefore it became necessary to ask for an extension of 6 months for the project in order to achieve this testing campaign. Finally it was successful and the campaign could be completed just before the end of the project in July 2009.

In the reporting period a total of 5 project meetings including all partners have been organized. This allowed to close collaboration and enhanced the understanding and integration of the European industry in this sector. Demand from outsiders to participate has been registered already which is a sign for successful management.

The reporting structure has been successfully explained to all partners and the respective reporting has been delivered without problems.

MOBILE Deliverable D 8.4a
The very short time between information of supporting the MOBILE project and the project start led to some difficulties in the first months as time for project preparation and making resources available was lacking. However, since year 2 in the project schedule is planned as more resources intense than year 1 all milestones could be met until the end of the first reporting period.

Furthermore it has to be mentioned that the consortium decided that the prototype should undergo a long term qualifying examination. As the implementation of such tests is very time consuming with overall duration of several months the examination will be done after year 2. Following this planned workflow all valuable resources are available for research and development of the prototype. However, a possibility to consider these examinations an extension of the MOBILE project has to be discussed with the EC.

The timetable already shows the extension that has been granted. Particular the work packages 6, 7 and 8 have been prolonged. It furthermore enabled a demonstration of the monitoring system (WP5) in the Netherlands within this period. This helped to improve the results considerably. Simulation and modeling has also been continued because of the feedback from the tests. This is actually a necessity which should have been considered from the beginning. A careful planning of this activity enabled the spreading of this work over the extended period without over tension on the respective partner.

It shall be mentioned that the long term qualification test of the new material has just been completed at the end of the project which is considered an achievement.
2.4.2 Coordination Activities

Administrative and Technical Meetings held in year 1 and 2:

<table>
<thead>
<tr>
<th>#</th>
<th>Name/Type</th>
<th>hosted by</th>
<th>Date</th>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Administrative and Technical Meetings held in year 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Kick off Meeting</td>
<td>VCE</td>
<td>15.02.2007</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Technical Meeting (Current Practice WS)</td>
<td>IKI</td>
<td>16.05.2007</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Steering Committee Meeting</td>
<td>Uni Weimar</td>
<td>18.09.2007</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Midterm / Steering Committee Meeting</td>
<td>VCE</td>
<td>06.02.2008</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>Technical Meeting</td>
<td>VCE</td>
<td>06.02.2008</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>Technical Meeting</td>
<td>MPA.USTUTT</td>
<td>08.05.2008</td>
<td>16</td>
</tr>
<tr>
<td>7</td>
<td>Steering Committee Meeting (WP 2, WP 6)</td>
<td>MS</td>
<td>09.07.2008</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>Progress Testing</td>
<td>MPA.USTUTT</td>
<td>04.09.2008</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>Technical Meeting</td>
<td>VCE</td>
<td>12.11.2008</td>
<td>22</td>
</tr>
<tr>
<td>10</td>
<td>Dissemination Workshop (WP 7)</td>
<td>Milano Politec</td>
<td>29.04.2009</td>
<td>27</td>
</tr>
<tr>
<td>11</td>
<td>Final Meeting</td>
<td>MPA.USTUTT</td>
<td>09.07.2009</td>
<td>30</td>
</tr>
</tbody>
</table>

Above table shows the meetings where the Consortium has met. Beside that a major number of individual meetings have been registered. It shall be pointed out that these much more frequent than intended meetings have been very fruitful and supported integration and collaboration among the Consortium considerably. It mainly contributes to the strengthening of the European Industry, which has been too small in size and too fragmented to compete against the upcoming competition from Asia. This collaboration has led to stronger and more competitive units, which collaborate on demand and targeted to the specific objectives. Despite the time requirement from the top management of these companies almost all of them participated in all of the meetings of the project. This can be called a major success.

There is agreement among the Consortium that this project has been a considerable asset for the industry. It has been decided to keep on collaborating in future and to eventually look into the organization of a follow-up project to deepen the collaboration and tackle the identified further subjects where this approach would make sense.
3 Dissemination and Use

See Annex 1