EURAMET PROJECT PROTOCOL

1. Reference Number: ***(please leave blank)***	**2. Technical Committee:** Length	
3. Proposed start date: October 2008	**Proposed end date: December 2010**	**Project Duration (months): 27**

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5. Full Project Title: Towards truly 3D metrology for advanced micro-parts	**Version number:v4.0 Final**
6. Project short name: micro-parts	

Summary of Participation in Work Packages

WP No	Work Package Name	Active Partners (Institutes; WP Leader in Bold)
WP1	Management and Coordination	**NMi VSL**, All
WP2	Development and characterisation of new micro-CMM probes	NPL, NMi VSL, METAS, PTB
WP3	Calibration aspects of micro-CMMs and micro-CT	**METAS**, NMi VSL, NPL, PTB
WP4	Virtual CMM	NMi VSL, NPL, METAS
WP5	Application of micro-CMM	NMi VSL, PTB, METAS
WP6	Application of enhanced micro CT for high precision measurements of microparts	PTB, BAM
WP7	IMPACT: exploitation, dissemination and knowledge transfer	**NPL**, All

Project Description

A – Problem and Projected Impact. (*Typically one page)*

Miniaturisation leads to larger functionality in a smaller volume. One can think of small free form lenses, which are used in mobile phones, use of a freeform limits the number of optical elements. Another very interesting application are small devices in the human body. Think of ear implants, eye-optics, but also devices for local administering of medicines and diagnostics. For these medical purposes, safety and reliability is an absolute necessity. Another example is the car industry. Due to miniaturisation more sensors can be applied, which can for instance monitor the road holding and CO2 exhaust, without adding to the weight of the car. Other examples are small gears and inkjet nozzles. We will call these products micro parts. In size they can range from some 10 mm, to sub-mm, and the local features to be measured demand sub micrometer uncertainty. They can be made with different production techniques, materials, shapes and surface features.

In order to underpin the quality of these products reliable measurements are necessary. Besides increased demands on the tolerances of these objects they have in common that they are quite complex. Traditionally, conventional 3D Coordinate Measurement Machines have been used to perform measurements on complex objects. The uncertainty of conventional CMMs is however no longer satisfactory for these advanced products, and furthermore there is an accessibility problem. To fulfil the increased accuracy demands, about 10 years ago the development of micro-CMMs was slowly started and the first micro-CMMs are now available. However the traceability, and therefore the reliability of the measurements performed which these CMMs are lacking. Another problem is that the development of small probes for these micro-CMMs is laging behind. Small probes are necessary to access the small features of the objects. Optical measurements have the advantage that they are contactless and can therefore be applied to delicate or easily deformed surfaces, such as optics and plastics. Also, the measurement speed is much higher than for typical contact measurements. Therefore, in recent years, there has been a large increase in the application of optical measurement techniques. Especially for micro-parts, a wide variety of measurement principles and technical realisations of optical sensors is available. But the influence of the used sensor together with the specific measurement task (material and surface characteristics) on the measurement result is much stronger and more difficult to assess for optical sensors than for tactile ones.

Besides micro-CMMs Computed tomography (CT) is an emerging and very promising field in dimensional measurement technology, especially for the non destructive characterization of complex components and hidden structures. For many applications the feature of CT to yield complete geometry information without holes, i.e. to perform high point density measurements, is very important.

This project will provide substantial support of European industrial CT and micro-CMM measurement infrastructure by means of progress in measurement technology, traceability and standardisation. A key step to achieve these objectives is the decrease of measurement uncertainty of industrial-dimensional micro-CT by the means of the methods being developed in this project.

B – Scientific and Technological Frame and Objectives. (*Typically one page)*

The first micro-CMM platforms have recently become available; however the traceability of these micro-CMMs is not yet realized. Therefore one of the objectives of this JRP is to realize the traceability and address standardization needs through pre-normative research and development of guidelines.
Currently the availability of probes for micro-CMMs is very limited. Basically only one type of tactile probe exists. This currently limits the amount of tasks that can be performed by a micro-CMM, therefore new probes will be developed, characterized and modelled and finally integrated in the micro-CMMs. Next step is to research the overall instrument behaviour, platform, probe and probe-surface interactions, to estimate the task specific uncertainty of measurement. On the application side the possibilities of small probes will be investigated as well as guidelines for scanning will be developed.
For a good characterization of microparts with micro-CMMs, a variety of probes and sensors is required. The ideal micro-CMM of the future will be equiped with a multiprobe/multisensor systems which allows the user to select various probes or sensors based on the measurement task at hand. Besides the above mentioned tactile probes, optical probe systems will be investigated. In particular, more knowledge about the interaction processes between probe and surface is required to achieve reliable measurements.
Computed tomography (CT) is an upcoming dimensional measurement technology, especially for the non destructive analysis of technical parts featuring complex and inner structures. Recently this technique has been developed from a non destructive testing method (checking of e.g. faults, cracks, pores) to perform dimensional measurement of industrial parts. Reliable results can now be achieved for many measurement tasks on larger bodies (e.g. cast cylinder heads).
CT measurements of smaller plastics parts, of electronic components and of micro gears are currently performed, too. Thus the measurement properties of microCT measurements are not well studied and the relative measurement uncertainty of these measurements is worse than for larger parts.
In general measurement deviations of CT measurements are much larger than those of to tactile measurements and frequently larger than those of many optical measurements. This is caused by multiple and complex influence quantities, therefore correction techniques are required. CT measurements are in most cases not traceable, thus no measurement uncertainty statement can be made. Additionally the resolution of micro-CT is not sufficient in certain cases.
General target:
- Achievement of higher measurement accuracy for industrial CT measurements (e.g. measurement of injection nozzles or micro gears) by the use of calibrated micro artefacts with a substantially low calibration uncertainty. These calibrated micro artefacts help to trace back micro-CT measurements and allow for the determination of the measurement uncertainty of this emerging measurement technology for technical micro parts.
Further targets:
- Development of guidelines for standardised procedures for dimensional measurements with CT

C - Description of the work.

C1 – WP1: Project Coordination – NMi VSL

C1a: Description of work

Project management
The overall project coordination will be done by NMi VSL. In WP6 the coordination between the non-NMi partner BAM and PTB will be coordinated by PTB. The CT measurements will be carried out mainly on micro-CT systems of the BAM in Berlin and (if technical necessary) at BAM beamline of the synchrotron facility BESSY in Berlin

Reporting
Each half year each partner will prepare a simple one-page report or presentation giving progress against plan and indicating any exceptions that might need attention. These will than be discussed at the respective half year meetings.
At the end of each year each partner will prepare a short report given the progress against the plan, and the planned future activities. The project coordinator will provide an annual report, which will be a summary of the individual partner contribution as well as an executive overview.

Meetings
Meetings will take place each half-year to review the project progress, to take action where necessary and agree on the work for the next period.
At the meetings also technical discussions will take place, this might be in smaller groups if necessary. This will limit the amount of travel between partners in between these meetings.
The final meeting at the end of the project will review all the results and draft the final report including the final impact report.

Exchange of information
A project email address will be made available to all partners so easy exchange of information is facilitated.

Intellectual property management
The standard IPR terms posted on the emrponline.eu web page will be used.

C1b Total person months for this work package:

WP number	NMi VSL	METAS	NPL	PTB	BAM					**TOTAL Σ**
WP1	1.0	0.5	0.5	0.5	0					3

C1c: Deliverables List

Ensure that deliverables are clearly stated and SMART (specific, measurable, attainable, realistic and time-bound). Add extra lines as required.

WP number	Task	Deliverable description	Lead Partner	Other Partners	Delivery date
WP1	D1.1	Review on progress and decision made on continuation or otherwise of the project	NMi VSL	All	Annually
	D1.2	Coordination between PTB and co-funding partner BAM	PTB	BAM	half-yearly

C2 – WP2: Development and characterization of new micro-CMM probes

C2a: Description of work

Over the past decade many research and commercial groups have expended significant effort to develop ever-smaller probes for use with micro-CMMs. This has led to a number of successful probes that can be used in a range of measurement tasks, both optical and contacting probes. However, there is still a need for a further reduction in size of the probing elements and a need to produce probes that can operate in fast, scanning modes. Furthermore, for tactile probes, there are only single style probes available. This is why in this WP also multiple styli probe will be developed. Also the uncertainty of the probes need improvement as they are probably dominating when measuring small parts. All of the above requires modelling and simulation work, probe development and characterisation. This work package will be concerned with developing and characterising small probing elements, developing vibrating probes that reduce the effects of contamination and speed up the measurement process. This work will significantly change the way in which probes are used in practice, characterised and their ultimate functionality.

Task 2.1 Development of small probing elements (NPL, METAS)

There are already commercially available probes with tip diameters of less than 100 μm. However, such probes have proved difficult and are delicate to use in practice and can have form errors that are difficult if not impossible to correct for. This WP will develop probes with tip diameters less than 50 μm with reasonable form and surface texture. Suitable materials will be chosen for probing characteristics and to suit the limited machining capabilities at such small dimensions. The NPL probe will be interfaced to a Zeiss F25 micro-CMM. METAS will focus on the fabrication of small probing elements made from tungsten wires. A micromanipulator station will be built to produce probes with 25 μm shaft diameter and probing sphere diameters below 50 μm. The probes will be interfaced to the METAS micro-CMM and their sphericity will be measured. The feasibility of scanning will be tested.

Task 2.2 Develop multiple styli probe (METAS)

The target is to assemble single styli probes from Task 2.1 (e.g. made from tungsten) into multiple styli probes (4 to 5-fold) and to develop the corresponding controller routines for their calibration. Also assemble multistylus probes with the smallest currently available ruby spheres of 125 μm will be assembled.

Task 2.3 Develop 3D vibrating probe (NPL)
As the dimensions of a CMM probe are reduced, the probing becomes more problematic due to the effects of damage to the surface and/or probes tip due to the relatively high probing pressures, the effect of liquid layers present at the surface and the effects of dirt and other contaminants (of similar orders of magnitude to the probing tip). The effects often mean that it is not possible to use scanning methods and that probing has to be carried out very slowly. There are currently probes available that overcome or minimise these detrimental effects by vibrating the probe tip. However, such probes usually only operate by vibrating the tip in one dimension. This WP will develop a probe that is capable of vibrating in any vector in a sphere, i.e. that can always probe normal to the surface being measured. This should allow fast, scanning probing methods.

Task 2.4 Vision probe (NMi VSL)
For optical sensors the physical principle, technical realisation and the work piece have a high influence to the measurement result. One type of optical sensors are the vision systems which make use of a microscope objective and a CCD camera, and can be positioned using the moving axis of a for instance a micro-CMM. The accuracy demands for the use of visions systems is increasing, and there are problems with the traceability. One specific problem is the definition of light-dark transitions, which depend among others on the lighting settings and surface texture. Absolute sizes of elements to be measured vary therefore and it is not clear which value is the closest to the true value. Experiments on specified test artefacts is therefore necessary. Use will be made of test artefacts, which are available.

C2b Total person months for this work package:

WP number	NMi VSL	METAS	NPL	PTB	BAM					**TOTAL Σ**
WP2	5	2	16	0	0					23

C2c: Deliverables List

Ensure that deliverables are clearly stated and SMART (specific, measurable, attainable, realistic and time-bound). Add extra lines as required.

WP number	**Task**	**Deliverable description**	**Lead Partner**	**Other Partners**	**Delivery date**
WP2	D2.1	CMM probes with tip diameters less than 50 μm	NPL	METAS	M24
	D2.2	Multiple-styli probe	METAS		M24
	D2.3	3D vibrating micro-probe	NPL		M24
	D2.4	Guidelines of measuring light dark transitions with vision systems	VSL		M15

C3 – WP3: Calibration aspects of micro-CMMs and micro-CTs – and international comparison

C3a: Description of work

In this work package general applicable methods and rules will be elaborated in order to provide traceability for micro-CMMs and micro-CT. Adequate artefacts of various types will be identified, calibrated and evaluated. Consistent performance tests will be proposed and a final international measurement comparison will validate the findings. The results will build the basis of the standardisation of artefacts and methods on the field of micro measurements. Within this work package different types of micro-CMMs which are available among the partners will be used. These types are fundamentally different in nature. For instance there is the line scale based Carl Zeiss F25 micro-CMM with moving probe and the laser rinterferometer-based micro-CMM of METAS with moving artefact. So for calibration (Task 3.1) it will be necessary do develop procedures applicable for the different types of micro-CMMs. Partly the calibration procedures have therefore to be different. For the performance testing emphasis will be put on making them as universally applicable to the different types of micro-CMMs that exist. Having different types of micro-CMMs available will allow for finding out the particularities of each specific type of micro-CMM. This is a large benefit when establishing traceability, since it means systematic differences based on the used measurement principle will be detected.

Task 3.1 Develop calibration procedures/methods (METAS, NMi VSL, NPL, PTB)
Bottom-up: Specific methods and rules will be elaborated in order to provide traceability of the micro-CMMs and micro-CT. First, the traceability chains of the different instruments in the group will be established. For each contribution in the chain adequate means of characterisation have to be found with the goal to obtain a complete calibration. All uncertainty contributions will be identified and specific methods and tools for their estimation will be developed.
Top down: Alternatively, universal applicable top-down calibration methods will be studied which will fulfil the needs of micro-CMMs and micro-CTs. This task is limited to the estimation of instrument uncertainties; measurement uncertainties are objectives of WP4 and WP5.

Task 3.2 Comparison of micro-CMMs/ micro-CT (All)
International measurement comparisons will validate the findings of the previous tasks. Up to now there has been no international comparison of mirco-measurement with different sensors and micro-CMM types. Firstly a comparison on relatively simple artefacts, e.g. ball-bars or ball plates will be carried out. A few specially selected advanced micro parts (similar to real work pieces) will finally serve as transfer standards for a second measurement comparison among the participants of this JRP. The result will be of general interest and show the state of art in this field. This will also help to discover remaining problems and to define future activities.

C3b Total person days months for this work package:

WP number	NMi VSL	METAS	NPL	PTB	BAM					**TOTAL Σ**
WP3	3	4	2	3	0					32

C3c: Deliverables List

Ensure that deliverables are clearly stated and SMART (specific, measurable, attainable, realistic and time-bound). Add extra lines as required.

WP number	Task	Deliverable description	Lead Partner	Other Partners	Delivery date
WP3	D3.1	Tested and verified procedures for micro CMM calibration		All	M12
	D3.2	Artefacts for microCMM calibration/comparison selected	METAS	All	M12
	D3.3	Comparison of micro-CMMs/ micro-CT finished and evaluated	METAS	All	M24

C4 – WP4: Virtual CMM

C4a: Description of work

Traceable measurements require an evaluation of the measurement uncertainty. In the field of coordinate metrology, the desired measurement result is typically a global parameter, extracted from a large set of measured points (e.g. the diameter of a circular hole measured at several tens or hundreds of points along the circumference). Each of these points has a 3D uncertainty. In evaluating the total uncertainty on the output parameter, one not only has to deal with a large number of individual contributions; the contributions of the individual points are also strongly correlated. In addition, there is the problem that the mathematical processing of the points often contains non-analytical steps, such as filtering and numerical regression. All this makes a 'classical' uncertainty evaluation impractical or even impossible, and other solutions have to be found.

In this work package tools for the task-specific uncertainty evaluation of micro-CMM measurements will developed, based on a Monte-Carlo method. A model of the instrument, a virtual CMM, is constructed. Based on the uncertainties in the measured data and the model parameters, the virtual CMM generates alternative sets of points to the set, which has actually been measured. These alternative sets of points can then be evaluated in the same way as the measured set, yielding a distribution of evaluation results. The distribution of evaluation results can subsequently be analysed to provide an uncertainty interval, as described in GUM supplement 2.

This approach has proved its merits in the field of large-scale CMMs, but the very specific properties of micro-CMMs provide new challenges. A major challenge lies in the small scale of the probe and the different probe-surface interactions, which come into play. Another important difference is the higher precision of micro-CMMs, which means that effects which are neglible for conventional CMMs can become substantial contributors to the overall uncertainty.

Task 4.1 Develop model of micro-CMMs (NMi VSL, METAS)

A model will be formulated covering all aspects of a micro-CMM, which contribute towards the uncertainty. The model will have a modular layout, with different modules for the guidance, probing system, probe-sample interaction etc. The overall structure will be made as general as possible, with device-specific aspects covered at the level of the modules. For the probe model, the results of Task 2.5 will be employed. A detailed model will be worked out for the Zeiss F25. First, a static model will be developed for measurements consisting of individual points. In a second phase, this model will be extended to incorporate dynamic effects encountered in scanning. METAS will formulate a simple model of the METAS micro-CMM based on the uncertainty budget and the probe shape correction.

Task 4.2 Implementation of virtual micro-CMM (NMi VSL)
The virtual CMM model will be translated into a software package. In order to use the virtual CMM, a Monte-Carlo framework will be implemented, consisting of random generation of the input parameters and the measurement data and a collection of evaluation methods to extract the output parameters from the simulated coordinates. The software will have an open architecture, allowing others to implement modelling modules specific for their device, or additional evaluation methods as needed.
In addition to this package, which is a post-processing tool, we will look into the possibilities for integrating the virtual CMM directly into the F25 control software. This will be discussed within the framework of the existing cooperation between Zeiss and NMi VSL.
The software will be tested in the comparison of Task 3.5.

Task 4.3 Implementation of the virtual micro-CMM (METAS)
The virtual CMM model will be translated into a virtual METAS micro-CMM LabView driver which will send simulated data to the Quindos7 high level software. Final evaluation will be in Excel. No specific high level software package will be needed.

C4b Total person days months for this work package:

WP number	NMi VSL	METAS	NPL	PTB	BAM					**TOTAL Σ**
WP4	6	1	0	0	0					7

C4c: Deliverables List

Ensure that deliverables are clearly stated and SMART (specific, measurable, attainable, realistic and time-bound). Add extra lines as required.

WP number	**Task**	**Deliverable description**	**Lead Partner**	**Other Partners**	**Delivery date**
WP4	D4.1	Mathematical formulation of virtual CMM	VSL	METAS	M20
	D4.2	Implementation virtual CMM package	VSL		M24
	D4.3	Implementation of virtual micro-CMM	METAS		M24

C5 – WP5: Application of micro-CMMs

C5a: Description of work

Task 5.1 Guidelines for optimal scan settings (NMi VSL)

When measuring complex geometries scanning is the preferred measurement method in order to get a good representation of the shape. A further advantage, especially for micro parts is that in scanning mode a lot of points are collected, which increases the accuracy and minimizes the effect of e.g. surface roughness on the overall shape determination. The scanning behaviour of a micro-CMM however is significantly different from that of a conventional CMM. To get reliable results research will be done to find optimal settings for scanning speed, probing force and size, point density, scan pattern and filtering settings. This in relation to the surface to be scanned and it properties such as form, roughness and material. Therefore measurements will be performed using the F25 micro-CMM of NMi VSL on special test artefacts of different material, shape and surface texture. Where possible use will be made of existing artefacts of the partners. The individual properties of these artefacts, such as the surface texture and flatness, will be determined using other available equipment within the consortium. The different parameters (scan speed probe radius, point density and scan pattern) will be varied, and the effect of the measurement results will be investigated. Use will also be made of the modelling, which will be done in Task 2.5. This will result in better knowledge of the scanning process in relation to repeatability, trueness of the measured value and measuring time. A set of guidelines will be the deliverable, which can be used to get optimal results for future measurements.

Task 5.2 Application of small tactile probing elements (METAS, PTB)

The application of small tactile probing elements will be tested for different measuring tasks. This means investigations near the technical limits of tactile probing, like surfaces of different inclination and surface characteristics. The first aspect is the practical realisation of different tasks because the working principle of the tactile probing has to been taken into account to find the limiting effects. For the realisation some of the artefacts developed in Task 3.2 can be used.

C5b Total person days months for this work package:

WP number	NMi VSL	METAS	NPL	PTB	BAM					**TOTAL Σ**
WP5	2	1	0	2	0					5

C4c: Deliverables List

Ensure that deliverables are clearly stated and SMART (specific, measurable, attainable, realistic and time-bound). Add extra lines as required.

WP number	Task	Deliverable description	Lead Partner	Other Partners	Delivery date
WP5	D5.1	Guidelines for optimal scan settings	NMi VSL		M24
	D5.2	Demonstrated applications of small tactile probing elements	METAS	PTB	M24
	D5.3	Tips & Tricks		All	

C6 – WP6: Application of enhanced micro CT for high precision measurements of microparts

C6a: Description of work

Task 6.1: Data fusion of multi-sensor data from tactile, tactile-optical, optical and CT sensors and nominal-actual value comparisons (PTB)
Micro artefacts need to be calibrated covering the total 3D volume including inner geometries. Therefore it is the approach here to overcome limitations of tactile measurements (been precise but having low measurement density, no measurement of inner geometries, may cause deformations when using micro probes, may cause pollution of the workpiece with adhesive dust or particles), optical measurements (lower accuracy, no measurement of inner geometries, specific measurement errors) and CT measurements (lower accuracy, but measurement of inner geometries, specific measurement errors) by the combination of the individual sensor results. This combination (data fusion) is based on a registration of measurement data sets and the forming of a common model of the geometry under study based on a weighted averaging, interpolation and morphing of the sensor data sets. The registration can be performed e.g. by applying a fit procedure over the total data set by a registration procedure taking focus on dedicated features of the body under study (feature based alignment). The task is to define and to describe a metrological stable and precise data fusion procedure for tactile, optical and CT sensor data. The process can be performed on the level of point datums (e.g. weighted mean value) or by altering the given CT data by the use of the data measured by tactile and optical sensors. In any case the method of forming surfaces from CT volume data sets has to be described (and constrained for the analysis and data fusion process).
At the end of this task the limits and accuracy of the developed procedure have to be analysed (e.g. by repetitive analysis or by symmetry operations).

Task 6.2: Correction of measurement deviations of X-ray tube-based micro CT by micro-artefacts (PTB, BAM).
The basis of this task are the micro artefacts developed in WP3 of this JRP.
Possible corrections are based on geometric features which are derived from CT measurements of the calibrated artefacts. Up to now this can be e.g. scaling factors, threshold values, linear anisotropies, beamhardening corrections and corrections for distorted projections.
The application of corrections will be made with calibrated artefacts and typical calibrated work pieces. Bodies with inner geometries need to be accessible or dismountable to carry out complete optical or tactile calibrations.

The workflow of this task will be as following:
- In a first step artefacts will be calibrated by means of tactile and optical sensors (PTB and others)
- State of the art micro-CT measurements will be performed by BAM with PTB support.
- After registration of CT measurement data and calibration data actual nominal value comparisons will be made to assess CT measurement deviations (PTB, BAM) or the measurement deviations will be estimated by numerical simulations of the CT measurement process.
- Finally deduced corrections will applied to an industrial micro-CT system of BAM (PTB).

Task 6.3: Determination of measurement uncertainty of optimized CT systems for specific measurement tasks (PTB, BAM)
The basis of this task are micro artefacts developed in WP3 of this JRP which have been calibrated using multi sensor calibration strategies developed in task 6.1 of this WP and the micro artefact based correction of measurement deviations of CT systems using correction techniques developed in task 6.2 of this WP

The approach to be followed is to measure calibrated micro parts with the CT system under study repetitively (BAM) and analyse the measurement deviations (PTB). This procedure is detailed in ISO 15530-3 for coordinate measurements. In the project, the CT system under study will be the system of the BAM. The procedure is based on the statistical analysis of the measurement results and of an analysis of additional sources of measurement uncertainty (e.g. varying workpiece roughness). The impact of uncorrected systematic errors will be assessed by the approach of GUM which differs in detail to the approach given in ISO 15530-3 (the influence of uncorrected systematic errors on measurement uncertainty is topic of an actual scientific discussion)
The calibrated micro parts to be used in the measurement uncertainty study are allowed to be calibrated micro artefacts developed in WP3 of this JRP under the condition that
1. the specific body has not been used to correct the CT system under study,
2. the micro artefact is in shape similar to bodies which are measured by this CT system for standard measurement tasks,
3. the measurement tasks to be performed are similar to standard measurement tasks to be performed on the CT system under study.
An important job in this project task is to check whether all sources of measurement uncertainty which are to be included in an analysis according to ISO 15530-3 are complete (PTB); e.g. the influence of complex software used to achieve the final CT measurement results has to included in an appropriate way.

C6 Total person days months for this work package:

WP number	NMi VSL	METAS	NPL	PTB	BAM					**TOTAL Σ**
WP6	0	0	0	6	3					9

C6c: Deliverables List

Ensure that deliverables are clearly stated and SMART (specific, measurable, attainable, realistic and time-bound). Add extra lines as required.

WP number	**Task**	**Deliverable description**	**Lead Partner**	**Other Partners**	**Delivery date**
WP6	D6.1	Data fusion of different sensor data and micro-CT measurement data achieved	PTB		M27
	D6.2	Correction of an industrial micro-CT system	PTB	BAM	M27
	D6.3	Determined measurement uncertainty of optimized industrial micro-CT system	PTB	BAM	M27

C7 – WP7: Dissemination, Exploitation and Knowledge Transfer activities – NPL (for the workshop)

C7a: Description of work

There are several ways in which the impact of this project will be realized:

- Organisation of one or two international workshops for the industrial and scientific community which deals with the emerging topics of dimensional CT measurements and high accuracy 3D coordinate measurements for advanced manufacturing. Cooperation with relevant organisation such as EUSPEN will be sought, perhaps through the cooperation/participation with the new special interest Structured & Freeform Surfaces - The partners will give presentations of the results at relevant national and international conferences and workshops, such as EUSPEN and Nanoscale

C7b Total person days months for this work package:

WP number	NMi VSL	METAS	NPL	PTB	BAM					**TOTAL Σ**
WP7	0.5	0.5	1	0.5	0					**2.5**

C7c: Deliverables List

Ensure that deliverables are clearly stated and SMART (specific, measurable, attainable, realistic and time-bound). Add extra lines as required.

WP number	**Task**	**Deliverable description**	**Lead Partner**	**Other Partners**	**Delivery date**
WP7	D7.1	International workshop	NPL	All	Oct 2009
	D7.2	Joined publications and conference proceedings		All	

D – Summary deliverable list

This table should collate all the deliverables detailed under the individual work packages in section C. Add extra lines as required.

WP number	Deliverable number	Deliverable description	Lead Partner	Other Partners	Delivery date
1	D1.1	Review on progress and decision made on continuation or otherwise of the project	NMi VSL	All	Annually
1	D1.2	Coordination between PTB and co-funding partner BAM	PTB	BAM	half-yearly
2	D2.1	CMM probes with tip diameters less than 50 μm	NPL	METAS	M24
2	D2.2	Multiple-styli probe	METAS		M24
2	D2.3	3D vibrating micro-probe	NPL		M24
2	D2.4	Guidelines of measuring light dark transitions with vision systems	VSL		M15
3	D3.1	Tested and verified procedures for micro CMM calibration	All	All	M12
3	D3.2	Artefacts for microCMM calibration/comparison selected	METAS	All	M12
3	D3.3	Comparison of micro-CMMs/ micro-CT finished and evaluated	METAS	All	M24
4	D4.1	Mathematical formulation of virtual CMM	VSL	METAS	M20
4	D4.2	Implementation virtual CMM package	VSL		M24
4	D4.3	Implementation of virtual micro-CMM	METAS		M24
5	D5.1	Guidelines for optimal scan settings	NMi VSL		M24
5	D5.2	Demonstrated applications of small tactile probing elements	METAS	PTB	M24
5	D5.3	Tips & Tricks		All	
6	D6.1	Data fusion of different sensor data and micro-CT measurement data achieved	PTB		M27
6	D6.2	Correction of an industrial micro-CT system	PTB	BAM	M27
6	D6.3	Determined measurement uncertainty of optimized industrial micro-CT system	PTB	BAM	M27
7	D7.1	International workshop	NPL	All	Oct 2009
7	D7.2	Joined publications and conference proceedings		All	

F –Project Resources

F1 - Summary of labour resources per work package in person months

Add extra columns as required.

Work package	Institute									
	NPL	METAS	PTB	NMi VSL	BAM					TOTAL
WP1	0.5	0.5	0.5	1	0					2.5
WP2	16	2	0	5	0					23
WP3	2	4	3	3	0					12
WP4	0	1	0	6	0					7
WP5	0	1	2	2	0					5
WP6	0	0	6	0	3					9
WP7	1	0.5	0.5	0.5	0					2.5
TOTAL person months	19.5	9	12	17.5	3					61

Annex 1: Contact Details

List the main contact for each institute. If more than one contact per institute is appropriate, please list all contacts, and indicate their tasks/responsibilities areas in the notes column.

Institute	Main Contact?	Contact Name	Address	Tel	Fax	e-mail	Notes
NMi VSL	Y	Rob Bergmans	Thijsseweg 11, P.O. Box 654 2600 AR Delft	+31-15-269 1641	+31-15 261 2971	rbergmans@nmi.nl	Coordinator
NMi VSL	N	Marijn van Veghel	Thijsseweg 11, P.O. Box 654 2600 AR Delft, The Netherlands	+31-15-269 1517	+31-15 261 2971	mvveghel@nmi.nl	
METAS	Y	Felix Meli	Lindenweg 50, CH-3003 Bern-Wabern	+41 31 32 33 346	+41 31 32 33 210	felix.meli@metas.ch	Comparison leader
METAS	N	Alain Küng	Lindenweg 50, CH-3003 Bern-Wabern	+41 31 32 34 641	+41 31 32 33 210	alain.kueng@metas.ch	
NPL	Y	Richard Leach	Hampton Road, Teddington, TW11 0LW, United Kingdom	+44 208 943 6303	+44 208 614 0420	richard.leach@npl.co.uk	Workshop leader
NPL	N	James Claverley	Hampton Road, Teddington, TW11 0LW, United Kingdom	+44 208 943 6242		james.claverley@npl.co.uk	
PTB	Y	Ulrich Neuschaefer-Rube	Bundesallee 100, 38116 Braunschweig, Germany	+49-531-5925311	+49-531-592695311	ulrich.neuschaefer-rube@ptb.de	Coordination with BAM
PTB	N	Markus Bartscher	Bundesallee 100, 38116 Braunschweig, Germany	+49-531-5925341	+49-531-5925305	markus.bartscher@ptb.de	