Implementation of the Quality Assurance Matrix (QAM) and methodology

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Abstract:

The purpose of this paper is to present the planning of a case study performed in the field of Geometrical and dimensional Measurement and Controllability Planning (GMCP, previously abbreviated GICP).

The case study is carried out at the Swedish automotive company Scania CV. The paper presents the preparation of the planned implementation work of the Quality Assurance Matrix and methodology (QAM). The QAM methodology is described and will later on, and when it has been implemented, be evaluated, verified and falsified.

The QAM framework is primarily being applied on complex products. In this case study a pinion and a crown wheel is being used as case study objects. These two critical components create a subassembly, i.e. conical or hypoid gearbox assembly, in the rear central gearbox of a Scania truck. Critical design and process requirements, characteristics and parameters and its related design classification, as defined by Scania CV internal standard specification, will be presented. The design classification is a major important input to the QAM model. Historical geometrical and dimensional measurement data and machine and process capability data from production of the pinion and crown wheel are also important inputs to the QAM matrix. Discussion of the findings and the so far captured results and a conclusion on the current work is presented in the end of this paper.

Keywords: Implementation, Quality assurance, Controllability planning, QAM

1. INTRODUTION

This paper will mainly focus on the current implementation status of QAM (Quality Assurance model and Matrix) methodology at Scania CV and give an overview of the ongoing planning activities and ideas. The future evaluation of the QAM implementation and how well it is working will be set to how many engineering design changes, production engineering and quality engineering related changes and issues captured in the industrialization phase of new designs and re-designs of crown wheels and pinions that has been achieved. The pinion and the crown wheel are critical components that are going to be process and operational planned for high capable manufacturing with the goal to reach zero defects in manufacturing, i.e. “first component through” or “first component correct”.

QAM, first presented by Lindqvist et. al. [1], is performed in integrated product developing teams in a concurrent engineering environment. The roles and members to act in the QAM team workshops are typically representatives from the design engineering, production engineering, operation and process planning, quality engineering and the production engineering metrology departments.

Through the interplay between design engineering, production engineering and production engineering metrology departments, Scania CV has the objective to show that it is possible to assure quality early in new product developments. The future vision and state on product development, industrialization activities, quality revision system and the overall quality assurance system are explained in fig. 1 to 3 and 5. It will be shown by the use of a systematic and holistic concurrent engineering teamwork approach that it is possible to meet the highly stated design engineering functional requirements (FR), design parameters (DP) and manufacturing and process parameters (MP) requirements with the support of productions knowledge on possibilities and production process capabilities. By the introduction and combination of a new kind of design and process FMEA (Failure Mode Effect Analysis) tool and an integrated methodology called QAM (Quality Assurance model and Matrix), fig. 5 and 6, the intention for the preproduction planning is to perform and identify:

- One risk assessment and a GMCP plan.

This will probably result in:

- Changed design engineering, production engineering, and production engineering metrology and related drawing requirement specifications, i.e. according to ISO/TC 213 “Geometrical Product Specification and Verification” defined; specification and verification operators.
- New or changed selection of applicable measurement types, measuring method and dimensional metrology equipment (DME)
- A first proposal on a suitable sampling and measurement frequency plan based on the risk assessment and identified current available machine and process capability in production.

2. METHODS AND MATERIALS

2.1 The Scania CV quality control system for production of crown wheels and pinions

Scania CV has currently a quality revision process, fig. 1, which they want to improve to a future state according to fig. 2. The current revision process which is an indicator on how well the products are quality assured only capture a few ppm (parts per million) of produced components and it only makes analysis on finished components, i.e. the total production process and not on individual and separate machines and production line operations that builds up the total production process.

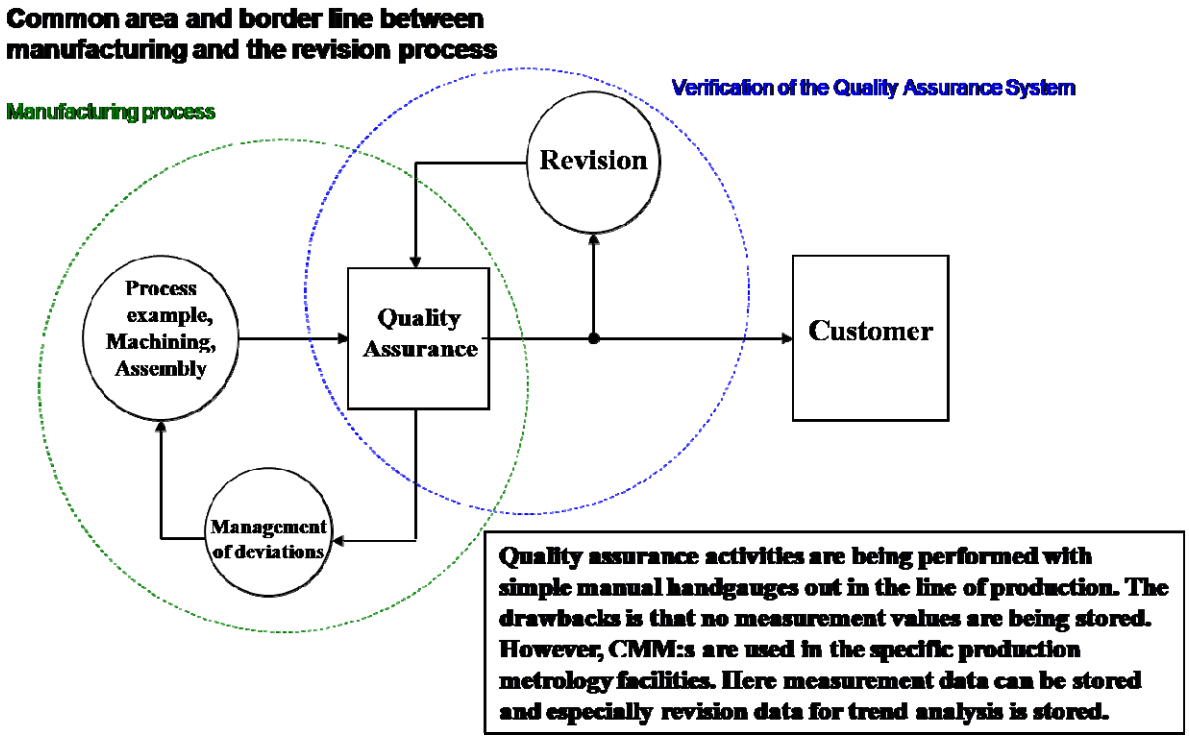

Fig. 1. Scania CV quality assurance process, current state.

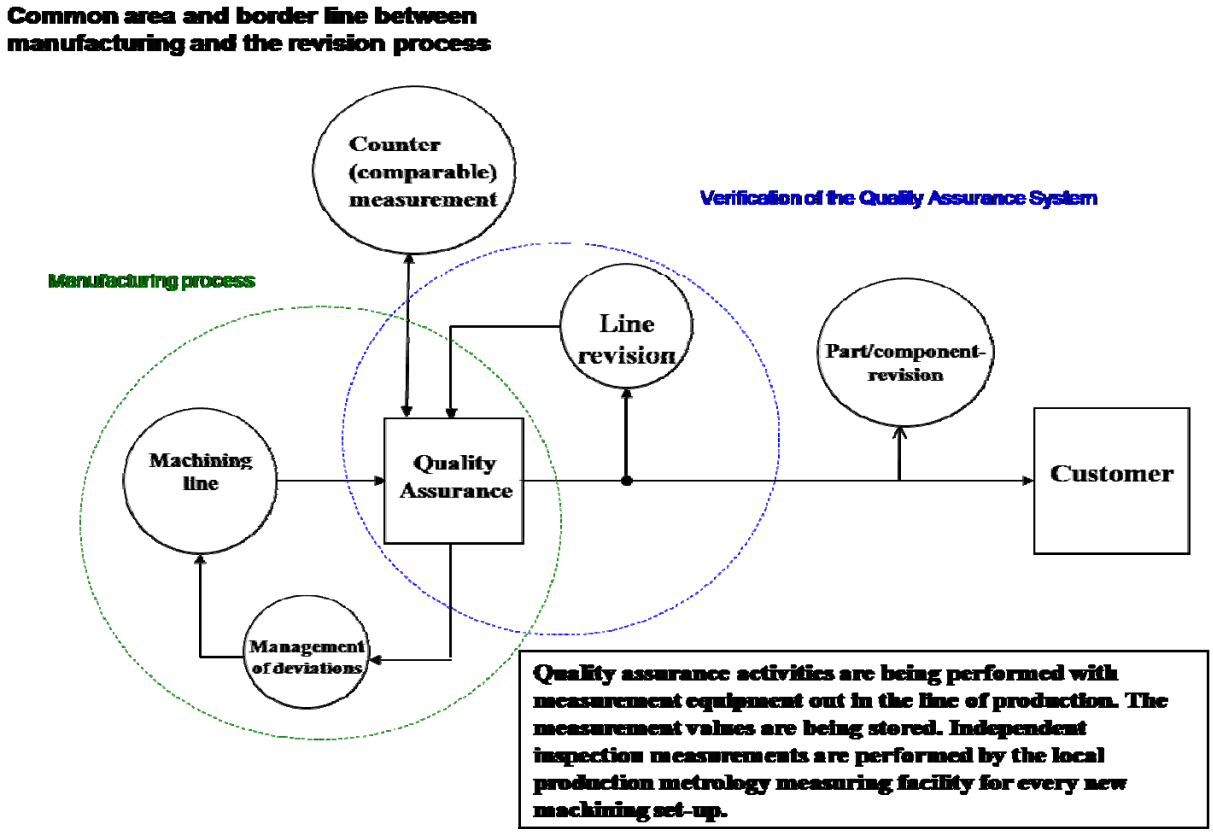

Fig. 2. Scania CV quality assurance process, proposed future state.

For the machine workshop producing the pinions and the crown wheels the following proposed process for line revisions instead of only performing a late final component revision on the finished and fabricated component is suggested to be implemented.

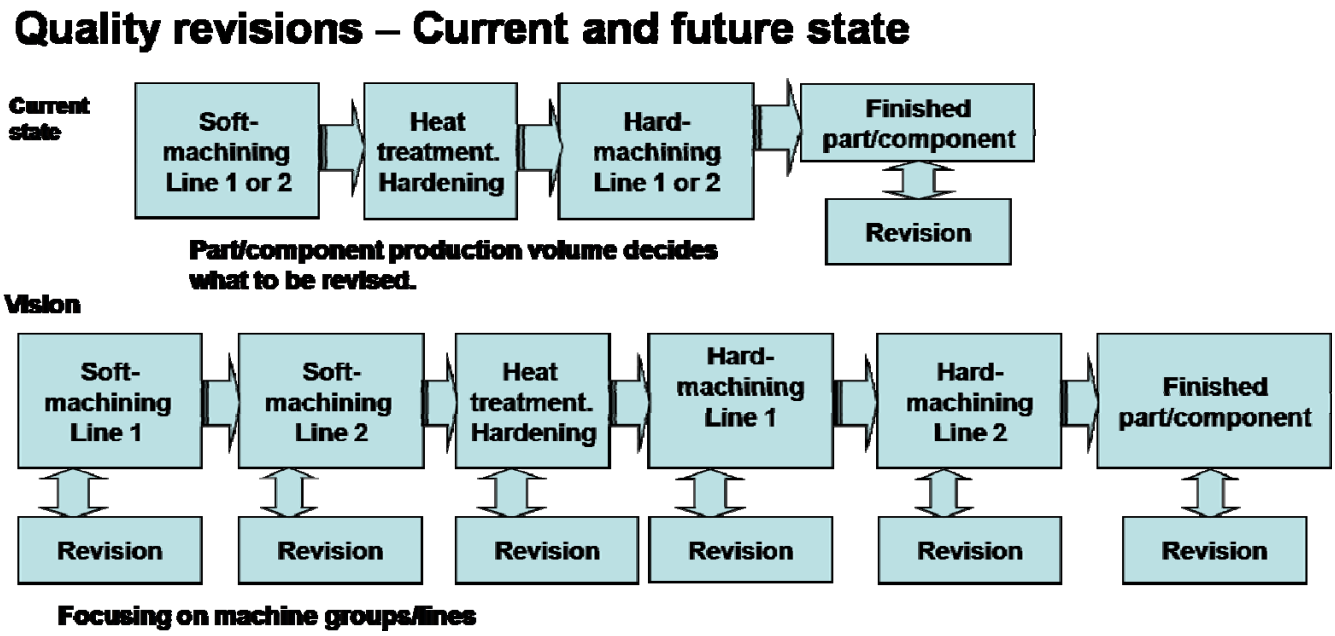

Fig. 3. Scania CV applied quality revisions, current and future state proposal.

A number of design and manufacturing process engineering parameters has been identified. According to data gathered from Scania there are 36 pinion related design engineering parameters (DP) and 20 crown wheel related DP:s with COR (Classification Of Requirements) classification, [2]. And there are 19 pinion related manufacturing process engineering parameters (MP) and 10 crown wheel related MP:s identified. All of these parameters are also related to geometrical, dimensional and surface structure requirements and will be used as an important input to the QAM matrix. In fig. 4 is a typical hypoid gearbox assembly displayed and where we can see how the crown wheel and the pinion are oriented to each other.

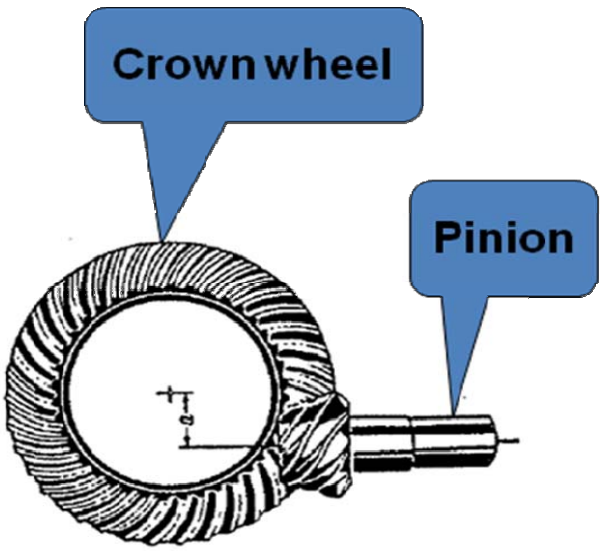

Fig. 4. The principal design and configuration of a representative hypoid gearbox assembly.

2.2 The QAM process and activity model

In fig. 5 is the contextualized and closed looped product realization process presented. An overview of the QAM process and working methodology has previously been described by Lindqvist et. al. in [1 and 3]. First a draft activity model on geometrical and dimensional measurement and controllability planning was developed using the ASTRAKAN modeling language. This activity model was later on simplified according to the developed QAM Microsoft Excel software application, fig. 6.

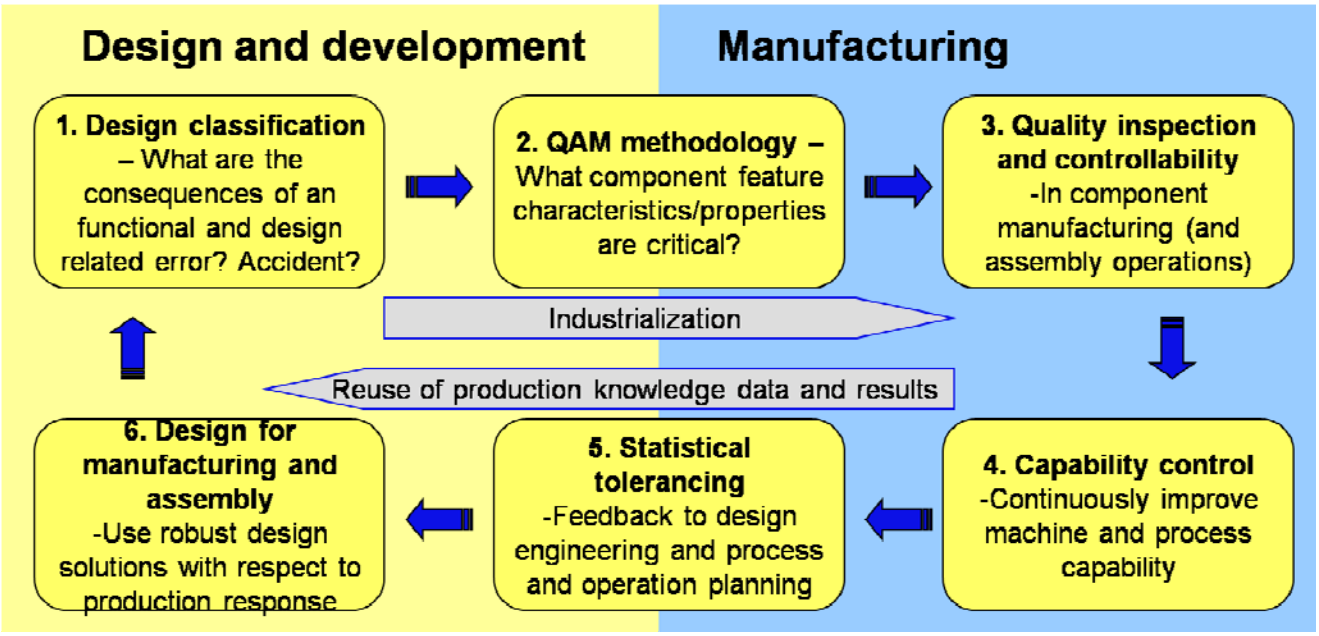

Fig. 5. The main activities in product realization, industrialization and reuse of production knowledge data and results.

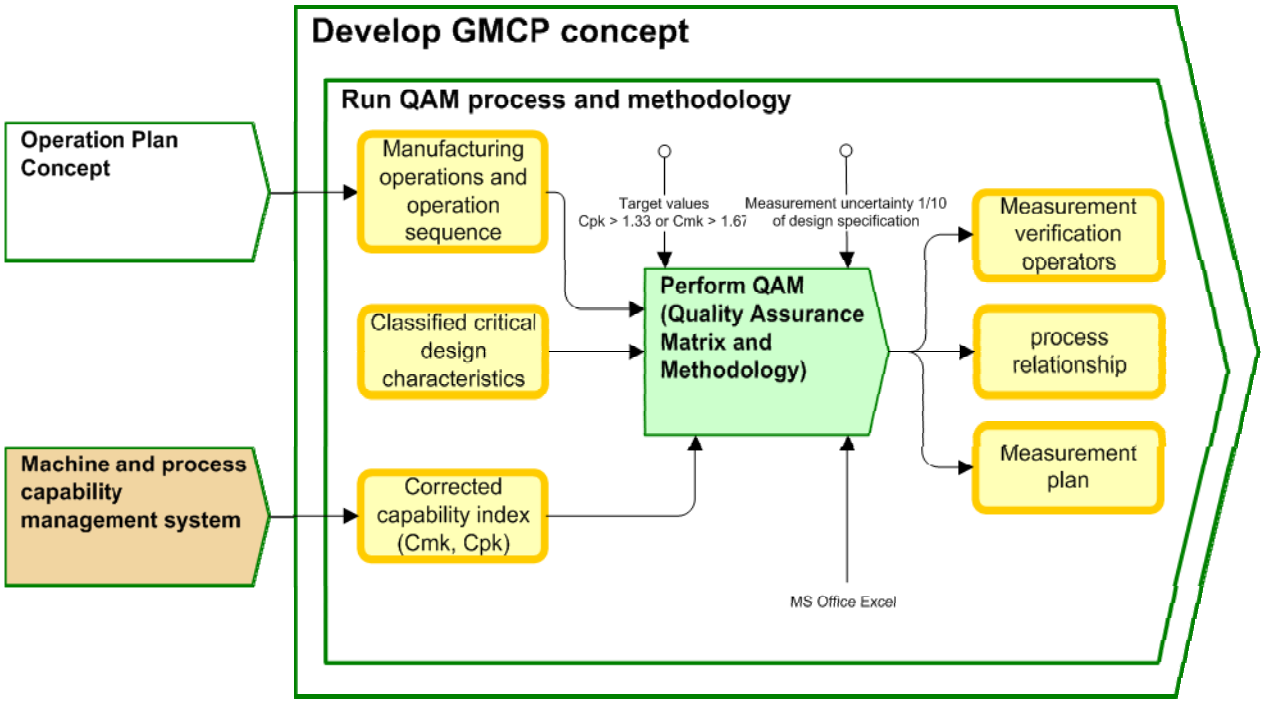

Fig. 6. A simplified ASTRAKAN activity model for performing and using the QAM methodology.

From a engineering development point of view the GMCP and QAM process and methodology should be performed in concurrent engineering teams and be accomplished, according to experiences gained from Volvo CE, within a typically 3-4 hours workshop for every new component. The team should at least include a workshop leader, one design engineer, one production engineer, one process and operation planner engineer and finally one production engineering metrology engineer. In fig. 7 the interaction and interplay between the addressed engineering disciplines in a typical manufacturing company is displayed.

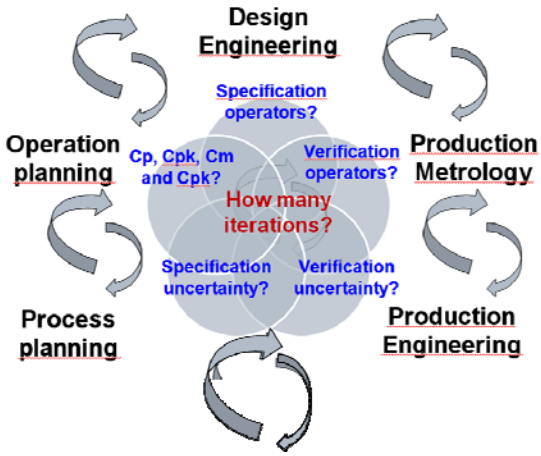

Fig. 7. The interplay and probable iterations between different disciplines in concurrent engineering work.

To start with, the key issue is to break down the design requirements, [4], and intents into manageable, producible and measurable design, production and metrology achievable requirements. In fig. 8, according to ISO/TC 213 "Geometrical Product Specifications and Verifications", there is a defined relationship and break down from a functional point of view into design and drawing specifications. Then the actual manufacturing is carried out and a physical component is produced and a real work piece is fabricated. After the fabrications process the actual measurement and/or inspection is carried out in order to compare the actual result (verification operators) gathered from the measuring equipment and compare it to the specification operator.

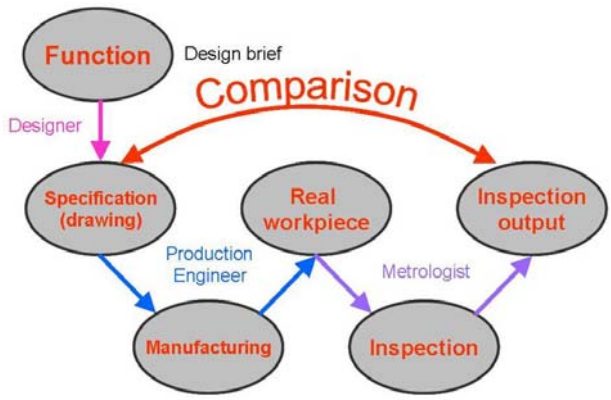

Fig. 8. Functional requirement relationship to specification and verification requirements.

In fig. 9 a more detailed description of the specification operator relationship to the verification operator, i.e. measurand is highlighted. In this case the specification operator generally contains of a skin model and the skin model contains of different operations and relates to a measurand. The verification operator generally contains of a real surface which contains of different operations and ends up in a measured value. The specification operators' measurand is validated and compared with the actual measured value and a conformance check is thereby carried out. The fig. 9 tries to explain the complexity of conformance in production engineering metrology measurements, [5].

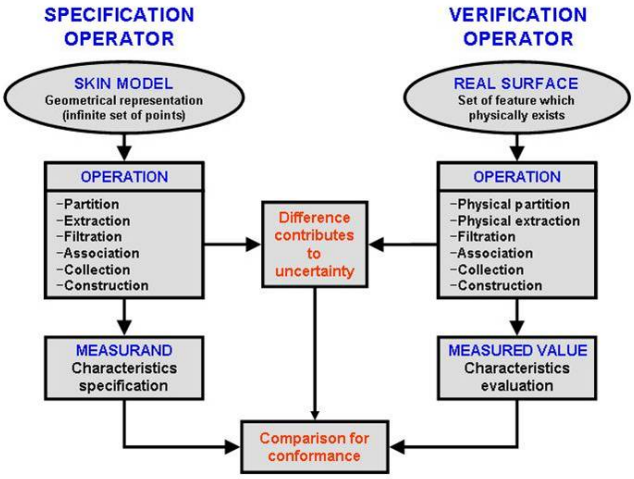

Fig. 9. Specification operator v.s. Verification operator, [4].

2.2 Detailed description of the QAM matrix

The developed QAM matrix and methodology is performed in a Microsoft Excel application. The QAM matrix and methodology contains the following working sheets in the Microsoft Excel application:

In worksheet 1 the user fills in general information about the component to be planned and prepared for production. A 2D or 3D model based drawing should be attached and linked to this specific Excel file. In worksheet 2 the main work is carried out. Here the user and workshop group fill in the classification template. The classification template itself contains of the following topics to be performed;

1. Preconditions for operation and process planning.
2. A preliminary operation and process plan for the component to be manufactured. The main part includes the measurement and controllability of the component, where controllability is a key principle.
3. The impact matrix, which means identification of the different process steps and identify what process step or steps that significantly impacts the design or manufacturing specification operator.
4. The last step the team develop a detailed GMCP plan for the component based on the previous working steps.

In fig. 10 to 16 screen prints taken from the actual QAM application starting with worksheet number 1, which is the introductory page or the general information page is presented below.

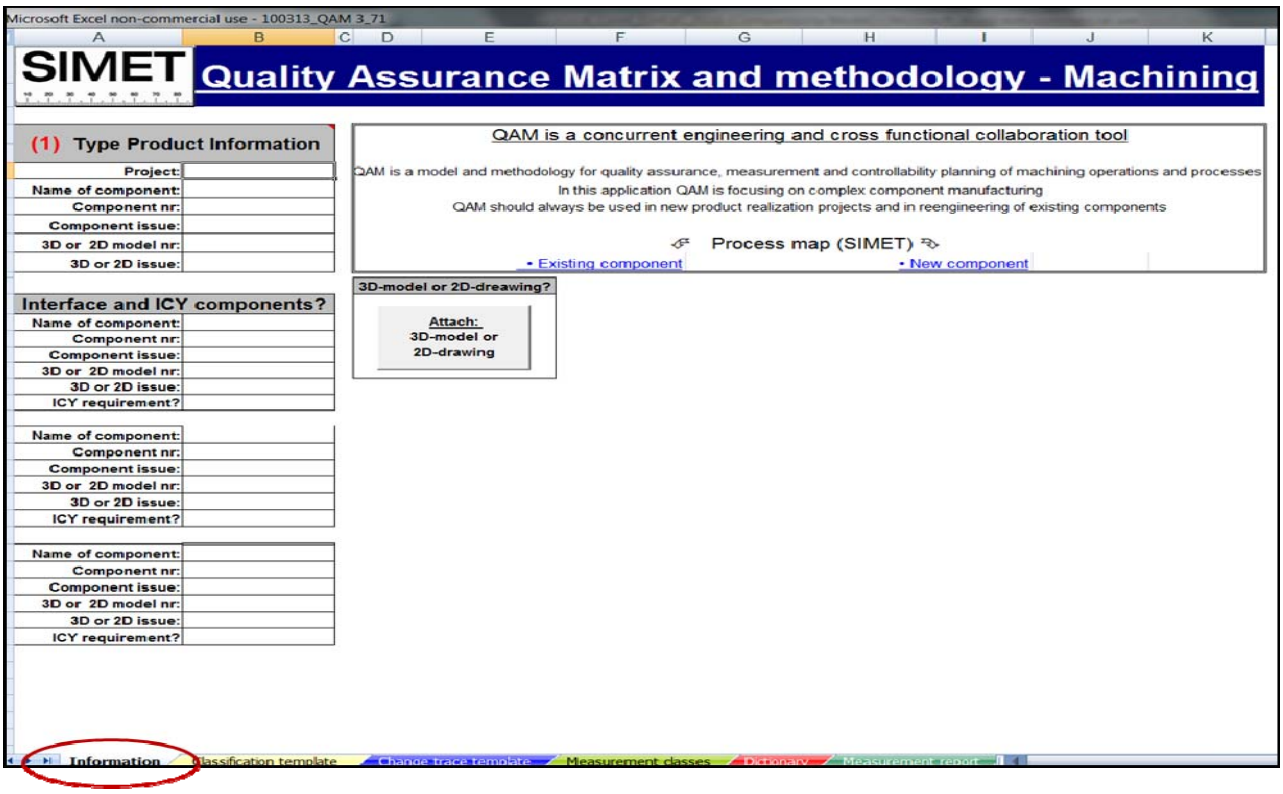

Fig. 10. The QAM application introductory or "Information" page and worksheet.

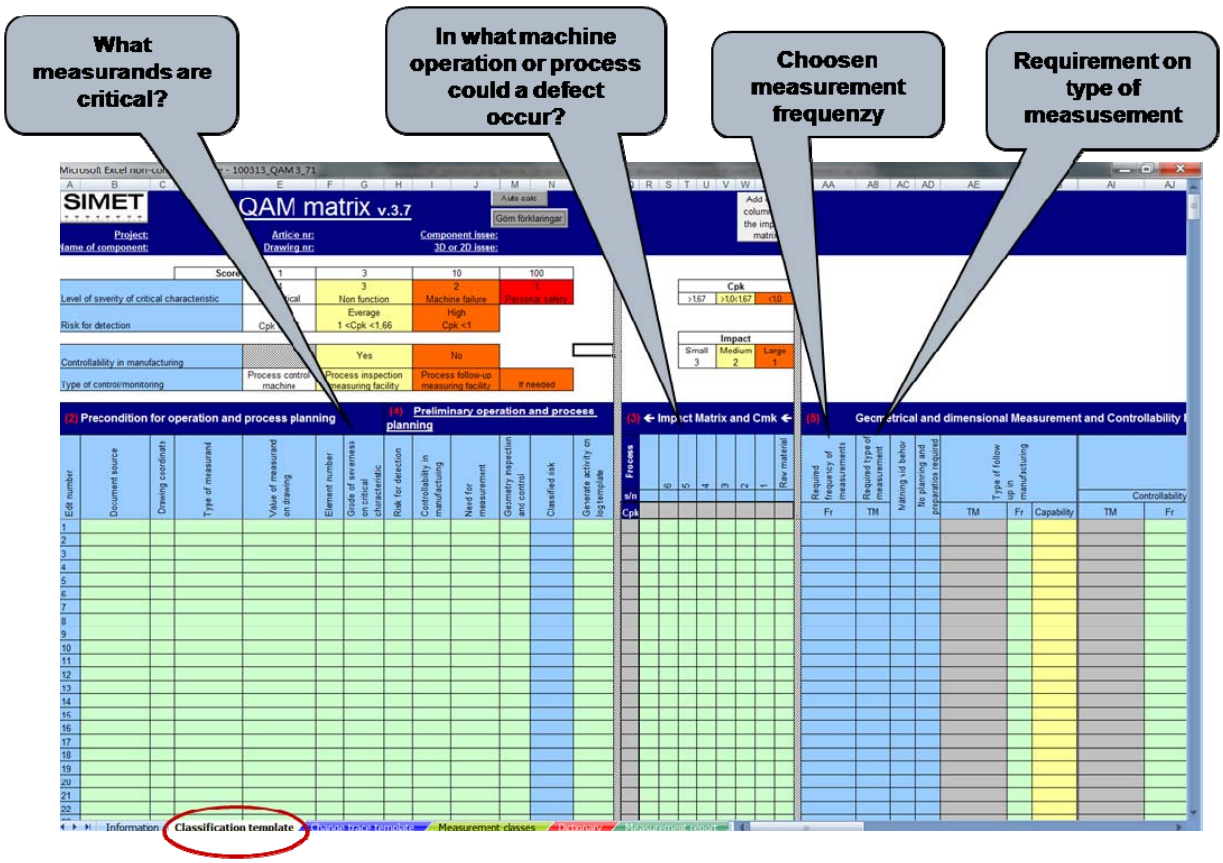

Fig. 11. The QAM application "Classification Template" worksheet.

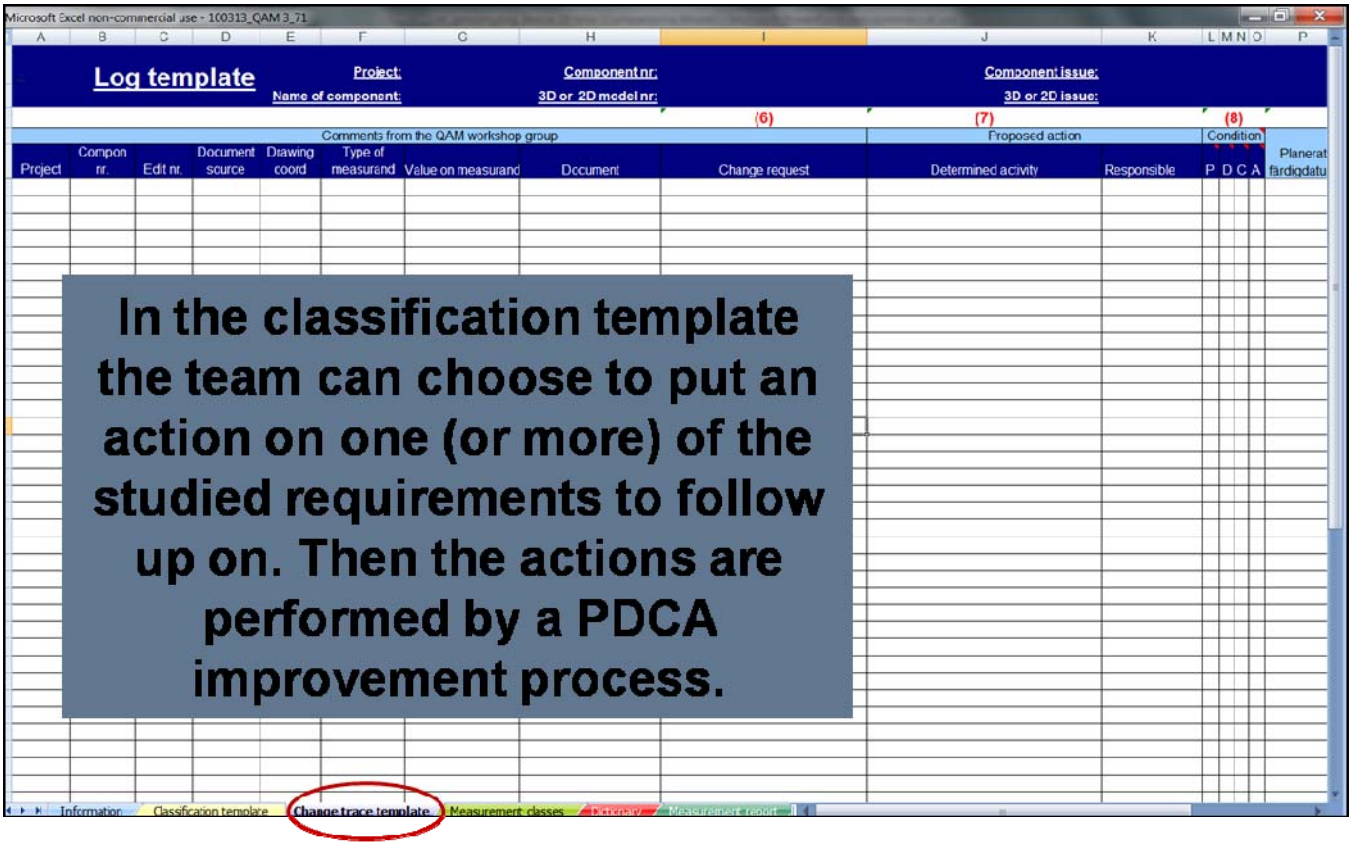

Fig. 12. The QAM application log or "Change trace template" worksheet.

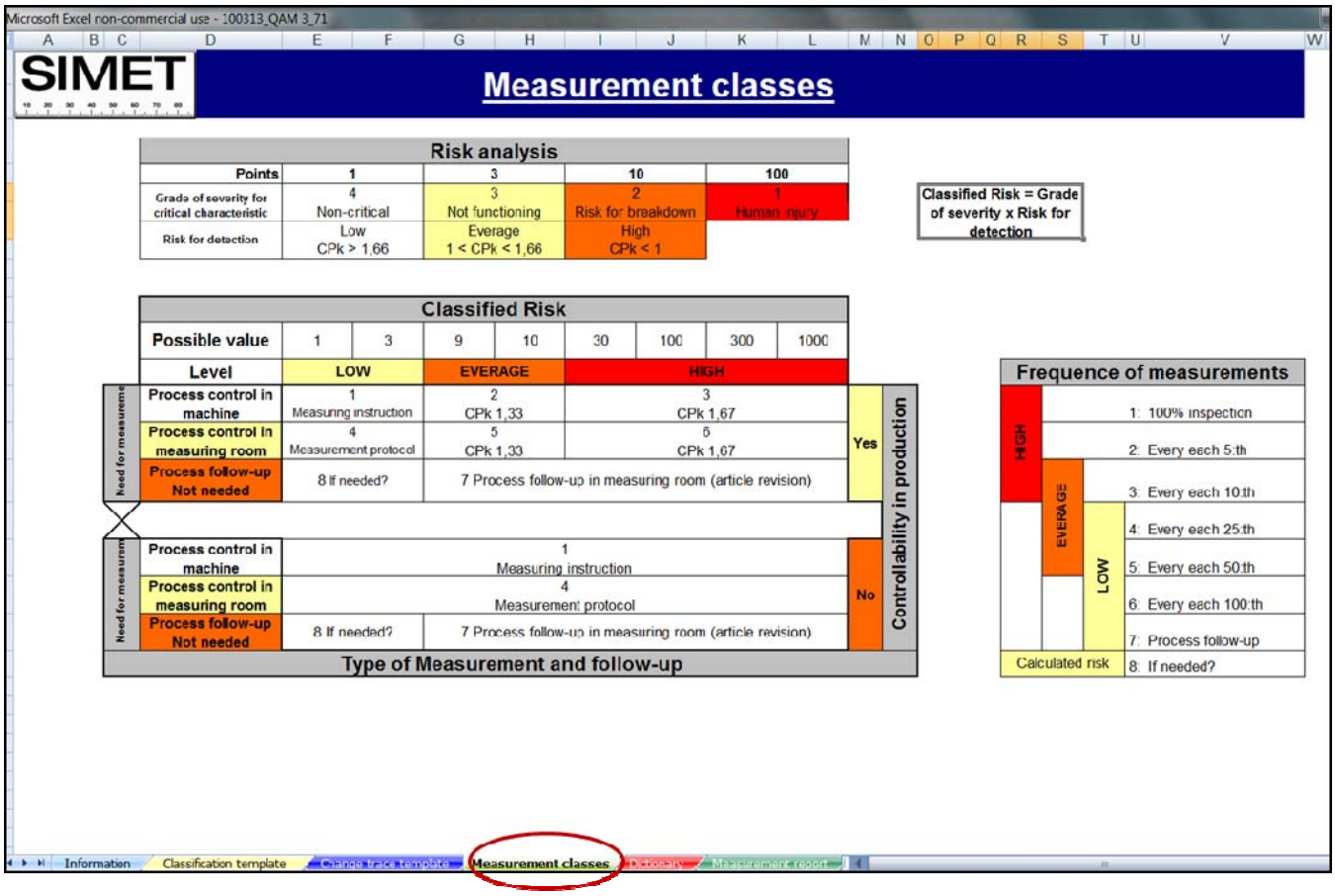

Fig. 13. The QAM application measurement classes and explanation worksheet.

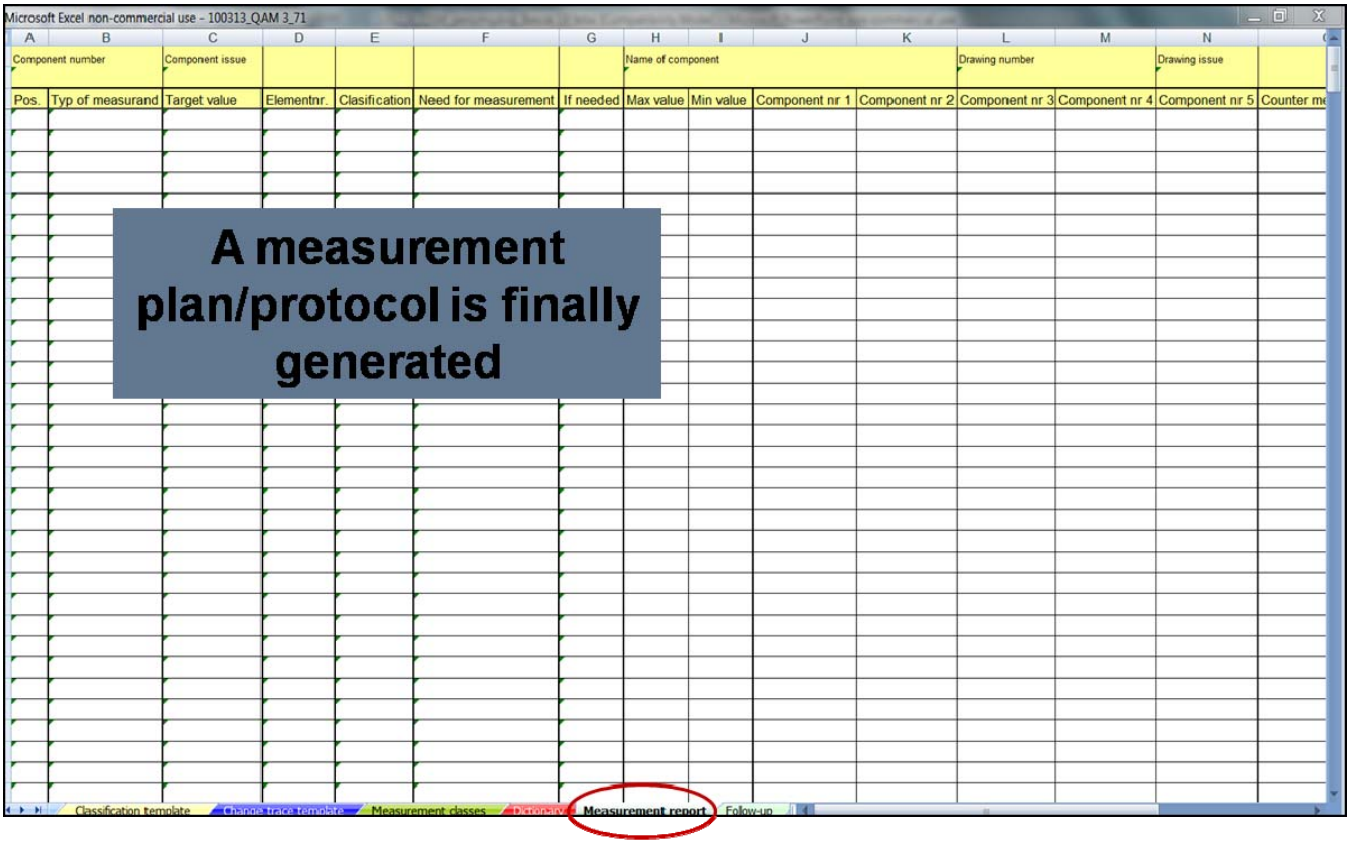

Fig. 14. The QAM application measurement report/plan protocol worksheet.

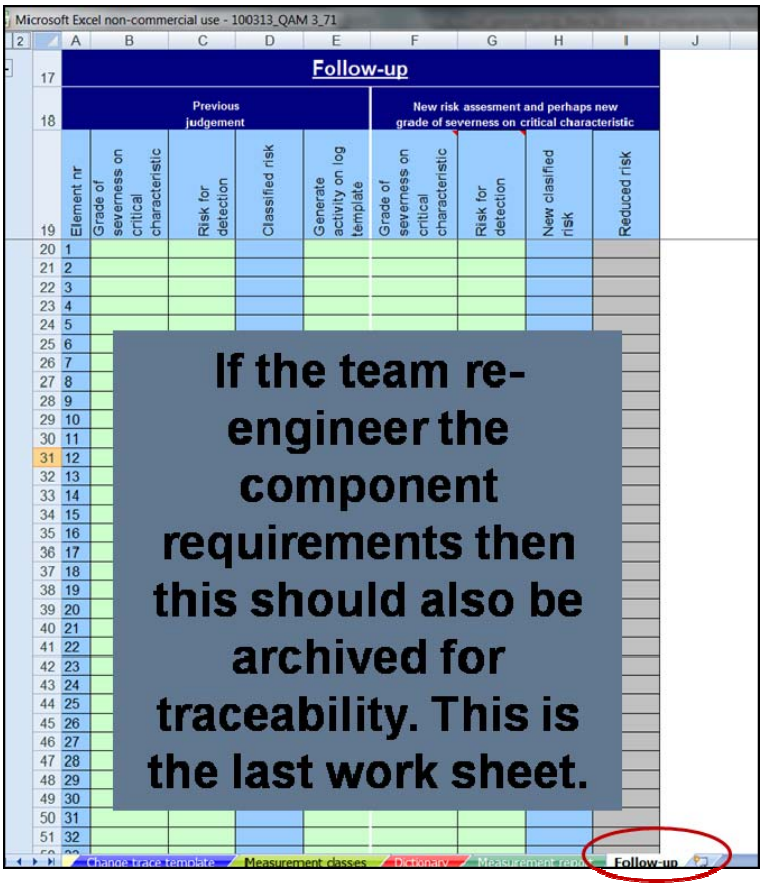

Fig. 15. The QAM application follow-up template worksheet.

In summary the QAM methodology and process could be simplified and explained by fig. 12. In fig. 12 the main process steps are presented. In real work a more extensive process with more complex questions and issues to solve will be present.

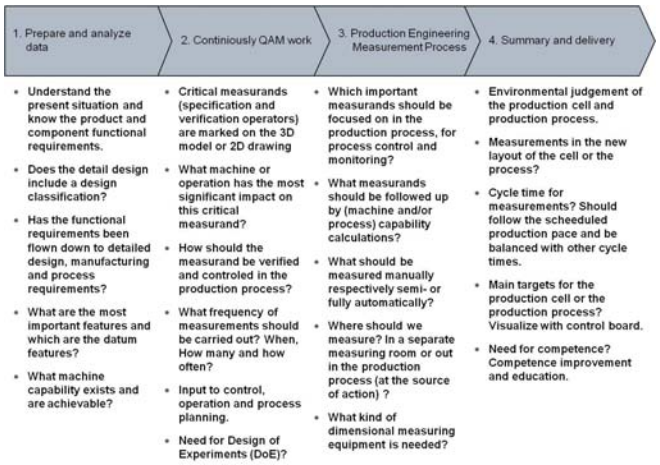

Fig. 16. The simplified and general QAM process and related questions and issues to be solved and managed.

2.4 QAM management and progress reporting

The QAM management and progress reporting could fairly easy be carried out in the Microsoft Excel application. The user can compile data from all started QAM development application projects and design a substantial management report. As an example, Volvo CE use the following reporting format, fig. 17.

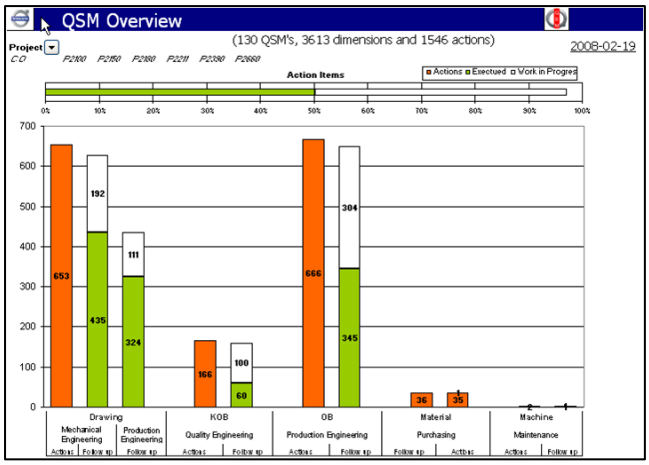

Fig. 17. QAM management tool for progress reporting.

In fig. 17 an example on Volvo CE management reports and follow up on the total number of QAM´s that has been carried out so far is displayed. The figure reveals how many actions that has been started and which actions that are now on-going activities. They are also related to the actual engineering discipline, weather it is design engineering, production engineering, production engineering metrology or quality engineering.

3. RESULTS

By the introduction and combination of a new kind of design and process FMEA tool and an integrated methodology called QAM (Quality Assurance model and Matrix), the intention for Scania CV is to implement the methodology and start evaluate it on two complex components. In this case study a pinion and a crown wheel will be used for the evaluation of the QAM methodology. The methodology and working process for QAM has been presented and scheduled for implementation and evaluation at Scania CV.

4. DISCUSSION

As stated in chapter 2 we will know ask the question; does the presented QAM process and methodology answer the important questions one should ask when performing GMCP planning? What questions should then be asked and answered?

- ***What?*** - Should be measured and controlled and monitored? How important is the specification operator, verification operator and is there any design and manufacturing classification performed?
- ***Why(×5)?*** - Reason for each specific measurement and the level of its importance?
- ***Where?*** - In the machine or specific operation, in close range to the machine or separate in a measuring room?
- ***How?*** - Manually. Semi-automatic or fully automatic?
- ***With what?*** - CMM, Portable CMM, hand gauges etc. and/or combinations?
- ***When?*** - According to the production pace and planned tact times.
- ***How often?*** - Every each, or every 10:th etc. and how many, and what sample size?
- ***By whom?*** - Competence profile, requirement on and for education, need for certification?

In our opinion the QAM process and methodology does answer all of the above stated questions. However it can be further developed, improved, validated and evaluated. This QAM tool will be further developed and implemented and explored in other Swedish companies engaged in the SIMET research project in order to falsify, validate and improve the methodology and process.

DISCLAIMER

The name and vendors products are used in this paper solely for descriptive purposes only. This does not imply any endorsement or recommendation of any vendors' products by the author.

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