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Uncertainty Assessment for Measurement Processes in the Aerospace Manufacturing Industry

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Abstract

Measurement processes are critical to the aerospace industry, which products must follow strict regulations and customer requirements. Additionally, measurement of uncertainty is fast becoming a requirement from both certification bodies and customers. An uncertainty assessment must be carried out for all processes that need to add an uncertainty statement to the measurement result. In order to maintain defined quality standards, aerospace manufacturing companies need to identify all measurement disciplines that benefit from stating the level of uncertainty and define a methodology to calculate it for complex measurement processes.
An extensive research has been conducted in order to define the most appropriate methodology to assess uncertainty on complex aerospace components and a case study has been applied to assess the strain gauge calibration test uncertainty of different aerospace components.
This study develops a generic framework, which helps the assessment of all individual sources of uncertainty and completes the one established by the Guide to the Expression of Uncertainty in Measurement. Conclusions have been extracted from the outcome of the case study.
The conducted research contributes to a better understanding of measurement processes and good practices that lead to lower uncertainty. The outcome will help manufacturing companies to be aware of the contributors of uncertainty to the tests, how to reduce this uncertainty and the reliability of the measurements taken during the process.

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Keywords: Mesasurement of Uncertainty, Assessment framework, Key drivers

1. Introduction

Aerospace manufacturing companies need to establish measurement process regularly, but the establishment of a measurement process is complicated, as it requires a good linkage between the acquired expertise and the measurement data, in order to decide what is necessary to be measured [1].

Every measurement carried out has some uncertainty associated. This uncertainty of the measurement is the doubt that exists about the result of the measurement process and it should not be confused with the term error, which is the difference that exists between the measured value and the 'actual value' of the item measured, while uncertainty is a quantification of the doubt that exists related to the measurement result [2].

The reasons behind the need of assessing uncertainty are various; the main are the increase in quality of the measurements and the better understanding of the results. Other particular reasons could be the need of reporting the uncertainty of the measurement on a calibration certificate, or, in relation with tests the uncertainty is needed to determine a pass or fail. An additional use of measured uncertainty is the assessment of whether or not you are meeting a tolerance.

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In order to have a complete measurement result, a statement of the uncertainty in it needs to be placed. For the industry, having really accurate measurements is crucial, as they represent a key source of decision making. Subsequently it needs to be understood that the reliability of each measure has to be high and clearly defined. That is why each measurement result should be linked to a measurement uncertainty value which represents the simplest way to express the reliability of the result [3].

Nevertheless, the concept of uncertainty as a quantifiable attribute is relatively new in the history of measurement [4] and only calibration laboratories are used to perform uncertainty evaluation for a long time. But currently, things are changing in the aerospace industry and measurement uncertainty is becoming progressively recognized by the testing community.

Nomenclature

UoM	Uncertainty of Measurement
GUM	Guide to the Expression of Uncertainty in Measurement
MoU	Measurement of Uncertainty

1.1 Background

Measurement of uncertainty is an important concern for aerospace manufacturing companies. For the last years it has become a common requirement from both customers and certification bodies. This uncertainty represents the interval around the result of the measurement where there is a high probability to find the real value.

Standards are continually becoming more demanding in terms of Measurement of Uncertainty (MoU), in order to assure the quality and the security of the final product.

Sources of uncertainty are various and can come from the measuring instrument, item being measured, the measurement process (incomplete definition of the test procedure), the environment, operator skills (imperfect realisation of the test procedure), sample (not representative sample), imported uncertainties or other sources.

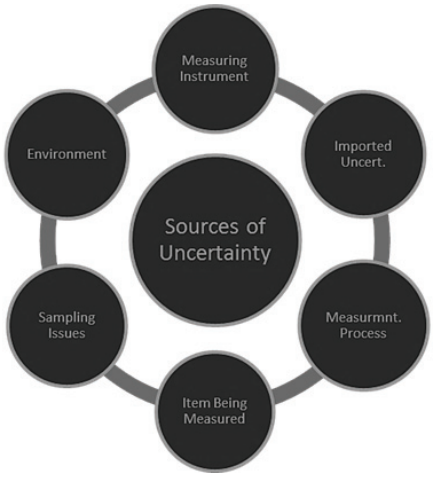

Figure 1: General Sources of Uncertainty

The quantification of each uncertainty source is a critical part in the calculation of uncertainty and it is currently one of the most challenging tasks in assessing the Uncertainty of Measurement (UoM). The sources of uncertainty are not necessarily independent and some or all can contribute to the variations in repeated observations.

Mistakes made by operators are not measurement uncertainties. They should not be counted as contributing to uncertainty and should be avoided by working carefully and by checking work.

1.2 Research Motivation

Conducting this research serves the aerospace industry in several ways. The most explicit benefits of measuring uncertainty are to:

- Give a starting point to improve existing measurement processes to become more efficient and cost-effective.
- Help the fulfilment of business requirements, as it is becoming a requirement from certification bodies and a need for internal and external customers.
- Reduce risks and improve credibility of tests results.
- Help the reduction of calibration costs.
- Bring new quantitative information on the measurement process and improve its understanding and reliability.
- May be requested by the customer to know the uncertainty associated with test results.
- Provide a competitive advantage. It promotes quality and adds value to the organisation.

The outcome of this study helps aerospace manufacturing companies to be aware of the contributors of uncertainty to the tests, how to reduce this uncertainty and the reliability of the measurements taken during different measurement processes.

2. Uncertainty Quantification

It is important to know how widely spread the readings are when repeated measurements differ in the result. The spread of values tells something about the uncertainty of a measurement. With it begins the judgement of the quality of the measurement. The usual way to quantify spread is standard deviation. The standard deviation of a set of numbers tells about how different the individual readings typically are from the average of the set.

Uncertainty in a measurement quantity is a result both of the incomplete knowledge of the value of the measured quantity and of the factors influencing it. Such uncertainties can be estimated using statistical analysis of a set of measurements, and using other kinds of information about the measurement process.

There are established rules for how to calculate an overall estimate of uncertainty from these individual pieces of information. The use of good practice, such as traceable calibration, careful calculation, record keeping, and checking, can reduce measurement uncertainties. When the uncertainty in a measurement is evaluated and stated, the fitness for purpose of the measurement can be properly judged [5].