



UQ&M SIG in High Value Manufacturing

Exploring the Opportunities

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KTN

the Knowledge Transfer Network

Innovate UK

Technology Strategy Board

Opportunities

The Context

- Whether bringing a new product from conception into production or operating complex plant and production processes, success rests on careful management and control of risk in the face of many interacting uncertainties.
- Today's fiercely competitive market and increasingly stringent regulatory environment is such that there is very little margin for error.
 - Failure to understand and manage risks can result in severe financial penalties and even damage to reputation.

Opportunities

The Context (cont.)

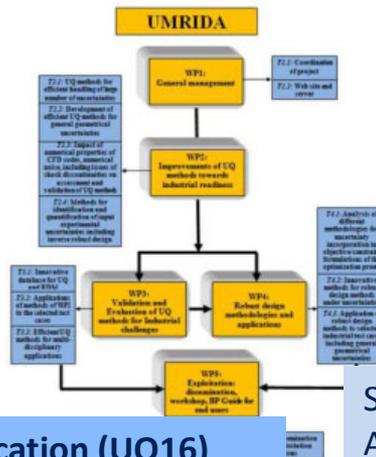
- Historically, chief engineers and project managers have estimated and managed risk using mostly human judgment founded upon years of experience and heritage.
- In the modern era of HVM, the design and engineering of products rely increasingly on computer modelling - *The era of virtual design and engineering*
- This era opens the opportunity to deal with uncertainty in a systematic formal way.
 - Better management of risk attaching to key decisions
 - Convergence on designs which are robust in the face of uncertainty

Opportunities The Context (cont.)

- Leading companies in many fields of engineering are increasingly aware of these possibilities and UQ&M is beginning to feature strongly in their strategic aspirations.
- The level of interest and investment in research is growing significantly across the globe.



SIAM Conference on Uncertainty Quantification (UQ16)
April 5 - 8, 2016
SwissTech Convention Center, EPFL Campus, Lausanne, Switzerland



- ▶ Learned societies
 - ▶ Royal Statistical Society study group on UQ to be formed
 - ▶ American Statistical Association and SIAM sections on UQ
- ▶ New UQ journal
- ▶ MUCM
 - ▶ <http://mucm.ac.uk>
 - ▶ MUCM Community



Special Edition on Uncertainty Quantification of the
 AIAA Journal of Aerospace Computing, Information,
 and Communication
 Luis G. Crespo & Sean P. Kenny,
 NASA Langley Research Center

Challenges

Multi-disciplinary Design & Assessment

- The challenges to be met in progressing to full industrial maturity are substantial
- Modelling of Data
 - Much is epistemic. It is due to lack of knowledge and must be modelled by expert judgement
 - Identifying and modelling dependency and covariance of such data
- Functional dependency. (co-variance of uncertainty in parameters shared and operated upon by coupled tools/models)
- Cross-discipline propagation of uncertainty
- Handling a large number of analyses across a high dimensional parameter space
- Developing early stage designs with a high level of confidence in downstream mitigation strategies for achieving compliance with performance requirements
- Inverse (i.e. which uncertain inputs contribute most to uncertain output) across coupled/ feedback loop processes
- Cultural/Educational. Engineers will need to be trained to an appropriate level in statistics

Opportunities

The UK Community

- In order to tackle these challenges we need to assemble an engaged and enthusiastic community of mathematicians; statisticians; researchers working in the field of MDO; design engineers; and end-users
- The UK is particularly well positioned to assemble such a community
- This was the primary motivation for forming the Innovate UK HVM SIG on UQ&M

Exploring the Opportunities

The UK HVM UQ&M SIG

- The top level aim of the SIG is to draw together an UQ&M community and provide a structured meeting space where all the players can share their aspirations, knowledge and expertise
- It is to be expected that much of tangible value will be created, such as:
 - Collaborative groupings that identify real benefit in working together
 - The development and refinement of challenges and aspirations
 - The emergence of a clutch of industry pulled projects that make significant advances against the above challenges within given industrial HVM sectors
 - An increasingly statistics-savvy engineering design and assessment community
 - A highly visible joined up and holistic UK based UQ&M capability that can respond positively to end-user aspirations and requirements

Exploring the Opportunities

Current Progress

- A portfolio of industrial Use Cases documented to a common format. These span aspiration (Can UQ&M help?) through to SoA applications (This is what we are doing & have achieved so far!)
- A UK based capability map
- A roadmap for Year-1. A series of Workshops leading towards a definition of the SoA (pulled by use-cases) and key gaps in capability

Uncertainty Quantification & Management in High Value Manufacturing Special Interest Group

Use Case Documentation Template

Title of Use Case:-

Industrial Sector:-

Author:-

Affiliation:-

Contact Email:-

1. DESCRIPTION OF USE CASE

Provide a brief description of the engineering design/assessment process underlying the use case. What are the design/assessment objectives? What are the design/assessment variables? What are the engineering analysis steps which need to be performed and linked to simulate the process?.

Provide an explanation of the UQ&M aspirations or objectives. How will the UQ&M analysis be used? E.g.

- Robust design
- Confidence levels in decision gates
- Confidence in the ability to mitigate if constraints are breached as design converges
- Risk of not meeting cost and time targets

Enhance/clarity the description with pictures and charts

2. KEY UQ&M CONSIDERATIONS

2.1 Process Inputs

What are the uncertain inputs? How can the uncertainty in these be characterized and quantified?

characterized statistically with of knowledge. If so what t. How can they be treated and presentation?

ACADEMIC CAPABILITY MAP INFORMATION REQUEST

UQ in HVM Capability Map

The aim of this capability map is to begin to map the academic capability in the field of Uncertainty Quantification (UQ) for High Value Manufacturing (HVM) in the UK. The ultimate aim of the group is to create a joined up community in UQ for HVM how can quickly identify common challenges and work together to solve them.

This map is an important first step in the process. Through mapping a network of UQ users, developers and practitioners, we can see what the UK is currently doing in this area, gaps and challenges can be identified and activities to address them can be undertaken.

Exploring the Opportunities

The First Workshop, June 2015

- This event brings together academics and industrialists to hear from companies who are actively investing in the implementation of UQ&M and to progress full visibility of the industrial state-of-the-art. This is the first step in a programme to establish a holistic, active UK UQ&M Community. Participation spans
 - Well-established industrial practitioners looking to discuss their challenges with a broad community of experience and expertise
 - Companies that aspire to implement UQ&M into their processes but have little experience and wish to hear more
 - Academics from mathematics, statistics and engineering who are looking for research exploitation routes