# Introducing the MEC – the Welsh Centre of Manufacturing Engineering Expertise

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## 1. Introduction

The Manufacturing Engineering Centre (MEC) forms part of the Systems Engineering Division of the School of Engineering, University of Wales Cardiff. Over the last three years, the MEC has seen a spectacular ten-fold expansion. The number of partnerships formed with industry has multiplied and the Centre has won research income in excess of £11M. The MEC has developed an international reputation for its leading edge research and development in advanced manufacturing and information technology. To support its research programme and the world-class facilities now available, the Centre has assembled a strong team comprising 70 externally-funded post-doctoral and doctoral researchers and 5 marketing/administrative staff. The MEC houses modern laboratories including 2 that are industrially sponsored: the Mitutoyo Metrology Centre and the Siemens Automation & Drives Centre. The MEC also operates a Commercial Unit which is equipped with multi-million pound state-of-the-art Rapid Prototyping, CAD/CAE/CAM software and computing systems. The Unit provides Rapid Prototyping and advanced manufacturing services to SMEs on a competitive basis. The Centre has a customer base of over 100 SMEs and large multinationals and regular contact has been established with over 2,000 other companies in the UK. The MEC is also a truly international centre, having collaborative projects with more than 15 countries in Europe, Asia and the Americas. In recognition of its achievements, the MEC was recently awarded the status of Centre of Expertise by the Welsh Development Agency (WDA).

## 2. History of the MEC

The origins of the MEC dated back to 1991 when a partnership was formed between the Computer-Aided Engineering (CAE) research group led by Professor Duc Truong Pham at the School of Engineering, University of Wales Cardiff and Seal Technology Systems (STS), a local SME manufacturing valve stem seals for car engines. The project was completed in 1994 and produced a working system enabling the company to improve productivity, reduce scrap and effect process savings totalling over £1,000,000. The success of this work and strong research potential of the group were rewarded in 1993 with a vitalising injection of capital from the Higher Education Funding Council for Wales (HEFCW) under its Research Quality Initiative to establish a state-of-the-art Computer-Integrated Manufacturing (CIM) Facility at Cardiff. With its infrastructure modernised and strengthened by this new Facility, the group attracted further grants and contracts from industrial and public sources for leading-edge research and development in manufacturing engineering. In particular, it resulted in a fruitful partnership with the UK operation of Mitutoyo, the world's largest manufacturer of precision measuring instrument. The Mitutoyo Metrology Centre was established at the MEC and equipped with the most advanced measuring equipment, which is updated and maintained regularly. The availability of such facilities enhances the quality of MEC research and underpins many of its industrial services. This successful venture has further generated strong interest in the group and served as a model for other partnerships to follow notably that with Siemens who recently endowed an Automation and Drives research laboratory at the MEC.

The rapid build up of industrial collaboration with the Group in advanced manufacturing engineering research led to the creation in 1996 of the present Manufacturing Engineering Centre under the directorship of Professor Pham. The Centre's mission is to promote collaboration between academia and industry in order to conduct leading edge research and development in all major areas of advanced manufacturing and information technology including rapid prototyping and tooling,

enterprise information management, intelligent control, multimedia systems, sensor systems, condition monitoring, advanced robotics and microsystems. These are key areas in helping UK manufacturing industry to achieve greater efficiency, better quality, less waste and higher competitiveness.

## 3. MEC-Industry:A Partnership

The work of the MEC has received the overwhelming endorsement of sponsors and supporters in the private and public sectors. Over 100 industrial partners including multinationals like Hewlett-Packard, IBS, Mitutoyo, SAP, Silicon Graphics, Siemens and Tecnomatix plus some 80 SMEs now support research projects at the Centre. As a result, the MEC is now one of the largest and most successful operations in any UK university. Apart from possessing a critical mass in terms of manpower and finances, the MEC enjoys unrivalled state-of-the-art facilities which include the very best in rapid prototyping hardware, computer-aided design and manufacturing, virtual reality and IT systems, enterprise information management systems, industrial process control equipment, metrological instruments, and robotic and computer-integrated machine tools and manufacturing systems. These facilities are kept up-to-date by external funds and by deploying the Centre's income from its Commercial Unit.

### 3.1 Research Activities

The MEC conducts basic, strategic and applied research as well as technology transfer. The research spans a broad spectrum of subjects, from robotics, condition monitoring, high-speed automation and intelligent control to rapid manufacturing, quality engineering, multi-media, virtual reality and enterprise information management.

**Basic and strategic research**. The Centre's basic research programme covers fundamental subjects such as non-linear control and mechanical behaviour of microsystems. Its strategic research programme focuses on achieving greater efficiency, better quality, less waste and higher competitiveness by judiciously integrating advanced IT tools and techniques. The areas selected for collaboration with industrial partners are key Foresight areas and present multi-billion pound opportunities for industry. These include the use of time compression technologies such as rapid prototyping and concurrent engineering to speed up the development and manufacture of new products thus increasing UK industry's competitiveness in the global market.

**Applied research and technology transfer**. Projects are aimed at solving specific problems for companies many of which are local SMEs. Activities at this end of the spectrum support the Regional Technology Plan for Wales which promotes the use of advanced and innovative IT-based systems and techniques to help Welsh SMEs achieve competitive advantage.

The MEC operates two kinds of research partnership with industry: generic and specific. Generic partnerships suit large sponsoring organisations, because whole areas of research are supported and not just a particular project. Generic partners assist in providing state-of-the-art facilities for the MEC and supporting research programmes relevant to the broad industrial sector in which they operate. In return, the Centre widely publicises non-confidential results on the Internet, in a quarterly newsletter targeted at over 2,000 potential partner companies and in academic publications, and also by holding regular industrial seminars and workshops. Several focused specific partnerships have also been established involving small and large enterprises. Some of these have developed from generic partnerships, because generic partners joining with the MEC in a strategic research programme often supplement generic support with targeted funding which in turn helps to lever further income from other sources. Specific partner companies benefit directly by having their problems solved using the MEC's extensive resources and gain ideas for process and product improvements.

### 3.2 Commercial Activities

The MEC's Commercial Unit draws on the expertise of the Centre to provide services to SMEs, in the areas of product design and development, rapid prototyping and manufacturing support. These services are underpinned by the Centre's extensive research into all aspects of advanced manufacturing engineering.

The MEC provides the following services on a competitive basis.

***Precision Measurement and Reverse Engineering***. Precision measuring to support research, check specifications or arbitrate in cases of disputes between suppliers and

customers is undertaken in the Mitutoyo Metrology Centre. 3D CAD models, generated by scanning existing products with co-ordinate measuring equipment can be used to create either photo-realistic images of the product and its variants for marketing purposes or and full engineering drawings.

***3D CAD Modelling***. 3D CAD models can be created from sketches, drawings or 2D CAD data in DXF or IGES format using Silicon Graphics work stations and Pro/Engineer software. These models can then be employed directly for engineering analysis (FEA), assembly and tolerance analysis, rapid prototyping, mould tool design and CNC machining.

***Virtual Prototyping***. Directly using CAD data and assemblies, interactive product simulations can be livened in a modern VR theatre by employing the latest technology: Silicon Graphics Onyx 2 Infinite Reality system and Division's d/Vise software. The theatre is equipped with state-of-the-art dual stereo projectors, 4x3 $m^2$ wrap-around screen, stereo glasses, motion detectors, head-mounted display, 3D mice and stereo sound. New product designs can be viewed and analysed as virtual prototypes to validate their assembly, operation and maintenance. Consequently prototyping costs can be reduced by replacing physical with virtual prototype and time-to-market can be shortened by using 3D CAD models to test downstream processes (assembly, maintenance, ergonomics, etc.).

***Rapid Prototyping (Layer Manufacturing Technology).*** The MEC employs the latest layer manufacturing techniques and machines available, Stereolithography (SLA) with 3D Systems SLA 250 and Selective Laser Sintering (SLS) with DTM Sinterstations 2000 & 2500. Both of these systems rely on specialist software, which slices a 3D CAD model into 0.1mm sections creating hundreds of cross-sectional images of the product structure. These images are fed into the SLA or SLS equipment which identifies each layer, one by one starting at the bottom, and builds up an accurate physical product model layer by layer using a carefully focussed laser to set a plastic material in the required form. Stereolithography uses a liquid epoxy resin producing very accurate prototypes for design verification. They can also be used as patterns for soft tooling so that the prototype can be replicated to simulate the properties of common thermo-plastics up to 20 times by vacuum casting or 100 times by resin injection moulding. Modified versions are also used as patterns for investment castings in aluminium.

The more recently developed DTM SLS process is more versatile in that it is capable of handling a wide range of powdered materials that are thermo-plastic in nature or, like sand or metal particles, can be coated with a thermo-plastic material. The SLS prototypes generated have a degree of functionality and can be employed for physical testing as well as the uses described for the SLA counterparts. The range of rigid and flexible materials available includes nylon (polyamides), glass reinforced nylon and Somos 201, a flexible rubber like product from DuPont. Physical prototypes can be used to produce working parts with snaps and hinges, electronics enclosures or automotive components. The SLS process can also be used to produce patterns and masters for investment casting from a special plastic powder blend called TrueForm which is low in density, durable and yields very low ash residues in the casting process.

***Rapid Tooling***. A unique feature of the SLS system is that it has been adapted to use a special fine particle size steel powder coated with a thermo-reactive adhesive to produce mould tools or inserts in a process known as RapidTool. Using the layer building technique it produces durable metal moulds and die inserts, often with complex specifications, at lower cost and in about half the time taken by conventional tooling methods. The 60% dense initial mould shape produced in the Sinterstation can be reinforced by infiltration with bronze or copper in a high temperature furnace cycle, to yield a fully dense durable moulding tool. Tools are finished to ensure dimensional accuracy in critical areas using conventional drilling, milling, grinding and polishing techniques as well as electro discharge or high speed machining. Whilst small tools up to 350x350x350 $mm^3$ can be produced readily in the RapidTool process, in most cases optimum production speed and cost, particularly of larger tools, can best be achieved using hybrid techniques where the ability of RapidTool to create complex inserts can be used to best advantage. Mould tools thus produced are capable of manufacturing in excess of 100,000 plastics injection mouldings or several hundred pressure die-castings in aluminium, zinc or magnesium.

***High Speed Machining, Electro Discharge Machining (EDM) and Injection Moulding***. A further technique for rapid production of moulds and dies directly from CAD data or for finishing DTM RapidTool inserts is high speed machining. The MEC houses the most advanced Mikron HSM 700 5 axis machining centre, with spindle speeds up to 42,000 rpm, feed rates up to 20,000 mm/min and a working volume of

700x550x450 $mm^3$. The Centre's ONA Datic 2060 EDM and Battenfeld 75t injection moulding machine complement the Mikron HSM and DTM Sinterstations and together offer complete tooling solutions for SMEs.

## 4. Conclusion

The MEC specialises in advanced manufacturing and information technologies. Through its achievements and growth over the past 3 years it has developed an international reputation and been recognised as the Centre of Expertise for Manufacturing Engineering.

It supports a broad programme of strategic and applied research, developing links with both large and small companies.

Industrial support for the MEC continues to grow as a consequence of the many solid results obtained. This success has also spawned additional public funding to enhance the MEC's infrastructure and enlarge its knowledge base. The joint effect has been to consolidate the MEC's world class status and increase its attractiveness to future industrial partners.