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AMRC Integrated Manufacturing Group

Capability directory

CATAPULT
High Value Manufacturing

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The AMRC Integrated Manufacturing Group (IMG) develops new ways of automatically assembling complex products, to help partners in the aerospace and other high-value industries improve their global competitiveness.

The aerospace industry is increasingly seeking to automate complex manual assembly tasks in order to improve manufacturing flexibility, speed and quality, whilst also reducing costs and keeping emissions and energy usage down wherever possible.

IMG work with industrial and academic partners to bring together advanced technologies including robotics, augmented reality and large-volume metrology to develop innovative integrated systems that ensure complex structures are assembled perfectly, first time and every time.

The group secured £20 million from the Higher Education Funding Council for England and European Regional Development Fund in 2014 towards the construction of ***Factory 2050*** – our new state of the art totally reconfigurable factory.

This £43 million facility will address a rising need for high variation and mass customisation in manufacturing. ***Factory 2050*** will respond to requests for the manufacture of new products by optimising its own operations, using 'Big Data' technology to process large volumes of information collected from sensors and systems on every machine and manufacturing cell.

This document is a brief introduction to current IMG capabilities. For any enquires relating to potential projects or IMG capability, please feel free to email me at the address below.

Ben Morgan, Head of IMG
b.morgan@amrc.co.uk

The AMRC Integrated Manufacturing Group can bring a wide range of capabilities and expertise to our industrial partners.

Click page to jump

Themes

IMG Skillset

IMG Projects

See next page for: Software and Equipment capabilities.

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Software

CAD Software

CAM, Robot Programming and Simulation Software

Measurement and Static Analysis Software

FEA and Dynamic Simulation Software

Additional Software Capabilities

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Equipment

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Equipment cont'd

Digitally Assisted Assembly

Non-Destructive Testing

Safety Systems

CNC Machines

Additive Manufacturing

Big Data Technology

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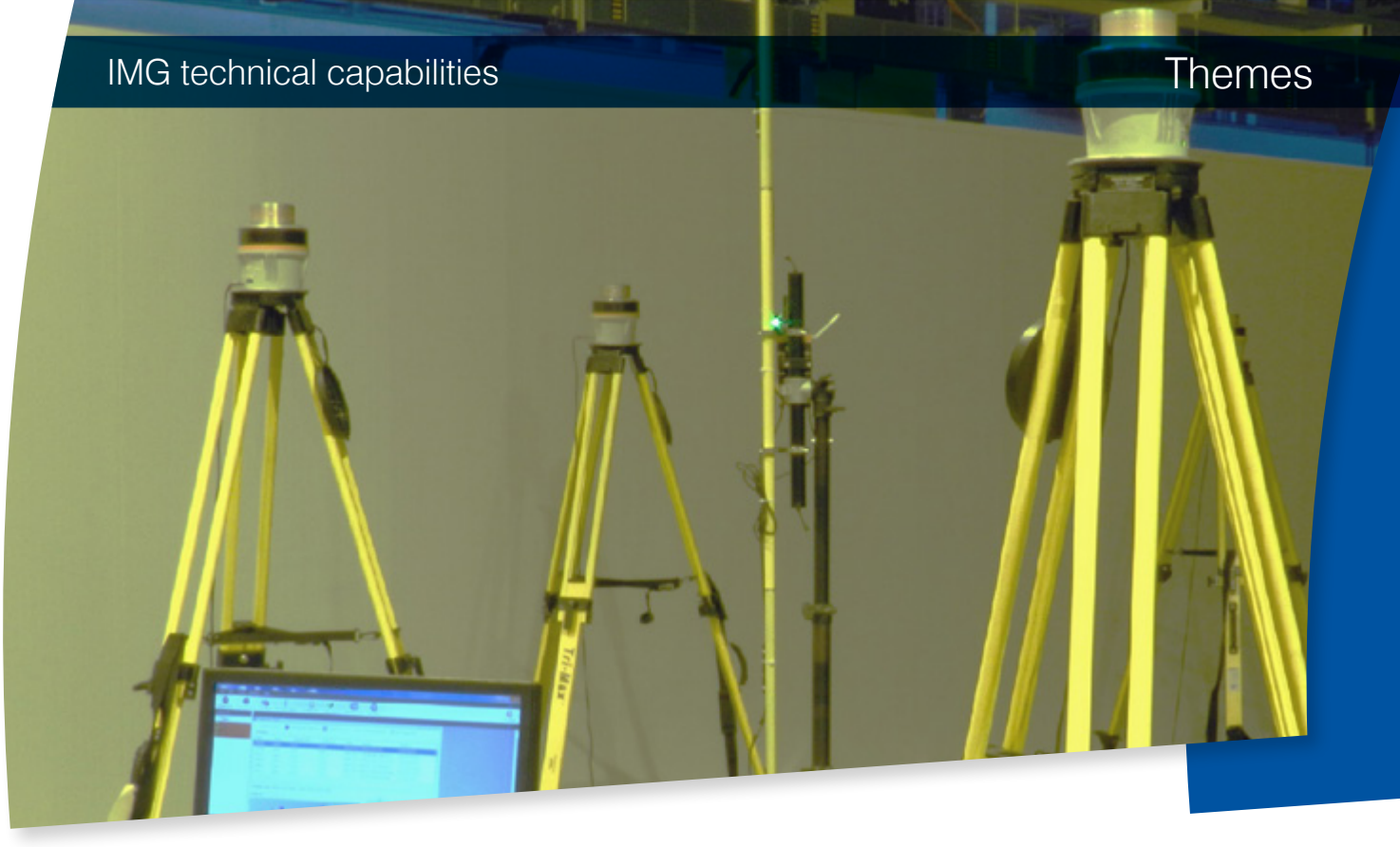
Robotics and Automation

Robotics and automation are widely used to carry out simple repeatable tasks in industries with high production volumes, such as automotive and food processing. IMG specialise in developing robotic systems for low-volume, high-value markets such as aerospace, where robots have to carry out significantly more complex and variable tasks with greater accuracy.

IMG use a diverse collection of robots and automation equipment from the world's most advanced suppliers, including Kuka, ABB, Mitsubishi, Güdel and Siemens.



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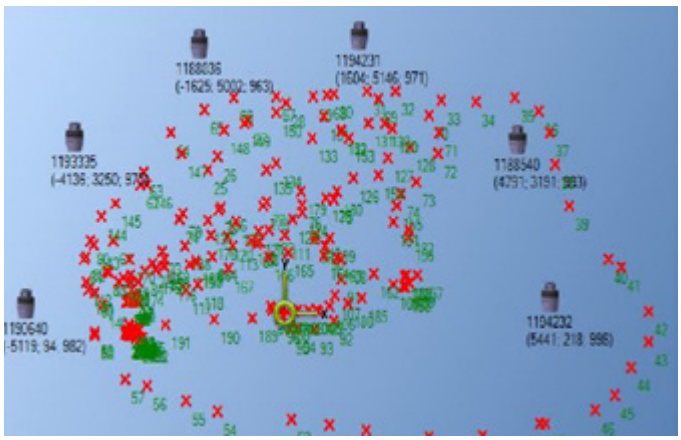
Integrated Large-Volume Metrology

The continuing drive for more fuel efficient aircraft has led to manufacturing tolerances becoming tighter and the introduction of weight saving materials whose properties are more unpredictable.

This has put increased emphasis on the importance of metrology and IMG work closely with AMRC partners to ensure that they are at the cutting edge in the field.

Metrology has been of paramount importance in flagship projects to build aircraft with high composite content, such as the Boeing 787 and Airbus A350.

Using in-process measurement and integrated metrology machinery simplifies the assembly of these flexible structures from components that have been supplied from multiple locations around the world.



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Digitally Assisted Assembly

Digitally Assisted Assembly provides opportunities for increasing production rates, improving quality and reducing cost when a task is too complex, involves too much variation or simply would not be cost effective to automate. IMG are developing digital, semi-automated assembly capabilities, incorporating Augmented Reality (AR) and Intelligent Workbenches.

These self-teaching systems supply detailed assembly instructions that allow inexperienced operators to successfully complete complex tasks. Systems can simultaneously capture data from intelligent tools and sensors which is then used to validate processes and ensure traceability. In-line quality checks provide early detection of manufacturing problems and decrease the number of defects at the end of the process.

IMG have an extensive suite of associated software from leading suppliers, ranging from CAD and offline programming to augmented reality and metrology data-analysis systems.

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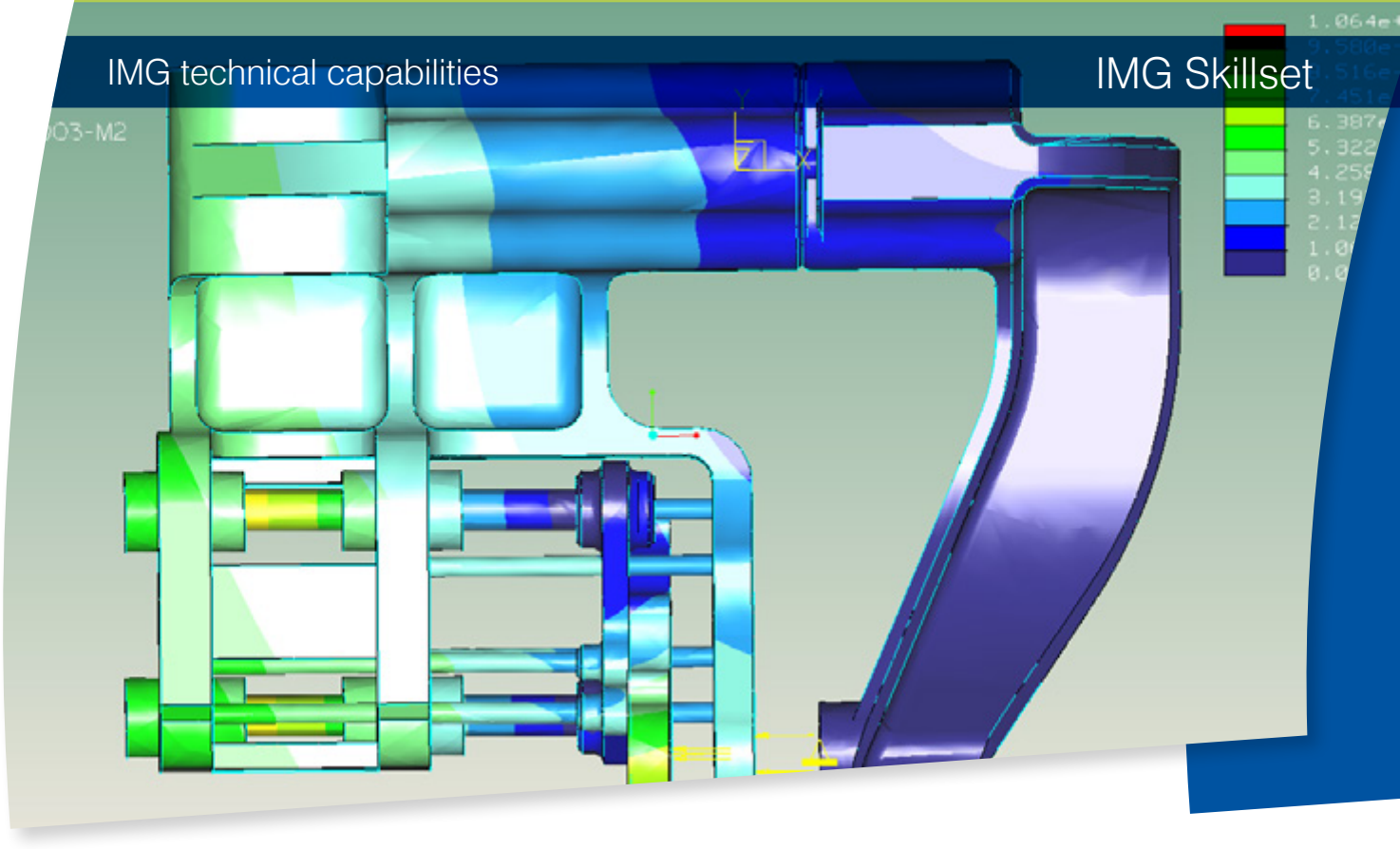
6-Axis Robots and Gantries

Industrial 6-axis robots form the bulk of the work within IMG, and all members of IMG staff are proficient in operating and programming robots from at least one of the leading manufacturers. Robots, gantries and external axes from ABB, Fanuc, Güdel, Kuka and Mitsubishi are either in-use already or are being investigated and developed by IMG to enable interchangeable and configurable manufacturing within aerospace assembly, manufacture and beyond.

IMG use a variety of online and offline programming software and methods including DELMIA, Delcam PowerMILL and RobotMaster to complete projects involving the integration of robotics with past, current and new technologies and processes.



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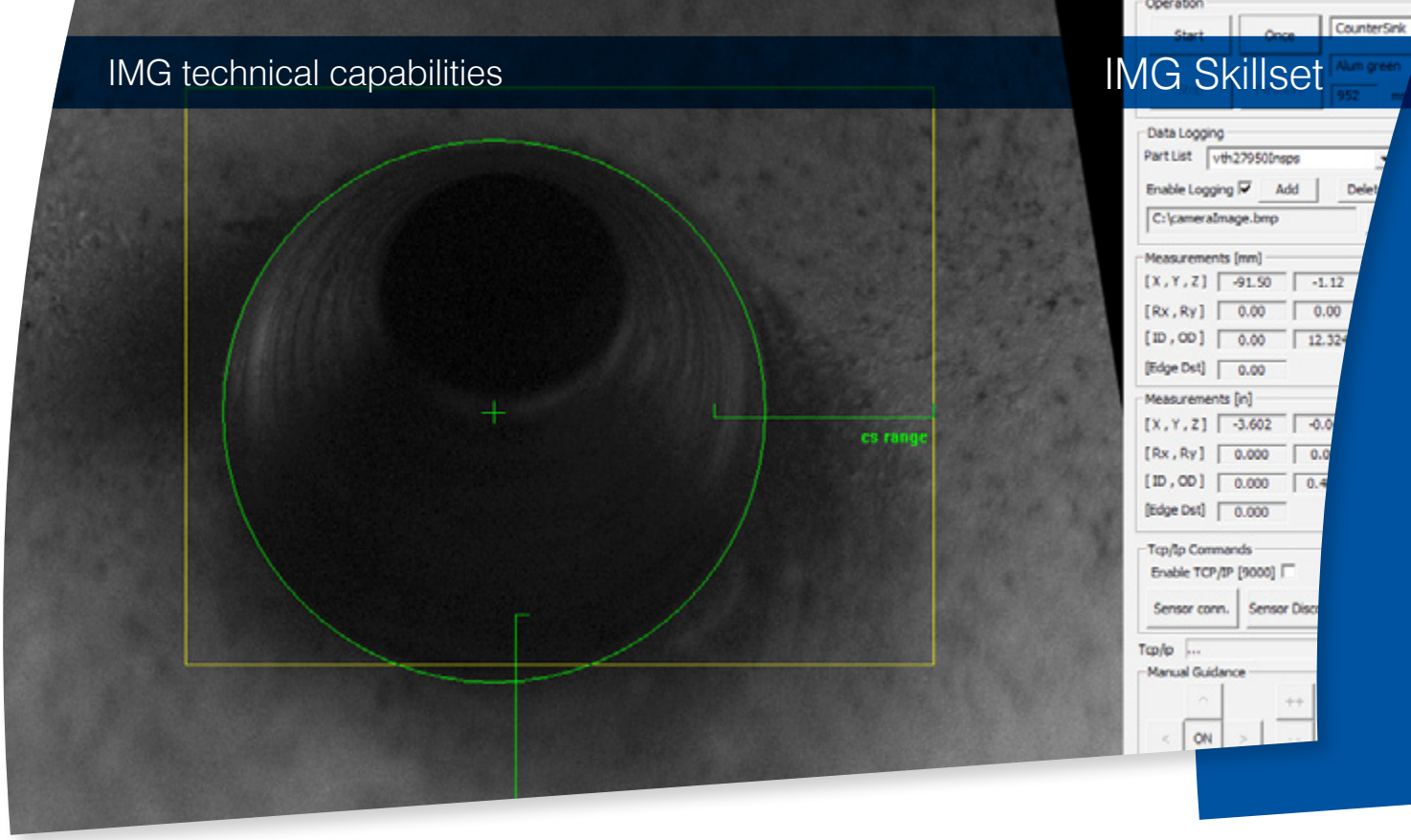
Design

Throughout project work, IMG aim to deliver complete solutions for our customers. An essential part of this process is designing appropriate components and setups to allow this to happen. This is done by delivering high-quality CAD to our in-house IMG and AMRC facilities and to local suppliers to fabricate items ranging from jigs and brackets, to end effectors and machining tables. IMG involvement covers the entire process from initial scoping, to integration and commissioning of final demonstrators, through to fully operational production cells.



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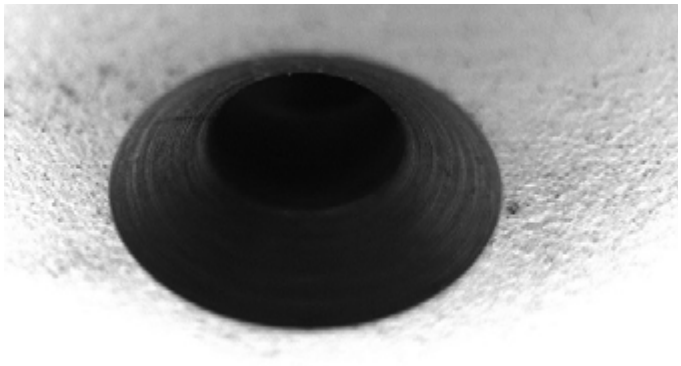
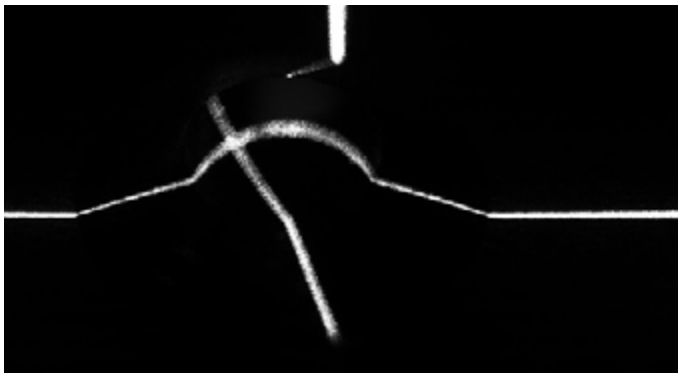
Measurement, Metrology and Vision Systems

Aerospace components and assemblies must be manufactured and assembled to high specification and strict quality requirements, to ensure that the finished product is entirely safe and fit for purpose. IMG have developed an in-house metrology expertise for measurement of large volumes. IMG also have a range of metrology hardware available for use, including laser trackers, CMM cameras, probes, scanners and indoor GPS for accurate measurement and reverse engineering capabilities.

In addition to metrology and measurement, IMG have conducted investigations into the integration and use of vision systems for verification and other purposes within manufacturing and automation cells. This includes safety scanning and supervision systems that provide an appropriately safe working environment where human-machine interaction is required in semi-automated manufacture and assembly.





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Virtual and Augmented Reality

As we approach Factory 2050 and investigate the art-of-the-possible, IMG have been working with new wearable and portable technologies to aid manufacturing. Areas of research include teaching, training, adhesive application and component fastening. Technologies and equipment such as optical projection, the intelligent workbench and utilisation of apps for smartphones, tablets and wearables are being trialled and tested for calibration and configuration, and as training and knowledge capture tools. This is of particular relevance to the UK's current aging aerospace workforce.

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Control Systems and Programming

Control is an integral part of automation to ensure high quality and consistency in production, and therefore has a key presence in many, if not all IMG project work. IMG's specialist control engineers have experience with Siemens and Mitsubishi PLCs and their associated programming environments and languages, including Ladder Diagram, Structured Control Language and Function Block Diagram, as well as other programming languages such as C and C#, and the Microsoft .Net framework.

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Developed Technologies

Through lessons learned in previous and current project work, IMG have developed extensive knowledge and exclusive experience in the following assembly processes and technologies through engaging with a variety of local, national and international partners, customers and suppliers:

- One-way build philosophy
- Composite lay-up
- Robotic drilling, countersinking and fastening
- Adhesive application and verification
- Robotic machining of metallics and composites
- Fully and semi-automated measurement
- Semi-automated assembly
- Use of external linear and rotary robotic axes
- Wireless technologies for industrial purposes
- Robotic accuracy improvement
- Robotic non-destructive testing
- Discrete event simulation
- Self-adaptive machining
- Robotic force control
- Pick and place
- Robotic deburring and finishing
- Digital work instructions
- Parallel kinematic machining
- iGPS
- Flexible and reconfigurable fixturing

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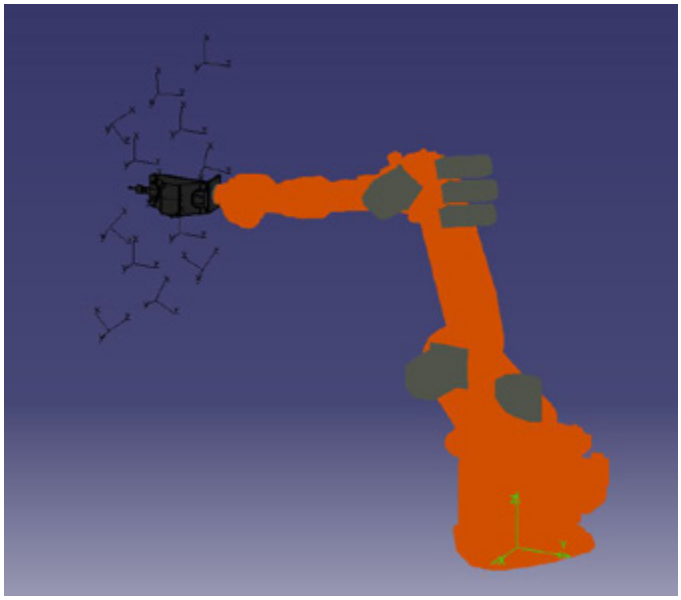
IMG Projects

IMG work on a wide range of industry-led research projects addressing current manufacturing challenges in the field of large-volume and complex assembly. IMG carry out a range of generic research projects on behalf of the AMRC's industrial members. Recent projects include:

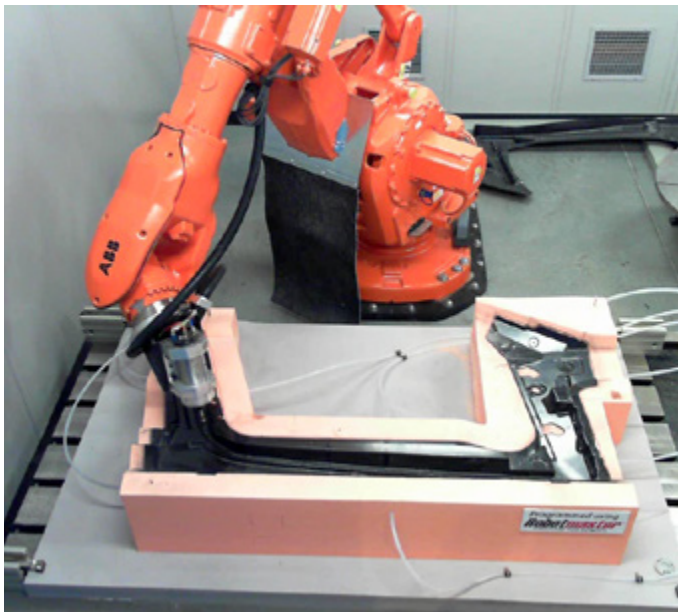
Robotic Calibration

Industrial robots produce results that are highly repeatable, but lack the accuracy required in most aerospace processes. IMG researchers are testing and developing calibration systems for robotic arms that will allow for relatively cheap 'plug-and-play' robots to undertake high-precision aerospace tasks.



Robotic Machining

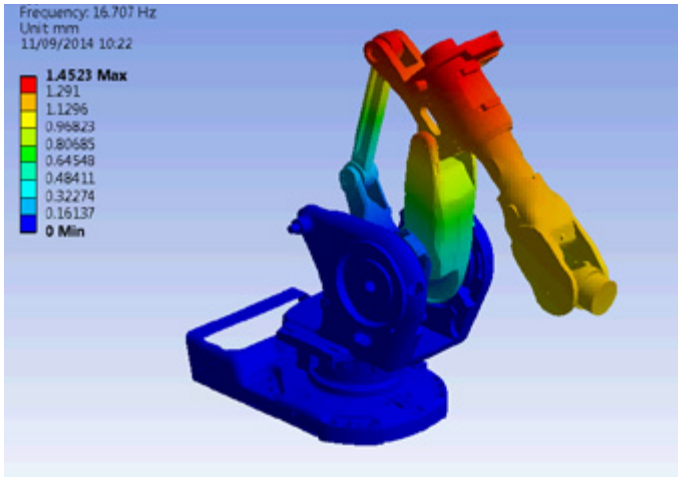
Significant improvements in recent years mean that robots can now be used for some machining tasks. IMG is currently working with leading high-end automotive manufacturers on several projects in this field.



Robot Dynamics

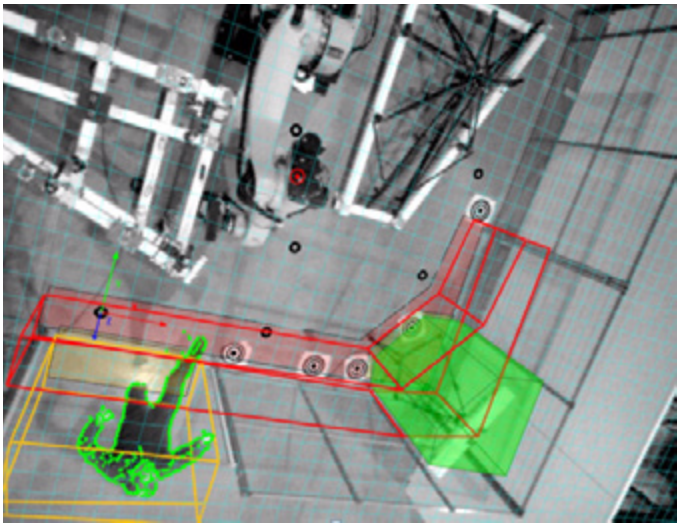
IMG researchers have been investigating the dynamic stability of serial robot arms to help develop new techniques to counteract structural vibrations that cause 'chatter' when robots are used for machining.

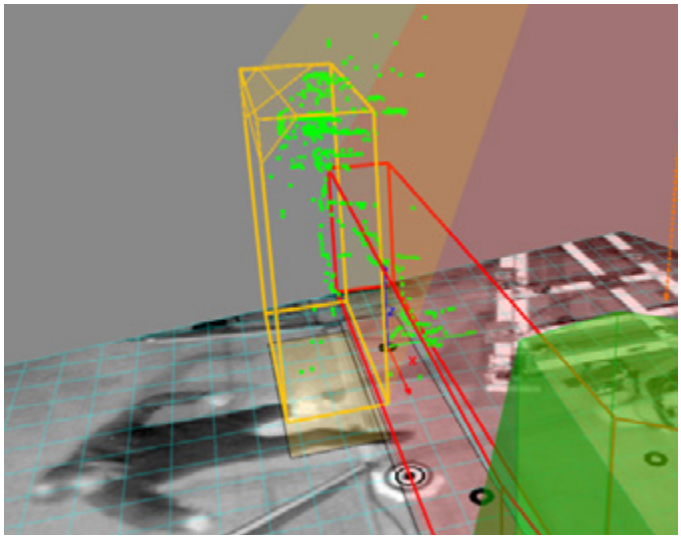
These extensive studies have resulted in major insights into how the dynamic response of robotic structures can be improved.

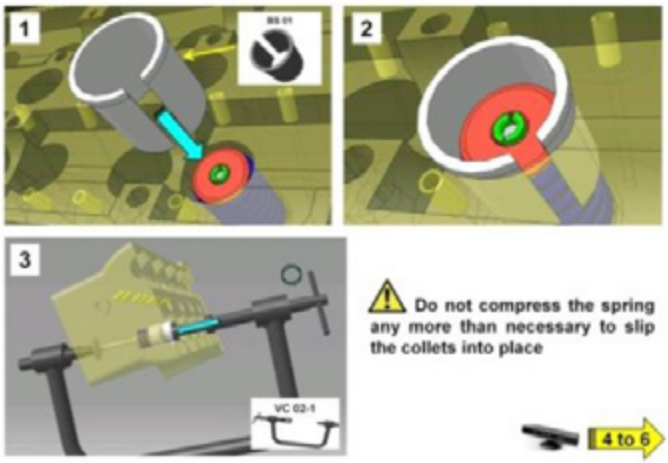


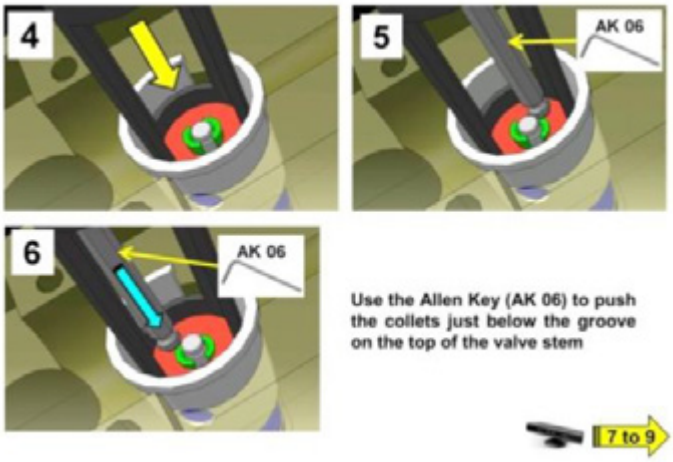
Human-Machine Interaction

IMG researchers have been assessing the suitability of revolutionary new ways for operators and automation to interact, which have emerged thanks to the impact of increased computing power on functionality and safety systems.









Augmented Reality Manual Assembly

IMG has developed an 'Augmented Reality' driven workbench to improve manual assembly performance where automation is not economically viable. This equipment enables operators to carry out complex assembly tasks with little or no training, and has the potential to be an incredibly useful knowledge capture tool.

Externally Funded Projects

IMG also work on a variety of externally funded collaborative projects alongside key industrial and academic partners. Recent and ongoing projects include Validation & Integration of Manufacturing Enablers for future Wing Structures (VIEWS), Future of the Aircraft Factory (FoAF) and Vehicle ARchitectures for CITY cars (VARCITY), a national programme led by Jaguar Cars with funding from the Innovate UK, which aims to develop technologies for a premium city car for the year 2020.

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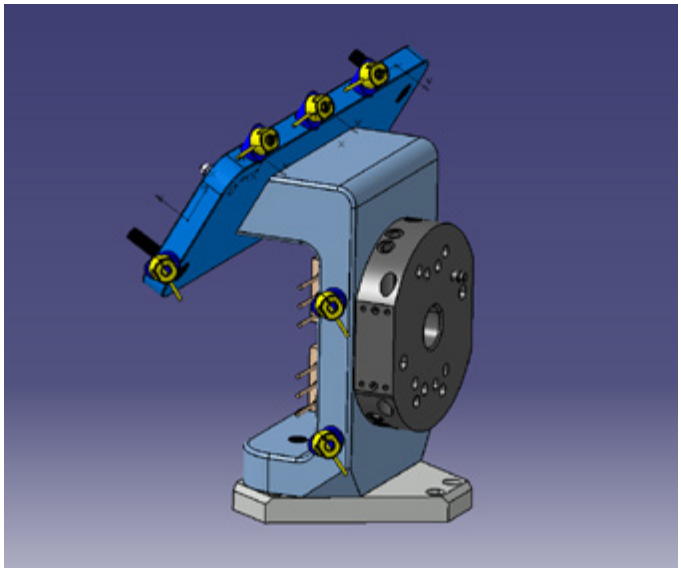
IMG Software

IMG have acquired an in-depth proficiency with a variety of software for design, offline programming, simulation and analysis for developed cells, systems and associated equipment, a few examples of which are described below. This also demonstrates how quickly and well IMG engineers are capable of learning and using new supplier and equipment specific software for project related activities.

CAD Software

Catia V5

Dassault Systèmes' CATIA V5 is IMG's most commonly used 3D CAD platform due to its specialist modules with features designed specifically for use in the aerospace and automotive industries. Individual fasteners to full aircraft assemblies can be modelled, analysed, and exported in a variety of file formats to other software packages for further manipulation, or simply for 2D or 3D drawings.



DS CATIA

CAM, Robot Programming and Simulation Software

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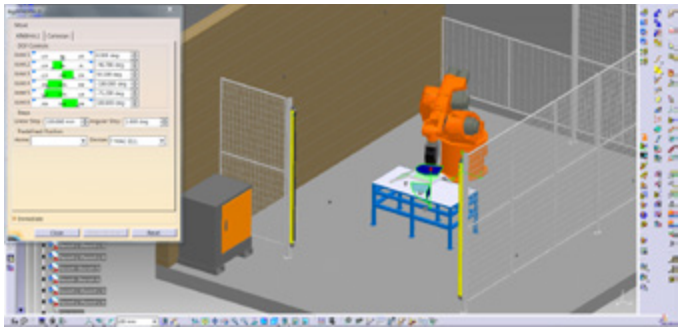
Delmia V5

Dassault Systèmes' DELMIA is a sister package to CATIA V5 used for the simulation and visualisation of moving mechanical parts, robots and personnel within the manufacturing process. This allows for offline planning, fault-finding and optimisation before designs are completed for prototyping and manufacture.



DELMIA

ABB RobotStudio

RobotStudio is an offline robot programming solution for ABB robots. Robotic movements and signals can be simulated, virtually tested and optimised, before being written in RAPID programming language and transferred directly to the robot controller or teach pendant via USB. This can provide numerous benefits including risk reduction, faster start-up, shorter change-over times and increased productivity when compared to manual ABB RAPID programming.

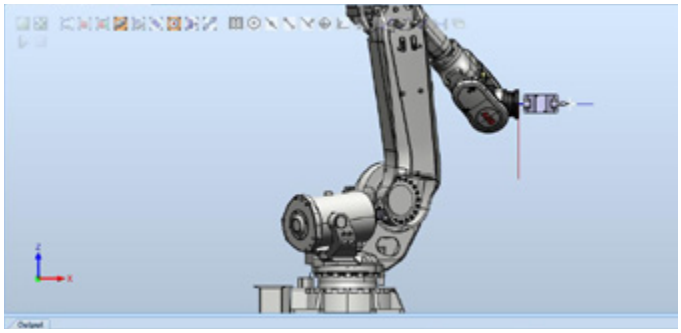
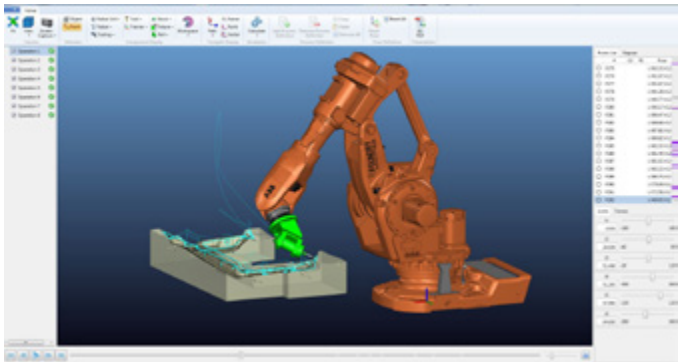


ABB RobotStudio

Delcam PowerSHAPE and PowerMILL Robot Interface

Delcam's PowerMILL software is commonly used in industry to produce CNC machining code, also known as G-code. This G-code can be converted via PowerMILL's Robot Interface into robot code for virtually any kind of industrial 6-axis robot. In this way, the specialist machining capabilities in Delcam can be transferred directly to robotic machining operations.



Delcam PowerMILL

CAM, Robot Programming and Simulation software

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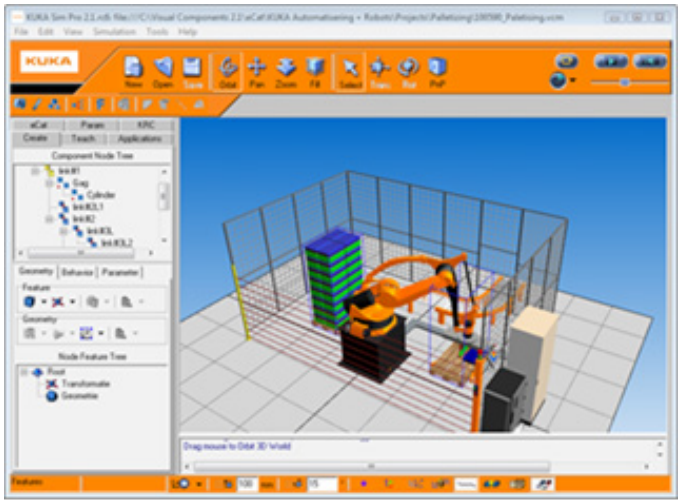
KUKA.Sim Pro

KUKA.Sim Pro is an offline robot programming solution for Kuka robots. Robot movements and outputs can be simulated and optimised before testing in virtual environment to obtain information such as cycle time including effects of physical constraints such as motors and brakes. With its library of components and support of a range of CAD formats KUKA.Sim Pro allows a process to be fully realised in simulation before deployment, reducing risk and start-up time compared to online programming.



KUKA

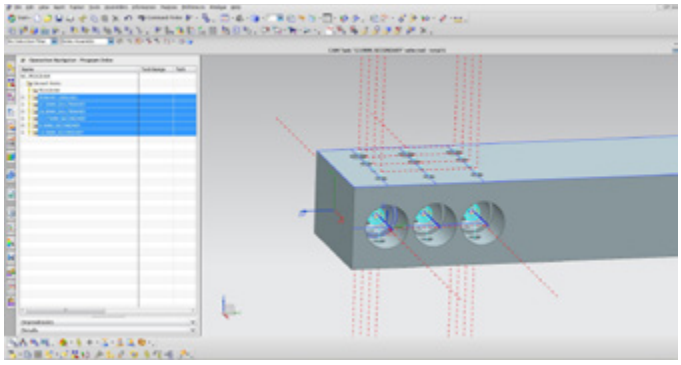
Mastercam Robotmaster

Mastercam's Robotmaster is able to generate simulations and robot program code for Stäubli, Fanuc, ABB, Motoman and Kuka robots for a range of machining operations. The software's unique robot path optimisation tool allows the user to identify exactly how and why the robot path is unfit for purpose and how they wish to resolve this.

Robotmaster® CAD/CAM FOR ROBOTS

Siemens NX

NX for manufacturing provides a complete solution for part manufacturing from CAM to CNC controller. NX can improve manufacturing productivity by means of reductions in NC programming, machining time, higher quality parts and maximisation of resources.



SIEMENS NX

Measurement and Static Analysis Software

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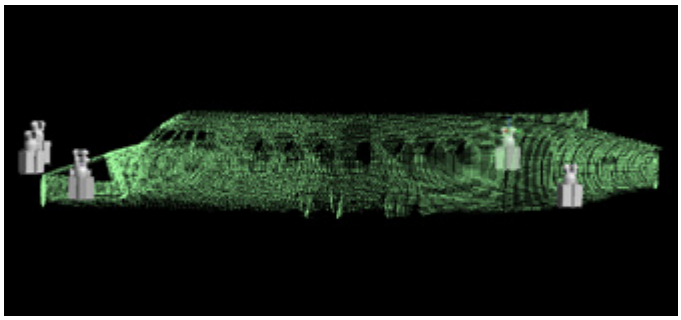
Spatial Analyser

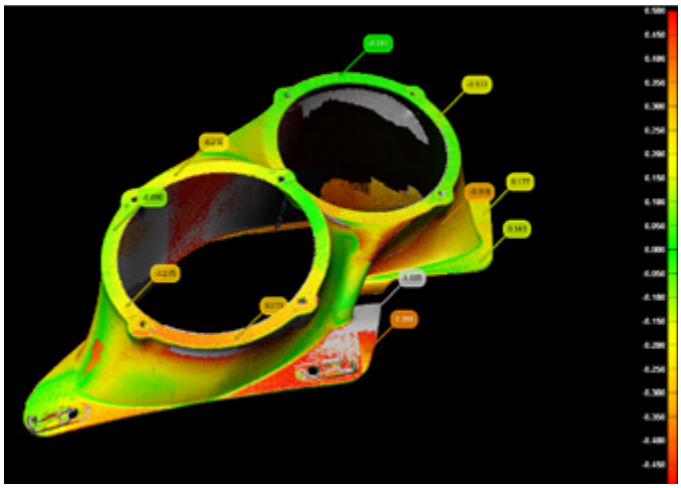
Spatial Analyser by New River Kinematics is an open source, instrument independent and traceable 3D graphical data analysis software. SA has the ability to automatically record data and analyse against imported CAD models or shapes built in SA, reporting the findings in a user friendly format.



SA SpatialAnalyzer

PolyWorks

PolyWorks is a comprehensive software solution that allows the extraction of CAD entities such as curves, surfaces, parametric sketches, and prismatic features from polygonal models of digitized parts to serve as the starting point in a professional CAD modelling solution. Polyworks is excellent at handing large data sets and point clouds, making it ideal for reverse engineering.



PolyWorks®
The Universal 3D Metrology Software Platform™

FEA and Dynamic Simulation Software

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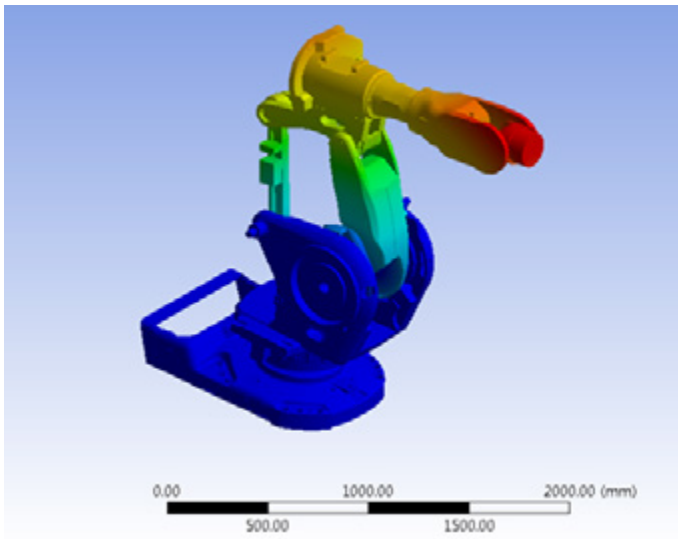
ANSYS Workbench

The ANSYS Workbench platform is a framework unifying the advanced engineering simulation suite of technologies from ANSYS. This allows complex multi-physics simulations such as robot-dynamics and machine-dynamics to be performed from CAD models, aiding the design and manufacturing process.



ANSYS

Additional Software Capabilities

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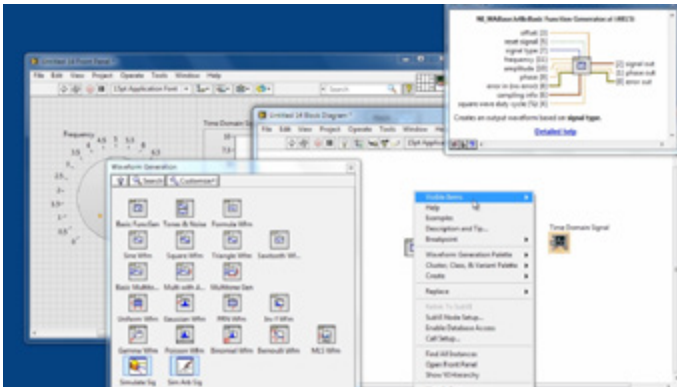
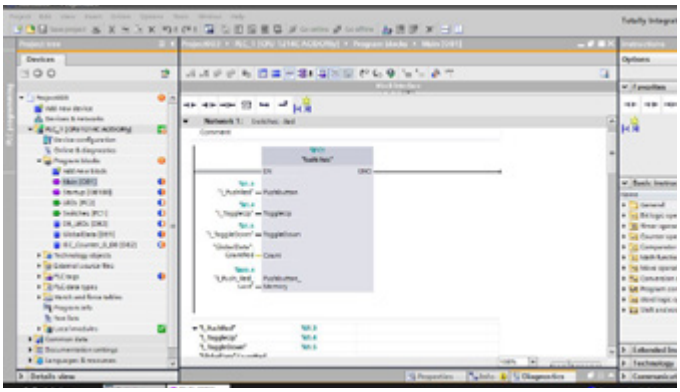


LabVIEW

LabVIEW is a graphical programming platform from National Instruments that aids the integration of hardware and software used in data acquisition, automation and instrument control.

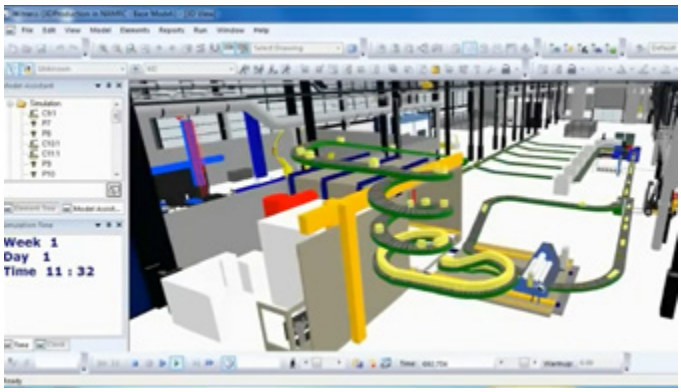
Metaio

Metaio is a platform for the development of augmented reality applications that will be used to aid in display and instruction for engineering tasks in Factory 2050.



Siemens WinCC and TIA portal

The Seimens' WinCC in the Totally Integrated Automation (TIA) Portal will be part of a supervisory control and data acquisition (SCADA) system to be installed in Factory 2050, showcasing how data gathering technology might be used in a modern factory to monitor variables such as power consumption and temperature.



Witness

Lanner's Witness software is a discrete event simulation package that allows the impact of automation and layout on factory flow to be analysed.

ABB 120

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The ABB 120 is a small multipurpose robot weighing just 25 kg but is capable of handling a payload of up to 3 kg. The ABB 120 is adept for rapid pick and place under an industry leading repeatability of 0.01 mm, whilst being extremely flexible it is also highly agile. IMG have two of these robots and because of their relatively light weight, they are used at shows and exhibitions to demonstrate the latest IMG projects.

Payload	3 kg
Max. reach	580 mm
Number of axes	6
Repeatability	0.01 mm
Weight	25 kg
Mounting positions	Floor, ceiling
Controller	IRC5

ABB IRB 4600

The IRB 4600 is a 6-axis serial arm capable of manipulating payloads up to 60 kg. Due to its low weight and compact design the IRB 4600 has fast acceleration and a high top speed, making it well suited to tasks such as material handling, welding or cutting.

Payload	3 kg
Supplementary payload	20 kg
Max. reach	2060 mm
Repeatability	±0.06 mm
Weight	435 kg
Mounting positions	Floor, ceiling
Controller	IRC5

ABB IRB 6700 with integrated MID 500 turntable

The IRB 6700 is a heavy duty 6-axis robot capable of handling payloads of up to 235 kg. In Factory 2050 this will be integrated with a MID 500 turntable capable of payloads up to 1300 kg, allowing the robot to perform machining operations on large components several metres cubed in volume.

Payload (arm)	235 kg
Supplementary payload (arm)	50 kg
Payload (turntable)	1300 kg
Max. reach	2650 mm
Repeatability	±0.05 mm
Mounting positions	Floor
Controller	IRC5

ABB IRB 6640

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The IRB 6640 is a high production capacity robot, with a payload capacity of 235 kg making it suitable for heavy load applications. IMG has two of these robots. The first is used as a general workhorse for machining metal and for workpiece inspection. The second 6640 is mounted on a Gudel motion track giving it an impressive working volume, whilst not decreasing its dynamic stiffness. It is currently used for gluing trials and can be fitted with either a Viscotec or Dopag adhesive dispensing system.

Payload	235 kg
Max. reach	2550 mm
Number of axes	6
Repeatability	0.07 mm
Weight	1310-1405 kg
Mounting positions	Floor
Controller	IRC5

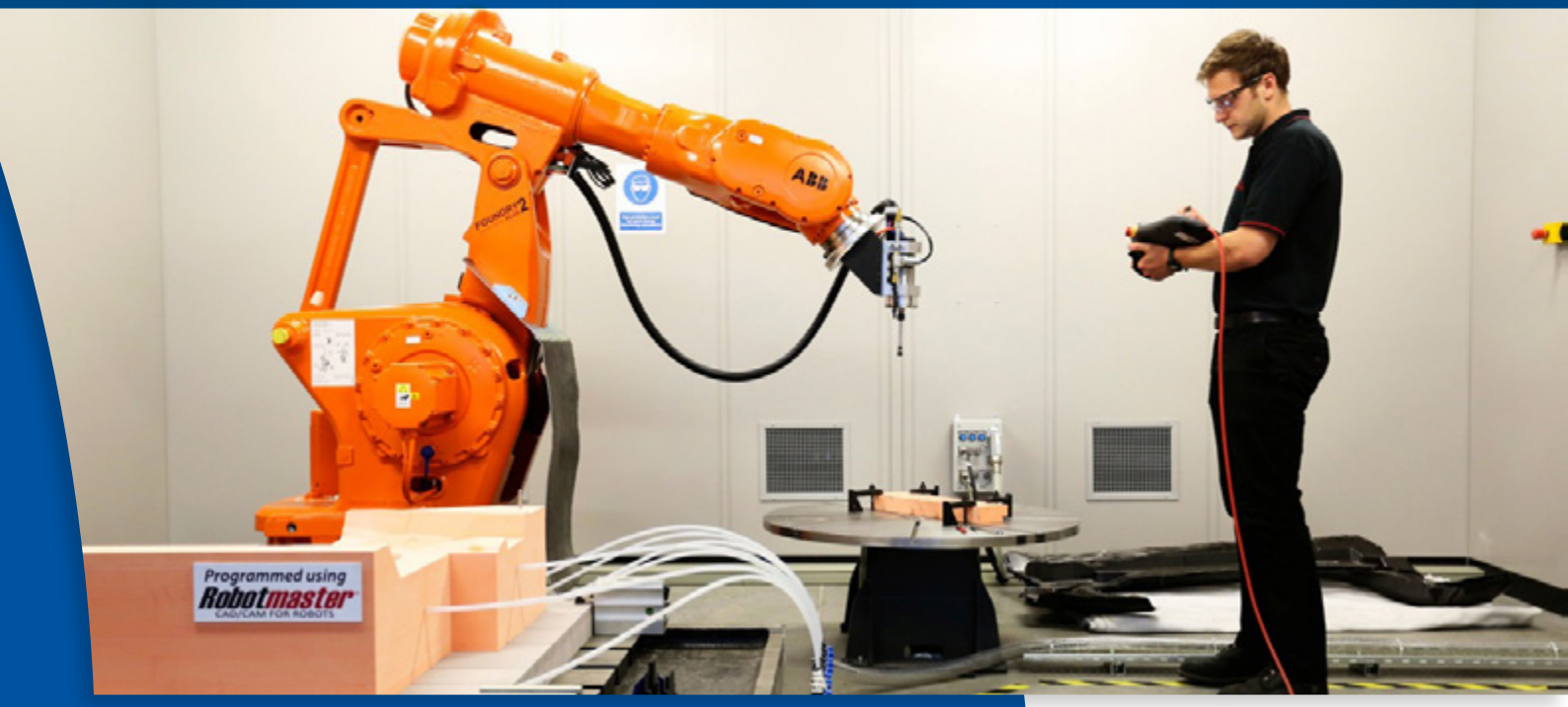

ABB IRB 6660

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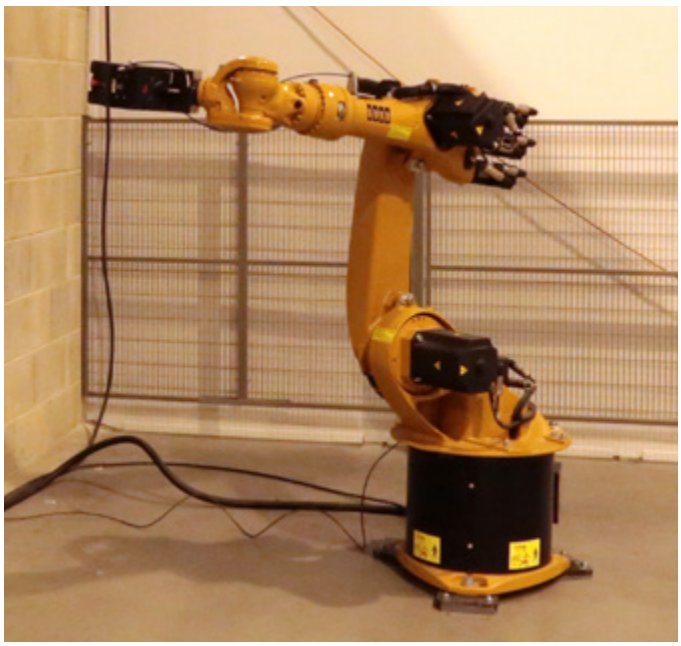
The IRB 6660 is the first dedicated robot for pre-machining applications in the foundry industry. The design for the 6660 was optimised for high-performance industries such as finishing, and pre-machining such as milling, grinding, cutting and sawing. The 6660 has the highest level of dynamic stiffness out of all the IMG robots, and is used for machining. This robot is situated in a room which has been fitted with a Camfil GS04 filter so that it can machine composite materials in a safe and secure environment.

Payload	205 kg
Max. reach	3100 mm
Number of axes	6
Repeatability	0.07 – 0.11 mm
Weight	1730 kg
Mounting positions	Floor
Controller	IRC5

KUKA KR 16-2

The KR 16-2 is a versatile and flexible 6-axis robot suitable for a range of manufacturing environments. The KR 16-2 can be used for handling, loading, welding, forming machine tools and palletizing. IMG found this robot invaluable for positioning the GOM scanner, the laser shearography system and for other metrology based projects.

Payload	16 kg
Supplementary payload	10 kg
Max. reach	1610 mm
Number of axes	6
Repeatability	< ±0.05 mm
Weight	235 kg
Mounting positions	Floor, ceiling
Controller	KR C4



KUKA KR 60 HA

The KR 60 HA is a 6-axis robot specifically designed for high-accuracy applications such as laser cutting, welding and machining. Due to its increased rigidity the KR 60 HA can repeatedly position a 60 kg payload to within 0.05 mm and will be used to investigate the accuracy of off-the-shelf robots with open-loop position control.

Payload	60 kg
Supplementary payload	35 kg
Max. reach	2033 mm
Number of axes	6
Repeatability	< ±0.05 mm
Weight	665 kg
Mounting positions	Floor, ceiling
Controller	KR C4

KUKA KR 240 R2900 ultra (x2)

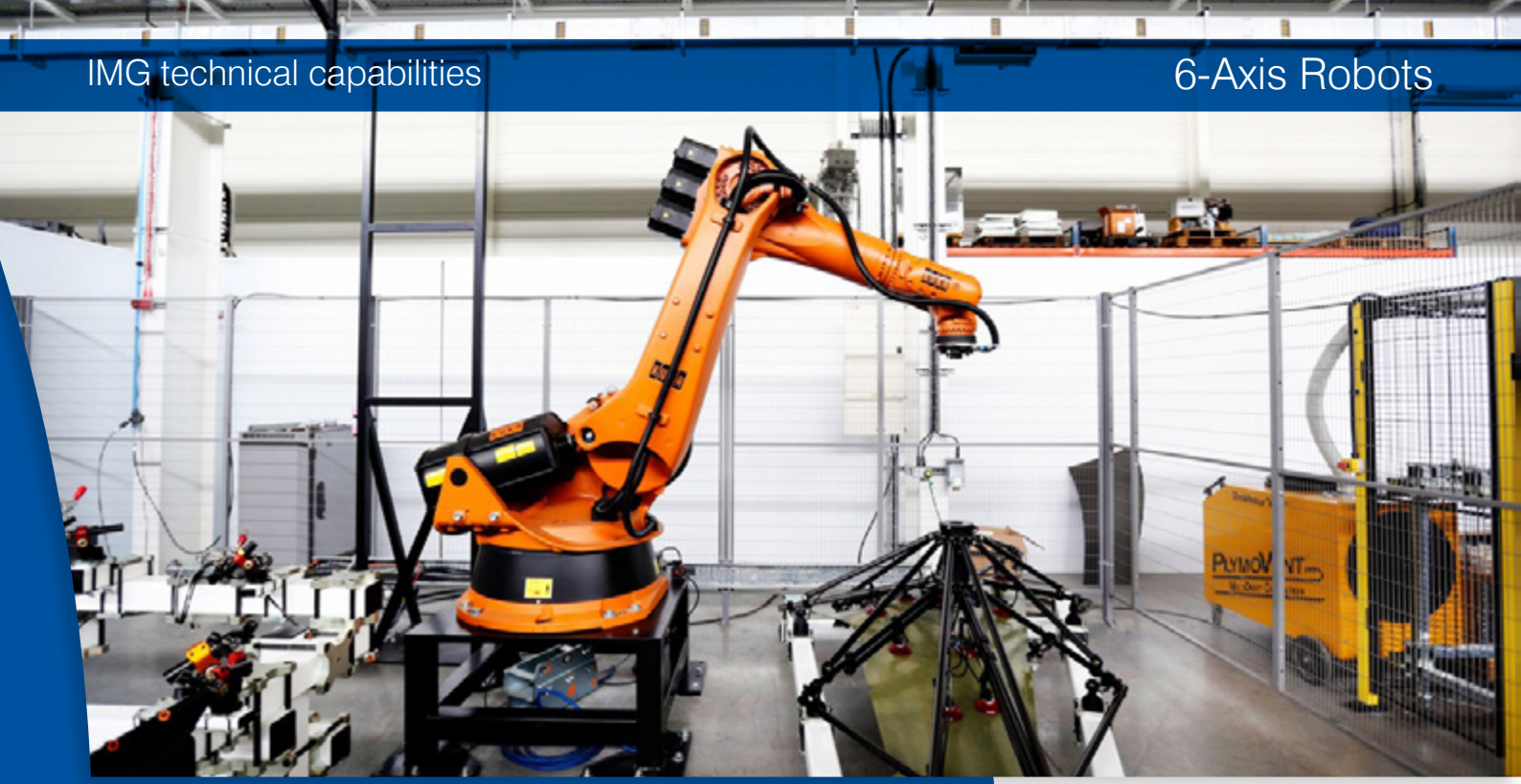
The KR 240 R2900 is the highest power-density currently available on the market in this range, handling payloads of up to 240 kg with a reach of 2.9 m. Two of these class-leading robots will be installed in Factory 2050.

Payload	240 kg
Supplementary payload	50 kg
Max. reach	2896 mm
Repeatability	±0.06 mm
Weight	1145 kg
Mounting positions	Floor, ceiling
Controller	KR C4
Protection class	IP 65

KUKA KR 1000 Titan LR750

The KR 1000 Titan LR750 is a heavy-duty 6-axis robot capable of bridging distances of up 7.5 m and handling payloads of up to 750 kg. The Titan will have the greatest lifting capacity of all robots in Factory 2050 and will be used for manoeuvring the very largest components.

Payload	750 kg
Supplementary payload	50 kg
Max. reach	3601 mm
Number of axes	6
Repeatability	< ±0.1 mm
Weight	4750 kg
Mounting positions	Floor
Controller	KR C4



KUKA KR 270

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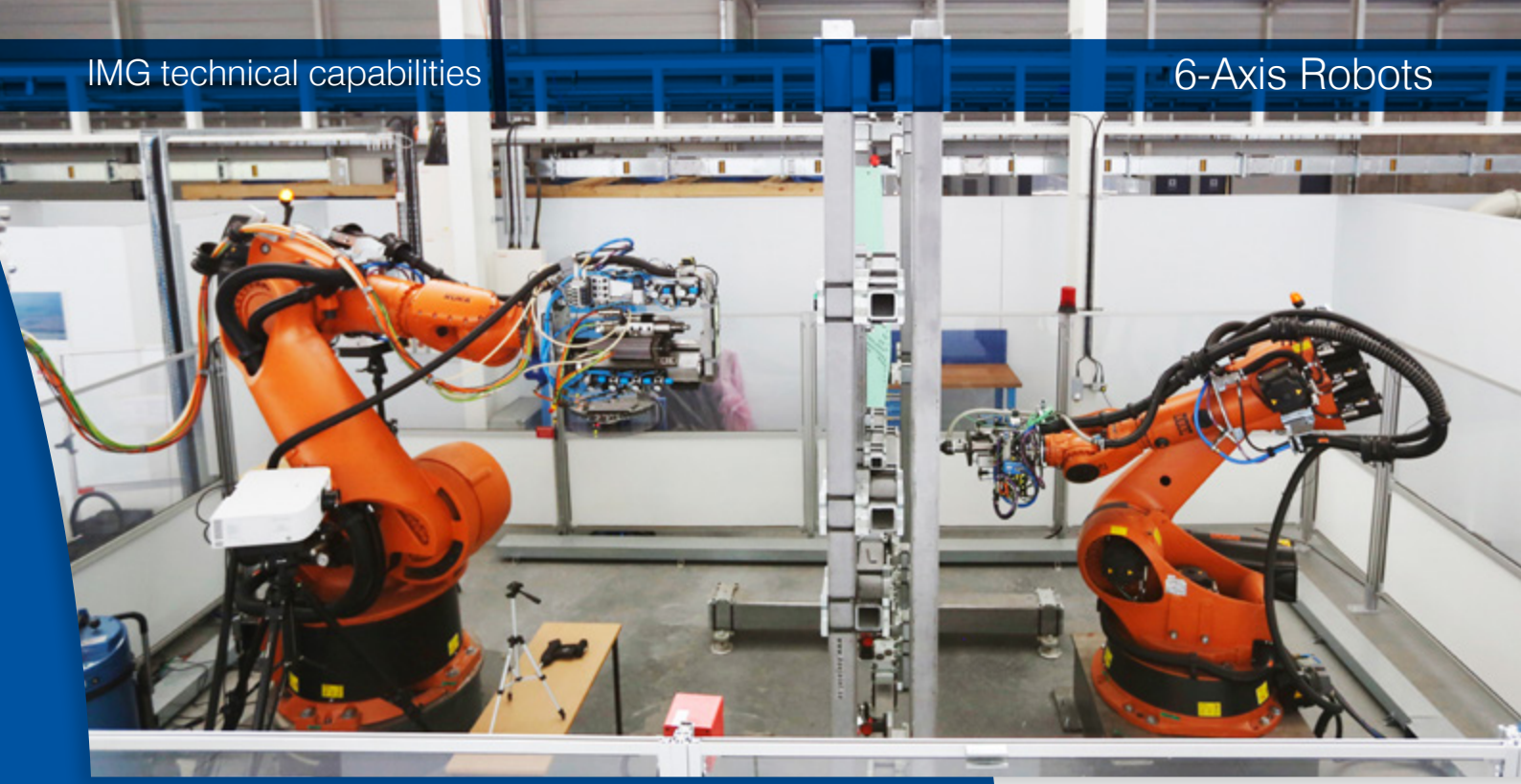
The KR 270 was the highest power-density 6-axis robot available on the market within the high payload range. Whilst having similar form and spatial requirements to other KUKA robots of the same class, the KR 270 gives maximum power. This robot is integrated into a cell that has three Stäubli tool changers and a KUKA seventh axis.

Payload	270 kg
Supplementary payload	50 kg
Max. reach	2700 mm
Number of axes	6
Repeatability	< ±0.06 mm
Weight	1412 kg
Mounting positions	Floor, ceiling
Controller	KR C4



KUKA KR 360 and KR180-2

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The KR 360 is a heavy-duty 6-axis robot offering a large working envelope and reach. Capable of handling loads of up to 360 kg with a repeatability of ±0.08 mm, the KR 360 is typically used for a wide range of applications, from welding to painting, assembly to machine operations. This robot is used at the AMRC to position a large drilling and countersinking end effector. The robot has been integrated with various vision and metrology systems to ascertain how accurately the end effector can be placed.

The KR 180-2 is a robust 6-axis robot designed for use in palletising operations. Utilising high performance gears, the KR 180-2 is capable of up 27 cycles per minute. It is designed for use in a small environment and has a narrow base frame and small footprint. This robot has been used at the AMRC as a slave robot on the drilling and counter-sinking rig.

KUKA KR 360

Payload	360 kg
Supplementary payload	50 kg
Max. reach	2826 mm
Number of axes	6
Repeatability	±0.08 mm
Weight	2385 kg
Mounting positions	Floor, ceiling
Controller	KR C4
Protection class	IP 65

KUKA KR 180-2

Payload	180 kg
Supplementary payload	50 kg
Max. reach	2700 mm
Number of axes	6
Repeatability	±0.06 mm
Weight	1267 kg
Mounting positions	Floor
Controller	KR C2 Edition 2005

Mitsubishi Melfa Robot RV-3SB

The RV-3SB is a high-speed, high-precision robot. It has a slim profile with a compact body, designed for integration into existing cells. This robot has been used on a variety of projects, including being mounted on the Güdel FP-1 gantry to create a redundant manipulator, providing a simulation of a snake arm robot.

Payload	3 kg
Max. reach	642 mm
Number of axes	6
Repeatability	0.01 mm
Weight	37 kg
Mounting positions	Floor, ceiling
Controller	CR1B-571

Güdel FP-4

The FP-4 is a portal type gantry system allowing for use in a diverse range of heavy industries such as logistics, automotive and aerospace. Utilising a rack and pinion drive, the gantry is suited for applications which require large work areas while maintaining a high degree of accuracy. The gantry has a repeatability of 0.05mm for loads 100kg and up to 160kg in high load mode.

Axis	x	y	z
Payload [N]	1000	1000	1000
Speed [m min-1]	112,5	112,5	67,5
Acceleration [ms-2]	1,5	4	2,5
Gearbox ratio	6	6	10
Size of GÜDEL gearbox type AE	090	060	060
Stroke of axis per motor revolution [mm]	25	25	25
Acceleration time [s]	1,25	0,469	0,45
Stroke of axis while accelerating [m]	1,172	0,439	0,253
Motor speed [min-1]	4500	4500	4500
Stall torque of motor [Nm]	1,8	1	4,5
Max. torque of motor [Nm]	9	5,3	5,6

KUKA youBot (x2)

The KUKA youBot is a 5-axis serial robot arm and gripper which can be mounted on an omnidirectional (omniMove) platform. The KUKA youBots will be used in Factory 2050 for research, training and demonstration of cooperative mobile robotics.

Manipulator

Height	655 mm
Working envelope	0.513 m^3
Weight	5.8 kg
Payload	0.5 kg
Repeatability	0.1 mm

OmniMove platform

Length	580 mm
Width	376 mm
Height	140 mm
Payload	20 kg
Repeatability	0.8 mm

Baxter Research Robot

The Baxter research robot is a twin-armed robot designed to work safely with humans. The robot has two 7-axis arms with compliant joints making it ideal for handling small payloads and working in cooperation with humans, performing tasks such as passing tools or components.

Baxter will be used in Factory 2050 to investigate and demonstrate how collaborative human-robot interaction could be used in manufacturing.

Height (on pedestal)	1.77 – 1.90 m

KUKA omniRob

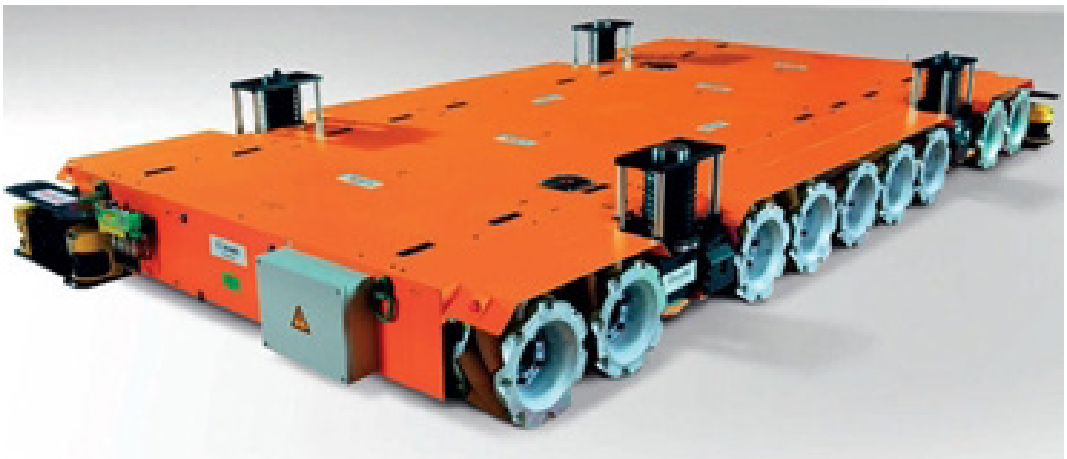
The omniRob uses omnidirectional drive allowing it to manoeuvre payloads up to 360 kg in tight spaces. Using laser scanners mounted on the vehicle and sensors on the wheels, the KUKA omniRob will be able to navigate autonomously around Factory 2050, creating a map of its surroundings using the simultaneous localisation and mapping (SLAM) method.

Dimensions	1.2 x 0.75 x 0.7 m
Weight	360 kg
Payload	400 kg
Positioning accuracy	±2 mm

KUKA omniMove UTV-2 E575 15000

The omniMove UTV-2 (universal transport vehicle) E575 15000 is a second, larger autonomous vehicle for Factory 2050. It uses an omnidirectional drive to allow it move sideways, diagonally, or to rotate on the spot, to deliver payloads of up to 15,000 kg to within a few millimetres under remote control by an operator.

Dimensions	4.2 x 1.7 x 0.65 m
Weight	7,500 kg
Payload	15,000 kg
Positioning accuracy	± 5 mm or ± 2 mm with optical guidance



BoxJoint

BoxJoint is a fixturing solution allowing for the joining of standard box sections beams without the need for welding. Using nuts, bolts and laser cut plates, the beams are joined together through a rigid friction joint and can be used for a wide range of materials, such as steel, aluminium, fibre glass and carbon fibre. The joints come in a variety of sizes, allowing various applications from tool holding to fixturing for aerostructures.

Schunk Fixturing

IMG employ a wide range of Schunk fixturing in machining cells, including:

- Rota-S Plus 160 stationary clamping chuck, with replaceable hard and soft jaws
- Rota-S Plus 400 stationary clamping chuck, with replaceable hard and soft jaws
- KSM 90-650 multiple clamping systems, with replaceable stationary and adjustable jaws
- Kontec KSK 5A 100 5-axis self-centring vice, with replaceable clamping jaws
- Kontec KSE wedge clamping elements
- SPK 180 jaw boxes, including replaceable hard jaws

Leica AT401 and AT402

The Leica Absolute Tracker AT401 and AT402 are portable CMMs for large volume inspection and measurement. The trackers record the absolute distance to reflectors placed on the test object by time of flight which can then be compared to nominal CAD models. The AT401 and AT402 trackers can be remotely controlled wirelessly over LAN or by IR remote control which, coupled with the large measurement volume, allows very large objects can be quickly scanned without the need to reposition the tracker.

	AT401	AT402
Typical Volume	160 m	120 m
Horizontal	360°	360°
Vertical	± 145°	± 145°
Angular Resolution	0.07 arc sec	0.07 arc sec
Angular Repeatability	± 7.5 µm +3 µm/m	± 7.5 µm +3 µm/m
Angle Accuracy	± 15 µm +6 µm/m	± 15 µm +6 µm/m
Distance Resolution	± 5 µm	± 5 µm
Distance Accuracy	± 10 µm	± 10 µm
Sensor size	290/221/188 mm	258/225/477 mm
Sensor weight	7.3 kg	7.3 kg
Controller Size	250/112/63 mm	250/112/63 mm
Controller Weight	0.8 kg	0.84 kg
Temperature Range	0 to 40°C	-25 to +70°C
Relative Humidity	Max 95% non-condensing	Max 95% non-condensing
Elevation	-700 to 5500 m	-700 to 5500 m

Leica Absolute Tracker AT901 and AT960

The AT901-LR, and AT960 laser trackers are portable CMMs which allow accurate large volume tracking and inspection across large distances. The AT901 and AT960 can be paired with various T-products to give hand-held wireless probing (Leica T-Probe), hand-held contactless scanning (Leica T-Scan), and full machine control abilities (Leica T-Mac). This allows the tracking of moving objects and the collection of large quantities of high-quality data from any material, without struggling with shiny or dark surfaces.

	AT901	A960
Typical Volume	160 m	120 m
Typical Volume with other T-products	30 m	30 m
Horizontal	360°	360°
Vertical	± 45°/360°	± 145°
Angular Resolution	0.14 arc sec	0.07 arc sec
Angular Repeatability	± 7.5 µm +3 µm/m	± 7.5 µm +3 µm/m
Angle accuracy	± 15 µm +6 µm/m	± 15 µm +6 µm/m
Sensor size	620/290/240 mm	258/225/477 mm
Sensor weight	22 kg	13.8 kg
Controller Size	510/485/200 mm	249/148/59 mm
Controller Weight	17 kg	1.65 kg (approx)
Temperature Range	0 to 40°C	-25 to +40°C
Relative Humidity	10-90% non-condensing	Max 95% non-condensing
Elevation	0-3050 m	<3500 m

ATI T3 Laser Tracker

The T3 laser tracker can be used in a wide array of circumstances, from calibration to inspection, alignment to assembly; it is used wherever ultra-precise measurements are necessary. Solid and compact, the T3 is the smallest and most accurate laser tracker available. The T3 features an exclusive on-the-shaft mounted laser head, which eliminates the need for bending mirrors, whilst minimising thermally induced errors and increasing accuracy and stability.

Linear Range (Diameter)	60 m
Azimuth	± 320°
Elevation	+77°/-60°
Angular Resolution	± 0.018 arc second
Angular Accuracy	3.5 μm/m
System Resolution	0.1 μm
Tracker Weight	8.5 kg
Controller Weight	3.2 kg
Tracker Size	185 x 190 x 360 mm
Controller Size	110 x 160 x 310 mm

Laser Radar MV330/350

The MV330 offers automated non-contact measurement capability for large volume applications of up to 50 m radius. It is able to precisely measure large-scale geometry without target or probes. Enhanced digital signal processing and signal-to-noise ratio guarantee highly reliable measurement data. As a result, the MV330/350 is able to perform repeatable range measurements of composites - the material of choice for future aerospace developments. As the laser radar does not need an SMR (spherical mirrored reflector) to reflect the laser light, it has the functionality to perform a low resolution scan of a surface or area that the operator may be unable to reach.

Scan speed	Up to 4000 pts/s
Range	MV330: 1 m to 30 m (diameter 60 m range) MV350: 1 m to 50 m (diameter 100 m range)
Field of view	Azimuth: 360° Elevation: +/- 45°
3D Accuracy (2)	24 μm at 2 m 102 μm at 10 m 301 μm at 30 m
Laser	Class II

White light scanner

The Hexagon Metrology WLS400 is a manually operated white light scanner used for non-contact 3D metrology, quality inspection and digitisation. The high-intensity blue LEDs project a random pattern onto the part which is simultaneously recorded on three cameras. This pattern is analysed to reconstruct the object surface, yielding high density point clouds which can be compared against CAD or used in reverse engineering.

Probing error	25 µm
Spacing error	25 µm
Flatness error	20 µm
Plane measurement accuracy (single tile)w	25 µm
Point cloud accuracy (3x2x1 m object)	0.1 mm
Planar hole centres accuracy (3x2x1 m object)	0.15 mm
Exposure time (typical)	10 ms

ROMER Absolute Arm RA7525SE

The RA7525SE is a portable 7-axis CMM which can be equipped with a HP-L-20.8 Laser Scanner for rapid point cloud capture for inspection and reverse engineering.

Arm

Measuring range	2.5 m
Probing point repeatability	27 µm
Probing volumetric accuracy	±38 µm
Arm weight	8.5 kg
Working temperature	0 to 50 °C
Relative humidity	10 to 90 % non-condensing

Laser Scanner

Data rate	Max. 150,000 points per second
Minimum point spacing	13 µm
Probing form error	9 µm
Probing dispersion value	36 µm

Nikon K600

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Nikon Metrology's K600 is a portable optical measuring CMM which is ideal for on-site measurement that requires a large measuring volume. The system uses three CCD cameras to triangulate the position of an ergonomic handheld probe. Alternatively, the K600 can be used with Nikon's MMDx hardware (handheld or robotically mounted) to create full optical scans or point clouds.

Once calibrated, the K600 itself can be moved around and still accurately record data without the requirement for more than one set-up due to its ability to track multiple strobes. Finally, the system can also be mounted to the ceiling or wall space frame enabling a large and expandable measurement volume of up 17 m^3.

Measurement Volume	Single Point Accuracy	Volumetric Accuracy	Temperature Range
17 m^3	Up to 60 μm	Up to 90 μm	15-40 °C

Renishaw RMP600 and RMP40 Machine Probes and Measurement Tips

The RMP600 is a compact, high accuracy touch probe with radio signal transmission, offering all the benefits of automated job set-up, plus the ability to measure complex 3D part geometries on all sizes of machining centres including 5-axis machines.

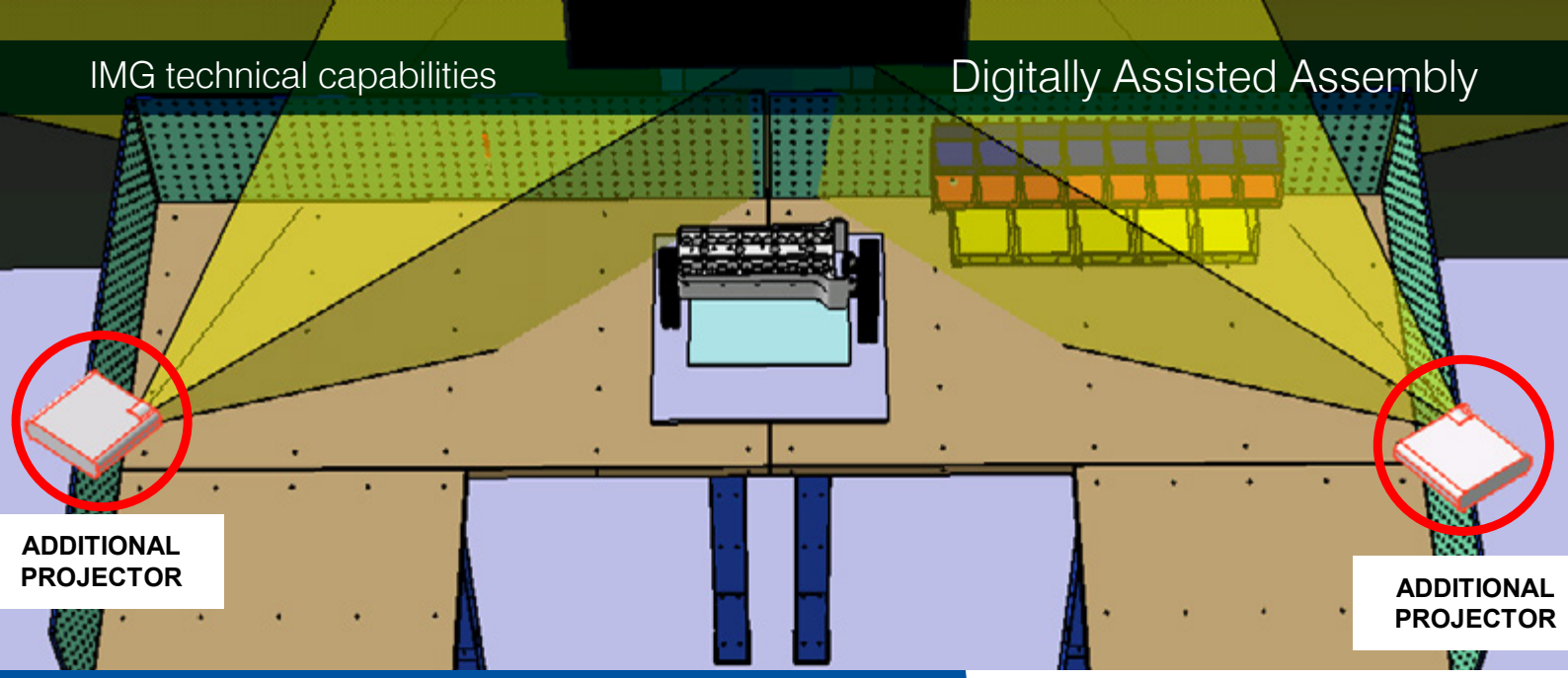
The RMP600 combines patented RENGAGE™ strain gauge technology with a unique frequency hopping radio transmission system that operates over a range of up to 15 m. The RMP600 is the most flexible, high precision machine tool radio probe in the world, and unlike other conventional probes, increased stylus lengths can be supported with no significant decrease in overall probe performance.

Whilst the RMP600 is suitable for medium to large machining centres and mill-turn centres, the RMP40 is an ultra-compact version, suitable for machines with small HSK and taper spindles.

Principal application	Workpiece inspection and job set-up on multi-tasking machines, machining centres and gantry machining centres.
Transmission type	Frequency hopping spread spectrum (FHSS) radio Radio frequency 2,400 MHz to 2,483.5 MHz.
Operating range	Up to 15 m
Recommended styli	High modulus carbon fibre, lengths 50 to 200 mm
Weight without shank	(including batteries) 1,010 g
Sense directions	±X, ±Y, +Z
2D lobing in X, Y	±0.25 µm with 50 mm stylus length ±0.25 µm with 100 mm stylus length
3D lobing in X, Y, Z	±1.00 µm with 50 mm stylus length ±1.75 µm with 100 mm stylus length
Stylus trigger force XY plane (typical minimum) +Z direction (typical minimum)	 0.20 N 1.90 N
Stylus overtravel force XY plane (typical minimum) +Z direction (typical minimum)	 2.80 N 9.80 N
Minimum probing speed	3 mm/min with auto-reset
Sealing	IPX8 (EN/IEC 60529)
Operating temperature	+5 to +50 °C

Omega Compression Load Cells

LCM401-50 and LCM401-100 Compression Load Cells are used for the measurement of applied forces in compression in one direction, for both metrology and control feedback purposes. Operating force ranges are 0-50 kg force and 0-100 kg force respectively.



Intelligent Workbench system

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The Intelligent Workbench is an IMG technology demonstrator designed to emphasise the benefits of the digitally assisted assembly methodology. Typically the system comprises multiple projectors, a monitor, a navigation device and some smart tools.

Presently the workbench is undergoing a major re-design and additional functionality is being added to augment its current capability which is:

- Gesture recognition to drive work instructions
- Zigbee connectivity to plunger and grip guns for measurement
- A maximum of 3 digital light projectors
- Laser projectors

The system is highly reconfigurable, allowing for many different types of setup depending on the required application.

LPT 10 Laser Projector

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The LPT 10 is a cost-effective and long-range light templating system. This targetless laser projector makes it possible to assist the assembly of parts by using CAD models and LPT's RayTracer software suite, to project 3D optical templates directly onto any work surface.
The system delivers a working range of 0.61 m to 12.19 m enabling a large working range with flexibility of positioning of the projectors.

Power Input	110/240 Vac 50/60 Hz
Laser Power	< 5 mW
Laser Class	3R
Laser Wavelength	532 nm (green)
Projection Distance	0.61 m to 12.19 m
Dynamic Projection Accuracy	0.25 mm
Line Width	0.5 mm
Projector Weight	25.78 kg
Projector Size (L x W x H)	717.5 mm x 404.4 mm x 174.75 mm

Projection Works
Optical Projection System

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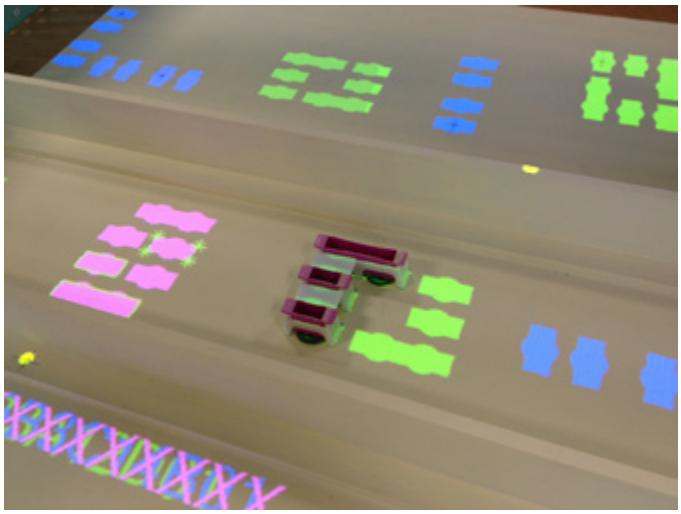
This system provides guidance and additional information to technicians and operators, by projecting assembly instructions directly onto the workpiece. The system is based around high-powered, rugged projectors that utilise interchangeable lenses, deliver high lumen output and are capable of a high number of duty cycles. Mounted beneath each projector, a ProjectorVision 3D translator uses the 3D data from the CAD model of the workpiece, together with the sensed geometry of the workpiece in relation to the projector, to calculate the correct distortions to apply to the projected image.



Dantec Dynamics Q800 NDT System

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The Dantec Dynamics Q800 system uses digital shearography, an optical non-destructive testing method, to provide fast and accurate analysis of material discontinuities. 4 75 watt heaters apply an excitation or loading to the part to be tested. As the loading is released and the part returns to its regular state, defects are identified by detecting the strain discontinuities on the part's surface using a high spec camera. This system offers an alternative solution to traditional manual ultrasonic NDT, and is ideal for thin composite and aluminium honeycomb sandwich structures.

Sick S3000 2D Safety Laser Scanners

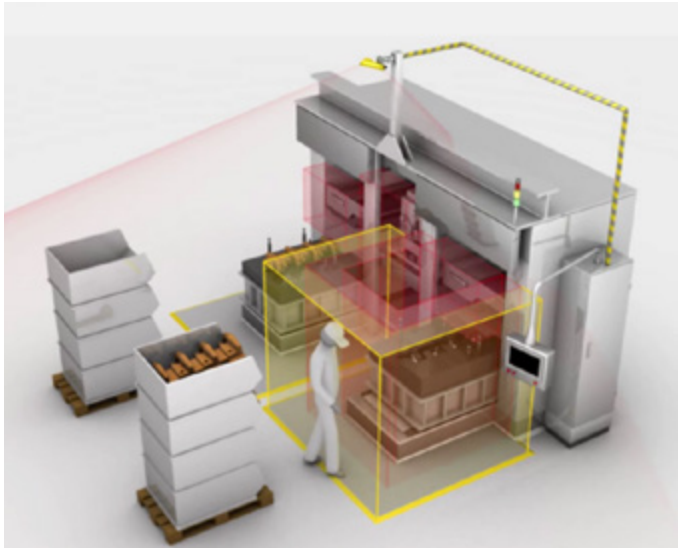
The Factory 2050 workshop floor will be made up of reconfigurable automated and robotic manufacturing and assembly cells. The safety of personnel on the workshop floor - be it staff, engineers, operators, customers, suppliers or visitors - must be monitored appropriately whilst these cells are in operation.

Floor mounted 2D safety laser scanners are installed to provide monitoring, control and protection of defined hazardous areas of 2D space.

These compact, intelligent systems scan their surroundings and measure distances by using the time-of-flight principle of measurement. The integrated rotating mirror creates a two-dimensional scan for freely defined protection areas.

The protective field is a 190° sector, extending up to 7 m from the scanner. The warning field extends out to a maximum of 49 m from the scanner. Response time is 60 ms and the resolution can be selected as 30, 40, 50, 70 or 150 mm as required.

Pilz SafetyEYE™ Safe Camera System



The SafetyEYE™ safe camera system provides 3D zone monitoring and control, by detecting and responding to objects (e.g. personnel, vehicles etc.) that encroach into defined 3D detection (amber) and 3D warning (red) zones. The system provides alerting and control responses appropriate to the type of zone violation that has been sensed.

A typical detection response would be to bring the relevant machine to a reduced speed, whereas a typical warning response would be to bring the machine to a safe standstill. Automatic restart can be programmed and the system copes well with human-robot cooperation within the detection and warning zones.

The system provides 3D body protection up to 7.5 m high operating range, with a maximum visible range (footprint) of approx. 72 m^2 in the form of a 4-sided pyramid shape. The system is capable of detecting objects down to 40 mm, with a minimum reaction time of 265 ms.

Pilz PSENopt Safety Light Curtains

Safety Light curtains with infra-red beams add rugged, reliable, and intelligent protection to machine cells, increasing the safety levels for operators and any other personnel who come into close proximity of the cell.

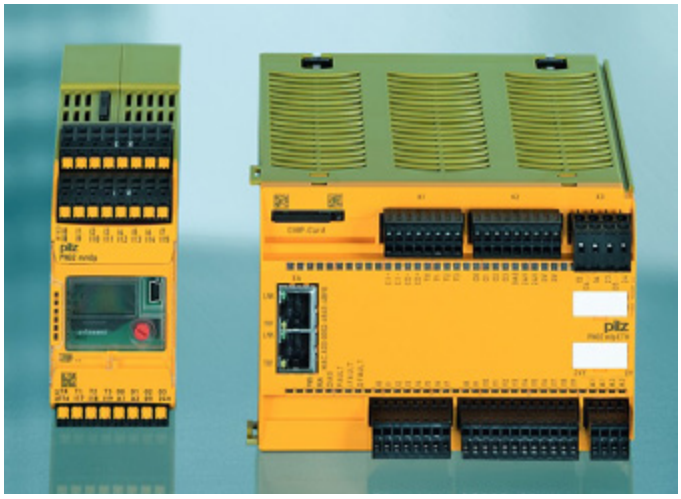
These intelligent light beam devices provide full body protection in accordance with EN/IEC 61496-1/-2, to prevent entry into cells whilst they are operating.

Pilz PNOZ Multi Safety Controllers

Dedicated Safety Controllers provide the intelligent core of flexible, re-configurable and re-usable safety systems, for use across many IMG research cells. The Pilz MP1 Safety Controllers bridge the gap between classic safety relays and programmable control systems, and consist of a base unit and various expansion modules.

The controllers accept and process inputs from a wide variety of safety sensors and devices, including:

- E-STOP pushbuttons
- Operating mode selector switches
- Enabling switches
- Two-hand buttons
- Safety gates
- Light curtains
- Light beam devices
- Speeds
- Analogue input signals
- Pressure sensitive mats



Masak VTC800/30SR

The MASAK VTC800 is a 5-axis vertical travelling column (VTC) CNC machining centre which will be used in Factory 2050 to fabricate specialist one-off components for a range of projects from materials including composites (i.e. carbon fibre, modelling block) and a variety of ferrous and non-ferrous metals (i.e. stainless steels, mild steels, aluminium and brass).

Zoller Automated Tool Setter

ZOLLER Redomatic universal presetting, measuring and heat-shrink machine has been especially designed for the heat-shrinking of tools to nominal length, while at the same time presetting and measuring tools of all kinds.

Using its automatic length adjustment device, tools can be shrunk to at least ±10 μm accuracy quickly, easily and automatically.

uPrint SE Plus 3D Printer

The 3D printer is used for rapidly creating parts and prototypes needed for conceptual modelling, functional prototyping, manufacturing tools, and end effector parts from engineering thermoplastics such as ABS.

The raw material used by the printer is available in a range of colours, so that the parts produced can easily have different coloured areas or volumes. The 3D printer uses soluble support technology, so that supporting structures generated during the creation of the part can be dissolved once the printing of the part is finished.

The minimum layer thickness is 0.254 mm and is adjustable by the user during the definition of the print job. The printer is able to process 3D CAD data in STL format generated by 3D CAD packages such as Catia.

Siemens WinCC v7.3 Shop-floor Data Capture system (SCADA)

The Siemens SCADA system is a flexible, modular, expandable data gathering system providing production analysis, remote operation/monitoring, and environmental/ power monitoring for multiple robotic cells, for aiding manufacture and demonstrating big data gathering technology.

The concept behind SCADA is to provide an initial showpiece of the data gathering technology that would be used in a modern factory, and to create a test-bed for research on the use of gathered data in innovative projects with the AMRC's partners.

SCADA operates on its own VPN and is based on Siemens technology, as used in many of the IMG cells in PLC and other control/monitoring systems.

Ubisense component tracking systems

The Ubisense component tracking system consists of networked sensors and industrial tags that will be used in Factory 2050 to track large pieces of equipment, machines and parts to within 15 cm. This information will be relayed to a networked device and used to effectively manage resources.

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