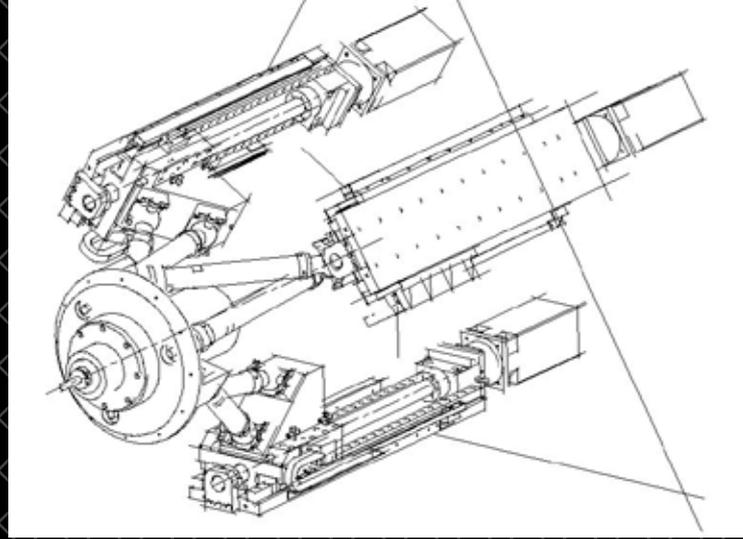




Dematerialised Manufacturing Systems



Dematerialised Manufacturing Systems

Conference Report 2013



*DEMAT is an SME-targeted
Collaborative Project funded by the
European Commission under the
Seventh Framework Programme (FP7)*

Consortium:



Dematerialised Manufacturing Systems

foreword

Dear Readers,

When we launched the DEMAT Project with our partners in July 2010, the consortium's main objective was to dematerialize the machine tools and manufacturing systems that are designed and produced in Europe. CECIMO's primary goal within the project was, by providing our companies with knowledge-based technologies including ultra-light, adaptive and 100% recyclable skeletal structures, innovative and flexible business models, and human-capital based services, to increase the European machine tool industry's sustainability and competitiveness.



We produced project results matching the needs of the European machine tool industry. The tremendous results presented for the first time at the DEMAT Conference at EMO Hannover on 20 September 2013 showed how the project lead to the advancement of the European machine tool and manufacturing industries. We are proud to share with you this report, intended as a tool to support further dissemination of these results.

I thank all the DEMAT Project partners for their contribution to this report.

A handwritten signature in blue ink, reading 'Filip Geerts'.

Filip Geerts
CECIMO Director General

inside this report:

- Page 4:** Mechatronics and process-machine approaches for designing lightweight milling machines while ensuring high productivity rates, by Juanjo Zulaika
- Page 6:** Methodologies and Tools for designing and managing Dematerialized Manufacturing Systems, by Stefania Pellegrinelli and Marcello Urgo
- Page 9:** New flexibility-oriented business models and sustainability assessment methodologies, by Giacomo Copani
- Page 11:** The DEMAT Information Sharing Platform, by Vimal Dhokia, Stephen T. Newman, Xianzhi Zhang and Aydin Nassehi
- Page 13:** Service-based business models in the machine tool building industry – Analyses of the DEMAT online survey, by Matthias Gotsch, Daniela Buschak and Angela Jäger

Mechatronics and process-machine approaches for designing lightweight milling machines while ensuring high productivity rates

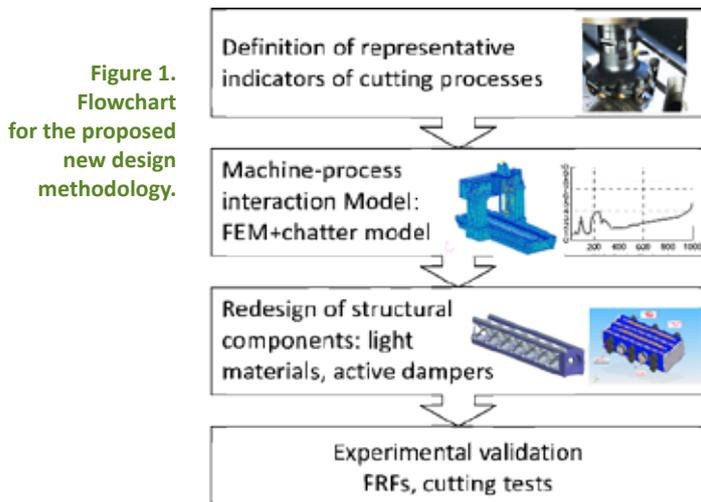


By Dr. Juanjo Zulaika, Head researcher, Tecnalia

Energy consumption is the key to the ecological impact of milling machines. One promising strategy for minimizing this energy consumption in milling machines is to reduce the mass of their mobile structural components. This solution, however, has a clear drawback: the mechanical stiffness of the machine is reduced, impairing its performance and, in the long run, its productivity. This study proposes a new methodology for overcoming such limitations, which involves the design of machine-tools with ultra-light structural components, and the development of strategies for counteracting the loss of mechanical stiffness. This methodology includes the use of modular boxes built with carbon-fibre trusses, the calculation of the dynamic stiffness of the new design, the identification of its weaknesses in terms of its cutting processes, and the design and integration of active damping systems in the machine for dampening the expected vibrations under the most critical cutting conditions.

Proposed methodology

The procedure for designing lightweight mobile machine-tool components that meet industrial needs has been structured into four steps shown in Figure 1:



As starting point, representative indicators of productivity and accuracy are defined for the new machine. These representative indicators will be translated into cutting conditions and into static and dynamic stiffness thresholds in the new design. Then a process-machine interaction model will be constructed for each of the representative machining operations. The model will be based on stability

diagrams for the representative cutting processes and FEM simulation of the machine.

With these inputs, the heaviest structural components will be redesigned, using for example lightweight, modular carbon-fibre blocks or other similar lightweight materials and structures. A minimum of mass is pursued in these mobile structural components, even though their mechanical performance will worsen with respect to conventional designs. Indeed, the reduced mechanical stiffness will be counteracted by means of active dampers that will be integrated into these lightweight components.

Application to actual industrial cases

The proposed methodology has been applied to the re-design of the ram for a Nicolas Correa EURO-2000 milling machine, shown in Figure 2.



Figure 2. View of a EURO-2000 milling machine

The new ram has completely changed the standard one; only the external geometrical dimensions are similar to the steel ram. It is based on a reticular structure of carbon-fibre bars and aluminium spherical knots, as shown in Figure 3.



Figure 3. New reticular design of the ram made of carbon-fibre bars

The new design obtains a 70.3% reduction in mass, passing from initial 370 kg to 110 kg, with also a 75% reduction in effective stiffness compared with the standard ram.

Construction of the new machine and experimental validation

Once the new ram has been manufactured, it has been mounted on the machine and a biaxial active damper has

been integrated in the ram for overcoming its vibration modes. Figure 4 shows an image of the new ram set-up in the machine.

Figure 4. Set up of the new ram in the milling machine



and in consequence, also the productivity of the machine, provided that chatter appearance is linked to the excitation of modes in that direction. In this regard, Figure 6 shows the experimental polar stability lobes that are linked to the redesigned machine, once again for the active damper switched on and off.

Figure 6 shows that the productivity of the machine is duplicated in the majority of the directions when the active damping is activated. In addition, when comparing these polar charts with the chart in grey on the left of Figure 6 (polar chart of the original machine), it can be seen that the redesigned machine has a higher productivity than the standard machines. Taking account of the 70% reduction in the weight of the ram in the new machine with almost twice the productivity, the conclusion is that its eco-efficiency has been considerably improved through the reduction of energy consumption during its use, coupled with an increase in the productivity rates of the machine.

Conclusions and future work

Figure 5 shows the FRFs of the new machine in the Y direction, both with the Active Damping Device-ADD switched on and off.

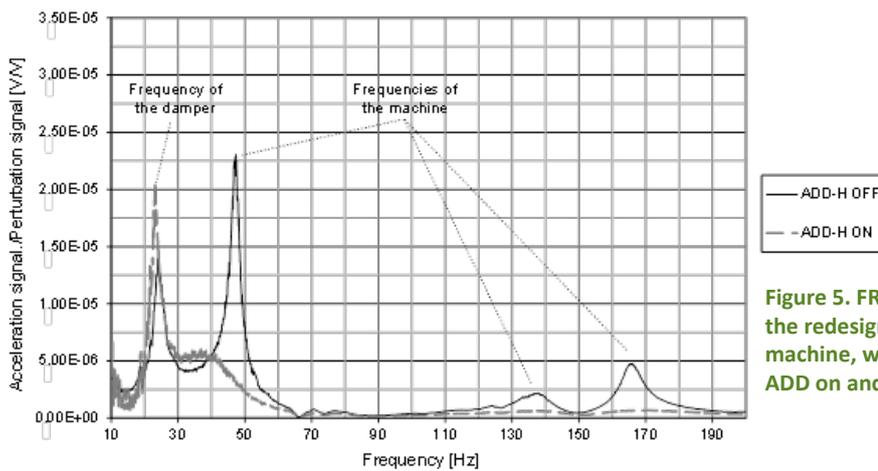


Figure 5. FRFs of the redesigned machine, with ADD on and off

This article has outlined a comprehensive methodology for the design of machine-tools, which sharply reduces their energy consumption in comparison with the standard machines in use today. This methodology has been tested

on a high-speed milling machine, achieving a 70% reduction in the weight of the ram with a comparable reduction in mechanical stiffness. In this respect, the design of an active biaxial damper has been able to counteract the effects of low stiffness on the chatter frequencies, thus maintaining and even improving the productivity rates of the machine, and consequently validating the accuracy and the use of the proposed machine tool and its underlying methodology.

FRFs in Figure 5 show that activating the Active Damper, the natural frequencies of the machine almost disappear in the Y direction. This means that the dynamic performance of the machine is dramatically improved in that direction,

This methodology will be used for redesigning new machines of Correa, with special emphasis on bridge-type milling machines, which are the most resource consuming machines.

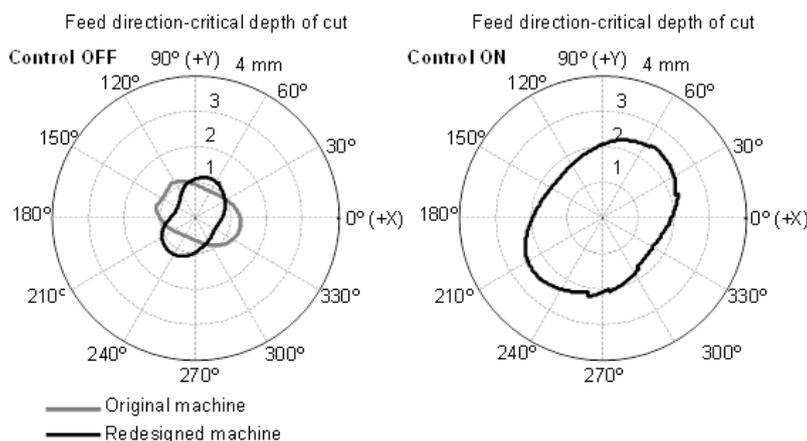


Figure 6. Effect of the active damper in the stability lobe diagrams of the redesigned machine: Left: Active damping Off; Right: Active Damping On (in grey: original machine)

Methodologies and Tools for designing and managing Dematerialized Manufacturing Systems



By Stefania Pellegrinelli, Institute of Industrial Technologies and Automation, National Research Council ITIA-CNR, Milan, Italy and Marcello Urgo, Department of Mechanical Engineering, Politecnico di Milano, Milan, Italy



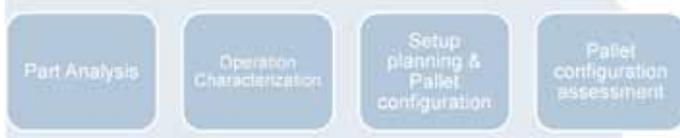
The principle of dematerialization aims at defining production system and machine tool architectures whose capabilities and level of flexibility are designed to match the production requirements. From the machine tool perspective, the dematerialization leads to the definition of a lighter machine tool structure and the obtaining of high range of performance in a limited range of process parameters. At the system level, the idea inspiring dematerialized manufacturing systems (DMS) is to define a set of machine tools and production resource able to match the production evolution of the production requirements over time.

To design and manage DMS, a two-stage approach has been developed able to generate several alternative process plans to machine a given part family and then to propose the best matching of system configuration and process plans.

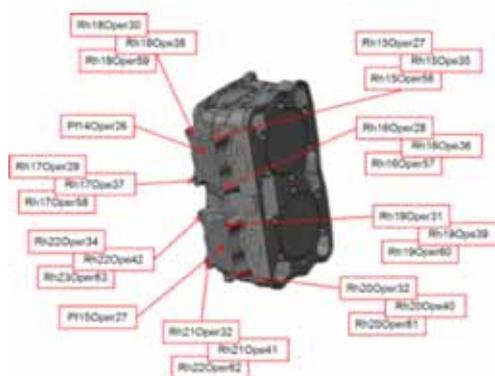
Process Planning

In order to define a process plan, the planner can exploit an ad-hoc developed software. The aim of the software is to support the process planner during the generation of process plans that are compliant to the new generation of dematerialized machine tools, thus focusing on the four main steps represented in Figure 1.

Figure 1. Process planning software architecture



As in common practice, the planner initially analyzes the family of workpieces in order to identify the operations that are necessary to completely machine the part family. The operations are defined in terms of machine parameters, strategy and cutting tool. In comparison to tradition process planning software, the employment of the here presented process planning tool allows the planner to describe the



same operation through different machine parameters, strategies or cutting tools (Figure 2).

Moreover, the planner does not have to definitively describe the whole working cycle at this stage: the software only requires the identification of technological precedence constraints among the operations in order to generate a network of operations (Figure 3). This network implicitly describes all the possible working cycle for the machining of the part while guarantying the satisfaction of manufacturing quality specifications. The planner, accordingly to his experience, has to identify two kinds of constraints: technological constraints (Figure 3) and tolerance constraints. The former represent the necessity to perform an operation before one another (e.g. roughing and finishing operation); the latter impose the machining of two operations in the same setup.

Finally, the planner identifies a set of machine tools on which the part may be executed. For each selected machine tool, the software is able to characterize the operation in terms of final product quality (i.e. surface finish quality), machine tool kinematics and dynamics compliance (i.e. spindle bearings load and tool cutter load) and machine too performance while executing the machining process (i.e. energy consumption). This information is exploited together with some data on possible fixture structure in order to generate alternative process plan in terms of workpiece setup plans and pallet configurations (Figure 4). The setup planning aims at determining the number of orientations of the workpiece in the 3D space to be completely machined. Indeed, each change in the orientation of the workpiece requires an un-mounting and re-mounting of the workpieces on the fixture, and consequently a certain time utilization and the risk of compromising the machining precision and manufacturing quality. The pallet configuration problem determines the number, disposition and mix of pieces to be clamped on

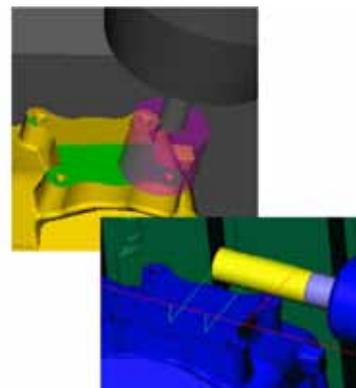
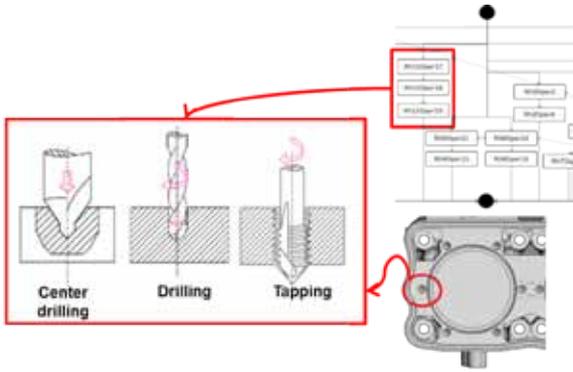


Figure 2. Workpiece operations and an example of operation alternative strategy

Figure 3. an example of technological constraints



the fixturing device of the pallet as well as part positions and orientations. While defining balanced pallet configuration, the planner will be able to choose between the minimization of the production costs (e.g. energy consumption, tool wear) or the minimization production time accordingly to his priorities.

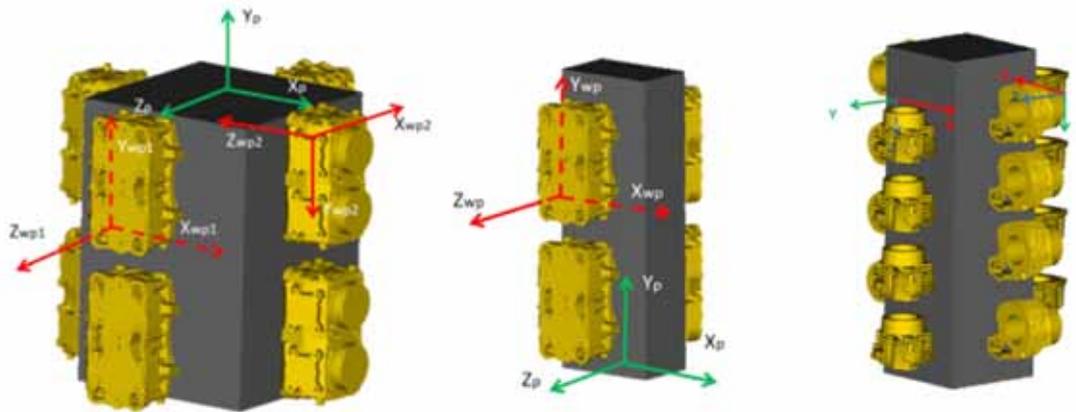


Figure 4. alternative pallet configurations

Finally, the planner can evaluate the machinability of the generated pallet configurations on the set of selected machine tools (Figure 5). Indeed, the pallet assignment to a specific shop-floor machine imply that the resource has the capability (e.g. maximum feed rate, spindle speed and power) to execute the requested operation (e.g. appropriate number of axes and working cube as well as the achievement of specific operation performance).

extremely critical in production environments characterized by frequent and uncertain changes affecting the family of products in terms of volumes and technological features. In other words, providing an optimized DMS configuration aims at cutting those capabilities that are not specifically needed and, consequently, reducing the ability of the manufacturing system to work in modified conditions.

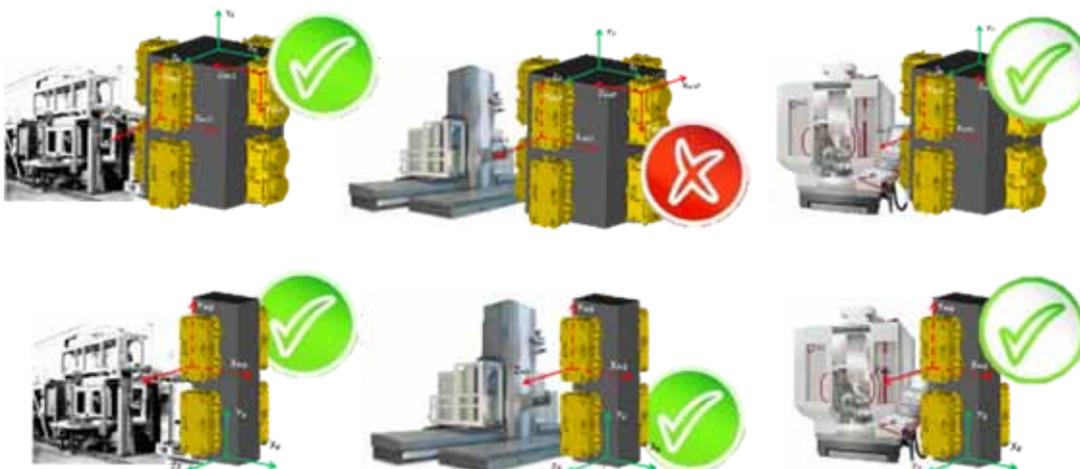


Figure 5. machinability of two pallet configurations on two selected machine tools

System Design

The configuration phase of a “Dematerialized Manufacturing System” (DMS) consists in identifying the set of resources (machines, load/unload stations, carriers) that exactly matches production requirements while minimizing investment and operational costs over time. This entails providing the system with the degree of flexibility and reconfigurability specifically needed for the addressed production requirements.

Dematerialized machines are extremely profitable from an economic perspective, since their capability is focused on a limited production domain and optimized for that.

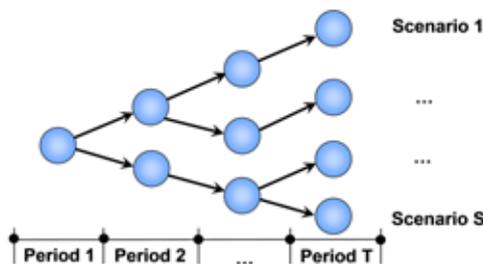
However, this also represents a source of risk. In fact, the high specialization of the machine’s design could make the impact of unforeseen changes more significant, compared to traditional manufacturing systems. This becomes

Methodologies and Tools for designing and managing Dematerialized Manufacturing Systems (continued)

To deal with this, robust configuration approaches are needed to formalize and manage uncertain and/or incomplete information.

The formalization of uncertain or incomplete information is done by means of a scenario tree representing a sequence of evolving production problems leading to a certain scenario. Each path from the root to the leaves provides a characterization of the production problem (parts, mix, volumes) and its evolution in time (Figure 6). Hence, scenarios provide a discrete model for uncertain events.

Figure 6. a scenario tree representation of uncertain events



Robust configuration approaches aim at providing robust solutions, i.e., a solution that is insensitive (at least to some degree) to the occurrence of uncertain events. And this must be accomplished taking into consideration the available information on the evolution of the production problem to be addressed, represented in the scenario tree.

Robustness can be addressed in different ways, reactive approaches aim at reacting to the occurrence of uncertain events while proactive approaches aim at protecting the performance of the system by anticipating preventative actions to manage some uncertain events.

Another class of approaches, called proactive-reactive, aims at being proactive and reactive at the same time, i.e., providing an initial system configuration addressing

the current production problem and a set of major future evolutions. But, at the same time, they also provide a reconfiguration plan to provide an adequate reaction to the occurrence of the remaining possible future events (Figure 7).

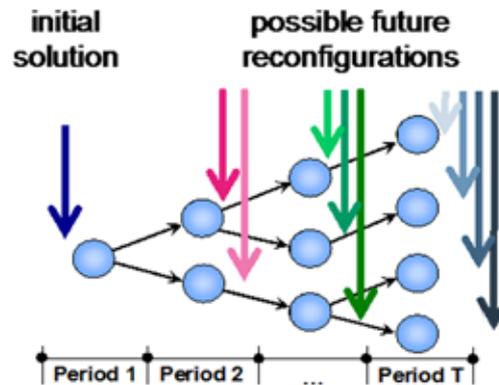


Figure 7. Proactive-reactive solution schema

Industrial Application

The viability of the proposed methodologies has been tested on an industrial case provided by Gilardoni, an Italian manufacturer of engine components (Figure 8).

The system configuration approach has provided the opportunity of selecting and comparing different near-optimal configurations having the cost function value within a certain range, together with the existing system at the Gilardoni premises. The results have demonstrated the viability of the DMS configuration approach, as well as the complexity of considering different aspects of a manufacturing plant, ranging from the technical capability to the energy consumption and the life-cycle of the system as a whole, thus highlighting the need of also addressing the relevance of the business model defining the relationship between the machine/system producer and the user.

Figure 8. Variety of Gilardoni manufactured products



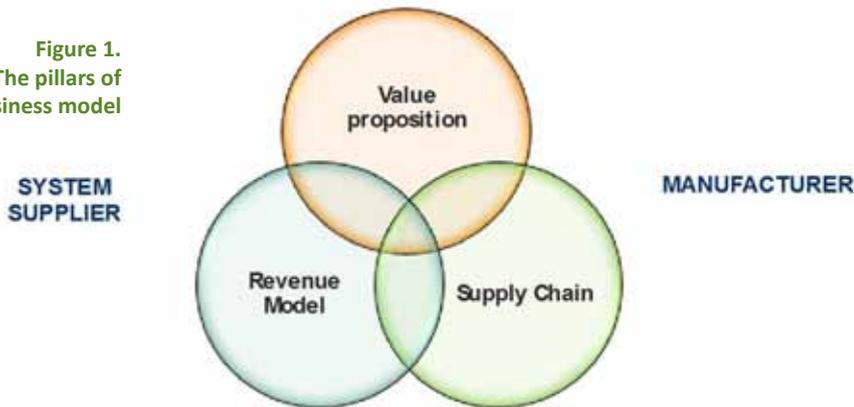
New flexibility-oriented business models and sustainability assessment methodologies

By Giacomo Copani, Institute of Industrial Technologies and Automation, National Research Council ITIA-CNR, Milan, Italy



The Business model of a company is the strategic definition of the products and services it offers, of the technologies, supply chain structure and processes through which it is able to produce and supply them, and of the financial mechanism through which it is remunerated (Figure 1).

Figure 1.
The pillars of
business model



In the last decade new service-oriented business models, i.e. business models characterised by a significant offering of value-added services, were indicated as a key factor to increase the competitiveness of manufacturing industry and of machine tools suppliers. Concepts as “Total Cost of Ownership”, “systems availability guarantee” and “Build-Operate-Own” are in fact strategic options considered by many systems suppliers willing to differentiate company’s value proposition from the suppliers and to provide additional value to their customers.

In the DEMAT project two new business concepts were conceived, aimed at increasing customers’ manufacturing competitiveness in turbulent environments where production volumes, mix and product features can change unpredictably. They are based on the concept that the system supplier is able to optimize the design and management of focused-flexibility production systems through the adoption of Dematerialized Manufacturing Systems and design tools, and offers this capability in the frame of advanced services.

The first business model, labelled “Reconfiguration guarantee business model”, foresees that system supplier tailors the flexibility level of the production system on the forecasted customer’s demand in the short-medium term, without adding extra-flexibility whose future utilization is uncertain. In addition, the supplier identifies the possible system reconfigurations that might be necessary in function of future demand scenarios and contractually states the conditions at which these reconfigurations might be available, having the customer the option to activate them if and when the market will require.

The second business model, named “Capacity guarantee business model”, implies that system supplier guarantees that the customer has always available the right production capacity and technology to manufacture what the market requires. The supplier remains the owner of the production system, maintains it, reconfigures it at own expenses when it is needed and is responsible for withdrawal. The customer does not have to take care of machinery ownership, maintenance and adaptation over time, and he pays per the capacity he uses inside a minimum and maximum contractual range of capacity that the parties agree at the beginning of the relationship. In this second business model, the supplier will completely undertake system lifecycle management responsibility, including reconfigurations, guaranteeing for the result of offering customer the right production capacity he will need in each period.

The adoption of these new business models implies a significant change in the usual machine tool companies’ business logic. In fact, in the first business model, machine builders risk would be increased due to the guarantee of future uncertain reconfiguration services at fixed price. In the second one, it would be increased for the obligation of assuring the right production capacity availability in all the phases of the contractual period. Thus, before deciding on their industrial implementation, the careful assessment of economic sustainability and potential benefits is an essential preliminary step.

Business model performance assessment is a challenging task and it is even more complicated in uncertain contexts. Very few approaches and tools were developed in the past to support this goal. Furthermore, they are based on Discounted Cash Flow methods, which are static because they oblige to make rigid initial assumptions on the events that may happen in the future and do not foresee that decisions are taken after that events happen.

For this purpose, a business model assessment methodology grounded on the event-decision tree approach was developed in the DEMAT project. It is based on a tree model in which nodes are events or decisions that can be taken after events happen, thus when the uncertainty is solved or reduced. The tree embeds all the possible event-decision alternatives that can be forecasted with assigned probabilities. Discounted cash flows are associated to

New flexibility-oriented business models and sustainability assessment methodologies (continued)

each branch of the tree and, “folding back” the tree by choosing the decision routes that lead to optimal results in each phase and weighing the discounted cash flows with the occurrence probability in each branch, it is possible to estimate the overall expected value of the business models and its volatility, too. The advantages of this method are that it values the flexibility by stating that the best decisions are taken while information on events is available; it decomposes the assessment period in smaller periods where a more accurate risk estimation can be addressed; it estimates the variability of returns in case different events happen over time. Thus, its application can offer a precious source of information supporting business model decisions in a intuitive way for industrial managers.

The new methodology was applied in a real customer-supplier industrial scenario in the automotive industry (Figures 2 & 3).

Figure 2.

The event/decision tree model of the industrial scenario (circles=events; rectangles=decisions; BM=Business Model; D= Demand; p=probability; R= Reconfiguration)

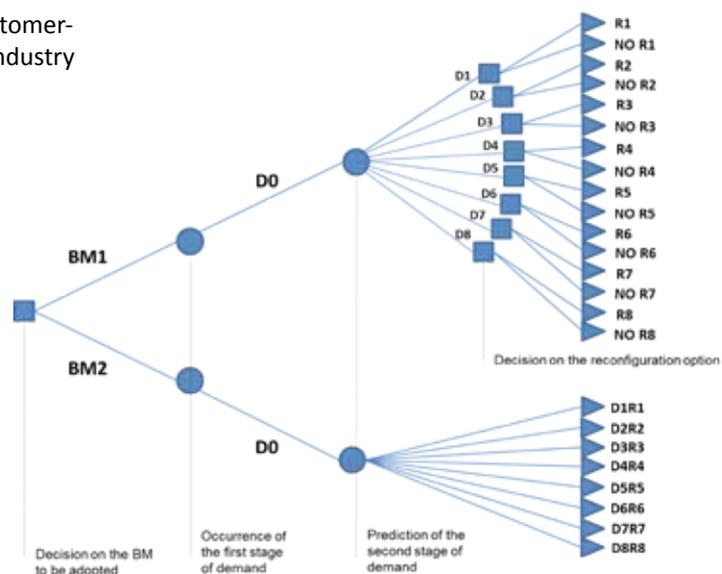
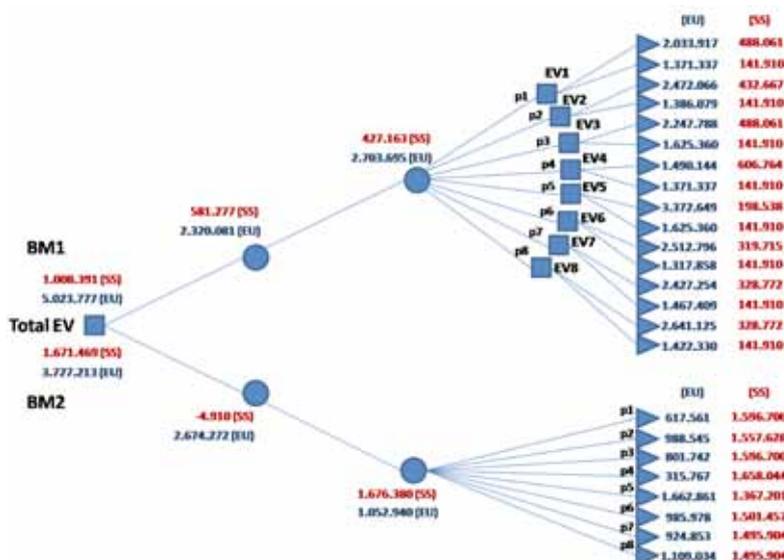


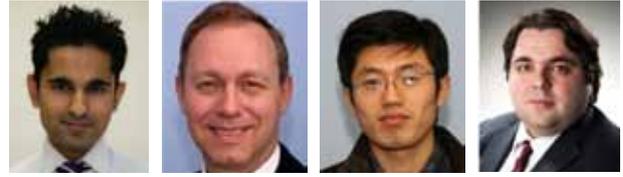
Figure 3.

Customer and supplier solved tree with input data provided by the two parties (SS=System Supplier; EU=End User; EV= Expected Value)



The DEMAT Information Sharing Platform

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Computer Numerical Controlled machining is considered to be a critical manufacturing process for the vast majority of the manufacturing sector and without which precision engineering would not be possible. As industry has progressed, the CNC machine tool has evolved, however in terms of core design consisting of a robust heavy rigid sand cast structure, axis positioned in a serial fashion and boxed carcass, the design configurations have remained relatively static. Machine tools have remained this way ever since the first machine tools were developed at the beginning of the 20th century.

The developments can be attributed to an evolutionary change rather than a revolutionary change. With the sustainable agenda becoming increasingly important in today's modern energy conscious society, new methods of manufacture are required. Machine tools traditionally consist of a serial structural frame, with a fully cast bed for isolation of vibrations and to provide structural rigidity. However, with the increasing use of sophisticated control and software, coupled with state of the art drive mechanisms, an opportunity is emerging to design next generation, modular, reconfigurable and sustainable machine tools, which consist of elements and components with significantly reduced mass.

Machine tools at present are designed based on pre-defined specifications which are often rigid and do not allow for design flexibility. This can be detrimental, as the machine tool cannot be reconfigured for different applications and uses. The development of modular machine tools using skeletal structures is enabling a new machine tool vision, which allows the user to adapt machines to their production and product based requirements, facilitating a move towards customised and personalised manufacture. However, with increased levels of customisation and flexibility, the amount of information increases substantially. Representing the resources of a flexible customisable machine tool is key in developing a coherent and logical data model that can demonstrate the attributes of the different machine tool resources and enable a dematerialised machine tool being realised.

The proposed approach

In order to realise a dematerialised machine tool vision a new method is required to capture the information of a

machine tool. In addition, this information does not simply consist of the machine tool components, but provides a new way in which to capture, store and reuse machine tool information throughout its complete lifecycle. This process is termed the information-sharing platform (ISP). The purpose of the ISP is to capture, store and manage specific component data and designed machine tool information. The following text will describe the ISP in greater detail.

The Information sharing platform

The quantity of data related to a machine tool is potentially large. In order to manage this and provide a seamless method and process in which to design customer specific DEMAT machine tools, a logical data model is required. This was achieved using a universal modelling language (UML) approach. A snap shot of the machine tool data model is presented below in figure 1, showing different machine tool components and their inherent attributes and relation to a global machine tool structure. The data model was used as the base architecture to develop the DEMAT

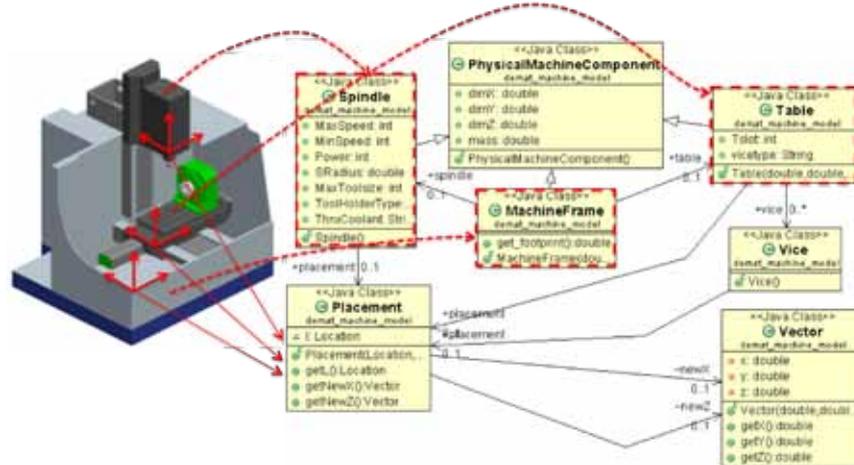


Figure 1. Snap shot of the DEMAT data model

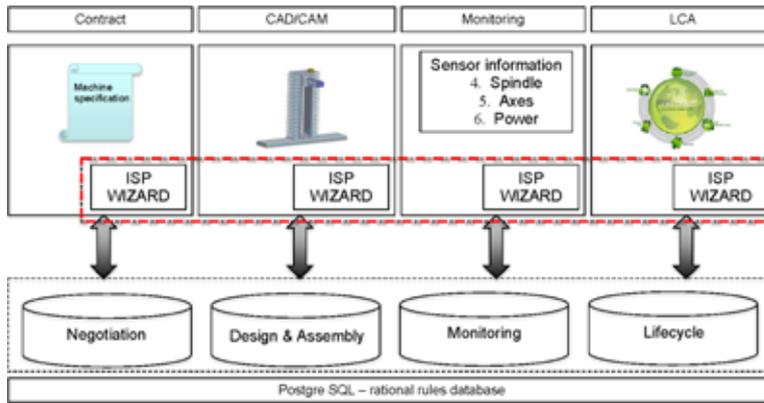
ISP, which is detailed in the next section. In particular this was used to inform the negotiation, design and assembly phases.

Design of the ISP

The ISP architecture is based on four interconnecting databases namely negotiation, design & assembly, monitoring and lifecycle assessment. The purpose of the ISP is to sit across these databases and allow the manufacturers to generate the customer specific machine tool. In addition, the design and manufactured machine tool can be monitored throughout its lifecycle in the form of

The DEMAT Information Sharing Platform (continued)

Figure 2.
Information sharing Platform (ISP) functionality



component cycle hours. This will provide increased levels of component data to the manufacturer, who can then update their future machine tool designs. Moreover, this can serve as a digital logbook of a particular machine tool so that it is maintained correctly and to the optimum manufacturers recommended standards. Figure 2 illustrates the ISP functionality consisting of the four defined areas. The different databases are designed and implemented using a rational rules database, namely, PostGRE SQL.

Prototype ISP development

The initial ISP prototype was developed to demonstrate the systems functionality. Figure 3 depicts the prototype ISP interface. In this particular screen shot the design phase is activated. This enables the user to pick their required machine tool components from a predefined list, which is held in the design and assembly databases. By selecting components and adding to the live design on the left, a tree structure of the machine tool can be created and updated accordingly. The

total cost of the machine tool can be calculated based on the various different machine tool element and component selections. This cost is continuously updated to provide a real time cost to the manufacturer and customer.

Conclusions and future work

This article has outlined the development and design of an information-sharing platform prototype system to allow designers and manufacturers to produce customer specific machine tools using a specific set of machine tool components. In addition it has provided a new vision of continuously monitoring machine tool components, with the aim of generating machine specific digital logbooks. This approach will be fully tested using a specific DEMAT machine tool. The future ISP vision will also encompass a computer aided design machine tool builder environment allowing designers and customers to visualise their specific machine tool during the negotiation and design phases, as depicted in figure 4.

The development of dematerialised machine tools is a radical new way to envisage the future of a significantly important manufacturing resource. This article has prescribed and demonstrated the different information constructs that are required for enabling a more customer specific machine tool being realised, using an enriched design environment.

Figure 3.
Prototype ISP interface

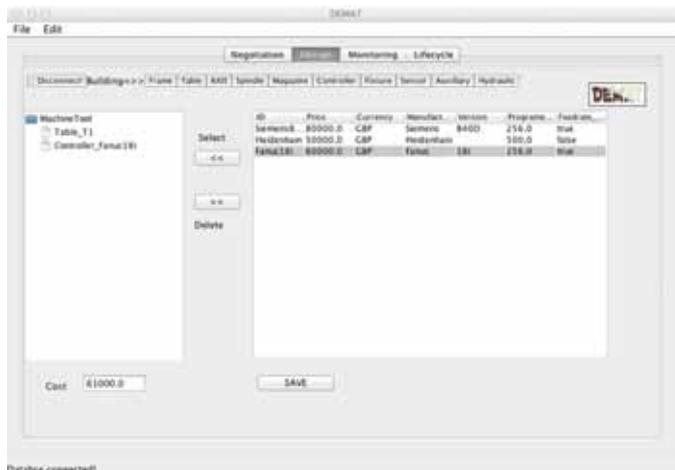
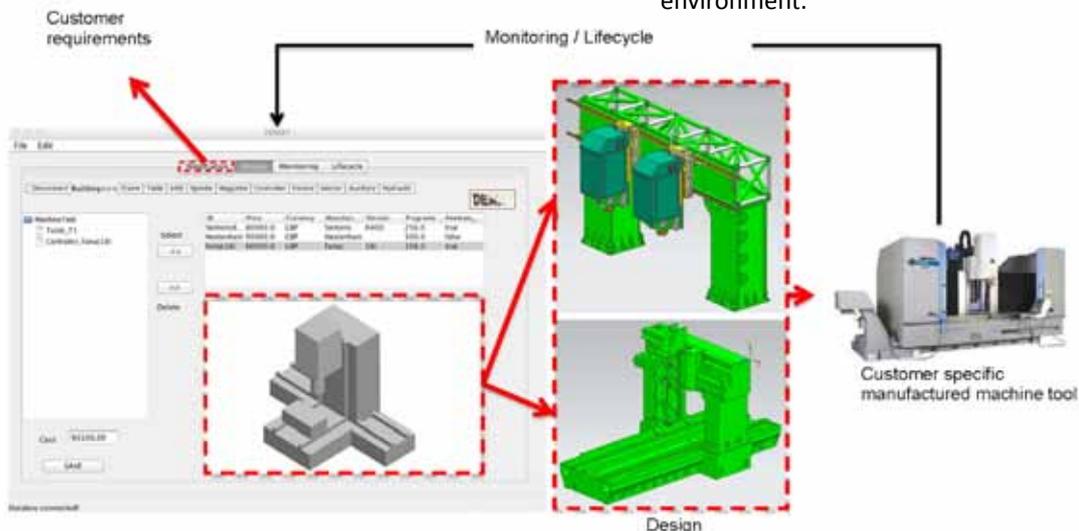


Figure 4.
The Information sharing platform future vision



Service-based business models in the machine tool building industry – Analyses of the DEMAT online survey

By Matthias Gotsch, Daniela Buschak and Angela Jäger
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Competence Center Industrial and Service Innovations



European machine tool builders (MTB) are facing competition from emerging countries in a situation shaped by the economic crisis. New business models with a stronger service orientation can be regarded as one way to react to the upcoming competition and future challenges. The peculiarity of new service-oriented business models is the turning away from selling the machine tool only. Instead the use of the machine tool or the result of operating the machine tool is offered.

Existing service-oriented business models in industrial practice can be divided into two concepts:

- Availability-oriented services which guarantee specific availability levels for the machine tools which are agreed with the client in advance and upon which the performance fee is determined, and
- Operational Services/Contract manufacturing (also termed Build-Operate-Own-Concepts) which include the offer to take over the production of parts for the machine tool customer.
- An emerging new type of service-oriented business models are flexibility-oriented services:
- Flexibility-oriented services which include the design, building and selling of a manufacturing system with a focus on flexibility, which means that the provider foresees and guarantees future reconfigurations of the machine and is paid at a fixed price in advance.

Against the background of the importance of industrial services as competitive factor for European MTBs the question arises to what extent individual industrial services as well as these new service-oriented business models are offered by European MTBs. We try to answer these questions by analyzing data of an online survey conducted in 2012 among the members of the European machine tool association CECIMO.

Offer of individual industrial services

Nearly all of the respondents offer at least one industrial service complementing the machine tools sold. The most frequently provided services are repairs and maintenance on request (94 %), installation and commissioning (93 %), retrofit/ modernization (80 %), remote maintenance (78 %), reconfiguration/ reconstruction (64 %), process optimization for clients (61 %), comprehensive service contracts (49 %), condition monitoring (33 %), rental of machines

(17 %) and other services (30 %). Overall, 99 % of the companies offered at least one of these industrial services. The analyses showed a high frequency of traditional services such as repair and maintenance and installation. However, comprehensive service contracts are offered by nearly half of the companies. The analyses confirm the high service orientation of European manufacturers.

Offer of service-oriented business models

For analyzing the distribution of new business models, participants were asked if they offer one of the three concepts by themselves (see Figure 1, “own company”) or if they know another company which offer these services (see Figure 1, “other company known”).

It seems remarkable, that nearly two-thirds of the companies know at least one other company which offers availability-oriented services and even about half provide it on their own. In contrast, operational services are only offered by a quarter of the respondents. Flexibility-oriented services are offered approximately by a quarter of the firms polled, which shows that there still is a huge potential for business models built on flexibility guarantees. While flexibility-oriented services are widely offered, we assume that only a certain number of those companies take full responsibility for the result in monetary terms. While availability guarantees and operational services are already being intensively investigated, flexibility-oriented business models are an emerging field for analysis in the manufacturing industry. The value proposed in these flexibility-oriented business models is to guard the customer against the dynamically changing environment. Flexibility in these models requires that the MTB is able to support customers at any time to have available the right production capacity to satisfy market demand, which might change in terms of features and volumes. The basis for calculating the revenue of the flexibility-oriented model is the additional value provided for customers by optimizing system flexibility design and guaranteeing the availability of manufacturing capacity accordingly.

Interesting insights can be won by combining the offered industrial services with the more comprehensive service-based business models. The comparison who is offering the different industrial services shows that most of the rather basic services, like installation and commissioning or repair and maintenance on request, are particularly offered by

Service-based business models in the machine tool building industry - Analyses of the DEMAT online survey (continued)

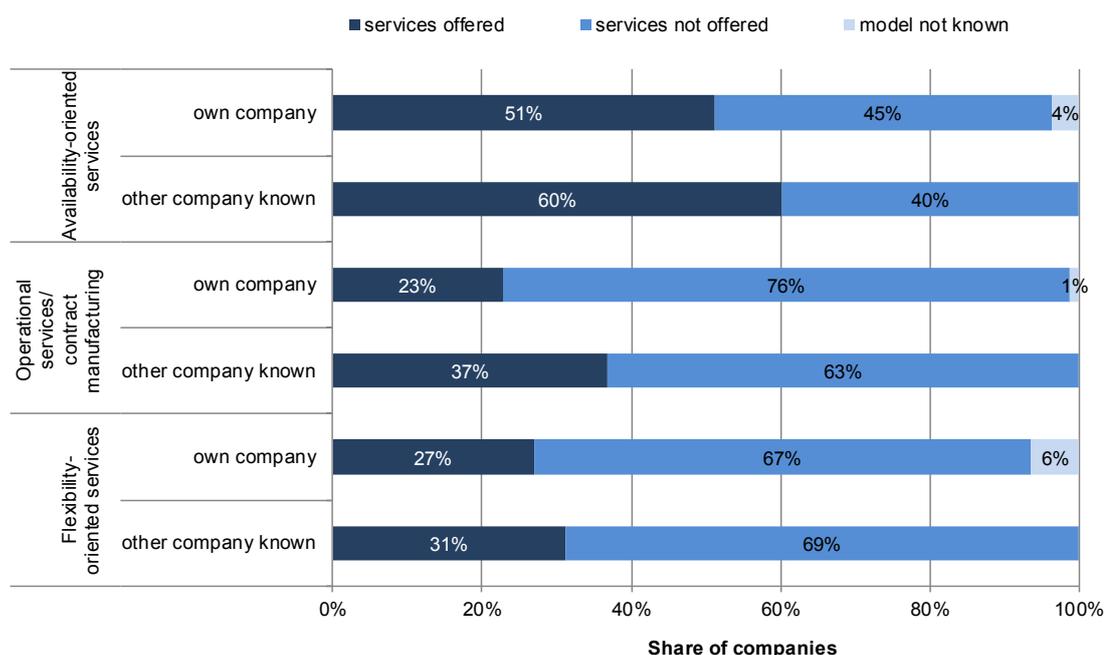


Figure 1. Offering of service-based business models

Source: DEMAT survey on machine tool industry 2012, n=80.

companies without flexibility-oriented services. In contrast to this, more comprehensive services, like process optimization, reconfigurations and reconstructions, condition monitoring or comprehensive service contracts, are offered to a greater extent by companies with flexibility guarantees. These kinds of industrial services seem to play an important role and may act as a precondition for the potential offer of flexibility-oriented services, which can help to support MTBs when facing new competition.

Data

Data was collected in the second half of 2012 among the members of the Euro-pean machine tool association CECIMO. The data covers a wide range of MTBs from different European countries. 110 respondents filled in the questionnaire; 24 used the English version, 11 the French, 35 the German, 27

the Italian, and 13 the Spanish version. Due to the survey frame the data does not provide any statistically representative picture; the sampling and addressing procedures did not provide a common probability to participate. However, the framework of the survey provides a broad coverage of the population and therefore a basis for statements about the group of MTBs in Europe. The main characteristics of the companies surveyed can be summarized as follows: Small (19 %) and medium-sized enterprises (33 %), as well as larger companies (48 %) are represented in the data. The survey includes companies which deliver their machine tools to a wide range of sectors as e.g. machinery and equipment, defence technology, space and aviation industry, automotive industry, producers of railway, cars or ships, medical instruments, precision mechanics and optics, metal working, and electrical engineering.

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Member Associations:

Austria: FMMI

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France: SYMOP

French Association for Manufacturing Technologies
www.symop.com/fr

Germany: VDW

Verein Deutscher Werkzeugmaschinenfabriken e.V.
www.vdw.de

Italy: UCIMU - SISTEMI PER PRODURRE

Associazione dei costruttori Italiani di macchine utensili robot e automazione
www.ucimu.it

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cecimo is the European Association of the Machine Tool Industries. We bring together 15 national Associations of Machine Tool Builders, which represent approximately 1500 industrial enterprises in Europe*, over 80% of which are SMEs. CECIMO covers 98% of total Machine Tool production in Europe and about one third worldwide. It accounts for almost 150,000 employees and a turnover of nearly €22 billion in 2012. More than three quarters of CECIMO production is shipped abroad, whereas half of it is exported outside Europe*. For more information visit www.cecimo.eu

*Europe = EU + EFTA + Turkey

