INNOVATIVE PROCESSES FOR COLLABORATIVE ENGINEERING IN THE AERO ENGINE INDUSTRY

Heinz Knittel, Martin Albers
MTU Aero Engines GmbH
Dachauer Strasse 665
80995 München

Abstract

Innovative development processes are key to the competitiveness of individual companies in the engine industry and to their future relative positions in the value chain. The market characteristics of the engine industry are presented. Based on market requirements, innovative approaches to engineering processes—portal concept and interactive visualization—are shown taking the GP7000 program as an example.

Breakdown

1. INTRODUCTION

As products go, engines have reached an elevated technical level. Still, to maintain their competitive viability, engine makers will have to keep developing their products. Engine efficiency (specific fuel consumption) is the primary object of optimization, but improvements on emission behavior (exhaust gas, noise level) and life are increasingly coming to the fore. All of these goals must be achieved at reduced up-front and ownership costs and reduced time to market.

2. CHARACTERISTICS AND TRENDS IN THE AIRCRAFT AND ENGINE MARKET:

The commercial aviation market trend is derived from the passenger kilometers flown. In the long term, a continuous growth trend on the order of 4 - 5% annually becomes apparent. This growth is still predicted also medium-term. Overlying the long-term market trend are intervening singular events. These cause declines in revenue passenger kilometers on the approximate order of 10%. Such events are typified by the breakout of the Gulf War in 1991 and the terrorist attacks of Sept. 11, 2001. Following closely on the heels of such events are notable shifts in new aircraft and associated engine orders. The long life of the products, in combination with the short-term parking and/or disposal of fleet capacities, triggers, at a moderate decline in logged passenger kilometers, a significant drop-off in new sales. The cyclical nature of the market compels companies to flexibly adjust their industrial resources and hence corporate business processes (Fig. 1).

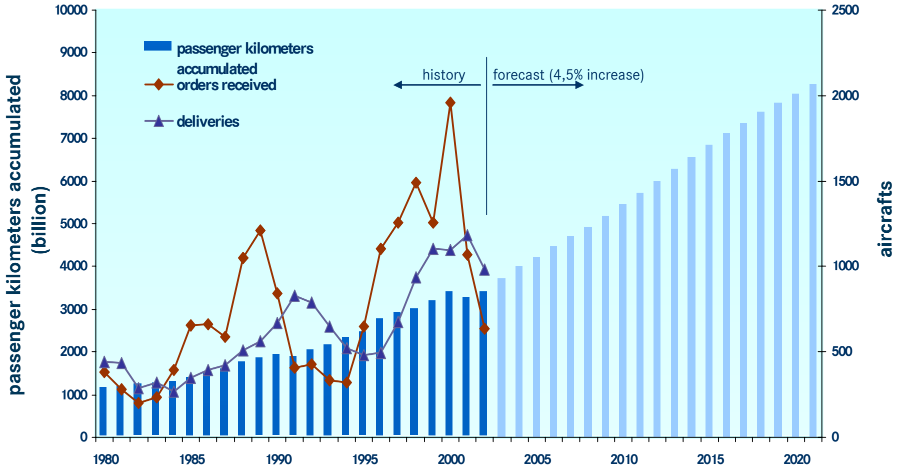

Fig.1: The market cycle: Heavy swings call for flexibility on the part of industry

Being high-tech products, engines require a great deal of development and investment. Because quantities are moderate, compared with other technologically sophisticated industrial products in say the automotive or home electronics sectors, payback periods of 15-25 years in the later phases of the product life cycle result. Normally, engines remain in production over periods in excess of 25 years, undergoing modifications and adjustments in the process (Fig. 2).

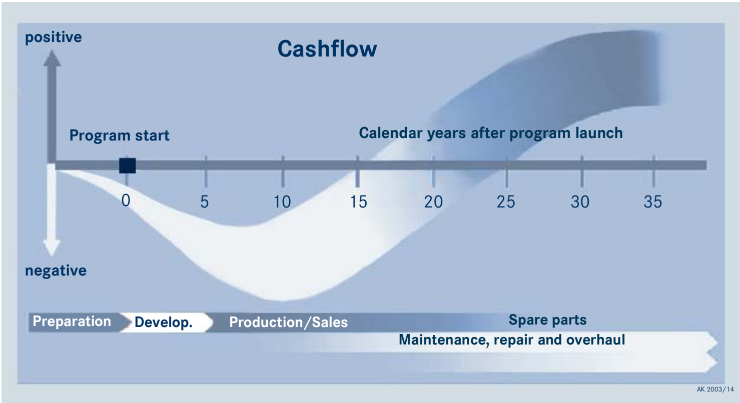

Fig. 2: Cash flow periods in the commercial business: late break-even point calls for extensive risk spreading.

To minimize risks and raise the necessary resources, engines are being developed and produced in global cooperative ventures. Such cooperations, formerly limited to traditional supplier roles, increasingly involve long-term risk and revenue sharing partnerships (Fig. 3).

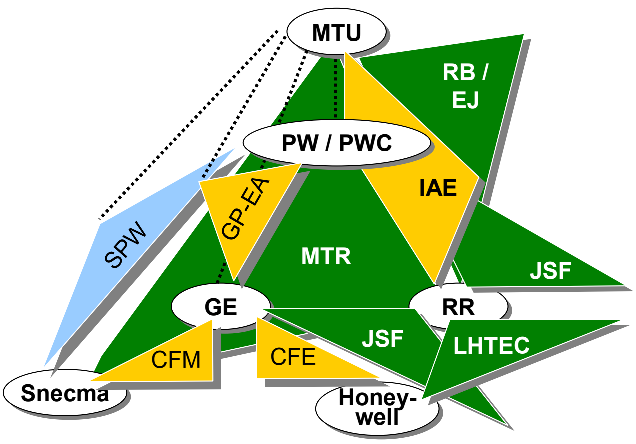

Fig. 3: The need to spread risks leads to complex partnership structures on engine programs.

For engine companies, here exemplified by MTU Aero Engines, this results in internationalization involving subsidiaries and joint ventures (Fig. 4).

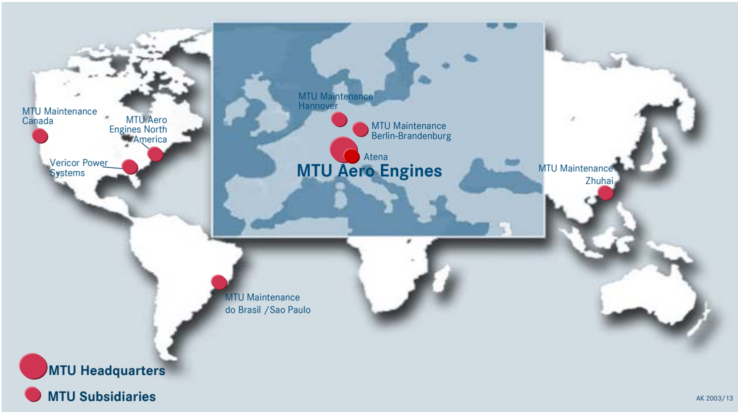

Fig. 4: MTU Aero Engines with its affiliates and global joint venture partners

To remain competitively viable long-term, engineering processes must continuously be adapted to suit changing requirements.

3. REQUIREMENTS FOR ENGINEERING PROCESSES

3.1 Definition of engineering process – major aspects

In accordance with DIN EN ISO 8402, a process is defined as a set of interrelated resources and activities which transform inputs into outputs. These resources may include personnel, finance, facilities, equipment, techniques and methods. In accordance with DIN Standard 19222, a process is defined as the entirety of interactive transactions within a system which transform, transport or save matter, energy or information. Engineering processes break down into the following components: competences and resources, methods, IT/engineering tools (software and hardware), information/product data and organization/workflow.

Future engineering processes will have to facilitate efficient development processes for use in global cooperative ventures. Partners in a program will continue to specialize in components or subcomponents and/or specific engineering know-how. Specialization and risk spreading in individual programs will result in growing outsourcing rates in the development area (Fig. 5). In this area, a trend will be replicated that in manufacturing has already become commonplace.

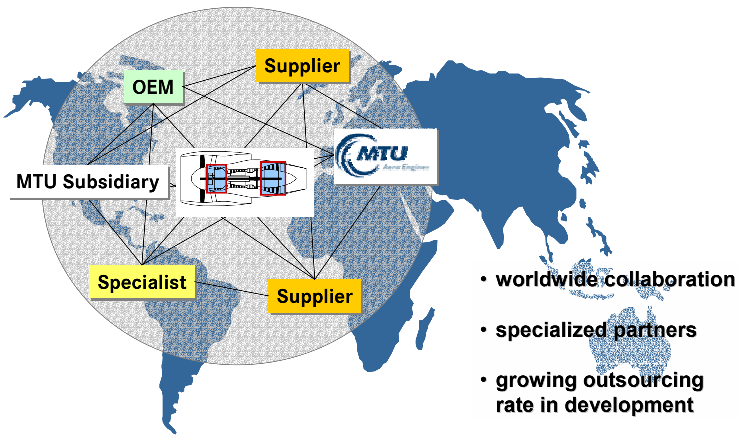

Fig. 5: Future development processes: scenario of collaborative network

Optimization of engineering processes requires an integral interdisciplinary approach that cuts across the lines of technical disciplines (engineering, computer science), social science disciplines (ergonomics, sociology, psychology), economics and jurisprudence.

3.2 Innovative approaches

On the GP7000 program—where a GE-P&W alliance operates as the OEM—MTU is a tier 1 supplier responsible for the development and manufacture of the turbine center frame and low-pressure turbine and the manufacture of liners and high-pressure turbine components (Fig. 6).

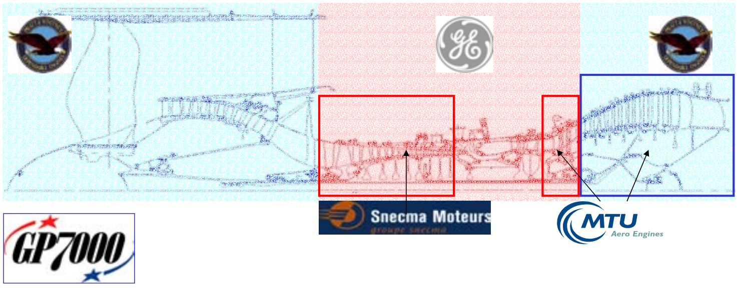

Fig. 6: Worksharing in the GP7000 program (OEM and tier 1 supplier)

Worksharing requires the exchange of data and information with OEMs and moreover close coordination with a plurality of partners and suppliers. This holds true for development (Fig. 7) and manufacturing (Fig. 8) alike.

Fig. 7: Worksharing in GP7000 development

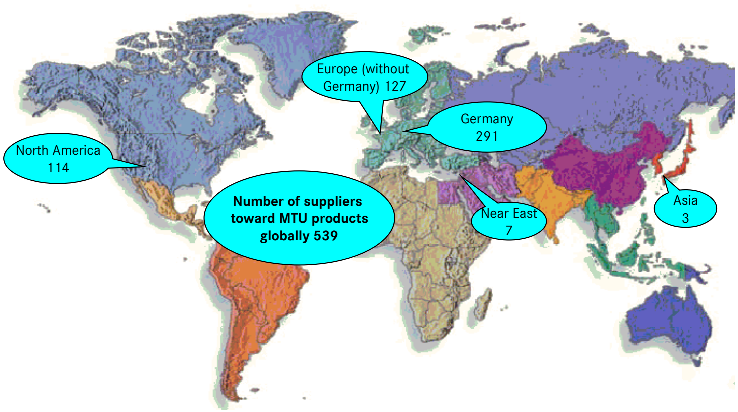

Fig. 8: Global production sourcing by MTU

Engineering processes are increasingly intermeshed among the various locations of a company as well as among partners in long-term cooperative ventures and temporary development alliances.
Workshares in such development alliances are restructured and so are the roles and structures of participating partners. To achieve efficiency improvements, consideration must be given to the effects of time differences (depending on geographical distances between locations), to diverse economic and legal (national) constraints, to the roles and responsibilities among the participating companies and institutions and to the intercultural appreciation of participants in the process design effort. Of paramount significance also is the ability of the CAx systems (both as closed processes with uniform data bases between CAD and CAE tools and between CAx systems of different manufacturers) to interact with each other. From the industrial users' standpoint, a need exists for cross-industry approaches that move away from proprietary systems and toward uniform, standardized interfaces; otherwise, the engineering partners and service providers cannot be cross-linked short-term or the linkage between them is embarrassed by substantial additional costs and aggravated error rates caused when several proprietary systems are operated in parallel.
Two innovative approaches offering solutions to the problem are the portal concept and interactive visualization.

3.2.1 Portal concept

Enterprise Application Integration (EAI) sets the stage for the process-oriented integration of application systems and data in heterogenous IT environments. EAI provides the automated exchange, also across corporate boundaries, of relevant information in a standardized format and context that is understood by all applications involved [1, 2].
EAI, accordingly, also provides a homebase for portals. A portal provides a single point of access to any number of resources including applications, information, secure interactions, communication tools and personalized content [3]. The architecture of a portal is largely determined by the company's business processes and integration into the corporate structure. The portal software provides the technical framework for the implementation of collaborative Internet-based applications. This includes functions like
structure management (management of the portal's content structure),
layout management,
content management (basic management of contents),
integration (interfaces for the incorporation and integration of systems),
security (management of rights and roles),
personalization (target group- and user-specific adaptation of portal contents and structures),
search (across diverse (integrated) data bases),
single sign-on (one-time log-on to all integrated systems through the portal), and
process support (implementation of enterprise-specific processes in the portal (outside the backend systems) [4].
For the GP7000 project, the OEM (P&W) has set up a project portal that is being hosted by an outside service provider.

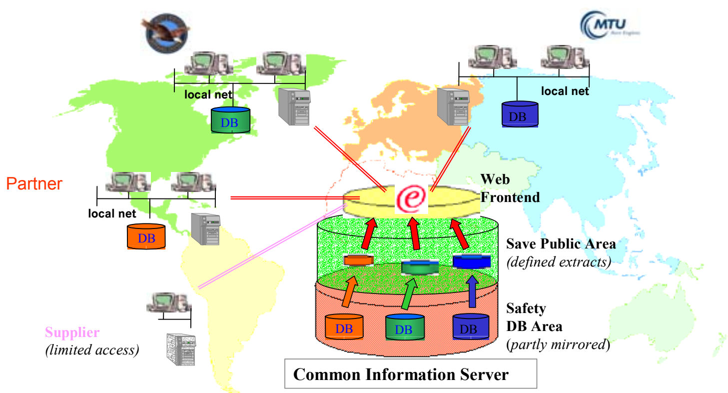

Fig. 9: GP7000 project portal

On the project portal, the participating partners are centrally posting all definitive documents (coordination memos, project plans, engineering documents). Access privileges to this data reflect the individual roles of the participating companies and of the staff within the companies.

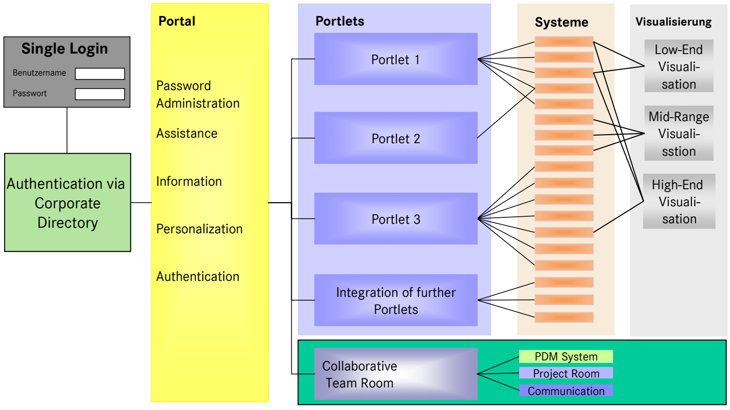

Fig. 10: Basic engineering portal concept

The engineering portal is to support all major engineering process activities on a single platform. It enables, also when the system environments are heterogeneous, uniform data filing and access control to be achieved across various platforms. The allocation of specific user privileges (referred to individual users, user groups and individual documents) permits uniform data filing to be extended also to cooperation across company lines. Multiple data maintenance and all the problems associated with it, therefore, can thus be prevented. The systematic allocation of version numbers for all data/documents moreover makes sure all staff are made aware of the currency of the data relevant for them.

The integration of PDM and CAD systems, as well as the selected CAE tools, is to support essential engineering processes both inside and across company lines. The functionality of the portal will not remain limited to data maintenance and exchange but will also support the workflow between the participating partners. In an initial configuration, the office functions and moreover the PDM systems and CAD systems are integrated into the portal. The use of the EDS Teamcenter system, can so provide continuity with the major partners in the cooperative effort. To exploit the potential of continuous flow processes, moreover, cooperation must be ensured also where system environments are heterogeneous. This is a topic pursued in current research efforts (potential approach together with DaimlerChrysler R&T)
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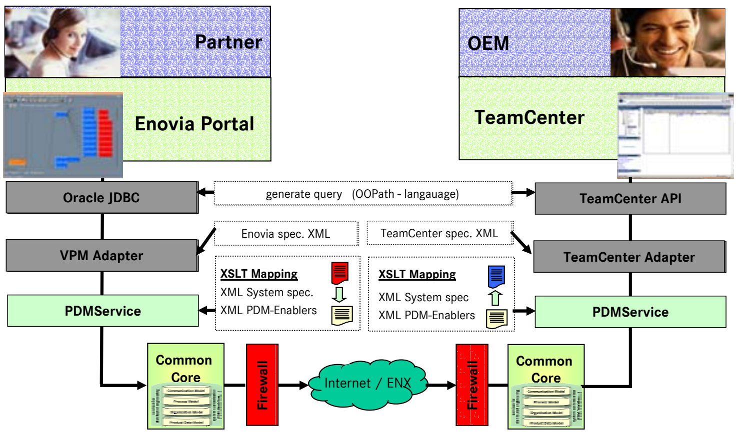


Fig. 11: PDM coupling of heterogeneous PDM systems

3.2.2 Innovative technologies to sustain data analysis and interactive visualization

In engine development, design processes are characterized by multiply linked and closely timed individual processes. In process analysis, the three major components--cooperation, communication and IT infrastructure--are evaluated. Analysis of communication under the blade design process (Fig. 12) reveals varying degrees of interaction among the various disciplines and areas [5].

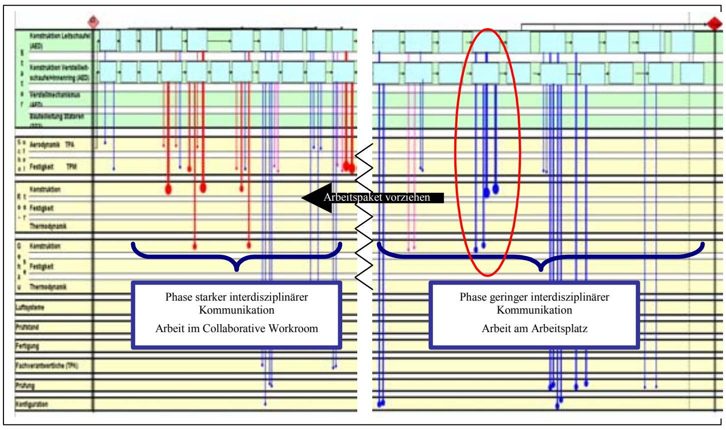


Fig. 12: Analysis of communication within the blade design process

In order to present complex technical results in individual disciplines and among them, interactive visualization is an essential factor in the attempt to improve efficiency both on teams and virtual teams and in cooperation among distributed workplaces.

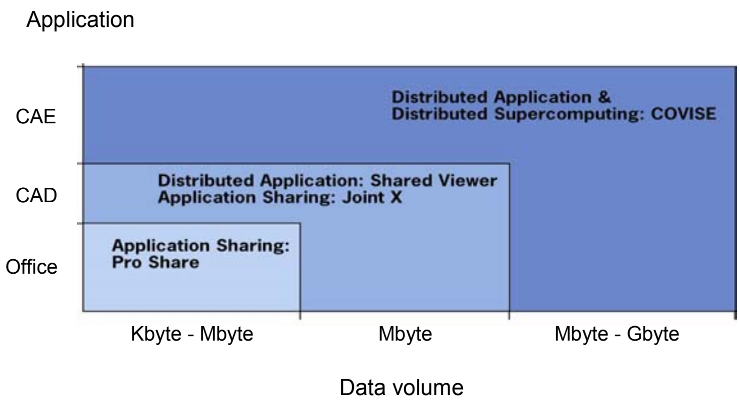


Fig. 13: Classification of user applications for visualization purposes

The scope of resulting data largely determines the application possibilities of interactive visualization, depending on the required computer power and data transfer options. Essentially, three different categories can be defined (Fig. 13) [6]:

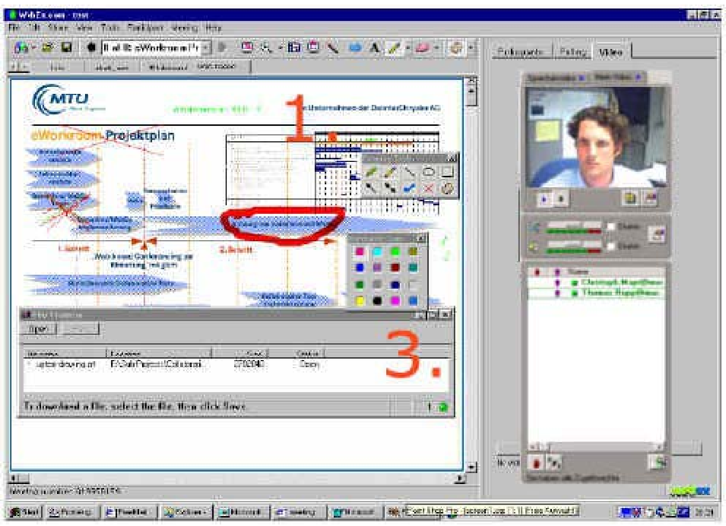
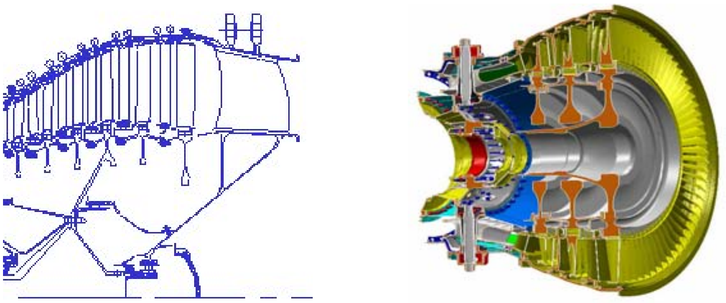


Fig. 14: Desktop conferencing: screenshot of Sametime

1. Application sharing for office applications (webex, sametime, Sun-Forum) is a basic tool for cooperation among regionally distributed project staff. Central. software-supported aids are desktop conferencing systems with their core functions of acoustic contact, visual contact, attendance list, chatroom, whiteboard and viewing. Pilot implementation of the desktop conferencing core functions reveals that their use can appreciably improve cooperation between two development engineers engaged in regionally distributed development work (Fig. 14).

2. Distributed Applications for Digital Mock-up (DMU) (VisMockUp): The design of adjacent components is done at different locations. Based on the three-dimensional reference model (DMU) and its visualization, modifications to the component design become readily apparent. Similarly, the effects component modifications have on adjacent components can be analyzed with the aid of fully automated test sequences (e.g. collision, kinematics) (Fig. 15).



General Arrangement 2D **Digital Mock Up 3D**

Fig. 15: Automated generation of GA (General Arrangement) and DMU (Digital Mock up) from the CAD models of the individual components

3. Distributed Applications & Distributed Supercomputing: Virtual Reality (VR) for the analysis of CFD output data

Complex three-dimensional flow phenomena can effectively and individually be analyzed with the aid of VR. The size of typical output files for visualization is around 5 GBytes. In the example shown above, the flow through a compressor rotor is being investigated. Apart from the pressure distribution (on the blade surfaces), the mach 1 isosurface is being shown (Fig. 16).

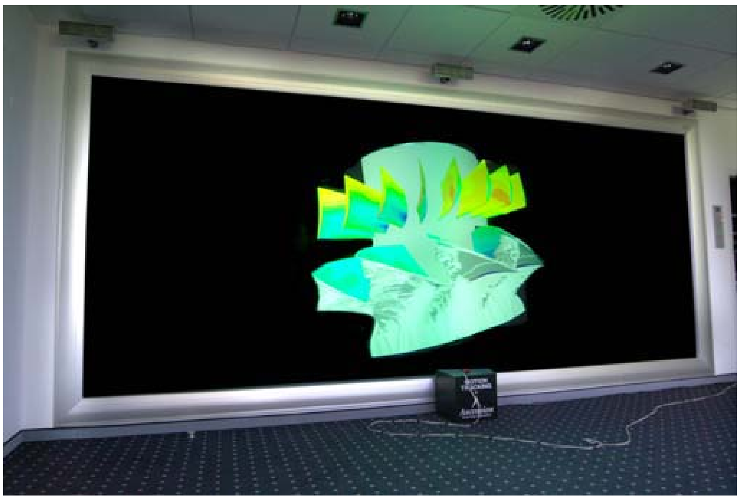


Fig. 16: Analysis of compressor rotor CFD output data

Larger teams (e.g. module teams, engineering teams and external specialists) can convene in suitably equipped team rooms at separate locations—collaborative workrooms for interdisciplinary teams—to jointly analyze and simultaneously monitor data from different locations [5]. Also, it is possible to project data from distributed locations to the other team, including such features as interactive rotation, marking and sectioning of complex 3D representations (Fig. 17).

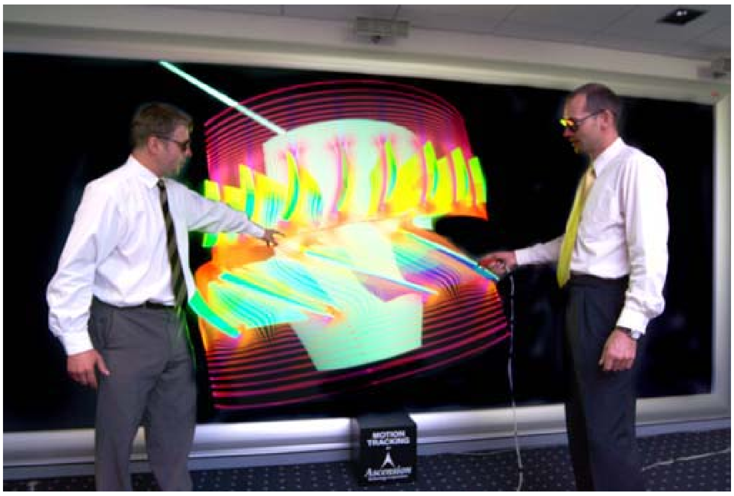


Fig. 17: Interactive data analysis using VR (Virtual Reality)

4. SUMMARY

The outsourcing quote of engineering tasks will grow.
Specialized engineering service provider will establish.
Cooperation within/between heterogeneous systems is a base competence for cooperation in networks.
Integrated and interdisciplinary processes seem necessary for successful reorientation of engineering processes; the human factor and the interaction man/machine are of central importance for successful approaches.

5. REFERENCES

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