

Supporting Distributed Engineering in the Aerospace Industry by Web-based Collaborative Applications

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Abstract

This paper reports on the process developed and applied to evaluating web-based collaborative applications that address the ever increasing demand for better and faster communication in engineering between partners and different locations within distributed industrial organisations in the aerospace industry. A three-step approach covering requirements analysis, market screening and tool ranking and filtering led to the decision for two collaborative applications that were implemented at MTU Aero Engines.

Keywords

Collaborative Engineering, Web-based Conferencing, Groupware, Computer Supported Collaborative Work, eBusiness

1 Introduction

Following the automotive industry's example [Rupp, 2001], companies in the aerospace industry have been moving more and more towards spreading their efforts in product development (engineering) and production to globally distributed partners in the supply chain while aiming to reduce co-ordination costs and shorten development and cycle times. This has led to long-term partnerships in which both the risks and the rewards of the joint efforts are shared across the entire life cycle of the products. As companies in this industry have been teaming-up in such partnerships, a particularly high degree of collaboration in production, logistics, procurement and product development has been introduced in their supply chains to gain competitive advantages and optimise profits. The new quality of collaboration has changed and increased the requirements for innovative organisational approaches and especially electronic tools that support the necessary exchange of engineering data (drawings, models and test data) and communication about the progress of work on all hierarchical levels and at any time.

2 Background and Existing Work

2.1 Distributed Engineering in the Aerospace Industry and at MTU Aero Engines

Full benefits of close collaboration within distributed engineering networks can only be achieved, if the individual companies can on the one hand asynchronously exchange engineering data (e.g. via direct links between different Product/Engineering Data Management (PDM/EDM) Systems and Engineering Portals [Karcher, Knarr, Jungkunuz, 2002]) and on the other hand communicate asynchronously and synchronously with each other about such engineering data utilising eMail software and web-based collaboration tools.

It is well understood that most of the problems during the product development phase are due to communication problems. These problems can be particularly far-reaching as 80% of the due

dates, 70% of the quality and 60% of the product costs cannot be changed easily after the termination of the engineering phase. Roughly one third of the product development costs can be attributed to avoidable changes. Ensuring high-quality communication during product development is therefore an important strategic goal [Herbst, 2000].

MTU Aero Engines - a DaimlerChrysler company and the world's fifth-largest engine manufacturer - develops and produces large modules (e.g. low pressure turbines, high pressure compressors) for civil and military aircraft engines at its Munich, Berlin (Germany) and USA locations and is the world's largest independent provider of commercial and military engine services with locations in Hannover, Germany and its at its subsidiaries and joint-ventures in China, Malaysia, Canada and Brazil. Additionally, MTU develops, manufactures and repairs industrial gas turbines. It has been the company's strategy for many years to team-up with partners (both customers such as Pratt & Whitney, General Electric and Rollce Royce) and suppliers such as Volvo Aero and Fiat Avio) in the development and production of civil engine programs such as the CF6 (Boeing 747), CFM56 (Boeing 737), V2500 (Airbus A320), PW4000 Growth (Boeing 777), GP7000 (Airbus A380), PW6000 (Airbus A318) and military engine programs such as the RB199 (Tornado), EJ200 (Eurofighter Typhoon) and the TP400 (Airbus A400M). The partnerships and supply chains vary from program to program (cf. Figure 1) so that flexibility in terms of communication and engineering data exchange is an important prerequisite for successful collaboration both within the company and beyond company borders.

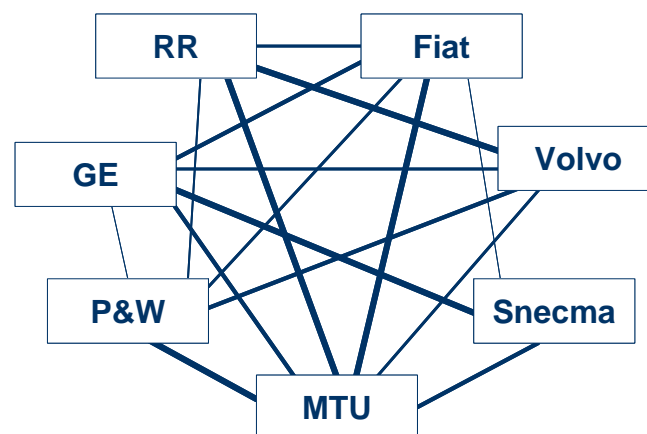


Figure 1: Co-operation Structures in the Aero Engines Field [MTU, 2003]

2.2 Web-based Collaborative Applications

Web-based collaborative applications are software tools that enable users in distributed locations to work together utilising different data exchange and communication functionalities via the Internet. The most important functionalities of such tools are summarised here.

eMail is the most widely spread computer-based communication medium. It ensures quick and uncomplicated information exchange between team members inside and outside the company.

File transfer can be performed in two different ways. On the one hand, files can be sent as attachments to eMails and on the other hand, files can be exchanged via dedicated FTP servers using the standardised file transfer protocol (FTP). Files can both be uploaded and downloaded.

Shared databases allow several users to access files on the same server simultaneously. Shared databases can be distributed for quick and transparent access of shared data.

Video conferences facilitate interactive sessions between individuals or groups wishing to collaborate from distributed locations. They allow for transmission of audio and video data and enable users to view, discuss and annotate documents synchronously.

Data conferences permit several persons to work simultaneously on a desktop representation of a product design and allow for two important features: Whiteboard Sharing and Application Sharing. The files that form the basis for whiteboard sharing are usually screenshots or 3D models. Each user can make modifications interactively using text or by sketching alterations. Application sharing permits users in distributed locations to work interactively and simultaneously in the same application (e.g. CAD system) that only needs to be installed and running on one of the connected computers. Keyboard and mouse control can be turned over to each user alternately so that all users are able to work in the application as if they were working on their own local computer.

Combined data and video conferences ensure the best common understanding during collaborative sessions and improve the efficiency of the interactive work.

2.3 Collaboration Tools

2.3.1 CAD Viewer-based Collaboration Tools

All Computer Aided Design (CAD) vendors have been providing a means for non-CAD-oriented users to view CAD data without the use of their expensive and complex CAD tools [Blomdahl, 2001]. This was done via light-weight versions of their tools or plug-ins for Web browsers. CAD viewers provided an inexpensive way to review product data created by the CAD vendor's software. The drawbacks of these tools were that no live connection for conferencing was provided and that tools could usually only be used with the file formats that the specific CAD program supports.

2.3.2 Project Management-based Collaboration Tools

Project management-based collaboration tools tended to focus on functionality such as project plans, Gantt chart creation, action items and To Do lists with calendars. These tools were also beginning to integrate the idea of collaborative product life cycle management for getting customers or suppliers more involved in the design process. They were becoming more Web-based but tended to lack any tools for improved engineering collaboration such as CAD viewing.

2.3.3 Current Tool Developments

Recently, important enhancements concerning the functionality of collaboration tools can be observed. On the one hand, collaboration tool vendors are shifting towards adding project management functionality to their CAD viewer-based and design-centric collaboration tools while making their tools truly Web-based. On the other hand, Web-based project management-focused collaboration tools have been given CAD-viewing functionality. Other current developments include the move towards more modular functionalities, combining conferencing features with engineering portal functionalities, customer-tailored licensing models and the availability of both hosted solutions and on-site installation of collaboration tools.

3 Collaboration Tool Evaluation Process

For the tool evaluation, a three-step approach was chosen (cf. Figure 2). At first, a MTU-internal requirements analysis was performed to determine the needs of the users and the MTU standards and restrictions. From this, the criteria for the ranking and filtering process were developed. In a second step, an extensive Internet research was conducted as a market screening activity and led to a longlist of collaboration tools. Finally, a ranking and filtering process left a shortlist of eligible tools that were matched with the requirement profiles to leave a tool recommendation for MTU.

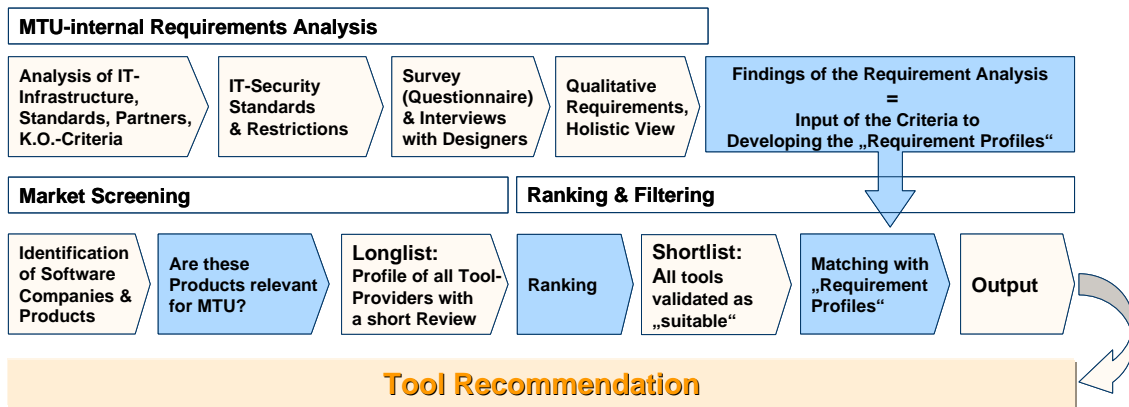


Figure 2: Collaboration Tool Evaluation Process [Steiner, 2003]

3.1 MTU-internal Requirements Analysis

In order to be able to support distributed engineering with suitable web-based collaborative applications, a thorough requirements analysis was performed. Both the general business requirements and specific user requirements were taken into account. By means of questionnaires and interviews with design engineers and IT experts from several hierarchical levels, the requirements for potential applications were derived. The most important ones are summarised here.

3.1.1 General Business Requirements

Security was identified as one of the most important business requirements. As MTU is involved in military engine programs it has very high security standards especially when communication via the Internet is concerned. A Web-based collaborative application had to be hosted in the so called Demilitarised Zone (DMZ) and the Local Area Network (LAN) had to be protected from external malicious attacks by the company's firewall. All data had to be Secure Socket Layer (SSL)-encrypted when being exchanged and when being stored on the server and collaborative sessions had to be password-protected.

Performance is critical for any web-based application. The great advantage of communicating via the Internet can easily be jeopardised when response times are unacceptably long and when the service is not available when needed.

Scalability is a very important factor and had to be ensured as the application was supposed to have the potential to be rolled-out across all MTU locations world-wide.

Ease of usage was seen as another critical factor for successful introduction of a web-based collaborative application. As the tool was going to be used not only by MTU's engineering experts but also by its management and by users from other companies, the tool had to be intuitive in usage and not too complex.

3.1.2 User-specific Requirements

This requirements analysis aimed to capture both a wide spectrum and an in-depth picture of the user-specific requirements. For this purpose, a questionnaire was developed and in-depth interviews with design engineers from different hierarchical levels were performed based on the findings from the questionnaire. The findings that had the strongest impact on the evaluation process are discussed here.

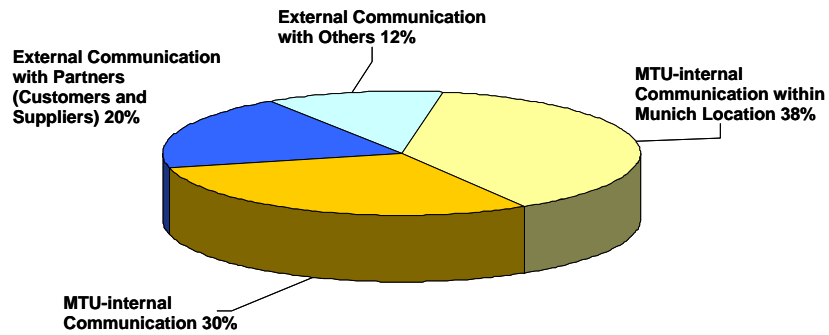


Figure 3: Distribution of Communication Partners

One of the most important findings of the requirements analysis was that two thirds of all engineering collaboration was performed with people that are external to MTU's Munich location (cf. Figure 3). A third of all communication took place within MTU. This indicated the strong need for a collaboration tool that could support the distributed character of MTU Aero Engine's development process.

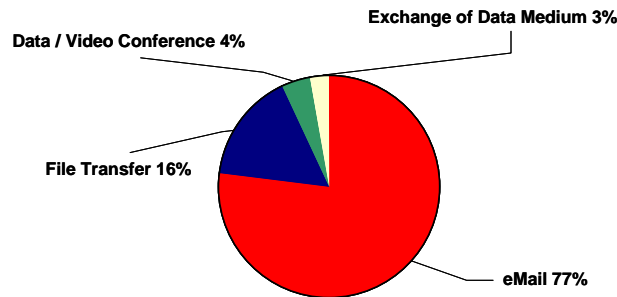


Figure 4: Distribution of Electronic Data Exchange Media

A second important finding was that virtually all engineering communication took place with the help of asynchronous collaboration tools such as eMail and file transfer (cf. Figure 4). Data and desktop conferences were hardly being used (4%) which indicated the great need for catching up in this field.

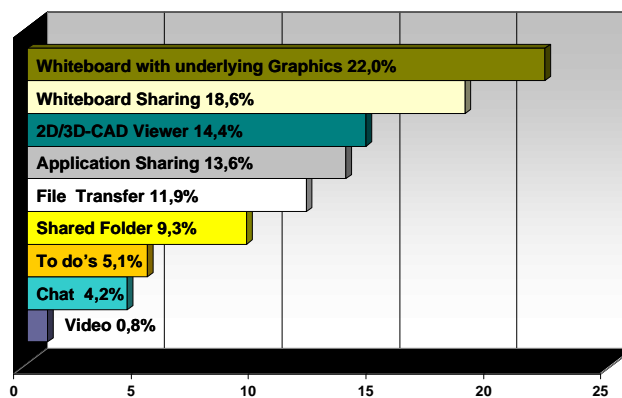


Figure 5: Functionality Requirements for Collaboration Tools (Absolutely Necessary)

The two most important findings in terms of functionality requirements for a collaborative application are shown in Figure 5 and Figure 6. Clearly, the most important functionalities for the design engineers were the whiteboard with underlying graphics, whiteboard sharing, a 2D/3D-CAD viewer and application sharing. These were the features that were named most as absolutely necessary for daily work. When asked, however, what functionality would be nice-to-have, more project management-focused features such as To do lists and a video picture were named.

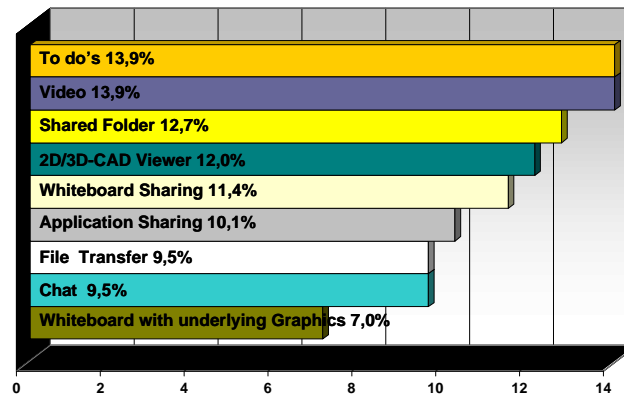


Figure 6: Functionality Requirements for Collaboration Tools (Nice-to-Have)

3.2 Requirement Profiles

The complete requirements analysis formed the basis for the development of a set of requirement profiles that intended to capture the tool usage by different hierarchical levels in MTU's engineering organisation. The requirement profiles were later used in the ranking and filtering process.

3.2.1 The Design Engineer

The design engineer works on CAD workstations and uses the collaboration tool primarily for quick queries about 2D drawing details that are copied into a whiteboard or for discussing 3D models in a CAD viewer. The possibility to engage ad-hoc into an online conference with one or two communication partners at different locations directly from his desktop is very important. Most of his communication takes place between locations within MTU's corporate LAN. However, communication to external partners should be possible as well. The necessary tools for the design engineer are the whiteboard, the CAD viewer and application sharing. High performance and security are very important while the tool can be relatively complex in its usage. Design engineers often work both on CAD workstations and on PCs.

3.2.2 The Engineering Team Leader

The engineering team leader is the interface between design engineers, other (engineering) departments and external partners. A large part of his work is concerned with managerial tasks that the collaboration tool must support. To do lists, application sharing and video are the most important features for him. The collaboration tool must be able to deal with a large number of different graphic files. The engineering team leader mostly holds scheduled online conferences from a designated conference room with up to four external communication partners but sometimes needs to start instant video conferences directly from his PC.

3.2.3 The Engineering Manager

The engineering manager is not directly involved in the design process like the design engineer and the engineering team leader. As his focus lies on managing different engineering teams he needs to be supported by a tool that provides for easy and quick video conferencing with both external partners and different locations from his desktop or from a conference room. Project management functionalities such as To Do lists are most important for him. Application sharing is only used for Microsoft Office documents from his PC.

3.3 Market Screening

The software market for engineering collaboration tools is very large as it covers the areas of groupware, Web-based conferencing, collaboration and others. The Internet research aimed to produce a longlist of collaboration tools that could be ranked and filtered in order to find a suitable tool for MTU. For this purpose, the Web sites of roughly 140 software vendors were

analysed. The collaboration tools were screened considering the following features: Security, CAD Viewing, Online Meetings, Project Management and File and Data Sharing. Additionally, the software vendors were analysed according to size, references and presence at MTU's locations.

The market screening activity left 17 tools that were ranked and filtered in the last evaluation step: Buzzsaw (Autodesk), CentraOne (Centra), Click to Meet (First Virtual Communications), E-vis (EDS), Facilitate.com (Facilitate.com), Genesys Meeting Center (Genesys Conferencing), Livelink (OpenText), NexPrise (NexPrise), OneSpace (CoCreate), PlaceWare (PlaceWare), Sametime (Lotus), Smarteam (3ds), TeamSpace (Flypaper), WebDemo (Linktivity), WebEx Meeting Center (WebEx), WebWorkZone (SiteScape) and WeMeeting (NetDIVE).

3.4 Ranking and Filtering

The tools from the longlist are not easily comparable as they all focus on a specific aspect of engineering collaboration and often have different and not comparable features. To address this difficulty, the tool functionalities were matched with the developed requirement profiles to choose the appropriate tool for MTU's engineering organisation. The findings are presented in the next section.

4 Findings

Four tools could be recommended for implementation at MTU Aero Engines: E-vis, OneSpace, Sametime and WebEx. The tools can be assigned to the three different requirements profiles as described below.

4.1 Suitable Tools for the Design Engineer and for the Engineering Team Leader

The tools suited best for the design engineer and the engineering team leader are E-vis and OneSpace. Both collaboration tools offer all necessary conferencing functionality and they both provide 2D/3D-CAD viewers for a very large number of different CAD file types. The client software can run both on CAD workstations and on PCs while they can be hosted externally in an Application Service Providing (ASP) model making no hardware investment necessary.

Sametime and WebEx are also suitable to support the design engineer and the engineering team leader as they offer all required video conferencing features. They do not offer as much design-centric functionality as E-vis and OneSpace, however, and cannot be used directly from CAD workstations, making communication between design engineers and engineering team leaders less spontaneous.

4.2 Suitable Tools for the Engineering Manager

The engineering manager is best supported by WebEx and Sametime. WebEx offers a direct integration with Microsoft Outlook - MTU's eMailing software - making meeting scheduling very user-friendly. Performance and security with Sametime are best as it can be hosted and run within MTU's LAN. Sametime is ideally suited for ad-hoc communication (instant messaging and video conferences) between PCs and for sharing Microsoft Office documents. These features make Sametime also interesting for all other MTU users who work from PCs and need to communicate quickly and easily with colleagues and external partners.

4.3 Tool Decision

The functional tool evaluation process has shown that the design-centric tools E-vis and OneSpace satisfy the requirements of the design engineer and the engineering team leader best while the engineering manager is better supported by the more project management-oriented tools Sametime and WebEx. Next to the purely functional aspects, however, also other decision criteria have to be taken into account. These are: licensing models, implementation and hosting

costs, security, performance and ease of implementation. Additionally, it is very important to consider with which external engineering partners the tools can be used. Here, the fact that Pratt & Whitney use Sametime and General Electric use WebEx to communicate with MTU and other external partners, influenced the tool decision strongly. Finally, the advantage that Sametime can be used as new means of communication by practically all MTU users at all locations had a strong effect on the tool decision. Therefore, it was decided to implement WebEx and Sametime.

4.4 Test Implementation

Both WebEx and Sametime were implemented as pilot systems and are currently being tested with design engineers, engineering team leaders and engineering management at different world-wide MTU locations and with external partners in a trial phase to gain experience with web-based collaborative applications. While WebEx was purchased as an Internet service that is hosted by WebEx and needed no hardware investment, Sametime was implemented on an own MTU server that is located in the DMZ. This brings additional advantages in terms of performance and security.

The experience from the tool implementation and initial trial phase has shown that the technical implementation difficulties - even though quite large due to MTU's extremely high security standards - were much less critical than the human reluctance to use a new technology. Here, communication and training - often several times - helped users loose their anxieties and appreciate the tool advantages. Ease of usage, high security and high performance were prerequisites that became often more important than the tool functionality itself.

5 Conclusions

This paper - being based on the findings of a diploma thesis performed at MTU Aero Engines [Steiner, 2003] - has reported on efforts in supporting distributed engineering in the aerospace industry by web-based collaborative applications. A review of the functionalities of such tools lead to an in-depth requirements analysis and tool evaluation that recommended two tools that are being tested in pilot implementations. The described work represents MTU's first steps towards utilising new-generation web-based collaborative applications to improve efficiency and speed up communication in distributed product development. Currently, a usage and performance analysis of both tools is being performed and a rollout to a much-enlarged user group is being planned.

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