STATUS OF THE CONCURRENT ENGINEERING FACILITY AT DLR BREMEN

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Abstract

Engineering processes for spacecraft design generally need much time, cost and effort due to the complexity of subsystem interaction and the challenging conditions in space. To ensure highest efficiency for system and mission design regarding quality, time and cost, the DLR-Institute of Space Systems in Bremen is currently installing a Concurrent Engineering Facility (CEF) which will be completed in autumn 2008. The facility contains 12 workstations for specialists of several disciplines and additional positions for customers, visitors and experts. The implementation of modern tools and communication technologies shall allow running the engineering and design processes efficiently. Currently the CE-process is based on the Integrated Design Model (IDM) used at ESA ESTEC's Concurrent Design Facility (CDF). In January 2008 DLR has started CE-training in a "Preliminary Design Workshop" (DWS), which is coached by the company JAQAR and ESTEC, having ten years of experience in this kind of systems engineering. The present paper gives an overview about the long-term vision and the current development status of the DLR Concurrent Engineering Facility at the Bremen DLR institute.

INTRODUCTION

A CONCURRENT DESIGN FACILITY (CDF) allows a team of space engineers and scientists from different disciplines within a short time and in a very effective manner to design complex systems and missions. There are several Concurrent Design Facilities, among others since 1994 at JPL (NASA). At ESA ESTEC a corresponding facility [Ref 1] has been established in 1998 in the frame of the General Studies Programme (GSP).

In 2004 there has been performed an international workshop [Ref 2] at ESTEC, where Concurrent Design experiences from JPL, from ESTEC as well as from ASI (Concurrent Development Environment, CODE) and from CNES (Remote Design Model, RDM) have been presented and discussed. A second Concurrent Engineering workshop took place at ESTEC in October 2006 [Ref 3].

Up to now a CDF tool is not available at DLR so far. Therefore, the intention is to establish a similar CDF at the new DLR Institute of Space Systems in Bremen, Germany, which has the central focus on Systems Engineering integrating and streamlining the DLR capacities of all DLR locations. The so called Concurrent *Engineering* Facility (CEF) would be an effective tool for these tasks. The CEF can be used on the one hand for system as well as subsystem design of transportation-, orbital- and exploration systems. On the other hand investigation concerning cost and evaluation regarding (future) space technology can be worked out in order to generate decision support for policy and programmatic.

The present paper presents the current status (Mid 2008) of the Bremen Concurrent Engineering Facility of the new DLR Institute of Space Systems, which will be a tool for internal and external users including industry from all over Europe.

THE APPROACH OF CONCURRENT ENGINEERING (CE)

The Concurrent Engineering approach generally consists of the following 5 key elements [Ref 4], which are:

- The CE-process
- An interdisciplinary team of experts
- The Integrated Design Model (IDM)
- A CE-facility
- A soft- and hardware infrastructure

These key elements are described more detailed within the next subsections.

Process Description

The Concurrent Engineering process bases on an approach which combines the advantages of the established design processes like e.g. centralized or sequential engineering [Ref 5]. It allows an efficient way of data sharing between the integrated subsystems ensured by the attendance of all discipline specialists and the utilization of a common data handling tool.

After definition of Mission and System Requirements and initial Mission Analysis the CE-process with all experts sitting in one room starts with a first configuration and estimation of mass budgets on subsystem level. This leads to a summarized overview which identifies the deviation to the desired mass target. Next tasks are either to revise the data or to define the different S/C budgets on more detailed equipment level. This depends on the conclusions of the first iteration and its analysis.

Repeating these sequences for several times will lead to different iteration steps which can be followed by the diagram of the Spiral Model in Figure 1.

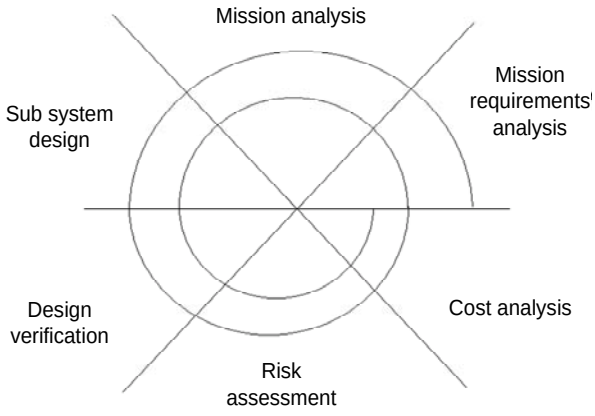

Figure 1: The Spiral Model [Ref 5]: converging design

A status requests to all disciplines, called “round table”, ensures that required data for further subsystem calculations are identified and forwarded as much as possible.

The CE-studies are a mixture of joint work in a Concurrent Engineering environment and post processing intersessions for detailed calculations and splinter meetings of the subsystem experts. At ESTEC there are two or three morning sessions during one week with study duration of several weeks. DLR currently follows the approach to condense the duration down to one week including up to four CE-sessions.

The Team

The process is moderated by a team leader who is responsible for the directed communication of the team and strategy of the engineering sessions. Furthermore, the system engineer as well as the space-specific subsystem position experts e.g. for mission analysis, thermal evaluation, spacecraft configuration, data handling, cost and risks estimation are involved in the process and attend the CEF team.

In addition to the technical and scientific executive personnel, the customer also participates in the CE-process to monitor the compliance with the requirements and to make decisions with respect to possible changes of the expected CE study results. Special experts and guests could join the team to give ad hoc comments and directions for the CE-process regarding their area of expertise.

The ESA/ESTEC Integrated Design Model

The iteration process of the study development requires an engineering model which is able to connect and update the different subsystems. This is realized by an Integrated Design Model (IDM) containing an interdisciplinary data structure and based on the application software MS Excel, for details see [Ref 5].

The discipline experts insert their calculated values regarding e.g. mass, dimensions, power consumption and temperature ranges into the IDM, which is enhanced by JAQAR [Ref 6] and used by ESTEC in the ESA-CDF for many years.

Input, calculation and output sheets of the IDM subsystem workbooks ensure a structured data management. The different output data are shared by a central data exchange workbook and then distributed to the corresponding input sheets of other workbooks. The data update has to be generated manually to avoid unnoticed changes. Figure 2 shows an example of the system output sheet layout.

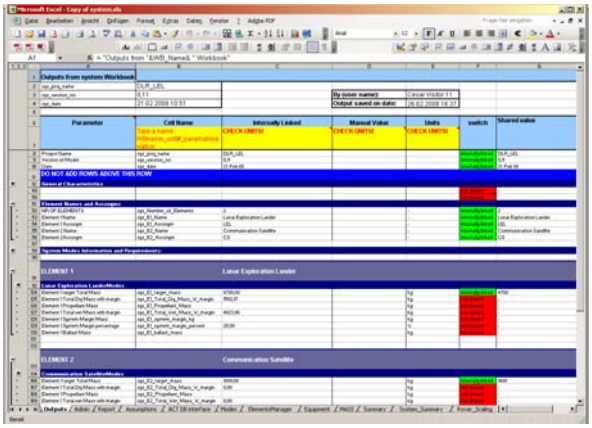

Figure 2: Layout of IDM system output sheet (ESA/ESTEC-IDM6.14)

It is possible to link values for internal calculation and external distribution automatically or manually. Furthermore, users are free to change, delete or add parameters for adapting their IDM working environment relating to the study-specific mission contents.

The CE Facility

Ideally, the facility provides one main conferencing room and some smaller rooms for splinter meetings. Additionally, there should be extra rooms available nearby for servers and technical devices, for wardrobe, toilets and breaks.

The ideal size of the main conferencing room especially depends on the size of the team. Every team member needs a working environment and a free view to the central video screens. In addition, every team member should be able to do a face-to-face discussion with all other team members. An adequate room infrastructure like furniture, air conditioning systems, preparations for wiring as well as control systems for lighting and temperature must also be considered.

The Software/Hardware Infrastructure

Beside the IDM, the software consists of some subsystem-specific applications and of software to support the operating of the CEF as well as the communication between team members.

The needed hardware for a modern CEF consists at least of:

- Server and workstations
- Networking devices
- Central video displays, speakers and corresponding media devices
- Interactive boards
- Cameras, microphones and related conferencing devices
- Miscellaneous devices like printer, visualiser, DVD/Blu-Ray Recorder

For example, the following services should be supported by the software and hardware:

- Controlling the complete media system
- Audio, video and web conferencing
- Security (authentication, authorisation, firewall)
- File and backup
- Terminal or application sharing

STATUS OF THE CEF AT DLR BREMEN

Since up to now DLR has practically no experience in the field of Concurrent Engineering, corresponding know-how from ESA ESTEC is used. The Concurrent Design Facility (CDF) at ESTEC

exists since 1998 and a lot of studies had been run there successfully.

Since End of 2007 DLR is coached on that topic by ESTEC as well as by the Dutch company JAQAR, which is the provider of the Integrated Design Model (IDM) software for the Concurrent Engineering process.

The target is to establish and to operate a similar Concurrent Engineering Facility at DLR Bremen, which is adapted to national needs. Before the complex infrastructure is functioning, which is expected for the End of 2008, training-sessions on Concurrent Engineering at ESTEC as well as at DLR Bremen are carried out.

For latter a special *Design Workshop* (DWS) has been built up, where the original software is installed and where the basic Concurrent Engineering process can be performed.

A sketch of the Design Workshop, which is used as preliminary CEF can be seen in Figure 3:

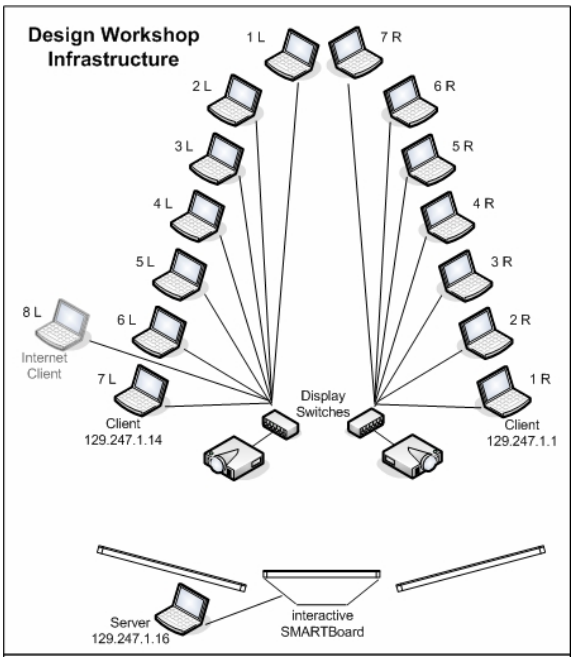

Figure 3: Sketch of Design Workshop at DLR-Bremen as preliminary Concurrent Engineering Facility

Since January 2008 this low cost facility is used for training of the *Concurrent Engineering Process* together with external specialists of other DLR-institutes from Berlin, Braunschweig as well as Oberpfaffenhofen. The CE-study team-leader and moderator, comes from the mentioned company JAQAR.

Besides a few fix installed computers in the Design Workshop it is possible to dock altogether 14 work positions (Laptops) to the system. Depending on the type of the CE-study, which can be based e.g. on Exploration, Orbital Systems, Space Transportation and more each specialist from “System” over “Thermal Control” to “Propulsion” has its own work station linked to the entire system. There are two display options (beamer) as well as one interactive SMART-Board for generating quick hand sketches or calculations during a session. A central server for CE-software handling and the possibility to switch between each position regarding calculation and visualisation of the individual work sheets enable the successful performance of the Concurrent Engineering process.

Figure 4 shows a photo taken during a one-week CE-study on the Compact Satellite project at the Design Workshop of DLR Bremen, which has been carried out in April 2008.

Figure 4: Concurrent Engineering Session on the Compact Satellite project at the Design Workshop of DLR Bremen (April 2008)

For that study depending on the subject and the day up to 22 external and internal specialists took part and made a great step forward regarding the corresponding Compact Satellite project.

Further CE-studies already performed dealt among others with exploration landing technologies.

OUTLOOK

The fully completion of the DLR Concurrent Engineering Facility in the new DLR building, see Figure 5, is planned for the end of the year 2008.

Figure 5: New Building of DLR Institute of Space Systems in Bremen

The facility is open for internal and external users as well as for industry. The first Concurrent Engineering studies in the final facility are further coached by the colleagues of JAQAR respectively ESA until the DLR staff will have enough know-how and experience for own CE-studies based on the ESTEC reference process.

In Figure 6 a sketch of the DLR Concurrent Engineering Facility with 12 special positions as well as work stations for external experts and guests is shown

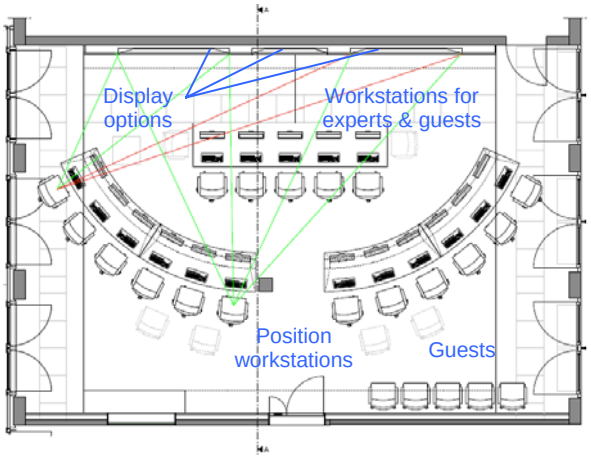

Figure 6: Sketch of Concurrent Engineering Facility of DLR Bremen with 12 special positions and work stations for external experts and guests.

ACKNOWLEDGEMENT

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[Ref 6] http://www.j-cds.nl/