

The Space Suppliers And Manufacturer Database to Support Concurrent Engineering Sessions at DLR

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Abstract

Concurrent Engineering is a modern and effective discipline of the systems engineering process. During Concurrent Engineering sessions, an interdisciplinary team negotiates optimal configurations of the intended space system. The Space Suppliers And Manufacturers (SSAM) database was created with the goal to support engineers during the design process. The CE engineer can search through SSAM by using an interface to specify the right subsystem or component resulting in a list of companies with each listing including the company profile as well as available product sheets. The Java based system consists of seven main subsystem categories (e.g. structure, power, thermal, etc.) and 61 component categories (e.g. batteries, solar cells, reaction wheels, patch antennas, etc.). Over 200 companies are currently listed with over thousands of different products related to space industry. Long-term scope of SSAM is the active involvement of the space industry (the supplier side). Here, the companies shall be animated to maintain their product portfolio via an online portal and add new products once they are introduced to the market. So CE engineers and project teams have always the latest update on the available subsystems and products.

1. INTRODUCTION

When designing a (Pre-) Phase-A space system or mission, subsystem engineers need access to a component database providing them with initial information regarding the parts they plan to use. This usually involves resorting to products the engineer has already used before or demands searching through catalogues from space related companies. While the former limits the range, so that a mission-depending/conform optimal choice might not be made, the latter takes a lot of time and effort. Especially in a Concurrent Engineering scenario [Ref 1], where specialists from different disciplines sit together to design space systems simultaneously, information regarding components needs to be on-hand and easily accessible.

This paper presents the software solution, which was developed during a student internship, for the described problem including:

- a description of the CE process
- the classification of related subsystems and the categorization of product groups
- the initial, Microsoft Access based solution
- the advanced Java and MySQL based successor, enabling access via web-browser
- the questionnaire with which companies were contacted
- an outlook for future improvements

2. CONCURRENT ENGINEERING

Spacecraft Design is an iterative process which generally needs 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, Germany, com-

pleted the build up of its *Concurrent Engineering Facility* (CEF) in early 2009. The installation contains 20 work stations for specialists of several disciplines and additional positions for customers, visitors and experts. The implementation of modern tools and communication technologies allows running the engineering and design processes efficiently.

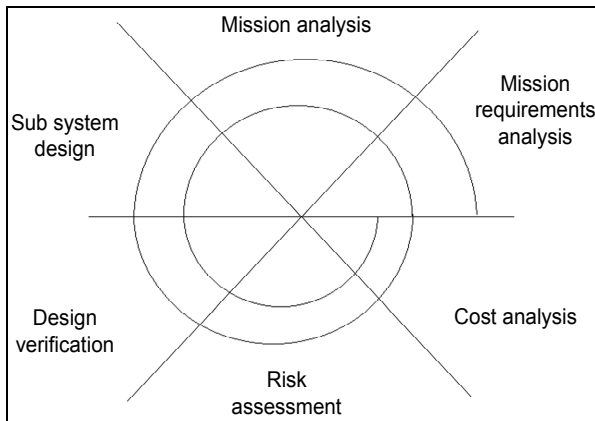


Fig. 1: The Spiral Model [Ref 1]: converging design

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 (compare Fig. 1). 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. Presently the process as well as the corresponding software is extended and adapted to the special conditions of DLR.

3. SCOPE OF SOFTWARE

As already stated the given task was to support the engineer during the CE stu-

dy, described in chapter 2, by making required information easier accessible to accelerate the design process.

In this case the basic idea was to establish a “who delivers what”-directory of space companies. The most obvious information needed of a company is its address as well as the webpage and contact-data like the telephone number and contact-person. In the case of space technologies it is also important to know what a company is specialized on.

As the database was set to concentrate on space related hardware, software solutions are not implemented so far. Other exclusions include:

- Payloads/Instruments
- Human Spaceflight Equipment
- Consulting Services
- Exploration Technologies

As a final requirement, the software had to provide datasheets for company portfolios - if available - to enable direct access to the information the user is looking for.

3.1 System Analysis

In analogy to the different engineering-fields of feasibility-studies, the following categories of specialization were defined during a workshop-meeting at DLR Bremen:

Structure/Mechanism

- | | |
|-------------------------|------------------------------|
| - Mechanisms | - Primary Structure |
| - Separation Mechanisms | - MS ¹ “Aircraft” |
| - Al Material | - MS “Military” |
| - Ti Material | - MS “Space” |
| - Composite Material | - Analysis |
| - Design | |

Thermal

- | | |
|--------------------------|--------------|
| - Multi Layer Insulation | - Radiators |
| - Phase Change Devices | - Coolers |
| - Thermal Control Units | - Coldplates |

¹ MS : Military Standard

- Heat Reservoirs
- Design
- Heatpipes
- Analysis

Data Handling

- Telemetry En-/Decoders
- FPGA Programming
- Core Avionics - SW
- Core Avionics - HW
- Board Production
- HMS/Sensors
- Data Storage
- Plates/Interfaces
- Board Computers

AOCS

- Propulsion Control Units
- Fuelling System
- Trimming Systems
- Piping Systems
- GPS
- Thrusters
- Star Sensors
- Sun Sensors
- Magnetic Coils
- Magnetometers
- Gyro Units
- Reaction Wheels

Propulsion

- Tanks
- Pipe Lines
- Thrusters (or constituent)
- Propulsion Control Unit
- P/A² Pressure Systems
- Valves
- LIQUID
- SOLID
- ELECTRICAL

Power

- Batteries (NiH2/Li)
- Solar Cells
- Solar Arrays
- Harness
- Power Control & Distrib. Units

Communication (TM/TC)

- Antennas (S- / X-Band)
- High Power Amplifiers
- Transmitters

Ground Station Equipment

- Ground Station Antennas
- Communication Equipment
- EGS Equipment
- Baseband Modulator

Categorizations may always miss certain elements or fail detailing them enough thus additional "Others" and "References / Comments"-fields for each subsystem are intended to cover these cases.

4. SCOPA - THE MS ACCESS BASED SOLUTION

The original program - called SCoPa (**S**pace **C**omponent **P**arts) - was devel-

oped using Microsoft Access³. Access, a database management system, is part of Microsoft's Office Suite and therefore installed on DLR Bremen's Windows-based computers. The big advantage of Access is that it offers an easy way to design a graphical user-interface by providing basic elements like text-fields, check-boxes and buttons. Using these, a form was designed translating the afore described data-model. The following examples give an impression of how the SCoPa MS Access solution looks like (includes German denotations):

Fig. 2: SCoPa Logo & Company Info

Fig. 3: Power Subsystem Category

Fig. 2 and Fig. 3 depict the information for the selected company while Fig. 4

² P/A : Passive/Active

³ Microsoft Access, see: <http://office.microsoft.com>

shows how available datasheets were displayed.

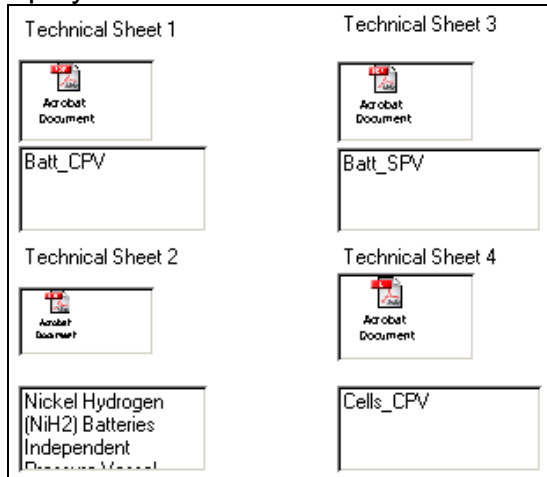


Fig. 4: Technical Datasheets

Utilizing Access' database management background, searching through company profiles was easy to implement. All the software needs is a keyword or the information whether or not a check-box should be ticked to then match it against the entries. An example: Searching for 'Italy' with a tick in 'Batteries' (as can be seen in Fig. 3) would minimize the data pool to companies from Italy, producing batteries. After the initial data input campaign, 91 company profiles could be found in the database.

5. SSAM - THE SPACE SUPPLIERS AND MANUFACTURERS DATABASE

Before starting a new campaign, i.e. contacting more companies, the next task was to improve the program. The Access solution was sufficient enough when using the tools once in a while but as stated at the beginning, the software was planned to be implemented into the Concurrent Engineering process. Therefore the presentation and navigation capabilities needed to be improved. It was also observed that the Access .mdb-file, con-

taining the program itself as well as the datasheets, with its 91 entries had grown to over 300 MB so that it took quite a while to open it from the network-drive it was stored on.

This led to the following requests for the new software:

- a more comfortable and professional user interface
- externally saved data to minimize loading-time

To match these two requirements it was decided to use a combination of Java⁴, an object oriented programming language, and MySQL⁵, as the new database management system. Both have the advantage of being Open Source, thus free of charge, and both support web-usability.

Programming the final tool took about four months and the result is described in the following.



Fig. 5: The SSAM Database

Fig. 5 gives an overview of the graphical user interface as a whole. This includes the company profile, its product range, existing technical datasheets and the search section which will be all described in more detail, now. The right side of the window includes the three search options, which can be selected separately or in combination:

⁴ Java, see: <http://java.sun.com>

⁵ MySQL, see: <http://www.mysql.com>

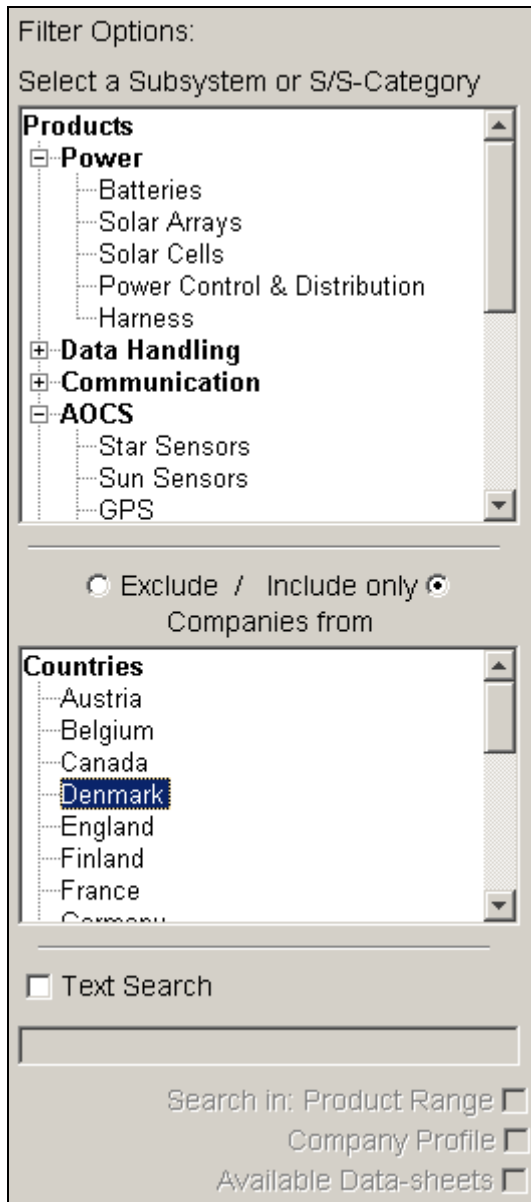


Fig. 6: The Search Options

At the top the user has the possibility to select the relevant subsystem or component he is searching for. The part in the middle gives the user the option to confine the search to certain countries (multiple selections possible) and at the bottom he can start the classic search for keywords. Finally, the 'Perform' button starts the search:



Fig. 7: Search Buttons (next to the SSAM Logo)

The company profile informs about the currently selected company - including its address, contact person, website and additional 'Comments / References'.



Fig. 8: The Company Profile

It also states when the data was updated last. Blue colored, underlined text marks hyperlinks which directly open either the web-browser or the e-Mail program when clicked with the mouse. When there is more than one search result (in this case there are 176) scrolling the mouse-wheel over the profile section or clicking the buttons in the upper right corner will

open the next/previous profile. This will also update the next two sections.

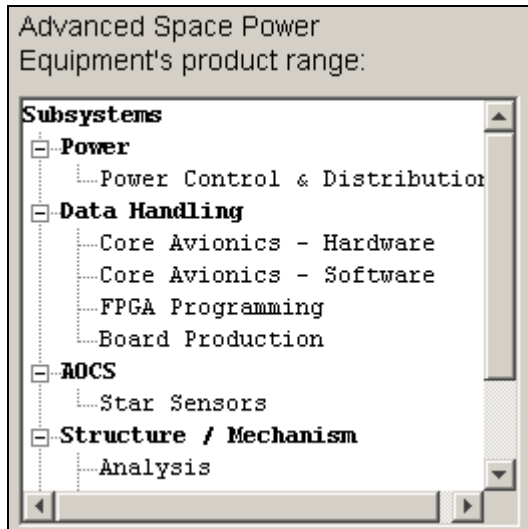


Fig. 9: The Product Range

Giving an overview of the selected company, the product range (Fig. 9) displays all subsystem categories the company has a product for.

To complete the available data, the following section shows all existing technical datasheets (a double-click will open the file):

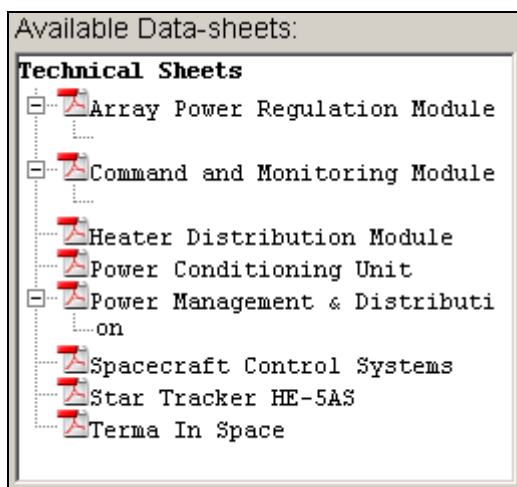


Fig. 10: The Technical Datasheets

Not depicted in this paper is another important part of SSAM: the supporting website. It includes a link to start the

program, the User Manual as well as references to similar databases.

6. THE QUESTIONNAIRE

The first questionnaire was created using the OpenOffice.org⁶ suit. In its design it was quite similar to the Access form depicted in Fig. 2 and Fig. 3. As OpenOffice.org supports interactive form-elements like check-boxes and also includes a PDF-exporter the questionnaire comprised the functionality to be filled out on the computer. Once that was done, it could be printed and then mailed back to DLR Bremen where the data was entered into the SCoPa database by hand.

To improve on this process of typing in the data manually the questionnaire was updated during the SSAM development as well. Here the request was to keep the ability of filling out the questionnaire on the computer but also to be able to send the completed questionnaire back via e-Mail.

Two solutions emerged meeting the new demand: a JavaScript-aided webpage or a newer version of the PDF file format. It was assessed that companies would be more familiar with PDF files so the latter option was chosen. As OpenOffice.org (at this point) only supports older PDF versions, the new questionnaire had to be created using Acrobat 9 Pro⁷ for which a license had to be bought.

The design followed its predecessor with the addition of the Propulsion category and a 'Submit by Email'-button at the end:

⁶ OpenOffice.org, see: <http://www.openoffice.org>

⁷ Acrobat 9 Pro, see: <http://www.adobe.com/products/acrobatpro/>

Fig. 11: Questionnaire - Example Page

Clicking the button will allocate the information the user filled in the form and send them as a XML-file to the functional address ssam-database@dlr.de.

As a precautionary first step the XML-file is then imported back into the questionnaire and saved as PDF.

Within the SSAM administration-area (see Fig. 12 and Fig. 13) an additional function was included to allow accessing the XML-file to extract the data and automatically upload it to the MySQL database.



Fig. 12: Button to Open the Admin Area

Fig. 13: SSAM Admin Area

As a final step and still to be done manually the datasheets, which are also asked for in the questionnaire and send separately, have to be uploaded.

During the initial phases of data acquisition, the focus was primarily on German companies whose business is related with small and medium sized satellite subsystems and component manufacturers. As the database progressed, however, a broader approach was considered, with space suppliers and manufacturers included from all over Europe and with a wider scope of specialisations.

7. OUTLOOK

Besides updating the database through future campaigns an additional extension is envisioned as well. The experience so far has shown that in most cases the datasheets sent by the companies include product lines with multiple components and more information than actually needed in the Concurrent Engineering process. So even though the SSAM database already disburdens the engineer by supplying him with products he might use, there is still some effort finding the exact information he needs. This is why another section is already included which

was not introduced so far. It is called the “Concurrent Engineering Interface”:

The image shows a vertical form titled "Concurrent Engineering Facility information". It contains eight input fields, each with a label above it: "Performance Value", "Dimension/Shape", "Mass", "Availability/TRL", "Cost", "Power (avrg/peak)", and "Thermal (avrg/peak)". The fields are currently empty, indicating they are disabled.

Fig. 14: The CE Interface

As it is not yet implemented, the text-fields are still disabled. But what they will display in the future are the (so far) seven most important values of a component for a CE study. While the lower fields are self-explanatory regarding their content, 'Performance Value' will contain component-specific values like thrust or data rate.

Increasing the complexity by accounting for single components will also increase the work that has to be put into the maintenance of SSAM. This is why it is planned to give the companies access to the software to be able to update their components themselves. It will be in their best interest to do so as making their data available would result in others being able to use them.

This idea will also be supported by the plan to make the database (space-) publicly accessible. Thanks to its Java-roots, SSAM is already started through a browser and runs platform-independent on all computers which have the Java-Runtime installed. MySQL on the other side also already runs on a separate, external server. At the moment, both are only accessible from DLR Bremen's Intranet but it would be quite easy to enable internet access.

Currently it is planned to realize the above described advancements in cooperation with the Bremen Institute of Metrology, Automation and Quality Science (BIMAQ). Within the scope of a two semester spanning student project five Systems Engineering students will then implement the following features:

- extension of the program (CE Interface)
- implementation of user-accounts
- enhancement of the search-functions

8. CONCLUSIONS

Websites like the European Space Industry Directory⁸ [Ref 2], operated by ESA, or the UK Space Directory⁹ [Ref 3] offer an easy way to search for space related companies or products. What they miss and the reason why the SSAM database was developed is making product details, needed during the design process, especially within CE studies, available to the engineers. Due to the web-based accessibility it will be possible to extend the reach beyond DLR Bremen's CEF and make it available to everyone in the space industry.

⁸ ESID, see: <http://www.esidirectory.com>

⁹ UK Space Directory, see: <http://www.ukspacedirectory.com>

9. REFERENCES

- [Ref 1] CDF System Description, Issue1 Review2; ESA/ESTEC, Noordwijk 2002
- [Ref 2] ESA Bulletin 105, EMITS: Improving Communication between ESA and Industry; February 2001
- [Ref 3] UK Space Directory Announcement of promotion opportunity, The Aerospace and Defence Knowledge Transfer Network; May 2008