

COMPUTER BASED TRAINING IN AIRCRAFT DESIGN EDUCATION

D. Scholz - University of Applied Sciences, Hamburg, DE
J. Thorbeck - Technical University of Berlin, DE

Keywords: *CBT, WBT, aircraft, design, education, costs*

Abstract

The paper summarizes approaches to computer based training (CBT) and lessons learned in aviation training. Based on these facts, requirements for CBT developments in aircraft design education are formulated. The pros and cons of different software tools for CBT development are briefly discussed. Subsequently, first results of an interactive and multimedia courseware for aircraft design education 1.) based on HTML and JavaScript and 2.) based on spreadsheets are presented. Due to the prohibitive high costs of courseware development for relatively small student groups, an internationally combined effort is required. Course modules linked in an open architecture on the World Wide Web could prove to be a solution to the problem.

1 Introduction

1.1 Aircraft Design Education

Formal aircraft design education takes place at universities, academies and on various short courses. This paper deals with aircraft design education in a traditional university setting covering preliminary sizing and conceptual design of aircraft. Aircraft design in this specific sense is just one element - but maybe the "capstone" [1] - in an aeronautical engineering degree program.

1.2 Computer Based Training

Definition: Computer based training (CBT) is "the use of computers to provide an interactive instructional experience" in which the computer is seen "as the primary mode of instruction" [2].

CBT is just one of the many terms to express just this. **CBT is also referred to as:**

- CAI (computer assisted instruction),
- CAL (computer aided learning),
- CBE (computer based education),
- CBI (computer based instruction),
- CBL (computer based learning) etc.

The beginnings of CBT are mostly traced back to a big project called *Programmed Logic for Automated Teaching Operations* (PLATO) which was developed at the University of Illinois and marketed by the Control Data Corporation (CDC). PLATO was begun in 1959. The early PLATO lessons ran on a large mainframe host. Later CDC pulled back from their PLATO effort and sold the name to The Roach Organization (TRO) (see also section 3.4). [2] [3]

Computer based training is intended to be **self-directed** and **self-paced** by the student. In its most simple form, CBT could be based on software that does little more than displaying a text. In such a simple CBT device, the sole student interaction would be to 'turn the page'. Software for CBT purposes is called courseware. Preferably, CBT is based on *interactive courseware* (ICW). The **interactive** courseware allows an exchange between the student and the computer program. The interaction may begin with a mouse click, a key press, a screen touch, or any other input by the student. The program may react visually, aurally, or in any other way that can be perceived by the student.

If appropriate to the training contents, the CBT courseware may include **multimedia elements**. Multimedia is the ability to

simultaneously present on a single workstation two or more dissimilar media types such as:

- text,
- still images,
- computer drawn graphics,
- audio,
- computer animation,
- motion video.

Often CBT is based on **hypertext**. Hypertext uses "a method of information delivery that provides multiple connected pathways through a body of information, allowing the user to jump easily from one topic to related or supplementary material". [2]

A hypertext-type document that contains text and other multimedia elements as well as triggers, or pre-defined areas on the screen that can link to sections of the file that contain information in different media is call **hypermedia**. [2]

1.3 Economic Problems of CBT in Aircraft Design Education

Producing CBT courseware is a very time consuming and hence costly job. What are the **costs for the development of a training course** that will take an average student 1 hour to work through? Required development time is quoted to be roughly between 90 hours and 260 hours [4], costs are estimated to be between 25000 US\$ and 50000 US\$ [5]. Development time and costs will increase if more interactive features and more multimedia elements get included into the courseware. The *Lilienthal Project* (Multimedia Off- and Online Distance Learning for European Pilot Training) [6] is an educational package with about 700 pages based on the *Hyper-Text Markup Language* (HTML). 100 student hours of its CBT course required an investment of 2.5 million euros [7], [8]; this is roughly 25000 US\$ per course hour. The development of one course hour in the PLATO project required an investment of up to 20000 US\$ [9]. Although these are only rough figures that deviate somewhat, they give an indication of the immense costs involved in CBT development.

These **development costs** may be justified if they can be **distributed** over a large number of students as in the case of the above-mentioned Europe-wide pilot training. Yet, the number of students in aircraft design education is small compared to the number of students in other fields of the aviation training business. For this reason, it does not come as a surprise that computer based training has not made much impact in aircraft design education today.

Due to the scarcity of CBT examples on aircraft design education, it will be necessary to draw from the experience gained in the whole field of aviation training. The paper will point out some general pros and cons of different software solutions and will present prototype sample CBT modules. Finally it tries to show a way, how the difficult economic situation for CBT in aircraft design education can be overcome by stressing the need for an internationally joint effort leading to a web-based open architecture pool of CBT modules on aircraft design.

2 Approaches to Aircraft Design Education

In order to get on common ground, it might be beneficial to look at traditional approaches to aircraft design education first.

Aircraft design education may crudely be grouped into traditional *aircraft design lectures* and *aircraft design projects*. In practice a combination of these two teaching forms may occur.

2.1 Aircraft Design Lectures

Traditional aircraft design lectures (like many other lectures) consist of presenting the information on a blackboard or on an overhead projector. Tutorials are often presented in a similar form. Students are requested to take notes. The active part in the student's learning process consists of copying the presented information. Handing out lecture notes or the reference to a textbook allows to cover more material in class and frees students to a certain extend from taking notes. By not attending the lecture, students take the risk of not being informed properly about the contents and/or

details of the lecture and are therefore not able to get efficiently prepared for the examination.

There is not much chance for the students to escape from such a learning situation and hence a minimum "exposure" to the subject is guaranteed. However, in such a setting, only very little processing of the information will take place in student's minds. Student's time permitting, processing of the information will only take place during the preparation phase for the examination.

2.2 Aircraft Design Projects

Aircraft design projects on the other hand require the students to actively apply aircraft design information. The aircraft design information could come from a traditional lecture or from textbooks. Some parts of the project work might require students to research specific aircraft design information themselves. The findings will then be included into the project work.

Such an active learning situation will help students to a better understanding of aircraft design with all its intricacies and pitfalls. Students can strongly be motivated by the preparation of an aircraft design. The design work can give the students a sense of achievement. The open learning environment requires students to take responsibility for their time management and work quality. There might be a certain risk for weaker or less motivated students to get lost in such an open learning environment. For the lecturer it might be difficult to find the best balance between tight student control and delegation of responsibilities.

The general outline of aircraft design projects as given above allows for many variants in its detailed setting:

- The project could be set up as an **individual task** for students working either separately or together as a uniform learning group.
- The project could be set up as a **team exercise** with individual "experts" in each team mirroring an industrial work situation [10]. Working with *small* teams versus *large* teams [11] will allow for a further

way to differentiate between aircraft design projects.

- The project could be set up jointly at two universities (even on two different continents) adding the difficulty of working in **international and separated teams** [1] - as it is also a reality in today's industrial aircraft design practice.
- The project could be set up in close or loose **cooperation with industry** or in the framework of an industry-inspired design challenge.

Aircraft design projects can further be classified by looking at **the design task** [12]:

- *whole* aircraft design versus *component* design,
- *new* aircraft design versus *derivative* design.

Aircraft design projects apply **problem-based learning** (PBL). PBL is praised for being a "constructive, contextualized, collaborative, systematic and self-directive teaching method". In PBL "knowledge acquisition is an active process in which the student is linking new information to his or her prior knowledge"; "the students are more or less each others' teachers" [13]. The task of the lecturer is that of a facilitator in

- helping to explore the assignment,
- relating or opposing ideas produced by the students,
- fostering students co-operation,
- encouraging the more silent members.

3 Computer Applications in Aviation Training

A look at the various forms of computer applications in aviation training should help to broaden the view on how CBT could be applied in general - and specifically to aircraft design education.

3.1 Pilot Training

Traditionally, most effort has been spent on computer applications for pilot training. Over the past decade CBT has seen a widespread adoption within the pilot training sphere. A **training pyramid** evolved with CBT forming

the base. The *flight training devices* (FTD) - also known as fixed based simulators (FBS) - are the middle segment including part task trainers (PTT), cockpit system trainers (CST), cockpit systems simulators (CSS), and instrument flight trainers (IFT). The apex is formed by the *airplane simulator* also known as *full flight simulator* (FFS). [14]

An "**airplane simulator** is a full-size replica of a specific type or make, model, and series airplane cockpit, including the assemblage of equipment and computer programs necessary to represent the airplane in ground and flight operations, a visual system providing an out-of-the-cockpit view, and a force cuing system ..." [15].

An "**airplane flight training device** is a full scale replica of an airplane's instruments, equipment, panels, and controls ... including ... computer software programs necessary to represent the airplane in ground and flight conditions ... does not require a force (motion) cueing or visual system ..." [16].

Another branch are the **PC aviation training devices** (PCATD). They come from a background of commercial game software and the general growth in PC processing power [14].

The FSS achieves the ultimate when it comes to interactivity and multimedia elements. Nevertheless, it is only a sparring partner for an experienced pilot. The FFSs, FTDs, and PCATDs lack to deliver the lecture and the necessary "instructional experience" to the student as demanded by the CBT definition given above. For that reason, these systems **cannot be considered as CBT devices**.

In a practical sense, CBT devices are associated with low-cost desktop computers. These CBT devices have evolved through the "use as flight management systems trainers (FMST) where by the addition of three dimensional mode control panels (MCP) and control display units (CDU) the desktop CBT system has become the FMST PTT." The next step is "to begin surrounding these basic CBT kernels in 3D cockpit hardware including throttle quadrants, partially working instrumentation, primary flight displays (PDF) and navigational displays (ND), seats and

cockpit surrounds" [14]. If these **CBT devices with added hardware** retain their capability of delivering a lecture to the student, their interactivity and closeness to reality is a definite advantage.

3.1 Aviation Maintenance Training

CBT is used for various levels of aviation maintenance training. CBT is used to teach

1. aircraft maintenance fundamentals,
2. generic aircraft systems concepts,
3. aircraft type-specific maintenance,
4. troubleshooting by means of simulation-type computer based training.

In addition, troubleshooting can be taught using maintenance training simulators (MTS), flight training devices (FTD), full flight simulators (FFS), or (of course) the real aircraft. A recent CBT project for each the four CBT areas will be described to provide more inside.

TRO Learning (UK) produced the **jet aircraft maintenance fundamentals** (JAMF) **course** for *Lufthansa Technical Training* (LTT) investing 20 man-years on course development [17]. In 1998 TRO's commercial aviation division was acquired by *VEGA Group PLC*. The 150 hours of courseware consists of high-resolution graphics, digital audio, scanned images and digital video. Examples are taken from Boeing and Airbus aircraft. [18].

VEGA in cooperation with *The Dutch Aviation Training College* (NLC) developed the PC-based **aircraft systems concepts** (ASC) **trainer** for KLM [19]. Simulations and multimedia content can be used as an aid to instructors in teaching the basic concepts of operation and behavior of the major systems of large passenger jet aircraft. The courseware can be used by students in a self-paced mode to assist in their understanding of system behavior. When performing troubleshooting, student actions are logged, allowing safety critical actions to be flagged to the instructor. The system is hosted on commercially available Pentium PCs running Windows 95 or NT. [18]

Both Airbus and Boeing have developed in-house **aircraft type-specific maintenance CBT** courses for their respective aircraft. The *Boeing 737-600/700/800* CBT is a course

consisting of both instructor-lead CBT (ILCBT) lessons and student-paced CBT (SPCBT) lessons. The instructor-lead lessons include tutorial information with photographs, animations, and interactive diagrams and schematics. These are designed to support a classroom instructor's presentation, but may also be used by individual students when the text box option is turned on. The SPCBT lessons focus on the performance of exercises and procedures by individuals. [20] The *Airbus* video and computer based instruction (VACBI) system [21] is intended for SPCBT lesson with diagrams, schematics, aural explanations, text boxes, and questions. A separate optical disk and a separate monitor show photos and video sequences. When the aural explanations are switched off, the VACBI courseware can also be used for ILCBT lessons.

The **B737 maintenance virtual workplace** from *Wicat Systems, Inc* simulates the mechanic's working environment, allowing real-time access to all of the resources, tools, and parts that are normally available to troubleshoot and maintain the aircraft. The virtual workplace has a "game-like" interface including 'troubleshooting tips' that contain data about components which have a high no-fault-found (NFF) removal rate. Each covered system also contains a CBT tutorial on system components, normal operation, non-normal conditions, built-in test equipment (BITE), and system-specific troubleshooting procedures. The Boeing 737 maintenance virtual workplace can be used as stand-alone instruction, delivered over a network, or may be used as instructor-led CBT. The troubleshooting simulations and fault-free practice allow the learner to engage in self-paced discovery learning through experimentation within the simulated environment. [22]. *Wicat* offers a similar cockpit maintenance operations simulation (CMOS) for the A320 [23].

From personal experience supported by findings from a literature review, the **lessons learned** from computer based *aviation maintenance training* are these:

- CBT on its own often does not provide a total training solution. Each course should

comprise the most suitable combination of traditional lectures, CBT, practical training elements and field trips. (See also [21], [24], [25]).

- Pure student-paced and -directed CBT does not work. Students tend to go through modules too quickly and/or get lost in the many details of modern aircraft systems. A better approach seems to be to start with ILCBT and to use SPCBT for minor subjects and the rehearsal of major subjects already introduced with ILCBT.
- Only three hours of intensive SPCBT per day is feasible because students are exhausted and have more difficulties to concentrate. [19]
- The human brain can no longer be the storage area; it has to become the processor of information. The information has to be put at the students' fingertips through easy-to-use retrieval systems. [19]

3.3 Other Branches of Aviation Training

Computer based training is also extensively used in other branches of the aviation training business:

- cabin crew training [26],
- x-ray interpretation training [27]
- general topic training (safety, emergency, security).

3.4 CBT Developers

The big players in professional aviation CBT development are:

- *VEGA Group PLC*. VEGA has bought TRO's Commercial Aviation Division and continues TRO's products alongside its own. It claims "VEGA has the largest library of computer-based training products for the aviation training world." [28]
- *Wicat Systems, Inc*. It claims that "more than half of the world's largest airlines use proven *Wicat* CBT products" [29]

Airbus Industrie and *FlightSafety Boeing Training International* develop to a large extent their own CBT courseware. Airlines like Lufthansa [24] [30] do some CBT development

also in-house. Both manufacturers and airlines cooperate with specialized CBT developers.

4 Requirements and Background for CBT in Aircraft Design Education

From the facts stated above it is clear that CBT should only be one element in an aircraft design teaching module. An attempt is made to write a list of requirements for CBT in aircraft design education. The full realization of these requirements is seen only in the long run. The requirements may give some guidance for CBT design decisions today. The requirements are stated in the next section. Some background and further details are given below.

4.1 Requirements

- Aircraft design *lectures* (see section 2.1) could consist of a combination of traditional teaching media (blackboard, overhead projector, ...), instructor-lead CBT (ILCBT), and student-paced CBT (SPCBT).
- Aircraft design *projects* (see section 2.2) follow the problem based learning (PBL) approach. Ideally, its CBT courseware should be made up of three different types.
 1. SPCBT **material on aircraft design fundamentals and theory** should form the course' backbone.
 2. Linked to the SPCBT material from no. 1. there should be **computing modules on preliminary sizing and conceptual aircraft design** that support the design *synthesis*.
 3. Ideally, the courseware should also include **elements of simulation-type CBT**. Here, it will be the student's aircraft design (put together under no. 2) to the specifications of the course assignment that gets simulated. In this respect, the simulation part of the CBT courseware could resemble traditional aircraft design programs (see section 4.2). Simulation results are aircraft weight, drag, cost figures like direct operating costs (DOC), and aircraft handling qualities. If things are carried one step further, aircraft simulation could even be

in the form of a (PC based) flight simulator (see section 4.3) so that the students could eventually flight test their aircraft on the computer and change design parameters according to test results.

As a further requirement may be stated that all CBT courseware should be capable of being delivered over the Internet. As such, CBT will become **web based training** (WBT) that is a specific form of **distance learning** (see section 4.4).

4.2 The roll of traditional aircraft design computer programs

Many aircraft design computer programs have been written with the primary intention to support research in the field. A summary of such German tools and activities is given e.g. in [31]. More appropriate to support aircraft design education are smaller packages like e.g. *Advanced Aircraft Analysis* (AAA) [32] or *RDS Aircraft Design Software* [33] written specifically to address student's needs.

The Advanced Aircraft Analysis (AAA) program displays a menu tree showing the design path selected by the user. After supplying input data in one window, several output parameters can be calculated and are displayed in another window. In the input/output windows, the user has access to information about the theory used. Context-sensitive help is provided which helps the user in working with the program. [32]

A closer look [34] [35] however reveals that these programs are quite good in aircraft analysis but lack support in the synthesis phase. In addition, they make no attempt in teaching aircraft design. On the contrary, they already assume a sound knowledge of aircraft design fundamentals and about strategies in aircraft design synthesis. For this reason, these valuable programs cannot be considered as a substitute for CBT in aircraft design education

4.3 PC based flight simulation in aircraft design education

PCs have become extremely fast making it viable to perform realistic flight training. Pilot

interface devices that are compatible with PCs (artificial stick, yoke and pedals) have been developed to supply the growing market of flight schools, universities and research organizations, who have a need for realistic, but inexpensive flight simulation. Low cost personal computer aviation training devices (PCATD) (see also section 3.1) have sparked a lot of interest recently. The *Federal Aviation Administration* (FAA) has commissioned a study at the University of Illinois into the effectiveness of PCATDs, with favorable results being reported. [36]

A study at the University of Limerick [36] points out two PCATDs that allow the input of individually designed aircrafts:

- X-Plane [37] with its feature 'planemaker' can easily be handled but today still lacks many necessary details in modeling aircraft dynamics.
- The Aviator Visual Design Simulator (AVDS) [38] utilizes a full nonlinear six degree of freedom model. However, all input files have to be written in C++ and require good programming skills. To make the package user-friendlier, a front-end module is needed.

4.4 Distance Learning and Web Based Training

Distance learning is defined as "The use of computers and communications technology to allow the interaction of teachers and students who are not co-located" [2]. Distance learning may be based on one-way or two-way audio/video teleconferencing, video broadcast, or correspondence courses. Distance learning may be delivered in real time, or it may be delayed and is called to be asynchronous.

Web based training (WBT) is one specific approach to distance learning. WBT is computer based training (CBT) that makes use of technologies and methodologies of the World Wide Web (WWW), the Internet, or intranets. Web based learning (WBL), web based instruction (WBI) and Internet based instruction (IBI) are just other terms used for WBT.

Chat, discussion groups, and e-mail can be a part of WBT. When appropriately used, these technologies can enhance learning and can improve student's performance. Discussion groups (private forums or Usenet newsgroups) are similar to text chat, only asynchronous. When one poses a question to the group, or answers another, all members of the group benefit, though not instantaneously. It's the group dynamic of these information sharing media that adds perspective perhaps not available in one-on-one instruction. When e-mail lists are used in sending private group messages, the learning effect is the same. [39]

It has to be acknowledged that today the traditional sequence of "school → university → work" applies to ever fewer people. It becomes more common to study, after some time of work experience has been gathered. Also, the necessity may arise to work and study at the same time which calls for part time studies. Quite often, students are bound to a certain place (due to a work or personal situation), which may not be at the location of the university. All these facts **call for more flexible forms of teaching**. Web based training (WBT) can be one step in this direction and should therefore be considered from the beginning in innovative course design.

5 Getting Started with CBT Development - Choosing a Tool

First of all it must be stressed that tool selection is only of secondary importance to CBT development. Establishing a formal development process is very important: listen, plan, design, test, build, deliver, observe, and refine. CBT development, in the first place, requires a good instructor.

Having said this, much depends on the selected tool, though. A discussion of the pros and cons of CBT tools can be a subject in its own right. The intention here is simply to provide a first insight for all those who have had very little or no exposure to CBT development.

If course notes are already available on the computer, they could be used in their original format. As stated in section 1.2, "CBT

could be based on software which does little more than displaying a text". Such simple "CBT", however, would rarely fulfill today's requirements (compare with section 4.1).

Possibilities for user interaction and multimedia elements can already be added to office documents produced e.g. in *Microsoft Word* or *Microsoft PowerPoint*. If delivered over the Internet, such a document format would assume that users work on a PC and possess Microsoft software. In addition, problems can arise with different versions of the software. The latest Microsoft versions allow automatic generation of HTML files. The results are not always as expected, especially if highly interactive documents get converted that make extensive use of multimedia elements.

Adobe Acrobat converts any document into Adobe's Portable Document Format (PDF). The layout of the original document is maintained and the PDF file can be read on almost any platform with the free *Acrobat Reader* that is available over the Internet. Multimedia elements and links can be added to PDF files. However, PDF offers no possibilities to add platform independent computing capabilities. [40]

If computing capabilities are required e.g. for preliminary sizing, conceptual aircraft design, or simple simulation-type CBT, spreadsheets like *Microsoft Excel* allow to crank out impressive results very efficiently. Unfortunately, the same restrictions and drawbacks apply as stated above for *Microsoft Word* and *Microsoft PowerPoint*. These restrictions may be acceptable if the software is intended to be used by a limited group of people.

Hypermedia CBT can be produced professionally with generic or specialized editors directly for the Internet, intranets or for a CD ROM using the Hyper-Text Markup Language (HTML). Interactivity and limited computing power can be added with **JavaScript** - a simple programming language. JavaScript code gets included directly into the HTML file. Java applets provide the possibility to include and offer also complex calculations with the courseware. The universal platform-independent

approach of HTML-based courseware has a few drawbacks: The detailed layout of the pages depends on the type of browser on the user's machine. Different versions of JavaScript exist; so courseware designed for one browser may not run properly with another browser. Programming in JavaScript is much more time consuming than spreadsheet programming. [41]

Professional CBT courseware is often produced with authoring systems like *Macromedia Director*. *Macromedia Director* is the leading authoring system. Its integrated language *Lingo* allows the specification of complex user interactions. Lingo is an object oriented programming language with features comparable to other programming languages. As such, it should be possible to apply Lingo also for the programming of aircraft design specific problems. The courseware runs on PCs with Windows as well as on Apple computers and is primarily intended to be distributed on a CD ROM. Moreover, conversion of the courseware is possible for use on the Internet. This requires the shockwave-plugin to be present on the user's computer. The free plug-in is available over the Internet. The development of courseware with *Macromedia Director* is quite complex. Considerable time is required to get acquainted with this powerful tool. [42], [43]

The evaluation of software tools can often become a matter of faith in one system over another. The best thing to do is to get started and to judge for oneself.

6 First Results

Only recently aircraft design activities started at the University of Applied Sciences in Hamburg and at the Technical University of Berlin on small, flexible and easy to handle computer modules which may be combined to larger entities and which can be made available over the Internet. Although these activities started independently, it turned out that today's computer technology almost demands a certain approach to the present day teaching challenge and way of thinking. Some of these ideas that evolved have been spelled out in preceding

sections of this paper. A summary of first results is presented here.

6.1 First Results at University of Applied Sciences, Hamburg

At University of Applied Sciences in Hamburg aircraft design is one of several modules leading to a degree in aeronautical engineering (Dipl.-Ing.). Aircraft design is taught by following the problem based learning (PBL) approach. Groups of five students work on an aircraft design to a common aircraft specification from industry. Each group follows its own ideas, so different designs evolve. The participants meet with their lecturer once a week for four hours. The time is used to discuss the details of the specification from industry, student's questions get answered, and details of the assignment are discussed. In short formal lectures aircraft design fundamentals and theory is summarized. Most learning is self-paced student learning which takes place outside class. Students get the course material from the Internet [44]. This material is not yet interactive but in plain Adobe's Portable Document Format (PDF). For the assignment, students perform hand calculations and work with own spreadsheets. A news bulletin board on the World Wide Web is maintained by the lecturer. Between meetings, students are supported by e-mail from the lecturer and by means of a newsgroup-like forum (organized with an e-mail list). Results are presented to industry at the end of the course.

A prototype CBT module on preliminary sizing of aircraft - based on [45] - is available on the Internet [46] (see Figure 1). It was programmed in HTML. The "computing modules" (see section 4.1) for design synthesis were programmed in JavaScript. Details are discussed in [47]. Work is ongoing and supported by students through research efforts towards their thesis (Diplomarbeit).

6.2 First Results at Technical University of Berlin

At the Berlin Technical University aircraft design is being taught in a 2 semester course consisting of an equally shared lecture and a

project based team exercise. Although there is a highly sophisticated computerized aircraft design system available, students are required to perform their analyses manually but are encouraged to use computation aids such as spreadsheets. The CBT approach is at that point in time intended to support the lectures only. After a theoretical introduction to a complex relation (e.g. the sizing of the engines for take-off and cruise, see Figure 2) the most important evidence is being simulated by a simple computer application which today is based on Excel programming but will be converted into a JAVA applet to become platform independent later on. By consequent application of menu elements for the parameters control any use of keyboards is avoided which facilitates the presentation. The students' feed back to that practise is encouraging. They are getting an immediate insight into both the practical range and the sensitivity of the various parameters. Furthermore, they are enabled to interactively take part in the lecture. There are plenty of such simple programs already prepared for conversion into JAVA applets and it is planned to develop an internet based aircraft design education support system which will provide the students with a remote access to the lecture notes and to a set of numerical tools which are standing in context with these. Consistency between the support material for exercises and the lecture will thus be ensured.

7 Conclusions

The application of professionally developed computer based training (CBT) courseware offers the chance to enhance learning and to improve student's performance in aircraft design education.

With CBT, material on aircraft design fundamentals and theory should form the course' backbone. Furthermore, the courseware should provide integrated computing modules on preliminary sizing and conceptual aircraft design that support the design *synthesis*. Ideally, the courseware should also include elements of simulation-type CBT.

Most promising is the application of CBT in problem based learning (PBL) because this teaching method offers considerable flexibility compared to aircraft design lectures. The situation of today's students (dictated by constraints at work or in their private life) calls for more flexible teaching forms. CBT delivered over the Internet called web based training (WBT) can be one step in this direction.

The biggest problems with CBT and WBT in aircraft design education are the development costs of the courseware in comparison to the relatively small number of students. This problem can be mastered

1. with simple yet professional and efficient software tools allowing student's participation in courseware development with their research projects,
2. with internationally combined forces linking course modules in an open architecture on the World Wide Web under a neutrally named Uniform Resource Locator (URL).

References

- [1] Jenkinson, L R, Page G J and Marchman J F. International teaming in aircraft design education. *SAE/AIAA World Aviation Conference*, San Francisco, California, USA, 1999. - Paper 1999-01-5533
- [2] Cooper T (Ed.). *Glossary of terms related to computer-based training*. Rev. 2.0, Aviation Industry CBT Committee, 1997. - Doc. No. CRS002, URL: <http://www.aicc.org/pages/down-docs-index.htm> (2000-04-26)
- [3] Friedman H G. *Whatever happened to Plato?*. 1993. - URL: <http://www.cs.uiuc.edu/whatsnew/newsletter/winter93/plato.html> (2000-04-30)
- [4] Brendel H. *Computer based training*. 1st edition, IWT, 1990.
- [5] <http://www.filename.com/wbt/faq.html> (2000-04-26)
- [6] <http://www.pilotschool.net>
- [7] Strecker R. PPL-Theorie via Internet - Europäische Flugschulen initiieren das Projekt Lilienthal. *Flight Training Special*, No. 3, pp 18-19, 1999. - URL: <http://www.pilotschool.net/psn/public/info/publication/lilien.pdf> (2000-04-29)
- [8] Sutton O. Use the Internet - a refreshing new approach to pilot training. *INTERAVIA*, Vol. 54, No. 4, pp 21-22, 1999.
- [9] Schulmeister, R. *Grundlagen hypermedialer Lernsysteme*. 2nd edition, Oldenbourg, 1997.
- [10] Fielding J P. High-capacity subsonic transport projects. *20th Congress of the International Council of the Aeronautical Sciences*, Sorrento, Napoli, Italy, Vol. 1, pp 879-891, 1996. - Paper: ICAS-96-3.4.5
- [11] Whitford R. The use of large teams in conceptual aircraft design, 1992. - Paper AIAA-92-1092
- [12] Whitford R. An anglo-US view of aircraft design education. *20th Congress of the International Council of the Aeronautical Sciences*, Sorrento, Napoli, Italy, Vol. 1, pp 858-865, 1996. - Paper: ICAS-96-3.4.3
- [13] Adriaanse H, Broekhuizen P, Geerligs T, van Oorde K and Zaremba T. Problem-based learning. *Civil Aviation Training*, Vol. 9, No. 3, pp 40-43, 1998.
- [14] Nash T. Low-cost training devices - pain or gain? *Civil Aviation Training*, Vol. 8, No. 5, pp 22-28, 1997.
- [15] US Department for Transportation, Federal Aviation Administration. *Advisory Circular 120-40B Airplane simulator qualification*. 1993.
- [16] US Department for Transportation, Federal Aviation Administration. *Advisory Circular 120-45A, Airplane Flight training device qualification*. 1992.
- [17] Emmings A. Aviation Maintenance Training Conference, Frankfurt *Civil Aviation Training*, Vol. 10, No. 4, pp 41-42, 1999.
- [18] <http://www.vega.co.uk/aviation/product/p2.htm> (2000-04-29)
- [19] Doyle A. Maintenance training. *Flight International*, 3-9 March, pp 58-62, 1999.
- [20] <http://www.FlightSafetyBoeing.com/traindev/td737678mcbt.html> (2000-04-29)
- [21] http://www.airbus.com/customer_training.html (2000-04-29)
- [22] <http://www.wicat.com/Maintenance/b737mvwp.htm> (2000-04-29)
- [23] <http://www.wicat.com/Maintenance/CMOS/cmos.html> (2000-04-29)
- [24] <http://www.lh-technical-training.com/trainingmedia.html> (2000-04-30)
- [25] Emmings A. Hardware based maintenance training. *Civil Aviation Training*, Vol. 9, No. 5, pp 21-27, 1998.
- [26] Prew S-J. SEP training technology. *Civil Aviation Training*, Vol. 9, No. 4, pp 35-43, 1998.
- [27] Figiel A. Computer-based training is a cost effective solution to constraints on time, training budgets. *ICAO Journal*, Vol. 53, No. 10, 1998
- [28] <http://www.vega.co.uk/aviation/product/p0.htm> and <http://www.vega.co.uk/aviation/product/p1.htm> (2000-04-29)
- [29] <http://www.wicat.com/wicat/about.htm> (2000-04-29)
- [30] http://www.lft-online.de/deutsch/tr_cb.htm (2000-04-30)

[31] Scholz D (Ed.). *DGLR Workshop: Entwicklungswerkzeuge zur Flugzeugauslegung*, Hamburg-Finkenwerder, 1995, Fachausschuß S2.1, Starrflügel-systeme. Bonn, 1995.

[32] <http://www.darcorp.com> (2000-04-30)

[33] <http://www.aircraftdesign.com> (2000-04-30)

[34] Albers B. *Flugzeugentwurf mit dem Programm "Advanced Aircraft Analysis"*. Hamburg, University of Applied Sciences, Department of Automotive and Aerospace Engineering, Diplomarbeit, 1999.

[35] Walde D. *Flugzeugentwurf mit dem Programm RDS*. Hamburg, University of Applied Sciences, Department of Automotive and Aerospace Engineering, Diplomarbeit, 2000.

[36] Young T. PC-based flight simulation - Any use in educating aeronautical engineers?. *Third European Workshop on Aircraft Design Education*, Bristol, UK, 1998.

[37] <http://www.X-plane.com>

[38] <http://www.rassimtech.com/products.htm>

[39] <http://www.webbasedtraining.com> (2000-04-29)

[40] <http://www.adobe.com/acrobat/>

[41] <http://developer.netscape.com/tech/javascript/javascript.html>

[42] <http://www.macromedia.com/software/director/>

[43] Handke J. *Multimedia - Anwendungen mit Macromedia Director*. 1st edition, Oldenbourg, 1999.

[44] Scholz D. *Skript zur Vorlesung Flugzeugentwurf*. 1999. - URL: <http://www.fh-hamburg.de/pers/Scholz/SkriptFE.html> (2000-04-29)

[45] Loftin L K. *Subsonic aircraft: Evolution and the matching of size to performance*. NASA Reference Publication 1060, 1980.

[46] <http://www.fh-hamburg.de/pers/Scholz/dimensionierung/start.htm> (2000-04-29)

[47] Perthel T. *Computer Based Learning in Aircraft Design – A Case Study with HTML and JavaScript*. Hamburg, University of Applied Sciences, Department of Automotive and Aerospace Engineering, Diplomarbeit, 2000. - URL: <http://www.fh-hamburg.de/pers/Scholz/arbeiten/TextPerthel.pdf>

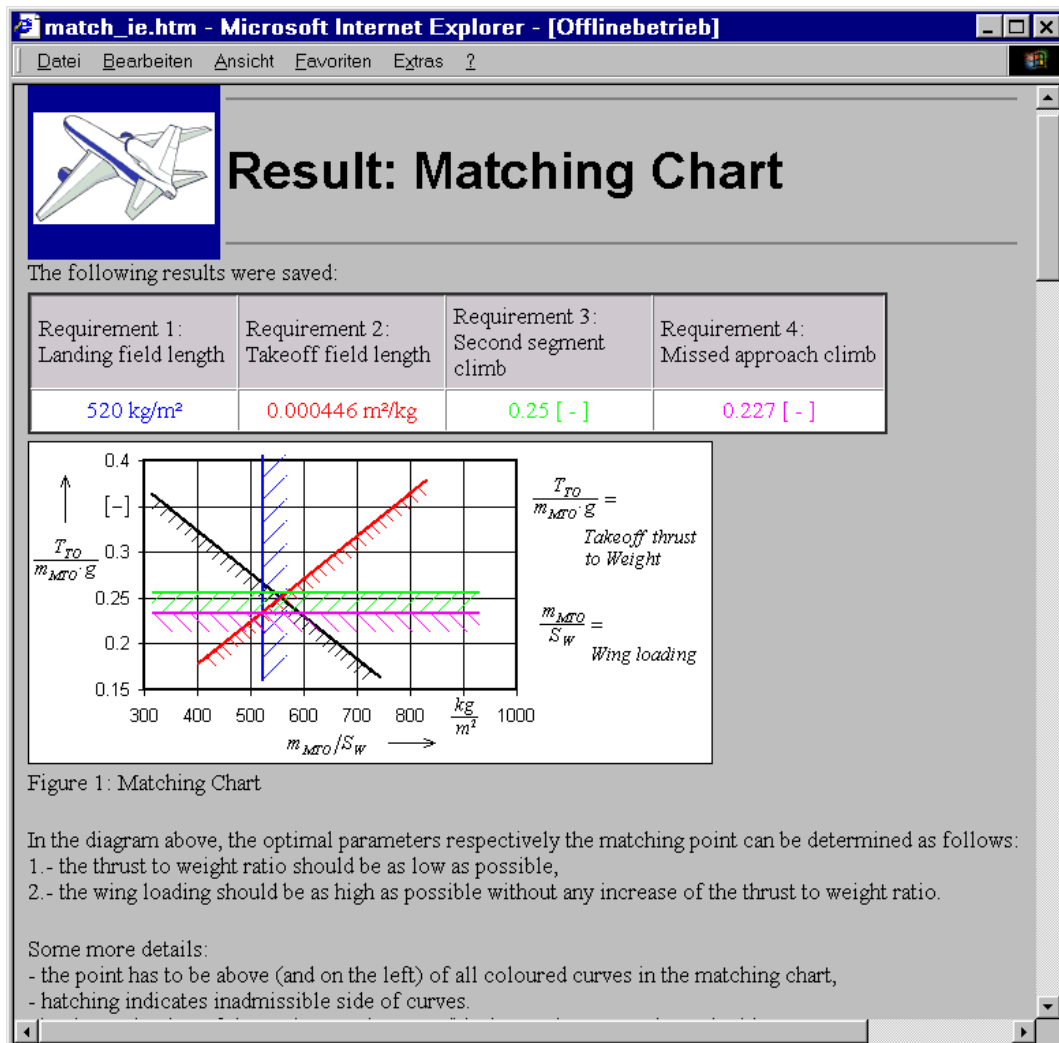


Figure 1: Screen shot from the CBT/WBT prototype module on preliminary sizing

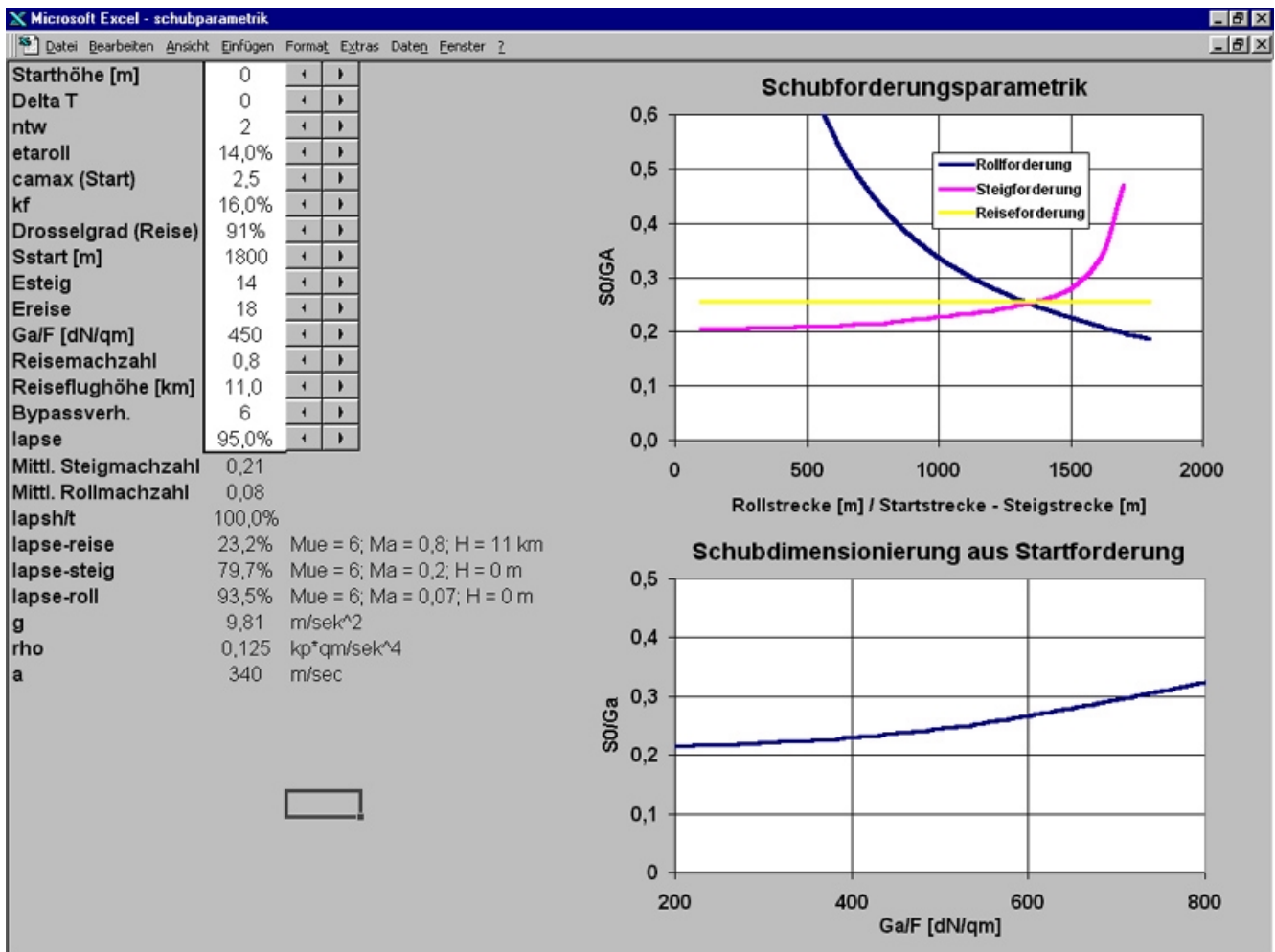


Figure 2: Screen shot from Excel program on sizing of the engines for take-off and cruise