An International Design-Synthesis Exercise in Aerospace Engineering

Melkert, JA; Gibson, A; Hulshoff, SJ

Publication date
2003

Document Version
Final published version

Published in
Global Journal of Engineering Education

Global J. of Engng. Educ., Vol.7, No.1
Published in Australia

An International Design-Synthesis Exercise in Aerospace Engineering*

Joris A. Melkert
Faculty of Aerospace Engineering, Delft University of Technology
Kluyverweg 1, 2629 Delft, The Netherlands
Alan Gibson
School of Aeronautical Engineering, Queen's University of Belfast
University Rd, Belfast BT7 1NN, Northern Ireland, United Kingdom
Steven J. Hulshoff
Faculty of Aerospace Engineering, Delft University of Technology
Kluyverweg 1, 2629 Delft, The Netherlands

Aircraft design is becoming more and more an international activity. In an effort to include the special challenges posed by international projects into engineering education, an international design exercise involving undergraduate students from two universities was developed and carried out. This exercise was based on the regular design-synthesis exercise that concludes the Bachelor's programme at the Faculty of Aerospace Engineering, Delft University of Technology (TU Delft), Delft, the Netherlands. However, unlike the regular exercise, the international exercise also required students to overcome communication and organisational challenges posed by working at universities with differing educational programmes and physical locations. Twelve students, six from the TU Delft and six from the School of Aeronautical Engineering, Queen's University of Belfast, Belfast, Northern Ireland, UK, were formed into a single design team. Students and staff met in person in Belfast for an inaugural and interim session and in Delft for the final presentation. In between, contact was maintained using state-of-the-art communication facilities, including regular videoconferencing sessions and a special *BlackBoard* Web site. The limited number of face-to-face meetings proved very beneficial to encourage students to develop long-distance communication and organisational skills, which are essential in today's aerospace industry.

INTRODUCTION

Design is considered an activity in which all other mono-disciplines are brought together. This poses a core challenge in the field of aerospace engineering. Designing aircraft and spacecraft is a demanding task, due to the often-conflicting requirements related to safety, performance and environmental impact. The designer is required to integrate many disciplines, taking into account a multitude of constraints. Design must, therefore, be considered a major discipline in an aerospace engineering educational programme.

The educational programme of the Faculty of Aerospace Engineering at Delft University of Technology (TU Delft), Delft, the Netherlands, includes several design exercises that aim to address this need. These culminate in the third-year design-synthesis exercise, which gives students a chance to apply the analysis techniques learned in their more fundamental courses. Likewise, at the Queen's University of Technology (QUB), Belfast, Northern Ireland, UK, design projects form an integral part of students' coursework.

Nowadays, however, the design, development and manufacture of aircraft are international activities. For instance, Japan was a risk-sharing partner in the design and development of the Boeing B-777. The design of the new Airbus A380 is also an international activity; the major partners can be found in France, Germany, the United Kingdom and Spain. Based on

*A revised and expanded version of a paper presented at the *3rd Global Congress on Engineering Education*, held in Glasgow, Scotland, UK, from 30 June to 5 July 2002.

this observation, the idea was conceived to perform an international design exercise based on the original Delft design-synthesis exercise.

To put this idea into action, discussions between TU Delft and Queen's University Belfast took place, which ended in the finalisation of a concept exercise in mid-December 2001.

After that, six suitable student candidates were selected from both Universities and educational conflicts between the two Faculties' programmes resolved. The exercise was carried out in the first half of 2002. This article describes and evaluates the preparation and conduct of the international design-synthesis exercise.

DESCRIPTION OF THE PARTICIPATING FACULTIES

TU Delft, Faculty of Aerospace Engineering

Founded in 1842, TU Delft now educates more than 13,000 students over a range of technical disciplines. TU Delft's Faculty of Aerospace Engineering is the largest aerospace faculty in Western Europe and currently has 1,600 students. It offers both a three-year Bachelor and a two-year Master programmes. The Faculty is known worldwide for its research in the areas of aeronautics and space. The educational programme has been given the rating of *substantial equivalency* by the USA's Accreditation Board for Engineering and Technology (ABET).

Queens University of Belfast, School of Aeronautical Engineering

Queen's University of Belfast was established in 1845 and has five faculties and educates 19,500 students. The School of Aeronautical Engineering is contained within the Faculty of Engineering. Students enrolled in this School receive instruction in the fundamental sciences from the Faculty's academic staff, and in realistic applications from visiting lecturers from Bombardier Aerospace Shorts. The School of Aeronautical Engineering was rated the maximum 5* in the British National Research Assessment Exercise in 2001. Furthermore, teaching at the School was recently evaluated as excellent in the Teaching Quality Assessment Exercise.

Common Elements between the Two Educational Programmes

Aeronautical engineering is a branch of engineering that is concerned with the design, development, manufacture, operation and maintenance of air vehicles, such as aircraft, helicopters and missiles. The philosophy of the educational programmes of both Universities is to provide the necessary environment for the training of students to learn and apply this learning so as to meet the requirements of modern aerospace industry. The aim is to develop an understanding of:

- The fundamentals of aeronautical sciences.
- Enterprise skills, such as communication and group skills.
- Design, development and manufacturing.

In order to maximise the achievement of these aims, courses are continually developed and improved.

THE DESIGN-SYNTHESIS EXERCISE

The standard TU Delft design-synthesis exercise ensures that there is sufficient design content in the aerospace engineering programme. The overall goals of the exercise are to improve the technical design skills of the students and to further develop teamwork, communication and project-management skills.

During the exercise, the whole process of designing is addressed, from the initial list of requirements up to the final presentation of the design. Typical aspects of real design processes, such as decision-making, optimisation and conflicting requirements, are therefore encountered. Acquiring experience often means going through iterative processes, in which design decisions must be continuously reviewed to make sure that the design requirements are met.

Much of the technical knowledge obtained by students during the Bachelor programme is either directly or indirectly applicable to design. The design-synthesis exercise, therefore, gives students the opportunity to prioritise and integrate this knowledge in the context of the given assignment.

During the exercise, the educational staff review the students' decision processes and overall management of the project. Aspects of design methodology and design management are also reviewed. Educational staff also provide technical assistance for those aspects of the projects where the students lack sufficient background.

The exercise provides students with experience in working in a team for an extended period of time. This means that students must learn to cooperate, schedule and meet targets, manage the workload and solve conflicts in a group setting. Apart from working effectively in a group, students are also expected to be able to communicate ideas and concepts regarding their work with external specialists and non-specialists.

Communication skills are, therefore, of major importance. To ensure the students' educational needs in this area are met, the design-synthesis exercise includes integrated short courses in written reporting and oral presentations.

STRUCTURE OF THE FIRST INTERNATIONAL DESIGN EXERCISE

The Delft team of staff and students flew to Belfast in January 2002 for the inaugural meeting. During an intensive two-day programme, the exercise got underway. First, an introduction to the subject was given and the set-up of the exercise explained to the student group. The exercise was structured as follows:

- Phase 1: organisation and planning.
- Phase 2: analysis of the list of requirements.
- Phase 3: development of a number of conceptual designs.
- Phase 4: trade-off study to choose one of the conceptual designs.
- Phase 5: detailed design.
- Phase 6: reporting.

In Phase 1, students organised themselves into a coherent design team and established the methods by which they would communicate and exchange data. They appointed a Head of Design who was responsible for the overall management of the exercise and who was the main focal point for communication between students and staff. They also appointed a Quality Assurance manager who was responsible for data handling. This role was to ensure that data and calculation methods were correct and uniform throughout the group for the duration of the exercise.

Students paired themselves into six teams in Phase 1, each consisting of one Delft student and one QUB student. Each team generated its own conceptual solution for the given design specification, with the concepts being evaluated in Phase 4.

Phase 2 was concerned with the necessary background research for the given specification. The specification given was relatively concise. Students first had to perform background research into the meaning of all of the requirements and assess the current technology level in order to determine the requirements' priorities and level of difficulty. The specification given was not a standard specification from which a typical outcome could be expected. Instead, it contained several contradictory requirements, as well as some which could not be met with current levels of technology.

In Phase 3, the group was required to generate six different concept designs that met the requirements, one from each team. This phase provided the most opportunities for creativity. Each team then analysed the performance, flight characteristics and weight of their conceptual design. They also had to consider the preliminary structural layout and pay attention to issues like manufacturing and reliability. Students used analytical tools in this phase to assess their designs. The staff supplied some of the tools but, in general, students had to develop tools of their own.

In Phase 4, the six different designs were discussed and ranked during a mid-term review with staff. This was also a face-to-face meeting in which students had to defend their designs. The most promising design was selected for further development in the next phase.

In Phase 5, students worked as a group on one particular design. The students were paired again in Delft-Belfast teams, these being different pairs than in the previous phases. This time, each team specialised in a single discipline. The disciplines included were:

- Aerodynamics;
- Structures and materials;
- Performance;
- Manufacturing and cost estimation;
- Propulsion;
- Stability and control.

As a unit, the group had to deliver one complete design at the end of the exercise. In this phase, students' existing knowledge was sometimes insufficient, so staff provided appropriate guidance. Staff members also acted as external experts for the specific disciplines. For the design-synthesis exercise, staff were taken from several faculty discipline groups so that, together, they could coach students in all the required disciplines. The analytical tools that students developed in Phase 3 were used again in Phase 5 and refined where necessary. Where needed, additional tools were developed or supplied by staff.

Students reported their achievements in the last phase. This was done in several ways, the main deliverable being a group report. The individual contribution of each student was indicated within the report. Students were graded separately in Delft and Belfast. In addition, a poster presentation was prepared and, finally, their work was publicised during a one-day symposium in Delft. At this symposium, the International Design Team presented their work along with all of the other groups that took part in the regular Delft design-synthesis exercise. The audience consisted of fellow students, staff and representatives from industry.

COMMUNICATION FACTOR

In a design process, communication is a key factor in achieving goals. Concurrent engineering requires participants to stay in constant contact with each other. Since there were a limited number of face-to-face meetings in the international design exercise, other less direct communication means had to be utilised.

A range of communication facilities was made available to the students. The facilities included telephone, e-mail, videoconferencing and the *BlackBoard* digital communication platform. A weekly videoconferencing session was held with staff generally being in attendance. For the purpose of these meetings, the students generated an agenda in consultation with staff and kept minutes of the proceedings.

The Internet-based communication platform, *Blackboard*, enabled the team to enter chat sessions, send group e-mails and make data available to each other. Staff members were able to log on and monitor progress. When necessary, they could also take part in the discussions and post additional design data on the platform. In general, this platform was used extensively during the exercise.

DESIGN SPECIFICATION

The specification for international design exercise in 2002 was for an ultra-long range reconnaissance aircraft.

With the increasing threat of terrorist attacks, it is required to have the capability to acquire intelligence worldwide in a flexible way. Satellites have the possibility to survey the earth in great detail nowadays. However, the sensors they use are determined years in advance, and getting them over the right location can sometimes require several days. Reconnaissance aircraft are more flexible but have the disadvantage of having to be refuelled frequently during long-range missions. This exercise is aimed at designing an ultra-long-range reconnaissance aircraft with the capability of flying around the world with only one refuelling.

Since the design and manufacturing of an aircraft is a very costly business, the design should offer multiple applications. Therefore, the aircraft should also be designed such that it can perform long-range or long-duration earth-observation missions. This will allow its use in both the civil and military markets. Potential use can be found in mapping studies, atmospheric sampling and for collecting crop and land management photographic data. The list of requirements for the aircraft is given in Table 1.

Table 1: List of requirements.

Range without refuelling	20,000 km
Minimum value for maximum cruise speed	350 km/h (TAS)
Payload mass	Unmanned: 200 kg Manned: 250 kg (one person to be included in the payload)
Payload power requirements	500 W
Field requirements	To be operated from standard 10,000 ft runways
Aeroelastic behaviour	Aeroelastically stable throughout the envelope
Refuelling	Being able to refuel using normal NATO class tanker aircraft
Flight requirements	Capable of being operated both manned and unmanned. Being able to take-off and land in wind conditions up to wind force 5
Propulsion system	Both piston and jet engines allowed
Reliability	95% reliability

TECHNICAL RESULTS OF THE DESIGN EXERCISE

Figures 1 through 4 give an overview of the design stages the students went through from concept generation to the trade-off phase. All the information was posted on the *BlackBoard* site for discussion and evaluation.

Students first started with the conceptual design phase where they sketched several possible solutions for the given specification. Figure 1 shows one such initial design sketch.

After these sketches had been made, they were analysed in some detail. Ensuring the use of the same analysis methods for the six different designs required serious coordination effort. Eventually, students came up with the six concepts illustrated in Figures 2a to 2f.

After developing the initial concepts, the trade-off phase began. For this, students met again in person. During a one-day preparatory session, they discussed the perceived advantages and disadvantages of the six concepts. On the second day, they first presented

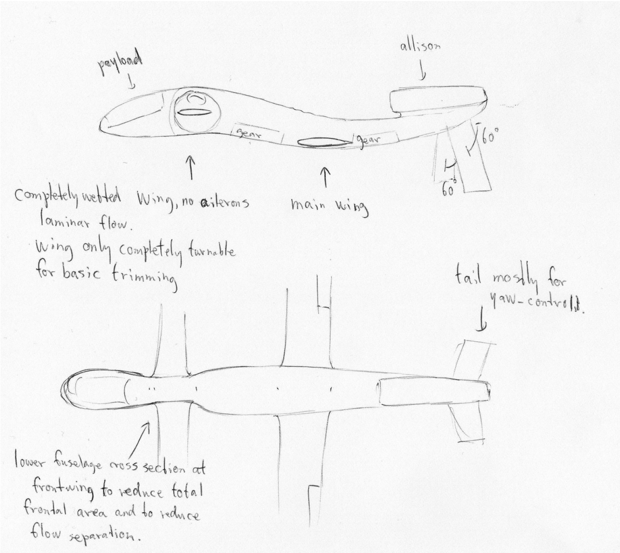

Figure 1: Example of an initial sketch.

the six designs to staff on a group-by-group basis. This was followed by an explanation of the procedure used for the trade-offs and the subsequent identification of the most promising design. The result showed that the twin boom concept was the most promising. Interestingly, students found that the twin boom design could be improved further by incorporating some of the features from the other designs. The engine location was moved from the top of the fuselage to the rear end of the fuselage and the intakes were placed on the left and right hand side of the fuselage.

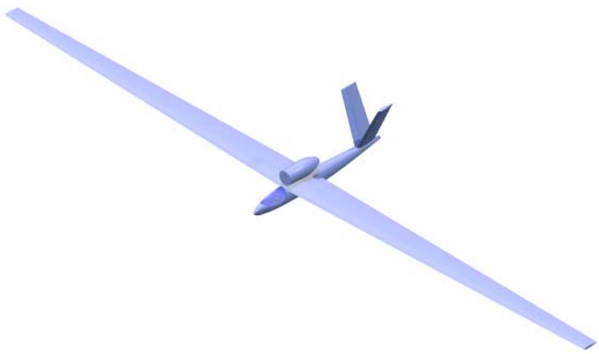

Figure 2a: *Glider* concept.

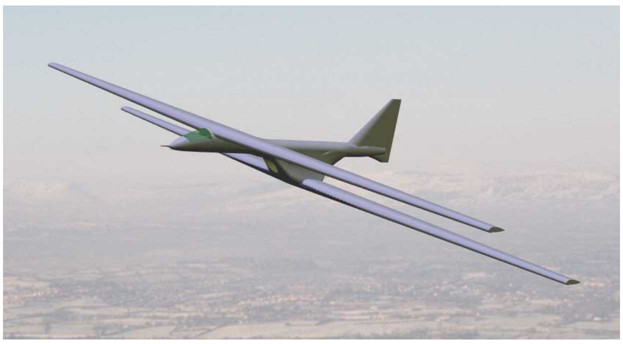

Figure 2b: *Tandem wing* concept.

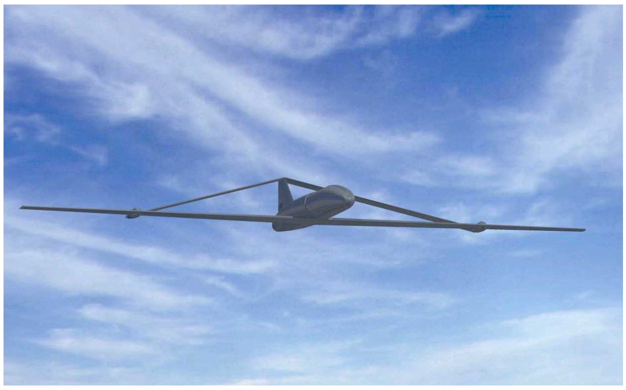

Figure 2c: *Joined wing* concept.

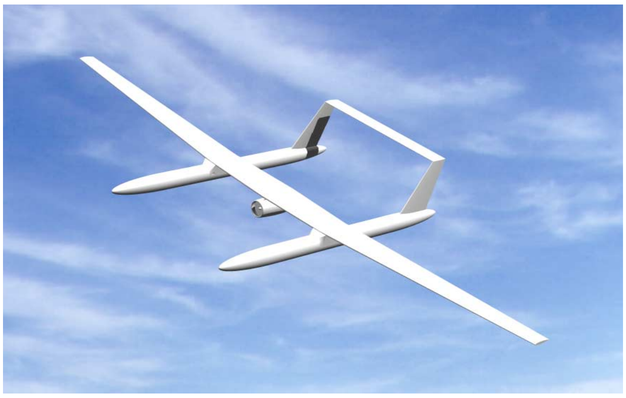

Figure 2d: *Twin fuselage* concept.

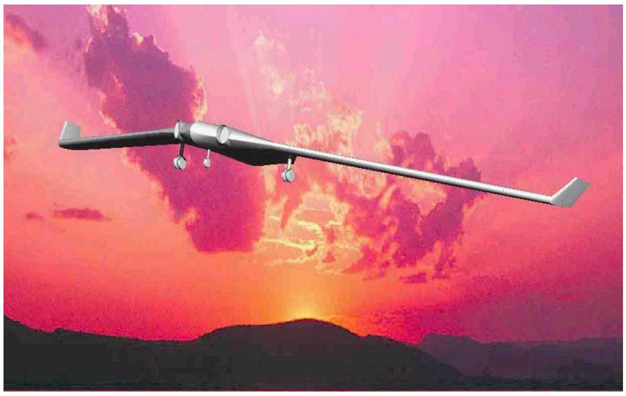

Figure 2e: *El condor* concept.

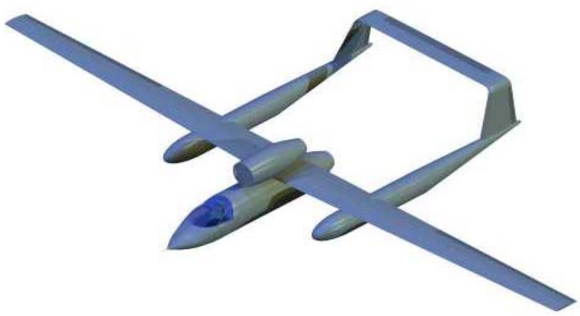

Figure 2f: *Twin boom* concept.

This then led to the detailed design phase with students working in the specialist discipline groups as mentioned previously. Each of these groups again consisted of one student from Belfast and one student from Delft. In this phase, they performed more detailed calculations on the aerodynamics and performance. Figures 3 and 4 show the geometry definition used for the aerodynamic calculations and the respective results.

The propulsion system to be used was a contentious issue. The specification was drafted so that both a propeller and a jet driven configuration could meet the requirements and intense discussions developed between the Delft and the Belfast team as to what type of engine to use. The Belfast team was in favour of the jet engine and the Delft team was in favour of the propeller-driven configuration. In the end, the issue was resolved with the selection of a jet-driven configuration. Figure 5 shows the final design.

The structures group focused on the development of a structural layout for the complete aircraft. It is normally the case in the aerospace industry that

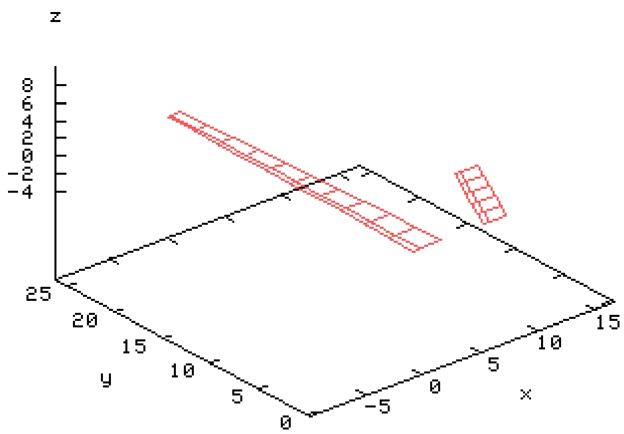

Figure 3: Geometry definition for aerodynamic calculations.

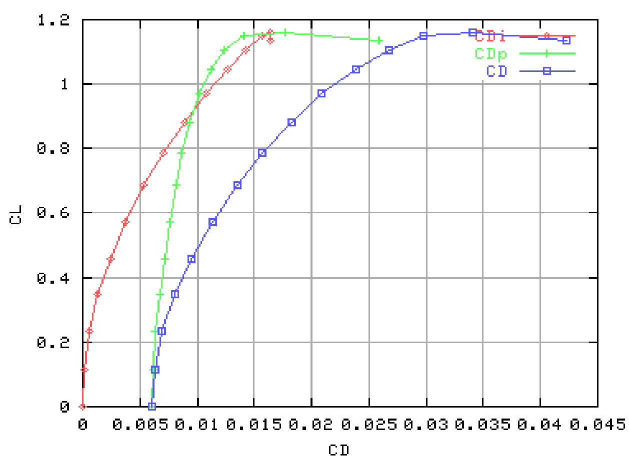

Figure 4: Results of aerodynamic calculations.

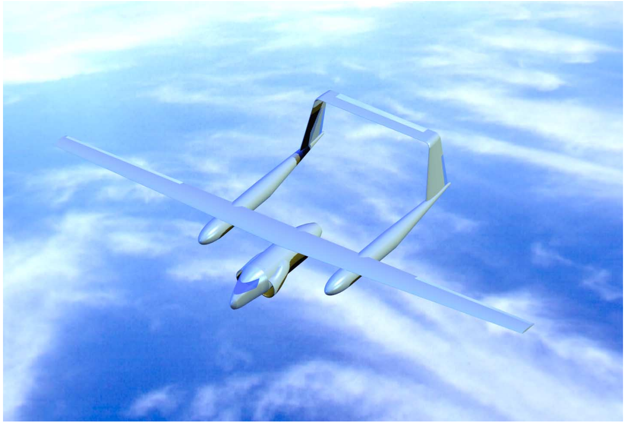

Figure 5: The final design.

partners in a project concentrate on different parts of the aircraft. The group decided to engineer the lifting structural parts (wing and tail surfaces) in Belfast and the non-lifting parts (fuselage and undercarriage) in Delft.

The costs and manufacturing group also split the work package into two parts. The manufacturing assessment of the design was performed in Belfast with the costs being analysed in Delft. However, there was no expertise available in Delft on this issue and the student involved completed the work with the assistance of a staff member from Belfast.

Full details of the initial concepts and the final design can be found in the group report [1].

EVALUATION

On completion of the project, a formal evaluation took place [2]. Evaluation of the exercise was based on interview sessions with all of the staff and almost all of the students involved. The aim of this evaluation was to determine if the modified engineering design exercise provided an effective platform for the development of international cooperation skills. In order to answer this question, the following topics were addressed:

- Preparation of the exercise;
- Students' characteristics;
- Collaboration;
- Communication.

Preparation

The TU Delft proposal to cooperate in this exercise was positively received at QUB. There, a comparable exercise or project is part of the curriculum. As the decision to cooperate was only taken in December, little time for preparation was available. Time schedules of both Universities were not similar, so adaptations had to be made. Delft students were to start earlier than normal (ie in January instead of April in the final period of their third year). The design and synthesis exercise would end on the same date for all students; the grading of students' work was to be done independently and separately at both Universities. The selection of students took place in December 2001.

Students' Characteristics

All students participating in the design and synthesis exercise were in their third year, ie at the end of their Bachelor programme. The aeronautical subjects taught in both curricula compare quite well. Asked for differences, staff at QUB and at TU Delft indicated that students at TU Delft have more general knowledge on a systems level, while QUB students have more in-depth knowledge (on certain subjects). TU Delft students were very fluent in the English language. However, sometimes, understanding the spoken Northern Irish dialect did prove problematic.

When asked to characterise themselves and their counterparts, QUB students indicated that TU Delft students seemed more inclined towards experimenting with ideas, while QUB students tended to be more conservative. TU Delft students saw themselves as being more strong-headed, with QUB students being more accommodating.

Collaboration as Observed by Staff

The supervisors observed the progression of the exercise (from a certain *distance*). This enabled them to evaluate the collaboration that took place. The supervisors expressed that the level of cooperation in the exercise did not considerably deviate from that of other (national) groups.

However, the supervisors saw that the way of cooperation and, more specifically, the amount of communication showed differences: highs and lows in the amount of communication could clearly be distinguished. The face-to-face meetings were very intense while the frequency of communication in between these meetings seemed, at times, to be low. Nevertheless, Internet-chatting was used on a regular basis during these periods. It seems that students are able to *store-up* a certain amount of communication needs and *release* this during the face-to-face meetings and chatting sessions. The quality of students' performance was rated as comparable, with TU Delft students being seen as more independent and autonomous.

Collaboration as Experienced by Students

Students appreciated the life-like situation of the simulated design environment as is often encountered in the global aeronautical industry. In general, they valued highly the experience of overcoming communication hurdles in order to fulfil the exercise's requirements.

COMMUNICATION METHODS

During the design and synthesis exercise, cooperation was achieved by making use of various methods of communication. This section highlights the importance and shortcomings of each method.

Face-to-Face Meetings

At the onset of the design and synthesis exercise, only two face-to-face meetings were planned: one at the beginning and one at the end. The organising staff reasoned that online communication would not suffice and that this would need to be supplemented. Both of these meetings were found to be most valuable. In the initial phase, while preparing and planning the exercise, getting personally acquainted seemed a necessity. Likewise, the final preparation of the design's presentation benefited from face-to-face contact.

Students confirmed the usefulness and even necessity of both meetings. Important responses from the interviews included:

- *Getting to know one another is a prerequisite for good cooperation.*
- *Preparing and doing the final presentation together strengthened the feeling of really being a group.*

Both of these meetings (including the extra one) had binding social elements, as well as more content-related elements.

An extra mid-exercise meeting was organised by request from the students involved. In order to finalise the trade-off study and to decide which conceptual design to develop further into the final product, a face-to-face meeting was deemed necessary. Fortunately, the budget for the design and synthesis exercise allowed for an extra visit by TU Delft students to Belfast. Students reported that this meeting was very efficient: *In 36 hours, we accomplished more than normally in a week.*

BlackBoard

The digital learning environment that TU Delft has implemented University-wide was also used for the

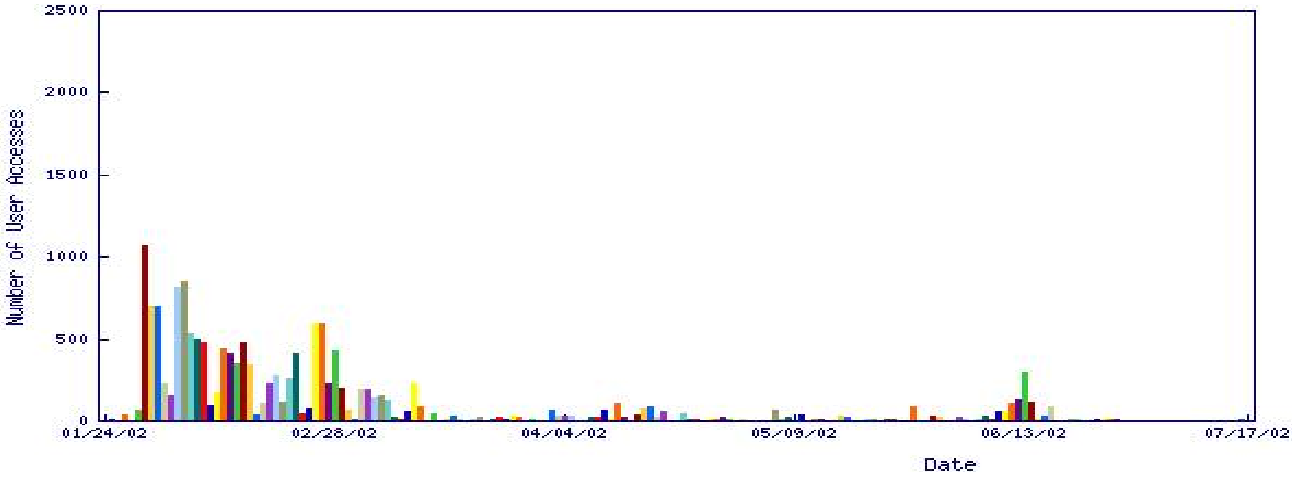

Figure 6: Frequency of use of *BlackBoard*.

design and synthesis exercise. Through *BlackBoard*, lecturers can supply information and content; it provides a means for communication and cooperation.

However, student experiences were not too favourable. For communication of the kind necessary in the design and synthesis exercise, *BlackBoard* fell short, they argued. The exchange of large data files was not well supported by *BlackBoard*. Synchronous cooperation cannot be realised easily within the digital learning environment. As such, students sought and found alternatives to overcome these obstacles.

Videoconferencing

Once each week, a one-hour videoconference meeting was organised, the rationale being that videoconferencing provides an excellent opportunity for synchronous communication and observing non-verbal reactions. From a technical point of view, the videoconferencing facilities (number of available lines) differed at TU Delft and QUB. As a result, the quality of the transmissions differed. Sound from Belfast, for example, was not received very well in Delft.

From an organisational point of view, sessions needed to be well prepared. An agenda had to be drawn up and a spokesperson appointed. During the session, minutes were taken on both sides. Although the students appreciated the sessions, they did not always bring what might have been expected.

Language

English, the *lingua franca* of aerospace science and industry, was the working language in the design and synthesis exercise. Although the TU Delft students were quite fluent in English, they had to get used to the accent spoken by the Northern Irish students and staff. During one or two videoconference meetings, the combination of limited sound quality and accent led to some misunderstanding on the TU Delft side.

However, students and staff from QUB and from TU Delft generally indicated that language was not an obstacle to cooperation.

DISCUSSION

The aim of this international design exercise was to expose students to a design exercise with the added challenge of having to complete it in collaboration with colleagues at a remote site. Modern communications technology, such as the Internet and videoconferencing facilities, made carrying out this exercise feasible within the given time constraint. It was still found essential to hold face-to-face meetings at certain intervals in order to facilitate progress. This was made financially viable due to the existence of low-cost airline flights between Belfast and Amsterdam.

Apart from the logistics of the exercise, it was essential to select high calibre students with sufficient drive and determination to succeed, regardless of the hurdles. Some rearranging of the Belfast students' modules for the 10-week period was required in order to allow them to spend time on the exercise in parallel with their Dutch colleagues. Each student's work was assessed by staff from their own University in order to provide continuity of marking between modules.

It was observed in previous Delft exercises that students enjoyed the conceptual design phase, Phase 3, the most, as it challenged them to come up with all kinds of futuristic designs. In Phase 5, concurrent engineering became very important, as the requirements of one expert team conflicted with those from other teams. With good communication on a regular basis, the group was able to come up with a feasible compromise of all requirements.

For students, experience was gained in the discipline of aircraft design as well as in teamworking, concurrent engineering and communication and reporting skills. The overall learning experience was considered enjoyable and rewarding by all students. Face-to-face meetings, two in Belfast and one in Delft, had both a business and a social aspect, the social aspect giving some incentive for the hard work involved.

The final symposium in Delft, in which the international design group had to publicise their work next to the regular Delft design exercise groups, was also a valuable learning experience for students. This was a very professional and fitting conclusion to the exercise.

CONCLUSION

In order to help students develop those international collaboration skills that are of increasing importance in aircraft design, an international design exercise was developed. The additional learning opportunities provided by the exercise were found to be very valuable, as they allowed students to develop essential long-distance communication and organisational skills.

Students and staff met in Belfast for an inaugural and interim session and in Delft for the final presentation. This limited number of face-to-face meetings proved very beneficial in order to encourage students to develop strategies for efficient long-distance collaboration.

REFERENCES

1. Bartlett, R. et al, LARES Ultra Long Range Reconnaissance Aircraft Report: International Design Synthesis Exercise 2002. Report, Delft: Delft University of Technology, June (2002).
2. Jacobs, M.A.F.M., Cooperation and Learning at a Distance in an Aerospace Design and Synthesis Exercise. Evaluation Report, Delft: Delft University of Technology, October (2002).

BIOGRAPHIES

Joris A. Melkert is an assistant professor for propulsion, noise and helicopters. He is also Head of the Bureau for Strategic Development in the Faculty of Aerospace Engineering at the Delft University of Technology (TU Delft), Delft, the Netherlands. He holds a Master's degree in aerospace engineering, as well as a Bachelor's degree in business administration.

He has experience as a flight test engineer and supervises students in design projects and performing their Master thesis work in the area of flight mechanics and propulsion.

Dr Alan Gibson is a lecturer in aeronautical engineering. He began his career as an apprentice fitter in the aircraft manufacturing industry. After several years in the industry, including a period in South Africa, he returned to full-time education as a mature student in 1989, studying for a BTEC Diploma in engineering. He subsequently graduated with a BEng in aeronautical engineering from Queen's University of Belfast (QUB) in 1994, followed with a Master's degree in aerospace vehicle design from Cranfield University in 1995. He returned to QUB in 1995 to study, initially full-time, for a PhD in the field of welded aircraft structures, graduating in 2000. In 1998, he was appointed as Research Assistant, working on the non-linear buckling analysis and testing of aircraft fuselage panels. He was appointed as Teaching Fellow in 2000 and as Lecturer in 2001, lecturing in aircraft design and structural analysis.

His research activity includes the analysis and testing of welded, extruded, bonded and integrally machined fuselage structures.

Steven J. Hulshoff is an active researcher in numerical methods for aerodynamics, with a particular interest in unsteady flows. After completing his doctoral work on the simulation of helicopter rotors, he has pursued projects in flight dynamics, aeroacoustics, and fluid-structure interaction.

He is currently an assistant professor at the Delft University of Technology, where he lectures in aeroelasticity and participates in the supervision of student design projects.

The Global Journal of Engineering Education

The UICEE s *Global Journal of Engineering Education* (GJEE) was launched by the Director-General of UNESCO, Dr Frederico Mayor at the April meeting of the UNESCO International Committee on Engineering Education (ICEE), held at UNESCO headquarters in Paris, France, in 1997.

The GJEE is set to become a benchmark for journals of engineering education. It is edited by the UICEE Director, Prof. Zenon J. Pudlowski, and has an impressive advisory board, comprising around 30 distinguished academics from around the world.

The Journal is a further step in the Centre s quest to fulfil its commission of human resources development within engineering through engineering education, in this instance, by providing both a global forum for debate on, and research and development into, issues of importance to engineering education, and a vehicle for the global transfer of such discourse.

In the first six years of the Journal s existence, 254 papers over 1,850 pages have been published, including award-winning papers from UICEE conferences held around the world. Papers have tackled issues of multimedia in engineering education, international collaboration, women in engineering education, curriculum development, the future of engineering education, the World Wide Web and the value of international experience, to name just a few. Other examples include: Vol.3, No.1 was dedicated to papers on quality issues in engineering education; Vol.3, No.3 focused on papers given at the *1st Conference on Life-Long Learning for Engineers*; Vol.4, No.2 centred on the German Network of Engineering Education and was the first issue published entirely in the German language; Vol.4, No.3 centred on the achievements of the *2nd Global Congress on Engineering Education*, held in Wismar, Germany; while Vol.5, No.2, had a more regional focus on Taiwan, and Vol.6, No.2 concentrated on engineering education in Denmark.

The GJEE is available to members of the UICEE at an individual member rate of $A100 p.a., or to libraries at a rate of $A200 p.a. (nominally two issues per year, although each volume has included an extra, complementary issue). For further details, contact the UICEE at: UICEE, Faculty of Engineering Monash University, Clayton, Victoria 3800, Australia. Tel: +61 3 990-54977 Fax: +61 3 990-51547, or visit the UICEE Website at:
http://www.eng.monash.edu.au/uicee