Mechanical and Aerospace Engineering Capstone Design Projects at Carleton University

M. John D. HAYES *Robert G. LANGLOIS* *Richard J. KIND*

Mechanical and Aerospace Engineering, Carleton University
Ottawa, ON., Canada.

Carleton University began offering Masters and Doctoral degrees in aeronautical engineering in the early 1960s. By the 1970s there were several faculty members who had spent some time in the United Kingdom and were well aware of the design project that was a major part of the educational activities at The College of Aeronautics, Cranfield, England (now Cranfield University). The Cranfield project involved a design team of about 20 students, guided by several faculty members. Over a period of a year or more the team would typically develop, to quite a high level of detail, the design of an aircraft for some specified mission. In 1986 a proposal to offer an undergraduate degree program in aerospace engineering was being prepared for Carleton University's senate and there was a consensus that a team design project similar to that at Cranfield should be included in the final year of the new program. The intent was to simulate insofar as possible the team-design environment typically found in the aerospace industry. It was felt that such a team project would not only provide students with substantial first-hand design experience but would also provide a vehicle for attaining other educational objectives, including making students aware of the importance of collaborative effort, communications, documentation and configuration control and for giving them opportunities to improve their presentation and report-writing skills. The proposal was accepted by Senate and both an aircraft and a satellite design project, each with about 20 students, were implemented in 1991-92, the final year of the first Aerospace Engineering graduating class.

Representatives of industry were involved in the projects from the beginning, both as lead engineers in the project work itself and as evaluators in the formal design review presentations at the end of each academic year, see [1], for example. The feedback from industry representatives was very positive, so much so that in 2001-02 the same team project format was adopted in the mechanical engineering degree program.

The current success and popularity of the capstone design projects largely can be attributed to three main factors: challenge, industrial relevance, and continuity. Experience has demonstrated that the more challenging the task faced by students, the greater the accomplishment that can be expected. To further foster this, project managers and lead engineers (faculty members and consultants) are finding that technical and management support rather than direction is an effective operating model for the projects. Each project is technically challenging and generally based on ambitious end objectives. Projects are industrially relevant in two senses - technically and administratively. The technical relevance of projects facilitates obtaining financial support and interaction between students and engineers in industry. The combined industrial and educational environment exposes students to industrial project management with greater tolerance for mistakes along the learning curve. The support provided by industry is partly due to the fact that these projects provide a pool of highly qualified personnel who are already familiar with technical and interpersonal aspects of large projects, and with potential technical solutions to difficult problems. Publicity with students and the public at large, and an opportunity to contribute to engineering education are additional factors. Continuity results from both the size of project teams and the multi-year nature of the projects. A typical project now involves approximately 25 students, five lead engineers, and a project manager, each contributing a minimum of 200 hours (sometimes much more) to the project each year. This results in a project budget in excess of 30,000 engineering hours over five years - representative of a large engineering project. The large number of participants and long duration allow for efficient parallel developments as well as long serial developments such as design iteration. While annual student turn-over necessitates more learning time than would otherwise be required, it provides many new perspectives and a continuous evaluation of previous design decisions. One result is that the projects are currently strong and are also evolving - quality is improving, student involvement at the graduate level and from programs external to Mechanical and Aerospace Engineering is growing, industrial interest and participation is increasing, and greater financial resources are becoming available.

At present, projects are proposed and selected by departmental faculty members. As industry fully appreciates the potential of these projects for tackling challenging problems that can more easily be undertaken in a university environment due to greater academic resources, greater cost effectiveness, and reduced requirements for guaranteed success or immediate results, it is likely that projects will be selected and coordinated collaboratively with the research and development activities of industrial and government partners.

The six current design projects are: 1) multifunctional simulator; 2) science data relay satellite; 3) micro gas turbine engine; 4) autonomous underground mining vehicle; 5) formula SAE; 6) unmanned air vehicle. The spectrum is broad and covers virtually all aspects of mechanical and aerospace engineering. It is evident that industrially-motivated needs provide challenging capstone design projects, and result in lasting benefits both in terms of student education and potential products.

REFERENCES

[1] Straznicky, P.V., Kind R.J.,"Trends in Aerospace Engineering Education - Meeting the Industry Needs Using a Team Project", *Canadian Aeronautics and Space Journal*, Vol. 46, No. 2, June 2000.

