CURRENT TRENDS IN AEROSPACE ENGINEERING EDUCATION ON TAIWAN

Sheng-Jii Hsieh
Institute of Aeronautics and Astronautics
National Cheng Kung University
Tainan 701, TAIWAN, R.O.C.

ABSTRACT - *A proposal for current trends in Aerospace Engineering Education on Taiwan has been drawn from the suggestions made after a national conference of "Workshop on Aerospace Engineering Education Reform." This workshop was held in January 18-20, 1998, at the Institute of Aeronautics and Astronautics, National Cheng Kung University, Tainan, Taiwan, R.O.C.. The purposes of holding this workshop is to review the current aerospace engineering education, both at unders and graduate programs, and then, try to make suggestions on course planning, courseware materials and modern topics, so that the aerospace graduates are able to work in the high-technology, challenging real world.*

At the closure of this workshop conference, some suggestions are proposed in details on the current trends of four aerospace engineering education programs on Taiwan, both for unders as well as graduate studies. In general, under- graduate courses are stressed on fundamentals and physical appreciation, whereas the graduate education is structured to contribute to the advancement of technology. International cooperation and technology transfer under mutual interests are recognized as the best way to achieve high technologies. It is expected that, the suggestions on current trends of aerospace engineering education on Taiwan would work as a good reference to other Countries if they also choose aerospace technology as one of the major industry in the challenging 21st Century.

I. MODERN AEROSPACE ENGINEERING EDUCATION

It is known that, the objectives of the engineering education are to train students being able to handle engineering problems in the analysis, design and fabrication of a real thing. Accordingly, the objectives of the aerospace engineering are to teach students familiar with aerospace systems in analysis, design and manufacture of flight vehicles. In order to keep in pace with the fast changing world, the engineering education needs frequent reviewed, and urges schools to make necessary improvement or reform on the educational programs. In the past four decades, there ever had three education reforms due to the striking of satellite Sputnik to start the space competition since 1957, the impact of energy crisis in 1970's, and the great achievements of computer and space communication technology in 1980's. Due to the technology progress of this shrinking world, it is clear that, the space-utilization industry and the information technology will be the major enterprises in the 21st Century. In other words, the matter that aerospace industry is one of the major industries in the near future, should awake engineering professors to re-evaluate the existing education programs they give to the students.

Aerospace engineering is characterized in its high technology, which is resulting in the requisites to produce most safe, fast, robotic and comfort systems, and which systems can also operate successfully in very critical conditions and in severe environments. Therefore, known by its high-technology senses, aerospace industry is taken as the driving force to push and to upgrade other branches of industry. The world is one, and its resources are so limited and distributed all over the Earth. Each Country possesses only some specific resources that other Countries does not have. Peoples in the world should cooperate and help one another to improve their living. Therefore, the sharing of resources and the transferring of technologies among Countries under mutual interests are the working model for the world toward bright future. International cooperation and partnership are the best way to help the developing Countries to become developed. Well developed high-technology companies should provide the research and education activities and interact with university and industry. The cooperation among government-industry-university should be linked tightly together to promote the technology level and students' abilities. It is noted that, well engineering education and a high-technology society are closely related, and an intensive interaction between education and technology would come up to a wealthy society and a peaceful world.

Due to the fast developing and highly competing aerospace technologies, aerospace industry nowadays is urged to produce an advanced vehicle with low life-cycle-cost, implemented with new technology, to meet high environment standard, and, of course, to operate the vehicle in automation, robotics and safety. As summarized by Prof. K. Y. Lin of the University of Washington at Seattle, there are four critical technologies for the present and near future development in aerospace industry. These critical technologies are: the information technologies to manage an autonomous and smart vehicle; the development of composite materials and structure configuration to optimize vehicle performance; the technologies associated with the systems issues of life-cycle-cost, operation, and maintenance, are a driving force in the design of new aerospace systems; the technologies relating to environmental factors, such as the control of pollution and reduction of noise, will play an important role in future aerospace vehicles and systems. Definitely, though most of the key technologies would be solved eventually, and the aerospace field will continue to flourish, but still there are some major and important changes occurring. Thus, today's and tomorrow's aerospace engineers must be well prepared to adapt to the field as it changes.

II. EDUCATION REFORM WORKSHOP

In confrontation with this highly technical, industrial world nowadays, it is the time to examine the results of our aerospace engineering education, whether the program is working properly and/or the knowledges are able to keep in pace with the technology development. A "Workshop on Aerospace Engineering Education Reform" was held in January 18-20, 1998, at the Institute of Aeronautics and Astronautics, National Cheng Kung University, Tainan, Taiwan, to discuss on four major aerospace engineering education programs offering in Taiwan. This Workshop aims to review current courseware work and to forecast the future developments in Aerospace Engineering Education in the 21st Century. It is known that, the subject of aerospace engineering covers the knowledges of aeronautical engineering and astronautical engineering. The aerospace engineering is a vehicle-oriented discipline and its educational mission should be the design, manufacturing, operations and maintenance of such aerospace vehicles. Therefore, the aerospace engineering education comprises four branches of educational programs. These four major educational programs in aerospace engineering are:
(1) Aerodynamics, flight mechanics, stability and control.
(2) Aerospace materials and structures.
(3) Aerospace engineering measurement methods.
(4) Space engineering systems and design.

In three days discussions in the workshop, participants firstly discussed on the current objectives of engineering education, and the coursework of education programs given at four aerospace engineering departments on Taiwan. Then, eight keynote speakers present the background materials of the current status and the future trends of aerospace development in the US and on Taiwan. Four of the keynote speakers are senior scholars from the US, and the other four keynote speakers are the top leaders of aircraft/space manufacturing companies or research institutions on Taiwan. With reference to the criteria of U.S. Accreditation Board for Engineering and Technology, the U.S. National Research Council's Board on Engineering Education, the Kansas Industry/University/Government Engineering Education Consortium, and many other essays about the attributes of good engineers, all participants generally agree the six objectives of modern engineering education concluded at the University of Kansas at Lawrence. These six objectives of engineering education are presented, by Prof. C. Edward Lan of that University, in the following:

(1) Technical Competence
To develop the course work, courseware planning and course contents, in theoretical, numerical and experimental techniques for the students capacitate for identifying, formulating, and solving engineering or real world problems. This also means that the relevance of course work to the real world problems should be maintained.

(2) Broad Education
Graduates must demonstrate the broad education necessary to understand the impact of engineering solutions, the knowledge of contemporary issues, and the ability to work effectively with customers in an international marketplace.

(3) Team Work and Leadership
Graduates must demonstrate an ability to function on multidisciplinary teams, to develop leadership skills, and to accept and support team decisions.

(4) Professional and Ethical Responsibility
The graduates should know how to develop products such that these products not only will improve people's lives, but also are safe.

(5) Communication
Home work and reports should be prepared professionally. Oral presentation to express and to exchange ideas can also be required.

(6) Life-long Learning
Aerospace engineering is a high technology and a dynamic profession, so that engineers must learn how to engage a life-long learning.

With the objectives of aerospace engineering education shown above, and the needs for graduating modern engineers to work in the 21st Century, an education reform on courseware work of aerospace engineering is widely discussed in the Workshop. Four major aerospace engineering education programs as indicated above were discussed, and the important course contents of the educational programs were suggested in the following sections.

III. SUGGESTED TOPICS IN AERODYNAMICS, AIRCRAFT PERFORMANCE, FLIGHT MECHANICS, STABILITY AND CONTROL

Aircraft Design course is the central theme and the senior subject of an aeronautical engineering undergraduate program. The pre-requisites courses for the Aircraft Design are Aerodynamics, Aircraft Performance, Flight Mechanics, and Stability and Control. Therefore, it needs great attention to consider these four courses in their course work together. That is, the methods of teaching and the course contents must be well prepared. Generally, for undergraduate program, the subjects are stressed on the fundamentals and physical appreciation, whereas the graduate courses are structured to contribute to the advancement of technology.

Because of the special features and unique prospects of each university, the course planning of the above four subjects, may have some differences, but the essential contents among them should be the same or very close to. Therefore, the course contents for these four courses should be reviewed and discussed all together in order to meet the teaching purposes of Aircraft Design course, as well as the training of aeronautical students. Therefore, in addition to the current topics teaching in Aerospace Engineering Departments in Taiwan, some more advanced topics in the Aerodynamics, Aircraft Performance, Flight Mechanics, and Stability and Control courses for modern undergraduate education, are recommended and/or stressed in:

(1) Detailed analysis of drag component build-up, and the importance of drag reduction on performance.
(2) Theories and applications of airdata sensors, such as altimeters, airspeed indicators, **(2**-sensors, and **n**-sensors.
(3) Wind tunnel testing projects and experimental methods, and data acquisition techniques should be pronounced.
(4) Take-off and landing analysis to satisfy requirements, with emphasis on engine-out operations.
(5) Air load estimation and performance limitations, such as: the g-load, buffet, guest loads, aging in relation to certification requirements.
(6) Flight safety and accident prevention of aircraft.
(7) Features of non-linear aerodynamics and their effects on flight and control of aircrafts.
(8) Discuss regulations on flying and handling qualities and how they affect flight dynamics.
(9) Use action media, such as videotapes, simple flight simulators, or PC-based flight simulation to illustrate some specific dynamic properties of aircraft.
(10) Use real-world examples, from flight test data and some professional aerospace engineering magazines, to illustrate the subject matters.

IV. SUGGESTED TOPICS IN AEROSPACE MATERIALS AND STRUCTURES

After discussion on the educational goals in aerospace structures and materials, it is concluded that all graduates from a B.S.A.E. degree should understand engineering materials and properties, mechanics of materials, aircraft structures and analysis methods, atmospherical flight mechanics, dynamics of flight vehicles, mechanical testing of materials and structures, design of aircraft and spacecraft systems. Evidently, these subjects or courses are already offered in the current undergraduate educational program on Taiwan, but there still needs a critical review and revision of course contents frequently to reflect recent changes in aerospace industry on Taiwan and worldwide.

Reviewing the courseware work given in aerospace engineering program on Taiwan, the following topics should be stressed and/or added in the relevant courses:

(1) Topic of composite materials and properties, or an introduction course of Composite Materials for Aerospace Structures should be given in the undergraduate program.
(2) Structural analysis methods and design projects on engineering syntheses should be pronounced in the class.
(3) Structural design, analysis and optimization are indispensable topics and training subjects in the design of aircraft and spacecraft systems.
(4) Finite element methods should be introduced and given as a tool on structural analysis and design problems.
(5) In aerospace graduate program majored in materials and structures, courses of Smart Materials and Structures, Concurrent Engineering, CAD/CAE, Signal Acquisition and Spectrum Analysis, Vibroacoustic Analysis and Measurement are suggested to offer.

V. SUGGESTED TOPICS IN AEROSPACE ENGINEERING MEASUREMENT METHODS

Generally speaking, an engineering education program trains students to solve engineering problems, and to provide academic knowledge with emphasis on problem solving skills. To accomplish these goals, there are several approaches that have been taken:

(1) Teach engineering courses to train students in area of in-depth engineering knowledge.
(2) Use computers and simulation tools to demonstrate the solutions, enhance physical meaning and help students to gain confidence in engineering problems.
(3) Offer experimental courses to equip students with testing skills and ensure their ability to develop appropriate solutions.

For modern experiments, there are basic tools that are required almost under any circumstance. These basic tools are:

(1) Machining – mechanism, engineering graphs, production methods, and materials.
(2) Data acquisition and analysis; Imaging acquisition and analysis.
(3) Software systems–Computer languages and computation skills for data acquisition and data analysis, including imaging processing.
(4) Hardware – fundamentals of electric circuits, electronics and electric devices. Design of basic circuitry for data acquisition.
(5) Optics and Lasers.
(6) Special instrument and its development.

The keynote paper on experimental curriculum for aerospace engineering education is provided by Dr. Tzong-Hsi Chen, President and CEO of Taitech, Inc. at Dayton, Ohio. After surveying 16 leading universities in the US offering aerospace engineering education, Chen indicates that, for experimental courses, some institutions emphasize systems, some institutions emphasize component, and some are dealing with both areas. However, the student must realize that nothing is real as hands-on experience.

Reviewing the experimental courses for aerospace engineering education on Taiwan, it is found that the traditional experiments and laboratories on thermo–fluids, materials and structures, aerodynamics, and navigation and control of the flight vehicles are arranged in the curriculum. The further suggestions in the workshop are to conduct some advanced experiments implemented with: electric strain gages; pressure transducers and thermocouples; hot-wire and hot-film velocimetry; optical, laser Doppler, and particle imaging methods in flow visualization and velocity measurements; Rayleigh scattering technique for flow visualization. It is encouraged to teach one course in undergraduate program on "Instrumentation for Experiments" to introduce electrical and electronic devices, sensors, and the principles of digital data acquisition, signal processing and statistical analysis of the experiments.

VI. SUGGESTED CURRICULUM AND TOPICS IN SPACE ENGINEERING SYSTEMS AND DESIGN

The program of Space Engineering is the other half of Aerospace Engineering education. The curriculum of space engineering for undergraduate study is suggested, with minimum modification, on the current Aeronautical Engineering education program. A new comprehensive and systematic space engineering program has been designed and taught at the Department of Mechanical and Aerospace Engineering at the University of Alabama in Huntsville, and it seems working very well as claimed by prof. S. T. Wu of that university. Due to its system integrity and its interdiciplinary engineering curriculum for satellite system design, the participants of this workshop appreciated and suggested this program to the aerospace engineering education on Taiwan. The scenario of this program is in the area of Microsat design, fabrication, testing and operation. The Microsat is a class of satellite generally defined as under 80 kg mass and can be launched as a secondary payload for cutting the cost. Though it is small, it has all the space sciences and technologies of the space engineering system.

This undergraduate program of space engineering education, with minimum modification to the current curriculum, is proposed by four courses of 12 credit semester hours in the senior year. These four courses are:

(1) Satellite Technology and Its Applications – 3 credit semester hours.
(2) Spacecraft Systems Engineering – 3 credit semester hours.
(3) Fundamental of Microsat Design and Fabrication – 3 credit semester hours.
(4) Microsat Electrical/Electronic Subsystems – 3 credit semester hours.

As for the graduate program of space engineering education, Prof. Jia-Ming Shyu, Director of National Space Program Office of R.O.C., suggested the following curriculum. This curriculum covers courses or topics as System Engineering and Process, Space Design and Analysis, Remote Sensing and Remote Control, Introduction to Payloads, Satellite Communication, Satellite Integration and Test, Satellite Ground System, Launch Vehicle and Launch Process, Satellite Mission Operations, Project Management, Satellite Signal and Data Processing, Quality Assurance and System Reliability.

VII. PROGRESS THROUGH PATERNSHIPS AND ENTERPRENUERSHIPS

Though the world is one and peoples are getting closer, there still have international competition among Countries because the world has only one market. There must have some international cooperation between Countries through the offset program, which promises key technology transfer and technical training programs between relating companies under mutual interests. It is important to note that, for the developing Countries like Taiwan, they can make progress only through the international cooperation on paternships and enterprenuerships with the advanced technology Countries. Evidently, this is the only way for the developing countries to become well developed.

VIII. CONCLUSIONS

The current trends on aerospace engineering education on Taiwan have been proposed after a three days workshop at IAA, NCKU, Taiwan, in January 1998. The curricula of four aerospace engineering departments on Taiwan were firstly reviewed, eight keynote speeches based on the current status in the US and in Taiwan local aerospace industries were followed, and finally, some suggestions on education reform for better education and promotion of aerospace industry in Taiwan were proposed.

An action item is strongly proposed in this workshop that, an Advisory Board or a Steering Committee on aerospace engineering education should be formed to review the current curriculum, courseware work, research programs and industrial cooperation projects of the Department. Besides, the Committee would give some responses or comments from the society to help the academic activities of the Department. This Committee should meet once every year, and all the faculties and student leaders are obliged to attend for ensuring a better aerospace engineering education to meet the advanced industry, and to become an advanced research institution at the international level.

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