

Viewpoint: Aerospace Education for 2000 and Beyond*

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To be responsive to the needs of the US aerospace industry in the future, the education system must undergo an evolution. The educational reforms are linked to the projected needs of the industry. Several specific recommendations are made including a major overhaul of the design education curriculum. An unprecedented alliance between universities, industry, and government will be needed to develop a strategic plan for aerospace education for 2000 and beyond.

INTRODUCTION

FACED with the end of the cold war and increasing foreign competition, the US aerospace industry is undergoing major changes. Although the industry currently contributes significantly to the balance of payment, we face strong competition from Europe and Japan in the future. A key element of industry's continued leadership in the world market is a highly educated workforce that can improve productivity, innovation, and adaptability. This means focusing the aerospace education in the context of producing high quality and cost-competitive products and services. The focus of this article is on several aspects of aerospace education and the changes recommended are discussed in the context of future trends and industry needs.

DESIGN EDUCATION

A typical aerospace engineering graduate is more scientist than engineer. This is not surprising in view of the fact that a basic foundation of aerospace engineering lies in the fundamental sciences. For the large part, our faculty have a narrow focus on their own discipline resulting in a weak knowledge of aircraft systems design. Most practicing engineers in the industry have one or two areas of functional expertise, however, only those engineers that understand how their specialty fits into the overall design are going to be effective in the future. Since most engineers in the aircraft industry develop and design products, design engineering should be a prominent part of our education [1, 2, 3].

Conventional aerospace products are designed by integrating vehicle configuration, structures, propulsion, avionics, and subsystems to meet

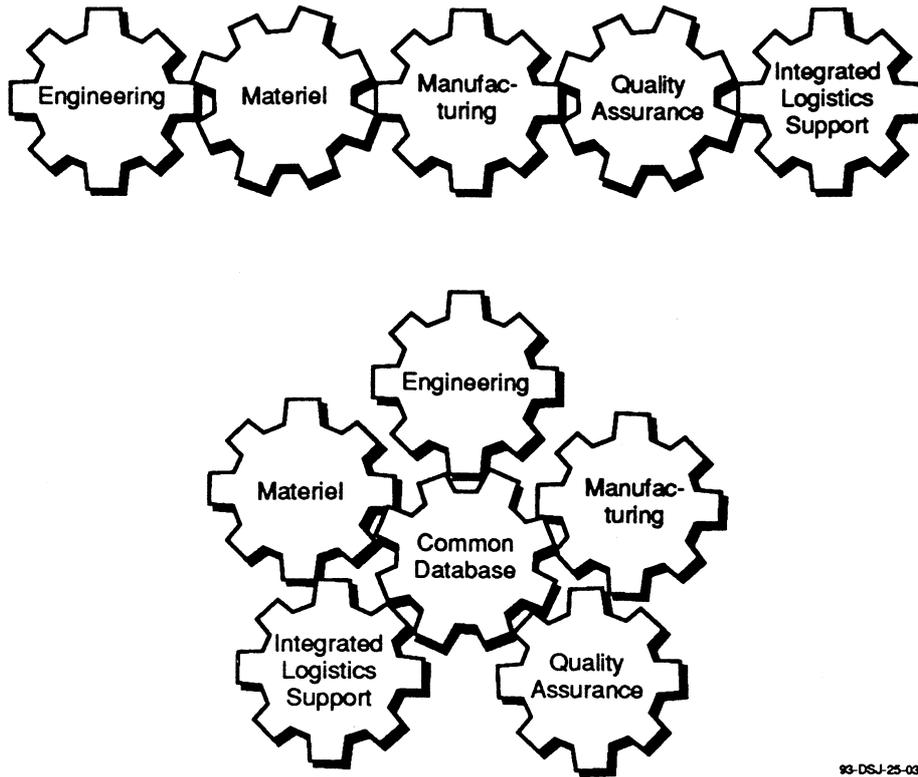
specific performance requirements. The output of preliminary, conceptual, and detailed design is engineering drawings and associated analysis that support the design. These are then given to manufacturing where fabrication of parts, components, subsystems, and assembly begins. Product delivery and support are brought into the equation at a later stage of the cycle.

In contrast to this serial approach, concurrent engineering is gaining wider acceptance by the aerospace manufacturers (Fig. 1). Product design proceeds concurrently with the design of the processes by which the product will be manufactured and supported after delivery to the customer. Representatives of each discipline, working as members of a closely knit team, develop and define completely the data required to produce and support the product. This collective effort fosters continuous improvement of the processes involved in developing and maintaining an aeronautical system.

The key elements of concurrent engineering are a multifunctional team, shared data, and formal methodology as shown in Fig. 2. Our military and commercial customers are dictating affordability (acquisition and life cycle cost) on equal priority with performance. Therefore, product teams consisting of traditional engineering disciplines, manufacturing, support, and business are expected to concurrently design producible and affordable aerospace systems [4].

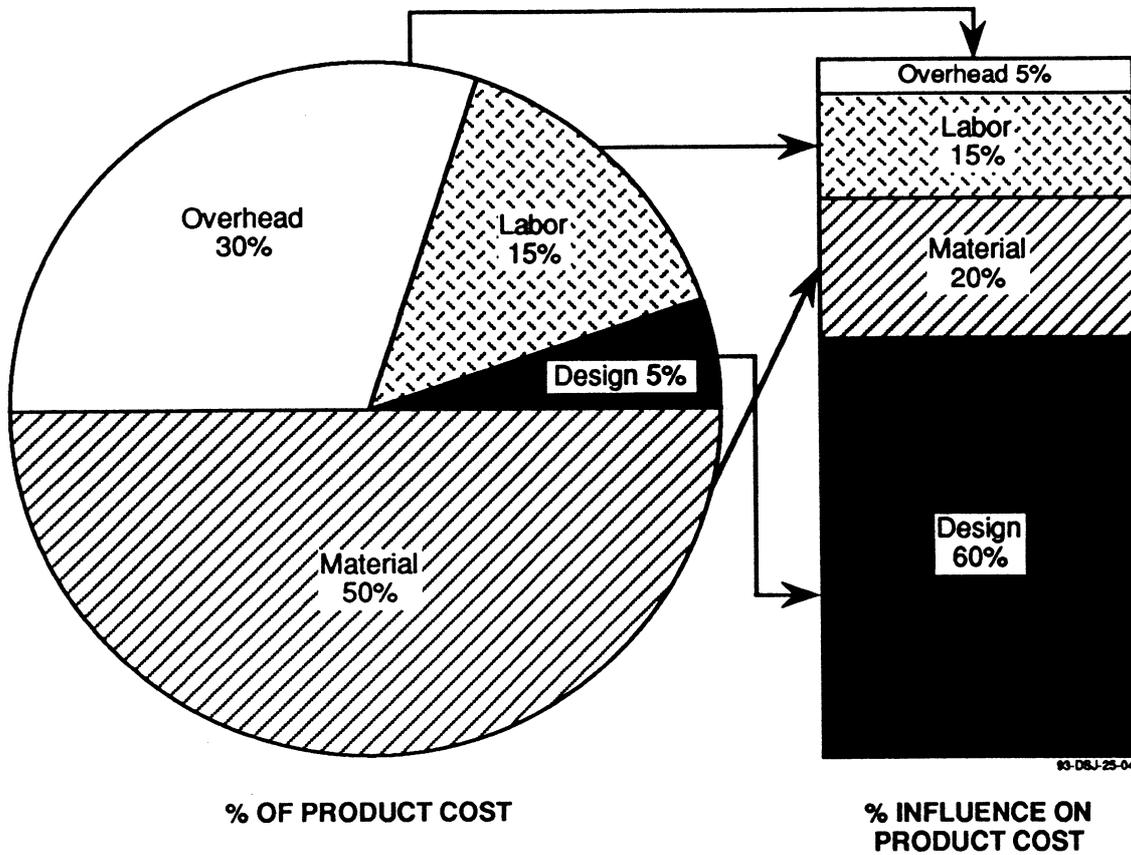
This integrated product approach significantly reduces the design cycle time by avoiding major redesign inherent in a series operation. Concurrent engineering also offers the potential of considerable cost savings. The design stage of a production program typically represents only 5% of the total program cost, yet during this stage, 70% of the product cost is determined, as shown in Fig. 3. The ability to influence cost, schedule, and quality is the most compelling reason for the industry to have embraced the principles of concurrent engineering.

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Fig. 1. Series vs concurrent engineering.



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Fig. 2. Influence of design on product cost.

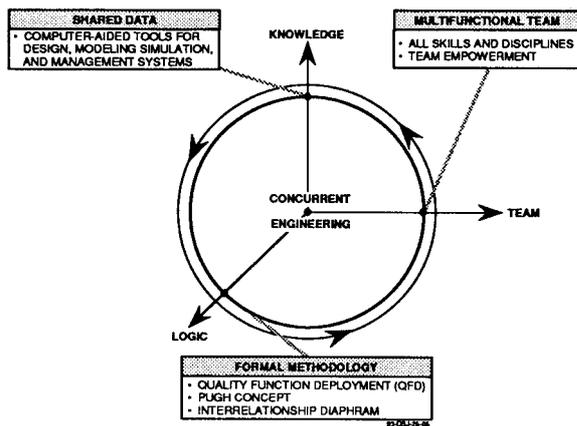


Fig. 3. Implementation of concurrent engineering.

By understanding the major challenges our industry is facing, the universities can evolve a curriculum that emphasizes design and the principles of concurrent engineering. I am not recommending that this be done at the expense of functional excellence, but as an adjunct to continued distinction in technical speciality. A meaningful design emphasis can only be placed after the student has reasonable understanding of core disciplines.

Figure 4 shows fundamental elements of a product design cycle consisting of requirements, baseline configuration development, trade studies, design interaction, and validation of a preferred concept. The shaded elements and subelements are

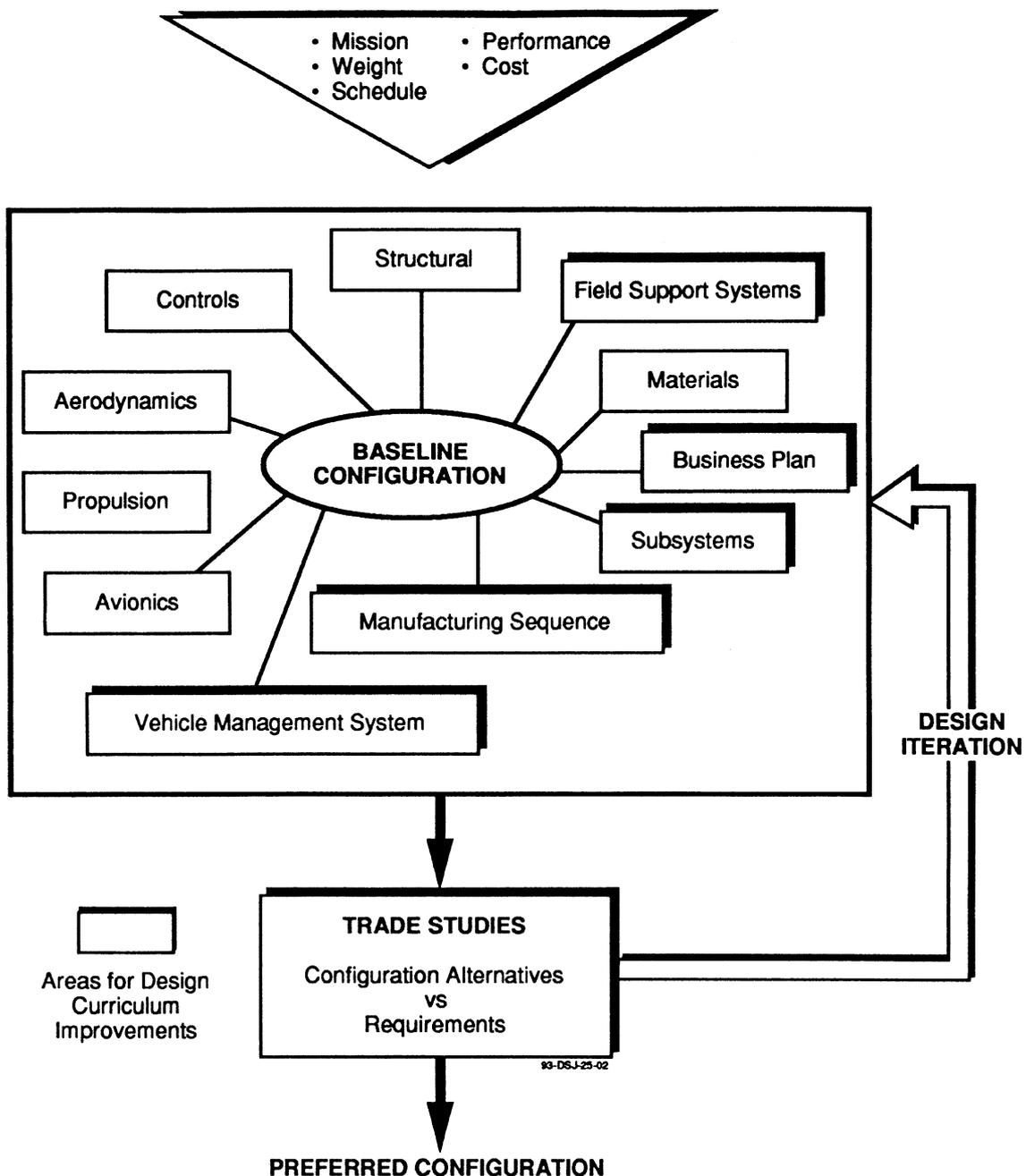


Fig. 4. Aerospace product design cycle with recommended curriculum improvement.

identified as areas for strengthening traditional design curricula:

- Students need to develop an understanding of how requirements are developed, flowed down, and managed.
- In developing the physical configuration, the student design team should incorporate a manufacturing plan, support systems, and a business plan.
- Students must have a background in systems engineering and awareness of formal methodologies, such as Quality Function Deployment, to trade configuration alternatives with requirements [5].
- The design iteration step provides students an opportunity to apply selection criteria to all of the competing alternatives and select the best design. Here the students learn that there are no absolute right or wrong answers.

This concurrent engineering approach to a design course would require increasing instructional hours of a typical two semester design course. The student grade should be based on their design as well as their understanding of the design process. This will require a greater level of commitment from instructors in terms of higher visibility on each design team. Obviously, instructors must have adequate knowledge in all these areas so that the underlying themes and design processes are made clear to the students.

How can our educational infrastructure evolve to ensure availability of faculty members and instructors to satisfy industry needs? The answer is to forge an unprecedented level of cooperation between industry, government, and universities:

- Industry must offer summer assignments or sabbatical placement to professors.
- Universities should hire practicing designers from industry to teach design courses. Most design practitioners that are at the forefront of concurrent engineering design do not have PhDs. Notwithstanding this limitation, the universities should consider hiring and, if appropriate, granting tenure to experienced designers.
- Place students in summer internship programs where they learn actual product development first-hand and an appreciation of industrial environment. The student should get a formal grade and credit toward their degree for participating in such programs.
- Government, DoD labs, NASA, and industry should fund programs that will provide faculty members incentive to consider design as their expertise allowing them to establish publication record.
- Professional societies should encourage further education of design teachers and increase the awareness of all faculty members to the importance of design.
- The Accreditation Board for Engineering and Technology (ABET) should aggressively

strengthen design requirements in aerospace engineering curricula.

MULTIDISCIPLINARY EDUCATION

From an industrial viewpoint, there is a need for engineering students to receive a 'cross-discipline' education consisting of a blend of technical courses and laboratory work which draws upon several classical programs of instructions. Our educators must become aware of the nature and skill requirements of a multidisciplinary education. They must also encourage such an awareness among students by actively supporting the notion of multidisciplinary education and emphasizing the many career opportunities afforded by such an education [6].

Practical education

US aerospace program should require some course in practical subjects such as manufacturing, shop practice, drawing, quality control, and business in addition to standard engineering courses. Most aerospace curricula outside the US offer these practical courses, although in longer academic programs.

Open- vs close-ended solutions

Our educational system emphasizes and rewards close-ended solutions to problems. However, the problems they are likely to face in the industry have no absolute right answers. The education should put the analytical knowledge in perspective in determining a range of applicability and indications of where mathematics can be sacrificed to achieve practical solutions. 'The answer' is not as important as the thought process behind it and rationale used in the problem formulation and finding physically realizable solution.

Communication

Ability to effectively communicate is one of the most important criterion for an engineer's success in the industry. Educators must find ways to improve both written and oral communication skills and emphasize its importance to students' careers. The faculty should establish forums such as report writing and briefings to allow students to practice and improve these skills.

Ethics and environmental education

The aerospace industry has faced many well publicized ethics cases and their financial consequence. Engineers must understand the ethical dimensions of the choices they are likely to face and their action must be above reproach. Additionally, environmental issues must be factored into any major engineering decisions. Therefore, the educational system should raise an awareness of both environmental and ethical issues.

SUMMARY

To be responsive to the projected needs of the industry, the aerospace education for 2000 and beyond must undergo an evolution. The educational leadership should recognize the aircraft

industry as one of their important customers. The universities should form a partnership with the industry in mapping a strategic national aerospace educational plan that will ensure our continued competitiveness in the world market.

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