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ΠΡΟΕΔΡΙΑ ΘΕΜΙΣΤΟΚΛΗ ΔΙΑΝΝΕΛΙΔΗ

THE AIRPLANE AS A VEHICLE FOR BRINGING PEOPLE TOGETHER FOR TECHNOLOGICAL, EDUCATIONAL, AND SOCIAL DEVELOPMENTS

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Transportation has been considered by many to be the second single contributor to global development in the twentieth century exceeded only by education(1). It is appropriate, therefore, to explore the link between airplane developments and formal education which can only be considered by accounting for technological as well as cultural developments. I think it is appropriate for this presentation in Plato's academy to begin by considering the legend of first flight - the mythological flight of Daedalus and Icarus.

As schematically illustrated in Fig. 1, several hundred years passed before the vehicular first flight of the Wright brothers in the 1900's for which the development of materials played a key role. Materials continue to play a key role in the development of modern airplanes in the 1900's (2). In the construction of the modern-day airplanes, there are several technology issues as schematically illustrated in Fig. 2. However, from my perspective, which is on materials, I will relate to them technological and cultural developments at large. By no means will I neglect the other important areas of the aircraft as well as economic issues and, especially if we are to consider the airlines in view of the competitive environment they have been operating in the last few years.

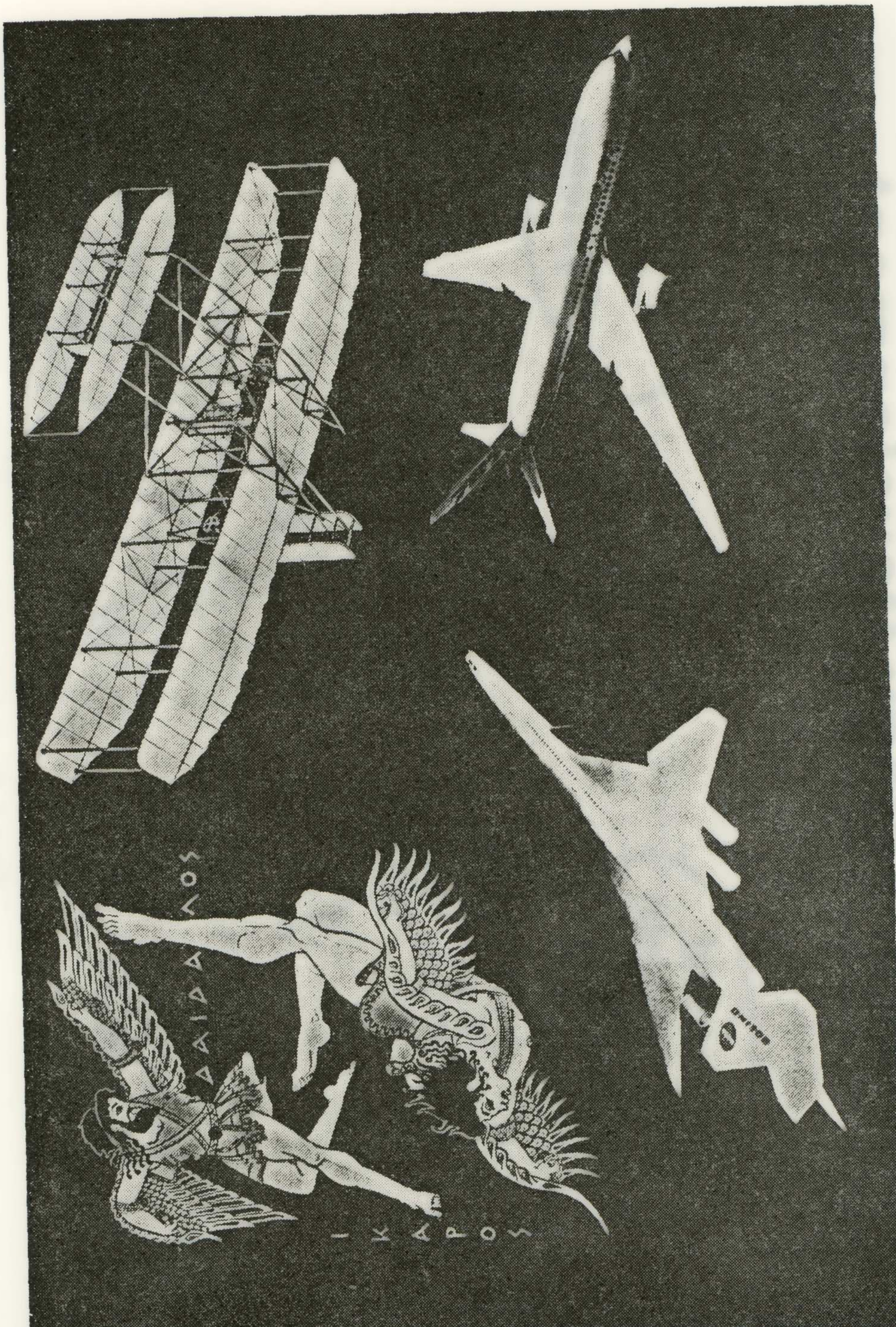

Figure 1. Aircraft Developments with Important Composite Material Utilization.

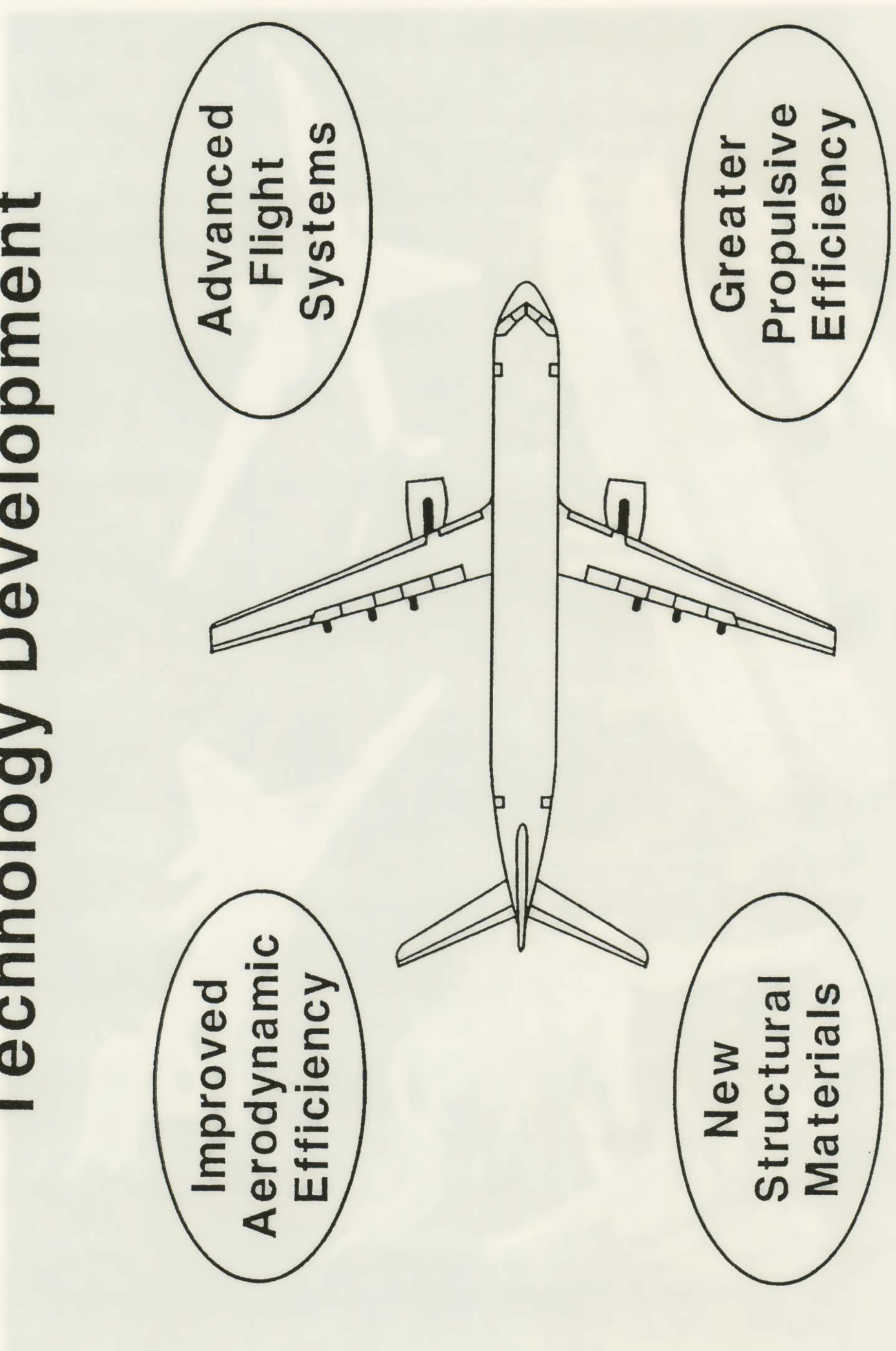

Figure 2. Key Technologies in Airplane Development.

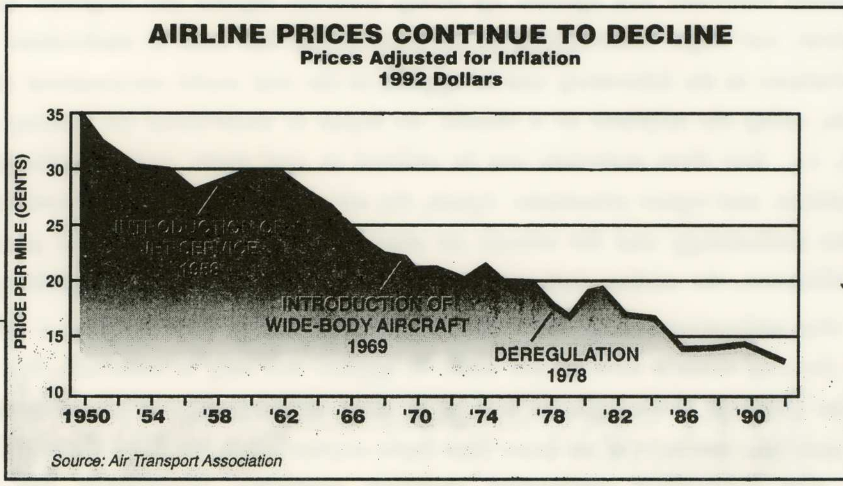

Figure 3. Air Transport Economics over Time.

As can be seen in Fig. 3, the basic price for flying and transporting passengers in the airplane has been steadily decreasing ever since the inception of modern-day jet transport(2). Primarily, these developments can be attributed to thechnology that provided lighter aircraft, more fuel efficient, and more reliable engines. Composite materials played a key role in technology developments for exterior structures in the 80's, but where most passengers have seen reinforced plastics in the airplane has been in the interiors. Many can recall the inconvenience of earlier aircraft where everything had to be stored underneath the seats. Now full-size suit cases can go in overhead bins. This passenger convenience is primarily due to technologies that were developed primarily for weight savings of load-bearing structure making passenger comfort now an unprecedented reality. In most applications of these plastic reinforced fibrous composites, the general public is more familiar with their introduction into sporting goods, i.e., tennis rackets, skis, pleasure boats, etc. This technology would not have been possible without the major investment that the airplane community made in these materials.

My laboratory at the University of Washington, in collaboration with the chemical and airplane industries, has contributed to this understanding of plastics from the fundamental research where one relates properties to molecular structure and the way the material is processed (3). What now has come to be accepted as the trinity for basic material characterization, this concept for polymeric *composite materials has opened up many avenues beyond the airplane usage. However, our major contribution in the past decade has been to understand how observations in the laboratory can be applied to the real world environment (4,5). Again, using the airplane as a vehicle, we began to understand the scaling concepts, i.e., how these materials can be utilized in real parts, real manufacturing operations, and repair situations. Again, the airplane was key in the development of this methodology and the minute we started asking the fundamental question of utilization, the airline industry became the arena for testing our philosophy.*

Our utilization trinity which you see depicted in Fig. 4 is not just a theory. It is the way modern aircraft are built. It applies not only to materials, but also to other airplane technologies as well as to other industries(6). It should be noted that costs now are more of an issue than basic science when one talks about utilization. The engineering community, chemical, electronic, aeronautics, has been dealing with costs as an integral part of their discipline. Indeed, established relations between operating costs and capital costs are key to any economic evaluations. The aircraft manufacturers over the last ten years have been very successful in reducing operating costs but not very successful in reducing capital costs or the cost of acquisition by customer airlines. Our desire to understand this utilization of a product and bring it back into the laboratory and educational environment forced us to visit several airline customers over the past seven years. However, before we examine this process, it is important to recognize how new product development in the aircraft industry was historically taking place. The manufacturer would propose a novel or improved aircraft design to selected customers and try continuously until it was accepted. Composite technology, avionics technology, landing gears, etc., were developed by manufacturers, checked with customers and the technology was pushed in the airplane. In 1990, Boeing decided to get the customer in front of that process and make him as a stakeholder partner along with suppliers and academia. In what is to become the new wave not only in building aircraft but also in global business, this unprecedented openness with the customer brought some revolutions not only in the aviation industry, but also in technology, cultures, and the educational institutions(7). Because of our established relations and technology link of composites with both the chemical and the aerospace industries, we participated in understanding developments of a new generation of composite materials(8). As can be seen in Fig. 5, this was done in collaboration with a Japanese chemical company that most of you are familiar with in textile products, including their famous trademarks of Ultrasuede(R) and Alkadara brands.

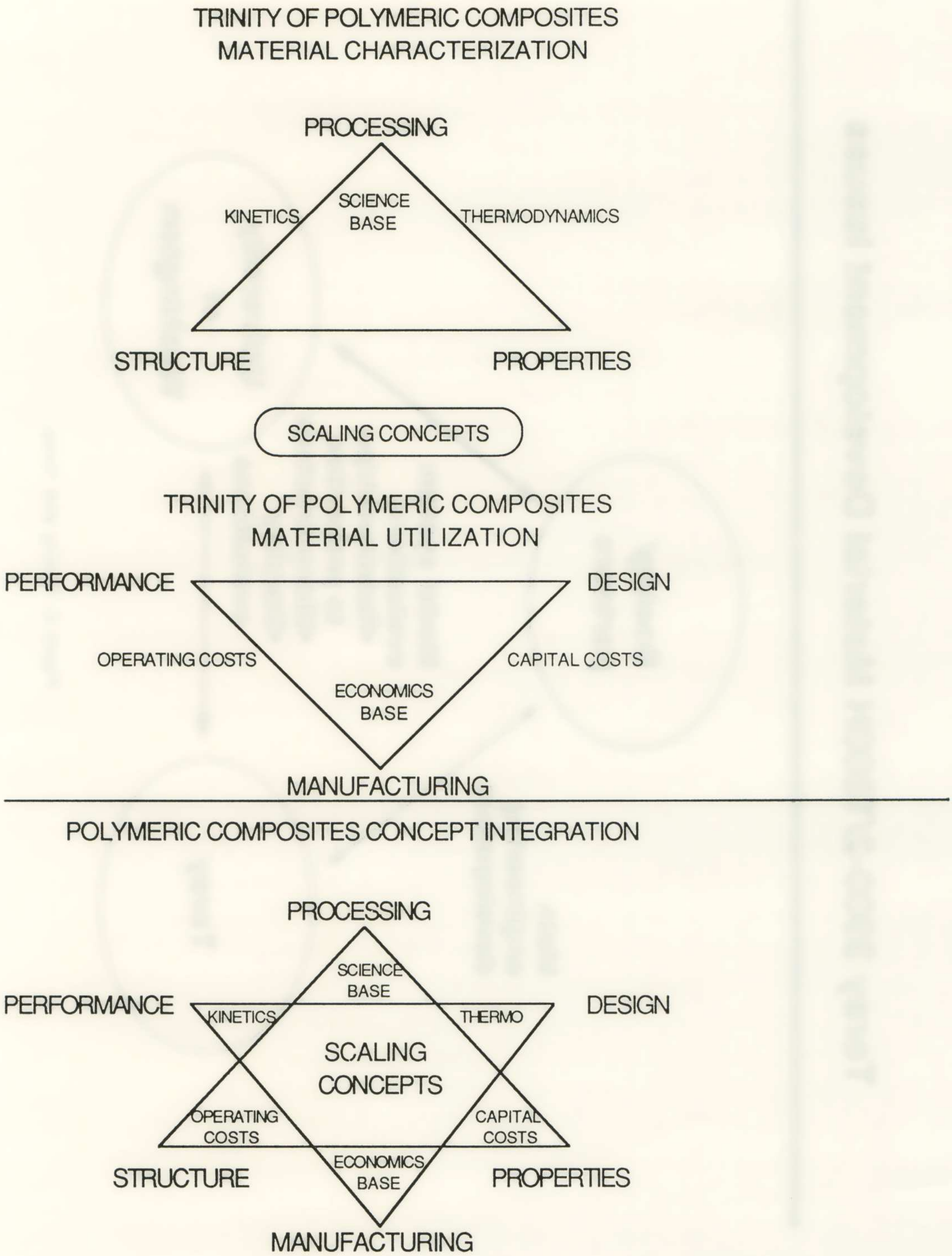

Figure 4. A Road Map for Technology Development and Understanding.

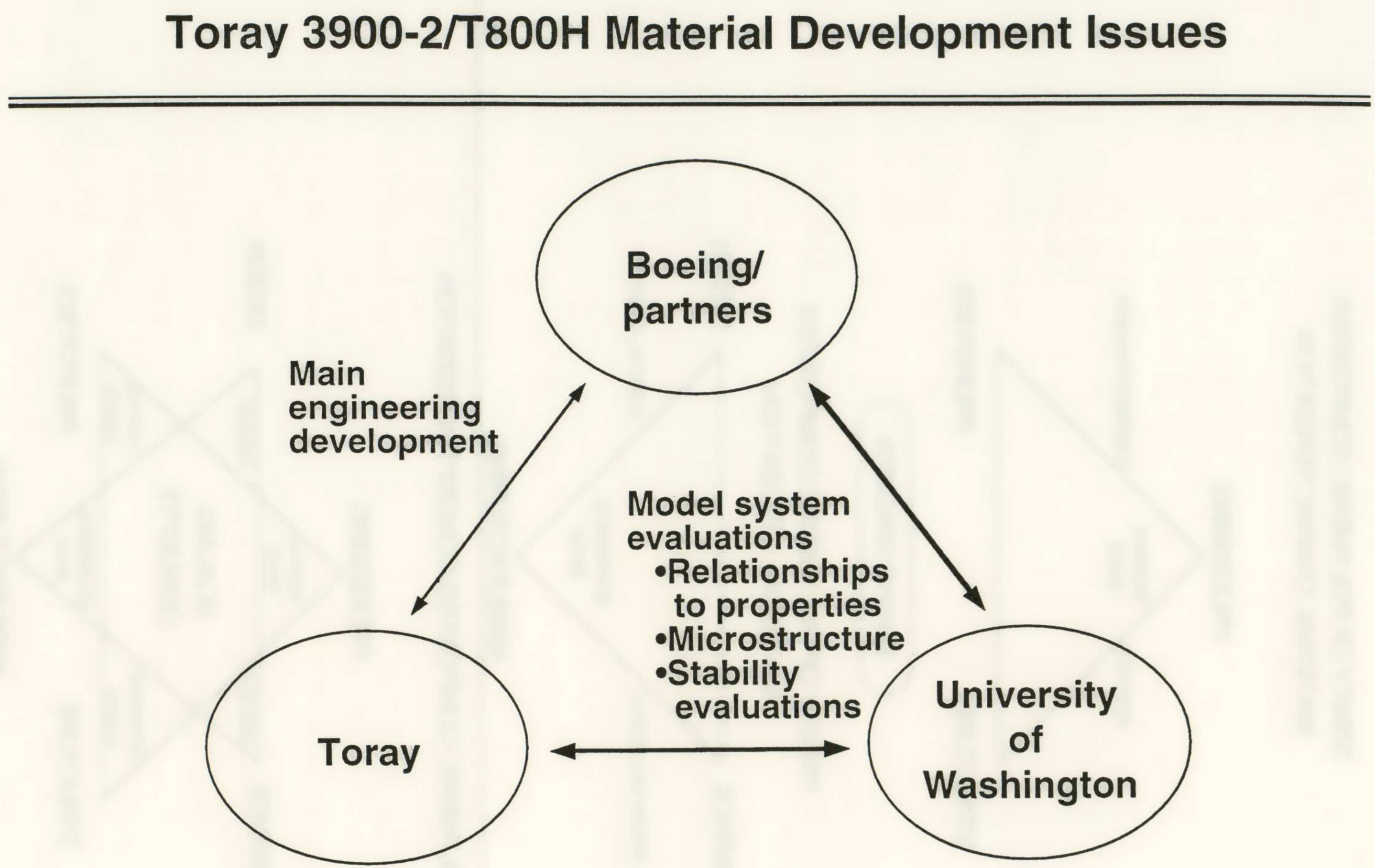

Figure 5. Trinity with Toray.

Thismaterial is currently being used in the 777 aircraft which will be flying within the year. The 777 program within the Boeing Company, with the thousands of suppliers involved, has forced not only reconsideration of technological issues, but cultural issues as well. Our association with manufacturers, suppliers, and airlines forced us to evaluate our interaction with industry as a traditional graduate academic program. We thought we were doing very well and had world recognition about our way of educating people in the 80's. However, as you can see in Fig. 6, the 90's with technology programs that are customer driven has changed our focus and is forcing us to question some of the fundamental principles of higher education; but before we address these issues, let me summarize for you what I believe some of my academician colleagues enjoyed in my latest presentation here last November when I presented our recent findings of how these composites are repaired in the field and how they have affected our basic research and educational mission(9).

My trinity of personal development, summarized in Fig. 7, I believe is shared by most academics either in technical or non-technical fields. Issues of communication in the twentieth century are now very much a part of education at any level from elementary to university. On the other hand, technology issues which traditionally were dealt with as a specialty now have to be viewed not only for the technical community but also for the social and even the psychological context of the individual. It is not by chance that this word appears on the chart with its Greek origin, but we do also have the help of a psychology expert in developing the educational mission of our programs. However, the combination of many individuals is required for most large engineering projects. The development of the jumbo jet required collaboration of several thousand individuals, and many executives in the airplane industry have said the difference between traditional education and building an airplane is that the final examination requires collaboration of 50,000 people that will receive one grade of success or failure. Indeed, these teaming concepts have some foundation in academia. In putting people together for technological, social, or educational developments, we all have to consider educational backgrounds that are quite diverse as well as abilities (skills) that are quite time-dependent.

Indeed, the next graph (Fig. 8) demonstrates these relations that I believe social psychologists have written a great deal about, but maybe not at the level which I am presenting here today. Nevertheless, we are talking about a culture development that also is scale-dependent and how this culture is focused on the customer,

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EVOLUTION OF UNIVERSITY INTERACTIONS WITH INDUSTRY

70's and 80's

IMPORTANCE OF INDUSTRY/UNIVERSITY COLLABORATION

- **Disciplinary boundaries shaken**
- **Off-line research, education, and training**
- **Technology transfer issues**

For the 90's

IMPORTANCE OF ACADEMIA IN GLOBAL TEAMING

- **Integration of disciplines required**
- **On-line research education and training**
- **Value added technology issues**

Figure 6. The Evolving Relations between Industry and Academia in the 80's and 90's.

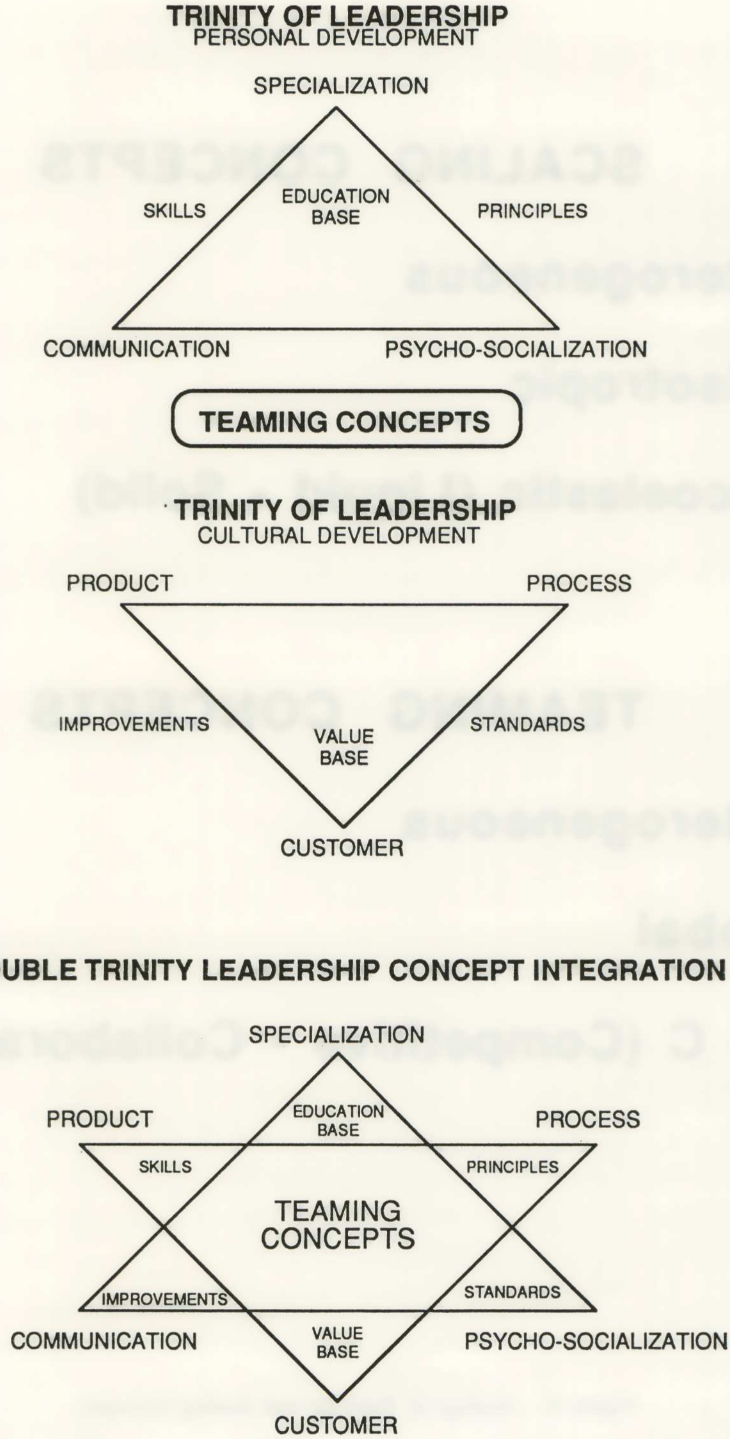

Figure 7. A Road Map for Educational Training Developments.

SCALING CONCEPTS

Heterogeneous

Anisotropic

Viscoelastic (Liquid - Solid)

TEAMING CONCEPTS

Heterogeneous

Global

C - C (Competitive - Collaborative)

Figure 8. Analogy of Teaming and Scaling Concepts.

the process, and the product. In the commercial world, value added can usually be measured in monetary terms. However, increasingly airline customers are finding that value means more than just return on investment, especially as they are surviving the changes that are taking place now in the world environment. Flexibility of the fleet coupled to strategic planning is essential for the success of a modern airline (Figs. 9,10). These concepts of the customer, the product, and the process have tremendous implications to academia. As of last year, we brought these concepts into the traditional classroom. Successful issues that were recognized almost immediately are summarized in Fig. 11. However, concerns also surfaced and continue to be brought out in this new way of teaching as summarized in Fig. 12. Our first-year experiment, as expected with many new things in an intellectual environment, may have gone too far, but we learned from that activity. During our second year, I think we are addressing some very basic points concerning not only technical education, but in broad terms graduate education.

We have also brought the teaming concept outside the classroom as summarized in Fig. 12. Among you tonight are members of the first team who have flown from Seattle to be here tonight and tomorrow, as part of a give-and-take exchange for education that will include cultural issues with a customer (Olympic Airways), a product, and a process.

The fact that we were involved with the airplane industry helped us define this program which is now formalized as part of our continuing education activity at the graduate level at the University of Washington(10). Our team certificate program is intended to educate both regular students and the practicing professional who now has to reach decisions in unprecedented timing fashion. Our focus on teaming by analogy to our scaling concepts has now been in three areas: 1) that our teams are heterogeneous (multidisciplinary); 2) the teams are global and 3) that the members of the team will actually have to be both competitive and collaborative. This last point is very important to emphasize in a real example again from the airplane industry, if one considers recent collaborative efforts in the development for the next generation very large airplane.

Let me try to summarize at this point what I hope I have been able to challenge all of you through developments of air transportation and education. Utilizing the concepts eloquently described by Alvin Toeffler and summarized in Fig. 13, we can safely assume that the airplane industry is moving gradually from second to third wave knowledge-based development(11). However, it is interesting to note that first wave feudal forces are still active within some of its elements.

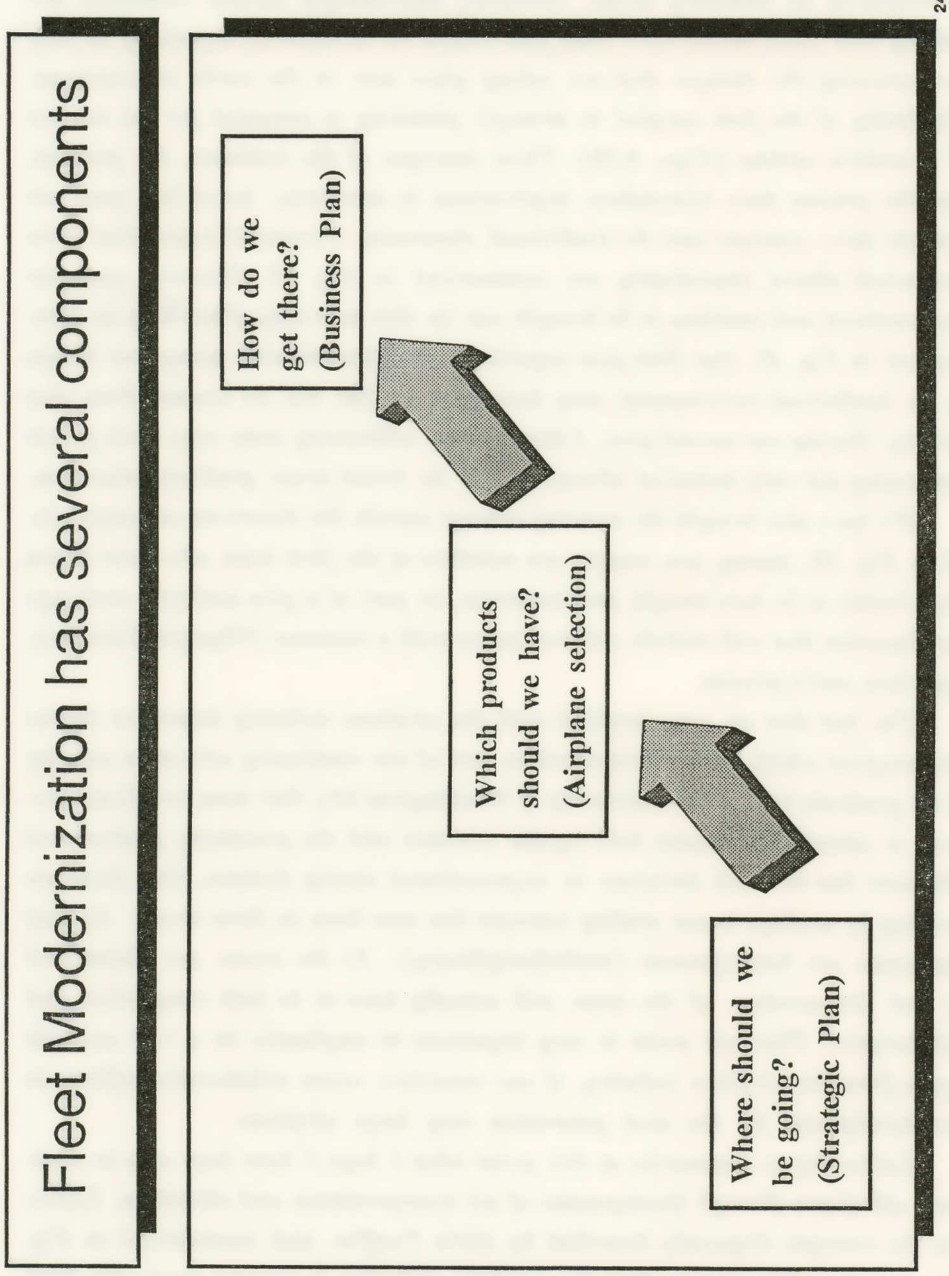

Figure 9. Steps for Flexible Airline.

Elements of Long Term Planning

Route Rationalization

Airplane Evaluation

Fleet Rationalization

Working Together

Africa

Figure 10. Strategic Planning.

TEAMING IN THE TRADITIONAL CLASSROOM

Positive Aspects:

- Customer driven learning
- Breadth as well as depth
- Facilitators learn better through teaching
- In the real world, teaming is essential for global competitiveness
- Students must read ahead

Figure 11. Successful Features of Teaming Concepts in the Classroom.

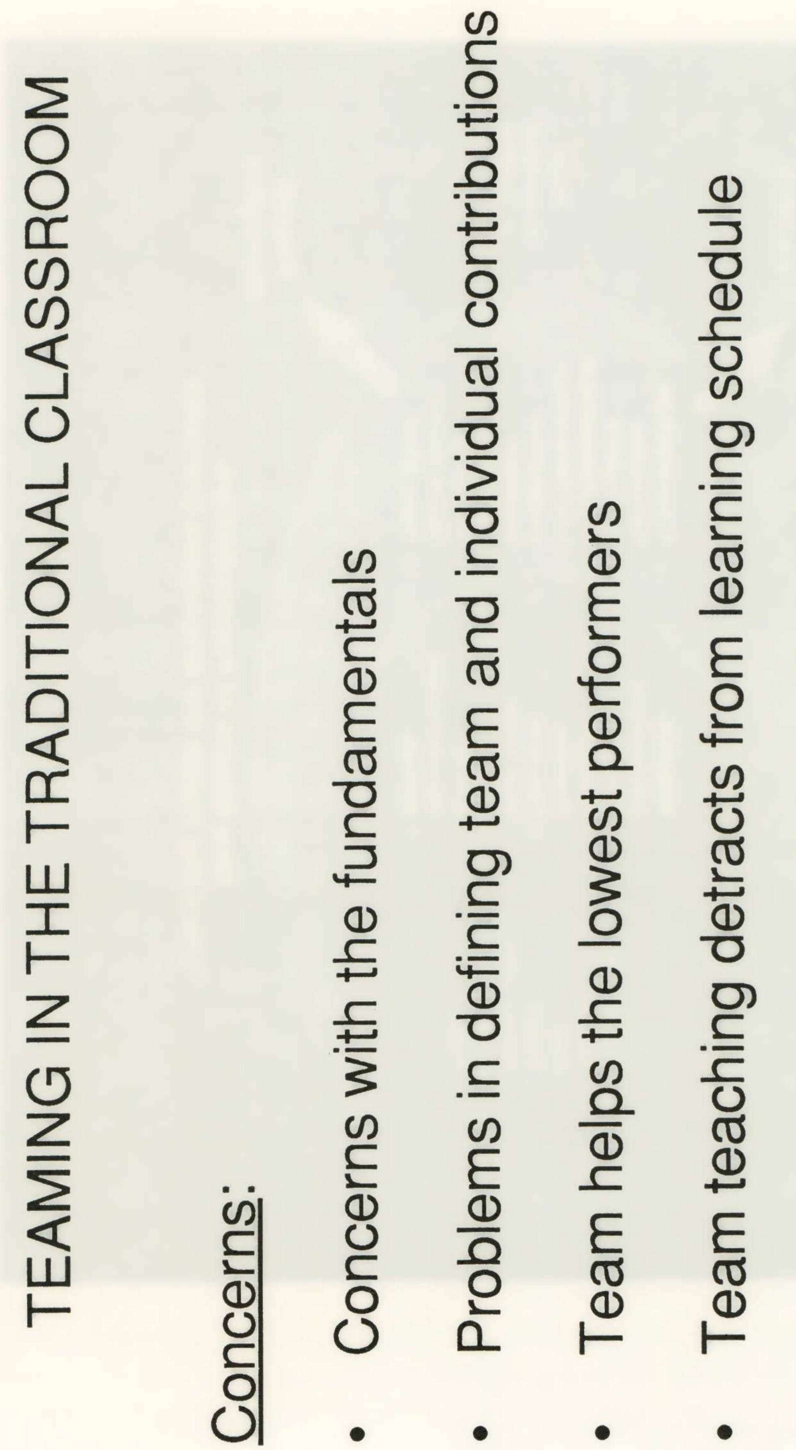

Figure 12. Concerns with Teaming in the Classroom.

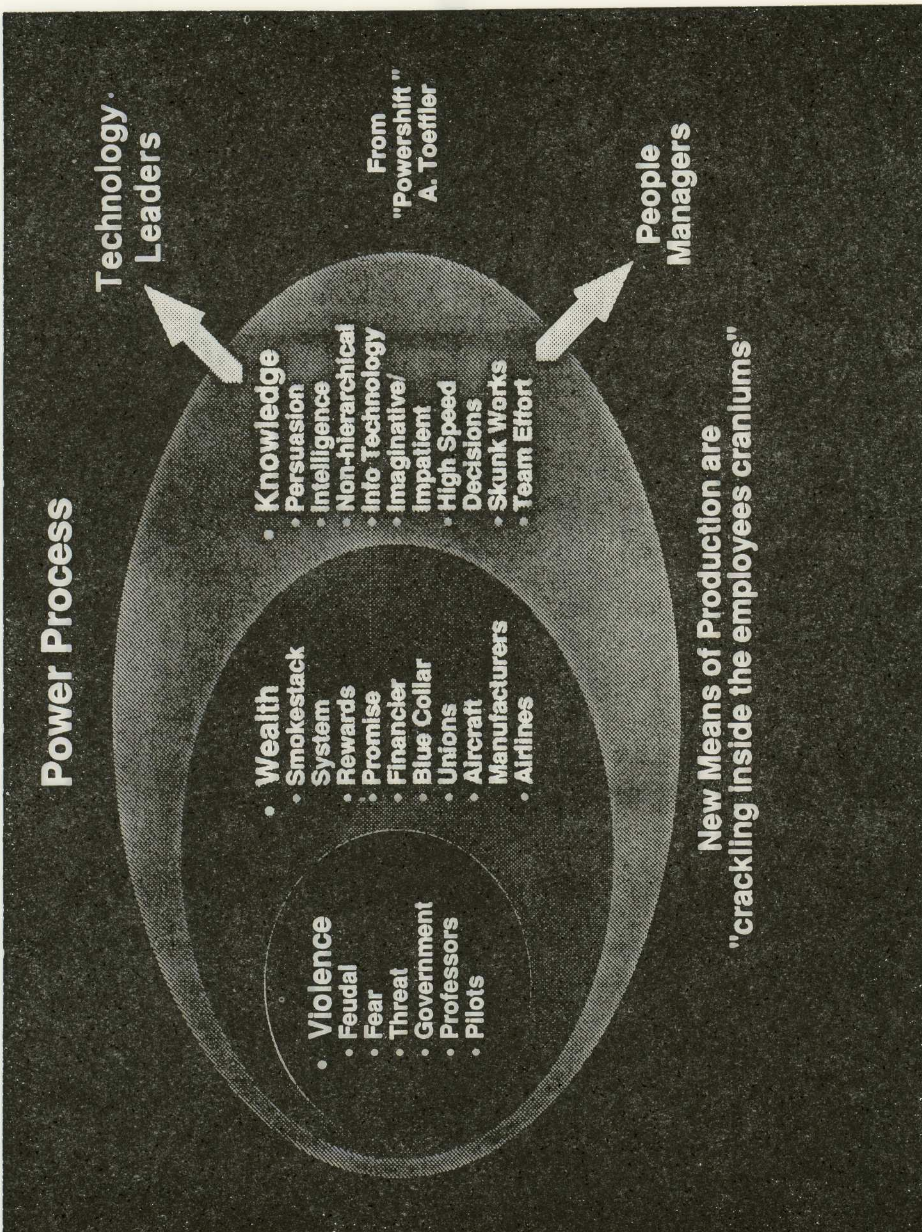

Figure 13. The Three Waves of the Power Shift Process.

There is no question that a traditional professor in academia still operates under the feudal system. I have added to Toeffler's concept that pilots are in the same category and I had an opportunity to experience striking similarities between my profession and that of pilots. There is a lot in the philosophy of a professor and a pilot that will go through some painful changes in the next ten years. They have to move toward the third wave concepts. One has only to look at airplane cockpit evolution to appreciate this change(14). After all, they are the basic instruments in both air transportation and education that cannot be replaced by computers. I cannot resist by quoting one of aviation's pioneers, the father of the 727 aircraft, Mr. Jack Steiner, for whom I have the honor of being named professor at the University of Washington, who recently told me that "if the obvious either in education or in airplanes is to create masses of computers with large amounts of RAM (Random Access Memory) for thinking, it will always be cheaper to create this capability through babies rather than by mechanically building them". I share his view that in transportation and education the human element will continue to play the leading role for its operation and existence.

For the airplane/airline industry, technology has already shifted from a push to pull development. Life cycle costs will have to be considered as part of the decision and operation process of these industries. For academia, the future is also challenging. It is no longer an argument of classic vs. technical education; it is no longer facts and figures vs. abstract concepts. It is a concept of life-long learning; it is a concept that will take the teacher into the role of the student and the student in the role of the teacher; it is a concept that will cause major change in our traditional way of learning.

Acknowledgment

The author is indebted to many colleagues from both industry and academia for the continuous development of these concepts. However, for this specific presentation, I am indebted to Mr. Jack Steiner for giving me an unprecedented insight into airplane development, Don Krebs of Boeing for bringing the human factor in both education and practice, and my students both traditional and «real time» for providing me the arena to practice. I am grateful to the participating companies of the first team project programs, Boeing, Dupont, and Lufthansa, as well as to our host for the first global experience, Olympic Airways and the Academy of Athens.

REFERENCES

1. *Steiner, J. E., «How Decisions are Made: Major Considerations for Aircraft Programs», presented before Int'l Council of the Aeronautical Sciences, AIAA (1982).*
2. *Aviation Week and Space Technology, February 28 (1994).*
3. *Seferis, J. C. and P. S. Theocaris, Eds., «Interrelations between Processing Structure and Properties of Polymeric Materials», Elsevier (1984).*
4. *Miller, A. G., D. T. Lovell, and J. C. Seferis, «The Evolution of an Aerospace Material: Influence of Design, Manufacturing, and In-Service Performance», Composite Structures,* **27** *193 (1993).*
5. *Fenbert, J. A. and J. C. Seferis, «Fundamentals of Composite Repair», Proc. SME Composites in Mfg. '92, Paper No. EM92-100 (1992).*
6. *Seferis, J. C., «Scaling Concepts for Composite Material Developments», Guest Composites Corner, SAMPE Journal, 24 6 (1988).*
7. *Condit, P. M., «Educating, Managing, and Accounting for the Customer», The Boeing Co., presented at 10th Annual Review of the Polymeric Composites Laboratory (1992).*
8. *Hoisington, M. A. and J. C. Seferis, «Model Multilayer Toughened Thermosetting Advanced Composites», ACS Symp. Series, Toughened Plastics 1, Advances in Chemistry Series 233, p. 507 (1993).*
9. *Seferis, J. C., S. Zeng, A. G. Miller, D. S. Krebs, and C. Blohm, «Composite Structures in Commercial Aircraft: From Research and Development to Field Experience», Proc. Nat'l Academy of Athens, GREECE,* **68** *275 (1993).*
10. *Seferis, J. C., Team Certificate Program on Advanced Materials and Manufacturing Processes, Graduate School, University of Washington (1994).*
11. *Toeffler, A., Power Shift (1991).*

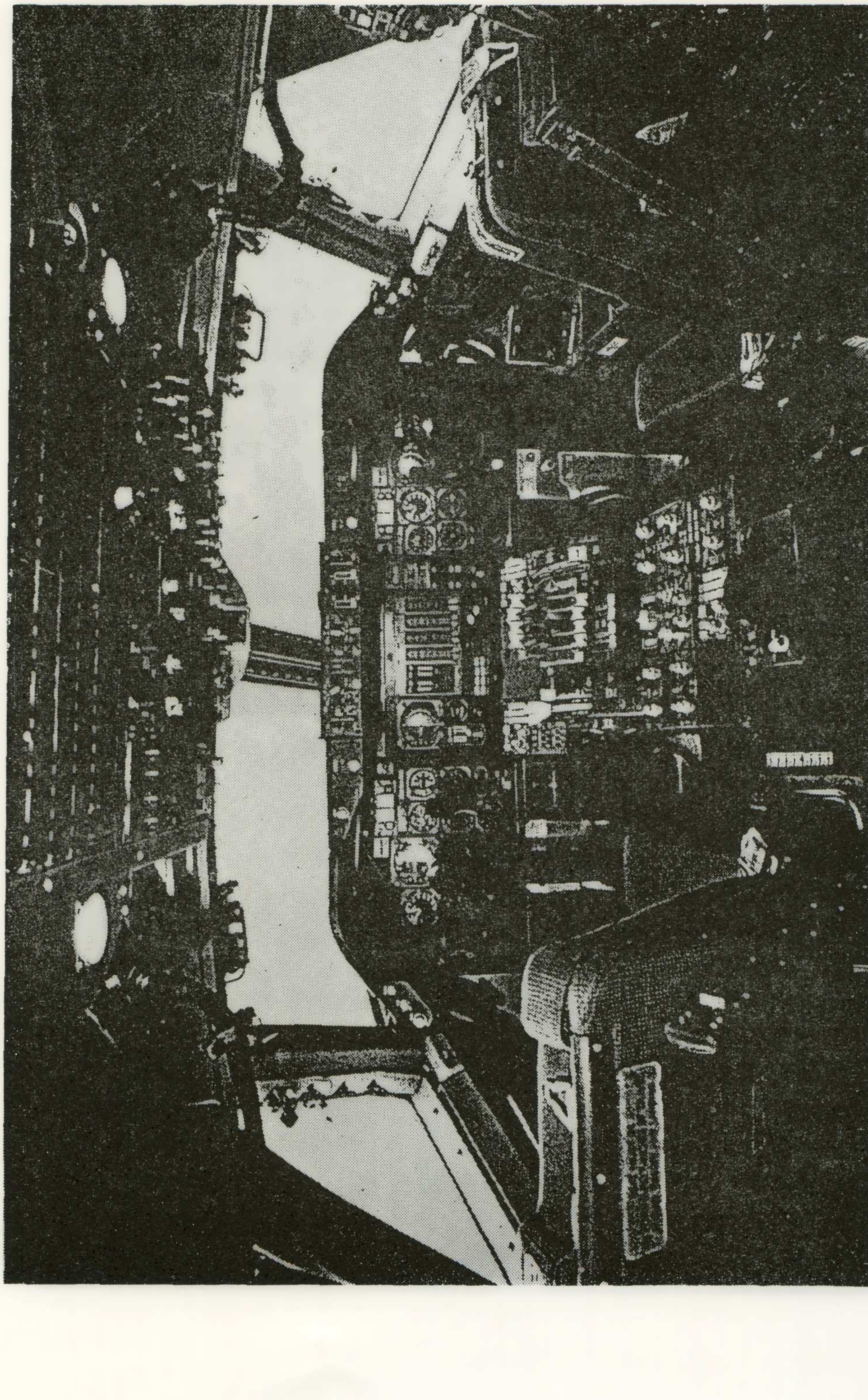

Figure 14(a). Evolution in the Airplane Cockpit.

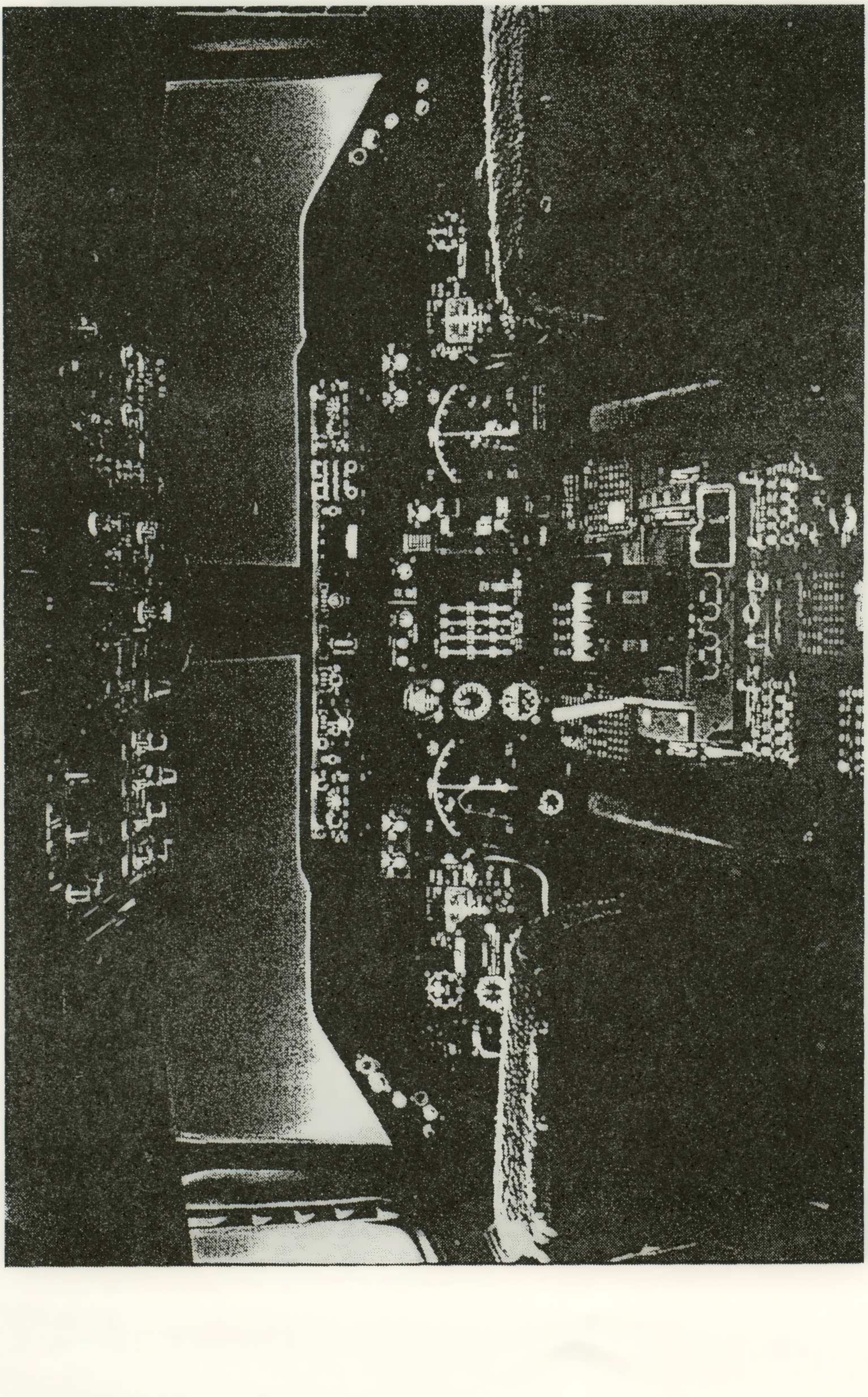

Figure 14(β).