**GEORGIA INSTITUTE OF TECHNOLOGY**
**OFFICE OF RESEARCH ADMINISTRATION**

# RESEARCH PROJECT INITIATION

Date: March 20, 1975

Project Title: Study of Engineering Manpower Needs

Project No: E-16-664

Principal Investigator: Dr. D. W. Dutton

Sponsor: Lockheed-Georgia Company

Agreement Period: From 1/20/75 Until 12/31/75

Type Agreement: P. O. No. CK27037P

Amount:

| | |
|---|---|
| $15,000 | Lockheed |
| 4,140 | GIT (E-16-356) |
| $19,140 | |

Reports Required: Bi-Monthly Status Reports; Final Report

Sponsor Contact Person (s):

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Assigned to: Aerospace Engineering

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RA-3 (6-71)

# GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

## SPONSORED PROJECT TERMINATION

Date: *March 18, 1977*

Project Title: *Study of Engineering Manpower Needs*

Project No: *E-16-664*

Project Director: *D. W. Dutton*

Sponsor: *Lockheed-Georgia Company*

Effective Termination Date: *6/1/76*

Clearance of Accounting Charges: *6/1/76*

Grant/Contract Closeout Actions Remaining:

- x Final Invoice ~~and Closing Documents~~ XXXXXXXXXXXXXXXX
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other ____________

igned to: *Aerospace Engineering* (School/Laboratory)

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CA-4 (3/76)

File with Tabs.
E-16-664

# FINAL REPORT

# OF

# GA TECH/GELAC JEMEO STUDY

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# JEMEOS FINAL REPORT

## I. THE CHARGE

Tabs A.1 ↓ A.6

The original charge as outlined in the early correspondence and memos by Anger, Tenold, and Dutton resolved into a study with the following three main objectives:

1. Determine the educational background and work experience of the technical and supervisory personnel in the Engineering Branch at Gelac.

2. Study these various backgrounds and supplement the data collected with personal interviews and discussions to determine if possible the proper mix of educational backgrounds and work experiences needed to staff an efficient engineering design organization.

3. Determine the proper education of technical people, particularly as related to the engineering design function and offer suggestions to the Engineering Schools, Technical Institutes, and Industry for improvements to the environment that encourages and nurtures design engineers.

Some of the peripheral problems considered during the study included:

1. The development of suggestions for improving the relationship between the Aerospace Industry and the Aerospace Engineering Schools.

2. The development of suggestions for the constructive involvement of the professional societies (particularly the AIAA, ECPD, NSPE, EJC, etc.) in the solution of the problems that have beset the Aerospace Industry and the Aerospace Engineering Schools.

3. A study of the changes that have taken place in the curricula of the traditional Aerospace Engineering Schools and the Technical Institute programs.

4. A study of the relative changes that are taking place in the enrollment trends of the 2 year Technical Institute Associate Degree programs, the 4 year Bachelor of Engineering Technology Programs, and the traditional engineering departments.

## II. WHAT WAS DONE

The undersigned's educational process and the collection of the necessary information to accomplish the objectives took almost a year (April 1, 1975 - April 1, 1976) and was accomplished by reviewing with the Engineering Manpower Group the sources of personnel information readily available (already existing). These consisted primarily of the PIC System and the Engineering Manpower Personnel information cards. B.1 ↓ B.

During this same period while the PICs were being updated, interviews were conducted with management, supervision and engineers in most of the Engineering Divisions. The heaviest concentration of interviews was conducted in the design, structures, and flight sciences divisions (71-30, 72-02, 72-03, 72-05, 72-06, 72-10).

## III. WHAT WAS LEARNED

A. In spite of a feeling of knowledge about and familiarity with the aerospace industry it was soon apparent from the visits and interviews that the design process or methodology, at least in the aerospace industry had changed since World War II.

Speaking directly to charges 2 and 3 under Sec. I, p. 1, a study of the educational and experience data collected and the information gleaned from the interviews indicates that there is a difference in the educational and experience backgrounds required of the designers in the three general categories preliminary or advanced, project, and liaison or sustaining.

The preliminary design personnel conduct the advanced studies and proposal work. They possess a larger percentage of advanced degrees than do the project design people and are more complete systems and performance oriented. Many of them have research experience as well as backgrounds in the design, structures and aerodynamics areas. This mix will remain important. Aerodynamics and structures people work with and assist them. B.1.6

The project designers are more hardware and manufacturing oriented. They do not require the advanced degree background. Many of them developed through the traditional draftsman, detailer, layout man, designer track and only a few aspire to become preliminary designers. The British design engineering educational programs or the older aeronautical Technical Institute programs provided many of them with a start. B.1.7

The growing capability of Cadam has practically eliminated the need for "draftsmen" but not for creative designers in either the preliminary or project design areas.

The C-141 stretch project design group was apparently an indication of the new look. Less than 2% "draftsmen" and the rest designers of various skills and the proper experience background, i.e., structural design, electrical, hydraulics, systems, etc., with approximately 10-15% of them Cadam operators. B.1.7

These project design people do and hereafter must depend upon the aerodynamics and structures people to make many of the decisions that they, the designer, made in the past when aerodynamics and structures were less theoretical and involved. They still need to be creative integrators with a knowledge of materials and processes to put it all together properly and economically but no longer aerodynamics or structures experts.

It is not clear where these people will come from in the future because no longer does the new engineering graduate, A.E. or otherwise, start on the drawing board and work "his way up" through the design areas to become Chief Engineer. Very few have any formal experience on the board, and even fewer are enthusiastic about acquiring any. Approximately 75% of the younger new hire employees would be interested in acquiring some design experience but only 25% indicated an interest in a design career. They were referring to preliminary or advanced design, not project design. C.1

During World War II and until approximately 1970 there was a general shortage of AE graduates so they usually hired in as aerodynamicists, stress analysts, or researchers and performed remarkably well.

Many draftsmen (present day designers) came from the other disciplines and the Technical Institutes, both private and company sponsored schools like Casey Jones School of Aeronautics, Northrop Institute, Embry Riddle, Spartan School of Aeronautics, etc. Many mechanical engineers went into the mechanical design and systems areas and many CEs were hired into structures. There simply were not enough AE graduates to fill all of the slots and until about 15 years ago there were few AE Schools with a strong structures program. They were much more interested in aerodynamics and its related areas. The fear of being "stuck" on the drawing board was ever present in the young engineering graduate's mind.

B. While the Industry was changing both in how it accomplished the job of designing, and from an emphasis on airplanes to space vehicles and now to the general transportation field (ships, transit cars, etc.), the Aerospace Engineering Schools were also changing more than their name.

The study now being conducted of the changes in the AE curriculum over the past four decades reveals very clearly that the emphasis has shifted from applied engineering (design) to engineering science. D.1 D.2

The following changes can be noted:

1. Skills courses and applied labs have practically been eliminated D.3

    a) No shop work of any kind. D.4

    b) A minimum of drafting, graphics, creative design, or descriptive geometry.

    c) No machine or detail design.

2. More Humanities and Social Sciences.

3. Fewer hours of Economics, Technical Writing, Speech, or Public Speaking.

4. More hours of and more advanced mathematics.

5. Fewer hours of metallurgy or materials of construction.

6. More "computers." In fact this is about the only skills course in some of the curricula.

7. Fewer weeks in the quarter or semester.

    Fewer days in the week.

    Fewer total hours in the curriculum.

It may be impossible for the traditional engineering schools to restructure their curricula to include these courses again without going to a five year program or depriving the industry of the engineering science types that, in spite of the complaints about their educational background performed admirably during a period of real need at the time of the space program build-up.

Another less obvious change that has occurred is the almost complete disappearance of the two year associate degree program in aeronautics that supplied so many of the designers presently populating our project and advanced design groups. In the few schools that retain these programs they are used as stepping stone programs to higher degrees either the new 4 year Bachelor of (AE) Engineering Technology (in a technical institute) or a Bachelor of (Aerospace) Engineering (in an institute of technology). The latter representing a rather fine distinction I would say.

- Purdue University at Indianapolis is known as the "School of Engineering <u>and</u> Technology".

- Our Southern Technical Institute has a program in Apparel Engineering Technology.

- The Academy of Aeronautics has a degree program, Bachelor of Technology.

The relatively new Bachelor of Engineering Technology programs have a real opportunity to move into and fill the vacuum created by the traditional engineering schools. It is my observation, however, that they are in danger of rushing right through it with their insistence upon faculty with higher degrees and less reliance on practical experience.

Industry representatives on the ECPD evaluation teams point out that these practical applied engineers are the kinds of engineers they want. At the same time the profession is denying them the privilege of registration and an engineering title in many states.

Students in these programs have asked if they will be recognized as engineer! How are they to be answered?

C. It is also obvious that the profession as a whole, not only the aerospace profession, has a problem.

Definitions for example

- Who or what and when is an engineer? E.1
- Are the terms "engineering" and "design" no longer synonomous terms? E.2
- When or how does a person become a professional (engineer)?

D. All of the above results in nagging questions for "the engineer in the middle"

- How important is professionalism? How do I attain it?
- How important is licensing to become a registered professional engineer?
- How important is additional education and should it be in the technical or management area? Unfortunately many of them are pursuing the management track first rather than the technical.
- How important is membership and participation in a technical (professional?) society like the AIAA, ASME, IEEE, ASCE, SAE, etc.
- And particularly for the non degree man, is membership in a union his only hope?

## IV. CONCLUSION AND OBSERVATION

There is a Problem!!! There are many of them! Some of them are more far reaching than the aerospace profession and the Aerospace Industry. They must be addressed by the profession as a whole.

1) The definitions mentioned in III.C. for example, the importance of registration, and unionism (ref. III.C. and III.D.).

   The Aerospace community cannot resolve them by itself. Maybe it can lead the way.

2) The country is in danger of exhausting another national resource (the design engineer) just as it has so many of its natural resources. G.1

3) It is clear that the Aerospace Industry appreciates the problems of a potential shortage of engineers (designers) as noted in 2) above, but G.2
it is not clear that they are prepared to take the necessary steps G.3
(see recommendations) to help in a long range solution to the problem.

4) It is also clear that the Aerospace Engineering Schools do not yet appreciate the problem of the (design) engineers noted above and that, in spite of the new criteria (including design) laid down by the ECPD, E.3
they are prepared or can do anything about helping to solve the problem.

5) There is going to be a continuing and growing need for engineers in all industries. There are projections that the energy effort alone when it gets cranked up will require more engineers than the schools can F.4
produce. Many of the Aerospace Engineering Schools have the talent and facilities to move into these areas and are doing so.

   The aging problem is a serious one for the Aerospace Industry. It is F.1
also apparent that within the industry the aging problem is most severe ↓
and critical in these very design areas where little if any replacements F.4
are being sought or trained.

   The new hires are going into structures and flight mechanics holding C.1
the average age down in these divisions and producing a better distribution. It is true that a designer needs years of experience behind him but it is not apparent that any younger people are securing this experience. The above represents a switch in the "starting" of engi- F.1
neers in industry. There are few draftsmen in evidence - only engineers and Cadam.

6) There is encouraging evidence that the Aerospace Engineering Community, G.4
the schools, the industry, and the AIAA recognize that their problems ↓
are mutual ones and that solutions can only come from discussions (not fussing or finger pointing) compromises, patience, and understanding. G.7

7) The practical realities of the market place and the drive by the unions to organize the "engineers" are contributing to the problems and not helping with the solutions.

## V. RECOMMENDATIONS

The following recommendations are believed to be applicable to and are meant for the aerospace industry as a whole and for the aerospace schools including the presently defined traditional engineering science, engineering technology, and associate degree programs.

### A. RECOMMENDATIONS FOR INDUSTRY

1. Expand the co-op program both at the undergraduate and graduate level and expand the student summer hire program. Seriously consider on an industry-wide basis the requirement that all graduate engineers spend at least 4 quarters in a training program of some kind before moving to the present associate engineer grade at the salary levels now being offered. Industry in its scramble for engineers in the good days spoiled many of the young people with large salary offers. It is very difficult to back down to this kind of a program but both the doctors and the lawyers have accomplished it and I think that it is one of the main problems that the engineering profession must zero in on. I recognize that the "Union" problem clouds the picture.

2. Sponsor summer faculty programs, seminars, and workshops, and participate in and encourage academic-industry sabbatical leave programs. The logistics problems of relocation and fringe benefits effects are critical here. If industry as a whole through the AIA, AIAA, or the NSPE participated, then the burden would be shared across the industry and the concern over participants moving from one company to another after training or participation would be reduced. The ASEE has sponsored an industry interim program in the past. H.1

3. Continue the pressure on the traditional engineering schools to either modify their programs or offer the student an option of an applied or theoretical path. As an alternative, continue to accept the responsibility for training the system integrators, coordinators, and research and science types while at the same time helping the technical institutes (rather than institutes of technology - a fine distinction) train the applied engineers.

   Try to appreciate and be more understanding of the pressures (from the necessity to secure outside sponsored research money and the publish or perish syndrome) on the schools and their engineering faculty that have produced the changes in the engineering curricula from applied engineering to engineering science.

4. Recognize that while industry does not recommend new graduate hires for the design areas, it is also true that students are not comfortable there. They have received little training or experience in these areas and have been led to believe that research and theory are the ultimate goals. The action is in the research area. That is where the reputations and money are made. There and in management. This is what they have seen their professors doing. The situation

could be corrected by some of the practices outlined above. The hands on stuff is extracurricular or for the technicians, wherever they are these days!

5. Institute in cooperation with the Aerospace Engineering Schools a design training program for the young, interested, promising design engineer. Send them off to take the additional course work and rotate them through applicable work areas to broaden their experience. A similar program is presently being conducted for promising, young management types. Why not the design engineers?

   The three types of designers, preliminary, project, and sustaining or liaison must be recognized and probably provided for separately.

6. Establish a Professorship of Design or something similar and insist that it be chaired by an individual who understands industry's problems.

7. Establish design clinics similar to the one at Harvey Mudd of the Claremont Colleges to provide engineering schools with real life engineering problems to assign and the students with the benefit of a professional critique of their solutions. H.2

B. RECOMMENDATIONS FOR THE PROFESSION

The engineering profession has some decisions of its own to make.

1. Reexamine the definitions of an engineer, an engineering technologist, and a technician to make certain the total technology spectrum is covered and everyone knows where he stands. This will require the cooperation of a national engineering society to look at the total engineering spectrum (ECPD, EJC, NSPE, ASEE).

2. Reexamining the licensing procedure and professional engineering exam particularly since it is now being used as an exit exam by some universities. Licensing can not really be equated with professionalism. Professionalism is an attitude or approach both ethical and moral. It is earned or established by the individual not by passing a law. Some doctors, lawyers, accountants, nurses, and so forth do not act or perform, unfortunately, in very professional ways and yet they retain their licenses.

   Too much time has been spent worrying about professionalism. It is not the central issue. Registration maybe! But maybe not for all engineers?

3. Advise the academic world on curriculum changes that it feels are necessary and through AIAA insist on industrial experience on the ECPD evaluation teams.

C. RECOMMENDATIONS FOR THE ACADEMIC WORLD

1. The Aerospace (all ECPD accredited programs) engineering schools decide what they want to do, where they are going and for whom they are preparing (educating) their graduates. Recognize that at the present time, they are preparing engineering scientists, D.1 not engineering designers or applied engineers of the kind that I.2 industry insists they need.

   This is not necessarily bad, industry has used the engineering science types in the past and will continue to do so. What's more, except for the last few years, there has not been enough of them around. As a consequence CEs and MEs have been brought into the structures and design areas. EEs are recognized as needed and used appropriately.

2. Recognize that very few of the engineering (science) graduates of the last several decades and none in the last few years have ended up in the design areas. It is important to note that the system in England has produced some excellent designers and that some excellent preliminary and advanced design people came out of the old NACA. The early industry sponsored, basically two-year aero design schools (Ref. Page 3) also prepared many excellent people. Many of these latter engineers (?) are now in responsible design and management positions.

3. Examine the changes that have taken place in the engineering curriculum over the last several decades and realize how severely D.3 the number of hours in the curriculum have been cut back. Also the number of weeks in a quarter, the number of days in a week, D.4 and the length and number of laboratories periods and courses. The so-called skills courses such as, composition, letter and report writing, public speaking, economics, and so forth have also been reduced. Recognize that only a few ambitious students acquire these necessary skills through competition in the student paper competitions or by electing them in their program. The laboratory courses that have drastically reduced include graphics or drawing, structural design, applied aerodynamics, shop, and design of any kind either preliminary or advanced. Neither metallurgy nor materials sciences receives much emphasis. Some of these courses need to be reinstated. It may be necessary to move to a five year program to accomplish the above or to a two option program, applied and theoretical.

4. Recognize that in many cases the above cutbacks came about because the faculty did not want to or have the time to teach the laboratories or grade the lab reports. They were too busy with their research, writing proposals, and acquiring same.

5. Recognize that the technical institutes have practically abandoned the two-year associate degree or used it as a stepping stone to the four year bachelor of engineering technology degree. There is nothing wrong with this either, except that an engineer needs practical experience or exposure. Unfortunately, even the bachelor of engineering technology is receiving only a limited amount of applied laboratory work.

6. Cooperate with industry in enlarging its co-op program and encouraging students to secure industrial experience.

7. Be concerned about the creating of double standards and first and second class citizens both in the faculty and in the student body. For example, bachelor of engineering technology students vs. bachelor of science students and practically oriented faculty members vs. theoretical Ph.D. types. All are needed, all are equally valuable in the educational process.

8. Take the leadership in the decisions and chances that must be made. Industry rather expects you to do so and I believe that they want you to do so. If you do not, then industry will handle this situation in their own way. They would rather be doing other things.

9. Recognize that the other peripheral groups that need to be sold on the philosophy are the people who supply the money and those that allocate it, state legislators, boards of trustees, boards of regents, chancellors, presidents and deans. They all need to recognize the problems facing engineering education. Industry might be able to apply some helpful pressure here.

   The clamour for economy and efficiency in education and teaching methods is contributing to the cutbacks and the demands for outside support and faculty to acquire this outside support. Self-paced instruction, larger classes, and fancy equipment have all contributed to the decline in labs and the insistence on larger class loads or at least no marginally sized classes. Department heads and faculty, with all of the present pressures, have a difficult time doing anything about this.

D. RECOMMENDATIONS FOR THE ENGINEERING COMMUNITY AS A WHOLE

1. Recognize that the problem of supplying (design) engineers is a real one, that it is bigger than the AE schools. It will take the combined efforts of the entire engineering profession.

2. Stop worrying about who is to blame or at fault, and what the other segment can do to correct it.

   Worry about what can be done for the profession rather than what the profession can do for each one individually. And if that sounds like a hackneyed stolen expression it is still a good one.

3. Think about the AE in the middle because we are all a part of him. His well being affects our well being. He expects the academic world to solve its share of the problems and provide him with the advantages for educational advancement as needed. He also expects the industry to provide him with the training that he needs for his chosen occupation and a reasonable break in the security and fringe benefits area.

   All need to believe and convince society that engineers are not a bad lot and they have done a considerable amount of good. They can and certainly will continue to do a lot of good.

4. Stop apologizing and recognize that an engineering background is one of the best basic backgrounds that a student can get. It is a recognized fact that he can branch out with his background into any field of endeavor as easily or more easily than from any other basic program.

5. Finally keep talking to each other and work the mutual problems out together.

Respectfully submitted,

Donnell W. Dutton