"THE PROBLEMS of AIRCRAFT DEVELOPMENT"

by

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** Mr. Martin began in 1907 to build gliders; designed and built pusher type airplane in 1908 and taught self to fly; established factory in 1909; flew first air mail in 1912; conducted Army's first bombing experiments, 1913; produced several new models for Army prior to World War I. Merged interest with Wright Co., in Wright-Martin Co., in 1917, withdrew during same year and organized Glenn L. Martin Co., of Cleveland in 1918, designing and building first American designed plane for Liberty engines and produced Martin bombers for Army and Navy. Current plant started at Baltimore in 1929.*

(based on: The Aircraft Year Book for 1948 - Aircraft Industries Association of America - Washington, 1948)

CREATING THE IMPOSSIBLE

The development of aircraft holds the key to aviation progress in our national security. For that reason, I am particularly happy to be able to address this statement to the President's Air Policy Commission at a time when air power is of such obvious importance.

The increased cost of aircraft development is amazing and completely beyond the imagination of the average layman. The development of modern aircraft and its associated implements of war combines the development of all the various branches of engineering science. We are constantly delving into the unknowns which we must do if this nation is to remain the foremost nation of the world and if our national independence is to be assured. All of you recall that the development of the atomic bomb cost two billion dollars. This is just one of the research developments now confronting the nation in an effort to maintain our position in the world of armament research and development.

It is often said that we are striving for the impossible, but where a nation's security is at stake it is mandatory that we create the impossible.

PROTOTYPE COSTS

Our prototype airplanes that 20 years ago cost a few hundred thousand dollars to develop, now cost up to 25 million dollars and more. It is true that increased labor and material costs have added to such expenditures, but that is only a small part of the many factors that go towards increased development costs. It is the increased requirements and complexity of present day aircraft that have so tremendously increased costs. I do not say for one minute that such requirements are not necessary because, in my own opinion, they are very necessary. We are moving into new speed ranges, going to and beyond the speed of sound. Each increment of such increased speed brings many new problems to be solved.

We are continually operating at higher altitudes which also creates many problems that must be solved to insure operation at such extreme heights. Airplane accessory equipment that operated successfully at the low altitudes fails to function in the higher atmosphere. There are many hazards always confronting the manufacturer when undertaking such advancements. Possibility of explosive vapor, of vapor lock in the plumbing system and similar conditions are forever present. Engine lubrication systems fail. Engine cooling, because of reduced air densities, demands more cumbersome and complex cooling aids. Ignition systems break down in the higher atmosphere.

World War II saw the development of many new aircraft installations, such as jet power, radar, radar countermeasure, radar remote and automatically controlled gunfire equipment and a wide variety of special bombs and rockets. Complex navigational equipment came into being. These are just a few of the many items of associated equipment in which advances must be made in order to function in the higher altitudes and higher speed ranges. Such advances must be taken step by step, and the research and development necessary for such advancement is by necessity extremely costly, but again I say mandatory.

PROPRIETARY RIGHTS

The Aircraft Industry enjoys an unusual position with respect to proprietary rights in its product. Our history is one of rapid inventive progress. Whenever it has been established that an invention or improvement has been made, the improved device may be adopted throughout the industry. We have operated under this system of free interchange of developments for over thirty years through our Manufacturers Aircraft Association, which gives to each member of the industry the right to use the airplane inventions and improvements of the other members. This Association was set up at the request of the Government during World War I to eliminate disputes between members of this industry concerning patents and inventions. The wisdom of this policy of eliminating disputes over proprietary rights was further demonstrated by the ready adoption during World War II of a large number of aircraft improvements.

REDUCING DATA TO EXPERIMENTAL PLANE

Such basic research data as is made available from other sources, in the form it reaches the aircraft industry, cannot be put to immediate use by the aircraft designer. These data must be analyzed in relation to the specific design project and then perhaps become the subject of further specific tests and study before their usefulness can be fully realized. An example of this is the basic research involved in the development of low-drag airfoils, or wing sections, carried out by the NACA over a period of several years. These studies resulted in the wing sections now being used on high-speed aircraft. However, the actual design and manufacture of airplane wings using these sections involved a great deal of additional development research on the part of the manufacturer. It was necessary to analyze, for the particular airplane, the effect of the various tip and root cross sections to use for optimum weight and performance. Structural design by the manufacturer required further study and test to develop wings of minimum weight utilizing the new sections. Wind tunnel models of wing attached to the actual aircraft fuselage required testing for interference and overall aerodynamic effects. Tooling and manufacturing methods required revision in order to get the surface smoothness which the new contours demanded. Many other design problems of similar nature required solution.

INDUSTRY FACILITIES REQUIRED

The problem of applying basic research data culled from many existing laboratories, both government and privately owned, involves the establishment and maintenance of expensive facilities to develop and test different units of the experimental airplane being developed from the basic element data. We have listed below some of the major facilities that either must be procured individually by each aircraft manufacturer or must be available for his use within a reasonable distance and at the proper time. Obviously the facilities needed, in first cost and operating requirements, are far beyond the individual manufacturer's financial reach under existing Government procurement policies and the present condition of the commercial airplane market. Present Government procurement policies do not permit the inclusion in contract costs of such overhead items as the cost of building and operating research facilities.

a. Wind Tunnels

For high altitude and high speed aircraft, there should be available at least three types of wind tunnels: (1) low speed tunnels capable of developing air speeds up to about 300 mph, to be used for establishing the basic configuration of the airplane without expending the large amount of money and time required for building the complex models needed for tunnels of higher speeds; (2) medium speed tunnels capable of developing air speeds up to about 750 mph, to be used for obtaining the final quantitative aerodynamic data required before actual construction of the full-size airplane begins; and (3) supersonic tunnels large enough to accommodate small scale models and to be used for the investigation of flight characteristics of airplanes and guided missiles at higher speeds.

In addition to the above, there is a need for tunnels to simulate icing conditions on various components and to investigate duct flows in the various air systems, such as cabin supercharging, ventilating, wing anti-icing, power plant induction and supercharging systems.

b. Flight Development Laboratories

There are many new design ideas which during the course of development require that they be proven experimentally by installing them on existing airplanes in order to determine their functioning excellence and the reaction on the pilot, or to develop new techniques of operation. This requires adequate instrumentation laboratories, airport facilities, flight personnel, engine test stands and beds, and aircraft capable of simulating the design conditions required for the new airplane or pilotless aircraft. An example of this type of investigation is the development on a B-26 airplane of the bicycle landing gear for the Martin XB-48 six-jet bomber. This type of work usually can be handled by the manufacturer at his plant if the aircraft and facilities needed are available to him.

c. Structural Testing

Static and dynamic structural test laboratories, large enough to test a full sized component. This type of laboratory should also include facilities for the investigation of the elastic and vibration characteristics of the structure and for the development of equipment and procedures for full scale measurement of stresses in flight and landing operations.

d. Miscellaneous Facilities

Completely equipped general laboratories adequately staffed and containing facilities for high altitude, low temperature testing, electronic development, hydraulic, electrical, and fuel system installation performance, as well as facilities for the firing of fixed and movable guns.

e. Propulsion Testing Facilities

For high speed missile propulsion applications, especially in the use of atmospheric engines such as turbo-jets, ram-jets, pulse-jets, a great deal of development testing must be done in rather large testing facilities. For example, air capacity of approximately 100,000 cubic feet per minute at 35 pounds per square inch is required to simulate high Mach number conditions for such a power plant. This blower capacity is equivalent to that required by the major steel plants for blast furnace work. This is needed to eliminate the high cost and slower time schedules which are the best that can be realized for alternate flight testing.

TIME ELEMENT

The application of new research data to an experimental airplane design will, in many cases, take place while the research investigation is still in progress because of the need for the military to retain a position of leadership in combat aircraft. For this reason, and because of the highly competitive nature of the industry, the aircraft manufacturer will make every effort to secure the maximum performance for his design by the utilization of the latest research ideas, proven or unproven. Our experience is that, expedited as much as possible, the time element will extend anywhere from 2 to 4 years just to translate basic research into experimental airplane, with another 2 to 4 years needed to turn out first production airplanes. This is one of the reasons it is so necessary that the United States maintain air forces of moderate war strength in peacetime.

DESIGN COMPROMISES

Experimental airplanes are not ordered unless there is a possibility of producing a quantity later. While uncertainty of future production makes it mandatory to spend as little as possible on an experimental airplane, certain production features have to be incorporated into it because it would be impractical to change them later.

The cheapest way to build a quantity of airplanes is to divide it into a number of parts, simultaneously build each part in a separate area and assemble them all together in still another area. The extent of this sub-division depends on the anticipated rate of production; the higher the rate of production the greatest the number of sub-assemblies.

The experimental airplane would still be built in one assembly for the sake of economy, but all of the joints between assemblies would be in it and would be tested for strength and performance so that if a production contract were undertaken the experimental tools and processing could be expanded to provide for the additional sub-assemblies that already exist in the proven design.

Designing an experimental airplane in that manner increases costs beyond the absolute minimum, but many times the increase can be saved in subsequent production.

FREEDOM TO MAKE CHANGES

Since experimental airplanes must be production prototypes as well as test articles, the contractor must have considerable freedom in making design changes that will facilitate production. For economical execution of a contract the manufacturer should be free to determine what units of the airplane can be made interchangeable within the limits of the design and tooling required by that contract and without additional expense to the customer. He must also be allowed to adapt the design to new and more economical processes of manufacture which are continually being developed.

Governmental procurement regulations and specifications are written primarily to give the Government complete control over all details of the design. At the same time, the contracts and contract specifications require the manufacturer to guarantee the weight and performance of the airplane. These two requirements are inconsistent. Attempting to freeze the detail specifications is anomalous in itself, since the very nature of the problem is such that the final design of the airplane is never frozen until it is actually built and ready for delivery. It would be far more economical and expeditious to draft the contracts and specifications in such a manner that the basic characteristics of the airplane are established, the tactical mission is clearly stated, and specific guarantees are required. The details of the design would then be the contractor's responsibility. This would reduce the elapsed time from inception of the program to delivery of the first airplane anywhere from 6 months to one year.

SERVICE TESTS

After a manufacturer has expended the large amount of money and has taken anywhere from two to four years to bring an experimental airplane to the point where in his opinion it is satisfactory for delivery under the contract terms, the airplane is then evaluated by the Services or the CAA from a standpoint of suitability for service operation.

The difficulty with this program so far as military aircraft are concerned is that the testing is done at an Army or Navy base remote from the manufacturer's plant, and there is no way at the present time of expediting such a program or of obtaining information concerning the evaluation concurrently as the tests progress. It is possible under that set-up for the evaluation of an experimental airplane to be delayed to such a point that deficiencies are not made known to the contractor until production design is well under way. The results of this practice are obvious. Changes must be made in drawings, tools and parts, with a consequent increase in cost.

We would propose, therefore, that Service evaluation, particularly that pertaining to flight characteristics, be performed at the manufacturer's plant with personnel assigned from the Service test centers, so that control could be maintained of the flight schedule and that information could be obtained at the earliest possible date.

The CAA certification testing of commercial airliners is performed at the manufacturer's plant, and our recent experience on our twin-engine 2-0-2 indicates that the CAA Flight Test Branch is willing to meet any reasonable flight schedule that the manufacturer desires to establish. Furthermore, the people engaged in the certification work devote their entire time to the model at hand, and are not distracted by any other business. A typical example of this cooperative approach was the 8-day, 17,000-mile accelerated service test recently completed by our 2-0-2 airliner. While some changes were made in personnel during the test, the CAA maintained a force of six specialists on the 2-0-2 at all times, along with the Martin Company personnel aboard.

That type of service testing does constitute a sizable additional cost especially when you consider that it usually follows many months of rigorous flight and ground testing of the new airliner to prove its soundness as to structure and flight characteristics. The accelerated service test for the 2-0-2 was completed, on schedule, at a cost of approximately $20,000. It should be noted, however, that no service or maintenance difficulty or delay was encountered. If a new airplane being so tested ran into such troubles, costs would mount rapidly.

COMMERCIAL AIRCRAFT DEVELOPMENT

While much of this statement has been addressed to the problems of military aircraft development, we should keep in mind that the problems of commercial airplane development follow much the same pattern and are growing as speeds and operational altitudes increase. The Martin Company's own recent experiences may serve to illustrate the seriousness of difficulties facing the manufacturers and their airline customers in regard to new equipment development. Immediately after V-J Day, in August, 1945, we undertook, as a part of our operations, the development of two types of twin-engine airliners designed to fill the needs of the airlines in short and medium haul transport.

Because the airlines were finding it impossible to make a profit at reasonable load factors with obsolete equipment, we took steps to foreshorten the development period by beginning production operations concurrently with the building and testing of the first airplane of each type. It appeared to be the thing to do to aid the airlines in quickly solving their financial problems. As a result, the Martin Company had approximately 42 million dollars invested in 2-0-2 and 3-0-3 airliner engineering, tooling and manufacturing before the first certificated airplane (a 2-0-2) was delivered to Northwest Airlines on August 1, 1947. Our plans to meet the problems of development cost, tooling and the beginning of manufacture were based on what we thought was a reasonably assured market, but the airline difficulties of 1947 have paralyzed the market we anticipated.

EQUIPMENT RESERVES

The airlines never have been able to make and retain a sufficient amount of profit over any period of time to be able to accumulate reserves adequate to finance the purchase of new equipment and provide necessary operating capital. These difficulties have been further heightened by the fact that the large banks, since early this year, have been cold to the idea of extending credit to the airlines for equipment needs.

If the commercial airlines are given a rate base sufficient to permit reasonable profits, are enabled to carry all first class mail on which they can deliver a time saving and are given the further new business of air parcel post, they should be able over a period of time to work themselves onto sound financial ground. However, they also must have new, modern airliners, economical to operate, if their financial progress is to be steady and appreciable. I believe that if the banks continue to withhold recognition of the ultimate soundness of the air transport industry, Government lending agencies, or perhaps equipment trusts underwritten by the Federal Government, should be brought into the picture to extend credit and permit the airlines to replace the outmoded equipment which is bleeding off so much of their revenue.

It is imperative from a national security point of view that we have a healthy, financially sound airline network.

The still untapped potential of passenger and air cargo business available to the airlines is tremendous. Provided a satisfactory economic basis has been developed for their operations, the airlines will be able to work out their own difficulties and replace outmoded equipment with modern, faster, more efficient transports which will be more economical to operate. They will be able to adjust to meet changing conditions while maintaining sound financial status.

With the airlines operating soundly and profitably, the market for new commercial transport airplanes will assume its proper importance to the aircraft manufacturing industry and long-range national security. The privately financed manufacturer will be able to keep his development and production operations going and, to a greater degree, be ready and able to take on the extra responsibilities called for in time of any national emergency.

AN IMPORTANT ADVANTAGE

The American aircraft industry has profited greatly from one significant advantage over some of the other countries - the fact that there has been free and open competition between the manufacturers in new aircraft development, even in peacetime. We have entered periods of frantic expansion in time of emergency with an active, alert competitive spirit already at work in behalf of faster progress.

When you are working in the fields of unknowns which the aircraft design engineer contemplates as he bends over the drafting table, you cannot always be certain, even after reviewing carefully all the information at hand, that the line of approach you have chosen to follow will bring the greatest possible degree of advanced performance. With more than one company tackling the same problem, or developing a competitive type to meet the same need, the nation stands far more chance, even if one or more projects miss fire, to come up with the best answer ahead of all the other countries which are restricting competition or attempting to specify which company shall make the "best" airplane. You can't legislate aeronautical progress into being; nor are you operating realistically when you tell one manufacturer, "Now, you're it. Pick one approach to the problem and come up with the best answer - even if the chosen approach proves to be wrong."

Out of more than 35 years of doing business with the military services, I am convinced that their continued stand in behalf of competitive aircraft development has been one of the soundest of all the policies they have observed.

PRODUCTION CONTRACTS

In discussing the problems of aircraft development, it would be easy to overlook the fact that design and construction of a prototype airplane provides only part of the aircraft development experience which manufacturers will need to be capable of rapid expansion of production when needed. Unless production contracts for reasonable quantities of aircraft are awarded, the companies find it impossible to retain an adequate number of skilled tool designers and tool makers, production experts and experienced manufacturing employees. Perhaps even more important is the need for airplanes in reasonable quantities to permit the air services to use them in actual service - maneuvers designed to prove the tactical adequacy of the design, to develop improvements for the next lot to be produced and to train flight and ground crews in operating and maintaining the latest types of aircraft.

FOREIGN DEVELOPMENTS

It is no secret that other nations are devoting important time, attention and appropriations to the development and manufacture of new aircraft. Where this country stands in relation to such international developments is difficult to judge in the absence of up-to-date and first-hand surveys of other nations. One of the executives of our company returned from Europe just last week. He was able to report that in commercial airplane development he is convinced that we maintain a considerable advantage. He pointed out, however, that Great Britain has a number of developmental projects under way which should "keep us on our toes." In jet and turbine power plant projects, he reported that Great Britain is considerably ahead of this country, timewise, although only comparative operating data when new American jet and turbine power plants now being developed are in use will reveal whether the British engines are more advanced in performance. What advanced projects other, less friendly, nations may have under way is not so well known but we may be certain that they are speeding their development of new aircraft and missiles while hoping that this country choose to rest on its past laurels.

THE INDUSTRY CAN SURVIVE, BUT...

I do not look upon the problems which the aircraft industry faces today as being insurmountable. The companies which are soundly grounded and competently managed will survive. That is, they will be able to keep their corporate names alive and stay in business. Whether or not the companies which make up the aircraft industry retain or lose their ability to meet any future challenge depends upon whether aircraft development and aircraft procurement programs, in peacetime, maintain minimum levels adequate to the purpose.