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Educational Opportunities For Aviation Management Students in Aviation Manufacturing

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A proposal to Southern Illinois University At Carbondale, College of Technical Careers, to provide educational opportunities to Aviation Management students dealing specifically with Aviation Manufacturing.

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The Aviation cirriculum at Southern Illinois University at Carbondale (SIU-C), provides its students with educational opportunities in a variety of general and specific topics within the industry. Beginning at the Associate level, students are given the hands-on training required to be federally licensed as pilots (with ratings from Private to Commercial), Avionics Technicians, and Airframe and Powerplant Mechanics. These programs are designed to educate students in the skills required to fill entry level positions in the operation, maintenance and support of commercial aircraft.

In order to make themselves more attractive (hireable and promotable) to prospective employers, many aviation students continue with their education, seeking the Bachelor of Science degree in Aviation Management. Using the skills learned at the Associate level as "building blocks", students are encouraged (and required) to take specialized courses which are designed to give them a feel for the "big picture". The following are examples of said courses, (consult the Catalog of Classes for a complete listing):

Airline Management

Aviation Maintenance Management

Airport Management

Aviation Law

Airport Planning

These courses provide the student with a broad understanding of the various segments which make up the Aviation Industry. Several courses are geared toward commercial operations, since it is the most publicized portion of the industry. However, with 3,168 aircraft in the commercial fleet, logging 8.5 million hours in the air for 1986, versus the general aviation fleet of 210,655 aircraft, with 33.8 million flight hours logged for the same period, commercial aviation is obviously not the largest portion of the industry (FAA p46-65).

One of the primary reasons for this slant toward commercial operations is because students are interested in commercial aviation. It is the portion of the industry with the highest (daily) public visability. It also can offer its employees above average compensation, good opportunity for professional and personal growth and a higher degree of stability when compared with general aviation. Commercial airline employees work to support and operate some of the most powerful and technically advanced machinery available. They are a part of the most sophisticated mass transportation system on Earth, which can involve traveling to many new and exciting places.

Another reason for this educational slant, is that Deregulation has allowed the airlines to truely manage themselves for the first time and there is a call for managers. As a service to the students as well as the community at large, SIU-C provides education in a variety of specific subjects which students may apply to become successful, and which provide the industry with better prepared employees. This ensures that classes remain full and in some circumstances, endears the University to components of the aviation community. They in turn show their support by hiring, with consistancy, aviation students (graduates) that have specialized training and interests.

Although commercial aviation is a major component of the industry, there are many other components which make up the Aviation Industry. In its efforts to address these specializations within the industry, SIU-C offers courses in Airport planning, Aviation Law, General Aviation Operations, etc... While these courses can offer excellent insight into these areas of specialization, the reality is that there are very few career employment opportunities with these fields of study.

As an example, most general aviation operators are family owned and operated businesses. They provide very few chances to rise up into the ranks of middle management, and virtually no chance (short of adoption or starting your own business) of assuming an upper management position. Most students realize this situation, and yet the course continues to be taught and remains popular as an elective course of study. It is important to offer these types of courses as they provide insight into various aspects of the industry which round out a Student's education and may prove helpful in the future.

Despite the variety of courses dealing with various segments of the aviation industry, there is one portion of the industry which the SIU-C cirriculum does not address, and yet many of its students focus their employment goals within this specialized area. As the largest segment of the aviation industry, (employing 1.2 million, versus 400,000 employed in commercial aviation for 1980), it is hard to believe that specialized coursework is not provided which deals with the subject of Aviation Manufacturing (Todd and Simpson p3).

Although the reasoning behind the absense of such an important topic from SIU-C's course offering is publicly unknown, it will be the goal of this paper to show enough suitable background on Aviation Manufacturing and its impact on the aviation community, where-by the University shall be left with the natural conclusion that Aviation Manufacturing is a significant force in the overall scheme of the industry and that coursework needs to be provided in order for students to be better prepared when they enter the work force.

Before beginning any discussion of the Aviation Manufacturing (AM) industry, it is important to understand the suitability of such coursework to the already established cirriculum, as well as to the employment goals of Aviation students. As stated earlier, whenever feasible, currently offered coursework draws from previous experience and education to better understand new material, using it as a "building-block" to greater comprehension. To this extent it seems only natural for an individual who has been educated as an Airframe and Powerplant Mechanic (A&P) to have a very good grasp of what it takes to make anaircraft fly.

A & P's learn about aircraft structures, forming sheet metal components, specialized fasteners, hydraulics, pneumatics, and electrical systems as well as fuel systems, methods of propulsion, mechanical systems, aerodynamics, navigation equipment, manufacturing processes, Federal Regulations and much more. Although it seems obvious that some areas are emphasized more than others, it is apparent that A&P mechanics have a very strong understanding of the basics of what it takes to make an aircraft.

Avionics Technicians learn how the components of the navigation instruments , radios, and flight control computers operate. They are trained to operate, maintain and replace system components as well as understand how the components interact, how they are made and how to test for failures. Avionics Technicians provide the industry with the specialized skills required to support what is generally the most advanced portion of any aircraft.

Both A&P's and Avionics Technicians are primarily geared toward maintaining aircraft and their systems and become federally licensed to do so. Although they have not been trained to acturally make aircraft, aircraft engines or avionics systems, it would require very little additional training to make the transition from maintaining to manufacturing. To this effect it is commonly recognized that the majority of the prolific number of kit airplanes are built by A&P's for fun and in some cases for profit.

While no figures are currently available, student interest in working for manufacturers is apparent. In fact, many graduates of the Aviation Management program do in fact end up working for manufacturers. As examples; General Electric Corporation, a leading manufacturer of jet engines, actively recruits at SIU-C for A&P's with Aviation Management degrees to work as Field Representatives. A solid understanding of jet engines combined with management skills and a good understanding of the industry make these individuals uniquely qualified. As another example, McDonnell Douglas (Douglas Commercial Aircraft Division) has recently hired several graduates as first level supervisors on the manufacturing floor. The McDonnell Aircraft Company has hired several graduates as Engineering Business Managers/Planners, listing a degree in Aviation Management as one of the qualifications. When aviation related businesses recruit on SIU-C's campus, Aviation Management majors are often refused opportunities to interview. The mistake that many of these companies make is that they end up hiring generalist, like Industrial Technology majors, that tend to know very little about aircraft and would be just as happy working for just about any type of manufacturer.

Aviation students seek employment with manufacturers rather than operators for a variety of reasons, but primarily it is because manufacturers (and of course the Government) provide the driving force behind the latest and greatest technological advancements and innovations in aviation. Manufacturers also tend to offer (of late) fairly stable employment, with above average wages and outstanding benefits. Another motivation behind working for a manufacturer may be that advancement opportunities are more readily available versus working for say, a commercial operator. This is because the types of entry level positions generally offered by a commercial operator are for unionized labor, which can lead to promotions based on seniority, along with contract negotiated pay raises. In contrast, new hires with degrees, working for a manufacturer generally tend to wind up in the white collar or professional ranks. This can provide easier access to a future management position, along with salary increases based on merit, and increased autonomy, which normally leads to greater job satisfaction.

Whether or not the preceding argument provides adequate reasoning to lead to a resolution to provide coursework dealing with AM, is over-shadowed by the important role that AM's have played and are continually playing in the development of the entire industry. By virtue of its influence on the past, present and the future of the aviation community and the world at large, AM should be an integral part of any aviation scholar's education. With this in mind, a discussion of AM's history will be followed by a look at what makes AM so unique and worthy of additional investigation and exposure.

In its infancy, Aviators made their first flying machines from various quantities of bicycle parts, sheet metal, wood and fabric along with a few engineered components. The engineered components were primarily parts for the engines and hand made propellers. In those days, aircraft were built wherever an inventor could find the available floor space, a barn made for a fine hobbyshop. No one was really out for capital gains, for success lie in the form of self-satisfaction and the ability to make a flying machine.

During this period, aircraft were made without a specific purpose in mind. Instead, they were made to be flown for sport and observation. They were of questionable reliability and were flown by only the most adventurous, who purchased them at a very reasonable price.

However, that all changed with the inception of World War I. The military had long recognized the value of aerial observation. They had been using balloons for many years and had just begun to experiment with airplanes as scouts and weapons. As a result, manufacturers began to receive numberous requests from European nations. In response, the United State Government formed the National Advisory Committee for Aeronautics (NACA). Its function was to act as a liason between industry and government in an effort to organize the AM's into streamlined production on a profit-making basis (Bluestone p17). In turn, the AM's united to become the Aircraft Manufacturer Association (AMA) in order to better bargain with the government.

Just before the start of World War I there were 16 AM's who collectively (according to the U.S. Census) produced an annual total of 49 aircraft. Within two years, the annual total had risen to more than 14,000 aircraft produced, with over 40,000 aircraft engines being produced (Simonson p23). Business was booming for the manufacturers - until the war ended.

Within days of signing the Armistice Treaty, contracts totaling over $100 million had been cancelled. In the following year, manufacturers produced 263 aircraft (Rae p2). Although this was substantially less than during the war, it was still an increase of over 500% when compared with pre-war activity levels. Additionally, the Government sold off many of its surplus aircraft and engines, in many cases, to the very same people it had trained to fly them. Despite the fact that this would be the first of several boom- bust cycles, the market had now expanded and experienced operators world-wide were buying modest quanities of aircraft. The industry had moved outof the barn and into the factory. The AM's had also become a profitable, organized industry (due largely to the formation of NACA and AMA).

When large corporations decided that they wanted to control this lucrative market in the late 1920's, there was an enormous amount of activity on the business side of the industry. There were many take-overs and aquisitions, as these large corporations endeavoured to become the primary proponent of aircraft building. When the dust had settled, three conglomerates emerged: Avco, Boeing and General Motors.

Avco, (Aviation Corporation), now owned Detroit Aircraft Company, Lockheed Aircraft, and Consolidated Vultee.

Boeing became United Aircraft and Transport Corporation& UA&T) and merged with Pratt and Whitney Aircraft in 1928. The following year UA&T merged with Hamilton Aero Manufacturing Company, Chance-Vought, Hamilton Metalplane Company, Stout Air Lines, Sikorsky Aviation Corporation, Standard Steel Propeller Corporation, Stearman Aircraft Company and Northrop.

General Motors now controlled Fokker, Bendix, Allison and Dayton-Wright and by virtue of a merger with North American Aviation, also controlled Curtiss-Wright, Sperry Gyroscope and Wright Aeronautical (Bluestone p21).

Between the three of them, they accounted for virtually the entire market supply of airframes and engines. In this case the market was primarily the U. S. Government, which was at that time procuring aircraft primarily for airmail service. In fact, 81% of this market was split between Curtiss-Wright (General Motors), and UA&T. Furthermore, 90% of all military contracts were being filled by only ten companies (three of which were you-know-who). This left the other 286 other AM's with little or no share in the stable and lucrative market of government contracts (Simmonson p86).

It was not long before charges of profit gouging and unfair competition lead to the Contract Airmail Act of 1934. This addressed (among other things) the issue of conglomerates charging the losses of one division (providing airmail services) against the profits of another division (aircraft manufacturing). For in this manner, conglomerates would bid (at a loss) to gain air mail contracts which in turn would be subsidized by the purchase of their own aircraft.

The Contract Airmail Act of 1934 caused direct anti-trust action to ensue, causing the following divestures:

> "UA&T was divided into three separate entities; two manufacturers, Boeing and United Aircraft and one transport company, United Airlines. United Aircraft maintained control over Pratt and Whitney, Hamilton-standard, Chance-Vought and Sikorsky Aviation.

"General Motors/North American Aviation separated into Eastern Airlines, Trans World Airlines and North American Aviation."

"Aviation Corporation split into Avco and American Airlines." (Bluestone p22)

As far as developments relating directly to the manufacturing of aircraft, the transition was being made from airframes made from primarily wood and cloth to the all metal airframe. By 1930, Boeing had begun to produce the Monomail, which was the first all metal transport. Its development led to the introduction of the Boeing 247, the Lockheed 10 and the Douglas Commercial. These aircraft, all monoplanes, signalled the end of the biplane era. Their metal structures allowed for higher design stress loading and reduced drag. The marginal difference in weight had been off-set by the new and improved, powerful, narrow, in-line liquid-cooled engines and later by the powerful and very reliable, air-cooled radial engines.

However, the single most significant aircraft developed during the 1930's was the Douglas DC-3. For here was an aircraft which was designed specifically to carry groups of passengers, in comfort, over long distances. This aircraft boasted a multiple spar wing with split flaps, and a pair of air-cooled, supercharged, radial engines, sporting three-bladed, variable pitch, metal propellers using constant speed govenors. Other features included; retractable landing gear with hydraulic, toe operated brakes, an auto-pilot system, air conditioning and significantly reduced cabin noise levels. The DC-3 was able to carry 24 passengers and their baggage 2,120 miles, with a maximum speed of 230 miles per hour. This is the aircraft which is largely responsible for proving to the public that air transportation was the fastest, safest and most reliable means of long distance travel and allowed the airling industry to make the transition from being predominantly a mail carrier to a personnel carrier.

With the beginning of World War II, the aircraft manufacturers again, as in World War I, became swamped with requests for aircraft. Just as before, the European nations became involved before the United States did and began ordering defense aircraft in 1938. However, the manufacturing industry had changed significantly since the last World War. To start with, the airframes and engines of the new generation of fighters, bombers and transports were now very different both in composition and in performance. They now required much more labor to produce than their predecessors had needed. AM's were not suitably setup to produce the large numbers of aircraft being requested. Additionally, even if they could produce the quantities requested, they would have great difficulty making shipments, for the Neutrality Act and the American public's desire to remain isolated from the war, made dealing with countries at war nearly impossible.

That all changed when Germany began bombing England in late 1939, and early 1940. President Roosevelt then repealed the Neutrality Act and requested that the AM's prduce 50,000 aircraft within the next years time (Bluestone p25). The manufacturers were not equipped to handle this large of a work load and they refused to expand their operations, knowing full well that they would experience the same type of industry-wide collapse that they had seen after World War I ended. Therefore, the required expansion was financed by the government by first allowing any new facilities that were to be built to be depreciated over a period of five years, and then by adopting the Emergency Plant Facilities Contract (EPF). Under the EPF agreement, AM's obtained private financing on their own for any expansion required and the government reimbursed the manufacturer over a five year period. After the five year period, the government either assumed the title or sold it back to the manufacturer. This arrangement proved to be mutually unsatisfactory and was later replaced with a system which was run by a government agency, the Defense Plant Corporation(DPC)c which built the new facilities itself and then leased them to the manufacturers. Although the DPC is no longer in operation, the government still owns to this day several manufacturing facilities built by DPC, complete with their original tenants.

Other attempts to expedite production included the introduction of large numbers of young, unskilled workers. The highlight and most successful part of this move was the introduction of women into the ranks of the skilled trades. This influx of unskilled, and newly trained labor, led to a revising of the methodology by which aircraft were to be made. Previously, a crew of craftsmen would assemble a complete aircraft from start to finish and then begin another. This was transformed using a technique borrowed from automobile manufacturers, known as the assembly line. Although it was modified to suit the needs of the AM's, the new method allowed the incorporation of individuals with lower required skill levels to become a part of aircraft production.

The assembly line technique was not the only thing that the AM's borrowed from automobile manufacturers. The concept of subcontracting work and entering into licensing agreements had, until now, never been a part of the way AM's did business. As part of the mobilization of the industry, the AM's actually began subcontracting and licensing a large share of their work load to the automobile manufacturers. It was through this orchestrated industrial effort, that the United States played what is perhaps the most significant role in the outcome of World War II. The net result of this massive effort can be seen by comparing the production rates of several countries.

> "The U.S.S.R. made 137,271 aircraft between January, 1941, and June, 1945; the U.S.A. turned out about 300,000 machines (96,318 in 1944 alone), while the U.K. built in excess of 119,000 aircraft from 1940 to 1946 (29,220 of them in 1944). Germany was able throughout 1944 to produce on average 2,811 aircraft each month."
> (Todd p27)

Toward the close of World War II, it was obvious that the product lines had received significant changes. The product lines were now much more diversified, with attack fighters, air-to-air fighters, bombers, dive bombers and a host of other specialized aircraft. Their look was much cleaner and aerodynamic. Avionics systems had become much more sophisticated as the age of the vacuum tube was ending and solid-state electronics were being introduced. But perhaps the single most important development of the war never played a role in the outcome of the war. Just before the war ended the Germans introduced the worlds first jet powered aircraft. It was much faster that anything the Allies or the United States had flying at the time, but the enemy had not learned to fully control so fast a machine. Before they could master both the building and operating of these jets, the war had ended. Shortly after the war ended, the United States (General Electric) developed its first jet engine and the world of aviation has never been the same.

Unlike the close of the previous world war, there was not an abrupt cancellation of contracts. This was part of the governments efforts to smooth out the exagerated war-time cycle of the industry. Legislation known as the Contracts Settlement Act of 1944 was drafted. It attempted to;

1). Phase out war contracts as gradually as conditions permitted.

2). Prevent manufacturers and their subcontractors from being left with vast quantities of unusable inventories.

3). Provide some assistance in reconverting to peace-time production. (Rae p173)

This turned out to be a very unsuccessful effort, for by 1946, contracts worth over $21 billion had been cancelled. This effectively put out of 66 airframe manufacturers and 18 out of 23 aircraft engine manufacturers out of business. In November of 1943, AM employment levels stood at 1,460,000, but by March of 1946, only 219,000 were employed (Bluestone 29).

While budgets were being trimmed and companies were reducing their size, a geographic centralization was taking place, with most of the airframe manufacturers concentrating in the sun-belt areas (particularly the west coast) and the engine manufacturers localizing in the New England area, with one exception, United Aircraft's Chance-Vought division, moved 1,500 people, 2,000 machines and over 50 million pounds of equipment, from Bridgeport area, as the corporation already owned six major aircraft manufacturing divisions within a 70 mile radius.

Despite the unique move of Chance-Vought, geographic trends had returned to pre-war levels. By 1950, California had once again regained the lion's share of airframe production, with 40% of the 212,000 people employed in making airframes, utilizing 45.4% of the production floor space. "In 1940, 42.6% of all aircraft engine employment was in New England. By 1944, it had fallen to 10.6% as licensees produces vast numbers of engines throughout the country. By 1950, however, 45.9% of all aircraft engine employment was back in the region. In propeller manufacturing, 63% of the nations employment was in New England (virtually all in Connecticut) in 1940. By 1944, the portion had declined to 17.4% and then rose again to 29.9% by 1950" (Bluestone p33).

By the time the military had re-equipped itself and the commercial market was beginning to show great promise, the Korean War broke out. Although the United States involvement in this war was not as extensive as in the previous two, it again produced a (smaller) boom cycle for AM's. Jet powered aircraft were found to be such a superior weapon, that a complete fleet re-equipment was required. The helicopter also proved itself as an invaluable asset to the army and production was increased accordingly. AM employment levels rose once again and by 1954, had reached 822,000. But, unlike previous wars, when the fighting had stopped, the industry did not collapse again. Instead, military spending stayed fairly steady, at only slightly reduced levels.

This was the result of the United States assuming a more strategic role in international affairs. General Hap Arnold, Chief on the Army Air Corp at the end of Warld War II, set the tone for the military jet-age when he said:

> "In two World Wars the aggressor has moved against other, peace-loving nations, hoping that the United States would remain aloof or that other nations could be defeated before this country's power on land, air and sea could be brought to bear against him. Luckily, in each war there has been time for the mobilization of such power and the U.S. has been the determining factor in the defense of civilization. The lesson is too plain for the next aggressor to miss: the U.S. will be the first target."
>
> "There will be no opportunity for our gradual mobilization, no chance to rely on the efforts of others. It is of the utmost importance that our first line of defense, in the air, must be manned and fully supplied with modern equipment. We must be able to provide for other parts of the national defense machine to mobilize and go into high gear. The U.S. must be the first power in military aviation"(Simmonson p178).

It is this type of attitude that helped provide more stabilized production levels for military aircraft manufacturers. This train of thought has also led to substantial ongoing government research that has produced benefits for everyone.

This stabilization period of the late 1950's was well-timed, for it allowed manufacuters to concentrate their attention on the growing commercial markets.

By 1958, the jet engine was an established powerplant for the Air Force, but had yet to be used commercially. Boeing became the first manufacturer to offer a jet powered commercial transport with its 707 model. This was a natural progression for the company as it had already developed the B-47 and the B-52 which were the first jet-powered bombers. Development of the 707 began in 1952, with the first prototype flying in 1954 and the first production aircraft rolling off the line in October of 1958.

Sales of the 707 were brisk, echoing the success of the first popular commercial airliner, the Douglas DC-3. Douglas Aircraft Company began late in its development of the DC-8 jet transport. The company was cautious of so large a commitment of its assets until American Airlines showed its support for commercial jets with a $400 million order for 30 of Boeing's 707's in 1955. The DC-8 went into service just one year after the 707, but the damage had already been done. The DC-8 had become the alternative to the 707, taking a supportive, rather than a leadership type role. Just as Douglas had become the industry's leader in piston-powered commercial transports, Boeing became the leader in jet-powered aircraft. It is a position that they hold to this day.

An even later arrival in the jet transport market was Convair with its 880 model. By the time this aircraft was introduced, the majority of airlines had already committed themselves to either Boeing or Douglas or both. Another builder of large aircraft, Lockheed, decided not to even enter into the jet transport competition. Instead, the company opted to target the eventually lucrative turboprop market with its "Electra" model.

What really made these aircraft so different was not so much their pressurized airframes, but their powerplants, for this was the beginning of the commercial jet-age. These new ultra-high technology engines, required large amounts of resources and experience to research, develop and produce. Only two manufacturers were up to the task of producing jet engines: General Electric and Pratt and Whitney.

General Electric had decided that the military market was where they needed to concentrate its efforts, and it was very good at it. But it was Pratt and Whitney's J-57 gas turbine that powered man faster than the speed of sound. And it was the commercial version of this engine, the JT-3 that was chosen as the powerplant for both the 707 and the DC-8. In fact, by 1968, Pratt and Whitney had captured over 90% of the commercial jet market. General Electric, like Douglas Aircraft, had misjudged the potential of the commercial jet transports.

The transition that commercial operators made from piston-powered aircraft to jet-powered aircraft is known as the first re-equipment cycle. It was manufacturing's response to the operator's and general public's demand for fast and comfortable long-distance transportation. The second re-equipment cycle began when manufacturers offered wide-body, jumbo jets, with first the Boeing 747, followed by the McDonnell-Douglas DC-10, and then by Lockheed's L-1011. These aircraft were AM's response to increasing demands for passenger-mile capacity and as a measure to help relieve over-crowded airlines. The third re-equipment cycle brings us to present day operations. Today, the type of aircraft being offered provide higher levels of efficiency (partially as a result of the energy crisis), reduced noise levels both inside and, to meet with Federal regulations, outside. The modern day commercial jet offers the latest in available high strenghth-to-weight materials, with highly engineered avionics systems, fly by wire control systems, on-board flight computers and much more.

Although the history of aircraft manufacturers is rich and interesting, an indepth look at its development is beyond the scope of this paper, for volumes have been written about it, and students could study it for several semesters before becoming fully versed on the development of aircraft manufacture.

Even the brief preceeding history does not address the development of general aviation, business aviation, the entire helicopter market, carrier based aircraft, bombers, stealth aircraft, commuter aircraft, research into aero-dynamics and high speed manuvering, nor does it make mention of space exploration. These are all highly interesting areas to many students of aviation.

However, students should also be educated in subject matter which they will some day find useful in their occupation. Those individuals who chose aircraft manufacturing as their occupation should understand what it is that makes it so unique and why it bears closer examination. While there are other types of industries which share some of the characteristics of AM's, the combination of them along with the inherrent nature of the industry makes Aircraft Manufacturing industry worth studying.

There are many characteristics which make-up the AM industry itself and give its components their identity. One of the primary features is that the business is oligopolistic. There are significant barriers to entering into today's market at any level of the industry. A wide variety of equipment, resources and materials combined with a specialized labor force are required to build any type of production aircraft. Precision components must be machined to tight tolerances from materials which are certified as Aviation Grade and may at times include exotic metals and alloys. The processing of these materials unvolves the use of Aviation Grade equipment (right down to the use of Aviation Grade drill bits), being used in a manner which the government certifies will produce an airworthy product. This equipment can include lathes, drilling machines, boring machines, milling machines, etc... all of which today are being controlled by computer to enhance accuracy and repeatability.

Other equipment requirements includes all the necessary machinery to form sheet metal components in a precise manner and at reasonable cost over short production runs. This can include the use of all manner of presses, brakes, shears and punches. Today's AM is also involved in the manufacture of composite (carbon/epoxy, graphite/epoxy, keylar laminate, etc.) components which requires ultra-clean environments, using highly specialized tooling and processing.

Another factor in the ologopoly equation, is the diverse, and specialized, knowledge required both in research and development and in the actual production of the product. For today's aircraft incorporate the latest in electronics, hydraulics, pneumatics, avionics, environmental systems and safety devices. With so many different types of systems being incorporated into one product, and with varying levels of redundancy, specialized knowledge is required to design and incorporate these systems into the aircraft and specialized skills are required to fabricate, assemble, install and test these systems.

To further insure that the aircraft is safe, the Federal government places strict regulations on the construction and certification of all current aircraft through the offices of the Federal Aviation Administration (FAA). These FAA personnel (inspectors) monitor the daily activity of civilian aircraft manufacturers, checking the configuration of the aircraft rolling off the assembly floor against its make up when it originally received its Certificate of Airworthiness. The original Certificate of Airworthiness and type certificate data sheet are issued by the FAA after exhaustive tests and evaluations of the design, handling and performance characteristics.

Similarly, all aircraft produced under military contract have military personnel that are assigned to the production facility(s) to continually monitor and audit the manufacturing processes. This is done to make sure that the contractor follows the strictest of specifications, regulations and procedures during production and, as required and/or requested, during modifications.

Despite all the regulations and efforts to maintain the highest level of quality and engineered safety, AM's (particularly those involved in general aviation) have very high liability costs. This is due to several factors: First, the consequences of equipment or structural failure can be catastrophic with possibly many lives at stake; Secondly, aircraft are engineered and maintained to operate for many years. It is very common to find aircraft for sale that are over 20 years old. As long as an aircraft maintains its airworthiness status, the manufacturer can remain liable for its safe operation. This results in the manufacturer paying liability insurance for increasingly larger numbers of aircraft. When combined with the general increase in all liability insurance, it is easy to understand how the General Aviation Manufacturers Association (GAMA) estimates that as much as $80,000 in liability insurance is added to the average price of general aviation aircraft. Because of their excellent service record and the level of paymentsthat would be required to insure large numbers of aircraft carrying so many people, commercial aircraft manufacturers do not carry liability insurance. Instead, they opt to self-insure themselves and use the cash reserve to enhance their business position.

Another characteristic of AM is the high costs of research and development and the risks that are associated with the introduction of new products. Unlike most industries, when an AM begins research and development on a new aircraft model, it is betting it's future on the success of the program. Such programs can cost companies billions of dollars even before deliveries begin. This betting the company has become known in the industry as "The Sporty Game" (Newhouse p3).

The Sporty Game is played amoung the manufacturers with the airlines being the spoils of victory. There are many examples of companies successfully playing the game, but the majority of players fail at one time or another with disasterous consequences. In fact, occassionally a manufacturer will play the game, only to lose and end up leaving the commercial business altogether. This is because the price of an airliner has to be competitive and does not reflect the production costs but rather reflects the costs of competition and what the aircraft can do for the operator in terms of passenger-seat-mile-costs and ten-mile costs. As a result it becomes difficult if not impossible to measure the break-even point of production.

In many cases, as in the Boeing 707 Vs the Douglas DC-8, timing can play a crucial role in a product's acceptance throughout the industry. Consider the competition during th second re-equipment cycle between McDonnell Douglas's DC-10 and Lockheed's L-1011 Tri-Star. The DC-10 was offered six months before the L-1011 was and due in part to that became the more popular of the two. In fact, despite the hindsight which recognizes the Tri-Star as the superior aircraft, Lockheed was forced by low demand to discontinue production, thereby stepping out of the commercial arena and in the process took a $2.5 billion loss (Newhouse p3).

But losses appear to be common in the industry according to John Newhouse:

> "Starting in 1952 with Britain's DC Havilland Comet, an airplane prone to metal fatigue and hence disaster (two of them fell apart in the air). There have been 22 commercial jet-powered transports, of which only two, thus far, are believed to have made any money. These are the Boeing company's first two entries: It's long range 707 and the medium range 727, the industry's biggest seller."(p4)

Despite the profits realized by Boeing during the first re-equipment cycle as noted, the company nearly went bankrupt in 1971. It had just begun production of their new 747 wide body airliner and were heavily invested in the project. "In today's harsher financial climate, it seems scarecly believable that Boeing would have gambled so heavily on a project not just capital, but facilities."(Newhouse p114). The new aircraft and the facility it was to be constructed in (the world's largest enclosed space) were built at the same time. The combination of these two investments meant that Boeing had placed its entire net worth (and then some, according to some experts) on the expectation of a successful product line. Then during the economic recession of 1970-71, Boeing was hit hard by cancelled orders. In 1968, Boeing earned over $83 million with 105,000 employees, but by 1969, earnings had dropped to $10 million. In order to save the company from bankruptucy, Boeing reduced its workforce to 38,000 by 1971.(Bluestone 57)

By the mid 1970's, Boeing was again operating successfully. It was now a leaner, meaner, more efficient operation which, during 1978, was able to produce 747's with the manpower it was using in 1973. This put Boeing in a class by itself as the most productive and successful AM. By 1980, the 747 had captured 43% of the wide body market which at one time had belonged to the DC-10 (Bluestone p57).

The gambles that commercial AM's take are different than those AM's producing military aircraft. In commercial aviation, the enormous first costs are recovered, if at all, after many years of production. On the other hand, the government assumes most or all of the first costs of military aircraft. If fact, not only does the government help with research and development costs, but it also buys the tooling needed for the contract to proceed.

Commercial AM's have no idea how many aircraft may be sold nor the concessions that mey need to be made to secure sales. Military AM's having only one primary customer are able to benefit through standardization. Therefore, it appears as if military AM's are able to invest with a clear understanding of what the near term future holds, while commercial AM's will be required to guess at the future market and gambles on future economic and political outcomes.

But all the advantages do not lie solely with military AM's. John McDonnell makes note of the risks involved when "your company is phasing out one program and anxious to begin another, you lose out on the only game in town - you could be out of business."(Newhouse p23). A prime example of the nature of this game is Rockwell International. When it's contract for the B1-B Bomber ended thousands were laid-off, the "ripple effect". Although Rockwell will continue to provide spare parts for many years to come, it is currently, for all practical purposes, out of the aviation game.

Another characteristic which makes AM's unique, is the game they must ply when marketing their product internationally. Most governments are unwilling to buy American goods which have high price tags without getting more than just product in return. They ar interested in the creation of jobs for their people and the transferring of technology. This is provided through the use of co-production agreements, joint licensing agreements and trade off-sets.

Through the use of these agreements, companies such as General Electric enter into an agreement with a foreign AM (in this case SNECMA of France) to form a consortium (CFM Industries) which enhances its appeal internationally. When given a choice of engines to power their aircraft, European operators are apt to choose products which provide jobs at home.

AM's recognize this marketing strategy and , at times, go to great lengths to enhance their international appeal. When Lockheed developed the Lockheed L-1011 Tri-Star they hiped to capitalize on the expanding European market by using Rolls-Royce's new RB-211 as its powerplant. However, the amount of difficulty which Lockheed encountered by entering into this agreement actually caused them to eventually withdraw from the commercial market.

Military manufacturers deal directly (with the aid of the federal government) with foreign governments which can lead to multi-aircraft purchases worth billions of dollars. These sales involve a high degree of offset activity. When McDonnell Douglas sold 100 of its F-15 Fighters to Japan it entered into the following agreement:

> "Of the 100 planes, 14 will be exported complete, 8 will be delivered in kit form to be assembled,and the remaining 78 will be produced in Japan by Mitsubishi and Kawasaki. Forty percent of the parts for the F-15 airframes will be imported from the United States as a result of the Air Force's reluctance to release high-technology classified components. Ishikawajima-Harima is being licensed by Pratt and Whitney to manufacture the 205 F100 engines for the 78 planes being produced abroad."
> (Bluestone p84)

Other such concessions made by U.S. AM's (and the government) have included the buying of Chrysler autos made in Canada for use as company cars to enhance the sale of several billion dollars worth of McDonnell Douglas' F/A-18's, and the purchase of $30 million worth of Belgian machine guns to secure sales of General Dynamics F-16 to NATO.

The international sale of commercial and military aircraft plays a vital role in our nation's well-being. Second only to agriculture, AM's provide billions of doolars annually to offset our own foreign trade deficit. The federal government relies heavily on this type of trade and provides support for this type of activity whenever it can. A prime example is the federal export-import bank, or Ex-Im. This bank which exists solely to enhance foreign trade, devotes as much as half of its considerable assets to the financing of American made aircraft being sold to foreign operators.(Newhouse p60) Ex-Im provides below market interest rates with extended payment schedules and in some cases, 100% financing of the sales. These terms can provide for an offer too good to resist.

In the recent past, major AM's in the United States dominated the world market with very little international competition. However, in the last two decades the world market has become increasingly competitive. Foreign AM's with different labor structures (and in many cases with coresponding governmental subsidies) have become significant players in the world market and thereby threaten the United States dominance of the industry.

In order for the U.S.A. to maintain its leadership role in aviation in the future, AM's will need to continue to provide innovative, cost effective products which operate efficiently and safely. Increased levels of reliability and maintainability will invariably lead to increased sales, provided the aircraft can be produced profitably and delivered on schedule. Although this may require the discovery and design of many new technologies, it will be their physical implementation which will be the focal point of their successful development. This type of successful implementationis one of the key responsiblities facing today's AM manager. With the numerous advancements taking place now and in the future, today's as well as tomorrows manager must be well informed as to how the industry and its competition operates.

While trade magazines offer the latest word in developments, they are merely relating those points of interest which the publishers feel will generate subscription and advertising dollars. These articles published normally deal with very specific topics and do not provide fundamental knowledge of the industry, rather they assume the reader already grasps the fundamentals. There are however, generous quantities of books available on the subject of Aviation Manufacturing, many of which appear to have been written to provide stimulating entertainment from a historical perspective for the aviation enthusiast. Still other books can provide great insight into the idiosyncrasies of the industry and cotain educational material which coul have practical applications.

By providing generalized courework centered around aviation manufacturing, SIU-C would be able to use its resources tobest select those publications which epitomized the goals and needs of those students with general and specific interests in aviation manufacturing, while rounding out the education of those students which have little or no knowledge of what AM's are all about. Once this generalized course (elective) becomes available it is not unrealistic to envision a specialization in aviation manufacturing which could be developed through a more detailed and indepth study of specific subjects such as; assembly flow, military procurement, contract negotiations, licensing, co-production, etc... These courses could be futher enhanced by allowing student the latitude to enroll in courses from other curricula (such as Indistrial Technology and Manufacturing Technology) which have little or no prerequisite conflict, while providing generalized manufacturing knowledge.

Graduates from such a program would be highly sought after by aviation manufacturers as they would be hiring individual that would be educated in an area which currently educates through direct exposure to the environment. Individuals who had received the type of education proposed would most assuredly shorten the initial learning curve associated with any new employee, providing for quicker assimulation into the framework of an organization, making them an immediate standout amoung their peers. Continued succes could only lead to increased enrollments and increased industry interest in the SIU-C aviation program.

To start up such a program would require nominal effort from the University. Ther are already instructors currently employed with SIU-C that have previous experience working for AM's and there is no shortage of reference material available. A pilot program would not have to involve much more than a single course offering, an available classroom, a qualified instructor and what ever type of paperwork is required to have an elective become accredited as an option for fulfilling graduation requirements. Several specialized coures aready exist within the framework of the established curriculum with average student to instructor ratios which are well below the campus-wide average. This should provide for a buffer which would allow the program (if need be) to get off to a slow start. An informal polling of student currently enrolled in various specializations as well as generalized areas of the aviation program (including Associate level) would be able to show preliminary interests. Once the student are made aware of the opportunities within the manufacturing sector, enrollment level should increase proportionately.

The succes of an Aviation Manufacturing prodram would be a real gem in SIU-C's crown and would allow the University to continue to take a leadership role in advanced aviation education, while providing the aviation manufacturers of the nation (and the world) with its potential leaders of the future.

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