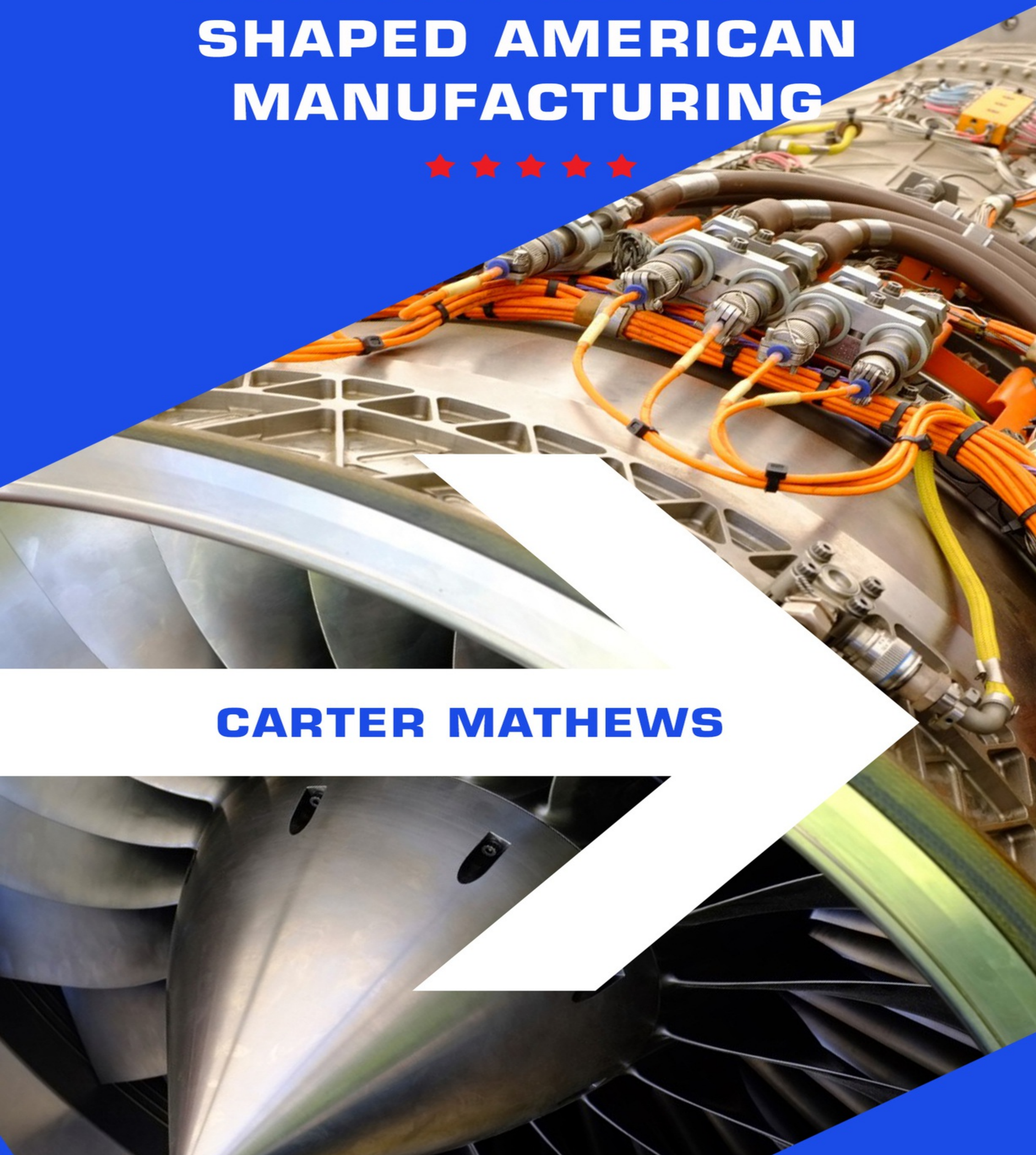
HOW THE AVIATION INDUSTRY SHAPED AMERICAN MANUFACTURING



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Aerospace Manufacturing:

How the Aviation Industry Shaped American Manufacturing

By Carter Mathews

Aerospace Manufacturing: How the Aviation Industry Shaped American Manufacturing by Carter Mathews. Published by Brithe Publishing, LLC.

Introduction

I want to thank you and congratulate you for downloading the book, “***Aerospace Manufacturing: How the Aviation Industry Shaped American Manufacturing.***"

This book is a short introduction to the history and development of the aerospace industry with regards to the manufacturing, production, and employment contributions world-wide.

The aviation industry ushered America into the electronics age of components and modernization. Manufacturing changed from one-stop shops that created the product from ore to assembly, like Henry Ford, to a paradigm shift of specialty mechanization. Where once the family business was producing one product for one merchant, now the small manufacturers will supply two, three or more products to a multitude of customers. Diversification has changed the relationship between the customer and the supplier.

In the name of economics, the aviation industry has been forced to outsource the needed components for aircraft manufacturing. This has resulted in equipment failures with parts that have no provable provenance and are counterfeit. This is one of the future challenges to be addressed by the industry.

In a time where manufacturing generally is in decline, the American Aviation industry has the potential to employ and sustain skilled labor, intellectual innovation, scientists, and creativity.

The lessons that can be learned have shaped not only the manufacturing industry within America, but have the potential to inspire a pathway for the international manufacturing industry of the future.

Thanks again for downloading this book, I hope you enjoy it!

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Chapter 1: A Short History of American Manufacturing

Introduction

There is a strong manufacturing tradition within the United States of America. One of the key intellectual contributions is the American system, also known as armory practice. This process of manufacturing developed interchangeable parts, which could be easily assembled by semi-skilled workers on assembly lines. This approach has proved significant within aerospace manufacture, which has led to innovations in American manufacturing.

Background

The traditional manufacturing method, known as the British or English system, had been commonly used into the 18th Century, but was highly impractical. The system required the use of highly skilled, slow, and expensive labor. This was because each manufactured part produced from the designs was unique, due to discrepancies in their production. Each individual part therefore required a trained machinist to fit and adjust it in order to make every product, which was not only expensive but also time consuming. Indeed, it was usually the same machinist who would be responsible for every stage of the manufacturing process, from beginning to end.

However, there were many situations, for instance during battle, when the inefficiencies of this system led to a need for innovation. This led to a French General arguing during the late 1700s that muskets must be manufactured using interchangeable parts instead. This would allow repairs to take place faster on the battlefield, since new parts could be simply exchanged for damaged ones, and would also make the manufacturing process considerably cheaper.

The vision was realized in 1803 by Brunel, Maudslay, and Goodrich who were working on behalf of Royal Navy in Britain. However, although this method was utilized during the Napoleonic War, it was not popular in Britain, and so its full potential was not realized until its later adoption within America.

The American, or Armory, Manufacturing System

History

The American system dates back to the 1800s, and was named after its strong association with manufacturing companies within the United States. The name also demonstrates the distinction between this approach and that of the British Factory approach.

This system of manufacturing is also called the armory practice, because of the system's use by prominent American armories in Virginia and Massachusetts. Indeed, it was the Department of War, which challenged the officers of Harper's Ferry and Springfield to design an effective way of achieving interchangeability in manufacturing. Although historians disagree on which armory was responsible for the most significant innovations, they do agree that it was these breakthroughs which transformed manufacturing from the 1820s. The American Government knew the significant impact, which the American system could have on manufacturing. Congress insisted that all pistols, rifles, and muskets produced after 1815 must be made with interchangeable parts.

Innovations of the American System

Machine tools

There were several important innovations in machine tools, which allowed interchangeability within manufacturing. One important development was the increased accuracy of many important machine tools, including the turret, screw cutting and slide lathe, the metal planer and the milling machine. The United States government actively encouraged these innovations. They provided a $10,000 incentive for the development of machine tools, which was won by David Wilkinson for his versatile machine lathe. Further innovations during this time include the development of jigs and specialist cutting tools, which allowed greater accuracy in making parts. The development of more accurate measuring equipment also allowed final parts to be more precise, and thereby more interchangeable.

Stamping was a process, which provided a cheaper alternative to either machining or die forging. The result was of a less, but still reasonable, quality and was used in the manufacture of products such as bicycles during the 1890's. Following the success of German imports, US manufacturers began to utilize the technique, and to have stamping machines built. Later, the automobile manufacturer Henry Ford reluctantly adopted the use of stamping due to its ability to produce large volumes of parts compared to the use of die forging.

The US Government's War Department encouraged the exchange of manufacturing ideas by insisting that contractors shared their manufacturing techniques with each other. They also made armories share their innovations with the private sector. This meant that ideas were shared and developed across networks of manufacturing experts. This spirit of collaboration would prove important in terms of later aerospace manufacturing. It was for this reason that the American system also became known as the armory system. Sewing machine specialists and clock makers, as well as manufacturers of steam locomotives and bicycles were therefore all benefiting from interchangeable manufacturing techniques by the end of the 1880s.

Division of the labor force

Another key feature which made American manufacturing more efficient was the division of its labor force. This was particularly important in the use of unskilled or low-skilled labor, which was cheaper and more readily available. Because manufacturing companies did not have to rely on skilled labor, or train specialist machinists themselves, they could invest their profits in innovative machinery and expansion.

Moreover, because parts were made to a pre-designed tolerance, and therefore did not have to be fitted by a skilled laborer, the American system allowed the process of manufacture to be separated from the system of assembly. This meant that the use of assembly lines could begin to take place. Assembly lines could use women, unskilled men, and children to assemble products quickly at a much reduced cost. Each person could learn a specific task, and would only need to be trained in that particular skill. At the same time, machines were increasingly being used instead of hand held tools, which also sped up the manufacturing process. Henry Ford, the automobile manufacturer, used the American system to achieve highly efficient and interchangeable assembly lines.

The American system was eventually favored and adopted worldwide because its use of interchangeable parts, and its focus on mechanization, meant that it was a more effective way of using labor.

Chapter 2: A Short History of Aerospace Manufacturing

Introduction

Aviation has become fundamental in our modern, fast-paced world. Many countries such as America have become dependent on planes for domestic travel, business, and the movement of goods. Indeed, General Aviation is a powerful contributor to the global economy, supporting $150 billion in financial activity in 2011 in the U.S. alone.

In the same year, $4.6 billion was generated through the exportation of manufactured aircraft by America. Indeed, Aerospace manufacturing is still creating positive trade despite a general decline in manufacturing. This includes the creation and sustenance of many highly skilled jobs. This chapter will explore the history behind this success.

Background

Early aviation was highly experimental, and frequently undertaken by amateur enthusiasts. The Wright brothers, famous for aviation innovation, received an order for one aircraft from the United States Army in 1908. Then in 1909 Glenn Curtiss began to sell aircraft.

However, before the outbreak of World War One, Europe was the key arena of aviation manufacturing. By 1914 British firms had built just under 1,000 aircraft, with Germany building slightly more and France building over 2,000 craft. In contrast, American built fewer than one hundred craft during this period. It is important to recognize that even in these early days of Aerospace manufacturing, aircraft relied upon the use of many types of materials, which had to be manufactured within very strict levels of tolerance. Due to a failure to recognize this, American aeroplanes were produced too slowly to either influence the outcome of the conflict or provide a good foundation for the American Aviation Industry. Following the end of the war, the industry stalled, with many companies converting into other areas of manufacturing.

However, some producers of aircraft engines, including Curtiss and also Wright, had been so successful in their production of Liberty engines that this part of the industry did begin to thrive. Moreover, the infrastructure had been created to allow the development of an American Aviation Industry in the future. This was a time of increasing innovation, with Universities in the U.S. researching aircraft engineering and also teaching the subject. The government also provided funds for testing facilities. A crucial moment came during the July of 1917 when all aircraft manufacturing firms agreed to share key design innovations.

Manufacturing of aircraft in the 1920s was not on a large scale. However, many of the design elements of modern aeroplanes, such as the use of monoplanes, air-cooled, radial engines, cowlings, and fuselages that were enclosed, began to be incorporated. Wood was replaced by metal, meaning that new components were required, creating new types of demand. Indeed, aerospace design began to be more specialized as planes began to be used to transport passengers and mail across the world. Due to its landmass, the aeroplane was competing with rail in the United States, leading to further innovations in comfort and safety. These included improved landing gear that was retractable, cabin pressurization and improved navigation and general instrumentation. For these reasons, by the outbreak of World War Two, America had developed superior design to their European counterparts, even if they had fewer actual aircraft.

The Second World War saw the success of the American manufacturing industry in creating aircraft on a phenomenal scale. During these six years, over 300,000 aircraft were built by the United States, meaning that by 1943 this industry was actually America’s biggest employer and biggest producer.

The effect of the Aviation Industry on American Manufacturing

It was from this time onwards that the Aviation Industry began to have an effect on American Manufacturing more generally. From the end of World War Two, other sectors, such as automobile manufacture, began to produce on a similarly escalated scale.

There were several important innovations in aerospace manufacturing at this time. Engineers increasingly used subcontractors to manufacture the component parts of aircraft and distributed manufacturing became increasingly important. Distributed manufacturing refers to manufacturing, which is dispersed across many geographical locations in order to reduce movement costs and maximize profit. This is possible since the processes of production are separated in the American system, meaning for instance that assembly can take place in a different location to manufacture.

The learning curve was also developed, which was a mechanism, which could predict cost reductions.

For the remainder of the 20th Century, American was the hub of the aviation industry. This was in spite of a drop in the actual production of aircraft. American research and innovation continued to be of critical importance worldwide.

The Cold War

Aircraft were highly important, both strategically and symbolically, during the Cold War. The Boeing aircraft for example included both bombers and enormous airliners. There were many key triumphs during this time, including experimental aircraft breaking through the sound barrier in 1947.

These developments and technologies led to a need to restructure the aviation industry. Firms invested their interests into research, with much of the actual manufacturing being undertaken by specialist new firms. For example, Hughes, Sperry, and Raythorn became known for Electronics, especially relating to missiles, and Bell, Hiller, and Sikorsky produced the helicopter. The reduction in scale but increased demand for quality of manufacture, led to the development of smaller factories, which had improved testing facilities.

Aerospace Manufacturing

Due to the increasingly complex nature of aviation and aerospace design, parts had to be extremely reliable but also produced at speed. This led to new management models developed by the aerospace industry, which were introduced into technological industries across the world. These models were vital in continually generating the high levels of technological innovation experienced during this period. With the creation of the Aerospace Industries Association the fields of aviation and aerospace became merged.

The 1960’s were a key decade for the aerospace industry, with NASA receiving and fulfilling missions to send people into space. This fueled the building of the space ports of Texas and Florida, further investment in research and also the expansion of subcontractor networks. During the 1970’s there was also an attempt to produce goods in space.

Because the government dominated sales of military aircraft during the 1960's, their needs were reflected in the way the aviation industry functioned. This meant an emphasis on producing a small number of aircraft, which were capable of having a long life-span. The high specifications of the planes meant that they were frequently expensive, and manufacturers were therefore encouraged to work together to acquire work contracts.

Within this context, systems engineering and program management were deemed to be very important. Systems engineering focuses on the life cycle of a product, and how best to design and manufacture to support and extend this. Program management considers several interrelated production lines at once, with the goal to improve the overall performance.

For the remainder of the Cold War, there was a steady demand for the production of American aircraft, despite competition from Japan and also from Europe. Unfortunately, standards did begin to decline as costs increased and the efficiency levels of the industry declined. This was true of the 1980's aerospace industry, with an increase in spending by NASA not translating into more shuttles being launched into space.

Post-Cold War to the present day

The end of the Cold War signaled a decline in the aerospace industry. Funding from government contracts was reduced, and there was a corresponding fall in contracts for civil aircraft. This meant that whereas nearly nine percent of people employed in manufacturing in 1989 worked in aerospace, this had more than halved to only 4.3 percent by 1995. The number of engineering research scientists choosing to work in aviation also fell during this time from around twenty percent to just seven percent.

The response of the industry was to become more focused. Companies began merging and acquiring the resources of failing rivals. The demand for satellite technology for the communications industry, as well as for defense, did keep the demand for space technology stable.

At the end of the twentieth century, the focus of the aerospace industry became the civil market. The trend moving into the twenty-first century is a break away from the influence of the military and towards a more global industry. This is reflected in transnational manufacturing contracts, the increasingly interchangeable and standardized parts used by companies within the industry, and the rise of both imports and also exports.

Chapter 3: Materials and Manufacturing

There are millions of parts that go into the manufacturing of an airplane. The Boeing 777 has over 3 million alone. In addition, there are hundreds of companies supplying the needs of the aircraft manufacturer. We discuss supply chains in Chapter 6.

Manufacturing processes are considered one of five types:

1. Batch Process
2. Continuous Process
3. Discrete
4. Job Shop
5. Repetitive

Many companies use more than one of these processes to move the product from the manufacturing floor to the customer. Here is a breakdown of the manufacturing processes:

Batch processes are very similar to the Discrete and Job Shop because they are a specific job that is limited in scope. It is usually one or more jobs for the same customer, but not something that is in demand by everyone. An example of a Batch Process would be a dashboard exclusive to one model of airplane that is limited in production. A custom aircraft that has options for 200 buyers, and limited to a production of 200 planes, for example.

Continuous processes are the thought most people associate with manufacturing. This is a production line that runs 24/7, however the products of this type of manufacturing are powders, gases, slurry, and liquids. There are many varieties for the continuous processes in manufacturing, as each substance must be handled and stored differently than metals.

Discrete manufacturing is a limited run of a product that may require several setup changes. The products requested may be similar with a few changes, like the facing of a lockset, or very different, like a door handle as opposed to a lift handle.

Job Shops are less likely to have production lines. Many times a job shop will produce one or two prototypes, to test for the design completeness and the operational performance. If the product is successful, then the job may move into a discrete line or more, depending on the product demand.

Repetitive is the most common type of manufacturing. This is a production line that delivers the same product, 24/7, until the product is no longer used. An example of the repetitive manufacturing process could be the airplane seats in commercial aviation. The seats are a standard unit for Coach, and a different seat for the Business Class. There are very few changes in the setup or the assembly process.

For a large aircraft, many different manufacturing processes go into the final product. Each stop along the way picks up the materials and experience for the completed airplane.

The first step for an airplane is the design. Before even the first stroke of the pencil is placed on the paper, the engineer must be told the specific requirements of the proposed aircraft. Some of the parameters will include the payload of the aircraft, (how many people should it hold with an average weight of 150 lbs.? how much luggage can it hold with the luggage weight of 45 lbs. each?). Other examples of payload will be the weight of the engines, the fuel load, and the chassis. We must include the pilot, co-pilot, and flight representatives, plus their luggage. We can't forget the instrumentation and the hardware for the seats, the seats themselves, and the seatbelts. Next we have the galley and the bathrooms with plumbing. The cargo hold has lifting equipment, plus we have the emergency equipment like oxygen masks and CPR equipment. Altogether, the weight specifics alone take months to calculate.

Next we must evaluate the circumstances of the use of the airplane. Is this a commercial airliner, a private jet, or for military use? What will the runway conditions be like? Will it land on long, paved runways, or the short, choppy fields of grass? Will there be adequate room for turning around, or will the pilot have no room for maneuvering? What about the runway surface? Will it be a flight deck, a well-lit long road, or a very limited space?

What can be anticipated in maintenance issues? Will this be a low-maintenance aircraft with expected low systems costs? Will the airplane be expected to have a long service life of twenty years or more? What will the expectations be of the reliability and survivability of this aircraft? What kind of damage tolerance is needed? A military aircraft under fire would have an entirely different set of parameters than a domestic commercial aircraft, one would only hope.

Who will inspect and approve this air design? Will it need to be certifiable by the FAA? Will it need to pass government regulations? Will it need community approval because of the noise level or the safety factors?

Once the engineers and designers have created the project concept, there will a hunt for the raw materials.

Aircraft are built with one side long and one side wide, unidirectional. The wing and the tail is longer than their width; the fuselage is also longer than wide, a propeller is bigger in diameter than the blade thickness, etc. This is the reason the designer uses the same kind of unidirectional material for designing the craft, the equivalent strength to weight ratio. Unidirectional components are long fibers that are a strong tensile flexible fiber.

The aircraft designer and engineers have to use a material that can handle tension and compression both, because the airplane has crosswinds and pressure from the surrounding air above and below the structure. The fibers are made stronger by bonding, somewhat like a piece of plywood. They are embedded with a glue-like resin that both increases the strength and holds the pieces together.

Some of the original airplane structures used wood; nature supplied it straight and tall, it had amazing strength and flexibility, but it is no longer an available resource. It was squandered and now it is depleted. We had to find a similar substance that was equally inexpensive, yet strong.

Aluminum

Because of manufacturing processes, we have extruded aluminum and its alloys that are also unidirectional, has a strong tension, and has a strong compression. Aluminum alloy sheets can be bent to provide tension and compression suitable for an aircraft. Aluminum is not supplied by nature. Bauxite is, the ore that is changed into aluminum by the application of electrical power. Aluminum is triple the strength of wood, but also triple the weight.

Steel

Steel is triple the strength of aluminum, and also triple the weight. The steel used in airplane components is chrome-molybdenum alloy. To use steel, we use either tubes or sheet metal in products that are too thin to hold a nice finish. When they are used in the construction of a fuselage, they are covered with fabric to enhance the strength and the appearance. This requires two methods of manufacturing: fabric covering and steel work.

The steel fuselage has the advantage of welding to be joined together. This method of construction is used only within North America; in Europe and Australia the weld has to be approved by inspectors.

Composites

Modern composites like glass, carbon, Kevlar, nylon, etc., are very strong and very light. On the negative side, they are also very flexible. This requires reinforcement by stiffening the composite within a honeycomb. The drawback for use of these resins in the honeycomb is this material is sensitive to temperatures, humidity, and curing. Resins also have a very limited time for use before they become weaker and unsafe. While the resins have served their purpose, it is time for a better material for aircraft safety.

Production of the components of the aircraft are farmed out to various manufacturers. As we have discussed, the American system of manufacturing has emphasized the importance of interchangeable parts, and distributed manufacturing the importance of using different locations for different stages of manufacture, in order to maximize efficiency and cost.

This has led to an industry utilizing global resources and manufacturing contracts, with large numbers of suppliers and manufacturers collaborating to fulfill manufacturing and maintenance contracts. As the pressure for increased efficiency grows, so does the need for advanced technological innovation, such as the use of automation to allow manufacturers to meet their delivery quotas.

After the manufacturing of the components are complete, the separate pieces are brought together to be assembled in one facility. The aircraft components are taken to one designated bay for all of the assembly. Each piece is built together as it moves down an assembly line, going from station to station, with tests for performance at each stop.

The two pieces of the fuselage initiate the assembly. The joined fuselage is lifted by a jig into the position where the wings will be attached. Next the engine pylons are fitted and then the landing gear. The assembly of the fuselage, engines, and stabilizers are expedited by the use of automated robots that move on railways. The pieces are all tested again for correct assembly and strength, and next it's time for the cabin to be installed. After the cabin, the engines, pressurization tests, painting, fuel and engine performance are examined and approved.

The aircraft is then moved on its wheels to the testing station for the systems check. Eighty-five or more systems are tested by various mechanics, moving from aircraft to aircraft. The airplanes stay in one place and the world revolves around them.

After tests of the hydraulic systems, onboard computers, fuel tanks, landing gear, and each mobile part have been completed; the aircraft are moved outdoors for the engine evaluation and the flight testing.

Once the airplane has passed its flight test, it receives certification and is delivered to the customer.

Within today's manufacturing climate, the total time to build a 777 is only 83 days, from the first wing nut to the first initial test flight. This includes the time it takes for the paint to dry.

Chapter 4: Manufacturing for Refit and Repair

An increasingly significant aspect of the aerospace industry is that of aircraft parts. This has become important, as the practice of selling used airplane component parts has become more common. With vehicles being expensive commodities, there has been an increasing demand to be able to efficiently and cost-effectively maintain them.

A crucial decision for any civil aviation company is whether to maintain or replace an aircraft. This will be based on the life-limit of the vehicle, as well as its ability to fulfill the required operational needs, such as travel frequency, seating capacity and fuel consumption. Manufacturing can play a vital role in predicting the life-limit of component parts, particularly when utilizing techniques from systems engineering. Since predicting the lifecycle of aircraft can never be precise, it is important that safety concerns are balanced with costs. This is where manufacturers may need to offer refit and repair services as an important option balancing these concerns.

Standards and Quality Control

The US has introduced specific procedures, government and industrial regulations which this section of the industry must adhere to, including using certified repair centers to repair, refurbish and then “tag” parts. Manufacturers who produce aerospace components must use a quality and easily traceable identity component. This is often applied with a laser, and is in the form of either a two-dimensional code or a language label. This system of identification allows parts to be linked back to the place they were manufactured regardless of where they are in the world. This allows for immediate recalls, which are crucial given the importance of safety within the industry. Identification also allows the supply chain to be easily determined, which again is important for part acquisition during refit and repair. The strict expectations of aviation organizations guarantee that the work carried out complies with quality standards.

The value of the repaired part or component is based on the demand for that part. Airlines lose profits when airplanes are grounded, and therefore the business needs of the civil aviation industry have heavily influenced the speed and cost of aircraft parts. In today’s global market, firms can utilize the Internet to advertise their refitted parts, thus supplying many diverse companies.

Six Sigma

Because of the use of second-hand components, it is even more important that new parts are manufactured to be interchangeable. This has led to techniques such as Six Sigma being even more significant. Trademarked in 1993, and used in many sectors including telecommunication, Six Sigma comprises of tools and techniques designed to cause process improvement. Quality is improved through identifying, considering and then removing the reasons for defects, particularly variability, within the manufacturing and also business process. Empirical, statistical measures are used to understand and interpret these changes. The approach uses pre-defined targets, for instance a desire to increase profits and customer satisfaction and reduce pollution and the time spent on the process cycle. Sigma ratings can then be used to describe the manufacturing process of a company, relating to the number of products it manufactures without defects. These ratings are frequently expressed as percentages, and there is an expectation that each part, which is manufactured, should have a 99.99966 percent chance of being produced without any defects. This standard has become the expectation of many aerospace manufacturers, which in turn has had an influence on the quality of manufacturing demanded from suppliers.

Chapter 5: Resource and Development

For an aircraft to be developed, from R&D to the final product, it takes years of comprehensive planning. The Boeing 787, for example, was announced on January 29, 2003. The 787 received the "type" certificate in August 2011. It made its first commercial flight on October 26, 2011. From the beginning concept to the first initial revenue flight was 8 years and approximately 9 months.

The steps required to complete the design and manufacturing for a prototype of an airplane are varied, but this is an approximation:

	Configuration / Development	Market Analysis / Customer Requirements	Major Milestones
1		Specifications	
2		Conceptual Designs	
3		Preliminary Design	
4	Detail Design	Detail Design	Project Authorized
5		Flight Tests	Construction Authorized
6	Product Support	Operations	First Prototype
7	Sales Push	Growth	Certification
8		History	Delivery
9		Archives	Retirement

In the previous chapter, we discussed the materials and manufacturing processes that were required to physically build a new airplane. In the above illustration, we see that the entire process from start to finish may take an entire decade, although once the "type" certificate is issued by the FAA, the manufacturer only has five years to move the airplane from a concept to a final product.

We will discuss now the intellectual requirements for a new airplane to move from concept to the test flight.

There are three components to aircraft design:

1. Scientific, this includes the preliminary activities and analysis
2. Technical, this includes the techniques and technologies of aviation
3. Production, this includes from the raw materials to the assembly and delivery

We discussed step 3 in the previous chapters on materials and manufacturing. Research and Development are concerned with the first two steps. The scientific and technical analyses involve:

- Acoustics
- Advanced avionics
- Aerothermodynamics
- Airframe concepts and technologies
- Aviation technologies
- Circuits
- Design and production processes
- Detectability and stealth
- Digital processing and methods
- Flight control
- Logistics support
- Preliminary scientific analyses
- Man-machine interface
- Methods and tools
- Performance
- Physical modeling and scientific calculation
- Software engineering

- Systems engineering
- Systems workshop
- Technical-operational simulation
- Vulnerability

From the R&D perspective, this team involves no less than 2,000 people for just the concept analysis. This team includes engineers, scientists, electronic technology, mathematics, physicists, solid mechanics, avionics, computer systems, pilots, computer software developers, and mechanical engineering professionals plus many more.

Boeing is the world's largest aircraft manufacturer, headquartered in Chicago, Illinois. Boeing employs more than 160,000 people worldwide. This is just one facet of the aerospace and aeronautics industry. For the manufacturing, assembly, testing and delivery there are many thousands more to deliver the 6 million assorted components that comprise a Boeing 747. These components are manufactured in 30 countries, with more than 550 separate suppliers.

Taking into consideration manufacturing, maintenance, supply, transport, media, etc., the aeronautics industry employs more than 453,610 workers within the United States during May 2015, according to the US Bureau of Labor and Statistics.

Unfortunately, the aerospace industry is losing the engineering and research pool of talent. The current engineers are retiring and the upcoming workforce requires more skill and education, mathematics and higher computational skills. Security clearances are required for these positions that many younger people cannot pass.

There is a shortage of acceptable candidates. Automation cannot replace imagination and creativity.

Chapter 6: The Supply Chain

The automobile industry provides us an example of how globally the supply chain has expanded since 100 years ago.

Henry Ford developed the commercial automobile. In the 1920s through the 1940s, The Ford Motor Company owned the River Rouge Production Complex in Dearborn, Michigan. The complex was measured one-mile-long by one mile and a half wide. It was comprised of 93 buildings and was the first "ore to assembly" complex.

This complex housed every piece of the assembly process, from the limestone quarries, coal mines, rubber plantation, 700,000 acres of forest and land, soybean fields for the basic material of plastics, a tire making plant, a stamping plant and furnaces that made the iron and steel. In the 15.8 million square feet of production space, the assembly lines made the frames, the transmissions, the radiators, the tool and die and included a paper mill. The complex also boasted its own power plant that could have lit the entire city of Detroit, and a soybean conversion plant.

This type of vertical integration was the likelihood; a small firm would design their own products, then create the raw materials needed for manufacturing, and produce and improve the product in-house.

After the World War II, the manufacturing firms began to build components that were interchangeable. Small and medium manufacturers narrowed their focus to one or two components made in mass production.

Today the supply chain starts with more than 230,000 small manufacturers within the U.S. alone. (A small manufacturing facility is one that has 499 or less employees.)

The mid-sized manufacturers and the larger manufacturers compete world-wide with a very small profit margin within the aerospace industry.

The challenges of the supply chain within aeronautics is indicative of the entire industry, namely antiquated methods that are slowing down the entire process. Counterfeit products that appear identical to the designated suppliers' provisions but perform inaccurately threaten the safety of everyone aboard an aircraft. With the onset of 3-D technologies, a component can be manufactured without ever going through the research and development period that assures the safety and effectiveness of the part.

Accepting that parts are made internationally, but that one component of the 6 million required of the Boeing jetliner may only have two or 3 suppliers, the entire manufacturing of the airplane can be stopped in its tracks with a faulty part or a late shipment.

Supply chain logistics within the aerospace industry needs to address these issues:

There are too many suppliers and tiers of suppliers. Even if the part can be outsourced cheaper, is this a good practice without the quality control needed by the aerospace industry?

Instead of moving outside of the OEM for decreased costs, why not collaborate with the Original Equipment Manufacturer and discuss the need for an agreed-upon profit margin? Communication and cooperation will improve the airplane and the relationship between the manufacturer, supplier, and the end product.

Risk Management needs to be addressed head on. There are wars every day in environments and countries once regarded as stable. Unexpected events in another country will greatly affect the supply chain here domestically. Production could be delayed for months if the one or two suppliers of one very necessary component are shut down by a coup, a natural disaster, or a war. We need contingency plans in place.

Provenance is an issue with parts supply. We need to develop a specific trail of provenance to ensure the parts ordered are the parts received. The counterfeit market of after-market components increases the risk of a failed flight and a disaster for the airline industry.

Chapter 7: The Support Organizations

As we have discussed, there have been a variety of challenging economic circumstances, shifts in markets and consumer expectations, which have made an impact on the aerospace industry today. It is increasingly important that American manufacturers can compete internationally, maintain and increase sales contracts, and continue to drive and innovate the industry. US manufacturers of avionics, engines, and various component parts could equip aircraft, which has been manufactured across the globe. However, it has been suggested that the government and manufacturing companies need to continue to adapt to meet these challenges. There are several important committees, organizations, and acts of legislation, which will allow this to take place.

The Federal Aviation Administration (FAA)

This organization is the national authority on aviation matters in the US, and regulates the civil aviation industry. Manufacturers rely on the FAA to approve their products, and their certification can dictate the areas of growth within the industry. However, the FAA can be slow, and this does not reflect the business needs of the civil aviation sector, leading to missed, or restricted business opportunities. Delays disadvantage American manufacturers in a competitive global market, and can prevent investment in innovation and expansion. Many feel that American Aerospace manufacturing will grow and both jobs and exports will increase if the FAA is supported in becoming more efficient.

The General Aviation Manufacturers’ Association (GAMA)

This organization represents aircraft manufacturers who are producing goods for general aviation use, excluding military vehicles and airliners. They also include makers of spare parts, avionics, engines, and maintenance services. The increasingly global nature of the aerospace industry means that GAMA companies are required internationally to allow American manufacturers to maintain and service the facilities where sales of their products take place. However, this is made difficult by security related concerns, which led to Congress withdrawing FAA approval for such service stations. However, these concerns must be tackled if the industry is to succeed.

The International Civil Aviation Organization (ICAO)

The International Civil Aviation Organization is a specialized agency appointed by the United Nations that codifies the planning and development for the international air transportation industry. The ICAO regulates flight inspection, border crossing procedures, air navigation, air accident investigations, and air accident safety. Located in Montreal, Canada, the ICAO is responsible for the safe growth of the air transport community.

Commitments to the Environment

Through the ICAO and GAMA, the airline industry has made commitments to reduce the carbon footprint of the aerospace industry. In addition to working with biofuels to reduce our reliance on fossil fuels and foreign governments, we believe that decreasing our dependence on other governments will increase our national security while we achieve alternative sources of energy supplies.

The Growing Issue of a Shrinking Pool of Qualified Workers

As mentioned in the previous chapter, the workforce with the education and experience within the aerospace industry is retiring. The scientists, engineers, aeronautic mechanics, pilots, and veterans with unique skills and aptitudes do not have a replacement pool of qualified applicants. Of particular concern is the lack of ability to pass a drug test and a security clearance.

The current trend for the millennial generation is to work 2 years at a job and move on. Many of the skills required in the aerospace industry take more than 5 years to learn.

Sixty-three percent of the industry's most experienced and educated personnel will be eligible to retire within the next five years. Who will be ready to take their place?

Conclusion

Thank you again for downloading this book!

I hope this book was able to help you to see the breadth and scope of the Aeronautics industry in relation to the American labor pool and transportation industry.

From its original inception to the empire of today, the aerospace industry has been the example of an explosion of growth and development, utilizing the most modern concepts available to design and construct the "giant birds in the sky". Virtually every employment sector within the United States is impacted in some way by the Aerospace and Aeronautics industries.

Finally, if you enjoyed this book, then I’d like to ask you for a favor, would you be kind enough to leave a review for this book on Amazon? It’d be greatly appreciated!

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Thank you and good luck!

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