FLEET SUPPORTABILITY AND AGING AIRCRAFT

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Table of Contents

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1.0 Introduction

The use of air cargo, freight and overnight express delivery has increased at an annual growth rate of over seven percent during the last thirty years. This expansion has seen the advent of many all cargo airlines, expanded fleets and a greater number of pilots. Projections are that by the year 2022 the cargo jet fleet will grow to 3,500 aircraft and that at least half of the present 1,600 cargo planes will need to be replaced. Many of these 800 older first generation narrow body jets are more then 35 years old and, even though inexpensive to buy, are expensive to maintain and fly. The average age of the worldwide passenger carrier fleets is approximately 7 years while their cargo counter parts have an average age of approximately 28 years – 4 times as old.[1] With this continued cargo growth, more jets will be converted from passenger-to-freighter (P to F) aircraft. Many of these converted P to F cargo aircraft have served with U. S. or other first world passenger airlines, been sold to a second tier or similar foreign passenger carrier, then finally have undergone a P to F conversion after 15 to 20 years of use. [2]

This paper addresses the need for industry to acknowledge the unique maintenance challenges and aging cargo aircraft faced by air cargo operators. It will illustrate the need for improved maintenance practices, and the oversight of those practices, in order to account for the unique aspects of cargo operations. It also identifies industry best practices and develops recommendations to further the use of such practices. The goal is to stimulate discussion at the Cargo Safety Forum that will lead to recommendations on methods to minimize the risks associated with maintenance of aging aircraft in the cargo fleet.

2.0 Overall Cargo Maintenance Issues

As noted above, many aircraft in cargo fleets are in their third generation of service. Typically, such aircraft are less capable in terms of performance, reliability, and automation. In addition, older aircraft and their subsystems (e.g. avionics, engines) usually have higher failure rates and hence require higher levels of maintenance. These higher failure rates coupled with a decreased ability to repair or replace failed components results in many aircraft being repeatedly operated with multiple Deferred Maintenance Items (inoperative equipment).

Cargo operators face many maintenance problems trying to adequately support their aircraft fleets. The source of much of this complexity is the fact that many cargo aircraft were manufactured as passenger aircraft and have been modified from the original configuration to become freighters. Many cargo aircraft undergo numerous modifications and/or conversions prior to being put into cargo service. The aircraft condition and configuration can be significantly different than when the aircraft was produced.

Extensive modifications result in major variations in aircraft cockpits and systems on the same model aircraft. These modifications may be the result of specific requirements by the original purchaser, Supplemental Type Certificates (STCs) by subsequent owners, or conversions to make a passenger aircraft into a cargo aircraft. These changes can result in non-standard configurations and increase the complexity of both operations and regular maintenance. Similarly, record keeping and other accountability processes become more complex.

Most cargo aircraft use a main deck cargo door for on- and off-loading cargo, which requires strengthening of the fuselage ribs and stringers. Removal or disabling of the passenger oxygen, galley, lavatories, water, interior and related systems is required to save weight and to accommodate cargo containers. Most conversions have a heavy maintenance check incorporated as part of the modification on P to F conversions. While many systems are checked, there are still many structural checks that cannot be accomplished, such as checking of a laminated wing spar or beam to investigate for pre-existing damage or internal corrosion. These P to F aircraft will be operated consistently at or close to maximum certified takeoff and landing weights, and any preexisting damage will be magnified when operating so close to these limits.

Many older aircraft and components are no longer produced and are no longer in widespread use. As a result, support by the airframe and component manufacturers is often limited. Some of the original equipment manufacturers of these aircraft and components are no longer in business. Since many cargo operators purchase their aircraft and components from other airlines and not from the original manufacturers, even if the original manufacturer is still in business, there are weaker communication and business ties between these operators and the original manufacturers.

Aging problems include corrosion and delaminating of lap skin joints requiring additional rivets or (in extreme cases) the need for re-skinning of portions or the entire aircraft. While re-skinning is expensive, it affords a closer inspection of frames, ribs and stringers and also affords weight savings with the elimination of windows and widow belts. Polyamide wire insulation becomes brittle with time and exposure to the elements. Once this deterioration process begins, polyamide is susceptible to arcing. The problems associated with aging polyamide insulation have been well documented, however, the FAA and industry need to aggressively identify a replacement product and require replacement at the earliest date.

The aviation industry began aggressively working on solutions to the problem of aircraft structural aging several years ago and has made great strides in overcoming that problem. However, some passenger operators have addressed their aging aircraft problems by selling older aircraft and buying new ones. As many of these older aircraft are sold, they go to other operators and not removed from service altogether. There are other (non-structural) problems caused by aging such as outdated technology, higher part failure rates, lack of availability of replacement parts, and a decrease in support available from manufacturers. Although the problems of aging aircraft are not unique to the cargo carriers, they are more pronounced.

3.0 Passenger-To-Freighter (P To F) Conversions And Aging Aircraft

In October 1996 the FAA completed a Freighter Conversion STC Review of a cargo operator. This review revealed that the company involved was not completing the conversion to FAA satisfaction and that some of the engineering was drawn and described after work had started or even been completed. The review further revealed a significant lack of quality control.[3] Several beams were unsupported or simply butted up and not fastened at all. It is commendable that this incomplete and dangerous work was discovered, while at the same time, it begs the question of what other shoddy effort has not been discovered but has been certified as complete and airworthy. Inspections of these modification facilities need to be more rigorous and at an increased schedule.

In 1998 the FAA found that numerous B-727 converted aircraft were not in compliance with their STC.[4] Sufficient engineering had not been completed to allow the higher weights to be carried in most positions on these aircraft. While it is good that the FAA discovered this problem and took action to bring these aircraft into compliance, it points out a potential weakness in the system that the situation developed in the first place, and that these aircraft flew for several years and were not airworthy.

Floor strength is a major concern with a converted passenger-to-freighter (P to F) aircraft. The increased loads throughout the cabin are substantially higher with cargo then when passengers are carried. The weight in a zone or pallet position can be more than doubled based upon 18 passengers with seats of 22-inch pitch and carry on baggage to be approximately 4,000 lbs. This same position on a cargo aircraft could be certified to carry more then 8,000 lbs. Aircraft have been found to have fuel tanks supported by the same floor beams that are carrying the main deck cargo load. In a FAA-published case, the combined floor weight and suspended fuel tanks with fuel would have exceeded the certified weight by 100% or twice the allowable weight. [3]

Due to structural modifications that add weight, freighter aircraft are usually operated at higher zero fuel and takeoff weights than passenger aircraft of the same type. These increased weights result in increased speeds and air loads. Operating at these higher weights increases loads on the landing gear, flight controls, spars, brakes and engines. The higher reference speeds also result in more frequent operation near the flap and gear limiting airspeeds, thus the assumptions made during initial certification about exposure rates to high loads may not be valid. There is an ongoing FAA Certification Process Study (CPS) to feed operational data back into the certification process. This effort and resultant recommendations may help to minimize this problem. These increased air loads have been responsible for several flap failures that have been close to loss-of-control events. Since the retirement of the Concorde, the MD-11, a favorite freighter airplane of many cargo airlines, has the highest approach speed of any commercial jet aircraft.

As noted above, polyamide wire insulation has been identified as becoming brittle over time. Brittle polyamide has the potential for arcing which can lead to an on board fire. While work is being accomplished to identify a replacement, the potential for a fire on an older cargo aircraft increases every day. Accident statistics show that the time between the onset of a fire and its resulting in a catastrophic failure can be as little as 20 minutes, so the ability to rapidly and positively extinguish a fire on board is critical.

Wiring deterioration in older aircraft has proven to be a continuing problem and the cause of numerous serious electrical problems and airborne emergencies. One cargo airline that is converting thirty-plus year old three cockpit crew aircraft into two pilot aircraft has found that instead of repairing the old wiring, it is actually quicker and ultimately safer to replace all wiring during the aircraft modification program.

With the quick expansion of the express cargo airlines in the late 1970s and through the 1980s, aircraft modification facilities expanded their business to include conversions of passenger planes into cargo aircraft. One of the major modifications was the addition of the main deck cargo door. It is widely known in the cargo industry that the best cargo door is the door that was incorporated in the manufacturing process, in other words, an original part of a new aircraft. Second best is usually an aircraft modified by the original manufacturer of the aircraft and third best is the after-market modification facilities. Some modification center doors even have and continue to use the actual cut out piece of the fuselage itself as the new door, and do not use a jig or any additional structural support during the modification.

Not only do these aircraft age, wear out and suffer the effects of time but so, as well, do the avionics and other components that make up a fully assembled, flyable aircraft. For many years replacements parts were produced for these older aircraft. But during the 1990s manufacturing switched to greater use of the more reliable computer chip. This change has meant older aircraft parts have often become hard to find, and many of those parts still in service have been repaired numerous times and are worn out.

On a positive note, some airlines have changed avionics systems and displays to those with more reliable liquid crystal screens and chip memory instead of having to continue to cannibalize parts from aircraft that are finally being retired. One cargo airline has taken its DC-10 fleet and upgraded the avionics, systems controllers, inertial navigation units and wiring to allow this aircraft to be operated with the same type certificate as the MD-11, thus extending the life of this old but reliable workhorse. In ALPA's opinion, this success story is good business and is one possible solution to some of the aging aircraft and fleet supportability issues.

4.0 Maintenance And Mechanics

Overnight express and many other cargo airlines use a hub and spoke route system. That is, aircraft are positioned at outstations where cargo is loaded and then flown to a central hub. The cargo is then off-loaded, sorted, reloaded and then flown to its destination, another outstation. Hub and spoke cargo systems usually mean that the aircraft lay over at the outstations where maintenance facilities, parts and personnel are limited. At the outstations, deferrals are repaired if parts are available, but with frequently limited parts supplies, the problem may remain be deferred for the repair at the hub. Often, even when maintenance write-ups are made at the main base (where the parts are most available and the most experienced mechanics are based), repairs are often deferred to a station down the line. In some cases however, the needed parts are loaded on the aircraft for repair at the outstation. If the analysis of the problem was wrong or the problem is more extensive than first thought, the aircraft continues to cycle through the hub and outer stations until the problem is finally repaired, sometimes only when the time limit on the deferral is finally reached. While the problem is eventually fixed, this method allows for deferred items to be flown around the system for longer periods of time than desired.

The hub system is also used for international operations. At times, flight crews arrive for a flight and discover that the aircraft has a deferred item that while legally deferred, is not safe because of extended over water operations. That is, the primary or backup system is deferred thus leaving only one system for the outbound and return flight.

Another maintenance problem faced by cargo airlines is outsourcing – the practice of an airline paying someone else to do its maintenance. Outsourcing of maintenance has become common practice by many cargo airlines. Outsourcing maintenance can result in the potential loss of two safety benefits: strong operational control and thorough familiarity with one's own fleet.

While outsourcing is most often less expensive, the greater organizational distance between the operator and the maintainer can result in reduced operational control by the airline. In addition, record keeping of work performed and procedures may not be in compliance with the airline FAA-approved maintenance program. The reduced operational control can create uncertainty as to what organization is responsible for ensuring compliance.

Outsourced maintenance also introduces a problem with having mechanics that are not familiar with that airline's procedures or aircraft. Often only a very limited number of mechanics are available from the outsource company. These factors can, and do, result in deferred problems not being fixed.

Some outsource heavy maintenance and modification facilities even allow non-certified personnel to work on aircraft without the direct supervision of a certified mechanic or inspector.

Outsourcing maintenance to foreign countries creates even more problems. There are additional problems with language, the maintenance procedures themselves, plus a problem with the responsibility of distributing and updating maintenance manuals. In addition to the language problem, off line mechanics may not be familiar with the aircraft and/or procedures used by the airline, and even relatively simple fixes can require extra time and numerous telephone calls to maintenance control to just defer the problem in order to not further delay the flight.

Outsourcing has become highly prevalent in the cargo airlines, and problems will continue to surface until clear responsibility for oversight is defined and compliance is ensured. The entire issue of outsourcing is driven by cost. In order to save money, corners are cut, quality is sacrificed and the result is a decrease in the safety margin.

Mechanic experience and knowledge of older systems creates difficulty. As many older mechanics retire and are replaced by younger and less experienced mechanics, a gap in knowledge has developed in maintaining older aircraft. This gap comes from several areas that include certification training, understanding older technology, newer technology of replacing components instead of repairing parts, lifetime exposure to computer technology instead of working with repairable parts and a possible desire to only work on new advanced systems.

An additional factor in the maintenance picture is that younger mechanics may have little or no training on older technology used on first and second-generation aircraft that comprise a majority of the cargo fleet. Most aviation mechanic schools are now emphasizing new technology and as older mechanics retire, the knowledge of how to keep these older aircraft flying leaves the industry along with them. This problem requires immediate recognition and correction by the operators of mixed fleets of older and newer aircraft. It cannot be allowed to continue unabated.

5.0 Conclusions

1. The cargo airlines will continue to acquire passenger aircraft for conversion to freighters in order to expand their cargo fleets. Thus, extensive fleet modifications and advanced age will continue to create potential problems for the cargo fleet. Record keeping of modifications and compliance with STCs are the responsibility of the operating airlines and FAA, requiring additional oversight and diligence on the part of both.

2. The cargo industry will continue to be faced with aging aircraft issues, including the airframe and replacement components. Methods are needed to overcome problems with: (1) continued use of old aircraft the industry, (2) aging of avionics and control systems, (3) the fact that many replacement components no longer being manufactured, and (4) the loss of experienced mechanics and their repair knowledge of older systems.

3. Outsourcing has become commonplace in the airline industry and has lead to a lessening of airline control in both maintenance performed and documentation.

4. The potential for an on board fire on a cargo aircraft is greater than on a passenger aircraft because of the types of items carried and the inaccessibility of the main deck. A replacement for polyamide wire insulation is needed as more aircraft are converted to freighters and as the cargo fleet continues to age.

6.0 Recommendations

1. The FAA needs to increase oversight of conversion facilities, insure compliance with approved conversion procedures, and foster the use of best maintenance practices for all passenger-to-freighter conversion modifications.

2. The FAA needs to continue monitoring of, and increase inspections and oversight on, aging aircraft issues, including the airframe, avionic systems, and replacement components.

3. The FAA needs to increase inspections of outsource maintenance companies and the airline to ensure: (1) compliance with maintenance procedures, (2) compliance with maintenance schedules, and (3) proper certification of the mechanics performing the work.

4. The industry and the FAA need to quickly identify a replacement for polyamide insulation and aggressively replace polyamide wires because they are a potential source of fire.

7.0 References:

1. Civil Aviation Authority of the Netherlands Report (NLR-TP-2000-210).
2. Aviation and Space Technology Week 2004 Source Book
3. FAA Freighter Conversion STC Review Report Number 1, Review of Supplemental Type Certificate SA1509SO - Installation of a Cargo Door & SA1543SO-Class E Interior, October 24, 1996
4. FAA AD 97-NM-09-AD Amendment 39-10961 through 10964