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FLIGHT OPERATIONS AND ENGINEERING DOCUMENTATION MANAGING AND DISTRIBUTION SUPPORTED BY INTELLIGENT TRANSPORT SYSTEMS

The Summary

Aviation as a multitude of activities is meant to satisfy needs of its customers to overcome distance and time between any departure and arrival point in the world. Airlines and other aircraft operators (governments, armed forces, general aviation, and business aviation) differ in their structure depending on their size and services they provide. Some departments are to be found in larger airlines only. However, core departments, to every airline or aircraft operator, are flight operations department and engineering department. Sophistication and the size of these departments depend on the size of the system they are incorporated in.

Business logistics of an airline consist of numerous distinctive activities and functions. These activities have to be planned and completed in synchronisation. The paper presents an overview to intelligent systems for the support to these activities with particular stress on flight operations and maintenance functions in a medium sized airline. Authors show how the approach to documentation management, as a part of logistics in the production of transportation service, has evolved since the early 1990s when aviation has started to recognise the value of digital technical data. In light of this, authors analyse conceptual framework adopted by today's aircraft manufacturers towards their logistics activities supported by Internet as a new means of transferring data.

The advent of new sophisticated pilot-machine interfaces and aircraft systems tends to increase the volume of the documentation describing these tools drastically. The paper communicates how operational documentation has to change to move towards a more easy and modern media. Intelligent systems that prove aviation entering a period where the "written book" is going to be complemented if not largely supplemented by the "electronic book" are presented from the early beginnings of digital data application to the most recent achievements.

1 INTRODUCTION

Aviation is a driving force in many technology fields. Concepts and designs on drawing board or computer aided design stations of today will appear on the runway sometime in 5 years. Documentation is supporting system for these great advancements.

Logistics process support for documentation in Flight Operations and Engineering has always been just in line with available documents media. Only recently original structure underlying documents was challenged by aircraft manufacturers, airlines, and aviation authorities. The availability of new information media (digital data), dedicated software, and hardware have called for a change. This change has already started affecting some airlines. When aviation community will shift to digital document, they will be tools that will have to be user friendly. This feature will ease their acceptance by immediate users -–engineers, pilots, and mechanics.

Flight operations and engineering activities support have been subject to modification and adjustments in order to keep pace with technology that already boarded aircraft, in recent 3-5 years. As technology is doubling every 18 months, it is of the highest importance to keep pace with developments. Having correct information enables potentially affected subjects to act accordingly. Today's Internet based, communication and commerce will make this requirement even more important.

The authors of the paper employed the methodology of analysing obvious and not so obvious trends in the field of documentation and it's support systems that are the part of logistics process in producing – transportation service – aviation product. This paper is not implying any specific solution. Its purpose has been to gather and organise information on intelligent systems for the support of flight operations and engineering. Then, at the moment when the decision has to be made, it is the role of particular organisation or person to make the most of the information presented in the paper.

Having in mind that the audience reading this article might not be from the field of aviation here are some terms used later on in the article:

ICAO = The International Civil Aviation Organisation. Organise together civil aviation authorities from the countries subscribers to the Chicago convention. This world governing body for civil aviation promotes safe, efficient and reliable operations in aspects of air transportation.

JAA = The Joint Aviation Authority is an associated body of the European Civil Aviation Conference (ECAC) representing the civil aviation regulatory authorities of 27 European states.

SITA = *Societe Internationale de Telecomunication Aeronautiques*, Private network shared by aviation users. Initially conceived for telex communication purposes today ffer a range of services and communication options.

2 FLIGHT OPERATIONS AND ENGINEERING

2.1 The Structure

Flight Operations and Engineering are just two out of several subsystems in any airline. Their existence is dedicated to deal with aircraft directly in the sense of creating the airline's product. Safe, timely, and efficient transportation of people, cargo, and mail are goals that are sought by all people working in them. As Wells [11] puts it like this, "Line departments are those areas that are directly involved in producing and selling air transportation."

Flight operations policies, procedures and techniques that are developed and put in place by flight operations oblige one tenth of airline's workforce [11], that are usually employed in it, to stick to well defined internal and international rules. International regulations started with ICAO Annexes sometime at the end of 40s, have been recently enriched, and broadened within JAA countries by JAR OPS. As Di Santo points out "…JAR-OPS, defines the Joint Aviation Requirements in the fields of aircraft operations." [2]

JAR-OPS Part 1 covering Commercial Air Transportation by aeroplanes was adopted by the JAA at the end of March 1995, and the first issue being published on 22 May 1995.

Apart from the obligation to the air transportation system itself flight operations is responsible for the development of schedule patterns and procedures in order to utilise flight equipment and personnel in most economical manner. It also directs an operations analysis and planning service that effectively plans and exercises continuous control over flight-operations activities throughout the system.

Engineering employs around 25 percent of the total workforce in a major airline. As Wells reports "…they spend a fifth of the revenue money." [11] This substantial effect on the economics of an airline results from the

mission of this department. They have to keep the company's equipment in condition to provide safe and saleable air transportation.

A carrier generally divides aircraft maintenance and servicing work into different levels of inclusiveness and intensity. According to Wells [11] these might include en-route service, terminal pre-flight check, service check, maintenance check, and overhaul. Arranged in ascending order the work and checks performed in each of them are based upon manufacturers and civil aviation authorities findings.

2.2 Documentation Requirements

Aviation specific knowledge is the product of different people working towards common goal. This way of gaining knowledge is not unknown to the human kind. The only thing that is very specific is rather short period of time during which it developed from the roots to today's level. This path has not always been covered in clean calculations and well cut definitions. Large amount of knowledge has been gathered from experiment and sometimes even disasters. "Only by proper coordination it is possible to aim all of them to a specific goal – production of aviation equipment." [10]

Numerous documents are used within airline to cover all aspects of its operations. Different airline's subsystems have different documentation. Until nowadays there has been hardly any change in the format, media and the way this documentation has been used.

Today an average of 60 technical publications are delivered with every aircraft, of which, 45 different manuals are still delivered as paper media. Airbus Industrie states that yearly for all customers, that sums to around 123 million paper pages, with their subsequent economical as well as qualitative constraints. [10]

Concentrating on Flight Operations there is one specific document that is a backbone of all activities related to the exploitation of the aircraft. This document describes aircraft as a piece of equipment.

Not only that it's purpose is to tell operating crew what are regular ways of operating it. It tells the crew what are physical limits to this machinery in order not to require more than the aircraft can do in normal operations. In the same time there are chapters telling crew why something can stray from normal and what to do in that case.

Different manufacturers use different terms to describe manual with this content. No matter whether it is called Flight Crew Operating Manual (FCOM) (as within Airbus Industrie) or Flight Operating Manual (as within Boeing Commercial Aircraft company), just to mention the largest manufacturers of today, it is present with all aircraft manufacturers and is a part of required documentation for aircraft to get airborne at its maiden or any other regular flight. As Speyer states "It is pertinent to every aircraft registration and due to specific modifications in the life time of an aircraft it is almost unique for every aircraft registry." [10] Moreover, it is a part of the airworthiness requirements and regulated by civil aviation regulation on national and international level.

Engineering and maintenance on the other side have the need to cover and document precisely all the parts of the aircraft, the manner they should be checked against documented benchmark values or procedures, and the way they can be repaired or even replaced with other parts that will serve the same purpose.

Documents for performing those checks are created and issued by engineering section and distributed to check stations. Engineering drawings and aperture cards are used to support different engineering and maintenance activities: major and minor structural repairs, heavy maintenance, modifications design, parts information inquiries and repairs. They serve multiple purposes. One part carries information on what is needed to be done, while the rest carries information who has actually done and checked the work. [11]

Up to now each new Airbus Industrie operator received with its firs aircraft a package of between 80000 to 120000 drawing aperture cards with a set of associated data on film. [8] Initial and update file supply depends on the aircraft type. The number can vary upon the aircraft model and manufacturer as well but the order of magnitude is the same. Thus depending on the size of the operator and its fleet, some airlines have to face the management of several collections reaching to some 1.8 million drawing aperture cards.

3 CLASSICAL DOCUMENTATION STRUCTURE AND SUPPORT SYSTEMS

The advancement in aircraft technology in the past three decades is very prominent and fast. This is very noticeable towards the actual operator of the aircraft – pilots as a part of flight operations. Numerous equipment improved human/ machine interface. It has also reduced workload and improved safety. In the meantime, documentation

together with related logistics for pilots has remained almost the same.

The evolution of avionics technology and the systematic use of computers on board have created new challenges. The advent of new sophisticated tools in avionics (Flight Management and Guidance System, Traffic and Collision Avoidance System, Global Positioning System, Enhanced Ground Proximity Warning System) tends to drastically increase the volume of the documentation describing these tools.

In spite of significant advances in aircraft design, particularly relative to the cockpit, flight operations documentation's format and medium have remained unchanged for years. Documentation continue to be always in "…"classic" paper document contained in a portable binder that can be updated periodically by physically replacing or adding pages." [10]

Flight safety and efficiency rely on aircraft operating information that is accurate, up to date, easy to add and use. Without a doubt, as aircraft have become more complex, the amounts and types of needed operating information have grown. A s the result, the task of preparing, distributing, accessing and using operating information has become more challenging to all.

In the same time the structure of documentation and logistics processes for providing correct and up, to date documentation or maintenance procedures have to be adapted to the new situation. That is common process and all aircraft manufacturers and aircraft users agree on it. It may take only one night to change a set of computers in the cockpit or in engine but may take weeks to modify/ update corresponding paper documentation.

Engineering wise the work performed by the airlines on their basic set of documentation represents a significant cost in terms of workload, demanding a level of quality which is not easy to maintain. As Docus points out "This work includes the update of the basic set, the incorporation of the airline's modification, the creation of derived documents such as job cards or maintenance planning documents, the duplication of the amended documentation and its shipment to the stations." [3]

Airlines typically file aperture cards in cabinets in their technical libraries. Filing of the cards is very time consuming process. According to Savio "…one person needs approximately an hour to file 500 aperture cards... it takes 168 hours to file an average Boeing 747-400 update containing 84000 aperture cards." [7]

Despite planning and control processes in place, all of these logistics processes are susceptible to simple errors such as the possibility of the misplacing an aperture card. Aperture cards are often misfiled, lost, or become unreadable from repeated use. It usually takes several weeks from the time a customer orders replacement card until they receive them.

4 TRENDS AND IDEAS IN DOCUMENTATION STRUCTURE AND SUPPORT SYSTEMS

If logistics is understood as the orientation towards services that comprises co-ordination of activities, "…in order to reach acceptable support of the system during its operating cycle…" [4], then all present developments in the field of intelligent systems for the support to flight operations and engineering can be grouped in several groups.

These groups corresponds to the basic elements of documentation systems themselves:

- people – documentation's authors and users;
- physical locations for the documentation.
- processes – creation, distribution, and manipulation of the documents;
- documentation itself;

Documentation end users, flight operations or engineering, are given possibility to integrate and publish their own information. They can integrate their findings into manufacturers data in order to improve safety and efficiency of the equipment they use. Cut and paste facilities allow them to enrich manufacturer's documentation not compromising its quality. In the same time, they improve their own data consultation efficiency and processing.

Access to documentation is improved. It is through single point of entry. Distribution cycle for revisions and updates are reduced. Costs to distribute them are reduced as well. More than one user can use documentation at the same time. This reduces the duplication and unnecessary maintenance of several sets of documents. By having fewer documents to maintain, the effort required to maintain current and accurate technical libraries is significantly reduced.

Document management is simplified not only for end users but for the airline manufacturers as well (e.g. Schuetze states that "…currently Airbus Industrie

Technical library manages more than one million aperture cards…" [8], while Mecham states that "... there are 4000000 part number records in Boeing." [5]). Hence, costs, and organisation in reduced facilities and technical drawing management reflect on the balance sheet as well.

Moreover, high-speed systems with search-and-retrieval capabilities reduce search and retrieval time. Instead of flipping through paper and microfilm document there is more time for engineering research (for example developing repair or more efficient flight operations procedures). With simple and accurate mechanism for data, retrieval users are ensured that current information is available to relevant personnel. Better planning due to more time available leads to streamlined engineering and maintenance operations for example.

Once impartial reference in a form of book documentation has started to be more of a troubleshooting or consultation tool recently. Data sources can be combined in order to give better advice or solution that is more effective. Intelligent text and graphics information interconnecting among several applicable data sources can help in finding already applied solution that proofed to be effective at least once before. End users can also add in-house information that they author.

According to Benavides " Portable Maintenance Aid (PMA) streamlines the often time consuming process of troubleshooting modern complex aeroplanes." Even more "…When designing the PMA we wanted to incorporate all technical documentation necessary for line maintenance in one application that can be carried on the aeroplane." [1]

5 BASIC CHANGES FOR INTELLIGENT SYSTEMS

5.1 Documents Media and Structure

Paper FCOM book or aperture cards are in the process to be replaced by their electronic representatives. Access to information through systems for digital data creating, organising, and distributing is undoubtedly more flexible than contemporary paper systems. As Speyer states these will include "… tape, video, network, CD-ROM, on line consultation." [10]

One of the prerequisites for digital data dissemination and use is the use of common standards for writing, interchange, delivery and use of digital data produced by aircraft, engine and component manufacturers, which are required for support and operation of their respective products. As Docus states "Today's standard in aviation is Airline Transport Association (ATA) specification 2100." [3]

Standard prescribed digital formats to be used are:

a) for textual information interchange SGML (Standard Generalised Marked up Language),

b) for the interchange of graphical info Tag Image File Format (TIFF),

c) for the interchange of graphical info in vector mode Computer Graphic Metafile (CGM).

Digital data products and services offered by aircraft manufacturers for end users are there to be exploited through hardware and data transfer media that is best suited for that purpose. The structure and organisation of operations' documents have been adjusted in order to make the most out of this combination. General practice is that every product is the result of testing among targeted users and validation by the manufacturer.

Although generally introduced by the most influential aircraft manufacturers of today, Airbus Industrie and Boeing Commercial Aircraft company, changes have not been left to their discretion only. Industry associations and government agencies in the countries of their origin have been taking close look at developments in this field. Speyer reinforces this by statement that for example "…1997. National Aeronautics and Space Administration (NASA) together with Federal Aviation Administration (FAA) had a project to examine operating documents." [10] On the other side of the Atlantic Ocean in Europe according to Di Santo "…since it is believed that a high degree of standardisation of Operations Manual within the JAA will lead to improved overall flight safety. JAR-OPS strongly recommends that the structure described in the JAR-OPS Subpart P (defining Flight Operations Manual structure) should be used by operators as far possible." [2]

5.2 Transfer Media

Having more documents in digital format shifts developments in intelligent support systems towards the change of access and data transfer technologies. Once isolated consultation or troubleshooting tools will become "live" and always "current" being connected on-line to the main repositories of data related to either flight operations or engineering.

This concept was introduced in late 70's by Boeing Commercial Aircraft company and their Boeing On Line Data (BOLD) system. 70 largest Boeing customers were connected via electronic data interchange channels in

order to facilitate 60% of all Boeing Commercial Aircraft spare part or maintenance documents orders.

Applying Menard's [6] comment that "Costs associated to the on line services are linked to the domains of communication, the hardware/ software as well as the relative domains that provide the support necessary for the efficient operation of the offered service." to this situation, it is not surprising that although that was a step forward the system was very expensive and not flexible.

Unit service costs will come down either by sharing communications line to access one particular service between several users or by accessing multiple services through single line from one user. In line with this Airbus Industrie is providing a group of intelligent support systems under Single Point Of Contact service"…that will generate a reduction in the communication costs on the customer side…the logistics to be implemented to access one or several on line services is the same time." [6] There are several options to access services available but the most common one nowadays via TCP/ IP protocol on the Internet or any other network that supports it (e.g. Aero Net by SITA.

Once experimental Cold-War era's electronic communication system, Internet has established itself as the leading information communication technology of today. Although only several years more than a decade after the introduction of World Wide Web (WWW) on the Internet, Hyper Text Markup Language (HTML) and hyperlinking information between documents made "The Web and telecommunications the new railroads to allow change at a pace similar to industrial revolution." [9] Next few years will prove whether Internet will continue to create digital society and influence it's development.

Aero Net is private aeronautical network that supports Internet standard with enough security, reliability and capacity for aerospace users. Public Internet connection compared to Aero Net is usually better in terms of connecting fees; but its use can pose some security problems. Several studies have been done related to secure server mechanism because there has been some inconveniences related to the reliability of the data transferred by the Internet. Both Boeing Commercial Aircraft and Airbus Industrie are aware "…that critical factors in the success of commercial Internet use lie in understanding the business streams, managing technological advances, addressing privacy and censorship issues and handling 'very complex' security." [9]

5.3 Contemporary Trends

Initial moves toward the present situation began in early 1990s. Moves were cautious and initiated by two major driving forces. Airbus Industrie was working on the necessary foundations for digital documents and systems while Boeing Commercial Aircraft has been exploiting the in house digital systems and developing them for commercial application.

The period between 1992 and 1998 has been characterised with:

- Boeing Commercial Aircraft developing and providing intelligent digital engineering data manipulation systems at airline's location using dedicated electronic data interchange lines,
- Airbus Industrie designing and developing flight operations and engineering manuals in standard digital formats and with new trouble shooting features.

Year 1998. has been very intensive for Airbus Industrie. They finished conversion of all its aircraft types' FCOM to digital format. In the same time these document , once available on CD-ROM for consultation on personal computer, came on-line.

Boeing Commercial Aircraft moved forward with several mainly engineering troubleshooting and consultation applications during 1999. They are available on personal computer and airline's network.

Year 1999. was also very specific year for both manufacturers and all airlines due to imminent 2000. This change of year has been calling for intensified efforts in preventing and proving that it will not have any minor or major impact on airline's operations. Evidences available by now show that transition was mainly smooth and eventless.

6 CONCLUSION

The abundance of information and their importance is present in every facet of today's world. Technology intensive industries such as aviation are even more affected by this fact. In most professional fields, there are several times more publications and information sources that an expert can read working full time.

Medium size airlines with all its departments have to observe and accomplish tasks needed for safe, efficient, and reliable operations. The criteria are given by airline manufacturers, airworthiness authorities, and airlines themselves. These tasks are not a function of the number

of employees. They are the function of fleet size mostly. Hence, regardless of restricted number of employees, tasks have to be accomplished in timely and high standard of quality comparable to larger airlines with more qualified employees. That is one reason more to accept the change in the way information is collected, put together, distributed and used.

Despite all new systems available, they will not be introduced to all aircraft operators immediately. There is not common logic that can describe who are the operators that are introducing these systems. All these new tools imply the personal computer as a tool to a pilot, engineer, and mechanic. This implies drastic changes in the organisation of the airlines. Although there are obvious, advantages regarding consulting, updating and storing of data these are not exclusive criteria to apply the change. Therefore paper documentation will still be produced and used in airlines in spite of their size.

Better use of time and storage space in flight operations and engineering departments that stems from recent change in documentation structure, media and logistics systems presented in the paper are very attractive to medium sized airlines. Having at hand digital media and hardware to create, use and transfer it, it will not be so difficult to maintain such demanding level of quality in crucial parts of any airline system despite of its size – flight operations and engineering.

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