An introduction to the Marconi U4100 Marshal Dual-mode AFTN message switching system

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Summary The International Civil Aviation Organization (ICAO) operates a unique world-wide low-speed data communication network, the Aeronautical Fixed Telecommunication Network (AFTN). The AFTN carries all the ground-to-ground communications relating to the movement of world-wide air traffic and consequently must be highly reliable in operation with extremely trustworthy Message Assurance requirements.

The overall volume of traffic handled by the AFTN is increasing and faster response times are required by users of the network. This means that the AFTN is less able to cope with the traffic and is now being supplemented with a world-wide data interchange system, the Common ICAO Data Interchange Network (CIDIN).

The Marconi U4100 Marshal Dual-mode Message Switching System has been developed as a cost-effective solution to AFTN requirements, while still enabling CIDIN circuits and other enhancements to be added when required.

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Introduction

The availablility of powerful microprocessor-based communications computers coupled with Marconi's many years of experience in fully automatic store-and-forward message switching systems[1,2] has enabled the company to develop and produce an extremely cost-effective solution to meet the requirements for AFTN message switching systems.

Paramount in the considerations for this type of system were the following criteria:

a) continuing compliance with ICAO standards,
b) maximum automation within the system,
c) minimum human intervention,
d) flexibility to allow easy expansion,
e) the ability to handle new requirements (e.g CIDIN),
f) comprehensive and 'user friendly' supervisory facilities,
g) use of modern technology to reduce maintenance activity to a minimum,
h) high reliability.

The System

The Marconi U7000 Microprocessor[2] is used as the main processing equipment, with H6500 Remote Peripheral Interfaces (RPI) used as intelligent front-end processors to provide a flexible method of interfacing to the AFTN channels and circuits in modules of 16 channels. The required high degree of reliability is provided by duplicating the complete system to give resilient processing, i.e no single failure will result in loss of service to a user, and many double-failure situations – an unlikely occurrence in these days of high-reliability microelectronics – are also catered for. A specially designed changeover unit transfers the output channel ends to whichever of the pair of processors is designated as the Main. Input channels are fed to both halves for independent processing and subsequent correlation. Coupled with this unit, a high-speed interprocessor link provides the interconnections between all the processing elements within the system i.e between the Main and Reserve U7000 processors, and between the U7000 processors and the RPI front-end processors.

High-reliability Winchester disc drives are provided for message filing and logging. The use of an Industry Standard Interface allows a range of discs up to 120Mbytes to be provided and these may be duplicated for added reliability or extra storage. Magnetic tape cartridges are used for long-term filing and retrieval.

The RPIs can also be configured to act as CIDIN interfaces, the provision of intelligent front-end interfaces enabling any new or updated facilities as defined by amendments to ICAO Annex 10, to be incorporated simply.

Supervisory channels are provided directly from the Main and Reserve U7000 processors, these positions are capable of fulfilling a variety of tasks depending on the operational and manning requirements of a particular system. Supervisory and engineering functions may be consolidated and, in the ultimate situation, all functions could be carried out from one position thus reducing operational staff to the absolute minimum.

Operational features

These are in compliance with ICAO standards as set out in Document

8259–Com/553/4 and Annex 10 Volume II including all relevant amendments. Where these standards are open to interpretation they have been biassed towards the highest possible degree of automation so as to minimize the number of trained staff necessary to run the system and to simplify their task as much as possible.

Message handling procedures

Considerable tolerance has been incorporated into the format heading line analysis to allow for all common syntex errors (which do not affect the sense of the heading) to be acceptable to the system. These errors include slipped shifts, mutilations not affecting obvious sense, extraneous space characters and transposition of space and shift characters.

Six levels of priority are built into the system, the composition and grouping of which can be modified by supervisory command or be set during commissioning.

The system relays its messages according to the rules of predetermined routeing responsibility as outlined in the ICAO manual on the Planning and Engineering of the AFTN, Document 8259. Address shipping according to Amendment 62 is included in the system.

Message validation procedures

The requirement to ensure safe and reliable transmission of messages from source to destination through a switch is absolute. The Marshal AFTN system has gone to considerable lengths to ensure that this is so.

Normal Channel Serial Numbering (CSN) is standard, and input and output channel check messages are transmitted at regular pre-set intervals, normally 20 minutes. The absence of a check within a prescribed period from the expected time causes a report to be generated. Midnight 'finals messages' are transmitted to all channels specifying the last received CSN for that day. In addition the system maintains close correlation of messages between the two half-systems.

Message filing and logging

With individual disc units capable of providing up to 120Mbytes of storage it is a relatively easy task to achieve the design aim of providing a minimum of 24-hour on-line storage for all messages, which is a considerable improvement on the minimum requirement of one hour. The final storage configuration on a system however is entirely dependent on the customers requirements and, as always, is a compromise between cost, reliability and requirement.

Short-term filing

The discs are used for all short-term filing, which includes all received and transmitted messages as well as the message logs comprising original heading and address lines, the origin line and output information. The information is duplicated on the disc stores for the main and reserve halves of the system.

Long-term filing

Dual magnetic tape cartridge drives are provided on each half of the system to allow 30-day storage of all logs on a removable cost-effective magnetic medium. As each tape holds approximately 20,000 logs it is a simple task to calculate the number of tapes neccessary for the 30 days.

System Control

Five main supervisory functions are obvious, these can however be concentrated onto fewer positions should a user wish to reduce the number of operational staff necessary to run his system.

Supervisor's command position

This would normally by equipped with a visual display unit operating at up to 9,600 baud and a receive-only report/logging printer working at up to 300 baud.

Facilities available at this position provide the commands necessary to control the functioning of the system and reports to assess the status of the switch and its users. Facilities include:

a) message and log recall,
b) routeing control,
c) circuit/channel allocation, identity and status,
d) Main and Reserve processor status and control,
e) system clock commands,
f) storage level, and alarm commands and reports,
g) use of stored pro-forma messages to ease workload,
h) queue and traffic controls,
i) message assurance commands,
j) status display commands,
k) statistics displays.

Engineering position

This is equipped with a 9600 baud v.d.u and two send-receive 300 baud printers, one connected to each half of the system. These printers, apart from being available for diagnostic purposes, can also be used for traffic monitoring.

In addition to technical control the supervisor's duties can be taken over from this position, and a sub-set of the commands available at the supervisor's position can be used to effect equipment control and receive status information.

The engineer is able to:

a) display memory and disc data,
b) monitor an input or output channel,
c) control peripheral units.

Report position

Effectively this is part of the supervisor's position and comprises a 300 baud receive-only teleprinter to provide a hard copy of all reports generated either automatically or in response to a supervisor's command.

Reject and return position

The equipment required here is entirely dependent on the quality of the incoming messages. The higher the reject rate the greater is the number of v.d.us working at 9600 baud required to deal with faulty messages.

Each v.d.u used in this way is able to:

a) edit messages,
b) originate and receive service messages,
c) recall messages from disc,
d) print out routeing list data,
e) correct and re-introduce reject messages,
f) take over supervisory functions if so desired.

A 300 baud send/receive printer is also associated with this position to provide hard copy of the transactions. Typically, one printer would serve two v.d.us.

Message journal position

This would be equipped with a high-speed receive-only printer to provide a hard copy record of all received messages through the system. A date/time check is provided at five minute intervals as a reference aid. It would also be

possible to provide journalling on magnetic tape should this be required.

Use of the system

The use of well-proven high-reliability microcomputer equipment has resulted in a basically simple equipment which is capable of virtually unattended operation and which needs an absolute minimum of preventive maintenance. All that is necessary is the cleaning of magnetic tape heads and the checking that fans are operating, tasks which can be performed by maintenance staff with a minimum of training.

The operational repair philosophy is equally simple, straightforward inbuilt diagnostics coupled with fault algorithms allow swift replacement of faulty units so as to allow the failed half of the system to be returned to service as quickly as possible.

The faulty module can then be repaired off-line, or returned to Marconi for replacement, depending on the level of maintenance required for the system.

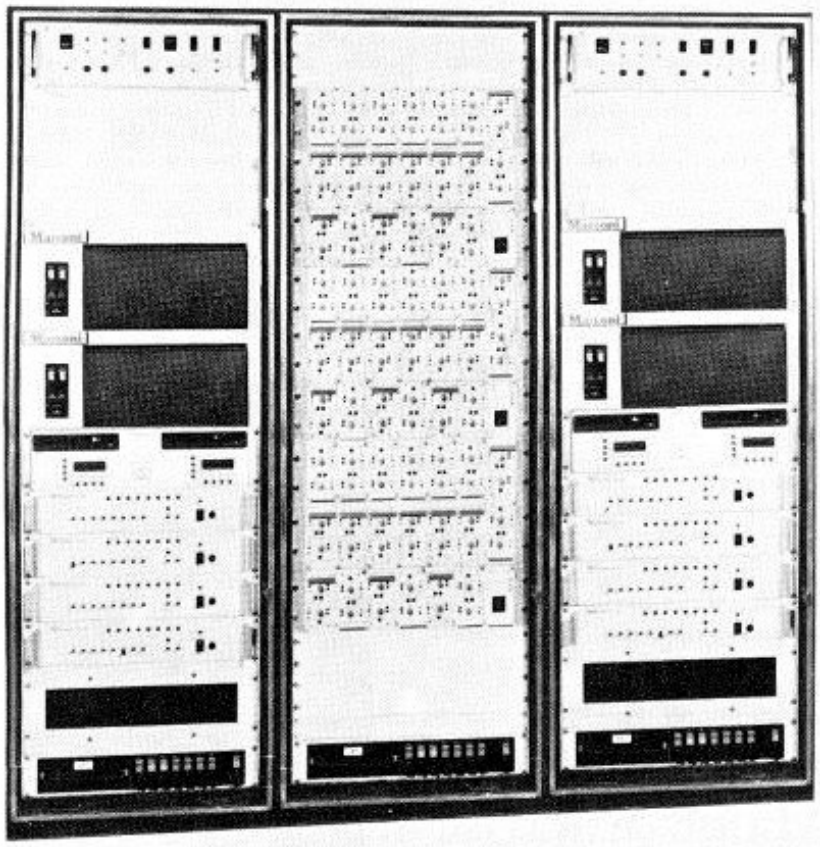

Fig. 1. A 64-channel U4100 Marshal Dual-mode AFTN Message Switching System

Optional features

The basic system described thus far is capable of meeting the needs of the majority of users with its standard telegraph and telex interfaces working at a wide range of codes and speeds under computer control. However it is recognized that one of the main functions of an AFTN switch is the transmission of weather and meteorological information according to a variety of national and international standards.

MOTNE/ROBEX

The compilation and dissemination of OPMET messages of varying lengths around the European MOTNE network and the interface to and from AFTN systems are handled automatically. NOTAM and SNOTAM bulletin distribution is also undertaken automatically. For other parts of the world where ROBEX standards apply, similar procedures are applicable.

CIDIN

The decision of the ICAO Automated Data Interchange Systems Panel (ADISP) to adopt the basic standards set out in the CCITT X25 Recommendations for its CIDIN network was welcomed by Marconi Communication Systems as it already had considerable experience of this type of circuit and its various derivatives as a result of work on distributed message switching.[2,3,4] It has already been mentioned that the use of RPIs permits CIDIN circuits to be interfaced to the U4100 Marshal AFTN switches.

Flight plan processing (FPP)

FPP is a large and complex topic and a requirement for the full FPP specification would present an unnecessary additional load within the basic AFTN switch. Methods for dealing with FPP, using separate processors, are under consideration.

Conclusions

The Marconi Marshal U4100 Dual-mode AFTN System is a cost-effective solution to meet the needs of present day AFTN users, and is capable of expansion to meet the changes and enhancements likely within the foreseeable future both for low-speed telegraphy within the AFTN and for higher speed requirements within CIDIN.

Figure 1 shows the front of a 64-channel dual-mode AFTN system configuration and is complete with high-level telegraph interfaces, dual, duplicated discs and magnetic tape. It can be seen that expansion to the present maximum system size of 124 channels would simply involve adding one more cabinet to provide a powerful configuration within a very small physical area.

References

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3. R. F. Moore: 'Operational control of the U4000 distributed message switching system', *Communication & Broadcasting*, Vol.8, No.1, (September 1982) pp.41–47.
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RÉSUMÉ

L'Organisation Internationale de l'Aviation Civile (I.C.A.O.) exploite un réseau de communication, unique dans son genre, couvrant le monde entier, pour la transmission de données à basse vitesse: le Réseau de Télécommunications Fixe Aéronautique (A.F.T.N.). L'A.F.T.N. transmet toutes les communications terre-terre concernant les mouvements de trafic aérien dans le monde entier et par conséquent son exploitation doit être hautement fiable et la garantie d'intégrité des messages, exceptionnelle.

Le volume d'ensemble du trafic pris en charge par l'A.F.T.N. est en augmentation et des temps de réponse plus rapides sont maintenant exigés par l'utilisateur de réseau. Ceci veut dire que l'A.F.T.N. est moins capable de faire face aux besoins du trafic et se trouve maintenant complémenté d'un système d'échange de données à l'échelle mondiale: le Réseau d'Echange de Données Commun I.C.A.O. (C.I.D.I.N.).

Le système de commutation de messages Marconi U4100 Marshal, à mode double, a été mis au point comme solution économique des besoins de l'A.F.T.N., permettant en outre l'adjonction de circuits C.I.D.I.N., et d'autres perfectionnements selon les besoins qui se présentent.

ZUSAMMENFASSUNG

Die Internazionale Civilluftfahrt-Organisation (I.C.A.O.) unterhält ein einzigartiges, weltweites, mit niedriger Geschwindigkeit arbeitendes Datenübertragungsnetz das als Aeronautical Fixed Telecommunications Network (A.F.T.N.) bekannt ist. A.F.T.N. führt die gesamten Boden-Boden-Meldungen des weltweiten Luftverkehrs und muß daher funktionsmäßig bei Forderungen höchst vertrauenswürdiger Meldungssicherheit äußerst zuverläßig sein.

Das von A.F.T.N. geführte Gesamtverkehrsvolumen steigt, und die Netzbenützer fordern schnellere Ansprechzeiten. Das bedeutet, daß A.F.T.N. den Verkehr jetzt weniger gut beherrscht und durch ein weltweites Datenaustauschsystem, das gemeinsame I.C.A.O. Datenaustauschnetz (C.I.D.I.N.) gestüzt wird.

Das von Marconi entwickelte, mit zwei Betriebsarten funktionierende Nachrichtenschaltsystem U4100 Marshal ist eine kostengünstige Lösung der A.F.T.N.-Anforderungen und gestattet nach Bedarf zusätzliches Anschalten von C.I.D.I.N.-Sätzen und anderen Leistungsmerkmalen.

RESUMEN

La Organización de Aviación Civil Internacional (I.C.A.O.) opera una red única mundial de comunicaciones de datos a baja velocidad, la Red de Telecomunicaciones Fijas Aeronáuticas (A.F.T.N.). La A.F.T.N. transmite todas las comunicaciones de tierra a tierra relacionadas con el movimiento del tráfico aéreo mundial y, consecuentemente, debe ser considerablemente fiable en operación con las necesidades sumamente fidedignas en lo que respecta a la Seguridad de Mensajes.

El volúmen total del tráfico manipulado por la A.F.T.N. está aumentando, y los usuarios de la red requieren tiempos de respuesta más rápidos. Esto significa que la A.F.T.N. es menos capaz de hacer frente al tráfico y actualmente se está suplementando con un sistema mundial de intercambio de datos, la Red Común de Intercambio de Datos de la I.C.A.O. (C.I.D.I.N.).

El sistema de conmutación del método de doble modo de Marconi U4100 Marshal se ha desarrollado como una solución rentable a las necesidades de la A.F.T.N., mientras pueden añadirse aún circuitos de la C.I.D.I.N. y otras intensificaciones cuando se requieran.