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Data Communication and New Information Technologies for Civil Aviation

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IIASA Working Paper

WP-83-015

January 1983

DATA COMMUNICATION AND NEW INFORMATION TECHNOLOGIES FOR CIVIL AVIATION

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Janurary 1983
WP-83-15

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PREFACE

This working paper is part of the IIASA study "Telecommunication Equipment and Administrative Procedures Relevant to Experimental and Operational East-West Computer Connections" supported by the Control Data Corporation, Minneapolis, USA and the Austrian Ministry for Science and Research in Vienna.

The main aim of this chapter is to describe the essential basics of data communication and computer networking for those readers less familiar with these topics, and is, therefore, a condensed, combined version of other known sources and our own work. As much of the information contained herein is also often required as a reference for our own work, it seemed advisable to publish this chapter as a separate working paper.

CONTENTS

DATA COMMUNICATION AND NEW INFORMATION TECHNOLOGIES FOR CIVIL AVIATION

Istvan Sebestyen

1. INTRODUCTION

Civil aviation started in many countries after World War I. For a long time aviation services were of marginal importance in public transport. It was rather the privilege of an exclusive minority and remained so practically until the 1950s. After World War II, aviation became a mass public transport service in a surprisingly short period of about twenty years. There were many reasons for this sudden change: primarily, the technological developments that allowed the introduction of reliable, relatively cheap mass produced airplanes driven first by internal combustion and then later by jet engines. The military role and importance of air forces certainly helped civil aviation in so far that it allowed--although with some delay--the diffusion of military aviation technologies into civil aviation. Second, after World War II, the economy became truly global and national systems were more and more interrelated and interconnected. With growing economic ties, political, institutional, and cultural relations were also linked closer together and last but not least mass tourism emerged on a scale never seen before. Generally there was a feeling that the world was becoming smaller and smaller. All these developments could obviously have not taken place if oil and energy prices were as high as they are today. Oil and consequently kerosene were cheap and the trade-off of civil aviation-- which could link continents in only a few hours, instead of the days and weeks that ships used to take--outweighed its relatively high energy demand and cost per passenger or unit of freight. Now, at the beginning of the eighties, the situation has changed dramatically. The increasing costs of energy and the general economic recession have meant that this mammoth aviation industry is also facing serious economic difficulties. The main slogan nowadays is to keep the "status quo"--to make airlines as economical as possible despite increasing costs.

Aviation and information industry, in broad terms, have always had a particularly close association. On the one hand aviation has been one of the main consumers of data, such as on weather, navigation, passenger or freight. On the other hand it has itself been a carrier of information in both a narrow and broad sense: in addition to the usual airmail baggages, one can also regard passengers as performing "information carrier and transfer" functions. In what follows we do not deal with this latter category; we only look at the civil aviation industry as a consumer of information with particular emphasis on the international transfer of relevant data.

From the very beginning, the aviation industry has been largely dependent on a vast amount of precise and readily available information. To satisfy this demand, the emerging aviation industry had to develop and built up its information and telecommunication infrastructure. In the early days of aviation this infrastructure was rather rudimentary and remained so for a long time. It is well known that pilots used rivers, lakes, mountains and towns as navigation aids--in fact in the early days of aviation these were almost the only aids available. Navigation aid from the ground was also rather limited: landing on an airfield was tracked by some kind of sign such as fire. New communication technologies such as radio have been invaluable from their introduction. In fact for a very long time radio has been the only effective means of communication between ground and air. As the volume of air traffic grew and the need for communication among airports, other ground facilities and planes increased, communication between ground units also increased--such as between town booking offices and airline reservation computers, or between one airport and another, e.g., when baggage gets lost--and also communication between the airplanes themselves.

This increase in the amount of information is required to keep civil aviation safe and to keep the rise in operational costs (caused by increasing fuel prices and labor) as low as possible with better information and management technologies. Fortunately, as we will explain in what follows, new information and telecommunication technologies will greatly promote this process. Since the end of the forties much has already been done in this field. For example, since the beginning of the seventies a huge international worldwide information and telecommunication network called S.I.T.A. has been built up to become one of the first international packet switched computer networks. The development of the aviation information and telecommunication network has not ceased; it is being upgraded day by day, incorporating the latest technologies and satisfying the increasing demand for aviation related information.

Although the demand for such information is still rising, it seems that for many applications the present infrastructure for handling the growing amount of more sensitive type of data is just not sufficient any more. Over the North Atlantic route between New York and Europe the heavy traffic and thus the overburden on the air traffic controllers was so heavy during the summer of 1981, that the entire traffic controller community of the US East coast went on strike for about two weeks in order to improve their working conditions.

The present navigation methods currently in practice seem to be rather primitive if we consider the opportunities offered by new telecommunication and information technologies. The majority of the communication between ground and airplanes is still by radio. This is basically real-time voice communication, meaning that the utilization of bandwidth is rather low, in addition to other difficulties caused by the speakers' ability to speak and pronounce English--i.e., communication is different from speaker to speaker. Improvements, such as the possibility of "store and forward" type of communication (mailbox principle) for certain purposes seems to be advisable and useful too. Also different types of computer supported applications could be initiated if other ways of communication existed.

With the emergence of new information and telecommunication technologies this becomes more and more feasible and S.I.T.A. is planning to introduce such services in the future.

With regard to East-West computer communication the exchange of aviation data is one of the most natural of the present transborder data flow applications. Although it could have created some issues of concern for some countries, it did not, and in fact it provides same examples of how nations should work together when satisfying their special "transborder data flow needs".

2. A DESCRIPTION OF S.I.T.A.'S SERVICES

Most major airlines use reservation systems in which terminals over a wide geographic area are connected to a central computer. Several major airlines have worldwide tele and data communication networks of their own. Many booking requests, however, cannot be fulfilled completely by only one airline. The airline might have no seats available, or the journey may necessitate flights on more than one carrier. Booking messages therefore have to be passed from the computer of one airline to the computer of another, and often the response is passed back swiftly enough to inform the booking agent who initiated the request at his terminal. In order to achieve this linking of separate systems, all participating airlines had to agree to a rigorously defined format for the messages passing between them. This format was standardized internationally by an industry association, called IATA. To operate the interlinking information data network, the airlines set up in 1947 an independent non-profit organization, called SITA (Societe International de Telecommunications Aeronautique). Through the SITA network separate airlines send IATA-format messages using SITA protocols.

2.1. SITA in Brief [1]

SITA is a non-profit making cooperative organization created by the airline community to meet its needs for telecommunication services. It was founded in 1949 by eleven airlines: Air France; three British companies, which form the present-day British Airways; KLM; SABENA; three Scandinavian companies, which today are merged in SAS; Swissair, and TWA. They pooled their existing telecommunications resources, which in those days consisted of radio-telegraph circuits and networks, with messages transmitted by Morse code or teleprinters.

From very modest beginnings SITA has today grown into a truly international enterprise, serving 241 member airlines in 154 countries of the world, and operates the largest private telecommunications network in existence.

The SITA network permits the worldwide exchange of commercial, technical, and administrative information for air transport and associated activities. By providing the airlines with a specialized, dedicated network, SITA ensures the rapid transmission of information relating particularly to aircraft movements and flight security. In this context, SITA holds a prominent position as a public service. Without the availability of the SITA network, member airlines would be greatly handicapped in their ability to communicate satisfactorily.

As of the end of 1980, there were over 18000 teleprinters and computer terminals in some 12000 airline offices located in 800 cities connected to the SITA network. Included are approximately 7000 terminals for 45 different computer based seat reservation systems, utilized by 103 member airlines.

In addition to its telecommunication network, SITA operates a large reservation system, called GABRIEL, in Atlanta, USA, which is shared by 30 airlines.

In 1980 SITA's total turnover reached 114 million US dollars.

SITA's worldwide operations are performed by a staff of 1750, most of them natives of the countries in which they work.

SITA's operation is truly international, with its 241 member airlines being represented at the General Assembly and on the Board of Directors, and by the various nationalities at the Headquarters and in Regional Management.

Since its creation in 1949, SITA has developed into a unique tool for worldwide air transportation, which, although based on the leasing of transmission circuits from the PTT administrations and "common carrier" organizations, is a "private" entity dedicated and restricted to the specific requirements of its users.

Services provided by SITA fall into one of two broad categories:

- **Telecommunications services**, the mainstay of SITA activities since its creation.

- **Information handling and supplementary services**, which SITA has offered since 1973/1974, and will be becoming more and more important in SITA's future services.

2.2. SITA's Telecommunication Services

2.2.1. SITA Worldwide Telecommunications Network

The SITA worldwide network today consists essentially of switching centers and teletype and data circuits, the circuits being meshed so as to provide a "fail-safe" alternative in case of outages on a particular route. The 174 switching centers, which are maintained and operated by SITA, perform a message and data switching function under the store-and-forward transmission principle.

The backbone of the network is the packet-switched (actually the first international packet-switched network in operation), meshed "High Level Network" currently composed of ten large switching nodes in Amsterdam, Beirut, Frankfurt, Hong Kong, London, Madrid, New York, Paris, Rome and Tokyo, linked by medium speed circuits operated in most cases at 9600 bits per second (Figure 1). It controls a second level of computerized nodes consisting of "Medium Level" centers, located in Bangkok, Manila and Sydney, and of 50 "Satellite Processors" (programmed data concentrators) scattered over the world and serving as interface devices for the connection of data terminals and teleprinters. A third level of the network is formed by Time Division Multiplexers serving as circuit concentrators, and by other types of data concentrators and manual telegraph switching centers.

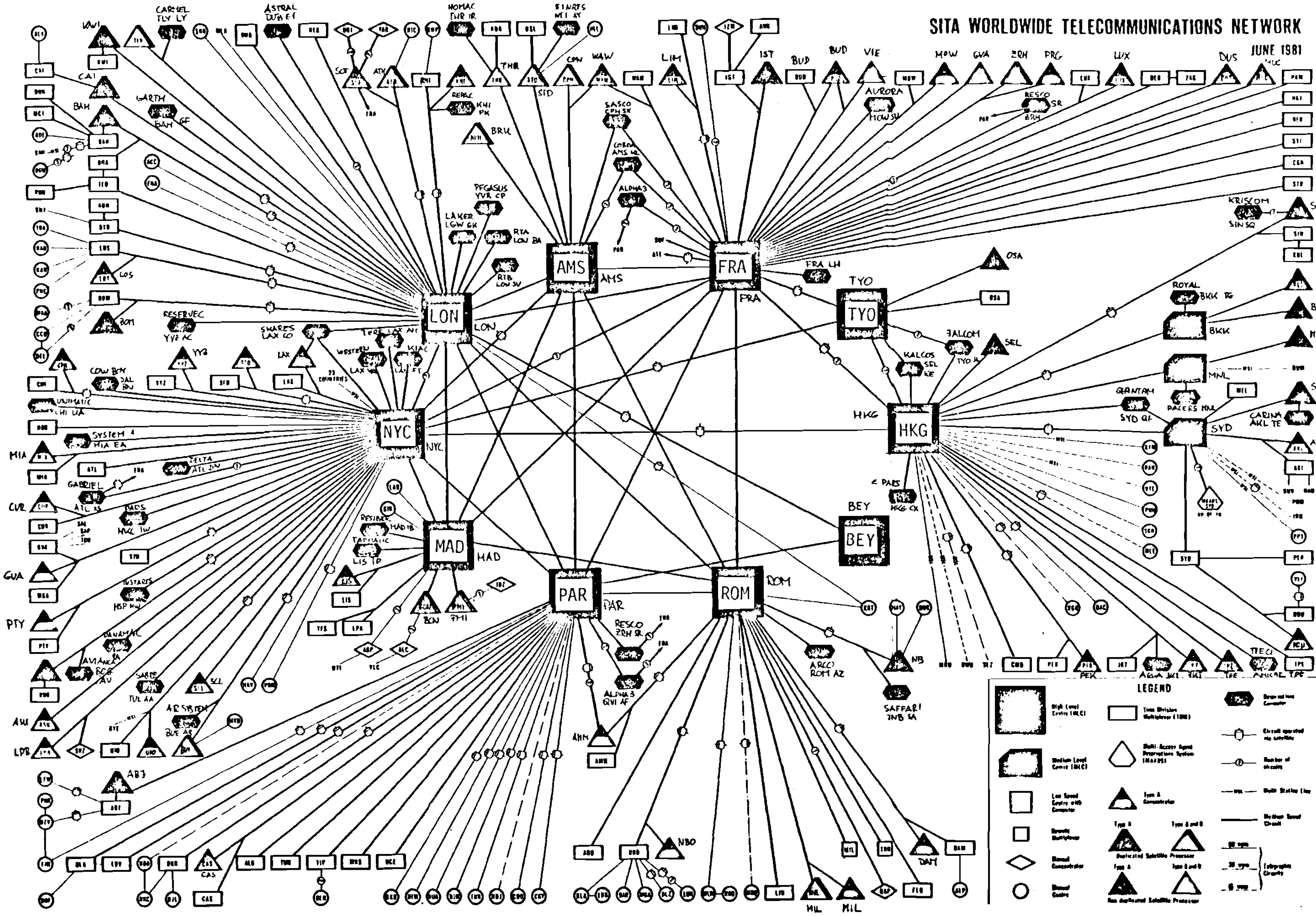

Figure 1. SITA worldwide telecommunications network.

In 1980 the SITA network included over 500 medium speed and 5000 low speed circuits.

The SITA network provides at present two types of communications services corresponding to two different types of traffic. Type "A" traffic refers to the conversational exchange of messages in real-time mode as used for instance for remote interrogation of airline seat reservation systems. For these relatively short (approximately 80 characters) enquiry/response type communication messages between usually a Visual Display Unit (VDU) terminal and a central computer, SITA offers a response time of about 3 seconds. Type "B" traffic refers to conventional telegraphic messages of about 200 characters whose functional information relates to flight operations and safety, aircraft movements, administrative matters such as lost luggage, flight services and status, and commercial activities such as sales and reservation. For this type of non-conversational traffic, SITA provides almost 100% security against message loss or mutilation.

In 1980, SITA transmitted approximately, 3.1 billion type "A" and 432 million type "B" messages.

The foreseen sustained increase in conversational type "A" traffic demand, together with the need to introduce new telecommunications services, have led SITA to study and define a new network architecture, the so-called **Advanced Network**, which is at present under development and implementation.

The *Advanced Network* intended to meet the airlines' future requirements in terms of evolving functional characteristics of communications services and of expanding traffic volumes, is recognized as being the largest civilian network project yet undertaken in view of the major development effort involved. There is a profound need to achieve a smooth transition from the current to the new architecture without disrupting the 24-hour-a-day service.

The definition of the **Advanced Network** architecture is the result of an in-depth analysis of the functions required for the provision of the present and future communications services. This analysis led to the identification of four major classes of functions, to which are associated four specific families of systems:

- **User Interface System (UIS)**

  for the support of user interface connections, concentration of data and translation of these data into internal network format.

- **Data Transport Network (DTN)**

  For the transport of data in transparent mode between two points.

- **Message Storage and Handling System (MSS)**

  For the storage and processing of messages requiring high protection (e.g., type "B" traffic).

- **Network Control System (NCS)**

  For the provision of control facilities required to operate the network.

2.2.2. Data Transmission Principles and Access Protocols

The present and future SITA automatic network may be accessed by its users through a variety of data transmission facilities and access protocols in line with the requirements expressed by the airlines.

Table 1 gives a summary of the transmission facilities and protocols presently available for accessing the SITA network.

Table 1. Access to the SITA network

Airline System	Data Transmission Facilities	Access protocol to SITA network	SITA service available
Teleprinter	Telegraph leased circuit	Point-to-point teleprinter procedure	Type B service
		Multi-station line procedure	Type B service
Telex procedure	Public Type B service	Teleprinter	Type B service
Reservation Agent Set (CRT)	Synchronous leased circuit	P1024 procedure	Type A service
		P1024 B procedures	Type A service
		P1024 C procedure	Type A service
Application Computer System	Synchronous leased circuit	P1024 (1) synchronous link control procedure	Type A service Type B service
		SIRCCO procedure	Type A service

(1) in compliance with ATA/IATA Synchronous Link Control Procedures

At present, SITA offers access through:

- Telegraph leased circuits of various types, according to local conditions in each country

- telex network, in which case the SITA connection complies with the regulations in force in each particular country
- voice grade circuits, of normal quality or complying with CCITT M1020 recommendations.

a) Interconnection Principles

For teletype traffic, airline offices are connected to the nearest SITA center via telegraph circuits leased by the airline from the local Post and Telecommunications administration (speeds of 50, 75 and 100 bauds).

If available, and for smaller volumes of traffic, the public telex service is quite convenient for delivering and receiving traffic to and from the network.

For conversational data traffic, modem-equipped medium-speed circuits operated at 2.4, 4.8, or 9.6 kbit/sec are leased by the airline between its offices and the nearest SITA center.

For this type of traffic, the SITA network can support different communications procedures and protocols as outlined in Table 1, according to the user's requirements. The access facility, as described, can connect either a terminal device in an airline office (teleprinter, VDU) or a more complex airline application system (Reservation, Check-in, etc.).

b) Access Protocols

Access protocols, such as the so-called SITA P1024 Synchronous Link Control Procedure, have been developed in compliance with ATA/IATA recommendations. The use of such standards permits the airlines to access the SITA network through the same protocol, irrespective of the computer equipment used at either end of the connection.

SITA has developed protocols for specific purposes to connect terminals or other equipment of a particular manufacturer, as for example, the P1024B procedure for terminal equipment responding to the IBM Airline Control Procedure known as IBM 1006 Line Control, the P1024C procedure for terminal equipment responding to the procedure defined in the UNIVAC document "UNISCOPE 100 Display Terminal Communication Control Procedure", and the IBM based SITA-IBM Reservation Computer Connection Protocol (SIRCCO).

Within the framework of the new Advanced Network development, SITA plans to support an even wider range of communications protocols, such as:

- The ATA-IATA based Airline Network Architecture (ANA) family of protocols
- the IBM based Synchronous Data Link Control protocol (SDLC).

2.3. SITA's Information Handling and Supplementary Services

SITA offers the following Information Handling and Supplementary Services on a cooperative, nonprofit making basis.

2.3.1. GABRIEL Reservation System

GABRIEL is a SITA owned and operated airlines reservation system based on a triple UNIVAC configuration located in Atlanta, Georgia; it provides a most comprehensive reservation and management information service to those airlines that for one reason or another, do not choose a privately owned or leased system.

The number of revenue passengers aboarded by the system in 1980 amounted to 17 million.

Currently more than 1700 terminals are connected to GABRIEL, which offers a system availability of 99.5% and an average response time of 3 seconds, worldwide.

There are currently thirty carriers using this system:

Aeroperu
Air Panama Internacional
Alia Royal Jordanian Airlines
Aviateca
Balkan Bulgarian Airlines
CAAC
Capitol International
Ceskoslovenske Aerolinie (CSA)
Cruzeiro do Sul
Ecuatoriana de Aviation
Ethiopian Airlines
Evergreen Int'l Airlines
Faucett
Flugleidir-Icelandair
Int'l Air Bahamas
Ladeco
Lan Chile
Lanica
Lineas Areas Paraguayas
Lloyd Aero Boliviano
LOT-Polish Airlines
Luxair
Malev Hungarian Airlines
Pakistan Int'l Airlines
SAHSA
Surinam Airways
Syrian Arab Airlines
TAN
Transamerica
Varig

As can be seen from the above list the carriers utilizing GABRIEL's services are smaller airlines, which would usually find it difficult to set up and operate their own computer reservation service linked to SITA. Other, bigger airlines operate usually their own reservation systems: thus, for example, AIR FRANCE operates its ALPHA III system located in

Valbonne (France) with 360 terminals, British Airways + Air India its BABS+RTB systems in London with 839 terminals, KLM its CORDA system in Amsterdam with 528 terminals. For tradition and resource sharing purposes it is also usual practice for some smaller airlines to join these systems rather than GABRIEL. For example, the British Airways system is also "host" for eight other small airlines. The same is true for the GDR airlines' INTERFLUG, which utilizes the AURORA system of Aeroflot located in Moscow, and serves 53 agent sets via SITA. It is interesting to note that the physical connection between East Berlin and Moscow goes through the Frankfurt/M node of SITA. Swissair and Austrian Airlines operate jointly the RESCO system in Zurich, JAT--the Yugoslavian airlines--has its reservation file under the KLM system in Amsterdam; Malev the Hungarian, CSA the Czechoslovak, LOT the Polish, and Balkan Bulgaria Airlines use GABRIEL in the USA.

Thus it can be seen that with this mixture of system usage there are no political fears in this category of transborder data flows-- not even because of vulnerability reasons. There is, however, some concern especially by some Western European countries about potential privacy problems [2]. Some French sources, for example, expressed their view with regard to SITA, that the most dangerous aspect of this network is the communication about the actual movement of people. For example, Air France puts on microfiche all its reservation transactions. It is feared that at some stage this information could be misused--although it would be against the French law.

GABRIEL is a shared real-time reservations and information processing system, a true multi-host system with participants sharing the central site hardware and programs, but with their data residing in each airline's discrete files. All airlines are treated by GABRIEL equally, with the same priority, and with full security.

The current GABRIEL system is based on 12 years of development, usage, and refinement by the user airlines and operating staff. It has been continuously updated and kept current in accordance with ATA/IATA standards.

The system also enhances service to the air traveler by providing immediate confirmation of interline space for both GABRIEL users and other airlines.

By utilizing the SITA high level data network, GABRIEL is available to all SITA members for online or interline services. SITA's offices throughout the world provide representation and liaison for all aspects regarding GABRIEL and associated telecommunications services.

The central site processors in Atlanta, purchased with the original system, consisted of two UNIVAC 494's. A third 494 was added to accommodate new users. More recently, UNIVAC 1100-83's were purchased to replace the 494's and to facilitate the addition of new applications and users.

Conversion of the programs from the current system (GABRIEL I) to GABRIEL II is underway. The first version of GABRIEL II is scheduled for early 1983.

GABRIEL II was developed from the basic UNIVAC Standard Airlines System (USAS), from selected features' from the original GABRIEL Services (GABRIEL I), and with new features emanating from GABRIEL user requirements.

Basically the current system provides:

- All the requirements of an airline reservations system.
- A hotel accommodation availability and inventory system.
- Interface with car rental systems for availability and direct sales.
- Interface with credit card systems for modifications and authorization.
- The IATA/SITA Baggage Tracing System (BAGTRAC).
- METEO - A worldwide weather data disseminating system.

Developments underway, or being considered at the request of SITA members, include centralized departure control, fare quotation, tour control and sales, and automated ticketing.

The New GABRIEL II Passenger Name Record Reservations System

The upcoming GABRIEL II Passenger Name Record (PNR) System provides state-of-the-art processing for all areas of reservations requirements. The following highlights some of the key features.

Reservations Sales

- Comprehensive displays of schedule and availability information.
- Logical transactions for creating, retrieving, modifying, and canceling PNR's.
- Provisions for up to five agents using a single CRT, or for one agent processing up to five transactions concurrently on a single CRT terminal.
- Control of transactions allowed for travel agencies equipped with user CRT's; e.g., one agency may not retrieve a PNR created by another agency, an important facility to secure privacy of passengers.

Reservations Control

- An extensive and sophisticated range of transactions and processing for parameters such as availability status (AVS) levels, group limits, combined classes of service, and payload control.
- Automated processing for waitlist confirmation. Confirmation priorities are ordered so as to realize maximum revenue while providing good passenger service.

Flight Schedules Management

- Provisions for loading and changing host flight schedules by CRT from each user's central reservations office. Processing is online and includes all necessary features such as passenger protection and advise-schedule-change notifications.
- Provisions for loading and changing other airline schedules by magnetic tape supplied by a third party. Content of the tape is dictated by user-supplied parameters.

Management Reports

- Reports containing data regarding reservations agent and office activity. For example, a report may be requested containing the following information for one or more agents: number of host seats booked, PNR's created, total transactions, and error responses.
- Reports containing data regarding inventory flight activity. Examples of these reports are: (1) load factor for the preceding day's flights; (2) seats booked, open, and waitlisted over a city pair for a specified date or date range; and (3) flights with less than a specified number of seats open for a date or date range.

Given the numerous report parameters contained in the system, the user controls the content and scope of each report.

2.3.2. BAGTRAC - The IATA/SITA Baggage Tracing System

BAGTRAC is a worldwide automated baggage tracing service, jointly developed by IATA and SITA and has been offered to the air transport industry since March 1980.

This service facilitates the speedy recovery of misrouted passenger baggage for all participating airlines. It allows information exchange both within a given airline as well as between airlines throughout the world.

IATA is responsible for the overall administration of the service, while SITA provides the technical support using its GABRIEL data processing center located in Atlanta. By the end of 1980, 54 airlines were connected to BAGTRAC.

This is how BAGTRAC works: Suppose a tourist is traveling from New York to Amsterdam, with a connecting flight *via* London. Arriving in Amsterdam, he cannot find his luggage, because in New York, through a conveyer belt mishap, the destination tag was ripped off and his bag ended up on another airline's baggage cart for a flight to Paris. He at once reports the loss. This is how "BAGTRAC" will work to return his bag:

- Amsterdam enters the missing baggage report in "BAGTRAC"
- Paris enters the unclaimed baggage information in "BAGTRAC"
- Amsterdam receives a computer match based on name, bag type and color.
- Amsterdam contacts Paris, verifies contents, etc., and determines that it is the tourist's bag
- Paris forwards the bag to Amsterdam on the next available flight--and Amsterdam delivers it to the tourist within 24 hours.

In a manual tracing environment, Amsterdam would receive negative replies from both New York and London, and would have no idea where to continue the search, resulting in interim passenger expenses and a lost claim processed after 5 days, another lost claim paid if the bag is not recovered in 21 days, plus a very dissatisfied customer!

BAGTRAC benefits are clear:

- **Improved customer service** with a faster return of mishandled baggage to the passenger.
- **Reduction in lost baggage claims** and "out of pocket" passenger expenses, through a more efficient baggage tracing system, at a reasonable cost.
- **Increase in the mishandled baggage recovery rate and improvement of staff productivity; less workload and paper to handle for local baggage tracing offices at every network station; less workload for Headquarters' Lost & Found Office,** with fewer missing baggage reports and unclaimed bags to process in the race against time to avoid the payment of a claim.
- **Provides useful management information:** A monthly statistical report generated for each carrier, by station, on the first day of each month for the previous month's tracing activity.
- **BAGTRAC reduces lost baggage claims on average by 25%:** BAGTRAC represents a typical transborder data flow application that could not be solved otherwise and that has clearly only positive aspects.

2.3.3. SITA's Meteorological Service

The Meteorological Services, currently provided to several airlines, consist of the selection of global meteorological data obtained from the US National Meteorological Center (NMC) in Suitland, USA.

SITA's Meteorological Service provides worldwide meteorological forecasts of wind speed and direction plus temperature for three upper air levels and also gives the so-called tropopause height.

The service dispatches information using SITA TYPE B telegrams or short delay TYPE A messages either automatically or on specific request.

According to specific user requirements, data are transmitted twice daily to the service participants for flight planning purposes.

The forecasts are generated by the NMC approximately 5-6 hours subsequent to the observation periods of 0000 GMT (midnight) and 1200 GMT (noon). Each forecast is sub-divided into so-called bulletins, which consist of all the data for one altitude category, such as high level, for one major geographical area such as South Pacific, and for one time period (12, 18, 24 or 30 hours after observation time). Each bulletin is further sub-divided into so-called blockettes, each consisting of one ten-degree square area within the major geographical area. (A blockette can contain up to eight sub-squares.)

It allows participants to select the specific information they wish to receive, based on observation period, altitude level, geographical area, and time period.

Each METEO participant will be allowed to identify the specific information to be received, as follows:

• Observation Period	(0000 and/or 1200 GMT)
• Altitude Level	(Low/Medium/High)
• Geographical Area	
• Time Period	(Forecasts for 12, 18, 24 or 30 hours after observations)

- Blockette Area (10-degree square area)

Forecast structure

Each forecast can be structured according to the following specifications:

- **Observation Time**
- **Altitude Category** (mb = millibar)
  (Low, middle and high level data--winds and temperatures).
- **Geographical Area**
  The forecasts for the entire globe are broken down into geographical regions, such as countries of the Northern Hemisphere (North America, North Atlantic, Arctic, North Pacific, Japan, Caribbean, Philippines, Pacific, Asia, Arabian Sea) and of the Southern Hemisphere (South America, South Pacific, Africa, Indian Ocean, Antarctic).

Benefits

METEO Provides accurate and up-to-date worldwide meteorological information essential for optimum **flight planning**, thus saving fuel, time, and operating expenses.

It permits selective choice of data thereby reducing transmission and processing costs, transmits via reliable channels the information as soon as it is received from NMC and provides a 24-hour service, 7 days a week.

2.3.4. SITA Departure Control Services

The SITA Departure Control Services (DEPCON) are based on a standalone system aimed at catering for the requirements of a group of airlines or individual carriers whose passenger volumes do not exceed 1000 per peak hour. The system provides for three basic functions, namely check-in, weight-and-balance, and boarding pass printing.

At present there are installations in Budapest (1978), Sofia (1979) and Abidjan (1981).

The Budapest installation will be expanded to include a flight information display system that will provide the airport and airlines with automated flight arrival and departure information.

2.4. Planned SITA Services

As mentioned above the services provided by the SITA network are being extended gradually with new facilities and services. By their nature, these tend to be more and more digitalized, being based on new information and telecommunication technologies.

The following telecommunications and data processing services are being evaluated technically and economically or are under development by SITA:

- Digital Air-Ground Communication Service (AIRCOM)
- Shared Air Cargo Service
- Shared Aeronautical Database (AERODAT)
- Tariff Reference System
- Data Processing Fallback (Disaster or Contingency Planning)
- Flight Planning

2.4.1. Digital Air-Ground Communication Service (AIRCOM)

In October 1981 SITA completed the implementation of an AIRCOM test facility consisting of a computerized central site and two remote ground stations. Service implementation is planned for the first half of

1984. This service will be an interesting new transborder data flow application in the sense that it will provide flow of digital data between fixed ground stations and mobile stations on the planes.

Background

Efficient and reliable air/ground communications facilities are a major requirement of the air transport industry.

As mentioned earlier, until recently the internal operational communications requirements of an airline were satisfied by and restricted to **voice** communication only, using VHF (Very High Frequency) or HF (High Frequency) radio transmission between aircraft and ground stations.

In 1977, the first operational air/ground digital service was introduced in North America by Aeronautical Radio Inc. (ARINC). This system, referred to as ACARS (ARINC Communications Addressing and Reporting System) has been successfully adopted by a large segment of the North American airline industry.

The requirements for the provision of a similar facility in other parts of the world remain to be fulfilled. At the request of its member airlines, SITA has initiated a digital air/ground communications study for those regions that are not covered by ACARS. This has resulted in the definition of a new SITA service called **AIRCOM**, which is proposed to be put into operation in the forthcoming years and which will be fully compatible with ACARS as provided in North America.

Service Overview

The basic function of the AIRCOM service is to allow the exchange of data in digital form between an aircraft and the airline ground based flight operation personnel and facilities.

The current voice communications system requires human intervention at several levels, and as a result suffers from multiple limitations, among which are:

- High overhead of redundant procedures required for reliable communication.
- Impossibility of transmitting automatically acquired data.
- No real-time data exchange capability.
- Limited efficiency in the utilization of the frequency spectrum.

The development of AIRCOM will introduce a 2400 bps air/ground data link capability for automatic, accurate, real-time data exchanges between an aircraft and a ground-based communication network. This link will take advantage of error detection and recovery features provided by modern communications protocols. It is intended to **complement** the existing air/ground voice communication and will provide a communication capability between the advanced avionics of current and future aircraft and ground-based airline data processing facilities.

AIRCOM is intended to support a wide range of data exchanges to fulfill a large spectrum of airline applications.

The availability of the AIRCOM Service to exchange digital data will facilitate the progressive automation of key airline operation applications in the fields of flight operations (flight movement supervision and flight management applications), aircraft maintenance and engineering, logistics support, etc.

AIRCOM System Architecture

From a technical standpoint, the AIRCOM service will be provided by a network of dedicated VHF ground stations (referred to as remote ground stations) supporting downlink and uplink data exchanges connected to the nearest SITA Network Interface System (i.e., Satellite Processor or any other type "A" access facility).

All AIRCOM traffic received by the remote ground stations will be routed as type "A" data blocks via the SITA Network to a so-called SITA "AIRCOM Service Processor" central computer system in charge of so-called AIRCOM Service supervision and AIRCOM message processing (addressing and routing, format and code conversions, end-to-end communications control, etc. ..). From the Service Processor, messages are then sent to the airline ground destination facility (terminal or computer system) via the Network.

This system architecture makes extensive use of the existing SITA Network infrastructure and facilities, thus minimizing system deployment investments and circuit costs.

Furthermore, the AIRCOM Service will benefit from the high performance (message delivery in a few seconds) and reliability of the SITA Network.

Applications

Company applications of digital air/ground communications encompass a very wide spectrum of activities and will depend upon each airline's procedures, organization, and general policy for computer assisted operations. For the above reasons, the "application profile" of air-ground data link technology will remain specific to each airline, while being related to general application fields that can be recognized and identified as being common to most airlines. The following are given for illustration purposes.

a) Flight Operations

- The automatic generation and transmission of flight events, and the transmission of additional information from or to the crew should provide the means to achieve accurate and efficient aircraft movement control.
- Cockpit delivery of Preflight Information/Documentation (Flight Plans, Weight and Balance, etc...).
- Transmission of flight operation parameters such as fuel status, engine thrust levels, etc...
- Transmission to the aircraft of weather updates and route diversion information.
- Flight Management Computer data exchanges for FMC database updates, etc...
- Transmission of Meteorological Data (Up and Down).
- Crew Registration.

b) Aircraft Maintenance and Engineering

Initially, so-called aids acquired engine operation data using short delay transmission can be used for urgent and fast computer aided analysis of incidents occurring at locations far remote from the home base. To reduce the number of such events there will be a continuous monitoring of flight times as extracted from flight events. The crew, at its own initiative, will provide direct transmission of maintenance related information from the cockpit to further shorter intervention delays on the ground.

This application will be extended to a more general trend of analysis of engine behavior involving very short "turnaround" delays. This approach will be very useful for preventive verifications/interventions and for more accurate management of engine performance data.

c) Logistic Support

- Transmission of flight events,
- Transmission of fuel status,
- Route diversion reporting,
- Seating arrangements,
- Miscellaneous information as needed by each particular airline procedure.

AIRCOM Development Plan

SITA plans a phased deployment of AIRCOM. At the end of 1981 a pilot AIRCOM unit including two remote ground stations and a basic AIRCOM Service Processor was available for service evaluation by the airlines (KLM was the first airline considering participation in the experiment). The operational deployment will start with the installation of 50 VHF ground stations offering coverage of major international airports and air routes in Western Europe and the Mediterranean Basin.

From the initial phase and according to airline needs, it is planned to extend the service coverage to other parts of the world, such as Asia, Africa and the Middle East, by adding ground stations connected to existing SITA type "A" access facilities.

The worldwide coverage of the SITA telecommunications network, and the already existing large number of ground station connection points, will permit SITA to provide AIRCOM coverage over very large continental areas at very moderate cost. For these reasons, SITA believes that VHF and HF data link technologies should not be considered redundant, but complementary, and that they should be combined so as to provide an optimum global coverage in terms of costs and performance.

AIRCOM is a typical example of how new information and telecommunication technology in specific applications help personnel (crew and land) cope with the growing amount of information, rather than just "kill" jobs.

2.4.2. Shared Air Cargo Service

This service is of interest to airlines that have not yet automated their cargo functions. The service is designed to monitor and control the entire cargo operation of an airline and includes reservation functions, warehouse control, flight load preparation, etc.

With the growth of the Air Cargo business and the pressure on airlines to reduce costs and to increase revenue, more and more airlines are placing emphasis on the profitability and marketability of their freight operations. This coupled with the increasing need for detailed, accurate and timely information about the cargo operation, has led many airlines to automate cargo functions, or to investigate the possibility of doing so.

Therefore, SITA decided to offer a Shared Cargo Service to the airline industry in 1981. This SITA service will be the first shared computerized airline cargo service in the world. It will offer to carriers a real time system featuring data capture and control functions for Airline Cargo Service and Cargo Revenue Accounting.

The Alitalia FAST III system, together with the Swissair online schedule change, has been selected for this new SITA service.

System Aspects

In early 1983 the SITA Shared Cargo Service will be operated on IBM equipment (IBM 4341) and located at the Paris Head Office premises. The configuration chosen is fully duplicated, which will ensure continuity and smooth operation of the system.

Like other services, the SITA Cargo service will be a continuous service operating 24 hours a day, 7 days a week.

Functional Aspects

A brief list of the major system functions is as follows:

- Capacity Control
- Reservations

  A reservation agent may display cargo availability either for a specific flight or city pair on a specific date/time.
- Warehouse Control and Inventory

  The system includes every aspect of warehouse management.
- Air Waybill Data Input/Printing

  The SITA system provides for the complete capture of all air waybill data, including total quantitative and charges information.
- Flight Preparation

  Prior to flight departure, the system will be requested to produce a pre-list of shipments based on a certain priority of selection established in the system.

These lists will be used in the terminal to assemble the flight, the agent having the ability to override the system selection by adding/deleting shipment records from a displayed list.

- Flight Manifesting and Dispatch

  At the conclusion of the pre-list preparation a request will be made for manifest product.

  At the time of actual flight departure a confirmation message will be entered in the system, which will update the status of all associated air waybill records.

- Flight Arrival

  Due to the early accessibility of information concerning flight load details, a receiving station has greater flexibility to preplan work-loads and special shipment handling.

- Flight Delivery/Transfer

  The final air waybill record entry, will be to inform the system of shipment delivery, or transfer to another airline.

- Cargo Revenue Accounting Functions

  A major design feature of the SITA system is the data capture of all finalized air waybill record transactions, providing total information for the airlines accounting and billing needs.

System Benefits

Taking advantage of the facilities described above, a SITA Shared Cargo Service user will benefit from improvements in:

- Customer service - Immediate ability to provide customer with current shipment status and information.
- Flight capacity - Improved utilization of flight capacity and allocation procedures.
- Freight claims - Reductions in shipment loss claims.
- Personnel Productivity - Improved accuracy of terminal control information.
- Accounting - Reduction in air waybill billing cycle times - Improved cash flow - Audit security.

The Shared Air Cargo Service will also be a typical transborder data flow application that could not otherwise be done.

2.4.3. Shared Aeronautical Database (AERODAT)

This new service plan covers the implementation of an aeronautical database containing information relevant to air navigation, flight preparation and operation. It is being defined in close cooperation with several airlines and should be of interest to the whole airline community. Work on the service is still being carried out; definite date for service introduction will be defined later.

2.4.4. Tariff Reference System

The purpose of this planned new service is to provide airlines with an efficient tool to perform fare calculations. This service also includes the maintenance and distribution of fare information.

As very few airlines are currently equipped with this type of facility, the proposed service would be of interest to a majority of SITA members.

2.4.5.Data Processing Fallback (also referred to as Disaster or Contingency Planning)

This service would make available real-time computer facilities to airlines with their data processing centers temporarily disabled by unforeseen events. Such a capability is of interest to a number of airlines and is being evaluated for implementation in 1983.

2.4.6. Flight Planning

This service provides for the automatic preparation of flight plans for those airlines not equipped with the necessary facilities, and is of interest to a large number of airlines.

The development of the SITA Flight Planning Service started early 1982. It is planned that the implementation of the service will take place in 1983.

Objectives

The objective of the system is to provide improvements in the accuracy and accessibility of Flight Planning Services through utilization of the SITA Network and State-of-the-Art data processing equipment. Basically, the system entails the execution of a number of software modules to find the optimum route from origin to destination for an airlines flight segments. The effects of weather and aircraft performance are considered over the authorized navigational routes to find the route that yields the minimum cost, minimum fuel, or minimum time as requested by the user. Starting in 1983 an airline may access this system through either CRT or teletype terminal for rapid delivery of tailor-made flight plans for any or all of its flight segments.

Obviously, the first priority in all flight operations activities is safety. Governmental and industry standards for proper fuel loads and navigational procedures must be strictly adhered to. Therefore, the system will be designed for use by licensed airline personnel (dispatchers and pilots) as a means of making an extensive analysis of all relevant parameters for the dual purpose of ensuring safety and generating the optimum route. The speed and accuracy of high speed computers will be used to aid the decision-maker in selecting the best route available under the prevailing circumstances.

Flight planning fits very well with other flight operations applications that are either already available or under review for possible future offering by SITA-METEO, AIRCOM, and AERODAT.

AIRCOM--as mentioned earlier--is a SITA project to provide an air to ground communications facility from the cockpit to flight operations. Flight planning will feature a direct utilization of this application for onboard delivery of flight plans either before departure or while actually en route in the event that a pilot desires to re-evaluate the data affecting the flight. An additional feature that many leading aviation authorities are discussing is the possibility of directly loading a flight plan generated at the ground based central site computer facility into the onboard Flight Management Computer (FMC) that will be present in many of the new generation of aircraft, such as the Boeing 757, Boeing 767, and Airbus 310. AIRCOM may provide the necessary communications link between the large database and very fast ground processors and the new intelligence of the microprocessor based onboard systems. The result could be another step forward in the technological advance toward more accurate and up to date flight plans.

AERODAT also fits very well into the group of Flight Operations Applications under discussion by supplying a new level of precision and comprehensive coverage in navigational data. This project is the result of a movement within the international airline community to improve upon and enhance existing sources of navigational data. SITA Flight Planning will benefit from this service by having a direct interface to this worldwide database to provide expanded geographical coverage and a new precision in the accuracy of the data elements themselves. An additional benefit for the user who chooses to use both AERODAT as the basis of onboard FMC data and SITA Flight Planning for optimum route selection is the added confidence to be gained in the knowledge that total compatibility is guaranteed since both the systems depend on the same source of data.

Features

While SITA Flight Planning will be offered on the same basis as other SITA Data Processing services and therefore will continuously evolve over time to reflect changing user requirements it is appropriate to describe those features that will be available to the first users when the service is initially handed over in 1983.

Typically, a user of the SITA Flight Planning Service will access the system through a CRT (Type A) or Teletype Terminal (Type B) located within the Airline Flight Operations Department.

By executing the appropriate transaction he may either display or update elements within the Data Base or direct that a Flight Plan be calculated for a specific flight. As mentioned above, the meteorological data and navigational data will be made available to the user by direct interface to SITA services such as METEO and AERODAT. In addition, the user will be provided with user friendly transactions for the entry of aircraft performance data and preferred company routes. Naturally all data will be edited for accuracy and reasonability. At the user's direction a number of mathematical algorithms will be executed to generate the optimum flight plan. A printed copy of the Operational Flight Plan and the ICAO Flight Plan will then be automatically delivered to the user. The

Operational Flight Plan will be tailored to reflect each individual user's format requirements. The ICAO Flight Plan will be automatically calculated.

A number of additional functional features will be available. Among these are:

- The availability of Organized Track System (OTS) fixed tracks in areas such as the North Atlantic and Pacific through an interface to the ICAO sponsored AFTN.
- The automatic mathematical formation of overwater route networks for three-dimensional selection of the optimum route.
- Variable speed and altitude changes during cruise phase.
- Special Flight Plans will be available to minimize reserve fuel requirements for those carriers who select this option.
- Reanalysis will be available to generate revised flight plans in the event that new forecasts become available or any other parameter can be modified while actually in flight.
- Equitime and point of no return will be available.
- Both Jet and turboprop Aircraft will be considered.

Benefits

Finally, through the shared services concept all participating carriers will benefit from lower costs. This will be true in direct benefits from reduced flight operations costs (fuel, aircraft, and pilot time) and also through lower administrative activity in the preparation of each flight plan. Also, a very important benefit is in the enhanced features that will result from shared ideas and concepts emerging as more users participate in the service and also from periodic user meetings.

Suggestions for improvements and cost saving measures will benefit not only the airline who originates the suggestion but also all other users. Last but not least this transborder data flow application will give an excellent example of how new information and telecommunication technologies can help to save energy and materials. It also provides services that help aviation staff to digest the vast flow of information, which would not be possible otherwise.

3. AERONAUTICAL FIXED TELECOMMUNICATION NETWORK (AFTN) [3]

Let us now have a look at the less known network that supports at present the Air Navigation Services system. Compared to the SITA network the so-called Aeronautical Fixed Telecommunication Network (AFTN) is not so advanced. This government operated network, which came into existence before the SITA network started to operate, is a dedicated telecommunication network for air traffic control purposes. It also allowed business information of airlines to be transmitted but only on a low degree of priority. This actually led some airlines as early as 1948 to pool their telecommunication resources and as we know in 1949 SITA was founded.

As mentioned above, AFTN is less advanced from the technical point of view. It is first of all considerably slower, is not suited for interactive traffic and does not support the distribution of large portions of information. Due to these deficiencies it only carries a small part of the total amount of information exchange within the Air Navigation Services

System (ANS). In [3] it has been found that about 175 different data types are distributed over six so-called Aeronatural Data Categories (Table 2). Many of these data types are presently exchanged by mail, standard telephone, or if speed is required, on dedicated lines. In fact only 35 of these are distributed through AFTN.

Table 2. Aeronautical data categories

Notam information	**ANS system internal information**
Class I	Emergency procedures
Snowtam	Letters of agreement
Airac	Hi-jack procedures
•	Fuel jettison areas
•	•
•	•
AFTN messages	**Meteorological messages**
distress message	Metar
Accident message	Sigmet
Flight plan	Current air pressure (QNH/QFE)
Departure message	•
•	•
•	•
•	•
AI information	**Technical Status message**
Regulations	Nav-aid status data
Routes	•
Reporting points	•
Zones	•
Areas	•
•	
•	
•	

There is a strong feeling by many experts that this system is hardly able to meet today's requirements. Apart from growing air traffic, meaning growing quantities of information, there is an increasing demand within the ANS system for more efficient methods of access to Aeronautical Information data. And modern information and telecommunication technologies favor the satisfaction of such demands.

The above demand is also reflected in the work of the UN organization for civil aviation (ICAO), which created already in 1967 a special panel working on the definition of a better ANS communications system, the common ICAO, Data Interchange Network (CIDIN). In Figure 2 a projected implementation plan for the European part of AFTN (CIDIN) is presented. As can be seen from its topology it is different and separate from the telecommunication network used by SITA.

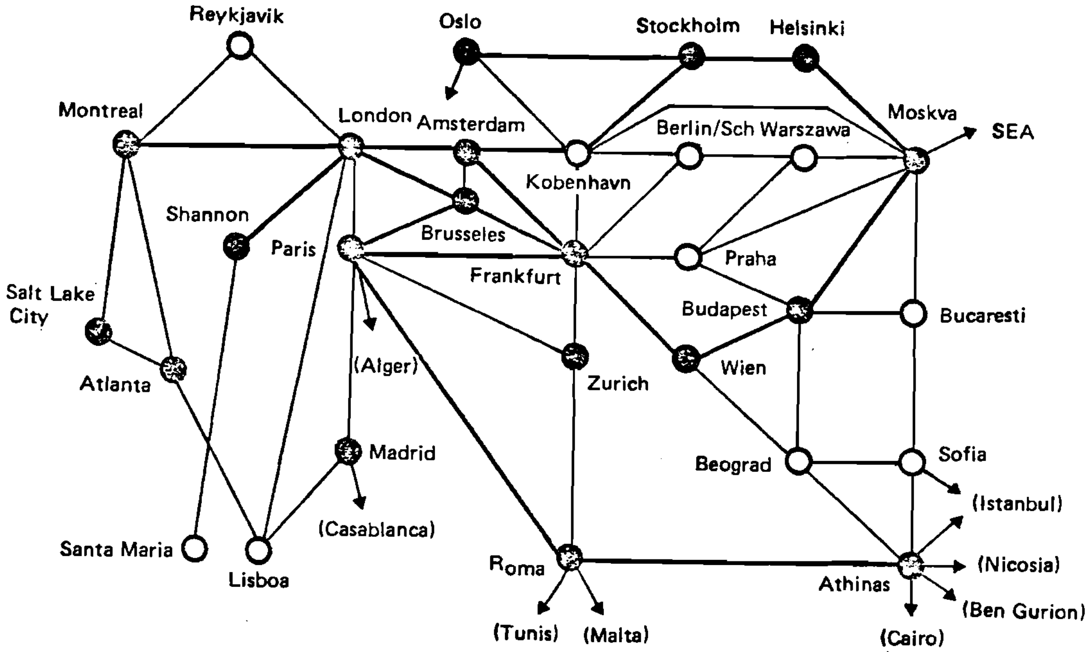

Figure 2. Typical example of AFTN development in the Eighties (CIDIN)

According to [3] up to the end of 1981 no concrete decision has been taken how CIDIN should actually be implemented.

It is, however, worthwhile to note that SITA, seemingly independently of AFTN, plans to introduce its AIRCOM system in 1984 to cover most aeronautical data categories anyway. In this respect we might see a convergence of these two network activities in the future.

4. CONCLUSIONS

It has been shown that data communication for aviation purposes is currently one of the most important transborder data flow applications. There are at present two networks, SITA and AFTN, which provide the telecommunication, data communication, and partly the data processing basis for such types of applications worldwide. Their importance is constantly growing and new services are continually being added. Major developments are expected in the field of digital air-ground communication services, which would provide better means for flight operations, for aircraft maintenance and engineering, and for logistics support.

With regard to transborder data flow problems the flow of aviation related information, be it for passenger reservation or for flight control, seems to be less sensitive; it is, however, not without any issues of worry. One problem, for example, is that data for passenger reservation systems crossing borders fall into the sensitive category of flow of personal information into foreign countries. Although this type of information is primarily serving "transactional" purposes, such as booking a seat for Mr. X on flight Y, or checking whether Mr. X is already a passenger of flight Y, a theoretical long term archiving of such information at the reservation computer's site or at one of the SITA switching nodes could bring major concerns in some countries with privacy legislations. A general legal problem is, for example, when reservation data (which are private data thus subject to privacy protection) have to be transferred from a country with strong privacy legislation to the reservation computer system of a carrier in another country, which is not protected that much or at all by local privacy laws. Usually, national privacy legislations or guidelines call for an equivalent privacy protection when such data is transferred, processed and stored abroad. If such regulations, however, were strictly followed then, for example, no one could fly from Sweden to the GDR by Interflug. The number of similar relations between other countries is vast.

In Hungary, for example, according to the Hungarian data regulations transmission of personal data over borders is is in principle possible, but all personal data are regarded as so-called "office secrets", which only can be transmitted over the border if crypted [4]. It is known, however, that the SITA transmission protocols do not entail cryptography of data, thus strictly speaking no single reservation request to GABRIEL could be made from any Hungarian terminal.

In other countries, such as Austria, any transmission of data from and to abroad requires export and import licenses, which would also make any booking reservation transaction impossible.

There are also other transactions of concern to many information policy making bodies, that are daily practice on SITA to everyone's greatest satisfaction. Database services containing personal data are operated in foreign countries, personal data flow between two countries is routed through a third, where the information for networking purposes is stored--and all these between countries with all possible political colors. The fact that in spite of these no-no's the whole system works to the full satisfaction of its users, and this for more than a decade, suggest that regulation of transborder data flow--if it has to be introduced--should also be approached from the different major application categories, rather than from a universal point of view.

There is, however, a tendency to drive towards a convergence and rapid change of the different application categories, which makes the regulatory process even more difficult. As we have shown the SITA network of yesterday, which carried primarily passenger bookings, air cargo and airlines information, in addition is carrying today and tomorrow, meteorological air navigation data and new types of data.

Another well known problem is that with the growing untilization of new telecommunication and information technologies we witness a growing dependence of developing nations on the developed nations. Problems of export and import embargoes and other trade restrictions are familiar in this field too.

All in all, data communication for aviation purposes is an essential field of transborder data flow applications, which could not be done without cooperation and mutual understanding between nations.

Many of the applications looked at prove that when new information and telecommunication technologies are rightly applied they do not have to kill jobs, they can also enable new services to be implemented (which could not be done otherwise) and lead to savings in energy and materials.

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