# Satellite fixed link offers higher operational availability than conventional ground links

Spain is upgrading its radar data distribution system by using satellite fixed links to connect remote radar sites to ATC units, and several other countries are also using such links as primary or sole links for radar data transmission.

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R ADAR service provided by air traffic controllers to aircraft is highly dependent on the quality and availability of the links used for transmitting the radar data from the radar sensors to the air traffic control (ATC) units concerned. Often, the ground communication lines used for these links are not designed specifically for data transmission and in many cases are of poor quality.

Data losses due to poor quality communication lines generate extra workload for the air traffic controller, reducing the maximum number of aircraft that can be controlled simultaneously, and therefore reducing ATC capacity. Data losses also create a feeling of uncertainty and a lack of confidence in the air traffic control system for both pilots and controllers.

Ground communication lines have another drawback: they can be cut easily during accidents or as a result of sabotage, cable theft, fire, flooding and other catastrophes. Line losses can cause a considerable reduction in ATC capacity and may produce dangerous situations which could affect aircraft safety. Microwave links are not so easily damaged, but are usually expensive and difficult to implement, requiring repeaters every 20 to 30 miles in order to achieve a good quality link.

In order to provide the redundancy required for radar services, two different types of data links (with different paths) between the radar sensor and the ATC unit should be continuously available. The utilization of different types of high-quality communication links provides diversity and minimizes risk of data losses.

## Radar data transmission via satellite

Satellite fixed links offer both a high level of quality and an alternative that can be used as a backup to the existing ground link in order to provide the required communications availability and reliability.

The quality of satellite fixed links is very good with an average bit error rate — for clear sky conditions — in the order of 1 to 1 billion.

The operational availability of a satellite fixed link is very high, normally much higher than the ground links in most countries. Several States (Italy, Australia, Mexico, etc.) are already using satellite fixed links as primary or sole links for radar data transmission.

#### Radar data sharing via satellite

A satellite fixed link can be used as a point-to-multipoint link. When a satellite fixed link is used to transmit radar data from a remote radar sensor to an area control centre (ACC), the sharing of radar data becomes easy and inexpensive. This avoids the costs of implementing and using radar networks which may need the addition of extra communication protocols, causing delay and adding unnecessary overhead.

Space segment providers charge only for uplinks, and therefore it costs the same (with respect to space segment charges) to send radar data to only one ACC as it does to send the same radar data to many centres. All users, of course, must be within the same satellite beam footprint.

The only extra cost needed for sharing radar data is associated with the relatively low cost (approximately U.S. \$100,000) of installing the ground earth station (receive-only) needed by the ACC for data acquisition.

Most adjacent States, being within the same satellite beam footprint, could benefit mutually by sharing radar data while increasing quality and availability through

# The Hispasat System

The Spanish multimission communications satellite system consists of two satellites (Hispasat 1A, Hispasat 1B), and a controlling earth station.

The satellites, weighing 2,150 kilograms each, have been launched using two Ariane 4 rockets and are currently located in a geostationary orbit at a height of 35,860 kilometres directly above the equator, between 30 and 31 degrees west.

Each satellite has three different payloads including the fixed service (FSS), which is the one used for radar data transmission. The FSS offers 16 operational transponders (eight per satellite) with different bandwidths. Eight of the

transponders function at 36 megahertz (MHz), two at 46 MHz, two at 54 MHz and four at 72 MHz. The effective isotropic radiated power (EIRP) is better than 50 decibels above one watt (dBw) over the national territory and some parts of Europe.

In order to meet the requirements of the fixed service, Hispasat has installed 12 channels and 12 high-power amplifiers in each satellite. This provides for a maximum of eight active channels and four backup channels.

The fixed service payload of each satellite consists of a reflector antenna subsystem (1.2 metres in diameter) fed by one waveguide horn and capable of producing two spot beams, one to illuminate the Iberian Peninsula and the other to illuminate the Canary Islands.

having an alternative connection via satellite between their radar sites and their ATC units.

Sharing radar data via satellite could contribute to optimizing the provision and use of the radar surveillance function in the European region, a stated objective of the strategy adopted in 1990 by the transport ministers of European Civil Aviation Conference (ECAC) countries.

A central flow management unit (CFMU) could benefit as well by receiving radar data in real time directly from all radar sensors in a region and using it for tactical purposes.

Currently at least one ground line is used per radar head to transmit remote control signals from an ACC. Using a single point-to-multipoint satellite link, which will be received by all radar heads, will permit the release of all ground lines used for remote control and therefore reduce costs significantly.

### Implementation programme in Spain

Spain's Airports and Air Navigation (AENA) organization, the government body responsible for airports and navigation facilities, is upgrading its radar data distribution system by using satellite fixed links to connect the remote radar sites to the ATC units in order:

• to improve the quality, reliability and flexibility of radar data transmission;

• to establish an alternative link so as to provide the required level of redundancy to guarantee continuity of radar service;

• to provide a cost-effective remote control link;

• to permit radar data sharing in an easy, flexible and low cost way; and

• to increase ATC capacity.

In the first phase of the upgrade programme now under way, two remote radar sensors located in Cancho Blanco and in Espiñeiras have been connected to Madrid ACC via the Spanish multimission commu-



nications satellite system (Hispasat). The architecture permits radar data sharing with Sevilla ACC and with any other adjacent ACC wishing to receive the data.

There are only two single channel per carrier (SCPC) uplinks transmitting at 9,600 bits per second (bps) each, one from Cancho Blanco and the other from Espiñeiras. Each channel multiplexes two user radar data channels at 2,400 bps and one link quality control channel at 2,400 bps used to monitor the bit error rate. In the SCPC technique, the transponder bandwidth is subdivided so that each baseband signal channel occupies a defined slot and has its own individual carrier.

Each ground earth station (used for transmission only) consists of the following components: 1.8-metre diameter parabolic antenna; one transmitting unit including two uplink frequency converters and two solid state amplifiers; one bit error rate control code generator; two multiplexers receiving as input the two radar data user channels (each at 2,400 bits per second) and the bit error rate control code; two modems; and a monitoring and remote control unit which controls the transmitting unit via the public switched network. The second frequency converter, amplifier, multiplexer and modem provide redundancy.

The ground earth station receiver at Madrid ACC consists of the following: a



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2.4-metre diameter parabolic antenna; two receiver units including two low noise amplifiers and two downlink frequency converters; four de-multiplexers; three modems; two bit error rate monitors; two satellite-to-ground link automatic switches; and a monitoring and remote control unit which controls the receiver unit via the public switched network. Redundancy is provided by the additional amplifier and frequency converter, two de-multiplexers and one modem.

Current ground lines will continue to be used. Radar data is transmitted simultaneously through both the primary satellite link and the backup ground link. The bit error rate of the satellite link is continously checked in real time, and in the event that the bit error rate reaches a predetermined value, a switch automatically activates the ground communication line to ensure that only radar data received via the backup link is used for air traffic control purposes. The switch automatically turns back to the satellite link once the integrity of the satellite link is restored.

Spain's PTT Telefonica, the signatory of Hispasat, has provided the equipment, the space segment at a cost of 140,000 pesetas (U.S. \$1,050) per month, and maintenance for a period of two years for a total cost of 108 million pesetas (\$812,030).

AENA is also carrying out a preliminary study on the possibility of using Hispasat to upgrade voice and data communications in the Canary Islands. The access technique to be used will probably be time division multiple access (TDMA) or demand assigned multiple access (DAMA), which will allow linkage of remote radar and very high frequency (VHF) communications sites and air traffic services (ATS) units to Las Palmas ACC in a reliable and costeffective manner.

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