Digital technology to overcome shortage of resources

The strong increase in air traffic especially in Europe with its densely populated areas has pushed radiocommunications systems in air traffic control to their full capacity. Moreover, the range from 118 MHz to 137 MHz in the VHF band allocated by the International Civil Aviation Organization (ICAO) for radiocommunications between air traffic controllers and pilots cannot be expanded due to other frequency allocations.

To overcome this shortage of frequency resources, air navigation service providers (ANSPs) are currently introducing a new service – controller pilot data link communications (CPDLC). Using CPDLC, air traffic controllers and pilots can exchange data telegrams in addition to communicating by voice. Routine messages, in particular, such as flight level releases, will in the future be communicated by means of data telegrams rather than voice transmission and displayed on the pilot’s cockpit terminal. This method saves resources, as data telegrams occupy a channel only for a fraction of the time that would be required for the same information sent as voice messages.

Data telegrams will be exchanged on a separate frequency in the aeronautical radio band. This reduces the load on the voice channels and significantly enhances safety and efficiency in air traffic control. In the past few years, data transmission methods referred to as VHF data link (VDL) were standardized for the communication of messages. Of the methods available, VDL mode 2 has become firmly established (see box on page 54).

ATC voice communication is via voice channels with a frequency spacing of 25 kHz or 8.33 kHz and uses double sideband amplitude modulation (AM-DSB). Military ATC takes place in the UHF band from 225 MHz to 400 MHz. Since there is hardly any shortage of frequency resources in this range, the introduction of digital data transmission methods has not been envisaged so far. Tactical communications already employ digital and encrypted transmission methods for data exchange.

Ready for the future in civil and military ATC

To meet future requirements, Rohde & Schwarz has developed a new generation of radios for air traffic control. The R&S®Series 4200 (FIG 1) is prepared to handle future digital transmission methods via the air interface as well as digital transmission methods on the network side. Like the renowned R&S®Series 200, radios of the R&S®Series 4200 offer extremely high reliability, while providing even better RF performance and lower operating costs owing to their thoroughly digital design. The radio equipment meets, and even surpasses, relevant standards defined in ICAO Annex 10 and ETSI 300676.
Adjustment-free modules

R&S®Series 4200 radio equipment can be configured in various ways and with various frequency ranges to yield complete radio systems for air traffic control (FIGs 2 and 3). All models of the R&S®Series 4200 come in identical housing that can be integrated into 19” system racks or into operator consoles, for example in a tower; the various models differ only with respect to the modules they use.

◆ Multichannel transmitter module (VHF or UHF version)
◆ Multichannel receiver module (VHF or UHF version)
◆ Power supply module for AC and DC operation

A transmitter, for example, consists of a transmitter module and a power supply module, a receiver contains a receiver module, and a transceiver a transmitter and a receiver and a power supply module (FIG 4). This concept greatly simplifies logistics and spare parts stock-keeping. An optional VDL processor will be available in the future.

Each module is accommodated in a separate metal cassette for optimum electromagnetic shielding. Modules can be replaced by the customer’s service personnel. There is no need to return equipment to a Rohde & Schwarz support center since no calibrations or adjustments are necessary.

Open-ended for future needs

The R&S®Series 4200 stands out for its thoroughly digital design – all essential functions are software-implemented. The advantages are obvious: It is no longer necessary to set jumpers or DIP switches to adapt the radio equipment to different system environments. No adjustments of components or modules are required either. Full calibration is

Technical features of VHF data link (VDL) modes

ICAO has approved three VDL modes for the digital transmission of voice and data. The key features of the various modes are listed in the table below.

VDL mode 2 is currently being introduced in Europe for data transmission between air traffic controller workstations and the cockpit (CPDLC). It will be binding for air traffic above flight level 285 as of 2009. It is expected that VDL mode 2 will also be adopted in other regions. The American VDL mode 3 is believed to have little chance of success. The future of VDL mode 4 is still unclear; yet mode 4 offers great potential for navigation and surveillance applications.

<table>
<thead>
<tr>
<th></th>
<th>VDL mode 2</th>
<th>VDL mode 3</th>
<th>VDL mode 4</th>
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<tbody>
<tr>
<td>Modulation</td>
<td>DBPSK</td>
<td>DBPSK</td>
<td>GFSK</td>
</tr>
<tr>
<td>Data rate</td>
<td>31.5 kbit/s</td>
<td>31.5 kbit/s</td>
<td>19.2 kbit/s</td>
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<tr>
<td>Medium access control</td>
<td>CSMA</td>
<td>TDMA</td>
<td>STDMA</td>
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<tr>
<td>Support of digital voice</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Applications</td>
<td>AOC / ATC (CPDLC)</td>
<td>ATC (voice and CPDLC)</td>
<td>no navigation and surveillance</td>
</tr>
</tbody>
</table>

Abbreviations

AOC Aeronautical operational communications
ATC Air traffic control
AVLC Aviation VHF link control
CSMA Carrier sense multiple access
DBPSK Differential 8 phase shift keying
GFSK Gaussian frequency shift keying
HDLC High-level data link control
IIC Inter-integrated circuit
ICAO International Civil Aviation Organization
OCXO Oven-controlled crystal oscillator
RS Reed-Solomon
STDMA Self-organizing time division multiple access
TCXO Temperature-compensated crystal oscillator
TDMA Time division multiple access

FIG 2 Models of the R&S® Series 4200.
**FIG 3**
Basic diagram of a communications system using multiple radio channels.

**FIG 4**
Modular architecture of the R&S®Series 4200. The figure shows an R&S®XU4200 VHF transceiver, which contains all modules.
The basic configuration of the radio equipment can be performed conveniently on a service PC connected to the USB port. All settings can be made via a straightforward graphical user interface.

The thoroughly digital design of the R&S® Series 400 makes it possible to implement customer-specific functions quickly and cost-efficiently — simply by modifying the software. Even complex changes that previously called for a hardware modification can be implemented. It will thus be possible to add, also in the future, new functions to R&S® Series 400 radio equipment, such as ones that do not yet exist or that may be needed only later during the equipment’s life.

Universal operability

Operation of R&S® Series 400 radio equipment is simple. This applies both to local control via the front panel or a PC connected to the USB interface, and remote control via the TCP/IP interface. For local control on the front panel, an LCD and a keypad are provided. All important parameters can be configured and displayed directly on the radio. Together with a headset and an antenna, it can thus also be operated as a stand-alone unit.

The R&S® ZS 4200 service and maintenance tool is available for putting R&S® Series 4200 radio equipment into operation and servicing it. Using this PC-based tool, the operator can configure the equipment, read error and event memories, and display equipment data such as the serial number or the software version. All parameters and data can be stored to the local memory and also transferred to another radio — a feature that is very helpful when a radio has to be replaced. Each radio can be assigned a name, which can be displayed. All radios in a network can thus be quickly and unambiguously identified.

Some settings can be blocked via the R&S® ZS 4200 service and maintenance tool to prevent modification of the equipment setup. For example, the operator can “freeze” the set frequency so that it cannot be varied either via the front panel or by remote control. It is also possible to disable local control completely. In this case, the radio equipment can only be operated by remote control.

Sophisticated remote control concept for nationwide networks

All R&S® Series 4200 radios are equipped with an IP interface for remote configuration and monitoring. In larger networks, the radios are assigned to a server — or several servers to provide redundancy — via which they communicate with a client. The servers and clients may be distributed nationwide, allowing the architecture of the management system to be designed to match the customer’s operational requirements. Rohde & Schwarz offers the R&S® RNMS 3000 RCMS radio network management system for remote control and monitoring of radio systems. It offers a convenient graphical user interface that informs the operator at a glance about the current status of all radios in a network.

All radios of the R&S® Series 4200 come with built-in test routines that continuously monitor compliance with nominal parameter values. Deviations from nominal are immediately signaled to the radio network management system. The radios can be parameterized as required for their intended use or operated in a test mode for carrying out maintenance.

Summary

The R&S® Series 4200 is a new generation of versatile and compact radios for air navigation service providers. Their modular architecture and thoroughly digital design make the radios future-proof and ensure low cost of operation. 

Bernhard Maier