

IMPLEMENTING VHF DATA LINK MODE 2 INCREASED CAPACITY AND SPEED OF AVIATION COMMUNICATION PROMISES BENEFITS TO AIRLINES AND CONTROLLERS



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SKYWAY readers will recall that in January 2000 the Ministers of Transport of the 38 Member States of the European Civil Aviation Conference (ECAC) approved the Air Traffic Management (ATM) Strategy for the years 2000+. This Strategy describes several avenues towards increasing ATM capacity in Europe, many of which have already been the subject of articles in *SKYWAY*. In this issue, we should like to focus on one of the key contributors towards increasing ATM capacity - the establishment of air/ground data link communications between air traffic controllers and cockpit crews. In the context of EUROCONTROL's performance-driven ATM enhancement programme (EATMP), this matter is being progressed by our Communications Unit.

Several vehicles can be used to exchange data between the cockpit and ground control - satellite communications, Mode S Secondary Surveillance Radar beams and Very High Frequency (VHF) radio. This article focuses on the latter solution and introduces you to yet another acronym, namely "VDL Mode 2", which - slightly less condensed - stands for "VHF Data Link Mode 2". The reference to "VHF" indicates that VHF radio channels with a 25 kHz channel spacing are used for the radio link. The "Mode 2" label refers to the application of the CSMA, or Carrier Sense Multiple Access, - technology which is widely used by LANs - Local Area computer Networks.

Data link applications already exist today. Airlines are using an "Aircraft Communications Addressing and Reporting System" (ACARS) to exchange company messages between their aircraft and their respective home bases. The problem is that ACARS has a low data transmission rate. VDL Mode 2 offers data rates of up to 31.5 kilobits per second, and therefore the possibility of increasing the messages between controllers and pilots.

Since 1997, EUROCONTROL has been active in the development of VDL Mode 2 with the objective of securing its implementation in the ECAC area by

the year 2002 and preparing the ground for the Agency and FAA data link programmes (respectively Petal II, followed by Link 2000+, and FAA - ADL, their Aeronautical DataLink Programme). In doing so, some outstanding crucial risks and problems were addressed at various levels - in particular at ICAO fora and with industry. The operational launch of VDL Mode 2 in fact requires the active participation of avionics and aircraft manufacturers as well as air/ground communications service providers. The airlines, the major customers, have already taken steps to order equipment.

ICAO AND INDUSTRY APPROACHES FOR VDL MODE 2

In 1997, the ICAO AMCP (Aeronautical Mobile Communications Panel) agreed on the specifications drafted for VDL Mode 2. Its design comprises a digital radio, introducing - for the first time ever in the aeronautical VHF band - a high-speed modulation scheme delivering data at the rate of 31.5 kilobits per second. Proven transmission protocol components have been selected such as the Carrier Sense Multiple Access with Collision Detection (CSMA-CD), a basic proven technology¹ that is widely used in the data communications world for channel-sharing between many users. The CSMA-CD

functions will be incorporated in the radio itself. Another reliable VDLMode 2 component is Aviation VHF Link Control, or AVLIC, an aviation-adapted version of High-level Data Link Control, which is used to exchange data between two computers without data loss or data corruption. Finally, VDL 2 contains an ISO 8208 layer (the ISO equivalent of X.25) on top of the AVLIC layer to support the Aeronautical Telecommunications Network (ATN).

In 1999, industry proposed that airlines limit the initial deployment of VDLMode 2 to the minimum, covering functions from the radio up to the AVLIC layer. This is called AOA(ACARS over AVLIC) and aims at delivering 10 to 15 times higher throughput between the as yet unchanged ACARS avionics and the ground network. With AOA, standard ACARS messages are "wrapped" in a VDL Mode 2 "frame". However, for advanced data link applications to be compliant with the ICAO FANS concept, additional ATN components will be required.

It soon became clear that there was a significant risk of delaying VDLMode 2 deployment:

- VDL 2 standards had only recently been introduced and were still subject to revisions, amendments and additional validation work.

¹ - Before sending data on the radio channel, a terminal checks that the channel is free; if necessary the transmission is postponed or repeated in the event of collisions with another user.

The bench, with a multi-mode radio running VDL 2, integrated onboard aircraft for flight-testing.

- Only a small number of products capable of supporting the standards set for VDL Mode 2 implementation were available.
 - Owing to the need to implement VHF 8.33 kHz channel spacing for voice communications, only multi-mode digital radios for aircraft (known as VHF Digital Radio, or VDR) were available on the market. Common hardware had been designed for a VDR to accommodate 8.33 kHz and 25 kHz voice communications as well as VDL Mode 2, or – subject to adequate software upgrades - future other VDL modes. Some VDRs were providing VDL Mode 2 software in prototype versions. A similar situation existed in respect of radio equipment for ground stations.
 - Surprisingly, the essential AVLC protocol layer, expected to be the easy part, was not incorporated in prototypes until 1999.
- Few trials and validation of VDL Mode 2 had taken place, either in a laboratory or in flight. Only a limited number of radio tests had been carried out successfully. No radio range tests had been performed, although such tests were essential to identify the correct density of ground stations needed to achieve an acceptable service coverage.
- The availability of VHF channels for VDL Mode 2 in the short or medium-term was a crucial factor. At the European level of ICAO (where national frequency managers cooperate in allocating aeronautical VHF channels), it was decided that the four upper VHF channels would be used for data link purposes. However, this assumed that digital

radios would have similar spectrum requirements to current analogue radios. With the increasing shortage of available aeronautical VHF channels, accurate and spectrum-efficient frequency planning became a top priority.

- Besides the issue of frequency availability, the fact that VDL Mode 2 had been engineered to share VHF channels between several communications service providers also raised new licensing and monitoring questions. Developing a policy for shared service provision appeared necessary before VDL Mode 2 operation could begin.
- Actual performance of VDL Mode 2 needed to be known at an early stage. It was designed as a simple replacement for airline operational communications, and an initial first air/ground ATN compliant sub-network. As its CSMA-CD mechanism does not allocate a dedicated bandwidth to each user, it will be necessary to confirm exactly which ATS applications are suitable for VDL Mode 2, prepare their certification and plan the channel deployment – all based on measured traffic performance.

EUROCONTROL'S VDL 2 ACTIVITIES

To help resolve the various problems identified, the EUROCONTROL Agency, and more specifically the EATMP Communications Unit, undertook a host of activities in conjunction with ICAO, the States' civil aviation authorities, airlines and industry:

Contribution to the standards drafting group

EUROCONTROL's efforts have been dedicated *inter alia* to supporting



ICAO AMCP, and EUROCAE WG 47. The latter is responsible for producing the documents used by industry to assess performance and to prepare product certification.

Critical and crucial work was required when in 1998 the ICAO AMCP was informed of cases of interference that had been detected on several frequencies adjacent to a D8PSK signal (the type of modulation used in VDL 2). The AMCP analysis reported that applying the existing frequency separation rules to VDL Mode 2 would lead to virtually unfeasible guard band requirements.

Important progress was achieved during 1999 by AMCP when the ICAO specifications on the spectrum mask (that describes the radiation of a VDL Mode 2 radio outside the allocated 25 kHz channel) were revisited.

In this, EUROCONTROL's role has been to draw the European civil avia-



IMPLEMENTING VHF DATA LINK MODE 2 (CONT'D)

tion authorities' and manufacturers' attention to (and gather support for) the one technical proposal that provided a trade-off, respecting frequency constraints while at same time avoiding any major radio redesigning.

Contribution to VDL 2 frequency planning issues

Although the spectrum mask had been improved, an accurate frequency plan for VDL Mode 2 channels could not be obtained without detailed knowledge of the interference involving VDL 2 in actual aircraft operation. This was required for aircraft in flight and for adjacent aircraft on the ground. EUROCONTROL radio experts developed a general interference measurement method which could be applied by any laboratory willing to contribute to VDL frequency planning.

With industry support, the provision and demonstration of the method to ICAO AMCP experts became the first task of the VDL Mode 2 laboratory programme launched at the EURO-

CONTROL Experimental Centre (EEC) at Brétigny, south of Paris. The EEC soon became a major contributor to the VDL Mode 2 interference testing campaign; by the end of 2000, it had tested several kinds of commercial ground and airborne equipment in order to acquire a full understanding of the frequency separation requirements.

In October 1999, a significant milestone was reached when European frequency managers granted SITA and ARINC the use of the first VDL Mode 2 channel. Jointly with EUROCONTROL, a presentation of the VDL Mode 2 concepts and channel-sharing principles was prepared. The fact that service providers, although competitors, had openly cooperated with EUROCONTROL, helped frequency managers to take an early decision securing VDL Mode 2 investments and planning.

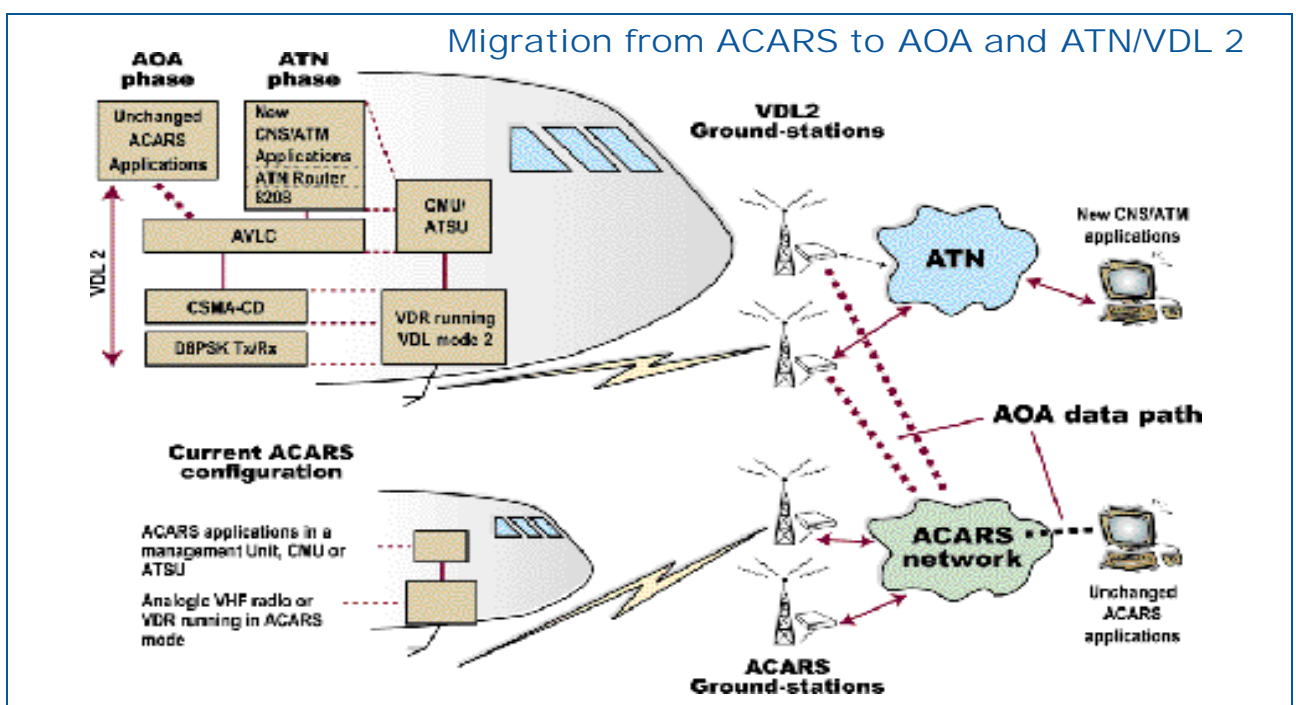
Recently, the consolidated measurements collected at the EEC have indicated that in-flight interference cases could be solved in separating a VDL 2 channel by at most 2 channels –

spaced at 25kHz - from any other VDL 2 or voice channel. Airport operation will require slightly more separation. Since only a few VDL 2 channels need to be deployed in Europe, ICAO AMCP is now expected to endorse the EEC recommendations in the summer of 2001, and VDL 2 is therefore no longer at risk as regards frequency issues.

Laboratory validation and flight tests based on first product generation

In parallel with interference measurements, additional validation work of the VDL Mode 2 standards for the physical radio and AVLC layers was undertaken in Summer 2000. This was done by using the available products and by integrating systems in a laboratory environment to verify their interoperability and global compliance with standards.

Next, with the support of the French "Service Technique de la Navigation Aérienne", a test aircraft was operated in summer 2000. In this



set-up, up-link and down-link transmissions were measured on different trajectories and altitudes; the quality of the transmission was recorded and then compared with the relevant ICAO recommendations.

Although the analysis of the results is still ongoing, first indications should give warning signals to industry and future service providers alike: at best, the VDL Mode 2 range will be the same as ACARS, and might even require a higher density of ground stations. The airborne "co-site problem" is also often discussed: this is when a VDL Mode 2 transmission interferes with, or itself experiences interference from, other systems on board the same aircraft. The integration and operation of VDL Mode 2 components in flight by the STNA has provided an opportunity to evaluate this problem at an early stage. Some interference was indeed observed between VDL Mode 2, voice and ILS signals. These were, however, triggered by extreme worst-case scenarios, used to identify the limits of VDL Mode 2. It goes without saying that this information has been shared with the major aircraft manufacturers – even though any such interference will be less severe on large commercial aircraft than on the smaller test aircraft used, owing to the greater distance between antennas.

The last crucial validation step concerns AVLC: the AVLC link layer maintains the connection between the aircraft and the ground stations overflown. There are many options, but even the basic configuration still needs to be validated through laboratory and flight trials.

Support for VDL 2 issues in Petal II extension

Since June 1998, the PETAL II project has been operating data link trials

during routine ATC operations at the Maastricht Upper Area Control Centre. The Petal II extension is planning the use of VDL Mode 2 for Aeronautical Telecommunications Network and Controller-to-Pilot Datalink Communications applications as from May 2001. The early need for VDL Mode 2 entailed specific risks for the project extension that were analysed from the earliest stage.

Coordination of "Euro VDL Mode 2" - a VDL 2 - focused project with civil aviation authorities, industry and airlines.

The Euro VDL Mode 2 project was initially launched by three civil aviation authorities and EUROCONTROL to trigger VDL 2 deployment across Europe. In the fullness of time, the project developed itself along different lines. Now, the first live operation of VDL Mode 2 on board AIRBUS aircraft is to be the subject of a technical survey: 8 to 10 aircraft from participating airlines will have their daily VDL 2 performance recorded and analysed over a 12-month period. Close support and feedback regarding VDL 2 will be provided, and possible fine-tuning may be identified for optimising VDL 2 implementation. The true capacity for supporting future data-link applications thus will be better known, and the stepwise deployment of the few VDL 2 channels in Europe will be more accurately planned.

CONCLUSIONS AND LESSONS LEARNED

■ When approaching the VDL Mode 2 launch, one would expect to have all the required components validated and proven production equipment available. While this is not yet completely the case, it is clear today that remaining risks and measures required have been iden-

tified and their timely resolution is planned.

- VDL Mode 2, especially in the initial AOA (ACARS over AVLC) phase, is an intermediate step in the development of datalink. There is no doubt that the traffic demand for ACARS-based ATS and airlines-internal applications will grow considerably as soon as VDL Mode 2 performance becomes available to a significant aircraft population. It will be important, in the medium term, to monitor traffic growth and to avoid a recurrence of the ACARS saturation problem by making optimum use of VDL Mode 2 capacity.
- The EUROCONTROL Agency can be seen as having the role of "neutral facilitator", whereby implementation of new aeronautical technologies for ATS is achieved by virtue of the common interests of Member States, civil aviation authorities, private communication service providers, manufacturers and airlines.
- Small is (also) beautiful. Each problem was addressed with the right experts in small teams. This turned out to be a most efficient and cost-effective process – and the successes obtained surely contributed towards motivation and work satisfaction of all those involved! ■

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