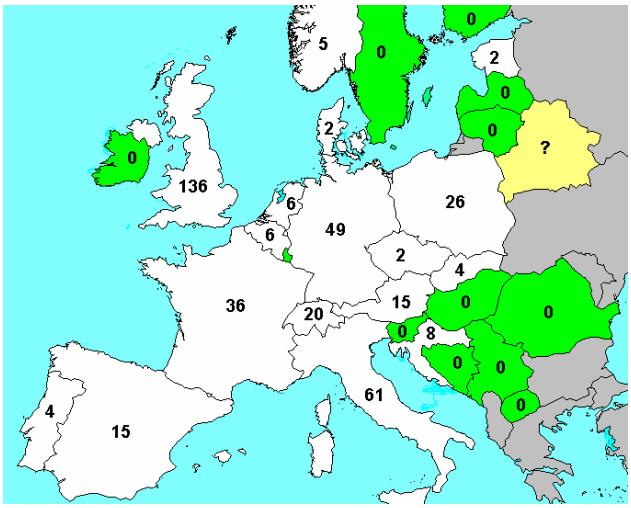
CLIMAX/8.33: To extend 8.33 kHz benefits

To face the VHF band congestion issue, European States have initiated a phased 8.33 kHz channels implementation program. However, up to now, existing CLIMAX systems (or multi-carrier [1]) still operating in 25 kHz have been kept out from such program, as CLIMAX operations over 8.33 kHz channel spacing was neither demonstrated nor standardized, thus preventing to get the maximum benefit from the 8.33 kHz system implementation. This has lead EUROCONTROL to initiate in 2004 a Study concerning the Feasibility of CLIMAX operation over VHF 8.33 kHz channel spacing.

The Study

The purpose was to study the feasibility and the benefit of CLIMAX operations over VHF 8.33 kHz channel spacing, and to provide elements for a decision to implement it in Europe. Various subjects have been processed in this study, from technical analysis to institutional issues.

There are 400 CLIMAX Systems currently operated in ECAC States to provide ATM services. The majority of them are used by Area Control Centers to ensure extended VHF coverage for Air-Ground Voice Communications. This map indicates the amount of climax systems in each country.



The Study permitted to evaluate the spectrum benefit that could be achieved by using CLIMAX operation on VHF 8.33 kHz channel spacing. Such quantification was represented by the number of extra assignments that could be converted from VHF 25 kHz to 8.33 kHz, while keeping the CLIMAX operations. Focusing above FL195 over the ECAC region core area, the analysis has identified:

- 22 two-leg CLIMAX systems candidates to operate in VHF 8.33 kHz channel spacing above FL195
- below FL195, 297 two-leg CLIMAX systems have the potential to be converted in 8.33 kHz channel spacing.

Compared with the non-CLIMAX 8.33 kHz conversions already achieved above FL195 (205 ACC conversions), and those possible below FL195, **CLIMAX/8.33 appears to bring an increase of 10% of additional conversions feasible all together above FL195 and a significantly more important increase of ACC conversions below FL195.**

The Study also covered a technical feasibility topic. It has consisted in studying the technical constraints and specifications for ground and airborne radios (especially the receiver bandwidth, Doppler Effect, airborne audio frequency response and ground transmitter frequency stability) in different radio configurations. Various modulation techniques, frequency offsets and multi-leg configurations have been evaluated. Finally the Study permitted to define and propose a technical solution for CLIMAX operations on

VHF 8.33 kHz channel spacing with very few impacts on the airborne receiver. The technical feasibility of the 8.33 kHz CLIMAX has been demonstrated using the following technical solution:

- Two-leg CLIMAX over VHF 8.33 kHz channel spacing system,
- DSB-AM modulation technique,
- A +/- 2.5 kHz offset.

The related impacts on avionics are then as follows:

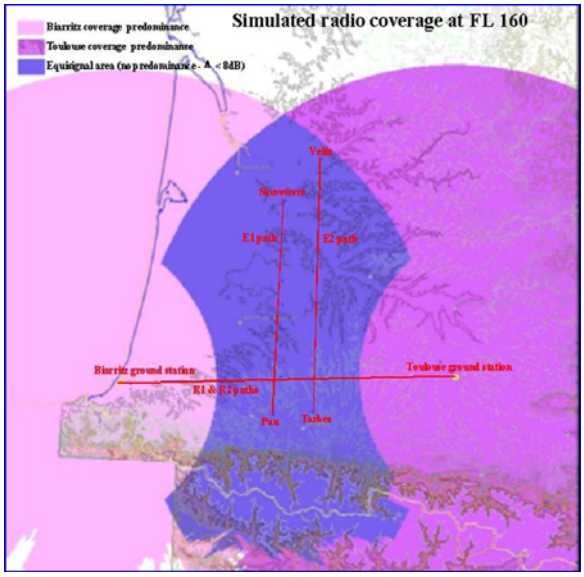
- The need for manufacturers to check compliance of the squelch function of the receivers with sensitivity level required in climax operations. This actually is an issue already required by 25 kHz CLIMAX operation. Some receivers have been identified with an insufficient sensitivity in CLIMAX operation, and specific additional tests are being added to EUROCAE and RTCA Standards.
- Improvement of audio bandwidth filter. This is not a safety requirement but an audio comfort requirement suitable for some avionics; it would be rather simple to improve on the digital radios (software upgrade) among them, and more critical for analog radios (hardware upgrade)

Flight trials

The Technical Feasibility was supported by flight trials. They have been processed in order to check the operational acceptability of the technical solution. They were supposed to clarify whether offset-carrier 8.33 kHz channel spacing operation may create or not any particular degradation compare to the one currently standardized with offset carrier operation on VHF 25 kHz channel separation.

A 2.5 kHz offset value was identified as the best compromise in term of heterodyne effects and receiver audio frequency response and has been evaluated in an operational environment to confirm the Technical Feasibility. The flight paths and scenarios have been designed to cover the worst case situation characterized by maximum Doppler Effect configurations (radial flights) and equi-signal overlapping area (cross flight at mid distance from the two ground stations). Those were respectively the horizontal and the duplicated vertical trajectories on the next map, flown within Biarritz and Toulouse ground-stations coverage.

For a comparison purpose, the same audio signal composed of a set of pre-recorded English sentences has been continuously transmitted from two ground stations on two distinct VHF frequencies corresponding respectively to a 8.33 kHz and a 25 kHz channel, both operating in offset carrier mode. The resulting signals received on board have been recorded during the flight for later analysis.



These audio records have shown that the behavior of 8.33 kHz offset carrier mode in real operation situation is globally better than the behavior quantified during measurements in laboratory. Potential issues have been identified during the trials on some airborne receivers. The issues are related to the Squelch function and Audio Comfort Quality. For some airborne radios known to be in operation in 2005 the squelch function behavior in 25 kHz CLIMAX operations did not meet the EUROCAE ED-23B and/or RTCA DO-186B standards requirements regarding receiver sensitivity in CLIMAX operations.

For 8.33 kHz CLIMAX Operation various tests have shown that a good audio filter could

significantly improve the audio quality by totally eliminating the heterodyne beat.

Next steps: Standardization and deployment preparation

As technical solutions have been approved, EUROCONTROL undertook the review of related standards. ICAO SARPS Annex10, EUROCAE ED-23B, RTCA DO186B and ETSI EN 300 676 V1.3.1 documents were identified to be updated.

The **ETSI EN 300 676 V1.3.1** document which concerns the ground radios, has been updated and approved for the One-Step-Approval Procedure by June 2006.

ICAO Annex 10 volume III document has been updated in order to introduce the requirements for offset carriers operations on VHF 8.33 kHz channel separation. The final approval has been made by the Aeronautical Communication Panel (ACP) in May 2007 with a potential applicability date of the amendment by end 2008.

EUROCAE ED-23B (in Europe) and **RTCA DO-186B** (in US) will introduce the 8.33 kHz offset carrier operation "class" of airborne radios. Requirements and associated test procedures have been reviewed to take into account the offset carrier operations over 8.33 kHz channel separation. These modifications have been submitted and new versions of these documents are pending revisions and adoptions by respective RTCA and EUROCAE Working Groups. EUROCAE has planned to start this work in November 2007. One may expect completion around mid-2008, to be confirmed when work will be started.

EUROCONTROL intends to organize at the occasion of RTCA and EUROCAE process a consultation of avionics manufacturers.

The purpose is to evaluate the population of radios to be retrofitted, due to previously identified potential squelch issue remaining or audio filter performance aspects, the affected radio types and aircraft segments. The outcome will be the possibility to develop a realistic schedule for deployment.
It is currently believed that those potential retrofits will not be an obstacle for CLIMAX/8.33 operation possibly at the same time as 8.33 kHz implementation below FL195.

Conclusion

CLIMAX operation in 8.33 kHz channel spacing is important to the completion of 8.33 kHz deployment. It can bring an increase of 10% conversions above FL195 and be much more important below FL195. In co-operation with Standards Bodies and Industry, EUROCONTROL is finalising the last steps of the 8.33 kHz CLIMAX preparation in view of its deployment.

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[1] Climax or Multi-carrier systems are sometimes used for redundancy reasons, but mainly for large geographical ATC sectors or sectors with difficult propagation due to relief or mountains. In such cases, the VHF coverage for air-ground communications cannot be met with a single ground transmitter. For ground-to-air transmissions, several legs (actually 2 to 5 at maximum) meaning several ground transmitters are used simultaneously. Each leg transmits a signal within the same 25 kHz channel with a specific slight carrier offset. Those offsets are standardized in ICAO documents, and fall within receiver bandwidth while the first order heterodyne products are outside receiver pass-band.