In-Flight Performance Analysis of a Wideband Radio Using SDR for Avionic Applications

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Along with the development of aviation industry, there has been a rising demand for In-Flight Entertainment and Connectivity (IFEC) services. In the era of Industry 4.0, establishing and maintaining a 24/7 connectivity has become the essential need and crucial requirement not only for the private jets, but also for the economy class of commercial flights. Nevertheless, the implementation of this system has to face severe challenges, naming just a few, the Size, Weight, Power, and Cost (SWaP-C) constraints of modern avionics, the Integrated Modular Avionics (IMA) architecture compatibility, and the spectrum efficiency.

Along with the development of digital signal processing/processor, Software Defined Avionics Radio (SDAR), or Software Defined Radio (SDR) in general, has become one of the best candidates to overcome the above-mentioned problems. On the one hand, by shifting most of the workload to the digital domain, SDAR brings the power and capability of the digital signal processing into avionics, offering the possibility of improving the performance of the avionics architecture. On the other hand, the software-based approach of the SDAR can be compatible with a multi-mode and reconfigurable avionic architecture, hence reducing the redundancy and enhancing the efficiency of the RF front-end footprint. In addition, the SDAR can be developed and integrated with an IMA-compatible fashion. Hence, SDAR architecture is adaptable to the standards and the requirements of the current avionics systems.

Within the scope of the AVIO-505 CRIAQ project (Consortium for Research and Innovation in Aerospace in Québec) at LASSENA, the implementation of a highly integrated SDAR for the next generation of RF avionics architecture has been studied and developed (the Multi-Mode SDAR, MM-SDAR), focusing on the most critical Communication, Navigation, and Surveillance applications. Among the developed and integrated Software Defined Avionics Module (SDAM), the SDR Wideband Radio (WBR) is the module aiming at the IFEC purposes, as well as the future use for Satellite Communication (SatCom). In order to maintain the optimized performance adapted to the complex conditions of in-flight environment, the fundamental of this WBR is the Adaptive Coding and Modulation (ACM) mechanism, granting this module the ability of changing the coding (Reed-Solomon (255, 191) / (255, 223)) and the modulations (M-ary Phase Shift Keying, Quadrature Amplitude Modulation) based on the transmission channel quality metrics such as the Signal-to-Noise-Ratio (SNR) and the bit rate of the channel. From the last five years, different aspects of this module, including the theory and the proposed ACM algorithm have been published, and positive feedback has been obtained.

From June 2017, along with other SDAM in the MM-SDAR, this WBR module has been flight-tested on a Cessna 172. The operation of the WBR, in particular, the ACM mechanism, was verified, and different metrics related to this module have been measured. Besides the conventional features such as the SNR vs. BER (Bit Error Rate) relation, the maximum distance, the throughput,

etc., in order to simulate as closely as possible an IFEC service, the WBR was also tested with real-time video streaming mode.

This paper will focus on analyzing the performance of the Software Defined WBR module with the experimentations in a controlled environment (laboratory test) and the flight tests. For a starter, a general description of the ACM and the implemented architecture will be discussed. After that, the performance of the WBR with and without the live streaming video in the laboratory tests will be presented, concentrating on the operation of the developed ACM and the quality of the streaming. Then, this paper will continue with the most important section, i.e. the flight scenarios and the behavior of the WBR during these flights. Finally, based on these analyses, the paper will come up with the discussion of the role of the ACM in the future of airborne network communication (with Cognitive Software Defined Wideband Radio proposed by AVIO-505 as an example), as well as the potential of the WBR module in the MM-SDAR for the future IFEC and SatCom services.

Keywords: SDR, SDAR, WBR, IFEC, SatCom, SDAM, ACM.