

WE LOOK AFTER THE EARTH BEAT

SEPT 12, 2016 | **5GHz SatCom solution for RPAS C2 Link**

ICAO FSMP/WG – Sept 6th – 14th 2016

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ThalesAlenia
A Thales / Finmeccanica Company *Space*

Since 2009, Thales has been designing a satellite solution to command and control remotely piloted air systems using the allocated AMS(R)S band at 5GHz

The resulting system is now at the verge of becoming a reality. In the frame of recent public discussions, we consider it is important to inform the ICAO FSMP of our initiative.

Introduction

Context & Concept

Studies and past activities

Spectrum Sharing in the 5GHz band

WRC-15 and FSS

Conclusions

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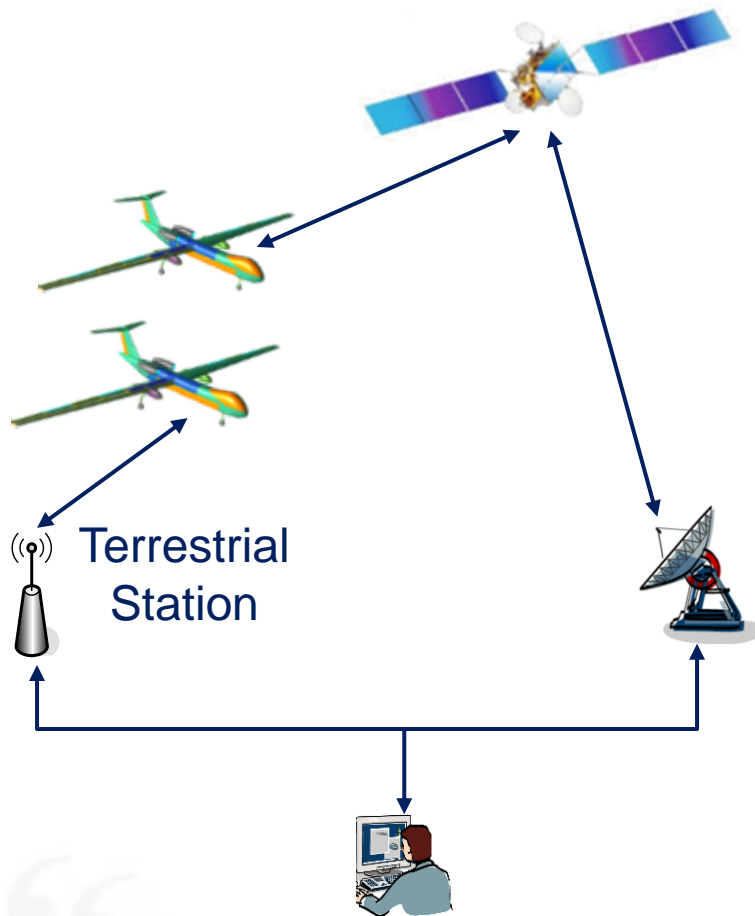
Context & Concept Overview

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- Considering the opportunity to develop new system infrastructures, TAS has been working on the 5GHz solution **since 2007** through self-funded activities or studies sponsored by the CNES (French Space Agency), ESA (European Space Agency) & European Commission, leading to a **portfolio of patents**.
- TAS, together with the French Civil Aviation authority, actively supported the use of the 5030-5091 MHz frequency band for RPAS at **WRC2012**.
- At the of end 2013 the **5GHz task force** was established within the EUROCAE **WG73** C3 group to which TAS actively participates
- RTCA SC-228 is finalizing a MOPS for a terrestrial data link on the US side.

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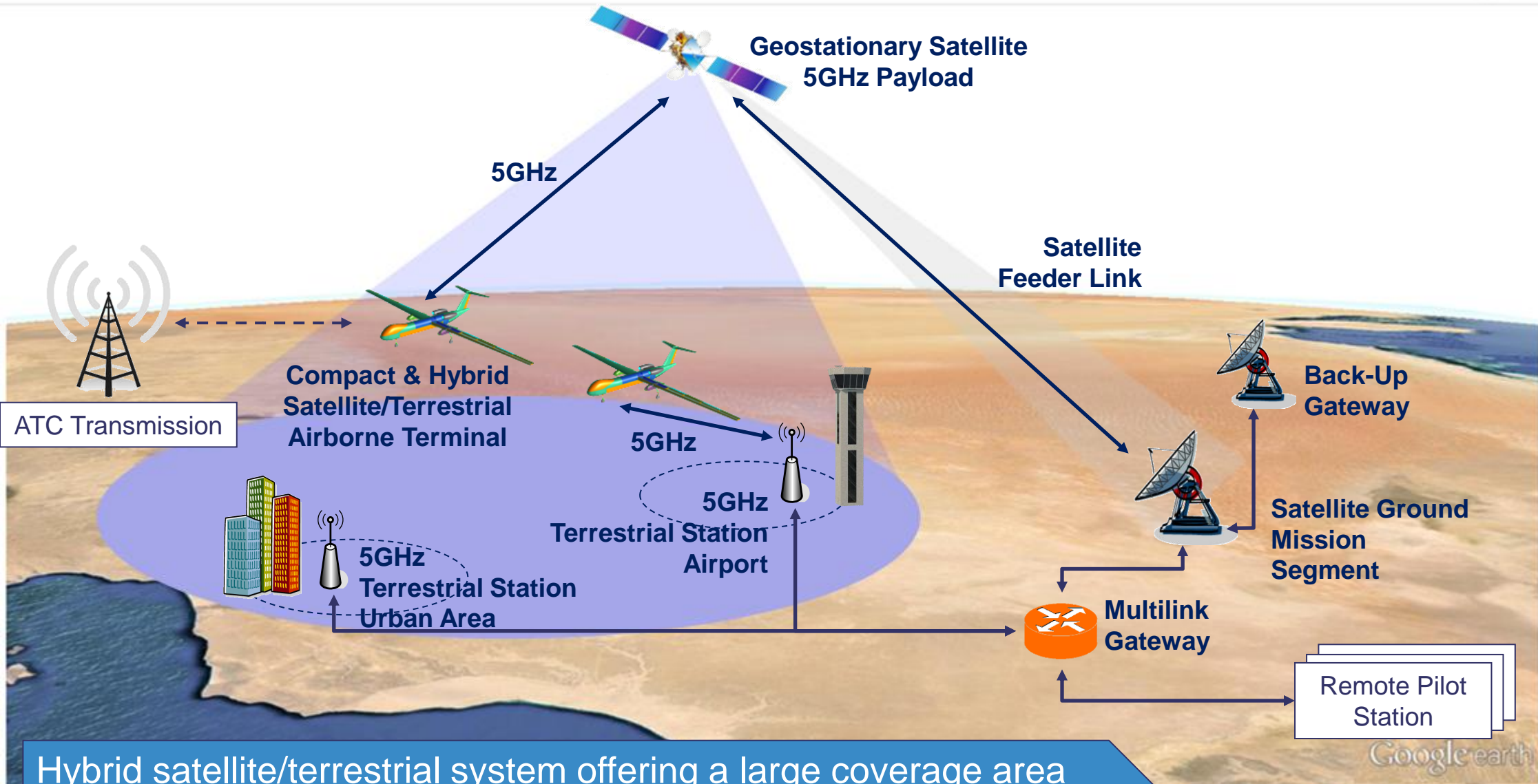
- The development of RPAS is the new challenge of aeronautics
- The insertion of RPAS cannot be achieved without safe and secure communications between the remote pilot and the drone, especially when Beyond Radio Line of Sight
- The use of the 5GHz band (5030-5091 MHz), dedicated worldwide to safety aeronautical services (AMS(R)S) is a solution for this.



A key enabler for the extension of drone operations
A promising opportunity for satellite operators & satcom service providers

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The 5GHz Solution – Architecture



Hybrid satellite/terrestrial system offering a large coverage area while ensuring very high safety performances where needed

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Studies in support of a 5GHz SatCom system for C2 link

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The 5GHz Solution – TAS Activity & overall context

A strong interest in the European agencies and industry since 2007 led to a number of public research contracts on 5GHz satcom solutions

ESA (European Space Agency)

- « ESPRIT » (5GHz C2 link in non-segregated airspace)

- « CERES » (CERTification REquirements and performance Standards”)

CNES (Centre National d’Etudes Spatiales, French Space Agency)

- « FOSTER » (Business case and value chain study)

- Multiple R&T contracts on the 5GHz system & data link studies

ANR (Agence Nationale pour la Recherche, French Science Foundation)

- « SURICATE » French study on the channel and waveform

EC (European Commission)

- « DeSIRE » and « DeSIRE2 » Demonstration of 5GHz for RLoS

- SESAR : Single European Sky for ATM Research

A number of internal, self-funded engineering studies at TAS

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The 5GHz Solution – Thales Alenia Space R&D results

4 doctorate thesis (finished or ongoing) related to a C-band C2 satcom link

- Sparse Graph-Based Coding Schemes for Continuous Phase Modulations
- Optimization of TCC decoders & their hardware implementation
- Joint Equalization & Synchronization for CPM/LDPC on 5GHz aeronautical channel
- Transport layer optimizations for CNPC traffic over satcom

Outcome of these activities have been widely published

- T. Benaddi, C. Pouillat, M.-L. Boucheret, B. Gadat, G. Lesthievant, Ensemble weight enumerators for protographs: a proof of ABU Surra's Conjecture and a Continuous Relaxation for Faster Enumeration. *IEEE International Symposium on Information Theory (ISIT), 2015*
- T. Benaddi, C. Pouillat, M.-L. Boucheret, B. Gadat, G. Lesthievant, Protograph-based LDPC convolutional codes for continuous phase modulation, *IEEE Conference on Communications (ICC), 2015*
- T. Benaddi, C. Pouillat, M.-L. Boucheret, B. Gadat, G. Lesthievant, Design of Systematic GIRA codes for CPM, *IEEE International Symposium on Turbo Codes and Iterative Information Processing (ISTC), 2014*
- T. Benaddi, C. Pouillat, M.-L. Boucheret, B. Gadat, G. Lesthievant, Design of unstructured and protograph-based LDPC coded continuous phase modulation, *IEEE International Symposium on Information Theory (ISIT), 2014*
- T. Benaddi, C. Pouillat, M.-L. Boucheret, B. Gadat, G. Lesthievant, Asymptotic Analysis and Design of LDPC codes for Laurent-based optimal and suboptimal CPM receivers, *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), 2014*

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Spectrum Sharing in 5GHz band

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The 5GHz Solution – 5030-5091 MHz frequency band sharing

See FSMP-WG03-WP10

Spectrum Sharing in C band for terrestrial and satcom C2 link for RPAS_v5

CONCLUSION

Sharing of the band can be achieved with limited operational impact



WRC-15 / FSS

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Spectrum available for C2 links development today

13

Two potential solutions for satellite C2

- *Ku/Ka-band* solution (mainly military concept) – FSS allocation
- *C-band* solution in the (5030-5091MHz) with AMS(R)S allocation



Our understanding of the current status is the following

➤ ***C-band has been allocated for UAS C2 link (satcom & terrestrial)***

- Footnote 5.367 of the ITU Radio Regulations since at least the early 90s
- MOPS for its terrestrial use is ready
- SATCOM was moved to table in the framework of WRC-12 Agenda Item 1.3

➤ ***WRC-15 opened the door to Ku/Ka band FSS – work still needed both at ICAO and ITU to determine usability***



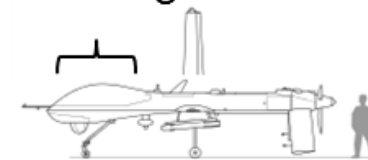
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A market likely to be segmented

Ku/Ka-bands require heavy and complex airborne equipment

- a large antenna (40-120 cm) to achieve required operation gain
 - an agile antenna to manage the satcom beam pointing (mechanically or electronically) esp. during maneuvers
 - a strong power source to mitigate rain attenuation on the satcom-UAS link
- ⇒ derived from proven military technology on heavy UAVs
- ⇒ but *costly and not fit for small, low-altitude flight*
- (25 - 500 kg, < 10 000 ft)

Ku antenna Housing



General Atomics Predator

C-band could enable simple and small size terminals

- smaller sized antenna (~ 10 cm)
 - lower rain margin requirement, better link budget at all altitudes
 - enables the use of a single equipment for terrestrial and satcom link
- ⇒ *compatible with 25-500kg UAS*



COTS C-band (ANTCOM)
5cm x 13cm x 8cm - 150g

The market will be segmented between those UAS which large size is compatible with Ku/Ka terminals and the smaller ones that will rely on simpler, lighter C-band terminals.



➤ EUROCAE WG-73 will continue work on C3 in SG3 (current ToR):

➤ Spectrum management

- OSED expected in 12/2017
- SPR, INTEROP expected by 06/2018

➤ SATCOM data-link

- MOPS expected in 09/2017

➤ RPASP will consider satellite solutions in the 5030-5091MHz frequency band in the frame of its WG-2 activities (see item 1.3.19 of the RPASP/5 report on agenda item 1 - WP/4)

➤ C Band is also considered by RTCA SC-228 SATCOM activities

TAS supports the elaboration of the relevant standards through industry groups

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- **There are two solutions for the UAS C2 satcom link :**
 - C-band
 - Ku/Ka-band

- **These two solutions are *not in competition* as they will most likely address different classes of airspace users.**

- **C-band will be hardly avoidable for smaller UAS and at low altitudes**

- **Significant level of European public investment in this domain**

- **Industrials such as TAS, and satellite operators expressed interest in a 5GHz SatCom solution for C2**

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Thank you

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