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FACT

FUTURE ALL AVIATION CNS TECHNOLOGY

This Report on AU's Business Concepts is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 894616 under European Union's Horizon 2020 research and innovation programme.

Abstract

This document analyses and compare project results and technological solutions as described in validation reports with business and operational analysis performed in previous project phases in order to assess their potential impact.

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1 Introduction

As discussed within the D4.1 and the D4.2, CNS solutions for low altitudes users need to be scalable and modular. In addition, application of performance-based CNS approach facilitates building of suitable solutions through various combinations of technological building blocks. This document presents several such promising components and demonstrate how some possible CNS solutions can be designed for specific airspace users.

Solutions are differentiated per cellular network types, showing how the solution can be adapted to specific environment.

1.1 Acronyms

AC	Aircraft
ACAS	Aircraft Collision Avoidance System
ADS-B	Automatic Dependent Surveillance-Broadcast
ATC	Air Traffic Control
ATM	Air Traffic Management
CNS	Communication, Navigation and Surveillance
DAA	Detect And Avoid
eID	Electronic Identification
FIS	Flight Information Service
GA	General Aviation
GNSS	Global Navigation Satellite System
GPWS	Ground Proximity Warning System
SAR	Search and Rescue
TCAS	Traffic Alert and Collision Avoidance System
TIS	Traffic Information Service
UAM	Urban Air Mobility
UAV	Unmanned Aircraft Vehicle
USSP	U-Space Service Provider
UTM	Unmanned Traffic Management

VLL	Very Low Level

2 Components of CNS Solution for Low Altitude Users

Following figure shows possible components considered for building different CNS solutions according to the operational requirements and environment needs/infrastructure. The list is not exhaustive and focuses on the elements discussed in the project's results and conclusions (D5.4). Additional functions that will benefit from CNS enabler such as Search And Rescue (SAR), etc can be easily added but they are not essential for provided discussion.

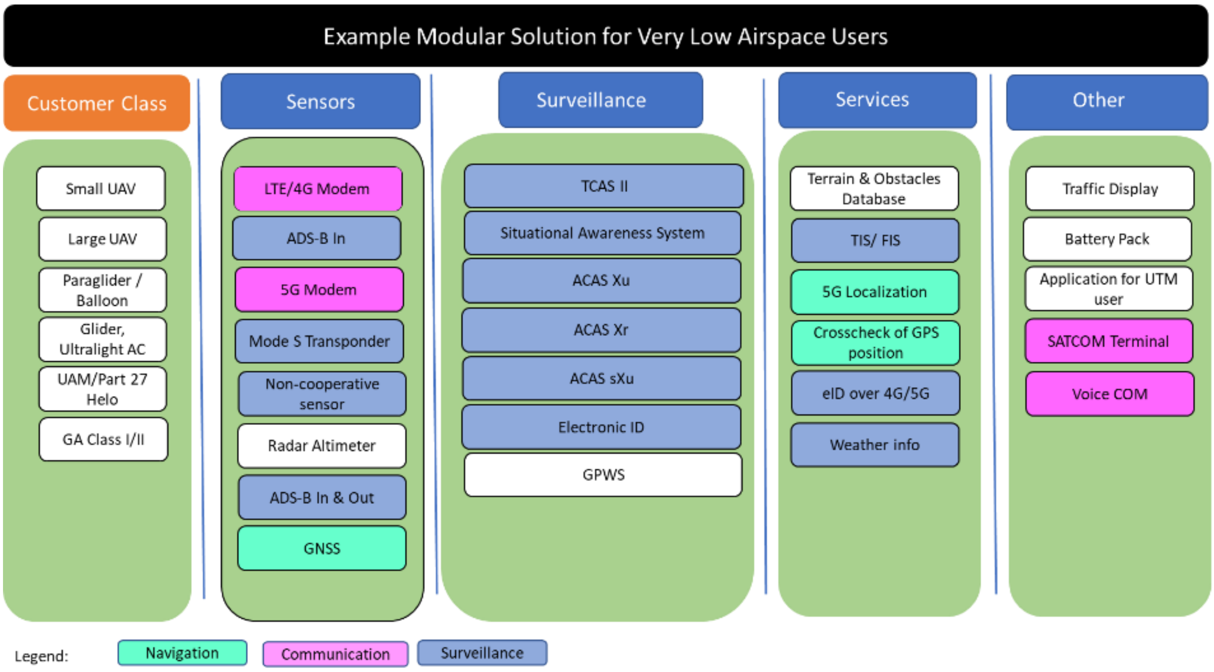

Figure 1: Example of Components for iCNS Device

Customer classes are grouped to six types – small UAV, large UAV, paraglider/balloon, glider/ultralight AC, UAM/Part 27 Helo and General Aviation Aircraft Part 23 Class I or II.

Within the document the terms VLL (Very Low Level airspace) and Low Altitude Airspace. While the first term is relatively frequently used for airspace below 500ft, the second term does not have such widely accepted meaning. For the project purposes we use the term low altitude airspace to cover operations up to 4000 ft of altitude. This altitude limit is expected to cover also future UAM operations.

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3 Solution for Use in Public LTE/4G Network

The main advantage of public LTE/4G network is wide deployment of the infrastructure. The main disadvantage is availability of connectivity especially at higher altitudes and that there is no guarantee of minimal quality of service.

The above limitations impose that for safety critical applications, support or backup by some additional technological means is required.

3.1 Paraglider / Hot Air Balloon

Suggested solution for paraglider is connectivity based on LTE/4G Modem which can serve also for receiving weather and traffic information (from U-space/ATM ground services) used for airborne situational awareness application. Affordable solution without display can be considered with alerting done only in terms of aural alerts. Battery pack is necessary.

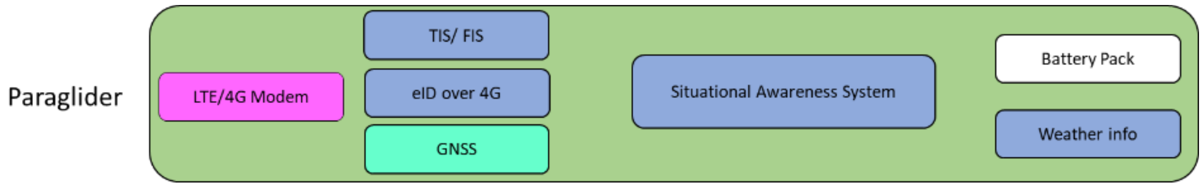

Figure 2: Example of Modular CNS Solution for Paraglider

3.2 Small UAV

Onboard CNS solution for small UAV may consist of LTE/4G modem as an enabler for U-space (UTM) services interacting with onboard Application for UTM user. Operational safety can be managed by DAA system based on ACAS sXu which uses information from ADS-B In and Traffic Information Service (TIS) for detection of other traffic and terrain/obstacles database for protection against terrain. Positioning can be based on affordable combination of GNSS with some independent navigation devices (such as inertial, barometer, etc.) to meet navigation requirements[1]. Drones will regularly report their position (eID) over LTE network.

[1] In the drawings is such hybrid positioning solution labelled as "GNSS" for simplicity.

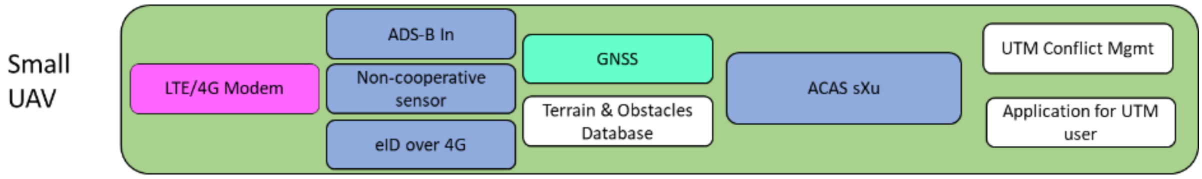

Figure 3: Example of onboard Modular CNS Solution for Small UAV

3.3 Urban Air Mobility

It is expected that UAM operations will be subject of more stringent CNS requirements, especially if air taxi use case is considered. Furthermore, they will need to operate across different types of airspace and need to be therefore compatible both with conventional ATM and U-space environment. In this context, proposed example shows CNS equipment using combination of public LTE/4G network and SATCOM to ensure higher availability and integrity of communication function. Communication function will enable interaction with U-space services. For piloted UAM operations, it is expected that at least for initial deployment, a conventional voice channel with ATC will need to be available as well. Operational safety will require protection against surrounding traffic (in particular in uncontrolled airspace) and also against terrain and obstacles (enabled at minimum by terrain and obstacles database and radar altimeter). This can be achieved through ACAS Xr system using active interrogation of other aircraft transponders, ADS-B In function, TIS information and preferably (depending on the type of operations) also through non-cooperative sensor. Navigation solution combining GNSS with other independent technologies will be needed, operations in GPS-denied environment becoming an important challenge.

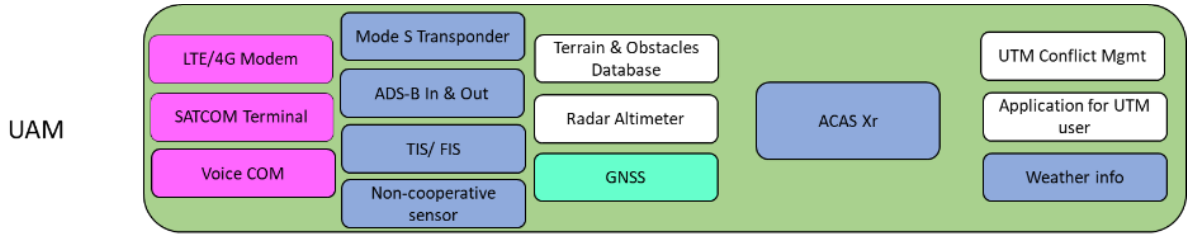

Figure 4: Example of onboard Modular CNS Solution for UAM

4 Solution for Use in Public 5G Network

Public 5G network provides some relevant advantages against the LTE/4G. 5G architecture is more flexible and enables some advanced features for signal processing like MIMO antenna setup. It also allows differentiation of services and potentially prioritize some of them to better manage quality of service for more critical applications. Possibility to use larger spectrum can further improve availability of network.

It is important to mention that some features are available only at standalone installations of 5G networks while, nowadays, great majority of 5G networks is non standalone (build on LTE core). Another limitation is that, very probably, coverage by 5G network will not be widespread. For these reasons, the most probable scenario is that use of 5G will be possible in urban areas while only LTE will be available when operating in remote/rural areas.

Business motivation of mobile network operators is still another independent parameter. Number of ground users will be always much higher than of the airborne ones. Thus, it will be important that the cellular network device will be able to operate in both network types – LTE/4G and 5G.

All the CNS solutions described in chapter 3 are applicable also for public 5G (with some performance benefits) assuming that a suitable 4G/5G modem is used. In the following we focus on the solutions where the added value of 5G will be a considerable difference.

4.1 Part 27 Rotorcraft

Following scheme shows an example of well-equipped Part 27 helicopter. It contains 5G Modem and SATCOM terminal for reliable communication. When mobile network signal is not available, communication will occur over satellite. ACAS Xr represent a possible onboard detect and avoid system with transponders active interrogation, ADS-B In, and TIS (when available) used for detecting of cooperative traffic, and terrain protection using database and radar altimeter inputs. Core navigation solution based on hybrid GNSS/inertial system can be augmented with cross-check using 5G positioning as a protection against GPS spoofing.

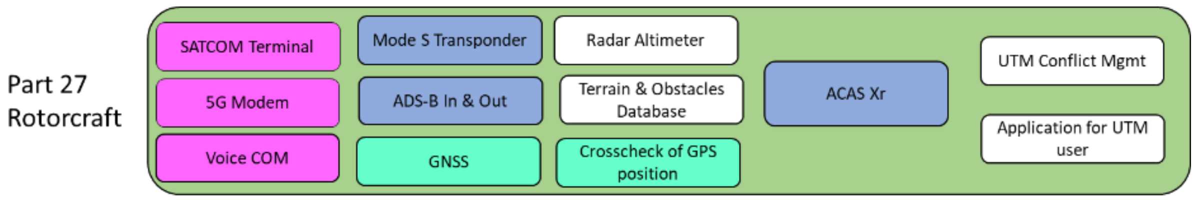

Figure 5: Example of onboard Modular CNS Solution for Part 27 Rotorcraft

4.2 Part 23 Class I/II GA Aircraft

This example shows lower class of GA aircraft. It contains 5G modem for communication (as complement to voice radio). Aircraft will broadcast own position (eID) via mobile network and receives consolidated traffic and weather data from other users through TIS (again over cellular network). In addition, ADS-B traffic is detected by onboard ADS-B In function and merged in situation awareness application with TIS data.

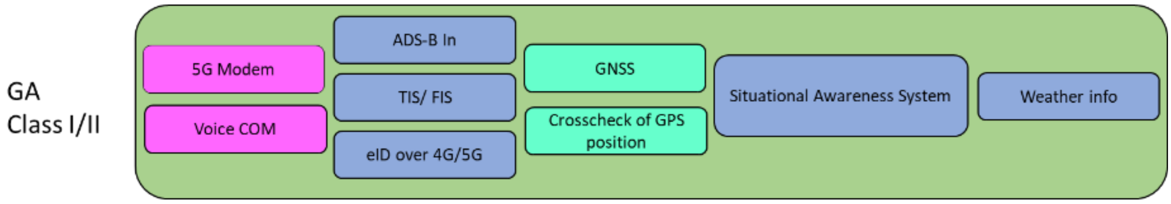

Figure 6: Example of onboard Modular CNS Solution for GA Class I/II

5 Solution for Use in Dedicated 4G/5G Network

Based on the project results (see for instance D5.4) it seems that dedicated cellular network is the only option applicable for safety critical applications. Dedicated networks can be tailored for availability in higher altitudes and can manage quality of service. It is probably the only business-viable option how to enable mobile network functions for precise navigation and how to benefit in foreseeable timeframe from advanced features of 5G standalone architecture such as ultra-low latency and high reliability.

Considering the initial investment needed to build such network, it is expected that this kind of networks will be deployed only in environment where CNS requirements are very high and meeting them through different technologies would be so expensive that the initial investment makes business sense – typical examples can be airports or city vertiports.

5.1 Urban Air Mobility

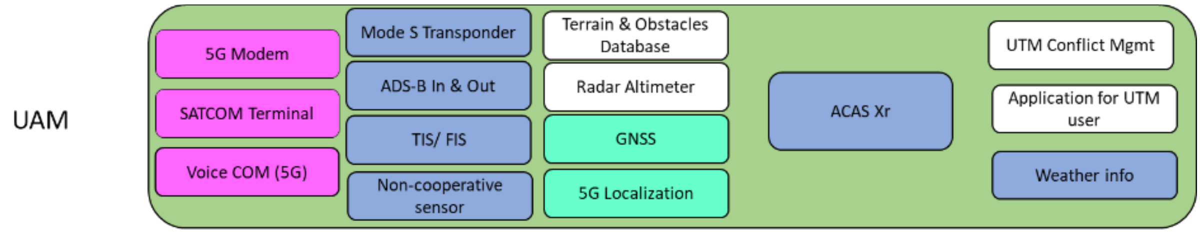

Figure 7: Example of onboard Modular CNS Solution for UAM using dedicated 5G network

Scheme in Figure 7 shows example of CNS solution for UAM. Key difference with respect to section 3.3 lies in possibility to solve GPS-denied requirements through 5G localization. While for communication still the combination of SATCOM and 5G is used, it is not expected to use SATCOM while operating in dedicated 5G network and it is considered only for other phases of flight. In addition, use of safety critical ground services (such as tactical conflict resolution) should be possible in this environment. From navigation perspective, 5G positioning represents here a second positioning system, independent on GNSS with comparable performance. Such combined navigation solution could be in the future one possible approach how to meet accuracy and integrity requirements needed for automated landing/take off even within GPS denied environment.

5.2 Large UAV/RPAS

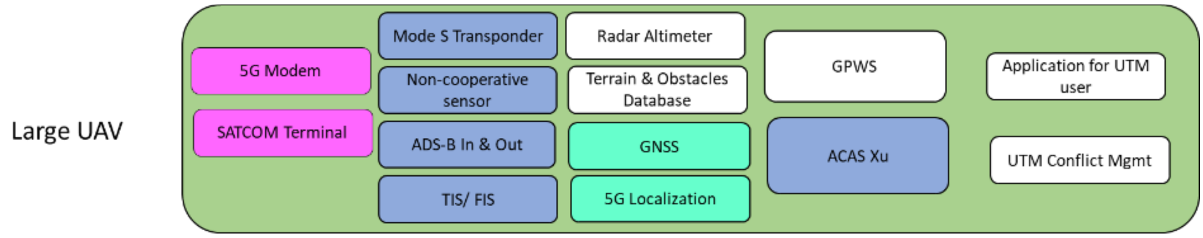

Figure 8: Example of onboard Modular CNS Solution for RPAS using dedicated 5G network

Possible CNS solution for RPAS is very similar to UAM – the main difference is the use of different type of DAA system based on ACAS Xu. This system does not provide protection against terrain, and this is why a GPWS system is included.

6 Conclusions

This document is based on previous deliverables D4.1 and D4.2 where airspace users were differentiated and their needs in area of CNS equipment analysed. In this document, simplified discussion of possible approaches to modular CNS equipment benefiting from mobile network infrastructure is provided considering different types of users and environments. In this discussion project's recommendations as documented in Validation Assessment Report (D5.4) are taken into account.

From business perspective, we can consider three possible approaches compatible with project's recommendations:

- Solution using public 4G/5G network which will be the most affordable but with known performance (mainly availability) limitations. It can be suitable solution for small UAV operating under VLL and (depending on the results of operational risk assessment) it could be potentially also enabler of increased operational performance (e.g., capacity) in the corresponding U-space. At the same time, such solution can represent an important safety enhancement for paraglide or balloons, and potentially also for ultralights/gliders.
- Solution using public 4G/5G network in combination with other communication/surveillance technology(ies) for more critical applications. This will represent already more expensive solutions but could already cover more complex operations, and drive higher operational benefits (airspace access, higher flexibility in flight planning, etc.). Typical users could be GA Class I/II, Large UAV, UAM and CS-27 Rotorcraft.
- Stand-alone solution using a dedicated 5G network is not so probable as the deployment of such networks may be only local. However, it can be a relatively affordable way how to augment lower performing CNS avionics to access also parts of airspace with high CNS requirements and potentially without any conventional aeronautical infrastructure – typical example could be vertiports for UAM, logistics hubs for large cargo UAV, access of UAV/UAM to airports, etc.

Although these conceptual ideas go beyond the extent of results obtained within the project, they aim to indicate potential directions for future work as identified within the project's activities.

7 References

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