AEOLUS FLIGHT MANAGEMENT SYSTEM – DIFFERENTIAL GPS LANDING SYSTEM: AN INSTANT-ON, TACTICAL AND PRECISION APPROACH CAPABILITY

Davide Ferraro, davide.ferraro@leonardocompany.com, Leonardo HD (Italy)
Dario Fresta, dario.fresta@leonardocompany.com, Leonardo HD (Italy)

Abstract

Since the beginning of rotorcraft era, the HEMS/SAR (Helicopter Emergency/Search and Rescue) helicopters are called out to intervene in case of medical evacuation or emergency or C-SAR (Combat SAR) thanks to their capability to safely approach and land on hospital helideck or temporary and remote helipad very close to the critical area. Unfortunately, these operations are affected by weather, since they require Visual Metrological Condition (VMC) during the final segment of the descent.

This proposal is aimed at extending the already certified *Aeolus* FMS's User Approach capability beyond the VMC, integrating a brand new Differential GPS Landing System (D-GLS), within the avionics of AW189/AW169 helicopters.

The D-GLS is based on a portable ground station comprising two GPS receivers and airborne GPS sensors capable to receive data from the ground station. It allows performing Precision approaches to a fixed or moving point, *anywhere* and in *All Weather Condition* with the same minima of ILS, LPV or GLS CAT-I approaches.

D-GLS, differently from LPV or GLS, neither requires any fixed-earth point survey for the truth reference nor to be under SBAS signal for Accuracy and Integrity. Since the only requirement is to set-up the D-GLS ground station at the landing point, it can be classified as an **"Instant-on", Tactical and Precision Landing System**.

1. INTRODUCTION

Over the past years several HEMS and SAR missions had been cancelled due to weather conditions which were below VFR limits.

Aeolus, the FMS (Flight Management System) internally developed by LHD, already features the VFR Approach function that allows automatic descent in Baro-VNAV to a user-defined landing point, with the same performance of a Non-Precision Approach, but with limited use in VMC.

The VFR User Approach, frequently used to provide a fully coupled FMS/AFSC automatic descent to hospital helideck or temporary and remote helipad, does not always comply with the accuracy required and especially DVE (Degraded Visibility Environmental) conditions typical of SAR/HEMS operations. The possibility to execute user approaches in DVE conditions can considerably improve the "All Weather Conditions" capability for HEMS and SAR/C-SAR helicopters.

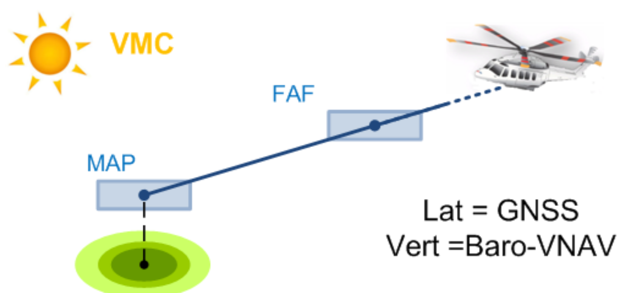

*Figure 1: during VFR approach the FMS lateral guidance is based on **linear** lateral deviation computed through the GNSS position, while on the vertical plane the FMS guidance is based on **linear** vertical deviation provided by the Baro-VNAV function.*

On the contrary, Precision Approaches such LPV or GLS CAT-I would guarantee the accuracy and integrity required in DVE conditions, but they are not suitable for most of tactical operations, because require:

- Costs to design and update a LPV/GLS procedure for SAR operator (e.g. PinS approach with LPV/LP minima at hospital helideck or SAR base helipad, etc.);

- An airport/heliport's fixed-earth point survey (near the runway/helipad) for truth reference for integrity and to precisely define the Final Approach Segment to the landing point;
- Government data (FAS) and NAV DB database update every 28 days;
- SBAS (EGNOS, WAAS, MSAS, etc.) coverage for LPV; moreover LPV/LP approach cannot be implemented beyond latitude72N and 72S;
- permanently installed ground infrastructures as "truth-reference" for GBAS differential corrections (i.e. GNSS receivers and VHF transmit antenna).

These requirements could be a significant limitation for helicopters in tactical approach operations.

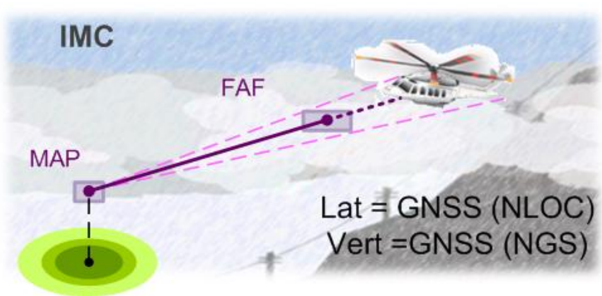

*Figure 2: figure description with D-GLS approach the FMS lateral and vertical guidance are an **angular** deviations based on GNSS on-board receivers.*

2. USER APPROACHES BEYOND VFR

The solution to the limitations of both VFR and Precision Approaches is a new type of User Approach, hereafter named D-GLS Approach, based on a Differential GPS Landing System (D-GLS), comprising a mobile ground station capable of autonomously computing and confirming its integrity [1] and an airborne GNSS receiver capable to receive data from the ground station. The use of this type of D-GLS allows extending the VFR Approach capability to IMC up to CAT I minima accuracy and integrity requirements anywhere and at any time.

The D-GLS Approach function, joint with other avionic systems such the Head-down CVS (Combined Vision System), Head-up EFVS (Enhanced Flight Vision System), FIPS (Full Ice Protection System) and Advanced Obstacle Warning System, will considerably increase the "All Weather Conditions" capability of HEMS and SAR/C-SAR helicopters. It means that critical operations, such as medical evacuation, rescue operations, C-SAR evacuation, military approach in remote area, etc. can be conducted safer and easier.

The aim of this paper is to present the D-GLS Approach as a new function of the *Aeolus* FMS, integrated within the avionics of LHD helicopters.

3. D-GLS CONCEPT

The D-GLS is based on the Differential GPS positioning concept and the new CMC (Esterline – CMC Electronics) patented Integrity computation [1], plus the capability of the GNSS aboard to receive through an integrated VDB receiver, via VHF link (1-way ground to air), the local corrections that mimics a LAAS (Local Area Augmentation System). These guarantee the accuracy and integrity necessary to perform an approach down to a pseudo MAP waypoint with CAT I minima (200 ft), with anywhere availability, without the need of any ground/space infrastructure used in ILS/LPV/GLS approach.

Omitting the math details about differential GPS [2], [3], the key of D-GLS system is to have two GPS independent receivers in the ground station and at least one airborne GPS all forced to operate in "Common Mode". It means that they use the same satellites, so all position errors are correlated (common mode errors) and become zero when relative position is computed, leading to high accuracy. Moreover, the integrity computed and confirmed by the ground station assures that it is correctly functioning and is capable of providing the "truth data" via the DVB transmitter to the airborne receiver. Therefore, the accuracy and integrity required by CAT I precision approaches is achieved.

The D-GLS integrity is based on the positioning of the two GPS of the ground station at a known fixed distance. Both GPS receivers of ground station:

- Track the same satellites;
- Take satellite measurements (pseudo range and delta range) at approximately the same time;
- Use the same satellites in their positioning solutions.

Therefore, the difference between the computed positions will be the known distance between the

GPS antenna positions plus non-common noise/error.

The D-GLS ground station integrity is computed by comparison of the distance between positioning solution of the two GPS antennas with the known distance between antennas.

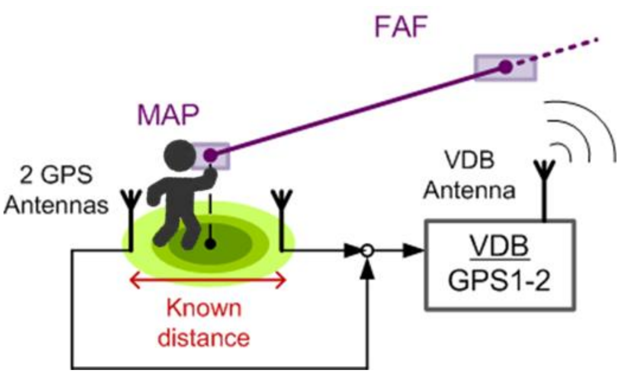

Figure 3: D-GLS base station basic architecture. The separation between the two antennas is precisely known and it used for Integrity computation. The Integrity is not affected by base station movement.

4. D-GLS APPROACH OPERATION

The D-GLS Approach mixes the flexibility of a User Approach definable anywhere with the operability of a standard GLS Approach designed on an airport area.

The D-GLS mobile ground station requires a fast set-up at the target point. It comprises at least two GPS antennas and receivers, one VDB transmitter and a computer. The two GPS antennas must be placed on the landing field at a known distance. Once installed the ground station, the D-GLS approach must be defined, through the ground station computer, in terms of approach course, glide slope aims at guaranteeing the obstacle clearance for the final approach segment. The ground system is so ready to transmit the approach data.

The avionics on-board, used for D-GLS Approach, is based upon an integrated dual Flight Management System (FMS) composed by dual MCDUs (Multipurpose Control Display Unit) or EDCU touch screen equipment as FMS-pilot interface for the approach settings and activation, a dual duplex 4-axis autopilot, dual TSO GNSS SBAS/GBAS receivers integrating a VDB receiver and glass cockpit with 8" x 10" wide screen displays as PFD (Primary Flight Display) and MFD (Multi-Function Display).

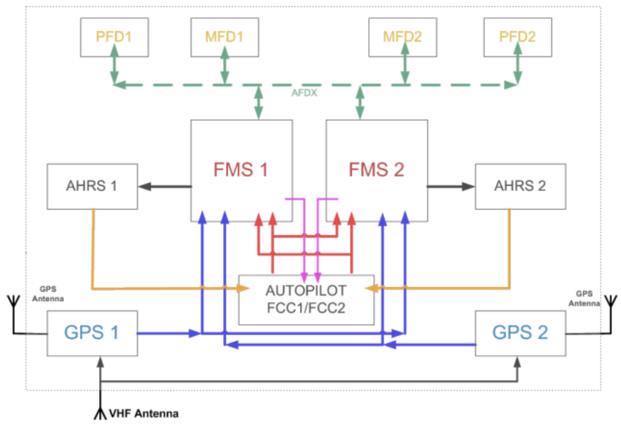

Figure 4: High-Level AW189/AW169 redundant Avionic System Architecture interface with D-GLS system (dual FMS, GNSS receivers with VDB module included and VHF antenna)

The *Aeolus* FMS allows inserting the D-GLS approach in the active flight plan, by selecting a target waypoint that should be located in the proximity of the landing field. The only datum required to activate the approach is the Channel ID of the ground station already known or provided via radio by the ground operation.

Figure 5: MCDU proposal layout for customaized precision approach: CH ID number only data required for autotunig of approach.

The Channel ID, set by the pilot through the MCDU/EDCU D-GLS Approach page, allows the FMS to correctly tune the VDB receiver inside both GNSS receivers; the Channel ID numbers used for these approaches will be out of the range reserved for LPV/GLS but inside the VDB spectrum reserved for GPS precision approach and used for aviation approach safety-of-life. Moreover, in order to provide the pilot with a complete "ILS-like" approach, the FMS allows defining a customized missed approach procedure (ref. to <MISS APP> in the Figure 5) to be used in case of Go-Around, as available for the VFR User Approach.

Once the D-GLS Approach is activated through the MCDU/EDCU page, the VDB is automatically tuned by the FMS. When the helicopter reaches a range distance to the base station around 10NM, the FMS receives the D-GLS approach data (course, glide path angle, offset, etc.) from the ground station. At this point the Avionics show on PFD/MFD the whole procedure providing a visual reference path for the pilot and the guidance data as for an "ILS-like" approach, allowing an easy and safe intercept of the final approach segment (ref. to figures 5 and 6).

In addition the FMS provides the pseudo LOC/GS deviations and longitudinal deceleration control to the Auto Pilot for a 4D fully coupled descent down to MAPt (Missed Approach Point).

Figure 5: AW189 glass cockpit with lateral/vertical angular deviations in final segment – image for reference only.

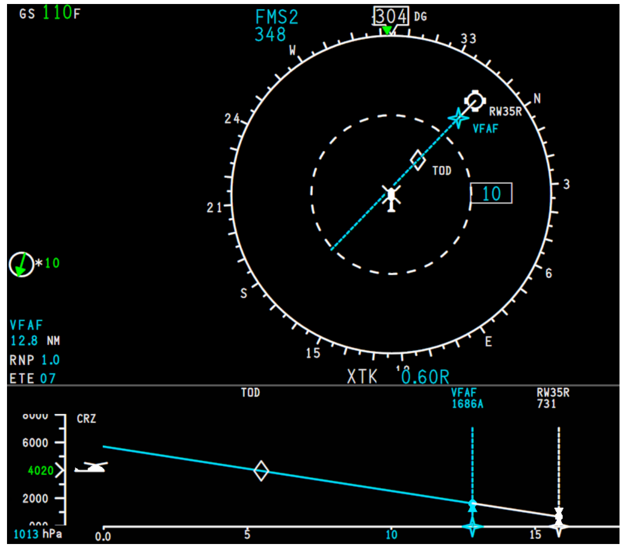

Figure 6: MFD presentation of the final approach segment lateral and vertical profile – image for reference only.

5. CONCLUSIONS

In conclusion, the authors believe that key aspects of future D-GLS Approach capability (Tactical – Instant-On – Precision), can be summarized by the following recap list:

- it's a key enabler for copter precision "tactical" approach operations;
- it improves the **safety** for the crew below the VFR limits during access to remote/critical helipad/helideck in DVE or adverse weather conditions or at night;
- it is crucial for saving lives in case of SAR/HEMS operations on helideck or not prepared helipad close to disaster area.

About the cost effectiveness it provides a high precision solution for small and private airport without any precision runway procedures. Moreover, the D-GLS Approach will have a positive impact on the environmental side, because it avoids the risk of multiple approach attempts with marginal VFR minimum condition, so reducing fuel consumption and pollution.

Regarding the possible applications this new type of User Approach has a wide spectrum of uses:

- SAR/HEMS applications for approaching to temporary helipad in remote area for MEDEVAC **anytime and anywhere**;
- Civil applications as alternative Oil Rig approach for offshore or small airport/heliport
- Military applications for approaching to military basecamp and ship deck (approach usable on moving deck also).

The D-GLS Approach function can be easily managed as optional kit, with limited installation impact and few involved components, broadening company's "*kit-portfolio*".

6. REFERENCES

[1] US20110231038 A1 – Aircraft landing system using relative GNSS

[2] Kaplan, Hegarty – Understanding GPS Principles and Applications, Editors, Second Edition

[3] Betz – Engineering Satellite-Based Navigation and Timing, Wiley

7. ABOUT THE AUTHORS

***Dario Fresta** – is a FMS (Flight Management System) and Navigation Database Specialist at Leonardo Helicopters since 2012. Before joining Leonardo, he got experience in vehicle's autonomous guidance systems. He received M.Sc. degree in Automation Engineering at "Politecnico di Milano".*

***Davide Ferraro** – is AW149/AW189&AW169 Avionic Principal System Engineer and GPS&FMS (Flight Management System) Specialist at Leonardo Helicopters since 2008. He received M.Sc. degree in Telecommunication Engineering at "Politecnico di Milano" University where he has been involved for 4 years as research assistant at DEI (Department of Electronics and Information) department in Antennas & Space RF Propagation.*