The versatility of helicopters as technology demonstrators for future operational capabilities and aerospace research

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Scope

To show how multiple aerospace research programs were developed using rotary wing assets by an integration, clearance and qualification process performed by RSV.

- The focus of this presentation is the versatility of the RW assets as technology demonstrators for future operational capabilities and aerospace research;
- All flight test activities were performed by helicopters in a prototype configuration.
Agenda

• Aerospace research programs accomplished:
  – *Directed Infrared CounterMeasures (DIRCM) development & Qualification*;
  – *Radar Altimeter probe development & qualification for space application (EXO MARS)*;
• Demostration & Development process (Methodology);
• Results & Way-Forward for future capabilities implementation;
• Conclusions.
Directed Infrared CounterMeasures
- DIRCM -
Objective:

To support the National Industry in the development, integration and qualification of a Directional InfraRed CounterMeasures System for FW and RW assets, in order to:

• Determine an integration process on C-130J, C-27J and HH-101 CSAR;
• Verify system functionality and capability to increase the operational utility of the system;
• Verify the jamming code effectiveness.
DIRCM – Test item description

DIRCM ELT 572:

• system designed to jamm MANPADS IR threats up to 3rd generation, as per actual international standard;

• the system works together with a MWS, from which it receives the spatial coordinates of the missile.
DIRCM – System Integration

Test configuration:

• due to the versatility and peculiarity (flight profile, test condition and configuration flexibility) the HH-212A helicopter was selected as technology demonstrator;

• H/C configuration:
  • double external turrets and MWS;
  • internal avionic rack;
  • circuit breaker on CP.
DIRCM – Integration

The integration and qualification process included the following steps:

- design, development and production of a dedicate support structure for the system and the control unit, able to be installed on the HH-212A helicopter;
- crash worthiness requirements demonstration (MIL-STD-8865B);
- Ansys Release 15.0.7 – FEM analysis.
DIRCM – System Integration

- Dynamic modal analysis for resonance phenomena – RAP test:

Analysis as per MIL-STD-810G:
- Reticular structure;
- Excitation in all the frequency mask;
- Answer in frequency;
- Modal deformation;
- Natural frequencies determination;
- Ensure no dynamic coupling was in act.
DIRCM – System Integration

• Electrical load analysis;

• EMC testing: intra-system;

• Electromagnetic environmental testing (safety margin of 16dB in terms of susceptibility) – as per MIL-STD-464A.
DIRCM – validation & qualification

• **Lab test** in order to demonstrate the system functionality;

• Development of NATO jamming code to be tested;

• **Ground test:**
  – IR measurement for laser source;
  – Demonstration of the effectiveness against *Surface to Air Missile* (SAM) threats.
DIRCM – validation & qualification

- Flight test:
  - IR measurement for laser source;
  - Demonstration of the effectiveness against *Surface to Air Missile* (SAM) threats;
  - Demonstration of absence of degradation of performance due to the vibrations introduced by the helicopter as demonstrator;
  - Tracking, time reaction and optical break lock (OBL) assessment.
DIRCM – Results

• An effectiveness evaluation was positively performed as well as a sensor characterization;

• Additionally a performance comparison with the conventional IR countermeasure system was assessed, by evaluating the OBL time;

• The system was assessed “mature” to be tested on fixed wing aircraft (Embow 2015 C-27J).
DIRCM – Results

• The effectiveness of the jamming capabilities against SAM threat was satisfactory;

• New test trials against threats of 4th generation were planned on the base of the helicopter test results.
DIRCM—Why helicopter as TD

• Due to the flight profile required for the system capacity demonstration the H/C was the only asset able to perform a build-up approach from 0 to 80 kts GS required for the performance evaluation;

• H/C allow to perform all the test required in a controlled area (ATZ PdM) – logistics and safety reason (laser beam, loss of objects in flight);
DIRCM—Why helicopter as TD

• Time around with H/C was really short – quick setting/configuration modification/change;

• Ability to hold a specific test condition (speed and altitude) for a long time in a given spatial position;

• Costs.
Qualification of the radar altimeter for Space exploration (2018)
- EXO MARS –
Thales Alenia Airspace (TAS-I) & European Space Agency (ESA)
EXO MARS

General Objective:

To support TAS-I into the qualification process (by following ESA requirements) of the radar altimeter of the probe that will be launched in 2018, for Mars exploration
EXO MARS – Test Item

- RDA is a 40cm radius disck on which were installed 4 antennas that realized a vertical scan with a cone angle of 120deg;
- RDA was controlled by a rack unit installed inside the test H/C.
EXO MARS – System Integration

Because of the type of aero-mechanical integration required and the flight profile to be demonstrated, RSV selected the HH-212A as the best platform on which to develop the program:

The Integration was designed by TAS-I and qualified by RSV
EXO MARS – System Integration
EXO MARS – System Integration

The purpose of qualification was to evaluate the RDA installation on the HH-212A helicopter from a safety, aircraft performance and flying qualities point of view:

– **Static Structural Analysis** – performed by TAS-I and verified by RSV (SW Ansys rel.15.0.7);

– **Ground fitting**: ground clearance and skids deformation assessment;

– **Ground vibration test** – dynamic modal analysis – RAP test;
EXO MARS – System Integration

cont’d

– **H/C performance and flying qualities testing** – controllability shake-down – envelope start;

– **Electromagnetic compatibility** (EMC) testing – Intra-system testing and safety margin determination, as per MIL-STD-464A.
EXO MARS – System Integration - RAP test

MIL-STD-810G: environmental engineering considerations and laboratory tests:

- capability to verify the absence of the dynamic coupling between the natural frequencies of the RDA installation (and the avionic rack) and the dynamic forces induced by the rotating systems on the test H/C (vibs) - Resonance.

<table>
<thead>
<tr>
<th>Blade Passage frequency</th>
<th>5.4 Hz</th>
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<tbody>
<tr>
<td>1st A</td>
<td>10.8 Hz</td>
</tr>
<tr>
<td>2nd</td>
<td>21.6 Hz</td>
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<tr>
<td>3rd</td>
<td>32.4 Hz</td>
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</table>
EXO MARS – Integration - RAP test

Vibs Mode | Frequency (Hz) | coupling, ±5% di $f_n$
--- | --- | ---
1 | 45.1 | NO
2 | 48.2 | NO
3 | 52.0 | NO
EXO MARS – Test Set-Up & Flight Conditions

• Test flight trial was focused on collecting data required from TASI -ESA in order to characterize radar functional characteristics;

• 14 Flight Hours were executed (4 per integration, 10 per data gathering);

• Test condition:
  • Hovering OGE up to 3500ft AMSL;
  • Vertical climb @ MCP and TOP;
  • Autorotation (almost vertical);
  • Quick stop - Low speed – forward flight.
EXO MARS – Results

- Each specific objective was achieved with safety and satisfactory results;
- RDA functionality and resolution were demonstrated positively;
- EXO MARS program successfully jumped on the next step.
EXO MARS – why helicopter as TD

• A RW asset was the only aircraft able to perform the vertical speed required to qualify the system, by following ESA requirements;

• Ability to hold a specific test condition (0kts GS and altitude) for long time in a given spatial position;

• Because of the short time frame given for the aero-mechanical integration, and the related structural verification, a RW asset was the only aircraft to install a prototype probe;
EXO MARS – why helicopter as TD

• H/C allowed to perform all the test required in a controlled area (ATZ PdM and Guidonia) – logistics and safety reason;

• Time around with H/C was really short – quick setting/configuration modification/change.
Conclusions (1/3)

Helicopter versatility:

• The configuration of the HH-212 has been modified for multiple purposes;
• Cost efficient and quick solution for urgent requirements;
• Confined “footprint” reducing the effort to coordinate airspace and reduce to the minimum the risk of “collateral” damage;
Conclusions (2/3)

By applying an overall development, integration & qualification process throughout:

• **installation design & production**;

• **aero-mechanical verification & qualification (static & dynamic analysis)**;

• **EMC compatibility assurance**;

• **Performance (system and H/C) flight testing**;
Conclusions (3/3)

RSV was able to operate an RW asset, in prototype configuration, in order to support the international aerospace research process for future operational capabilities development.