SHIP/HELICOPTER QUALIFICATION TESTING FOR A NON-NAVAL HELICOPTER

Maj. Stefano RAGAGLINI (stefano.ragaglini@am.difesa.it)
Capt. Antonio CIOTOLA (antonio.ciotola@am.difesa.it)
Italian Air Force - Reparto Sperimentale Volo (Italy)

Summary

In 2015, for the first time, the Reparto Sperimentale Volo (RSV - Italian official flight test center) has been asked to conduct a limited scope evaluation of a land-based attack helicopter, the Leonardo A129D, for shipboard operations. Requirements from Italian armed forces imposed to reach this capability without the introduction of any modification to both the helicopter and the ships and relying to a limited instrumentation package. A short description of the qualification process used and of performance requirements considered is presented. Then, after an assessment of helicopter characteristics that could affect shipboard operation, a description of the test method used is provided. Structures, helicopter-ship dynamic interference, electromagnetic compatibility and operational tests and evaluations performed are finally presented. Key factors in reducing flight hours dedicated to ship operations where the use of STANAG 1380 Ed. 5 to limit EMC, HERO and HIRF testing and the adoption of a build-up approach in dynamic interference testing. Land based critical azimuth testing was performed at the target referred weight to define a reasonable Candidate Flight Envelope that has been then validated during. This paper in intended to provide to flight test engineers and program managers guidelines about the test method used by RSV to achieve the operational need expressed by Italian armed forces in the shortest, safest and more efficient way as possible

1. SYMBOLS AND ABBREVIATIONS

°	Degree (temperature)
AFCS	Automatic Flight Control System
ATS	Airborne Tactical Server
CFE	Candidate Flight Envelope
deg	Degree (angel)
deg/sec	Degree / second
DAAA	Direzione degli Armamenti Aeronautici e per l'Aeronavigabilità
DIPES	Dynamic Interface Pilot Environmental Scale
E	Electric field
Ei	Risk Event
EM	Electro-Magnetic
EMC	Electro-Magnetic Compatibility
EMCON	Emission CONtrolled
FARP	Forward Area Refueling Position
FTI	Flight Test Instrumentation
HERO	Hazards of Electromagnetic Radiation to Ordnance
HIRF	High Intensity Radiated Fields
HMI	Human Machine Interface
HQ	Handling Qualities
kts	knots
LHD	Landing Helicopter Dock
MoD	Minister of Defense
MTC	Military Type Certificate
MTE	Mission Task Element
RSV	Reparto Spettacoli in Volo
SCES	Safety critical electronic systems
SHOL	Ship Helicopter Operating Limitations
SIAP	Sistema Integrato di AutoProtezione
SRAD	Susceptibility RADhaz Designator
TRAD	Transmitter RADhaz Designator

2. BACKGROUND

In 2015, for the first time, the Italian armed forces expressed the operational need to re-fuel and re-arm an attack helicopter, the A129D, on board of Navy's ships considered as a Forward Area Refueling Position (FARP). Additionally, they specified that, due to time and cost constraints, this capability should be acquired without the introduction of modifications applicable to both the helicopter and the ships. Following this operational need, the Italian Military Airworthiness Authority (DAAA, Direzione degli Armamenti Aeronautici e per l'Aeronavigabilità) requested to Reparto Sperimentale Volo (RSV - Italian Official Test Center) to plan and conduct a test campaign in order to determine applicable normal/emergency procedures and operational limitations that will allow the helicopter to perform safe ship-operations. As the Military Type Certificate (MTC) of the helicopter does not include ship-operations capabilities, the activity has been defined as a flight envelope expansion.

While procedures were available about Helicopter Ship Qualifications (dynamic interference testing), little references were found about a comprehensive and time constrained evaluation of a land-based helicopter for ship operations. The purpose of this paper is to present the approach used by RSV regarding the qualification program.

Figure 1: A129D during ship operation

3. AIRWORTHINESS AND PERFORMANCE REQUIREMENTS

DAAA process described at reference [1] has been used for qualification with the definition of airworthiness and performance requirements. Airworthiness requirements have been defined using guidelines provided in the document at reference [2]. The following areas were considered: Performance, Handling Qualities, Electro-Magnetic Compatibility (EMC), High Intensity Radiated Fields (HIRF), Hazards of Electromagnetic Radiation to Ordnance (HERO), Visual Cues, Human Machine Interface (HMI) and Structure. Performance requirements were derived from the operational need received. The helicopter was required to take off, land, start and stop the rotor, refuel and rearm on three landing spots of a Landing Helicopter Dock (LHD)-class ship up to Sea State 4 and the following ship envelope:

Table 1: Desired ship envelope

Characteristic	Limits
Pitch oscillations (deg)	±1
Roll oscillations (deg)	±3
Relative wind speed (KIAS)	10 – 40
Relative wind direction (deg)	-45 - +45

4. DESCRIPTION OF TEST ITEMS

The “Mangusta” AH-129D is a tandem attack helicopter produced by Leonardo Helicopters and used for Close Air Support, Close Combat Attack and Escort operations. The helicopter has a 20mm machine gun TM-197B, can be armed with Rafael SPIKE-ER missiles and it’s equipped with passive electronic warfare countermeasure system with flare dispensers called Sistema Integrato di AutoProtezione (SIAP).

As confirmed by its operational History (Somalia, Iraq, and Afghanistan) the helicopter design has been optimized for land-based operations. Then many characteristics typical of naval helicopters (flotation system, harpoons, mooring anchor points, ship-compatible landing gears, blade folding) have not been implemented. The helicopters used for the test were production representative.

The ship used in this test campaign has a 18 knts maximum sail speed and a stabilization system to reduce roll and pitch oscillations due to the interaction with the sea. The ship has a 170m long deck with 6 landing spots foreseen for helicopter flight operations. The ship is equipped with several electro-magnetic emitters required for line of sight communications, satellite communications and radars for air and sea control.

5. TEST INSTRUMENTATION

Data required from the helicopter has been recorded using production instruments and a data-recording tool called Airborne Tactical Server (ATS). Ship data as deck attitudes and rates was measured and recorded using an iNAV-RQH iMAR® inertial platform and ship production instruments. Two high-speed cameras were installed on deck to record rotor acceleration characteristics during start and stop. Ship anemometers have been used, without applying corrections, to measure winds relative to the ship in both azimuths and speed.

Leonardo anechoic chamber in Torino Caselle was used to characterize 20x102mm bullet electro-magnetic susceptibility. The chamber has a square base of 30m and a 20m height.

6. SCOPE OF TEST

Purpose of the test trail was to develop and execute an omni-comprehensive methodology applicable to the evaluation of the A129, a non-naval helicopter, as a naval one by defining a “limited safety envelope” in which to perform the intended mission. This test evaluation required the analysis of several aspects referred to the peculiarity of a land-based helicopter operated outside of the usual (authorized) envelope.

This assessment has been performed, as state, without any modification and by installing a reduced Flight Test Instrumentation (FTI).

The overall test trials required 24 sorties (20 in day-time and 5 in night-time, aided and unaided) for a total of 27 flight hours (20 day and 7 night). Helicopter weight was controlled between 4200 Kg and 4600 Kg. Center of gravity variation resulted from fuel consumption, it was in mid position and considered mission representative. Relative winds achieved on deck were between 10 to 40 KIAS with azimuth between -45 and +45 deg. Sea state evaluated was up to 4 (average wave height of 2,5m).

7. METHOD OF TEST

All test performed can be related to 2 different macro-areas, that required deep analysis in order to provide an omni-comprehensive approach of the overall helicopter-ship interface capabilities evaluation:

Area 1 - Ship-helicopter Dynamic Interface, including performance and handling qualities issues, based on the guidelines presented in the RTO-AG-300 Vol. 22 “Helicopter/Ship Qualification Testing [3]”;

Area 2 - EMC aspects and issues, based on the guidelines provided by STANAG-1380 Ed.5 dated 15.02.2011 [4], MIL-STD-1605A dated 08.10.2009[5], MIL-STD-461F dated 01.01.2008[6], MIL-STD-464C dated 01.12.2010 [7].

7.1. Dynamic Interface Testing

7.1.1 A129 Handling Qualities evaluation and wind envelope determination:

As anticipated the A-129 has been optimized for land-based operations by the manufacturer and then, in order to achieve the capability to be operated from sea-based platform it was required to analyze all factors described in reference [3].

Helicopters launch and recovery wind envelopes are usually influenced by a large number of factors: air-wake turbulence (given by the ship superstructure), gust wind conditions, relative wind on-deck (may be constrained by ship operational requirements), fannell gas ingestion, take-off and landing special procedures (not provided by the helicopter manufacturer), visual cues and HMI elements. All these factors characterized the on-board ship-helicopter operations as “high gain” operations, performed in a very adverse and turbulent aerodynamic and electromagnetic environment.

A Candidate Flight Envelope (CFE) was first determined as result of the Critical Azimuth Testing (land-based performance and handling qualities testing). The aim of these tests was to asses control margins and pilot workload changing relative winds in both azimuth and speed. This test is usually performed at several corrected mass that are intended to be used in operation. For the limited scope of this evaluation, only one corrected mass of (4600 Kg) has been chosen. This corresponded to operation with an AUM of 4350Kg, at sea level and 30°C. Test weight has been controlled within ±5% of target weight

The CFE was than validated throughout on-board ship deck flight test (SHOL).

Critical azimuth testing was performed in HOGE condition to simulate the power reduction generated the interaction of the super-structure of the ship with the on-deck airstream. The basic idea was to determine where the control and power margin were limited by the helicopter low speed handling characteristics and, by applying the consolidated build-up approach, to investigate and limit the on-deck evaluation to wind direction and intensity values lower than what was determined in the CFE. Additionally pilots’ workload obtaining desired or adequate performance was evaluated for determination of limts, as per following table:

Table 2: Critical azimuth performance criteria

Parameter	Desired	Adequate
Altitude (FT AGL)	±3	±5
Airspeed (KIAS)	±2	±4
Heading (deg)	±5	±10

Figure 2 presents the CFE obtained.

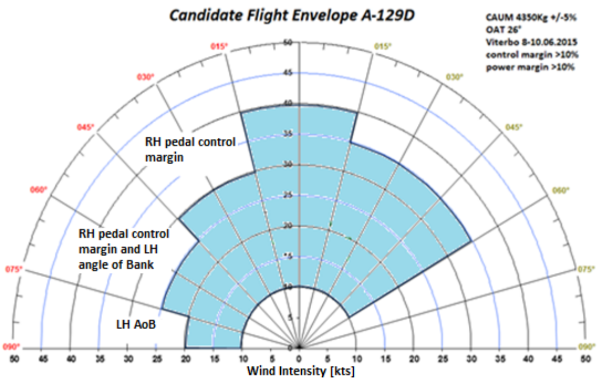

Figure 2: A129D Candidate Flight Envelope

Starting from the determined CFE and from evidences collected during similar flight test on the same ship with a similar-class helicopter about on deck airflow characteristics, it was possible to identify a list of consecutive test point for which control and power reduction were not expected during the ship trials (wind coming from left). By knowing the Handling Qualities (HQ) response of the helicopter, the limiting characteristics and the residual control and power margins for each test point evaluated, it was possible to predict when the next test point would have been safe to be performed (even if with a significant workload). These predictions were re-considered after each test point performed. This approach allowed to reduce by 15% the number of test points to be performed and to minimize the flight time required for each sorties.

HQ evaluation was performed by using the Dynamic Interface Pilot Environmental Scale (DIPES) rating scale. Ship trials were performed while in navigation on the ship by fixing the wind direction and varying the intensity values (increments of 5-10kts). Once a critical condition was reached (DIPES 3), relative wind azimuth was changed than (increments of +/-15deg).

Helicopter controllability was evaluated also in nighttime normal operations (due to the increase of the pilot's workload by defining dedicated HQ Mission Related Task), emergency condition (by simulating engine failure during on-deck rolling landing as MRT HQ task or AFCS failure/Off).

Result of this testing phase was a wind envelope diagram for each deck-spot of the ship investigated – Figure 3.

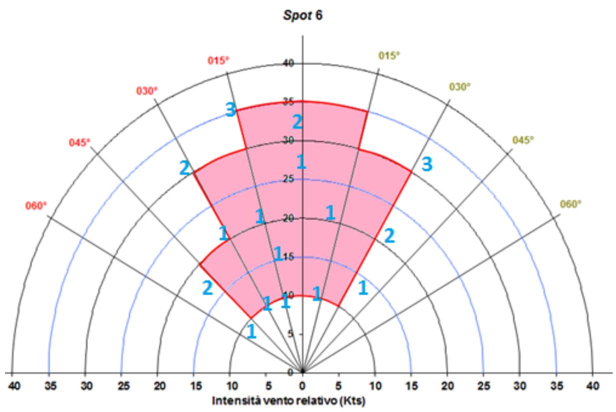

Figure 3: A-129D final wind envelope

7.1.2 Deck pitch and roll limitations determination:

Deck pitch and roll limitations were determined at first by analysis of the mechanical and structural characteristics of the A129 (maximum tolerable load on landing gear, slope landing capability, static and dynamic roll-over angle, etc.) and, than, validated by flight testing during the SHOL. In particular, it was demonstrated by calculations that the H/C won't slip when on the deck (without mooring) until the ship reaches a 11deg roll attitude. Than by considering the rate of the roll and pitch variations (assumed equal to 1deg/sec) and the slope landing limitations (9deg from each direction), it was derived that by limiting the platform movement up to +/-3deg in roll and +/-1deg in pitch the dynamic effect would be acceptable for the helicopter. Additionally maximum load provided by the ship movements to the A129 were recorded by the FTI installed and compared with the structural limits of the landing gear (10ft/s or 2.35g).

The relative motion of the helicopter and the ship has been modeled using a conservative approach here define. With the iNAV-RQH both ship and roll rate of the ship have been recorded during ship navigation under sea state 4 conditions. The maximum value observed for both axes in the time histories has been then considered for a structural assessment of the landing gear. The maximum roll rate observed was multiplied by ship's deck width. A similar approach has been used for the maximum pitch rate observed multiplied by half the deck's length. The two speeds obtained were then combined with the helicopter vertical rate of descent observed during landing and this value was compared with landing gear limits.

Following Figure 4 presents the variation of the vertical load factor felt by the A129 "corrected" for the inertial contribution given by the ship movement (@2,5deg of roll with rate of 1 deg/sec). This chart shows how the vertical factor was within the limits defined for the landing gear, in conjunction with the collective position (control parameter due to determine the "touch down time").

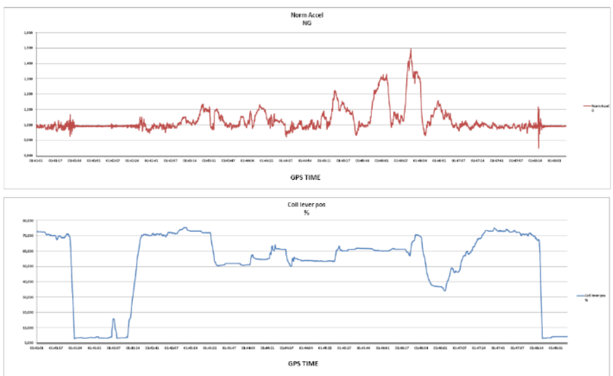

Figure 4: Load factor during deck landing

Output of this process was a determination of a maximum roll motion of the ship in relation with a maximum pitch angle, and vice versa, for SHOL operations.

7.1.3 Main rotor blades launch and recovery wind limitations determination:

Main rotor blades launch and recovery wind limitations envelopes were determined without instrumenting the blades. Anyway the effect produced by the turbulent airflow during the main rotor blades acceleration /deceleration phases were identified with the following approach. Wind limitations on ground for launching and recovering the main rotor were first assumed decreasing the land-based value of a safety buffer to take into account gust conditions. It was then fixed a maximum wind value for the start and stop procedure with headwind. After that dedicated test point were executed to gathered data useful for the specific objective.

Rotor accelerations characteristics (main rotor start and stop) were evaluated, with a build up approach, first on ground and then on board of the ship. Time required from idle to flight condition was recorded as well as unusual vibrations or blade flapping. When on the ship relative wind was first increased in intensity up to 40 KIAS and then varied in relative azimuth with ±15° variations. High speed cameras were used as supporting data to better describe unusual rotor behavior if observed. This allowed to better understand critical conditions met by the blade otherwise impossible without instrumented blades, even if it was assumed a risk that consequences of this approach could result in blade scrap. During testing conducted rotor acceleration characteristics on board the ship resulted as comparable to characteristics observed on land. Data analysis focused in the 0 – 20 % RPM range as, due to little centrifugal forces developed, aerodynamic effects and ship contributions to blade dynamics were considered not negligible.

Not being detected unusual pattern of flapping it was possible to state that the additional loads it has undergone the rotor, are among those that determine the form of standard blade flapping, and therefore do not exceed those recorded during normal land-based operations, in compliance with the current wind limitations. These results were also confirmed by pilots feedback.

7.1.4 Lashing condition and mooring point:

Due to the non naval characteristics of the A129, it was required to determine specific points on the airframe structure able to retrain the helicopter during the deck-operation required for the asset. A129 does not have dedicate mooring points and it was required to analyze the structural characteristics of each attachment point along the fuselage. This study was conducted together with Leonardo Helicopter Division and it was identified a set of "candidate mooring points" to be used for the aim. In particular, it was required to calculate the maximum load factor of each point and compare it with the loading factor provided by the ship movement. For this purpose it was used the same FTI used for the platform pitch and roll limitations.

As candidate mooring points were analyzed, and approved, the landing gear hooks (75400N) and the rear landing gear (24000N) – Figure 5.

Figure 5: Landing gear mooring point

Result of this analysis was a set of pitch and roll conditions for which it is required to use 2 or 3 mooring points (nr.2 lashing chain for each point) able to guarantee safe operation with and without rotor running. The final mooring scheme is depicted in Figure 6:

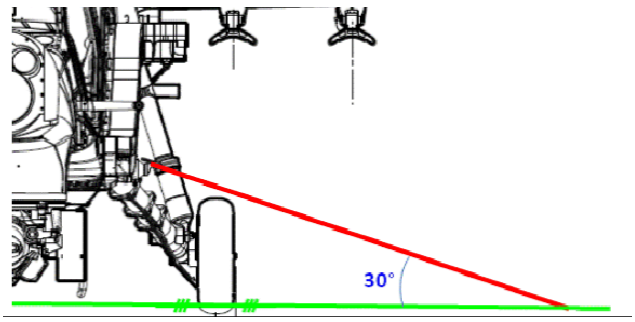

Figure 6 – Mooring scheme

7.2. EMC HIRF & HERO testing

EMC assessment represents one of the critical issue to be addressed in relation to the ship/helicopter interface characteristics. In this regard HIRF and HERO compatibility levels are the specific field of interest that were analyzed and observed during the A129 trial.

In particular, before starting flight test, the ship/helicopter electromagnetic compatibility - HIRF, and vice versa, was assessed in accordance to STANAG 1380 Ed.5, at reference [4], and to AECP-02 Ed. D, Ver.1, at reference [8], by analysis.

The A129 was not certified against MIL-STD-464C requirements at aircraft level (i.e. fixed values of electric field at different frequencies), at reference [7], as well as no dedicated EMC requirements were foreseen in the helicopter acquisition contract. Each safety-critical system and mission systems were tested, and cleared for land-based operations, against some MIL-STD-461 requirements at reference [6]. This was not sufficient for the purpose of our evaluation due to electrical field not comparable with level usually observed. In this condition, thanks also to LHD project engineering support, a safety analysis was performed in order to classify systems as Safety critical electronic systems (SCES) due to possible EMC interferences or EMC immune. Output of this analysis was a list of "safety-critical systems" that can be divided in two groups:

Group1 - SCES for which a minimum EM (Electro Magnetic) level was assured and it was possible to use the STANAG 1380 methodology; and

Group 2 - SCES to be evaluated in-flight testing in order to be cleared due to the lack of technical/certification information.

By applying the test methodology provided by STANAG 1380 to the first class of systems, it was possible to determine the safety distance of the helicopter from each EM source on the ship. This process was performed throughout the comparison between the platform Susceptibility RADhaz Designator – SRAD- code (which describes the RADHAZ susceptibility of a materiel in terms of its maximum PEL for each RADHAZ frequency range), and the platform Transmitter RADhaz Designator - TRAD - code (which describes the level of emission of a transmitter in terms of the maximum EMR environment capable of generating).

For each system/sub-system, radiating component, store and/or equipment it was determined a SRAD/TRAD code (as per Figure 7)

R2	T5	U3	V1	WA6	WB6	YA1	YB1	Z0

Figure 8: Generic SRAD/TRAD code

They were combined together, at aircraft and ship level, in order to determine only one SRAD and TRAD codes for each platforms (as per Figure 8). For system related to the second class was assumed to be characterized by the lowest SRAD/TRAD codes for each system due to the lack of susceptibility information.

		RADHAZ FREQUENCY RANGES								
		R	T	U	V	WA	WB	YA	YB	Z
TRANSMITTERS	Tr_1	-	2	1	-	-	-	-	-	-
	Tr_2	-	1	4	-	1	1			-
	Tr_3	-	-	2	-	1	1	-	-	-
	Tr_4	-	-	-	-	3	3	-	-	-
	Tr_5	-	-	-	-	2	2	3	3	-
	Tr_6	-	-	-	-	-	-	4	4	0
	Tr_7	-	-	-	-	-	-			3
	Overall	-	**T2**	**U4**	**-**	**WA3**	**WB3**	**YA4**	**YB4**	**Z3**

The overall TRAD of the platform is determined by taking the highest index for each radio & radar radiation hazards frequency range (RADHAZ FR).

Figure 8: SRAD/TRAD combination

Then, by comparing the helicopter SRAD and platform SRAD (Figure 12, in appendix) it was possible to define the safety distance as per previous point:

If the output of this comparison was a distance compatible with the ship deck, no additional action/investigation were required for the clearance. If the distances were assessed incompatible with the ship "geometry", and the radiating systems were considered operational relevant, EMC intra-system testing safely, as per MIL-STD-464C (second class of safety-critical system) were performed. The EM incompatibility risks were mitigated by applying specific operational procedure that foreseen to pull out specific circuit breakers, as well as inhibition of a specific system, and/or by defining a take-off/landing traffic pattern procedures that would not intercept the primary lobe of the radiating system.

HERO clearance for the A129 ordnance were assured both by analysis and laboratory, and flight, testing. In particular:

- for missile Spike-ER, the clearance was provided by the calculation of the EM safety margins (as per MIL-STD-464C) throughout laboratory testing (anechoic chamber);
- A129 is equipped also with the TM197 20mm electric machine gun, used in various other naval helicopter and/or sea-based gun system (i.e. Phalanx). The 20mm round has a semi-conductive electric primer activator (type M52A3B1) for which EM susceptibility data was not available. Because of the M52A3B1 primer intrinsic characteristics, it

had a wide range of resistance characteristics and it was not possible to instrument the principal filament in order to establish critical electromagnetic filed level due to a specific excitation (safety margin testing).

Novel feature in the previous testing phase is related to the methodology applied in order to provide HERO clearance for the machine gun rounds. In this frame it was assumed to perform an investigation focused on the determination of the E field values able to provide the primer activation, instead of the classical "safety margin determination". So this "EM susceptibility testing" on 20mm machine gun ammunitions were performed in anechoic chamber in order to determine the EM level of susceptibility and, than, to apply them adequate "safety margins" due to guarantee safety operations. In particular a complete EM susceptibility evaluation was performed by exciting the A129 machine gun ammunitions (bare rounds and loaded on the helicopter) through several EM sources (variable frequency, polarization, field intensity and modulation), by recording level of E filed in conjunction of the primer activation, if any would be occurred.

Figure 9 presents a comparison between the level of E field required by the MIL-STD-464C and the level of the E field tested in the anechoic chamber.

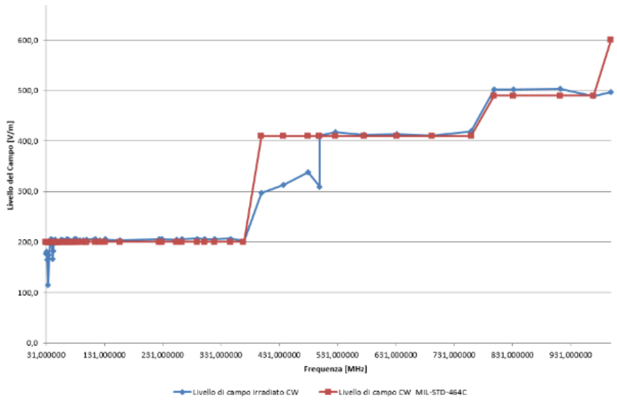

Figure 9: E filed comparison

Test were performed on dummy ammunitions, prepared by the Italian Official Test Center (Centro Sperimentale Volo), by removing the explosive component from the rounds (maintaining unchanged the characteristics of the primer) and providing a means to certify the activation in case of concurrency. Test methodology required test performed in anechoic chamber (c/o Leonardo facilities in Torino-Caselle) on ammunitions "bare round" (in different configurations – Figure 10) and loaded on the helicopter (operational configuration– Figure 11).

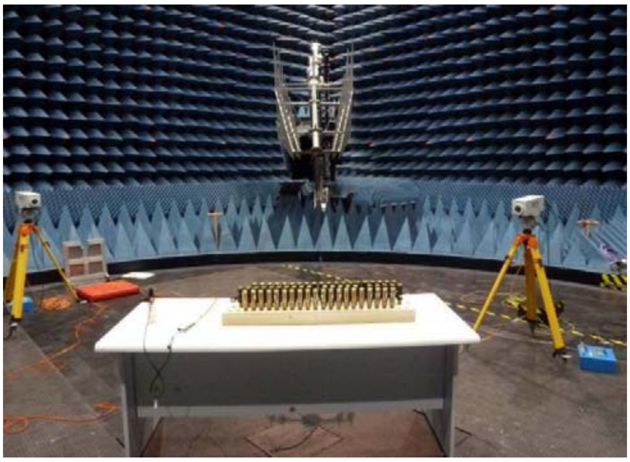

Figure 10: 20mm bare round ammo configuration

Figure 11: 20mm operational configuration

Both test cases were successful with no primer activations observed and provided an acceptable level of electromagnetic field to be used for the definition of an EMCON bill between the EM sources of the ship and the helicopter. Test execution guaranteed a complete EM characterization of the 20mm ammunitions.

8. TEST HAZARD ANALYSIS

Due the "non-naval" design of the A129 helicopter, it was required to analyze each peculiar characteristic that could affect the safety during the various kind of test performed, with particular emphasis on the flight conditions related with on-deck operations. This safety assessment resulted in a high cumulative probability of catastrophic event. Then, in order to mitigate the probability of these occurrences, it was required to evaluate each single risk-event associated to ship trials testing against the A129 peculiarity according to RSV protocols. Even applying the classical build-up approach and flying the aircraft in accordance with the actual flight limitation provided by the manufacturer, there were characterized the following events of risk that needed the definition of extra safety mitigations (procedures and limitations):

- “mid air collision” due to the limited experience of test pilot (Air Force and Navy) with Army A129 helicopter (E1);
- “Controlled Flight Into Terrain/Deck” due to the limited experience of test pilot (Air Force and Navy) with Army A129 (E2);
- “lost of aircraft control” due to degrade helicopter HQ, during high gain task, as ship landing (E3);
- “aircraft system and avionic malfunctions” due to EMC issues during on-deck ops and traffic pattern (E4);
- “landing gear damage” due to deck-landing and impact with the ship super-structures and antenna (E5);
- “Yaw Divergence” and “Vertical Bounce” (E6);
- “deck-resonance” (E7);
- “lost of cyclic and pedal control Authority (E8);
- “engine failure” on deck-ship (E9);
- “Personnel hazard” during on-deck ops (E10);
- “Helicopter, planned and emergency, ditching event (E11)”.

All risk event were assessed in terms of probability and gravity of concurrency. All possible mitigations were applied in order to reduce the event occurrence probability.

Particular relevance was assumed by risk events E3, E4 and E5 for which the safety considerations and mitigations are hereafter reassumed:

8.1. Lost of aircraft control due to degrade helicopter HQ, during high gain task (E3)

this event was assessed due to the increase of the pilot’s workload during the high gain task evaluation (i.e. on-deck landing). The increase of workload could be generated by the canalization of the pilot’s while achieving task’s performance criterias (lateral and longitudinal position of the helicopter on spot-deck descending from hovering at a certain vertical velocity on the moving ship deck) in a degraded visual environment (i.e. night and/or NVG landing) in the fringe of the wind envelope. This occurrence was assessed to be possible in all high gain task and could result in the lost of the aircraft and the aircrew (improbable occurrence and catastrophic effect). In order to mitigate the HQ degradation and the controllability of the A129, by discovering a possible controllability or power limitations during on-deck flight testing, it was determined a CFE throughout low speed controllability testing land-based

In-flight testing confirmed what was planned, by determining a safe flight envelope free from lack of power and control degradation of the flight control displacement greater than 10%.

Additionally, in order to provide sufficient confidence to the test evaluators during the ship trials, were performed dedicated HQ mission related task (i.e. partial on-deck hover ladder at different wind airspeed and direction – maintaining a desire position with different portion of the main rotor disk on deck, due to assess the stability and performance of the main rotor in a certain wind condition). On top, adequate pilot’s cockpit time and workload sharing were applied due to reduce the “heads down time” during each run.

8.2. Aircraft system and avionic malfunctions due to EMC issues (E4)

Due to the complex EM environment (characteristics of each ship) it was required to determine a safety way-forward to assure a safe way to test the mutual EM compatibility helo-ship. This event could be generated by the EM interaction from the transmitting system of the ship and all critical avionic system of the helicopter, and it could result in the lost of the aircraft and the aircrew (remote probability and catastrophic effect). In order to mitigate this event it was applied the risk reduction methodology described in the previous paragraph, by determining:

- helicopter SRAD code by knowing certification/testing data (if available), or using empiric data coming from the in-service experience);
- performing EMC intra-system testing, in accordance with MIL-STD-461;
- identifying traffic pattern for take-off and land landing away from the “nominal” radiation pattern of the transmitting systems (i.e. surface or surveillance radar) in normal and emergency procedures.

8.3. Landing gear damage due to deck-landing (E5)

Due to the peculiar landing gear configuration (rigid tricycle, usual for land-based helicopter) in was required to assure that the loads experienced from the helicopter during ship landing, and on-deck permanence in general, could not result in the system failure. This event could result in a catastrophic failure of the landing system and the potential injury for the aircrew (if it would happened during flight trials). So it was required to register the helicopter loads and compare them with the maximum load achievable from the landing gear and the airframe structure. In order to provide this data, both, A129 and ship, were instrumented with inertial platform due to determine the loads given by the ship motion and the loads felt by the airframe structure during the landings. Data, than, were checked after each sortie by applying a build-up approach for each flight conditions tested.

On top of all mitigations raised in the safety analysis due to perform a safety risk reduction, it is mandatory to state that a residual level of risk was assumed by the Test Organization in order to perform the test trial. Even if all safety procedures and limitations were formulated to reduce the probability of occurrence of each event, the trials required to assume a consistent "controlled" level of risk, justified by the operational needs to achieve a capability assessed as "strategically relevant" for IT MoD.

9. RESULTS AND EVALUATION

The approach described in this paper allowed to evaluate in a short time and with limited resources a non- naval helicopter for minimal safe ship ops. The helicopter was then considered suitable for the operational need expressed by Italian armed forces.

10. LESSONS LEARNED

When the activity started the EMC testing appeared to be incompatible with time and resources available. Using STANAG 1380 Ed. 5 has been determinant in achieving the desired results in the time and costs required.

11. CONCLUSION

The A129D has been considered satisfactory in limited envelope tested for ship operations.

FIGURES

SRAD									TRAD																		
									R, T, U,V, WA, WB, YA, YB, Z																		
R	T	U	V	WA	WB	YA	YB	Z	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
							7		3	3	3	3	3	3	3	3	3	3	3	3	10	10	20	30	50	90	160
					7				3	3	3	3	3	3	3	3	3	3	3	3	10	10	20	30	50	90	160
						7			3	3	3	3	3	3	3	3	3	3	3	10	10	10	20	40	60	100	180
						6			3	3	3	3	3	3	3	3	3	3	3	10	10	20	30	50	80	150	250
				7					3	3	3	3	3	3	3	3	3	3	10	10	20	30	40	80	130	240	400
				6					3	3	3	3	3	3	3	3	3	3	10	10	20	30	50	80	140	260	440
					5				3	3	3	3	3	3	3	3	3	3	10	10	20	30	50	90	160	290	490
								7	3	3	3	3	3	3	3	3	3	10	10	10	20	40	60	100	180	320	550
								6	3	3	3	3	3	3	3	3	3	10	10	20	20	40	70	120	200	370	640
								5	3	3	3	3	3	3	3	3	3	10	10	20	30	40	70	130	220	400	700
			7			4			3	3	3	3	3	3	3	3	3	10	10	20	30	50	80	150	250	450	780
	7								3	3	3	3	3	3	3	3	10	10	10	20	40	60	100	190	320	580	1000
			6			3			3	3	3	3	3	3	3	3	10	10	20	20	40	70	110	200	350	640	1100
7/6	6	7				2			3	3	3	3	3	3	3	3	10	10	20	30	50	90	160	290	490	900	1600
		6				1	1	1	3	3	3	3	3	3	3	10	10	20	30	50	80	150	250	450	780	1500	2500
	5								3	3	3	3	3	3	10	10	10	20	30	60	100	180	300	550	950	1800	3000
	4			1		0	0		3	3	3	3	3	3	10	10	20	30	50	100	160	290	500	920	1600	2900	>5000
	3			0					3	3	3	3	10	10	20	30	50	90	150	280	480	870	1500	2800	4800	>5000	>5000
	2								3	3	10	10	10	20	40	60	100	180	300	550	950	1800	3000	>5000	>5000	>5000	>5000
1			1						3	3	10	10	20	30	60	90	160	290	490	900	1600	2900	4900	>5000	>5000	>5000	>5000
			0						3	10	10	20	30	40	80	130	230	400	700	1300	2200	4000	>5000	>5000	>5000	>5000	>5000
	1								10	10	20	20	40	60	110	190	330	580	1000	1900	3200	>5000	>5000	>5000	>5000	>5000	>5000
0									10	10	20	30	50	90	160	280	490	870	1500	2800	4800	>5000	>5000	>5000	>5000	>5000	>5000
	0								20	40	70	110	200	350	620	1100	2000	3500	>5000	>5000	>5000	>5000	>5000	>5000	>5000	>5000	>5000

Figure 12: Determination of safety distances from SRAD and TRAD codes

REFERENCES

[1] DAAA, AER(EP).P-2 Omologazione, certificazione e qualificazione di tipo militare, idoneità all'installazione, 01/08/2013

[2] DAAA, AER(EP).P-516 Criteri per la definizione dei requisiti di airworthiness, 24/09/2013

[3] Geyer, W.P. Jr., Long, K., Carico, D.,Helicopter/Ship Qualification Testing, American clearance process, RTO-AG-300 Vol.22, AC/323(SCI-038)TP/53, 2003;

[4] STANAG 1380 Ed. 5, NATO naval radio and radar radiation hazard manual, 20/08/2015

[5] MIL-STD-1605A, Procedures for conducting a shipboard electromagnetic interference(EMI) survey (surface ship), 08/10/2009

[6] MIL-STD-461F, Requirements for the control of ectromagnetic interference characteristics requirements for equipment, 10/12/2007

[7] MIL-STD-464C, Electromagnetic environmental effects requirements for systems, 01/12/2010

[8] AECP-02/MECP-02, NATO naval radio and radar radiation hazards manual, 08/2015

ERF
European Rotorcraft Forum

Milan - ITALY
12-15 September 2017

43rd
European
Rotorcraft
Forum

PUBLIC RELEASE AUTHORISATION

43rd European Rotorcraft Forum

September 12th to 15th 2017 in Milan, Italy

Herewith undersigned certifies that the author's paper is unclassified and suitable for public release

SHIP/HELICOPTER QUALIFICATION TESTING FOR A NON-NAVAL HELICOPTER
ABSTRACT TITLE

ITALIAN AIR FORCE - REPARTO SPERIMENTALE VOLO (RSV)
ORGANISATION

STEFANO
ANTONIO
FIRST NAME

RAGAGLINI
CIOTOLA
SURNAME

FABRIZIO BECCARISI
AUTHORITY NAME & SUNAME

LIEUTENANT COLONEL
TITLE & RANK

TECHNICAL DIRECTOR
FUNCTION

ITALIAN AIR FORCE - RSV
ORGANISATION

31/07/2017
DATE

PRATICA DI MARE
PLACE

SIGNATURE

Mail to: ERF2017@leonardocompany.com
Tel : +39 0331 711158