Nationaal Lucht- en Ruimtevaartlaboratorium
National Aerospace Laboratory NLR

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Military rotorcraft certification in the Netherlands

The role of NLR

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Samenvatting

De kwalificatie van (gemodificeerde) militaire luchtvaartuigen is in Nederland aan strikte regelgeving onderworpen, hetgeen resulteert in een gestructureerd proces waarin het NLR zowel een sturende als een ondersteunende rol speelt. De inbreng spitst zich enerzijds toe op het opzetten en sturen van het kwalificatie proces, anderzijds op het uitvoeren van testen en analyses, teneinde het voldoen aan de eisen te bewijzen.
Het NLR heeft ruime ervaring in het ondersteunen van de Koninklijke Luchtmacht en de Koninklijke Marine op het vlak van de kwalificatie van zowel nieuwe helikopters alsook modificaties aan bestaande helikopters.
In de lezing wordt een overzicht gegeven van de bestaande regelgeving in Nederland, en de wijze waarop deze regelgeving vertaald wordt in gedetailleerde kwalificatieplannen en -procedures.
Tevens wordt een oplossing gepresenteerd hoe om te gaan met het probleem van het ontbreken van een universele militaire certificatie basis vergelijkbaar met de civiele FAR/JAR certificatiebasis.
Aan de hand van recente en lopende kwalificatie programma's worden voorbeelden gegeven van de NLR inbreng in test activiteiten en bewijsvoering.

Van 30 augustus tot 3 september 2004 werd het 24e congres van de International Council of Aeronautical Sciences (ICAS) bezocht te Yokohama, Japan, en werd tevens een voordracht gehouden, getiteld: "Military Rotorcraft Certification in the Netherlands – The role of NLR".
Het ICAS congres wordt tweejaarlijks gehouden, en is een van de belangrijkste congressen op het gebied van de luchtvaartwetenschap. De belangrijkste pijlers van het congres zijn aerodynamica en conceptual design, maar gedurende de laatste paar congressen komen ook onderwerpen als structures, Air traffic control en human factors meer aan bod.
Het congres was zeer goed bezet met meer dan 300 gepresenteerde papers, en meer dan 550 aanwezigen, waaronder een aantal NLR collega's.

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1 Introduction

Ever since the introduction of aircraft, owners, and later governments have been imposing requirements on the manufacturers of these aircraft, first only in a performance kind of way, but later also on issues concerning airworthiness. While the civil authorities placed more and more emphasis on airworthiness, the military authorities were mainly concerned with performance. Because of longer lifecycles of aircraft and mounting requests for public accountability after accidents had occurred, airworthiness of military aircraft became an issue in the spotlight. However, due to the emphasis on performance, and because there is no widely accepted standard for the certification of military aircraft, the regulations governing military aircraft certification differ from nation to nation.
Based on the Netherlands National military airworthiness regulations, NLR has performed many aircraft qualification and certification programs, both fixed and rotary wing.

2 National military procedures and regulations

2.1 Definition

'Qualification is the process leading to the recognition that the design of an aircraft, aircraft system or aircraft component complies with the applicable airworthiness and operational requirements' [1].

2.2 National military regulations

In the Netherlands, military aircraft airworthiness is governed by the 'Regulation for the Qualification and Continued Airworthiness of Military Aircraft in the Netherlands'[1]. The regulation gives procedural advice for the certification of both new types of aircraft and add-on modifications for existing aircraft, as well as expansion of the operational envelope. Later on, examples will be given for each of these cases.
The responsibility for the certification process lies with the Secretary of Defense, who has delegated his authority to the Director of Materiel of the Royal Netherlands Armed Forces. In turn, the work of managing and conducting the process has been delegated to the weapon system manager of the relevant rotorcraft type.
As start of the process, a Certification Committee is established, consisting in most cases of a chairman and secretary, the weapon system manager, a flight technical member (most often a test pilot), an advising member (the NLR projectleader), and the armed forces project leader. It is the task of the committee to write a certification plan, in which responsibilities are assigned and the distribution of activities is made. When all qualification activities have been

performed, the certification committee has to validate all substantiating evidence and render a certification advise.

2.3 The certification process

The certification process itself is a built-in part of the whole qualification process, which also takes into account performance requirements of rotorcraft. Performance in this case is not limited to flight performance, but encompasses the whole set of requirements (technical, logistic, flight-technical etc.) the rotorcraft must comply with. Therefore it is not really effective to strictly separate the airworthiness part from the performance qualification part as far as activities are concerned.

The certification process as described in the earlier mentioned regulation is composed of the following phases:

1. Certification plan and Requirements basis definition:
   The certification plan holds reference to the (modified) configuration and it's qualification status. The activities in this phase comprises the gathering, definition and if necessary clarification of the applicable requirements to which the (new/modified) aircraft must conform. The requirements basis consist of airworthiness, functional and operational requirements.
2. Means of compliance definition
   In this phase, a whole program must be set up and harmonized between parties involved (government and industry) to devise the means to proof compliance to the requirements basis. These means can be categorized in:
   Inspection of the Design: from the design it is inherently clear that a requirement is met,
   Analysis: By analyzing the design and/or it's properties, it is proven that a requirement is met, or
   Test: by performing ground and/or flight tests, either on a test article or a whole aircraft, compliance with the requirements is proven.
   In many instances, a means of compliance definition in relation to a single requirement can consist of all of the above categories in succession.
3. Compliance demonstration
   The compliance demonstration is the phase in the qualification process in which all verification activities take place as laid down in the means of compliance definition. The results of these activities are documented in verification reports.
4. Review of all data.
   All data obtained through the compliance demonstration phase is reviewed in relation to the requirements as laid down in the Requirements basis. If compliance with some requirements can not be proven, it is sometimes possible to prove airworthiness on the

basis of equivalent safety findings. The final outcome of this review is the certification advise to the director of materiel, possibly with restrictions in the operational envelope.

In figure 1 an overview of the certification process is given, including the dependencies from one part of the process to the other.

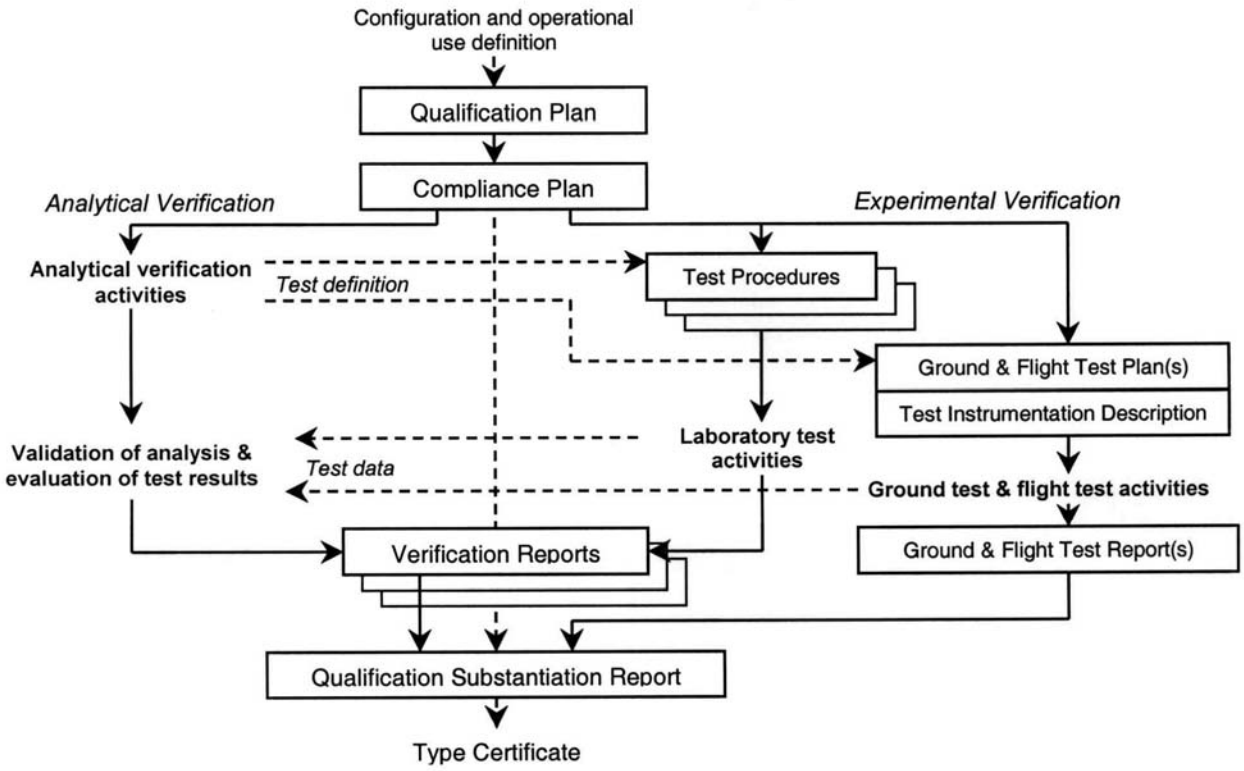

Fig. 1…Overview of the certification process

3 Differences between civil and military qualification and certification

3.1 The problem

In the civil world, one overall standard is in use for rotorcraft airworthiness qualification, being the FAR 27&29 and its european counterpart, the JAR 27&29. These standards, together with it's advisory circulars, define all requirements a helicopter has to comply with in order to be qualified as airworthy.

In the military domain, the main driver for the design requirements is performance, for instance speed, agility or payload. Airworthiness is more or less an (unwanted) constraint to these requirements, and often certain compromises are made, trading (to a certain limit) safety against performance.

Different manufacturers use a multitude of differing standards, each describing in detail requirements for parts of the aircraft, eg. Wiring, hydraulics, structural strength. Often these requirements are adapted or only partly declared valid in the rotorcraft model specification. As stated before, there often is a lack of dedicated airworthiness requirements.
On the other hand, different countries have their own national standards to which they want or have to certify their rotorcraft. This often is a challenging task, as the national requirements and the manufacturers specifications do not match. If a country insists on certifying the rotorcraft to it's own standards, this is a costly and time consuming operation, of which the outcome (a certified rotorcraft) is often uncertain.

3.2 A possible solution

Due to the fact that often qualification requirements and the (original) manufacturers specification are not harmonized, problems arise when a government other than the launching customer government wants to buy a new helicopter, because it's certification standards surely differ from those of the first customer.
As a result, a lot of tailoring and translation of requirements is necessary.
This experience stresses the need for a worldwide accepted standard governing the qualification of military aircraft, both fixed and rotary wing aircraft. Due to the differences in regulations between various countries, this is a major challenge.
In order to have a good starting point, it would be wise to start with a developed civil standard like the FAR29 or alike. However, due to the special environment military rotorcraft operate in, and the performance requirements imposed on them, a conscious tailoring and addition of requirements is necessary.
It would be a worthwhile effort to conduct a study into the harmonisation of national standards, forming a more widely accepted standard for the design and certification of military rotorcraft. For it to succeed, a number of countries operating large military helicopter fleets would have to join the effort.
Until then, unless the original standard is already a comprehensive one, NLR uses the British DEFSTAN 00-970, part 2 [2] as a basis to streamline and organize the requirements emanating from different standards as imposed by the manufacturers. This is being done by organizing the different requirements under the various chapter and paragraph titles of the DEFSTAN. In this way, an organized requirements basis evolves, turning a myriad of requirements in a tightly structured format, without compromising the actual requirements.

4 The role of NLR

Due to its multi-disciplinary organisational setup, covering all fields of aircraft design, NLR is well suited to play a leading role in the process of rotorcraft qualification, and has done so more and more since both the Royal Netherlands Navy and the Royal Netherlands Air Force have started acquiring helicopters. The task NLR has is to interprete and monitor the requirements, set up and organize the requirements basis, to propose testplans and conduct inspection, analysis, ground and flight tests. Afterwards, the task is to couple the outcome of analysis and test to the fullfilment of the requirements.
The capacities NLR has are a.o. in the field of environmental testing and qualification of sub systems, full scale electro magnetic interference testing, structural analysis and test, wind tunnel test and aerodynamic analysis and ground and flight test.

5 Some examples of military qualification programs performed by NLR

5.1 NH90 helicopter

The NH90 helicopter, which will enter service with the Royal Netherlands Navy (RNLN) in a number of years, is a completely new designed helicopter, jointly developed by four European countries. NLR monitors on behalf of the RNLN all national and international tasks and activities required to qualify this new helicopter design. A problem which often arises in this project is the difference in interpretation between the various partner nations, which is not a small wonder because each nation has its own regulations concerning military airworthiness. After the government airworthiness parties have reached an agreement, the next goal is to clarify the requirements and the means of compliance with the participating industries. As it is always the industries' goal to perform the minimum allowable amount of compliance demonstration, this can be a tough job.
As part of the whole certification process, NLR also assesses the required substantiation for flight clearance of the five prototype aircraft, which are used during the development phase. In this phase, in order to gather necessary data, requirements will sometimes deviate from the original requirements in order to achieve the required test results.

5.2 Determination of ship helicopter operational limitations

Qualifying a helicopter for ship borne operations is an expansion of the operating envelope and as such a possible certification topic. Under order of amongst others the Royal Netherlands Navy, NLR has been tasked to determine the ship helicopter operational limitations for each new class of ship and/or each new type of helicopter.

In this process, performance requirements and airworthiness requirements are balancing on scales against each other. On the one hand, there is the wish to operate under as severe as possible environmental conditions at the maximum all up mass, on the other hand the airworthiness requirements which stipulate that under all conditions, the controllability of the helicopter is safe guarded.
The method NLR employs to expand the operational envelop to it's maximum while still safeguarding airworthiness are based upon detailed wind tunnel tests of the class of ship, full scale wind climate measurements onboard the class of ship and hover trials of the new helicopter type. Based on the results of these tests, a helicopter-ship flight test plan is drafted and executed. The results of the trials are limitations based upon amongst others wind speed and direction, referred helicopter mass, and ship motions.
NLR has conducted this process for both national and foreign navies.

5.3 Qualification of a new integrated self-protection system for the RNLAF CH-47D Chinook helicopter

As the RNLAF uses its helicopters more and more in peace-keeping scenarios, a requirement was developed for a new Electronic Warfare protection system. The qualification process and the certification part of it are typically a process of new add-on equipment on an existing helicopter.
One of the major workpackages of this process was the structuring of the requirements basis. The Chinook requirements for both airworthiness and performance are depicted in the CH-47D model specification, in which in turn a multitude of Mil standards, Mil handbooks and other detailed standards are referred to. Often the applicability or validity of the standards is reduced or altered by the wordings in the model specification
In order to structure the requirements basis, NLR has used the structure of the UK DEFSTAN 00-970 [2], which is the standard used by the British Ministry of Defense to qualify new rotorcraft. The advantage of this standard is that it gives requirements for both the aircraft as a whole and for the various main subsystems. However, the requirements in the UK DEFSTAN are different than those in the Chinook model specification.
Because of this, the approach was chosen to rearrange the Chinook requirements as emanating from the model specification in the order of the chapters of the DEFSTAN. This gives an ordered table in which all aircraft systems and structures are mentioned with their applicable requirements. As mentioned before, this is a poorman's solution, but given the circumstances the best possible.
The modification involved installation of new structures on the outside of the helicopter, the addition of cockpit equipment and hookup of the system to electrical, databus and intercom systems.

From the design definition, and taking into account the requirements database, the means of compliance definition lies in the field of structural analysis, pilot vehicle interface, electromagnetic compatibility, and safe rotor separation. As the new system involves electro explosive devices, the influence of High Intensity Radiated Fields (HIRF) must also be assessed.
During the compliance demonstration phase, a structural analysis on the new structures was performed, a well as a vibration test. After integration of the new system, electromagnetic intersystem compatibility testing was conducted, in order to verify that the addition of the new system didn't influence the existing helicopter electronic equipment and vice versa. Also HIRF tests were conducted on the helicopter to check for Electro magnetic immunity.
A flight trial campaign was performed with actual decoy firing to check for safe separation with the rotorsystem. A video camera system was installed to record the decoy behavior (fig.2).

Fig. 2 Flare separation trials on RNLAF CH-47D Chinook (photo: RNLAF)

Having conducted all the analyses and tests, the results were reported in the verification reports and checked against the requirements basis. The certification committee validated the results and a recommendation for certification of the modified helicopter was given. The certification was granted and the new system is now in operational service.

6 Conclusion

Military certification differs from civil certification, mainly in the field of applicable requirements. An overview of the Netherlands military procedure was presented.
It is concluded that military certification is only nationally organized, and that no widely accepted international standard exists for both development and certification.
A solution is presented to cope with this problem, both in the long term and in the short term.

7 References

[1] Anon. *Regulation for the Qualification and continued airworthiness of Military Aircraft in The Netherlands (RNLAF edition)*, RNLAF, April 1998.

[2] Anon. *Defence Standard 00-970,/Volume 2, Design and Airworthiness requirements for service aircraft, Volume 2-Rotorcraft*. Ministry of Defence (UK), October 1995 .