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RESEARCH AND TECHNOLOGY ORGANISATION

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RTO AGARDograph 300

Flight Test Techniques Series – Volume 22

Helicopter/Ship Qualification Testing

(Les essais de qualification hélicoptère/navire)

This AGARDograph has been sponsored by the SCI-055 Task Group, the Flight Test Technology Team of the Systems Concepts and Integration Panel (SCI) of RTO.

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Helicopter/Ship Qualification Testing

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Edited by

G.D. Carico, R. Fang, R.S. Finch, W.P. Geyer Jr., Cdr. (Ret.) H.W. Krijns and K. Long

This AGARDograph has been sponsored by the SCI-055 Task Group, the Flight Test Technology Team of the Systems Concepts and Integration Panel (SCI) of RTO.

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RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote cooperative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective coordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also coordinates RTO's cooperation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of initial cooperation.

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- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS Studies, Analysis and Simulation Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier cooperation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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Helicopter/Ship Qualification Testing

(RTO AG-300 Vol. 22 / SCI-038)

Executive Summary

NATO's rotorcraft aviation forces rely heavily on ship-based operations for both military and commercial applications. The requirements to provide surveillance, supplies and force projection options in areas where land-based operations are not available also dictate aircraft/ship operations. These multi-national forces operate from a variety of different aircraft and ships in both weather and visibility extremes.

Basic helicopter flight limitations are usually determined in a land-based environment by the aircraft manufacturer and/or by the procuring activity. The land-based limitations are not valid in the shipboard environment due to the individual factors including ship air wake/turbulence, ship motion, confined landing areas and visual cue limitations and due to the combined effects of these factors. Future NATO operators and force commanders may require the maximum helicopter/ship operational capability that can be accomplished in any environmental condition.

The purpose of this AGARDograph is to document the helicopter/ship qualification test procedures including the preparation, execution and data analysis of helicopter/ship flight testing that should be employed, combined with best safety practices to obtain that maximum operational capability. Attention is focused on helicopter take-off and landing, which constitutes the main part of the test programme.

The following topics are described:

- the factors influencing the helicopter/ship operations;
- how these factors are determined in various qualification programme elements;
- how these factors are used to set up a flight test programme on board the ship;
- how the ship-borne flight tests, within the constraints of safety and efficiency, are carried out;
- in what way, during the tests, repeated use is made of the data obtained in the previous qualification programme elements and of the experience of the test team, resulting in the smallest possible number of flying hours without affecting the quality of the results.

A brief outline of helicopter/ship qualification programmes as carried out by the Netherlands' National Aerospace Laboratory (NLR) at Amsterdam, the United Kingdom's Defence Evaluation & Research Agency (DERA) at Boscombe Down and the United States' Rotorcraft Shipboard Suitability Branch of the Naval Air Systems Command at Patuxent River, Maryland are given. It describes how detailed information of the helicopter capabilities, ship's motion characteristics and the wind-climate above the ship's flight deck is used to set up and to execute a safe and efficient flight test programme. The programme leads to a safe and maximum operational availability of the helicopter on board the ship in terms of take-off and landing capabilities as a function of relative wind and sea-state.

Les essais de qualification hélicoptère/navire

(RTO AG-300 Vol. 22 / SCI-038)

Synthèse

Les flottes d'aéronefs à voilure tournante de l'OTAN sont fortement tributaires des opérations embarquées pour valider leurs applications militaires et commerciales. La mise en œuvre d'aéronefs à partir de navires est également dictée par la nécessité de disposer de capacités de surveillance, d'approvisionnement et de projection de force dans des zones où l'utilisation de bases terrestres est exclue. Ces forces multinationales mettent en œuvre une grande variété d'aéronefs et de plates formes maritimes et ce, dans des conditions météorologiques et de visibilité souvent extrêmes.

D'une façon générale, les limites de vol standard des hélicoptères sont fixées par l'avionneur et/ou par les services des approvisionnements en fonction d'un environnement terrestre. Or, ces limitations ne sont pas adaptées à l'environnement maritime embarqué en raison de facteurs propres tels que les turbulences de sillage et les mouvements des plates formes, l'exiguïté des aires d'atterrissage et les limitations des repères visuels, sans compter les effets combinés de tous ces facteurs. Les futurs équipages et commandants de forces de l'OTAN auront probablement besoin d'une synergie opérationnelle la plus grande possible entre hélicoptères et navires, quel que soit l'environnement.

Cette AGARDographie a pour objet de répertorier en les documentant les procédures pour les essais de qualification des hélicoptères à la mer, et notamment la préparation, l'exécution et l'analyse des données des essais en vol des hélicoptères, ainsi que les meilleures procédures de sécurité, afin de disposer de cette synergie opérationnelle maximale. L'accent est mis sur le décollage et l'atterrissage des hélicoptères car ils constituent l'essentiel du programme d'essais.

Les sujets suivants sont abordés :

- les facteurs ayant une influence sur les opérations des hélicoptères à la mer;
- la prise en compte de ces facteurs dans différents éléments des programmes de qualification;
- l'intégration de ces facteurs dans l'établissement d'un programme d'essais en vol dans le cadre d'un embarquement à la mer;
- l'exécution de ces essais en vol à partir de navires, compte tenu des contraintes de sécurité et d'efficacité associées;
- le recours répété durant les essais aux données obtenues lors de l'exécution des programmes de qualification précédents, ainsi qu'à l'expérience de l'équipe d'essais, de façon à réduire au minimum les heures de vol nécessaires sans nuire à la qualité des résultats.

Un bref aperçu est donné des programmes de qualification des hélicoptères à la mer tels qu'ils sont conduits par le Netherlands National Aerospace Laboratory (NLR) d'Amsterdam, le Defence Evaluation and Research Agency (DERA) de Boscombe Down au Royaume-Uni et par le Rotorcraft Shipboard Suitability Branch du Naval Air Systems Command de Patuxent River aux Etats-Unis. Cet aperçu décrit aussi comment les informations détaillées sur les capacités de l'hélicoptère, les caractéristiques des mouvements du navire et celles du vent sur le pont d'envol sont exploitées en vue de la préparation et l'exécution d'un programme d'essais en vol dans de bonnes conditions de sécurité et d'efficacité. Ce programme permettra d'assurer en toute sécurité une disponibilité opérationnelle maximale de l'hélicoptère embarqué du point de vue de ses capacités de décollage et d'atterrissage en fonction du vent relatif et de l'état de la mer.

Click inside the blue boxes to view the corresponding section

Contents

	Page
Executive Summary	**iii**
Synthèse	**iv**
AGARDograph Series 160 and 300	**vi**
Foreword	**vii**
Acknowledgements	**viii**
Part 1: Dutch/British Clearance Process	**1-1**
Part 2: American Clearance Process	**2-1**
Annex AGARD and RTO Flight Test Instrumentation and Flight Test Techniques Series	**A-1**

1. Volumes in the AGARD and RTO Flight Test Instrumentation Series, AGARDograph 160
2. Volumes in the AGARD and RTO Flight Test Techniques Series, AGARDograph 300

AGARDograph Series 160 and 300

The Systems Concepts and Integration (SCI) Panel has a mission to distribute knowledge concerning advanced systems, concepts, integration, engineering techniques, and technologies across the spectrum of platforms and operating environments to assure cost-effective mission area capabilities. Integrated defence systems, including air, land, sea, and space systems (manned and unmanned) and associated weapon and countermeasure integration are covered. Panel activities focus on NATO and national mid- to long-term system level operational needs. The scope of the Panel covers a multidisciplinary range of theoretical concepts, design, development, and evaluation methods applied to integrated defence systems.

One of the technical teams formed under the SCI Panel is dedicated to Flight Test Technology. Its mission is to disseminate information through publication of monographs on flight test technology derived from best practices which support the development of concepts and systems critical to maintaining NATO's technological and operational superiority. It also serves as the focal point for flight test subjects and issues within the SCI Panel and ensures continued vitality of the network of flight test experts within NATO.

These tasks were recognized and addressed by the former AGARD organization of NATO in the form of two AGARDograph series. The team continues this important activity by adding to the series described below.

In 1968, as a result of developments in the field of flight test instrumentation, it was decided that monographs should be published to document best practices in the NATO community. The monographs in this series are being published as individually numbered volumes of the AGARDograph 160 Flight Test Instrumentation Series.

In 1981, it was further decided that specialist monographs should be published covering aspects of Volume 1 and 2 of the original Flight Test Manual, including the flight testing of aircraft systems. The monographs in this series (with the exception of AG 237, which was separately numbered) are being published as individually numbered volumes of the AGARDograph 300 Flight Test Techniques Series.

At the end of each AGARDograph 160 Flight Test Instrumentation Series and AGARDograph 300 Flight Test Techniques Series volume is an annex listing all of the monographs published in both series.

Foreword

Introduction to the subject

Ships have been used for commercial and military sea-based applications for many centuries. The airplane has gained fame during the twentieth century for both commercial and military applications. Helicopter/ship operations have been ongoing since the middle of the twentieth century. Many countries and numerous commercial activities use the helicopter to extend the capability of ships. The helicopter is often considered a very versatile aircraft with few flight limitations. Basic helicopter flight limitations are usually determined in a land-based environment by the aircraft manufacturer and/or by the procuring activity. The land-based limitations are not valid in the shipboard environment due to the individual factors listed below and due to the combined effects of the following factors:

- Ship airwake/turbulence
- Ship motion
- Confined landing area
- Visual cue limitations

Operators request the maximum helicopter/ship operational capability that can be exercised in any environmental condition. To obtain the maximum operational capability, combined with best safety practices, helicopter/ship qualification testing is required. Helicopter/ship qualification testing, sometimes referred to as "dynamic interface (DI) testing" or as the "clearing process", is used to develop safe operational envelopes for helicopters operating off ships under a variety of weather conditions. The results of helicopter/ship qualification testing are referred to as the Ship Helicopter Operating Limitations (SHOLs).

Contributions from three countries in two separate parts

Helicopter/ship testing is considered high risk testing that should only be performed by agencies that have specialized flight test and research teams that are knowledgeable of, and have experience in, this type of testing. In NATO these conditions are fulfilled only in a limited number of countries amongst which are The Netherlands, the United Kingdom and the United States of America. Specialists from those countries have contributed to this AGARDograph. All three countries have several similar procedures related to determining SHOLs. At the same time some of the procedures differ, with the NL/UK flight test programs being more similar to each other than to the procedures employed by the US. To accommodate these differences it was decided to split the AGARDograph into two parts, one covering the NL/UK clearance process and the other dealing with the process in the US. Although as a consequence of this approach some overlap will be found comparing the two parts, the big advantage is that the process described in each part is consistent in its nomenclature and its sequence and that each part can be read independently from the other.

The Netherlands National Aerospace Laboratory (NLR) in Amsterdam and the UK Defense Evaluation Research Agency (DERA) at Boscombe Down have conducted numerous helicopter/ship qualification tests on national, as well as foreign, contractor aircraft/ship types to establish the SHOLs.

The Naval Air Warfare Center, Aircraft Division at Patuxent River, MD, in the USA has used Dynamic Interface (DI) testing over the past several years to try to eliminate a large helicopter/ship test backlog.

For some time, prior to the actual helicopter/ship flight testing, the Dutch have successfully used a combination of wind tunnel data (ship model), full-scale airwake data, and land-based helicopter data to predict operating limits. The UK and USA rely primarily on basic helicopter/ship testing.

Future developments

Future developments are expected in the field of increased application of simulation. The ability to predict helicopter/ship operational envelopes analytically represents one of the more difficult challenges associated with flight-testing. Inspired by the cost of testing and the inability to readily control test conditions, both the UK and USA have strong ongoing analytic efforts to help support future helicopter/ship qualification testing. With 3 new ship classes operating with 5 types of aircraft anticipated within the coming decade, the UK has initiated a First of Class Flying Trials program in 1997, which includes developing an advanced simulation capability. In the USA DI testing continues, with more emphasis being placed on simulation and wind tunnel efforts as potential test support tools of the future. The USA initiated an Office of Secretary of Defense (OSD) sponsored Joint Helicopter Ship Integration Program (JHSIP) in 1998. This program focuses on validating and evaluating joint service helicopter/ship operational capabilities, with some work in the area of DI simulation.

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The Netherlands contribution to the AGARDograph was only possible due to the valuable assistance and contribution received from the Royal Netherlands Navy in the course of the years. The author wishes to express his appreciation for the valuable contribution received from the following departments of the Royal Netherlands Navy:

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Flight Deck Qualification	Sea states
Flight decks	Seakeeping
Flight maneuvers	Ship decks
Flight tests	Ship maneuvering
Helicopter flight tests	Ship motion
Helicopter/Ship Clearance	Shipboard landing
Helicopter/Ship Qualification	SHOL (Ship Helicopter Operating Limitations)
Helicopters	Trials

14. Abstract

The purpose of this AGARDograph is to document the preparation, execution, and data analysis of helicopter/ship flight-testing. The attention is focused on helicopter take-off and landing which constitutes the main part of the test programme.

Described are:
- the factors influencing the helicopter/ship operations;
- how these factors are determined in various qualification programme elements;
- how these factors are used to set up a flight test programme on board the ship;
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A brief outline of helicopter-ship qualification programmes as carried out by the Netherlands National Aerospace Laboratory (NLR), by QinetiQ (formerly the UK Defence Evaluation & Research Agency (DERA) at Boscombe Down in the UK and by the US Naval Air Warfare Center Aircraft Division (NAWCAD) at Patuxent River is given. It describes how detailed information of the helicopter capabilities, ship's motion characteristics and the wind-climate above the ship's flight deck, is used to set up and to execute a safe and efficient flight test programme. The programme leads to a safe and maximum operational availability of the helicopter on board the ship in terms of take-off and landing capabilities as a function of relative wind and sea-state.

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