



Executive summary

Cost effective flight testing and certification in a small but ambitious Air Force



This paper describes how flight tests required to fulfil its long term mission are being organized and executed in the Royal Netherlands Air Force (RNLA F). It is believed to be an example of how efficient and effective flight testing is possible and ambitious goals can be met in an environment with quite some limitations in the field of materiel, manpower and financial means.

In some detail the F-16 flight test organization (FTO) is described in conjunction with the recently implemented new airworthiness regulations in the RNLA F. The certification process of the RecceLite reconnaissance system on F-16 is described as an example. Key success factors are the compactness of the team, its clear responsibilities and the availability of a fully instrumented aircraft.

Report no.

NLR-TP-2010-415

Author(s)

P. Koks

G.J. Kobus

Report classification

UNCLASSIFIED

Date

October 2010

Knowledge area(s)

Vliegproeven en
Instrumentatiesystemen
Luchtwaardigheid van militaire
vliegtuigen
Avionicasystemen

Descriptor(s)

F-16
Flight
Test
Instrumentation
Certification

This report is based on a presentation held at the Society of Flight Test Engineers 21st European Chapter Symposium, Vergiate (VA), Italy, 3-6 October 2010.

Cost effective flight testing and certification in a small but ambitious Air Force

Nationaal Lucht- en Ruimtevaartlaboratorium, National Aerospace Laboratory NLR

Anthony Fokkerweg 2, 1059 CM Amsterdam,
P.O. Box 90502, 1006 BM Amsterdam, The Netherlands
Telephone +31 20 511 31 13, Fax +31 20 511 32 10, Web site: www.nlr.nl



NLR-TP-2010-415

Cost effective flight testing and certification in a small but ambitious Air Force

P. Koks and G.J. Kobus¹

¹ Ministry of Defence

This report is based on a presentation held at the Society of Flight Test Engineers 21st European Chapter Symposium, Vergiate (VA), Italy, 3-6 October 2010.

The contents of this report may be cited on condition that full credit is given to NLR and the authors.

Customer National Aerospace Laboratory NLR
Contract number ----
Owner NLR + partner(s)
Division NLR Aerospace Systems and Applications
Distribution Unlimited
Classification of title Unclassified
 October 2010

Approved by:

Author <i>G.J.</i> <i>GJK</i> 23/9/2010	Reviewer <i>GJK</i> 23/9/2010	Managing department <i>GJK</i> 23/9/2010
--	----------------------------------	---



Summary

The motto of the Royal Netherlands Air Force (RNLAf) reads “Parvus numero - Magnus merito” meaning “Small in number - Great in merit”. This motto implies that it is the ambition of the RNLAf to incorporate new developments and modifications on their aircraft in a cost and time effective manner. The introduction of the Military Airworthiness Regulations (MAR-21) in the past decade marked the beginning of a new era. In order to support several F-16 certification programmes the RNLAf has a small and efficient Flight Test Organization (FTO), which operates an instrumented F-16BM test aircraft, nicknamed the “Orange Jumper”.

From the start of the flight test instrumentation system design process, strict configuration control rules were applied. This enabled the team to complete the modification of the aircraft and the airworthiness certification as scheduled and to produce a complete certification data package as well as maintenance procedures. The result is a state of the art test aircraft, which fully maintained its operational capabilities. When it is not participating in a test programme, the test aircraft is operated by the 323rd Squadron by regular pilots and maintenance personnel.

The flight test team consists of a small number of people from the air staff, DMO, Air Base Leeuwarden and NLR. Within the preparation and execution of flight test programmes this team closely cooperates with the Military Aviation Authority (MAA) during the approval process of design changes and flight test plans. Within this group, consisting of approximately 10 people, each member has its own task, responsibility and clear mandate. This results in a quick, safe and efficient decision making process. Applying this methodology the team has been able to successfully cooperate with the USAF Seek Eagle Office in several joint test programmes.

Within the multidisciplinary team all new test requirements can be discussed freely and with an open mind. At the same time the team is very much aware of the risks as well as the technical and financial boundaries posed by the programme. For instance, “flight envelope expansion” for the F-16 will not be considered. On the other hand, certification of new stores within the F-16 flight envelope has been demonstrated on numerous occasions and sometimes surprising results were found in already cleared store carriage and employment flight envelopes.

This paper will:

- Describe the introduction of airworthiness regulations in the RNLAf;
- Describe the F-16 flight test organization (FTO) in the RNLAf;
- Describe, as an example, the certification process of the RecceLite system for the RNLAf.



Furthermore, this paper will present you with a methodology on how a small Air Force is able to realise its ambitious goals in a cost effective manner to fulfil its long term mission:

“Flight test and certification programmes within the Royal Netherlands Air Force (RNLAf) are primarily intended to support the RNLAf main objective: safe and cost effective Air Power”.

Contents

1	Introduction	7
2	The F-16 weapon system and requirement for a test aircraft	7
2.1	Requirements for long term sustainment of a test aircraft	8
2.2	Selections of the flight test equipment suite	8
2.3	Design of the modification to transfer a F-16 into a test aircraft	9
2.4	Selection of the aircraft	10
2.5	Project team	11
2.6	Contract with NLR	12
2.7	Sustainment and further developments	12
3	Airworthiness Regulations in the RNLAF	13
3.1	Programme footholds	14
3.1.1	Complacency	14
3.1.2	Scope creep	15
4	Certification methodology	15
5	The flight test organization (TFO) in the RNLAF	19
6	Certification of the RecceLite system	21
7	Conclusions and recommendations	22
	References	24
Appendix A	Track record RNLAF F-16 test capability	25
Appendix B	Author's biography	28

Abbreviations

AFI	Air Force Instruction
ASHM	Aft Seat HUD Monitor
CLSK	Commando Lucht Strijd Krachten (Dutch acronym for RNLAF)
CP	Certification Plan
CVE	Compliance Verification Engineer
DMO	Defence Materiel Organization
DT&E	Development Test and Evaluation
EASA	European Aviation Safety Agency
EOA	Early Operational Assessment
ETPS	Empire Test Pilot School
FAR	Federal Aviation Regulations
FTE	Flight Test Engineer
FTO	Flight Test Organization
HUD	Head Up Display
JAR	Joint Aviation Requirements
LCO	Limit Cycle Oscillation
MAA	Military Airworthiness Authority
MAR-21	Military Airworthiness Regulations, part 21
MLU	Mid Life Update
MNFP	Multi National Fighter Programme
MTCHO(E)	Military Type Certificate Holder Organization (Exposition)
MSTC	Military Supplemental Type Certificate
MTC	Military Type Certificate
NLR	National Aerospace Laboratory NLR
OEM	Original Equipment Manufacturer
OT&E	Operational Test and Evaluation
QA	Quality Assurance
RNLAF	Royal Netherlands Air Force
SME	Subject Matter Expert
TC	Type Certificate
TCTO	Time Compliance Technical Order
TP	Test Pilot
USAF	United States Air Force
USNTPS	United States Naval Test Pilot School



1 Introduction

This paper describes, in short, methods and procedures for flight testing and certification, based on the current policies for the F-16 weapon system. Due to policy and/or regulation changes, these procedures may change in the future.

Note: Due to several reorganizations in the Netherlands Defence Organizations, the names of the materiel and operational organizations changed over time. In this paper the Royal Netherlands Air Force (RNLAf) is responsible for operating the aircraft and the Defence Materiel Organization (DMO) is responsible for the technical, logistical and engineering support of the fleet operated by the RNLAf.

2 The F-16 weapon system and requirement for a test aircraft

The F-16 weapon system was introduced in the RNLAf in 1979. In total 213 aircraft were acquired. The RNLAf also takes part in the Multi National Fighter Programme (MNFP) and through its participation controls the configuration of the aircraft in cooperation with the USAF, Belgium, Norway and Denmark. Portugal joined the MNFP at a later stage. The original intention was (and still is) to maintain aircraft configurations of the different nations as similar as possible.

Early in the programme (1984) the RNLAf formulated a recommendation for a dedicated test aircraft in order to test (and certify) primarily Netherlands' specific, ammunition and aircraft modifications. Originally, a single seat F-16 was instrumented but that did not prove to be the best choice. Then it was decided to thoroughly modify 2 two-seat aircraft. One to be used as a test aircraft and one to act as back-up. Using these aircraft numerous tests were performed and several national store certification programmes, avionics and weapon programmes were successfully completed.

A serious problem with the "legacy" test aircraft was the lack of regular funding for maintenance, documentation and configuration control. Only new programmes allowed budgets for upgrades and repairs. Due to this problem these aircraft could not be operated by regular aircrew anymore. A second problem was the large volume of the 'legacy' flight test instrumentation components installed in the aircraft, which made removal of existing aircraft systems necessary and thus affected the operational status of the aircraft.

With the introduction of the Mid Life Update (MLU) of the F-16, the number of upgraded aircraft was reduced to 137 airframes. Since the ambition of the RNLAF, being able to perform national certification and test programmes, was maintained, new requirements for a MLU configured test aircraft were issued. Based on these new requirements a new modification programme was started with a MLU aircraft, aiming to operate and maintain a test aircraft cost effectively with sufficient budget for continuity for the long term.

2.1 Requirements for long term sustainment of a test aircraft

In a small Air Force limited funding is available. This implies that it is not feasible to sustain a large test community and a complicated instrumented aircraft. Due to these limitations the following requirements for the new test aircraft were formulated:

- the operational status of the aircraft shall be maintained;
- the aircraft can be flown by regular aircrew;
- the flight test instrumentation will not interfere with the regular aircraft equipment;
- the aircraft can be maintained by regular aircraft maintenance personnel as much as possible;
- the aircraft will be modified by using airworthy materials, equipment and procedures;
- the modification will be completely documented and requirements;
- the flight test instrumentation effort will adhere to regular certification procedures.

In order to comply with these requirements during development, production and sustainment a project team led by the DMO was assembled and personnel from DMO, National Aerospace Laboratory NLR, Fokker Services and RNLAF joined the team.

2.2 Selections of the flight test equipment suite

As the regular and long-term partner of the RNLAF in flight test and certification, the National Aerospace Laboratory (NLR) was highly involved in the selection process of the new system. Due to operational requirements, a much smaller flight test instrumentation suite was preferred. This meant the suite should contain smaller data acquisition equipment, recorders and controls. Furthermore, it was decided to install a dedicated digital flight test instrumentation bus for communicating with remotely installed data acquisition units in stead of one centralized package.

The ambitions for possible tests were extensively debated. Options for spin chutes and other systems, highly affecting the structural integrity of the airframe, were discussed but finally abandoned. In short, high risk tests and flight envelope expansion would not be considered unless absolutely necessary.

The necessity for telemetry was also discussed and, as a compromise, reduced to ‘provisions for’ only. This decision was based on the fact that during all regular test flights a Flight Test Engineer (FTE) is present in the backseat. The FTE has the provisions of a highly sophisticated Aft Seat HUD Monitor (ASHM), on which he can monitor flight test data in real-time during the flight. During the programme this display and associated software have been continuously improved.

The selection of the flight test instrumentation bus proved to be a huge success in operating the aircraft and provided the test programmes with large flexibility. In the past, new test requirements resulted in complicated wire modifications. Using the bus system, most test requirements can be incorporated with relative ease by just adding or reconfiguring a remote data acquisition unit and sensors. Furthermore, the possibilities for software reconfiguration of the flight test instrumentation system significantly reduced the amount of work required on the aircraft to incorporate new programme related flight test instrumentation requirements.

2.3 Design of the modification to transfer a F-16 into a test aircraft

After the first selection of the instrumentation equipment, the formal design of the flight test instrumentation system and the installation in the aircraft was performed. During each step, the maintainability, configuration control and documentation issues were discussed and choices were made. Extensive relocations of regular aircraft equipment had to be avoided as much as possible to comply with the RNLAf main requirement to keep the aircraft fully operational. However, some difficult modifications, e.g. in the ammodrum compartment of the aircraft, could not be avoided.

Modifications in the forward crew station were avoided as much as possible. Only the basic control functions of the flight test instrumentation system being made available for the test pilot. The aft crew station’s panels, displays and controls were expanded as required. Due to the limited ‘‘filling’’ of the original aft cockpit consoles, this proved to be possible without highly disturbing the original layout and design.

The main ‘eye catcher’ in the aft cockpit is the flight test instrumentation display on top of the glare shield of the centre console. For the mechanical housing of this display, an existing design for an Aft HUD Display from General Dynamics was used and modified. Extensive cooperation was required between DMO and NLR to finally integrate, package and install all the instrumentation in the aircraft. See Figure 1 for an overview of the integrated flight test instrumentation system.

Documentation

The flight test instrumentation suite was fully documented by the NLR. The installation of the system in the aircraft was documented by Fokker and the required operational and technical documentation was produced by the DMO. The complete aircraft modification was extensively documented in an official F-16 Time Compliance Technical Order (TCTO), also produced by DMO.

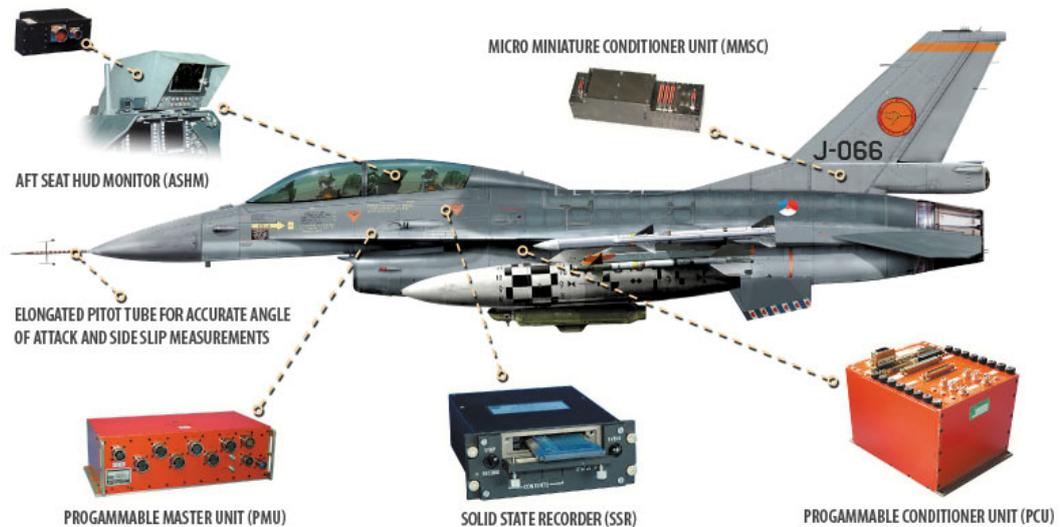


Figure 1 Schematic overview of key flight test instrumentation components

Certification of the design

At the time of the initial modification the RNLAf did not operate under formal Airworthiness Authority regulations. However, the design was formally certified by the Director of Materiel, based on reviewed engineering data and a separately conducted and documented safety reviews.

2.4 Selection of the aircraft

Based on the past experiences again a two-seat version F-16 was selected. Most test requirements of the RNLAf can be performed solitary by this aircraft and no other support is required. If an chase aircraft is required any other F-16 can be used. One of the youngest airframes was selected and of course an aircraft in the MLU configuration. With a limited amount of flight hours aircraft serial number 87-0066, tail number J-066, was selected. This aircraft is now nicknamed as ‘the 66’ or ‘Orange Jumper’, with a bright orange kangaroo on its tail and an extended red and white stripped pitot tube on the radome.

Due to the very high density of the F-16 avionics, every possible flight test instrumentation location was evaluated, checked and rechecked, but nevertheless small design changes had to be

applied to the installation as clearly illustrated in Figure 2, where the instrumentation is “wrapped around” existing aircraft components.

2.5 Project team

A great success in the programme was to adopt the philosophy to keep the project team ‘mean and lean’ without compromising safety. An excellent team was created containing players from several organizations and disciplines of the DMO, RNLAF and NLR. Personnel from the Technical, Operational, Maintenance, Quality and Procurement departments all have a dedication to the programme and a full sense of responsibility and accountability acting when within a controlled process. The project leaders (respectively from DMO/RNLAF and NLR) have adequate mandates to make quick decisions on technical and financial matters.

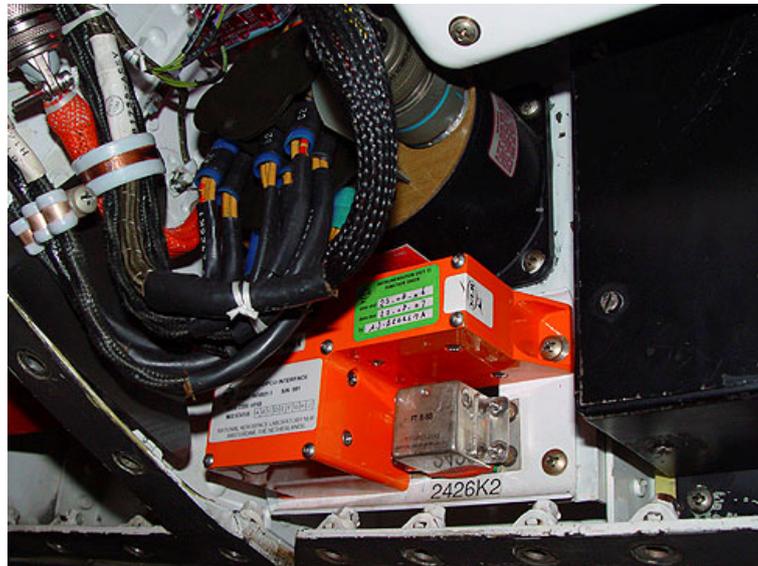


Figure 2 Making the most of small spaces

During the process continuous monitoring of the Quality Assurance (QA) system is applied and the procurement officer is able to make quick decisions on minor contract issues. The team meets on a regular basis and is able to tackle most technical, organizational and planning problems resulting from newly defined test requirements.

The operational team members create the flight test plans, always including a risk assessment, which are then approved in a controlled and efficient process (if required through the MAA). Key players in the Project team are the RNLAF Flight Test Office of the 323rd Squadron at Leeuwarden Air Base and the Flight Test Instrumentation group at NLR.



Flight Test Office

The complement of staff of this office consists of a Major Test Pilot (TP) leading the office, a Captain Test Pilot and a Captain Flight Test Engineer. They are permanently assisted by two experienced avionics maintenance experts who also received additional training on flight test instrumentation equipment. Both the Test Pilot as well as the Flight Test Engineer are graduates from an official flight test school like the ETPS at Boscombe Down or the USNTPS at Patuxent River.

Flight test instrumentation group at NLR

This group consists of two or three flight test instrumentation engineers with specialized knowledge of data acquisition equipment and processes, data buses, electrical and mechanical engineering and aircraft integrations aspects. Additionally, this group is able to consult with subject matter experts (SME) based on specific challenges and requirements for any flight test programme.

2.6 Contract with NLR

A solid follow-on support contract for the sustainment, maintenance, calibration and reconfiguration is periodically renewed between the DMO and NLR. The contract is valid for periods of three years and provides a lot of flexibility to the project leaders, as long as formal boundaries are not exceeded. This flexibility implies that small modifications to the system and small test programmes can be prepared, approved and accomplished in a very short time span. For larger and more expensive programmes, additional funds need to be reserved, but the terms and conditions of the existing follow-on support contract are applied and implemented for most programmes.

2.7 Sustainment and further developments

The system has been operated in the sustainment phase for more than 10 years. During this time the original requirements have not been affected and the aircraft has been used for national and international programmes, the latter mostly in cooperation with the USAF. Due to reductions in the number of airframes the current number of operational F-16's has been reduced to 87 and further reductions can be expected. This increases the significance of having a fully operational test aircraft. During the sustainment phase several upgrades were made to the aircraft to maintain its operational status and improvements were implemented to the flight test instrumentation system.



Figure 3 F-16 MLU J-066 instrumented test aircraft

During these flight test instrumentation upgrades the basic design proved to be very successful and the basic architecture of the systems has remained intact. A major “room saver” in the upgrade programmes was the replacement of the Merlin encoder equipment and traditional magnetic tape recorders by solid state recorders. Another important improvement was the addition of a LCO module in the monitoring software application running on the ASHM. This software module gives the FTE real-time access to LCO sensor data and aids in making quick decisions on aborting or continuing the test flight.

Further technology developments in the field of flight test instrumentation will be monitored and pros and cons are carefully weighed. If further efficiency improvements are to be expected from new technology, this might find its way into the test aircraft.

3 Airworthiness Regulations in the RNLAF

Although the flight test instrumentation suite aircraft was developed and certified in the RNLAF pre-MAA period, the introduction of the MAA and associated MAR’s were adapted easily by the Project Team. Especially the early decision in the programme, to apply full configuration control, quality control and regular documentation updates proved to be very helpful and made the conversion to the new regulations a smooth operation. The ‘Orange Jumper’ has been used

in numerous certification programmes, where the instrumentation system was used to produce certification data for many new systems currently used in the RNLAf. The produced data was analyzed by the NLR, formatted in reports and used by the DMO as a certification report and presented to the MAA.



Figure 4 The past and present; a line up of two Hunter fighters with the J-066

Another major benefit of having a test aircraft is that during the introduction of new (already certified) systems, the aircraft could also be used to support fielding of these systems (upgrades), for instance during Operational Test and Evaluation (OT&E) test programmes. During several programmes, e.g. for the AT or RecceLite pod, all kinds of integration issues were identified and solved using the data recorded with the flight test instrumentation system in the standard configuration.

3.1 Programme footholds

Every successful programme has its problems and footholds, the largest being complacency and scope creep. Both aspects are problems of a very different nature but both are challenging and can be potentially dangerous.

3.1.1 Complacency

As Chuck Yeager said a long time ago: “Flight testing is potentially dangerous.”. By definition you perform flight testing in areas where you do not know the outcome for sure, but an

impressive list of successfully performed programmes may give you the feeling that you know it all. In every programme a serious technical, operational and risk assessment is incorporated and all the important decisions are documented. Each flight in a new and not yet certified configuration requires detailed technical and operational data, which is routed through the Defence organization via the proper channels. If circumstances demand, a quick decision can be made.

3.1.2 Scope creep

As everybody will admit, flight testing is a very adventurous business and if you are not careful everything that is testable will be tested. Due to the limitations of a small organization and limited budgets, a constant watch over the requirements, feasibility and associated manpower, material and costs is mandatory. We experienced that a well 'engineered' contract and very intensive cooperation within the project team will keep you on track and enables one to avoid impossible programmes or nasty financial surprises.

4 Certification methodology

Historically the Royal Netherlands Air Force and Navy both had their own regulations for airworthiness and certification. At that time, an independent airworthiness body did not exist. At the end of the 90's progress was made in forming an independent body, responsible for airworthiness regulations, certification and approval of organizations.

In 2005 the Netherlands Military Aviation Authority (MAA) was established and several Military Aviation Regulations (MAR) were documented and issued. For certification purposes the MAR-21 are applicable. The main difference between MAR-21 and the comparable FAR/JAR/ EASA Part-21 regulations is that MAR-21 was not issued for a design organization, but rewritten to specifically fit a "Military Type Certificate Holder Organization" (MTCHO), the new role of the Defence Materiel Organization.

The main task of the MTCHO is to adopt aircraft data, certification data and documentation from recognized authorities and OEM's in the Dutch Military Forces, assuring the Continued Airworthiness of these aircraft during their service life.

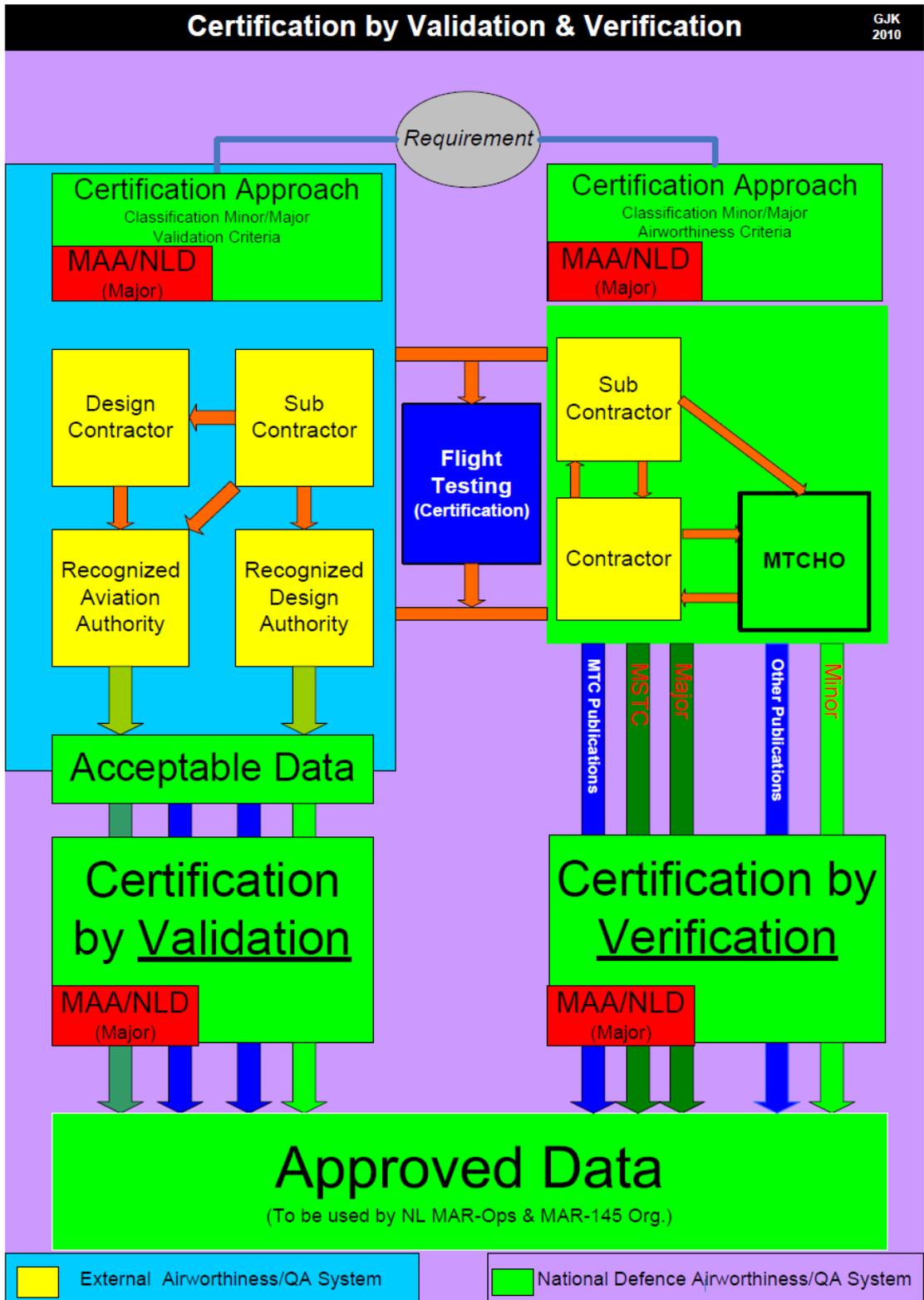


Figure 5 Flow Chart of the Certification Process



This proved to be a complicated and challenging task; especially when it seems that no air system in the RNLAf (in total 16 types!) applied the same methodology in procedures and documentation.

The second task of the MTCHO is to perform national certification projects of aircraft and aircraft systems. The procedures for national certification are almost identical to the common civil procedures.

The MAA issued privileges to the MTCHO for allowing them to approve minor modifications, publications and minor (and under specific conditions major) repairs. Major modification and documentation changes which can have an effect on the Type Certificate require approval of the MAA.

Since hardly any of the current aircraft in the inventory of the RNLAf has a Type Certificate, a project will be started in order to supply a "Retroactive" Military Type Certificate (MTC) for all the existing aircraft in service. New aircraft entering service in the RNLAf will require a complete Military Type Certificate approval process.

According to MAR-21 definitions, the certification of air systems through recognized authorities is called "Certification through Validation" and a national certification process is called "Certification by Verification". See Figure 5 for a schematic overview of the process and its details. The next paragraphs will explain both processes in more detail.

Certification by validation

The process "Certification by Validation" is a relative short process. This process is used when certification data is already available and approved by a recognized Aviation Authority. This certification data package is supplied by aircraft manufactures and is qualified as "Acceptable Data". The Acceptable Data is assessed and validated within the DMO based on the following criteria:

1. Is the data supplied by, or on behalf of, an approved Aviation Authority?
2. Is the data applicable for a specific Aircraft Type?
3. Is the data not in contradiction with specific RNLAf configuration?
4. Is the data not in contradiction with specific Netherlands MAA directives?



After the validation process has been completed, the data is formally approved and now qualified as “Approved data” and can be used by operators (MAR-Ops) and the MAR-145 approved maintenance organization of the RNLAf.

Certification by verification

The process “Certification by Verification” is an extensive process for design changes, which are engineered by manufacturers not under the supervision of a recognized Aviation Authority. Design changes engineered by or under the supervision of the DMO (maintenance branch) are also subjected to a “Certification by Verification” process. Design changes are assessed and validated within the DMO based on the following actions:

1. A Certification Team will be established. The complement of staff consists of: Post holder Engineering, Project Lead, Engineer(s), Compliance Verification Engineer(s) and Subject Matter Experts (SME). If necessary, DMO has the possibility to consult and contract CVE(s) and SME(s) from outside the DMO organization.
2. The design change has to be classified Minor or Major following MAR-21 directives. All major classified projects run under MAA control.
3. The Certification Base Line has to be established. Mostly accomplished under LC-516 (Netherlands adaptation of the Mil-Hdbk-516) methodology.
4. DMO will compose a Certification Plan, which has to be checked by the project CVE(s). In case of a major classified project MAA approval is required; otherwise approval is required from the (mandated) MTC holder.
5. Based on an approved Certification Plan a Certification Process will be executed including the mandatory Compliance Demonstration activities. Compliance Demonstration can be performed by means of: Development, Laboratory Testing, Ground Testing and Flight Testing. Again, DMO has the option to consult and contract recognized facilities and CVE(s) and SME(s) outside the DMO organization to support the certification effort. The results of the activities will be documented in Compliance Reports.
6. All Compliance Reports have to be verified by the designated CVE(s) of the project.
7. This results in a Certification Report including a Declaration of Compliance, which will be presented for approval by the MAA in case of a major design change or the (mandated) MTC holder.
8. After the certification process is successfully completed, a formal approval will be issued to the DMO by the MAA or (mandated) MTC holder.

After the validation process has been completed, the data is formally approved and now qualified as ‘Approved data’ and can be used by operators (MAR-Ops) and the MAR-145 approved maintenance organization of the RNLAf.

5 The flight test organization (TFO) in the RNLAf

As discussed in the previous chapters having the ability to prepare and execute flight test programmes in the RNLAf can be an important part of the certification effort. This requires a dedicated organization for flight testing with its own regulations. In the future Flight Testing Regulations will be documented in a dedicated MAR for the Test Flight Organizations (MAR-TFO). The current procedure used for the authorization of a flight test programme generally follows the process described below. Each step has to be completed successfully prior to execution of the test flight(s):

1. A Flight Test Meeting will be organized, in which the requirement for a test flight is discussed. Requirements, flight profile, methods of testing and risks are identified and discussed. Also all pre-requisite requirements (computational modelling (e.g. CFD calculations), analysis, laboratory testing, safety of flight test, ground testing, etc.) are identified and need to be completed before the test flights can commence.
2. The Operational Research Branch prepares and approves a flight test order called the Research Directive, in which for instance the organizational aspects and specific flight test instrumentation requirements of the flight test programme are identified.
3. The Flight Test Office prepares a Flight Test Plan in which the details of the test flight(s) and risks and appropriate mitigation are described. This plan has to be approved by the head of the Operational Research Branch.
4. The DMO prepares a ‘No Technical Objection’ for the flight test programme in which the technical issues are identified and conditions for the flight(s) are described.
5. The MAA prepares an Exemption and if required, a Permit to Fly is issued to the RNLAf with the approval (and conditions) for the test flight(s).

Note: An exemption is not required if the aircraft remains in a previously certified configuration and the flight test programme is classified as a Low or Medium Risk.

An illustration of the process is presented in detail in Figure 6.

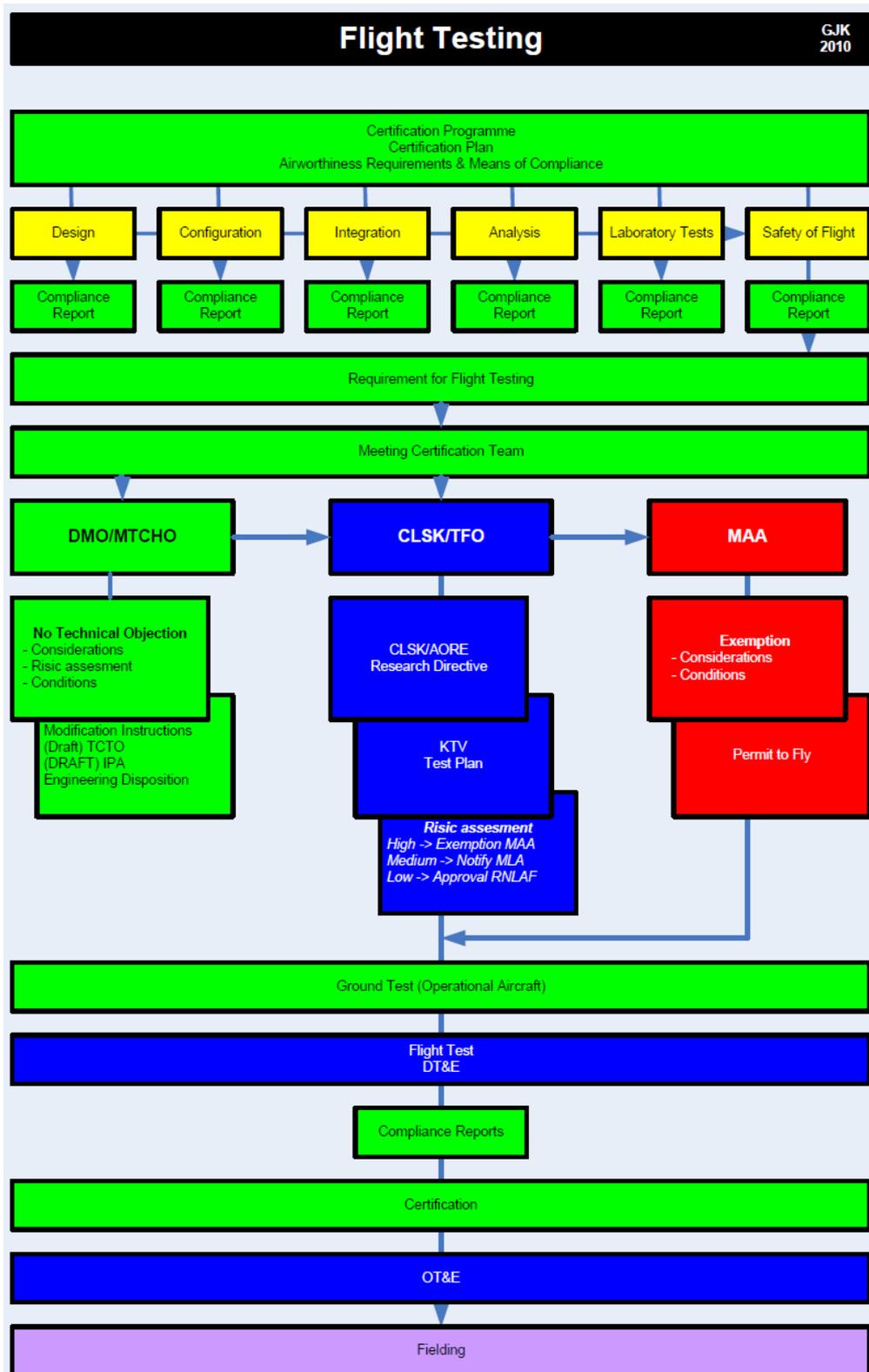


Figure 6 Flow Chart of the Flight Test Organization

6 Certification of the RecceLite system

To demonstrate the process being applied as described in the previous chapters the certification effort of the RecceLite system will be discussed. The RecceLite system was purchased by the DMO in 2005 as its primary air reconnaissance system for the F-16 aircraft.

The RecceLite system is one of the first systems certified with the aid of the Orange Jumper in accordance with the MAR-21 regulations. This system consists of a Pod, very similar to a Target Pod, a ground based system and a data link. The system was produced by the Israeli company Rafael and the system had not been formally certified and integrated on the F-16 by Lockheed Martin or the USAF. Being classified as a Major change, a large national certification programme was started by DMO and RNLAf with the aid of the NLR and Rafael.



Figure 7 RecceLite pod installed on STA5R

The first major task was to accomplish a complete certification baseline. For this purpose the methodology of the USAF (Seek Eagle process) AFI 63-104 was adopted. The certification baseline and certification plan required approval of the MAA before the actual certification work could be started.

Rafael produced the majority of the required laboratory test results and issued design documentation. Before the test flights could start an exemption was requested by the DMO and a Permit to Fly was issued by the MAA to the RNLAf based on the certification data package. The Orange Jumper was important for the programme and was used for establishing the vibration spectrum of the pod, including gun employment, flight handling, integration testing and data link tests.

As a novelty, all compliance reports were bundled and summarized in a large certification report produced via the 'do-check-approve' philosophy and verified by the Compliance Verification



Engineer (CVE). The certification report was issued to the MAA for formal approval. In August 2008 the certification process was completed and a Military Supplementary Type Certificate (MSTC) was issued by the MAA to the DMO.

Lessons learned

Composing and defining a complete certification baseline for the RecceLite programme proved to be a major task. This resulted in the need for a (software) tool which can be used solely for that purpose and which would save time and effort. At the same time the LC-516 was adopted as the primary methodology for certification within the RNLAf. Combining the two resulted in a data mining tool offering you the opportunity to select and tailor the certification airworthiness requirements baseline depending on the nature and magnitude of the programme in a controlled process.

Nowadays this tool is being used successfully to determine the certification baseline as part of the certification plan. Future improvements will further enhance the tool and to keep DMO staff up to date additional training is scheduled later this year.

7 Conclusions and recommendation

A small Air Force is able to sustain its own Flight Test Organization. This can be realized by establishing a compact test team with professional players having profound expert knowledge and awareness of their responsibilities. Tight budget planning must be performed and the scope of the test programmes must be tailored to the technical and financial possibilities to keep the projects under control.

The RNLAf test group is very successful in performing all their required tasks. The team knows what it can and cannot do. In the past years the group performed many different test programmes, clearly illustrated in Appendix A. Very important: most of the programmes were successfully completed on time and within budget.

A major contribution is, having an instrumented F-16 test aircraft capable of supporting the flight test effort. Not only to support certification programmes in the RNLAf but also to assist at international DT&E and OT&E projects. With the "Orange Jumper" the RNLAf operates a unique test aircraft. In order to retain its unique capabilities the test aircraft needs to be modified and maintained using proper configuration control, documentation and airworthiness standards.



MAR's will be evaluated over time due to policy or regulation changes and lessons learned from previous programmes. These will be implemented to improve the efficiency of the certification process in the future.

Due to the overall scope and safeguarding airworthiness regulations and safety awareness, an excellent safety record has been produced.

References

1. Implementation of MAR-21 and MTHOE at the fighter and training aircraft division at DMO, issue 3.5, dated July 29, 2010
2. NLR-TP-2000-362, New FTI for the RNLAf F-16 MLU aircraft
3. NLR-TP-2007-653, F-16 fighter aircraft flight testing in the Netherlands
4. Ministry of Defence: <http://www.mindef.nl>
5. Defence Materiel Organization: <http://www.defensie.nl/dmo>
6. MAA: http://www.defensie.nl/bestuursstaf/directies/militaire_luchtvaart_autoriteit
7. National Aerospace Laboratory NLR: <http://www.nlr.nl>
8. Lockheed Martin: <http://www.lockheedmartin.com>

Acknowledgement:

The photographs of Figure 3 and Figure 4 are used by courtesy of Mr. Frank Crébas.
(<http://www.bluelifeaviation.nl>)

Appendix A Track record RNLAFF F-16 test capability

Year	Test programmes ¹⁾	Customer(s)
1998	Modification programme to transfer F-16 MLU aircraft J-066 into an instrumented test aircraft (GP I)	Defence
1999	Start operations with F-16 J-066 as an instrumented test aircraft	Defence
	National certification programme: LANTIRN targeting and navigation pod, phase 1	Defence + manufacturer
2000	Verification LCO behaviour AMRAAM	Defence/ NLR
	National certification programme: LANTIRN targeting and navigation pod, phase 2	Defence + manufacturer
	Fuel tank separation (High Speed camera system) combined with MARS system installed on STA5 for navigation pod integration	Defence + manufacturer
	Investigation of F-16 generator system performance, phase 1	Defence (DMO/JLV/MA)
2001	Technology demonstration: Wing deflection measurements (video) and structural load model validation	Defence/ NLR
	M2 modification programme (GP II, ALR/EW)	Defence
	ALR/EW tests (UK range)	Defence
	Fuel tank separation (High Speed camera system) combined with MARS system installed on STA5, phase 1	Defence
2002	(Re-) Certification PIDS/ Mk84	Defence/ SPO/ MNFP
	Fuel tank separation (High Speed camera system) combined with MARS system installed on STA5, phase 2	Defence
2003	Technology demonstration: Titanium Matrix Composite Drag Brace programme	Stork SP Aerospace
	(Re-) certification GBU-10 (flight test preparation)	Defence/ SPO/ MNFP
2004	(Re-) certification GBU-10 (flight test programme), phase 1	Defence/ SPO/ MNFP
	Store (MK84) separation from PIDS/3	Defence + manufacturer
	(Re-) certification GBU-10 (flight test programme), phase 2	Defence/ SPO/ MNFP
	Investigation of F-16 generator system performance, phase 2	Defence (DMO/JLV/MA)
	OT&E AACMI pod	Defence + manufacturer
	Preparation M3 modification (GP III)	Defence
2005	M3 modification programme (GP III)	Defence

2006	Selection new flare type and evaluation (UK range)	Defence + manufacturers
	OT&E AACMI pod (continued)	Defence + manufacturer
	OT&E M4.2 OFP	Defence/ SPO/ MNFP
	FWIT asymmetrical load configuration	Defence
2007	National certification programme: RecceLite pod	Defence + manufacturer
	Technology demonstration: OUTCAST programme	Defence
	DT&E en OT&E M4.3 OFP (Edwards AFB test lead)	Defence/ SPO/ MNFP
	OT&E Recce Lite pod en Litening ATP	Defence + manufacturers
	DT&E Litening ATP	Defence + manufacturer
	Demonstration K7 thrusted flares (UK range)	Defence + manufacturers
	Preparation of M5 modification (GP IV)	Defence
2008	M5 modification programme (GP IV, part 1)	Defence
	Early Operational Assessment (EOA) M5	Defence/ SPO/ MNFP
	OT&E Litening ATP	Defence + manufacturers
	OT&E Recce Lite pod	Defence + manufacturer
	Demonstration K7 thrusted flares (UK range)	Defence + manufacturers
	National certification programme: BLOSCOM pod (LCO)	Defence + manufacturer
2009	M5 modification programme (GP IV, part 2: ATD)	Defence
	Store (MK-84) separation from PIDS/U	Defence
	DT&E BLOSCOM pod, part 1	Defence + manufacturer
	OT&E M5.1 OFP in Norway	Defence/ SPO/ MNFP
	National certification programme: Cockpit video system	Defence
	Development dummy MIDS MT	Defence
	Technology demonstration: Engine noise reduction programme	Defence/ NLR
2010	Evaluation EGI performance and Ng load	Defence/ SPO
	DT&E BLOSCOM pod, part 2	Defence + manufacturer
	OT&E RecceLite pod V7	Defence + manufacturer

1) This represents only a summary of F-16 flight test programmes executed over the years within the RNLAf but is by no means complete.

Definition DT&E

The field tests verifying that the design solution meets the system technical and operational requirements and the system is prepared for successful OT&E.



Purpose DT&E (DoDI 5000.02)

Activities to assess progress towards resolving critical operational issues, the validity of cost-performance trade off decisions, the mitigation of acquisition technical risk and the achievement of system maturity.

Definition OT&E

The field test, under realistic operating conditions, of any weapon system, equipment or munitions (or key component) for the purpose of determining its effectiveness and suitability for use in combat by typical military users and the evaluation of the results of such tests to resolve stated critical operational issues.

Definition of Operational Effectivity

The capability of a system to perform its mission in an operational environment, including countermeasures in the face of the expected threats. Or – “How well it does what it was built to do.”

Definition of Operational Suitability

The capability of a system, when operated and maintained by typical fleet personnel in the expected number and of the expected experience level, to be supportable when deployed, compatible and interoperable.

Purpose OT&E (DoDI 5000.2)

The Purpose of Test, Evaluation & Operational Suitability is to determine:

“The degree to which a system can be placed satisfactorily in field use with consideration given to availability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistics supportability, natural environment effects and impacts, documentation and training requirements.”

Appendix B Author's biography

Gert Jan Kobus holds a BSc degree in Electrical Engineering from the Technical University of Alkmaar where he graduated in 1981. After fulfilling his military services in the Royal Netherlands Army he joined the RNLAf. At the F-16 avionics office he was responsible for several projects concerning the maintenance, modification and configuration control of F-16 electrical and electronic systems. During the modification of the F-16 MLU aircraft J-066 into an instrumented test aircraft he was project leader for the design, installation and configuration control of the transformation of the J-066 into an instrumented test aircraft called the 'Orange Jumper'. Until July 2010 he was the RNLAf project leader of the follow-on support of the flight test instrumentation in the J-066 'Orange Jumper' and was the airworthiness coordinator of the fighter and training aircraft division at DMO, where he prepared the specific procedures for the implementation of the MAR-21 for the F-16 and PC-7. He recently transferred from DMO to the MAA and accepted the position of Certification Team Lead. In the past he was co-author for a paper about F-16 flight test instrumentation presented at the SFTE symposium in 2000.

Paul Koks holds a BSc degree in Aeronautical Engineering from the Technical University of Haarlem where he graduated in 1985. After fulfilling his military service in the Royal Netherlands Army he joined NLR in 1986 as a flight test instrumentation engineer at the Flight Test Systems & Applications Department of the Aerospace Systems & Applications Division. He participated in the NLR's operational flight test instrumentation team for the certification of the Fokker 50 and Fokker 100 aircraft and was team leader during the Fokker 70 certification. During the modification and transformation of the F-16 MLU aircraft J-066 into an instrumented test aircraft he was responsible for the mechanical design and installation of the F-16 MLU flight test instrumentation. In his current position he is NLR project leader for the follow-on support of the J-066 'Orange Jumper' and he is involved in both military and civil airworthiness projects. In the past he presented papers about F-16 flight test instrumentation and F-16 military flight testing at symposia of the SFTE in 2000 and 2006.