Miysis DIRCM: The smallest, lightest multi-head DIRCM System available today

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ABSTRACT

Building on Leonardo's unique experience in this domain, the Miysis DIRCM System is the culmination of over ten years of extensive development, test, validation and certification, resulting in a twin-head, spherical coverage DIRCM system that is less than 40kg and is capable of protecting the full range of platform types from the smallest helicopters to the largest transport aircraft.

This paper discusses some of the benefits that have been achieved from the application of advanced EO technology to the Miysis DIRCM System, and also considers some of the system trades a designer may have to undertake.

The extensive test and evaluation that was undertaken at every stage of the programme, including simulation, laboratory testing, platform and target dynamic testing in a System Integration Laboratory (SIL), flight trial, missile live-fire, environmental testing and reliability testing, all of which was required in order to ensure that the system provides the requisite levels of protection against the latest, sophisticated all-aspect IR MANPADS is also covered.

In particular, recent developments and system level testing will also be discussed in some detail.

Keywords: Lightweight DIRCM, full coverage, Advanced Technology, Test and Evaluation.

1. INTRODUCTION

Leonardo has been a global leader in the design, development, manufacture and support of airborne laser and electro-optic pointing and stabilisation systems for over 40 years. As far back as 1995, Leonardo was selected as the supplier of pointer/trackers for the AN/AAQ-24(V) DIRCM system. Since then, over 2400 combat-proven units of various types have been built and deployed on over 50 aircraft types, including rotary, fixed wing turbo-prop and jet transport.

The Miysis DIRCM System is the latest generation Leonardo DIRCM, and has been designed from the outset to be suitable for use on a wide range of air platforms from the smallest of helicopters to large, wide-bodied jet transports.

The development of Miysis capitalised heavily on key IR sensor, laser and sightline control technologies made available from Leonardo's internal advanced technology investment. The latest open-architecture system concepts such as those defined by SCI-260 (N-DAS) have been applied and MOTS/COTS hardware used wherever possible. This open-architecture design readily supports integration of the equipment onto aircraft platforms, either as a stand-alone DIRCM solution or as part of a broader Defensive Aids Suite.

Leonardo believe that the Miysis DIRCM System is the smallest and lightest high Energy-on-Target, multi-turret, full DIRCM system available to the world market today, with a total system weight of <40kg excluding the Missile Warning Sub-system (MWS). It has a peak power draw of less than 1300W, and typically draws less than 600W during jamming with both heads, giving it the lowest aircraft power requirements of any comparable system.

The inherent high reliability of the Miysis DIRCM System design, coupled with its ease of manufacture and repair also offers a step change in through-life cost in comparison to previous generation systems.

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In addition, a core element of the development process was to leverage Leonardo's extensive domain knowledge in design, manufacture and in-service support of such airborne electro-optical systems, including the company's world leading experience in design for ease of manufacture and in growing the reliability of such systems in real operational environments.

This approach, coupled with a phased development programme that included extensive test and evaluation at every stage, has produced a mature, highly reliable, elegant and low risk system.

The Miysis DIRCM System is fully qualified, and is now in volume production for several customers, for installation on a large fixed wing turbo-prop special mission platform, a medium sized jet transport and a large helicopter.

An early variant of the Miysis DIRCM System was used in the UK MOD CDAS programme, and a further variant of the pointer/tracker was selected for the US Army CIRCM programme EMD phase.

A production standard Miysis DIRCM System was the key element of an N-DAS compatible UK EW System recently taken to a UK MoD live-fire trial for extensive test and evaluation.

1.1 Miysis DIRCM System Description

The baseline twin-headed Miysis DIRCM System is shown in Figure 1; it comprises two integrated Laser Pointer/Trackers, a Single ruggedised COTS Control Electronics Unit (EU) and a Cockpit Interface Unit (CIU), integrated with a DIRCM-capable Missile Warning Sub-system (MWS). The system can operate completely autonomously in this configuration with no additional inputs from the aircraft other than power and a weight-on-wheels laser interlock; however, the interface architecture has been designed such that the system can also be readily integrated with appropriate cockpit display systems or a Defensive Aids System Controller (DASC) if required. The use of open architecture interfaces and standards significantly simplifies the integration approaches that can be adopted for different aircraft platforms and customer requirements. This approach also provides benefits in obsolescence management.

As per our previous generation product, all of the individual units have been qualified for the full MIL STD 810 rotary wing, turbo-prop and jet transport environments, such that the system can easily be integrated onto an aircraft without the need for further qualification testing. Additionally, extensive system level performance testing has verified that the laser output, combined with the laser sightline tracking accuracy, is such that jam-to-signal (J/S) ratios can be achieved which are sufficient to protect platforms from the smallest helicopter to the highest signature jet transport platforms with a single hardware configuration.

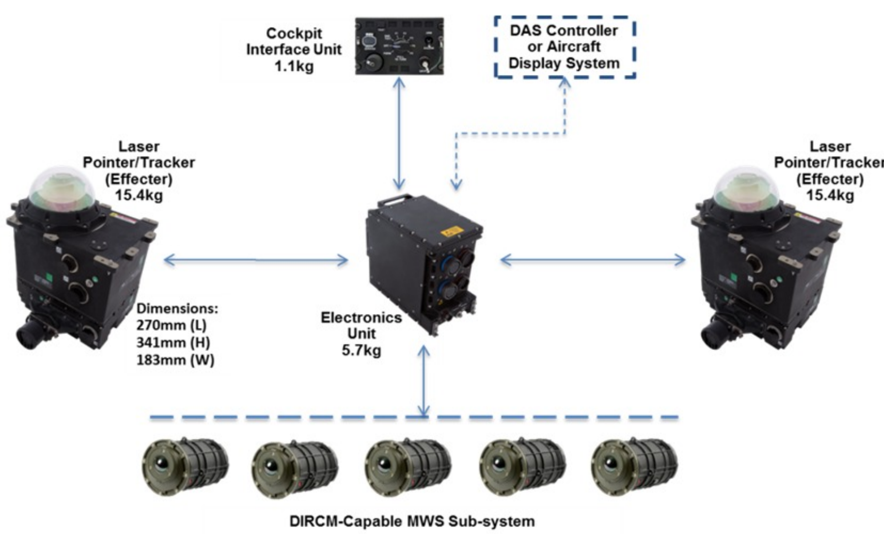

Figure 1: The Miysis DIRCM System

The compact Laser Pointer/Tracker Assemblies each comprise a hyper-hemispherical beam director assembly enclosed by a sapphire dome, a strap-down inertial sensor, and a Leonardo, third generation, mid-wave, focal plane array (FPA). Each Pointer/Tracker is directly coupled with a Type 160 multi-band IRCM laser to form the integrated assembly. With the exception of specific laser arm discrete signals, each integrated Laser Pointer/Track has a completely digital interface with the Control Electronics Unit.

The Type 160 is a compact, high efficiency, multi-band, multi-watt output Thulium Fibre pumped Ho:YAG/ZGP laser, producing the appropriate wavebands. This laser is the culmination of many years of joint working between Leonardo and the UK DSTL, during which the core technologies making up the laser have been progressively developed and optimised in order to provide the mature, capable production product used in the Miysis DIRCM System today.

The single DIRCM System Control Electronics Unit is a ruggedised unit comprising COTS/MOTS components of less than 6kg. This unit undertakes all of the necessary system level moding, control and threat prioritisation, and manages hand-over to the DIRCM System from the MWS, and also between Laser Pointer/Trackers, as required. It contains the video acquisition and track sub-system, image processing and all camera control functions, including scene based pixel non-uniformity correction and stare time control. It also hosts advanced sightline stabilisation and control algorithms including through nadir tracking, and provides fully reprogrammable laser jam code control.

While the actual processing hardware has evolved several times during the course of the Miysis development programme, the advanced model driven engineering processes used by Leonardo have allowed for rapid and effective re-use of software and firmware, providing a mature and well proven capability hosted on state-of-the-art COTS/MOTS hardware.

The system is designed to incorporate any ***DIRCM-capable*** MWS, and has been successfully integrated with six different MWS's. As part of this work a number of requirements, processes, algorithms and capabilities have been developed that significantly aid in the integration of the MWS.

Leonardo has invested considerable internal funding over many years to develop and mature the underpinning technologies used by the Miysis DIRCM System. One example is the mid wave focal plane array sensor used, which is the latest generation device from the Leonardo detector facility in Southampton, UK. It uses a well proven FPA, but additionally has a customised read-out circuit optimised specifically for DIRCM. This is installed in an extremely robust integrated dewar/cooler assembly which utilises a small, lightweight, long-life cooler, fundamentally necessary to operate effectively in the varied environments that a DIRCM system may see.

The laser is also the culmination of many years of technology investment by Leonardo. This technology has then been packaged into an extremely small, robust unit capable of operating effectively over the full environmental envelope necessary using Leonardo's world-leading design for manufacturing capability.

The sightline stabilisation and tracking algorithms are the latest iteration of algorithms that have been at the heart of many of our most successful laser pointing and stabilisation products, including the Leonardo Laser Pointer/Tracker used in the AN/AAQ-24(V) DIRCM System. The beam director sub-system has been designed from the outset to capitalise of this extensive pointing and stabilisation capability.

Additionally, during the course of the Miysis DIRCM System development programme, to compliment the full System Design Verification and Qualification Programme that was completed in 2016, the key sub-systems have also been subjected to extensive reliability growth and demonstration testing to ensure that the system provides the requisite extremely high reliability from day one.

2. CONSIDERATIONS IN THE DESIGN OF AN ADVANCED DIRCM SYSTEM

While conceptually the requirements for a DIRCM system are straight forward, in that the system must detect missiles launched at the target platform, and then apply the requisite, modulated Energy-on-Target (EoT) as rapidly as possible, there are a number of key attributes that must be considered in the design of an advanced DIRCM System.

2.1 The Need for DIRCM

The need for DIRCM Systems is now well established. One of the greatest threats to any airborne platform is the IR guided MANPADS surface to air missile. These weapons are inexpensive, very easy to operate and use a lightweight and disposable launch mechanism. Weapons developed as much as 50 years ago remain lethal today. Additionally, all generations of these weapons have been modified to become increasingly resistant to standard countermeasure decoy flares. As a result, a high powered Laser DIRCM System is the most effective defence.

Furthermore, the more modern IR MANPAD threats can engage even low signature threats from any aspect, making it essential to provide coverage over 360° in azimuth, and as much elevation coverage as the platform installation permits.

2.2 Missile Warner Sub-system Considerations

For successful DIRCM operation, generally the MWS requires a number of key modifications to optimise performance within a DIRCM System.

Rapid threat declaration is essential to minimise the time between missile launch and jamming laser energy being incident on the threat seeker. This is critical in ensuring good protection for short range missile engagements, and also to allow multiple engagements on one side of a platform to be effectively handled by a single DIRCM Laser Pointer/Tracker.

This early declaration approach generally requires a fairly significant change to the baseline software used for a flare dispensing MWS, and can result in the MWS having a rapid, high probability of detection (Pd), at the expense of a higher false alarm rate (FAR) which would be completely unsuitable for flare dispensing.

However, as the DIRCM uses a high resolution, narrow field of view (FoV), mid wave infra-red fine track sensor (FTS) to acquire and establish track, confirming the detection as a threat, the resulting overall DIRCM System probability of detection remains extremely high with the false alarm rate being low, despite the early MWS declaration.

Moreover, because the laser output is not a finite resource in the way that flares are, the benefits of early jamming of a potential threat very much outweigh the potential downside of jamming a false target. Thus, the system trades in this area are very different to those of a flare based system.

In addition to the above timing considerations, the accuracy of the threat cue provided by the MWS for successful, rapid DIRCM hand-off needs to be substantially higher than that required for effective flare release, making some flare based MWS's not suitable for use with a DIRCM System.

2.3 DIRCM System Effectiveness

DIRCM systems defeat IR MANPADS by injecting modulated laser energy directly into the threat missile seeker, disrupting the seeker guidance algorithms, preventing the threat missile from tracking its target and often inducing a false guidance signal for the missile.

It is fairly obvious that rapid disruption of the threat seeker is essential for close-range engagements where missile time of flight is extremely short. However, while less obvious this is also important for longer range engagements, where early application of jamming modulation still significantly increases the probability of rapid seeker defeat, particularly for advanced threats. Four main parameters contribute to the rapid disruption of missile guidance:

- The Time to achieve effective Energy on Target (T_{EoT});
- The magnitude of the incident Energy on Target (EoT), or more correctly the incident in-band irradiance (W/cm^2);
- The effectiveness of the jamming modulation against the engaged threat seeker (and the missiles control system);
- Effective coverage over the missile engagement envelope (Laser based systems require line-of-sight to the target).

The T_{EoT} is a combination of the time taken for the MWS to detect the threat and pass the threat direction data to the DIRCM, and the time taken for the Pointer/Tracker to slew to, acquire and track the threat, and commence laser firing.

The EoT capability of a DIRCM System comes from a number of contributing elements, including the actual laser beam output characteristics (at the DIRCM Laser Pointer/Tracker dome, not out of the laser itself), the system laser sightline tracking accuracy (i.e. the accuracy with which the laser sightline tracks the missile seeker), the output laser beam width, the output laser beam quality, plus a range of atmospheric effects. All of these combine to define the actual laser energy that will be incident on the seeker.

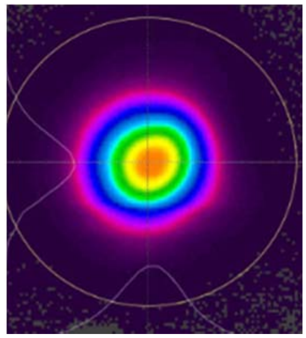

Figure 2: Miysis DIRCM Output Beam Profile

As can be seen from Figure 2, the output laser beam profile from the Miysis DIRCM System is extremely good. A key element in achieving this quality of beam out of the system is the fact that the laser is directly coupled rather than remotely coupled via a fibre link.

This beam quality, combined with extremely accurate tracking, (i.e. a 95th Percentile laser line-of-sight tracking error over a rolling 0.2s period of less than 1/3rd of the 1/e^2 beam radius), provides for extremely high and consistent EoT.

Note that both the beam quality and the tracking accuracy need to be maintained over the full environmental envelope that the system may be subjected to.

When assessing the likely effectiveness of a DIRCM System against a specific missile seeker it is important to ensure that every pulse of a jamming modulation sequence incident on the seeker is above the effective incident irradiance threshold required for that specific jamming modulation. This means using an rms video tracking error to determine DIRCM System effectiveness is a completely invalid approach, and will result in a larger over-estimate of system performance.

There are a number of design elements in the Miysis DIRCM System that are fundamental to achieving the necessary laser line-of-sight tracking error, including an advanced continuous laser autoboresight mechanism, advanced threat seeker tracking techniques and complex sightline stabilisation and control algorithms, including a through-nadir tracking capability.

The actual DIRCM laser modulation is controlled through a laser jamming code. A single, known threat can be readily defeated by illuminating the seeker with a laser modulation precisely matched to its guidance characteristics. However, as the threat type is invariably unknown, it is essential that an operational jamming code is capable of providing a modulation pattern that is effective against a full range of operationally fielded threats, properly considering production variability, while still achieving effective defeat within the shortest possible engagement periods.

While the actual performance characteristics of the Miysis DIRCM System are above the classification level of this paper, it is clear that for the system to be effective for the shortest range MANPADS engagements achievable with the most advance threats, the combined time for MWS declaration, DIRCM acquisition and track and time taken for the jam code to be effective must be no more than 2.5s.

Additionally, for the jam code to be effective, particularly against the more modern threats, the energy incident on the seeker must provide the high jam-to-signal (J/S) levels required to protect the full range of platforms, including those with the highest of signatures.

Advanced IR MANPADS can attack from any aspect. It is therefore imperative that the DIRCM threat detection and engagement sub-systems have the greatest possible MWS Field of Detection and Laser Pointer/Tracker Field of Engagement respectively.

For rotary wing platforms, the minimum number of MWS sensors required is generally five, which, if correctly sited, will give 360° azimuth coverage and elevation coverage from straight down to the rotor blade obscuration region. For fixed wing aircraft, six sensors are the optimum, in that these will provide full spherical coverage around the platform, if correctly sited.

Leonardo has in the past considered the use of a single Laser Pointer/Tracker to provide DIRCM System protection to aircraft (both fixed and rotary wing). However, regardless of location and the degree of hyper-hemispherical coverage, a single Laser Pointer/Tracker cannot provide full coverage around the aircraft, particularly during manoeuvre, and would therefore leave a significant portion the potential missile engagement region unprotected, as shown in Figure 3. This could degrade the aircraft survivability against advanced threats by as much as 40% in some circumstances.

Previous generation Leonardo DIRCM Pointer/Trackers had significant hyper-hemispherical coverage, which increased the complexity of the design and manufacture of the product. Furthermore, almost without exception, the aircraft installations for these systems could not utilise the full engagement coverage available from the Pointer/Trackers due to a combination of fuselage obscuration and availability of optimum locations.

Figure 3: FoE Limitations with Single Laser Pointer/Tracker

As a consequence Leonardo has designed the Miysis DIRCM System as twin-headed from the outset, with sufficient overlapping coverage to seamlessly pass threats between Laser Pointer/Trackers during an engagement, if required. For the majority of platforms, a twin-headed System, when installed appropriately, provides sufficient coverage to protect the aircraft. For the very largest of platforms where the coverage provided by two heads is insufficient, the baseline system can be grown to accommodate a third head.

The two Laser Pointer/Trackers are integrated via completely digital interfaces with a single DIRCM System Control Electronics Unit. This approach provides a number of benefits, including minimising the mass and volume of the Laser Pointer/Trackers, which are the units that need to be positioned in typically non-standard locations on the platform to optimise the engagement coverage, while also allowing the use of ruggedised COTS/MOTS hardware in the electronics unit.

In order to mechanise a rapid hand-off from the MWS to the DIRCM Laser Pointer/Tracker it is necessary for the threat to be positioned within the field of view of the Laser Pointer/Tracker once it has slewed to the position indicated by the MWS. In addition to requiring the MWS to accurately cue the threat position to the DIRCM System, this also places a number of constraints on the installation design. In particular, the MWS sensors and Laser Pointer/Tracker assemblies must use a common sightline reference, and it is essential that the alignment between the two is known, and maintained accurately through all phases of flight. For some installation designs, dynamic platform flexure can have a significantly negative impact on this alignment.

Additionally, any errors resulting from platform/target motion and latency in threat position reporting must also be corrected for.

The Miysis DIRCM System addresses these requirements through a number mechanical and electronic means, including predictive feed-forward mechanisms and dynamic transfer alignment techniques.

3. THE IMPORTANCE OF EXTENSIVE DEVELOPMENT TEST AND EVALUATION

Given the critical nature of air platform protection, it is essential that development of systems like DIRCM is supported by an extensive set of test and evaluation activities.

This work included:

- Lab and SIL based development testing;
- Independent reliability characterisation and performance characterisation;
- US based dry and wet-shot live-fire testing;
- Combined target and own-ship motion full system testing, characterisation and performance validation;
- Operationally representative ground trials;
- Helicopter flight trials;
- Further reliability demonstration and growth testing;
- UK MoD CDAS Programme (SIL, ground and flight trials);
- 2014 ground and flight trials;
- 2014 missile live-fire trials;
- Production standard system level design verification & qualification testing (DVT & Qual);
- Customer led independent verification & validation (IV&V) testing & analysis;
- 2018 missile dry & wet-shot five-fire testing.

The following sections describe some of the test and evaluation highlights.

3.1 The Miysis DIRCM System Integration Laboratory (SIL)

The requirement for comprehensive System level testing at every stage of the development programme led Leonardo to investment significantly in DIRCM test and evaluation infrastructure and capability during the Miysis DIRCM System development programme.

One of the key assets that resulted from this investment is our world leading, state of the art, DIRCM System Integration Laboratory (SIL) facility, shown in Figure 4.

Figure 4: The Miysis DIRCM System SIL

This facility has been developed from a long standing, existing DIRCM SIL test capability that was used for our previous generation products, and comprises two fundamental elements:

- A six-degree-of-freedom robot arm to simulate platform motion, onto which a full, multi-headed/multi-threat warner DIRCM system can be mounted in representative orientations;
- A rotating target motion simulator that is specifically designed to emulate the most demanding missile motions that may be seen during a real engagement.

Mounted on the target motion simulator is the target module. This module contains both UV and IR controllable target sources, and additionally also has a very high frame rate FPA imager co-located with these sources, allowing the position of the laser spot relative to target to be accurately measured at carrier pulse frequencies while the system is subjected to simultaneous, fully representative target and platform motion.

Underpinning all of this is a control and recording system that allows complex test scenarios to be automatically implemented and a full set of data recorded for subsequent analysis.

This world leading facility provides the capability for complete end-to-end testing of a full, multi-headed/multi-threat warner DIRCM System while under representative platform motion and with representative target motion for complex scenarios.

3.2 Field Testing

In addition to extensive simulation, key technology component testing, laboratory testing, SIL testing, and environmental testing, the Miysis DIRCM System and its constituent elements has also been subjected to extensive live-fire and flight testing. Some of the significant events undertaken are described below.

Figure 5 – The Miysis DIRCM System during Early Flight Testing in 2008

One key element of this work was undertaken by the UK DSTL as part of the UK CDAS TDP, where an extensive ground and flight trials evaluation of a pre-production standard, twin headed Miysis DIRCM System was undertaken.

This testing included system performance assessment for complex threat scenarios, end-to-end stimulation through to energy on target, Laser Pointer/Tracker to Laser Pointer/Tracker hand-off during jamming and DAS/DIRCM interaction, and was extremely instrumental in maturing and refining the final production standard Miysis DIRCM System design. This programme was also where most of the ground work was done that has now been picked up by SCI-260/N-DAS.

Figure 6 - Miysis DIRCM during CDAS Flight Testing in 2012

In the spring of 2013, Leonardo was asked to provide a DIRCM system to allow test and evaluation of jamming codes.

In support of this work, the French Direction Générale de l'Armement (DGA) offered their CASA 212 as a test platform, and Leonardo and the DGA worked through the later part of 2013 to design, certify and manufacture an appropriate installation. This work was assisted by a number of groups including Airbus D&S (now Hensoldt), the Royal Canadian Air Force, Defence Research and Development Canada (DRDC) and the UK MoD/DSTL.

The flight trials configuration was successfully subjected to extensive ground test and evaluation at the DGA laser range at Cazaux over a number of weeks in early January 2014.

The work included demonstrating rapid and effective capability to jam an operationally representative spread of threats, for a range of simulated platform signatures, from initial MWS acquisition through hand-off, acquisition and track to laser firing and modulation.

Additionally, comprehensive high speed radiometric measurements were made of the laser output to ensure that the desired jamming code was correctly output.

Following this ground testing, the system was integrated onto the aircraft in February 2014, and during the course of the trial a significant number of runs were undertaken against a seeker rig, including a series of live VIP demonstrations. During this testing:

- Rapid MWS detection, hand-off, DIRCM acquisition, track and EoT was demonstrated for a variety of flight profiles and ranges;
- A spread engagement ranges were tested out to the maximum seeker acquisition ranges of the seekers under test;
- An assessment of the results indicated that The Miysis DIRCM System has the capability to successfully jam a variety of operationally representative MANPAD threats using the jam code under test.

The test and demonstration of the Miysis DIRCM System integrated with appropriate jam codes was considered a great success by all the parties involved in the programme.

Figure 7 – The Miysis DIRCM System during the 2014 Flight Trials (Photo's courtesy DGA)

Following rapidly on from the flight trial, in May 2014, Leonardo, in conjunction with Saab and RUAG, supported a multi-national missile live-fire trial.

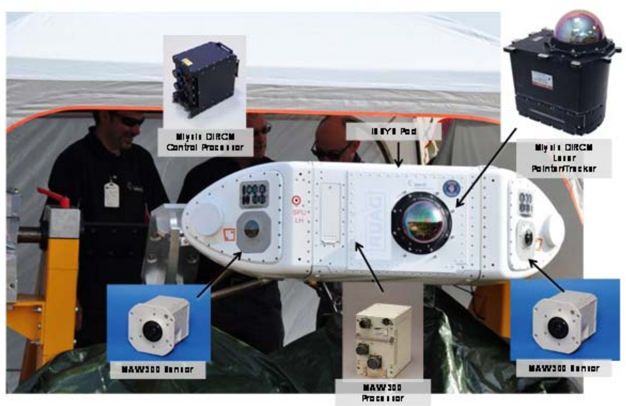

Figure 8 – The Miysis DIRCM System during the 2014 DIRCM Missile Live-Fire Testing

For this trial, Leonardo provided a full production standard Miysis DIRCM System, integrated with the Saab MAW 300 and installed in a RUAG pod. Following successful Lab/SIL/Roof-lab testing, the equipment was shipped to the trial at the end of April 2014.

The trial was successfully undertaken during May 2014; all of the missiles that were successfully fired during the course of the trial were acquired, handed-off and tracked with the accuracy necessary.

3.3 Qualification and Design Verification Testing

In addition to the above test and evaluation, the Miysis DIRCM System has been formally validated over its specified environment via an extensive Design Verification and Qualification programme, which complete in 2016. The two primary elements of this programme were:

- Qualification Testing, to prove that the system operates across a fully representative environment as defined by appropriate Military Standards. This included qualification for the Airborne Rotary Wing, Turbo-prop and Jet Transport;
- Design Verification Testing, to prove that the system performance levels defined in the Product Specification are achieved and maintained throughout the qualified environment, through the product life.

Those tests and the associated analyses supports Leonardo issuing a compliance statement against the Product Specification.

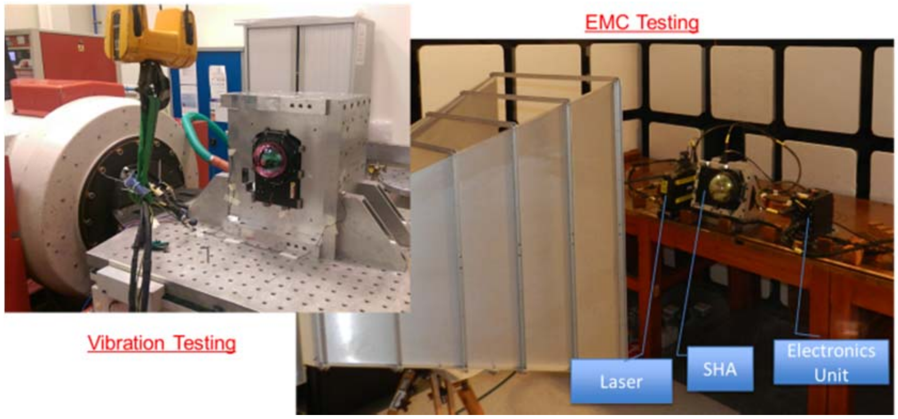

Figure 9 – The Miysis DIRCM System during Vibration and EMC Tests

Additionally, following on from Leonardo's formal testing, several customers have subsequently undertaken a level of Independent Verification and Validation testing (IV&V) to confirm the Leonardo DVT & Qual results and the anticipated System level installed performance.

3.4 Recent (Post DVT/Qual) Field Testing

In addition to the various strands of testing and validation described above, Leonardo recently supported a UK MoD sponsored live-fire activity.

The UK had a specific objective to demonstrate, in a live fire environment, a complete, operationally representative, UK NDAS-compatible EW System, comprising:

- An IR Threat Warner (Thales UK Elix-IR);
- An advanced DIRCM System (Miysis DIRCM);
- A Leonardo (Luton) EW Controller;
- An N-DAS/SCI-260 compatible architecture;
- A UK MoD (DSTL) developed operationally representative test jamming waveform.

The team also had an objective to facilitate the fielding and assessment of other DIRCM jamming waveforms deployed in the UK DIRCM hardware.

The major components of this DIRCM System are shown in Figure 10 below.

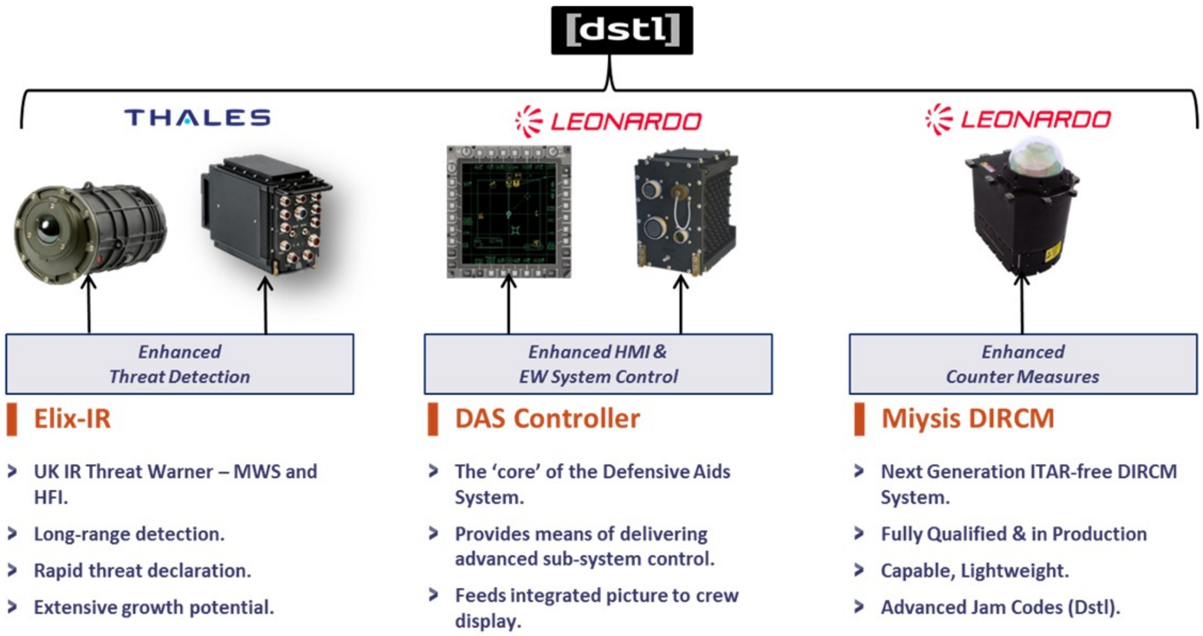

Figure 10 – The UK DIRCM System: Major Components

For the trial these components were then integrated into a representative pod supplied by Terma. This is shown in Figure 11 below.

Figure 11 – The UK DIRCM System (including Miysis) at the Recent Missile Live-Fire Trial

While details of the performance demonstrated are above the classification of this paper, a number of conclusions can be shared:

- The complete UK DIRCM System as described above performed at the trial *"as expected"* by the UK DSTL and the supporting industry team members;
- Both the MWS threat declaration times and the Miysis DIRCM slew, settle, track & jam were very quick;
    - These combined to give an extremely rapid Time to EoT;

- The Miysis DIRCM System tracked (dry shots) / jammed (wet shots) every threat declared by the MWS;
- Effective short range shot capability was demonstrated;
- Effective long-range shot capability was demonstrated, including Post-Burn Out (PBO) tracking at maximum likely range;
- Twin-shot defeat capability with a single head was demonstrated.

Figure 12 shows some examples of missile behaviour at the on-set of jamming.

Figure 12 – Examples of missile behaviour at the onset of jamming (Photo's courtesy DSTL)

Initial analysis of the trials data has indicated that the trial was an extremely successful missile live-fire laser jamming test of a complete UK DIRCM System, with effective threat defeat performance demonstrated against a spread of IR guided MANPADS threats.

4. CONCLUSIONS

Leonardo has undertaken a progressive, phased development for the Miysis DIRCM System over the last ten years. This development capitalised heavily on key IR sensor, laser and sightline control technologies made available from Leonardo internal company advanced technology investment. It utilised the latest open-architecture system concepts and MOTS/COTS hardware was used wherever possible.

This open-architecture design readily supports integration of the equipment onto aircraft platforms, either as a stand-alone DIRCM solution or as part of a broader Defensive Aids Suite.

In addition, a central element of the development process was to leverage the Leonardo extensive domain knowledge in design, manufacture and in-service support of advanced airborne electro-optical systems including DIRCM, and applying our experience in design for ease of manufacture and in growing the reliability of such systems in real operational environments.

All of the development work was underpinned by extensive laboratory, SIL, livefire, ground and flight testing.

This approach, coupled with a phased development programme that included extensive test and evaluation at every stage, has produced a mature, highly reliable, elegant and low risk system, now in series production for a number of different customers to be installed on a range of different aircraft types.

Recent UK MoD led missile live-fire trials continued to underpin the performance and capability of the Miysis DIRCM System.