

## Flight Testing the Nimrod MRA4

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### ***ABSTRACT***

*The Nimrod MRA4 has been designed to replace the Nimrod MR2 maritime patrol aircraft currently used by the Royal Air Force. Whilst drawing on the airframe configuration of the existing Nimrod, the MRA4 is essentially a new aircraft comprising 95% new design and a new fully integrated mission system. It is undoubtedly the most complex aircraft built by BAE SYSTEMS, with the most challenging flight test programme in terms of time scale.*

*The flight trials are being conducted as a Joint Trials Team in conjunction with, the Defence Procurement Agency, the RAF and Qinetiq. Such trials support can be provided both on board (using flight test observers) and/or via a telemetry down link to the Warton flight test ground station.*

*This paper is to give an overview on the progress of the Nimrod MRA4 flight trials and highlight the innovative methods being used to deliver an efficient and affordable flight test programme.*



**Figure 1 Nimrod MRA4 PA01 During High Speed Taxi Trials**

Gill, A.; Bellamy, A. (2005) Flight Testing the Nimrod MRA4. In *Flight Test – Sharing Knowledge and Experience* (pp. 9-1 – 9-18). Meeting Proceedings RTO-MP-SCI-162, Paper 9. Neuilly-sur-Seine, France: RTO. Available from: <http://www.rto.nato.int/abstracts.asp>.

## 1.0 INTRODUCTION

On 2 Dec 1996, BAE Systems were awarded a fixed-price contract to be the sole prime contractor and design authority for a virtually brand new aircraft – Nimrod MRA4.

Nimrod MRA4 is a worthy and hugely capable successor to the successful but ageing Nimrod MR2. The aircraft is equipped with the latest in sensors and mission systems for the ‘three-in-one’ maritime patrol mission. This includes Anti Submarine Warfare, Anti-Surface Unit Warfare and Search And Rescue.

By the end of 2002, it was clear that a combination of factors arising from the overlap of development and production activities was leading to further scheduling difficulties. In response to this, agreement was reached in February 2003 between BAE SYSTEMS and the MoD to make changes to the contract structure. The new contract agreement consists solely of design and development using the first three aircraft for development flight trials.

In addition to demonstrating cost and schedule performance, it is expected that once an acceptable level of product maturity had been proven through flight trials, that the contract for the production of the remaining aircraft will be awarded.

## 2.0 TRIALS AIRCRAFT

The Nimrod MRA4 flight test programme comprises three development aircraft, PA01, PA02 and PA03.

PA01 which flew for the first time in the summer of 2004 is the principal air-vehicle test aircraft and will be used for handling trials, flutter, performance, stalling and general systems testing. PA01 temporarily differs from the production standard MRA4 because the majority of the mission system has been removed and replaced with a comprehensive suite of instrumentation equipment and flight test workstations.

The second development aircraft (PA02) flew for the first time at the end of 2004 and was the first mission systems aircraft to fly. In addition to mission systems testing, PA2 is the primary trials aircraft for hot/cold climatic trials and weapon store safe separation testing.

PA03 is expected to make its first flight during the summer of 2005. PA3’s primary trials involve the testing of Mission System Avionics (MSA), with a bias towards DASS and ESM clearance. The aircraft is also being used for Avionics Testing (navigation-aids and AFCS) and Human Engineering Noise and Vibration Trials. PA3 is the dedicated aircraft for lightning testing.

## 3.0 FIRST FLIGHT

At 1431 hrs on Thursday 26<sup>th</sup> August 2004, the first development Nimrod MRA4, PA01, lined up for take-off from runway 25 at the BAE Systems Woodford site, signalling the start of the flight test phase for what is potentially the very last new British designed and built military aircraft programme. The aircraft was airborne for 2 hours and the flight met all of its major objectives:

- Low speed handling assessed down to  $V_{REF} - 10$  kts.
- Basic airframe systems in normal operation checked.
- Air data system calibrated with chase aircraft,
- Yaw Damper engaged and assessed.
- Wing flaps cycled through full range.

- Landing gear retracted and extended.
- Lateral and direction handling assessed.
- Longitudinal static stability assessed.
- Initial engine handling completed on all 4 engines, including slam accels and decels.



**Figure 2 Nimrod MRA4 PA01 takes off from Woodford runway 25 on flight 1.**

The aircraft was accompanied by a Pilatus PC-9 and a BAe Hawk T1 chase aircraft throughout and first flight concluded after two hours airborne with a successful landing on runway 26 at BAE Systems flight test centre at Warton.

The aircraft was flown by a flight crew of 4, captained by John Turner, BAE Systems Nimrod MRA4 Chief Test Pilot. The other crew members were Bill Ovel (Co-pilot), Paul Bayley (FTO) and Harry Nockolds (Mission Crew - Cabin Safety). In addition, the flight crew was supported throughout by a team of flight test engineers, monitoring the flight via a data telemetry link at both Woodford (utilizing the BAES mobile telemetry groundstation) and Warton.



**Figure 3 Nimrod MRA4 PA01 during flight 1 accompanied by chase aircraft.**

The first flight was the culmination of months of intensive effort by the whole flight trials team, including full up simulator rehearsals, with the simulator linked to the Warton telemetry ground station. This allowed the entire team to practice and refine the operating procedures and the sortie profile. In the event, the flight itself was almost an anti-climax – the aircraft proved itself to be extremely reliable and didn't spring any major surprises.

## Flight Testing the Nimrod MRA4

The flight did uncover a few minor anomalies that warranted follow-up action:

- An un-commanded early rotation during the take-off roll.
- Failure of both radio altimeters.
- Elevator trimmer gearing higher than desirable.
- Alerting system generating some spurious caution and warning indications.

In flight experience also confirmed the pre-flight handling and performance predictions, both from modelling and flight simulation – the aircraft behaved exactly as expected.



**Figure 4 Nimrod MRA4 PA01 lands on Warton runway 26 at the conclusion of Flight 1**

First flight is a defining moment in any new aircraft programme and the Nimrod MRA4 exceeded all of our expectations. It is an event that those who participated in it will continue to savour over the years to come.



**Figure 5 Nimrod MRA4 First Flight Crew congratulated by Senior Management**

## 4.0 SORTIE CHRONOLOGY

The following section tabulates the flight test activities to date, discounting the engine ground run phase for each aircraft, which, although organised by Flight Test Engineering, is a manufacturing activity.

Iron Bird Rig testing of the wheel brakes had suggested that there might be issues with the feel and stability of the system (see later), consequently, the programme was reorganised to allow PA01 to undertake an early low speed taxi to confirm the rig testing. Once complete, the aircraft returned to the engine ground running programme until a taxi clearance of greater than 70 kts was available.

Immediately following Flight 1, PA01 undertook an upgrade programme. Although a higher standard of flight deck display software was available prior to Flight 1, the flight crew elected to remain with the flight deck standard that had been used throughout taxi and engine ground runs for flight 1, accepting the higher workload. Having achieved flight 1, the flight deck was upgraded to flight deck display software version L4.2, which has reduced pilot workload.

PA02 joined the programme in December 2004, achieving one of the major business objectives for the project – flying the first two aircraft before the end of 2004.

At the time of writing, PA01 has recommenced flight trials after completion of Ground Resonance Testing. It's priority tasks will be high and low speed flight envelope expansion – primarily flutter, handling and stalling. PA02 is currently at Norwich Airport for painting before flying to Woodford for an engineering upgrade pause. PA03 is currently being prepared for engine ground running.



**Figure 6 Nimrod MRA4 PA01 flaps & gear up during flight 1.**

Date	Aircraft	Activity	Flight Time	Objectives
12/06/04	PA01	Taxy 01	-	Low speed braking and NWS assessment.
13/06/04	PA01	Taxy02	-	Low speed braking and NWS assessment.
09/07/04	PA01	Taxy 03	-	Sub 70 kts accel / stop brake testing.
21/08/04	PA01	Taxy 04	-	High-speed brake testing.
23/08/04	PA01	Taxy 05	-	High-speed brake testing.
24/08/04	PA01	Taxy 06	-	High-speed brake testing & lateral FCS asst.
25/08/04	PA01	Taxy 07	-	Nose raises for intake compatibility.
26/08/04	PA01	Flight 1	1:56 hrs	Shakedown & ADC checks.
13/10/04	PA01	Taxy 08	-	High-speed brake testing with brake mods.
15/10/04	PA01	Flight 2	2:13 hrs	Shakedown with FCS mods.
01/11/04	PA01	Flight 3	1:26 hrs	Air Data Calibration low level tower fly-bys.
04/11/04	PA01	Flight 4	2:34 hrs	General Handling and IFF Mode C assessment.
19/11/04	PA01	Taxy 09	-	High-speed brake testing with brake mods.
25/11/04	PA01	Flight 5	2:01 hrs	Anti-ice dry air testing & general handling.
08/12/04	PA02	Taxy 01	-	Low speed braking and NWS assessment.
09/12/04	PA02	Taxy 02	-	High-speed brake testing.
10/12/04	PA02	Taxy 03	-	High speed braking & nose raise.
15/12/04	PA02	Flight 1	2:04 hrs	Shakedown.
21/12/04	PA02	Flight 2	1:26 hrs	General Handling.
13/01/05	PA02	Flight 3	2:03 hrs	Radio Nav Aids
08/02/05	PA02	Flight 4	3:07 hrs	General Handling
10/02/05	PA02	Flight 5	2:25 hrs	Radar Functionality & Initial Assisted Re-lights.
17/02/05	PA02	Flight 6	2:54 hrs	Approach Aids
21/02/05	PA02	Flight 7	2:23 hrs	Radio Nav Aids
25/02/05	PA02	Flight 8	3:03 hrs	Radio Nav Aids
01/03/05	PA02	Flight 9	2:31 hrs	General Handling
03/03/05	PA02	Flight 10	3:48 hrs	Radar Functionality & ECS assessment
14/04/05	PA02	Flight 11	2:00 hrs	General handling
19/04/05	PA02	Flight 12	2:07 hrs	General handling
21/04/05	PA02	Flight 13	2:47 hrs	Radio Nav Aids / Autonomous Navigation
27/04/05	PA02	Flight 14	2:19 hrs	Radio Nav Aids / Transit to Norwich
29/04/05	PA01	Flight 6	3:47 hrs	Engine Relights
04/05/05	PA01	Flight 7	0:57 hrs	Slowdowns / Fuel Dumping

**Table 1 History of Nimrod MRA4 Flight Test Activities**

## 5.0 HIGHLIGHTS AND ACHIEVEMENTS

In addition to first flights, there have been a number of other significant highlights:

- Ground Resonance Testing on PA01 commenced November 2004 and completed in February 2005.
- Limited IMC clearance (cloud penetration) achieved by December 2004, extended IMC clearance achieved by February 2005.

- Modifications to primary wheel brake system tested successfully in October 2004.
- 3 RAF pilots have flown the aircraft.
- 10 crew operations demonstrated including RAF mission crew.
- Initial Airframe and Intake Anti-Ice dry air testing completed. Clearances for anti-ice systems available for trials aircraft in support of IMC clearances.
- Air data calibration within initial flight envelope completed.
- General handling within the initial flight envelope completed.
- Flight envelope expansion in line with planned programme..
- Initial air assisted re-lights demonstrated on both an outboard and inboard engine.
- Tactical depressurisation for sonobuoy releases demonstrated.
- Thales Searchwater 2000MR radar demonstrated in principal modes of operation.
- AQS 970 acoustics processor operated in simulated / training modes.
- 3 x V/UHF radios tested and assessed using communications suite.
- Completion of avionics testing required to support initial European detachment.

## **6.0 TECHNICAL DIFFICULTIES**

As would be expected in the early phases of testing a brand new aeroplane, a number of technical difficulties have been encountered:

1. Hydraulic instability in the primary wheel braking system revealed during high speed taxi trials resulted in uncomfortable ride when anti-skid was active. Whilst considered safe for flight initial flying progressed using the alternate braking system (with primary as backup) until a modification to the primary system could be embodied and tested successfully. Aircraft now operating normally, using primary braking system.
2. During flight 2 smoke and fumes were seen to vent from one of the flight deck ECS outlets. Following investigation, the problem was caused by a fault in the flight deck temperature selector, which caused the associated ECS pack to run at full hot. Some build residue vaporising caused the smoke and fumes. There has been no recurrence of the problem.
3. An apparent flap failure mode was identified on PA1 Flight 3. The FCC drills were carried out and flap function restored, allowing the aircraft to return to Warton. The problem was traced to a manufacturing fault in the flap selector baulk mechanism, which has now been rectified.
4. The Searchwater radar exhibited overheating problems on the early flights of PA02, preventing some of the planned testing from being carried out. After investigation during subsequent engine ground runs, it was found that the ECS cooling flow to the radar was deficient and the radar was shutting itself down. Pending a long term solution, a short term fix was effected by reconfiguring the associated part of the ECS using CBs. The radar was operated successfully on PA02 Flight 3 and a significant proportion of the required dedicated radar testing has subsequently been completed.

These incidents apart, the aircraft has proved to be extremely reliable. The despatch rate has been almost 100%.

## **7.0 FLIGHT TEST INNOVATIONS**

### **7.1 Concept of Operation**



**Figure 7 Nimrod MRA4 PA02 Flight Deck**

The Nimrod MRA4 offers a high degree of flexibility for conducting flight test operations. It has the proven data telemetry system developed and used by the UK fast jet programmes but it also has an onboard data analysis suite in the cabin of the aircraft. This allows it to exploit the best of both fast jet and heavy aircraft real time test methodology. The data analysis software is common to both the onboard workstations and the telemetry ground station, so the engineers have the same displays and tools available wherever they're located. The intent being to make the transition from onboard to telemetry data analysis as seamless as possible. Indeed, crew intercom is broadcast as part of the encrypted telemetry data stream (termed 'hot mic') so FTE's in telemetry are really just an extension of the aircraft crew.

The aircraft has a minimum flight crew for test flights of 2 pilots, a flight deck observer and a cabin safety supervisor. Both Flight Test Observers and Mission Aircrew, depending on the type of flight being undertaken, can supplement this basic crew.



Figure 8 Nimrod MRA4 PA02 Mission Deck (TACCO & Comms Op)

All flight trials are assessed and categorised for risk and graded as Low, Medium or High, depending on the inherent hazards. The crew constitution is managed via the Flying Order Book, taking due account of the risk categorisation of the flight.

Consequently, the concept of operations has to be flexible enough to account for the crew required to perform the test plus respecting the need to minimise the number of people exposed to the risks of test flying.



Figure 9 Nimrod MRA4 PA02 Mission Deck (Radar Op)

## **Flight Testing the Nimrod MRA4**

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The concepts for the test aircraft were initially evolved by studying the traditional methods of fast jet and heavy aircraft test. They were then examined during a series of simulator rehearsals (see later section) and have been further refined in light of the test flights on the aircraft to date.

Consequently, the MRA4 programme has adopted the following concepts of operation for the test aircraft:

### **7.1.1 High Risk Air Vehicle Trials**

- Telemetry Monitoring mandatory.
- Crew emergency escape system enabled (escape hatches, air dam & parachutes).
- Testing conducted overland (crew not equipped with PSPs).
- Minimum crew - no cabin FTOs on board aircraft.
- Selected FTE team located in telemetry ground station, including a Safety Pilot if necessary.
- Design IPT invited to witness / support testing in telemetry ground station.
- Test Direction provided by telemetry ground station.

### **7.1.2 Medium & Low Risk Air Vehicle Trials - Telemetry Available**

- Telemetry monitoring is desirable but not mandatory, could elect to fly without.
- If telemetry available and appropriate, it will be used.
- Selected FTE team will be located in telemetry ground station.
- Design IPT invited to witness / support testing in telemetry ground station.
- Test Direction may come from telemetry.
- Cabin FTOs carried, sufficient to continue testing if telemetry support lost.
- Lead FTO nominated to act as reversionary Test Director, should telemetry be lost.

### **7.1.3 Medium & Low Risk Air Vehicle Trials - Autonomous Operation**

- Telemetry known to be unavailable or not appropriate - premeditated decision to fly without it.
- Cabin FTO crew includes Test Director onboard aircraft in the cabin. Location of Test Director transparent to flight deck crew – still just a voice in their headsets.

### **7.1.4 Mission Systems Testing**

Mission Systems testing is being performed in two ways – dedicated and simultaneously. Following the contract revision in early 2003 (see Section 1.0), the amount of dedicated mission system sensor trials was drastically reduced. The basis for this decision was to gather as much information as possible by scheduling mission systems testing concurrently with the air vehicle trials, due in the main, to the confidence gained in the mission system during extensive rig testing. Consequently, as long as the risk categorisation of the flight allows it, elements of the mission crew are routinely flown on air vehicle flights. This is the concept of simultaneous test.

To date, the Searchwater 2000 radar, sonobuoy acoustics processor and V/UHF communications systems have been exercised in this way. The air vehicle testing is unaffected by the simultaneous mission system testing however, if it becomes clear at the planning stage that a mission sensor test would affect the primary air vehicle test, then dedicated time is allocated to the mission systems test.

The aim with mission systems operations is to emulate the proven processes for air vehicle trials, again to make the transition between AV and MS flying as seamless as possible.



Figure 10 Nimrod MRA4 PA02 onboard FTE Workstations

### 7.1.5 Terms of Reference

In order to mechanise these different operational methods, the following roles and names have been adopted:

**‘Observer’** – Flight Deck Supernumerary - drives the conduct of the test in hand, briefs the test card, ensures correct switch selections are made and records pilot observations.

**‘Boffin’** – Test Director - orchestrates FTE team, directs sequence of testing and decides which tests may be omitted or terminated. Also acts as flight limitations safety monitor, including derivation of minimum and reference speeds. Provides Ground to Air communications if using telemetry.

**Specialist FTE** – Cabin FTO or Telemetry FTE - analyses data from test in hand, decides whether a good test has been achieved and provides feedback to flight crew on test results.

**Trials Co-ordinator** - Mission Deck Supernumerary - co-ordinating MS priorities with Boffin and the mission aircrew. Oversight and direction of MS testing, including driving the conduct of the test in hand, briefing the test cards and recording operator observations. Effectively, a similar role to the Flight Deck Observer.

## 8.0 FLIGHT TEST REHEARSALS

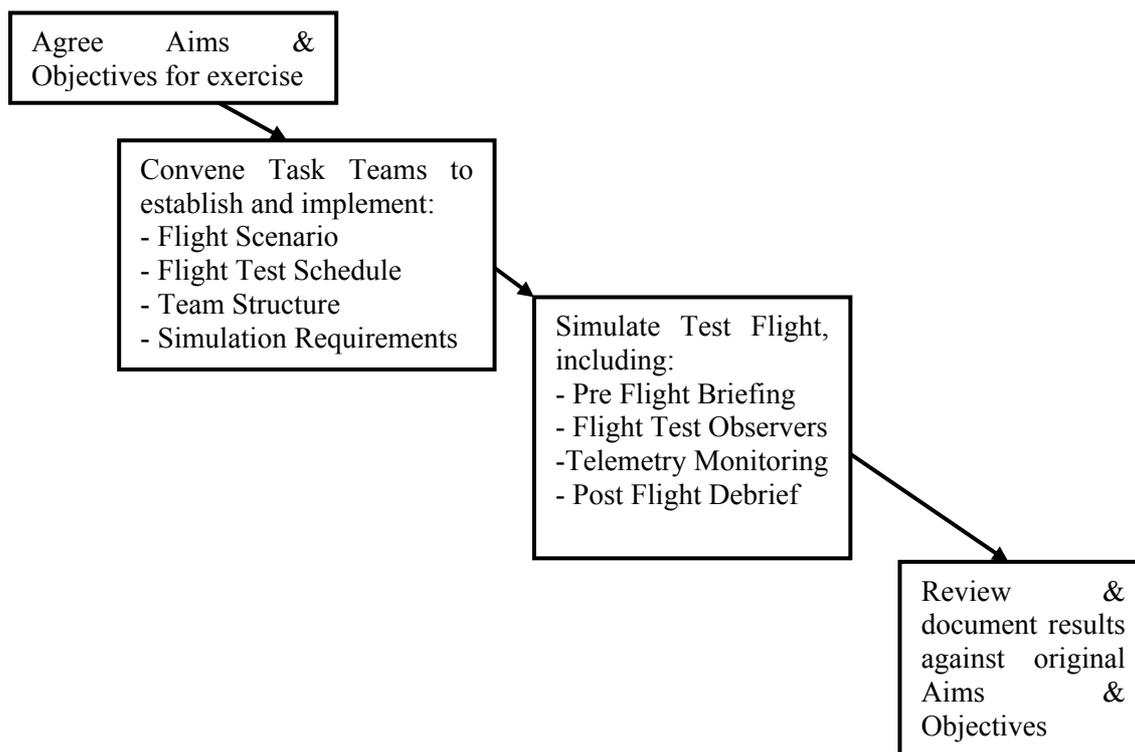
It was evident from the outset of planning the flight test programme, the Nimrod MRA4 was going to need a re-appraisal of the traditional concept of operation. A series of flight test rehearsals were carried out to investigate the alternatives in a safe and in-expensive way. This section will provide an summary of these activities, which ultimately resulted in the Flight Test and Flight Operations team being awarded a BAE Systems Chairman’s Award for Innovation.

The ultimate aim was to devise optimum concepts for the operation of the trials aircraft to increase efficiency and consequently shorten the flight test programme.

## Flight Testing the Nimrod MRA4

Existing flight simulation facilities, the Flight Deck Assessment Rig (FDAR) and the Weapon System Integration Rig (WSIR), were adapted to provide a platform for realistic flight test scenarios to be run, exploring both mission systems and air vehicle trials. The FDAR was even linked to the Warton telemetry monitoring ground station, allowing the Flight Test Engineers to use authentic real time analysis displays. The use of existing facilities was instrumental in keeping the costs down although this did require some innovative solutions to use them for a purpose for which they were never intended.

The activities were implemented in a structured manner to derive the maximum learning from each exercise:



**Figure 11 Flight Test Rehearsal Process**

The primary advantages of the rehearsal exercises has already been documented in the Concept of Operations section but there were other tangible benefits to the exercises:

1. The delays to the commencement of the flight test programme have been well documented in the media - the rehearsals provided a morale boost at these difficult times and were an excellent vehicle for bonding the team prior to real flight test commencing.
2. Flight Test Engineer training – maintaining currency during periods of no flying
3. In the absence of real flight test data, the rehearsals provided a means of underpinning the planning assumptions upon which the flight test programme was built, e.g. flight efficiency, sortie duration, sortie frequency.
4. Representatives from the UK MoD were involved at every stage, providing visibility of the planned con-ops and the credibility of the long term programme.
5. The tools set up for rehearsals are still being used to practice high risk trials and other elements of the flight test programme.

## **8.1 Flight Test Management System**

The Nimrod MRA4 Flight Trials Management System (FTMS) is a web based information management tool. It has been designed to improve the efficiency of handling and tracking the day-to-day information associated with the planning, execution and summary reporting of flight trials.

Essentially, FTMS is a database that contains all the information that is required to manage and track the progress of individual test-points through the flight testing process.

### **8.1.1 The Test Point Life Cycle in FTMS**

In its simplest form the central element of FTMS is essentially a database containing details about individual test-points. Test-points are written directly into FTMS as part of Flight Test Programmes (FTP's). At the appropriate point, they are then selected to be included in one or more Flight Test Schedules. Once a FTS has been 'flown' the outcome for each test-point is recorded.

As each test-point moves through this life-cycle it's status will change. The status attached to each test-point is fundamental. It controls what can and cannot be done with that test and enables progress through the overall test programme to be assessed at any instant in time.

### **8.1.2 Flight Test Schedules (FTS)**

FTMS is capable of generating flight test schedules using the test points input into the system by flight test specialists. Operations & planning engineers can choose and sequence each test point needed for a specific flight and compile a complete flight test schedule – including the test procedures.

Once a schedule has been flown (or the activity completed if not a flight) the schedule must be actioned. This process tells the database what to do with all the test points that were on the schedule (i.e. are they complete, is a re-test required etc) and creates an activity log entry for that activity.

It is then up to flight test specialists to add test results to each test point and decide whether the qualification objective of the test has been met. If so, the test may be marked as complete. If not, then a retest requirement may be highlighted.

## **8.2 Split Site Operations**

The BAE Systems MRA4 design teams are located across the UK at the following sites:

- Warton
- Woodford
- Farnborough
- Prestwick
- Brough
- Chadderton

However, the manufacture of the aircraft is conducted at Woodford, with flight testing being conducted at Warton. The benefits and disadvantages of each are detailed below:

### **8.2.1 Warton**

Warton is the site at the centre of the flight test programme and is home to the majority of design, flight test and flight operations personnel.

## Flight Testing the Nimrod MRA4

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Warton Aerodrome is situated on the north west coast of England in uncontrolled airspace. The principal test area is the uncontrolled airspace over the Irish Sea with a radar information service being provided by Warton Radar LARS. Each test flight is allocated a dedicated air traffic controller who will manage the airspace requirements of each test and ensure the test aircraft remains clear of other aircraft, controlled airspace and active danger areas. This facility allows the test crew to focus on the testing at hand and do not need to be in communications with numerous ATC agencies.

Warton aerodrome is also home to the telemetry ground station. Flight test from Warton allows both on aircraft and telemetry support during start up, taxi and take off.

However, maintenance facilities at Warton are limited for large aircraft and hangar space is only available for one MRA4.

### 8.2.2 Woodford

Woodford aerodrome is the assembly site for the MRA4 aircraft and is the home base to the majority of the production workforce.

Woodford is located within Manchester Airport Controlled Airspace is approximately 35 nautical miles from Warton.

With plenty of free hangar space, the production workforce sited here and the constraints of Warton, Woodford is the perfect site to conduct aircraft upgrades and programme lay-ups.

Unfortunately Woodford Aerodrome has a relatively short landing distance available and as such a special landing technique was used to allow MRA4 to return to the site.

Having the versatility to operate each site to its strengths has proved vital to keeping the programme on schedule and maximising efficiency from a geographically displaced workforce.

## 9.0 THE FUTURE – THE NEXT 12 MONTHS

The next twelve months looks to be extremely busy with three test aircraft in the flight test programme. The testing currently scheduled to take place during this period includes:

### Airframe

- Flutter flights to clear speeds up to 300 knots / 0.73 Mach (PA1).
- Air data pressure error testing up to 300 knots;
- Initial exploration of stall characteristics (PA1).
- Assess longitudinal stability over a representative speed envelope (PA1 / PA2)
- Assess hand wheel force over a representative speed envelope (PA1 / PA2)
- Mid mass aft CG handling trials
- Aircraft handling with artificial ice shapes.

A final key objective to demonstrate operational capability to the customer is:

- Sonobuoy Safe Separation, required as an enabler for acoustics mission systems testing.

**Avionics**

The focus of avionics testing is on extending the current IMC and IFR clearances and assessing equipment yet to be turned on.

- Subset of ILS, TACAN and DME qualification testpoints plus an initial assessment of FD guidance to enable limit removal to permit ILS and TACAN approaches for flight test use.
- Gather sufficient evidence for aircraft to navigate autonomously during test programme.
  - Subset of VOR, DME, ILS, IFF (including Mode C above FL200) and Marker testpoints to enable limit removal and therefore permit routine penetration of Class 'A' airspace.
  - Subset of FMS and AFCS flight director testpoints to quantify the position fixing accuracy and tracking accuracy of LNAV.
- Initial assessments of Radalt performance (with revised antennas), TCAS and EGPWS for flight test use, giving both risk reduction and flight safety enhancement.
- Initial auto throttle and auto pilot engagement.

**General Systems**

- Demonstrate engine relights prior to stalling.
- Demonstrate cabin pressurisation safety features prior to operations above FL250.
- Improve crosswind limitations on an opportunity basis.
- Complete acquisition of engine controller data
- Demonstrate landing gear lowering using alternate mode of operation.
- Acquire further data on brake and tyre cooling on an opportunity basis to alleviate tyre cooling limitations on future taxi trials.
- Assess full fuel system functionality.
- Complete APU build and qualification tests to allow autonomous operations.
- Assess landing gear loads during arrestor cable trampling and runway bump trials.
- Assess aircraft operation in hot weather conditions through a European risk reduction climatic trial.
- Assess aircraft engine and APU susceptibility to water ingestion by way of water trough trials.

**Mission Systems**

The mission systems objectives are focused on demonstrating developing military capability of the platform:

- Demonstrate full acoustics system functionality, in particular the SPS.
- Demonstrate Searchwater 2000 radar capability to detect and identify maritime targets, avoid adverse weather and interrogate and classify IFF transponders.
- Demonstrate communications capability, in particular V/UHF and HF radios – required for overseas detachments or offshore operation.
- Demonstrate the ability to operate the aircraft tactically, using the TCS to drive the aircraft.

**10.0 GLOSSARY**

AFCS	Automatic Flight Control System
APU	Auxiliary Power Unit
ATC	Air Traffic Control
AV	Air Vehicle
CB	Circuit Breaker
Comms Op	Communications Operator
CPCS	Cabin Pressurisation Control System
DASS	Defensive Aids Sub System
DME	Distance Measuring Equipment
ECS	Environmental Control System
EEC	Electronic Engine Controller
EGPWS	Enhanced Ground Proximity Warning System
ESM	Electronic Support Measures
FCC	Flight Crew Checklist
FCS	Flight Control System
FDAR	Flight Deck Assessment Rig
FDSS	Flight Deck Display System
FL	Flight Level
FMS	Flight Management System
ft	Feet
FTE	Flight Test Engineer
FTI	Flight Test Instrumentation
FTMS	Flight Test Management System
FTO	Flight Test Observer
FTP	Flight Test Programme
FTS	Flight Test Schedule
G	Normal Acceleration
IFF	Identification Friend or Foe
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IPT	Integrated Product Team
KIAS	Knots Indicated Air Speed
kts	Knots
LNAV	Lateral Navigation
MoD	Ministry Of Defence
MRA	Maritime Reconnaissance Attack
MS	Mission Systems
MSA	Mission System Avionics
NWS	Nose Wheel Steering
PA	Production Aircraft
PSP	Personal Survival Pack
Radar Op	Radar Operator
RAF	Royal Air Force
ROS	Reduced Operating Standard
SPS	Sonobuoy Positioning System
TACAN	Tactical Air Navigation
TACCO	Tactical Co-ordinator
TADS	Triple Air Data System

TCAS	Traffic Collision Avoidance System
TCS	Tactical Command System
TPt	Test Point
UHF	Ultra High Frequency
UK	United Kingdom
VHF	Very High Frequency
VOR	VHF Omni-Range
$V_{REF}$	Landing Threshold Speed ( $1.3V_S$ )
$V_S$	Stall Speed
WSIR	Weapon System Integration Rig

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