

# FURY



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## 1 Introduction.

In June 2008 BAE SYSTEMS unveiled the latest member of its Unmanned Air Systems (UAS) family. Fury is an armed reconnaissance and close air support UAS which features latest generation mission systems avionics, a newly developed stores management system and a proven weapon guidance system.

With a great deal of experience of operating reconnaissance and surveillance platforms, weaponisation brought new challenges to the design and clearance of an unmanned system. This paper will provide an overview of the Fury programme and give an insight into some of the obstacles that needed to be overcome in order to fly a weaponised UAS.

## 2 Why Weaponise?

Since developing an unmanned capability within the company it has been a natural evolution to investigate how such systems could be weaponised. A weaponised UAV would make use of the existing platform sensors to provide the potential to deliver an immediate response from a persistent air presence countering, for example:-

- Surface and air targets
- Counter Terrorism
- Flank Protection
- Stealth Operations
- Non Line Of Site Targets

BAE SYSTEMS as a prime platform and systems integrator has a vast and successful experience of integrating weapons on manned platforms. However, it was recognised that to weaponise an unmanned system would bring new problems and issues that would present a new challenge. In solving the problems, a new capability would be developed that would be unrivalled in Europe.

However, the need for weaponisation must have military utility. So it was not just a simple case of taking an existing weapon that had been integrated on one of our manned platforms and fitting it to an unmanned platform. What was needed was a new weapon that was compatible with an unmanned aircraft system

The company had progressed the development of its Herti UAS as a surveillance platform. BAE Systems developed a new stores management system and a new mission system utilising the existing HERTI airframe. This new variant became the basis for a weaponised UAS that became known as Fury (see Figure 1). By Weaponising a UAS the company could develop a new product line but more importantly, develop the skills and knowledge for a new industrial capability.

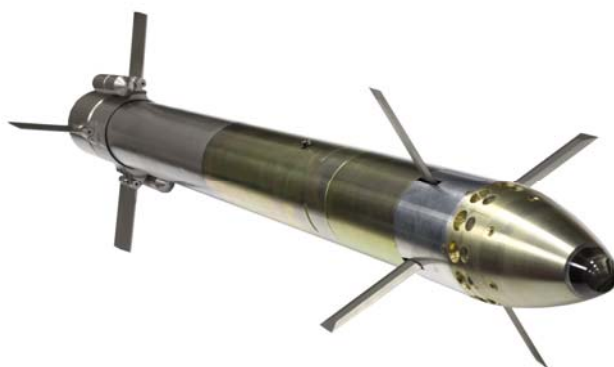


**Figure 1 – Fury – the Converted HERTI Airframe.**

### **3 The Challenge.**

BAE SYSTEMS was approached by Thales Air Defence Limited (TADL) to discuss the possibility of integrating the Light-weight Multi-role Missile (LMM) on a UAS. The LMM system (see Figure 2) draws on the TADL pedigree of air defence missiles from Starburst through to Starstreak and will be a light-weight missile in the sub-25kg class (weighing approximately 13kg). At the time of those early discussions LMM hardware was not available. However, the Javelin S15 man-portable air defence system was a fielded system that was identified as being a suitable alternative for an experiment to weaponise a vehicle based on the Herti airframe.

The team was set the challenge to develop the mission system and SMS and design a new carriage system that could enable the firing, control and guidance of the missile. Simply put, the team had to take a vehicle that had never been designed to carry weapons and integrate a weapon that had never been designed for air carriage and firing; all in a challenging timescale.



**Figure 2 – Light-weight Multi-role Missile System.**

## 4 Programme Considerations.

The programme was initiated as a controlled trial with the eventual aim of firing a live weapon on a test range. It was necessary to develop the aircraft system to control the weapon, a system to physically attach the weapon to the aircraft and the guidance system. These were some of the engineering problems that had to be solved. However, to take a UAS on a range to carry and then fire a live weapon would also mean that the range authorities would have to be convinced of the safety of the system and that all eventualities had been mitigated. As the chosen range was the Woomera Prohibited Area (WPA) in South Australia, then it was essential that discussions started immediately to understand their requirements for clearing such a system. Also, as the WPA is operated by the Commonwealth of Australia Government, undertaking weapon trials required the sponsorship of the United Kingdom (UK) Ministry of Defence (MoD) to secure range slots. MoD sponsorship also helped to raise the priority of the trials, therefore giving a level of stability to our planning.

## 5 UK Trials.

However, before embarking on a complex flight trials programme there was the need to undertake ground-based trials to understand the impact on the airframe from missile firing and to ensure that the aircraft system could guide the weapon on to the target. To achieve this, two trials were undertaken.

The first trial was at Ballykinler in Northern Ireland and included first stage rocket motor firings of a missile loaded on to a suspended airframe (see Figure 3). Using high-speed cameras to record airframe deflections, a number of firings were performed. The trial proved that the recoilless nature of the missile system had little impact on the airframe.



**Figure 3 – Ground-based Launch Motor Blast Trials.**

The second trial was at Manorbier in South Wales. The trial demonstrated the ability of the aircraft's guidance system to control a live missile and guide it on to a surface target located 1.5km offshore (see Figure 4). The results of this trial enabled us to improve the performance of the guidance system.



**Figure 4 – Guidance System Trial.**

Both trials were completed efficiently and successfully. No significant impact was experienced on the Fury airframe due to the launch blast effects. The surface target was destroyed.

## **6 Team Size.**

The weaponisation task was deemed to be of a lower priority than other autonomous system activities within the business. Therefore it was not possible to have a dedicated team to develop the aircraft and ground station components of the UAS. TADL provided essential weapons expertise for their missile system, although providing the required qualification evidence from existing ground based trials was itself a challenge. Table 1 shows the number of people in BAE SYSTEMS that were engaged in the Fury programme on a part-time basis. There was no full-time, dedicated resource.

Discipline	Number of Engineers	Comments
Avionic Systems	4	Includes 3 engineers for detachment.
Weapons Integration	1	With 1 additional engineer providing support to ensure a level of independence.
Aerodynamics	1.5	
Structures	0.5	
Safety	1	
Trials	1	With 3 Flight Test engineers for detachment.
Shops	1	With 3 personnel for detachment.
Quality / Inspection	1	
Project Management	1	
Design Office	1	
Chief Engineer	1	
<b>Total</b>	14	Total team for detachment was a maximum of 11 people.

**Table 1 – Fury Development Team Size.**

Clearly, this is a very small team size although there were several other people (e.g. Airworthiness, Engineering Director, etc) who were involved when required. TADL also provided a significant systems engineering support with regard to the integration of the system on the platform and a team to support the detachments varying in size depending upon the trials responsibilities and the trials location.

## **7 Range Authorities.**

Firing a live missile from a UAS was also a new experience for the Woomera Range Authorities. It was essential that the aircraft would not fly outside strict range boundaries and that when the missile was fired, that its maximum energy boundary was inside the controlled area. For this, BAE SYSTEMS had to review the missile documentation and overlay this with a map of the range. From this it was possible to find a suitable location for the target that met all the range safety criteria and provided a suitable flight path for the firing run.

The missile is a low power laser guided weapon and therefore laser safety issues had to be addressed particularly any failure cases that could mean third parties could be illuminated.

In some instances, the system was designed to mitigate hazards. In others, an overall analysis of the credible failures showed that the probability of the hazard occurring was sufficiently remote.

The Range Authorities had to be convinced that the overall design of the weapon control system was robust and that there was no possibility of inadvertently firing the missile. Potential hang-fire situations also had to be considered and elements were designed into the system to help determine if the missile had been initiated but failed to fire. The procedures for recovering the aircraft safely had to be developed and agreed with the Range Authorities.

Although there were many issues to address, all were mitigated either by existing company procedures or extensions to those procedures in both BAE SYSTEMS and TADL. In essence, our own processes and procedures worked well and this, coupled with an extremely good and open working relationship with TADL and the WPA personnel, ensured that we could get a clearance to take Fury on the range and fire a live missile.

## 8 Safety Case.

In developing the Fury Safety Case, the argument had to be constructed that showed that the overall system design was safe, that the weapon operating in its new environment would remain safe and that all hazards had been adequately mitigated either by design (the preferred solution) or by tight procedures. Although operating on a sterile range, the team worked to develop a system that had a level of integrity commensurate with that of a weaponised manned aircraft.

## 9 Export Control.

From a UK export control viewpoint, weaponised unmanned systems fall into the most complex category, requiring a great deal of discussion with the authorities. This makes it very difficult to move system components outside the UK, specifically to Australia. Close working with the MoD sponsor enabled the necessary export paperwork to be approved in a timely manner such that shipping dates for the equipment could be maintained. On arrival in Australia, the BAE SYSTEMS site in Adelaide and the Thales in country Import Agent provided assistance in getting equipment cleared through customs and shipped to Woomera.

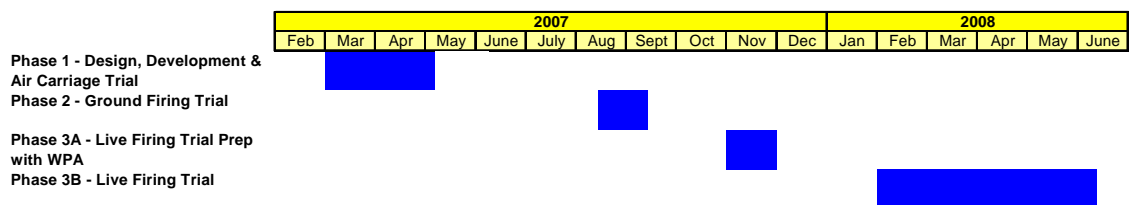
Even so, there was an Uninterruptible Power Supply for the ground station that managed to find its way on to a ship bound for New Zealand - a good lesson that even when you think you have everything planned, the unforeseen can still happen. Good logistics support and assistance from our local business units saved the day.

## 10 Timeline.

The Fury programme has progressed in three distinct phases as follows:

1. Design, development and air carriage trial.
2. A ground firing of the missile to demonstrate guidance.
3. Live firing trial.

The timescales are shown in Figure 5, below. Between phases very little work was performed as the team had other priorities within the company.



**Figure 5 – Fury Programme Timescales.**

By far the largest block of work was the final preparation for the live firing trial, although the actual detachment (which included building and testing the aircraft after shipment to Australia and the rectification of aircraft problems not related to the trial) was around four weeks.

## 11 Success

From being set the challenge to weaponise a Herti airframe at the end of February 2007, the team designed and built the Fury system<sup>1</sup>, developed new pylons for the aircraft, modified a Herti vehicle and cleared the missile system for carriage and release (including a first stage motor firing from a suspended Herti airframe at Ballykinler in Northern Ireland) within 8 weeks from concept to completion, demonstrating how well the BAE SYSTEMS and TADL teams worked together. The aircraft made its maiden flight from Woomera air field on the 9th May 2007. Phase 2 consisted of a ground firing of two live missiles at the Royal Artillery Range in Manorbier, South Wales on the 18th / 19th September 2007. Phase 3 consisted of securing range approval in principle (Phase 3A in November 2007) and upgrading the turret system. The Fury programme accomplished the first live guided firing (Figure 6) of a weapon from a UK developed UAS on the 11th June 2008. All programme objectives were achieved!



**Figure 6 – High-speed Camera Still from First Live Firing of Javelin S15 from Fury.**

## 12 Conclusions.

In developing Fury, BAE SYSTEMS has demonstrated the capability to weaponise UAS with new system components and a proven missile system. This places the

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company as the prime UAS weapons integrator in Europe and this will enable future programmes such as MANTIS to be a success.

The programme demonstrated the potential capability of a light-weight precision weapon carried on a medium-sized unmanned aircraft which could be exploited effectively in modern warfare.

The programme also secured what are believed to be a number of ‘firsts’; not only the first live missile firing from a UK UAS, but also the first planned live firing of a missile from an aircraft on the ground in the UK.

### **13 Acknowledgements.**

In compiling this paper on behalf of BAE SYSTEMS, I would like to thank the following for providing an input and in reviewing the content:

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Figure 2 and Figure 3 are used with the kind permission of Thales Air Defence Limited.

### **14 Abbreviations.**

LMMS	Light-weight Multi-role Missile
MoD	Ministry of Defence
SMS	Stores Management System
TADL	Thales Air Defence Limited
UAS	Unmanned Air System
UK	United Kingdom
WPA	Woomera Prohibited Area



**Fury on the Flight Line at Woomera (note the Camera Pod on the port pylon).**