ASTRAEA

Autonomous Systems Technology Related Airborne Evaluation & Assessment

UK Autonomous Systems Technology Validation Programme

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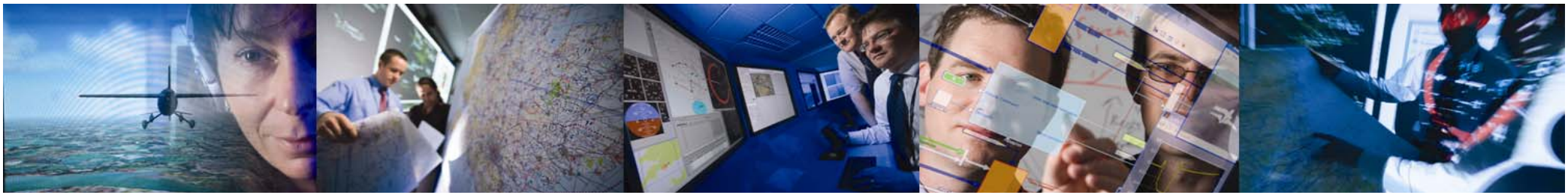
ASTRAEA Programme Director
ICAS Workshop, 24th September 2007



ASTRAEA
Autonomous Systems Technology Related Airborne Evaluation & Assessment

- What is ASTRAEA?
- Who is involved?
- How is it addressing the challenge?
- Where have we got to?
- Where next?

What is ASTRAEA?

A collaborative research and validation programme

- To enable the opening up of the UK and European airspace to the routine use of autonomous Unmanned Aircraft Systems (UAS), without the need for special, restrictive conditions of operation, through the development and demonstration of technologies and operating procedures.
- A key element of the National Aerospace Technology Strategy to build on the collective capability of UK plc in the realm of aerospace technology

Who is involved?

A £32 million partnership, jointly funded by industry and the public sector

- **BERR / TSB**

- **Regions**
  - Welsh Assembly Govt
  - Scottish Enterprise
  - SEEDA
  - SWRDA
  - NWDA

- **CAA**

- **Industry**
  - Agent Oriented Software
  - BAE Systems
  - EADS
  - Flight Refuelling
  - QinetiQ
  - Rolls-Royce
  - Thales

- **Universities**
  - Cranfield
  - Lancaster
  - Leicester
  - Loughborough
  - Sheffield
  - West of England

40+ Subcontract SMEs and Universities

‘Hard’ Technical Drivers

- **Highly dependable and secure communications (spectrum/bandwidth)**
- **Sense & Avoidance of other air traffic (non-cooperative) in air and ground**
- **Dependable ability to monitor, comply and respond to ATC instructions**
- **Integration of Sense & Avoidance with existing co-operative systems (e.g. TCAS) and air traffic management**
- **Highly dependable navigation, including the ability to re-route**
- **Management of faults to a similar level afforded by pilots**
- **Dependable flight termination in emergencies (including forced landings)**
- **Obstacle / Terrain avoidance**
- **Affordability**

Source: JAA/EUROCONTROL UAV Task Force

‘Soft’ Drivers

Regulatory (e.g.)

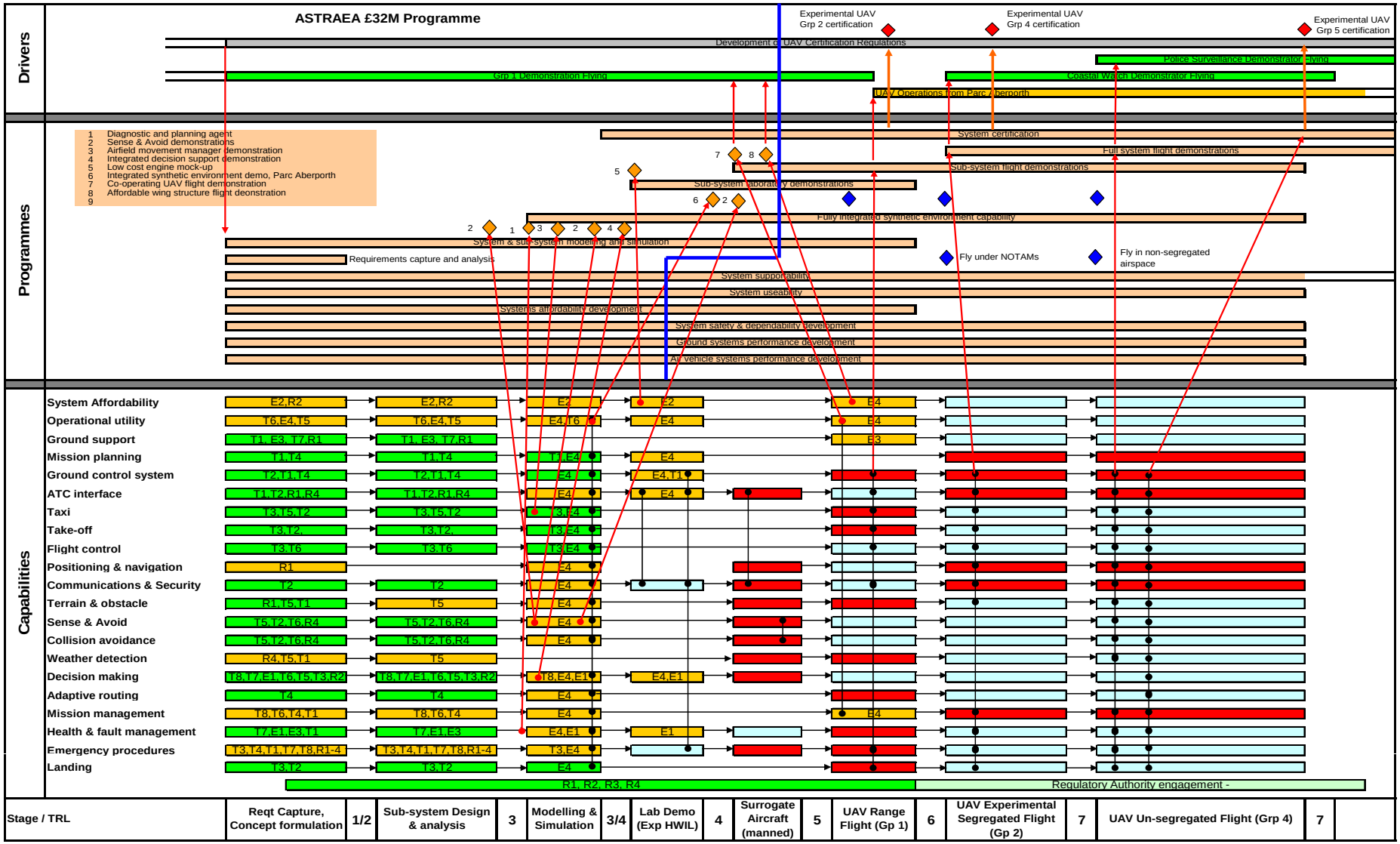
- Acceptance that visual signals are unnecessary

Procedures / Training

- Submission, maintenance and closure of flight plans
- Pilot licensing and training
- Ground handling and maintenance
- Preventing disruption of UAV operator
- Establishing pilot fatigue criteria
- Establishing weather minima

Source: JAA/EUROCONTROL UAV Task Force

Programme Roadmap



Key

ASTRAEA addresses (>80%)
ASTRAEA part addresses

Critical milestone (future phase)
Further data gathering (future phase)

What *is* Autonomy?

Automation has fixed choice points and a number of fixed alternatives

- e.g. bank of lifts in a building
- 'black box' implementation – logic not visible to the human, but simple
- does not take account of current circumstances

The concept of automation has a long history, evolving from 19th century mechanical industrial control technology

Autonomy, a contemporary concept, is distinguished on the other hand by need for decisions to be made at any time. Such a system

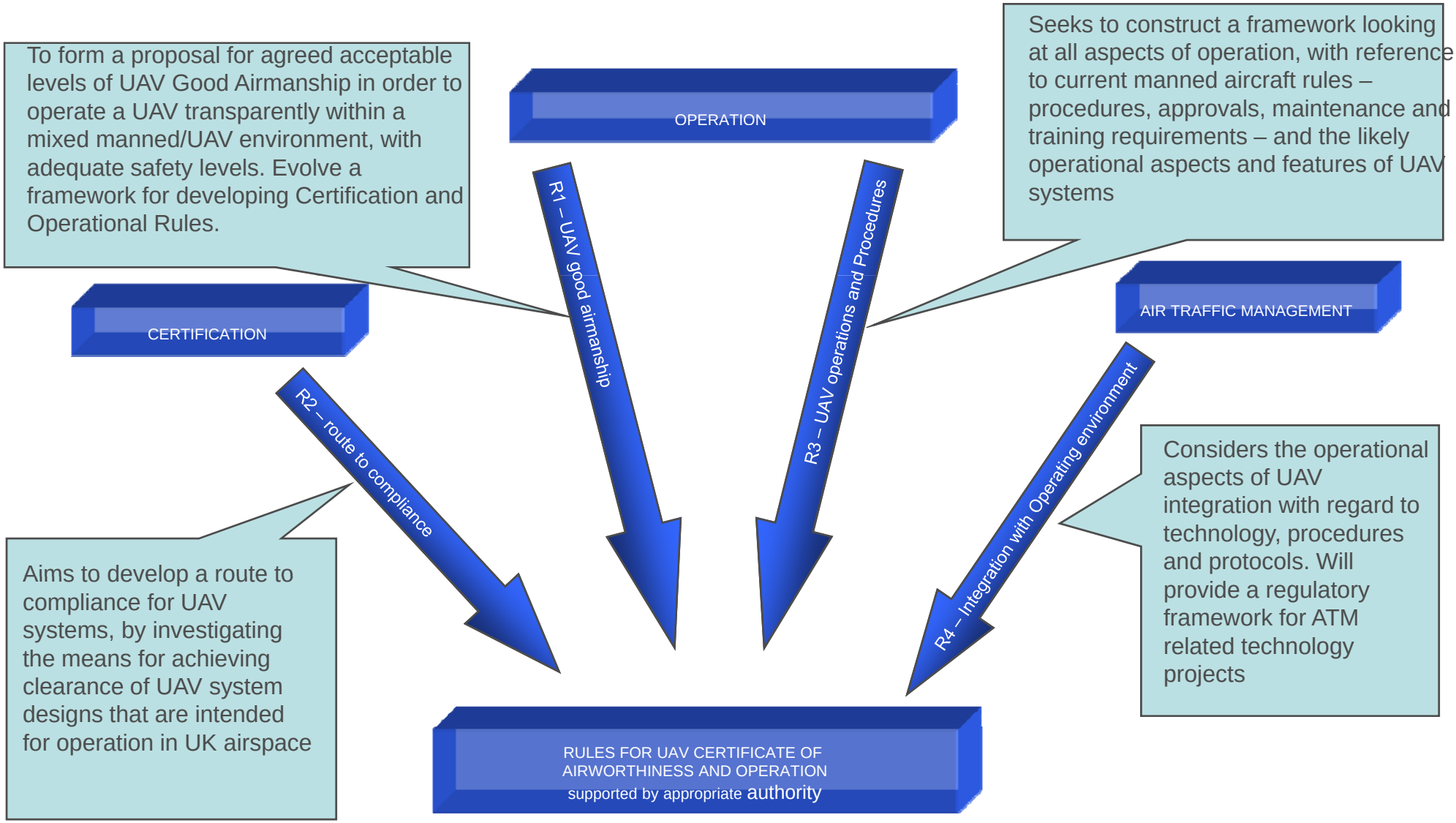
- makes "rational" decisions
- has a view of current situation
- evaluates potential courses of action in light of this appreciation
- needs to expose its reasoning process to humans

Regulatory framework and procedures

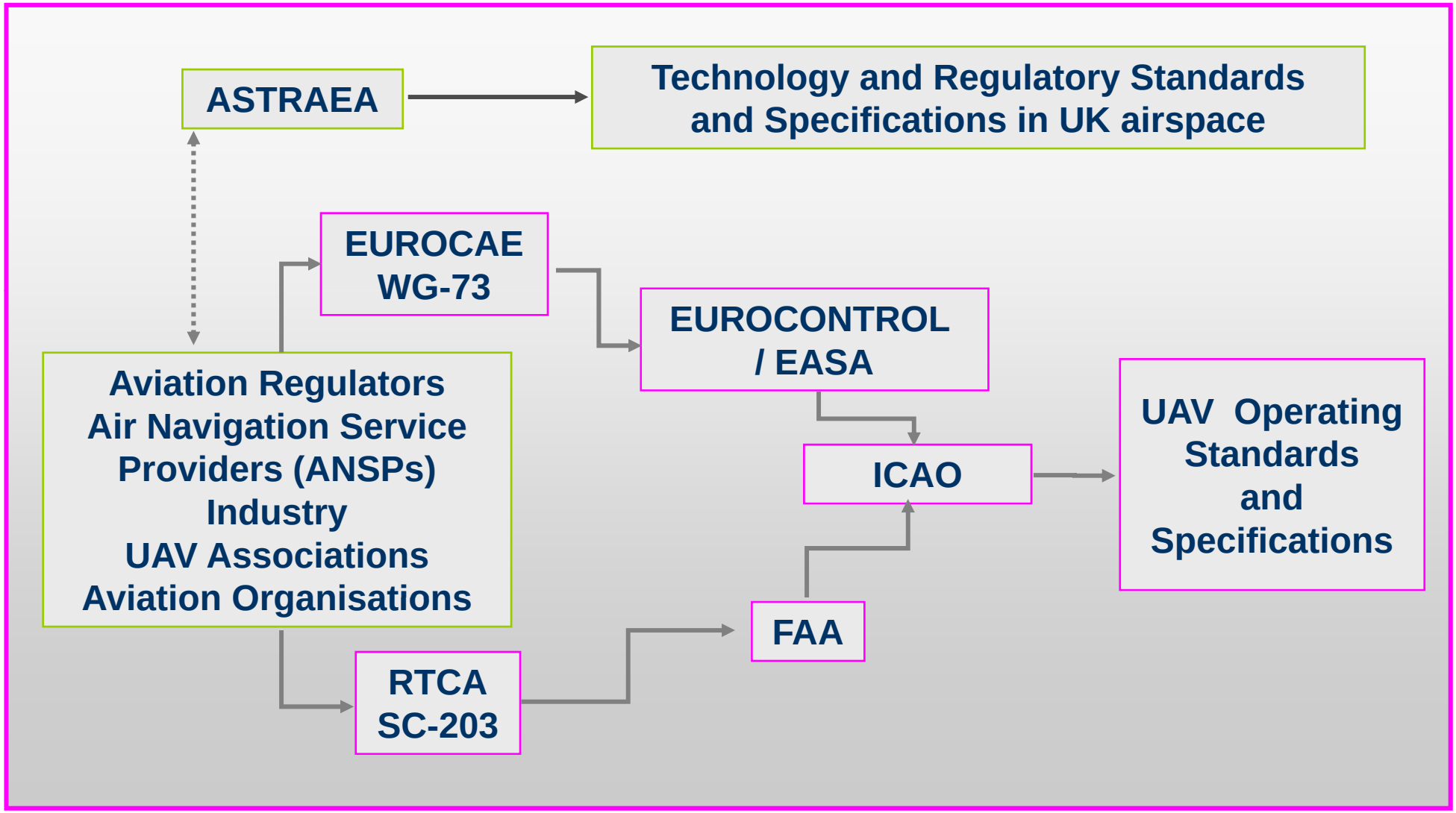
For UAS to be routinely used in place of manned aircraft for common operational missions, the current regulatory framework requires re-interpretation

- **UAS should operate at an equivalent level of safety within the existing Air Traffic Management (ATM) structure.**
- **UAS should show an equivalent level of compliance with ATM and Communications, Navigation and Surveillance (CNS) requirements.**
- **The provision of Air Traffic Services to a UAS must be transparent to the controller and other airspace users.**

Regulatory processes



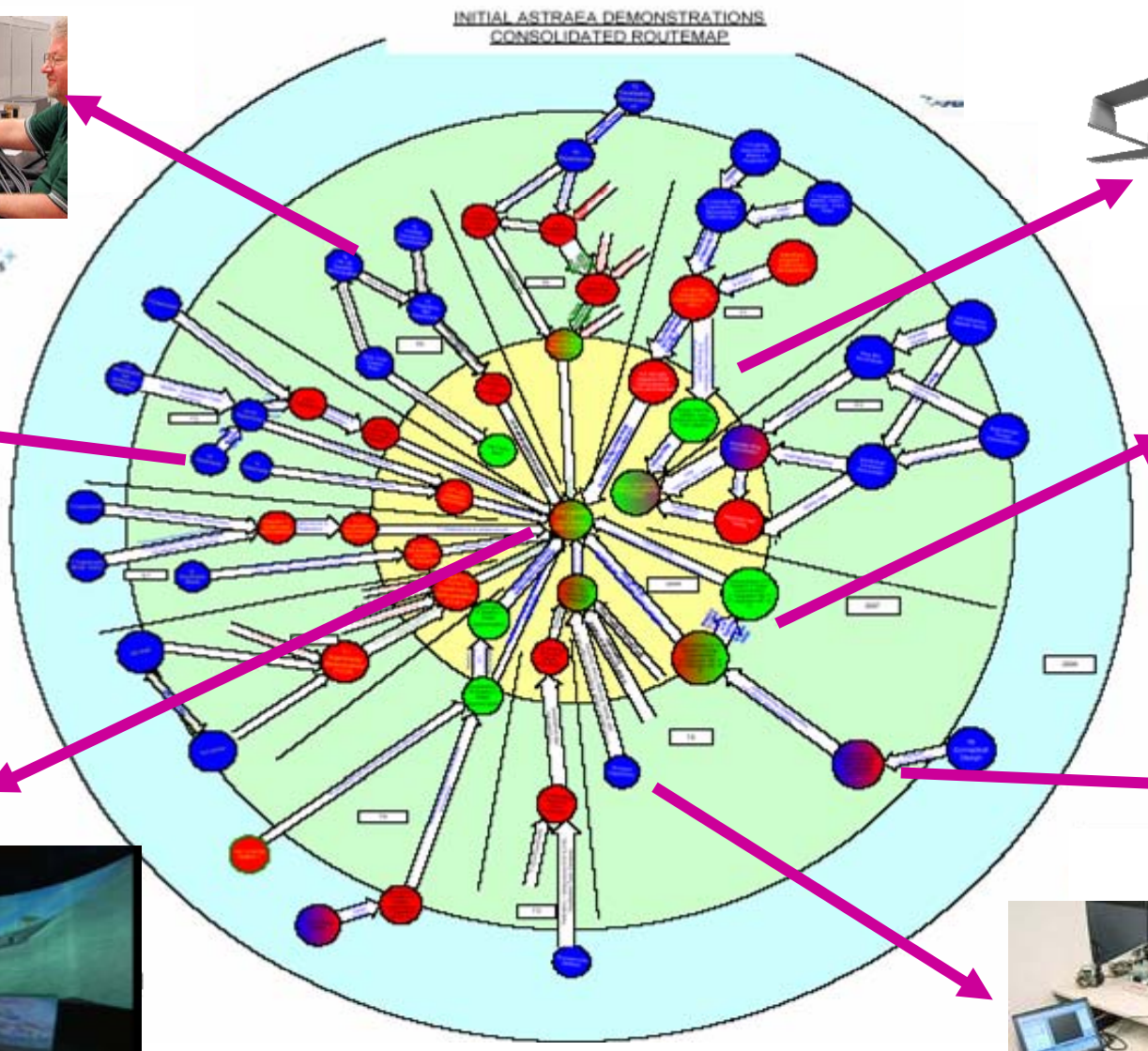
Engaging wider Regulation Authorities

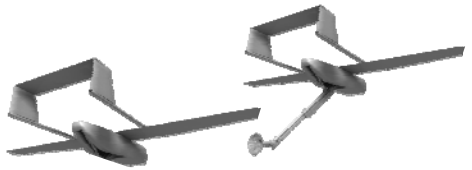


Capability Developments

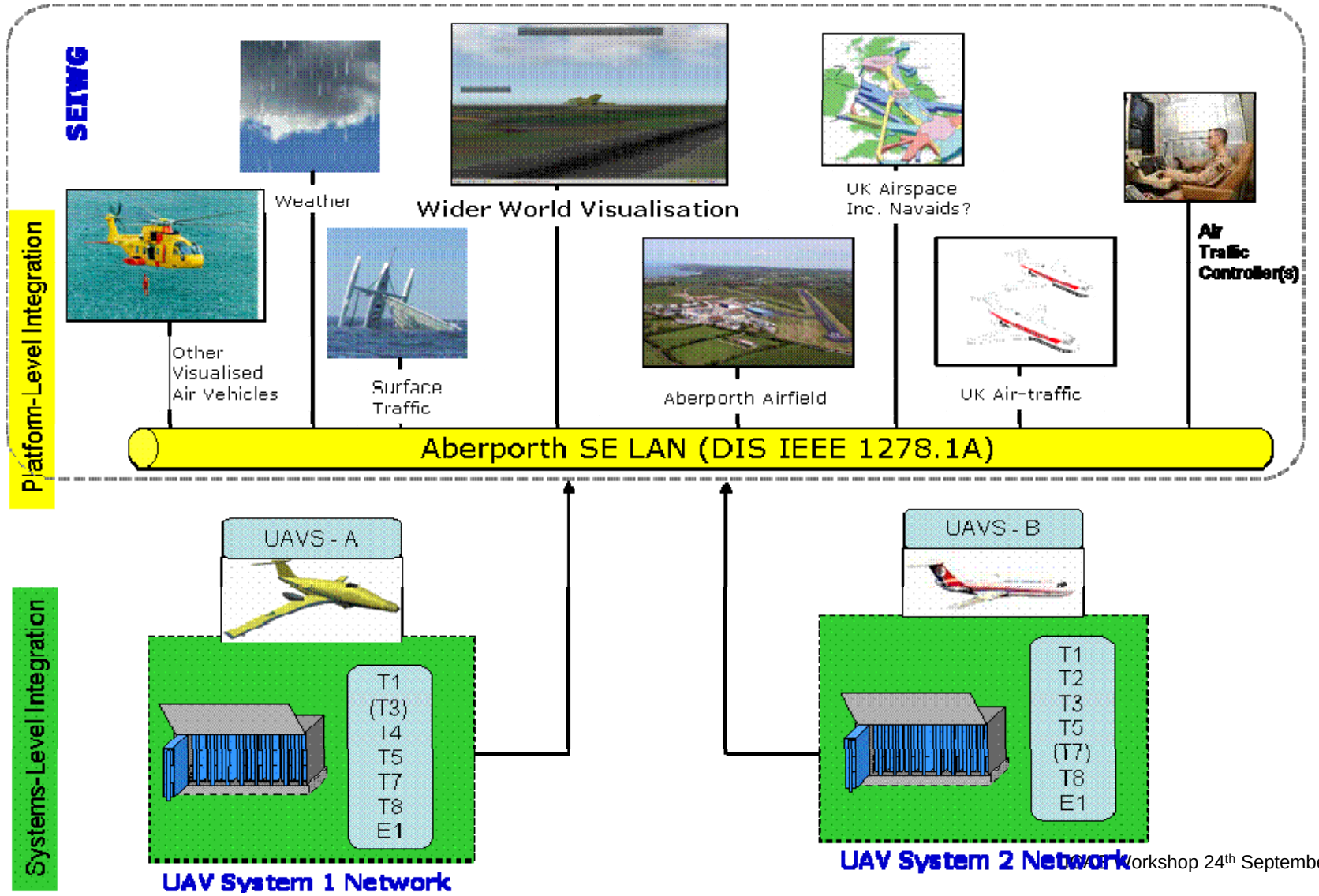
- Ground operations and human system interface (T1)
- Communications & Air Traffic Control (T2)
- UAV handling (T3)
- Adaptive routeing (T4)
- Collision avoidance systems (T5)
- Multiple air vehicle integration (T6)
- Prognostics & health management (T7)
- Decision making (T8)
- Propulsion & power systems (E1)
- Qualification of affordable processes (E2)

Demonstrations





Synthetic Environment at Parc Aberporth



ASTRAEA Achievements

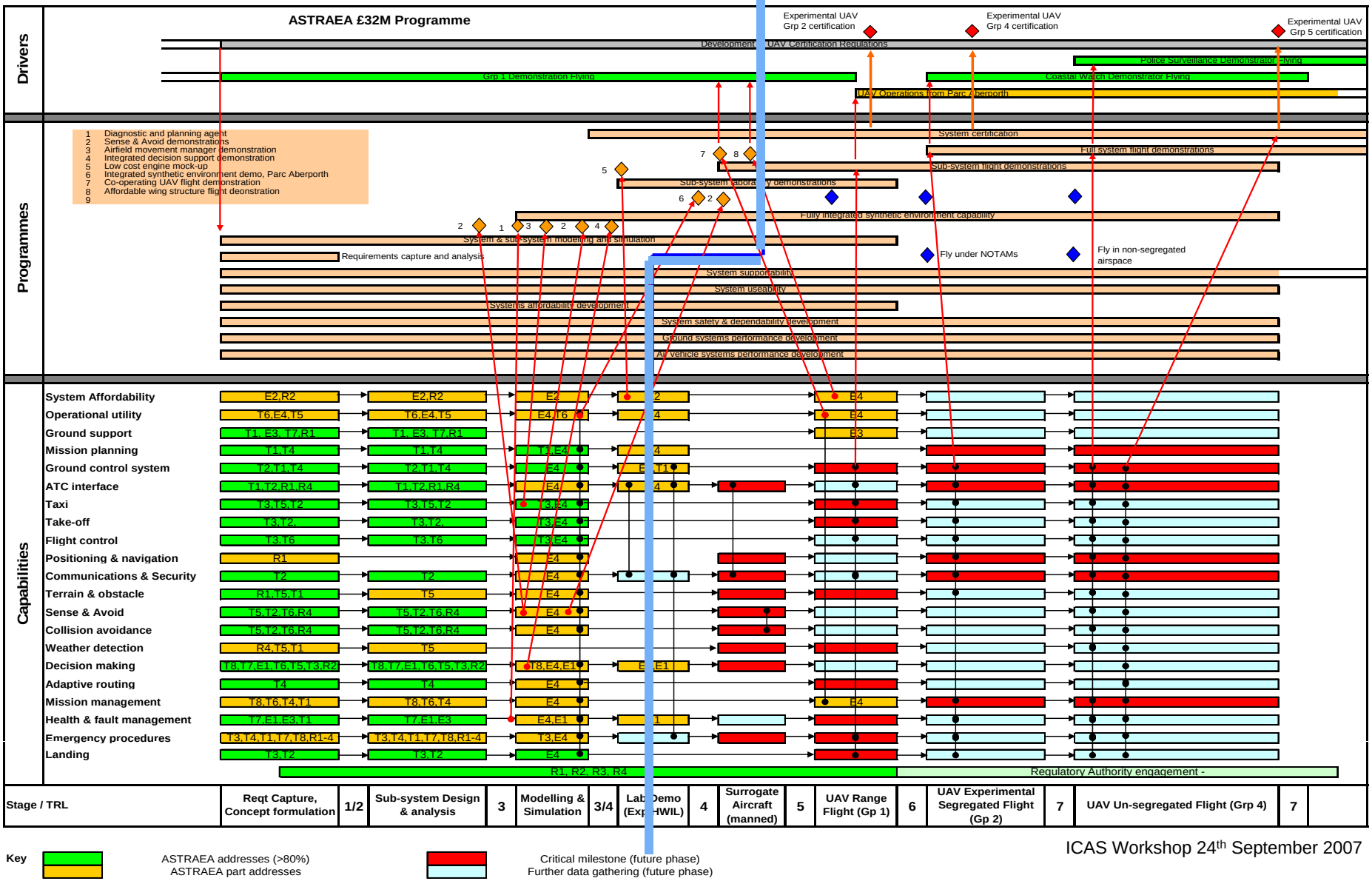
The first year of activity saw the following tasks completed:

- **Requirements captured for technology projects**
- **Established a co-ordinated set of practical and synthetic demonstrations**
- **Identified a roadmap to achieve the ultimate goal**
- **Input to CAP 722 Issue 4**
- **Initial demonstrations**

Year 2 and 3 will:

- **Mature the understanding of the route to routine operation of UAS by development of technology and engagement with regulators**
- **Undertake further practical and synthetic demonstrations**
- **Identify the critical areas still to be addressed in a future phase**

Next step



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Website www.ASTRAEA.aero

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ASTRAEA

The next big aerospace market

ASTRAEA Programme Unmanned Systems National Conference

Bristol, 17 October 2007

BAE Systems, EADS Defence & Security Systems Ltd, Flight Refueling, QinetiQ, Rolls-Royce and Thales, along with autonomous systems specialist Agent Oriented Software and many of the UK's brightest academic minds, are partners in the ASTRAEA programme, backed by Government at national and regional level.

Find out what they have achieved and what the future has in store at the first ASTRAEA national conference in Bristol on 17 October 2007. The event is being hosted by the South West of England Regional Development Agency, one of the public sector partners in the programme.

Unmanned Airborne Systems (UASs) are set to revolutionise aviation, with potential uses ranging from surveillance and border control to traffic management and search and rescue.

As a key element of the National Aerospace Technology Strategy, ASTRAEA (Autonomous Systems Technology Related Airborne Evaluation & Assessment) seeks to research, develop and validate the necessary technologies, systems, facilities and procedures to promote and enable safe and routine use of UASs in non-segregated air space.

Bringing together representatives from leading aerospace companies, suppliers, specialist consultants, national and regional government and academic and research institutions, the Conference will detail progress on specific elements of the ASTRAEA programme as well as examining wider issues of regulation and utility of autonomous airborne systems.

With contributions from the Civil Aviation Authority, the Aerospace Technology Strategy Group and public sector partners, the day will explore the economic benefits of the ASTRAEA programme, particularly in maintaining the global strength of the UK aerospace industry through development of world class technologies.

Senior businesses are already involved in ASTRAEA and the conference will include a presentation from the SME perspective.

Where and when?
The conference is taking place at the Marriott Royal Hotel, College Green, Bristol BS1 5TA, on 17 October 2007 from 8.30 am to 5.00 pm. Parking is available at the hotel.

Delegate fees
£125 (excl VAT) for members of the ASTRAEA Programme, also for members of the West of England Aerospace Forum, Farnborough Aerospace Consortium, the Northwest Aerospace Alliance, Aerospace Wales and SBAC Scotland
£175 (excl VAT) for all other delegates

To book your place, please complete the attached booking form and return by fax or post (including a cheque for the conference fee) to Karen Ashcroft at the West of England Aerospace Forum

Karen Ashcroft, WEAF (ASTRAEA),
Unit 8, St David's Court, Winterhill Road, Clevedon,
North Somerset BS21 6UP
Fax: +44 (0)1275 873566

Accommodation
Delegates requiring accommodation on 16 October can book rooms at the Marriott Royal Hotel at a preconfirmed rate of £130.00 by calling 0870 400 7240 by 19 September and quoting reference CCS6

www.astraea.aero

First ASTRAEA Conference

Bristol, 17th October 2007

www.astraea.aero

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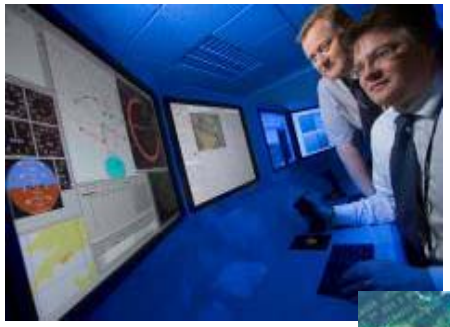






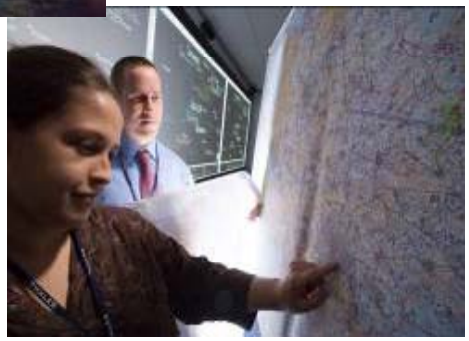

Technology validation

Ground operations and human system interface (T1)

Objective: aimed at defining ground-based elements involved in the management of flight operations for civil UAS and providing an understanding of the role of the human in such operations

Innovations & outputs

- **Identified operator roles within a civil context (including location, numbers, skills and required toolset)**
- **Planning, monitoring and control systems capable of supporting autonomous air vehicle operations**
- **Presentation of decision support information in line with platform-variable autonomy levels**

Technology validation

Communications & Air Traffic Control (T2)

Objective: aimed at the data requirements for autonomous operation, it also addresses the communications technology needed to interact with Air Traffic Control system.

Innovations & outputs

- **To define requirements for the first CAA-certified communication system to control the flight of a UAS**

Technology validation

UAV handling (T3)

Objective: developing basic enabling systems for flight control and airfield movement management

Innovations & outputs

- **Airfield movement algorithms for autonomous air vehicles.**
- **Emergency recovery algorithms for autonomous air vehicles**

Experimentation and demonstration

Propulsion & power systems (E1)

Objective: to assess, in the absence of a pilot-in-the-loop, the functionality and interface requirements between a typical propulsion system and a modern Aircraft Management System,

Innovations & outputs

- **Automate the functionality of the pilot with regard to propulsion & power delivery decision-making**
- **Develop an autonomous intelligent response to environmental and goal-based inputs**

Experimentation and demonstration

Qualification of affordable processes (E2)

Objective: to develop affordable and qualifiable processes for the design and manufacture of UAS airframes and engines,

Innovations & outputs

- **Use of low-cost, resin-infused composites as flight-qualified primary structure**
- **Target of 80% reduction in cost of engine components**

Technology validation

Multiple air vehicle integration (T6)

Objective: researching of technologies and procedures that will increase UAS utility by enabling safe and affordable task co-operation among multiple air vehicles (UAS or manned) within a common air environment

Innovations & outputs

- **Non co-operative autonomous sensing systems**
- **Integration of 'sense and co-operate' with 'sense and avoid'**
- **Co-operative multi-vehicle search patterns**
- **Modeling of wake turbulence effects**

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Technology validation

Prognostics & health management (T7)

Objective: aims to provide technology and systems so that UAS can monitor their own state, perform real-time prognosis of immediate and future capabilities and to make decisions on how best to assist optimal mission performance

Innovations & outputs

- **Development of innovative hazard identification, reliability analysis, prognostics & health management design tools and methods, and Phased Mission Modelling methods facilitating UAS Contingency Management**
- **Platform Level PHM Demonstration in a Synthetic Environment**
- **'No-harm' flight demonstration**

Loughborough University

Prifysgol Cymru Aberystwyth The University of Wales

BAE SYSTEMS

FLIGHT REFUELLING

Rolls-Royce

QinetiQ

Technology validation

Decision making (T8)

Objective: to develop a robust and clearable system that will provide on-board decision-making capability for operational UAS

Innovations & outputs

- **Demonstration of prototype UAS decision-making system operating within a civil scenario**
- **A roadmap for certification of decision-making technologies operating in civil airspace**

Technology validation

Adaptive routeing (T4)

Objective: aimed at developing and implementing an adaptive routeing algorithm for use aboard UAS to aid their use in civil operations

Innovations & outputs

- **Adaptive routeing algorithm for autonomous air vehicles.**
- **Application for auto-routeing**
- **Application for setting rules and constraints for adaptive routeing algorithm**

Technology validation

Collision avoidance systems (T5)

Objective: to verify the merits of 'sense and avoid' system capabilities to provide a realistic and informed set of options for use by various categories of UAS to support routine operations in all classes of airspace

Innovations & outputs

- **Application of technologies (sensors, fusion, avoidance algorithms and decision-making architectures) to identify 'sense and avoid' system solutions for various UAS platforms**
- **Synthetic demonstration of unmanned air systems 'sense and avoid' with rule-based decision-making capabilities**

Where is ASTRAEA taking us?

The first year of activity saw the following tasks completed:

- **Requirements captured for technology projects**
- **Established a co-ordinated set of practical and synthetic demonstrations**
- **Identified a roadmap to achieve the ultimate goal**
- **Regulatory engagement plans drafted**
- **Initial demonstrations**

Year 2 and 3 will:

- **Mature the understanding of the route to routine operation of UAS by development of technology and engagement with regulators**
- **Culminate in a series of practical and synthetic demonstrations**
- **Identify the critical areas still to be addressed in a future phase**