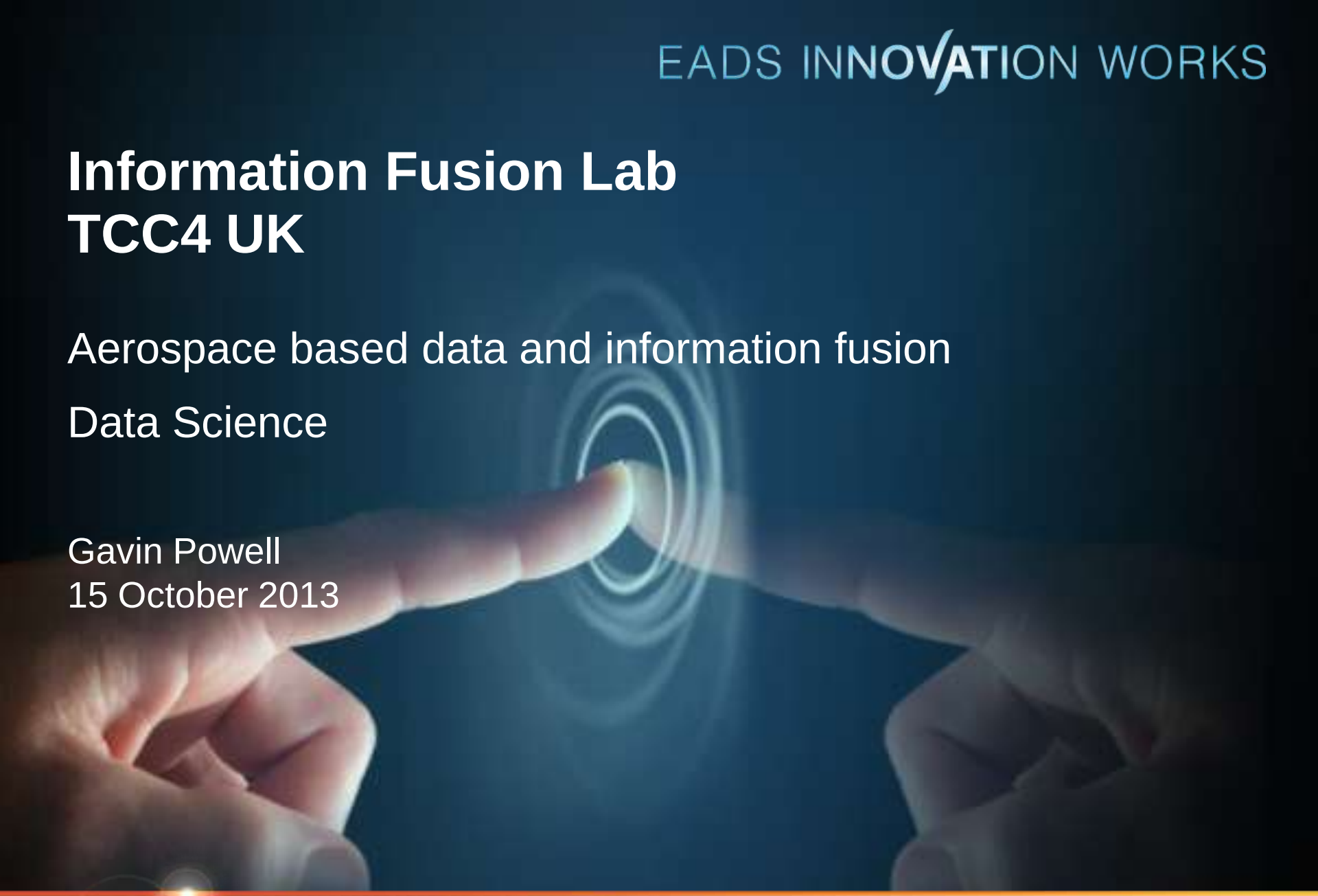
EADS INNOVATION WORKS

Information Fusion Lab
TCC4 UK

Aerospace based data and information fusion

Data Science

Gavin Powell
15 October 2013



EADS

The corporate introduction

EADS – A Global Leader
European Aeronautic Defence & Space Company


AIRBUS


ASTRIUM


CASSIDIAN


EUROCOPTER

EADS Innovation Works

Organized in Six
Technology Capability Centres

- Composite Technologies
- Metallic Technologies & Surface Engineering
- Structure Engineering, Production & Aeromechanics
- **Electronics, Communications &Systems integration**
- Systems Engineering, Information Technologies and Applied Mathematics
- Energy & Propulsion

Composites technologies | Friction stir welding | Smart structures

Adv. structural modeling | Advanced concepts | EMC simulation

Cabin-air test rig | Virtual product engineering

Microsystems

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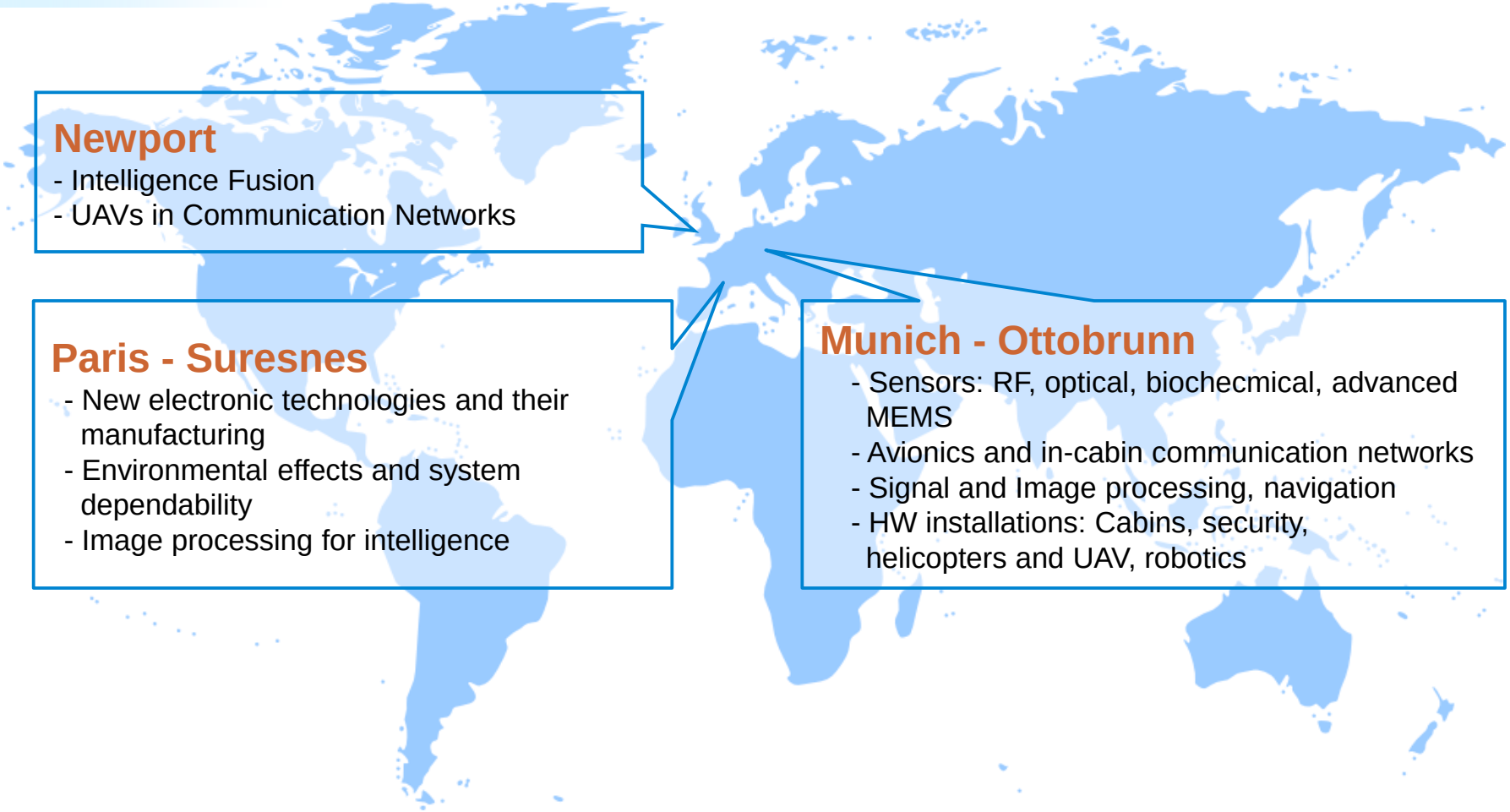
Sensors, Electronics & Systems Integration – (TCC4)



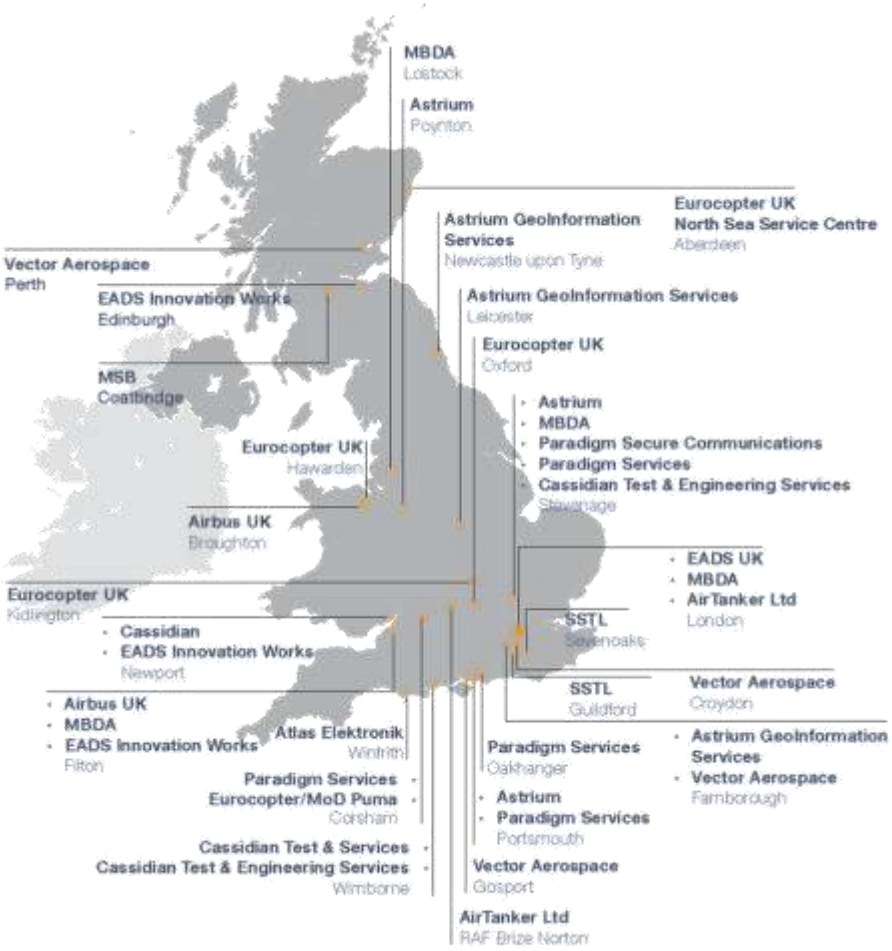
Newport
- Intelligence Fusion
- UAVs in Communication Networks

Paris - Suresnes
- New electronic technologies and their manufacturing
- Environmental effects and system dependability
- Image processing for intelligence

Munich - Ottobrunn
- Sensors: RF, optical, biochecmical, advanced MEMS
- Avionics and in-cabin communication networks
- Signal and Image processing, navigation
- HW installations: Cabins, security, helicopters and UAV, robotics

EADS - A Global Leader

- The UK is an important market for EADS : in both aerospace and defence
- The UK is a home market for EADS:
- EADS is the second UK A&D company (after BAES) for employment and revenues
- Our divisions are established national champions in their business areas
- EADS revenues are approx €2bn and employ ~15,000 people directly
- Frequently ranked as highest R&D spender in A&D sector in UK



EADS INNOVATION WORKS

Mission Systems Interoperability

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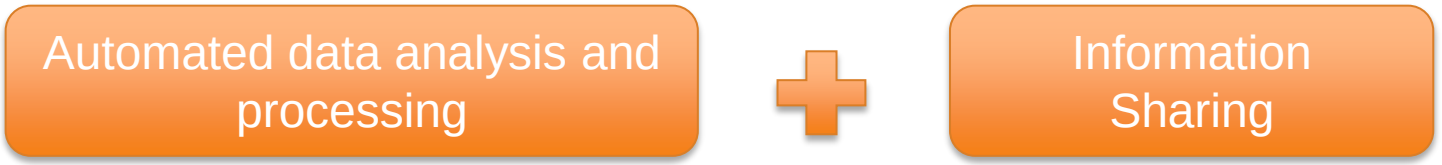
Why do we carry sensors on our platforms ?

What are the key **requirements** towards the utilization of sensor data/information/intelligence ?

- Availability
- Integrity
- Relevance
- Consolidation (where possible)
- Annotation (where sensible)
- Suitable for sharing inside / beyond system boundaries (interoperability)
- Efficiency

Growing data availability in shared environments



- **NATO STANAG**s and other standards for interoperability
  - Standardization Agreement
  - Transmission and file formats, compression, complexity, etc
  - Annotation and metadata
- Automated processing and **fusion** of relevant data
  - Primary (raw images) and secondary (annotated images) data
  - Tactical and intelligence data using IMINT, SIGINT, ELINT
  - Automated preparation of Intelligence Data for internal or external requesters
  - Automated consolidation and cross-checking of mission critical and sensitive data and information

Main technical areas of interest

- **Architecture for interoperable mission systems**
  - Acquisition of aircraft data from sensors
  - Acquisition of data from image intelligence (IMINT) systems
  - Processing and fusion of IMINT and aircraft data
- **What can be done with the fused data**?
  - Generate intelligence relevant to the mission
  - Image Annotation (secondary imagery) → STANAG 4545
    - Real-time annotation based on mission system sensor data streams
    - Assembly of NATO Secondary Imagery Format (NSIF) files
  - Video annotation (digital motion imagery) → STANAG 4609
    - Metadata included in video stream
    - Synchronisation of video and metadata
  - Acquisition, interpretation and processing of ground moving target indicator (GMTI) → STANAG 4607
    - Using IMINT

Fused data exploitation

- Data analysis (real-time or not)
  - *Conflict detection* for data of unknown provenance
  - Multi-sensor *corroboration* and confirmation
  - Information *change detection*
  - Threat *assessment*
- Applications
  - *Sharing* of flight data in a standard NATO format (video, imagery, ground moving target indicator)
  - Automated *intelligence gathering* through Fusion processes
  - *Alignment and registration* of data from multiple sensors
  - Automation of *recognition and surveillance*
  - Threat *assessment on mission* systems

Example

Preparation of NATO Secondary Imagery Files (NSIF)

I. Receiving intelligence request
II. Requesting and receiving ATD/ATR info, including classification info
III. Consolidation with additional sensor data/information
IV. Annotation of requested sensor data with IMINT information & standard annotation (geo-ref, time, system specific data)
V. Prepare NSIF
VI. Make file available to entitled requesters

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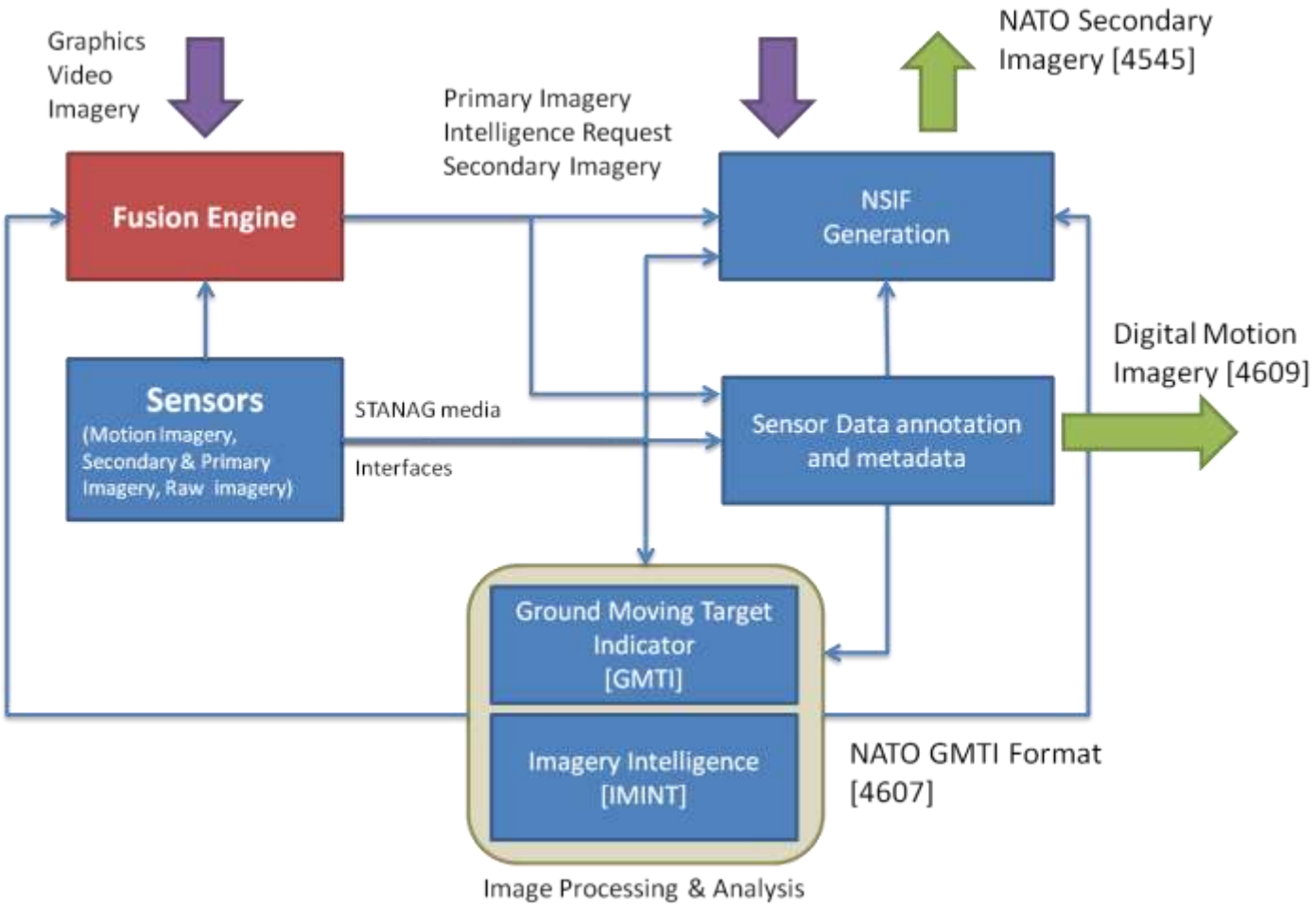
Example

Interoperable system architecture for IMINT integration



All electric aircraft

All electric aircraft

ACTUATION 2015 (Modular Electro Mechanical Actuators for ACARE 2020 Aircraft and Helicopters) is a collaborative research and development project coordinated by Goodrich Actuation Systems SAS, a UTC AEROSPACE SYSTEMS COMPANY gathering 53 partners including the European key players in the aircraft industry.

ACTUATION 2015 aims to develop and validate a common set of standardised, modular and scalable Electro Mechanical Actuators (EMA) resources for all actuators (flight control, high lift, landing gear, door, thrust reverser) and all types of aircraft (business/regional/commercial airplanes and helicopters).

ACTUATION 2015 is supported by the European Commission under the 7th Framework Programme, grant number 284916.

With a project budget of 33M € the project is implemented during 3 years (2011-2014).

EADS Innovation Works

Key Research Themes:

- Prognostic and health monitoring of electromechanical actuators (EMAs)
- Develop a standardised architecture for:
  - Storing and exchanging sensor data and remaining useful life (RUL) calculations.
  - Enabling the development of new algorithms for calculating RULs.

Partners/Collaborators

- Tekniker
- Univeristy of Nottingham
- BAE Systems
- SAAB
- UTC/Goodrich
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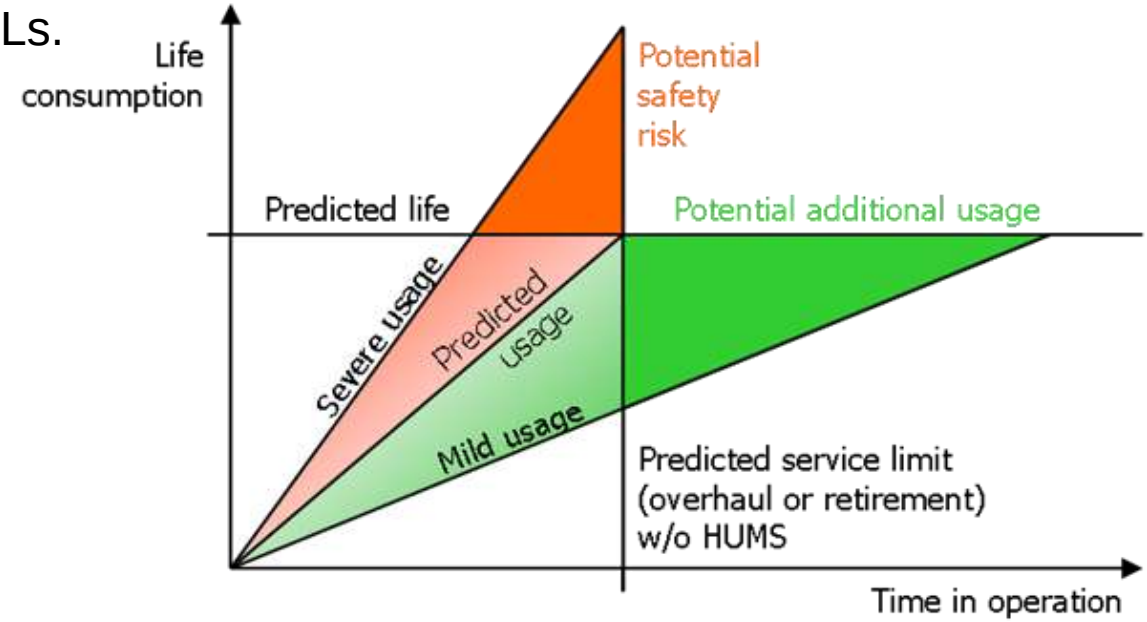
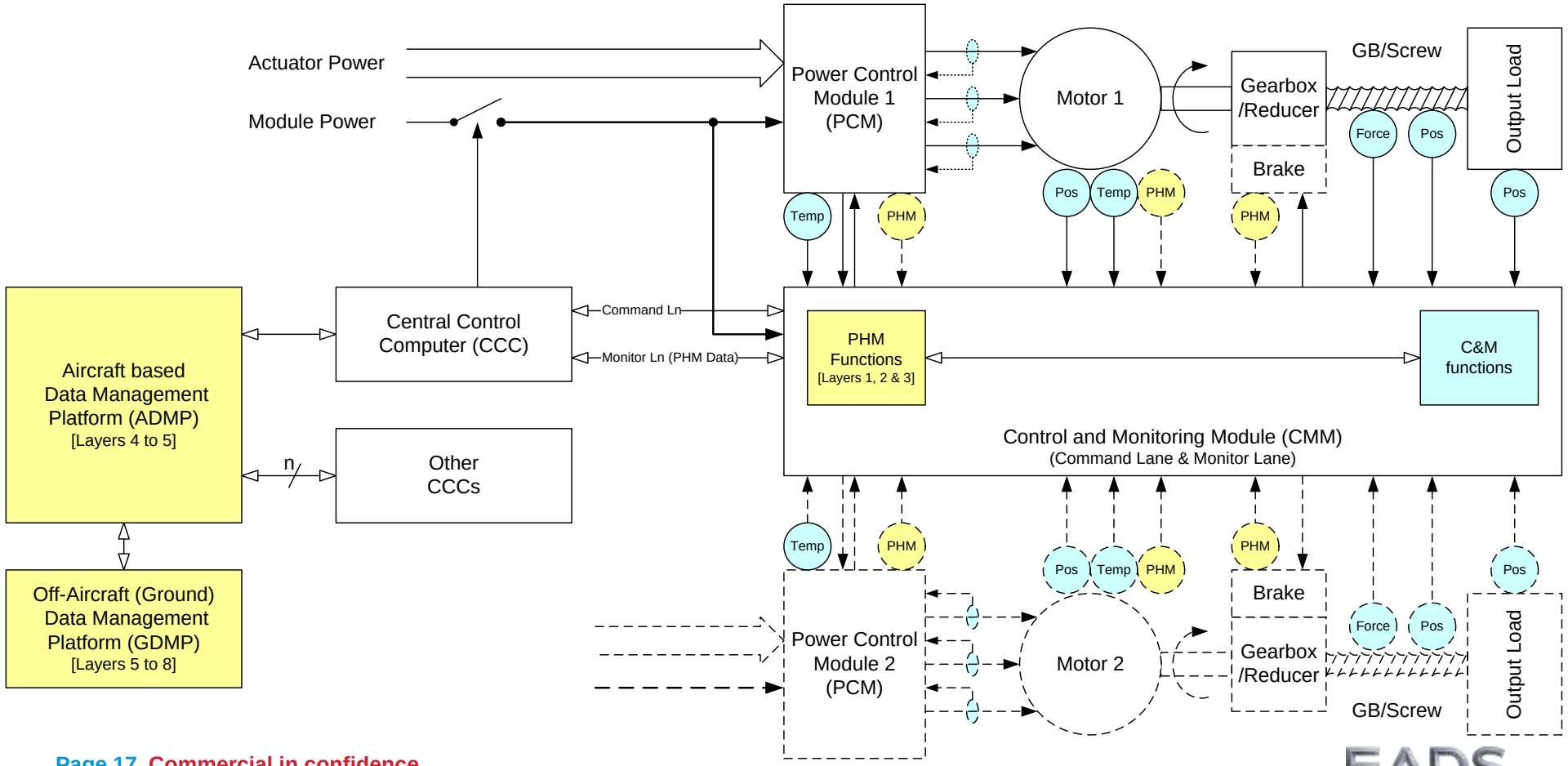
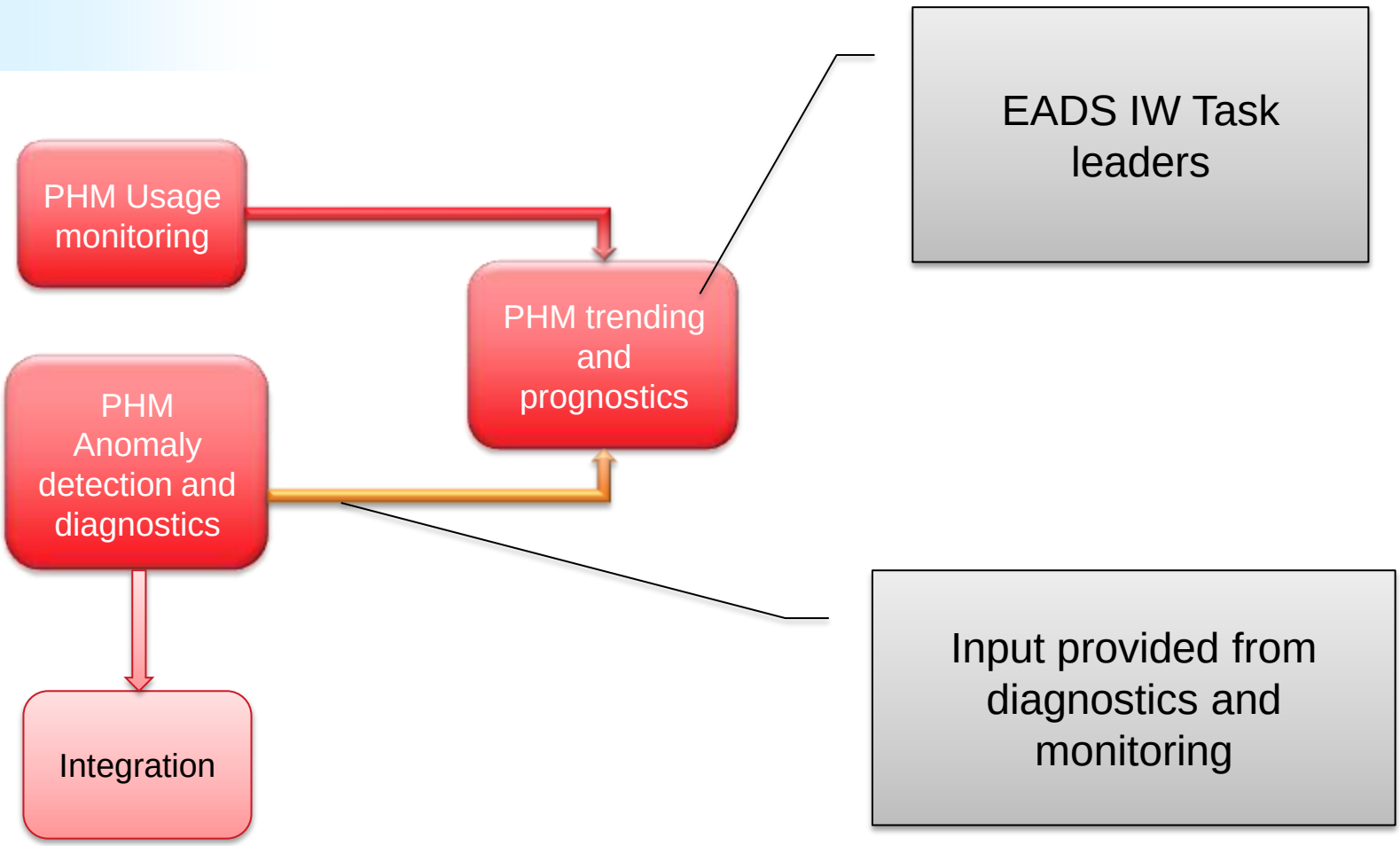


Actuation 2015

- Data processing on-board and off the aircraft.
- Prognostic and health monitoring performed without additional sensors



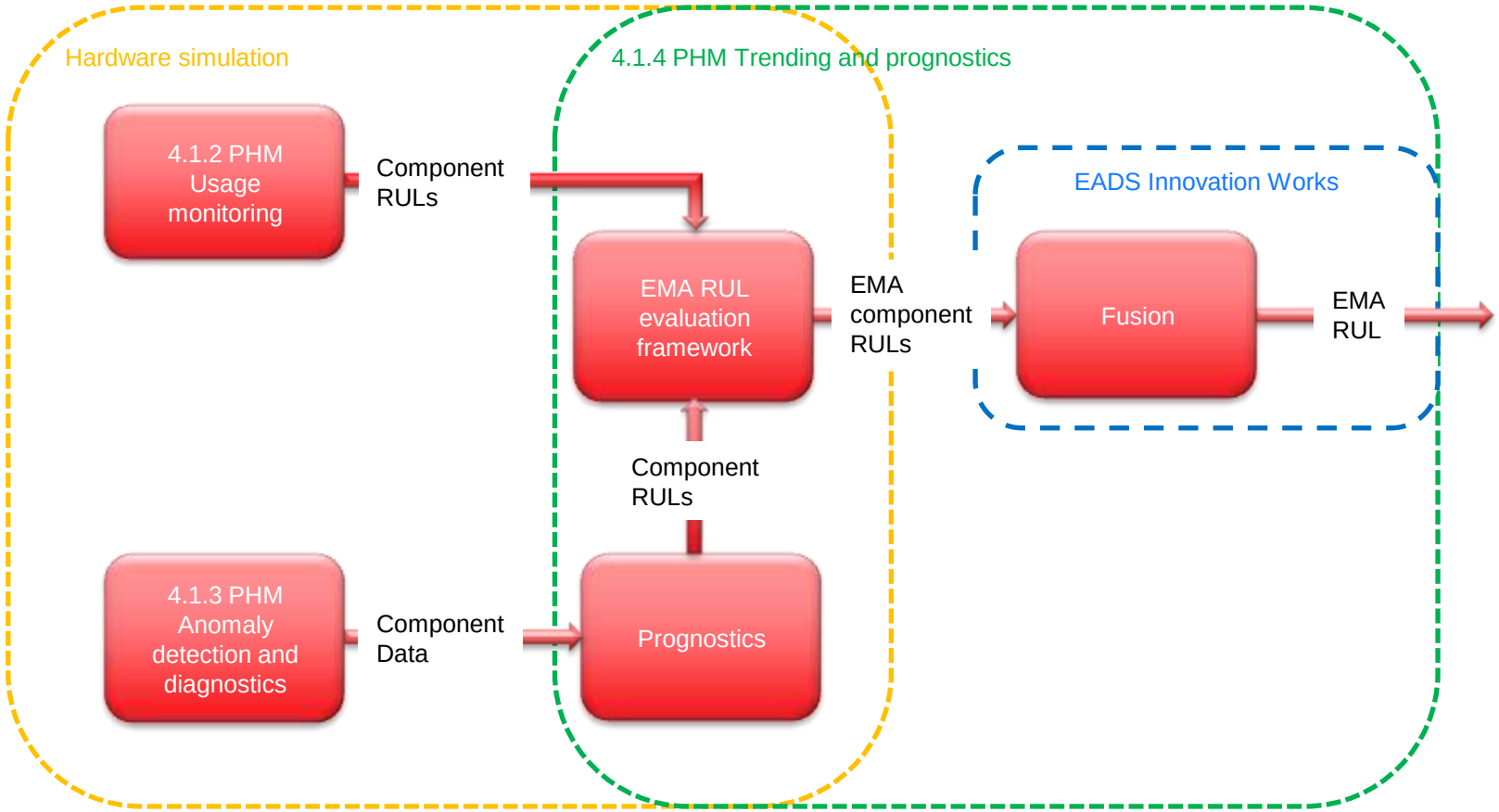
Prognostic data feeds



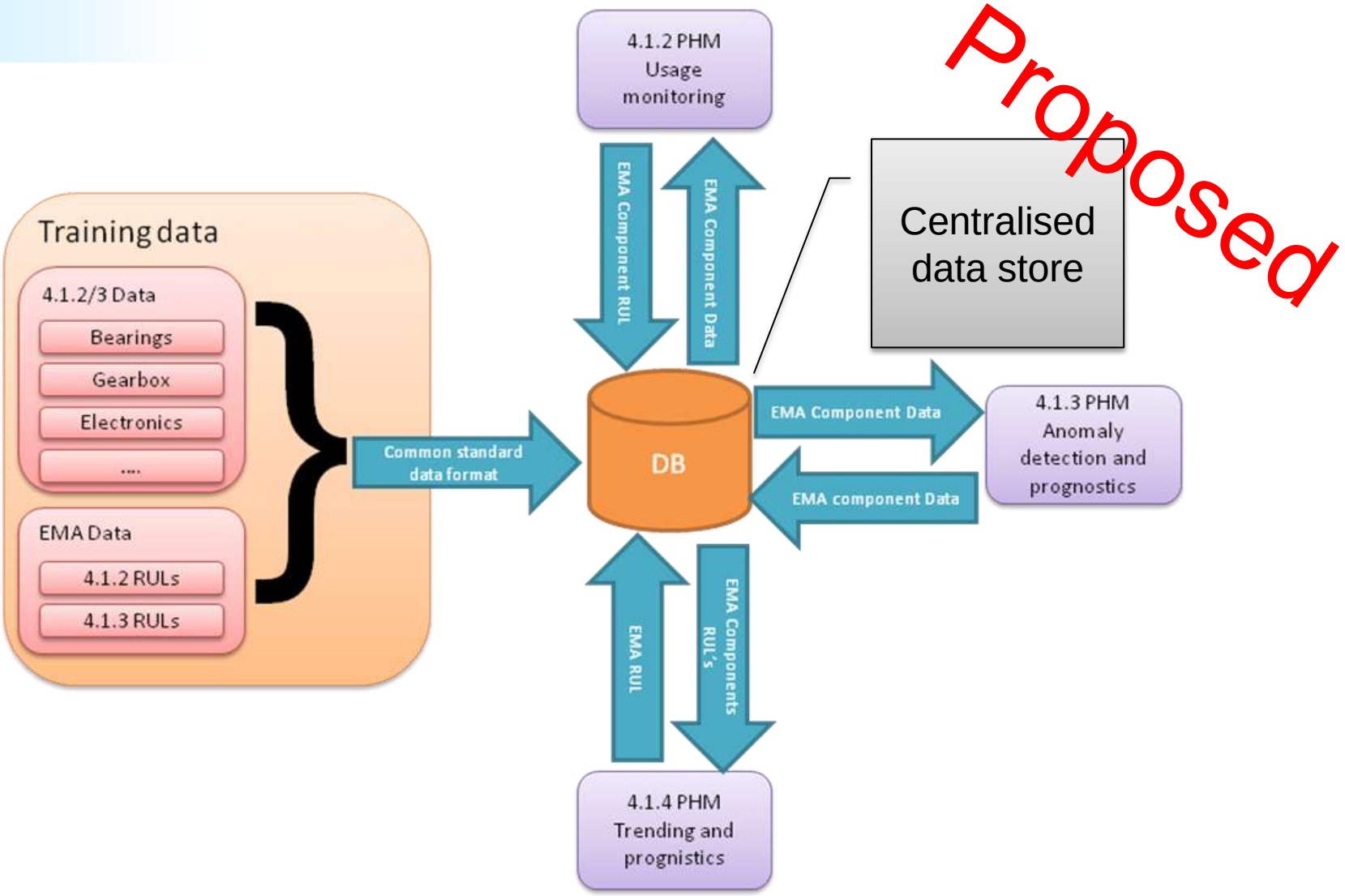
What are we looking to achieve?

- Anomaly detection and usage based monitoring are inputs
- These work on the component level
- Provide remaining useful life of components
- Systems of components (i.e. EMAs) have interactions
- Fuse the component analysis to gain a system level view

PHM Trending and prognostics system



Data sharing, a common data format



Summary

- Predictive health monitoring for EMAs
- Input from usage and physics based models
- Output of Remaining Useful Life from fusion of information sources
- Moving from component to EMA level prognostics

EADS INNOVATION WORKS

User welfare and information delivery

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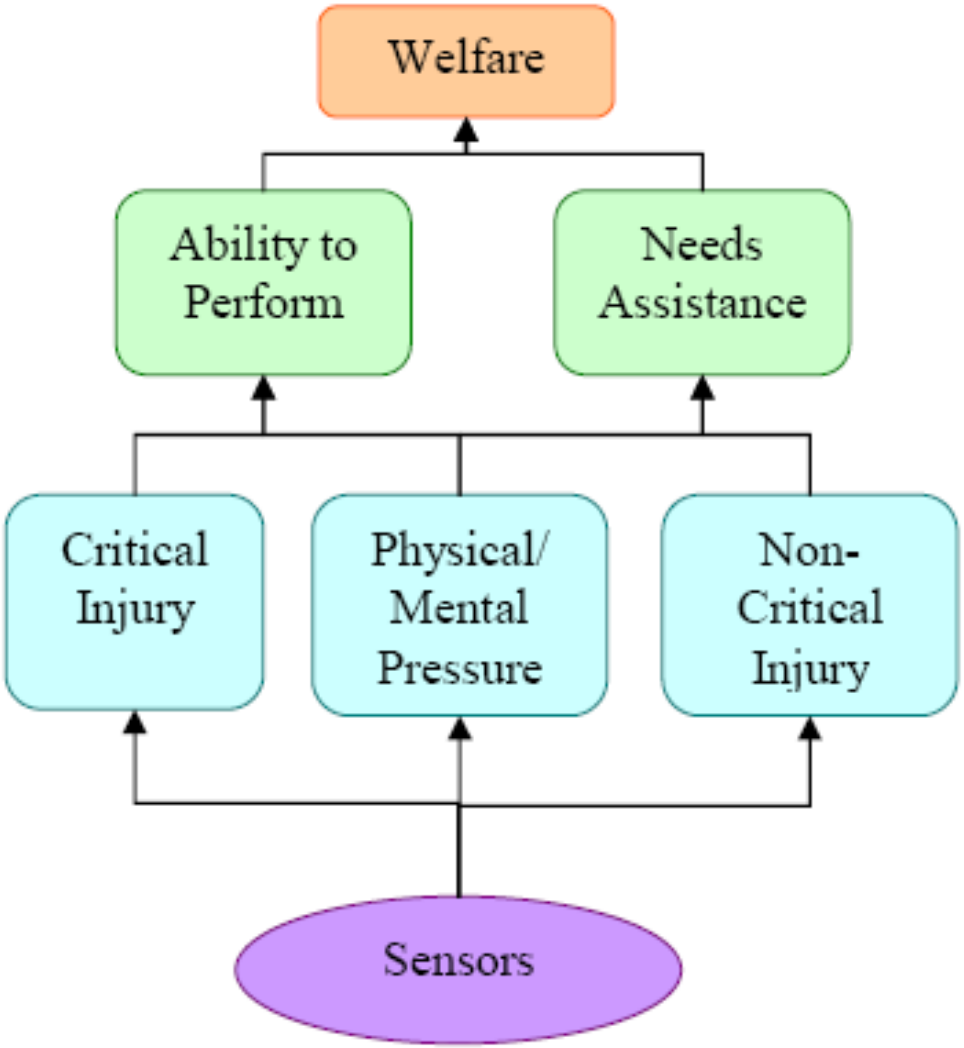
Context

- Workers, such as pilots, operate in critical stress rich environments
- Users are overloaded with information both in receiving and delivering
- User welfare monitoring can ensure that optimal (and safe) output is achieved from the worker
- Allow efficient decision making from the user
- Allow efficient tasking and monitoring of the user where required
- Optimise communication of information to and from user with respect to operating conditions, environment, user welfare and information content

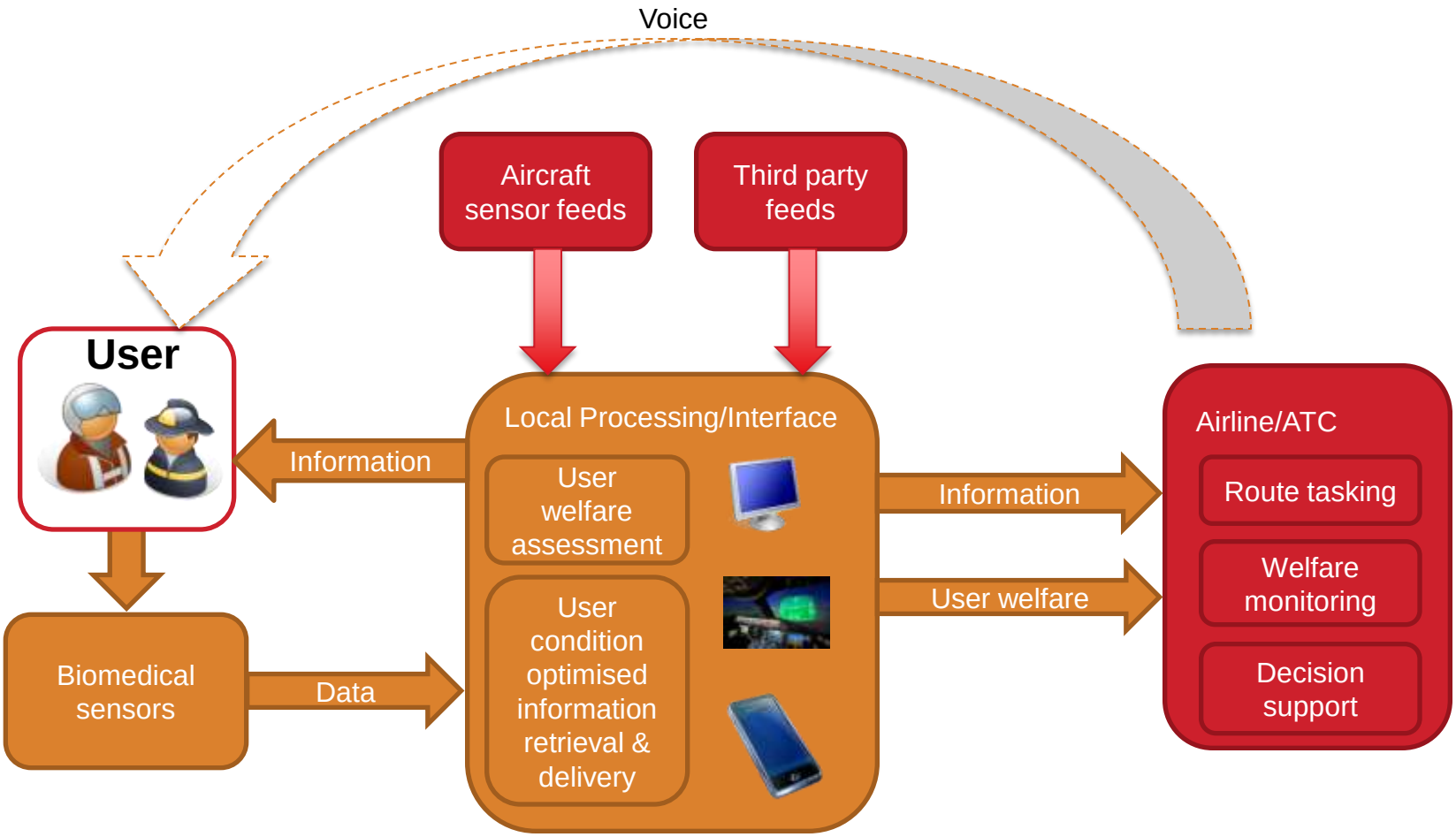
Environmental Stress and Welfare

- Adapt information delivery to user with respect to real time operating conditions. **Adaptable displays**
- Adapt tasking with respect to real time operating conditions
- Optimise information type, content, detail and timeliness in real time for display to user or retrieval from user
- Development of a non intrusive means of measuring physical and mental work loads
- Develop non invasive sensing of human biomedical signs
- Improve user decision making ability
- Test and validate in a stressful information rich/critical end user environment

User Welfare



Airline system application



Human Welfare Assessment with Wearable Sensors

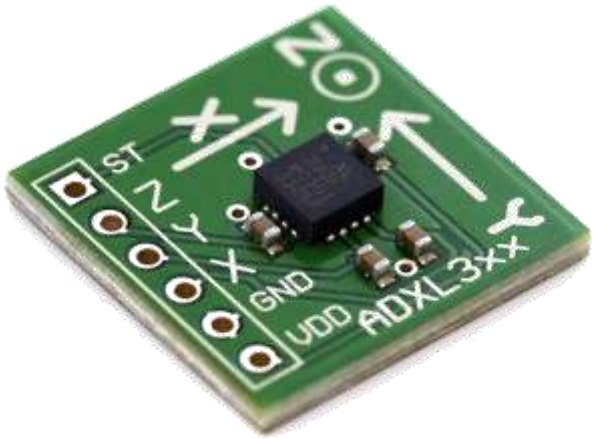
We have created a body worn sensor system with user customisable sensors to include:

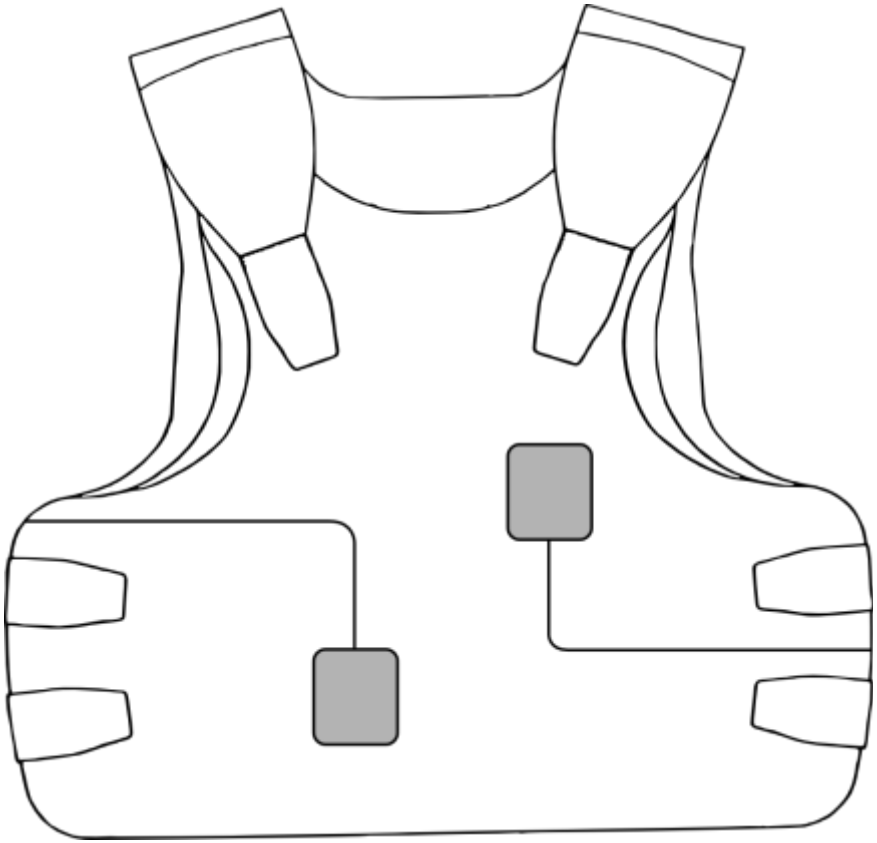
•Accelerometers for motion analysis & impact detection

- Currently using an Analog Devices ADXL330 Accelerometer (the same as used in a Wii Remote) - 3 axis, ±3g accelerometer

•Localisation, both GPS and non-GPS

•Biomedical

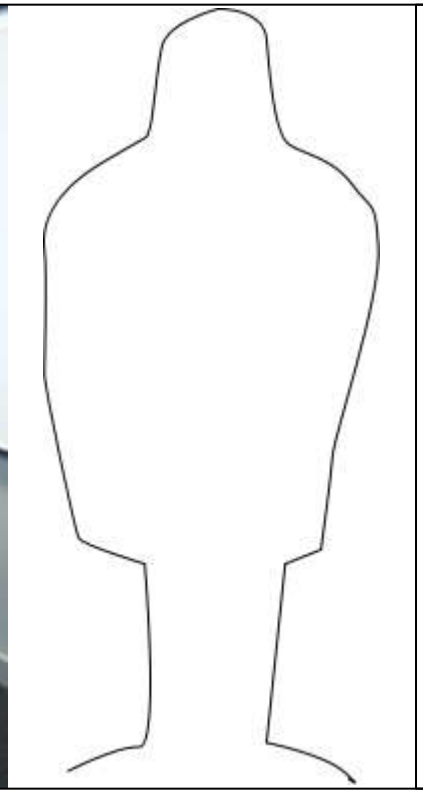




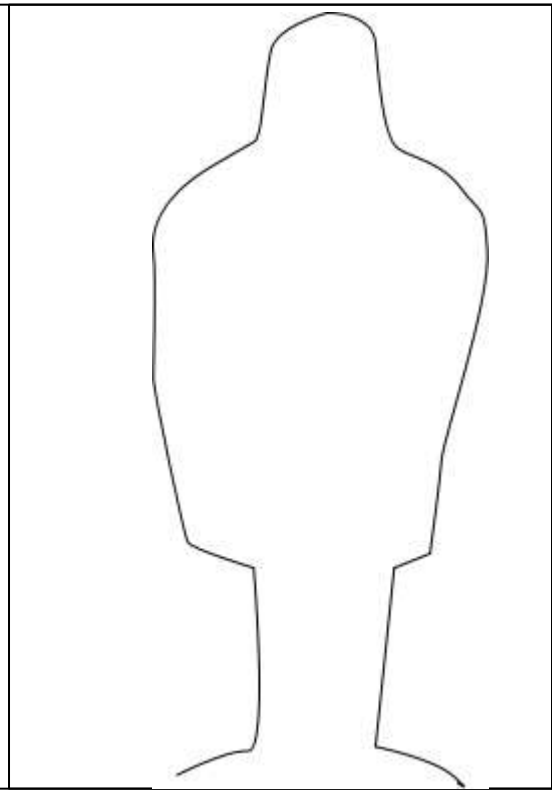
Mk1 and Mk2 prototypes

Mk I(a) Q2 2010

Mk I(b) Q2 2011



Mk II(a) Q2 2012



Mk II(b) Q3 2012

Latest version

Wearable Sensor Systems

•Selection of sensors which allow the environment and the user to be sensed.

•Allow us to detect various factors which can then make a decision on

- Critical Injury (such as a gun shot)
- Non Critical Injury (such as a fall)
- Pressure (Mental and Physical)

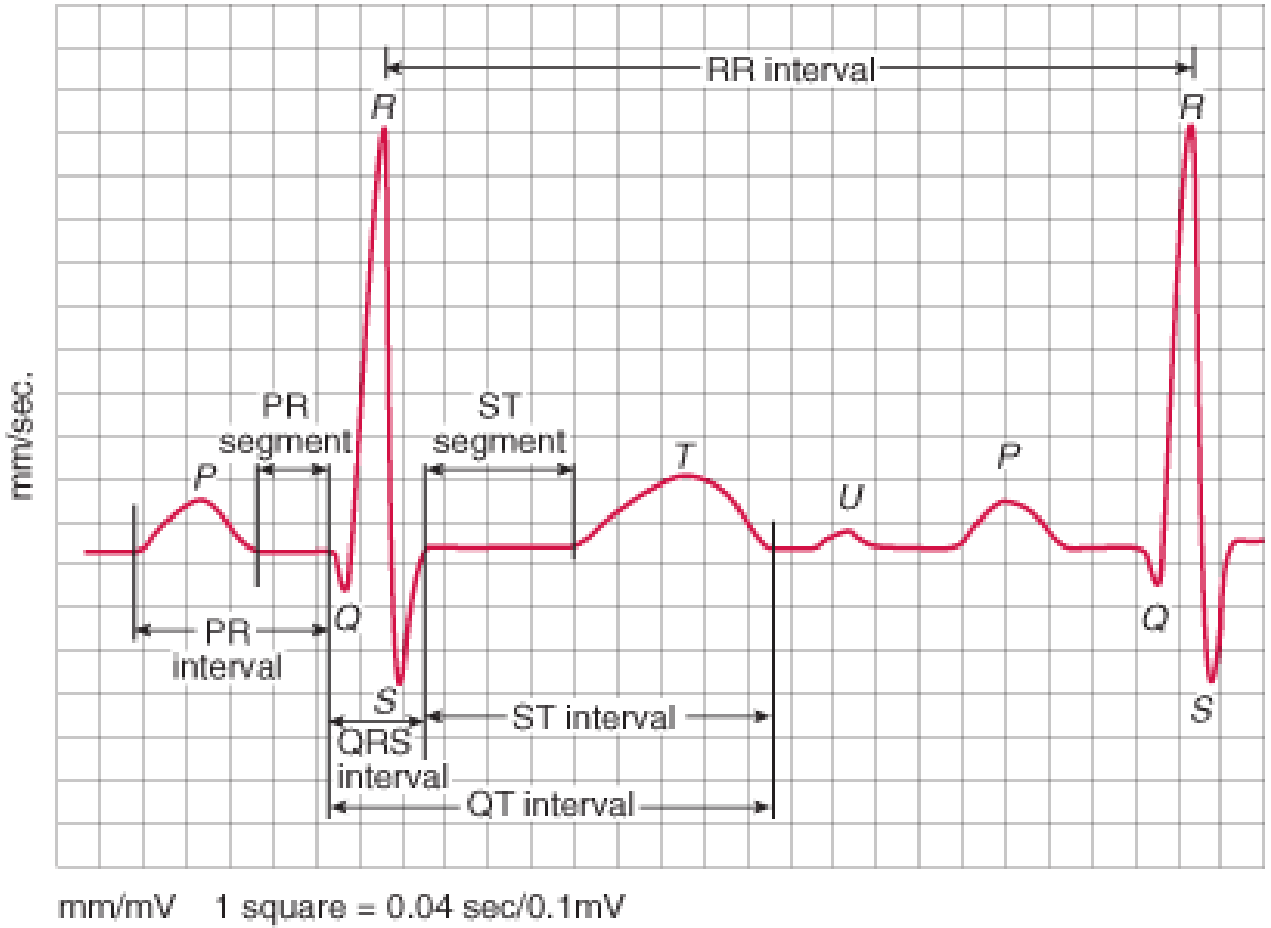
Non-Critical Injury Classification
Activity Classification

- Currently TRL 3-4
- In-house modular and generic machine learning library — customised for activity classification
- Implemented, tested, and demonstrated using the Mk I vest
- **Integrated with IBM Information Fabric**
- Reliable — can discern between different activities with a high degree of accuracy
  - E.g. Stand, walk, run, jog, crawl, lying down, ascending/descending stairs...
  - Up to 99% accuracy in offline tests
  - Does not need to be trained for each user

Non-Critical Injury Classification
Activity Classification

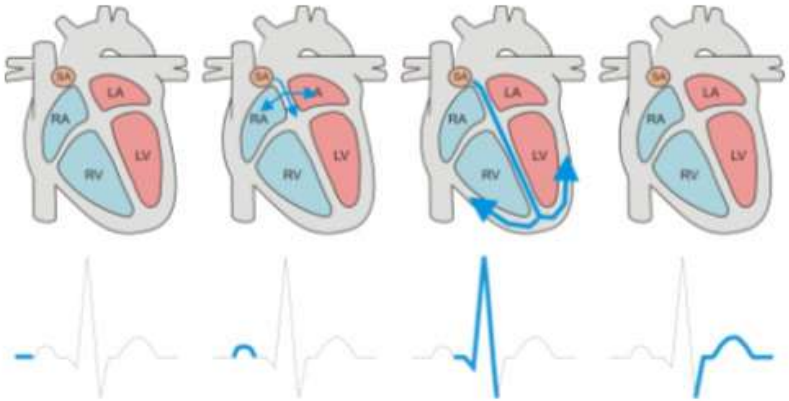
- **Simple — requires a single torso-mounted accelerometer**
  - Contained within a sensor box
  - Some limitations, particularly when stationary — can be solved by using multiple sensors
- **Flexible — not limited to a particular classifier or set of activities**
- **In progress: Feasibility study for activity classification using COTS products**
  - Nearing completion
  - Smartphone + cheap microcontroller board

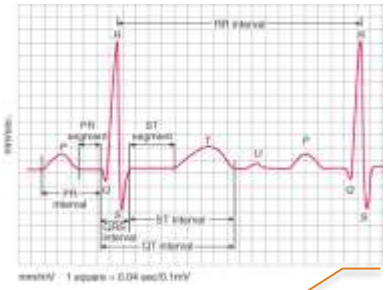
An ECG and RR intervals



Biomedical Monitoring

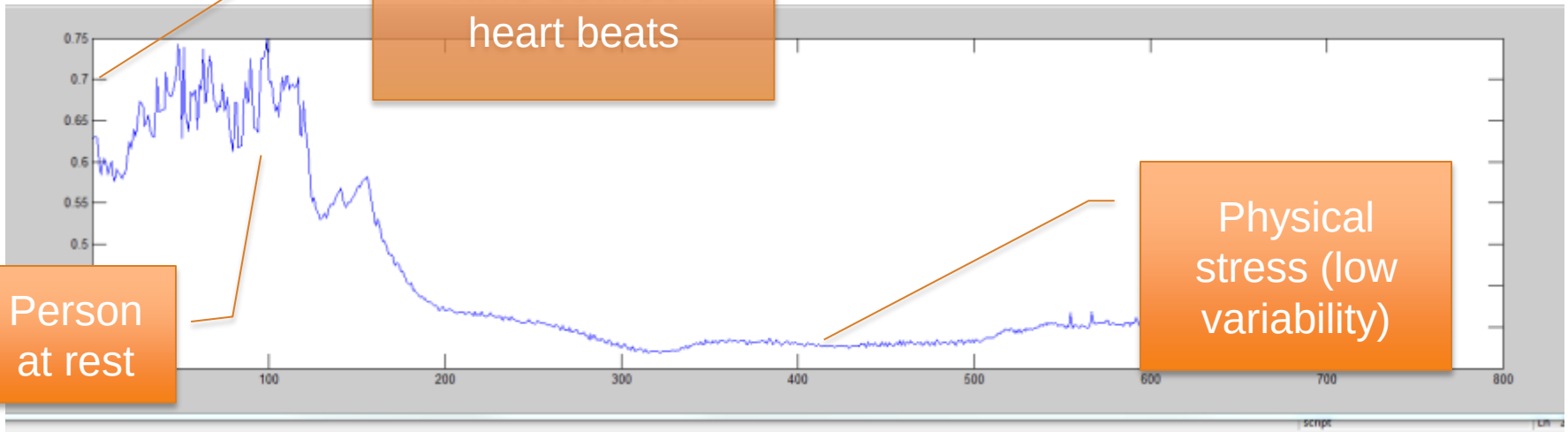
Use of biomed sensors to determine physical and mental stress and duress.





Heart rhythms change under stress

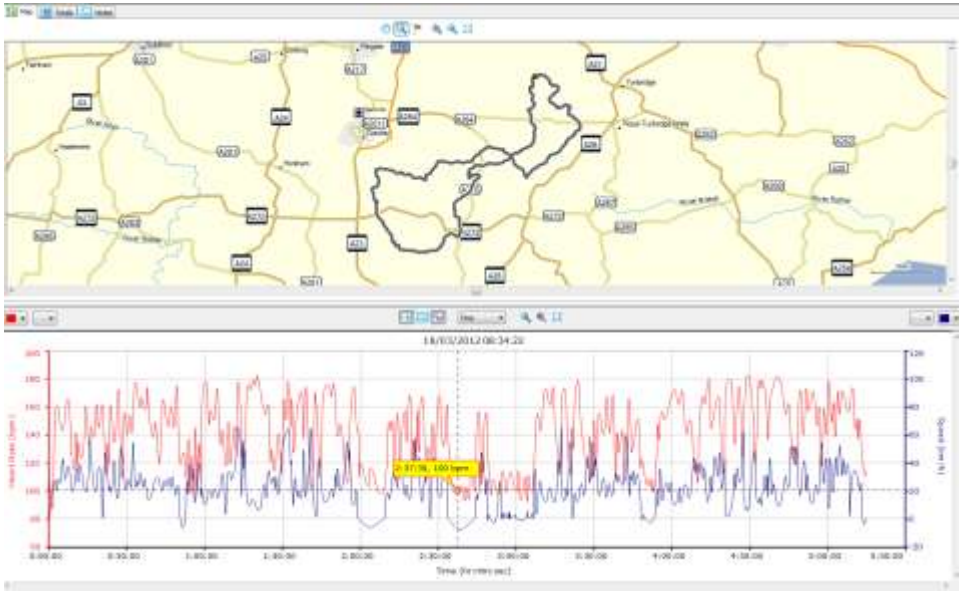
Time between heart beats



Person at rest

Physical stress (low variability)

Building the model and testing



Phase I

- Mathematical tests
- Cycle racing

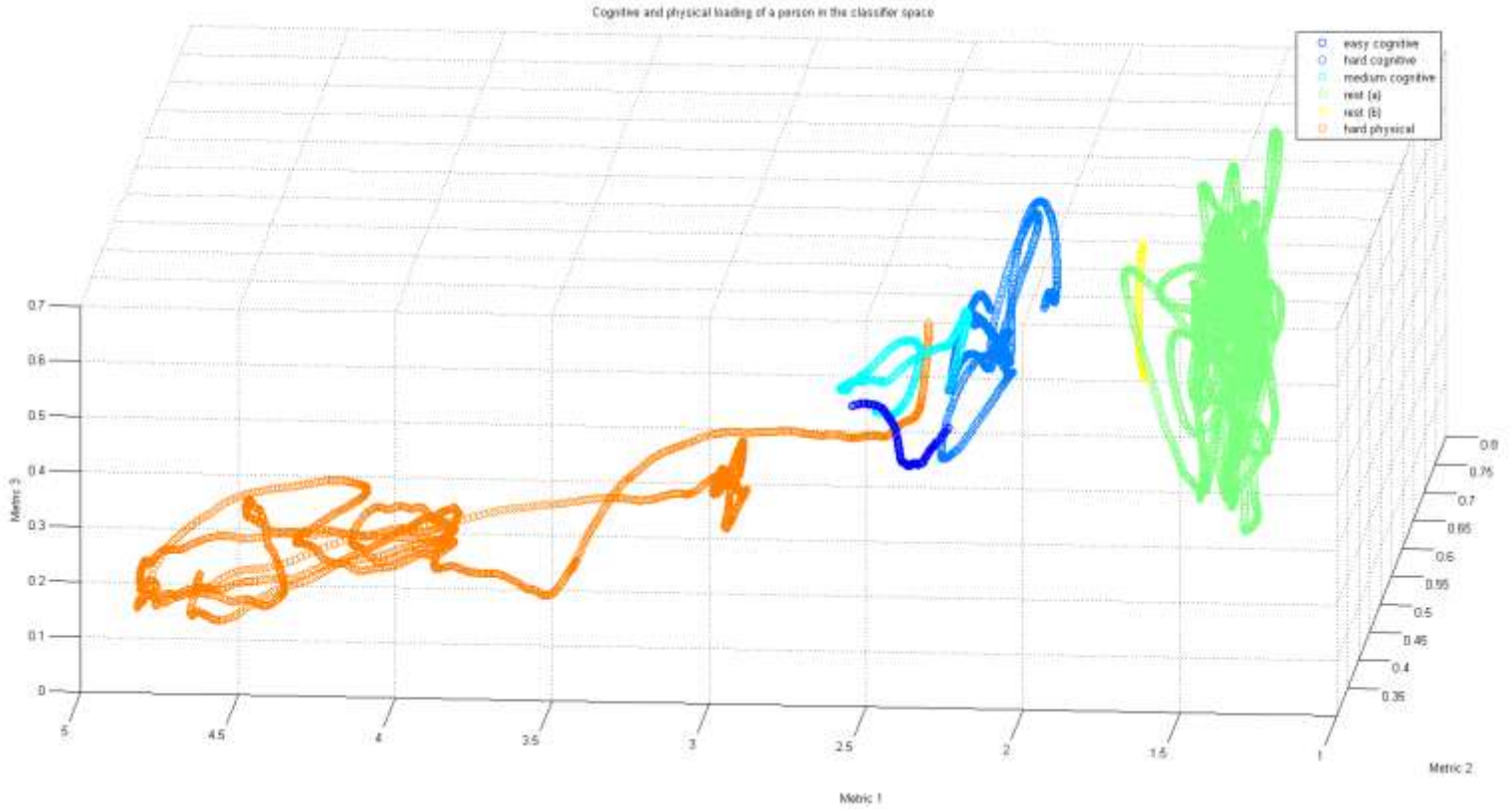
Phase II

- Hot bath & cognitive testing

Phase III

- Treadmill, VO2 Max, extended cognitive loading

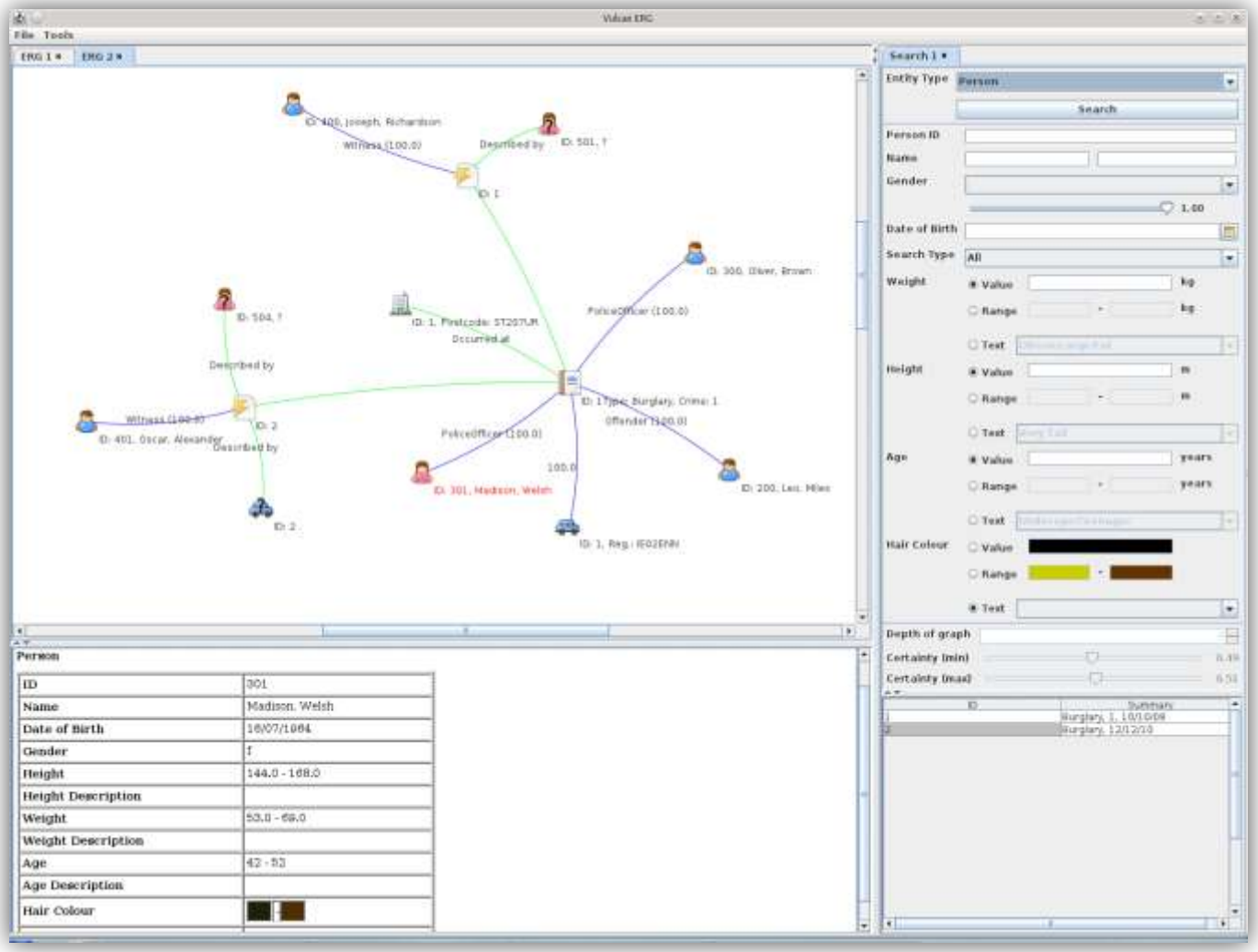
Physical and Cognitive load detection with HRV
Initial Feasibility



Data hungry applications outside of the aircraft

Welfare monitoring of astronauts and rover control

Finding the villain from vague data



Cohesion and tension detection in the community

Collect data → explore & predict → output to user

twitter

UK National Statistics

data.gov.uk

GOV.UK

Web Lab

Analyse & predict

- Measure metrics
- Fuse information
- Assess cohesion & tension