Value-Driven-Design of Unmanned Aerial Vehicles

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Royal Aeronautical Society UAS Conference
20/09/2012
Overview

- Southampton and Unmanned Systems
  - MSc Unmanned Systems
  - C2ASE
  - ASTRA
  - DECODE
  - 2Seas
MSc Unmanned System Vehicle Design

“Practical Systems Engineering”

- Launched 2011
- Provide graduate engineers with the necessary skills and knowledge to become unmanned vehicle systems designers.
- Give students realistic experience in undertaking a full conceive, design, build, operate development cycle.
- Provide students with the ability to undertake an individual project where they can undertake a deep exploration of a research topic relevant to unmanned systems.
- Encourage students to explore innovative but possibly high risk design solutions that might not be possible within a commercial setting.
C2ASE (Centre for Complex Autonomous Systems Engineering)

- Multidisciplinary experts:
  - Faculty of Engineering and the Environment,
  - Faculty of Physical and Applied Sciences,
  - Institute Life Sciences and the National Oceanography Centre Southampton.
C2ASE example artefacts

- Autosub
- 5 DoF test lab
- Satellite system
- Student UAV
- Oceanography UAV
- Rotary wing
- Inflatable wing
- SULSA aircraft
- Ground Vehicle
Projects

- EPSRC project: Reliability control of AUVs
- EPSRC project: EASS - Engineering Autonomous Spacecraft Software
- EPSRC project: DECODE – Decision Environments for Complex Designs
- EPSRC project: RCSF – Robust control of spacecraft formation flying
- EPSRC project: Autonomous Spacecraft Testing Facility
- EPSRC project: Intelligent Agents for Home Energy Management
- EPSRC project: ORCHID: Human-Agent Collectives - From Foundations to Applications
- EPSRC project: PATINA: Personal Architectonics Through Interactions with Artifacts
- EPSRC project: GLACSWEB - Sensor networks for glaciers
- EPSRC Project: RAUT – Reconfigurable Autonomy
- EPSRC Project: DCMA – Distributed Sensing, Control and Decision Making in Multiagent Systems
- Industry project: sEASS - sEnglish based programming of autonomous surface ships
- Industry project: iDEaS – Intelligent Decentralised Energy-Aware Systems
- Industry project: AuRec – Autonomous reconfiguration of damaged AGVs
- Industry project: ASHAG - Autonomous systems in the household and garden
- Industry project: VUAV – Verifiable UAV systems
- Industry project: NAUV – Range only navigation of AUVs
- Industry project: UAVO – Unmanned Aerial Vehicle for Oceanography Applications
- Industry project: MACSI – Multi-Agent Control of Space Based Interferometry
- Life sciences project: NMIL - Neural Modelling of Insect Locomotion
ASTRA (Atmospheric Science Through Robotic Aircraft)

- BAS
- Met Office
- MAVIS (Massive Airspace Volume Instrumentation System)
MAVIS: What, Why

Input
Payload/Sensor type, mass and target mission

Rapid Design and prototyping of low cost custom sensorcraft

Balloon trajectory modelling

Sensorcraft path optimisation

Release, tracking and recovery

Output
Low cost optimally sampled airspace volume

- minimizing the disruption; volcano eruptions (the Eyjafjallajökull event estimated to have caused GDP losses exceeding 4 billion pounds mere two weeks in 2010)
- protecting from Fukushima-type nuclear fallout and other pollution events
- providing early warning for wildfires and
- enhancing our understanding of atmospheric phenomena connected to climate change or extreme weather events, to name only a few.
DECODE

• DECODE (Decision Environment for Complex DEsign)

• Primary deliverable; **Value** evaluation software tools and techniques
WHY IS VALUE METRIC USEFUL?

Spitfire

13000 manhours

SPITFIRE; EXAMPLE OF POOR VALUE!

Me 109

– 7000 manhours

JP Scanlan
DECODE Value Modelling

• Can show the “value” effect of scaling/modifying a concept

• Finds “best” platform solution for a given mission

• Cannot evaluate multiple widely different concepts (Topology optimisation).............
Workflow

Low fidelity/high fidelity

- Product Definition (Explicit variable)
- Unit cost estimation
- Performance prediction
- Operational simulation
- Reliability/maintainability

Value Metric (cost to achieve service level constraint)
Rapid Prototyping

• Pros:
  – Fast
  – No tooling
  – Suits low volume production

• Cons
  – Complex labour intensive geometry*
  – Relatively poor material properties
The need for validation and testing

- Several hundred flight test hours planned for DECODE 2Seas
- Engine test rigs
- Actuator test rigs
- Reliability data
2Seas Project

- Maritime Surveillance UAV technology assessment

- Dutch, UK, French Police forces
2Seas

- Very wide range of possible UAV solutions; Small, Large, Electric, Petrol, Mixed fleet, fixed wing, rotary wing, Catapult launch, long loiter, short high speed, semi-disposable, seaplane.....

- Partner prejudices and preferences; Dutch Police prefer no prepared landing area (catapult) UK police happy to have prepared operating strip, Delft prefer electric aircraft....
The need for rational analysis metrics and tools?

**Danger of Intuition**

- Squares A and B are exactly the same shade.
- Human eye is deceived by misleading context.
- Design decisions for complex systems also counter-intuitive unless viewed in the correct context.
DECODE Value Modelling

Performance metric
output plots

Concept Search
Development of the Topological Concept Design Tool

- Requires user to provide fewer input parameters
- Cheaper and faster compared to PACELAB and other software
- Should allow quick trade studies to be carried out.
Topological search Rolls-Royce UAV Test Case

- Anglo-French project to develop a Future Combat Air System (FCAS), another unmanned air system, which is to be completed by the years 2030-40.

- BAE Systems, Dassault Aviation and Rolls Royce/Snecma have also signed an industrial agreement to work together in support of this contract.

- Goal To apply VDD in order to carry out trade studies of the engine and power generation systems design.
Topological Search; UAV Classification

• Identify the functional requirements of a UAV and break them down to individual Modules.

• Develop a scheme that classifies a given UAV configuration based on the modules that define its shape, size, the propulsion system it carries, etc.

• Vision of classification scheme: UAV – 1001236.......
Finally;
The influence of Certification and the need for Highly dependant systems