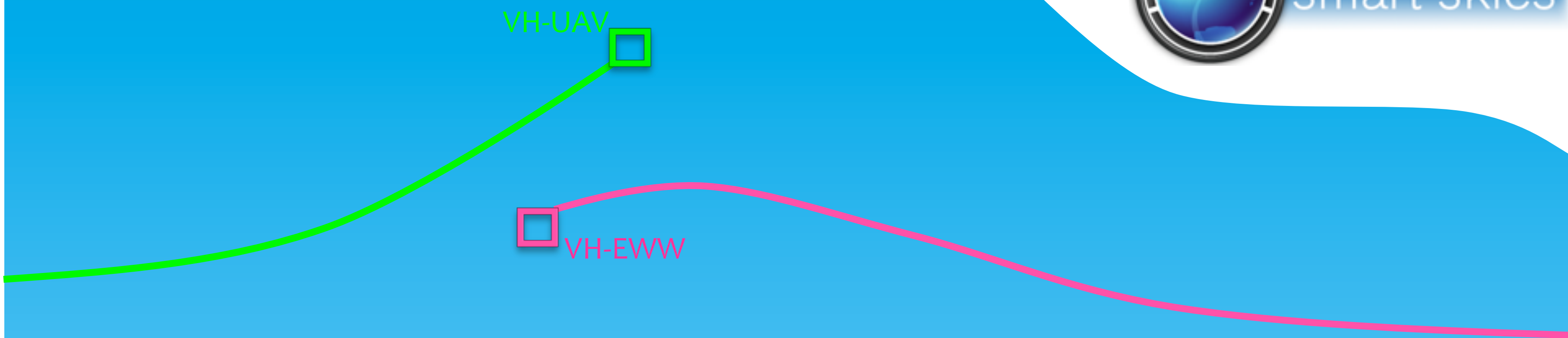


The Smart Skies Project

Enabling Technologies for UAS Operations in Non-segregated Airspace

Mr. Reece Clothier

Introduction

* 3 year, AUD$10M joint research project
  * Australian Research Centre for Aerospace Automation
    * Queensland University of Technology
    * CSIRO ICT Centre
  * Boeing Research & Technology (United States)
  * Boeing Research & Technology (Australia)
  * Insitu Pacific Ltd
* Supported by a Queensland State Government NIRAP Grant

Objectives

* Develop and demonstrate automated separation management technologies that facilitate greater utilisation of the national airspace system by both manned and unmanned aircraft

* Utilise the information and experiences gained to support the further development of standards, regulations and safe operating practices for civil and commercial UAS in Australia and overseas

Research Areas

1. Mobile Aircraft Tracking System (MATS) – a mobile, networked, multi-sensor surveillance system supporting UAS operations in non-segregated airspace

2. Vision-based Sense and Act (SAA) system – an automated system capable of replicating the See-and-Avoid function of a human pilot

3. Static Obstacle Avoidance (SOA) system – an automated avoidance system for low-altitude aircraft operations

4. Future automated airspace management system – capable of managing complex and dynamic airspace

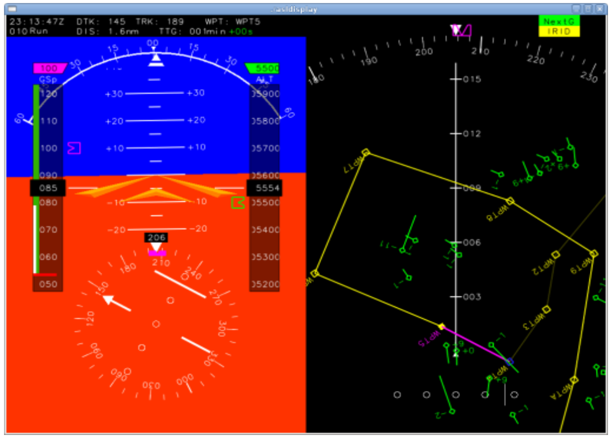
Flight Test Capability

* As well as fundamental research & development, an extensive flight test campaign was conducted

* Aim was to develop and prove research concepts through a series of phased flight experiments

Flight Test Capability

* Automated Cessna 172R
  * Onboard flight & sensor data capture
  * Custom flight management system & display, with input to onboard autopilot
  * Iridium and NextG™ communications facilitating automated telemetry, command and control from anywhere in the world



Unmanned Systems

* ARCAA Flamingo UAS

  * MicroPilot 2128 Autopilot
  * ~20kg MTOW
  * 4m wingspan
  * ~ 1 hour endurance
  * Iridium and NextG™ communications facilitating automated telemetry, command & control from anywhere in the world
  * Over 70 hours of automated operations

Unmanned Systems

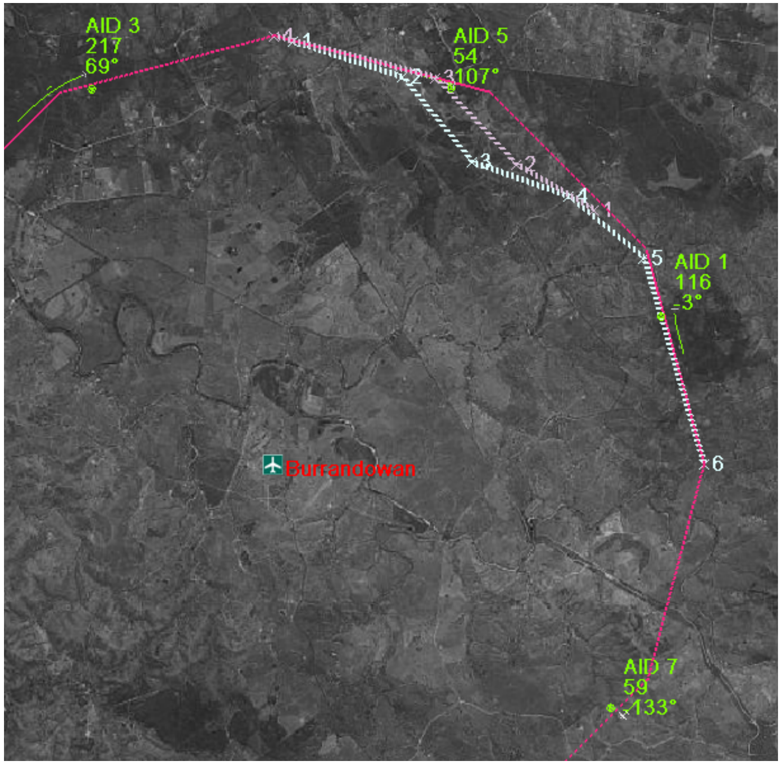
- ARCAA Heli UAS
  - Custom autopilot, FMS & ground station
  - 12.3kg MTOW
  - 1.8m rotor
  - 45 mins endurance
  - Scanning laser & stereo vision sensors
  - Iridium and NextG™ communications facilitating automated telemetry, command & control from anywhere in the world

Mobile Aircraft Tracking System

* Research, develop & demonstrate a field-deployable surveillance system
* Designed to support UAS operations in non-segregated airspace
* Commercial off-the-shelf primary radar & tracking system
* Automatic Dependent Surveillance- Broadcast (ADS-B)
* Filtering, display & communication systems

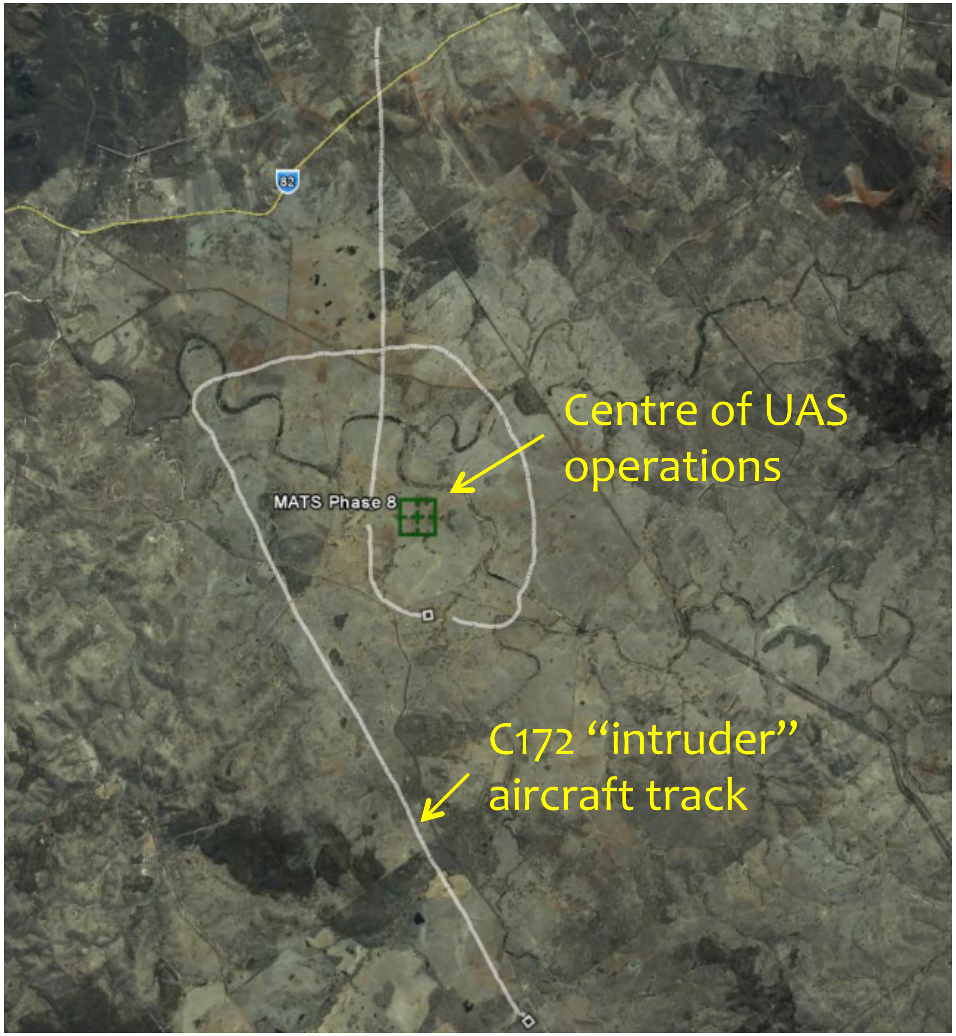
Results

* Radar detection and tracking performance characterisation testing for a C172 and small fixed wing UAS targets
* Tracking between 5-15NM depending on radar site



Results

* Experimental UAS operational scenarios with “intruder” C172 aircraft
  * Demonstrated use of radar for additional situational awareness
  * Valuable lessons learnt on how UAS operators can effectively use the data

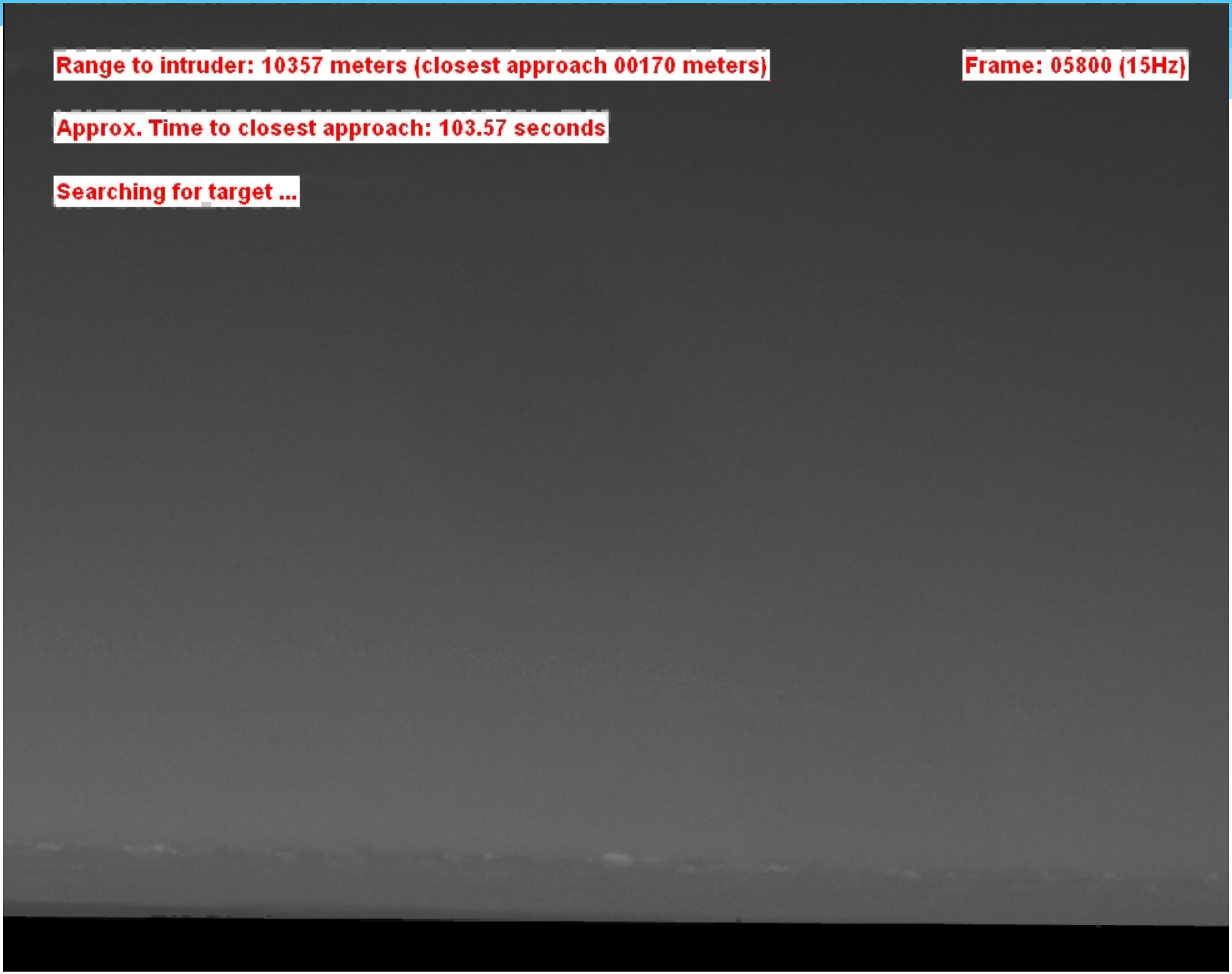


Sense-and-Act

* To research, develop & flight test an automated Sense-and-Act (SAA) system for detecting & avoiding mid-air collisions

* Full closed-loop control of the ARCAA C172
* Controlled experiments involving head-on and over-taking scenarios with a C182
* Range of FoV, image processing & control law configurations explored

Results


Range to intruder: 10357 meters (closest approach 00170 meters)
Frame: 05800 (15Hz)
Approx. Time to closest approach: 103.57 seconds
Searching for target ...

Results

* Believed to be the first in the world to demonstrate fully automated real-time onboard collision avoidance using a vision-based SAA system
  * Real aircraft, real hardware, real conditions
  * 80+ data sets collected

* Demonstrated detection ranges in excess of 10km to time to closest point of approach

* Key challenges:
  * Prevention & compensation of vibration
  * Finding the optimal configuration to minimise the MDR & FAR across a range of atmospheric, cloud and lighting conditions

* Outcomes & Future Direction:
  * Current concept is a feasible & cost-effective SAA solution for UAS or collision avoidance aid for conventionally piloted aircraft
  * Exploration of multi-spectral sensors

Static Obstacle Avoidance

* To research, develop & flight test an autonomous Static-Obstacle-Avoidance (SOA) system suitable for close range (<30m) Rotorcraft UAS operations at low-altitudes
* Research explored the use of a 2D scanning laser and stereo-camera sensors
* Detection of trees & autonomous operations around infrastructure

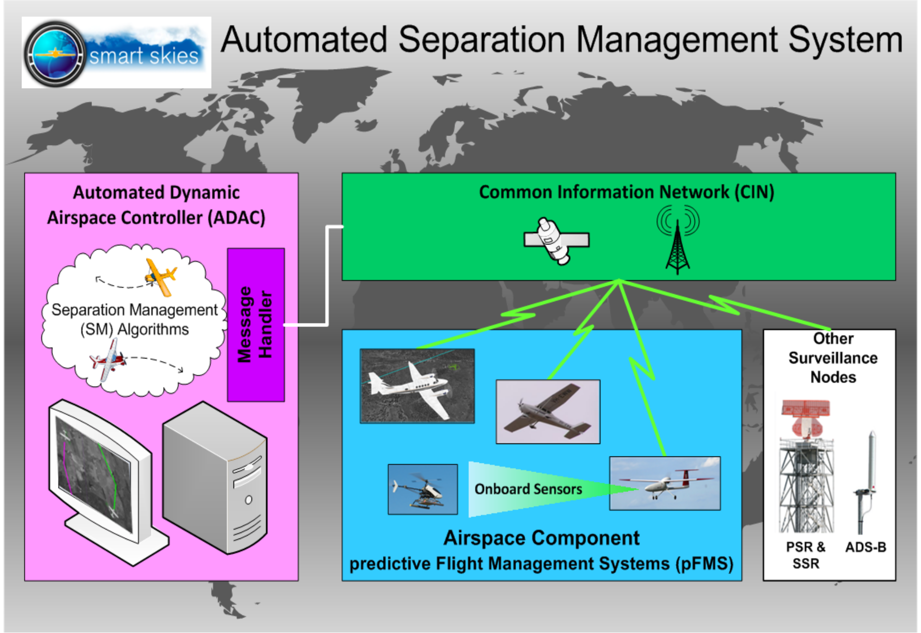
Results

Results

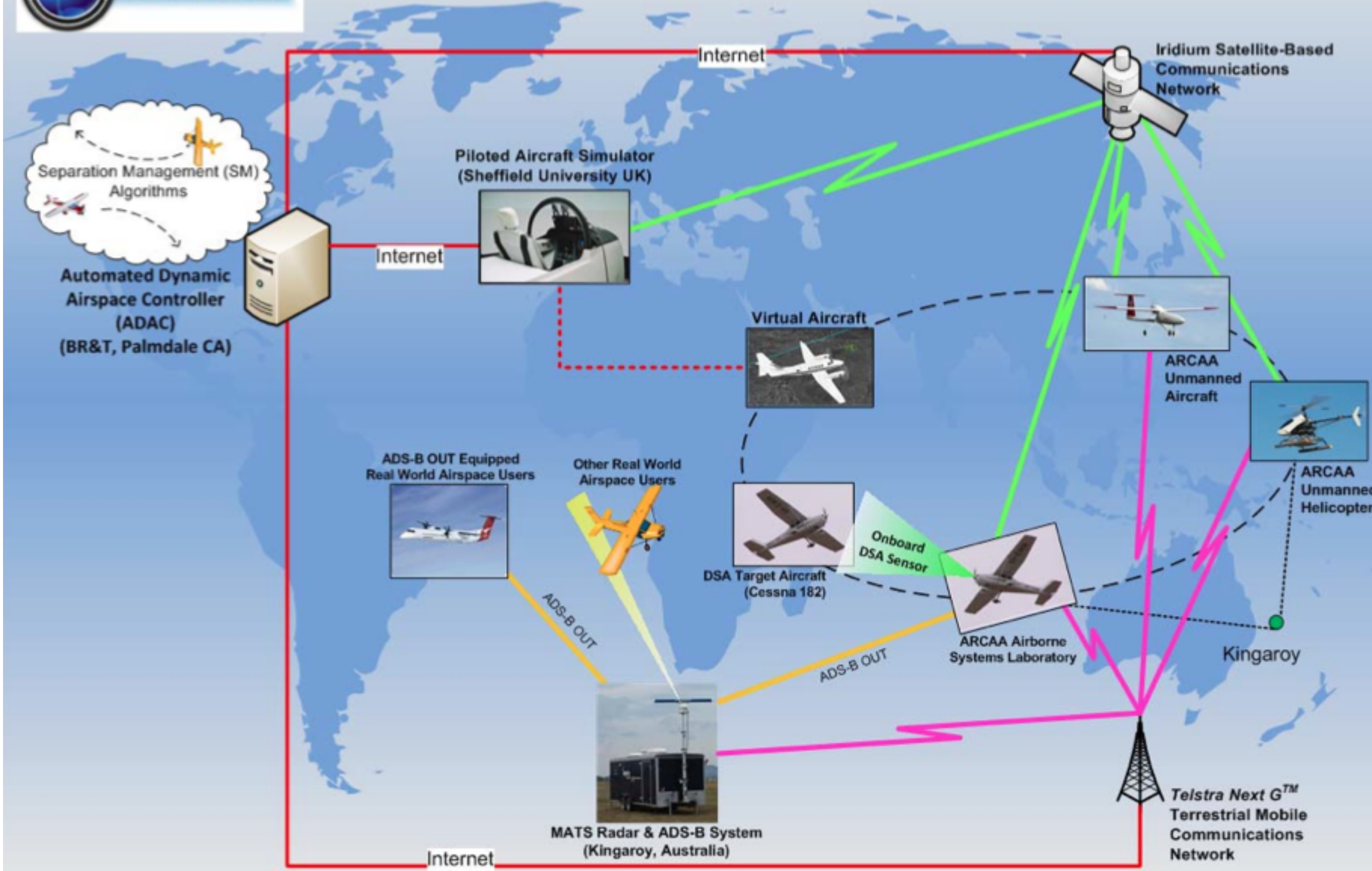
* Demonstrated automated, beyond visual range operation in “unknown” obstacle environment
* Over 60 flights were completed exploring a range of single and multi sensor configurations
* Laser produced most reliable avoidance capability
  * 84% success rate vs 42%
  * Detected trees out to 23m, microwave tower out to 18m
  * Sensing range was less than stereo vision sensor
* The wide (270 deg) horizontal field of view of the laser allowed it to continue sensing obstacles even when flying alongside them
* Future Direction
  * Further development of LIDAR sensor for use in complex obstacle and infrastructure inspection tasks

Global Automated Separation Management System

* Global automated separation management service from anywhere in the world
* Automated conflict detection and resolution
* 4D separation resolution
* Multiple communications links
* Complex mix of airspace users, intent & behaviour
* Separation commands fed directly into aircraft FMS



Automated Separation Management System



Results

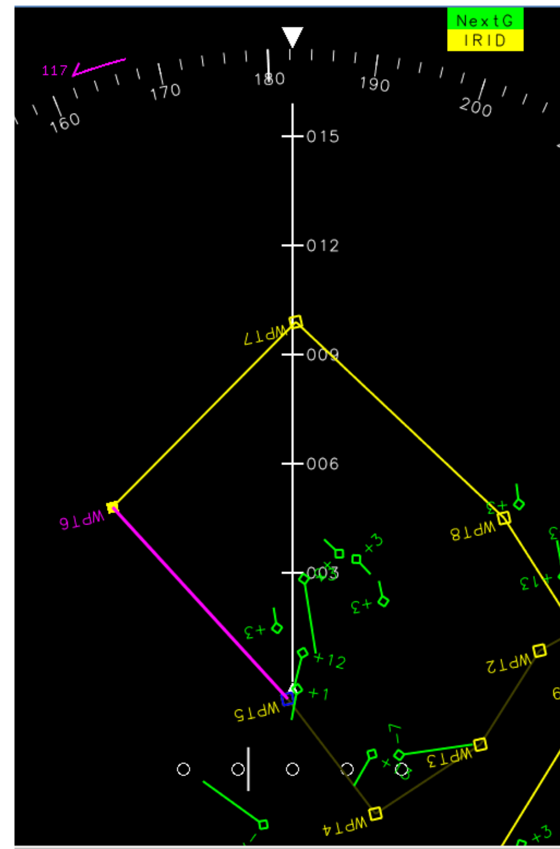
Experiment View

C172 Flight Display

Results

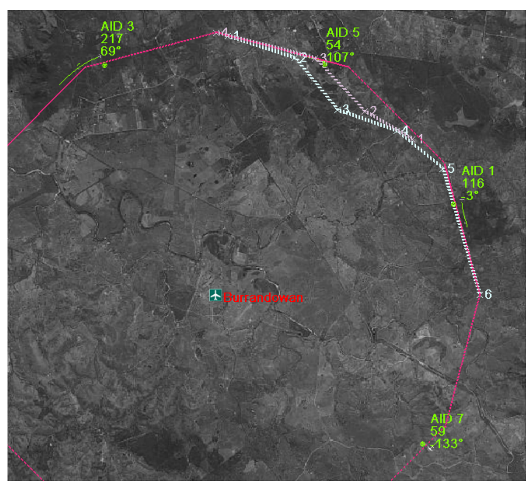
UAS on C172 Scenarios

Complex scenarios:
C172 Primary Flight Display showing some of the 49 other aircraft



UAS on UAS Scenarios

Scenarios using radar data



Results

* Demonstrated for real aircraft, real communications links, in complex scenarios involving up to 50 real and simulated aircraft
  * Real communications performance, real aircraft dynamics, real sensors
  * Truly global system – providing a completely automated separation service from Palmdale CA to Queensland Australia

* Trials included non-cooperative aircraft detected using the MATS and SAA systems
  * Mixed mode separation (*i.e.*, global/central separation or local/aircraft-based separation)

* Key challenges:
  * Ensuring the quality of the separation service under variable communications performance (latencies & drop outs)
  * Managing processor

* Outcomes & Future Direction:
  * Believed to be the first in the world to autonomously command & control UAS using a civil mobile cellular network (from the other side of the world)
  * Extension to terminal area operations
  * System trialed with USAF AWACS

Summary

* Smart Skies has researched, developed and demonstrated real technologies, that can potentially open the skies to autonomous aircraft and improve the safety and efficiency of conventionally piloted aviation operations

* Outcomes
  * World firsts in sense-and-act and global automated control of civil UAS
  * MATS to be trialled in support of Insitu Pacific ScanEagle™ operations
  * Ongoing research program in the development of the SAA
  * Award winning research project (Engineers Australia, QLD Division)

Summary

More Information

* Australian Research Centre for Aerospace Automation (ARCAA)
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smart skies

... the research, development & flight testing of technologies supporting the more efficient utilisation of airspace for manned & unmanned aircraft.

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