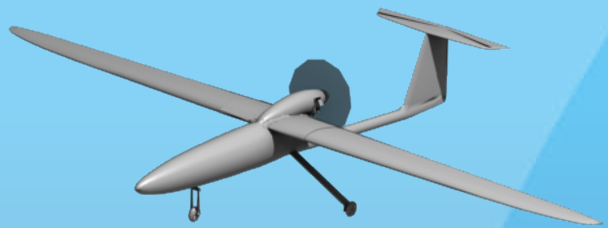


arcaa

An Overview of UAS Capabilities and Challenges

Reece Clothier
Senior Research Fellow
Australian Research Centre for Aerospace Automation
Queensland University of Technology
r.clothier@qut.edu.au

Overview of Presentation

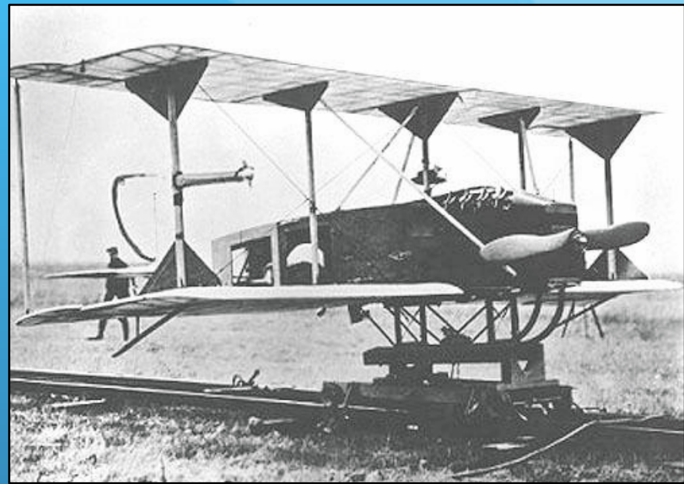
- A quick history lesson
- Snapshot of current systems and recent operations
- Potential civil and commercial applications
- When it makes sense to use them
- Discussion on autonomy
- General challenges
- Enabling research

What are Unmanned Aircraft Systems?

- "An aircraft and its associated elements which are operated with no pilot on board" (ICAO, Circular 328)
  - Remotely Piloted Aircraft
  - "Fully Autonomous UAS"
- Unmanned Aircraft *System*
  - Can comprise of one or **more** unmanned aircraft
  - Remote pilot station
  - Communications
  - Launch and recovery
  - The remote pilot crew!

A New Technology?

- 350 BC Archytas' "Pigeon"
- 1849 Austrian balloon bombs
- 1916 Hewitt-Sperry Automatic Airplane



- 1935 Tiger Moth DH.82 "Queen Bee"
- 1944/46 B-17 Conversions
- 1955 Ryan Firebee for Reconnaissance
- … Modern day systems

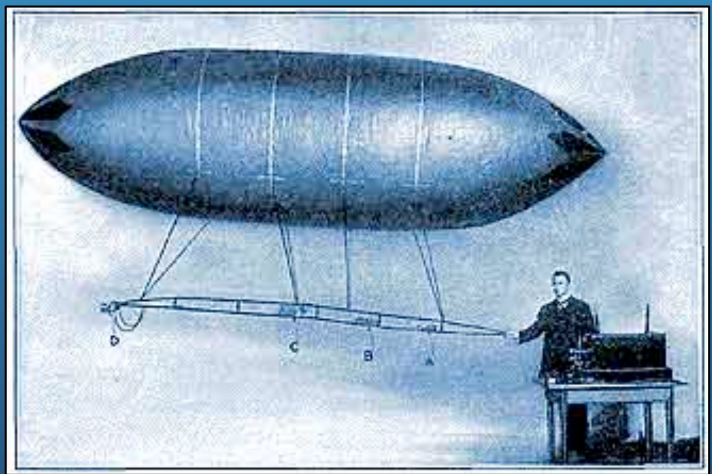
Hewitt-Sperry Automatic Airplane aka "The Flying Bomb" Photo: General Motors Institute

"Queen Bee" - "Radio Controls Robot Plane On Pilotless Flight." Popular Mechanics, October 1935, p.551

Australian History – A Snapshot

- **c1910** A.J Roberts' Aerial Torpedo
- **1952** Jindivik – aerial target
- ~**1996** Nulka – active missile decoy
- ~1997 MQM-107E Kalkara
- **1998** Aerosonde crosses the North Atlantic

© Aerosonde, Pty Ltd.



Miessner, BF (1916) "Radiodynamics, the wireless control of torpedoes and other mechanisms"

Jindivik. Image: Commonwealth Government of Australia, RAN Website

Australian Unmanned Aircraft Industry

cyberQuad
Cyber Technology, WA

ScanEagle
Insitu Pacific Ltd, QLD

Kingfisher II
BAE Systems Australia, VIC

Flamingo – Silvertone, NSW

CyberEye II – Cyber Technology, WA

Medium Airship
Airship Solutions, NSW

Australian Unmanned Aircraft Industry

Aerosonde Mark 4.7
AAI, Aersonde VIC

KESTREL

Kestral Automated Target
Detection Software,
Sentient, VIC

CM160 Gimbaled
Camera
UAV Vision, NSW

i-Flight 650
Flight Vision, NSW

T2000UAV-L, Mode 3/A
Transponder
Microair, QLD

Phoenix Jet Aerial Targets
Air Affairs Australia, NSW

ARCAA Rotor-Wing UAS
ARCAA, QLD

ADF Trials, Operational Platforms & Procurement

- 2001 Global Hawk (Demonstration)
- 2005 - Skylark I
- 2006 Mariner (Demonstration)
- 2007 ScanEagle (Contracted Service)
- 2009 Heron (Contracted Service)
- 2010/2011 Shadow 200B TUAS
- 2013 – 2015 Small “Tier 1” UAS (Skylark replacement)
- 2020? ADF HALE Multi-mission UAS (AIR-7000-1B)

Photos courtesy of the Australian Department of Defence and USAF

Civil and Commercial Opportunities

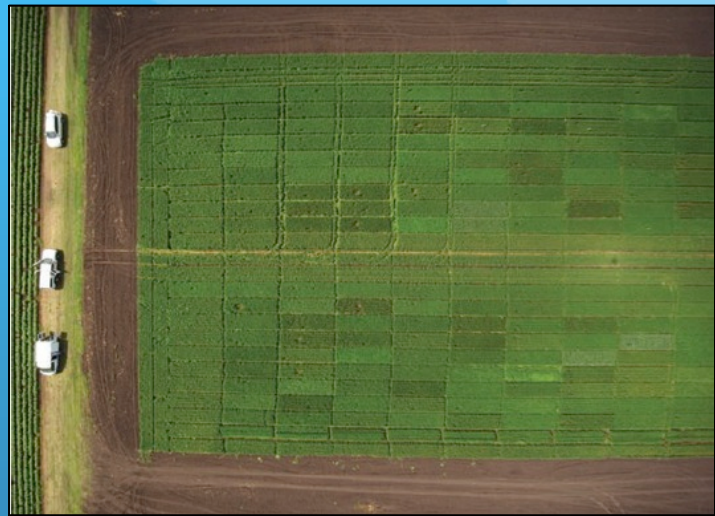
ARCAA automated marine mammal detection from an aircraft

Sharks off South Stradbroke Island – Photo: Sarah Marshall

Fire front mapping - WA 2010 – Photo: Channel 10

QLD Floods 2011 – Photo: Lyndon Mechielsen, Jono Searle

Civil and Commercial Opportunities



ARCAA Helicopter UAS performing crop phenotyping

Damage to Fukushima Dai-ichi nuclear power plant – photo taken from a UAS. (AP Photo/Air Photo Service)

Automated inspection of power lines.
Photo taken from a UAS with automated power line dete
algorithm (ARCAA and CRC-SI)

When it Makes Sense to Use Them

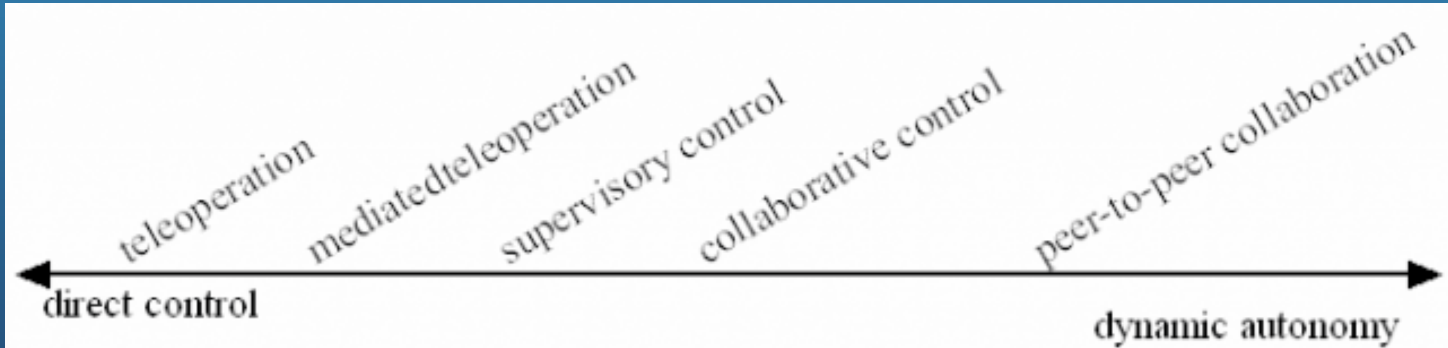
- Not just cost (in some cases UAS can be *MORE* expensive)
- For any application considered too:
  - Dull (e.g., persistent communications relay)
  - Dirty (e.g., Fukushima power plant, ash clouds)
  - Dangerous (e.g., low altitude, poor weather conditions)
  - Demanding (e.g., too fast or too long for a pilot)
- UAS are not a panacea to all problems
  - They are not without their disadvantages
  - They cannot replace piloted aircraft in many applications

Why Remove the Human?

- Smaller, faster, longer, stronger… but are they safer??
  - Pilots account for 60-70% of accidents…
  - What we don't typically consider is how often the pilot saves the day
    - E.g., the Gimili Glider
- New safety paradigm emerges:
  - Dealing with a system instead of just an aircraft
  - Impact on all aspects of design, manufacture, maintenance, and operation
  - New hazards are created and the significance of existing or "known" hazards changes
  - New public attitude towards the risks
  - Diverse range of unmanned aircraft equally diverse risk profile
  - New design philosophy - commercial commodity, potentially disposable

How Far Removed?

Automation Level	Automation Description
1	The computer offers no assistance: human must take all decision and actions.
2	The computer offers a complete set of decision/action alternatives, or
3	narrows the selection down to a few, or
4	suggests one alternative, and
5	executes that suggestion if the human approves, or
6	allows the human a restricted time to veto before automatic execution, or
7	executes automatically, then necessarily informs humans, and
8	informs the human only if asked, or
9	informs the human only if it, the computer, decides to.
10	The computer decides everything and acts autonomously, ignoring the human.



Sheridan, T.B. and Verplank, W., "Human and Computer Control of Undersea Teleoperators." Cambridge, MA: Man-Machine Systems Laboratory, Department of Mechanical Engineering, MIT. 1978.

Challenge 1 – Understanding the Role of The Human

- Human is just as critical to the safe operation of UAS as it is to conventionally piloted aviation
- New "human factors" emerge across all aspects of the design, manufacture, maintenance and operation of UAS:
  - The absence of a "shared fate" between the pilot and the aircraft leading to a propensity for more risk taking behaviour
  - Physical - parallax, spatial disorientation, glare
  - Situational awareness - changes in the information available to the pilot and the manner in which it is presented
    - Tone of the engine, smell of smoke or the "feel" of icing?
  - Operator trust in the system and knowledge of its "correct" behaviour
  - Complacency and reduced pilot proficiency due to a reliance on automation
  - Maintenance *i.e.*, the "model aircraft attitude"

Challenge 2 - Social Concerns

- Social perception
  - Weapons of war
  - Lack of knowledge
  - Perception of the risks
- Increasingly risk averse society
- Who's to blame?
- Broader social issues
  - Privacy
  - Noise
  - Job losses?
- Difference between model aircraft and UAS

TECHNOLOGY

Domestic Drone Programs Spark Civil-Liberties Lawsuit

Surveillance drone industry plans PR effort to counter negative image

Groups representing drone industry want to 'paint a more positive picture' of unmanned surveillance aircraft in UK

Droning on

The Times, London. Jan 6, 2012.

"…in Gaza the sound of drones buzzing overhead is known as zenana, the slang for a persistently nagging wife."

Increased use of 'personal drones' needs urgent regulation

Reports of spy drones used by media corporations could constitute misuse of private information and harassment

C130 and RQ 7 collision, fingers pointing at C130 crew.

19 August 2011

By Gary Mortimer

Challenge 3 – Managing the Risks

- Developing and promulgating appropriate regulations
  - UAS are expected to demonstrate a minimum of an equivalent level of safety to manned aviation, in relation to:
    - Risks to other airspace users
    - Risks to people on the ground over-flown by UAS
- Absence of prescriptive regulations
  - UAS operations are currently managed on a case-by-case basis
  - Approval often includes significant restrictions on where and how they can be operated
  - Significant effort to progress regulations to permit greater freedom in the operation for UAS

Managing the Risk to People on the Ground

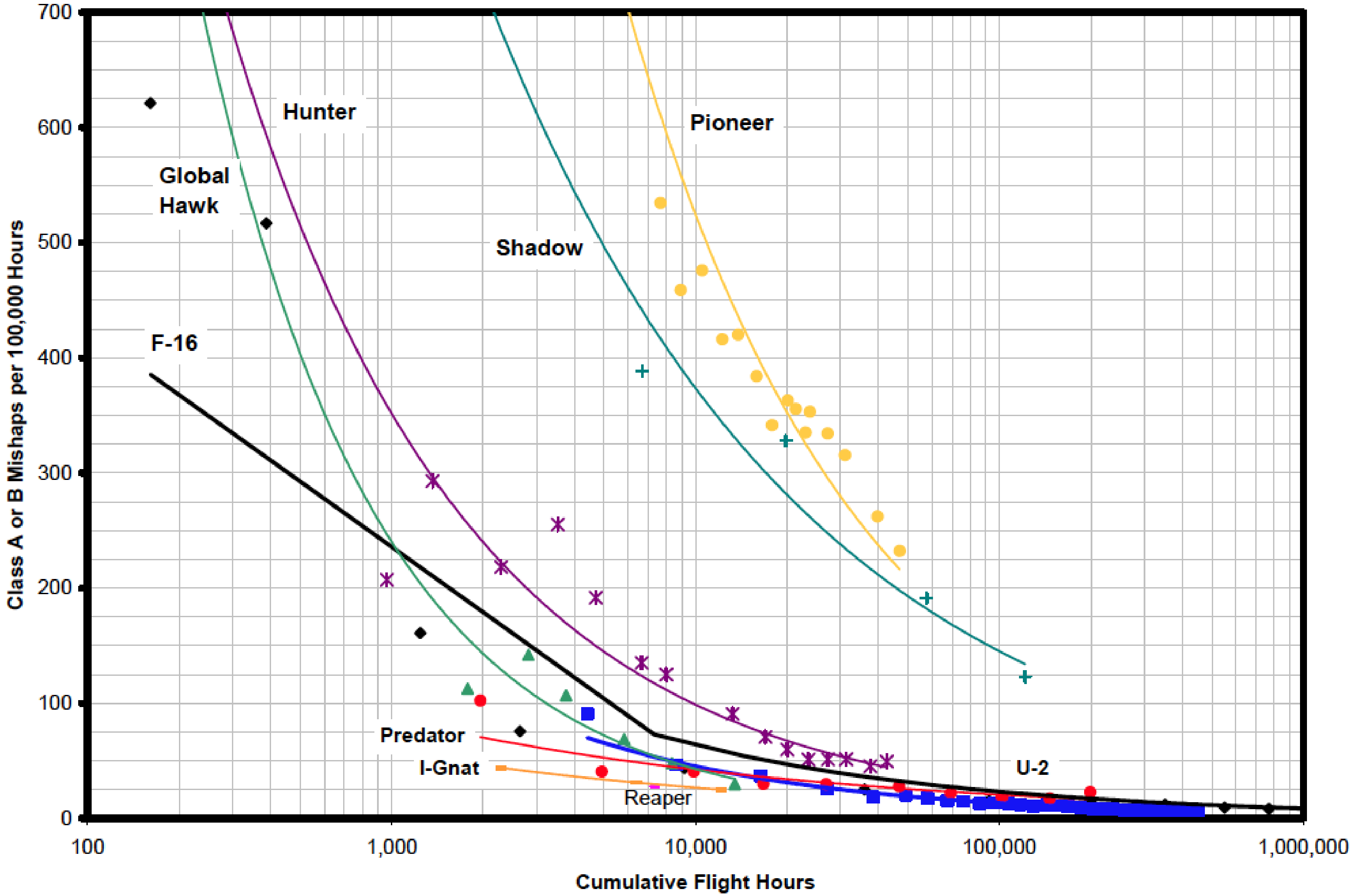


Figure A.2. U.S. Military Aircraft and UAS Class A Mishap Rates (Lifetime), 1986–2006

Image taken from: Unmanned Systems Integrated Roadmap FY2009-2034, US Department of Defence

Managing the Risks to People on the Ground

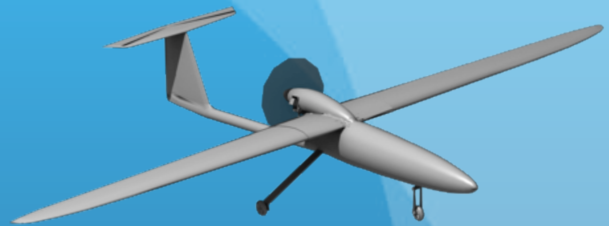
- Higher degree of system airworthiness is needed to operate over populous areas
- Difficulty in demonstrating reliability
  - The required level has not been defined
  - Limited operational data, quality aviation components, data on components to make safety assessments
  - No person on-board - potential tradeoffs in airworthiness
- Mitigations:
  - Constrain operations to unpopulated regions
  - Automated Emergency Landing Systems
  - Automated Recovery Systems (pre-programmed)
  - Flight Termination Systems (e.g., parachute)
  - Frangible systems

Managing the Risk to Other Airspace Users

- Not like it was in the early 20th century
- UAS must:
  - Demonstrate an Equivalent Level of Safety to conventionally piloted aircraft operations


Photo: SUAS News

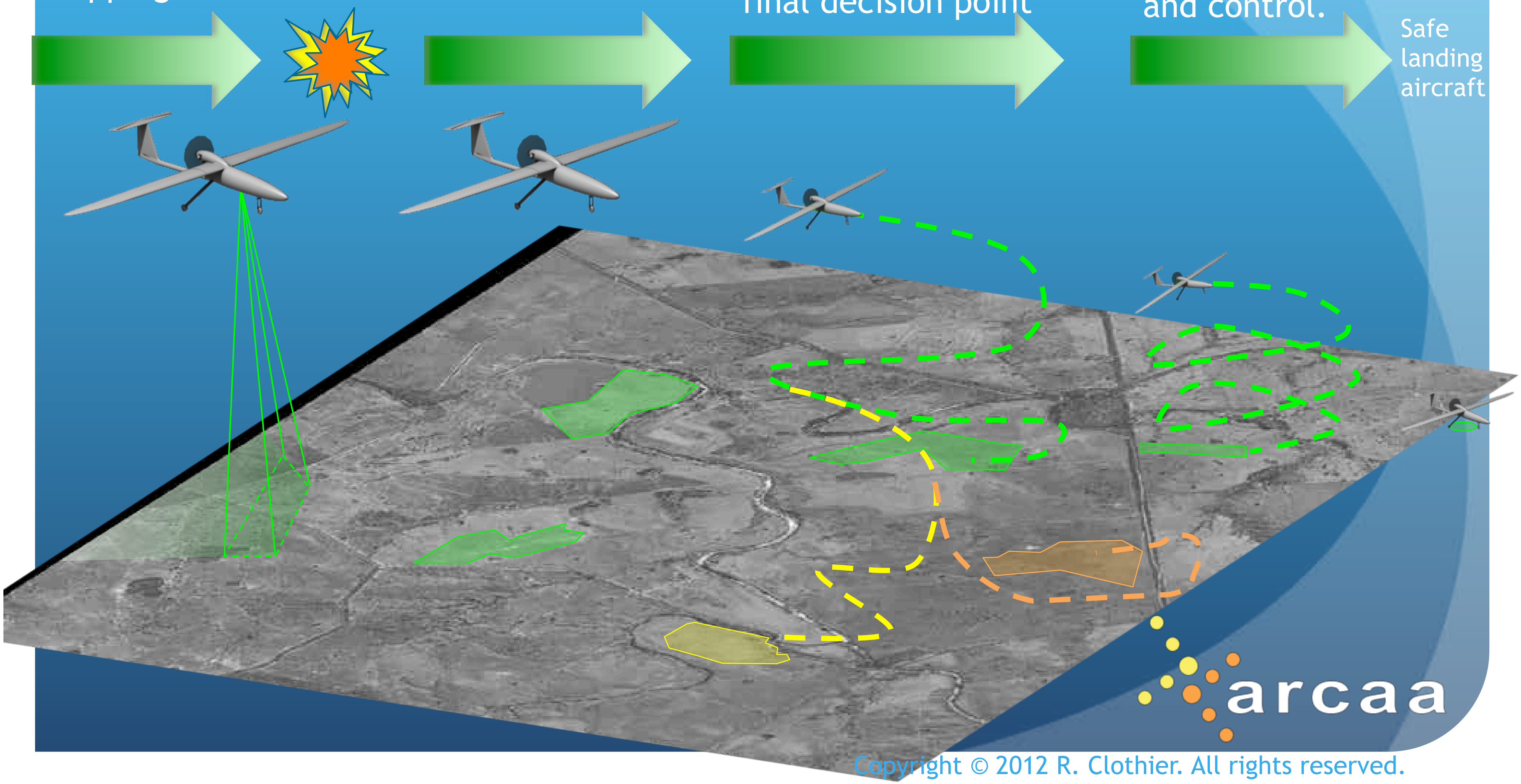
  - Seamlessly operate alongside other airspace users (same rules of the air)
  - Appear to ATC as no different to any other aircraft
- Routine UAS operations require technologies to
  - mitigate the risk of a midair collision
  - operate alongside manned aviation (i.e., radio calls, coordination) in the absence of a communications link to the remote pilot station



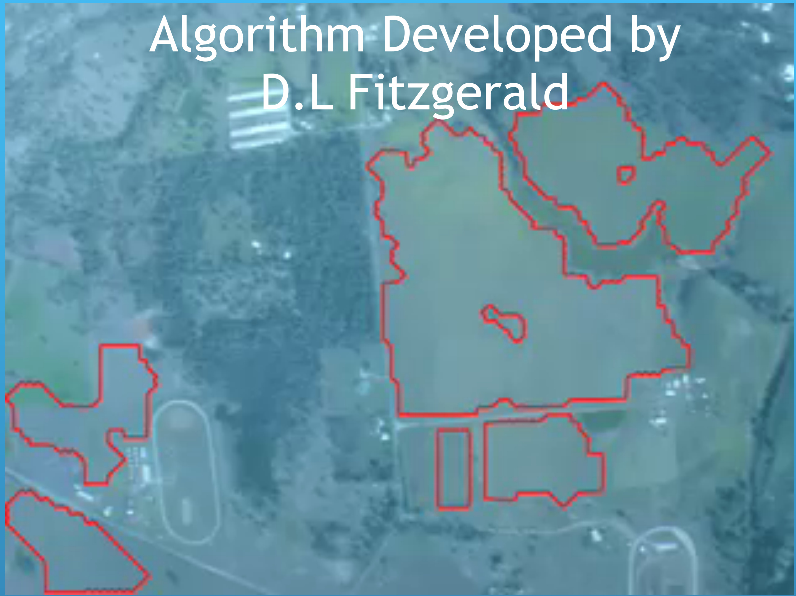
Addressing the Challenges…

Enabling Technologies

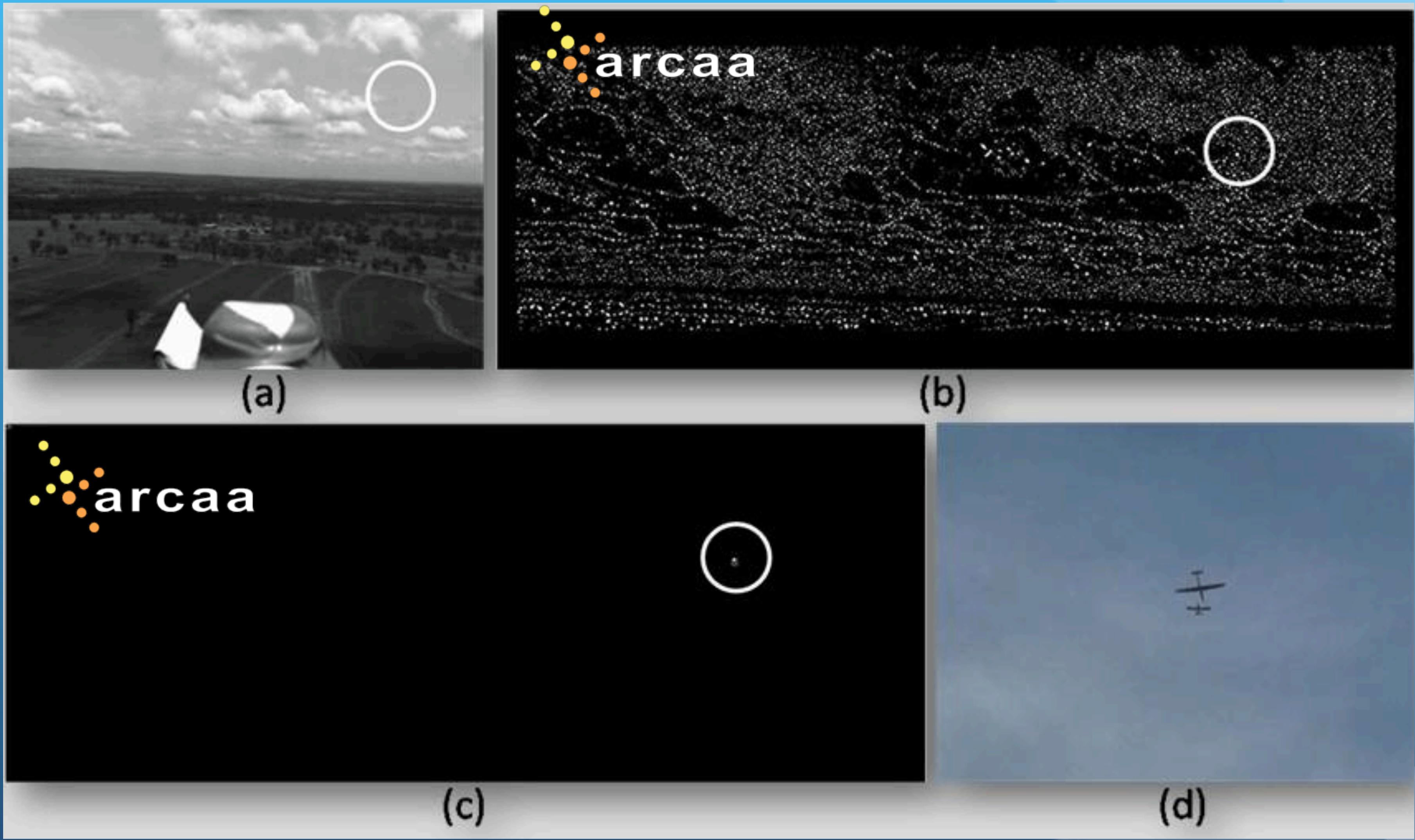
Automated Emergency Landing Systems



Research – Automated Emergency Landing System



Automated Midair Collision Avoidance System



(a) (b) (c) (d)


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

Regulation Development

- 2005/2006 – ARCAA UAS Workshops
- 2007 UAS Australia formed
- 2009 Australia Aerospace Industry Forum, Certification & Regulation Working Group for UAS formed
    - Recommendations to CASA
- 2009 Aviation White Paper
- June 2011 – CASA project to review CASR 101
- Nov 2012 – CASA SCC Formed

Australia a Leader in Civil UAS?

- Unique "pull" for technology
  - End users with unique applications
  - Limited budget to provide services to a distributed country (e.g., SAR, environmental management, infrastructure management, etc.)
- Unique environment for their operation
  - Airspace and unpopulated regions
- Unique combination of skills to overcome challenges
  - Cooperative industry and proactive safety regulator
  - Indigenous research and industry capabilities
  - Operational experience in civil UAS operations

Summary

- UAS are not a new technology but they have recently matured to a point where many civil & commercial applications are becoming viable
- There is greater awareness of their capability in end user groups
- However, UAS are not without their challenges
  - Not a replacement for piloted aircraft
  - Not as simple as just "removing the pilot"
  - Restrictions on their operation over populous areas and in non-segregated airspace
  - There are public concerns
- Research to overcome these challenges

QUESTIONS

Reece Clothier

Australian Research Centre for Aerospace Automation

r.clothier@qut.edu.au

www.arcaa.aero

arcaa