Industry Experience in the Trust of Unmanned Autonomous Systems

EDTAS on Trusted Autonomy

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BAE Systems Australia

EDINBURGH PARKS, SOUTH AUSTRALIA HEADQUARTERS

4,000+ EMPLOYEES

AUD $1.4 BILLION
ANNUAL SALES

35+ MAJOR DEFENCE CONTRACTS

BAES- Weapons Systems Business

BAE Systems Australia has a proven Product Design, Development, Production and In-Service Support capability underpinned by the success of numerous defense projects including:

- Nulka Active Missile Decoy (E&MD + Production)
- Evolved Sea Sparrow Missile (ESSM)
  - Block I E&MD and Production
  - Block II E&MD
- ASRAAM
- UAV Technology
  - Kingfisher, Herti, Mantis, Turanis

Provides world-class system solutions for global Defense customers in areas such as:

- Flight Dynamics & Simulation
- Encrypted Telemetry Systems (Nulka)
- Mission Critical Software
- Verification Planning & Test
- Launch System Integration

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INSPIRED WORK

Trusted Autonomy

“Technologies for trusted autonomous systems are important because they have the potential to extend the reach and capability of traditional military forces while reducing operational footprint and threat to personnel. This theme explores the Defence and National Security applications of these technologies.”

“….and what it means for them to be trusted for decision making. “

The principal issue for Unmanned Air Systems is knowing where we are in space and where everything/everyone else is. Then the trust part becomes making sure we know those things at all times and make good decisions to keep them separate?

Trusted Autonomy

- UAV technology is perceived to have a lack of intelligence relative to a human pilot.
- Unforeseen events during a UAV mission that would prevent it from returning home can often result in the UAV being discarded.

Third Party Injury & Property Damage

Trusted Autonomy – Weapons Systems Business

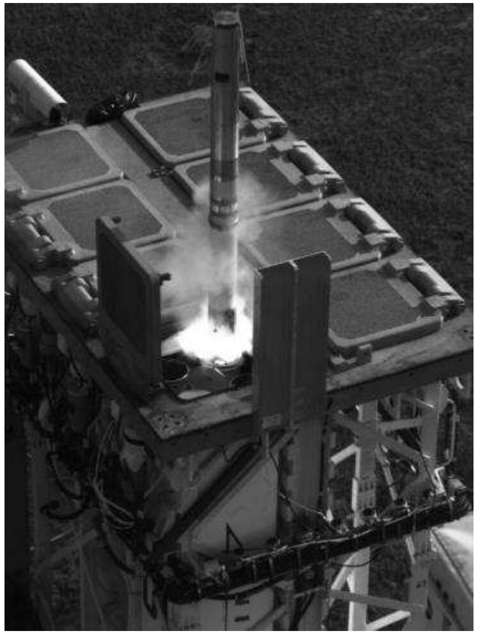
Our ability to trust autonomous systems is ever improving due to:

- Ability to model (tools & techniques) better (moving from Fortran (text) to Matlab & Simulink (visual))
- Access to high fidelity system models (6Dof)
- Increased Hardware reliability and capability (sensors are much better today)
- A safety approach underpins developing i.e. integrating requirements, modelling, coding & testing <- it's not an after thought.
- Better Safety awareness and supporting tools & techniques

Limitations still exist e.g. reliance on GPS, battery limitations (although much better now) end up with trade-offs in range and endurance, jamming, comms links, etc.

BAE –WS Experience in Trusted Autonomous Systems

1. Nulka Active Missile Decoy
2. UAS Flight Control Systems
    1. All Source Navigation
    2. Intelligent Landing System
    3. Modelling/Test/Trials



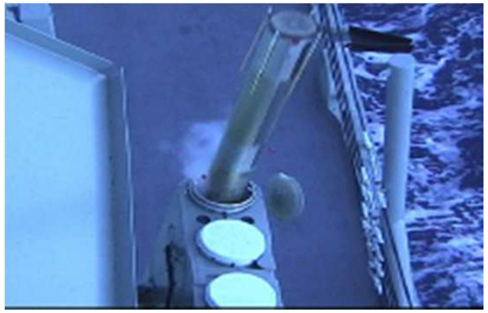
Nulka Active Missile Decoy

- Third generation soft-kill system
- Active offboard decoy, counters active RF ASMs
- 'Hovering' rocket flight vehicle executes specific flightpath depending on threat type
- Automatic or semi-automatic response
- Integral component of layered defence

RF	Radar frequency
ASM	Anti-ship missile

Nulka System Characteristics

- Quick rection
- **Fully autonomous after launch**
- Independent of wind speed or direction
- No restrictions on ship manoeuvre
- Capable against stream attacks
- Capable against high-g, low RCS threats
- Complementary to hard-kill
- Single decoy counters multiple threat missiles
- Effective in the littoral
- No threat to friendly forces – “weapon of least regret”



Nulka AMD Challenges in Trusted Autonomy

- Fly's autonomously at slow speeds in proximity of the ship
- As a ‘soft-kill’ system Nulka doesn’t come with any of the physical indicators of direct response.
- Fire Control Panel engagement (sailor presses fire and then system waits to launch at optimal time – no immediate response)
- Lots of education, modelling, analysis, live flight trials required to gain Navy confidence in this autonomous system.
  - This refined the approach required to gain defence acceptance of an autonomous system
- Nulka set the foundation for follow-on autonomous systems work

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All-Source Navigation (ASN)

- Navigation systems are typically designed for specific applications – tailored by expensive specialists
- For high accuracy, expensive IMU's are combined with GPS
- Instead of relying on **one high cost sensor**, ASN combines the information from a **wide variety of low-cost sensors**
    - Achieves comparable navigation accuracy
    - Provides redundancy
    - Not reliant on GPS
- ASN's ability to operate in GPS-denied environments is a real improvement in the field of navigation
    - Inherently self-contained
    - Truly autonomous
- Increases the probability that a system (e.g., a UAV) can safely perform its mission
- Therefore, this increased reliability, reduces the risk of injury to the general community and reduces the risk of damage to the environment

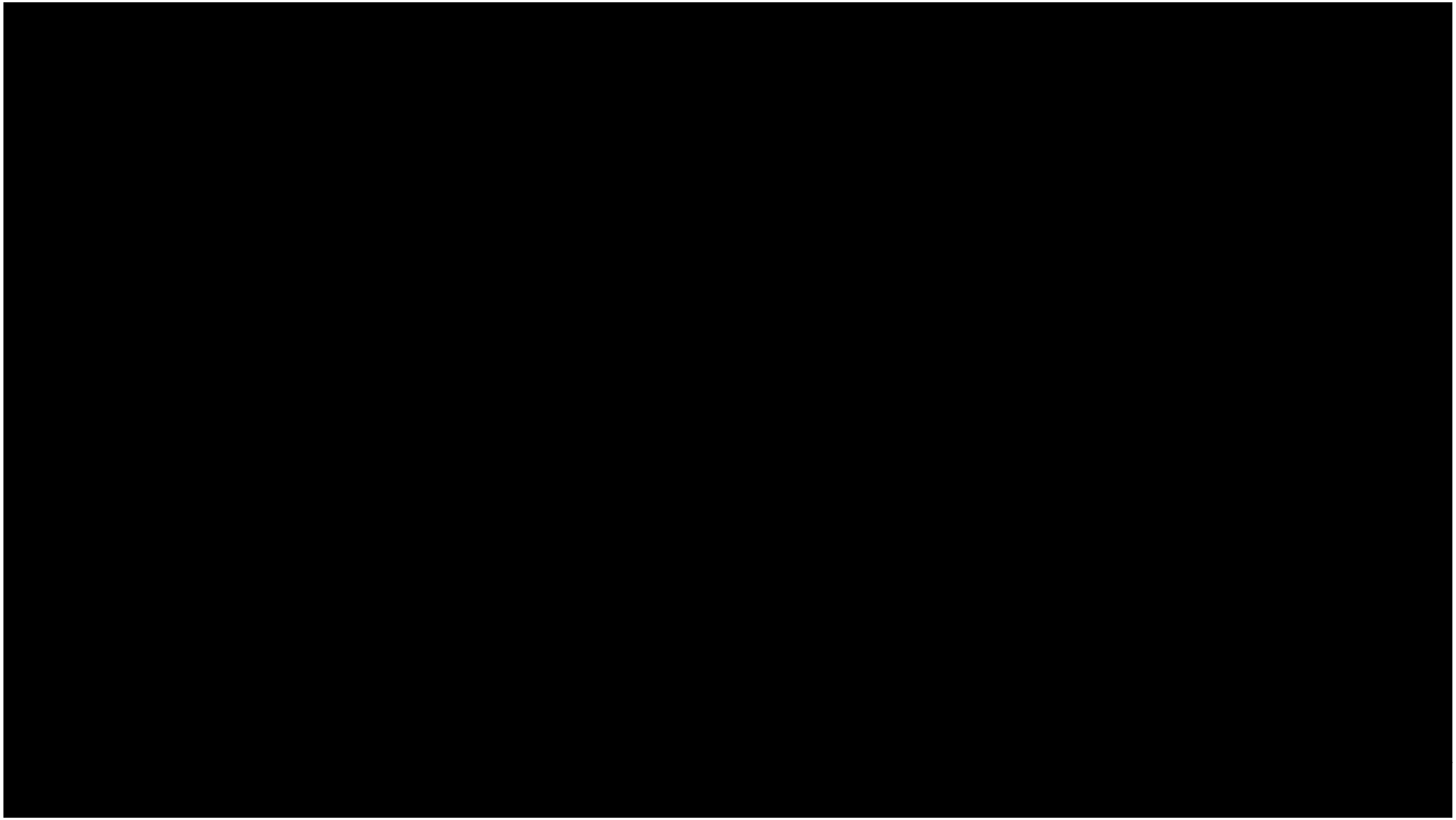
UAV Intelligent Landing System

- Successfully demonstrated through flight trial by BAE Systems in 2012
- Supported by All Source Navigation, developed as a GPS denied, self contained landing system
- Further developed for possible Naval Carrier based landings
- Technology development directly addresses trust in autonomous systems

UAV Intelligent Landing System Details

- UAV technology is perceived to have a lack of intelligence relative to a human pilot.
- Unforeseen events during a UAV mission that would prevent it from returning home can often result in the UAV being discarded.
  - Automated landing systems require infrastructure at an alternate airfield (differential GPS), as well as surveyed coordinates of the runway
  - This is costly, time-consuming, and limits the available options for landing
- The Intelligent Landing System responds to such situations, takes control of the plane, and performs a precision landing at previously unvisited alternate airfields.
- The Intelligent Landing System is entirely self-contained and requires no supporting infrastructure at the target airfield.
  - Intelligent Landing System exploits advances in image processing and navigation algorithms
  - Intelligent Landing System improves the accuracy and robustness of existing automated landing technology

Intelligent Landing System Demonstration



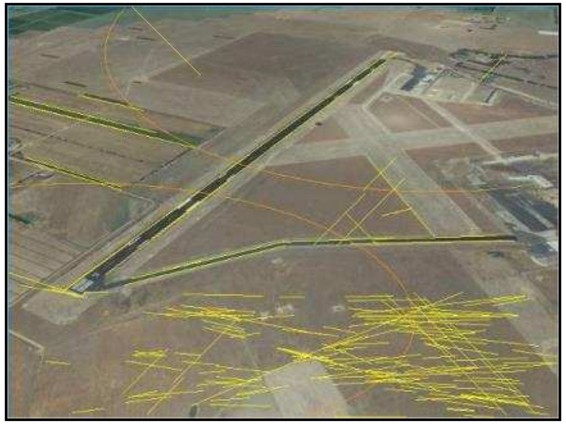
Intelligent Landing System - Originality

- The system differs fundamentally from previous attempts at vision-based landing systems
- It takes a synergistic approach to the entire landing sequence, from airfield selection to touchdown
- It is designed to replace all the actions of a human pilot (in a manner that a pilot would)
- It removes human operators from low level decision-making, and can recover the vehicle fully autonomously
- Intelligent Landing System embeds the runway “track” into the All-Source Navigation system, which allows it to decouple navigation errors from tracking errors (prevents GPS jumps from affecting landing accuracy)

Intelligent Landing System - Benefits

- Prevents Loss of Aircraft/Human Life
  - Primary goal of system is to prevent loss of aircraft that would otherwise occur if it was piloted by a human
  - Adds enormous value to existing assets (less crashes/less replacements)
  - Inadvertent UAV crashes can lead to loss of life, impacting company's public profile if it as ours or we are operating it

- **Improves Customer Acceptance of Autonomous Technology**
  - **ILS adds a level of robustness to UAV recovery never seen before, reducing the potential for loss of confidence in unmanned technology (when onboard systems fail inadvertently)**
  - **Adds significant long-term value in autonomous technology by increased reliability**



Intelligent Landing System – Benefits Cont'd

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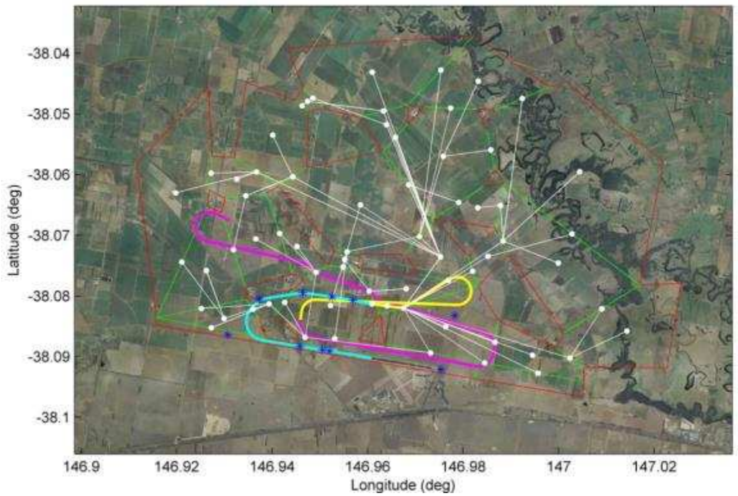
- UAV Path Planning Solution
  - The system solves a long-standing problem in autonomous mission planning
    - Flight around complex no-fly areas
  - Flying through no-fly areas can result in catastrophic collisions, such as with elevated terrain
  - The system takes current position/orientation, and a desired destination, and synthesises a set of flyable waypoints
  - Waypoints must satisfy detailed performance constraints that makes manual waypoint positioning tedious and costly
  - Intelligent Landing System plans feasible waypoint trajectories in milliseconds rather than hours



Intelligent Landing System – Benefits Cont'd

- No Supporting Infrastructure is Required at the Landing Site
    - Conventional landing systems require on-ground support systems
        - Differential GPS for autonomous systems
        - Instrument landing system for manned aircraft (Or a local pilot to take control and remotely land it - an amazing number of systems still need this)
    - Conventional systems require detailed supporting information (runway survey), to enable landing
    - ILS requires no supporting infrastructure or even personnel at the landing site
    - ILS can be used for ad hoc military landing sites with nil setup and maintenance cost
    - Reduces cost and adds flexibility to existing systems

Intelligent Landing System – Benefits Cont’d

- Unmanned systems are currently viewed as inherently risky.
- ILS significantly reduces the risk of UAV technology by improving system reliability and robustness.
- ILS paves the way forward for utilising unmanned systems in place of manned – even in an emergency, the system can land the plane
- ILS demonstrates a commitment to the value of human life over the cost of technology
- ILS itself results in systems that are far less likely to crash, benefiting society in general by reducing accidental death or property damage

Future Challenges & Opportunities in Trusted Autonomy

- Certification
- Regulatory acceptance and provisions
- Public acceptance
- Technology - batteries, processing power, sensors, High Fidelity HWIL simulation tools, etc... These need to get better so we can improve the levels or autonomy
- Modelling/Test/Trials has been proven to support increased levels of trust in UAS's.

Back Up Slides

Future Challenges & Opportunities in Trusted Autonomy

1. Barriers and Drivers
   - Regulatory acceptance and provisions
   - Public acceptance
2. Gaps in Knowledge (or science base)
   - Certification Requirements
     - Operation of UAS platforms in General Aviation environments
3. How will technology and methods of application change
   - Technology - batteries, processing power etc...
     - These need to get better so we can improve the levels or autonomy
   - High-Fidelity HWIL Simulation tools
   - Low cost, high grade sensors