Australian Government
Department of Defence
Science and Technology

Autonomy Strategic Challenge Achievements at Autonomous Warrior 2018

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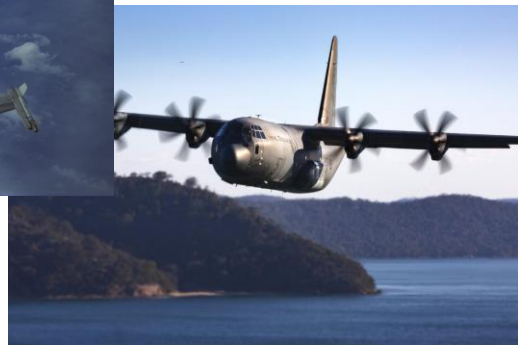
Defence Human Sciences Symposium
19-20 November 2019

Dr Michael Skinner (1956-2019)



Mike at Autonomous Warrior 2018

TTCP Autonomy Strategic Challenge

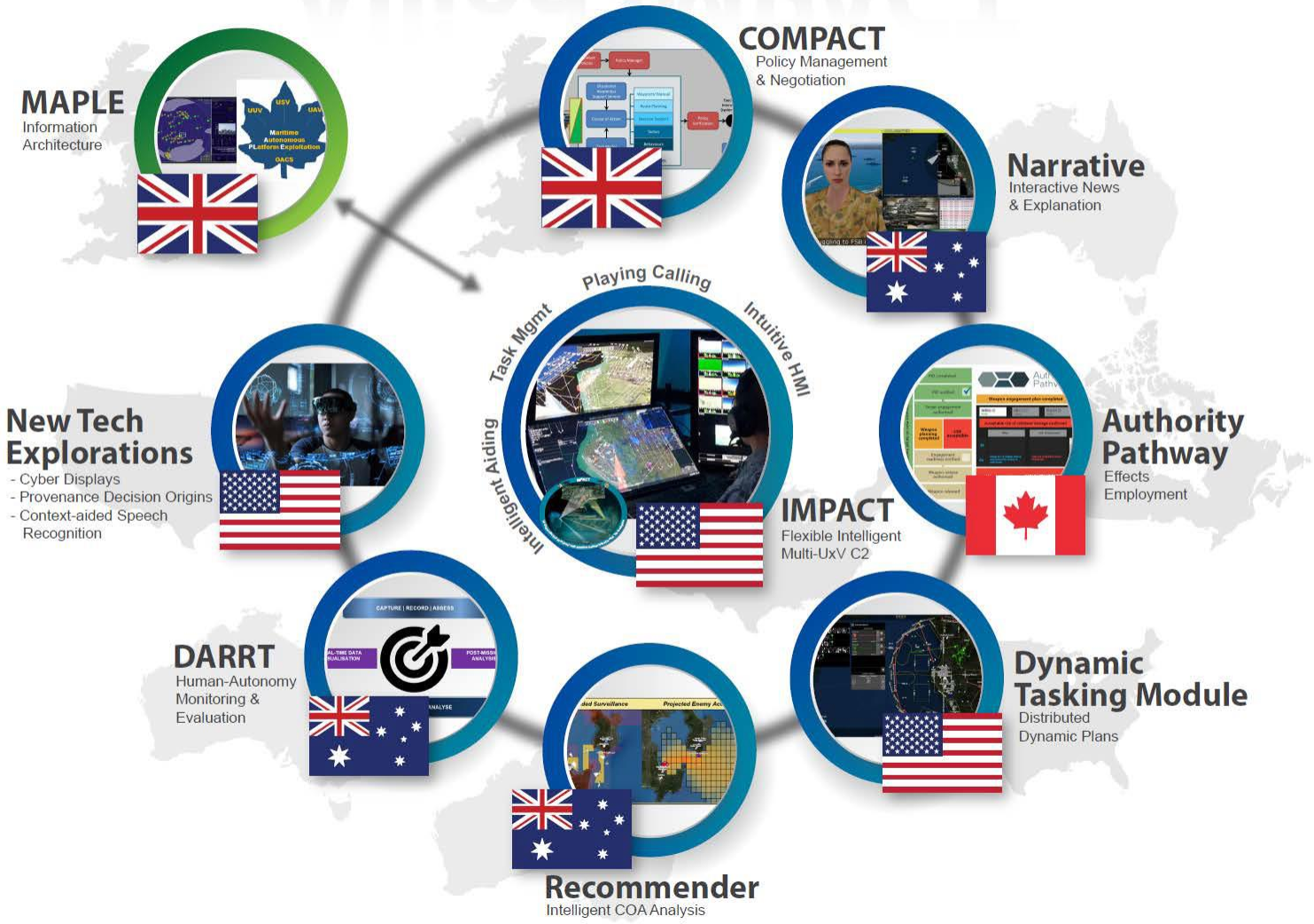
"Controlling different autonomous platforms like this is a game changer. Like getting lions, tigers and bears to hunt as one species."

CMDR Paul Hornsby

Autonomy Strategic Challenge

- Mission
  - To enhance, demonstrate and evaluate the military utility of autonomous systems for future littoral operations
- Objectives
  - Determine the potential military utility of autonomy technologies
  - Advance and demonstrate human-autonomy teaming through simulation and live trials
  - Improve interoperability of emerging autonomous systems
  - Harness industry developments for military requirements

Allied IMPACT



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Narrative

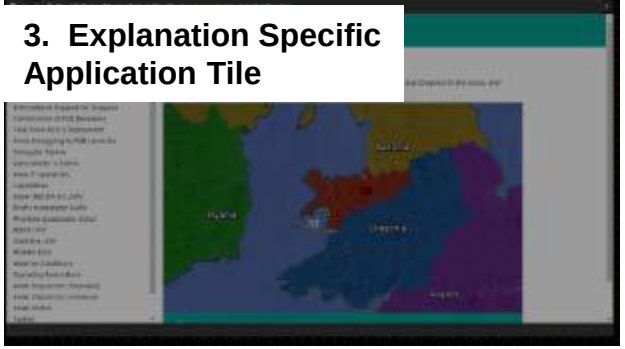
Multimedia Narration for naturalistic interaction and enhanced situation awareness

- Context and time sensitive
- Implementation:
  - Adaptive mission briefings for operators
  - Multimodal Q&A and notifications
  - Platform status reports on demand
  - Recommendation and plan explanation on demand
  - Provenance reporting on demand

1. Virtual Human Avatar

2. Geospatial Tile

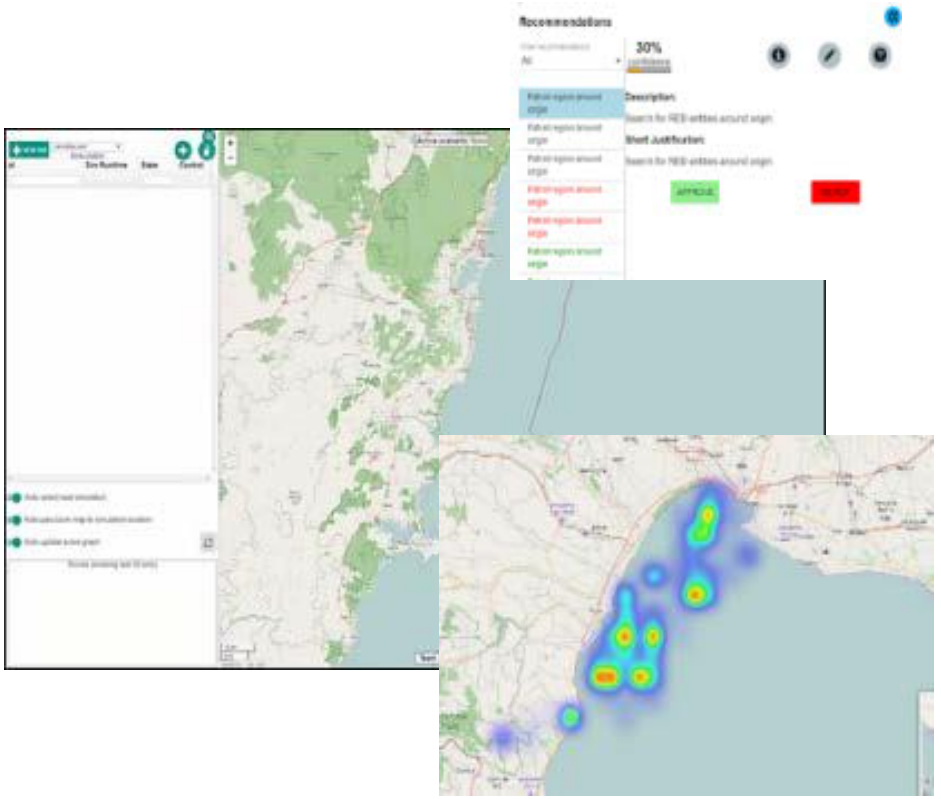
3. Explanation Specific Application Tile



Recommender

Enhanced agent learning and modelling tool to identify areas with high probability of threat detection

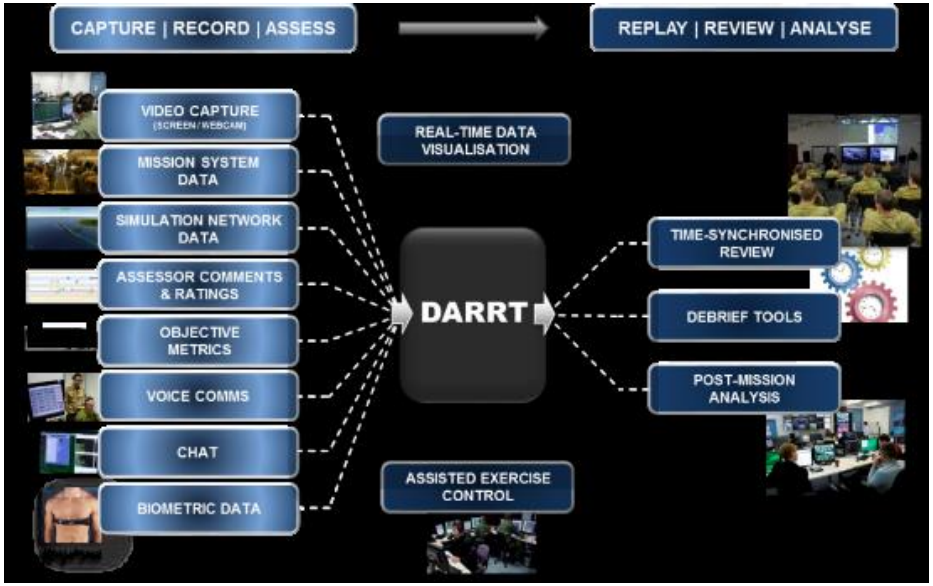
- Uses Simulated Annealing, Evolutionary Algorithms, and Bayesian Learning techniques
- Based on available intelligence information and internal simulations of threat behaviour



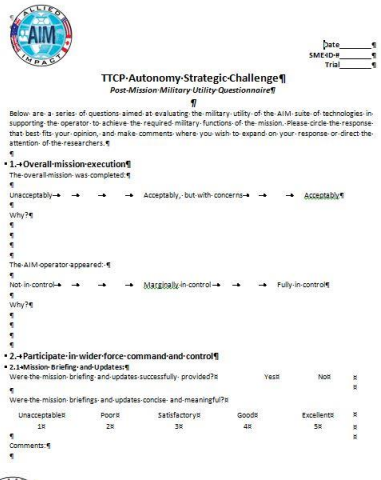
DARRT: DSTG Assessment & Review Research Tool

An assessment and review tool that supports real-time data analysis and rapid, focused after-action reviews

- Calculate, store, and display key mission performance metrics
- Present real-time status and mode of autonomous platforms
- Deliver multi-media after-action review of mission performance



Evaluation Metrics



TTCP·Autonomy·Strategic·Challenge¶

Post-Mission·Military·Utility·Questionnaire¶

Below·are·a·series·of·questions·aimed·at·evaluating·the·military·utility·of·the·AIM·suite·of·technologies·in·supporting·the·operator·to·achieve·the·required·military·functions·of·the·mission.·Please·circle·the·response·that·best·fits·your·opinion,·and·make·comments·where·you·wish·to·expand·on·your·response·or·direct·the·attention·of·the·researchers.¶

• 1.·Overall·mission·execution¶

The·overall·mission·was·completed:¶

Unacceptably·→ → → → Acceptably,·but·with·concerns·→ → → Acceptably¶

Why?¶

The·AIM·operator·appeared:·¶

Not·in·control·→ → → → Marginally·in·control·→ → → Fully·in·control¶

Why?¶

• 2.·Participate·in·wider·force·command·and·control¶

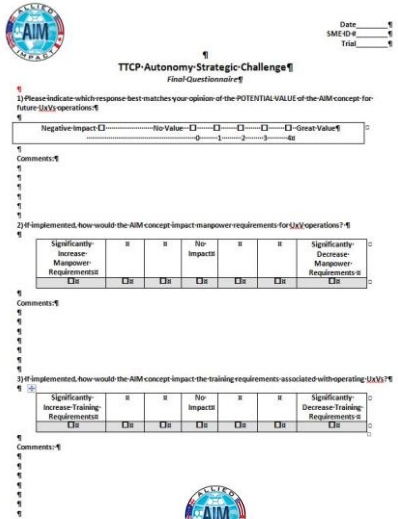
• 2.1·Mission·briefing·and·updates¶

Were·the·mission·briefing·and·updates·successfully· provided?¤ Yes¤ No¤

Were·the·mission·briefings·and·updates·concise· and·meaningful?¤

Unacceptable¤	Poor¤	Satisfactory¤	Good¤	Excellent¤
1¤	2¤	3¤	4¤	5¤

Comments:·¶



TTCP·Autonomy·Strategic·Challenge¶

Final·Questionnaire¶

1)·Please·indicate·which·response·best·matches·your·opinion·of·the·POTENTIAL·VALUE·of·the·AIM·concept·for·future·UxV·operations:¶

Negative·Impact·□ ·····No·Value·····□ ·····□ ·····□ ·····□ ·····□ ·Great·Value¶

0 1 2 3 4¤

Comments:¶

2)·If·implemented,·how·would·the·AIM·concept·impact·manpower·requirements·for·UxV·operations?·¶

Significantly·Increase·Manpower·Requirements¤	¤	¤	No·Impact¤	¤	¤	Significantly·Decrease·Manpower·Requirements¤
□¤	□¤	□¤	□¤	□¤	□¤	□¤

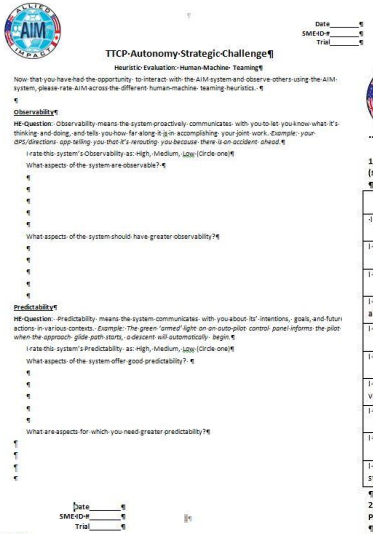
Comments:¶

3)·If·implemented,·how·would·the·AIM·concept·impact·the·training·requirements·associated·with·operating·UxVs?¶

Significantly·Increase·Training·Requirements¤	¤	¤	No·Impact¤	¤	¤	Significantly·Decrease·Training·Requirements¤
□¤	□¤	□¤	□¤	□¤	□¤	□¤

Comments:¶

Page·Break



TTCP·Autonomy·Strategic·Challenge¶

Heuristic·Evaluation:·Human-Machine· Teaming¶

Now·that·you·have·had·the·opportunity· to·interact· with·the·AIM·system·and·observe·others·using·the·AIM·system,·please·rate·AIM·across·the·different·human-machine· teaming·heuristics.·¶

Observability¶

HE·Question:· Observability·means·the·system·proactively· communicates· with· you·to·let· you·know·what·it's·thinking·and·doing,·and·tells· you·how·far·along·it·is·in·accomplishing· your·joint·work.·*Example:· your·CPS/directions· app·telling· you·that·it's·rerouting· you·because· there·is·an·accident· ahead.*¶

I·rate·this·system's·Observability·as:·High,·Medium,·Low·(Circle·one)¶

What·aspects· of·the·system·are·observable?·¶

What·aspects· of·the·system·should· have·greater·observability?¶

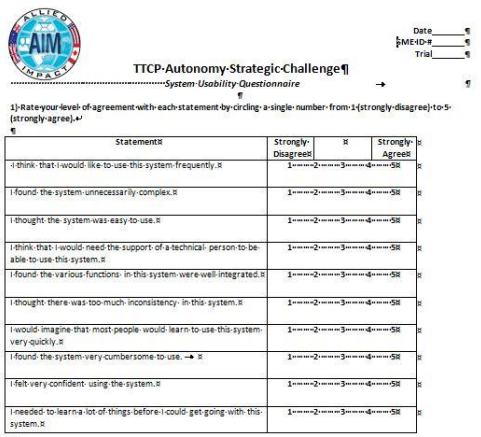
Predictability¶

HE·Question:· Predictability· means·the·system·communicates· with· you·about· its'·intentions,· goals,·and·future·actions·in·various·contexts.· *Example:· The·green·'armed'·light·on·an·auto-pilot· control· panel·informs· the·pilot·when·the·approach· glide·path·starts,· a·descent· will·automatically· begin.*¶

I·rate·this·system's·Predictability· as:·High,·Medium,·Low·(Circle·one)¶

What·aspects· of·the·system·offer· good·predictability?· ¶

What·are·aspects· for·which· you·need·greater·predictability?¶



TTCP·Autonomy·Strategic·Challenge¶

System·Usability·Questionnaire →

1)·Rate·your·level· of·agreement·with· each·statement·by·circling· a·single· number· from·1·(strongly·disagree)·to·5·(strongly·agree).·

Statement¤	Strongly·Disagree¤	¤	Strongly·Agree¤
I·think· that·I·would· like·to·use·this·system·frequently.¤	1	2	3	4	5¤
I·found· the·system· unnecessarily· complex.¤	1	2	3	4	5¤
I·thought· the· system·was·easy·to·use.¤	1	2	3	4	5¤
I·think· that·I·would· need·the·support·of·a·technical· person·to·be·able·to·use·this·system.¤	1	2	3	4	5¤
I·found· the·various·functions· in·this·system·were·well·integrated.¤	1	2	3	4	5¤
I·thought· there·was·too·much· inconsistency· in·this· system.¤	1	2	3	4	5¤
I·would· imagine·that· most·people· would· learn·to·use·this·system· very·quickly.¤	1	2	3	4	5¤
I·found· the·system·very·cumbersome·to·use.·→ ¤	1	2	3	4	5¤
I·felt·very·confident· using·the·system.¤	1	2	3	4	5¤
I·needed· to·learn·a·lot·of·things·before·I·could·get·going·with· this·system.¤	1	2	3	4	5¤

2)·Rate·your·ability·to·accomplish· each·of·the·key·mission· requirements· listed· below·by·checking· a·single· box.·Please·use·the·comments· section·to·explain.·¶

Rate·your·ability·to·complete· your·high-level· mission¶

Ability·was:¤	Unacceptable¶ □¤	Poor¶ □¤	Satisfactory·¶ □¤	Good¶ □¤	Excellent¶ □¤

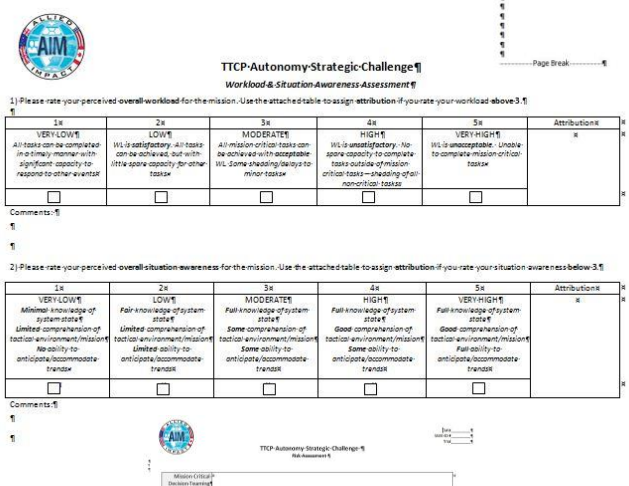
Comments:¶

Rate·your·ability·to·track·your·overall·mission·performance¶

Ability·was:¤	Unacceptable¶ □¤	Poor¶ □¤	Satisfactory·¶ □¤	Good¶ □¤	Excellent¶ □¤

Comments:¶

Page·Break



TTCP·Autonomy·Strategic·Challenge¶

Workload·&·Situation·Awareness·Assessment¶

1)·Please·rate·your·perceived· overall·workload· for·the·mission.·Use·the·attached·table·to·assign· attribution· if·you·rate·your·workload· above·3.¶

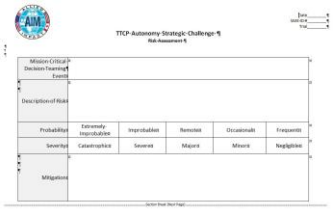
1¤	2¤	3¤	4¤	5¤	Attribution¤
VERY·LOW¶ *All·tasks·can·be·completed·in·a·timely·manner·with·significant· capacity·to·respond·to·other·events¤*	LOW¶ *WL·is satisfactory.·All·tasks·can·be·achieved,·but·with·little·spare·capacity·for·other·tasks¤*	MODERATE¶ *All·mission·critical·tasks·can·be·achieved·with·acceptable·WL.·Some·shedding/delays·to·minor·tasks¤*	HIGH¶ *WL·is unsatisfactory.·No·spare·capacity·to·complete·tasks·outside·of·mission·critical·tasks—shedding·of·all·non-critical·tasks¤*	VERY·HIGH¶ *WL·is unacceptable.·Unable·to·complete·mission·critical·tasks¤*	¤
□	□	□	□	□	

Comments:·¶

2)·Please·rate·your·perceived· overall·situation·awareness· for·the·mission.·Use·the·attached·table·to·assign· attribution· if·you·rate·your·situation·awareness·below·3.¶

1¤	2¤	3¤	4¤	5¤	Attribution¤
VERY·LOW¶ *Minimal·knowledge·of·system·state¶ Limited·comprehension·of·tactical·environment/mission¶ No·ability·to·anticipate/accommodate·trends¤*	LOW¶ *Fair·knowledge·of·system·state¶ Limited·comprehension·of·tactical·environment/mission¶ Limited·ability·to·anticipate/accommodate·trends¤*	MODERATE¶ *Full·knowledge·of·system·state¶ Some·comprehension·of·tactical·environment/mission¶ Some·ability·to·anticipate/accommodate·trends¤*	HIGH¶ *Full·knowledge·of·system·state¶ Good·comprehension·of·tactical·environment/mission¶ Some·ability·to·anticipate/accommodate·trends¤*	VERY·HIGH¶ *Full·knowledge·of·system·state¶ Good·comprehension·of·tactical·environment/mission¶ Full·ability·to·anticipate/accommodate·trends¤*	¤
□	□	□	□	□	

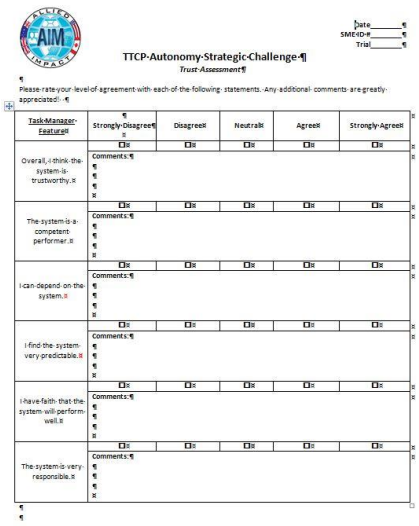
Comments:¶



TTCP·Autonomy·Strategic·Challenge·¶

Risk·Assessment·¶

Mission·Critical·Decision·Teaming¶ Event¤						
Description·of·Risk¤						
Probability¤	Extremely·Improbable¤	Improbable¤	Remote¤	Occasional¤	Frequent¤	
Severity¤	Catastrophic¤	Severe¤	Major¤	Minor¤	Negligible¤	
Mitigations¤						

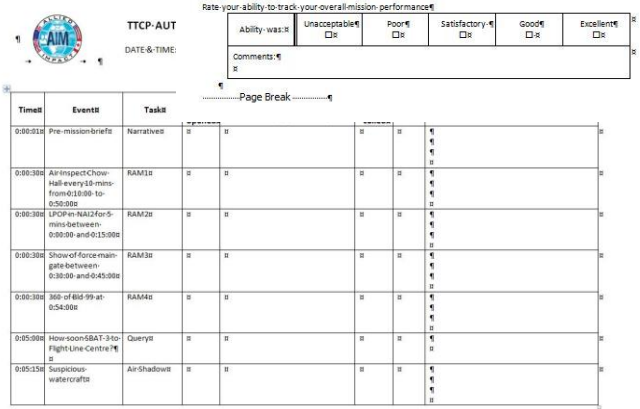


TTCP·Autonomy·Strategic·Challenge·¶

Trust·Assessment¶

Please·rate·your·level·of·agreement·with· each·of·the·following· statements.·Any·additional· comments·are·greatly·appreciated!·¶

Task·Manager·Feature¤	Strongly·Disagree¤	Disagree¤	Neutral¤	Agree¤	Strongly·Agree¤
Overall,·I·think·the·system·is·trustworthy.¤	□¤ Comments:·¶	□¤	□¤	□¤	□¤
The·system·is·a·competent·performer.¤	□¤ Comments:·¶	□¤	□¤	□¤	□¤
I·can·depend·on·the·system.¤	□¤ Comments:·¶	□¤	□¤	□¤	□¤
I·find·the·system·very·predictable.¤	□¤ Comments:·¶	□¤	□¤	□¤	□¤
I·have·faith·that·the·system·will·perform·well.¤	□¤ Comments:·¶	□¤	□¤	□¤	□¤
The·system·is·very·responsible.¤	□¤ Comments:·¶	□¤	□¤	□¤	□¤



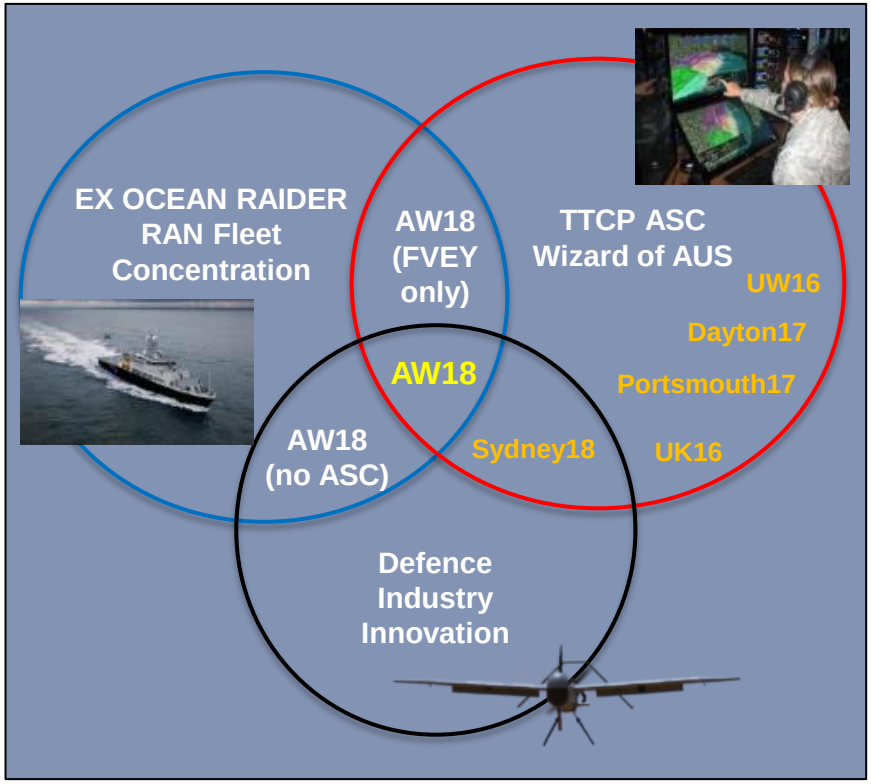
TTCP·AUT

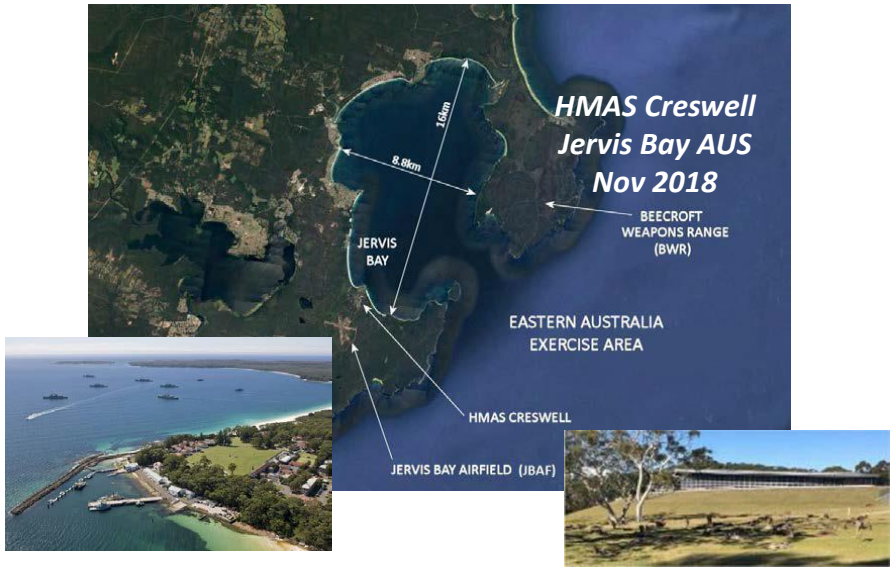
DATE·&·TIME:

Time¤	Event¤	Task¤					
0:00:01¤	Pre-mission·brief¤	Narrative¤	¤	¤		¤	¤
0:00:30¤	Air·inspect·Chow·Hall·every·10·mins·from·0:10:00·to·0:50:00¤	RAM1¤	¤	¤		¤	¤
0:00:30¤	LPOP·in·NAI2·for·5·mins·between·0:00:00·and·0:15:00¤	RAM2¤	¤	¤		¤	¤
0:00:30¤	Show·of·force·main·gate·between·0:30:00·and·0:45:00¤	RAM3¤	¤	¤		¤	¤
0:00:30¤	360·of·Bld·99·at·0:54:00¤	RAM4¤	¤	¤		¤	¤
0:05:00¤	How·soon·SBAT·3·to·Flight·Line·Centre?¶ ¤	Query¤	¤	¤		¤	¤
0:05:15¤	Suspicious·watercraft¤	Air·Shadow¤	¤	¤		¤	¤

Capstone Event

Team of **100+ scientists** from **5 nations** & **8 research labs** demonstrated and evaluated the military assessment of AIM





Evaluation

- Live Trials
  - 3 use cases: counter-smuggling, unit protection, base attack
  - Experienced AIM operator at controls, 7 SMEs (AUS, UK, US, CAN) observe, comment and rate AIM system performance
  - 6 trials

- Synthetic Trials
  - Use elements from all 3 live use cases, in simulated 1 hour trial (4 event types and 35 tasks)
  - SMEs at the controls of the AIM system, collect objective/subjective performance data
  - 7 trials

Metrics

- Objective
  - Number of assets managed by a single operator
  - % mission completeness
  - Response time (intruder events, commander queries)
  - Commander query accuracy
  - Number of plan monitor and/or COMPACT violations
  - Weapon engagement accuracy
- Subjective
  - System usability scale
  - Situation Awareness, Workload, Trust, Risks
  - Military Utility
  - Human-Autonomy Teaming heuristics (observability, predictability, directability, directing attention, adaptability, calibrated trust, common ground, information presentation, exploring the solution space)

High Level Accomplishments

- Improved interoperability of emerging TTCP autonomous systems
  - Full integration of 22 components developed by 14 organisations from all 5 TTCP countries
- Enabled a single operator to manage 17 unmanned assets (6 live inclusive of air, sea and ground platforms)
- Successfully used novel data logging capability for rapid, interactive after-action reviews

Results (1)

- Mission Performance
  - Mission Completeness – average > 92%
  - Response Time to Intruder Events – (100.5 → 28.3 secs)
  - Commander Queries
    - Response time (69 → 45 secs), accuracy >95%
- Workload and Situation Awareness
  - Workload associated with *time pressure* and *mental effort*
    - Acceptable level, with some shedding of lower value tasks.
  - SA – overall rated "high"
- Trust & HAT
  - Varied somewhat
    - Likely reflecting the immaturity of the system and/or SME understanding

"I always felt like I had good situational awareness and could easily figure out what my assets were doing at a given time " - SME 2

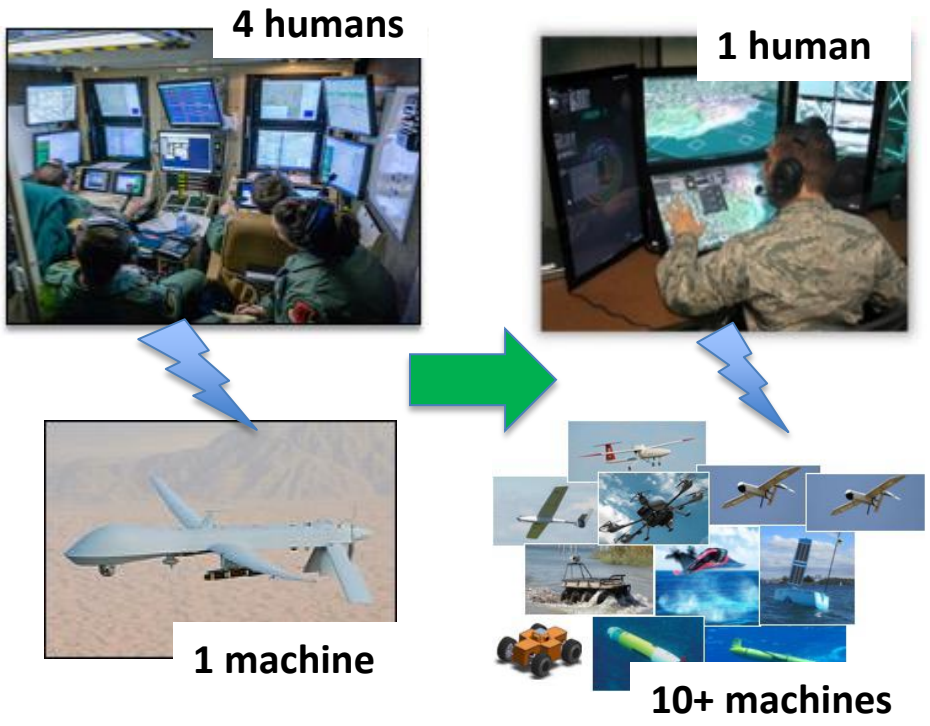
Results (2)

- Military Utility
  - 6/7 SMEs indicated the AIM concept had "**great value**" for future UxV operations
    - **"Amazing system! Truly needs to proliferate into current C-UxS systems as well as multi-domain C2. Solves missing autonomy piece for several efforts" – SME 7**
    - "This week has shown the systems is adaptable enough to meet different mission sets. More use to build proficiency and trust is required especially to learn the nuances of the system" – SME 2
  - 6/7 SMEs: AIM concept could **decrease manpower requirements**
    - "Has the potential to reduce the number of operators needed" – SME 2
    - **"Potential for reducing manpower requirement is evident" – SME 1**
  - 7/7 SMEs: AIM concept could **decrease operators' response time** to new events
    - "AIM is able to create plays quicker than a human. This will significantly reduce response time" – SME 5

"The automation and cueing of events allows the operator to respond much faster" – SME 2

Outcomes demonstrated

- **Force Multiplication** by small teams of human operators controlling a large autonomous fleet in a dynamic threat environment
- **Interoperability architecture** to provide guidelines for industry innovation
- **Integration** of autonomous technologies between the 5 nations, for faster and more informed decisions, saving on national development costs
- **Enhanced Agility** by merging tactical and operational control for faster military decision cycles



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