

Towards Intelligent Operator Interfaces in Support of Autonomous UVS Operations

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Outline

- Background & UAS Overview
- Future UAS Employment: Capabilities and Challenges
- Study Goals & Objectives
- UAS Evolution: Areas of Improvement & Requirements
- Increasing Autonomy Through the Use of Intelligent Systems
- Simulation-based UAS Concept Development & Experimentation
- Conclusion

Background

- UAV platforms increasingly employed in growing variety of missions and roles.
- UAVs operators are faced with high workloads, that are not decreasing. The use of intelligent systems by operators has been suggested as a means to assist them in an increasingly complex and dynamic environment.
- Next generation UAS will require higher levels of Autonomy and Automation
- The introduction of Net-Enabled Capabilities (NEC), aided by the gradual digitization of the battlespace, imposes a review of current UAS architectures that will benefit from augmented, automated information flows.

Types of UAV Classification

Range

Tier n/a:	Micro UAVs (MUAV),
Tier I:	Low altitude, low endurance (LALE)
Tier II:	Medium altitude, long endurance (MALE)
Tier II+:	High altitude, long endurance (HALE)
Tier III-:	HALE + low observability.

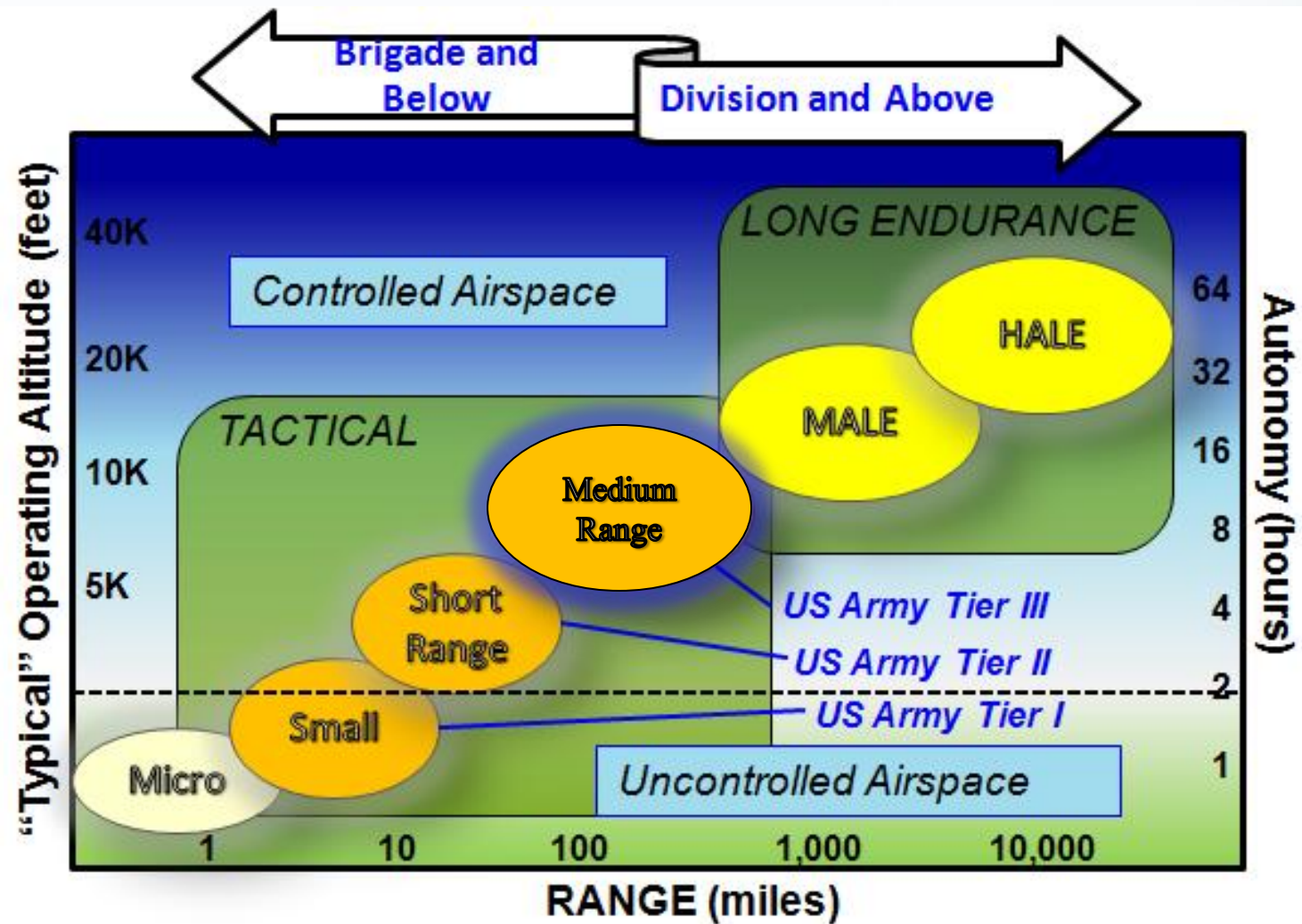
Echelon

Class I –	Small units
Class II –	Companies
Class III –	Battalions
Class IV –	Brigades

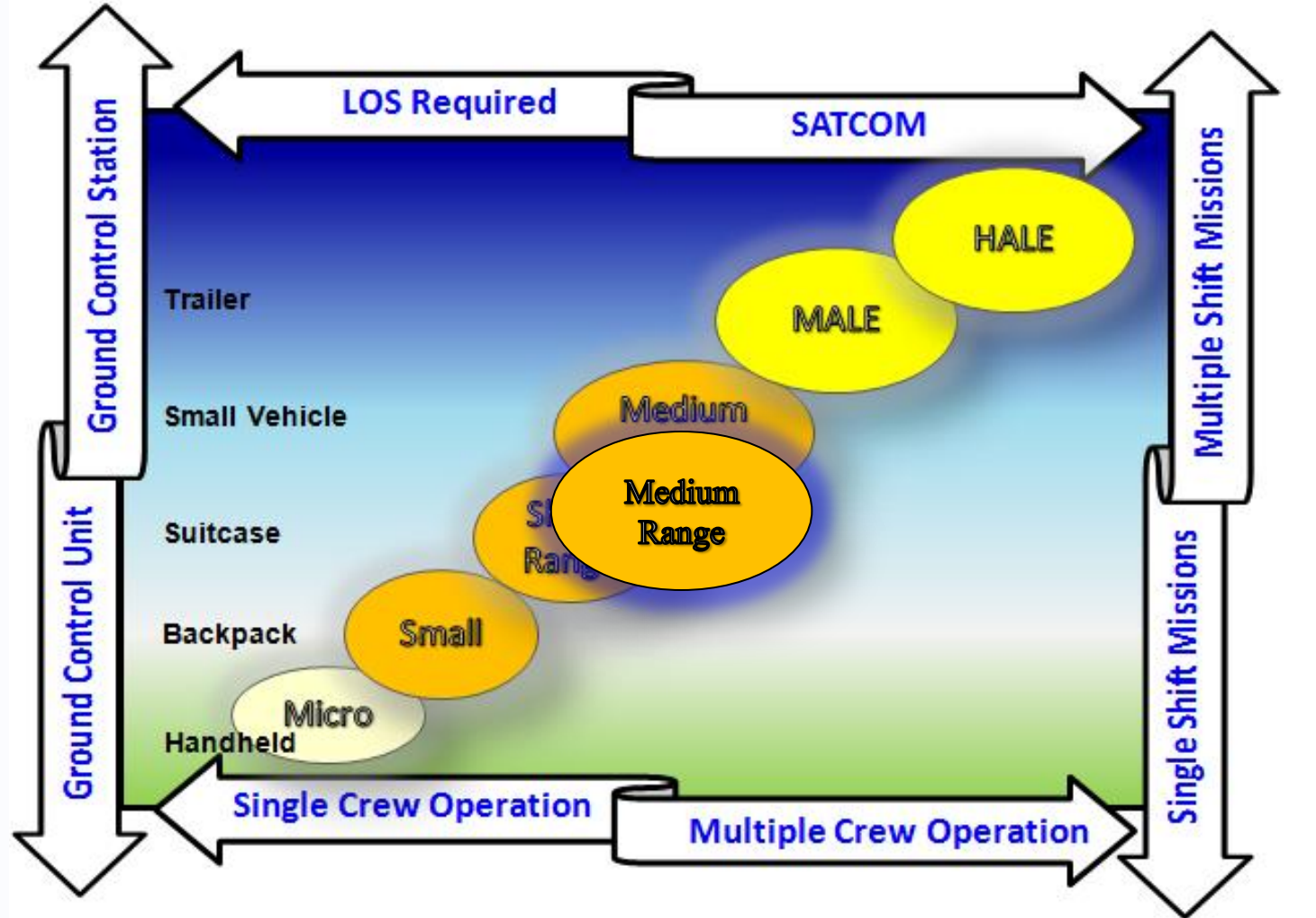
Function

Reconnaissance
Target & Decoy
Logistics
Combat
R & D

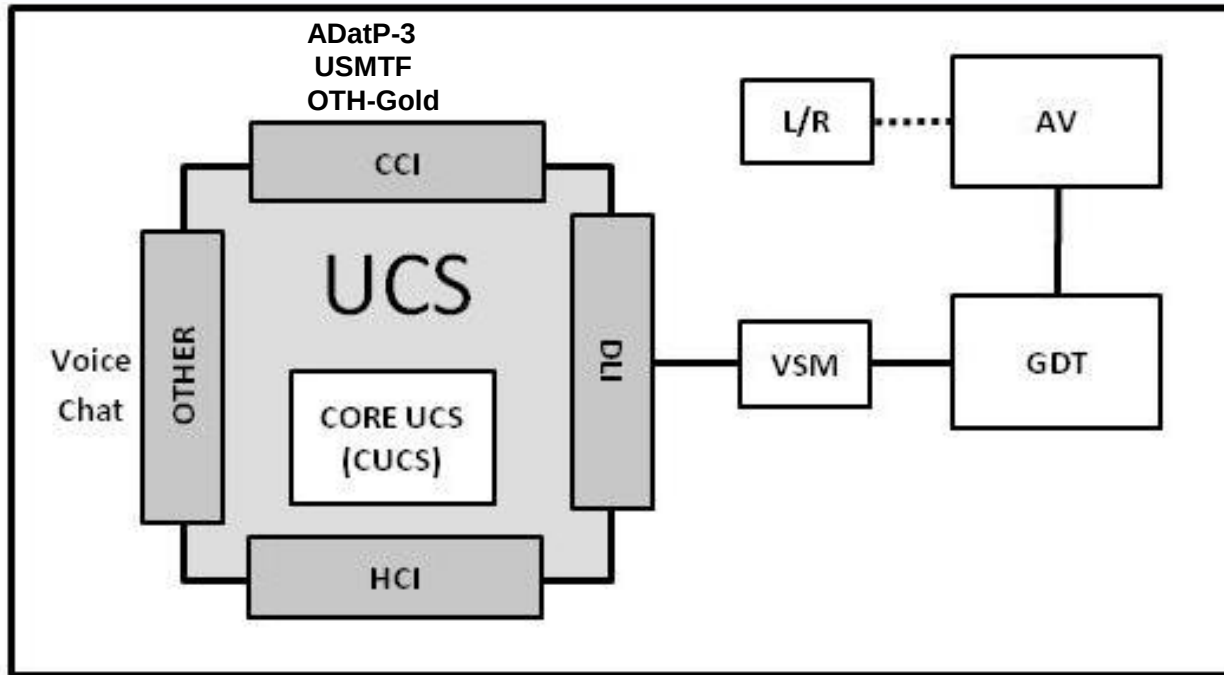
US Army Unmanned Aircraft Systems



UAS Control and Communication



UAS System Components



CCI – Command and Control Interface

DLI – Data Link Interface

HCI – Human Computer Interface

AV – Air Vehicle

GDT – Ground Data Terminal

L/R – Launch & Recovery

VSM – Vehicle Specific Module

Future UAS Employment

Capabilities

Challenges

Collaborative UAVs

Swarming UAVs – Inter UAV collaboration
Communication transmission support
Fighter-UAV Support – Extra-UAV collaboration

Airspace deconfliction
Dynamic Re-routing

Augmented Payload Capabilities

Automatic Target Recognition
Automated Weapons Fire

Legalities (e.g. Accountability)
New doctrine and TTP

Dismounted Soldier Systems

Localized reconnaissance

Size Weight and Power (SWaP)
Operator Interface, Info sharing

Enhanced Operator Interfaces

Lightened Operator Cognitive Load
Multiple UAV, single operator

Automation strategies
Higher levels of autonomy

Study Goals & Objectives

- Explore the use of intelligent systems in supporting requirements for future UAV operator interfaces and for increasing platform autonomy in UAS Operations.
 - Investigate the use of higher-level automation management strategies, including the use of agent-based systems;
 - Consider the use of formal languages and related technologies for automated communication between C2 and UAS sub-systems;
 - Propose a simulation-based approach for Concept Development & Experimentation (CD&E) of new concepts for the Command and Control of Autonomous (and non-autonomous) UAS.

UAS Evolution: Areas of Improvement & Requirements

Key Emerging UAS Requirements

OPERATOR, OPERATOR – STAKEHOLDER, PLATFORM

OPERATOR

- Operator Interfaces
 - Intelligent Interfaces to facilitate situation awareness and decision-making
 - AV Monitoring
 - Automated Reporting
 - Multi-UAV single operator control

Key Emerging UAS Requirements

OPERATOR-STAKEHOLDER COMMUNICATION

- Dynamic re-tasking of UAV during mission execution
- Chat – Currently extensively utilized in UAS operations
 - BUT, represents an interoperability GAP
 - Needs to be factored into future concepts of employment
 - May evolve into a digitized chat (e.g. like auto-fill IM)
- UAS Operations Agility – being able to respond faster, without increased risk
 - Airspace Deconfliction (e.g. JASMAD)
 - Integrated Dynamic Command & Control

Key Emerging UAS Requirements

PLATFORM

- Platform Autonomy
 - Collaborating, Swarming UAVs
 - Human Supervisory Control
 - Sense and Avoid

Nearly all of these areas could benefit from the introduction of agent-based intelligent systems for semi-automated and automated information exchange through the use of a formal language.

STANAG 4586 Future Capabilities Focus Areas

STANAG 4586 Custodial Support Team (CST) works under the NATO Joint Capability Group on Unmanned Aerial Vehicles (JCGUAV)

- Sense and Avoid
- Weaponisation
- Collaboration/Swarming
- **Support for Higher Levels of Autonomy**
- **Enhanced Support for Automated Missions**
- **Multi-domain Unmanned Vehicle Platforms**
- **Service-Oriented Architecture / Net-Centric Approach**

The foremost UAV interface standardization body is already addressing these capability areas.

Increasing Autonomy Through the Use of Intelligent Systems

Command and Control & Automation/Autonomy

Command

Authoritative act of making decisions and ordering action.

Control

The act of monitoring and influencing this action.

Mission Goals

Autonomy

Tasks

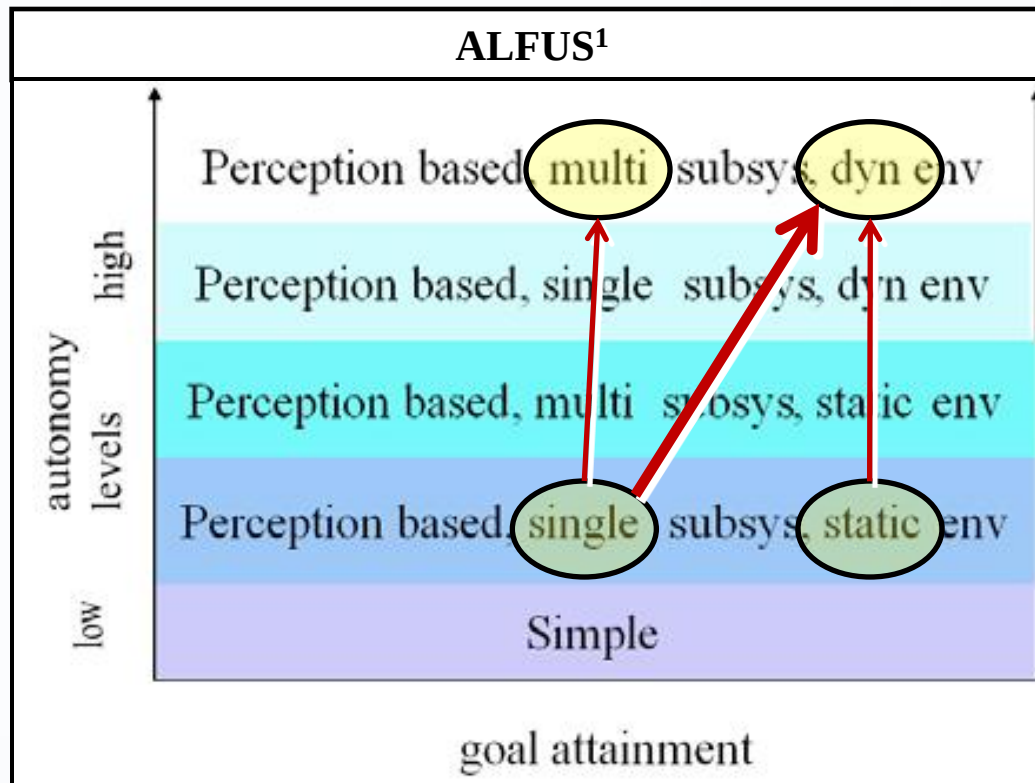
Automation

Using automation as an enabler for higher levels of autonomy requires automation strategies

Levels of Autonomy

Autonomy

Achieving a set of prescribed objectives, adapt to major changes, develop its own objectives.



UAS Autonomy²

“An Unmanned Aircraft system exhibits autonomy when the system software is capable of making - and is entrusted to make - substantial real-time decisions, without human involvement or supervision.”

¹http://www.isd.mel.nist.gov/projects/autonomy_levels/

²Autonomous Civil Unmanned Aircraft Systems Software Quality Assessment and Safety Assurance - AeroVations Associates, 2007

Levels of Automation & Automation Strategies

Levels of Automation [*]		Sheridan and Verplank 1978
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	
9	informs the human only if it, the	
10	The computer decides everything	

Automation Management Strategies		LOA
A	Human-based Management	Level 1
B	Management-by-consent	Level 5
C	Management-by-exception	Level 6
D	Machine-based Management	Levels 7, 8, 9, 10

Implementing higher-level automation management strategies requires a greater formalism than found in formatted text messages.

Formal Language Based Approach

Coalition Battle Management Language (C-BML)

Common Interface: for exchange of expressions

Expressiveness: of all relevant actions to be performed by real, simulated or robotic forces. Intended to generate ATO, or to express the NATO 5-paragraph Operations Order (OPORD) and other tactical messages.

Unambiguous and Parsable: allows for a mathematical representation that supports automated processing.

BML Example Order: Who/What/Where

<pre> <OrderPush> <Task> <AirTask> <TaskeeWho> <UnitID>CA-UAV</UnitID> </TaskeeWho> <What> <WhatCode>CLARSP</WhatCode> </What> </pre>	<pre> <Where> <WhereID>14010000784100000427</WhereID> ... GENCOORDINATE ... <WhereLocation> <GDC> <Latitude>40.062195</Latitude> <Longitude>47.57694</Longitude> <ElevationAGL>3000.0</ElevationAGL> </GDC> </WhereLocation> ... </Where> </pre>
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BML Example Order: When +

```

<StartWhen>
  <WhenTime>
    <StartTimeQualifier>AT</StartTimeQualifier>
    <DateTime>20091022141229.359</DateTime>
  </WhenTime>
</StartWhen>

<AffectedWho><UnitID>OMF195-B12</UnitID> </AffectedWho>
  <TaskID>14099999000000000019</TaskID>
  </AirTask>
</Task>
<OrderIssuedWhen>20091022141443.000</OrderIssuedWhen>
<OrderID>14099999000000000030</OrderID>
<TaskerWho> <UnitID> 1-HBCT </UnitID> </TaskerWho>

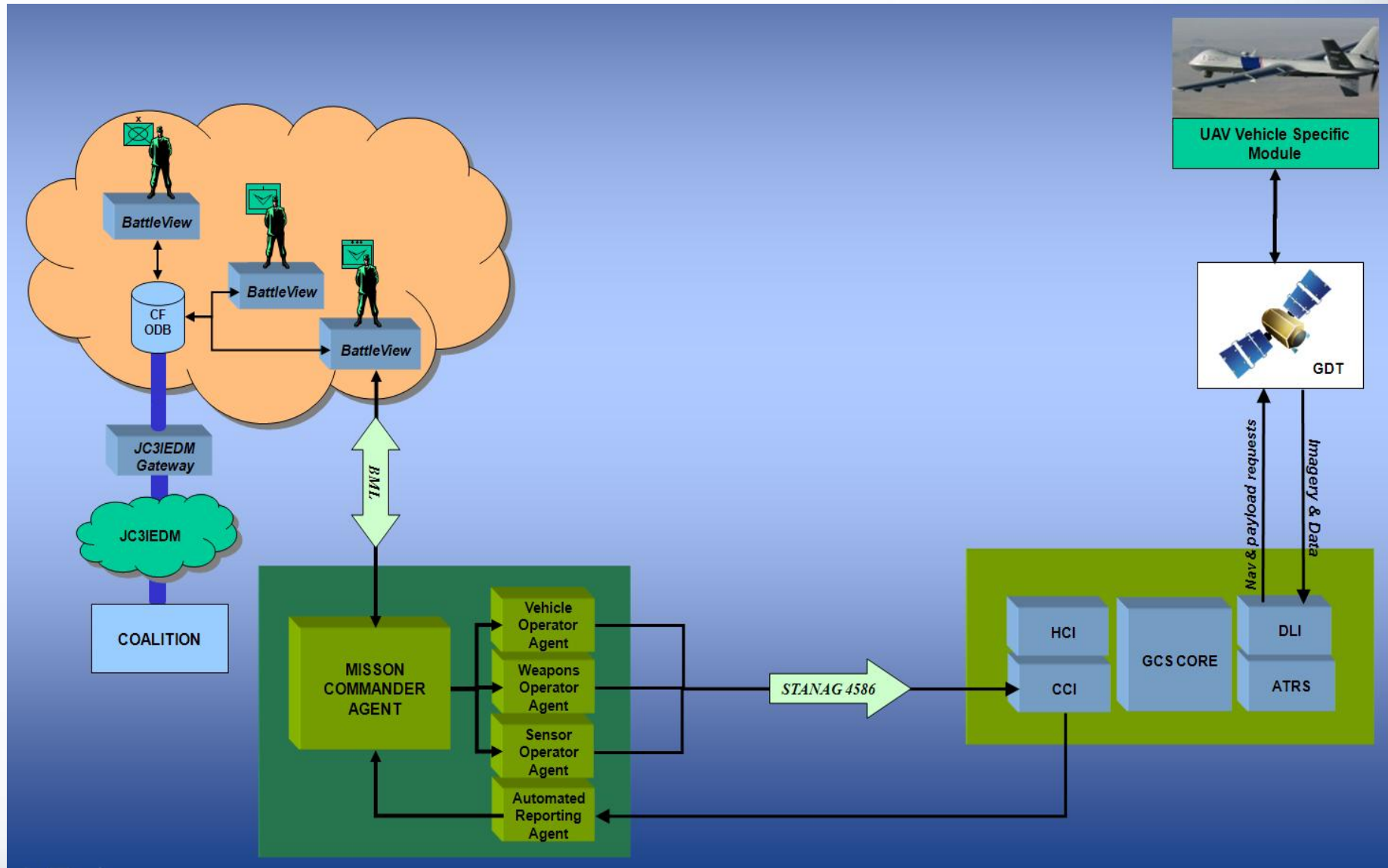
...

<TaskOrganization> <UnitID> CA-UAV </UnitID> </TaskOrganization>
</OrderPush>

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Simulation-based UAS Concept Development & Experimentation

Current DRDC/CAE BML-Enabled Capability



DRDC/CAE UAV-BML Capability Benefits

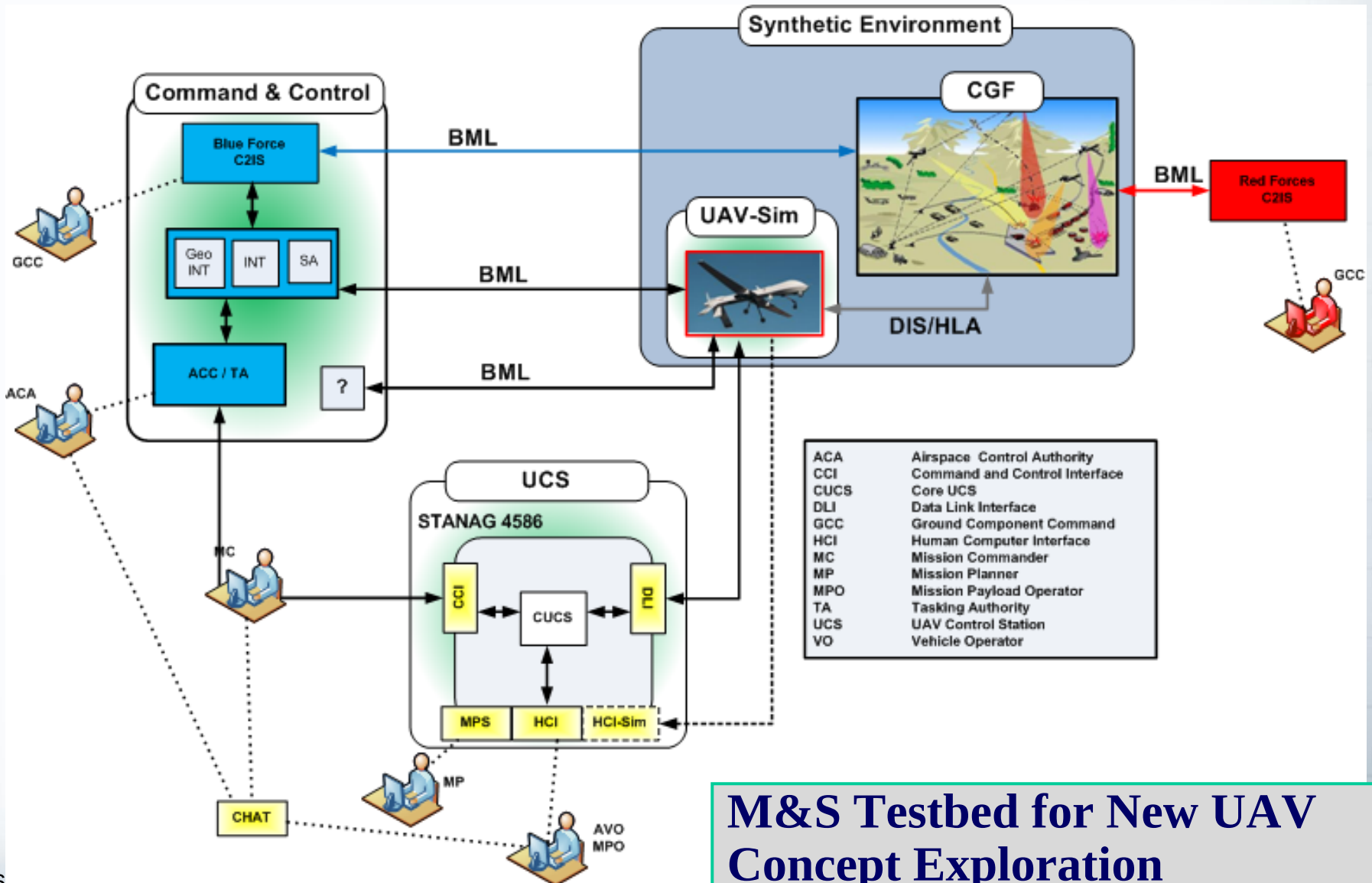
- Can task unmanned assets from C2 system during training exercise without simulation/UAV operators.
- Can be extended to include human operator intervention to support other automation management strategies (e.g. takeover to manual control for Time-Sensitive Targeting and subsequent turnover to automated mode).
- Can support concept development and experimentation

DRDC Research Project

C2 - Autonomous Systems Interoperability

**M&S Testbed for New UAV
Concept Exploration**

C2 - Autonomous Systems Interoperability



C2 - Autonomous Systems Interoperability

Expected Benefits

Explore the effectiveness of C-BML for the Command and Control of UAVs as a means to:

1. Eliminate/reduce some of existing air-gaps (and resulting potential errors)
2. Shorter decision making cycles - both the “commander” and the UAV operator(s) could have control of the UAV platform
 - ex: UAV Dynamic re-tasking use case
3. Explore new C4ISR concepts (and architectures)
4. Benefit from advances in UAV automation in order to achieve higher degrees of autonomy
 - Operator (software agent) assisted control
 - Multiple-vehicle, single-operator control

Conclusion

- There is a clear need to introduce higher levels of automation and autonomy into current and future UVS; in particular with respect to the Human Computer Interface.
- This need can be addressed in part through the introduction of automated information flows between C2 stakeholders and UCS subsystems – including the elimination of air gaps.
- The use of formal languages is key to establishing these automated information flows.
- BML, currently being developed as a C2-simulation interoperability standard, is a formal language that also has potential for C2-UVS interoperability.
- BML is also an enabling technology for constructing simulation-based experimentation capabilities that can support Concept Development and Experimentation involving unmanned vehicle assets. This is currently being explored by the DRDC.



Questions?

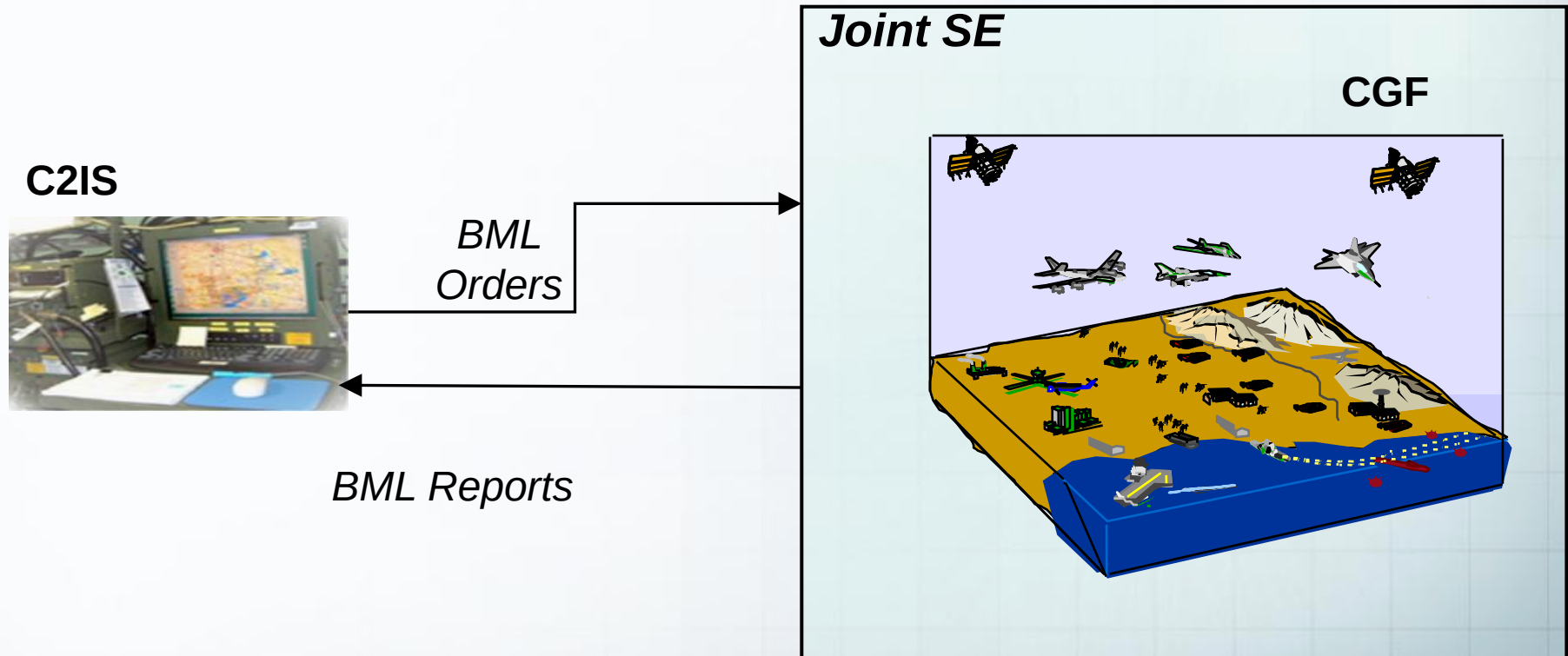


Backup Slides



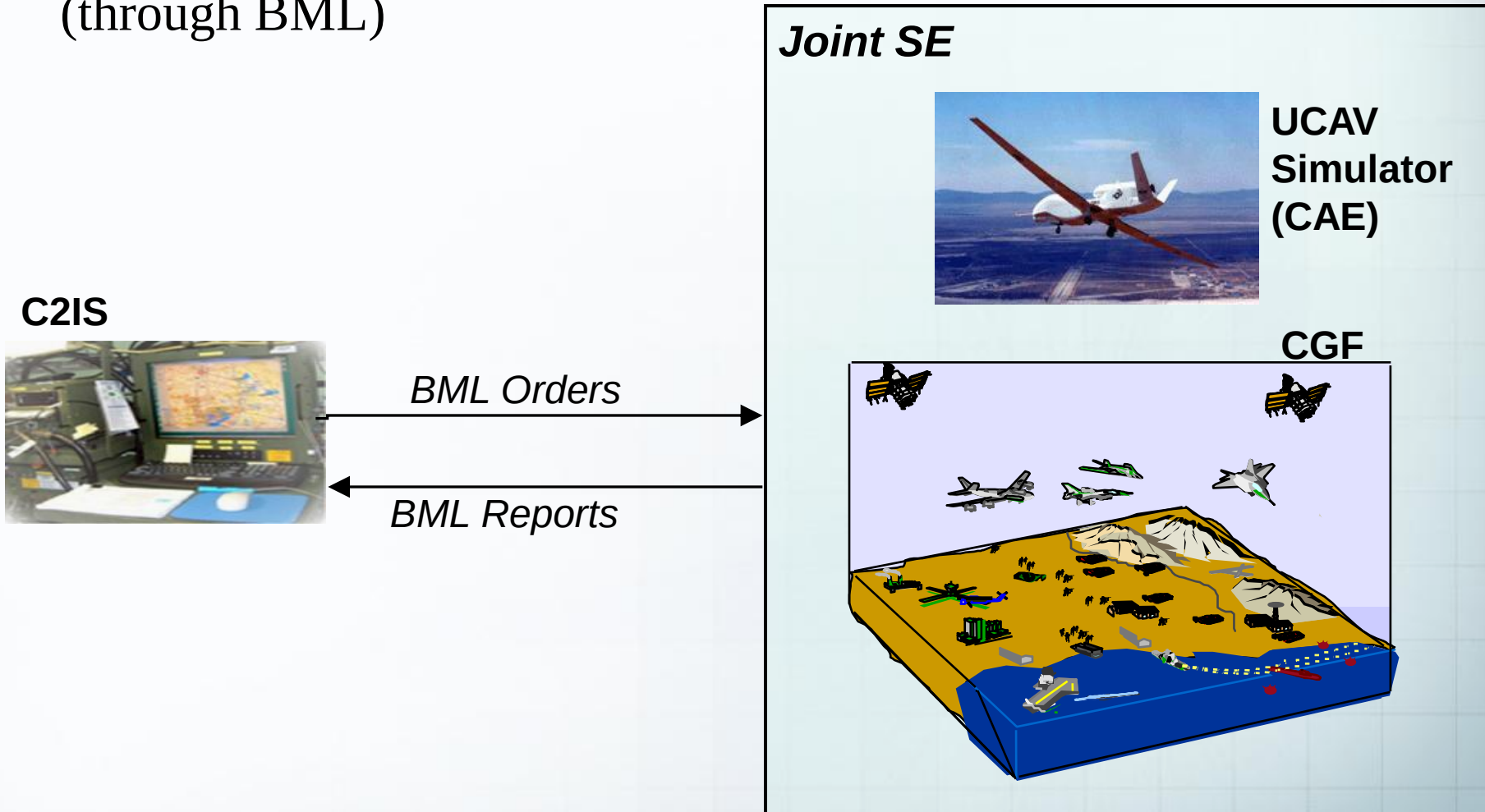
DRDC BML Activity Background – Phase 1

- Initial use of BML technology: C2-Constructive Sim (CGF) Interoperation



DRDC BML Activity Background – Phase 2

- Second Phase: UAV simulation controlled by a C2 system (through BML)



DRDC/CAE UAV-BML Capability Highlights

- UAV Tasking (From BattleView to UAV-Sim)
 - Tactical Air Surveillance and Reconnaissance
 - Deliberate Air Support
- UAV Reporting (From UAV-Sim to BattleView)
 - General Status Reports
 - Task Status Reports
 - Contact/Position Reports
 - Battle Damage Assessment
- UAV Simulation
 - STANAG 4586 Ground Control Station Emulation
 - DIS Gateway (can join any DIS exercise)
 - High fidelity EO/IR display

Levels of Automation

Automation - Using machines to perform tasks and execute processes

Levels of Automation*	
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.

*T.B. Sheridan and W.L. Verplank 1978