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Using BML to Command and Control UAV Systems in a Coalition

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Outline

- **Introduction**
- Levels of Automation
- CAE/DRDC UAV-BML Capability
- MSG-048 2009 Experimentation
- Future Work
- Conclusions

Introduction: Motivation of work

- Much focus in BML research on C2-simulation interfacing, less experimental work on C2-robotic forces interoperability
- Interfaces to unmanned systems and simulation systems are similar & well-suited to make use of BML
- Need capability to support experimentation in the area of command & control of automated systems such as robotic forces
- Increasing global use of UAVs, particularly in military arena
- UAV already benefit from a standardized communication link and protocol (STANAG 4586)
- Some UAV functions are already automated
  - e.g. navigation, sensor

Introduction: Unmanned Air Vehicles

- UAV have a range of functional roles
  - Target Drones
  - Observation/intelligence-gathering
  - Attack
  - Scientific
- UAV come in various ranges and sizes
  - Micro hand-held UAV
  - Low, Medium, High Altitude and Orbital
  - Endurance and tiers categories

Introduction: Background

- **DRDC** has an Advanced Research Project (ARP) interested in :
  - C2IS interoperability with simulation and robotic systems
- **CAE** has developed an advanced UAV Operator Training Solution
  - Emulates Ground Control Station Functionality
  - Support STANAG 4586 protocol
  - High fidelity models and EO/IR & Radar Displays
  - Initial development done in collaboration with the DRDC
- Started to collaborate on **CAE-DRDC UAV-BML Capability** in 2009
- **CAE** and **DRDC** decide to participate in MSG-048 Experimentation in Apr. 2009

Introduction: Objectives of work

Demonstrate how C-BML can act as enabler for interoperability between:

- **C2IS and Simulations**
  - UAV Operator Training, Command & Staff Training
  - Planning, decision-support
  - Mission rehearsal

- **C2IS and Robotic forces**
  - Benefits /liabilities with increasing levels of automation
  - Aides for the development of emerging doctrine and tactics for UAV
  - Support review of impact on current C2IS architectures / force generation / force employment
  - Use of intelligent adaptive interfaces for enhanced operator-machine interfaces

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Levels of Automation

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.

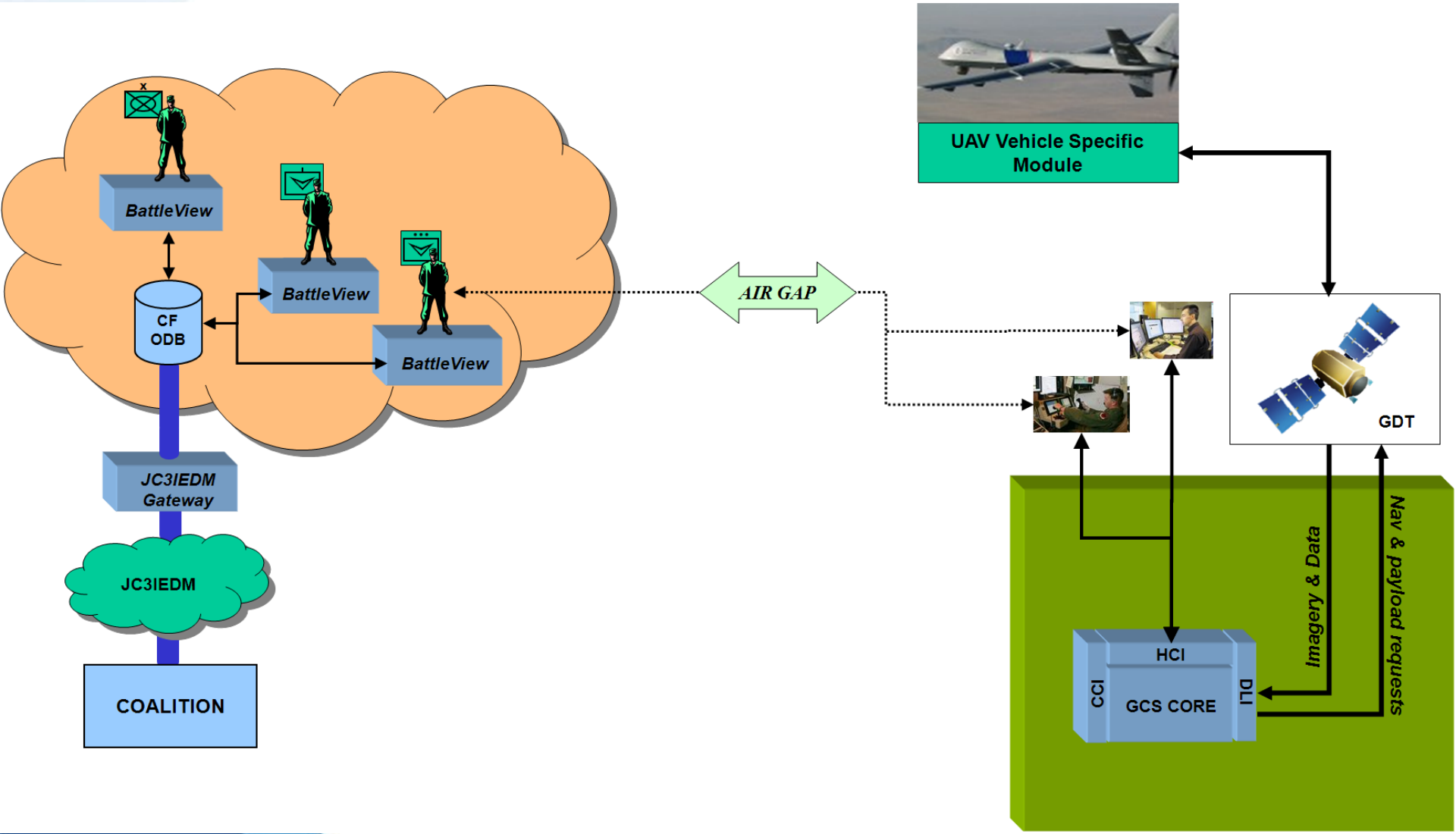
T.B. Sheridan and W.L. Verplank : *Human and Computer Control of Undersea Tele-operators*, MIT, Cambridge, Man-Machine Systems Laboratory Report, 1978

Levels of Automation

Automation Level	Automation Description
	MANUAL
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
	SEMI-AUTOMATED
6	allows the human a restricted time to veto before automatic execution, or
7	executes automatically, then necessarily informs humans, and
8	[illegible] if asked, or
	AUTOMATED
10	The computer decides everything and acts autonomously, ignoring the human.

T.B. Sheridan and W.L. Verplank : *Human and Computer Control of Undersea Tele-operators*, MIT, Cambridge, Man-Machine Systems Laboratory Report, 1978

Traditional UAV Command & Control: Level 1 automation (existing)



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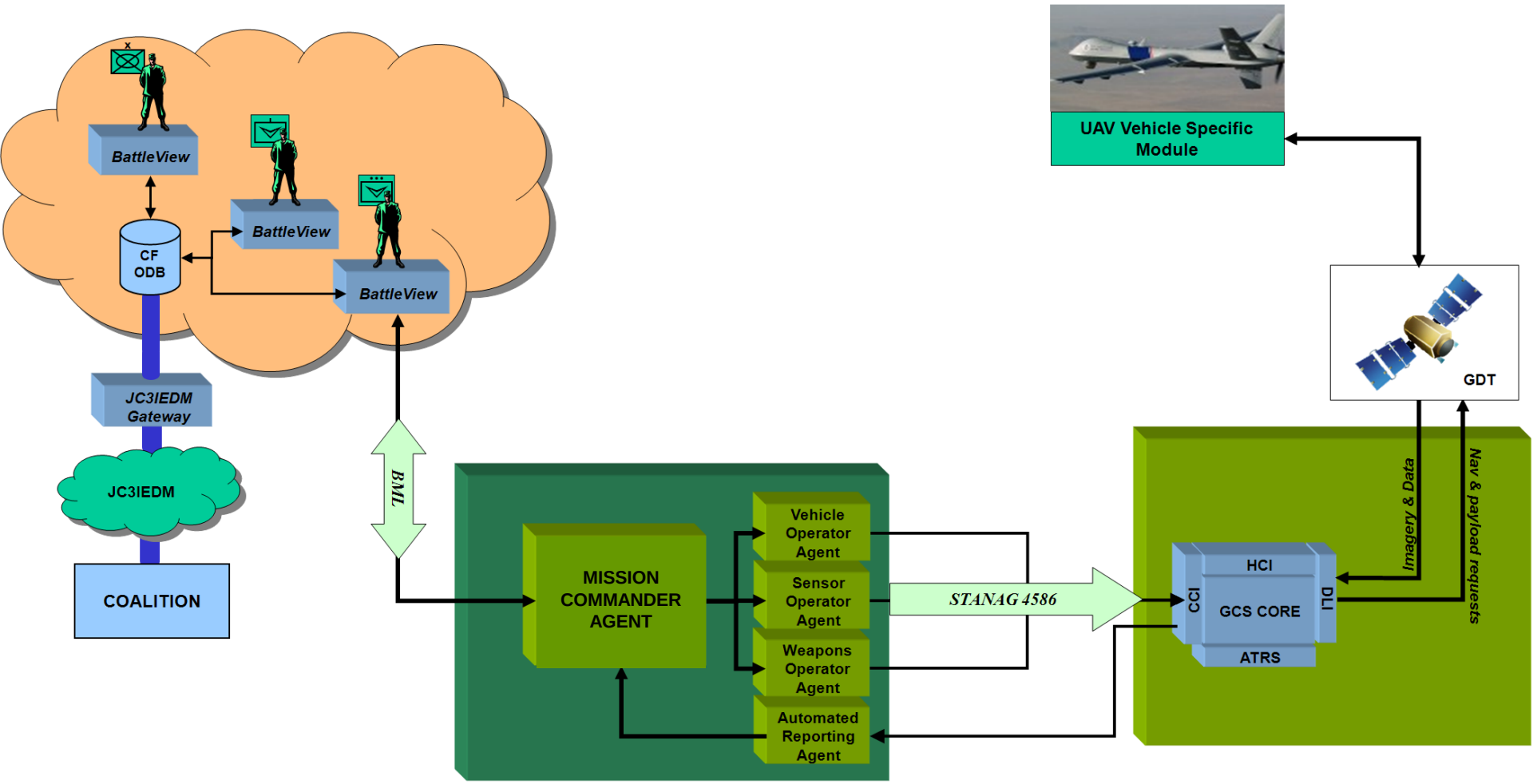
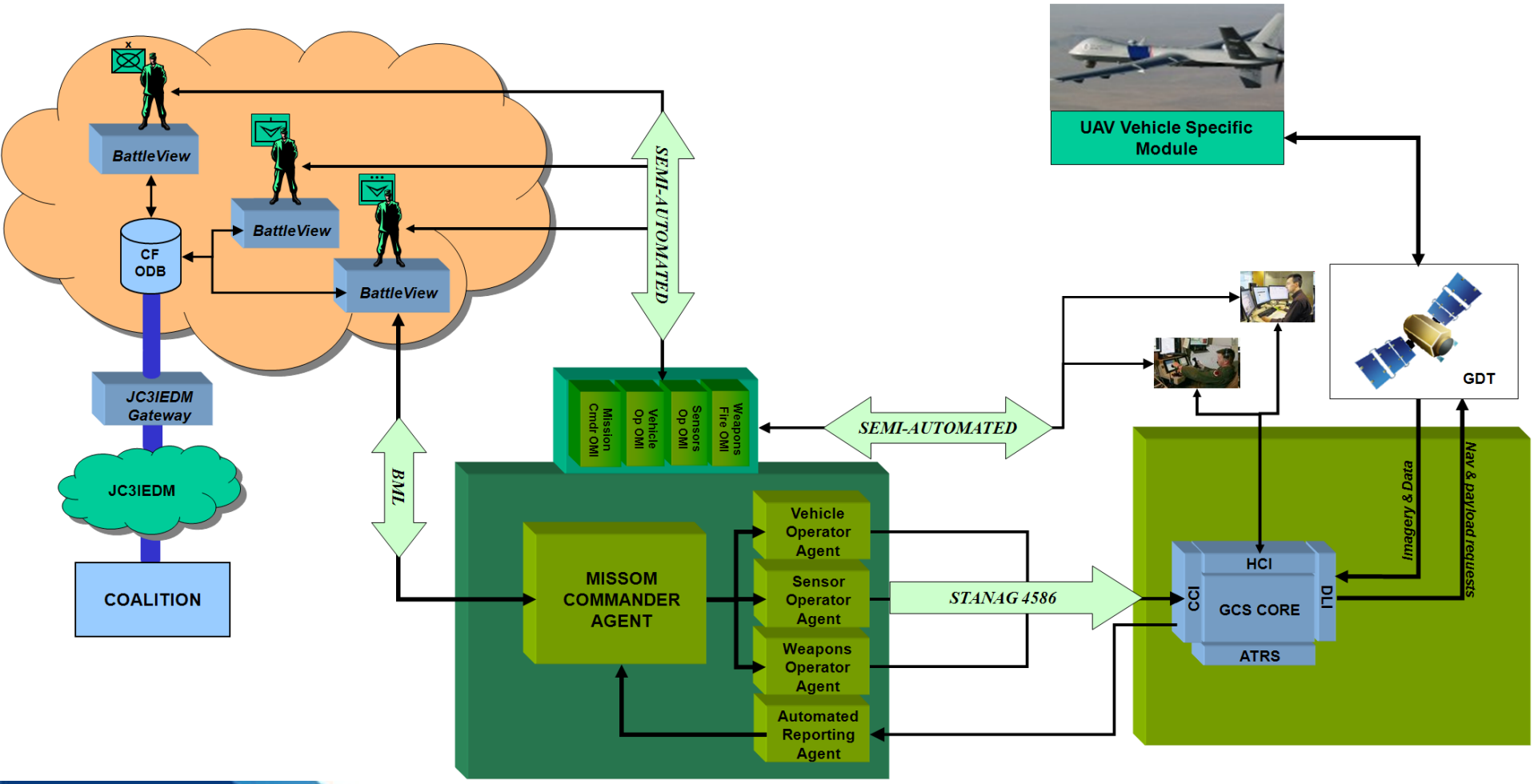
Automated UAV Command & Control: Level 9 automation (current prototype)



Semi-Automated UAV Command & Control: Level 5 automation (future work)



CAE/DRDC UAV-BML Capability: Status

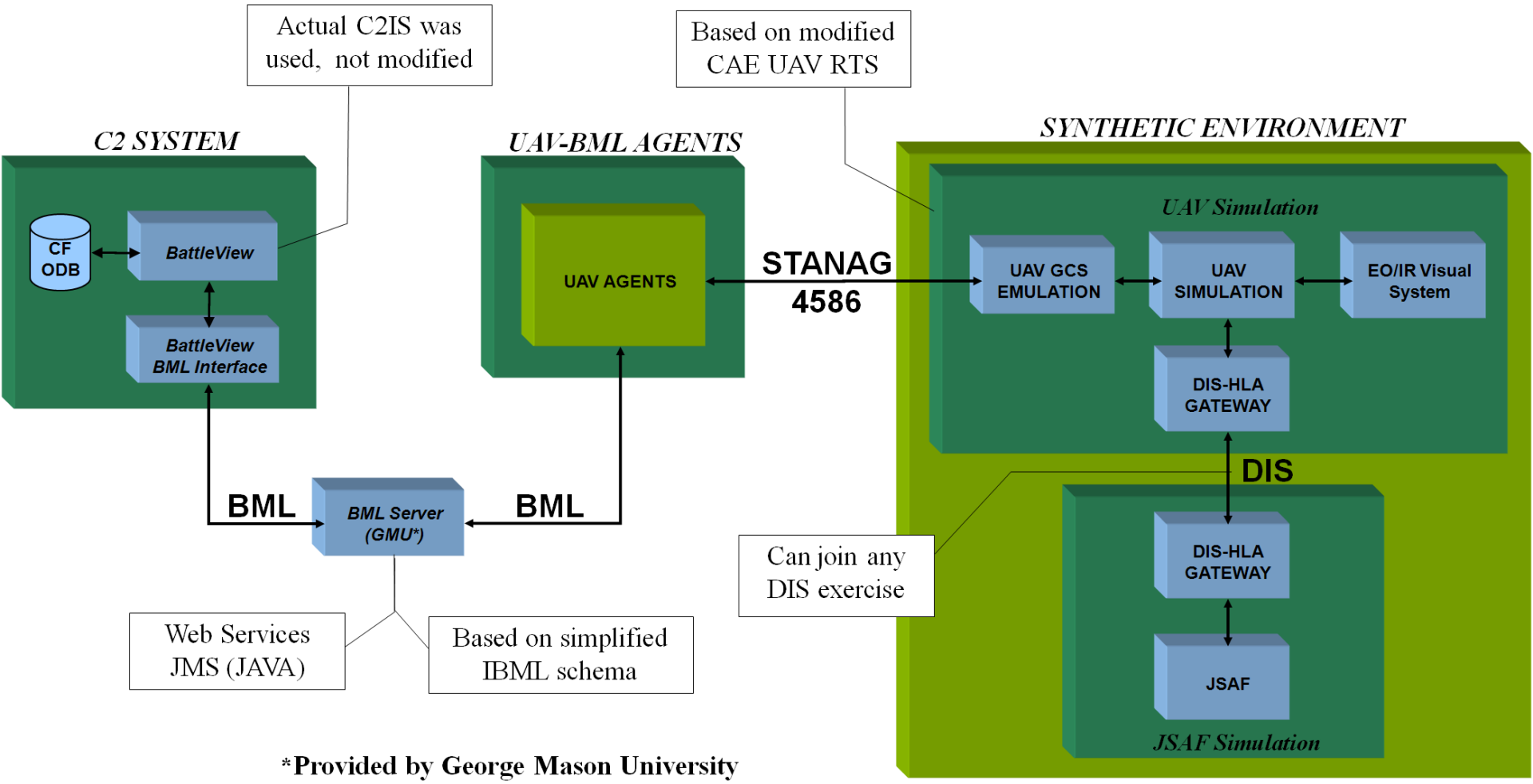
CAE and **DRDC** have developed a prototype capability that was used in the MSG-048 Experimentation

- Concept demonstrates the Army C2IS (BattleView) controlling a BML enabled UAV (simulation)
- Technical Readiness Level ~ 3 (proof of concept)
- Level of automation 9, highly-automated UAV Control
  - No UAV operators /interactors
  - Simplified algorithms for automatic target recognition emulation DRCI (detection, recognition, classification & identification)
- Utilized George Mason University (GMU) BML implementation based on simplified IBML schema
- UAV model is General Atomics MQ-9 Reaper (Predator B)

CAE/DRDC UAV-BML Capability: Functionality highlights

- **UAV Tasking** (From BattleView to UAV-Sim)
  - Tactical Air 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

CAE/DRDC UAV-BML Capability: Architecture Overview



*Provided by George Mason University

UAV Vignette 1 – ISR Mission

- Order may contain one or more areas of interest
- Order may include ingress or egress route
- Order may have different priorities
- Order may include control features such as Air corridors, restricted areas, etc.
- UAV mission commander will interpret Order and assigns a series of tasks to the UAV operator(s).

Vignette 2 – Offensive Air Support Mission

- Order may contain one or more targets
- Order may include ingress or egress route
- Order may have different priorities
- Order may include control features such as Air corridors, restricted areas, etc.
- UAV mission commander will interpret Order and assigns a series of tasks to the UAV operator(s).

*Vignette 3 – Close Air Support Mission

- Order may contain one or targets
- Order may include ingress or egress route
- Order may have different priorities
- Order may include control features such as Air corridors, restricted areas, etc.
- CAS mission will require close cooperation between UAV and ground forces during execution

*Not implemented in current prototype

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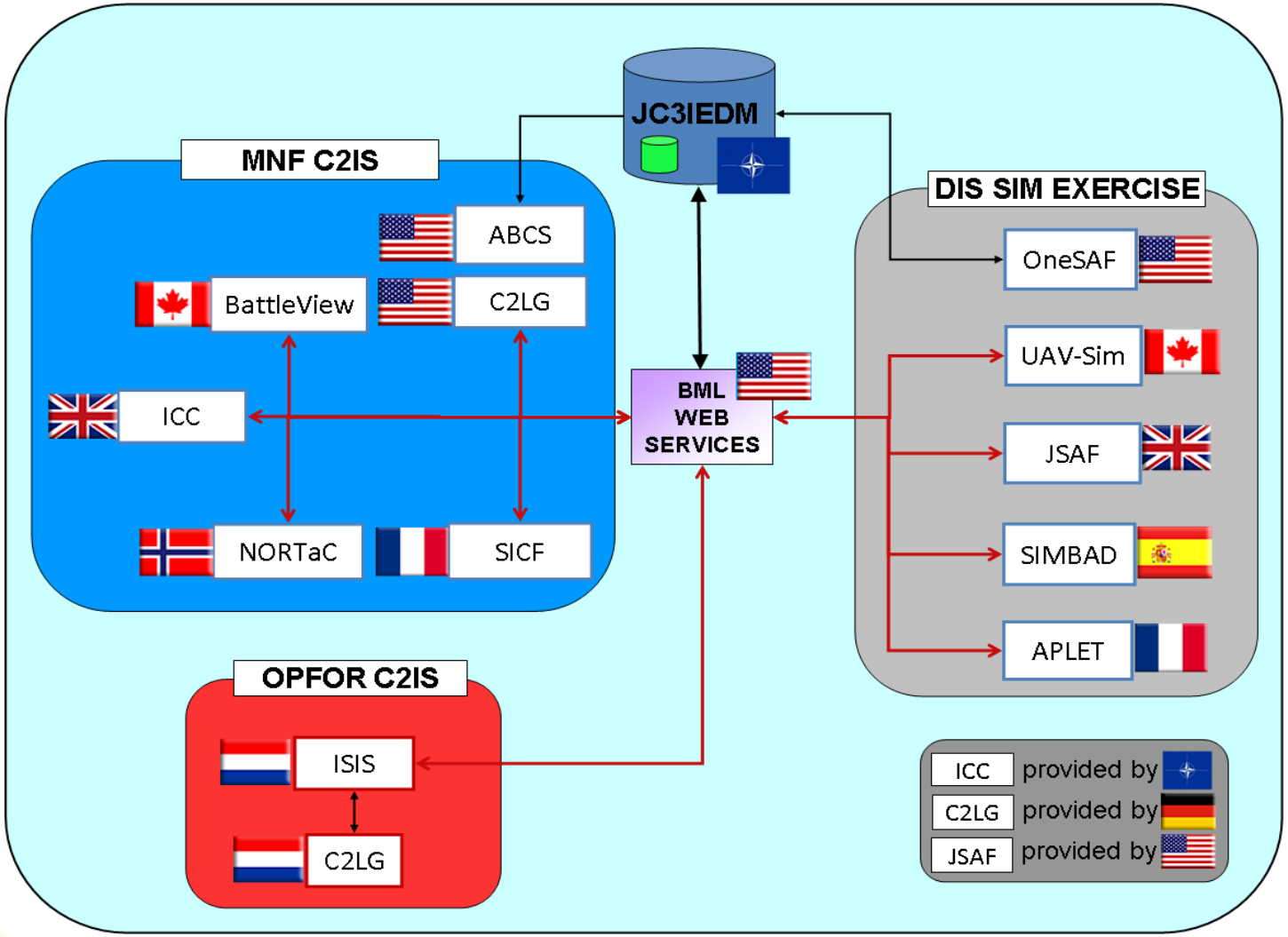
MSG-048 2009 Experimentation: Overview

- **MSG-048 Final Experimentation Event**
  - Coalition Planning, Training and Mission Rehearsal Activities
  - One-week event
  - Involving active and retired commanding officers from 7 nations
  - Dedicated simulation room and command & control cell
- **Multi-National Force (MNF) and Opposing Forces (OPFOR)**
  - Scenario in Caspian Sea Region
  - Several MNF and OPFOR Courses of Action (COA)

MSG-048 2009 Experimentation: Architecture Overview



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Future Work

- Level 5 Automation
  - UAV Operator intervention
    - Manual override from Level 9
    - Time-sensitive Targets
    - Return control to Level 9 automated mode
- Canadian Forces BML Implementation
  - Based on emerging SISO C-BML standard
- Closer Integration with OneSAF
- Application to control of multiple UAVs and/or other robotic systems

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Conclusions

- BML lends itself very well as C2 interface to UAV
- BML has potential to reduce workload considerably
- BML can increase UAV utilization efficiency
- Provides opportunities for swarming UAVs control in a single integrated (C2IS) environment
- Use of agents may prove to be more reliable than humans
- Remains a considerable psychological barrier to allow certain degree of automation to UAV
- Advances in intelligent/autonomous UAV (robotic forces) will foster the use BML

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Questions

Extra Slides

Mission Commander & Automated Agent

Level	Behaviour
1	The human is expected to do all the work. The agent can still provide some assistance in the translation and presentation of the BML order to the Mission Commander. The latter can gain efficiency by using simple tools such as cut and paste to ensure that the content of the mission is accurately relayed to his subordinates.
5	The agent assesses the BML mission and translates the mission into distinct tasks for his subordinates. The UAV-MCA fills the content of a user interface for the Mission Commander. The latter validates the content of the user interface and forwards the task to his subordinates (the vehicle operator and payload operator).
6	Same as for 5 but the mission commander is given a set amount of time to validate the order otherwise the agent forwards the order automatically.
7	Same as 5 except that the order is forwarded immediately. The agent will then display the ordered issued so that the commander is aware of any decision previously made by the agent.

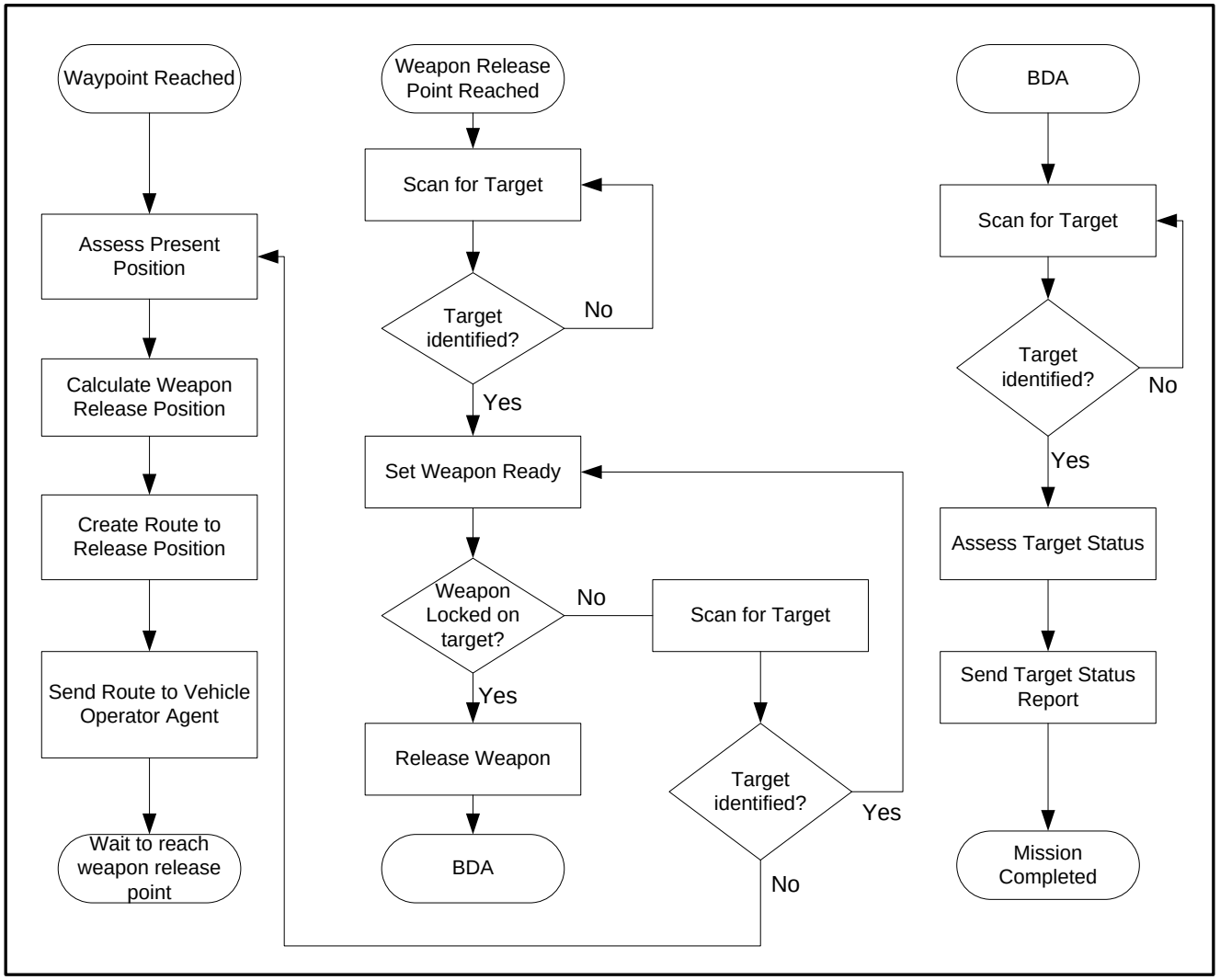
Vehicle Operator and Automated Agent

Level	Behaviour
1	In this mode the human is expected to do all the work. The agent can still provide some assistance in the translation and presentation of the order to the Vehicle Operator. The latter can gain efficiency by using simple tools such as cut and paste to ensure that the content of the mission is accurately relayed to the UAV.
5	The agent assesses the BML mission and converts it to a format usable by the Ground Control Station (GCS). The Vehicle Operator validates the content of the user interface and forwards it to the vehicle (manual or auto pilot).
6	Same as for 5 but the vehicle operator is given a set amount of time to validate the order otherwise the agent forwards the order automatically.
7	Same as 5 except that the order is forwarded immediately. The agent will then display the ordered issued so that the Vehicle Operator is aware of any decision previously made by the agent.

Payload Operator & Automated Agent

Level	Behaviour
1	In this mode the human is expected to do all the work. The agent can still provide some assistance in the translation and presentation of the order to the Payload Operator. The Payload Operator performs the rest of the work unassisted.
5	The agent will maintain a dynamic list of entities that have been detected by the human operator and will attempt to track the entities in relation to the UAV movement, the entity movement or both. The UAV-POA will prepare BML reports for the entities and bring the report up to the screen for the human payload operator to validate and send.
6	Same as for 5 but the payload operator is given a set amount of time to validate the report otherwise the agent forwards the report automatically.
7	Same as 5 except that the report is forwarded immediately. The agent will then display the report issued so that the payload operator is aware of any reports previously made by the agent.

OAS Payload Operator Agent Logic



Payload Operator & Automated Agent

Level	Behaviour
1	In this mode the human is expected to do all the work. The agent can still provide some assistance in the translation and presentation of the order to the Payload Operator. The Payload Operator performs the rest of the work unassisted.
5	The agent will scan for the target and identify the most likely entity as a target. The human payload operator will confirm target identification. Once the weapon is locked on target, the human operator will be prompted to authorize the weapon release. The UAV-POA will prepare BML reports for the BDA and bring the report up to the screen for the human payload operator to validate and send.
6	Same as for 5 but the human payload operator is given a set amount of time to validate the target and weapon release otherwise the agent engages the target automatically. Similarly, the human payload operator will be given a set amount of time to validate the BDA report otherwise the report will be forwarded automatically.
7	Same as 5 except that the target validation and weapon release is performed immediately. The agent will then display the target validation and weapon release so that the payload operator is aware of any decision previously made by the agent.

Payload Operator and Automated Agent

Level	Behaviour
1	In this mode the human is expected to do all the work. The agent can still provide some assistance in the translation and presentation of the order to the Payload Operator. The Payload Operator performs the rest of the work unassisted.
5	The agent will scan for the target and identify the most likely entity as a target. The human payload operator will confirm target identification and forward the information to the ground force. Once the weapon is locked on target, the human operator will be prompted to authorize the weapon release.
6	Same as for 5 but the human payload operator is given a set amount of time to validate the target and weapon release otherwise the agent engages the target automatically.
7	Same as 5 except that the target validation and weapon release is performed immediately. The agent will then display the target validation and weapon release so that the payload operator is aware of any decision previously made by the agent.

CAS Payload Operator Agent Logic