



# Benefits of Modelling and Simulation to Military Commands in Federated Mission Networking

*MSG-211 Technical Course, Session 1.7*

**Curtis Blais, PhD**  
Naval Postgraduate School  
Lead, MSG-211

16 October 2023



# Outline

- Introduction
  - Key Military Enterprise Activities (NATO/Nations)
  - Links to Command, Control, Communications (C3) Taxonomy
- Modelling and Simulation Support to Military Activities
- Interoperability Challenges
  - Digitized Command and Control (C2)
  - Integrating Systems
- Application of Modelling and Simulation
  - Force Readiness and Training
  - Support to Operations including Mission Planning (COAA, Wargaming) and Mission Rehearsal
  - Capability Acquisition and Test & Evaluation (T&E)
  - Concept Development and Experimentation (CDE)

# Military Enterprise Activities (1)

- Definition of an *Enterprise* in the Merriam-Webster Dictionary:
  - a project or undertaking that is especially difficult, complicated, or risky
  - readiness to engage in daring or difficult action
  - a unit of economic organization or activity; or a systematic purposeful activity
- Definition of *Military* in the Oxford Dictionary:
  - relating to the armed forces of a country

# Military Enterprise Activities (2)

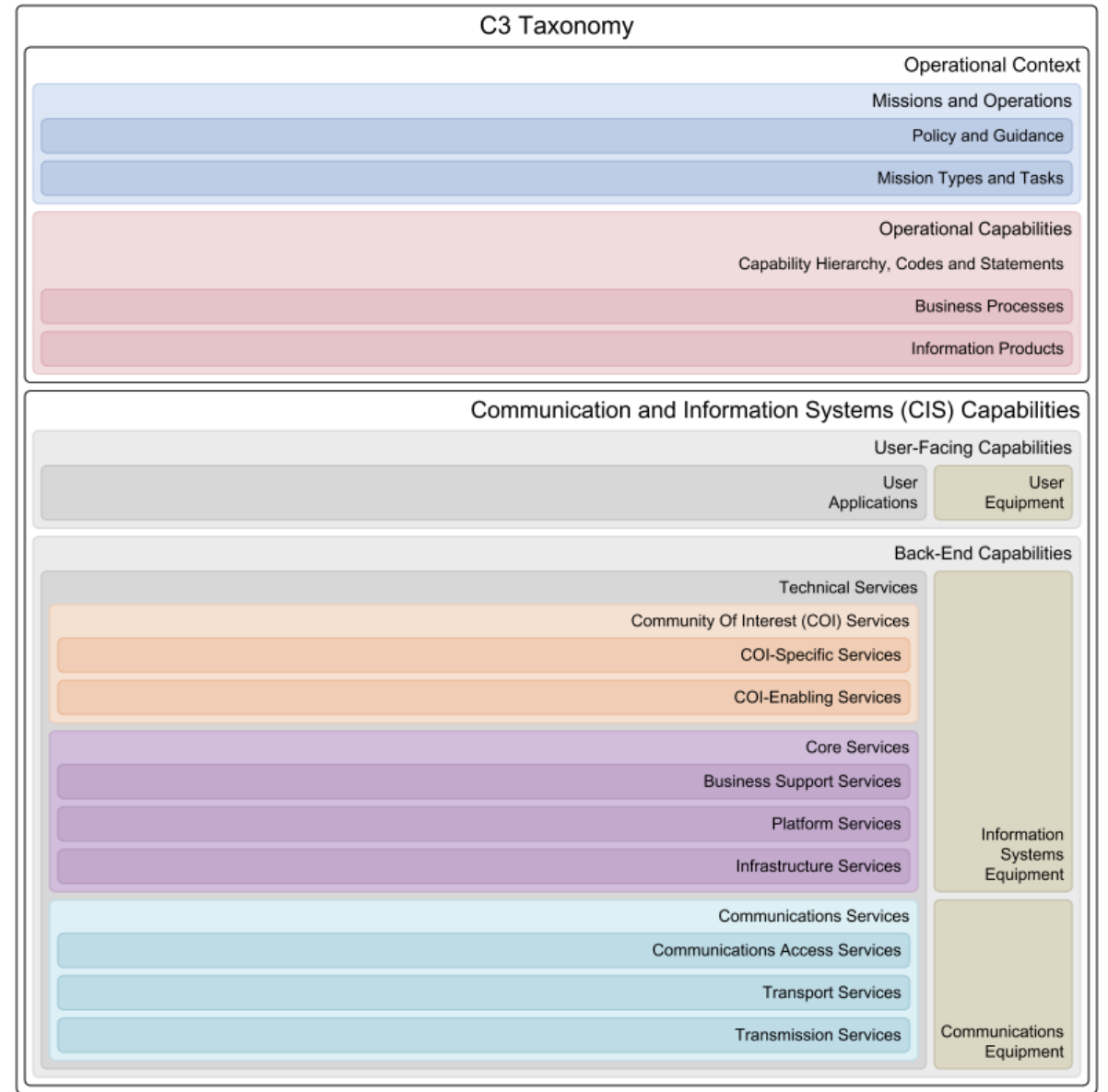
- For the purposes of this presentation, we define *Military Enterprise Activities* as:
  - A set of activities conducted by a military organisation (*enterprise*) in order to effectively and efficiently deliver a capability or capabilities to carry out an agreed-upon set of military tasks as part of a formal coalition of nations or by individual countries
- High-Level Military Tasks are defined by Nations individually or in tandem with other Nations which are agreed by treaties
  - For example, NATO's fundamental security tasks are laid down in the Washington Treaty (also known as the North Atlantic Treaty)

# NATO's Strategic Concepts

- Strategic Concepts equip the Alliance for security challenges and guide its future political and military development.
- They reiterate NATO's enduring purpose and nature, and its fundamental security tasks.
- They are reviewed to take account of changes to the global security environment to ensure the Alliance is properly prepared to execute its core tasks, making transformation in the broad sense of the term, a permanent feature of the Organization.
- The current Strategic Concept “Active Engagement, Modern Defence” (2010) outlines three essential core tasks:
  - Collective defence
  - Crisis management
  - Cooperative security

# C3 Taxonomy

- The C3 Taxonomy provides a tool to synchronize all C3 Capability Activities in the NATO Alliance by connecting the Strategic Concept and Political Guidance through the NATO Defence Planning Process (NDPP) to traditional Communications and Information Systems (CIS) architecture and design constructs.
- The C3 Taxonomy starts with an Operational Context describing the environment in which CIS capabilities are defined and used.
- This includes the Mission Types and Tasks and Operational Capabilities.



Current Baseline: Version 5

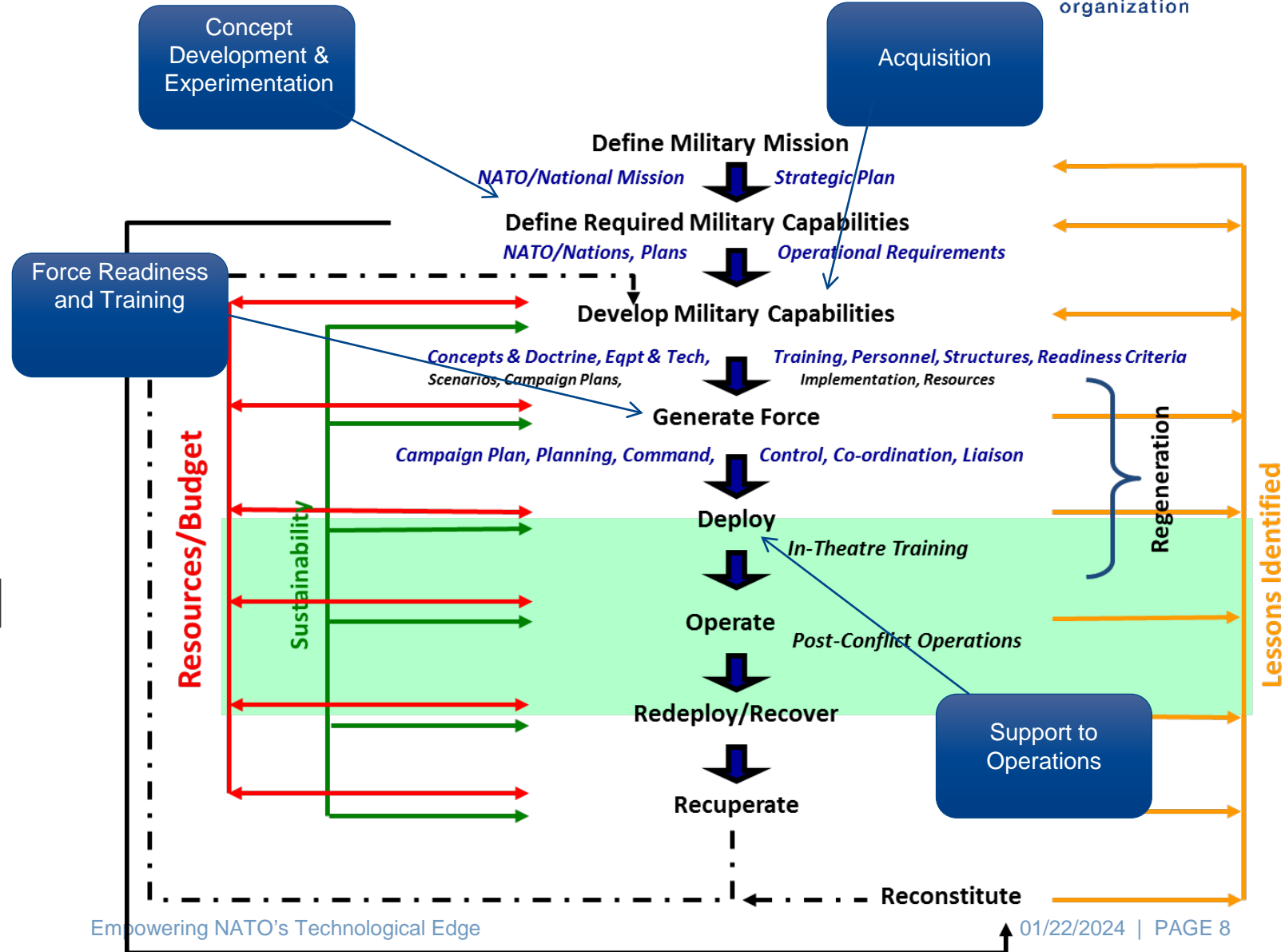
# Military Types and Tasks / Operational Capabilities



Current Baseline is Version 5

# High-Level Set of Military Activities

This diagram illustrates a high-level view of military activities based on work in the UK (1995-2000) and adjusted to reflect how NATO and Nations would fit into this model.

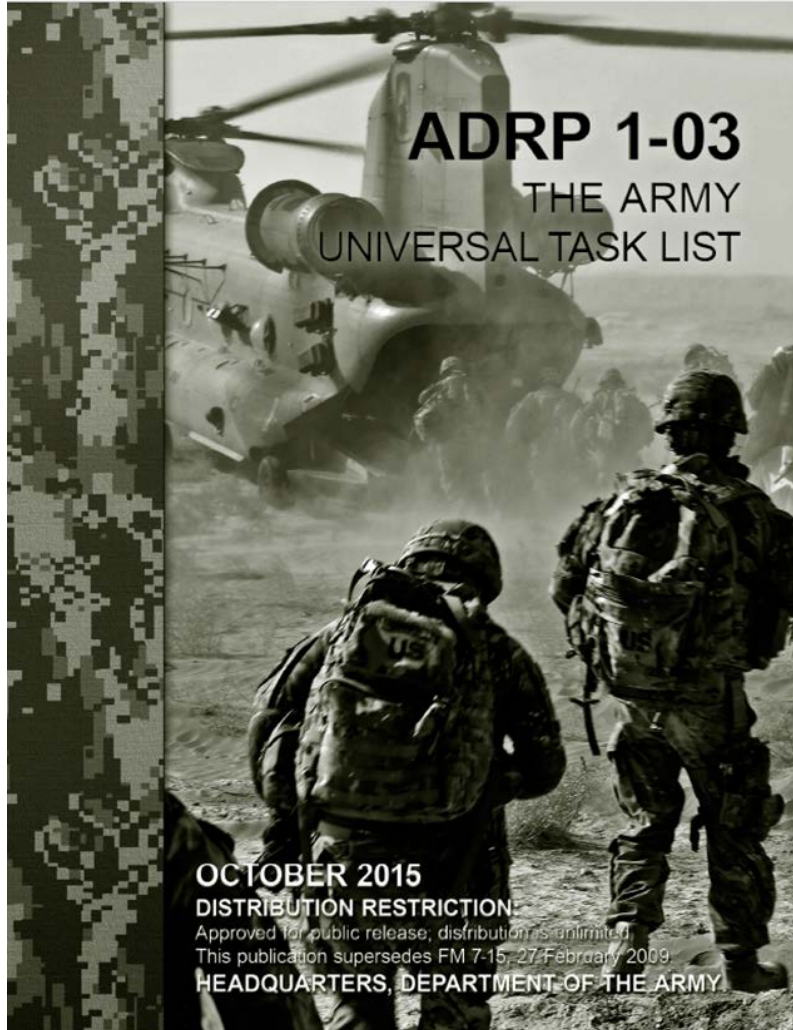




# Military Tasks

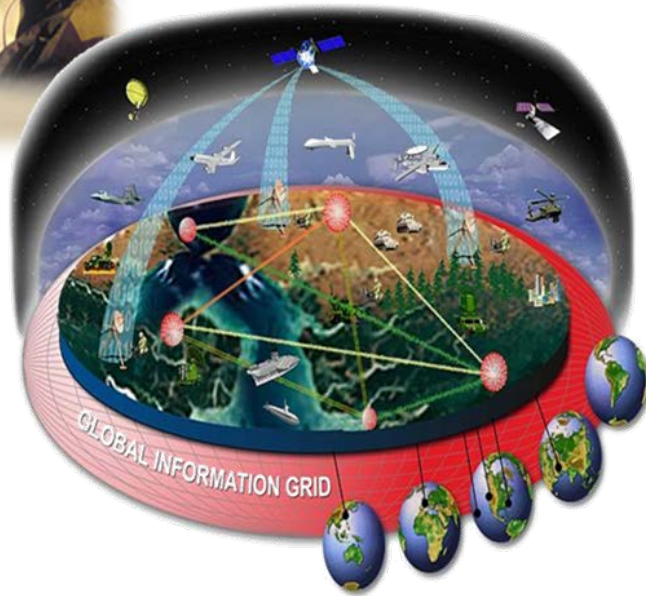
- Most nations assign their armed forces a number of high-level tasks determining the organization and capabilities required to support those missions. For example, the UK Ministry of Defence has 8 defence tasks:
  - Defence, security and resilience of the UK and its overseas territories
  - Nuclear deterrence and the defence nuclear enterprise
  - Contribute to improved understanding of the world through strategic intelligence and the global defence network
  - Influence through international defence engagement
  - Overseas defence activity
  - Promote UK prosperity and civil society
  - Direct defence
  - Strategic base and enabling functions
- An analysis of the high-level tasks or missions enable a nation's armed forces to determine what tasks have to be trained for. These are described in documents referred to as Mission Tasks Lists which can be tailored into a Mission Essential Task List to reflect a particular mission that an organisation undertakes.

# Military Tasks



- For example, the U.S. Army Universal Task List (AUTL) links to the Universal Joint Task List (UJTL) at tactical, operational, and strategic levels aiding analysts and planners in understanding the Army's role and integrating joint operations.
- Example: ART 5.1.1.2 CONDUCT THE MILITARY DECISION MAKING PROCESS
  - 5-9. Units employ the logic and techniques of an iterative planning methodology – the military decision-making process (MDMP) – to understand the situation, determine the restated mission, and develop courses of action (COAs) to accomplish the mission. Units recommend the most effective COA. Units prepare orders and plans to communicate the selected COA, commander's intent, and decisions to subordinates and coalition forces, focusing on the expected results. (ADP 5-0).

# Interoperability Challenges



"Linking sensors, decision makers and weapon systems so that information can be translated into synchronised and overwhelming military effect at optimum tempo."

Lt Gen Sir Robert Fulton,  
Deputy Chief of Defence Staff  
29th May 2002

# Some Observations

- Captain D. F. Heseey of the Royal Canadian Signals made the following statement in an article on future military communications for the British Army Review journal.

“Future communications systems will not only be compatible with each other but they will be integrated with automatic data processing (ADP) systems.”
- He went on to state:

“The integrated system will require a common language, a problem which the needs of the computer resolves in favour of digital code; the digital language will be readily translated into the language of the users.”
- He was writing in 1968 and looking at the timeline 1980-2000.

# Uses for C2/Sim Interoperability

- Longtime refrain: “Train as you fight!”
  - Live C2 systems; virtual or constructive simulation systems.
- System test and evaluation.
- Post-exercise analysis and instruction.
- Operations planning:
  - Military Decision Making Process: course of action evaluation.
- Operations rehearsal.
- Exploration and replanning during operations.
- Post-operations analysis and lessons learned:
  - Battle of 73 Easting.

# Impact of Digitised C2 Systems

- The development of digitised C2 systems also meant that they required location information for units to be input into the system to provide situational awareness. This led to the development of one-way feeds to the C2 system from the simulation.
- The US Army conducted a number of C4I\* experiments to investigate how the situation could be improved.
- However, to exchange all C4I digital, voice, and video data that would be passed in a tactical situation with future modern simulations, a more **robust digital interface** was considered to be necessary.

\* C4I: Command, Control, Communications, Computers and Intelligence

# Reasons to Develop Robust Interfaces

- Stove-piped C4I systems required unique input of common information – the same information was required to be input multiple times into each C4I system and the simulation.
- The majority of automated data flow was one-way, from the simulation to the C4I device for updating of unit locations, status, etc.
- There was no direct control of the simulation from the C4I device.
- There was no reduction in the size of the workstation controller contingent that were still required to translate and input commands into the simulation and therefore no change on the training requirement in order to serve as controllers.
- In addition, each stovepipe C4I device required its own black box to translate information between it and the simulation.

# The Problem is...

- The military needs to move information:
  - faster
  - with more accuracy
  - over a widely dispersed battlespace
- Increasingly, this is over a more widely dispersed battlespace in order to:
  - control autonomous/robotic forces
  - conduct rapid Mission Planning including Course of Action Analysis (COAA) and wargaming
  - conduct Mission Rehearsal
- Equally important is the need to train commanders and their staffs using new C2 applications within coalitions like NATO



... but

- Both C2 and simulation systems have been standalone
- The simulations are uncoupled from the digitized Command and Control (C2) systems
- Both often require specialized skills when deployed

# NATO M&S Master Plan

- NATO, the Modelling and Simulation Master Plan is currently at Version 2.
- It contains 4 guiding principles to support the NATO M&S vision:
  - **Synergy:** Capitalise on, leverage, and share the existing NATO and national M&S to enable more effective and affordable capabilities for NATO.
  - **Interoperability:** Direct the development of common M&S standards and services for simulation interoperability and foster interoperability between C4ISTAR and simulation systems.
  - **Reuse:** Increase the visibility, accessibility, and awareness of M&S to foster sharing and ensure its best exploitation across all NATO M&S application areas.
  - **Affordability:** Employ and develop readily available, flexible and cost-effective M&S to improve NATO effectiveness to address the changing nature and increased complexity of the Alliance strategic environment.

# NATO M&S Master Plan

## Objective 1

Establish a Common Technical Framework

### Sub-objectives

- Develop NATO standard interoperability architecture and supporting material
- Establish recommended standards pertaining to data interchange for M&S and C2 systems promotion of true interoperability, pursue trust in M&S
- Establish a NATO wide (incl. National Stakeholders) technical environment for distributed networked M&S application areas

## Objective 2

Provide Coordination & Common Services

### Sub-objectives

- Develop common process and procedures to guide actions and decisions regarding M&S application
- Compile M&S information
- Establish capability to share M&S education resources with NATO organizations and Alliance nations
- Promote the sharing of M&S resources through a knowledge management process and system
- Establish a help desk to facilitate the development and use of M&S

## Objective 3

Develop Models & Simulations

### Sub-objectives

- Identify and prioritize M&S requirements
- Identify the most effective strategies to satisfy each simulation requirement
- Allocate resources to satisfy the highest priority simulation requirements
- Execute the selected and resourced development strategy
- Provide information to the larger NATO community regarding the resultant simulations and any lessons learned during development

## Objective 4

Employ Simulations

### Sub-objectives

- Plan employment
- Provide resources to operate simulations
- provide databases
- Operate simulations to improve all aspects of NATO/national military activities
- Conduct impact assessments and document lessons learned to guide further development / investments

## Objective 5

Incorporate Technological Advances

### Sub-objectives

- Monitor M&S related technological advances
- Conduct R&D, experiments and pilot projects as needed to support Alliance requirements
- Share information on realized advances to facilitate incorporation
- Implement technological advances

# Key Objective is to Establish a Common Technical Framework

- A **common standard interoperability architecture** and supporting material;
- **Common standards** that promote **common understanding of data across models**, simulations and live systems (e.g., C2 systems, Communication and Information Systems (CIS), weapon systems on instrumented ranges, hardware-in-the-loop, etc.);
- **Common standards that promote “true” interoperability**, i.e., interoperability up to the conceptual level including a common understanding of the static and dynamic representation and the context of the piece of the world to be simulated (thereby guaranteeing a fair fight in training and exercise applications);
- **Common standard processes and recommended practices**, (e.g., Verification, Validation and Accreditation (VV&A) to pursue a level of trust in simulations); and a NATO-wide, including national stakeholders, technical environment for distributed networked M&S application areas.

# C2 Interoperability with Other Systems: Easy Challenge to Solve?

- In theory, yes ... in practice, it is more complex because:
  - C2, training systems, simulations and autonomous systems are not developed coherently.
  - Few simulation systems have the capability of bi-directional exchange of data with C2 systems.
  - Not all C2 systems can exchange data with other C2 systems.
  - Require significant intervention in order to support military staff.
  - The refinement and standardisation of a battle management language (BML) was a proposed solution to this problem for C2 to simulation interoperability.
  - Requirement is not just national but multi-national and gave rise to the development of a Coalition BML (C-BML) and the Military Scenario Definition Language (MSDL) (SISO standards).
- NATO and National research has supported the development of C2SIM standardisation work over a number of years which has resulted in development of the C2 Systems – Simulation Systems Interoperation (C2SIM) Standard by SISO.

# C2 to Simulation Interoperability

- The development of a C2 to Simulation interoperability standard was recognised as being as a potential enabler to address the challenges faced by the military in using digitised C2 systems with simulation applications that had provided standalone capability to support training
- From the onset, C2Sim Standards were developed to address military activities that included:
  - force readiness and training
  - support to operations including mission planning (COAA, Wargaming) and mission rehearsal
  - concept development/experimentation
  - acquisition

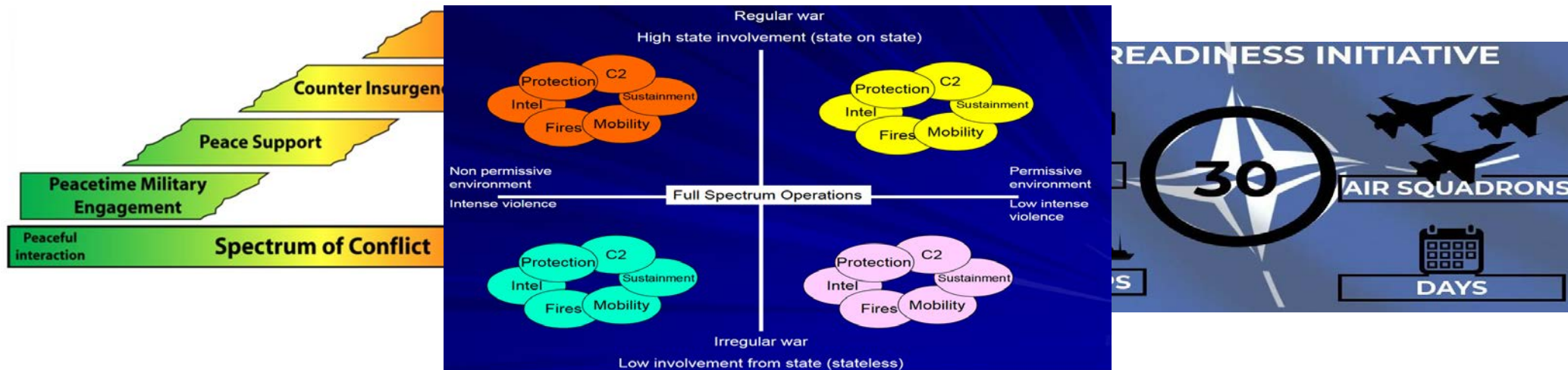
# Force Readiness and Training

- *“It cannot be too often repeated that in modern war ... the chief factor in achieving triumph is what has been done in the way of preparation and training before the beginning of the war.”*

- Theodore Roosevelt, 1902

# Force Readiness and Training

- NATO and the Alliance members agree to provide Forces at Readiness which have to meet the full spectrum of operations.
- This will include Command and Staff Training which will often be distributed before deployed.





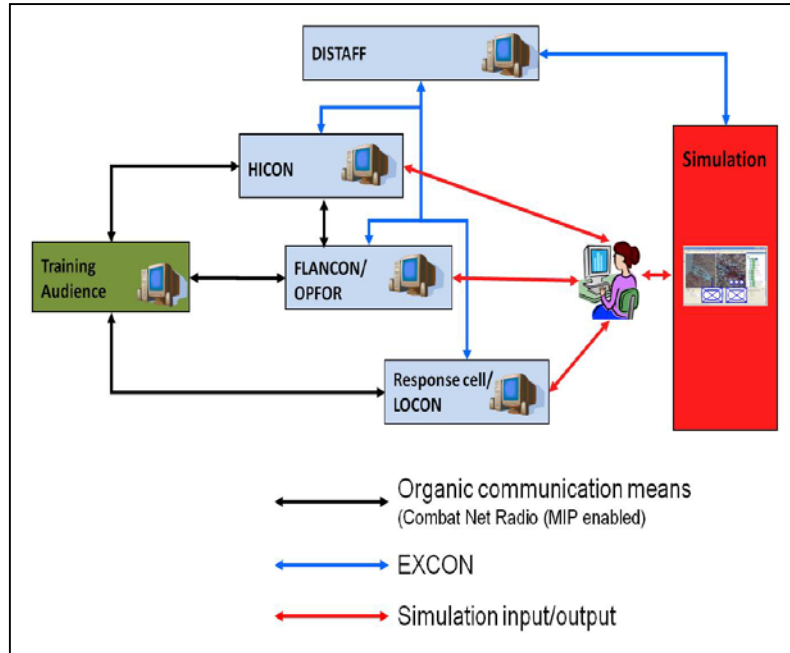
# Training Commanders and Staffs



- Training as to cover the **full spectrum of conflict** to prepare military forces for military operations.
- Large scale FTX and more limited CPX were mechanisms for this training.
- They are expensive to conduct and an FTX although providing training in real-time creates environmental problems.
- Commanders and their staffs need to be trained and the early development of simulation and then digital Battle Management Languages focussed on this to support Command and Staff Training.
- This was only one area that the C2Sim Standard was designed to support.

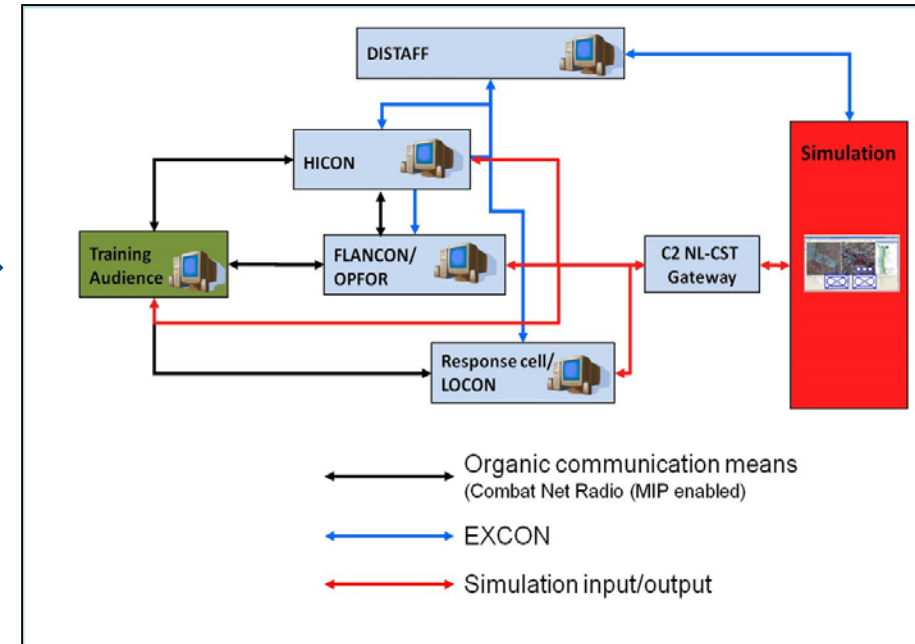
# Command Post Training

From ...



The Manual 'Swivel-Chair' Interface ...

...to a Future Command Post Training



... enabled by the C2SIM standard

# Support to Operations

- *“In preparing for battle I have always found that plans are useless, but planning is indispensable”*
  - Dwight D. Eisenhower

# Support to Operations

- Support to Operations and where C2Sim can be applied is in the Military Decision Making Process (MDMP) in Course of Action Analysis (COAA) and Wargaming.
- This activity can be distributed and take advantage of new concepts such as Modelling and Simulation as a Service (M&SaaS)
- Once a plan is agreed C2Sim can also be used to support Mission Rehearsal.

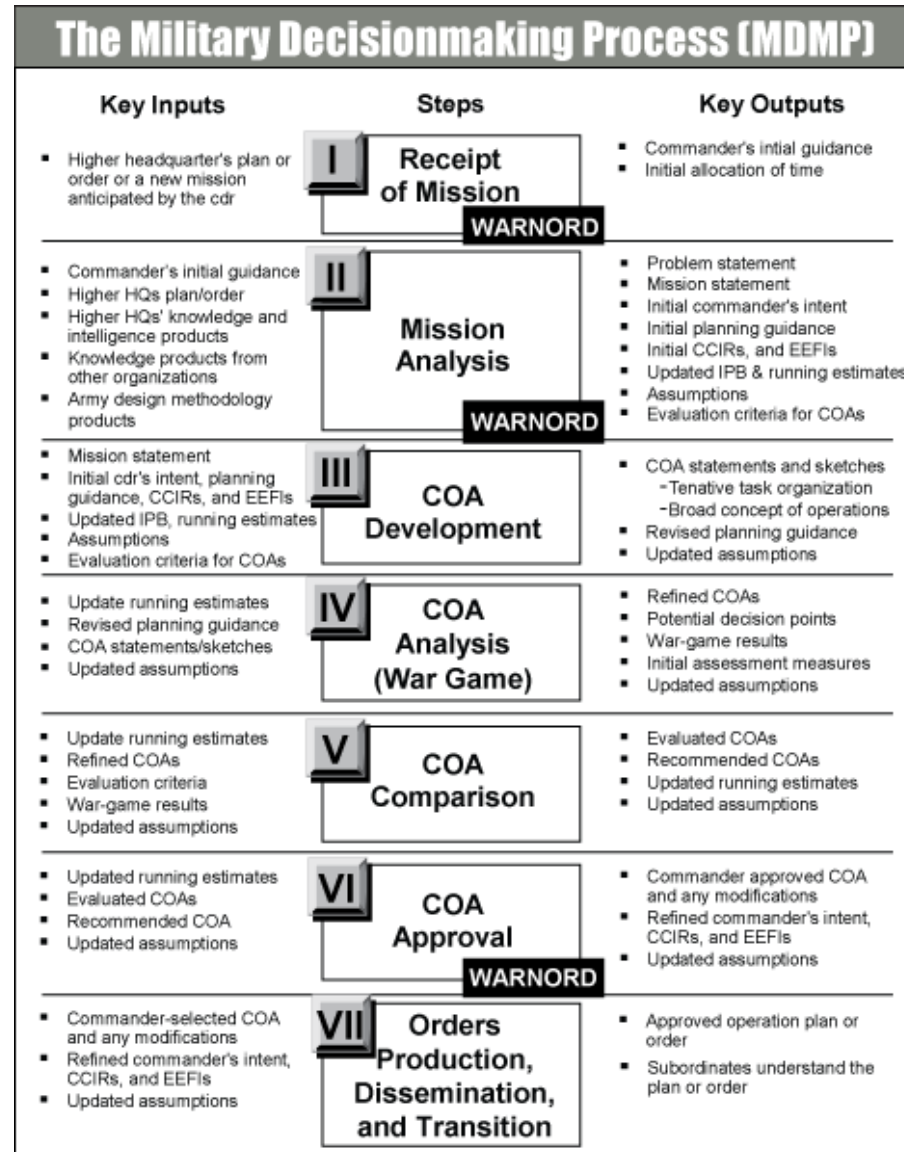
# Mission Planning

*“Warfare is not simple. Our business is increasingly and at times inconceivably complex. The planning process used by the Army has evolved over the years to allow for this increased complexity but at its core it is a system to help commanders understand a problem, and then derive an executable solution. The plans we create by the end of the process will not necessarily be simple, and indeed they may run to pages of complex coordination to sequence several lines of activity. But the problem will have been understood, and a plan created which is simplified for execution.”*

Major General J I Bashall CBE, GOC 1 (UK) Armoured Division, 2012

# Military Decision Making Process

- Mission planning has always been the major function of a headquarters in the military decision-making process.
- Each nation has developed a mission decision making process based on a planning and execution process. This is often referred to as Plan, Refine, Execute, Evaluate (PREE) process.
- Some nations use Assess, Plan, Refine, Execute (APRE).



# Comparison of Military Planning Processes

	Military Decision Making Process	Navy Planning Process	Joint Planning Process	Marine Corps Planning Process	USAF Air & Space Estimate Process
Planning Initiation			✓		
Problem Framing				✓	
Receipt of Mission	✓				
Mission Analysis	✓	✓	✓		✓
COA Development	✓	✓	✓	✓ and COA Wargaming	✓ and Situation Development
COA Analysis	✓ and Wargaming	✓ and Wargaming	✓ and Wargaming		✓ and Refinement
COA Comparison	✓	✓ and Decision	✓	✓ and Decision	✓ and COA Selection
COA Approval	✓		✓ and COA Selection		
Orders Production	✓				
Orders Development		✓ and Plans	✓ and Plans	✓	
JAOP Development					✓
Transition		✓		✓	

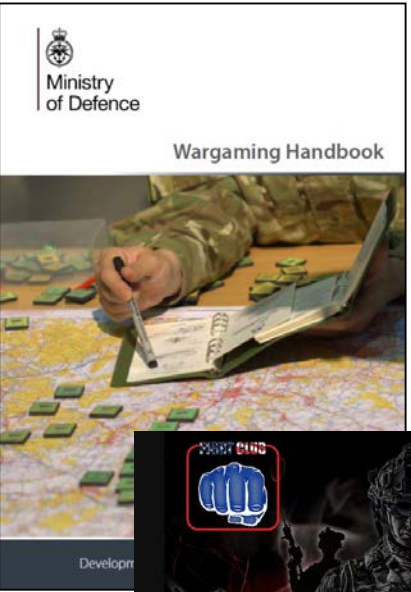
PLANNING PROCESS STEPS

# Wargaming

- *“This is not a game! This is training for war! I must recommend it to the whole Army.”*
- General von Muffling, Chief of the Prussian General Staff, 1824



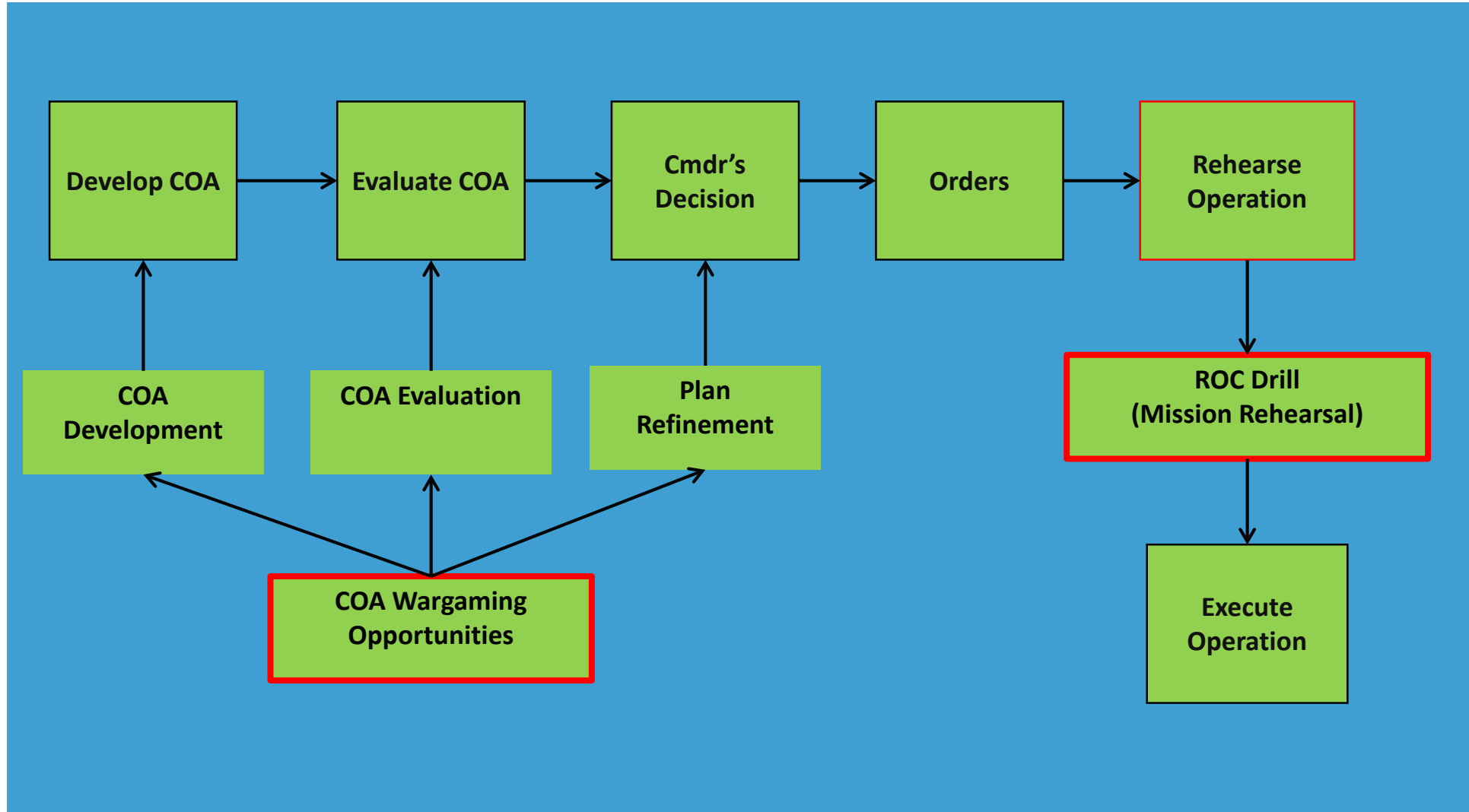
# Traditional Approach to COA Wargaming



# Purpose of COA Wargaming

- The purpose of a COA Wargame is: to identify risks (opportunities and threats) and areas of weakness in a forming plan;
- Provide a thorough understanding of the interactions of various actors to the plan;
- Highlight additional tasks which may have been overlooked in planning and;
- Refine the synchronisation, resourcing, activity, prioritisation and coordination of a COA(s).
- COA Wargaming can apply to multiple COAs for comparative reasons or in a single selected COA to refine it and add robustness; to ‘bullet proof’ it. Hence a COA Wargame must rigorously test the plan.

# COA Wargaming Opportunities



# Conducting Mission Rehearsal

*“A poor plan thoroughly rehearsed has a greater chance of success than an excellent plan that is never rehearsed”.*

General George S. Patton, Jr

# What is Mission Rehearsal?

- A rehearsal is the act or process of practising an action in preparation for the actual conduct of that activity.
- A mission rehearsal allows participants to practise and thereby visualise the conduct, coordination and synchronisation of a military operation.
- There are a number of types of mission rehearsal, which can be conducted at different levels of command in varying degrees of complexity.

Note: Although doctrine makes reference to the requirement for rehearsals, it is not specific on how to conduct an effective rehearsal, the different types and which is most appropriate to conduct when.

# Mission Rehearsal Types, Techniques, and Scope

## MR Types

Force Rehearsal

Core Role Rehearsal

## MR Techniques

Physical Rehearsal

Simulation Rehearsal

Terrain Model Rehearsal

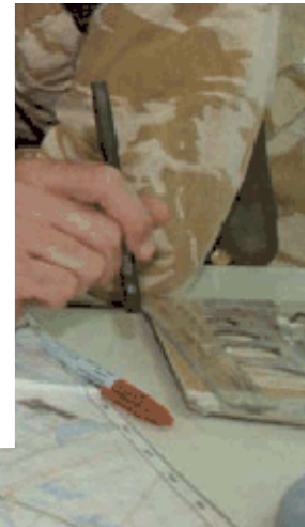
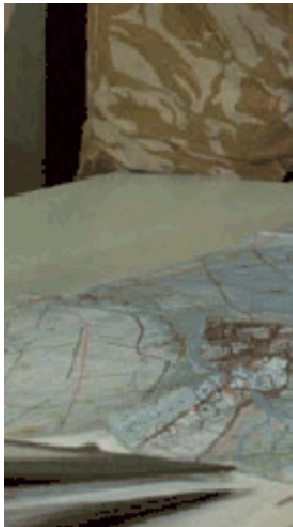
Sketch Map Rehearsal

Map Rehearsal

## MR Scope

Full Rehearsal

Part Rehearsal



# Simulation Rehearsal

- Generic mission rehearsals can be conducted using constructive or virtual simulation.
- Although current systems have limited deployability and are best suited to mission rehearsals, based on likely tasks, during Pre-Deployment Training.
- Conversely, simulation systems can exploit Operational Analysis (OA) data and provide After Action Review (AAR) capabilities.
- The application of C2Sim provides a mechanism to exploit technology in order to support rehearsal techniques in the future which can also be distributed.

# Wargaming vs Mission Rehearsal

- There is a clear distinction between wargaming and rehearsals.
- Wargaming is a staff process to develop, refine and synchronise the plan.
- Rehearsals ensure that subordinate commanders and the staff have a common visualisation of the plan, the terrain, and the relationship between them.
- If rehearsals are conducted effectively, with full participation by staff and commanders, both individual and collective activity will be practised and validated.
- The overriding purpose of rehearsals is to enhance operational effectiveness.

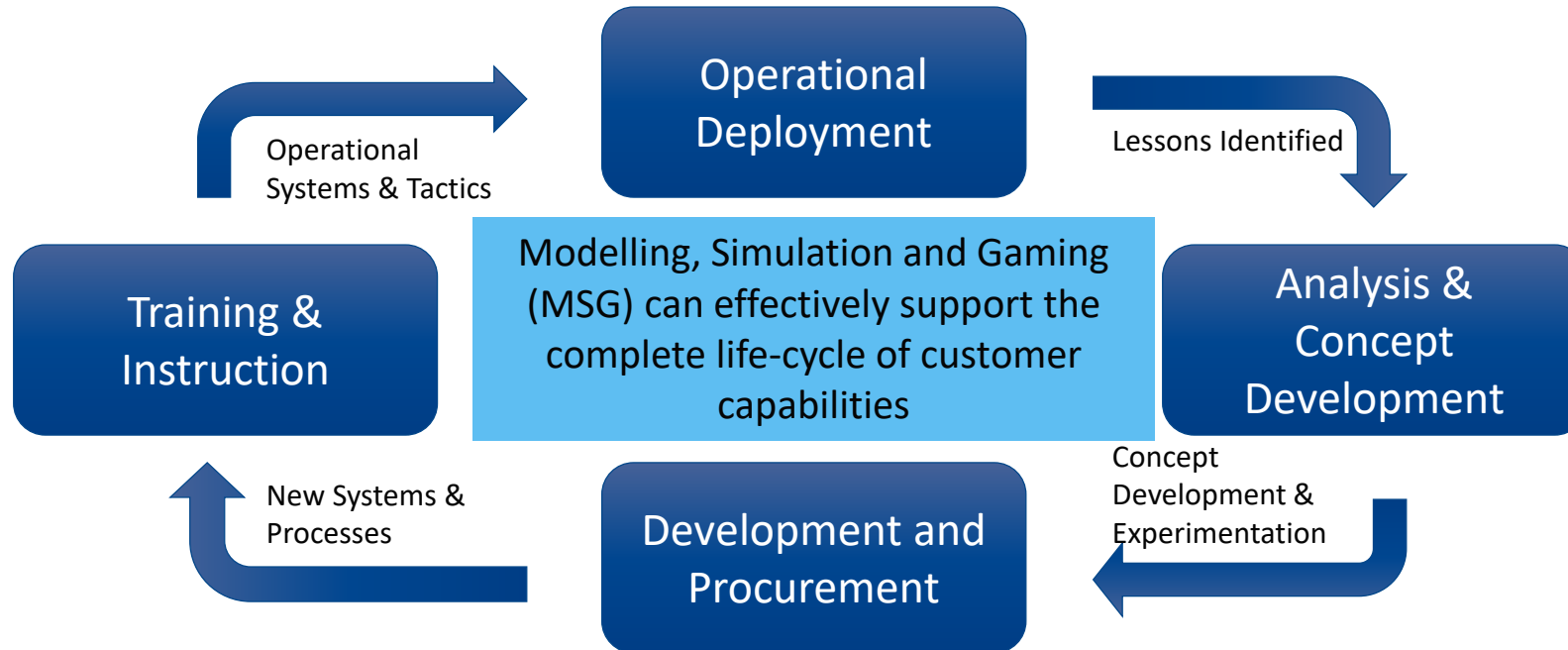


# C2SIM Requirements for Mission Rehearsal

- C2SIM interoperability requirements for MR are similar to those associated with training events, and often involves the same systems.
- However, the following distinction could be made: training generally focuses on acquiring skills and achieving operator proficiency, whereas MR focuses on achieving a high level of preparedness with respect to a specific mission and context, often, involving forces that will be deployed.
- The same flexibility and advantages discussed with respect to training also could have advantages for MR.
- However, the focus of MR is on risk mitigation and team-building rather than on operator proficiency and reducing the required number of interactors.

# Capability Acquisition

- NATO and Nations have developed their Acquisition processes over many years but fundamentally they all follow a similar pattern.

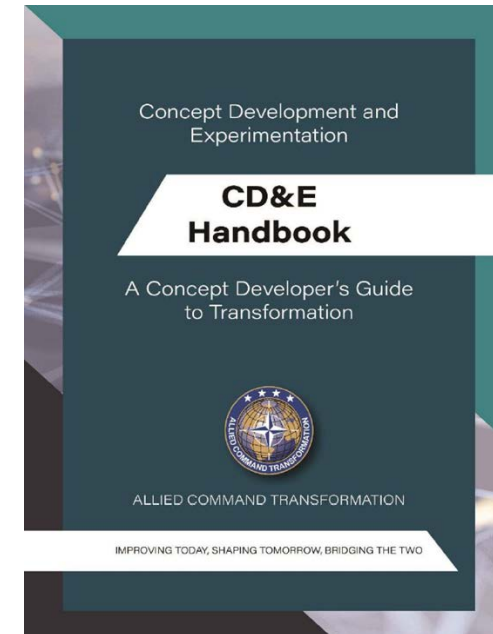


# Concept Development and Experimentation

- Concept Development and Experimentation (CD&E) is the application of the structure and methods of experimental science to the challenge of developing future military capability. CD&E is a forward-looking process for developing and evaluating new concepts, before committing extensive resources.
- M&S supports CD&E and C2Sim can be used when testing new C2 and Simulation systems at places like CWIX.
- NATO has its own CD&E Handbook as do other nations.

United Kingdom	Australia	Canada	USA	Czech Republic	TTCP
High Level (High Level Operational Concept)	Joint	Capstone	Capstone Concept for Joint Operations (CCJO)	High Level Operating Concept (2003)	Defence level
Military Task Operating Concept	Australian Military Strategy	Joint Operating Concepts (JOC)	Mission		Operating/Operational Concept
Analytical Environmental	Environ-mental	Environ-mental	Service Concepts (Army Operatin Concept)	Service Concept (Air support and Heli Concept)	Services Concept, Environmental (Land, Air, Navy)
Hybrid Concepts	Integrating /Enabling Concept	Integrating Concept	Joint Concepts		Integrating / Enabling Concept
		Functional Concept	Joint Functional Concepts	Functional Concept	Functional Concept

You can find an electronic copy of this handbook at [https://www.act.nato.int/application/files/1316/2857/5217/NATO-ACT-CDE-Handbook A Concept Developers Toolbox.pdf](https://www.act.nato.int/application/files/1316/2857/5217/NATO-ACT-CDE-Handbook_A_Concept_Developers_Toolbox.pdf)

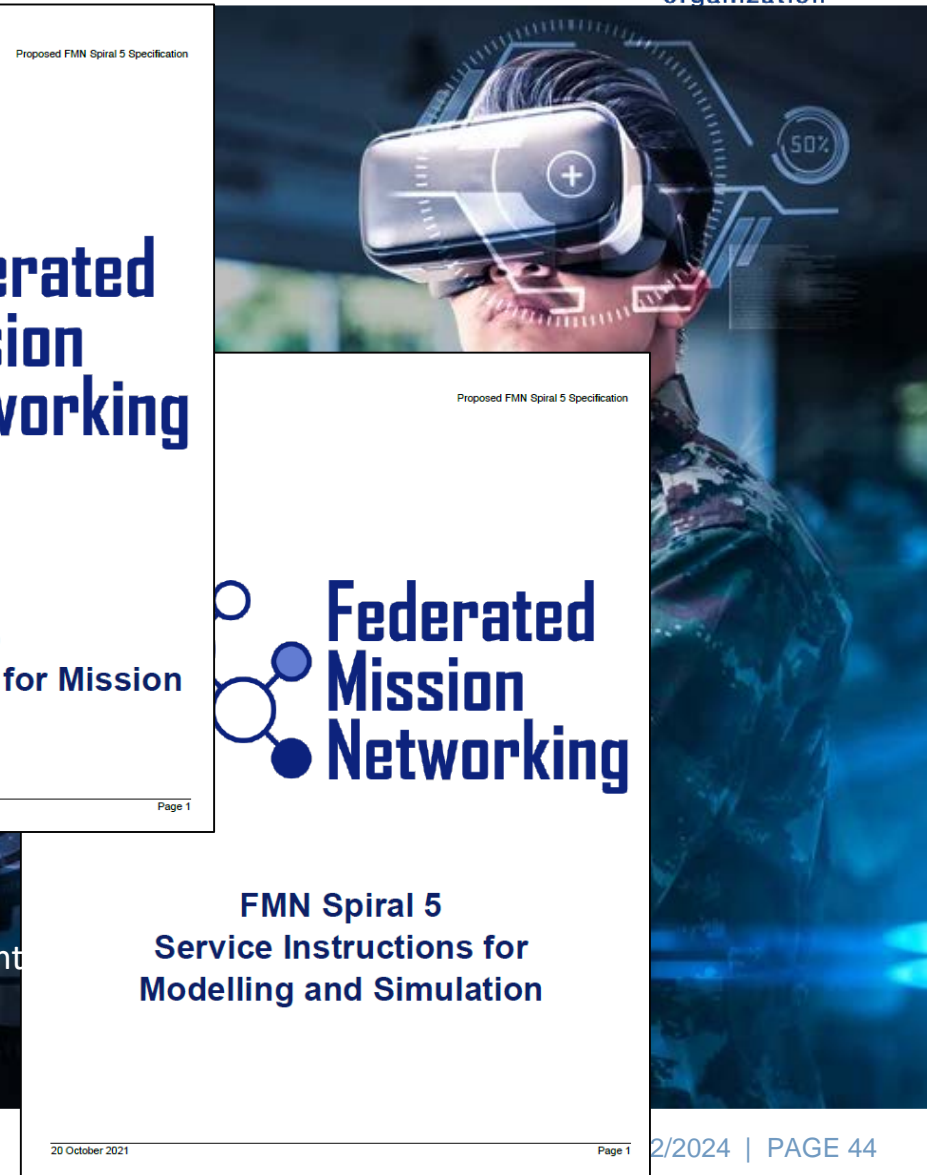


# M&S in Federated Mission Networking

- M&S has played a major role in NATO and the Alliance in the delivery of training, but this has often been standalone applications.
- The Operational Capability Working Group (OCWG) is responsible for prioritizing requirements which are approved by the nations
- In FMN Spiral 5 there was an approved requirement to provide M&S to support Mission Rehearsal but Spiral 5 was descoped and Mission Rehearsal moved to Spiral 6 and subsequently Spiral 7.



Source: <https://www.army-technology.com/comment/internet-of-military-things-leading-technology-trends-revealed/>



- Modelling and Simulation (M&S) has made a major contribution to the training of military personnel in all domains and is used to support Operational Analysis (in predominantly standalone applications).
- There is a desire on the part of warfighters to utilise M&S to support not only Collective Training but also Decision Support (Course of Action Analysis (COAA) & Wargaming) & Mission Rehearsal .
- Currently, NATO's focus is on Digital Transformation which will be underpinned by Federated Mission Networking (FMN), Multi-Domain Operations (MDO), & Data Driven Decision Making within which M&S will play a major role.
- M&S to support FMN was introduced as a requirement for Spiral 5 for Mission Rehearsal.
- NATO M&S Group established NMSG-193 as a one-year Specialist Team to work with Allied Command Transformation (ACT) and Allied Command Operations (ACO) organizations to elicit the requirements for M&S in FMN for Mission Rehearsal and to develop the Procedural Instruction (PI) & Service Instruction (SI).
- A follow-on activity was undertaken in the establishment of NMSG-201 starting in January 2022 and running for 3 years.

# Need for M&S Standards in FMN

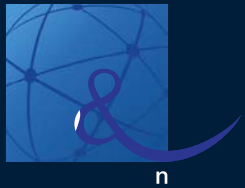
- Force Readiness and Training – M&S provides the synthetic environment to support collective training
  - Stimulates C2 systems for “train as you fight”
- Support to Operations – M&S provides alternative timings and schemes of maneuver to evaluate current and future plans
  - Mission Planning
  - Wargaming
  - Mission Rehearsal
  - Decision Support

# Summary

- Modelling and Simulation (M&S) supports military operations through training, analysis, testing, planning, and execution
- M&S is an identified requirement for Federated Mission Networking (FMN)
- Interoperability is achieved through application of established standards
- Instruction in “M&S Standards for NATO FMN” by the MSG-211 team will equip FMN developers and users in essential knowledge to ensure success



NORTH ATLANTIC TREATY ORGANIZATION  
SCIENCE & TECHNOLOGY ORGANIZATION



# Presenter Contact Info:

**Curtis Blais, PhD**  
**clblais@nps.edu**

# Contact us

E-MAIL [NMSG@cso.nato.int](mailto:NMSG@cso.nato.int)

WEB [www.sto.nato.int](http://www.sto.nato.int)

The screenshot shows the NATO STO website header with the logo and navigation menu: ORGANIZATION, NEWS, PROGRAMME, ACTIVITIES, PUBLICATIONS, CONTACT. The main content area is titled 'NEWSROOM' and features a large article titled '2022 HIGHLIGHTS' from the Science and Technology Organization. Below this are two smaller news items: 'NATO STO hosts wargame on Space Deterrence ...' and 'NATO STO releases 2023 Collaborative Programme of Work Report ...'.