



# M&S Standards for FMN Workshop Introduction & Standards Review

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# Outline

- Goals of workshop
- Ground rules for workshop
- Need for M&S in FMN
- NMSG/SISO relationship
- C2SIM history, standards, ontology, architecture
- NETN history, standards, and architecture

# Introduction

- This course is sponsored by
  - NATO Science & Technology Organization (STO)
  - Modelling & Simulation Group (NMSG)
- in cooperation with SISO C2SIM PDG/PSG
- open to attendees from NATO member & partner nations
- Slides and recordings will be made available after course delivery
- Please mute your microphone except when asking questions
- Hold discussion for reserved times; ask clarifying questions during the talks

# Day 3: M&S in FMN Workshop

- Hands-on exercise in assembling and running a C2SIM Coalition with NETN/HLA
  - Follows hybrid online course (online & Monterey CA)
  - Active participants at Naval Postgraduate School Monterey
  - Passive participants can view online – no hands-on component
  - In future, might have online hands-on participation
- Systems involved
  - C2SIM Reference Implementation Server (open source)
  - C2SIM GUI Editor (open source)
  - MAK VRForces under demo license with VRLink and MAK HLA
  - SWORD running at MSG-145 participant MASA
  - Pitch Runtime Infrastructure (RTI) for HLA
- Open source on GitHub: <https://openc2sim.github.io>

# Workshop Agenda

subject to revision

1. Welcome and setup (.5 hour)
2. Refresher summary of MSG-194 RTC (1 hour)
3. C2SIM & NETN HLA standard hands-on internal details (1.5 hour)  
Ontologies, Messages, information flow
4. Assembling C2SIM Initialization, Orders and Reports (1 hour)
5. Individuals create tasking orders and run independently (1 hour)
6. Group runs a collective exercise and group discussion (1 hour)

# NATO FMN Interoperability

NATO Federated Mission Networking (FMN) is a capability

- aiming to support command and control and decision-making in future operations through improved information-sharing
- provides the agility, flexibility and scalability needed to manage the emerging requirements of any mission environment in future NATO operations
- cost effectiveness
- maximum reuse of existing standards and capabilities
  - Day Zero capability

# Need for M&S Standards in Federated Mission Networking

- 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

# Interdependency of NATO and SISO

NATO MSG depends on SISO for open industry-based standards

SISO depends on NATO Technical Activities to field and validate C2SIM technology



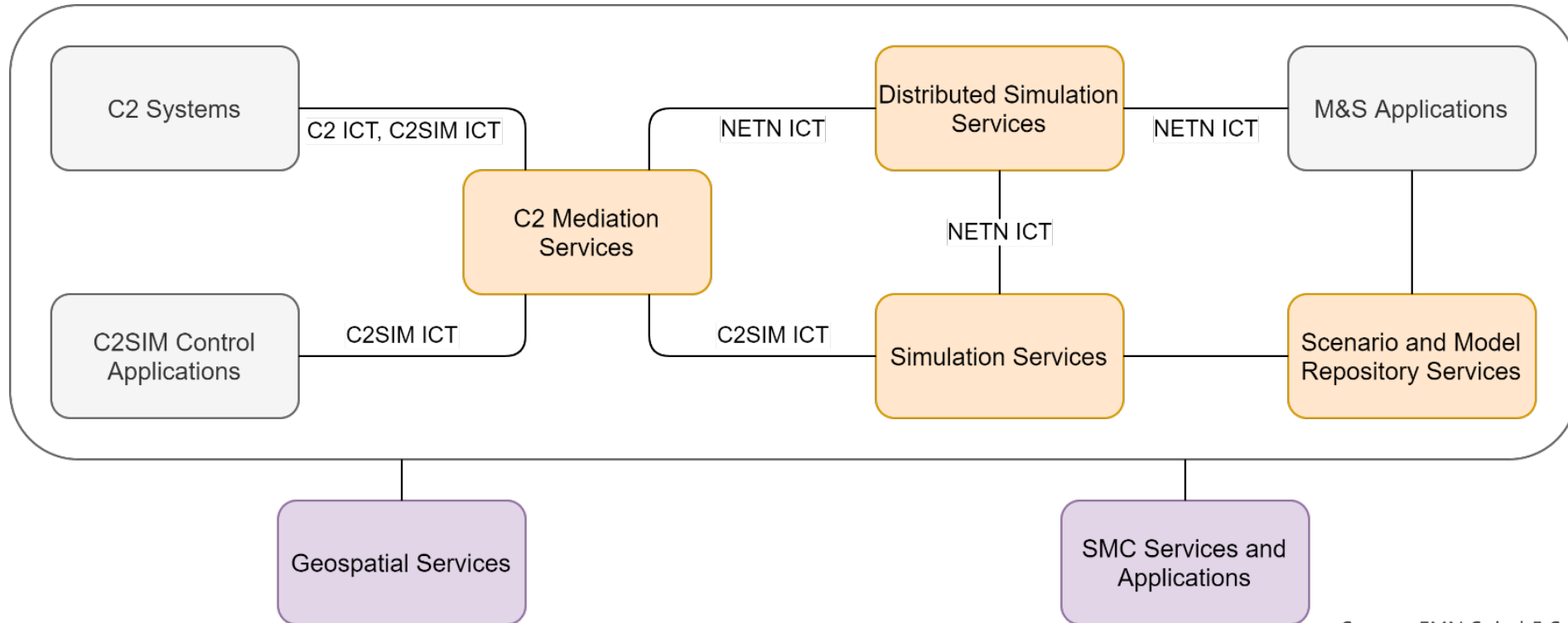
## But...

- Both C2 and simulation systems have been standalone,
  - Simulation systems coupled by High Level Architecture (HLA)
  - Now expanded by NATO Education & Training Network (NETN)
- The simulations are uncoupled from the digitized Command and Control (C2) systems,
- Both often require specialist skills when deployed.

# Note on Terminology

- We will use these terms interchangeably:
  - Command and Control (C2) system
  - Command and Control Information System (C2IS)
  - Mission Command (MC) system
- We is the collective term “Coalition” for a C2SIM system-of-systems
  - Reflecting the fact it is more loosely structured than an HLA Federation

# M&S Architecture in FMN



Source: FMN Spiral 5 Service Instructions for Modelling and Simulation, 2022.

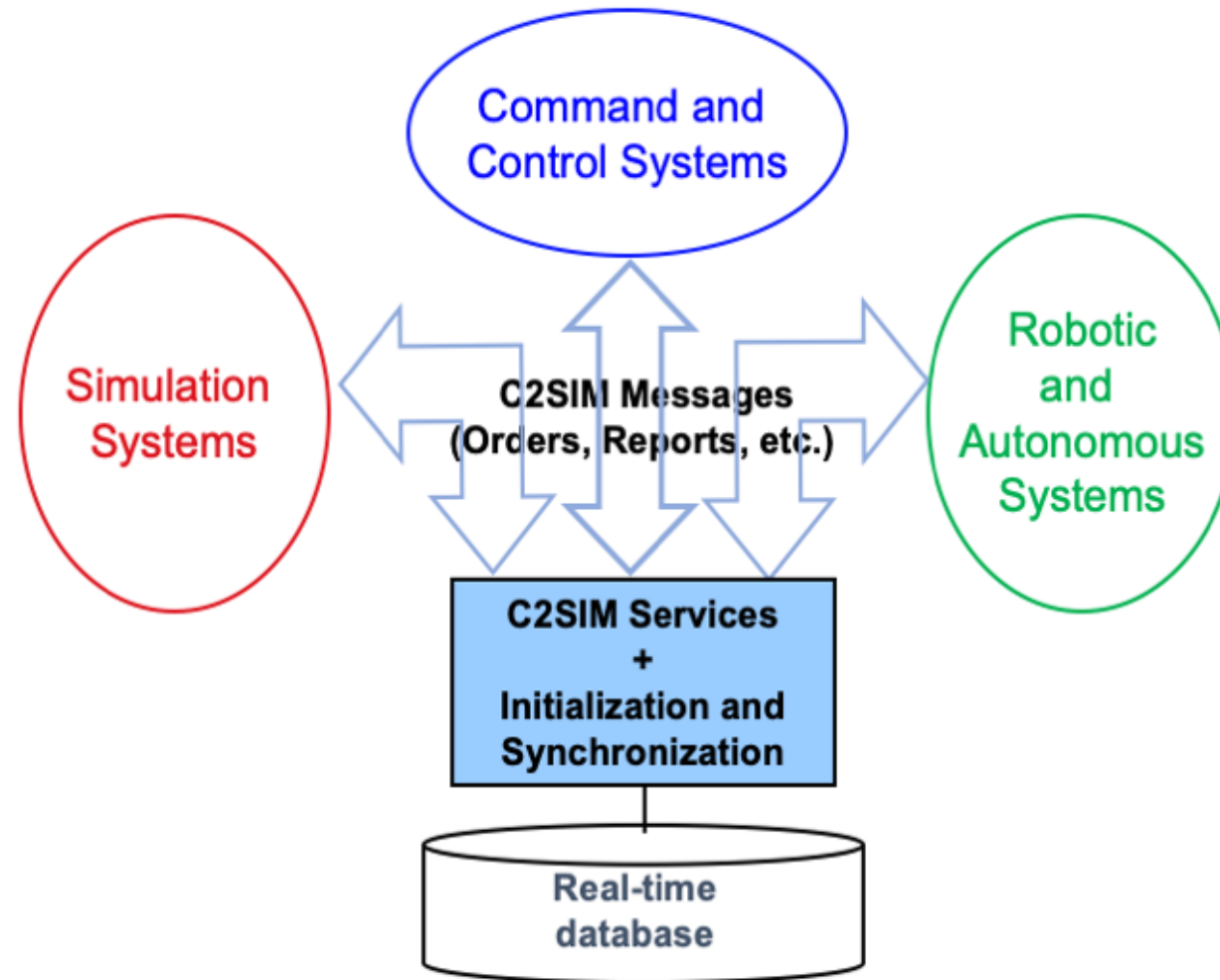
C2: Command and Control; C2IS: C2 Information System; C2SIM: C2 Systems – Simulation Systems Interoperation; ICT: Initialization, Control, Tasking and Reporting interactions; M&S: Modelling and Simulation; NETN: NATO Education and Training Network

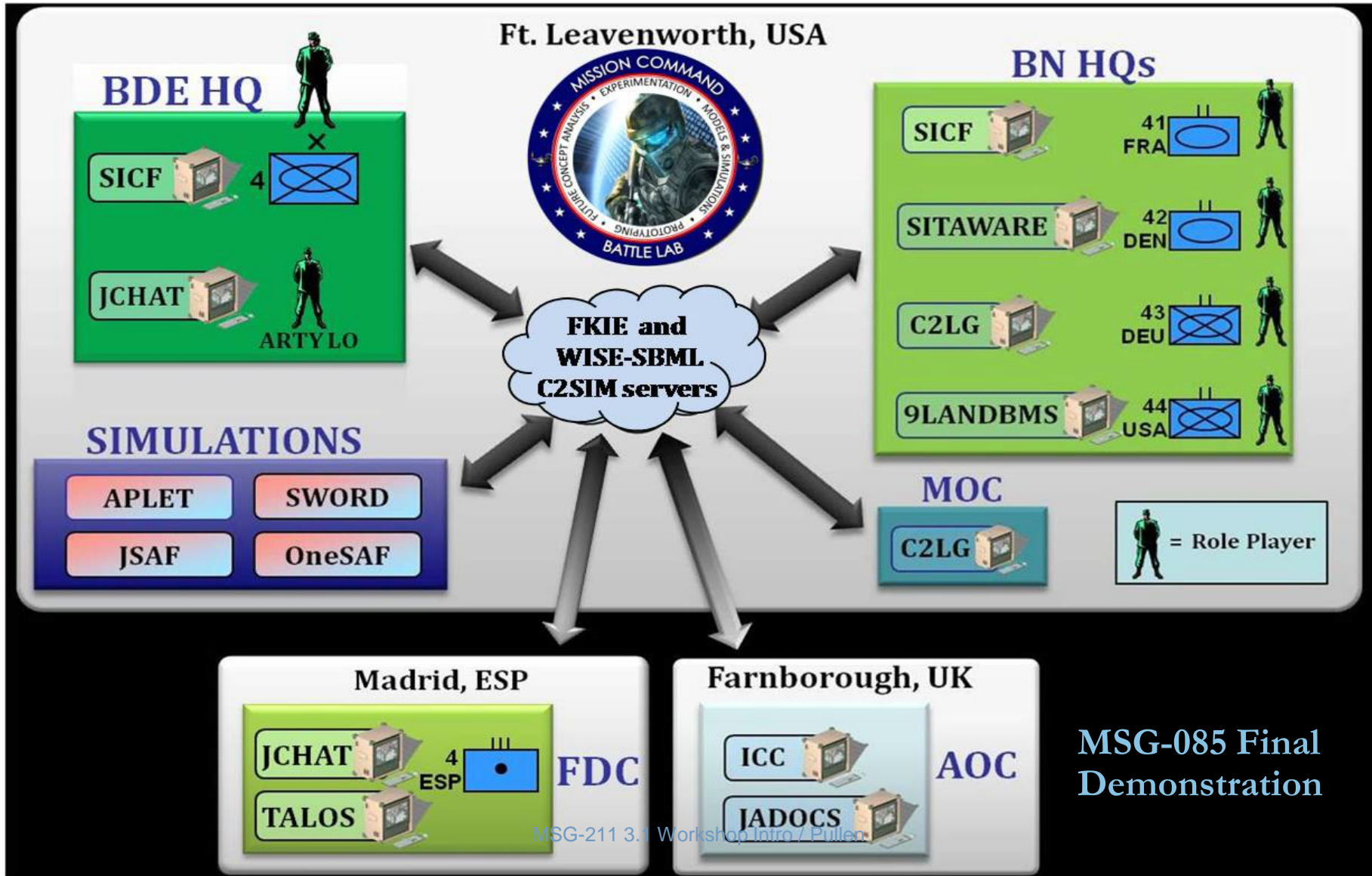
# C2SIM Vision

We have been working toward a day when the members of a coalition interconnect their networks, command and control (C2) systems, and simulations simply by turning them on and authenticating, in a standards-based environment.

A C2SIM Coalition is a system of systems.

# C2SIM Basic Architecture





# NATO MSG-145 Mission Statement

*Assess the C2SIM standard in development and implement extensions to the unified C2SIM Logical Data Model (LDM) for specific functional areas in order to demonstrate its usability to the simulation community and support the definition of a STANAG (adopted as STANAG 4856 approved in 2023)*

# C2SIM Standardization and Benefits



# Need for C2SIM

- Military need to move information:
  - faster
  - with more accuracy , and
  - over a widely dispersed battlespace
- Increasingly over a more widely dispersed battlespace:
  - control autonomous/robotic forces,
  - conduct rapid Mission Planning including Course of Action Analysis (COAA)
  - conduct Mission Rehearsal
- need to train commanders and their staffs using new C2 applications within coalitions

# C2SIM Standard

- SISO develops international, open standards
- Initial versions of C2-simulation interop standards
  - Military Scenario Definition Language (MSDL) supports initialization
  - Coalition BML (C-BML) provides for exchange of Tasking (orders and requests) and Reporting information
- Unified second-generation standard recently completed: C2SIM
  - C2SIM Core and Standard Military Extension (SMX) Ontologies
  - Initialization & Synchronization and Tasking & Reporting messaging
  - Extension Mechanism and Land Operations Extension
  - Guidance document

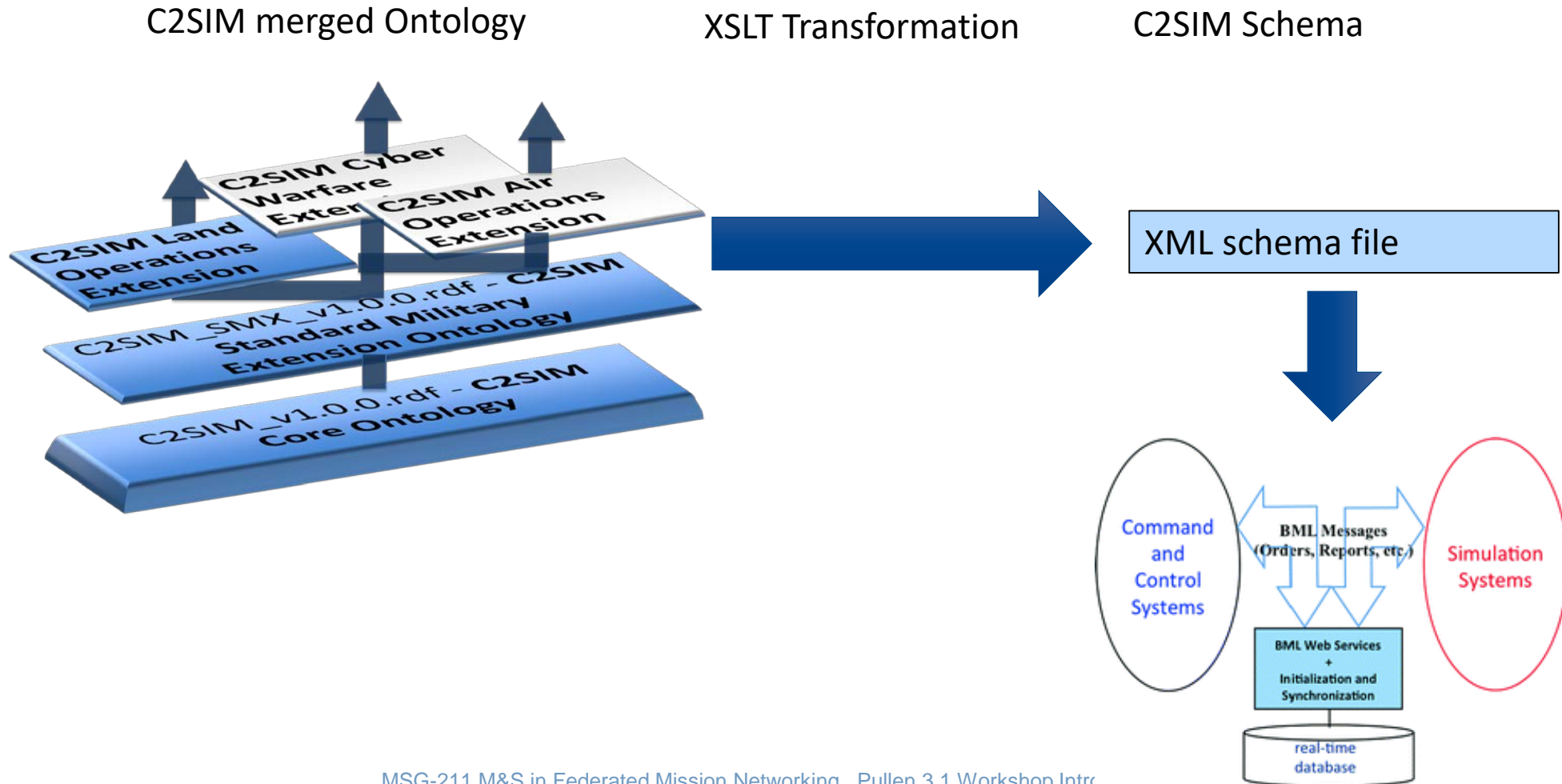
# How C2SIM can support FMN

- command and control (C2) information support for participants
- information interoperability between C2 and simulation systems
- unambiguous data exchange among systems (C2 and Simulation Systems)
- “train as you fight” in collective and individual training, mission rehearsal, operational planning, concept development and experimentation

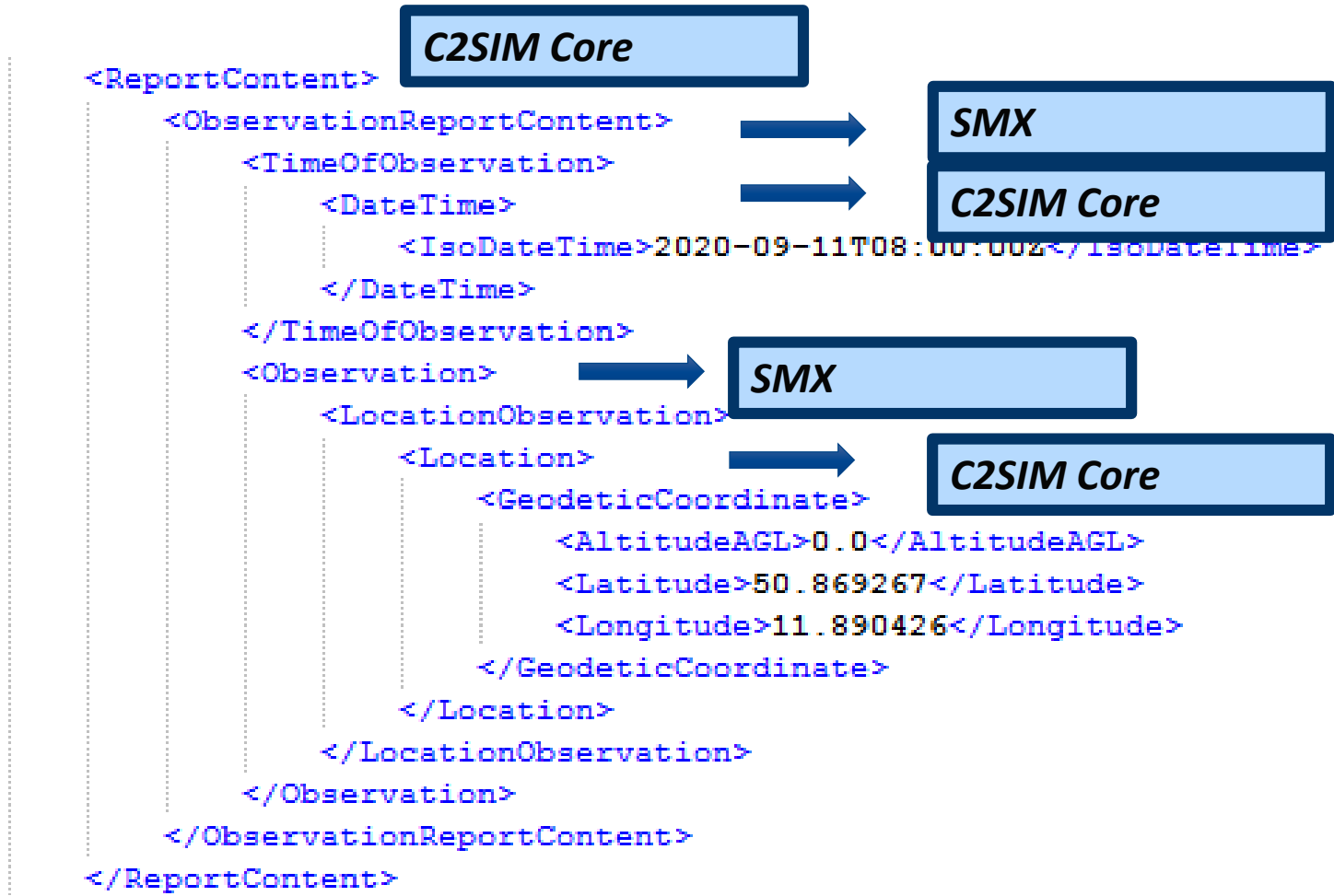
# C2SIM Ontologies

- Definition: Set of concepts and categories in a subject area or domain that shows their properties and the relations between them
- Core: data classes and properties that are needed by all C2 and simulation systems to interoperate (Who, what, when, where)
- Standard military extension (SMX): classes and properties that are needed by all military C2 and simulation systems
  - Mostly more properties for core classes, e.g. Entity has a ForceSide
- Land Operations Extension (LOX): classes and properties that are needed by ground C2 and simulation systems
  - Separate standard; example for other new extensions

# Data exchange with schema



# XSD Schema



# XSD Schema

```

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  <DomainMessageBody>
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  </DomainMessageBody>

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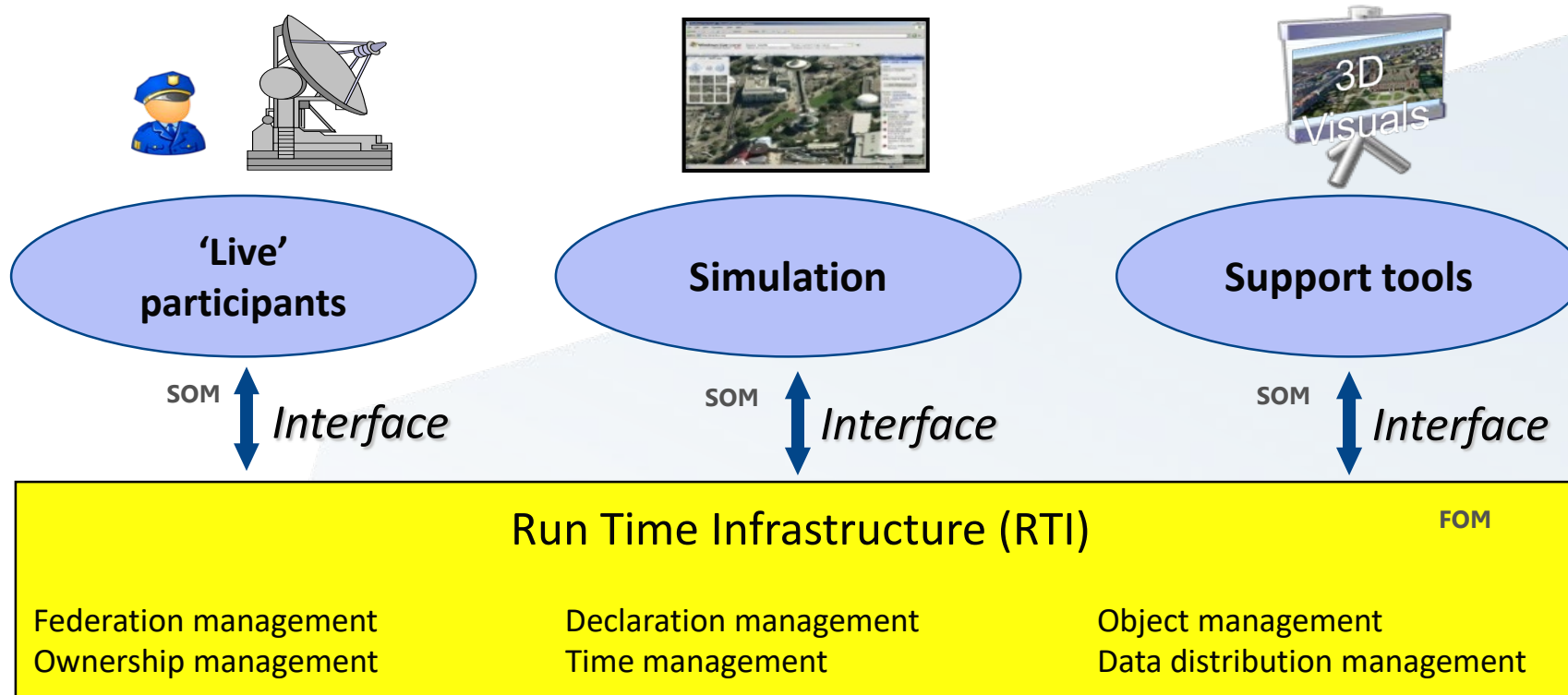
**C2SIM- Core**

**LOX**

**C2SIM- Core**

# Overview of the High Level Architecture

following slides adopted from Tom van den Berg presentations in MSG-211





# HLA design principles

- The HLA is focused on interoperability between various types of simulations, and to promote reuse of simulations and their components
- The HLA follows two general design principles:
  - *modularity*: simulation components (federates) are composed into larger systems (federations) to obtain a specific functional behavior
  - *separation of concerns*: the functional behavior of the components (federates) are separated from the supporting communication infrastructure (RTI) via a well-defined interface

# The HLA standard: HLA Evolved

- IEEE 1516-2010: HLA Framework and Rules
- IEEE 1516.1-2010: HLA Interface Specification
- IEEE 1516.2-2010: HLA Object Model Template

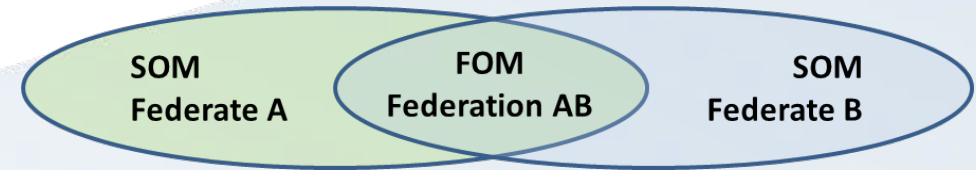
# HLA Framework and Rules

- Rules that must be observed by federates
  - 5 requirements for federations
  - 5 requirements for particular federates
- For instance
  - During a federation execution, all exchange of FOM data among joined federates shall occur via the RTI
  - Federates shall have an HLA SOM, documented in accordance with the HLA OMT

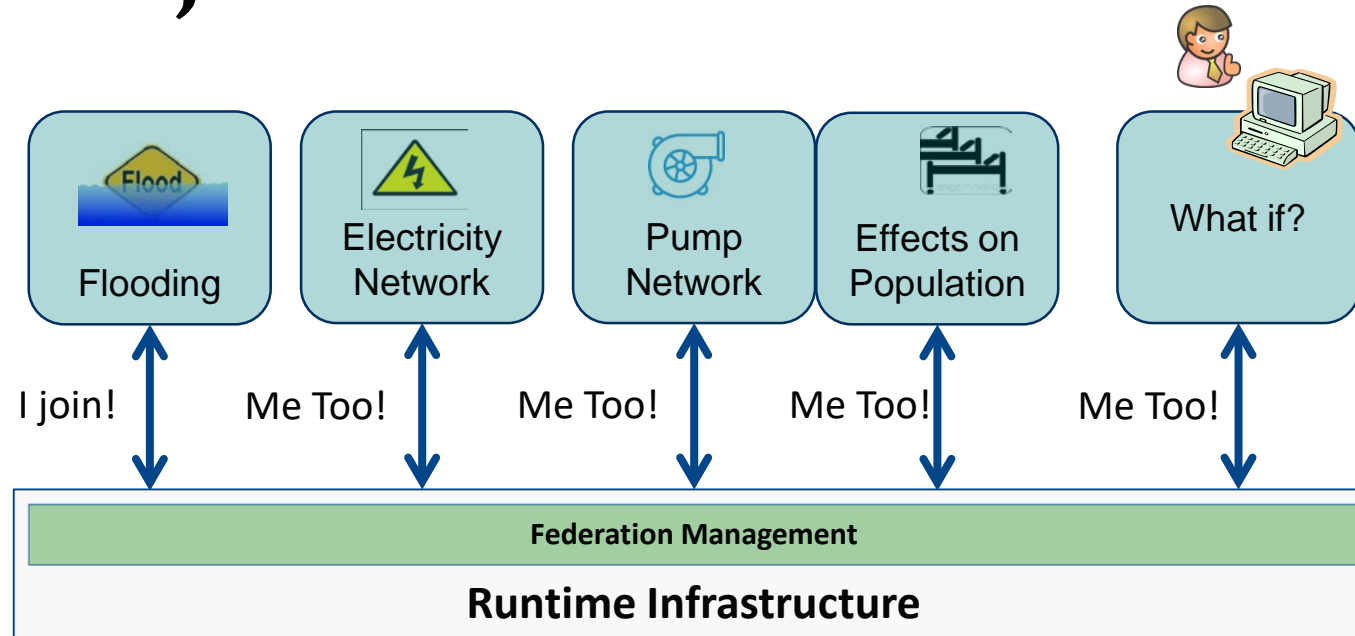
# HLA Object Model Template

- Format to specify the data exchanged between federates
  - HLA object classes and attributes
  - HLA interaction classes and parameters
- Three kinds of object model
  - **Federation Object Model (FOM)**: Describes all shared information for a particular federation
  - **Simulation Object Model (SOM)**: Describes objects, attributes, and interactions of a particular federate
  - **Management Object Model (MOM)**: Describes predefined constructs that provide support for monitoring and controlling a federation execution

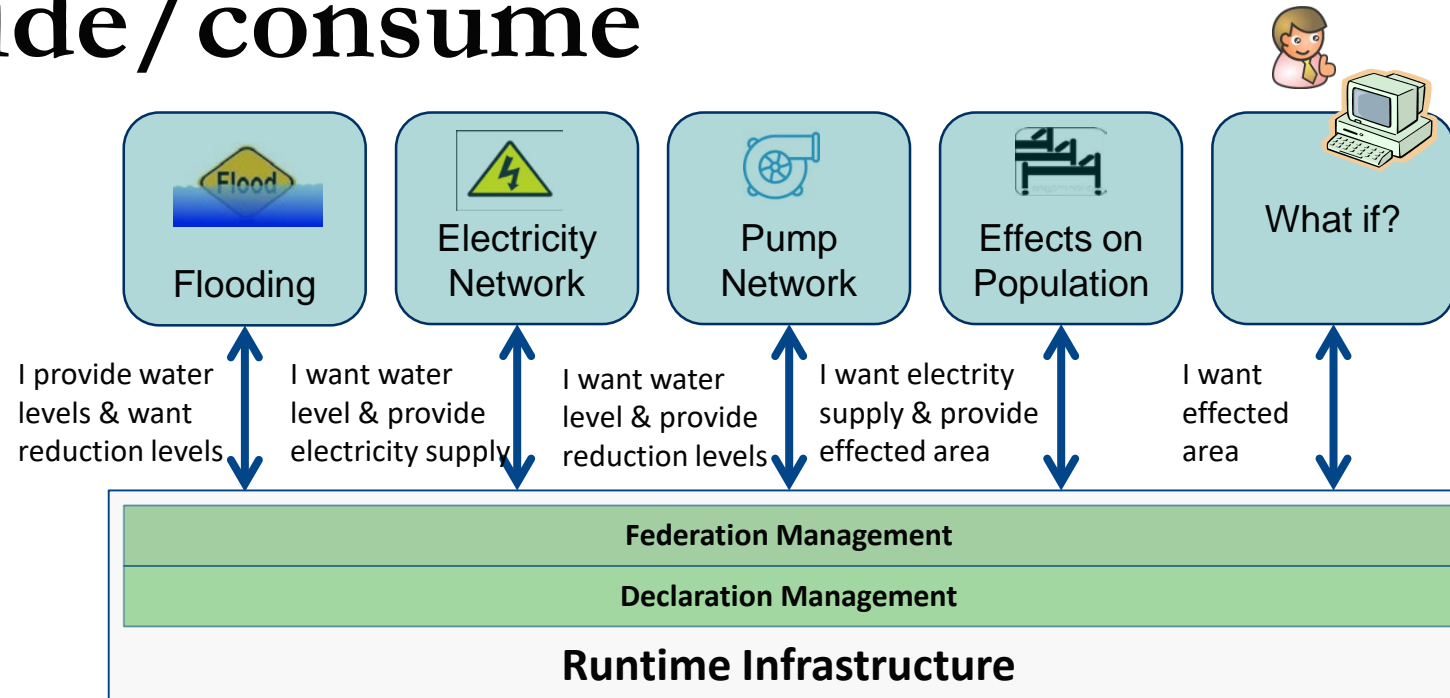
A typical view on SOMs and FOM



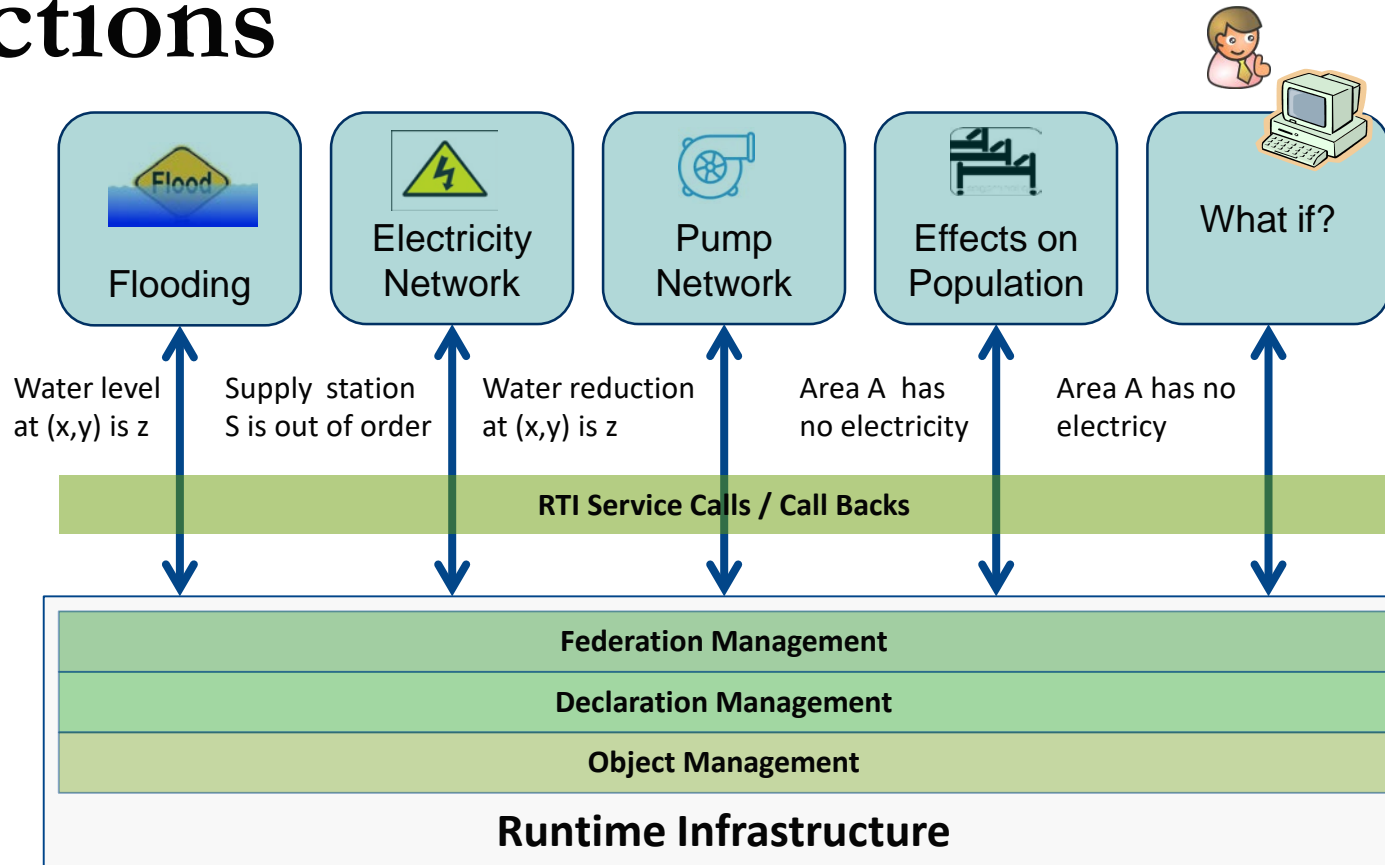
## Federates join a Federation



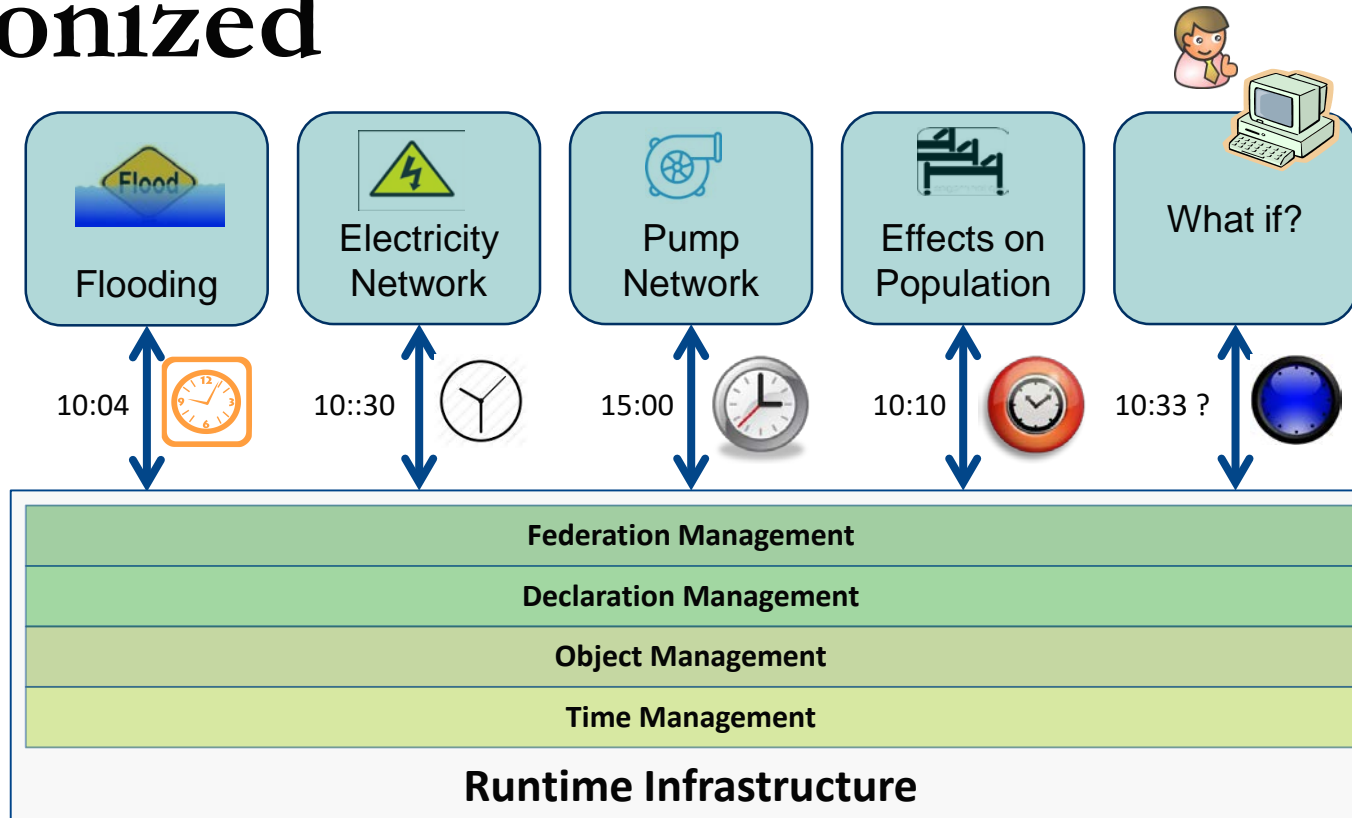
# Federates need to describe what data they provide/consume



# Federates need to exchange data and interactions

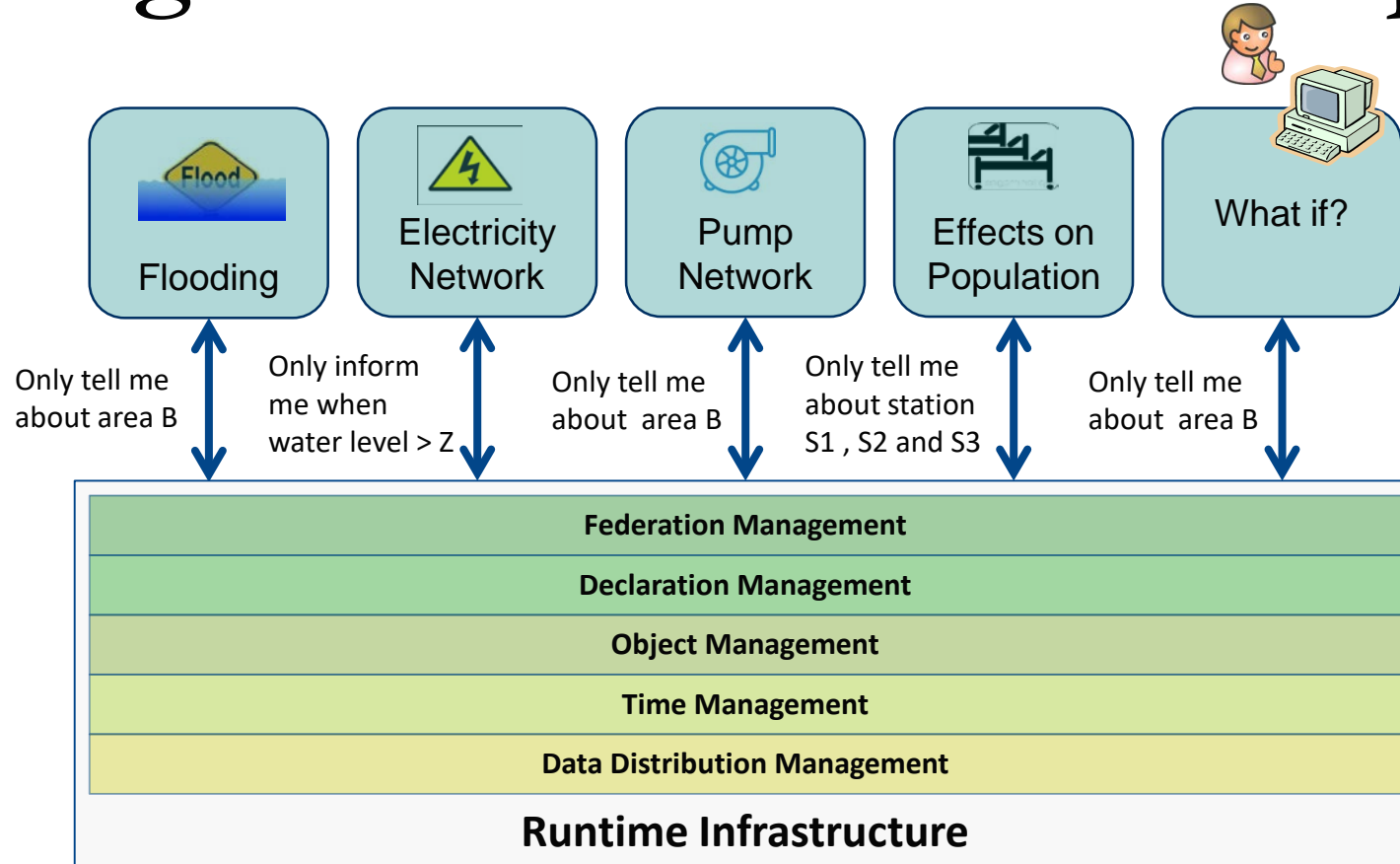


# Federate simulation time needs to be synchronized





# Updating of information can be optimized



# Overview of NATO Education and Training Network (NETN) HLA-FOM

- NETN Federation Architecture and FOM Design (FAFD)
  - a modular reference federation agreement that contains a set of HLA FOM Modules that extends and complements the SISO-STD-001 RPR-FOM v2.0
  - described in AMSP-04 (STANREC 4800)
  - maintained and updated by the NATO Modelling and Simulation Group (**NMSG**) Modelling and Simulation Standards Subgroup (**MS3**)
  - maintenance and updates of the **NETN FOM** is delegated to MSG Research Task Groups

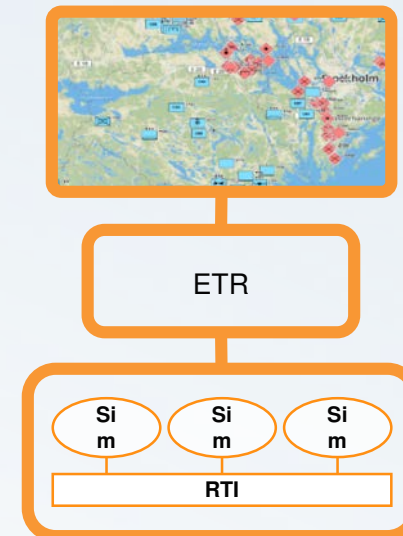
# NETN FOM modules

RPR-FOM Modules	NETN-BASE	<b>NETN-Physical</b> Physical Entities, Platforms & Lifeforms
		<b>NETN-MRM</b> Aggregation & Disaggregation Pattern
		<b>NETN-COM</b> Communication Networks
		<b>NETN-METOC</b> Environment Conditions & Weather
		<b>NETN-CBRN</b> Chemical, Biological, Radiological & Nuclear
		<b>NETN-LOG</b> Logistics Pattern
		<b>NETN-TMR</b> Transfer of Modelling Responsibilities Pattern
		<b>NETN-SE</b> Facilities & Synthetic Environment Objects
		<b>NETN-ETR</b> Entity Tasking & Reporting
		<b>NETN-ORG</b> Organizations & Relationships Initialization
		<b>NETN-AIS</b> Vessel Traffic Identification & Tracking

- The current NETN FOM v3.0 includes 11 FOM modules that complement and/or extend existing RPR-FOM v2.0 modules

# Entity Tasking and Reporting

- NETN Entity Tasking & Reporting (ETR) module
  - represents lower-level tasks suitable for providing simulation instructions to federates modelling individual units or platforms
  - allows one federate to control multiple CGFs



# MSaaS

- M&S for FMN has begun to use the “cloud computing” aspect of MSaaS.
- The intention is to provide M&S support from a central FMN-based MSaaS facility in the operational level
- As MSaaS matures there will be other functionality applicable to FMN.

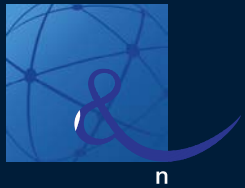
# Questions?

MSG-211 3.1 Workshop Intro / Pullen

MSG-211 M&S in Federated Mission Networking. Pullen 3.1 Workshop Intro



NORTH ATLANTIC TREATY ORGANIZATION  
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