



# High Level Architecture and NATO Education and Training Network (NETN) Federation Object Model (FOM) overview

MSG-211 Lecture Series on M&S Standards in NATO  
Federated Mission Networking

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# Outline

- Introduction
- Overview of the High Level Architecture (HLA)
- Overview of NATO Education and Training Network (NETN) HLA-FOM
- Distributed Simulation Engineering and Execution Process (DSEEP)
- Federation Engineering Agreements Template (FEAT)
- Summary

# NATO M&S Master Plan

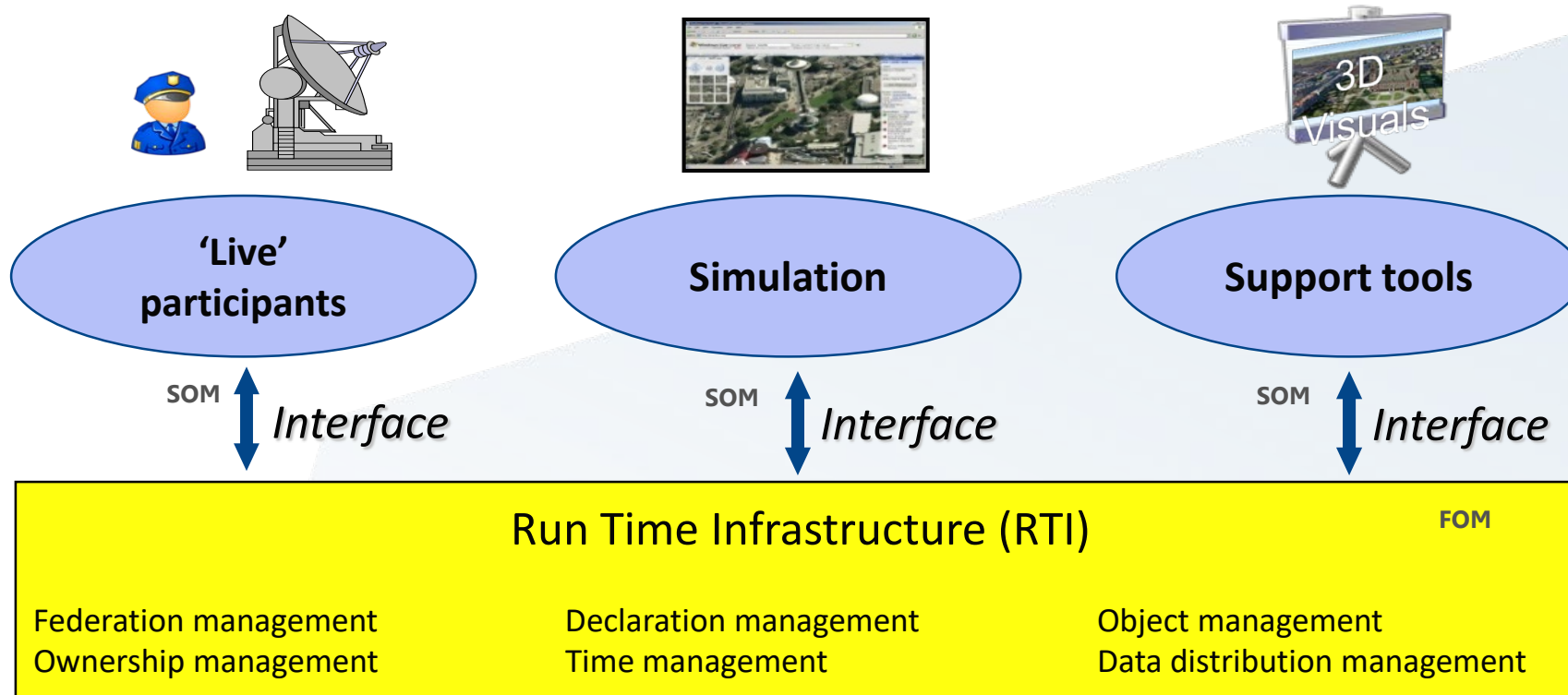
## M&S Strategic & Implementation Plans for the Alliance

1. Establish Common Technical Framework
2. Provide Coordination & Common Services
3. Develop Models & Simulations
4. Employ Simulations
5. Incorporate Technological Advances

# Common Technical Framework objective

- STANAG 4603
  - mandates the use of the IEEE 1516 High-Level Architecture standard for federated distributed simulation
  - recommends the use of IEEE 1730 DSEEP and SISO-STD-012 FEAT
- STANREC 4800
  - recommends the use of AMSP-04 NATO Education and Training Network Federation Architecture and FOM Design (NETN FAFD)

# Overview of the High Level Architecture



# 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

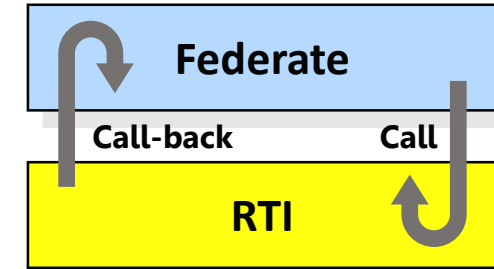
# HLA Framework and Rules

- 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 Interface Specification

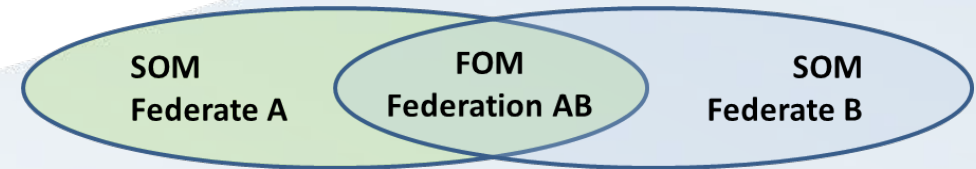
- Seven service groups used by the federate to interact with the RTI
  - Federation Management:** to coordinate federation-wide activities
  - Declaration Management:** to specify the types of data that a federate will supply to or receive from the federation execution
  - Object Management:** to register and discover object instances, to update and reflect instance attributes, to delete or remove object instances, and to send and receive interactions
  - Ownership Management:** to establish a specific joined federate's privilege to provide values for an object instance attribute as well as to facilitate dynamic transfer of this privilege (ownership) to other joined federates during a federation execution
  - Time Management:** to provide a logical concept of time and to jointly maintain a distributed virtual clock
  - Data Distribution Management:** to the distribution conditions beyond those provided via Declaration Management services) for the specific data they send or ask to receive
  - Support Services:** miscellaneous services utilized by joined federates



# HLA Object Model Template

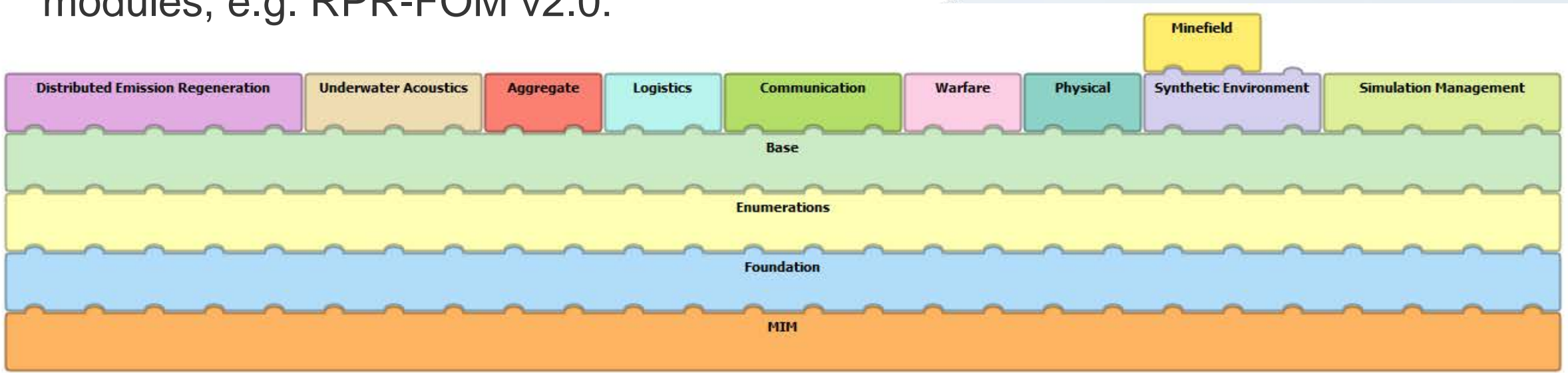
- Format to specify the data exchanged between federates
  - HLA object classes and attributes
  - HLA interaction classes and parameters
- Three kinds of object model
  - **Federation Object Model (FOM)**: Describes all shared information for a particular federation
  - **Simulation Object Model (SOM)**: 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

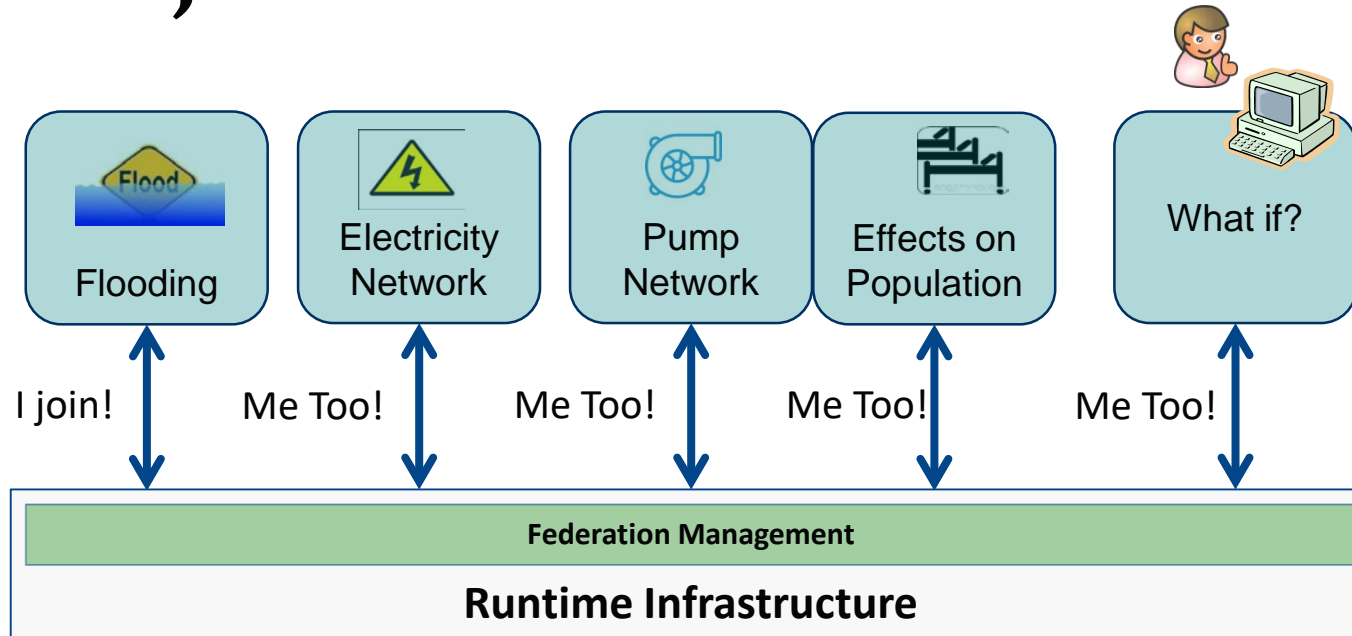


# HLA Object Model Template - modules

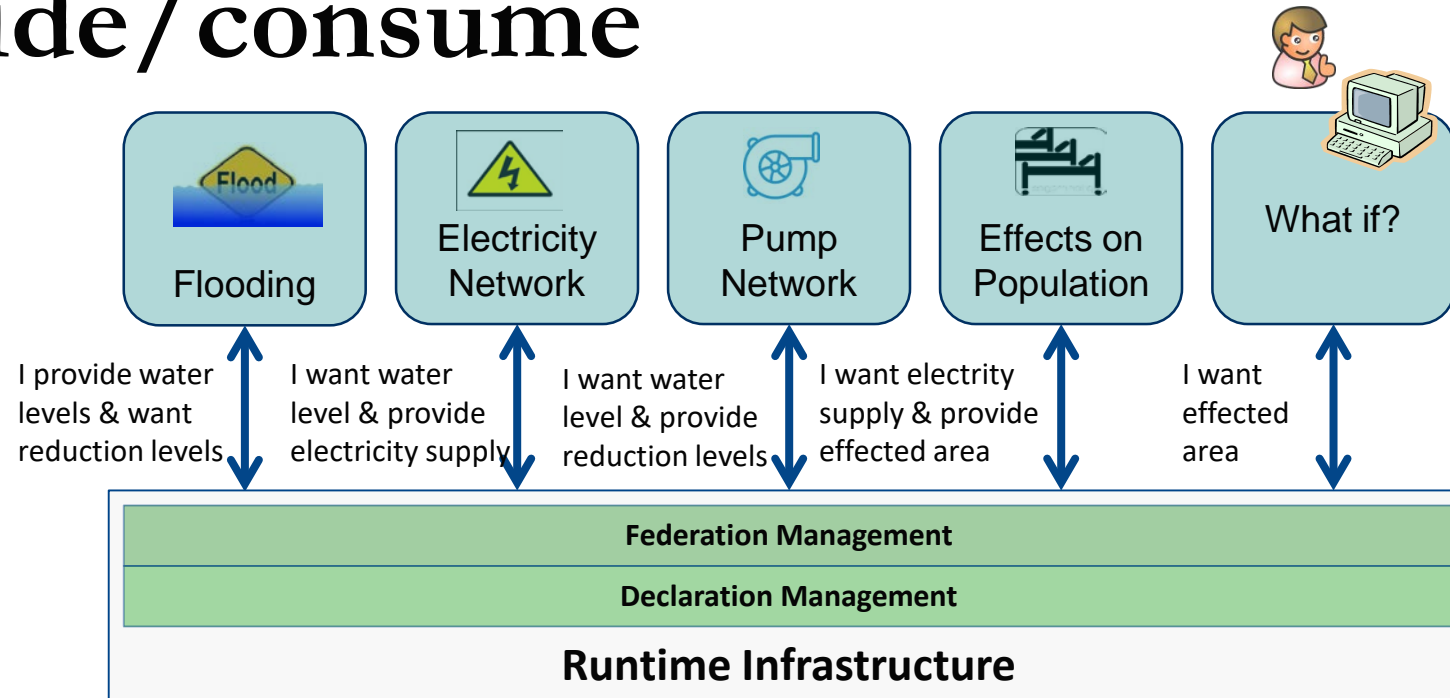
- An object model (FOM, SOM, MOM) may be described by one or more modules, e.g. RPR-FOM v2.0:



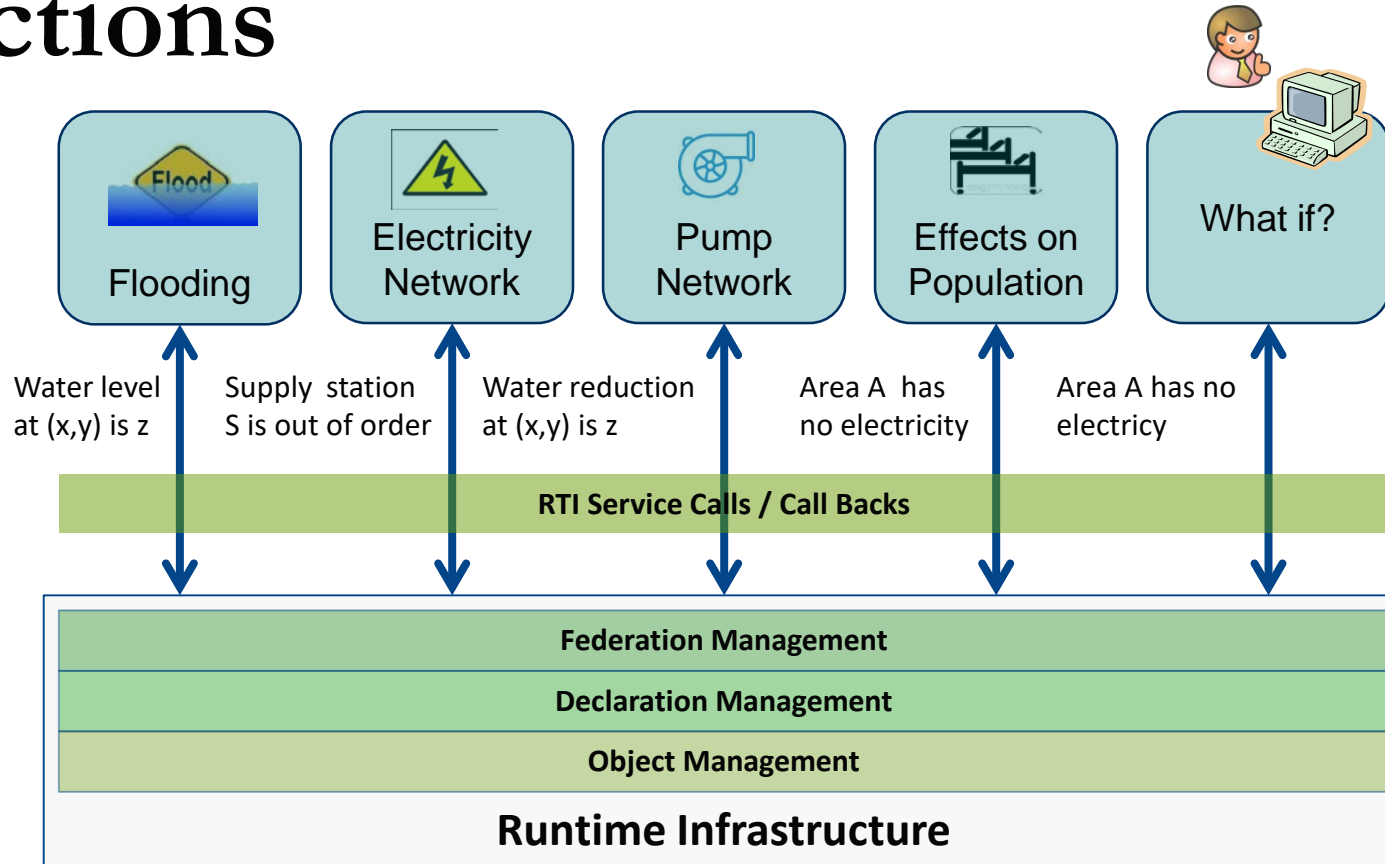
## Federates join a Federation



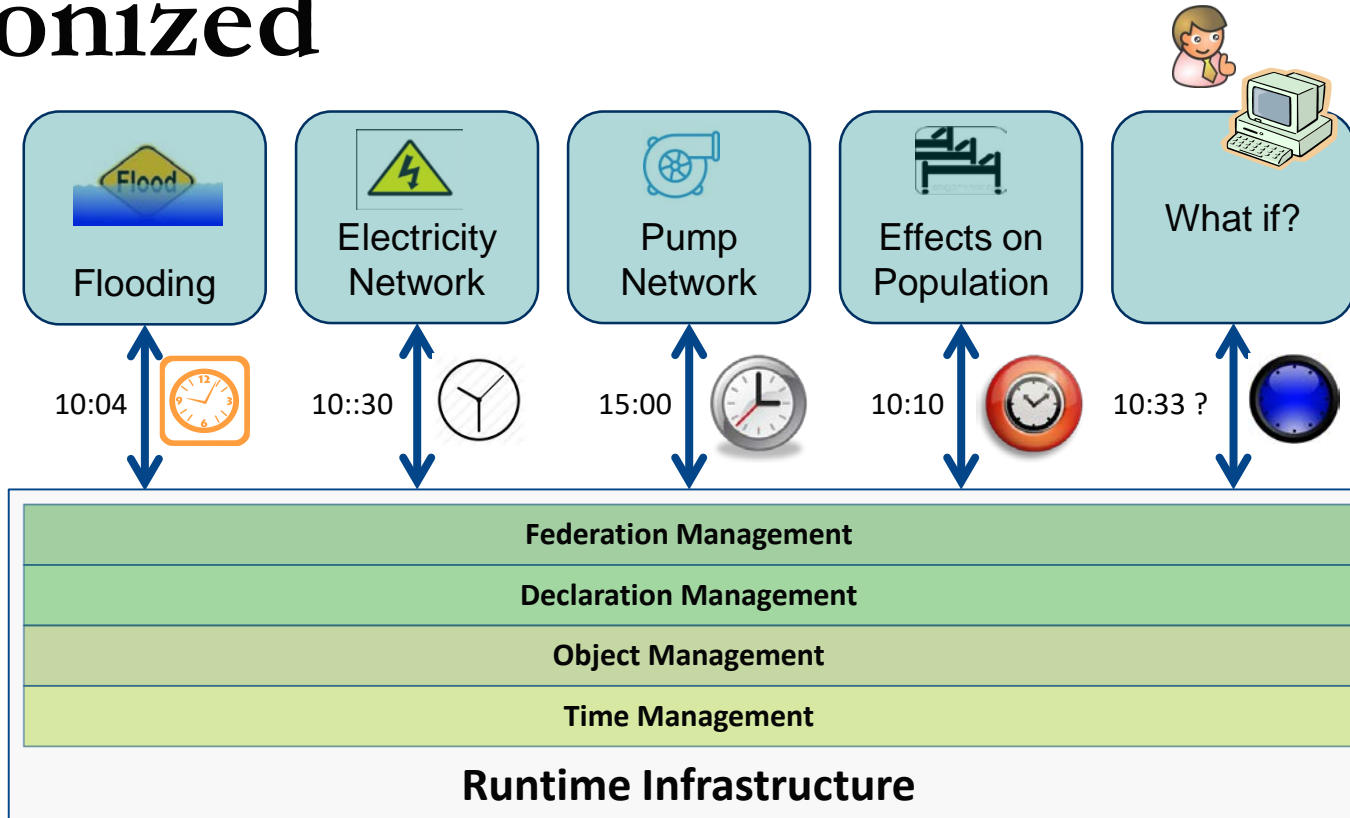
# Federates need to describe what data they provide/consume



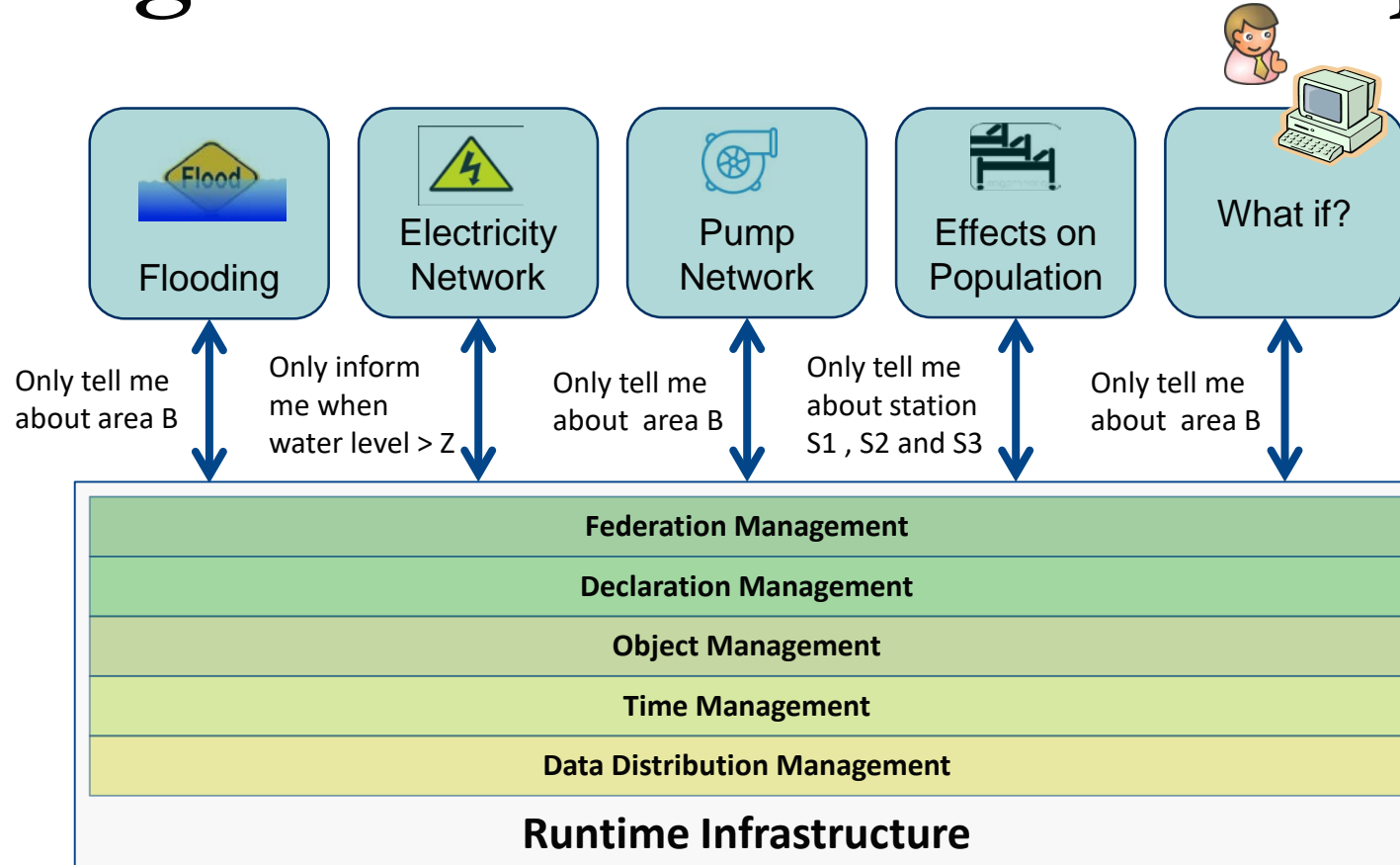
# Federates need to exchange data and interactions



# Federate simulation time need to be synchronized

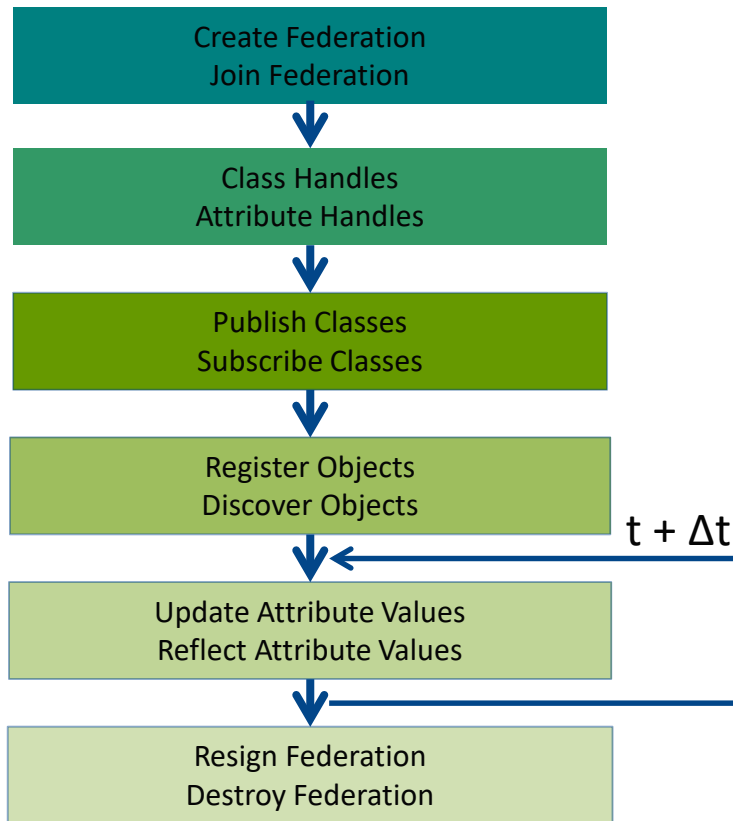


# Updating of information can be optimized

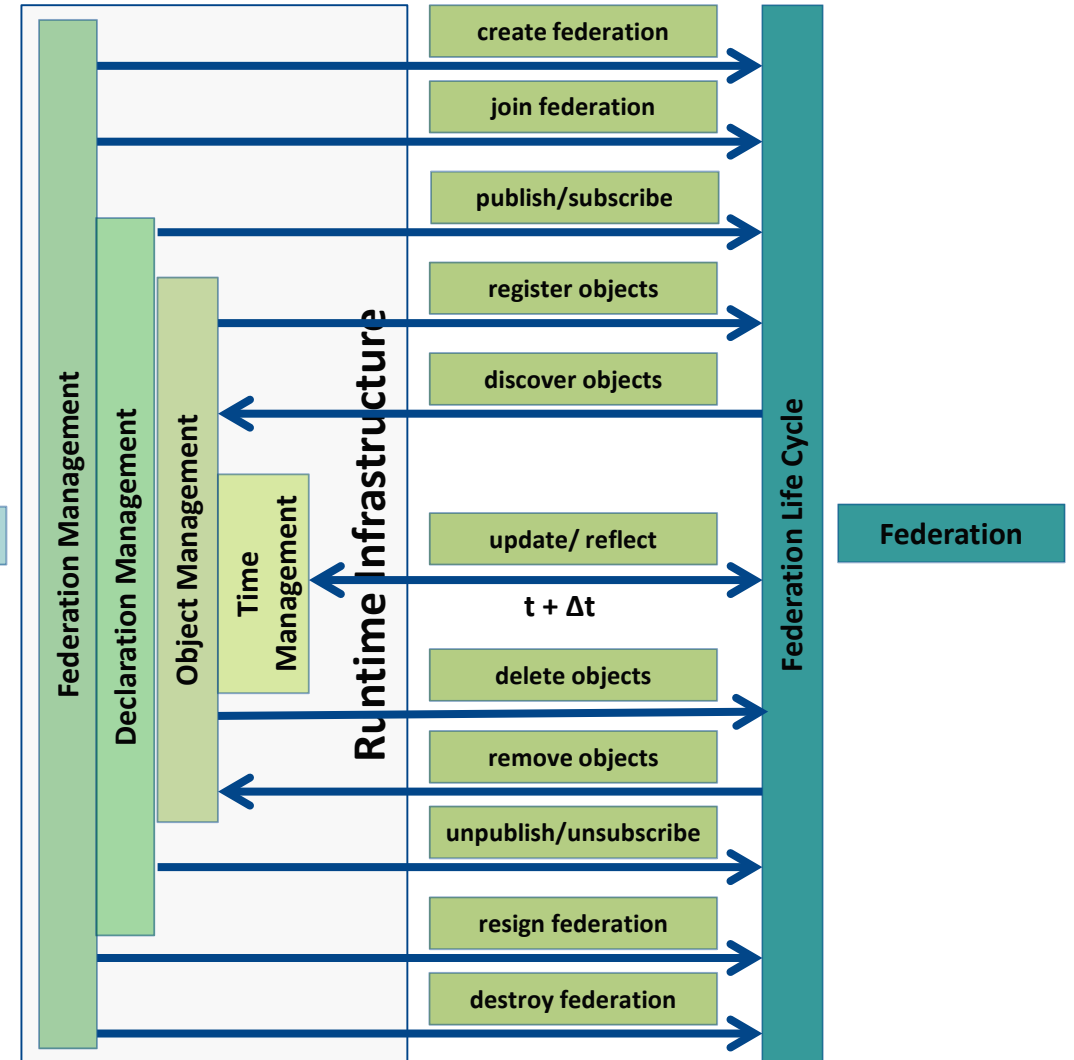




# Federate walkthrough



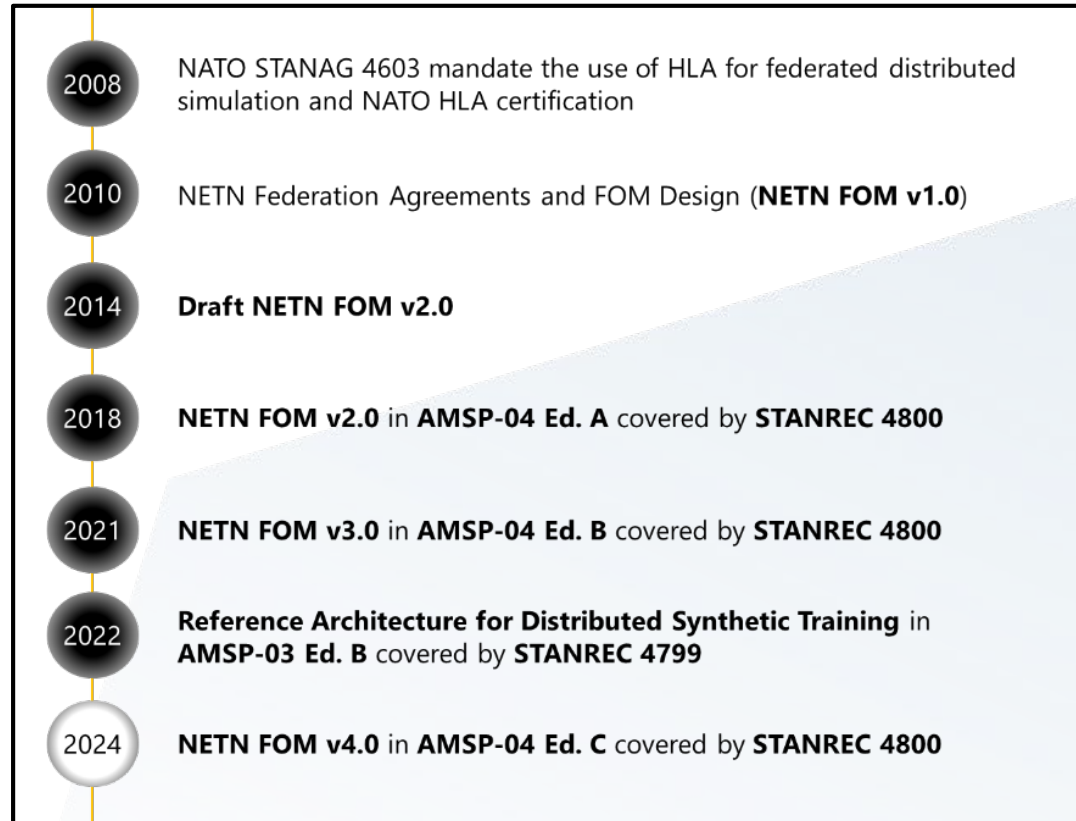
Federate



# 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 evolution over time

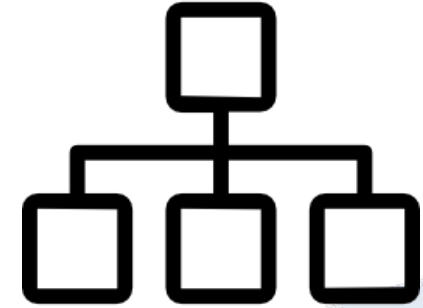


# NETN FOM modules

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

# Representation of Organizations



- NETN-ORG FOM module
  - provides a standard way of representing the state, organization and relationships of units at a given point in time
  - used for (re-)initialization of scenarios and for distributing dynamic changes of organizational relationships
    - Dynamic Task Organisation
    - Force Relationships
  - based on SISO-STD-007-2008: Military Scenario Definition Language (MSDL) with extensions

# NETN-ORG

## Initial Modelling Responsibilities

## Initial Unit Data

### Universally Unique Identifier

E.g. 0c958265-97ee-4acc-b3efa825dcb5e31c

- Unique between federation executions
- Pre-defined or generated
- Can reference Physical Entities and Aggregate Unit

ORG Root			
Name	Text255	ps	ro
UUID	UuidArrayOf...	ps	ro

Federate			
Units	ArrayOfUuid	ps	ro

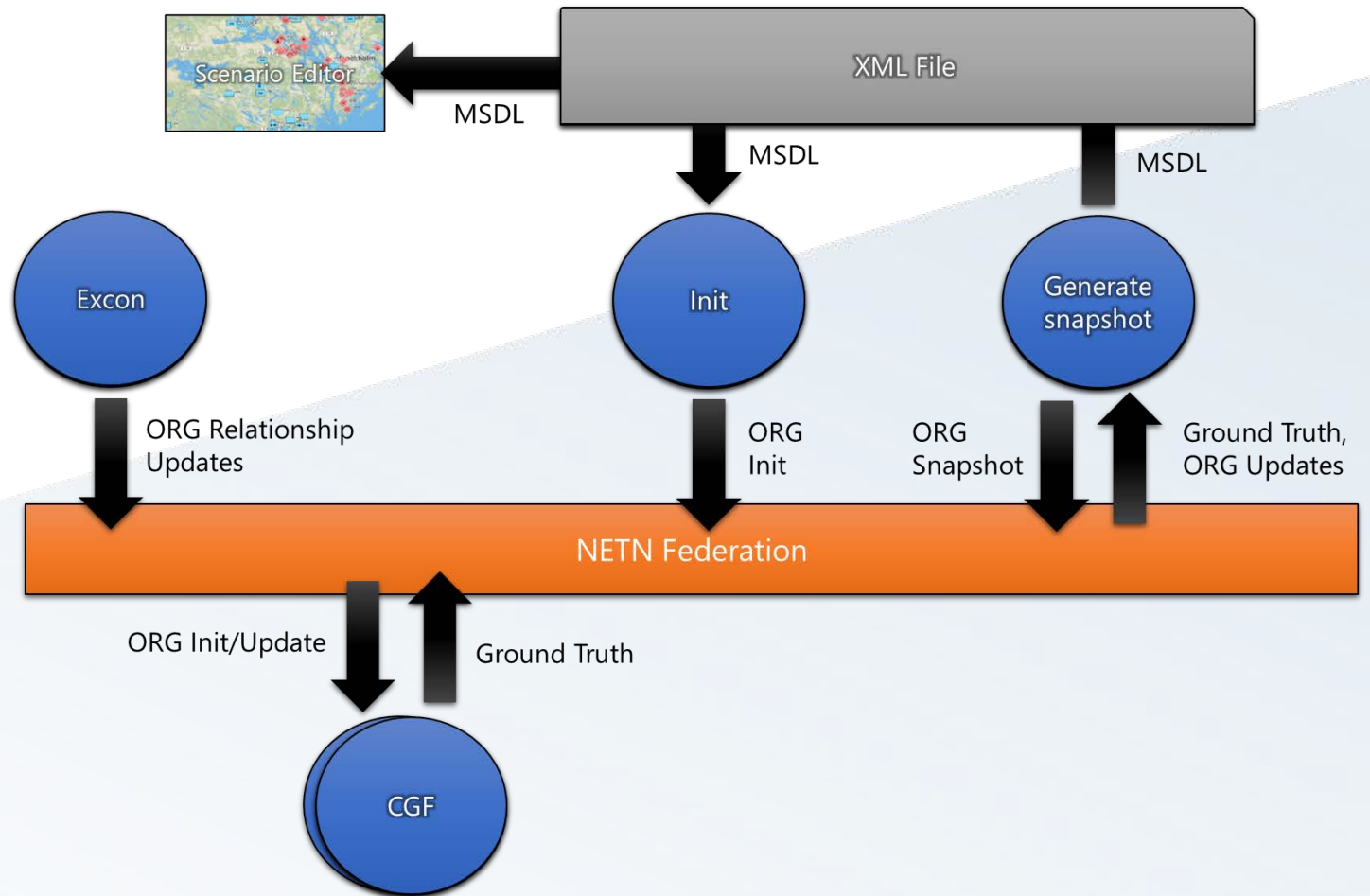
OrbatObject			
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Unit			
SuperiorUnit	UuidArrayOfHLAbyte16	ps	ro
EntityType	EntityTypeStruct	ps	ro
SymbolIdentifier	SymbolIdentifierArray15	ps	ro
Force	UuidArrayOfHLAbyte16	ps	ro
Holdings	ArrayOfHoldings	ps	ro
IsSimulationEntity	HLAboolean	ps	ro
EmbarkedIn	UuidArrayOfHLAbyte16	ps	ro
UniqueDesignation	Text21	ps	ro
Echelon	EchelonEnum32	ps	ro
CombatEffectiveness	CombatEffectivenessTypeEnum32	ps	ro
HigherFormation	Text21	ps	ro
IFF	IFF5	ps	ro
Location	LocationStruct	ps	ro
Direction	DegreesFloat32	ps	ro
Speed	SpeedFloat32	ps	ro
FormationPosition	FormationPositionStruct	ps	ro
OwnFormation	OwnFormationStruct	ps	ro
CategoryCode	UnitTypeCategoryCodeEnum32	ps	ro
CommandFunctionIndicatorCode	OrganisationTypeCommandFunctionI...	ps	ro
SizeCode	UnitTypeSizeCodeEnum32	ps	ro
ArmCategoryCode	UnitTypeArmCategoryCodeEnum32	ps	ro
TypeServiceCode	MilitaryOrganisationTypeServiceCode...	ps	ro

Force			
Relations	ArrayOfRelations	ps	ro

### Force relationships with other Forces

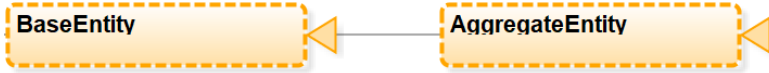
# Typical design



# Aggregate Units & Physical Entities

- NETN Aggregate and NETN Physical FOM modules
  - extensions to the corresponding RPR-FOM v2.0 FOM modules for representing Ground Truth state of Aggregate Entities, Platforms, Equipment, Life Forms, Cultural Features and Environment Objects
  - UUID attribute based on MSDL/NETN-ORG are used to uniquely identify simulated entities in a scenario





NETN Aggregate		ps
UnitPersonnel	ArrayOfResourceStatus	ps da ro
Callsign	HLAunicodeString	ps da ro
VisualSignature	VisualSignatureStruct	ps da ro
SourceUnit	HLAunicodeString	ps da ro
Mission	MissionStruct	ps da ro
Mounted	QuantityFloat64	ps da ro
UnitSupplies	NETN_ArrayOfSupplyStruct	ps da ro
HigherHeadquarters	UuidArrayOfHLAbyte16	ps da ro
CombatValue	CombatValueFloat64	ps da ro
WeaponsControlOrder	WeaponControlOrderEnum8	ps da ro
SupportUnit	SupportRelationshipStruct	ps da ro
Activity	AggregateMissionEnum16	ps da ro
Symbol	HLAunicodeString	ps da ro
CaptureStatus	CaptureStatusEnum8	ps da ro
UnitEquipment	ArrayOfResourceStatus	ps da ro
Echelon	EchelonEnum8	ps da ro
HUMINTSignature	HUMINTSignatureStruct	ps da ro
ElectronicSignature	ElectronicSignatureStruct	ps da ro
Footprint	ArrayOfWorldLocationStruct3	ps da ro
CoverStatus	CoverStatusStruct	ps da ro
EntityList	EntityListVariableLengthStruct	ps da ro
Status	ActiveStatusEnum8	ps da ro
UniqueID	UuidArrayOfHLAbyte16	ps da ro
EmbeddedUnitList	ArrayOfUuid	ps da ro

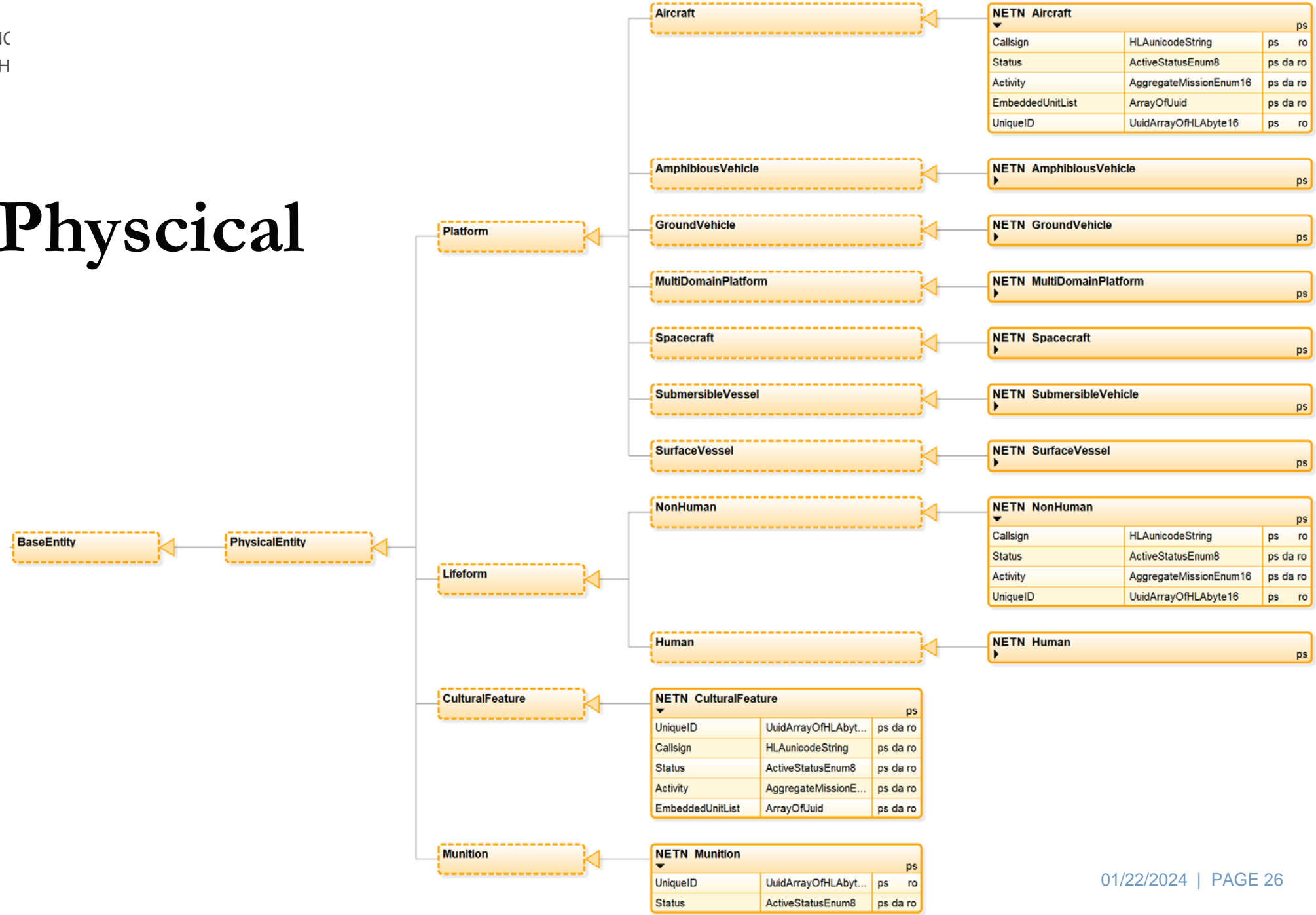
# NETN Aggregate

## Universally Unique Identifier

Refers to NETN ORG unit



# NETN Phycical



NETN Aircraft			
Callsign	HLAunicodeString	ps	ro
Status	ActiveStatusEnum8	ps	da ro
Activity	AggregateMissionEnum16	ps	da ro
EmbeddedUnitList	ArrayOfJuid	ps	da ro
UniqueID	UuidArrayOfHLAbyte16	ps	ro

NETN AmphibiousVehicle	
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NETN GroundVehicle	
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NETN MultiDomainPlatform	
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NETN Spacecraft	
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NETN SubmersibleVehicle	
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NETN SurfaceVessel	
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NETN NonHuman			
Callsign	HLAunicodeString	ps	ro
Status	ActiveStatusEnum8	ps	da ro
Activity	AggregateMissionEnum16	ps	da ro
UniqueID	UuidArrayOfHLAbyte16	ps	ro

NETN Human	
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NETN CulturalFeature			
UniqueID	UuidArrayOfHLAbyt...	ps	da ro
Callsign	HLAunicodeString	ps	da ro
Status	ActiveStatusEnum8	ps	da ro
Activity	AggregateMissionE...	ps	da ro
EmbeddedUnitList	ArrayOfJuid	ps	da ro

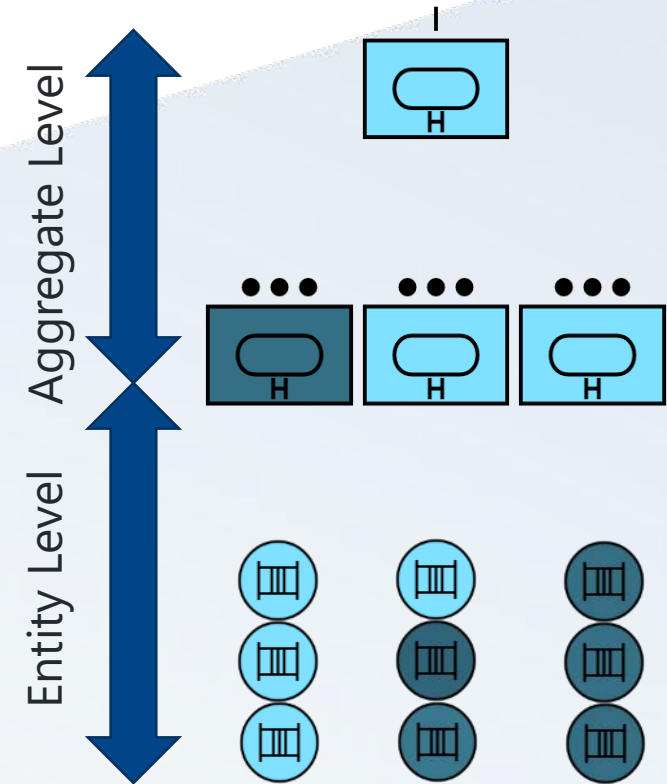
NETN Munition			
UniqueID	UuidArrayOfHLAbyt...	ps	ro
Status	ActiveStatusEnum8	ps	da ro

# Aggregation and Disaggregation

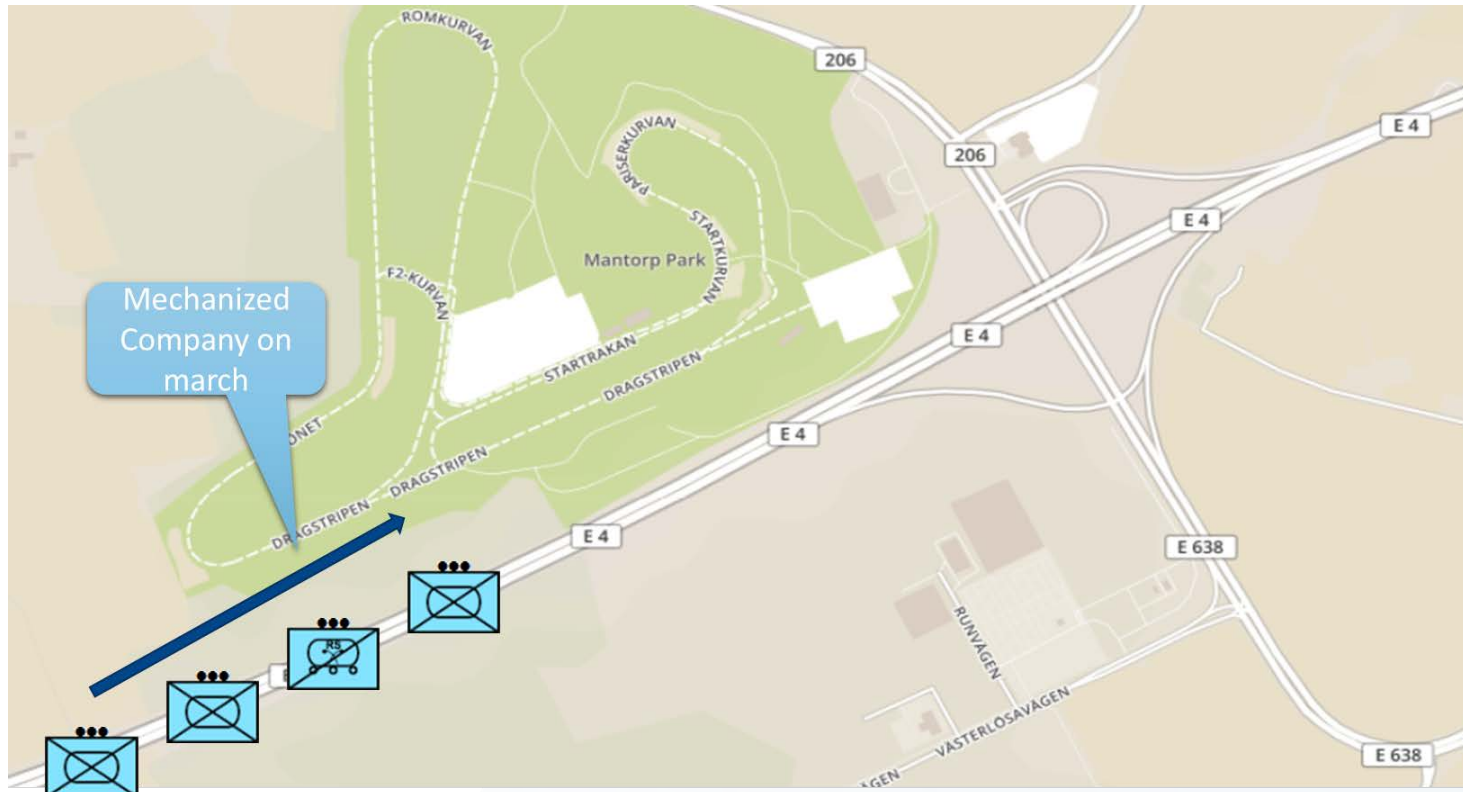
- NETN Multi-Resolution Modelling (MRM) module
  - provides a standard way to manage aggregation and disaggregation of simulated units and physical entities

# NETN Multi-Resolution Modelling

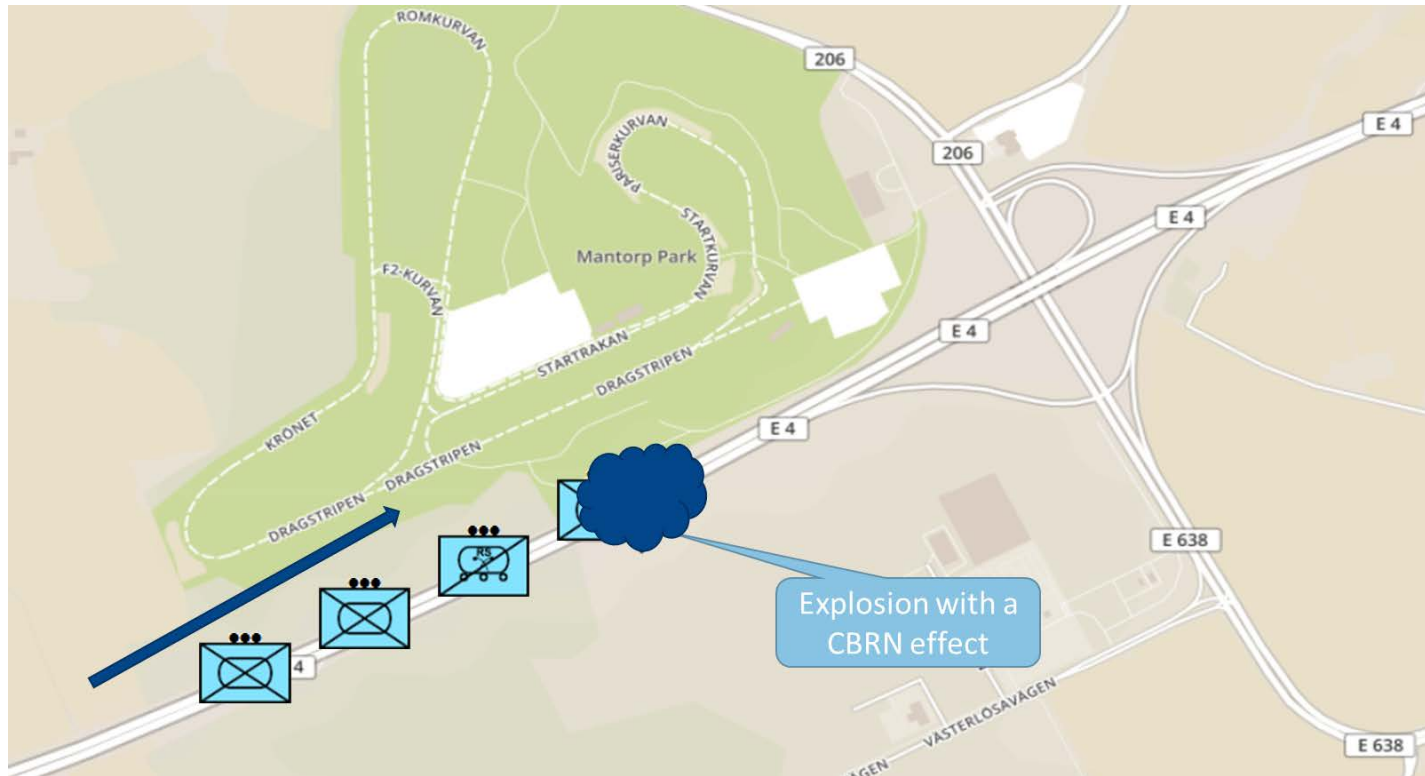
- The purpose of NETN-MRM is to support federations where models are represented at multiple levels of resolution and where the level of resolution can change dynamically during simulation.
- The NETN-MRM FOM module defines messages for conducting negotiated and coordinated aggregation and disaggregation of simulated units and entities in a federated simulation.



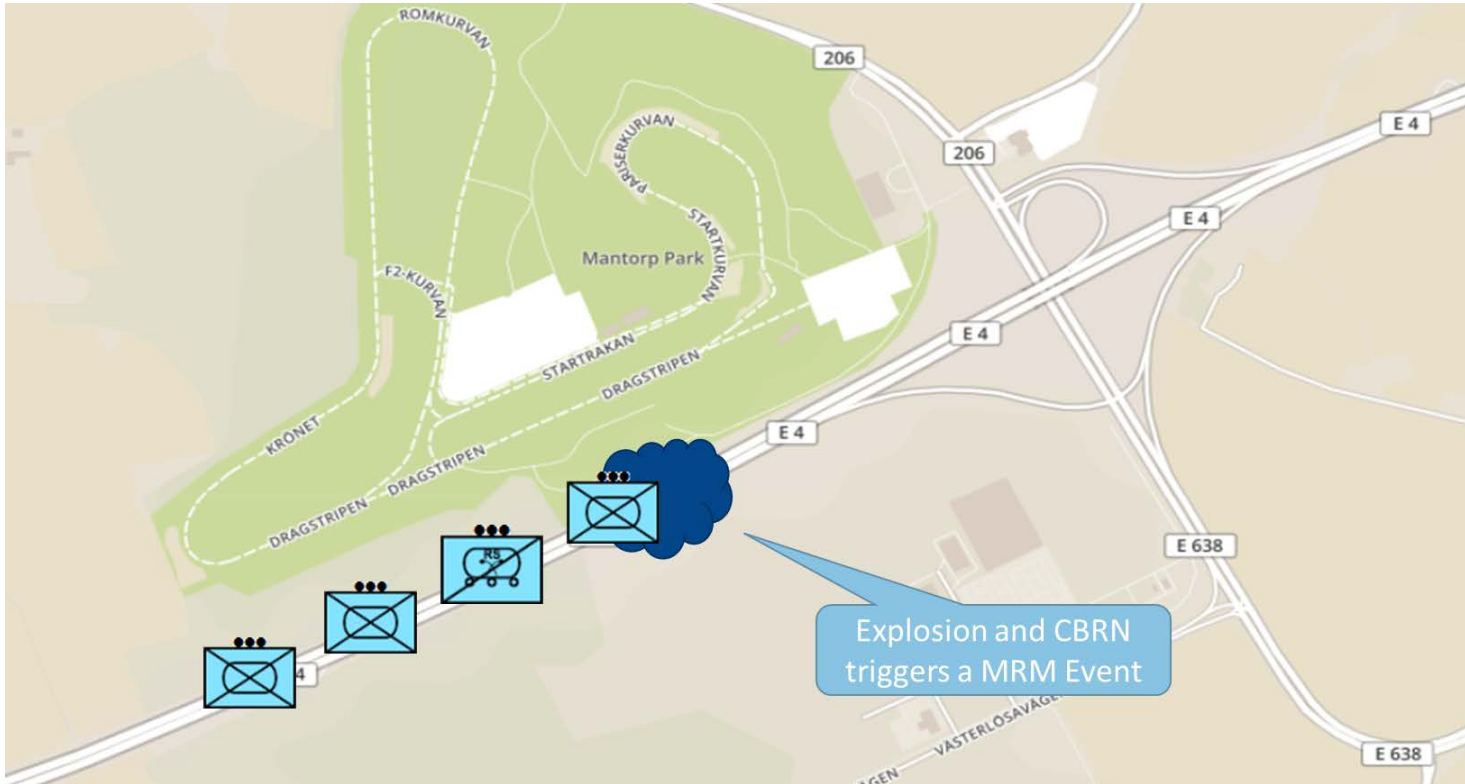
# Example



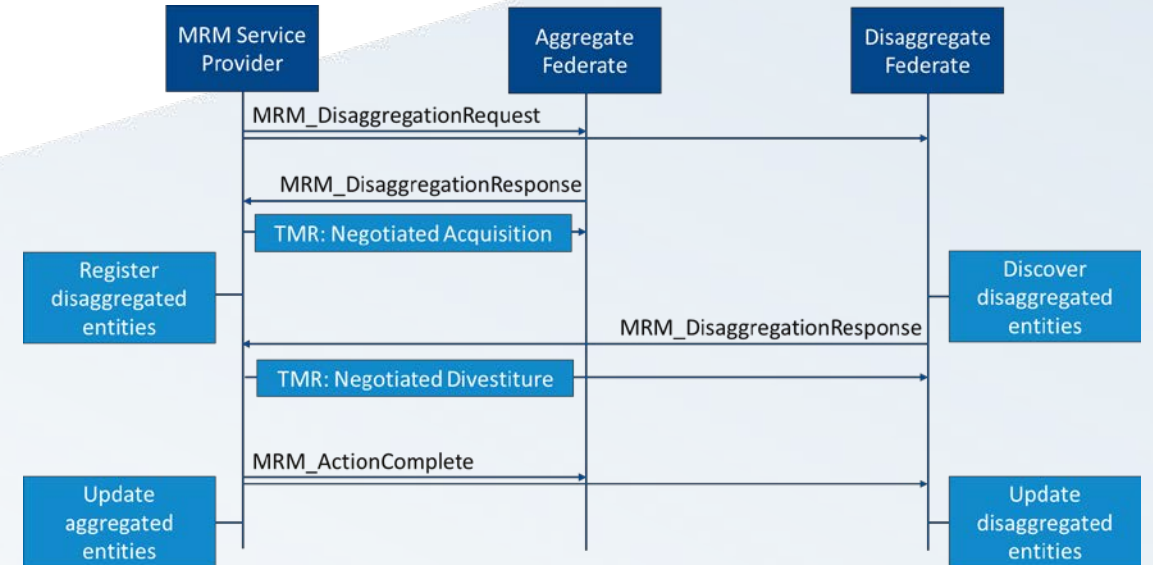
# Event



# MRM Trigger

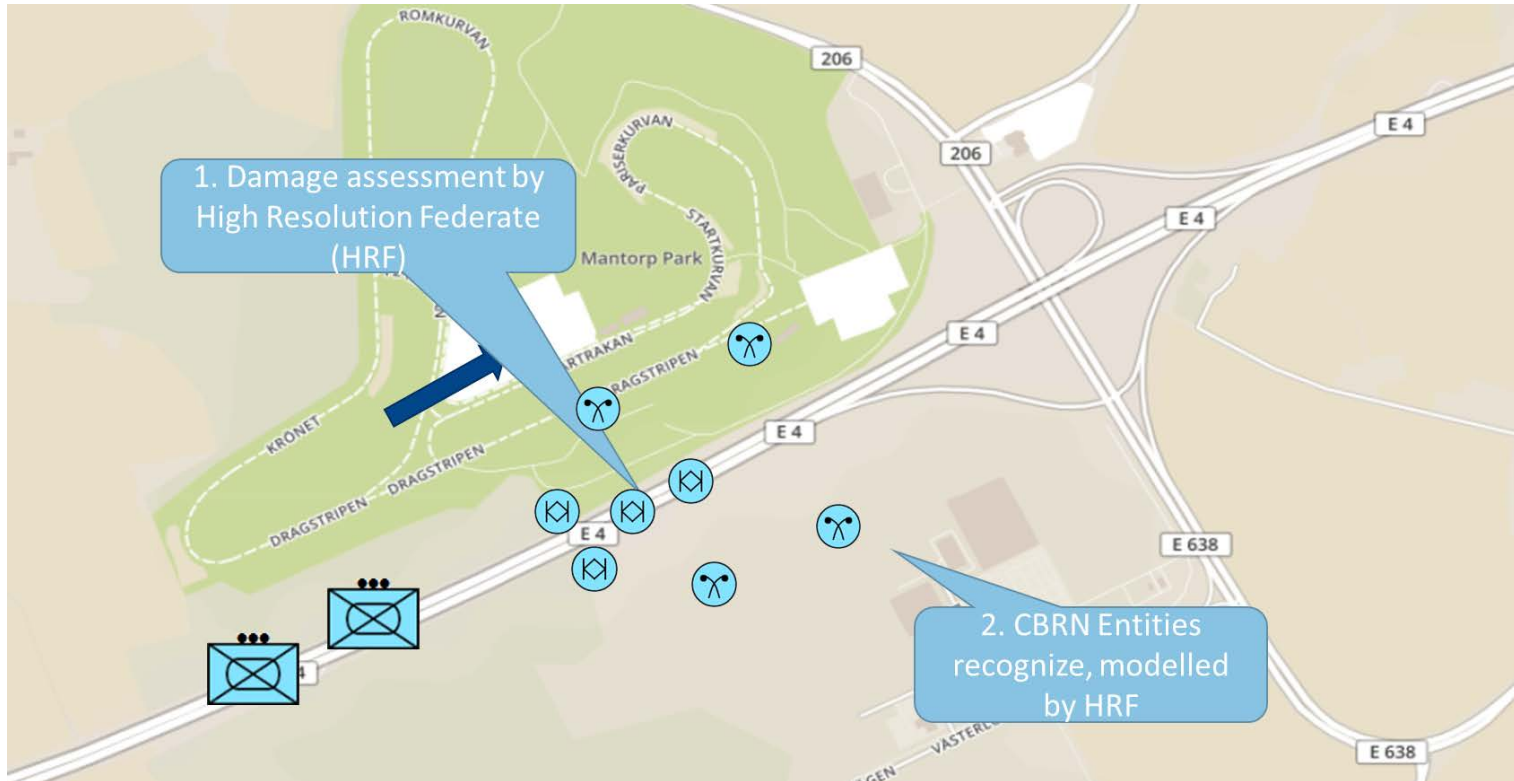


# MRM Disaggregation

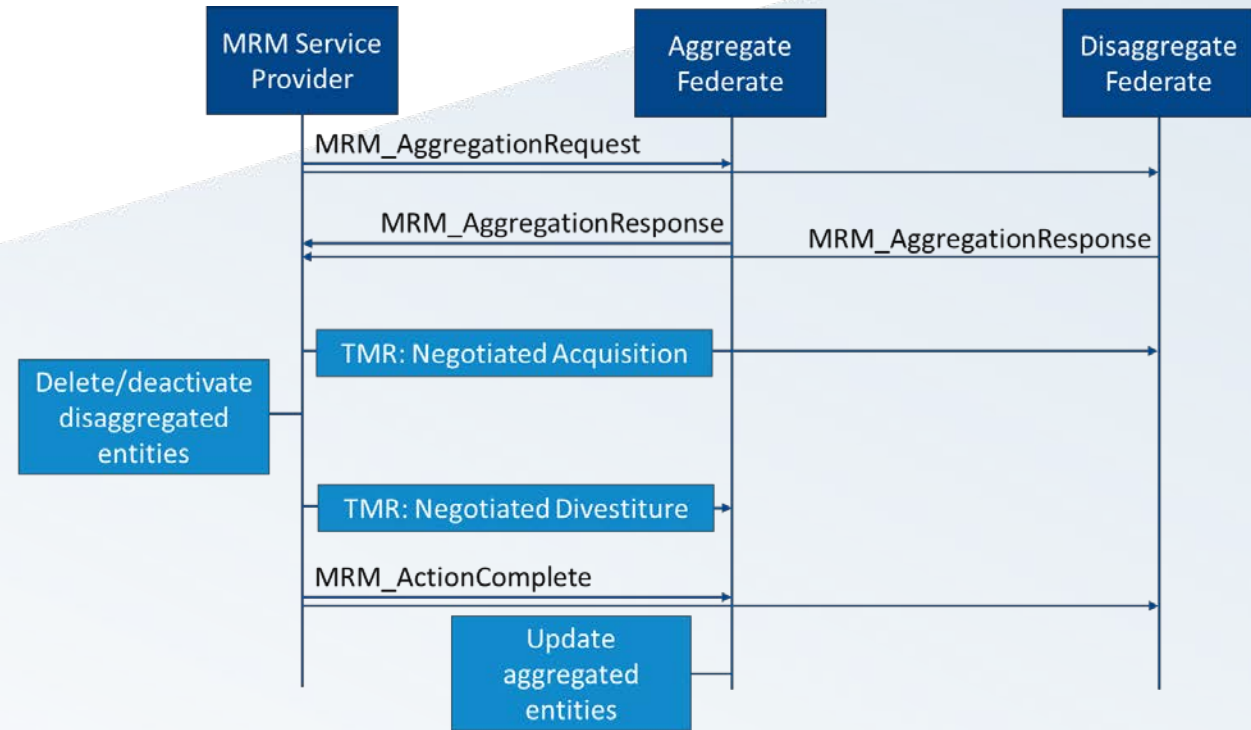
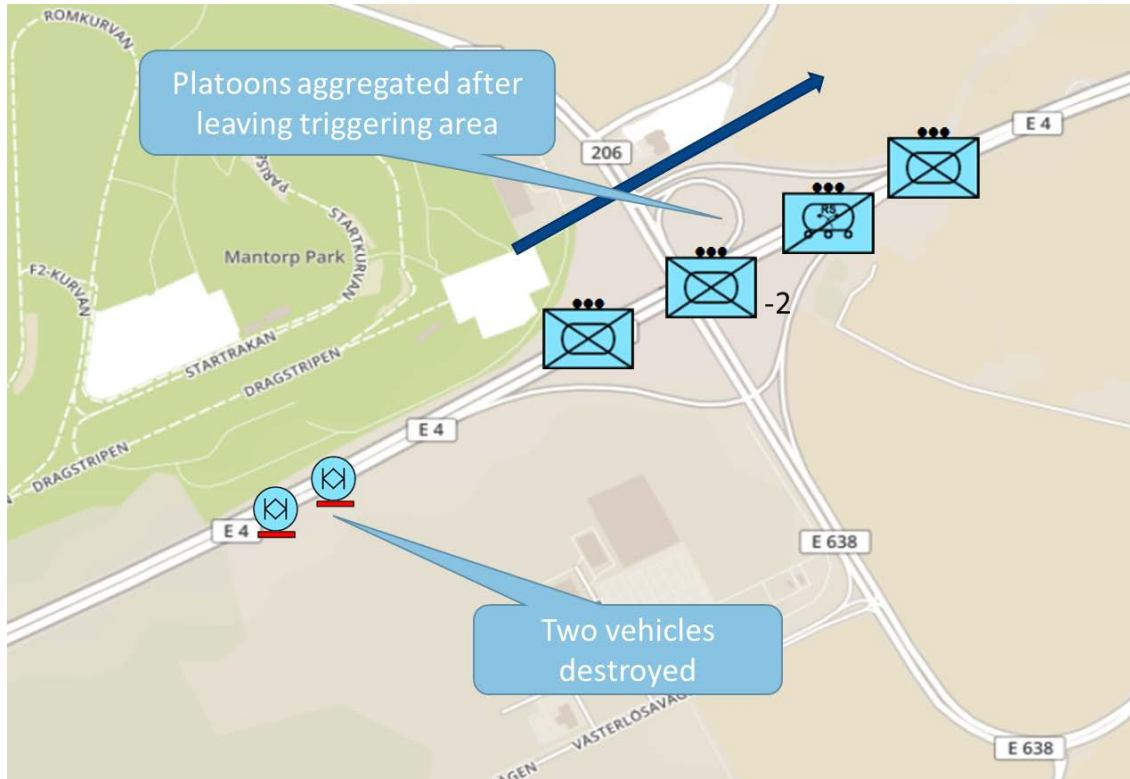




# Disaggregated entities modelled

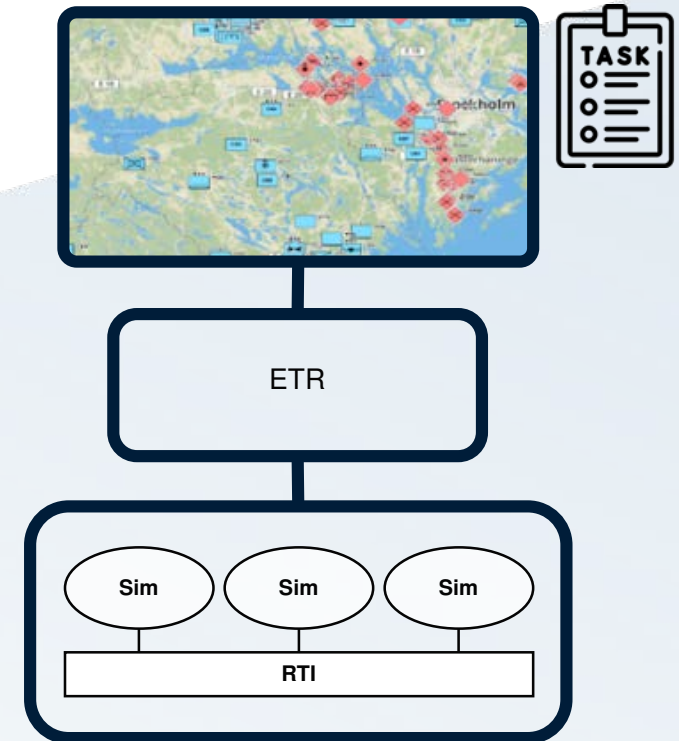


# MRM Aggregation

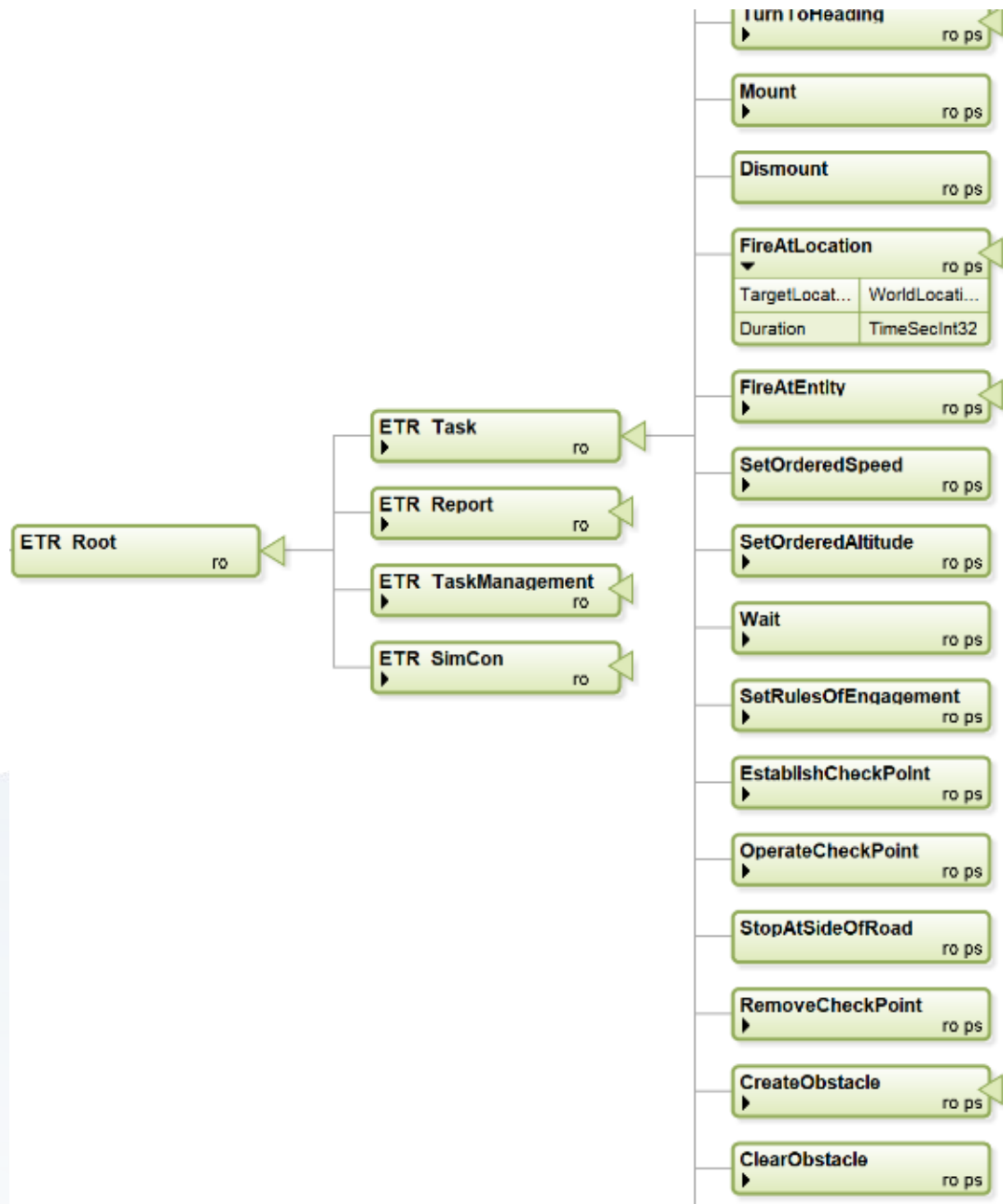


# Entity Tasking and Reporting

- 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



# NETN-ETR





# Transfer of Modelling Responsibilities

- NETN Transfer of Modelling Responsibility (TMR) module
  - used to dynamically change which federate is responsible for the simulation of a specific object in the synthetic environment.
    - Transfer from a Live to a Virtual or Constructive simulation
    - Transfer between Virtual and Constructive simulations
    - Transfer between hi- and low-fidelity models
    - Transfer to allow backup, maintenance or load-balancing
    - Transfer of certain attributes to functional models such as movement, damage assessment etc.

# Chemical, Biological, Radiological and Nuclear M&S

- NETN Chemical, Biological, Radiological and Nuclear (CBRN) module
  - defines a standard way to distribute dispersion calculations and information about dispersion effects on entities and the environment.
    - Source release & Hazard area
    - CBRN Detectors
    - CBRN Effects
    - Protective measures



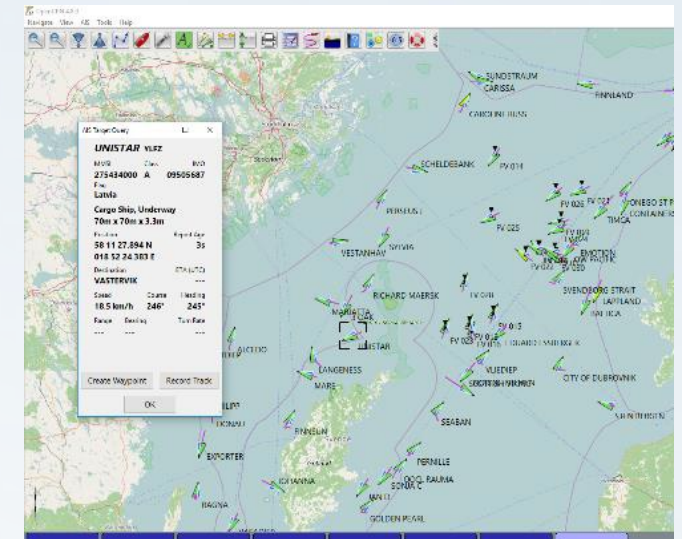
# Representation of Weather



- NETN METOC module
  - represents environment conditions associated with geographical locations, areas, simulated entities, and terrain features
    - Terrain Surface
    - Water Surface
    - Atmospheric Layers
    - Subsurface volumes of water

# Vessel Identification and Data

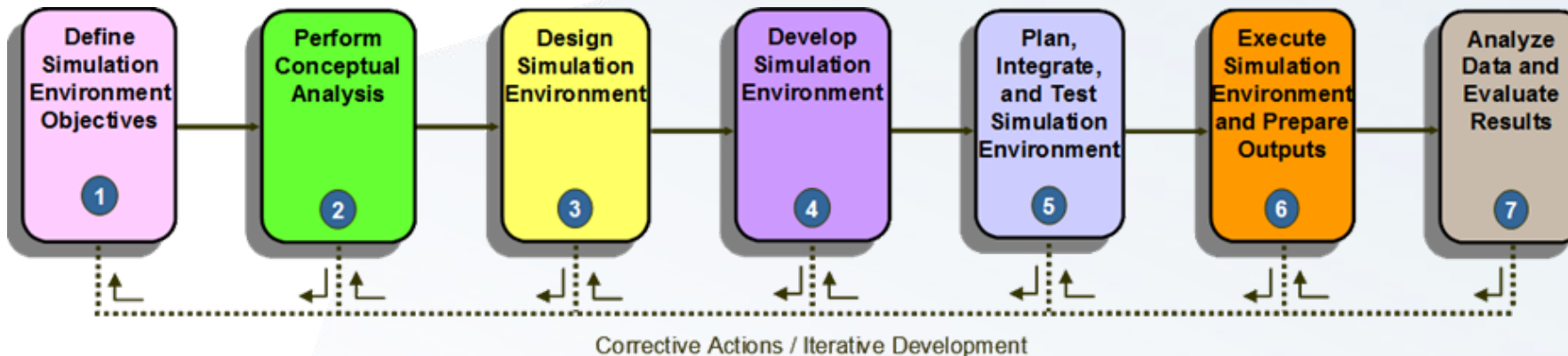
- NETN AIS module
  - simulation oriented representation of vessel traffic identification and data used by the international Automatic Identification System (AIS)
    - Navigation Data including position, speed, direction etc.
    - Voyage Data including destination, route, cargo etc.





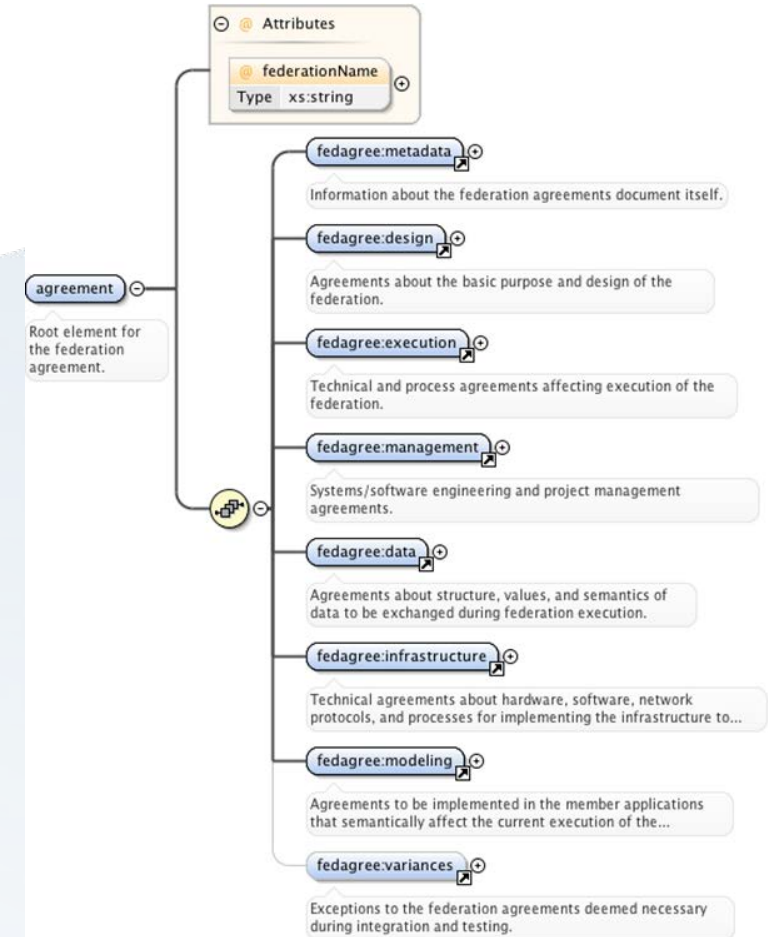
# Distributed Simulation Engineering and Execution Process (DSEEP)

- IEEE 1730 DSEEP
  - A recommended practice developed by M&S practitioners
  - Seven-step process model, to be tailored to the specifics of the project



# Federation Engineering Agreements Template (FEAT)

- SISO-STD-012 Federation Engineering Agreements Template
  - A template to capture the results of the various steps within the DSEEP, such as:
    - objectives
    - scenario information
    - conceptual model
    - requirements
    - HLA FOMs and SOMs
    - HLA RTI middleware version

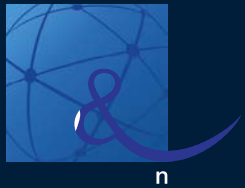


# Summary

- NATO Standards for Federated Simulation, as well as processes and tools for simulation engineering, are important to NATO in order to successfully connect and integrate multi-national M&S assets
  - The NATO Education and Training Network Federation Architecture and FOM Design (**NETN FAFD**) is a NATO M&S interoperability standard (STANREC 4800), based on the use of STANAG 4603 **HLA** and the SISO-STD-001 **Real-Time Platform Reference FOM**
  - The IEEE 1730 **DSEEP** is a recommended practice for simulation engineering, and the SISO-STD-012 **FEAT** a template for capturing federation agreements



NORTH ATLANTIC TREATY ORGANIZATION  
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WEB [www.sto.nato.int](http://www.sto.nato.int)

The screenshot shows the NATO STO website homepage. At the top left is the NATO OTAN logo. To its right is the text "NORTH ATLANTIC TREATY ORGANIZATION" and "SCIENCE AND TECHNOLOGY ORGANIZATION". On the far right is a "Sign In" link and social media icons for YouTube, Facebook, and LinkedIn, along with the "S&T organization" logo. Below the header is a navigation menu with links for "ORGANIZATION", "NEWS", "PROGRAMME", "ACTIVITIES", "PUBLICATIONS", and "CONTACT". The main content area is titled "NEWSROOM" and features a large banner for "2022 HIGHLIGHTS" with the subtitle "SCIENCE AND TECHNOLOGY ORGANIZATION". The banner image shows a person's profile with digital data overlaid. To the right of the banner are two smaller news items. The first shows a satellite in space with the text "NATO STO hosts wargame on Space Deterrence ...". The second shows a person at a computer with the text "2023 COLLABORATIVE Programme of Work Report ...".