



NORTH ATLANTIC TREATY ORGANIZATION  
SCIENCE & TECHNOLOGY ORGANIZATION



# M&S Standards Processes

*MSG-211 Technical Course, Session 2.2*

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# Outline

- NATO Standardization Office
- Institute of Electrical and Electronic Engineers (IEEE)
- Simulation Interoperability Standards Organization (SISO)
- Standardization Process Overview

# M&S Standards in Federated Mission Networking

- Information exchange content and protocols are governed by a number of established standards and best practices within NATO and across the international M&S community:
  - Command and Control Systems – Simulation Systems Interoperation (C2SIM), SISO-STD-019-2020 / NATO STANAG 4856 Ed 01
  - High Level Architecture (HLA), IEEE Standard 1516 / NATO STANAG 4603 Ed 03
  - NATO Education and Training Network Federated Object Model (NETN-FOM), AMSP-04
  - Modeling and Simulation as a Service (MSaaS)

# NATO Standardization Office (NSO)

- Initiates, coordinates, supports, and administers NATO standardization activities
  - Under authority of the Committee for Standardization (CS)
  - Integrated NATO Headquarters staff element reporting to the Military Committee and CS
  - Goal of enhancing interoperability and operational effectiveness of Alliance military forces
  - NSO encourages implementation of Standardization Agreements (STANAGs), NATO documents specifying the agreement of member countries to implement a standard
  - Liases with civilian standards-developing organisations

Source: [NATO - Topic: NATO Standardization Office \(NSO\)](#)

# Key Terms in NATO Standardization

- Standard: “a document, established by consensus and approved by a recognised body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.”
- Interoperability: “The ability to act together coherently, effectively and efficiently to achieve Allied tactical, operational and strategic objectives.”
- STANAG: “a NATO standardization document that specifies the agreement of member countries to implement a standard.”

Source: [NATO - Topic: Standardization](#)

# NATO Standardization Process

- Identifying standardization requirements or deficiencies
- Formulating and agreeing on priority standardization objectives
- Formulating or updating NATO standards
- Ratifying NATO standards by nations individually (based on national interests and policies)
- Promulgating NATO standards (to all relevant national authorities, military commands and industry)
- Implementing agreed NATO standards as a matter of national policy
- Verifying and validating the implementation of agreed NATO standards

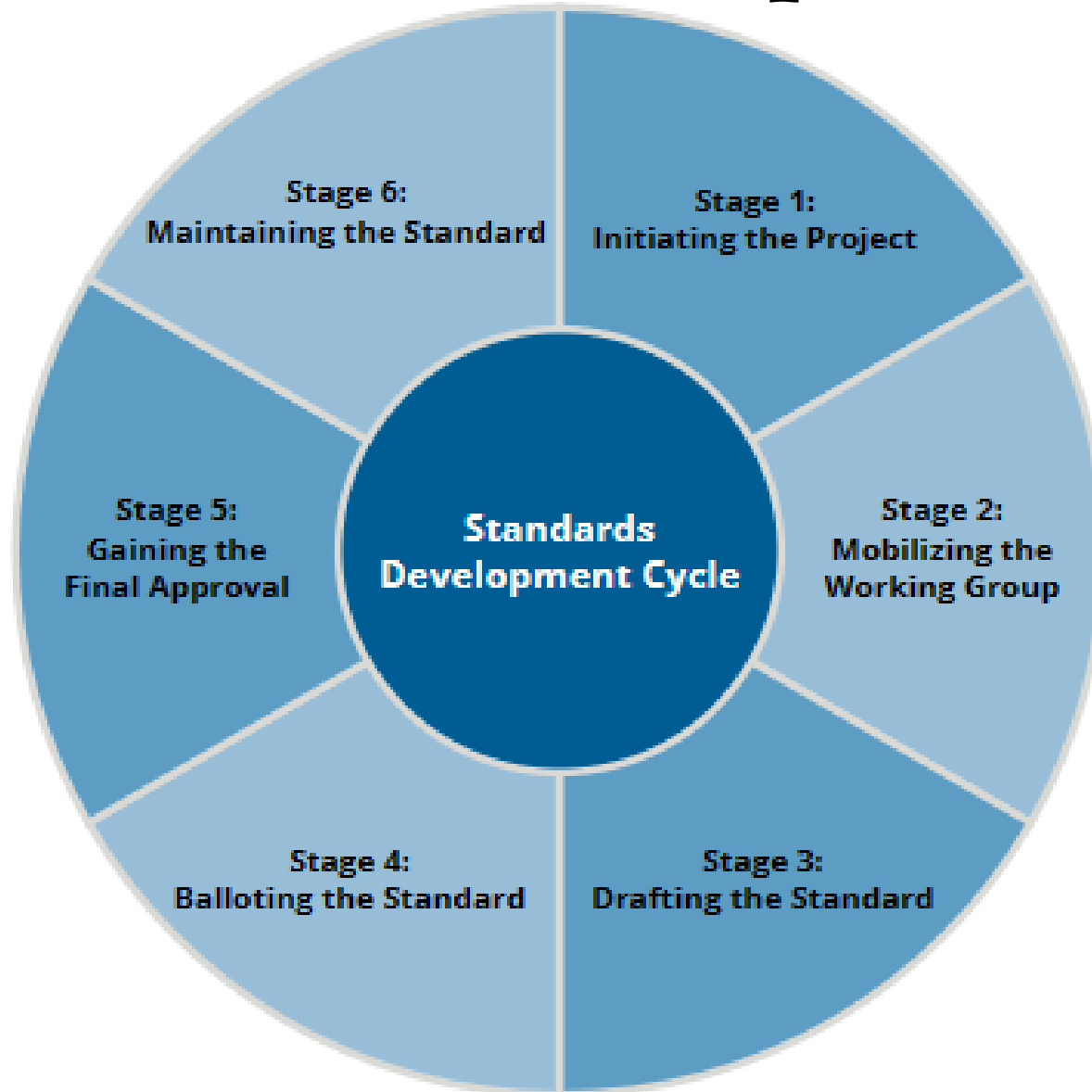
Source: [NATO - Topic: Standardization](#)



# Institute of Electrical and Electronics Engineers (IEEE)

- International technical professional organization (world's largest) dedicated to advancing technology for the benefit of humanity (<https://www.ieee.org>)
- IEEE has a major focus on development of international standards and best practices
- Key M&S products include: High Level Architecture (HLA, IEEE 1516-2010 series), Distributed Interactive Simulation (DIS, IEEE 1278-2012 series), Distributed Simulation Engineering and Execution Process (DSEEP, IEEE 1730-2010 series)

# IEEE Standards Development Life Cycle



Source: [IEEE SA - Developing Standards](#)



# Simulation Interoperability Standards Organization (SISO)

- SISO is an international organization on Modeling and Simulation (M&S) supporting:
  - Exchange of ideas
  - Examination and advancement of technologies and practices
  - Development of standards and other products
    - Working with other standards organizations, such as IEEE and ISO (International Organization for Standardization)
    - SISO standards, guides, reference products

# Central Role of SISO



- NATO and SISO have a formal agreement to collaborate on simulation interoperability standards and best practices
  - Technical Cooperation Agreement established between the NATO Modelling and Simulation Group (NMSG) and the SISO
- SISO is recognized by IEEE as the standardization organization for modelling and simulation, operating under the authority of and in conformance with the processes and procedures of IEEE on specially identified standards and best practices

# Role of SISO for M&S

- SISO goal of activities is to enable greater M&S:
  - Capability
  - Interoperability
  - Credibility
  - Reuse
  - Cost-effectiveness

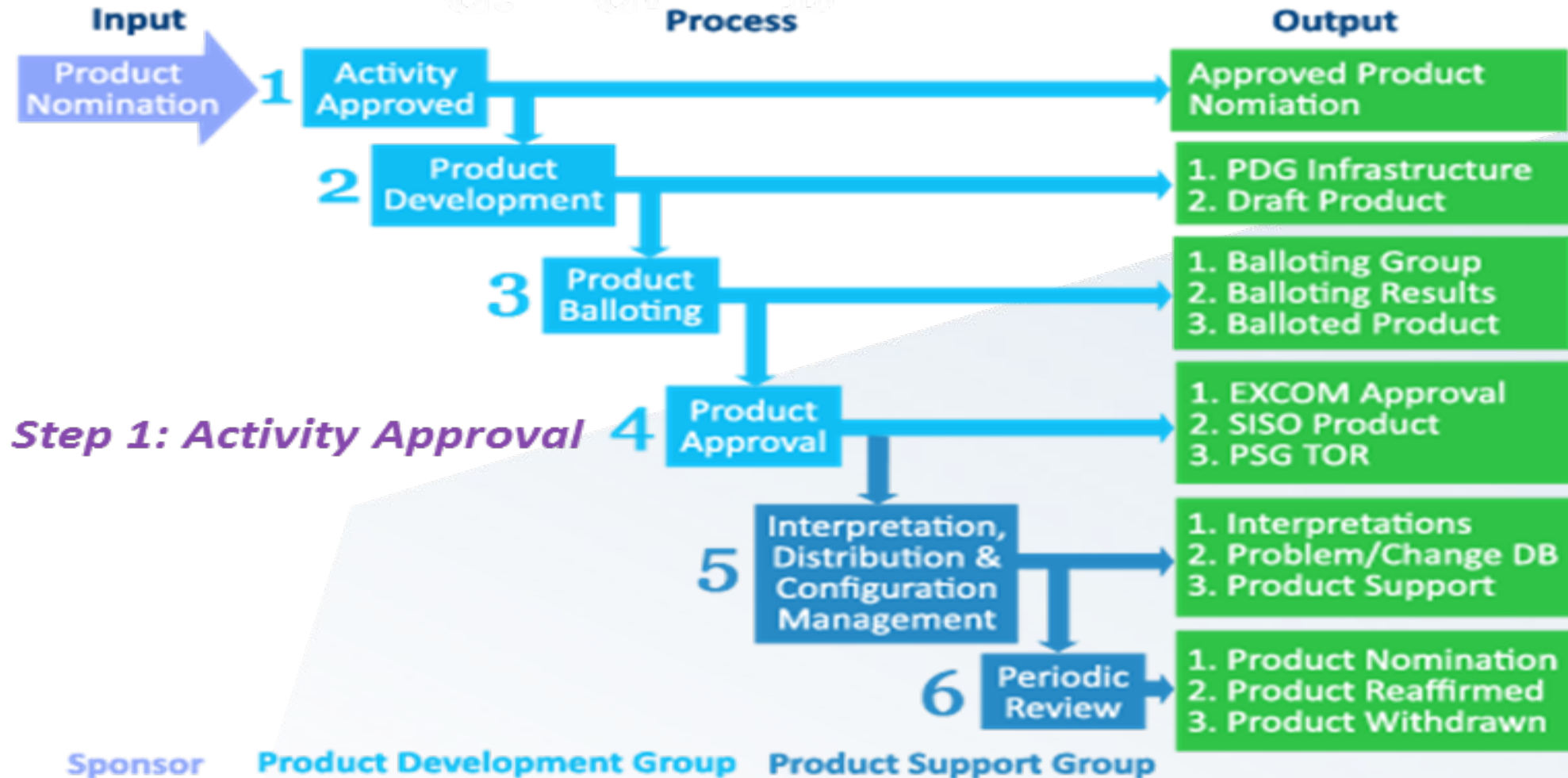
# SISO Standardization Principles

- **Generality:** “Standards Products shall be as general as possible, while still maintaining usefulness, to support the broadest community of current and future users.”
- **Stability:** “Standards Products shall be established and changed only as necessary. They shall be prototyped and tested before being proposed for adoption to demonstrate their maturity.”
- **Supportability** “Standards Products shall maintain the integrity of the existing product suite and the needs of the user.”

Source: <https://www.sisostds.org/ProductsPublications/Standards.aspx>

# SISO Process for Standardization

## Six-Step Process



# C2SIM Product Nomination and Approval

- Step 1 (2014): MSDL and CBML PDGs proposed new C2SIM to (not fully) combine:
  - Military Scenario Definition Language (MSDL) (SISO-STD-007-2008): Initialization of military scenarios using XML schema (element relationships, data types and boundary constraints, business rules of each element and its attribution)
  - Coalition Battle Management Language (C-BML) (SISO-STD-011-2014) language for expressing and exchanging plans, orders, requests, and reports, XML schema for information exchange, defined content and structure
- C2SIM was proposed as a new approach to combine and harmonize both prior standards using formalized semantics (ontology) for specification of the standard

# C2SIM Product Development and Balloting

- Step 2 (2014 - 2020): SISO-C2SIM-PDG developed products:
  - C2SIM ontologies
  - Process and guidelines to use and extend C2SIM
  - Build consensus among the members
- Step 3 (2020): SISO-C2SIM-PDG organized a ballot group:
  - Balance the composition of the ballot group
  - Resolve ballot comments with ballot group members
  - Result: Balloted C2SIM Standard



# Role of NATO MSG-145 in C2SIM

- NATO Modelling & Simulation Group -145 (Operationalization of Standardized C2 Interoperability) formed to:
  - Test the C2SIM standard in Step 2 for different coalitions and use cases
  - Provide input to SISO-C2SIM-PDG
  - Evaluate possibilities to use C2SIM in NATO, e.g. as STANAG

# Role of MSG-145 in C2SIM

- MSG-145 exploited C2SIM with use cases (SISO Guideline on Scenario Development (GSD)):
  - Operational Scenario: defines and models operational needs
  - Conceptual Scenario: represents re-usable abstractions of scenario
  - Executable Scenario: represents executable versions of the scenario and is directly usable for experimentation

# Role of MSG-145 in C2SIM

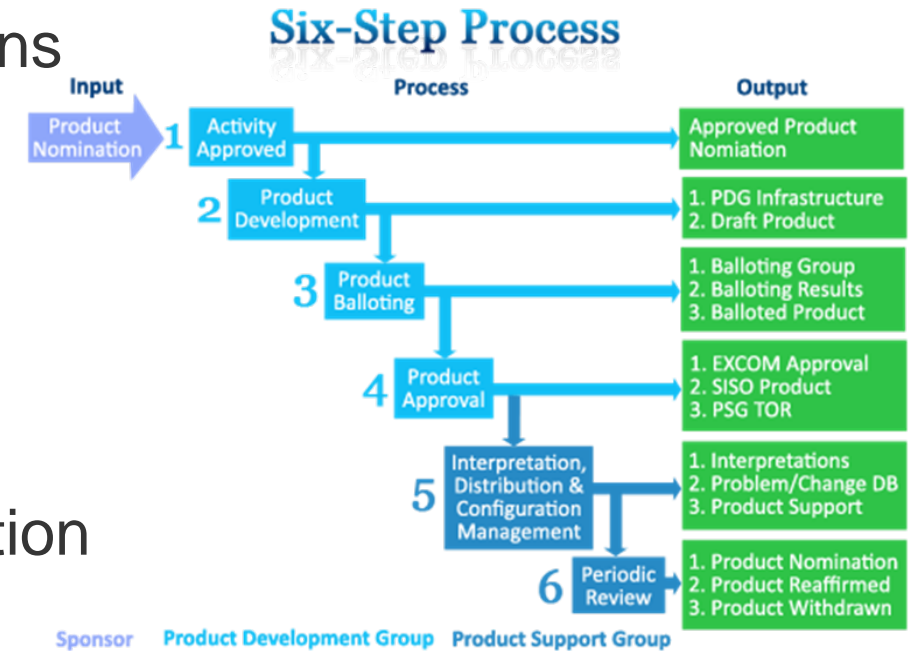
- C2SIM was tested for various use cases:
  - For different coalitions, C2SIM Sandbox (GMU)
  - Across different nations: Italy, USA, Norway, France, Germany, UK
  - For different domains: Land, Air, UAV operations, Cyber Warfare
  - For various application objectives: mission planning, joint mission planning, command post (collective) training, mission rehearsal

# Role of MSG-145 in C2SIM

- Experience with C2SIM led to:
  - Feedback to the SISO C2SIM PDG
  - Assessment of maturity and usefulness of C2SIM (before balloting phase)
  - Assistance to the community with future adoption of C2SIM and with providing C2SIM sandbox for use in early testing
  - Initiation of acceptance as a C2SIM STANAG

# Product Approval for C2SIM (Step 4)

- SISO-STD-019-2020: Standard for Command and Control Systems - Simulation Systems Interoperation
- SISO-STD-020-2020: Standard for Land Operations Extension to Command and Control Systems - Simulation Systems Interoperation
- SISO-GUIDE-010-2020: Guide for Command and Control Systems - Simulation Systems Interoperation



# Current State of C2SIM (1 of 3)

- Step 5: Interpretation, Product Change and Support

- Initiation of a C2SIM Product Support Group (PSG)

- Configuration Management:

- Process for product change

- Problem Reports/Change Requests (PRs/CRs)

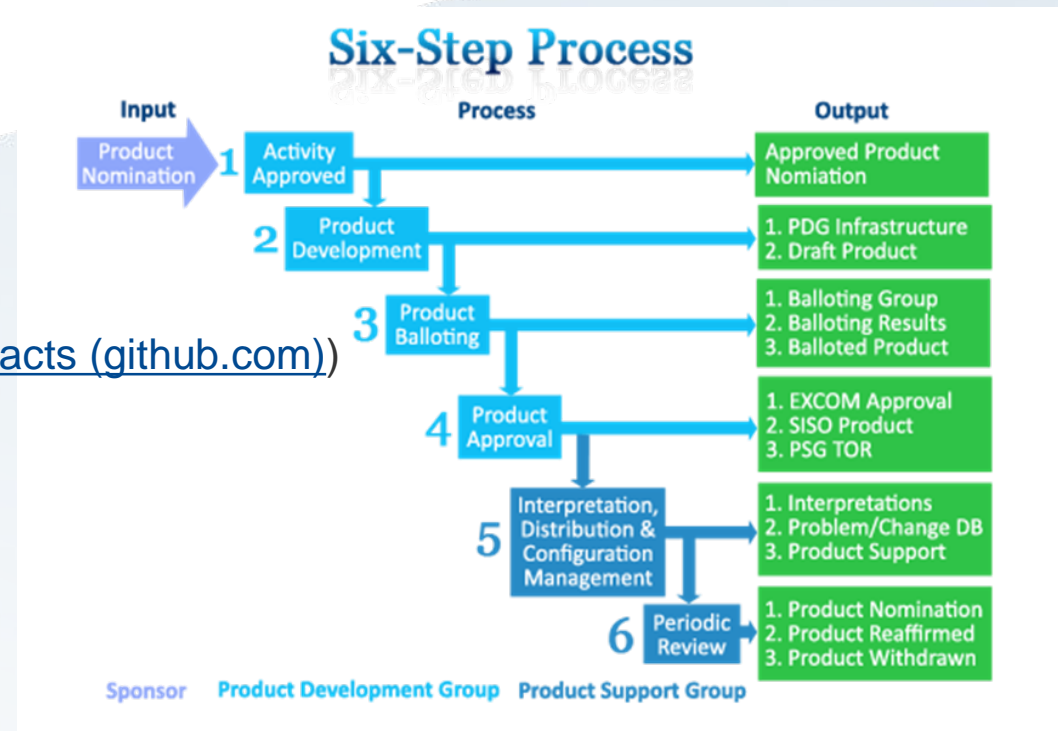
- Template for documenting issues

- Github site ([OpenC2SIM/C2SIMArtifacts: C2SIM Artifacts \(github.com\)](https://github.com/OpenC2SIM/C2SIMArtifacts))

- Document and ontology evaluators

- Ballot for new standard version when necessary

- Outreach and assistance to adopters



# Current State of C2SIM (2 of 3)

- Step 5: Interpretation, Product Change and Support

- C2SIM Ontology Subgroup (COS)

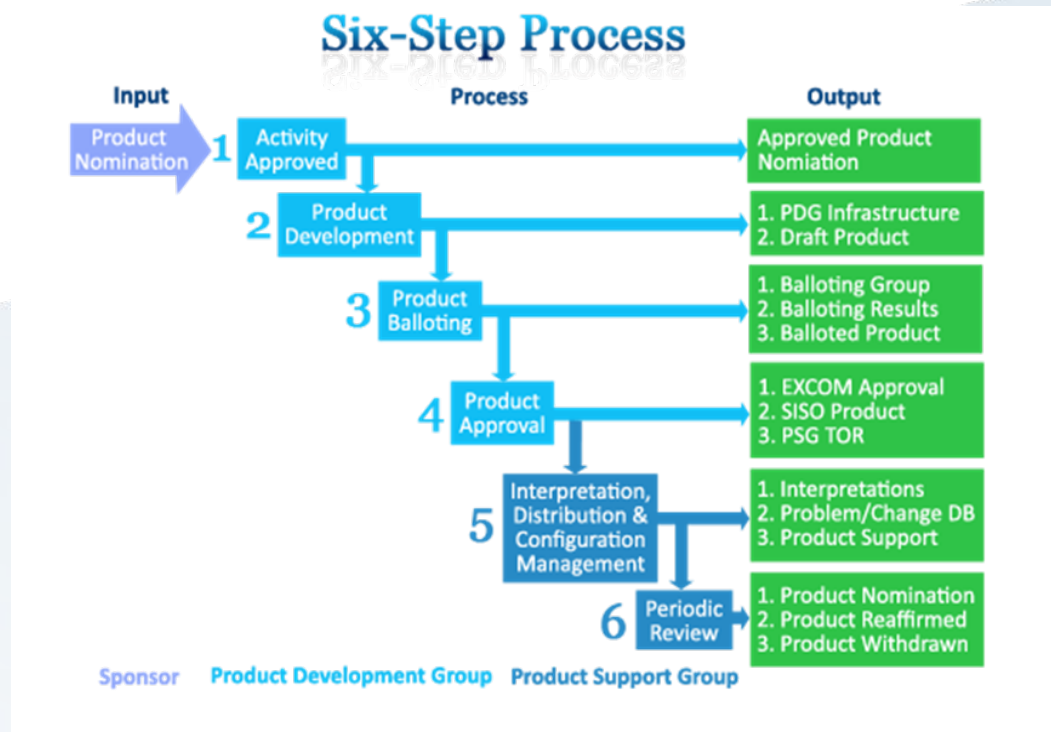
- Improvement and refinement of ontologies
    - Analysis and resolution of PRs/CRs
    - based on COS internal evaluations

- Future extensions

- Cyber Warfare (Blais, 2022a)
    - NETN-FOM (Blais, 2022b)

- Transformation process

- XSLT version (Blais et al., 2019)
    - Alternative (software-based) transformation process (Dembach et al., 2022)

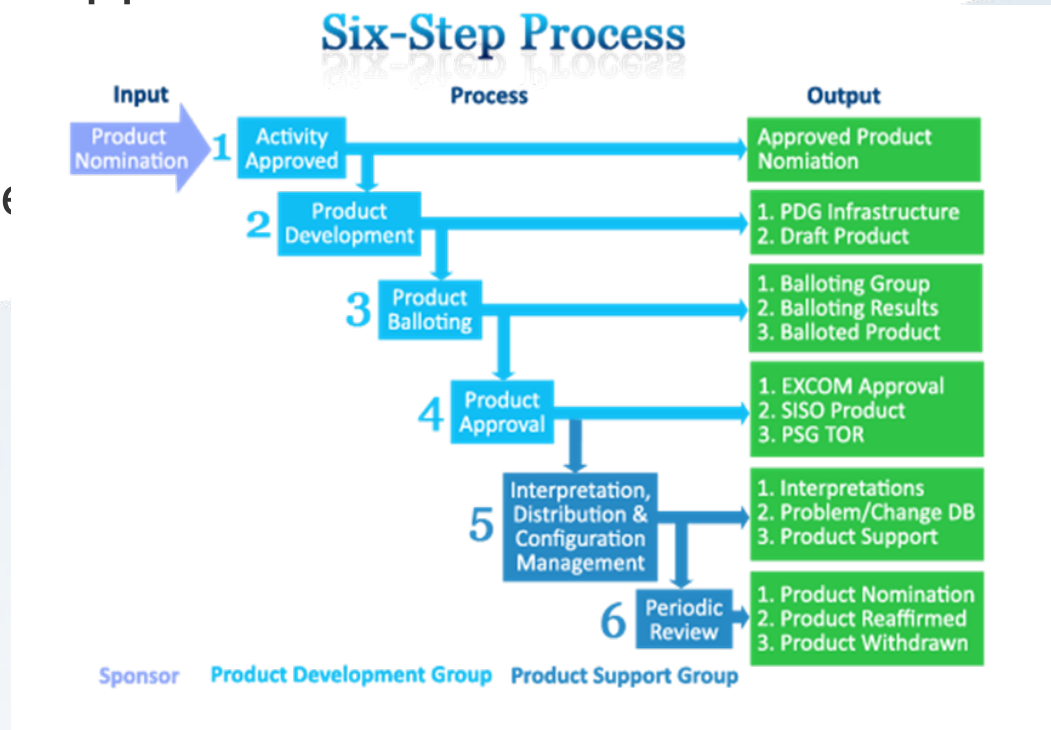




# Current State of C2SIM (3 of 3)

- Step 5: Interpretation, Product Change and Support

- C2SIM Ontology Subgroup (COS)
- Reasoning: utilize implicit information in ontologies
  - technical possibilities
  - ontology adjustments
- Outreach



- Future Step 6: Periodic Review

# SISO-C2SIM for STANAG

- “A Standardization Agreement (STANAG) is a NATO standardization document that specifies the agreement of member nations to implement a standard.”
- STANAG objectives are to support NATO forces and partner forces:
  - Work together effectively and efficiently
  - Share a common set of standards to allow for more efficient use of resources
  - Enhance the effectiveness of the Alliance’s defense capabilities

*Source: [www.nato.int/cps/en/natohq/topics\\_69269.htm](http://www.nato.int/cps/en/natohq/topics_69269.htm)*

# Role of Nato Modeling and Simulation Group in STANAG

- NMSG Vision: “Exploit M&S to its full potential across NATO and the Nations to enhance both operational and cost effectiveness.”
- NMSG is the Delegated Tasking Authority for Standardization in the M&S Domain
- NATO recognizes SISO as a Civil Standards Developing Organization of interest for NATO M&S
  - NMSG promoted adoption of C2SIM into STANAG 4856

Source: <https://nmsg.sto.nato.int>

# C2SIM to Support 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
  - Providing the agility, flexibility and scalability needed to manage the emerging requirements of any mission environment in future NATO operations
  - Improving cost effectiveness
  - Maximizing reuse of existing standards and capabilities
    - “Day Zero” interoperability

# C2SIM to Support NATO FMN Interoperability

- C2SIM provides:
  - Command and control (C2) information exchange support for participants
  - Information interoperability between C2 and simulation systems (among others)
  - Unambiguous data exchange among systems
  - “Train as you fight” in collective and individual training
  - Support to mission rehearsal, operational planning, concept development and experimentation
    - Aligns with FMN objectives

# Implementation of C2SIM into FMN

FMN **GOVERNANCE** sets objectives, defines the regulatory framework and environment (rules, procedures, policies, standards etc.).

Reports back

Incorporates adjustments

Management Level translates strategies and plans into action by Federated Mission Networking Affiliates.



Source: [https://www.act.nato.int/images/stories/events/2015/fmn/fmn\\_02.png](https://www.act.nato.int/images/stories/events/2015/fmn/fmn_02.png)

# Implementation into FMN

- FMN Spiral approach leads to:
  - Development cycles focus on close interaction with users (better, faster, lower cost)
  - “Plan-a-little/build-a-little/test-with-users/rethink-results“ and start a new spiral
  - Interoperability architecture, standards profile, instructions
  - Better results than traditional military acquisition

Source: Pullen (2021)



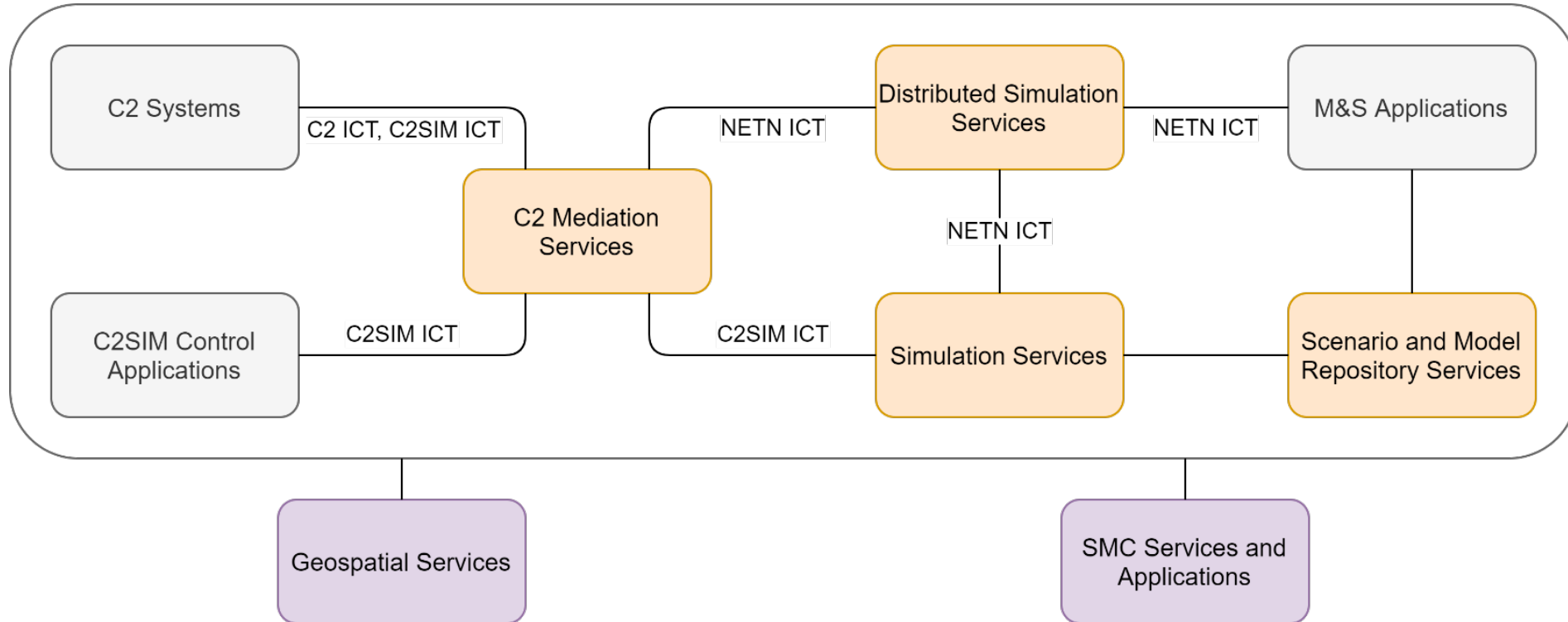
# NMSG-193: Modelling and Simulation Standards in Federated Mission Networking (FMN)

- Syndicate for M&S for Mission Rehearsal to include capability into FMN spiral 5
- Provided documents due to FMN requirements:
  - Mission Thread
  - Procedural Instructions
    - Context: Capability Need
    - Operational Environment
    - Interoperability Architecture
    - Standards (C2SIM, HLA, MSaaS, etc)

# NMSG-193: Modelling and Simulation Standards in Federated Mission Networking (FMN)

- Service Instructions describe:
  - Services
  - Service architecture
  - Data Properties
  - Reference to standards

# 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

# NMSG-201: Modelling and Simulation in Federated Mission Networking (FMN)

- Provide evidence that M&S standards work for FMN
- Annual CWIX (Coalition Warrior Interoperability Exercise):
  - Test and develop interoperability between deployable national and NATO Communication and Information Systems in a coalition environment

Source: [CWIX 2021-Improving Interoperability for Day Zero Readiness! :: JFTC - NATO](#)

# NMSG-201: Modelling and Simulation in FMN

- Coalitions and federations implemented according to FMN Service Instructions (different simulation systems, C2 surrogates)
- Use Case: Mission Rehearsal
- System experts for C2 and Simulation Systems across different nations
- Interoperability using standards (C2SIM, NETN-FOM, HLA) to share information across systems

# CWIX 2023 Outcome

- Evidence that M&S works for Mission Rehearsal
  - Capability
  - Interoperability
  - Credibility
  - Reuse
  - Cost-effectiveness

# CWIX 2023 Outcome and Future

- Feedback to SISO-C2SIM-PDG/PSG/COS
  - PRs/CRs
  - Investigation of extensions to the standard
- Plans to participate at CWIX 2024 to test further use cases (Collective Training, Decision Support)
- Include new capabilities (crawl, walk, run approach)



# Summary

- The complexity of the FMN system-of-systems architecture requires application of standards
- M&S standards are laying the groundwork for interoperation of C2 systems and simulation systems, with promise for including even more classes of systems
- M&S standards are providing the opportunity to exploit benefits of M&S for military readiness and planning/conduct of military operations
- NATO works closely with international standards organizations to identify, select, and apply the best available standards to advance technical and operational capabilities



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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' with the subtitle 'SCIENCE AND TECHNOLOGY ORGANIZATION'. Below this, there are two smaller article thumbnails. The first thumbnail shows a satellite and is titled 'NATO STO hosts wargame on Space Deterrence ...'. The second thumbnail shows a person in a futuristic setting and is titled '2023 COLLABORATIVE Programme of Work Report ...'.

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- Standard documents:

<https://www.sisostds.org/Default.aspx?tabid=105&EntryId=51761>

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- FMN: <https://www.act.nato.int/activities/fmn>
- SISO documents: <https://www.sisostds.org/AboutSISO/Overview.aspx>
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