NORTH ATLANTIC TREATY ORGANISATION

RESEARCH AND TECHNOLOGY ORGANISATION

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RTO TECHNICAL REPORT **TR-MSG-058**

Conceptual Modeling (CM) for Military Modeling and Simulation (M&S)

(Modélisation conceptuelle (MC) pour la modélisation et la simulation (M&S) militaires)

Final Report of MSG-058.

Published July 2012

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- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

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List of Acronyms

ACIMS	Arizona Center for Integrative Modeling and Simulation
AF	Argumentation Framework
AMRDEC	Aviation and Missile Research, Development and Engineering Center
AV	All View
BCI	BOM Component Implementations
BOM	Base Object Models
BPGS	Best-Practice Guidance Specification
BPMN	Business Process Modeling Notation
C2IEDM	Command and Control Information Exchange Data Model
C-BML	Coalition Battle Management Language
CBML	Cell Behavior Markup Language
CIM	Computation Independent Model
CM	Conceptual Model, Conceptual Modeling
CML	Conceptual Modeling Language
CMMI	Capability Maturity Model Integration
CMMS	Conceptual Model of the Mission Space
COI	Critical Operational Issues
CONOPS	Concept of Operation
COTS	Commercial-Off-The-Shelf
CSDP	Conceptual Schema Design Procedure
CWM	Part of SWAP – Semantic Web Application Program
DAML	DARPA Agent Markup Language
DCMF	Defence Conceptual Model Framework
DEVS	Discrete-Event Systems
DMWG	Data Modeling Working Group
DoD	Department of Defense
DoDAF	DoD Architecture Framework
DSEEP	Distributed Simulation Engineering and Execution Process
EA	Enterprise Architecture
ER	Entity Relationship
ERM	Entity Relationship Modeling
FEDEP	Federation Development and Execution Process
FEDEX	Federation Execution
FFI	Norwegian Defence Research Establishment
FOI	Swedish Defence Research Agency
FORML	Formal Object-Role Modeling Language
GM	Generic Methodology
GM-V&V	Generic Methodology for Verification, Validation
HLA	High Level Architecture
HPKB	High Performance Knowledge Base Program
IDEF	Integration Definition for Function Modeling
IEC	Infomentum Classification Engine

IEEE	Institute of Electrical and Electronics Engineers
INCOSE	International Council on Systems Engineering
IR	Information Retrieval
ISDEFE	Ingenería de Sistemas para la DEFensa de España
ISO	International Organization for Standardization
IST	Information System Theoretic
JC3IEDM	Joint Command Control Communications Information Exchange Data Model
KA	Knowledge Acquisition
KE	Knowledge Elicitation
KIF	Knowledge Interchange Format
KM3	Kernel Meta Meta Model
KRS	Knowledge Representation System
M&S	Modeling and Simulation
MDA	Model-Driven Architecture
MOF	Meta Object Facility
MSCO	Modeling and Simulation Coordination Office
MSG	Modeling and Simulation Group
MSM	Mission Space Model
MSMP	Modeling and Simulation Master Plan
NAF	NATO Architecture Framework
NATO	North Atlantic Treaty Organisation
NDAG	NATO Data Administration Group
NLIAM	Natural Language Information Analysis Method
NIST	National Institute of Standards and Technology
NMM	NAF Meta-Model
NMSG	NATO Modeling and Simulation Group
OCL	Object Constraint Language
OIL	Ontology Interface Layer
OKBC	Open Knowledge Base Connectivity
OMG	Object Management Group
ORM	Object-Role Modeling
OV	Operational View
OWL	Web Ontology Language
OXL	Ontology Exchange Language
PA	Process Activity
PfP	Partners for Peace
PIM	Platform Independent Model
POC	Point Of Contact
PP	Process Phase
PSM	Platform Specific Model
RDECOM	Research, Development, and Engineering Command
RDF	Resource Description Framework
RPR	Real Platform Reference
RTG	Research Technology Group
RTO	Research and Technology Organisation
RUP	Rational Unified Process

SCAMPI	Standard CMMI Appraisal Method for Process Improvement
SEI	Software Engineering Institute
SES	Senior Executive Service
SISO	Simulation Interoperability Standards Organization
SME	Subject Matter Expert
SSDD	System Simulation and Development Directorate
SV	System View
SysML	Systems Modeling Language
TAP	Technical Advisory Panel
TG	Task Group
TOR	Terms of Reference
TS	Technical Standards
UML	Unified Modeling Language
V&V	Verification and Validation
VEA	Microsoft® Visio® for Enterprise Architects
VV&A	Verification, Validation and Accreditation
W3C	World Wide Web Consortium
XMI	XML Metadata Interchange
XML	Extensible Markup Language

MSG-058 Participating Members

Jan-Jelle Boomgaardt *is a senior scientist concerned with Modeling & Simulation at TNO Defence, Security and Safety. He has some 9 years of experience in the field of applied research. The main focus of his research has been on distributed simulation architectures, such as the High Level Architecture (HLA). The M&S field of expertise is supported by his previous 7 years of experience in computer architectures and software engineering.*

Mircea Cernat *was born in Romania, in 1957. He finished the PhD studies in 1996 with the thesis entitled "Study of the solid propellant burning chambers under dynamic loading". He is the Deputy Director for Science at Military Equipment and Technologies Agency, Bucharest (http://www.acttm.ro/en/index.html). Since 1987 he worked in positions linked to education and research, being entitled professor at Military Technical Academy in Bucharest since 2001. In 2006, he graduated the National Defence College and has been involved in several projects linked to defence and security since then. Since 2009 he is also a senior researcher succeeding to manage or to contribute as member in research Groups to several projects regarding weapon systems technology and aerospace engineering. His research topics are focused on applied mathematics to weapon systems and structural mechanics. Since 2005 he has been mandated to represent Romania as voting member in NATO Modeling and Simulation Group (NMSG).*

Nathalie Harrison *is a defence scientist at Defence R&D Canada – Valcartier since 2000. She works in the Electro-Optical Warfare Section where she develops and uses Modeling and Simulation (M&S) processes and tools to study engagements between military platforms, guided weapons and countermeasures. She received a Bachelor's degree in Engineering Physics from Laval University (Quebec, Canada) in 1998. She also received a Master's degree in Electrical Engineering from the same university for her research on virtual reality cryosurgery simulation and modeling of heat transfer in human tissues. Her research interests include: physics-based modeling; verification and validation process and techniques; model exchange; software engineering applied to M&S; Conceptual Modeling and Model-Driven Architecture applied to M&S; and simulation frameworks and synthetic environments.*

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Arne C. Jenssen *is a senior scientist with the Norwegian Defence Research Establishment (FFI). He has received BEng, MSc and PhD degrees in electrical engineering. He has been working with test and evaluation in a naval context for the last decade. These activities comprise substantial efforts in modeling and simulation for evaluation of torpedo and missile defence capabilities.*

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Jeroen Voogd *is a member of the scientific staff at the Modeling & Simulation and Gaming Department of TNO Defence, Security and Safety Division. He holds a Ph.D. in Computational Physics from the University of Amsterdam in the field of modeling and simulating (M&S) of biophysical systems on parallel and distributed computing platforms. A recurring theme in his work of the last years is the quality of simulations. This includes verification and validation of M&S assets, as well as quality assurance within TNO.*

William F. Waite *is co-founder and Chairman of The AEgis Technologies Group, Inc., where he directs a staff involved in a wide variety of modeling and simulation (M&S) activities including simulation technologies evolution; simulation systems development; simulation verification, validation, and accreditation; simulation-based studies and analyses; and the development of hardware and software products supporting modern M&S practice. He has more than 30 years of professional involvement in all phases of the M&S life cycle and its application to systems engineering lifecycle. Mr. Waite is currently active in the evolution of the M&S profession, industry, and market. He is also engaged in the further discovery and invention of M&S business practice, emphasizing M&S employment in business enterprise operations.*

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Stakeholders
Standards

14. Abstract

The objectives of the Task Group (MSG-058) include: 1) Clarify the "Conceptual Model" concepts, discuss the terminology, and emphasize the utility to better formalize conceptual models; 2) Investigate methodologies, simulation and software engineering processes, initiatives and technologies useful for the establishment of conceptual models; 3) Identify the relevant stakeholders of conceptual models; 4) Address the needs of M&S community, identifying the way conceptual models may contribute to M&S development, and provide guidance to implementation; 5) Provide guidelines for standards in conceptual modeling for M&S; thereby specifying a conceptual model to be (re)usable by users with similar knowledge; 6) Draft a guidance document on conceptual models that can be used by different stakeholders; and 7) Foster the establishment of the guidance document as a SISO standard.

This document is intended to serve as best-practice prescriptive guidance for the life cycle management of conceptual modeling in support of modeling and simulation effort within the NATO M&S enterprise. Subsequently, the contents of this document are expected to serve as a basis of evolution of conceptual modeling throughout the international M&S community of practice by virtue of its influence upon further international standards.

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