National Defence / Défense nationale

ASSISTANT DEPUTY MINISTER (SCIENCE AND TECHNOLOGY) / LE SOUS-MINISTRE ADJOINT (SCIENCE ET TECHNOLOGIE)

Director General Air Force and Navy (DGSTAN) / Le directeur général de la Force aérienne et la Marine (DGSTAM)

"In Silico"

Dale F. Reding

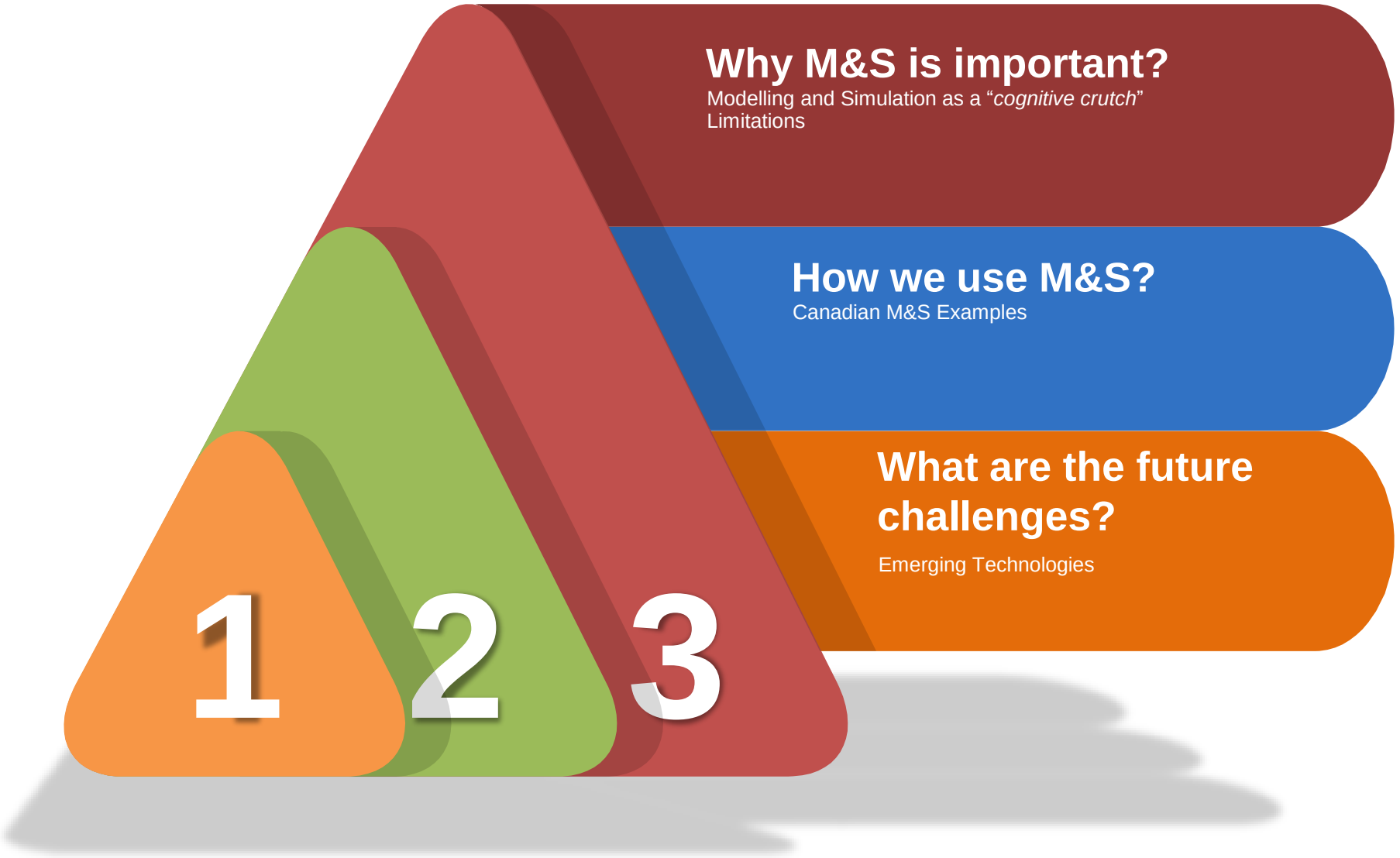
Director General - S&T Air Force and Navy (DGSTAN) /
Le directeur général de la Force aérienne et la Marine (DGSTAM)

Defence Research and Development Canada /
Recherche et développement pour la défense Canada

October 16 2018

Canada

0.1 OUTLINE



Why M&S is important?

Modelling and Simulation as a "*cognitive crutch*"
Limitations

How we use M&S?

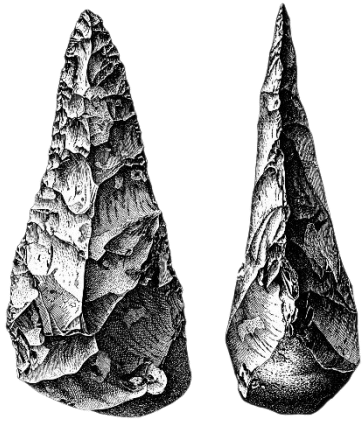
Canadian M&S Examples

What are the future challenges?

Emerging Technologies

1.1 Homo Sapien Technologicus

Stories, Games & Tools



- **We are challenged to understanding <u>complex</u> and <u>complicated</u> (human-information-physical) systems**
  - Employ reductive and narrative tools; simplified models/games; explore options and act accordingly

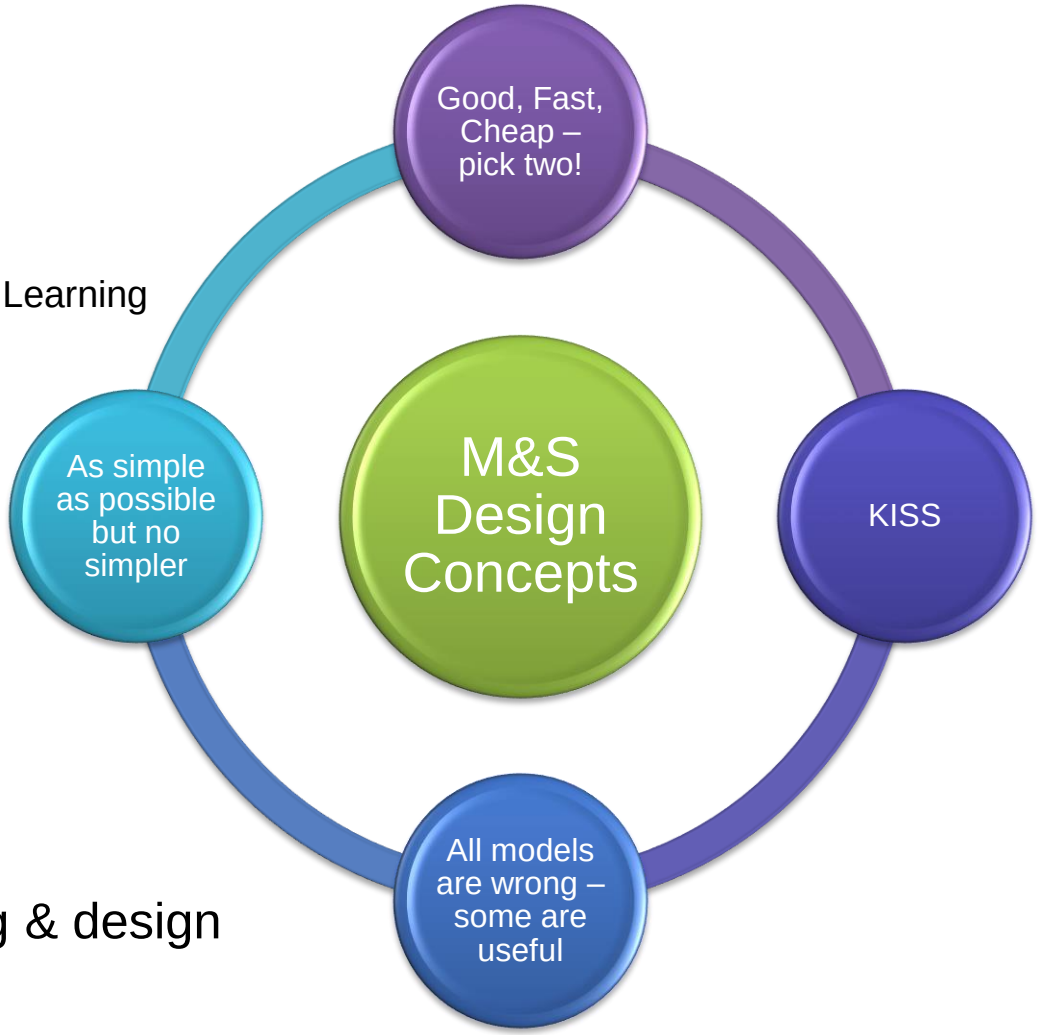
Decision processes

- "*The **slowness of our thinking** and the **small amount of information** that we can process at any one time, our tendency to protect **our sense of competence**, the **limited inflow** capacity of our memory, and our tendency to focus only on **immediately pressing problems** – these are the simple causes of the mistakes we make in dealing with complex systems*."
  - Dietrich Dörner, The Logic of Failure (1989)

Failure	Success
Changing Priorities	Define Goals
Information Overload	Model
Reductive Hypotheses	Predict / Extrapolate
Delayed Feedback	Act (Plan and Execute)
Linear Extrapolation	Feedback & Revise
Contradicting Goals	

1.2 Challenges

- Decision Making
  - {reduce costs, optimize, control, improve, manage risks}
  - Explainability
- Expandability
- Increased complexity
- Fidelity
- Reality of LVC
  - Omission; Negative Transfer; Negative Learning
  - Not as good as real?
  - Cost versus complexity
  - LVC balance
- Reuse / KM
- Ways and mean
  - As a service / In the cloud
  - Networked
  - Interoperability
- “Care and feeding”
- CFD and FEA
  - e.g. advanced manufacturing & design
- New Technologies



2.1 STRONG. SECURE. ENGAGED.

Simulation and modelling will be instrumental in achieving these goals!

STRONG AT HOME

- Enhanced air and maritime surveillance and control, including Arctic
- Concurrent response to multiple domestic emergencies
- Support to counter-terrorism
- Search and rescue support
- Looking after our people

SECURE IN NORTH AMERICA

- Modernize NORAD
- Expanded aerospace and maritime domain awareness and control
- Cutting edge defence innovation

ENGAGED IN THE WORLD

CAF prepared to concurrently deploy:

- 2 major sustained deployments
- 1 major time-limited deployment (6-9 months)
- 2 minor sustained & 2 minor time-limited deployments
- 1 Disaster Assistance Response Team (DART) mission
- 1 Non-combatant Evacuation Operation

NEW INITIATIVES

Putting our People First

- New **Total Health and Wellness Strategy**
- Reinvented **transition of ill and injured** to service/civilian life
- **Tax relief** for deployed operations
- Taking care of **Families**
- **Integrate GBA+** and meet **gender** & **diversity** targets
- **Increase of 3,500 Regular Force** for key priorities
- **Increase of 1,500 Reserve Force** – full-time capability, part-time force
- **Increase of 1,150 civilians** to support operations

Investing in the Future Force

- **Invest** additional $62B for capital expenses to $104B
- Rebuild **core capabilities**: **88** fighter aircraft, **15** surface combatants, **2** joint support ships, **6** Arctic offshore patrol ships
- Increase emerging capabilities in **cyber**, **space**, and **remotely piloted vehicles** to maintain effectiveness and interoperability with allies
- Capability enhancements, including **intelligence, satellite communications**, **surveillance** and **logistics vehicles**

Modernizing the Business of Defence

- A **transformative innovation agenda** with defence research clusters linked to procurement
- More accountable, transparent, and streamlined **defence procurement** process
- **Reduced carbon footprint** through green infrastructure and focus on energy efficiency
- Modernized **infrastructure management** through expanded partnership with the private sector

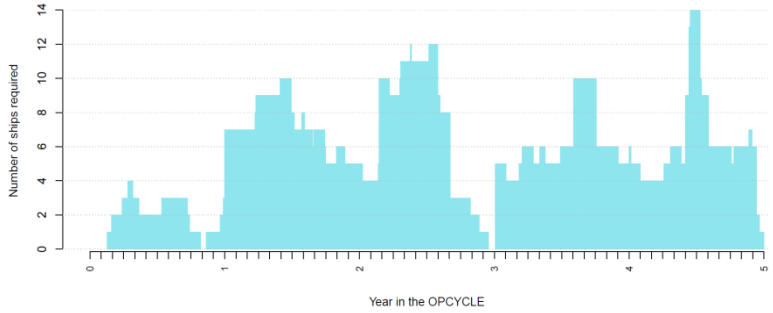
2.2 Canadian Surface Combatant (CSC)

Fleet Options

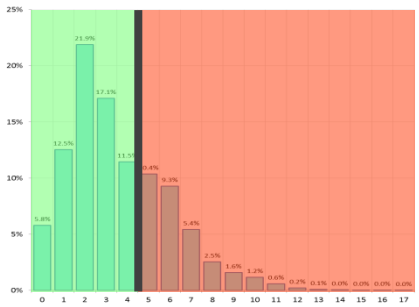
- **Objective**:

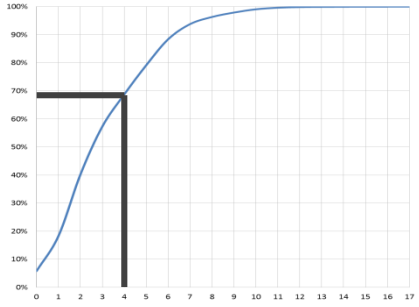
  To provide evidence and insight into **CSC fleet size** and how it affects the **operational output** of the fleet and the ability to meet **expected demand**

Potential Future



Operational Demand





Supply over Demand

Number of Ships in Fleet	Months at High Readiness / OPCYCLE														
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
20	68.8%	72.2%	75.7%	79.1%	82.2%	85.3%	88.4%	90.2%	92.0%	93.8%	94.6%	95.5%	96.3%	96.8%	97.4%
19	66.5%	70.0%	73.2%	76.5%	79.7%	82.7%	85.6%	88.5%	90.2%	91.9%	93.6%	94.5%	95.3%	96.1%	96.7%
18	64.2%	67.6%	70.8%	73.9%	77.0%	80.0%	82.8%	85.6%	88.4%	90.0%	91.6%	93.2%	94.3%	95.1%	95.8%
17	61.9%	65.1%	68.4%	71.3%	74.3%	77.2%	80.0%	82.7%	85.3%	87.9%	89.6%	91.2%	92.7%	94.0%	94.7%
16	59.6%	62.6%	65.7%	68.8%	71.5%	74.3%	77.0%	79.7%	82.2%	84.7%	87.1%	89.1%	90.5%	92.0%	93.4%
15	57.3%	60.2%	63.0%	65.9%	68.8%	71.3%	73.9%	76.5%	79.1%	81.4%	83.7%	86.1%	88.4%	89.7%	91.1%
14	53.9%	57.7%	60.4%	63.0%	65.7%	68.4%	70.8%	73.2%	75.7%	78.1%	80.3%	82.5%	84.7%	86.8%	88.7%
13	50.5%	54.2%	57.7%	60.2%	62.6%	65.1%	67.6%	70.0%	72.2%	74.5%	76.7%	78.9%	81.0%	83.0%	85.0%
12	47.0%	50.5%	53.9%	57.3%	59.6%	61.9%	64.2%	66.5%	68.8%	70.8%	72.9%	75.0%	77.0%	79.1%	81.0%
11	43.6%	46.8%	49.9%	53.0%	56.2%	58.6%	60.7%	62.8%	64.9%	67.0%	69.1%	71.0%	72.9%	74.8%	76.7%
10	40.2%	43.1%	45.9%	48.8%	51.6%	54.5%	57.3%	59.2%	61.1%	63.0%	64.9%	66.8%	68.8%	70.5%	72.2%
9	35.8%	39.1%	41.9%	44.5%	47.0%	49.6%	52.2%	54.7%	57.3%	59.0%	60.7%	62.5%	64.2%	65.9%	67.6%
8	31.5%	34.4%	37.3%	40.2%	42.5%	44.8%	47.0%	49.3%	51.6%	53.9%	56.2%	58.1%	59.6%	61.1%	62.6%
7	27.1%	29.6%	32.2%	34.7%	37.3%	39.8%	41.9%	43.9%	45.9%	47.9%	49.9%	51.9%	53.9%	55.9%	57.7%
6	22.7%	24.9%	27.1%	29.3%	31.5%	33.6%	35.8%	38.0%	40.2%	41.9%	43.6%	45.3%	47.0%	48.8%	50.5%

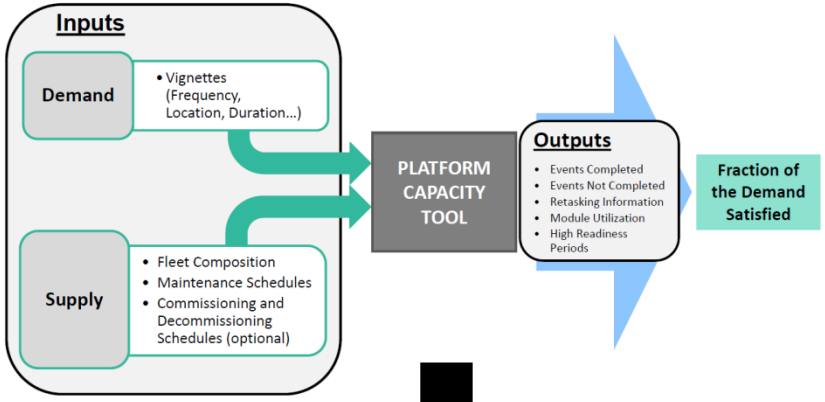
2.3 Impact of the Maritime Coastal Defence Vessels

Fleet Sizing

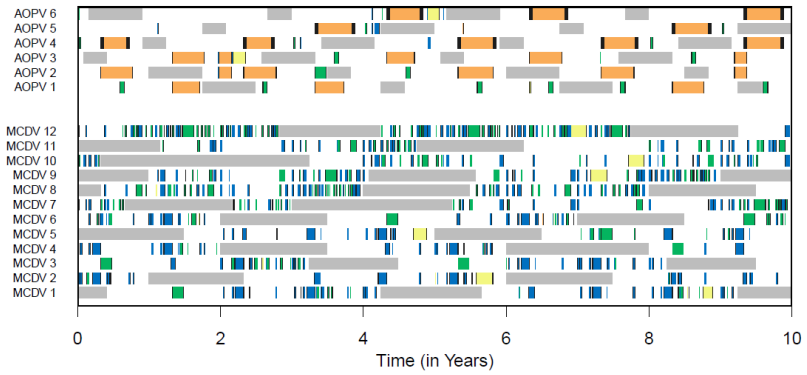
- **Objective**:

  To assess the effectiveness of an RCN Force Structure **with** and **without the MCDVs** and to **quantify the gap** and impact of losing the 12 MCDVs on **operational output**

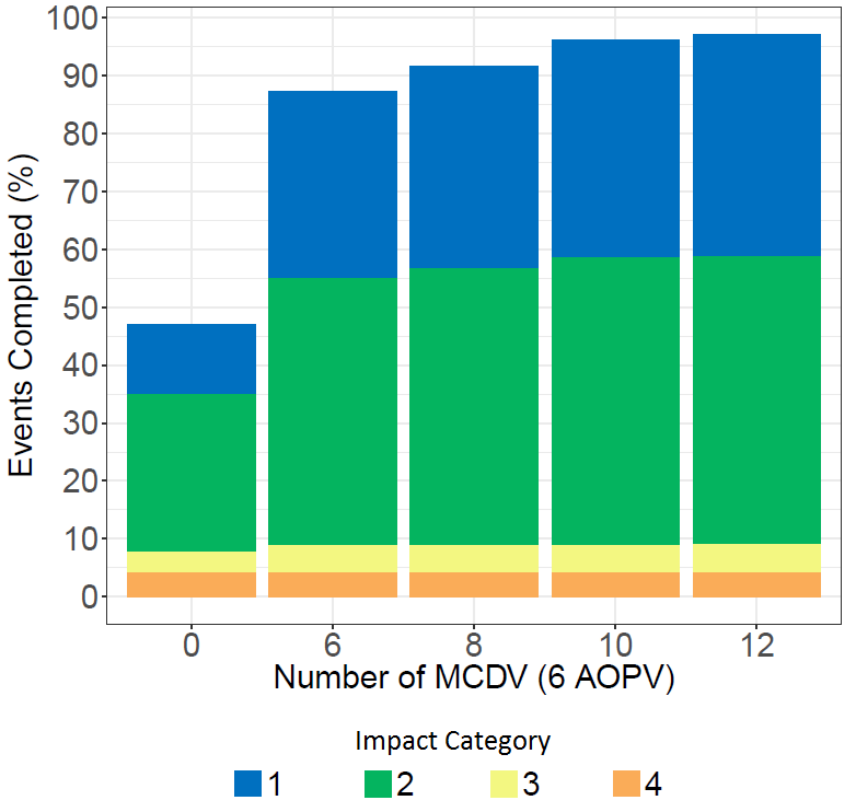
Discrete-Event Simulation



Scheduling



Operational Demand Satisfied

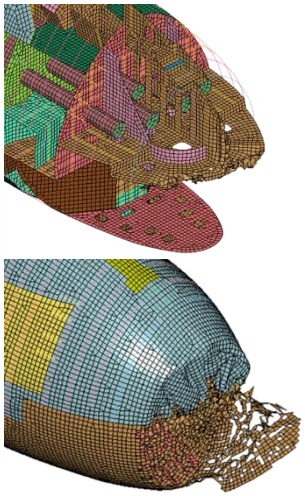


2.4 Ship Design and Acquisition

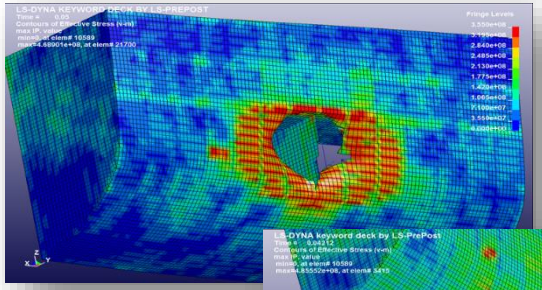
- **Arctic Patrol Vessel**
  - Experiments and numerical simulations strongly influenced design, including utilization of active stabilizer fins

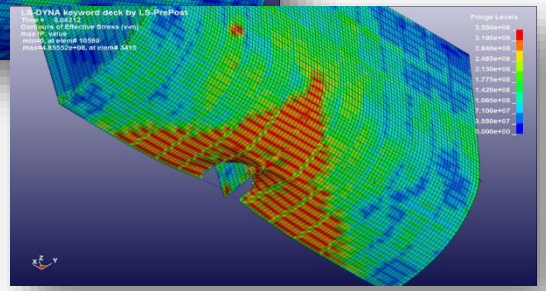
- **MV Asterix**
  - M&S applied to ensure safe integration into naval operations

- **Submarine Collision Modelling**



- **Response to Hostile Threats**



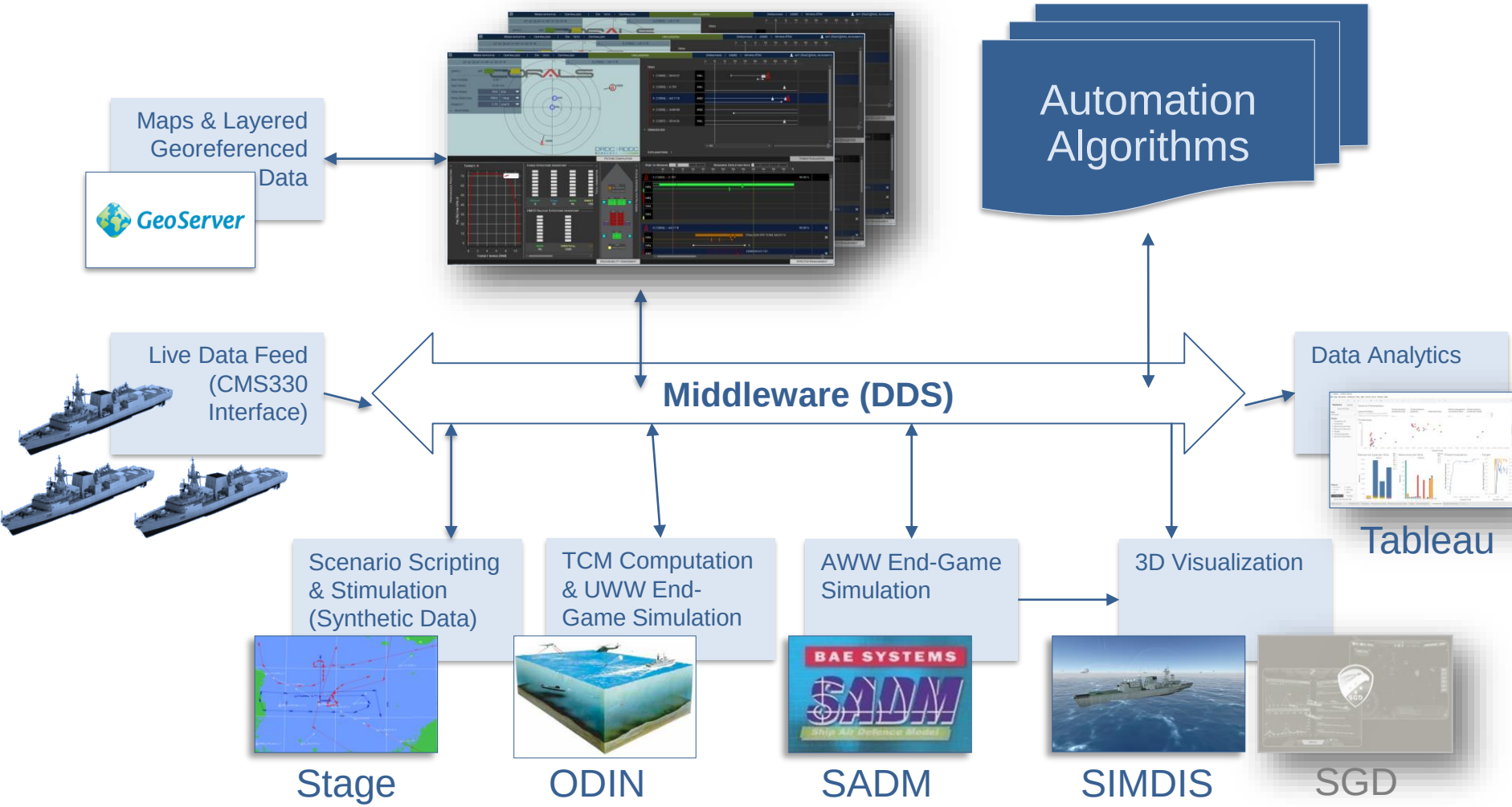


2.5 SHOLAS

Ship-Helicopter Operational Limits Analysis and Simulation

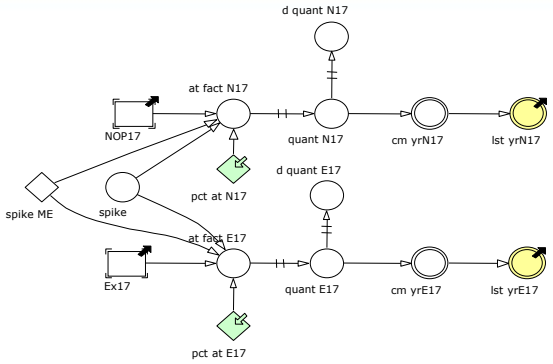
- Royal Canadian Navy & Air Force operate helicopters in Sea State 6
  - 4 to 6 m significant wave height
- Aerodynamic effects significantly contribute to the challenges
- Modelling and simulation is being used to support safe flying activities
  - Improve flight simulators for training and testing during shipboard operations
- Apply SHOLAS tools for helicopters to future UAS acquisitions and certification
- Allow ship design optimization through the use of virtual reality and flight simulation tools
  - e.g. Joint Support Ships

2.6 Naval Battle Management Lab

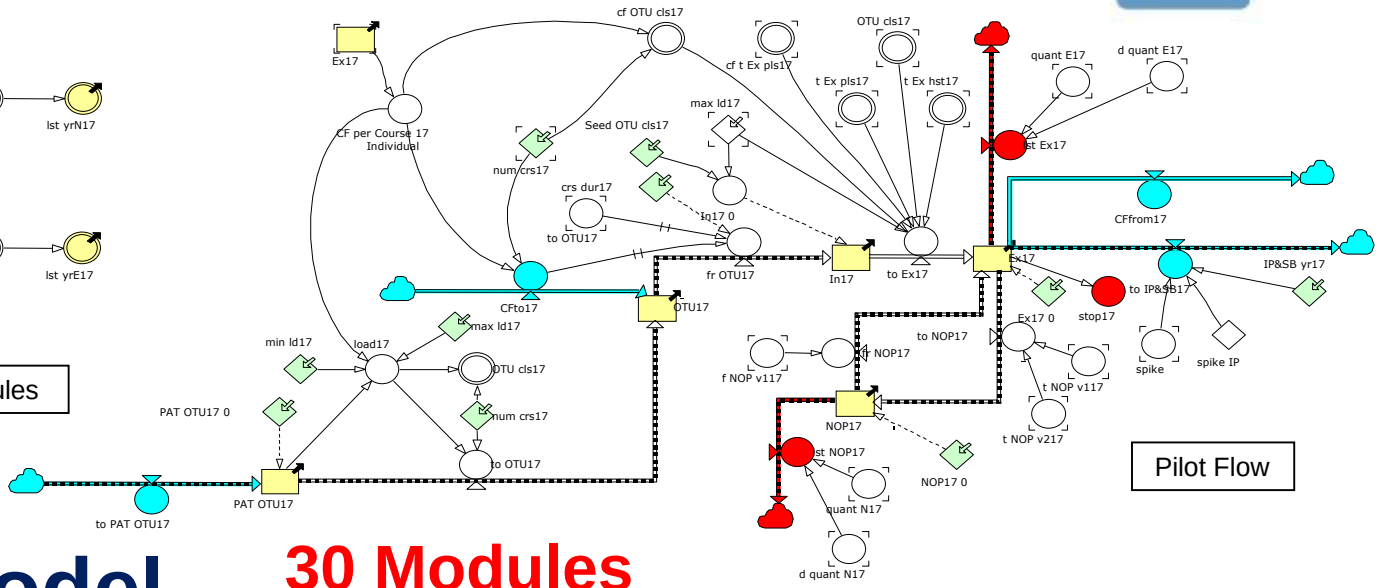


2.7 PARSim:

Pilot Production Absorption Retention Simulation



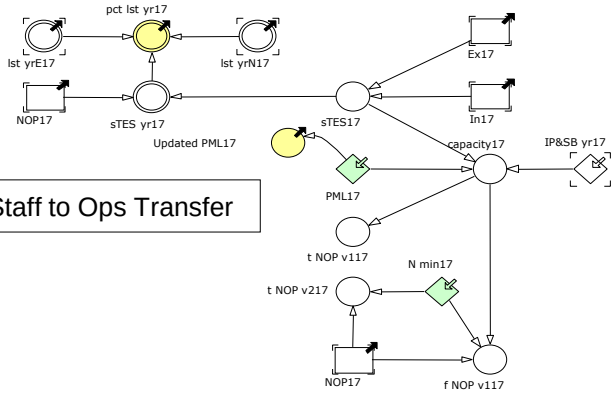
Attrition & Recovery Control Modules



Pilot Flow

Fleet sub-model

30 Modules



Ops to Staff to Ops Transfer

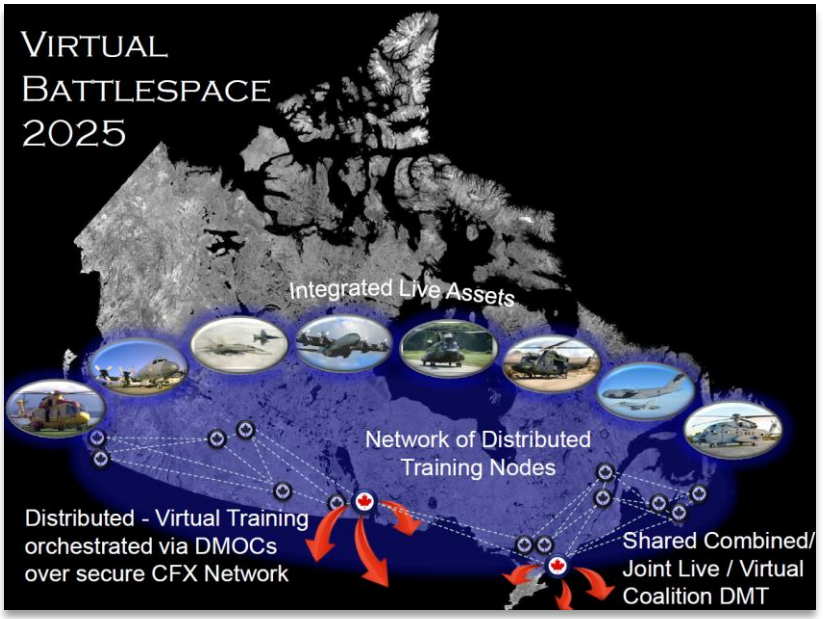
A options test bed:

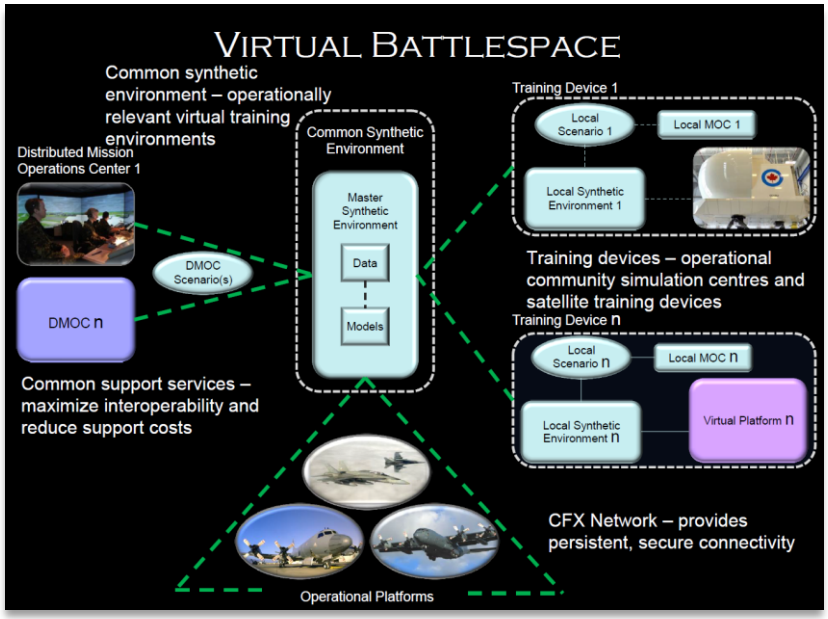
- Pilot training options
- Pilots transfers
- Platform replacement (Fighter)
- Platform introduction (Strat lift)
- Feeder fleet (Light Helo to Heavy Helo)
- Splitting fleet (Light Helo & Spec Ops)

2.8 RCAF Simulation Strategy

Training

- **Vision**
  - By 2025, the RCAF will have a simulation focused training system, leveraging live, virtual, and constructive (LVC) domains within a networked common synthetic environment





- **Ways and Means**
  - Networked and Common Services
  - Increased Interoperability and reduced support costs
  - Operational community simulation centres and satellite training devices

2.9 EO/IR Virtual Proving Ground (VPG)

"Integrated M&S"

- A system-of-systems based on high-fidelity simulations to optimize self-defence against EO/IR-guided threat systems to improve force protection and combat effectiveness in high threat environments.
- The current technical challenges in EW are:
  - Threat diversity, complexity, variability & inconsistency
  - Off-the-shelf self-protection systems ≠ off-the-self protection
  - Countermeasures are lagging behind the threats

PIRATES

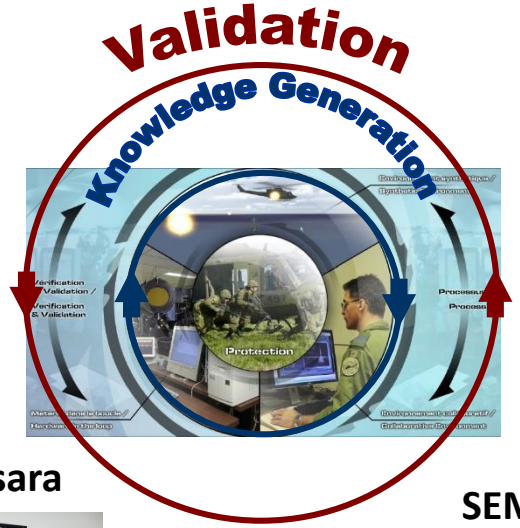
Harfang

Signature Measurement

Live simulation (field trials)

Karma

Virtual and constructive simulation



HFI

VTS

Samsara

Signal injection

HIL Simulation

MWS

SEMAC

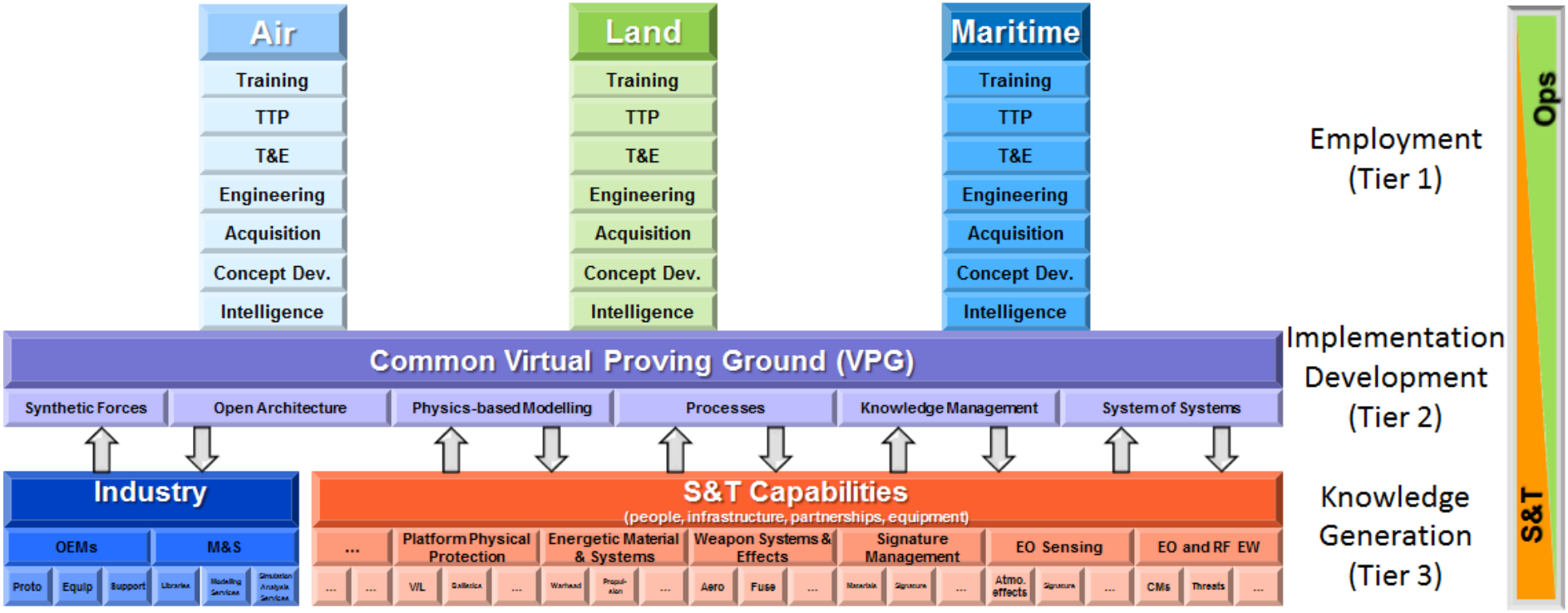
ASPECT

Scene projection

2.10 VPG Development & Implementation

Evolving Concept as a CAF "Value Proposition"

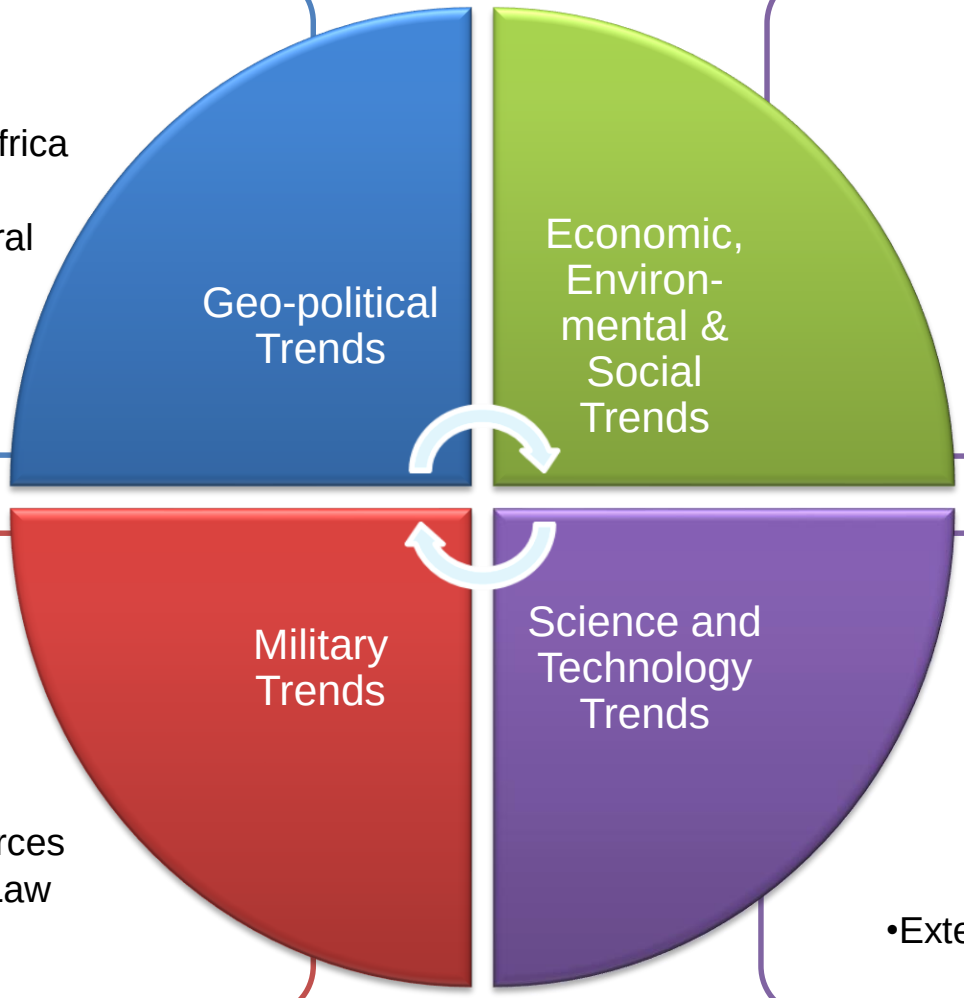
- Based on M&S technology to capture knowledge into executable models
- Integrated answer at a level of language significant and useful to the CAF operators



3.1 Increasingly Complex Security Environment:

2013 - 2040

- Major Global Powers
- Global and Regional Influencers
- Middle East & North Africa
- Arctic Powers
- Alliances & Multi-Lateral Organizations
- Potential for Instability



- Globalization
- Economic Trends
- Environment
- Social Trends
- Demographics

- Historical Trends
- Future Armed Conflict
- Non-State Actors
- Flexibility
- Capabilities ⇔ Resources
- Future Conflict & the Law
- Future Operating Environment

- Globalization of S&T
- Affordability of Technology
- Additive Manufacturing
- Socio-technical Networks
- Cloud Computing
- Evolving Sensing & Analysis Technologies
- Extensions of the Human Frontier
- Technological Surprise

3.2 Emerging Technologies

S&T TRENDS

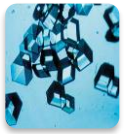
- Affordability
- Cloud Computing
- Globalization of S&T
- Technological Surprise
- Additive Manufacturing
- Socio-Technical Networks
- Extension of the Human Frontier
- Sensing & Analysis Technologies
- Commercial Space

Cyber

Advanced Materials & Stealth Technologies

Quantum Science

Big Data



Biotechnologies

Advanced Information & Communication Technologies

Human Systems, Augmentation and Neuroscience

Advanced Sensors and ISR

Artificial Intelligence & Autonomous Systems

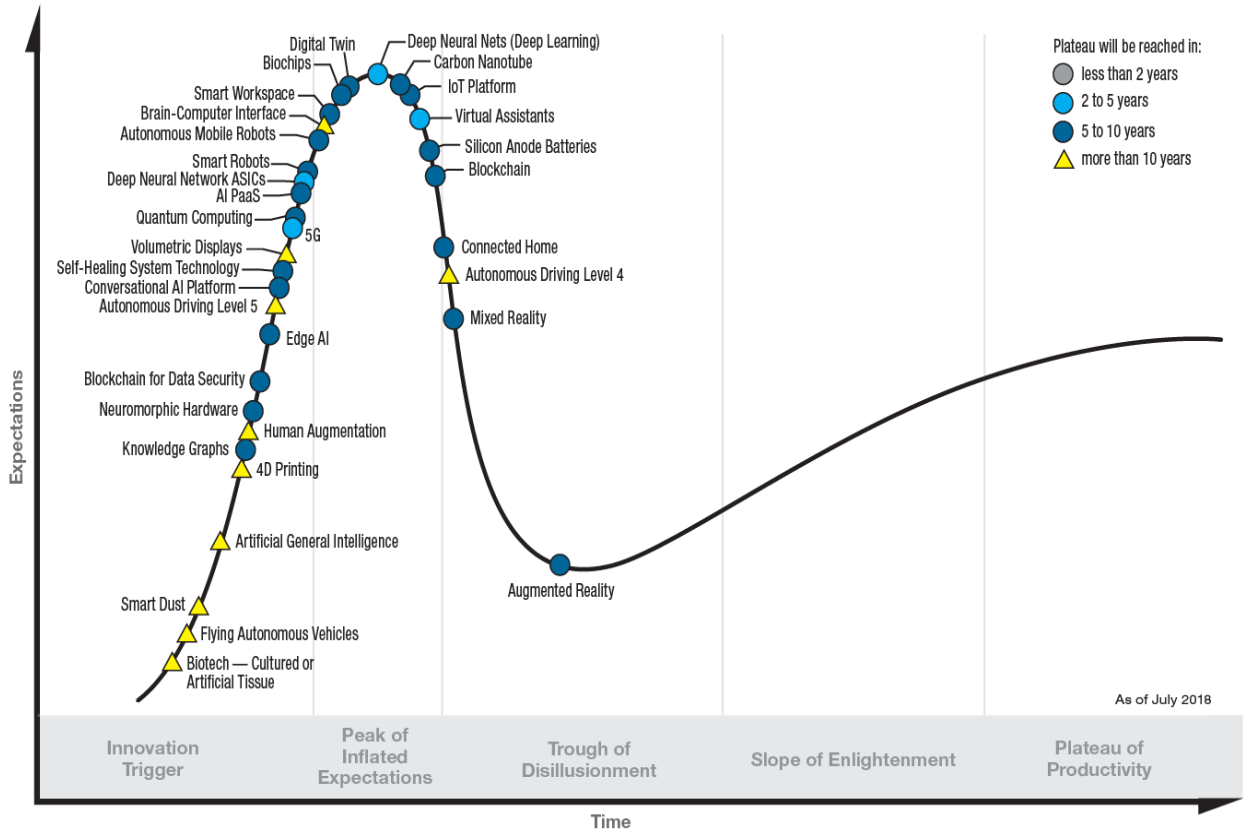
Advanced Weapons

Resilient Additive Manufacturing

Power and Energy

Human – Information – Physical Domains

3.3 Emerging M&S Opportunities & Challenges



gartner.com/SmarterWithGartner

Gartner

Human augmentation

Autonomy

Conversational AI

Quantum Computing

Deep Neural Networks

Brain-Computer Interfaces

Smart Workspace

Digital Twin

Virtual Assistants

Mixed Reality

Augmented Reality

Neuromorphic Hardware

Advanced Manufacturing / 4D Printing

Predictive Analytics

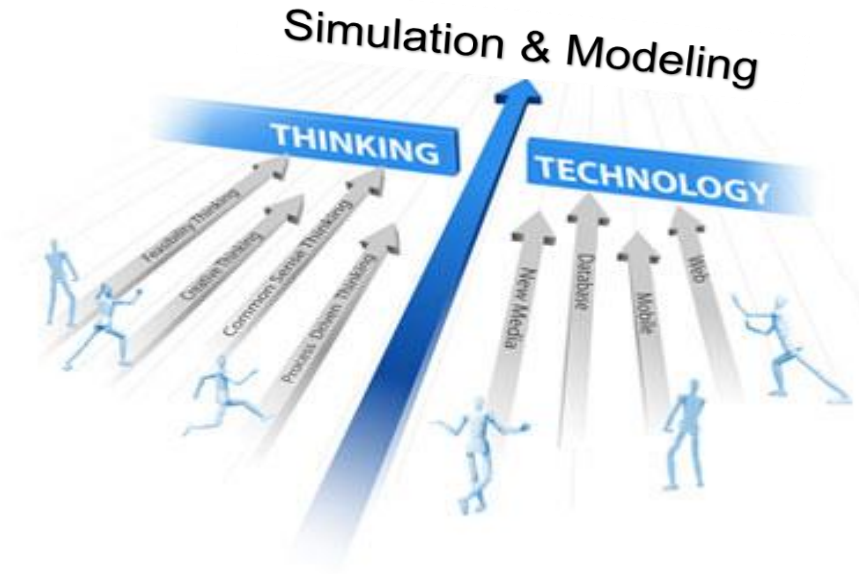
Virtual Reality

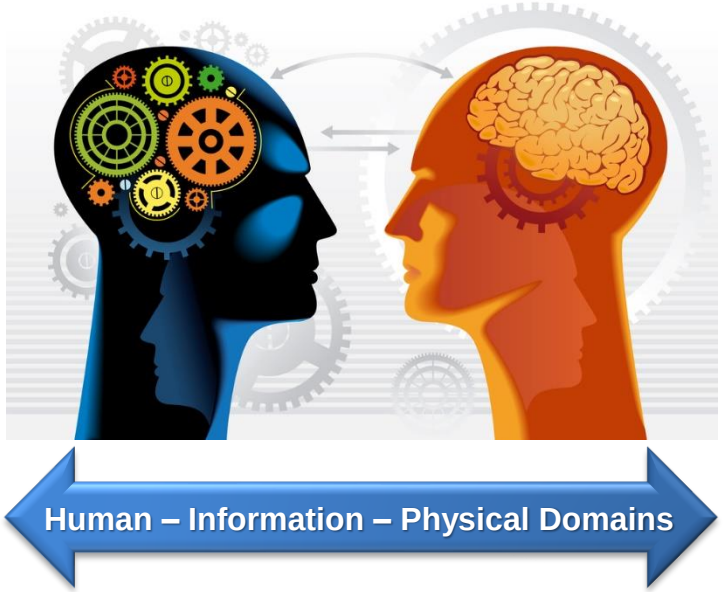
Advanced Materials

Cyber vulnerabilities

4.0 Summary

- **Common themes and challenges**
  - Changing strategic environment
  - Translation of emerging technologies to effective M&S capabilities and modeling the impact of these technologies on concepts, doctrine and operations
  - Explainable M&S
  - Complex & complicated systems
  - Ethical, legal and policy frameworks
  - Emerging Technologies & Environments





- **Key S&T Areas**
  - AI / Big Data
  - Quantum Computing
    - Algorithms
  - Autonomy
  - Human Systems
  - Cyber

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