

# M&S support to operationalization of NATO principles of responsible use of AI

NMSG Symposium 2022

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# Outline

1. **M&S in NATO**
2. **AI in NATO**
3. **M&S and NATO principles of responsible use of AI**
4. **Explainability Use Case**
  - **JANES and Data Set**
  - **Four different AI models**
5. **Conclusion**

# M&S in NATO

- **NATO AAP15 (2019)**
  - “A discipline that develops and/or uses models, simulations and simulation systems.”

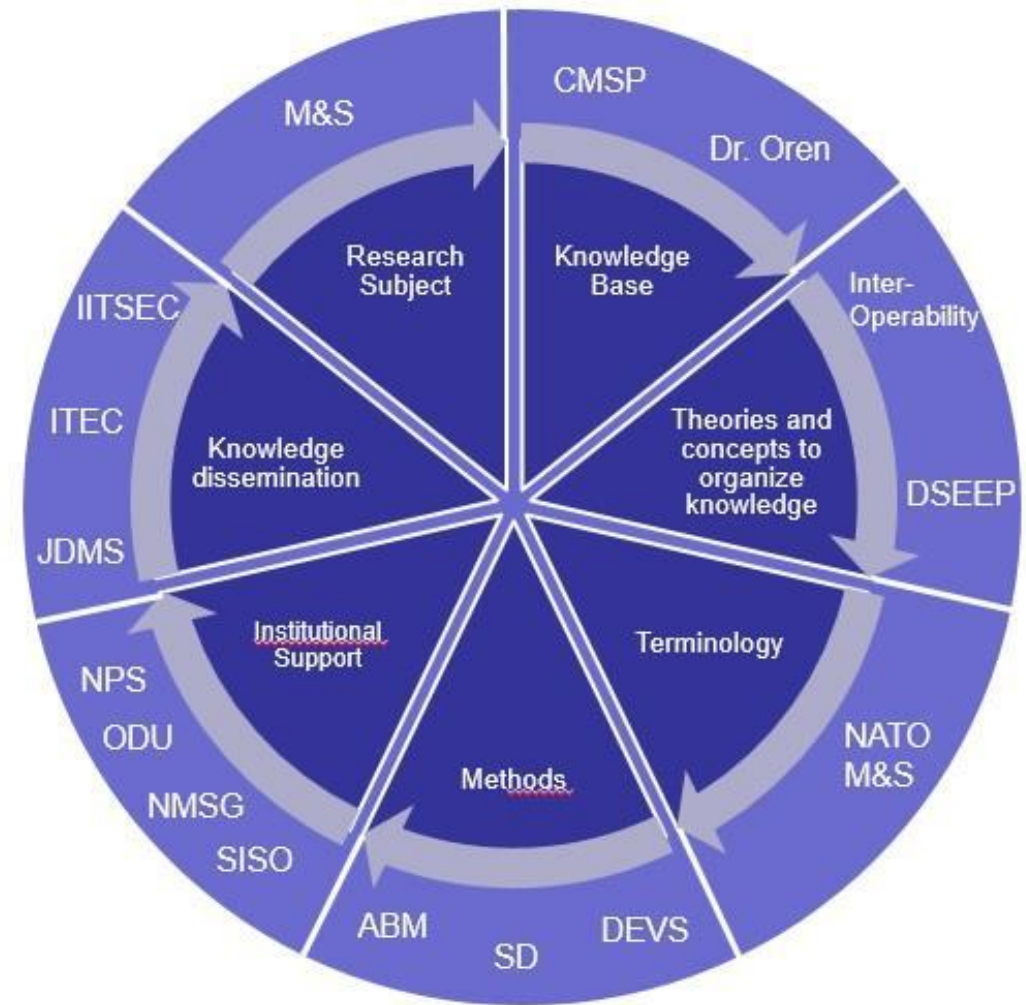
## M&S applications      NATO M&S organization

- Training and Education
- Capability Development
- Support to Operations
- Mission Rehearsal
- Procurement

- ACT JFD MSLT
- JWC, JFTC
- STO NMSG
- CMRE

## NATO M&S Related Capability Programmes

- Nex Gen of NATO M&S
- Audacious Wargaming
- PM- ADM



# AI in NATO

- **NATO AI Strategy (2021)**

- “The ability of machines to perform tasks that typically require human intelligence.”

## AI tasks

- Pattern recognition
- Learning from experience
- Drawing conclusions
- Making predictions
- Taking action

## Related body and activities

- NATO IS Emerging Security Challenges
- Data Exploitation Framework Strategic Plan
- Alliance Data Exploitation (DE) use cases
- NIAG Study

## NATO Principles of Responsible Use

- Lawfulness
- Responsibility and accountability
- Explainability and traceability
- Reliability
- Governability
- Bias mitigation

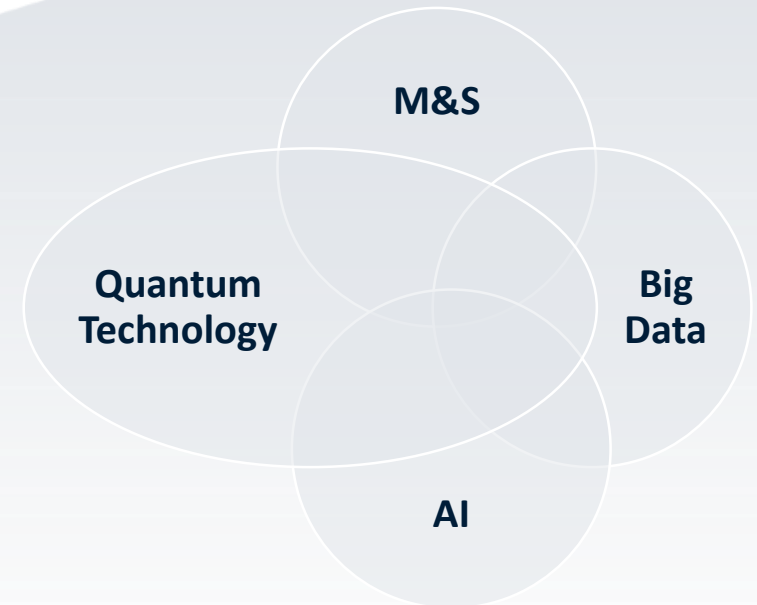
# M&S and NATO principles of responsible use of AI

- **M&S can help to**
  - understand principles
  - operationalize principles
  - check compliance with principles

Modelling of context

Simulation Based Experimentation

Verification and Validation



# Explainability Use Case

## ▪ Motivation

- Use modelling to “overcome black box behaviour” of AI driven solutions.

## ▪ Project presumption for explainability

- Different stakeholders require explanations for different purposes and with different objectives, and explanations needs to be tailored to their needs.

## Users

- NAC
- ACO/ACT
- JFC

## Purpose: Study relation between

- power index score of each nation
- quality of military capabilities
- percentage of gross domestic product (GDP) spent in military budget

## AI based classification

- power index helps to define threshold for classification

# Power index – Global Firepower Ranking

- **Black box Nations evaluation**

- “The finalized Global Firepower ranking below utilizes over 50 individual factors to determine a given nation's PowerIndex (PIV) score with categories ranging from military might and financials to logistical capability and geography.”

- **PIV = (0..1)**

- where 0 means the best score and 1 means the worst score

## Available at:

- <https://www.globalfirepower.com>

# DataSet and Pre-processing

- **21 types of military capabilities + financial indicators from JANES**
  - Color codes: from “Black” meaning no capability up to “Green” meaning sufficient capability
  - Converted and normalized ~ (0..1)
- **and**
  - Total Defense Budget (TDB)
  - Percentage of gross domestic product (GDP)
- **and**
  - PIV score of 31 nations
    - Collected and normalized

## Classification threshold

- PIV Average value of NATO nations = 0.2659

$$Fit4Purpose_{Nation_j} = \begin{cases} 1, & \text{if } Nation_j(PIV) < 0.2659 \\ 0, & \text{otherwise} \end{cases}$$



# DataSet Types

MC <sub>i</sub>	Military Capability (MC)	Capability Domain
1	Air-to-Air Warfare	Air Defence
2	Ground Based Air Defence	Air Defence
3	Maritime Anti-Air Warfare	Air Defence
4	Offensive Air Support	Fire Support
5	Indirect Fire	Fire Support
6	Naval Surface Fire Support	Fire Support
7	Air (Space) Recon	ISR
8	Ground Recon	ISR
9	Maritime Surveillance	ISR
10	Aerial Refuelling	Logistics
11	Airlift	Logistics
12	Maritime Transport	Logistics
13	A SuW – Airborne	Anti-surface Warfare
14	A SuW – Surface	Anti-surface Warfare
15	A SuW- Submarine	Anti-surface Warfare
16	ASW – Airborne	Anti-Submarine Warfare
17	ASW – Surface	Anti-Submarine Warfare
18	ASW- Submarine	Anti-Submarine Warfare
19	Armoured Warfare	Direct Ground Combat
20	Infantry Ops	Direct Ground Combat
21	Combat Engineering	Direct Ground Combat
22	Total Defence Budget - TDB	Financial
23	Gross Domestic Product % – % GDP	Financial
24	Global Firepower Ranking	PIV Score from website
25	Fit4Purpose	Label generated for Classification purpose based on the threshold value (0.2659)

# Four AI models with different level of details

- 1) **Neural Network Classification with All Features in DataSet for Baseline comparison**
- 2) **Explainability by Linear Regression (LR) - All Features in Dataset for Operational Level User**
- 3) **Explainability by Linear Regression (LR) - Domain-Based Features for Strategic Level User**
- 4) **Explainability by Linear Regression (LR) - Fully Aggregated Military Capabilities and %GDP for Political Level User**

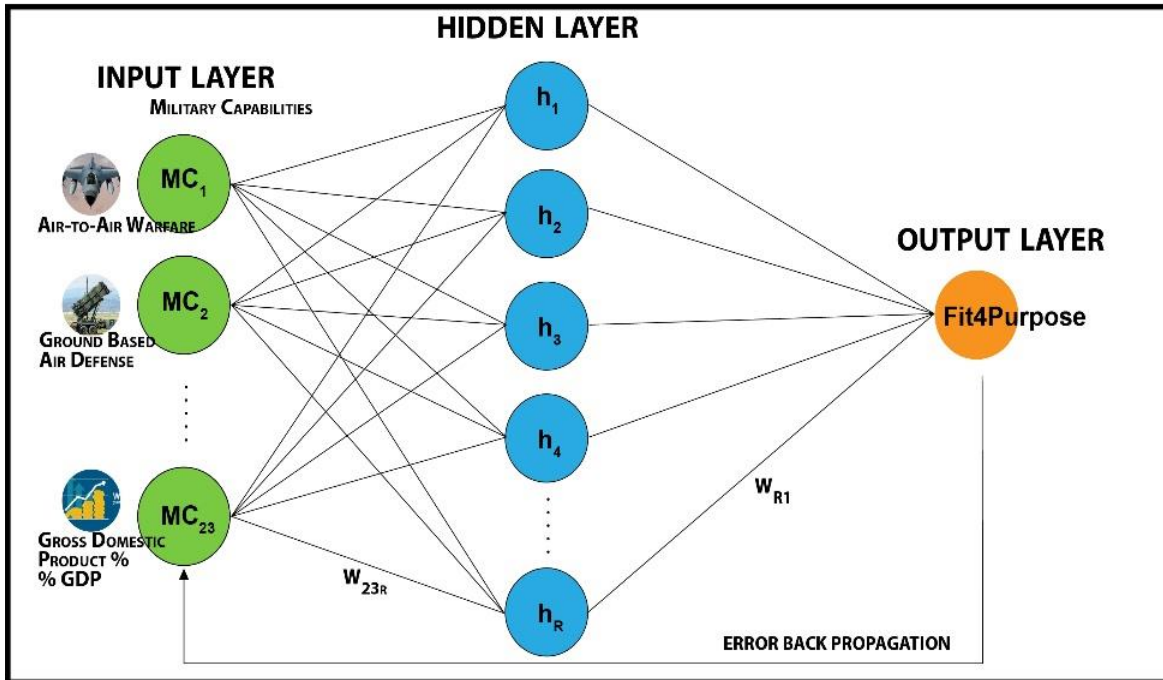
- **Training data 20 Nations, Testing data 11 Nations**

- **WEKA**
  - Used to create AI models
  - Open source Java based

## Available at:

- <https://www.weka.io/>

# Neural Network Classification with All Features in DataSet for Baseline comparison



Country	PIV	Class based on PIV	Predicted Class (NN Result)	Country	PIV	Class based on PIV	Predicted Class (NN Result)
1	1	0	0	7	0.002	1	1
2	0.032	1	1	8	0.002	1	1
3	0.072	1	1	9	0.145	1	1
4	0.052	1	1	10	0.329	0	1
5	0.855	0	0	11	0.108	1	1
6	0.638	0	0				

- Model complexity needs to reflect user needs

# Explainability by Linear Regression (LR) - All Features in Dataset for Operational Level User

- **Presumption:** Use all data available for operational level

i	Capability (MC <sub>i</sub> )	Weight (w <sub>i</sub> )	#	Capability (X <sub>i</sub> )	Weight (w <sub>i</sub> )
1	Air-to-Air Warfare	-0.14704	13	A SuW – Airborne	0.13195
2	Ground Based Air Defence	-0.11267	14	A SuW – Surface	-0.02302
3	Maritime Anti-Air Warfare	0.46032	15	A SuW- Submarine	-0.20917
4	Offensive Air Support	-0.22945	16	ASW – Airborne	0.16949
5	Indirect Fire	-0.29129	17	ASW – Surface	-0.42871
6	Naval Surface Fire Support	0.02939	18	ASW- Submarine	-0.03204
7	Air (Space) Recon	0.08968	19	Armoured Warfare	0.28709
8	Ground Recon	0.14598	20	Infantry Ops	0.19512
9	Maritime Surveillance	0.15639	21	Combat Engineering	-0.17213
10	Aerial Refuelling	-0.11916	22	Total Defence Budget - TDB	-0.03878
11	Airlift	0.08507	23	Gross Domestic Product – GDP	-0.00086
12	Maritime Transport	-0.27631		Intercept (α)	0.32289

$$CPIV = a_0 + w_1 \cdot MC_1 + \dots + w_{23} \cdot MC_{23}$$

Country	CPIV – LR Result	Class based on CPIV (threshold: 0.2659)	Predicted Class (NN Result)	Country	CPIV – LR Result	Class based on CPIV (threshold: 0.2659)	Predicted Class (NN Result)
1	0.363	0	0	7	-0.095	1	1
2	0.123	1	1	8	0.215	1	1
3	0.112	1	1	9	0.006	1	1
4	-0.047	1	1	10	0.213	1	1
5	0.585	0	0	11	-0.113	1	1
6	0.381	0	0				

# Explainability by Linear Regression (LR) - Domain-Based Features for Strategic Level User

- **Presumption:** Use only Capability Domain (CD) level data for strategic level

$$CPIV = a_0 + w_1 \cdot CD_1 + \dots + w_9 \cdot CD_9$$

i	Capability (MC <sub>i</sub> )	Weight (w <sub>i</sub> )
1	Air Defence	-0.14704
2	Fire Support	-0.11267
3	ISR	0.46032
4	Logistics	0.02939
5	Anti-surface Warfare	0.08968
6	Anti-Submarine Warfare	0.08507
7	Direct Ground Combat	-0.27631
8	Total Defence Budget - TDB	-0.1416
9	Gross Domestic Product % – % GDP	-0.1037
	Intercept (α)	0.4136

Country	CPIV – LR Result	Class based on CPIV (threshold: 0.2659)	Predicted Class (NN Result)	Country	CPIV – LR Result	Class based on CPIV (threshold: 0.2659)	Predicted Class (NN Result)
1	0.362	0	0	7	0.001	1	1
2	0.159	1	1	8	-0.003	1	1
3	0.232	1	1	9	0.160	1	1
4	0.164	1	1	10	0.313	0	1
5	0.419	0	0	11	0.193	1	1
6	0.340	0	0				

# Explainability by Linear Regression (LR) - Fully Aggregated Military Capabilities and %GDP for Political level User

- **Presumption:** Use only fully aggregated military data - Combined Military Power (CMP) and budget (GDP) for political level

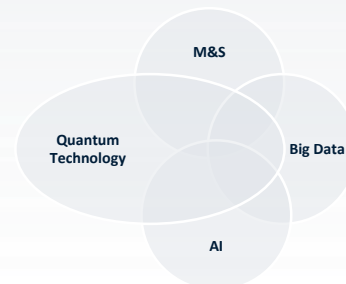
$$CPIV = a_0 + w_{CMP} \cdot CD_{CMP} + w_{GDP} \cdot CD_{GDP}$$

#	Input	Weight ( $w_i$ )
1	CMP	-0.534
2	% GDP	-0.1713
	Intercept ( $\alpha$ )	0.4829

Country	CPIV – LR Result	Class based on CPIV (threshold: 0.2659)	Predicted Class (NN Result)	Country	CPIV – LR Result	Class based on CPIV (threshold: 0.2659)	Predicted Class (NN Result)
1	0.447	0	0	7	0.099	1	1
2	0.1	1	1	8	0.133	1	1
3	0.109	1	1	9	0.151	1	1
4	0.101	1	1	10	0.22	1	1
5	0.422	0	0	11	0.392	0	1
6	0.421	0	0				

# Conclusion

- **AI based classification Use Case addressed Explainability**
  - **Same data set is used to build different models respecting different end-user needs delivering “same results”**
  - **Complexity of model is reduced by data set aggregation**
  - **Classification threshold drives the what-if analysis of end-user**
  - **Amount of data for training is limited**
- 
- **AI developers should be actively looking for implementing other AI models that would bring similar results from the same dataset but creating the value for explainability!**





ALLIED COMMAND TRANSFORMATION

# Questions?