

# Modelling and analysis of Defence Lines of Developments using causal maps

Professor Dobrila Petrovic

d.petrovic@coventry.ac.uk

Pawel Zdanowicz –Research Assistant

ab3145@coventry.ac.uk

Coventry University, UK



Colin Irwin – Technical Partner

DSTL, Policy & Capability Studies Department, UK

Funded by Centre for Defence Enterprise, UK

Contract No. DSTLX1000068169

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# Outline

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# Objectives

Design a new system:

- for modelling and analysis of allocation of resources to Defence Lines of Development (DLoDs) and
  - for analysis of its impact on military capability of Force Elements (FE) and Capability Packages (CP).
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# Proposed methodology

Rule Based Fuzzy Causal Maps (RBFCM)

Existing systems:

- Forest Fire Modelling
  - Fishermen's behaviour in a pelagic fishery
  - Students' behaviour
  - Defence Lines of Development ← new system
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# Characteristics of RBFCM

- Modelling of variations in concepts
  - Qualitative data
    - Budget is increased *Much*
  - Dynamics (time parameter)
  - Accumulative causality
    - Variations of different concepts are accumulated.
  - Non-symmetric and non-linear relationships
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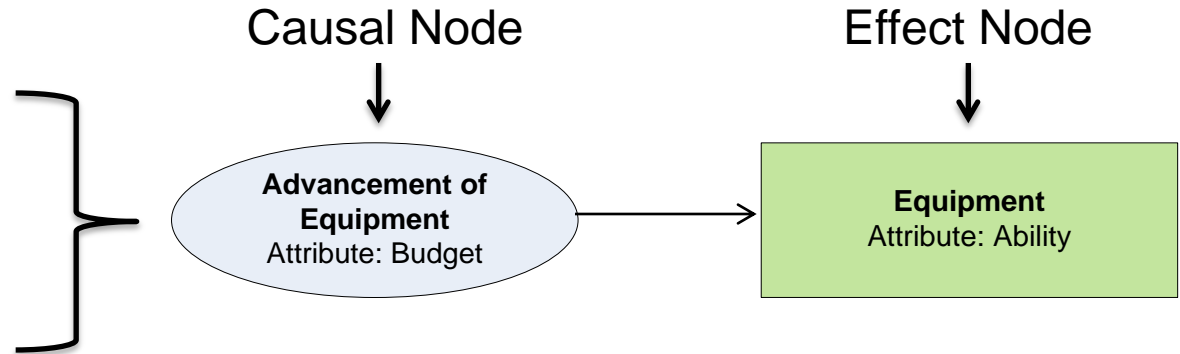
# Elements of a causal map

- Concepts

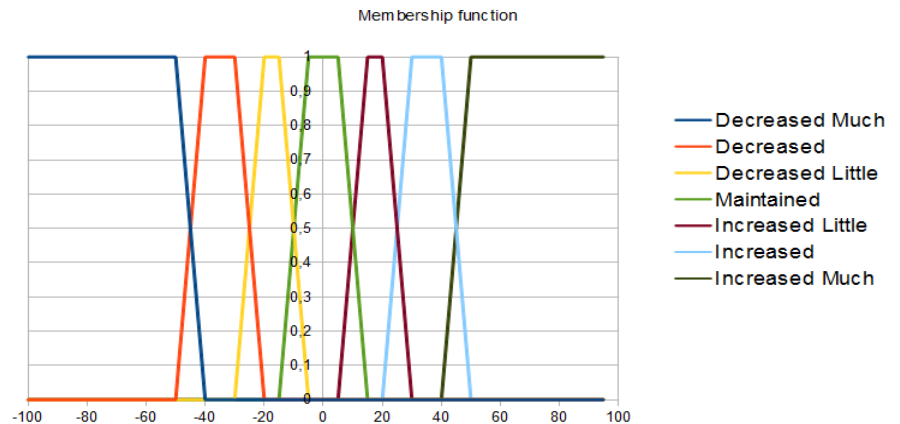
- Relationships

- Rules

- Membership functions



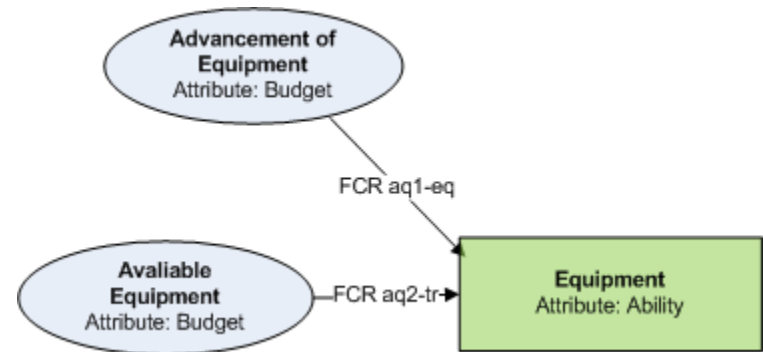
IF Budget for Advancement of Equipment is *Increased*  
THEN Ability of Equipment is *Increased Little*



# Causal Map



# Accumulation of impacts



IF Budget for Advancement of Equipment is *Increased*  
THEN Ability of Equipment is *Increased Little*

IF Budget for Available Equipment is *Increased Much*  
THEN Ability of Equipment is *Increased*

EQUIPMENT IS *MORE  
THAN INCREASED*



# Examples of rules

## **TRAINING METHODOLOGY -> TRAINING DL0D (FCR TME-TR)**

IF Training Methodology is Decreased Much

THEN Training is Decreased

IF Training Methodology is Decreased

THEN Training is Decreased Little

IF Training Methodology is Decreased Little

THEN Training is Maintained

IF Training Methodology is Maintained

THEN Training is Maintained

IF Training Methodology is Increased Little

THEN Training is Maintained

IF Training Methodology is Increased

THEN Training is Increased Little

IF Training Methodology is Increased Much

THEN Training is Increased

# Examples of rules

## ADVANCEMENT OF EQUIPMENT->TRAINING DLOD (FCR AQ1-TR)

IF Advancement of Equipment is Decreased Much

THEN Training is Maintained

IF Advancement of Equipment is Decreased

THEN Training is Maintained

IF Advancement of Equipment is Maintained

THEN Training is Maintained

IF Advancement of Equipment is Increased a-Little

THEN Training is Maintained

IF Advancement of Equipment is Increased

AND (Training Equipment is Increased

OR is Increased Much)

THEN Training is Maintained

IF Advancement of Equipment is Increased

AND NOT (Training Equipment is Increased

OR is Increased Much)

THEN Training is Decreased a-Little

IF Advancement of Equipment is Increased Much

AND (Training Equipment is Increased

OR is Increased Much)

THEN Training is Maintained

IF Advancement of Equipment is Increased Much

AND NOT (Training Equipment is Increased

OR is Increased Much)

THEN Training is Decreased

# DLoD's to FE and FE's to CP relationships

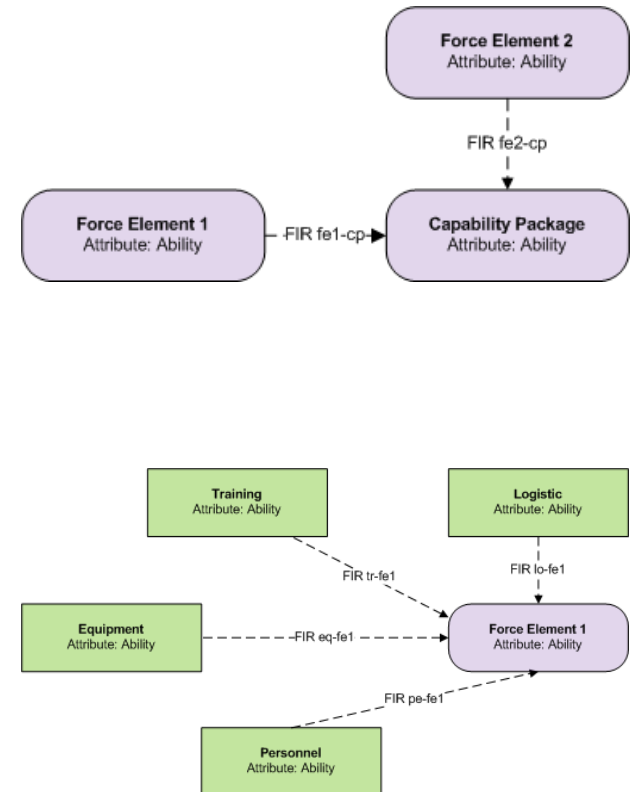
$$E_1 = \sum a_{DLoD} * w_1 - \text{Lower endpoint}$$

$$E_2 = \sum a_{DLoD} * w_2 - \text{Higher endpoint}$$

$$\text{FE ability} = [E_1, E_2]$$

DLoD	Ability	Importance	Assessed Ability
Training	30	30 – 35	9 – 10.5
Equipment	25	20 – 30	5 – 7.5
Logistics	25	35 – 25	8.75 - 6.25
Personnel	20	15 – 10	3 – 2
Force Element Ability			[25.75 , 26.25]

The same algorithm applies for calculating ability of Capability Package



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# Time component

- The system has a Base Unit parameter – the smallest time unit in which it is possible to observe the effect of the changes
- Time in which the change of effect node occurs vary depending on the relationship

Node A causes a change in Node B  
after the time period of 3 base units  
Node A causes a change in Node C  
after the time period of 1 base unit

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# Conclusion

- RBFCM can be used to model DLoDs and analyse impact of variations of budget

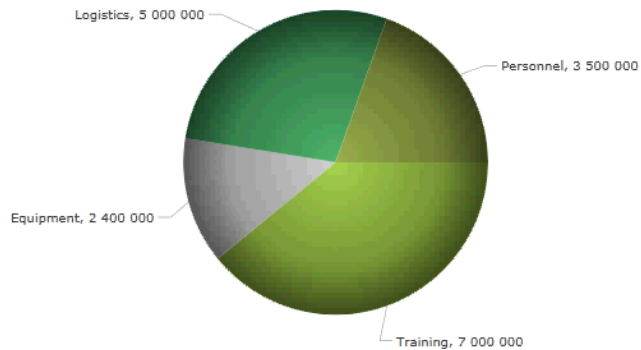
## Further Development

- Build the RBFCM further using expert knowledge
  - Model different states of Force Generation process
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# Demo

SystemWindow				25			
Reset Save Run Simulation Show Graphs Show Map							
<b>Components:</b>	Current Budget:	New Budget:	Change (%):	<b>DLoDs:</b>	Current ability:	New ability:	Change (%):
Training Methodology	1000000	1000000	0	Training DLOD	40	40	0
Training Equipment	3000000	3000000	0	Equipment DLOD	30	30	0
Training Personnel	3000000	3000000	0	Personnel DLOD	35	35	0
Advancement of Equipment	400000	400000	0	Logistics DLOD	40	40	0
Available Equipment	2000000	2000000	0	<b>Force Elements:</b>			
Number of People	1000000	1000000	0	Force Element 1	37 - 38,5	37 - 38,5	0
Psychological Support	500000	500000	0	<b>Capability Packages:</b>			
Skill Profile	2000000	2000000	0	Capability Package	14,8 - 25,9	14,8 - 25,9	0
Logistics Equipment	5000000	5000000	0				
<b>Overall Budget:</b>	<b>17900000</b>	<b>17900000</b>	<b>0</b>				

Current Budget Distribution (%)



New Budget Distribution (%)

