"Data Farming Services in Support of Military Decision Making"

(MSG-155 contribution to IST-160)

IST-160

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Contents

- Experiment based Decision Support
- Introduction to Data Farming (MSG-155; services)
- Current Data Farming use cases (MSG-155)
- AI and Data Farming
- Way ahead

Decision Support

Why Decision Support

- More complex operations
- Comprehensive operations (operations in three landscapes)
- More and more data available

Decision making requires insight in underlying environment (system)

Experimentation Based Decision Support

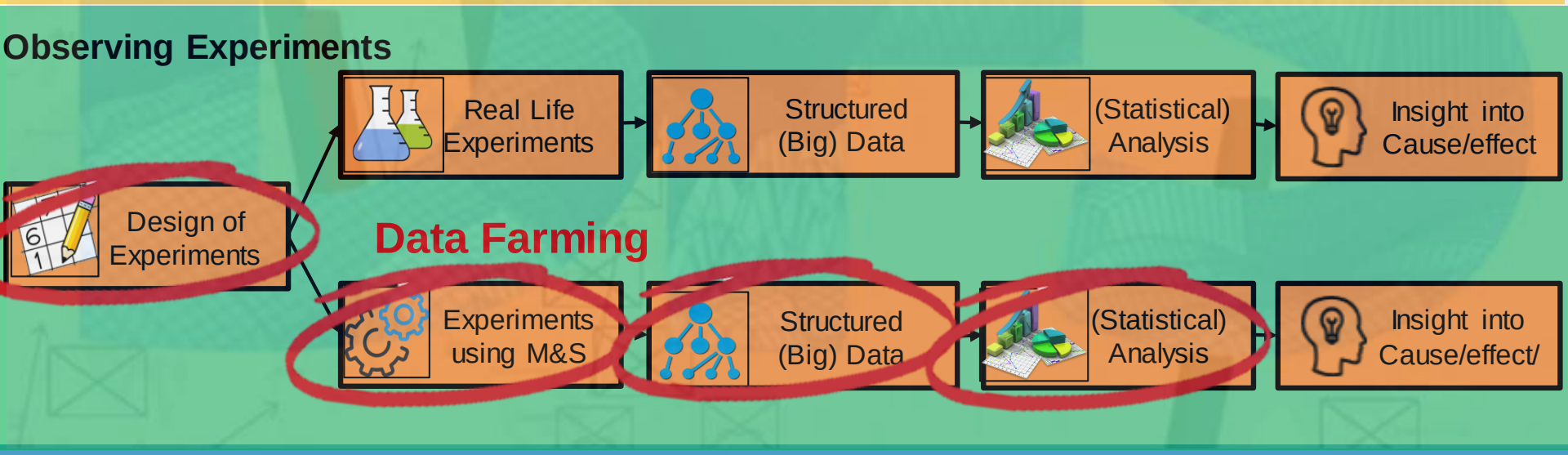
- **Military Decision making is about making optimal decisions**
- **Optimal decisions require insight into the system**
- **(Big) Data can provide insight**
- **Experimentation can provide Big Data**
- **MSG-155: Data Farming Services is about doing experimentation with simulation models**

Alan Shafer's (Director, Collaboration Support Office) invitation (Aug 2017) to contribute to IST-160:

Because "…the Task Group (RTG)-155 on "Data Farming Services for Analysis and Simulation-Based Decision Support" … is very much aligned with the STO Theme on Military Decision Making Using the Tools of Big Data and Artificial Intelligence.

How to study a system

- **Gain insight by observing system behavior**



Mining vs. Farming

Miners seek valuable buried nuggets

- Miners have no control over what's there or how hard it is to separate it out
- Data Mining seeks valuable information buried within massive amounts of data

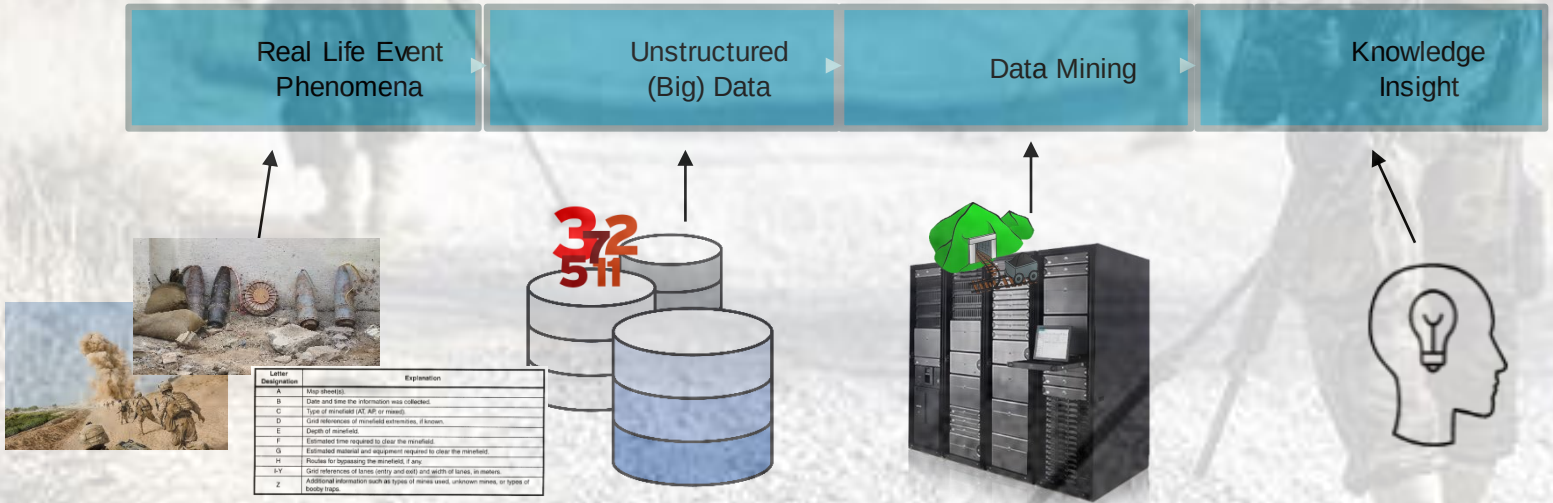
Farmers cultivate to maximize yield

- Farmers manipulate the environment to their advantage: pest control, irrigation, fertilizer, etc.
- **Data Farming** manipulates simulation models to advantage to "grow" data with designed experimentation

Decision Support using observations from live systems

Example:

Discovering patterns in (observations/reports of) IED incidents (day of week, year, location, situation,…) for counter IED operations planning.



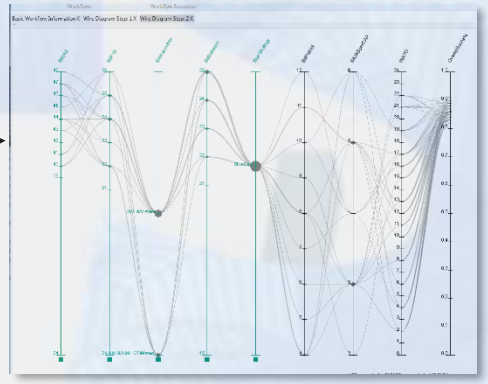
Letter Designation	Explanation
A	Map sheet(s).
B	Date and time the information was collected.
C	Type of minefield (AT, AP, or mixed).
D	Grid references of minefield extremities, if known.
E	Depth of minefield.
F	Estimated time required to clear the minefield.
G	Estimated material and equipment required to clear the minefield.
H	Routes for bypassing the minefield, if any.
I-Y	Grid references of lanes (entry and exit) and width of lanes, in meters.
Z	Additional information such as types of mines used, unknown mines, or types of booby traps.

Decision Support using observations from experiments

Design of Experiments → Experiments using M&S → Structured (Big) Data → (Statistical) Analysis → Knowledge/ Insight

<u>Example</u> (from MSG-124) Planning Support:

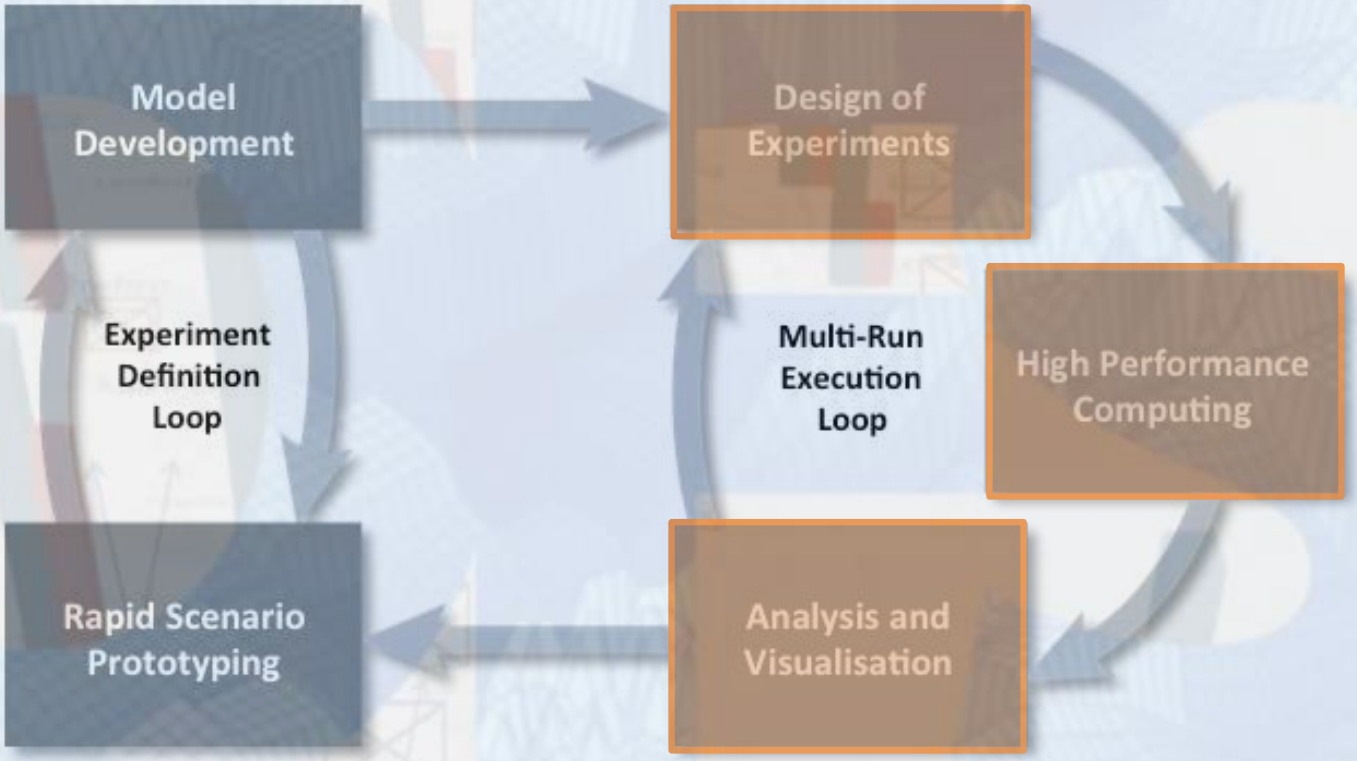
Run (kinetic) simulation model

Set of COAs →  → MOEs → 

Commander's question
"How do we use best what we have?"

Commander's answer
"Best" COA

Data Farming Loop of loops



Importance of Design Of Experiments (DOE)

- **Full factorial design gives exponential growth**
  - Consider a model with 100 factors
  - Study each factor at only 2 levels
  - Full factorial design would require $2^{100} \approx 10^{30}$ (experiments). I.e impossible to perform!
- **DOE can help overcome this problem**
- **E.g. space filling designs:**

5	3			7				
6			1	9	5			
	9	8					6	
8				6				3
4			8		3			1
7				2				6
	6					2	8	
			4	1	9			5
				8			7	9

5	3	4	6	7	8	9	1	2
6	7	2	1	9	5	3	4	8
1	9	8	3	4	2	5	6	7
8	5	9	7	6	1	4	2	3
4	2	6	8	5	3	7	9	1
7	1	3	9	2	4	8	5	6
9	6	1	5	3	7	2	8	4
2	8	7	4	1	9	6	3	5
3	4	5	2	8	6	1	7	9

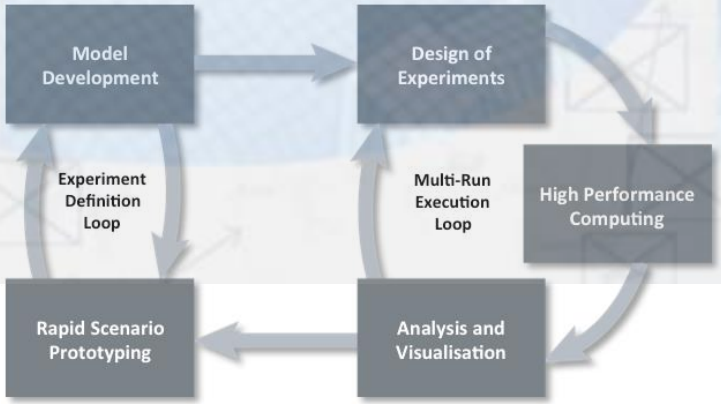
NMSG-155: Data Farming Services

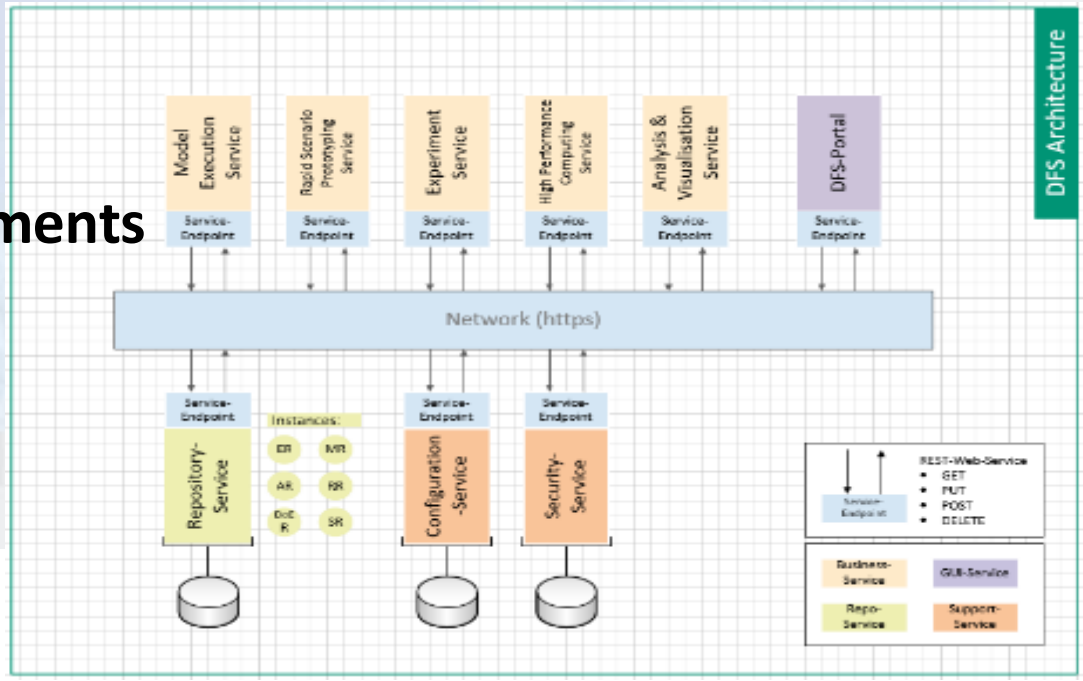
Objective:

- **Extend data farming capability and accessibility through developing Data Farming Services (DFS)**
  - Using the Modelling&Simulation as a Service concept (NMSG 136)

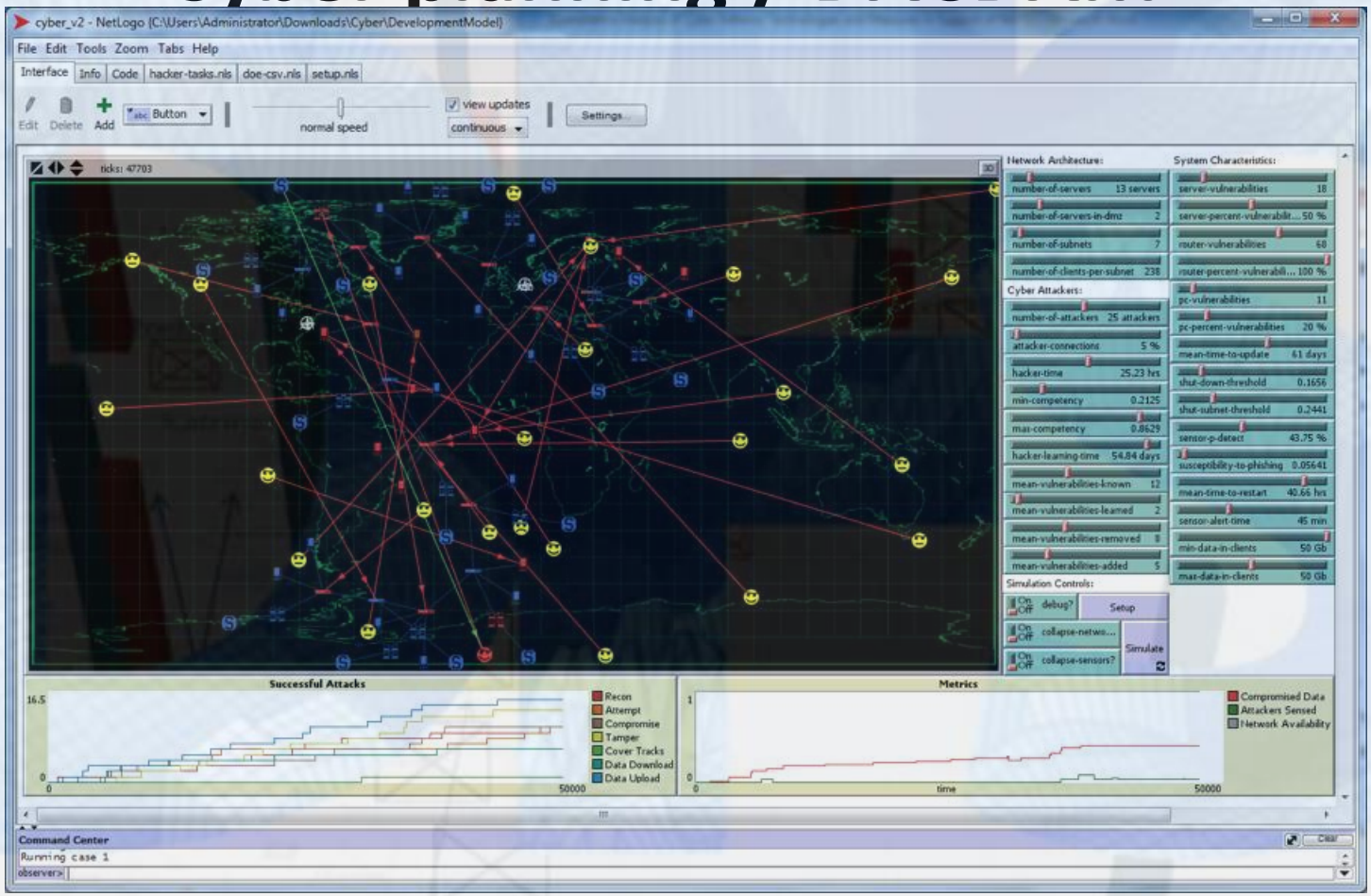
Way of Work:

- **Develop DFS framework**
- **Use-cases to find requirements**





MSG155 use case
Cyber planning / DACDAM



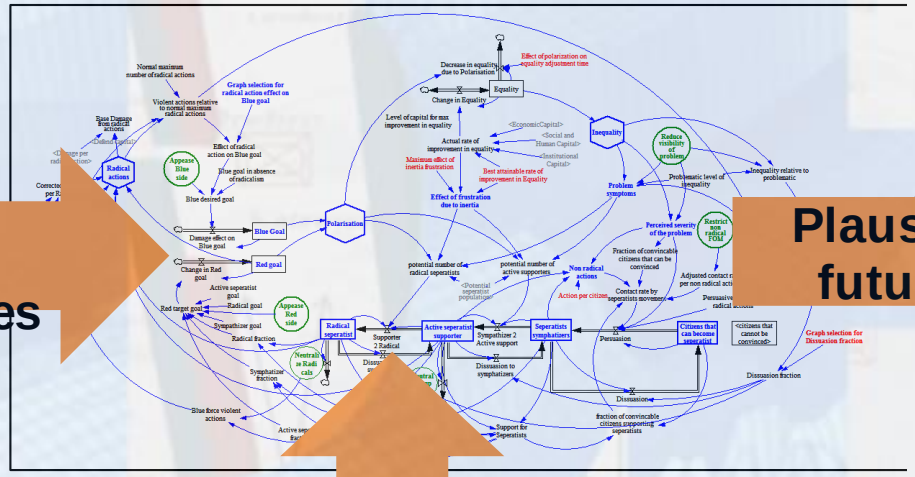
Data-Farmable Agent-based Cyber Defence Assessment Model (DACDAM)

MSG155 use case: Comprehensive Operations with Modelling & Simulation (COSMOS)

- **Comprehensive Operations are performed in three "landscapes"**
- **Models for the behaviour in these landscapes contain typically a lot of uncertainty**
  - Therefore finding (robust) optimal policies must take uncertainty explicitly into account.
  - The Exploratory Modelling & Analysis approach is a way to do this.

COSMOS: radicalisation scenario

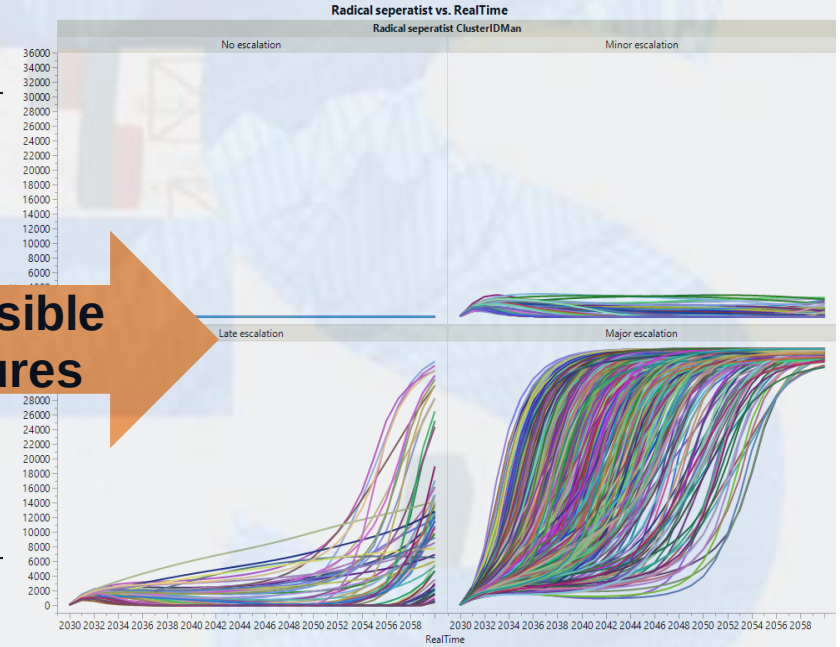
Exploratory Modelling & Analysis



Policies

Uncertainties

Plausible futures



- The variation in uncertain parameters results in many plausible systems and thus many “plausible futures”.
- The analysis concentrates on finding polices that are “robust”, i.e. policies that are “insensitive” to parameter uncertainty.

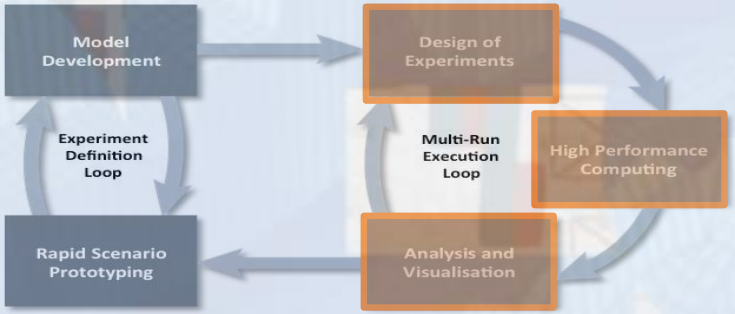
Using AI in Data Farming; Examples

- **Model Development support**
  - Use of live data to enhance sim-model
  - Reinforcement learning for finding red COAs
  - Assemble and use in DF "simple" NN model based on complex model
- **Design Of Experiments support**
  - Iterating to better DOEs based on output analysis
- **Analysis support**
  - Gain insight into cause-effect by finding patterns in output
  - Use expert knowledge for DF experiment support
  - Learn "best" solution for varying MOEs to be optimized

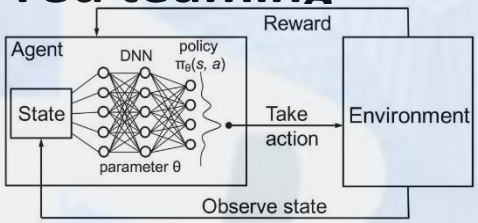
AI in DF: Model Development support

- **Use data from live observations to enhance simulation model**

Live observation based analysis



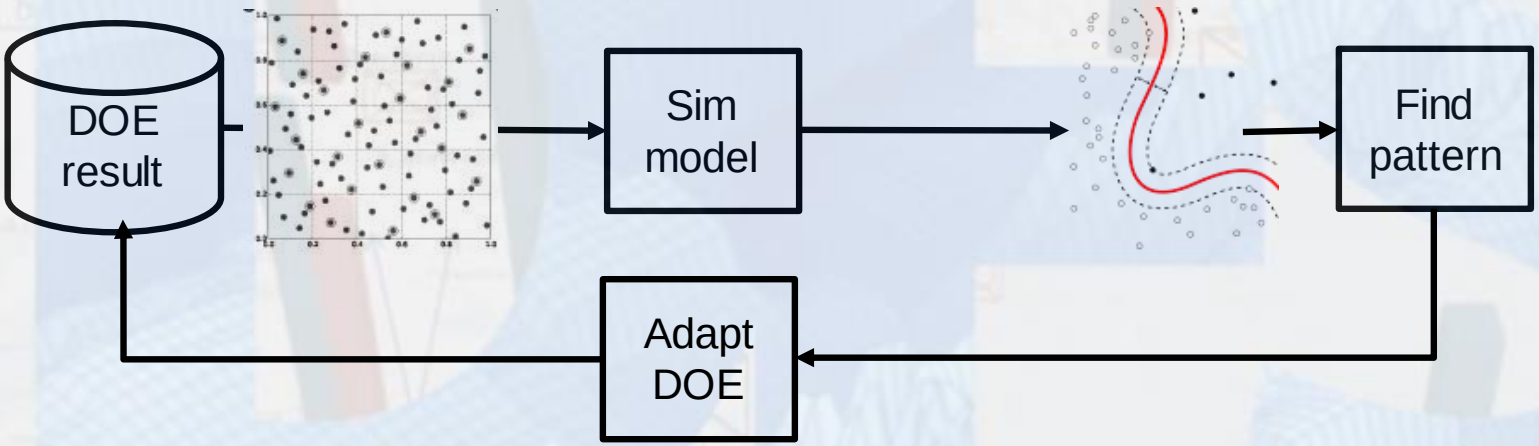
- **(Reinforcement) learning for Automated red teaming**
  - ➢ Learn optimal red players' behavior. Support defining red-COAs.



- **Meta-modelling**
  - ➢ Metamodels (response surfaces, surrogates models) can be found by learning from complex model runs and subsequently be used thereby saving computation time.

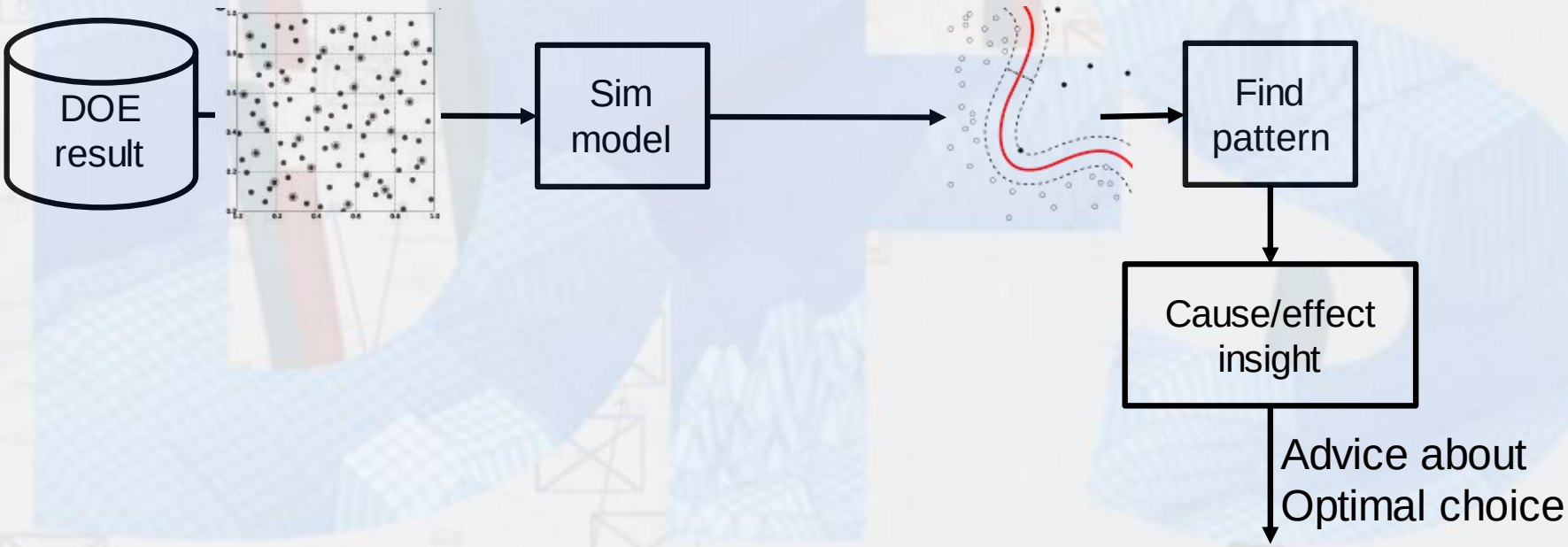
AI in DF: Design Of Experiments support

- **Automatic DOE adaptation based on patterns in output**
  - Find patterns in IO (Adapted sensitivity analysis) and adapt DOE based on found output



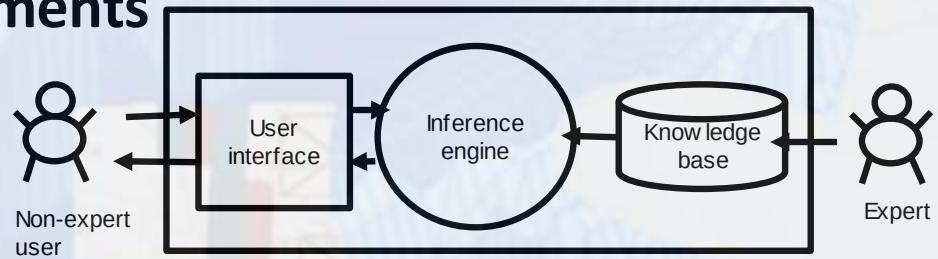
AI in DF: Analysis support

- **Gain insight into cause-effect by finding patterns in output**

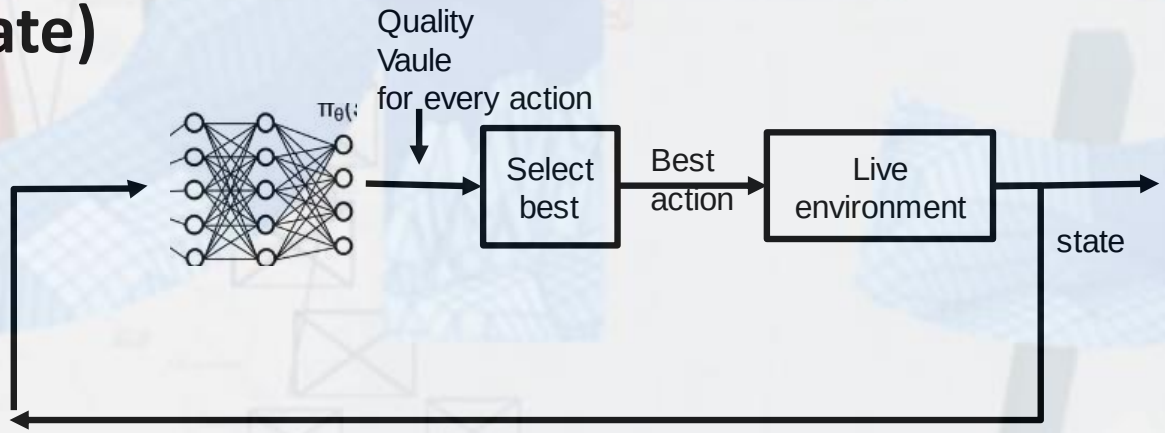


AI in DF: Analysis support

- **Advise for setting up DF experiments**
  - Rule based, expert system (eg for optimal DOE)



- **Train NN based on DF runs (reinforcement learning), use the resulting NN in real time planning (based on current state)**



Recommendations

MSG-155 will be demonstrating services at CWIX-2020.

- **It is to recommended to study AI support possibilities (for <u>Scenario/Model development, DOE and Analysis</u>) and enhance the MSG-155 demo with that.**
- **IST160 participants are invited to elaborate AI ideas and build tools.**
  - Either as an augmentation of existing use-cases, or
  - As a separate AI supported DF use-case.