



Modeling and Simulation supporting the capability planning process

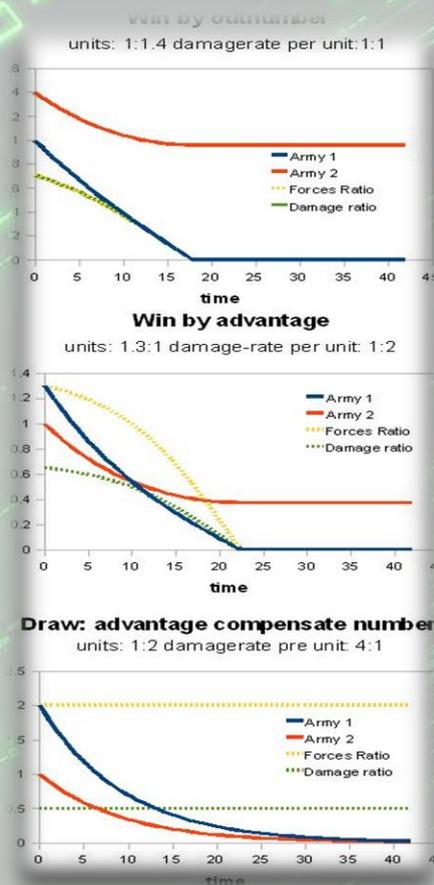
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Modelling and Simulation in Military

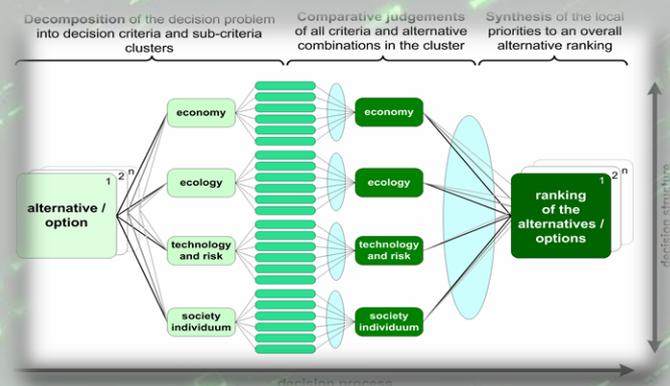
“quick look to the past”

- Math modeling and simulation is widely applied in many areas of science, industry and business
- Approaches to mathematically simulate the combat were carried out in the middle of previous century.
- Original math models were very generic - Lancasters models of combat, Force ratios calculations, etc..
- Developed in context of the available technology and available information.
- Achievement of acceptable results was almost impossible.



Future battlefield and perspectives for M&S

- Pursue of effectiveness - Social requirements impose new implementations on Defence Systems.
- New Character of future conflicts:
 - New dimension of threats
 - New approaches
 - New concepts of combat activities
- Quantity of information in C4ISTAR prevents its processing as we use to do in the past.
- Operational planning – to the depth / to the width.
- M&S contain a great potential for structured and unstructured problem solution.



M&S is a natural component of any Decision Making Process – let us use it professionally

M&S in Strategic Domain

- Computer decision support in Strategic domain is one of the biggest challenge for Modelling and Simulation area,
- Social-economic systems on strategic level are highly stochastic
- Realistic outputs from the one simulation could be hardly achieved.
- Correct approach and level of understanding of the simulation results is decisive.

M&S in Strategic Domain

- From the logical and philosophical point of view, there is no theoretical boundary limiting a MS implementation in strategic domains
- Only the human stereotypes and technology readiness (computationally intensive) could prevent that applications.
- From the technological point of view, situation changed dramatically within a last decade, but human approaches and trust into the possible solutions do not.

M&S in Strategic Domain

- From a mathematical point of view, the military strategy can be viewed as a selected sequence of the data configurations, defined on the set of all possible variations of the system state.
- Depending on a level of approximation and level of the model detail, there exist approaches how to implement promising solutions even in strategic domain.
- Generally, the strategy can be defined as a sequence of transformation vectors driving the transition of the system from state N to $N + 1$.

M&S of the Strategic Defence Capability Development

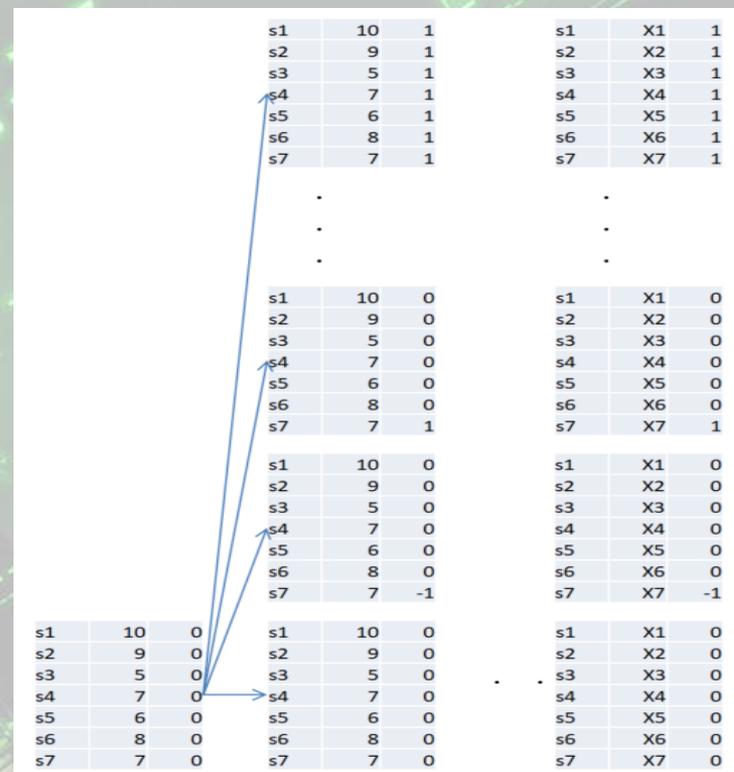
- Following slides describing a procedural approach to the Strategic Defence Capability Development, what is very common problem for the defence strategists.
- The aim of the optimal strategy search we could describe as an ideal defence budget distribution to the army specializations in context of readiness for future threat confrontation.

Construction of the capability model

Generic steps, we could delineate following possible approach:

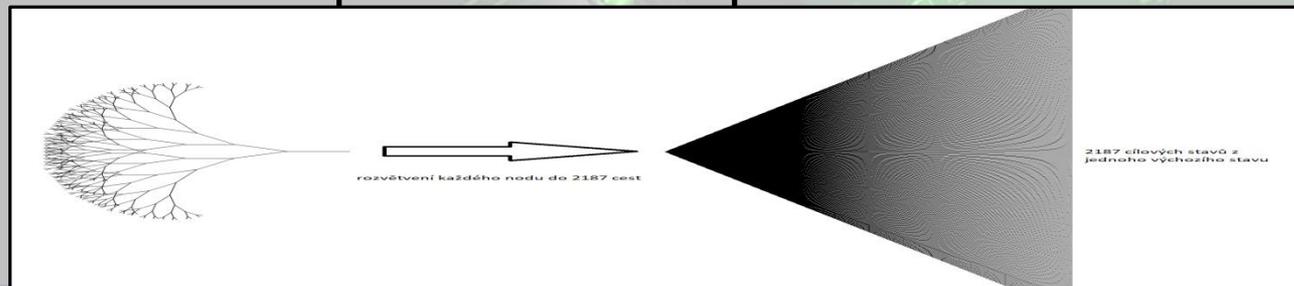
- aggregating the statuses of quantified coefficients of individual capabilities within a operational spectra.
- It could be represented as mathematical vector with indexes representing each capability,
- Quantification of each capability should be derived from the current status of organization structures, equipment and armament, usually calculated from the ratio of current status divided by some “ideal” model of a corresponding basic tactical unit (platoon, company, battalion...)

Si	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇
Capability level	10	9	5	7	6	8	7
Transition coefficient within a year	0	-1	0	1	1	0	-1



Possible configurations of the capability models (state graph/tree)

- Construction of the status graph of the possible configuration of the capability model
- It is the set of possible capability configurations in time (usually in the years) can be viewed from the mathematical point of view as the math graph (having a shape of traditional oriented tree) of possible combinations of the data model of the defence capabilities.
- Usually there is respected discrete and limited improvements or degradation of capability (hardly achievable improvement of the capability from 0 to 10 within a one year, for instance), what actually drives and reduce the speed of tree expansion in time



Cost of transitions within the capability model

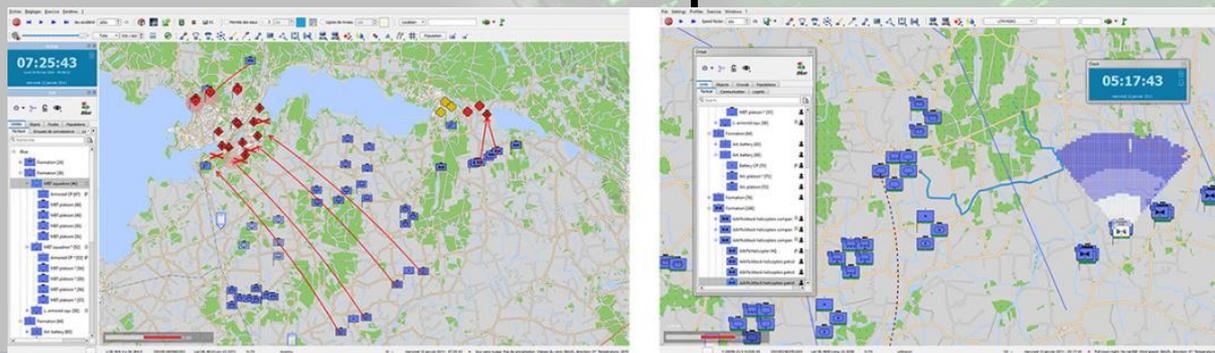
- Evaluation of overall cost of transition between individual configurations of the status graph
- Transitions between time steps and potential capability levels should be valued by the financial cost of a given capability improvement, stagnation or deterioration.
- Usually for simplifications only positive numbers, we do not expect any financial profit from the defence (for instance selling some asset).

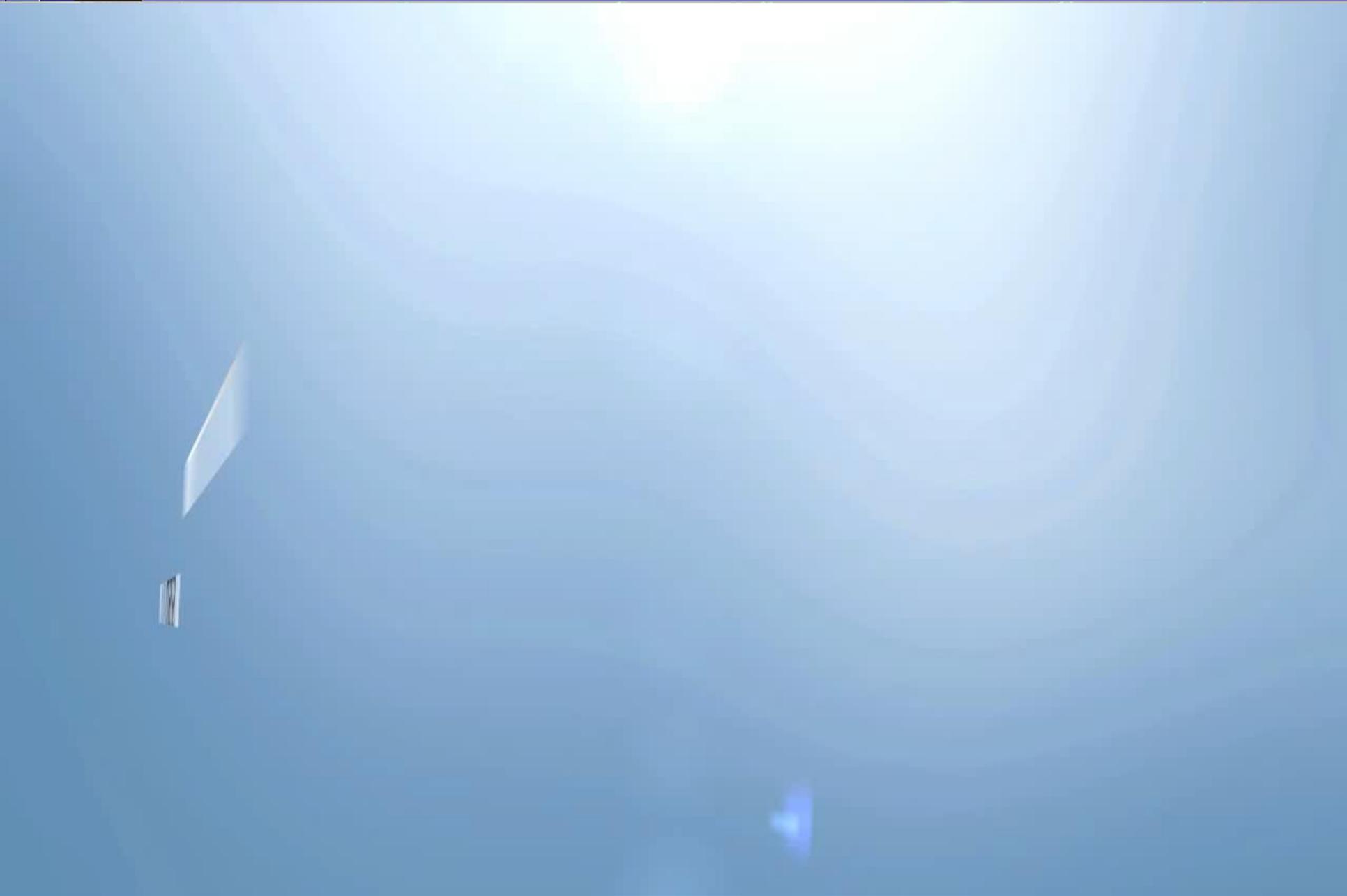
$$I_x = \sum_{k=0}^n V_{Ia} \cdot S_k \cdot S_{Ux} \cdot p_c; \quad n \in N \cap n \in \langle 1,7 \rangle$$

- I_x – Total cost of particular variant MC
- x – node index
- V_{Ia} – ratio coefficient „+1, 0, -1“.
- S_k – Cost for intial capability „k“.
- S_{Ux} – level of capability S_k in node x
- P_c – ratio coefficient (modifying S_{Ux} in context of financial costs)

Operational effectiveness evaluation using “constructive wargaming”

- Evaluate operational level of efficiency/readiness for a given status of capability to face the future threats
- Evaluate operational efficiency of the capability configuration (model) is one of the key parameters in the capability graph, with several methods being available for the calculation process.



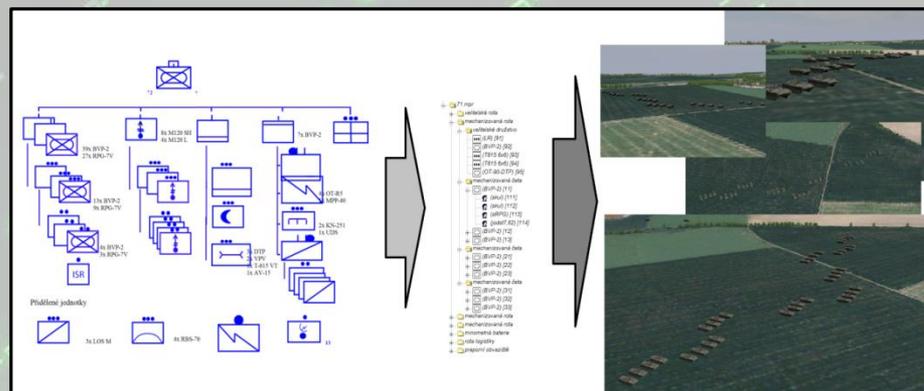


Construction of the data model of capabilities

Possible option copying an intuitive approach and logic

can be characterized by the following steps:

1. Transformation capabilities into the model organizational structures
2. Create organization structures of the supposed opponent
3. Create/define scenarios
4. Place scenarios into expected/probable areas of the future operational deployment
5. Execute statistically representative counts of constructive wargaming within each scenario
6. Statistical evaluation of success ratio of given capability configuration and setting this value into the capability graph



Calculate a possible solution

- Calculation of a possible solution should be developed in two phases
- The first is to apply the Foyd-Warshall algorithm or its equivalent to the graph of financial part of capability development expenses
- After that, it is necessary to apply a expected budgeting filter on each node in the graph within a time step/year and exclude all “over budget” nodes with its connections from the graph

Calculate a possible solution

- Second step is the search for the optimal solution or a set of optimal solutions for the development of individual military capabilities in time (years)
- So that the total sum of the operational efficiencies of the individual capabilities configurations will be maximal or moves within a certain (max close) interval.
- This problem could be solved by the original or modified CPM method.
- In the case of situation where a defined budget capacity for the capability development prevent the effective capability status achievement, addressing forecasted threats and risks, so the military budget for capability development need to be reconsidered (increased).

M&S of the Strategic Defence Capability Development

- Mentioned approach indicate, that this trend leads to a need for additional research in management areas, revitalization of operational research principles implemented in „social-everyday“ practice, there is the time for a BigData and DataFarming concepts in decision support infrastructure, and mainly appropriate personnel development throughout proper education and training.



Conclusion



- M&S applications in Decision Support areas will constitute the „backbone“ of the Future Defence Systems.
- Dynamics of future conflicts
- Strong link and aspects with C4ISTAR and real time issue.
- Effectiveness of Military Systems
- Strategic/Operational tasks are multi-criteria decision problems, it follows pragmatic aspects - > mathematical optimization could be implemented
- Great potential to put operational planning/management to a new dimension of effectiveness
- **No alternative available !!!**