Matthias Dehmer, Bo Hu and Stefan Pickl

Project Contracting and Strategic Planning (Scheduling)

System Dynamics Modeling and Management Science Approaches Toward Increasing Acquisition Process Efficiency

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AFCEA
Acquisition Research:
Creating Synergy for Informed Change
MAY 14 – 15, 2014 · EMBASSY SUITES MONTEREY BAY - SEASIDE
MONTEREY, CA

System dynamics modeling for project acquisition

A web based management cockpit for project contracting

Conclusion and further research activities

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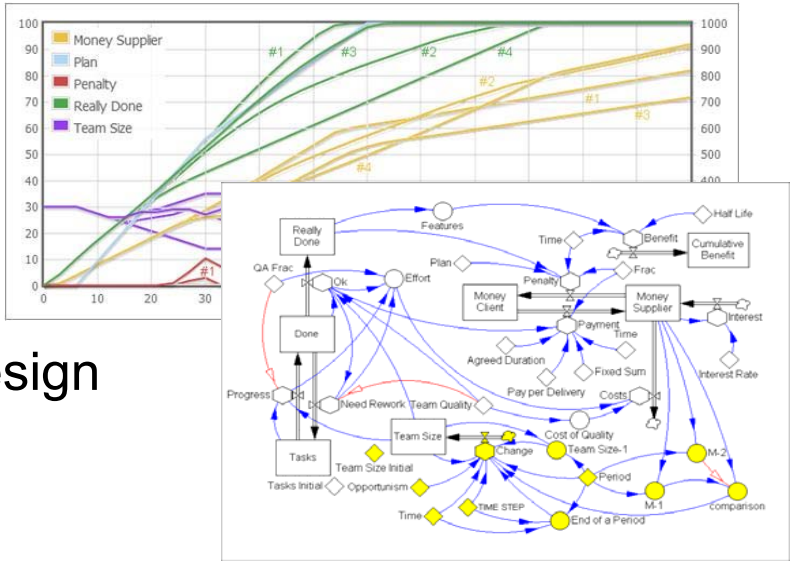
Introduction / Motivation

- Public private partnership (PPP)
- Contracting: impact on acquisition process efficiency
- Conflict of interests: Public-Private: delay and additional costs in project execution => opportunistic behavior of private-sector suppliers
- New approach:
  - system dynamics model
  - web based tool
- Goal: train project purchasers to design optimal contracts



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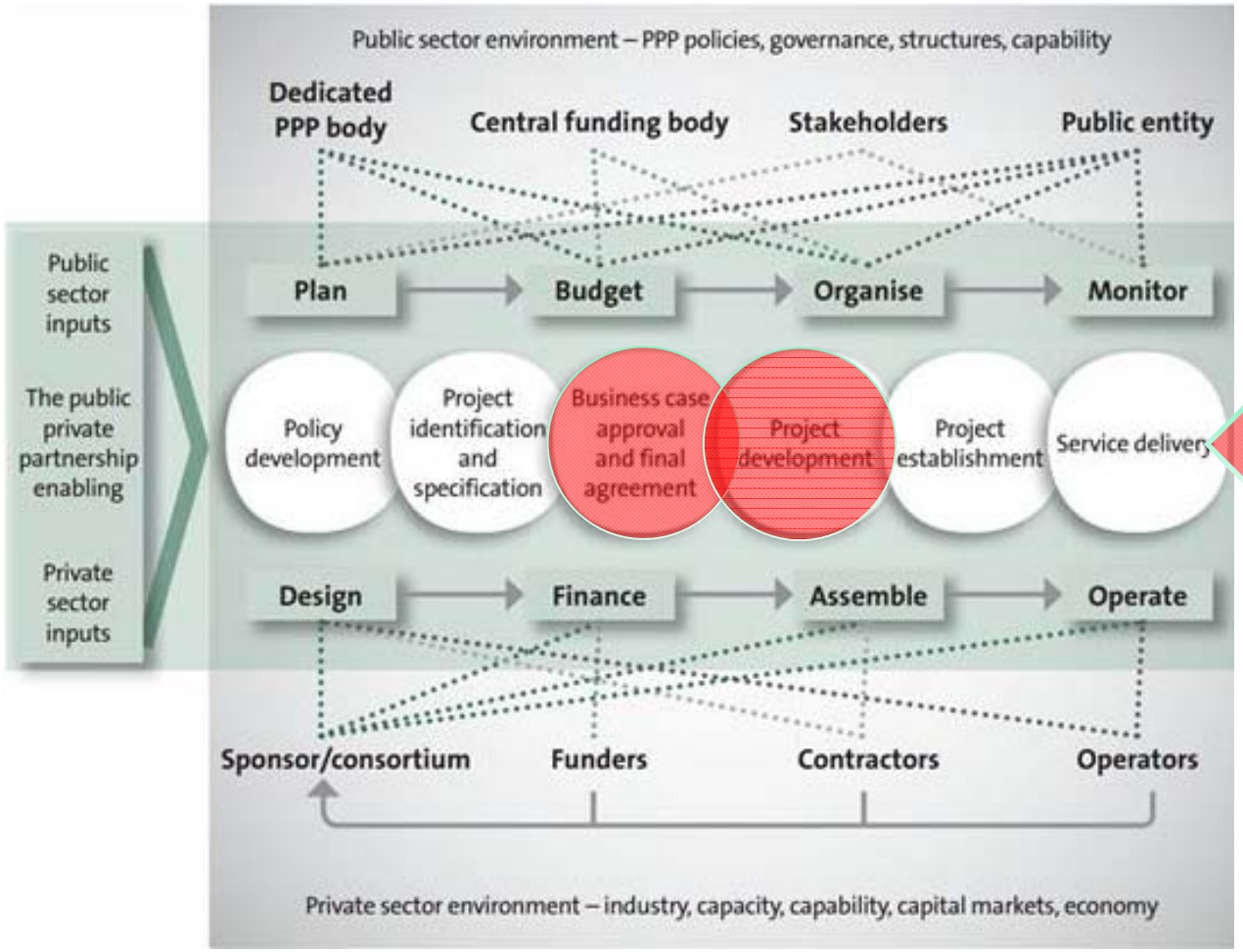
Public meets private interests in PPP projects



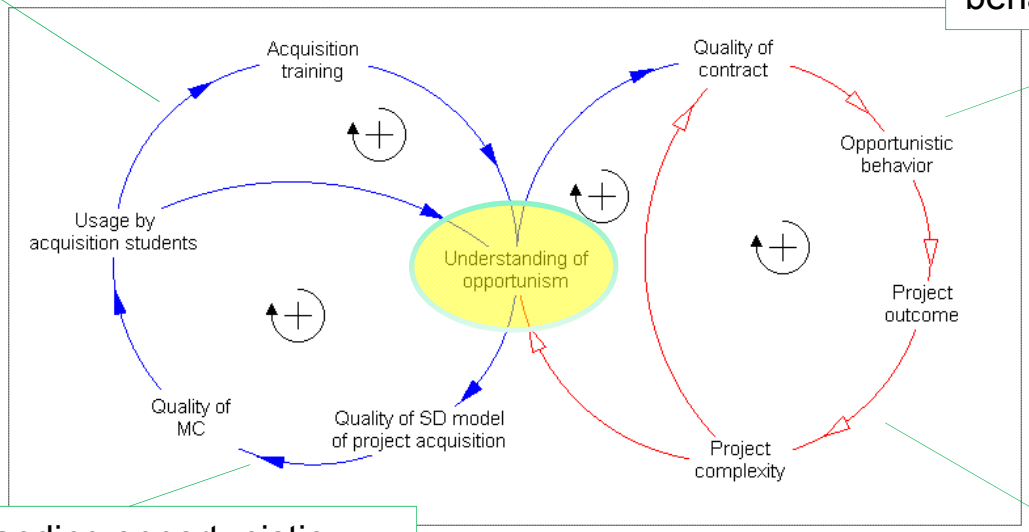
This is where public interest meets private interest and opportunistic behavior evolves.

Provost 2011

Understanding opportunistic behavior is a critical success factor for PPP projects

Acquisition research and training shall contribute significantly to better acquisition processes

Increasing project complexity causes often to poorer contract quality and stronger opportunistic behavior



Understanding opportunistic behavior during PPP acquisition and execution is a critical success factor for PPP projects

As a result, poorer project outcome leads to wish for even more complex projects

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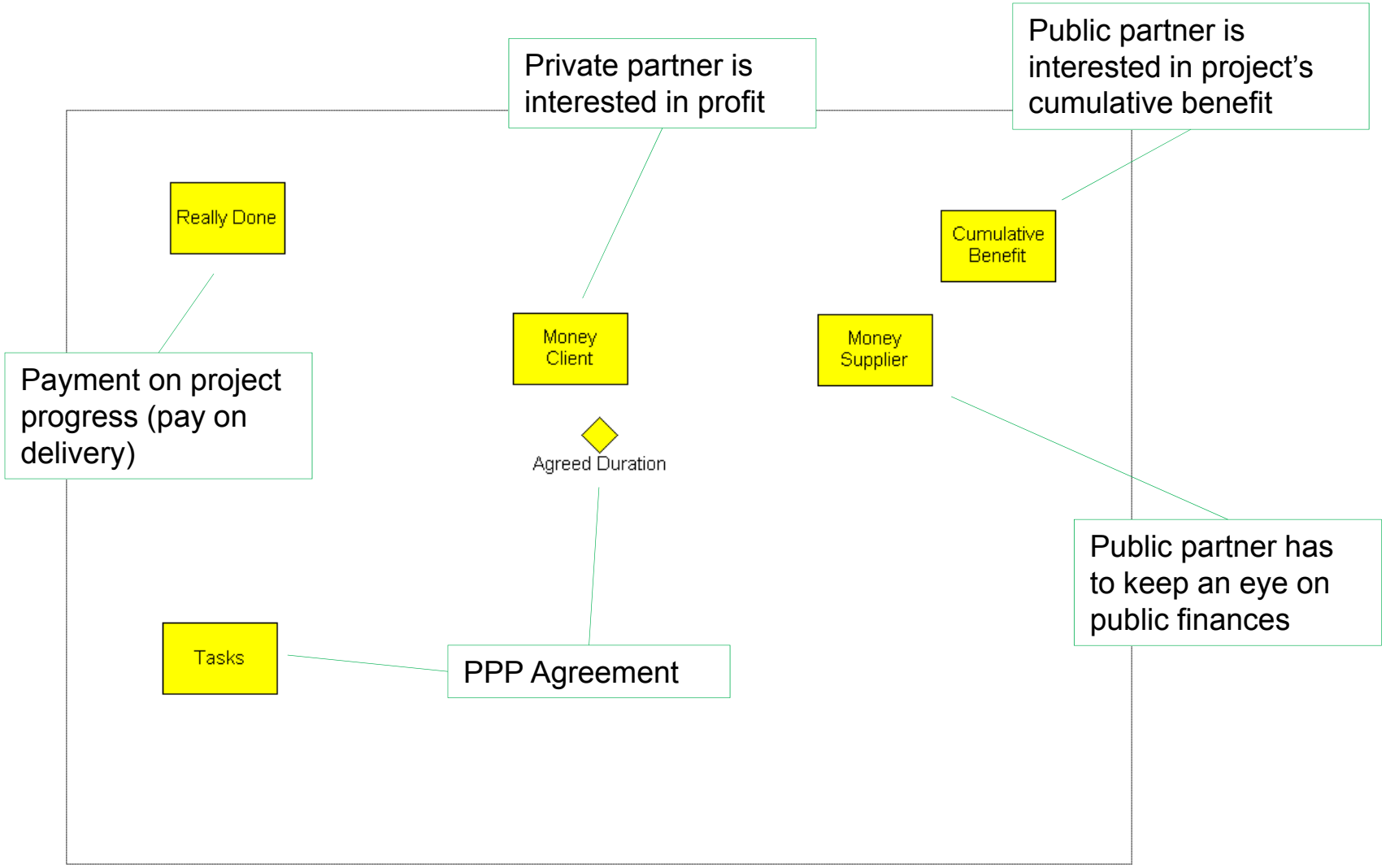
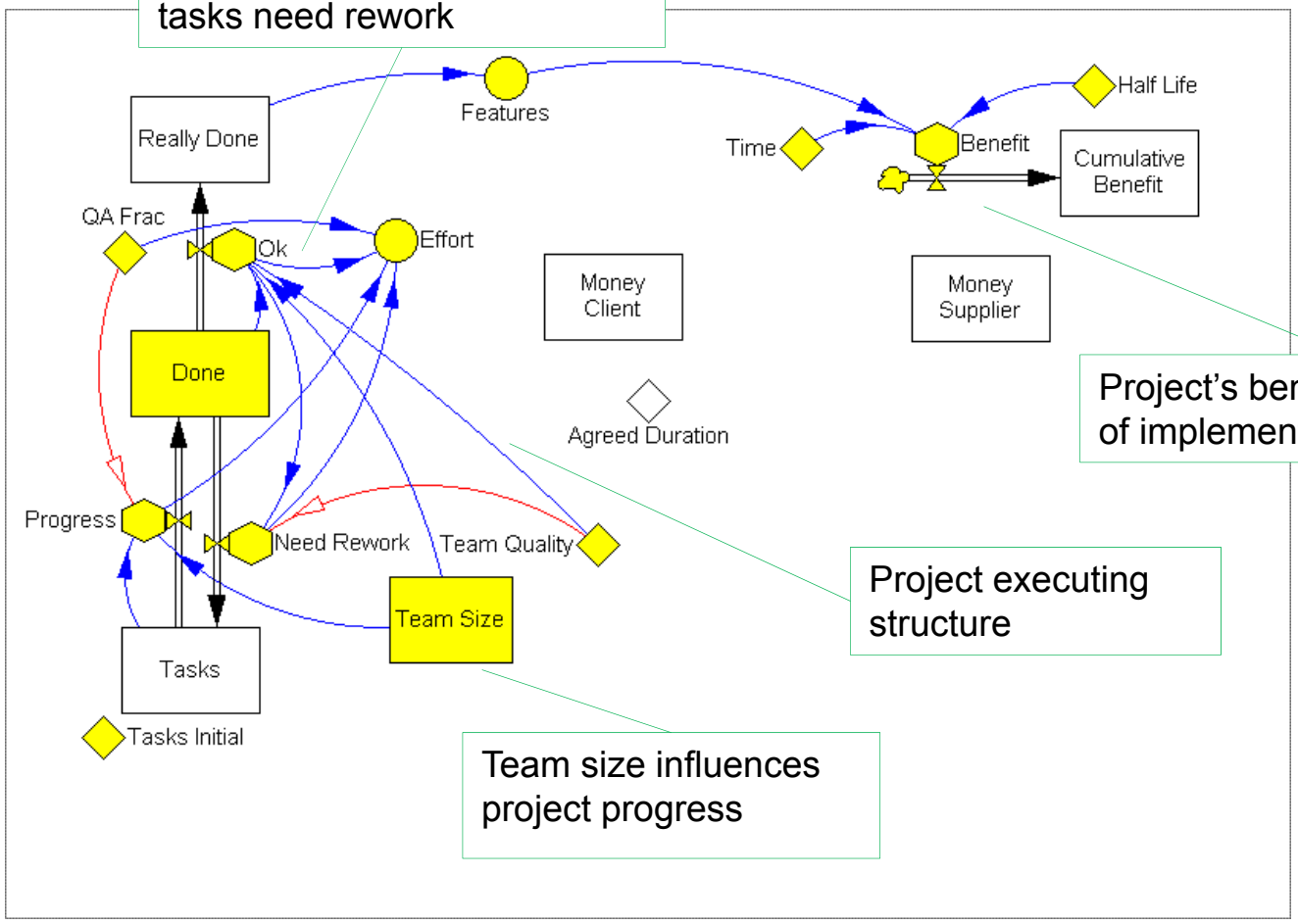
Purpose of our web-based simulation tool for public-private project contracting, based on a system dynamics model

- To give a better understanding of the opportunistic behavior of the private-sector supplier.
- Gives the participants the possibility to test different outcomes of the consequences of different contract types.
- Shows how project contracts that include incentives and carefully designed timely penalties help to keep a project on track, in budget and within the planned timeline
- Our web tool shall be used for teaching project contracting in the future

Key indicators describing a PPP-project



Project executing structure



Project deliveries have to pass a quality gate: some tasks need rework

Project's benefit is a function of implemented features

Project executing structure

Team size influences project progress

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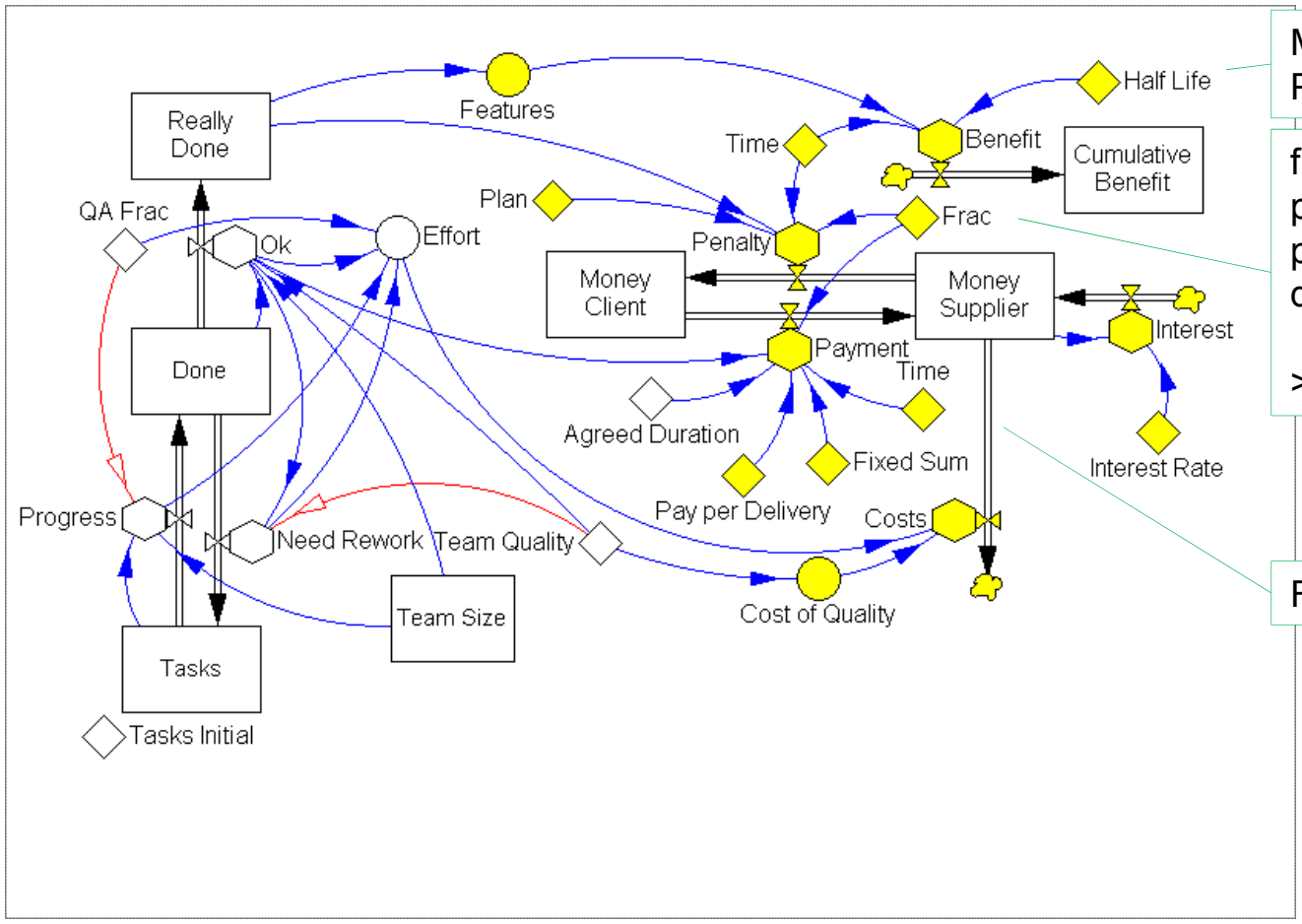
Benefits for the public and financial aspects



Mainly at IT-Projects

fraction of payment on a pay-per-delivery basis

>1 = penalty

Financial flows

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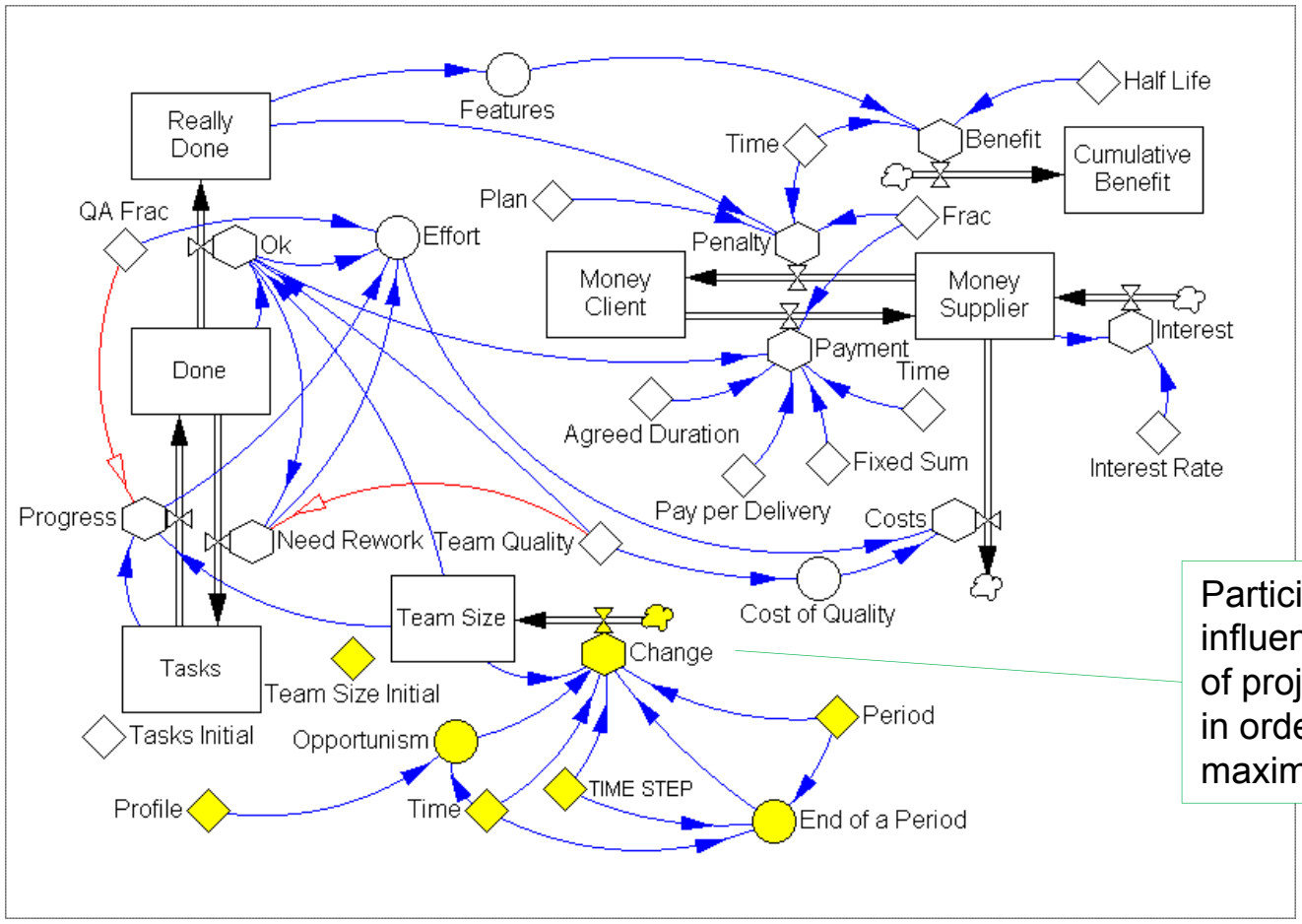
Setup for the field study: opportunistic project supplier



Participants influence size of project staff in order to maximize profit

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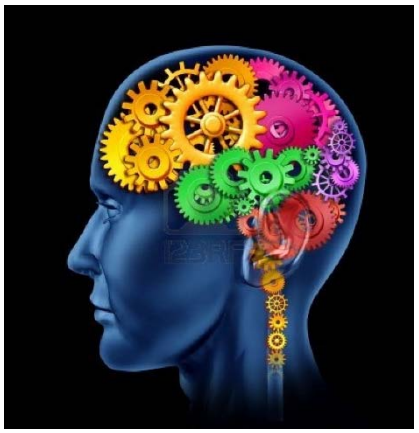
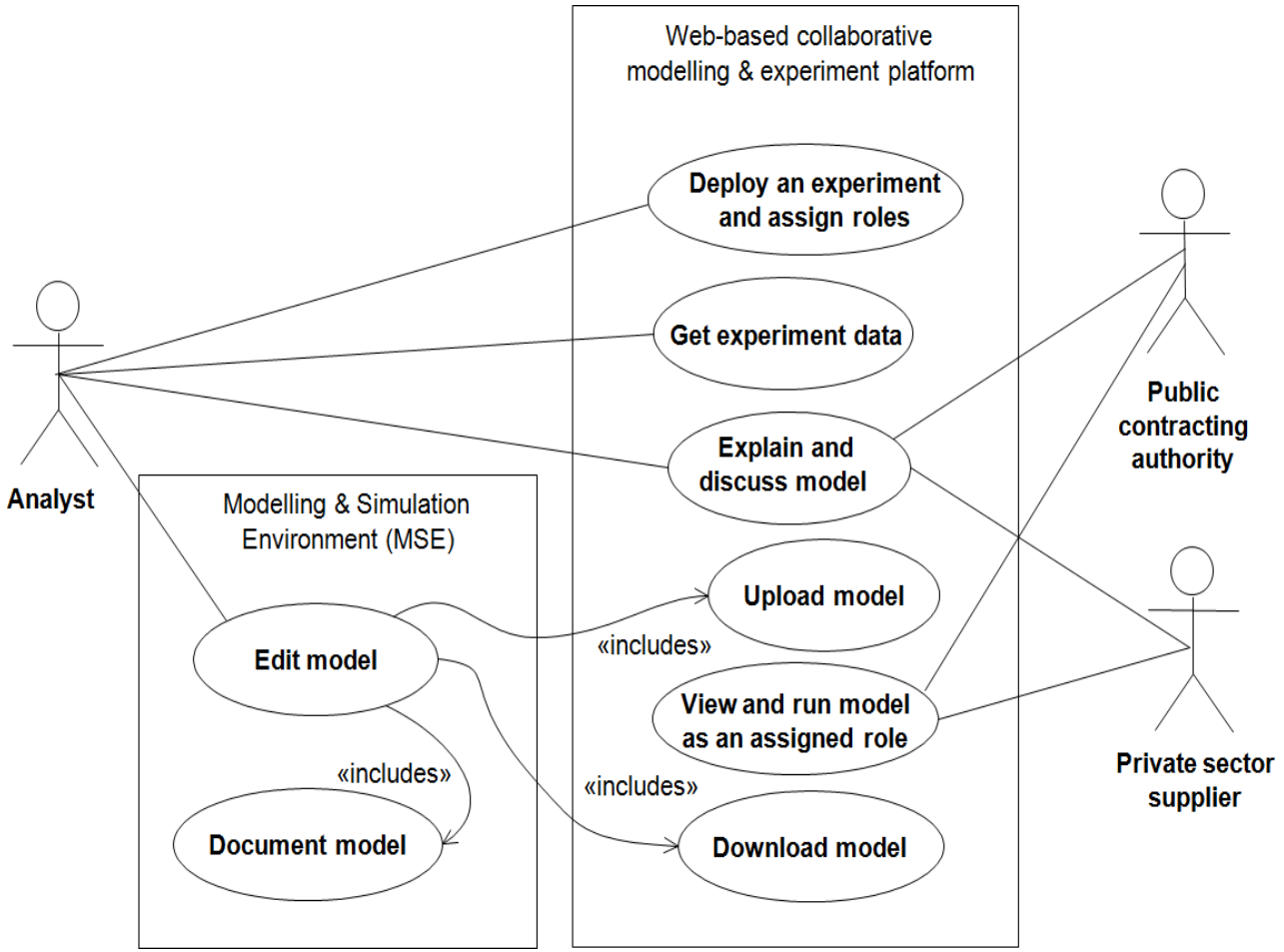
Our web tool for project contracting

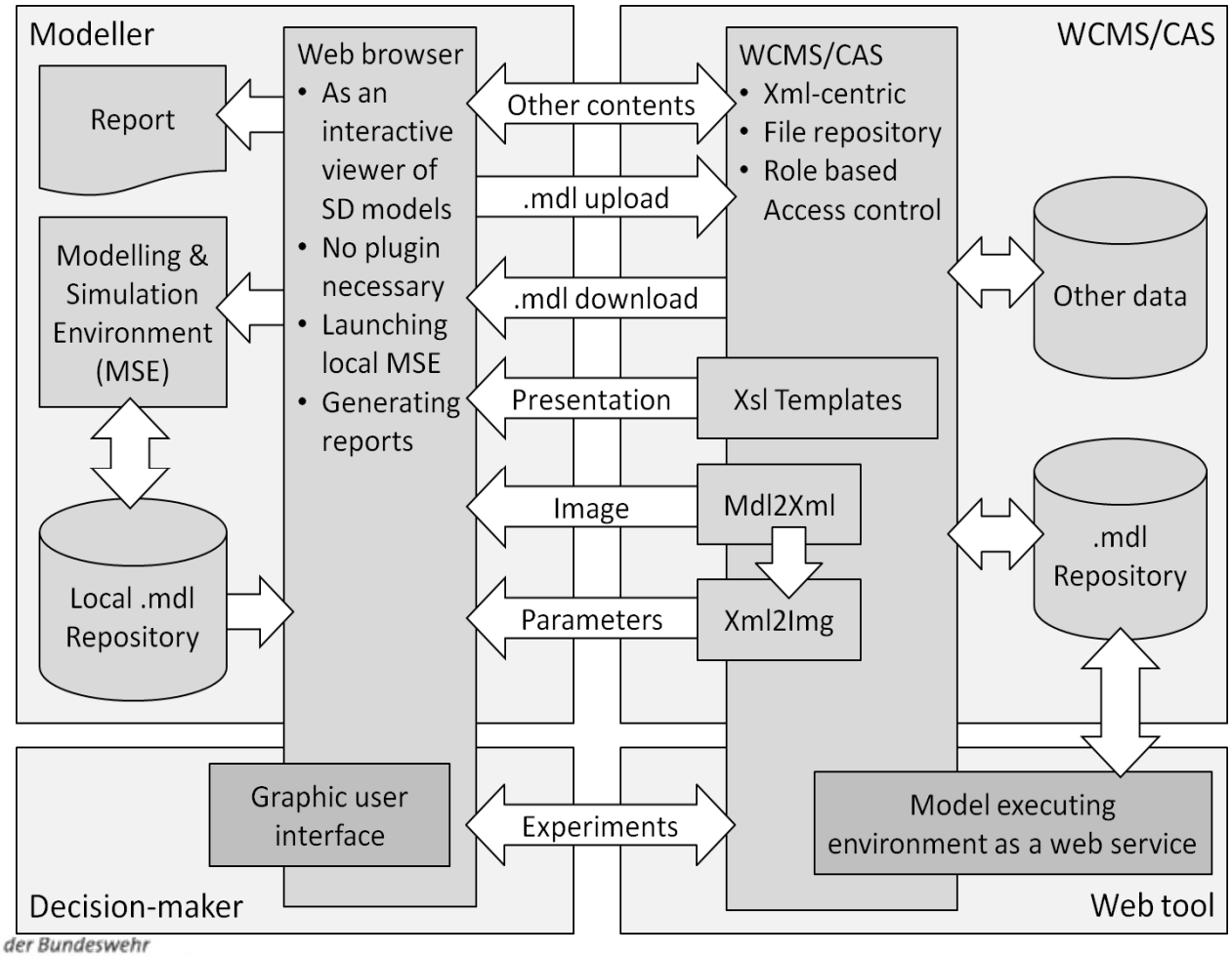
- Influence the pilot study decision process
  - accuracy of the participant's mental model
  - presentation of data material
- Possibility to achieve optimized decisions:
  - Better understandable data and information management
  - by the prototype of a web tool for project studies supported by a System Dynamics model



Use case diagram for a web tool for collective studies



System architecture of the collaborative modelling and experiment platform



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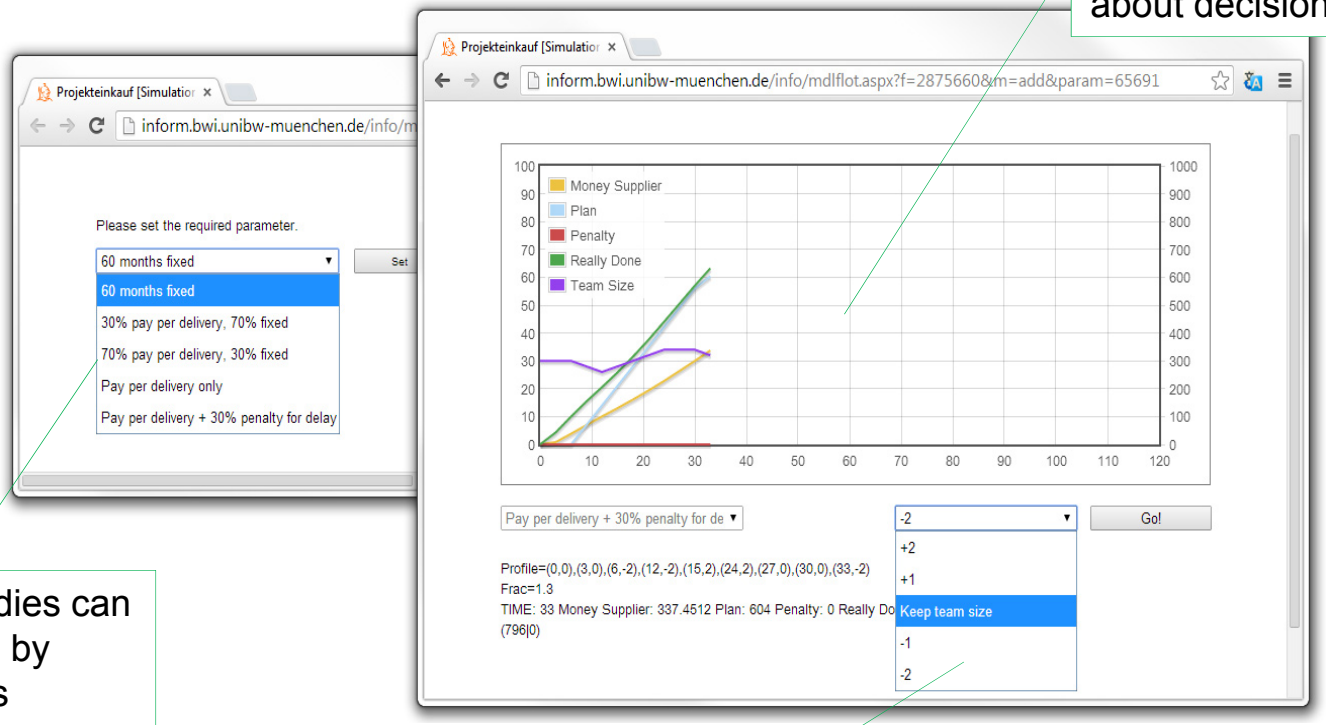
User interface of the web based management cockpit for project contracting



Key performance indicators inform about decision results

Individual studies can be configured by administrators

Participants influence size of project team during simulation run

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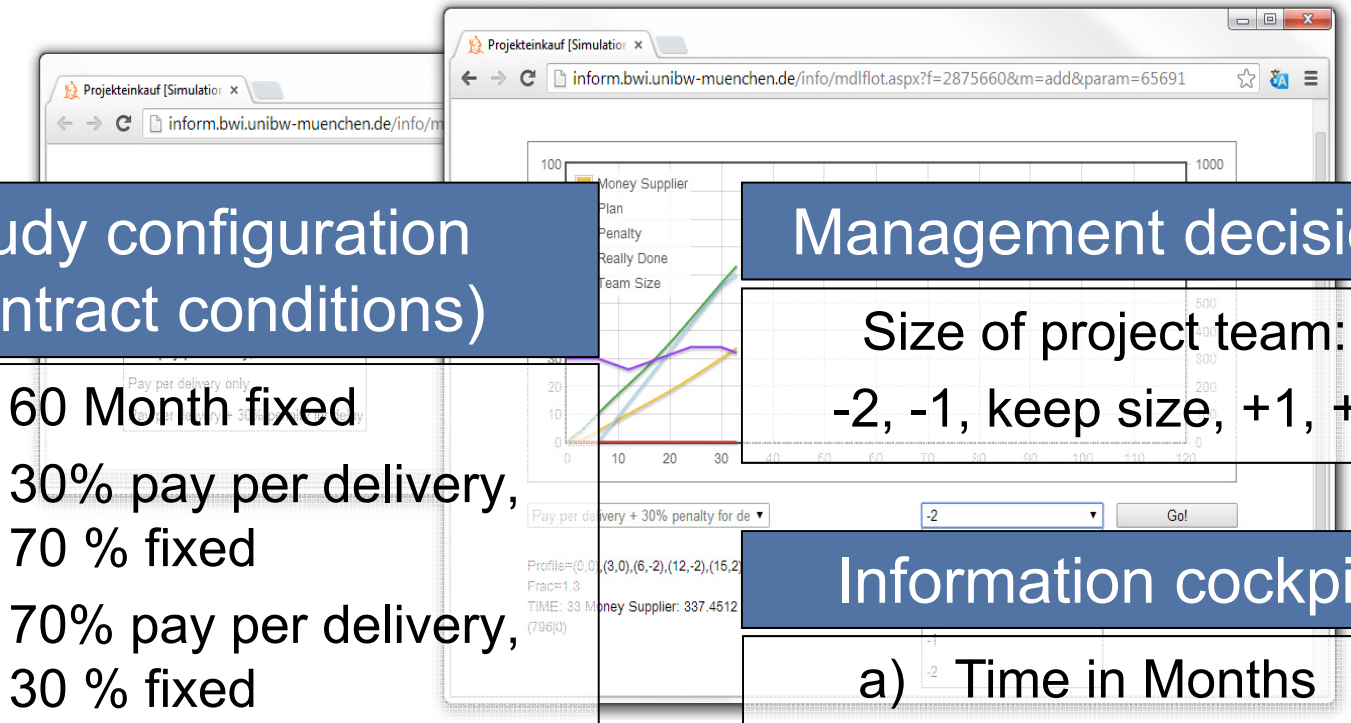
Features of the web tool for project contracting



Study configuration (contract conditions)

a) 60 Month fixed

b) 30% pay per delivery, 70 % fixed

c) 70% pay per delivery, 30 % fixed

d) Pay per delivery only

e) Pay per delivery + 30% penalty for delay

Role: **Administrator**

Management decision

Size of project team:

-2, -1, keep size, +1, +2

Information cockpit

a) Time in Months

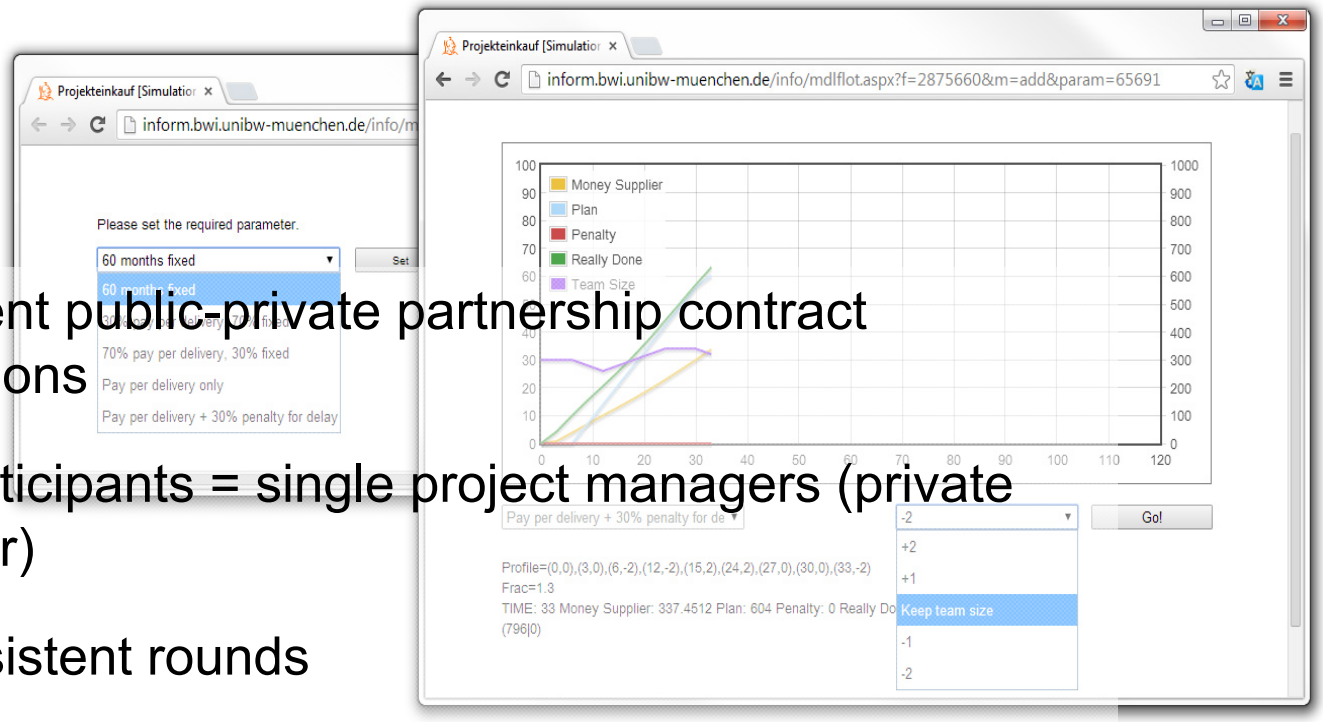
b) Money earned

c) Finished tasks

d) Actual team size

Role: **Private partner**

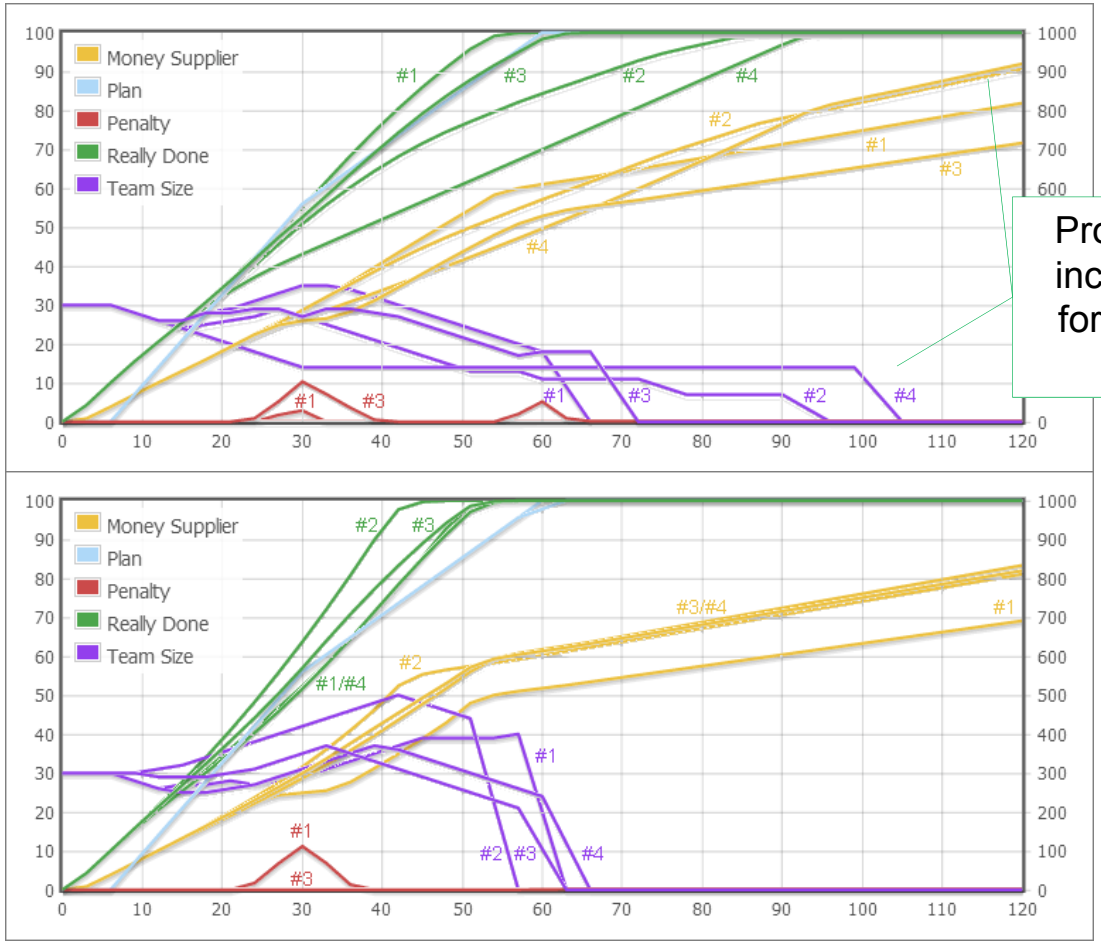
Configuration for the pilot study



- Different public-private partnership contract conditions
- 14 participants = single project managers (private partner)
- 4 consistent rounds
- Time limit for project completion: 120 Months
- Initial size of project team: 30 members

A flight simulator for project execution for studying opportunistic behavior

- Understanding conflicting public and private interests in a PPP project
- Understanding possible opportunistic behavior of private-sector project suppliers



Project delays increase profit for the private partner

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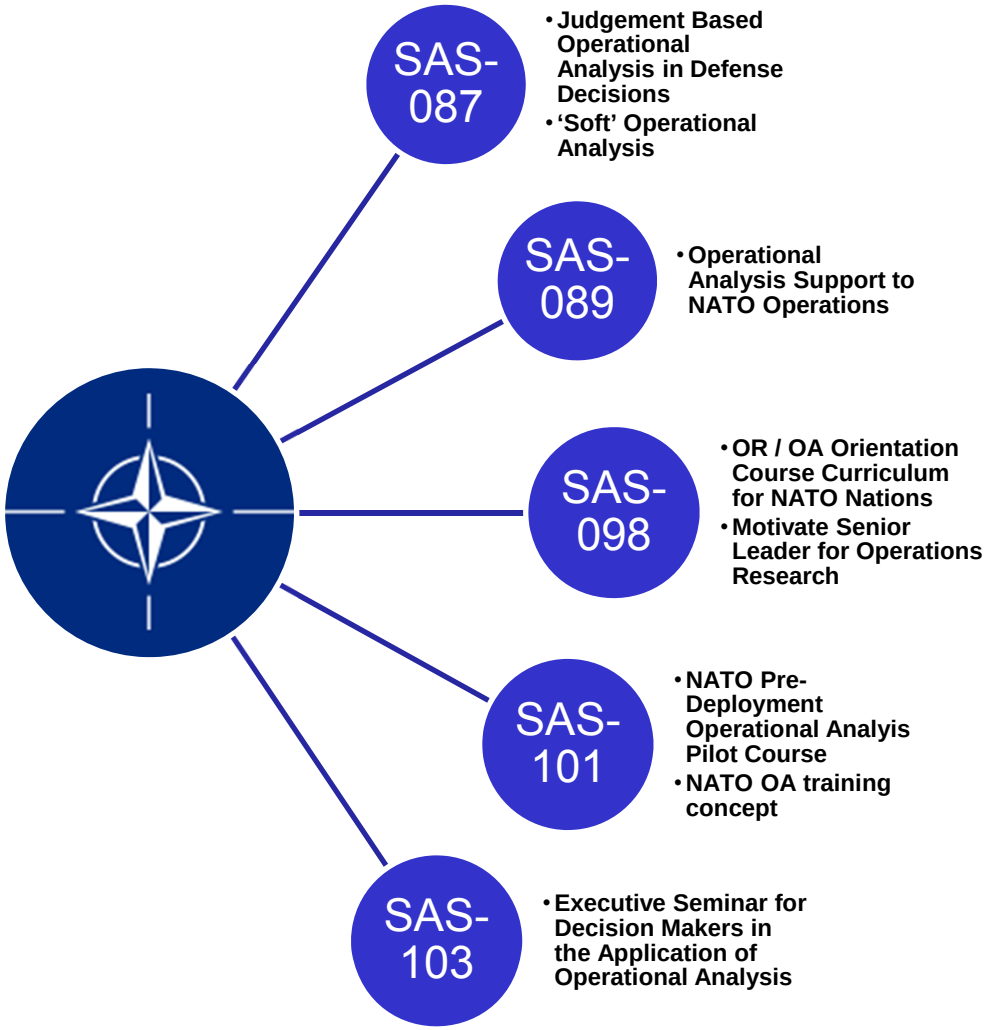
Conclusion

- The web tool allows students to play decision makers and to understand and realize the effects of their specific actions.
- The web tool in combination with a System Dynamics model offers a high grade of flexibility and attractiveness for further studies.
- The System Dynamics model shows the critical interdependencies of the key performance indicators for PPP projects.
- Outlook:
  - Further studies with more students (public partner)
  - Improvement of the web tool
  - Configuration of further specific scenarios in the System Dynamics model

NATO courses

- Developing new NATO training course on operational analysis in defense decisions
- Motivating senior leaders for operations research issues
- Carrying out existing comprehensive NATO courses on hard and soft OR



RiKoV

- Joint project together with KIT, FHK and Airbus DS; Consortium leader: UniBw
- Sponsor: German Federal Ministry of Education and Research
- Critical infrastructure protection (CIP) in the fight against terrorism
- Scenario-based multi-criteria decision support balancing protective effects, costs and acceptance
- Management of uninsurable security risks
- Mathematical modeling and numeric simulations in combination with real world experiments

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Structural network analysis

- How can we quantify the structure of a network?
  - A topological descriptor (measure) is a mapping $I : \mathcal{G} \longrightarrow R$
  - Prominent examples are the Wiener index and Randić index

$$W(G) := \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} d(v_i, v_j) \qquad R(G) := \sum_{(v_i,v_j)\in E} [k_{v_i} k_{v_j}]^{-\frac{1}{2}}$$

- Using computational techniques a special graph entropy can be introduced:

$$I_f(G) = -\sum_{i=1}^{|V|} \frac{f(v_i)}{\sum_{j=1}^{|V|} f(v_j)} \log\left(\frac{f(v_i)}{\sum_{j=1}^{|V|} f(v_j)}\right)$$

where

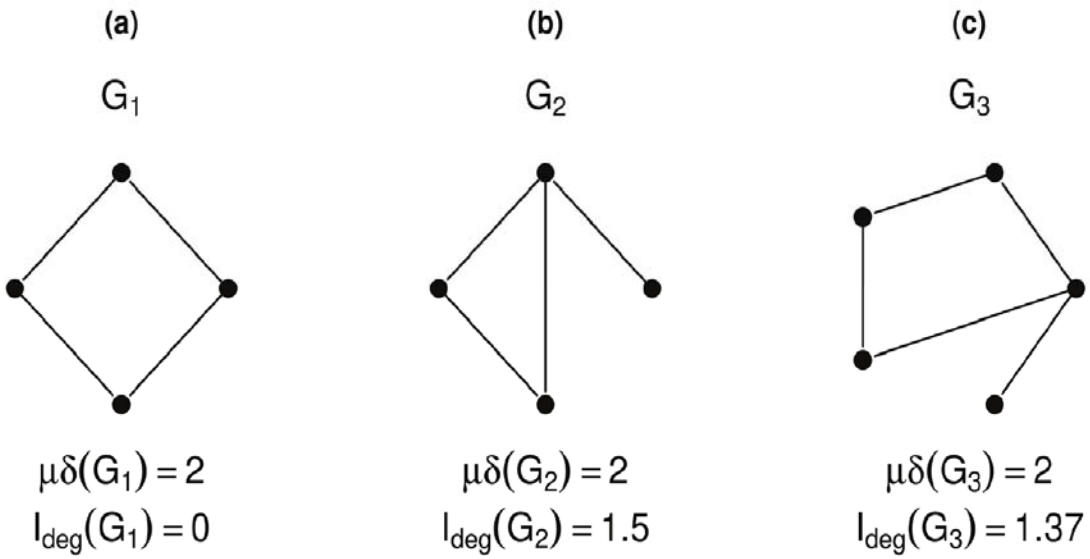
$$f(v_i) := \alpha^{c_1|S_1(v_i,G)|+c_2|S_2(v_i,G)|+\cdots+c_{\rho(G)}|S_{\rho(G)}(v_i,G)|}$$

$$c_k > 0, 1 \leq k \leq \rho(G), \alpha > 0$$

  - Graph entropies turned out to be quite unique when discriminating graphs structurally

Uniqueness of structural network measures

- Example: Let $\mu\delta(G) := \frac{\sum_i \delta_i}{N}$ and let $I_{deg}(G) := -\sum_{i=1}^{k} \frac{|\delta_i|}{N} \log \frac{|\delta_i|}{N}$

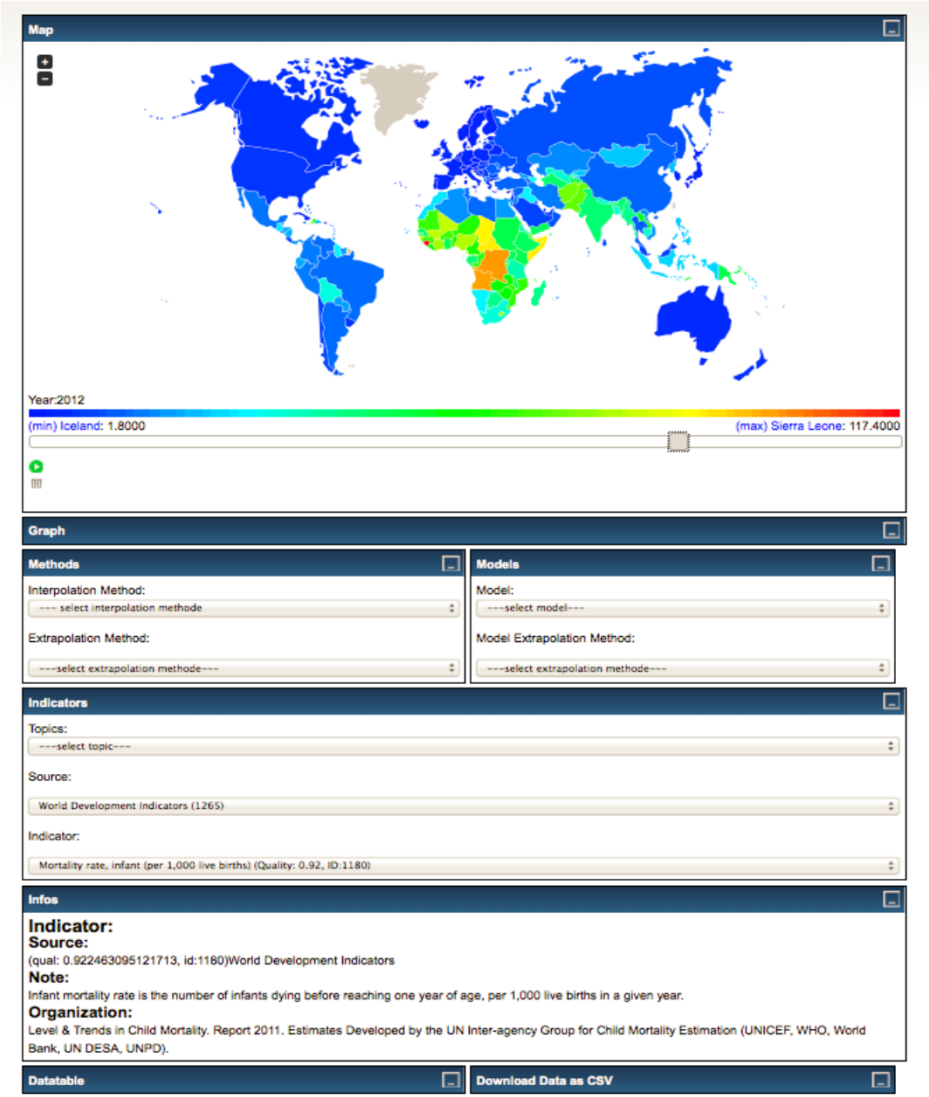


- Graph entropy measures play an important role in a variety of problem areas, including biology, chemistry, and sociology

Müller and Dehmer 2011, Dehmer and Mowshowitz 2011

RAHS – Risk Assessment and Horizon Scanning

- Quantitative methods of future studies
- Web mining: periodic scanning of keywords in more than 100 languages of the World
- Big data: trend and geographic analysis
- Identifying hot spots of the near future



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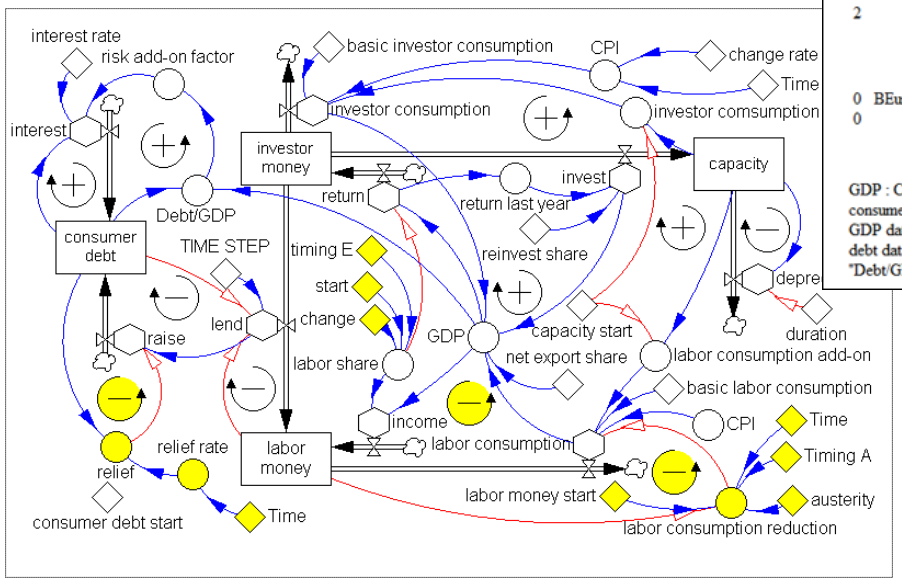
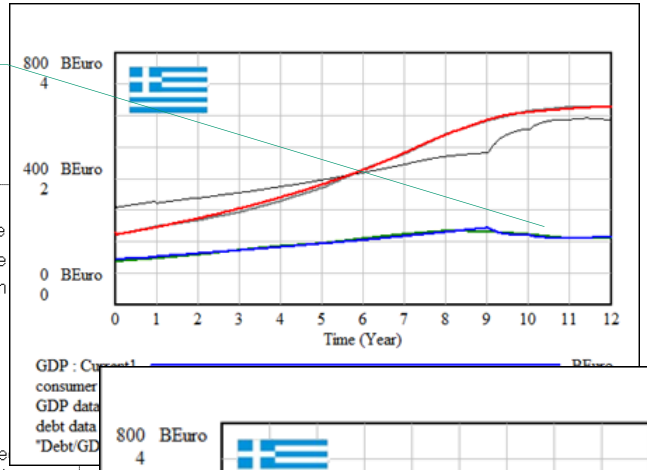
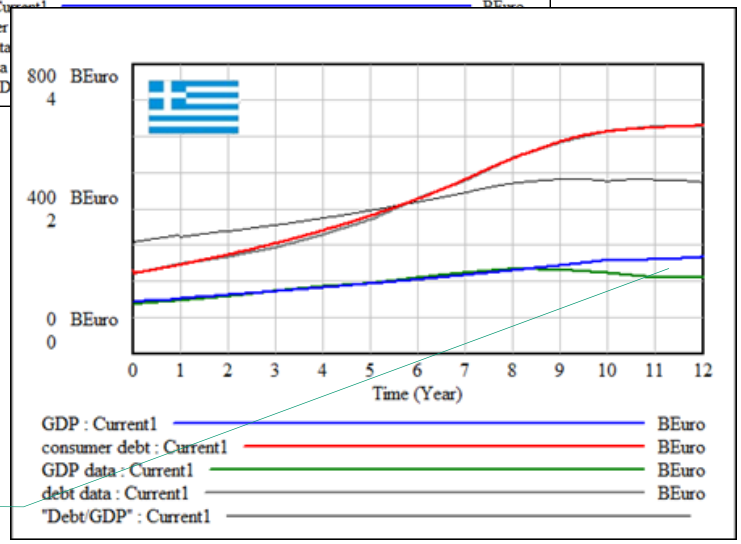
System dynamics modeling and simulation using real data to compare different (bailout) policies (of Greece)

What has happened in Greece: Austerity reduces both debt and GDP







What would have happened: 20%+ Higher GDP through higher income equality

Data source: eurostat

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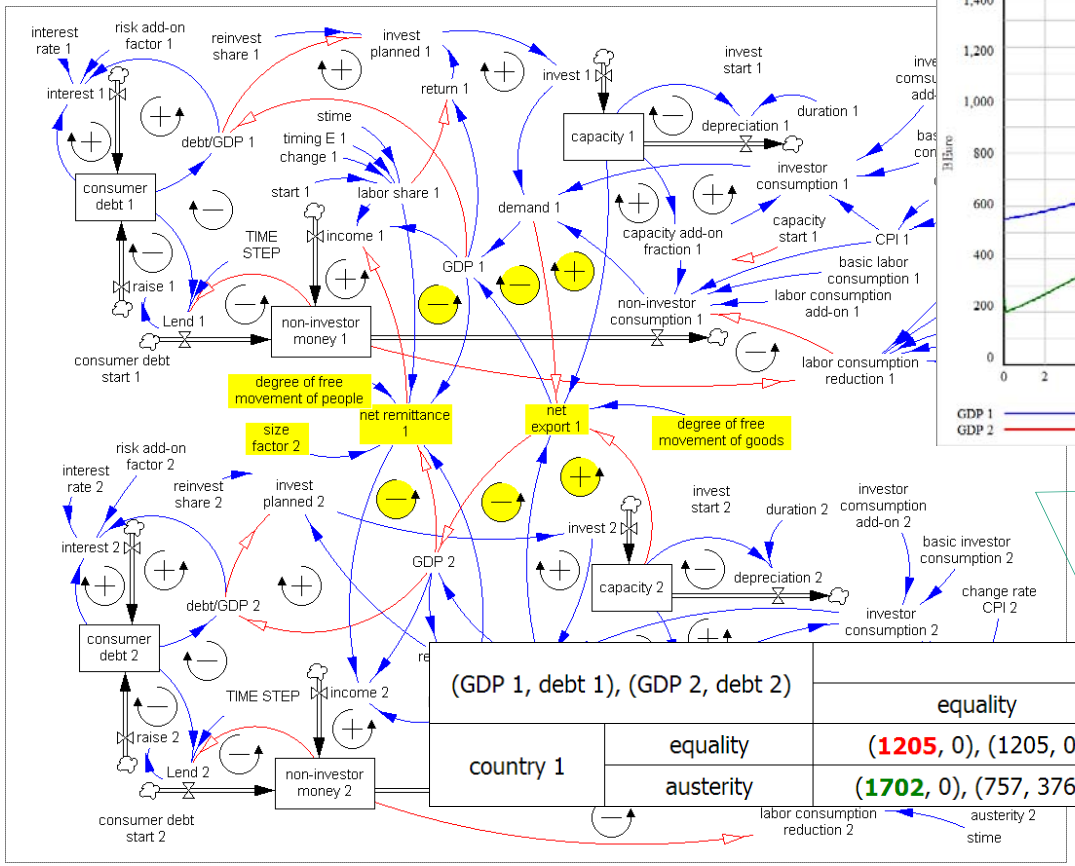
In a two-country case: policy makers facing a Prisoners' Dilemma



(GDP 1, debt 1), (GDP 2, debt 2)		country 2	
		equality	austerity
country 1	equality	(**1205**, 0), (1205, 0)	(757, **3762**), (1702, 0)
	austerity	(**1702**, 0), (757, 3762)	(722, **0**), (722, 0)

"self-interested action seems to lead inexorably to a Pareto inferior outcome" which is the austerity policy in both countries.

Lipman 1986

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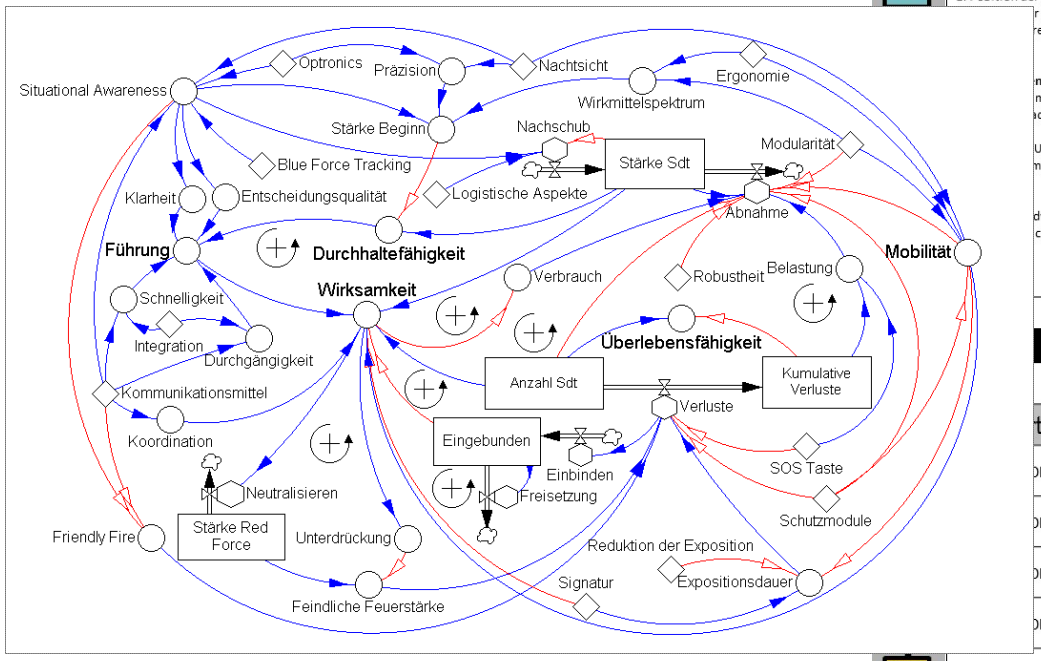
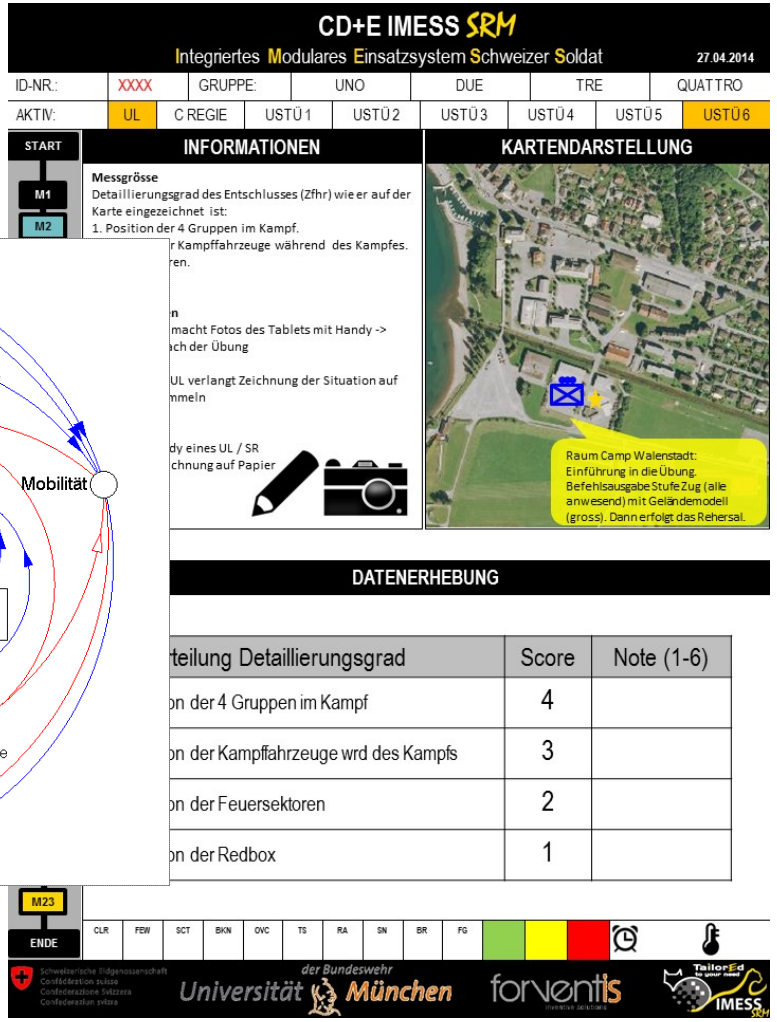
IMESS – system dynamics modeling supporting experimentation during an acquisition process

- **I**ntegriertes **M**odulares **E**insatzsystem **S**chweizer **S**oldat





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Q&A

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