This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 608090.

HyRiM

G-DPS: A Game-theoretical Decision-making Framework for Physical Surveillance Games

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Agenda

- Introduction
- Game-Theoretic Modeling using Uncertainty
- Decision-Making Framework and Physical Surveillance Games
- Example: Risk of Physical Intrusion in Critical Infrastructure Environment
- Conclusion

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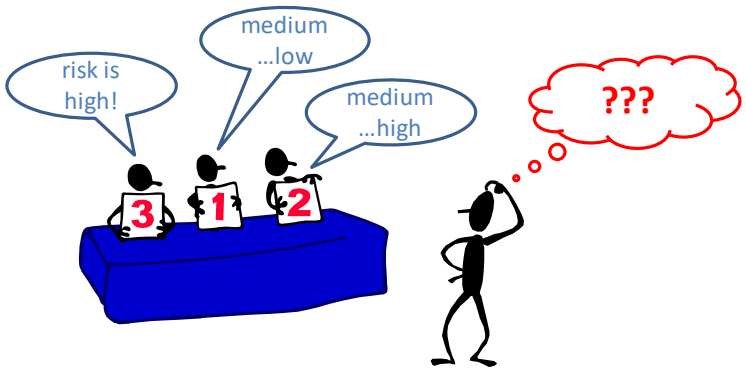
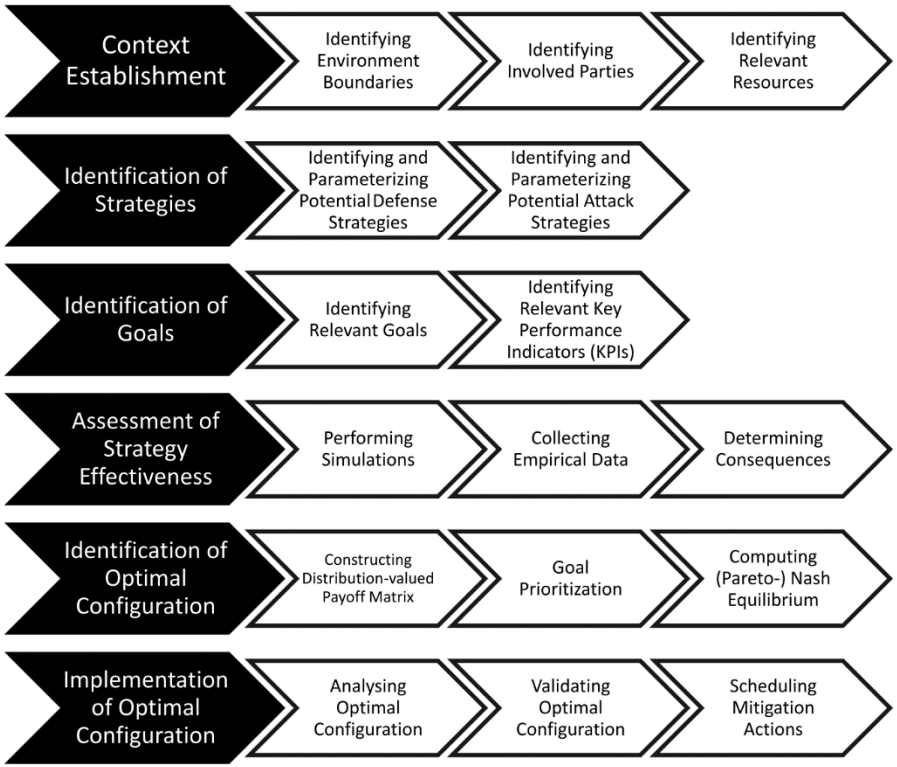
Introduction

- Risk Management Approaches are typically generic and leave degrees of freedom in the „how“ to accomplish individual steps
- Input in each step relies on domain expertise
- Asking experts is occasionally problematic:

3 People asked → 4 opinions told





G-DPS Framework

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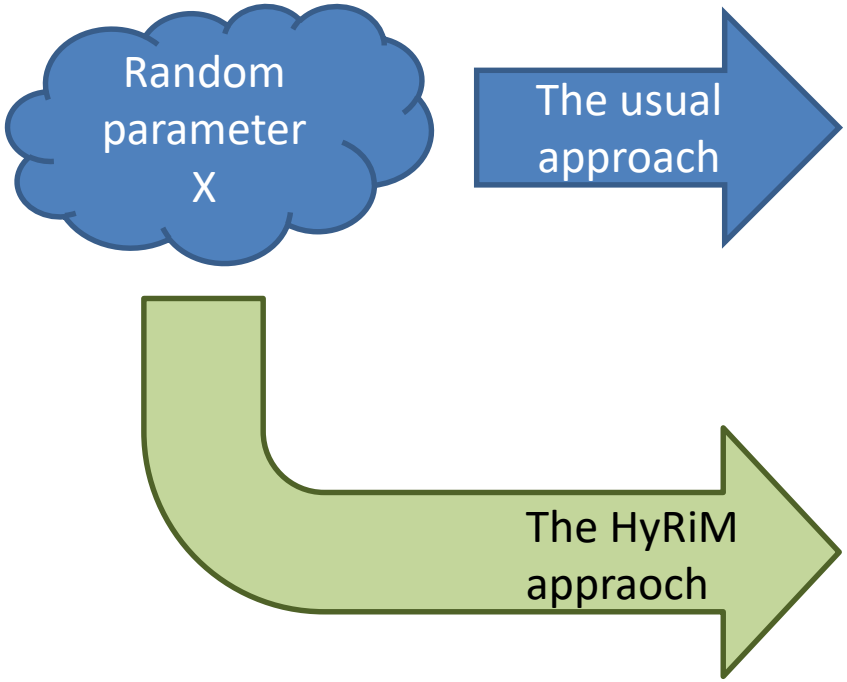
Uncertainty Modeling

- Suppose we have a random parameter or quantity X to deal with (such as „risk“ for decision making)



- „Average out the randomness“ (talk only about means, not concrete outcomes)
- Simplifies matters, as we are back at familiar numbers
- But burns lot of information

- Work with the full-featured random variable
- Theoretically more involved
- Yet preserves the available information (that is scarce anyway)

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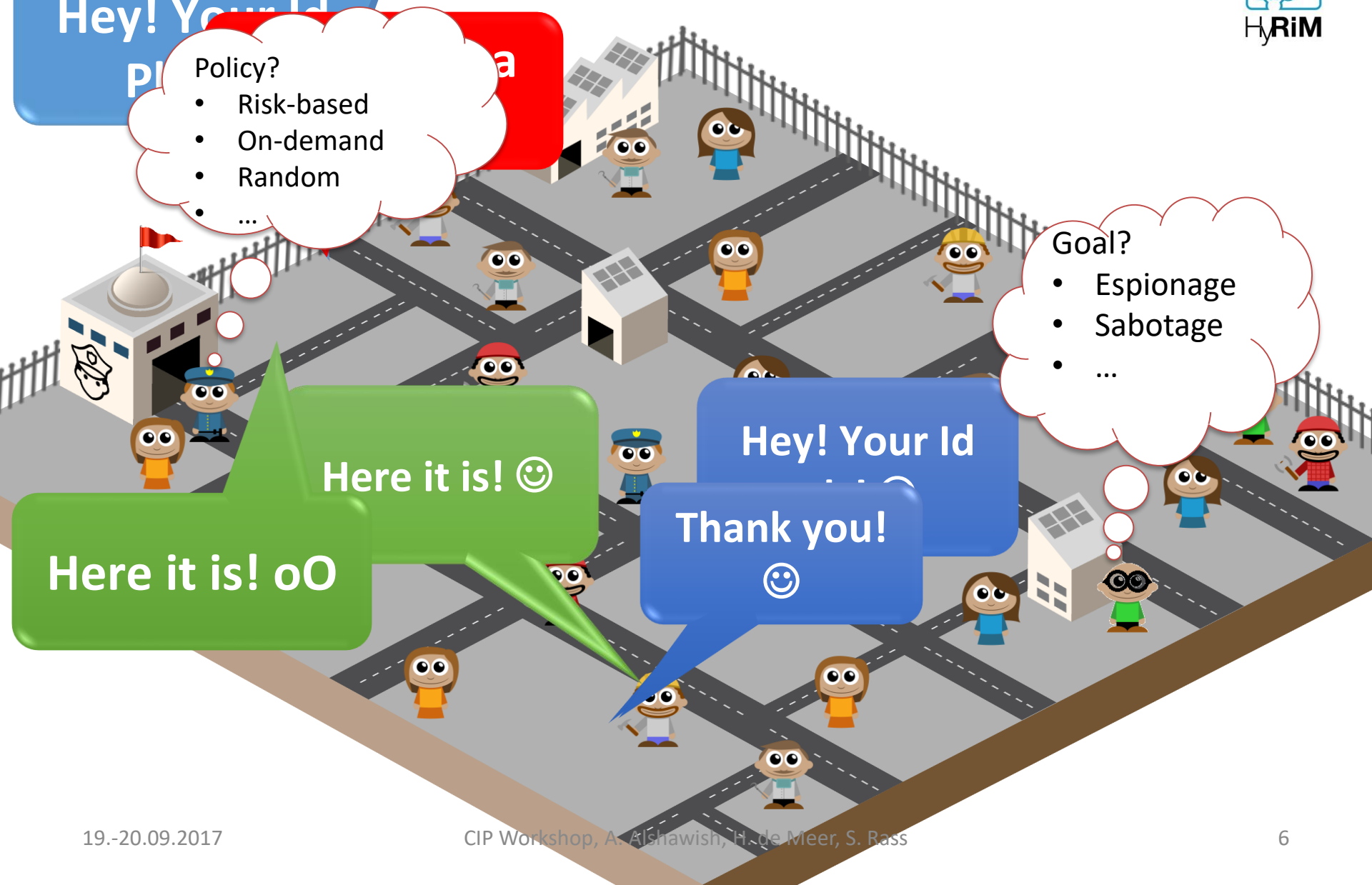
Uncertainty in Games

- Game Theory: …the (natural) model for the non-cooperative competition between the defender and the adversary
- Game Theory in HyRiM:
  - In practice: Play a worst-case game (what is the best defense against any action of the adversary? What are the worst case attack scenarios?)
  - In theory: lift games to abstract spaces of probability distributions, and use stochastic orders for optimization
- In this talk:
  - Two-Player game: Surveillance people (player 1) vs. Intruders (player 2)
  - Outcome: Intruders either get caught or get missed
  - Uncertainty: …several kinds of…
    - Blind spots of cameras (static surveillance system)
    - Coincidental misses upon location visitations (adversary was „just not seen“)
    - …

Example

Physical Surveillance Games



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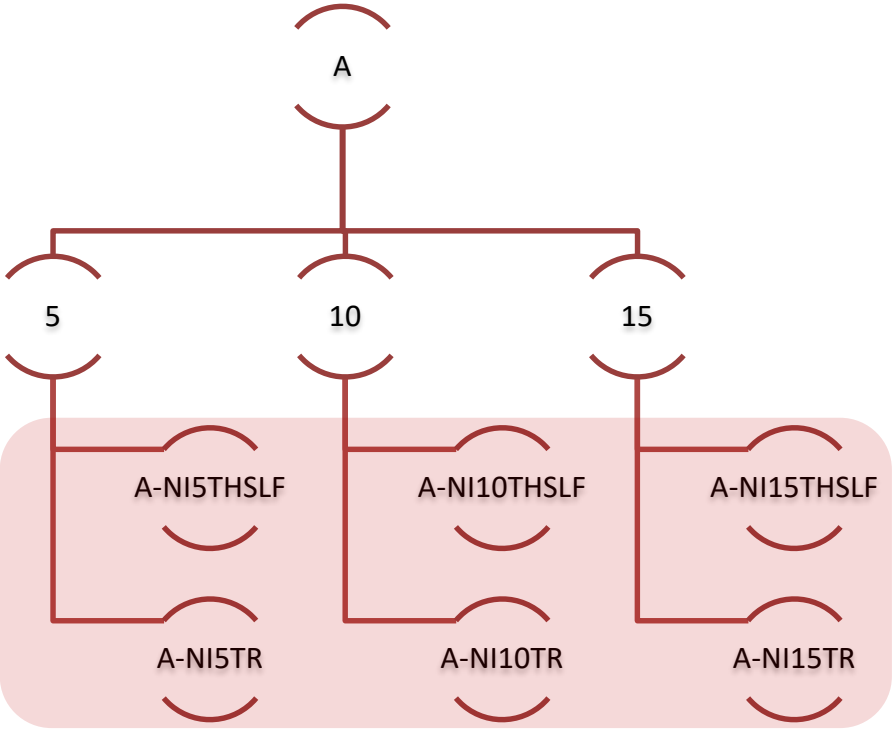
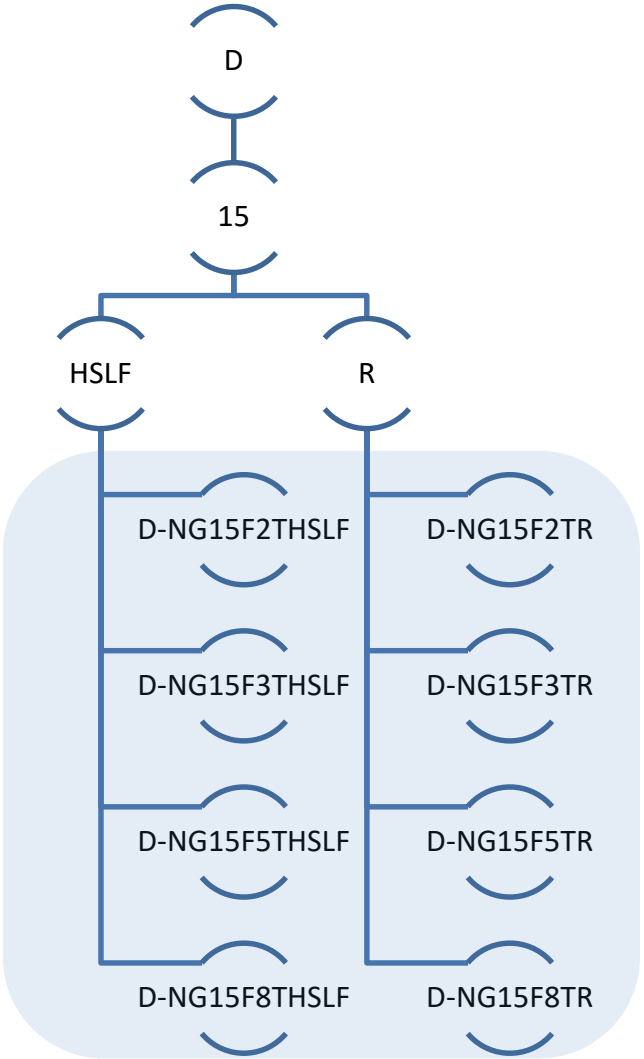
G-DPS Framework

Identification of Strategies





HSLF: **H**igher **S**ecurity **L**evel **F**irst

R : **R**andom

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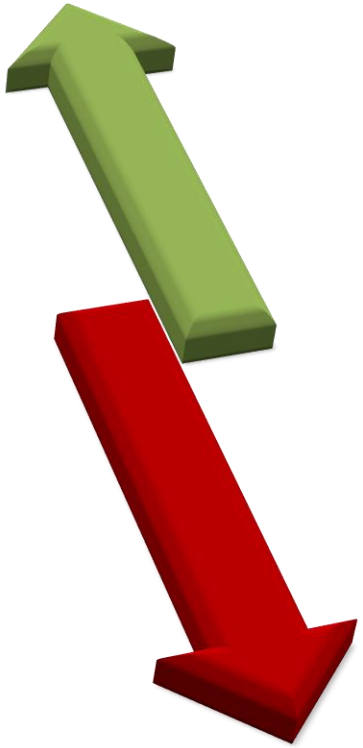
G-DPS Framework

Identification of Goals

- Detection Rate:
  - Number of detected intruders/Total number of intruders (NI)
- Minimum Privacy preservation:
  - Inversely related to the maximum possible disclosure of employees' locations
- Average Caused Damage
  - $\frac{1}{NI}\sum_i \sum_j timeSpent(intruder_i, area_j) \times secLevel(area_j)$
  - where $secLevel(area_j)$ gives the security level of area j
- Maximum Comfort Breach
  - The maximum comfort breach experienced by the employees
- **The multi-objective security game (MOSG): 8 Def. Strategies x 6 Atk. Strategies x 4 goals**



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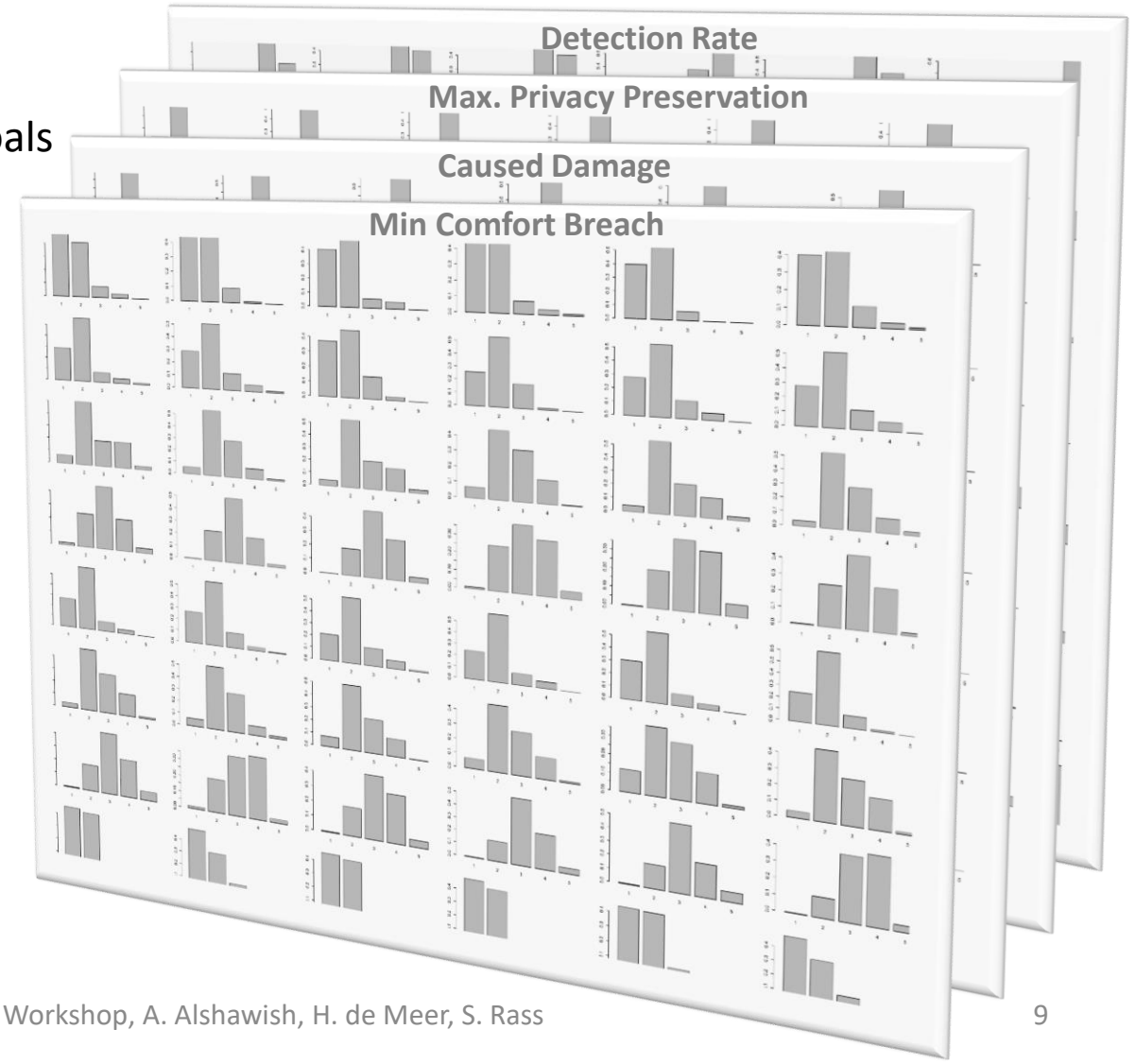
G-DPS Framework

Assessment of Strategies

- Strategy assessment
  - w.r.t. the identified goals
  - Classical surveys
  - Expert opinions
  - Statistical data
  - Simulation

  → Distribution-valued payoff matrix
  - Demo *„Simulation Framework to Assess Physical Surveillance Strategies “* on Wednesday at 10:00



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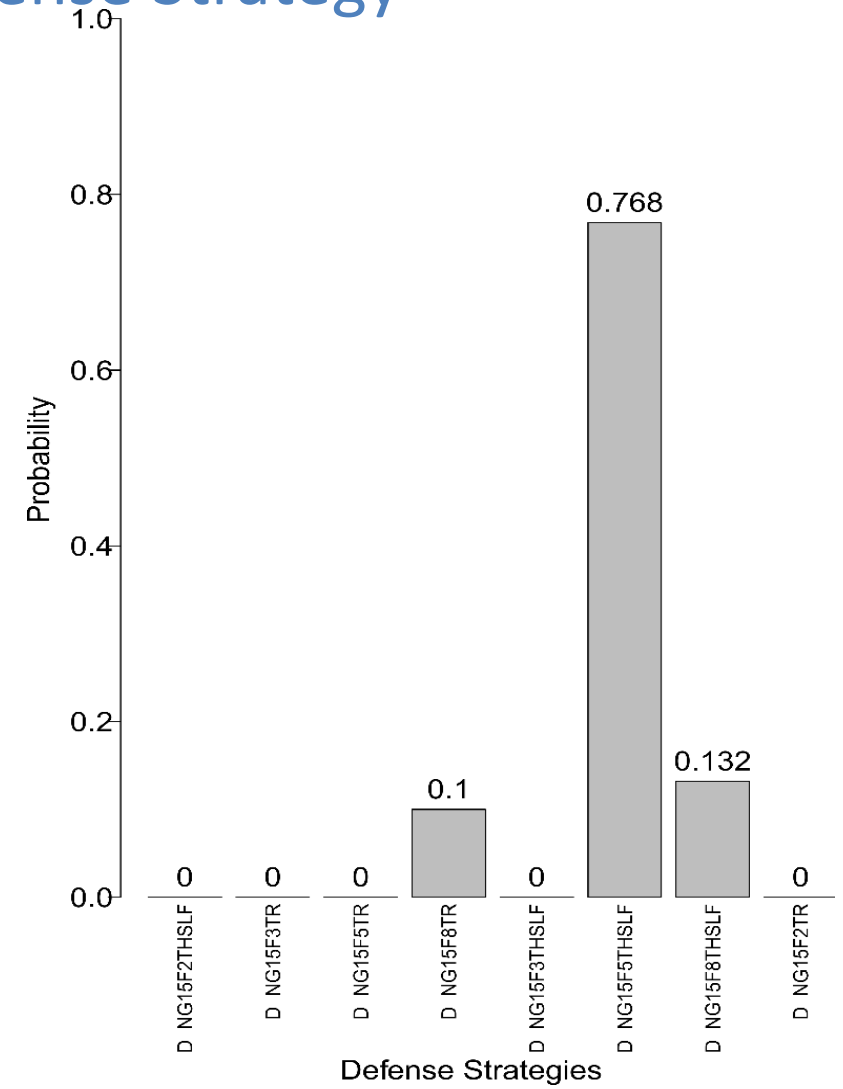
G-DPS Framework

Optimal Defense Strategy

Applying HyRiM R-package

- Optimal defense strategy
  - No single optimal defense precaution
  - The best is a „mix“ of defense measures



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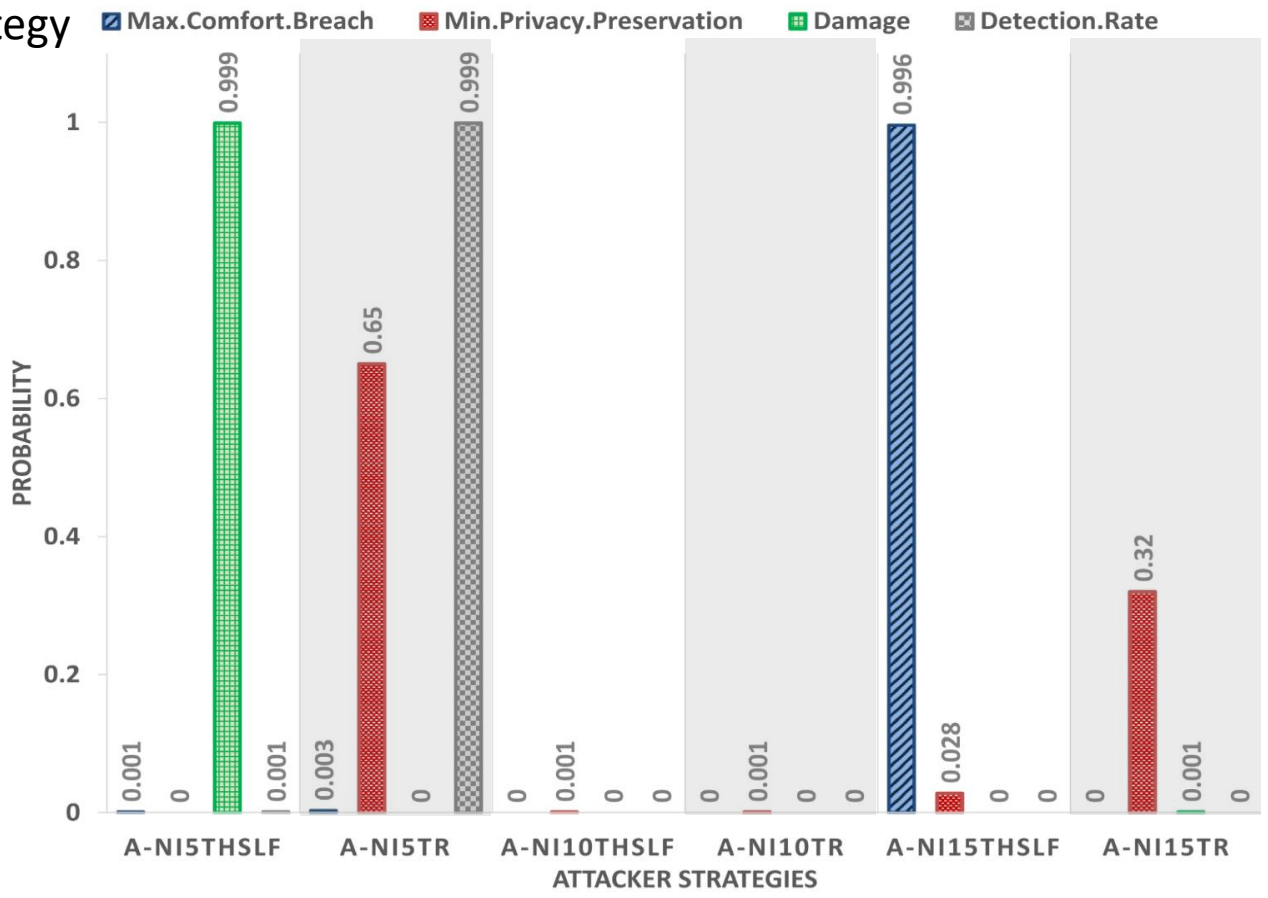
G-DPS Framework

Worst-case Attack Strategy

Applying HyRiM R-package

- Worst-case attack strategy
  - No single adversarial plan causes maximal loss in all goals
  - Real losses (in all goals) are less than predicted by the game



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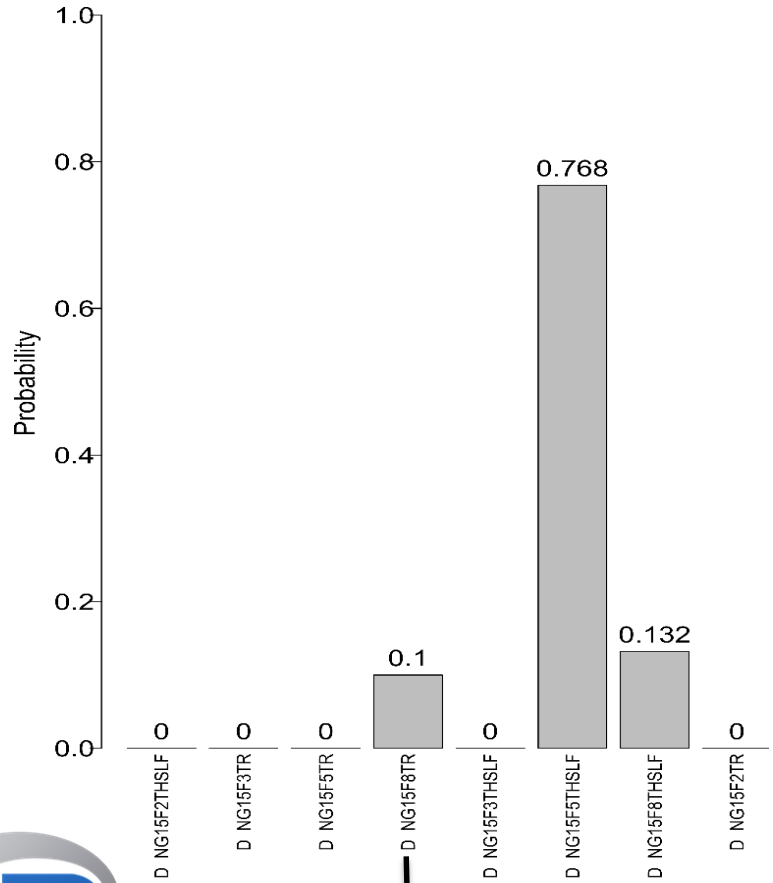
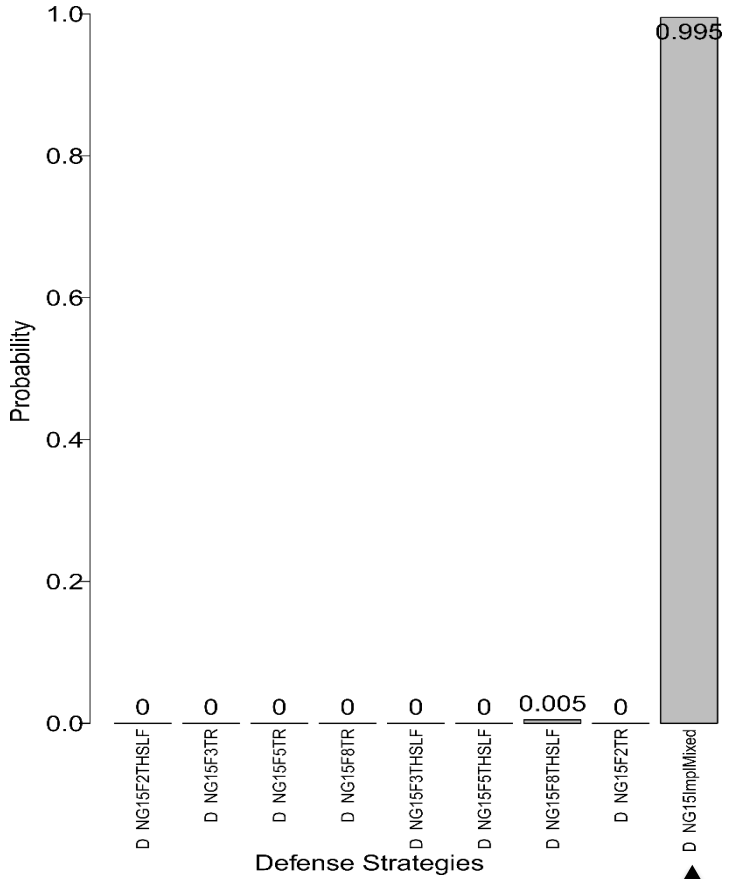
G-DPS Framework

Validation





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Conclusion

- Risk management in critical infrastructure involves maintaining a high level of situational awareness by means of surveillance and on-site observation.

- The challenge: resource allocation decisions
  - Uncertainty
  - Multiple competing goals

- Therefore, HyRiM approach delivers a tailored framework for game theory that allows:
  - playing games towards risk minimization over stochastic orders, and
  - optimizing over different goals (e.g., damage caused by the adversary, costs for security measures, acceptance of the security measures by the end-users, etc.)

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Thank you for your attention

Questions?

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