Augmented Teams

Assembling Smart Sensors, Intelligent Networks and Humans into Agile Task Groups

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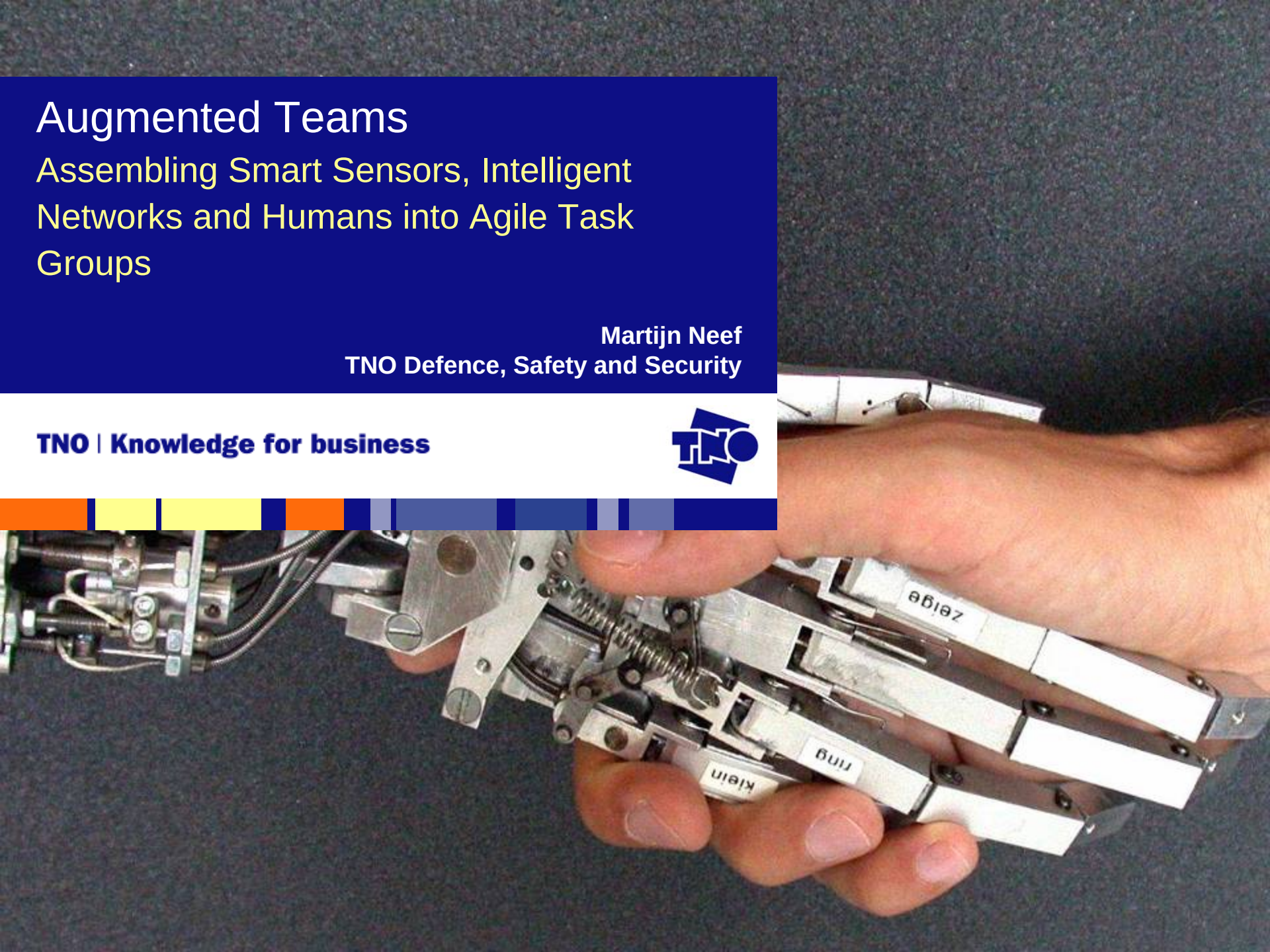
TNO | Knowledge for business



Augmented Teams:
Assembling Smart Sensors, Intelligent Networks and Humans into Agile Task Groups

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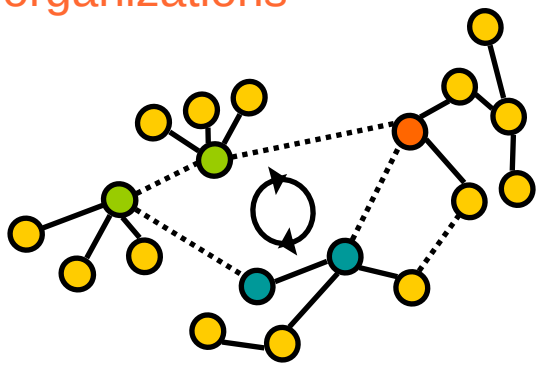
- Introduction and context
- Approach and ingredients
- Experiments
- Observations, conclusions
- Outlook

Augmented Teams

- Network-centric approaches are becoming common in defense and civil domains
  - more sensor networks, communication networks, smart systems, distributed decision making, distributed organizations.
  - new response options through smart coupling of capabilities
  - more prominent and active role for intelligent, autonomous systems

- Increase of system autonomy leads to different team dynamics.
  - technology role goes from supplement to active participant
  - task groups will gradually develop into hybrid organizations

Need for a new understanding of teamwork that recognizes the dynamics of man-machine organizations.



Augmented Teams

We are exploring design principles for augmented teams.

An augmented team consists of a collective of sensors, actuators, information processing systems and humans

- that are interconnected by a intelligent network
- that collaborate in a close and adaptive fashion, and
- that, by presence of the artificial actors, augment the capabilities of the human actors alone.

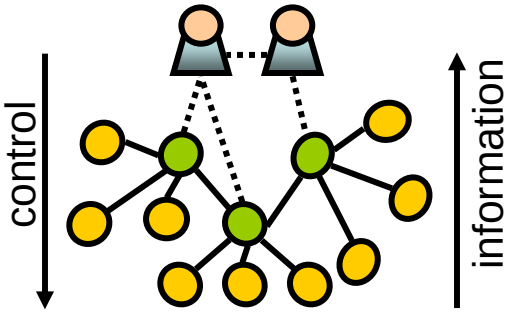
Design challenges

Can we come up with a design concept for augmented teams..

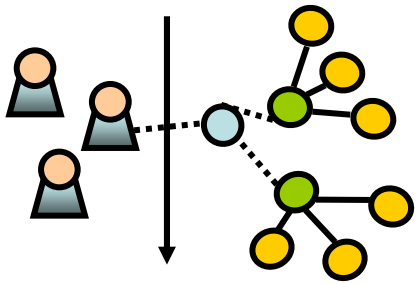
- .. with adaptive role- and tasking capabilities between human and artificial actors
  - Essential for agility and resilience. The team must be able to cope with changing circumstances, e.g. by changing the behaviour or structure of the organization.

- .. that is suitable for the current and future state of technology
  - Prevent technology bias. Limit the influence of the current state or technology on the approach as much as possible.

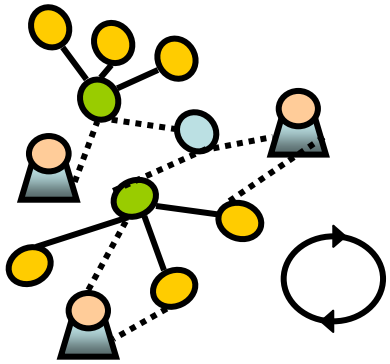
Design challenges



human team with sensor network



hybrid team with clear divison of labour



self organising adaptive team

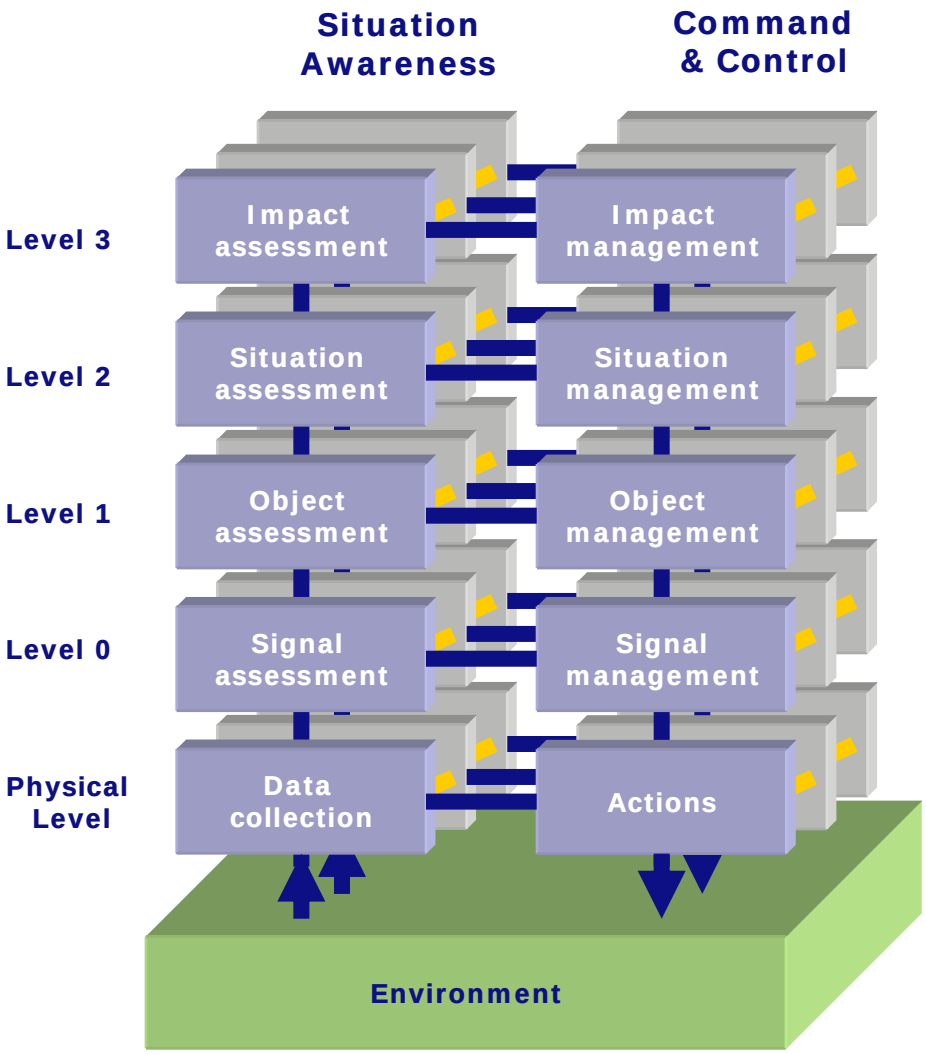
Basic challenges

- It must be possible to change the organization structure
- The team must be configurable at run-time
- All elements must be network-connected
- Actors must be able to represent themselves
- The information flow must self-organize

Approach

- Three main ingredients:
  - Functional model
    - Provides a functional blueprint for augmented teams
  - Organization modeling framework
    - Provides means to structure interactions and responsibilities
  - Social and interaction contracts
    - Provides a way to specify community rules and collaboration demands

Functional Model



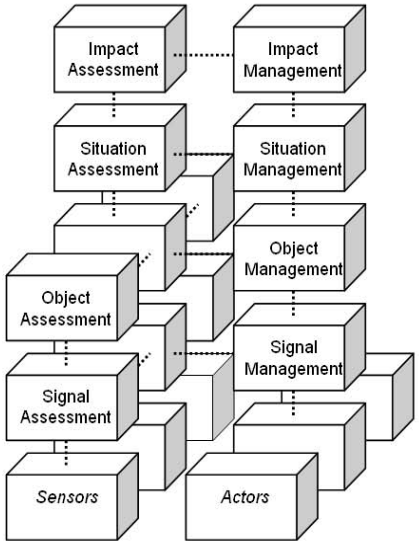
- Networked Adaptive Interactive Hybrid Systems model (**NAIHS**)
- Blueprint for networked cognitive systems, grounded in the JDL model
- *Elements* fulfill *functional components.*

- Three steering dimensions:
  - level of information abstraction
  - timescale of effects
  - physical structure

Organizational Model

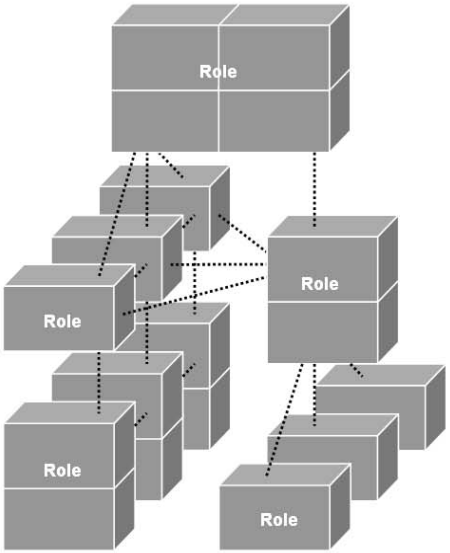
- Based on **OperA** (Virginia Dignum, Utrecht University, NL).
  - framework for the specification of multi-agent organizations
  - uses a formal specification language

1. Organizational Model



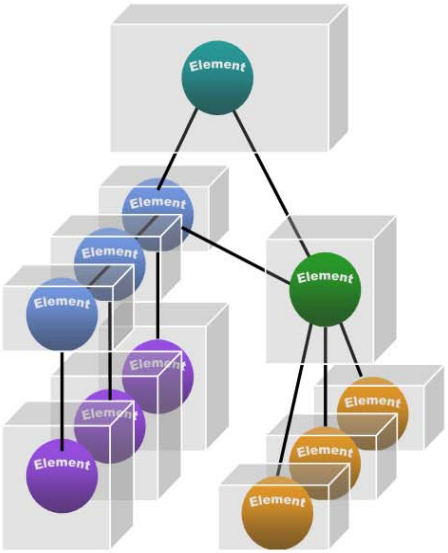
Functionalities of the system presented as Functional Components and the required information flow

2. Social Model



Roles presented as 'Job Contracts' with structural interactions in between

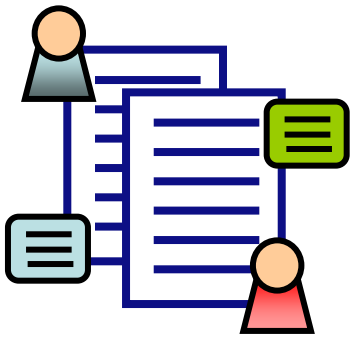
3. Interaction Model

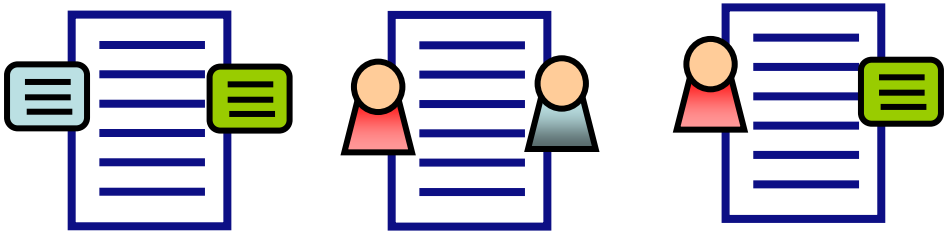


Elements 'employed' in the system with their *final* agreements on interaction to fulfill their Roles

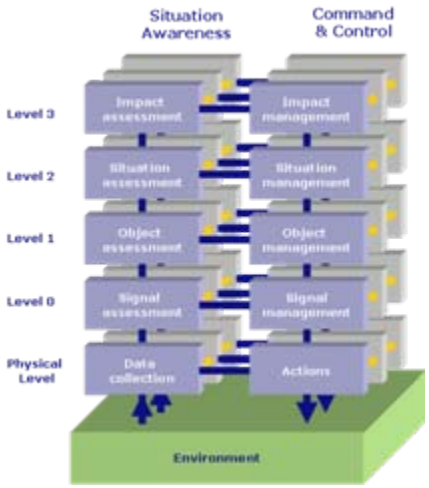
Social contracts, Interaction contracts

- Social contracts
  - General agreements that need to be adopted to become part of the organization (job contracts)
    - organizational aspects (norms and policies, coordination scheme, organization structure)
    - social rules, administrative rules, communication language …
- Interaction contracts
  - collaborative agreements between actors per task
    - interaction behaviour (relation between parties, task division)
    - format and conditions

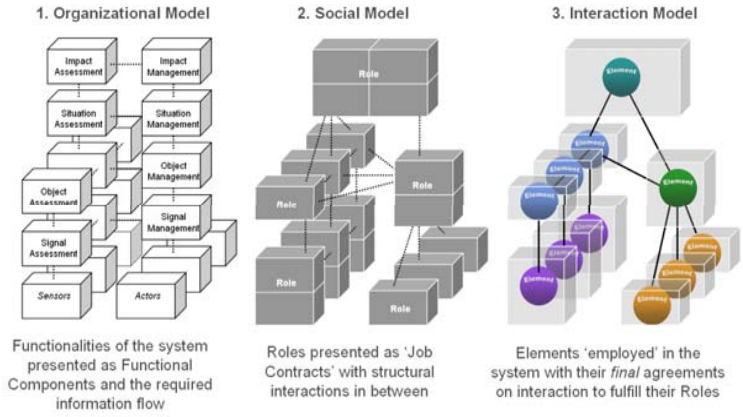




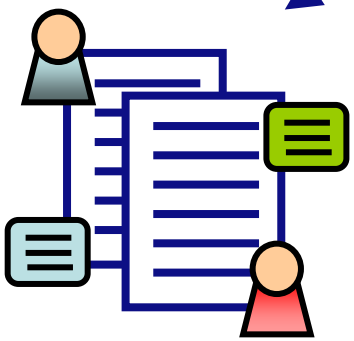
Putting it all together…



a) a functional model to structure the general



b) three levels of abstraction to represent dependencies and interactions



c) social and interaction contracts to put the organization into practice

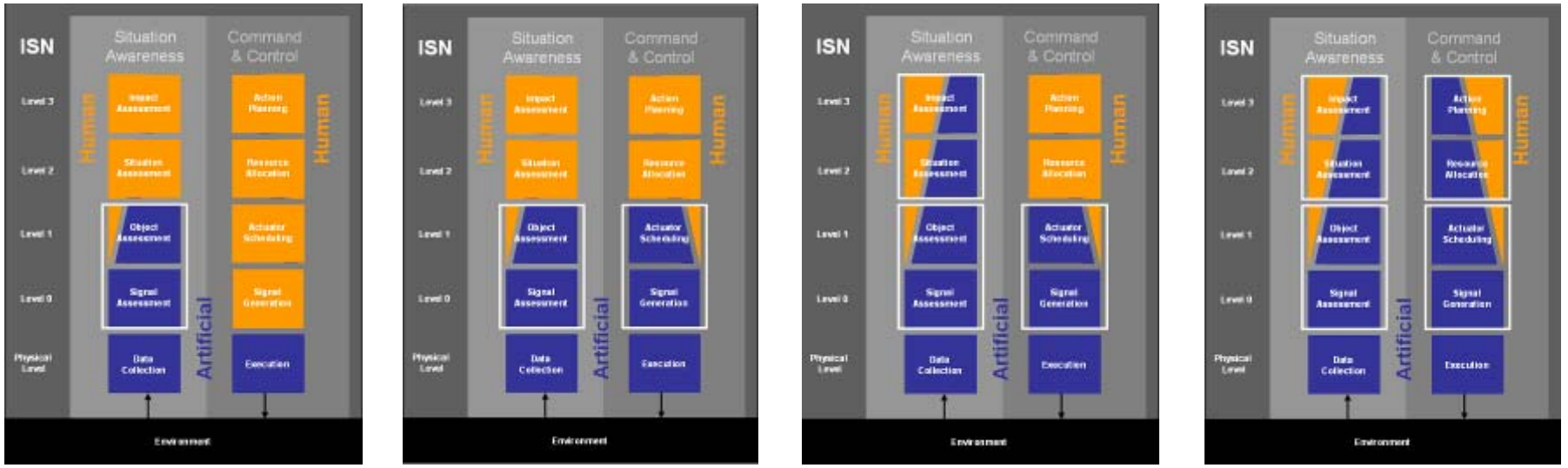
Adaptivity and agility

→ Organization levels give means to express adaptive measures

Level	Changes	Description	Impact
1	Real-time adjustments in the **Interaction Model**	• Elements change their interaction agreements to adapt to a certain situation. • Example: Two elements decide to use a different form of communication in response to new circumstances.	**Low**
2	Real-time adjustments in the **Social Model.**	• A role is transferred from one element to another element that is better qualified. • Example: the 'coordinator' role is transferred from the actor in the control room to an actor in the field, because he is in a better position to coordinate other actors.	**Medium**
3	Real-time adjustments in the **Organizational Model**	• The organization is redesigned to some degree. This might involve added or deleting roles, changing objectives or behavior rules. Changes on this level might necessitate changes in the Social and Interaction Model too. • Example: Because several elements have stopped working, the objectives can no longer be reached. In response, new objectives are set with the remaining set of elements.	**Severe**

Adaptivity and agility

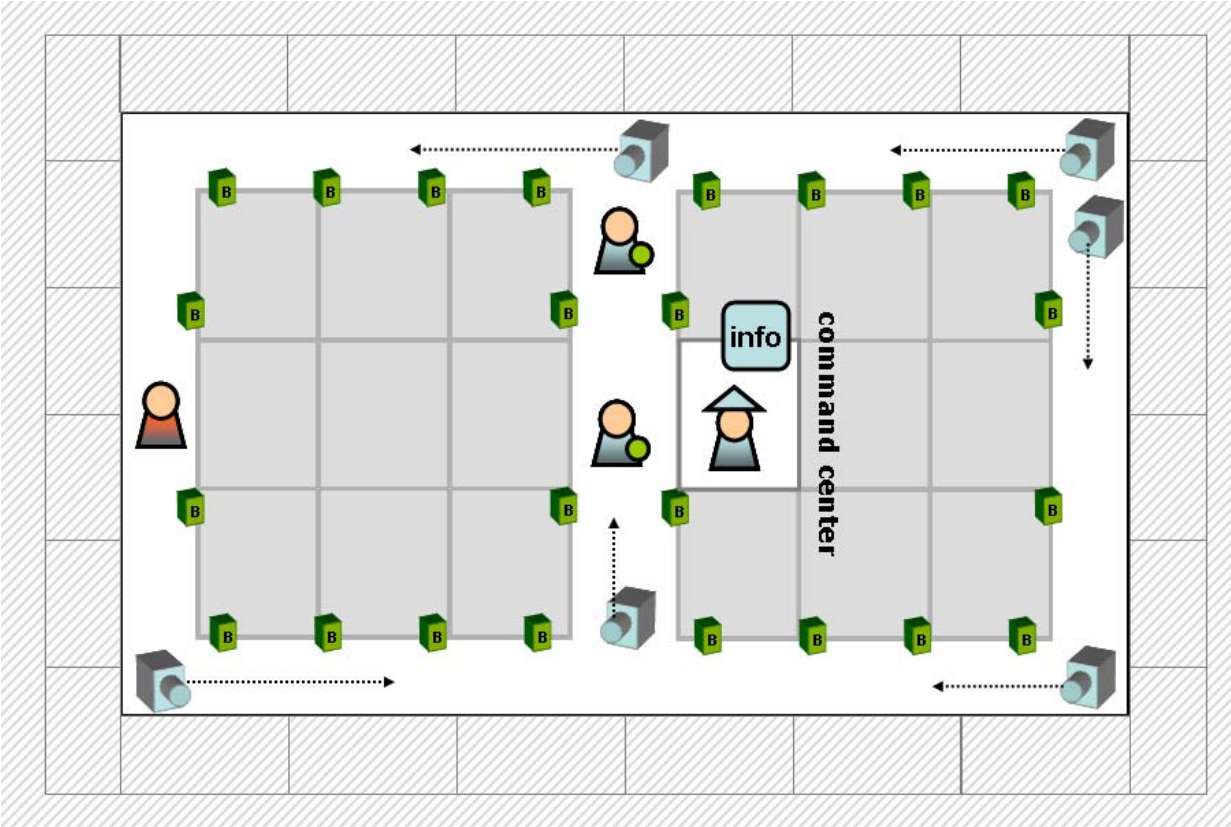
→ Approachs allows for gradual introduction of new elements
→ For instance: introduce artificial actors at higher functional levels



artificial actors at lower functional levels

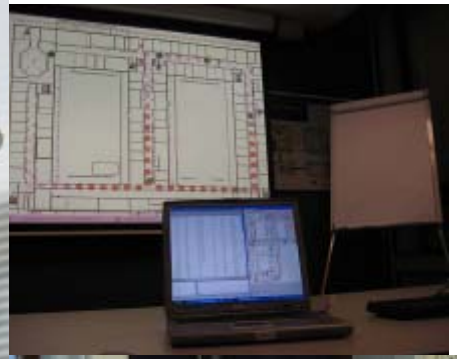
artificial actors at higher functional levels

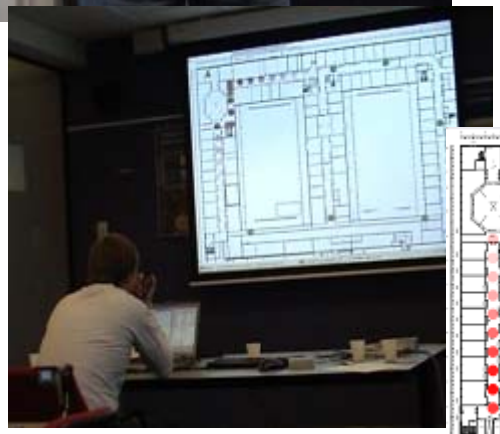
Experiments

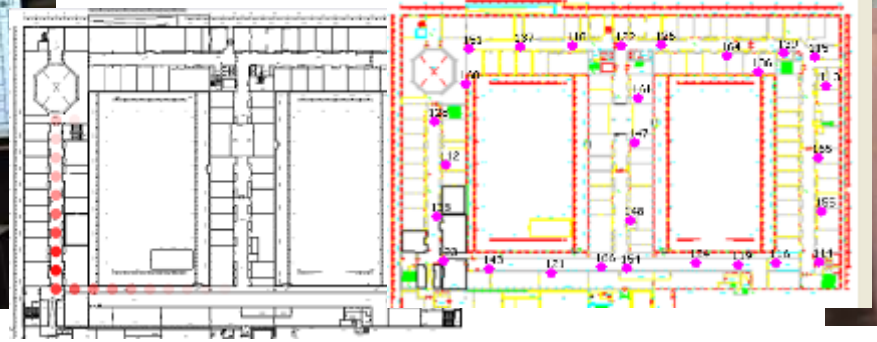


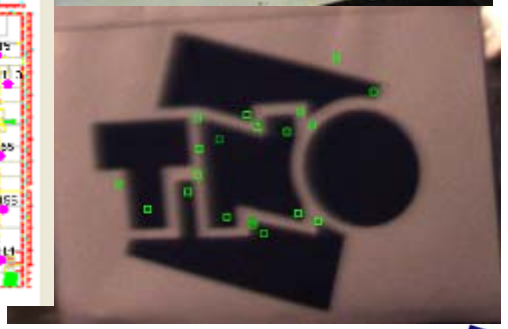
- **Fieldlab Indoor Safety and Security**
- **Components**
  - Wireless positioning system
  - Network of smart cameras
  - Communication devices
  - Tracking and position prediction service
  - Information fusion services
  - Command center with common operational picture
- Basic scenarios: **intruder apprehension** and **incident management**

Fieldlab Indoor Safety and Security









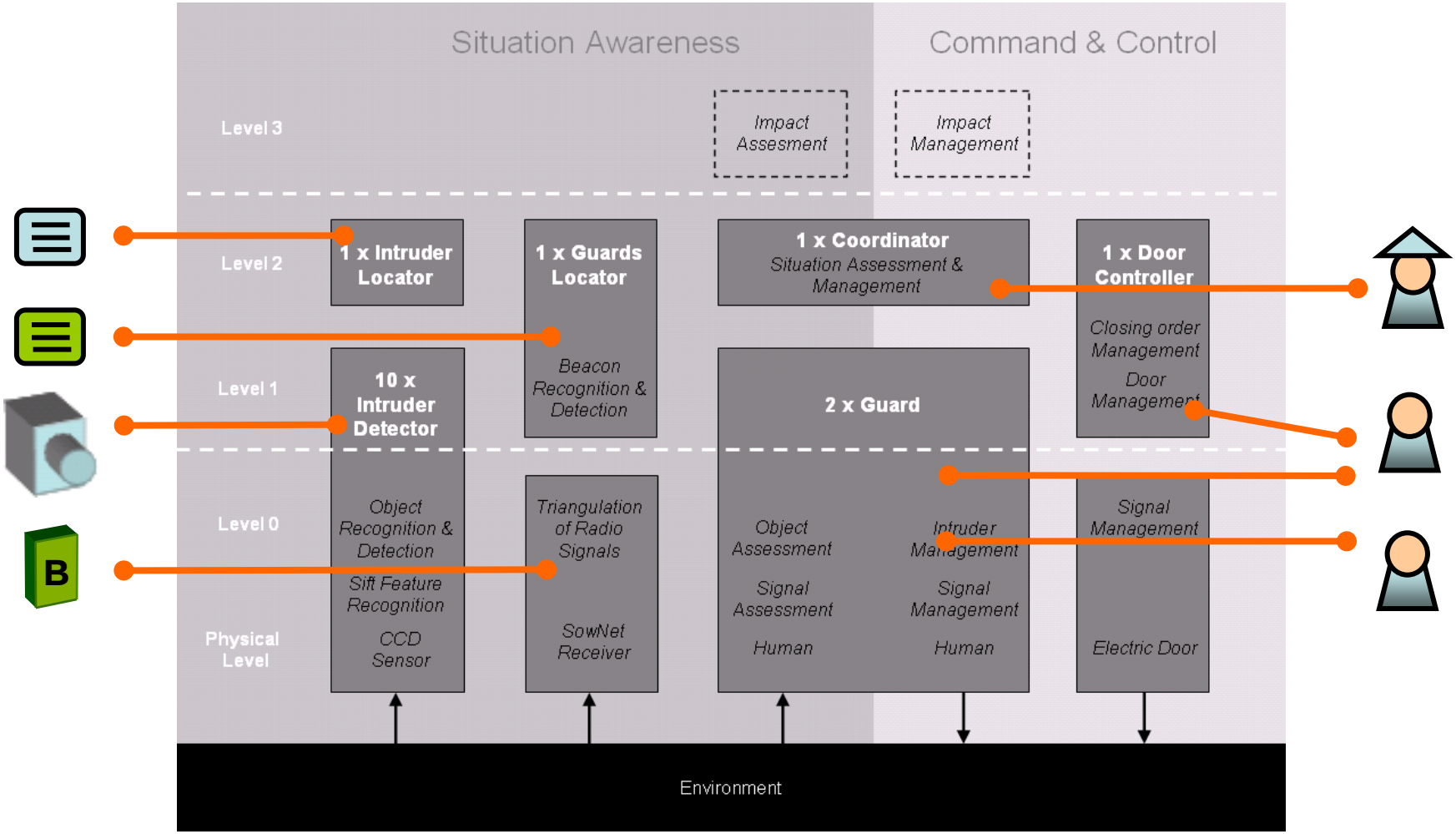
Building Tomorrow

Experiments

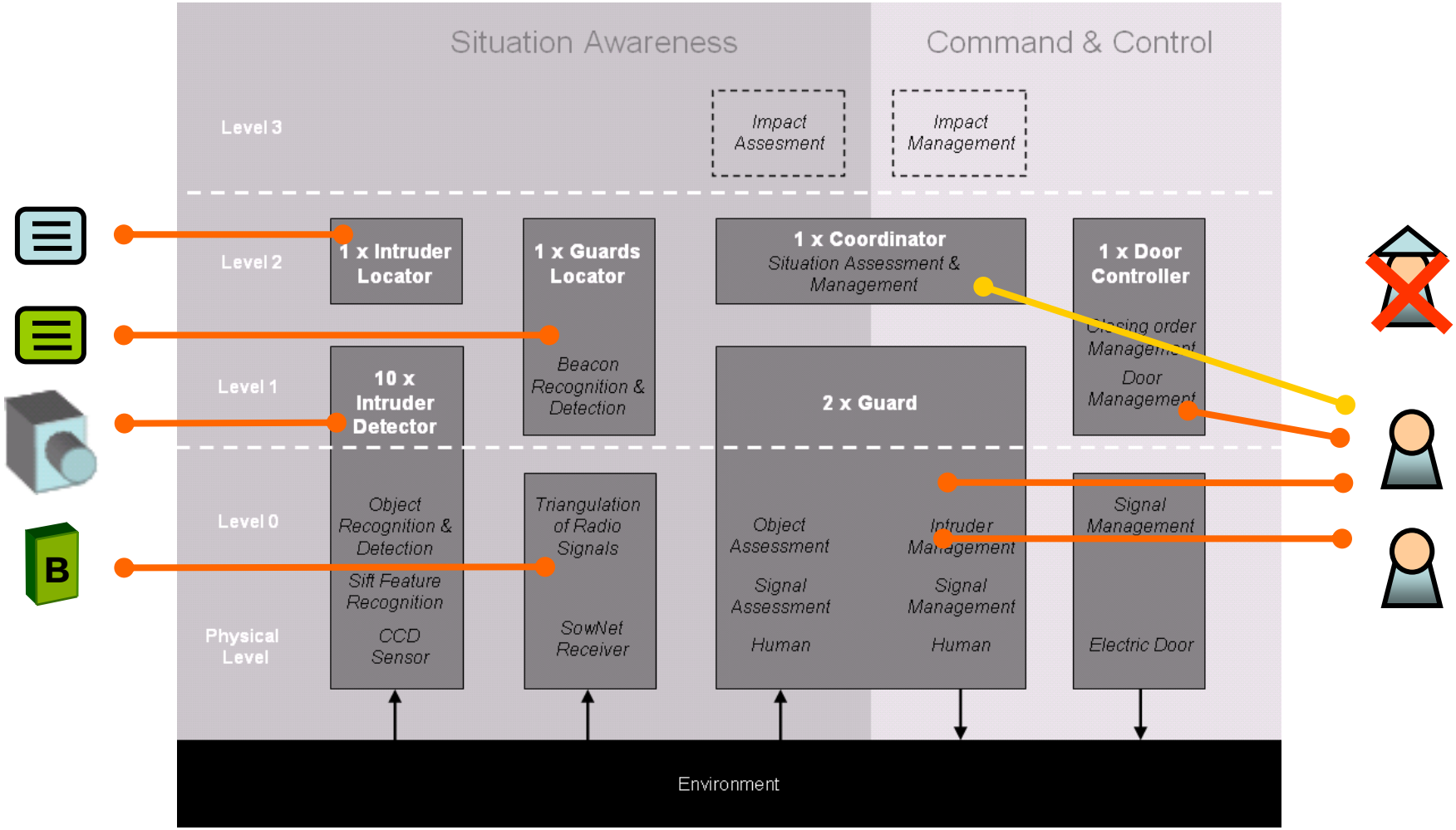
- Network built around a service oriented network (RESTlet)
- Human contracts are still just ‘on paper’, but used strictly (before and during an experiment)

- Some initial studies
  - transfer of the coordinator role from the central position to a mobile guard **(role transfer among humans)**
  - transfer intruder tracking role from the camera network to coordinator **(task transfer from system to human)**
  - transfer tracking from positioning system to coordinator **(task transfer from system to human)**

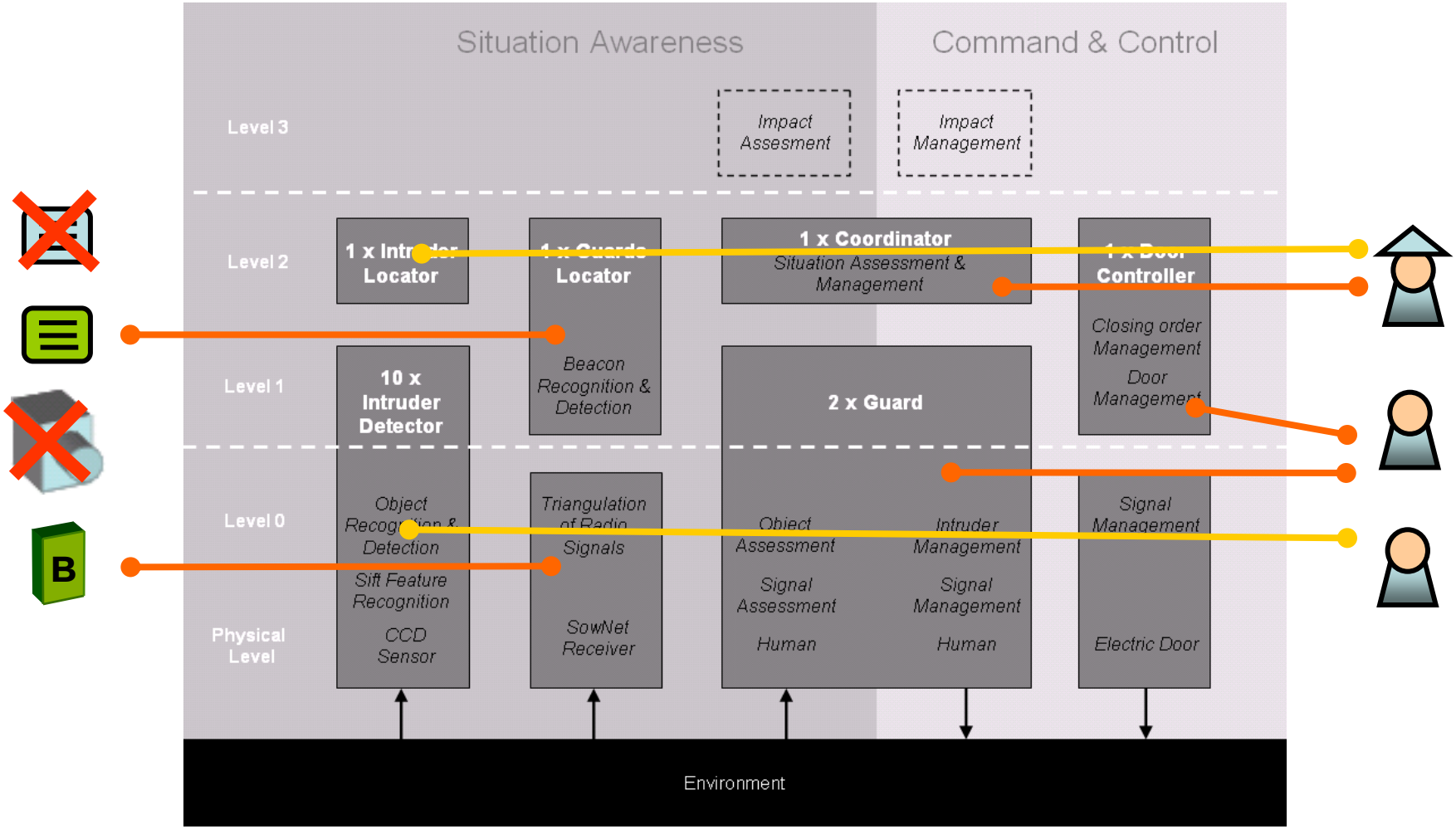
Roles changes



Roles changes



Roles changes



Some observations and design concerns

- Observations
  - Using organizational models and contracts seems worthwhile to express adaptivity and interaction dynamics in man – machine organizations
  - Functional model helps to make basic allocation choices

- Design concerns
  - **Define who is responsible for role and task allocation**
  - Set boundaries for dynamic allocation
  - **Ensure observability of attributes and responsibilities**
  - Make the type of adaptivity a design choice
  - **Prevent issues caused by multi-level or multi-role allocation**
  - Prevent communication and interaction issues after role change
  - **Prevent loss of situation and system awareness among humans**
  - Counter complacency and skill degredation
  - Prevent unneccessary increase of mental workload
  - Gradually build up user acceptance

Further developments

Current developments:

- Further **formalize interaction contracts and contract management,** especially between human and artificial actors
- Explore **dynamic task allocation schemes**
- Explore ways to balance **self-organising capabilities and procedures**
- New series of experiments with **additional technology** (new services, new mobile devices, more sensors) and an **extensive scenario** (incident management and evacuation, larger set of human actors)

Other applications under development:

- **Damage control teams** aboard naval frigats
- Various **distributed sensor network** applications
- Training environments for **civil firefighter teams**

More information

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Thank you for your attention!