

*Power to the Edge...  
Also under Threat?*

Wim Kamphuis, PhD  
TNO Human Factors, NLD

**TNO | Knowledge for business**



15<sup>th</sup> International Command and Control  
Research and Technology Symposium  
June 22-24, 2010 - Santa Monica, CA



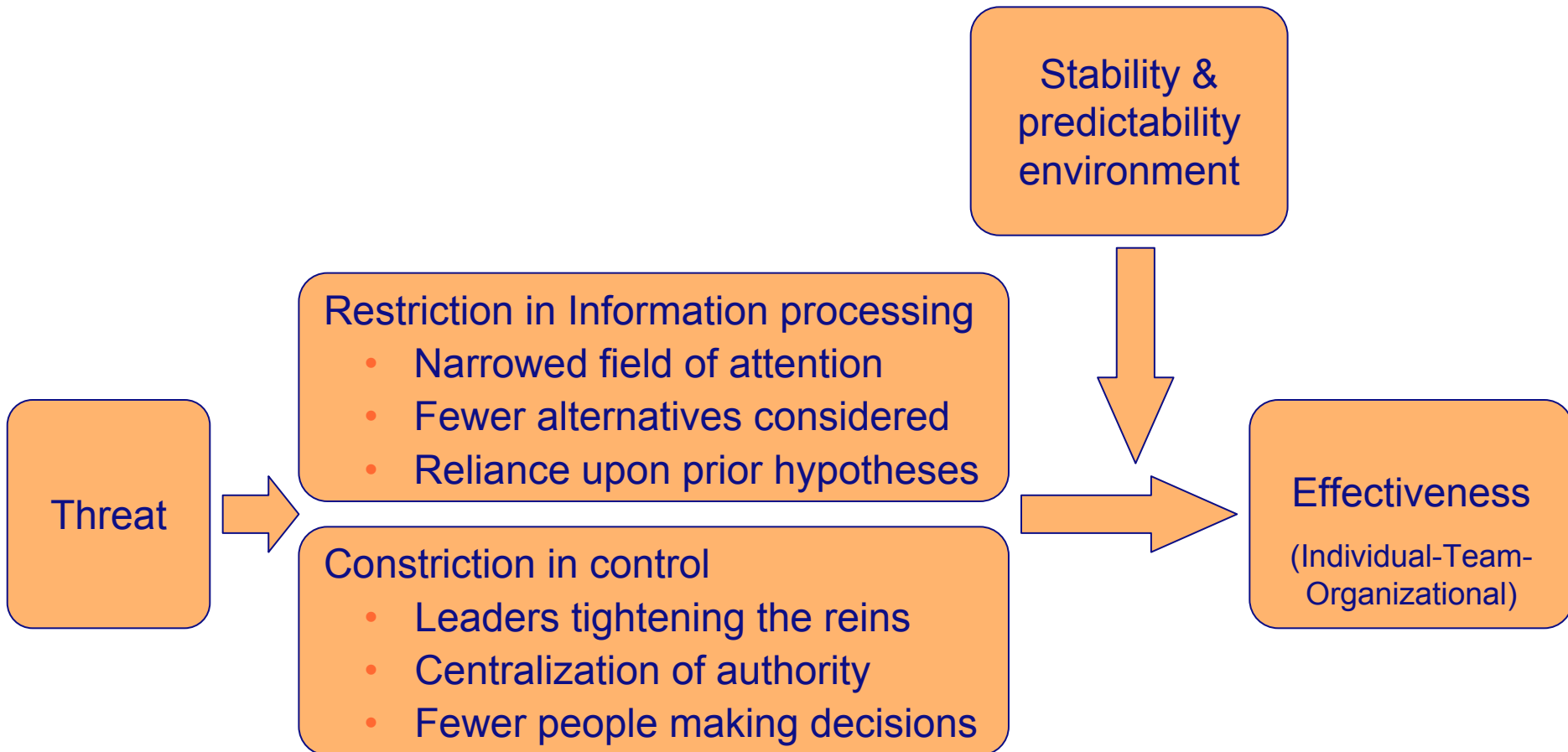


# Ambush in Iraq

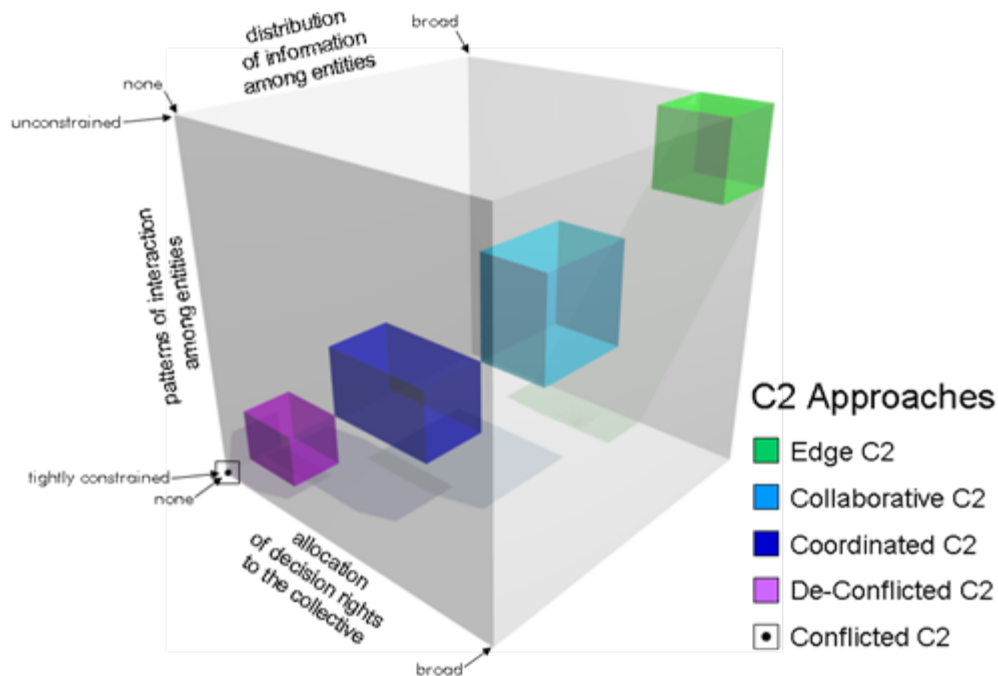
- Large scale ambush rather than small scale hit-and-run attack
- Company command orders QRF to drive straight into large-scale ambush
  - Adherence to initial hypothesis (small scale)
  - Fitting in of conflicting information
- Company command denies valuable assistance from battalion
  - Drive to stay in control
  - Keeping off interference of others



# Threat-Rigidity Thesis (Staw, Sandelands, & Dutton, 1981)



# C2 Approach Space



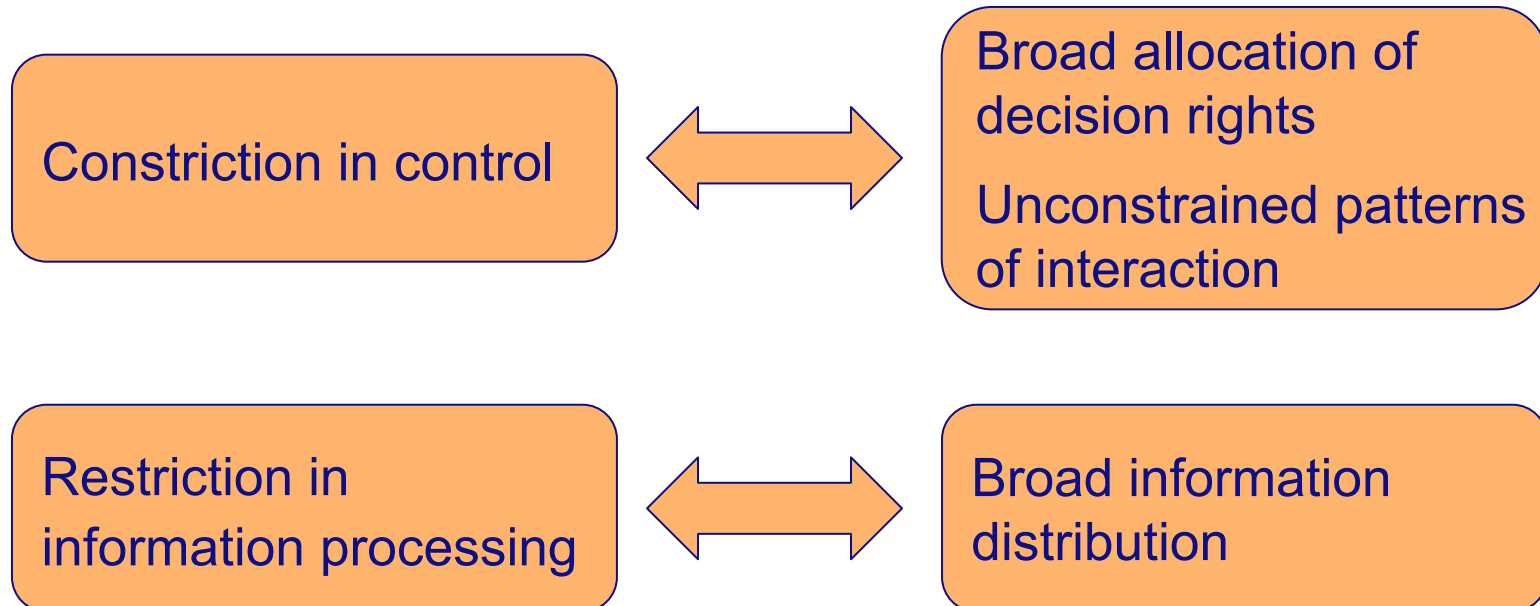
In more capable C2 approaches:

- Decision rights are more broadly allocated to the collective;
- Interaction patterns among entities are less constrained;
- Information is more broadly distributed among entities;

leading to higher levels of shared awareness and understanding and increased effectiveness

# However...

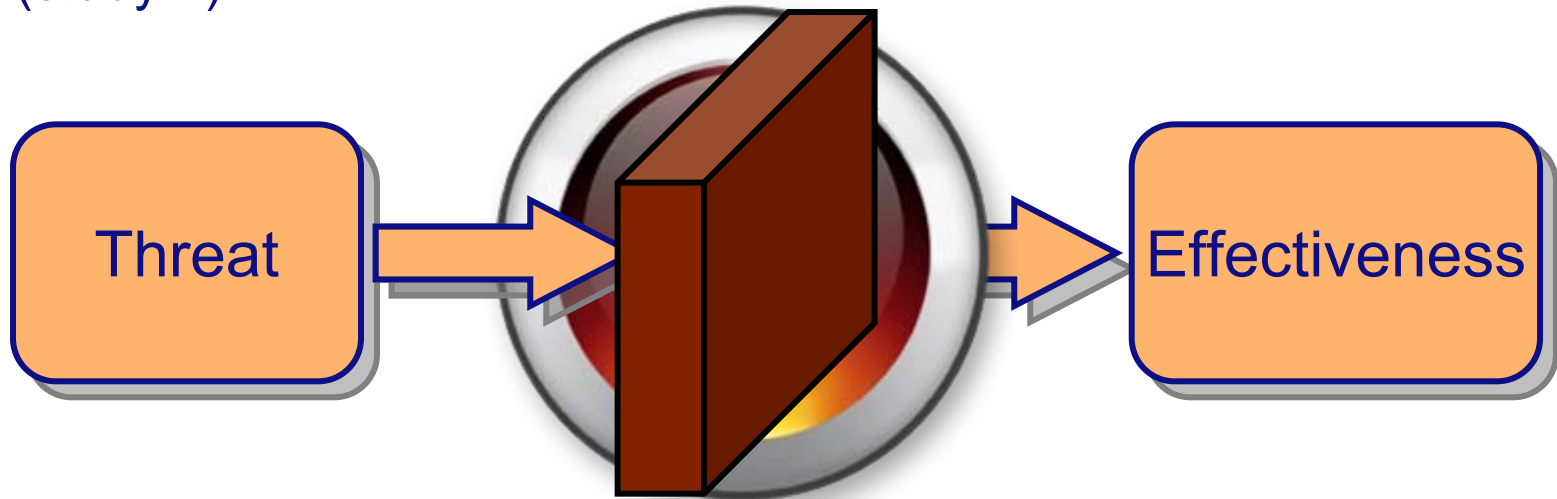
- *The hypothesized effects of threat diametrically oppose the more capable positions on the dimensions of the C2 Approach Space:*



# Research Question

In theory, effects of threat may be detrimental to more capable C2 approaches

- What exactly are the effects of threat on teams during complex tasks? (study 1)
- What can be done to stop threat from negatively affecting teams? (study 2)



# Research methodology - Prior research

**Goal:** Controlled experimental research on team performance in *complex environments*

## ■ Simple team tasks

(Winter Survival Exercise, Decide which of two patterns contains more white, etc.)

- + Highly controllable
- Lack of interdependence, team processes, and complexity

## ■ High-fidelity simulations

(Management simulations (Tycoon), flight simulators, etc.)

- + Real team behavior, highly complex
- Little experimental control

## ■ Tactical team tasks

(TANDEM, DDD, TIDE<sup>2</sup>, C3FIRE, etc.)

- + Real team behavior, good degree of control
- Focus on *action aspects* of performance (*rule-based*), no higher-level, non-routine, problem-solving processes demanded



# Creating a New Research Environment

- Development of a research environment for controlled experimental research on team performance in complex environments
  
- Requirements:
  - Real team behavior
  - Complex tasks
  - Experimental control
  - Efficient data collection
  - Broad range of measurement possibilities (real-time, automated behavioral measures and online embedded questionnaires)
  - High flexibility

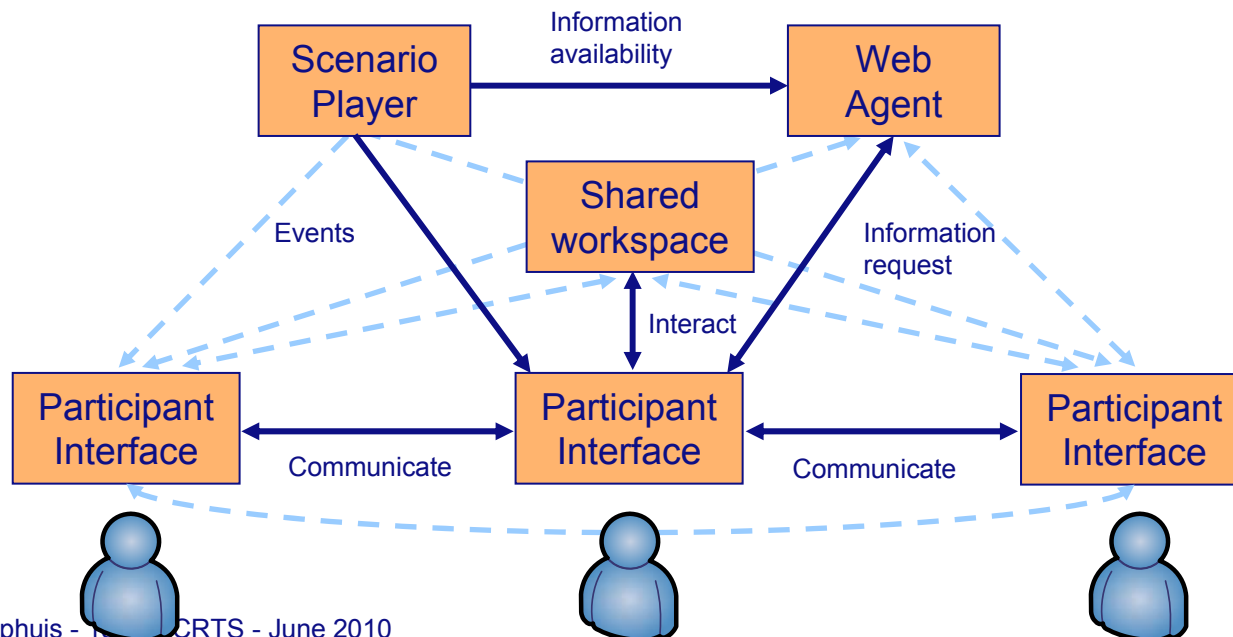
# PLATT (Kamphuis, Essens, Houttuin, & Gaillard (in press), Behavior Research Methods)

## What is PLATT?

- A flexible software platform for experimental team research
- Two components:
  - Modular software architecture (*JADE agent platform*)
  - Research-specific scenarios
- Software architecture is research question independent and guarantees large degree of flexibility
- Scenario development is driven by research question and based on research model

# PLATT – Software architecture

- **Scenario Player** sends scenario events
- Scenario Player controls access and updating of web pages on **Web Agent**
- Participant uses **Participant Interface** to:
  - Process scenario events
  - Requests web pages
  - Interact with shared workspace
  - Interact with other participants

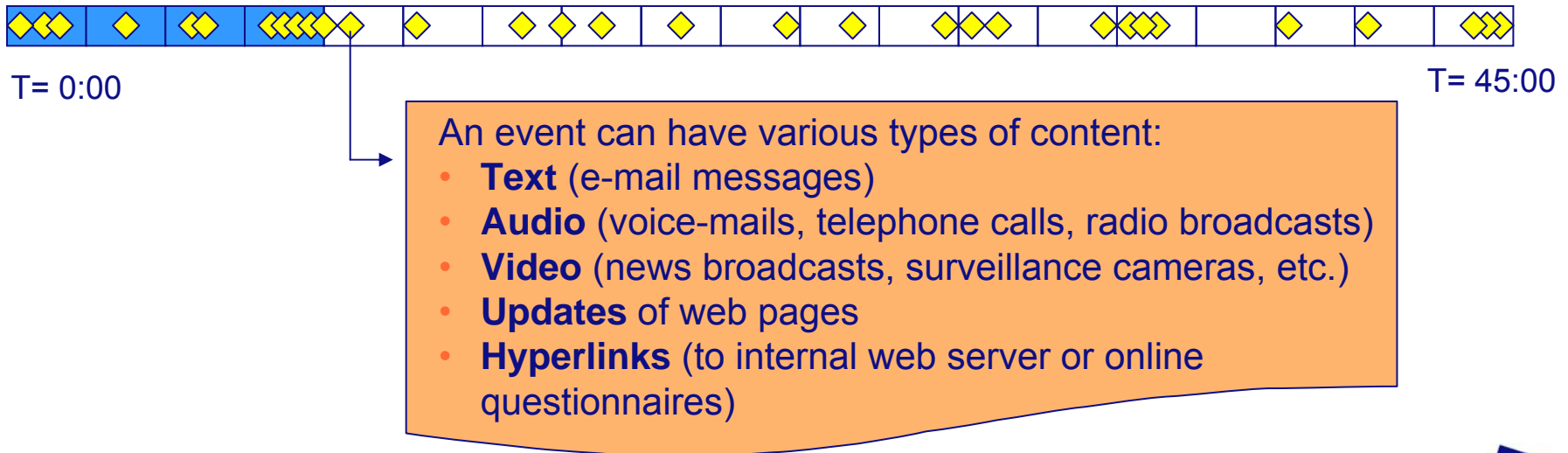


# PLATT – Software architecture

- Different participant applications can be plugged into the framework:
  - Every component loads on a new tab in participant interface
  - Different communication media (e-mail/ video-conferencing/ chat)
  - Different shared workspaces (COP/ postings board/ whiteboard)
  
- Many configurable variables, e.g.:
  - Communication structure of team (or teams)
  - Interface components participants receive
  - Information access rights

# PLATT – Scenarios

- Scenarios are research-question specific. So far:
  - Military planning
  - Crisis management
  - Collaborative decision-making
- Scenarios are written in Excel by defining events on a linear timeline
  - Write own scenarios
  - Adjust existing scenarios



# PLATT – Excerpt of scenario file

Time	Sender	Recipient	Subject	Message	Hyperlink
00.10.30	Local civilians	Intelligence	Information: Rebels in the west	Today, our cousin travelled from Iskra to Golesh. At the river, he was shot at by a sniper. He barely managed to escape. It is advisable to avoid this road.	
00.11.00	Patrol	Intelligence	Information: Rocket launchers	At the northern part of the road between Debrashtsa and Ustrem, we observed a Group of 20 rebels, some of which were carrying rocket launchers. If you want to make use of this road for the evacuation, you will need to plan a deployment of the infantry unit to clear this part of the route.	
00.11.00	Local Radio Station	Logistics	Weather Report	In the north, heavy snowfall occurred in the mountains. As a consequence, some roads may have become obstructed. At this moment, more accurate information can not be provided.	
00.11.00	Home	Operations	Home front: Everything ok	Hi there! How are you? Here everything is all right. We hope to hear from you soon...	
00.12.00		Intelligence			<a href="#">roads/RoadLG_2.htm</a>
00.12.30	Transportation unit	Logistics	Information: Loss of vehicle	One of our transportation vehicles broke down. Sadly, it is not possible to repair this vehicle.	
00.13.00		Intelligence			<a href="#">roads/RoadIG_2.htm</a>
00.13.30	Local Radio Station	Intelligence	Newsflash: Demonstration	On the road between Kriva Bara and Popintsi, a large crowd demands president Tsankov's resignation. For the time being, the demonstration is peaceful. However, motorists making use of this road should already expect a delay of 45 minutes.	
00.13.30	Patrol	Logistics	Information: Pass taken	The pass between Ustrem and Straro Selo that seemed to have been taken by the rebels, proves to be entirely safe.	
00.14.00	Local civilians	Intelligence	Information: Rebels in the east	In the east, between Debrashtsa and Bogdantsi, rebels have been spotted. This road seems not to be safe anymore.	
00.14.00		Logistics			<a href="#">roads/LRoadUP_2.htm</a>
00.14.00		All	- Questionnaire-		<a href="http://tmquest.tm.tno.nl/~">http://tmquest.tm.tno.nl/~</a>

# PLATT – Measures

## ■ Behavioral data

- All actions automatically logged in log file
  - Real-time unobtrusive measures
  - Analysis supported by Data Analysis Tool

## ■ Self-report data

- Online embedded questionnaires
  - Integrated in scenario, sent at specific time
  - Real-time measurement of processes and cognitions

## ■ Outcome measures

- Scenario-specific

# PLATT – Summary

- PLATT allows:
  - Integration of complexity while maintaining experimental control
  - Real-time behavioral measures
  - High degree of flexibility
  - High degree of realism
  - Wide range of research questions
  - Modifications by researcher
  - Unlimited number of participants and teams
  
- Suitable research environment for C2 experimentation relating to:
  - Complex endeavors
  - Networked collaboration
  - Comprehensive approach
  - Multi Team Systems



# Study 1

## The Effects of Physical Threat on Team Processes During Complex Task Performance

# Theory & Hypotheses

- Few prior studies
- Threat-rigidity thesis (Staw et al., 1981):
  - Restriction in information processing (e.g., Gladstein & Reilly, 1985)
  - Constriction in control (e.g., Argote et al., 1989)
  - Narrowing of team perspective (Driskell et al., 1999; Ellis 2006)

# Method – Design

- 81 participants (civilians)
- 26 three-person teams
- Complex scenario in PLATT: military evacuation scenario
- 1 factor: physical threat
- Between teams design:
  - Physical threat (13 teams)
  - No physical threat (13 teams)

# Method – Military evacuation scenario

- **Assignment:**

Make plan to extract group of people from hostile area

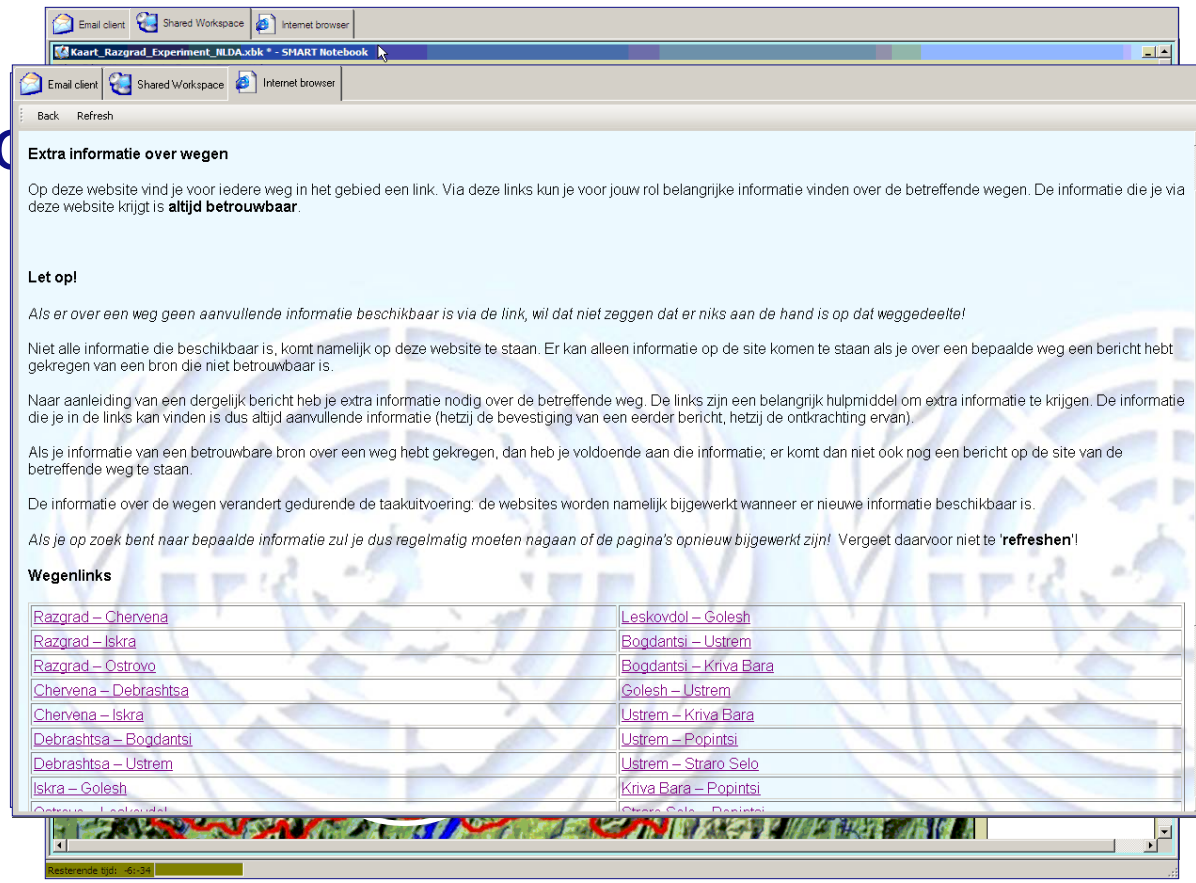
- **Three roles**, with unique knowledge, expertise and responsibilities:

- S2 – Intelligence (safety and reliability)
- S3 – Operations (leader, coordinating and directing)
- S4 – Logistics (personnel, materiel, condition and length of roads)

- **Events** (messages coming from different sources):

- Enemy activities
- Road conditions
- Delays
- Wheather reports
- Home front events
- Personnel problems
- Materiel problems
- Local unrelated events

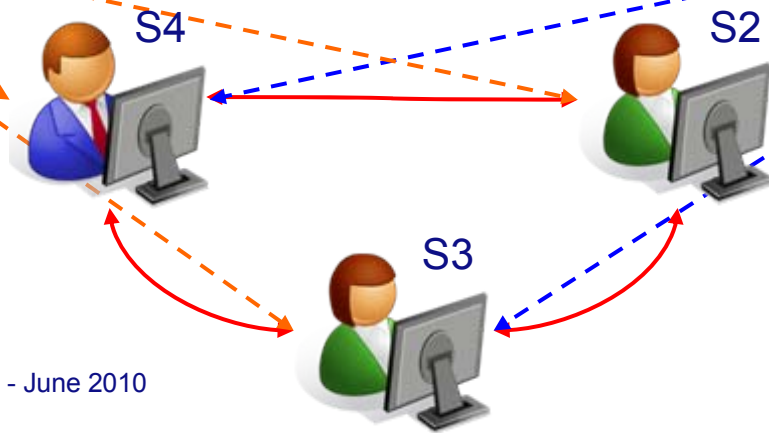
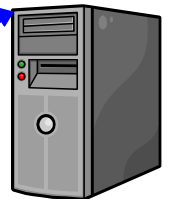
# Method



SCENARIO/  
WEB SERVER



SHARED  
WORKSPACE

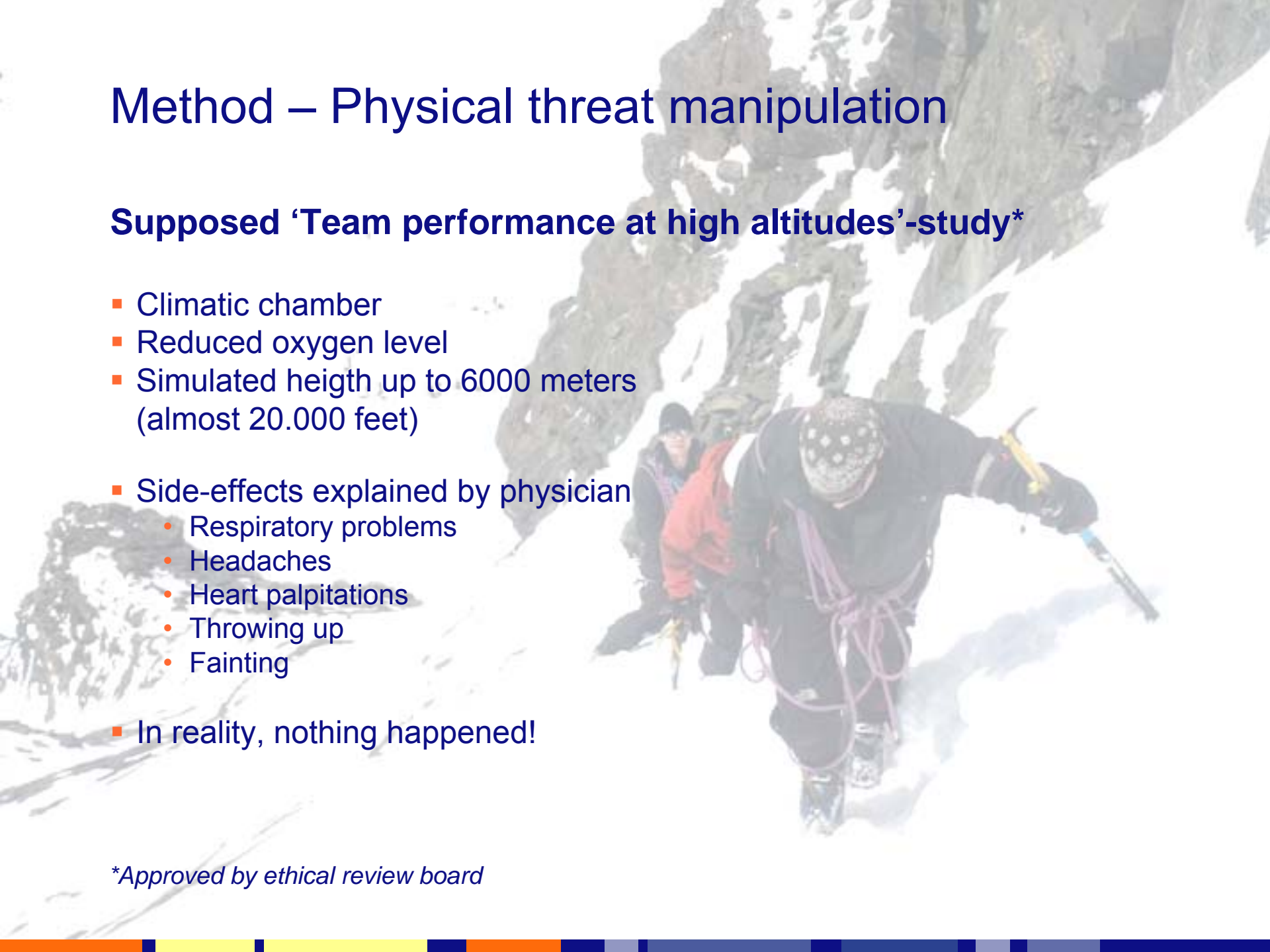


# Method – Physical threat manipulation

## Supposed ‘Team performance at high altitudes’-study\*

- Climatic chamber
- Reduced oxygen level
- Simulated height up to 6000 meters (almost 20.000 feet)
  
- Side-effects explained by physician
  - Respiratory problems
  - Headaches
  - Heart palpitations
  - Throwing up
  - Fainting
  
- In reality, nothing happened!

*\*Approved by ethical review board*



# Method – Measures

## ■ Information processing

- Attention to relevant 'hidden' information (logging of opening of messages)
- Degree of overview (self-report)

## ■ Degree of control

- Leadership control (self-report)
- Participative leadership (self-report)
- Amount of deliberation (content of e-mails)

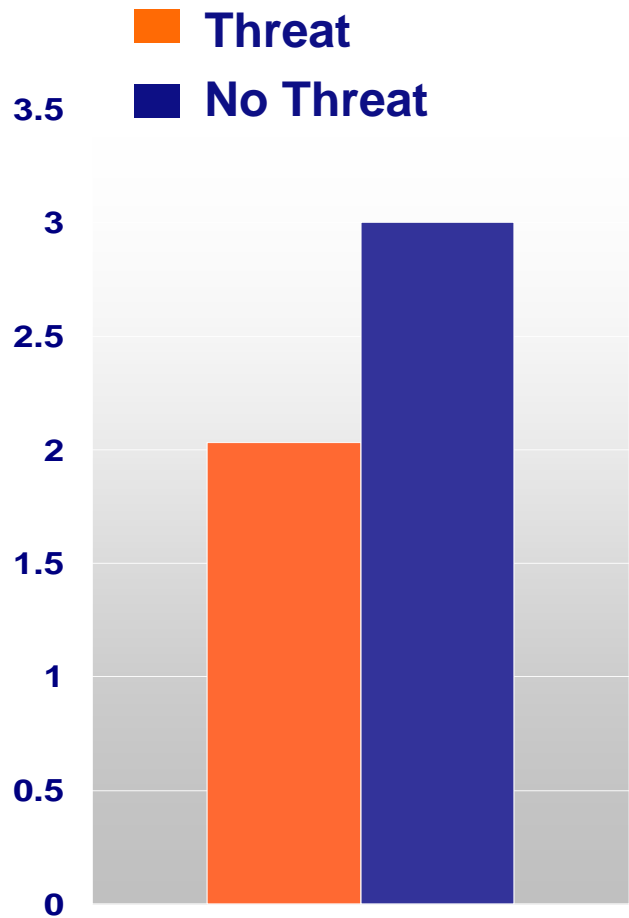
## ■ Collaboration

- Coordination (logging of allocation of information)
- Supporting behavior (logging of forwarding of 'missed' messages)

## ■ Team effectiveness

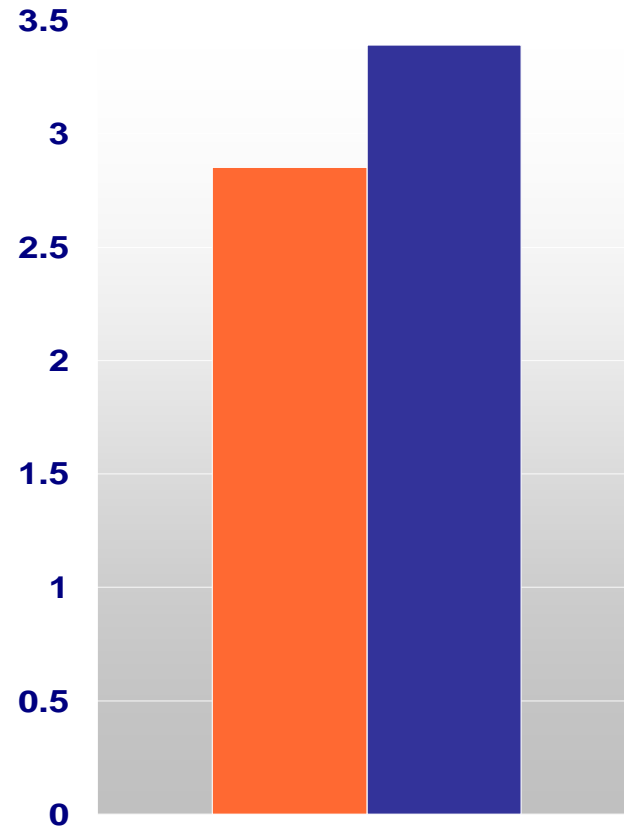
- Objective errors in evacuation plan

# Results – Information processing



**Opened messages**

$t(24) = 1.77, p < .05, d = 0.72$

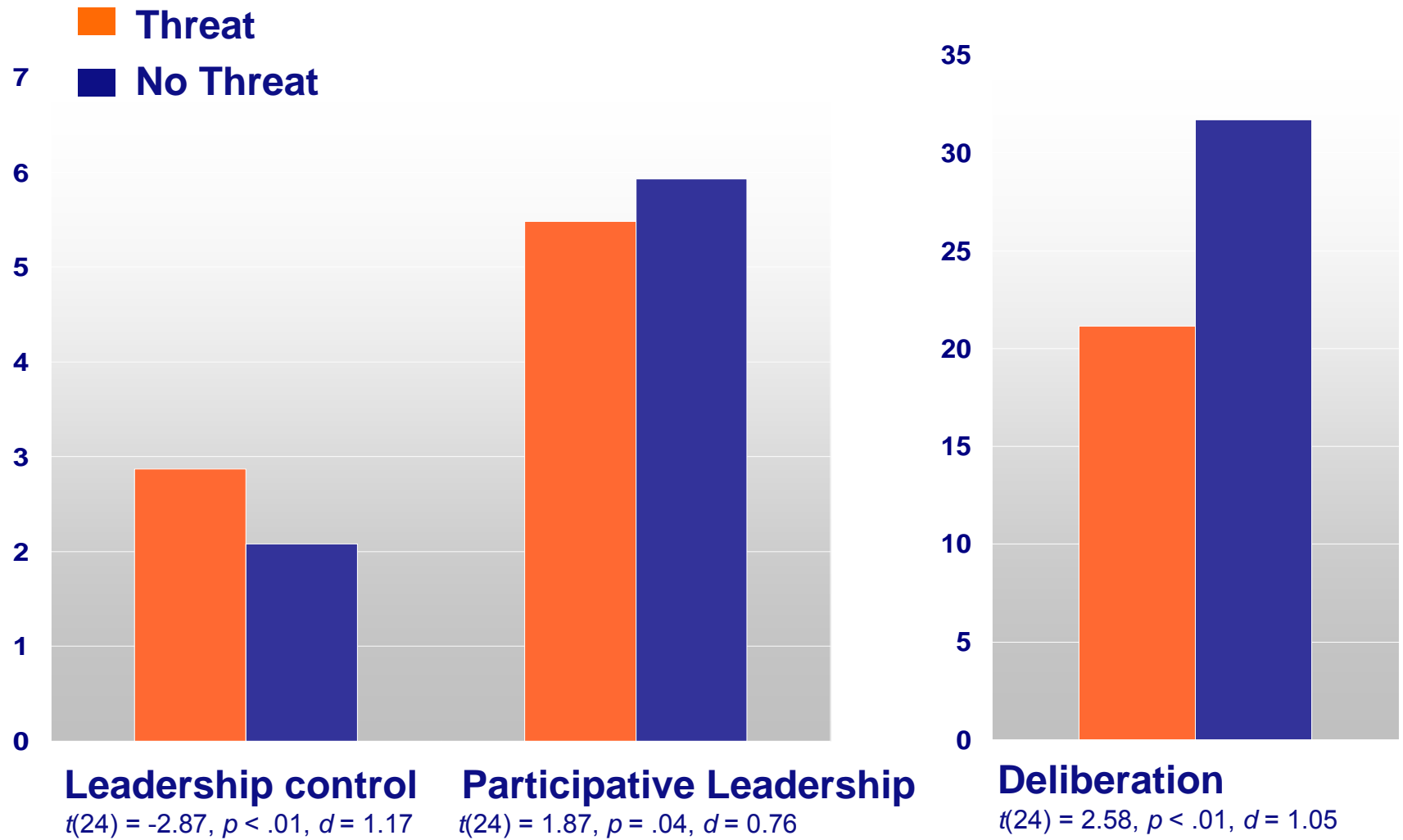


**Degree of overview**

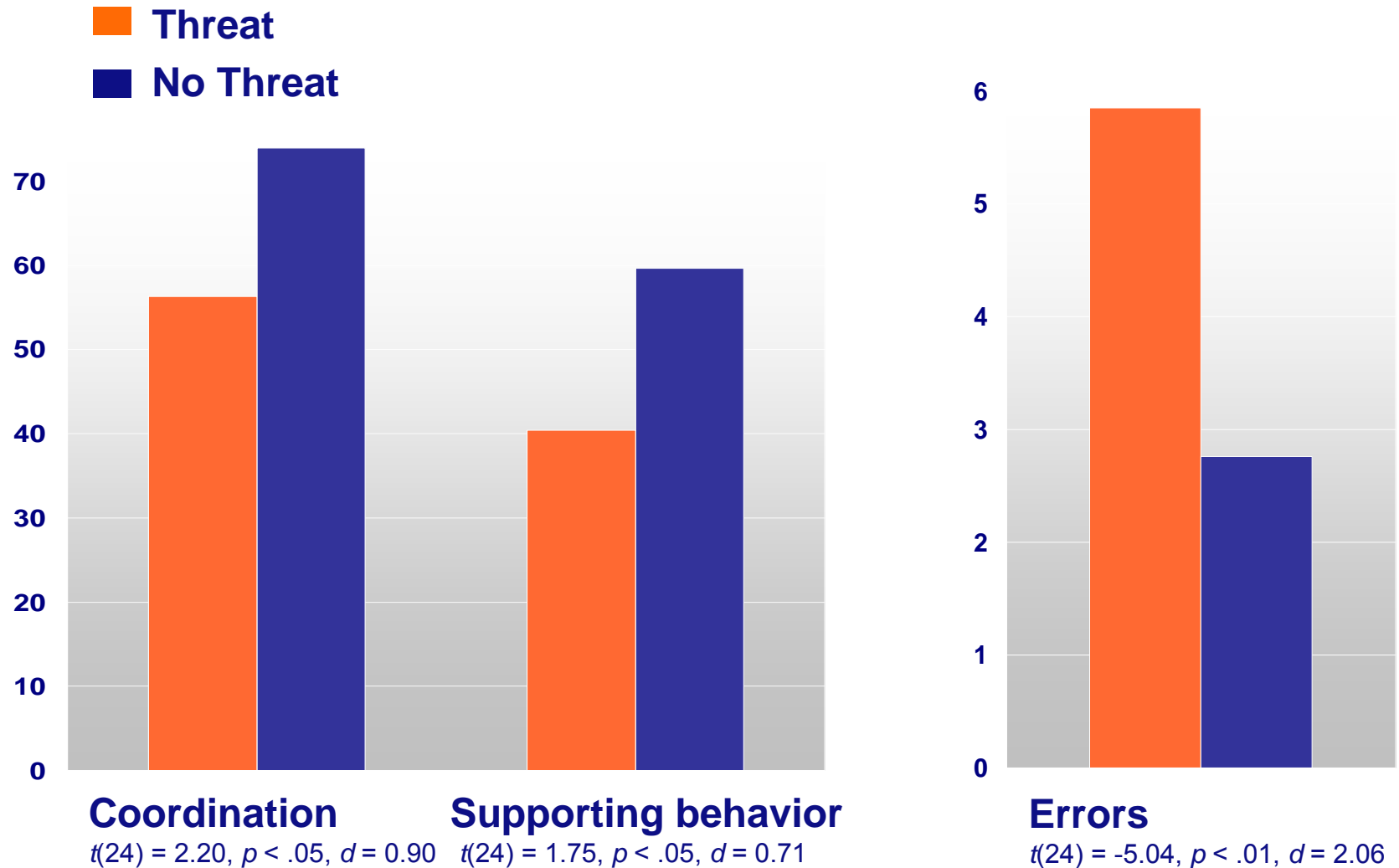
$t(24) = -2.52, p < .01, d = 1.03$



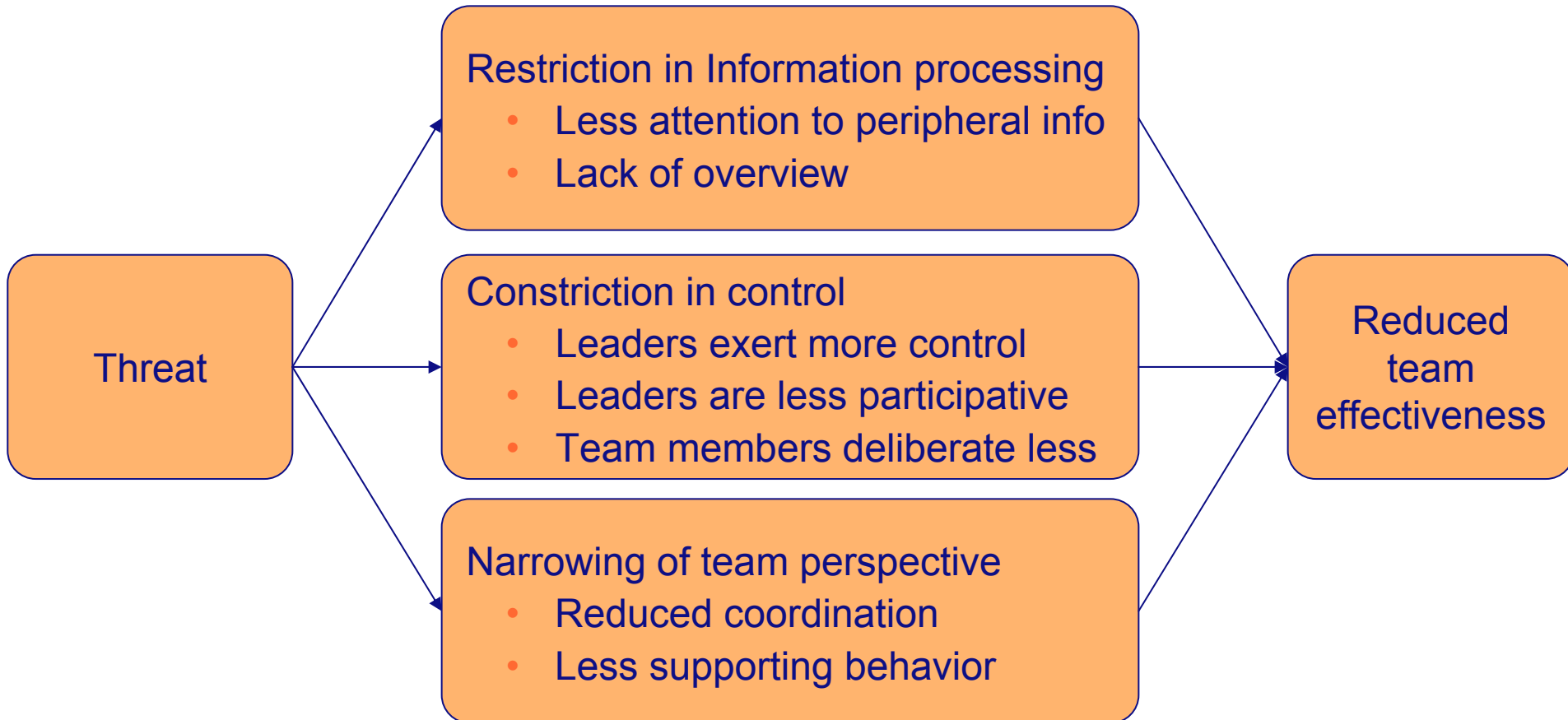
# Results – Degree of control



# Results – Collaboration and effectiveness



# Conclusions study 1



# Study 2

## Mitigating the Effects of Threat on Teams through Training

# Theory & Hypotheses

- How can the negative effects of threat be mitigated?
  
- Prior research suggests: Cross-training
  - Each team member is trained on tasks, duties, and responsibilities of all other team members to develop shared mental models (SMM)*
    - Positive effects on communication, coordination, and effectiveness
    - Not very practical
    - Not time-efficient
  
- Alternative: focus on distribution rather than sharedness → distinction between Transactive Memory Systems (TMS) and Shared Mental Models

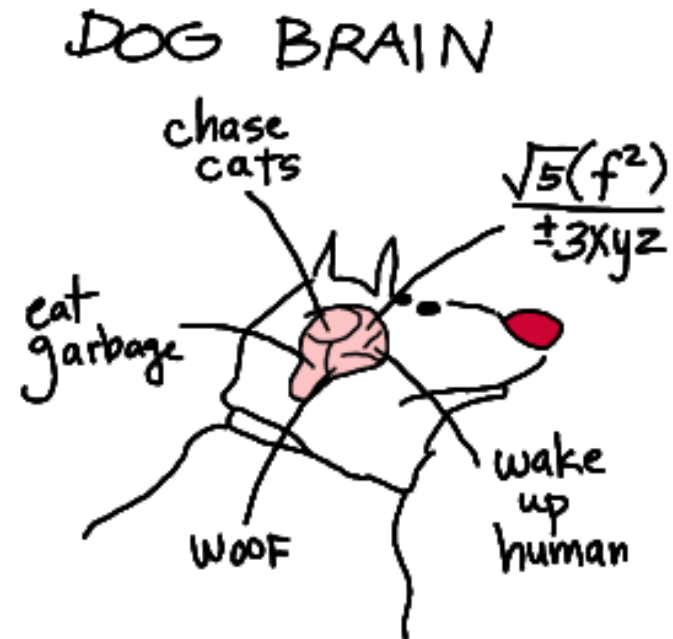
# Transactive Memory Theory (Wegner, 1987, 1995)

## Transactive Memory System

- Set of individual memory systems
- Shared awareness of who knows what

## Benefits

- Cognitively efficient
  - Reduced cognitive load
  - Expanded pool of expertise
  - Reduced redundancy
- Improved planning
- Improved coordination
- Buffer against threat?



# Newly developed TM-training

## TM-training:

*Highlight distribution of expertise in team and address strategies to combine distributed expertise effectively*

## Goal:

- Awareness of distributed expertise
- Awareness of interdependency
- Facilitation of coordination

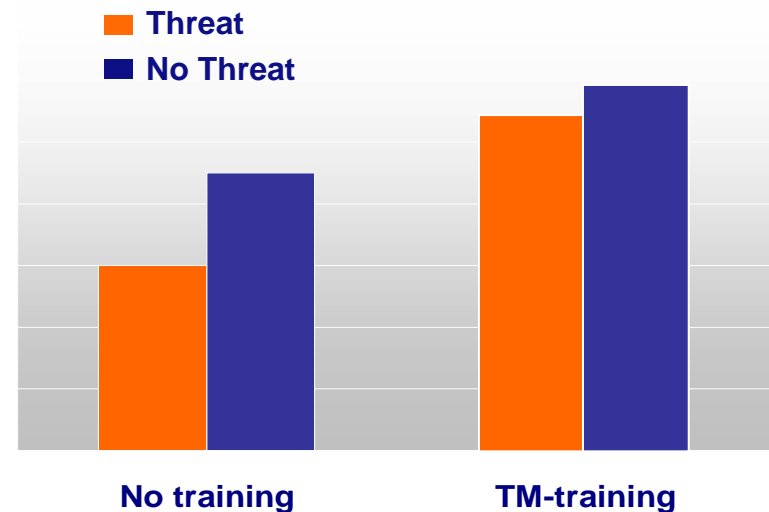
## Elements:

- Positional clarification
- Guided group discussion

# Design & Results

- 174 participants (officers cadets, Netherlands Defence Academy)
- 58 three-person teams
- Military evacuation scenario in PLATT
- 2 factors: Threat (high vs. low) X TM-training (training vs. no training)

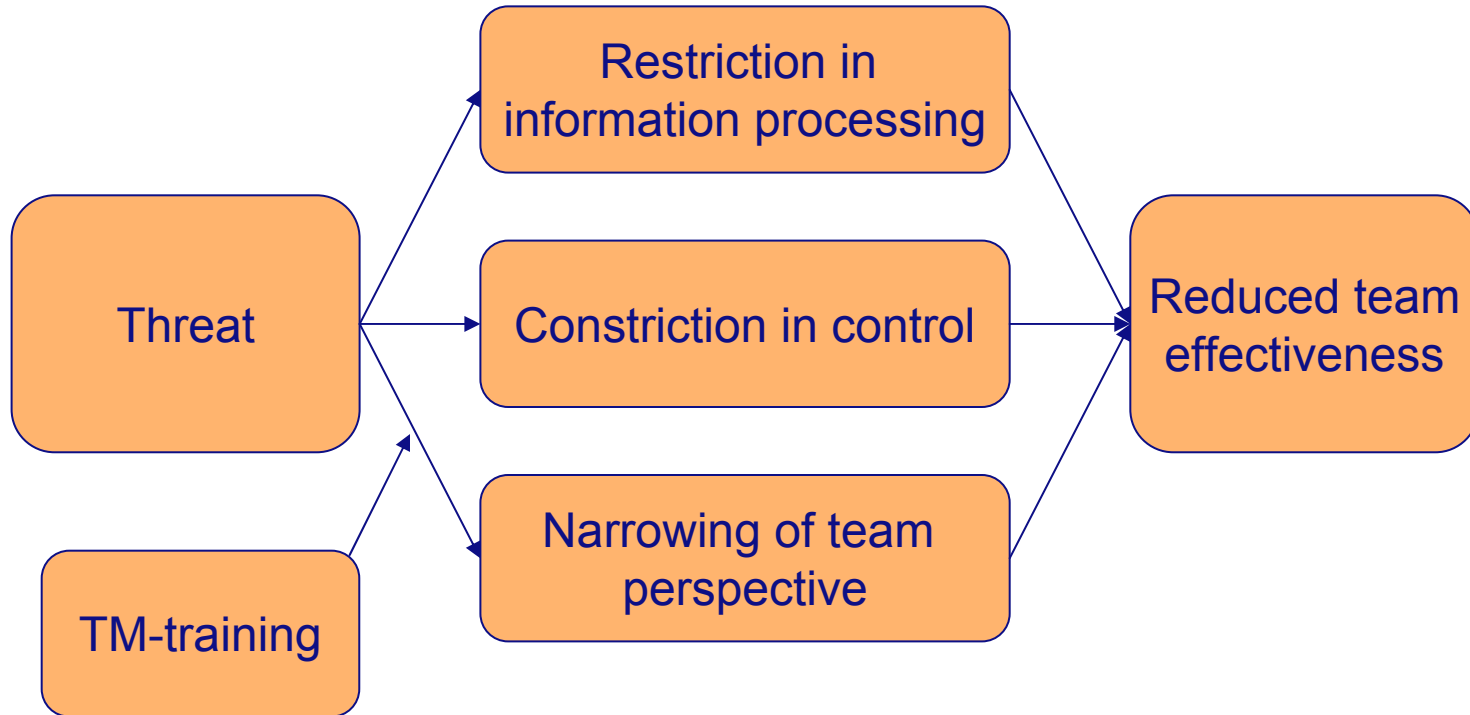
- Threat negatively affected:
  - Transactive Memory
  - Coordination
  - Performance monitoring



...only in teams that did not receive training, **but not in teams that did receive training**

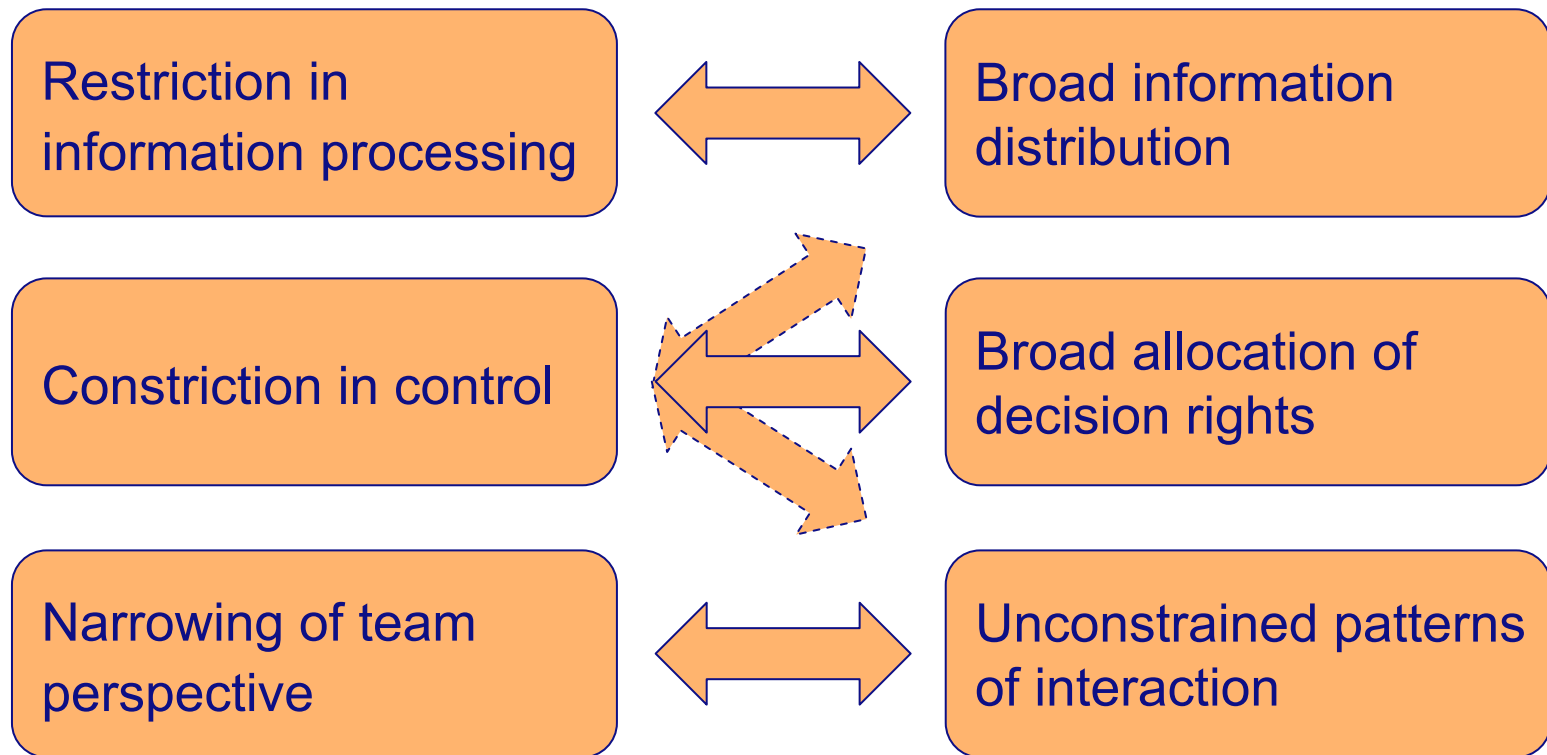


# Conclusions study 1 and 2



# Consequences for C2

- Threat may seriously influence the C2 approach dimensions

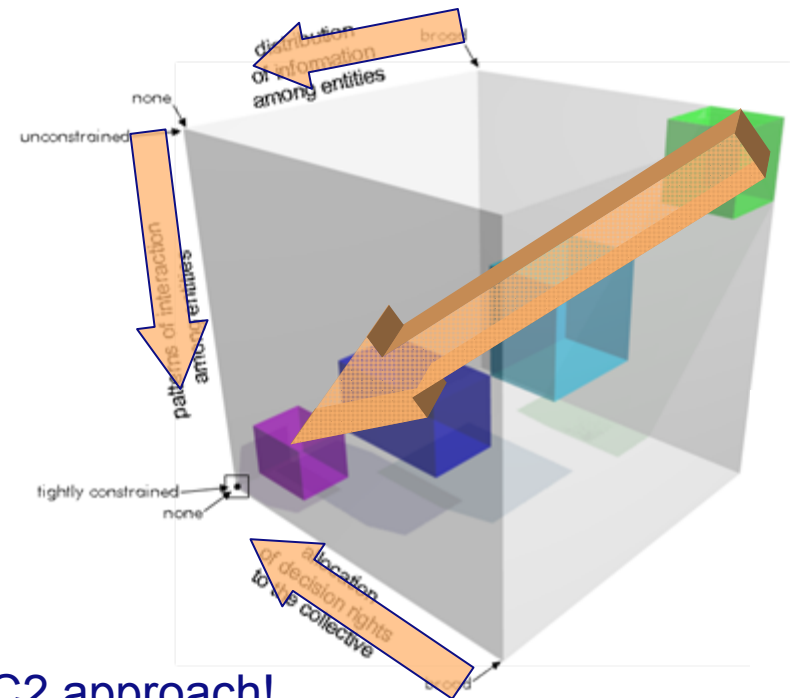


# Implications for C2 Research

- Include threat (or other stressors) in research design:
  - Allows for fair comparison between 'traditional C2' and edge C2
  - Edge C2 also better option with threat...?
  
- Integrate real complexity in research environments:
  - Rule-based actions do not suffer under threat!
  - Complexity is inherent in current military operations
  - Unfamiliarity, high dynamism, multiple goals, no standard solutions
  
- Investigate methods to counter threat-effects
  - Training and instruction methods
  - ...?

# Implications for C2 Practice

- Very nature of Edge C2 may make it vulnerable to the effects of threat
- Position on all dimensions shifts back to origin:
  - Revoked
  - Constrained
  - Restricted
- Threat thus may lead to a 'relapse' in C2 approach
- Relapsing from edge leads to:
  - Loss of large amounts of information
  - Authority that lacks knowledge to make decisions
- Worse than *starting* with less capable C2 approach!



# Implications for C2 Practice

- NNec C2 Maturity Model

*“Operating at a high C2 maturity level makes it possible to select different C2 approaches”*

- In case of threat:

If task does not require edge C2 → Select less capable C2 approach  
If task does require edge C2 → Be prepared for the risks of threat

- Preparation:

- Creating awareness of threat effects
- Selecting the right people
- Providing appropriate training
- Monitoring C2 processes
- Timely adjusting rigid tendencies

- Eventually, the human factor is the decisive factor!