Using a Functional Simulation of Crisis Management to test the C2 Agility Model

Isabelle Turcotte – Université Laval
Sébastien Tremblay – Université Laval
Philip Farrell – DRDC Toronto
Marie-Eve Jobidon – DRDC Toronto
Main issues

• Major operations require several players
  • Different levels of government, departments, international governments, and non-governmental actors.

• No one agency has the staff or capability to successfully act on its own
  • The Comprehensive Approach

• Inherent cost: groups with different cultures, procedures and potentially conflicting mandates have to work together to accomplish a joint mission.

• Organizational Agility: minimizing these costs while maximizing effectiveness
Other challenges

- Decision making under severe constraints:
  - High risk
  - Time pressure
  - Complexity and ambiguity

- Principal functions of C2
  - Planning, directing, coordinating, and controlling the employment of available resources.

- Cognitive domain is paramount!
Other challenges

• Cognitive resources
  • Situation assessment, monitoring, recognition, problem solving, causal learning, search, planning, judgment, and choice

• Promote Agility
  • Improving and adopting situation-tailored C2 approaches

• Validating the model
  • Decision-making tool

• More research is needed!
C² Approaches

3 Primary dimensions

- Allocation of Decision Rights
- Distribution of Information
- Patterns of Interaction
**C^2 Approaches**

**Primitives**
- Size
- Resistance
- Stiffness

**Assumptions:**
- Size: respond faster
- Resistance: facilitate the transition

Complexity
Objectives

- To test and evaluate the key concepts of the C² Agility Model

- Settling time

<table>
<thead>
<tr>
<th></th>
<th>Low resistance</th>
<th>High resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low size</td>
<td>$t_1$</td>
<td>$t_2 &gt; t_1$ over-damped</td>
</tr>
<tr>
<td>High size</td>
<td>$t_3 \approx t_2 &gt; t_1$ under-damped</td>
<td>$t_4 = t_1$</td>
</tr>
</tbody>
</table>

- To evaluate the impact of team size and resistance on team performance
Hypotheses

1) \( \downarrow \text{Size} \downarrow \text{Resistance} \): making the transitions in time

2) \( \downarrow \text{Size} \uparrow \text{Resistance} \): would yield an over-damped response

3) \( \uparrow \text{Size} \downarrow \text{Resistance} \): would yield an under-damped response

4) \( \uparrow \text{Size} \uparrow \text{Resistance} \): would equally scaled from low size and low resistance
Microworld - C3Fire (Granlund, 2002)

- Laboratory testing
- Study of specific processes

- Real world task
- Direct application of results

Ecological Validity

- Exact timing of occurrence of events
- Systematic variations of values on dimensions of stimuli and limited choices
- Multiple repetitions of similar events
- Predetermined moments of responses

Experimental Control

- Events unfold in a variable manner
- Responses occur in anywhere in time and are loosely linked to specific testing conditions
**Microworld - C3Fire** (Granlund, 2002)

- Simulated environment of command, control and communication.

- Fires spread in real time, both autonomously and as a consequence of human actions.

- Team members pursue multiple objectives:
  1) Rescue population
  2) Extinguish houses already on fire
  3) Prevent spread to houses
Microworld - C3Fire (Granlund, 2002)
Design of the study

• Team size
  • 15 Teams of 4 and 15 teams of 6
  • Each team includes 2 confederates

• Resistance
  • High:
    - Confederate resisting to structure change
  • Low:
    - Confederate promoting structure change
Design of the study

**De-Conflicted** (function-based role allocation)

Allocated responsibility for specific units in C3Fire (e.g., Firefighter, Fire Breaker, Water Tanker, Fuel Tanker, Search Unit, and Rescue Unit). What goals were allocated to which team member was randomized.

**Collaborative** (goal-based)

No a priori allocation of goals or functions was given in this condition. What goals and units were allocated to which team member was left to the team to decide.
Design of the study

• Complexity of the situation

  • High:
    - Apparition of new fire
    - Sabotage unit
  • Low:
    - Aircrafts filled with water
**Procedure**

10 min

**General tutorial**

15 min

**Familiarization**

5 min

**Collaborative tutorial**

10 min

**Collaborative training**

5 min

**De-conflicted tutorial**

10 min

**De-conflicted training**

10 min pause

40 min

**Scenario 1**

15 min

**Q1**

40 min

**Scenario 2**

15 min

**Q2**

10 min

**Debriefing**

5 min

**Post debriefing Q**

**Q.1 and Q.2:**

Goal Commitment, Trust & NASA TLX
Objective measures

• Settling time
  
  • the time from $t = 0$ to the point in time where the response is always within 3% or 4% of the steady state value

• Performance

  \[
  \frac{\text{Total number of cells extinguished}}{\text{Duration of the period}}
  \]

• Coordination

  \[
  \frac{\text{Duration of the period} - \text{Average time without resources for all units}}{\text{Duration of the period}}
  \]
Subjective measures

• Goal commitment questionnaire:
  • Measures the degree of team investment in achieving their goals
    • 5 point Likert scale (*not true at all* to *totally true*)

• Post-debriefing questionnaire:
  • Measures participants’ awareness of the experimental conditions (situation complexity and the presence of confederates)
    • 5 point Likert scale (*strongly disagree* to *strongly agree*)
Results

- **Subjective measures**

  Figure 1. Mean goal commitment score as a function of team size and resistance. Error bars represent standard errors.

  **Goal commitment**

  - Post-debriefing
    - 62% perceived workload
    - 95% did not perceive confederates

  **Low**
  - Four-person team (Low) vs. Six-person team (Low)
  - Goal commitment score (1-5)

  **High**
  - Four-person team (High) vs. Six-person team (High)
  - Goal commitment score (1-5)
Results

- **Objective measures**

**Performance**

![Graph showing the mean number of cells extinguished as a function of team size and resistance. Error bars represent standard errors.]

*Figure 2. Mean number of cells extinguished as a function of team size and resistance. Error bars represent standard errors.*

**Coordination**

![Graph showing mean coordination effectiveness as a function of team size and resistance. Error bars represent standard errors.]

*Figure 3. Mean coordination effectiveness as a function of team size and resistance. Error bars represent standard errors.*
Discussion

• Team size
  • Does not seem to affect team performance or coordination
    • Variability between team structures
      • Role ambiguity?

• Resistance
  • Does not seem to affect team performance or coordination
Conclusion

• Validity of the study design
  • High levels of goal commitment
  • Situation complexity perceived, presence of confederates
  • Resistance manipulation
  • Larger team size?

• Still to come…
  • Other questionnaires
  • Complexity parameter
  • Social network analyses