17th ICCRTS
"Operationalizing C2 Agility"

Title: Organizational Agility Olympic Event Case Studies

Topic 2: Approaches and Organization
Topic 7: Military and Civil-Military Operations
Topic 1: Experimentation, Metrics, and Analysis

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Abstract

Two case studies found evidence for C2 Agility defined as "the capability to transition from one C2 Approach to another more appropriate approach as circumstances change (SAS-085, draft)."

The Vancouver 2010 Olympics did not have any major security incidents that produced high endeavour complexity, and so the required approach was between de-conflicted and coordinated throughout the event. In terms of the C2 Approach model (SAS-065, 2010), the desired approach was collaborative but the actual approach was coordinated. Nevertheless, no transitions were required or actually happened. Thus, no evidence was found for C2 Agility.

The Munich 1972 Olympics (Banbury, Kelsey, & Kersten, 2011) experienced a major security incident – a terrorist attack –with hostages being killed. This case study concluded that although the situation complexity demanded a collaborative or even an edge-like approach, the C2 approach was characterised as conflicted (even anarchical). The collective did not transition to the required approach because of high opposing organizational forces (resistance to change and high comfort level with inner circle). A lack of C2 Agility was noted.

This paper presents the case studies' key findings that are used to refine the C2 Agility concept, model, and simulation, and begin to design a model validation study.

Introduction

This paper presents key findings from Olympic Event case studies that are used to substantiate and refine the Organizational Agility conceptual model (Farrell, 2011; Farrell & Connell, 2010). The Vancouver 2010 Olympics (Jobidon, Fraser, Smith, & Farrell, 2011) and Munich 1972 Olympics (Banbury, et al., 2011) case studies found evidence for several of model concepts. The Vancouver case study did not have the opportunity to determine whether agility was present or not, while the Munich case study clearly indicated that there was a definite lack of agility. This introduction to the paper provides the practical justification for the research as well as a full description of the Organizational Agility conceptual model.

Complex Endeavours require a Comprehensive Approach (CA) to operations (Alberts, 2007; CFD, 2010; Farrell, et al., 2006)[1]. Much of the complexity comes from the interwoven nature of the endeavour's political, military, economic, social, infrastructure, and information (PMESII) aspects that require multi-disciplinary expertise to develop solutions, and both kinetic and non-kinetic instruments of national power to employ them. The Canadian government has used language such as Diplomacy, Defence, Development, and Commerce to describe instruments of national power (Government of Canada, 2005).

In order to command and control (C2) or govern and manage (GM) organizations that come together to meet the challenges of complex endeavours, it has been argued that governments and alliances should invest in all C2 or GM approaches (see Figure 1), especially Edge (SAS-065, 2010). These collectives would need to invest in policy, process (standard operating procedures and tactics, techniques, and procedures, business rules), organization (people, roles, responsibilities), technology (computers, Common Operating Pictures, etc.), and infrastructure (networks)[2] commensurate with every C2 approach.

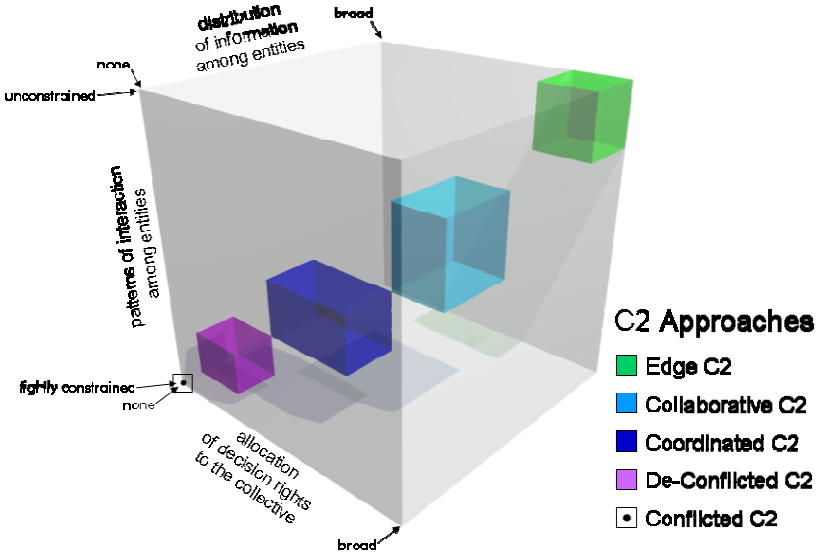


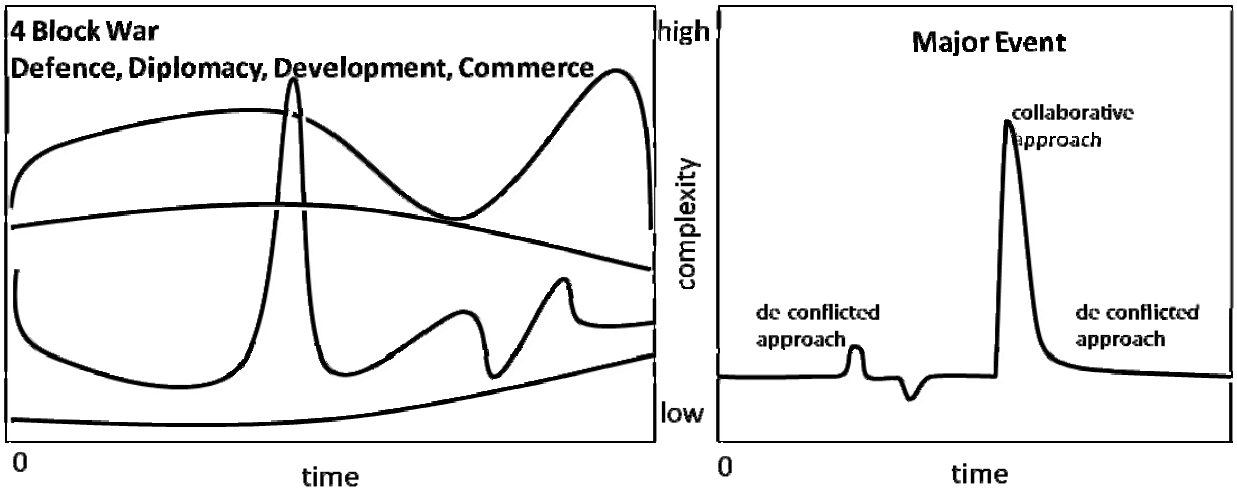
Figure 1: C2 Approaches and the C2 Approach Space (SAS-065, 2010)

Table 1 provides the characteristics of the various approaches along three dimensions: Allocation of Decision Rights (ADR), Patterns of Interaction (PI), and Distribution of Information (DI). ADR is the extent to which roles, responsibilities and authorities are shared amongst entities of the collective.

Table 1: Variables Defining Collective C2 Approach (SAS-065, 2010)

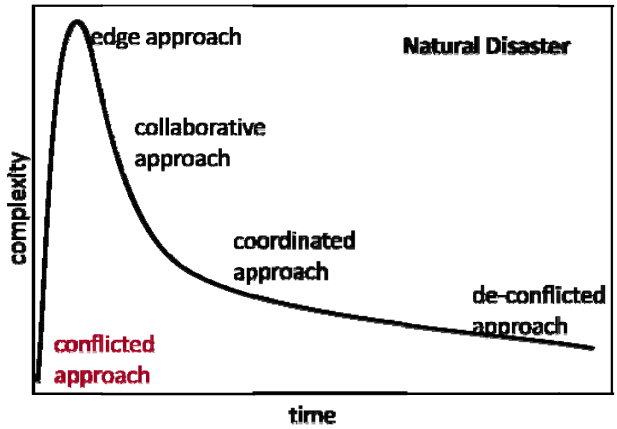
[1] Chief of Force Development (CFD)
[2] The Policy, Processes, Organization, Technology, and Infrastructure framework was proposed as a Major Event Security Architecture for Canadian domestic events (Farrell, 2008).

C2 Approach	Allocation of Decision Rights to the Collective	Patterns of Interaction Among Participating Entities	Distribution of Information (Entity Information Positions)
Edge C2	Not Explicit, Self-Allocated (Emergent, Tailored, and Dynamic)	Unlimited As Required	All Available and Relevant Information Accessible
Collaborative C2	Collaborative Process and Shared Plan	Significant Broad	Additional Information Across Collaborative Areas/Functions
Coordinated C2	Coordination Process and Linked Plans	Limited and Focused	Additional Information About Coordinated Areas/Functions
De-Conflicted C2	Establish Constraints	Very Limited Sharply Focused	Additional Information About Constraints and Seams
Conflicted C2	None	None	Organic Information



a) theorized complexity vs. time for 4 block war

b) complexity vs. time for fictitious Major Event



c) Required approach depends on complexity level

Figure 2: Hypothetical Complexity Profiles for Three Different Complex Endeavours

According to Table 1, ADR for De-conflicted is 'Established Constraints', which means that the collective may have policy that clearly states the responsibilities and authorities of each entity. PI refers to, in the most simplest of terms, the organizational chart: that is, how entities relate to each other. PI for Collaborative C2 is 'Significant Broad, which means less of a hierarchical structure and more of a 'flat' organization. DI is akin to Information Sharing. DI for Edge is 'All Available and Relevant Information Accessible' where every entity has access to all information. The descriptions in this table are used in the case studies to infer[3] the C2 or GM approach used by a collective.

Is there a more effective and efficient way to govern and manage an endeavour rather than adopting an Edge approach all the time? An Edge approach is expensive (Farrell, 2011) and requires significant investments in time, money, and effort, while at the same time they are arguably required for complex endeavours. On the other hand, De-conflicted may be the most efficient, but only effective for straightforward (simple) endeavours. Perhaps somewhere between Coordinated and Collaborative lies a reasonable trade-off between effectiveness and efficiency for all levels of complexity if the entity is willing to assume some risk. Alternatively, the organization may employ an approach commensurate with the endeavour's level of complexity (see Figure 2). This strategy has been defined as Organizational Agility or C2 Agility (Farrell & Connell, 2010; SAS-065, 2010).

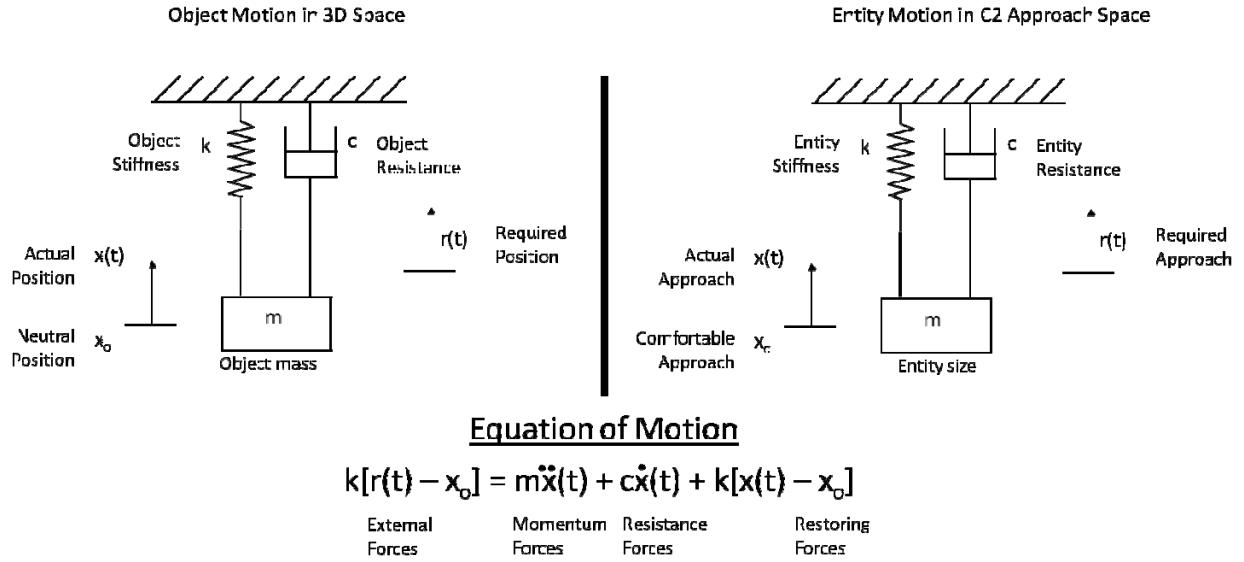


Figure 3: One to one mapping of object motion in 3D space to entity motion in C2 approach space subject to external, resistance, and restoring forces.

It is assumed that an entity moving around in the C2 Approach space has the same dynamic properties of an object moving around in physical space. From this assumption, a conceptual mathematical model was developed that likens an entity transitioning from one approach to another within the C2 Approach Space (Figure 1) to an object transitioning from one position to another in 3D space and subject due to external, resistance, and restoring forces (Farrell, 2011; Farrell & Connell, 2010). Figure 3 shows a straight one-to-one analogy of object and entity schematic diagrams common to dynamics modelling.

From the diagram, it is postulated that just as an object has mass, an entity (individual, team, organization, or collective) has size (m): just as an object has stiffness (opposite of compliance), an entity

[3] 'Infer' is a better word than 'Identify' because it is unlikely that a case study report will have any of the same words provided in Table 1. The analyst must infer the ADR, PI, and DI level from these reports.

has stiffness (k); and just as an object experiences resistance while moving, an entity experiences resistance (c) while transitioning from one approach to another. The actual, required, and neutral object positions are akin to the actual, x(t), required, r(t), and comfortable, x_o, entity approaches. Note the change of term from 'neutral position' to 'comfortable approach'. However, the concept is the same. That is, just as an object with no external forces comes to rest in a neutral position, an entity with no external influences reverts to an approach they are most familiar with – a comfortable approach.

The equation of motion in Figure 3 is derived from Newton's second law of motion that states that the change in an object's momentum is influenced by external (same direction), and resistance and restoring (opposite direction) forces acting on the object. Continuing the analogy, it is postulated that the change of an entity's momentum is influenced by external, and resistance and restoring forces as it moves within the C2 Approach space. That is, complexity level is an external force that drives the entity towards the required approach. Meanwhile, resisting forces (e.g., slow communications or bureaucracy) and restoring forces (e.g., desire to return to a familiar or comfortable approach) slow down the entity from reaching the required approach. Equation 1 suggests that once these forces reach an equilibrium, the entity comes to rest at the required approach: that is, x(t) = r(t) when $\dot{x} = 0$ and $\ddot{x} = 0$,

$$k\,[r(t) - x_o] = m\,\ddot{x}(t) + c\,\dot{x}(t) + k\,[x(t) - x_o] \qquad (1)$$

The parameters m, c, and k dictate the dynamics (nature and timing) of the transition. That is, an object may reach the required position in an over-damped (lag), under-damped (oscillations), critically-damped (minimum lag with no oscillations), or unstable fashion. These parameters also determine the rise time, time period ($T = 2\pi m/c$), and settling time ($T_s = 4T$ yields within 2% of steady state value) for the first three stable responses.

Unlike an object whose position can be sensed throughout the motion, an observer might not be able to assess all the intermediate stages of an entity's transition at a frequency that would allow an estimate of the transient response. Equation 1 was implemented into a computer simulation that included an option to filter out the transient response and display the steady state response only (Farrell, 2011). With the steady state response alone, it becomes difficult to determine the nature of the response although obvious lags and overshoots can be observed. The transition time from one approach to another (i.e., T_s) can be recorded and related back to the model parameters. T_s as well as any obvious lag or overshoot in achieving the steady state response can be observed, and therefore one could estimate values for c and k for a given m, and ultimate the entity's natural frequency $\omega_n = (k/m)^{0.5}$ and damping ratio $\xi = 0.5c/(mk)^{0.5}$.

In the same manner that car mechanics use ω_n and ξ to 'tune' a shock absorber, this model suggests that organizational designers may be able to 'tune' an entity by, for example, manipulating the organization size (m) by making it smaller, resistance (c) by speeding up communications and minimizing bureaucracy, and stiffness (k) by becoming familiar with more than one approach. The two previous papers (Farrell, 2011; Farrell & Connell, 2010) describe in detail four entity behaviours for improving the transition from one approach to another (shorter T_s with no oscillations): compensatory, anticipatory, adaptive, and learning behaviours.

Table 2 provides a summary of the C2 Agility model variables, parameters, and behaviours. Note that throughout this discussion, numerical values are not mentioned or necessary for that matter. Rather relative or ordinal values are assumed by the analyst to look for certain dynamic characteristics as the entity transitions, and by the organizational designer to modify resistance and stiffness elements to improve transition performance. Ultimately, the Organizational Agility model remains a theoretical construct unless there is evidence in real life for the postulated variables, parameters, and behaviours.

Two case studies were conducted finding evidence for the model variables, parameters, and behaviours: the Vancouver 2010 Olympics (Jobidon, et al., 2011) and the Munich 1972 Olympics (Banbury, et al., 2011). The next sections provide a synopsis of each study followed by a discussion of the model refinement based on the findings. The final section of the paper summarizes the conclusions from the case studies and model refinement, and presents recommendations for further validation of the model.

Vancouver 2010 Olympics Case Study

Background

This case study focused on security operations for the 2010 Vancouver Olympic Games. In February and March 2010, the city of Vancouver, British Columbia hosted the Olympic and Paralympic Winter Games (V2010). The Integrated Security Unit (ISU) was in charge of security operations for the Games, which was led by the Royal Canadian Mounted Police (RCMP). The mandate of the ISU was to provide public safety and security throughout all the Olympic venues for the duration of the Olympic and Paralympic Games (Goodwin, Essens, & Smith, 2011). V2010 was a major international sporting event and the security efforts involved multiple entities in charge of different aspects of security, including several municipal and provincial police forces, civilian government departments, and the Canadian Forces (CF).

Table 2: C2 Agility model Variables, Parameters, and Behaviours

C2 Agility Definition (SAS-085, draft):	The capability to transition from one C2 Approach to another more appropriate approach as circumstances change.
Variables	
ADR(t)	Allocation of Decision Rights varies from 'none' to 'broad' in the C2 Approach Space (see Figure 1 and Table 1).
DI(t)	Distribution of Information (or Information Sharing) varies from 'none' to 'broad' in the C2 Approach Space (see Figure 1 and Table 1)
PI(t)	Patterns of Interaction varies from 'constrained' to 'unconstrained' in the C2 Approach Space (see Figure 1 and Table 1)
r(t) = r(complexity(t))	Required approach as a function of complexity level (see Figure 2)
x(t) = x[ADR(t),DI(t),PI(t)]	Actual approach at time, t.
$x_o = x_o[ADR_o,DI_o,PI_o]$	Comfortable approach when no forces are acting on entity (may drift over time)
Parameters	
m	Entity size may include (but not limited to) number of people, equipment, assets, etc
c	Resistance characterizes those resisting elements during a transition
k	Stiffness characterizes the extent to which the entity is comfortable/familiar with one or more approaches
Behaviours	
Compensatory	Using feedback to compensate for differences between r(t) and x(t)
Anticipatory	Predicting a change in complexity and beginning to move to the predicted required approach.
Adaptive	Changing parameter values as a function of variables: often the variable is e(t) = r(t) – x(t)
Learning	Changing parameters through training and education: typically between endeavours

The goal of this analysis was to determine whether evidence supporting the GM approach agility model could be found in reports documenting V2010 security operations. Hence, for each concept of the model the attempt was to find excerpts from the documents that seemed to reflect the concept.

Methodology

Evidence was sought for each variable, parameter, and behaviour (i.e., each model concept) by attempting to find excerpts from source documents specifically in the three main phases of the model: 1) before the event, 2) during the event, and 3) after the event. In order to determine whether evidence was present in each phase, relevant quotations were organized into by phase and concept. This process was repeated for each document resulting in a final spreadsheet. If sufficient evidence existed for a given variable, a nominal or ordinal value was inferred and entered into the spreadsheet.

Based on availability and classification, eight reports were used as source documents for this analysis, and are listed below. The majority of the evidence was extracted from the 3350-1 Canada Command Joint Task Force Games (JTFG) report (2010). One challenge faced in compiling evidence from the JTFG report as well as several of the other papers and reports was their heavy focus on the CF. Though the CF was part of the collective, they were not the collective as a whole. As a result, CF-focused evidence was extrapolated to the collective when it made sense to do so.

- 3350-1 (DCOS ops) (August 2010). *Canada Command Joint Task Force Games Post-Operations Report – Op PODIUM*.
- Genik, L., & Smith, D. G. (2011). Command and control analysis of the South West Provincial Regional Emergency Operations Centre during Vancouver 2010. *Proceedings of the 16th International Command and Control Research and Technology Symposium*, Québec City, Canada.
- Goodwin, G. F., Essens, P. J. M. D., & Smith, D. (2011). Multiteam systems in the public sector. In S. J. Zaccaro, M. A. Marks & L. DeChurch (Eds.), *Multiteam systems: An organization form for dynamic and complex environments* (Part I: Introduction). New York: Routledge Academic.
- Smith, D. G. & Maceda, G. E. (2010). *Strategies for ad-hoc data collection and analysis during major event interagency exercises and operations*. Paper presented at Knowledge Systems for Coalition Operations 2010, Vancouver, Canada.
- Smith, D. G., McLellan, L., & Hobbs, D. (2010). *Cultural differences between the Canadian Forces and the Royal Canadian Mounted Police*. Paper presented at the NATO Workshop on Collaboration in a Comprehensive Approach to Operations, Toronto, Canada.

The ISU for V2010 was led by the RCMP and also included the following organizations: the CF, the Vancouver Police Department (VPD) and the West Vancouver Police Department (WVPD). For this case study, these entities together were defined as the 'collective'.

Results

During each phase, evidence, both existence of a variable and its 'value', was sought for six variables (ADR, DI, PI, required, actual, and comfortable approaches), three parameters (size, resistance, and stiffness), and four behaviours (compensatory, anticipatory, adaptive, and learning). One aspect of the model is that several concepts are contingent on the occurrence of a significant disturbance in Phase 2 (during the event), requiring the collective to transition from one approach to another. However, there was no significant disturbance during the V2010 Olympics, such as a terrorist attack or a natural disaster, so there was no potential for finding evidence for resistance as well as compensatory, anticipatory, and adaptive behaviours.

Table 3 summarizes the evidence supporting the concepts defined in the model. It is important to note that the inferred values for the C2 approaches were based on definitions described in (SAS-065, 2010) rather than from inferred levels of ADR, DI, and PI in Table 1.

ADR: In the judgement of the case study analysts in interpreting the source documents, evidence was inferred for ADR at the strategic level; that is, the RCMP was tasked as the lead agency of the ISU and other organizations were supporting entities. However, there was no evidence in the documents reviewed of the specific allocation of decision rights at the operational level, although each position in the ISU had been allocated specific roles and responsibilities.

Table 3: Summary of Evidence Found for Agility Model within V2010 Case Study

	Concept	**Phase 1** Pre-Event	**Phase 2** During Event	**Phase 3** Post-Event
Variables				
ADR	Allocation of Decision Rights	√		
DI	Distribution of Information	√	√	
PI	Patterns of Interaction	√		
r(t)	Required approach	√	√	
d(t) *new*!	Desired approach	√	√	√
x(t)	Actual approach	√		
x_o	Comfortable approach			
Parameters				
m	Size	√	√	
c	Resistance	√		
k	Stiffness			
Behaviours				
	Compensatory			
	Anticipatory	√		
	Adaptive			
	Learning	√		√

PI: Although the collective tried to build ties between the various organizations prior to the Olympics (Phase 1) through several exercises, evidence indicates that the interactions were hampered by a complex command structure. For instance, there were four CF commands operating in the Joint Operations Area, which created interaction challenges for the other members of the collective.

DI: There was no evidence from the source documents to determine how information was distributed specifically. However, the ISU employed an Incident Management System (Allen, Chow, Trinh, & Farrell, 2009) – a database and interface that was updated each time an incident took place. This computer application also had email capability. There were business rules regarding who had the authority to input information, view information, change information attributes (status, classification, etc), and send the information outside of the ISU. The distribution of information was coupled to both PI and ADR.

Required approach: Theoretically, it should be possible to use the ADR, DI, and PI descriptors in Table 1 to determine approach and ultimately the location within the C2 Approach space. However, because there were no similar words found in the source documents that matched the descriptors, the inferred values for the approaches were based on the global definitions described of De-conflicted, Coordinated, and Collaborative rather than from inferred levels of ADR, DI, and PI. Phase 1 occurred before the start

of the Games but included exercises and other preparations. It is inferred that during Phase 1, the required approach was somewhere on the continuum between De-conflicted and Collaborative (assuming a direct relationship between situation complexity and required approach). During the event (Phase 2), the Games were planned and conducted to be safe and secure – everything from access passes to vehicle traffic control was carefully predetermined, planned, and executed to plan. The Olympics ran smoothly with no significant security issues. That is, the situation complexity was relatively low since no major security-related events took place. Thus, the required approach was likely closer to De-conflicted than Coordinated. In Phase 3, following the Games, members of the ISU returned to normal operations as dictated by government legislation (i.e., likely De-conflicted).

Desired approach: Although not originally part of the model, V2010 operations were partially driven by the desire to reach a certain approach. The source documents indicated that the organizations within the collective were directed to adopt a collaborative approach. That is, the ISU was intended as a means to carry out security operations as an integrated interagency team. In Phase 2, there was no evidence to suggest that the desired approach had changed from Phase 1, and the expectation remained that the ISU would operate at a collaborative level. Evidence suggests that after the end of the Olympics, the desired approach was somewhere between De-conflicted and Coordinated. For instance, the CF expressed the intent to maintain the relationships built during the Olympics with regional and provincial security partners.

Actual approach: Case study analysts discussed the approach in the context of the source documents and came to consensus that the evidence suggests that the actual approach went from De-conflicted to somewhere around coordinated. The Government of Canada gave guidance to the collective as to the level of cooperation it should achieve (i.e., the desired approach), which was a powerful external force that aided in moving the actual approach towards the desired approach, collaborative. However, it seems that the collective achieved an approach close to coordinated by the end of the exercise phase and the start of the Olympics, which was maintained throughout the Games (Phase 2). No evidence was found to indicate what the actual approach was in Phase 3. Given that the collective dispersed following the Games, the approach in Phase 3 could be inferred to be somewhere between De-conflicted and Coordinated (i.e., they did not remain at the approach that they achieved during the Olympics).

Comfortable approach: No evidence was found from the source documents that would infer a particular comfortable approach for the collective.

Size: The collective comprised of the RCMP, CF, Vancouver Police Department, and West Vancouver Police Department. There was no practical way of quantifying the collective size. However, the number of people did surge at the beginning of Phase 2 as security personnel on the ground came on strength for the event. After the end of the Games, the ISU stood down and the collective dispersed. Thus, there was evidence for the change in size over time.

Resistance: The analysis revealed various types of resistance in Phase 1. For instance, there were significant cultural differences among the organizations of the collective. Some of the differences included discipline, terminology, and treatment of overtime, training, and work conditions. These differences created challenges for interoperability since the same instructions could be treated differently by the various organizations. This, at times, had a negative impact on the passage of information among partners as well as the ease at which they interacted with one another. There were a number of times that conscious efforts were made to reduce the presence of resistive elements. There was no opportunity to seek evidence for resistance during Phase 2 because there was no security incident that would have required the collective to transition from one approach to another during the event. Similarly, there was no evidence in the documents regarding resistance during Phase 3.

Entity behaviours: Evidence for learning (exercises) and anticipatory (planning and contingency planning) behaviours were found for Phase 1. A key learning behaviour was to hold Whole-of-Government training exercises. During these exercises, multiple organizations had a chance not only to train on their tasks but also to experience interacting with one another and establish interoperability. Anticipatory behaviours took the form, among other things, of contingency planning through red teaming efforts. Because there was no significant disturbance during the Games and therefore no need to transition from one approach to another, there was no opportunity to identify compensatory, anticipatory, or adaptive behaviours for Phase 2. As expected, there were no signs of compensatory, anticipatory, or adaptive behaviours during Phase 3. However, there was evidence of intent to incorporate learning behaviours in preparation for other events (e.g., implementing an exercise plan for future events similar to the one conducted for the V2010 Olympics).

Figure 4 provides a summary of the approach(es) that the collective adopted during each phase. It is constructed from the inferred values discussed in this section and it illustrates the notion of movement within the C2 Approach space. Note that the desired approach is an additional external force that influences the actual approach. The double ellipses in Phase 1 reflect the significant change in the collective from the beginning of that phase (i.e., when the ISU was created and members of the collective were still interacting in a day-to-day manner) to the end of Phase 1 (when the collective was operationally ready for the Olympics).

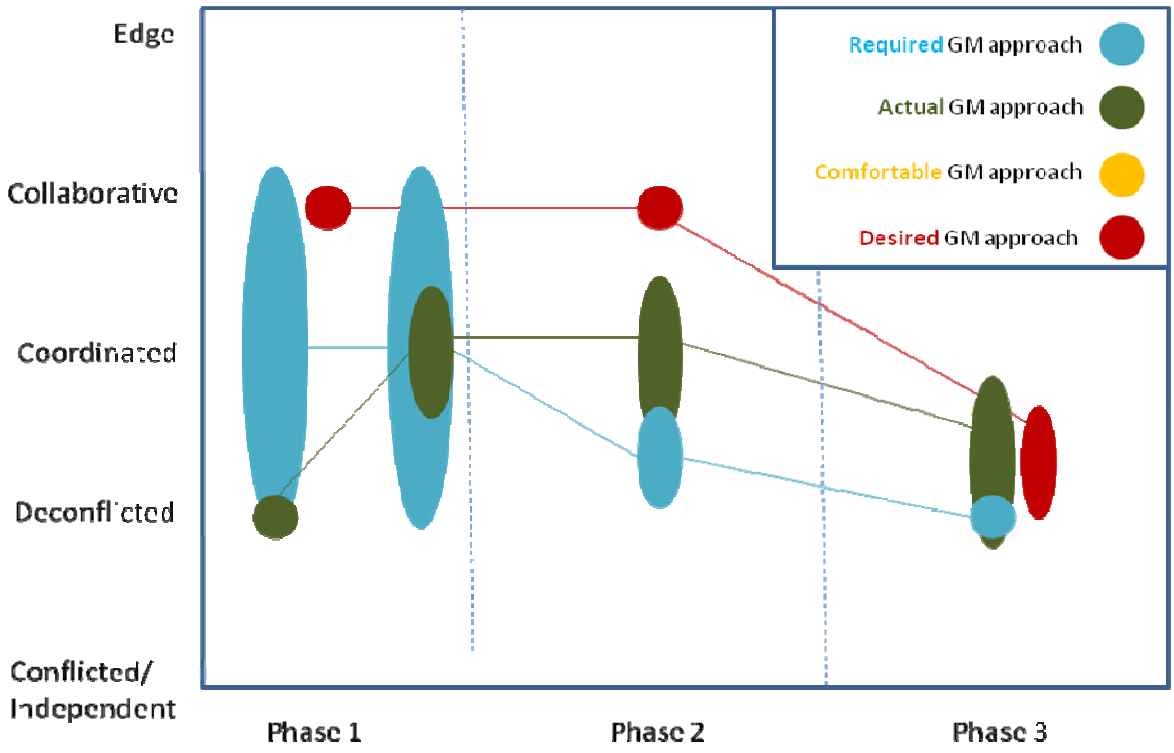


Figure 4: Inferred approaches adopted by the collective throughout V2010 (Jobidon, et al., 2011).

Effectiveness and Efficiency

Theoretically, the actual approach is completely effective when it matches the required approach. As shown in Figure 4, the required and actual approaches do not match completely during Phase 2 despite some overlap. That is, the actual approach is at a higher level than required for the situation. Thus, the inference is that the approach was only somewhat effective. It could also be interpreted that the approach

was not as efficient as it could have been, since approach efficiency is some function of approach effectiveness modulated by cost to reach that approach, where one would argue that the cost of maintaining a Coordinated approach is more than a De-conflicted approach. In this case, cost could be measured by the amount of monetary, human, and physical resources it took to implement the V2010 security operations, but the source documents did not contain this information.

A responsible and accountable government must prepare for "worst-case" scenarios during a complex endeavour, such as the V2010 Olympics. Though the model posits that the actual and required approaches should match for optimal effectiveness, a security collective may need to operate at a higher approach level than actually required during the event. Indeed, there is a cost associate with moving from one approach to another as well as a cost with operating at a different level than required. From a cost-benefit perspective, it is conceivable that operating consistently at a single GM approach throughout the event (say Coordinated) might be preferable than trying to transition from one approach to another as needed.

Concluding Remarks

Security during the Vancouver 2010 Olympics required the interaction among multiple organizations. This provided an opportunity to look for evidence of the agility model concepts in the source documents. A new variable was discovered, desired approach, to account for other external forces (e.g., political influences) that influence the actual approach as it moves through the C2 Approach space. Evidence was found for most concepts in Phase 1, that is, before the Olympics. As there was no significant disturbance during the event (Phase 2) that would require the collective to move from one approach to another, there was no potential for finding evidence for several of the concepts in that phase. Evidence was found for a number of the concepts in Phase 3 that apply primarily to the CF.

This case study was limited to the materials made available and the particular circumstances around the Olympics. This limited the scope of the analysis as most of the documents reviewed were written for or by the CF. Although concepts were deemed to be present, the concept's level was only inferred, when possible, after discussion and consensus. The lack of evidence for a given concept does not necessarily entail that this concept was not present but that it may not have been documented in the materials.

Munich 1972 Olympics Case Study

Background

The objective of this case study was to collect evidence for agility within the Munich 1972 Olympics, and by doing so, evaluate the organizational agility model outlined in the introduction. The case study's final report (Banbury, et al., 2011) provided a model description, outlined the data collection and analysis methodology, provided results, discussion, conclusions and future directions. This section provides a synopsis of the methodology and results found in the Banbury et al. report.

Tragic events at the 1972 Munich Olympic Games occurred where terrorists took athletes and coaches as hostages, all losing their lives. Before the terrorists took the hostages, the Games were touted as the 'happy Games'. Security was present but intentionally as invisible as possible. Although security forces had trained on scenarios based on actual events that occurred during previous Olympics, it would soon become evident that they were not prepared for what was to happen next. The hostage taking would constitute a high level of complexity as shown in Figure 2b, requiring security forces to adopt a Collaborative GM approach as a minimum. Although an ideal situation for C2 Agility to occur, the case study showed that the collective did not reach a Collaborative level, and at some points the command and control seemed Anarchic.

Methodology

The methodology involved, first, extracting key concepts from the agility model. All the variables, parameters, and behaviours in Table 2 were clearly identified as the model concepts to look for in the Munich 1972 Olympics case study. Also, there were a few more attributes that were deemed important for this particular case study:

- *Robustness*: ability to maintain effectiveness across a range of tasks, situations, and conditions.
- *Responsiveness*: ability to react to a change in the environment in a timely manner.
- *Resilience*: ability to recover from or adjust to misfortune or damage to itself.
- *Disturbance Rejection*: ability to recover from known or unknown transition disturbances.
- *Effectiveness*: extent to which an entity's actual approach matches the required approach.
- *Efficiency*: transition's value or worth (i.e., effectiveness) compared to the resources (costs) used to accomplish the transition.

These additional attributes are further explained in (Farrell, 2011) and come into play when there is an opportunity to transition from one approach to another.

Three analytical approaches were proposed to evaluate the model concepts (variables, parameters, behaviours, and attributes): narrative descriptions, conceptual and relational analyses, and subjective inference. Narrative descriptions comprised the construction of a short verbal description of the specific instance of the concepts under study. Conceptual analysis involves counting the number of times a concept appears in the case study data sources (Carley, 1992) and relational analysis seeks relationships among the concepts. Together they form "relationship maps" of the concepts. Figure 5 provides a relationship map based on the model, overlaid with the analytical steps required to find evidence for that particular concept and relationship.

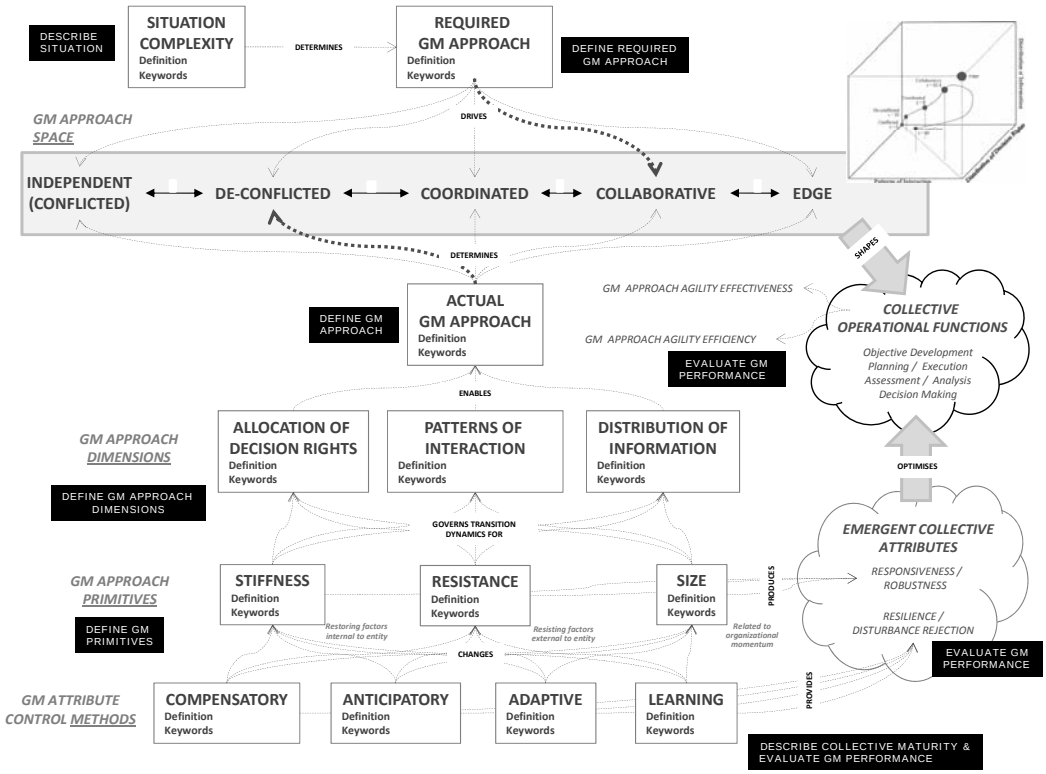


Figure 5: Methodology steps for gathering evidence overlaid on agility model relationship map.

It became evident that this hybrid methodology would problematic since the model's esoteric terms (agility, stiffness, etc.) would not be found verbatim in the media. To mitigate this issue, three analysts, well-versed in the concepts and their relationships, interpreted the media individually and then came to a consensus on whether a concept, as well as the relationship between that concept and others, appeared in the media. Subjective inferences were necessary from the ADR, PI, and DI data in order to infer their values and the resultant actual approach and from the complexity level in order to infer the required approach.

The analysis was repeated for five time periods: pre-terrorist attack, hostages in apartment, apartment to airfield move, at the airfield, and post-terrorist attack. The first time period included the pre-Olympic exercises as well as the first few days of the Olympics. The middle three time periods were not so crisply defined but were mainly characterized by three failed attempts to rescue the hostages – the final one ended with the death of all the hostages. The fifth time period included those events that took place after the terrorist attack and failed rescue, which included a recreation of events and changes to security policies and tactics.

The data sources used for this case study are listed below. In general, the data sources provide a series of interviews from top officials who participated in the Olympic event approximately 30 years from the time of the interview. Wherever possible, archived footage of events was incorporated in the film and television programs to help tell the story. The data sources were numbered, and whenever a concept was identified, the source number as well as the page and paragraph, or time stamp, was recorded.

Film: MacDonald, K. (Director) (1999). One Day in September. United States: Passion Pictures. http://www.youtube.com/watch?v=UftbXtupuBo&feature=fvw

Television: Clarke, S. (Director) (2007). Olympic Massacre: The True Story. United Kingdom: Channel Five. http://www.youtube.com/watch?v=yZx6PcQG-hY&feature=related

Report: Pro Sport München (1972). Die Spiele: The official report of the Organizing Committee for the Games of the XXth Olympiad Munich 1972. Volume 1: The Organisation. http://olympic-museum.de/o-reports/report1972.htm

E-Book: Schiller, K., and Young, C. (2010). The 1972 Munich Olympics and the Making of Modern Germany. University of California Press. http://www.ebooks.com/ebooks/book_display.asp?IID=566752

Book: Reeve, S. (2001), One Day in September: the full story of the 1972 Munich Olympic massacre and Israeli revenge operation "Wrath of God". Arcade Books.

Results

Table 4 summarizes the evidence found for the model's concepts in this case study. The case study report provides a link to the data source as well as justification for each of the items where evidence was found.

Figure 6 shows the subjective inferences of the required and actual approaches across the five time periods. The inferences for the required approach were made based on the current complexity within that time period. That is, if the complexity were high then required ADR, DI, and PI would need to be broad, broad, and unconstrained, respectively: that is, a Collaborative nearly Edge-like required approach. The inferences for the actual approach were made based on ADR, DI, and PI evidence from the source data for that time period. And so, there are transitions from one approach to another (a necessary condition for C2 Agility), but not to the appropriate (required) approach (a sufficient condition for C2 Agility).

Table 4: Summary of Evidence Found for Munich Case Study

Variables	**Name**	**All Time Periods**
ADR	Allocation of Decision Rights	√
DI	Distribution of Information	√
PI	Patterns of Interaction	√
r(t)	Required approach	(inferred from Situation Complexity)
x(t)	Actual approach	(inferred from ADR, DI, PI)
x_o	Comfortable approach	√
Parameters		
m	Entity size	√
c	Resistance (lack of trust)	√
k	Stiffness	√
Behaviours		
	Compensatory	
	Anticipatory	√
	Adaptive	
	Learning	√
Other Attributes		
	Situation Complexity	√
	Resilience	√
	Transition Effectiveness	√
	Transition Efficiency	√
	Robustness	
	Responsiveness	
	Disturbance Rejection	

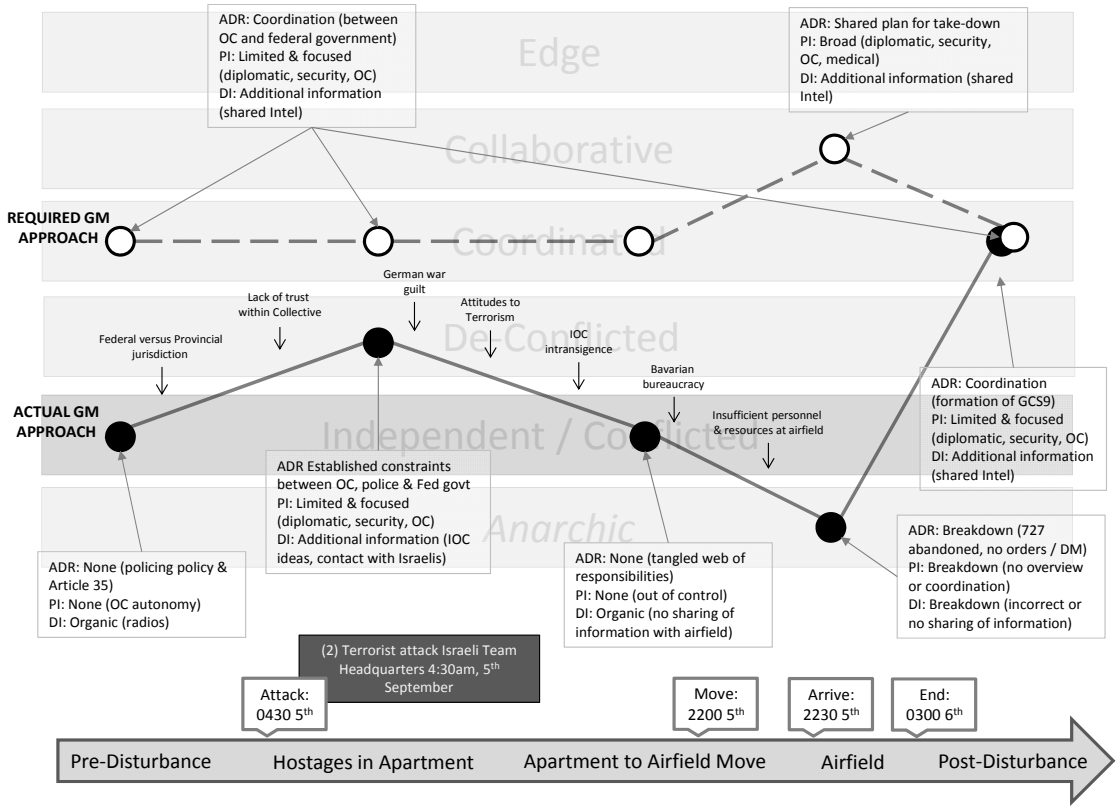


Figure 6: Required and Actual Approaches inferred from complexity level and ADR, PI, DI, respectively, for each time period.

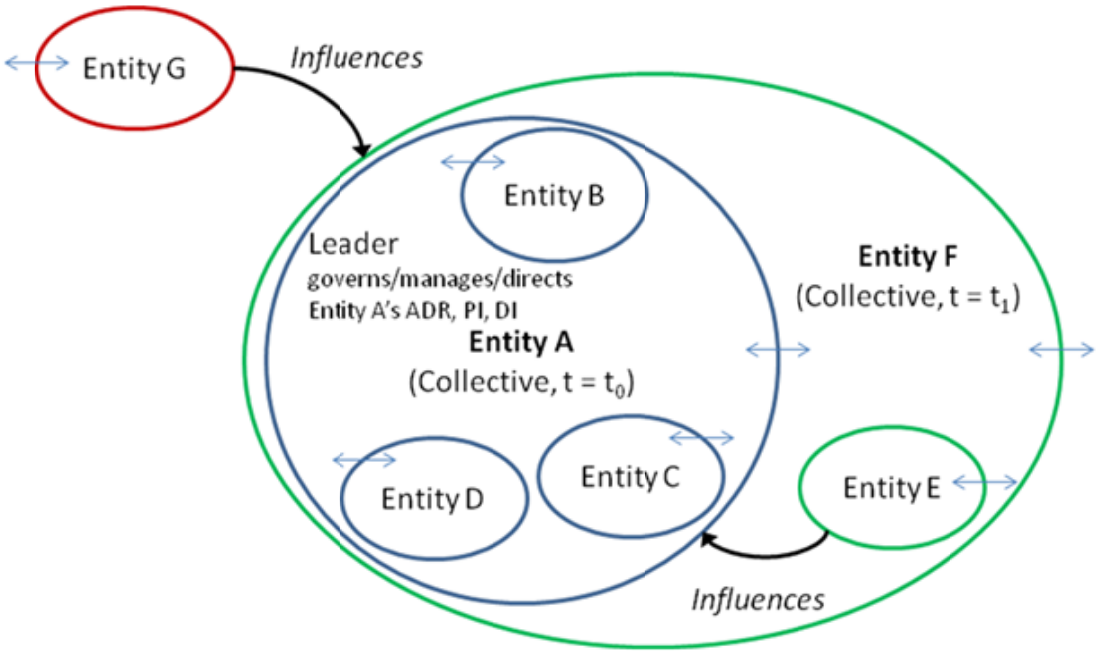


Figure 7: Entities expand and contract over time

Size changing over time

One important observation was that the security organization was changing as the events unfolded, authorities and responsibilities were unclear, and the collective did not take advantage of key competencies available to them. That is, although the Federal, State, and Municipal governments were responsible for the security of the Games, their roles and responsibilities were not clear. Moreover, the Federal government refused support from the Israeli Special Forces that would have been an excellent addition to the collective. The National Army assisted in the Games but did not play a role in the terrorist attack. Other organizations involved included the West German border Guards, City of Munich, and the Munich Police. Other organizations had varying degrees of influence over the security collective including the International Olympic Committee, Olympic Organization Committee, Israel, Egypt, Tunisian Republic, and the Arab League. All had some part to play but the governance and management of this collective was somewhat disjointed, even chaotic at times. Figures 7 shows how Entity A becomes Entity F sometime later and fundamentally size is not static but changes over time.

Leadership

Key leaders emerged that played a significant role in how the collective acted and reacted to events. Manfred Schrieber, Chief of Police assumed leadership of the police efforts which included negotiation attempts with the terrorists and decision making upon organized rescue attempts. Georg Wolf, deputy commander of the Munich Police was given responsibility over the rescue attempt at Fürstenfeldbruck airfield; and George Sieber, Police Psychologist, worked with police force pre-Olympics with the intension to prepare them so that they could react efficiently and effectively towards security threats.

Concluding Remarks

Overall, the evaluation found evidence for changes to the Munich collective's C2 approach when dealing with the terrorist attack. Although the collective did not transition to the required approaches as dictated

by the situation, it was apparent from the evidence that the explanations for why they were not able to do so were consistent with the concepts of stiffness and resistance in the model.

It is important to note that extracting evidence was very difficult because the model terms simply did not appear in the source data, and the case study therefore relied on the analyst's ability to interpret the case study in the context of the model. Notwithstanding this fact, this study was able to collect sufficient evidence using a combination of conceptual and relational analyses to suggest that in the particular case of the Israeli hostage crisis at the 1972 Munich Olympic Games, the lack of C2 agility (inability to transition to the appropriate approach) was a contributing factor in the ineffectiveness of the collective to achieve their desired outcomes.

Model Refinements

For this meta-analysis, seven concepts were identified from conducting both case studies that can be used to refine the organizational agility model: Role of Leadership, Beyond Conflicted Approach, Off-diagonal Approaches, Desired Approach, Comfortable Approach Refinement, Size as a Function of Time, and C2 Maturity and Risk Models.

Role of Leadership

The role of leadership in these case studies was no different from the role that leadership plays in any endeavour. The Balanced Command Envelope concept introduced by Pigeau and McCann asserts that, first, leadership occurs at every level of an organization and, second, each leader at each level needs to have the appropriate balance between competency, authority, and responsibility (Pigeau & McCann, 2000). The decisions that the key leaders made during the Munich Olympics such as the decision to not include the Israeli Special Forces, in fact prevented the successful transition from their current actual approach to a more appropriate Collaborative approach, and in a real sense remain at a Conflicted level. Perhaps Leadership could be a treated as a resistance force in this model where poor leadership decisions contribute to high resistance and even an unstable response.

Beyond Conflicted Approach

In domestic operations, it is unlikely that entities would start off at a Conflicted/Independent approach (i.e., at the origin of the C2 Approach Space) as existing legislation would have established mandates and jurisdictions that provide some level of ADR, DI, and PI between the various Security organizations (e.g., military, federal, provincial and municipal police). For expeditionary operations, it becomes easier to observe a collective's Conflicted/Independent C2 Approach when no specific legislation exists, yet security organizations come together anyway (e.g., Haiti Earthquake 2010).

The Munich case study proposed a new GM approach that goes well beyond Conflicted: Anarchic GM approach. Anarchic approach attempts to describe the complete, catastrophic break-down, and disintegration of governance and management across the collective. Conflicted approach did not adequately describe the hostage rescue at Fürstenfeldbruck airfield. During this time period the collective's ADR was not 'none' but seemingly 'random', DI was 'none', and PI was 'dysfunctional'. It is unclear where such an approach might be placed in the C2 Approach space, but it does provide some food for thought.

During the V2010 case study, analysts found it very difficult to identify a specific point in the C2 Approach space. Rather they were more comfortable in identifying a region of the space. This is not surprising since the C2 Approach space dimensions' scales are strictly nominal but could be argued to be

ordinal. That is, while 'none' to 'broad' might have some order, it is not clear what the order is for 'tightly constrained' and 'unconstrained' since we have already seen that 'unconstrained' PI looked similar to 'dysfunctional' PI in the Munich case study. Further analysis is required to fully understand the nature of the C2 Approach space in order to better assess future case studies.

Off-diagonal Approach

Related to the above paragraph is the notion of Off-diagonal approaches. During V2010, an Incident Management System (IMS) was set up in the ISU that allowed everyone to see all the incidents that occurred at their computer terminals: DI was potentially 'broad'. However, the ISU was organized hierarchy (albeit fairly flat – two to three levels): that is, ADR was 'established constraints'. This situation would yield an Off-diagonal approach.

The model can be made more explicit to reflect off-diagonal approaches. Table 1 suggests that the actual approach x(t) is defined by the position of ADR, DI, and PI in the C2 Approach Space and they themselves vary with time: that is x = x[ADR, PI, DI] or x(t) = x[u(t), v(t), w(t)] where ADR = w, DI = v, and PI = w. By analogy, equations of motion for each variable may take a similar form as equation 1. That is:

$$k_u [r_u(t) - u_o] = m \ddot{u}(t) + c_u \dot{u}(t) + k_u [u(t) - u_o] \quad (2)$$

$$k_v [r_v(t) - v_o] = m \ddot{v}(t) + c_v \dot{v}(t) + k_v [v(t) - v_o] \quad (3)$$

$$k_w [r_w(t) - w_o] = m \ddot{w}(t) + c_w \dot{w}(t) + k_w [w(t) - w_o] \quad (4)$$

$$\text{Therefore: } x(t) = x[u(t), v(t), w(t)] \quad (5)$$

While size, m, remains the same for all variables, it is conceivable that resistance (c's) and stiffness (k's) may be different for Allocation of Decision Rights (u), Distribution of Information (v), and Patterns of Interaction (w). And so, c's and k's have the corresponding subscript. Once the three variables are solved for, equation 5 provides the location of the actual approach anywhere in the C2 Approach space at time, t. It has already observed that u, v, and w are coupled or u = u(v, w), v = v(u, w), and w = w(u, v). Conceptually, two of these coupling equations may be substituted into equations 2, 3, and 4 resulting in a single expression for the equation of motion.

Desired Approach

Given that the required and desired approaches are external forces (or influencers) it is not surprising that during phase 2 that the actual approach fell somewhere in between these two: it is almost like the actual approach was being pulled from two sides (or perhaps Coordinated was the best approach they could have achieved given the constraints on time and resources). This 'median' value between the required approach and desired approach, d(t), may represent the external forces acting on the collective and can be added to equation 1 as follows:

$$k [(r(t) + d(t))/2 - x_o] = m \ddot{x}(t) + c \dot{x}(t) + k [x(t) - x_o] \quad (6)$$

Nothing is unique about the choice of this 'median' value, and we may find that in other circumstances some other expression involving r(t) and d(t) would be better suited. The key observation here is that the model in this form provides a way of adding desired approach to the Organizational Agility concept.

Comfortable Approach

There was evidence for comfortable approach in the Munich case study but not in the Vancouver case study. But this does not necessarily mean that a comfortable approach did not exist amongst the security forces at the Games. In Canada, there exists legislation and policy that clearly lays out the jurisdiction of each security organization. This legislation was superseded (although not in any way contradictory) by specific game policy that said (simplified and paraphrased) that the Games shall have no security incidents and the ISU shall organize themselves accordingly. There was no evidence (i.e., a questionnaire) that would indicate the collective was comfortable at some C2 approach level before the Games and Co-ordinated during phase 2 (since they had been practicing at this level for at least 2 years previous to the start of the Games). After the Games, any special policy became null and void and individual entities were then governed by the existing legislation.

A few months later many of the same organizations (and some of the same personnel) came together for the G8 and G20 summits held in the province of Ontario, and there was a desire to maintain some level of co-ordination. Just like the Olympics, each organization came to these major events with their own preferred GM approach, and they were not all the same. Thus, it remains difficult to determine a person's or an organization's comfortable approach before during and after an event. For future analyses, it would be advantageous to ask participants about their level of comfort for the various approaches, as it is conceivable that their comfortable approach may change over time as well albeit maybe at a slower rate than the actual approach. x_o as a function of time can be expressed in the equation of motion as follows:

$$k\,[(r(t) + d(t))/2 - x_o(t)] = m\,\ddot{x}(t) + c\,\dot{x}(t) + k\,[x(t) - x_o(t)] \tag{7}$$

Size as a function of time

It was noted that people and resources were moving in and out of the collective during the Munich Olympics. Size as a function of time can be expressed in equation of motion by recalling Newton's second law of motion: the rate of change of momentum is equal to the sum of forces where organizational momentum is the size multiplied by the rate of change of the actual approach or $\dot{m}(t)\,\dot{x}(t)$. Taking the derivative of this term and equating it to the other forces yields the following equation:

$$k\,[(r(t) + d(t))/2 - x_o(t)] = m\,\ddot{x}(t) + [c+\dot{m}]\,\dot{x}(t) + k\,[x(t) - x_o(t)] \tag{8}$$

Equation 8 remains linear and tractable if $\dot{m}$ is constant. Alternatively, the equation can be solved in a piecewise fashion if $\dot{m}$ is constant over each time interval. Ultimately, numerical methods can be used to solve the equation for the nonlinear equation when $\dot{m}(t)$.

The key insight is not that size as a function of time makes the equation of motion nonlinear, rather $\dot{m}$ conceptually becomes an additional model parameter that influences the overall resisting forces as the collective moves from one approach to another. That is, as the collective grows ($\dot{m}$ increasing) it becomes harder to move through the C2 Approach, and vice-versa.

Agility Model, Risk and C2 Maturity

We observed during the Vancouver 2010 case study that the collective remained around a Coordinated level throughout the event, which was more than what was likely required. However, being in this position would have been beneficial if the situation complexity rose and there was a need for a Coordinated approach. During the pre-Olympic exercises, the ISU did work through some 'worst case scenarios' that may have required Collaborative or Edge approaches to resolve. Through these exercises they showed that they were capable of handling fairly complex (yet fictitious) situations.

Because transitioning from one approach to another is theoretically expensive in time, money, and effort, it may be more appropriate for collectives to remain at a single approach and accept the risk if the situation escalates beyond the capability of that approach. A risk analysis could be performed that maps probability of an event occurring versus its impact if it occurs. Table 5 shows a two-level (low and high – there can be multiple levels of probability and impact) risk quad chart with idealized and hypothetical required and actual approaches shown for each quadrant for illustrative purposes. One can determine the amount of risk the collective would assume by assessing the difference between the required and actual approaches.

Table 5: Risk Assessment along the dimensions of Probability and Impact

	Low Impact Events	**High Impact Events**
Low Probability Events	Required: De-conflicted Actual: Co-ordinated Therefore: no risk	Required: Collaborative Actual: Co-ordinated Therefore: some risk
High Probability Events	Required: Co-ordinated Actual: Co-ordinated Therefore: no risk	Required: Edge Actual: Co-ordinated Therefore: significant risk

For complex endeavours, it is conceivable that events from all four quadrants occur requiring all four GM approaches (see Figure 2a). The C2 Maturity Model (SAS-065, 2010) addresses this situation by suggesting that a collective at level 5 C2 Maturity has in its command and control 'toolbox' all four approaches ready to be activated when needed. But to get to this level of maturity requires a tremendous amount of time and resources (years of training together) and is the most expensive maturity level to achieve. One school of thought is that if a collective strives for edge, it will naturally move through the intermediate steps of de-conflicted, co-ordinated, and collaborative, and therefore it would be fairly straightforward to 'degrade' to any of these approaches as needed.

The C2 Maturity Model might be the most appropriate model to describe the V2010 ISU command and control since they trained over several years on a range of fictitious events, rather than the agility model since there was no significant event that required a change in approach. The risk model may also apply as it was clear that the strategic political levels were risk adverse and desired collaboration regardless of the probability or impact of events.

Conclusions

We have asserted that Organizational Agility or C2 Agility is the ability of an entity to recognize a need to transition to an appropriate approach commensurate with the complexity of the endeavour. The ability to transition from one approach to another is a necessary but not sufficient condition for Organizational Agility. The entity also needs to recognize that the situation complexity has changed and then transition to the appropriate or required approach. The required and desired approaches were not the same in the case studies (although this would be ideal). The size, change in size, resistance elements such as poor decision-making, and stiffness or level of comfort with approaches together not only provide insight on the nature and timing of the transition but can be used to help 'tune' the entity and improve the transition. These Organizational Agility variables also determine whether the transition occurs in an effective (actual approach matches required approach) and efficient (transition time is minimized) manner. This conceptual model is quite powerful and so we set out to find some substantiation in actual situations.

Evidence was found for many of the variables, parameters, behaviours, and attributes that make up the Organizational Agility model. The Vancouver 2010 Olympics did not have any major security incidents that caused unusual levels of endeavour complexity, and therefore, no transitions from one approach to

another were needed or took place during the event, and so Organizational Agility was not evident. On the other hand, the Munich 1972 Olympics did witness a significant security incident of a terrorist attack. However, the collective did not transition to the required approach because of high resistance to collaborating and high level of comfort in dealing with one's own organization. A lack of Organizational Agility was noted.

The case studies yielded a number of new insights that aided in understanding and refining the organizational agility model. The role of Leadership was identified as affecting (either positively or negatively) resistance while transitioning from one approach to another. Further research is recommended to fully understand Conflicted, Independent, and Anarchic approaches and their relationship to each other. Related to this research would be Off-diagonal approaches where each dimension can be expressed, conceptually, as having its own equation of motion albeit the equations are likely coupled.

The desired approach is new to the Organizational Agility model, and has been described as an additional external influence (typically a mandated GM approach) similar to the required approach which is derived from the situation complexity. Although there are still outstanding questions regarding the comfortable approach, the model now recognizes that the comfortable approach is not a static parameter but it changes with time. Similarly, we observed that the size changes with time, and so $\dot{m}$ is an additional parameter included in the equation of motion. Finally, it was noted that a Risk model or a C2 Maturity Level model may provide a better understanding of agility within a case study than this Organizational Agility model. Most likely, case studies could be explained using some combination of all three models.

Future research may involve further refinement of the model's concepts and terms as well as seeking evidence for those concepts that were not found during these case studies. Other research topics could be to apply this methodology to four-block war and natural disaster complex endeavours. However, our next research activity will be to focus in on the three parameters of the equation of motion, m, c, and k, generate and hypotheses. For instance, what happens when an entity doubles in size or what is the nature and timing of the transition when the entity is familiar with only one GM approach compared to all four GM approaches? These hypotheses are two of four that have been identified for experimentation. After the experiment is completed, we will begin to make strategic investment recommendations to our government and those recommendations will be based on the scientifically validated model. We hope to report on the experimental results as well as the strategic investment recommendations in the fourth and final paper of the Organizational Agility series.

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