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Bounding Wicked Problems: The C2 of Military Planning

Topic 3: Information Sharing and Collaboration Processes and Behaviors

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Bounding Wicked Problems: The C2 of Military Planning

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Abstract

Defining C2 as "the establishment of common intent to achieve coordinated action", Pigeau and McCann outline a spectrum of approaches for coordinating action, ranging from *explicit control* through to *spontaneous emergent behaviour*. They further emphasise the role of creativity in Command. We examine application of Pigeau and McCann's concepts of C2 to military planning in a headquarters.

Many cases of military planning involve complex problem solving, strongly dependent on human creativity, with no straight path from initial problem statement to problem solution. Problems of this nature have rightly been characterised as "wicked". *Explicit control* may limit innovation in challenging situations, while *spontaneous emergent behaviour* could impede progress towards an acceptable solution. We argue that depending on the novelty and complexity of the missions under consideration, choosing an appropriate boundary between nonlinear creative elements and an overarching process-based structure can promote innovation while facilitating timely solutions.

Such adaptation in the degree of "process-centricity" in planning for different challenges needs to be accompanied by a corresponding adaptation in the *headquarters structures* for developing and integrating specialist inputs. Using an organisational model developed by Hollenbeck and collaborators, we explore how variations in centralisation and departmentation can facilitate structural adaptation.

"Well done," said Aramis: "you do not speak often, Athos, but when you do speak, it is like St John with the golden mouth. I adopt the plan of Athos."
"And you, Porthos?"
"And I also," said Porthos, "if it suits d'Artagnan. As the bearer of the letter he is naturally the leader of the enterprise. Let him decide, and we will execute."
"Well, then," said d'Artagnan, "I decide that we adopt the plan of Athos, and that we set out in half an hour."
"Agreed!" exclaimed the three musketeers, in chorus.

Ch.19: The Plan of Campaign,
The Three Musketeers,
by Alexander Dumas

1. Introduction

Military planning is an art and a science. The art aspect, captured in "operational art", is characterised by terms such as synergy, balance, tempo and depth. The science aspect is reflected in the detail, sequencing and manipulations of sheer quantities of personnel and materiel that are moved by the idea that sits at the heart of a plan. Wars and Operations Other Than War are planned by significantly large organisations in most militaries. The quest is ongoing to find the best way to organise planning professionals such that their ingenuity and mastery of specialised disciplines of warfare are unleashed when addressing difficult challenges. In this paper we draw together insights from a diverse body of literature on Military Planning, Command and Control (C2) and Organisational Theory to provide a formative theoretical underpinning to what many military practitioners already understand intuitively. By giving a language and structure to this intuition we aim to promote further dialogue and development of the understanding of planning between the military analyst and practitioner communities.

The theme of this conference is "C2-Agility", where agility is difficult to define but nonetheless carries associations with (among other things) robustness, responsiveness, flexibility and adaptation. At the very least, the implication of C2-Agility is that as a C2 system is confronted by a diversity of situations spanning a range of novelty and complexity, it must be able to internally change – hopefully seamlessly – from one configuration to another to best respond to each situation. In other words, one is seeking to reflect in C2 systems Ashby's [1957] Law of Requisite Variety. The variety in the external environment facing military planners is reflected in the interacting issues, actors and constraints of many of the places where many military forces are currently employed. These include responses to natural disasters, terrorism, insurgencies, piracy and drug smuggling in failing-, failed- or non-state contexts that may require whole-of-government or even multinational responses. General Sir Rupert Smith [2005] has termed this "War among the People". However, as underscored by US Secretary of Defence Robert Gates:

> Even as its military hones and institutionalizes new and unconventional skills, the United States still has to contend with the security challenges posed by the military forces of other countries [Gates, 2009].

Conventional warfare remains part of the variety of challenges. The capacity of military planners to respond to this diversity is our concern.

The key question we address is "*how can structures and processes in a modern operational level military headquarters be adapted so that it can best plan responses to a diversity of challenges?*" We confine ourselves here to contemporary military organisational structures, without considering more futuristic proposals such as Edge organisations [Alberts and Hayes, 2003] or UC2 [Lambert and Scholz, 2005]. Moreover, we focus on headquarters planning

without the burden of heightened time pressure, which may enhance or even diminish (by dint of urgency) the difficulty of the problem confronting headquarters planners. Thus, we are concerned with "deliberate" as opposed to "crisis" planning.

In unravelling the above question we confront the following issues:

- How can we characterise the *diversity of challenges*?
- How can elements requiring human creativity be identified in the military planning context?
- What are the strengths and limitations of traditional military planning processes?
- In what ways can the organisational structures and processes be adapted?

In considering these issues, we explore the nature of so-called "Wicked Problems", the Pigeau-McCann understanding of C2, and a model for organisational structure explored by academics at Michigan State University [MSU] and their collaborators. We cannot avoid, in this respect, also briefly reviewing work by Mintzberg on strategy and other writers on the Contingency Theory of organisations. The literature here will be familiar to many C2 analysts, but the implications perhaps have not yet been pursued in the present context. Our explorations raise a number of questions that could be addressed through future experimentation.

Our main findings are:

- Both the organisational structure and the formal planning process must be varied to address all the types of problems that military planners are required to confront.
- The degree of "process-centricity" must be varied in step with adaptive organisational planning staff structures.
- The transition between different organisational structures requires out-of-the-ordinary interactions between Commander, the subordinate leadership and planning staff.

We argue that these are important considerations if a military headquarters is to deal in an agile manner with the spectrum of modern challenges.

The following section reviews the body of literature on which we draw in reaching these findings. It seeks to provide short, self-contained primers on Wicked Problems, Pigeau-McCann C2, Traditional Military Planning Processes, Mintzberg's notion of strategy formation, Contingency Theory and, within that, the MSU model for organisational structure and adaptation. In Section 3 we draw on this material to explore mechanisms for adapting the degree of process centricity employed. In Section 4 we progress to the implications for military planning and processes of the MSU model for organisational structure. The final section discusses the broad implications of our work.

2. Background Concepts

Wicked Problems

Rittel and Webber [1973] address a class of planning problems that they call "Wicked Problems", which do not yield to traditional "scientific bases" for problem solution. They are manifested, for example, in the context of social and urban planning. Rather than provide a compact definition of Wicked Problems they develop a list of characteristics that have been distilled by Conklin [2005]. Based on the latter we provide the following concise list of the characteristics of Wicked Problems:

1. *Development of candidate solutions reveals further aspects of the problem.*
2. *Wicked problems have no stopping rule: correct solutions cannot be identified*.
3. *Solutions to Wicked problems are not simply right or wrong.*
4. *Every Wicked problem is essentially unique and novel.*
5. *Every solution to a Wicked problem is a 'one-shot operation.'*

6. *Wicked problems have no given alternative solutions.*

We expand on some of these points below. One may already wonder how Wicked Problems compare with other categories in military, social and engineering problems. A rigorous comparison is difficult. The proponents of the various approaches use varying language and degrees of precision appropriate to the field of application. However, they invariably use the term "complex"[1] as do, occasionally, Rittel and Webber. We can regard "complex systems" as having *many components* that are subject to *many interactions*. For example, the "Cynefin" approach to sense-making [Kurtz and Snowden, 2003] distinguishes Simple, Complicated, Complex and Chaotic environments or "domains": the "Complex Domain" is one where cause and effect can be recognised only in retrospect. In the "Complex Endeavours" of Alberts and Hayes [2007] the interacting and disparate nature of "effects" by many different entities is emphasised[2]. "Normal Accident Theory" [Perrow, 1984] proposes that systems prone to *systemic accidents* have tight "coupling" and high "interactive complexity". Pigeau and McCann, whose work we review below, address "open-ended problems" but highlight the role of "emergence", another phenomenon of complexity. The explicit or implicit use of "complex" at the very least suggests that these approaches overlap without any one of them necessarily wholly containing the others.

Focusing on Wicked Problems specifically then, the first point of Conklin's list expresses that such problems do not yield to the traditional straightforward path from problem formulation to problem solution. By contrast, "Tame Problems", which may be very complicated, submit to the direct path through "solution space". For Wicked Problems, multiple backtracking, problem restatements in the light of partial answers and even jumps forward to trial solutions are intrinsic to the solution process. The path through "solution" space for Tame Problems is characterised as "linear" and that for Wicked Problems as "nonlinear". Such "opportunity driven problem solving" [Conklin, 2005] is invaluable in achieving insight into Wicked Problems by exposing unstated requirements and important details of the problem's context. Particularly relevant here are interacting issues and constraints, allowing identification of potentially inconsistent tacit assumptions or adjustment of assumptions in light of a rapidly changing environment. Finally, implementation of a supposed solution may uncover additional problems. The nonlinearity highlights an intrinsic *inefficiency* in Wicked Problem solving: personnel and resources cannot be allocated to solve the problem in a rational manner, and many draft plans will never be implemented. Inefficiency is a *necessary* by-product of Wicked Problems[3]. On the other hand, the necessary degree of inefficiency is less with Tame Problems.

For Tame Problems the traditional linear method of progressing from problem formulation to solution is appropriate [Conklin, 2005]. This path is typically seen as comprising four stages: Gather Data, Analyse Data, Formulate Solution and Implement Solution. Conklin provides a roughly comparable list of characteristics of Tame Problems:

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[1] This term continues to defy an exhaustive and self-consistent definition because of the diversity of contexts in which "complex", "complexity" and "complex systems" are used: in physics, mathematics, computer science, biology and the social sciences. Gell-Mann [1994] offers a popular account that at least covers most of this spectrum and points to the scientific literature where the different notions of these words are rigorously explored.

[2] The archetypal example of a Complex Endeavour is the goal of achieving military-strategic end-states within the network of coalition military, governmental and non-governmental and tribal agencies operating in the major areas of conflict in the Middle-East or South Asia at the time of writing.

[3] We note in this respect, a related conclusion by Taylor [2008] made in the context of assessing effectiveness and efficiency of organisations in light of computational logic: any useful question about the efficiency or effectiveness of organisations addressing complex problems can have no solution method, algorithm or program that generates correct answers for all such organisations and their inputs. This means that one cannot *optimise* efficiency for organisations that work in the complex domain.

1. *Tame Problems have well-defined and stable problem statements;*
2. *Tame Problems have defined stopping points: correct solutions can be identified;*
3. *Tame Problems can be categorised into classes of similar problems for which workable solutions are known; and*
4. *Tame Problems in some situations, have solutions that can be tried and, if necessary, abandoned.*

Diagrammatically, the different methods can be summarised as follows:

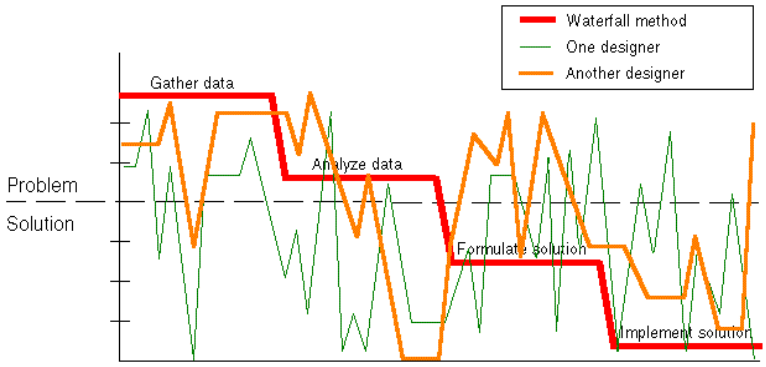

Figure 1 Different paths from problem formulation to problem solution: human collaborations on complex problems typically involve nonlinear paths (green and orange) as opposed to linear (red). The diagram is taken from www.cognexus.com.

The fifth point of Conklin's list of criteria for Wicked Problems raises issues in the degree to which Planning and Execution can be separated. Wicked Problems have a "Catch 22": you can't learn about the problem without trying solutions, but every solution you try may be both expensive and have lasting unintended consequences that are likely to change the problem. In Rittel and Webber's [1973] terms "every attempt counts significantly". For example, the scale of some operations is (and has to be) so large that there is no prospect of iterating or blurring the distinction between planning and execution, as for example in building a freeway, public works or changes to the educational curriculum; the half-life of these actions is long. This characteristic contrasts with recommended actions derived in some of the other approaches to "problem complexity" mentioned above: both Kurtz and Snowden [2003] and Alberts and Hayes [2007] recommend a mode of interacting with the environment that intertwines the Action, Orient and Decide steps of Boyd's[4] OODA loop, for example "Probe-Sense-Respond" (PSR) as in the Cynefin approach. This is not *inconsistent* with the implications of the Wicked Problem literature, but is *not universally applicable*. In a true Wicked Problem, even a mild probe enmeshes the actor in the network of relationships from which withdrawal is difficult ("Mission Creep" or "drift"). For large scale operations significant planning must sometimes precede execution, but with the acknowledgement of the consequences of Wickedness.

What guidance for addressing Wicked Problems can we glean from the literature? Most authors in this area emphasise the human skill of creative problem-solving to reach an acceptable solution. Conklin [2005] expands on the human social relationships of effective collaboration, the creation of "shared commitment and shared understanding of the problem" in order to enable a team to "collectively exercise creativity and judgement" in developing innovative solutions to a design problem. O'Grady [2008] points out that contrary to popular opinion, creativity does not require "never-before-seen" originality (but can arise through applying known techniques to a new problem), is not the preserve of uniquely gifted individuals and need not be in conflict with social or organisational norms. O'Grady also offers suggestions for improving responses to Wicked Problems, such as brainstorming in a

[4] See, for example, http://www.d-n-i.net/second_level/boyd_military.htm

supportive environment, use of appropriate styles of thinking and maintaining a culture of innovation. Both Rittel and Webber [1973] and Conklin [2005] stress that it is important not to decide too early which type of solution to pursue. Ritchey [2007] advocates structuring and synthesising of the "solution space" in terms of relevant fields of specialisation, drivers, and stakeholder interests within which multiple solutions can be explored. Though technically this leads to "morphological analysis", which may be impractical in some military contexts, its broader dimensions are within the ambit of most professionals.

We would add that a critical step is to recognise as early as possible (perhaps through exploratory attempts at a solution) whether a problem has intrinsically Wicked elements as opposed to being a (possibly complicated) Tame Problem. This is because management of expectations within a team and to stakeholders of how to progress is important to maintaining social cohesiveness in the team.

While the above points can assist in dealing with Wicked Problems, they may at the same time tend to encourage unproductive divergence ("fragmentation") and make progress somewhat erratic. Pigeau and McCann's [2006] understanding of C2 in terms of Common Intent is evidently relevant to promoting timely convergence of creative activities towards an agreed solution.

C2 and Common Intent

In Redefining Command and Control, Pigeau and McCann [2000] provide the following definitions of the key terms of our discussion:

- Command: the creative expression of human will to accomplish the mission;
- Control: those structures and processes devised by command to enable it and to manage risk;
- Command and Control: the establishment of Common Intent to achieve coordinated action.

The consequences of these definitions have been explored in a number of subsequent works [Pigeau and McCann, 2002, 2006]. The lynchpin of their work is their emphasis on the role of creativity and human will as unique features of Command. Significant is the elegant paradox they derive in [2002]: not only Commanders exercise Command (as defined above). We make extensive use of this insight. They further explore explicit and implicit elements of Common Intent. Explicit intent refers to a commander's stated objective (with all its elaborations) whereas implicit intent refers to the element that "remains unexpressed for reasons of expediency but nonetheless is assumed to be understood". Implicit intent guides or bounds but does not direct the actions of subordinates, allowing for spontaneous behaviour to emerge consistent with the overall objective. The implicit element of intent develops over time, in part as a result of training, shared experiences, doctrine and socialisation (and sometimes even culture, religion and nationality).

In particular, Pigeau and McCann [2006] explore the dimensions of their definition for "solving open-ended problems" and the significance of Commander's Intent in "bounding the solution space". The commander's guidance (as expressed through the explicit portion of intent) is critical in stating objectives, giving direction that is sufficient without being overly prescriptive and setting appropriate ethical, legal and professional bounds to the solution space. Based on their common intent, staff can then use their creativity and judgement to converge to an innovative yet acceptable solution to the problem within constraints. These behaviours are consistent with the Mission Command or *Auftragstaktik* [van Creveld, 1985] doctrine that is accepted in many military forces today. Though the stated concern of Pigeau and McCann [2006] is coordinated "action", it is implicit that they are also addressing coordinated "planning". This is our point of departure in a subsequent section.

Traditional Military Planning Processes

We now review the more detailed "processes" that the military apply to "solve problems", in this case planning. Military Planning Processes have drawn heavily on developments in the business world, namely, the use of Business Processes. In the business environment, there are many definitions (see, for example, Aguilar-Savén [2004] for a review) but some characteristics are common. A Business Process has clear boundaries, clear input, intermediate and output products, a clear ordered sequence of activities in time and space, and a clear recipient of the process output. At each stage of the process value-addition occurs. Finally a Business Process is embedded in a definite organisation calling on a diversity of specialisations or functions. In the military environment there has been ongoing debate as to how rigidly or flexibly these characteristics should be sustained, a debate to which we contribute below.

The formal planning processes of various military forces (such as NATO, the US and Canada) go by different names; for example, the Deliberate Planning Process, Military Decision-Making Process, Command Estimate Process and Mission Analysis Process. We do not consider here the case of planning under heightened time pressure, such as Crisis Action Planning, where doctrines may explicitly permit "steps to be done sequentially, concurrently or skipped altogether" [Joint Staff Officers Guide, 1997]. All these variations on the Deliberate Planning Process contain many common elements; crucially, selection of a Course of Action (COA). They are also all basically elaborations in the military operational context of the OODA loop. These planning processes are iterative (like the OODA loop), taking as inputs the consequences in the external environment of execution of the previous planning cycle. A survey of various planning processes can be found in Guitouni *et al*. [2006].

In the Australian Defence Force, the planning process is the Joint Military Appreciation Process (JMAP). After an initial Preliminary Scoping (PS) step, whose form varies according to military command level but generally determines initial higher guidance and constraints, the JMAP has four key stages: Mission Analysis (MA); Course of Action Development (COADEV); Course of Action Analysis (COAAN); and Decision (DEC) and Execution (EXEC). The resulting product is a Concept of Operations (CONOPS). This is illustrated in typical waterfall fashion in Figure 2. The stages of the JMAP are interlaced with another process, the Joint Intelligence Preparation of the Battlespace (JIPB), by which intelligence products inform and update the planners throughout the activity.

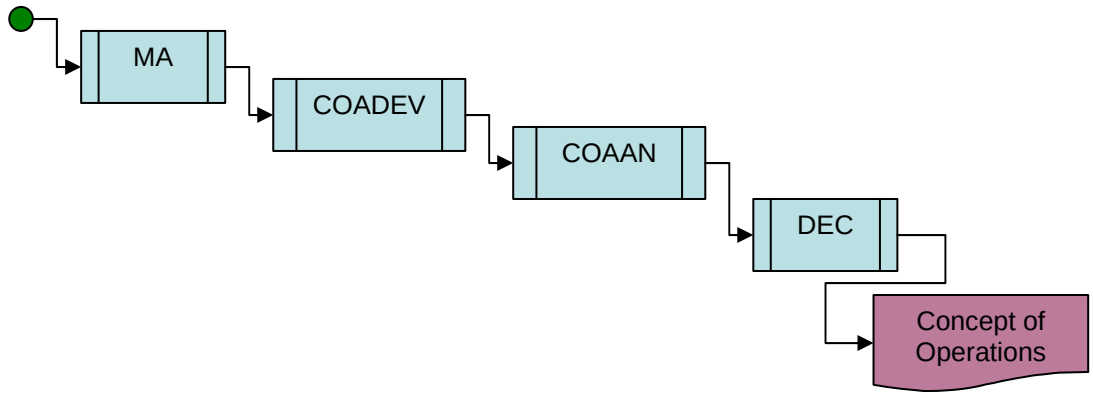

Figure 2 The Joint Military Appreciation Process (JMAP), used by the Australian Defence Force for operational planning.

The figure in the Appendix (Figure 10) shows an example of a typical military planning process in more detail and its relationship to other processes, such as that conducted by Intelligence. Though not set out in a waterfall manner, such representations reflect a linear cascade from trigger through a combination of serial and parallel tasks with clearly defined intermediate products to operational orders. In other words, military (and business) processes as sets of ordered discrete non-decomposable tasks are *essentially* linear. We say "essentially" because a type of "weak" nonlinearity can be introduced (and does occur in practice) by simple feedback loops between the discrete planning stages. The type of nonlinearity required for Wicked Problems is of another order altogether but we shall later highlight that it is already manifested *within* the discrete stages of doctrinal planning processes. Other key elements common to all traditional planning processes are the Information and Decision Briefs to the Commander that are culminations of intermediate steps in the process. These Briefs facilitate Control, and indicate that, though the detailed plan development may be decentralised (in the staff work), the final approval is centralised in the person of the Commander.

We have thus discussed quite different modes of planning to this point: the flexible collaborative format for Wicked Problems in contrast with the linear, discrete and well-defined stages of the Deliberate Planning Process that, by extension of Conklin's arguments [2005], is most appropriate for Tame Problems.

Mintzberg and Strategy

Henry Mintzberg's published work on organisational theory is extensive. However, his *Rise and Fall of Strategic Planning* [Mintzberg, 1994] is particularly salient here. Because it is well-known we can afford to be circumspect. Effectively, Mintzberg dismantles the efforts at defining a process for "strategic planning". He contrasts the analysis (namely, decomposition of something into parts) inherent in planning with the synthesis (namely, joining together parts to form something new) intrinsic to strategy. Rather than strategic planning, he speaks of "strategy formation" and its dependence on creativity and intuition. In light of Pigeau-McCann this should sound familiar. For Mintzberg, strategy formation, which may be deliberate or emergent, cannot be decomposed into a process but is an "impenetrable black box" [1994: p331] that resides within the formal processes of organisations. The degrees of formalisation around the "edges" of strategy formation play a delicate role. The sequence of increasing formalisation [1994: Fig 6-6] – focus attention, establish participation, order data, schedule activity, set agenda – remains "viable support" to strategy formation. Beyond this point of formalisation – decompose activity, program activity – one is in the realm of intrusive control and in danger of "killing" the essence of strategy. Mintzberg finally discusses these aspects in light of his taxonomy of organisations. However, we apply these ideas within an alternate taxonomy that arises from so-called Contingency Theory.

Contingency Theory, Organisational Dimensions and Asymmetric Adaptation

Contingency Theory originally postulated in the 1960s that organisations undergo change to maintain performance against changing contingencies, such as an organisation's size and the nature of its task. Donaldson [2001] provides a history of this approach with a defence of it in light of criticisms of the 1970s and '80s. In its most recent form, Structural Contingency Theory (for example, Hollenbeck *et al.* [2002]) is drawn on in many military applications with the intent of enabling a Commander to *deliberately* adapt an organisation according to environmental changes using the levers provided by the Theory. In the context of planning, Contingency Theory says that the ways in which teams of personnel are drawn together and coordinated to develop a plan must be dynamically adaptable[5]. While attractive in principle,

[5] A novel support for the theory is provided by Conway's [1968] conjecture that a system *design* (here a *plan*) will reflect the structure of the organisation that derived the design

academics at MSU and their collaborators have observed impediments to certain team adaptations. We refer to the organisational degrees of freedom used by these researchers as the MSU "model", though they are referred to in much of the contingency theoretic literature [Donaldson, 2001]

The MSU model involves two dimensions for organisational structure. On one axis is the distribution of decision-making authority, going from the extremes of Centralised (C) to Decentralised (DeC). On the other axis is the nature of organisational "departmentation". On one side of this axis is Divisional (D) departmentation, representing a breakup of organisational units according to location or the type of product they generate. This is contrasted with Functional (F) departmentation, which groups personnel according to specialist skills.

The MSU model partially aligns with that of the SAS-050 [NATO SAS-050, 2006] so-called "cube" or "C2-reference" model for the "C2-Approach space" that invokes three dimensions: allocation of decision rights (ranging from unitary to peer-to-peer), patterns of interaction (from tightly to un-constrained) and distribution of information (from tight control to broad dissemination). The decision rights axes are identical in the two models. However, the SAS-050 model does not distinguish between *types* of patterns of interaction, of which "Divisional" and "Functional" are but two. The two models also align in that they posit a "problem space" for which a certain type of organisation is suited. In the SAS-050 model this is the similarly three-dimensional "C2 Problem Space". In the MSU model there is no corresponding geometrical model but an association:

- Centralised organisational setups are appropriate for problems that are *decomposable* (so that work can be distributed but coordinated) while Decentralised decision making is appropriate for *non-decomposable* problems;
- Functional organisational units work best in *predictable* problem environments while Divisional units are more appropriate for random environments since they integrate specialisations and therefore can call on a more diverse pool of skills.

Two types of structures are common in traditional organisations. Structures that are centralised and functionally decomposed are Mechanistic (M) while those that are decentralised and divisional in breakdown are Organic (O). The problem spaces for which these two structures are appropriate can easily be derived from the above:

- Mechanistic (C+F) structures are typically tall and are suited to problems that are decomposable in environments that are predictable. Mechanistic structures can deliver accuracy of results with an efficient use of resources: the predictability of inputs means personnel and materiel can be allocated rationally.
- Organic (DeC+D) structures are typically flat and appropriate for non-decomposable problems in unpredictable environments. Organic structures work with speed and flexibility. However, they sacrifice accuracy and efficiency in use of resources.

We summarise the various aspects of the MSU model in Figure 3. The problem space for which Organic structures are appropriate is clearly that of Wicked Problems, while that for Mechanistic structures is the regime of Tame Problems.

No single position in the two-dimensional space is universally appropriate for the diversity of problems that a given organisation may confront (in accord with Structural Contingency Theory). According to the nature of the problem, a team may be required to operate functionally/divisionally with centralised/ decentralised decision making for one task, but change to another mode of departmentation and decision making for a different task.

In experiments exploring the ability of teams to move between different regions of Figure 3, Jundt *et al.* [2005] assigned teams to perform a distributed dynamic decision making

simulation, wherein the teams must prevent enemy agents entering certain regions of a map while permitting friendly agents freedom of movement in and out of the same areas. The simulation provided a diversity of platforms for attack, detection and interdiction (tank, helicopter, jet, AWACS). While the decomposability of the problem is difficult to assess, the researchers themselves characterise the environment as "neither totally random nor totally predictable". The problem is therefore one for which "pure" organisational structures are inappropriate. In the experiments, teams were configured one way (as described below) at one time and then reconfigured in an alternate fashion for a new set of inputs.

Ellis *et al.* [2003] tested the ability of teams to make the transition C→DeC versus DeC→C and found the former transition easier. Moon *et al.* [2004] found evidence that it was easier for teams to make the transition F→D in going from one to task to the next than to reconfigure from D→F. On this basis, one would conclude that it is easier for teams to reconfigure in the direction M→O than the converse. This was confirmed by Jundt *et al.* [2005]. Further evidence here is provided by Leweling and Nissen's [2007] studies of the ease with which experimental subjects transitioned between differing organisational structures. They found that Hierarchical to Edge transitions (roughly similar to, but more extreme than, M→O) were less disruptive than the converse.

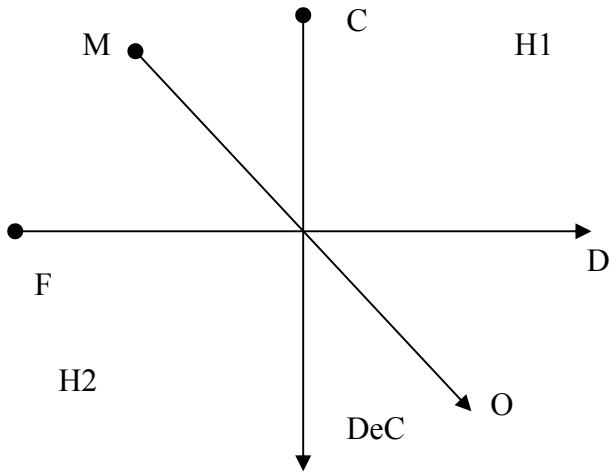

Figure 3 The two dimensions of an organisation according to the MSU model, showing Mechanistic (M) and Organic (O) structures and the observed asymmetries in adaptability (indicated by an arrow with a solid circle at one end and arrowhead in the preferred direction). Also shown are two additional "hybrid" structures, H1 (=C+D) and H2 (=DeC+F).

These effects have been called "asymmetric adaptability" by the authors[6]. The same authors explore the value of "hybrid" structures that may avoid these asymmetries: Centralised but Divisional (C+D), which we label H1, and Decentralised and Functional, which we label H2. For example, H1 combines the flexibility of a Divisional structure with the Centralising coordination provided by a leader. H2 combines the benefits of the superior cooperation that occurs in specialised teams with the motivational benefits of autonomy under decentralisation. Jundt *et al.* do not find evidence of an asymmetry in adaptability of teams between H1↔H2.

Some cautionary remarks are warranted here.

[6] This asymmetry has been explained variously by "entrainment theory" and the idea of "entropy" or "disorder" from thermodynamics [Johnson *et al.*, 2006]. One of us is also developing a mathematical theory of organisational disorder [Kalloniatis, 2008]. However, the underlying mechanism is not our concern here.

First, the experiments showing asymmetric adaptability pit *different team structures* against the *same problem type*. It cannot yet be concluded that the asymmetries exist also for teams changing configuration for changing problem types. For the following discussion, pending experimental investigation of this question, we accept the worst case scenario and assume such asymmetries exist.

Second, the studies observe teams only at two discrete points in time rather than over the course of a long trajectory. There is some evidence that over longer histories of organisations any asymmetry is in fact opposite in direction to that above. Pruijt [2002] cites evidence from various manufacturing and construction organisations that, after the introduction of innovations such as decentralisation, alleviation of technical discipline, rotating leadership and other forms of autonomy, eventually saw the re-emergence of Taylorism [Taylor,1911], an extreme form of the Mechanistic structure. In other words, teams of subordinates that had been reconfigured as Organic eventually allowed Mechanistic structures to crystallise within them.

A third caveat is that research by the MSU-based team does not yet preclude an organisation being trained to switch multiple times between configurations for different problem types. It may well be that once a transition O→M is achieved it becomes easier subsequently – any asymmetry may diminish with practice. For a military planning staff of stable membership over a two-year posting cycle at high operational tempo, there may be enough events of sufficient variety early in the cycle to overcome any asymmetry. Further experimentation is needed to investigate practice effects in relation to asymmetric adaptability.

3. Bounding Wickedness I: Process Adaptability

We now analyse the implications of Pigeau and McCann's understanding of C2 and Common Intent in the explicit context of military planning and its associated processes, and attempt to relate their concepts to the nonlinearities that dominate the solution to Wicked Problems. Straightforwardly, the degree of Wickedness of planning can vary according to the command level, where some planning at the Battalion or Company level may be relatively Tame. However at the operational level, with its required interactions in Whole-of-Government planning, the true Wickedness of some planning will be unavoidable and, due to complexity, the Strategic dimension may be entwined with the Tactical. We therefore remain focused on operational level military planning.

We touched earlier on the manifestations of "weak" nonlinearity as feedback loops between discrete, well-defined process steps. We now explore this dimension further. To highlight the contrast between the waterfall nature of traditional military planning and the nonlinearities of Wicked Problem solutions, Lambert and Scholz [2005] noted a mapping between the waterfall linear path of Figure 1 and Figure 2: Gather Data → MA, Analyse Data → COADEV, Formulate Solution → COAAN, Implement Solution → DEC. We should contrast the human-centric nature of military planning – highlighted by the Pigeau-McCann definition of Command and Control – with the means by which manufacturing produces a definite physical product out of initial and intermediate components. It is difficult (and we have tried!) to universally decompose military planning into a clear set of microscopic tasks and products because of the human dimension to Command. The nature of the fundamental components of human creativity itself is obscure (but subject to ongoing scientific exploration), so that specifying the order in which they occur in time and space, and therefore the possible *instantiations of nonlinearity*, is not yet possible. We call this "strong nonlinearity". Pigeau and McCann [2006] caution against over-control, namely "over-specification" of processes, because it can suppress the creativity of staff, clearly here the planners. The same warning is present in Mintzberg's writing [1994]. Indeed, in the context of planning, we can now identify Mintzberg's strategy formation with the Pigeau-McCann notion of Command, an intrinsically

human activity involving creativity and will. On practical grounds, the mapping of such paths for human creative work is the reason a certain level of *aggregation* is assumed for representing traditional planning processes: aggregation hides microscopic details of which analysts and military professionals are well aware but cannot exhaustively specify. In other words, nonlinearity is not absent from traditional military planning; it is aggregated inside the discretely identifiable stages of planning. We represent this diagrammatically in Figure 4. The boxes in this figure can be identified with Mintzberg's [1994] "impenetrable black box" into which we now, albeit impressionistically, have penetrated.

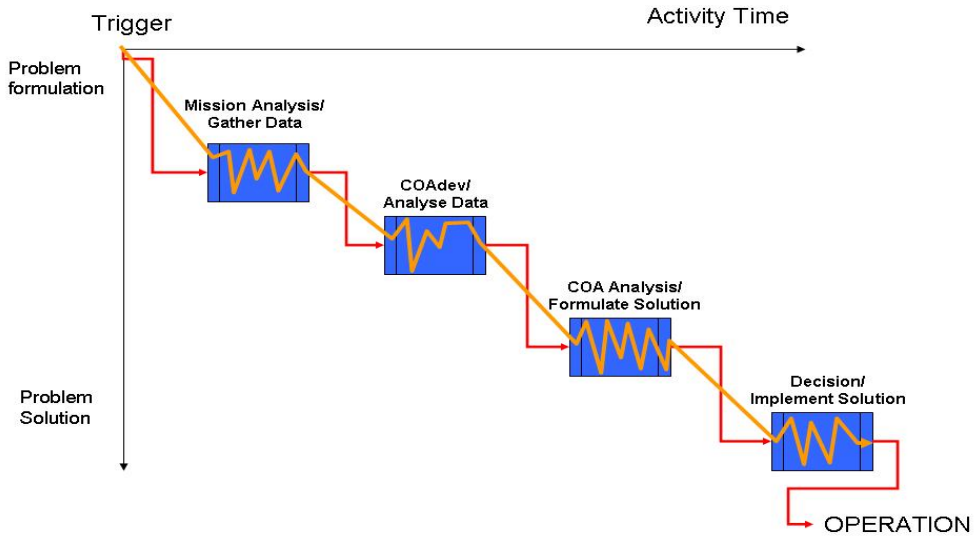

Figure 4 A representation of a nonlinear path (orange) between problem formulation and solution in the course of traditional military planning, such as Australia's JMAP. Deviations from a linear path are contained within the discrete planning activities that represent an aggregation of human creativity.

There is a corresponding nonlinear path analogous to those in Figure 4 within the typical military organisation structure, from Commander, to Branch or Divisional Heads and finally to specialist staff, as shown in Figure 5. The relationship between planning activity and the organisational structure is discussed in the following section.

What bounds the nonlinearities, particularly in the path through problem space? It is in large part Common Intent, including the Commander's Intent, the explicit planning doctrine and the organisational Standard Operating Procedures, as well as the diverse sources of implicit Intent discussed by Pigeau and McCann. Thus Common Intent, as discussed earlier, acts as much in coordinating military planning as in coordinating action. Not only the Commander "commands" (exercises human creativity) in guiding the planning. Based on the converging common intent, planning staff "command" (use their creativity and judgement) in formulating an innovative yet acceptable plan to achieve the stated objectives. In the military Joint environment, the constitution of planning teams from members with a variety of service backgrounds and specialisations (as well as other stakeholders) helps avoid "group think", but the factors that contribute to implicit Common Intent also act to limit the time spent resolving differences between team members.

The flexible, creative engine of staff planning work is nested within an overarching structure of a process, whose *Intent* and *degree of structuring* demand creative thinking from the Commander. This is a possibly inadequately recognised function of Command in the context of military planning.

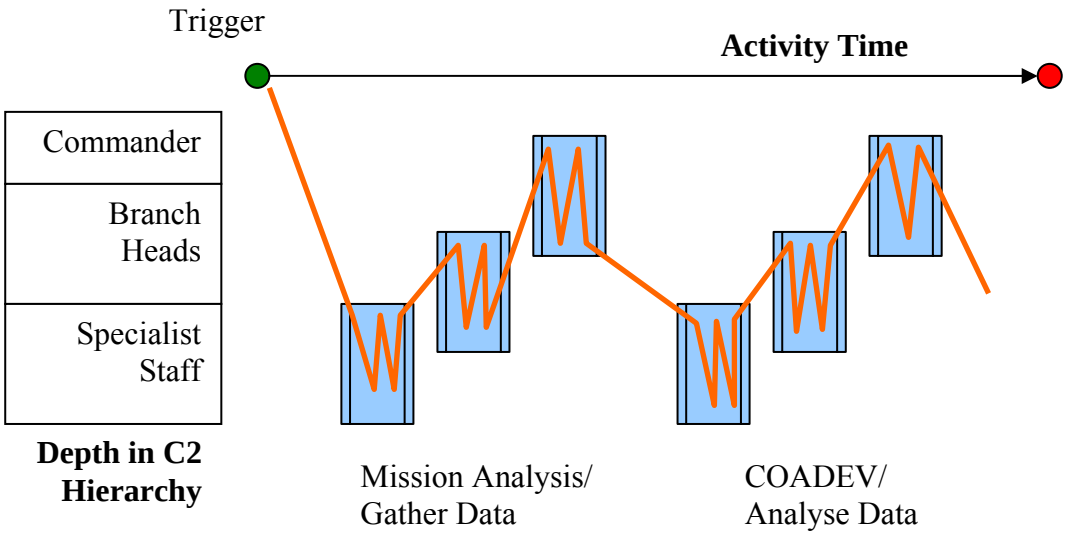

Figure 5 Nonlinear paths in the military organisational structure in the conduct of traditional planning processes.

For us, a new insight is that the *level of aggregation* of the collaborative activity is a *lever* that can be selected by the Commander to tune the planning work practice *according to the nature of the problem* to be solved by the plan. We state this in the following propositions:

- Military Planning is invariably *some mixture* of flexible and process-centric work practices.
- Process-centric work practice defines an *outer envelope* for the conduct of the work. This determines which organisational units should come together at what times and to process which specific products.
- Flexible work practice takes place within the steps of the process envelope. Namely, once organisational elements come together to plan it is the environment where innovative thinking is undertaken to develop a plan or part of a plan in accordance with the Commander's Intent.
- The degree of process-centricity versus partial-structuring *can be varied* according to the degree of Wickedness of the problem being addressed.

We can illustrate our proposal by a sequence of diagrams. Figure 6 is similar to Figure 4, however now we distinguish the *process stage* from the *region in problem space*, between Problem Formulation to Solution. For Tame Problems, it so happens that the nonlinearities of the path only dominate within the regions. Therefore a well-defined process stage, with clear purpose and products, can be localised inside a single region.

In the presence of "mildly" Wicked Problems, this localisation of nonlinearities in the path towards a solution still occurs "mildly" but straddles regions of problem space. This is shown in Figure 7. Process steps are largely definable, but have a hybrid character. Moreover, there is sufficient freedom to permit even stronger deviations from nonlinearity: rare jumps ahead to trial solutions or occasional backtracking to problem redefinition. The "porous" nature of process steps reflects some degree of Conklin's opportunity-driven problem-solving. The formation of Common Intent among collaborators enables the occasional adventurous jumps ahead and back to converge back again and the work to progress. Finally, Figure 8 depicts the path in problem space for a truly Wicked Problem. The path is entirely "chaotic", with no linearity whatsoever. Steps with clearly definable purpose or products cannot be localised

within the path. Only non-descript breakdowns in the time available provide a way of decomposing this path.

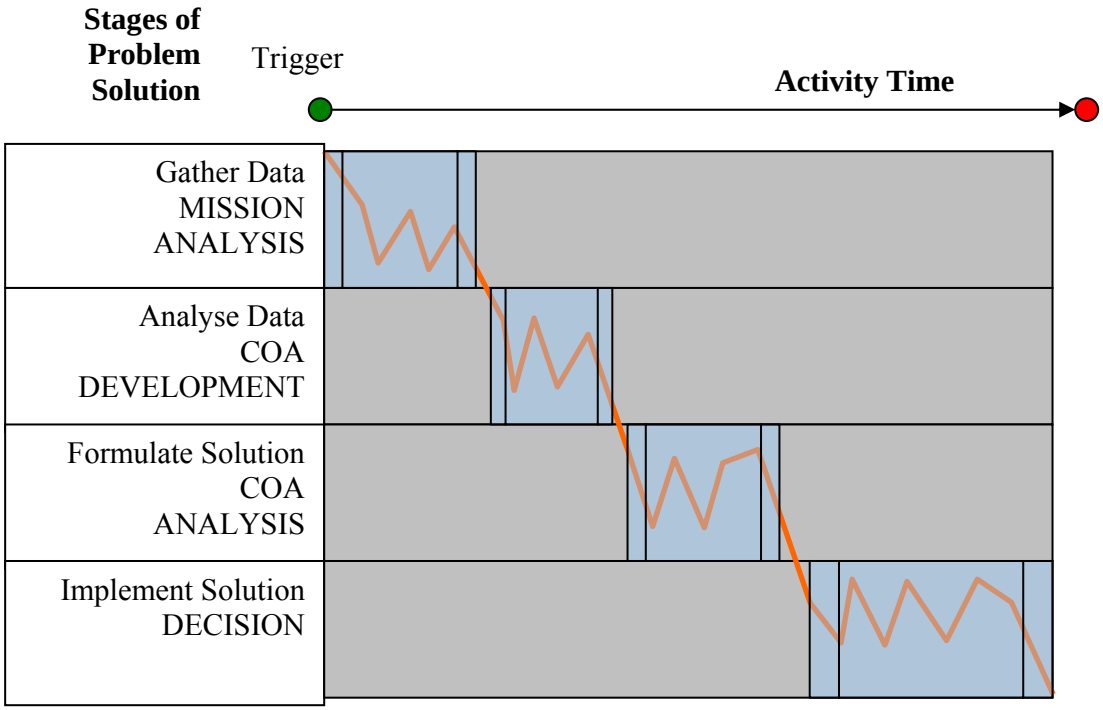

Figure 6 Traditional military planning shown as a path (orange) with mild deviations from linearity. This would be appropriate for Tame Problems. The figure has essentially the same content as Figure 4 but now the planning phases are shown both as regions (gray) between Problem Formulation and Problem Solution and formalised process steps (blue boxes).

In our experience, rarely in an actual military headquarters is a doctrinal planning process conducted to microscopic detail from start-to-finish (every product developed at the required step, every step conducted); military planners know intuitively how to exercise flexibility and to what degree. Equally rarely do military officers have the luxury of open-ended, unstructured brainstorming from start-to-finish, and even less frequently will this be conducted with Commander, senior leaders and staff together. The reality lies somewhere between. Figure 7 already reflects, to some extent, current military practice. This is certainly the case for Crisis Action Planning, where time pressure does not easily permit multiple COAs to be developed or evaluated[7]. However, our argument (and observation of planners) is that even for Deliberate Planning, adaptability of process is required in light of the nature of the problem.

We therefore describe the *degree of process-centricity* as *bounding* the degree of flexibility to confront a problem with a certain degree of Wickedness. But the extent of bounding, or degree of "process-centricity", can be varied by a Commander according to the *problem type*: from strictly doctrinal (or even more precisely, with extra control) through to a broad peer-to-peer collaboration involving (in the extreme) the Commander, senior leadership, staff and

[7] Crisis Action Planning is the regime where so-called naturalistic decision making theories, such as Recognition Primed Decision Making [Klein, 1998], are being explored [Cheah *et al*., 2005]. Here, an experienced decision maker selects a *single* COA on recognising patterns in the developing contingency. However, if the problem being confronted is, in turn, Wicked such pattern matching may lead to errors because of Conklin's Criterion 4. Clearly the area of Wicked Problems Under Time Pressure deserves a separate, detailed analysis beyond the scope of this paper.

external stakeholders. The hidden glue in any case is Intent, Commander's Intent evolving into Common Intent, *even in a planning process*. This suggests that the transition from "traditional" to "collaborative" and finally to "network centric" planning, as shown in Figures 8, 10 and 11 of Alberts and Hayes [2007], is smoother than might be expected.

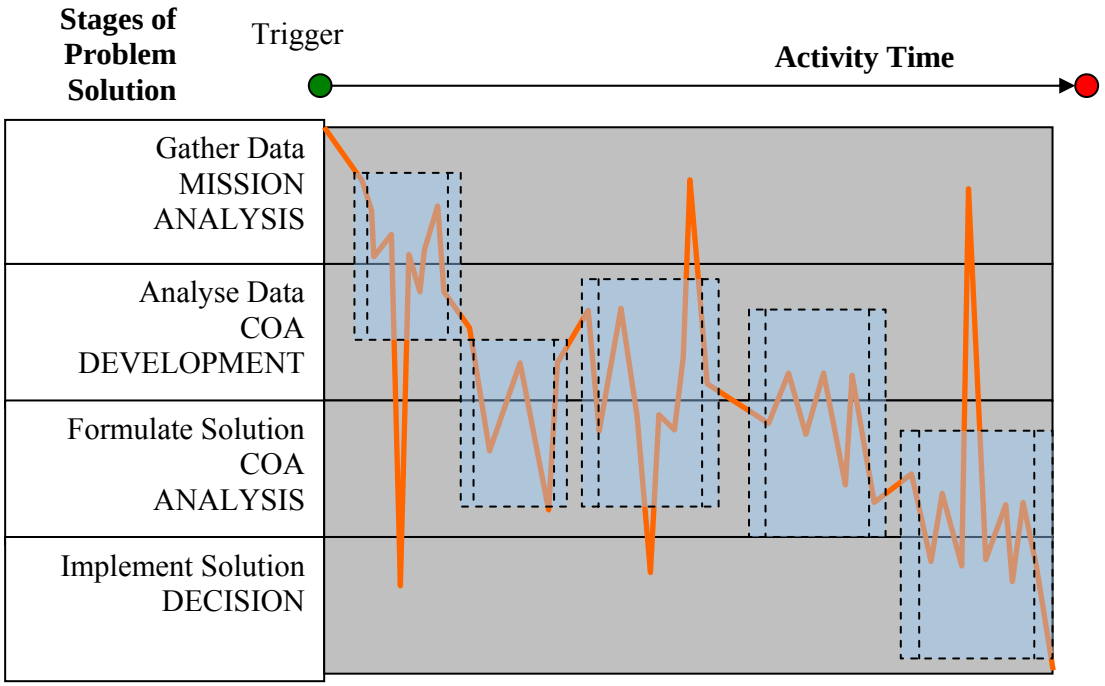

Figure 7 A planning activity of intermediate-level process-centricity. A path (orange) with strong deviations from linearity progresses from Formulation to Solution. This would be appropriate for a problem with some degree of Wickedness. Formalised activities can occur but with a hybrid purpose but also with the flexibility to allow for rare deviations from that purpose, as emphasised by the dashed boundaries for the blue boxes. The process steps can be described as "porous".

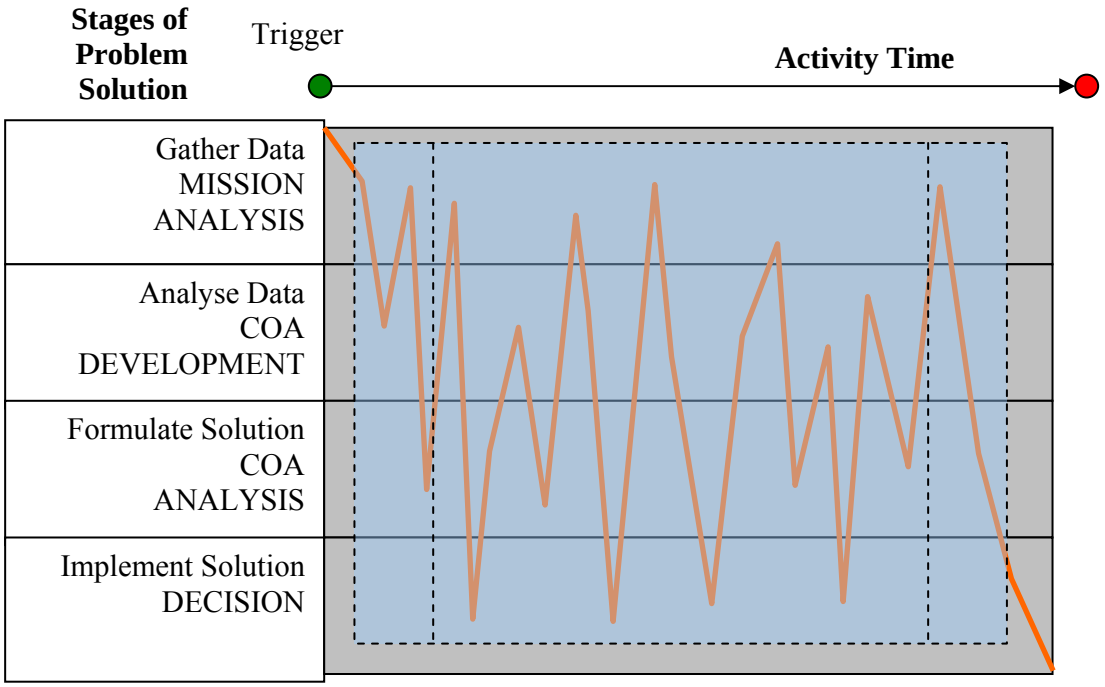

Figure 8 A planning activity that cannot be decomposed into an orderly progression from Problem Formulation to Solution: the path has no underlying linearity. This would be appropriate for a genuinely Wicked Problem.

Concretely, how may a Commander manipulate the degree of process centricity? There are many levers available. A partial and overlapping list is as follows:

- Specifying the number of discrete stages over which planning will be conducted;
- Specifying the nature of a planning stage: for a Tame Problem distinguishing Problem Formulation from Data Gathering and Problem Solution is important, for Wicked Problems such an *a priori* delineation of the nature of the task is dangerous;
- Specifying the intermediate products required in the course of planning: some, none or all of the traditional products, or occasionally novel products outside doctrinal practice may be required;
- Specifying the breakdown in time for stages of planning: it may not be uniform, nor even conform to the "80:20 rule" of military heuristics[8];
- Specifying the diversity of participants in the stages of planning: Tame Problems can be broken down and allocated to discrete groups of narrow specialists while Wicked Problems require a rich spectrum of social complexity in order to achieve "buy-in" by stakeholders [Conklin, 2005];
- Specifying the degree to which the participants must work independently or in collaboration; and
- Varying the degree to which the Commander and senior leaders are also involved in the details of planning.

These levers can be mapped to Mintzberg's degrees of formalisation around strategy formation [1994: Fig 6-6]. However, according to our hypothesis, the point at which the degree of formalisation turns from supporting to hindering depends on the nature of the problem: the peak in Mintzberg's curve *shifts* according to the Wickedness↔Tameness of the planning problem.

These degrees of freedom offer a single military headquarters organisation the capacity to tackle planning tasks with varying degrees between Wicked and Tame. Such an organisation may assume, in the first instance, traditional military structures, for example the Continental Joint Staff System (CJSS). Indeed, we argue below that a well defined hierarchical structure is necessary. However, the manner in which elements from the defined organisation are used can change according to the nature of the problem. We therefore propose a form of Structural Contingency Theory for the purposes of Military Planning.

Our exposure to military planning in the Australian Defence Force suggests that military planners intuitively know that different types of planning tasks require different degrees of structure and process. However, our analysis of this intuitive practice according to the literature discussed earlier reveals several key elements that are necessary for such process adaptability to take place.

First, military commanders must have a capacity to recognise Wicked Problems and therefore to be able to appropriately adapt the process by which military planning is to be conducted. Many military planners already do this, though they may not use the language of Rittel and Webber. Second, there must be an initial attempt at discerning the degree of Wickedness of the Problem that planning is attempting to address. This must occur early in the planning activity – early enough that, if the problem is sufficiently Tame, a doctrinal planning process can be initiated. Therefore, the Scoping stage (as in Australia's higher C2 process) is an appropriate point to make such a judgement. This would involve, essentially, a trial attempt at

[8] The "80:20 rule" encapsulates another phenomenon from complex systems, the Pareto Principle, and reflects statistical distributions that are quite different from the normal "Gaussian" type, namely "power law" distributions that have unusually long tails.

problem solution within which is recognised the purpose of the exercise: to determine the nature of the problem and not just to define the specific problem. Third, once the Wickedness of the operation and the degree of process-centricity of planning have been determined, these must be *promulgated to all organisational entities relevant to the planning activity*. In other words, the degree of adaption of the planning process and the reasons for it should form part of the Commander's Intent/Guidance. This is because the *perception of inefficiency* in flexible, unstructured problem-solving can generate friction between collaborators that undermines the formation of Common Intent between Commander and Staff. Finally, there must be a capacity for Commander and Staff to switch between these different degrees of planning styles; namely, to adapt the degree of process in planning appropriate to the operational context. Possible asymmetries in team adaptability, as discovered with the MSU model, become relevant. It is to these we now turn.

4. Bounding Wickedness II: Organisational Adaptability

Given the predictability and decomposability of the problem context, Business Processes are (not surprisingly) effective in Mechanistic structures. In the military context though, planning processes involve partitioning the problem and delegation of detailed work to specialisations, and therefore a degree of freedom as discussed above. Nonetheless, the results of each stage are subject to centralised control. To the extent that any Wickedness can be aggregated within the stages of a traditional planning process, identification of the organisational structure appropriate to military planning processes as Centralised and Functional is therefore appropriate.

Planning for Wicked Problems, as implied earlier, is difficult to specify as a well-defined Business Process but requires a much richer, flexible and egalitarian spectrum of interactions than can practically be specified in a work flow chart or checklist. Such work practices are naturally enabled in Organic structures, with their richly interacting mix of specialisations and decentralised control.

Our suggestion that military headquarters adapt the degree of process-centricity according to the nature of the problem therefore dictates a corresponding ability for the military organisation to adapt its structure between Mechanistic and Organic modes. The gradations can be achieved by the twin levers of degree of autonomy in decision making and the mixture of skills specialisations in the task. The asymmetric adaptability observed by various researchers suggests that it could well be easier for a military planning organisation to move from a highly process-centric work mode towards a partially-structured mode than the reverse.

As mentioned at the outset, Tame (though highly complicated) Problems remain relevant challenges for military forces. It is *unnecessarily* inefficient to pit Organic planning structures against operationally Tame Problems (while the perceived inefficiencies of Organic structures solving Wicked Problems are necessary). Mechanistic structures and therefore process-centric modes of planning must remain viable options for a military headquarters. Moreover, possible asymmetries in team adaptation suggest it is reasonable to maintain traditional structures for a military headquarters as the *default* mode of conduct for organising and conducting planning. Planning in Organic mode with unstructured work practices should not be the permanent mode for conducting business, especially for military professional organisations. The *sustained* experience of inefficiency and adhockery can, at the very least, eat away at the Professional Mastery of headquarters personnel.

The question is, therefore, how to negotiate the transition back, if this proves to be necessary in view of adaptation asymmetries? To explore the issues here further it is worth expanding on the CJSS by which many military organisations are structured. Some J-numbers are easily recognised as discipline specialisations, for example Intelligence (J2), Logistics (J4) or

Signals/Communications (J6). Other J-numbers appear Divisional in nature: Operations (J3) and Plans (J5) by virtue of their requirement to integrate the products of intelligence, logistics and signals into coherent concepts of operations and orders. The distinction is, however, somewhat blurred: many military "specialists" produce, or are driven (rightly or wrongly) to produce, specific "products".

In the *operational* headquarters of many small to medium sized militaries not all single J-numbers are assigned the same level of military rank because of the inability to staff each J-numbered organisation adequately. Often, most J-numbers are subordinated to the J3. In other cases, the J3 and J5 may be of equivalent rank with other positions subordinated. These in turn are subordinated to the J0, the Commander. For example, the United Kingdom's Permanent Joint Headquarters[9] has the J-numbers subordinated to two Deputy Commanders, one dedicated to Operations and the other to Operations Support, who in turn serve the Chief of Joint Operations. In Australia, the new Headquarters Joint Operations Command [Leschen, 2007] currently envisages the Chief of Joint Operations as having four core[10] subordinate Branch Heads (Plans, Operations, Support and Joint Exercises) which in turn integrate specialist J-number functions. These Branches equate to Divisional departmentation in the MSU model. A similar model applies to New Zealand's HQ Joint Forces[11].

We thus see that in many cases operational military headquarters structured traditionally are *hybrid from the departmentation perspective,* thus offering a greater variety of structures and work practices. The allocation of decision authority may also vary down the formal command chain. The Commander may work centrally with the immediate subordinates who in turn may operate in a decentralised fashion with respect to their staff. The converse can also occur: a peer-to-peer relationship existing between Commander and Divisional Heads who in turn exercise more centralised decision making within their organisations. Correspondingly, the degree of centralisation may be uniform down the chain of command.

To be generic, let us denote the Commander and Deputies, Branch or Divisional Heads the "Command Team" and the teams of J-numbered specialists serving under the Deputies the "Staff Teams". The former is intrinsically Divisional in nature while the latter may be Functional or Divisional. We therefore have a number of different organisations possible in the MSU model, working with the organisational types M, O, H1 and H2.

To the extent that adaptation asymmetries are manifest, a solution would appear to be that both Command and Staff Teams work in H1 mode: centralised decision making but divisional structure. In the context of planning, this means all specialist staff providing input to a plan, such as intelligence and logistics, would be engaged in planning together with the Commander and Divisional Heads. This is too unstable to be a permanent mode: sustaining central coordination of detailed discussions across all areas of specialisation interactions relevant to the problem in a rich network for the entire course of planning will lead either to partitioning of work and instigation of a process (Mechanistic mode for staff teams) or a surrendering of Centralising role (Organic mode for the combined structure). However, any instability in the H1 mode does not rule it out as an intermediate state in facilitating the return of Staff Teams from Organic to Mechanistic structures.

Figure 9 presents an example of how various senior and subordinate teams might adapt organisationally in moving between Tame and Wicked Problems. Staff Teams are initially configured to solve a Tame Problem at time t_1. Later, at time t_2 a Wicked Problem arises

[9] http://www.mod.uk/DefenceInternet/AboutDefence/WhatWeDo/DoctrineOperationsandDiplomacy/PJHQ/PjhqOrganisation.htm

[10] Other Branches may be "Force Assigned" but are not under Direct Command of CJOPS.

[11] http://www.nzdf.mil.nz/operations/hqjfnz/structure.htm

requiring the staff to move to Organic mode. There is no apparent impediment, from the asymmetry perspective, to this transition. Later still, at time t_3, a Tame Problem arises. In order to facilitate the staff transition back to Mechanistic mode, the Command Team becomes more directly involved so that the combined Command and Staff Teams assume a hybrid H1 structure. However as the work is broken down and allocated to specialist teams the Command Team can pull back and resume their role in exercising Control of the outcomes of delegated work. The Staff Team has been restored to Mechanistic mode.

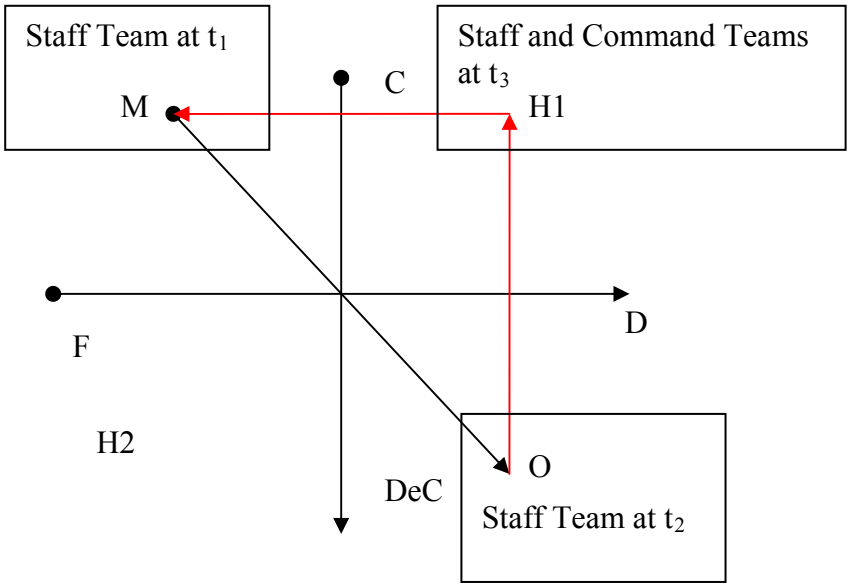

Figure 9 The path for returning to Mechanistic organisational mode via the hybrid H1 (Centralised + Divisional) intermediate mode. Three times are indicated at which, respectively, Tame, Wicked and then Tame Problems require operational planning. Initially a process-centric Mechanistic organisational mode is adopted, which adapts later to the partially-structured Organic mode. However, to return to process-centric modes of planning, the Core Team of Commander and Divisional Heads engage centrally in the planning initially before naturally delegating down and reinitiating planning processes.

This discussion may seem somewhat esoteric. We stress that the key variables in this transition are the degree of Centralisation and the time for which it is maintained before "recovering" to the Mechanistic mode. These are the levers that a Commander and the leadership team can manipulate to negotiate these structural transitions, over and above the means provided by training and military culture.

It appears, as a final comment, that headquarters organisational designs have evolved to cater for problems with a range of novelty and complexity, and that (fortuitously or through evolution?) the current CJSS structure has the capacity to adapt along the lines we suggest.

5. Discussion

Space does not permit us to explore the relationships between our hypotheses and related work from C2 researchers. For example, Stewart [2006] has explored the implications of adaptive control from the perspective of culture, trust and the different components, explicit and implicit, of Shared Intent. Lloyd [2006] studies the impact of changing command styles in moving between Perrow's [1984] quadrants. There are clearly implications of these studies for headquarters planning within the context of our work. These will be explored elsewhere.

In summary, when assessed by Conklin's [2005] criteria, many military missions have elements that fall clearly into the Wicked domain, though this may not be initially apparent to planners. At the same time, other missions may be sufficiently familiar and straightforward, even if complicated, that they are effectively Tame. Military headquarters need to be adaptable to confront both mission types in planning responses, drawing on the ingenuity and imagination that commanders and staff, as military professionals, can bring to bear. What guidance does our analysis of the literature provide to enable such adaptability?

- Wicked problem-solving requires human creativity, which functions best in a collaborative flexible environment.
- Creativity, in Pigeau and McCann's understanding of Command, is fundamental for both commanders and staff.
- Common Intent is the underlying force that enables timely convergence in planning, especially in the absence of explicit control.
- An overarching planning process enables creative focus on particular aspects of the problem and maintains overall progress towards an acceptable solution.
- Both the degree to which this process is specified and the organisational structures in which these work practices are embedded need to be adapted in line with the nature of particular problems.
- Potential asymmetries in transitioning planning teams between different modes of working may require dynamically varying degrees of centralisation exercised by the senior leadership of a headquarters as they work together to identify possible solutions. Further experimentation is warranted regarding the effects of problem type and practice with different team structures on any asymmetries here.

We conclude that through the creativity and judgement of headquarters Commander and staff, planning structures and process can be adapted to suit the characteristics of complex problems and that Wickedness can indeed be bounded.

Appendix: Deliberate Planning Process

Figure 10, taken from Guitouni *et al.* [2006], portrays the Deliberate Planning Process in great detail, including tasks, products and related workflows.

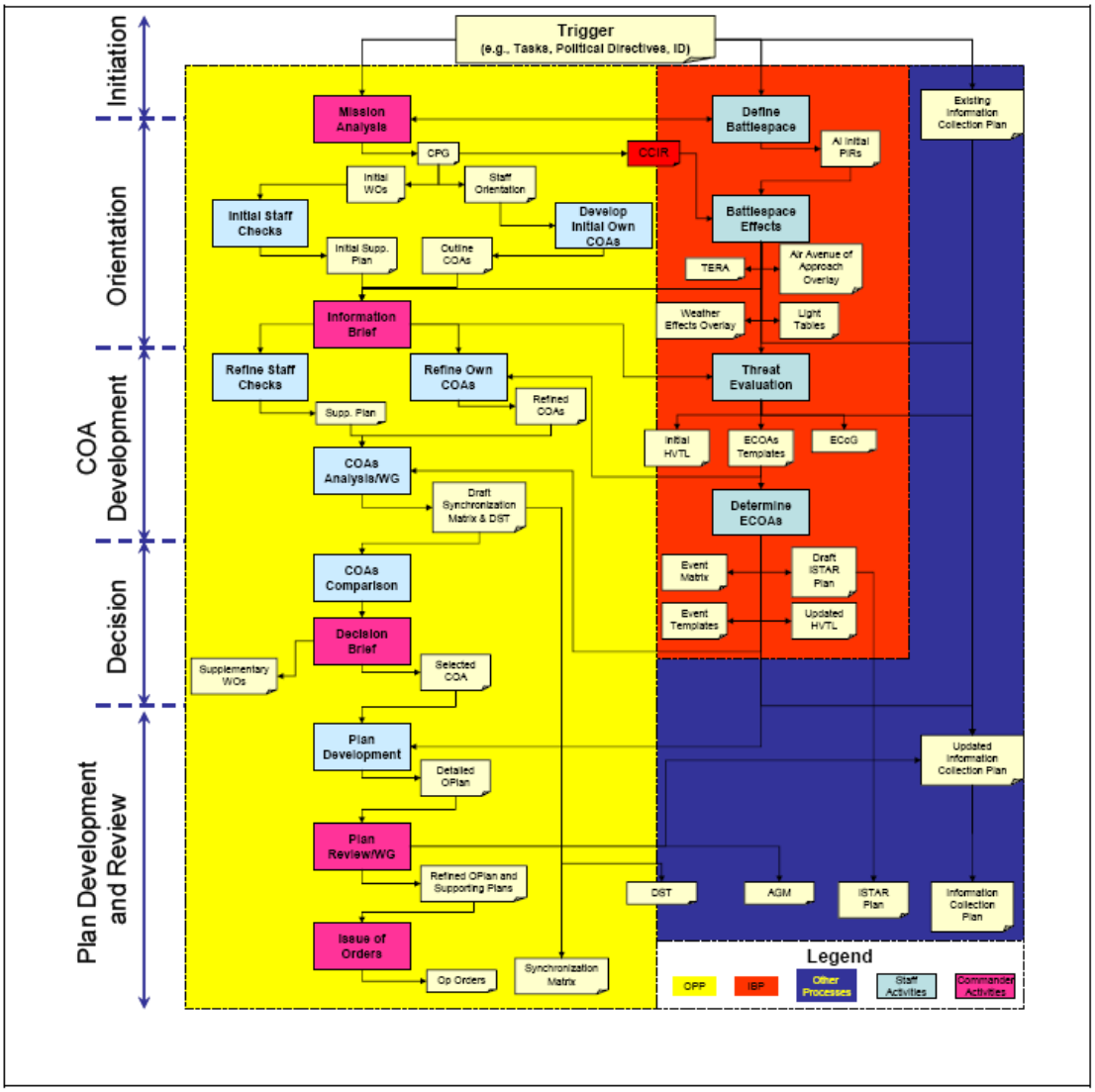

Figure 10 An example of the detail in a typical military planning processes (from Guitouni *et al.* [2006]).

Some of the features in this representation are common to all traditional planning processes: Mission Analysis, the development of Courses of Action, the delivery of Information and Decision Briefs and the issuing of Orders as well as interactions with other organisational processes, such as Intelligence Preparation of the Battlespace. The essential linearity and discrete decomposition of the activity into tasks is highlighted in the main part of this paper.

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