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ORDERS OF C2 AGILITY AND IMPLICATIONS FOR INFORMATION AND DECISION-MAKING

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ABSTRACT

In a paper at 17th International Command and Control Research and Technology Symposium (ICCRTS), different forms of Command and Control (C2) agility were related to different forms of time. In this paper we broaden this idea to consider *orders of agility*. An immediate consequence is the clarification of the interplay between continuity and change, as seen in all manifestations of agility and, in particular, in discussions of resilience.

Orders of agility also invite the re-examination of conceptions of value in informing decision-making, leading to the exposition of a hierarchical model of nested decision-making and decision-taking. Further, if we take a purposive definition of information, being that which is required to enable decision-making, then different types of information, and indeed different definitions of information, can also be related to this hierarchical scheme.

Thus, model of orders of agility provides a unifying scheme for ostensibly diverse and incompatible interpretations of decision-making and information. It also gives greater confidence that different conceptions of value and assessment measures can be organized systematically, rather than being subverted by being mapped on to inappropriate solution-driven preferences. Thus orders of agility become a useful source of rigour in the design of C2 experiments, the formulation and exercise of simulations and the assessment of C2 capability.

INTRODUCTION

Agility is a theme which arises in relation to a range of endeavours in the military and the non-military world, appearing either in accounts of practical experience or in statements of aspirations. Specifically, C2 agility is an essential capability attribute for military forces if they are to be able operate effectively in the context of future operations characterised by two forms of complexity:

- situational complexity, reflected in situations with:
  - no obvious precedents;
  - uncertain outcomes;
  - shifting objectives;
  - issues with measuring progress.
- organizational complexity, when people are working with different levels and degrees of:
  - co-operation and forms of coupling with partners;
  - unanticipated alliances;
  - interactions between multiple Instruments of Power;
  - dynamic synthesis and construction of working practices at the ‘point of use’.

These issues have been the explicit focus of the United Kingdom (UK) Ministry of Defence (MOD) Command Information Battlespace Management (CIBM) Research Programme’s Task 10 (C2 agility) and an implicit focus of Task 9 (Shared Situational Awareness in the context of the Integrated Approach). An earlier paper derived from Task 10 [1] was presented at 17th ICCRTS (“Operationalizing C2 Agility”) in June 2012, focussing on the different forms of time

which are exhibited in, or are relevant to, the exercise of agility. The purpose of the current paper is to extend the earlier work to make more explicit the impact of these different forms of time on decision-making, where this includes any decision that considers potential changes of any kind: this includes courses of action, ways of organizing, and means of maintaining communication. The paper also considers the impact on information, which can be viewed in the most general terms as a conditioner of decision-making.

Structure of this paper

The first section of this paper reviews the key elements of the earlier paper on forms of time [1], which leads us to the idea of *orders of agility*, which is the central idea in the paper.

The second section moves on to discuss decision-making, and in particular the creation, tasking, configuration, execution and reporting of *decision systems*. These are organizational constructs which will reflect all of the dimensions of organizational behaviour (process, structure, participation, knowledge, etc.). So, for example, a planning team which has been tasked to develop a course of action can be viewed as a decision system. The aim is to use the principles of orders of agility to understand the construction of the 'decision space' within which decision systems are operating.

Finally there is a brief observation on the role of information in determining, conditioning and reflecting the behaviour of decision systems, an observation which is supported by a longer discussion in an Appendix.

FROM FORMS OF TIME TO ORDERS OF AGILITY

Whilst the accounts presented of agility differ widely, common to all of them is the interplay between continuity (i.e. regarding preservation of identity and forms of order) and change (i.e. regarding preservation of requisite variety and diversity). Both continuity and change imply some notion of time, but different concepts of agility adopt different uses of time, and indeed different forms of time.

The importance of the interplay between the two is reflected in the concept of being *chaordic*. Dyer and Schafer [2] cite Dee Hock[1], who used the term to describe the need for organizations to be both chaotic and ordered to achieve agility. Chaos allows for initiative to flourish (i.e. use of personal agency with a hint of tolerance for generative[2] instability and learning through failure), whilst being held within a system of overall co-operation (i.e. an appropriate holding structure for such agency in the form of Jaques' sense of requisite organization [3]).

The work on requisite organization also draws on Jacques' earlier work [4] in which he presents two dimensions (or forms) of time, and asserts that "In the form of time is to be found the form of living". These two forms of time, successive and intentional, can be related to the two Greek notions of time:

- *kairos* - opportune timing, more about time in between;
- *chronos* – sequential, according to an assumed chronology.

Put simply, kairos is about qualitative moments of opportunity whereas chronos is about quantitative, linear, clock-tick time. So kairos relates more to Jaques' successive dimension of time as it embodies elements of quality (i.e. assessment of "success" or appropriateness),

[1] Former president of VISA International

[2] Those that are organizationally adept, open to experimentation, fast learners and appliers of new knowledge, and team players [2].

whilst chronos relates more to Jaques' intentional dimension of time as it covers looking forward in time (i.e. short-term or long-term projections).

In the earlier paper [1], we developed this insight to present a number of different images of time (along different dimensions of human and organizational activity). The paper considered:

- operational responses to changes in the environment: options summarised as *react, anticipate shape*;
- observing, reporting and interpreting events and situations;
- making decisions, or moving (in organizational terms) the point at which decisions are made;
- different knowledge types in use in making decisions:
    - technical skills and practices: *techne*;
    - teachable knowledge: *episteme*;
    - experiential knowledge learnt through felt experience: *phronesis*;
    - conjectural knowledge and cunning learnt through complexity: *metis*.

These are summarised in the consolidated view in Figure 1(a), which invites us to recognise some similarities in the relationships between the options presented by the different dimensions.

As a bold and intuitive attempt to put the earlier discussions into a common framework, Figure 1(a) runs the risk of encouraging over-interpretation. The figure is not suggesting that 'anticipation' correlates with 'classification', simply because both are drawn at approximately the same radius. The point is more that the shift from reaction to anticipation is a change in *order*, rather than a change in detail, with a resultant change in the form of time (i.e. away from *chronos* towards something rather more akin to *kairos*). A similar change is exhibited in the shift from merely observing and reporting events to a focus on classification in which, again, events may begin to be abstracted away from their original chronometer settings and viewed against different temporal logics (e.g. A happened after B when conditions C were prevailing).

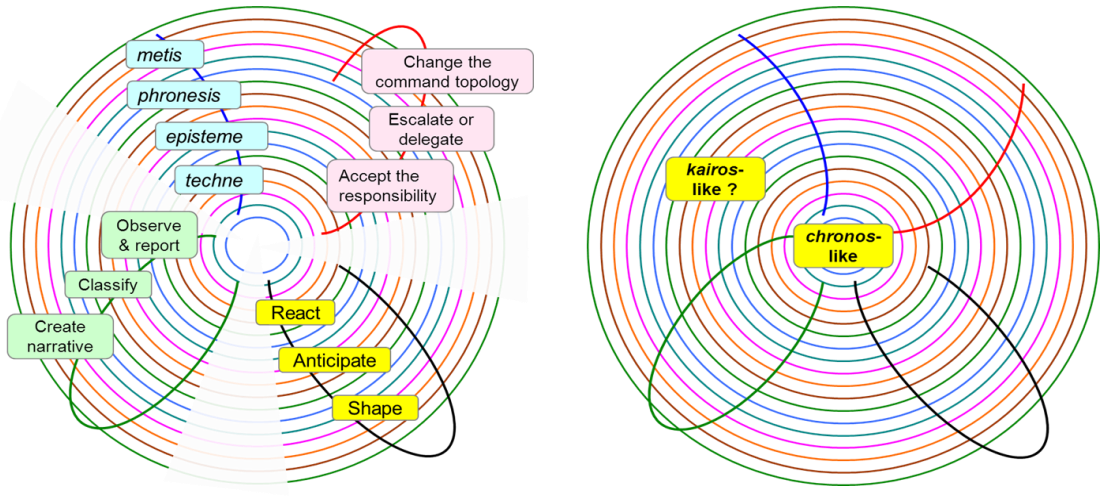

Figure 1: Consolidated views of forms of time

A number of cycles become evident in the consolidated Figure 1(a), of which the innermost ring is perhaps the most familiar to a military C2 audience: it is effectively the OODA loop applied to the task of an operator (e.g. a platform commander) responding to the situation with which he is engaged. There is a chronos-based time-measure associated with how fast the OODA loop can be executed, relative to the rate of change of the operational environment.

Moving outwards in radial terms, what the cycle begins to describe is the 'OODA loop for HQ', which is obviously much richer than for platform C2, which is why a more general model of sensemaking might be more appropriate as the move is away from response activity towards adaptation. Here, then, the reservations which many have expressed in relation to the OODA loop can be characterised in terms of the need to accommodate the shift from chronos to kairos, as depicted in Figure 1(b); something which can easily be obscured in conventional 'process-like' or 'feedback loop' images and models of C2.

But each of the dimensions of agility also has its own cycle, whereby the effects of higher-order processes filter back down to lower-order activities. This is exemplified by institutional learning, as shown in Figure 2.

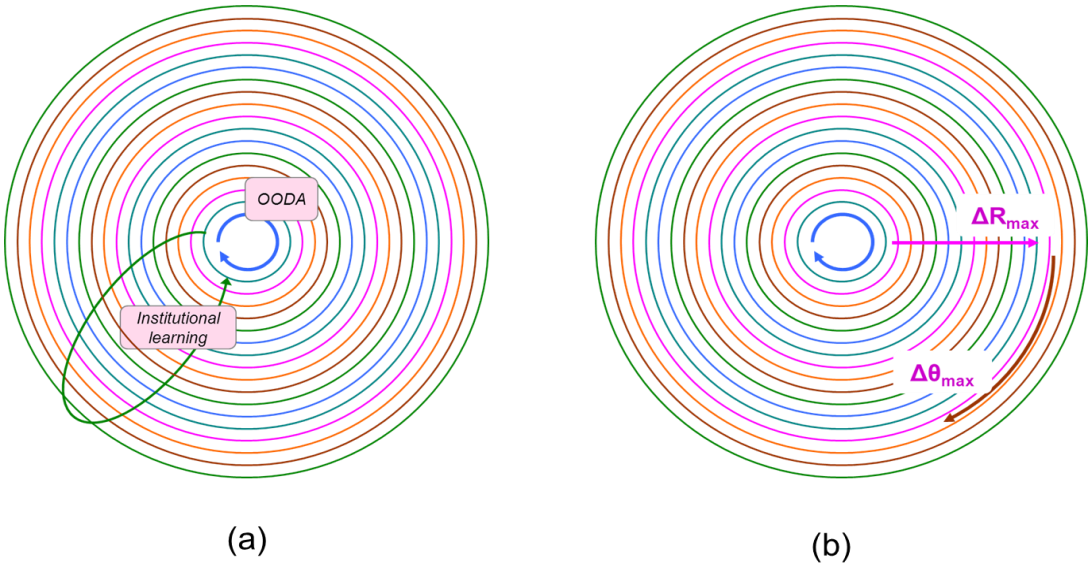

Figure 2: Examples of cycles, and higher-order changes in the form of time

We are also invited to consider what forms of agility are involved in moving around the backdrop to Figure 1 and Figure 2(a). This reveals (at least) the two qualitatively different forms of movement identified in Figure 2(b), where:

- ΔR_{max} represents a shift of focus, e.g. from reacting to anticipating;
- $\Delta \theta_{max}$ represents a shift of emphasis between observing, interpreting and taking action.

Each of these shifts is accompanied by a change in the form of time which is appropriate. Of course, the change itself requires 'time' (in yet another sense) to be carried out.

Orders of agility

The idea of orders of change (Figure 2(b)) can now be generalised in an expression of *orders of agility*. This recognises differences in kind in the different forms of agility, which have been

identified within the CIBM C2 agility work, the first phase of which was a thorough literature review[3] covering the academic, military and commercial uses of the term *agility*.

A simple example of orders of agility is presented by the distinctions evident in the work of the SAS-085 working group [5] between:

- C2 approach agility - the degree of movement attainable, in terms of coverage of the operational challenge space, within any particular C2 Approach (for example, de-conflicted, coordinated, collaborative);
- C2 agility - the ability to move between different C2 Approaches (assumes sensing capability and cognitive capability to recognize need to move and then how 'best to move') [6] [7].

We would describe C2 agility, as defined here, as being *of higher order* than C2 approach agility. Table 1 identifies four orders of agility, shown as columns. The entries in Table 1 in the different rows include the various dimensions of agility developed above in relation to forms of time, along with some additional entries, drawn from the broader work on C2 agility:

- *qualities* (i.e. 'ilities') relate to the attributes or *dimensions* of agility identified by the SAS-085 group [5];
- *change and continuity* refers back to the earlier paper [1], which noted the ever-present interplay between continuity (i.e. preservation of identity and forms of order) and change, and the need to understand the model of change through which agility is exhibited.

Looking at the broader agility literature, it is possible to see where authors have picked on particular orders of agility as being truly characteristic of agility. For example, Kidd [8] describes agility as:

> "*a strategic response, not tactical, and involves building defense against primary competitive forces through co-operation….a holistic concept….a paradigm shift, where processes, structures, organization, people, implementation capabilities, etc., are the main issues*".

Such second-order and third-order characteristics, as an exhibition of agility relating to flow of movement and openness to change of direction, etc., should be contrasted with the more recently-emerging understanding of agility in terms of addressing firmly-stated customer requirements within the modern competitive environment. Here the dominant characteristics appear to be efficiency, performance, leanness and responsiveness to changing levels of demand [9], which all point to first-order characteristics.

The contrast lies between the process-performance concepts of doing business in an agile manner (i.e. physically lean to perform efficient actions and to deliver a speedy response) and being capable and configurable to be agile (i.e. being open and able to sense and effect change). Van Hoek et al [10] express it thus:

> *Agility is all about creating that responsiveness and mastering the uncertainty. In that respect the agile mindset is at variance with the lean production model that is commonly embraced in supply chain management."*

Thus, orders of agility give us a framework within which interactions between these (and other) competing perceptions of agility can be understood and then used in C2 research and practice.

[3] This is a set of three unpublished working papers that can be requested via the point of contact for this paper.

Dimensions	Zeroeth order	First order	Second order	Third order
Orders of agility in respect of entries in Figure 1				
React, anticipate, shape	• React (but no change)	• React (within extant model of change)	• Anticipate	• Shape
Locus of decision-making	• (No decision required)	• (No decision required)	• Escalate • Devolve • Change the conditions on escalation / delegation	• Change the topology of command • Change the principles of command and delegation
Knowledge type	• *Techne* • *Episteme*	• *Episteme* • *Phronesis*	• *Phronesis* • *Metis*	• *Phronesis* • *Metis*
Understanding, formulation and conceptualisation	• Observe and report • Feedback-based control	• Registration of comfort / discomfort • Appreciation, identification of choosable Ways, evaluation, commitment • Classification • Application of narrative	• Vantage point analysis of focus / frame evaluation • Re-framing • Modify the basis for classification • Modify the narrative • Change appreciation of utility of Means • Change the locus and bounds of choosable Ways	• Change the way in which the environment is appreciated • Change the narrative landscape
Forms of time	• *intentional*	• *intentional* or *successive*	• *intentional* and *successive* components & interplay	• *successive*
Orders of agility for other aspects of agility				
Qualities (i.e. 'ilities')	• Resilience; tolerances and adjustability	• Associated with adaptation: flexibility, innovation, availability, versatility, responsiveness		• Associated with transformation
Change and continuity	• Continuity (no change)	• Change, using extant model of change	• Adjustments to model of change employed (e.g. within regulatory framework for market / ecology)	• Change to a completely different model of change

Table 1: Orders of agility

Interpreting and using orders of agility

Orders of agility, as set out in Table 1, offer numerous insights. One of many patterns visible in Table 1 is made explicit in Figure 3, which develops the theme of continuity and change with which this paper opened.

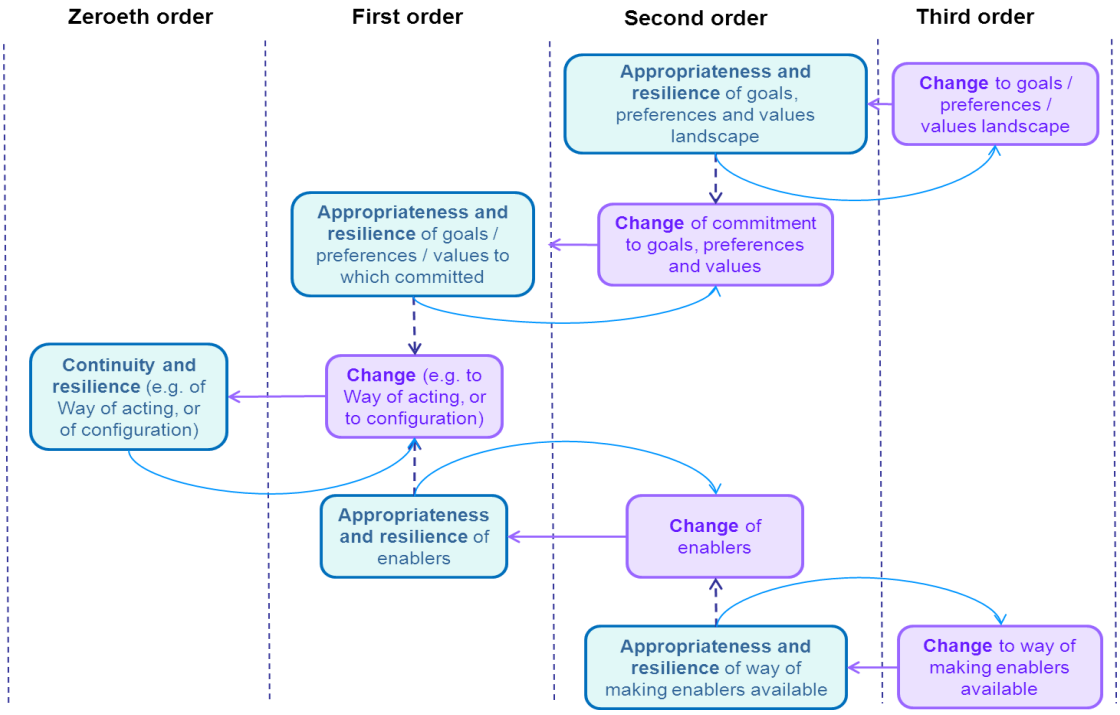

Figure 3: Continuity, resilience and change shown against orders of agility

Similarly, it is possible to infer from Table 1 the recourse to increasingly 'smart' responses (to real or potential challenges) open to intelligent commanders through having access to higher-order agility (both capacity and capability), when faced with poor outcomes or behaviours exhibited by lower-order responses (for example, errant behaviours relating to organizational disturbance, diffusion or rigidity).

THE CREATION, TASKING, CONFIGURATION, EXECUTION AND REPORTING OF *DECISION SYSTEMS*

This discussion leads naturally to a desire to unify our understanding of orders of agility with our understanding of decision-making. Command and control is about people making decisions according to whatever choices might be available to them at the time of decision. Choices are options relating to focus of attention, interpretations of a situation, and courses of action, adaptation and/or transformation.

Theories based around a focus on people's freedoms or remits for choice are central to C2 agility. One such theory of choice [11] can provide conceptual support when there is both a complex social mix and a challenging degree of open-endedness, uncertainty, ambiguity, confusion, volatility, contention and unknowns in the situations being faced. Such theories can provide insight and support reasoning about the challenges brought about by differences in ways of sensing, observing, noticing, interpreting, modelling, sense-making, deciding, assessing, adapting and acting in our increasingly open, contentious and complex world.

In this paper, the concern is not with discrimination *between* options, but rather with where choices come from (i.e. *choice-ma*king, and the ways in which choice options and freedoms for choice can be negotiated). A simple approach here might be to portray decision-making as the traversal and execution of graphs instantiating the pattern shown in Figure 3, searching for satisfaction at the lower orders of agility and, if not found, then standing back to re-visit the higher-order decisions that change the choice conditions (goals, preferences, values, enablers) which define the wider problem-space. In practice, this account has to be taken apart and examined more forensically, taking greater care (for example) to distinguish between decision-*making* and decision-*taking*; also adding *choice-making* or *shaping*. This leads to a decision-based architecture, which can be more fully reconciled with the notion of orders of agility.

One possible characterization of decision-taking is as the pursuit of a solution within a declared space of possibilities which is bounded by constraints and enablers[4]. The results of applying the principle of orders to decision-taking are shown iconically in Figure 4, where we have characterised the space of possibilities as a cube[5].

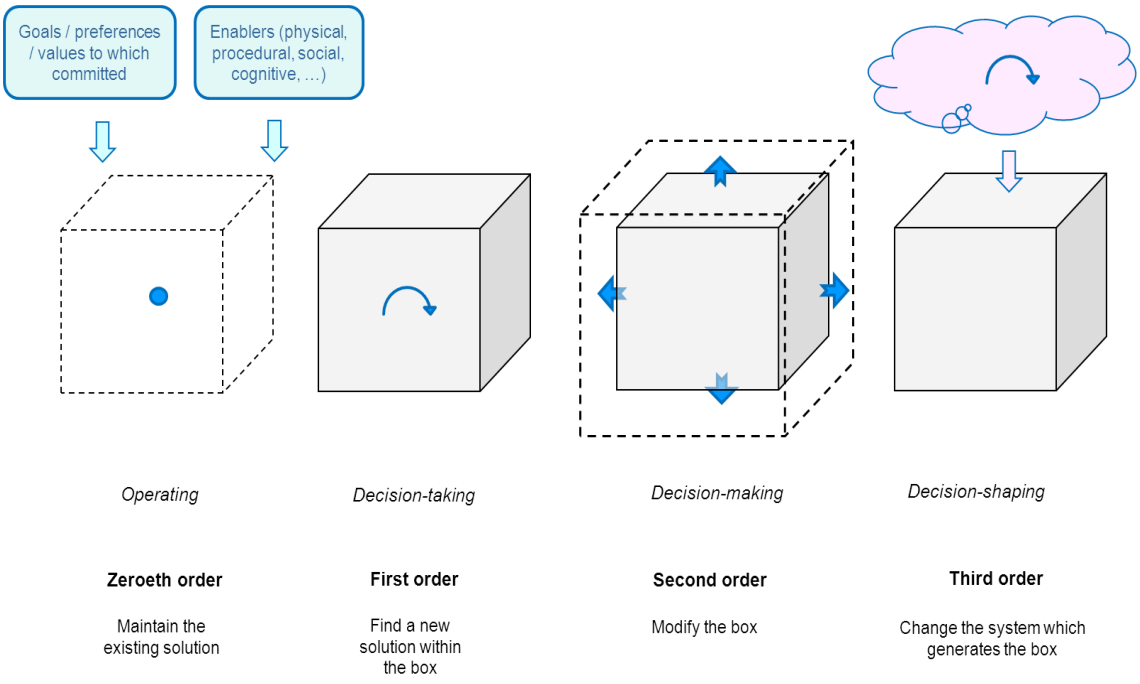

Figure 4: Application of the principle of orders to decision-making and decision-taking

The zeroeth-to-third orders in Figure 4 have been labelled, respectively, as:

- *operating*: choosing to take response (re)actions to sustain and maintain operative functions;
- *decision-taking*: selecting courses of action to achieve operational outcome;

[4] This reflects a model of planning as design, which corresponds to the use of a *computational* lens; as will be discussed later, this is not the only possible model of planning.

[5] So the cube always represents both the computational problem to be solved (e.g. allocation of physical resources to the meeting of an operational objective) and the capacities (physical, procedural, social, cognitive, etc.) which are made available to the decision process.

- *decision-making*: organizing to restrain, enable and empower the decision-taking, through for example delegating decision rights, setting up depths of supervision on behalf of others, tightening or loosening tolerances and freedoms of action;
- *shaping*: setting and re-setting policy and boundary conditions, veto arrangements and building relationships to shape the operational context.

A model of the making and taking of decisions

In order to illustrate the relationships between operating, decision-taking, decision-making and shaping, it is useful to consider a two-level model in which the taking of decisions at one order is contextualised by higher-order decisions defining the decision-space (or problem-space). This is presented in Figure 5; note that the construction of this diagram is described in more incremental and discursive terms in Appendix A.

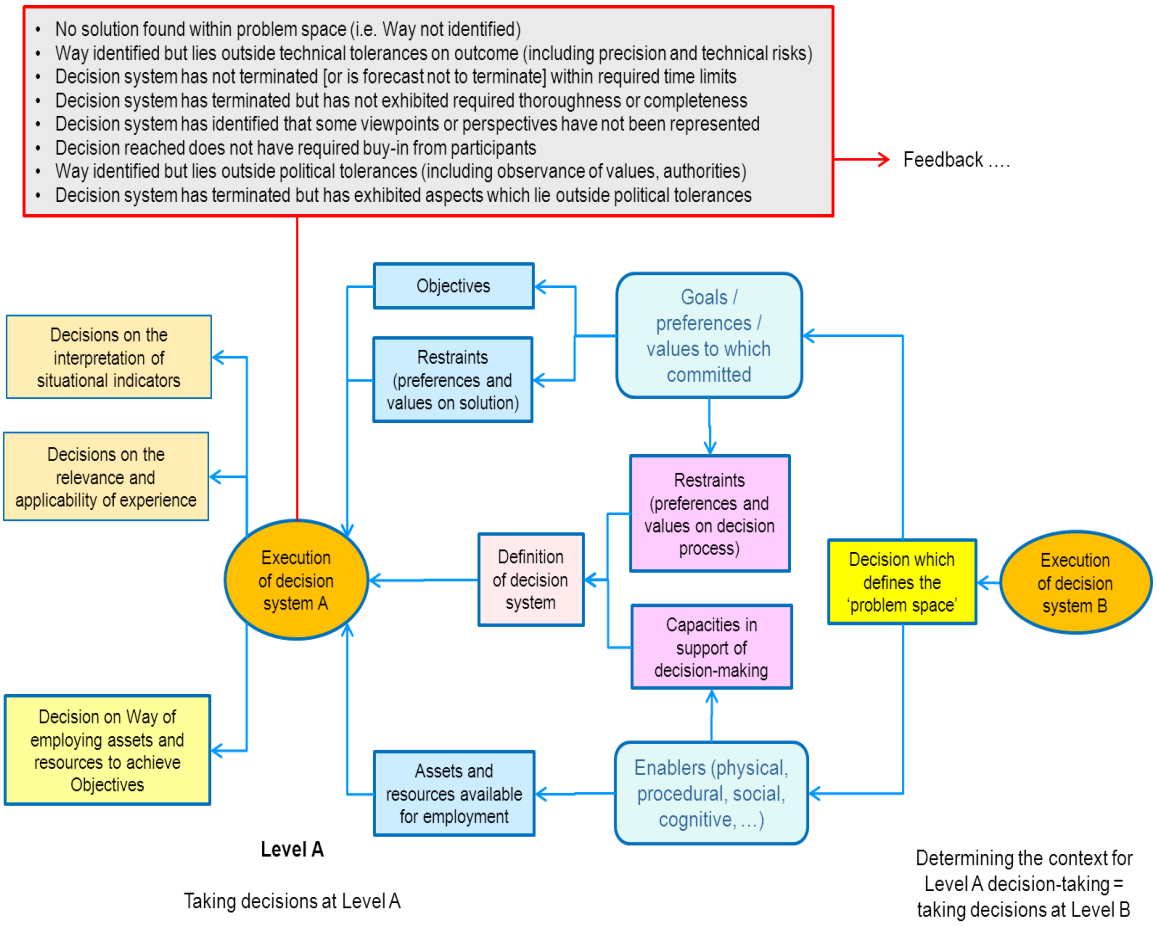

Figure 5: A model of the making and taking of decisions

In this figure, the 'problem space' (as represented by the cubes in Figure 4) is defined or constructed at Level B, and decisions within that space are made at Level A. The feedback messages essentially represent requests for re-formulation which amount to second-order agility (or higher). In other words, having not found solutions at the lower orders of agility, requests are made to re-visit and revise, higher-order decisions. Higher-order decisions may be taken to:

- change the decision system, e.g. the way in decisions are intended to be reached at Level A;
- change people's preferences and evaluation criteria. which are pertinent to the Ways of employing assets and resources to achieve Objectives;
- change the understanding, formulation and conceptualisation of the situation, via changes in the reference frames being employed at Level A.

In the longer discussion of this diagram in Appendix A, the point is made that differences of order cannot be related directly to the levels of the command hierarchy. We must resist the easy identification of the movement from left to right in Figure 5 (i.e. from zeroeth to third order) with the command hierarchy (i.e. subordinates to the left, superiors to the right).

The exercise of agility through interaction between orders

We can say in summary that agility can be exercised, at the four different orders introduced previously, through *activities.* These *a*ctivities encompass:

- *instruction* – tasking, allocation, communication of constraint, restraint, preference or value;
- *application* - exercise of an instruction, constraint, restraint, preference or value;
- *violation* - of an application;
- *reporting* - of a successful application, or of a violation;
- *requesting* - of a suspension or modification;
- *suspension* - taking a local decision to rescind or not to apply an instruction;
- *creation* – of a new tasking, allocation or constraint;
- *modification* - effecting a change in an extant item which may then form the basis for an instruction.

Figure 6 shows the activities in relation to two adjacent orders, at each of which decisions are taken and the results communicated to the other order. Again, the figure can be applied recursively to span our orders zero-to-three.

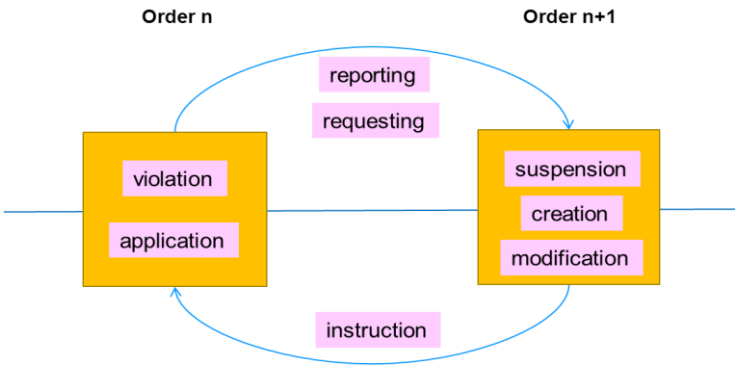

Figure 6 Activities shown on a simple two-order model

The instructions being passed from the higher to the lower order may constitute either enablers or inhibitors of agility. In other words, the higher orders of agility may be pointing to constraints, restraints, preferences and values which, if not addressed, are the key inhibitors of agility at lower levels[6]. Change can be blocked, as well as enabled, by the higher-order activities.

Although Figure 6 portrays a message-passing system, we need to remember that the two blocks in the figure (labelled 'Order n' and 'Order n+1') are a*bstract* or *virtual* 'nodes': they *may* be distinct in physical and/or structural terms, but they could equally well be referring to sets of activities taking place within the mind of a single individual.

Understanding organizational activities in relation to agility in decision-making

Figure 5 showed objectives, enablers, constraints and definitions (e.g. prescriptions) impacting on the execution of the decision system A. The activities of Figure 6 provide us with one way of abstracting what is happening, but we need also to attend to a second dimension which pertains more to the socio-technical form of the C2 organization.

An unduly mechanical interpretation of Figure 6 (e.g. as a set of 'information flows') conceals the fact that the activities and interactions in Figure 5 exhibit differences in kind. For instance, preferences (such as aversion to particular types of risk) may be established and communicated through cultural systems (of training, education, relationships with superiors) which are quite separate from the administrative dimension of formal orders and allocation of assets and resources. We may speak of multiple 'media' or 'organizational systems' (which we could denote as 'o-systems') through which activities and interactions are played out. Thus we have already mentioned:

- an o-system through which formal tasking of subordinates and staff is achieved;
- an o-system through which personnel (both military and non-military) are allocated to decision systems – this will have both administrative and social dimensions;
- an o-system through which preferences and risk appetites are promulgated – this will have both doctrinal and political dimensions.

These examples point us towards a general model of agility in decision-making: agility can be exercised, at different orders, through different o-*systems*. These o-systems are inter-penetrating, in that they are all present at all points in the C2 organization, although each may also extend into the wider world in different directions. Each o-system also constitutes a channel for communication and adaptation, and of course each o-system has its own forms of time and its own models of change. 'Agile decisioning' means taking decisions to pursue efforts (or invoke actions) in respect of particular orders in relation to particular o-systems or (more commonly) combinations of o-systems.

This has now opened up a second dimension to our message-passing visualisation, in that we now have 'messages' being sent between o-systems (as well as between orders).

- Thus (for example) a commander may be aware of a possibility of a novel course of action, and may have the assets to enable it, but it will not happen if he does not also have the *will* to commit to it – and this will may be inhibited by a 'risk aversion' signal

[6] Such changes can be capable of trumping the presence of other enablers and valencies (for example, the intellectual capacity of the commander to exercise 'first-order' creativity in coming up with novel courses of action).

coming from some kind of doctrinal and political o-system. The following distillation of practitioner views was generated earlier[7] in the CIBM research work on C2 agility [12]:

> "When any military person understands doctrine and his Commanders' Intent (note plural), including devolvement of responsibility and authority, then he is empowered to act with agility. His mind-set and his training help to determine whether or not he will act with agility. When thinking or acting in an agile fashion, he will tend to be willing to take assessed risks. A risk-averse (and therefore non-agile) mind-set can often be tracked back to lack of trust between him and his superiors, subordinates or colleagues. Whether or not he can act with agility sometimes depends on the availability or absence of communications and on having the correct level and/or coherent display of relevant information."

Whilst the availability of Means and the intellectual capacity to identify a Way of employing these Means could be characterised as enablers of first-order agility, the engendering of Will (through a culture of empowerment, as opposed to risk aversion) seems to point to higher orders of agility. Means, Ways and Will analysis is often used as a triplet to inform trade-offs. We can now see this as being an interaction between different o-systems.

From o-systems to lenses

Although the idea of o-systems is interesting, we are hostages to fortune if we attempt to enumerate them. However we can side-step this problem if we think not just about the o-systems themselves but about the ways in which the different o-systems might exhibit properties and might be observed or described. This does nothing for our appreciation of organizational ontology, but it does at least give us a classification of appearances.

For this purpose we can employ a set of *lenses* which have evolved within the CIBM Research Programme. Lenses are *ways of viewing* organizational activity, and have now been employed in a series of Research tasks, and so offer a reasonably mature set. Twelve lenses have been identified:

- administrative;
- functional;
- computational;
- procedural;
- communicational;
- socio-structural;
- physical;
- judgemental;
- macrocognitive;
- adaptational and transformational;
- representational;
- anthropological.

[7] This account [12] was written before our abstract models of C2 agility were developed, but its anticipation of the ideas in the current paper should be evident.

A definition is offered for each of these lenses in Appendix B, which also relates each to one or more founding metaphors based (for the most part) on the work of Morgan [13].

A general model of agility in decision-making

If we move from o-systems to lenses, we can say that agility can be exercised, at different orders, through activities which can be viewed through different lenses. Since the activity set (Figure 6) is independent of the lenses, this agile activity can be portrayed as occurring on a two-dimensional grid (order x lenses), as shown in Figure 7.

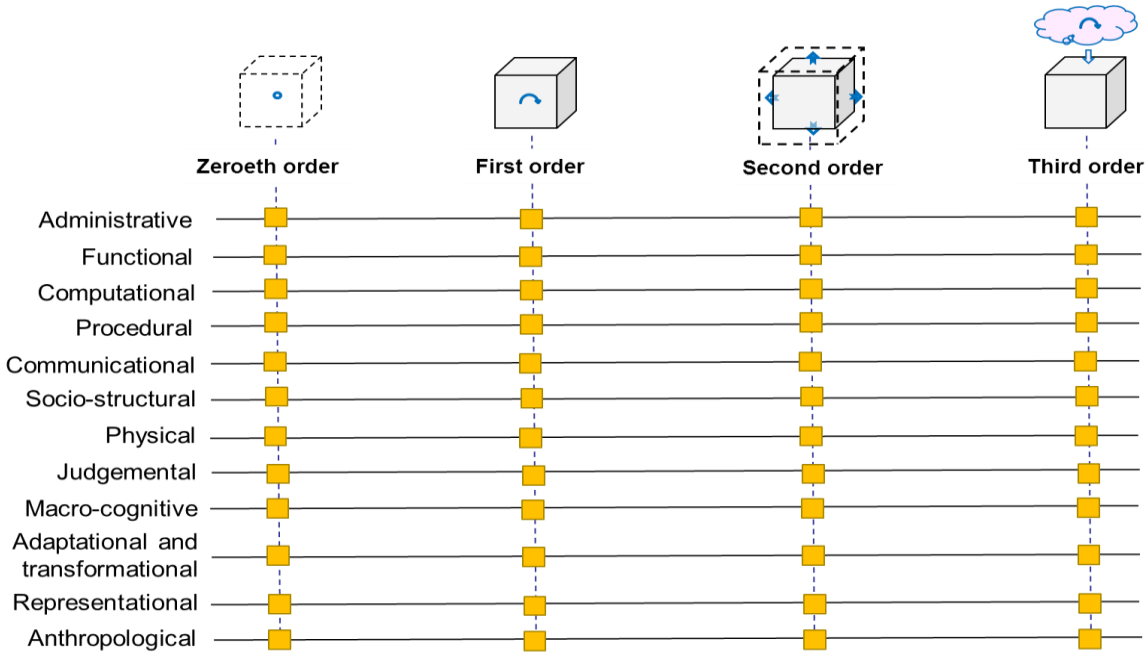

Figure 7: Grid on which agility options can be exercised

Again we must reinforce the fact that the 'nodes' in Figure 7 are purely abstract: this is an *interpretation model*, which is being applied to the whole of the C2 organization but which could also, in the limit, be applied to the activities of a single individual. So the 'messages' being sent (both horizontally and vertically) may not be (and in generally will not be) exhibited directly as physical messages.

Note that decisions can be exhibited in relation to any of the 48 nodes shown in Figure 7, and indeed it may not be possible to localise a particular decision to a single node, but rather to groups of nodes which are implicated. Note that the classical view of "the decision made by the commander", as the 'operational-decision-taker-in-chief' (i.e. the selector of the Course of Action from the alternatives presented) focusses on just *one* of these nodes (the first-order computational entry). Thus should appreciation of organizational decision-making be expanded.

In the earlier Table 1, we showed a number of facets of agility organized against the dimension of orders of agility. We can now update that table (to create the new Table 2) by showing the same items (and some additional entries) organized in terms of the two dimensions of the grid in Figure 7.

Dimensions	Zeroeth order	First order	Second order	Third order
Administrative	Fixed objectives	Fixed objectives	Change the objectives and the policies applied Change the Means made available	Change the operations landscape Change the way in which Means are made available
Functional			Change the way in which specific dependencies are fulfilled	Changes the way in which dependencies are created and fulfilled generally
Computational	Fixed objectives Feedback-based control	Fixed objectives Feedback-based control Appreciation, identification of choosable Ways, evaluation, commitment	Change the objectives, constraints and tolerances Change the Means made available	Change the operations landscape Change the way in which Means are made available
Socio-structural		Exercise of the different perspectives represented	Include or exclude representatives of different functional / organizational / cultural perspectives	Change terms of participation in operation by representatives with different organizational / cultural affiliations
Macro-cognitive		Application of classification Application of narrative Appreciation, identification of choosable Ways, evaluation, commitment	Vantage point analysis of focus / frame evaluation Re-framing Modify the basis for classification Modify the narrative	Change the ontological landscape Change the narrative landscape
Adaptational and transformational		Feedback-based control Registration of comfort / discomfort Appreciation, identification of choosable Ways, evaluation, commitment	Re-framing Modify the basis for classification Modify the narrative	Change the ontological landscape Change the narrative landscape Change the way in which Means are made available
Representational		Application of classification	Change the Means which are employed Modify the classification	Change the ontological landscape
Anthropological		Empowerment Registration of comfort / discomfort Application of narrative	Change the commitment to or application of preferences and values Modify narrative Suppress or promote diifferent organizational/ cultural perspectives Change the Means which are employed	Change the preferences / values landscape Change the narrative landscape Change the way in which Means are made available

Table 2: Illustrative entries for the different lenses in respect of orders of agility

Note that Table 2 makes use of eight of the twelve lenses[8].

Relationships between nodes on the grid

In relation to the earlier one-dimensional figure (Figure 6), we interpreted the instructions being passed from the higher to the lower order as either enablers or inhibitors of agility.

This understanding now needs to be extended to the two dimensions of the grid (Figure 7), by dealing with the 'vertical' relationships between the activities as observed using the different lenses. This richness provides alternative, relational ways of viewing any organization, although particular metaphors (and hence particular lenses) may prove more or less compelling in specific circumstances.

Again we are concerned with the flow of:

- *enablement* or *inhibition* (the vertical equivalent of the earlier *instruction*);
- expressions of *comfort* or *discomfort* (i.e. including signals of success or failure - the vertical equivalent of the earlier *reporting* and *requesting*)

A working organization has to operate effectively through all of its o-systems, as viewed through all of the available lenses. Thus for example, an inhibition or disabler visible in one lens affects the organization as a whole: we cannot bypass the blockage simply by focussing on lenses which portray an 'unblocked' picture.

Losada [14] takes a psychological view of what might limit or *afford* agility and flow in individuals and organizations. So, for example, he looks to connectivity as providing the measure of a relationship's 'generativity' (i.e. ability to generate agility) and openness to new ideas and influences and ability to deflect behaviours that will shut down 'good' generative processes. Connectivity is made up of three 'balances' being made between:

- inquiry and advocacy;
- external and internal focus;
- positivity and negativity.

Losada's work has been used to study high performing teams (i.e. those that have the capability and are being supported organizationally in order to do and give of their best). He takes a complex adaptive systems view of team behaviours, seeing them as emergent behaviours. So he talks about the ability of a team to dissolve attractors that close possibilities and to evolve attractors that open possibilities for effective action. So, in his language, high performing teams are high in both inquiry and advocacy, they do not get locked down with negativity, advocacy or self[9]. They are

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[8] The remaining four lenses are procedural, communicational, physical and judgemental. The first three of these are perhaps more implementational rather than conceptual in their flavour, and hence less suited to what is (at this stage) a conceptual analysis. In respect of the judgemental lens, it would be very interesting to consider the facets (e.g. biases) which might come into operation within our scheme, but this is well beyond the scope of the current paper.

[9] The "Losada Line" separates people who are able to reach a complex understanding of others from those who do not. People who "flourish" are above the Losada Line, and those who "languish" are below it. The Losada Line bisects the type of dynamics that are possible for an interactive human system. Below it, we find limiting dynamics represented by fixed-point attractors; at or above it, we find innovative dynamics represented by complex order attractors.

able to dissolve these attractors, consciously or unconsciously carrying out meta-learning, double-loop learning or something at an even higher degree of adaptation – all of which we now express as a recourse to higher orders of agility.

INFORMATION: ENABLING AND INFLUENCING DECISION MAKING

We have repeatedly referred to the idea of 'message-passing' between the nodes on the grid, albeit with the caveats that the nodes are abstract and the 'messages' will in general not be exhibited directly as physical messages. It is pertinent to consider how these messages (both horizontal and vertical) be correlated with our understanding of information and, in particular, the capacity to enable and influence decision-making.

In Appendix C, we show how these issues relate to strands in the broader literature on information, understood as that which makes a difference to the way we think about things or to our disposition to act [15]. The observation that there are forms of information which may need to be received 'just to stand still' (rather than to induce any change in 'information position') conflicts with the more commonly-held view (e.g. [16]) that information is a message meant to change the receiver's perception. The upshot is the rejection of 'mechanical' or 'computational' treatments of information and its impact on decision-making.

Consideration of the 'vertical' messaging on the grid (e.g. the cross-inhibition of activity in one lens-line by another), finding some general expression of the rules of an information system addressing multiple lenses appears challenging. This lead to the conclusion that the framework through which information is assigned both meaning and value is dependent on the model or pattern of the 'decision-work' which is being followed.

This understanding of information would undoubtedly be helped by the pursuit of a parallel analysis (to the one offered in this paper) which considers *sensemaking* rather than decision-making. One of the points of departure could be the reference to $\Delta\theta_{max}$ in Figure 2(b), denoting a shift of emphasis between observing, interpreting and taking action. Also of interest here would be the idea of weak signals, alertness to which is, for Holsapple and Xi [17], a hallmark of organizational agility.

CONCLUSIONS

The paper has built on and reinforced the conclusions from the earlier paper [1]:

- A rich understanding of agility cannot then be related to a single form of time derived from classical mechanics.
- There are some important concepts of C2 agility – particularly those associated with mental agility – which can only be understood in relation to forms of time other than the *chronos* of sequential, clock-tick time or, equivalently, Jaques' intentional and forward-projected dimension of time [4].
- There is a need to employ organizational metaphors [13] other than that of the machine in order to understand the organizational complexes from which C2 agility emerges. Use of different metaphors (e.g. brain, culture, organism) provides us with the stimulus to see the various forms of time being exercised in both the C2 organization and the environment in which it is operating.

The earlier recognition of different forms of time at work in relation to C2 agility can be broadened to recognise different *orders of agility*. Different exhibitions of agility

(involving the physical, computational, cognitive, social and political facets of the C2 organization) can now be related to different orders of agility.

We have considered the application of orders of agility to decision-making, where our primary concern is not with discriminating between options, but rather with where choices come from (i.e. *choice-making*, and the ways in which choice options and freedoms for choice can be negotiated). We have developed a model of interacting decision systems whose behaviour can be interpreted using orders of agility (and indeed different forms of time). We have noted the fallacy of seeking to correlate directly the orders of agility with the levels in the command hierarchy. It is more appropriate and useful to relate the orders of agility with the degree and form of time defining the feedback. For example, third-order changes may not be discernible in terms of observable outcomes; they may need to be *felt* in terms of changes in nature of opportunity, which may also take many cycles of change to be realised.

Decision systems are organizational constructs, and hence their behaviour needs to be viewed and expressed using multiple dimensions which we associate with the use of different *lenses* (i.e. different ways of viewing organizations). This has given rise to a model of organizational decision making taking place on a two-dimensional grid formed from the orders of agility and the lenses, with various forms of message-passing taking place between the nodes of the grid and acting to inhibit or enable the different forms of exercise of agility.

This grid is an interpretation model, rather than a specific reference to ontological components within the C2 organization. So the 'messages' being sent will, in generally, not be exhibited directly as physical messages. This has led naturally to a reconsideration of *information*, understood as that which makes a difference to the way we think about things or to our disposition to act [15].

The outcome is a rejection of 'mechanical' or 'computational' treatments of information and its impact on decision-making. Furthermore, we have shown that it is not possible to assign a value to information without access to the dominant model(s) of 'decision-work' in use within the decision systems.

Acknowledgement

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References

[1] Dodd, L. and Markham, G. 'C2 agility, different models of change and reasoning with time', Paper 014, 17th ICCRTS, June 2012

[2] Dyer, L and Schafer, R.A, 'From human resource strategy to organizational effectiveness: lessons from research on organizational agility', Centre for Advanced Human Resource Studies, Working Paper 98-12, 1998

[3] E. Jaques, 'Requisite Organization, Total System for Effective Managerial Organization and Managerial Leadership for the 21st Century', Gower, London, 1997

[4] E. Jaques, 'The Form of Time', Heinemann, London, 1982

[5] NATO SAS-085 Working Group on C2 Agility

[6] Pearce, P., 'Contemporary views on C2 agility', DSTL/TR51344/v1.0, October 2010

[7] Alberts, D.S., "Measuring Agility", presented to 16th ICCRTS, Quebec City, June 2011

[8] Kidd, P.T., 'Agile Manufacturing: A strategy for the 21st Century', 1995, from: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=00494775, accessed 10 Oct 2011

[9] Katayama, H., and Bennett, D., "Agility, adaptability and leanness: A comparison of concepts and a study of practice", Int. J. Production Economics 60-61 (1999) 43-51

[10] van Hoek, R.I., Harrison, A. and Christopher, M., 'Measuring the agile capabilities in the supply chain', International Journal of operations and Production Management, 21(1/2): 126-147, 2001

[11] Dodd, L., 'A Theory of Choice: melding black swans, butterflies and swallowtails', Proceedings of International Conference on Complexity Science, Boston June 2011

[12] Harmer, A., Beswick, N. and Rees, A., 'Current Practical Approaches to C2 Agility - Edited Report', CIBM Milestone MCCI_11_02_205_06, Issue 1.0, February 2012

[13] Morgan, G., 'Images of Organization', Sage, 2006

[14] Losada, M., 'The complex dynamics of high performance teams, *Mathematical and Computer Modelling*, 30(9–10), 179–192, 1999

[15] Boisot, M. H., 'Information Space: A framework for learning in organizations, institutions and culture', Routledge, London, UK, 1995

[16] Davenport, T. H. and Prusak, L., 'Working Knowledge: How organizations manage what they know', Harvard Business School Press, Boston, 1998

[17] Holsapple, C.W. and Li, X., 'Understanding Organizational Agility: a work-design perspective', 13th ICCRTS: C2 for Complex Endeavours, Seattle, 2008

[18] Klein, G., 'The recognition-primed decision (RPD) model: Looking back, looking forward', in C. E. Zsambok & G. Klein (Eds.), Naturalistic decision making (pp. 285- 292), Lawrence Erlbaum Associates, Mahwah, NJ, 1997

[19] Pepper, M. and Markham, G., 'The employment of structures and work patterns in organizations involved in modern, complex, multi-national operations', Paper 084, 16th ICCRTS, 2011

[20] Houghton, P., 'Developing Relevant Situation Awareness for Coalition Net-Centric Operations', TTCP Technical Report TR-C3I-TP2-1-2006, 2006

[21] Markham, G., 'Information design for synchronization and co-ordination of modern, complex, multi-national operations', Paper 085, 16th ICCRTS, June 2011

[22] Shannon, C.E. and Weaver, W., 'The mathematical theory of communication', Urbana, University of Illinois Press, 1949

[23] Searle, J., 'Speech Acts: An Essay in the Philosophy of Language', Cambridge University Press, 1969

APPENDIX A: A MODEL OF THE MAKING AND TAKING OF DECISIONS

In this Appendix, we present a more incremental and discursive account of the thinking leading to the model of the making and taking decisions presented in Figure 5. We also consider the extent to which the orders of agility can be correlated with the levels of the command hierarchy:

- In Table 1 we identified escalation of decision-taking as an illustration of second-order decision-making.
- It is also very easy to characterise operating, decision-taking, etc. as a set of roles played at various levels in a command hierarchy (e.g. thinking of shapers as operating primarily at higher levels in a command hierarchy, such as coalition commanders). Indications like this might lead us to conclude that the movement from left to right in Figure 4 (i.e. from zeroeth to third order) might be describing the workings of the command hierarchy (i.e. subordinates to the left, superiors to the right).
- We need to resist this easy identification, and the demonstration of why this is so should prove instructive.

We start by considering a simple model of decision-making and decision-taking that might have led us naturally to the command levels interpretation. In Figure 8 the 'problem space' (as represented by the cubes in Figure 4) is defined or constructed at Level B, and decisions within that space are made at Level A. The feedback messages essentially represent requests for re-formulation which amount to second-order agility (or higher). In other words, having not found solutions at the lower orders of agility, requests are made to re-visit and revise, higher-order decisions.

Note that moving from left to right in Figure 8 is, as with Figure 4, a move to a higher order. Although this is only a two-level model, it can be applied recursively (so decision process B is in turn executing decisions whose context has been set at a yet higher-level).

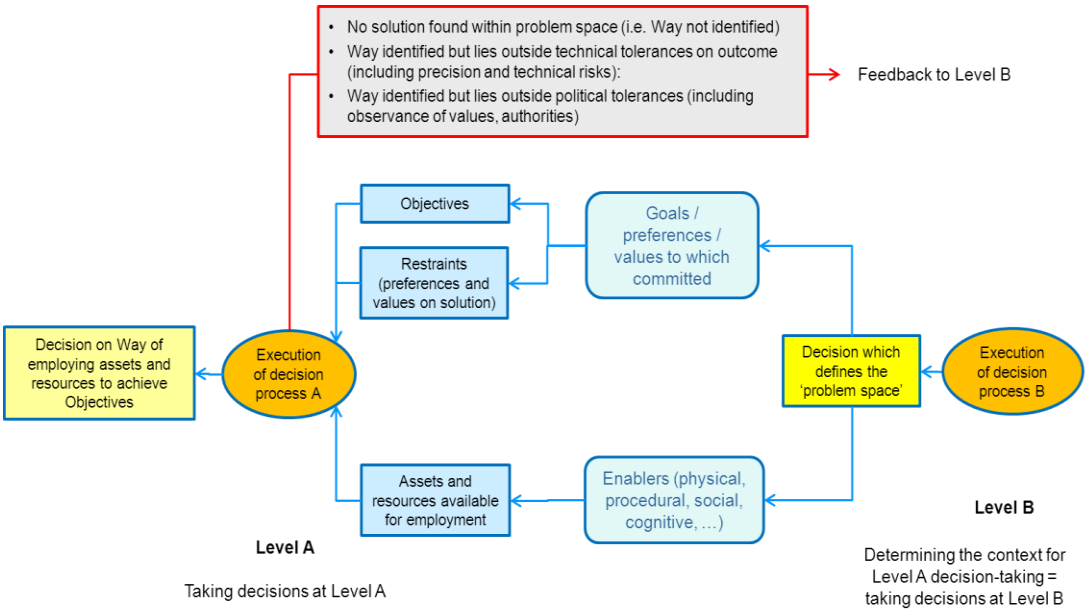

Figure 8: A simple model of the making and taking of decisions

Thus far, it may be tempting to equate Level B with the role of a superior commander. But missing entirely from the discussion so far is the *decision process*. The decision process may itself have constraints and enablers, meaning (for example) that pursuing an exhaustive search of the space of possibilities is unrealistic. Hence, a decision procedure such as Recognition-Primed [18] may be advocated, placing a high value on the ability to relate a problem or a proposed solution to previous cases.

Returning to Figure 4, recalling that the cubes are a representation of both the computational problem to be solved and the capacities being made available to the decision process, then we should be speaking here of a *decision system*, which will reflect all of the dimensions of organizational behaviour (process, structure, participation, knowledge, etc.).

Decision systems are created with a view to more than just computational challenges. In previous work, we have considered how decision systems can be created under conditions of high social diversity (i.e. representatives of multiple organizations). Decision systems will be collaborations in the sense of structures in which diverse participants, with a common purpose or an overlapping set of purposes. There are circumstances in which this diversity is so great that consensual decision-making is not a viable option and yet competing views still need to be voiced and heard.

Organizational patterns such as 'Breathing in, Breathing out', 'Generalised Future Scenarios' and 'Re-connecting with Reality' [19] are choices for decision system architectures which seek to resolve competing tensions in effective organizational design; for example, the inherent tensions in:

- the dangers of mindset / groupthink (i.e. premature framing) *versus* lack of a compelling narrative (multiple and competing frames);
- the desire to maintaining momentum (with the risk of ignoring reality) *versus* the desire to attend to changes in the environment (with the risk of 'over-fitting the data' or hypersensitivity).

In view of the fact that there is no *universal* way of resolving such tensions, the only option is to adopt pragmatic decisions about the organizational patterns to be pursued in the context of particular situations. This makes it clear that the commander has two roles:

- Campaign / Operation / Mission Management, in which the Commander is 'looking outwards' to the operating environment and actually managing the progress of the campaign (or operation, or mission) itself;
- Command Management, in which he sets in place (and monitors the effectiveness of) the internal arrangements of his own organization – which clearly includes defining the decision system.

Indeed, notwithstanding his continuing role as 'operational-decision-taker-in-chief', determining the shape of the decision system may represent the most important decisions which the commander can take. It will in fact do much to determine whether his HQ is capable of exhibiting C2 agility.

Thus, Figure 8 needs modification to add a step to the determination of the decision system, and add new forms of feedback granularity pertaining to how well the decision system is working, resulting in the model depicted in Figure 9 (which reproduces Figure 5 in the main body of the paper).

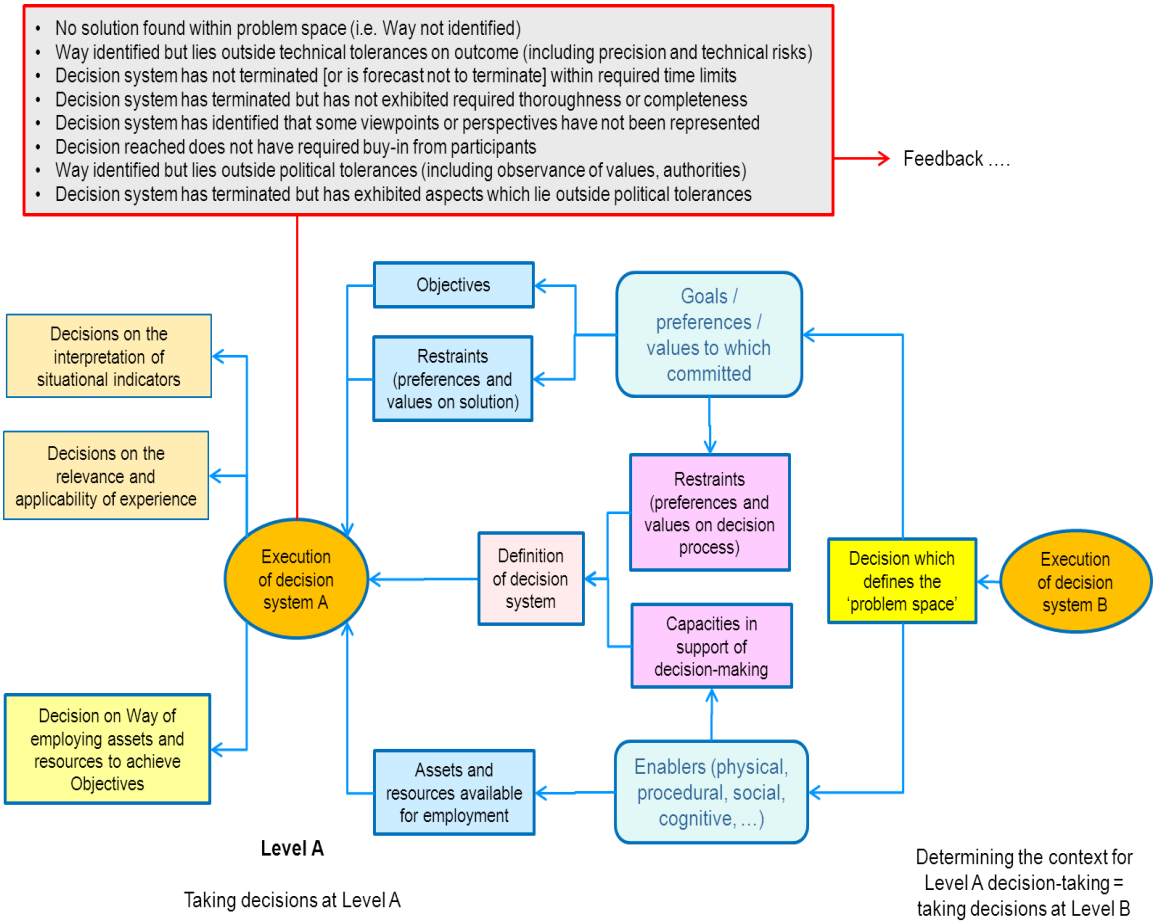

Figure 9: A refined model of the making and taking of decisions

It should now be obvious that, in general, the possible responses to this feedback cannot be associated with a single role. If we assert that the decision-taking level denoted Level B represents the superior commander, we cannot simultaneously assert that Level B is invariably where the following changes are effected.

- <u>Changes to the decision system</u>.

  The decision system may well be defined at Level A (rather than at Level B), working with the available capacities and in respect of extant preferences and values. So some feedback on the workings of the decision system could well be addressable internally within the Level A organization.

  On the other hand, there are preferences being declared, not only on decision-outcomes but also on the way in which those decisions are reached. These preferences may reside in a broader system (with social and political content), which may extend well beyond the military organization and yet they all have to mesh to generate coherent activity (as Clausewitz's "war is policy").

For example, Figure 9 identifies one possible form of feedback as "Decision reached does not have required buy-in from participants"[10]. In the context of inter-organizational involvement in the planning, this would be tantamount to a decision-system failure condition, even if the solution emerging was technically or objectively satisfactory. The term "required buy-in" refers to a preference for, or value placed upon, the willingness of partners to endorse solutions.

When preferences are violated, solutions are more akin to resolutions and so could include:

- going ahead with the decision anyway;
- the local relaxation or finessing of that preference (a second-order approach); or,
- the re-shaping of the preferences landscape (a third-order approach) – in our specific example, re-shaping such that the general expectation of partner endorsement is relaxed.

Neither of these may lie within the remit, authority or capability of the superior commander who created the original tasking.

- Changes to people's preferences and evaluation criteria. which are pertinent to the Ways of employing assets and resources to achieve Objectives.

  Preferences and values include risk profiles and authority / responsibility guidelines. A commander at any level may be willing to suspend or finesse these locally, but such actions (and indeed the making of more fundamental shifts in expectations) belong to a political system within the organization which cannot be equated to the formal command hierarchy.

- Changes to the understanding, formulation and conceptualisation of the situation via changes in the reference frames or viewing lens.

  Symptoms of this are the way in which situational indicators are interpreted, and the way in which relevance and applicability of experience are assessed (e.g. is this a situation we have met before?).

  Classification schemes and narratives may have been assumed or even re-stated by a superior 'Level B' commander, but refinement and evolution of these take place within a broader system which will have social, political and doctrinal facets. Nor can we assume that superior (or even strategic) commanders have a monopoly in this area: tactical commanders, non-military partners, local social entities and even the media may play key roles in changing the narrative. A good commander should, of course, recognise and exploit this, but we cannot express the capacity to achieve this in terms of the formal command hierarchy of a military organization, even though this is a key aspect of civil-military coordination regularly discussed in the C2 community.

[10] Implying that diverse views have been brought to the table but the decision system has not succeeded in generating a solution with which the various parties present are sufficiently happy.

APPENDIX B: DEFINITION OF THE LENSES

Table 3 describes the meaning of each of the lenses, and also relates each to one or more founding metaphors based (for the most part) on the work of Morgan [13].

Lens	Founding metaphors	What it describes
Administrative	Machine, political system	How the work of the C2 organization is managed (tasked, approved); also how administration within the operation is planned
Functional	Machine, organism	The purposes met by the decision system; the requirements it places on other parts of the C2 organization (including other functions such as Intelligence); how it contributes to the delivery of superior functions; other functional interdependencies
Computational	Machine, organism, brain	An abstract account of the 'operational problem' posed to the decision system; ideally expressed in terms of universal constraints
Procedural	Machine	How work 'triggers' work; how these workflows are formalised
Communicational	Machine, network	How information flows through, into and out of the decision system
Socio-structural	Machine, political system, instruments of domination	How the work of the decision system is organized, within a HQ and between actors
Physical	Machine, brain, culture, instruments of domination	How the work of the decision system is embedded and organized in physical space, and around physical objects (e.g. bird-tables)
Judgemental	Brain, political system	The deviations from 'good' decision-making that occur, and the factors that make them more or less likely
Macrocognitive	Brain, political system, culture	The bases of expert performance in individuals and teams participating in decision systems; addressing cognitive processes, heuristics, meanings…
Adaptational and transformational	Organism, flux and transformation	How aspects of decision systems are adapted, and how their participants learn, in response to the situation;
Representational	Machine, culture	The explicit models of representation (e.g. plans, orders) that decision systems employ
Anthropological	Brain, political system, culture, psychic prison, instrument of domination	Political, moral, ethical and legal considerations that bear on decision systems; also culturally-specific practices (e.g. rituals). How the decision systems create a script for the work to 'control the narrative' in-theatre, and for interpreting success or failure

Table 3: Lenses employed in the description of the C2 organization

APPENDIX C: INFORMATION: ENABLING AND INFLUENCING DECISION-MAKING

We have repeatedly referred to the idea of 'message-passing' between the nodes on the grid, albeit with the caveats that the nodes are abstract and the 'messages' will in general not be exhibited directly as physical messages. So to what extent can these messages (both horizontal and vertical) be correlated with our understanding of information and, in particular, the capacity to enable and influence decision-making?

In his review of different definitions of information, Houghton [20] identifies that many definitions of information focus on the correspondence between information and the state of the world. [20] seeks to distinguish between:

- observable aspects of the external world
    - i.e. 'external to the information system' - this could refer to a number of different domains which are physical, social, cognitive or virtual in character;
- representations (e.g. in symbolic form);
- the consequences of attention-setting (embedded assumptions or active decisions about which observable aspects are worthy of representation, transmission and perception);
- the assignment of meaning (i.e. the interpretation of symbols and signs in a purposive context;
- the assignment of value (i.e. the capacity to change the way that people think and their disposition to act).

In the present paper, we are concerned solely with information *value* and the *nature of the referents* to which information (in support of decision-making) relates[11].

Clearly these referents will pertain to both the C2 organization (in its physical, social and cognitive domains, viewable through the twelve lenses) and the environment in which the organization is living. In both [21] and the continuing CIBM research[14], we have emphasised that there is significant human and organizational content in the information employed in support of decision-making, wherever we are dealing with situational and organizational complexity. Working with partners (e.g. non-military) within the collaborations on which decision systems are based, we must have knowledge not only of the 'external conflict situation'[12] but also of ourselves and each other. For example, how do our different cultures, norms and practices impact upon our ability to generate 'cognitive alignment'? How might personal, organizational and societal history of education, learning and experience also affect such alignments?

In our new language, we can assert that the information 'about ourselves' must reflect all of the o-systems (administrative, social, political, doctrinal, etc.). Given our unwillingness to enumerate these o-systems, the best we can say is that there are distinctive forms or appearances of information in respect of each of the lenses (administrative, computational, socio-structural, etc.). Specifically, there are forms of information flowing along the lens-lines between the nodes in Figure 7.

Turning to information value, we are seeking to understand how to express the capacity of our 'messages' to change the way that people think and their disposition

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[11] In contrast, in an earlier paper [21], we were concerned primarily with *meaning* (how it is constructed, how it is conveyed and shared, and how it can be lost through loss of context).

[12] The quotation marks reminding us that (a) the notion of an objective external world may be fallacious and (b) we may not have access to it anyway – we know only what our own sensors and sources are telling us.

to act. Shannon [22] regards information as something that modifies our knowledge or beliefs[13] about the world. Houghton [20] attributes to Boisot [15] the insight that information acts upon our probability distributions and modifies them, in other words that *information makes a difference to the way we think about things or to our disposition to act*. The reference to 'probability distributions' surely anchors the idea to a computational view on decision-making. Our newly-gained awareness of the other lenses should encourage us to think of other forms of 'knowledge-state' (e.g. appreciation of societal norms) and other ways of acting upon such states.

The nature and impact of information is expanded in the position taken within the CIBM Research Programme on inter-organizational shared situational appreciation (SSApp)[14]. Here, information is that which contributes to the cognitive alignment necessary to enable participants in a collaboration to achieve coherent decision making. Clearly this includes knowledge of our partners as well as some external world, and again we cannot expect to be modelling organizational belief systems using probability distributions.

Note that Boisot [15] does not commit to saying that the arrival of information *will* make us act differently. The reporting, requesting and instruction elements of Figure 6 when viewed through the different lenses, represent particular types of informing which have at least the potential to make a difference to the way we think about things or to our disposition to act. As we have pointed out earlier, an instruction exhibited in one lens may invite a disposition to act in a certain way, but this disposition may be inhibited by an instruction exhibited in another lens. So (for example), formal empowerment (as viewed through an administrative lens) does not ensure the taking of initiative, since it may be undermined (for example by lack of trust, as viewed through an anthropological lens).

It should by now be clear that, if our informatic perspective is simply to view a decision system as a simple input-process-output machine, and seek to place a value on (input) information in terms of its impact on its outputs, we are not going to achieve anything which will hold up in practice. Nor are we going to get far with some kind of 'information reservoir' model, in which maintaining some level of 'information position' is deemed a necessary and sufficient condition for decision-taking. In fact:

- no 'single lens' view is going to yield stable and deterministic results on information value, and on the outcome of receiving information – unless we are sure that decision-taking has been 'locked down' to one of purely-objective algorithmic computation;
- different lenses will require different calculi to explain the impact of accumulating information.

On the latter point, we will need to question the inference, that may be drawn from Shannon [22], Boisot [15] and Davenport and Prusak [16], that you cannot be given the same information twice (i.e. it is not information if you already know it). This now seems to derive from a view of a decision system which is exclusively administrative or computational. From an anthropological perspective, it may be (for example) that trust relations require constant reinforcement. So the decision system may need a constant flow of this kind of information just to keep functioning. To interpret the

[13] Shannon's probabilities pertain formally to objective properties of the world, but his account points to an impact on beliefs and can be easily interpreted in the language of subjective probabilities and Bayesian probabilistic reasoning.

[14] CIBM Task 9, 'Shared situational awareness in the context of the Integrated Approach'.

value of this sort of information properly, we need to focus on the meaning of the *act of transmission*, not (solely) on the data content of the transmission (c.f. Searle's idea of speech acts [23]). We may also need to employ counter-factual logics to argue that the 'difference' (to use Boisot's term) lies in what would have happened had the information *not* been sent.

How can we cope with the 'vertical' messaging between lenses (e.g. the cross-inhibition of activity in one node by a node in another lens)? Finding some general expression of the rules of an information system addressing multiple lenses appears challenging. To make any progress, we appear to need knowledge of the internal architecture of the decision system, for example of the dominant model(s) in use, e.g.:

- Is the decision system being conducted as if it were a computational planning task?
- How highly do the participants rank the avoidance of violations of institutional preferences (and taking a satisficing view of other criteria)?

Another way of asking this is to enquire "What are the critical dimensions of the *cognitive alignment* of the decision systems' participants?" And, clearly, the answers will be pattern-, if not situation-, dependent. This reinforces the conclusion of [21] that there is a real need for a more mature account linking informatics, work and organization.