A philosophical approach to time in military knowledge management

Wayne R. Philp and Christopher P. Martin


Wayne Philp is Head of Land Systems Information Management, Land Operations Division, Defence Science and Technology Organisation (DSTO), Edinburgh, Australia.
Chistopher Martin is also based at the Land Operations Division, Defence Science and Technology Organisation, Edinburgh, Australia.

Abstract

Purpose – *The purpose of this paper is to explore the temporal relationship of information to decision making (based on shared intentions and common desired end-states) by proposing a moment of temporal convergence when the human perception of events in time, and the time-depreciating-value of knowledge in the face of opposition and uncertainty, may map onto a future goal-state. The concept of temporal convergence was developed to help apply information and knowledge management theory to some of the complex military processes addressed under Network-Centric Warfare, such as: commander's intent, course of action, situational awareness and self-synchronisation.*

Design/methodology/approach – *The approach is grounded in a pragmatist philosophy and constructivist epistemology. The argument is intuitive and uses common-sense examples to elucidate the concepts.*

Findings – *The framework is shown to be useful in describing and reasoning about the knowledge requirements and prerequisites for distributed decision-making through the sharing of situational knowledge and common intentions, with practical application to the planning and execution of operations. And to the designers of knowledge management systems seeking to address this space, it presents a real and practical challenge that could generate novel temporal approaches to data and information management.*

Originality/value – *The importance of time and epistemology has been neglected in the knowledge and information management literature, especially in the operational context. Time and knowledge have been conceptualised in conventional knowledge management systems as either ''timeless'' recordings of procedures, or time-stamped records of past events and states. This paper explores relatively new conceptions of time-and-knowledge, which should be of significance and interest to the wider community.*

Keywords *Knowledge management, Time study, Armed forces*

Paper type *Conceptual paper*

Introduction

Dalmaris *et al.* (2006) introduced the concept of temporal convergence in the context of the time-value of knowledge. This paper clarifies the concept and explores epistemological aspects of knowledge management through notions of human cognitive awareness and mental models, by which one may share situational knowledge and common intentions, in the hope of better understanding the base requirements for shared situational awareness and distributed decision-making.

Temporal convergence is about finding an implementation path between one's present state or condition in time and a desired state or condition at a future time. When one's perceived state can be plausibly linked via a chain of foreseeable events to an intended or desired endstate, the authors describe temporal convergence. When there is no foreseeable chain of possible events linking one's perceived state to an intended or desired endstate, the authors describe temporal divergence.

Received: 22 June 2007
Accepted: 28 October 2007

A state of temporal convergence employs real-time creativity, whereby the timely and sequential exercise of intended action is applied to achieve a predetermined[1] objective outcome or end-state; essentially, to ''make it so''. A future predicted state, once having been declared, may be realised via the predictor's timely actions (or those of a collective of people who believe in that prediction). The French phrase ''fait accompli'' (literally ''accomplished fact'') well describes temporal convergence when the implementation pathway appears certain (from a stochastic position).

''Being at a loss'' well describes a state of temporal divergence, whereby one cannot envisage any pathway to achieve a goal-state (a desired future end-state); failure seems inevitable. However, ''fait accompli'' and ''being at a loss'' are two extremes in managing the possibilities. The former is the degenerate case, while the latter may simply imply insufficient capability to navigate and adapt towards an unrealistic goal.

Martin *et al.* (in press) make this same case along mathematical lines, arguing that the types of knowledge most valuable to goal-directed agents in uncertain environments can be modelled as directed graph topologies. Therein the authors considered simple binomial decision trees with a single desired end-state and described an abstract situation image bifurcation process by which an agent uses an outcome-action-outcome triad to differentiate situational classes indicating potential success or failure. This paper is an exposition in parallel with that work and as such reflects the binary argument of success or failure against a single desired end-state.

However, the authors realise that this cannot adequately exemplify all problem spaces. Rather, goals are more generally definable in functional terms. A problem space may contain many points, which satisfy a given function. A functionally defined goal state may include a location parameter, or the function that defines a goal state may include a time parameter such as a deadline. It is a functionally defined goal that allows one to say, ''I don't know what it looks like, but I'll know it when I see it.'' The parameters of the function may be interrelated in complex ways; the more complex the interrelation, the more difficult it becomes to predict the end-state of a sequence of parameter adjustments.

In mitigation to the polarity of success or failure there is also the softer position of ''stance'' and ''poise'', as being in a good (or better) position to achieve one's general goals. Prepositioning (in the military sense) could be described as shaping the potential actualisation paths to achieve a (yet to be defined) goal-state. Nevertheless, the authors presume that the use of straightforward bipolar examples will not detract from the foundational argument.

The authors' general philosophical approach falls within the epistemological domain of ''soft determinism'' or ''logical positivism'', as characterised by the works of David Hume (1711-1776). This approach seeks to consider the complementary duality (as in two sides of a coin) of causal-determinism (*Stanford Encyclopaedia of Philosophy*, 2003), (herein called stochastic future) and free-will[2] (herein called intentional future). The authors' concept of a moment of temporal convergence, or some cognitive state of human-appreciation, from whence stochastic and intentional futures are fused, is deeply embedded in empirical versus inductivist philosophies,which might not be resolved. Nevertheless, both are truly part of the human experience and condition and therefore rightfully addressed together as a pair – as attempted in this paper.

The authors consider that most persons, at some time in their lives, have experienced a moment when reality gives substance to hope[3]. In this case ''what will be'' is not the sole outcome of cause and effect[4] nor the creation of an individual's power of positive thinking, but rather a hybrid of these two as evidenced by the sense of power and achievement people experience when they successfully act to achieve a planned outcome – ''to make it so'' – despite opposition from every quarter. The authors hold the view that the average person naturally and reasonably employs a mix of both ''causally deterministic'' (stochastic) and ''willful'' (intentional) thinking in the daily management of their affairs and in the pursuit of their ambitions.

"Calendar time an event-relative time are not necessarily connected, but as some moment in the mind of an individual, these time frames may converge – the moment of temporal convergence."

The dichotomy between cause and effect and individual positive thinking is an artificial construct. It is not the individual's positive thoughts but the manifestation of these thoughts as actions to shape the potential to achieve both a path to the desired goal and the achievement of that goal. As such temporal convergence is more the product of the shaping of cause and effect (to the limits of the decision-maker or more often parallel decision makers) to achieve the goals (Personal communication with Dr H. Mark Unewisse, Research Leader Land Systems, DSTO, 27 March 2007).

The intention of this paper is not to enter into a philosophical review, but rather to explore the way ordinary people – those people served by information systems and knowledge management processes – go about their business, especially with regard to their different perspectives of time and events. Any knowledge management system designed to facilitate the information needs of the average person (especially under stress) will pragmatically need to cater for haphazard or inventive modes of thinking, and because people schedule events in different ways within different modes of thinking, the temporal nature of information must be managed in two ways:

1. *Calendar time*. To manage the unfolding future, as deterministically projected from the past and present, and limited by one's mental ability to process and understand the microcosm of cause and effect (one's event-horizon). In this case, time is absolute, the experienced ''now'' being referenced to a clock or calendar, e.g. relative to 0000 01 JAN 1970.
2. *Event-relative time*. To describe and record one's consideration of possible events and times leading up to, and surrounding, an envisaged future goal-state, one must address time as being relative to a key future event in that goal-state. This is effectively a floating (but constrained) possible future environment. Thinking thus helps one to consider how one might act in future times, as events unfold, and effectively shape that future environment. In this case, time is mostly considered relative to the unfixed time of a key event, e.g. lift-off minus eight hours.

Calendar time and event-relative time are not necessarily connected, but at some moment in the mind of an individual, time frames (1) and (2) may converge – the moment of temporal convergence. Before (the moment of temporal convergence), the intentional future is not grounded in reality, but thereafter it becomes possible to plausibly fuse a temporal array of projected events in calendar time with a like array of planned events in event-relative time. In this context of ''fused time'', one can start to gauge the probability of success or failure of one's hopes and plans; that is, one has established a stochastic future which is tied to a criterion of success.

In a state of temporal convergence, the closer in time one gets to one's goal-state, the more important the ''time to take effect'' of any corrective action becomes. After an action is initiated, it generally takes some time before the effect of that action is evident in a changing environment – a hiatus – and some effects take longer than others, both absolutely (calendar time) and with respect to the remaining event-relative time before a planned key event. It may be that the rate or magnitude of environmental variation and/or opposing effects exceeds one's capacity to adequately respond in time such that one can no longer reach the goal-state in the time remaining. In this case, one faces probable failure – a state of temporal divergence. Thus it is possible for temporal divergence to occur after temporal

convergence because unlikely, but possible, events may still happen that block the stochastic chain of events leading to the goal-state.

In grounding the argument for temporal convergence or divergence with a decision maker, the authors acknowledge that decisions are made with varying degrees of resolution at multiple levels with different temporal event-horizons. Consequently, not all levels may achieve temporal convergence simultaneously, if at all. This also raises the issue of steps/decision-points at one level being decomposed of multiple sub-points at lower levels: temporal convergence would then be relative to the resolution and actualisation path of each decision maker, at each level, within context. There may be temporal convergence to an intermediate goal given to a lower team member, without that team's goal being temporally convergent against a broader plan. This is important in multi-level teams. However, this paper will keep it simple while expanding on the basic concept.

Concept

The authors follow the position of Piaget (1977) in the view that knowledge held by an individual is subjective and constructed from personal experiences and interpretations, resulting in personal (and unique) schemata. This is a narrow view which does not acknowledge shared or organisational knowledge or collective experience; however, it is useful as a starting point in the authors' knowledge framework. Furthermore, in the style of Thomas Kuhn (1970), both individuals and groups can simultaneously maintain multiple mental models which are not necessarily consistent, such as classical and quantum theories in the mind of a physicist.

The following discussion also presumes the existence of goal-directed intentional agents. That is, an agent's behaviour need not always be goal-directed but the agent has at least a presupposed desire to continue existing and a presupposed belief in its own ability, given opportunities, to take action in (re)shaping itself and its environment to satisfy its desires. Such an agent may be attributed with an internal locus of control orientation with a high sense of self-efficacy (Rotter, 1966; Bandura, 2001). An agent's situation image (Bickhard, 1998; Stojanov and Kulakov, 2003) consists of information about the ongoing interactive properties of the environment, which interactions have been engaged in, which sorts of interactions are now available, and which might become available if certain other interactions are engaged in first.

This paper contrasts two perspectives on the future that can be adopted for decision making: a view of the future as stochastic, and a view of the future as intentional.

The stochastic future is anticipated by a divergent projection of the immediate past and present onto possible future states. The near future may be predicted, based on known causes and effects, with the assumption that environmental conditions will not substantially change. Of course, the stochastic future tends to be quite near-term because environmental conditions do change continually over a continuum of time scales. Some changes are highly predictable; some are imperceptible (or at least nearly so) but highly significant, and some are unexpected and catastrophic. One's relation to the stochastic future must therefore be opportunistic.

''Happenstance'' (happen + (circum)stance) is a good word in this context to describe an event or interaction that occurs purely by chance; without intention. Epistemologically, within a model based on a stochastic future, one may state either: ''I know that it is possible'' or, ''I know that it is not possible''. But, in regard to a hypothetical goal-state, which has not been causally linked with the past or present, one can only state: ''I just don't know – I have no basis at all to say anything about the possibility or impossibility of a given future event happening at any future time.'' (Note that within a stochastic future all possible outcomes must be empirically grounded).

In contrast, an intentional future is anticipated by a belief in one's ability and opportunity to take action in shaping oneself and the environment to realise a goal-state. The timing of the goal could be in the next second, or the next decade, or unspecified; what matters is that at the present moment, the goal has yet to be realised: ''I intend to make it happen sometime.''

In between stochastic and intentional futures, before the moment of temporal convergence, is a grey area in which one does not know whether success is either possible or impossible, and one will draw on information from all sources (and seek support from knowledge management systems) to help substantiate a state of temporal convergence or temporal divergence. Again, epistemologically, one ''doesn't know'', but yet creativity (free-will) may emerge: ''It is conceivable. It could happen. One can't say it won't happen. Maybe, I can find a way to make it happen.'' Once (and if) a pathway to actualisation can be envisaged, and elucidated, a temporal convergence is achieved.

Martin *et al.* (in press) argue for the central importance of planning and human cognition as goal-directed constructive processes in knowledge management systems for military purposes: when temporal convergence has been found between a stochastic future and an intentional future, or when temporal divergence has occurred and it is time for a strategic withdrawal and change of intent. Knowledge management systems could well serve a client in the production and dissemination of artefacts for associates to (re)construct their own situation images. Such a client may be a military commander or CEO, who must think and act now in order to achieve future goals.

The above conceptual framework is needed to consider the dilemma of the operational information manager, who must think deterministically for immediate control actions and also wilfully in affecting and effecting higher strategic intent. Taken together, these complementary Weltanschauung[5] (worldviews) may support many real-life decision-making processes categorised by choosing actions in the present to both:

1. manage the unfolding moment-by-moment situation; and
2. effect change in oneself and one's environment so as to shape future possibilities to converge on a goal-state.

By way of illustration, consider a hypothetical scenario based on the notion of appropriate social behaviour and arranged marriages, as may have been typical between conservative western families at the turn of the last century[6]. Loving parents may have deemed it desirable that their 17-year-old son marry a loving young wife from a socially appropriate family upon the completion of his tour of military duty. This is in event-relative time; that is, when their son takes up civilian affairs on completion of his military service. We'll call this an intentional future. The time, circumstance and details are vague as the parents effectively float/hope-for a future desired state of affairs, or goal-state.

However, should at sometime (a calendar time event) between ''now'' and ''then'' their young soldier fall in love with a poor maiden from the local working-class village, the parents may act decisively to dissuade the relationship and directly initiate effects to cause their son to abandon the undesirable liaison. Alternatively, they may take steps to cause her to rebuff him. The parents calculate the relative effect of their actions on the situation to so affect the environment such that their desired outcome becomes the most likely outcome. This is their stochastic future, where several plausible solutions to the present dilemma may exist. Ongoing intervention may be necessary, as determined on a day-by-day basis, as the changing state of affairs is revealed.

In taking this story one step further, the parents may facilitate their simple plan by making timely and appropriate introductions for their son to significantly younger girls from socially appropriate families. They shape the future by placing ''hooks'' in the lives of selected [enduring] people/relationships by which they may ''stitch together'' their intentional future with their stochastic future. Thus may one describe the parents' attempt to shape the future by the means at their disposal.

At some future time, a reiteration and projection of their stochastic future may reveal a causal pathway between the here/now and the goal-state (temporal convergence); namely, they know where/when their son is coming home, they know who is available to marry, they know their own social standing, they know within whom they have ''hooks''. Hope finds substance in reality.

The point of the illustration is to make clear how the parents must manage the day-by-day contingencies surrounding their son's present circumstances, independence and experiences. At the same time they also maintain their goals and intentions for the future and take every favourable opportunity, as it presents, to fashion their goal-state: They just work-it-out along the way – seeding preliminary trends which may, in combination and longitudinal effect, collectively help to realise their ambitions. They seek to ''make it so!'' However, their effectiveness is dependent on other factors such as the parent's ability to act (capability/capacity) and to influence their son (relevance).

However, as previously stated, during a state of temporal convergence, the closer in time one gets to one's goal-state, the more important the ''time to take effect'' of any corrective action becomes. It may be that the rate or magnitude of environmental variation and/or opposing effects exceeds one's capacity to adequately respond in time, such that one can no long reach one's goal-state in the remaining time. If in the lead up to coming home, even though parent-initiated marriage arrangements are in place, the son falls in love with, elopes with, and marries the poor maiden, the parents must face probable failure – a state of temporal divergence.

Thus temporal divergence may occur after temporal convergence because some chance or unforeseen event effectively negates an otherwise achievable goal-state. Or, even though a solution path can be identified to redeem a failing situation (still in temporal convergence), the ''time to take effect'' of some necessary corrective action(s) may be such as to not effectively counter the disruptive condition in the remaining time; thus a state of temporal divergence applied.

Application to NCW

Temporal convergence, as a philosophical approach to time, is implicit within the structure, approach and activities of military staff in support of realising a Commander's intent. This paper makes this philosophy explicit. The development of the authors' concept of temporal convergence was needed because of a broader remit to articulate Information Exchange Requirements for military decision-making within the paradigm of Network-Centric Warfare (NCW).

It quickly became apparent that two different knowledge-bases were needed for NCW distributed decision making:

1. detailed knowledge and change information about a particular tactical[7] situation in a warfighting environment (for which calendar time and causal determinism well applied); and
2. relevant knowledge and change update about the cooperative and combined progress of different force-elements toward a operational-level military objective (event-relative time based on the Commander's plans in achieving temporal convergence upon a culmination point[8] within an intentional future).

Both knowledge sets are spatially consistent, but rarely the same: the time (temporal) parameters and the scale/resolution of the two being quite different. The tactical situation requires detailed knowledge about the microcosm of local cause and effect, where that knowledge has a finite (mostly short) lifetime or relevance in a dynamically changing environment. On the other hand, the operational-level of war[9] has quite different time-dependency and cognisance of situation image.

"Temporal convergence, as a philosophical approach to time, is implicit within the structure, approach and activities of military staff in support of realizing a Commander's intent."

The temporal nature of information reiteration/update, reliability, lifetime, lag/latency, sequence, timeliness and obsolescence are critical to both tactical and operational-level domains. But these temporal parameters can remain quite separate and very different only until an operational-level goal-state is within clear reach of tactical actions and effects (in series, parallel or both), and immediate events thereafter unfold in a deterministic and intentional way. A moment of temporal convergence is implicitly declared in the sigh of relief uttered when a tactical course of action is revealed that will (in all likelihood) achieve the culmination point.

Before that moment of temporal convergence, the intentional future is not grounded in tactical reality, but thereafter it becomes possible to plausibly fuse a temporal array of projected events in calendar time (a stochastic future) with an intentional future course of action in event-relative time (a prepared synchronisation matrix). Only in this context of ''fused time'' can one start to gauge the probability of success or failure of one's hope and plans; that is, one has established a stochastic future which is tied to an intentional future and a criterion of success.

In the light of these arguments, consider the current situation in Iraq where allied Coalition Forces are working towards the goal-state of democratic stability for the recreated nation under mounting levels of internal insurgency and indigenous resistance. Many approaches and activities may be tried, but they remain temporally divergent until a time-dependent pathway to actualisation can be articulated. Once temporal convergence is achieved, the Coalition will be able to plan and phase their withdrawal; but until that moment they must ''hang in there'' and keep trying to find a realisable solution. In the meantime the Coalition Forces must attempt to contain an unstable situation, on a day-by-day, case-by-case basis while the stochastic future is separate to the intentional future.

Based on this argument, one would expect that the stochastic world of the tactical commanders would require a different set of knowledge management tools to the intentional world of the operational planners. It would be interesting to investigate how the hypothesised knowledge disparity is managed.

Before attaining temporal convergence there may be little alignment of information temporal parameters (i.e. reiteration/refresh rate, reliability, lifetime, lag/latency, sequence, timeliness and obsolescence etc.). If one were to naively impose an operational-level mindset upon soldiers engaged in a tactical mission through a ''common operating picture'' or an automated ''shared situational awareness'' system, or conversely, a tactical mindset was imposed upon the situation image of an operational-level commander, confusion would inevitably result.

So, with respect to NCW, one can in principle describe three domains for knowledge management:

1. *Pre-temporal convergence*. Before temporal convergence is achieved, tactical and operational-level knowledge management systems are separate and operate against different calendar times and event-relative times, respectively. Situation images need not be shared between current-operations staff and planning staff, although situation images must be coherently shared within those respective teams.
2. *Moment of temporal convergence*. Tactical and operational-level knowledge sets must be fused in both time and space; specifically that calendar time is mapped to event-relative time against each/all of the envisaged tactical paths of implementation (plausible tactical courses of action) toward the culmination point or goal-state.
3. *In an ongoing state of temporal convergence*. Tactical and operational-level operatives share and commonly employ reliable, timely and specific knowledge against the agreed situation image in calendar time.

In the latter case of temporal convergence, Rick Hayes-Roth (2006) developed the concept of ''condition monitoring'' in a similar context to temporal convergence herein described. One monitors the condition of the present ''course of action'' (in comparison with the ideal

path, as planned) to effect change and shape the future the way one wants it to be. In this context knowledge/information management becomes dynamic and vital as the core function of an Information Manager, aided by an automated process of change sensors.

However, the methodologies, tools and information system architectures for the first two knowledge management domains are quite different, although there may be parts in common. Certainly, the temporal frame of reference is different between calendar and event-relative times and this will need to be carefully managed at, and following, the moment of temporal convergence. This brings us to consider the nature of information and knowledge management for military decision making.

OODA Loops

The stochastic future may be predicted for decision-making purposes. In order to appreciate one's present state ''now'' (in calendar time) and to gauge what action one should take ''now'', one may follow a series of deliberations:

1. OBSERVE. Observation is the means by which one collects/registers information about the state of the external world. What is one's current state with respect to the environment? What are the causes & effects that have brought us {where/when} to {here/now}?
2. ORIENT. Orientation comprises the internal processes by which observations are compared with prior knowledge and experience to update an understanding of the world. Given one's state {here/now}, in what state is one likely to be {there/then}, all variables remaining the same in one's present environment?
3. DECIDE. Decision is the internal process by which various tentative solutions are assessed and one selected for action. Rationalise the projected change of state required, if any.
4. ACT. Action is the process by which the internally constructed solution is applied to the world. Initiate change action {here/now}, which by cause and effect is likely to bring about the required state else {where/when}.
5. Repeat.

The acronym of steps 1-4 above spells ''OODA'' and its reiteration is the OODA Loop, as described by the late USAF Col. John Boyd (1996) to generally describe how individuals or groups observe, understand and interact with the world to shape their action. But how does this causally-deterministic worldview with a stochastic future map to one's ''free will'' worldview based on an intentional future? How is it possible to represent a moment of temporal convergence using an OODA model?

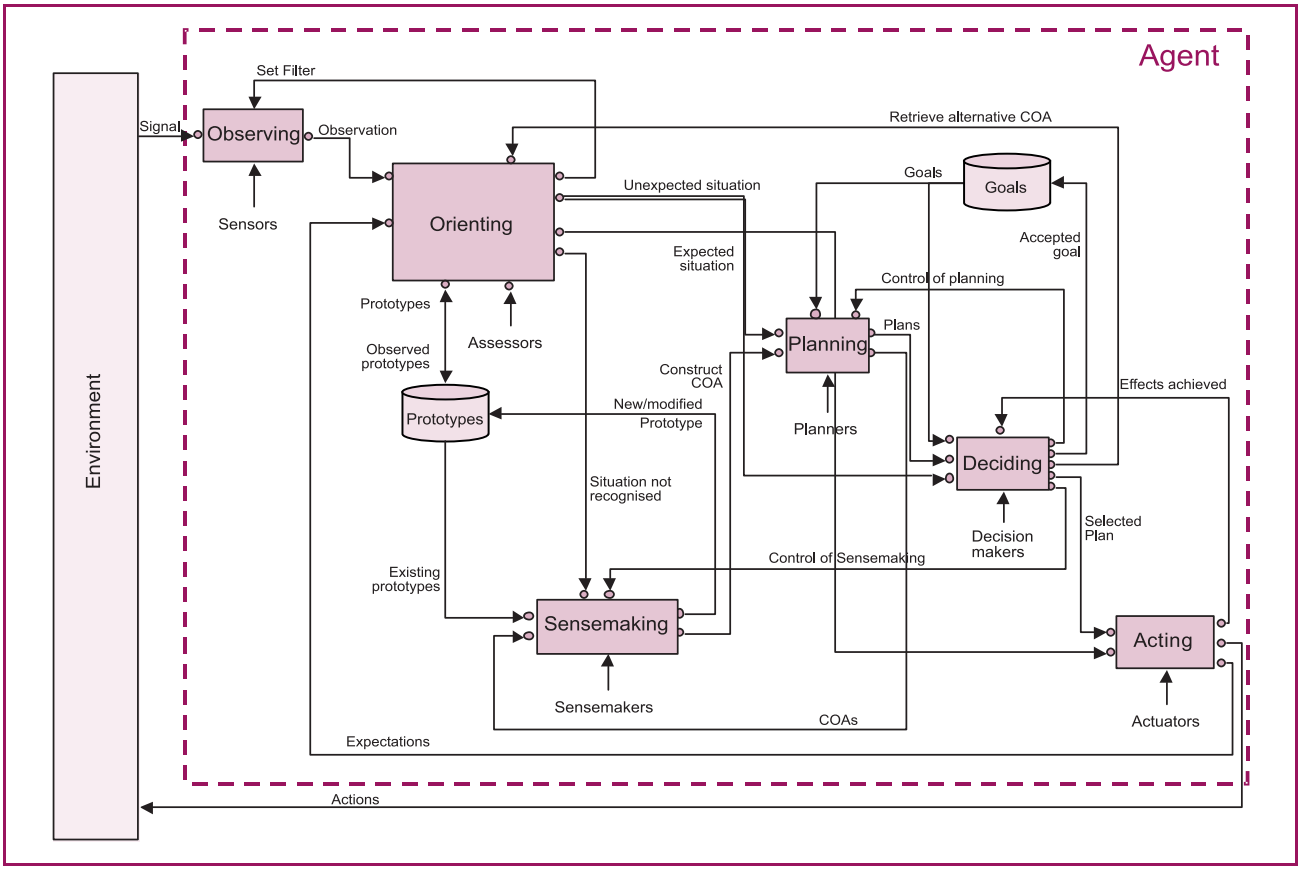
Although Boyd's work is often oversimplified and misrepresented in the current critical literature, the original paper (developed from observing jet fighter pilots in combat) was seminal in addressing the military decision-making process. Grant and Kooter (2005) effectively re-engineered Boyd's 1996 OODA model and have provided an excellent review of alternative decision-making models. Grant and Kooter point out that ''OODA exhibits shortcomings in psychological validity, in that it lacks concepts of memory and attention, and cognitive representations of *inter alia* world states and domain knowledge. This should be rectified by explicitly including a world model in OODA, with world states and models represented appropriately and store/recall functions for updating the world model. In addition, OODA needs a mechanism that determines the focus of attention appropriate to the current situation.''

Grant (2005) reconstructed and formalised Boyd's (1996) OODA model by integrating ''Plan'' and ''Sensemaking'' (using SADT/IDEF0 notation), as shown in Figure 1.

The basic OODA model can now be restructured along these lines:

1. PLAN. Plan to be (there/then) in accord with a projected situation image.
2. DECIDE. I (here/now) gauge the difference solution to {there/then} to be . . . I {here/now} recommend action, which based on past experience, has previously proven helpful.

Figure 1 Rationally reconstructed OODA model (Grant, 2005)



3. ACT. Take action to initiate change (here/now).
4. OBSERVE. What's happening (here/now)? How is my environment changing?
5. ORIENT. Does my evolving state favour my normative state? Better? Same? Worse?
6. SENSEMAKING. What actions have I experienced or learnt between like states and similar situations that may lead to improved resolution between my presently projected situation image and my initially projected situation image?
7. Repeat 1-6 with a new situation image.

Grant's revised formulation presents, at first appearance, to help represent an intentional future by introducing the cognitive processes of planning and relational sense making (with respect to the plan). However like its predecessor, it still assumes that empirical data collection (to observe), with inductive accommodation (to orient) can causally lead to effective and timely decisions (via sense-making) and actions through some form of time independent, deductive logic or definable pathway. Therefore, Grant's model does not help represent temporal convergence. Rather, the cognitive ''Ah-ha experience'' associated with the moment of temporal convergence is fundamentally time dependent and can only be achieved at some penultimate time, once an instance or reiteration of a projected stochastic future reveals a causal pathway between the here/now and the goal-state (temporal convergence).

As a consequence, the revised OODA construct still does not address the cognitive time dimensions (calendar time versus event-relative time) evident in the collaborative decision-making of individuals and teams, as in military commanders, command staffs and combat teams. For example, no processes are shown representing negotiation or

collaboration between team members; shared situation images; nor the time dependency and criticality of finding a pathway to actualisation for one's plans.

Knowledge management

In the case of a military headquarters, which often experiences strong opposition and deliberate frustration in achieving complex plans, the stochastic future is constructed in parts by the operational-level headquarters staff. The staff are subdivided into teams with distinct roles and responsibilities. The Chief of Staff leads dialogue with these teams to construct the complete situation image.

The job of the operational-level commander is essentially to select effects and actions in the present to both manage the unfolding moment-by-moment situation (stochastic future); and effect change in oneself and one's environment so as to shape future possibilities to converge on a goal-state (intentional future). It is through continual, extended dialogue that the Chief of Staff and Commander together construct the stochastic and intentional futures to a moment of temporal convergence when the two futures intersect, or a moment of temporal divergence when it becomes clear that the two futures cannot intersect.

Before temporal convergence is achieved, the tasks of developing the stochastic future and the intentional future are considered separately, by the ''Operations'' staff team and the ''Plans'' staff team respectively, where different sources of information may be filtered and partitioned. In the formative stages of developing ''Commander's Intent'', the Plans-team has priority. Once temporal convergence is achieved, the Commander must fuse his ''planned'' world with the ''real'' world to thereafter modify, in calendar time, the trajectory of combined battlespace effects in the face of enemy opposition. The Operations-team then has priority in bringing the plan to fruition. The moment of temporal convergence, as stochastic and intentional futures merge, is made evident by the switch in activity with the headquarters from deliberate planning to immediate planning.

So, the operational commander principally maintains an intentional future until he can become temporally convergent and therefore provide a causal (tactical) pathway by which his intent can be realised – plans to actions. Likewise, but vice versa, the tactical commander maintains a stochastic future in his immediate actions until he can also become temporally convergent in effecting his operational commander's intent – actions to plans. By what mechanism does this fusion take place? Is there a specific role for an Information Manager?

Consider also the simple example of an optical prescription during an optometrist's examination of a myopic patient's visual acuity. There are many design factors and lens corrections that make for a good set of spectacles, but neither the patient nor the optometrist will ever have to work it all out at once. Instead, the patient is asked to concentrate on a distant eye chart through a sequence of inserted optical media and simply decide, in each instance, whether or not the chart appears better or worse than with the last: ''Is this better? – Yes? or No?''

The key point here is that the patient is only required to focus on the eye-chart and to make simple, comparative decisions with respect to his attentions. But whereas the patient is focused entirely on the present, the optometrist is generating the future sequence dynamically in response to the patient's responses in the present. There is no temporal convergence in the patient's compare-and-respond activity; but there is temporal convergence in the optometrist's use of the patient's responses.

In many ways this could be the experience of the operational commander; one only need gauge the effect upon introducing new information/knowledge, with respect to the relative clarity for the achievement of a culmination point or goal-state, in terms of: ''Is the intended future clearer in the light of this new information?'' ''Better or worse?'' If the goal-state is paramount, then most other issues just don't matter. However, there may be an important sequence or timeliness to the order of the information considered.

> **"The temporal nature of information reiteration/update, reliability, lifetime, lag/latency, sequence, timeliness and obsolescence are critical to both tactical and operational-level domains."**

The real issue is who decides (by nature, sequence and tempo within the particular context at hand), what should be placed in view of the decision maker for ''revision'' of the chosen ''course of action'' toward the goal-state. Although the decision process appears to be linear and simple, the flow and exchange of information is far more complex, recursive and iterative. Because (unlike the optometrist's patient) the Commander is active in requesting information instead of just responding to that revealed, the analogy is limited in its usefulness. But, the analogy does legitimately raise the question: ''Who (like the optometrist) decides what information (lenses) to place before the decision maker?'' Is there an explicit role for an Information Manager, or is this function implicit to the Chief of Staff? The authors are engaged in research to support making this role explicit.

Conclusion

Dalmaris *et al.* (2006) attempted to extend knowledge-business processes improvement (KBPI) to incorporate the idea of the time-value of knowledge, a term coined and defined as a qualification helpful in assessing the applicability of knowledge to solving problems with a variety of time horizons. This examination extended from the simple observation that knowledge requirements (knowledge objects, relationships and supporting infrastructure that make up business processes) for the typical knowledge worker, such as a help desk customer support agent, were very different to those of a military commander or CEO, who must to think and/or act now in order to achieve their future goals.

For reasons of business process analysis, the authors needed to examine the interaction between two process functions that belonged in two different temporal domains. In knowledge management, this point is very important because it is seen as the interface between the present and the future. In this first articulation, the ''point of temporal convergence'' was the state of transition when the focus of the knowledge worker shifted from a stochastic future to an intentional future.

This paper has now developed that early concept to include the articulation of a plausible situation image. The authors now define temporal convergence as the intersection of stochastic and intentional futures – allowing the mapping of calendar time to event-relative time – when one's mind embraces ''what is'', ''what is desired'' and ''a possible way to make it so''. If a single key event is identified that connects an intentional and stochastic future, that event is the point of temporal convergence.

In many cases, there will be not one single event but a cluster of interconnected events representing a region of temporal convergence. In one's mind, at the moment of temporal convergence when one becomes conscious of that point or region – the ''Ah-ha experience'' – hope reveals its substance in reality. Thereafter one must wrestle with the probability of success or failure as one's intentions merge and buffer with one's experience of the unfolding present.

In defining, understanding and accommodating this pivot of cognitive change, it is necessary that information systems be better designed to facilitate the temporal parameters of knowledge requirements across the operational spectrum.

The time-value of knowledge is critical. Once in temporal convergence, the closer in time one gets to one's goal-state, the more important the ''time to take effect'' becomes in correcting any misalignment, in a changing environment, between one's stochastic future and one's intentional future. It may be that the rate or magnitude of environmental variation

and/or opposing effects exceeds one's capacity to respond in time, such that one can no long reach the goal-state, or culmination point, in the time remaining. The effectiveness of opposition increases as freedoms are reduced.

In this paper, the authors have laid the conceptual framework needed to consider the role of the military Information Manager. This is the focus of ongoing research.

Notes

1. As in preset, set in advance: ''a preset plan of action''.
2. Wikipedia on ''Free Will'': http://en.wikipedia.org/wiki/Free_will
3. ''Hope is a desire for something to happen, while expecting or being confident that it will come true. Hope also implies a certain amount of perseverance, believing that something is possible even when there is some evidence to the contrary. Hope may be directed toward something minor or towards something extremely significant . . . '', see Wikipedia on ''Hope'': http://en.wikipedia.org/wiki/Hope
4. ''Future events are necessitated by past and present events combined with the laws of nature . . . '', see Wikipedia on ''Determinism'': http://en.wikipedia.org/wiki/Determinism
5. *Weltanschauung* (German) meaning ''look into the world.'' See Sire (2004).
6. This hypothetical scenario is fictitious but makes clear social classes, biases and prejudices that were relevant in the 1800s that are unacceptable in 2007, under non-discriminatory norms and legislation. The authors' have no intent to offer offence to any reader in the selection of this example, but use the illustration only because of its direct application to the concept of temporal divergence and convergence.
7. The level of war at which battles and engagements are planned and executed to accomplish military objectives assigned to tactical units or task forces. Activities at this level focus on the ordered arrangement and manoeuvre of combat elements in relation to each other and to the enemy to achieve combat objectives. See also operational level of war; strategic level of war.
8. The point in a battle/war following which an enemy is no longer able to mount or maintain a successful offensive.
9. The level of war at which campaigns and major operations are planned, conducted, and sustained to accomplish strategic objectives within theatres or areas of operations. Activities at this level link tactics and strategy by establishing operational objectives needed to accomplish the strategic objectives, sequencing events to achieve the operational objectives, initiating actions, and applying resources to bring about and sustain these events. These activities imply a broader dimension of time or space than do tactics; they ensure the logistic and administrative support of tactical forces, and provide the means by which tactical successes are exploited to achieve strategic objectives. See http://usmilitary.about.com/od/glossarytermso/g/o4531.htm

References

Bandura, A. (2001), ''Social cognitive theory: an agentic perspective'', *Annual Review of Psychology*, Vol. 52, pp. 1-26.

Bickhard, M.H. (1998), ''Levels of representationality'', *Journal of Experimental & Theoretical Artificial Intelligence*, Vol. 10 No. 2, pp. 179-215.

Boyd (1996), ''The essence of winning and losing.'', available at: www.belisarius.com/modern_business_strategy/boyd/essence/eowl_frameset.htm.

Dalmaris, P., Hall, W.P. and Philp, W.R. (2006), ''The time-value of knowledge: a temporal qualification of knowledge, its issues, and role in the improvement of knowledge intense business processes'', in *Proceedings of the 3rd Asia-Pacific International Conference on Knowledge Management (KMAP06)*, Hong Kong, 11-13 December 2006.

Grant, T.J. (2005), ''Unifying planning and control using OODA-based architecture'', in *Proceedings of SAICSIT 2005 South African Institute of Computer Scientists and Information Technologists*, Mpumalanga, South Africa, 20-22 September 2005.

Grant, T.J. and Kooter, B.M. (2005), ''Comparing OODA & other models as operational view C2 architecture.'', in *Proceedings of the 10th International Command and Control Research Technology Symposium, McLean, Virginia, June 2005*.

Hayes-Roth, R. (2006), ''Two theories of process design for information superiority: smart pull vs smart push'', *Proceedings of CCRTS 2006: the Command and Control Research and Technology Symposium, June 20-22, 2006, San Diego, CA*.

Kuhn, T. (1970), *The Structure of Scientific Revolutions*, 2nd ed., University of Chicago Press, Chicago, IL.

Martin, C.P., Philp, W.R. and Hall, W.P. (in press), ''Temporal convergence for knowledge management'', *Journal of Knowledge Management*.

Piaget, J. (1977), *The Development of Thought: Equilibrium of Cognitive Structures*, Viking, New York, NY.

Rotter, J.B. (1966), ''Generalized expectancies for internal versus external control of reinforcement'', *Psychological Monographs*, Vol. 80 No. 1, pp. 1-28.

Sire, J. (2004), *The Universe Next Door: A Basic Worldview Catalog*, 4th ed., InterVarsity Press, Downers Grove, IL.

Stanford Encyclopaedia of Philosophy (2003), ''Casual determinism'', available at: http://plato.stanford.edu/entries/determinism-casual/

Stojanov, G. and Kulakov, A. (2003), ''Interactivist approach to representation in epigenetic agents'', in Prince, C.G., Berthouze, L., Kozima, H., Bullock, D., Stojanov, G. and Balkenius, C. (Eds), *Proceedings of the Third International Workshop on Epigenetic Robotics: Modelling Cognitive Development in Robotic Systems 101, Boston, MA*, pp. 123-30.

Further reading

Hobbes, T. (1997), *The Leviathan*, edited by Flatman, R.E. and Johnston, D., W.W. Norton & Co., New York, NY.

Hume, D. (1978), *An Enquiry Concerning Human Understanding*, edited by Niditch, P.H., Clarendon Press, Oxford.

Hume, D. (1978), *A Treatise of Human Nature*, edited by Niditch, P.H., Clarendon Press, Oxford.

About the authors

Wayne R. Philp is an applied physicist and systems analyst for Land Operations Division, Defence Science and Technology Organisation (DSTO), Edinburgh, Australia. Wayne had an early career as a Naval Officer (BSc., UNSW, 1975) and teacher (DipEd., UMelb, 1985) followed by a PhD in Optical Physics (VUT, 1994) and a Senior Research Fellowship in Optoelectronics at University of Strathclyde (Glasgow, 1995-1996). Since 1997, Wayne has been employed by the Australian Department of Defence as: Head of Support System Studies (Adelaide, 2000-2004), Scientific Adviser Joint (Canberra, 2004-2005) and presently, Head, Land Systems Information Management in Adelaide. In this position he leads DSTO's systems-level analytical support in the design & implementation of options and processes for Knowledge and Information Management of a networked Land force. Wayne R. Philp is the corresponding author and can be contacted at: wayne.philp@dsto.defence.gov.au

Christopher P. Martin is a systems analyst and developer for Land Operations Division, Defence Science and Technology Organisation (DSTO), Edinburgh, Australia. From early interests in linguistics, ecology and ethology, he eventually stumbled across computer science and psychology and applied these fields to research in mathematics education and teacher-training. He also taught mathematics and computing at secondary and tertiary levels. A decade later in 2001, he joined DSTO where he now works in the domains of information management and robotics. He has a BSc from the University of Queensland and a GradDipEd from the University of Western Sydney.