13TH ICCRTS

"C2 for Complex Endeavors"

Reducing Operational Planning Cycle Time Using BPR and Concurrent Engineering

Topics: (1) C2 concepts, theory & policy; (5) Organizational issues; (9) Collaborative technologies for network-centric operations.

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Abstract

This paper reports on on-going research aimed at contributing to the development of a new conceptual model of planning by reducing the cycle time for operational planning by an order of magnitude or more. Experience in other domains show that this should be feasible using technologies such as intelligent planning and scheduling, simulation, and concurrent engineering.

Business process re-engineering methods and cycle time reduction techniques are applied to the illustrative example of the Royal Netherlands Army's Decision Making Process. The results show that it is not sufficient to flatten or to plan concurrently at all levels of the organizational hierarchy. The planning process within each unit must itself be streamlined. The paper investigates incremental and radical measures for reducing the cycle time of the planning process. It makes recommendations for comparing a variety of planning processes, for further study of specific radical measures, and for concept development and experimentation.

Introduction

Alberts and Hayes (2007) observe that traditional planning practices maximize the benefits available from problem decomposition, de-confliction, and specialization. However, this means that military units can only achieve synergy by centralizing planning. Traditional planning processes are not agile enough to meet today's challenges of the multiplication of threats, globalisation, the increasing pace of change, and the arrival of the information age. They cannot accommodate the needs for increased decision tempo, speed of command, and frequency of decision-making. In short, the state of the practice is not effective for complex endeavours. The way ahead lies in developing a conceptual model of planning that is consistent with information-age models of Command & Control.

This paper reports on on-going research aimed at contributing to the development of a new conceptual model of planning by reducing the cycle time for operational planning. The goal is to speed up planning to such an extent that it can be integrated with real-time execution, eliminating the existing separation between planning and execution processes. The target should be at least one order of magnitude reduction in planning cycle time. Experience in other domains show that this should be feasible using technologies such as intelligent planning and scheduling (Ghallab et al, 2004), simulation (Arcioni & Van der Plas, 2002), and concurrent engineering (Swink, 1998) (Bandecchi et al, 1999) (Koufteros et al, 2001).

Central to this research is the application of business process re-engineering (BPR) methods (Davenport, 1993) (Hammer & Champy, 1993), particularly cycle time reduction (CTR) techniques (Wetherbe & Frolick, 2000). The objective is to find measures for reducing planning cycle time. The emphasis is on radical measures, such as identifying assumptions about industrial-age organizational forms and processes that place constraints on planning, and then finding a way to remove them.

One difficulty that has already been encountered is the profusion of military planning processes, e.g. at least four within NATO alone. Separate research is needed to compare these processes, to identify commonalities and differences, and to explain why these commonalities and differences occur. For the purposes of the current research, we adopt the Royal Netherlands Army's (RNLA) existing Decision-Making Process (DMP) as our illustrative example. While the DMP is currently being redesigned to bring it more into line with network-centric operations, it has the advantage of being well documented, in current operational use, based on NATO standards, and familiar to the authors.

This paper consists of five chapters, plus references. Chapter 1 introduces and motivates the research reported here. Chapter 2 reviews BPR methods, including a checklist specifically designed for cycle time reduction (CTR). Chapter 3 describes the RNLA's existing Decision-Making Process in some detail. Chapter 4 applies CTR to the DMP, identifying the underlying constraints and possible ways of removing them. Finally, Chapter 5 draws conclusions and recommends further research.

BPR and Cycle Time Reduction

Business Process Re-engineering

O'Neill and Sohal (1999) review a variety of definitions of BPR. Davenport and Short (1990) view it as the analysis and design of workflows and processes within and between organisations. Hammer and Champy (1993) define BPR as the rethinking and redesign of business processes to achieve improvements in performance measures such as cost, quality, customer service, and speed. Talwar (1993) regards it as the rethinking, restructuring, and streamlining of the business structure, processes, methods of working, management systems, and external relationships through which value is created and delivered. Petrozzo and Stepper (1994) see BPR as the concurrent design of processes, organisations, and supporting information systems to achieve radical improvement in time, cost, quality, and customers' regard for products and services.

The concept of a business process is central to all these definitions. Hammer and Champy (1993) define a business process as "a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer". Davenport (1993) puts more emphasis on the ordering of activities in time and space in defining a process as "a specific ordering of work activities across time and space, with a beginning and an end, and clearly defined inputs and outputs: a structure for action". Key characteristics of a business process are:

- It consists of activities that are ordered in time and space.
- It is embedded in an organisational structure, often spanning multiple functions or disciplines within the organisation.
- It has clearly defined inputs and outputs.
- There must be a recipient of the process output, i.e., a customer.
- The process must add value for the customer.

A business process can often be decomposed into several sub-processes, each having its own attributes. Decomposition terminates when primitive activities are reached that can be directly executed. The characteristics of business processes include (Harrington, 1991):

- *Efficiency*, i.e., how well resources are used to produce an output.
- *Effectiveness*, i.e., how well customer expectations are met.
- *Quality*, i.e., the quality of the output.
- *Cost*, i.e., the total cost of performing the process.
- *Flow*, i.e., methods for transforming the input into output.
- *Cycle time*, i.e., the time taken for transforming input into output.

The re-engineering process – which can be incremental or radical – comprises the following steps (Valiris & Glykas, 1999):

1. Establish business vision and objectives.
2. Identify core business processes.
3. Model and analyse business environment.
4. Streamline business processes to match objectives and environment.
5. Continuous control and improvement of steps 1 to 4 above.

Valiris and Glykas (1999) identify three perspectives from which BPR methodologies approach the re-engineering process. The *management accounting* perspective focuses on process characteristics and aims to reorganise business processes using information and communications technologies (ICT). The *information systems* perspective supplements this process focus by also focusing on structure, i.e., objects in the business environment and their relationships, and on behaviour, i.e., the objects' life histories. The aim is to understand – and possibly reorganise – business processes to heighten the impact of ICT. The *organisational theoretic* perspective focuses on people, their accountabilities and their roles, noting that this focus is generally absent in the other two perspectives. The aim is to understand how process changes impact on organisational changes, and vice versa. Valiris and Glykas advocate the use of BPT methodologies that combine all three perspectives.

Duffy (1994) states that the biggest improvement gains can be achieved in the areas of cross-functional, cross-divisional, and cross-company processes. In military terms, this is equivalent to saying that the biggest gains are to be found in joint, combined, and civil-military coalitions, i.e., complex military endeavours.

Relationship to ICT

BPR is closely related to ICT. O'Neill and Sohal (1999) point out that a common theme in improvements resulting from BPR is the use of ICT, e.g. for the integrated automation of manual processes. Chan (2000) identifies three roles that ICT can assume in business processes, depending on the business environment and how the technology is being applied:

- The *enabler* role is one in which ICT offers the ability to accomplish process innovation, e.g. by accelerating specific process steps or providing more rapid information capture, processing, and analysis. This role has received the most attention in the BPR literature.
- The *facilitator* role is one in which ICT serves to make work easier. In this role ICT often becomes part of the product. For example, supplementary software may be embedded in a computer imaging system to make it easier for users to prepare, transmit, and manage images, as well as to capture them.
- The *initiator* role is one in which ICT acts as an agent of change, e.g. new processes may become possible by using ICT. Chan gives the example of how the introduction of computer imaging in a hospital led to a total change in the process of ward ordering.

The enabler and facilitator roles correspond to incremental changes in business processes. By contrast, the initiator role is more radical. Examples of companies that have successfully used Internet technologies to create new business models *ab initio* include Amazon, eBay, Google, low-cost airlines like Southwest, EasyJet and Ryanair, and social networking websites like MySpace and YouTube. Existing companies that have radically changed key business processes include UPS, FedEx, and Boeing.

Manganelli (1993) warns that BPR should never be driven by technological goals. Davenport (1994) notes that ICT systems – the hard side of the organisation – can fail to match the users' soft requirements. O'Neill and Sohal (1999) identify several pitfalls in applying ICT in BPR, as follows:

- Many companies have achieved only the automation of existing manual processes. In essence, the role of ICT comes no further than that of enabler or facilitator. For example, the Royal Netherlands Army's Integrated Staff Information System (ISIS) and Battlefield Management System (BMS) may be regarded as just automating existing manual processes. Nevertheless, despite the limited ambition implied by the enabler and facilitator roles, ISIS and BMS users are delighted with the resulting improvements in efficiency.
- Many managers do not rely solely on computer-based information to make decisions. A military C2 example is where GPS or radar data must be fused with human intelligence or visual sightings to build up a complete operational picture.
- Merely changing an ICT system will not change a company's culture, strategy, or structure. In the Network Enabled Capabilities (NEC) literature, this is expressed in terms of need to *co-evolve* the Doctrine, Command & Control, Materiel, Operations, Training, and Personnel (DCMOTP) factors.

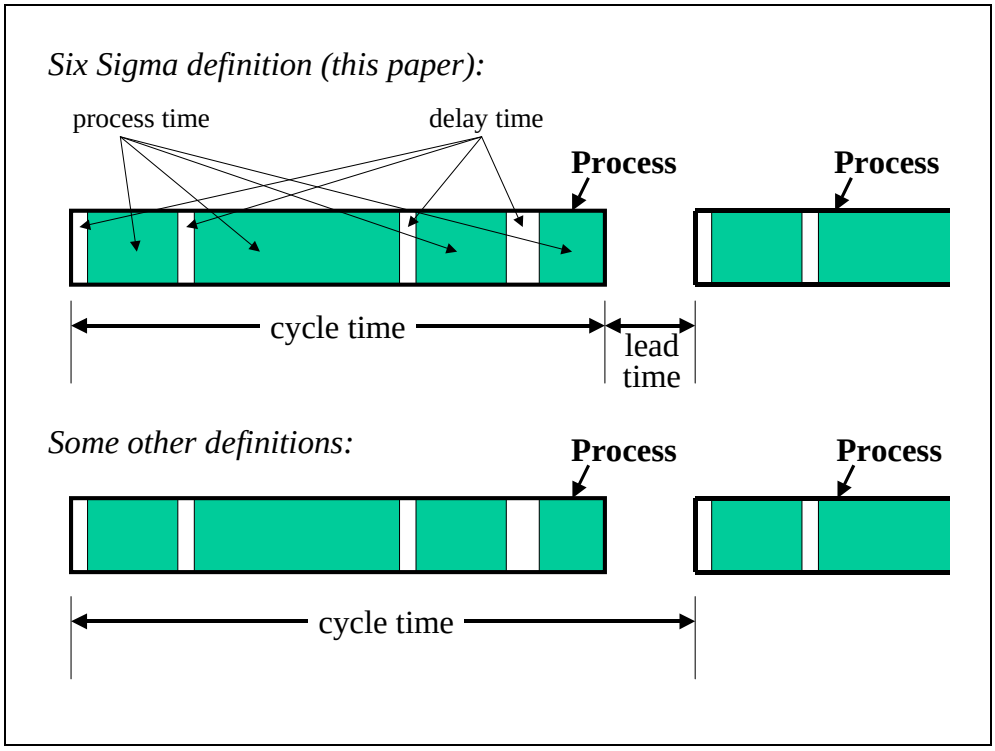

Figure 1. Process and cycle time.

Cycle Time Reduction

There is an offshoot of the BPR literature that concentrates on Cycle Time Reduction (CTR). There are various definitions of cycle time in the literature. In this paper, we adopt the Six Sigma definition of cycle time as the total time from the beginning to the end of a process; see upper part of Figure 1. This is divided into *process time*, i.e., the time during which some action is occurring that brings the process closer to output, and *delay time*, i.e., the time during which no such action is occurring. Other definitions are based on the time interval from the start of one cycle to the start of the next cycle or on dividing the total time interval for performing (say) 200 processes by 200; see lower part of Figure 1. Such definitions incorporate *lead-time* – the time between the end of one process and the start of the next – into cycle time. However,

we do not take this approach because lead-time may well be determined by extraneous factors that have nothing to do with the process.

A key concept in CTR is the cyclical thinking approach, originating from Senge's (1990) work on the learning organization. Wetherbe (1995) argues that processes are typically viewed as a linear sequence of actions. In CTR, the analyst must adopt the approach of viewing each process as a cycle of activities, with multiple cyclic processes interacting with one another. As an example, he shows the interactions between the processes of recruiting sales employees, training and developing them, and marketing in a consulting company. Figure 2 depicts a military operation as a set of three sub-processes – planning the operation, executing the plan, and gathering lessons learned – viewed as a linear sequence (upper part) and as a cycle (lower part).

This cyclic thinking approach enables the analyst to take the next mental step, namely to view the sub-processes and activities as overlapping, or, stronger still, as running concurrently. From this viewpoint, a military operation can be regarded as planning, execution, and lessons learned overlapping one another or even all taking place simultaneously. Adapting a slogan from software engineering, where iterative programming is often described as "design a little, implement a little, and learn a lot", we could describe the overlapping or concurrent approaches to military operations as "plan a little, execute a little, and learn a lot".

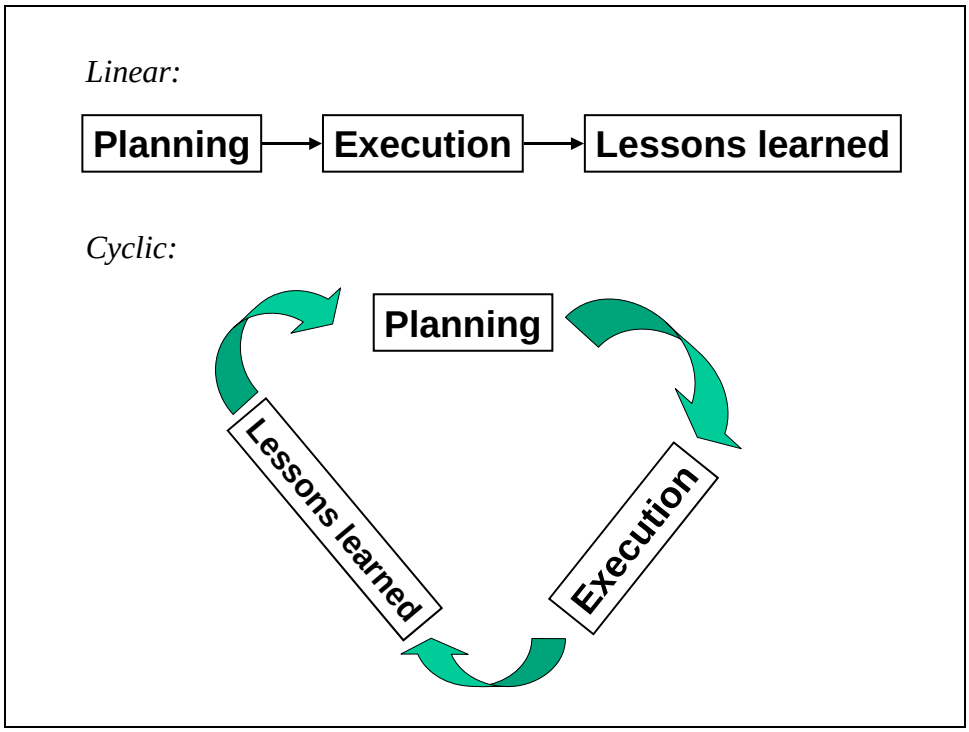

Figure 2. Contrasting linear and cyclic approach to a process.

Wetherbe (1995) emphasises that the aim of CTR is not just to accomplish activities at a "blinding speed" without regard for other process characteristics. Rather, the aim is to reduce cycle time in ways that reduce cost and/or increase customer service.

The CTR literature is dominated by Wetherbe's (1995) five major *constructs*: management / organization, human resource, product management, operations, and

inter-organizational. Each construct is used as a framework for determining one or more points of leverage for reducing the cycle time. Each point of leverage is a word ending in “ing”. For example, the points of leverage within the inter-organizational construct are:

- *Networking*, defined as communication and collaboration between organizations.
- *Partnering*, defined as the willingness for organizations to share information and other resources.
- *Risk-sharing*, defined as the contractual agreement between organizations to pools their resources, including costs, in bringing a new product to market and/or in marketing it.
- *Outsourcing*, defined as contracting with a supplier organization to perform a function, produce a product, or deliver a service to reduce cycle time for the client organization.
- *Virtualizing*, defined as creating a virtual organization from several different organizations.

Wetherbe’s (1995) five constructs and 46 points of leverage provide a checklist for exploring and discovering opportunities for reducing the cycle time of a process. In short, they enable the analyst to identify where possible improvements may be made.

The CTR literature lacks a taxonomy of process changes that lead to reduction in cycle time. Some general principles are mentioned in various papers, such as:

- *Speed-up*, i.e., assigning activities to resources that can perform them faster. This leads to a reduction in process time, but delay time is unchanged.
- *Time compression*, i.e., removing activities that do not add value. In essence, this reduces the delay time, while leaving the process time unaltered.
- *Simplification*, i.e., replacing a set of activities by an alternative set that is fewer in number. Reduction in the number of activities leads to a reduction in the number of inter-activity delays, and hence is likely to result in reduced delay time. The process time is also likely to change, but there is no guarantee that it will be reduced. An increase in process time would be acceptable if this increase is less than the reduction in delay time. The alternative set of activities must take the same inputs and provide the same outputs as the activity set being replaced.
- *Overlapping*, i.e., scheduling an activity sequence in which a following activity starts before the preceding activity ends. This reduces both delay and process time, but is only practical if the overlapping activities can run partly or wholly in parallel with one another. *Parallel planning* is where the planning processes partly overlap, and *concurrent planning* is where they wholly overlap.

These principles are incremental. There seem to be no documented principles for radical change, such as not doing a process at all or migrating a process to an external organizational entity. An example of eliminating a process entirely can be found in the domain of supplying goods by mail order (Wetherbe, 1995). Most mail order companies perform a creditworthiness check on a customer before they supply the ordered goods. However, Fingerhut streamlined its processes by supplying goods without first checking creditworthiness. The company only supplies cheap items to new customers, increasing the value of items that may be ordered progressively as a customer places repeat orders. If a customer defaults on payment, then the customer’s name is blacklisted so that all future orders from the customer are refused. The historical default rate is about 3%. The company no longer needs a credit-checking

department, and the associated savings more than cover Fingerhut's losses from defaulting. An everyday example of migrating processes to an external organization is Internet banking. This enables banks to transfer processes from bank clerks to their customers, enabling savings to be made in manpower and in associated office costs.

It should be noted that the CTR literature has only been applied to supply chain management. Its application to military operations is breaking new ground.

CTR does not offer a CTR-specific methodology, e.g. one for applying the constructs and points of leverage. Nevertheless, one can be drawn from the parent BPR literature. In this paper, we use Valiris and Glykas' (1999) re-engineering process.

RNLA's Decision Making Process

There are many military planning processes, both within NATO and between nations. Even different military services within a given nation may have different planning processes. For our analysis, we adopt the Royal Netherlands Army's deliberative C2 planning process – known as the Decision Making Process (DMP) – as our starting point[1]. While the DMP is currently being redesigned to bring it more into line with network-centric operations, it has the advantages of being well documented, in current operational use, based on NATO standards, and familiar to the authors. This doctrine has been documented, both in Dutch and in English, as Army Field Manual 1 (in Dutch: Leidraad 1). We use the English version (AFM1, 2000) as our source. For clarity, we will restrict our analysis to single-service operations, avoiding the complications of NATO, joint, combined, and civil-military operations.

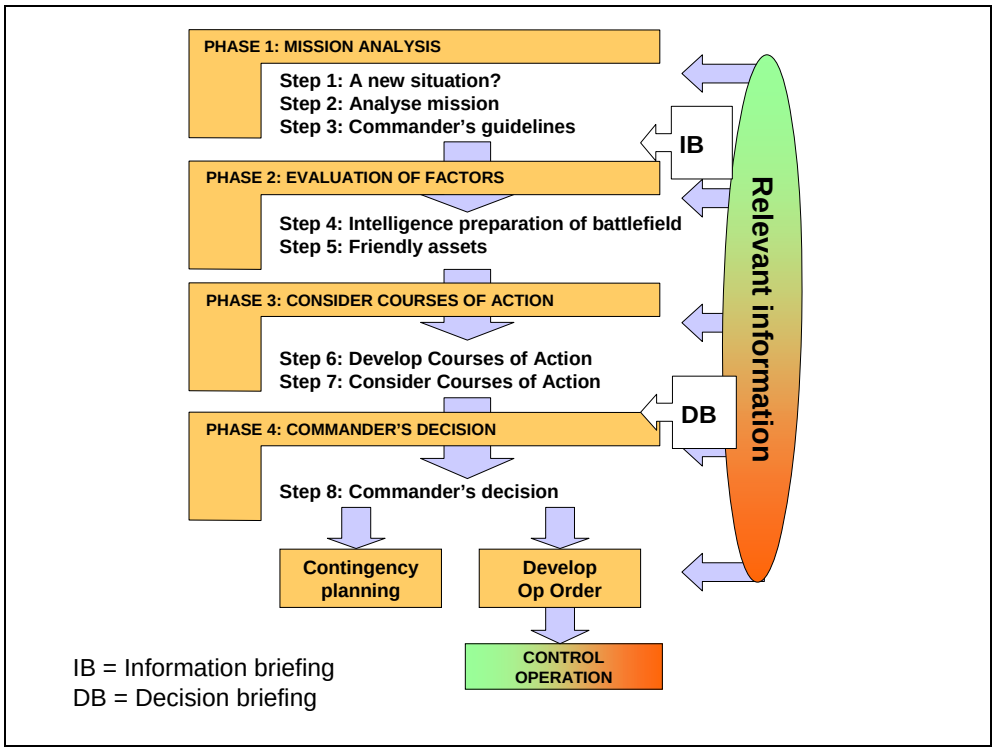

Figure 3. Royal Netherlands Army's Decision Making Process (AFM1, 2000, p.72).

[1] There is an abbreviated form of this process, known as OTVOEM, for use as a mental drill when in contact with the enemy, i.e., for reactive planning.

In RNLA doctrine, C2 consists of three elements (AFM1, 2000, p.41): leadership, decision-making, and control. Leadership is defined as the conscious influencing of the behaviour of others in order to jointly accomplish the set objective. Decision-making is deciding on the method of operating to achieve the assigned objective in support of the higher commander's intent. Control is the process used by the commander, with the assistance of his/her staff, to direct and coordinate the activities of the troops he/she has been assigned. This includes writing and issuing operation orders. RNLA C2 doctrine is based on mission command and on manoeuvre warfare.

In AFM1 (2000), one chapter is devoted to each element of C2. An introductory chapter, a chapter giving a historical perspective on C2, and a chapter placing C2 in its doctrinal context lead in to the element-specific chapters. The manual closes with a chapter on C2 support, covering the command staff, command posts, liaison officers, and C2 systems. There are 26 annexes. Eight annexes provide detailed information on decision-making. The next 14 annexes provide details on the content and format of an operation order, i.e., supplement the chapter on control. The remaining four annexes elaborate on C2 support topics, on C2 in a NATO context, operational reporting, and command relationships. Finally, there is a glossary of terms.

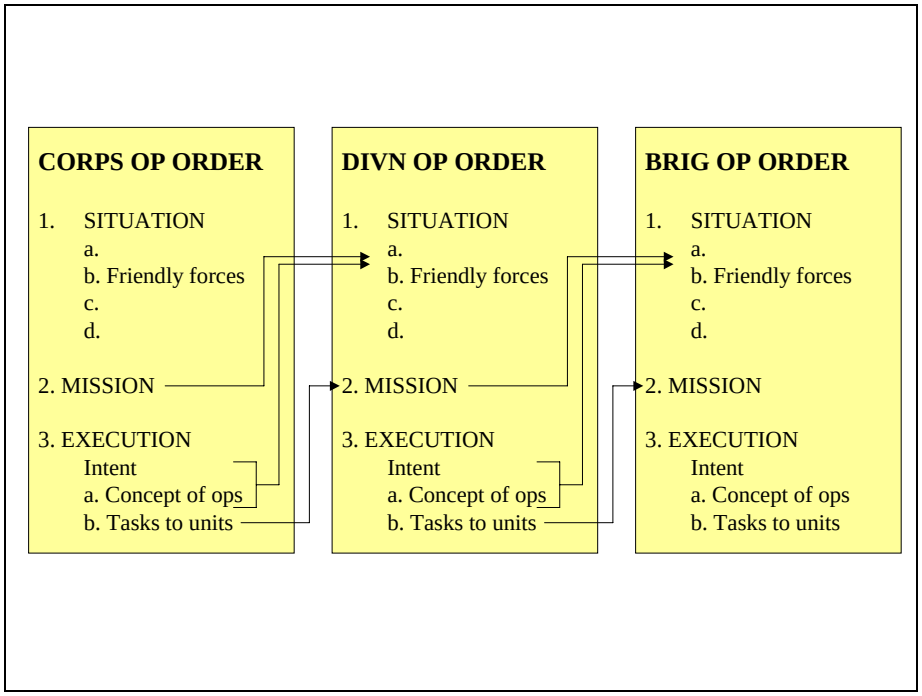

Figure 4. Relationship between Operation Orders at three levels (AFM1, 2000, p.105).

For the purposes of this paper, we are concerned with decision-making. This C2 element constitutes the deliberative planning process within a particular military unit, as shown in Figure 3. The process comprises four phases, consisting of eight steps. As described in AFM1 (2000), it is a linear process, triggered by the receipt of an operation order from the next higher level in the organization. At the conclusion of the planning process, the command staff develop the commander's decision into an operation order. If necessary, they also do contingency planning and start early planning for follow-on missions. The operation order is sent to subordinate units, triggering their planning processes. As the structure of AFM1 (2000) shows,

developing the operation order is part of the control element of C2, rather than decision-making. From the DMP viewpoint, it is delay time.

In practice, RNLA units have developed variants of the DMP that enable partial overlapping with the DMP processes at the higher and lower levels. This is achieved by issuing a warning order partway through the DMP, allowing subordinate units to start their DMP earlier than if they had had to wait for the operation order. Separately, one of the co-authors of this paper has studied possible measures for and benefits of parallel planning (Van der Kleij, 2004: 2005). We consider parallel and concurrent planning in the next chapter.

As described in AFM1 (2000), the DMP at a given level in the organizational hierarchy can only start when the operation order from the superior level has been received. The DMP ends at the point where the operational order for subordinate units can be written. In developing an operations order information on the mission, the higher-level commander's intent, and the concept of operations must be transferred from the superior's operation order into the operation order for the subordinate units (see Figure 4). The need to transfer information enforces a strict sequential ordering between the operation orders and, therefore, between the planning processes at different levels (see Figure 5). The dissemination of an operation order links the development of the operation order – part of the control process – *after* the end of the preceding planning process to the start of the succeeding planning processes[2]. In short, the need to write an operation order builds in lead-time between DMP cycles.

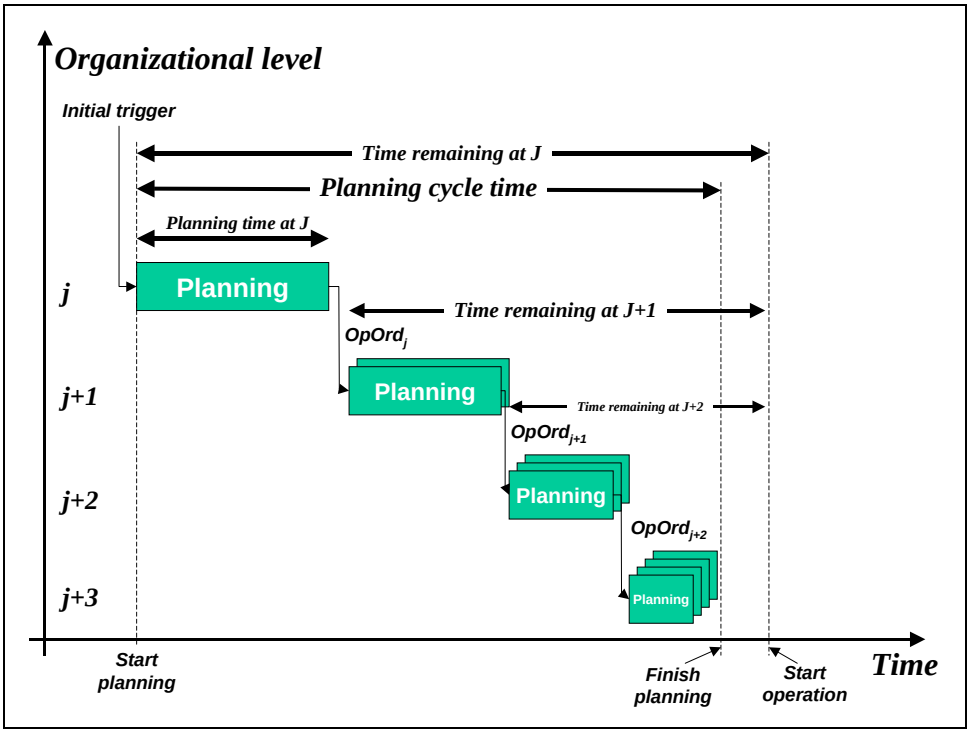

Figure 5. Relationship between planning processes at four levels.

[2] For simplicity, Figure 5 has been drawn as if the development of the operation order was a ninth step in the planning process.

Although the superior commander's mission, intent, and concept of operations are known at the start of Step 1 of the DMP, this information is not passed on to the subordinate units until after Step 8 of the DMP has been completed. From the subordinate units' viewpoint, their superior's DMP process delays their receipt of information about the situation. For example, Figure 4 shows that brigade-level units could be given the division's mission as soon as the corps issues that mission.

To consolidate this analysis, we look at a numeric example. Suppose that a task force consisting of four echelons (levels j to j+3) must develop a plan for an operation that will begin 18 hours later (see Figure 5). The doctrinal rule of thumb is that a unit at a given level can take up to one-third of the time remaining to perform its planning process, leaving two-thirds of the time remaining for planning at all lower levels. Hence, at the top level, j, the planning process can take six hours, i.e., one-third of 18 hours. At the next level down, j+1, 12 hours remains, and four hours can be allocated for planning at that level. At level j+2, there will be eight hours remaining, and planning can take two hours and 40 minutes. At the lowest level, there will be five hours and 20 minutes remaining, and planning can take just under two hours. The overall planning cycle time is about 14 hours and 30 minutes, leaving about three hours and 30 minutes between finishing planning and starting the operation. Some of this cycle time of 14 hours and 30 minutes is delay time, namely the sum of the times taken to develop the operation orders at levels j to j+3.

Applying CTR to DMP

We perform the first four steps of the BPR process (Valiris & Glykas, 1999): establish vision, identify core processes, model the environment, and streamline the processes, both incrementally and radically.

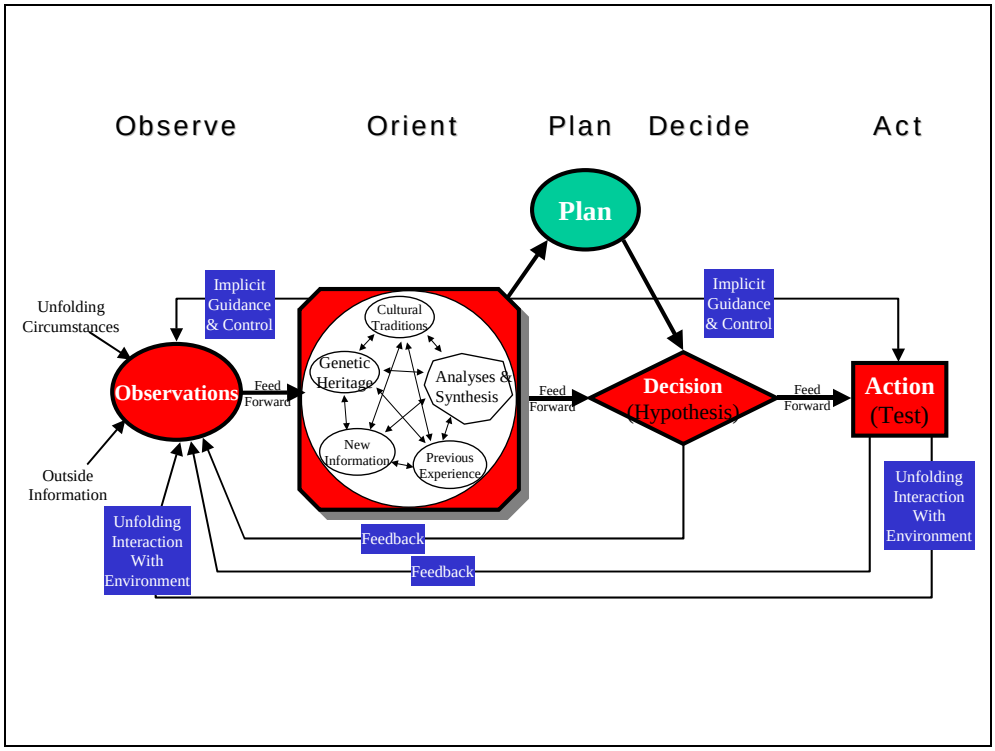

Figure 6. Boyd's (1996) OODA loop, with Plan added.

Vision

The goal is to speed up planning to such an extent that it can be integrated with real-time execution, eliminating the existing separation between planning and execution processes. Conceptually, a Plan process must be integrated into Boyd's (1996) OODA loop; see Figure 6. Grant and Kooter (2005) have proposed a rationally reconstructed model of OODA incorporating planning and learning. Grant (2005b) has evaluated the consequences this would have on the choice of algorithms for supporting or automating the generation of courses of action (COAs) and scheduling them.

Core processes

If we take the rationally reconstructed OODA model (Grant & Kooter, 2005) as our starting point for reducing planning cycle time, then the core processes are Orienting, Planning, and Deciding. Observing and Acting are less affected because they are not directly connected to Planning. Sensemaking (learning) is directly affected by introducing Planning, but, for simplicity, we do not discuss this further in this paper. More details can be found in (Grant, 2005a).

Environment

The key aspects of the envisaged environment are increased decision tempo, speed of command, and frequency of decision-making. Developments in other domains, such as manufacturing (Drabble, 2000) and space mission analysis (Bandecchi et al, 1999), show that it is not unreasonable to set a target of reducing planning cycle time by an order of magnitude. In terms of our numeric example, the planning cycle time would have to reduce from 14 hours and 30 minutes to 90 minutes. This indicates that incremental re-engineering of the planning process will almost certainly be inadequate, and that radical change is essential.

Streamlining

We consider the principles for incremental CTR first. Then we turn to radical measures.

Incremental CTR

There are several statements in the last chapter of AFM1 (2000) that show that achievements have already been made in streamlining the military planning process by employing ICT:

- C2 systems "accelerate time-consuming, routine processes".
- "All orders, sketches, texts, and overlays can be transmitted electronically".
- "Data can be processed and presented by computer".
- "The commander receives the right information early and is thus able to provide his subordinate commanders with information early on".

All these statements describe incremental speed-up by using ICT in its enabler role to reduce the process time of planning sub-processes and activities.

We note that there are still several planning sub-processes that have yet to benefit from automation, such as using intelligent planning and scheduling techniques

(Ghallab et al, 2004) to automate COA construction in Step 6, and using simulation techniques to automate "war gaming" in Step 7.

There are no indications that time compression or simplification has been used to accelerate planning.

Another measure that has already been adopted is the use of warning orders to enable the partial overlapping of planning sub-processes and activities. One of the co-authors of this paper has studied the feasibility of further streamlining the planning process by supporting parallel planning (Van der Kleij et al, 2004; 2005).

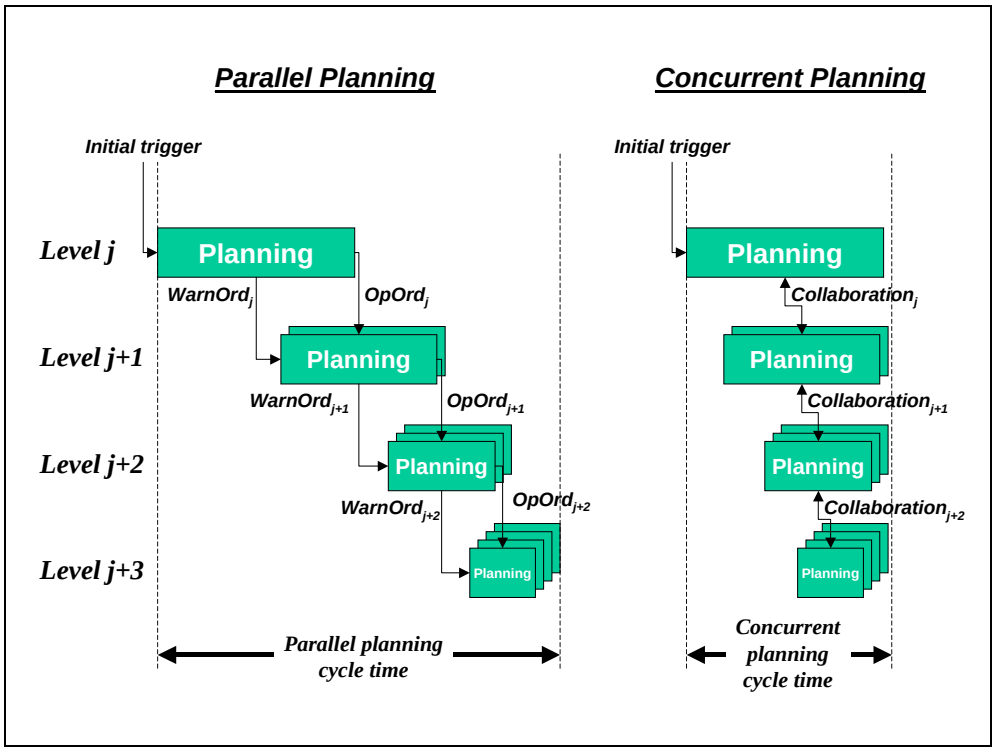

Figure 7. Parallel and concurrent/collaborative planning.

However, this alone will not enable us to reach our target of reducing planning cycle time by an order of magnitude, as further consideration of our numeric example shows. Suppose that a given unit issues a warning order to its subordinates halfway through its planning process (see left-hand side of Figure 7). Calculation gives a shortened planning cycle time of 10.3 hours (i.e., the sum of the planning time at level j plus half of each of the planning times at levels j+1 to j+3), instead of 14 hours 30 minutes.

Even if the planning processes at all levels were completely concurrent – see right-hand side of Figure 7 – the planning cycle time would be equal to the longest planning time, i.e., the planning time at level j of six hours.

Another possibility is to flatten the organizational hierarchy, e.g. by removing one level. The benefit would depend on whether the level removed is at the top or at a lower level in the hierarchy, as the following table of planning cycle times shows:

	4 levels	Subordinate removed	Top removed
DMP	14.5	12.6	8.4
Parallel	10.3	9.3	6.2
Concurrent	6.0	6.0	4.0

None of these measures is sufficient to enable us to reach our target of reducing planning cycle time by an order of magnitude. The inescapable conclusion is that, to achieve an order of magnitude reduction, the DMP process itself must also be streamlined. Note that this conclusion is independent of the particular planning process chosen (here DMP).

Radical CTR

More radical measures include omitting a (sub-)process, transferring a (sub-)process to an external entity, removing constraints, and re-partitioning or re-ordering sub-processes and activities.

An obvious sub-process that could be omitted is the “ninth” step of developing an operation order. We have already seen that this delays the planning process. While an operation order is essential for execution, it adds at least two sub-processes that are detrimental to reducing planning cycle time: the need to “parse” an operation order received from the superior commander in Step 1 and part of Step 2, and the need to write an operation order for subordinates in “Step 9”. These steps could be omitted if the C2 system could generate automatically a data-structure representing an operation order when the commander makes his/her decision in Step 8. This data-structure could then be transmitted electronically to the C2 systems of the subordinate units. A “human-readable” version of the operation order would only be generated from the data-structure on demand. The functionality for disseminating planning overlays in graphical form, as in ISIS and BMS, is already a first step in this direction.

Other activities that could usefully be omitted are those associated with deconfliction. This could be achieved by making subordinate units responsible for deconfliction by peer-to-peer self-synchronisation.

It is not obvious that any planning sub-process could be usefully transferred to an entity outside the command team, i.e., outsourcing it. This aspect deserves separate study.

The DMP is highly constrained, and many of these constraints are tacit assumptions. Key constraints include:

- Military organizations are hierarchical.
- Planning is a top-down, linear decomposition process.
- Planning takes the form of rational or analytic decision-making and should be deliberative. There is ample evidence that, in practice, expert planners employ naturalistic decision-making (Schmitt & Klein, 1999) and are more reactive (Holewijn, 2005) than the DMP assumes.
- The only suitable roles for ICT are in processing and displaying data, transmitting information electronically, and accelerating time-consuming, routine processes.

The planning process could be beneficially re-engineered assuming that these constraints do not hold. Then a suitable change in the DCMOTP factors should be sought that enables the constraints to be relaxed.

Some possibilities for re-partitioning planning sub-processes include the following:

- The three activities making up the Intelligence Preparation of the Battlefield sub-process (Step 4) could be re-partitioned. Battlefield area evaluation should be separated from the threat evaluation and integration activities, and performed as soon as a warning or operational order is received. It is possible that battlefield area evaluation could usefully be integrated with the activities of Step 2.
- Currently, a separate organizational unit is responsible for developing intelligence. It may well be beneficial to remove this organizational partitioning between intelligence and C2. This deserves further study.

Finally, we use Wetherbe's (1995) five constructs and 46 points of leverage as a checklist to evaluate this research. We found that:

- The C2 community is already applying several points of leverage. Examples include *automating*, *anticipatory scheduling*, and *standardizing* (all from the operations construct). *Time-boxing* (from the product management construct) is used to a limited extent, as the rule of thumb for dividing the time remaining for planning into one-third and two-thirds demonstrates.
- NEC covers several additional points of leverage, such as *transforming* (from the management / organization construct), *empowering* (from the human resource construct), *prototyping* in the form of concept development and experimentation (from the product management construct), *informating* (from the operations construct), and *networking*, *partnering*, and *risk-sharing* (from the inter-organizational construct). Moreover, Alberts and Hayes' (2007) call for the development of a conceptual model of planning that is consistent with information-age models of Command & Control can be seen as *visioning* (from the management / organization construct). This paper has made this vision more concrete by proposing a target of one order of magnitude reduction in planning cycle time. The NEC idea of "power to the edge" seems to run counter to one point of leverage: *co-locating* (from the human resource construct). Perhaps the challenge here is to employ ICT in such a way that the "edge" involved in collaborative planning feels as if it is co-located, even though it is in reality geographically dispersed.
- This paper has addressed further points of leverage, such as *front-ending* and *flattening* (from the management / organization construct), and *challenging*, *eliminating*, *integrating*, *paralleling*, and *simplifying* (from the operations construct).
- There are two groups of points of leverage not covered so far that offer potential for reducing planning cycle time. *Platforming*, *deriving*, and *re-using* (all from product management) suggest the idea of maintaining a repository of frequently-used COAs or COA segments, together with a tool to retrieve COAs or COA segments that match the current situation and propose them to the planner. *Outsourcing* and *virtualizing* (from the inter-organizational construct) suggest other ways of organizing C2. Outsourcing suggests the idea of outsourcing all or part of the work that the command staff do to another organizational entity that specialises in C2. In essence, this would extend the concept of reachback. Some security companies outsource the operational control of their security guards to a

combined control centre, using call centre technologies. Virtualizing suggests the idea of dispersing or decentralising the C2 process over the subordinate units, retaining a very small command nucleus (e.g. the commander, his/her deputy, and the chief of staff). These ideas deserve more detailed study.

Conclusions and Further Research

This paper reports on on-going research aimed at contributing to the development of a new conceptual model of planning by reducing the cycle time for operational planning by an order of magnitude or more. Experience in other domains show that this should be feasible using technologies such as intelligent planning and scheduling, simulation, and concurrent engineering. Central to this research is the application of business process re-engineering (BPR) methods and associated cycle time reduction (CTR) techniques.

The contribution in this paper is the application of BPR methods and Wetherbe's (1995) CTR constructs and points of leverage to identify promising measures for reducing planning cycle time. The emphasis is on radical measures. The Royal Netherlands Army's Decision Making Process is used as an illustrative example of a planning process. The research shows that it is not sufficient to flatten or to plan concurrently at all levels of the organizational hierarchy. The planning process within each unit must itself be streamlined. Moreover, this conclusion is independent of the particular planning process chosen.

The main limitations of the research reported here are that just one example planning process has been analysed and that it is a somewhat older process that is currently being redesigned to bring it more into line with network-centric operations. Moreover, no concept development and experimentation has yet taken place.

Further research is needed in the following areas:

- There is a profusion of military planning processes. These processes should be compared to identify commonalities and differences and to explain why these commonalities and differences occur.
- Concept development and experimentation is needed into:
  - An electronic operations order that can be sent from one C2 system to another without human intervention.
  - Tools for deconfliction by self-synchronisation.
  - Prototyping a fully concurrent multi-echelon, multi-discipline planning system using concurrent engineering techniques.
  - Applying modelling, simulation, and gaming technologies to the "war gaming" sub-process in which own and enemy COAs are compared.
  - Applying intelligent planning and scheduling technologies to automate or support the COA construction sub-process.
- Further study is needed into:
  - Radical reduction of the planning cycle time by relaxing constraints and assumptions that planning should be a top-down, linear decomposition process performed in a hierarchical organization using rational decision-making and applying ICT simply to process and display data, to transmit information electronically, and to speed-up processes.

- Repartitioning the planning process, such as re-distributing the Intelligence Preparation of the Battlefield sub-process and removing the organizational barrier between military intelligence and C2.
- Exploring the possibility of maintaining a repository of frequently-used COAs or COA segments, together with a tool to retrieve COAs or COA segments that match the current situation.
- Outsourcing and virtualizing the C2 process.

References

AFM1, 2000	Army Field Manual 1. 2000. *Command & Control*. Royal Netherlands Army, The Hague, The Netherlands.
Alberts & Hayes, 2007	Alberts, D.S., and Hayes, R.E. 2007. *Planning: Complex Endeavors*. US DoD Command and Control Research Program.
Arcioni & Van der Plas, 2002	Arcioni, M., & Van der Plas, P. 2002. *Simulators Rapid Prototyping in the Concurrent Design Facility*. Proceedings, 7th International workshop on Simulation for European Space Programmes (SESP2002), European Space Agency, Noordwijk, Netherlands, November 12-14, 2002
Bandecchi et al, 1999	Bandecchi, M., Melton, B., & Ongaro, F. 1999. *Concurrent Engineering Applied to Space Mission Assessment and Design*. European Space Agency Bulletin, 99, September 1999. Downloaded from http://www.esa.int/esapub/bulletin/bullet99_.htm (accessed 10 October 2005).
Boyd, 1996	Boyd, J.R. 1996. *The Essence of Winning and Losing*. Unpublished lecture notes.
Chan, 2000	Chan, S.L. 2000. *Information Technology in Business Processes*. Business Process Management Journal, 6, 3, 224-237.
Davenport, 1993	Davenport, T. 1993. *Process Innovation: Re-engineering work though information technology*. Harvard Business School Press, Boston, USA.
Davenport, 1994	Davenport, T. 1994. *Saving IT's Soul: Human-centred information management*. Harvard Business Review, March-April 1994, 119-131.
Davenport & Short, 1990	Davenport, T.H., and Short, J.E. 1990. *The New Industrial Engineering: Information technology and business process redesign*. Sloan Management Review, 31, 4, 11-27.
Drabble, 2000	Drabble, B. 2000. *From Aircraft to Submarines – A scheduling journey*, European Union Network of Excellence in AI Planning (PLANET) Information Day in Marseilles, France, March 31, 2000. Downloaded from http://www.planet-noe.org/service/Resources/Marseille/drabble.ps (accessed 20 December 2000).
Duffy, 1994	Duffy, D. 1994. *Managing the White Space (cross-functional processes)*. Management, April 1994, 35-36.
Ghallab et al, 2004	Ghallab, M., Nau, D., and Traverso, P. 2004. *Automated Planning: Theory and practice*. Morgan Kaufman, San Francisco, USA.
Grant, 2005a	Grant, T.J. 2005a. *Integrating Sensemaking and Response using Planning Operator Induction*. In Proceedings, 2nd International

	Conference on Information Systems for Crisis Response and Management (ISCRAM), Brussels, Belgium, 18-20 April 2005. SCK.CEN and University of Tilburg, ISBN 9076971099, pp.89-96.
Grant, 2005b	Grant, T.J. 2005b. *Characterising the Planning Niche in a Real-Time Control Architecture*. Proceedings, 24th workshop of the UK Planning & Scheduling Special Interest Group, City University, London, UK, 181-194.
Grant & Kooter, 2005	Grant, T.J., and Kooter, B.M. (2005). *Comparing OODA and Other Models as Operational View Architecture*. Proceedings, 10th International Command & Control Research & Technology Symposium (ICCRTS), McLean, Virginia, USA, paper 196.
Hammer & Champy, 1993	Hammer, M., and Champy, J. 1993. *Re-engineering the Corporation: A manifesto for business revolution*. Harper Business, New York, USA.
Holewijn, 2005	Holewijn, B.J. 2005. *Snel geschoten is vaak raak: Een alternatief model voor militaire besluitvorming*. Militaire Spectator, JRG 174, 10-2005, 430-439. (In English: *A fast shot often hits the target: an alternative model for military decision-making*.)
Koufteros et al, 2001	Koufteros, X., Vonderembse, M., and Doll, W. 2001. *Concurrent Engineering and its Consequences*. Journal of Operations Management, 19, 97-115.
Manganelli, 1993	Manganelli, R.L. 1993. *Define 'Re-engineer'*. Computerworld, 27, 29 (19 July 1993), 86-87.
O'Neill & Sohal, 1999	O'Neill, P., and Sohal, A.S. 1999. *Business Process Reengineering: A review of recent literature*. Technovation, 19, 571-581.
Otondo et al, 2004	Otondo, R.F., Nichols, E.L. jnr., Feder, L., and Hankins, P.D. 2004. *From Cyclical to Systems Thinking: Cycle time reduction in complex systems*. Issues in Supply Chain Management, 1, 3, 2004. Downloaded from https://umdrive.memphis.edu/g-cscm/www/journals.html (12 Jan 08).
Petrozzo & Stepper, 1994	Petrozzo, D.P., and Stepper, J.C. 1994. *Successful Reengineering*. Van Nostrand Reinhold, New York, NY, USA.
Schmitt & Klein, 1999	Schmitt, J., & Klein, G. 1999. *A Recognitional Planning Model*. Proceedings, 1999 Command & Control Research & Technology Symposium (CCRTS 1999), paper 105.
Senge, 1990	Senge, P.M. 1990. *The Fifth Discipline: The art & practice of the learning organization*. Doubleday, New York, NY, USA.
Swink, 1998	Swink, M.L. 1998. *A Tutorial on Implementing Concurrent Engineering in New Product Development Programs*. Journal of Operations Management, 16, 103-116.
Talwar, 1993	Talwar, R. 1993. *Business Re-engineering: A strategy-driven approach*. Long Range Planning, 26, 6, 22-40.
Valiris & Glykas, 1999	Valiris, G., and Glykas, M. 1999. *Critical Review of Existing BPR Methodologies: The need for a holistic approach*. Business Process Management Journal, 5, 1, 65-86.
Van der Kleij et al, 2004	Van der Kleij, R., & le Grand, N.P. 2004. *Maatregelen om de Operationele Besluitvorming te Versnellen: Landmachtdoctrine en de militaire praktijk*. TNO report TM-04-A053 dated 14 September

	2004, TNO Defensie & Veiligheid, Soesterberg, Netherlands (title in English: *Measures for Speeding up Operational Decision Making: Army doctrine and military practice*).
Van der Kleij et al, 2005	Van der Kleij, R., Janssen, H.J.W., & Van den Dobbelsteen, G.J.H. 2005. *Parallelle Planning: Mogelijkheden, randvoorwaarden en beperkingen*. TNO report TNO-DV3 2005 A160 dated November 2005, TNO Defensie & Veiligheid, Soesterberg, Netherlands (title in English: *Parallel Planning: possibilities, preconditions and limitations*).
Wetherbe, 1995	Wetherbe, J.C. 1995. *Principles of Cycle Time Reduction: You can have your cake and eat it too*. Cycle Time Research, 1, 1. Downloaded from https://umdrive.memphis.edu/g-cscm/www/archive.html (12 Jan 08).
Wetherbe & Frolick, 2000	Wetherbe, J.C., and Frolick, M.N. 2000. *Cycle Time Reduction: Concepts and case studies*. Communications of the Association for Information Systems, 3, 13 (May 2000).