Time Resource Management Determines System Effectiveness[1]

A.E.R. Woodcock, Ph.D.*
Guest Professor, National Defence College
Po.Box. 27805, 115 93 Stockholm, Sweden
Telephone Number: +46 8 788 7500
woodcock@syncorp.com

Henrik Friman, MBA.
Department of Operations, National Defence College
Po.Box. 27805, 115 93 Stockholm, Sweden
Telephone Number: +46 8 788 7500
henrik.friman@fhs.mil.se

Abstract

Time Resource Management (TRM) has been identified during the study described in this paper as a critical component in determining the effectiveness of military and civilian activities. TRM is not the simple dependency of processes on the 'arrow' or the 'march' of time but represents the efficiency with which time itself is utilized. In this context, time can be considered to be an intangible resource. While individual sub-processes may proceed with maximal efficiency, the capability of an overall system may be reduced by a failure to link the outputs and inputs of such sub-processes in a timely, coherent, and integrated manner. Time Resource Management is involved in insuring that such linkages take place in an optimal manner.

The impact of Time Resource Management on overall system performance has been examined with the aid of four computer-based models. These models have been developed and used to illustrate the nature of Time Resource Management in the following contexts: (1) Military force attrition capability, (2). Force training and readiness, (3). The transport, storage, and use of physical resources, and (4). The impact of system responsiveness on system performance. Results and insights obtained from the use of these models have provided guidance on the nature of Time Resource Management and how it might be used with benefit to support command and control decision-making, combat management, and a range of other military and civilian activities.

* A.E.R. Woodcock is Vice President and Chief Scientist at BAE SYSTEMS-Synectics, Fairfax, Virginia, USA.

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1. **Introduction**

Military commanders must be able to function in environments characterized by high levels of uncertainty and under great time pressure. Decisions often have to be made on the basis of partial knowledge collected under adverse circumstances in which it may be more important to take actions very quickly, even if such actions are less than optimal and different from those that would be taken under more relaxed conditions. Such problems are associated with the way that resources are provided and used to support on-going activities. There are many different types of resource. Most resources such as weapons, sensors, command and control facilities, supplies, and personnel are tangible entities and can be stored, held in reserve, and then used in order to achieve defined aims and goals. The management of these resources is aimed at providing required amounts of physical entities to physical locations in a timely manner.

The ability to manage time as a resource can also provide significant advantages. However, time itself appears to be a completely different type of resource from the physical resources mentioned above. People often talk about ”time running out,” ”there is never enough time,” and ”time is moving quickly (or slowly),” for example. A perception that events are taking place rapidly can create stresses and force individuals to make decisions and take actions that they might not otherwise have undertaken. However, time cannot be stored for future use as is possible with other more physical types of resource, so the management of time as a resource creates special problems.

Commanders and decision-makers who can manage the time resource will have distinct advantages compared with others who are unable of manage this type of resource. The apparently intangible nature of time creates planning and operational difficulties for those who are faced with its management as a resource. In order to address this problem, a series of relatively simple computer-based models that provide a realization of the properties of the time resource have been developed. These models demonstrate how the ability to control the utilization of time resources in military environments involving combat attrition, training and forgetting, resource transport and use, command and control responsiveness, and related areas can provide significant advantages.

The concept of Time Resource Management (TRM) has been developed during the study reported in this paper to represent the activities associated with the controlled use of time as a resource. What is being examined here is not the simple dependency of processes on the ‘arrow’ or the ‘march’ of time. Rather an attempt is made to develop models that represent the efficiency with which activities are carried out in a particular period of time. Such models provide a representation of the degree of control that individuals and entities are able to exert over the way that time is utilized. High levels of time control are assumed to represent conditions where processes and activities are carried out in some form of optimal manner with minimal delays between events and with little or no unnecessary duplication of effort or repetition of tasks, for example. Low levels of time control, by contrast, are assumed to represent situations involving lack of coordination between events, unnecessary duplication, and repetition of actions that reduce overall efficiency.

This paper will demonstrate how the management of time resources can provide significant advantages in terms of the effectiveness of competing systems (Figure 1). The nature of time resource management will be described and related to the management of other types of resource. The nature of time and its role in combat simulations is also discussed. Four types of computer-based model have been developed and used to illustrate the nature of time resource management in the following contexts:

1. The impact of Time Resource Management on military force attrition capability.
2. The impact of Time Resource Management on force training.
3. The impact of Time Resource Management on the transport, storage, and use of resources.
4. The impact of system responsiveness on system performance.

The paper concludes with a summary of the results obtained from the use of these models and a discussion of some possible further uses of the concept of Time Resource Management.

2. The Nature of Time Resource Management

The study reported in this paper has led to the definition of a property called Time Resource Management (TRM) that can play a critical role in defining the effectiveness of a wide range of command and control, production, and other types of system. In situations involving high levels of Resource Time Management, the linking of events and processes is assumed to produce a highly efficient overall process with minimal interruptions and other distractions that reduce overall productivity. Relatively low levels of Time Resource Management are associated with inefficient processes and low overall productivity.

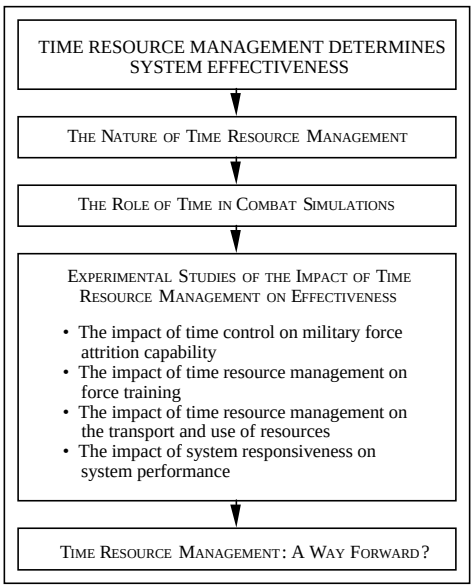

Figure 1: Time Resource Management can determine the effectiveness of military and other types of system.

3. **The Impact of Time Resource Management on Notional Production Systems**

Time Resource Management can insure that component processes in an overall system can act in a coordinated and integrated manner. Military and many other types of system involve the interaction of many sub-systems and processes organized in parallel and serial architectures and the ability to coordinate the timing of such activities can provide significant advantages. High levels of Time Resource Management can support increased levels of production. Absence of such Resource Management can cause a lack of integration and coordination of linked processes and activities that has a negative impact on overall efficiency and production capabilities and thus reduces overall output.

Time Resource Management involves the allocation of time to the undertaking of different tasks. In one case, more of the available time is allocated to Task 1 compared to the other case where more time is allocated for the undertaking of Task 2. While the simple allocation of time to specific tasks will not insure increased overall productivity, coupling the time allocation process to knowledge of the nature of, and relationship between, the tasks can provide the information necessary to increase overall production efficiency.

Time Resource Management is involved in insuring that linked processes are carried out with a minimal amount of delay. For example in "just-in time" activities. Such circumstances could correspond to a very high level of Time Resource Management where the individual processes are linked in ways that prevent any loss of otherwise available production time due to unavailability or delay in the provision of input to the different processes. It is evident that the introduction of such delays in the provision of inputs to down-stream processes can cause serious disruption and may even prevent those processes from functioning at all. Faced with such circumstances, Time Resource Management activities would attempt to increase overall system efficiency and productivity by identifying where delays and other types of process incompatibility take place. This would set the scene for modification of the nature and linkage of the different process sub-components in order to reduce delays and increase overall system coordination.

4. **The Role of Time in Combat Simulations**

In order to discuss the role of time in combat simulations we need to discussion the nature and role of Time Resource Management in military environments. There are many examples of importance for the success of military operations of an adequate understanding of the nature of time. All examples point to the need for command and control activities to be undertaken in the relevant time scales in military operations. They also indicate the existence of many different time scales caused by the different time constants of the different activities, processes, and functions that take place on and off the battlefield. Such differences in time scales can cause friction and lead to inappropriate and unanticipated actions by both friendly and adversarial forces. It is clearly of great importance to understand the nature of time and time scales in this context. Two methods have been used to address such problems: (1) case studies and (2) experiments. Military joint operations have proved to be a complex issue and it is not obvious

that international experiences can be transformed to Swedish circumstances. Other ways involving the use of experiments are needed to collect data.

Time is an essential management asset that can create problems for its utilization [Friman and Brehmer, 1999]. They point out that executives normally talk about linear time measured by watches, and ask the question that if time is so simple, why do problems arise when attempts are made to use the time asset? They also observe that discussions of time are abstract, and time is often related to specific events in order to make it more concrete. Studies have shown that differences can exist between the objective time of what people may agree about and the subjective time related to the individual perception of the progression of events and activities. In strategic war-games time itself is not generally the focus. In military studies, there is a long tradition of using war-games to create decision support capabilities or to train officers. In these games the three geographical or spatial dimensions have been of central interest and time is often taken for granted or assumed to progress in a uniform manner. In war-games understanding the nature of the time scale is essential, but still very little emphasis is put on time management in strategic games. If it is necessary to create a representation of the nature of battle dynamics, more emphasis should be placed on descriptions of the properties of the time scales used in such games. Results from these activities could provide insight into the nature of intuitive battle dynamics.

A model called OpWar (Operational War) has been developed as a conceptual facility that describes war on an abstract level [Friman and Brehmer, 1999]. A causal loop representation of the processes associated with the allocation of resources either to planning or to direct activity provided by the OpWar model is shown in Figure 2. In the OpWar concept, resources are allocated to planning activities and to direct activities involving actions that are aimed at achieving specified goals and missions within defined planning horizons. The concept permits the weighting or selective allocation of resources to planning and direct activities. In some cases, detailed planning may be necessary while in other cases, relatively small amounts of planning effort maybe needed to support relatively extensive operations. Higher-level control activities can be used to monitor the efficiency of the use of resources by planning and direct activity and to modify such resource allocations where necessary. Such control activities can play a critical role in responding to planning uncertainties by modifying the relative emphasis on planning and direct activity tasks within the overall operational environment.

The OpWar model was implemented in Powersim (a modeling and simulation software system based on systems dynamics principles). During use of the model, events could be controlled by changing the values of six parameters of interest. Users were provided with information on the total level of resources remaining as well as the degree of control. Initial use of the model failed to detect any relations between executive experience level and time perceptions or capacity to handle time in the model. Subsequent work by the model users, which involved the development of more customized operational knowledge representations, did provide an enhanced insight into the nature of causal relations in the combat environment. This work with the OpWar model demonstrated the need for additional modeling and simulation activities to be undertaken in order to explore the role of time in combat modeling and simulation. Results of such activities are reported in the next section of this paper.

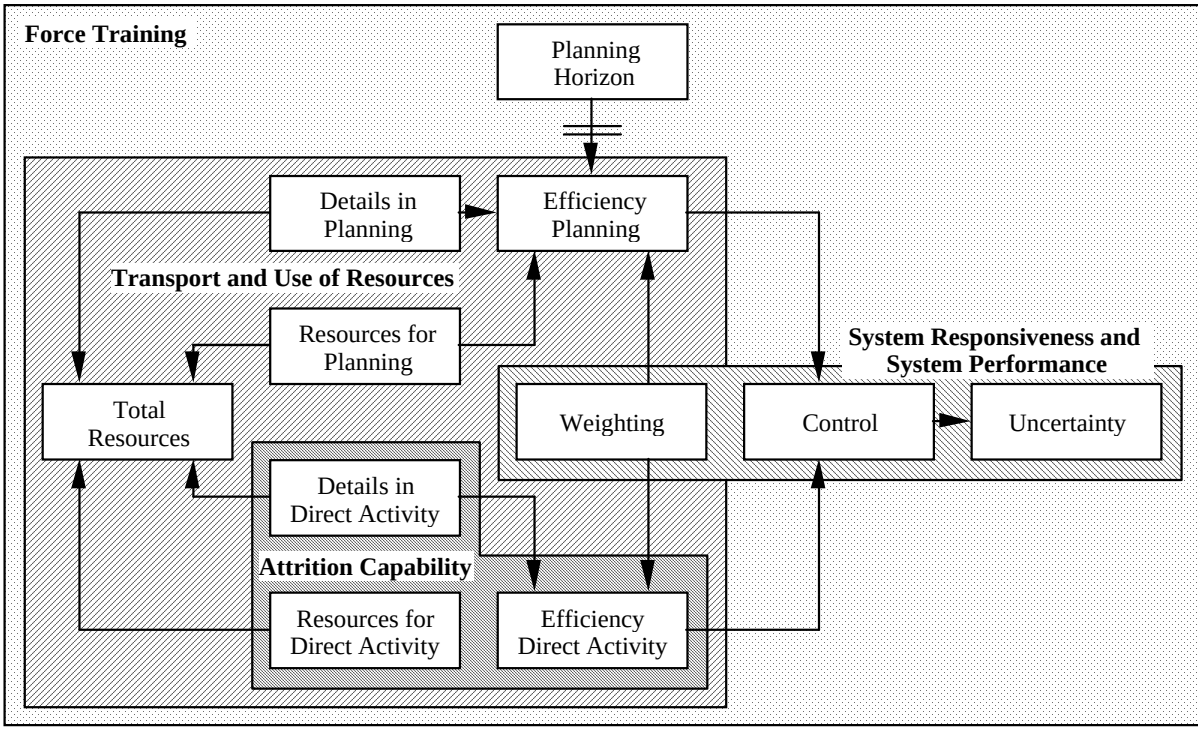

Figure 2: Causal loop relationships for the OpWar model developed to provide new insights into the use of time and other resources in war operations (After: Friman and Brehmer, 1999).

5. Experimental Studies of the Impact of Time Resource Management on System Effectiveness

These initial studies with the OpWar model demonstrated that time is an essential component in the understanding of the nature of battle dynamics. The studies also showed that commanders put most effort in building situation awareness based on the review and analysis of historical data rather than in creating forecasts of future activities. Initial discussions of the property referred to as Time Resource Management in this paper indicated that additional studies were also needed to develop an understanding of the role of such management capabilities for undertaking planning, operational, and other activities.

This section of the paper describes the development and use of four models that have provided insight into the nature and importance of Time Resource Management. Results of these studies can provide the basis for the development of a more fundamental understanding of its role in a wide range of command and control decision-making and defence management environments.

Four different computer-based experiments were undertaken in order to study the nature and impact of Time Resource Management on system performance. In each case, a relatively simple model was developed or enhanced using the Powersim software system. These models were used to demonstrate the impact of changes in the levels of the model control values representing time control and other properties on the model-generated output. In three of these models, the level of Time Resource Management is represented by the value of a parameter referred to as Time Control. High values of Time Control in these experiments were assumed to represent high levels of Time Resource Management. Under such conditions little if any distractions or interruptions of system behavior from the intended behavior occur was assumed to take place. Low Time Control values are assumed to represent highly distracting conditions associated with low levels of Time Resource Management. It is a consequence of such definitions that systems with a high level of Time Control would tend to be more efficient and produce higher levels of output while systems with lower levels of Time Control would be less efficient and generate lower levels of output.

The four models used in the study were used to undertake the following investigations:

1. *The impact of Time Resource Management on military force attrition capability*. The model developed for this study consists of a version of one of the Lanchester combat attrition equations enhanced to incorporate a representation of the level of Time Resource Management represented as a parameter referred to as Time Control. This part of the overall study provided information on aspects of the Details in Direct Activity, the Resources for Direct Activity, and Efficiency [of] Direct Activity components of the OpWar model (Figure 2).

2. *The impact of Time Resource Management on force training*. The model developed for this study was an enhanced version of an earlier model of learning and forgetting developed by Woodcock (1993). The enhanced model provided a representation of the impact of Time Resource Management in terms of a Time Control parameter. The model also incorporated the explicit impact of personal motivation, training time, and distractive noise on training performance. This part of the overall study provided information on aspects of all components of the OpWar model (Figure 2).

3. *The impact of Time Resource Management on the transport and use of resources*. The model developed for this study represented the impact of Time Resource Management on supply and use rates and storage levels reflected in the values of Transport and Use Time Control parameters. The model was based on an earlier model developed by Woodcock and used during a course at the Swedish National Defence College in 1999 [Woodcock *et al*., 1999]. This part of the overall study provided information on the Total Resources, Details in Planning, Resources for Planning, Efficiency [of] Planning, Details in Direct Activity, the Resources for Direct Activity, and Efficiency [of] Direct Activity components of the OpWar model (Figure 2).

4. *The impact of system responsiveness on system performance*. The model used in this study incorporated a system responsiveness parameter in an existing thermostat control

model. This model was provided as a functional example in the documentation of the Powersim system [Powersim, 1998]. This part of the overall study provided information on aspects of the Weighting, Control, and Uncertainty components of the OpWar model (Figure 2).

6. **Results from the Study**

Significant research has been undertaken in the development of models of military systems involving time-dependent processes in which properties of the environment undergo changes as time progresses. The major foundations for such research are the Lanchester combat equations developed initially in the second decade of this century (see Dockery and Woodcock, 1993, for example). Lanchester models are essentially time-dependent process models where the change in the strength of one force is proportional to the strength of an adversarial force, and *vice versa* for the other force. Such proportionality is represented by parameters called attrition coefficients that reflect the combat capabilities of the two opposing forces. This work has provided the basis for generations of combat-related modeling and simulation activities. Many large, advanced, military simulations consist of models that are based on Lanchester-related concepts. Other models and simulations have incorporated time- and space-dependency in fundamental ways through the use of such techniques as Intelligent Automata.

The relatively simple computer experiments undertaken in this study have demonstrated the impact of a parameter defined as Time Control. This demonstration of the impact of modeled Time Control parameter on outcomes leads naturally to the need to define the operational properties of Time Resource Management. Time Resource Management has impact on:

1. *The force capability and force attrition*. Results obtained from the use of the enhanced version of the Lanchester Aimed Fire model suggest that the ability to coordinate and use inter-dependent activities to achieve defined goals in multi-component systems can provide significant advantages. Additional modeling and analysis activities with other Lanchester-based time-dependent models and/or time and space-based models based on Intelligent Automata, for example, could provide a basis for the development of new approaches to overall system resource management.

2. *The training of military forces*. These model-based experiments have demonstrated the impact of Training Rate, Training Period, Motivation, and Time Control on the ability of individuals to perform above a specified criterion level. Computer-based experiments with the first three of these parameters provided a baseline against which the experiments on the impact of Time Control, representing Time Resource Management, were carried out. The Training Rate parameter used in the model is associated with the intensity of the training effort and can be considered to represent the amount of the total material that is presented to the students during each time interval of the training process. The Training Period is the total duration of the training activity. This training period is assumed to be continuous in the models described in this paper. Training involving distinct isolated periods of learning can be represented by a multi-phased learning and forgetting process in which much or all of the learned materials

might be forgotten if the intervals between training episodes is sufficiently long and the rate of forgetting particularly rapid (see: Woodcock, 1993, for example). The Motivation parameter reflects the willingness of the students to learn the materials presented during the training process.

Time Control as specified in this model is assumed to represent the degree to which the brain of the student provides access to the neural processes associated with sensory detection, perception, cognition, learning, and knowledge development. The ability of such processes to take place are also influenced by noisy distractions created by external human, mechanical, electronic, environmental, and activities that disrupt the transfer of data and information from the teacher or trainer to the student.

3. *The transport, storage, and use capabilities*. The experiments have demonstrated the impact of different rates of the consumption of resources on the dynamics of an integrated transport, storage, and use system. Low consumption rates can be offset by a regular low-level transport supply capability. However, higher rates of consumption can cause the amount of materials in storage to drop below a user-definable threshold level. The system responds to this storage shortfall by providing a user-definable boost supply. The storage and consumption graphs exhibit saw-toothed profiles as the result of such supply boosts. This behavior assumes that all of the linked processes take place with minimal delay on a ”just-in-time” or ”as-needed” basis. The study has investigated the consequences of delays on overall system performance.

The impact of Time Resource Management on the transport, storage, and use processes associated with a linked supply and consumption system has been investigated during the study. A parameter defined as U_Time_Control that represents the Time Resource Management associated with those processes involved in the movement of materials from storage, their provision to consumption facilities, and their use by those facilities. High levels of the U_Time_Control parameter reflect situations where the linked use-related processes take place with minimal delays. The computer experiments reveal that boosts in resource supply are needed when the use rate is relatively high and the U_Time_Control parameter is at or close to unity, reflecting good Time Resource Management. Reducing the U_Time_Control parameter to a low value reflects poor Time Resource Management conditions and such conditions can produce relatively low rates of consumption. Under some circumstances of high nominal use rates the result of poor Time Resource Management creates sufficiently low consumption rates that the need for additional boost supplies to be made available to the system is prevented. Such conditions could occur, for example, when large amounts of materials are shipped into airport or road transport storage facilities and remain unused despite a need for, and an ability to use, such materials.

The transport-related aspects of the impact of Time Resource Management on the transport, storage, and use processes associated with a linked supply and consumption system has also been investigated in this study. In this case, a parameter called Tr_Time_Control has been defined to represent the quality of the Time Resource

Management of the overall transport processes involved in moving materials from a production facility to a storage depot. High levels of the Tr_Time_Control parameter reflect good time management capabilities as materials are moved into storage in a timely manner with little or no delay. Low Tr_Time_Control values reflect poor time resource management conditions where significant delays in the components of the overall transport process produce inefficiencies and lost opportunities for consumption. The computer generated graphs produced for low Tr_Time_Control values show a very irregular behavior. Such behavior might be caused by a failure to provide adequate levels of materials to the storage facility and further studies of these phenomena are clearly needed.

This investigation has not considered the impact of the quality of Time Resource Management on the initial production of the resource materials that are transported to the storage facilities described in the model. The inclusion of models of the production process from the processing of raw materials to the production of finished products could provide the basis for a more comprehensive analysis of the impact of Time Resource Management on supply and consumption processes. Of interest in this context would the development of cost models that provide an indication of the impact of Time Resource Management on the economics of supply and consumption systems. A relatively inclusive and realistic model of such systems could be used to identify bottlenecks and other problem areas and to assess their economic cost impact on overall system capabilities. Additional work could explore the impact of different Time Resource Management strategies on minimizing cost and increasing overall economic, production, transport, storage, and consumption efficiencies for systems of interest.

4. *The system responsiveness and system performance*. The command and control of military and other systems depends on an ability of the leadership to specify goals and missions; collect, analyze, and assess information; develop tactics and strategies; and issue orders aimed at achieving those goals and missions. Dockery and Woodcock (1993) have defined command as a feed-forward process and control as a feedback process. Models involving feed-forward and feed-back could represent the behavior of command and control systems in which commands are issued in order to trigger events aimed at achieving particular goals. Control activities represent a feedback of information to the command entity about actual system behavior and such activities could lead to the issuing of additional commands. The ability of the system to respond in a timely manner will depend on its responsiveness in detecting and responding to changes in the environment within which a system of interest operates.

These experiments have demonstrated the applicability of a metaphor based on a thermostatic control system can provide insights into the possible behavior of other types of control system. In particular, the impact of the modeled Responsiveness parameter on the behavior of the feed-forward and feed-back components of the thermostat system appear to suggest implications for the design of military command and control systems. Conditions of low responsiveness can prevent a system (in this case the thermostat system) from achieving a desired goal. Conditions of increased

responsiveness can cause the thermostat systems to reach a goal rapidly, and even overshoot the goal as the heat losses are replaced by additional heating.

Command and control systems with hyper-vigilant individuals could exhibit rapid changes in behavior as the system attempts to track rapidly changing external conditions and internally defined requirements. Such systems could be characterized as Low Inertia systems since they could undergo relatively rapid changes in behavior. By contrast, systems consisting of individuals and processes with low Responsiveness capabilities can be described as High Inertia systems due to their relative inability to respond to changing conditions in a timely manner. Such system could even be incapable of achieving desired goals or end-states in ways that are metaphorically similar to the inability of a poorly responsive thermostat system to reach a desired temperature goal.

Lack of system responsiveness can be attributed to an inability to manage the allocation and use of the time resource. Such inability could result in the lack of coordination and integration of linked processes in a multi-component system where the output of one component is made available to other components with significant delay. The resulting loss of time for potential processing and other activities caused by these delays can reduce overall system efficiency. High levels of system responsiveness can permit the output from one process to be made available relatively rapidly to other components in the system. While this may increase system efficiency, excessive rates of production in parts of a system may actually have a negative impact if all components of the system are not able to increase their levels of activity in a commensurate manner. Under these conditions materials may collect at process bottlenecks and prevent the smooth, integrated, behavior of an overall system.

The possibility that such behavior might occur under conditions where the components of a system possess different levels of responsiveness and where the time resource is managed in different ways in these components, suggest that additional model-based studies should be undertaken. These studies could investigate the behavior of systems composed of a relatively large number of linked network components each with particular input, processing, and time resource management capabilities. It is expected that the results of such studies could provide additional insight into the nature and behavior of multi-component systems that could guide the production of a new generation of Time Resource Management facilities, for example.

7. **Summary and Discussion**

The nature of the Time Resource Management concept has been studied with the aid of four simple computer-based models that are themselves an extension of earlier models. The models used in this study permit an analysis of the impact of Time Resource Management on: (1). Military force attrition capabilities; (2). Training involving learning and forgetting; and (3). The transport, storage, and use of resources. (4) A fourth model permits analysis of the impact of system responsiveness on system performance. Results of this study have shown how the ability to control the use of the Time Resource can provide significant advantages to individuals involved in both civilian and military activities.

In particular, results obtained from the use of the Lanchester equation-based combat attrition models show that high levels of resource management can offset disadvantages caused by otherwise relatively ineffective combat systems. Results obtained from the learning and forgetting model show that effectiveness is increased when high levels of Time Resource Management (which has been assumed to be associated with the allocation of internal neural-based assets) are made available within the brain of a student during the training process. Poor Time Resource Management of transport and utilization processes can negatively impact the capabilities of supply and consumption processes compared with systems with better management facilities. System Responsiveness, which has been described in terms of Time Resource Management concepts in the paper, can create conditions of hyper- or hypo-vigilance that can lead to over-reaction or under-reaction, respectively, to changing circumstances.

With the saying that ”time is money” in mind, it is possible to identify how the work described in this paper might be extended to provide an analysis of the economic and financial implications of Time Resource Management (Figure 3). Additional studies could generate new models that could be used to study the cost-effectiveness of different types and methods for Time Resource Management as applied to combat modeling, training, supply and consumption systems, and command and control capabilities.

We have already seen, for example, that longer training periods or more intense levels of training are needed to offset the impact of relatively poor Time Resource Management in training activities. Increased training time and training intensity would generally be more expensive than shorter training times and less intense training efforts. It should be possible to quantify these additional costs and provide them as input to a more advanced model for analytic purposes. While further research is needed on the nature and role of time Resource Management in this context, it is possible to make the following observations: The control of Time Resource Management clearly involves the internal neural-based capabilities of the students involved in training. Experienced individuals often appear to have developed particular strategies for learning, and such strategies represent increased Time Resource Management capabilities. It is possible that increased level of Time Resource Management could be achieved by providing some form of pre-training information about learning how to learn that could facilitate the overall process. The cost of such pre-training could also be included in a cost-effectiveness analysis of the impact of Time Resource Management on training activities.

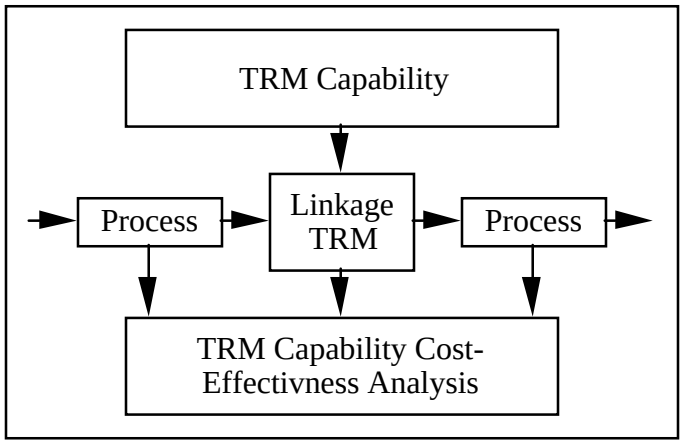

Figure 3: Future work could study the cost effectiveness of Time Resource Management in different application areas.

High quality Time Resource Management also appears to provide significant advantages as reflected in the results obtained from the Lanchester Aimed Fire combat model ad the supply and consumption models described above. Additional model-building activities could concentrate on the development of more extensive and realistic representations of both systems. Of particular importance in this context would be the need to develop component and interface models of the links between the sub-components and sub-processes involved in supporting overall system activity. Such representations are critical since it is in the interface between components that Time Resource Management can play the critical role in determining that materials and other inputs are provided to down-stream processes and activities on a timely basis with minimal delay. Reductions in such delays would permit the system components to be active for longer periods of time, insuring that the Time Resource was utilized to the maximum extent possible.

Inclusion of the Responsiveness concept into command and control models can provide a representation of the ability of individuals and entities to reduce the delay between the receipt of input information and the generation of orders that trigger actions by subordinates. Additional studies are needed to examine the nature and role of Responsiveness and its relationship to the Time Resource Management concept.

Another area of interest and concern is the need to understand the impact of Time Resource Management in extensive systems where different qualities of such management are provided to the different components of an overall system. Such extensive systems could include distributed military command and control and combat systems; communication networks; and distributed production, storage and consumption facilities. The concept of Network Centric Warfare envisions complex multi-component combat and command and control systems with parallel and serial links between components. In all cases, is evident that an understanding of the nature and role of Time Resource Management could provide significant benefits.

In the notional example illustrated in Figure 4, the processing and linkage components of a large system may are divided into three regions, each with a different quality of Time Resource

Management. Such differences could be caused by such factors as the intrinsic nature of the processes and the links between the processes in these regions, the personalities and task-related capabilities of the management personnel and their interactions with subordinates, the personalities and task-related capabilities of those subordinates, and the levels of other facilitating resources provided to these regions. Other differences could be caused by difference in perception of data and information provided in the different regions and the overall level of training and experience of the individuals concerned.

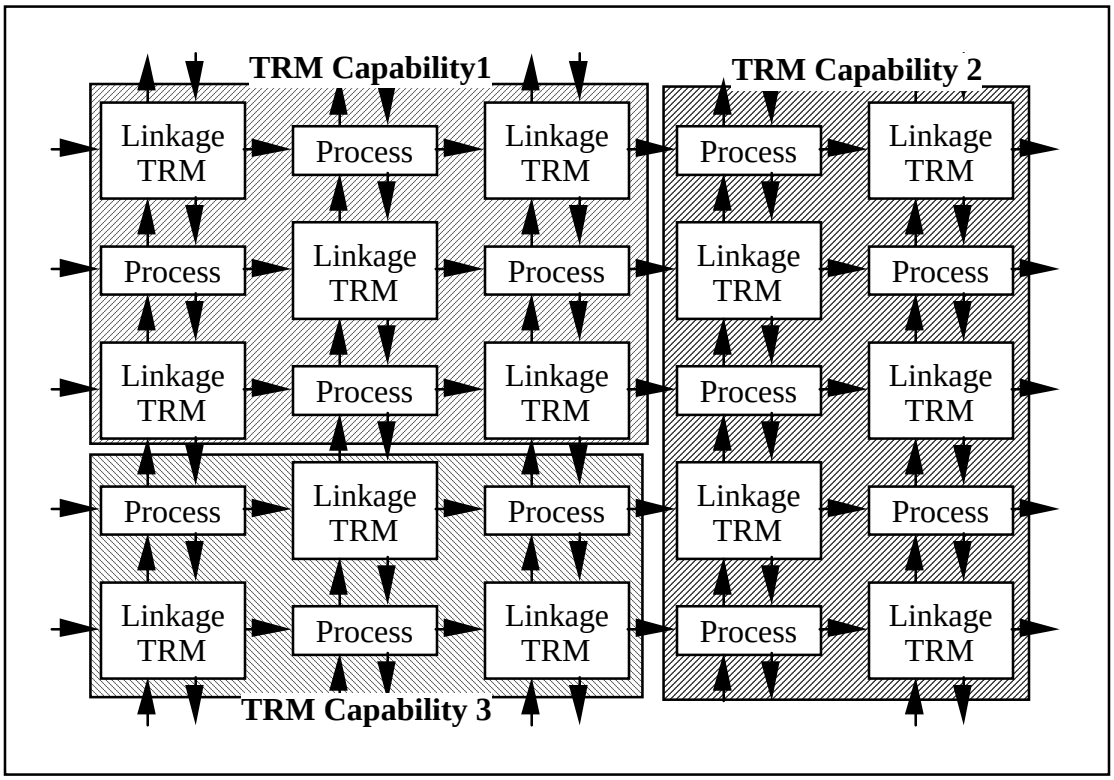

Figure 4: Extensive multi-component systems may involve different qualities of Time Resource Management for different components.

These matters provide extra dimensions of complexity to the problem of resource management and entity control. It is clear from this very brief discussion that additional modeling and analysis-based studies are needed to gain an appropriate level of insight into the nature and role of Time Resource Management in extensive multi-component systems. Such insights could provide the basis for the development of new techniques and processes that would provide high quality Time Resource Management to support existing and new activities in both the military and the civilian sectors. The authors are very interested in being involved in such studies in the future.

8. **Resource Materials**

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