Network Centric Operations and the Brigade Unit of Action:
A System Dynamics Perspective

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Abstract

In the midst of fighting a global War on Terror, the U.S. Army is concurrently attempting to transform to a more agile and deployable organization, which is centered largely on the integration of new information technologies into its command posts. While most Army leaders are reporting that many of these new information "tools" such as the Army Battle Command System (ABCS) give them an unprecedented level of situational awareness and are beginning to enable a new style of war labeled by some as Network Centric Warfare, other leaders are reporting that the integration of this new digital technology comes with some unintended consequences that in some cases actually slows and decreases the quality of information flow by orders of magnitude. We studied the "Brigade Unit of Action" concept with specific emphasis on the Brigade's ability to disseminate and process information within and between command posts, using System Dynamics as a modeling tool to help better understand the impact of various policy decisions made by the U.S. Army. Our study concentrated on some of the possible strengths and pitfalls of NCW theory, and led to the formulation of five heuristics that Army leaders should consider when developing the future command and control architecture for the Brigade Unit of Action.

Introduction

As the U.S. Army conducts transformation in the midst of an ongoing information driven Revolution in Military Affairs (RMA) and the War on Terror, there has been an increasing emphasis placed on the need to develop leaner, more agile, versatile and deployable forces. Much of this initial effort has focused on improving the "tooth to tail" ratio of Army forces and transferring from a Cold War "Divisional" force structure to one focused around more deployable and sustainable Brigade Units of Action.[1] Ironically, this transformation to what is supposed to become a more lean and deployable force structure has produced larger and more heavily staffed battalion, brigade and division command posts. Despite introduction of the Army Battle Command System (ABCS), a system of digital systems that are intended to help speed up the Army's ability to transfer information, improve situational awareness, make decisions, and maneuver on the battlefield, in some aspects the Army may have actually taken a step backwards.

Unfortunately, these larger command posts are becoming more hierarchical and bureaucratic, and are often decreasing the Army's ability to get ahead of the enemy's decision cycle. Our research examined one small aspect of this problem, the architecture of the Battalion Tactical Operations Center (TOC), and its interaction with its higher and subordinate headquarters within the Brigade Unit of Action. Our research began with an extensive literature review of the latest Network Centric Warfare (NCW) and other current military literature, and included a number of interviews with U.S. Army officers. Most of these officers were Captains who served as Company Commanders in Iraq and Afghanistan, and as Battalion, Brigade and Division Assistant Operations Officers in charge of daily TOC operations. We then developed a System Dynamics Model (SDM) that would allow us to simulate the impact of various policy decisions on the quality of information flow both within the Battalion TOC (internal information flow) and between the Battalion TOC and both its higher Brigade Headquarters and its subordinate Company Headquarters (external information flow).

[1] In this paper, the terms Brigade Combat Team (BCT) and Brigade Unit of Action are used interchangeably. Both describe a combined arms capable, Brigade size combat unit, consisting of approximately 3,000 to 3,500 soldiers.

Background and Context

Since the fall of the Soviet Union and the First Gulf War in the early 1990s, two major trends have begun to revolutionize the face of war. The first is the change in the nature of the threats faced by the United States and its allies, and the second is the recent surge in the creation of new information technologies. In the case of the first trend, increased world instability and the elimination of a peer rival has forced America's "weaker" enemies to adopt asymmetrical capabilities, while the U.S. Army has also been called on to operate against a more distributed threat and on noncontiguous battlefields (e.g. Afghanistan and Iraq). These two changes to the nature of the contemporary operating environment has forced Army leaders to re-look practically every aspect of its current organization and policies, which has produced many changes. Concurrently, new information technologies including the internet and satellite digital and voice communications have led to new theories on war such as NCW and Effects Based Operations (EBO), both of which many believe will help the U.S. and its allies to win not only against the rise of a peer competitor, but will also help it to deal with new asymmetrical threats.

In creating new Brigade Units of Action, Army leaders hope to create lighter, more deployable, and logistically sustainable units that can deploy anywhere around the world and conduct full spectrum operations (offensive, defensive, stability and support). The linchpin to the new Brigade Units of Action operational concept is a family of digital information systems, similar to the ABCS, which is being developed and integrated into the Brigade using a spiral development and integration model. Nevertheless, despite these new digital information tools, the Brigade Unit of Action's hierarchical architecture and Battalion TOC layout has not changed significantly from the traditional configuration. What has changed, is the size of the TOC and the amount of communications and computer equipment as well as personnel needed to operate this equipment. Figures 1-3 below depict a simplified hierarchical architecture of the new Brigade Unit of Action, an example of a typical Battalion TOC layout, as well as a diagram depicting the composition and interaction of the ABCS systems, which are enabled by a combination of both line of sight and satellite communications technologies.

Simplified Brigade Unit of Action C2 Architecture

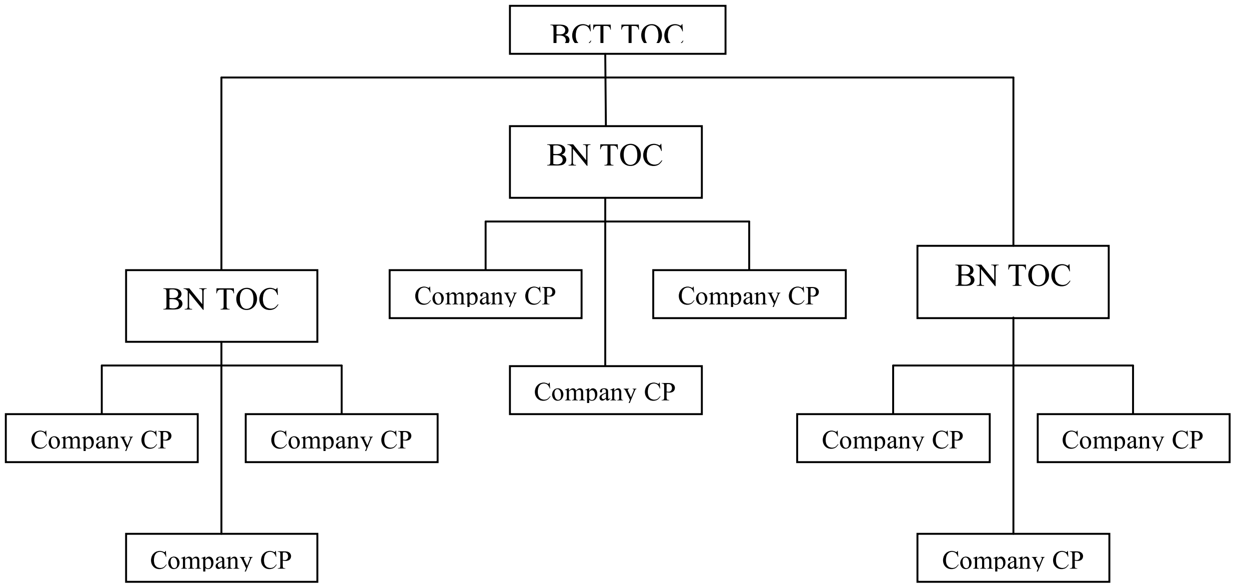

Figure 1 (Simplified Brigade Unit of Action C2 Architecture)

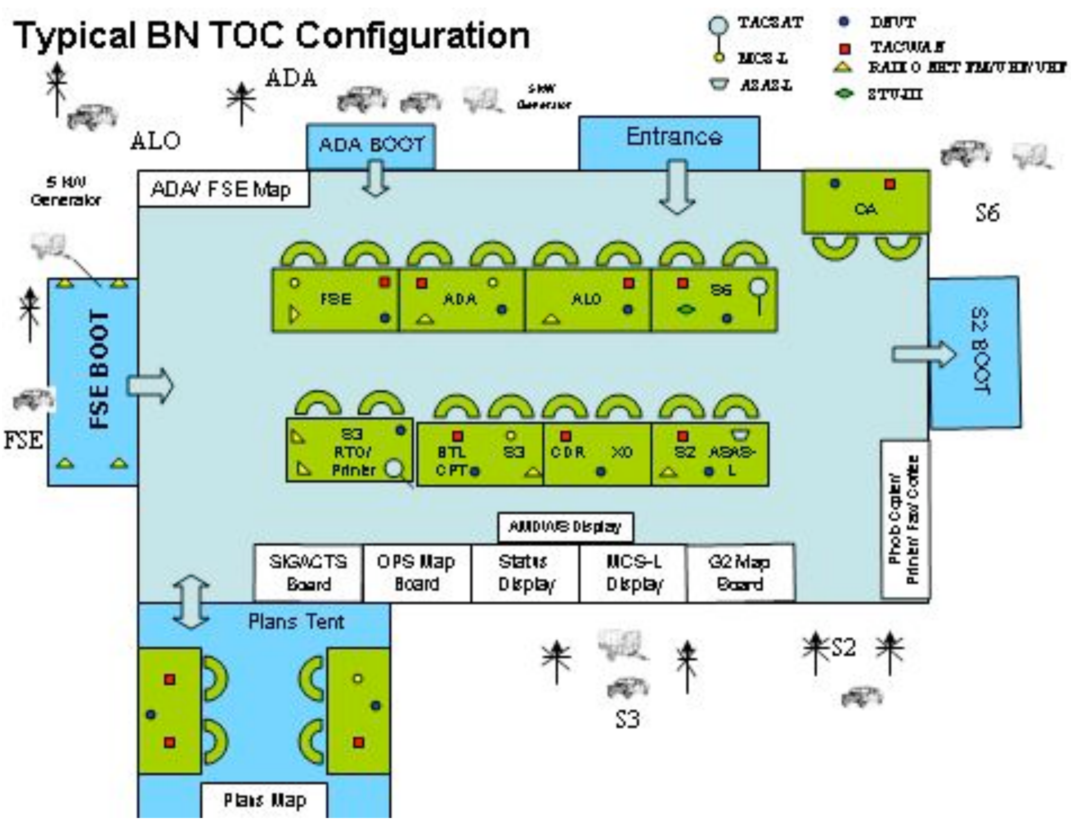

Figure 2 (Typical Battalion TOC Configuration)

Figure 4.7
ABCS Components

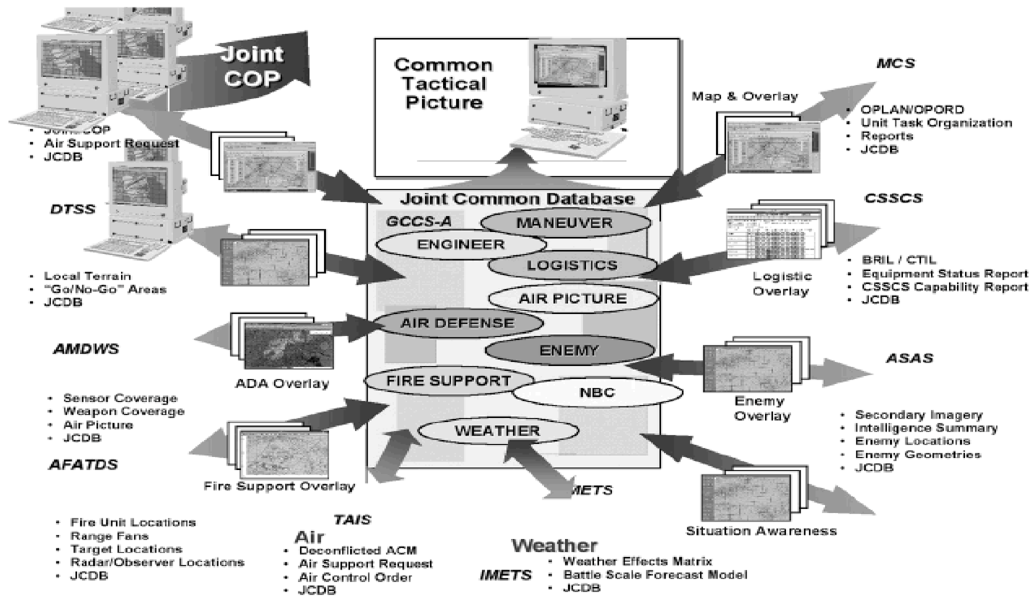

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Figure 3 (ABCS Systems Concept)[2]

Much of the focus in creation of the Brigade Units of Action, as well as discussion found among various authors within NCW and EBO literature, is centered on how new digital systems such as the ABCS will affect the interconnectivity and command relationships between units.[3] Central to this debate is discussion over whether a centralized or distributed (sometimes called network) command structure is optimal. To date, there has not been any revolutionary changes to Figures 1 and 2, with the exception that the TOCs and Command Posts at all levels (Company, Battalion, and Brigade) are becoming larger in physical size, equipment, and personnel; and that the time to transfer information between hierarchical levels within the Brigade organization is often taking longer than desired.

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[2] RAND, p. 54.

[3] Specifically, much discussion is taking place regarding how new digital systems such as the ABCS in Figure 3 will affect the traditional hierarchical architecture shown in Figure 1, as well as how they will fit into and change the configuration of the Battalion TOC as in Figure 2.

System Dynamics Modeling

In our attempt to better understand the various aspects of this problem, we began by constructing two conceptual, high-level, System Dynamics models that would help us to better understand the effects of various feedback loops involved with internal and external TOC information flow. Shown below is the conceptual model that we developed for Internal TOC Information Flow.

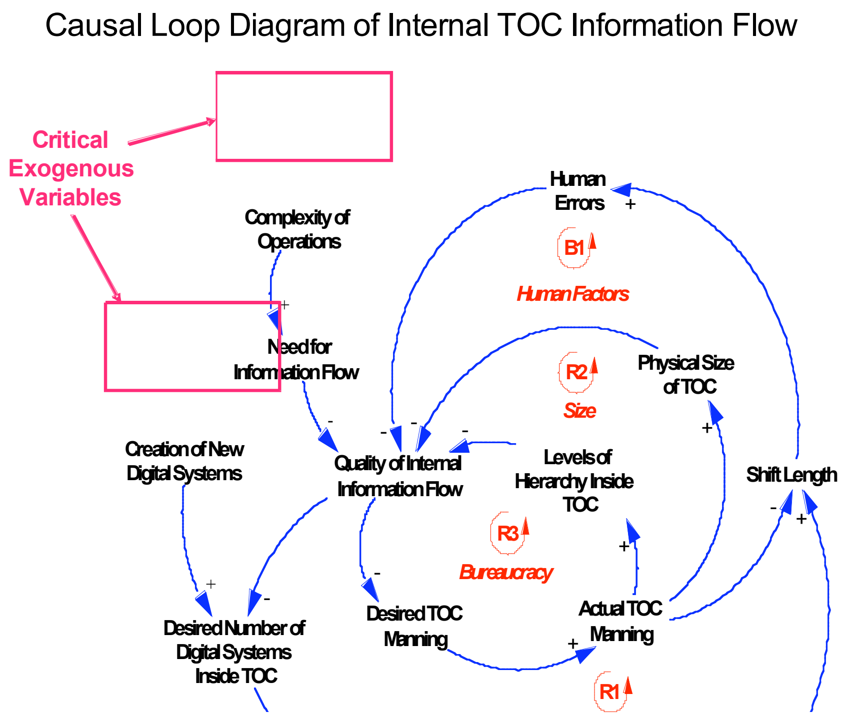


Figure 4

As shown in Figure 4 above, there are three critical reinforcing feedback loops and one key balancing loop that affect the Quality of Internal Information Flow as determined by manning requirements, bureaucracy, size and human factors. The critical endogenous variables in this model are Quality of Information Flow which is a dimensionless variable that measures the Quality of Information Flow on a scale of 0-10, with 5 being "normal." Other key endogenous variables are Actual TOC Manning, Shift Length, and TOC Manning Requirements. The critical exogenous variables are Complexity of Operations and Creation of New Digital Systems. As evidenced from our literature review and interviews with officers, the complex nature of current U.S. military operations in Iraq and Afghanistan calls for an increased number of functions to be conducted within the TOC. This includes a greater amount and increased types of information to be transferred between TOCs, placing greater requirements on the flow of information within the TOC, not to mention increased manning levels. The second variable, Creation of New Digital

Systems has led to an increase in the number of systems on the market and therefore a greater appetite to acquire these systems and place them inside the command post to help in enhance information flow. These systems include the ABCS systems, as well as additional laptop computers, plasma/LCD screens, radios, etc.

After developing the conceptual System Dynamics model for internal information flow, we then created a causal loop diagram to help us better understand the effects of the different variables and feedback loops that affect the Quality of External Information Flow. The dynamics involved with external information flow are somewhat different than those involved with internal information flow. The critical feedback loops affecting the Quality of External Information Flow are Digital System Acquisition, and Connectivity and Learning, as depicted in Figure 5 below.

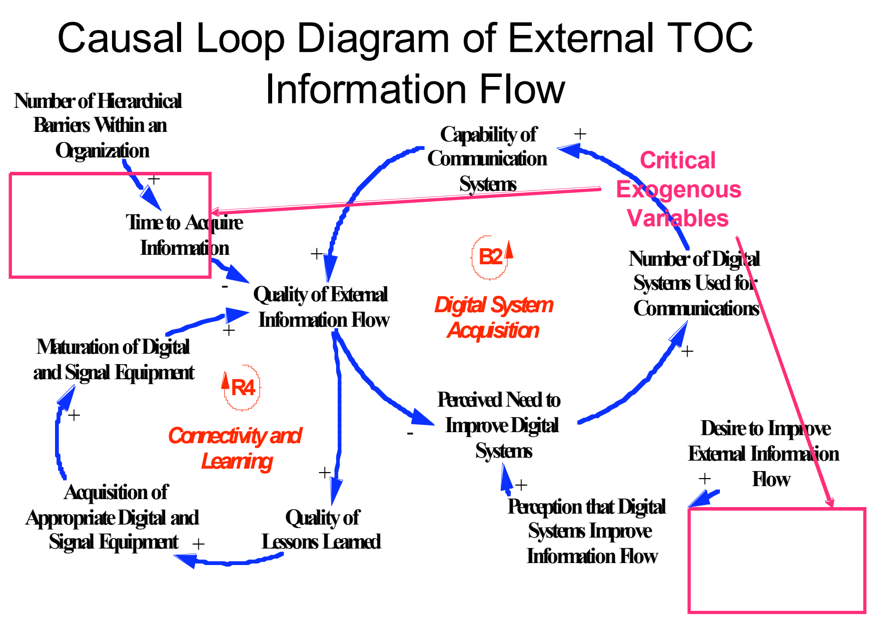


Figure 5

As shown above in balancing loop B2, an increase in the Quality of External Information Flow lowers the Perceived Need to Improve Digital Systems. As the Perceived Need to Improve Digital Systems decreases, the Number of Digital Systems Used for Communications decreases, and over time the Capability of Communications Systems decreases, which results in a decrease in the Quality of External Information Flow. Concurrently, as the Quality of External Information Flow increases, the Quality of Lessons Learned inside the TOC also increases, which leads to the acquisition of appropriate digital and signal equipment, which then improves the Maturation of Digital and Signal Equipment and therefore improves the Quality of External Information Flow. While these two loops alone would produce some variation of S-shaped growth in the Quality of External Information Flow, two other exogenous variables are critical in this model. The first is the Desire to Improve External Information Flow, which produces a constant increase in the Perceived Need to Improve Digital Systems. While this has a positive effect on external information flow, as can be seen in Figures 4 and 6, it also has the unintended consequence of leading to an increase in TOC Manning and therefore an increased size and bureaucracy of TOCs, which decreases the quality of internal information flow. The second critical exogenous variable here is the Number of Hierarchical Barriers within an Organization. An increase in the number of hierarchical barriers means that there are more TOCs or "nodes" through which the information must be sent, with a delay occurring at each node. Therefore, an increase in the Number of Hierarchical Barriers ultimately produces a decrease in the Quality of External Information Flow as information has a higher propensity to arrive late.

Finally, Figure 6 below shows the combination of the Internal TOC Information Flow model and the External TOC Information Flow model into one combined conceptual System Dynamics model. The key link between the two models is the variable Number of Digital Systems Inside TOC. Appendix B shows the actual low-level System Dynamics model used for this study. It is much more complex than the conceptual models described here but is based on the same major concepts.[4]

[4] For a fully documented version of the model, please contact the authors.

Combined Causal Loop Diagram of Information Flow

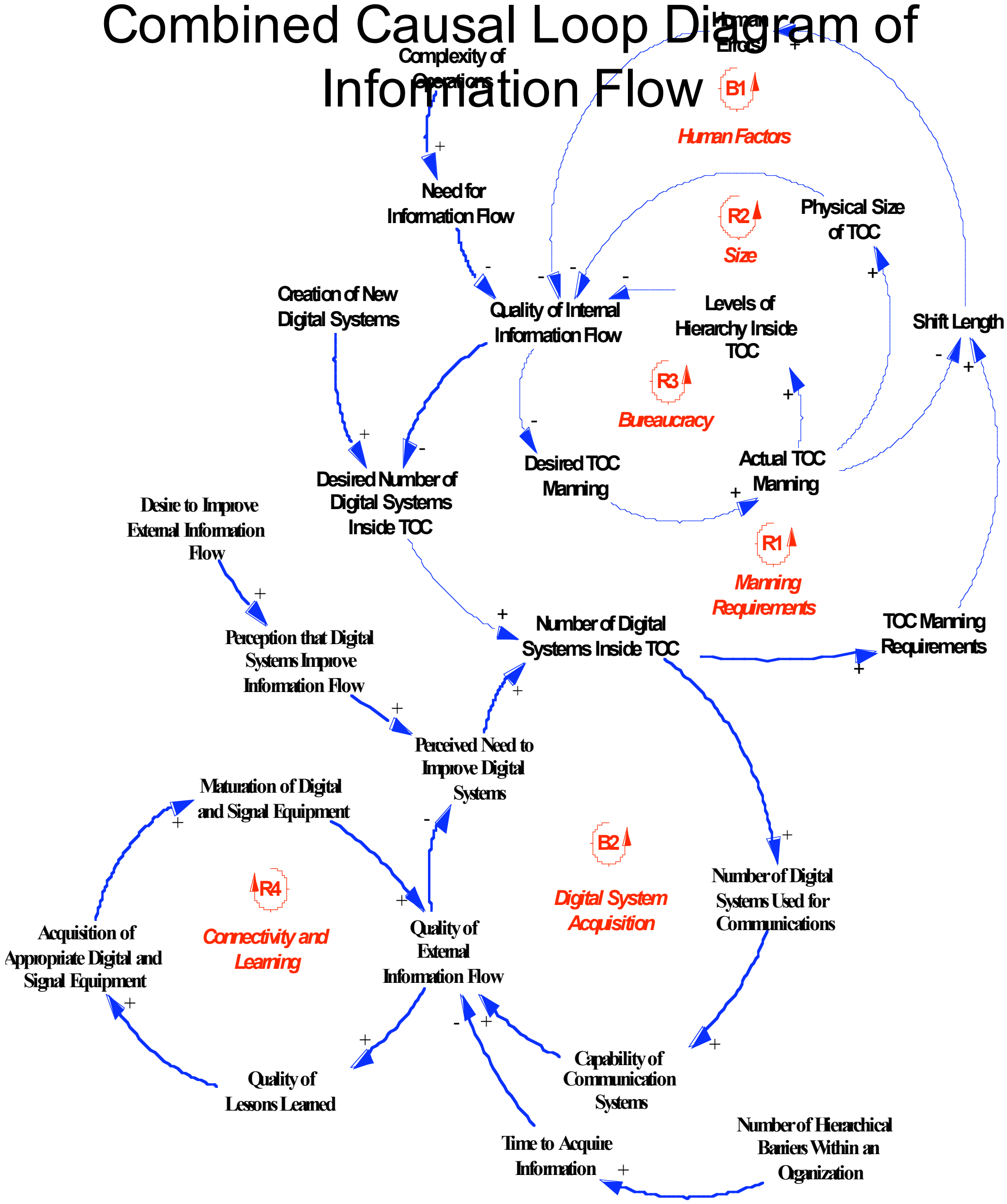


Figure 6

Simulation Results

After formulating our System Dynamics models for this study, we then conducted a number of simulations to see what further insights could be learned from the model. We used a combination of both "one variable at a time" testing as well as using various arrays. In this short paper, we only cover the findings that were discovered from the "one variable at a time" approach, however, the simulations using arrays also corroborated our findings discussed below.

Impact of Increasing Complexity of Operations on Information Flow

The first simulations that we conducted looked at the impact that increasing complexity of Operations has on both Internal and External Information Flow. In the low-level model, this variable was called Simultaneous Full Spectrum Operations (SFSO). SFSO measured the additional functional areas that are needed inside the TOC as mission sets become more diverse (i.e. when Army units are expected to conduct multiple operations simultaneously as has been the case in Iraq and Afghanistan). The model considers a value of four additional functional areas to be normal. Experimental trials were conducted by raising the value of SFSO by 2 at a time for a total value of six, eight, and ten additional functional areas inside the TOC (The baseline functional areas considered are Operations, Intelligence, and Fire Support). Additional Functional areas are considered to be specialties such as Civil Affairs, Psychological Operations (PSYOPS), Air Defense, Aviation, Information Operations, Police Liaison Officers, Reconstruction Teams, etc. Figure 7 shows how the exogenous variable SFSO was changed in each of the experiments, while Figure 8 depicts the fairly significant negative impact that an increase in SFSO (or Operational Complexity) has on internal information flow and the lesser but not insignificant impact that SFSO has on external information flow.

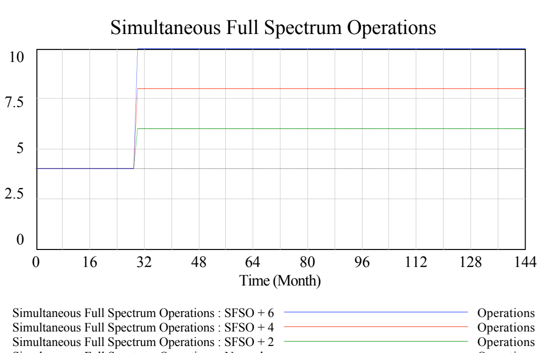


Figure 7

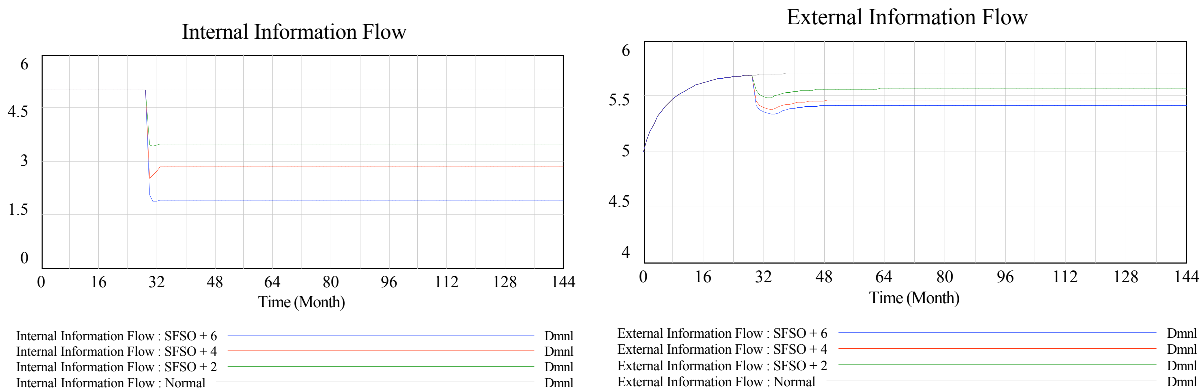


Figure 8

Impact of Increasing Number of Digital Systems on Information Flow

The next four simulations were conducted by manipulating the exogenous variable "New Digital System Development." As the low-level System Dynamics model in Appendix B shows, increasing the "New Digital System Development" increases the "Creation of New Digital Systems" which increases the "Digital Systems on the Market." In short, these variables represent the creation of new digital systems produced by both private and government industries. The model considers a value of zero to be normal, therefore representing the situation prior to 1995 when early digitalization of Battalion TOCs began (note: the time horizon for the simulation is 12 years, thus simulating the time period from 1995 to 2007). Experimental trials were conducted by raising the value of New Digital System Development from zero, to one new system every six months, then to one new system every two months, and finally to one new system per month. The exogenous variable was changed at 30 months. Figure 9 demonstrates how changes in the exogenous variable New Digital Systems Development was manipulated during each experiment. Figure 10 shows the impact that increasing Digital Systems on the Market has on the system. As the graphs indicate, increased Digital Systems on the Market produces a significant decrease in Internal Information Flow and a very modest decrease in External Information Flow.

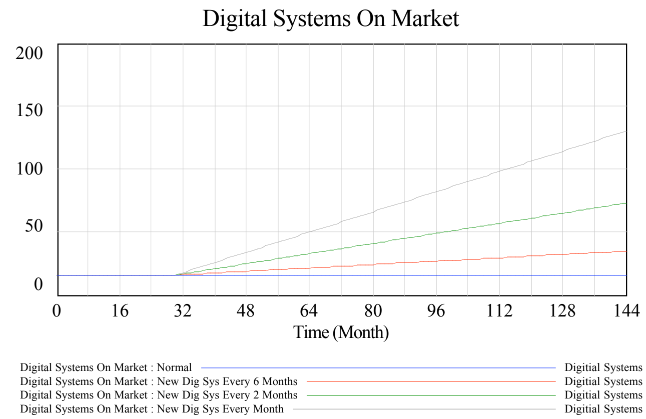


Figure 9

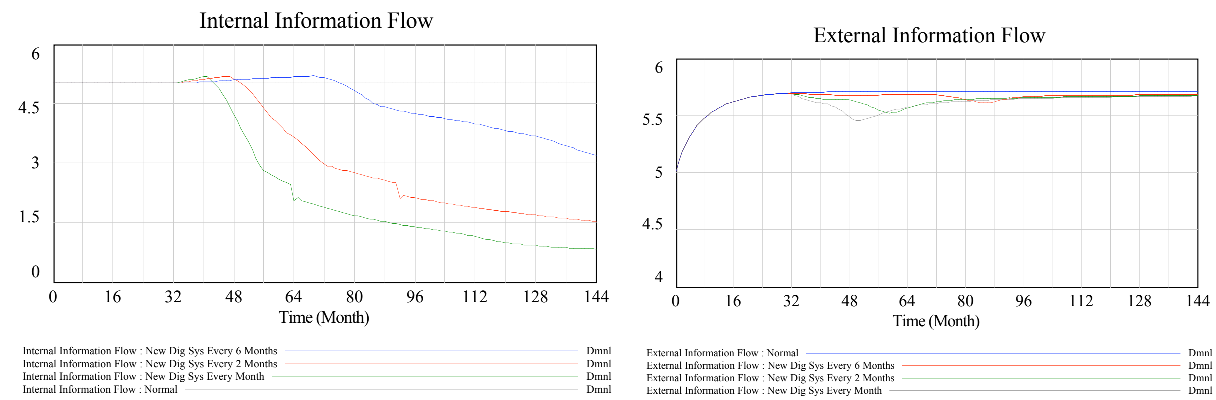


Figure 10

Impact of Number of Hierarchical Barriers on Information Flow

The next four simulations were conducted by manipulating the exogenous variable "Number of Hierarchical Barriers." In short, this variable measures the number of Hierarchical Barriers involved with transmittal of information between TOCs or between command and control nodes. For example, it is not normal practice for Army units to share information laterally, which places hierarchical barriers to information flow on the system.[5] In the model, a value of four hierarchical barriers is normal. At the tactical level where Platoons are the primary units of maneuver, these barriers are at Company, Battalion, Brigade and Division levels. Simulations

[5] Lower levels in the Army are normally more likely to share information laterally than higher levels. For example, many company commanders encourage lateral reporting of operational events between platoon leaders, where the company command post monitors this discussion as well. But, this is not the organizational norm, and most often focus is on reporting information vertically in the organization.

were conducted by decreasing the value of Hierarchical Barriers from 4 to 3, then to 2 and 1. What this represents is moving from a stove-piped hierarchical reporting system to where information is shared laterally throughout the network of command and control nodes. The following graphs show the impact of changing the Number of Hierarchical Barriers on the system. The exogenous variable was changed at time = 30 months or t = 30. Figure 11 indicates how changes in the exogenous variable Number of Hierarchical Barriers were manipulated during each simulation. Figure 12 shows the impact that decreasing the Number of Hierarchical Barriers has on the system. As the graphs show, decreased Hierarchical Barriers has an almost insignificant impact on Internal Information Flow, but has a tremendously positive impact on External Information Flow.

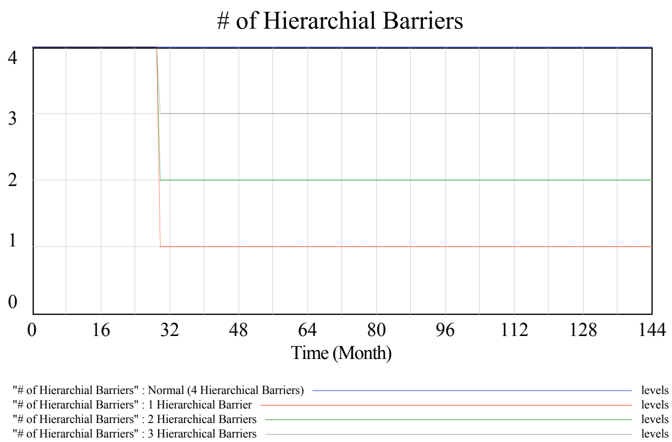


Figure 11

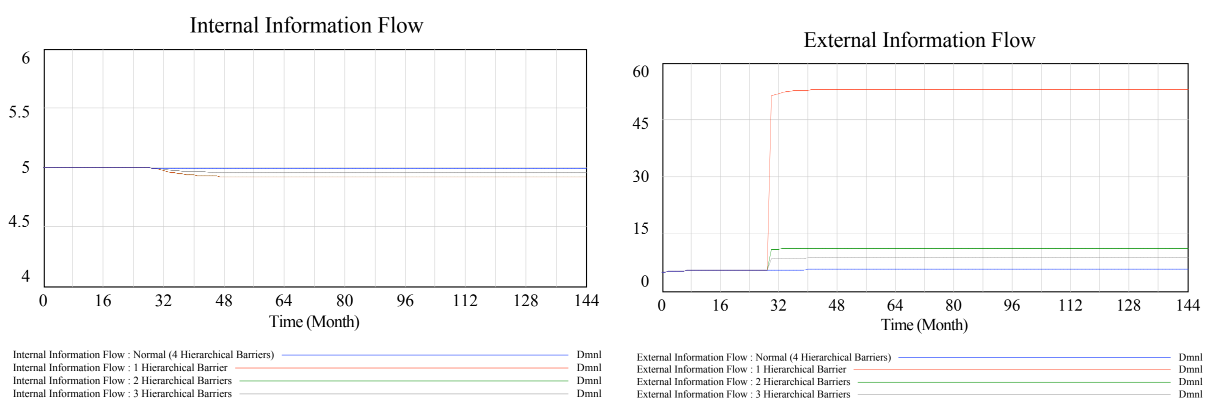
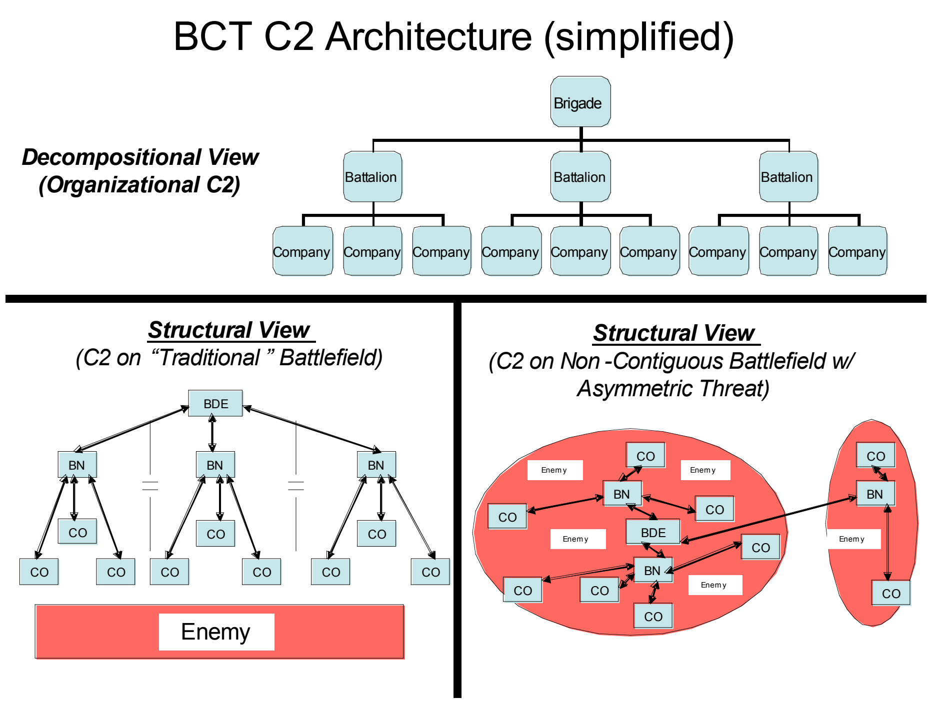


Figure 12

Heuristics

The following five heuristics result from the synthesis of material discussed in both the literature review of our original study and findings from our analysis using the System Dynamics Model described above.[6] These heuristics are intended to provide a concept for future design improvements of the Brigade Unit of Action command and control architecture and the Battalion TOC. While they do not completely support all tenets of current NCW theory, they do clearly support the majority, while also providing guidance to help avoid some of the potential pitfalls of NCW theory.

1) ***A flatter C2 Architecture will lead to improved quality and timeliness of information flow.*** This is clearly supported by both the findings of our System Dynamics simulations, current NCW literature, as well as interviews with current U.S. Army Officers. This requires elimination of the stove-piped command and control structure, focusing on lateral reporting and transmittal of intelligence across the organization in lieu of stove-piped vertical reporting. It also includes a change from "push" to "pull" information flow. Figures 13 and 14 provide a visual depiction of this heuristic.



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[6] Contact author for original thesis which contains the entire literature review and a more detailed description of the modeling process used for this study.

Figure 13 Current BCT C2 Architecture

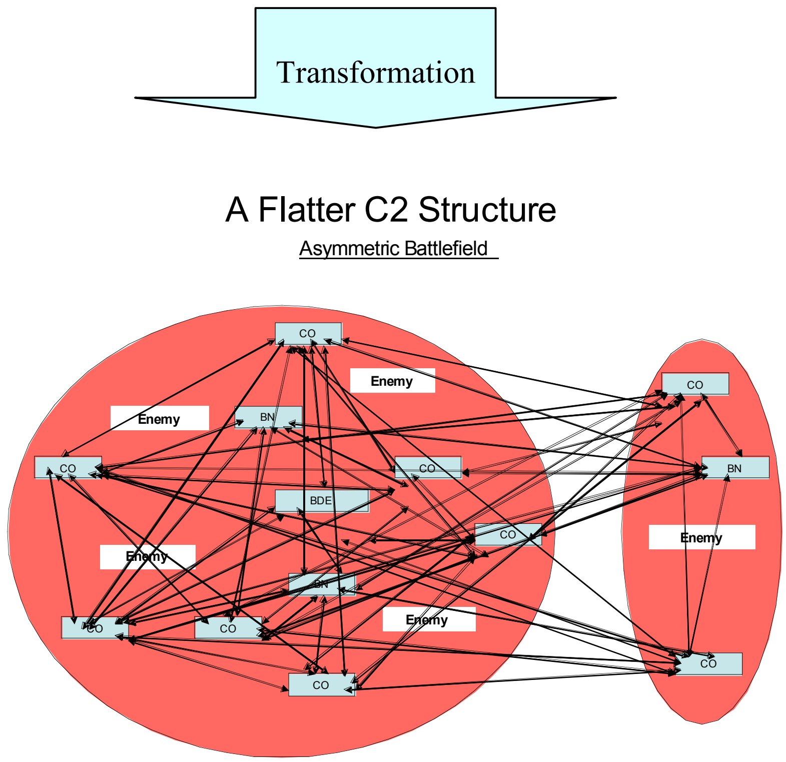

Figure 14 Transformation to a Flatter C2 Structure

2) ***Switching the locus of power control by distributing authority within the organization facilitates and enables a flatter C2 architecture and will improve information flow and the ability make decisions and act faster than the enemy.*** Modern wars are fought by platoons and companies. New digital C2 capabilities give these platoons and companies an unprecedented real time view of the battlefield and therefore an improved ability to make decisions while understanding the larger context. In order to expand the locus of power control cultural change is required. Currently, the Army's least experienced people (Lieutenants with no experience and Captains with normally less than seven years experience) command these "edge" organizations.[7] In order to effectively transfer decision making ability from centralized to distributed control, the Army should consider placing more experienced people in these positions (i.e. senior Lieutenants and junior Captains with three to six years experience as platoon leaders and senior Captains or junior Majors with eight to twelve years experience as company commanders). This would require changes to the entire Army personnel manning system and therefore much study would

[7] See Alberts and Hayes' "Power to the Edge" for a more thorough discussion of this heuristic.

be needed to determine how to best implement this system. But in the context of the Contemporary Operating Environment and the information revolution, it no longer appears optimal to have the most experienced people staffing brigade headquarters and above, while the least experienced people are in a position to make timely and critical decisions on the battlefield.

3) ***Applying Lean thinking to help maintain a smaller sized BN TOC will improve the flexibility and agility of the organization by improving the quality and timeliness of information flow.*** The simulation results derived from the System Dynamics model for this study clearly suggests the importance of this, as does the literature review section and interviews with Army officers. In order to accomplish this, special attention should be paid to how many digital systems are needed in the TOC, and eliminating those that do not create sufficient value for the organization to justify an increase in equipment and manning. Critical to this endeavor is understanding that more does not necessarily mean better. Indeed, as the System Dynamics model shows, more equipment and people can produce inferior results. In addition, it is critical to minimize the manning of the digital systems that are added to the TOC. Also, as the Contemporary Operating Environment and non-contiguity of the battlefield require more functions to be accomplished within the TOC, it is important to minimize the number of people who are added to the TOC to accomplish these functions by asking: Can one person accomplish two or more functions? Can a particular function be accomplished by one or two people in lieu of five or six?

4) ***Switching from deliberate to more expedited decision making techniques and procedures will increase the speed of command and improve the flexibility and agility of the organization.*** The current Military Decision Making Process (MDMP) is a very long and laborious process that is symptomatic of the current focus on objective-specific problem solving style of command and control. Switching to a command focused system such as the mission-specific philosophy of command and control supports NCW theory and will improve the flow of information and the speed of command within the Brigade and the BN TOC. Figure 15 demonstrates some of the different command and control philosophies available. Also, switching from the lengthy MDMP to an expedited process such as the Recognition Primed Decision Making (RPDM) should also be considered. Indeed, our findings are very clear in support of this heuristic, as an expedited

decision making process would result in less planners and therefore less people and equipment inside the TOC, therefore increasing the quality of internal information flow.

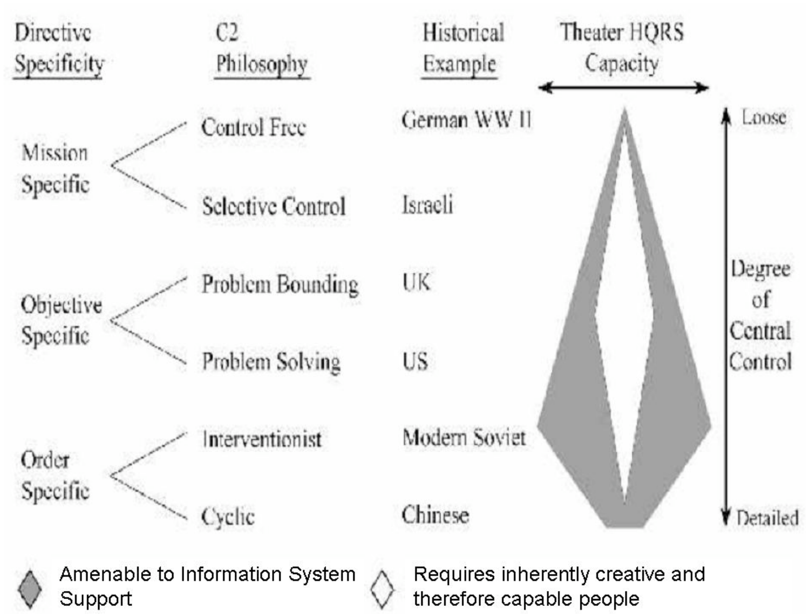

Figure 15[8]

5) ***Improved Intelligence, Surveillance and Reconnaissance capability within the Brigade Unit of Action, and a switch from push to pull intelligence will improve information flow and the ability to act faster than the enemy.*** As previously mentioned, the current stove-piped hierarchy focuses on reporting vertically within the organization. This translates to critical intelligence being stored and processed for lengthy periods of times at the highest levels of the organization (usually at levels above the BCT such as Division and Corps). As our System Dynamics model showed, this unnecessary hierarchy within the information flow process produces a decrease in the timeliness and therefore quality of external information flow. By creating a database where all members within the hierarchy can access information, lower level organizations can pull the intelligence they need from higher organizations in a timely manner. , This will help them to make decisions and action target packages much faster than they have in the past. Ultimately, this will improve the Brigade Unit of Action's ability to act faster than its adversaries, and achieve unprecedented dominance on the battlefield.

[8] Alberts, Understanding Information Age Warfare, p. 170.

Conclusions

In light of the current changes to the contemporary operating environment, organizational and institutional change is undoubtedly necessary in order to ensure success in the future, as well as the contemporary battlefield. Indeed, history is full of examples of great armies and great nations that fell because of their inability to adapt to changes in technology and socio-political conditions.

This study assists in the effort to better prepare the U.S. Army for both contemporary and future battles, by providing a set of heuristics that could be used to help guide future architectural enhancements to both the BCT C2 Architecture and to organization of the BN TOC. Further study is needed to determine how to best implement each of these five heuristics, and to determine to what extent each of them should be implemented.

This study also demonstrates the ability of System Dynamics to be used as a tool to help better understand the complex nonlinear relationships and feedback loops involved with understanding military command and control problems.

In addition, this study demonstrates some of the strengths and weakness of both hierarchical command and control structures and network structures. Specifically, the System Dynamics modeling process suggests that a network structure, as argued for by NCW theorists, is likely to lead to greatly enhanced external information flow, but with the unintended side effect of slowing internal information flow if care is not taken to limit the amount of people and digital systems added to the TOC.

Perhaps one of the best areas for concentrating future study would be to help find the balance between a hierarchical and network structure, and between centralized and decentralized command and control. Like many things in nature, the optimal solution is most likely not one system or the other, but a harmonious relationship somewhere between the two extremes.

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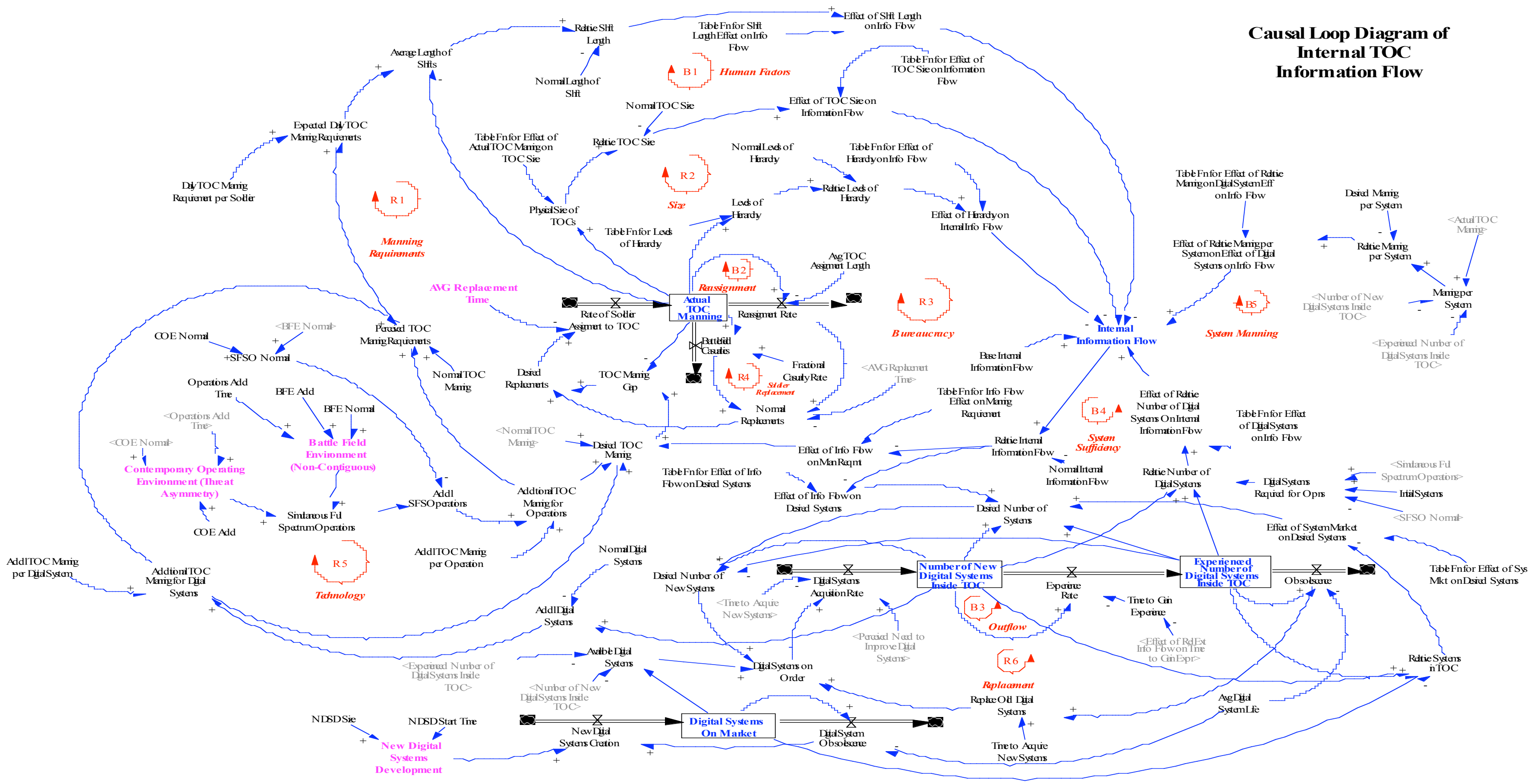
Appendix A: Acronyms

ABCS	Army Battle Command System
ADA	Air Defense Artillery
AFATDS	Advanced Field Artillery Tactical Data System
ALO	Air Liaison Officer
AMDWS	Air and Missile Defense Work Stations
ASAS	All Source Analysis System
BFT	Blue Force Tracker
BN	Battalion
BOOT	The connection between the main tent and a connected vehicle.
C2	Command and Control
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CA	Civil Affairs
CAS	Close Air Support
CDR	Commander
CO	Company
CP	Command Post
CSSCS	Combat Service Support Computer System
CTCP	Combat Trains Command Post
DNVT	Digital Non-Secure Voice Terminal
EBO	Effects Based Operations
FBCB2	Force XXI Battle Command, Brigade-and-Below
FSE	Fire Support Element
FCS	Future Combat Systems
G2	Designates the Intelligence Section of the General Staff.
MCS	Maneuver Control Station
MCS-L	Maneuver Control Station- Light
NBC	Nuclear, Biological and Chemical
NCO	Network Centric Operations
NCW	Network Centric Warfare
OODA	Observe-Orient-Decide-Act (AKA Boyd Cycle)
OPS	Operations
RTO	Radio Telephone Operator
S1	Personnel Officer/ Section (S denotes BN or BCT Staff, G denotes General Officer Staff (Division and Above))
S2	Intelligence Officer/Section
S3	Operations Officer/Section
S4	Logistics Officer/Section
S6	Signal Officer/Section
SIGACTS	Significant Activities
STU-III	Secure Telephone Unit- Third Generation
TACSAT	Satellite Radio
TOC	Tactical Operations Center
XO	Executive Office (2^{nd} in Command)

Appendix B: System Dynamics Model



Causal Loop Diagram of External TOC Information Flow