Knowledge Process and System Design for the Carrier Battle Group

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Introduction

Interest in and attention to knowledge management have exploded recently. But integration of knowledge process design with information system design has long been missing from the corresponding literature and practice. The research described in this paper builds upon recent work focused on knowledge management and system design from three integrated perspectives: 1) reengineering process innovation, 2) expert systems knowledge acquisition and representation, and 3) information systems analysis and design. With this work, we now have an integrated framework for knowledge process and system design that covers the gamut of design considerations from the enterprise process in the large, through alternative classes of knowledge in the middle, and on to specific systems in the detail. We illustrate the use and utility of the approach through an extreme enterprise example addressing Navy carrier battlegroups in operational theaters, which addresses many factors widely considered important in the knowledge management environment. Using this integrated methodology, the reader can see how to identify, select, compose and integrate the many component applications and technologies required for effective knowledge system and process design.

Knowledge Management and System Design

The power of knowledge has long been ascribed to successful individuals in the organization. But today it is recognized and pursued at the enterprise level through a practice known as knowledge management [1]. According to recent surveys of the literature [2], interest in and attention to knowledge management (KM) have exploded recently, and many prominent technology firms now depend upon knowledge-work processes to compete through innovation more than production and service [3].

Even a quick look through the trade press shows information technology (IT) lies at the center of most knowledge management projects today. But IT employed to enable knowledge work appears to target data and information, as opposed to knowledge itself [4]. For instance, extant IT used to support knowledge management is limited primarily to conventional database management systems

(DBMS), data warehouses and mining tools (DW/DM), intranets/extranets and groupware [5]. Arguably, just looking at the word "data" in the names of many "knowledge management tools" (e.g., DBMS, DW/DM), we are not even working at the level of information, much less knowledge.

We feel this contributes to difficulties experienced with knowledge management to date. Knowledge is noted as being quite distinct from data and information (cf. [6,7,8]). And it is naïve to expect systems and tools developed to support data and information flows to prove useful for supporting the flow of knowledge through the enterprise. For purposes of this article, we draw from the literature and operationalize knowledge in terms of the actions it enables (e.g., making good decisions, affecting appropriate behaviors).

The research described in this paper builds upon recent work [2] focused on knowledge management and system design from three integrated perspectives: 1) reengineering process innovation, 2) expert systems knowledge acquisition and representation, and 3) information systems analysis and design. This recent work developed an integrated framework for knowledge process and system design. Such a framework covers the gamut of design considerations from the enterprise process in the large, through alternative classes of knowledge in the middle, and on to specific systems in the detail. In this paper, we demonstrate the application of this framework for integrated process and system design using a knowledge-intensive process example from the U.S. Navy: Battle Group Theater Transition. This method has been successfully applied to other maritime processes [9], and its application in this paper builds on the field work performed by Oxendine [10].

In the sections that follow, we provide some background information drawn from the knowledge management literature. We then summarize the prior work to describe the framework for integrating knowledge process and system design. We subsequently employ this design approach through a specific Navy battle group example. This example addresses many factors widely considered important in the knowledge management environment (e.g., cross-functional virtual teams, collaborative work, distributed tacit and explicit knowledge, both routine and non-routine work processes, a dynamic market/organizational environment) and illustrates the use and utility of our integrated approach to analysis and design of knowledge systems and processes. The final section closes with key conclusions and implications for practice, in addition to a focused agenda for future research along these lines.

Knowledge Management Background

In this section, we summarize background information from the knowledge management literature. Drawing from Nissen et al. [2], to help organize this discussion, we employ a two-dimensional feature space of specific activities and stages comprising knowledge management as a process. We begin discussion of the first dimension by drawing from the literature to integrate a number of various life cycle models emerging for managing knowledge.

Table One -- Knowledge Management Life Cycle Models
(Adapted from [2])

Model	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Nissen	Capture	Organize	Formalize	Distribute	Apply	
Despres and Chauvel	Create	Map/bundle	Store	Share/transfer	Reuse	Evolve
Gartner Group	Create	Organize	Capture	Access	Use	
Davenport & Prusak	Generate		Codify	Transfer		
Amalgamated	Create	Organize	Formalize	Distribute	Apply	Evolve

Nissen et al. [2] observe a sense of process flow or a life cycle associated with knowledge management, and integrating their survey of the literature (e.g., [11,12,13,14]), they synthesize an amalgamated knowledge management life cycle model as outlined in Table One. Briefly, the "create" phase begins the life cycle, as new knowledge is generated by an enterprise. The second phase pertains to the organization, mapping or bundling of knowledge. Phase three addresses some mechanism for making knowledge formal or explicit, and the fourth phase concerns the ability to share or distribute knowledge in the enterprise. Knowledge application for problem solving or decision making in the organization constitutes phase five, and a sixth phase is included to cover knowledge evolution, which reflects organizational learning through time.

The second dimension is termed *knowledge management level* and draws from Nonaka [7] and others (e.g., [12]). The knowledge management level includes both individual and collective entities, the latter of which are further distinguished between groups (e.g., of relatively small collections such as work teams or functional departments) and organizations (e.g., relatively large collections such as enterprises or corporations). This dimension pertains to the reach of knowledge management through the enterprise. Combined with the life cycle steps from above, we employ these levels to classify extant knowledge management applications.

Drawing further from the prior research discussed above, we note the coverage of extant systems and practices across these two dimensions—knowledge management life cycle phase and knowledge management level—is patchy. For instance, across all three knowledge management levels, numerous systems and practices are identified from the literature to support three of the six life cycle phases: knowledge organization, knowledge formalization and knowledge distribution. But relatively few counterpart systems and practices are found to correspond with the other three phases: knowledge application, knowledge evolution and knowledge creation. We thus observe a relative abundance and dearth of available systems and practices available to support these respective phases of the KM life cycle (see [2] for details).

Integrated Framework

The feature space of systems and technologies outlined above defines a broad design space for KM systems. The design space is further defined and constrained in this section by a set of contextual factors that impinge on the implementation of these systems in organizations. In the prior research, three complementary design methods are identified and integrated to address knowledge management. These methods draw from business process reengineering (BPR), expert systems (ES) development and information systems (IS) analysis and design. Each plays a key role in the progression of knowledge process design, through knowledge analysis, and onto information system design. And a key contribution of this prior work involves integration of these methods into a single, coherent knowledge management design methodology.

To summarize, the prior researchers combine the two-dimensional feature space from above with contextual analysis to outline an integrated framework for knowledge process and system design. In short, one first analyzes the processes associated with knowledge work performed in the enterprise. This step draws from common reengineering methods (e.g., [14,15,16]). Each process of interest must be understood and analyzed—and perhaps redesigned—to interpret the knowledge required for its effective performance. For instance, a recently-developed, measurement-driven redesign method (cf. [17]) can be particularly useful for identifying and treating process pathologies in advance of system design.

The next step is to identify and analyze the underlying knowledge itself. The two-dimensional framework for analysis—combining phases of the amalgamated knowledge management life cycle with knowledge levels—facilitates this analysis. And we draw from textbook knowledge engineering methods employed for development of expert systems (cf. [18,19]). Because such methods focus directly on knowledge—as opposed to data and information—analysis at this stage can obviate many problems associated with knowledge management systems in development today. And as a useful side effect, mechanisms such as rules, frames, semantic nets and similar knowledge engineering techniques can be used to represent enterprise knowledge, tacit as well as explicit. Once represented in digital form, these techniques can support direct application and evolution of knowledge. Recall from the discussion above that such enhanced knowledge management activities are poorly supported by systems and practices in use today.

In the third stage of analysis, one must assess the contextual factors associated with the process of interest. Critical in this assessment is understanding the organization, and the nature of knowledge underlying the task. Specifically, Nissen et al. [2] indicate that organizational memory represents an important design consideration, as does organizational structure and the incentives used to stimulate workers to contribute knowledge to systems. Also key is the nature of knowledge underlying process tasks. In particular, the distribution of canonical and non-canonical knowledge and practices through the enterprise exerts strong constraints over the types of systems that can be employed for knowledge management.

Finally, armed with results from these three levels of analysis (i.e., process, knowledge, and context), one can then effectively analyze and design the information systems required to automate and support knowledge work in the process. To accomplish this final stage of analysis, traditional IS methods (e.g., use of data flow diagrams, entity-relationship diagrams, object models and use cases) are employed. We find it interesting to note, most current knowledge management projects *start* at this (final) stage of analysis.

Navy Battle Group Application

This section applies the knowledge management framework from above to the U.S. Navy Battle Group Theater Transition Process (BGTTP). The BGTTP represents an extreme process in terms of knowledge-transfer demands, so it serves as a useful process for investigation and subsequent generalization of results. We begin with background information pertaining to the BGTTP and describe our application to key knowledge tasks that greatly impact the outcome of the deployment process. We then address how a process and system can be designed to improve knowledge transfer, both across time and between different organizations. This process is described in considerable detail by Oxendine [10].

BGTTP Background

As the United States Navy continues to support the naval strategic concept *Forward…From the Sea* [20] into the twenty-first century, one of the Navy's primary responsibilities is to maintain a forward presence throughout the world and project power to possibly deter actions that may threaten U.S. interests. In order to support this objective, the Department of the Navy (DoN) maintains naval forces abroad and periodically deploys ships throughout the high seas to protect U.S. interests. With this, the Navy has long used the carrier battle group (CVBG) as an instrument for power projection and forward presence.

The CVBG is a combat formation of ships and aircraft, which comprises a principal element of U.S. national power projection capability. It is the essential foundation of U.S. ability to conduct operations envisioned in

> *Forward…From the Sea*. The CVBG includes capabilities sufficient to accomplish a variety of combat tasks in war, and it serves a wide variety of functions in situations short of war. The CVBG's peacetime mission is to conduct forward presence operations to help shape the strategic environment by deterring conflict, building interoperability, and by responding, as necessary, to fast breaking crises with the demonstration and application of credible combat power [21].
>
> In order to support this peacetime objective, the DoN periodically deploys CVBGs to theaters of U.S. interests (e.g., the Arabian Gulf). Typically, a CVBG remains on station for three months. Subsequently, the CVBG personnel, equipment, and support are relieved by another CVBG, which conducts a successive, three-month deployment in theater. This periodic BG rotation continues four times a year or until the theater is non longer deemed in need of battle group presence. In the case of battle groups in the Arabian Gulf, for reference, such BG rotations have been recurring since the Gulf War over a decade ago.
>
> The transition from one CVBG to another in theater is facilitated by the BGTTP. The primary objective of this process is to capture and transfer knowledge between CVBGs in order to reduce the arriving battle group's (BG) theater acclimation period. The acclimation period is the time it takes for the arriving BG to become familiar with the new environment (e.g., understanding the nature and seriousness of regional threats). During each acclimation period, the arriving BG is at some risk in terms of effectively responding to any indication and warning (I&W) and engaging a potential threat accordingly if the immediate need arises. The current theater turnover process provides the arriving BG with explicit, theater, background information, but the regional experience and local knowledge gained through theater operations by the departing BG is not transferred well during the process. Although IT has helped facilitate the BGTTP, only data and information are transferred at present, not knowledge.

If the arriving BG is to effectively conduct its peacetime and wartime missions, it must possess as much knowledge of the theater in which it is operating as the departing BG, the latter of which has been on station for three months. By applying our integrated knowledge process and system design method to the BGTTP, we seek to significantly improve the flow of knowledge from one BG to another. As an objective, one might then expect the arriving BG to perform, on day one of operations in theater, as effectively as the departing BG on its 90th day.

Because the BGTTP as a whole represents a large, complex process (e.g., involving roughly 15 ships, 15,000 people at sea, often off the coast of a hostile nation), we focus this investigation on a relatively-small, but absolutely-critical, subprocess associated with the transfer of knowledge acquired by naval intelligence officers. And through field research [10], we find a central component of such intelligence officers' knowledge pertains to the identification of patterns and norms and trend analysis.

Specifically, learning to recognize patterns and norms represents the key knowledge desired by CVBG commanders prior to entering the Arabian Gulf, and the ability to perform trend analysis represents the key knowledge acquired on station. Together, the identification and continued analysis of patterns and norms are essential for planning and conducting safe and effective operations in the Arabian Gulf. Tactically speaking, these activities are referred to as *intelligence preparation of the battlespace* (IPB) and used primarily for I&W. As per Naval Doctrine Publication 2 [22], IPB is the systematic and continuous analysis of the current or potential adversary, terrain and weather in the battlespace.

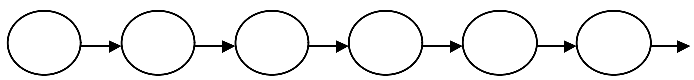
Process Analysis

Drawing from the integrated framework above, the first step involves process analysis. We perform this high-level analytical step in two increments. The first involves the kind of process-redesign analysis that is customary in reengineering engagements (cf. [14,15]). Such redesign analysis focuses on work-process flows that we term *horizontal processes*, for their representations are generally presented as directed graphs, with process activities running horizontally across the page. This first increment of analysis provides guidance for (re)designing the process, for example, to overcome process pathologies. The second increment involves knowledge management aspects of the process. Such knowledge management analysis focuses on cross-process flows that we term *vertical processes* (cf. [9]). These latter process representations are also generally presented as directed graphs. But the corresponding process activities run vertically down the page, *across* the kinds of work-process flows (i.e., horizontal processes) examined for redesign. We return to the concept of vertical processes in a subsequent section below.

Redesign Analysis

The battle group intelligence process is delineated in Figure One. In this representation, process activities are denoted by nodes in a graph, which are connected by edges to denote the flow of work through the process. Each activity node also includes eight attributes to describe the corresponding work tasks: 1) activity name, 2) role of the agent responsible for its performance, 3) organization associated with the activity, 4) inputs to the activity, 5) outputs from the activity, 6) IT employed to support the activity, 7) IT employed to support communication, and 8) IT employed to automate the activity.

For example, in the first step of data collection, shipboard systems (e.g., networks, radios, radar and other sensors) receive and provide raw intelligence data to users. In this case, the user is an intelligence watchstander on a tactical, I&W watch, which involves vigilantly scanning and monitoring the environment in search of potential threats. This watchstander is either part of the BG intelligence staff (N2) or the carrier intelligence center (CVIC). After the data are collected, the N2 staff or the CVIC Intelligence Analysis & Reporting Cell (A&R) uses various IT applications to process the raw data and convert them into a usable form of information. Subsequently, intelligence personnel conduct trend analysis by integrating, analyzing, evaluating, and interpreting the processed information. The N2 staff or the A&R uses various IT tools to incorporate the data and produce an intelligence product that is distributed to the BG and Destroyer Squadron (DESRON) commanders. Commanders, in turn, integrate the intelligence product with their own experience and observations to produce actionable knowledge.



Task:	Collect$_1$	Process$_1$	Analyze$_1$	Assess$_1$	Produce$_1$	Disseminate$_1$
Agent:	Watch	IO	A&R	A&R	A&R	A&R
Org:	N2	N2	CVIC	CVIC	CVIC	CVIC
Input:		Raw data	Info	Anal	Assess	Intel
Output:		Info	Anal	Assess	Intel	Knowledge
IT-S:	Collect	Various			Office	
IT-C:						Network
IT-A:						

Figure One -- Battle Group Intelligence Process

The representation in Figure One supports the kind of process analysis generally associated with business process reengineering. And as noted above, using this representation, one would strive to understand and possibly redesign the process at this stage. We obtain diagnostic measurements from the process and employ the KOPeR system (cf. [18]) to support its redesign. KOPeR is an expert system that automates and supports key aspects of process redesign.

Table Two -- Process Measurements and Diagnoses

Configuration Measure	**Value**	**Diagnosis**
Parallelism	1.00*	Sequential process flows
Handoffs fraction	0.33	Friction
Feedback fraction	0.16	OK
IT support fraction	0.50	Manual process
IT communication fraction	0.16	Paper-based process
IT automation fraction	0.00*	Labor-intensive process

* denotes theoretical extremum for a measure

The key measurements are summarized in Table Two. From measured values presented in the table, one can see the baseline process suffers from a number of serious pathologies (e.g., sequential flows, process friction, manual, paper-based & labor-intensive process). We return to use this diagnostic information to drive process redesign in a subsequent section below.

Knowledge Management Analysis

To support integrated knowledge process and system design, we extend the process diagram from above to reflect its performance through time and across different BGs. This extended process representation augments the horizontal process graph presented in Figure One to also include vertical processes that flow across various work-process flows. This cross-process perspective facilitates process design in terms of knowledge management and is depicted in Figure Two.

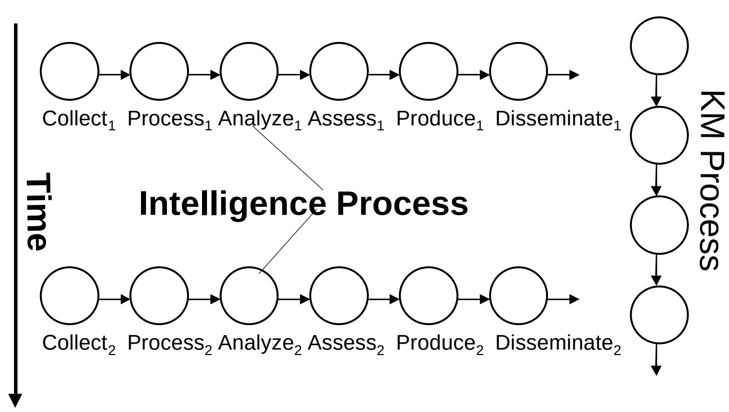


Figure Two -- BG Vertical Processes

Here, we show the same basic process flow (e.g., activities represented by nodes and connected by directed edges) for two particular instantiations of the process. In the first instantiation (activities with the subscript 1, e.g., "$Collect_1$"), a particular BG would perform each of the process activities (i.e., as represented by nodes in the figure) at some point in time. At some other point in time, another instantiation of the process (activities with the subscript 2, e.g., "$Collect_2$") would proceed through the same process activities. However, this latter instantiation involves a different BG team and is enacted at a later point in time (e.g., following a 90-day deployment). A principal concern in terms of knowledge management involves consistency and efficacy across process instantiations. This, *vertical process provides the basis for knowledge flow in the enterprise*.

For instance, prior research focused on the U.S. Coast Guard [9] identified seven cross-process flows associated with the maritime-interdiction process: 1) personnel assignment, 2) after-action review (AAR), 3) qualification, 4) debrief, 5) training, 6) post-deployment debrief, and 7) IT support. These and other vertical-process examples may also apply well to our BGTTP. But for space considerations, we do not detail these processes here. Clearly, the cross-process flows represent the essence of knowledge management activities.

Knowledge Analysis

The second step involves knowledge analysis. For integrated knowledge process and system design, we need to focus on vertical processes as well as their horizontal, work-process counterparts. Prior to conducting knowledge analysis, the organization's mission and goals must be understood. Subsequently, knowledge analysis involves identifying key knowledge within an organization and results in a thorough understanding of critical success factors (CSFs). The term *knowledge mapping* could be substituted, with caution, for *knowledge analysis* here. Knowledge analysis also identifies the key explicit and tacit knowledge employed to make decisions and take action [2].

Table Three -- Mission Objectives and Critical Success Factors

Operation Southern Watch (OSW) *Primary Objective* ➢ Enforce the No-Fly Zone in southern Iraq *Critical Success Factors* ➢ High situational awareness (current, accurate intelligence) ➢ Prevent violation ➢ Complete air tasking order (ATO) ➢ Good, reliable communication within theater ➢ Adequate I &W of potential violation
Maritime Interdiction Operations (MIO) *Primary Objective* ➢ Enforce economic sanctions against Iraq

Critical Success Factors

- High situational awareness (current, accurate intelligence)
- Good, reliable communication within theater
- Well trained and properly equipped boarding crew
- Sufficient assets for ship placement and boardings
- Prevent violation

CVBGs are capable of conducting a variety of missions depending on the theater of operations and its geo-political environment. For CVBGs operating in the Arabian Gulf, the key BG operations are Operation Southern Watch (OSW), led by the BG commander, and maritime-interdiction operations (MIO), led by the DESRON commander. Each operation has a primary objective and CSFs listed in Table Three. The success of each operation depends on the achievement of each CSF, thus accomplishing the primary objective.

For both BG operations, intelligence is a significant factor and provides key knowledge essential for success. Both operations require a high degree of situational awareness derived from trend analysis. The Intelligence Officer provides this intelligence support to the BG commander and his staff for day-to-day decision making regarding OSW and MIO. To develop and acquire the analytical skill applied in trend analysis requires training, experience and specific knowledge, both explicit and tacit.

Explicit knowledge of patterns and norms is accessible prior to deployment through various intelligence products, such as manuals, books, lessons learned and training exercises. And the BG intelligence staff systematically relies on an 18-month Inter-Deployment Training Cycle (IDTC) to prepare for deployment. The IDTC's primary purpose is to increase the unit's readiness, teamwork and warfighting skills. During the IDTC, the BG intelligence staff conducts exercises simulating operations in the threat environment. These training exercises serve as an introduction to provide the intelligence staff with explicit, theater knowledge of the threat and operating environment. Prior to deployment, the N2 provides the BG and DESRON commanders with known patterns and norms, which are used for *deliberate planning*. As per NDP 2, in *deliberate planning*, the commander's emphasis is on developing a carefully crafted plan for military operations.

Unlike such explicit knowledge, however, tacit knowledge used in trend analysis is not readily accessible, and it is gained only through on-the-job training (OJT) and experience. In other words, formal training during the IDTC provides only explicit, not tacit, knowledge. Tacit knowledge is necessary to classify operations or activities as "normal" or "abnormal," for instance, and such identification is based on how each individual analyst evaluates and interprets the data. For contrast with deliberate planning from above, classification of an activity or operation as "abnormal" is used as I&W, which supports *crisis action planning*.

In crisis action planning, the commander's emphasis is on quickly developing a course of action to respond to an emergent crisis. Currently, the intelligence staff acquires tacit knowledge required for support of such crisis-action planning only through physical presence and operations in the Gulf. Thus, such tacit knowledge represents the focus of our efforts to improve knowledge flow.

Contextual Analysis

The third step involves contextual analysis. As with most organizations, explicit knowledge is readily available when required by BGs (e.g., in the form of manuals, policies, intelligence reports). Table Four outlines current methods used to codify and transfer knowledge. But BGs do not codify tacit knowledge required to perform their responsibilities, because there is no organized system in place to assist in transferring such knowledge. Rather, the majority of tacit knowledge is obtained, at the individual level, through OJT. Even when turnovers are conducted via face-to-face meetings between arriving and departing BG representatives (e.g., exchanging documents, providing briefings, answering questions), reading and hearing stories about I&W or crisis-planning activities is not the same as identifying and experiencing them first hand.

IS Analysis and Design

The fourth step involves IS analysis and design. To reiterate from above, IT represents a powerful enabler of knowledge management. But we find that process (re)design, along with knowledge and contextual analysis, is necessary before implementing IT. For instance, the pathologies diagnosed above (e.g., manual, paper-based, labor-intensive process) provide guidance for IT applications at this stage of analysis, and contextual factors serve to highlight constraints that require consideration at this stage.

Table Four -- Current BGTTP Methods

BGTTP Instruments
Lessons Learned - Review on-station CVBG's mid-cruise and end-of-cruise lessons learned via website, email, or message traffic - Review 6 mos or less prior to deployment
Secret Internet Protocol Routing Network (SIPRNET) - Access command websites - Email relieving fleet counterpart and others throughout course of deployment
Inter-Deployment Training Cycle (IDTC) - Initiate 18 mos prior to deployment - Increase unit's readiness, teamwork and warfighting skills prior to deployment

Message Traffic
- Add relieving CVBG to message traffic list to receive routine message traffic - Receive departing CVBG's message traffic 6 mos prior to deployment
Phone
- Use secure phone (STU III) when enroute to Gulf

In system analysis, the organization's current procedures and information systems used to perform organizational tasks are analyzed. For trend analysis, there is no formal IT system presently capable of capturing and sharing the departing CVBG's tacit knowledge and experience. As indicated in the KOPeR diagnosis, the current process lacks adequate IT in the support and communication areas.

In order to treat these pathologies, three requirements emerge for systems to improve knowledge flow: 1) serves as a knowledge repository; 2) facilitates knowledge exchange; and 3) captures and transfers tacit knowledge. We use these three requirements to guide development of corresponding BG intelligence process redesigns.

BG Intelligence Process Redesigns

Recalling the KOPeR diagnosis of the intelligence process from above, the "as is" trend analysis process requires improvement in IT support and communication. In this current process, IT is not used to capture and exchange knowledge necessary for effective trend analysis. As a result, the intelligence staffs of CVBGs repeatedly construct new knowledge bases that are common to, but not shared with, those of other CVBG intelligence staffs. Therefore, we focus on IT to correct the current trend analysis process pathologies.

Specifically, we concentrate on knowledge repositories, groupware and knowledge-based systems (KBS). Knowledge repositories (e.g., via Web) are relatively-quick and -easy to construct, but they require some degree of user expertise and time to find specific desired knowledge, because the user must search manually. Conversely, KBS (e.g., expert systems, intelligent agents) require minimum user expertise and time to find the desired knowledge, but formal capture and organization of knowledge, which is required to construct the knowledge base, can be difficult and time consuming. Groupware falls somewhere in between the two. Knowledge repositories, groupware and KBS are employed in turn to redesign the BGTTP below.

Redesign 1: Knowledge Repositories

Through repositories, corporate knowledge can be organized and saved for future use. Knowledge repositories capture and maintain structured, explicit knowledge, usually in document form, for use throughout an organization. There are three basic types of repositories: 1) *external knowledge* (e.g., competitive intelligence), which refers to knowledge about external entities 2) *structured internal knowledge* (e.g., research reports, techniques and methods), and 3) *informal internal knowledge* (e.g., discussion databases full of know-how, sometimes referred to as “lessons learned") [6].

The knowledge applied in trend analysis is tacit: plain and simple know-how. To transfer tacit knowledge from individuals into a repository, some sort of community-based electronic discussion is often employed. This type of knowledge repository, a combination of structured internal and informal internal knowledge, is an attempt to accelerate and broaden the traditional knowledge sharing that happens with the socialization of newcomers, the generation of myths and stories within communities of practice, and the general transmission of cultural rituals and organizational routines [6].

While such knowledge is relatively quick-and–easy to capture and store, unless some means for effectively indexing and searching it is established, knowledge stored in repositories can be very difficult to find, particularly under time constraints (e.g., when in crisis mode). Unfortunately, such indexing and searching techniques remain somewhat primitive at present and are the focus of current research. Thus, repositories are principally limited to explicit knowledge at present and therefore likely to be used mostly for deliberate planning.

***Redesign 2: Groupware*.**

Today, groupware is becoming more prevalent in enterprises as a tool to help teams operate more effectively across geographical distances and innovate by building on shared corporate knowledge. Groupware is software that permits two or more people to communicate and collaborate across geographical and temporal boundaries, and it is the cornerstone for most electronic knowledge sharing [23]. Groupware provides rich content and real interactivity via presentations, demonstrations, e-whiteboards, chat, audio, and video. Through groupware, people separated by space (and time) can interact using many of the same, rich communication media customarily employed for face-to-face conversations. Although it is technically feasible to capture and store such groupware interactions (e.g., in repositories of audio-video conversations), problems noted above associated with organization and search remain and impede effective, timely retrieval. This, repository-focused application of groupware is, therefore, also relegated principally to support of deliberate planning.

Alternatively, by using groupware interactions as surrogates for face-to-face conversations, at least some tacit knowledge can be transferred in a way inconceivable through formal reports (e.g., lessons learned), repositories (e.g., Web content) or other textual approaches. Specifically, through real-time groupware interaction, personnel assigned to an arriving BG can participate in intelligence operations of the BG on station, through a moderate form of telepresence. Such, active participation (even though remote) may lead to development of comparable levels of tacit knowledge that are normally acquired by intelligence personnel on station through OJT. This represents a substantial improvement over the repository approach from above. But, of course, such tacit knowledge is ephemeral and likely to require relearning on the successive BG transfer.

Redesign 3: Expert Systems

Expert systems (ES) are programs that assist non-experts in making decisions comparable to those of experts. An expert system emulates the interaction between user and expert in a specific domain (e.g., medicine, electronics, finance). Unlike other KM technologies, which assume the user already possesses knowledge about the subject, ES allow almost anyone to solve problems and make decisions in a subject area. ES capture part of an expert's decision-making knowledge, store it in a knowledge base, and allow its effective dissemination to users through an interface [18,23,24].

Given that an expert system has a knowledge base and an inferencing capability, it can be used to assist the intelligence staff in conducting trend analysis. First, knowledge and expertise used to conduct trend analysis must be codified and stored in the expert system's knowledge base. Clearly, such capture and formalization is non-trivial, as this step has long been acknowledged as the bottleneck in ES development [25], across nearly every application domain. However, an effective set of knowledge-engineering tools and techniques has been developed and refined over the last forty years, and ES applications have been successfully implemented in many, critical areas, including medicine (e.g., MYCIN [26]), computer design (e.g., R1/XCON [27]), electronics troubleshooting (e.g., SOPHIE [28]) and others. Although expected to be difficult and time-consuming, acquiring key knowledge required for effective trend analysis appears to represent an achievable knowledge-engineering task as well.

Once operational, the expert system would interact with and assist the user in conducting trend analysis. For instance, certain flight profiles (e.g., course, speed, altitude, maneuvers) of non-allied aircraft in the region occur routinely and now appear to be associated with pilot training. But until a trend associated with such flights can be established, the profiles themselves possibly appear to represent hostile profiles, and intelligence analysts lacking specific, tacit knowledge associated with pilot training profiles can lead to overreaction by BG commanders and crews. Alternatively, an ES could be developed to recognize and correctly interpret such profiles, just as experienced intelligence analysts do after serving on station for some time in the region.

Further, once such an expert system has been developed to assist the intelligence staff in conducting trend analysis, the associated knowledge has been made explicit, and the expert system itself, as an application of information technology, can be duplicated and transferred from one BG to another. This represents a quantum shift in capability regarding knowledge flow in the CVBG enterprise. Whereas the ships and personnel comprising one BG or another are separate and distinct (i.e., negligible overlap or interchange of ships or personnel), knowledge captured and formalized via ES can remain on station in a given theater of operations indefinitely. It therefore serves not only as a repository of intelligence knowledge that can easily be passed between outgoing and incoming CVBGs, but it can also improve the performance of all subsequent BGs, as this knowledge may be refined and improved through time. Such use of ES, thus, represents a fundamental change to our vertical process, which we re-emphasize is central to KM and knowledge flow.

Migration Plan

With these three redesigns, we need to establish a migration plan for transitioning the intelligence process from its current, baseline or "as is" configuration. This plan envisions near, medium and far-term migrations that incorporate the three redesign alternatives developed above. For the near term (i.e., immediately), the Navy should continue building repositories for explicit knowledge and making them available to geographically-dispersed units via networks. Compared to paper-based documents and learning such explicit knowledge by trial and error, network availability represents a qualitative improvement. Rather than calling this a “redesign” per se, Redesign 1 represents more of a confirmation that current BG practices and plans appear to be on target in terms of promoting knowledge flow. Nonetheless, problems noted above with respect to repositories (e.g., indexing, search) serve to mitigate the efficacy of this approach in terms of tacit knowledge flow.

Over the medium term (e.g., next 1 – 2 years), results of this analysis suggest the Navy should employ groupware technology and apply it as an instrument to facilitate the exchange of tacit knowledge. As noted above, groupware supports tacit knowledge exchange, with rich communication media that serve as surrogates for face-to-face conversations, and they enable remote participation in intelligence processes via moderate telepresence. Interestingly, acknowledging this redesign, groupware technology is already being implemented within the STENNIS CVBG, and plans are underway to implement the same groupware technology within other battle groups as well.

However, problems noted above with respect to groupware (e.g., ephemeral knowledge) also serve to mitigate the efficacy of this approach in terms of knowledge flow. Moreover, if the individual commands do not support this effort, then relying on personnel to share knowledge or contribute to the knowledge base is impractical [1,18,24]).

In the far term (e.g., 3 – 5 years), expert systems should be developed to assist with and partially automate key aspects of the intelligence process. Once difficulties with knowledge engineering are overcome, this approach offers great potential to decrease the acclimation period required by arriving CVBGs. And if the associated knowledge bases can be updated and refined over time, it is conceivable that the BGTTP may some day be seamless and transparent; that is, the arriving BG may someday be just as capable on Day 1 of operations in theater as it departing counterpart on Day 90. This would represent a substantial feat in terms of knowledge flow.

Conclusions and Future Research

The research described in this paper focuses on knowledge process and system design from three integrated perspectives: 1) reengineering process innovation, 2) expert systems knowledge acquisition and representation, and 3) information systems analysis and design. Building upon prior work, we show how to integrate these three perspectives in a systematic manner, beginning with analysis and design of the enterprise process of interest, progressively moving into knowledge capture and formalization, and then system design and implementation. With this, we illustrate the use and utility of integrated knowledge process and system design through an application to the Battle Group Theater Transition Process (BGTTP), which represents an extreme example in terms of knowledge-transfer requirements. This provides a central contribution of the paper, as it reveals the underlying components of KM, prescribes design guidance specific to each and demonstrates how the integrated framework for knowledge process and system design can be effectively applied to a non-trivial, real-world, knowledge-intensive process.

A number of other important findings and conclusions emerge from this research. First, an organization must clearly define its goals and CSFs in order to design a suitable KM system. Otherwise, it will be difficult to identify the appropriate cross-process flows that nurture knowledge transfer. Second, the paper re-emphasizes the fact that analysis of the process, knowledge and context is important in designing an appropriate KM system. Focusing on technology alone will, more often than not, result in a system that does not serve the organization.

Third, the techniques and technologies identified to redesign intelligence processes appear to also offer potential for improving other CVBG activities (e.g., operations), and results of this investigation should help focus and streamline IS development targeted for the battle group. Finally, we note that the forward-presence environment associated with CVBGs represents a unique context in terms of process performance. But we see no reason why the integrated framework for process and system design (i.e., as presented and discussed in the paper) cannot be effectively employed for a variety of other processes, within the Navy and beyond. Thus, we feel the results of this investigation are highly generalizable. Indeed, the power of such a framework may derive from its robustness and broad applicability. And we see a fruitful line of continued research along these lines.

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Biographies

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Currently, Lieutenant Elias Oxendine IV is assigned to Commander-in-Chief, U.S. Pacific Fleet, Directorate for Intelligence, Pearl Harbor, HI, as the Intelligence Information Systems Officer.

Lieutenant Oxendine graduated from the Norfolk State University in 1993 receiving a Bachelor of Science Degree in Physics. His military education includes Naval Nuclear Power School, the Navy and Marine Corps Intelligence Center, and the Naval Postgraduate School. In 1993, he was assigned to Naval Nuclear Power School, at Orlando, Florida as a student. In 1994, Lieutenant Oxendine was selected for the Special Duty Naval Intelligence Community through the lateral conversion program. From October 1994 to November 1995, he attended the Naval Intelligence Officer Basic Course (NIOBC) at the Navy and Marine Corps Intelligence Training Command (NMITC) in Dam Neck, Virginia.

From August 1998 to September 2000, Lieutenant Oxendine was assigned to the Computer Science Curriculum, Naval Postgraduate School, at Monterey, California as a student. He completed a Master of Science Degree in Information Technology Management, focusing his thesis research on knowledge management applications to the Battle Group Theater Transition Process (BGTTP). From November 1995 to August 1998, Lieutenant Oxendine was assigned to the USS INDEPENDENCE (CV-62), homeported in Yokosuka, Japan, where he served as the Ship's Intelligence Production Officer and Command Security Manager. He completed deployments to the Pacific and the Arabian Gulf, and qualified as Officer of the Deck, Supplementary Plot Officer, and Operations Duty Officer. During this tour, he was responsible for managing all phases of intelligence production to support embarked staff and air wing.

Mark E. Nissen, Ph.D.

Mark Nissen is Assistant Professor of Information Systems and Acquisition Management at the Naval Postgraduate School and Office of Naval Research Young Investigator. His research focuses on the investigation of knowledge systems for enabling and managing change in areas such as process innovation, electronic business and knowledge flow. Recently he has been investigating knowledge systems to innovate processes in the acquisition domain, and he is currently involved with intelligent supply chain agents, as well as techniques and technologies for the capture and distribution of knowledge in very-large enterprises. Mark's publications span both the information systems and acquisition fields, with recent and forthcoming articles in journals such as *MIS Quarterly*, *Journal of Management Information* Systems, *Decision Support Systems*, *Journal of Information Technology Management*, *Acquisition Review Quarterly* and *National Contract Management Journal*. He has also recently published his first book, entitled *Contracting Process Innovation*, and he received the Menneken Faculty Award for Excellence in Scientific Research, the top research honor bestowed upon faculty at the Naval Postgraduate School. Before his information systems doctoral work at the University of Southern California, he acquired over a dozen years' management experience in the aerospace and electronics industry and served as a Supply Officer in the Naval Reserve.