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NATO Human View Architecture and Human Networks

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Abstract. The NATO Human View is a system architectural viewpoint that focuses on the human as part of a system. Its purpose is to capture the human requirements and to inform on how the human impacts the system design. The viewpoint contains seven static models that include different aspects of the human element, such as roles, tasks, constraints, training and metrics. It also includes a Human Dynamics component to perform simulations of the human system under design. One of the static models, termed Human Networks, focuses on the human-to-human communication patterns that occur as a result of ad hoc or deliberate team formation, especially teams distributed across space and time. Parameters of human teams that effect system performance can be captured in this model. Human centered aspects of networks, such as differences in operational tempo (sense of urgency), priorities (common goal), and team history (knowledge of the other team members), can be incorporated. The information captured in the Human Network static model can then be included in the Human Dynamics component so that the impact of distributed teams is represented in the simulation. As the NATO militaries transform to a more networked force, the Human View architecture is an important tool that can be used to make recommendations on the proper mix of technological innovations and human interactions.

1. INTRODUCTION

At the Prague Summit in November 2002, NATO recognized that transformation of the military based upon information age principles was essential, and pursued a course of transformation termed NATO Network-Enabled Capabilities (NNEC)[1]. The objective was to initiate a culture of information sharing to induce better situational awareness, faster decision making, and improved collaboration between nations. The potential NNEC benefits would also include improved efficiency, increased interoperability between nations, secure information sharing, improved information quality, and faster speed of command. While NNEC is often perceived as a technical transformation, in practice NNEC emphasizes people first, then processes, and finally technology. The challenge of NNEC is to achieve the proper mix of new human behaviors and competencies, organizational changes, and innovative technologies.

In order to make the transformation to NNEC, methodologies on how to represent the integration of technology and human/social systems are needed. The objective of this paper is to describe the NATO Human View Architecture, and specifically the Human Network product. Human networks can connect different individuals performing roles in the same or different locations and the same or different organizations. The performance of the process supported by the human network is affected by the assignment of roles, responsibilities, and the existence of needed relationships. Attributes of human networks can also be implemented in a dynamic model to simulate the effect on process performance outcomes. The Human View Architecture can "effectively use information technology to rapidly mesh the individual skills of strangers into interdependent work products" [7].

2. THE NATO HUMAN VIEW

The NATO Research and Technology Organization (RTO) Human Factors and Medicine (HFM) Panel 155 convened a Human View Workshop in July 2007 to discuss and propose a cross-national Human View; that is an architectural viewpoint that focuses on the human as part of a system. A Human View is required to explicitly represent the human and to document the unique implications humans bring to the system. The workshop panel evaluated emerging human view concepts, proposed a candidate human view construct, and developed an outline of a NATO-wide Human View. The Human View was designed to be independent of any specific architecture framework and adaptable to different processes. The outcomes of the workshop resulted in the definition of a NATO Human View composed of eight products [5].

[1]http://www.nato.int/cps/en/SID-1F7151AF-2FE364A1/natolive/topics_54644.htm

The NATO Human View can be used to capture the human requirements and the way that humans interact with other elements of a system. It can be a design aid to specify future systems or it can be the basis for a methodology to answer questions regarding systems that have already been created. The main focus of the Human View is to capture human data and information about the interactions between humans and between humans and other elements of a system. The set of eight products that compose the NATO Human View are:

- HV-A : Concept - a conceptual, high-level representation of the human component in the enterprise architecture.
- HV-B : Contraints - sets of characteristics that are used to adjust the expected roles and tasks based on the capabilities and limitations of the human in the system.
- HV-C: Tasks - descriptions of the human-specific activities in the system.
- HV-D: Roles - descriptions of the roles that have been defined for the humans interacting with other elements of the system.
- HV-E: Human Network - the human to human communication patterns that occur as a result of ad hoc or deliberate team formation, especially teams distributed across space and time.
- HV-F: Training - a detailed accounting of how training requirements, strategy, and implementation will impact the human.
- HV-G: Metrics - a repository for human-related values, priorities and performance criteria, that maps human factors metrics to any other Human View elements.
- HV-H: Human Dynamics - dynamic aspects of human system components defined in other views.

The objective of the Human Dynamics (HV-H) product is to capture the interaction of the human system components defined in the other products (HV-A to HV-G). The design decisions recorded in the static Human View products can be appraised through a dynamic evaluation of the human system performance using the Human Dynamics. A tool such as the Improved Performance Research Integration Tool (IMPRINT)[2], a human performance modeling tool developed by the US Army Research Laboratory (ARL), can be used to implement the Human Dynamics product and help system developers predict the impact of operator attributes on system performance. Trade off analyses can also be conducted to determine the impact of system parameters on human performance metrics.

3. HUMAN NETWORK (HV-E)

The Human Network (HV-E) product focuses on the interaction of the human elements of the system: what nodes they reside at, how the human functions are distributed and what technology-based communication network enables collaboration. The HV-E maps frequent or critical types of information exchanges related to human roles as a way of expressing communication-based dependencies; this may include information exchange links to technological systems [1]. Elements of the HV-E may include:

- Role groupings or teams formed, including the physical proximity of the roles and virtual roles included for specific team tasks.
- Type of interaction – i.e., collaborate, coordinate, supervise, etc.
- Team cohesiveness indicators - i.e., trust, sharing, etc.
- Team performance impacts - i.e., synchronization (battle rhythm), level of engagement (command directed).
- Team dependencies - i.e., frequency/degree of interaction between roles.
- Communication/Technology impact to the team network - i.e., distributed cognition, shared awareness, common operational picture, etc.

The HV-E architecture product can be decomposed into several sub views to represent different types of information. An example of this is shown in Figure 1. The HV-E has been subdivided: HV-E1 Role Groupings (Teams), HV-E2 Team Interactions, and HV-E3 Information Requirements. This figure also shows the interconnections between the HV-E and other architectural products, including Operational Views (OV) and System Views (SV).

[2] http://www.arl.army.mil/ARL-Directorates/HRED/imb/imprint/Imprint7.htm

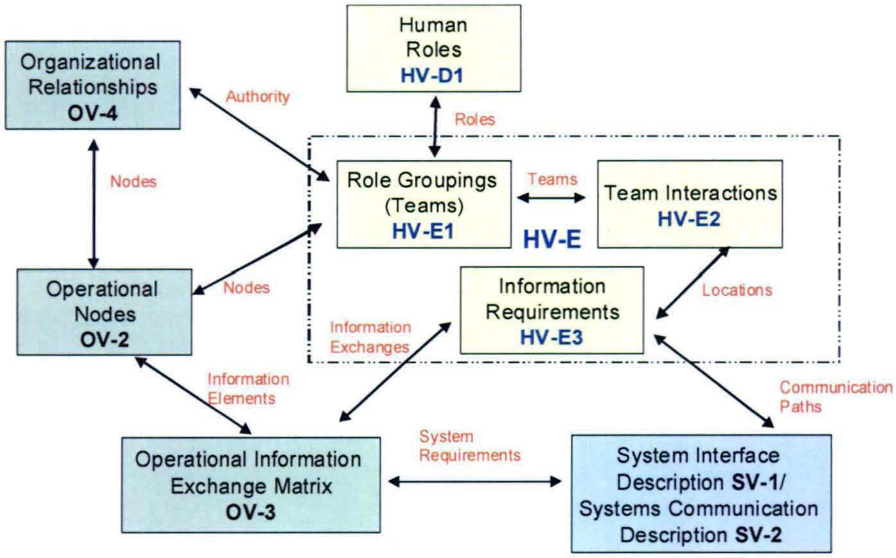

Figure 1: Human Network Relationships

4. HUMAN NETWORK AND DYNAMICS

The need for a technology-supported human information network is often driven by a *reachback* situation. Reachback is "the process of obtaining products, services, and applications, or forces, or equipment, or material from organizations that are not forward deployed[3]." This term is becoming widely used in the military community to indicate a virtual team. Virtual teams exist when decision-making activities are distributed across a team and the team is also distributed across physical locations. This has implications as to which types of communication media are suitable, how complex data can be shared so they are meaningful, how to organize team members across locations to minimize technology needs, or where to place the authority to ensure effective communication of commands [1].

An example of a HV-E, shown in Figure 2, depicts the collaboration requirements of a distributed military team. The need to conduct an operational activity shared between several roles creates the need for communication independent of where they are located and the need for technology supporting collaborative work. Some of the variables that may be inferred from the diagram include: which roles are at which locations, which activities are performed by what role, what roles need to share information, and what networks are active between locations. Additionally, the roles (ovals) are shown grouped by their work centers (boxes).

The Human Dynamics captures the interaction of the human system components defined in the other products. The impact on performance of the information captured in the Human Networks product can be assessed through the dynamic model. For example, human networks, representing a collaborative team, can connect different individuals fulfilling roles in the same or different locations and the same or different organizations. The performance of the process supported by the human network is affected by the assignment of roles, the organizations to which they belong, and the connectivity between them. Personnel fulfilling designated roles must have the training and experience required to complete the task and roles in different organizations may have different leadership styles and procedures. Collaborative teams also have differing degrees of situation awareness and team history. Remote nodes experience the greatest impact of system connectivity and interoperability. Table 1 identifies the three human-related entities of role, center (organization) and collaborative team, the relevant attributes of each entity, the baseline requirement in a co-located situation, and the impact on specific performance variables as reachback may impact each attribute.

[3] Dictionary of Military and Associated Terms, US Department of Defense, 2005

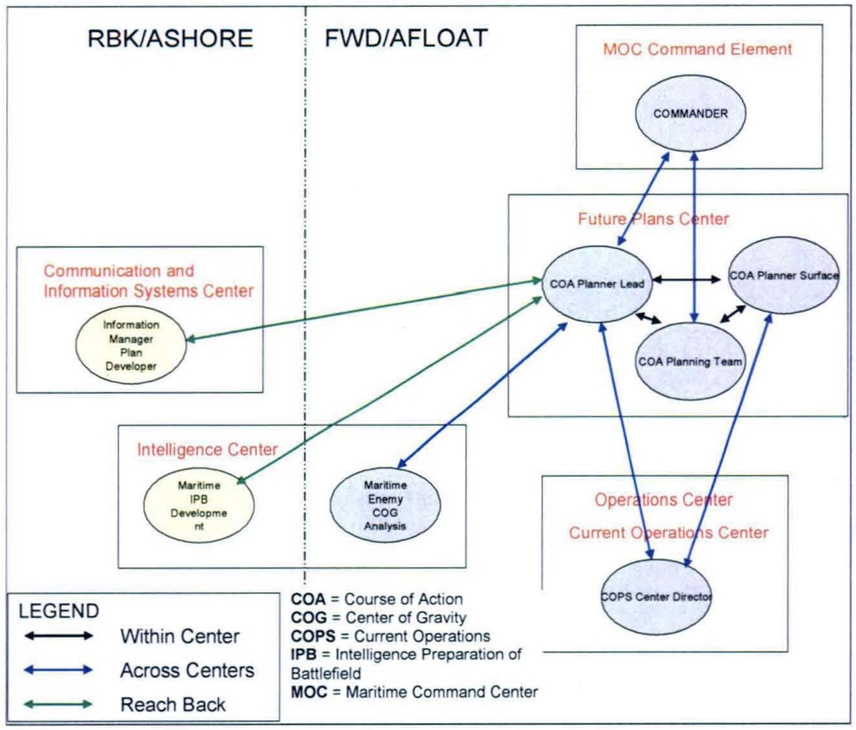

Figure 2: Human Network (HV-E) Example [4].

Table 1: Reachback Impacts

Entity	Attribute	Baseline Requirement	Performance Impact (as deviate from Baseline)
Role	Training & Experience	Fully capable to complete task.	Accuracy
Center (Organization)	Leadership & Objectives	Common goal, sense of urgency and commitment.	Timeliness
Center (Organization)	Guidance & Procedures	Same/similar task, techniques, and procedures.	Accuracy
Collaborative Team	Shared Awareness	Remote roles currently engaged in the operation	Completeness
Collaborative Team	Team History	Prior interaction with the team – leads to understanding of what knowledge, expertise, and resources each member possesses and requires.	Completeness
System	Connectivity/ Reliability/ Accessibility	Reliable and adequate communication; access to necessary information.	Timeliness

5. HUMAN DYNAMICS IMPLEMENTATION

The Improved Performance Research Integration Tool (IMPRINT) is a human performance modeling tool to help system developers predict the impact of operator attributes on system performance. IMPRINT can be used to predict the impact of design decisions captured in the HV-E on the performance of the operators of a system; the system can then be optimized by building models representing alternative human and technology allocations [6]. Data are entered through user interfaces and task-network diagrams; underlying human performance algorithms are then employed to perform simulations. IMPRINT incorporates task analysis, workload modeling, performance shaping and degradation functions and stressors, and embedded personnel characteristics data. Performance time and accuracy requirements are collected and workload profiles are generated so that role-workload distribution and role-system task allocation can be examined.

In order to demonstrate how the variables captured in the HV-E product can impact the Human Dynamics model, a methodology to implement reachback in an IMPRINT model was devised. First the entity types of the Human Network diagram were identified. Secondly, the attributes of the entity that vary under a reachback or co-located situations were described, along with their impact on performance. Finally, based on network theory research, workload demand differences that can be manipulated in the IMPRINT model were identified.

As an example of how reachback can be incorporated in the IMPRINT model and affect the performance outcomes, the two "collaborative team" entity attributes from Table 1 were explored further. Research on network theory has characterized Command, Control, Communications and Intelligence (C3I) architectures by the elements of People, Knowledge and Tasks and has defined the set of six relationships linking them, defined as a Meta-Network [3]. The Meta-Network also defines measures to assess each of the six defined relationships. By mapping the entity attributes of Shared Awareness and Team History to the Meta-Network, the resulting measures can be used as surrogate variables in the IMPRINT model to represent differing degrees of reachback. Shared Awareness involves knowing what knowledge is needed for a task; this is represented by the Knowledge-to-Task relationship. Team History involves knowing who knows what; this is represented by the People-to-Knowledge relationships; see Table 2.

Table 2: People, Knowledge & Tasks Network [2]

	People	Knowledge	Tasks
People	Who knows who	Who knows what: **Team History**	Who does what
Knowledge		What informs what	Knowledge needed: **Shared Awareness**
Tasks			What task has precedence

Both the People-to-Knowledge and Knowledge-to-Tasks relationships effect workload outcomes and can be assessed using components of cognitive load. Cognitive load is increased when the individual roles are more interdependent (increased cognitive demand) and require more interaction between roles (increased communication demand); this is more pronounced in a reachback situation. Therefore, the cognitive and speech/auditory parameters within IMPRINT can be used as surrogate variables to represent the presence of reachback in a simulation model.

Reachback can be implemented in the model by adjusting these parameters as shown in Table 3. The IMPRINT simulation can then be configured to use the correct parameter when the interactions between team members are in either a co-located or a reachback condition. The impact of the difference will be reflected in the overall role workload, which in turn impacts the timeliness and accuracy of the work process being simulated. For example, as shown in Figure 2, there is a reachback condition between the Intelligence Center and the Future Plans Center. When these nodes communicate additional workload is added to the communication function in the model. This increases the overall workload of each role, and if it surpasses a set workload limit, it will cause a detriment in the performance of the role's functions. Several variables will impact the severity of the performance impact, including the workload threshold, the timeliness penalty, and the workload management strategy. This may include dropping tasks, off-loading tasks and/or delaying tasks.

Table 3: Reachback adjustments to IMPRINT Parameters

Entity / Attribute	Meta-Network Relationship	IMPRINT Workload Demand Settings* *Workload Demand scale is 0 to 7	
		Without Reachback	**With Reachback**
Collaborative Team: Shared Awareness	Knowledge-to-Tasks	Cognitive = 4.6 Eval/Judge/ Consider Single Aspect	Cognitive = 6.8 Eval/Judge/Consider Several Aspects
Collaborative Team: Team History	People-to-Knowledge	Speech = 2.0 Simple Auditory = 3.0 Simple	Speech = 4.0 Complex (Sentence) Auditory = 6.0 Interpret Speech Complex (Sentences)

6. CONCLUSION

For network-based operations, such as NATO NNEC, the collaboration requirements between distributed roles and the resulting communication patterns are of particular importance. The NATO Human View product, Human Networks, focuses on capturing the parameters and variables that characterize the human communication processes and can provide the necessary data for a simulation model for evaluation of network-based systems.

The NATO Human View is currently being evaluated for integration into the NATO Architecture Framework (NAF) 3.0 through the Human Views extension to Enterprise Architecture project. Through this process, the NNEC elements for the Human View products have been defined, the integration of these products into the overall framework has been designed, and example Human View products have been created for the NAF Running Example. These documents have been posted on the NATO TIDEPEDIA[4] for comment and evaluation.

By providing a mechanism for capturing the required data to characterize the human interactions, the Human Network provides a valuable tool for designing human centered systems and evaluating the impact of the human component on the overall system. As the NATO militaries transform to a more networked force, the Human View architecture is an important tool that can be used to make recommendations on the proper mix of technological innovations and human roles, interactions, and behaviors.

[4]http://tide.act.nato.int/mediawiki/index.php/Human_Views_extension_to_Enterprise_Architecture_project

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