Human Systems Integration Enhancing Performance in Network Centric Warfare: The SEAPRINT Perspective

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Abstract

The US Navy established the System Engineering, Acquisition and PeRsonnel INTegration (SEAPRINT) program to develop processes, architectures and policies that lay the groundwork for successful implementation of effective systems that are configurable, reusable, and scalable. Implementation of SEAPRINT rests on defining and practicing the processes and establishing policy to support the systems engineering requirements for human system integration.

KEYWORDS: SEAPRINT, *Human Systems Integration (HSI), Policy, Process Engineering, Systems Engineering*

1 Introduction

Development of Network Centric Warfare (NCW) solutions have focused on software and hardware implementations, but success for NCW will hinge on successful performance of the human users. In defining the requirements for NCW it is essential to include both the "capacity" of user populations and the operational environments in which they work. This is more than the basic anthropometrics or cognitive capability of the average member of the user population. It requires a Target Audience Description (TAD) identifying the knowledges, skills, and abilities (KSA's) of the people that will be operating (and maintaining) the system as well as other attributes that may impact total system performance. These more diverse data must be included in systems engineering trade space analyses to ensure that the system will perform as envisioned in the operational environment. It is also essential to address organizational issues. NCW will result in overt or covert changes in the business rules of both small and large organizations. These organizational changes can affect the work to be performed and must be considered as part of the overarching design.

To achieve the goal of successfully integrating humans into NCW, especially for successful decision-making, it is essential to achieve human systems integration, writ large. This requires actually integrating the human domains and applying the products of that successful integration to the design of NCW systems. The effects of manpower, personnel, training, human factors, safety, habitability, survivability, and Environmental, Safety, and Occupational Health (ESOH) impinge on the NCW systems by clarifying the human cognitive, physical, organizational, and personal roles. The integration of domains identifies the work to be performed, the target audience, successful and economical training, optimal design for information architectures, ensuring successful performance of the system not at the expense of the human component.

1.1 Humans in NCW

NCW systems are complex both in technological implementation as well as in human and organizational content. Warfare systems' successes are predicated on the people that are part of that system effectively interacting with other system components (hardware and software) to meet operational capabilities. Historically, the emphasis in NCW systems is focused on the development and implementation of new technologies. More recently there has been recognition of the organizational aspects (Atkinson and Moffat, 2005) but even this approach depends on the appropriate integration of human users into the systems design. The appropriate integration of the human is particularity relevant as the ongoing US Navy efforts advancing performance in all missions including warfighting, peacekeeping, and operations other than war increases in the amount of information carried, reduces the methods for

verifying trust in both the information and the information carrier, as well as the enhanced opportunity for user error induced by information.

The US Navy has emphasized a Sailor-centred approach to improve the implementation of systems and the utilization of decision making support. The System Engineering, Acquisition and PeRsonnel INTegration (SEAPRINT) program was developed to facilitate a Sailor-centred approach to Human System Integration (HSI) throughout the Navy. This program also aims to identify tools and processes that are scalable across varying Navy organizational structures. The SEAPRINT process was developed to facilitate effective application of HSI throughout the systems engineering process. SEAPRINT identifies the seven actionable tenets which directly impact Navy programs: 1) Initiate HSI early; 2) Identify Issues – Plan Analysis; 3) Document/Crosswalk HSI Requirements; 4) Make HSI a Factor in Source Selection; 5) Execute Integrated Technical Process; 6) Conduct Proactive Trade-Offs; and 7) Conduct HSI Milestone Assessments. These tenets are intended to be applied across all domains of Manpower, Personnel, Training, Human Factors, Safety, Habitability, Survivability, and Environmental Occupational Safety and Health. Promoting HSI along every phase of the systems engineering process allows a number of actions. These include setting realistic systems requirements, identifying future manpower and personnel constraints, and promoting a better understanding of human performance.

1.2 Systems Engineering and NCW

Systems engineering activities begin with thorough requirements definition. This requirements definition includes detailing the relationship between human operators, maintainers, other users and the system. A number of authors have detailed the systems engineering process (Kossiakoff & Sweet, 2003; Martin, 1997). The interface between systems engineering and human factors results in defining and understanding the needs and requirements of the humans using the system in the operational environment. Figure 1 illustrates the areas in the systems engineering cycle in which HIS is essential.

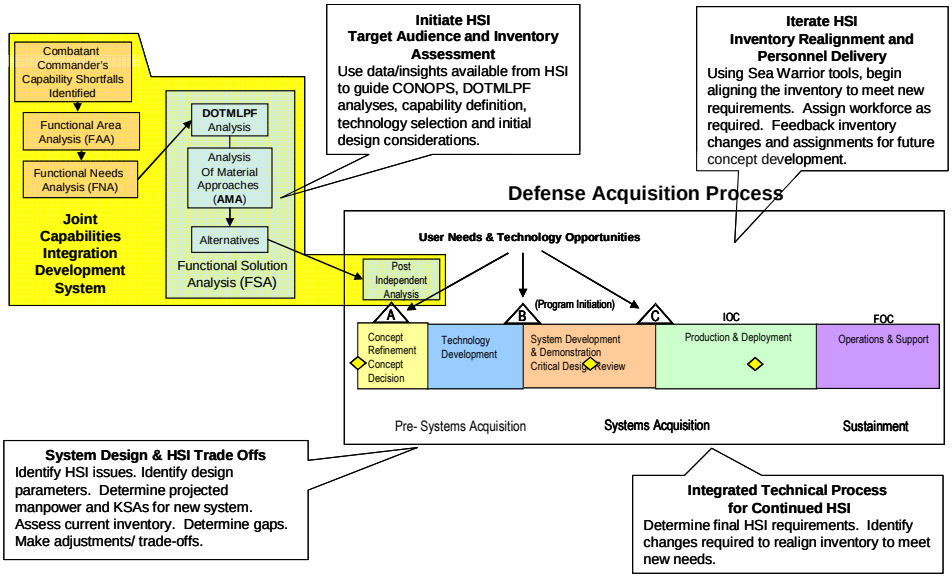

Figure 1. The Systems Engineering Process with representative HSI activities.

To define the requirements of humans as a major system component, it is essential to understand the inherent "capacity" of user populations and the operational environment in which they work. A number of authors have detailed HSI and to some extent, the place of the human disciplines in systems engineering (Booher, 2003,

Chapanis, 1996). This is more than the basic anthropometrics or cognitive capability of the average member of the user population. It requires a detailed description of the target audience of users and maintainers and explicit understanding of the knowledge, skills, and abilities (KSAs) of the people that will be operating (and maintaining) the system as well as other attributes that may impact total system performance. It is also essential to understand the work that will be performed. A number of authors have explored the definition and use of occupational information as well as the effects of organizational structure, business processes, and work structure (Cook, 1996; Kubeck, 1995; Peterson, et al., 1999; Sheridan, 2002; and Wilson & Corlett, 1995). These more diverse data must be included in systems engineering to ensure that the system will perform as envisioned and specified in the operational environment. It is also necessary to address organizational issues. Many systems result in overt or covert changes in the organizational structure and business rules of both organizations regardless of size. These organizational changes can affect the work to be performed and must be considered in global design decisions. They must be reflected in the information architecture of the system as well, especially if there are automation or decision making support elements. It is critical to understand the work and the context in which it will occur when designing any new system; the SEAPRINT process enables this understanding for system designers, operators of the system, and program managers. The work the humans perform (including workflow) must also be defined. This definition of work must be utilized both locally in the human factors aspects of the design and globally in the overall systems design. In addition, it is important to socialize that definition of the work to be performed in the organization and among the claimants of that work. These business processes, organizational structures, and occupational work must also be factored into the systems thinking and design. This includes the eliciting the information flows necessary to support NCW systems and the human decision making processes that will be supported by a solution system and its performance. To achieve the goal of successfully integrating NCW systems, it is essential to integrate human systems. This requires integrating the human domains and applying the products of that successful integration to the design of NCW systems.

2 SEAPRINT and NCW

Meaningful integration of the domains is more than just inserting human factors into the system design of highly networked systems. Integration requires awareness of the system performance as affected by all of the components of that system. The context and predictability measures also contribute greatly to the HSI process. Effective integration of the domains allows for better, more balanced compromises with other specialty engineering disciplines. The effects of manpower, personnel, training, human factors, safety, habitability, survivability, and Environmental Occupational Safety and Health impinge on decision making by clarifying the human cognitive, physical, organizational, and personal roles. These domains effect automation and decision-aiding and support by identifying work to be performed; target audience; successful and economical training; and optimal design for information architectures. The SEAPRINT process also provides a platform to explore manpower, personnel, and training effects of specific designs and implementations. Optimized systems can be explored, designed and iterated while requirements and function allocations are still being established. Further, the tools and processes deliver insight to the potential outcomes of requirements from the earliest phases of development. The resulting systems have an apposite mix of an optimized number of human operators or maintainers, an appropriately architected automation capability, are staffed by the optimum selection of people, correctly trained, and organizationally supported to execute suitable business rules.

The Department of Defense and the Navy has established direction and guidance to perform HSI in programs. These documents state that programs must include HSI but are quite vague. The SEAPRINT program developed identified and documented structures and further instruction to help program managers perform HSI within their programs. SEAPRINT has used a number of tools to explore the means to successfully integrate HSI into acquisition while leveraging already existing tools, processes, methodologies, and structures.

HSI activities occur in organizations across the Navy and within acquisition organizations that develop systems, organizations, and personnel. These essential activities have grown up independent of one another and separate from the acquisition of materiel. The systems engineering process is clearly the most effective means to include human requirements into the materiel solution.

Human Factors Engineering is the human discipline already coupled with systems engineering in acquisition, therefore it makes an excellent starting point. It is not, however, the endpoint. The diverse activities and organizations of other domains have to be incorporated as well. The SEAPRINT program explored the concept of

this integration through a series of case studies. The aim of the case studies is to demonstrate the data integration required to perform HSI. These data exchanges are necessary because lack of a common data framework hinders much HSI work.

2.1 Linking SEAPRINT and NCW

The initial case study linked the elements of manpower and personnel tools to human factors tools. By establishing a link between the occupational work and the detailed human factors task analysis the effects of potential staffing changes on mission performance was established. A second case study explored linking the human performance model to an engineering process model. This linkage not only allowed exploration of the effects of staffing on the larger mission performance but also allowed the engineering process model to more accurately represent the human operators that were previously modeled with no error or variance. Another case study applied SEAPRINT process and modeling to a networked ISR excursion.

The Navy is using SkillsNET® SkillObjects℠ technology to collect the occupation work data of the Navy including the positions for NCW. These data quantify occupational information (called Level I data) and operator contextual information, describing job and their required knowledge, skills, and abilities (KSAs) of the work performed (e.g., Manpower) as well as the required characteristics of the Sailor to efficiently execute the work (called Level II data). These data quantify the relationship between performance standards, certifications and KSAs required by the job. The case studies established a linkage between these manpower and personnel oriented data and the system data as represented by human performance models. These human factors engineering data (called Level III data) describe comprehensive system functions and performance requirements of the system or capability. These human engineering data provide information that supports a top-down functional analysis and facilitates building task network models. The human factors data decompose missions into required executable activities (i.e., tasks, subtasks, sub-subtasks) at a granular level and include information about all system activities – not just human activities, but also activities performed by the hardware and software, and those performed by interdependent external entities (hardware, software or human).

For a set of activities related to a particular mission and/or scenario, the human factors data contain information about the environmental conditions (e.g., noise, temperature, vibration) and the controls and standards (e.g., policy, laws, doctrine) under which the activities are performed. For each activity (task, subtask, sub-subtask), Level III Data contain extensive information about that activity and its relationship to other activities (e.g., activity sequencing, inputs/outputs, priority, delay tolerance, and criticality). Level III Data also contain information about the performance requirements of each activity, work process or capability. Examples include time to complete activity, acceptable error rate, input/output modality, human mental workload demand and nature of the activity (e.g., numerical, discrete fine motor). Level III Data consist of the knowledge, skills and abilities required and/or desired in order for the system and work processes to meet the current and projected required mission performance. Level III Data are being developed for all new Navy systems, systems undergoing significant modification or upgrade, and systems with noted or potential performance deficiencies. These human factors engineering data would not typically be developed for existing systems with acceptable performance and little need or opportunity for modification. Level III Data may be developed for existing systems in order to validate existing (i.e., “as is”) work definitions and/or Sailor development requirements.

Congruently with DoD Instruction 5000.2, the SEAPRINT program promotes comprehensive system engineering to optimize total system performance. This program promotes standardized approaches to ensure that 1) Sailors are considered an integral component of the total system; and 2) systems are designed that facilitate improved human performance and minimize lifecycle costs. Proper use of Level I, Level II, and Level III data provide a method to assess the effectiveness of design decisions across the system lifecycle. Preliminary modelling case studies performed to date have indicated the potential outcomes of advanced solutions for crew reduction scenarios. These case studies indicate that careful requirements definition, integration across the human domains, trade offs across the specialty engineering disciplines have the potential to result in more optimized systems that support human users and achieve the necessary capabilities.

3 Why is SEAPRINT important to NCW?

The concept of NCW is powerful, but the execution is intimidating. Far from simplifying warfighting, if improperly implemented the concepts of information warfare, networked forces, and geographically distant forces have the potential to increase problems rather than generate solutions. If designed incorrectly, the solutions for NCW can create a greater Fog of War generated with more data but less information.

The humans in the network will bring the necessary elements to the war. NCW has been defined as warfare which derives its power from the robust networking of a *well informed* but *geographically dispersed* force which is joined via highly networked information services providing timely access to all relevant and appropriate information sources. This approach is essential to gain the multiplicative force needed however, this solution is not sufficient. It must also have compatible data structures, protocol standards, graphics Symbology, and display interpretation. This definition of the needs of the users and the resulting requirements will result in a successful solution.

Both HSI and NCW are applicable to all levels of warfare. NCW contributes to the coalescence of strategy, operations, technology and tactics, and is transparent to mission, force size and composition, and geography. HSI ensures the design is both necessary and sufficient to achieve these aims.

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