Systems Engineering, Acquisition and Personnel Integration (SEAPRINT): Achieving the Promise of Human Systems Integration

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ABSTRACT

Emphasis on mission systems performance has focused on the development and implementation of technology. The success of these systems hinges on the successful performance of the humans interacting with these systems to meet the desired operational capabilirties. The Sysetms Engineering, Acqusition, and Personnel Integration (SEAPRINT) program identified and documented the processes and tool sets that allow successful implementation of mission systems that work and are scalable across organizational structures and working within the current structure while it transforms.

1.0 INTRODUCTION

While much of the emphasis on advanced mission systems, especially those that are automated or provide enhanced cognition has focused on the development and implementation of technology, the success of these systems hinges on the successful performance of the humans interacting with these systems to meet the operational capabilities. This is true for any organization that wishes to optimize mission performance. It is particularity relevant to the US Navy and its efforts to revolutionize both warfighting and peacekeeping mission performance. The Navy is focusing on a sailor centered approach which will impact the implementation of advanced technology and automated systems. The System Engineering, Acquisition and PeRsonnel INTegration (SEAPRINT) program identifies toolsets, and processes that lay the groundwork that will allow successful implementation of decision-making systems that work and are scalable.

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2.0 SYSTEMS ENGINEERING

Thorough systems engineering practice demands meticulous requirements definition detailing the relationship between the human and the system. A number of authors have detailed the systems engineering process (Kossiakoff and Sweet, 2003, Martin, 1997). Human factors is the specialty engineering discipline that specifies the human component of the system. The interaction of systems engineering and human factors results in defining and understanding the needs and requirements of the humans using the system in the operational environment. This inclusion of the human as a major system component is part of the trade space in any system design. However, it is an essential part of the trade space for advanced mission systems, especially those with decision-aiding or automation systems. The challenging part is to understand this portion of the trade space and use it with respect to the remaining trade space to balance "human friendly" solutions for users and program managers.

Figure 1 below illustrates the major phases and iterative nature of the systems engineering process. While this process is quite good and appropriate to the design, development, and deployment of complex systems, systems of systems, and families of systems, the outputs of the process continue to fall below expected performance when deployed and used by representative users and maintainers in operational scenarios. It is clear that human systems integration will bring a great deal of improvement to systems engineering by ensuring the most contentious element of the system is included in the design and development of the system, throughout the systems engineering process.

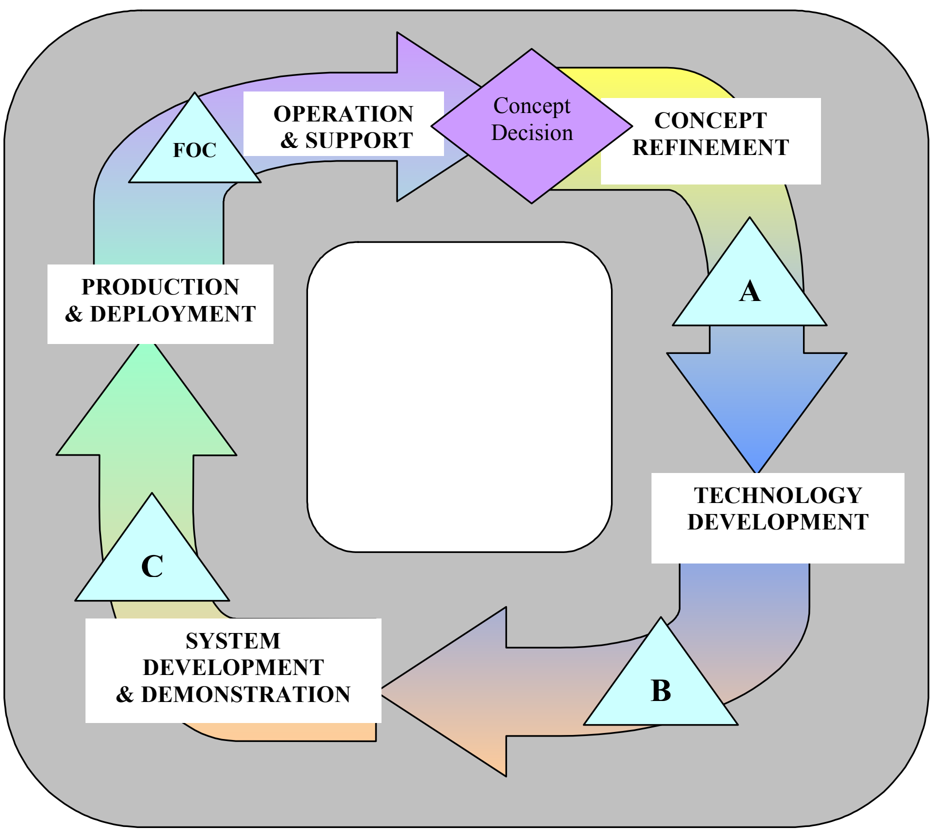

Figure 1. The Systems Engineering Process

3.0 HUMAN SYSTEMS INTEGRATION

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 Human Systems Integration 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 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. It is also essential to understand all the work that must 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 and Corlett, 1995 are some examples of these diverse disciplines). These more diverse data must be included in systems engineering and trade space analyses to ensure that the system will perform as envisioned and specified in the operational environment and with the likely crew mix. It is also necessary to address organizational issues as many automated 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 as part of the overarching design. 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 truly understand the work and the context in which it will occur when using the system under development. Modern, automated mission systems have made many technological advances toward being more responsive or appropriate to the humans with whom they interact. However, the effect of the implementation of the system on the work performed by the component humans is not well understood or accounted for in design of those systems. The work the humans perform (including workflow) must be defined. That definition must be utilized locally in the human factors of the design and globally in the overall systems design and organizational structure. In addition, it is important to socialize that definition of the work to be performed into 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 explicit and implicit information flows necessary to perform the mission and to support the human decision making processes.

To achieve the goal of successfully integrating humans into the systems engineering of automated systems, especially for 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 automated decision-making systems.

4.0 SEAPRINT

Meaningful integration of the human domains requires more than just inserting human factors into the system design. It requires viewing system performance that arises from the interaction of all the components of that system in its operational environments. All of the human centered domains contribute to the definition, specification, and utilization of the system. The context and predictability measures also contribute greatly to the HSI process. Trade offs must be made inside the human domains and the integration of the domains allows for better, more balanced trade-offs with other specialty engineering disciplines. The effects of manpower, personnel, training, human factors, safety, habitability, survivability, and Environmental

Occupational Safety and Health (EOSH) impinge on weapons systems by clarifying the human cognitive, physical, organizational, and personal roles. These domains effect automation and decision-aiding and support by identifying the work to be performed; identifying the target audience; identifying successful and economical training; identifying the optimal design for information architectures, ensuring successful performance of the system not at the expense of the human component.

The SEAPRINT process was developed to achieve this human system integration and insert it appropriately throughout the systems engineering process. The process is not new but rather integrates over 200 established documents generated across the acquisition life cycle. SEAPRINT identifies seven actionable tenants which directly impact programs resulting in enhanced systems engineering through human systems integration. These seven tenants are:

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
7. Conduct HSI Milestone Assessments

and result in programs that have documented HSI requirements, analysis and issues that are articulated early and throughout the systems engineering acquisition phases. This ensures that the human domains exercise their full trade space in the same manner the other specialty engineering disciplines do. Figure 2 illustrates these HSI elements within the systems engineering phases.

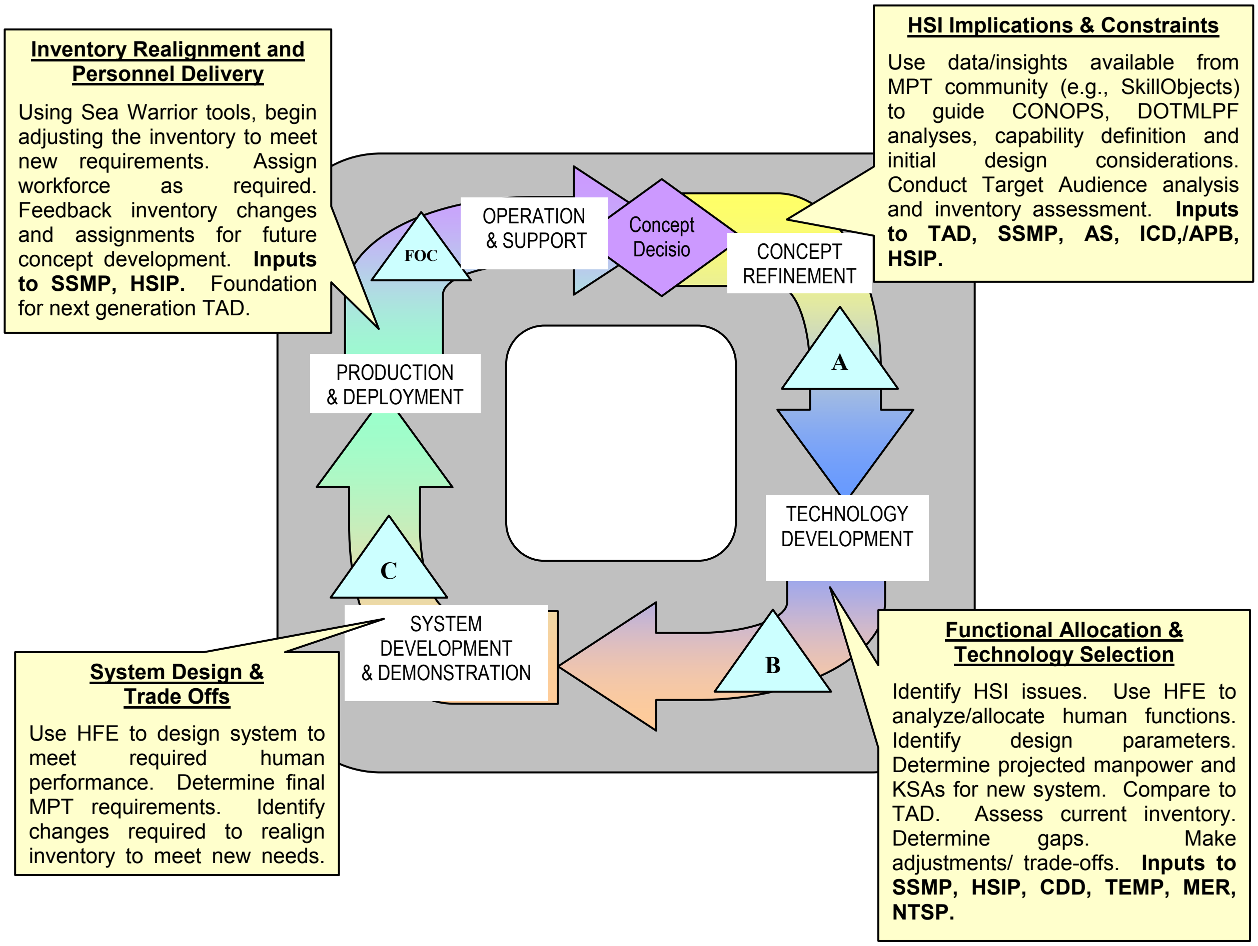

Figure 2. HSI Elements in the Systems Engineering Process

Integration of HSI elements in the systems engineering process and phases allows a number of successful actions. These include setting realistic systems requirements, identifying future manpower and personnel constraints and evaluation of operator, crew, and maintainer workloads. It is possible to use tools and processes to test alternate system-crew functional allocations assess the work hours required for maintenance and assess performance during extreme conditions. Further processes and tools provide a platform for evaluating performance effects of personnel characteristics and training. Finally, focus of test and evaluation resources can be sharpened.

The SEAPRINT process has direct effect for modern high technology mission systems, especially those that rely on automated decision support or decision aiding systems and subsystems. By providing a platform to explore manpower, personnel, and training effects of specific designs and implementations, optimized systems can be explored, designed and fleshed out while requirements and function allocations are still being made. 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.

Case studies performed to date have indicated the potential outcomes of automated systems 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.

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