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Where Are the People? The Human Viewpoint Approach for Architecting and Acquisition

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Where Are the People? *The Human Viewpoint Approach for Architecting and Acquisition*

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The U.S. Department of Defense Architecture Framework (DoDAF) provides a standard framework for transforming systems concepts into a consistent set of products containing the elements and relationships required to represent a complex operational system. However, without a human perspective, the current DoDAF does not account for the human performance aspects needed to calculate the human contribution to system effectiveness and cost. The Human Viewpoint gives systems engineers additional tools to integrate human considerations into systems development by facilitating identification and collection of human-focused data. It provides a way to include Human Systems Integration (HSI) constructs into mainstream acquisition and systems engineering processes by promoting early, frequent coordination of analysis efforts by both the systems engineering and HSI communities.

« Image designed by Diane Fleischer

The U.S. Department of Defense Architecture Framework (DoDAF) is used by the engineering and acquisition communities to describe the overall structure for designing, developing, and implementing systems (DoDAF Working Group, 2004). DoDAF provides a standard framework for transforming systems concepts into a consistent set of products that contains the elements and relationships required to represent a complex operational system. The use of an architecture framework, such as DoDAF, in the acquisition process can be a critical enabler for systems success since it provides a structured approach to identifying and addressing technical issues early in the systems life-cycle process.

Background

DoDAF was designed to meet the needs of multiple stakeholders, including program managers, systems engineers, and acquisition executives. The architecture framework can be used to provide pertinent information to different communities by employing various viewpoints. Each viewpoint is built by extracting data focused on a specific facet of the system and displaying it to the user through a set of models. Models can be documents, spreadsheets, dashboards, or other graphical representations that organize and display system data. This allows users to focus on specific areas of interest, such as capabilities, data and information, projects, services, and standards, among other viewpoints (DoDAF Working Group, 2010). However, noticeably missing from the list of viewpoints is one that focuses on the human perspective: the Human Viewpoint.

DoDAF is fundamentally about creating a set of models representing the system to enable effective decision making to support systems engineering and acquisition processes. However, without including models that focus on the human perspective, the current DoDAF framework does not account for the human-performance aspects needed to contribute to systems effectiveness and cost. Without this type of information, there is no basis to make informed decisions about the tradeoffs between systems design and human-related issues (Knapp & Smillie, 2010). DoDAF ensures that the architecture descriptions facilitate the creation of systems requirements that will achieve the desired outcomes; however, systems engineers currently do not have sufficient tools to quantitatively integrate human considerations into systems development (Hardman & Colombi, 2012).

This article reviews the Human Viewpoint and then presents a current methodology for identifying and capturing data in the Human Viewpoint models. The relationship between the Human Viewpoint and Human Systems Integration (HSI) is then identified, and support for using the Human Viewpoint in the acquisition process is provided. Finally, an example of how the Human Viewpoint can be used to capture appropriate human system data to support systems design decisions is described.

The Need for a Human Perspective

DoDAF defines different perspectives or views that logically combine to describe a system architecture. A viewpoint provides a self-contained set of models that provides a complete set of data for evaluation consistent with the perspective of the view. When DoDAF was initially released, HSI practitioners argued that without a viewpoint that included the human component of the system, there was no basis in the architecture for analysis of human issues that may impact multiple aspects of the system (Hildebrand & Adams, 2002). For example, analyses that measure the human impact on system performance; cost-benefit analyses that consider the influence of manpower, personnel, and training on total costs; and requirement analyses that include the human specifications to adequately operate and maintain the system all require human-focused data—none of these analyses could be performed with the data currently captured in the framework. With a viewpoint that captures human considerations, these factors could be assessed and addressed early in the acquisition process, similar to technical evaluations. The consideration of human issues can enhance overall systems performance by ensuring efficient and effective use of human resources within the system, ultimately reducing the overall cost of a system (Knapp & Smillie, 2010).

4

Developers of the original DoDAF deskbook made an initial attempt to represent humans in the Operational Viewpoint products by including the role of the human and human activities associated with a system (Hildebrand & Adams, 2002). Likewise, in the recent version of DoDAF (version 2.02), human components can be identified under the Performer construct in the Services Viewpoint (DoDAF Working Group, 2010). While both of these attempts allow the identification of the human as an element of the system, simply identifying what functions are allocated to humans does not provide the robustness required to evaluate the human component and its impact on the system; it does not capture the multiple human attributes required to evaluate the ability of a system to support operational requirements and accomplish a mission with the current human configuration. This requires an integrated viewpoint, with a set of models appropriate for analysis from the human perspective.

The consideration of human issues can enhance overall systems performance by ensuring efficient and effective use of human resources within the system, ultimately reducing the overall cost of a system (Knapp & Smillie, 2010).

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With a defined Human Viewpoint, the role of the human within the system is defined and task activities are described at a level useful for analysis. Human characteristics, limitations, and constraints that affect performance are also included in the models, as well as human-centered coordination and metrics. The design of a complete viewpoint allows the impact of the human presence to be evaluated and may be the driver for change in the other views. Without this view, no basis exists in the architecture for analysis and propagation of human issues (Handley & Smillie, 2008).

The Human Viewpoint was developed by an international panel of systems engineering and HSI practitioners (Handley & Smillie, 2008). The goal was to develop an integrated set of models, similar to the other viewpoints, that organized human data for use in the architecture description. These models were also linked to other architecture components, through relationships with the Operational and System Viewpoints, to provide connections to the overall system. The Human Viewpoint contains seven models that include different aspects of the human element, such as roles, tasks, constraints, training, and metrics (Table 1). It also includes a human dynamics component to capture temporal information pertinent to the behavior of the human system. The resulting human perspective provides a basis for stakeholder decisions regarding the human component by linking the systems engineering community to the manpower and personnel integration, training, and human factors communities (Baker, Pogue, Pagotto, & Greenley, 2006).

TABLE 1. HUMAN VIEWPOINT MODELS

Product	Name	Description
HV-A	Concept	A conceptual, high-level representation of the human component of the enterprise architecture framework.
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 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; it maps human factors metrics to any other Human View elements.
HV-H	Human Dynamics	Dynamic aspects of human systems components defined in other views.

Note. Adapted from "Architecture Framework Human View: The NATO Approach," by H.A.H. Handley and R. J. Smillie (2008), *Systems Engineering, 11*(2), pp. 156–164.

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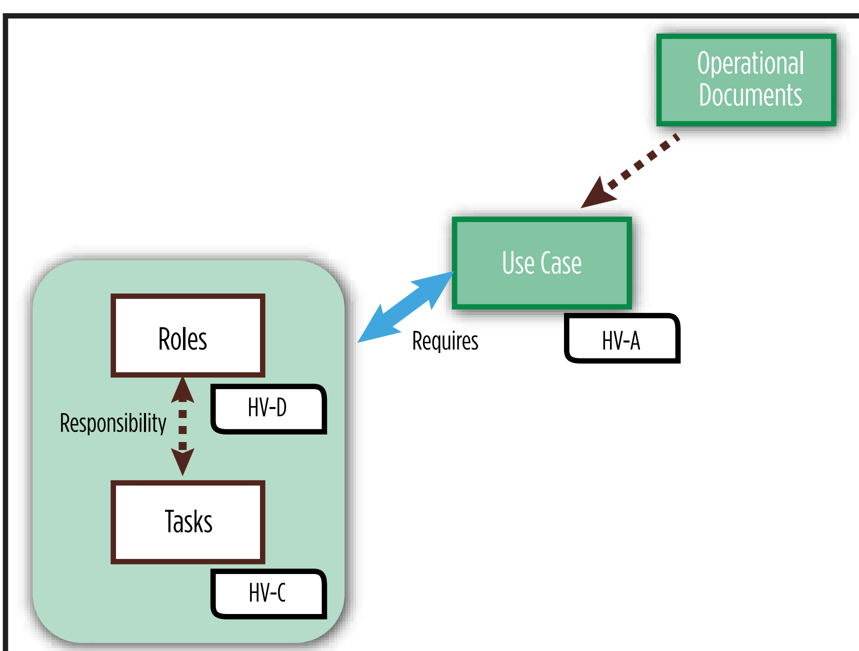
Building a Human Viewpoint

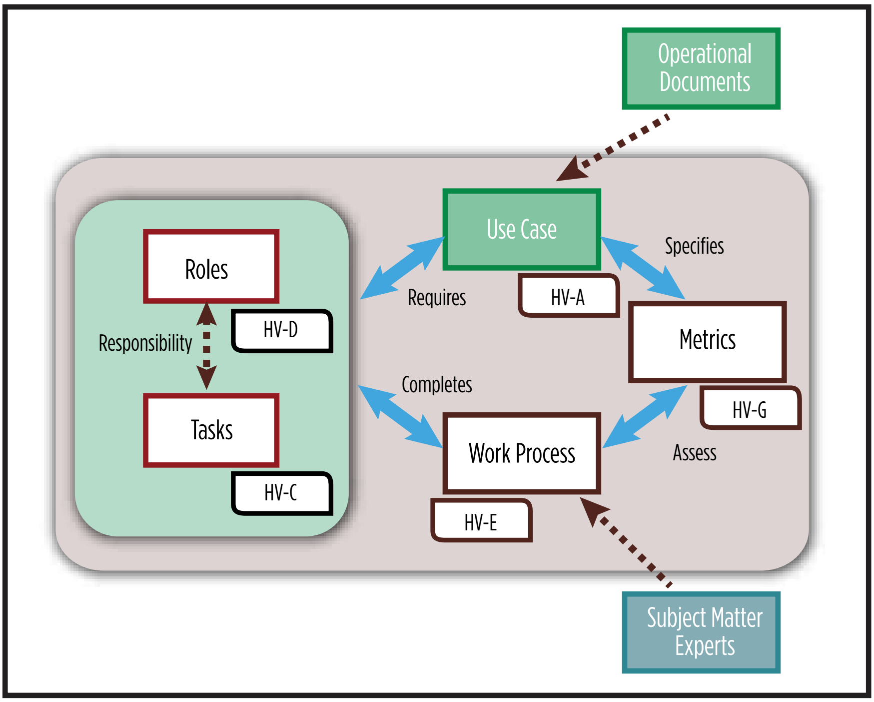
The original Human Viewpoint was defined as a set of required products, but without a prescribed methodology to identify and capture the human data. More recent work has identified how the Human Viewpoint models can be compiled by following a series of steps, broken into stages (Handley & Kandemir, 2013). Each stage represents the development of a critical human performance dimension. The first stage is initiated by visually representing the system concept of operations, using one or more diagramming methods (e.g., concept map, systemigram, rich pictures, etc.). Use cases (HV-A) are then developed that describe the interaction of humans with the operational environment and system components. The second stage develops the human roles (HV-D) and tasks (HV-C), often in tandem. Tasks describe the human activities, usually by more fully decomposing higher level functions. Roles represent job functions or task groupings. The mapping between the two is a key product of the development as it drives manning and training requirements. These first two stages are shown in Figure 1.

FIGURE 1. HUMAN VIEWPOINT AND DEVELOPMENT—STAGES I AND II



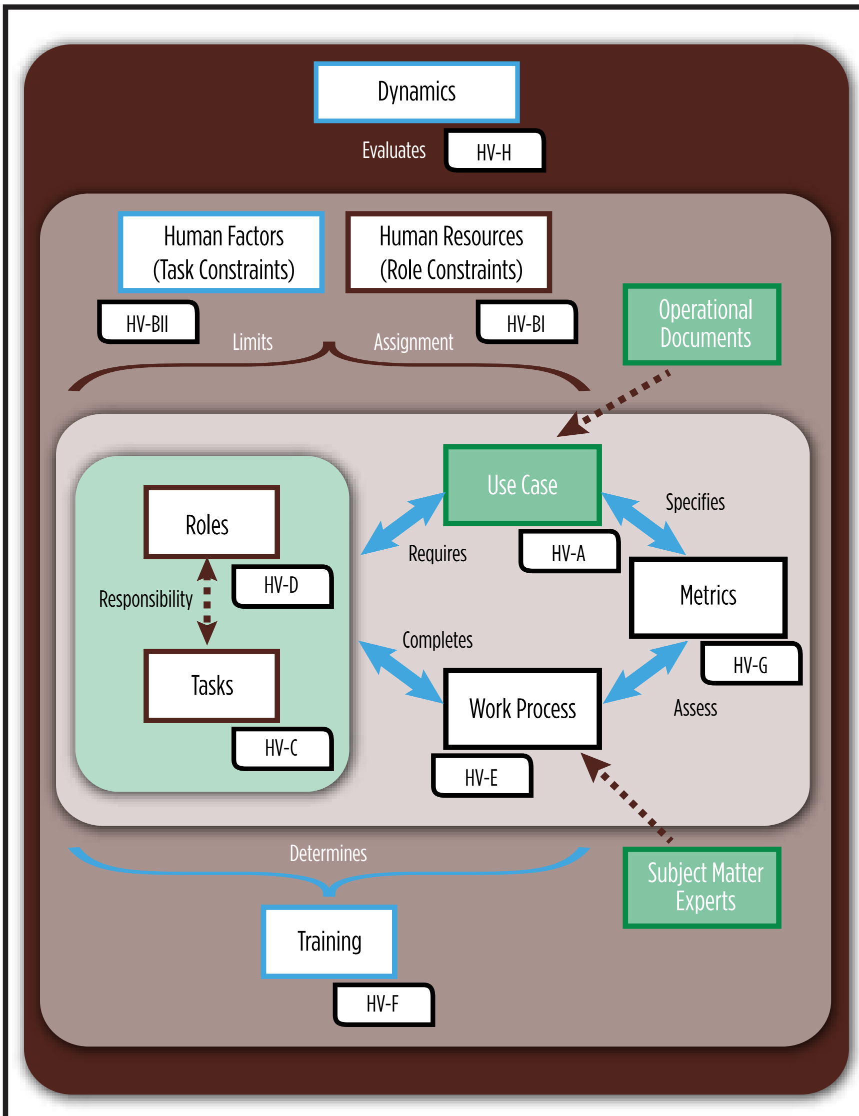
The third stage focuses on human interactions and develops a human network, usually represented as a work process (HV-E), which describes the interactions of the roles completing tasks to support the use case. This is another key product of the Human Viewpoint as it describes human activity over time, which is a driver of workload (and overload) for the individual roles. At this stage, role locations can also be included, which is important for designing distributed teams. Metrics (HV-G) representing human performance criteria are also determined. Subject matter experts, often HSI practitioners, are usually consulted at this stage to ensure that the human interactions with the system are accurately represented. This stage is shown in Figure 2.

FIGURE 2. HUMAN VIEWPOINT DEVELOPMENT—STAGE III



In the fourth stage, manning or crew assignments (HV-BI) are completed by mapping personnel to roles based on current qualifications. Additional training (HV-F) requirements are determined based on anticipated knowledge, skills, and abilities requirements. Other human factor constraints (HV-BII) are captured that may impact the human system, such as work cycle and availability. Figure 3 shows the completed Human Viewpoint development process.

FIGURE 3. HUMAN VIEWPOINT DEVELOPMENT—COMPLETED



After the completion of the individual products, the human dynamics (HV-H) can be used to pull together the information captured in all the products to evaluate the total human system behavior.

For example, an event from the environment may trigger a task (HV-C). The role (HV-D) responsible for the task begins processing it. The role may coordinate with team members (HV-E) for information exchange during processing. The way the task is processed may depend on traits of the actual person fulfilling the role (HV-B) and training completed (HV-F). Use of a system resource (HV-C) to complete the task can also be included. Additionally, other constraints such as human characteristics and health hazards (HV-B) may moderate the performance of the task. Once the task is completed, metrics (HV-G) are used to evaluate the task performance (Handley & Smillie, 2010).

The Human Viewpoint models should capture information about all personnel who interact with the system in any capacity. The operators, maintainers, and support personnel possess particular knowledge, skills, and abilities that must be accounted for in the system design along with their physical characteristics and constraints, just as the technology elements of the system have inherent capabilities and constraints. The inclusion of the human component in the architecture is essential to ensure efficient interfaces between technology elements and the system's intended users, as well as the fit to their physical characteristics.

The initial Human Viewpoint development was done as a "product-based" approach, that is the viewpoint was designed as a set of architecture products that captured the elements representing the interaction of the human with the system. These products were aligned with the other DoDAF Version 1.0 viewpoints and were specifically designed to extend existing DoDAF products wherever possible. For example, elements such as "task" or "role" can be derived from a further refinement of data already captured in the DoDAF Version 1.0 products. However, DoDAF Version 2.0 (initially released in 2009) is a data-based approach with a focus on capturing the data needed for a system, and products or views are rendered as needed from the data for decision making or system design considerations (DoDAF Working Group, 2010). The Human Viewpoint was aligned with the DoDAF Version 2.0 Meta Model (DM2) to produce "Fit for Purpose" views. These views can be used to augment the standard sets of architectural products with human-centered information important to the system description. See Handley (2012a) for a complete description of the implementation of the Human Viewpoint with DoDAF Version 2.0.

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The Link Between Systems Engineers and Human Systems Integration

HSI is a disciplined, unified, and interactive approach that integrates human considerations into systems design to improve total system performance and reduce costs of ownership (Cochrane & Hagan, 2001). It is also a strategy to integrate the multiple domains of Human Factors Engineering, Training, Manpower, Personnel, Health Hazards and System Safety. These domains collectively define how the human component will impact systems performance (e.g., mission achievement, safety, and cost), and also define how the system impacts the human component, as reflected in skill gaps and training requirements, manning levels, and workload (Baker et al., 2006). HSI ensures that the needs of the human user are considered throughout the system acquisition process and life cycle, but it represents a departure point for current architecture frameworks, as these human considerations are not captured in the standard DoDAF viewpoints.

The Human Viewpoint can provide the data and relationships necessary to address HSI concerns that are lacking in current architecture frameworks. For example, the Human Viewpoint can evaluate the anticipated impact of a new system development on the number and type of personnel required; the requisite knowledge, skills, and abilities of the personnel; and the anticipated training that will be necessary to achieve proficiency. To maximize task performance, which affects system performance, information on human characteristics as well as impacts to safety and health hazards should be included in the design, development, and evaluation of the new system. The Human Viewpoint assists in influencing the architecture framework from a "people" perspective—it identifies the effect on the development of the workforce and changes to their working environment by identifying the roles, and therefore personnel, that are affected and the requirements that are necessary to transition the workforce and their workstations to the future system (Hewitt, 2010).

The Human Viewpoint gives systems engineers an additional tool to integrate human considerations into systems development by facilitating the identification and collection of human component data that can be used to improve systems design. The increase in the complexity of systems and the missions they support heighten the need for HSI to be considered early in systems development. Ultimately, the goal of HSI is to integrate considerations of human capabilities and limitations into the design decision-making process, similar to what is done for hardware and software—integration of HSI analysis into the acquisition and systems engineering process is the key to achieving this goal (Pharmer, 2007). The human—the most important and unique system within the system of systems—can also be the weakest link or highest risk in that system; therefore, expressing the capabilities and limitations of the human in the system is imperative (Baker et al., 2006). By developing the Human Viewpoint to be tightly coupled with the DoDAF, the Human Viewpoint provides hooks to include HSI in the evolving systems concept.

The Human Viewpoint assists in influencing the architecture framework from a "people" perspective—it identifies the impact on the development of the workforce and changes to their working environment.

HSI is practiced across the Services, with slightly different definitions for the set of domains. The Army has taken the lead in furthering the development of the Human Viewpoint and has completed the first steps to integrate it into procedures and apply it to systems acquisition. (MANPRINT, or Manpower and Personnel Integration, is the Army's term for the implementation of HSI.) HSI policy information is shared among the Services through the Joint HSI Working Group (2012), which provides a venue for inter-Service collaboration to support DoD HSI initiatives.

Applying the Human Viewpoint in Acquisition

The Human Viewpoint captures human systems data in a programmatic way that closely aligns with systems engineering approaches. This not only supports collaboration between the systems engineering and HSI communities, but helps support the HSI objectives of informing tradeoff analysis; in fact, one of the original drivers for the development of the Human Viewpoint was the concern that the DoDAF views were insufficient to address HSI issues. By explicit modeling, the human elements can be considered early and related closely to the design and implementation of technology (Bruseberg, 2009). In this way, the Human Viewpoint models are appropriate inputs to the acquisition of complex systems.

The application of DoDAF and the Human Viewpoint architecture products is suited to different phases of the Defense Acquisition System (DoD, 2013). The Human Viewpoint models can inform the Joint Capabilities Integration and Development System (JCIDS) analysis starting before Milestone A as capability gaps and approaches to desired end states are identified. Functional requirements emerge by progressing through the Functional Area Analysis (FAA), Functional Needs Analysis (FNA), and the Functional Solution Analysis (FSA; Chairman of the Joint Chiefs of Staff, 2012). Manpower, personnel, and training options can be explored for the conceptual system by including the human data from the Human Viewpoint. Table 2 shows the individual Human Viewpoint models that support the JCIDS process.

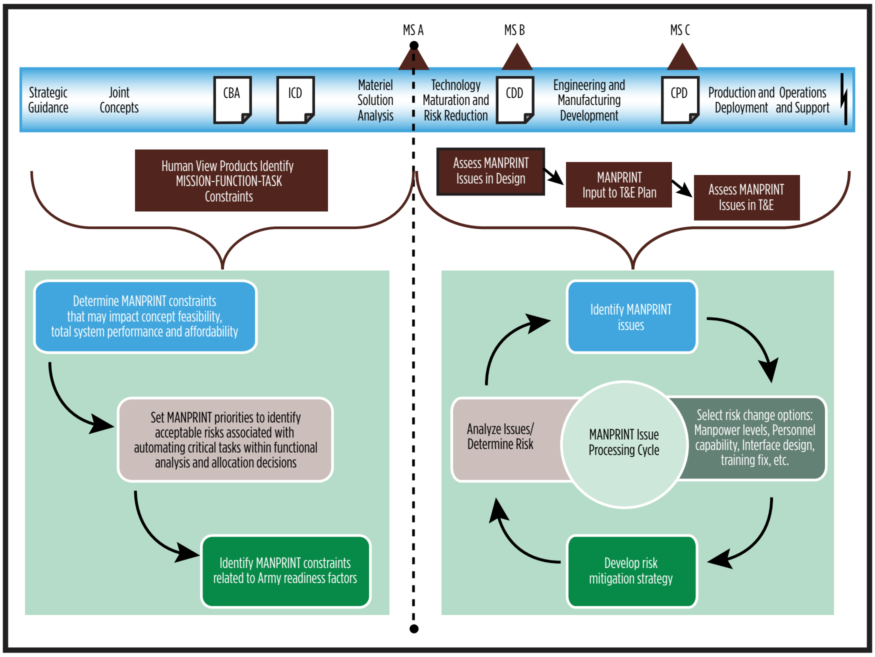
TABLE 2. SUPPORT OF HUMAN VIEWPOINT PRODUCTS FOR JCIDS

JCIDS Step	Goal	Supporting Human Viewpoint Models
Functional Area Analysis (FAA)	Tasks to be accomplished	•HV-A provides an overview of objectives •HV-C provides insights into tasks that are required to achieve military objectives •HV-G provides performance standards and metrics for systems tasks
Functional Needs Analysis (FNA)	List of capability gaps	•HV-B1 may identify manpower gaps that cannot be supported by current personnel •HV-D identifies the needed roles to support tasks •HV-E identifies information exchange requirements between roles–may also identify implications of distributed reach-back teams
Functional Solution Analysis (FSA)	Potential integrated DOTmLPF-P (Doctrine, Organization, Training, materiel, Leadership and Education, Personnel, Facilities–Policy) Change Recommendations approach to capability gaps	•HV-B1 provides the ability to conduct strategic manpower tradeoffs and comparisons between potential options •HV-B2 identifies the impact of personnel issues on career progressions (as well as costs) •HV-F identifies the impact on training programs (and costs)
Post Independent Analysis (PIA)	Initial Capabilities Document (ICD)	Complete set of initial Human View product documents

Using the Human Viewpoint to support the pre-Milestone A outcomes facilitates the identification of HSI issues (Baker, Steward, Pogue, & Ramotar, 2008). For example, during the FAA, the HV-C highlights critical tasks that are most likely to be assigned to humans; in the FNA, the HV-B and HV-D assist in the identification of the current and projected personnel required to accomplish those tasks, followed by the FSA, where the HV-F can identify training requirements that may mitigate a manpower gap.

The Human Viewpoint supports the Army MANPRINT program's goals of optimizing total systems performance, reducing life-cycle costs, and minimizing risk of soldier loss or injury by ensuring a systematic consideration of the impact of the materiel design on soldiers throughout the acquisition process (Department of the Army, 2001). Figure 4 shows application of the Army MANPRINT program, both pre- and post-Milestone A. The Human Viewpoint products directly support the MANPRINT processes, which are applied during pre-Milestone A, and can result in risk reduction and fewer changes in the mature system. The MANPRINT issue-processing cycle (post-Milestone A) supports personnel planning for the deployed system by analyzing the work allocation, personnel demand, and required training. It also allows early assessment and mitigation alternatives for personnel survivability (i.e., force protection, safety, and health hazards).

FIGURE 4. MANPRINT ACTIVITIES PRE- AND POST-MILESTONE A



Note. CBA = Capabilities Based Assessment; CDD = Capability Development Document; CPD = Capability Productino Document; ICD = Initial Capabilities Document; T&E = Test and Evaluation; MANPRINT = Manpower and Personnel Integration; MS = Milestone.

In short, HSI issues and systems requirements that impact the human role can be identified pre-Milestone A (Materiel Solution Analysis) using the Human Viewpoint. Then during pre-Milestone B (Technology Maturation and Risk Reduction), the FSA can be revisited to assess the MANPRINT implications of a materiel solution. For example, changes to the initial manpower and personnel assessment, based on a specific materiel option, can be determined by examining the updated architectural products. This may then impact the expected training requirement, and there may also be updates to health and safety issues. During pre-Milestone C (Engineering and Manufacturing Development), the Human Viewpoint products should be updated to align with the final HSI requirements and serve as an authoritative source for formal test and evaluation activities, as well for post-Milestone C Production and Deployment.

The Human Viewpoint provides a way to include HSI in the mainstream acquisition and systems engineering process by promoting early and frequent consideration of human roles. It also provides coordination of task analysis efforts by both systems engineering and HSI teams. Implementing a human perspective can significantly reduce systems risk due to technical design problems by communicating information about the needs and constraints of the human component and ensuring optimal performance and safety.

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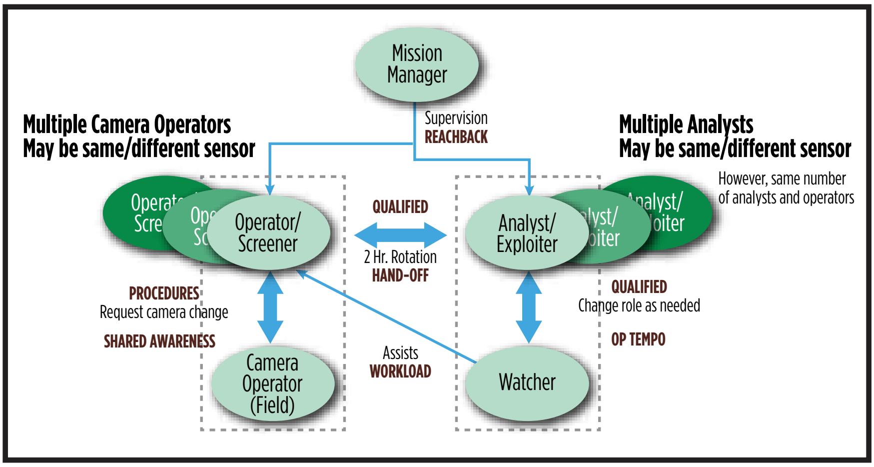
Supporting Analysis and Design

It is not necessary to complete the full set of Human Viewpoint models to benefit from a human architecting effort. Each individual model captures a "snapshot" of different aspects of the human system and can add value to the architecture description. For example, the HV-C captures the human-level activities of a system. These tasks can be described in terms of a sequence diagram (i.e., a temporal ordering of the tasks). This can give an indication of how well a given sequence of tasks will perform, and the performance predictions for alternative sequences of tasks can be compared. Analyses with single products can also provide insights by comparing "as-is" and "to-be" architectures (Handley, 2012b). For example, an analysis of the role assignments (HV-D) due to task changes may result in recommendations to reallocate tasks to other roles based on workload, skill requirements, or locations. For network-based systems, an analysis of the HV-E may result in different coordination requirements for distributed team members to define responsibilities and information sharing. Figure 5 illustrates the interactions between roles on a distributed team and identifies parameters that may be impacted. Even using a subset of the Human Viewpoint models provides the opportunity to capture and organize diverse human information to assess design decisions and recommend improvements.

FIGURE 5. EXAMPLE OF A HUMAN NETWORK (HV-E)



Note. Adapted from "Human View Considerations of the Intelligence Crew for the Multi-Intelligence Platform Long Endurance," by H. A. H. Handley and C. Kandemir, 2013, Alion Science & Technology Final Report. Hr = Hour; OP = Operations Tempo.

Having a dedicated Human Viewpoint allows evaluation and adjustment of the human parameters associated with a system. This analysis can be completed initially with the data captured in the Human Viewpoint and then associated with other architecture viewpoints for a more comprehensive analysis. For example, multi-intelligence, multisensor platforms are designed to carry a variety of sensor types to provide persistent surveillance for long-duration missions (Kerish & Perez, 2010). The dramatic increase in available sensors over a longer period of time demands a more agile and adaptable crew capable of rapidly processing sensor data from multiple sources. Because the frequency and combinations of sensors can vary, the crew will need to be able to adjust to different types and combinations of sensors with minimum disruption to its organizational processes. The Human Viewpoint can be applied to generate alternative crew designs for different sets of constraints, and then evaluate the potential configurations to assess the organizational performance. As the sensor combination shifts, personnel are reassigned to new tasks, based on the constraints of required knowledge, skills, and abilities, while performing within an acceptable workload threshold. For each configuration, both the impact to the system design and compliance with HSI requirements can be evaluated.

In this context, the Human Viewpoint can be used to evaluate Manpower issues (the impact of a fixed crew size responding to varied task-loading over time); Personnel issues (the impact of fixed specialties responding to varied sensor types); and Human Factors issues (the impact of operational tempo on task assignment). The Human Viewpoint analyses can evaluate options such as increased cross training and varying skill levels to improve the adaptability of the crew to meet system needs. By identifying the attributes and parameters used to define the crew, a data map can be created that defines the data to be captured in each product, as well as the relationships between the variables of interest (Figure 6). These relationships can then be further explored to identify both limitations and opportunities for change.

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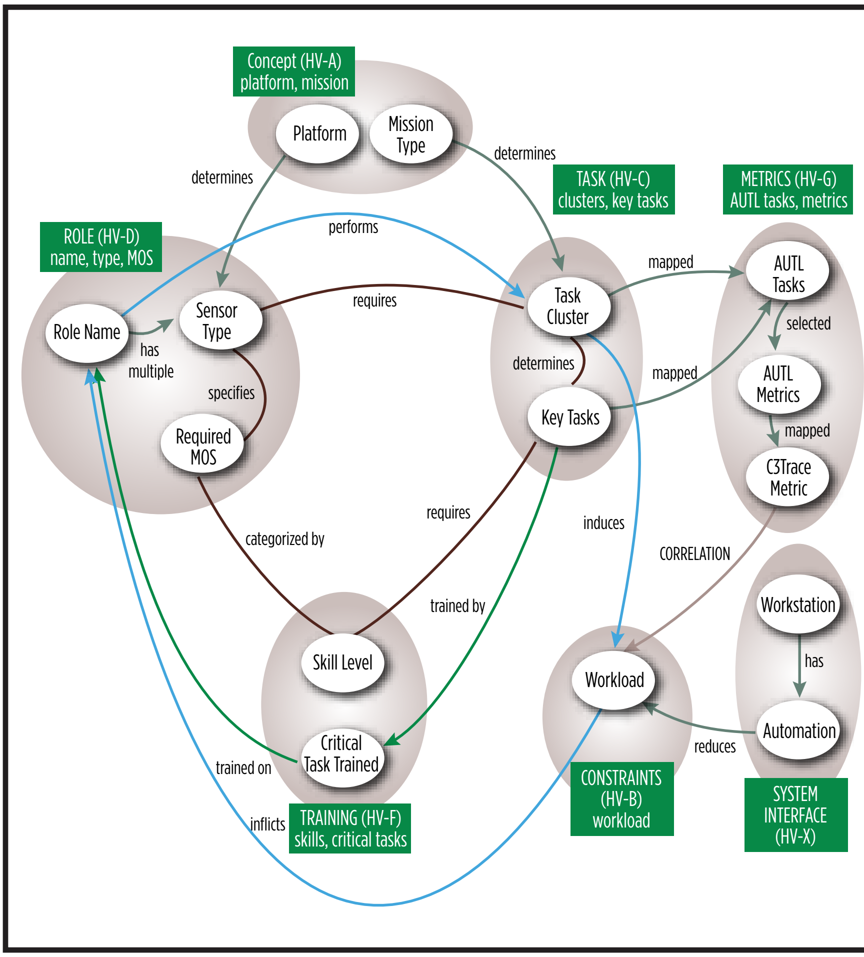
The Human Viewpoint analysis of the intelligence crew supporting long-endurance, multisensor platforms facilitated the design of alternative operator and task arrangements by first capturing the human systems requirements of the baseline configuration. Next, the operator requirements for different crew configurations were determined by evaluating the roles, tasks, and work processes with different sets of constraints. Finally, a simulation model was used to evaluate the effectiveness of the crew in the mission environment (Handley & Kandemir, 2013). After evaluating the impact of the change, the candidate crew configuration was either accepted as a viable alternative, or rejected and other parameter variances explored.

Conclusions

Humans play a pivotal role in the performance and operation of most systems, because systems must be supported by sufficient manpower, and personnel must be adequately trained to operate the system. Therefore, the absence of a human perspective in the architecture framework leaves a gap in both the systems architecting and acquisition processes. The Human Viewpoint organizes information and provides a comprehensive and understandable representation of human capabilities related to expected performance. It provides a basis to inform stakeholder decisions by enabling structured linkages between the engineering community and the HSI communities. Finally, it provides a fully integrated set of products that can be used to inform and influence system design; it facilitates human systems tradeoff analyses; and it ensures the human component has visibility as a routine part of the systems design and acquisition processes.

FIGURE 6. HUMAN VIEWPOINT DATA MAP



Note. AUTL = Army Universal Task List; C3TRACE = Command, Control, and Communications: Techniques for the Reliable Assessment of Concept Execution Modeling Environment; MOS = Military Occupational Specialty.

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Author Biographies

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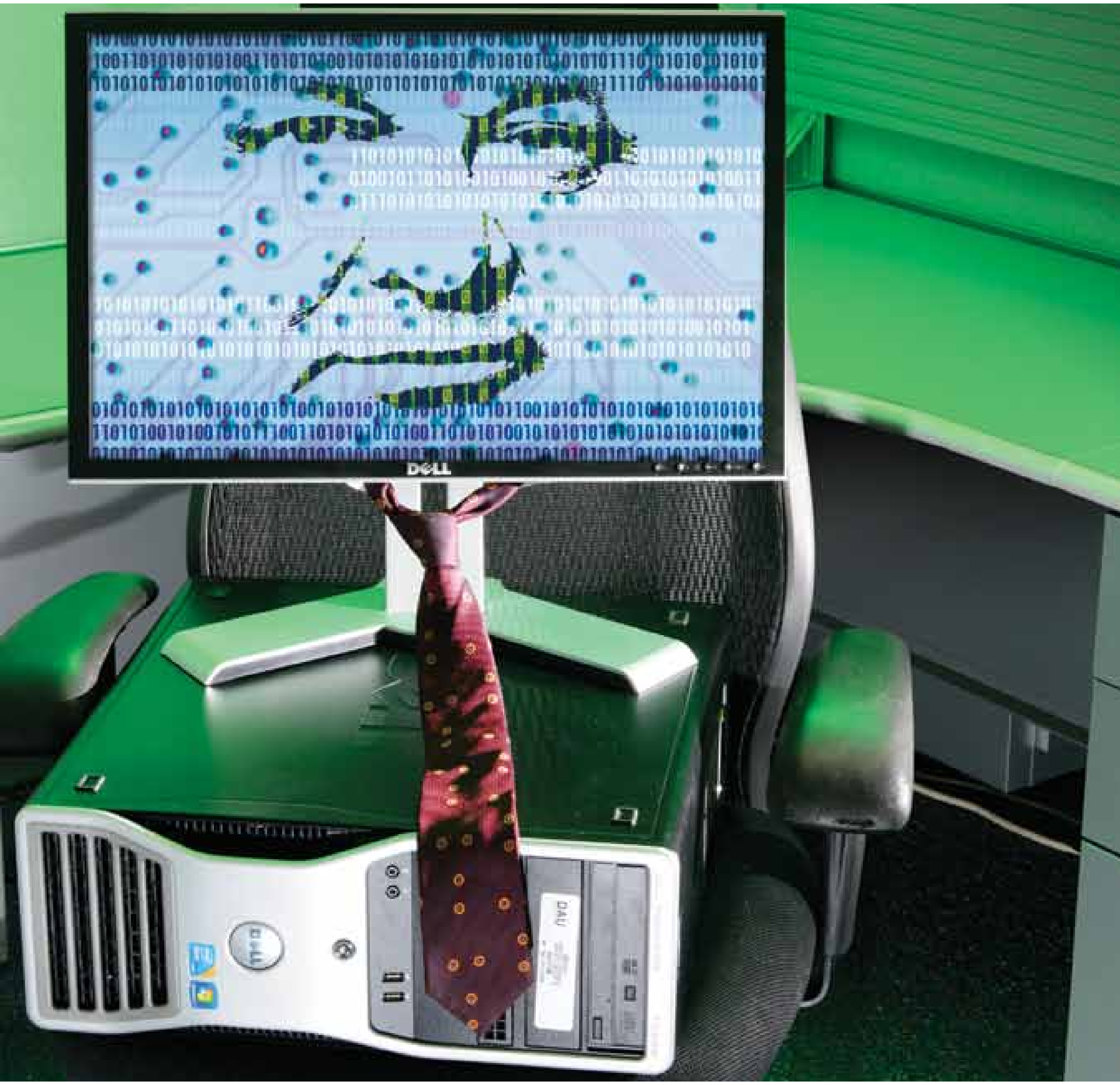
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