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Modeling and Evaluating Role and Team Work Processes using the Improved Performance Research and Integration Tool

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Abstract
The Human View architecture was designed to capture the human requirements of a system and to answer questions about the interactions between humans and systems. Data captured in the Human View can be used to populate a simulation model to evaluate the performance of the humans interacting in a work process. The work process model can be used to investigate different types of human system analyses, at both the role and team levels, and to identify the appropriate metrics to evaluate the results. This study examined individual role performance using the metrics readily available in the simulation tool, and then augmented these with "calculated metrics" in order to add additional insights to the simulation output. The second part of the study investigated the use of internal indicators to identify different aspects of team interactions. These indicators enable the work process model to be useful for evaluating team processes, and can aid in the understanding of the impact of the communication and coordination functions on crew performance.

Introduction

The Human View 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 design (Handley & Smillie, 2008). The Human View is a supplementary view to existing architecture descriptions, providing an additional set of eight products. The products illustrate the interaction and integration of human, organization, technology, and information. An executable model, the Human Dynamics, can be derived from the Human View static models in order to help system developers predict the impact of operator attributes on system performance. The Improved Performance Research Integration Tool (IMPRINT) is a human performance modeling tool developed by the US Army Research Laboratory. Data are entered through user interfaces and task-network diagrams; underlying human performance algorithms are then employed to perform simulations. IMPRINT can be used to predict the impact of design decisions on the performance of the operators of a system, the system can then be optimized by building models representing alternative human and technology allocations (Mitchell, 2005).

In order to utilize IMPRINT as a Human Dynamics model, a mapping was created between the constructs of the Human View products and the requirements of the IMPRINT model. The objective of the original mapping was to identify relationships between the data collected in the Human View products to the necessary inputs or outputs of the IMPRINT model (Handley & Imler, 2009). In this current work, that mapping is extended to a more conceptual realization of the relationships that are modeled in the Human View; this schema can then be used to identify relationships of interest that can be explored in the IMPRINT model to assess the impact of roles and teams interacting in work processes on system performance.

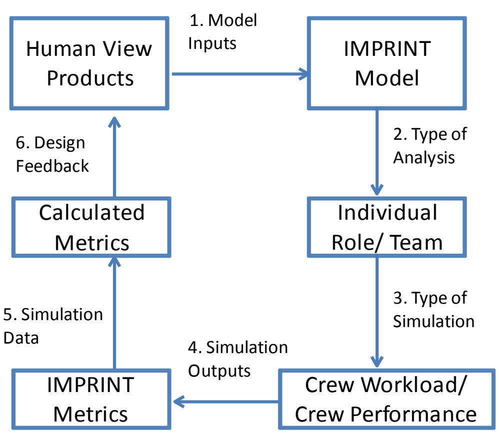
The aim of the Human Dynamics approach is to expand the focus of Human System Integration (HSI) to include integrated models of humans and systems. While the idea of modeling work processes is not new, nor is representing work processes as systems (Pajerek, 2000), the continuing challenge of modeling humans and systems in an integrated process was one of several research recommendations of the National Research Council (2007) study. Of particular interest are the process metrics of the operators that impact overall system performance that demonstrate the value of the integrated human-system approach (Madni, 2010).

The first part of this project identified different types of individual role analyses that can be completed using IMPRINT and the appropriate metrics to evaluate the results. Initally metrics readily available in the IMPRINT simulation were used; these were then augmented with calculated metrics with the goal of adding additional insights to the simulation output. Two different perspectives were included: Crew Performance, focusing on the output of the work process, and Crew Workload, focusing on the impact of the process on the operator. For each of the methodologies identified, a small simulation experiment was conducted in order to evaluate the applicability of the identified metrics. In most cases, the choice of metric was driven by the need to more fully understand the simulation outputs and the behavior of the model.

The second part of this project investigated the use of IMPRINT to model teams. INPRINT's strength is in modeling individual operators; its applicability to model teams of operators had not been fully explored. Before appropriate team metrics could be determined, it was first necessary to identify additional team behavior tasks that are performed, but may not be captured, in a typical work process model. These behaviors are what differentiate the modeled process as belonging to a team, rather than a set of individuals. The identified team behavior tasks were categorized as either Process Management Coordination, Content Management Coordination, or Team Communication functions. A model design was developed based on the presence of the different sets of team behavior tasks, and simulations were executed in order to assess impact on the value of the process performance metrics, as well as internal indicators identified by the researchers.

Both the individual role analyses and the team analyses rely on the Human View framework to collect the human system information, which can then be used as inputs to an IMPRINT simulation. The work process modeling cycle is shown in Exhibit 1. Different types of analyses (role or team) can be performed using IMPRINT and the focus of the simulation output can be on Crew Workload and/or Crew Performance; the IMPRINT provided outputs can be used to evaluate models based on these criteria. In addition, the calculated metrics, can be used to augment this output and used to further evaluate modeling hypotheses.

Exhibit 1. IMPRINT Modeling Cycle.



The Human View Schema

The Human View architecture was developed as part of a NATO panel to address the lack of representation of the human in systems architectures (Handley & Smillie, 2008). Its goal was to capture the human system requirements that enable the human component of the system. The Human View contains seven static products 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. Exhibit 2 lists the Human View products and their definitions.

Exhibit 2. Human View Product Description.

Human View Product	Description
HV-A Concept	High-level representation of the human component in the system
HV-B Constraints	Repository for different classes of human limitations
HV-C Tasks	Describes the human-specific activities
HV-D Roles	Job functions defined for the humans interacting with the system
HV-E Human Network	Human-to-human communication patterns that occur in teams
HV-F Training	Accounting of training requirements, strategy, and implementation
HV-G Metrics	Repository for human-related values and performance criteria
HV-H Dynamics	Scenarios and triggers for a simulation of the humans in the system

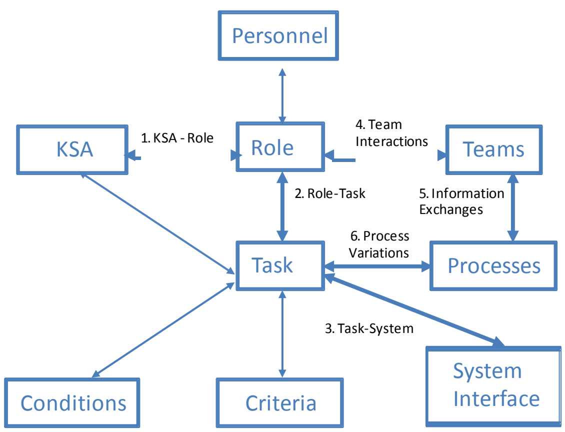
Exhibit 3. Mapping of Human View Products to IMPRINT Data.

Information Captured in Human View		Data Required by IMPRINT Model
HV-A Concept	Goal for the human component of the architecture.	Hypothesis to be tested by the model.
HV-B Human Factors Constraints	Operator capabilities and limitations under various conditions.	Selection of the Moderator settings of Personnel and Stressors.
HV-C Tasks	Task decomposition and interdependencies; systems available for task completion.	Generation of the Network Diagram composed of Tasks and Subtasks; Assignment of System Interfaces to Tasks.
HV-D Roles	List of roles and assigned task responsibilities.	Creation of Operator list; Assignment of Operators to Tasks.
HV-E Human Network	Role groupings or teams formed; interaction types between roles and teams.	Identification of Team Functions and Operator Teams.
HV-F Training	Training required to obtain necessary knowledge, skills, and abilities to perform assigned tasks.	Selection of the Moderator setting of Training.
HV-G Metrics	Performance parameters and standards.	Identification of Mission Level Time & Accuracy criterion and selection of Task Level Time & Accuracy standards.

In order to implement the modeling schema devised for the Human View Dynamics using the IMPRINT modeling tool, a mapping was created between the constructs of the Human View products and the IMPRINT model (Handley & Smillie, 2010); this mapping is shown in Exhibit 3. The mapping indicates how the information captured in the Human View static products can be applied as input data to the IMPRINT model.

While this mapping focused on the specific data captured in the products and required by the model, a more conceptual "schema" was required in order to more broadly identify the relationships between the data that can be explored in the IMPRINT model. Exhibit 4 shows this conceptual schema.

Exhibit 4. Human View Schema



Individual Role and Team Analyses

The conceptual Human View schema was used to identify relationships of interest that could be explored using IMPRINT to assess the impact of individual roles and teams on work processes. The first area of investigation was individual roles, which includes the mapping of Roles to KSAs and Tasks, along with System Interface requirements. This part of the model can be used to study the impact on the role, through workload metrics, and the role's impact on the system, through task performance measures.

Three relationships are identified in Exhibit 4 that represent the impact of roles:

1. KSA to Role Allocation: This relationship explores the effect of training by evaluating the impact of the required competencies for the role on performance. This allows the investigation of the question "Do the roles have the correct skills?"
2. Role to Task Allocation: This relationship explores the impact of different responsibility assignments, especially the impact of overloaded roles. This allows investigation of the question "Are the right roles doing the tasks?"
3. Task to System Allocation: This relationship explores the impact of the system interfaces used to complete the task. This allows investigation of the question "Are the right resources available to assist in the task?"

The second area of investigation is "teams", which includes the mapping of Roles to Teams, along with the Process and composite Tasks. This part of the model can be used to evaluate interacting roles as well as process outcomes. IMPRINT has not previously been used as a tool to evaluate team performance.

Three relationships are identified in Exhibit 4 that represent the impact of teams:

4. Team Interactions: This relationship explores the dependencies between roles. This allows the investigation of the question "What types of communications are required between the roles?" *This will be mapped to the Team Communication behavior tasks*.
5. Information Exchanges: This relationship explores the impact of the team interactions. This allows investigation of the question "Is the right information being shared?" *This will be mapped to the Content Management Coordination behavior tasks*.
6. Process Variations: This relationship explores the interrelationships and information demands between tasks. This allows investigation of the question "Are the right tasks included?" *This will be mapped to the Process Management Coordination behavior tasks.*

Three types of team behavior tasks have been identified that contribute to team work process outcomes. Team Communication represents the transmitting and receiving of information among team members. Content Management Coordination represents the integration of information across team members work products that must occur. Process Management Coordination represents the mechanics of the work process that keep the team members aligned, such as the trigger to initiate the process and clarifying the process requirements.

Candidate Metrics for Individual Role Evaluations

Additional metrics for the evaluation of IMPRINT human performance simulations had been previously identified and divided into four categories (Handley, 2010): Workload Averages, Graph Workload Averages, Workload Analysis and Sensitivity Analysis. The Workload Averages category identified different ways to calculate averages using the data collected by IMPRINT in the graph data tab of the output report. The Graph Workload Averages used the graph itself to predict average workload. The Workload Analysis used Percent Time Busy, Percent Workload over Threshold, and Toxic Task Combinations to determine specific intervals in the scenario where operators were overloaded and assisted in identifying troublesome tasks. Two other workload type metrics were explored: Cognitive Load and Load Balance that looked at the distribution of tasks among roles. The Sensitivity Analysis looked at specific independent variables to assess their impact on the dependent variables. The objective of this study is to identify how these "calculated" metrics may augment the IMPRINT simulation outputs in the different types of analyses.

The IMPRINT model can be used in two ways. It can be used to evaluate the impact of the role on the system; that is it can be used to assess the Crew Performance. Common metrics for this case include mission completion measures such as accuracy, timeliness, and completeness. Crew Performance metrics available in the IMPRINT output include Task Accuracy, Function Duration, and Task Failures. Secondly, IMPRINT can be used to evaluate the impact of the system on the roles; this is assessed through Crew Workload. Metrics of interest for this case include workload, decision speed, and correctness of decisions. The IMPRINT output report for Crew Workload provides information on Operator Task Workload, Operator Maximum Workload and Task Failures.

The metrics provided with the IMPRINT output report can now be supplemented with additional information from the calculated metrics. It should be noted that because there is a direct relationship between operator workload and task performance, some of the calculated metrics that apply to Crew Workload also may apply to Crew Performance. The calculation of these metrics can provide additional information as to the cause of poor task performance. The calculated metrics were assigned to the different cases to evaluate both the utility and the applicability of the metrics. Exhibit 5 indicates where each of the metrics was used. The purpose of the evaluation simulations was to provide an example of the applicability of the metric, and evaluate its usefulness in the assessment of the simulation outcomes.

Evaluation of Metrics for Role Simulations

A previously completed IMPRINT model was used as a test bed to examine different types of simulations and the usefulness of the metrics. This model is based on the Maritime Operations Center (MOC) Course of Action planning process (Handley & Imler, 2009). The Course of Action Planning process can be decomposed into three top level functions: Mission Analysis, Course of Action (COA) Development, and Provide Plans and Orders. Throughout the process the roles that are interacting in the process are also monitoring communications, both direct, concerning the current task, and indirect, on other topics. Each of these mission level tasks is further decomposed into interdependent sub task required to complete the mission task; a complete description of the model can be found in (Handley & Imler, 2009).

Exhibit 5. Calculated Metrics Applied to Simulations.

Additional Metrics	Additional information	Example of Use
Workload Average	The Workload Average can be used to compare values across operators.	Role-Task, Crew Performance - To augment performance results with workload information.
Graph Workload Average	The Graph Workload Average can be used to compute the workload average over different segments of the mission where the baseline workload varies.	KSA-Role, Crew Performance - To assess impact of workload on performance over a time period.
Timeline Analysis	A timeline analysis can be used in addition to, or in place of a workload analysis, to indicate what percentage of the mission operator is occupied with tasks.	KSA-Role, Crew Workload - To further understand the workload results.
Overload Density	The percentage of the total workload that is above the threshold values.	Role-Task, Crew Workload - To assess the impact of the operator overload.
TAWL Analysis	This method looks at the tasks at a particular time that cause the workload to be overloaded.	KSA-Role, Crew Performance - To drill down to a deeper level of detail.
Component Overload	Looks at the individual components of workload to determine which resources are overloaded.	Task-System - To identify the cause of the overload
Overloaded Conditions	Examines all workload to determine if any components are overloaded, even if the total workload is not over the threshold.	Task-System - To assess the potential for task conflicts.
Cognitive Load / Load Balance	This method looks at the ratios of tasks that must be completed over the course of the mission and how that tasks are distributed among roles.	KSA-Role, Crew Workload - To further drill down into a troublesome area.

Five sample work process simulations were performed. Two were configured to explore the KSA to Role relationship, two were configured to explore the Role to Task relationships, and one was configured to represent the Task to System relationship. In the first two cases, both Crew Workload and Crew Performance were evaluated, while in the case of the Task to System relationship only the Crew Workload was evaluated, as there was no manipulation available to allow the evaluation of Crew Performance. Detailed results of the experimental design and simulations can be found in (Handley & Broznak, 2011). Initally metrics readily available in the IMPRINT output were used to evaluate the results; these were then augmented with "calculated metrics with the goal of adding additional insights to the simulation output. A summary of these results are shown in Exhibit 6. No direct method of assigning the calculated metrics to specific analysis was determined, rather the metrics should be provided as a toolbox of choices for analysts to use. In most cases the choice of metric to use is driven by the need to better understand the behavior of the model in some aspect. Usually, neither the IMPRINT metrics or the calculated metrics alone provided the answer, but combined they both provided information that added to a clearer understanding of the simulation outputs.

Exhibit 6. Summary of Role Simulation Metrics.

Simulation	**IMPRINT Metrics**	**Calculated Metrics**	**Results**
Role-KSA, Crew Performance	Function Duration; Task Accuracy	Graph Workload Average; TAWL Analysis	As the Training Frequency was increased, the Function Delay was smaller and the Task Accuracy increased. The Graph Workload Average gave an indication of the variability of the workload experienced by the roles under the different conditions. A TAWL was used to take a closer look at the workload experienced by the specific role under stressed conditions.
Role-KSA, Crew Workload	Maximum Workload; Task Failures	Percent Time Busy; Cognitive Load	When the role is better matched to the task, there are less task failures. The Percent Time Busy was used to understand the impact of the external communication tasks. The Cognitive Load indicated that the cognitive load is well balanced across the roles.
Role-Task, Crew Performance	Function Duration; Task Failure	Workload Average	The results indicated that the implications of reassigning tasks to less qualified operators is apparent in the number of tasks that fail, rather than the delay of the combined tasks. The Average Workload over the course of the scenario indicated that the role workload increases with the task reassignment.
Role-Task, Crew Workload	Maximum Workload; Times Over Threshold	Percent Time over Threshold	These results show the impact of assigning an extra task to the operators. To augment these results, the Percent Time over the Workload was also calculated These analyses can be used to find the optimal assignment of the additional task.
Task System, Crew Workload	Maximum Workload; Times Over Threshold	Component Overload; Overloaded Conditions	The more specialized the interface results in a lower workload burden on the role. Both the Maximum Workload parameters and the Times over Threshold increase as the generic interface is used for more tasks. Component Overload tallies the number of times each of the individual workload components was over the threshold; Overloaded condition, on the other hand, tallies the number of times the individual component is overloaded, but the overall threshold is not exceeded. This indicates when the operators are working at a high level of stress.

Team Behavior Modeling

Team performance is not only a function of the individual team members performing their assigned tasks within the work process, it is also a function of the ability of team members to coordinate their work and communicate effectively with one another; individual performance is not sufficient for successful team performance. The tasks performed by the team members are interdependent, meaning that each team member accomplishes a part of the overall team process. Each individual contribution needs to be merged to produce the final team product. Coordination is required to accomplish this in an effective manner and communication is central to team success. While the metrics described in the previous section can capture the performance of the individual roles that form the team, they do not evaluate the team work interactions and outcomes.

Communication includes two individual processes: information transmission, i.e., preparing information for transmission, transmitting it through a medium, and receiving information, and information processing, i.e., understanding the meaning of information and integrating it into a mental model (Dennis, Fuller & Valacich, 2008). Coordination, on the other hand, is the act of managing interdependencies between activities performed by group members and gathering, combining and integrating information coming from different members (Malone & Crowston, 1994).

The IMPRINT model used in this study was created based on the Commander's Daily Brief work process (Heacox, 2005). In this process, multiple team members work to prepare sets of slides, which are then collated into a single brief to present to the commander. The current research evaluates the addition of team behavior tasks to the work process to mimic activities team members can take to ensure that each member has understood the requirements, is preparing the proper materials, and is contributing relevant data to the overall brief.

In order to use the IMPRINT work process model to evaluate team performance, three types of team behavior tasks were defined for use in the IMPRINT model: process management coordination, content management coordination, and team communication. The placement of these tasks within the work process was determined by the perceived need for a coordination or communication task among the team members. Additionally, tasks that already existed in the work process and included in the model that indicated team behaviors were identified. These included tasks such as Access Briefing Session (process management coordination), Present Brief (team communication) and Discuss Issues (content management coordination). Additional tasks included in the work process were actions such as Notify Availability (team communication) and Clarifying Request (content management coordination).

Team Indicators and Metrics

To more fully understand the impact of the addition of team behavior tasks on the model's actions, a set of internal indicators were defined. These indicators are variables defined in the IMPRINT model; their values accrue throughout the simulation of the modeled process depending on specific tasks executed. The execution of feedback paths and the addition of the team behavior tasks can increase the value of the indicator variable. The indicator variable can, in turn, impact delays and branching probabilities as the model progresses, thus ultimately impacting the performance metric, i.e., mission completion time. The indicators chosen were: Aware, Available, Correct, Complete, Current, and Consistent. The details of these indicators are shown in Exhibit 7.

Exhibit 7. Table of Indicators.

Indicator	Definition	Measure	Impact in Model	Correlation to Performance
Timeliness (Metric)	Time to Prepare the Brief	Total Process Time		Brief is completed in time for the meeting
Complete	All team members have submitted slides	Increment as Teams submit slides	Probability of Feedback Loops	All team members submit slides
Aware	Understand to start the brief	Counter of Awareness Tasks	Probability of a Delay	Brief development is started on time
Available	Ability to assist with brief	Counter of Available Tasks	Probability of a Delay	Reviewers are available when needed
Consistent	Data in the brief is consistent among members	Counter of Sharing Functions	Probability of need for changes	Requirements were understood
Correct	Slides submitted for brief do not have errors	Counter of Revision Tasks	Probability of need for revisions	Final brief is Error free
Current	Data in the slides is up to date	Counter of Import Data Tasks	Probability of need for updates	Latest information is in the brief

To evaluate the utility and applicability of these indicators, an experimental design was created that iteratively added different sets of team behavior tasks. The impact of the configurations was then assessed using both the Crew Performance metric, mission timeliness, as well as the value of the internal team process indicators. The different experimental configurations started with the baseline work process and iteratively included team communication tasks, followed by process management coordination tasks, and finally content management coordination tasks. Three analyses were performed on the outcomes of the different simulations: a comparison of the indicator values for each model configuration; a comparison of the performance metrics for each model configuration; and an investigation of the impact of team behavior task delay time on completion time.

Detailed results of the team simulations can be found in (Handley & Pazos-Lago, 2011). In summary, by inspection of the internal indicator data, Team Communication improves Awareness and Availability, Content Management Coordination improves Correctness and Consistency, and Process Management Coordination improves Completeness. The performance metric simulations indicated that Content Coordination & Team Communication resulted in the fastest mission completion time and the least number of repeated functions. These results are summarized in Exhibit 8.

Exhibit 8. Team Analyses Summary.

Human View Schema Relationship	Team Process Behavior	Internal Indicator Values	Crew Performance Improvement
Team Interactions	Team Communication	Awareness Availability	Yes
Information Exchanges	Content Management Coordination	Correctness Consistency	Yes
Process Variations	Process Management Coordination	Completeness	No

Conclusions

This investigation explored the use of methods and metrics to evaluate individual role and team process relationships. The Human View schema was converted to a more conceptual representation in order to identify relationships between the Human View elements. This schema was then used to identify relationships of interest that could be explored using the IMPRINT model to assess the impact of roles and teams on work processes. In the first investigation, metrics readily available in the IMPRINT output were used to evaluate the result of individual role simulations; these were then augmented with calculated metrics with the goal of adding additional insights to the simulation output. No direct method of assigning the calculated metrics to specific analysis was determined, rather the metrics were provided as a toolbox of choices for analysts to use to improve their understanding of the simulation results.

The second investigation of the team relationships showed how IMPRINT can capture a collaborative, team approach to a work process by including additional tasks that imitate the interactions between team members. Modeling must include tasks representing the behaviors that team members use to coordinate their actions and communicate their intentions, along with the underlying work process tasks. Indicators variables were defined in the model to monitor the impact of the additional team behavior tasks, and mission completion time was used as the performance parameter. Different sets of the team behavior tasks were added to the baseline model in order to evaluate the impact on the work process results. The simulations conducted in this study also show that under performing teams could be sacrificing coordination and communication functions in the name of timeliness. However, the savings is short term, as over the long term the team behaviors improve output. Results like this show that IMPRINT can be a useful tool for modeling both individual and team work processes and understanding the impact of the communication and coordination functions on crew performance.

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References

Dennis, A. R., R. M. Fuller & J. S. Valacich, "Media, Tasks, and Communication Processes: A Theory of Media Synchronicity," MIS Quarterly Vol. 32, No. 3, (2008), pp. 575-600.

Handley, H.A.H. *Developing, Enhancing and Utilizing Human System Integration Tools – Task 7: Interoperability of the Human View and IMPRINT Modeling, Follow on Project Task A - Workload Metrics, ARL Final Report.* San Diego, CA: Pacific Science & Engineering, Inc., (June 2010).

Handley, Holly & Daniel Broznak, *Developing, Enhancing and Utilizing Human System Integration Tools – Task 7: Human View Processes and Measures, Role Analyses.* Army Research Laboratory Interim Report. Norfolk, VA: Old Dominion University, (June 2011).

Handley, Holly, & Kathryn Imler, Developing, Enhancing and Utilizing Human System Integration Tools – Task 7: Interoperability of the Human View and IMPRINT Modeling, ARL Final Report. San Diego, CA: Pacific Science & Engineering, Inc., (December 2009).

Handley, Holly & Pilar Pazos-Lago, Developing, Enhancing and Utilizing Human System Integration Tools – Task 7: Human View Processes and Measures, Team Analyses. Army Research Laboratory Interim Report. Norfolk, VA: Old Dominion University, (October 2011).

Handley, H.A.H. & R. J. Smillie, "Human View Dynamics - The NATO approach". Systems Engineering, Vol. 13, No. 1, (2010), pp. 72-79.

Handley, H.A.H. & R.J. Smillie, "Architecture framework human view: The NATO Approach". Systems Engineering, Vol. 11, No. 2, (2008), pp. 156-164.

Heacox, Nancy, Transforming the Commander's Daily Update Brief, White Paper, Trident Warrior 2005. San Diego, CA: Pacific Science & Engineering, Inc., (2005).

Madni, A., "Integrating Humans with Software and ".
Systems: Technical Challenges and a Research Agenda". Systems Engineering, Vol. 13, No. 3, (2010), pp. 232-245.

Malone, T. W. & K. Crowston, "The interdisciplinary study of coordination", ACM Computer Surveys Vol. 26, No. 1, (1994) pp. 87–119.

Mitchell, Diane, "Enhancing system design by modeling IMPRINT task workload", Human System Integration Symposium, Arlington, VA, (June 2005).

National Research Council, "Human-system integration in the system development process: A new look." Committee on Human Factors, R.W. Pew and A. S. Mavor (Eds.), Washington, DC: National Academies Press, (2007).

Pajerek, L., "Processes and Organizations as Systems: When the Processors are People, not Pentiums". Systems Engineering, Vol. 3, No. 2, (2000), pp. 103-111

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