SYSTEMS INTEGRATED HUMAN ENGINEERING ON THE NAVY'S RAPID ACQUISITION OF MANUFACTURED PARTS/TEST AND INTEGRATION FACILITY

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ABSTRACT

The Human Engineering function in many projects is at best a limited support function. In this NAVY project the Human Engineering function is an integral component of the systems design and development process. Human Engineering is a member of the systems design organization. This ensures that people considerations are: 1) Identified early in the project; 2) Accounted for in the specifications; 3) Incorporated into the design; and 4) The tested product meets the needs and expectations of the people while meeting the overall systems requirements. The project exemplifies achievements that can be made by the symbiosis between systems designers, engineers, and Human Engineering. This approach increases Human Engineering's effectiveness and value to a project because it becomes an accepted, contributing team member. It is an approach to doing Human Engineering that should be considered for most projects. The functional and organizational issues that give this approach strength are described in the paper.

PROJECT BACKGROUND

The purpose of the Rapid Acquisition of Manufactured Parts Test and Integration Facility (RAMP/RTIF) project is to quickly produce quality replacement and spare parts for the Navy which are unavailable when needed. The objective is to make a substantial reduction in the total time required to produce parts to thirty working days after notification of award. Figure 1 shows present supply system responsiveness and the performance requirements to be accomplished in the RAMP/RTIF project.

The RAMP/RTIF Manufacturing System will initially include manufacturing and process planning systems, engineering, production control, and order entry for the production of Small Mechanical Parts (SMP) and for the production of Printed Wiring Assemblies (PWA).

PROJECT HUMAN ENGINEERING ISSUES

The NAVY, from the beginning of the project, has emphasized that people issues require significant and appropriate consideration in system design work. The RAMP/RTIF Human Engineering Program is a response to those concerns by integrating human engineering considerations into the design and development of the RAMP SMP/PWA workcell hardware, software, procedures and facilities. Special emphasis is being placed on human engineering concerns associated with the introduction of automation into manufacturing, administration, fabrication, and maintenance of the SMPs and PWAs. Some of these concerns include ensuring that:

1. Task complexity is not increased by automation, but rather simplified and made more efficient.
2. Newly created user interfaces are designed to be user-friendly, easy to learn, and easy to use.
3. Potential safety hazards are examined and eliminated from the design of user workstations.
4. The user population can effectively, efficiently and safely operate and maintain all equipment/software in the RAMP/RTIF (i.e., users can see, reach, and operate equipment, and can understand and easily use commands and menus in the software).
5. The data and information that people must deal with will be appropriate for their tasks, in a form that will make the task doable within their skill level, and/or appropriate training is provided.
6. The RAMP/RTIF system is being designed to ensure that maintenance personnel can effectively, efficiently, and safely perform maintenance functions.

THE STRENGTH OF THIS PROJECT APPROACH

The resolution to the NAVY's request for quality Human Engineering has been a commitment by the prime contractor (South Carolina Research Authority) to include Human Engineering in all stages of the RAMP/RTIF project design and development. Although the individual tasks that the human engineer will do on the project are not uncommon, the manner that they are tied together, the organization position, and the assignment of responsibility/accountability are among the factors that make this Human Engineering function an effective system engineering team member. The benefits of this position are that Human Engineering will contribute to:

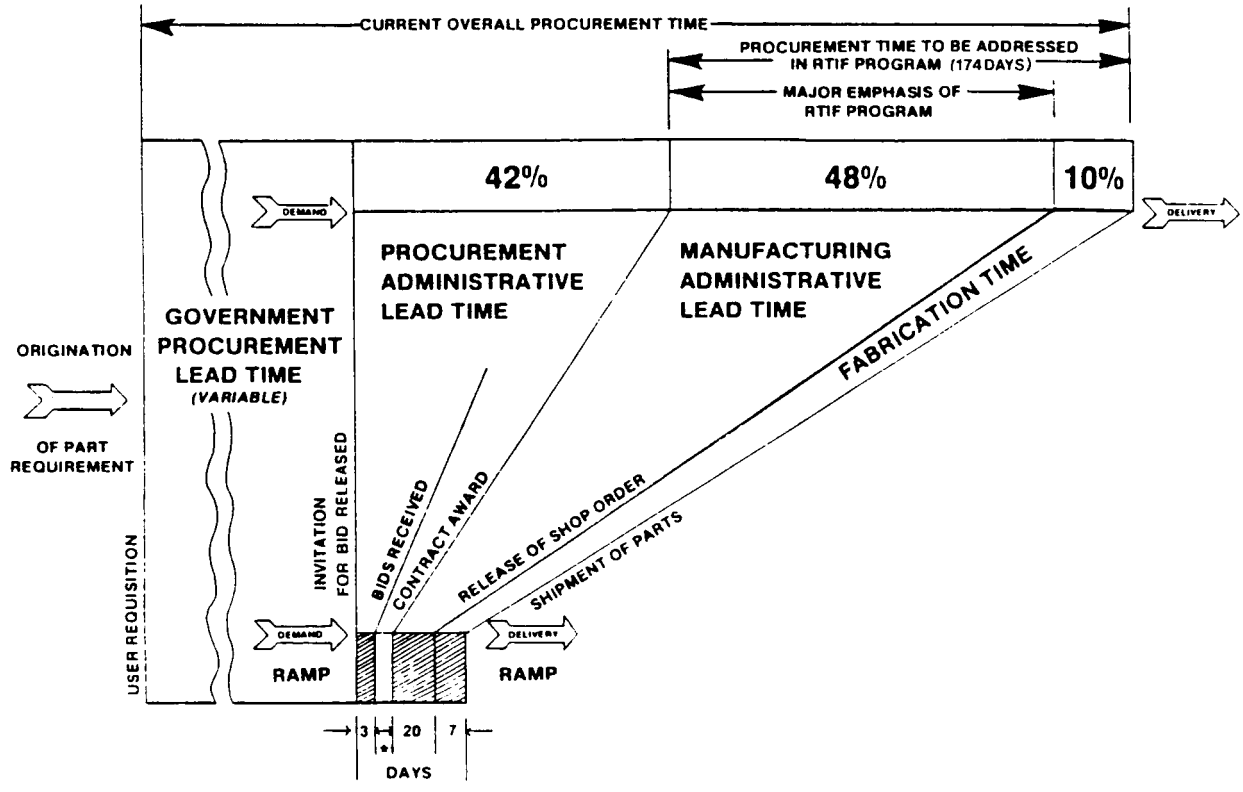

Figure 1 RAMP System Requirements Vs Present Average Supply System Responsiveness

1. Likelihood that the WHOLE PROJECT will succeed because people were properly accounted for in the design.
2. A practical approach to design where human needs are identified early and incorporated (integrated) into the systems requirements specs.
3. A realistic accounting for people issues in terms of accomplishing a balance between people needs and overall system needs.
3. Providing an effective symbiosis between people and the system that meets the performance, accuracy, and acceptability required.

This paper is to show the attributes of the RAMP/RTIF Human Engineering function that takes Human Engineering out of a support function (with little impact on overall system design) and makes it a system design team member (with appropriate impact on system design). Each of the following topics contributes to making Human Engineering a valuable team member. They are discussed here to encourage other projects to place Human Engineering into a similar role where they can greatly improve their contribution to a project.

Strength: SYSTEMS DESIGN CONCEPT

In the RAMP/RTIF project the human engineer must be concerned with all the various tasks, interfaces, and specific involvements that people will have with the RAMP. This means that the human engineer must work with each of the following functional areas in order to deal adequately with the people issues across the project:

- o Systems design, simulation, and integration
- o Hardware/software/process design
- o Safety/hazard analysis
- o Manpower and training
- o Test and evaluation
- o Logistics engineering
- o Operations and maintenance doctrinal development
- o Configuration control and management (software/hardware)
- o Program review/approval processes
- o Vendor evaluation and selection
- o Architectural facility design, development, review and approval
- o Engineering change review/implementation processes

As one looks at all these views that effect design and development, it is obvious that there must be synthesis of information across the technical areas in order to develop a workable design and development solution. The synthesis of information across these areas means that important aspects of a "Systems Design" process are being used. This concept is being emphasized here because the human engineer is a RAMP/RTIF team member in this process which gives great value to the Human Engineering function. By taking a system view in RAMP/RTIF, the people issues are dealt with wherever people have to perform a task, process information, or will physically come into contact with equipment and materials. As a result of the systems design approach, a consistent standard of interaction with people can be maintained across the system so that people will always know what to expect and be able to properly interact.

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Strength: STAGES OF SYSTEM DEVELOPMENT

The stages of system development presented below are not specifically identified in the same form in the project but the content is normally covered in the military system design process. The stages are mentioned here to clarify and emphasize the scope of the "System Design" work that the human engineer has to deal with. The human engineer will play a role in each of these stages throughout the project. Collectively the roles describe a methodology designed to maximize the effectiveness of the Human Engineering contributions to the project while minimizing the Human Engineering resources needed.

- o Conceptualization -- The initial identification and description of the people parameters must be made here.
- o Specification -- With the people issues identified in the conceptualization stage, conversion of those issues into integrated requirements will be more effective. Performance and acceptance test methods should be defined here. The tests must specify that the people who will be using the system will be a part of the test.
- o Design -- Human engineering will develop specific solutions to meet system specifications. The person works with the systems, software, hardware, and other engineers to generate design solutions that appropriately take care of and implements a design that meets needs.
- o Development -- As the design is being implemented the human engineer works with the engineering to formulate and ensure that design solutions are appropriate for the people who will be involved with the system. Implementation solutions will be user tested throughout the development stage to evaluate effectiveness of design and aid in making modifications in implementation where necessary.
- o Test -- Participate in evaluation of the system. Evaluate the effects of the system on people and the effectiveness of people to use the system. Show that system performance and acceptance meets requirements with people using the system.

Strength: HUMAN ENGINEERING APPROACH TO WORK

Support Function, No!

Traditionally people outside the Human Engineering discipline have viewed Human Engineering as a support function that is limited to concern for computer screen design, and controls and displays work. Human Engineering therefore has often been relegated to do specific, and very limited tasks that are considered to be within the domain of Human Engineering. The resulting piecemeal, out of context approach usually minimizes the likelihood that many/most of the important people issues across a project(i.e. uniform useability, system performance, acceptance) are addressed. An analogy would be like asking an architect to specify windows and doors for a building but not telling the architect for what type of building (critical information needed for the architect to determine the correct doors and windows to specify). The people who would use the building might find, for example, that they needed a garage door but none was included.

This approach usually results, at best, in a small amount of improvement for people who will come into contact with the system, but will generally result in forcing a poor match between the system and the people who must use it (See Figure 2, the square peg in the round hole syndrome). Since this is not an effective approach to deal with people issues, it is not being used.

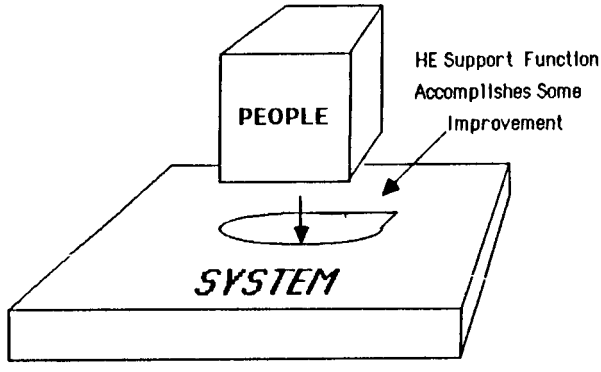

Figure 2 People Forced to Fit the Design of the "System" (The Square peg in the round hole approach)

Design System From Human Engineering Perspective, No!

A reverse approach to designing a system might be to place primary emphasis on designing it from the human engineering perspective. This would optimize the system for the people who will use it and/or come into contact with it (See Figure 3, Fitting the System to the People).. This approach might make the system easy to use, easy to understand, easy to learn, etc. but probably not meet overall system objectives, costs, performance, and other system requirements. Again this is due to taking a single, narrow, non-systems view of the project which decreases the likelihood of project succeed. Since this also is not an effective approach to deal with people issues, it is not being used.

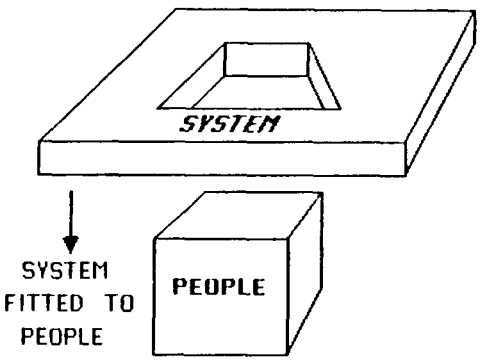

Figure 3 People Considerations are Prime Design Consideration. The System is Fitted to the People and Tasks (Overall system requirements may not be met because of lack of integration of people and system)

Integrated Engineering Team Member, Yes!

A very effective approach to integrating the system design with people's needs is to have Human Engineering play an active design team member role throughout the project. Through the application of the system design, development, and integration process to all Human Engineering issues, people's needs will be addressed and dealt with.

This ensures that all people interfaces with the system (hardware, software, other people, documentation, the environment) will be consistent, complete, and effective. This approach ensures that all Human Engineering considerations are considered in context with other engineering discipline considerations. Thus Human Engineering concerns are put into the perspective of being one of many concerns to be considered in the product being developed. The considerations are integrated into the design solution so that it provides the best product to meet the design criteria (See Figure 4, Integrating the System With the People). This integrated team design approach is being used successfully on the RAMP/RTIF project.

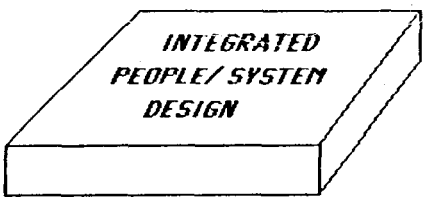

Figure 4 All Concerns Integrated Into a Total System Design (appropriately accounting for people issues)

This plan set the stage for Human Engineering to be a equal partner in the design of the system along with all the other disciplines. As the A and B specifications are being developed Human Engineering has a specific Human Engineering Section. But more importantly Human Engineering will work with all functions described in the spec to ensure that human engineering concerns are addressed. This means that Human Engineering inputs will be incorporated into those sections and not identified as specifically a "Human Engineering Concern" which is a concept that increases the effectiveness of the product.

Strength: HUMAN PERFORMANCE SYSTEM MODELING AND SIMULATION

To determine or predict the effectiveness of the RAMP/RTIF system human interfaces and task requirements, Human Engineering incorporates human tasks, human information processing, and performance data into the system design modeling and simulation. Examples of specific areas to be accounted for are:

1. Human information handling and processing requirements.
2. Tasks that must be performed in conjunction with the RAMP/RTIF hardware and software.
3. Manual vs automation task trade-off comparison for performance, quality, cost, and safety.
4. Maintenance performance as related to system availability.

By including this data in the system model and simulation, realistic system performance can be predicted.

Strength: ADMINISTRATION/MANAGEMENT

Responsibility

The Human Engineering function has primary organizational responsibility for the appropriate and timely decisions regarding integration of human engineering concerns throughout the RAMP/RTIF development, design, test, and integration process. Human Engineering participates in design, technical interchange meetings, program and critical design reviews, vendor evaluation and selection, and test and evaluation activities. The Human Engineering function must monitor, review, analyze, and respond

to human engineering related issues generated by all design development groups, and attend and participate in all significant design/development review processes. All Human Engineering tasks are scheduled to coincide with the master schedules, such as Preliminary, System, and Critical Design reviews and tasks that support those schedules.

Assigning the Human Engineering responsibility to the people that have the expertise ensures that the people concerns are appropriately addressed and resolved in the systems context.
Organizational Position is Important

The Human Engineering function is organizationally a part of the Systems engineering functional element in the RAMP/RTIF Systems Engineering Organization. This relationship will optimize the effective integration of Human Engineering concerns throughout the system development, integration, and test process.

Strength: DEFINE AND ALLOCATE SYSTEM FUNCTIONS

An operator versus machine functional task allocation describes those characteristics of the system which are strictly hardware and software functions and those that are functions of the operator. This important allocation function in RAMP/RTIF is performed by Human Engineering in conjunction with design engineers throughout the system specification process. An example of the process that is used to perform this task is:

1. Determine task requirements -- Once requirements have been identified for each task and cluster of tasks, the requirements are be analyzed in terms of the capabilities and limitations of people and/or machines that could perform the tasks. Humans and machines both have capabilities that they are very good at and limitations to what they can do. Performance, safety, acceptance, strength, information processing requirements, decision making capability, and cost of performance are some of the issues that can be used to determine approach.
2. Compare people and machine capabilities and weaknesses with requirements -- When there is a significant cost or performance differential between the two approaches, further evaluation (a trade study) is proposed. To aid the selection process, the system simulation model is used to look at the trade-offs between manual and automated task approaches.
3. Allocate people and/or machine resources to tasks -- Based on the analysis, the allocation of resources (people and/or machinery) to tasks are made and included in the B Specs. In cases where system functional requirements are outside the capabilities of the people who will use the system, an "expert system" AI package may be considered to perform the function.
4. Design system to efficiently and effectively use these resources.
5. Test against requirements.

These operator-machine interfaces will be described as an operational baseline to identify and standardize the functions to be performed or supported by the various segments of the RAMP/RTIF system. This analysis also serves to specify critical people, procedures, equipment, facility, environmental, and software performance/interface requirements for system operations, maintenance, and control functions. The choice of functions that are allocated to the system hardware and software and those allocated to the operator are assessed and validated.

HUMAN ENGINEERING PLAN DESCRIPTION

The scope of the Human Engineering activity for the RAMP/RTIF project was formalized early in the project through the Human Engineering Program Plan which is a part of the System Engineering Plan. The Human Engineering Plan identified the approach to be taken by Human Engineering, the responsibilities, and the working relationship with other functions in the project. This plan explicitly defined the issues that have been defined as strengths. The table of contents for the plan is listed here to show the scope of the definition:

- o Human Engineering Program Tasks
- o Establish RAMP/RTIF Human Engineering focus
  - o Drawing Approval
  - o Traceability and Access to Human Engineering System Data
- o Define and Allocate System Functions
- o Determine Potential Operator/Maintainer Processing Capabilities
- o Evaluate RAMP/RTIF System-Human Effectiveness
  - o Human Performance System Modeling & Simulation
  - o Decision/Action Flow Diagrams
  - o Timelines
  - o Workload Analysis
  - o Link Analysis
  - o Human Information Processing Analysis
- o Support the Selection/Design of RAMP/RTIF Equipment
- o Support the Selection/Design of RAMP/RTIF Software
- o Perform Human Engineering Task Analysis
- o Conduct Studies, Experiments and Laboratory Tests
- o Support RAMP PWA/SMP Workcell Environment and RTIF Facility Design
- o Support Test and Evaluation of Human Performance in the RAMP/RTIF
- o Site Specific Analysis
- o Human Engineering Deliverables

VALUE OF INTEGRATION APPROACH

By definition all COMPONENTS of a SYSTEM have impact on a SYSTEM. In the RAMP it has been realized that people issues can have a major impact on the SYSTEM. The degree to which the system meets the physical needs, mental needs, and expectations of those people can determine the level of system performance and acceptance that is

achieved. An important function of the system such as delivering the number and quality of parts within the cost requirements will depend as much on the people that use and run the system as to the technological aspects of the system. Therefore it is important to gain the best people performance in the system by ensuring that design solutions incorporate/integrate people needs.

CONCLUSION

In this NAVY program the Human Engineering function is an integral team member that contributes value to the systems engineering organization. Human Engineering works with people issues throughout the design and development of the system in such areas as: 1) Identifying people issues early in the project; 2) Accounting for those issues in the specification; 3) Appropriately resolved the issues in design; and 4) Testing the product to ensure it meets the needs and expectations of the people while meeting the overall systems requirements.

The Human Engineering approach being taken in this project facilitates the symbiosis between systems designers, engineers, and Human Engineering. This approach increases Human Engineering's effectiveness and value to a project because it becomes an accepted, contributing team member. It is an approach to doing Human Engineering that should be considered for most projects.

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