HUMAN FACTORS SUCCESS STORIES

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INTRODUCTION

As participants in the 28th Annual Meeting of the Human Factors Society, we are all concerned with the influence of human characteristics on engineering and design processes. We know that success in our endeavors depends on how well we understand human factors and how well we translate that understanding into the development of products, entertainment, systems, facilities, environments, organizations, and procedures.

We also know that success can take a variety of forms and can be attained to varying degrees depending on our objective, the way we measure our progress, and the stage of the development process that we address. These three dimensions of success – objectives, measures, and stages – provide the framework within which I will tell you some human factors success stories

OBJECTIVES AND MEASURES

Five major categories of human factors objectives are listed in the table[?] below. Two measures typically employed to assess results are also shown for each category objective.

Performance enhancement encompasses the greatest amount of human factors attention and diversity. Much of our effort is directed toward facilitating human performance through the way displays, procedures, and controls are designed and related to each other. One strategy is to improve the performance of a baseline system by increasing the speed and accuracy of human performance. Another strategy is to define human performance criteria and to design to meet them.

Resource conservation is often the objective of human factors effort when resources are limited or when resource reduction is desirable. For example, the objective might be to reduce aircrew workload so that missions can be completed successfully with a smaller crew. Another example is the design of vehicles so they can be satisfactorily maintained by persons with limited technical skills.

Acceptance is typically linked to one or more of the other four objectives, and is typically assessed means of user preferences and opinions. As users of products become more sophisticated and demanding, human factors become more important. Furthermore, adequate design from the point of view of operability may not be sufficient to gain user acceptance. The designer may be required also to address user perceptions of product attributes such as quality, value, and durability.

Cost reduction and corollary improvements in productivity provide a fertile area for human factors research and engineering. For example, the nuclear industry learned from Three Mile Island and other less publicized catastrophes that dealing with human factors by “common sense” alone was a costly mistake. A less dramatic but equally great potential for cost reduction is the cumulative impact of small reductions in the cost of operations. For example, a cost savings of $1 billion is only a four % reduction in the army’s $25 billion annual maintenance bill.

Promotion of human welfare is generally equated to safety and to the associated reduction of accidents, injuries, and disabilities. There can be little doubt about the great importance of this objective to individuals and groups within our society. But also included in this category are reductions in the frustrations and increases in the quality of life in our increasingly

complex society. Comprehensible instructions, adequate feedback, comfortable body support, informative displays, and manageable controls all help.

STAGES OF SUCCESS

Since engineering is a process, the attainment of human factors objectives depends upon a progression of intermediate successes. In this sense, success can be attained to varying degrees as each of the five activities shown in the figure[?] below is satisfactorily completed. A major human factors success story is produced by successes at each stage and by the ultimate attainment of one or more of the human factors objectives discussed earlier.

User requirements drive the developmental process. Consequently, appropriate observations, interviews, and analyses must be completed to define and describe user needs, and to delineate the behavioral information that must be obtained and applied. Applicable behavioral information can be found in reports, journals, texts, handbooks, and computer files. When needed information is not available, it must be generated through experimentation, extrapolation, analysis, and expert judgment.

The transformation of behavioral information into design specifications continues to be more art than science. This is not necessarily bad since sufficient latitude should be allowed to nurture design creativity. Intermediate success at this point is defined by design features that satisfy user requirements and adhere to appropriate human factors principles. However, because it is not realistic to assume that we can get everything right the first time, provisions must be made for testing to identify needed modifications. Tests might consist of observations, simulations, experiments, failure analyses, and opinion measurements.

The final stage is implementation. This stage is critical because if the results of the developmental effort are not used, no matter how magnificent they might be, there is no human factors success story.

Success Stories

The following success stories were contributed by the Human Factors Society members listed[?] at the end of the paper. In each story, successes were achieved at each of the five stages of development and, in addition, one or more of the five human factors objectives was met. Of course, these successes were seldom achieved by human factors specialists alone. Most successes were team efforts in which human factors specialists made major contributions.

In compiling these stories there was no attempt to be exhaustive or representative. Since some interesting and important stories took place many years ago, there was also no attempt to be current. The stories serve only to illustrate the variety of contributions that our profession has been making to performance enhancement, resource conservation, acceptance, cost reduction, and human welfare.

Please note that the space limitations of the proceedings document precluded presenting here the many illustrations employed in the address.

Advanced aircraft flight deck design. A crew-centered approach was employed in designing the flight deck for the new Boeing 757 and 767 commercial aircraft. Design simplicity, equipment redundancy, and automated features were emphasized. Workload studies verified that these design efforts paid off in resource conservation, and that these aircraft could be safely operated with a crew of two rather than three pilots. Subsequent assessments of in-flight operational workload confirmed the validity of the earlier human factors analyses and simulations. Emphasis was also given to the design of color CRT displays for the flight deck. Louis D. Silverstein received the Society’s 1983 Alexander C. Williams Award for this contribution to the flight deck design.

Aircraft altimeter improvements. A new altimeter configuration was defined and developed for the Douglas DC-10 commercial aircraft, and for the new MD-80 aircraft. The altimeter has been one of the most error-producing displays in aircraft cockpits. The new snap-action, counter-pointer altimeter has substantially increased the accuracy of altitude readings.

Improved aerial refueling operators station. To initiate aircraft refueling, the boom operator on the aerial tanker "flies" the boom into the receiver aircraft's receptacle. As a result of experimental studies of the side-stick controller, boom handling qualities, and visual envelope requirements, major improvements were achieved in KC-10 operator effectiveness over that of previous aircraft. In addition, workspace layout studies produced a more comfortable and convenient operator station.

Development of computer-generated maps. One of the greatest problems faced in military operations is that of maintaining geographic orientation. The greatest hope for solving this problem for pilots, tank commanders, and others is a world-wide digital map database and computer-generated maps. Human factors specialists have resolved many of the perceptual and cognitive issues in the display of maps from digital data. Furthermore, they have supported the development of a functioning digital map system. The adaptive display features of the system greatly aid the maintenance of geographic orientation during operations, facilitate tactical decision making, and provide for more effective mission planning.

Safe aircraft evacuation. Human factors played an important role in the design, testing, and certification of the slide-raft evacuation system for the Douglas DC-10 commercial aircraft. The effectiveness of this system has been demonstrated in several incidents and accidents. Particularly noteworthy was an incident at Los Angeles in which a fully loaded aircraft was forced to abort a take-off. The aircraft ran off the runway, sheared a landing gear, and caught on fire. All of the passengers, most of whom were elderly, evacuated safely.

Fire escape stockings. Human factors efforts in Switzerland and Japan have resulted in a safe and efficient way to escape from fires in buildings. The system consists of a woven fireproof stocking. If inside a building, the stocking is contained within a fire-brick tube. If outside, the stocking rolls down the outside of the building in the event of fire. To escape from fire, a person simply steps into the stocking and slides down to safety.

Textured paths for the blind. Human factors principles have been applied in Japan to facilitate the movement, with safety and confidence, of blind persons on streets and in subways. Textured paths are provided for guidance around obstacles and at crosswalks.

Industrial gas monitor improvements. Gas monitors are designed to assure maintenance workers that there is sufficient oxygen to breathe and that no explosive gases are present in an area. Existing monitors were found to have problems such as inadequate alarms, awkward packaging, obscure operating procedures, and inconvenient cable wrap. In addition, usage was inconsistent. Human factors analysis and engineering led to a new concept in gas monitor design, overcoming the various problems enumerated. The result was a product that served the user well in aesthetics, perception, communication, and operation. As a commercial product, the new gas monitor was highly successful.

An improved work vest for dredge operators. The safety work vests worn for dredge operations were found to interfere with work tasks, build up heat next to the body, and provide little utility when the wearer was not in the water. The vests were redesigned to overcome these deficiencies. Pads were reshaped to provide more arm space; ribs were added to the pads to aid air circulation, a second strap was added for safety, and a pocket was added for utility. Laboratory and field tests were very positive. The manufacturer has incorporated the human factors features into a new work vest for the dredge and offshore industry.

Component assembly reliability. The discovery of an error in the assembly of rack-and-panel connectors for a critical major system served as the starting point for two success stories. The first was the human factors fix that was made to assure that the error would not occur again. The second was the validation it provided for the Technique for Human Error Rate Predication

(THERP) used in human reliability analysis. A sample of major systems was disassembled to check for any similar errors. The findings of this check compared well to what was predicted by THERP.

*Test equipment improvements***.** A difficult area for the application of human factors methods is in the procurement of test equipment. This equipment often consists of off-the-shelf, rack-and-stack assemblies put together with little concern for operability. An example is the thermal-vacuum chamber used for testing electronic subassemblies. The poor design of this equipment led to the overheating and scrapping of a very expensive assembly. Analyses found 79 design deficiencies in the display-control unit of the tester, with 12 considered to be major. Inadequate displays, ambiguous control, and other deficiencies were corrected in all units. In addition to the error-free performance that followed, a lesson was learned by company executives. One commented, "It was tragic that we had to burn up an expensive flight-qualified box before we could appreciate the value of human engineering."

Fabrication of integrated circuits. Twenty years ago the process of making large-scale integrated circuits was transformed from the laboratory to the production line. Human factors specialists contributed significantly to enhancing production capabilities and yields. At an early stage, task analyses identified critical performance requirements. Then, new tools and procedures were designed to increase productivity. New wafer carries reduced handling errors by 80%. New handling tools reduced wafer damage and breakage by 68%. New alignment marks, based on minimum separable visual acuity, increased photomask alignment speed by 35% and accuracy by 66%.

Better control of oil-field services. The Treatment Monitor Vehicle (TMV) is a new concept for monitoring and controlling oil- and gas-well cementing and stimulation treatments. The TMV was designed from the inside out. Vehicle dimensions, workplace layout, operator-computer dialog, viewing rays, and external storage and hookup were all dictated by operator requirements. Thirteen vehicles are now in use throughout the United States and Canada, providing a major advance in the quality and technical application of these oil-field services. As a consequence, the company that has developed and now operates the TMV has increased its share of the market for the larger, more complex and profitable treatment jobs.

Cost-effective control-panel enhancement. Most operational power plant–control rooms were designed with little, if any, attention to human factors. Because they were hardwired to last for more than 40 years, the problem was how to enhance their operability without expensive changes. Study showed that dramatic improvements could be achieved by systematically reviewing the information needs of the operator and reshaping surfaces of existing panels to better reflect these needs. For example, functional grouping was delineated and labeled, control color coded, and off-normal conditions highlighted with color on displays. These approaches now serve current world-wide efforts to enhance operability of nuclear power plant–control rooms.

Development of an emergency response information system. To overcome the type of catastrophe that occurred at Three Mile Island, a system was developed to support the management of emergencies within a nuclear power plant. The system collected, stored, and processed plant parameter data, and generated displays for plant operators. Human factors design support and testing were an important part of system development. Human factors efforts focused on display content, off-normal detection provisions, display format and techniques display characteristics, illumination, signals, and accessibility of instruments and equipment. Field tests revealed that the emergency response information system was very useful during the management of emergencies, and most useful during major critical emergencies of the type faced at Three Mile Island.

Audio distribution system for 1984 Olympics. The IBM Audio Distribution System was designed and implemented by human factors people. Its design was based upon behavioral research. The system allows users to send messages to anybody in the world and[?] to receive messages from anybody in the world using push-button telephones as terminals. The system

provides editing, filing, retrieval, distribution, and control functions. For the Olympics, the challenge was to adapt the system for 15,000 Olympians who had [no?] opportunity to be trained, who spoke many different languages, and who had little or no experience using computers.

*Maintenance performance system for the army***.** The army teaches soldiers some basic maintenance skills in school; however, the bulk of maintenance skill must be learned on the job. To enhance learning on the job, human factors specialists developed a computer-based maintenance performance system. The system maintains a skills profile for every mechanic in a battalion, establishes and monitors a certification program, measures the efficiency and quality of maintenance in the battalion, specifies training priorities, and provides information for maintenance improvements. During the past year the system has been used by three army battalions at Fort Carson, Colorado, with very favorable results. One battalion, which had received poor evaluations for maintenance prior to having the system, improved significantly after the system was installed. The battalion went on to be evaluated as the best in maintenance support of any unit completing field exercises at the National Training Center at Fort Irwin, California.

Versatile keyboard for the personal computer. The objective was to design a small keyboard that could be used easily for diverse functions (typing, numeric input, menu selection) for the various applications of the HP 150 personal computer. The objective was met by functional grouping of keys, color coding, enhancing contrast ratios of characters and symbols, and using a stepped sculptured shape to minimize finger travel and provide keyboard adjustability. Customer and sales feedback on the keyboard has been extremely favorable; the keyboard will become standard on all Hewlett-Packard computer products.

Display pager operability. A prototype display pager required 3,000 words of instruction to operate, and produced excessive operation errors and user frustration. A new display-control design was developed through the application of human factors principles. The resulting design required only 150 words of written instruction, and reduced errors and system failures significantly. Ultimately, the product achieved broad market success. The OPTRIX display pager was also selected by *Fortune* magazine as one of the 10 best products of 1980.

A more effective toothbrush. The commercial success of the REACH toothbrush can be traced directly to the thorough human factors work completed during its design. Features resulting from the painstaking human factors methodology include bi-level bristles, compact head, angled neck, and multigrip handle. Special versions of the toothbrush have now been developed for special segments of the population. The toothbrush is a clinical as well as commercial success. The REACH toothbrush was found consistently more effective in plaque removal compared with the standard-design brush. Also, the REACH toothbrush won a design award in the *23rd Annual Design Review*.

Development of the disc camera. The successful disc system of photographic products came from one of the most extensive new product development programs in the history of Eastman Kodak Company. Human factors efforts played a very important part in this program. Proceeding from the concept of photographic space – the lighting conditions and distances at which amateur photographers take pictures – disc photography was designed to accommodate this space and other user requirements as well. The result of numerous human factors efforts was a camera that provided expanded capability and increased user convenience. The payoff to the amateur photographer includes halving the number of unexposed pictures, reducing the number of blurred pictures, shrinking the number of blank frames by a factor of four, and increasing by 25% the number of pictures rated excellent.

Sports car seating comfort. Drivers of the 1984 Pontiac Fiero will experience a new generation of car seating. Human factors analyses led to improved lumbar and thigh support, greater adaptability, and a more comfortable seat configuration. These advances in body support and comfort, along with other improvements in interior accommodations, have contributed to the appeal of this new automobile.

Reduction of rear-end car crashes. Starting September 1, 1985, all new automobiles sold in this country will be required to have a center high-mounted lamp stop (CHMLS). This new ruling is expected to prevent about 500,000 rear-end crashes annually on the nation's highways, significantly reducing deaths and injuries and providing an estimated new dollar benefit of $196,000,000. According to a representative of the national Highway Traffic Safety Administration, this product of human factors work may be the most significant accident avoidance countermeasure ever produced. General Motors plans to incorporate this change in its 1985 model cars, 1 year before the deadline of compliance.

Increased on-the-road detection of drunk drivers. About 25,000 people are killed in this country each year by drunk drivers. In an attempt to enhance the enforcement of laws prohibiting driving while intoxicated (DWI), and to further the deterrence of drunk driving, a drunk-driver detection guide was developed for use by police officers. Human factors research identified and validated important visual cues. These were listed on a pocket-size plastic card along with associated DWI probability values and probability rules for multiple cues. A national field test conducted over a 15-month period involving 466 patrol officers showed that the guide increased the DWI arrest rate by 12%.

Investigative techniques for law enforcement. Law enforcement officers have traditionally been better at collecting information than analyzing it. Human factors specialists developed a logical framework for criminal investigations and designed a series of graphic procedures for integrating information collected during investigation. At the present time these techniques and procedures are employed by law-enforcement agencies throughout the United States, Canada, Australia, and Great Britain. During the past 12 years, more than 300 training courses have been conducted for investigators, analysts, attorneys, agents, security officers, and judges from over 1,000 agencies. Special training has been provided to the Federal Bureau of Investigation, Scotland Yard, Royal Canadian Mounted Police, Drug Enforcement Administration, Customs Service, Department of Labor, and many other federal, state, county, and municipal agencies.

CONCLUSION

I hope you are as impressed as I am with the size, nature, and variety of the human factors contributions contained in this sample of success stories. As impressive as they are, however, these contributions represent just a token of what is possible in the future. The present momentum of our profession, if maintained, can benefit ourselves, our society, and the world in ways we have not as yet imagined.