GOVERNMENT ELECTRONICS AND INFORMATION TECHNOLOGY ASSOCIATION
A Sector of the Electronic Industries Alliance

Information Technology Forecast (Enabling and Emerging)

Human-Machine Interface (HMI)

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21 September 1999

Executive Summary

This year, GEIA has added a new forecast area to its highly acclaimed annual forecasts: Enabling and Emerging Technologies. This forecast adds a technical dimension to the programmatic and budget focus found in prior year forecasts. This new forecast comprises several technology areas, one of which is Human Machine Interface (HMI). Other common names for this area are Human-System Interface, User-Computer Interface and User-System Interface. The disciplines of Human Factors Engineering and Ergonomics are commonly associated with HMI development and testing.

This forecast will provide valuable information to government, industry and academia on HMI technologies that have been identified as important needs through the interview process. This analysis is not intended to be an in-depth technical discussion and assessment. It is intended to provide a general forecast of technologies and needs for use by CIOs, CTOs, CEOs and business development managers for planning of Information Technology (IT) resources, internal research and development, business development and corporate strategies to meet these needs. The information presented can be used by these organizations to justify funding for research and product development.

Human-Machine Interfaces are an important facet of systems, whether for military, transportation, recreation or other purposes. Often "transparent" to the user, the HMI can determine the overall usefulness, mission effectiveness or market success of a system. In a strict sense, HMI consists of displays and controls employed by a user to interact with a system. Other related technologies such as information fusion and computing are maturing at such a rapid pace that the nature of user interfaces is also advancing, becoming more realistic and intuitive, easier to use and more portable.

Our analysis focused on identifying the emerging technologies for human machine interface. The technology areas of greatest importance over the next five years include more natural human interfaces, more intuitive and realistic displays and intelligent aiding.

Two messages are clear. First, HMI depends heavily upon technological advances in associated areas (e.g., display hardware, computer software, and automation) to achieve significant advances in system usability. Second, the consistent application of accepted HMI principles and methods to system design is equally important to the interface technologies themselves.

Unfortunately, many decision-makers and managers do not recognize the significant impact that HMI typically has on product success. Consequently, important government policies supporting the application of HMI technologies by industry are being eliminated in as a part of the acquisition reform initiative and funding for HMI research and development is dwindling in government agencies,

industry organizations and universities. By including HMI in this year's Enabling Technologies forecast, the GEIA has a timely opportunity to help government and industry correct this problem in the near term. If remedied, future HMI may not become a constraint on system performance and user acceptance.

1. Introduction/Description

Human Machine Interface (HMI) technologies consist of those control and display media used to integrate humans into typically complex systems. It includes the application of other technologies not expressly resident at the human-machine interface (such as data fusion, decision aiding, software and information handling) to help "package" information for the human operator and make intelligent use of operator control inputs. The HMI technology area is a stand-alone technology as well as a user/adapter of other technologies. It's purpose is to improve or optimize operator performance with the end goal of maximizing overall system effectiveness. A general HMI model is shown in Figure 1. Taken beyond the application of HMI to purposeful "systems" (such as transportation or military weapon systems), HMI can be used to:

- enhance a user's experience and performance,
- provide for very rapid acquisition of skills, and,
- provide unique opportunities for recreation, education & other applications.

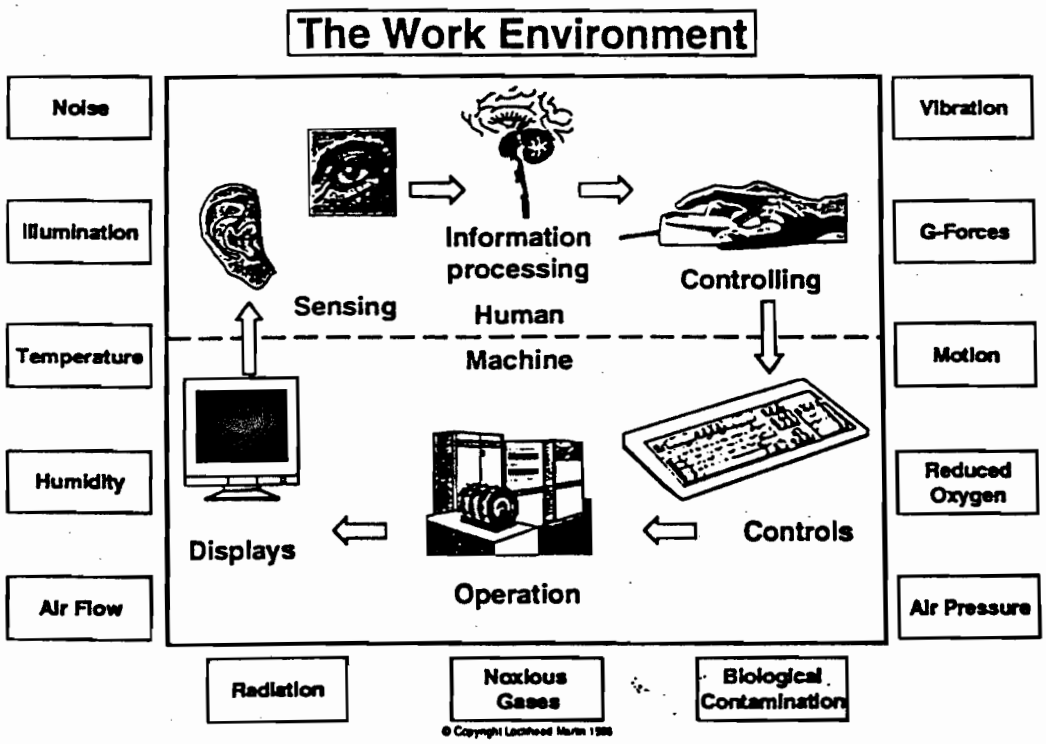

Figure 1. Human Machine Interface (HMI) Model

An effective HMI is the result of applying human factors design criteria and methodologies to the design of tools, machines, systems, tasks, jobs, interfaces and environments for safe, comfortable, enjoyable and effective human use. The degree of success with which HMI technologies are selected and integrated into systems has great leverage in terms of overall system adequacy, performance, effectiveness, robustness, availability and reliability. Ineffective HMI can render an otherwise acceptable system unusable, unacceptable for service, or a total "flop" in the marketplace. HMI technologies can also have great impact on advanced system analysis, development and manufacturing. For example, technologies, which allow designers to realistically visualize and operate systems in virtual environments, contribute powerfully to the early assessment and determination of system viability. The HMI objectives of human factors engineers are listed in the Table 1.

Human-Machine Interface (HMI) Objectives			
Basic Operational	**RMA* and ILS***	**Operator**	**Economic**
Reduce Errors	Increase Reliability	Improve Situational Awareness	Reduce Losses of Time and Equipment
Increase Safety	Improve Maintainability	Reduce Fatigue and Physical Stress	Increase Economy of Production
Increase System Performance	Reduce Personnel & Skill Requirements	Increase Comfort	Increase Sales and Customer Brand Loyalty
	Reduce Training Requirements	Reduce Boredom and Monotony	Increase Productivity and Efficiency
		Increase User Acceptance	
* RMA = Reliability, Maintainability, Availability ILS = Integrated Logistics Support		Reduce Task Saturation	

Table 1. Human Machine Interface (HMI) Objectives

Whenever a new technology is developed, its HMI must be validated and verified throughout system development. Human Factors Engineering (HFE) methods should be applied iteratively to end-user needs to produce the data needed to satisfy system specifications and requirements.

It is appropriate that HMI technology was selected as an area for the Government Electronic Industry Association (GEIA) Enabling Technology Forecast: "Today and Tomorrow's Emerging Technologies Enabling the Business and Mission Critical Solutions for the Future" 3-5 Year Look. Based on a variety of current estimates, the competent application of HMI technologies, following proven methodologies, can immediately add 30% or more to worker productivity and/or revenue from software-based products. It has been demonstrated that HMI technology, based on proven practices and principles, when applied at the earliest stage of product design, ensures that the product will be designed in terms of the user's needs and expectations. Consistent with the

theme of the meeting, we have attempted to identify enabling and emerging technologies with a tight coupling to business/mission requirements. This will provide a more credible base to build this Technology Forecast.

2. Stakeholders

Interested Parties (government, industry, academia, etc.)

Industry organizations, government agencies, professional and standards bodies (both domestic and international) value and invest in HMI technologies. These organizations have a strong interest in achieving the objectives listed in the above chart. For example, government agencies and industries associated with national defense, aviation and transportation are particularly concerned with maintaining high system performance, system and personnel safety and also lowering operating and maintenance costs through minimizing personnel, skills and training. Computer/software, entertainment and telecommunications industries are interested in developing and extending their HMI expertise and technology base, especially to introduce novel user interfaces (e.g., virtual reality), enhance user experience and ease of use (e.g., more intuitive GUI). The most recent example is the Internet, where web pages are being constantly designed toward the goals of capturing a viewer's interest and being easy to use and informative. Professional and standards bodies (e.g., ISO, GEIA) currently maintain 400+ standards and guidelines in the HMI area.

Users, investors, developers, researchers, transfer agents, etc.)

Everyone uses HMI technology, whether it be sending Email on a PC, playing video games as a passenger on a commercial jetliner, piloting a Space Shuttle or driving a car. Since HMI technology is ubiquitous, and typically evolutionary (as opposed to revolutionary), it is often not even recognized as a technology area – i.e., it is usually "transparent" to the user. With related technologies developing at a rapid pace (e.g., personal computers, internet access, flat panel & virtual displays, information fusion & pattern recognition), HMI developers have ample opportunity to create novel and powerful interaction paradigms using combinations of traditional and emerging interfaces.

A preponderance of HMI researchers work in computer/software and telecommunications industries, government defense and transportation agencies. This is because of their continuing need to improve system performance, safety and/or customer satisfaction. Entertainment industries also have made sizable investments into advancing the state-of-the-art in HMI technology in attempts to capture increased market share. HMI advancement also seems to be an ideal area for small business investment, since success is as likely to result from unique combinations of existing technologies than the invention of new ones.