

Sensory, Perceptual, and Cognitive Human Factors Engineering Principles: Application to Experiment Design, Test, and Evaluation of Modern Flight Systems and Displays

Lecturers:

Mr. Richard Ranaudo

Test pilot and former Aviation Systems Professor, Aviation Systems and Flight Research Program, University of Tennessee Space Institute, Tullahoma, TN

Mr. Clarence E. Rash

Research Physicist, former Director, Helmet-Mounted Display Program, Visual Sciences Branch, U.S. Army Aeromedical Research Laboratory, Ft. Rucker, AL

Course Description and Objectives:

The rapid advancement of technology has resulted in the accelerated proliferation of modern flight systems and associated crew station displays. These systems and displays are designed with the expectation that they will improve mission performance by increasing human-machine capability and efficiency. Historically, not all modern flight systems have met the designer’s goals, and in some cases, have resulted in poorer than expected system performance, increased human error, and additional safety of flight concerns. Many of these problems originate at the pilot-system interface because the design failed to properly consider important human sensory, perceptual, and cognitive characteristics affecting the pilot’s attention, situational awareness, decisions and actions. Further, if these characteristics were not properly considered in the methodology selected for evaluating the system, erroneous findings would result with latent problems discovered later in operational use. Unfortunately, when this happens the system must be fixed or accepted with deficiencies that may require burdensome work-around procedures affecting pilot work load and confidence in its use. In the worst case, pilots may elect to ignore many of the systems attributes or decide to not use it at all.

There always remains a risk that new and untried man-machine systems will not deliver expected performance. The objective of this course therefore is to mitigate this risk by providing course attendees with applied training in sensory, perceptual, and cognitive human factors engineering principals using case studies to demonstrate their practical application during human subject testing and evaluation of modern flight systems.

Who should attend this course:

This course is for all personnel involved with designing, testing, evaluating and certifying modern flight systems and is especially valuable to those who have not had a background in human factors or human subject testing. The course has application to both civil and military flight systems testing and evaluation.

Course Outline:

The course is divided into eleven lectures, which are presented over three days. The first two days consists of four 1.5-hour lecture periods that focus on human factors issues, and the third day consists of three 1.5-hour lectures that primarily focus on case studies. A description of each day’s schedule is provided below:

Day 1

0800 – 0815 Introduction and Overview

Strines, Ranaudo

0815 – 0945 Physiology and Characteristics of Visual, Auditory, and Somatosensory Systems

The stimuli humans most often use to assess the “state of the world” come from visual, auditory, and somatosensory signals. This lecture discusses the physiology of the eyes, ears, and somatosensory sensors with consideration to their capabilities and limitations when operating and interacting with flight systems.

Rash

0945 – 1000 Break

1000 – 1130 Introduction to Information Processing

Situational awareness in an aviation environment begins with sensory inputs, which are processed to develop an assessment of the world state. This lecture introduces an information processing model, which describes the use of short and long term memory in this process, including the impact of biases, heuristics, and various factors affecting decisions and errors.

Ranaudo

1130 – 1230 Lunch

1230 – 1400 Visual Perception and Cognitive Performance

The correct assessment or recognition of visual cues will ultimately affect cognitive performance. This lecture focuses on characteristics of the visual field such as brightness, size, object shape, resolution, and contrast as they affect correct perception and attention capture. Additionally, the characteristics of monocular and binocular systems are discussed in relation to their effect on perception and performance.

Rash

1400 – 1415 Break

1415 – 1545 Auditory Perception and Cognitive Performance

Characteristics of the human auditory system can degrade a person’s ability to correctly respond to an auditory cue, understand verbal communications, and ultimately affect attention capture. This lecture provides a discussion of basic human auditory characteristics and limits that include audible frequency range, discrimination, loudness and noise, and aspects of sound quality as they affect perception and recognition.

Ranaudo

Day 2

0830 – 1000 Visual Perceptual Conflicts and Illusions

The correct perception or recognition of a visual signal can be affected by system design characteristics and environmental factors. This lecture discusses various illusions (e.g. static and dynamic), which can cause false percepts. System characteristics such as masking, binocular rivalry, and hyper-stereopsis also can cause false visual percepts, which ultimately degrade human performance. The effects of illusions on use of visually-coupled and night vision systems are also presented and discussed.

Rash

1000 – 1015 Break

1015 – 1145 Auditory Conflicts, Illusions, and Visual - Auditory Interactions

Humans can process a limited amount of similar auditory information, such as speech, and warning signals, simultaneously. This lecture explains the differences between auditory conflicts and illusions, which are caused by various characteristics of sound sources. It also discusses means for more efficient human processing of the environment by the use of multi-sensory cueing, which uses both auditory and visual modalities. This includes examples of applications in an aviation environment.

Ranaudo

1145 – 1245 Lunch

1245 – 1415 The Human Component

Overview of anthropometric and bio-mechanic characteristics. This lecture will discuss available data bases, design rules, applications, and issues related to their use in crew station evaluation. Application to crew station visibility and location of head-up display systems are discussed as they relate to attention issues.

Ranaudo

1415 – 1430 Break

1430 – 1600 Introduction to Test and Evaluation

When a flight system is to be evaluated by means of human subject testing, there are several important protocols that should be followed. This lecture discusses considerations one should make in the experimental approach to human subject testing including behavioral characteristics of both test personnel and test conductors that can affect the experimental outcome. Experiment design concepts, planning, writing subject questionnaires, data handling analysis methods, and report writing are some of the topics presented.

Rash

Day 3

0830 – 1000 A Selected Series of Human Factors Case Histories in U.S.

Army Rotary-Wing Aviation

This lecture is a continuation of the previous lecture and discusses the USAARL’s experience with various experimental evaluations of flight systems on combat aircraft. These case histories provide valuable information and lessons learned from actual subject testing.

Rash

1000 – 1015 Break

1015 – 1145 ICEPro Test and Evaluation Case Study (Part I) Pilot in the loop simulator experiment

A NASA sponsored grant was awarded to the University of Tennessee Space Institute to design, develop, and evaluate a real time vehicle state assessment system to mitigate the hazards of inflight icing. This system became known as the Ice Contamination Envelope Protection System (ICEPro). ICEPro provided flyable cues and messaging to the cockpit based upon real time state assessment. A comprehensive pilot in the loop test and evaluation was conducted to determine the utility of this system for reducing loss of control due to ice contamination. The object of the experiment was to determine if the system made a *real* difference in pilot performance over the baseline system without cues. This lecture deconstructs and examines the experiment using many of the principles presented in earlier lectures. Beginning with the initial problem statement and continuing through the subsequent steps, strengths and weaknesses are identified, including changes that could have strengthened the experiment. This lecture examines key aspects of the test including the initial problem statement, variable definition, hypothesis development, experiment design, subject selection, test planning, data collection, data management, Likert Scale pilot questionnaires, workload methods and assessment, hypothesis testing, subject selection and qualification, subject training, and report writing.

1145 – 1245 Lunch

1245 – 1415 Case Study ICEPro Test and Evaluation (Part II), Data Handling and Results of Analysis

Selected examples of data recovered during this experiment are presented, and the method of analysis is described. The organization of the final report and presentation of results is also discussed.

Rash, Ranaudo

1415 – 1500 Break

1500 – 1530 Wrap-up, and Course Critique

This will be an opportunity for attendees to make comments or ask any lingering questions regarding the course material. Attendees will be asked to complete a course critique.

Rash, Ranaudo

Prerequisites

There are no prerequisites for this course.

Textbooks and course notes:

Course materials will consist of slide handouts for note taking, pads, pens, and pencils, and two DVDs. One DVD contains all course notes, and the second DVD is a complimentary copy of Mr. Rash’s text, *Helmet Mounted Displays: Sensation, Perception, and Cognition Issues, Edited by Clarence E. Rash, Michael B. Russo, Tomasz R. Letowski, and Elmar T. Schmeisser, USAARL, Fort Rucker, AL.*

Other textbooks which are referenced in the lectures include the following:

Human Factors in Aviation, Edited by Earl L. Weiner, and David C. Nagel, Academic Press, 1988, ISBN D-12-750031-6

Cockpit Engineering, D. N. Jarrett, Ashgate Publishing, 2005, ISBN 0 7546 1751 3

Human Factors for Civil Flight Deck Design, Edited by Don Harris, Ashgate Publishing, 2004, ISBN 0 7546 1380 1

Handbook of Aviation Factors, Edited by Daniel J. Garland, John A. Wise, and V. David Hopkin, Lawrence Erlbaum Associates, 1999, ISBN 0 8058 1680 1

Fees

The cost of the course is \$1895 which is payable by check, money order, Visa, MasterCard, or Discover.

Biographies

Richard J.Ranaudo earned a B.S. in Civil Engineering from the University of Connecticut (1967) and a M.S. in Aeronautical and Astronautical Engineering from Ohio State University (1978). He has been a professional aviator and test pilot for over 40 years, accumulating over 12,500 flight hours in high performance fighter, transport, and research and development aircraft. Mr. Ranaudo began his flying career as an Air Force fighter pilot. Upon leaving active duty, he was hired by NASA (1973) and served in that capacity for 25 years, eventually becoming the Chief of Flight Operations at the Glenn Research Center, Cleveland, Ohio. While at Glenn, Mr. Ranaudo performed flight investigations for advanced subsonic and supersonic propulsion systems, icing effects on aircraft handling and performance, microgravity science and astronaut training, and for USAF sponsored 3-D Audio and Voice Recognition research. He was also instrumental in developing simulator systems to test and evaluate advanced propulsion and integrated controls concepts at Glenn. In 1998, Mr. Ranaudo joined Bombardier Aerospace as the Manager, Canadair Flight Test Programs. There, he was responsible for flight testing and systems evaluations that supported the development, and certification of the Global Express Intercontinental Business Jet and the CRJ 700 and 900 Regional Jet aircraft. After retiring from Bombardier, Mr. Ranaudo joined the University of Tennessee Space Institute (2002) where he developed and taught four graduate level courses including two courses in human factors. He was also the principal investigator for NASA and USAF sponsored research programs and advisor to students who wrote theses on human factors topics, some of which became technical publications. Mr. Ranaudo developed the highly popular UTSI aircraft icing short course, which has been attended by over 200 civil, military and government flight test and certification personnel worldwide. Mr. Ranaudo has authored 28 technical papers. His most recent paper, Piloted Simulation to Evaluate the Utility of a Real Time Envelope Protection System for Mitigating In-Flight Icing Hazards, AIAA 2010-7986 will be used as the basis for one of the case studies presented in this short course. Mr. Ranaudo retired from UTSI in January, 2010, and remains a consultant to the University for Sponsored Research and the Continuing Education Program.

Clarence E. Rash is a research physicist and former Director, Helmet-Mounted Display Program, Visual Sciences Branch, U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL. He holds a B.S. (1971) and M.S. (1978), in Physics from Old Dominion University, Norfolk, VA. In 1970, he was a recipient of a NASA Scholarship in Astrophysics at Columbia University, New York, NY. From 1979 to 2007, he held the position of Optical Physicist at the USAARL. Over this period, he conducted both theoretical and applied research in numerous areas of the functional design and visual performance of military displays. Specializing in head-mounted displays (HMDs), he was the U.S. Army’s vision subject matter expert over the development of the Integrated Helmet and Display Sighting System (IHADSS) for the AH-64 Apache helicopter and served on the Source Selection Board during the development of the HMD for the RAH-66 Comanche. He also has several decades of experience with visual performance issues with Night Vision Goggles (NVGs). He has authored/coauthored 300+ papers, book chapters and presentations in the field of displays and holds 5 patent awards. Long active in the display technical community, he served for 25 years in various capacities with the SPIE International HMD Conference, first as Session Chair, then as Conference Chair, and finally as Conference Track Chair for the SPIE Display Symposium. Following retirement from Federal Service, he served as a display technology consultant to Army Aviation at Fort Rucker, AL, from 2007 to 2009. He is the author of Helmet-Mounted Displays: Design Issues for Rotary-Wing Aircraft (2001) and Chief Editor (and author) of Helmet-Mounted Displays: Sensation, Perception and Cognition Issues (2009). In addition to his research profession, Mr. Rash has served as adjunct faculty at numerous colleges for over 30 years, teaching courses in physics, physical science, astronomy, calculus and statistics.

Office of Continuing Education

Reservations may be made by using the registration form. The registration fee of \$1,895.00 includes all necessary supplies. Early reservations are recommended. Refund of registration fee can be made if cancellation notice is received ten working days prior to beginning of the course. Cancellation received less than 10 working days prior to the course will be assessed 20% of the registration fee. Registration within the 10 working days prior to the course is also subject to the same cancellation policy. Substitution may be made at any time.

Please register by mail, FAX, or telephone. A telephoned, mailed, or faxed reservation made by an official training office is considered a firm registration and cancellation policy will apply. A letter of acknowledgment will be mailed to the individual for whom the reservation is made, or to the training office, as we are instructed. Class size will be limited to ensure optimum interaction among participants. UTSI reserves the right to cancel the course. The liability of The University of Tennessee Space Institute is limited to the registration fee. UTSI will not be responsible for airline ticket cancellation fees or any other expenses incurred because of course cancellation. Enrollees will be notified and a full refund will be made. Late applicants will be considered on a space available basis.

The course is payable in advance. The fee does not include expenses for motel accommodations or meals. Payment may be made by check, money order, Visa, MasterCard or

