Human Factors and TSOs

TSO Workshop

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Overview

- What is Human Factors?
- FAA Human Factors issues
- Human Factors in TSOs
- Color Usage
- Resources

What is Human Factors?

“The discovery and application of information about human abilities, limitations, and other characteristics to the design of tools, machines, systems, tasks, jobs, and environments for safe, comfortable, and effective human use.” - Chapanis (1983)

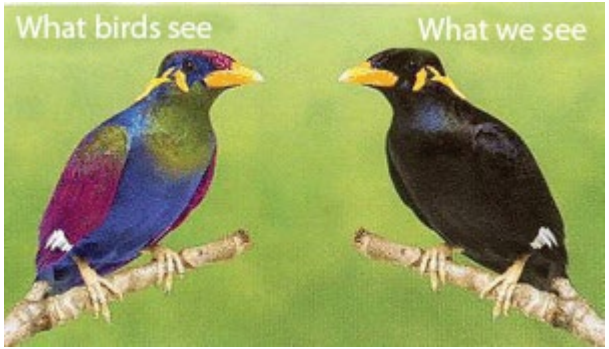
“Human factors – anything that influences human performance”

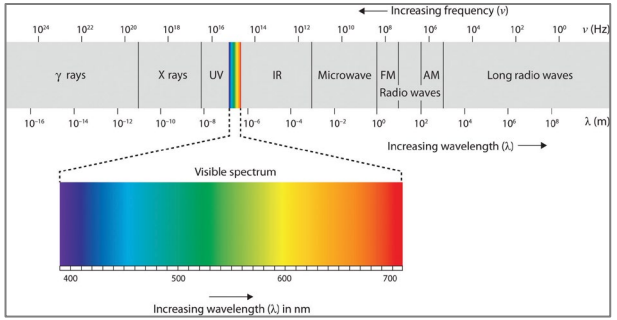
- European Human Factors Strategy

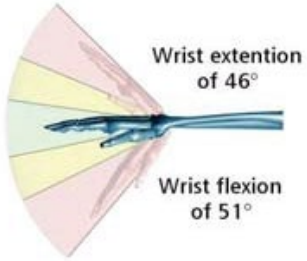
Human Factors

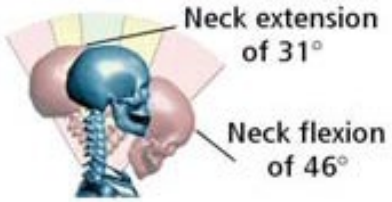
Physical

- Five senses
- Human body size, strength, & mechanics
- Physiological limits: tolerance & effects of heat/cold, fatigue, noise, vibration, acceleration





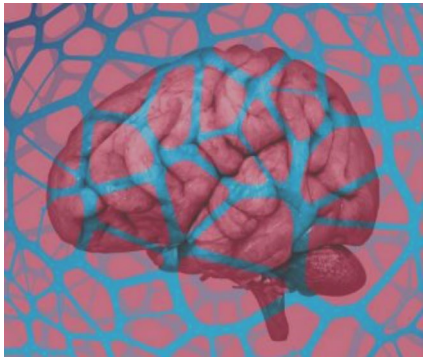




Human Factors

Mental

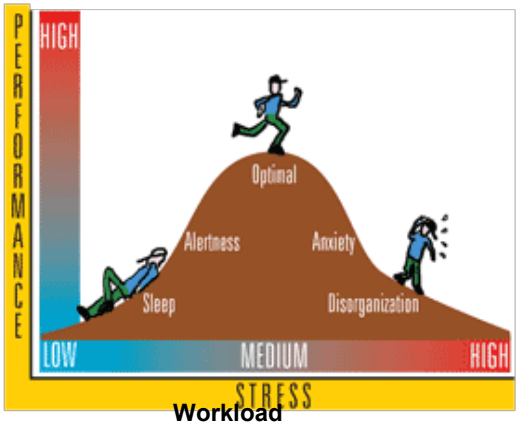
- Perception: How we take in information
- Cognition: How we analyze and organize information
- Memory: How we store and retrieve that information
- Decision Making: How we choose alternatives based on that information
- Attention: How we manage limited mental resources



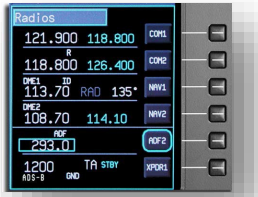
FAA Human Factors Issues

- **Intended Function**
- **Usability**
  - Symbology
  - Color
  - Labeling
  - Feedback
  - Location and readability
  - Environment
  - Inadvertent operation
  - Accessibility
  - Error prevention and recovery
- **System Behavior**

- **Integration**
- **Workload**



Workload



Human Factors in TSOs – Examples

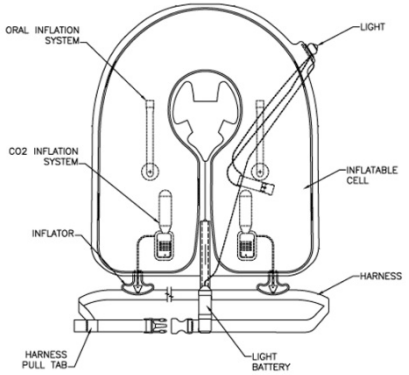
TSO	Industry Standard	Human Factors Elements Examples	Notes
TSO-C13g, *Life Preservers*	SAE AS1354, *Individual Inflatable Life Preserver*	• Testing with human participants • Donning test, Chilled Hands Test • Retention	Cabin Safety
TSO-C70b, *Life Rafts*	SAE AS1356, *Life Rafts*	• Testing with human participants • Capsize Resistance Tests: • Boarding and Adverse Loading	Cabin Safety
TSO-C113b, *Airborne Multipurpose Electronic Displays*	SAE AS8034C, *Minimum Performance Standards for Airborne Multipurpose Electronic Displays*	• Requires color coding to meet airworthiness standards for the appropriate category for 14 CFR parts 23, 25, 27, and/or 29	Flightdeck
TSO-C165b, *Electronic Map Display Equipment for Graphical Depiction of Aircraft Position (Own-Ship)*	RTCA DO-257B, *MOPS for the Depiction of Navigational Information on Electronic Maps*	• Color usage • Symbology • Clutter	Flightdeck
TSO-C194, *Helicopter Terrain Awareness and Warning System (HTAWS)*	RTCA DO-309, *MOPS for Helicopter Terrain Awareness and Warning Systems (HTAWS) Airborne Equipment*	• Terrain and obstacle depiction • Aural and visual alerts • Color usage	Flightdeck

Example: TSO-C13g Life Preservers

TSO-C13g invokes:

- SAE Aerospace Standard (AS) 1354, *Individual Inflatable Life Preserver*

THE FAA CIVIL AEROSPACE MEDICAL INSTITUTE (CAMI)

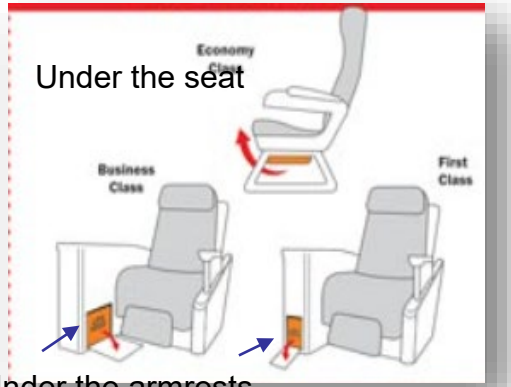


Example: TSO-C13g Life Preservers / SAE AS1354

Human Factors Issues:

- Where is the life preserver stored?
  - Is it easy to find?
  - Is it accessible?

Life vest is under your seat



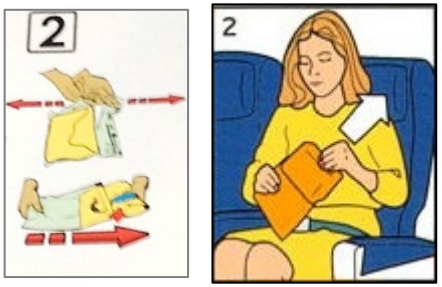
Under the seat

Under the armrests

Example: TSO-C13g Life Preservers / SAE AS1354

Human Factors Issues: Can passengers open the package quickly and easily?

- Life preserver package
  - How is it constructed?
  - Are the instructions readable and universally understandable?
  - Is the package easy to open?
    - What force is required?
    - What is the opening mechanism?
  - Is the vest easy to remove?



Example: TSO-C13g Life Preservers / SAE AS1354

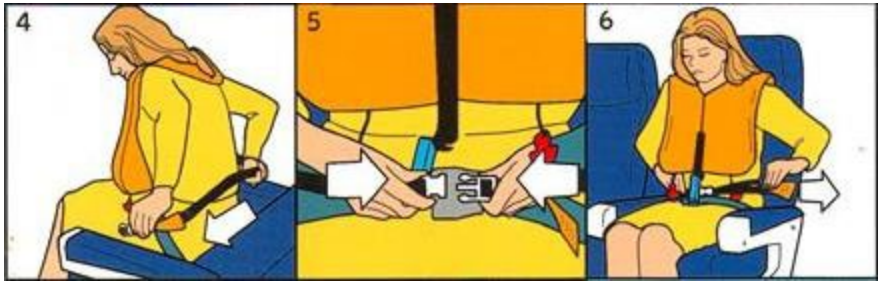
Woman participant struggles to open life preserver package. Final time was 37.9 seconds to open and remove the life preserver. (CAMI)

Example: TSO-C13g Life Preservers / SAE AS1354

Human Factors Issues: Can passengers quickly and easily don the life preserver?

Life preserver

- Instructions on vest
  - Are they visible?
  - Easy to understand?
- Is the vest comfortable – no chafing?
- How well does the vest perform?
  - Is strap length appropriate?
  - Is the buckle easy to find and use?
  - Does the vest fit as intended?
  - Does it pass the TSO donning test?



TSOs - Color Usage

TSOs (partial list)	Industry Standard	Notes
TSO-C113b, *Airborne Multipurpose Electronic Displays*	SAE AS8034C, Minimum Performance Standards for Airborne Multipurpose Electronic Displays	TSO Appendix 1. Color AS8034C • 4.3.4 Color • …installed in all types of aircraft (Part 23, 25, 27, and 29) meet the requirements in 14 CFR 25.1322 and the guidance in AC 25.1322
TSO-C145e, *Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System (SBAS)*	RTCA DO-229E Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment	DO-229E 2.2.1.1.4.2 Brightness, Contrast, and Color • Red…for warning indications • Yellow…for caution indications
TSO-C151d, *Terrain Awareness and Warning Systems (TAWS)*	RTCA DO-367, Minimum Operational Performance Standards (MOPS) for Terrain Awareness and Warning Systems (TAWS) Airborne Equipment	DO-367 –multiple subsections Visual alerts- • warning…red indication • caution…yellow or amber indication
TSO-C165b, *Electronic Map Display Equipment for Graphical Depiction of Aircraft Position (Own-Ship)*	RTCA DO-257B Minimum Operational Performance Standards for the Depiction of Navigational Information on Electronic Maps	DO-257B - 2.1.6 Color (color guidelines, flight crew awareness and response) - Appendix E

Using Color – Red, Amber, and Yellow

Be consistent with the appropriate 14 CFRs -

- § 23.1322 (historic), § 23.2605 *Installation and operation*
- § 25.1322 *Flightcrew alerting*
- §§ 27.1322, and 29.1322 *Warning, caution, and advisory lights*

Appropriate use:

- Reserve red for warnings
- Reserve amber/yellow for cautions
- Limited use for non-alerting functions
  - Weather radar, TAWS
- Why? To retain the effectiveness of alert indications to the pilot

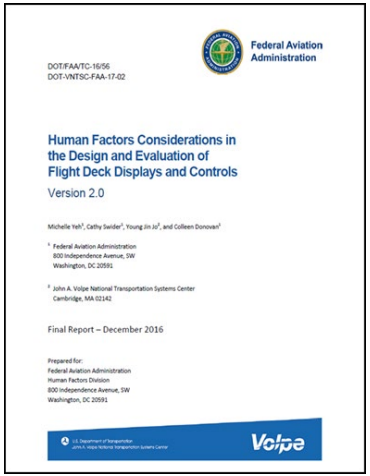
HF Resources

Human Factors Considerations in the Design and Evaluation of Flight Deck Displays and Controls, Version 2, also known as the ***HF General Guidance*** **document**

What is it?

Single source document for human factors issues for avionics (displays & controls)

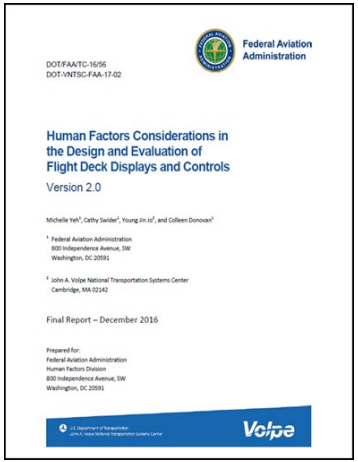
- References 200+ documents
- FAA Regulations, ACs, TSOs, Policy Statements
- Parts 23, 25, 27, and 29
- RTCA & SAE standards
- EASA, ICAO
- Military standards (MIL-STDs)
- Research papers and reports
- Version 3 is coming soon
- Not regulatory; not to be used as a compliance document



HF Resources

Topic Areas / Chapters:

- Display Hardware
- Electronic Display Information Elements and Features
- Considerations for Alerting
- Organizing Electronic Display Information Elements
- Controls
- Design Philosophy
- Intended Function
- Error Management, Prevention, Detection, and Recovery
- Workload
- Automation



https://rosap.ntl.bts.gov/view/dot/12411

Human Factors in Aviation Safety – FAA website

Human Factors in Aviation Safety (AVS)

Human factors specialists in the FAA's Aviation Safety (AVS) organization promote safety in the National Airspace by working to reduce the occurrence and impact of human error in aviation systems and improve human performance. These specialists have expertise in the design and/or evaluation of aircraft systems, maintenance, operations, procedures, pilot performance, associated FAA policy, and guidance. They develop regulations, guidance, and procedures that support the certification, production approval, and continued airworthiness of aircraft; and certification of pilots, mechanics, and others in safety-related positions.

Two relevant and human factors reports are listed below.

The first is a report from the PARC/CAST Flight Deck Automation Working Group: Operational Use of Flight Path Management System (PDF). Final Report of the Performance-based Aviation Rulemaking Committee/Commercial Aviation Safety Team Flight Deck Automation Working Group. The group reviewed worldwide data from accidents, incidents, normal operations, structured interviews with manufacturers, operators, and training organizations, and reports from related activities. These data were analyzed and the results were used to identify changes since 1996, and to develop findings and recommendations.

The second is a report that describes regulatory requirements and guidance for the design and evaluation of flight deck displays and controls: Human Factors Considerations in the Design and Evaluation of Flight Deck Displays and Controls: Version 2.0.

- About Us, AVS Human Factors Directory and Biographies
- Aircraft Certification Service (AIR)
  - Human Factors-related policy and guidance

Human Factors – Aircraft Certification Service (AIR)
Policies and Guidance

Advisory Circulars

- AC 00-74, Avionics Human Factors Considerations for Design and Evaluation
- AC 20-175, Controls for Flight Deck Systems
- AC 23-8C, Flight Test Guide for Certification of Part 23 Airplanes
- AC 23.1309-1E, System Safety Analysis and Assessment for Part 23 Airplanes
- AC 23.1311-1C, Installation of Electronic Displays in Part 23 Airplanes
- AC 23.1523, Workload-minimum Crew
- AC 25-7D, Flight, Test Guide for Certification of Transport Airplanes
- AC 25-11B, Electronic Flight Deck Displays
- AC 25-1302-1, Installed Systems and Equipment for Use by the Flightcrew
- AC 25.1309-1, System Design Analysis
- AC 25.1322-1, Flightcrew Alerting
- AC 25.1523-1, Minimum Flightcrew
- AC 27-1B, Certification of Normal Category Rotorcraft
- AC 29-2C, Certification of Transport Category Rotorcraft

Orders

- Order 8150.1C, Technical Standard Order Program
- Order 9500.25, Protection of Human Research Subjects
- Order AM 9950.3, Aerospace Medicine Research Program

Human Factors – Aircraft Certification Service (AIR)
Title 14 Code of Federal Regulations (14 CFR)

The following is a list of aircraft certification regulations that typically require applicants carefully consider human factors issues when showing compliance. This is not a comprehensive list of human factors topics applicants must address during aircraft certification; rather, the list identifies examples of common human factors topics in aircraft certification. Note the list shows "legacy" Part 23 regulations. For new Part 23 (Amendment no 23-64, August 30, 2017) regulations see http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgRegulatoryBasis.nsf/MainFrameOpenFrameset

Sections under 14 CFR Parts

23	25	27	29	Subpart and Section Content/Topic
23.143	25.143	27.143	29.143	Controllability and Maneuverability: General
23.671	25.671	27.671	29.671	Control Systems: General
23.771	25.771	27.771	29.771	Pilot Compartment
23.773	25.773	27.773	29.773	Pilot Compartment View
23.777	25.777	27.777	29.777	Cockpit Controls
23.785	25.785	27.785	29.785	Seats, Berths, Litters, Safety Belts, and Harnesses
23.1141	25.1141	27.1141	29.1141	Powerplant Controls: General
23.1301	25.1301	27.1301	29.1301	Equipment: Function and Installation

Links

- **FAA Human Factors in Aviation Safety (AVS)**
  https://www.faa.gov/aircraft/air_cert/design_approvals/human_factors
- **Human factors considerations in the design and evaluation of flight deck displays and controls: version 2.0**
  https://rosap.ntl.bts.gov/view/dot/12411
- **FAA Dynamic Regulatory System https://drs.faa.gov/browse**

References

CAMI research reports:

- Inflatable Emergency Equipment I: Evaluation of Individual Inflatable Aviation Life Preserver Donning Tests
  https://www.tc.faa.gov/its/worldpac/techrpt/am14-14.pdf
- Inflatable Emergency Equipment II: Evaluation of Individual Inflatable Aviation Life Preserver Retention Characteristics
  https://www.faa.gov/sites/faa.gov/files/data_research/research/med_humanfacs/oamtechreports/202010.pdf

Questions?

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