Minimizing Human Factors Mishaps in Unmanned Aircraft Systems

Forum for Human Factors in Control
Trondheim, Norway

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Introduction

- 10 Years @ Smartronix
  - Payload
  - Payload GCS
  - UAS GCS
- Research
  - HF in GCSs
  - Technology and HF
- Grad School
  - M.Sc., S.E, JHU, Sep 2007
  - Ph.D., HFE, GWU, Jan 2013

Introduction – Smartronix, Inc.

- Founded in 1995
- 650+ Employees
- Innovative solutions provider
- US DoD, Federal Agency, and Commercial
- Labs (HW/SW, Fabrication, Light Manufacturing, and RF Design)

Agenda

- Study
- Findings
- Framework
- Research
- Summary

Study

Basis

- UAS Mishap studies
  - Mishaps 100 to 200 times than manned aviation
  - 69% of all UAS mishaps are due to Human Factors
  - Up to 43% of these mishaps are associated to Ergonomics Human Factors (EHF) in Ground Control Stations (GCS)
- UAS
  - 45+ countries
  - 300+ manufacturers
  - 600+ types
- UAS demand increasing exponentially
  - Civilian
  - Military

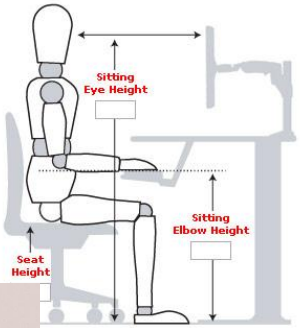
Basis (cont.)

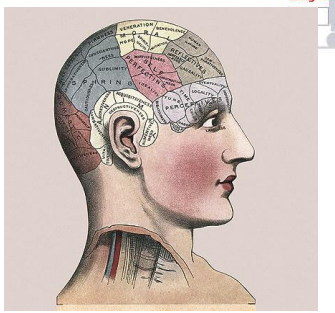
- UAS Studies
  - Mishaps cost millions of dollars each year
  - GCS designs do not account for human abilities, characteristics, and limitations
  - Lack of Ergonomic Human Factors (EHF) Standards

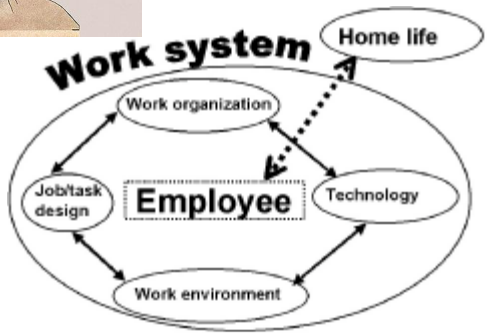


Ergonomic Human Factors

- Physical Ergonomics
- Cognitive Ergonomics
- Organizational Ergonomics







Common EHFs

EHF Related Mishaps

Mishap Year	Cause	Mishap Cost
2001	Visual display mounting and GCS lightning	$1.50 Million
2005	Visual display mounting and GCS lightning	$4.35 Million
2006	Improper control placement	$1.50 Million
2010	Improper seating	$2.75 Million
N/A	Display Arrangement	N/A

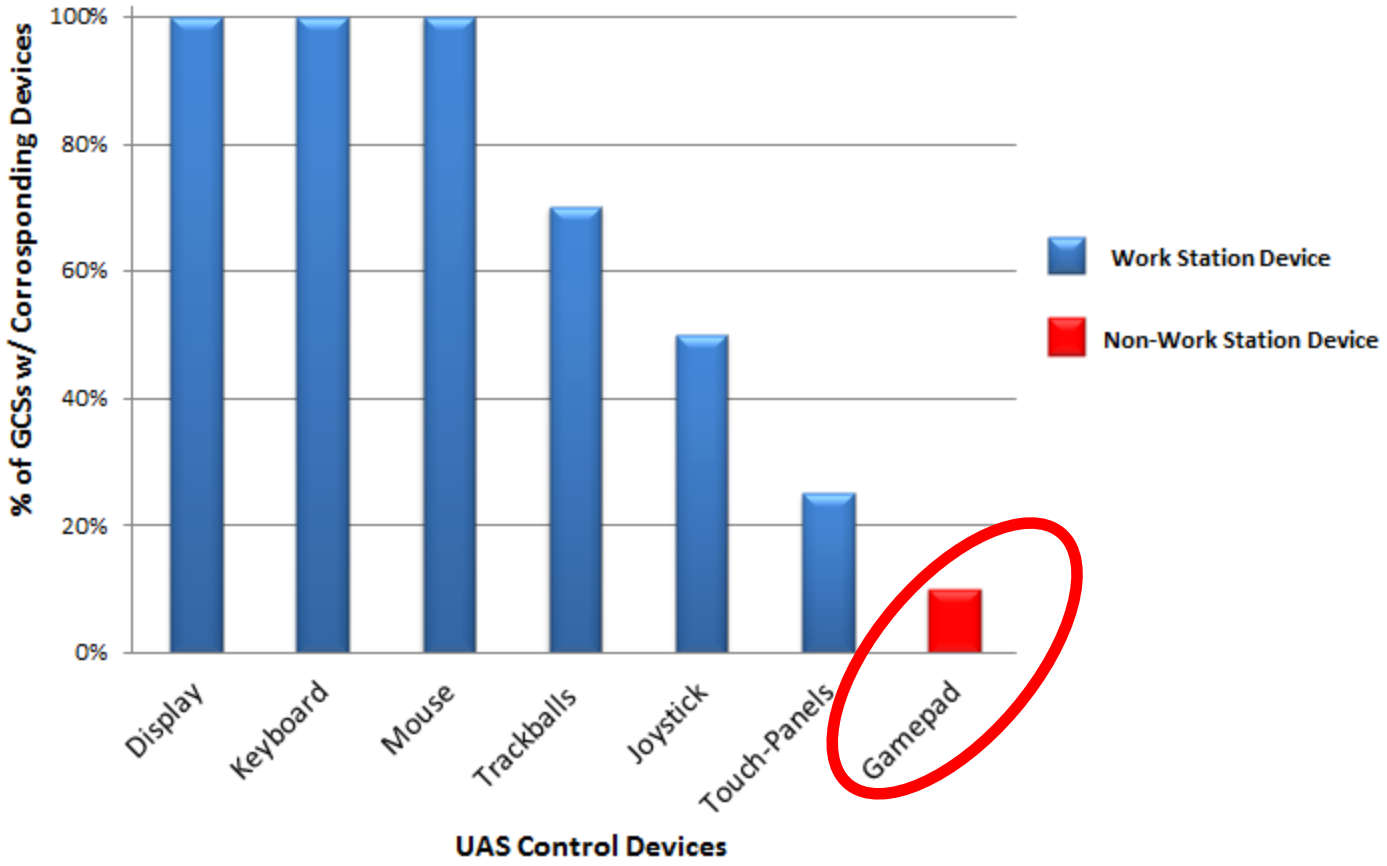
Cognitive Ergonomics

What's Included?

- Ergonomic Human Factors (EHF)
- Total 20 UASs (Group 2 – 5) encompass
- UAS GCS Control Mechanism
  - Semi-Autonomous
  - Autonomous
- UAS/GCS operators 6.5 to 15 years of experience
- Human Factors Engineering of Computer Workstations (ANSI/HFES-100)
- Questions
  - IO devices usage GCS Vs. Workstation
  - Usability of IO devices GCS Vs. Workstation

Findings

GCS IO Devices



Control Vs. IO Devices

IO Devices	Semi-autonomous	Autonomous
Display	100%	100%
Keyboard	100%	100%
Mouse	100%	100%
Trackball	90%	50%
Joystick	100%	0%
Touch-Panel	10%	40%
Gamepad	0%	20%

Usability GCS Vs. Workstation

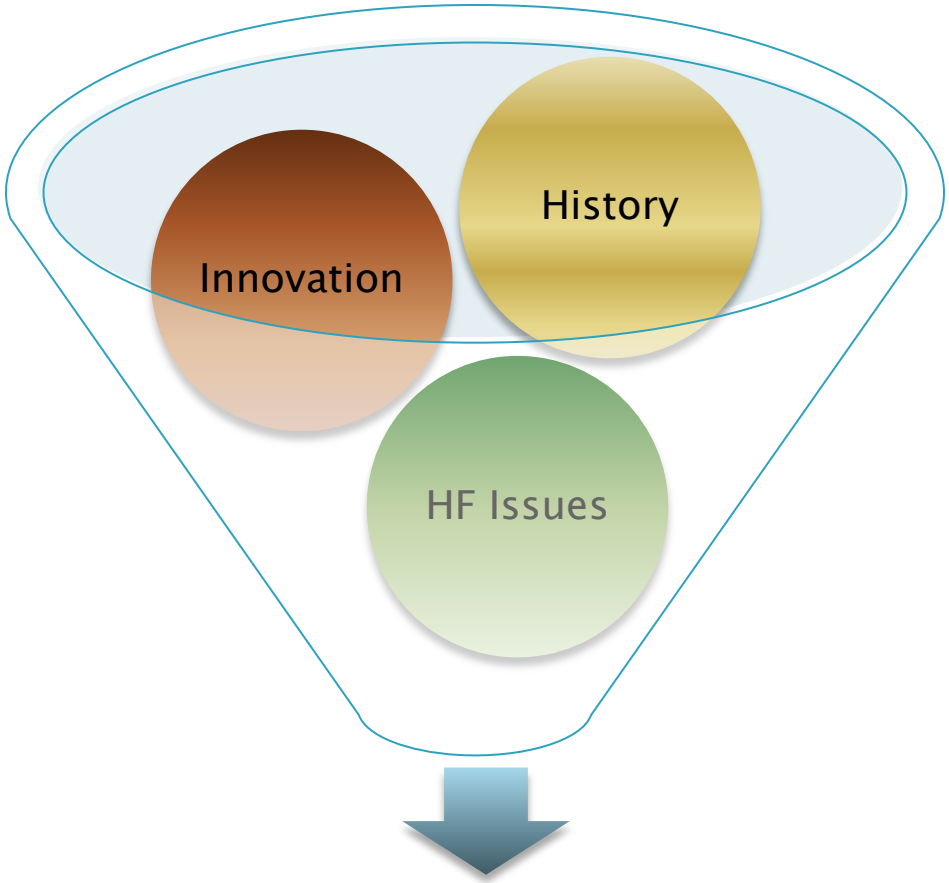
- Questionnaire (seven point Likert-scale)
  - Non-Emergency
  - Emergency
- Resulting Data
  - Same sized
  - Non-parametric statistical analysis
- Virtually the same

Case Study

Mishap Year	Cause	Mishap Cost	ANSI/HFES-100
2001	Visual display mounting and GCS lightning	$1.50 Million	Yes
2005	Visual display mounting and GCS lightning	$4.35 Million	Yes
2006	Improper control placement	$1.50 Million	Yes
2010	Improper seating	$2.75 Million	Yes
N/A	Display location	N/A	Yes

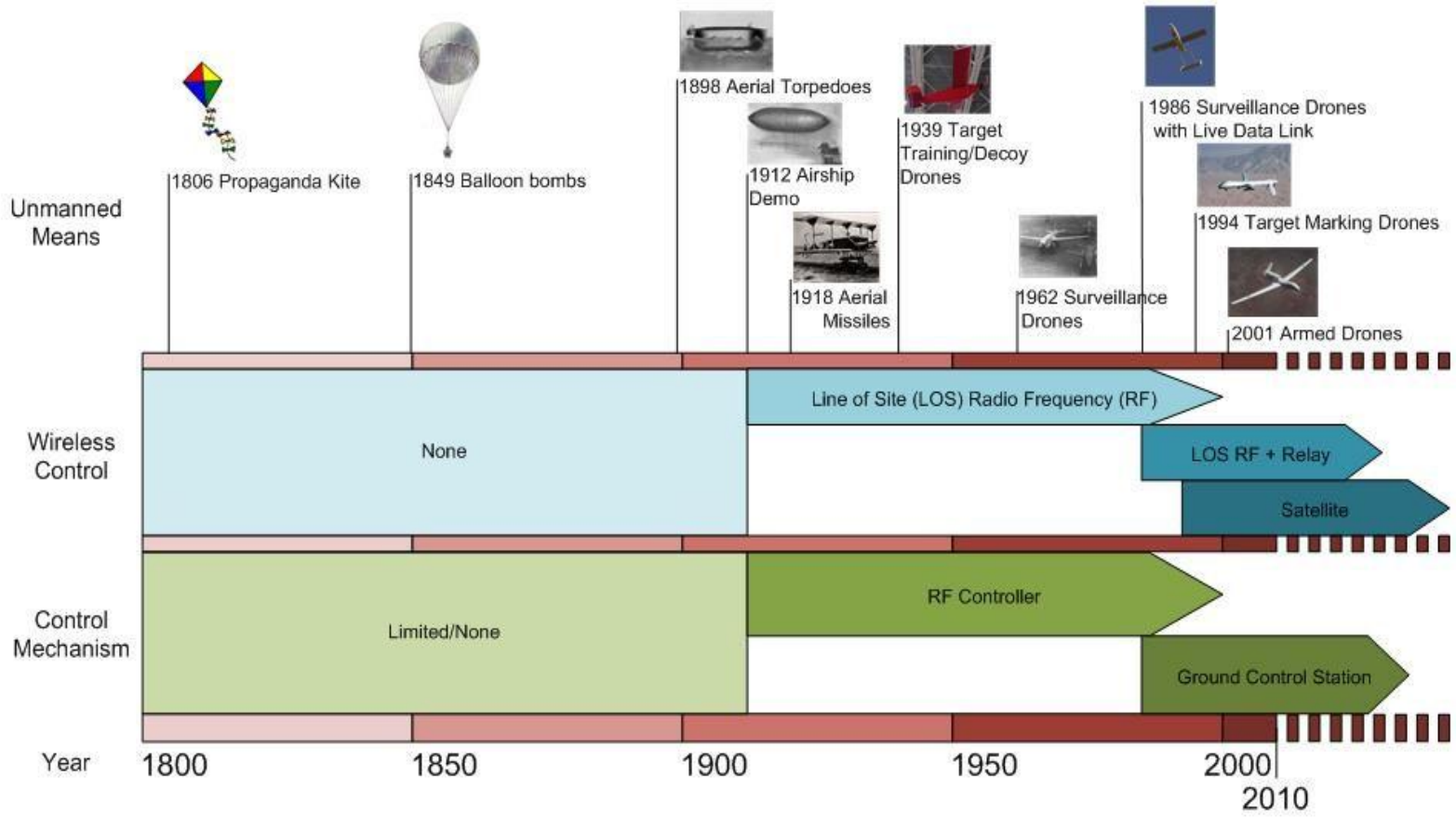
Framework

Solving EHF



Solution to EHF

History – GCS


Unmanned Means
Wireless Control
Control Mechanism
Year
1806 Propaganda Kite
1849 Balloon bombs
1898 Aerial Torpedoes
1912 Airship Demo
1918 Aerial Missiles
1939 Target Training/Decoy Drones
1962 Surveillance Drones
1986 Surveillance Drones with Live Data Link
1994 Target Marking Drones
2001 Armed Drones
None
Line of Site (LOS) Radio Frequency (RF)
LOS RF + Relay
Satellite
Limited/None
RF Controller
Ground Control Station
1800
1850
1900
1950
2000
2010

GCS HF Issues – IO

- Display Arrangement
  - Vertical Vs. Horizontal
- Screen Focus Areas
  - Top Vs. Bottom
- Situational Awareness
  - Sign Vs. Text
- Alertness
  - Interactive
- Task Sequence
  - Control Layout Sequence
- Input Methods
  - Touchscreens Vs. Ancillary Device

Innovation – Gamepad

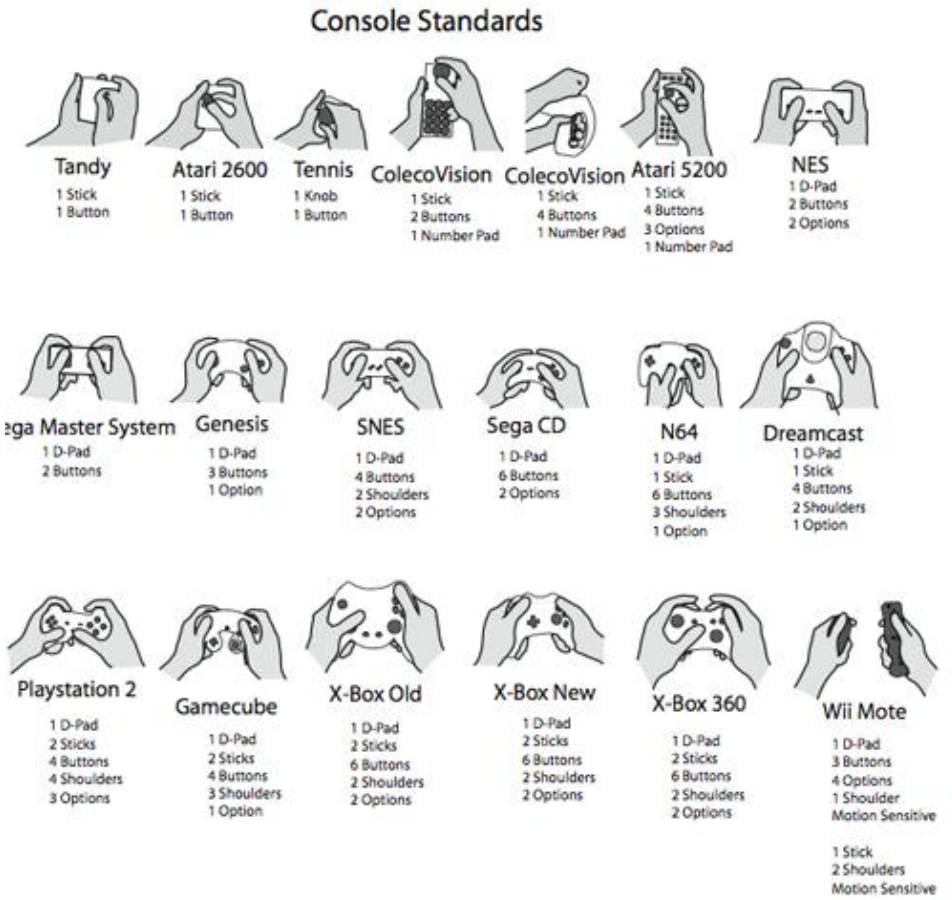
- >60% of 16-21 years old own a gaming system
- >40% are expert in operating Gamepads
- Existing experience

Solution

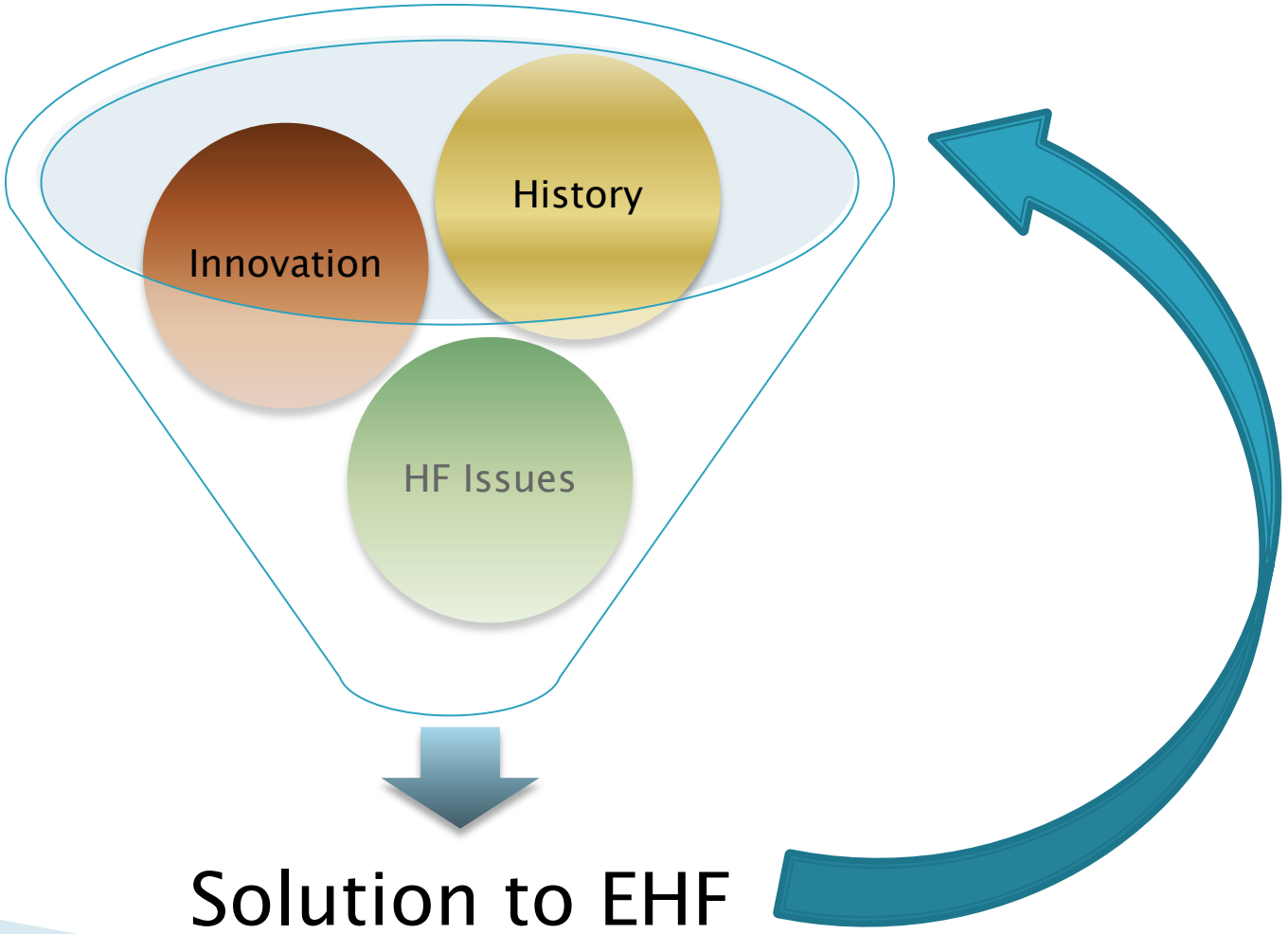
- Used to surf through menus
- Utilized existing experience
- Learning curve
- Results were impressive

REVISE

- Reassess
- Evolution
- Versatile
- Interchangeable
- Sustain
- Effective

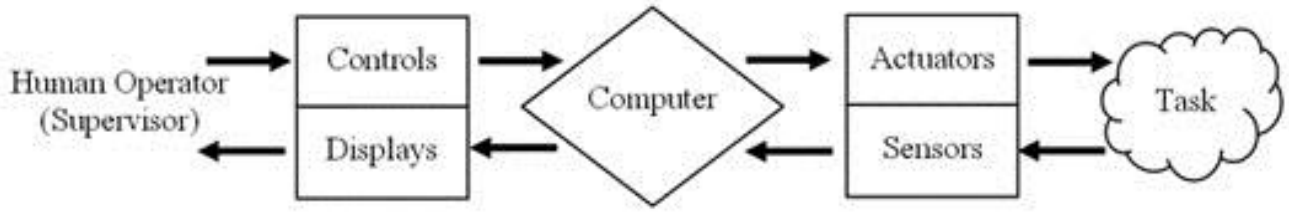


EHF Solution Cycle



Supervisory Controls

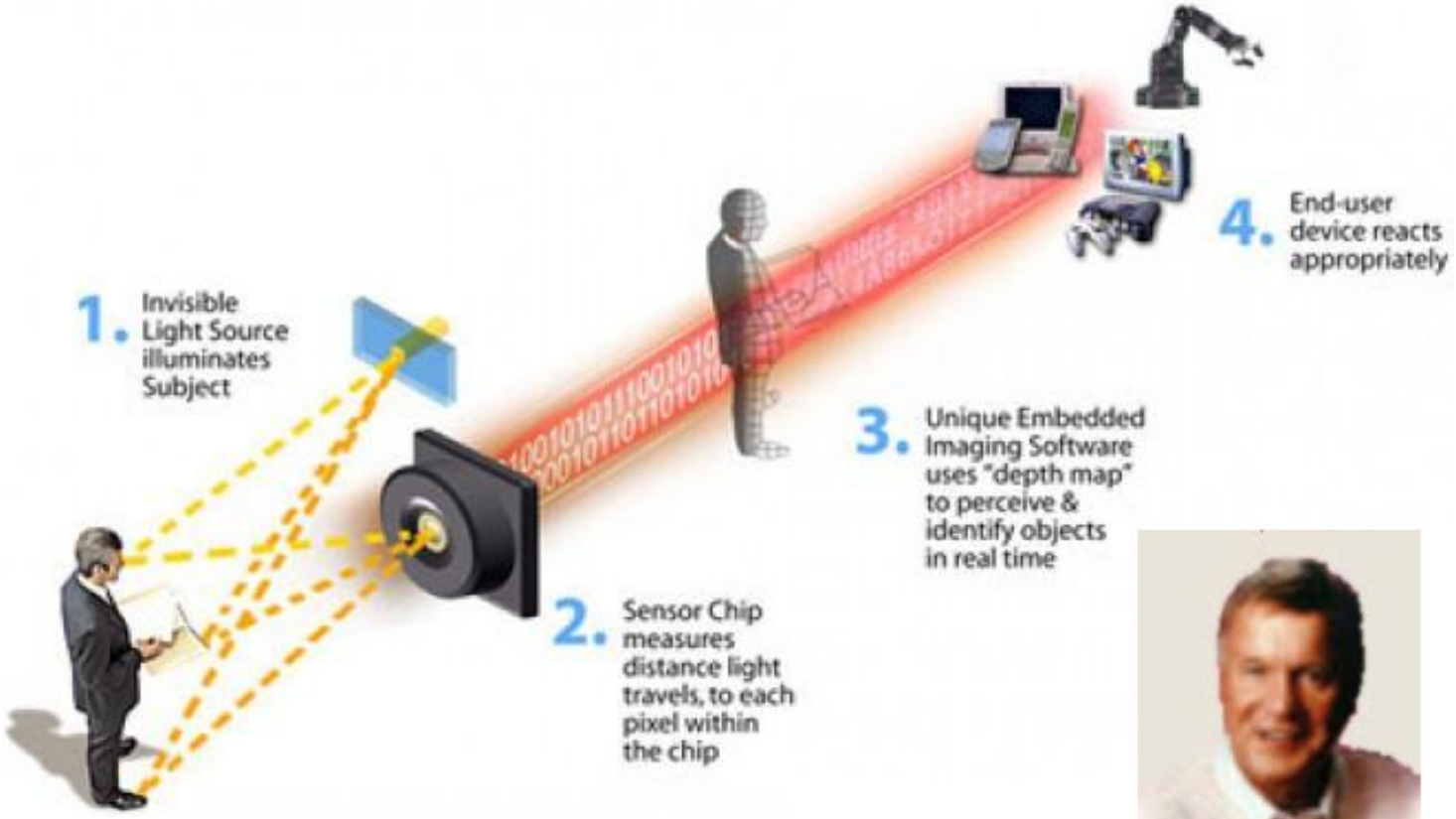
- Telerobotics, Automation, and Human Supervisory Control by Thomas B. Sheridan



- Simplified approach to understanding the human machine interface
- Accurate diagram
- Updated IO Methods

Research

Microsoft Kinect for CCTV



Summary

Summary

- Study history of the system/issue at hand
- Study comparable systems
- Study comparable standards
- Understand your clients/workers
- Understand available IO technology
- Apply relevant available technology for EHF
- Design modular control stations

Questions?

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EHF Standard

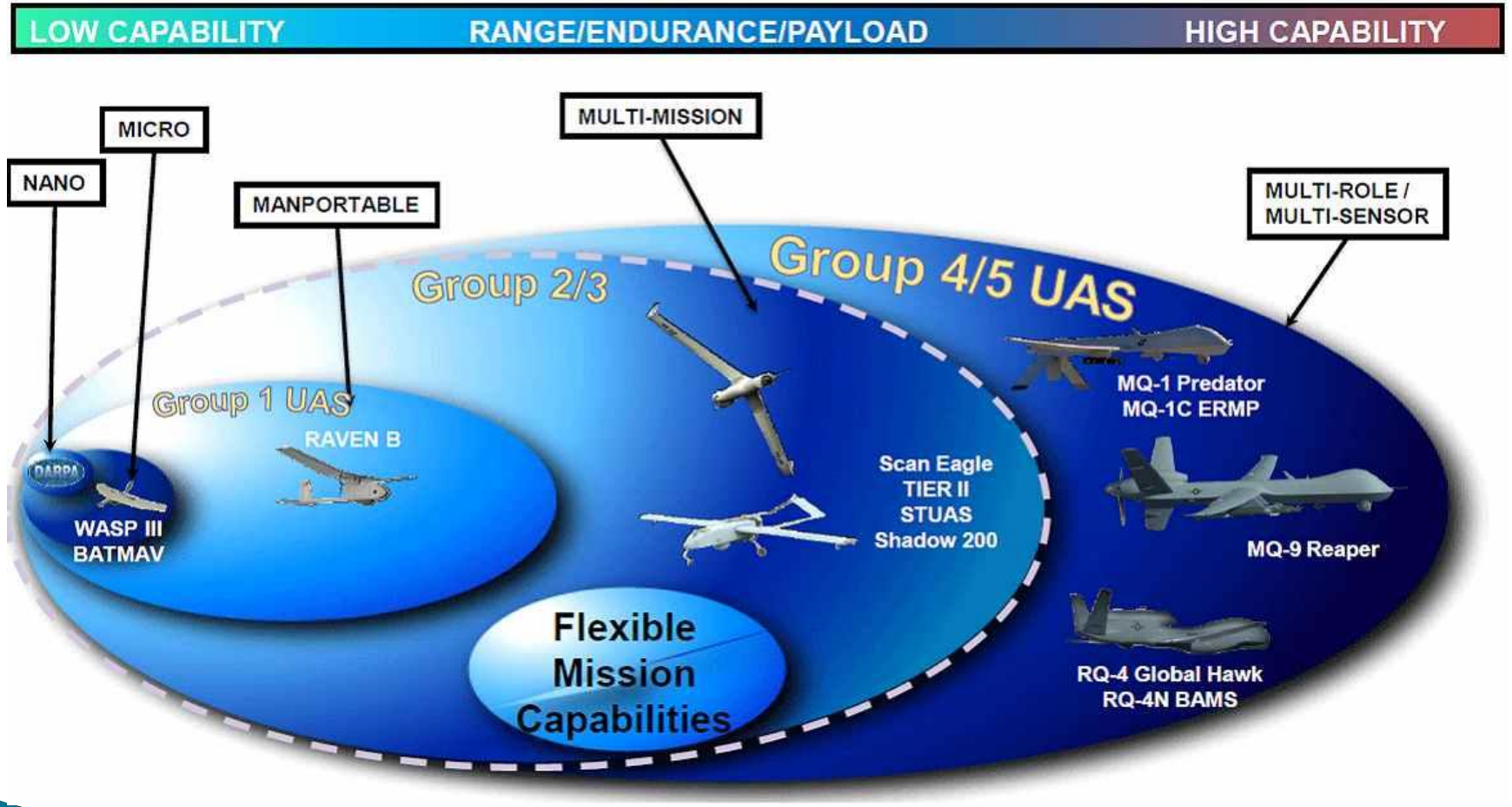
- ISO 10075-1:1991, Ergonomic principles related to mental workload — Part 1: General terms and definitions
- ISO 10075-2:1996, Ergonomic principles related to mental workload — Part 2: Design principles
- ISO 10075-3:2004, Ergonomic principles related to mental workload — Part 3: Principles and requirements concerning methods for measuring and assessing mental workload

Study: Selection of UAS

UAS Group	Weight (lbs)	Altitude (ft AGL)	Airspeed (knots)
Group 1	Greater than 20	Less than 1,200	Less than 250
Group 2	Between 21 – 55	Less than 3,500	Less than 250
Group 3	Between 55 – 1,320	Less than 18,000	Less than 250
Group 4	Greater than 1,320	Greater than 18,000	Any
Group 5	Greater than 1,320	Greater than 18,000	Any

- UAS Control Mechanisms
  - Ground Control
    - Directly controlled from takeoff to landing; Group 1 – 5; like cockpit
  - Semi-autonomous
    - Supervisory tasks and some direct control; Group 2 – 5; like CWS
  - Autonomous
    - Supervisory tasks and mission modification; Group 2 – 5; like CWS

Background: UAS Groups



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