Human Factors of Remotely Piloted Aircraft

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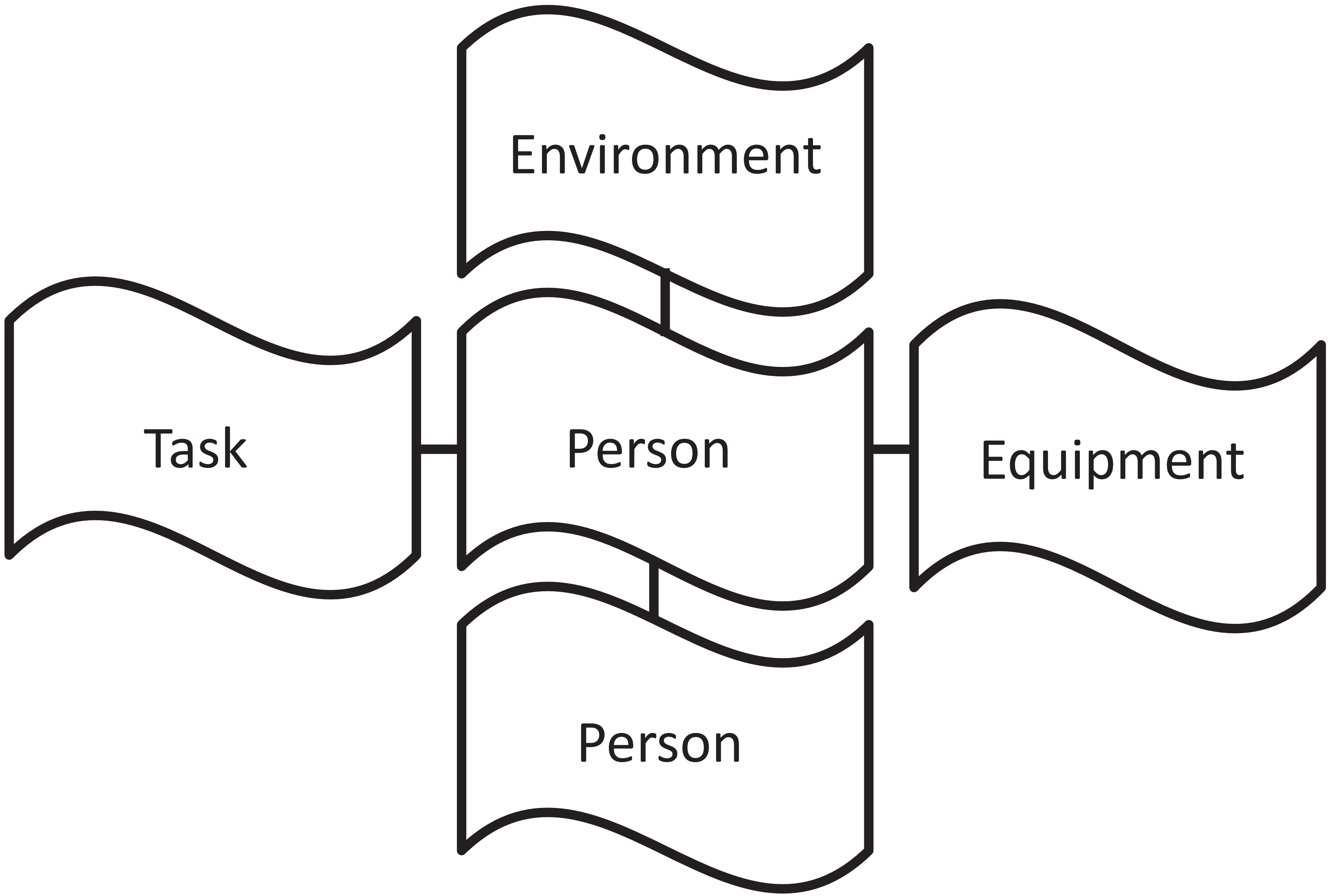
A Definition of Human Factors

Human factors is a body of knowledge about human abilities, human limitations, and other human characteristics relevant to the design of tools, machines, systems, tasks and environments.

Chapanis

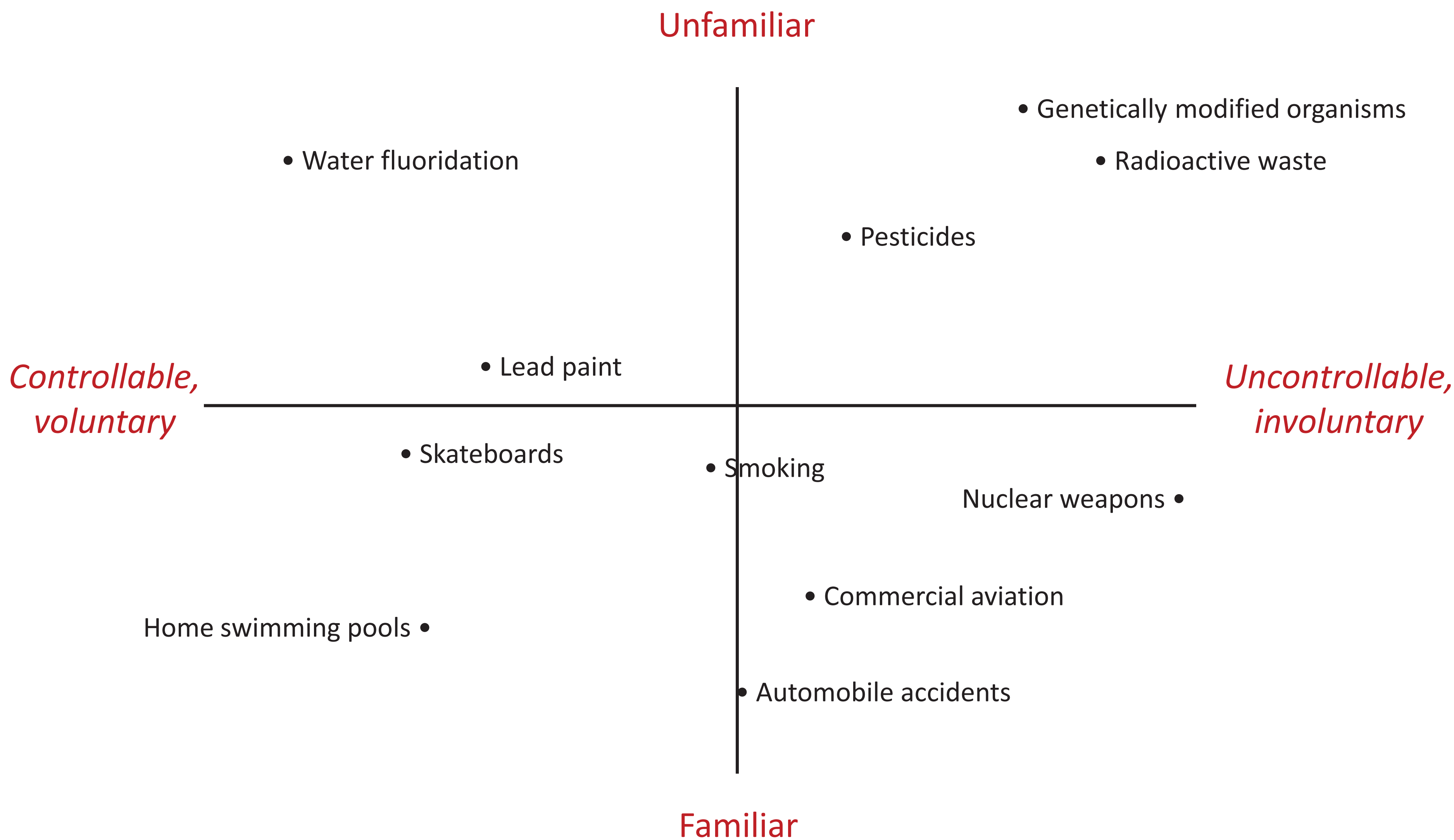

Environment
Task
Person
Equipment
Person

Transfer of Risk

UA collides with people or property on ground

Other airspace user collides with UA

Public Tolerance of Risk



Paul Slovic, 2000

Key Issues

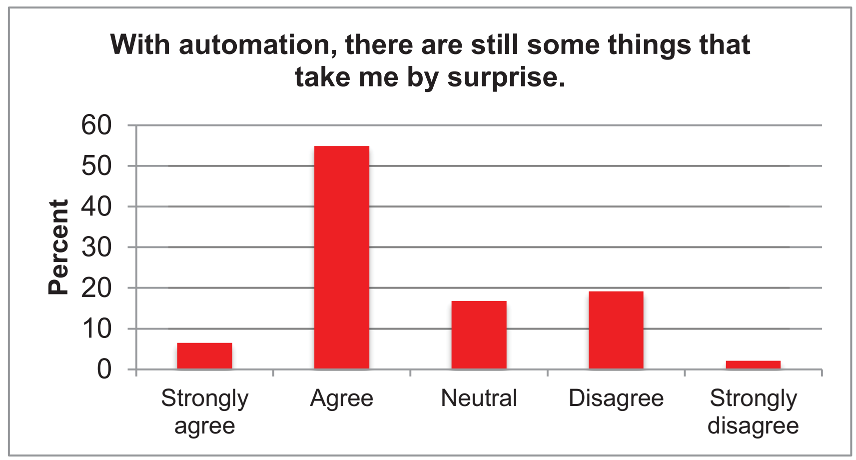
- Teleoperation
- Automation
- Detect and avoid
- Transfer of Control
- Control station design
- Flight termination
- Maintenance
- Operator skills and qualifications

Teleoperation

- Reduced perceptual cues
- Potential for reduced situational awareness
- Control/consequence incompatibility
- Latencies
- Link management

Automation

- Automation surprise
- Automation complacency
- Mode awareness & mode errors
- Engagement & workload
- Workarounds
- Data entry errors
  - – Tunes out small errors
  - – May increase probability of large errors

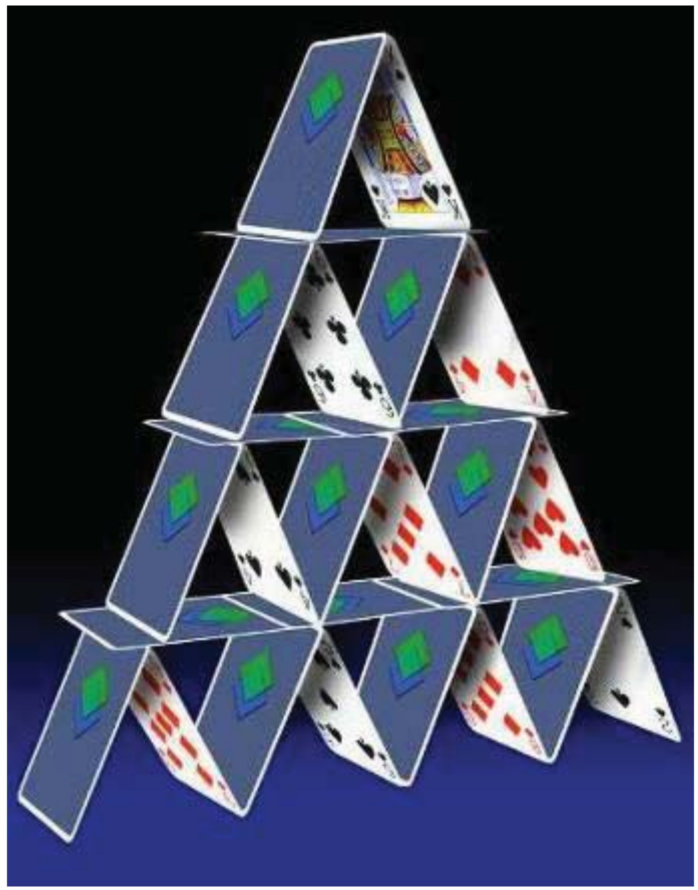


Automation

- Transitions between HITL – HOTL- HOOTL
- Automated systems more susceptible to maintenance set-up/programming errors

Automation

Teleoperation + Automation = fragility?

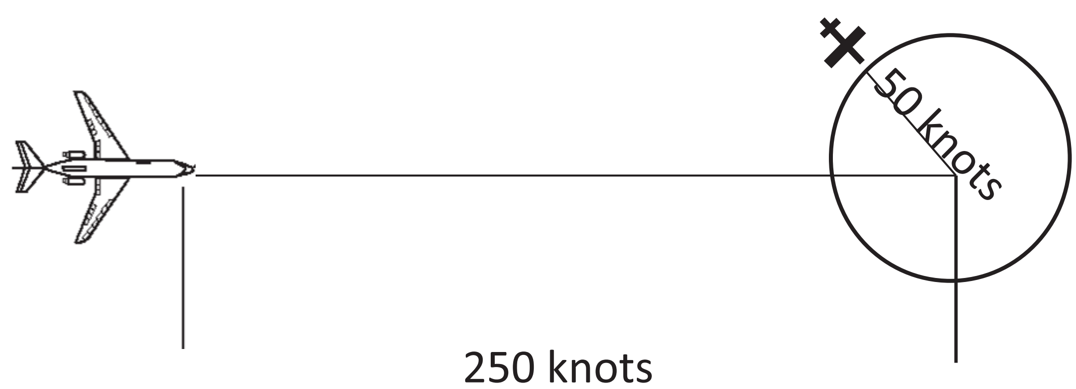


Automation

“After take-off the UA began an uncommanded bank to the left. The operator attempted to command the UA to a waypoint but the system would not accept it. The operator then commanded wings level, without any response. The UA continued to turn left from its assigned heading until it had turned through 180 degrees at which point it overflew the ground control station. It then impacted the ground at full power in a nose down attitude approx 60 feet from the launch site. The aircraft was damaged beyond repair. No system errors or faults were identified during the launch or upon review of the telemetry. The UA appeared fully functional at the time of launch. Testing after the accident indicated that the ground station computer was running slow and the software was locking up. The computer was changed and the system returned to normal status”.

Detect and Avoid

- Remain well clear vs collision avoidance
- Timeliness of response
- Autonomous collision avoidance?
- Impact on ATC workload and efficiency



Transfer of Control

- Between control stations, between consoles within GCS, crew change, link change
- Complicating factors:
  - Off-duty crew may leave workplace
  - Geographical separation
  - High potential for mode error
  - Long duration flights

Control Stations

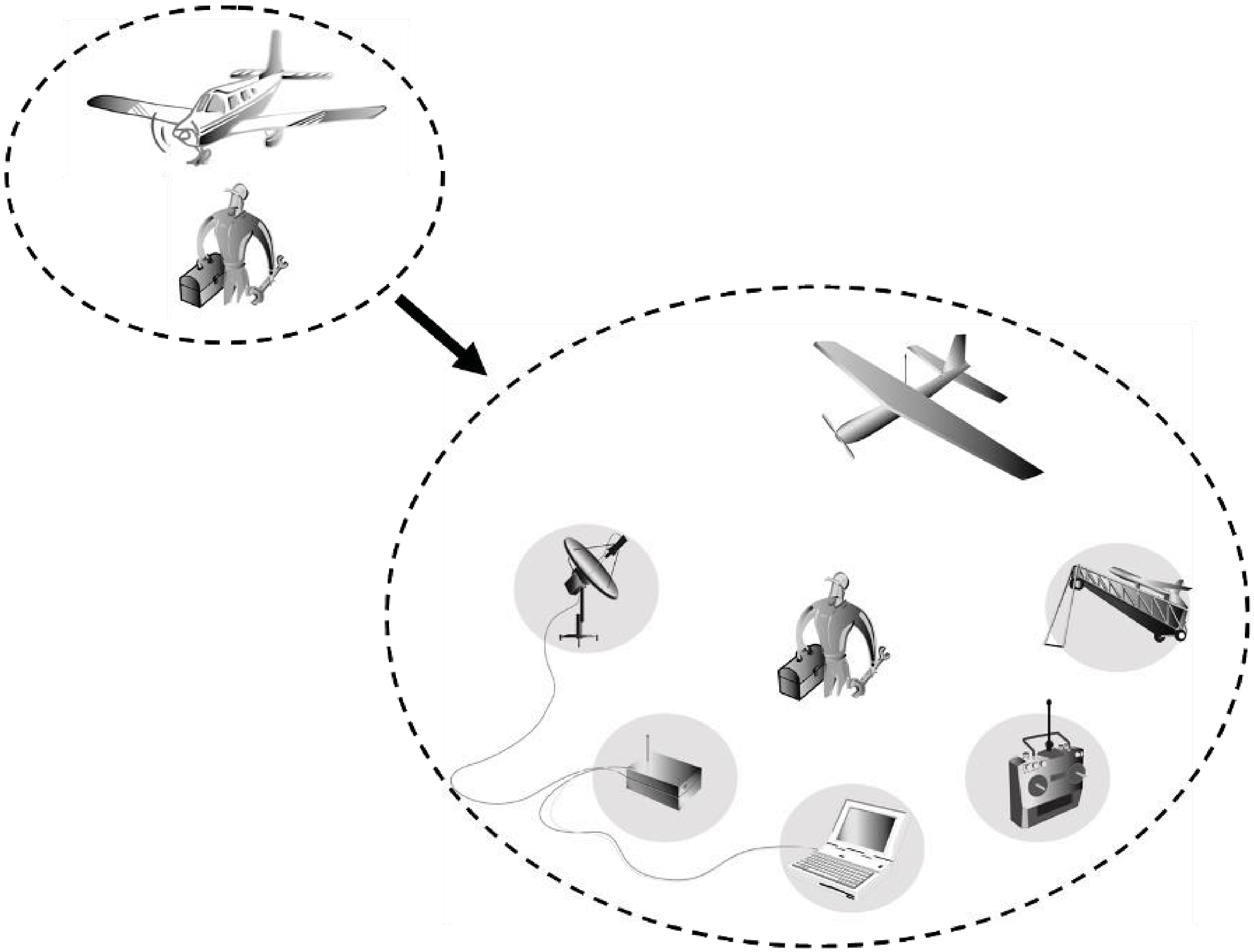
Control Stations

- Inadequate feedback to crew on system state
- Multi-mode controls and displays
- Difficult to read fonts and colors
- Placement of critical controls next to non-critical controls
- Reliance on text displays
- Display proliferation

Flight Termination

- Manned vs unmanned mindset
- Information requirements

Human Factors in UAS Maintenance



Human Factors in UAS Maintenance

- Diverse skill and knowledge requirements
- Lack of direct feedback on aircraft performance
- Repetitive assembly and handling
- Maintenance while missions underway
- Model aircraft culture
- Lack of documentation
- Salvage decisions
- Maintenance and fault diagnosis of IT systems

Maintenance and Fault Diagnosis of IT Systems

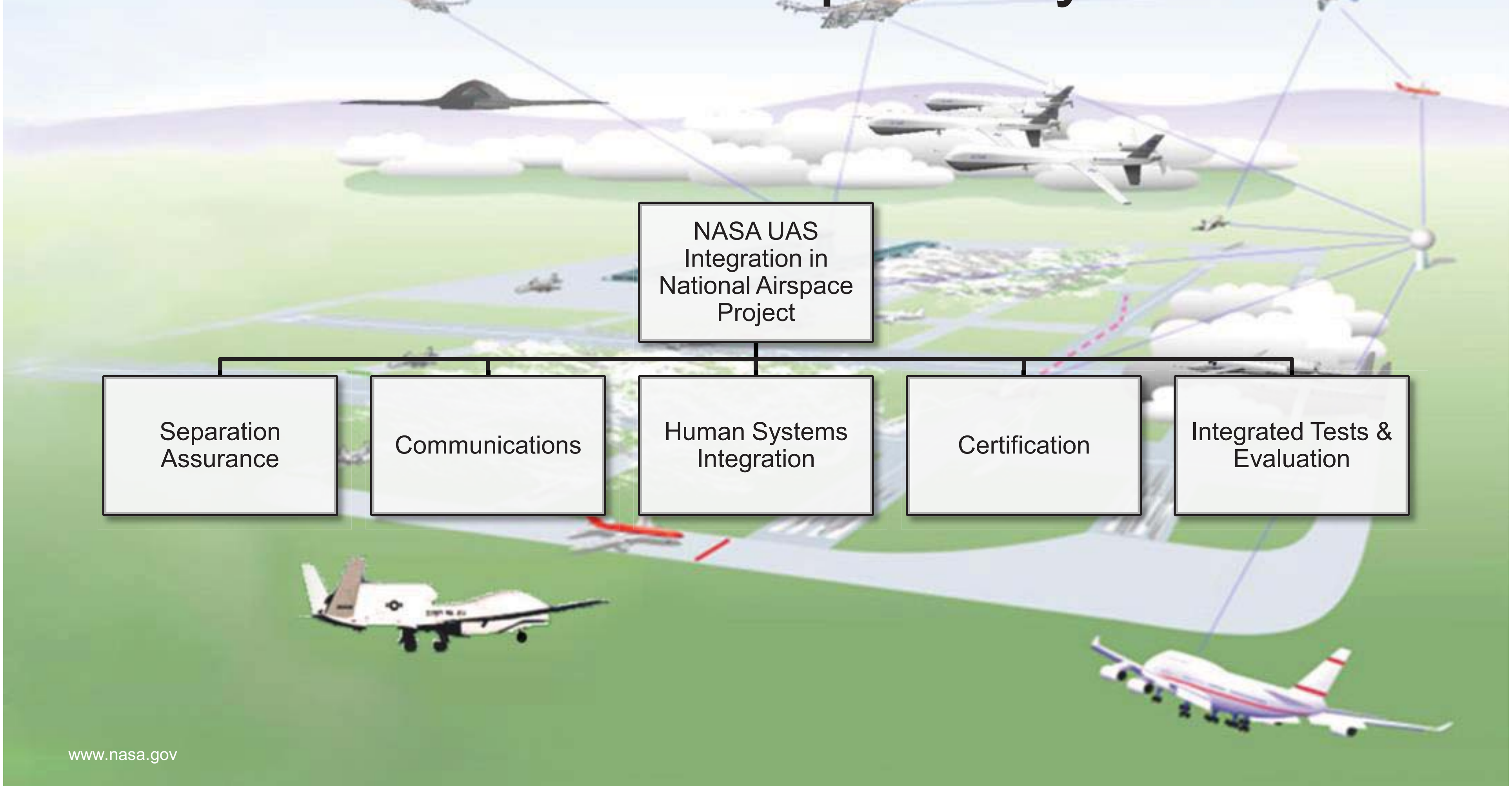
- Ill-defined faults
- Consumer hardware and software
- Laptop use discipline

Maintenance and Fault Diagnosis of IT Systems

"The desktop computer, which was serving as the ground control system, locked up while the unmanned aircraft was in flight. The PC-based computer was housed in the ground control station trailer. The only alternative was to re-boot the computer, and this took about two to three minutes before command-and-control was reestablished. The unmanned aircraft's flight path, however, was already uploaded so there was no effect on the flight sequence."

National Aeronautics and Space Administration

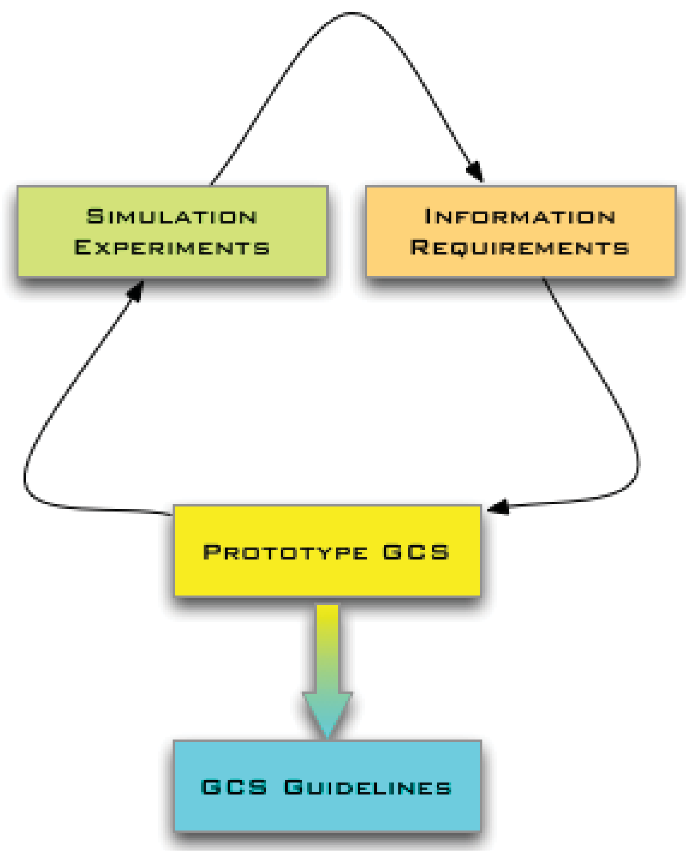
Unmanned Aircraft Systems Integration in the National Airspace System



Human Systems Integration (HSI) Overview

- Objectives:
  I. Develop GCS guidelines to operate in the NAS
  II. Develop a prototype display suite within an existing GCS to serve as a test bed for UAS pilot procedures and displays, and support guidelines development

- Technical Activities:
  - Information requirements analysis to identify the minimum GCS information to operate in the NAS
  - Simulation experiments to examine:
    - UAS pilot performance under various operating conditions and GCS configurations
    - The impact of nominal and off-nominal UAS operations on Air Traffic Control (ATC) performance and workload



Human Systems Integration

Coordinate with ATC - w/o increase to ATC workload

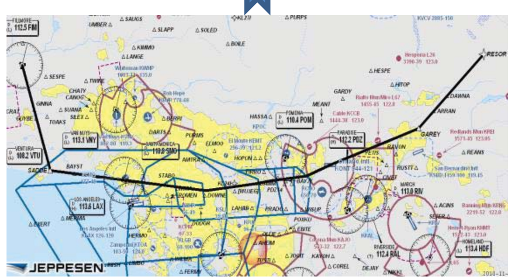
Efficiently manage contingency operations w/o disruption of the NAS

Seamlessly interact with SSI

Research test-bed and database to provide data and proof of concept for GCS operations in the NAS

Human factors guidelines for GCS operation in the NAS

Ensure operator knowledge of complex airspace and rules



Standard aeronautical database for compatibility

Traffic information for situation awareness and self-separation (well clear)

Summary of Current HSI Activities

- Information Requirements by:
    - Phase of Flight
    - Functional (e.g., aviate/control, manage, avoid, etc.)
    - Evaluation of existing Federal Air Regulations (FARs)
- Simulation Experiments:
  - Pilot Performance
    - Part Task Simulation 1– Baseline Compliance
    - Measured Response A – Response to ATC Clearances
    - Full Mission Simulation 1 – Command and Control Interfaces
  - ATC Performance
    - Part Task Simulation 3 – Contingency Management
    - Measured Response B – Pilot Communication and Execution Delay

Summary of Planned HSI Activities

- Simulation experiments to focus on DAA requirements:
  - Part Task Simulation 4:
    - Minimum display requirements
    - Advanced information and pilot guidance
    - Stand alone versus integrated displays
  - Part Task Simulation 5:
    - Evaluation of additional DAA displays
  - Full Mission Simulation 2:
    - Evaluation of boundary between self-separation, collision avoidance and autonomous collision avoidance
- Flight Tests to validate prototype GCS displays in operationally relevant environment
  - ACAS Xu Flight Test NOV 2014

Human Factor Design Guidelines

A statement describing a characteristic of the engineered system with the intention of promoting safe and effective human use.

Final thoughts

- Public perceptions may matter more than "equivalent level of safety"
- The human is part of the system
- There is an acute need to learn from UAS incidents and accidents
- Guidelines will need to be regularly updated as experience accumulates