User interaction with CNPC link

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NASA UAS Integration in National Airspace Project

- Separation Assurance
- Communications
- Human Systems Integration
- Certification
- Integrated Tests & Evaluation
Human Systems Integration

- Simulation experiments
- Development of a prototype display suite
- Flight tests
- Analysis of pilot information requirements
- Develop GCS guidelines for operation in the NAS
1. What tasks must the user perform to operate the equipment?

2. What outputs must the equipment provide to the user?

3. What inputs must the equipment accept from the user?
RTCA MOPS template

1.5 Operational goals may include:
   a. Accuracy
   b. Sensitivity
   c. Resolution
   d. Manual data inputs
   e. Outputs
   f. Failure modes, warnings and flags
   g. Self test
   h. Data display
   i. Interface with other airborne equipment/systems
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4. What properties of the interface contribute to usability?
RTCA MOPS template

2.1.5 Operation of controls
2.1.6 Accessibility of controls
3.1.1 Accessibility
3.1.3 Display visibility
3.1.7 Inadvertent turnoff
FAA Roadmap Assumptions

3. File and fly IFR flight plan
6. Each UAS will have a pilot in command
7. Autonomous operations are not permitted. The PIC has full control, or override authority to assume control at all times during normal UAS operations.
Manage

Plan for normal and non-normal conditions
Make decisions in normal conditions
Recognize and respond to non-normal conditions
Handoff control

Aviate
- Monitor and control aircraft systems, including automation
- Monitor consumable resources
- Monitor and configure control station
- Maneuver to avoid imminent hazard (e.g. aircraft or terrain)
- Monitor status of links and take actions as necessary
- Send aviate commands to aircraft

Navigate
- Control and monitor location and flight path of aircraft
- Remain clear of static hazards (e.g. terrain, airspace boundaries)
- Remain clear of dynamic hazards (e.g. weather, other aircraft)
- Send navigation commands to aircraft

Communicate
- Communicate with ATC
- Communicate with other airspace users
- Communicate with other flight crew or ground support
- Communicate with ancillary services (e.g. weather)
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What user interactions will occur with the equipment?

- SMEs, including UAS pilots
- Review of existing standards & guidance material, e.g. STANAGs, RTCA DO-304, USD GCS HMI Guide
Monitor status of links and take actions as necessary

Monitoring during establishment of link

Confirm spectrum availability before selecting link

Maintain awareness of link mode (e.g. terrestrial/satellite, frequency)

Maintain awareness of selected communication mode

Confirm that effective link is established with correct UA

Identify if more than one control station is linked with UA

Monitoring link performance

Maintain awareness of link strength (incl. loss of link)

Maintain awareness of link latency, where variable

Anticipate changes in link quality (e.g. fading, masking)

Respond to abnormality

Diagnose cause of abnormality & identify appropriate response

Maintain awareness of lost link threshold setting

Identify abnormalities (e.g. other users of frequency, jamming, EMI)

Monitoring during in-flight changes of link

Identify need to change link in-flight

Assess link quality before changing to new link

Monitor accomplishment of link change
Monitor status of links and take actions as necessary

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Monitoring during in-flight changes of link

- Identify need to change link in-flight
- Assess link quality before changing to new link
- Monitor accomplishment of link change
Outputs to user

Monitoring during establishment of link

- Quality and latency of link before it used to control the UA.
- Information to identify which CNPC link settings are active (e.g. selected frequency).
- Information to confirm that effective control is established with the correct UA.

Monitoring link performance

- Lost link.
- Lost link threshold setting.
- Duration of lost link.
- Resumption of link.
- Link quality.
- Presence of interference (Jamming, other users of spectrum, EMI).
- Information to enable the pilot to identify the nature of the interference and formulate an appropriate response.
- Latency.
- Information to anticipate changes of link strength.
Inputs from user

- System set-up
- Management of abnormalities
- As required by design solution
Ongoing work

- Continued development of guidelines
- Additional information from UAS pilots and SMEs
- Integration of information from NASA simulations and flight tests
So what?

- Information on tasks, inputs, and outputs can be used to help develop content for:
  1.5 Operational goals
  2.1.5 Operation of controls
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  3.1.7 Inadvertent turnoff
Additional material

- **STANAG 4671**
  - U1607 (c) For each command and control data link, the integrity of the uplink and downlink must be continuously monitored at a refresh rate consistent with safe operation.
  - U1607 (b) For each command and control data link, the effective maximum range which may include a safety margin ... must be displayed in the UCS for a specific availability level for both uplink and downlink .... The corresponding availability level must be displayable on UAV crew request at the appropriate position on the UCS display.
  - U1607 (d) Maximum range cues must be provided in the UCS on UAV crew request or automatically in case of a likely breakdown of the command and control data link.
  - U1613 (c) There must be an alert for the UAV crew, via a clear and distinct aural and visual signal, for any total loss of the command and control data link.
  - U1615 (c) Warning cues shall be provided to the UAV crew in case of approaching masking attitudes in order to prevent a total loss of command and control data link.
Additional material

• **STANAG 4671 U1613 (c)**
  – There must be an alert for the UAV crew, via a clear and distinct aural and visual signal, for any total loss of the command and control data link

• **STANAG “4568”**
  – Consistency: Minimize the differences within and across operator interfaces
  – Feedback: Provide the operator with feedback and error-correction capabilities
  – Mental workload: Keep operator mental workload within acceptable limits
Additional material

- **DO-238 Human Engineering Guidance for Data Link Systems**
  - 7.1.3 The HCI should clearly distinguish between the various functions and modes of the system and indicate the type and format of data expected. To the extent possible, data link systems should ensure that data intended for one purpose cannot be used erroneously for a different purpose.
  - 7.2.2 A positive indication of failures of the data link system and each of its functions should be provided. The indication should not itself be subject to silent failures.
  - 7.2.6 In cases of failure, the operator should have the information required to reestablish communication expeditiously