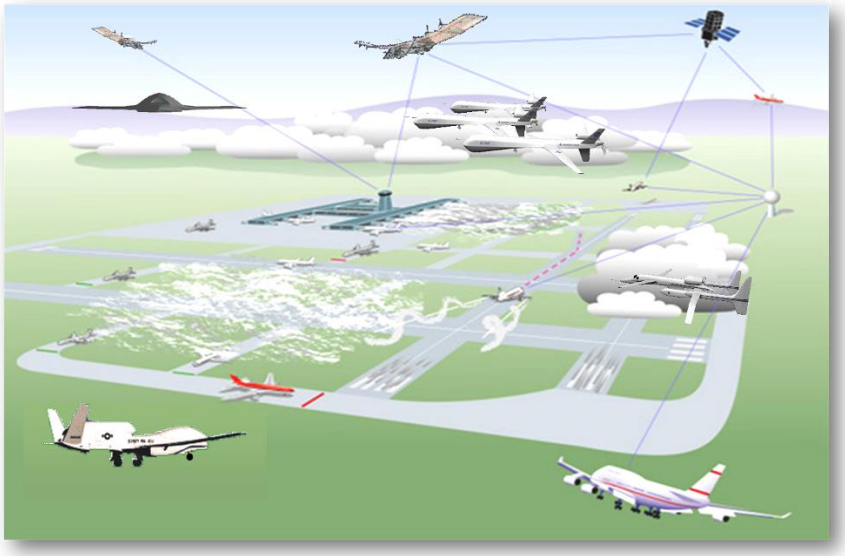
# User interaction with CNPC link



Alan Hobbs
San Jose State University/NASA Ames Research Center

Elizabeth A. Lyall
Research Integrations, Inc.

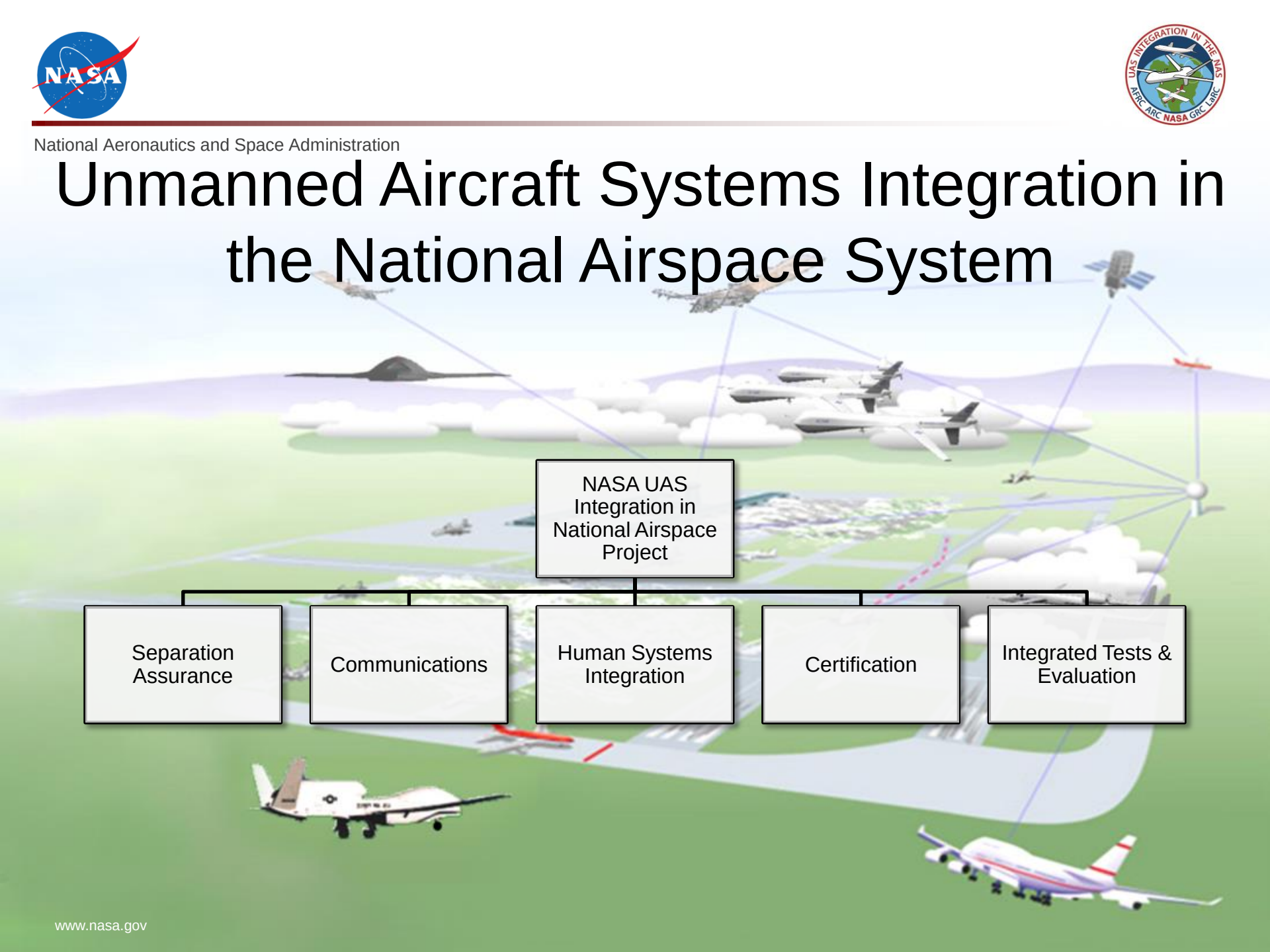
Ames Research Center

RESEARCH INTEGRATIONS INCORPORATED

San José State UNIVERSITY

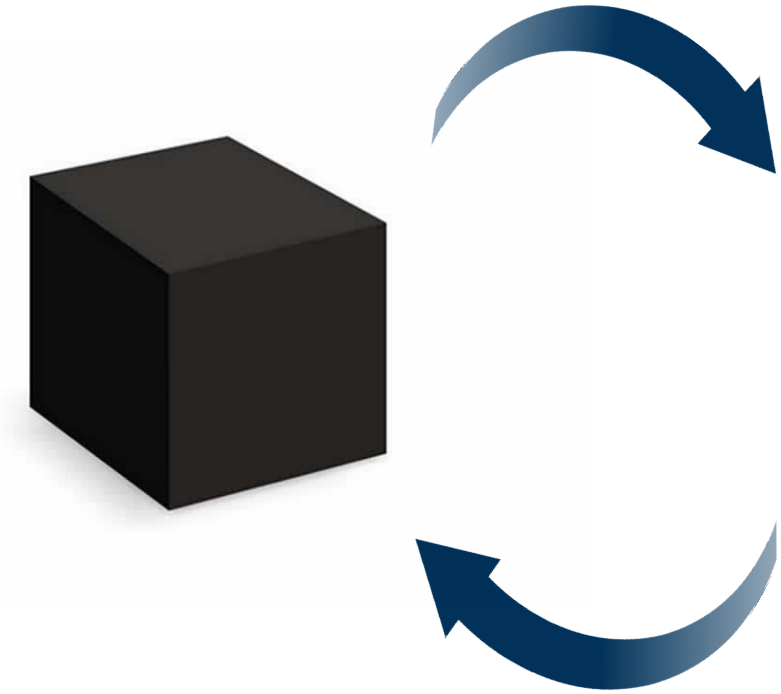
National Aeronautics and Space Administration

# Unmanned Aircraft Systems Integration in the National Airspace System



# 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?

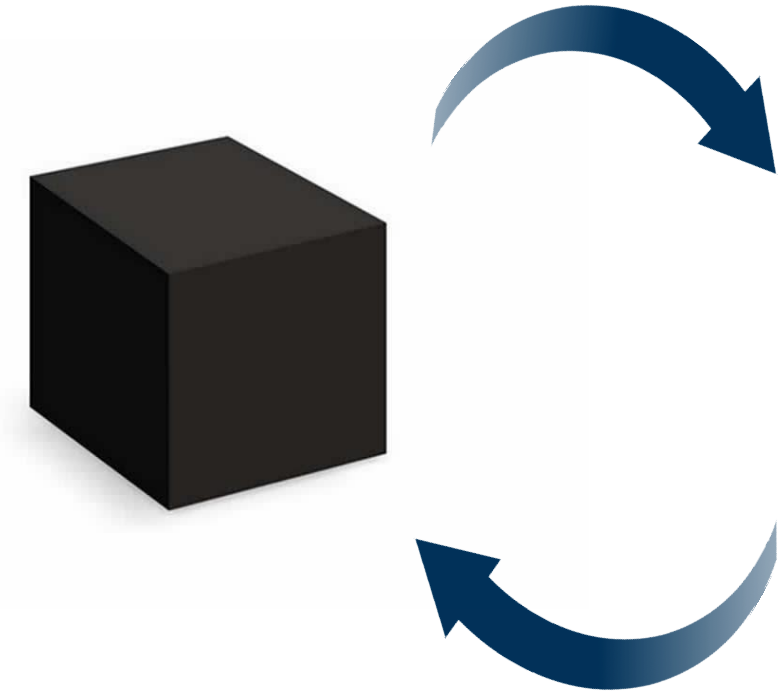
2. What outputs must the equipment provide to the user?

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



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?

4. What properties of the interface contribute to usability?

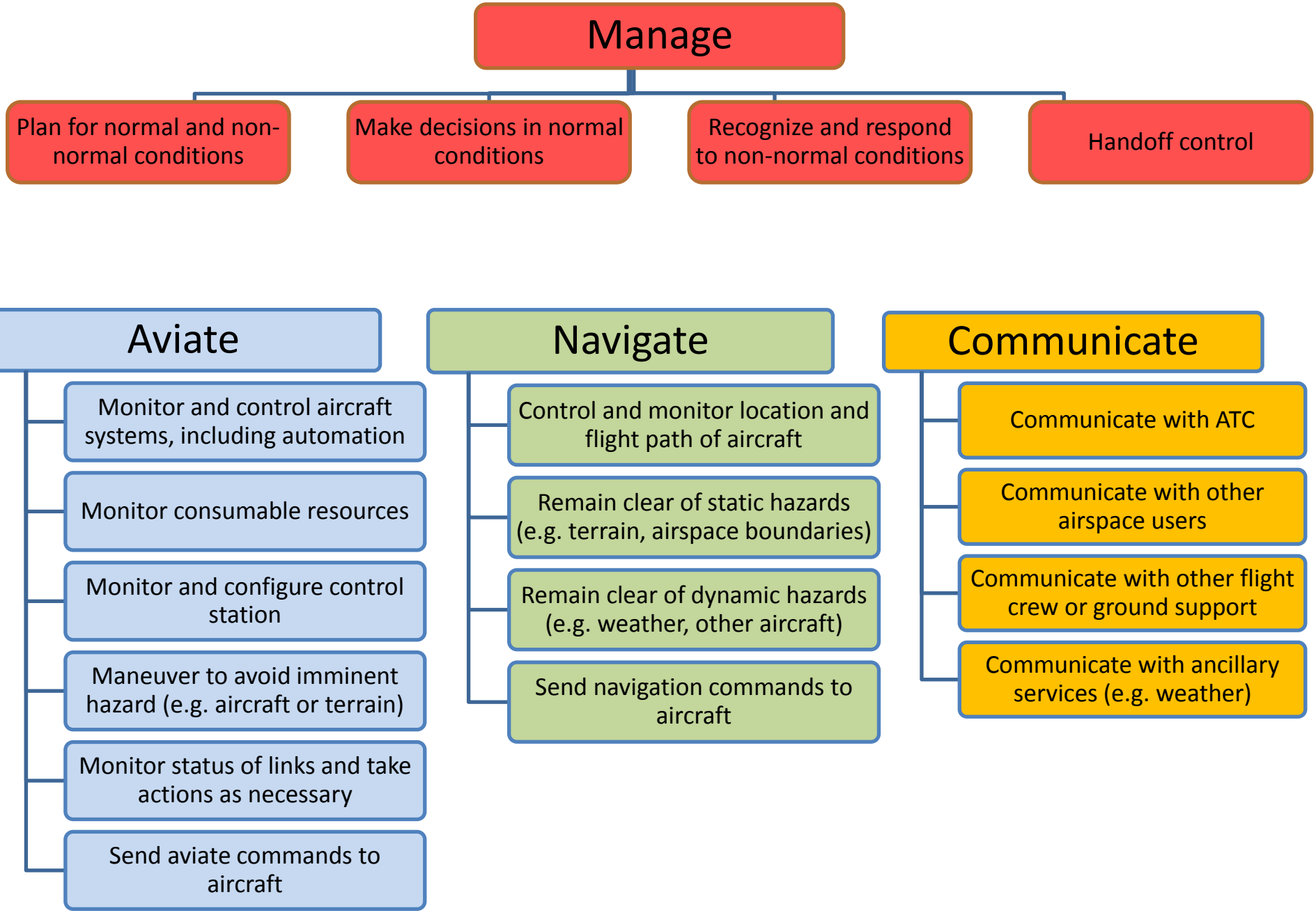
# RTCA MOPS template

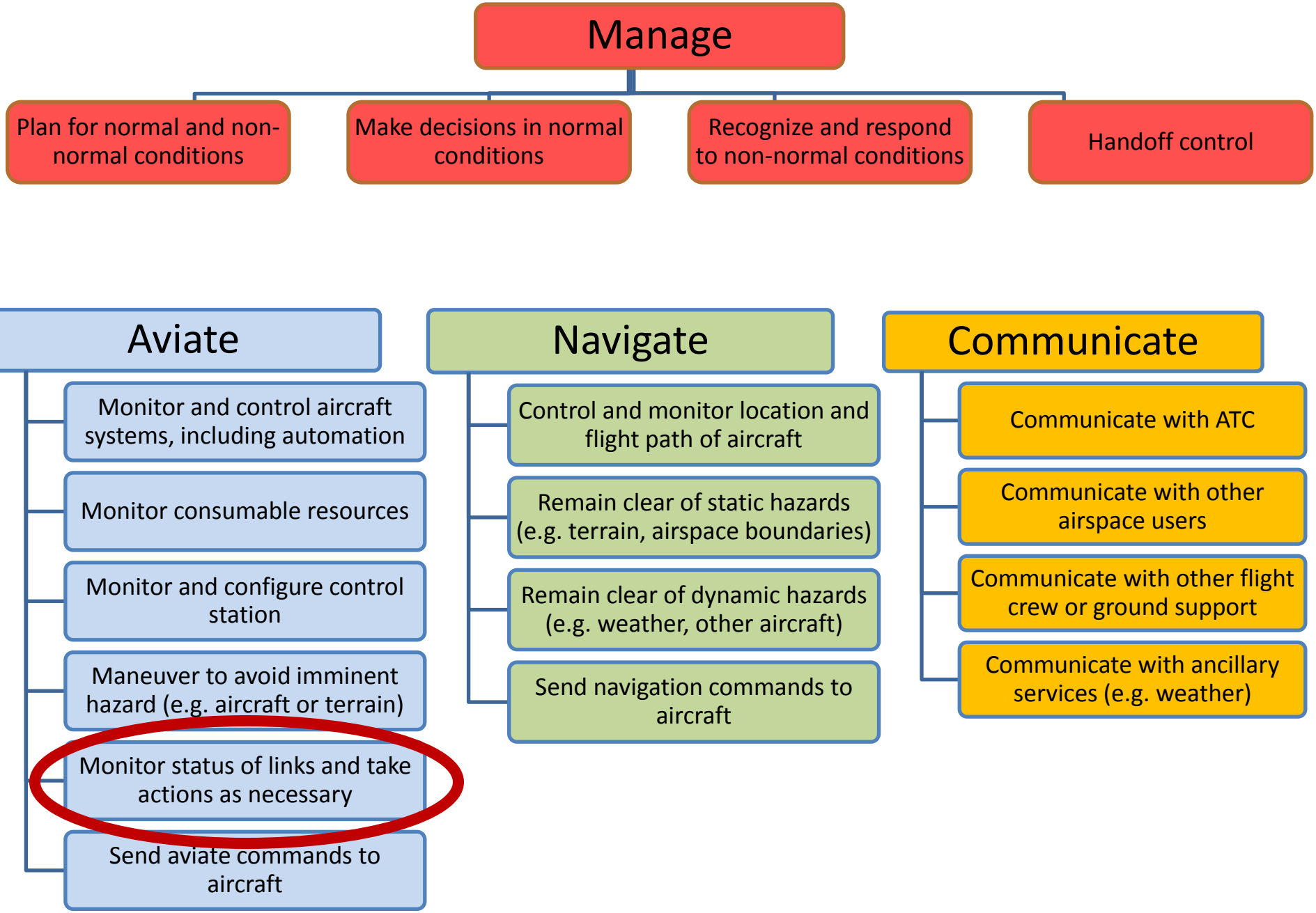
| | |
|---|---|
| 2.1.5 | Operation of controls |
| 2.1.6 | Accessibility of controls |
| 3.1.1 | Accessibility |
| 3.1.3 | Display visibility |
| 3.1.7 | Inadvertent turnoff |

# 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.

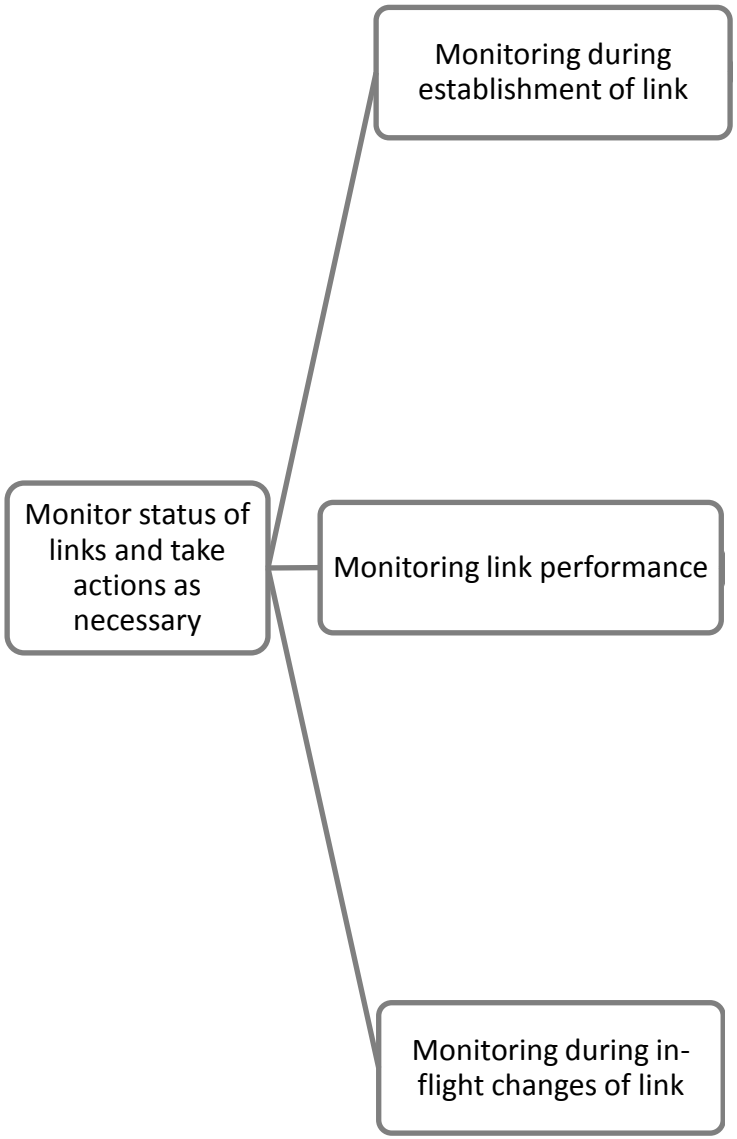
Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap
First Edition – 2013

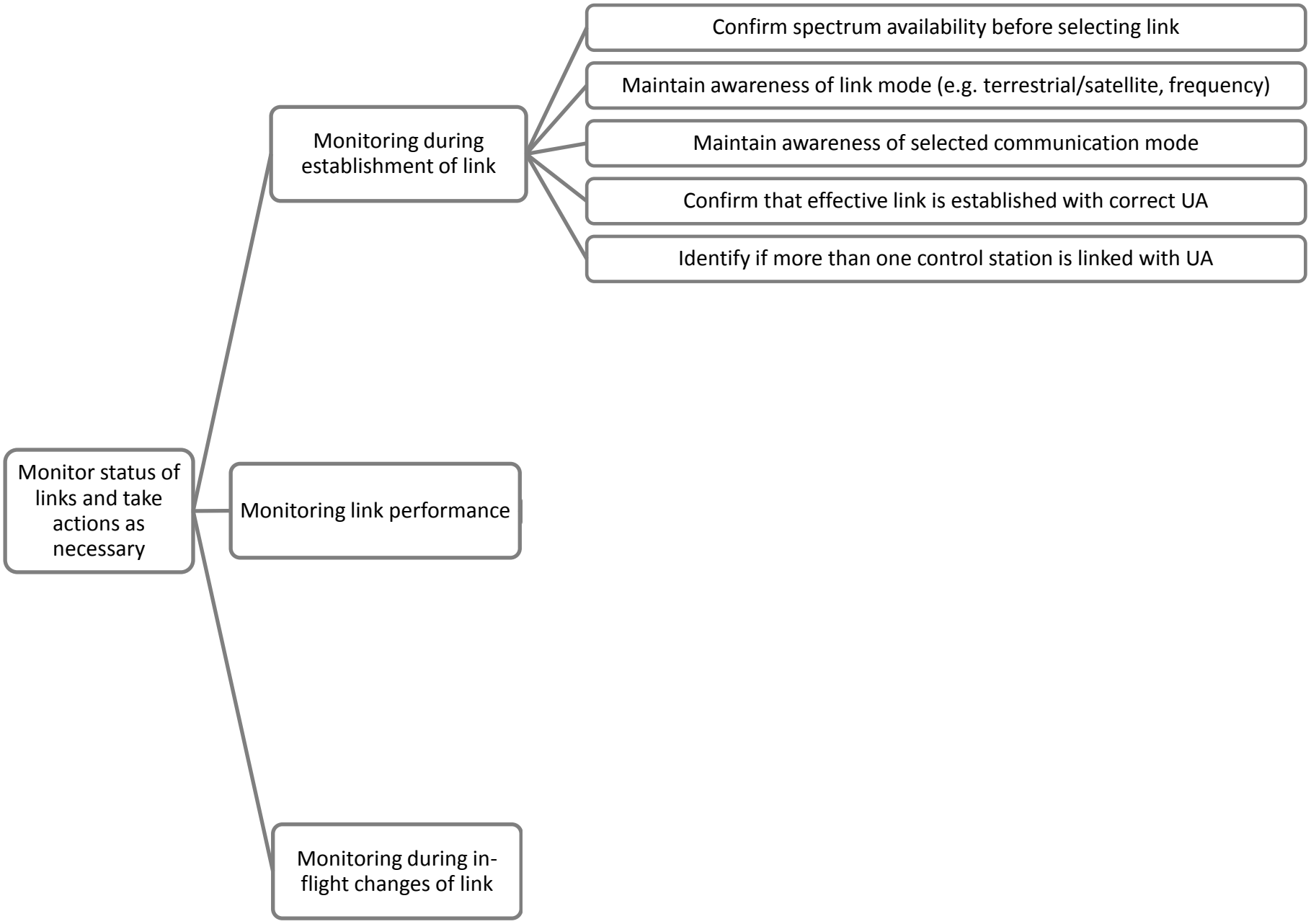

Manage
Plan for normal and non-normal conditions
Make decisions in normal conditions
Recognize and respond to non-normal conditions
Handoff control
Aviate
Monitor and control aircraft systems, including automation
Monitor consumable resources
Monitor and configure control station
Maneuver to avoid imminent 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)


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)

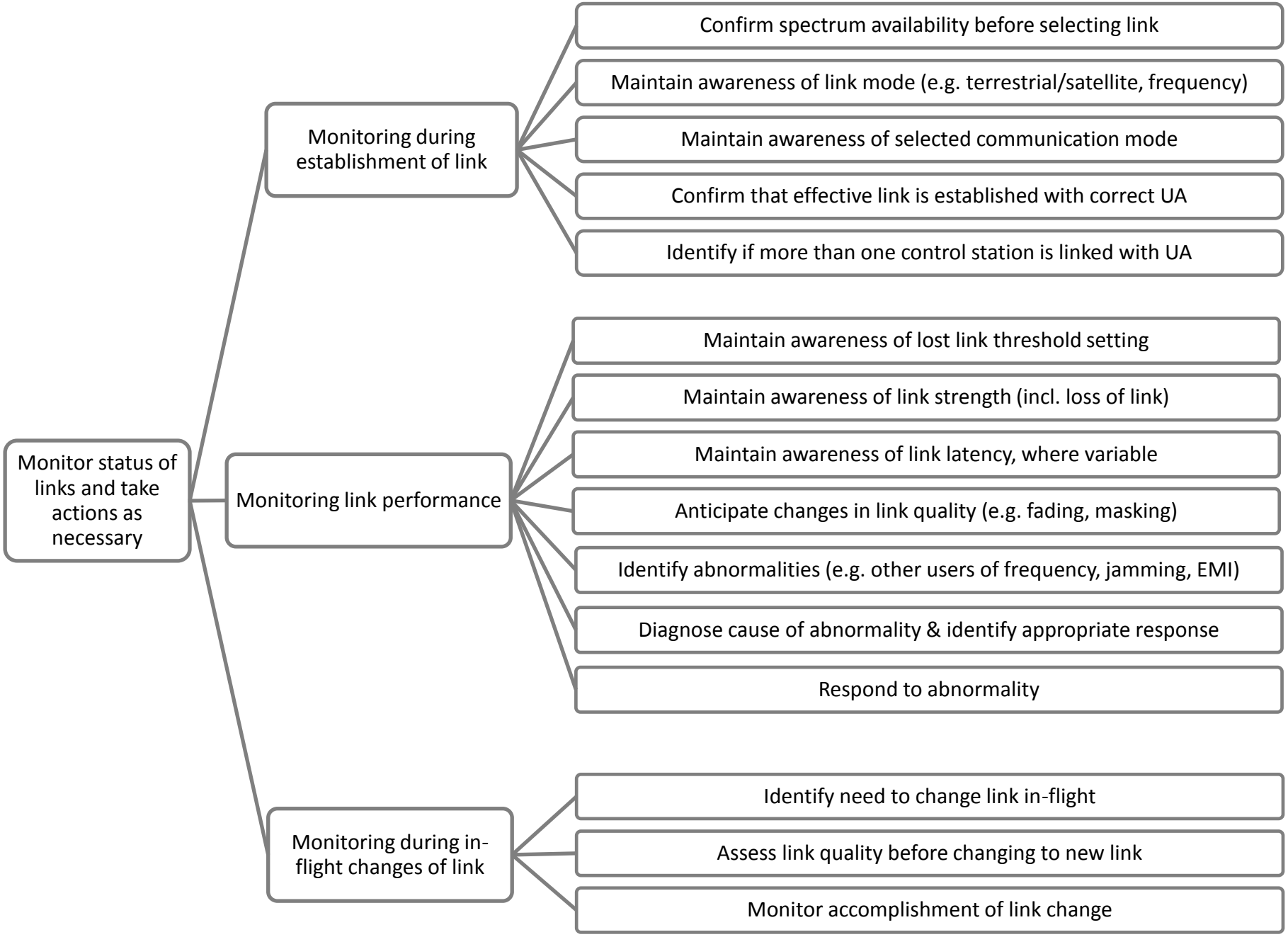
# What user interactions will occur with the equipment?

- SMEs, including UAS pilots
- Review of existing standards & guidance material, e.g. STANAGs, RTCA DO-304, USD GCS HMI Guide

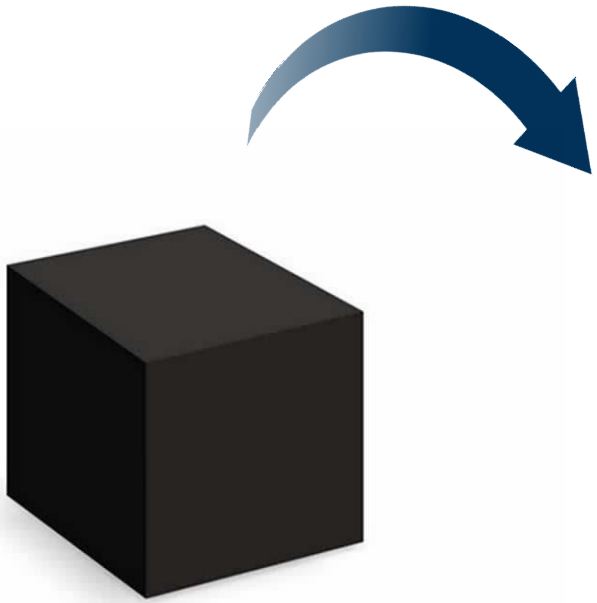

Monitor status of links and take actions as necessary
Monitoring during establishment of link
Monitoring link performance
Monitoring during in-flight changes of link


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
Monitoring during in-flight changes of link

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 lost link threshold setting
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)
Identify abnormalities (e.g. other users of frequency, jamming, EMI)
Diagnose cause of abnormality & identify appropriate response
Respond to abnormality
Monitoring during in-flight changes of link


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 lost link threshold setting
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)
Identify abnormalities (e.g. other users of frequency, jamming, EMI)
Diagnose cause of abnormality & identify appropriate response
Respond to abnormality
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



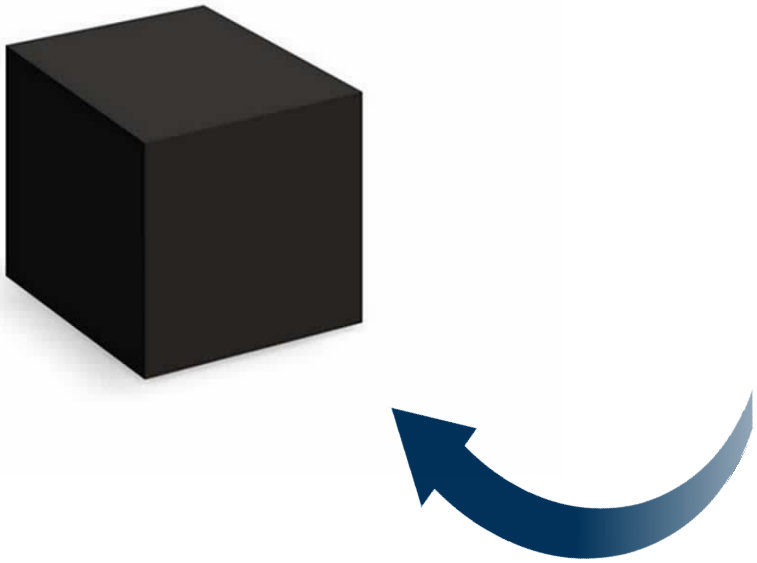
**Monitoring during establishment of link**

- 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 |
| 2.1.6 | Accessibility of controls |
| 3.1.1 | Accessibility |
| 3.1.3 | Display visibility |
| 3.1.7 | Inadvertent turnoff |

alan.hobbs@nasa.gov

# 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