



ACAS Xr Part Task Sim

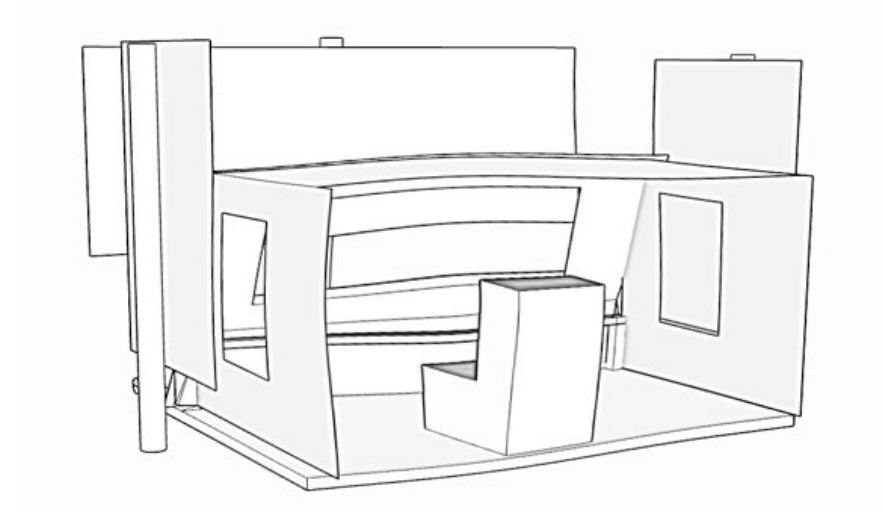
Preliminary Experimental Design

Oct. 14, 2021



- NASA's Advanced Air Mobility (AAM) – Automated Flight and Contingency Management (AFCM) Sub-Project is looking at higher levels of automation for eVTOL aircraft
- Our group – Hazard Perception and Avoidance (HPA) – is kicking off our technical work with a part task human-in-the-loop (HITL) simulation
- ACAS Xr (v1) will be automated for Resolution Advisories (RAs) and the return-to-course (RTC)
 - ACAS Xr RAs will be horizontal (i.e., a target track angle), vertical (i.e., a target vertical speed) or blended (i.e., target track angle + target vertical speed)
 - Xr will also generate Remain Well Clear (RWC)/Detect and Avoid alerting and guidance, which pilots will respond to manually

- The study will collect data on the effectiveness of the ACAS Xr guidance and the utility of the automated maneuvers
- Pilots will fly short en-route/cruise scenarios in our lab's eVTOL fixed-base simulator and encounter a variety of scripted conflicts
 - We will vary the level of automation and intruder dynamics and measure their effect on the pilot's ability to maintain well clear and avoid NMACs
 - Pilot feedback on the display of ACAS Xr information and on the presentation of the automated maneuvers will also be collected



- Independent Variables

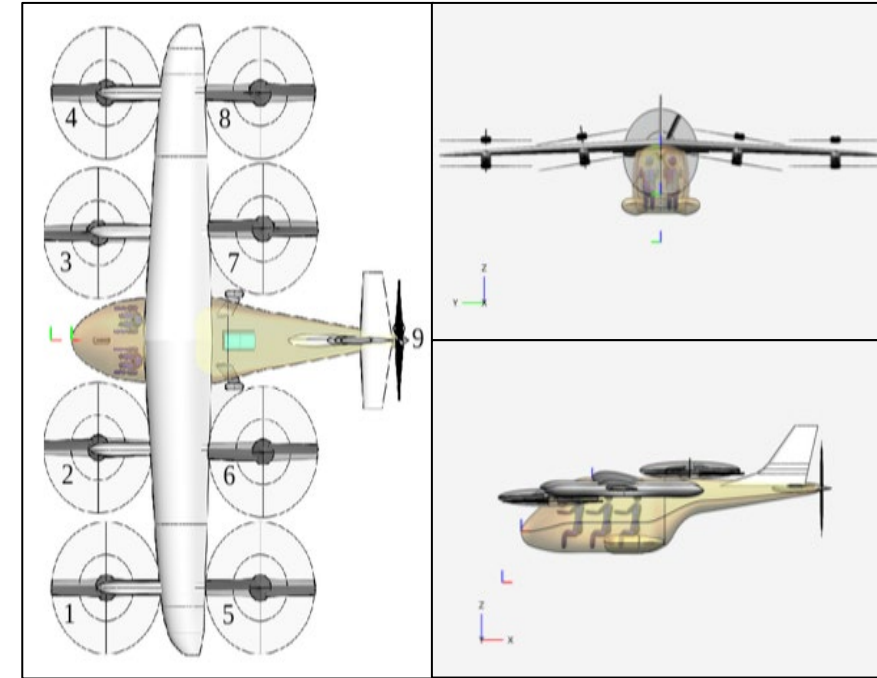
- Automation Level – 2 levels, within-subjects
 - *Manual* = pilot manually performs the RA and RTC maneuvers
 - *Auto-RA & RTC* = vehicle automatically complies with RA and performs the RTC
 - Logic will check to ensure there is no active alert or Corrective-level banding before performing the RTC
- Conflict Type – 2 levels; within-subjects
 - *Remain Well Clear* (RWC) = intruder starts as Corrective alert; pilot responds manually
 - *Resolution Advisory* (RA) = intruder starts as an RA; response dependent on automation condition
(Intruder speed, time to CPA, and angle of approach will also vary from scenario to scenario)

- Dependent Variables

- Response Times: pilot response times to Corrective alerts and RAs in the manual condition will be recorded
- Losses of DAA Well Clear (LoDWC): the number and severity of LoDWC against RWC and RA conflict types will be recorded
- Maneuver Size: the size of the maneuver/path deviation will be recorded for each encounter
- Maneuver Duration: the time from the onset of the conflict and the start of the RTC maneuver will be captured
- Subjective Ratings:
 - Automated maneuver acceptability
 - Workload - NASA TLX (Post Encounter)
 - Display/Information Acceptability – ratings on availability and utility of interface elements (Post Block & Post Sim)
 - Meaningful Human Control - did the interfaces allow for sufficient MHC (Post Sim)

- Ownship

- eVTOL flight model
 - Lift + cruise, 6DoF
- Maneuverability:
 - Cruise speed: 80KTAS
 - Minimum turn rate: 3 deg/sec
 - Climb/descent rate: 1000 ft/min
- Equipage: ADS-B In/Out
 - Perfect data assumed (no sensor models)

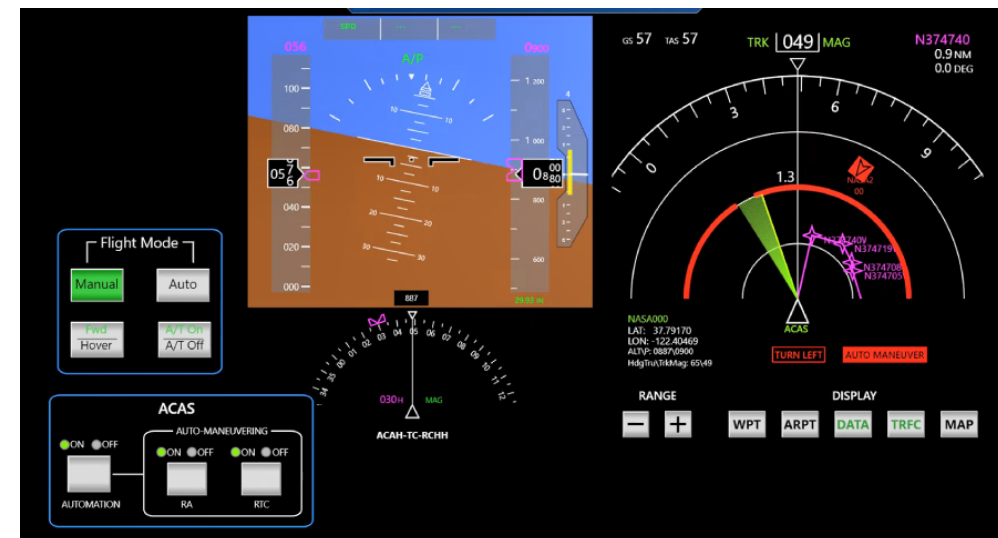
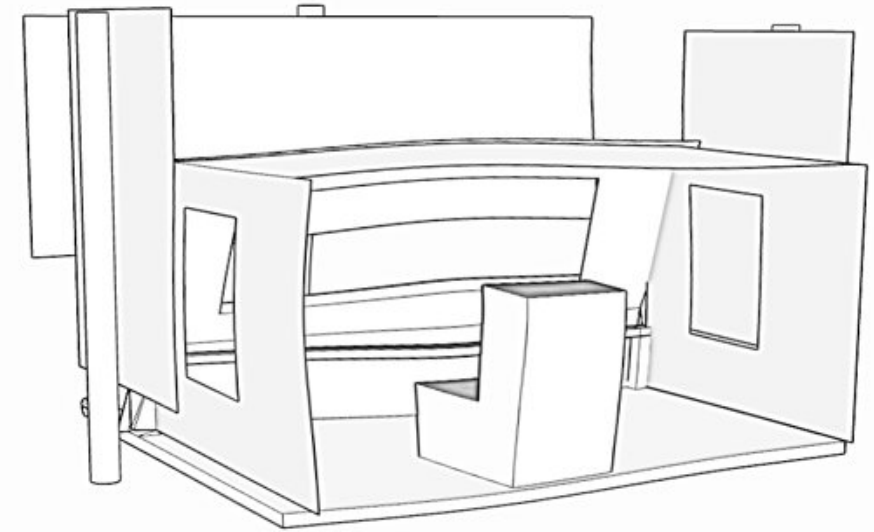


- Intruders

- General Aviation (e.g., Cessna)
- Maneuverability:
 - Cruise speed: 120KTAS
 - Minimum turn rate: 3 deg/sec
 - Climb/descent rate: 1000 ft/min
- Equipage: ADS-B In/Out



- Participants
 - 12-16 IFR-rated participants will be recruited for this study
- Simulator
 - Participants will be flying an eVTOL flight model in our fixed-base simulator
 - Vehicle will start at mission altitude (1000ft AGL) in level flight and in auto-pilot mode
 - Controls:
 - 1 side-stick controller: longitudinal/latitudinal direction of motion with twist to control rudders (yaw)
 - 1 side-stick controller: acceleration/deceleration
 - Tablet & touch screen monitor: flight mode, contingency maneuvers, & navigational map interfaces
- Airspace
 - Vehicle will be in transit between two vertiports in San Francisco in VMC conditions and VFR rules
 - No Provider of Services for UAM (PSU) interactions will be included in this study
 - No background traffic or ATC interactions will be included
 - Traffic will not be included in out-the-window displays



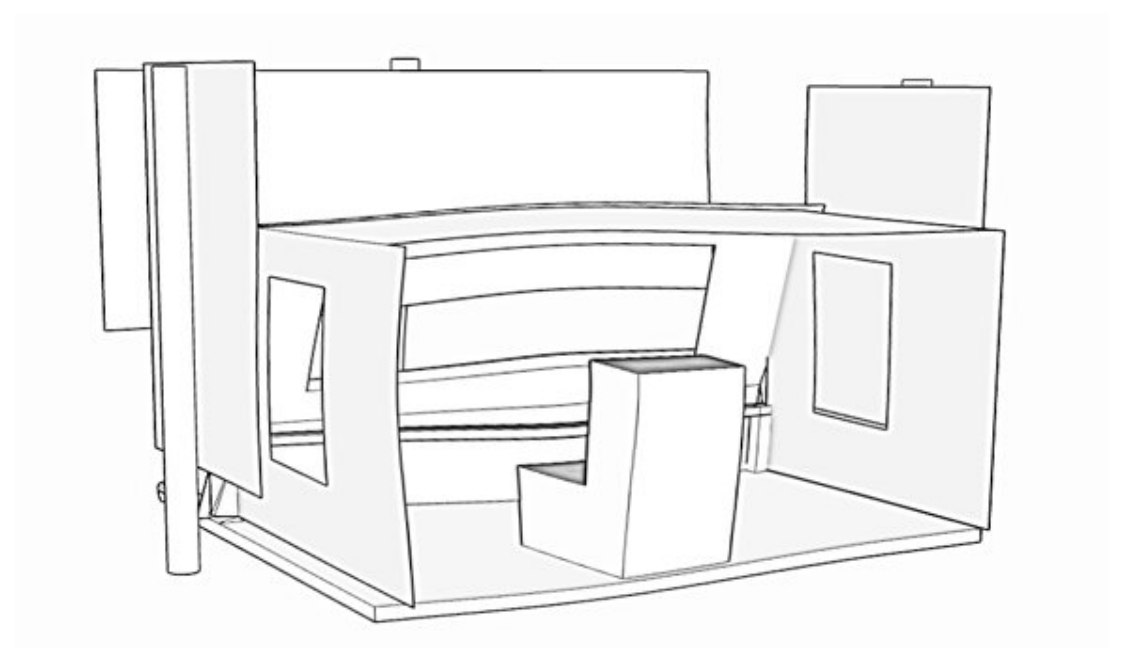
- Pilot Task:
 - Use ACAS Xr alerting and guidance to resolve scripted conflicts
 - Pilots will disengage the auto-pilot to manually respond to RWC/Corrective alerts and to RAs in the manual condition
 - The RAs will be flown automatically in the automated condition
 - Pilots will be asked to return to course (in the manual condition) as soon as practical
- Experimental Scenarios:
 - Pilots will run through 10-12, ~5 minute encounters per experimental condition
 - Manual vs Automatic
 - Conflicts will be scripted to start as a Corrective alert or an RA and will vary by intruder geometry
 - Two multi-threat encounters will be included per condition

- Development, shakedown, & pre-test through January 21st, 2022
- Data Collection to start late January 2022
 - Should be able to brief RTCA SC-147 and/or SC-228 on the results in late March, early April
- Future Projects
 - Next study (scheduled for September 2022)
 - Will use ACAS Xr v2 to look at RAs in different phases of flight
 - Project planned for the Vertical Motion Simulator
 - Flight tests
 - Canada's National Research Council in FY23
 - National Campaign in FY23 and FY25
 - Exploring future versions of ACAS Xr, generating and presenting:
 - terrain, obstacle, and weather information
 - speed DAA guidance and RAs
- Questions?



BACKUP SLIDES

- ACAS Xr Part Task Sim
 - Our lab's first study with ACAS Xr (using version 1)
 - Data collection planned for Jan-Feb 2022
 - ACAS Xr was integrated with FlightDeckZ (aircraft modeling software used by NASA Ames) and with our lab's new manned eVTOL simulator
- Sim will focus on how pilots interact with/perceive automatic Resolution Advisory (RA) and Return to Course (RTC) maneuvering
 - Incorporating as many relevant automation requirements as possible from DO-365B

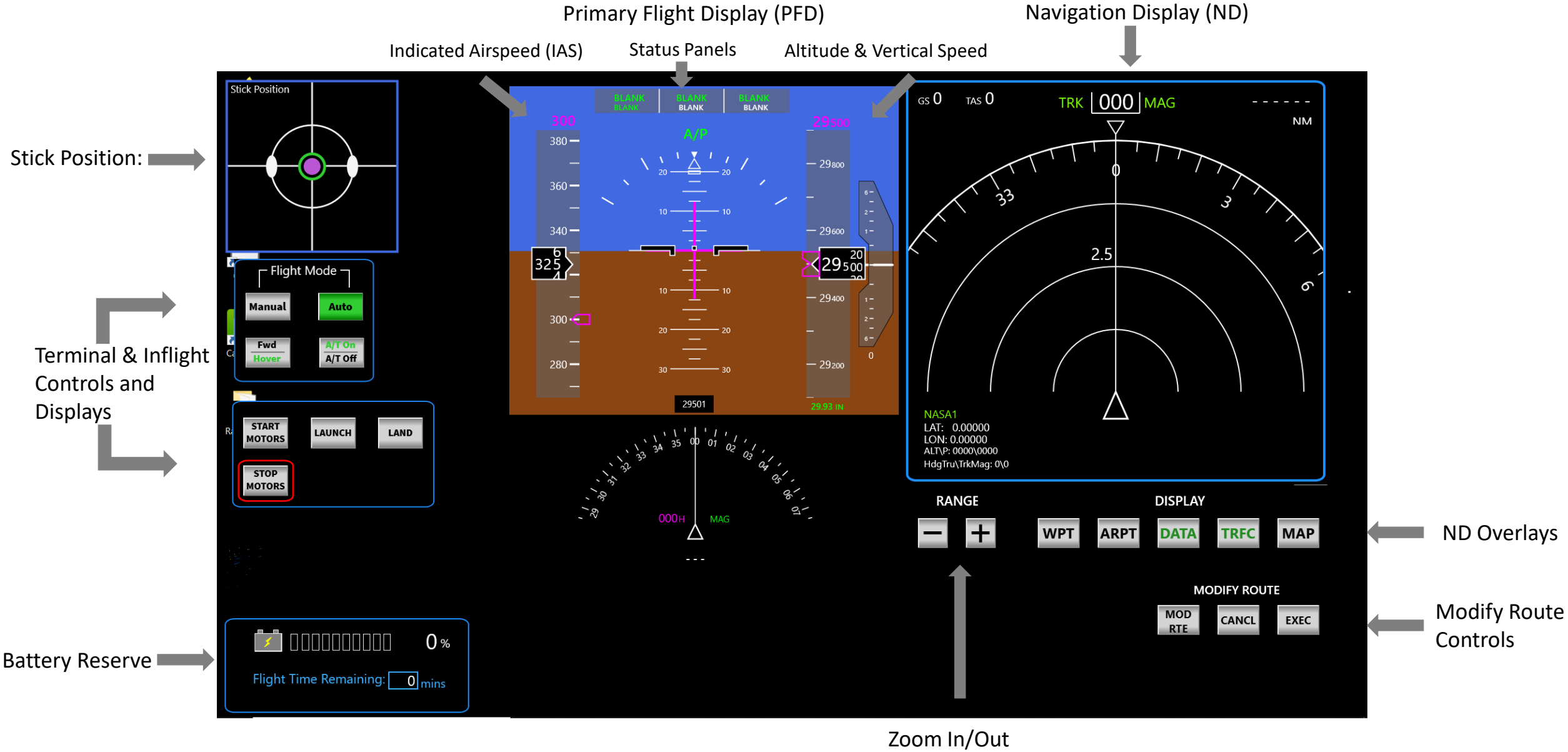




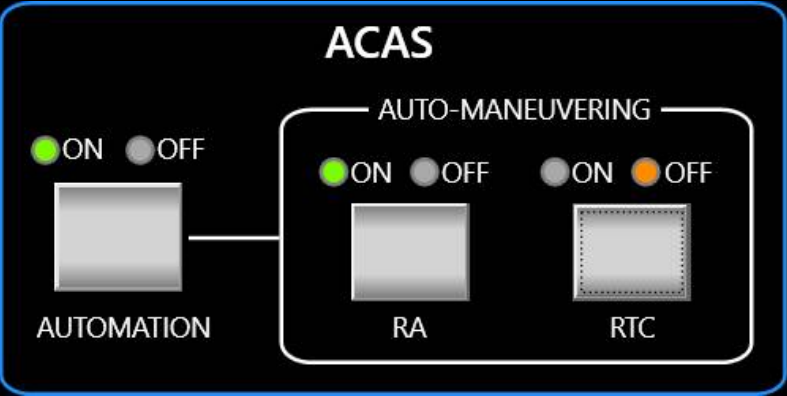
- Independent Variable (tentative)
 - Automation Annunciation
 - None – no additional annunciations/indications regarding automatic response behavior
 - Aural – aural annunciation indicates automatic response behavior
 - Visual – visual indication accompanies automatic response behavior
 - Aural & Visual – aural annunciation & visual indication accompanies
- Scenarios
 - Automatic Response Configuration
 - No automation enabled (baseline; no Automation Annunciation conditions necessary)
 - Auto-RA enabled only
 - Auto-RA & RTC enabled
 - Auto-RTC enabled only



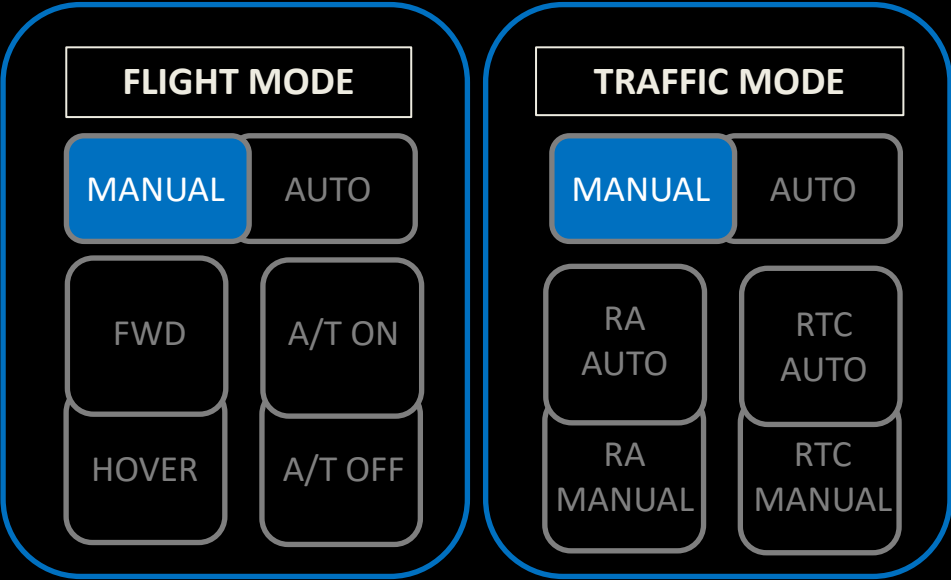
Simulator Displays (Example Designs)



Option 1
(in C#)



Option 2
(in powerpoint)



Example Auto RA & RTC Clip



