A CLOSER LOOK AT AUTOMATION BEHAVIOR DURING A HUMAN-IN-THE-LOOP SIMULATION

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Outline

Background & Motivation

Human-in-the-Loop Simulation

Current Investigation

Results

Concluding Remarks

Background & Motivation

- Driving question:
  - How do controllers resolve conflicts?
  - How does automation resolve conflicts?
  - **How do controllers work with automation in resolving conflicts?**

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Human-in-the-Loop Simulation

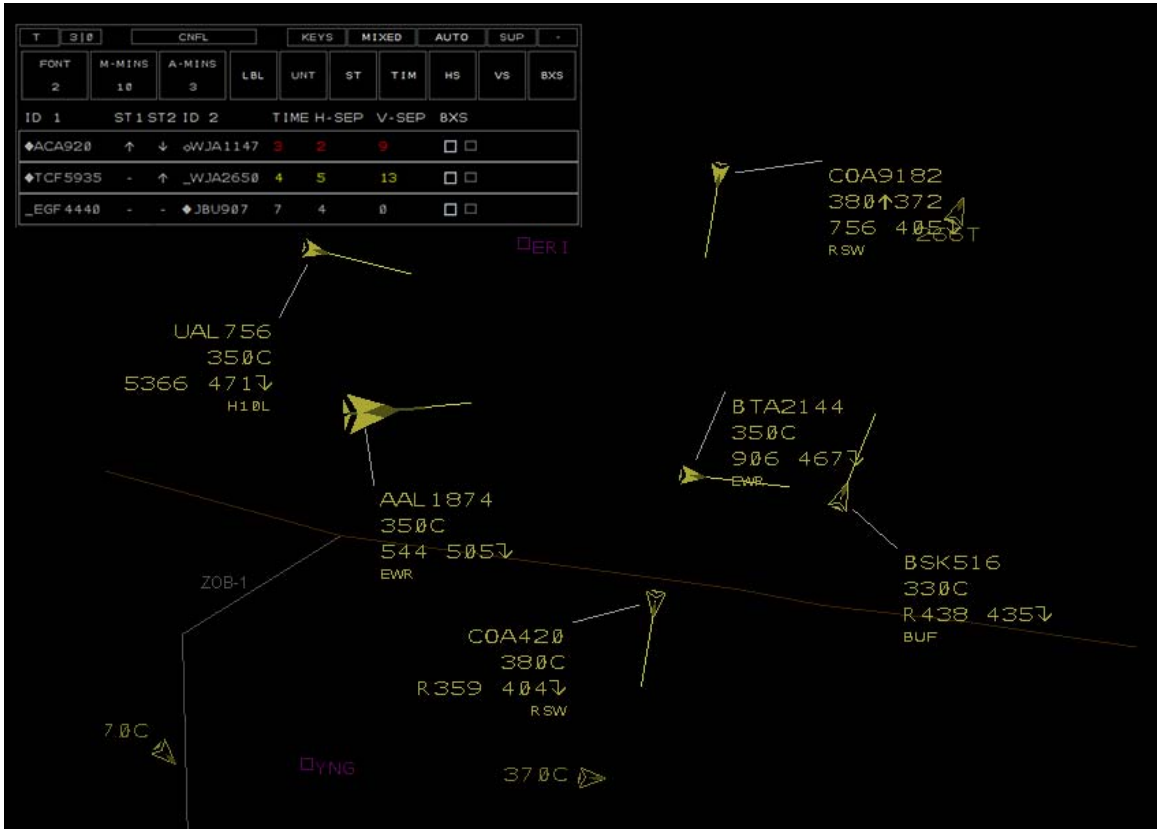
- Ground-Based Separation Assurance Concept
  - Expand performance beyond today's limits by introducing more automation
  - Allocate certain tasks to the automation:
    - Transferring ownership and communication frequency
    - Conflict detection and resolution (CD&R)
  - Enabling technologies:
    - Automatic Dependent Surveillance-Broadcast (ADS-B)
    - Data Comm
    - Flight Management Systems (FMS)
    - CD&R automation working at strategic and tactical time-horizons

Human-in-the-Loop Simulation

- Investigated four NextGen 'time-frames' that captured:
  - Roll-out of technological advancements
  - Increasing population of equipped aircraft
  - Increasing utilization of automation
  - Changes in the human-automation teaming

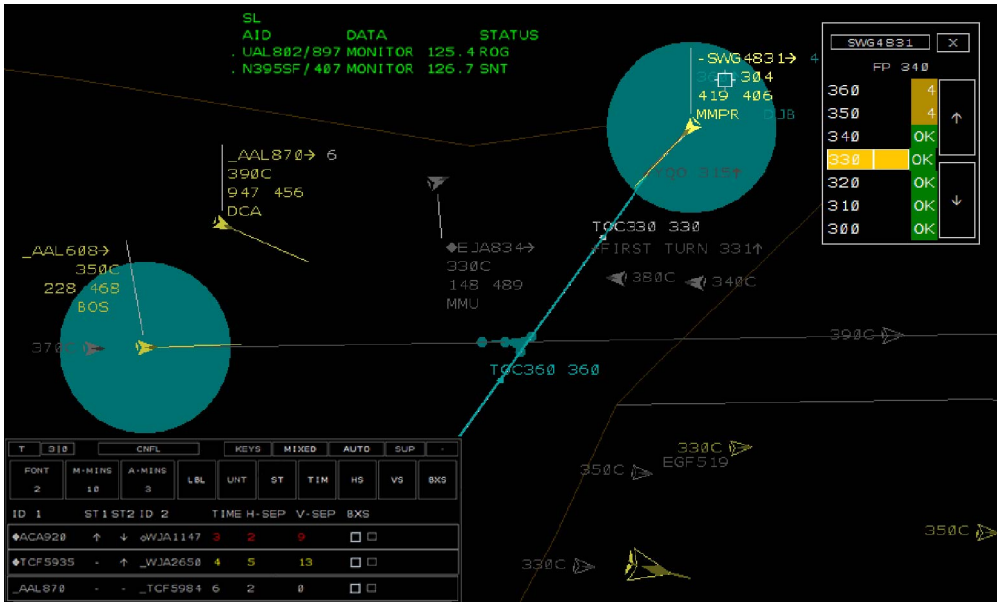
Human-in-the-Loop Simulation

- 'Current-Day' NextGen time-frame (baseline condition)
  - 100% ADS-B out
  - Position & state information
  - Directional target symbology
  - Conflict probe/list



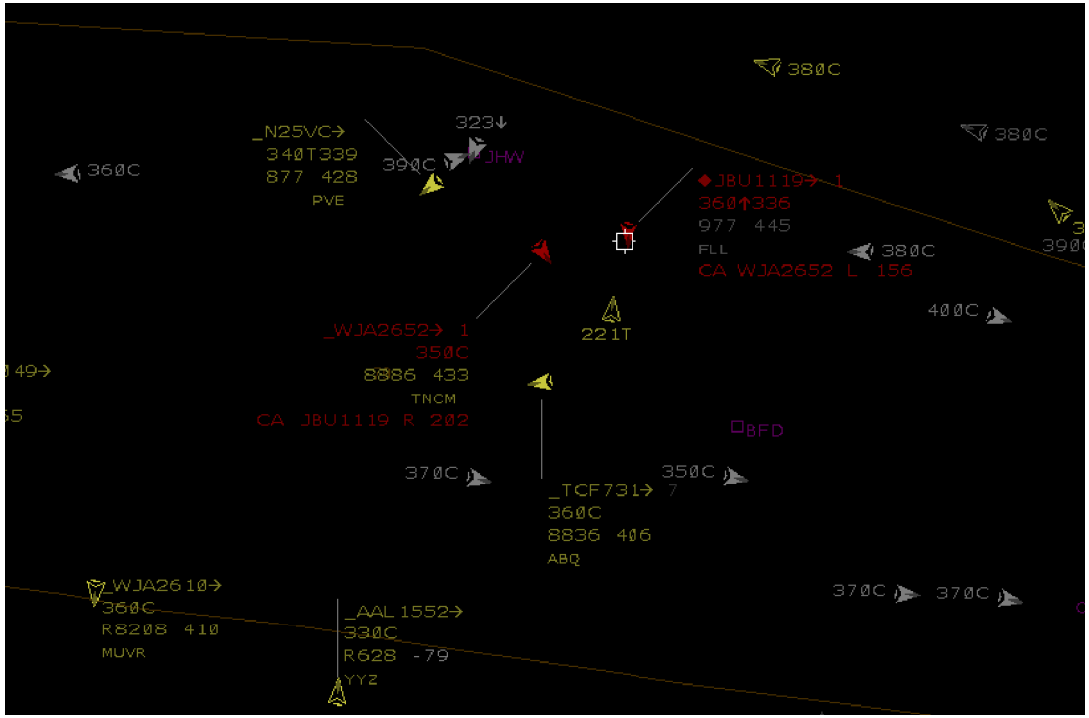
Human-in-the-Loop Simulation

- ‘Minimum’ NextGen time-frame
  - Trial-planning functions
  - Conflict probe integrated with trial-planner and datablock
  - 25% Data Comm equipped
    - Used only for transfer of communication
    - Auto hand-offs
    - Pre-cleared to follow FMS vertical profile
    - Color-coded data blocks, usually limited



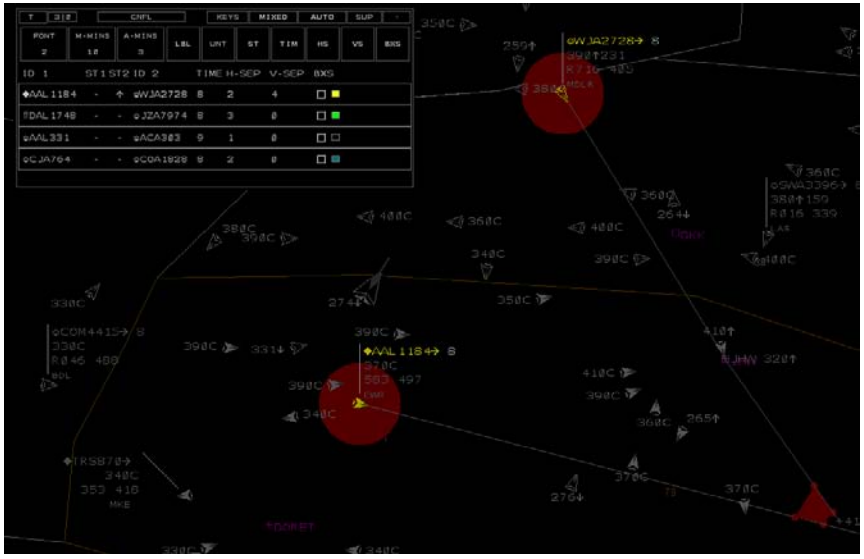
Human-in-the-Loop Simulation

- 'Moderate' NextGen time-frame
  - 50% Data Comm equipped
    - Data Comm expanded to include trajectory changes
  - Trial-planner enhanced with interactive auto-resolver
  - TSAFE advisories



Human-in-the-Loop Simulation

- 'Maximum' NextGen time-frame
  - 100% Data Comm equipped
  - New controller-automation teaming paradigm
    - Automation's role:
      - Conflict detection
      - LOS avoidance
      - Resolve strategic conflicts (*90, 60, 2200, 50)
      - Alerting controller to exceptional situations
    - Controller's role:
      - Supervise the automation
      - Address exceptional situations

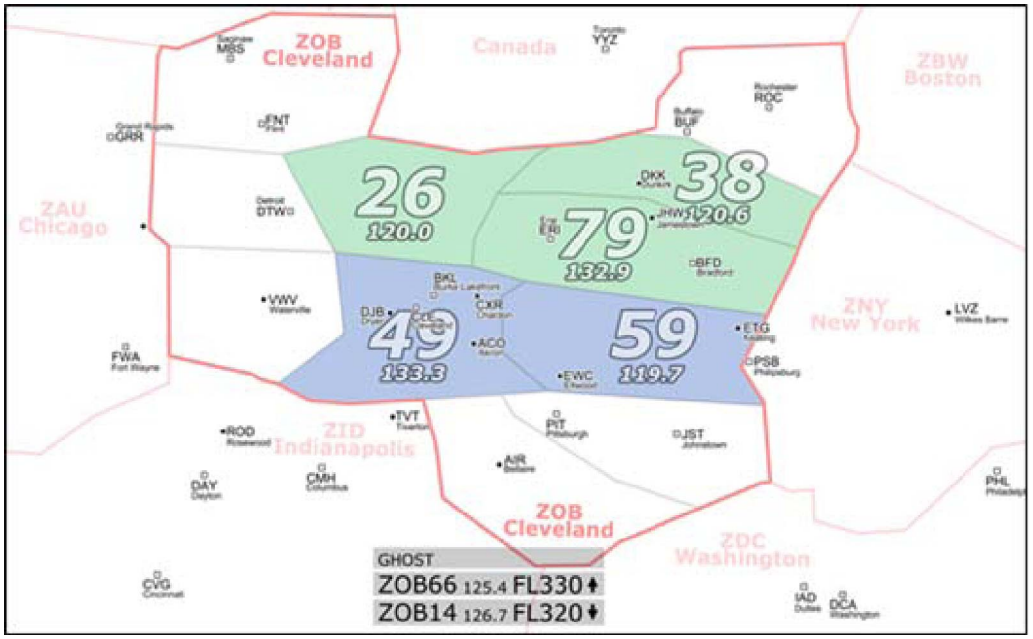


Human-in-the-Loop Simulation

- Traffic levels:

Current-Day	Minimum	Moderate	Maximum
1x	1.2x	1.5x	2x
18 a/c	22 a/c	27 a/c	36 a/c

- Participants:
  - Current FAA Front-Line Managers (FLMs) certified to work radar positions



Human-in-the-Loop Simulation

- Conducted in the Airspace Operations Laboratory, August 2012
  - Data gathered during 24, 40-minute runs:
    - Aircraft flight states
    - **Operator actions**
    - **Automation states**
    - Real-time subjective workload ratings (ATWIT)
    - Screen recordings
    - Post-run and post-simulation questionnaires
    - Debrief discussion

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data from the simulation

…from the test sectors

set of analyzed conflicts

…those with any logged actions

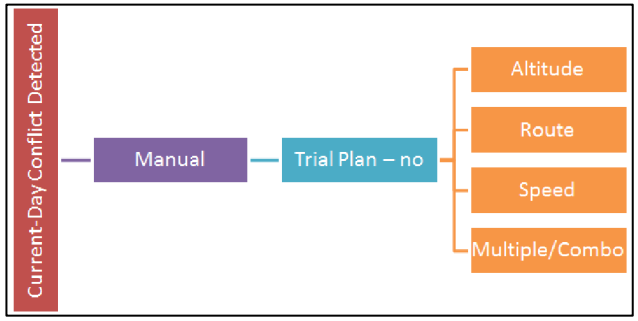
conflict-resolution actions

…those relevant to the conflict-resolution task

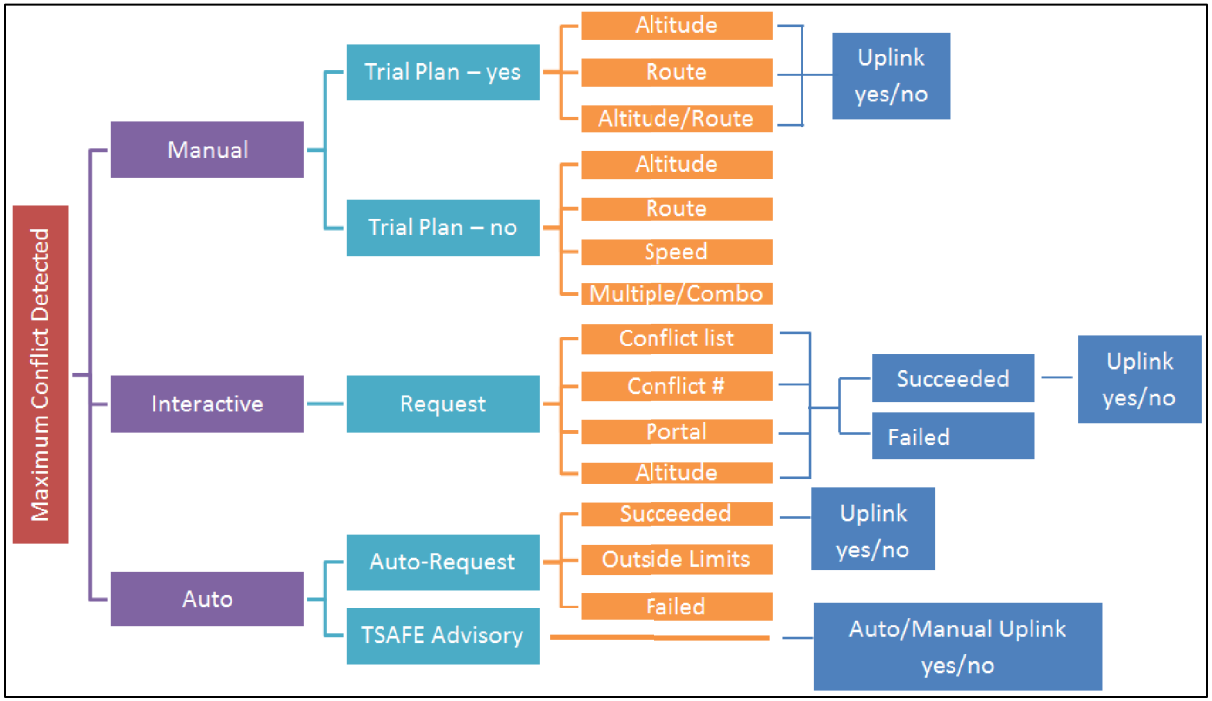
Current Investigation

- Categorization of conflict-resolution actions
  - ‘action trees’

baseline action tree



maximum action tree



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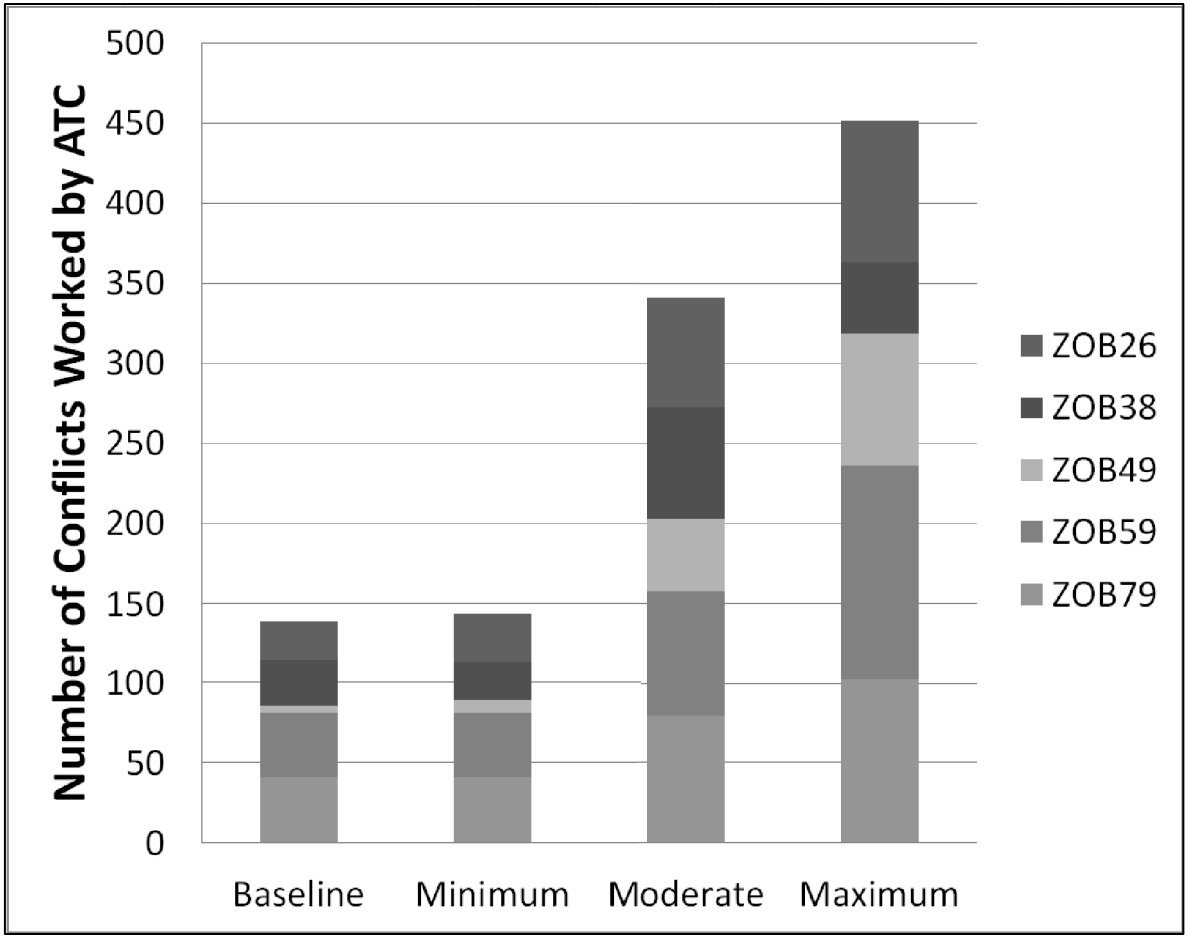
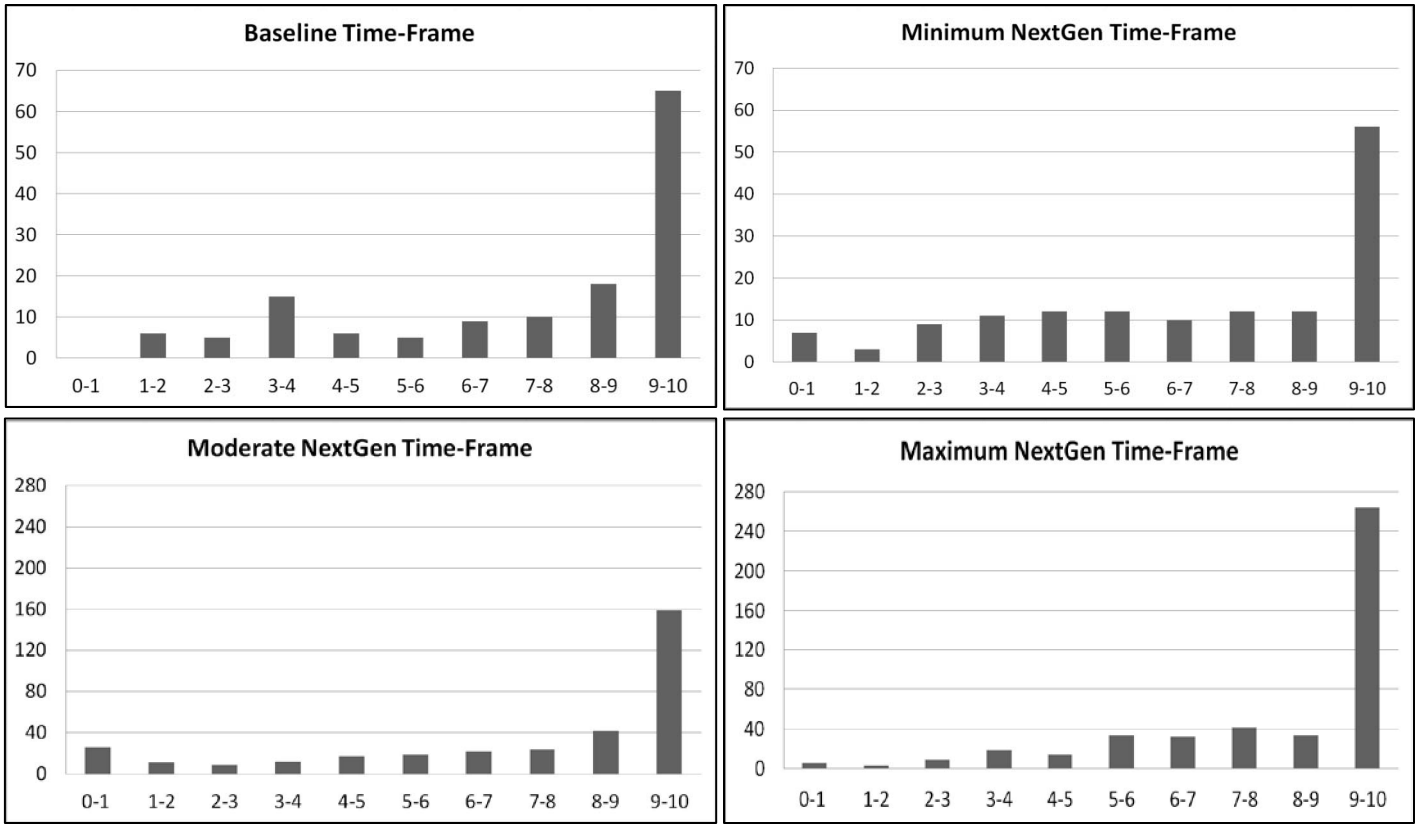
Results

- Set of analyzed conflicts
  - Counts



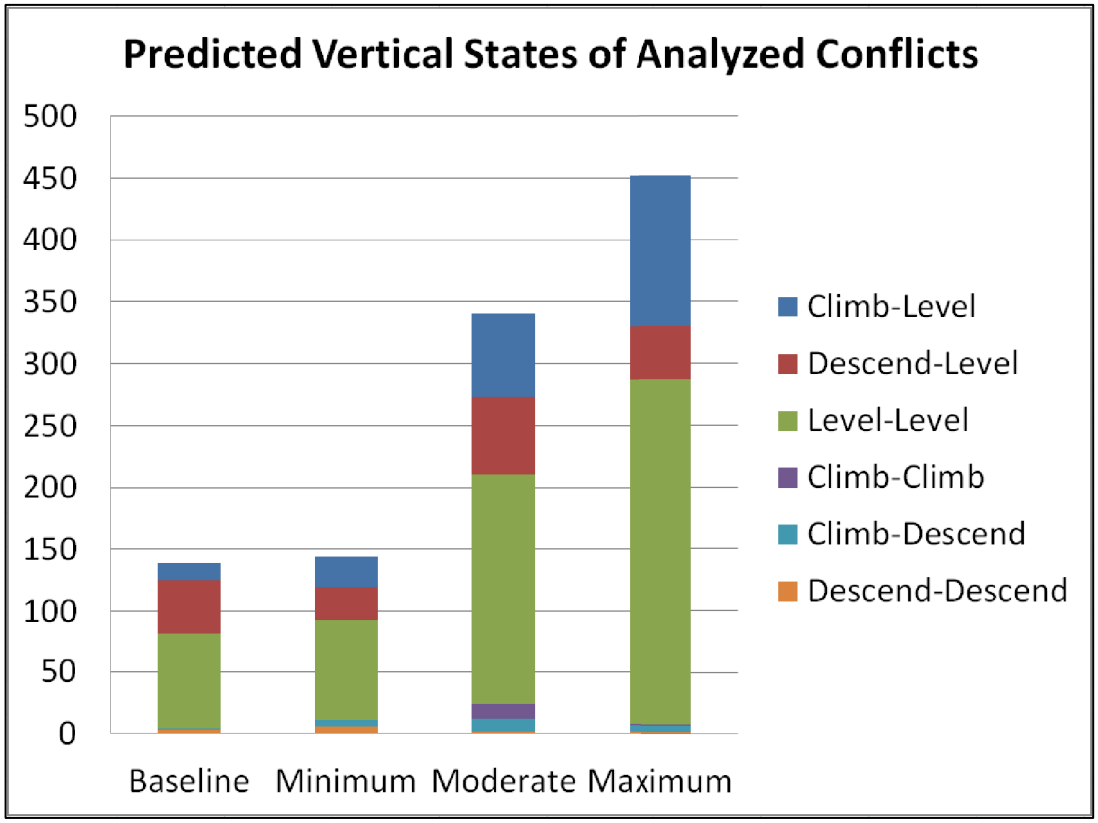
Results

- Set of analyzed conflicts
  - Time-to-go at time of first detection



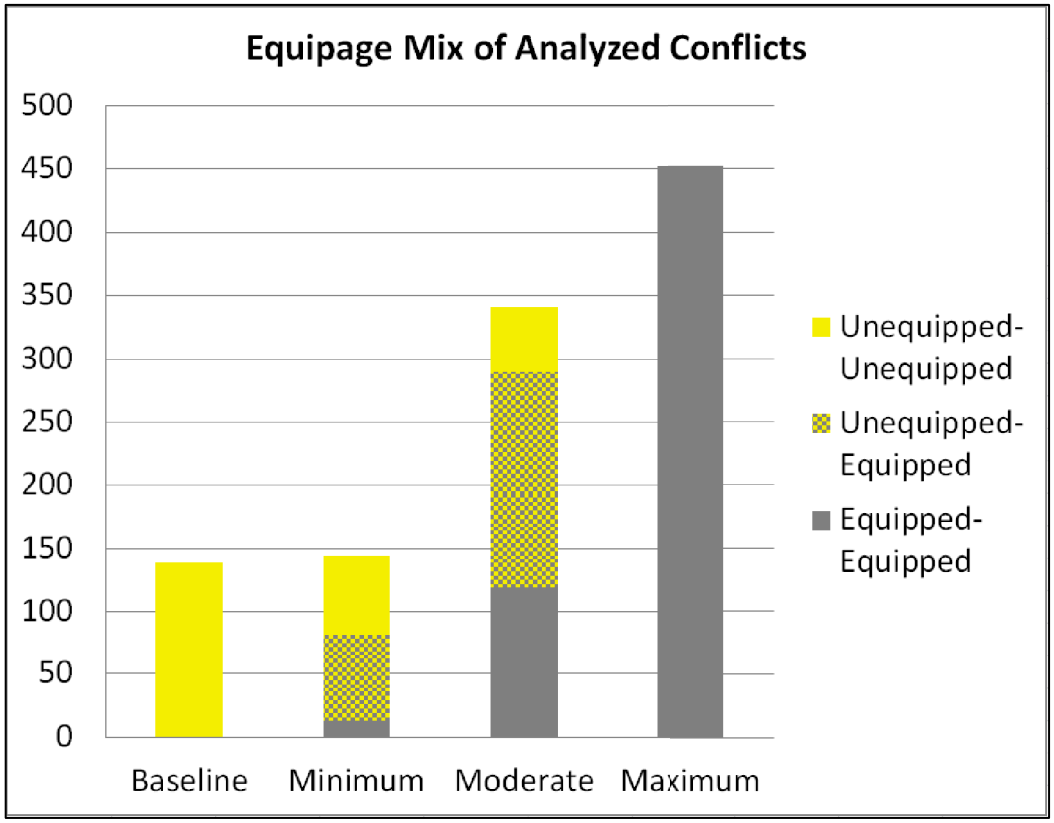
Results

- Set of analyzed conflicts
  - Predicted vertical-state pairings



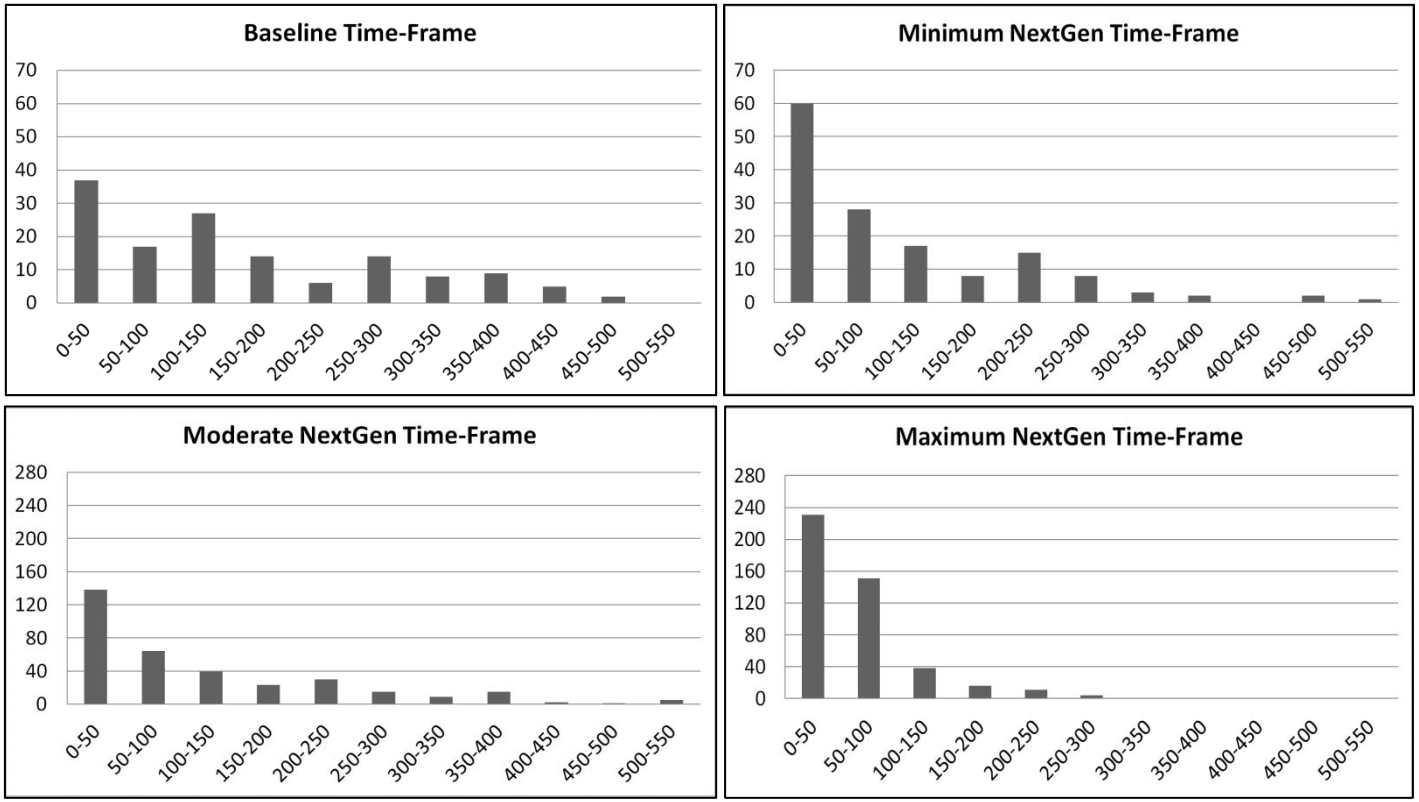
Results

- Set of analyzed conflicts
  - Aircraft-equipage pairings



Results

- Conflict-resolution actions
  - When did the response occur?



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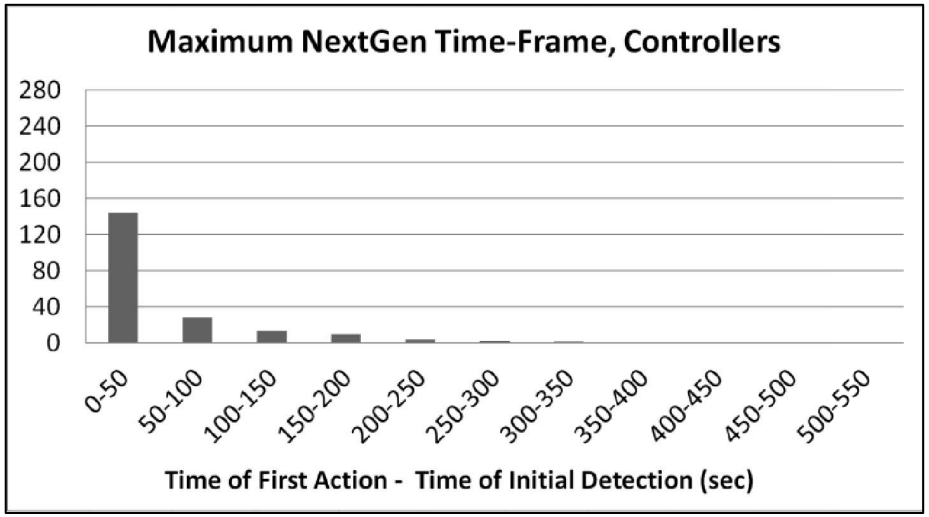

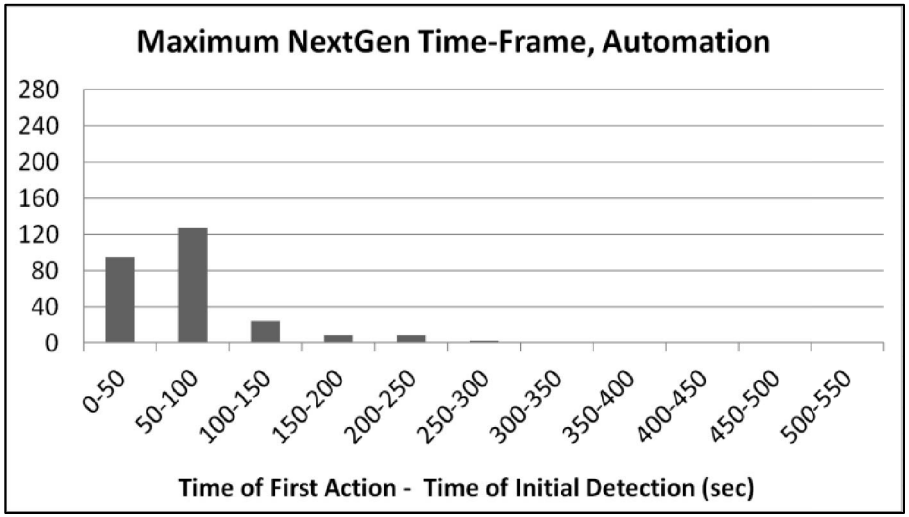

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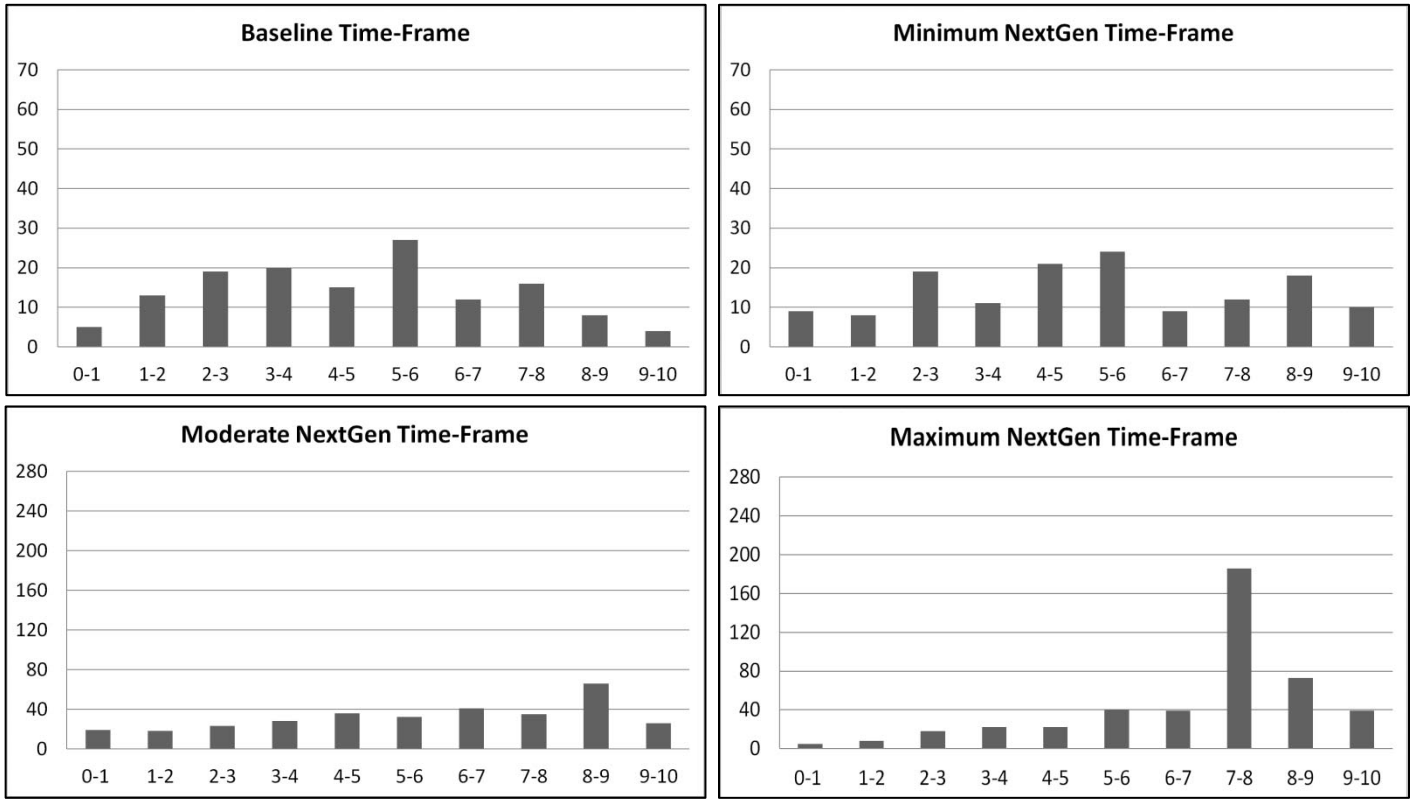

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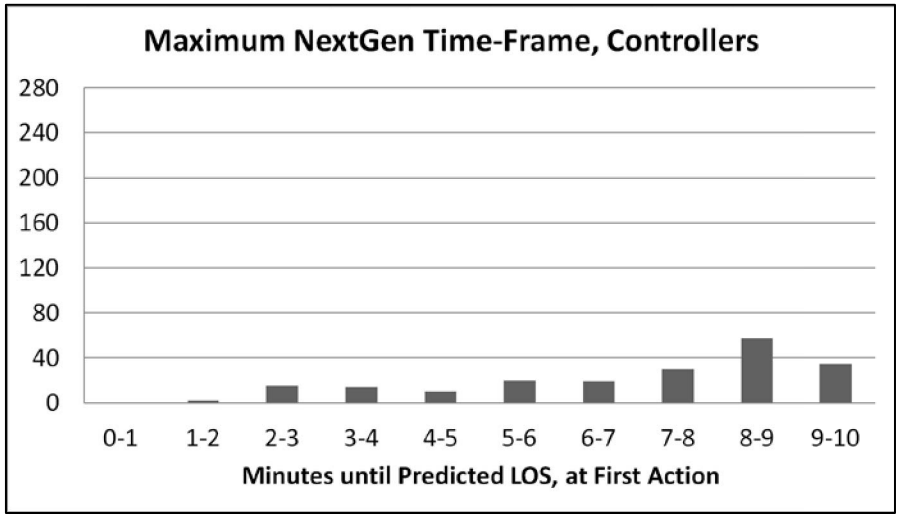
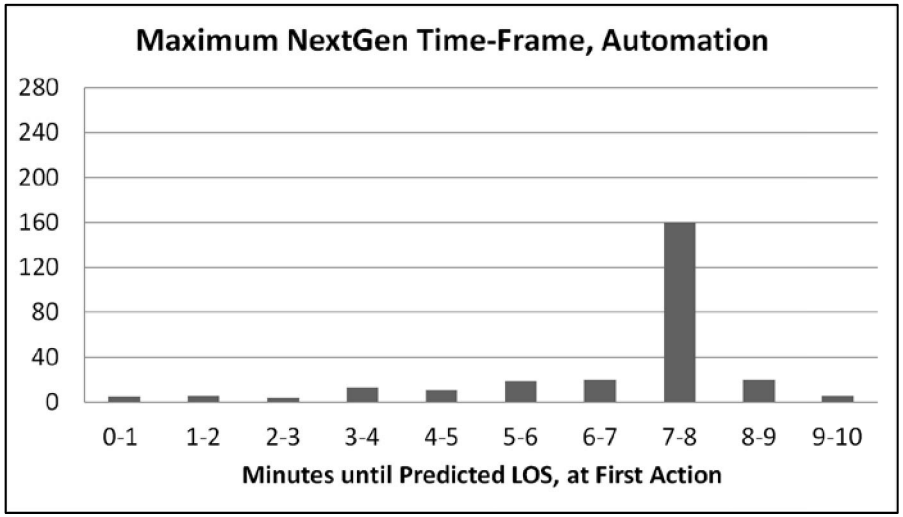
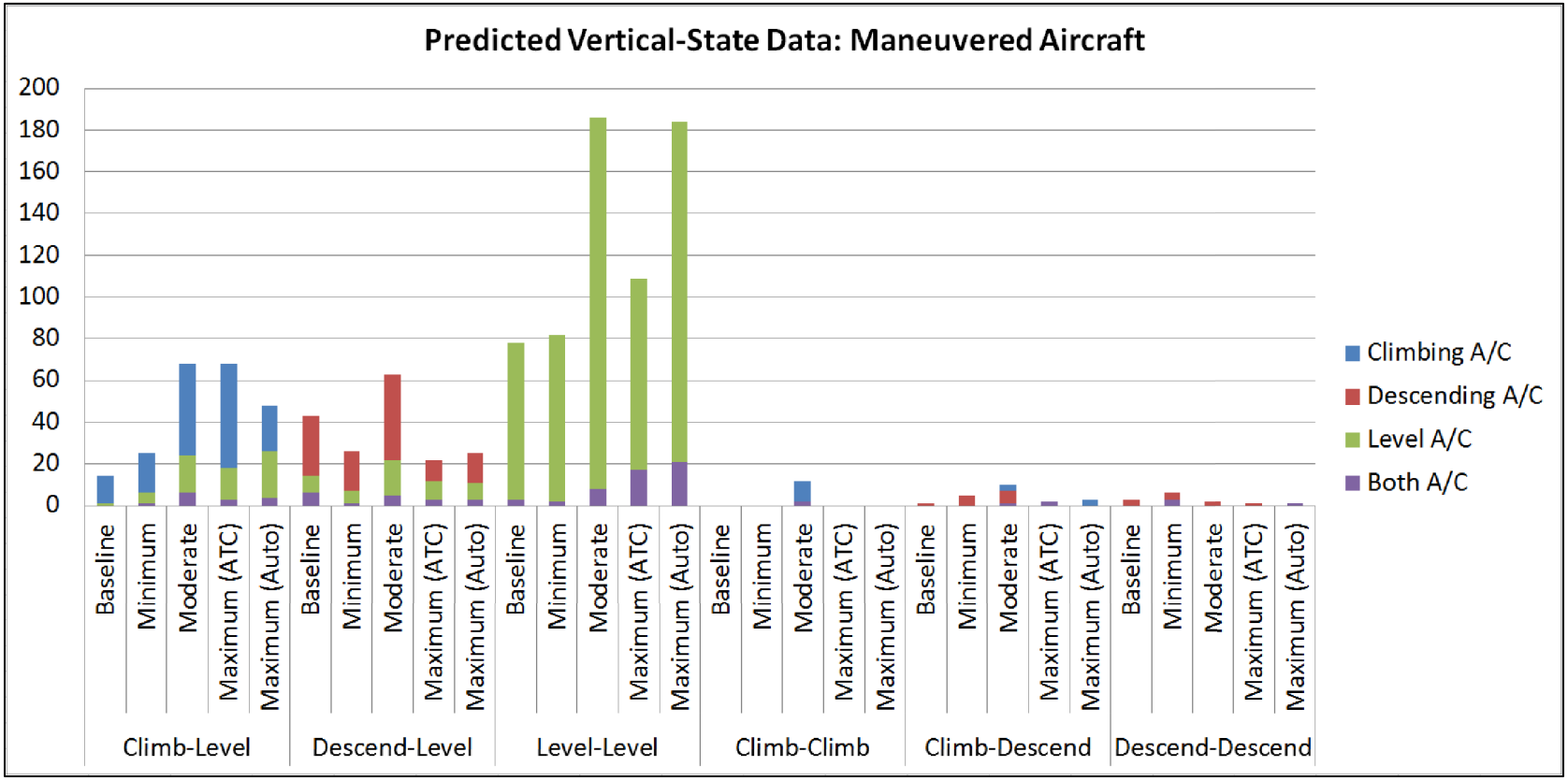




Results

- Conflict-resolution actions
  - Which aircraft resolved the conflict?



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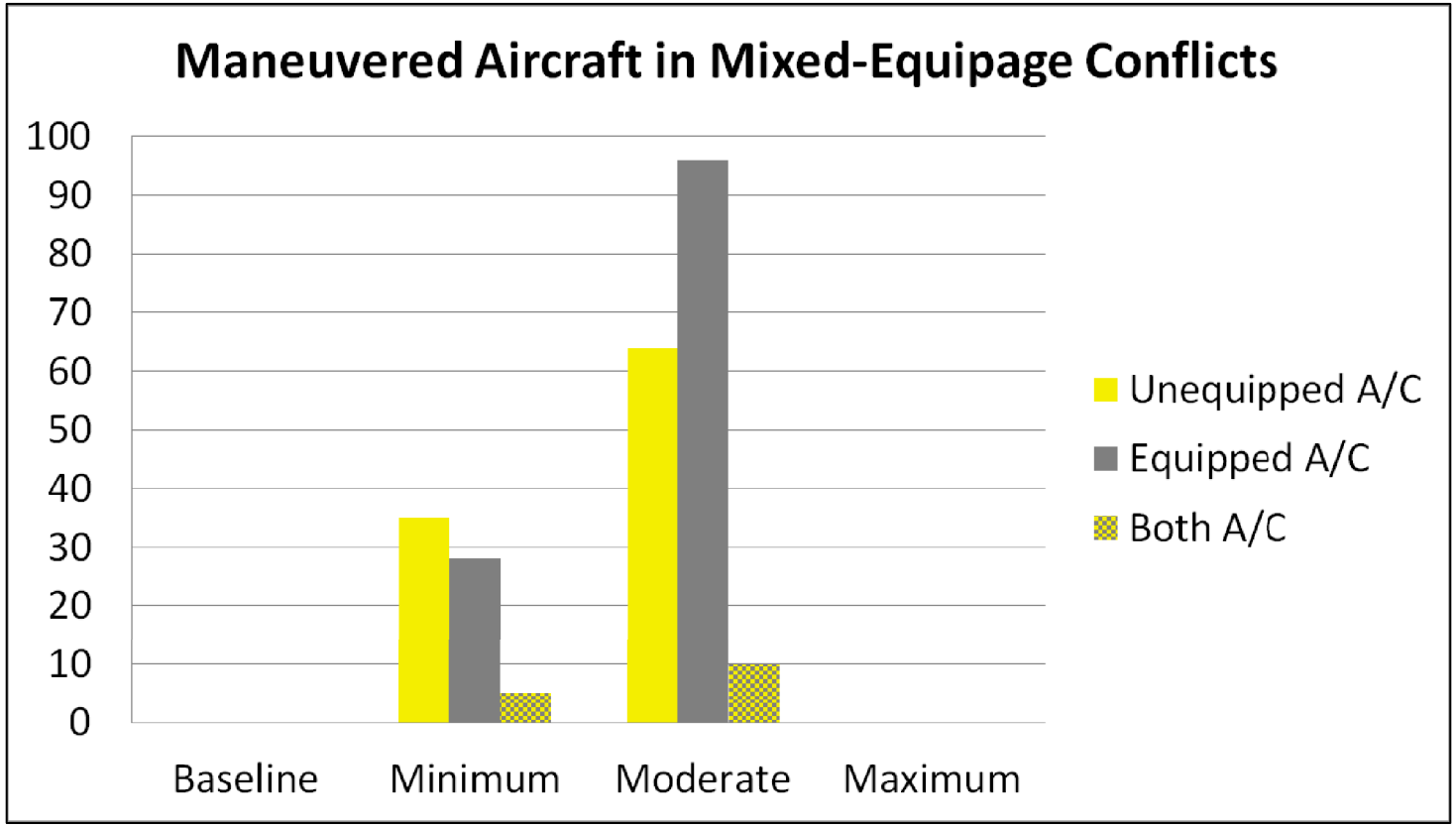
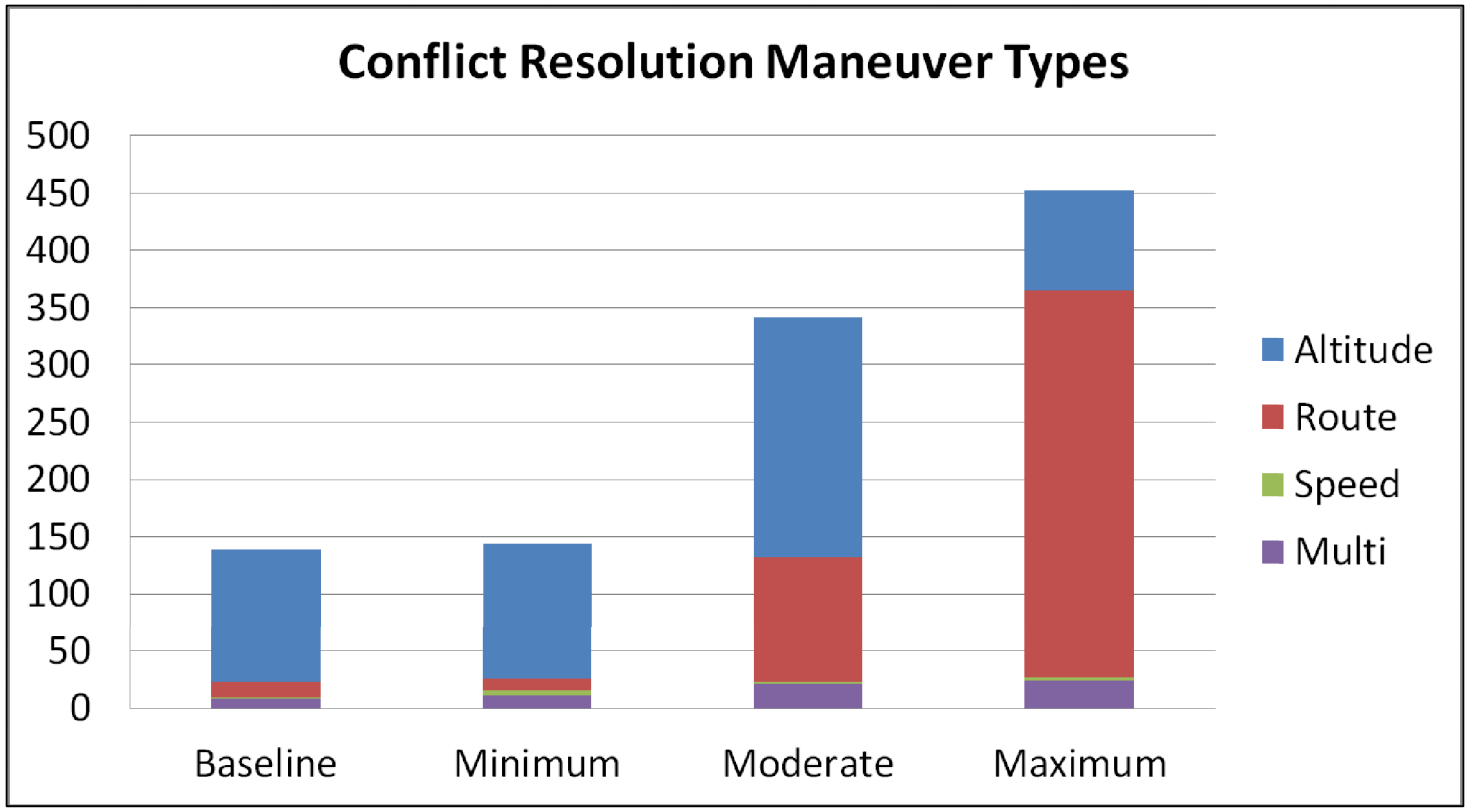


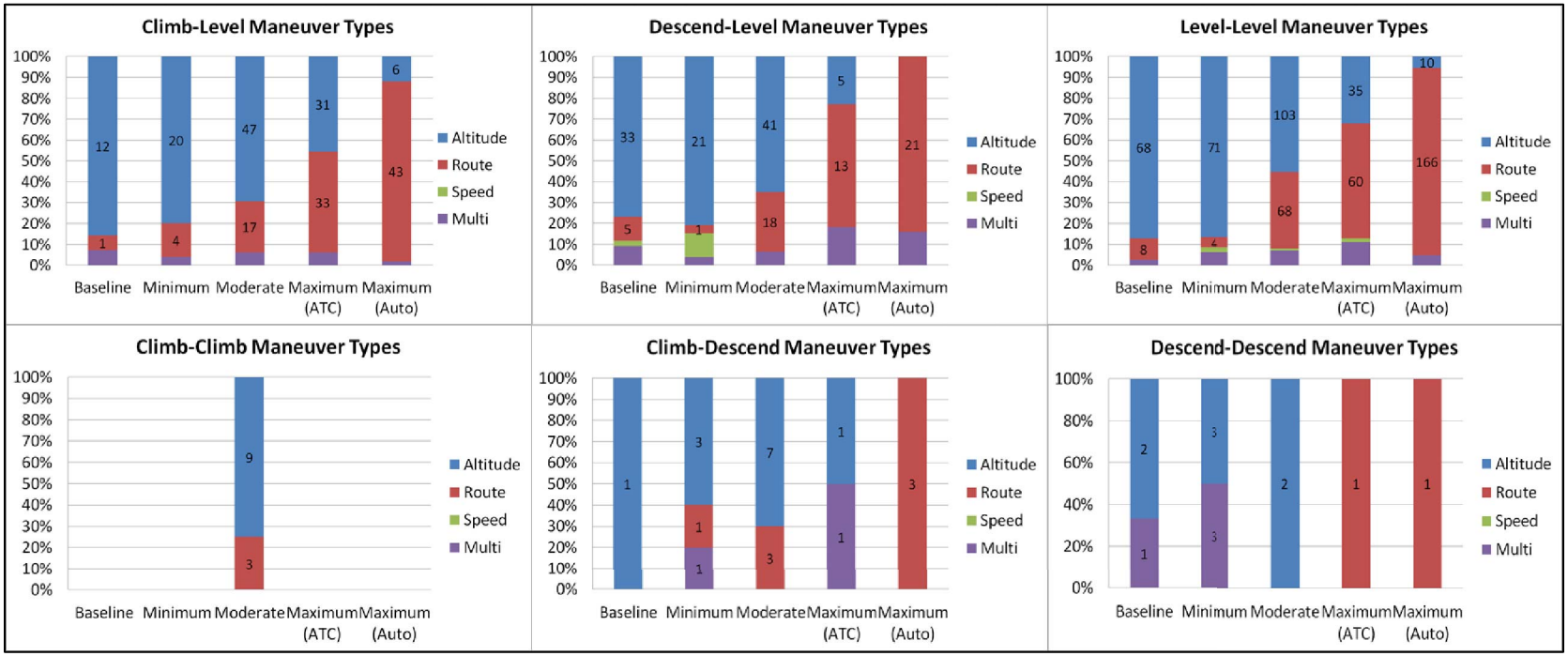
Results

- Conflict-resolution actions
  - Which type of maneuver resolved the conflict?



Results

- Conflict-resolution actions
  - Which type of maneuver resolved the conflict?
    - For each vertical-state pairing



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- Conflict-resolution actions
  - Which type of maneuver resolved the conflict?
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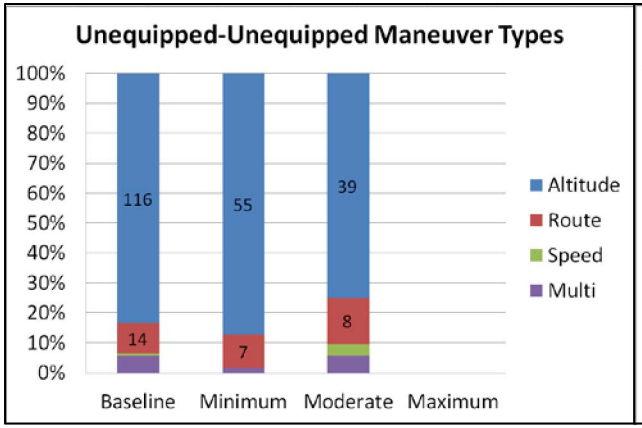

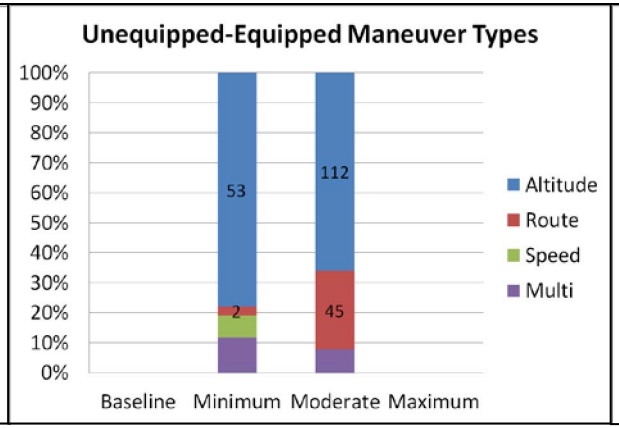

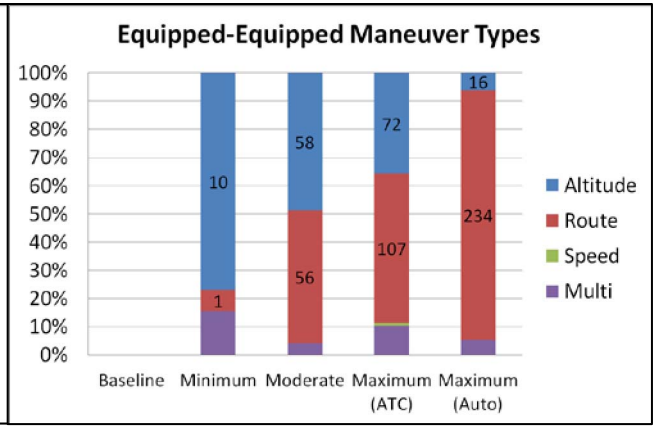

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- How did the controllers resolve the conflicts?
  - For conflicts involving transitioning aircraft, controllers more often maneuvered the transitioning aircraft
  - In NextGen time-frames where it was possible to send trajectory changes via Data Comm, the controllers more often maneuvered the equipped aircraft
- How did the automation resolve the conflicts?
  - As designed and configured…

Concluding Remarks

- How did the controllers work with the automation in resolving conflicts?
  - Differently, in two aspects:
    - Controllers' time of first action was earlier than the automation's
    - Controllers issued more altitude maneuvers than the automation

Concluding Remarks

- Next steps and future work:
  - Also analyze ‘the process’
  - Categorize actions through all possible combinations across all layers
  - Continue to improve our understanding of the conflict-resolution task, perhaps leading to…
    - More useful, better accepted decision-support tools
    - Automation whose logic uses ‘context-dependent’ criteria

QUESTIONS?

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EXTRAS

Human-in-the-Loop Simulation

- Equipment:
  - Multi-Aircraft Control System (MACS) platform
    - Display System Replacement (DSR) emulated workstation with fielded monitor and input devices
    - Pseudo-pilot stations
  - Eight Aircraft Simulation for Traffic Operations Research (ASTOR) flight decks
    - Air-Ground allocations of separation functions were also investigated, but not discussed in this paper
  - Voice Switching and Communications System (VSCS) emulation

Human-in-the-Loop Simulation

- Notes:
  - Conflict detection settings:
    - 10/5-minute look-ahead; < 5.9nmi, 1000’/1500’