Preliminary Investigation of Civil Tiltrotor in NextGen Airspace

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Rotorcraft in the Next Gen Airspace

• Demonstrate analytically that rotorcraft can be successfully integrated into Next Gen airspace
• Identify unique Next Gen technologies and concepts of operations that might be required to maximize safe, efficient, environmental responsive, and economic employment of rotorcraft in the Next Gen airspace
• Demonstrate with modern, accepted analysis/simulation tools that rotorcraft can be a potential solution to airport/airspace congestion
• Provide insights into rotorcraft-specific technology advances that will be required
Making Sure Rotorcraft Requirements are Factored into Next Gen Tech & CONOPS

• Primary emphasis of Next Gen implementation is, not unexpectedly, on subsonic fixed-wing jet aircraft

• It is vitally important to ensure that rotorcraft requirements are adequately factored into Next Gen technologies and concepts of operation

• Without proper attention to rotorcraft-specific technology and operational questions and issues the full potentiality of future rotorcraft systems might not be realized
NASA Airspace Systems’ NRA Effort

• Ongoing Airspace Systems-sponsored “Advanced Vehicles in Next Gen Airspace” study; in the final few months of an 18-month study effort by two contractor teams

• NASA provided Sensis-led NRA team 90-PAX LCTR2 reference design for airspace modeling effort‡

• But consensus within SRW is that NRA Effort needs to be expanded upon -- that led to the initiation of SRW-sponsored “Civil Tiltrotor (CTR) in Next Gen” study

"CTR in Next Gen" Study Tasks

Year 1
- Task 1: Identify CTR Attributes Using tiltrotor design tools
- Task 2: Develop CTR operational procedures and ConOps using high fidelity Manned simulator
  - Performance optimization
  - Year 1 report
    - CTR performance attributes
    - CTR fleet BADA database
    - CTR 4D Trajectories

Year 2
- Task 3: Identify CTR metrics in NextGen
- Task 4: NextGen system analysis tool survey
- Task 5: CTR system performance analysis and tradeoffs in NextGen using NAS system tools
  - Additional gaps
  - Year 2 report
    - CTR performance and tradeoffs in NextGen

Year 3
- Task 6: Safety and risk mitigation for CTR in NextGen
- Task 7: Disaster relief effectiveness evaluation for CTR in NextGen
- Task 8: Identify future research and critical topics
  - Report #1
  - Report #2
  - Report #3
Not One, but a Family of Vehicles Being Studied

• CTR airspace simulations will be based on a fleet of 10-, 30-, 90-, and 120-PAX vehicles
• 10- and 30-PAX vehicle design heritage based, in part, on BA-609 and V-22
• 90- and 120-PAX vehicles will be clean-sheet conceptual designs based on Bell Helicopter technology projections for IOP’s of 2020.
• Additionally, both VTOL and STOL takeoff and landing profiles will be incorporated in the pilot-in-the-loop and airspace simulations
• Bell PRESTO sizing analysis used for vehicles
Progress to Date

- Nine months into Year 2 effort
- Design requirements for family of CTR vehicles agreed to by team
- Conceptual designs completed for 10-, 30-, and 120-PAX vehicles
- Demand modeling and informal team assessments established a baseline fleet size for vehicles for 2025 time frame
- Given design data, BADA models are developed
- Pilot-in-the-loop simulations completed
- Coupled ACES/AvTerminal airspace simulations have begun
### General Conceptual Design Requirements

<table>
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<th>10</th>
<th>30</th>
<th>90</th>
<th>120</th>
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<tbody>
<tr>
<td><strong>Number of Pax</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Takeoff Condition</strong></td>
<td>5k/Hot</td>
<td>--&gt;</td>
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<td><strong>Takeoff Procedure (1)</strong></td>
<td>VTOL</td>
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<td>Helo</td>
<td>Helo</td>
<td>Helo</td>
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<td><strong>Payload, lbs</strong></td>
<td>2200</td>
<td>6600</td>
<td>19800</td>
<td>26400</td>
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<td><strong>Design Range, nm</strong></td>
<td>800 (2)</td>
<td>1000 (2)</td>
<td>1000</td>
<td>1200</td>
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<td><strong>Cruise Altitude, 1000 ft</strong></td>
<td>25</td>
<td>25</td>
<td>30 (2)</td>
<td>27.5</td>
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<tr>
<td><strong>Cruise Speed, ktas</strong></td>
<td>Fallout</td>
<td>Fallout</td>
<td>300 (2)</td>
<td>345</td>
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</table>

(1) VTOL is assumed to be a Cat A procedure and is a target for 10 and 30-pax designs
(2) Target
30-Pax CTR Conceptual Design

BL 0.0
BL 275.00
ICDS CL
6 deg forward sweep

457.00 dia
95.0 dia

152.36
119.536
417.000
859.164

739.628
16 deg

412x253
397x239
498x243
663x252
748x238
881x252
242x126
412x253
397x239
498x243
663x252
748x238
881x252
30-Pax CTR Cont.

34 x 72 Aft Entry Door

34 x 72 Fwd Entry Door

This seat only on aft row at aft bhd

Lavatory

70.0 Cabin Height

21.50 Floor

72.0 Floor

95.0

88.0

21.0

21.0

21.0

91.50 cockpit

352.0 cabin length
120-PAX CTR Conceptual Design

850.10 Dia

BL 0.0

6 deg fwd sweep

BL 590.40

FS 988.12

FS 421.09

WL 269.37

WL 64.0

156.0

FS 1763.73
120-Pax CTR Cont.

- 34 x 72 Aft Entry Door
- 34 x 72 Service Door
- 20 x 38 Emergency Exit (2)
- 34 x 72 Fwd Entry Door
- 21 width x 32 pitch seats
- Lavatory
- Stowage
- Fwd Galley
- Closet
- 74.0 cockpit
- First Class
- 28 width x 38 pitch seats
- 941.0 cabin floor
- Aft Pressure Bhd
- Aft Galley
- Lavatory
- 149.0
- 90 in plus cabin
- 21.0 seats
- 20.0 aisle
- 36 in floor
Pilot-in-the-Loop Simulations

- Pilot-in-the-loop simulations were performed at Bell Helicopter
- Because of simulator logistics reasons terminal area simulations were at Miami airport (MIA)
- ACES airspace simulations, though, will focus primarily on Northeast Corridor
- Pilot-in-the-loop simulations tested applicable terminal area CONOPS
- Additionally, Bell simulator data was used to validate BADA/ACES models
Fixed-Base Simulator used in PITL Sim
Coupled ACES/AvTerminal Simulations

- During Year 2 effort, CTR BADA models was transformed to ACES models
- ACES is a well-known NASA-developed airspace simulation tool
- AvTerminal is a Sensis-developed terminal area tool
- Airspace simulations are being used to assess impact of CTR fleet to increase capacity/throughput of congested airports in 2025 time frame
- Study primary focus will be on Northeast Corridor
- CTR fleet size for 2025 was based in part on demand modeling and informal team assessments
Northeast Corridor Nine Airport Network
“Productivity Index” to refine Flight Profiles

![Productivity Index Chart]

Productivity Index (NM/Hr)

<table>
<thead>
<tr>
<th>120-pax</th>
<th>90-pax</th>
<th>30-pax</th>
<th>10-pax</th>
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<tr>
<td>BOS-PIT</td>
<td>430 NM</td>
<td>BOS-DCA</td>
<td>346 NM</td>
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<td>BOS-PHL</td>
<td>237 NM</td>
<td>PHL-IAD</td>
<td>117 NM</td>
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<td>PHL-BWI</td>
<td>78 NM</td>
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CTR in NextGen - 17
CTR Fleet Noise and Emissions Modeling

- **BADA**
  - Performance & Profiles
  - Connects to **ACES**
  - Input: Enroute track data
- **ACES**
  - Connects to **AvTerminal**
  - Connects to **AEDT**
  - Output: Fuel burn, noise and emissions
  - Input: Tracks
  - Connects to **AvTerminal**
  - Output: Excess/transit time terminal area trajectory and track data

Diagram visualizes the flow of data and processes involved in CTR Fleet Noise and Emissions Modeling.
Future Plans -- CTR Public Service/Disaster Relief Modeling

- Public service missions are a singular and key aspect of rotorcraft; CTR will be no different
- During Year 3 effort, specialized simulation tools will be used to assess utility of CTR fleet for disaster relief missions
- Prototypical scenario to consider is a hurricane relief effort
- One possibility to consider in analysis is a CRAF-like (Civil Reserve Air Fleet) CTR civilian fleet response to disaster scenario
Concluding Remarks

- A challenging but valuable exercise so far

- SRW-sponsored “CTR in Next Gen Airspace” study significantly leverages off Airspace Systems Program “Advanced Vehicles in Next Gen” NRA Studies

- Already gaining considerable insights from CTR conceptual design and pilot-in-the-loop sim efforts

- Coupled ACES/AvTerminal airspace simulations have begun
Questions?