Improving Sequencing and Separation at a SATS Airport Including Human Factors Considerations

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Overview

1. Current Air Traffic Situation
   1. Non-radar approach operations
2. Small Aircraft Transportation System (SATS)
   1. Overview of Self-Controlled Area (SCA) Operations
   2. Current Concept of Operations
3. Tools Used for Testing of Procedures
   1. Test Scenario
4. Problems with Current Concepts
5. Proposed Solutions
   1. Test Results
6. Summary and Conclusions
7. Further Research
Current Air Traffic Situation

1. Air traffic is on a continual rise
2. The current Air Traffic Control (ATC) system is already over capacity
   - Bottlenecks are resulting in costly delays
   - Passengers are inconvenienced by late flights
3. Capacity must be increased
   - Increase capacity at current commercial airports
   - Limited by safety considerations
   - Build new airports
   - Cost is prohibitively high
   - Land in prime locations is scarce
4. Utilize existing small airports?
Underutilized Airports and Airspace ...

... an Opportunity for Increasing Mobility

Of 5,400 public-use airports, only 715 (13%) have precision instrument approaches (ILS).

Near all-weather accessibility to 5,400 public-use airports?

- 22% within 30 minutes of major/hub airport
- 41% within 30 minutes of any commercial airport
- 93% of population within 30 minutes of SATS-type airport

Airports today with “near all weather” availability

Expanded Accessibility to several times more destinations

5400 Public Use Airports

IFR Airports
VFR Airports
VFR Landing Facilities (including heliports)
Current Non-Radar Airport Operations

7. Visual Flight Rules (VFR)
   7. Pilots maintain visual separation from other aircraft

7. Instrument Flight Rules (IFR)
   7. Radar separation maintained while in “controlled” airspace
   7. “Procedural separation” is used in the non-radar airport environment
      7. Only one aircraft allowed at a time
      7. Other aircraft must hold until the preceding aircraft has landed

7. Problems with current system
   7. IFR holding times can be very high
   7. IFR operation volume is very limited
Small Aircraft Transportation System (SATS)

7. SATS High Volume Operations (HVO)
   7. Allow simultaneous operations by multiple aircraft in non-radar airspace surrounding non-towered airports in IFR conditions

7. Logistical considerations
   7. ATC workload must not be significantly increased
   7. Pilot workload must be kept to a minimum
      7. Overstressed pilots are more prone to make mistakes

7. Self-Controlled Area (SCA)
   7. Allows safe operation of multiple aircraft in a non-radar environment in IFR conditions
Overview of SCA Operations

- ATC Clears Aircraft to SCA Holding Stack at IAF.
- Approach Sequencing and Airport Info. via AMM.

**ATC:** FAA Air Traffic Control.

**IAF & FAF:** Initial- and Final-Approach Fixes.

**ADS-B:** Automatic Dependent Surveillance Broadcast (Radar Xpndr.)

**AMM:** Airport Management Module (Digital Data-Link)
Based on instrument approach "GPS RWY 17L for KCNW"
Center: LEROI
Radius: 10nm
Height: 3000ft (AGL)
Current Concept of Operations

7. Aircraft are sequenced on a first come, first served basis
   7. Pilot contacts AMM when within 5 nm plus 5 min.
   7. AMM responds with follow notification and entry type (lateral or vertical)
      7. Lateral Entry – Aircraft may enter SCA at lowest available altitude
      7. Vertical Entry – Aircraft must hold above SCA then descend in
7. Once in the SCA, pilots must maintain separation
   7. Other aircraft positions are shown on a moving map display
   7. Pilot must maintain 5 nm of spacing throughout approach
Tools Used for Testing of Procedures

7. TAMU Real Time Flight Simulator

7. Pilot Stations
   7. Allow three additional pilots to participate in simulations
   7. Total of four pilots in real time simulation environment

7. Agent Aircraft
   7. Rules based logic
   7. Able to simulate different types of aircraft
Test Scenario (Ideal Agents Case)

7. Four aircraft used with varying speeds
   7. Commander 700 (TAMU Real Time Flight Simulator)
   7. Cessna 172, Mooney 201, Piper Cub (Agent Aircraft)

<table>
<thead>
<tr>
<th>Aircraft Type</th>
<th>Cruise Speed (kts)</th>
<th>Distance to IAF (nm)</th>
<th>Intended IAF</th>
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</thead>
<tbody>
<tr>
<td>Mooney 201</td>
<td>180</td>
<td>20</td>
<td>RAZVY</td>
</tr>
<tr>
<td>Cessna 172</td>
<td>125</td>
<td>22</td>
<td>RAZVY</td>
</tr>
<tr>
<td>Commander 700</td>
<td>150</td>
<td>20</td>
<td>LOUIE</td>
</tr>
<tr>
<td>Piper Cub</td>
<td>75</td>
<td>16</td>
<td>LOUIE</td>
</tr>
</tbody>
</table>
Initial Setup
Aircraft Converging on Approach
Two Aircraft on Approach
Three Aircraft on Approach

INITIAL APPROACH

SCA Approach Request Sent To ATC
N78SAE cleared to the LOUIE fix, maintain 5000. Hold reaching the LOUIE fix.
N78SAE, hold the LOUIE fix and descend to 4000.

CENTR/DECNTR
Leading Request Sent To AAM

AAM Lateral Entry: Following H5000L, Miss Approach Holding Fix LOUIE.

DECLTR

Scale: 15 NM

ZOOM OUT

ZOOM IN

EMERG

Traffic (1) LERO1 114.3
2.3 NM ETA: 0800:00
NEXT (2) TITAN
174° 7.5 NM
Issues With Current Concepts

Issue

7. First come, first served sequencing
   7. First aircraft to contact may be farther from the fix
   7. Faster aircraft may contact later because of distance but arrive first

Solution

7. Delay sequencing of aircraft
   7. Wait until aircraft are within 5 nm of their IAF before assigning entry or follow notification
Issues With Current Concepts (cont.)

**Issue**

7. Maintaining separation within the SCA
   7. 5 nm separation may be excessive if preceding aircraft is faster

**Solution**

7. Change spacing minimums
   7. 2 nm of separation throughout approach
   7. 2 min. separation of arrival at runway
      7. Allows preceding aircraft to stop and clear runway
Issues With Current Concepts (cont.)

Issue

7. Maintaining separation within the SCA
   7. Pilot must make calculations to maintain separation
      7. Calculations are difficult if aircraft are of different speeds
      7. Pilot may make math errors
      7. Pilot workload is increased, increasing chance of accidents

Solution

7. Use avionics to assist the pilot in spacing decisions
   7. Avionics calculate speed difference with information from ADS-B messages
   7. Calculates when the approach may be initialized to maintain spacing throughout approach
   7. Alerts pilot to begin approach
Test Results

7. Same test scenario run with old and new rules
7. Total Holding Time (THT) used to quantitatively measure efficiency

<table>
<thead>
<tr>
<th></th>
<th>THT (min)</th>
<th>THT Savings (min)</th>
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<tbody>
<tr>
<td>Original SATS Sequencing and Spacing</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Improved Sequencing Into the SCA</td>
<td>23</td>
<td>15</td>
</tr>
<tr>
<td>Improved Sequencing and Approach Spacing</td>
<td>12</td>
<td>26</td>
</tr>
</tbody>
</table>

7. Pilot workload noticeably reduced although difficult to quantify at early stage
Summary and Conclusions

7. Started with concept for SATS-HVO airport created to handle large volumes of traffic at non-radar, non-towered airports

7. Improved sequencing into the SCA
   7. THT reduced by 15 min.

7. Spacing calculations shifted from pilot to avionics and spacing requirements improved
   7. THT reduced by an additional 11 min. for total 26 min. THT reduction
   7. Pilot workload noticeably reduced
Further Research

7. Formal Pilot Workload study
   7. Human factors analysis of different procedures and displays
7. Introduction of dynamic spacing
   7. Spacing scenarios are continuously updated throughout the approach
7. Avionics will suggest speed changes as necessary