Analysis of Multi-Sector Planner Concepts in U.S. Airspace

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Sponsorship: Richard Jehlen, Diana Liang, Steve Bradford (ATOP)
Agenda

- STATEMENT OF RESEARCH INTEREST
  - PRIOR RESEARCH
  - CURRENT FOCUS
- EXPERIMENTAL DESIGN
  - ROLES & RESPONSIBILITIES FOR OPCON
  - TOOLS & EQUIPMENT FOR OPCON
  - AIRSPACE STRUCTURE
  - EXPERIMENTAL MANIPULATIONS
- RESULTS
  - EFFICIENCY & EFFECTIVENESS
  - COMMUNICATIONS
  - WORKLOAD
- DISCUSSION
- CONCLUSIONS & FUTURE DIRECTIONS
Statement of Research Interest

- Opportunity for re-assessment of En Route organizational and functional configurations based on:
  - Digital data communication among all operators
  - Improved positioning accuracy for flight operations,
  - System-wide information management
  - Medium-term conflict prediction
  - Predictive sector complexity assessment

- Opportunity to leverage prior work in Multi-Sector Operations

- Motivation to explore flexible staffing configurations

- Motivation to examine co-location and workstation layout requirements
En Route Control Reconfiguration: Multi-Sector Planner Operations: Prior Research

- Mitre-CASSD En Route efficiency: Celio, et al. (2005)
- SJSU: Cognitive Task Analysis Corker et al. (2005)

Summary:
- Two distinct operational roles for the MSP emerge (Multi-D & Area Flow)
- No conclusive or comparative data for which of these two are better and under what airspace management context
Examine feasibility of MSP operations in US Airspace operations with prior research as a starting point

Explore the range of MSP functions and efficiencies that can be gained
- MSP supporting several Radar controllers by performing an expanded set of functions as a Data (or radar associate) controller “Multi-D”
- MSP supporting MSP area-wide operations by interacting with adjacent MSP and managing traffic flows. “Area-Flow Controller”

Explore decision-support tool requirements for each operational requirement
Cognitive Systems Engineering Approach

- Analyses of prior MSP and En Route staffing modifications
- Cognitive walkthrough with controllers and supervisors on range of MSP functional options
- Medium fidelity simulation (NASA Ames) to test function allocation and simulation
- High fidelity full mission simulation
MSP Roles and Responsibilities

Multi-D

- Monitor Multi-sector status for conflict detection
- Coordinate with R sides to ensure effective actions, including handouts and point outs
- Prioritize conflicts for medium term or multi-sector evaluation
- Coordinate solutions with adjacent Multi-Ds and TMUs as needed
- Modify trajectories for conflicts, weather, and congestion
- Resolve medium term or multi-sector conflicts
- Ensure routing separations, impact of traffic and complexity levels
- Coordinate with R sides to ensure effective actions
- Manage traffic flow
- House keeping

Area Flow

- Monitor multi-sector status and traffic flow
- Coordinate with adjacent Area Flow to anticipate traffic flow requirements
- Plan and develop traffic flow
- Develop multi-sector traffic and airport initiatives with TMU’s and R-sides
- Ensure that traffic management initiatives are carried out by R-sides
- Advise R-sides on adhering to current FAA separation requirements
- Continuously review traffic management initiatives
- Coordinate solutions with adjacent Multi-Ds and TMUs as needed
- Modify trajectories for conflicts, weather, and congestion
- Initiate local traffic flow initiatives and rerouting
- Coordinate with R-sides
- Ensure medium term or multi-sector conflicts
- Manage traffic flow
- House keeping
Tools in Support for MSP

**Multi-D**
- Traffic Display
- Conflict Probe
- Route and Altitude Trial Plans
- Ground/Ground Data Link (controller-controller clearance coordination)
- Voice Communication Systems
- Sector Load Graphs and Load Table
- Electronic Flight Strips
- “Quick Look” capability to view any of the r-side traffic displays (DSR)
- “See All” DSR Repeater

**Area Flow**
- Traffic Display
- Route and Altitude Trial Plans
- Ground/Ground Data link (controller-controller clearance coordination)
- Voice Communication System
- Sector Load Graphs and Load Table
- Electronics Flight Strips
- “Quick Look”
- “See All” DSR Repeater
## Radar Controller Operations

**Roles/Responsibilities**

- Ensure separation
- Initiate control instructions
- Monitor and operate radios
- Accept and initiate automation supported handoffs
- Ensure computer entries are completed on instructions or clearances you issue or receive
- Monitor & assure that handoff is initiated
- Ensure transfer of communications

**Tools**

- Traffic Display
- Conflict Probe
- Short-term Conflict Alert
- Route and Altitude Trial Plans
- Air/Ground Data Link (controller-pilot data link communication, or CPDLC)
- Ground/Ground Data Link (controller-controller clearance coordination)
- Automation–Supported Transfer of Communication (TOC)
- Voice Communication Systems
R-side Display and Tools

Trial Planning Tools

Medium Term Conflict Probe
MSP Display and Tools

Sector Load Table & Graphs

Area Flow Reduced Data Blocks
Controller Workstation & Trail Plan Sequence
Airspace Traffic Patterns

Kansas City Center (ZKC)
Albuquerque Center (ZAB)
Memphis Center (ZME)
Fort Worth Center (ZFW)
Ardmore (48)
Wichita Falls (47)
Decod (42)

Ghost 93
127.85

Ghost 50
135.45

Ghost 75
133.25

230↓

BAMBOO
GREGS
KARLA
Experimental Design

- Multi-D and Area Flow tested separately
  - Prevents the possibility that an exposure to one concept affects the outcome of the other concept

- 2x2 Design per MSP concept
  - Operational Configuration
    - Baseline (advanced tools & current sector roles)
    - MSP (either Multi-D and Area Flow)
  - Two Disturbance Functions
    - Weather in Sectors
    - No Weather, Higher Traffic
Sector Load Balancing

- **Multi-D**
  - Did not affect the overall traffic that traversed through the test sectors
  - Reduced traffic complexity with traffic flow initiatives (e.g. arrivals down to FL290)

- **Area Flow**
  - Reduced the peak traffic levels below assigned MAPs with lateral route modifications
  - Reduced traffic complexity with traffic flow initiatives (e.g. arrivals down to FL290)
Strategic Traffic Management

- **Number of weather penetration reduced for both Multi-D and Area Flow**
  - MSP positions rerouted aircraft strategically around weather

- **Aircraft received fewer tactical maneuvers (via verbal vectors/altitude changes) in Area Flow condition**

- **“Late” conflict resolutions (<5min) reduced in high traffic/no weather scenarios for Multi-D**
## Delay in ETA

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<th>MSP</th>
<th>Baseline</th>
<th>MSP – Baseline</th>
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<tbody>
<tr>
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<td>Weather</td>
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<td>68.4</td>
<td>100.4</td>
<td>-32.0*</td>
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<td>40.9</td>
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\( Wx, p < 0.07 \)

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<td>97.3</td>
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<td>56.3</td>
<td>39.5</td>
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\( \text{High Traffic}, p < 0.03 \)
Average Number of Coordination

Average number of Coordinations

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Workload Distribution

**Multi-D**

![Multi-D graph]

**Area Flow**

![Area Flow graph]

Better workload balance between R and MSP (both Multi-D and Area Flow) than between R and D.
Comparison of Multi-D and D WAKS ratings with no weather, scenario 1
Comparison of WAKS ratings for AF and D-side positions, under scenario 2 with no weather.
Multi-D rated ability to maintain situation awareness as difficult

Area Flow rated ability to maintain required situation awareness as difficult in traditional sense- but indicated no requirement to have that level of awareness
Discussion

- **Strategic Vs. Tactical Control:** traffic was managed more strategically in the MSP operations.
  - More aircraft successfully avoided weather cells for both AF and MD operations compared to baseline.
  - Controllers resorted to fewer tactical maneuvers (defined as last-minute verbal clearances) in weather scenarios under the AF operations compared to baseline.
  - Controllers resolved conflicts earlier in no weather/high traffic situation with the help of a Multi-D operator.
  - Under weather scenarios, AF operations resulted in no delays compared to baseline while aircraft in MD operations resulted in ETAs that were earlier than those in baseline operations.
  - Voice Communication was reduced in the AF condition
  - AF concept was determined to be more consistent with a strategic traffic flow process
Discussion

- **Efficiency:**
  - Controllers rated MSP concepts as more efficient than standard operations
  - Operational Measures suggest slight efficiency gains

- **Workload:**
  - Workload was more evenly distributed in both MSP conditions

- **Coordination**
  - Coordination was found more effective in the AF condition
  - Different MSP AF role reduced coordination issues
  - Coordination with external adjacent MSP areas and Traffic Management will need to be explored
What was achieved

- Multiple high altitude sector interactions
- Complex traffic and weather scenarios
- Credible R/D interactions and credible R/MSP interactions

What was not investigated

- Credible MSP/MSP interactions
- Actual role for TMU
- Any MSP/TMC interactions
- Concept evaluation at a larger scope – at NAS level? Command center involvement?
Future Directions

Area Flow Operations:

- Provide a more consistent path for future development aligned with Operational Evolution Plan (OEP) and NextGen development.
- Change of roles to a planner, and the strategy of reduction of possible conflicts to reduce reliance on tactical response from the D-side provides for a clearer interaction and authority process for the controllers.
- Area Flow operations allows for a more flexible control station configuration as the Area Flow operations did not require the Area Flow to be physically co-located with the Radar-controllers in the operations.