Super-Dispatchers: Remote Operations Centers for On-Demand Fleet Management

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March 14, 2018
NASA Ames/ADF EAS Dispatcher Workshop

Outline

1. What is a remote operations center (ROC)?
2. Why would we need ROCs for on-demand mobility (ODM)?
3. How could ROC requirements vary with autonomous systems?
4. What should we consider when staffing and designing ROCs?
5. Where do we need to focus our ROC efforts for ODM concepts to become operational?
What is a remote operations center (ROC)?

- **Vehicle**
  - Pilot
  - Passenger

- **Vertiport**
  - Ticket Agent/ Customer Service
  - Maintenance Personnel
  - Safety/ Security Agent

- **Environment**
  - ATC
  - Local Weather Tracker
  - Regional Network Manager
Why would we need ROCs for on-demand mobility (ODM)?

Vehicle concept by Aurora (2017)

Vehicle and vertiport concept by Lilium (2017)

Vehicle concept by Vahana (2016)

ROC concept by Ehang (2016)
Why would we need ROCs for on-demand mobility (ODM)?

• To remotely manage fleets of vehicles
• To interface with air traffic control
  • Conflict avoidance
  • Separation of aircraft
  • Scheduling of shared resources
Why would we need ROCs for on-demand mobility (ODM)?

- Dispatch operations center/call center/supervisory control center
  - Energy requirements
  - Passenger requirements
  - Contingency requirements
How could ROC requirements vary with autonomous systems?

<table>
<thead>
<tr>
<th>Maintain Vehicle Safety</th>
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<tbody>
<tr>
<td>Maintain Safe Separation</td>
</tr>
<tr>
<td>• From other Participating Vehicles</td>
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<tr>
<td>• From Fixed and Dynamic Hazards</td>
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<tr>
<td>Maintain Vehicle Control</td>
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<tr>
<td>• Nominal and Contingency Limits</td>
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<tr>
<td>• Physical and Cyber Security</td>
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<tr>
<td>Maintain Sufficient Conditions to Complete Trip</td>
</tr>
<tr>
<td>• Ride Quality</td>
</tr>
<tr>
<td>• Energy</td>
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<td>• Vehicle Performance</td>
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<td>• Navigation Accuracy</td>
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</table>
A Concept of Operations for On-Demand Passenger Aircraft

1. Passenger requests flight
2. Passenger and pilot arrive to depot
3. Pilot completes pre-takeoff checks
4. Pilot maneuvers aircraft for takeoff
5. Enroute
6. Pilot communicates with dispatch for clear landing pad
7. Pilot lands aircraft
8. Aircraft is serviced

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1. Passenger requests flight
2. Passenger arrives to depot
3. System completes pre-takeoff checks
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1. Passenger requests flight
2. Passenger and pilot arrive to depot
3. Pilot completes pre-takeoff checks
4. Pilot supervises aircraft takeoff
5. Enroute
6. Pilot communicates with dispatch for clear landing pad
7. Pilot supervises aircraft landing
8. Aircraft is serviced

How could ROC requirements vary with autonomous systems?

<table>
<thead>
<tr>
<th>Function to Maintain:</th>
<th>Remote Operations Center Tasks</th>
<th>Conventional</th>
<th>Revolutionary Vehicle Autonomy</th>
<th>Evolutionary* Vehicle Autonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe Separation from traffic</td>
<td>Plan flights within ATC restrictions</td>
<td>Monitor airspace status, command aircraft to UTM</td>
<td>Monitor airspace, communicate with pilots if adjusting separation</td>
<td></td>
</tr>
<tr>
<td>Safe separation from hazards</td>
<td>Plan flights to avoid obstructions</td>
<td>Calibrate fleet maps with local infrastructure data streams</td>
<td>Share new information w/ &amp; between PIC to avoid hazards</td>
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<tr>
<td>Vehicle control</td>
<td>Communicate with PIC if rerouting</td>
<td>Monitor A/C sensor-actuator status, use AIDA if rerouting</td>
<td>Monitor fleet, use AIDA if rerouting &amp; communicate w/ PIC</td>
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</tr>
<tr>
<td>Physical and cyber security</td>
<td>Verify PIC, monitor PIC</td>
<td>Monitor fleet network status, maintain command authority</td>
<td>Verify PIC, communicate &amp; maintain alertness</td>
<td></td>
</tr>
<tr>
<td>Energy management</td>
<td>Compute flight energy</td>
<td>Compute feasibility to land, ensure sufficient between re-charges</td>
<td>Monitor fleet, provide PIC safe landing alternatives if low energy</td>
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<tr>
<td>Navigation</td>
<td>Follow flights</td>
<td>Verify navigation of A/Cs on approach</td>
<td>Verify navigation w/ PIC</td>
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<tr>
<td>Ride quality</td>
<td>Communicate with PIC if disturbance</td>
<td>Monitor A/C sensors, communicate pertinent new info with passengers</td>
<td>Monitor &amp; provide update information for passenger comfort</td>
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<tr>
<td>Systems management</td>
<td>Communicate with PIC in contingency</td>
<td>Monitor network, supervisory control if A/C fails, redirect resources w/ AIDA</td>
<td>Monitor subsystem health, communicate w/ PIC if A/C fails</td>
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</tbody>
</table>
What should we consider when staffing and designing ROCs?

• Customer service
• Vertiport service
• Resource scheduling
• Vehicle command authority

• Teams of human and AI agents
  • Path planning
  • Scheduling
  • Resource allocation

• Remote operator tactical interface
  • Monitor
  • Command

• Scaling up to network-level
  • Exception management
  • Emergent behavior identification
Where do we need to focus our ROC efforts for ODM concepts to become operational?

• Metrics for ROC operator workload, system safety and efficiency
• How many more or less ROC operators can be staffed to manage vehicles with revolutionary autonomy?
• Which types of artificial intelligence decision aids should be designed for ROC operators?
• How many different types of ODM vehicles can be managed?
• How many vehicles can be managed at a time?

As vehicles and vertiports are being designed, ROC concepts must also be investigated to support equivalent or better levels of performance on functional requirements.
How will these remote operations centers need to innovate to support new fleet demands?
Methods

Collective Case Study
Discrete Event Simulation

Model Input Parameters
- Service time of remote operators
- Arrival process of fleet condition and team coordination-generated and events
- Multinomial distribution event type

Data Recorded from Case Study
- Duration of task performance
- Arrival times of planning, calls, and issue resolutions tasks during shift
- Count of each type of task arriving during shift

Model Output Measures
- Workload
- Delays
- Throughput
- Errors

Team Expertise

Environment

Remote Operator
- Attention Allocation

Service Process
- Shift
- Team Size
- AI Support
- Team Coordination
Transportation networks rely on remote operations centers (ROCs) for supervisory control. Reduction in crew size and rise in vehicle and network autonomy have led to the need for ROCs. The figures illustrate the impact on workload, delays, and throughput.
Acknowledgements

• American Airlines, Southwest Airlines, Rio Grande Pacific Company, UPS
• FAA, NASA Ames, NUAIR, UTM, Kairos, Uber, Airbus A3, Ehang, Lilium Aviation, Gryphon Sensors, Lockheed Martin-Sikorsky
• Federal Railroad Administration and US Department of Transportation
• National Institute of Aerospace and NASA Langley Research Center
• Missy Cummings, Alfredo Garcia, Jeffrey Glass, Michael Zavlanos
• Comrades in Duke Robotics and AIAA
Thank you

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References


References


