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

Victoria Chibuogu Nneji[1],

Mary (Missy) Cummings[1], Alexander Stimpson[1], Kenneth H. Goodrich[2]

[1]Duke University

[2]NASA Langley Research Center

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Nneji, V. C., Cummings, M. L., Stimpson, A. J., & Goodrich, K. H. (2018). Functional Requirements for Remotely Managing Fleets of On-Demand Passenger Aircraft. In *2018 AIAA Aerospace Sciences Meeting* (p. 2007).

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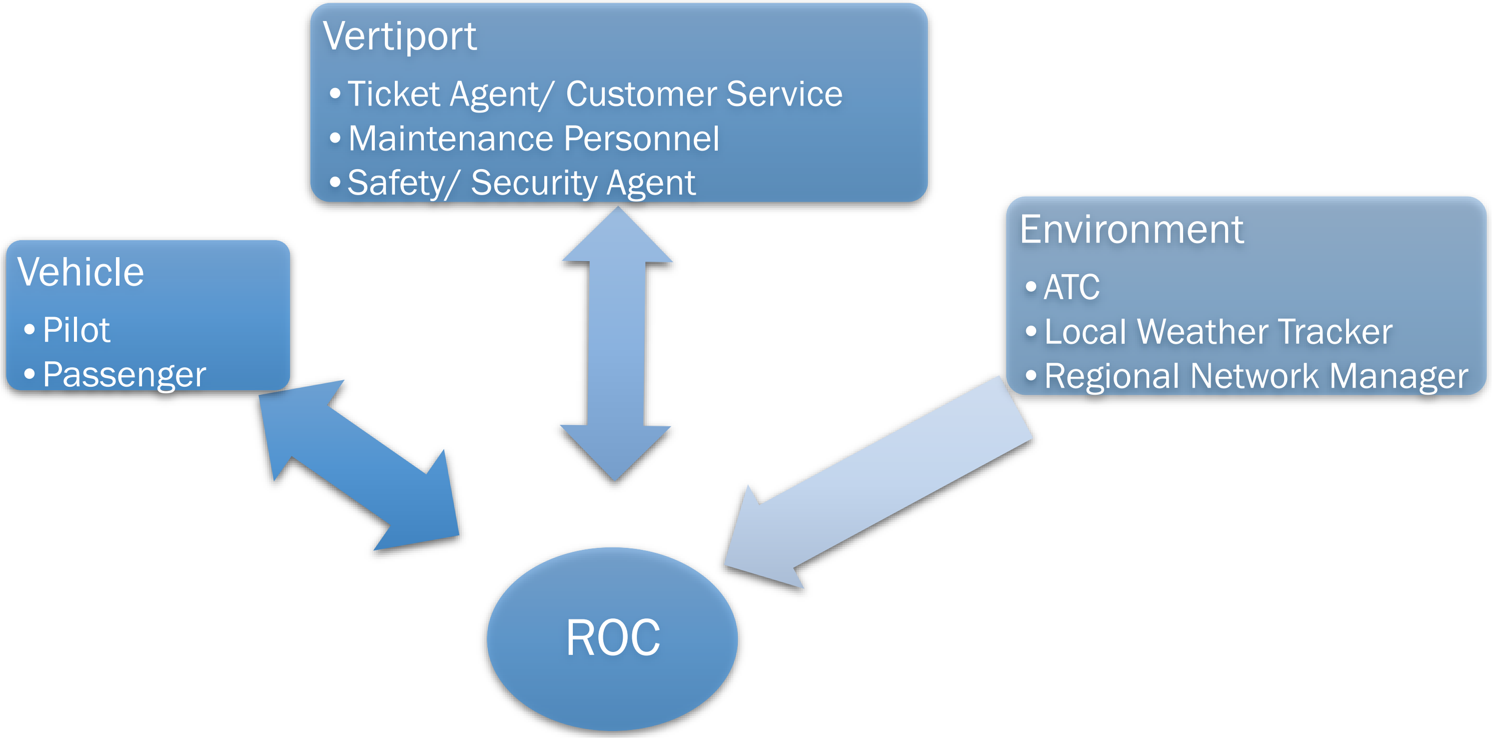
Outline

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)?

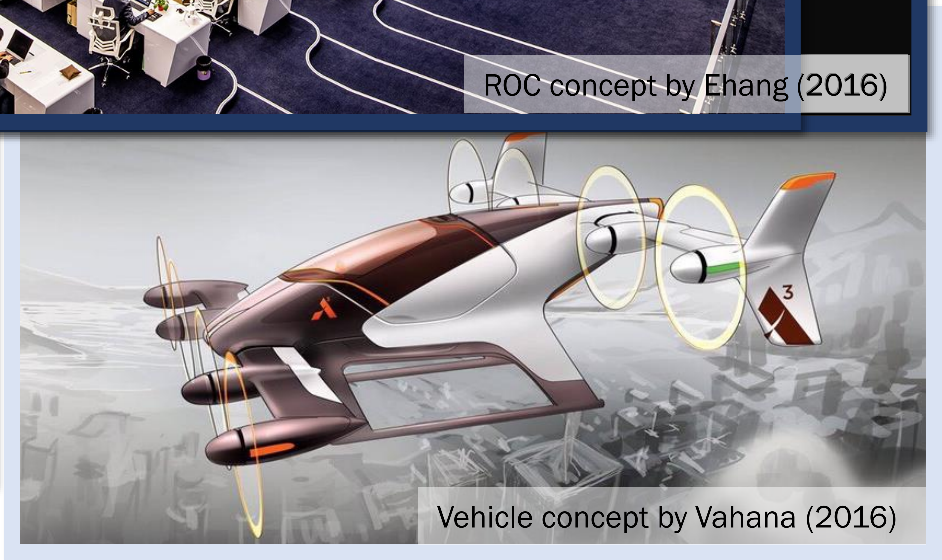


Why would we need ROCs for on-demand mobility (ODM)?

Vehicle and vertiport concept by Lilium (2017)

ROC concept by Ehang (2016)

Vehicle concept by Aurora (2017)



Vehicle concept by Vahana (2016)

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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

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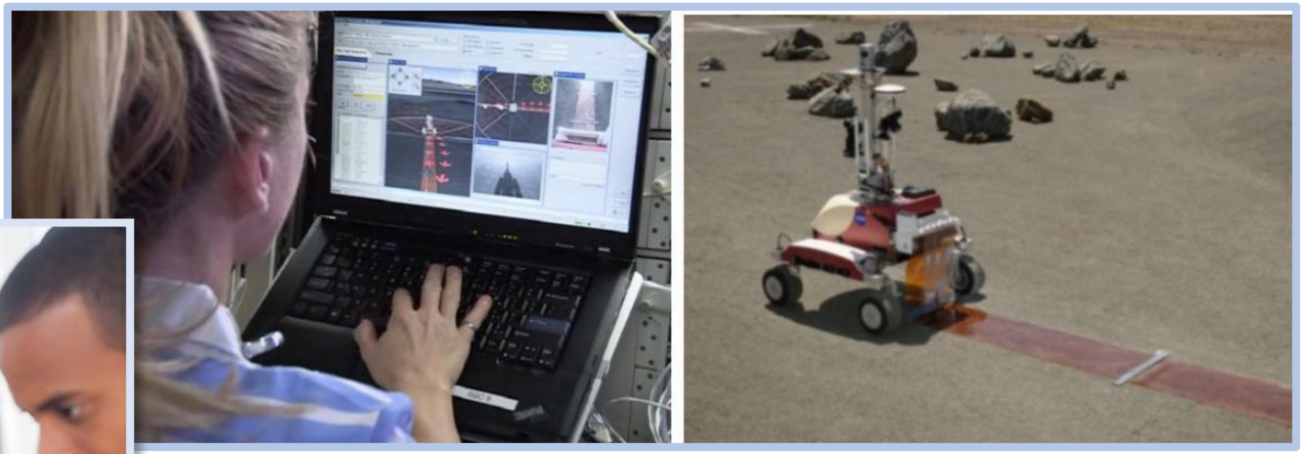
Why would we need ROCs for on-demand mobility (ODM)?



- Dispatch operations center/call center/supervisory control center
  - Energy requirements
  - Passenger requirements
  - Contingency requirements

How could ROC requirements vary with autonomous systems?

Maintain Vehicle Safety

Maintain Safe Separation	Maintain Vehicle Control	Maintain Sufficient Conditions to Complete Trip
• From other Participating Vehicles • From Fixed and Dynamic Hazards	• Nominal and Contingency Limits • Physical and Cyber Security	• Ride Quality • Energy • Vehicle Performance • Navigation Accuracy

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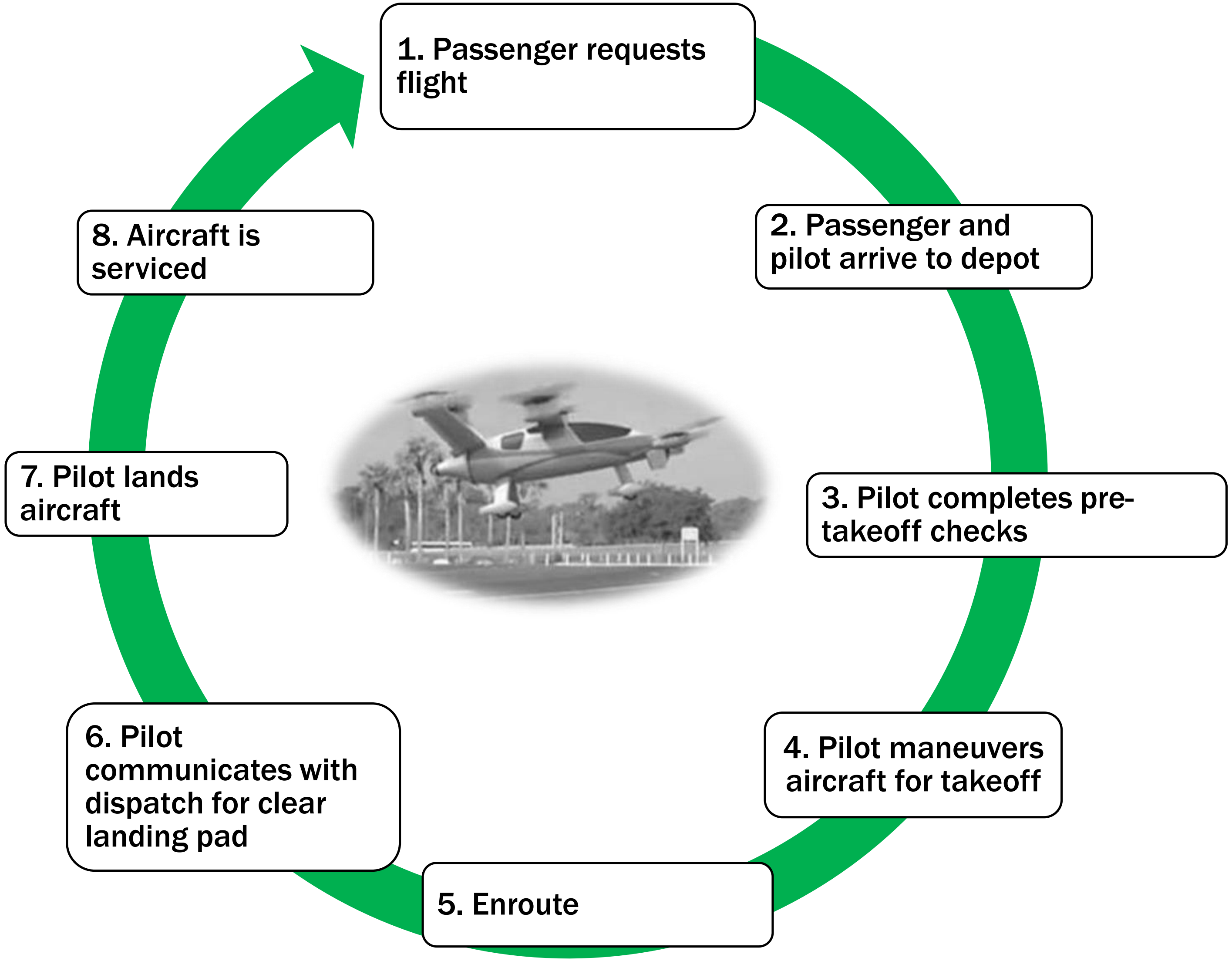
A Concept of Operations for On-Demand Passenger Aircraft



Nneji, Stimpson, Cummings, & Goodrich (2017). Exploring Concepts of Operations for On-Demand Passenger Air Transportation. In *17th AIAA Aviation Technology, Integration, and Operations Conference* (p. 3085).

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

Nneji, Stimpson, Cummings, & Goodrich (2017). Exploring Concepts of Operations for On-Demand Passenger Air Transportation. In *17th AIAA Aviation Technology, Integration, and Operations Conference* (p. 3085).

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How could ROC requirements vary with autonomous systems?

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

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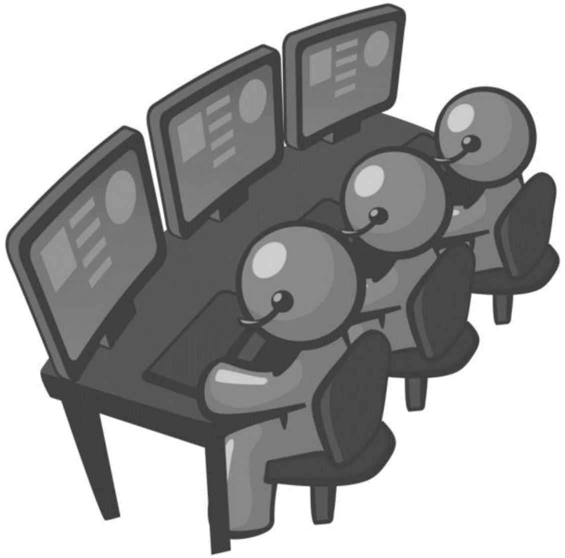
What should we consider when staffing and designing ROCs?

- 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

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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?

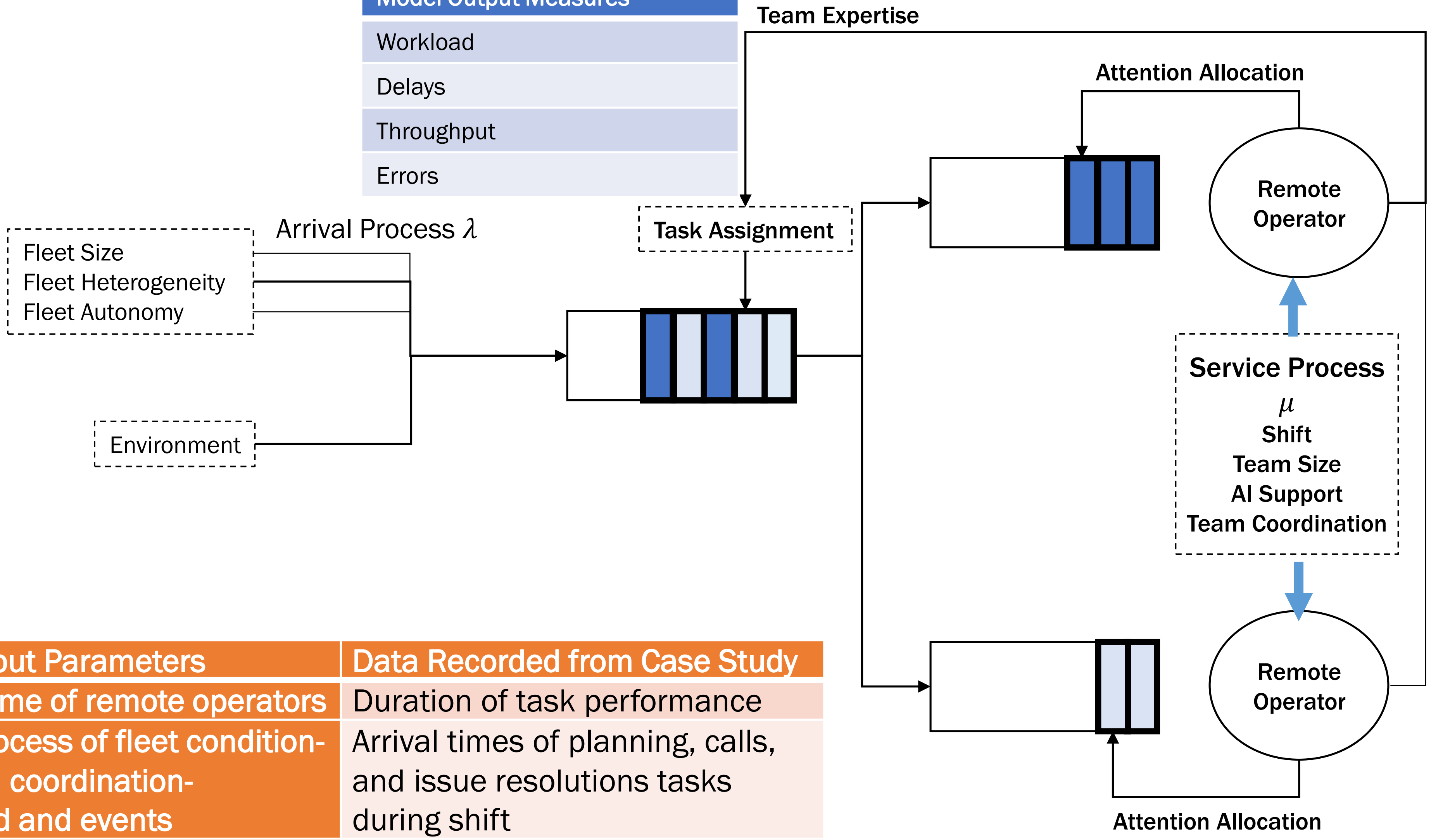
As vehicles and vertiports are being designed, ROC concepts must also be investigated to support equivalent or better levels of performance on functional requirements.

How will these remote operations centers need to innovate to support new fleet demands?

Methods

Collective Case Study
Discrete Event Simulation

Model Output Measures
Workload
Delays
Throughput
Errors



Model Input Parameters	Data Recorded from Case Study
Service time of remote operators	Duration of task performance
Arrival process of fleet condition- and team coordination-generated and events	Arrival times of planning, calls, and issue resolutions tasks during shift
Multinomial distribution event type	Count of each type of task arriving during shift

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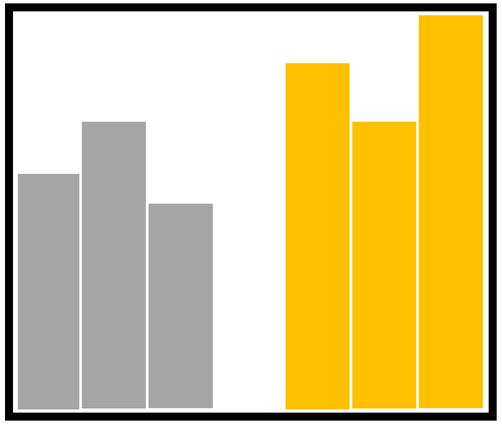
Motivation

Transportation networks rely on remote operations centers (ROCs)

Reduction in crew size and rise in vehicle and network autonomy

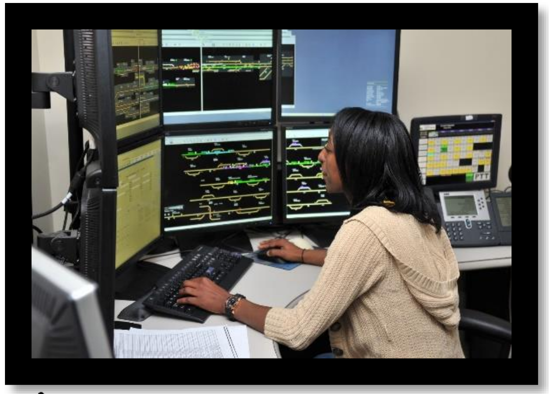
ROCs required for supervisory control

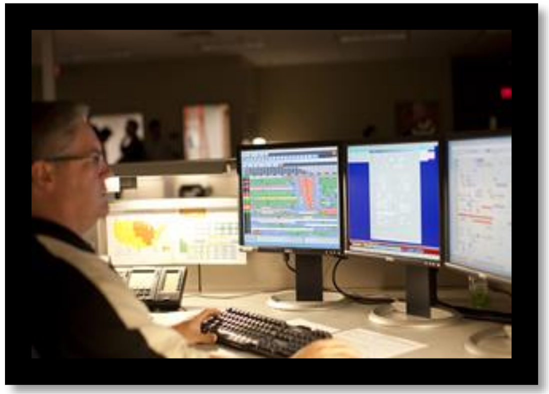
Workload



Delays

Throughput





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Thank you

Let's get coffee: vcn3@duke.edu
linkedin.com/in/victorian @ifindx

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