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Investigating Autonomous Air Operations Centers for On-Demand Mobility Networks

Victoria Chibuogu Nneji, Ph.D. Candidate
victoria.nneji@duke.edu

Mary "Missy" Cummings, Ph.D.
m.cummings@duke.edu

Pratt School of Engineering, Duke University

Summary

The concept of on-demand mobility (ODM) in aviation has gained popularity since Uber Technologies' 2016 Elevate announcement and several manufacturers proposed vehicles for high-speed intra-city air taxis. However, there are few proposals on how fleets would be operationally managed. To this end, we:

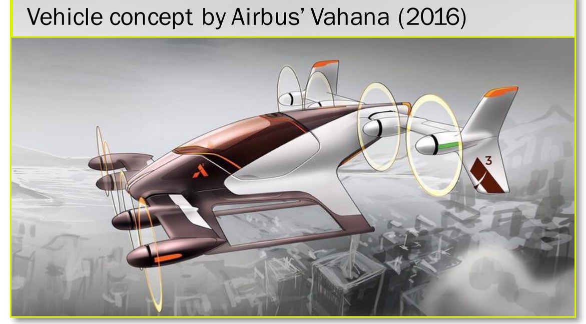
- Identified concepts of operations for ODM
- Defined key functional requirements for concepts
- Designed a predictive model of human-system performance in air operations centers for ODM

Problem Description

Traditional airlines rely on operations centers

New ODM aircraft require new fleet management functions

Vehicle concept by Airbus' Vahana (2016)



Vehicle concept by Boeing's Aurora (2017)

Air operations center concept by Ehang (2016)

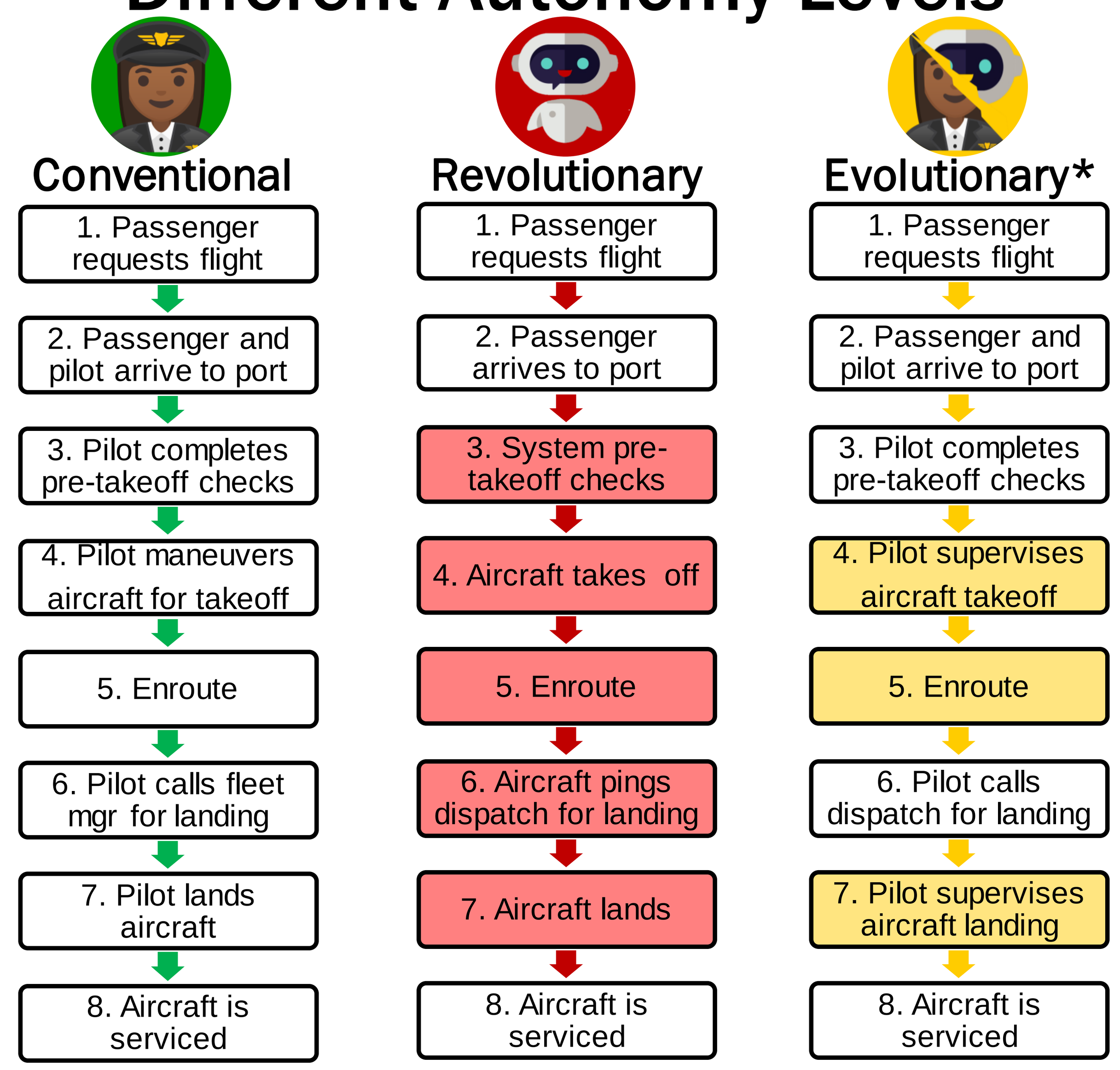
Vehicle Safety Functions

Maintain Safe Separation
- From other Participating Vehicles
- From Fixed and Dynamic Hazards

Maintain Vehicle Control
- Nominal and Contingency Limits
- Physical and Cyber Security

Maintain Sufficient Trip Conditions
- Ride Quality
- Energy
- Vehicle Performance
- Navigation Accuracy

ODM Vehicle Concepts of Operations with Different Autonomy Levels [1]



*Evolutionary is a range of possibilities, here we consider optionally-piloted aircraft

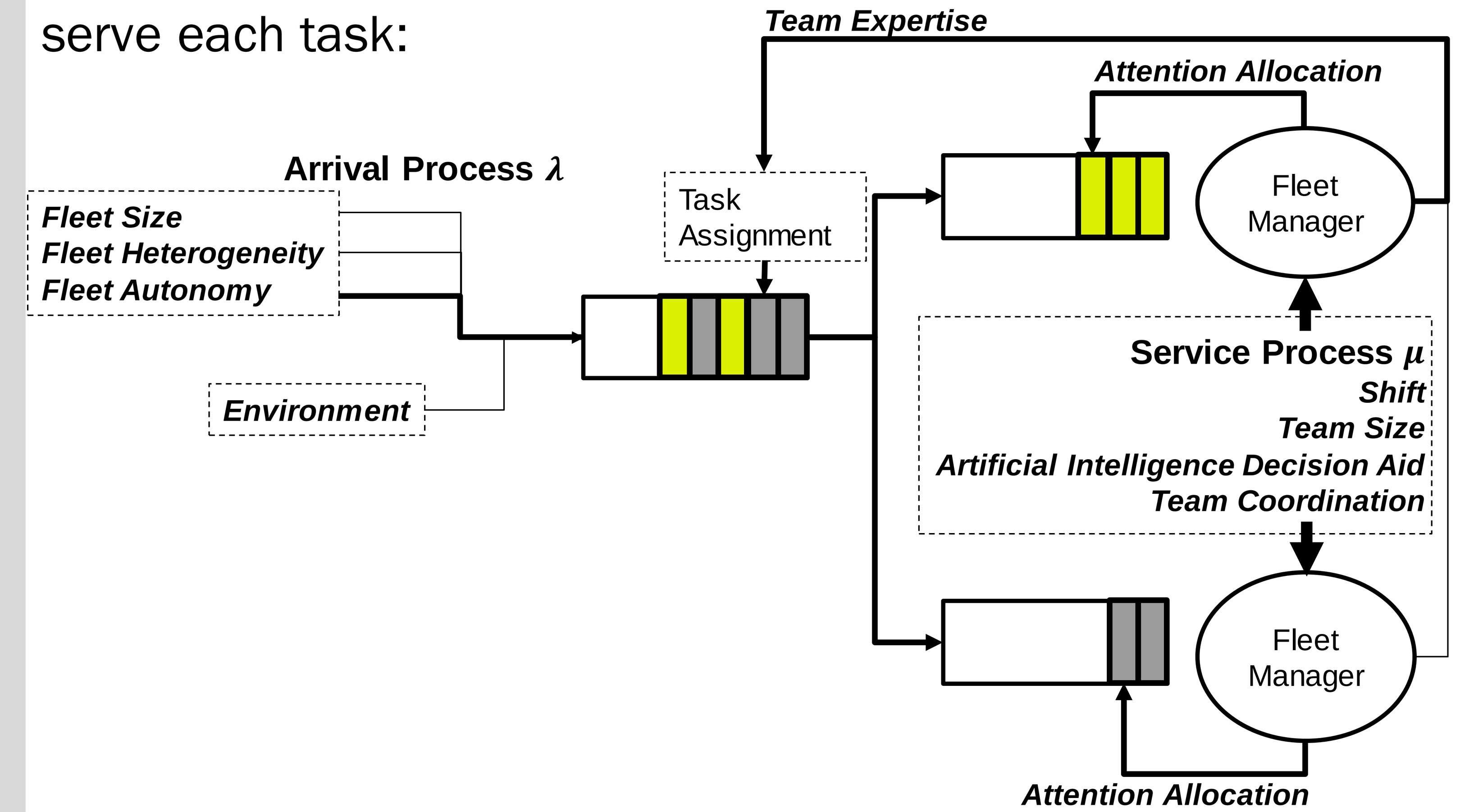
Air Operations Center Functional Requirements [2]

	Conventional	Revolutionary	Evolutionary*
Safe Separation from traffic	Plan flights within air traffic control (ATC) restrictions	Monitor airspace status, command aircraft to unmanned aircraft system traffic management (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 pilot-in-command (PIC) if rerouting	Monitor A/C (aircraft) sensor-actuator status, use artificially intelligent decision aids (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
Performance 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

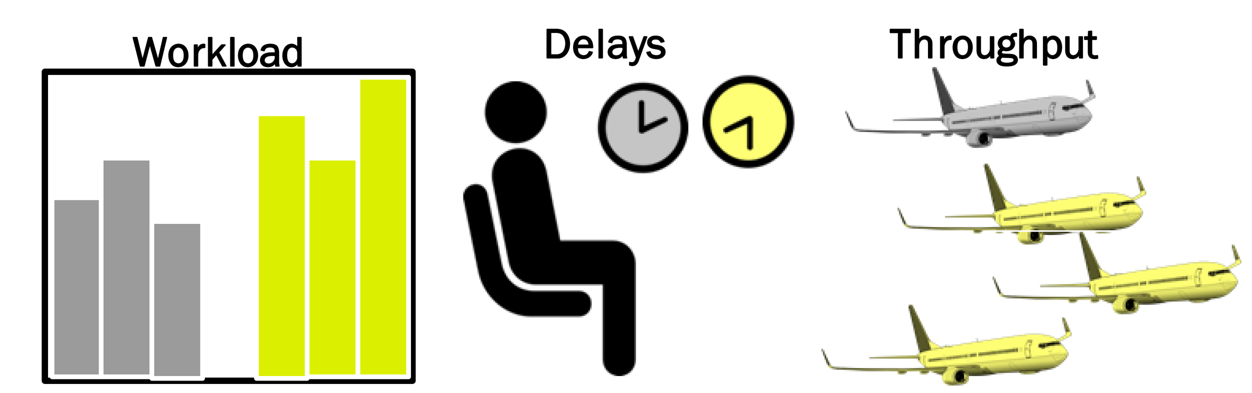
Understanding and Predicting Performance in Air Operations Centers

Conduct airline case studies for field observations and subject matter expert interviews to gather arrival and service process data on fleet manager functional tasks

Design a discrete event simulation (DES) to model how tasks (e.g. calls) stochastically arrive from the network, and how environmental and internal factors affect when fleet managers serve each task:



Validate DES and tune internal and input parameters to predict how human-system performance in air operations centers may change with new ODM vehicle concepts:



Conclusion

With this DES tool, strategic, tactical, and operational decisionmakers can rapidly prototype future fleet management concepts to investigate what-if scenarios. This supports informed planning of how to staff and design air operations centers to serve on-demand mobility networks.

References

[1] 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).

[2] 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).