



# Taxonomy and Abstraction of the On-Demand Mobility for Smart Cities

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# Outline

1. Introduction
2. Background
3. Framework
4. Conclusions
5. Future directions
6. Questions / Comments



# 1. Introduction

## 1.1 Transportation issues

### a. Population growth in the U.S.

- Past:

5.56% (2010-2017)

- Forecast:

29.69% (2017-2060)



### b. Traffic Congestion

- Physical Bottlenecks (40%)
- Traffic Incidents (25%)
- Work Zones (20%)
- Weather (15%)



# 1. Introduction

## 1.2 On-Demand Mobility (ODM)

- Point-to-point air services.
- Urban and suburban areas.
- Addresses need for short/middle range air services



Source: <https://hypebeast.com/2017/2/uber-elevate>

## 1.3 Benefits of using ODM

- Improves ground traffic congestion.
- Enhances environmental issues.
- Creates new business models.
- Increases transportation efficiency and level of service.

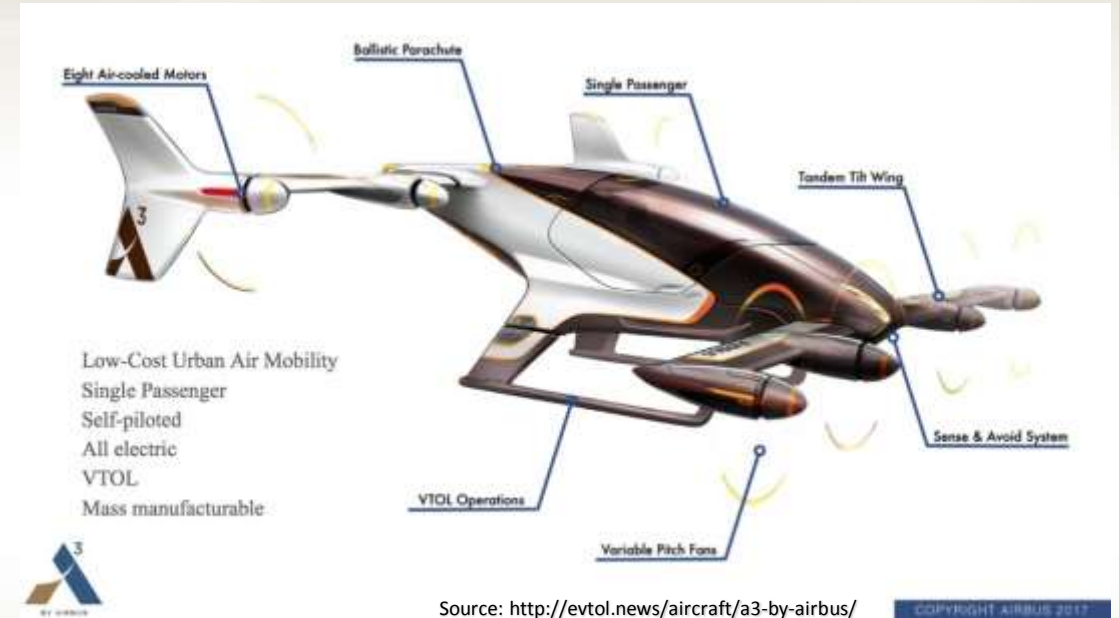


<https://auto.ndtv.com/news/uber-and-nasa-to-work-on-flying-car-concept-1849774>

# 2. Background

## 2.1 Technology available for ODM air vehicles

- Vertical Take-off and Landing Vehicle (VTOL)
- Distributed Electrical Propulsion (DEP)
- Physical Dimensions
- Automation and path planning (optional)



# 2. Background

## 2.2 Solutions in advance

Topic	Number	References
Technology	9	Brown and Harris (2018), Gohardani (2012), Adolf et al. (2010), Liu et al. (2017), Stoll et al. (2013), Lu et al. (2017), Zhu and Wei (2016), Snyder (2017), Stoll and Mikic (2016).
Modeling of supply and demand	4	Smith et al. (2012), Grawdiak et al. (2012), Baik et al. (2008), Gawdiak et al. (2012).
Infrastructure	6	Uber Elevate (2016), Holmes et al. (2017), Vascik and Hansman (2017), Vascik and Hansman (2017), Stewart et al. (2010), FAA Document (2005).
Framework	8	Moore et al. (2013), Narkus-Kramer (2013), Moore (2006), Uber Elevate (2016), Holmes et al. (2017), Nneji et al. (2017), Moore (2012), Moore (2010).

# 3. Framework

## 3.1 System-of-System (SoS) Framework

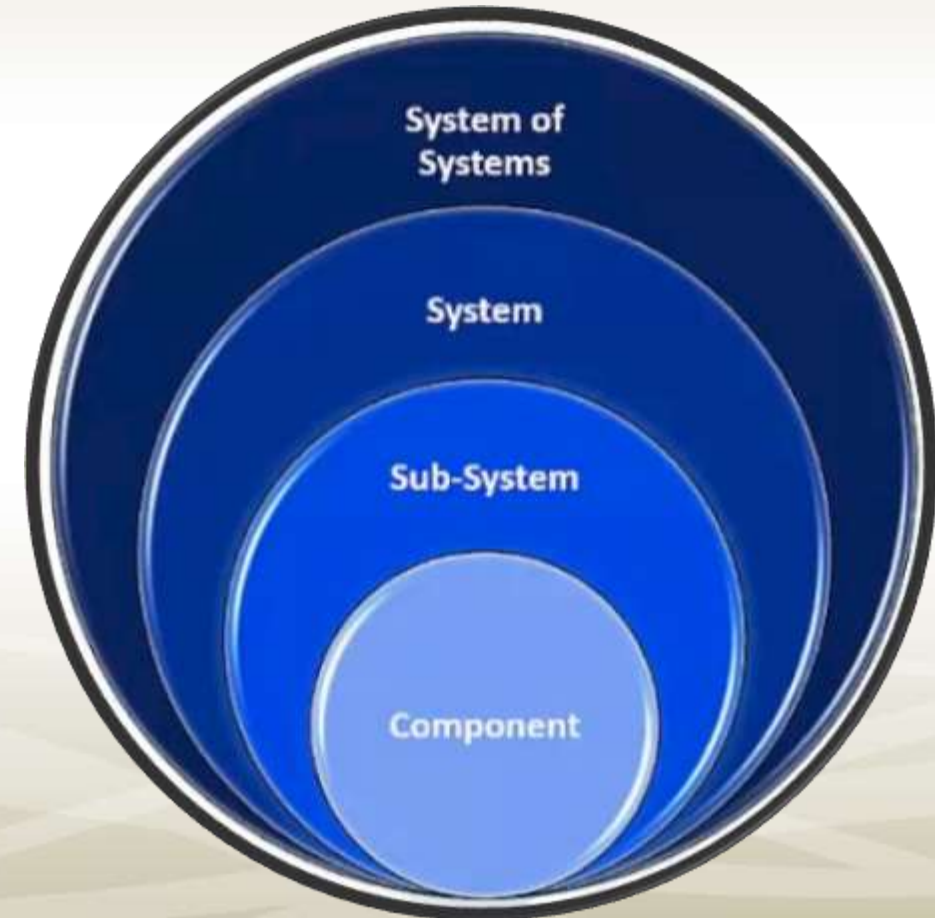
- ODM system is a complex system
  - Interacts with the ground and air transportation systems.
  - Associated with Recourses, Operations, Economics, and Policies.
  - Intelligent transportation system to serve smart cities.
- A robust framework is needed to improve ODM understanding for informed decisions by stakeholders.
- SoS will be employed in this research.



# 3. Framework

## 3.1 System-of-System (SoS) Framework

- What is a SoS?
  - Set of different systems forms a larger “system-of-systems”
  - Performs a function not performable by a single system alone.
  - Traits
    - Operational Independence of Elements
    - Managerial Independence of Elements
    - Evolutionary Development
    - Emergent Behavior
    - Geographical Distribution of Elements
    - Interdisciplinary Study
    - Heterogeneity of Systems
    - Networks of Systems





# 3. Framework

## 3.2 On-Demand Mobility (ODM) Framework

### Four categories & Five components

- Resources

- The physical entities that give physical action to the system-of-systems.

- Operations

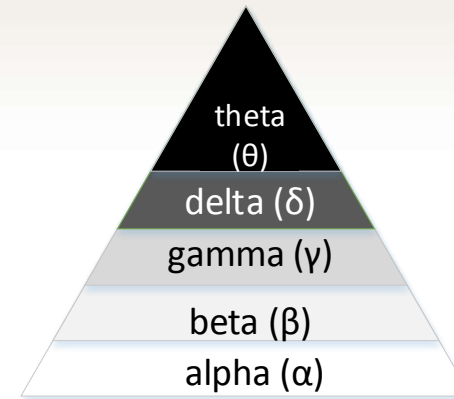
- The applications of policies procedures to direct the activity of physical entities.

- Economics

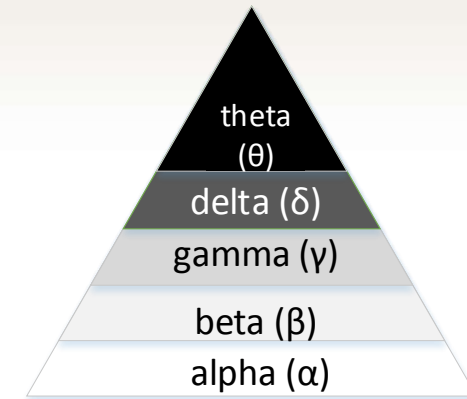
- The non-physical systems that give a operation of the physical entities in market economy.

- Policies

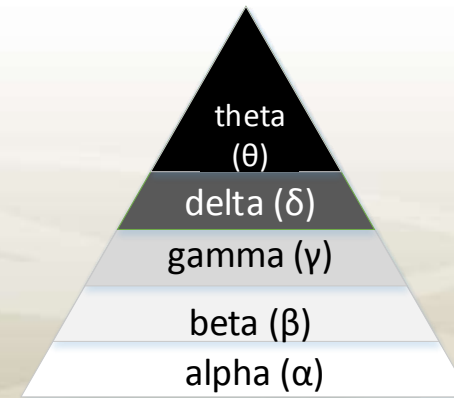
- The external forcing functions that impact the physical & non-physical entities.



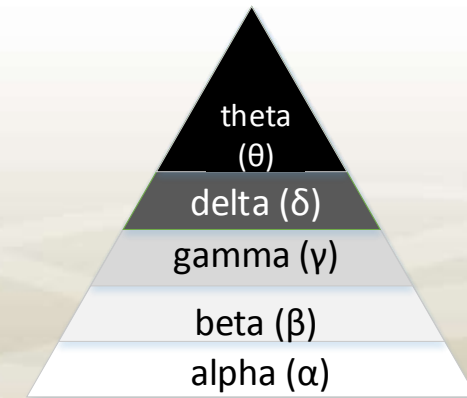
**Resources**



**Operations**



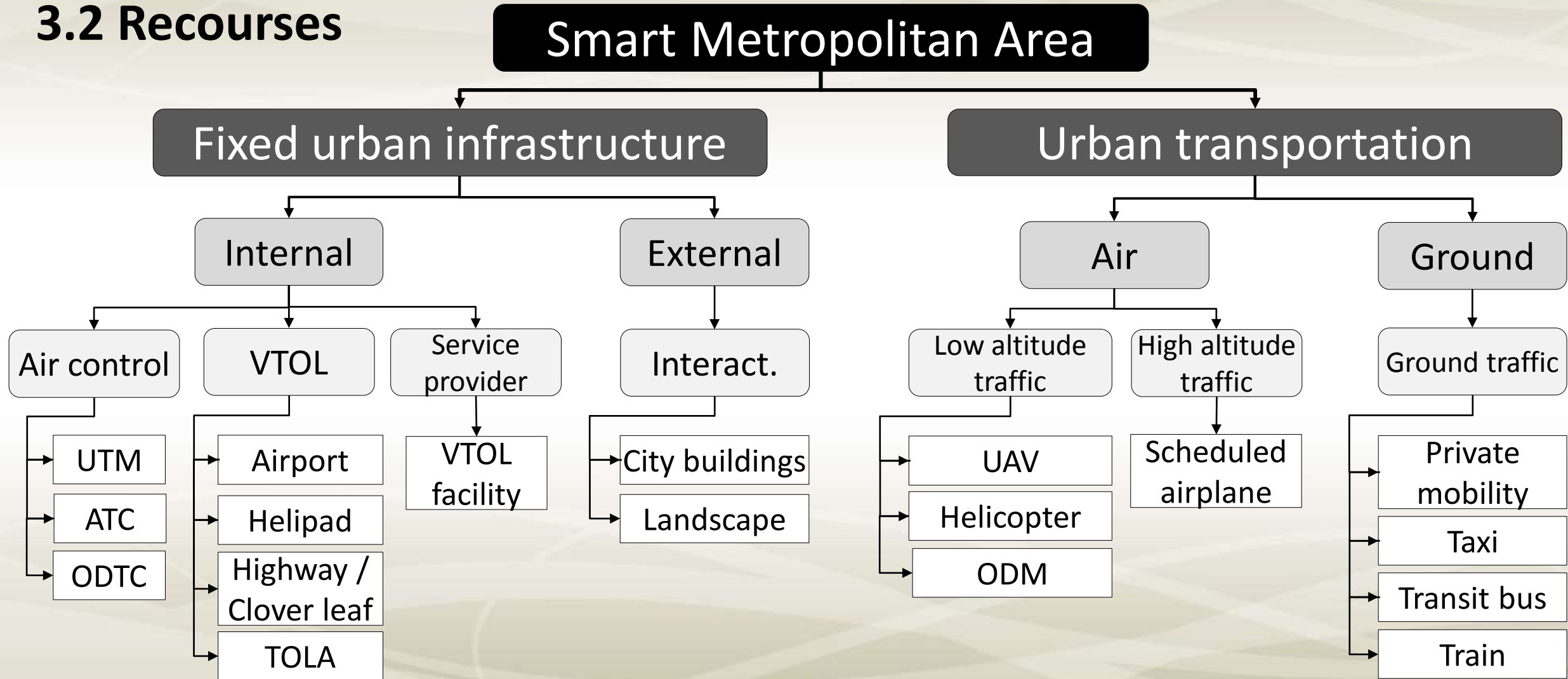
**Economics**



**Policies**

# 3. Framework

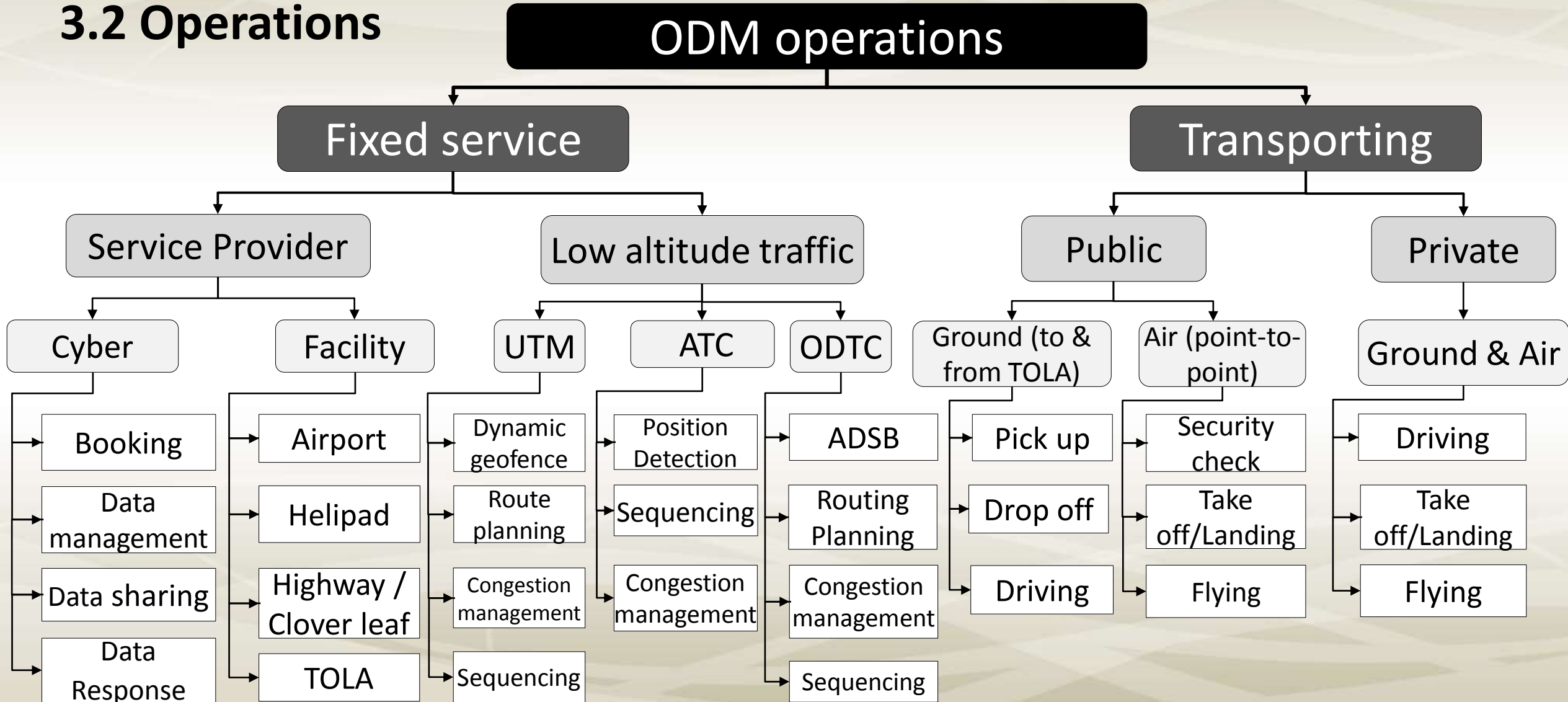
## 3.2 Recourses



UTM: Unmanned Traffic Management; ATC: Air Traffic Control; ODT: On-Demand Traffic Control; VTOL: Vertical Take-off and Landing; TOLA: Take-off and Landing Area; UAV: Unmanned Aerial Vehicle; ODM: ON-Demand Mobility

# 3. Framework

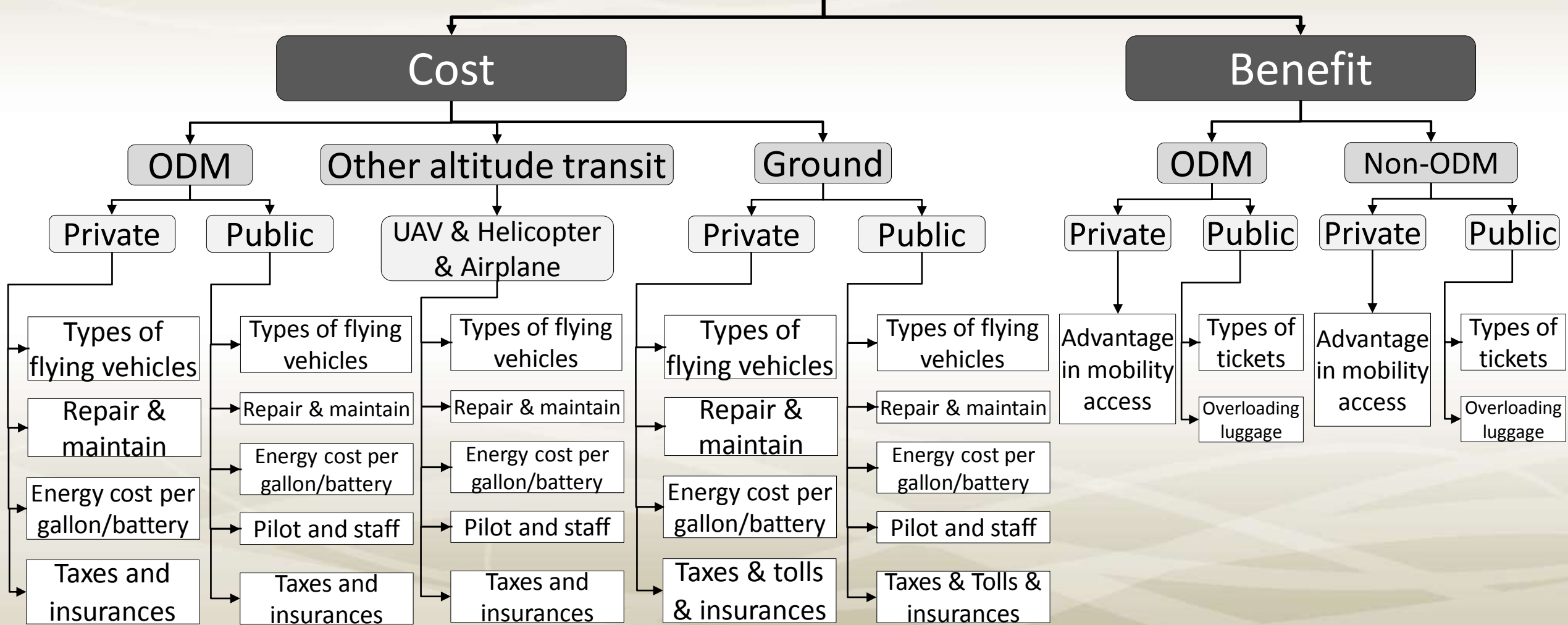
## 3.2 Operations



# 3. Framework

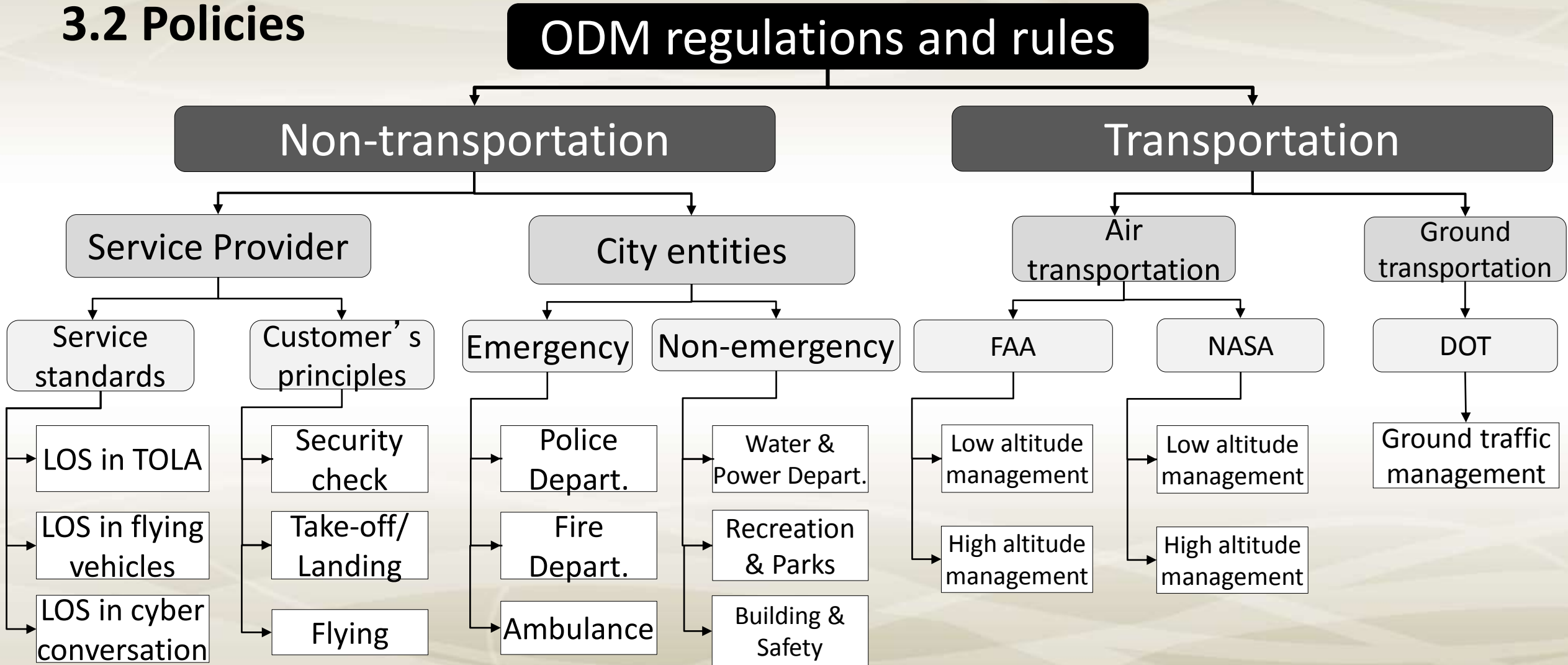
## 3.2 Economics

### ODM Economics



# 3. Framework

## 3.2 Policies



LOS: Level of Service; FAA: Federal Aviation Administration; NASA: National Aeronautics and Space Administration; DOT: Department of Transportation; Depart: Department

# 4. Conclusion

- Proposed ODM framework can be used to assess ODM operations in smart cities.
- Helps to better understand the individual component of the SoS, levels of aggregation, and interactions.
- Guidance to early adopter in the market.
- Systematizes complexity to help decision making.



# 5. Future directions

- Transportation demand model.
- Agent-based simulations.
- Policies and rules.
- Testing new ideas for transportation and urban planning.



Source: <https://www.nasa.gov/aero/nasa-embraces-urban-air-mobility>



# 6. Questions / Comments

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