MIT International Center for Air Transportation

Opportunities and Challenges for Urban Air Mobility

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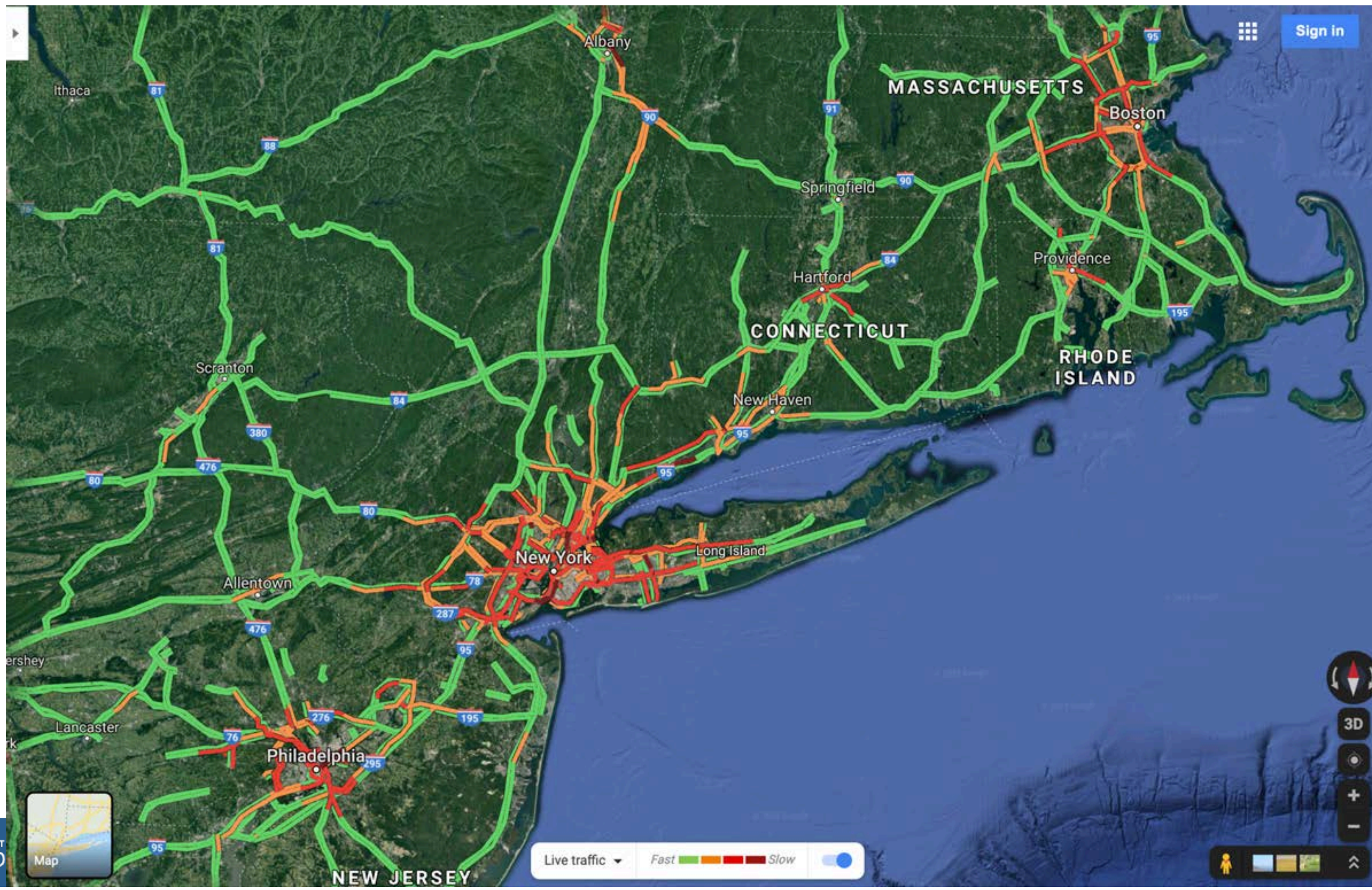
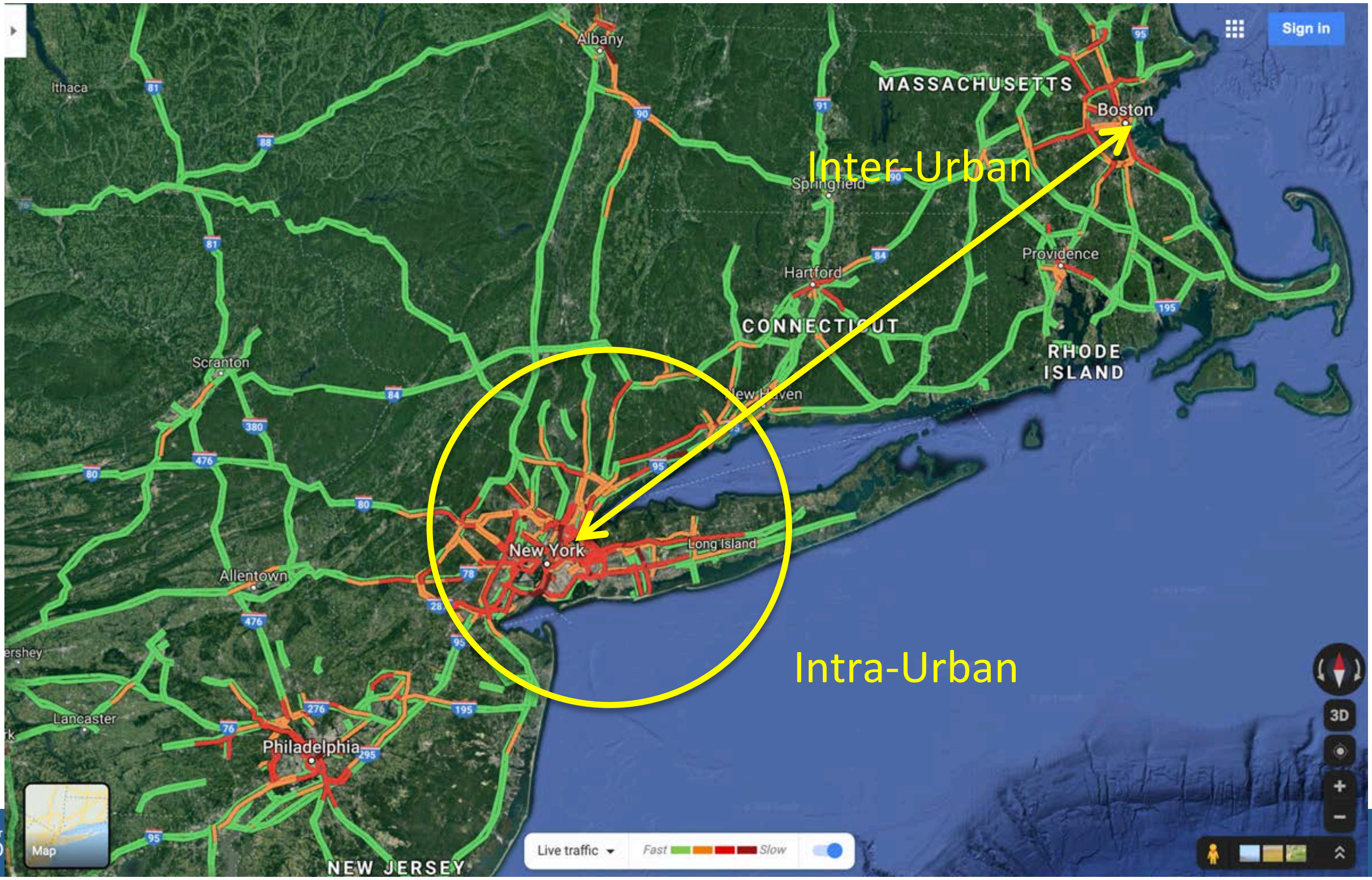
Urban Air Mobility

- On Demand Air Mobility motivated by growing surface congestion, success of TNCs and perceived technology transfer from electric vehicles, UAVs and automation



Urban Air Mobility

- UAM Markets
  - Intra-Urban
  - Inter-Urban



UAM Vehicles

vs.

UAM Vehicles

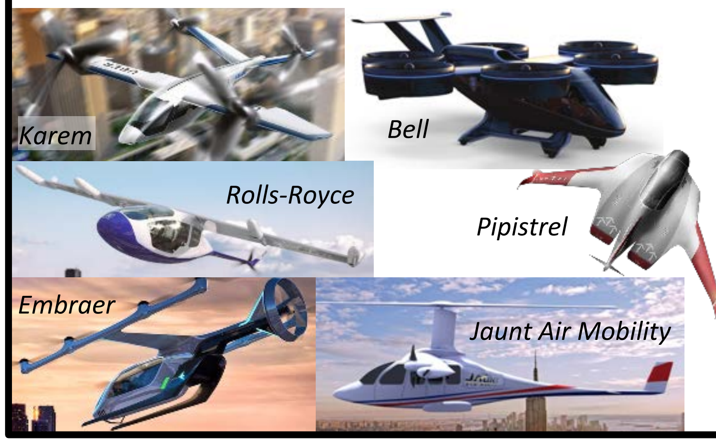
vs.

UAM Aircraft Development

Over 200[1] announced vehicle concepts (of varying credibility)

Example Flying Full-Scale Prototypes

Other Advanced Developments

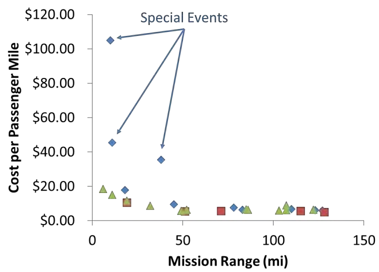


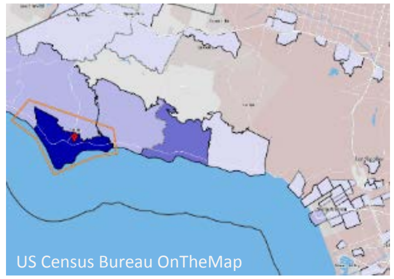
Many Additional Vehicle Concepts

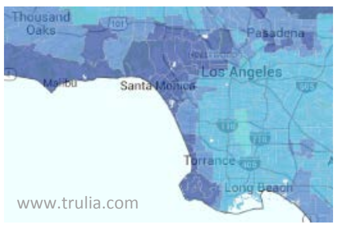
1. The Vertical Flight Society, *The Electric VTOL News World eVTOL Directory*. October 2019

Case Study Approach to Identify UAM Operational Constraints (LAX, BOS, DFW)

1. Identified Promising Markets



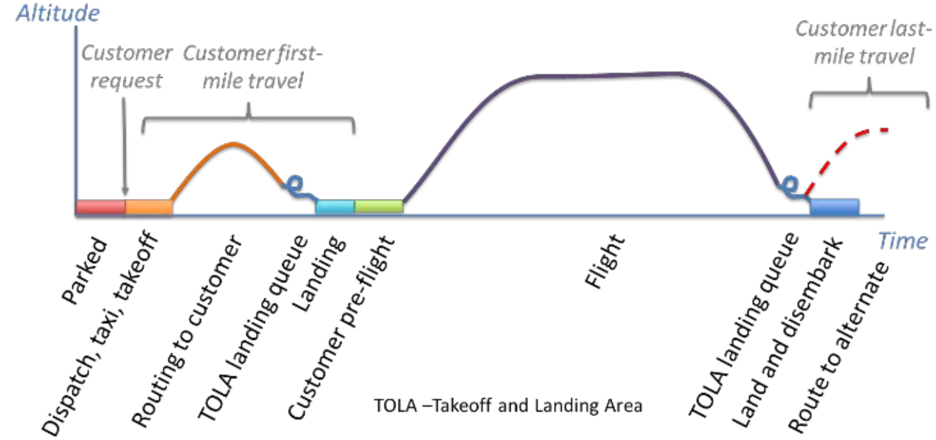




- Current helicopter charter services
- US census and commuting data
- Housing market data

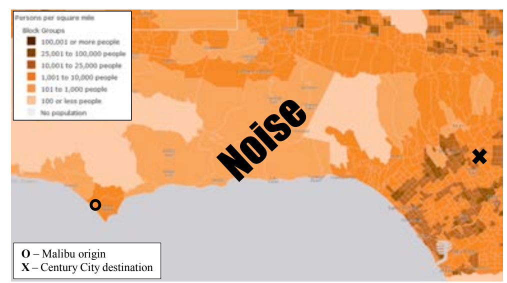
2. Defined Reference Missions

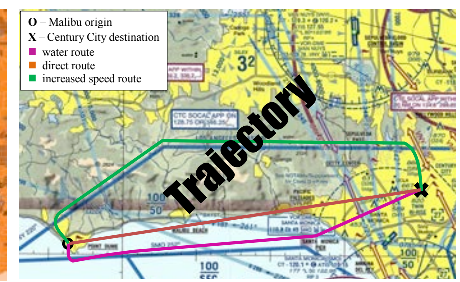
3. Applied Notional ConOps* to Each Mission

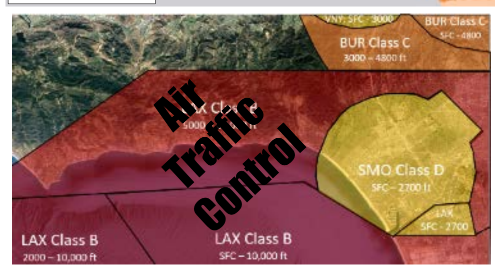


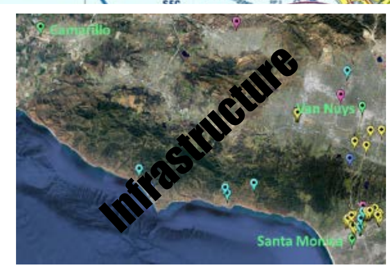
*ConOps assessed conventional technologies as well as electric propulsion and pilot automation

4. Identified Operational Challenges in Missions









AEROASTRO

UAM Operational Constraints Identified from City Case Studies

	Constraints
1	**Aircraft Noise and Community Acceptance**
2	**Availability of Takeoff and Landing Areas (TOLAs)**
3	**Scalability of Air Traffic Control (ATC)**
4	**Safety and Certification of Electric Aircraft Operations**
5	Logistics of Network Operations
6	Pilot Availability and Advanced Autonomy
7	All-Weather Operation

Summary of Case Study Results:

- *P. D. Vascik and R. J. Hansman, "Constraint Identification in On-Demand Mobility for Aviation through an Exploratory Case Study of Los Angeles," in 17th AIAA Aviation Technology, Integration, and Operations Conference, 2017.*
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Challenge to Site Infrastructure Near Demand

Existing aviation infrastructure in Boston

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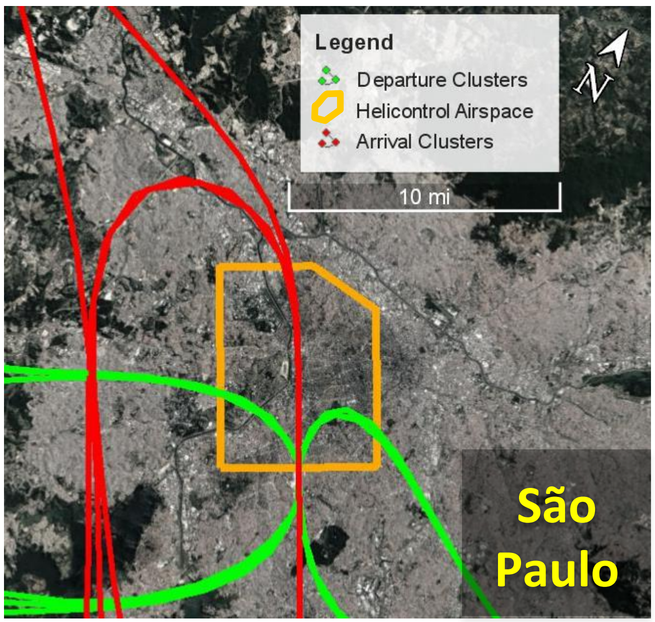
Current ATC Procedures Will Not Scale Controller Workload Constraint

São Paulo "helicontrol" Area

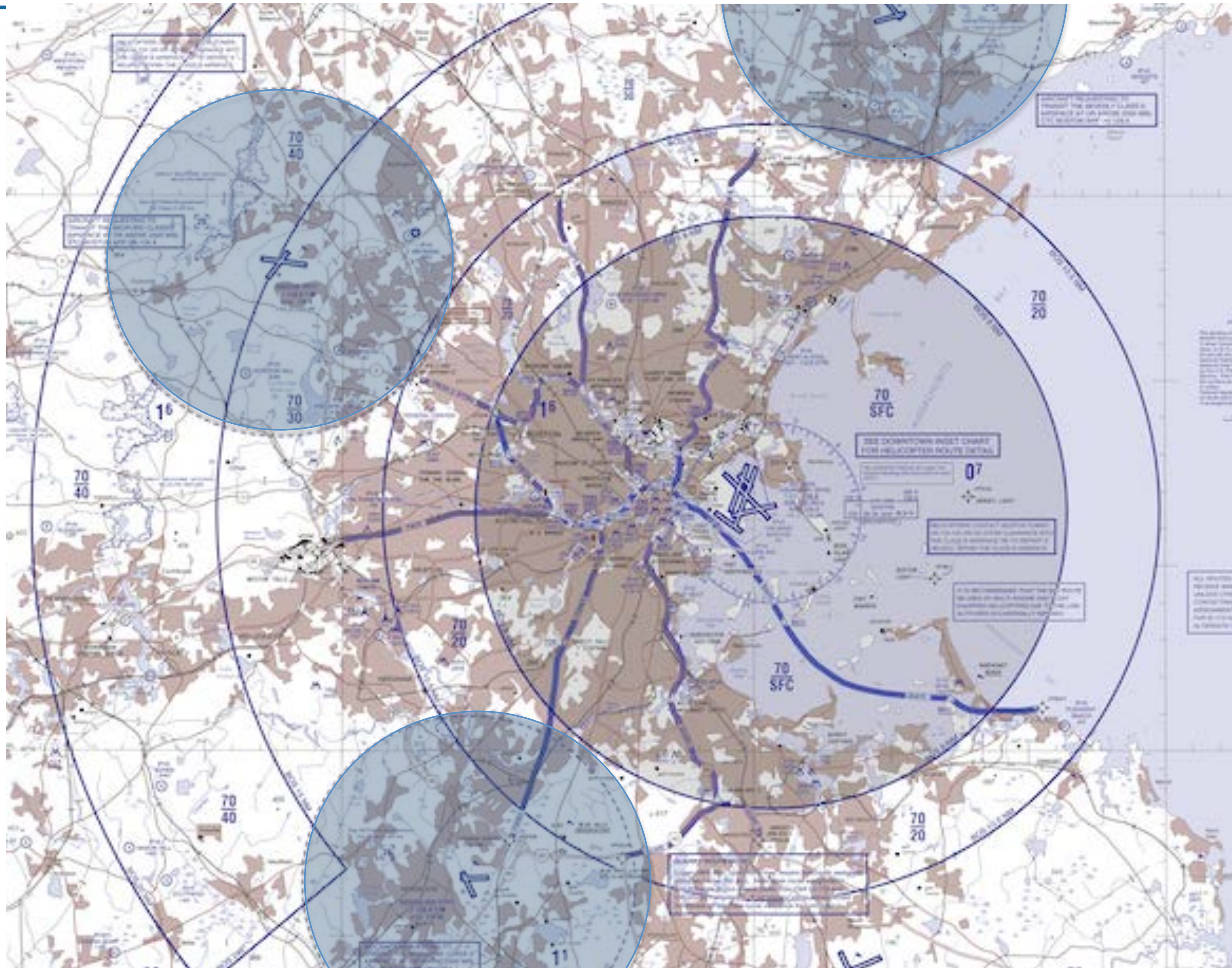
- limited to 6 simultaneous helicopter operations[15]
- designated entry points and routes

Boston Logan Controlled Airspace

- additional controller staffed for >3 operations
- designated helicopter routes



ATC Surface Controlled Airspace BOS



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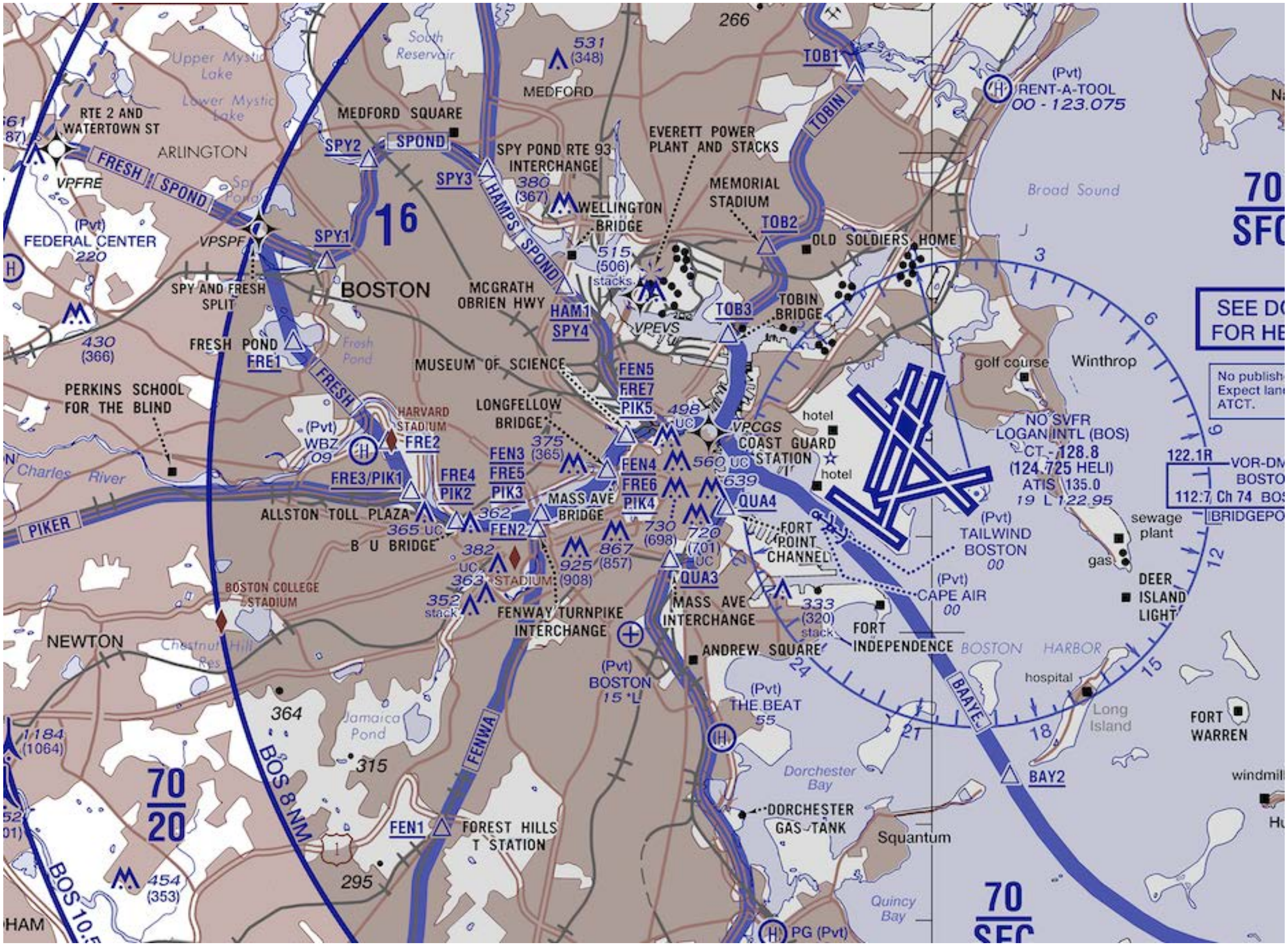
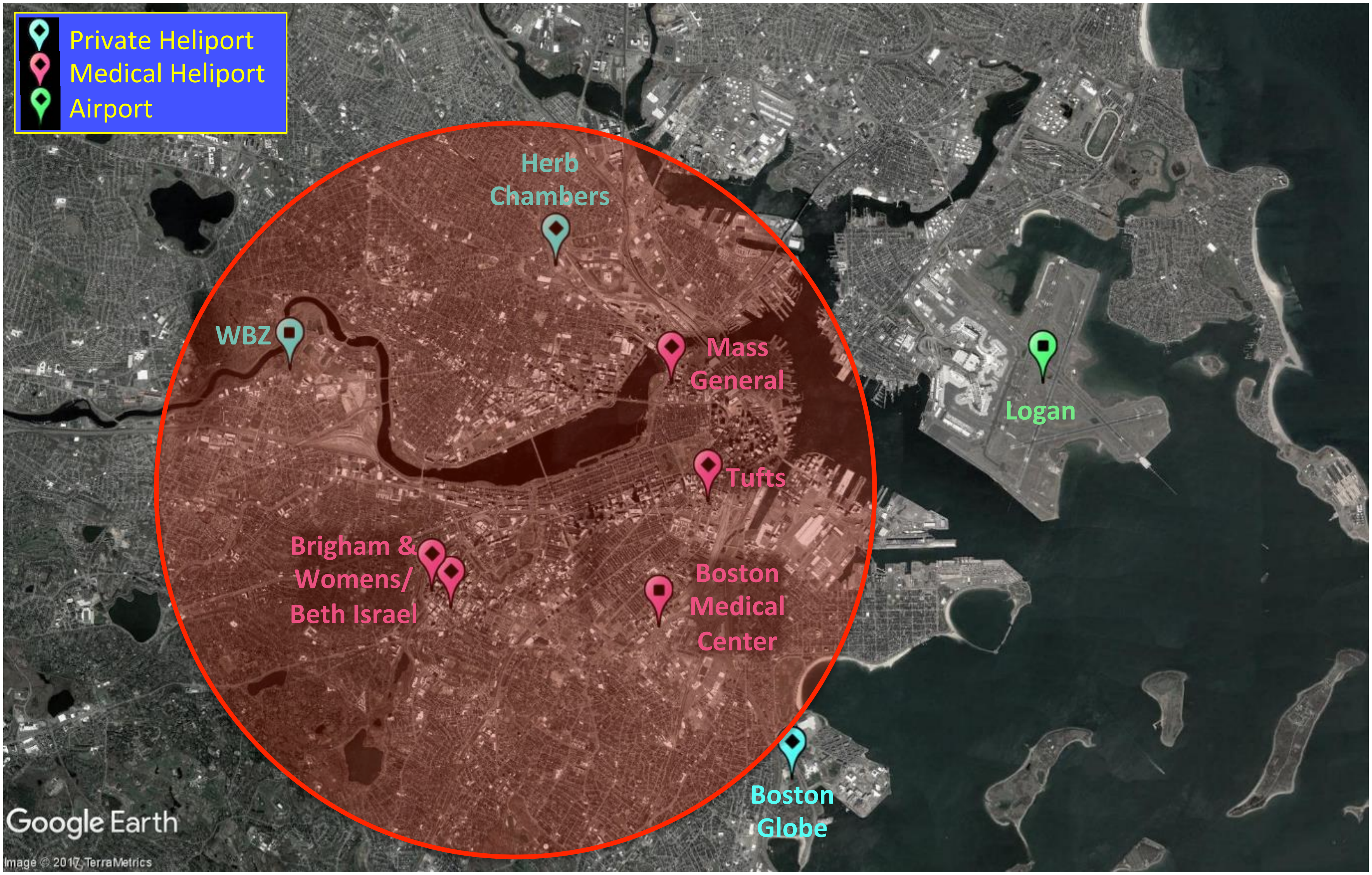


Special Use Airspace

Red Sox Game Example

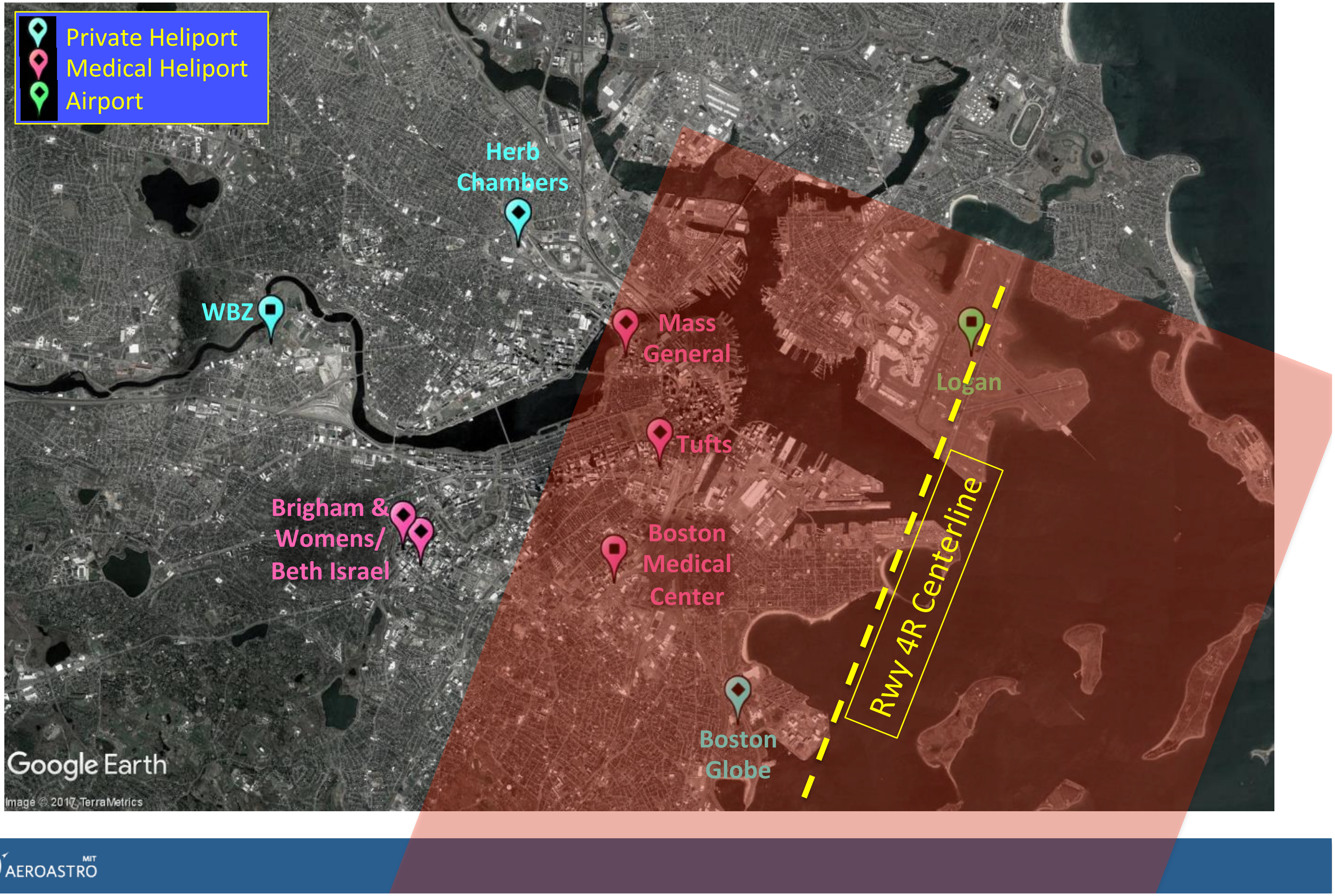


ATC Separation Standards

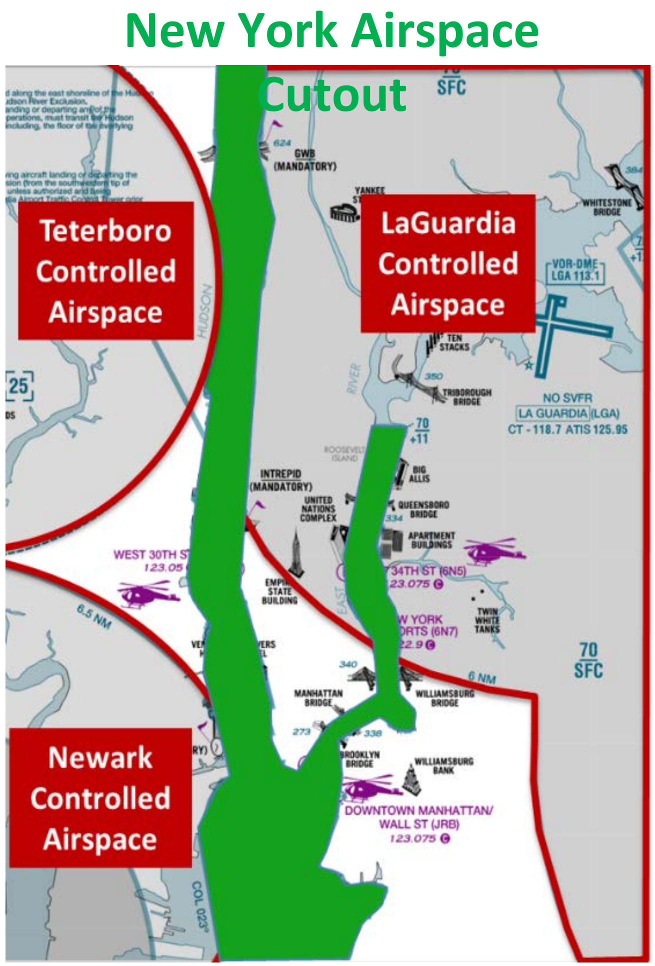
For Terminal Area Operations

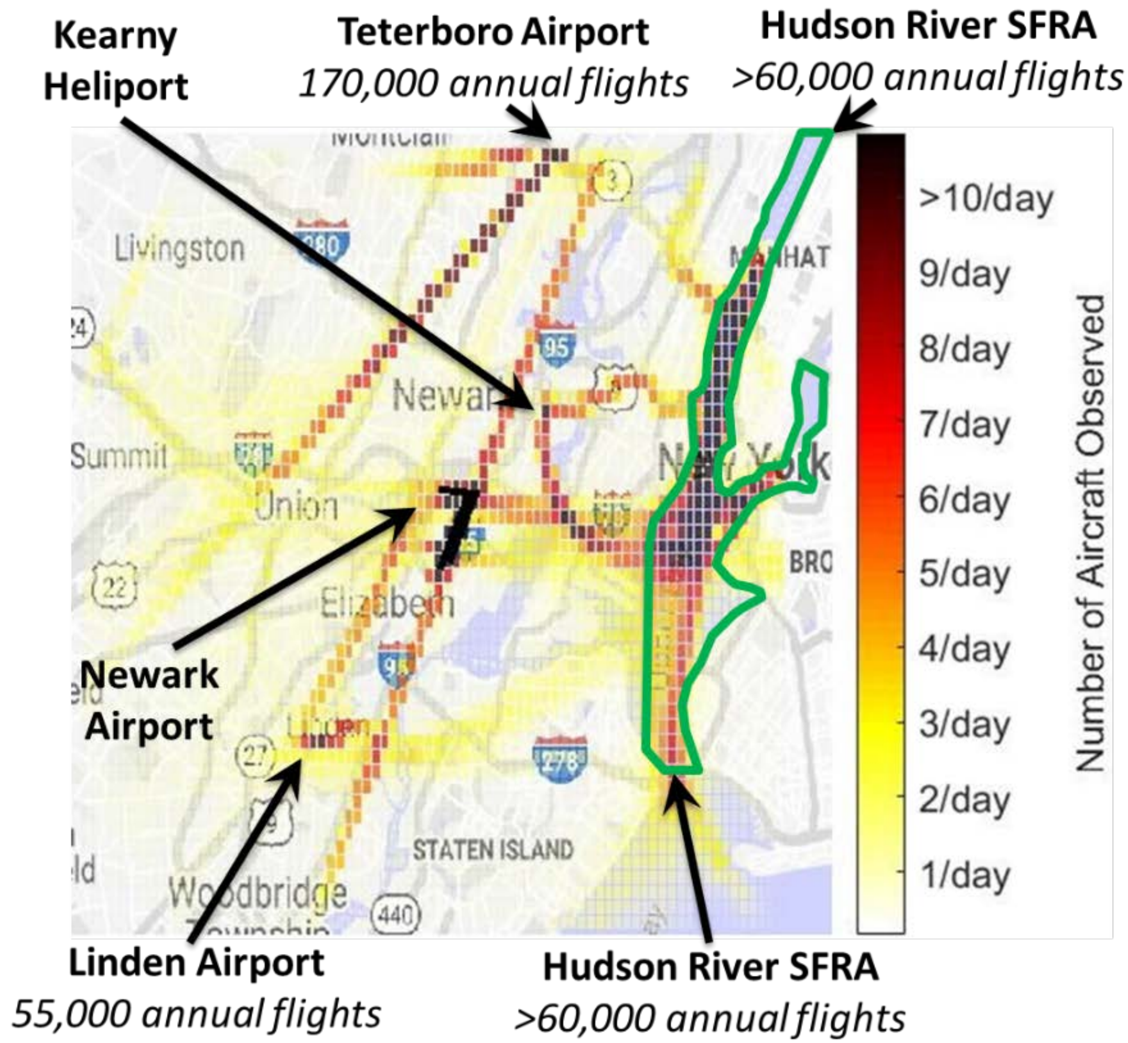
Aircraft Involved	Lateral Separation Req.	Vertical Separation Req.	Longitudinal Separation Req.
IFR to IFR *All classes*	3 NM	1000 ft	up to 8 NM
IFR to VFR *Class: B,C*	Radar Target Resolution	500 ft	up to 8 NM
IFR to Obstruction	3 NM	1000 ft	N/A
Tower or Pilot Visual Separation *Class: B,C,D*	"pass well clear" "see and avoid"	"pass well clear" "see and avoid"	"see and avoid"

BOS Runway 4R IFR Separation Zone



Controlled Airspace Cutout Example
New York SFRA Example





Impact of ATC Scenarios on Magnitude of Constraint

San Francisco MSA

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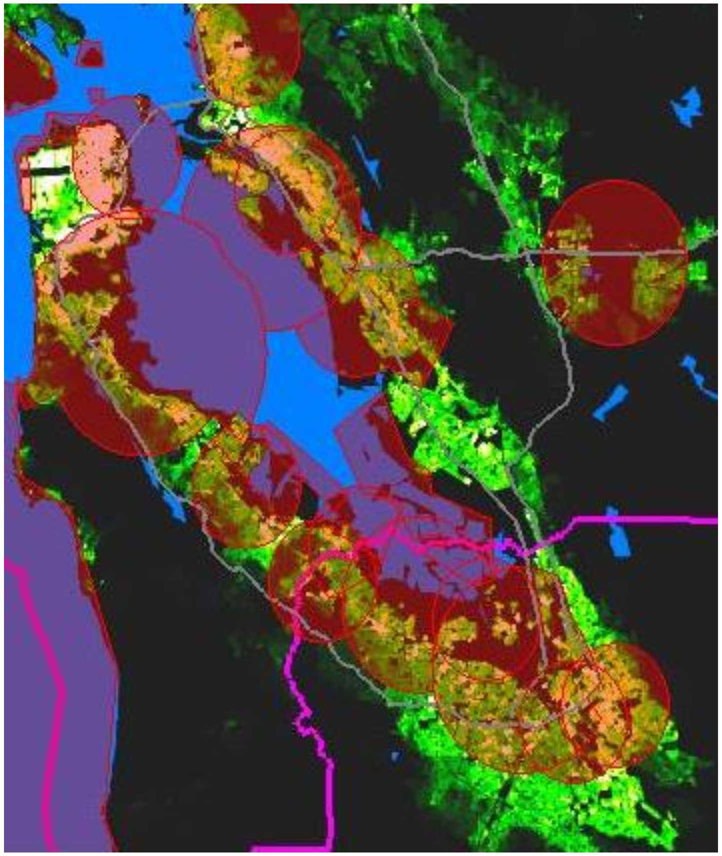
Fully Segregated



Accessible Population: 48%
Accessible Commuter Residences: 57%
Accessible Commuter Workplaces: 24%

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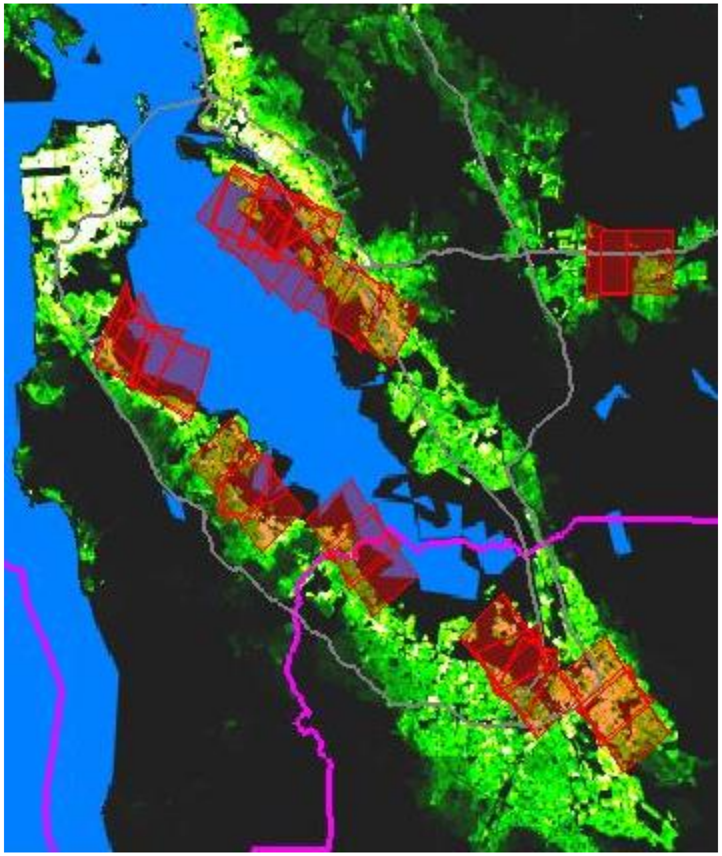
Static VFR Cutout & SUA Access



Accessible Population: 86%
Accessible Commuter Residences: 90%
Accessible Commuter Workplaces: 86%

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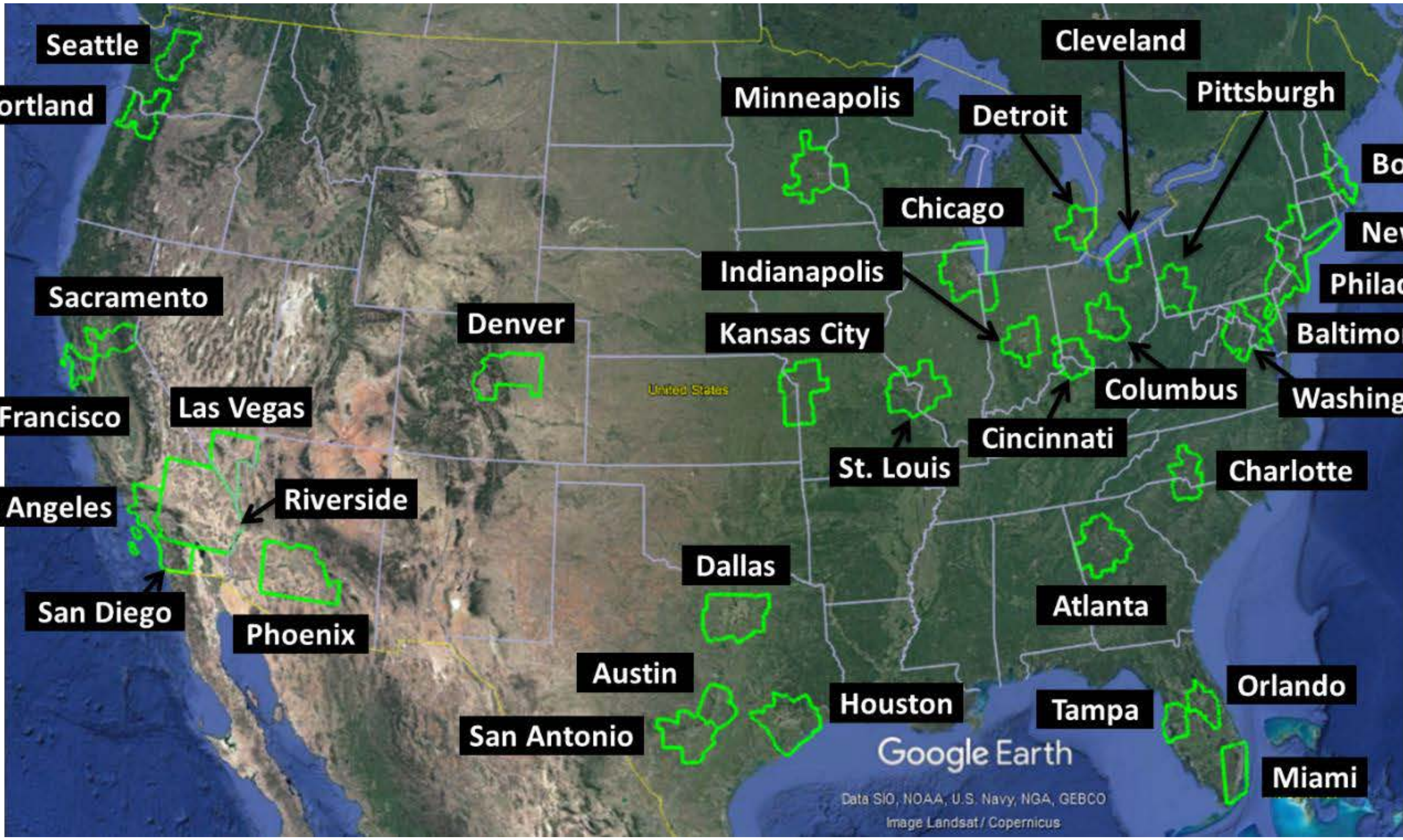
ATC Restriction Analysis of US Major Metropolitan Statistical Areas



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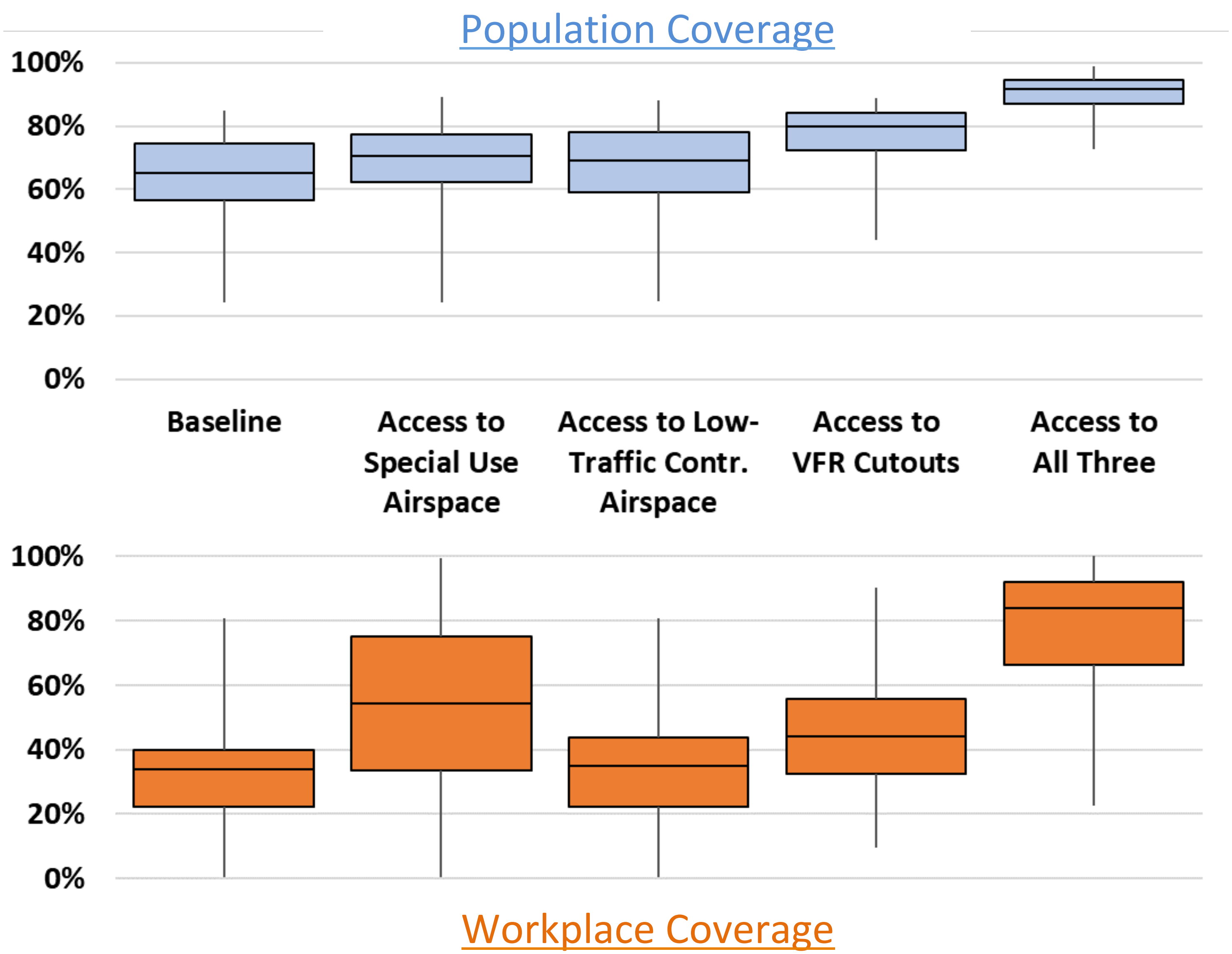

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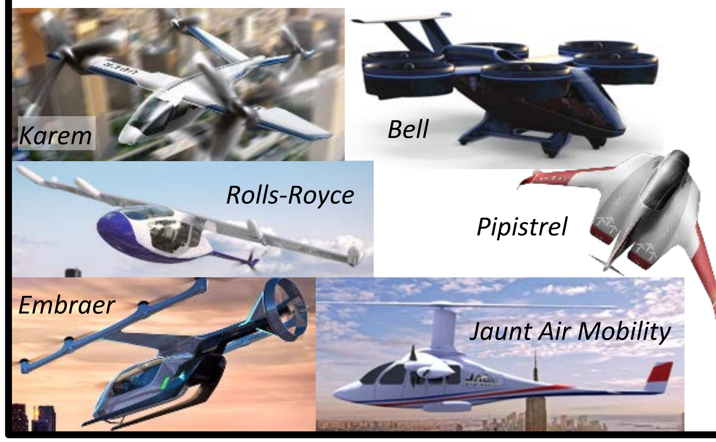

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Broad Range of Vehicle Architectures

	Rotor Lift	Actuating Hybrid Lift	Static Hybrid Lift	Wing Lift
Few Propulsors (1-3)	 google.com Helicopter	 elytronaircraft.com Tilt-lift	 cartercopters.com Static Hybrid	 pipistrel.si Fixed Wing
	Rotorcraft			
Many Propulsors (4+)	 volocopter.com Multirotor	 jobyaviation.com DEP Tilt-lift	 aurora.aero Stopped Rotor	 nasa.gov DEP Fixed Wing
	Multirotor	**DEP Powered Lift**		**Fixed Wing**

Multirotor and DEP Powered Lift most widely proposed for UAM applications

Certification Challenges for Electric UAM Configurations

Risk Severity= Probability x Consequence
High, Medium, Low

   

Hazard Description	Multirotor	DEP Powered Lift	Rotorcraft	Fixed Wing
Common Mode Power Failure (Low-/High-Altitude)	High/High	High/Medium	Medium/Medium	Medium/ Medium
Battery Thermal Runaway	High	High	High	High
Battery Energy Uncertainty	High	High	Medium	Medium
Fly-By-Wire System Failure	High	High*	Low**	Low
Bird Strike	Medium	Medium	Medium	Medium
High-Level Autonomy Failure	High	High	High	High

The severity of some challenges changes with configurations

Hybrid Electric SSTOL Alternative

30% scale flight demonstrator of a 4 passenger, 2700 lb blown wing aircraft with <100 ft takeoff/landing distance

MIT Beaverworks Prototype

Vehicle designed and built by 16.82 class in SY 2018-2019

Subscale SSTOL Protoype

Flight demonstrator shows that high lift ($C_L > 10$)is achievable in real-world flight environment but that there are control challenges to be addressed.

UAM V1