

**DRONE ENABLE**

**ICAO's Unmanned Aircraft Systems (UAS) Industry Symposium (UAS2017)**

**Friday, 22 September, 2017 @ ICAO HQ, Montreal, Canada**

**Session: UTM – A common framework with core boundaries for global harmonization**

# Framework for urban Traffic Management of Unmanned Aircraft System (uTM-UAS)

*presented by*

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**Collaborators**

**AGI, M1, Nova Systems**



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# Agenda

**1. Introduction**

**2. Motivation**

**3. Signature of Singapore's Urban Infrastructure**

**4. Proposed UTM Framework**

**5. A Singapore Case Study**

**6. Summary**



# Introduction

To define a Framework for an **urban** Traffic Management (uTM) System to operate Unmanned Aircraft Systems (UAS) effectively, safely and efficiently



# Motivation

- Growing demands for UAV operations by government agencies, recreational and commercial users
- Government Initiatives: Future Smart City & Future Mobility (unmanned systems, including UAVs); Singapore: Garden City with 100% urbanized; area: 720 km<sup>2</sup>; population: 5.6+ million)

## Building a SMART CITY

A slew of initiatives are taking place islandwide, the goal of which is to sharpen the Government's response to city issues and hence improve people's day-to-day lives.

**TOWN PLANNING**  
**What:** A modelling system to simulate a city's built environment and its impact on the natural environment, people, resources and costs.  
**Who:** HDB, Electricite de France, Veolia  
**Uses:** Among other things, show how different land uses affect amenities and transport networks; how to design new housing blocks to get ideal wind flow; where best to build cycling paths  
**Status:** Research collaboration / prototype stage

**WATER QUALITY AND LEAKS**  
**What:** A network of wireless sensors that monitors water quality and detects leaks in real time.  
**Who:** PUB, Singapore-MIT Alliance for Research and Technology, Vient  
**Uses:** Allows PUB to repair leaks faster and reduce water loss  
**Status:** About 300 sensors installed by end-2015

**3D MAPPING**  
**What:** Mapping the country in 3D from the air by using light planes equipped with lasers and cameras.  
**Who:** Singapore Land Authority  
**Uses:** PUB could use the map to model flood patterns, while the Civil Aviation Authority of Singapore could plan more efficient landing paths for planes  
**Status:** Expected to be completed by 2016

**DISEASE AND HYGIENE**  
**What:** Computer models that use sensors and mobile apps to help detect and forestall dengue and food poisoning outbreaks.  
**Who:** National Environment Agency (NEA), IBM  
**Uses:** For example, if people complain on Facebook or Twitter of being sick after eating at a particular restaurant, the system would alert NEA officers  
**Status:** Research collaboration

**IMPROVING PUBLIC TRANSPORT**  
**What:** Analysing CCTV video feeds and anonymised location-based data from mobile subscribers to learn commuters' travel patterns  
**Who:** Land Transport Authority, SMART, StarHub, IBM  
**Uses:** Help agencies respond better to unplanned incidents on the train and bus network, such as breakdowns or emergencies  
**Status:** Research collaboration

**ERP II**  
**What:** A satellite-based electronic road pricing (ERP) system that can use an on-board monitor to charge motorists according to distance travelled  
**Who:** Land Transport Authority, IBM  
**Uses:** This may replace the current system, which charges motorists each time they pass through an ERP gantry during certain times  
**Status:** Feasibility being studied

**SECURITY**  
**What:** A public-private Safe City Test Bed that produced, for example, a mobile app for commanders to track security forces in real time  
**Who:** Economic Development Board, Ministry of Home Affairs, ACG International, Airbus Defence and Space, NCS, NEC Asia Pacific  
**Uses:** Could help commanders respond to incidents more quickly and precisely  
**Status:** Test bed completed

**JURONG LAKE DISTRICT - 'SMART CITY'**  
**What:** A government vision for the area to use smart technologies such as driverless cars to improve liveability for residents  
**Who:** Singapore Government, various partners  
**Uses:** For now, driverless cars will ply the Chinese and Japanese Gardens later this year. Expected to be used at Jurong East MRT next year  
**Status:** Ongoing

**PROTECTING THE SEA**  
**What:** Eight buoys along coastline with sensors that test waters for pollutants and send real-time updates wirelessly to the NEA  
**Who:** National Environment Agency (NEA)  
**Uses:** Early detection of oil or chemical spills  
**Status:** In place

NOTE: Artist's Impression  
 GRAPHICS: NIKKI M. O'CONNOR AND DAVID BE



# Drone Applications in Urban Environment

**Popular applications:**



**Videography**



**Surveillance**



**Inspection**



**Delivery**

**Future scenario: Multiple drones operated at the same time**



# Signature of Singapore Urban Infrastructure: Proposed Guidelines

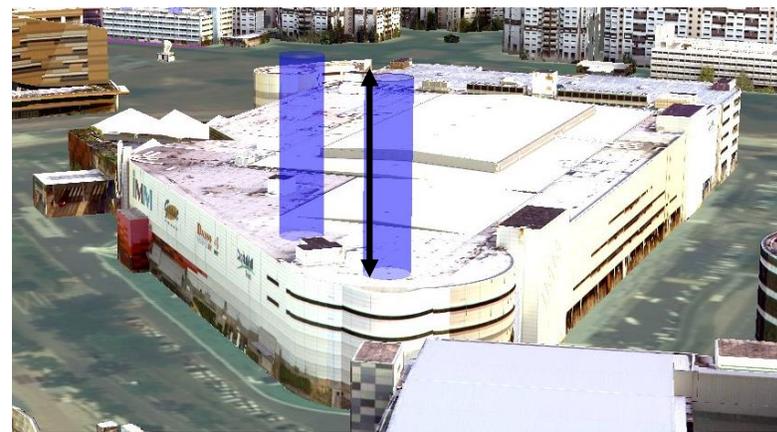


- Zoning of urban town in small areas (for efficient and effective management of drone operations)
- Retail area @ designated supply/delivering point
- Residential area @ designated demand/receiving point
  - Multi storey carpark
  - Open area

# Signature of Singapore Urban Infrastructure: Proposed Guidelines



- Zoning of urban areas
- Retail area @ designated supply/delivering point
- Residential area @ designated Radius of service coverage



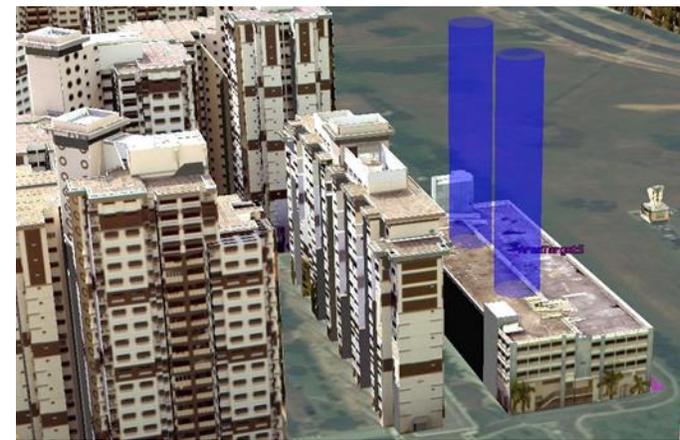
Height of **Take-off** and **Landing (ToLd)**: up to 60m (200ft)



**Distance** between Take-off and Landing (ToLd): **20m**

**Note: For cost-effective, make good use of existing urban infrastructure and facilities**

# Signature of Singapore Urban Infrastructure: Proposed Guidelines



Multi storey carpark



Open area

- Zoning of urban areas
- Retail area @ designated supply/delivering point
- Residential area @ designated demand/receiving point
  - Multi storey carpark
  - Open area
- Radius of service coverage

# Signature of Singapore Urban Infrastructure: Proposed Guidelines

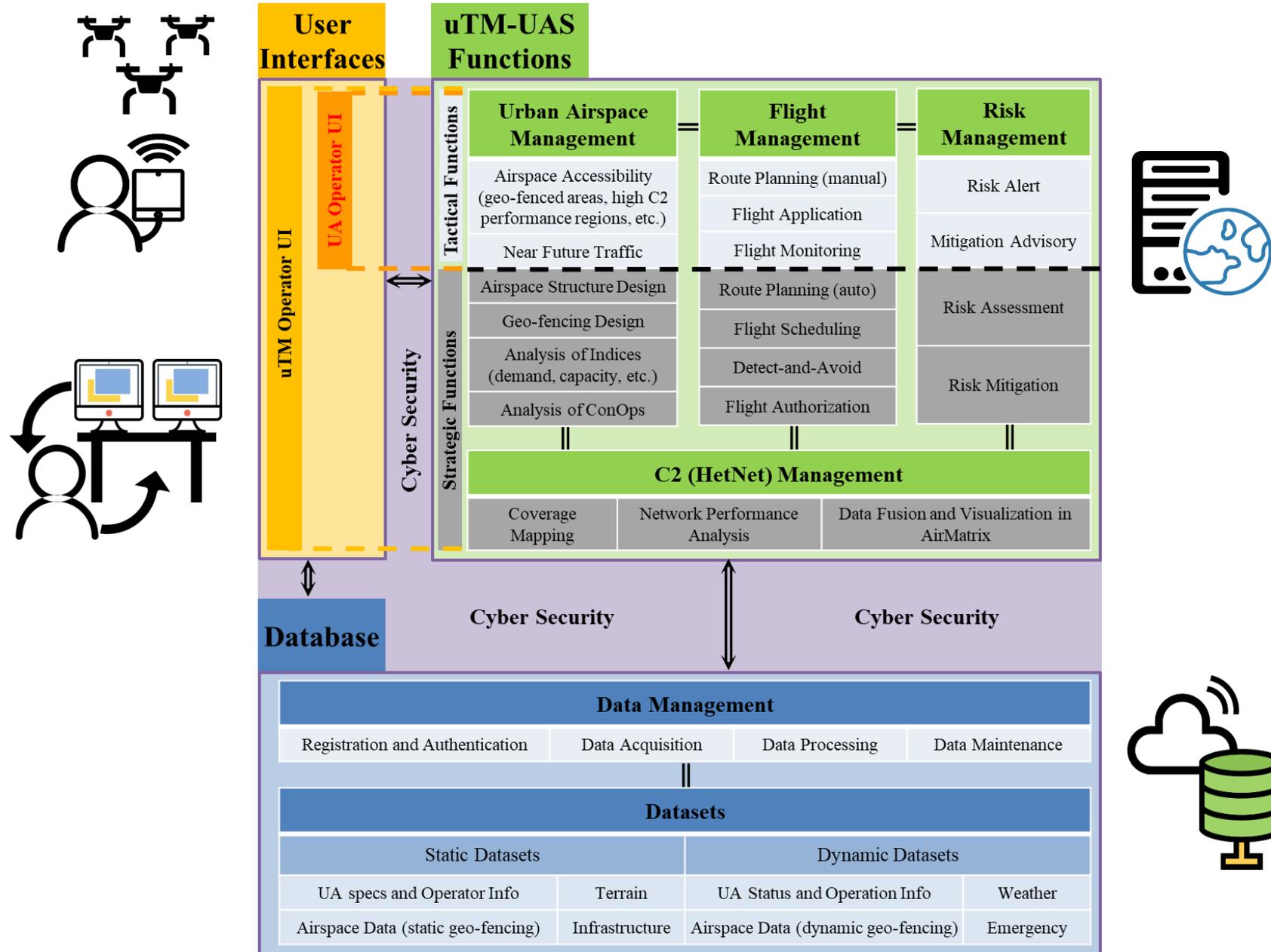


- Zoning of urban areas
- Retail area @ designated supply/delivering point
- Residential area @ designated demand/receiving point
  - Multi storey carpark
  - Open area
- Radius of service coverage

# Key Requirements for Urban UTM Framework

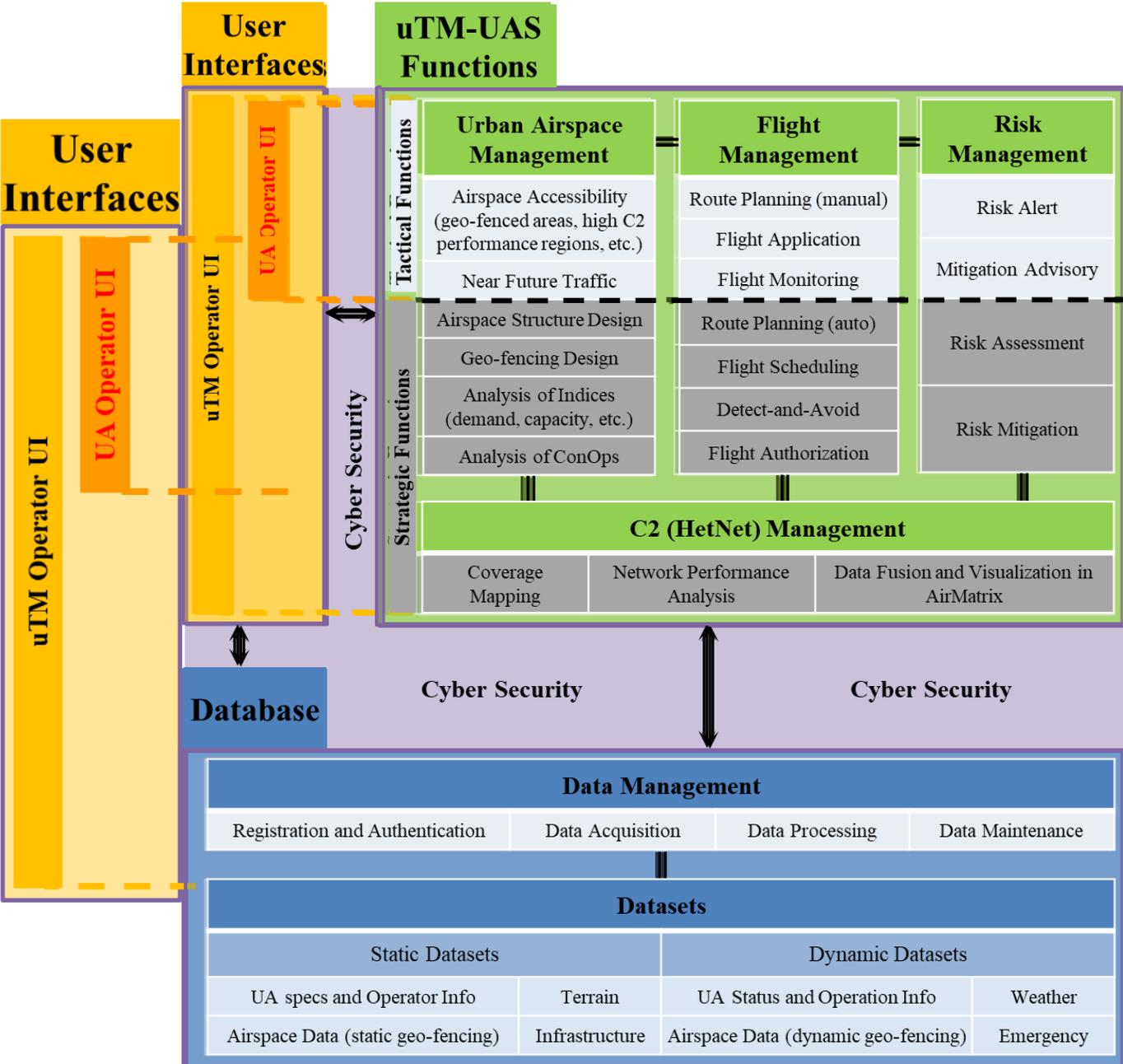
- **Reliable systems with essential functionality to ensure effective, safe, and efficient UAV Operations**
- **Flexible, dynamic and optimal airspace management developed specially for urban environment**
- **Enabling technologies, risk modelling and management required/suitable for urban environment**

# Proposed *Modular* UTM Framework

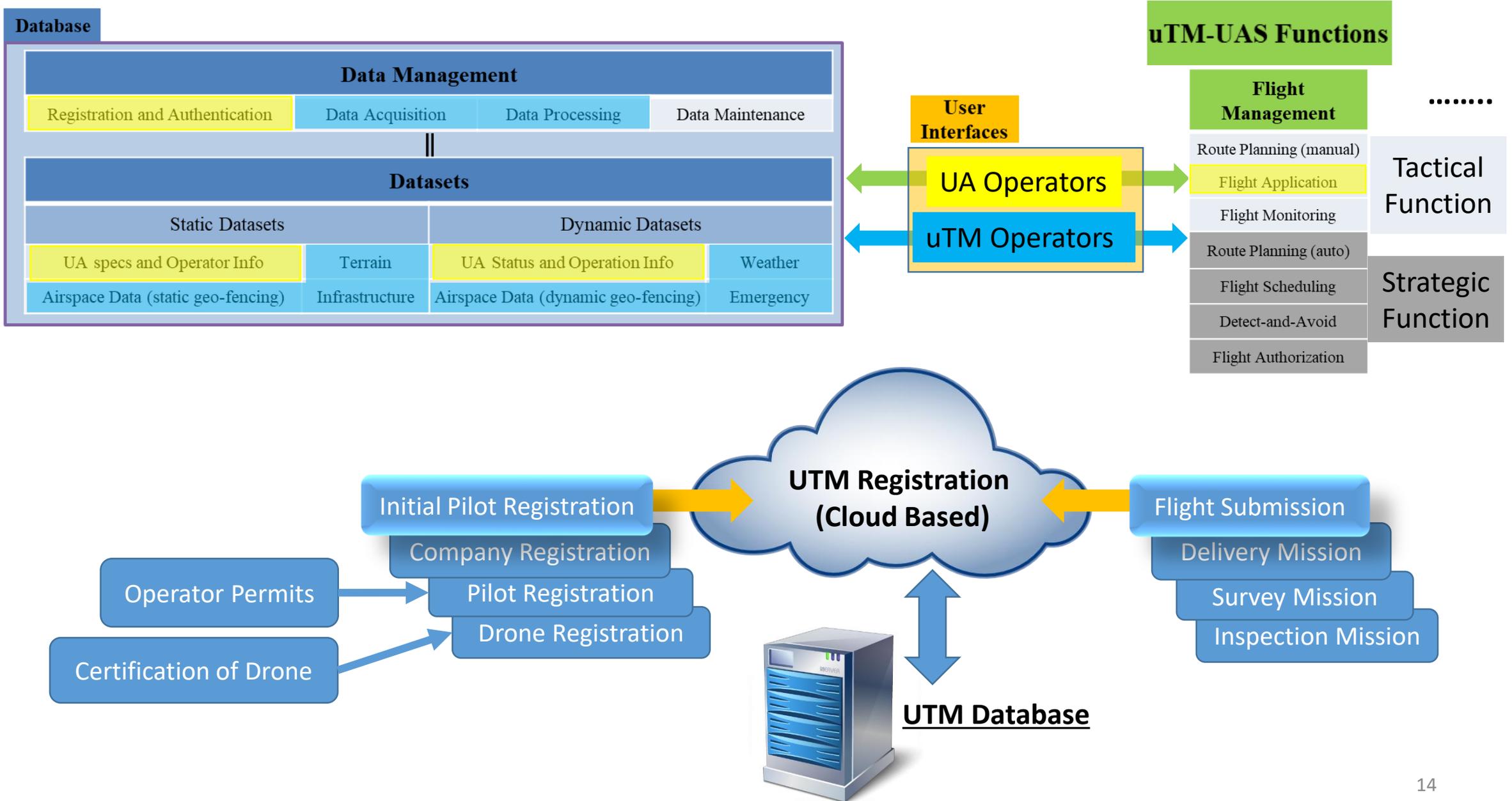


*Advantages of Modules:*  
 Different topics, areas, and sub-areas can be added and removed systematically for particular conditions, cases and applications considered.

# Proposed UTM System – Framework Structure

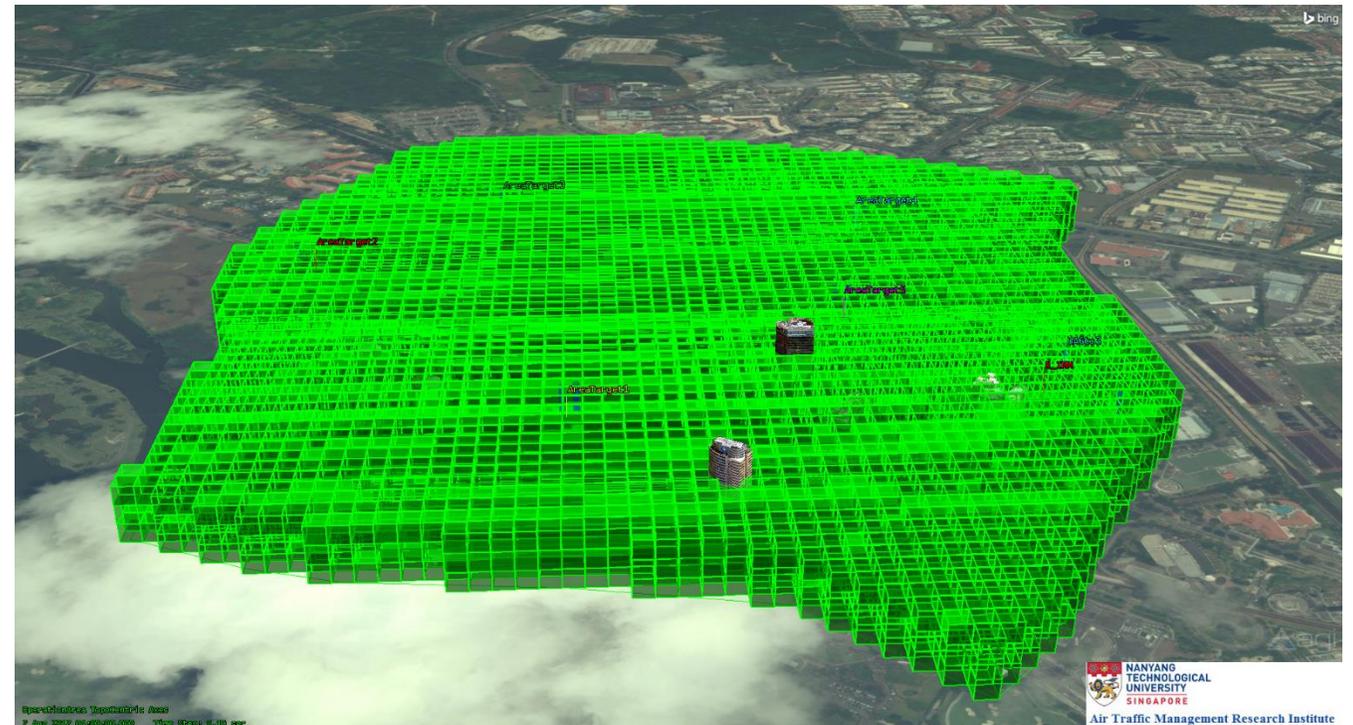
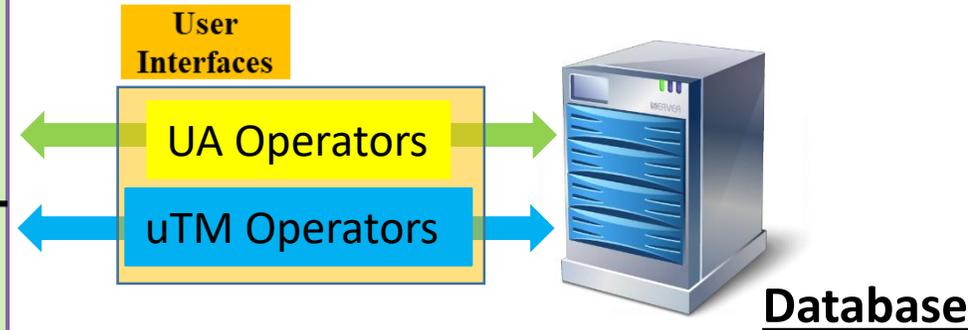
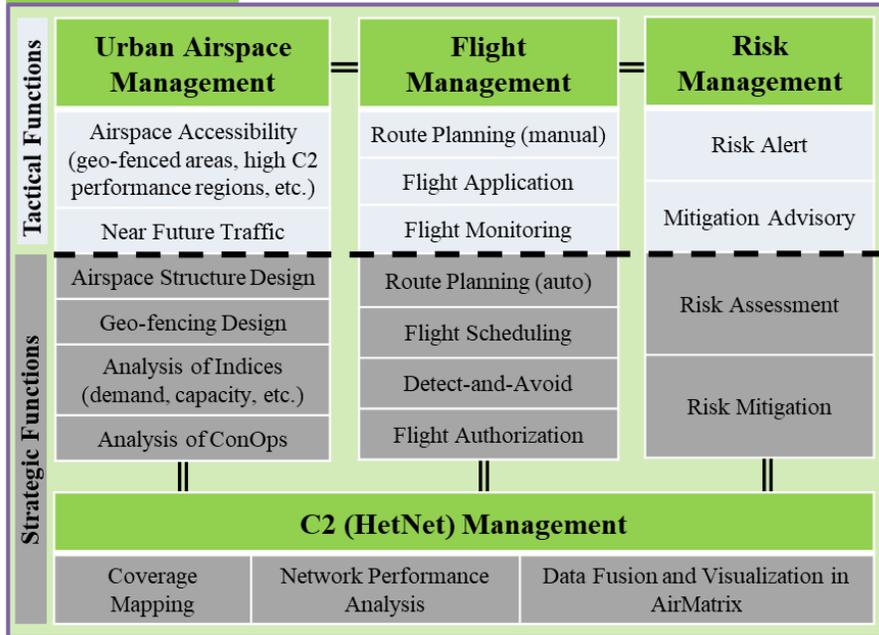


# Framework Structure – Database



# Framework Structure – uTM-UAS Functions

## uTM-UAS Functions

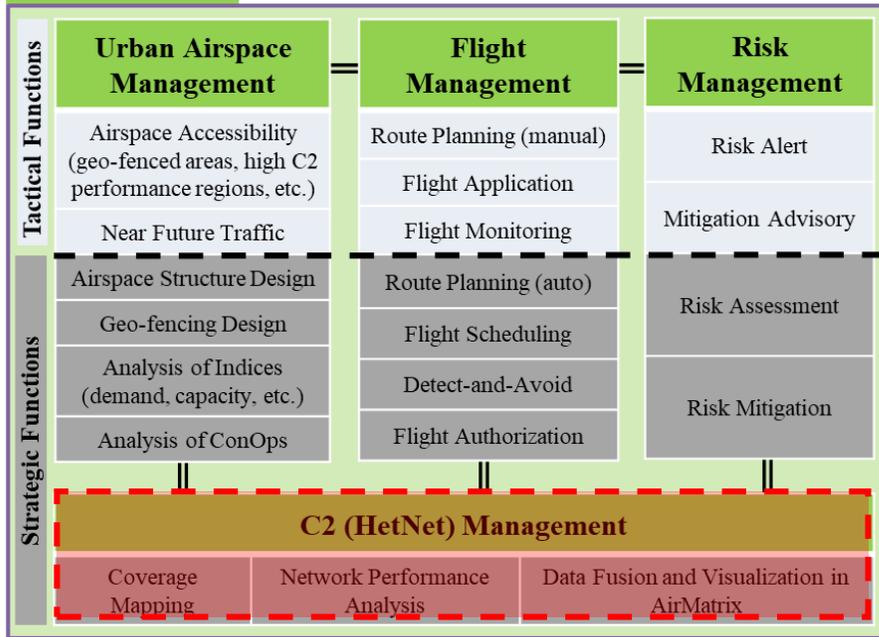


Proposed solutions for managing urban airspace: **AirMatrix**

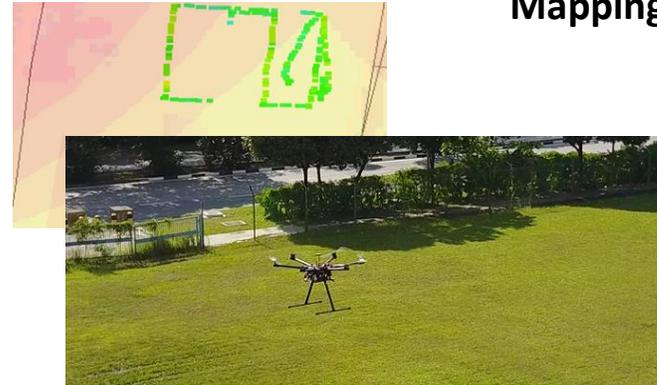
- Multi-layered in altitude
- *Airblocks* in latitude and longitude

# Framework Structure – C2 Management

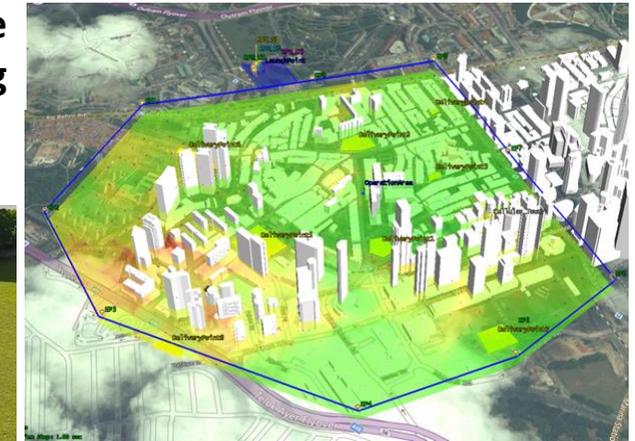
## uTM-UAS Functions



## Actual Flight Validation



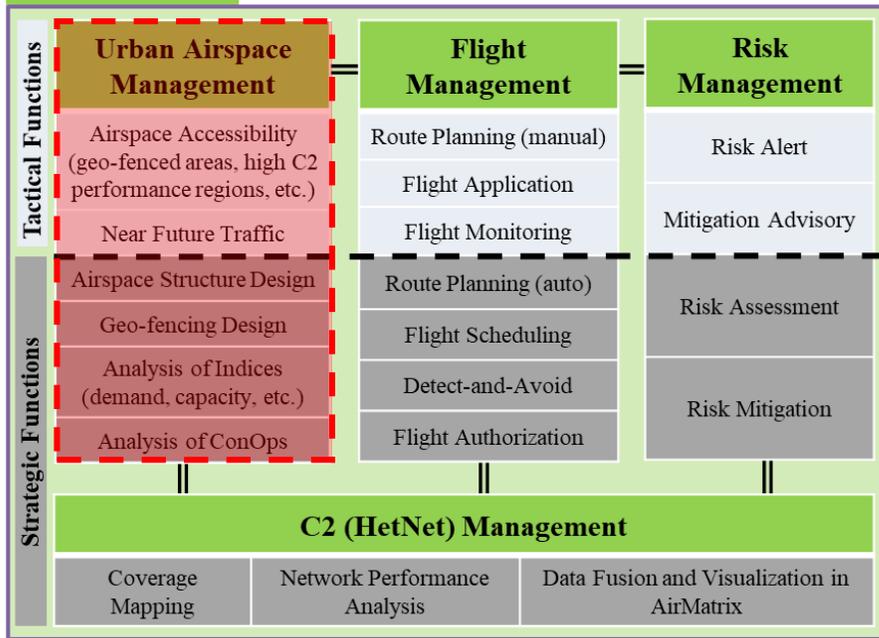
## Coverage Mapping



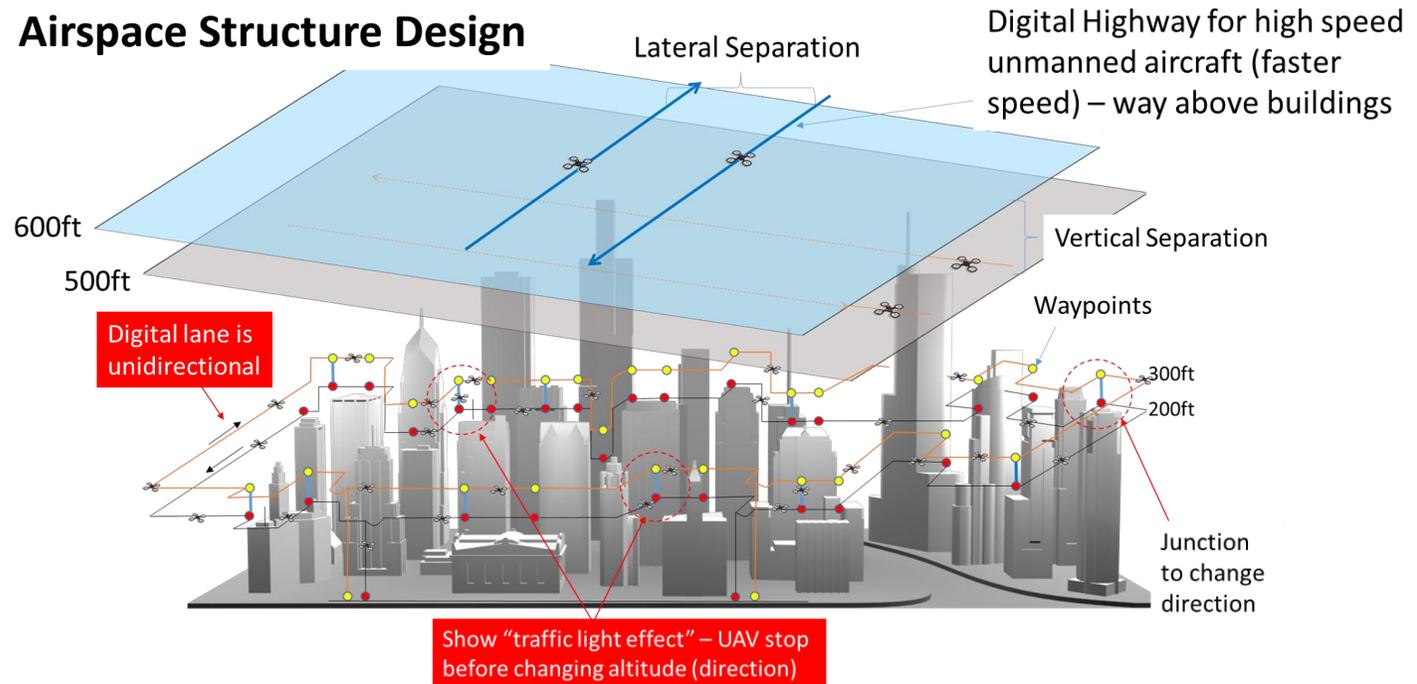
- Able to analyse *coverage mapping* based on real network data performance
- Able to determine the performance of individual airblocks
- Provide a reference for the function of uTM-UAS modules

# Framework Structure – Urban Airspace Management

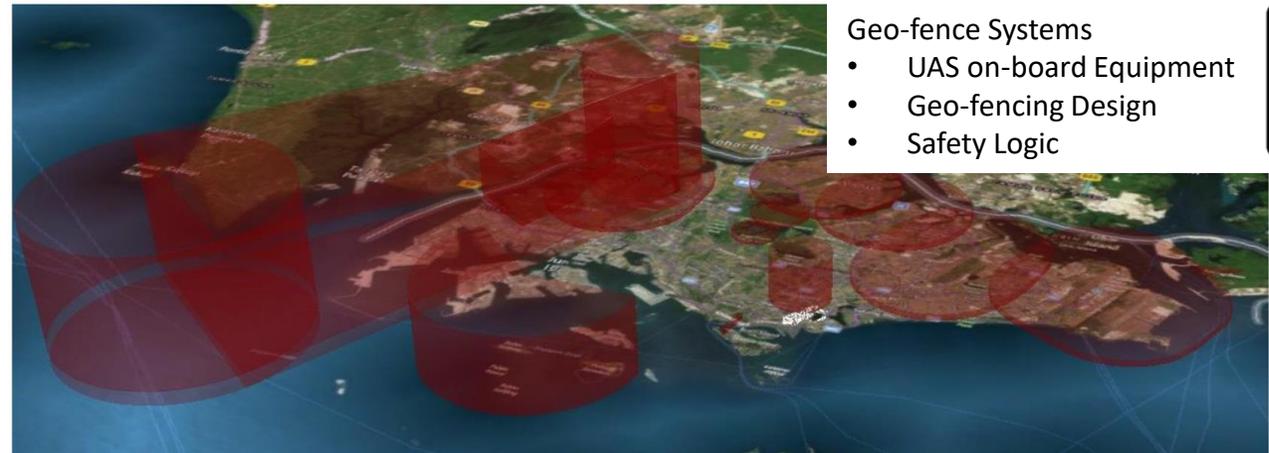
## uTM-UAS Functions



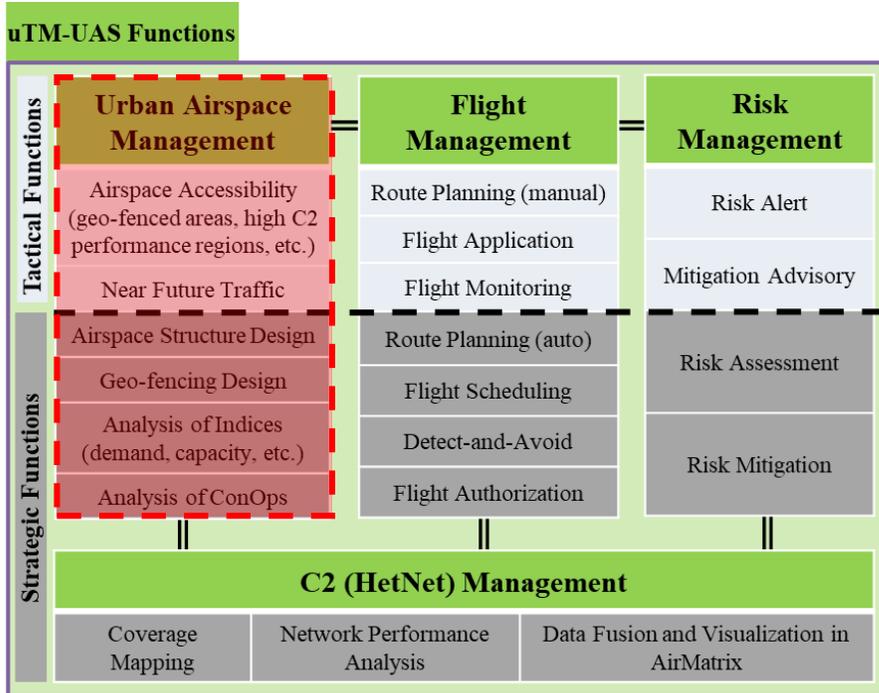
## Airspace Structure Design



- Allow uTM operators to study and design different airspace structures
- Allow the extraction of essential geometric data for analytical studies



# Framework Structure – Urban Airspace Management



## Analytical Study of Capacity

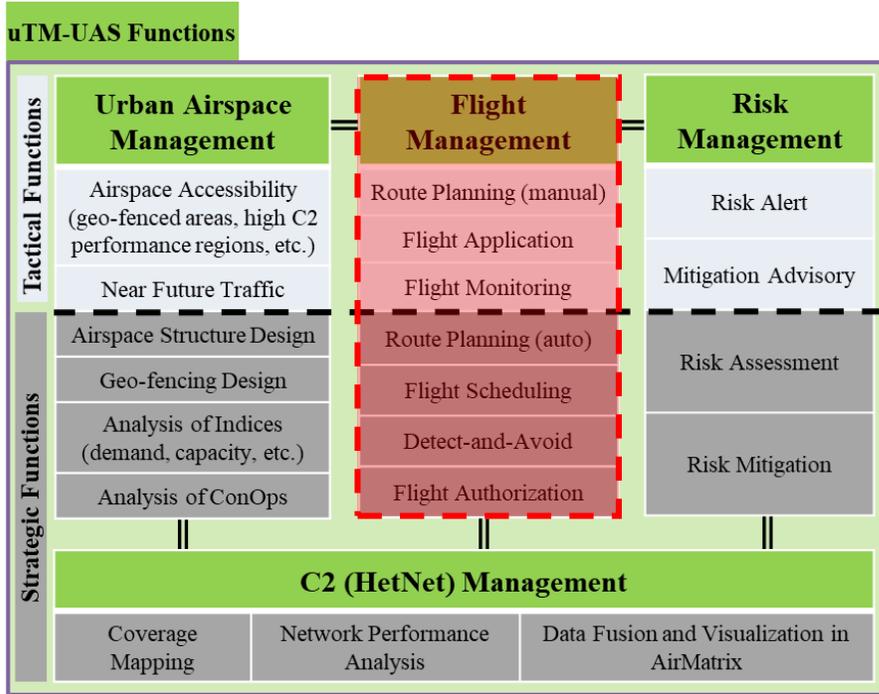
Distance from Supply Area to Service Area 1 & Service Area 2: 1.3 km & 2 km, respectively

- Allow uTM operators to study and design different airspace structures
- Allow the extraction of essential geometric data for analytical studies
- Able to simulate traffic of UAS operations and to study airspace performance, such as capacity, efficiency and safety

- Performance of UA
- Separation requirements
- Reaction time (similar to car crash prevention analysis)

	Two Sec Reaction Time		50 ft Lateral Separation	
Service Area	1	2	1	2
Maximum Capacity from Supply to Service Areas	66	99	88	133
Maximum Capacity from Service to Supply Areas	92	104	123	139

# Framework Structure – Flight Management



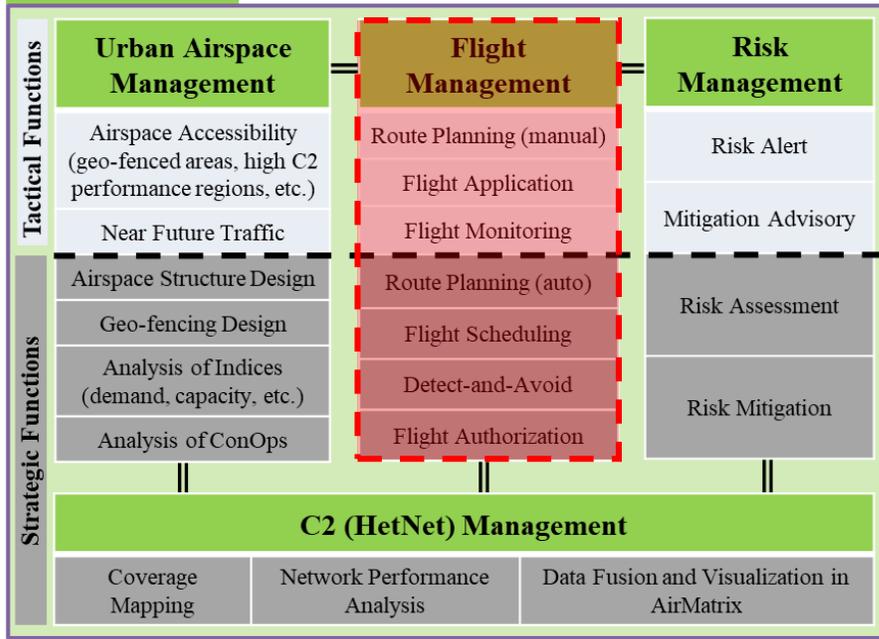
- Manage flight **planning** (airblocks, well-clear consideration etc.)

## Route Planning



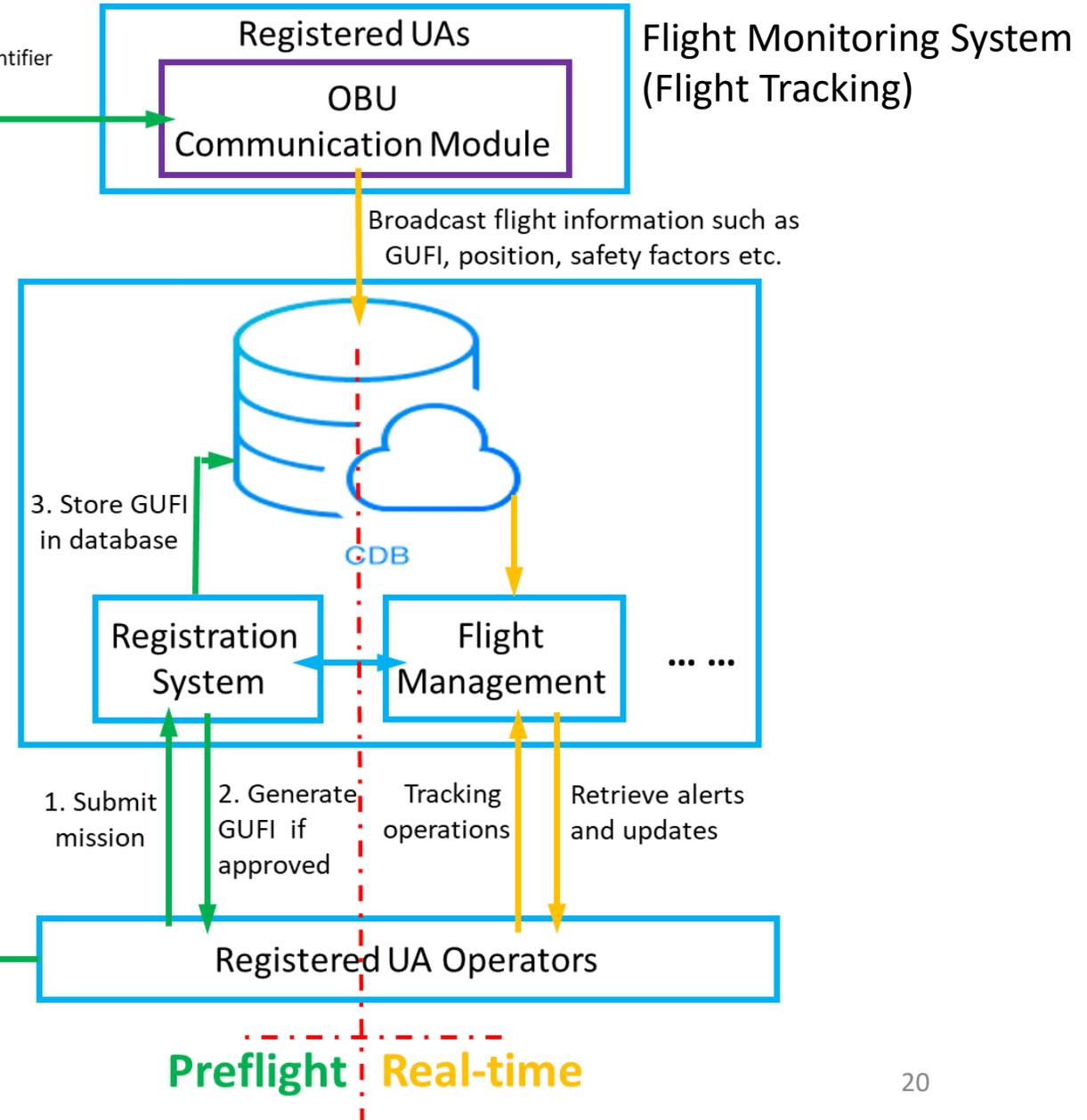
# Framework Structure – Flight Management

## uTM-UAS Functions



OBU: On Board Unit  
 GUF: Global Unique Flight Identifier  
 CDB : Cloud Data Base

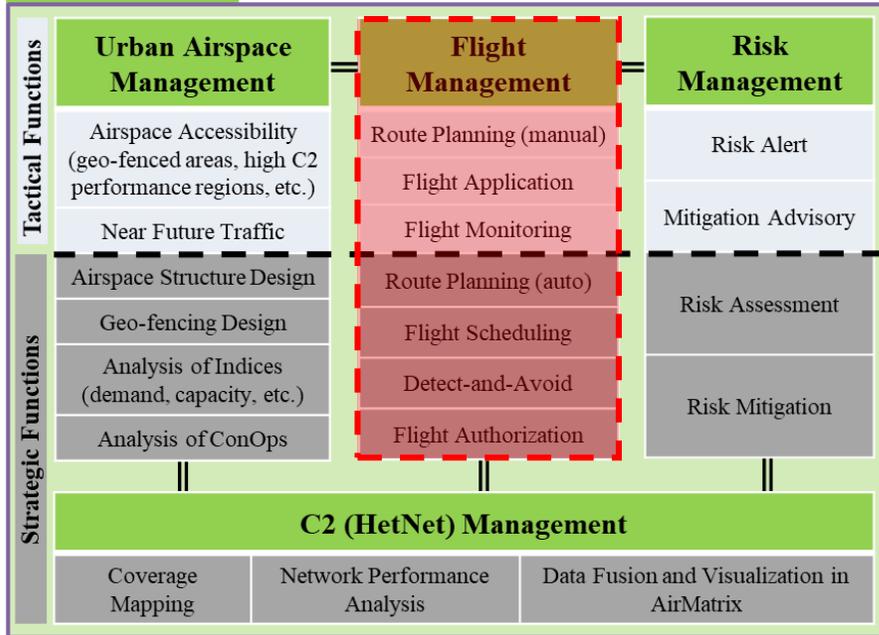
3. Initialize OBU with assigned GUF



- Manage flight **tracking** (monitoring system)

# Framework Structure – Flight Management

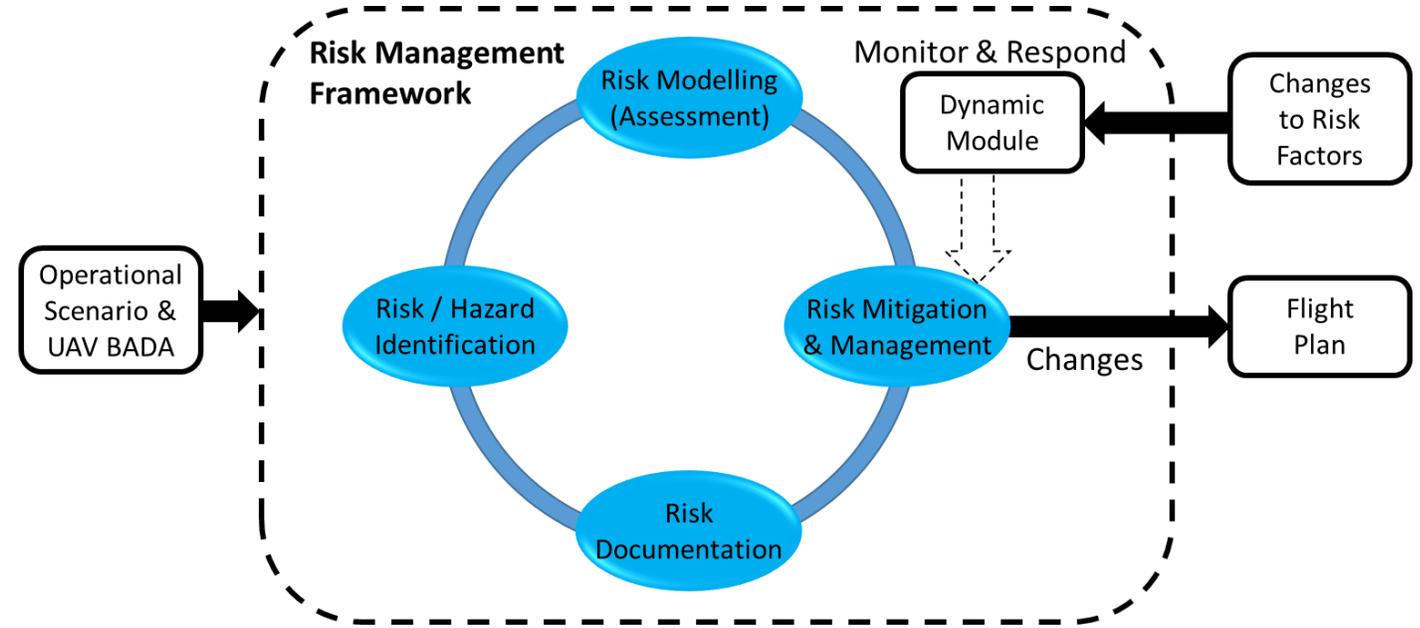
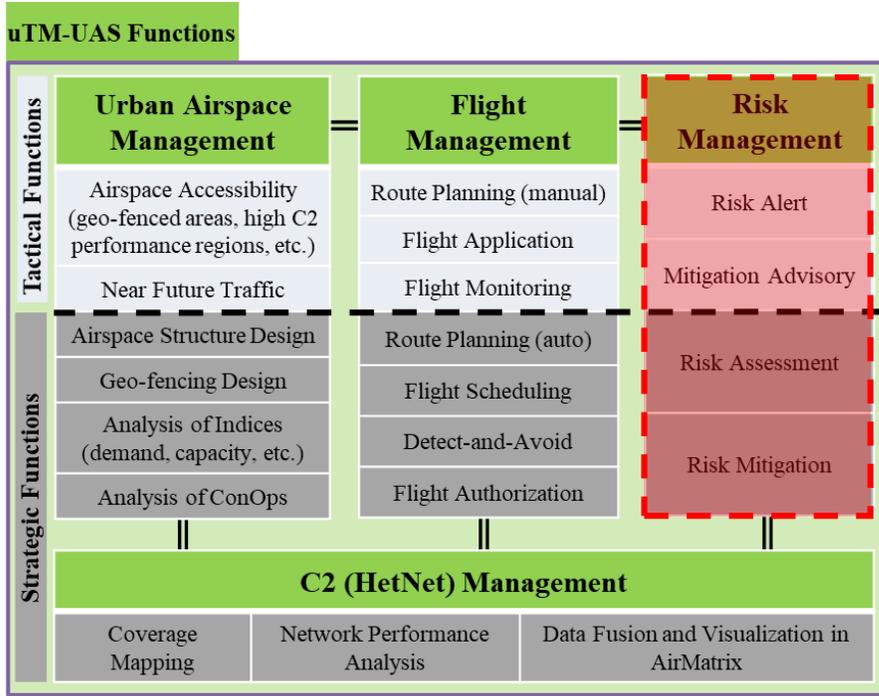
## uTM-UAS Functions



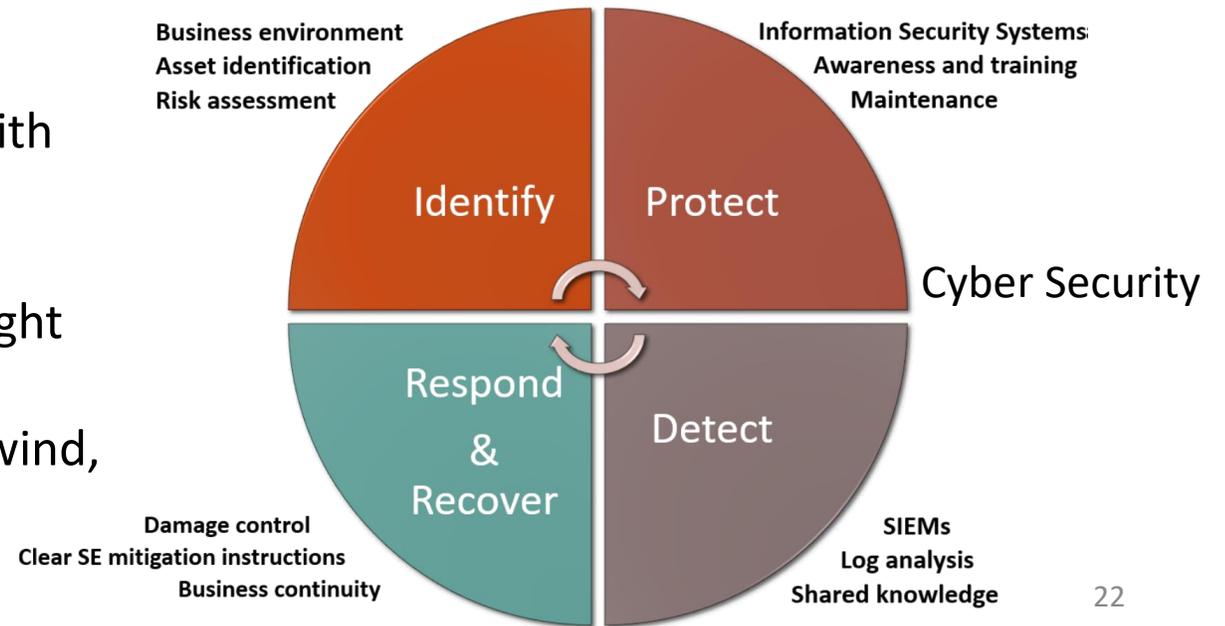
- Manage flight planning and tracking
- Allow optimal route to be developed through route planning function
- Enable live data of flight operations streamed back to database and display in UI for flight monitoring



# Framework Structure – Risk Management



- Estimate and quantify the risk of UAV operations with risk mitigation for different applications
- Able to estimate various risks associated with UA platform, for example, risk assessment by UAV Weight Threshold Study by NTU
- Allow on-line monitoring for various risks (such as wind, rain etc.); provide alerts and advice to all operators



# A Singapore Case Study

 [Home](#) [Flights](#) **[Drones](#)** [Pilots](#) [Account](#) UA Operator - Registration

## Drones

Model	Name	Reference	Expiry	Status
DJI Inspire 1 Pro	Surveillance-A1	339568	22 Sep 2017	Approved
3DR Iris+	Delivery-D1	6624135		Approved
DJI S900	Photo-1	583BDG	03 Jan 2017	Submitted for Approval

### Add a new drone

**Model**

—

**Drone name**

Drone name

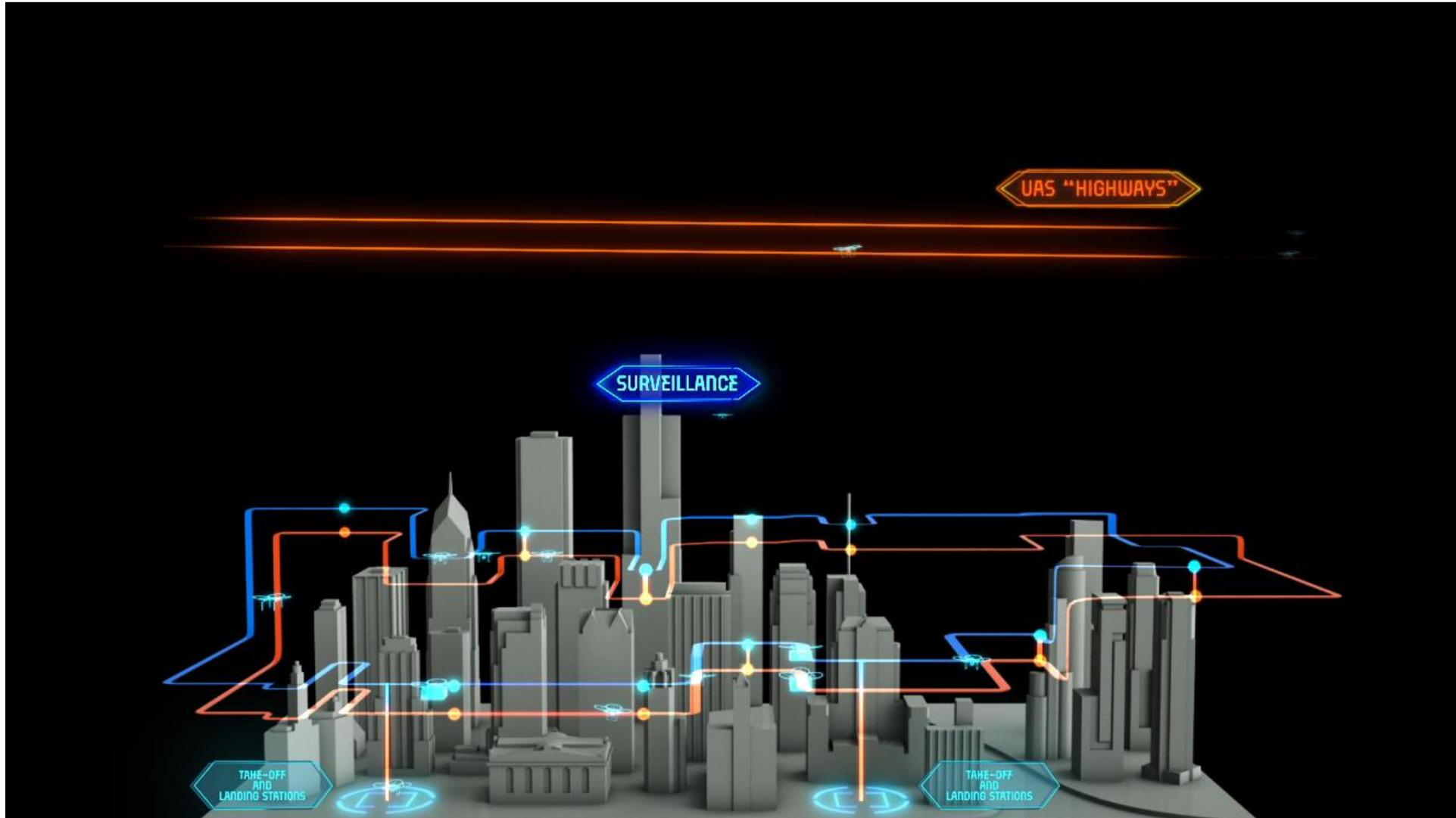
**Drone reference**

Drone reference

**Drone expiry**

[+ Add drone](#)

# Future *Urban* Drone Operations and Airspace Management (version: Sep 2017)



**Main features of drone operations:**

- Dynamic airspace planning
- UAS Highways for inter-zone UAV operations

# Summary

## Effectiveness

- Provided a modular framework with structured workflows
- Developed a system of systems that can communicate among different modules
- Covered *Tactical* and *Strategic* functions for detailed studies and considered other factors, such as cybersecurity, privacy & noise

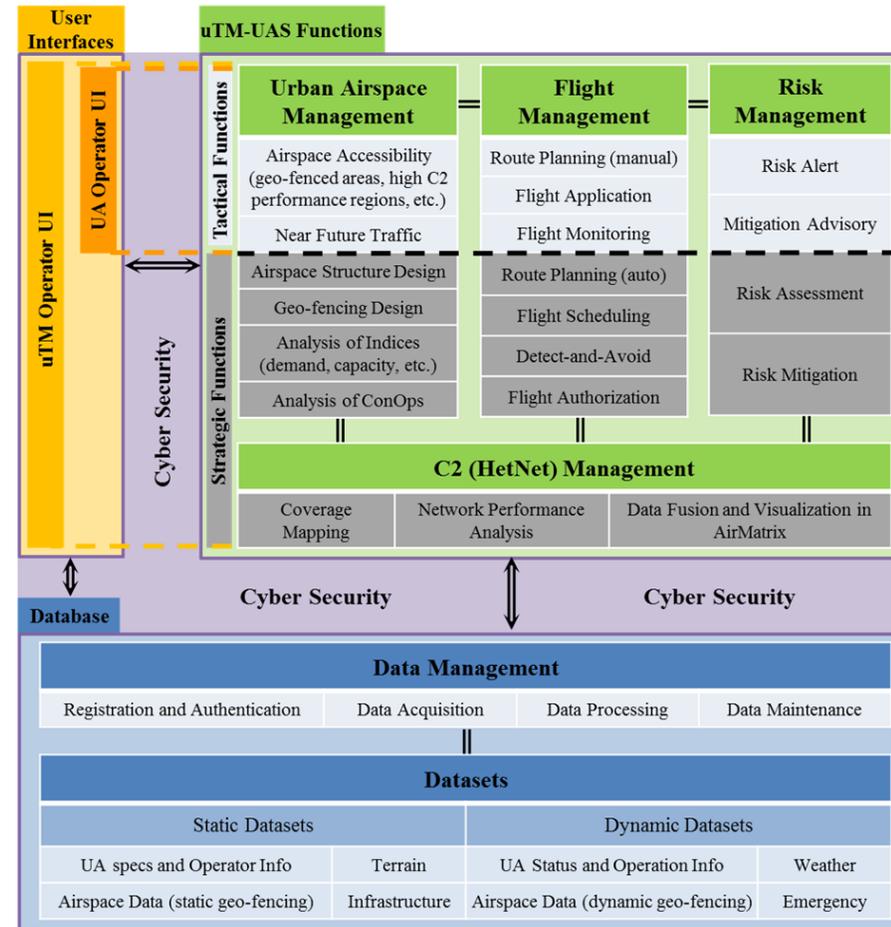
## Safety

- Developed a risk management module to ensure all possible risks have been taken into account
- Explored geo-fence safety logic to ensure safe UAV operations
- Covered enabling technologies such as DAA that can be deployed as a safety enabler for UAV operations

## Efficiency

- To provide a detailed analysis of the airspace performance by using the proposed AirMatrix formed by Airblocks
- To analyze demand & capacity to ensure efficient traffic flow of UAVs
- To self-generate optimized route(s) for UAV operations

## Modular UTM Framework (version: July 2017)



## **A Further Note ....**

- **A developed modular framework presented in its first version; further revision and expansion are possible by the enhancement and validation of technologies and ConOps**
- **Research and development programme not only focusing enabling technologies (C2, DAA, Geofence etc.), but also emphasizing urban traffic management, risk management, capacity planning and dynamic routes**
- **A “huge” and complex programme requiring more R &D works in collaborate with industry, regulators; working, understand and learning from each other**

# Thank You for Your Attention 😊

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