European Innovation Day
October 15, 2018, 16:45–17:45
EU Delegation Tokyo

Research to Market Session 5

 # Artificial Intelligence
 # Automated Vehicles
 # Aeronautics

From Flying Cameras to Flying Cars

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Unmanned Aircraft System Traffic Management (UTM) System

Our Vision

- Automation of UTM System

Our Focus

- Design, specification, and simulation of entire UTM System – with special consideration of pre-flight and in-flight CDR (Conflict Detection and Resolution) methods
- Experimentation of advanced CDR methods in the real world

Real-Time System (IT)

- Design and implementation of highly complex distributed systems (→ UTM System)
- 3D Visualization and Simulation
- Human-Machine Interface

Hardware (Robotics)

- UAV ("drone")

We buy off-the-shelf components

- "Flying Car" (passenger drone)

Not our topic

Artificial Intelligence (IT)

- Deep Learning algorithms
- Algorithms for pre-flight CDR
- Algorithms for in-flight CDR

Markets for Camera Drones and Passenger/Cargo Drones

Camera Drones

1. Energy/**Infrastructure Inspection**
2. Agriculture and Forestry
3. Site/Layout Planning: Construction Sector
4. Environmental Protection
5. **Emergency Response** and Police
6. **Security**
7. Film and Photography
8. Development Aid

Use of UAV for environmental purpose (**5**); Source: Avinc

Police applications of UAVs (**6**); Source: Telegraph, Falcon-UAV

UAV application in agriculture (**3**); Source: vespadrones.com

Inspection of offshore wind power plants in the North Sea (**2**); Source: Blog Zeit

Matternet field test in Haiti (**8**); Source: SkyDev.net

Cargo Drones

1. Delivery
2. **Mobility**

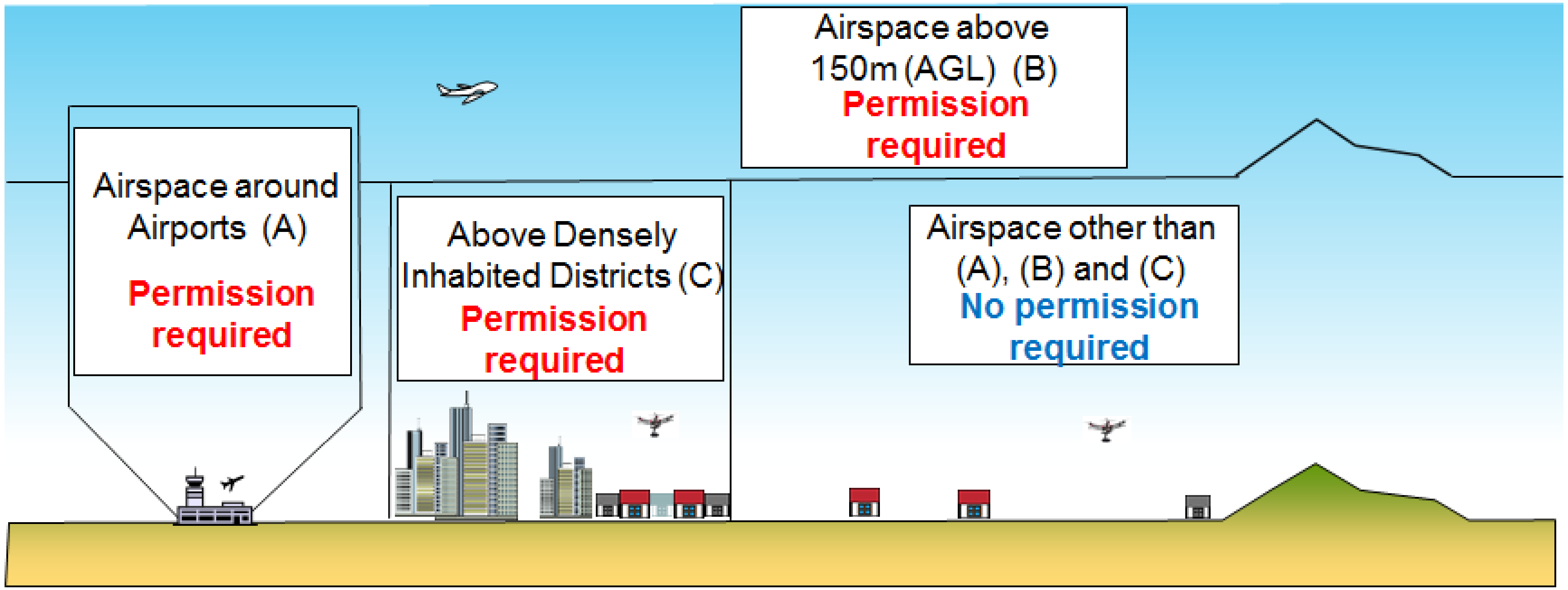
CART!VATOR (Toyota etc.)

Delivery (**1**); Source: DHL

Slide source: "Unmanned Aerial Vehicles in Logistics: A DHL perspective on implications and use cases for the logistics industry"

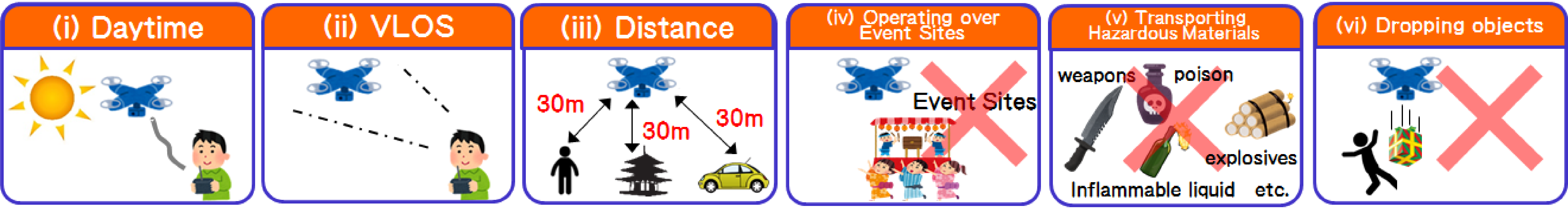
Japan’s Safety Rules on Unmanned Aircraft/Drone by MLIT

Amendment to the Aeronautical Act issued on Sep. 11, 2015



Conceptual Airspace

Operating Limitations



http://www.mlit.go.jp/en/koku/uas.html

Research for Camera Drone Applications

Deep Learning

Pixel-wise labeling of input video frame based on Fully Convolutional Networks (FCN)

Why Deep Learning works (now) ?

① Computing Power:

Drastically increased chip processing abilities (GPU: Graphical Processing Unit) for **training** neural networks
> 8 TFLOPs

1000 GFLOPS = 1 TFLOPS:
1 trillion floating-point operations per second
(1,000,000,000,000)

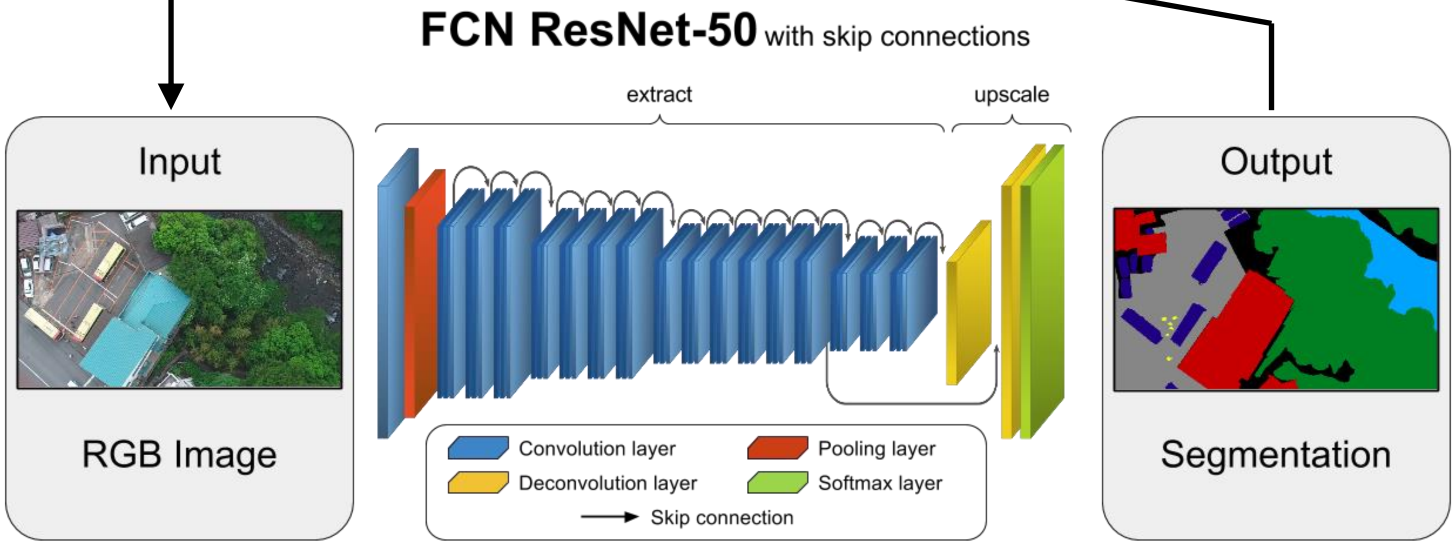
② Big Data:

Significantly increased size of data sets used for training, e.g. ImageNet (14,000,000 images)

③ Advances in DL:

New DL architectures and advances in algorithms

Input video frame by frame



“Human-Centered Situation Awareness Platform for Disaster Response and Recovery”

国立情報学研究所 National Institute of Informatics

JST-NSF Project “Big Data and Disaster”

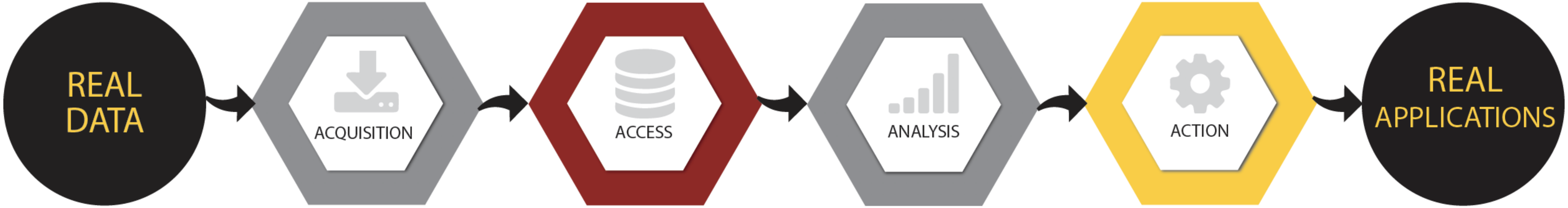
(FY2014 – FY2016)

USC University of Southern California

Video footage from Okutama, Japan

USC MediaQ, AWS

UAV-based Real-time Disaster Response System



DJI Matrice 100

- Video by **Unmanned Aerial Vehicles (UAVs)**
- Efficient and safe Big Data collection in wide area

Real-time video processing using **Deep Learning**

Formal **collaboration with Okutama** on disaster response, etc.

Situational Awareness and Dynamic Mapping (1/2)

Markets

- Real-time damage assessment for **Disaster Response**
- Real-time recognition of (geo-referenced) objects for Dynamic Mapping in **Construction**

Current situation ⟷ Historical situation

Compare current situation to historical situation

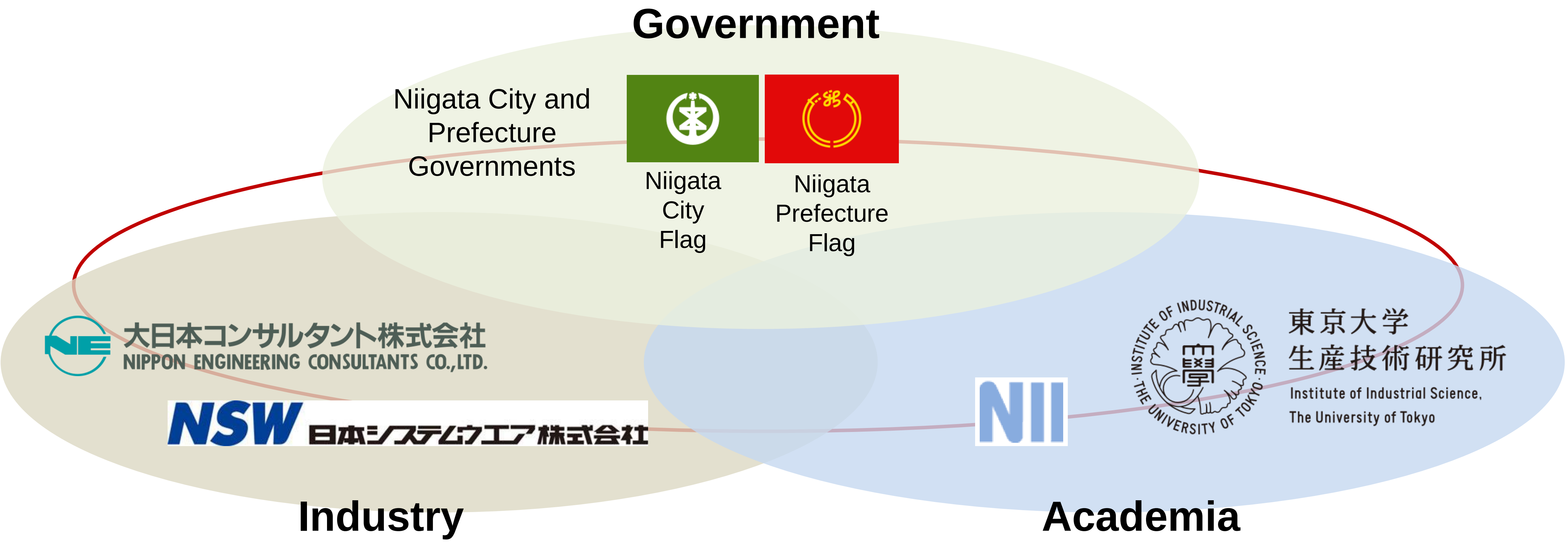
Situational Awareness and Dynamic Mapping (2/2)

Markets

- Real-time multi-person, multi-action recognition & tracking for **Security**
- **Crowd Management, Traffic Management**

Infrastructure Inspection Project

- In Japan, most infrastructures were built from the 1960s to the 1980s; in recent years, there are many cases of degradation
- Hence, increasing maintenance and repair costs, and possibility of serious accident, became serious social issue
- Lack of qualified inspectors (especially in rural areas), which leads to subjective/inconsistent interpretation of degradation state
- Therefore, a cost-efficient, reliable and effective solution for infrastructure inspection and maintenance is needed



Bridge Degradation Judgment System based on Deep Learning

① Client Scenario

Asset intensive industries (bridge maintenance)

Inspector collects data of client asset

② Visual Inspection

(a) Standard: Tablet PC

(b) Enhanced: UAV ("drone")

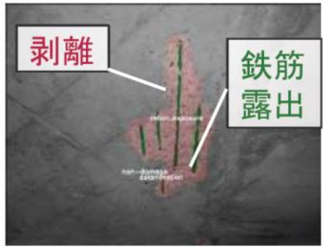
Data Processing

③ Deep Learning

Inspection pictures are processed in the cloud

元の画像

判定結果



Degradation Judgement

④ Automated Assistance

- Inspector can compare classification result to own judgement in near real-time (processing in cloud)
- The DL model provides a "Gold Standard" interpretation for the inspector, which is helpful for less skilled inspector in rural areas

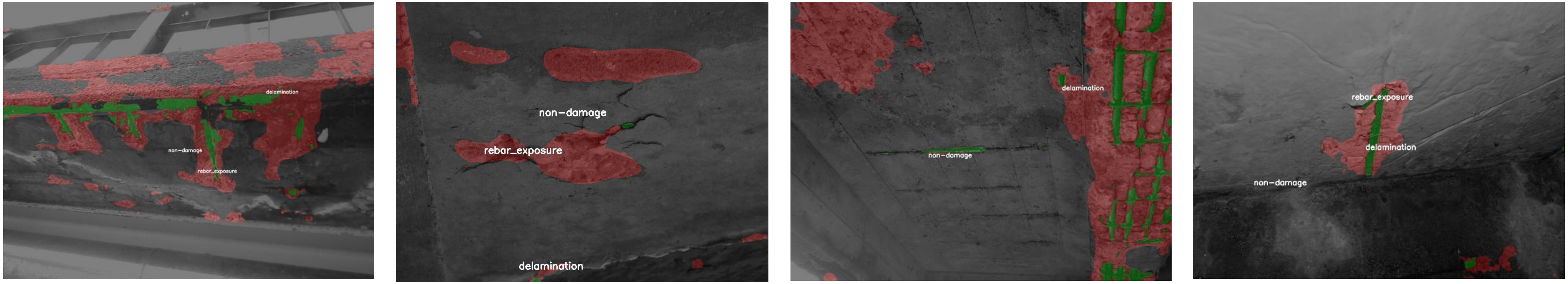
Integration to Client system

(generate maintenance plan, etc.)

Automated Recognition of Damage on Bridge Deck

Input to Deep Learning

Output



Delamination (red) Rebar Exposure (green) No-damage (grey)

Flying Camera Related Business Models

	Type of Company	Type of Services	Business Model	Customer
PrecisionHawk	Drone data management and analysis	• Process, analyze, share (PrecisionMapper) • Drone safety platform (LATAS)	• Flight service • Training • Consulting	Energy, insurance, mining, construction, etc
SkyCatch	Drone data management and analysis	• Turn drone data into maps and 3D models • Mission planning app -> upload for cloud processing • Organize, search, share your data set • Analyze data	• Monthly pricing plans: basic, pro, premier, high precision, reality capture • Enterprise solutions	• KOMATSU
DroneDeploy	Drone data management and analysis	• "Spend less time w/ data, more time w/ flying" • Real-time data mapping • Flight planning, image processing, map analysis	• Monthly pricing plans: explore, pro, business	Agriculture, construction
Kespry	Drone data management and analysis	• Platform: plan -> capture -> process -> analysis -> report • ML/AI	N/A (maybe individual business solutions)	Mining, construction, insurance
NEC Fielding	Drone data management and analysis	• Drone solution • Total support (Offering hardware, Training, Maintenance, etc.) https://solution.fielding.co.jp/drone_support/		
Hitachi High-Technologies	Drone data management and analysis	• Drone solution http://www.hitachi-hightech.com/hsl/product_detail/?pn=uav-drone_solution		Logistics, Security

FAA in US predicts 7,000,000 drones regularly flying by 2020*
DFS (Air Traffic Control) in Germany predicts 1,000,000 drones by 2020*

Shared airspace that is safe and efficient

* Excluding passenger drones

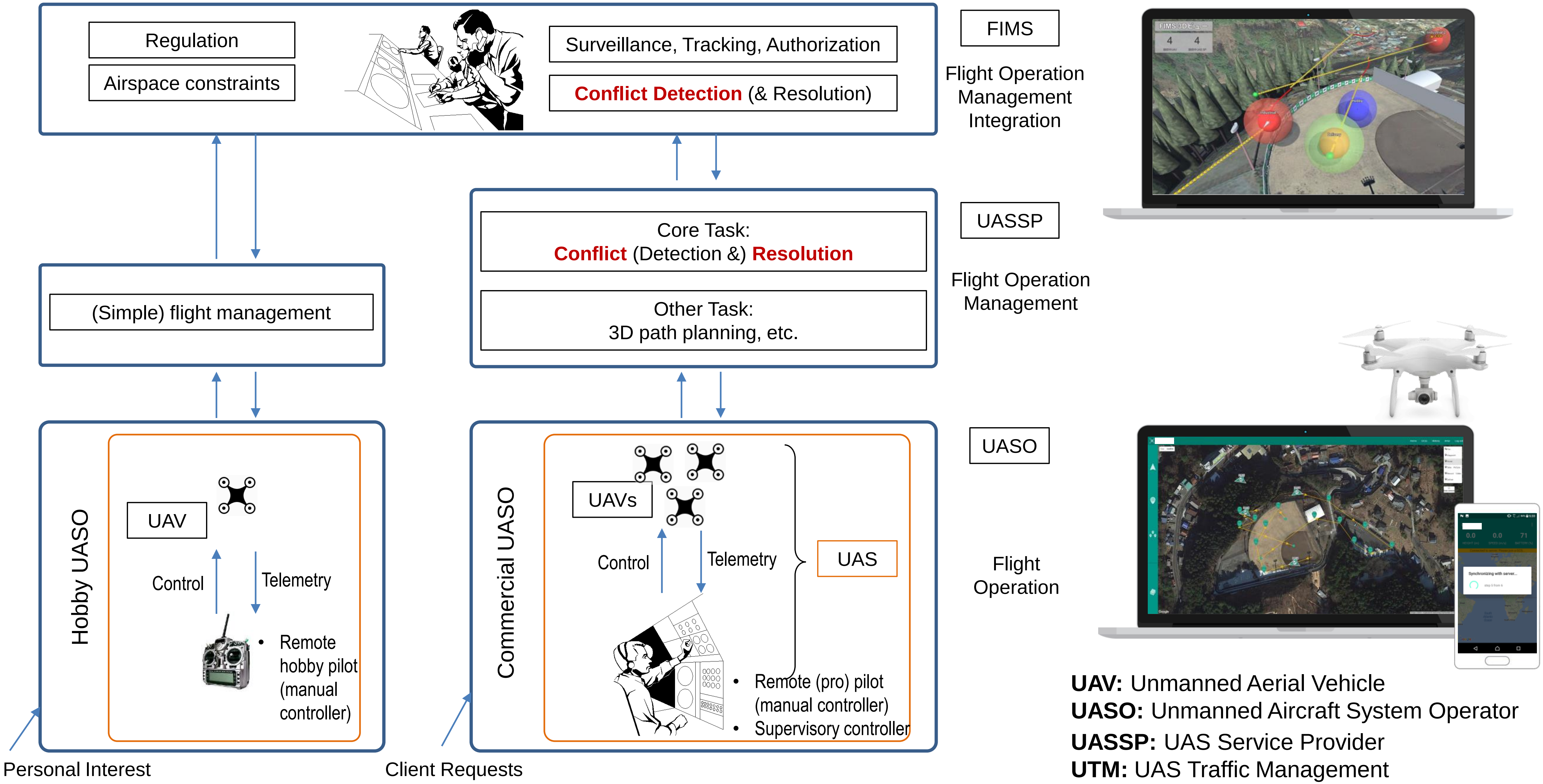
Project on Unmanned Aircraft System Traffic Management (UTM)

NEDO

(FY2017 – FY2019)

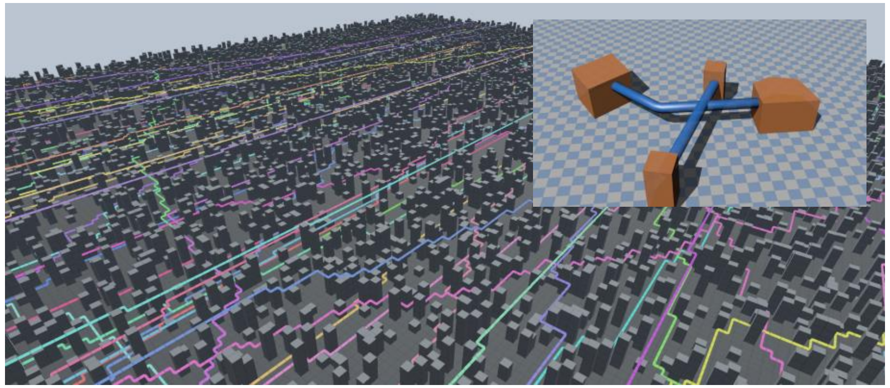
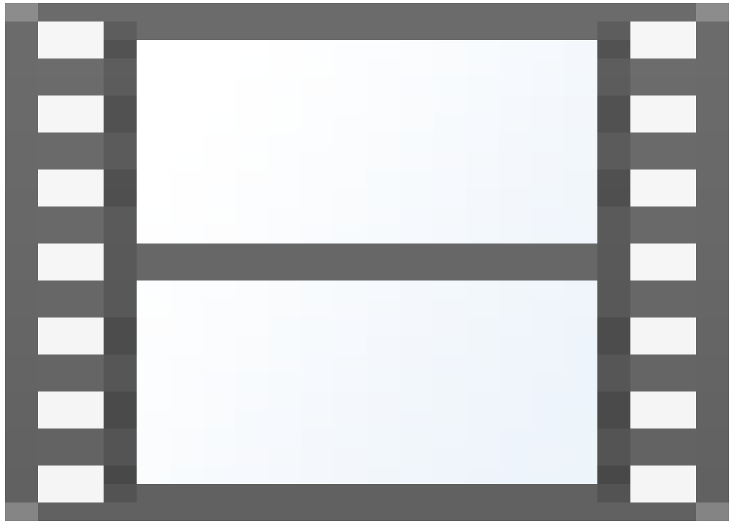
※ Observer: METI, Ministry of Land, Infrastructure and Transport (MLIT), Ministry of Internal Affairs and Communications (MIC), Ministry of Education, Culture, Sports, Science and Technology (MEXT), NEDO

UTM System Entities



UAV: Unmanned Aerial Vehicle
UASO: Unmanned Aircraft System Operator
UASSP: UAS Service Provider
UTM: UAS Traffic Management

Airspace Redundancies: Conflict Detection and Resolution (CDR)

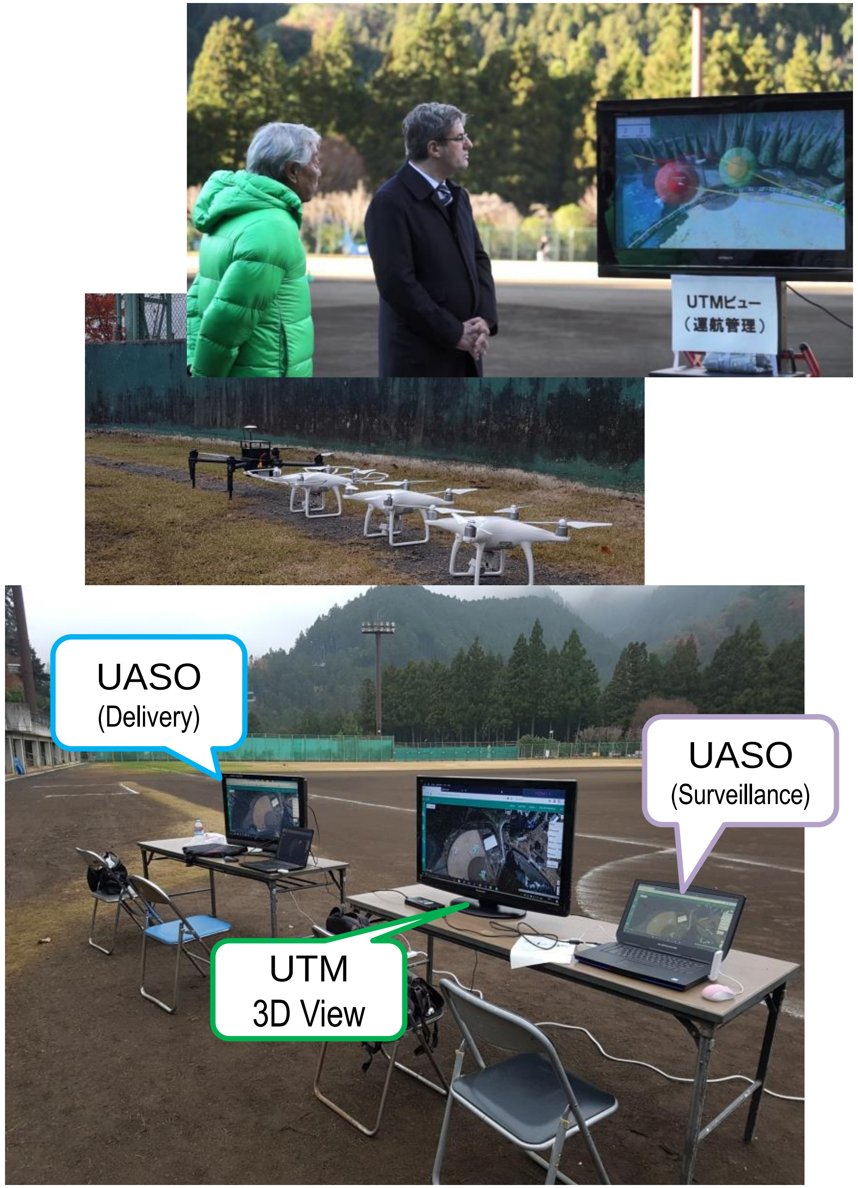
ATM (general)	**U-space** (Europe)	**UTM** (Japan)	Conflict Detection	Conflict Resolution (Algorithms)
Strategic Conflict Management	Strategic Deconfliction (U2 : U-space initial services)	Pre-Flight CDR	Predicted time-space overlap of two or more flight routes, or “tubes” (off-line process)	
Separation Provision	Tactical Deconfliction (U3 : U-space advanced services)	In-Flight CDR	Predicted loss of minimum separation between two or more aircrafts* (online)	

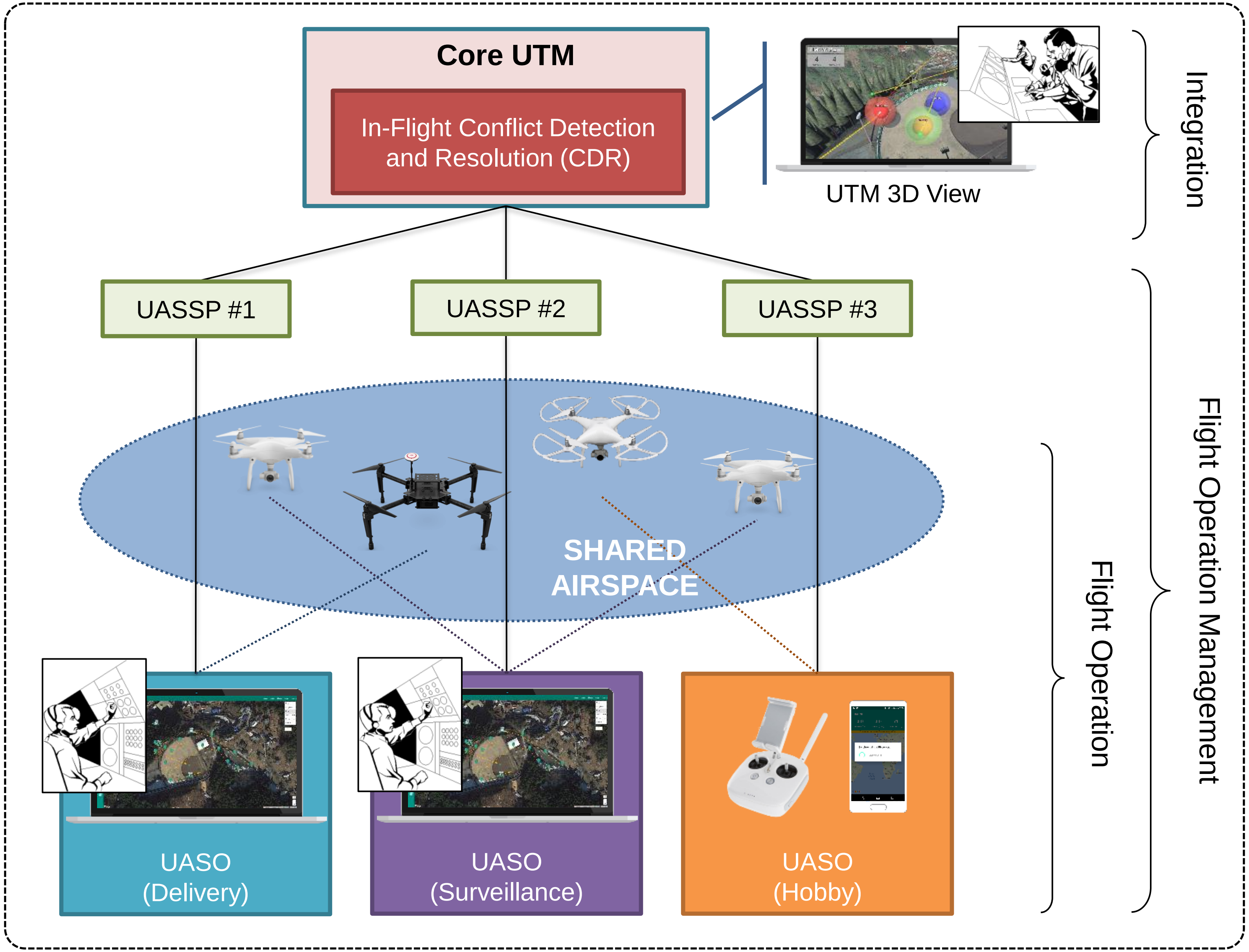
Collision Avoidance (Detect and Avoid)

*Kuchar and Yang (2000): “… an event in the future in which two or more aircrafts will experience a loss of minimum separation between each other”

Field Test of NII UTM Prototype and In-Flight CDR in Okutama

- **Setup** of NII UTM Prototype System at Press Release (Dec. 5, 2017)

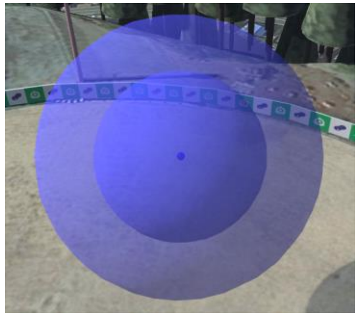




Field Test of In-Flight CDR Algorithm

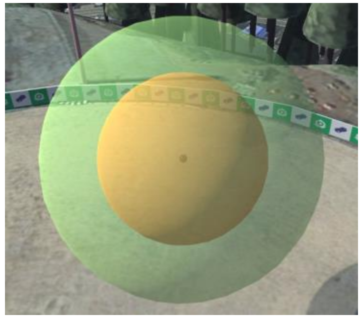
- **3 CDR States** (Conflict Detection and Resolution)

Non-Cooperative



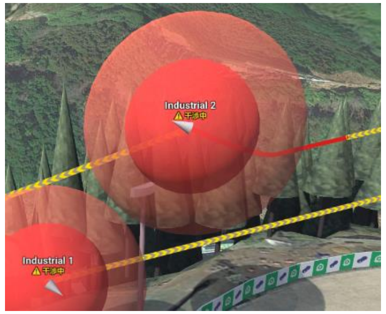
Does not cooperate with CDR service (e.g. helicopter, hobby pilot)

Cooperative (not in conflict)



Cooperates with CDR service (Automated UAVs in-flight)

Cooperative (in conflict, predicted loss of separation minimum)



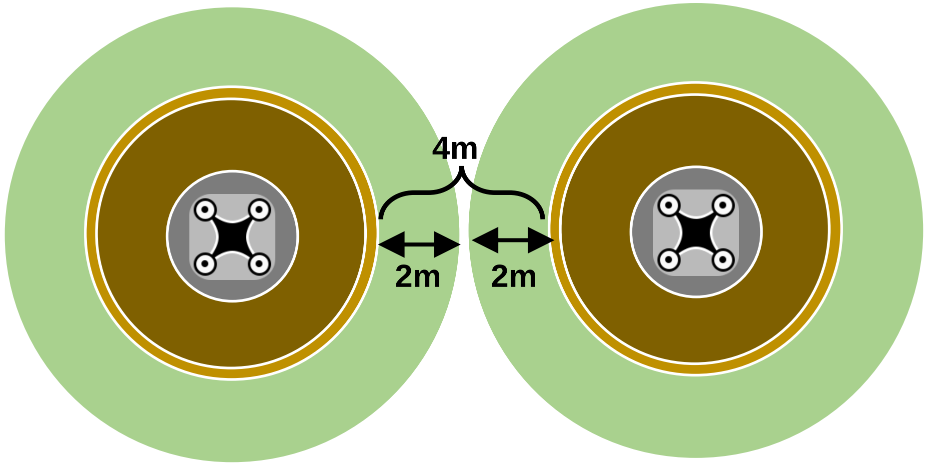
Follows conflict-free velocity commands sent by CDR service

- **UTM Airspace Constraint: Separation Minimum**

UTM $\quad sep.min.$

UAV $\quad \frac{sep.min.}{2} \wedge \frac{sep.min.}{2}$

For PR, a very small value (4m) for separation minimum was chosen b/c of size of baseball field (test area). Realistically, much larger value should be used.



NII UTM System 2017

Intelligent In-Flight Conflict Detection and Resolution

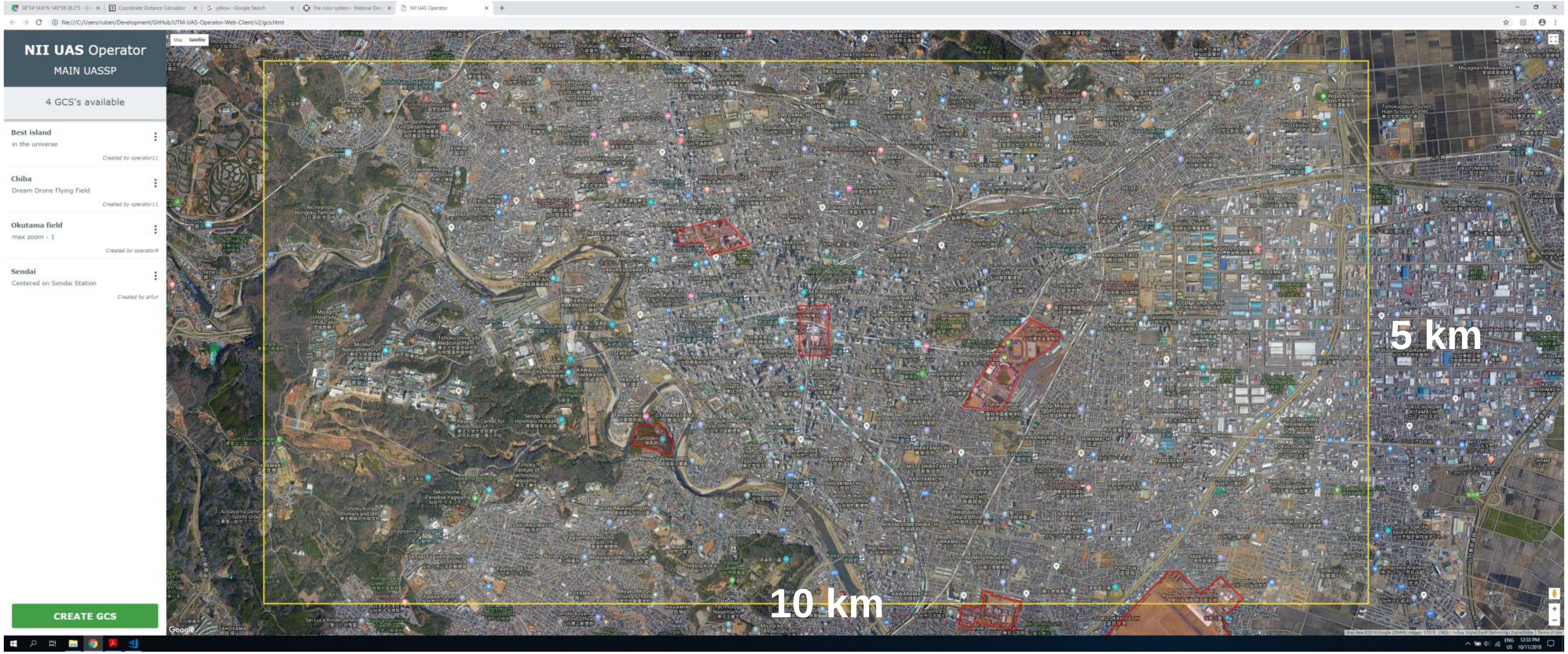
Core UTM 3D - Okutama Scenario

NII UTM System Prototype

Real-time simulation of 40 UAVs
in Okutama
using deployed cloud system

Market: Drone Usage Model Case for 2030 – Sendai City

- Uses of drone: initial focus on delivery, security, infrastructure maintenance; also transport of blood product
- Delivery: hub-to-hub and hub-to-home (short distance, light weight package) – about 13,000 per day
- Surveillance of facilities (shopping center, exhibition hall, football stadium, amusement park, etc.)
- No-fly zones



Deloitte.
デロイト トーマツ

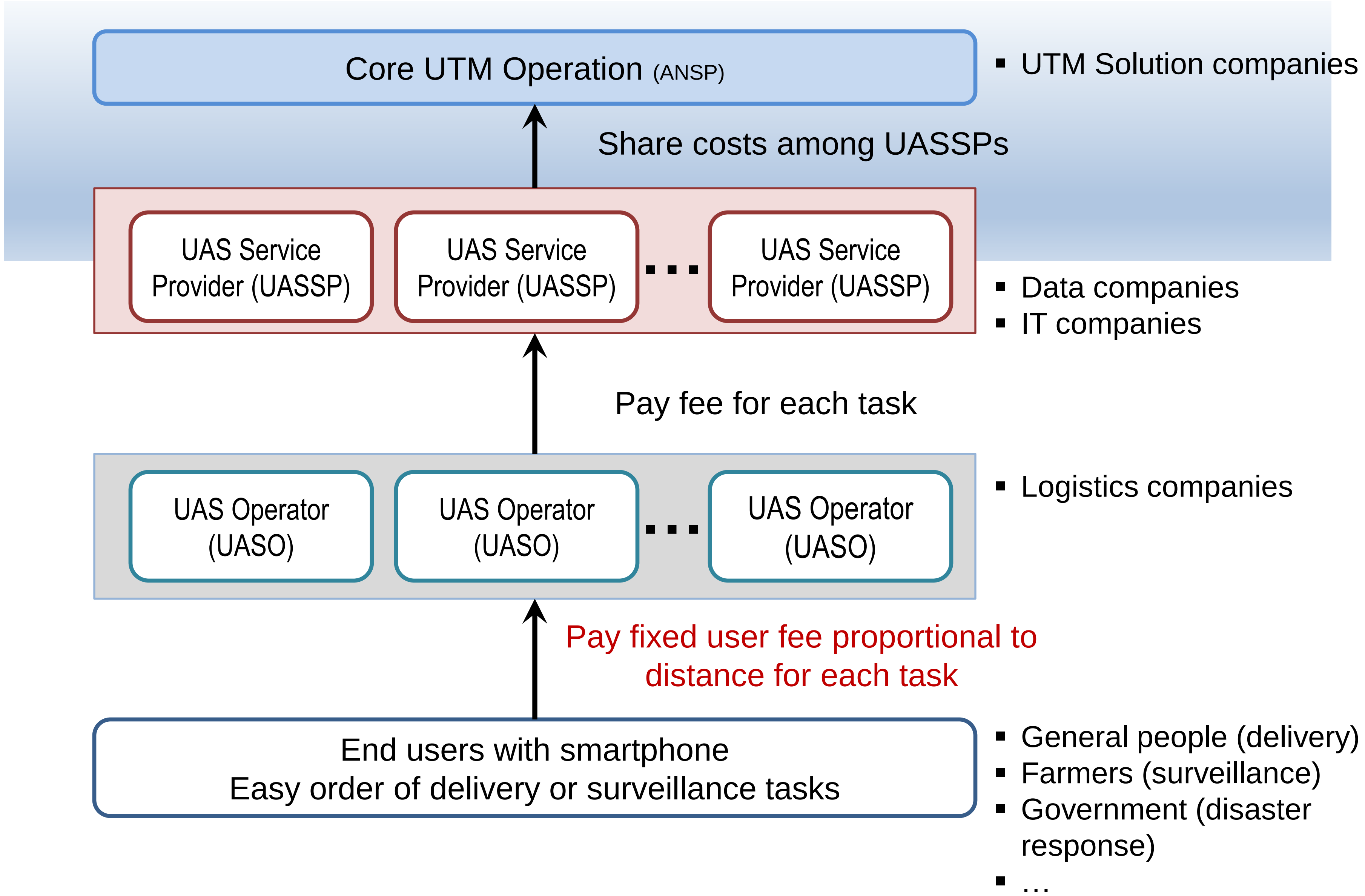
UTM Project

Air Management Related Business Models

	Type of Company	Type of Services	Business Model	Customer
AirMap	Hybrid of UASSP and Core UTM Solution	• Source and share information • Facilitate communication between all the stakeholders • Services for planning and flying safe routes		Airspace managing entity Drone manufacturer
Rakuten AirMap, Inc.	UASSP, not Core UTM	Same as AirMap, but no Core UTM		Airspace managing entity Drone manufacturer
UniFly	Hybrid of UASSP and Core UTM Solution	Same as AirMap		
NEC	General Electric UTM Solution	• …		Airspace managing entity Drone manufacturer
NTT DATA	IT Solution UTM Solution	• Package of FOS (Flight Operation System) & UTM core http://www.airpalette.net/utm		Airspace managing entity Drone manufacturer Disaster Response, Inspection, Survey / Observation, Logistics, etc.
Hitachi	General Electric UTM Solution	• …		Airspace managing entity Drone manufacturer

Business Model for Air Management

Presented at NTT DATA Open Innovation Business Contest (March 2, 2017)



meti.go.jp

経済産業省
Ministry of Economy, Trade and Industry

menu

第1回 空の移動革命に向けた官民協議会

The 1st Public-Private Council for the Movement in the Sky Revolution

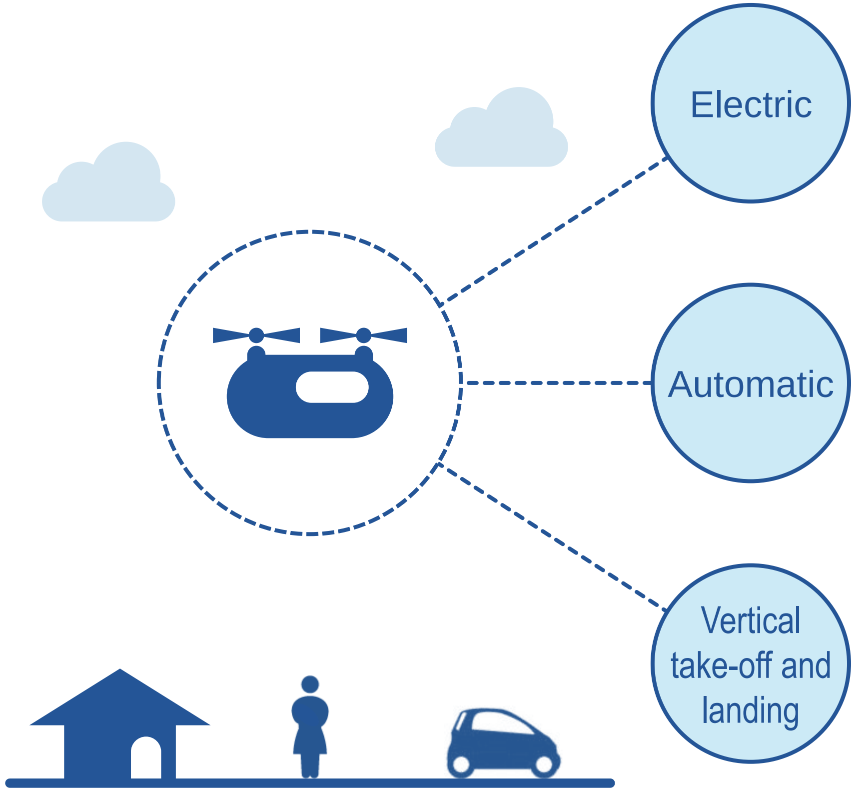
開催日

2018年8月29日

開催資料

Vision of Urban Air Mobility with “Flying Car”

- “Flying car” has elements of (non-pilot) drone and passenger aircraft
- Urban Air Mobility (UAM) – transforming transportation



Comparison with helicopter

Number of parts: low → maintenance cost: cheap

Noise: small

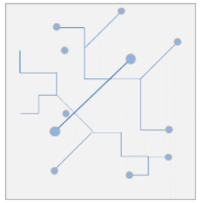
Affinity with automatic flight: high

↓

Pilot: None → Operation cost: cheap

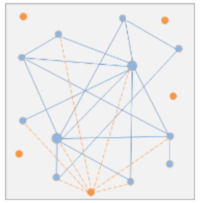
Change the concept of movement

Line



→

Point to point



“Popularization of movement in the sky"

Movement
- does not depend on existing infrastructure
- fastest and shortest path possible

* Although it is called "car", it does not necessarily have the function of traveling on the road. It represents an image that an individual uses for daily mobility.

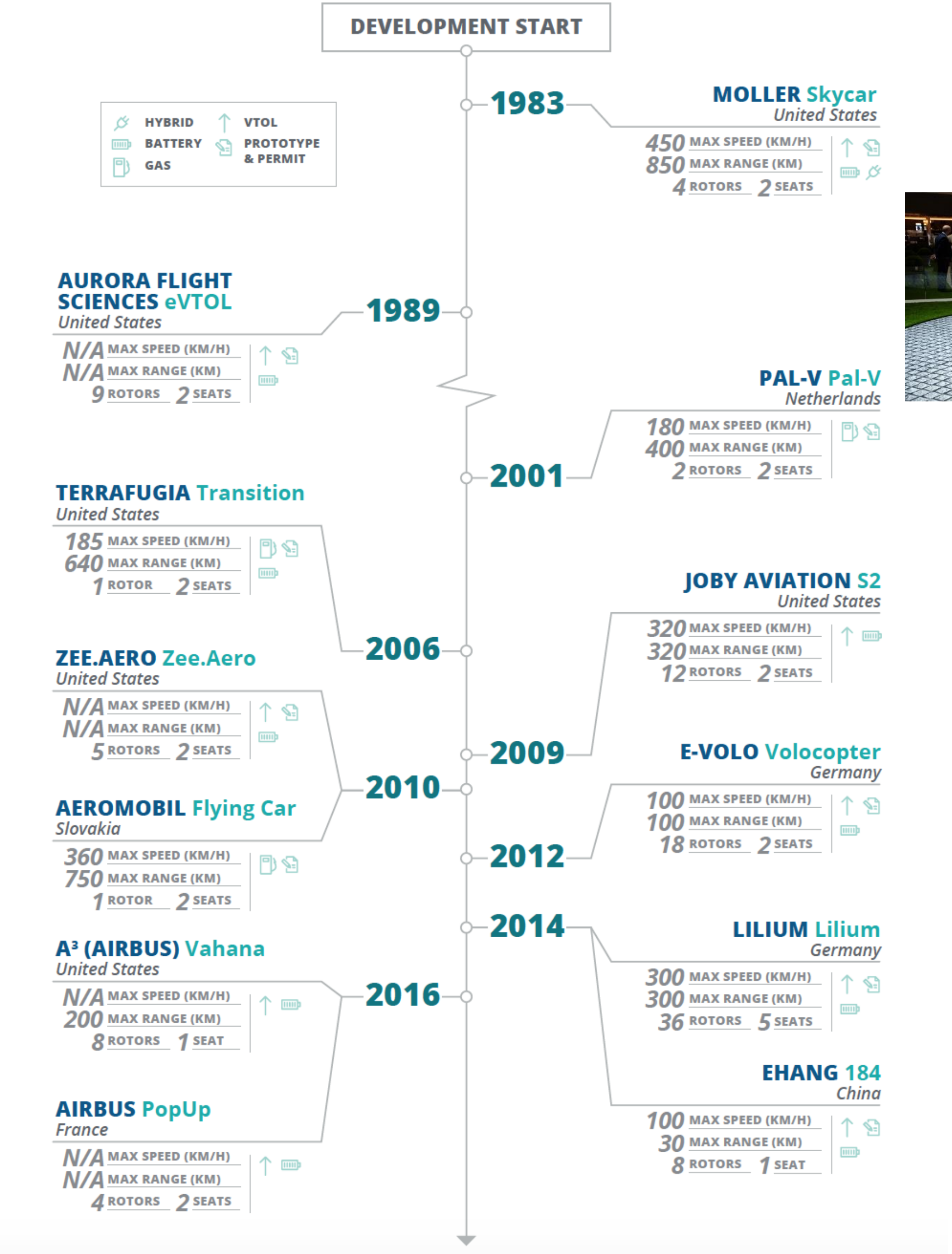
* It is not necessarily limited to "electric", "automatic", "vertical takeoff and landing", hybrids with internal combustion engines, manned maneuvers, horizontal takeoff and landing are also being developed.

Source: 経済産業省

Some Flying Cars under Development

Vahana (Airbus)

Pop.Up (Airbus × Audi × Italdesign)



Source: Deloitte analysis based on data from Drone Industry Insights. **Deloitte Insights | deloitte.com/insights**

PAL-V

Volocopter (E-VOLO)

Lilium

Safety Standards for Urban Air Mobility – Current Law/Regulation in Japan

Input by Yasuo Hashimoto
(Japan Aviation Management Research,
Japan Transport Research Institute)

Air Transport / Airplane:

- Civil Aeronautics Act (MLIT)
  - Ordinance for Enforcement of the Civil Aeronautics Act
    - ❑ Business Standards (License)
    - ❑ Safety Standards
      1. Operational Safety Standards
      2. Hardware Safety Standards

- Aircraft Manufacturing Industry Act (METI)
  - Ordinance for Enforcement of the Aircraft Manufacturing Industry Act

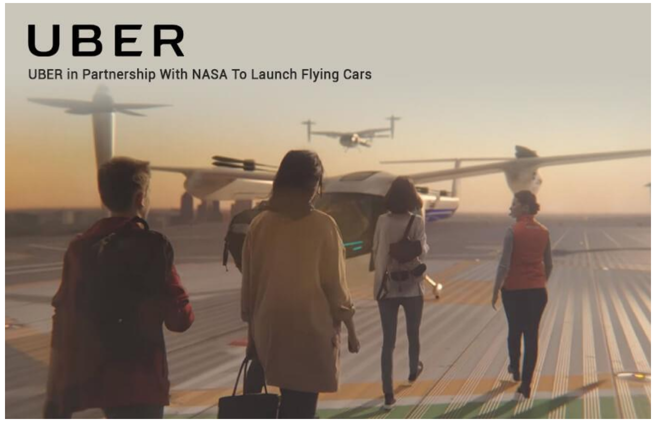
Ground Transportation:

- Road Transportation Act (MLIT)
  - Ordinance for Enforcement of the Road Transportation Act
    - ❑ Business Standards (License)
    - ❑ Safety Standards

Uber Elevate – On-Demand Urban Air Transportation

Requirements for Air Traffic Operations

- High Volume Voiceless Air Traffic Control Interactions → Voice-based pilot-to-airspace control does not scale (**Automation!**)
- UTM-like Management Extended Above 500 Feet Altitudes → **Extension of current UTM System**
- Seamless Integration with Airports and Terminal Areas
- Building Infrastructure Toward Autonomy → precision navigation (satellite system, GPS) / communication (ADS-B, cell ph., sat)



Year	2020	2023	2025	2030～2035
City (number)	Demonstration flight	3 cities or more	5 cities or more	12 cities or more
# of aircraft / City	–	–	300 to 500 aircraft	1000 or more
# of passengers / city / day	–	–	60,000 people	100,000s
# of passengers / machine	4 passengers 1 pilot	4 passengers 1 pilot	4 passengers 1 pilot	5 passengers Automatic flight

Table source:

経済産業省

Source: https://www.uber.com/info/elevate/, https://www.youtube.com/watch?v=JuWOUEFB_IQ

Thank you for your kind attention !

https://www.uasvision.com/