
# AI Powered UAV and Future Prospects

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ISO JTC1 IEC

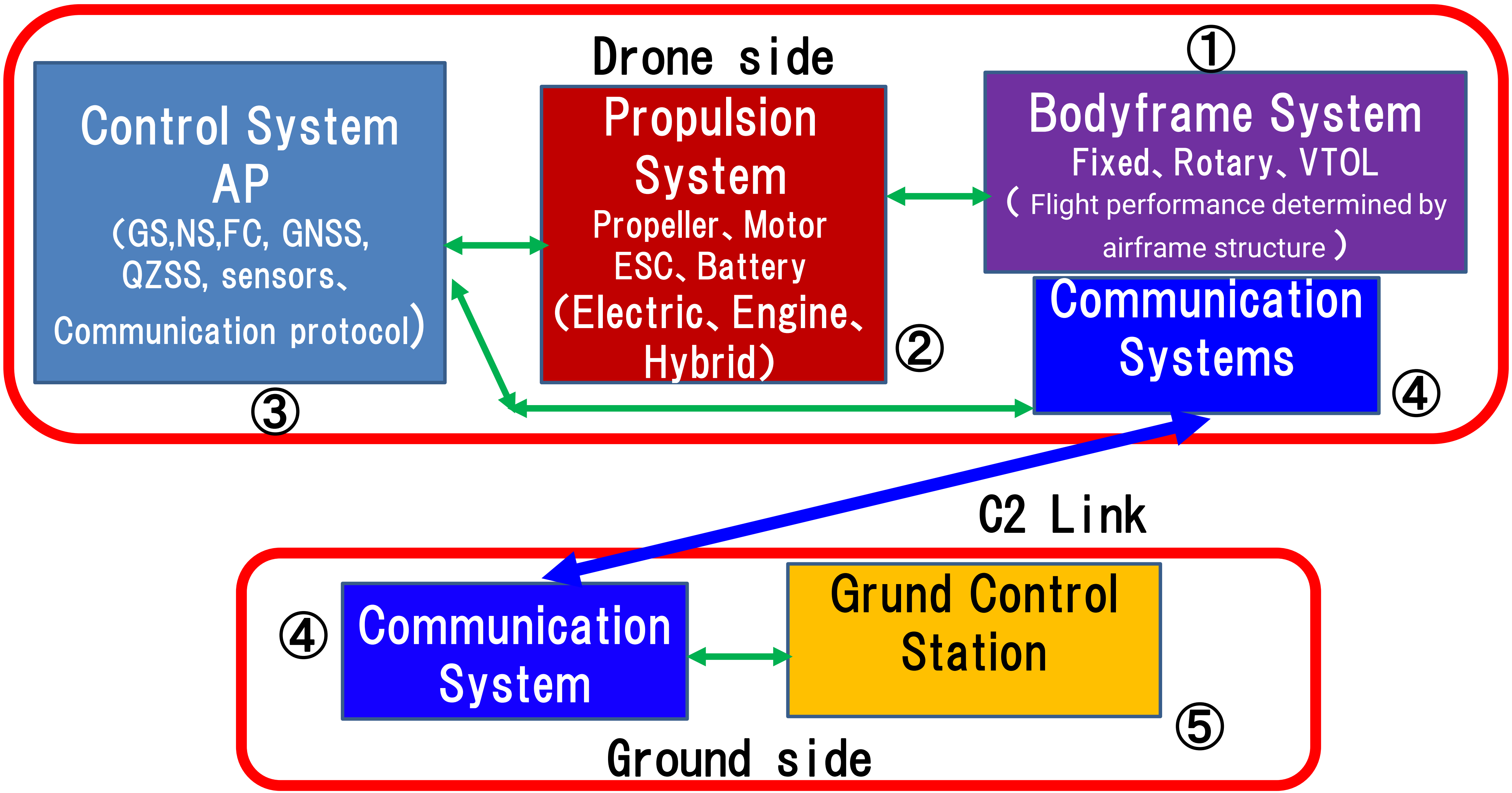
INFORMATION TECHNOLOGY STANDARDS

*SC 42 – Artificial Intelligence*

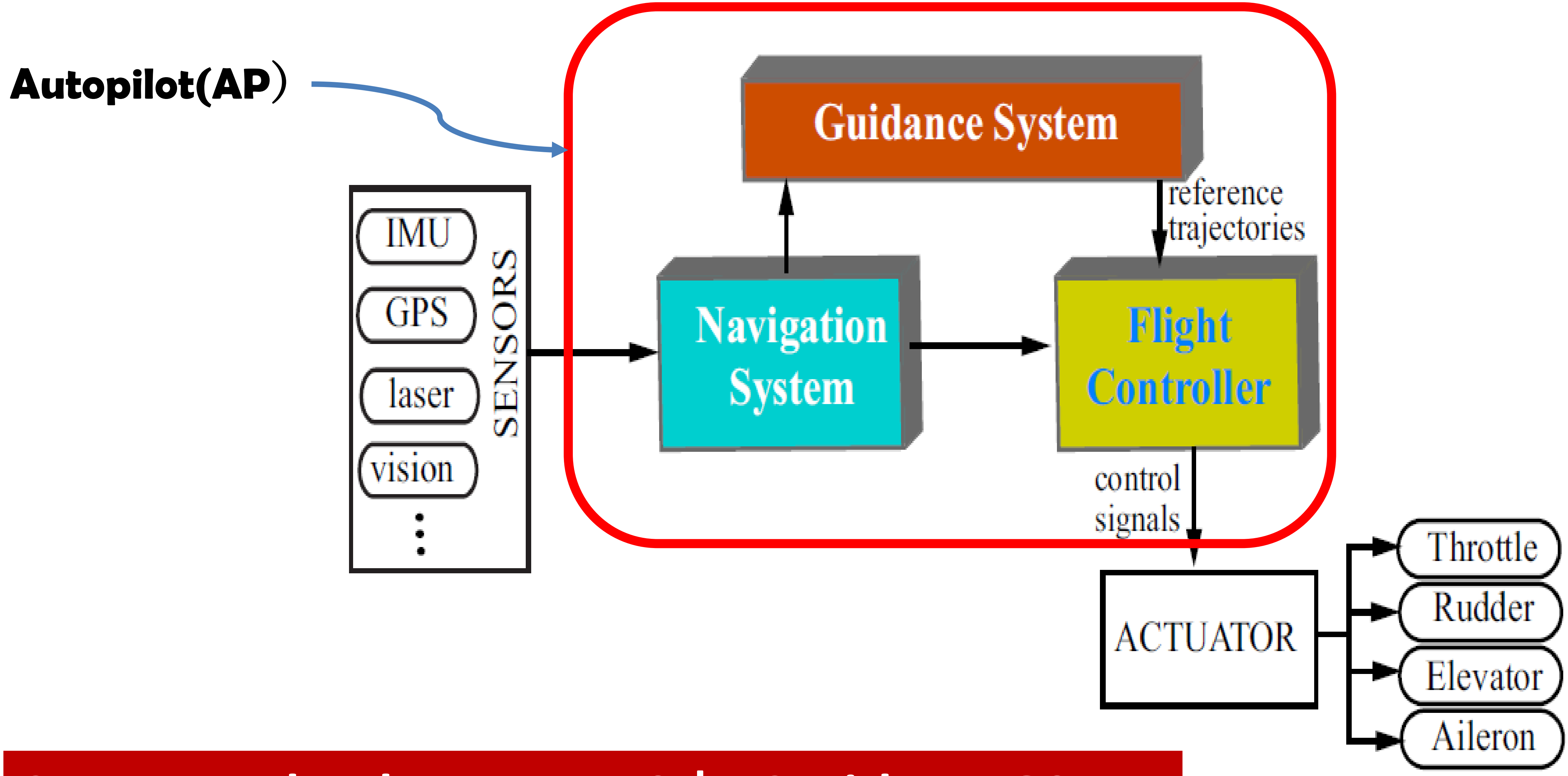
# Introduction

There are a wide variety of AI applications in the field of unmanned aerial vehicles. In particular, the application of AI to the autopilot section, which is the brain of UAVs, is the most important and most urgent field. Manned aircraft make various decisions when a skilled pilot experiences an anomaly. On the other hand, UAVs are now judged by those who are operating on the ground. This makes it insufficient to deal with abnormalities. It is necessary for the edge computer mounted on the aircraft to provide guidance, which is the role of the pilot. This is AI technology. This makes pilotless operation feasible.

# Relationships with the five components of the drone

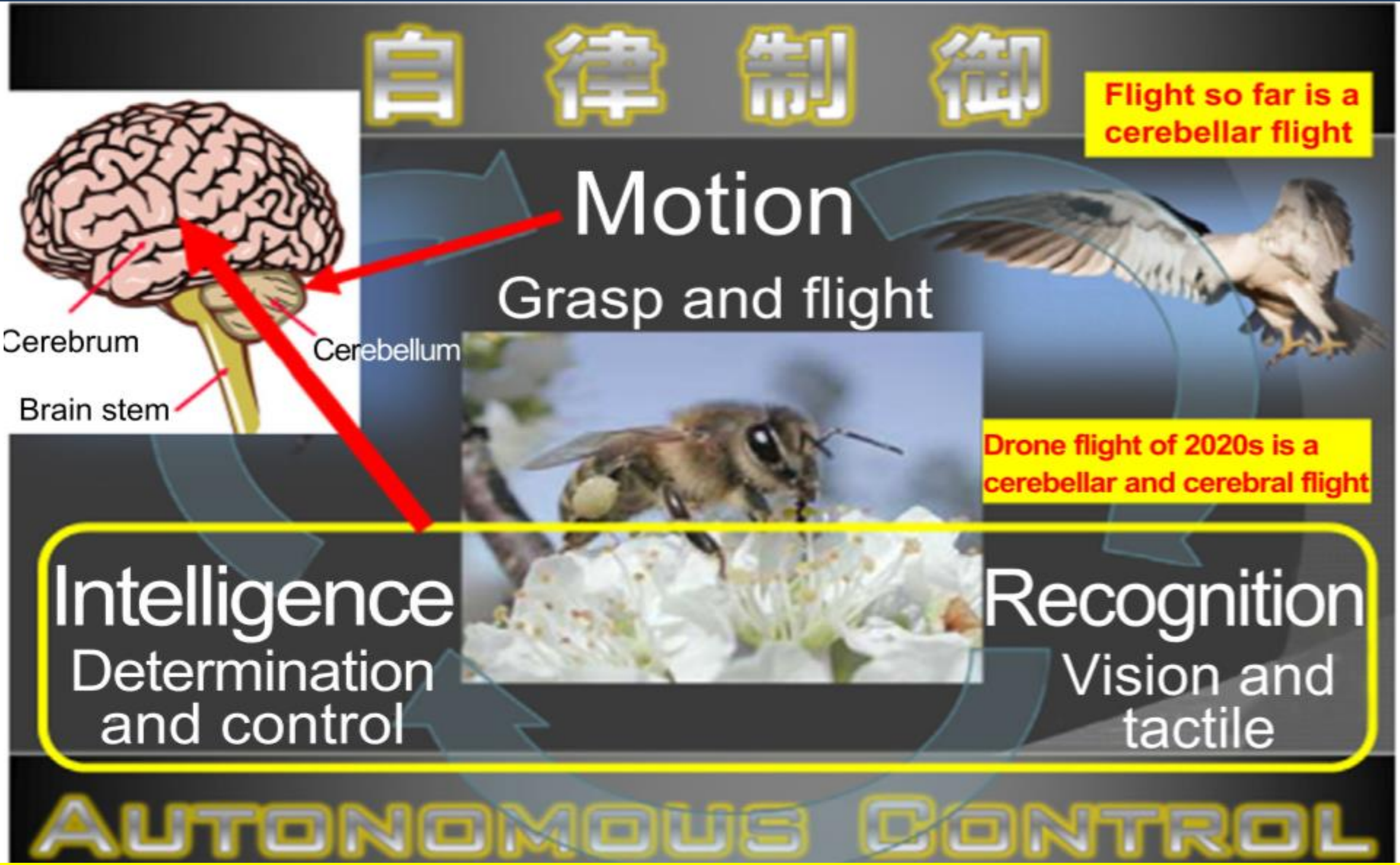


# Autopilot consisting of GS, NS and FC




**Current technology：AP=NS＋FC without GS**

# Revolution of Autonomy & Prospect of Celebrum AP (AI Pilot)




**Ideal state of autonomous control in near future (Bio-inspired flight)**

# 5 Levels of Autonomy & Revolution for Celebrum AP

| Autonomy Level | Level 0 | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|---|---|
| Human Involvement | | | | | | |
| Machine Involvement | | | | | | |
| Degree of Automation | **No Automation** | **Low Automation** | **Partial Automation** | **Conditional Automation** | **High Automation** | **Full Automation** |
| Description | Drone control is 100% manual. | Pilot remains in control.<br>Drone has control of at least one vital function. | Pilot remains responsible for safe operation.<br>Drone can take over heading, altitude under certain conditions. | Pilot acts as fall-back system.<br>Drone can perform all functions 'given certain conditions'. | Pilot is out of the loop.<br>Drone has backup systems so that if one fails, the platform will still be operational. | Drones will be able to use AI tools to plan their flights as autonomous learning systems. |
| Obstacle Avoidance | NONE | SENSE & ALERT | | SENSE & AVOID | SENSE & NAVIGATE | |

# Revolution of Autonomy & Prospect of Celebrum AP

## Sensor fusion: towards navigational autonomy

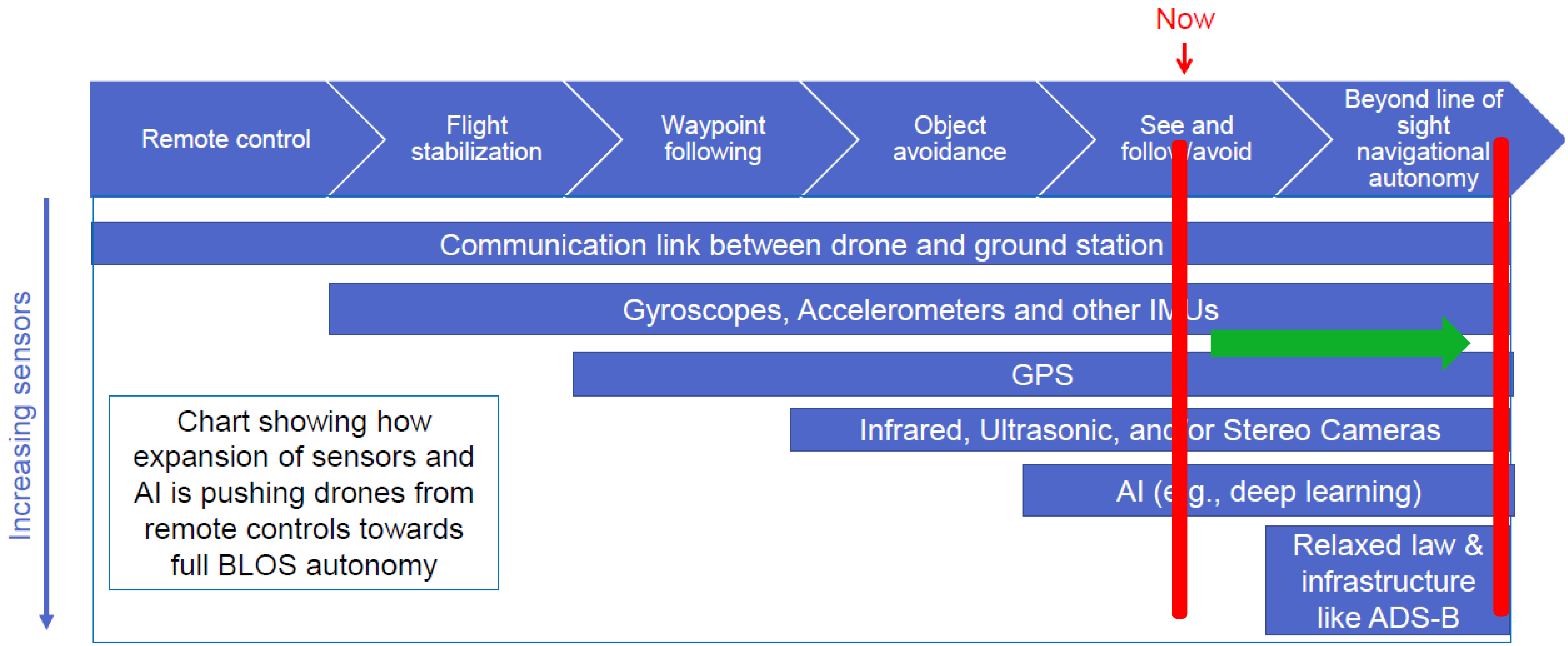



Chart showing how expansion of sensors and AI is pushing drones from remote controls towards full BLOS autonomy

# Level 5 Flight as Redundant Celebrum AP and AI Implementation

**3rd Stage**

Automatic flight route generation and search for the optimal route by AI

**Positioning**

GNSS, QZSS(CLAS),
Non-GNSS environment
(Vision based)

**2nd Stage**

**Collision avoidance(DAA)**

Manned and unmanned aerial vehicles, birds, power lines, trees
(By deep learning by AI Flying smarter every day)

**1st Stage**

◆Takeoff control, landing control, attitude stabilization control,
◆ Distance control for multiple aircrafts

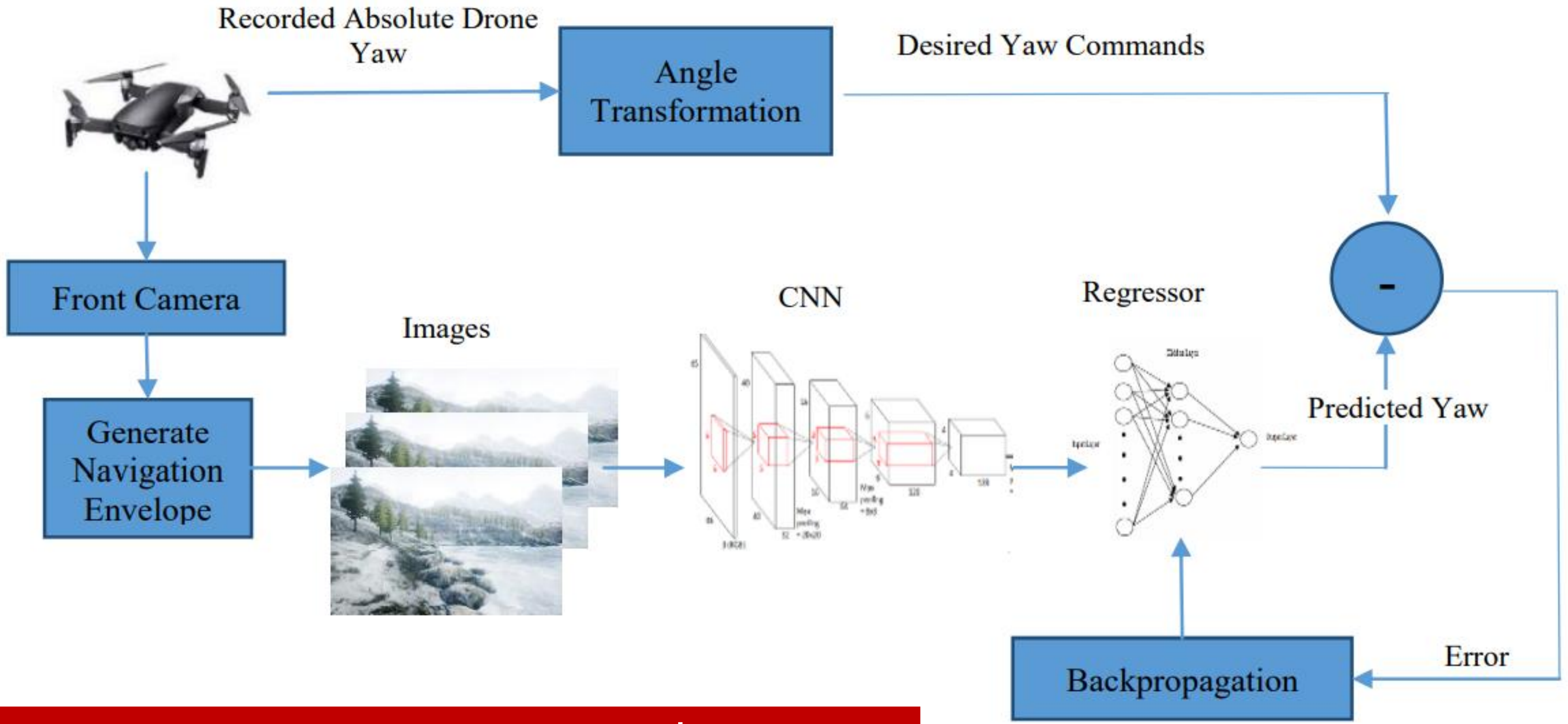
◆ AI conducts a health check to detect abnormalities during flight Redundant system as control when an error occurs (One Fail Operative Control)
◆ Implementation of AI for response to local sudden weather events
◆ Control to determine and guide the emergency landing point with AI when an abnormality occurs
◆ AI implementation and redundant Celebrum AP for the urban flight as Level 5

# Technical challenges for evolution to cerebral drones

1. Natural environment (wind resistance, low temperature resistance, high temperature resistance, rain resistance, snow resistance, dust resistance, lightning resistance)
2. Flight in GNSS-resistant lost environment (autonomous flight in non-GPS environment, Level 5)
3. Airworthiness (redundant AP, reliability, durability, safety and AI implementation, Level 5)
4. Ground Station GCS Trouble (Completely Autonomous Flight Control, Level 5)
5. Communication resistance trouble (disruption, jamming, cyber security, Level 5)
6. Obstacle autonomous avoidance and real-time routing (SAA & RT-TP, Level 5)

7. Flight performance 1 (long distance, long time flight, high speed flight, 100km / 1 hour / 100km /h))
8. Flight performance 2 (high-precision landing, safe emergency landing function, within 50 cm))
9. Flight performance 3 (payload increase, transport capacity of about 10 kg)

# Collision Avoidance by CAP and AI Implementation with Yaw Control




**Cerebrum AP technology and AI ：AP=NS＋FC with GS**

# Toward Low-Flying Autonomous MAV Trail Navigation using Deep Neural Networks for Environmental Awareness

## Autonomous Flight Over 250m Trail

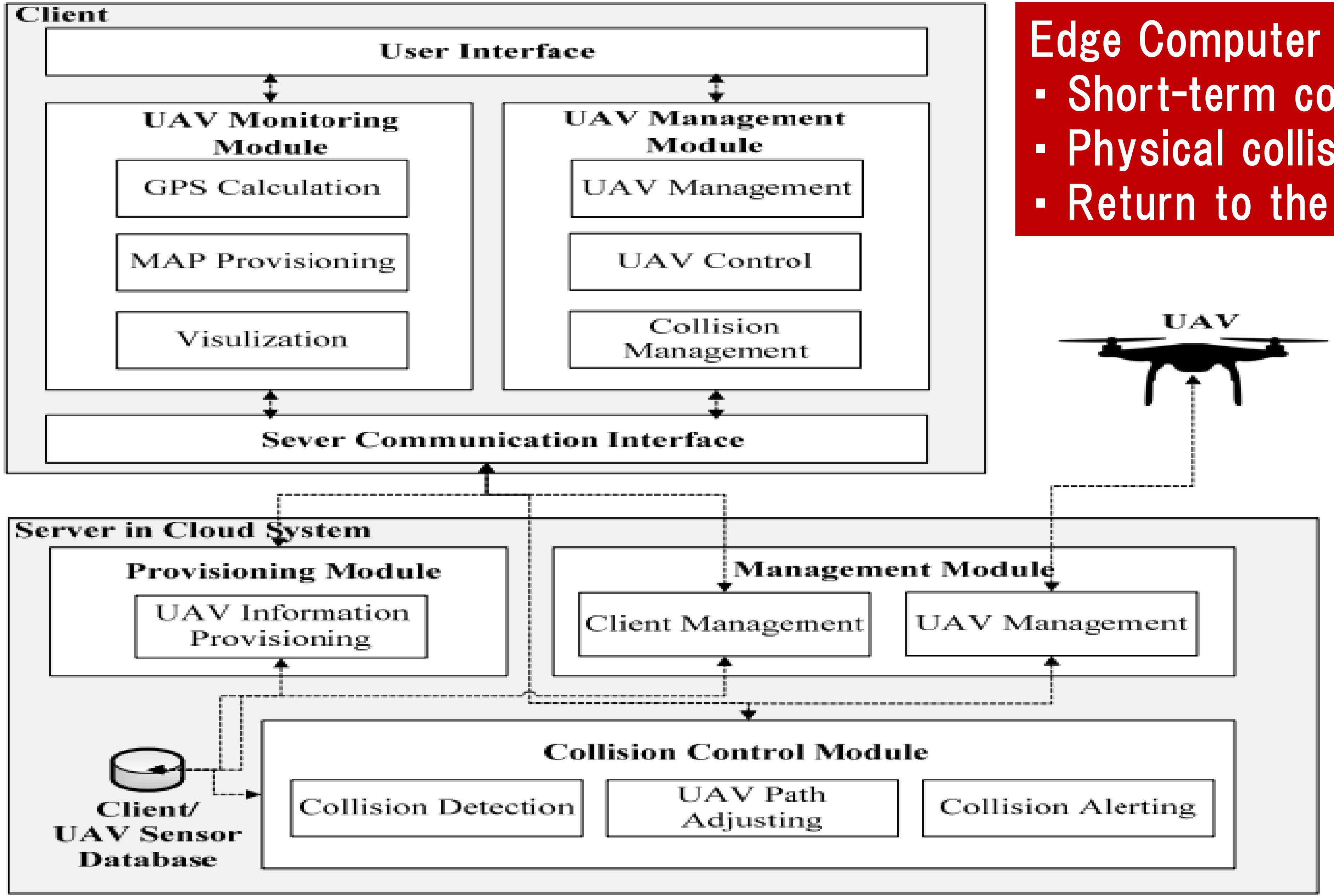
Nikolai Smolyanskiy, Alexey Kamenev, Jeffrey Smith, Stan Birchfield

NVIDIA Corporation

arXiv:1705.02550 [cs.RO], May 7, 2017

# AI drone flying in an unknown environment

# Collision Avoidance by CAP and AI Implementation with Edge and Cloud




**Edge Computer (CAP)**

- Short-term collision avoidance
- Physical collision avoidance
- Return to the original route

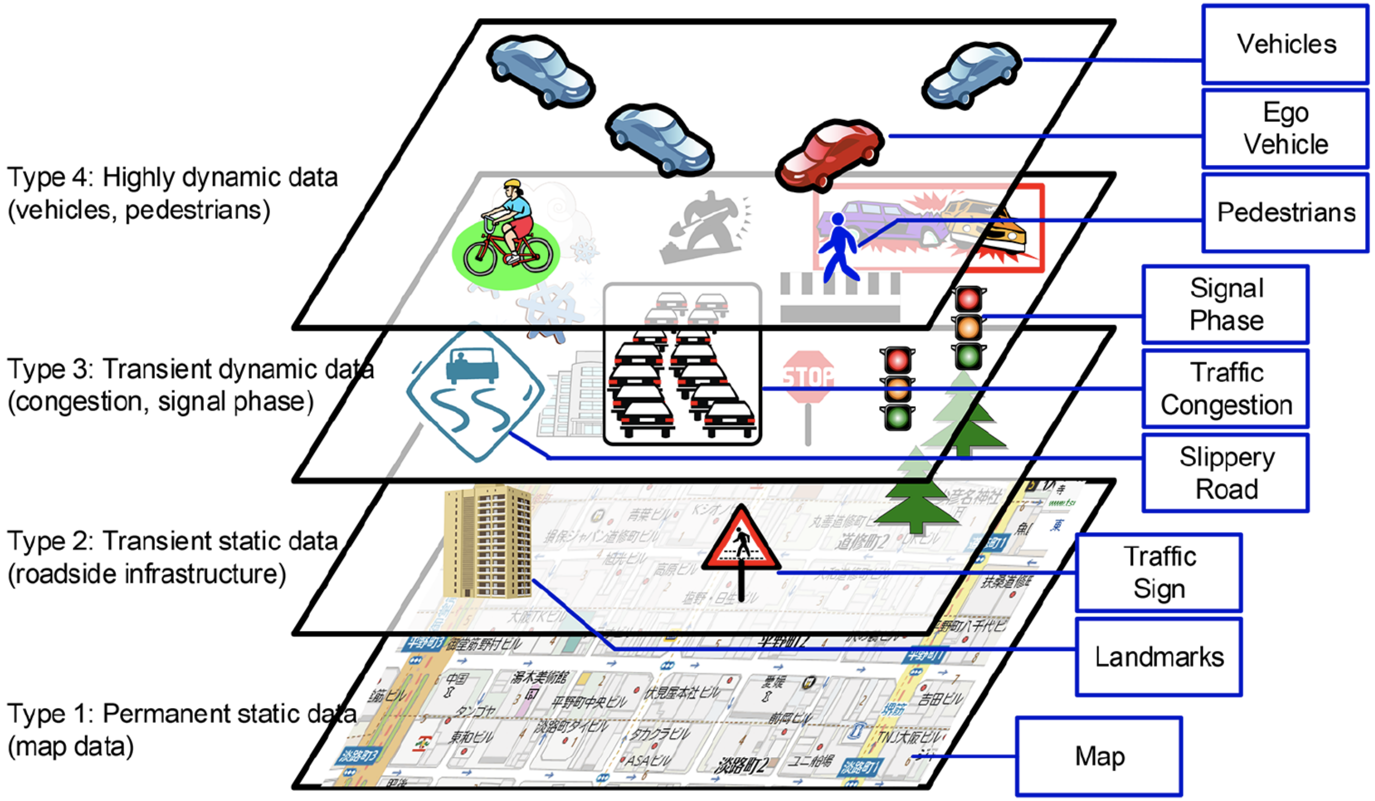
**Cloud Computer (UTM)**

- Long-term collision avoidance
- Planned collision avoidance
- Airspace separation
- Automatic route generation
- By new route flight


AI DRONE
?
faster than
HUMAN
?

# Dynamic Map for Autonomous Vehicles VS
# Dynamic Map for Autonomous Flight Control of Drone

## Dynamic Map for Autonomous Driving




## Dynamic Map for Autonomous Drone

Type 4: Highly dynamic data
- Airspace: drones, helicopter, manned aircraft, birds, weather report, UTM info, ATM info, Airspace info
- Ground: people, cars

Type 3: Transient(Semi) dynamic data
- Airspace: wind, precipitation, telecommunication info, drone traffic info
- Ground: crowd, drone station info

Type 2: Transient(Semi) static data
- Ground: drone landing spot info. landing spot traffic info

Type 1: Permanent static data
- Airspace/Ground: high precision 3D map data, powerlines, building data, trees and vegetation data, emergency landing area

- Data in dark red can be efficiently processed by AI (Deep Learning) using visual/thermal sensor data
- Note that drones need to consider “Ground” (1) to find a suitable landing spot, or (2) to estimate risk(GRC, ARC), e.g., risk of falling on people → see SORA

Shimada, H., Yamaguchi, A., Takada, H. and Sato, K. (2015) Implementation and Evaluation of Local Dynamic Map in Safety Driving Systems. Journal of Transportation Technologies, 5, 102-112. http://dx.doi.org/10.4236/jtts.2015.52010

# Industrial Utilization for Drone of AI with Dynamic Map

**Objective: Creation of Dynamic Map (DM) by Drone**

DM is the result of a mapping technology with

**Input**: Example 4：Industrial utilization of AI by Dynamic Map

◆Video feed from camera attached to drone

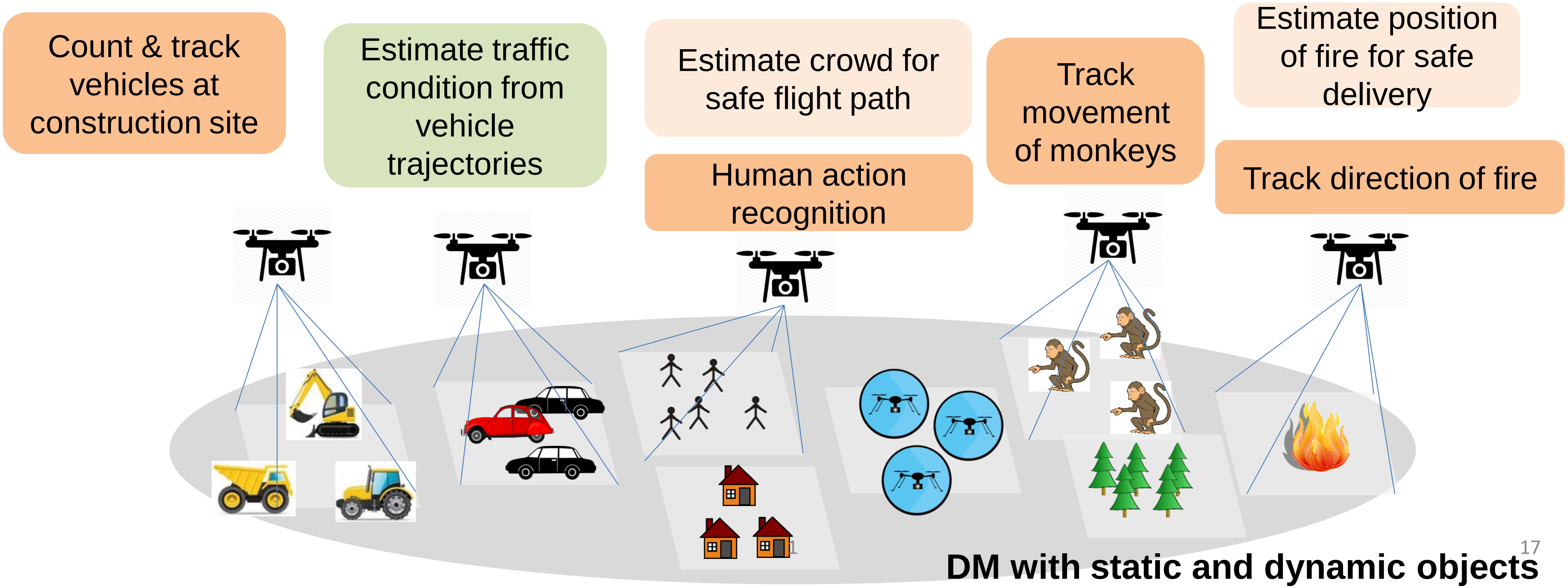
**Output**:

◆ Real-time categorization (detection, recognition) and tracking of each object and object behavior from video feed

# Industrial Utilization for Drone of AI with Dynamic Map (cont'd)

These services will use dedicated data analytics algorithms to predict traffic, movement patterns, etc.

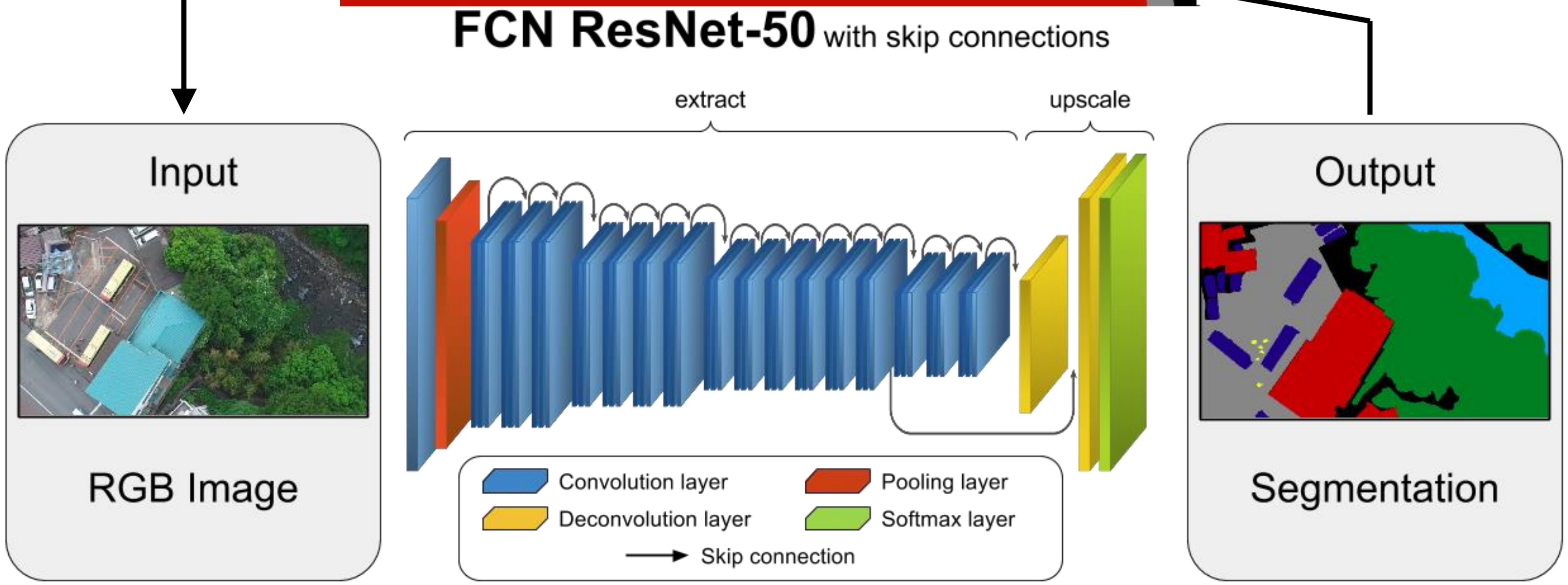
| DM-based Services | Delivery | Traffic/Crowd Management | Surveillance / Disaster Response |
|---|---|---|---|



# Situational Awareness of AI with Dynamic Map

- Semantic segmentation (pixel-wise labeling) of video stream

Input video frame by frame

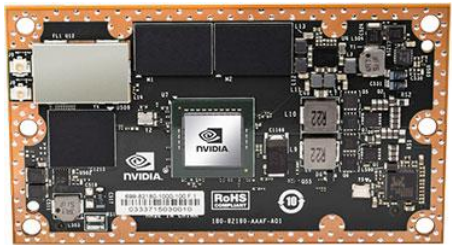



# Situational Awareness of Moving Objects on Superchip

Video Frame | Segmentation | Confidence

"White" color: high confidence in segmentation results

Hardware



NVIDIA Jetson TX1 credit card sized chip (1TFLOP/s)

Result: 3 frames per sec (non-optimized code) → real-time

# Surveillance by Deep Learning

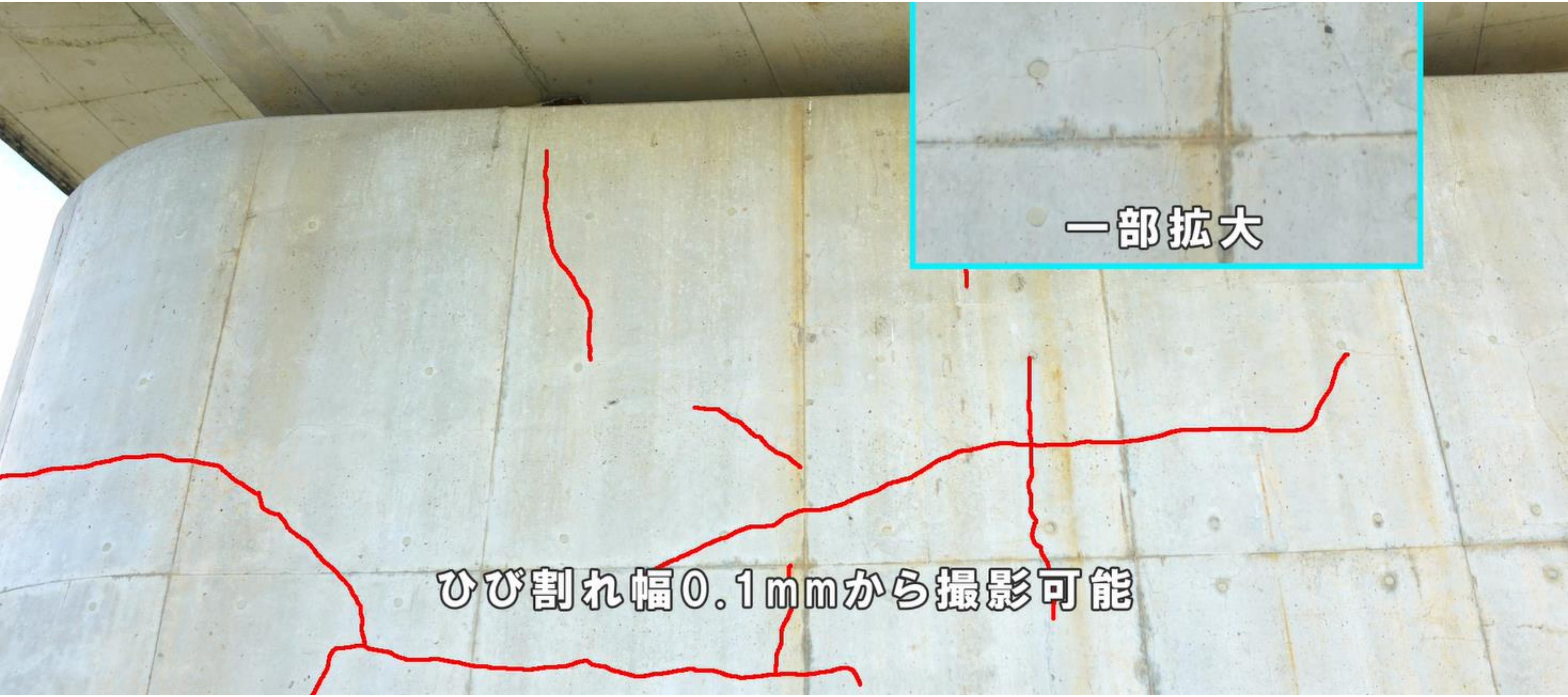
**Multi-Person Detection**

- Trained on resized images (512x512) for 20K iterations
- Single Shot MultiBox Detector (SSD) 72.3% mean Average Precision (mAP)

# Animation of Annotated Dataset

# Abnormality Detection for Bridge Pier

# Abnormality Detection for Bridge Pier(cont’d)



# Capability of AI Technology for UAV (1)

## Manufacturing Process of Drone

1. Parts check, quality inspection and quality assurance in the drone manufacturing process using AI
2. Assembly process check, quality inspection and quality assurance in drone assembly process using AI

## AI based Drone Flight (Flight replacing manned pilots with AI)

1. Health monitoring during AI drone flight, abnormality diagnosis, abnormality detection and cause investigation
2. AI based Guidance and Path planning using time-environment dynamic map
3. Searching for a crash landing point and determining a crash landing when an abnormality occurs

## UTM

1. Airspace management using AI
2. Collision avoidance using AI
3. Take off and landing management using AI
4. Weather check during drone flight using AI
5. Dynamic map creation with AI

## Pilot License Procedures

1. School examiner certification
2. School operator skill certification
3. Paper test judgment

# Capability of AI Technology for UAV (2)

## Utilization of AI in precision agriculture

1. Analysis of growth surveys and disease outbreaks in precision agriculture using Deep learning AI
2. Determining the optimal harvest time
3. Others

## Utilization of AI by dynamic map

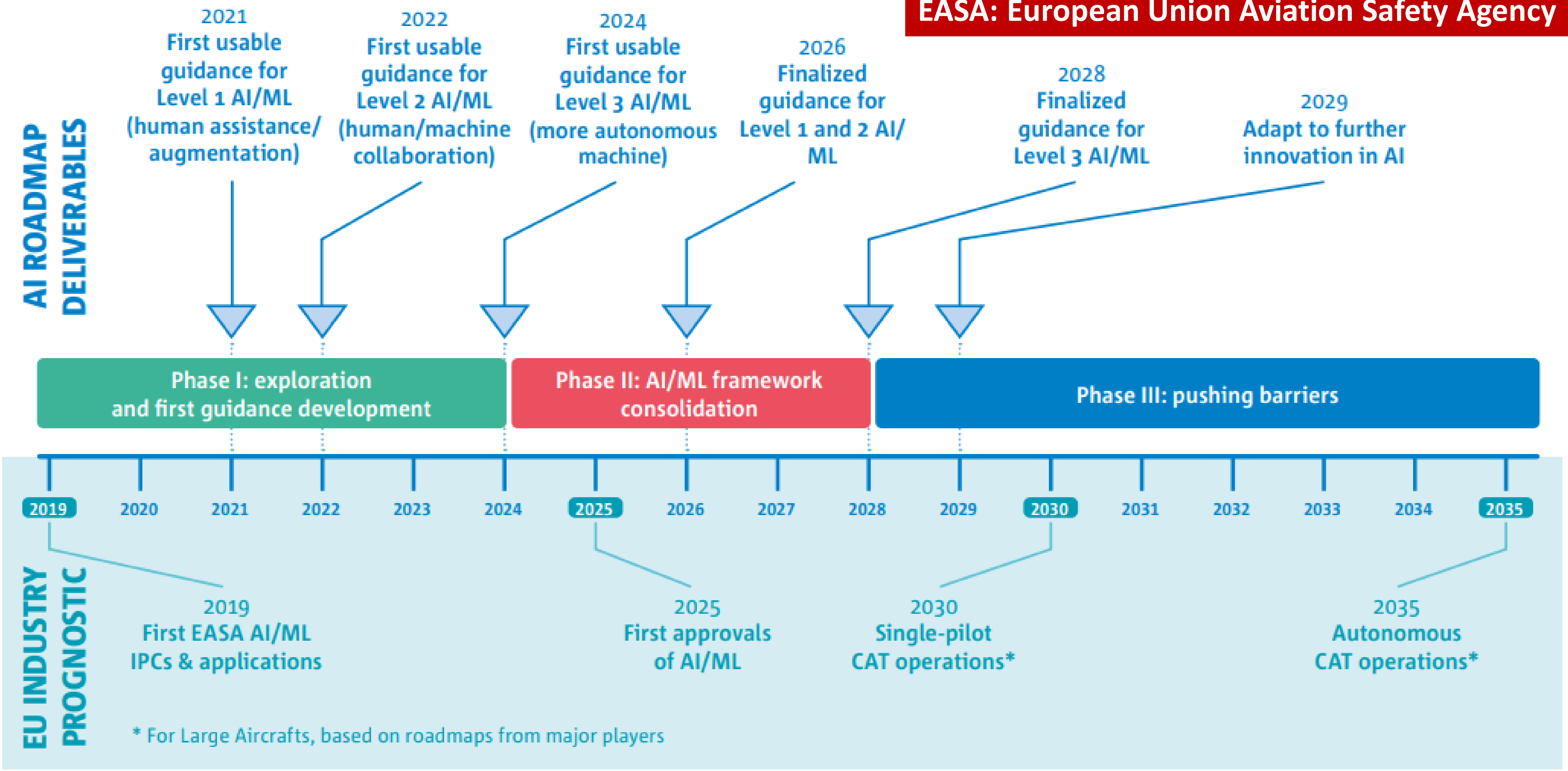
1. These services will use dedicated data analytics algorithms to predict traffic, movement patterns, disaster responses, etc.
2. Delivery service and optimization
3. Warehouse management
4. Precision 3D mapping and database
5. Security
6. Aerial survey and construction
7. Precise whether report
8. Others

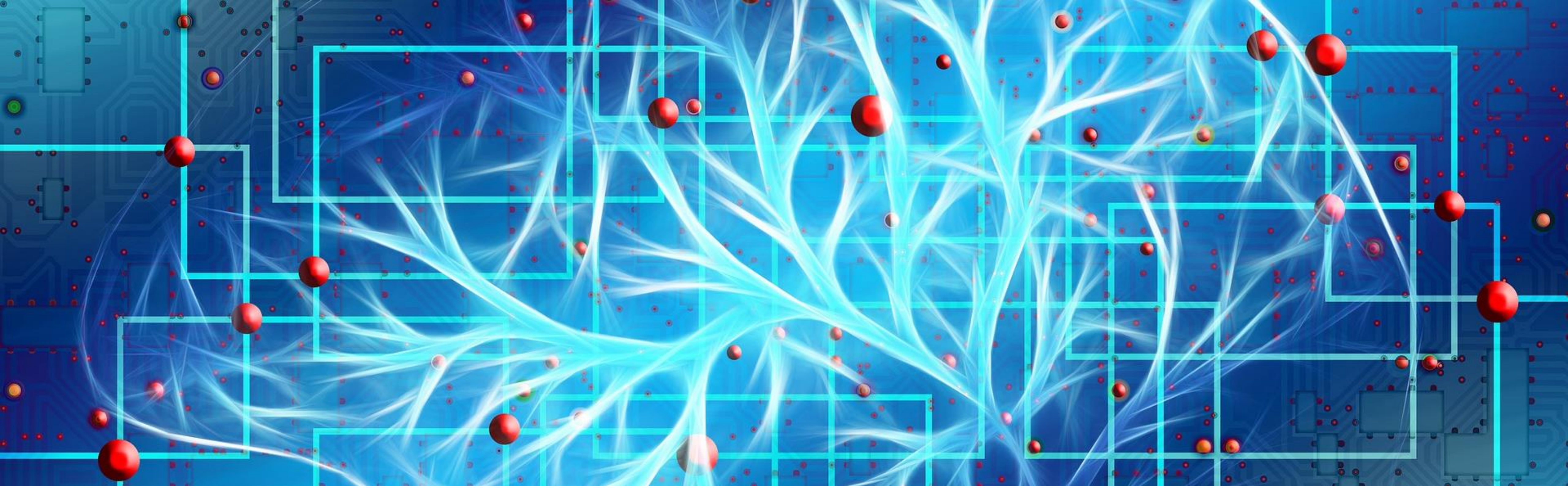
## Inspection of infrastructure equipment using AI

1. Abnormality detection for bridge, tunnel, building, tower and chemical plant, etc (See example 5)
2. Advanced maintenance and operation
3. Others

# EASA AI Roadmap

**EASA: European Union Aviation Safety Agency**

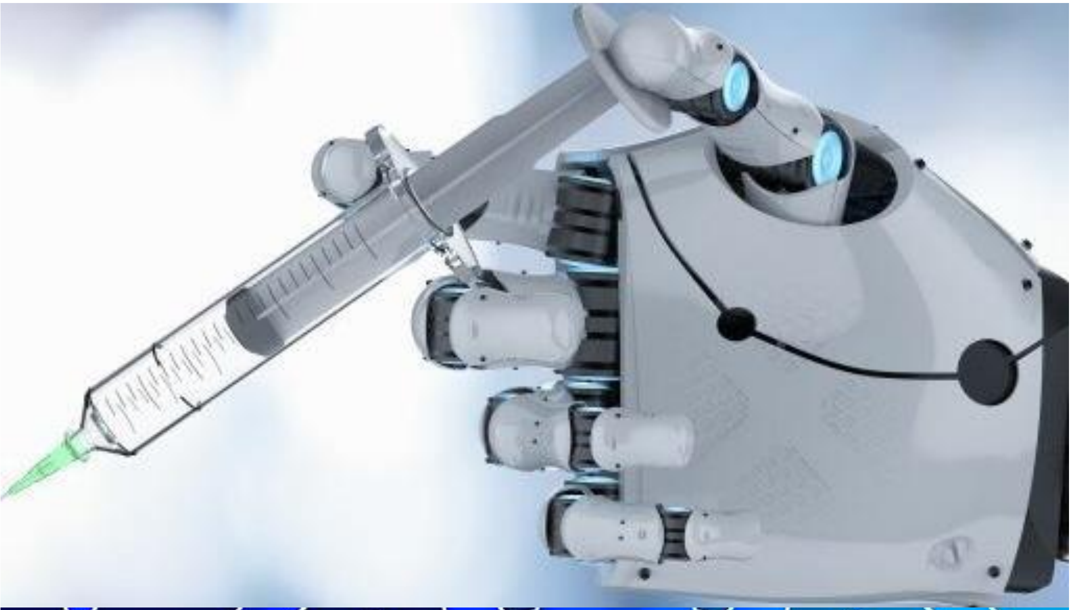




# Summary

Research and development of cerebral drones is being carried out all over the world in fierce competition through industry-academia-government collaboration. By the end of the 2020s, drones that require no human operation may appear. It will be a real “industrial revolution of the sky″. At that time, the world will change games with AI technology innovation.

# Thank you



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