AI and Drone Control

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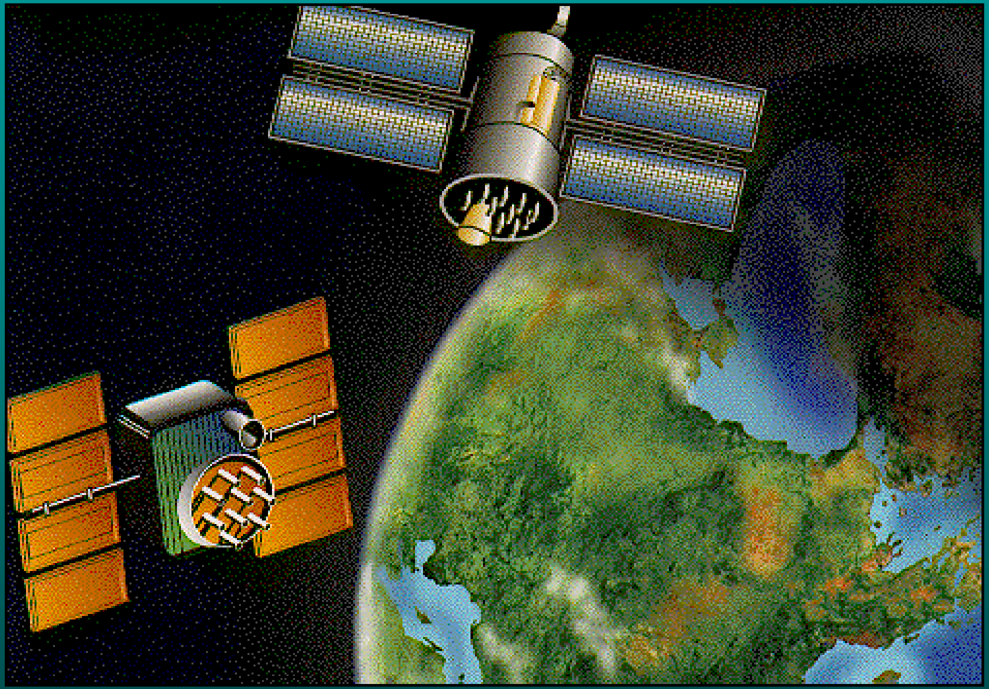
Foldable Drone

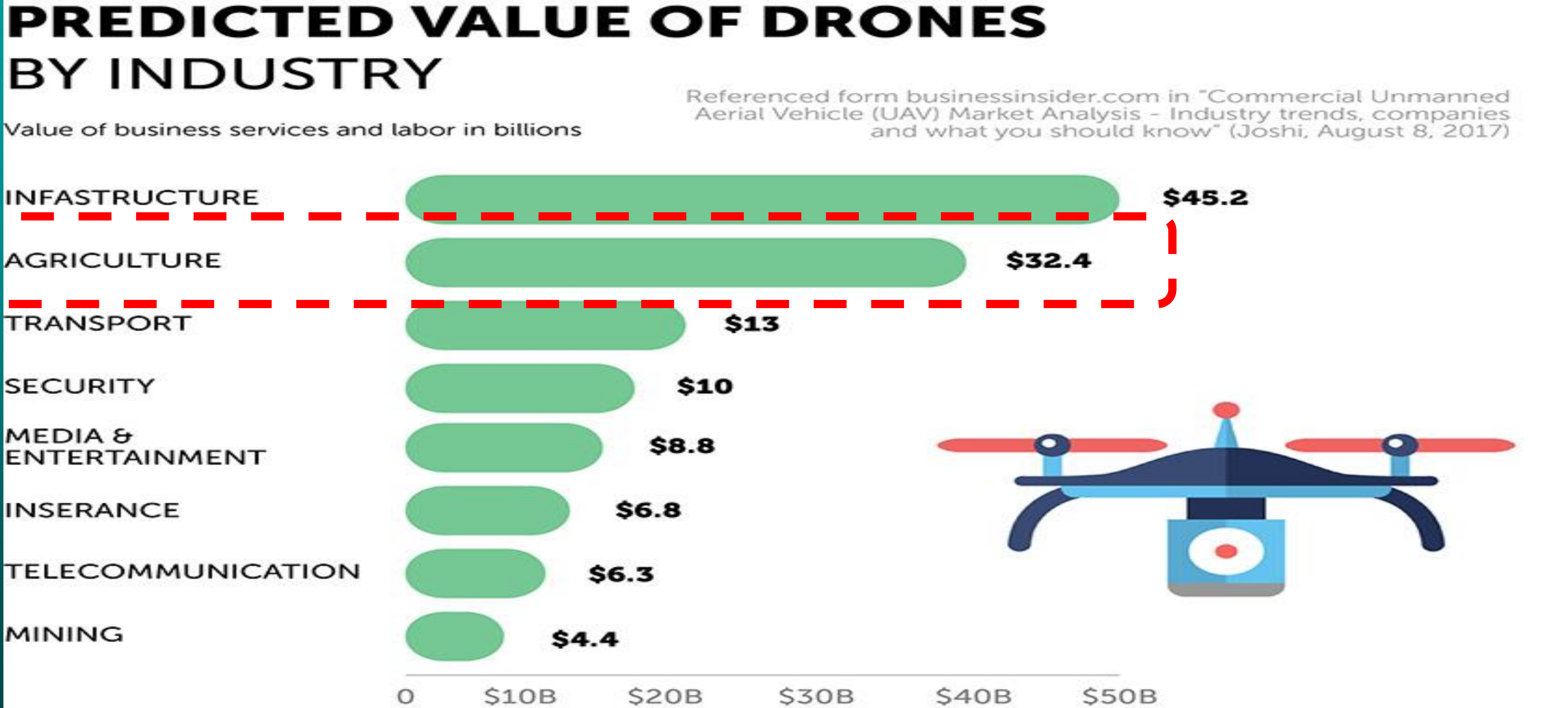
Background

Why Drone?



Drone Application Area

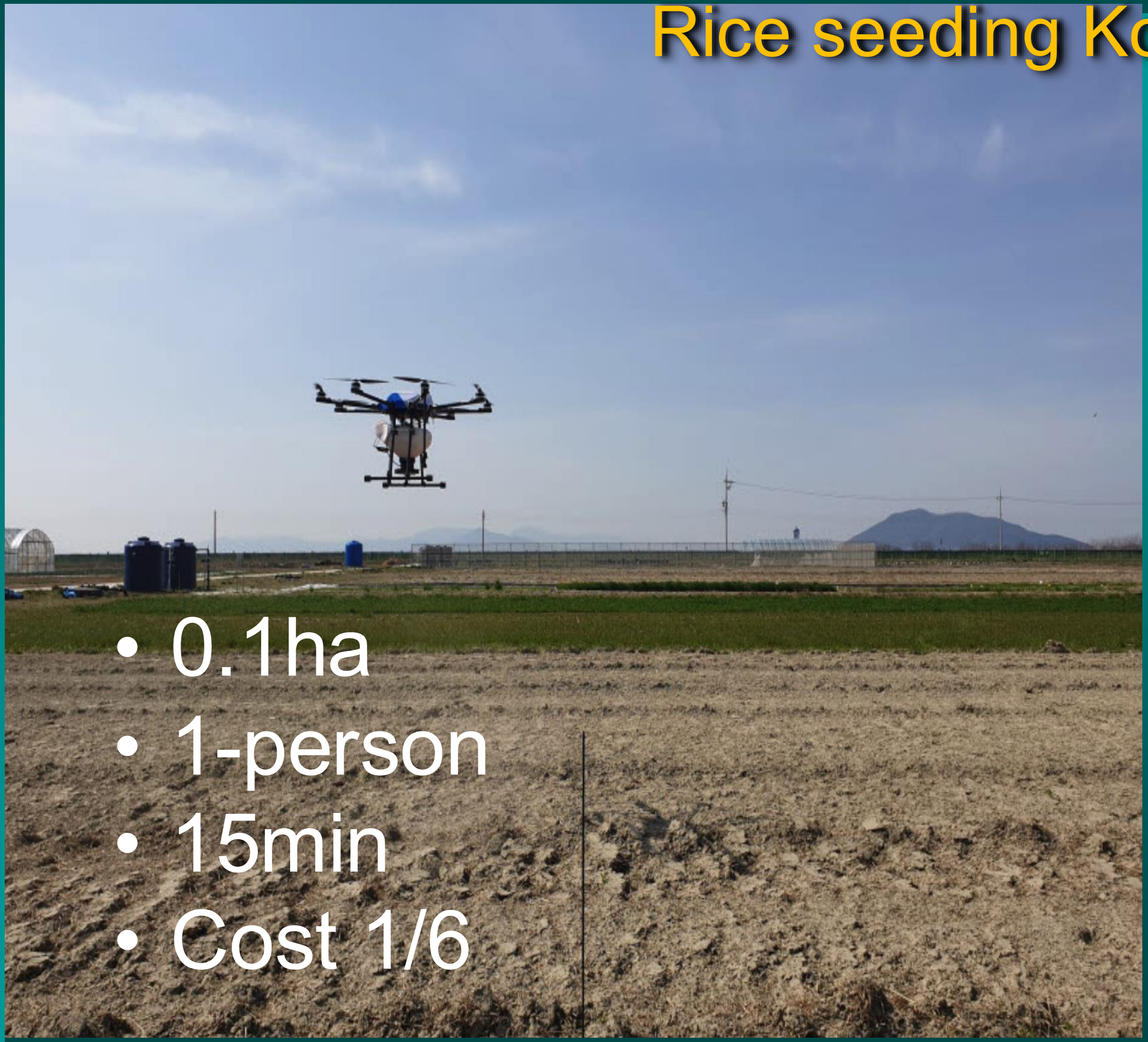
https://www.videocaddy.com/blog/the-technical-and-market-might-of-aerial-videography/



Drone and Agriculture

Rice seeding Korea (농촌진흥청)

Rural Development Administration



- 0.1ha
- 1-person
- 15min
- Cost 1/6

- 0.1ha
- 2-3-person
- 1.5hr

African Drone

Drone Taxi

MLIT (Ministry of Land, Infrastructure and Transport), Korea

Bankkok Post (Thailand), Nov 25. 2020

- MLIT (Ministry of Land, Infrastructure and Transport) moves to launching unmanned air Taxi by 2025.
- South Korea is investing around 24.5 billion won ($22 million) to develop the so-called K-Drone System.

Drone Taxi

Dubai ready

Digital Transformation

- Taxi-drone service ready to take off in Dubai
- Two technologies with an increasing number of appli cations are joining forces in Dubai to provide citizens with a service that was previously only in the imagina tion of filmgoers: autonomous flying cars or, in other words, taxi-drones.

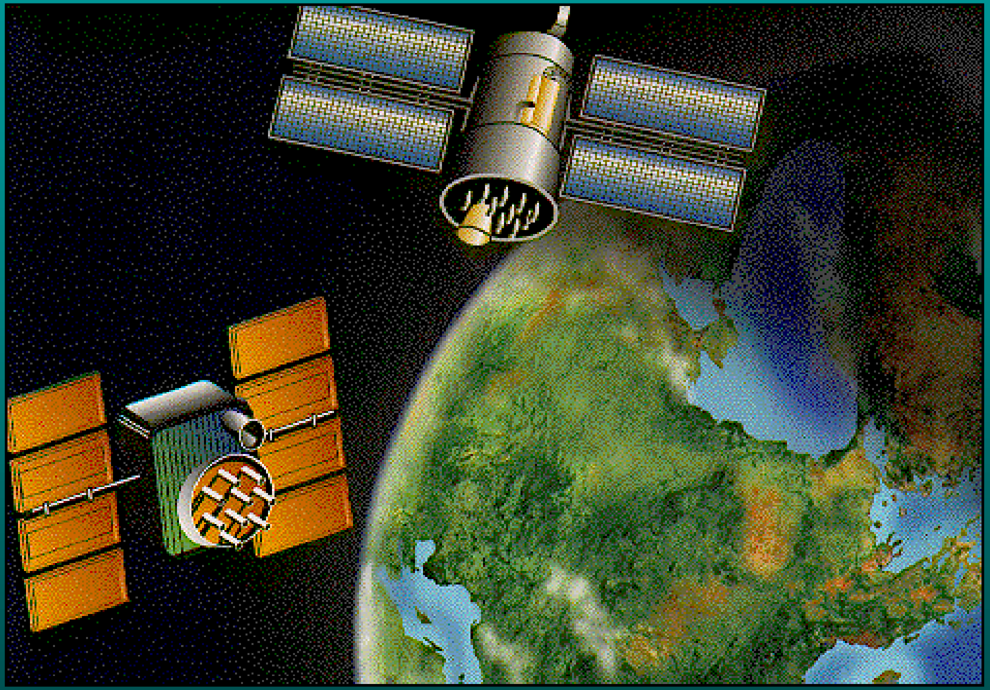
Drone and Construction

Drones could save 100s of construction workers' lives each year?

Drone Delivery

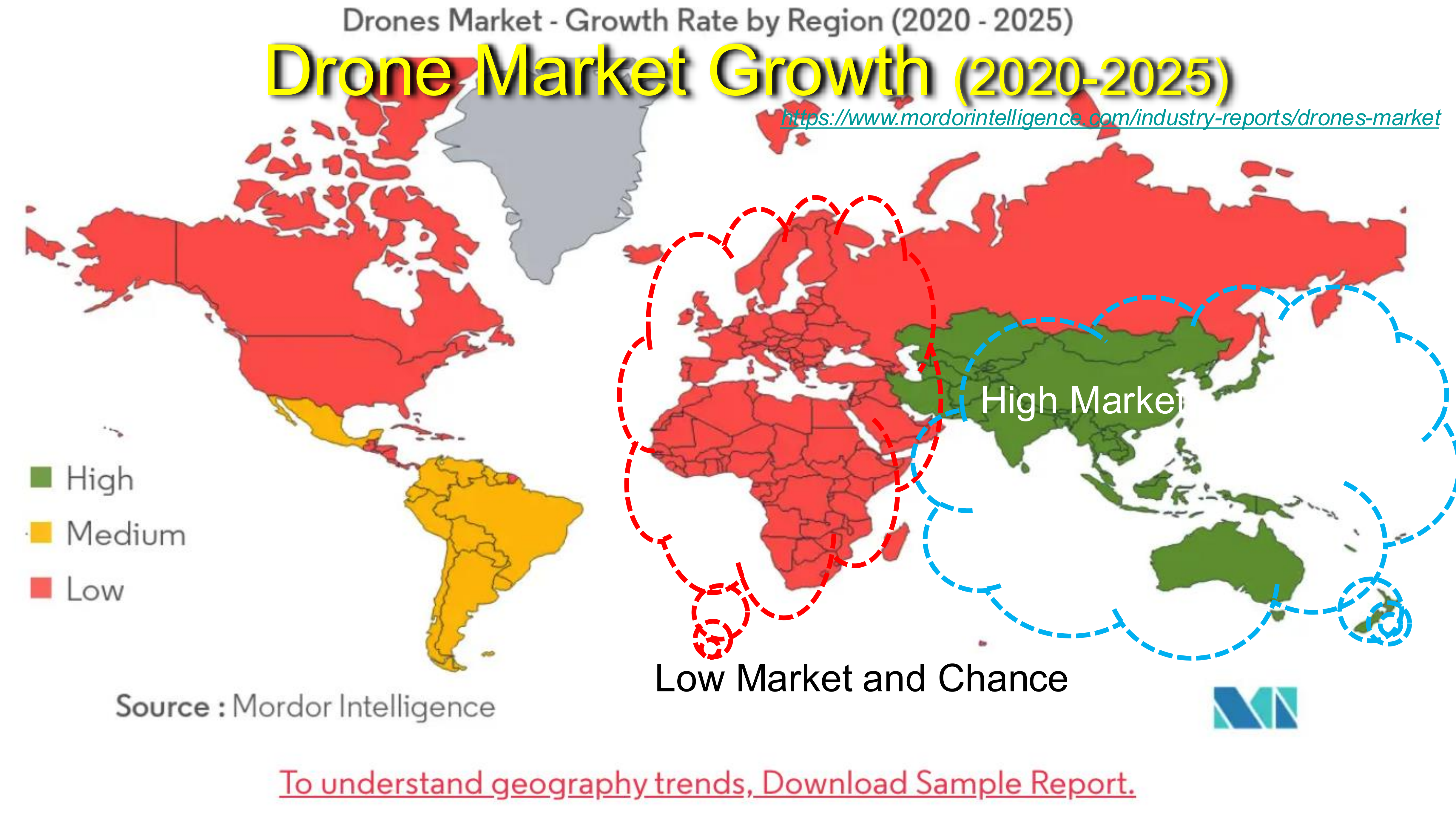
Section 1

Drone Policy & Market



Drone Market Growth (2020-2025)

https://www.mordorintelligence.com/industry-reports/drones-market



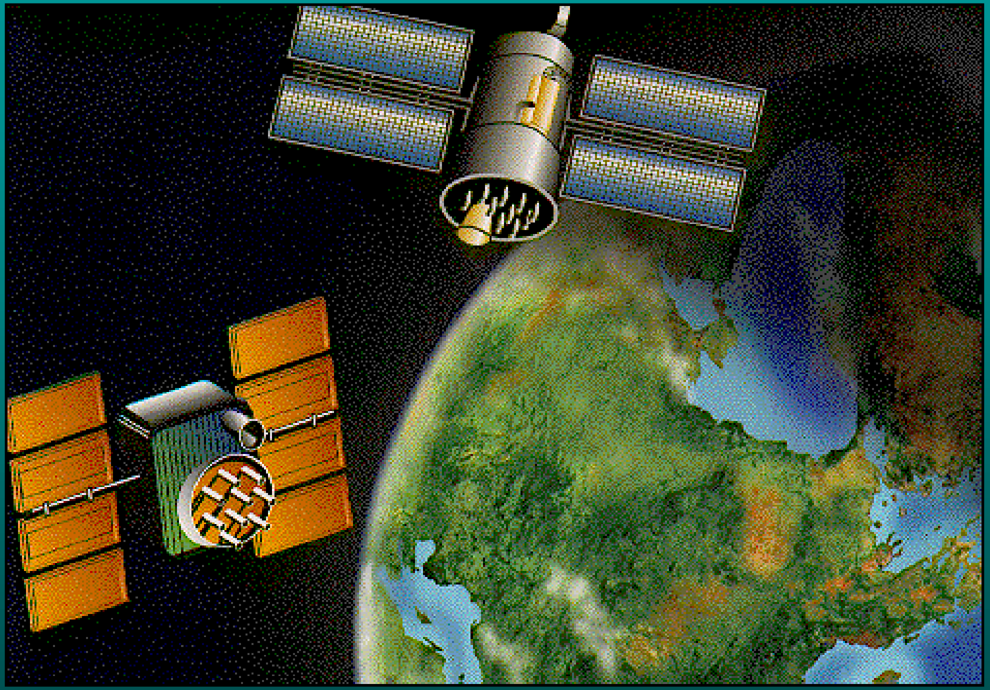
Major Drone Com.

Item	Com.	Products
Global	DJI	Agriculture/Phantom4Indoor racing
	Xiaomi	MI Drone
	ihang	ihang184
	Facebook	Internet Drone
	Intel	Tyhoon
	Parrot	Drone, Plane drone
	Airbus	Survey for plane

Item	Com.	Products
Korea (200)	UMAC AIR (주)유멕에어)	General / Racing
	Unicon system	Military/Industr
	KEVA (카바드론)	Military/Construction
	X Drone (엑스드론)	Small multipurpose/Research
	Troizen (트로젠)	Racing/Toy
	Byrobot	Toy
	UVify (유비파이)	AI based Auto
	Huins (휴인스)	Embedded/Education
	JuniLab (주니랩)	Smartphone control
	EsV (이에스브이)	Race/Toy/Export
	Essen Digital (엣센디지탈)	Race/Expert

Section 3

What Kinds of Drone



What Types of Drone

What Types of Drone

Toy Drone

Technology Education Drone

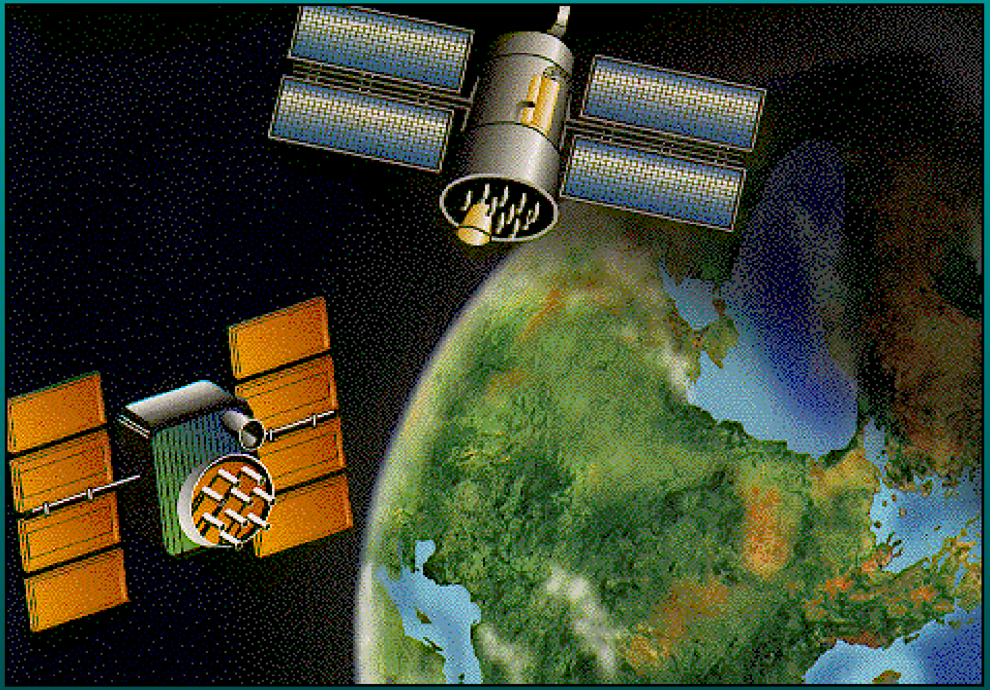
Public Drone (Fire, Agriculture)

Commercial Drone

Racing Drone

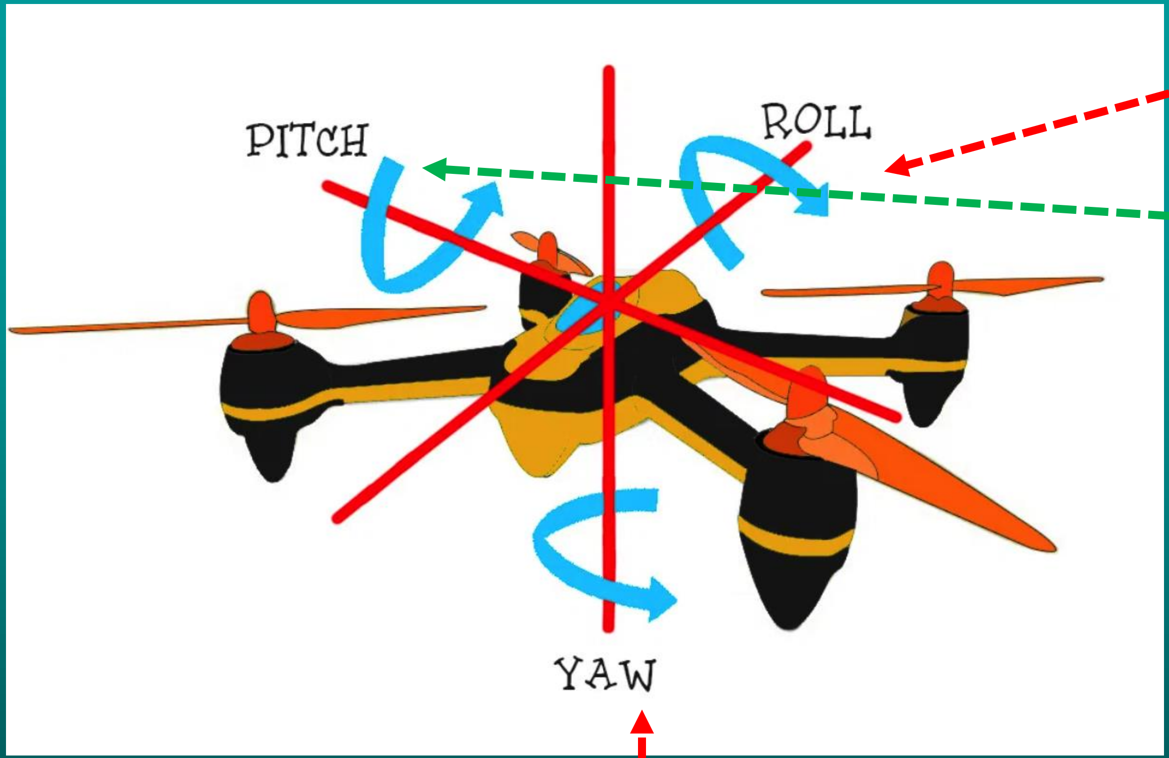
Section 4

Drone Control Technology

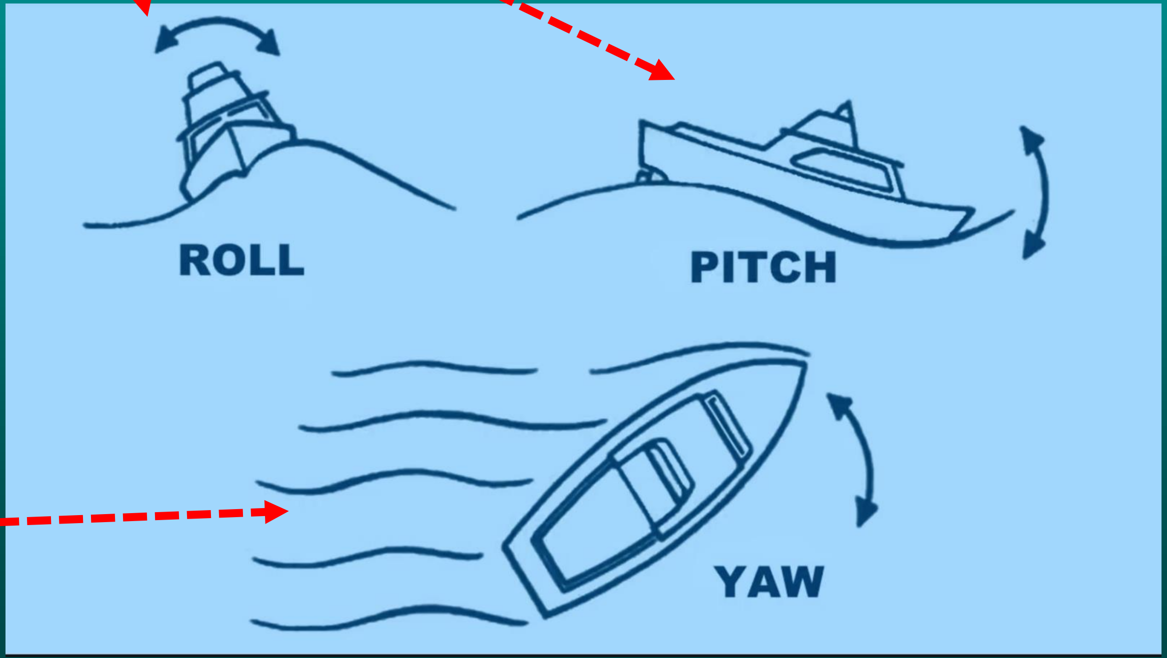


How to Move

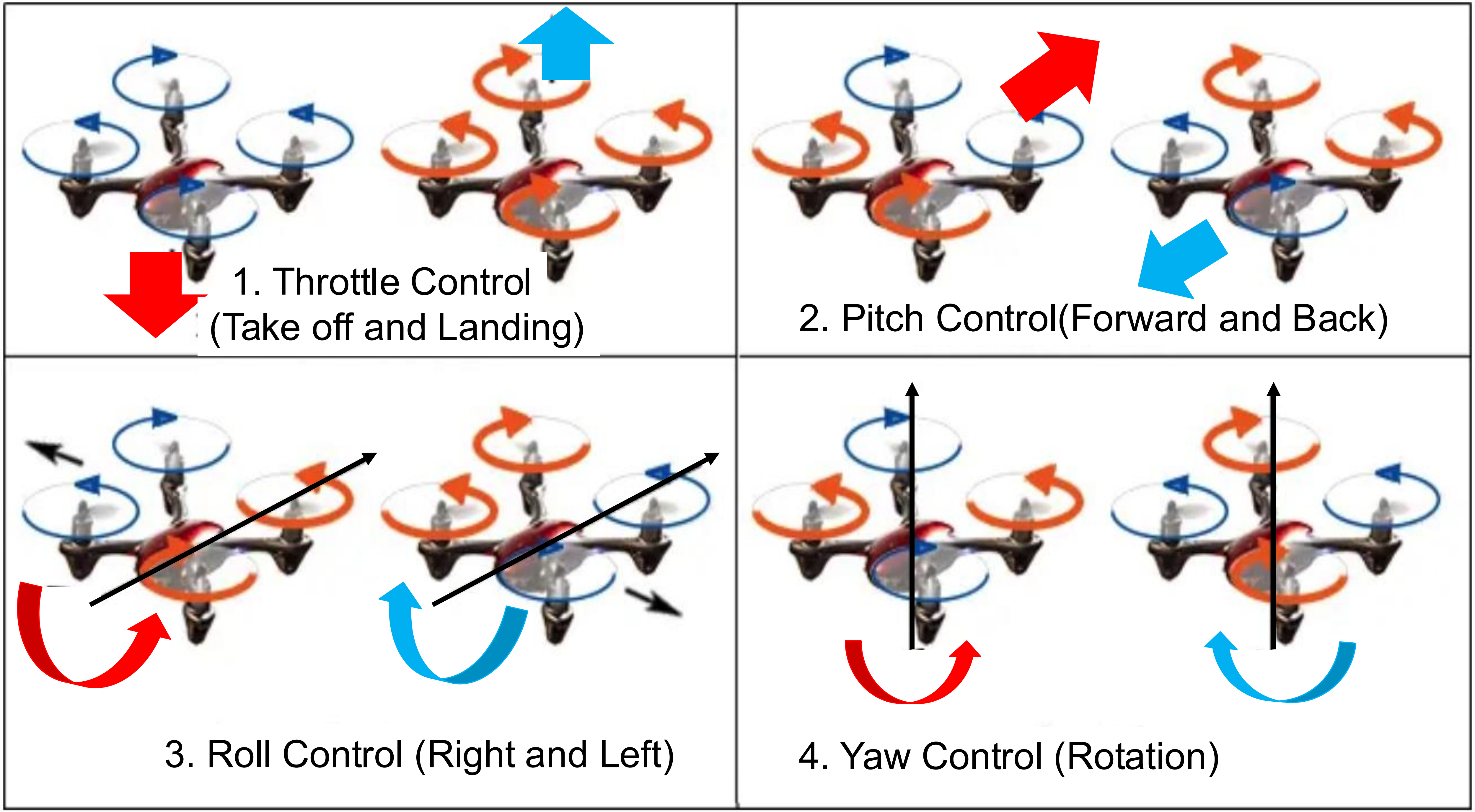
Pitch, Roll, Yaw



- Roll: Moving to left or Right
- Pitch: Moving Forward or Backwards.



- Yaw: Rotation


1. Throttle Control
(Take off and Landing)
2. Pitch Control(Forward and Back)
3. Roll Control (Right and Left)
4. Yaw Control (Rotation)

Dynamic Equation

R rotation matrix is as follows;

Moving Equation (robot, Drone)

$$R = \begin{bmatrix} \cos\theta\cos\psi & \cos\theta\sin\psi & -\sin\theta \\ \sin\psi\sin\theta\cos\psi - \cos\phi\sin\psi & \cos\phi\cos\psi + \sin\phi\sin\theta\sin\psi & \sin\phi\cos\theta \\ \cos\phi\sin\theta\cos\psi + \sin\phi\sin\psi & \sin\theta\cos\phi\sin\psi - \sin\phi\cos\psi & \cos\theta\cos\phi \end{bmatrix}$$

T is a matrix for angular transformations[20].

$$T = \begin{bmatrix} 1 & \sin(\phi)\tan(\theta) & \cos(\phi)\tan(\theta) \\ 0 & \cos(\phi) & -\sin(\phi) \\ 0 & \dfrac{\sin(\phi)}{\cos(\theta)} & \dfrac{\cos(\phi)}{\cos(\theta)} \end{bmatrix}$$

Transformation Matrix

Dynamic Equation (5/9)

$$\dot{x} = w[s(\phi)\,c(\psi) + c(\phi)\,c(\psi)\,s(\theta)] - v[c(\phi)\,s(\psi) - c(\psi)\,s(\phi)\,s(\theta) + u[c(\psi)\,c(\theta)]]$$

$$\dot{y} = v[c(\phi)\,c(\psi) + s(\phi)\,s(\psi)\,s(\theta)] - w[c(\psi)\,s(\phi) - c(\phi)\,s(\psi)\,s(\theta) + u[c(\theta)\,s(\psi)]]$$

$$\dot{z} = w[c(\phi)\,c(\theta)] - u[s(\theta)] + v[c(\theta)\,s(\phi)]$$

$$\dot{\phi} = p + r[c(\phi)\,t(\theta)] + q[s(\phi)\,t(\theta)]$$

$$\dot{\theta} = q[c(\phi)] - r[s(\phi)]$$

$$\dot{\psi} = r\frac{s(\phi)}{c(\theta)} + q\frac{s(\phi)}{c(\theta)}$$

$$\dot{u} = (vr - wq) + g\,s(\theta)$$

$$\dot{v} = (wp - ur) - g\,c(\theta)\,s(\phi)$$

$$\dot{w} = (uq - vp) - g\,c(\theta)\,s(\phi)\frac{U_1}{m}$$

$$\dot{p} = \frac{I_y - I_z}{I_x}qr + \frac{U_2}{I_x}$$

$$\dot{q} = \frac{I_z - I_x}{I_y}pr + \frac{U_3}{I_y}$$

$$\dot{r} = \frac{I_x - I_y}{I_z}pq + \frac{U_4}{I_z}$$

12 variables

Dynamic Equation

- $\dot{x} = Ax(t) + Bu(t)$
- $y = Cx(t) + Du(t)$

Modern Control Dynamic Equation

$G(s)=C(SI-A)^{-1}+DU$

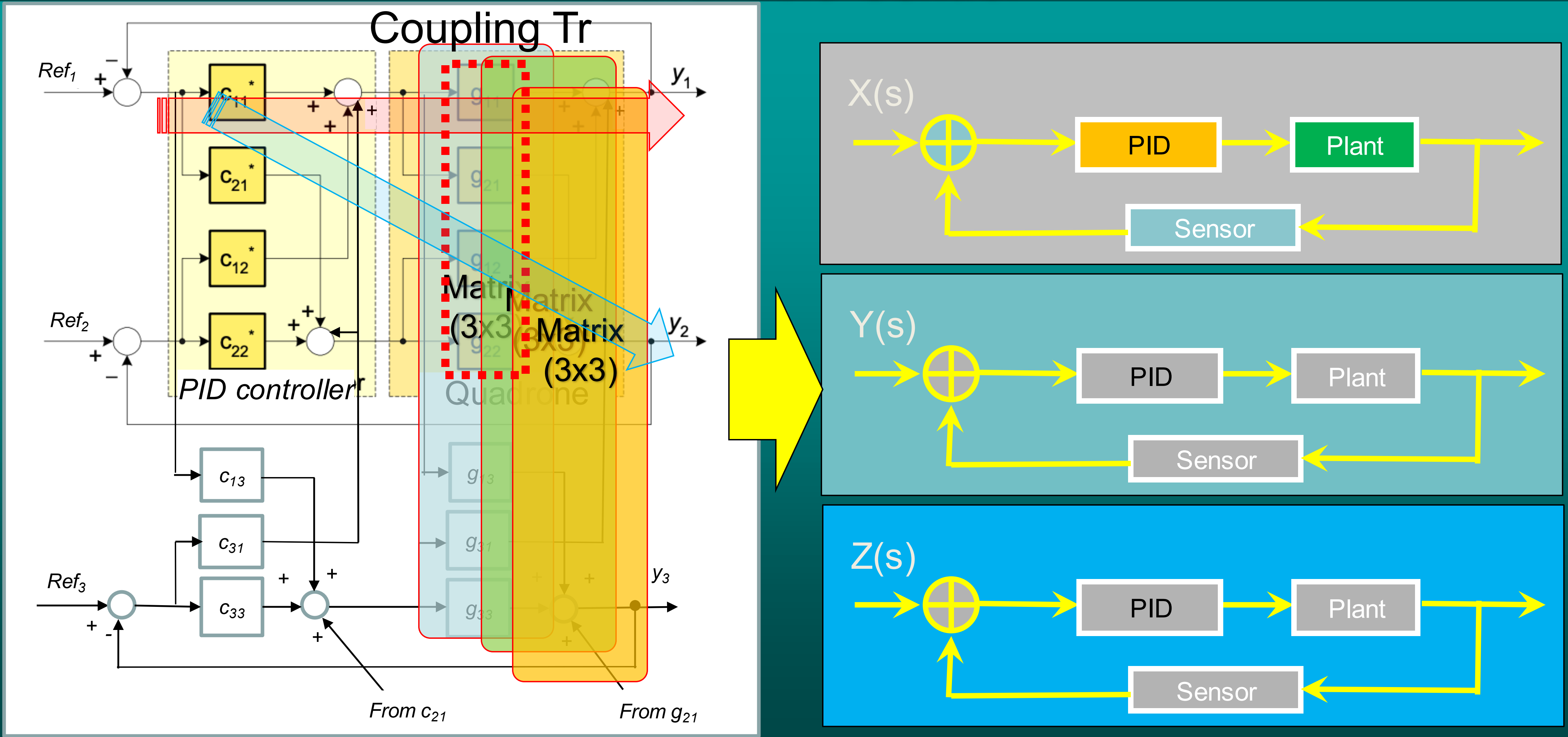
- After the linearization is done
- The input matrix is determined,

Dynamic Equation

- Accordingly quadrotor hover, longitudinal and lateral flight PID would be as follows, respectively:
    - $u(t) = K_{ph} e(t) + K_{ih} \int e(v) d(v) + K_{dh} de(t)/dt$
    - $u(t) = K_{p\theta} e(t) + K_{i\theta} \int e(v) d(v) + K_{d\theta}\ det/dt$
    - $u(t) = K_{p\theta} e(t) + K_{i\theta} \int e(v) d(v) + K_{d\theta}\ det/dt$

Drone Control

Multivariable Control



Multijoint Dancing Robot with Emotion Function

Conclusion