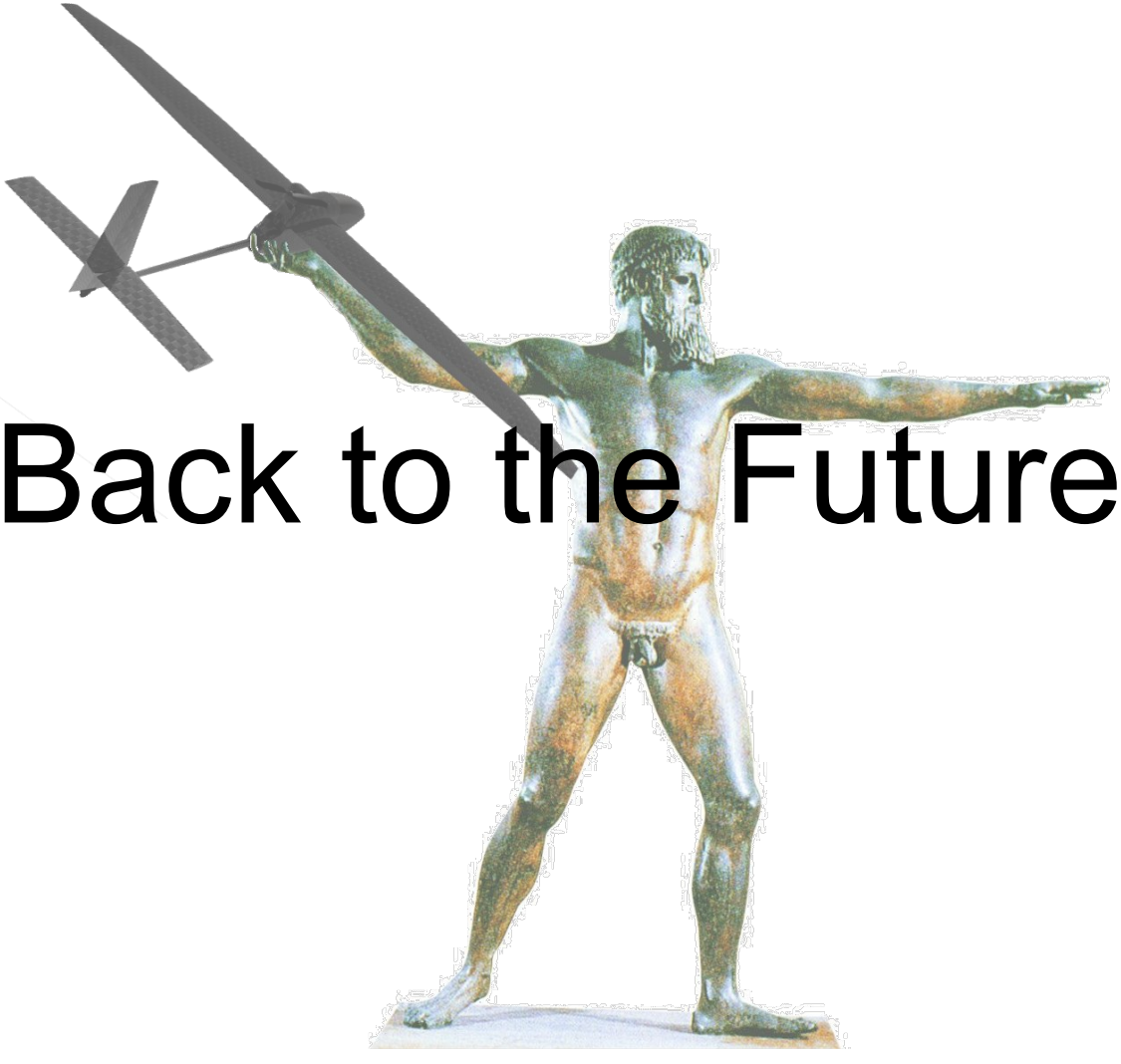


Back to the Future

A drone by any other name

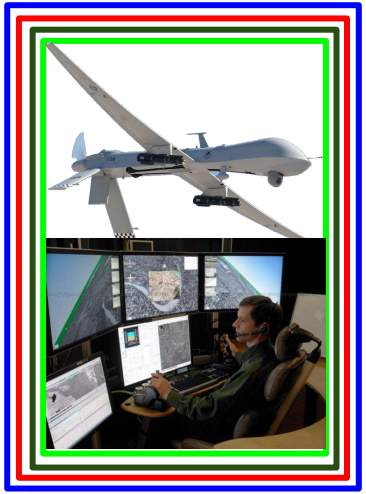
UAV

UAS

R/C

RPAS

FPV



All of these are “drones”

Prehistoric times

Radio control makes an appearance at the end 19th century.

First autopilots make an appearance just before WWI.

WWI: radio controlled aircraft appear mostly as targets - (attempts at unmanned planes as weapons generally unsuccessful).

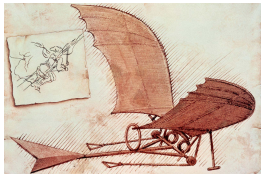
WWII: V-1 and V-2 are first cruise missiles.

Medieval times

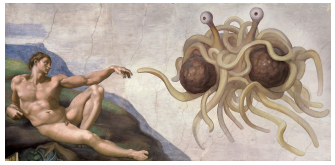
After WWII, autopilots make autonomous flight mainstream (aviation, cruise missiles, spacecraft).

1950s: hobby remote control starts becoming mainstream.

Today’s drone scene is largely a continuation of this tradition, merged with 21st century electronics.



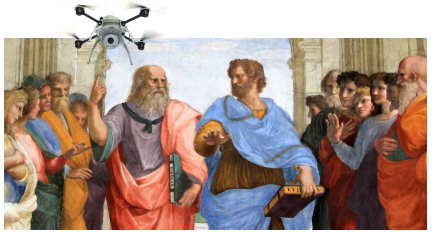
Renaissance



In the 90s, we have important developments:

- GPS becomes mainstream for civilian applications.
- Mobile phone ownership and coverage explodes.
- The internet facilitates the open source movement.

Are we there yet? Not yet. The electronics needed for small and cheap autopilots exist but are too bulky and expensive for widespread adoption.

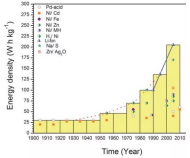


Age of Enlightenment

At the start of the 21st century, things are moving fast:

Turtlenecks, round eyeglasses and smartphones are trending

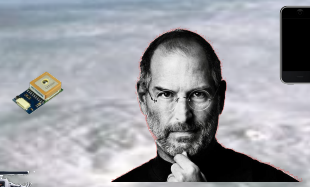
Huge demand for smartphones leads to rapid advances in:

- Batteries 
- Inertial and other sensors  
- GPS 
- Small, low power, high performance processors 

In short, mobile computing and assorted peripherals.

The Perfect Storm

2003: **Paparazzi** (ENAC, France)
initially thermopile based.



2005: **Arduino** (IDII, Italy).

2009: **Ardupilot**
IMUs replace thermopiles.

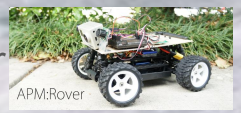
Arduplane

Arducopter

Arduboat

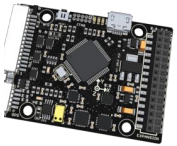
Ardusub

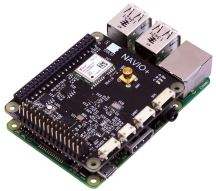
Ardurover

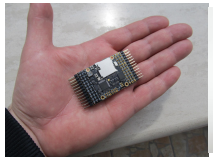
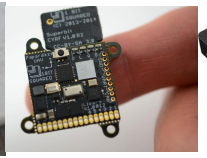


No time like the present

Currently, there are multiple, low cost autopilots, capable of fully autonomous flight.



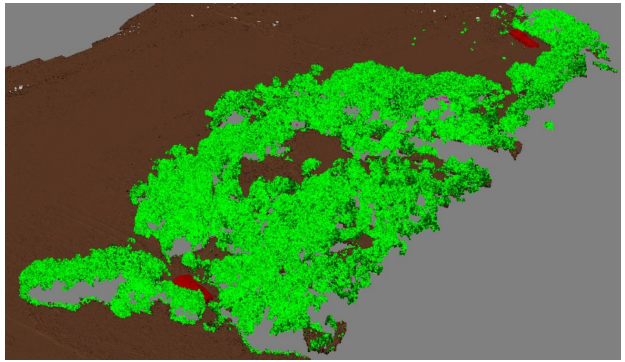





Current mainstream

Current mainstream

DSM overlaid on Google Earth

Dense point cloud



Classified point cloud

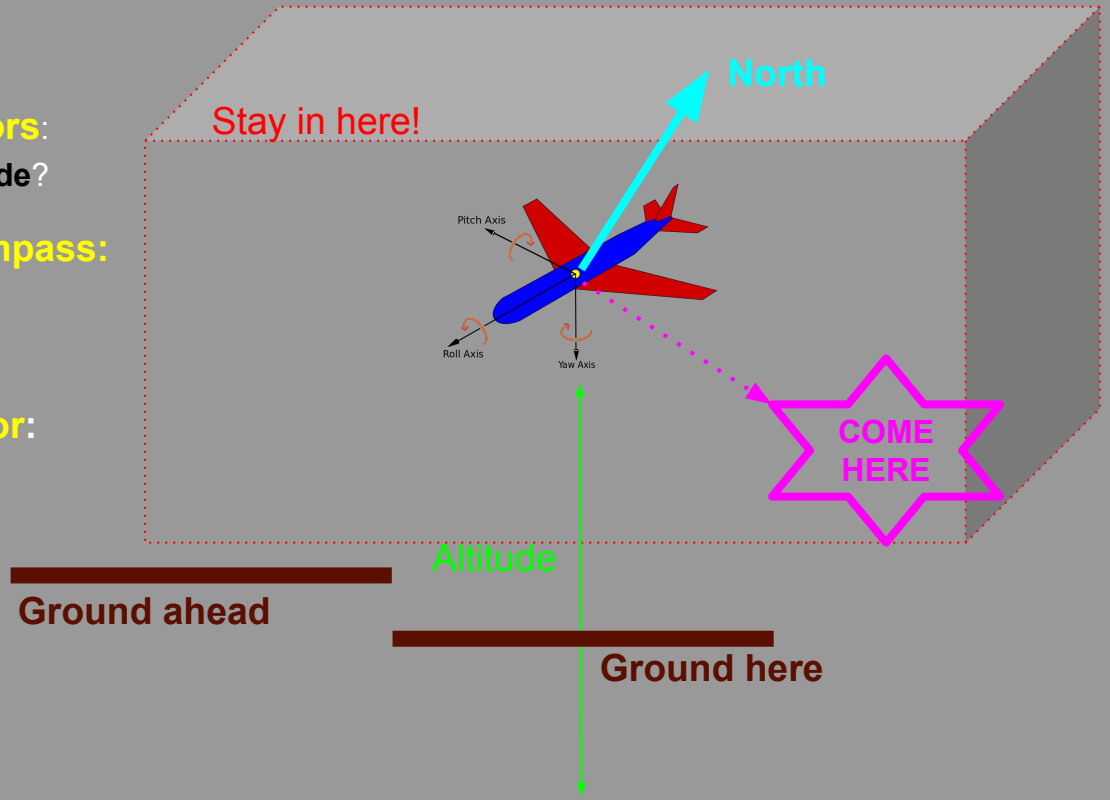
What's in an autopilot?

AHRS

Inertial sensors:
what's my **attitude**?

Magnetic compass:
Where's **north**?

Air pressure sensor:
what's my **altitude**?



GPS: what's my **position & ground speed**

Memory:
Target waypoint?
Fence?
Ground elevation?

Autopilots+

2012: Lidar (MIT)

2016: Radar (Aerotenna)

2015: Cameras (MIT)

Aircraft types (heavier than air)

	The Good	The Bad
 Fixed wing	Stable, most efficient, excellent for long missions	Can’t hover, take-off and landing problematic
 Helicopter	Mostly stable, middle efficiency, excellent for VTOL	Mechanically complicated, not as manoeuvrable as multirotor
 Multirotor	Mechanically simple, excellent manoeuvrability, VTOL, low entry barrier	Not stable, very inefficient

Major uses

	Camera	Funny cam	Lidar	Chemical	Cargo	Radio
Agriculture	✓	✓	✓	X	X	X
Mapping & Surveying	✓	✓	✓	✓	X	X
Construction & mining	✓	✓	✓	X	X	X
Cinematography	✓	X	X	X	X	X
SAR / humanitarian	✓	✓	✓	✓	✓	✓
Eco / conservation	✓	✓	✓	✓	X	X
Medical	X	X	X	X	✓	X
Delivery	X	X	X	X	✓	X
Relay	X	X	X	X	X	✓

Legal matters

Two big issues currently related to the use of drones:

- **Sense and avoid** (roughly EU wide): In order to be able to fly **beyond visual line of sight** (BVLOS), drones need to be able to sense and avoid other airborne entities.
  Current regulation implies use cases are approximately restricted to the 1 square kilometre region which is typical multirotor capability.

- **Camera use** (Sweden): severe restrictions on airborne camera use will impact large sections of the industry.

Legal impact

	Camera	Funny cam	Lidar	Chemical	Cargo	Radio
Agriculture	✓	✓	✓	X	X	X
Mapping & Surveying	✓	✓	✓	✓	X	X
Construction & mining	✓	✓	✓	X	X	X
Cinematography	✓	X	X	X	X	X
SAR / humanitarian	✓	✓	✓	✓	✓	✓
Eco / conservation	✓	✓	✓	✓	X	X
Medical	X	X	X	X	✓	X
Delivery	X	X	X	X	✓	X
Relay	X	X	X	X	X	✓

KEEP CALM AND PANIC !!

BVLOS:
Inhibited
~~Blocked~~

Cam law:
~~Blocked~~

Interesting Technology

Reasonable cost ADS-B receivers.

Promising developments but transmitters still expensive, unequipped aircraft do not benefit.

Photogrammetry vs Lidar

Photogrammetry has taken a blow in Sweden. However, low cost and solid state Lidar might be coming soon.

Radar & microwave sensing

Radar and microwave based avoidance and sensing seems to be becoming small enough for the small UAV market.

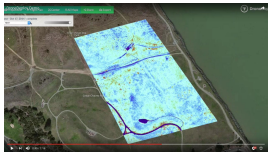
RTK GPS

Real time kinematics GPS is becoming mainstream, offering cm level accuracy for the cost of being anchored to a known location. Both Lidar and Photogrammetry based surveys can benefit.

Deep Learning

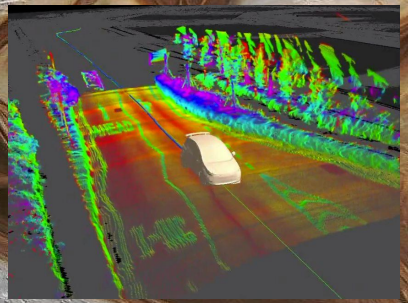
Feature extraction accurate and fast enough to be used for obstacle avoidance is the holy grail which might win over the other technologies.

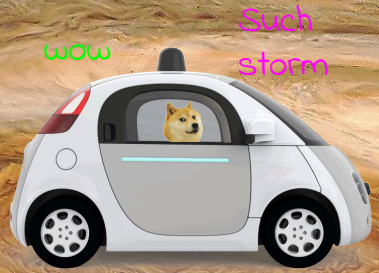
Drone Deploy

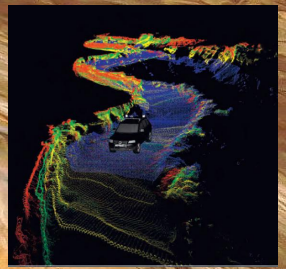


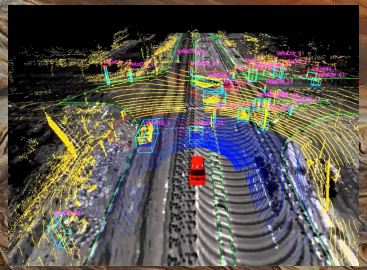
Real-time, online model creation (Dronedeploy, US). This is an indication of the way ubiquitous connectivity is changing post processing.

Perfect Storm 2.0









Thank you

Now, let’s have some questions.

Andreas Gazis

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