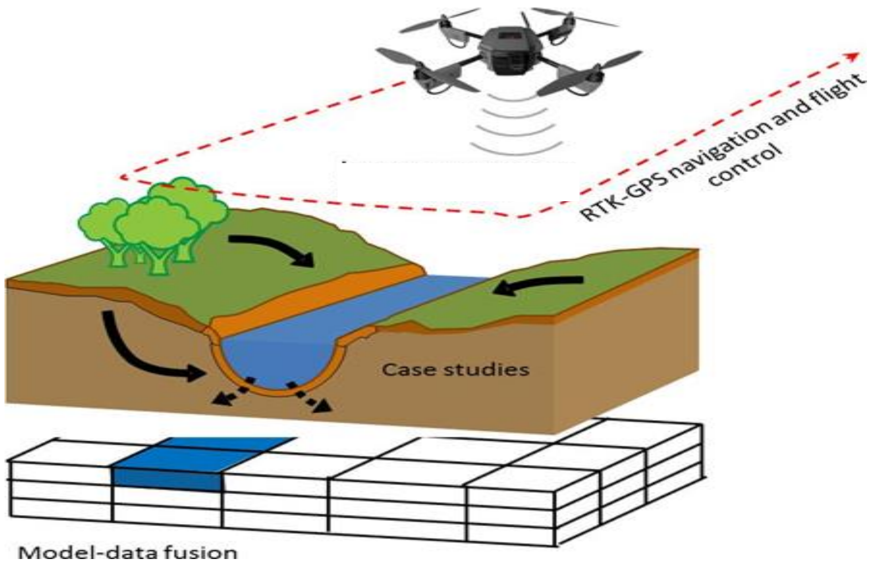
Applications of UAVs



NKG Summerschool 2016

By Jakob Jakobsen

DTU Space
National Space Institute

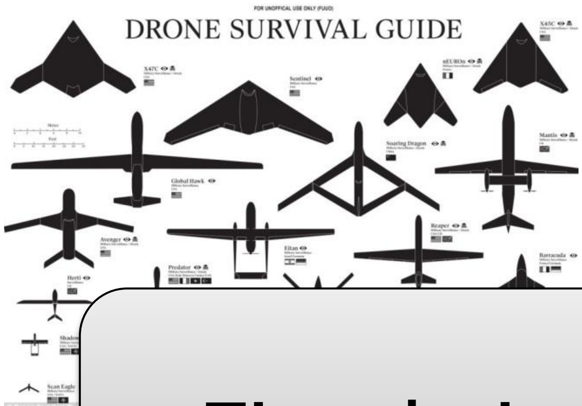
Outline

- What is a drone application
- Type of drones and how do they work
- Payload setup
- Application example
- Navigation implementation on the Smart UAV

What does a drone application consist of

Drone + Payload + Data Processing = Application

Drones comes in all shape and sizes



Fixedwings

Multirotors

Photo: M. Daniel J. McLain

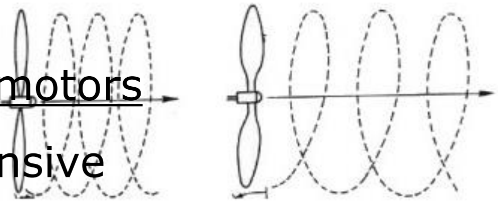
And then all the others called hybrids

Multirotor anatomy

Pitch

High more thrust

Low more efficient



Brushless motors

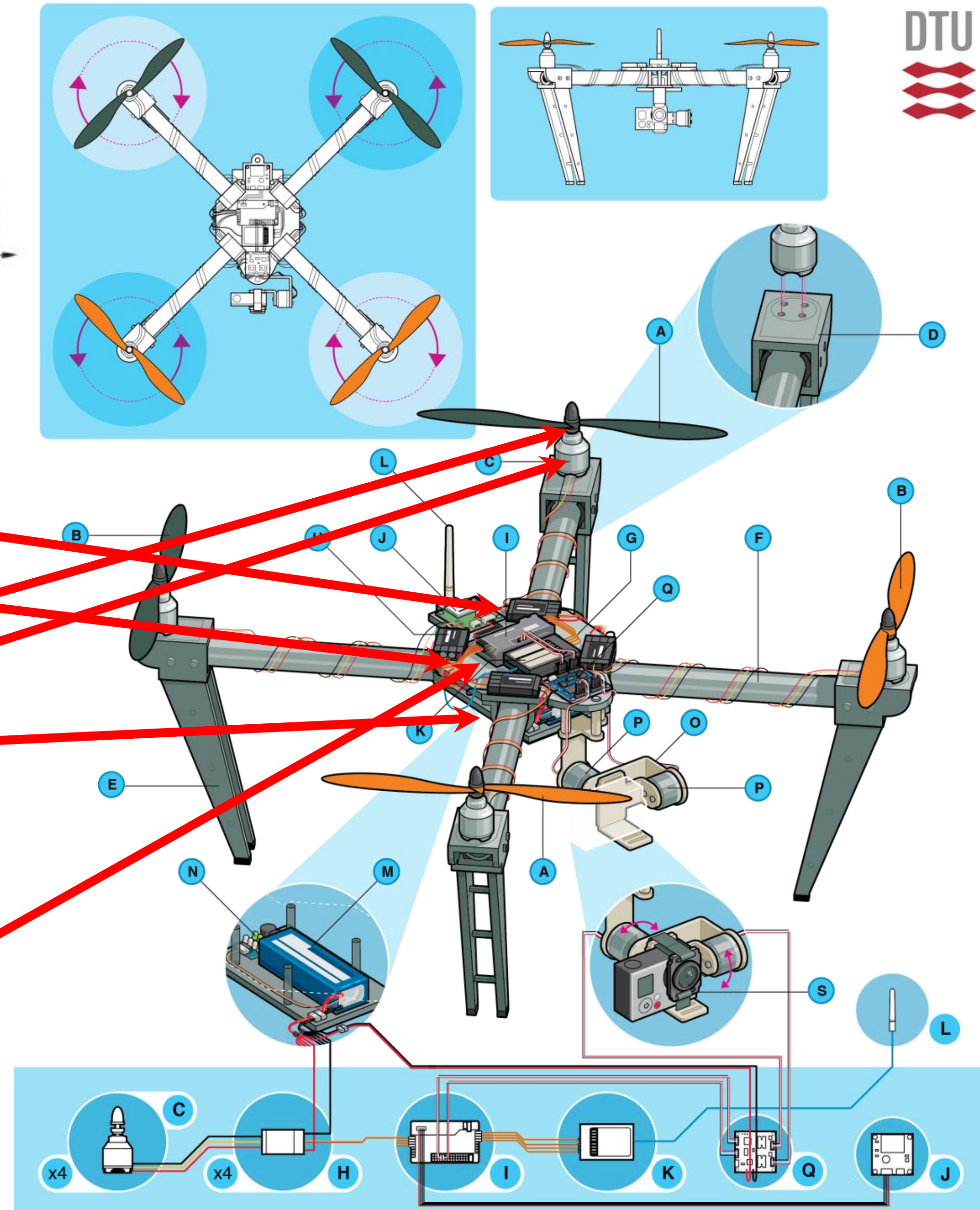
More expensive

Zero friction

Stronger

Faster

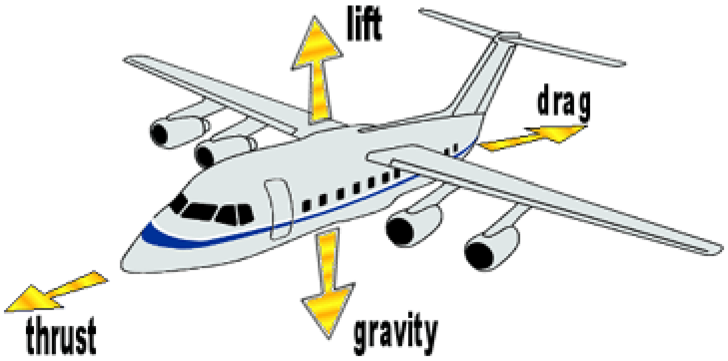
Longer lifespan

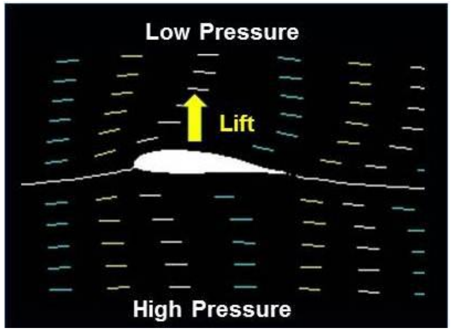


Dronetrest.com

Fixedwing dynamics of flight

4 forces of flight

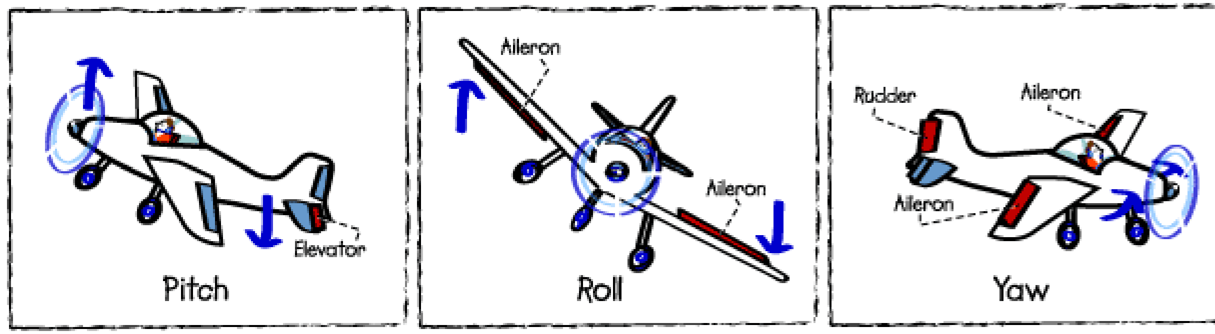




Fixedwings need to reach stall speed at takeoff

Fixedwing controls

Controls



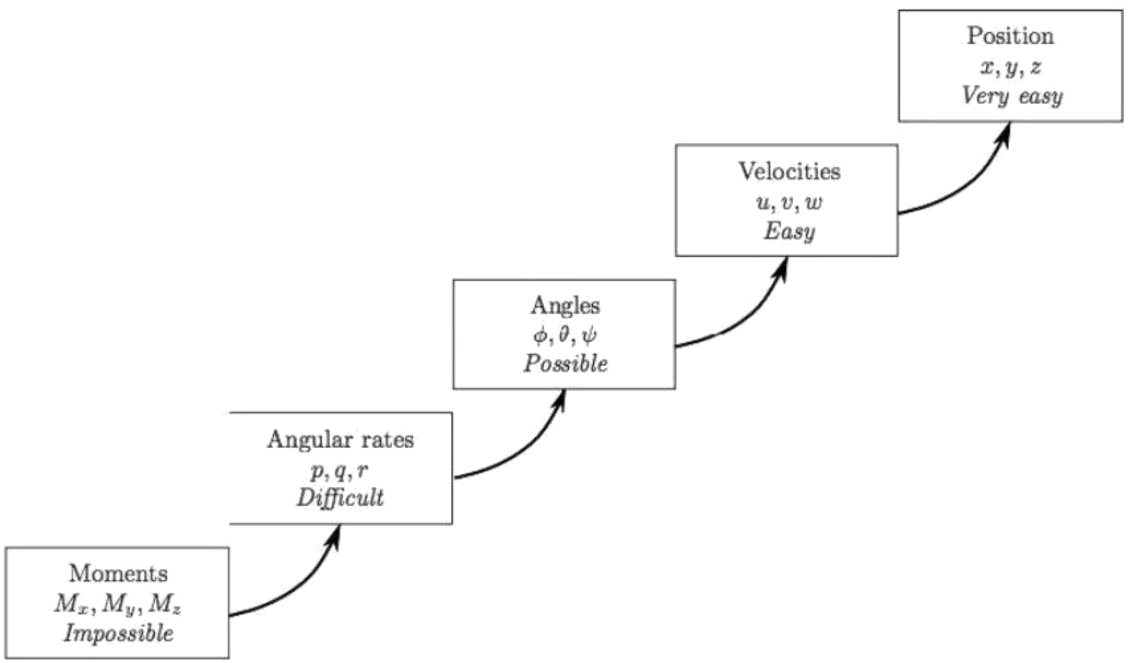
Transmitter

Receiver

Flightcontroller

Autonomous flight, one layer up

An autopilot system is used to control the trajectory of the vehicle without constant control by a human operator



Autonomous flight components

GNSS

Navigation controller

In general a loosely coupled kalman filter solution using a code based GNSS

Mavlink protokol

RPM

Pitch, yaw, roll

Position

Sensordata

Ground speed

Ground control

Waypoint navigation

Camera trigger

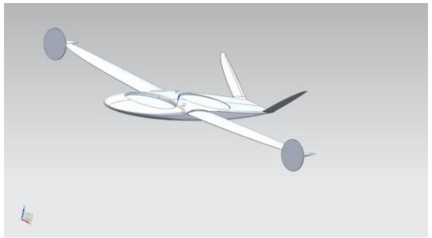
Start and land point

…

UAV capabilities

Multirotors

Hybrids



Fixed wings

- VTOL, vertical take-off and landing
- Agile maneuvering
- Hovering

- Long distance
- Long flight times

General

- Payload
- Autonomous flight
- Sensor triggering
- Sensor integration
- Gimbal

DTU Drone Center fleet

Cumulus One from
Sky-Watch A/S

Smart UAV

Huginn X1 from
Sky-Watch A/S

Erlecopter

Modular based
educational kit

DJI tarot hexa

DJI s900 hexa

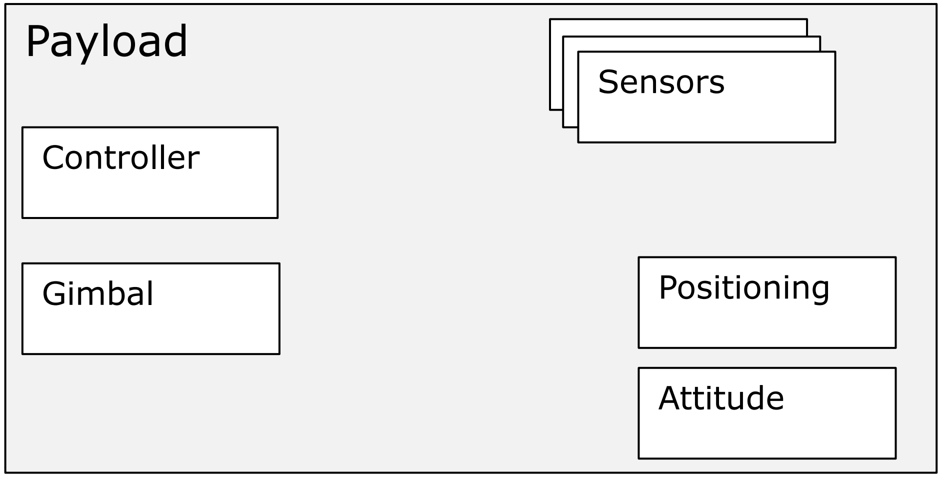
Mini Aerial Vehicle, MAV

Hubsan 107D and DJI Phantom 2 for pilot training

A drone application

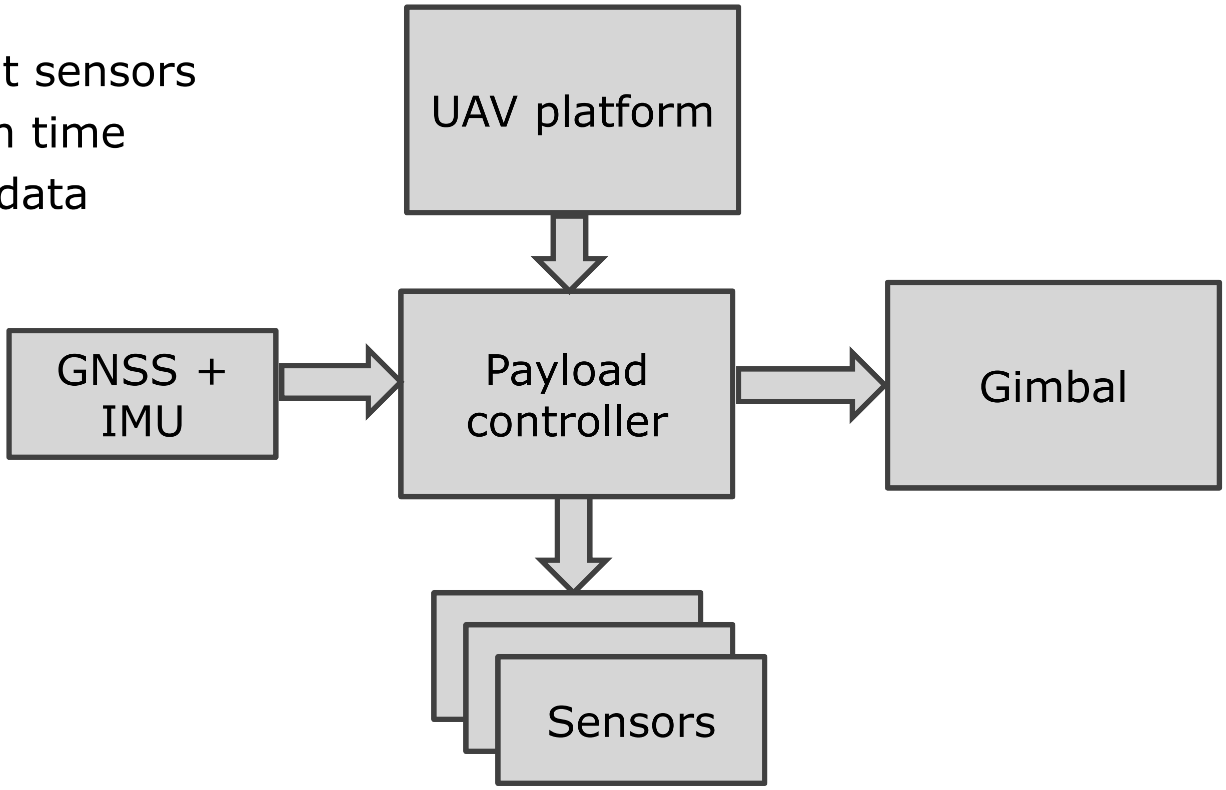
Drone + Payload + Data Processing = Application

Payload components



Purpose of the payload controller

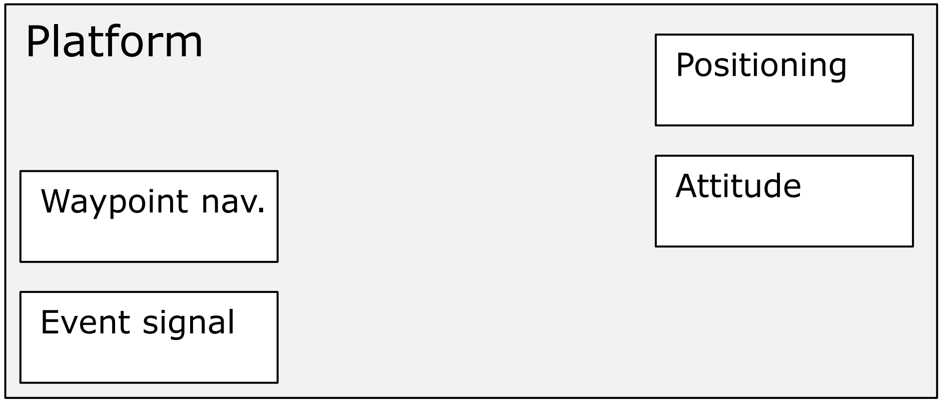
- Link between the UAV platform, sensors and gimbal
- Save data for the different sensors
- Synchronise sensordata in time
- Store GNSS and attitude data
- Interact with gimbal
- Interact with sensors



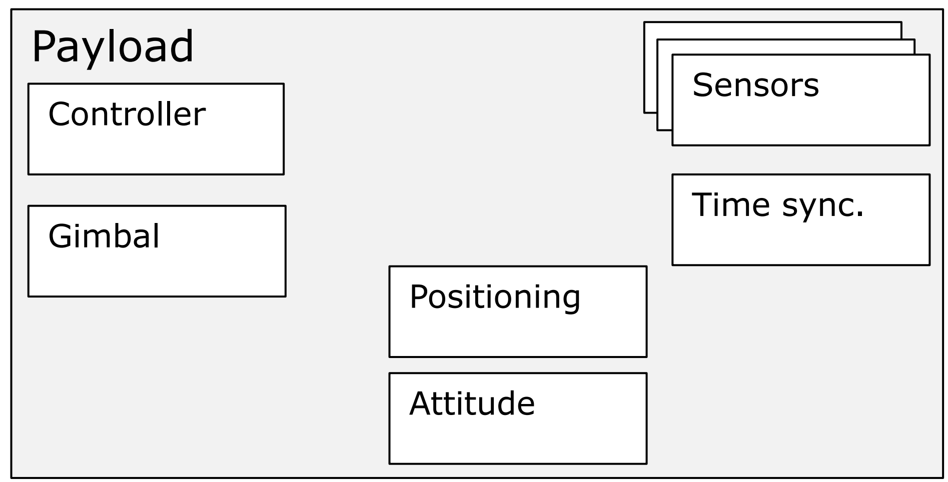
Payload controller hardware

- Open-source hardware board
- 1GHz ARM processor
- SERIAL/SPI/I^2C/CAN supported
- 512MB DDR3 RAM
- μSD slot for additional storage
- Weight 39,68 g
- Size 86.40 mm × 53.3 mm

Payload interface




```xml
<?xml version="1.0" encoding="utf-8"?>
<Payload-SMART-UAV>
<data>
<data>
<identifier> 1 </identifier>
<time> 22:16 </time>
<ID> 1 </ID>
<distance> 0.900000 </distance>
<standard-deviation> 2.100000 </standard-deviation>
<position-longitude> 41.200001 </position-longitude>
<position-latitude> 85.199997 </position-latitude>
<height> 215.300003 </height>
<pitch> 51.700001 </pitch>
<roll> 15.300000 </roll>
<yaw> 21.100000 </yaw>
<gimbal-pitch> 25.100000 </gimbal-pitch>
<gimbal-roll> 27.000000 </gimbal-roll>
</data>
<data>
<data>
<data>
</Payload-SMART-UAV>
```

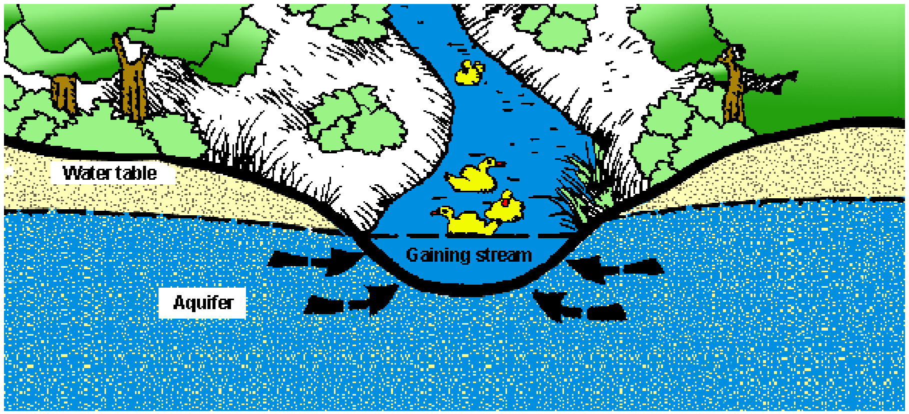



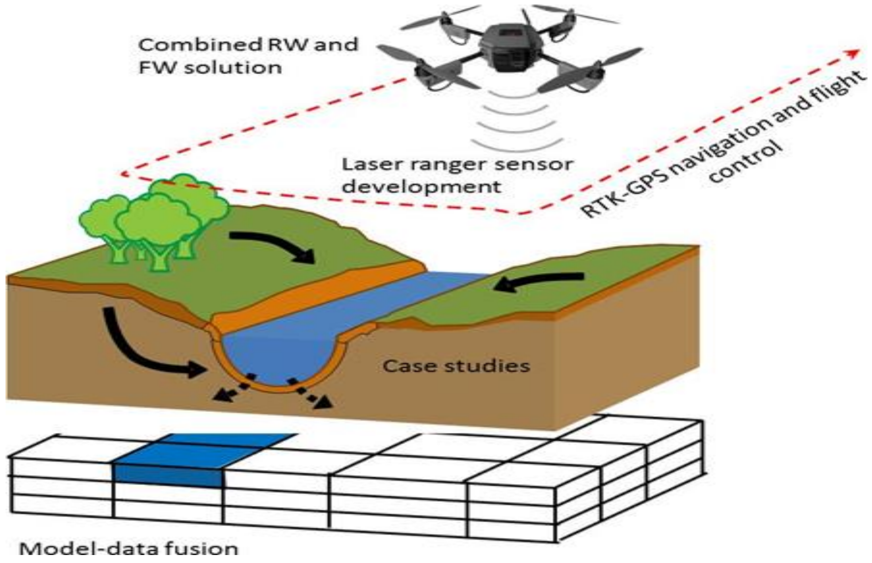
identifier	time	ID	distance	standard-deviation	position-longitude	position-latitude	height	pitch	roll	yaw	gimbal-pitch	gimbal-roll
0	22:15	1	0,9	2,1	41,200001	85,199997	215,300003	51,700001	15,3	21,1	25,1	27
1	22:16	1	0,9	2,1	41,200001	85,199997	215,300003	51,700001	15,3	21,1	25,1	27
2	22:17	1	0,9	2,1	41,200001	85,199997	215,300003	51,700001	15,3	21,1	25,1	27
3	22:18	1	0,9	2,1	41,200001	85,199997	215,300003	51,700001	15,3	21,1	25,1	27
4	22:19	1	0,9	2,1	41,200001	85,199997	215,300003	51,700001	15,3	21,1	25,1	27

A drone application

Drone + Payload + Data Processing = Application

Measure height of water level





Gaining or loosing stream? That is essential for understanding pollution dynamics

Other applications in hydrology

- Flood Propagation Mapping
- Hydrologic monitoring of sinkholes, ephemeral lakes and other unconventional targets
- Remote sensing of ice and snow depth

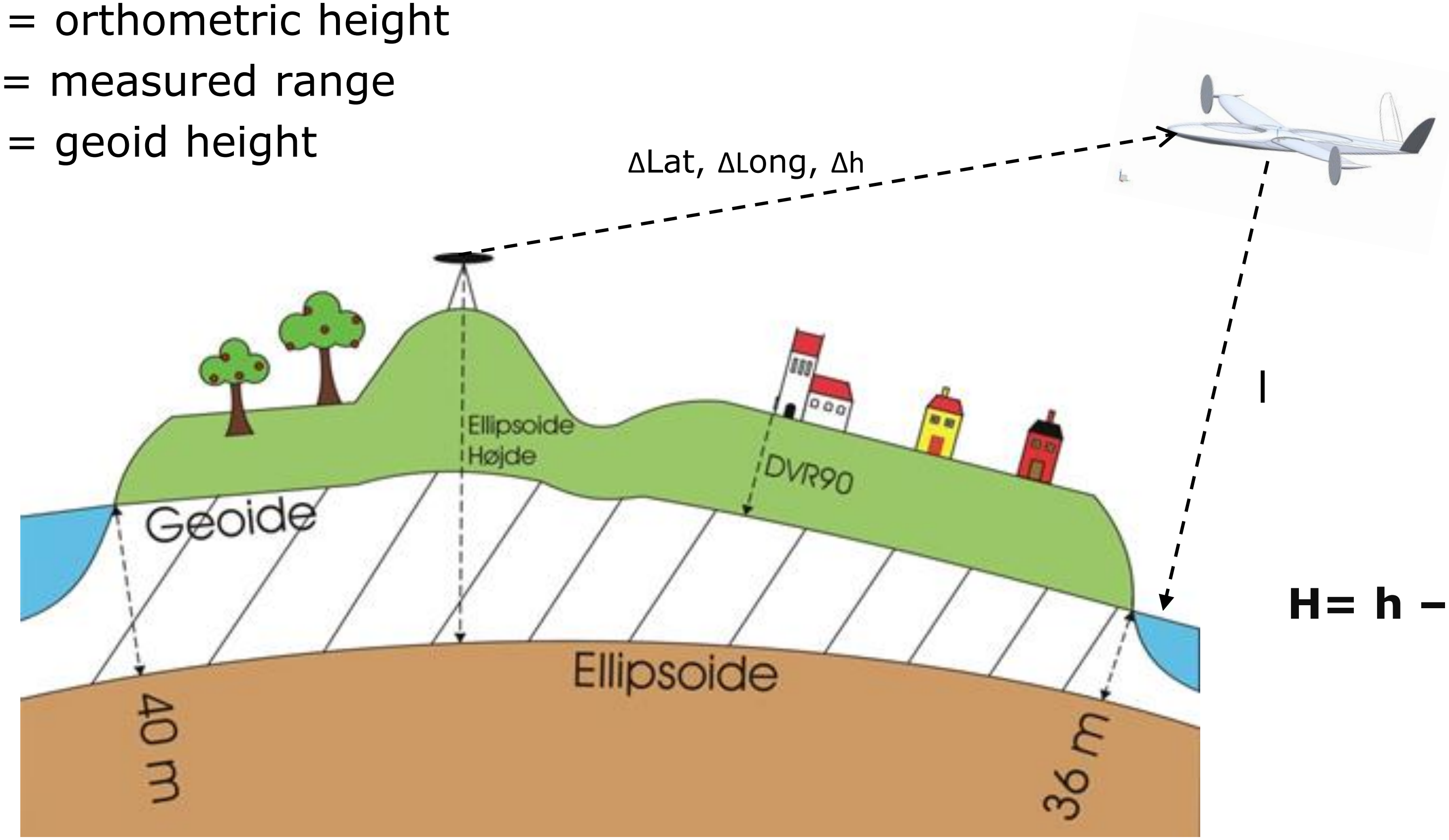
Urban flood in Copenhagen

Sacred Blue Cenote, Mexico.

Arctic region

Obtain the orthometric height (RTK)

- h = ellipsoidal height
- H = orthometric height
- l = measured range
- N = geoid height



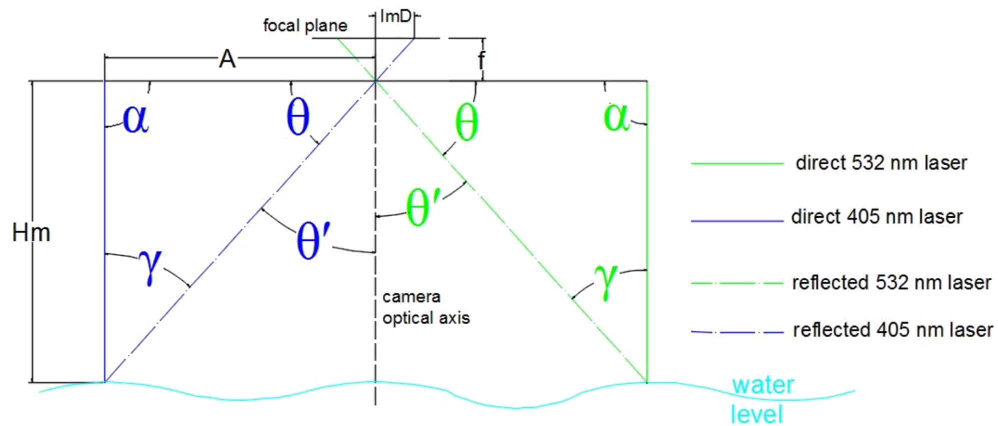
H= h – l - N

Water height measuring 3 ranger principles

- Sonar
- Maxbotix HRXL-MaxSonar®-WRLT (MB7386)
- Distance up to 10 m

- Radar
- Continental ARS 308-2T
- Accuracy: 0.25 m or 1.5 %@>1 m

- Camera based laser



High precision implementation

<u>GNSS signals for solution</u>
- GPS L1 and L2
- GLONASS L1 and L2
- L-band reception

GNSS Base station

Novatel
Pinwheel 703-GGG

Novatel Flex6

<u>Postprocessed solution</u>

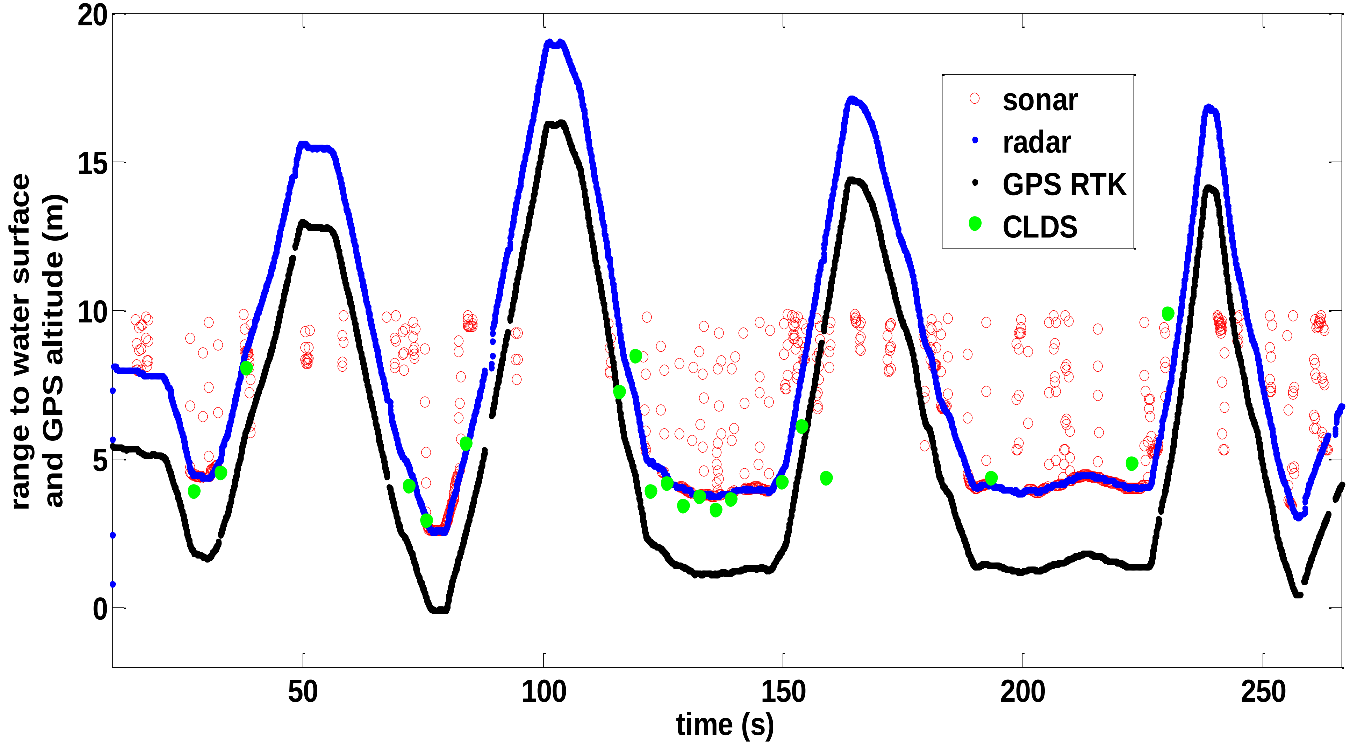
RTCM

Hexa

Antcom
3GNSSA-XT-1

Novatel
OEM628

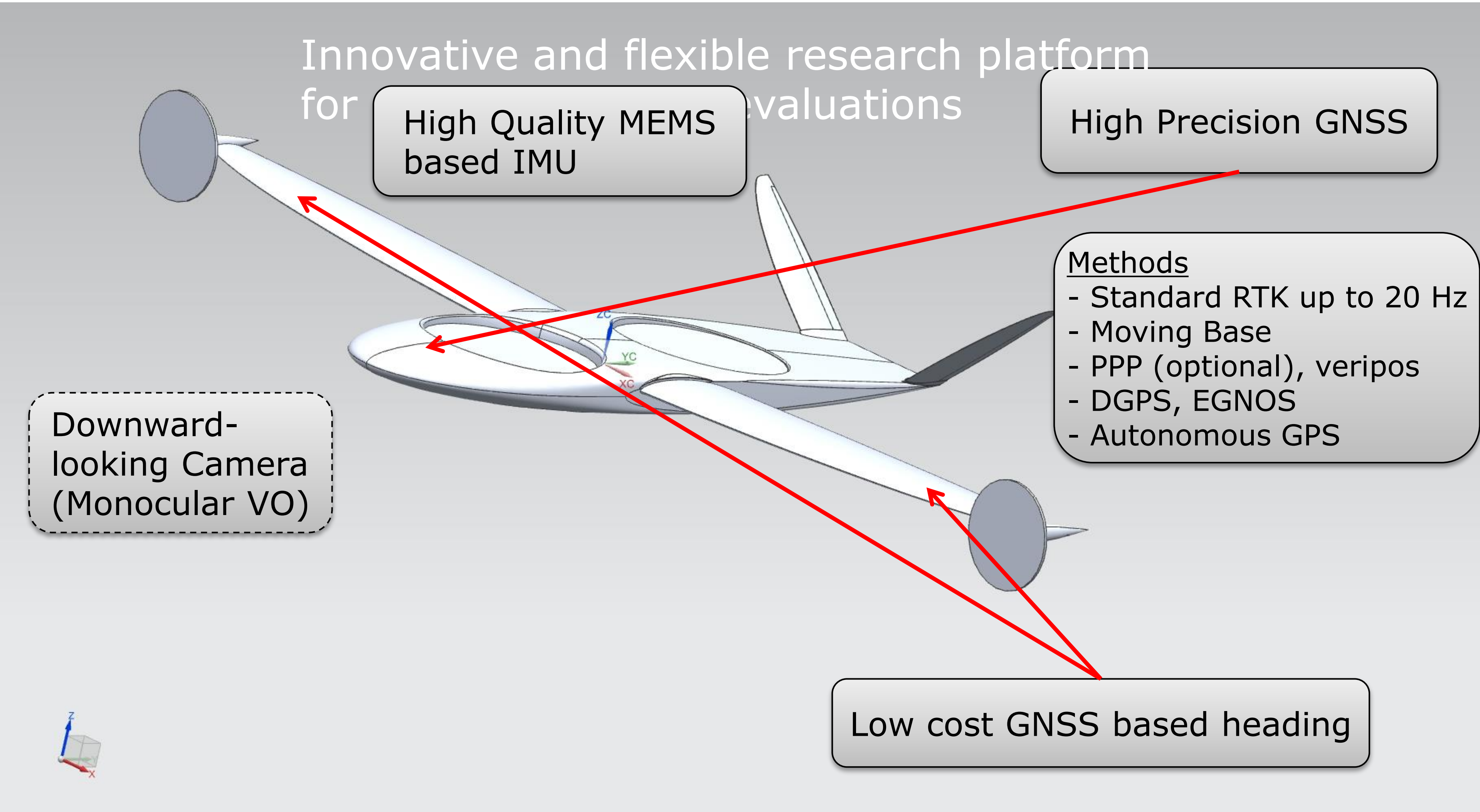
Results range to water surface



Statistics

Flight statistics		Flight date (dd/mm/2016)				
		17/03	04/04	13/04	05/13	27/05
Flight time (s)		500	270	200	250	260
Minimum-Maximum flight height (magl)		3-28	4-18.5	5-60	8-48	9-58
Ground truth (mamsl)		missing	24.10±0.06	24.13±0.06	24.04±0.06	24.01±0.06
Standard Deviation (m) of water height retrieved by	radar	0.07	0.05	0.08	0.09	0.05
	sonar	0.80	2.31	1.3	0.36	14.42
	CLDS	missing	1.08	0.95	1.68	2.05

Navigation for the Smart UAV payload

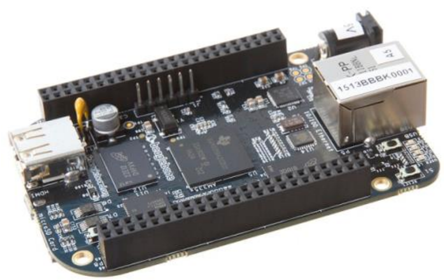


Hardware

GNSS-based heading

RTK-GNSS + INS

SBC (storage + Interface)

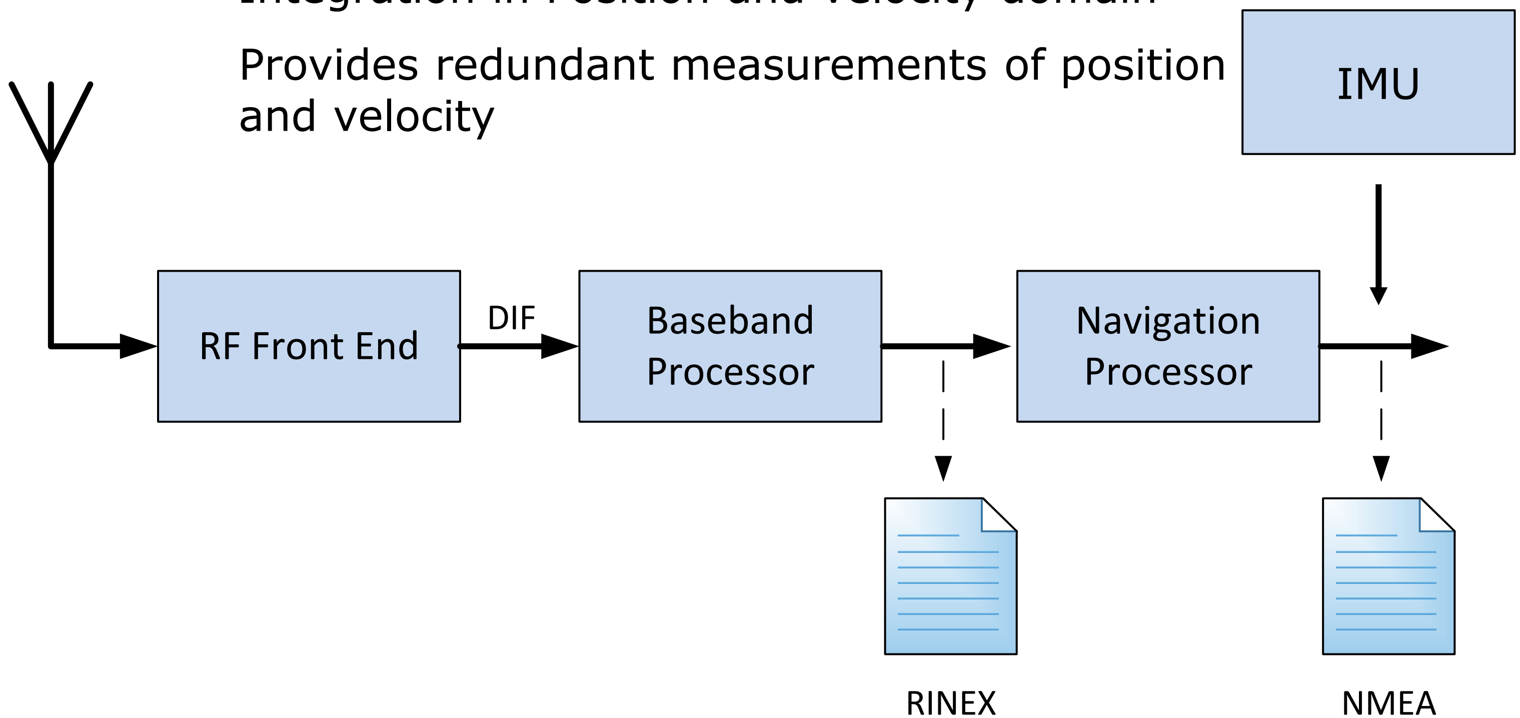


GNSS and INS integration

<u>Loose integration</u>

Integration in Position and velocity domain

Provides redundant measurements of position and velocity

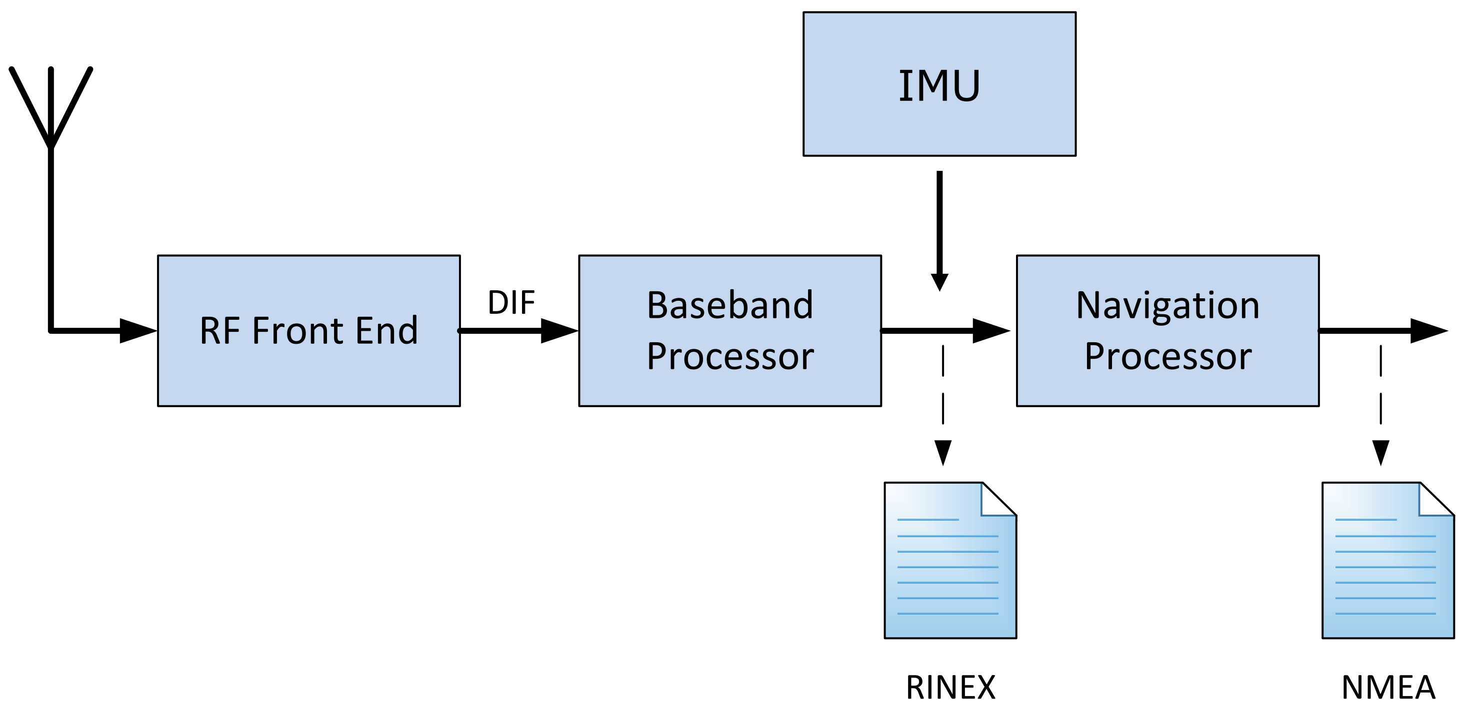


GNSS and INS integration

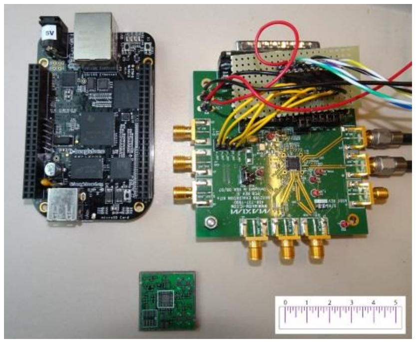
Tight integration

Integration in Range-domain

Can be used with less than 4 available GNSS satellites



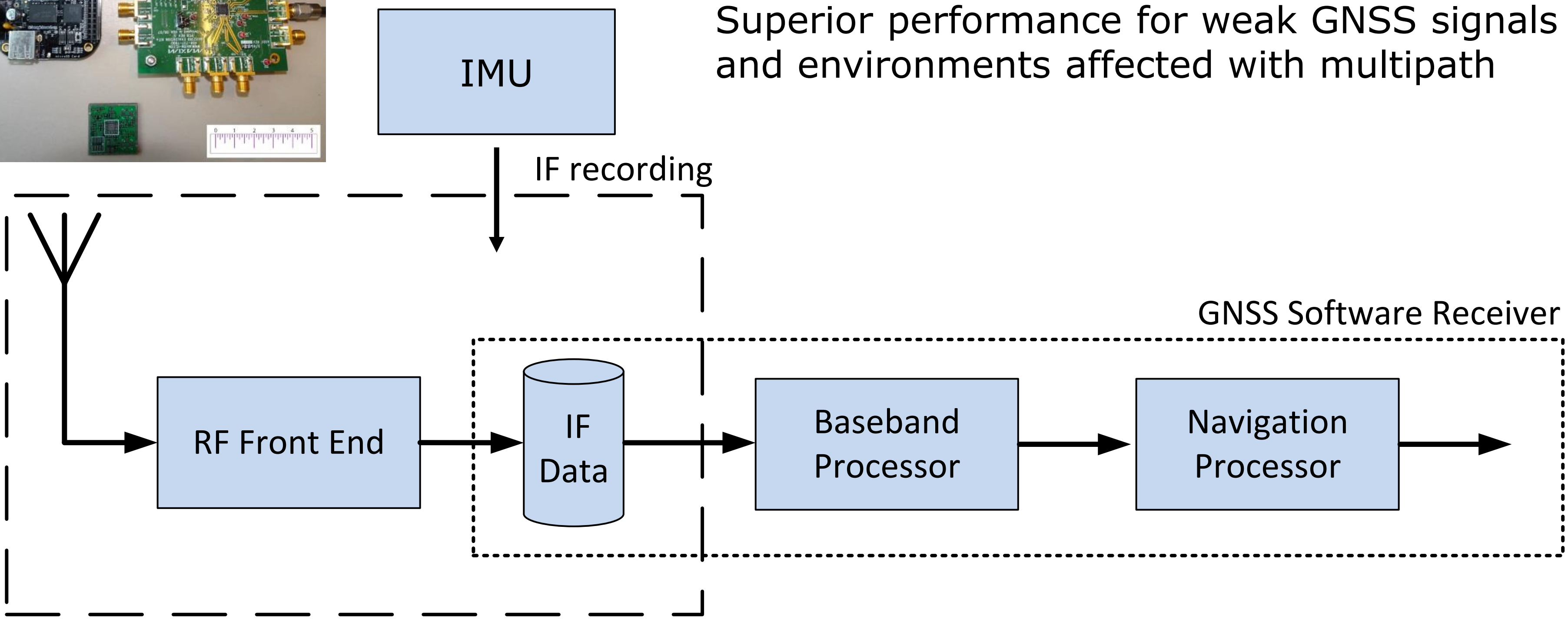
GNSS and INS integration



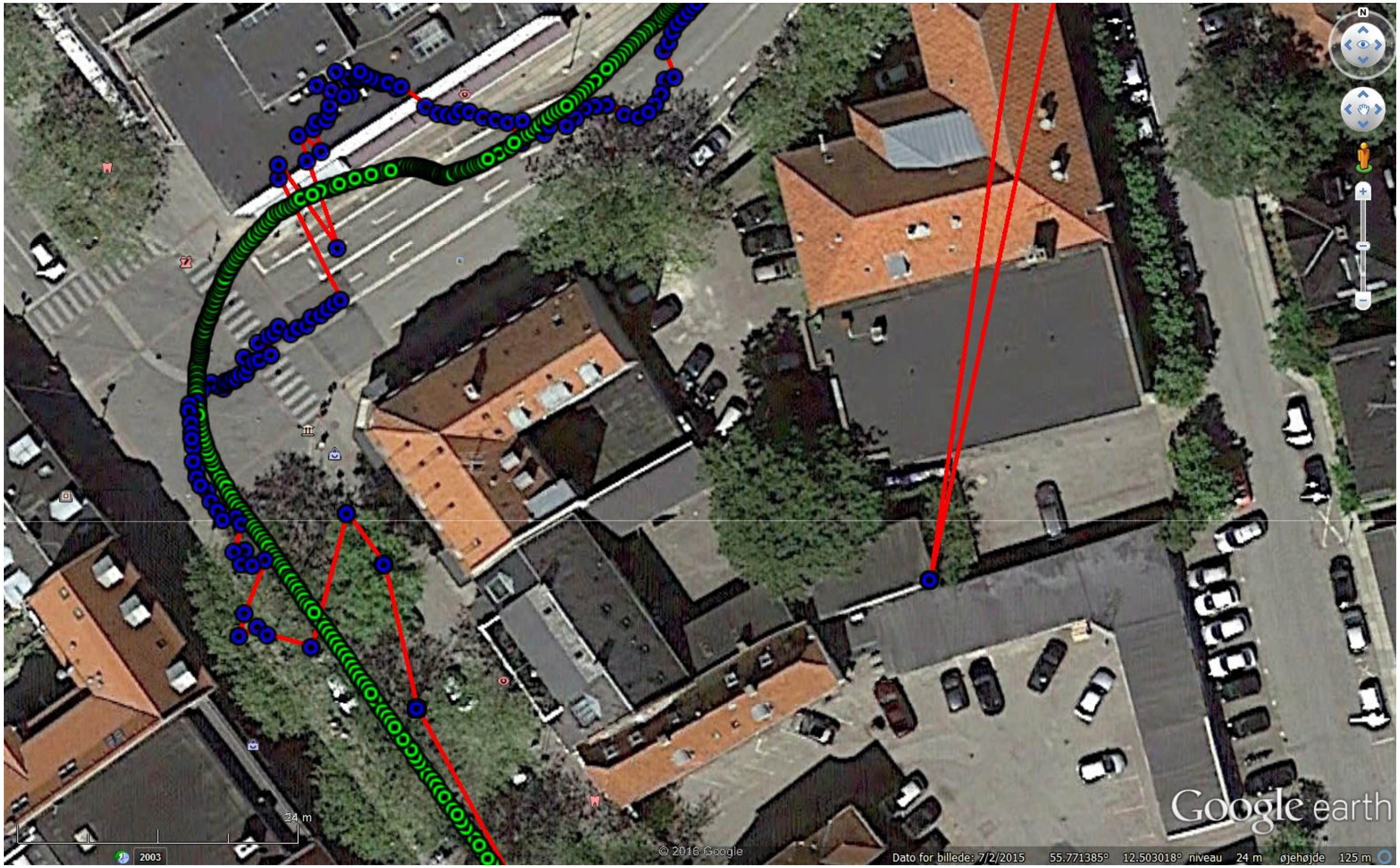
Ultra-tight/deep integration

Integration on Tracking Loop level (GNSS receiver hardware)

Superior performance for weak GNSS signals and environments affected with multipath

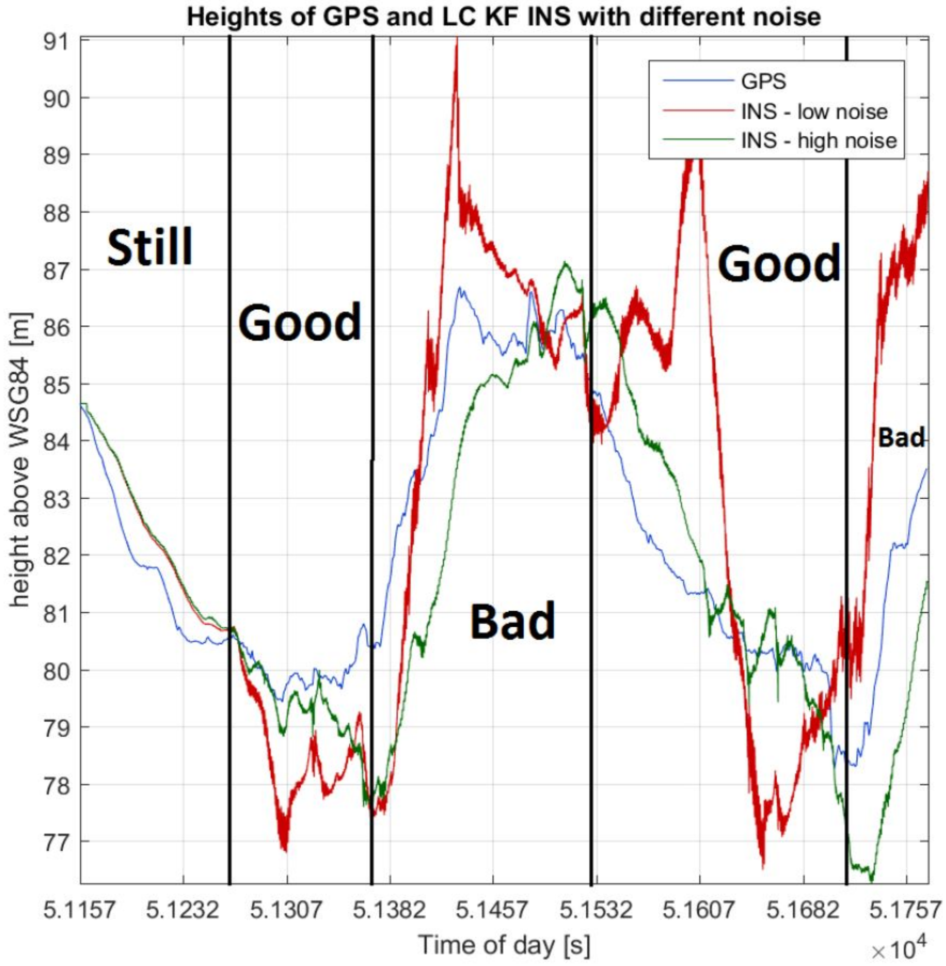


Experimental Results (LC, Automotive test)



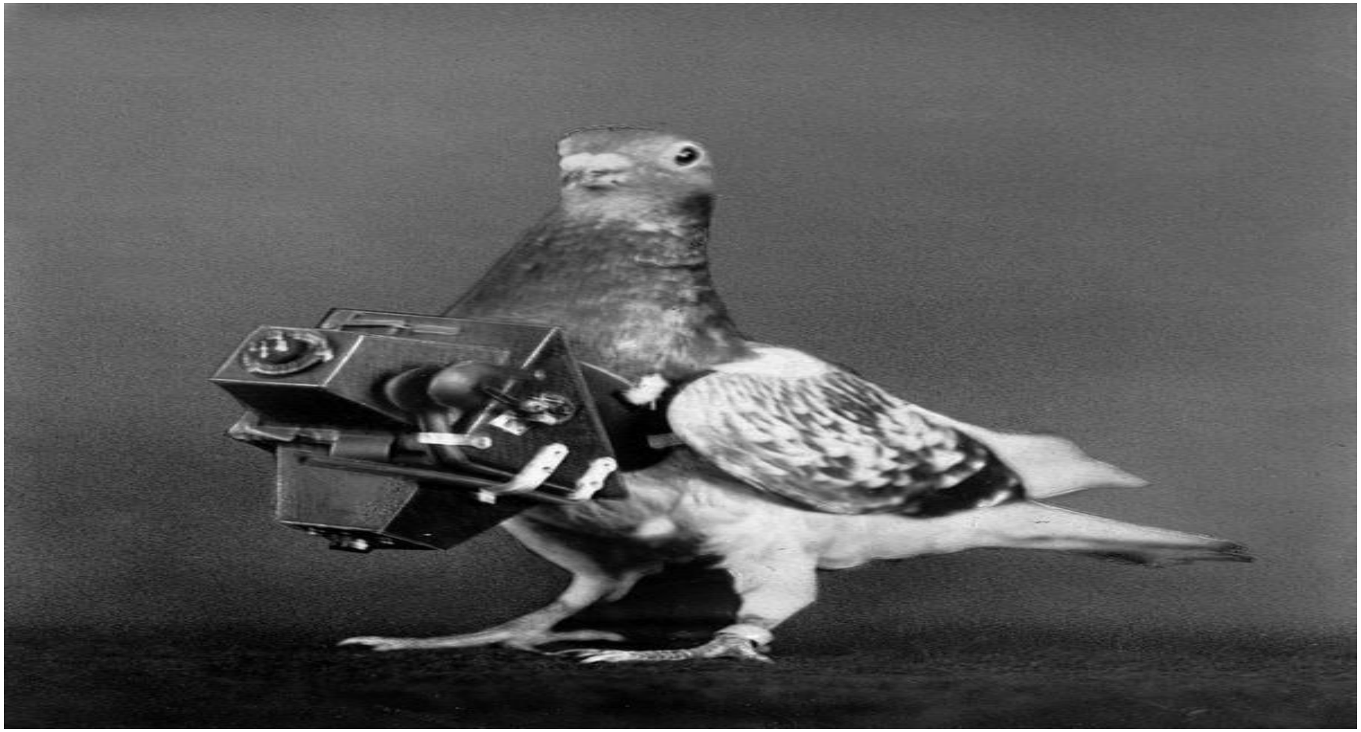
Daniel Olesen

Increasing height



Questions!

First Unmanned Aerial Vehicle in history?



Pigeons fitted with cameras to take aerial photos (1908)

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