Destressing drones operations by model-based navigation

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2022-12-07

Activities
QGroundControl
Thu 14:48
QGroundControl Development mod_structure:b4a1486 2020-06-17 17:07:08 +0200
File
Widgets
89% Stabilized Armed
Fly
Route de Cossonay
Les Sorens
Flight Time
00:00:28
Roll (deg)
2.5
Pitch (deg)
4.3
Air Speed (m/s)
0.9
Alt (Rel) (m)
-0.2
Ground Speed
Distance to Home
Wind Direction
Wind Spd
Voltage
Percent
20.27
89
Set Waypoint
Adjust current waypoint to 77.
Slide to confirm
No Flight Data selected.
Replay Flight Data

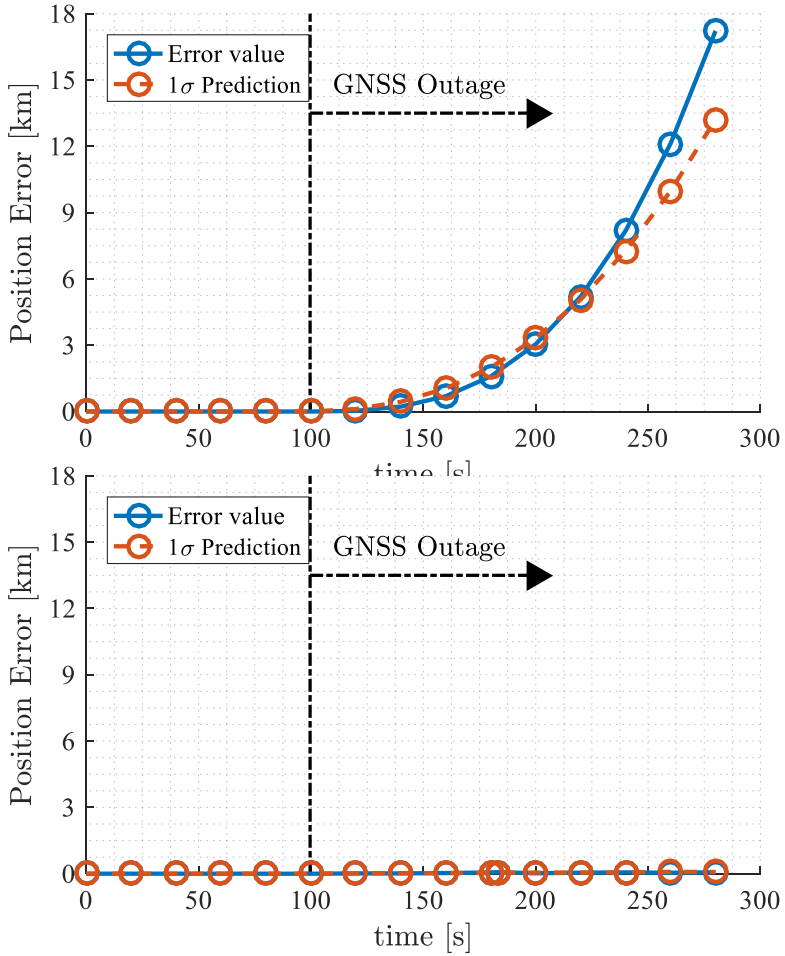
The received GPS signal is 1/10th of 1 millionth of 1 billionth of a Watt.

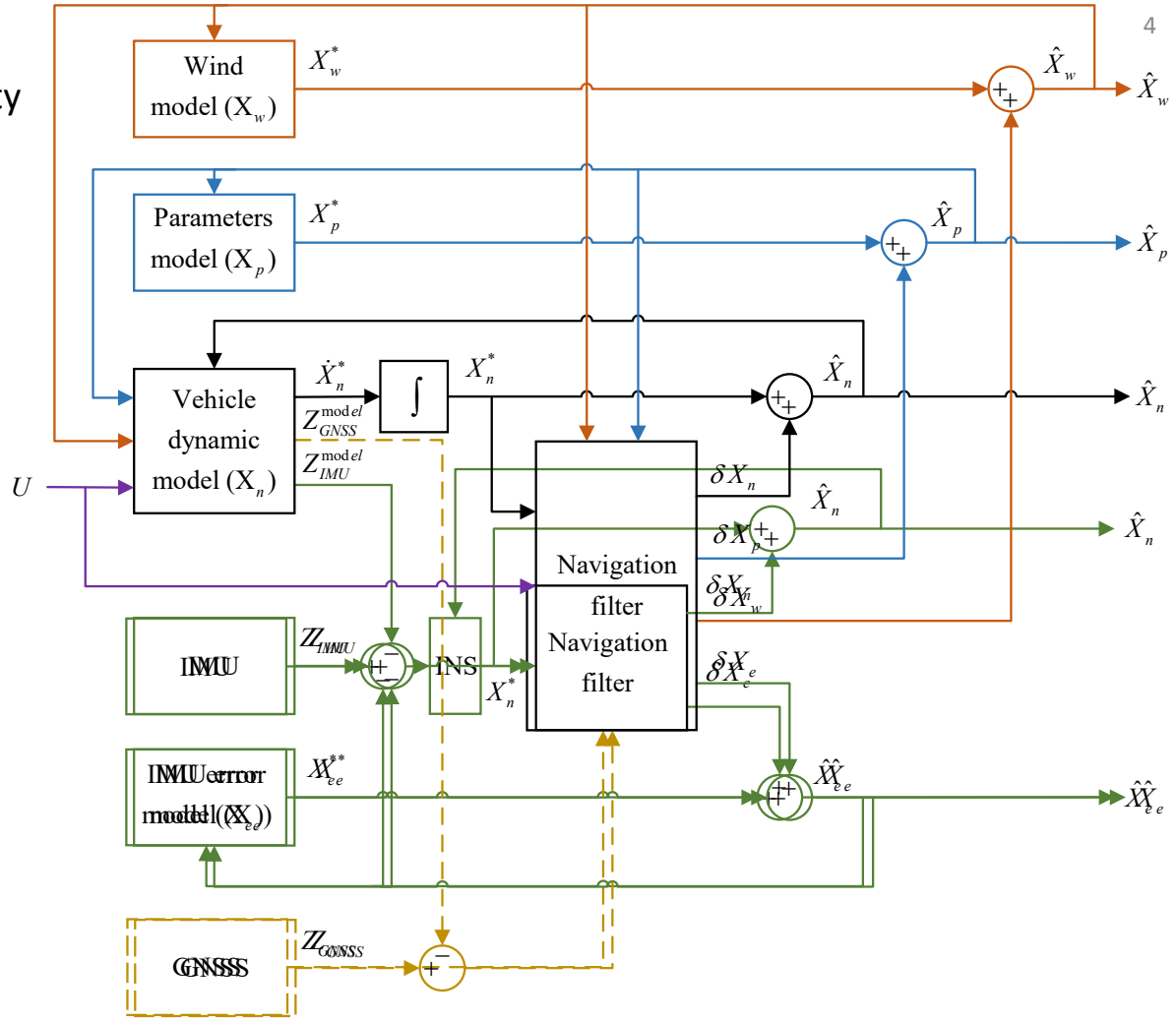
Agenda

- Background
- Calibration
- Real-time

t, X(t), P(t)

Selected contribution < 2020 drone's operation safety

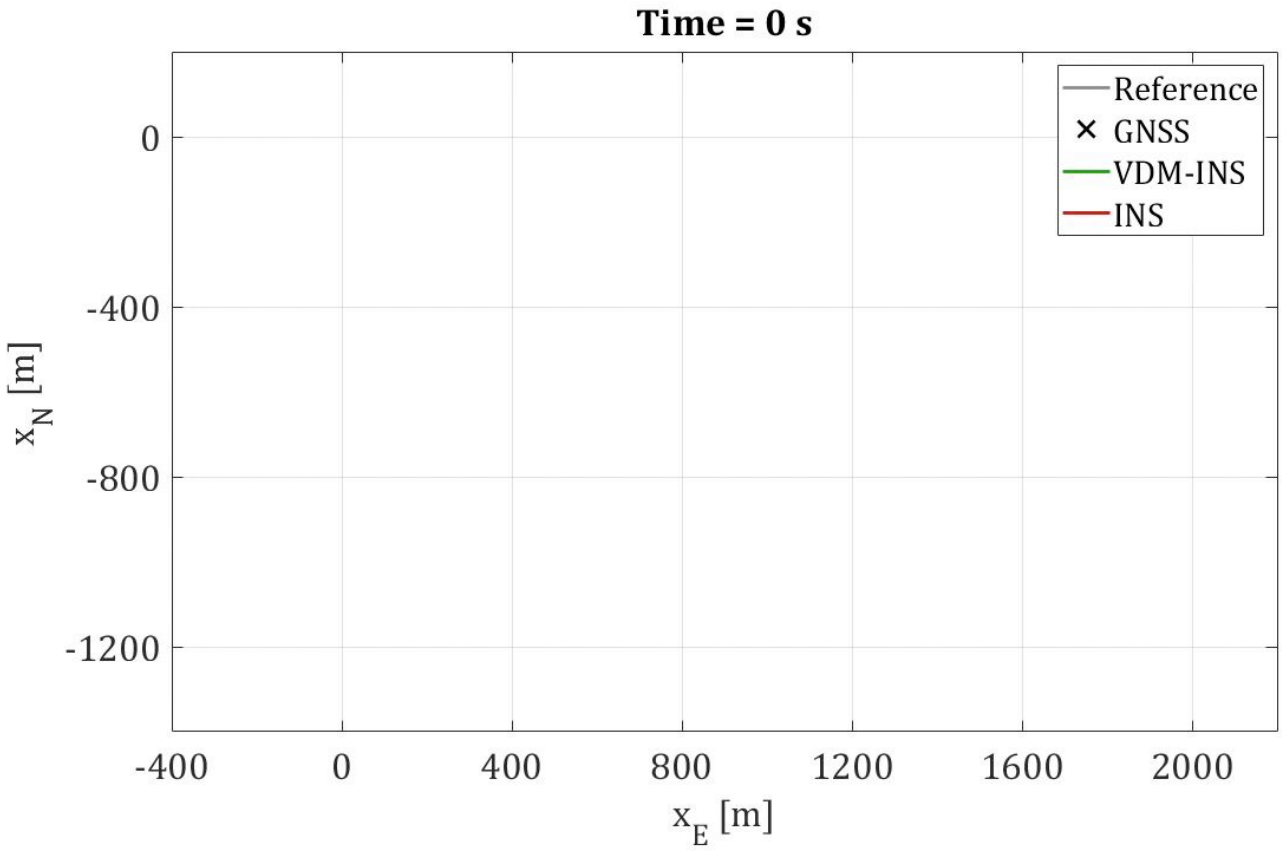




Khaghani, Skaloud (2016) Autonomous vehicle dynamic model based navigation for small UAVs, J. of Navigation

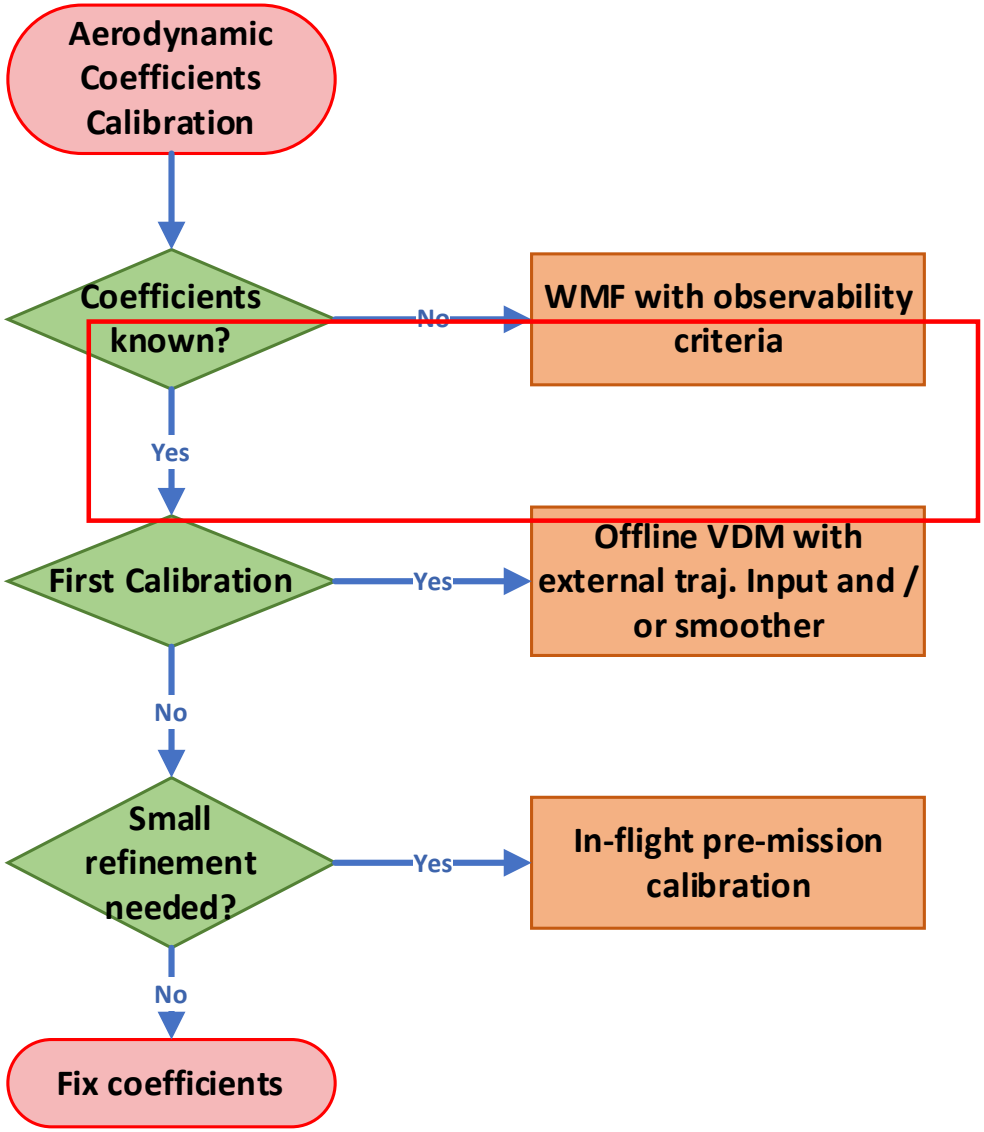
EPFL

Selected contribution < 2020 drone's operation safety (offline)

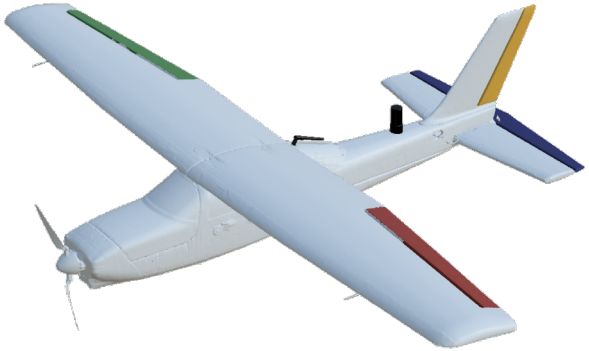


Khaghani, Skaloud (2018) Assessment of VDM-based autonomous navigation of a UAV under operational conditions, Robot. & autonom. syst.

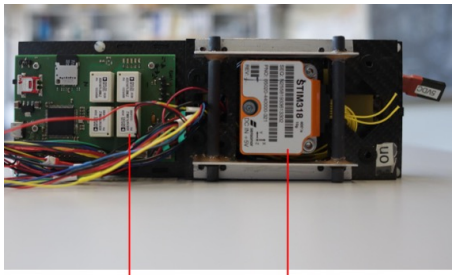
- **Q1: Calibration of model coefficients**
  - Without initial knowledge?
  - In-flight data only?
- **Q2: Real-time**
  - I/O handling (sensors, auto-pilot)?
  - Sensor-fusion (speed, observability)?
- **Q3: Performance**
  - Autonomous navigation (GNSS outage)?
  - Repeatability?


Aerodynamic Coefficients Calibration
Coefficients known?
No
WMF with observability criteria
Yes
First Calibration
Yes
Offline VDM with external traj. Input and / or smoother
No
Small refinement needed?
Yes
In-flight pre-mission calibration
No
Fix coefficients

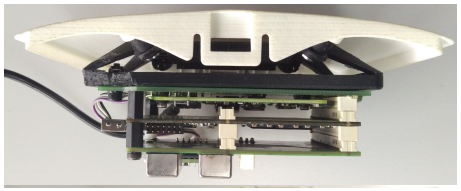
- 0 Calibration w. ZERO priors (per vehicle-type)
  - Input 1: IMU,GNSS, airspeed, ctrl commands
  - Input 2: precise trajectory (INS/PPK-GNSS)



- Estimate
  - **W**ind (KF)
  - **M**oment coefficients (RLS)
  - **F**orce coefficients (RLS)



- Req.
  - IMU >$50,

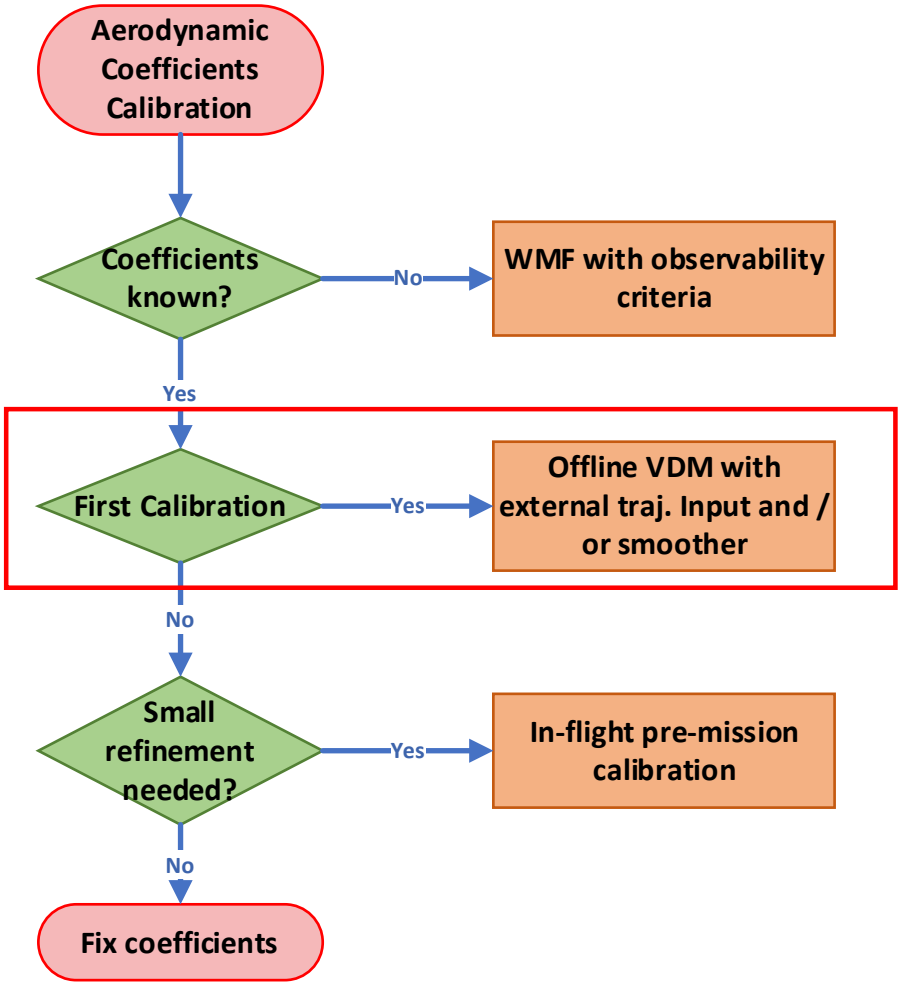


EPFL

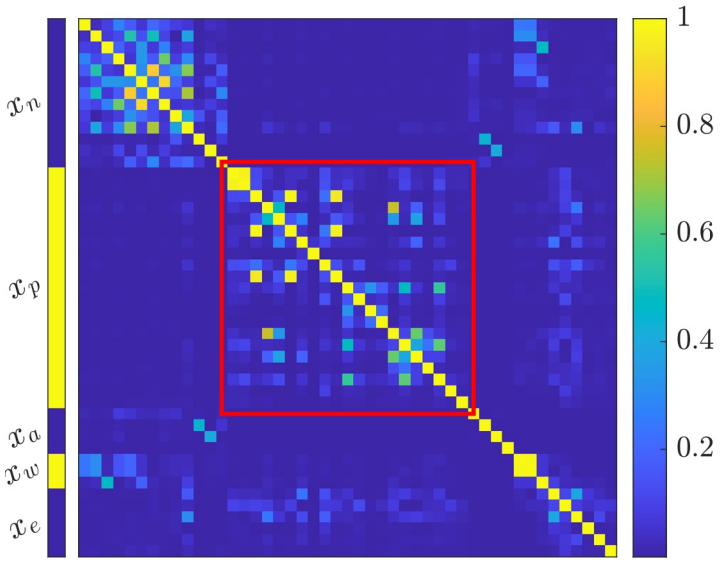
- Challenges
  - Number of unknowns
  - Few % of useful data

	model param No.	
Linear estimators	Reduced	General
1. Wind	4	4
2. Moments	11	20
3. Forces	10	24

- For each (linear) estimator
  - Evaluate observability Grammian W for each epoch k (recursively)
  - Perform orthogonal decomposition of state-space (new base-vectors)
  - Estimate the states (in the new base) only when observable (partial-update)



- 1st Calibration (per unit)
  - **optimal smoother** INS/GNSS
- P used as a prior



P after smoothing, *IGN8*

Q2

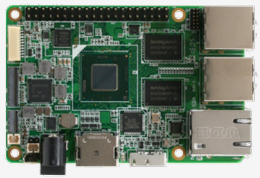
Autopilot

PX4

Companion Computer

ROS

ubuntu

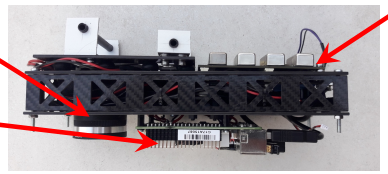


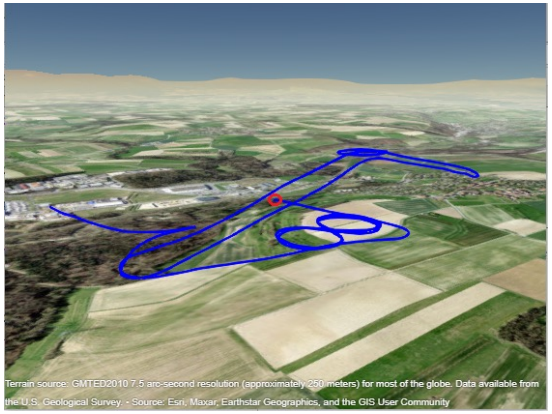
Sensors

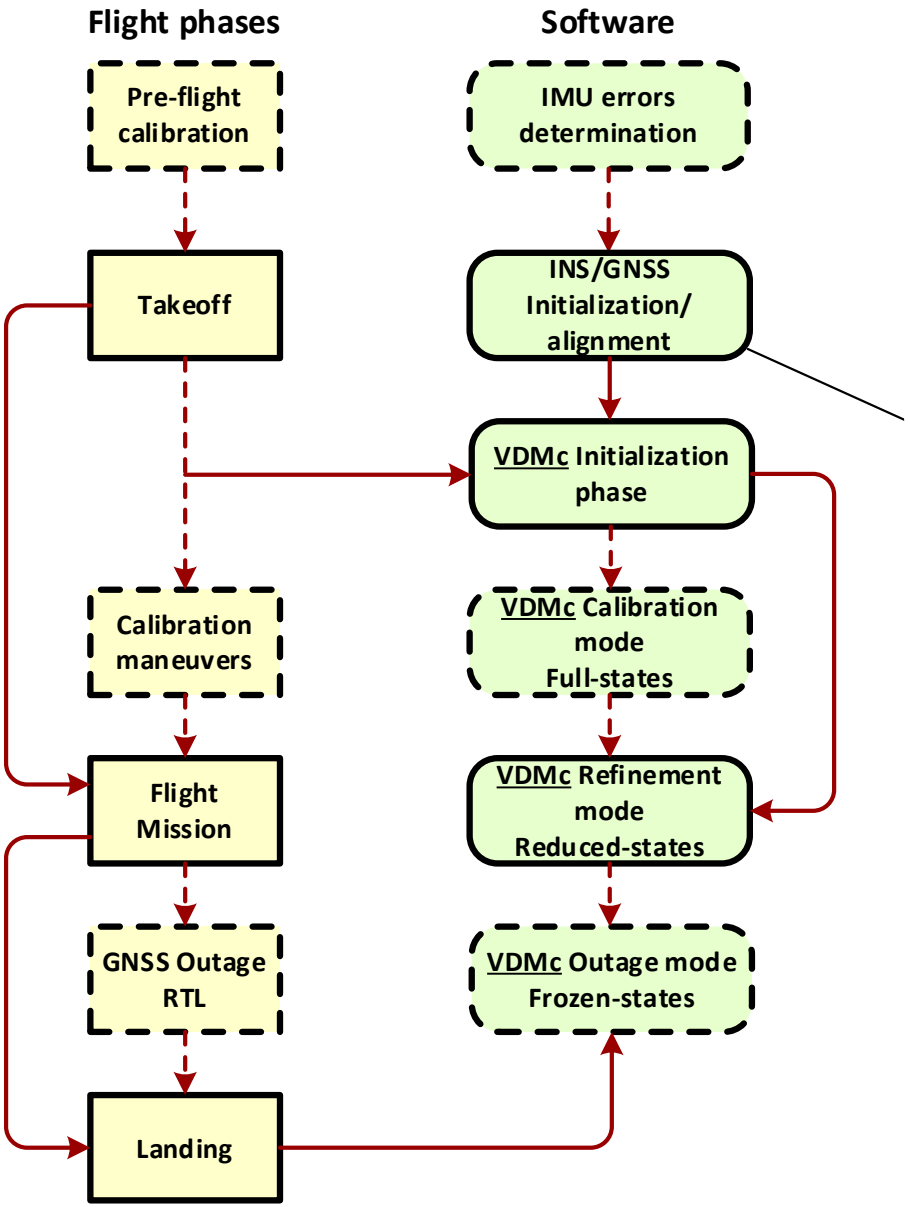
DATA Manager

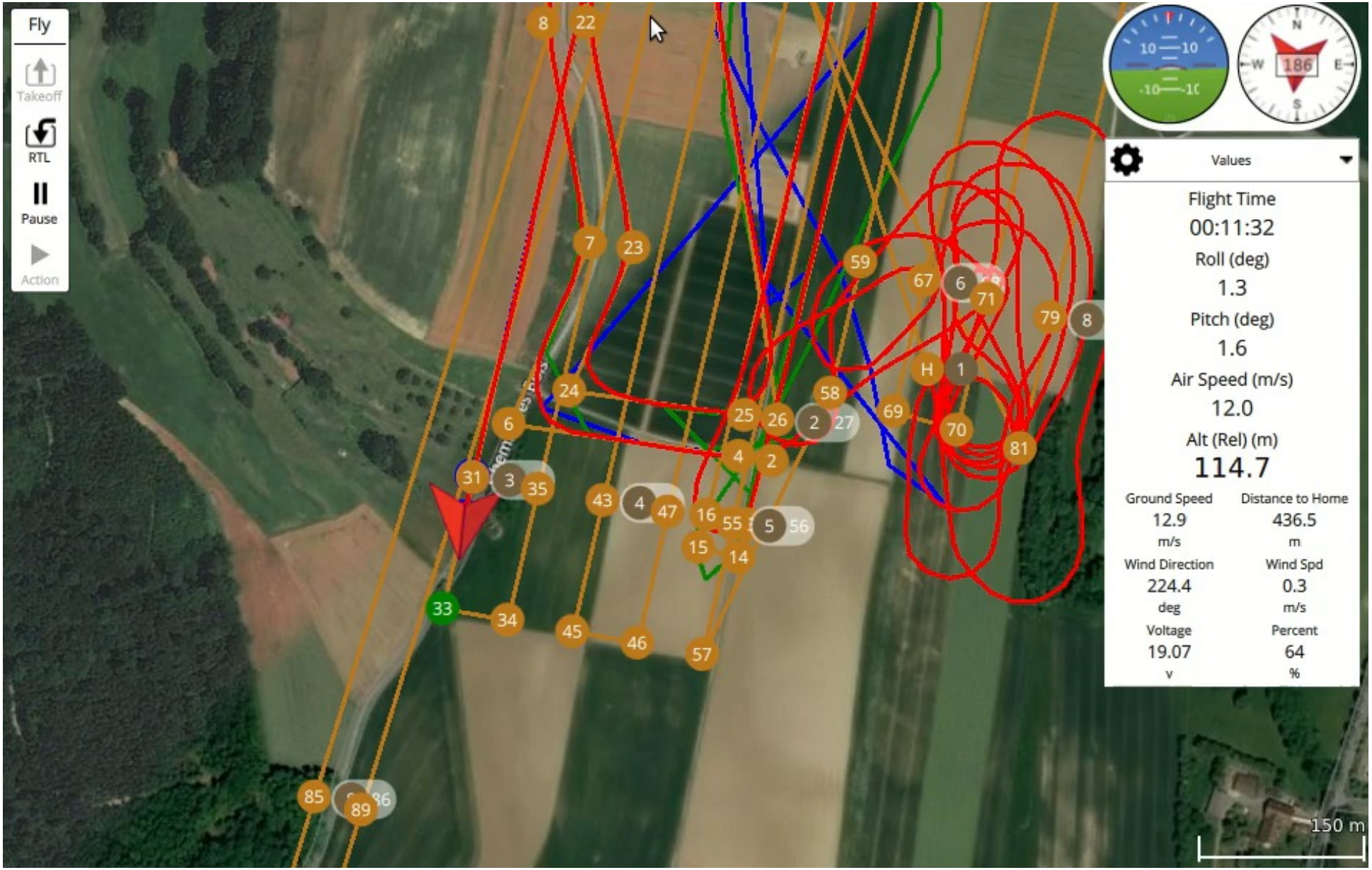
Camera

IMUs

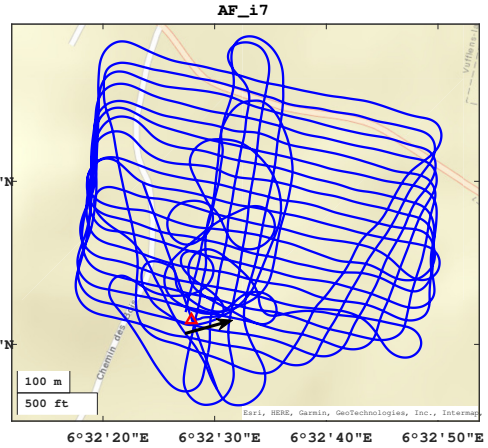


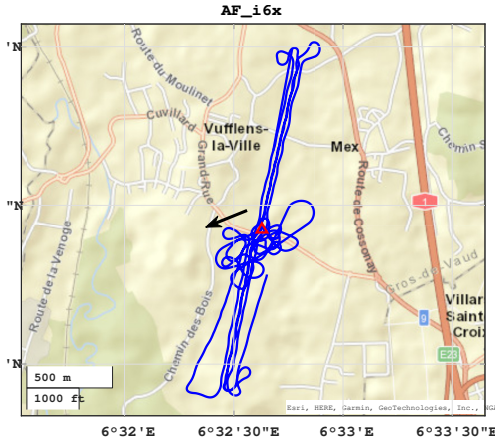

Terrain source: GMTED2010 7.5 arc-second resolution (approximately 250 meters) for most of the globe. Data available from the U.S. Geological Survey - Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

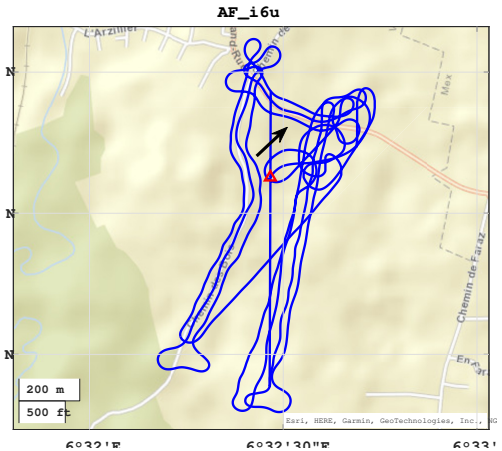

Flight phases
Software
Pre-flight calibration
IMU errors determination
Takeoff
INS/GNSS Initialization/ alignment
VDMc Initialization phase
Calibration maneuvers
VDMc Calibration mode Full-states
Flight Mission
VDMc Refinement mode Reduced-states
GNSS Outage RTL
VDMc Outage mode Frozen-states
Landing

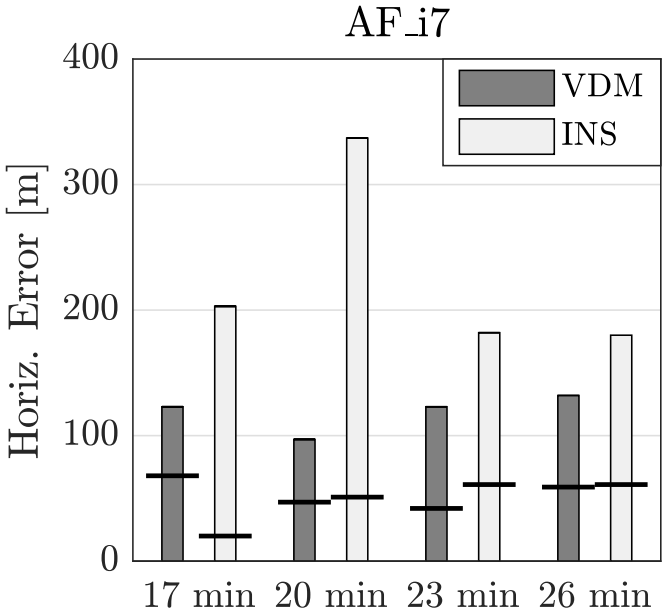

Fly
Takeoff
RTL
Pause
Action
Values
Flight Time
00:11:32
Roll (deg)
1.3
Pitch (deg)
1.6
Air Speed (m/s)
12.0
Alt (Rel) (m)
114.7
Ground Speed
12.9
m/s
Distance to Home
436.5
m
Wind Direction
224.4
deg
Wind Spd
0.3
m/s
Voltage
19.07
v
Percent
64
%
150 m

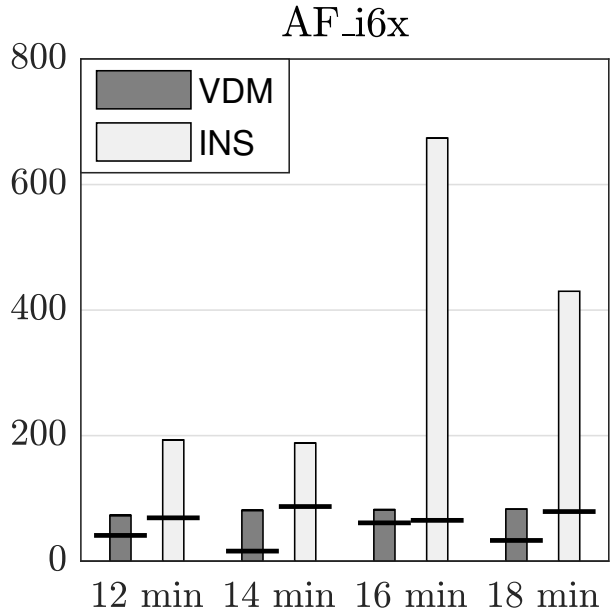
Q3

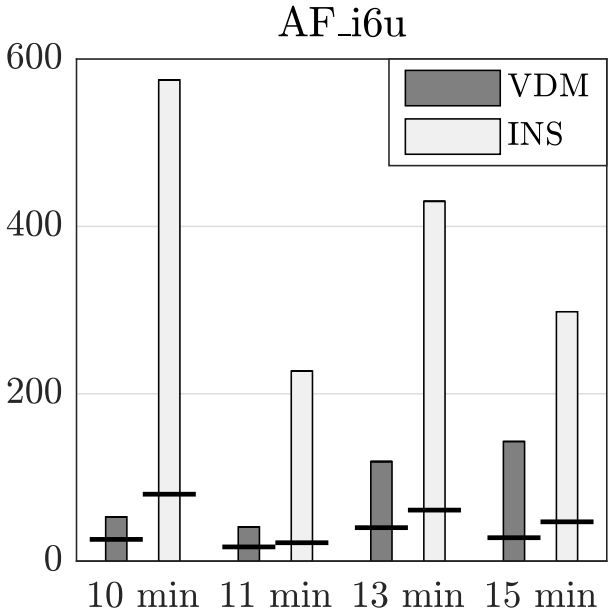

AF_i7
100 m
500 ft
6°32'20"E
6°32'30"E
6°32'40"E
6°32'50"E


AF_i6x
Vufflens-
la-Ville
Mex
Route du Moulinet
Route de la Venoge
Route de Cossonay
Chemin des Bois
500 m
1000 ft
6°32'E
6°32'30"E
6°33'E
6°33'30"E


AF_i6u
200 m
500 ft

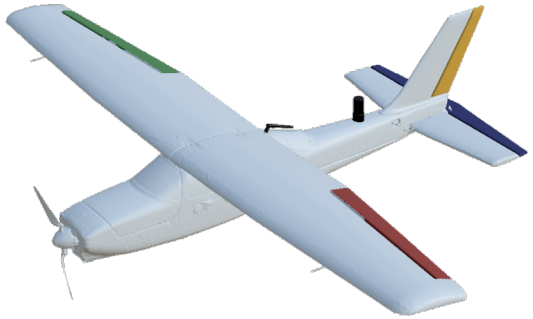
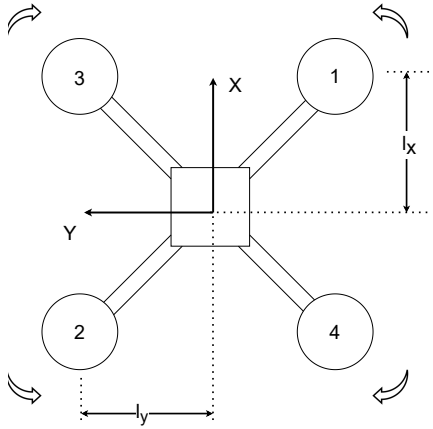

AF_i7
Horiz. Error [m]
0
100
200
300
400
VDM
INS
17 min
20 min
23 min
26 min


AF_i6x
0
200
400
600
800
VDM
INS
12 min
14 min
16 min
18 min


AF_i6u
0
200
400
600
VDM
INS
10 min
11 min
13 min
15 min

- Improvements factors: VDM-IMU vs. INS

		ADIS-16475 ~500$	NavChip (calibrated) ~600$	STIM318 (~6000$)
GNSS outages (min)	2	2 - 5x	1 - 8x	1 - 3x
	5	-*	>10x	6x
	>5	-*	-*	>10x

Perspectives : model dynamic navigation – platforms & methods

- real-time
- model structure adaptation
- estimation strategies