UAV systems for cultural heritage
HERICT ERASMUS IP
Technical lecture 2

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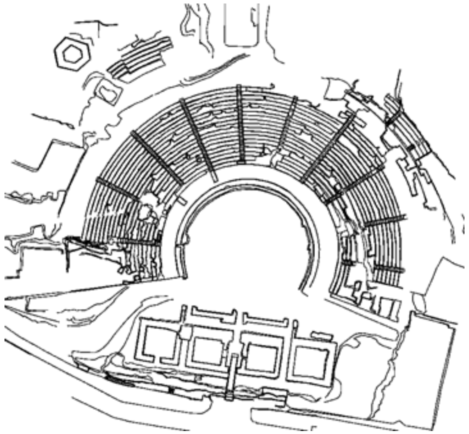
Technical lecture layout

- Definitions and categories
- Brief flashback and problems
- Commercial Systems
- Planning and navigating the flight
- Applications

Photogrammetry and deliverables



Vector plots

Digital Elevation Models [3D]

Ortho-photo-mosaics

UAV: Definition and categories

RC vs Autonomous

Fixed wings vs multi rotors

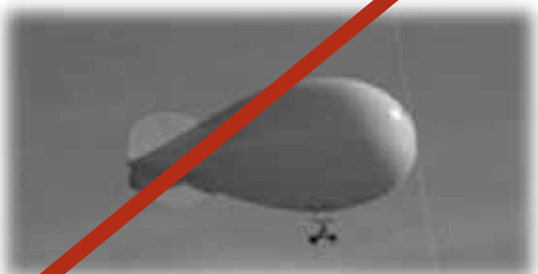
UAV Definition

- **Unmanned aerial vehicle** (UAV), are to be understood as uninhabited and reusable motorized aerial vehicles (Blyenburgh, 1999).

- Developed mainly for military applications
- Reusable (excluding missiles)
- Flight using an engine and aerodynamics (excluding balloons and kites)

May be categorized in RC, assisted, autonomous

Following the definition …



More categories UASystems

RPAS (Remotely Piloted Aircraft Systems)

Brief flashback and problems

Radio controlled flights

Improvements by using UAVs

Examples of photo coverage's from standard aerial photography

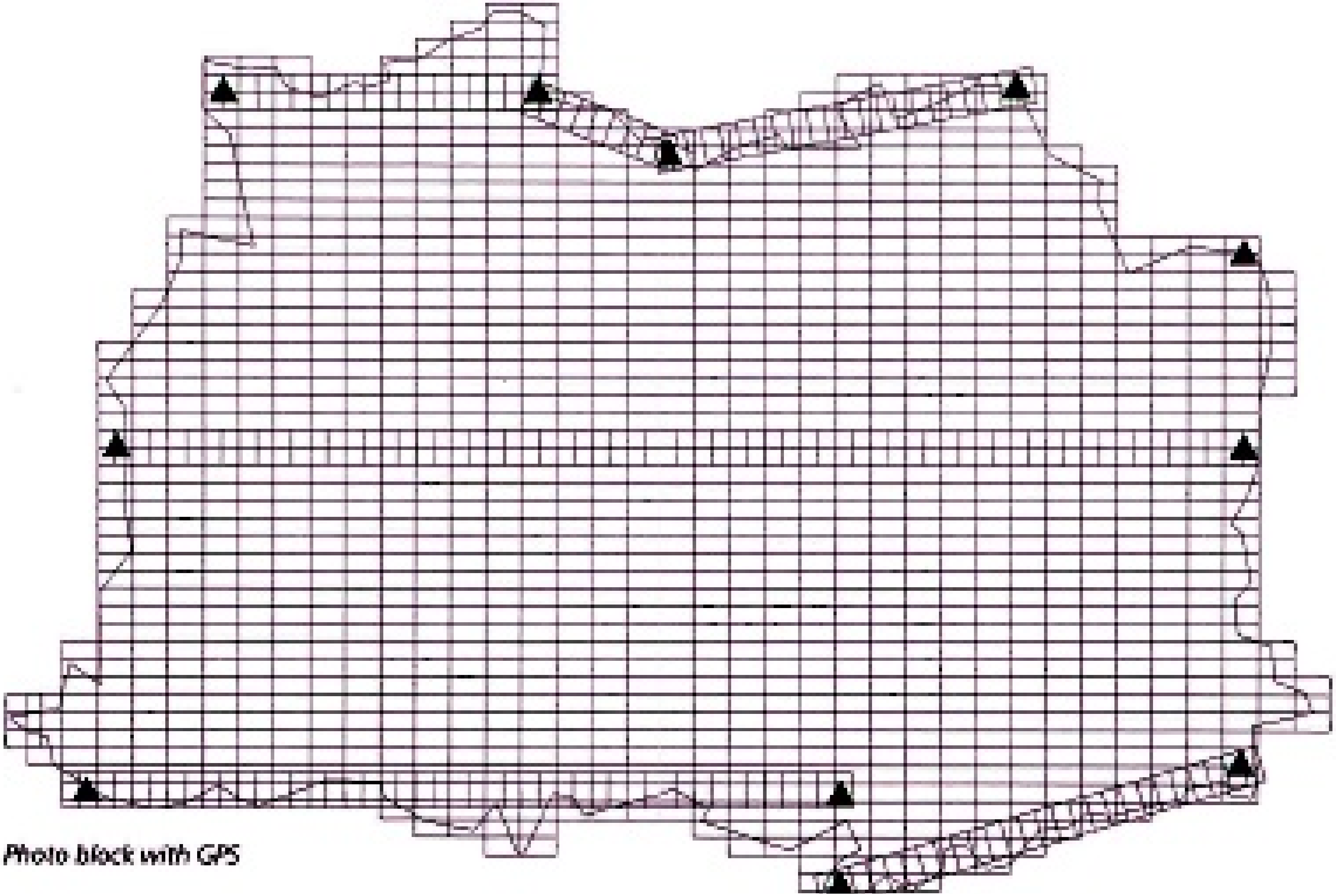
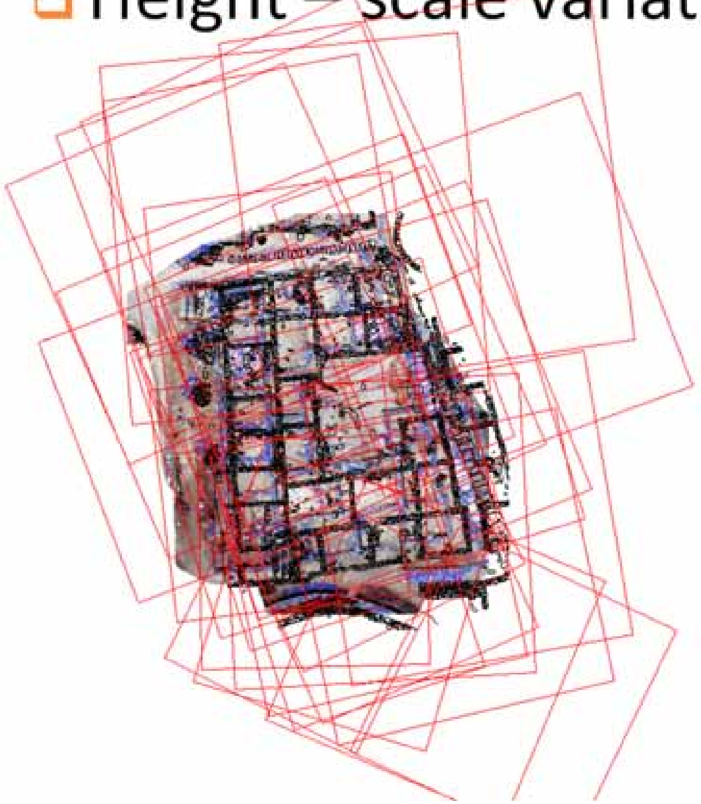
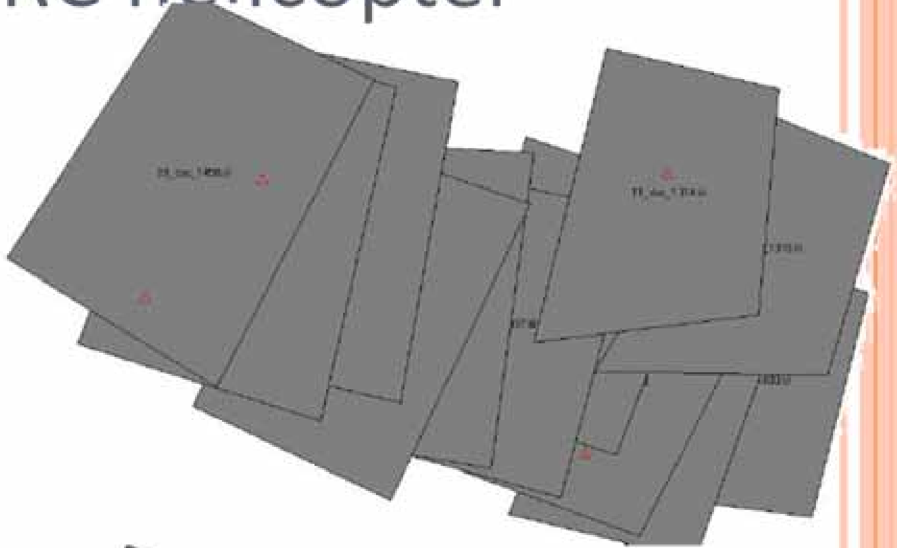


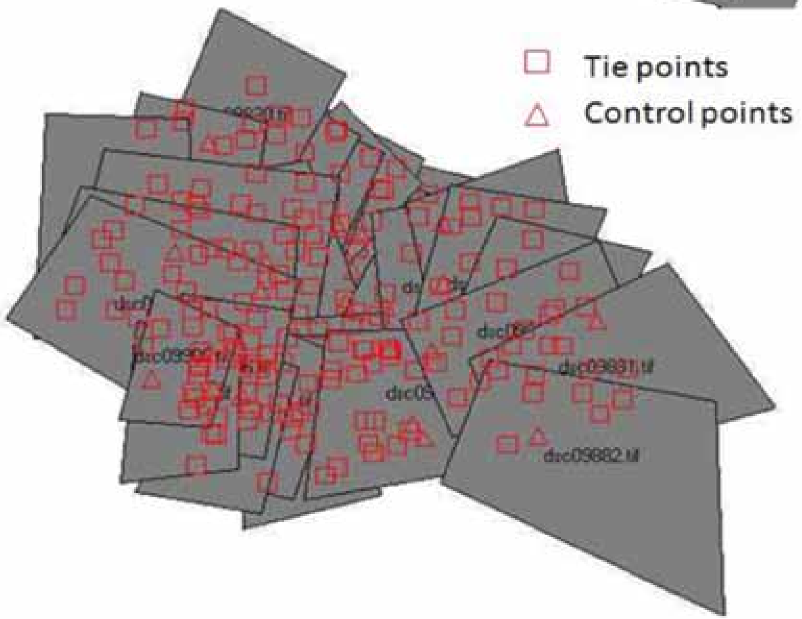
Photo block with GPS

Examples of photo coverage's from kite, balloon and RC helicopter

- Not vertical
- Coverage - completeness
- Height – scale variations







GPS/INS systems for UAVs

Position awareness

- GPS for global positioning
  - L1 (most cases)
  - L1/L2 RTK (weight)
- INS or IMU for relative positioning
  - 3 gyroscopes
  - 3 accelerometers
  - 3-axis magnetometer
- LSQ Kalman filter
- RT and/or PP

Additional navigation sensors

Barometer
Laser/Sonar height measurement
Wind speedometer
Compass

Advantages of using GPS/INS

Autonomous flight

- Program the flight
- No flight and camera operator
- Guaranteed coverage
- Signal loss
- Autonomous return
- Flight on dangerous areas

Flight stability

- Vertical photography
- Guaranteed % of coverage

Flight altitude fixation

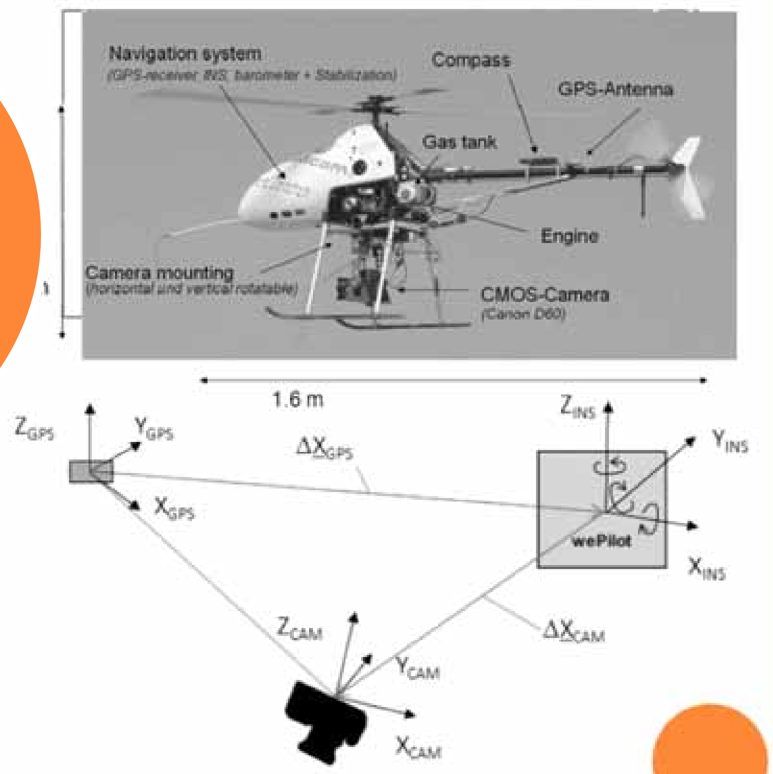
Meta data for post processing and A/T

Disadvantages

GPS/INS and camera eccentricity

Obstacle avoidance

Legal aspects not fully addressed – different among countries



Inherent advantages of AUAVs

- Low cost (buy and maintain)
- Low flying heights (small groundel)
- No need for operators
- Pin point photography
- Flexibility on programming and execution of flights
- Small response time
- Vertical, oblique or horizontal shooting
- Meta data recording
- Real time data link
- Use in emergencies and hostile environment
- Educational use

Inherent disadvantages of AUAVs

- Low payloads
- Low flying roof height (up to 300m)
- Data links are usually up to 5km, more typically to 1 km

- Legal background

Aviation legislation

Depends on the country…

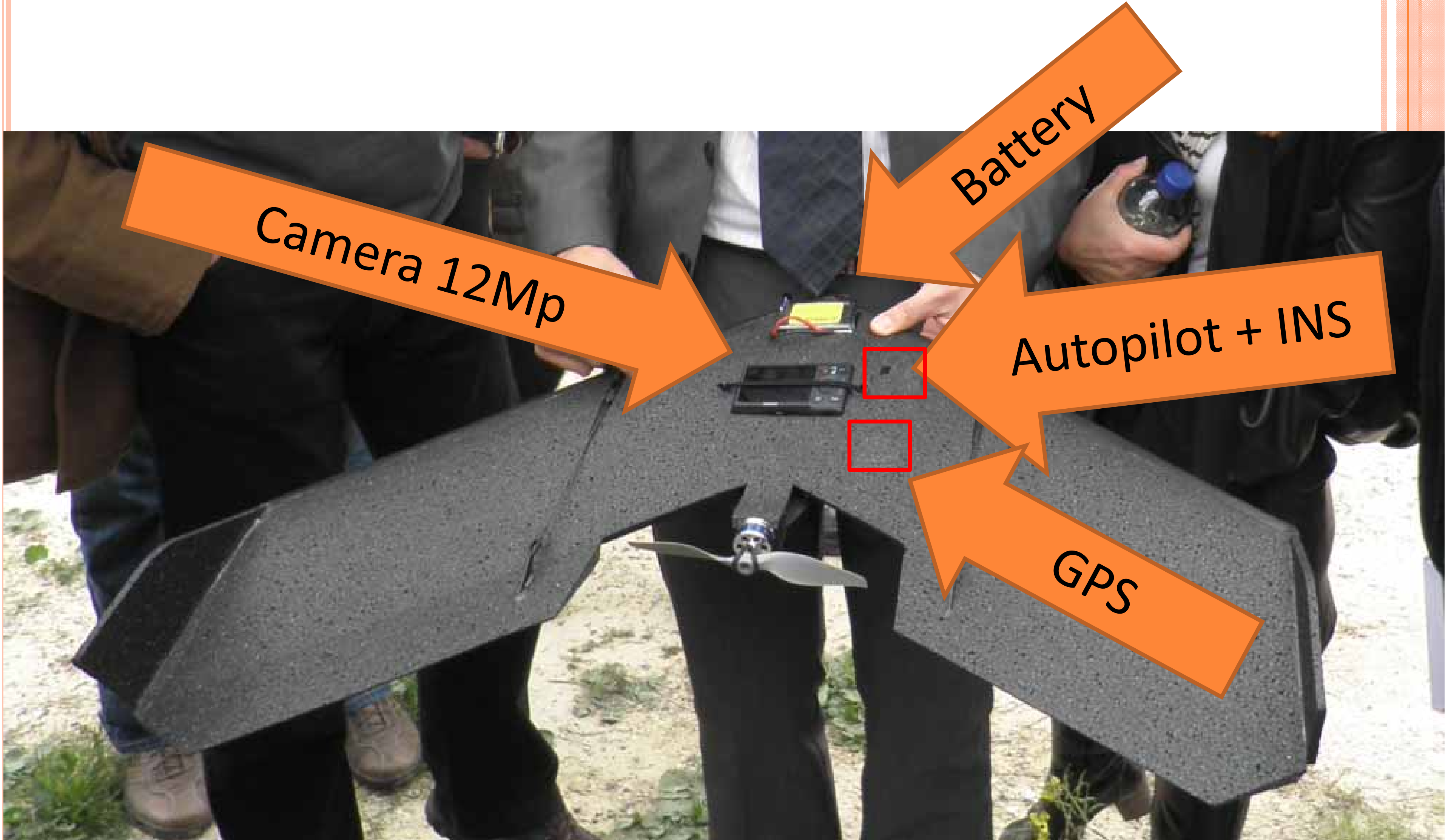
1) Stand by operator
2) Within visual range
3) Take off and landing by operator
4) Need to get testify flight plan and ask for permission from local civil aircraft authority for every flight above 150m
5) Combinations…

The article 8 of the Convention on International Civil Aviation, about the Pilotless aircraft says :

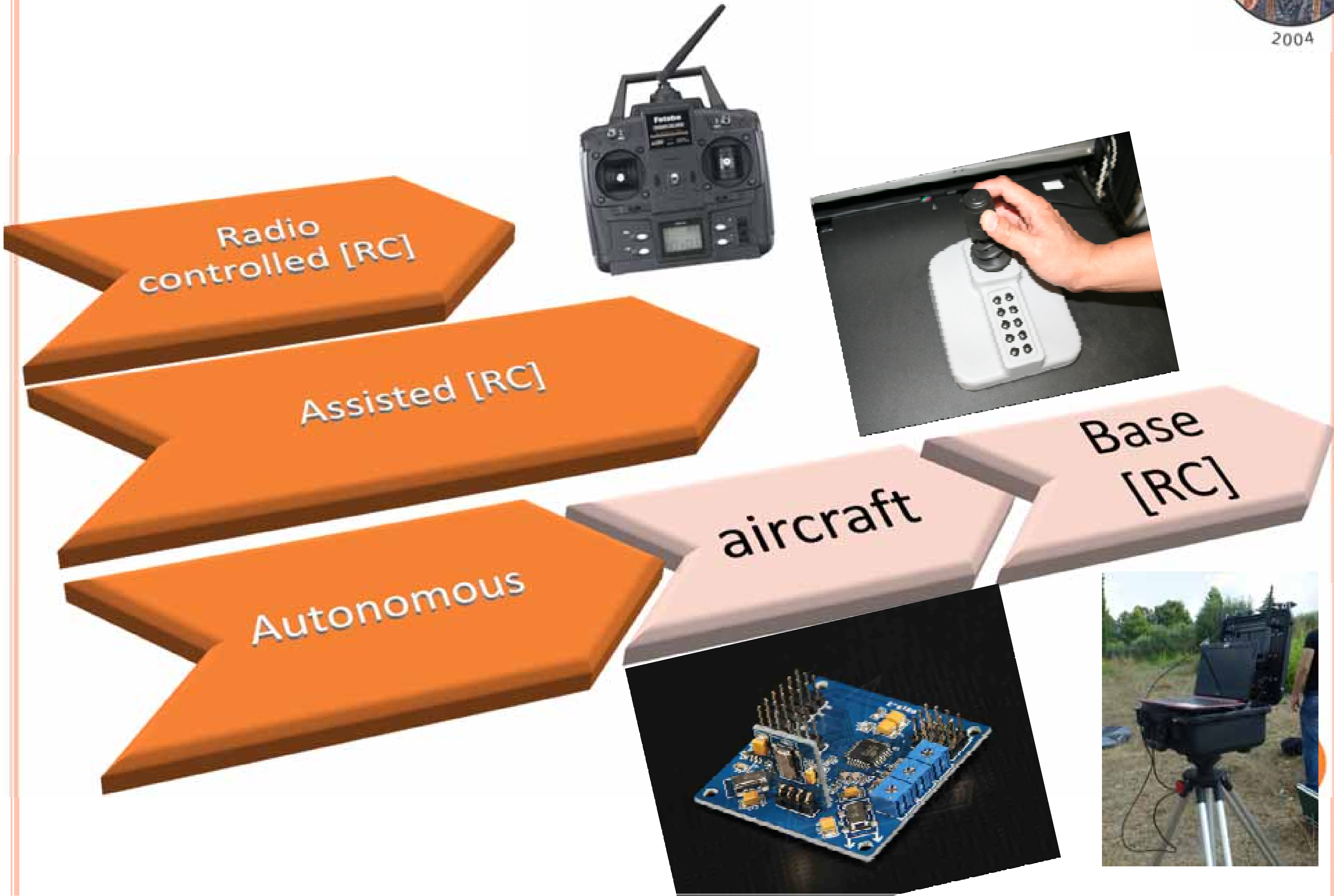
"No aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization by that State and in accordance with the terms of such authorization. Each contracting State undertakes to insure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft."

CUT's AUAV

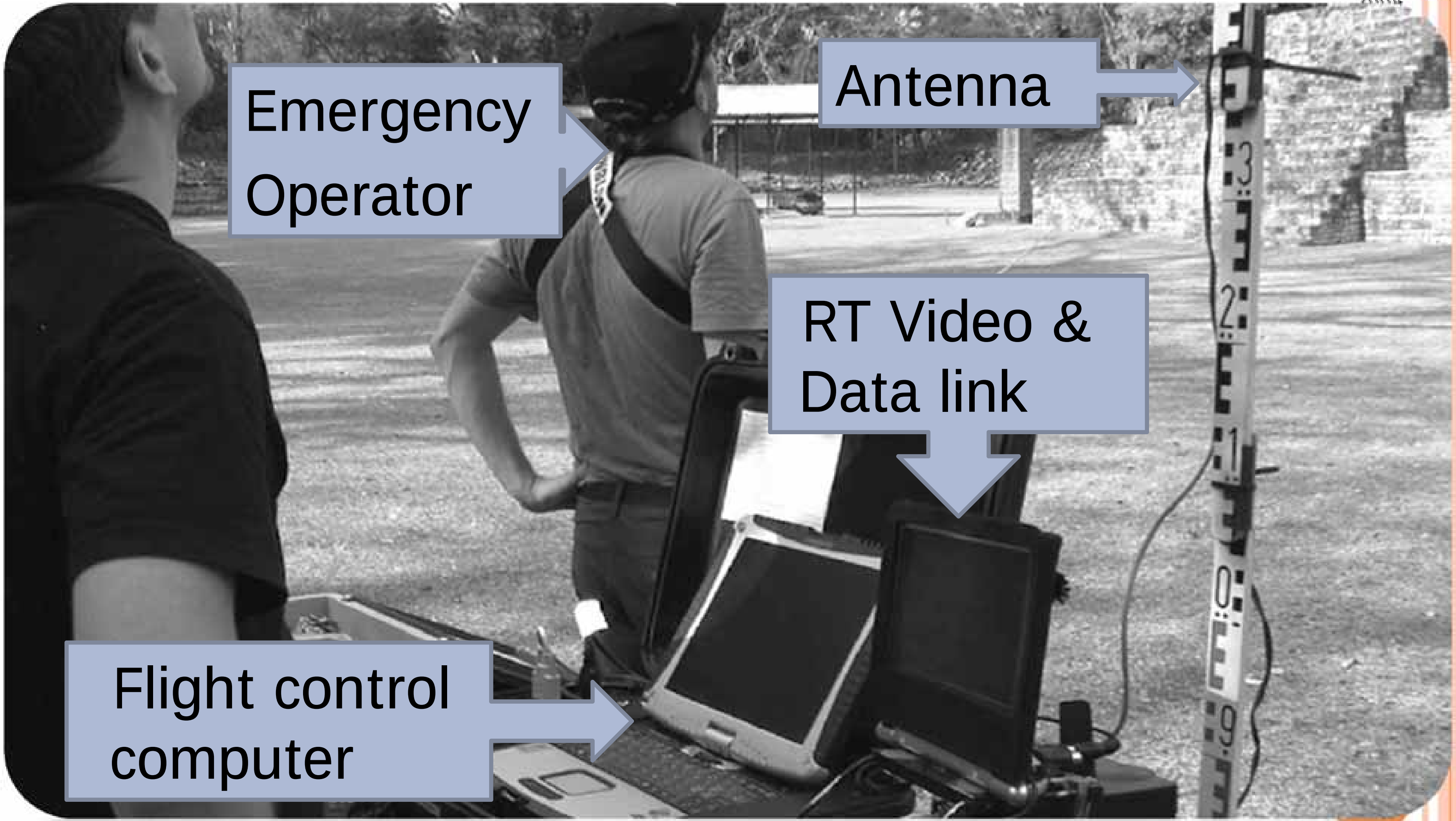
SwingletCam by SensFly



Navigation


Radio controlled [RC]
Assisted [RC]
Autonomous
aircraft
Base [RC]

Typical base station



Flight stability [rotations]

WePilot 1000

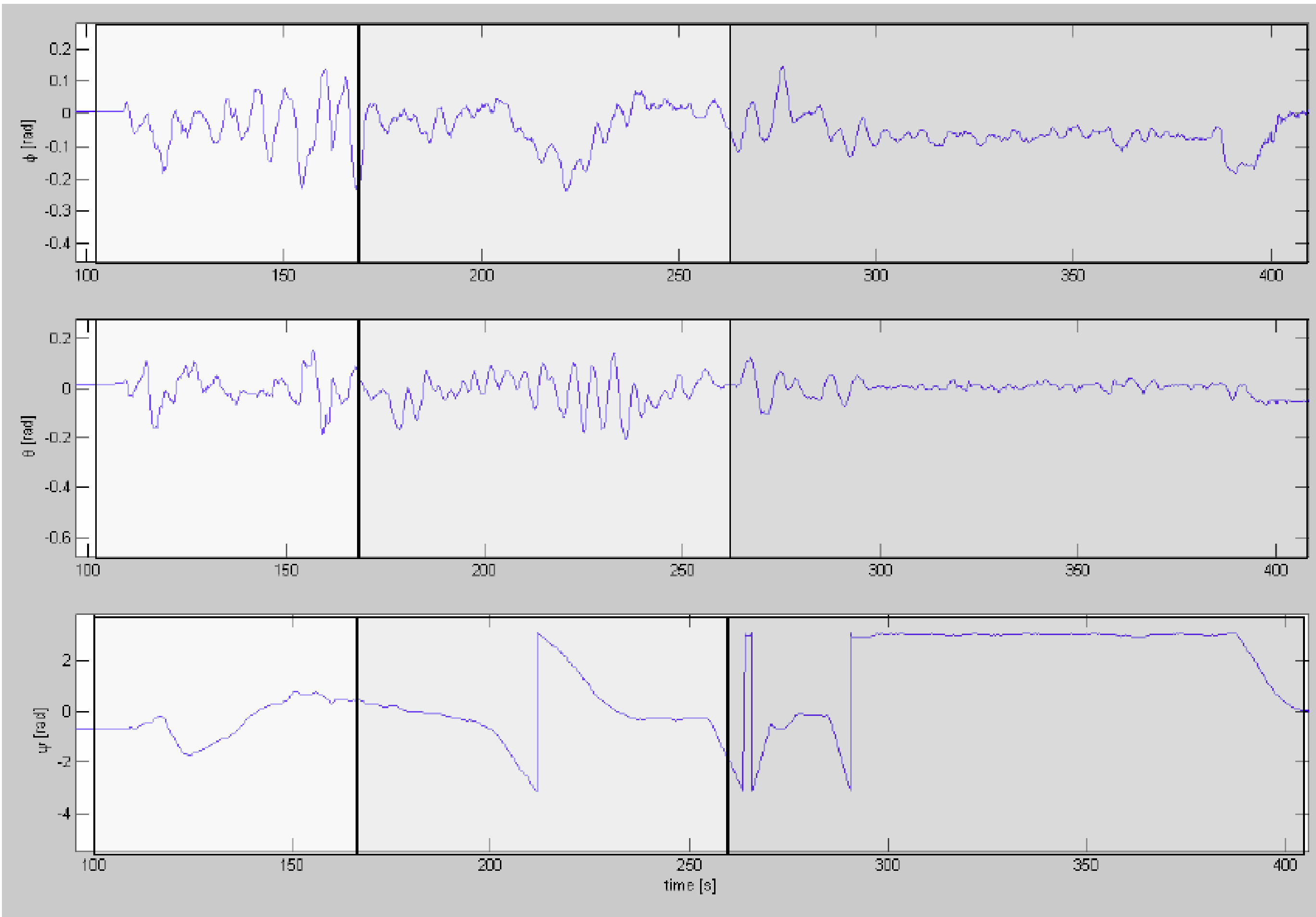


Figure 4-23: Example for the transition between manual (white), assisted controlled (light gray) and autonomous (gray) flight. Upper graph: Roll (Φ) angle around x-axis; Middle graph: pitch (Θ) angle around y-axis; Lower graph: yaw (Ψ) angle around z-axis.

Flight stability [speed]

WePilot 1000

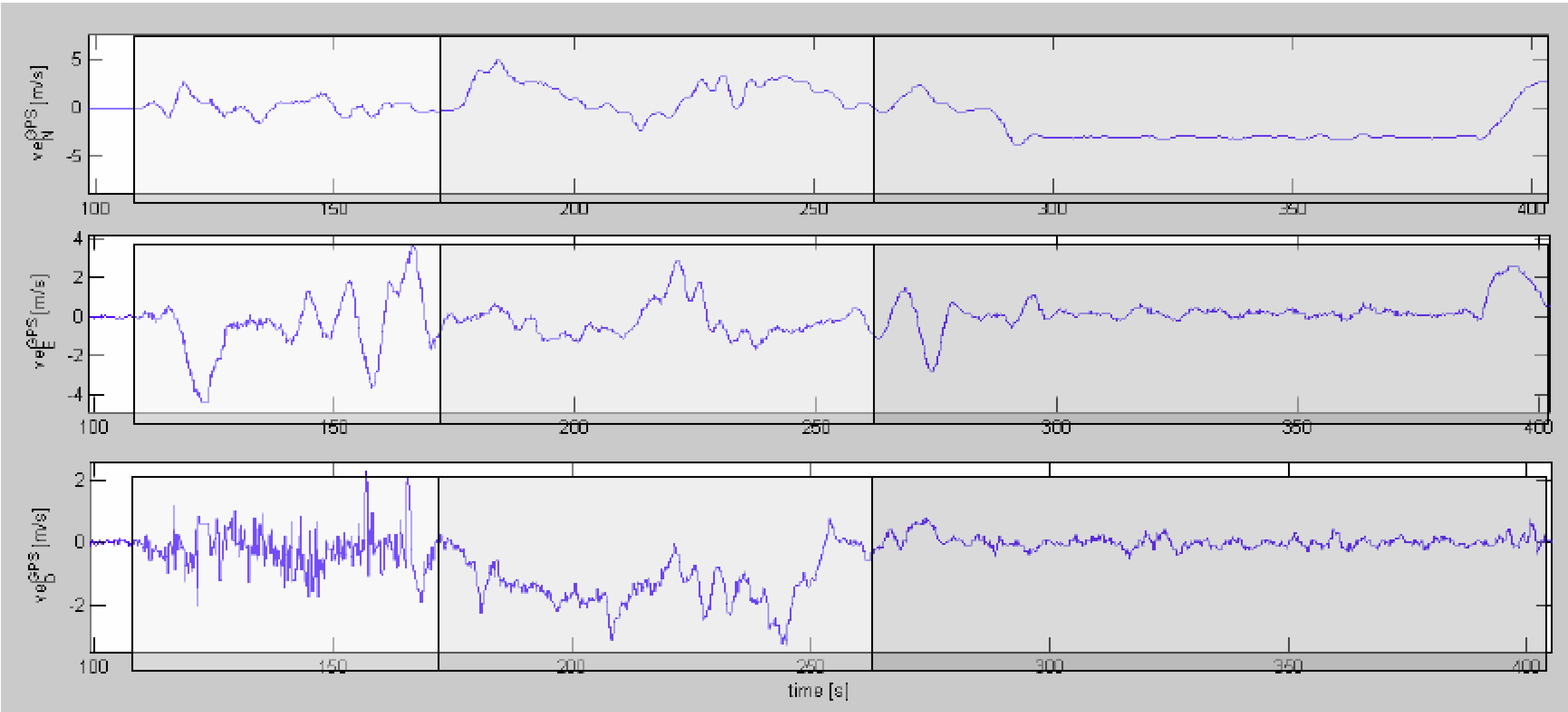
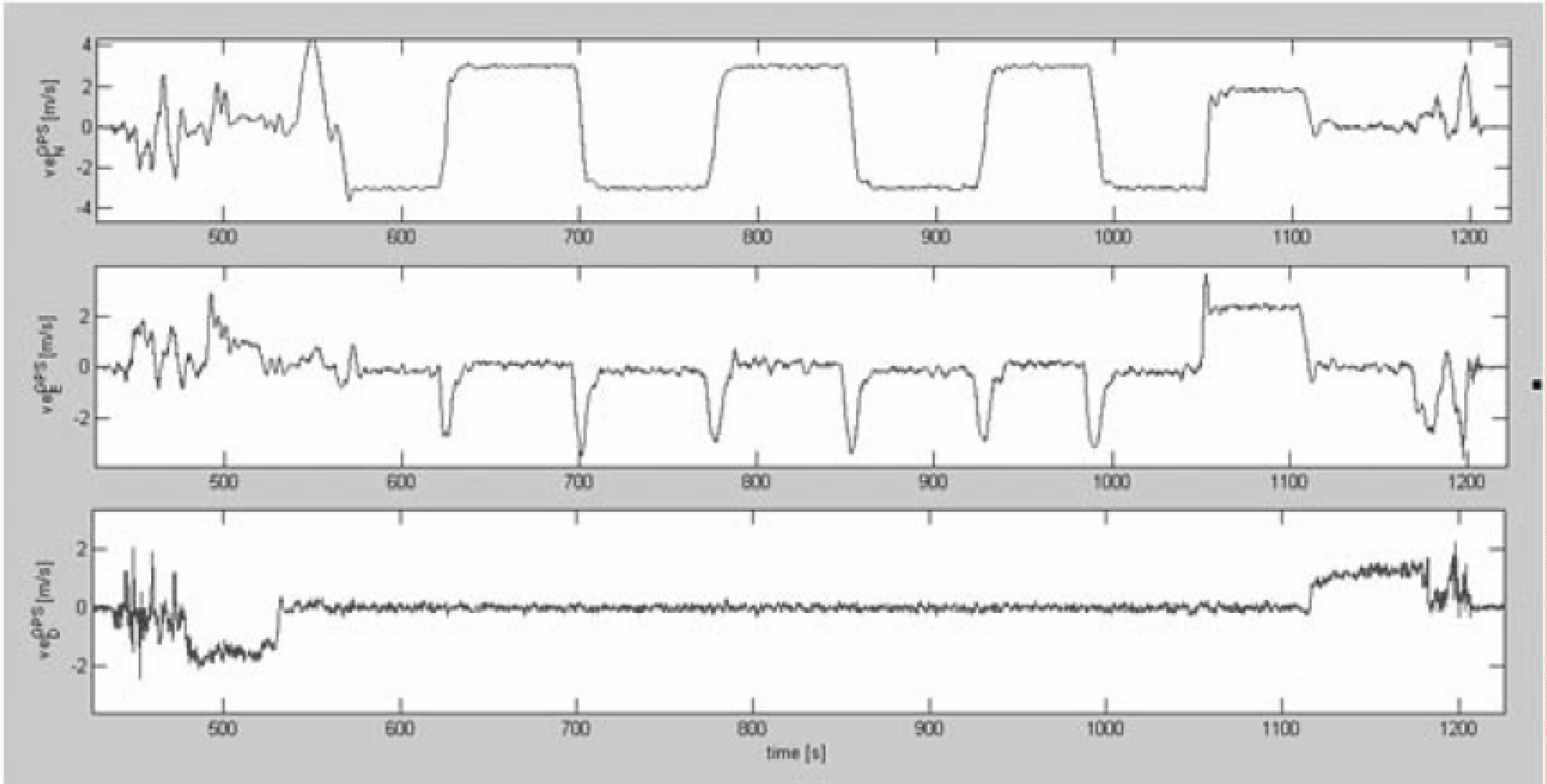


Figure 4-24: Example for the transition between manual (white), assisted controlled (light gray) and autonomous (gray) flight. Upper graph: Velocity v_N (North component); Middle graph: Velocity v_E (East component); Lower graph: Velocity v_D (Height component).

Speed: Design vs Execution

WePilot 1000



Fixed wings Vs multi rotor

Flight planning

Assisted control

Base station

Meta data

Major category

Fixed wings	Multi rotor
Much better range	Lower flying height
Cover large areas ($1km^2$ or more)	Wind endurance
Fully autonomous	Smaller take off and landing space

Take off by hand

Mavinci

Lehmann Aviation

Swinglet

Zephyr

Take off and landing

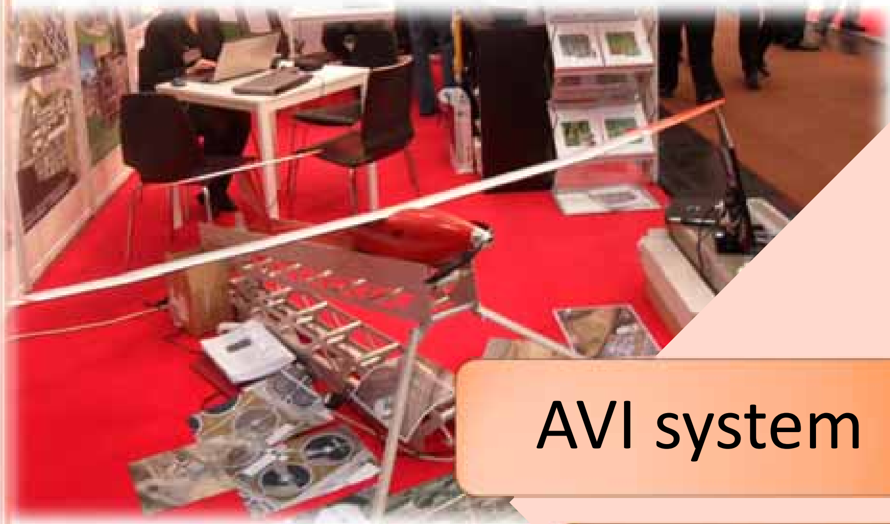
… in a single short video

Take off

Best landing ever

Take off with catapult

(some may land using parachute)



AVI system

Gatewing

C-ASTRAL

Pteryx

Multi rotor

Aibotix

Microdrones

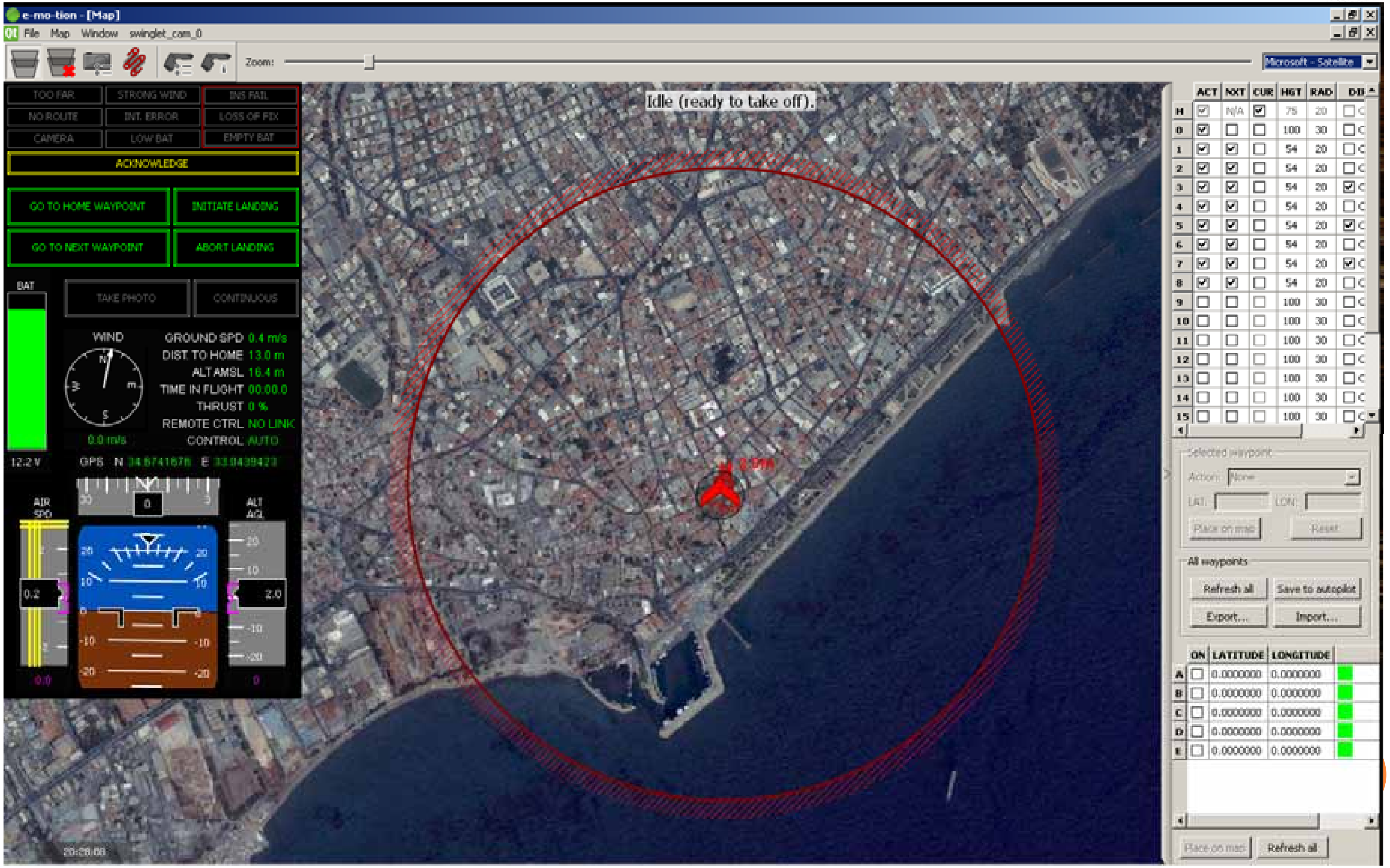
Dragonfly

High Tech

Microdrones

Aibotix

Flight planning s/w



Planning vs Excecution

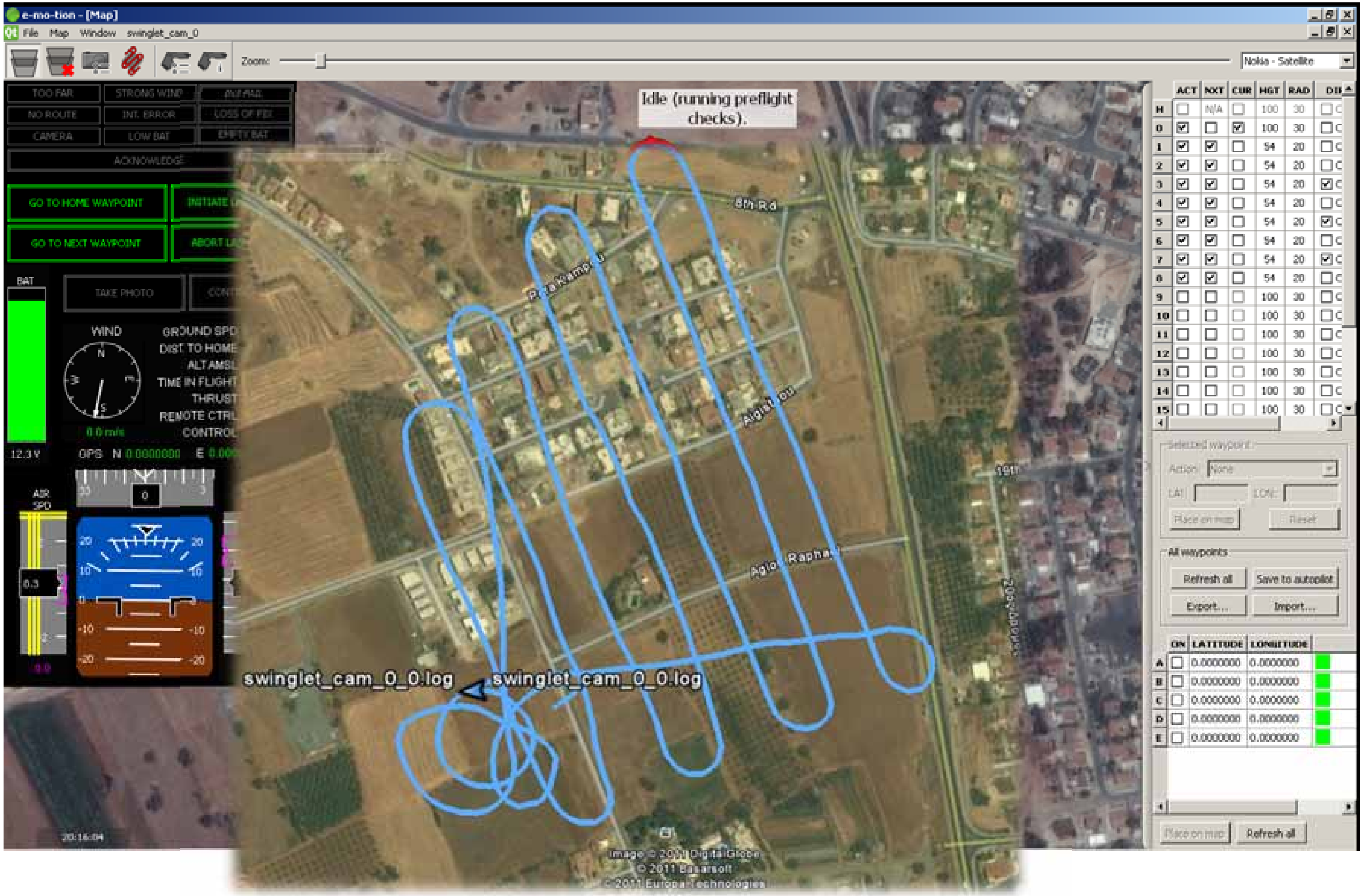


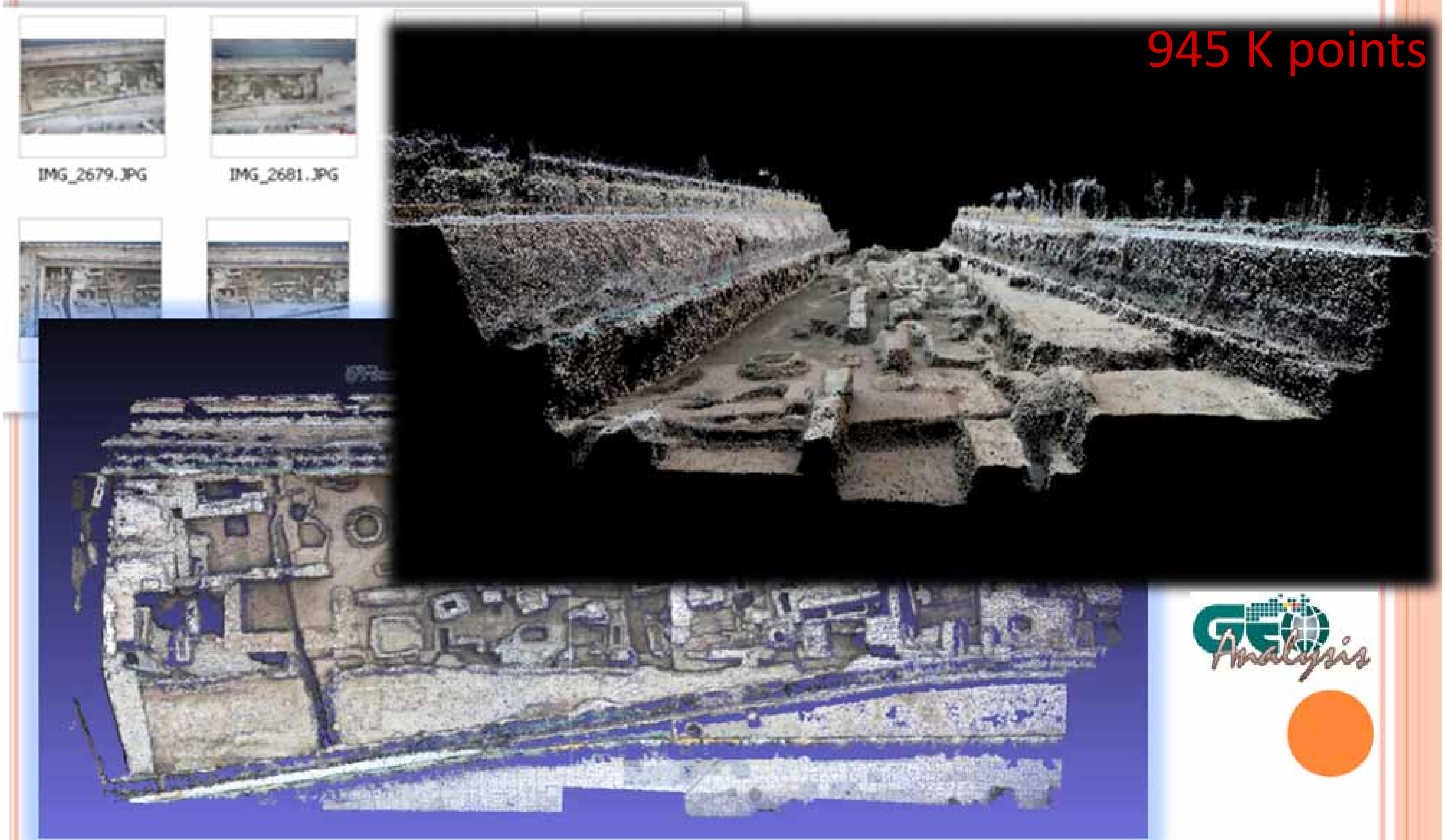
Photo triggering

- Manual through video link
- Automatically using on board GPS
- With time interval
- Hovering above the exact location and manual triggering [only multi rotor]

Archaeological applications & examples

3D color point cloud

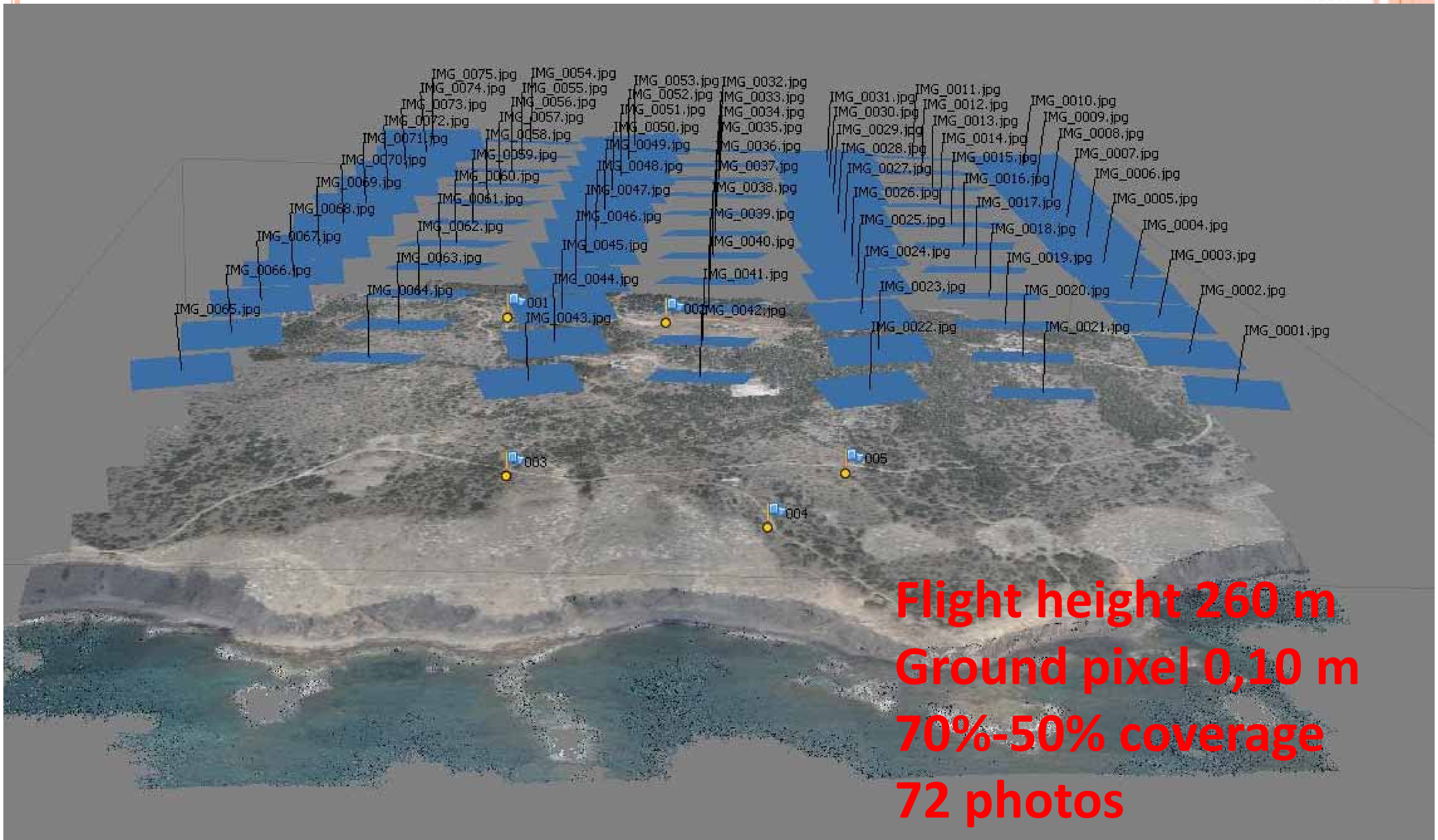
RC Helicopter (8 high resolution full frame photos)



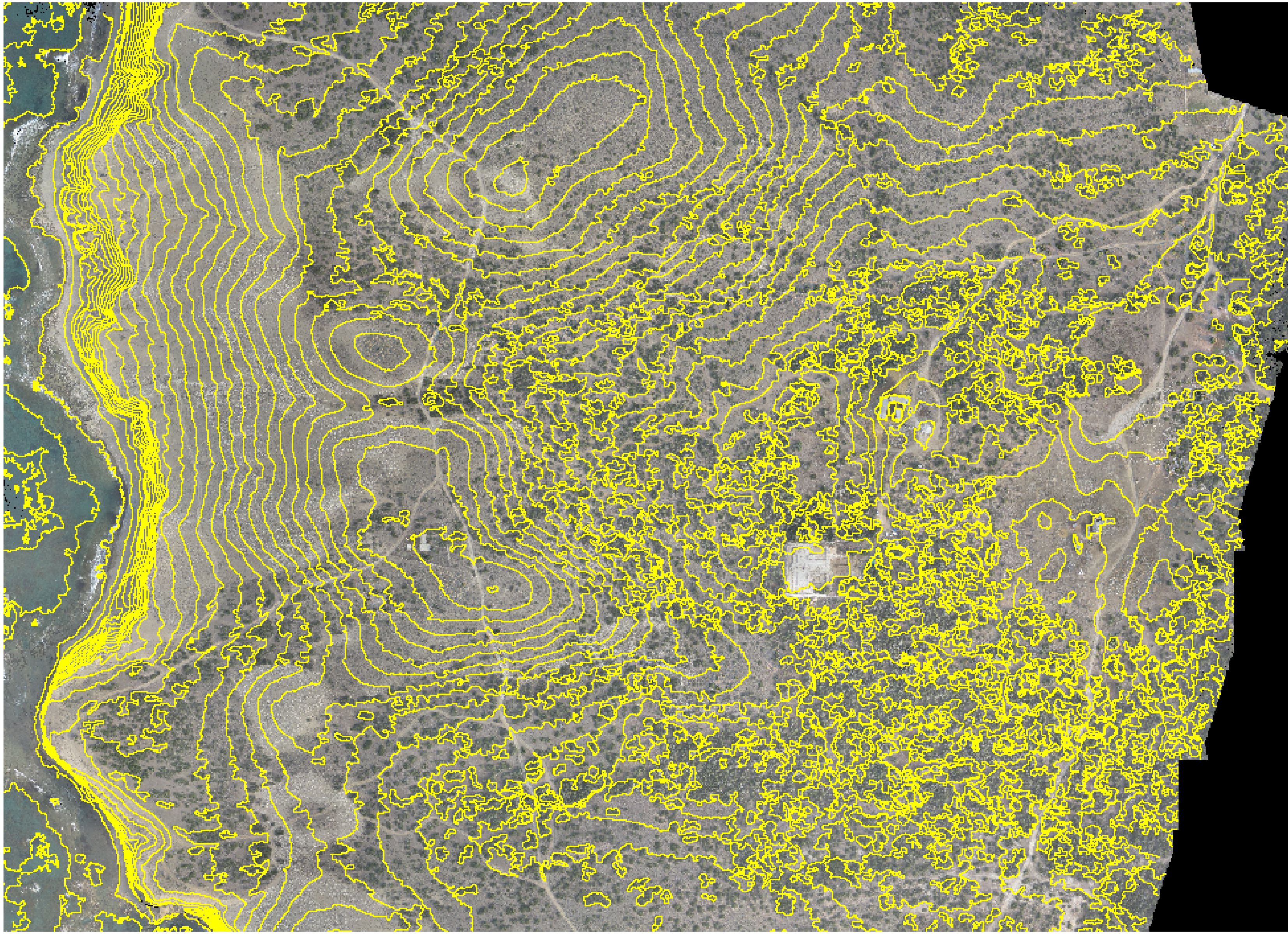
Orthophotomap in Akrotiri arcaeological site

- AUAV flights under permission from SBA
  - Total on site time for flight preparation and flight = 40min
- Control point collection with GPS (3 hr)
- Fully automated processing
  - Aerial triangulation
  - DEM @ 20cm and contour creation
  - Orthophotomosaic with 10cm pixel size
- Final result and assessment
  - RMSE on check points = 0.12 m
  - RMSE using direct georeferencing = 0.80 m

Flight and A/T

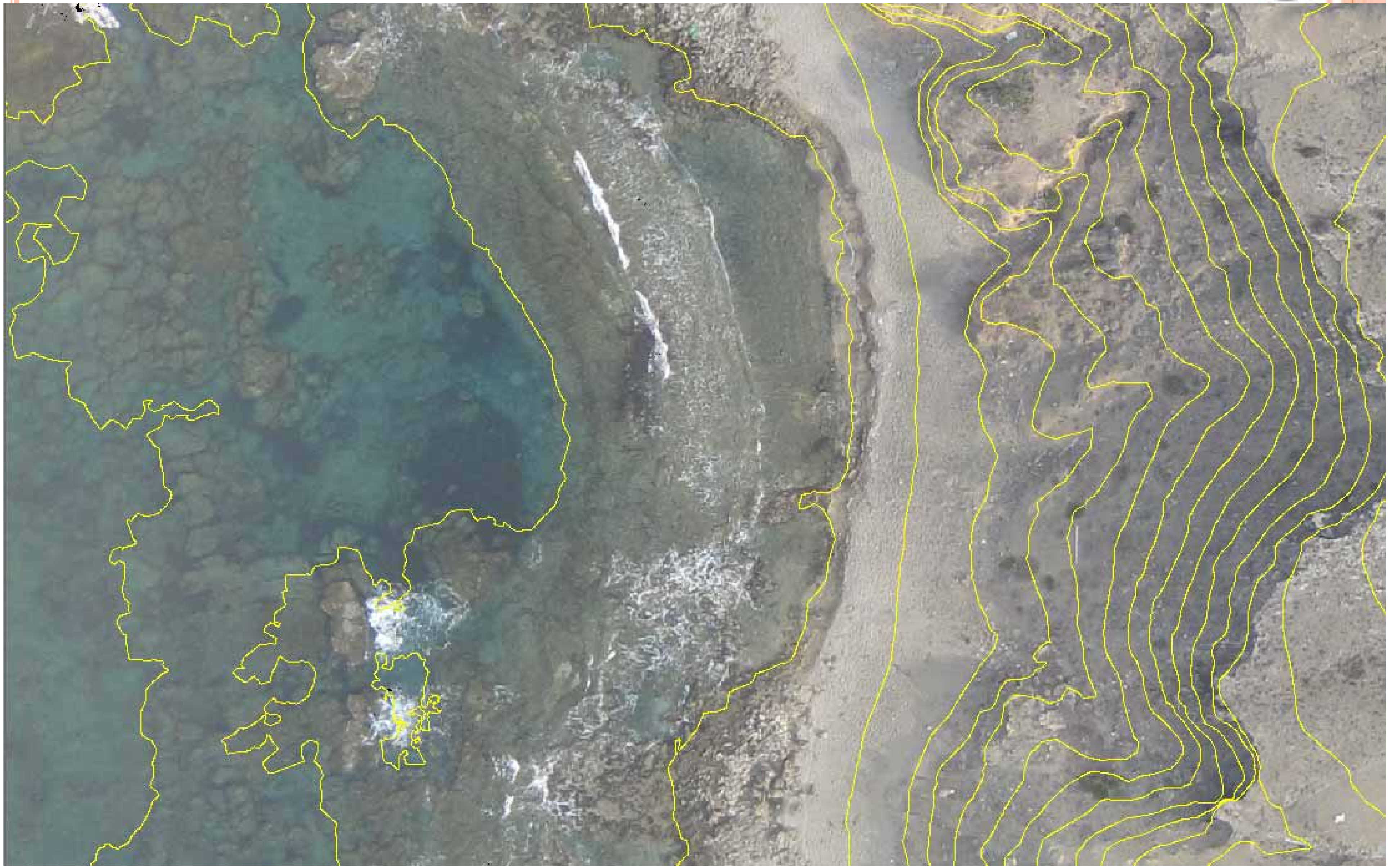


Orthophoto with 1m contours



ΤΕΧΝΟΛΟΓΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΥΠΡΟΥ
2004

Λεπτομέρεια



Detail ortho & DEM

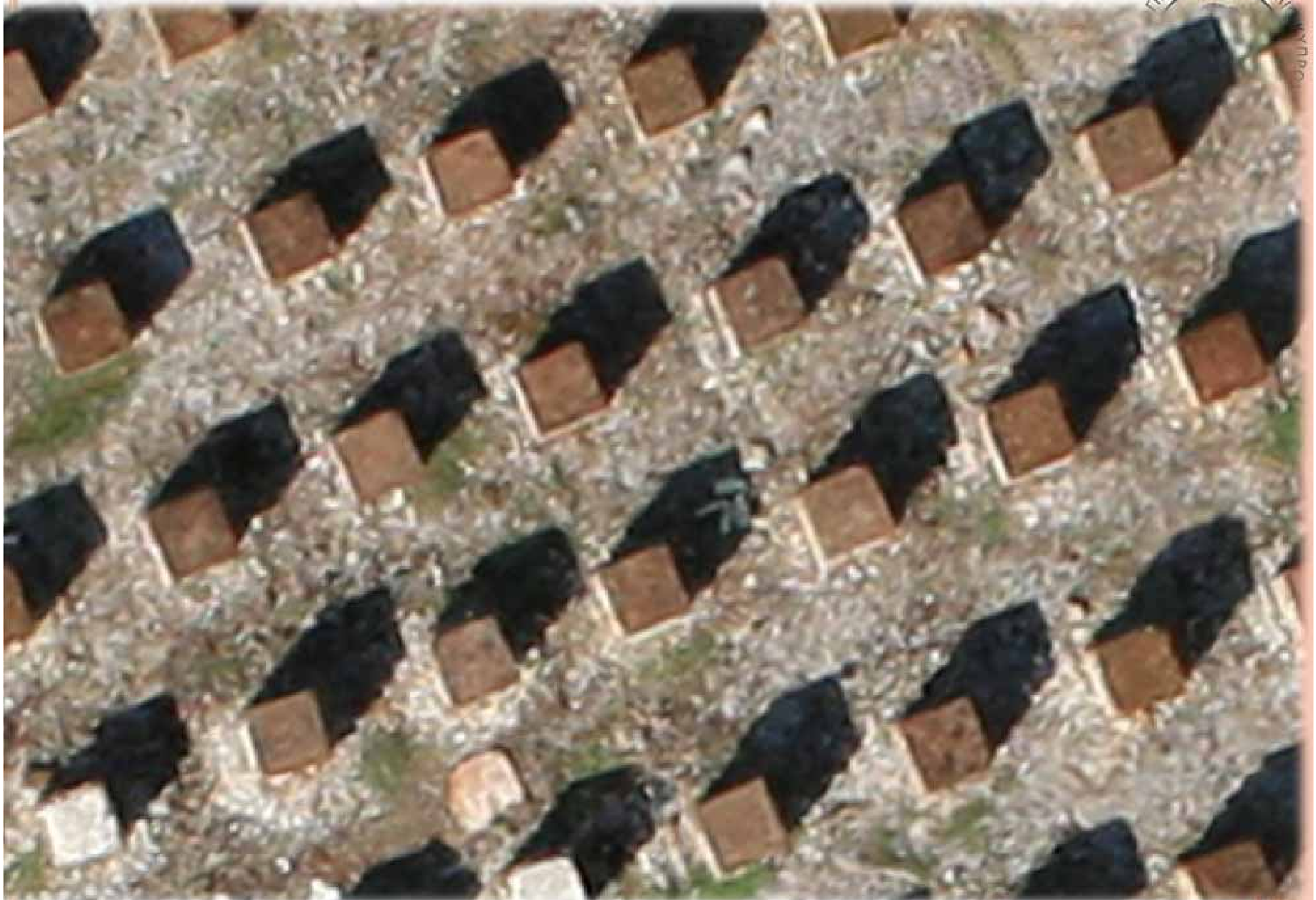
Low flight

- 42m flight height (minimum)
- 0.012 m ground pixel size


Ancient DION
Δίον 601 00, Ελλάδα
Δίον

2007

- 600 acres in total
- RC helicopter
- Full frame camera
- 25-35m flying height
- 120 acres ortho with 0.01m pixel size
- Separated to sub-areas



Improvements to be anticipated…

- Obstacle avoidance
- Automation improvements towards a fully functional and autonomous cartographic tool
- Payload increase
- Incorporation of more sensors (LiDAR & Linear Array Cameras)
- Sensor calibration
- SLAM using the optical sensors onboard
- Swarm of AUVs to map larger areas
- Increased navigational accuracy
- Open source code
- New applications

Thanks

Presentation will be available at

http://photogrammetric-vision.com/presentations.html

References

- Eisenbeib, H., 2009. UAV Photogrammetry. PhD thesis, ETH Zurich, Diss. ETH No 18515.
- Everaerts, J., 2009. New platforms. EuroSDR.
- Blyenburgh, 2008. Unmanned aircraft systems: The current situation. Presentation in EASE UAS Workshop, Paris.
- Pteryx flyer & specification pricelist
- Geoanalysis S.A. flyer
- A. Gruen, 2011, *Advances in UAV Photogrammetry*, International Scientific and Technical Conference "From imagery to map: digital photogrammetric technologies", Sept. 2011, Spain
- Remondino F., presentation in UAV photogrammetry: Current status and future perspectives