International Workshop on Disaster Risk Reduction and Management under the e-ASIA Joint Research Program and Typhoon Yolanda related J-RAPID Program
April 15, 2015, Quezon City

Potential Applications of small UAV to disaster risk assessment, monitoring and response: its needs and challenges

"Going Low Altitude"

Hiroshi Inoue

National Research Institute for Earth Science and Disaster Prevention, Japan

Minami-Sanriku, Japan in April, 2011

What is UAV (Unmanned Aerial Vehicle)?

Military Drone (13m)
100,000,000 USD

Chemical Spray (2m)
100,000 USD

Full-spec Multicopter(1m)
10,000 USD

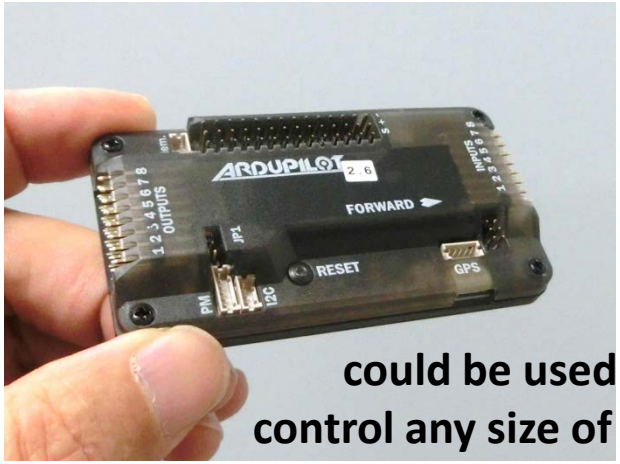
Our small UAVs

Payload: 500g, Price 1,000 USD

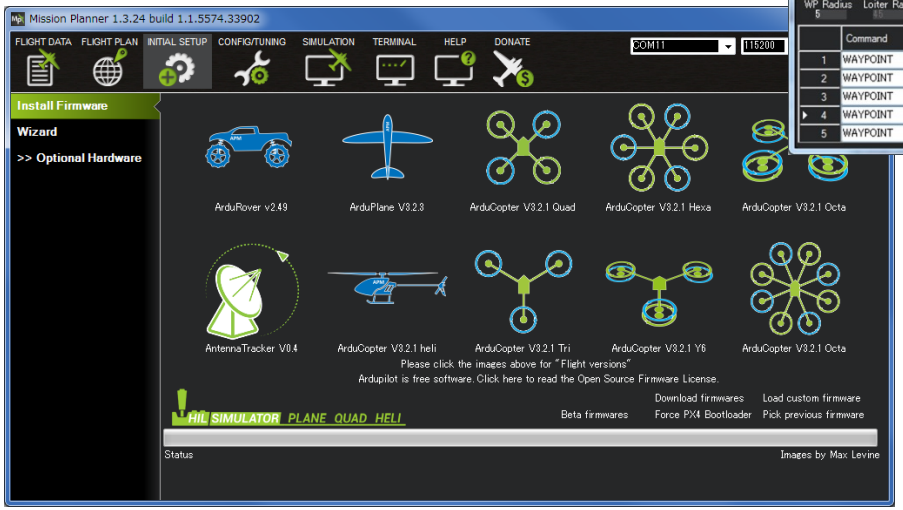
Multicopter		Fixed-wing plane
50 cm	Size	1 m
30 km/h	Speed	60 km/h
10 min	Time	30 min
5 km	Distance	30 km

Our Autopilot System

APM Flight Controller (350 USD) and Mission Planner (free)



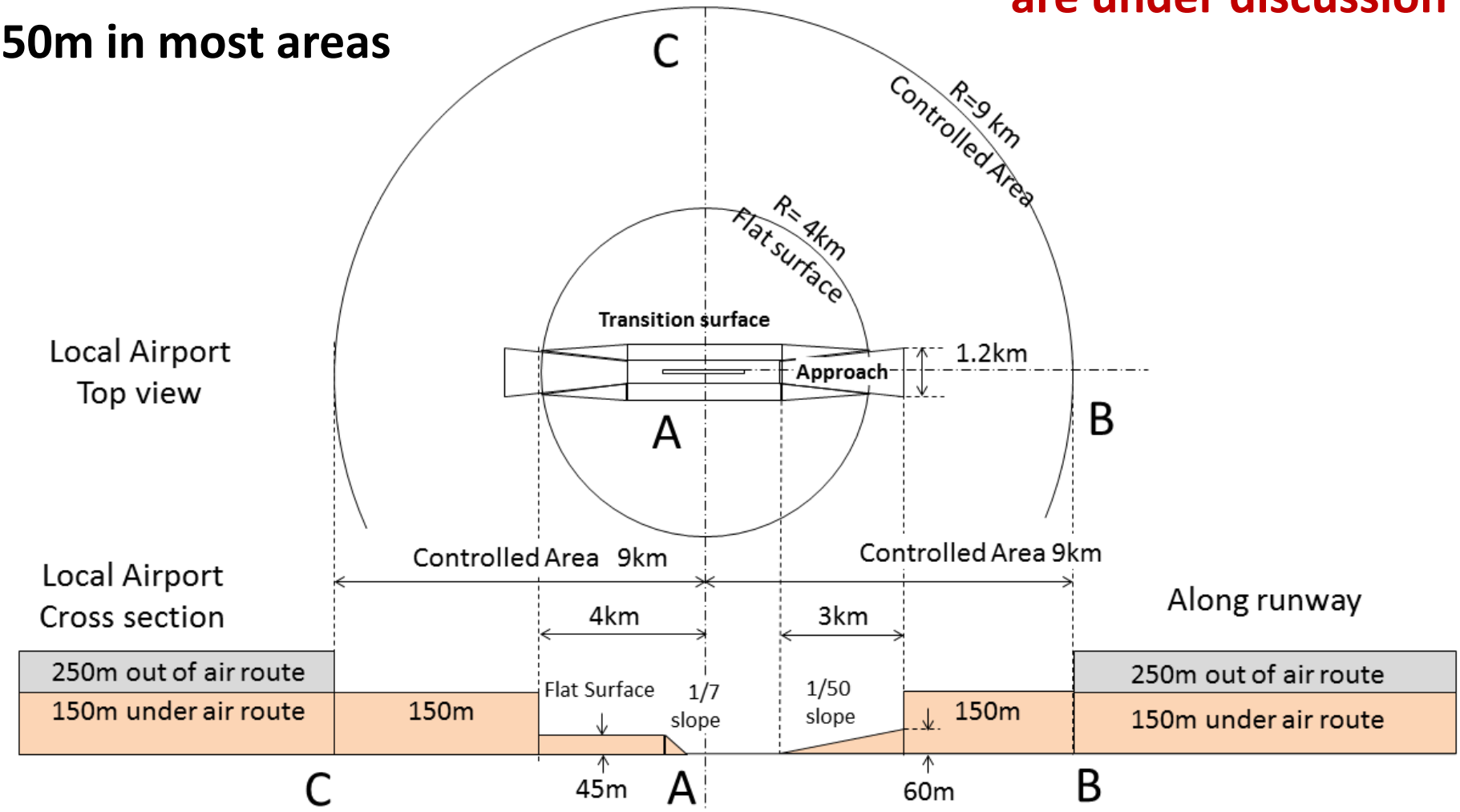
could be used to
control any size of drones



Flight Regulation for Small UAV in Japan

Ground altitude limit
Limit surface near airport (fig. below)
250m outside air routes
150m in most areas

More strict regulations for Safety, Privacy, and Security are under discussion

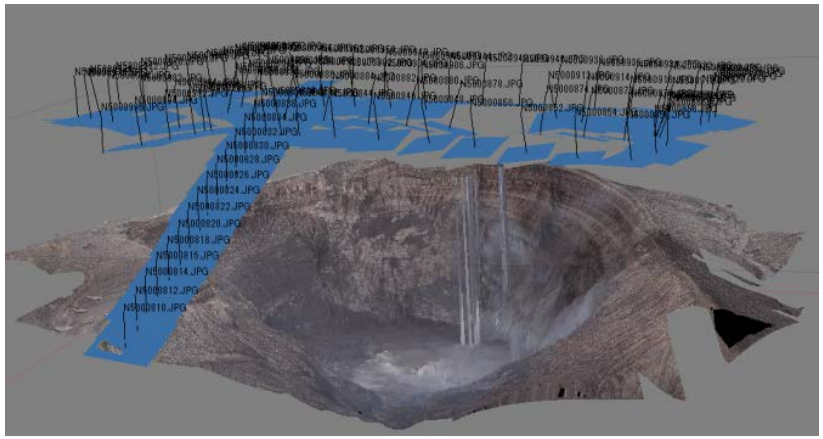


Cameras on UAV

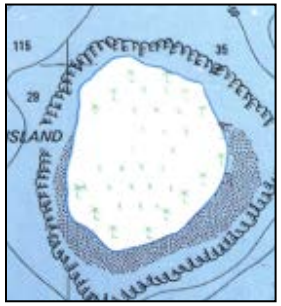
Still and movie for picturing
1) Raw images and
2) 3D Surface Model
by SfM/MVS

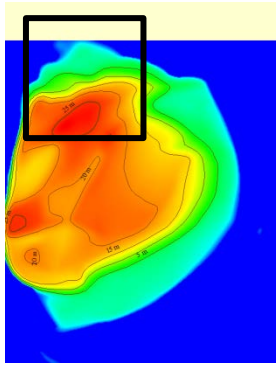
Ricoh GR GoPro

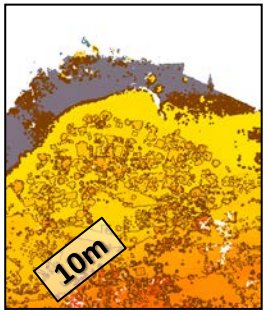
Other possible on-board sensors
1) Night scope (infrared)
2) Thermo-camera (infrared)
3) LiDAR for topo
4) Dual frequency GNSS


Agisoft PhotoScan

Vertical Resolusion	Topo Data	
10 m	Conventional 1/50,000	
1 m	Airborne IFSAR	
10 cm	LiDAR DTM	Photo DSM

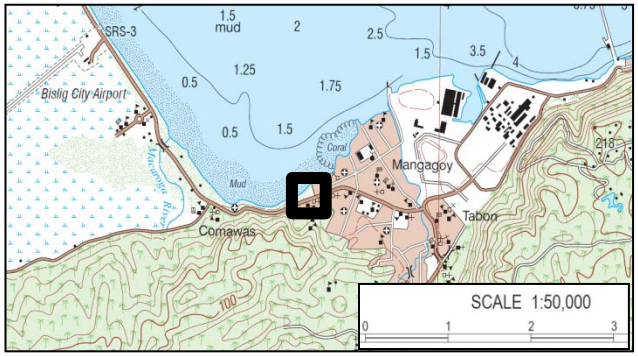






"Going low altitude and high resolution"

Coastal Topo for Tsunami/Storm Surge inundation modeling



Digital Surface Model

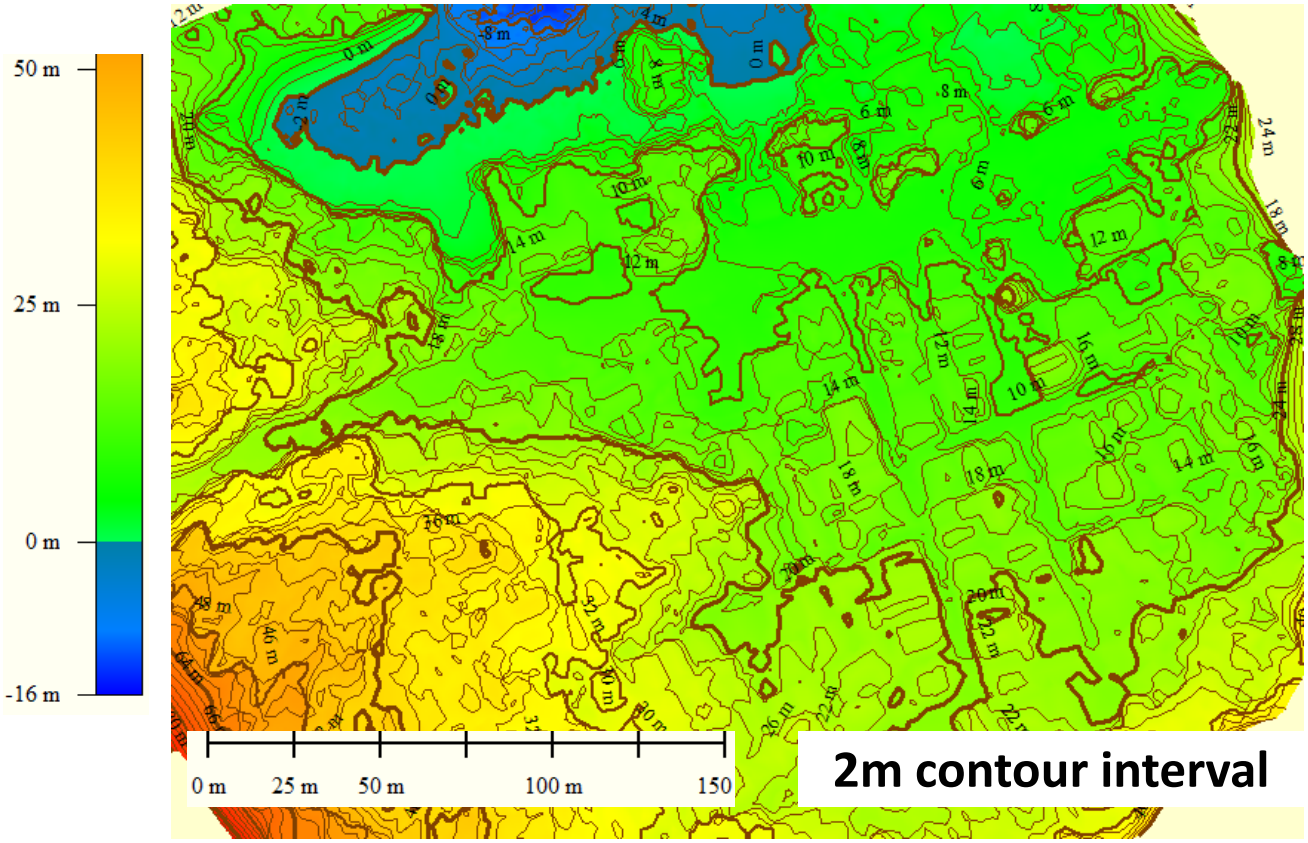
Cameras at 100m

GCP (Ground Control Point)

Digital Surface Model

Height resolution ~ 1/1,000 of ground altitude

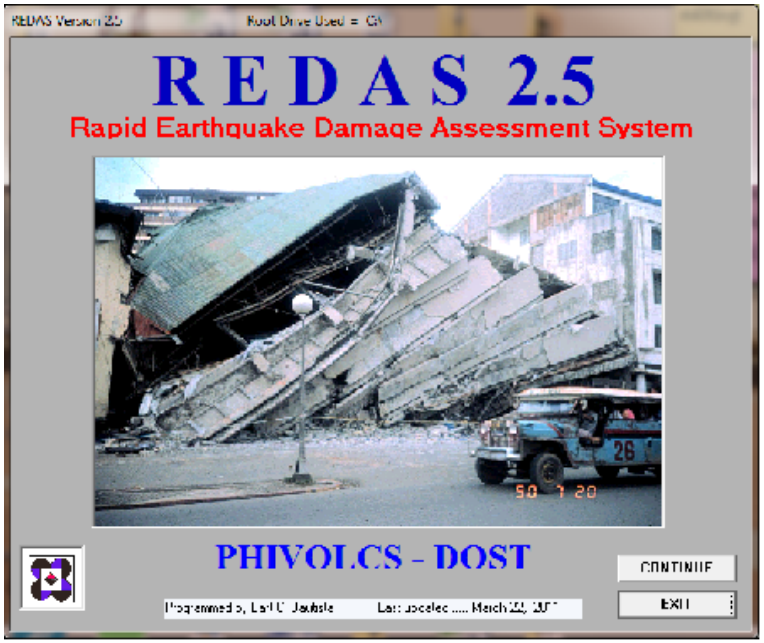
(e.g. 10cm resolution from 100m ground altitude)

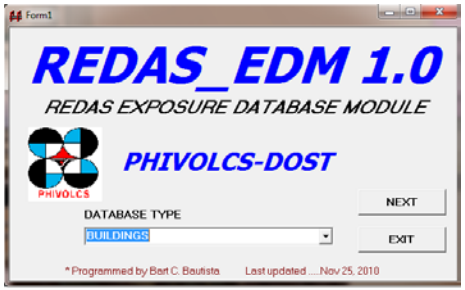


RTK GPS

Height accuracy is important for disaster risk assessment

Building Exposure Database for Earthquake Risk Assessment by PHIVOLCS

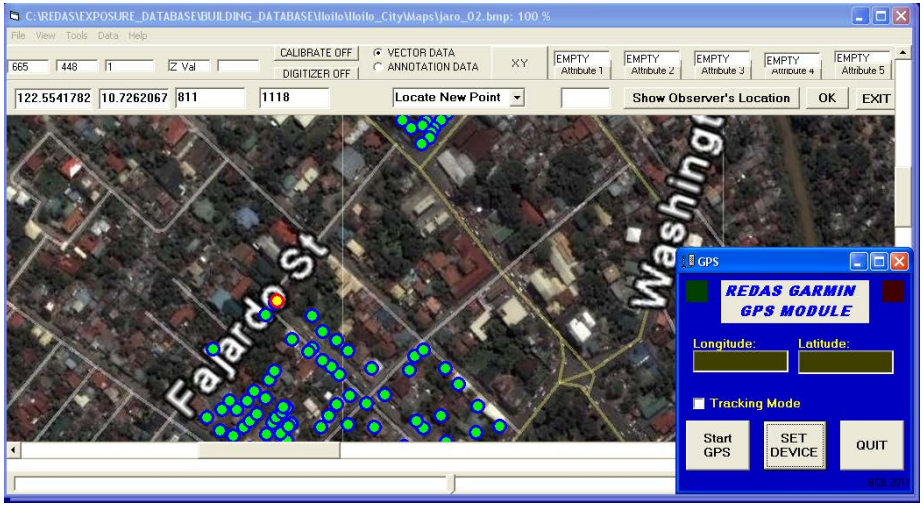




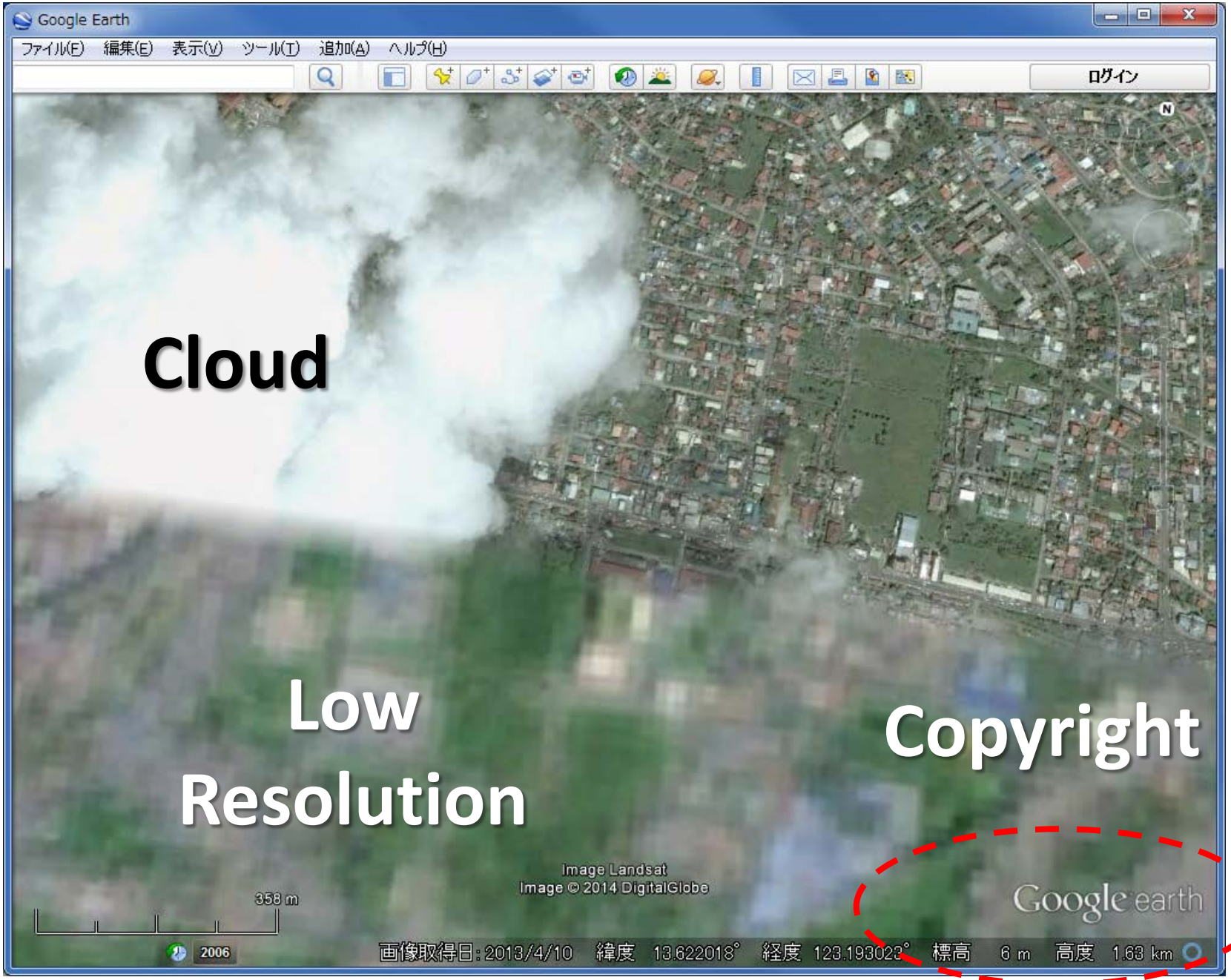
Building locations and classifications

Field Survey

Handheld Tool with GPS



GoogleEarth Image of Iriga-City, Philippines



UAV survey in Iriga-City, Philippines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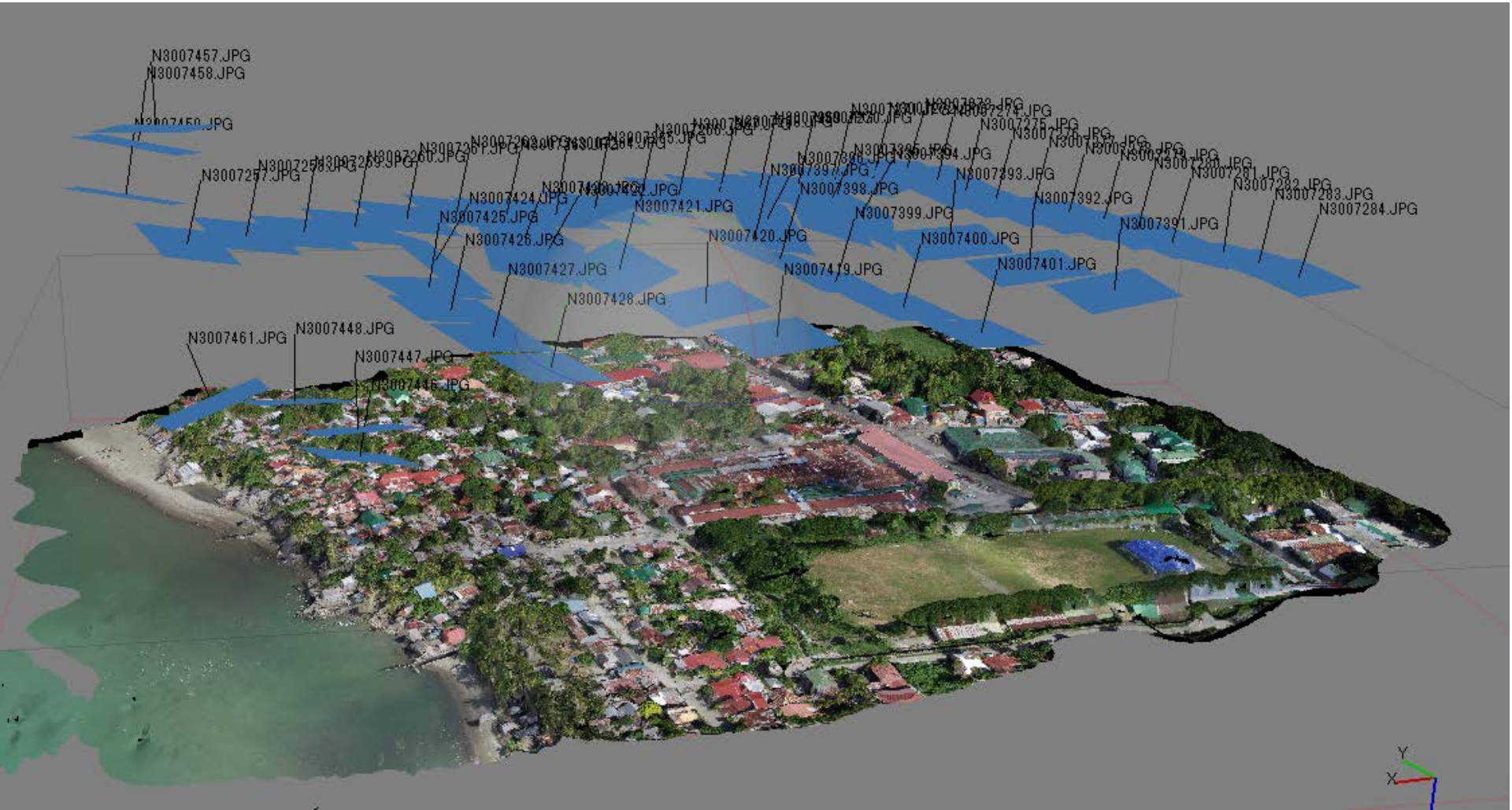
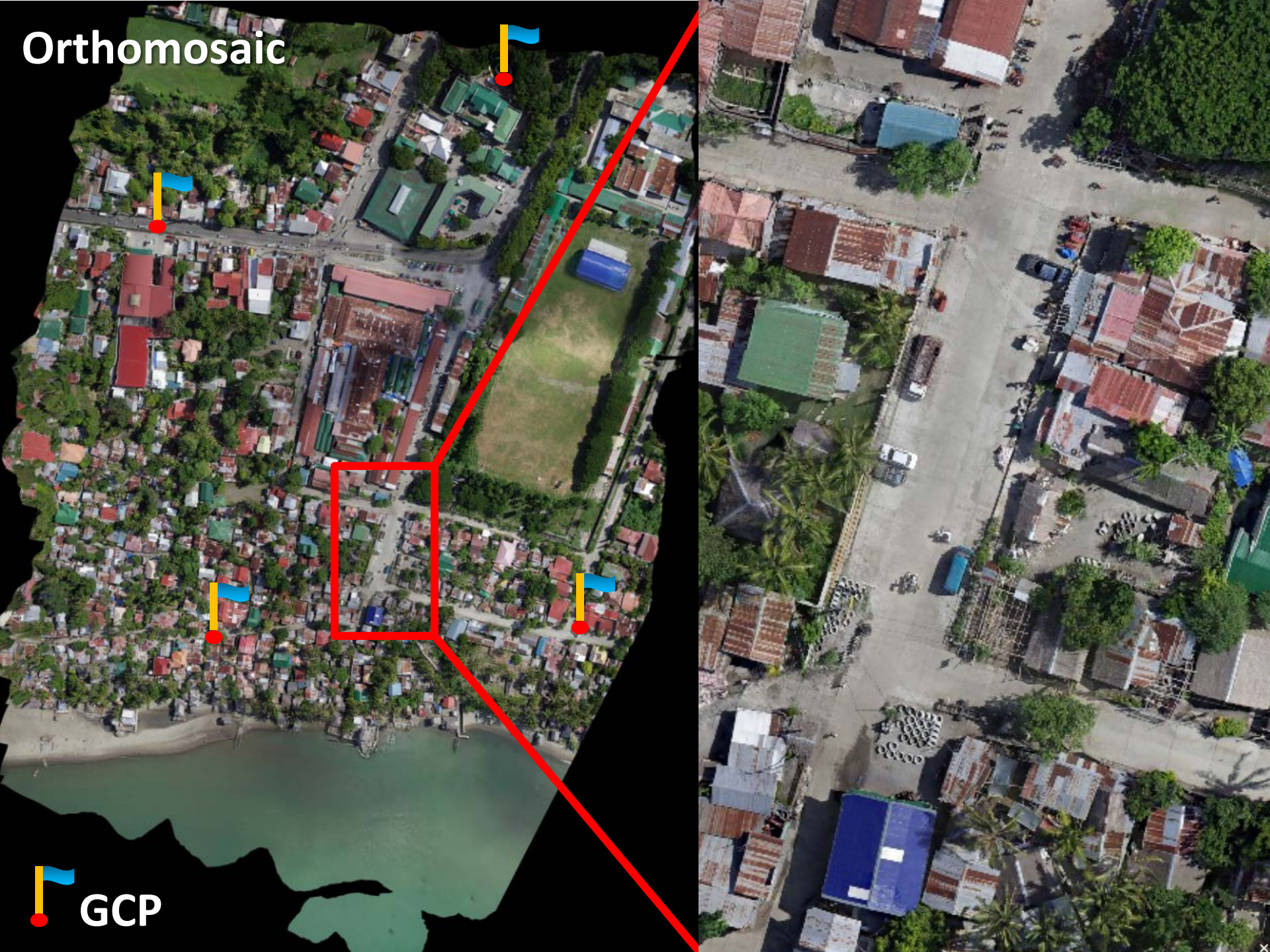
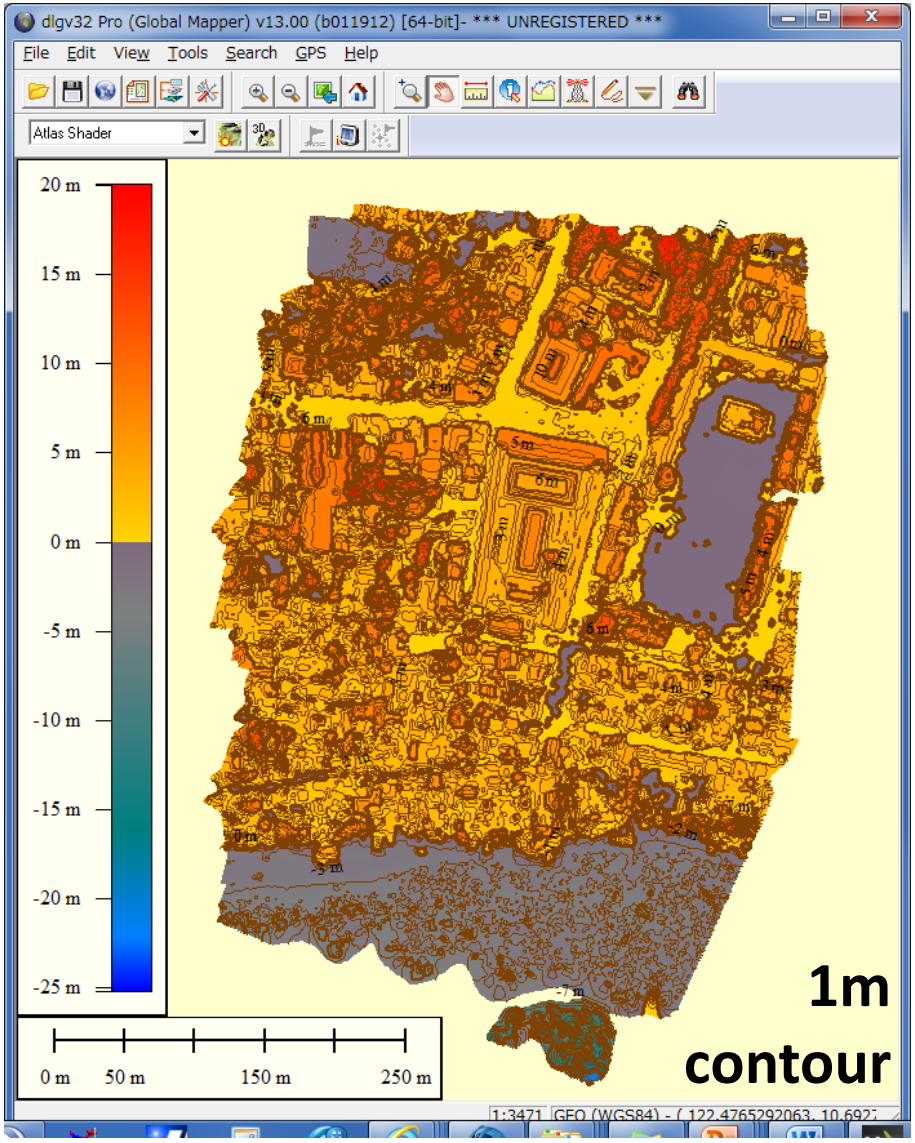
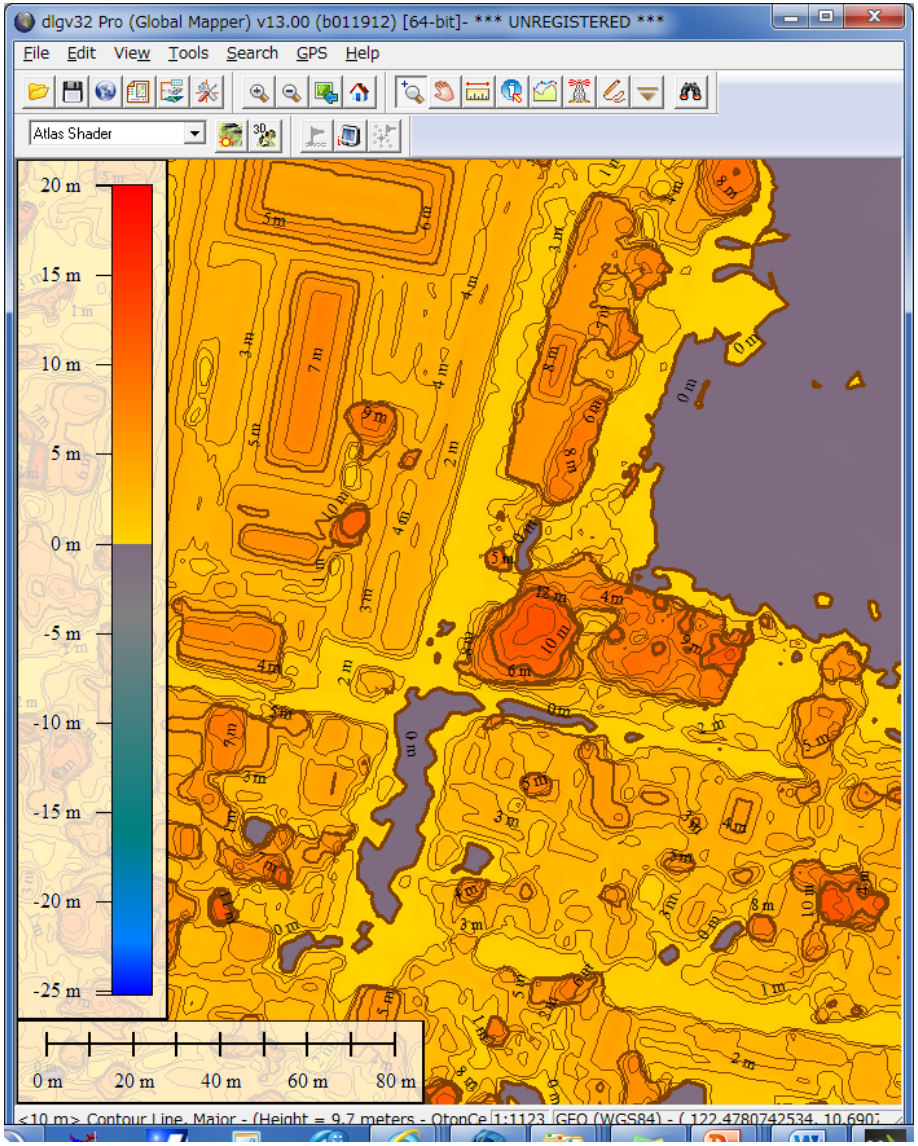



Orthomosaic
GCP

Location and height of buildings from orthophoto and DSM

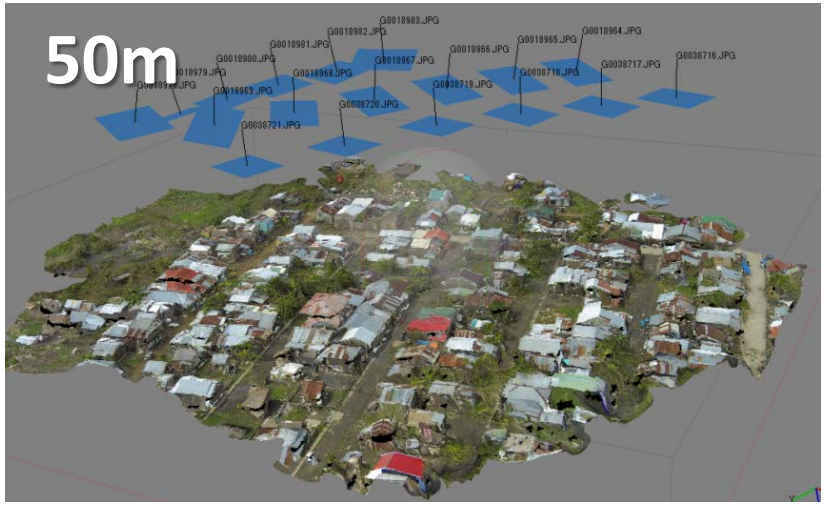




Precise GCP coordinates are not necessary.

Bird-view for building classifications

Wide-angle camera (GoPro)

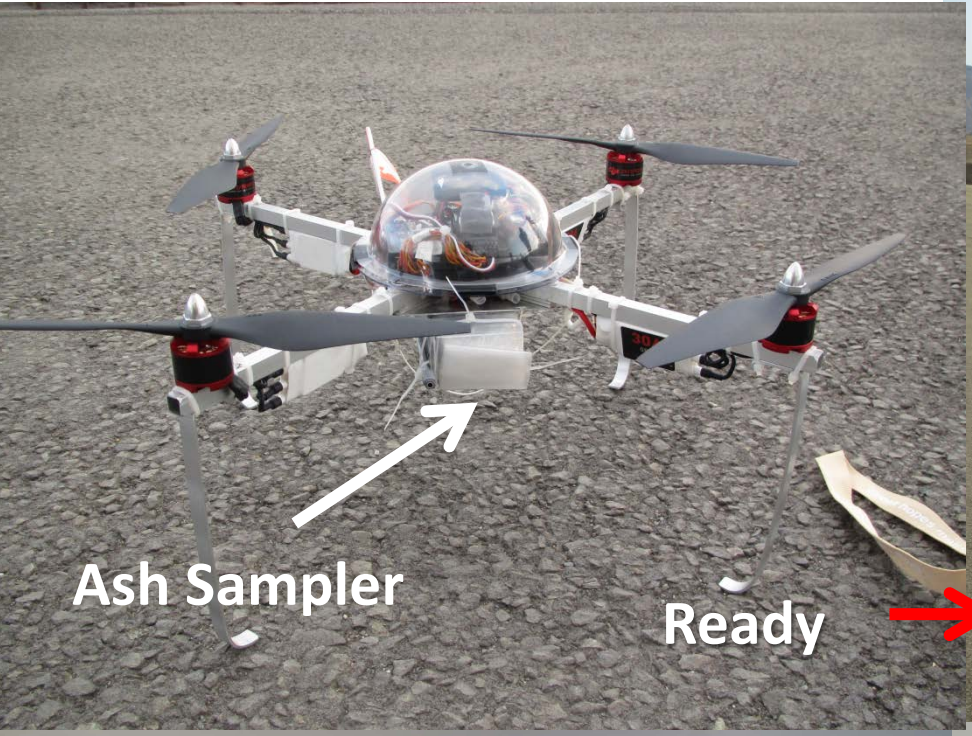


Oblique photos (Ricoh GR)

Volcano Crater Monitoring

Central Crater of Mt. Aso, Kyushu, Japan

Diameter: 400m, Depth: 130m, Alert Level 1 , Nov.7, 2014

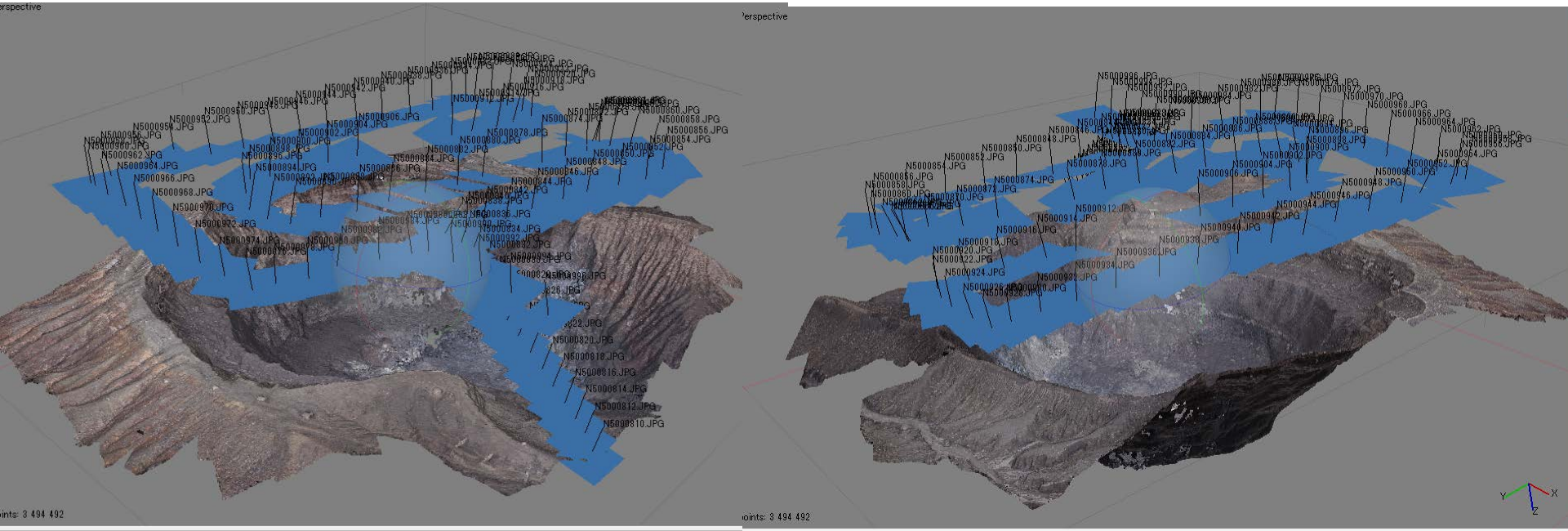

Ash Sampler
Ready

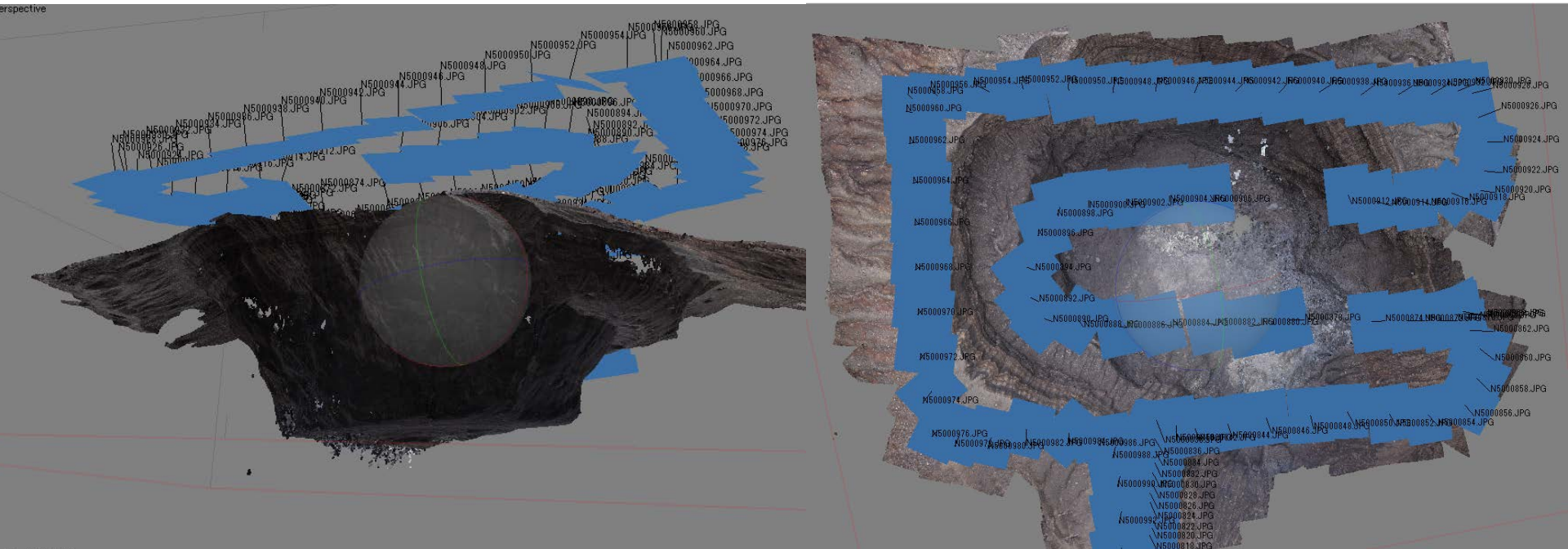

Arm


Charge


Fly
KEEP OUT · 출입금지 ·

Digital Surface Model of Aso Volcano Central Crater





Disaster Response Support

Typhoon Glenda (Rammasun)
2014.7.15-16 in the Philippines
106 casualties

Damaged Resort Pier in Albay

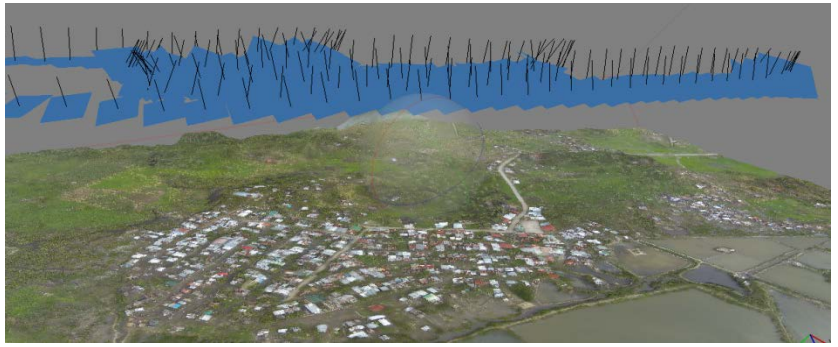
Provincial Governor showed interest in UAV and requested a quick survey

Altitude 150 m
Distance 3.14 km

Brgy Cotta,
Lucena City,
Quezon Province,
Philippines

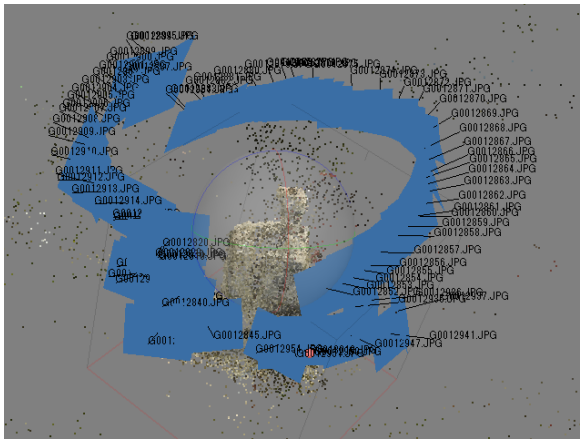
Take-off and
Landing point

1 km

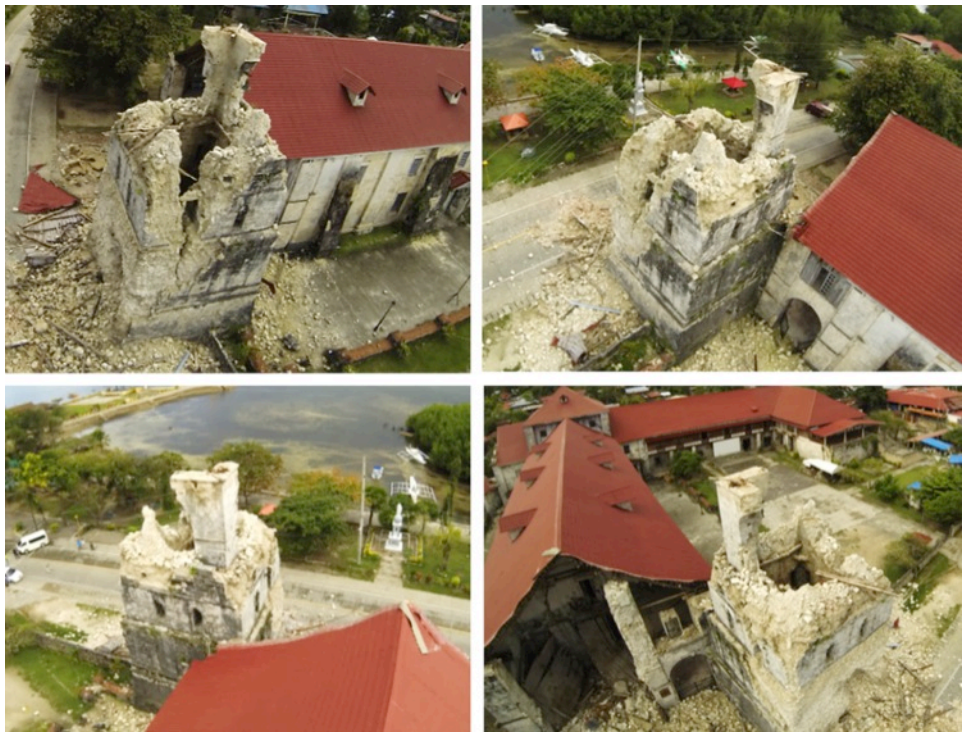



Provincial Disaster Management Office used
the data for recovery planning of the area
and examines the introduction of UAV

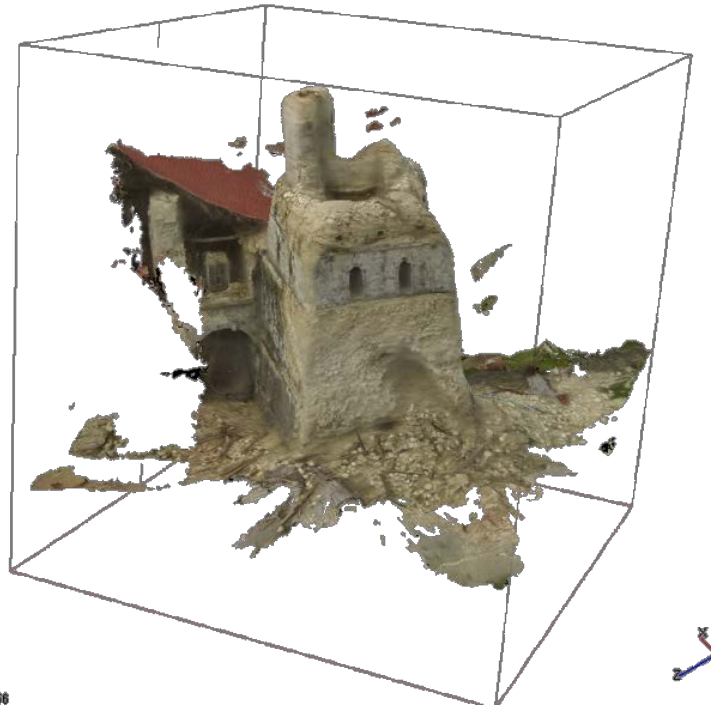
Damage survey of Oct. 2013 Bohol Earthquake M7.2



Baclayon Church



3D modeling



Debris Flow Disaster in Hiroshima, August 2014
Rapid UAV survey requested by the fire department and self-defence forces rescue

Self-Defence Forces

Orthomosaic photo of the debris superimposed to residential map

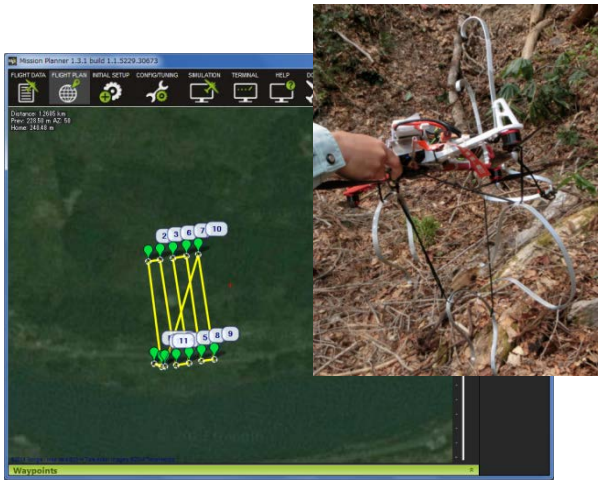
Potential Applications of UAVs to Disaster Risk Assessment, Monitoring and Response

	Target
Risk Assessment (Pre-disaster)	Mapping topo for assessing hazards by 'flooding materials' (tsunami, storm surge, river flood, debris, lava, lahar) and active faults for EQ risk. Mapping vulnerability and exposure of buildings for assessing the disaster risks
Monitoring (for Early Warning)	Monitoring slow-moving landslide Monitoring volcano crater (magma, ash) Monitoring slow-moving lava
Response (by LGU/OCD)	Rapid and frequent information gathering of an on-going disaster for rescue and relief. Information gathering after the disaster for recovery planning and monitoring

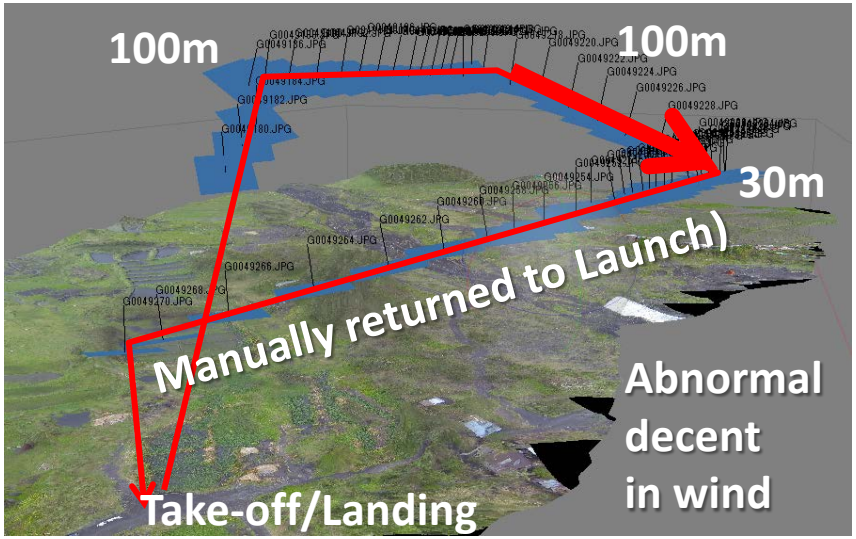
Challenge 1: Safety

Fell down from 5m only

Hit concrete floor from 4m



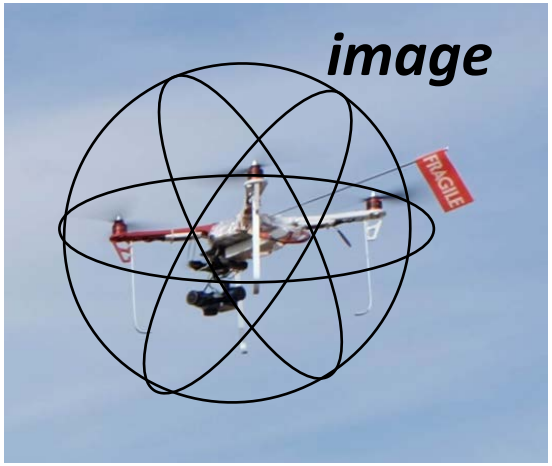
Wrong preset altitude



Accidents are mostly caused by human errors including misjudgment of situation

Safety measures for copters

Prop Guard
available



Full protection
to be developed

Parachute
to be developed

Safety Operational Procedure

1) Enough skill of control for emergency
2) Calibration and double-check of equipment and missions
3) Right judgments of situation

Still difficult to reduce crash rate from 1/100 to 1/1000.

Without full protection gears, you should not fly copters over inhabited areas. But, disasters occur inhabited areas.

A solution: Fixed Wing Foam Plane

absorbs shocks when it crashes by breaking itself. People hit feel pain, but not injured.

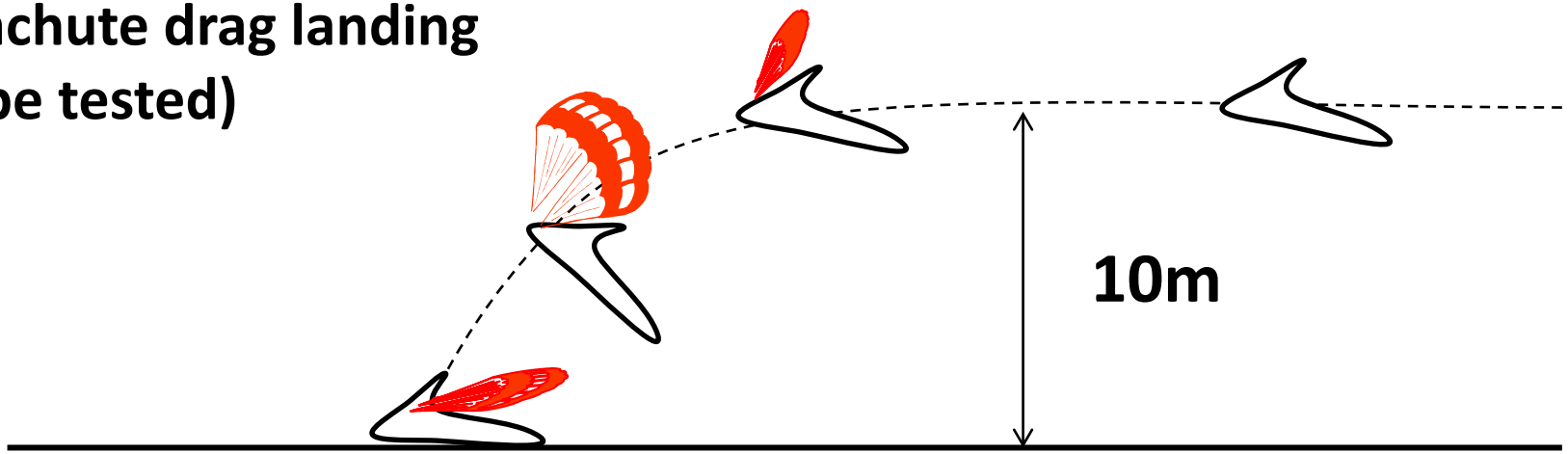
Another big advantage: larger flight speed (60km/h) , longer flight time(~30min) and distance (~30km)

Price: same as copters (or even cheaper)

Cons: Needs control skill and wider space for landing.

Landing TECHNOLOGY for small or rough landing area or even at a building top

Parachute drag landing (to be tested)



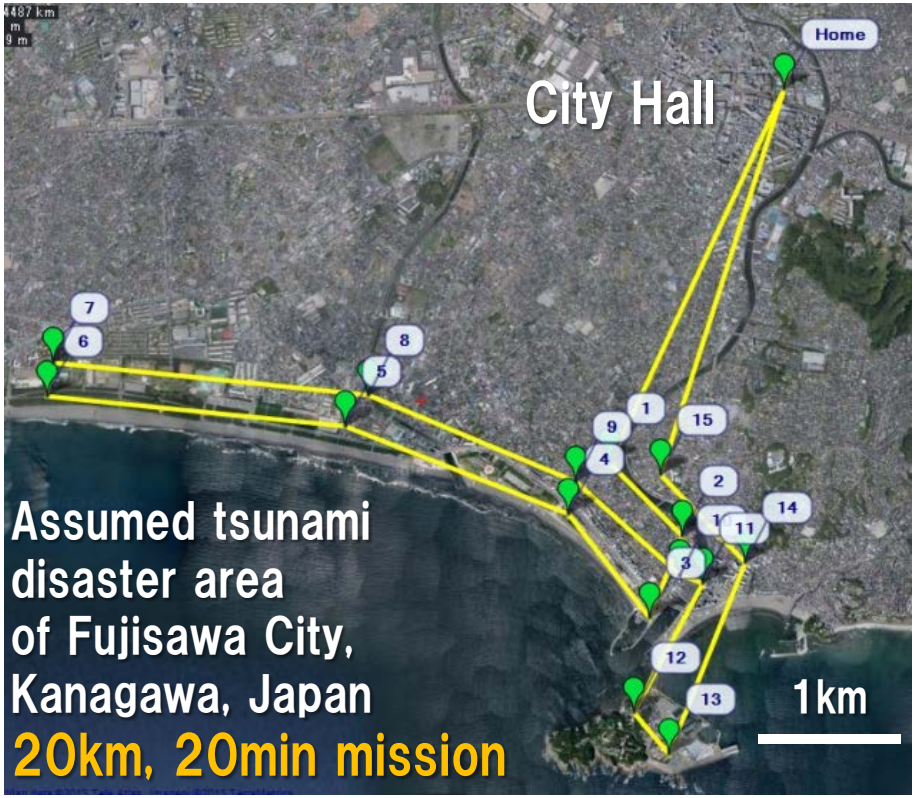
Challenge 2: Long range and Wind

Multicopter

30 km/h	Speed	**60 km/h**
10 min	Time	**30 min**
5 km	Distance	**30 km**

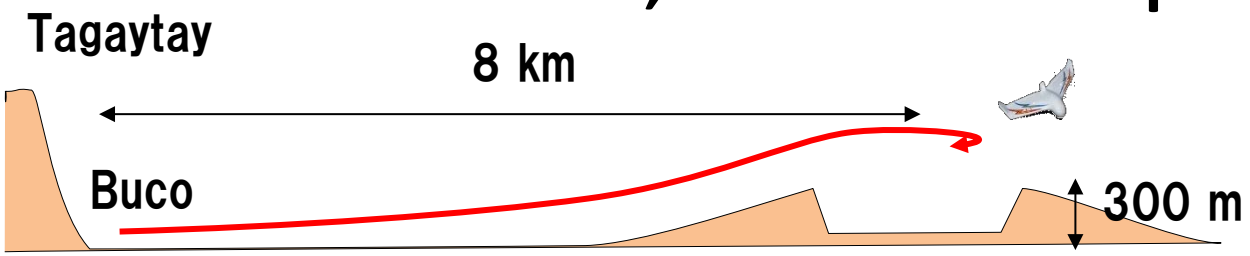
Fixed-wing plane

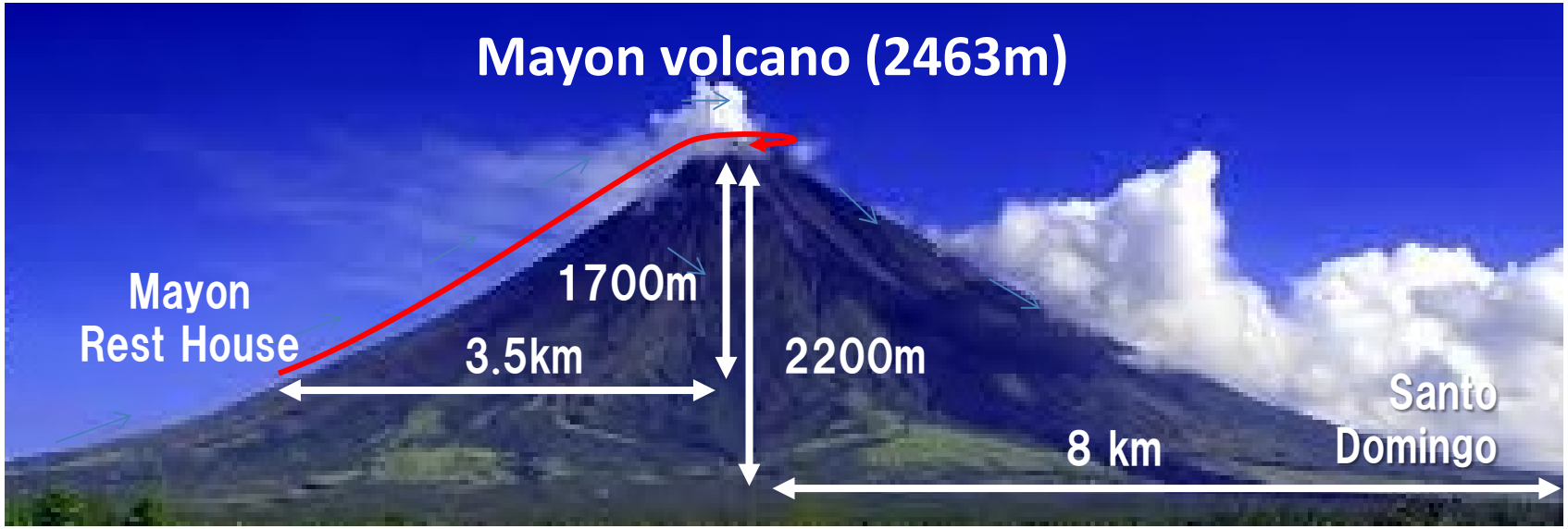
For wider coverage of pre/post-disaster mission



Volcano crater mission

Taal volcano, 20km round trip





Elevation, Strong wind, Thin Atmosphere

Climbing up in tail wind and gliding down in head wind

Long-range flight test

Inland field, no wind
1km go-around
40km in 50 minutes

FX-61
1.5m wingspan
6600mAh batt.

Coast line in strong wind (8m/s)
19 km round trip in 35 minutes

(movie)
Take off for a coast line mission against 6 m/s head wind

Windy coast, Round trip

Wind speed
8m/s (28km/h)

Plane air speed
56km/h

Need faster plane
in stronger wind

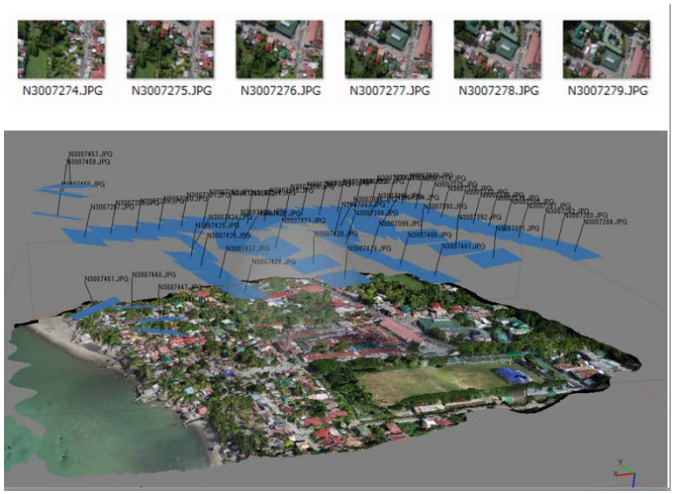
Challenge 3: Easier operation

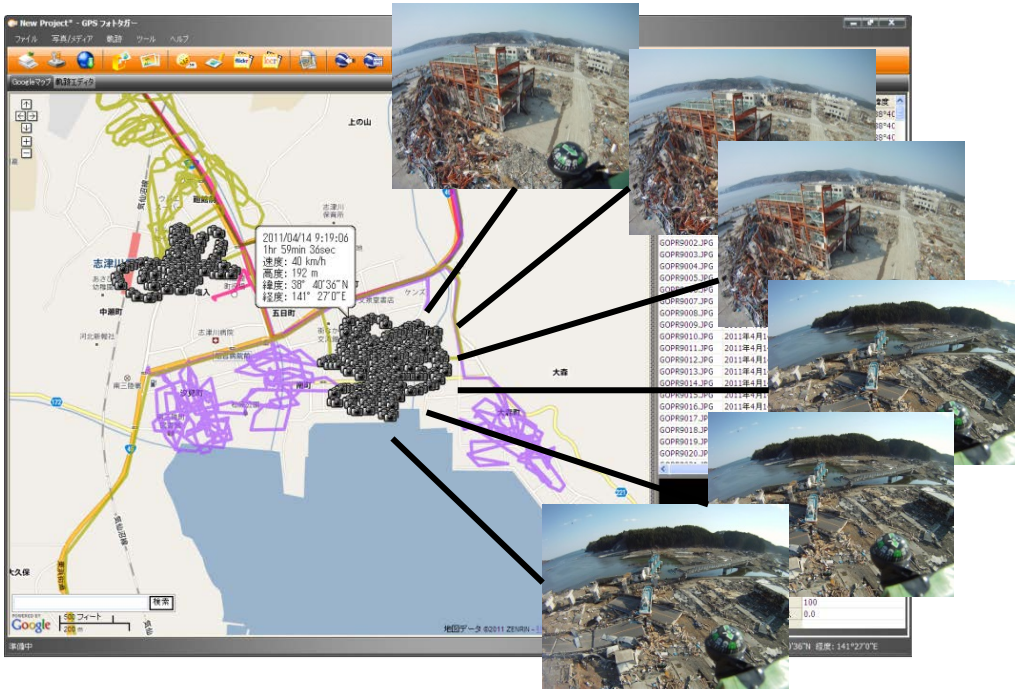
The system is in practical use by UAV-specialists and trained researchers. Training can be provided.

For emergency response purposes, however, the system has to be much simpler and easier to be operated and maintained by LGU staff.

Challenge 4: Easier data handling

The system is in practical use by specialists for research purposes. Training can be provided.





For emergency response purposes, however, the system has to be much simpler and easier for LGU/OCD staff, e.g., to quickly browse the images

Conclusion

1. Small UAVs are powerful tool for disaster risk assessment, monitoring and response
2. Cost-effective equipment is available in the market.
3. Fixed wing plane has advantages of safety and long range mission.
4. Easy landing, long-range flight, durability against wind are the major technical challenges
5. The system is ready to be deployed by experts, but has to be much simpler and easier to use for LGU staff for emergency operations.

Join us. Thank you

UAV Training for PHIVOLCS, March 3, 2015, in Lantic, Cavite

Activities in the Philippines were in SATREPS project by JICA/JST