Unmanned aircraft JR GSR260Z equipped with laser scanner and high resolution camera used for the demonstration.

Sharper Shape drone operators supervising the flight with ground control station.

Demonstration of Unmanned Aircraft for Powerline Inspections

In 2013 Finnish law for electricity markets set forth rules for electricity distribution and availability of electricity for customers. The maximum allowed duration of an interruption of electricity is 6 hours in urban and suburban areas; 36 hours in rural areas. Exceeding the time limits results in substantial penalties to distribution companies.

The length of medium and low voltage distribution networks in Finland is over 380,000 kilometers (240,000 miles). The main challenges of electricity distribution reliability concern customers in rural areas: the distances are long and the networks are built mainly using overhead line structures. Over 90% of all interruptions are caused by faults in the medium voltage distribution networks (typically 20 kV), which are vulnerable to severe weather conditions.

Helicopter surveillance flights are a widely used method for medium voltage power line inspection in Finland. There are two main principal demands on aerial inspections of power network:

1. Incident Response: Surveillance flights to observe major damages in power system due to severe weather conditions
2. Regular Patrol Cycle: Power network structure aerial photography and LIDAR scanning to gather inspection information for regular maintenance purposes.

Maintenance inspection flights (type 2) are accomplished periodically using typically 4-6 years cycles.

BY VILLE **KOIVURANTA**

The traditional inspection flights are effective but a costly method to assess the condition of the power network. The development of unmanned aerial vehicles has been very fast during the past years, especially electrical multirotor helicopters with sophisticated autopilot control system. These are now available from numerous vendors.

The expected benefits of UAV-Based inspections include cost-efficiency, flexibility and time to obtain results. Power network inspection costs should decrease substantially when UAV systems can be successfully utilized for the maintenance surveillance.

Finnish high-tech company Sharper Shape executed unique public demonstration flights on Sept. 25, 2014, near Joensuu, in eastern Finland. For the first time in the world an unmanned Remotely Piloted Aircraft System (RPAS) took off to inspect local power lines with a full set of sensors.

The main idea for this study was to demonstrate UAV[1] aircrafts readiness for power network aerial inspections. The task was very challenging due to needed long distance unmanned B-VLOS[2] flight with significant instrument payload on board and the regulatory requirements for safety set by the aviation authorities.

The study was conducted with the presence of independent energy sector analyst Jouko Tervo (Reneco Consulting Ltd.) and several local utilities as observers to the study.

The focus of the case study was to test currently available affordable unmanned aerial vehicle with affordable and

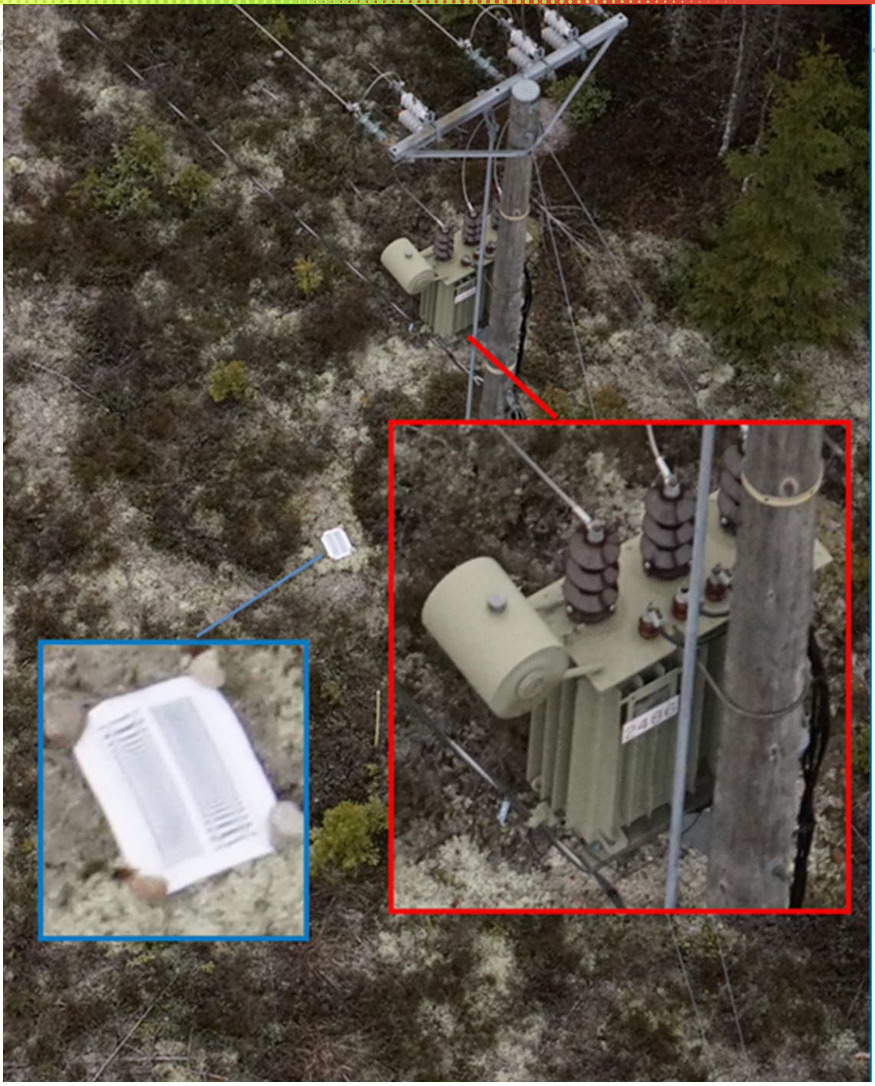


Image of 20 kV pole taken with UAV during the flight.

compact measuring instruments. The demonstration system configuration was:

- Helicopter: JR GSR260Z, combustion engine
- Autopilot: 3DR Pixhawk
- IMU: NovAtel SPAN-IGM-S1 for LIDAR data normalization
- GPS receiver: NEO M8N
- Real time video for PC control: 720p IR camera with h.264 coding
- Surveillance camera: Sony α7R, 36.4 megapixel full area (35.9 × 24mm) CMOS image sensor, objective 70mm zoom, firing control via autopilot. Memory card 128GB SDXC
- LIDAR: Hokuyo UXM-30LXH-EWA
- Logcam: GoPro Hero3
- Control communications: 16 channel radio controller and 3G/4G public mobile networks for tele control
- Mission Planner GCS open source software for mission planning
- Finnish basic land maps and Google maps

[1] UAV—Unmanned Aerial Vehicle or RPAS—Remotely Piloted Aerial System

[2] B-VLOS—Beyond Visual Line Of Sight

Main tasks of the study were;

1. Design and integration of the study system
2. Plan the test cases and required flight operation types
3. Getting several aviation and other authority permissions for the B-VLOS flight
4. Detailed planning of the public demonstration flight
5. Hundreds of hours of test flights with the UAV and equipment to ensure the airworthiness according to the test flight plan
6. Perform a public pilot flight on 13th of November 2014 in North Carelian district in Finland
7. Analysis of the test results
8. Report the study

Summary of the main experiences and some ideas for future development

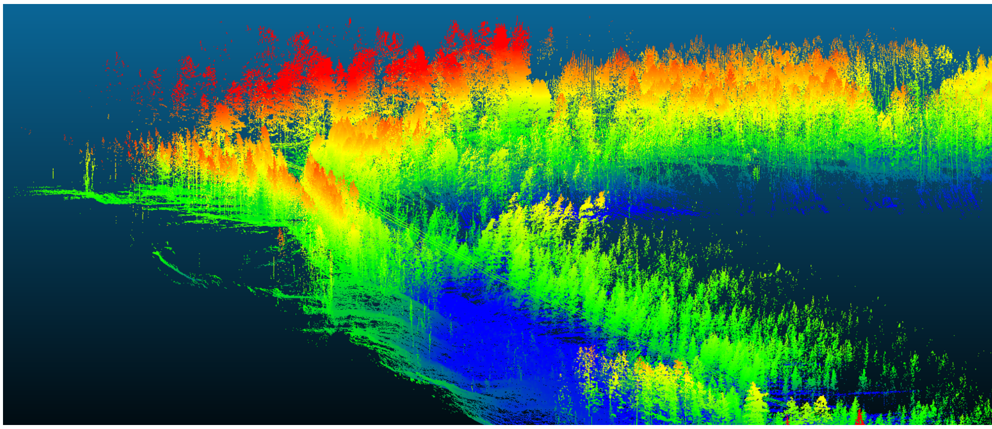
Flight regulations and legal permissions

Flight regulations in Finland do not allow unmanned flights in the non-segregated aerospace. It is possible, however, to reserve airspace under 150 meter from the ground to segregate the unmanned flights from other traffic. In addition, a separate permission is required for B-VLOS flights.

The existing regulatory processes support these needs already.

The needs for further regulation and law-making include:

- faster airspace reservation procedure
- in case of inspecting major incidents or emergencies, a very fast process for temporary airspace reservation
- well-established and documented processes between the operators and aviation authority.



Lidar point cloud generated from UAV during the flight.

Flight

The total duration of the public unmanned flight was about 30 minutes and the length of the flight was 8.1 kilometers. Take-off and landing was controlled by manual controller and actual flight was piloted by autopilot using IMU and GPS satellite navigation information. As a conclusion, affordable RPAS/UAVs are already capable to perform long power line inspection flights implemented in B-VLOS conditions.

Camera and LIDAR data collection

Normal standard RGB camera (Sony α7R) was used for visual photography of power lines and power network components such as transformers, insulators and wires. Photo data quality was very high and the resolution of pictures was considered sufficient for power network maintenance inspection purposes. Minor development in flight control algorithms is needed to achieve more accurate heading along power lines and/or use of a stabilizing gimbal is recommended.

LIDAR data was gathered using Hokuyo UXM-30LXH-EWA equipment and analyzed manually. Also automated analyzing software was tested. Laser data included some minor inaccuracies caused by resonance in the equipment platform. Collected LIDAR data resolution was of sufficiently high quality for vegetation and clearance analysis for overhead line corridors.

Conclusions

RPAS/UAV systems are very efficient and economical for making surveillance flights for collecting aerial data for power network maintenance purposes. The test team has estimated that 50% reductions in aerial inspection costs can be achieved by using RPAS/UAV systems. Some further technical and regulatory development is still needed to enable fast and easy regular operations.

Ville Koivuranta has worked several years with Fortum, the largest northern Europe power company, in a wide selection of tasks including asset data quality management and LIDAR based vegetation clearance planning. Now he works in Sharper Shape as a senior technical specialist and consultant for leading northern European power companies.