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Introduction

Australia and New Zealand utilities have additional approaches to performing substation inspections and equipment condition checks using drones, OpsWAN cameras and more recently robots. The use of drones and OpsWAN cameras are an excellent air inspection solution, visibly viewing the condition of equipment and structures which cannot usually be performed on ground-level without outage and several items involved. Robots can be used for multi purposes such as for SF6 gas monitoring, oil level monitoring, thermal imaging and PD measurement.

Aside from reducing inspection time and labour cost, these methods of substation inspection from the air eliminates safety risk for workers.

Use of Drones

In Australia and New Zealand, utilities often opt for using drone pilots in substations for ad-hoc inspections of plants which would otherwise be unsafe or impractical to inspect via a traditional method. These drones can identify oil leaks on the top of transformers, identify corrosion on earth wire peaks, inspect insulator strings, take thermal image of equipment or conductors and more.

Using a drone however is not a simple task, it requires the development of a procedure, guidelines and instructions covering how drone operations are planned and performed in substations, as well as a standard for determining if a drone can be flown in a particular phase-phase or phase-earth air gap. For operations in substations, only a licenced drone pilots is allowed to perform drone work – it's a requirement of the licence that pilots demonstrate capability to control the drone in manual mode without the assistance of GPS positioning which may be lost due to electrical interference.

When preparing to fly a drone within a substation or transmission line easement, a flight plan detailing the intended path of the drone during the inspection must be prepared. This may be sketched onto a General Arrangement or Electrical Plant Plan drawing and needs to identify the path and direction of the drone flight, 'no-go zones' where the drone should not be flown, 'base' locations for starting and ending the flight, etc. Typical 'no-go zones' include transformers with a risk that failure of the drone may result in breaching clearances between phases and/or between HV and LV terminals. Transformer tops are also fitted with monitoring equipment which may be sensitive to physical damage. This does not apply to the radiator bank and main conservator.

Similar reactive plants (e.g. capacitor banks, SVC infrastructure, etc.) often contains lower voltage elements with smaller clearances (e.g. between levels of a capacitor bank). A failed RPA coming into contact with such plant is likely to result in the complete short circuit of such an element. Oil filled reactors should be considered with the same restrictions as transformers. Open disconnectors represent isolation points and should be avoided at all times

Generally, any traversal of the yard would be done at least 6m above the highest obstacle and then once in position, the drone is brought down to get closer pictures. However, modern drones have very capable zoom cameras and it's often not necessary to zoom in closer – good photos of small details can be achieved from 20m away or more.

Use of OpsWAN Cameras

Some utilities in Australia use permanently installed cameras at High Voltage Substation sites to enable visual monitoring of substation assets in real time. They have the ability to view and inspect hardware within the substation yard (e.g. inspection for damage after a fault or as a result of a weather event). Each substation is required to have at least one camera installed, with some sites requiring multiple cameras to guarantee full visual coverage of the substation yard.

The number of cameras and their location is decided considering the following:

- Good visibility to up to 100m
- Good cover of primary plant
- Direct view of the point of entry building
- View of the main site entry (fence line)
- A complete view of the site
- Accessibility: access to the camera for maintenance – sufficient HV clearance

The OpsWAN cameras and associated equipment is installed on individual poles or earth wire poles as a first choice, however telecoms towers are also acceptable where no suitable earth wire poles are available. The camera is mounted approximately 1m from the top of the pole i.e. approximately 12m to 15m in height. Engineers, technicians, and others can access OpsWAN cameras from their desktop computer once granted approval.

The use of OpsWAN cameras is highly reliable as it provides 24 hours monitoring of substation equipment and hardware. New cameras have very high resolution, providing extremely clear images, showing small details such as corrosion of bolts and nuts. It is cost effective, saves time and could be used for different purposes, eliminating any safety risks associated with equipment being present on site.

Use of Robots

The use of robots is a developing area, as utilities internationally are finding ways to use them for managing assets and improving safety. Transpower is part of the CIGRE international working group, contributing research and experience to the worldwide knowledge in this space (refer to Cigre technical brochure TB807 WG B3.47 application of robotics in substations)

Transpower NZ was the first deployed robot at their remote Tuai's Substation, enabling bi-weekly checks of the leaking breaker density gauge, providing critical assurance while planned complex bus changes to enable repairs. The SF6 gas leakage monitoring allowed early intervention in the form of top-ups, preventing low alarms and the potential lockout of the breaker, giving assurance to the business and our customer. Previously, the permanent presence of a maintenance operator was required to perform this task.

Robot deployment saves travelling time, reduces costs and minimises personal safety risks. Through a Microsoft Teams feed, engineers and experts can view and direct the robot and operator as required, therefore, removing the need to travel to a remote site. Based on the performance to date, robots can provide a robust visual confirmation of equipment statuses to support this opportunity.

Usually, engineers can remotely interrogate site relays following fault events. Combined with the high-definition visual information provided by the robot, we can better inform our maintenance response with the provided intelligence.

The platform has significant scope to support a greater range of packages. This could be in the form of acoustic/thermovision cameras or GPS 'missions' (asset locations identified and preconfigured viewing positions supported by auto navigation including auto parking and charging capabilities).

Missions can include:

- Regular station inspections and pre/post maintenance checks
- Implementation of machine learning, feeding data into our Asset Works Plan and better informing our investment decisions
- Planned outage risk management, through the identification of defects or conditions that might affect security
- Quality assurance, proving an interface into our engineering groups when carrying out repair activities on the grid

Conclusion

The additional use of drones, OpsWAN cameras and robots for substation equipment and hardware condition monitoring has been proven to be safe, efficient, and cost effective in Australia and New Zealand. These methods are highly useful to inspect equipment and hardware from above as there is difficulty to view their details from ground level, unless it is taken out of service. Drones, OpsWAN cameras and robots aid with equipment replacement scooping, project planning, design and post failure analysis. The use of robots is highly convenient, especially at remote locations, as there is no need to send a person to the immediate site and be exposed to potential safety risks.