Study Committee A3

Transmission & Distribution Equipment

Paper 11133_2022

Unmanned Aerial Vehicles usage for Asset Condition Assessment

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Motivation

- Asset Condition Assessment of Switchgear and Substation's exposed equipment without interrupting the facilities' operation (LIVE inspection). Previously executed using “looking-up” method (binoculars) or “ground-up” manual photography in extremely high Electromagnetic (EM) fields (up to 400 kV)
- AIM: intelligently prioritize the replacement of external diameter's / busbar's equipment, without compromising the reliability of the National Grid

Method/Approach

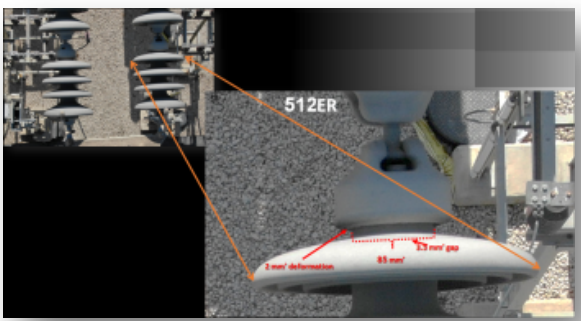
- Operations sequences follows strict safety rules.
- Cyber restrictions, data processed in safe environment.
- Each matrix element corresponds to several pictures.
- Criticality is assessed by identifying individual failed insulator positioned in the string in a manner that can lead to an imminent failure.

Objects of investigation

- “Weak" tension dead-end chains (single and double strings, 4 - 5 insulator each)
- Main objective: Mapping for “visual” Risk assessment.
- Objective 2: Reliable Prioritization of replacements - to minimize the National System risk and Bus Bar’s “near to failure” insulators strings replacement sequence.
- Objective 3: Extrapolating the method for all exposed elements in the Switchyards / Substation and adjacent portals and EHV / HV towers.
- Objective 4: Correct Specifications for UAV missions inside or adjacent energized Substations / Switchyards

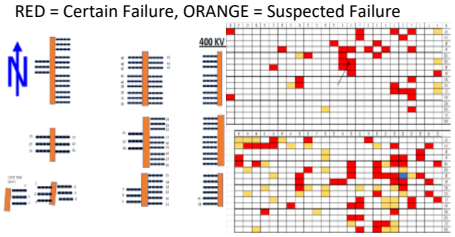
Measuring Method

- Post – image enhancement assessment
- Good light, good focus, precise angle, Ultra-Resolution achievement



Experimental setup & test results

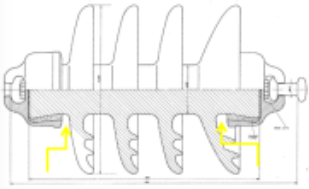
- Visual identification of every "cap-pin" type insulator deterioration: perceive and document a minimum 1 mm displacement at all insulators in all strings. **MAIN STEPS**:
  1. Airborne System Calibration: focus on keeping and control specified safety distances.
  2. In-situ Command &Control deployment, proof of UAV's maneuvering close to Electro Magnetic field with similar intensity as the target zone.
  3. Mission performing, active monitoring, security supervision according to specs.
  4. Initial report : risk matrix, samples of failure deciphering and conclusions
  5. IEC experts' analysis in dedicated workshop: the resulting risk matrix is base for Bus Bar string replacement schedule.
- From Switchgear’s schematic layout profile (left) to "risk matrix" provided by service provider (right). RED = Certain Failure, ORANGE = Suspected Failure



- Insulator (strings) classification / replacement prioritization due to proven criticality (example).

"*" [“Advanced degradation” (orange)] is the level of imminent failure risk

Criticality (Certain failure assessment)	No. of occurrences	String	Classification
	9	A	12
*	2	1	8
*	1	3	10
	1	7	16
(**) ***	3	8	2
	2	9	15
	1	22	16
(****) ****	0	25	1



Profile and sizes of Dead-End Antifog - type Insulator: Emphasis on possible unsheathing areas.

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Discussion

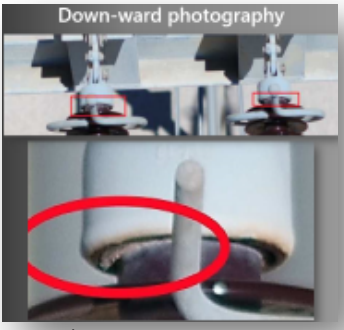
- It is very difficult and inefficient to identify network objects and establish a comprehensive understanding of equipment's' technical condition (at less than 1 mm displacements as inside insulators) using binoculars or photo camera by simply looking up: additional tests (method) must be employed.
- All findings based on ground methodology are in fact "assumption" of a failure, needing subsequent confirmation, usually during an (un) planned outage.
- A more efficient and economical approach: downward photography using steady UAV, making possible an objective ranking process (based on evidence), with minimal involvement of Utility's specialists.
- Service provider "learning curve rate" after 2 "rounds" is ~85-93%.
- After ranking, a portfolio of scheduled works can be prepared without any ado, with sufficient guarantee that the established priorities and the correct replacement sequence are optimal and safe for the Grid.

Outsourced E2E assessment

- Fully Regulated process
- Usually strict schedule (for Grid stability/safety reasons)
- Safety operation (each step must be approved)
- Mission plan and mapping (security issues)
- Actual Arial photo execution (in the approved "window")
- Post processing, analysis & report (~2-3 weeks Time 2 Market)

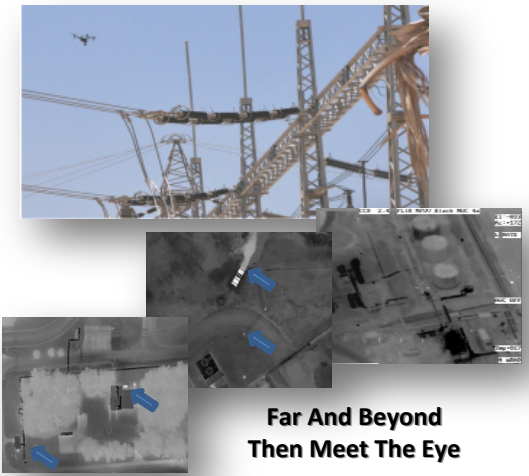
Evidence

- Establishing Failure Mode or Factory improper QA



Conclusion

- Regarding the **use and operation of UAV in an energized environment**:
  1. currently, no substitute for an external service provider, in all issues.
  2. It is possible to discover external failures in (extra) high voltage network equipment in general, and in insulators in particular, by implementation of advanced image collection and processing.
  3. Key-condition for success: a clear technical specification in which the conditions are accurately described.
- **Final deciphering, subsequent failure ranking, work prioritization**: Utility internal service-"in house" know-how.
- **Substantial reduction of O&M without jeopardizing system stability** / safety or interfere with PM works.



Far And Beyond Then Meet The Eye

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