Application of autonomous platforms/robots in power cable operation and maintenance

Introduction:

Advancements in socio-economic development and technology are driving urban power grids to transition from overhead lines to underground cable systems, establishing a new standard for modern city power infrastructure. With this in mind, Task Force B1.93 was established to review how robotic technologies are being used to improve safety and reliability of power cable systems. The Australian member of this Task Force was Samir MD Aris.

Currently, most inspection tasks for underground cables are conducted manually, but this approach has notable limitations such as safety risks caused by confined spaces and inspection inefficiencies.

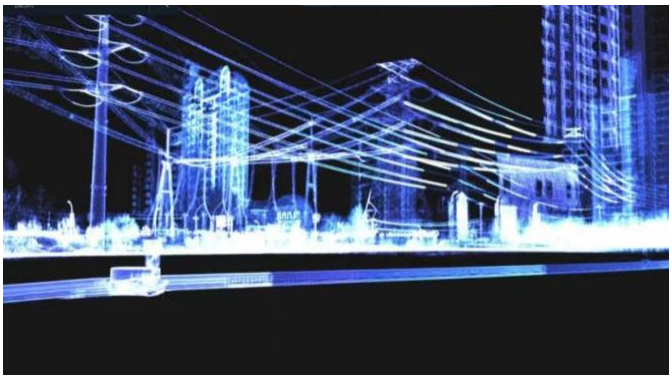

Figure 1: Transitioning of power cables from overhead lines to underground tunnels

Robotic inspection technologies are becoming essential tools for maintaining the safety and reliability of modern power cable systems, particularly in challenging environments such as tunnels, underwater locations, and joint bays. These robots utilize a range of sensors and detection methods including visual, acoustic, thermal, magnetic, and sound-based technologies to overcome the limitations of traditional manual inspections. Use of robotic technologies minimizes human exposure to hazardous environments such as toxic gases, extreme temperatures, under water and confined space. This will reduce work health and safety risks and injuries to employees. In addition, advanced sensors with modern Artificial Intelligence driven analysis will enhance inspection precision, reduce

false alarms and support predictive maintenance strategies. This enables more frequent data-informed inspections, early fault detection, and greater operational reliability across the network.

（a）rail-based robot (Source: courtesy of State Grid Corporation of China)

(b) wheeled robot (Source: courtesy of State Grid Intelligent Technology Co., Ltd)

(c) aerial robot （Source: courtesy of Da-Jiang Innovations）

(d) legged robot （Source: courtesy of Boston Dynamics, Inc. and Unitree Robotics Co., Ltd.）

(e) diving robot （Source: courtesy of Sublue Technology Co., Ltd.）

Figure 2 Types of robotics

Aim and Scope:

CIGRE Task Force B1.93 focuses on advancing robotic applications in power cable inspection and maintenance to enhance system reliability, safety, and cost efficiency.

- The report conducts a systematic examination of diverse robotic platforms, assessing their specific strengths, limitations, and suitability across various cable environments.
- It further explores the expanding role of robots in inspection and maintenance activities, placing particular emphasis on the integration of Artificial Intelligence (AI) and Machine Learning (ML), which enables functionalities such as real-time anomaly detection, predictive analytics, autonomous navigation in complex tunnels, and automated reporting.
- The report also outlines the complete technological framework required for successful deployment, covering mobility systems, navigation technologies, communication protocols for shielded environments, power supply and autonomous charging, and electromagnetic compatibility.
- Additionally, a thorough techno-economic analysis highlights that while initial investments in robotics can be substantial, lifecycle cost models demonstrate compelling returns, further justifying their adoption in the power sector.

Recommendation for Future development

The report of CIGRE B1.93 demonstrates how autonomous systems/robots improve safety, inspection efficiency, and operational reliability in power cable operation and maintenance. Looking ahead, advancements in AI, communication, and mechanical design will further boost robot performance and adaptability. To support global deployment and ensure consistent quality, the development of international standards (e.g., IEC, ISO) is strongly recommended, focusing on performance, interoperability, and system reliability.

The report is free for members and €30 for non-members.