# Paradigm Shift in Operational Philosophy of POWERGRID

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## SUMMARY

POWERGRID (A Central Transmission Utility) has played a role of key catalyst in rapid growth of Indian Power Sector over last decade. POWERGRID wheels around 50% of total power generated in India on its EHV transmission network. As on March 2019, POWERGRID owns 242 EHV class substations having 153128 ckm of transmission line and 365467 MVA transformation capacity.

With the rapid expansion of transmission assets at an annual growth of ~15% in 2010, POWERGRID assessed the situation of enhanced requirement of expertise at every substation. Expert manpower availability seems to be further accentuated with impending retirement of individuals in coming years. To obviate such problem, POWERGRID envisaged paradigm shift in operational philosophy with the conceptualization of National Transmission Asset Management Centre (NTAMC) project.

POWERGRID's flagship project (NTAMC) is equipped with multiple intelligent systems for centralized control and monitoring of remote substations. Prior to NTAMC, round the clock control and monitoring activity used to be carried out at individual substation.

NTAMC consists of 11 control centres located at 9 locations, comprising of 2 National level control centres (main and backup) and 9 Regional level control centres, being manned round the clock. Control centre infrastructure consists of various intelligent subsystems like SCADA/Data Historian, Remote Accessibility System, Automatic Fault Analysis System, Visual Monitoring System and VOIP Subsystem. As on date, project has been implemented and 210 substations are under remote operation through real time reporting of more than 5.5 lakhs signals from different substations. These substations have been upgraded with required adaptation and automation including all conventional type and SAS based substations, located over pan India. The adaptation requirement for remote operation of substations was complex on account of asset's varied age and technology. Automation & interlocking logics have been built up at station level with required IEDs, sensors and transducers etc. The communication system for entire network is implemented over MPLS cloud. The communication architecture has been designed ensuring adequate bandwidth and redundant path.

This paper will cover the implementation details and challenges of the NTAMC Project which has brought a paradigm shift in asset management and operational philosophy of POWERGRID.

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## KEYWORDS

National Transmission Asset Management Centre-NTAMC, Supervisory Control and Data Acquisition System- SCADA, Remote Accessibility System-RAS, Automated Fault Analysis System-AFAS, Data Historian, System Operation from remote Control Centre, Visualization of Incident, Quick Decision, Reduced Outage Time

### 1. BACKGROUND AND MOTIVATION FOR NTAMC

Indian Power system is one of the largest Power system Networks in the world. It has the installed capacity of about 356.1 GW as on March 2019. Power System development in recent years has earned great importance in the rapid development of the country.

Transmission, an important element in the power delivery value chain, facilitates evacuation of power from generating stations and its delivery to the load centres. POWERGRID, the Central Transmission Utility (CTU) of the country and one of the largest transmission utilities in the world, is playing a strategic role in the Indian Power Sector and is responsible for coordination and supervision for development of Inter-state transmission system (ISTS) in the central sector matching with generation capacity addition to facilitate inter-state/inter-regional exchange of Power.

The availability of quality human resources especially in the field of O&M of transmission systems is a key challenge. The centralized remote operation of transmission asset i.e National Transmission Asset Management Centre (NTAMC) was proposed to bring about a paradigm shift in the way transmission systems are managed in India and presently 210 no. of substations are being remotely operated. In 2010, POWERGRID took initiative to create a National Transmission asset management centre (NTAMC) 2 no. - Main & Back-up control centres along with 7 no. regional transmission asset management centres (RTAMCs – SR, WR, NR & ER regions) infrastructure in India under a single project.

The Primary objective of the project is to operate and manage substations from remote control centres by achieving remote operation of the substation. The establishment of NTAMC project has optimised utilization of manpower in O&M and thereby resulting in to reduction in overall O&M cost. Better situational awareness and visibility of the system and round the clock deployment of experts are also helping in reducing the downtime of the network, thereby improving the reliability of the system.

### 2. SUBSYSTEMS OF NTAMC

a. SCADA/ Data Historian /RTU/BCU/Substation Adaptation:

The technological advancement progressively adopted over the tenure of last few decades lead to the designing and operation of substations in different manners. This has added the complexities and challenges to translate the uniformity for applications of NTAMC over the spread of 242 no. substations which have been commissioned over the period of time. Thus, substations have been demarcated in following sub categories to facilitate effective, efficient and trouble free engineering, implementation, execution of adaptation and configuration works at substations for NTAMC requirement:

a. Category- I: Conventional substations
b. Category- II: Existing Remote Operated Substations
c. Category- III: SAS Based Substations
d. Category- IV: HVDC substations

Category-I Substation:
Conventional control and relay panels have been installed in these substations. All the monitoring and control is done locally through the control panels. The main protection relays are of either static type or numerical type. All the relays are gradually being replaced with numerical relays. These numerical relays are connected to their respective PC based configuration and DR evaluation systems. However, these are not connected on a common communication network. Also, all the parameters of auxiliary systems (DG set, LT supply, Air conditioning equipment, Fire fighting system, Lighting system, DC power supply system etc) are not available through telemetry.

Category-II Substation:
These substations are also of conventional type but have RTU (Remote terminal Units) installed for operation from a remote location. The RTUs are monitoring most of the points required for remote operation which includes the various analog parameters (MW, MVAR, Voltage, Current, Freq, tap position), Status of switchgear (Circuit breakers, Isolators, Earth switches), Status of Protection relays etc. However, the auxiliary system is not being completely monitored. The main protection relays are of either static type or numerical type. Also, similar to Category-I substation, these are not connected on a common communication network and all the parameters of auxiliary systems ( DG set, LT supply, Air conditioning equipment, Fire fighting system, Lighting system, DCDB system etc) are not available through telemetry.

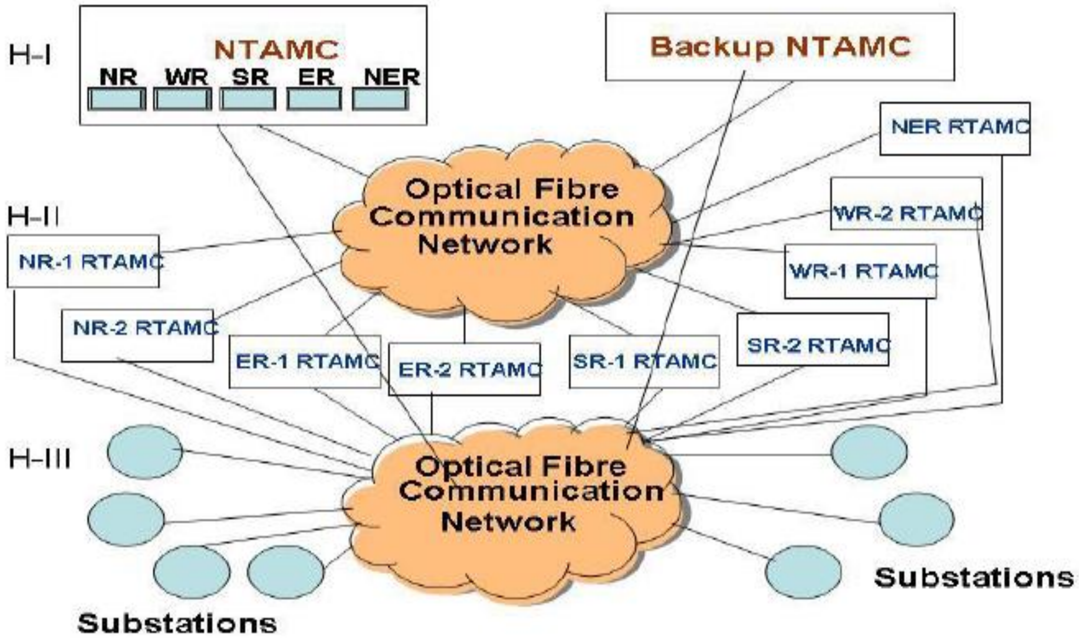
Category- III Substation:
These substations are having substation automation system (SAS) based on IEC 61850 and have all the parameters, device states, status of protection equipment monitored and available on a local SCADA system. These substations are operated from HMI (Human Machine Interface). However, some signals (of auxiliary system) may not be available for complete monitoring. All the signals are available through substation gateways on IEC 60870-5-101 protocol. All the main protection relays are connected on a common LAN.

Category –IV Substation:
These substations include the HVDC substation which includes both Back-to-Back and Bipole type of HVDC substations. There are a total of 10 substations of HVDC type. These stations have automated systems for plant control and monitoring and the operations are carried out using computer based HMI. There is also a provision of RCI (Remote communication interface) provided for communication to remote control centers like Regional Load Despatch centers (RLDC). A protocol converter is being used for making suitable RCI to communicate to the both NTAMC control centers as well as to the existing RLDCs.

Depending upon the type of category, different methodologies were adopted for integrating the above types of substations with control centres. For Conventional substations, BCU based architecture was implemented (One no. of BCU was installed per diameter) for bay level control and automation. For balance categories, RTU was supplied for protocol conversion & transmitting the data to all the control centres.

SCADA application acquires real time data from remote substation covering complete information of Power System flows, switchgear status, alarms and events from substation equipment including substation auxiliary devices. The monitoring signals are analysed using intelligent alarm processing and abnormal signals are identified for necessary action. Further, Data Historian archive all the signal information and provide data to in-house developed web based application for further analysis and generation of reports on schedule as well as on demand basis to identify incipient fault for condition based maintenance.

The hierarchical control authority levels with clear priorities have been defined to prevent simultaneous control of device from various control levels. The lower hierarchy is given the higher control priority.



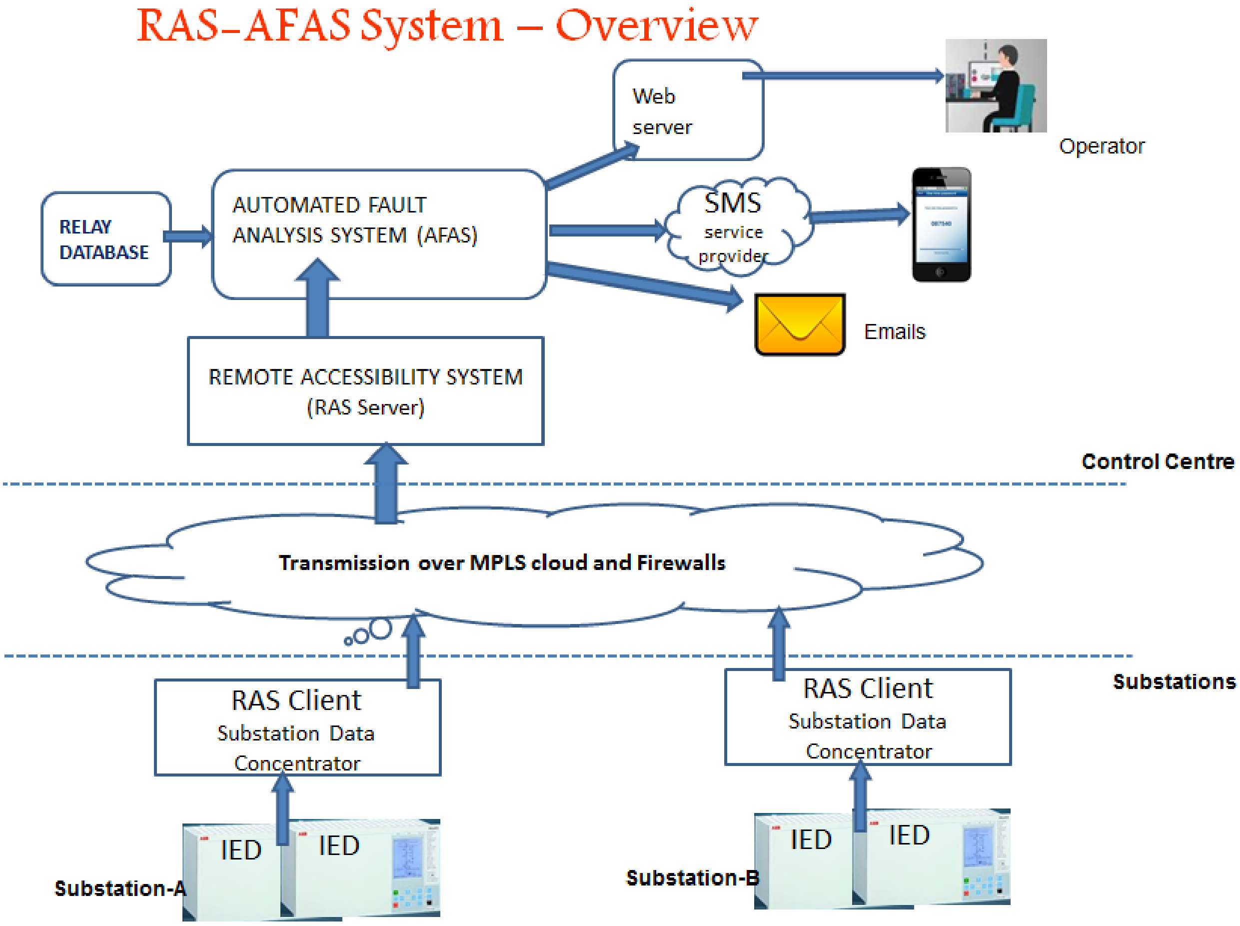

b. RAS-AFAS (Remote accessibility system and automated fault analysis system):

Faults in power systems are inevitable and interrupt the power flow leading to economic loss and may also cause physical damage to the power system equipment. Numerical protection relays are installed with each power system element which continuously monitor the system parameters and ensure the fast & precise isolation of the faulted element from the grid to ensure operational reliability and safety of the equipment. During the fault, the numerical relays also generate the disturbance record with pre fault & post fault system parameters for the analysis of the incident. Conventionally, protection engineers in a substation download the disturbance records (DR) & events from relays for manual analysis of the fault. The acquisition of disturbance records and its analysis for restoration of power system elements requires certain exposure as well as it is a time consuming process.

Along with centralised SCADA system, the need for development of a system was envisaged for remote access of protection IED and automatic analysis of power system faults to support fast decision making by operators at remote control centre.

Remote Accessibility system (RAS) and Automated Fault analysis System (AFAS) are the tools to analyse system conditions during fault and immediate transfer of DR files & events from various make & model of relays. RAS-AFAS uses the communication capabilities of relays to share the DR files with identified devices over certain protocol (IEC61850, IEC103, Courier, SPA & SEL). It provides the fault details to operators at remote control centres to take quick decision. Thus, RAS-AFAS reduces the no. of experts placed at every station for local analysis, as expertise can be polled at centralised control centre only. The DR files of relays at substations is transmitted to the RAS server at remote control centre and the AFAS server analyses the incident based on the DR file shared by RAS server. In order to expedite the spread of information regarding the tripping of the power system element, the RAS-AFAS has been configured with the capability to send the email & SMS alerts to the concerned. Also, the appreciable features of remote access of relays from control centre and more precise fault location based on cumulative DR files from both ends of transmission line are available with RAS-AFAS system. Also, the comprehensive analysis and historical information helps in better asset management of the transmission system.

The project is executed with the integration of approx. 7200 no. of IED installed at remote substations, geographically spread all over the India. It includes various make and model of relays- supporting RS232, RS485 & Ethernet communication over Copper wire, RJ45 & fibre optic connection over different protocols. Also, Redundancy of hardware & ports has been ensured at substation as well as control centre level.




Implementation challenges:

i. Unique & customised design of software & hardware
ii. First time implementation on large scale (relays of various make & model and protocol support) which results in multiple patches & fine tuning
iii. Non-uniformity in signal names and type of Disturbance recorders
iv. Choosing the right Algorithm depending upon the fault detected
v. Management of multiple versions of relay specific configuration tool and restriction of multiple access of a particular relay
vi. Partial configuration of relay communication port for data exchange on supported protocol

RAS-AFAS seems the main technological change to fulfil the requirement of remote operation of substations.

c. VMS (Video Monitoring System) and VOIP:

Real time video recording system is installed at each substation which is helpful during planned maintenance and shutdowns to closely monitor activities at remote substations. Traffic segregation and traffic prioritization has been done to avoid bandwidth issue due to video data. The Visual Monitoring System comprises of IP cameras, Network Video Recorders and local clients at substation. The number of cameras and their placement have been decided in such a way that any location in the switchyard area could be monitored. Also, it is possible to configure video devices for zooming, type of image and also other additional video functions like snapshot etc. Here, integration of Existing IP based cameras compatible with VMS application software at NTAMC has also been ensured.

Further, each site is equipped with VOIP Infrastructure enabling dedicated voice communication between control centres and substations.

## 3. CHALLENGES FACED AND SCOPE FOR FUTURE ENHANCEMENT:

The major challenges faced during integration of different type of substations which were commissioned over the last decades are as follows:

1) Adaptation work to make it suitable for remote operation from NTAMC.
2) Implementation of VT selection logic
3) Adaptation of different types of relays for remote resetting.
4) Integration of different type of SAS systems (GE, ALSTOM. SIEMENS, ABB etc) with SCADA/EMS system.
5) Adaptation of signals on Live system for the voltage levels 400kV, 220kV etc to maintain the availability of system.
6) Space Constraints for cabling and adaptation of signals in existing panels.
7) Integration of OTI/WTI/DGA of transformer and reactors
8) Adaptation of auxiliary system for
    1. LT system Automation
    2. Integration of DG set signals
    3. Integration of Fire fighting system
    4. Integration of Air conditioning system alarms
    5. Integration of Switchyard Lighting
9) Ensuring the safety and element availability aspects during execution of works for operational substations.

System operators have had the first-hand experience of the benefits of NTAMC subsystems, with deployment done at POWERGRID substations. The following enhancement may be considered as scope for future:

1) Fault signature analysis to identify the cause of faults in transmission lines like lightning, tree encroachment, insulator flashing, earth wire & conductor snapping etc., using Artificial Intelligence.
2) Automatic reading of relay event logs & transfer to server at control centre.
3) Up gradation of existing gateway at substation to IEC104.

## 4. CONCLUSION

The paper has shared the POWERGRID experience of application of SCADA, Remote Accessibility System & Automated Fault Analysis System, Video Monitoring system & VOIP system for remote operation of various types of substations, located over pan India. NTAMC subsystems expedites the decision making to reduce the outage time of power system equipment and thus, the implementation cost seems to be recovered within one year with full utilization of the system.

NTAMC Project has brought a paradigm shift in asset management and operational philosophy of POWERGRID which has enabled company to make data driven resilient decisions. Increased efficiency in asset maintenance, reduction in operational cost and formation of a centralized knowledge base for all assets are some noticeable benefits of NTAMC project.

## BIBLIOGRAPHY

Working experience during the development, deployment & operation of NTAMC subsystems from remote control centre under NTAMC project