

***CHAPTER 05 - Smart Water Management with “scada” System***



**5.1 Introduction:**

Dhaka Water Supply and Sewerage Authority (DWASA) is the Government authority for water supply and sewage disposal of the city Dhaka, DWASA operates a big water production and distribution network. The pumping stations equipped with deep tube wells, are the main network nodes of the system. DWASA management wants to implement a SCADA (Supervisory Control and Acquisition) system in the network, complete with remote monitoring and control. For that reason, DWASA management had formed a committee to produce a conceptual overview to WASA for a unified, fully integrated Central SCADA Platform with Interactive loT and HMI Dashboard. The report meant to provide a brief overview of the architecture and framework that has been envisioned by the SCADA Committee for deploying the ideal solution at Dhaka WASA. This automation guideline was meant to guide water production and distribution monitoring and control processes mainly.

The following were the scope of work for that committee:

1. SCADA Software Specification Preparation
2. Detail specification preparation of required field devices
3. Specified of Standard Communication Protocol
4. Proposed common platform to integrate DTW, Meter, Valve and Treatment Plant's SCADA or non-SCADA data.
5. Compatibility assessment of existing piloting SCADA.

Although I was not a formal member of the committee, as divisional head of Planning and Design (Electrical & Mechanical) division I worked with the team, joined their meetings and gave inputs into the planning.

**5.2 What is SCADA:**

**SCADA stands for: Supervisory Control & Data Acquisition**

* It is a technology to collect data and monitor the performance of production and distribution processes.
* It is an application that can help to increase efficiency, lower costs and increase the profitability of operations by turning data into information.
* Reduce manpower needed for operation and monitoring activities thus reducing costs.

**Components of SCADA:**

SCADA encompasses two components:

Component 1: The first component is the equipment that is installed in water distribution network we want to monitor and control.

Component 2: The second component is the network of intelligent devices called Remote Terminal Units (RTU) and/or Programmable logical controller (PLC). RTU’s and PLCs are able to send and receive information for monitoring and operation.

**Activities of a SCADA System:**

1. Data acquisition through sensors from various field devices.
2. Data transfer using communication network to various RTU, Local SCADA or Central SCADA.
3. Data processing and data or information presentation
4. User authentication and user access control into the SCADA monitoring and control system based upon various levels of user roles.
5. Instruments Control – Control various pumps motors, valves and chlorination systems remotely.

**SCADA system monitoring parameters for measurement and control:**

1. Pump on/off & pump running time
2. Power consumption for safety, billing and efficiency
3. Chlorine cylinder full or empty.
4. Pressure & flow measurement.
5. Failures & malfunctioning of electrical or mechanical devices.
6. Water level in well/ Dry-running protection system
7. Water sensor in DMA chamber etc.

**SCADA system outputs:**

1. Alarm analysis – Causes of alarm and response to alarm from DWASA.
2. Trend analysis – Analyze various patterns of device performance, operator behaviour & mistakes, system or failures, maintenance work, impacts etc.
3. Periodic reports – Hourly, daily, weekly, monthly & yearly etc.

**5.3 Existing Status of SCADA:**

Present and future use of SCADA:

At present DWASA uses SCADA primarily & mainly for:

* “Visualization” = see what is happening, monitoring.

In future DWASA can use SCADA for

* “Automation” = work with data in a more comprehensive way and monitor situation, gather data, process data, operate remotely, example – Automated or semi-automated control of a pressurized water network.

In 2017, Dhaka WASA started the piloting project work for DTW (Deep Tube Well) SCADA, and has covered 163 out of 913 DTW under SCADA systems. Around 8 (eight) company was done this work. Above them 77 DTW has done by one vendor and he had sold the License software to Dhaka WASA and also found that the software is not perfect to fulfil WASA requirements. All SCADA are running under the vendor-controlled demo software. Vendors used several different field devices as well as different demo software which is running at vendor end. On the other hand, total 23 used such communication device which are infeasible to integrate into central SCADA.

Two type of standardized Demo software was used named Rockwell Talk View and SIEMENS WINCC software. On the other hand, one company had used own developed customized software which is cloud based hosting.

Water Treatment Plant SCADA: In Dhaka WASA, Three WTP has used SCADA for Plant. All SCADA brand are Schneider.

**5.4 Dividing the Requirements:**

The Committee divided WASA's requirements for SCADA automation for smart water management into 4 parts

Its compatibility from Deep Tube Well, District Metered Area and Water Treatment Plant - all the way to Central SCADA will be possible as long as standardized along international best practices. The four requirements are described with their functionality as below.

1. Field Devices
   1. Collect data from Field
   2. Monitoring Status of Equipment
   3. Control Equipment
   4. Communicating with remote station
2. Communication Network
   1. Use safe & standard protocol to communicate or send/receive data
   2. Between field devices and Central SCADA at least two types of connection.
3. SCADA Software Platform
   1. Application Data Acquisition & Supervisory control by Zonal Personnel
   2. Device Configuration
   3. Central data preservation and distribution
   4. Template creation for operation and management
4. Common Infrastructure and Computer-network & hardware
   1. Establish Data center or operation room
   2. Establish communication tool
   3. Install software
   4. Establish video wall

**5.5 Compatibility assessment**

DWASA aims to integrate of the existing SCADA with Central SCADA. Future expansion and up-gradating will be made under proposed system.

Following challenges were determined-

1. Current SCADA servers are located remotely on vendor’s servers or on cloud servers, not in Dhaka WASA office.
2. Each contractor implemented its own device and software.
3. No compatibility in Field Remote Terminal Units, Communication & Network.
4. Current SCADA software makes the integration into Central SCADA infeasible.
5. Dhaka WASA local office does not possess the ownership of the data and server control.

**5.6 Major Integration steps:-**

1. Micro-controller based system shall be replaced with PLC (programmable logic controller)-based system which have compatible communication system for hardware compatibility.
2. Electric meter, Water Flow meter shall be connected to PLC in order to maintain records of power consumption and water supplied.
3. Old software cannot be integrated into new central SCADA. Only hardware can be saved through required modification to certain degree.
4. Those are general requirement. Individual system in each DTW shall be closely examined to determine required modification and/or replacement in order to integrate to zonal or central SCADA.

The SCADA system (Supervisory Control and Data Acquisition) is a complete system consisting of hardware and software, whereby information regarding the status of pumps and regulation valves, flow rates from pumps and distribution pipes, pressures in the network, water's level of PTWs, water consumers consumption in Dhaka is sent to a central server (computer) in the desired local and central offices of DWASA.

With this information, DWASA has insight into the water balance within the distribution network, and it should be able to take necessary corrective measures to control the flow and pressure through the DMAs of Dhaka city.

**5.7 Design Considerations for SCADA Systems:**

a) Electronic instruments shall utilize solid state electronic components, integrated circuits, microprocessors, etc. and shall be of proven design.

b) All instruments shall be suitable for continuous operation;

c) All digital outputs shall be volt free; transmitting a sensor’s output as a voltage over long distances has several drawbacks,

d) All instrumentation systems for use out of doors shall be protected to IP 65 for sensors and transmitters, while enclosures under submersible conditions shall be protected to IP 68;

e) All analogue displays shall be of the digital type with no moving parts utilizing back lit liquid crystal diode technology;

f) For transmitting instruments, output signal shall be 4-20 mA DC linear having two wire system.

g) Unless otherwise stated, overall accuracy of all measurement systems shall be .5% of measured value.

h) After a power failure, when power supply resumes, the instruments and associated equipment shall start working automatically.

i) The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.

j) The instruments shall be designed to work at extremes of the ambient conditions of temperature, humidity, and chlorine contamination that may prevail. The instruments shall be given enough protection against corrosion.

k) Lockable enclosure shall be provided for the field instruments wherever required

l) All field instruments, and cabinets / panel-mounted instruments shall have tag plates / name plates permanently attached to them.

m) The performance of all instruments shall be unaffected for the $10% variation in power supply voltage and 15% variation in frequency simultaneously.

n) All wet parts of sensors shall be made out of non-corrosive material capable of working with chlorine content of 5 ppm

o) For all instruments (transmitting analogue signals) installed in the field, surge protection devices (SPDs) shall be provided at both ends of the connecting cable for the protection against static discharges / lightning and electromagnetic interference.

p) Pressure transmitters shall be provided with two valve manifold and a test port, so that in situ calibration can be carried out.

q) Two wire transmitters shall be provided with on-line test terminals.

r) The ranges of all instruments shall be suitable for the application in the process.

s) Instruments of similar type shall be of same type of specification for appropriate inventory of spares, ease of maintenance and training.

t) The Bangladesh agents of imported equipment should have establishment to provide after sales maintenance facilities.

**5.8 Equipment needed in a SCADA system:**

**Various equipment and tasks of SCADA system:**

* Bulk water flow meter - A water flow meter is needed for measuring the amount of water passing through a pipe. The meter creates a pulse signal and transmits them to SCADA system or data loggers.
* Pressure Sensor - Pressure sensor is capable to detect the system pressure and convert it in an electrical signal. This allows the pressure to be monitored by SCADA or other relevant systems.
* Water Level Sensor - A water level sensor is a device that relays information back to a control panel to indicate whether the aquifer has a high or low water level.
* Chlorination Sensor and Monitoring - Chlorination Sensor used in DWASA SCADA System shows if the chlorination unit is active or inactive. The Chlorination chamber has separate monitoring of the chlorine system.
* Electric Meter - Electric Meter is sued to measure the amount of electricity use. This meter is also connected with SCADA system so that the energy consumption can be monitored.
* RTU (Remote Terminal Unit) - Sensors and process controller devices are attached to remote terminal units (RTU). Multiple remote terminal units at different sites transmit the data collected to a single master station which displays the information in a browser.
* PLC (Programmable Logic Controller) - Data from sensors on individual assets is transmitted to the PLC. The PLC translates that data into a format that can be used by the software. Users access the data through the HMI on the software. If the data crosses certain thresholds, a maintenance work order is created.
* HMI (Human-Machine Interface) - An HMI SCADA system, or SCADA Master, can provide several helpful extensions for network alarm management of monitoring equipment. If connected to an RTU, the gathered data can be filtered, analyzed, and monitored against functional standards. Out-of-range data can generate alerts to operators or maintenance personnel as required.
* Internet/radio frequency/GPRS - Wireless SCADA systems are the ones in which the communication between the Remote Terminal Unit (RTUs) and Human Machine Interface (HMI) is wireless in nature. General Packet Radio Service (GPRS) is the commonly used wireless technique used in wireless SCADA systems.
* Data base, cloud, server, SD card - To store the data and operated the equipment.
* Physical monitoring facility - Reading and analyzing on Desktop Computer, Laptop Computer, mobile, tablet, staff, and panel - To see the data and use it accordingly.

**System Monitoring and Controlling Console:**

Control room equipment and furniture (system console) including but not limited to control console for dual redundant workstations, desk for engineering workstations. Servers, manager workstations and printer compartment along with chairs. The system console design shall be submitted to the Employer for prior approval, before starting any work.

**5.9 Standard Communication Network and Protocol:**

**Protocol for SCADA:**

1. It shall support all telemetry protocols such as Modbus, DNP 3.0, IEC 104, MQTT etc.

2. Users should be able to retrieve data from RTU data log in case of communication failure using DNP3.0 communication.

3. It shall support (Open Platform Communications) OPC DA (Data Access) and OPC UA (Unified Architecture) communication protocol/server systems.

OPC stands for Open Platform Communications or some say OLE (Object Linking and Embedding) for Process Control. It is a type of protocol used in Industrial Automation. The OPC is always used in the Client/Server pair. The OPC server converts the hardware communicated data from PLC into OPC protocol. OPC is the interoperability standard for the secure and reliable exchange of data in the industrial automation space and in other industries. It is platform independent and ensures the seamless flow of information among devices from multiple vendors. The OPC Foundation is responsible for the development and maintenance of this standard. The OPC standard is a series of specifications developed by industry vendors, end-users and software developers. These specifications define the interface between Clients and Servers, as well as Servers and Servers, including access to real-time data, monitoring of alarms and events, access to historical data and other applications. When the standard was first released in 1996, its purpose was to abstract PLC specific protocols (such as Modbus, Profibus, etc.) into a standardized interface allowing HMI/SCADA systems to interface with a “middle-man” who would convert generic-OPC read/write requests into device-specific requests and vice-versa. As a result, an entire cottage industry of products emerged allowing end-users to implement systems using best-of-breed products all seamlessly interacting via OPC.

**Data acquisition and processing:**

* Since Central SCADA is to be used at Water treatment Plants and a large number of Deep tube wells including DMA, standardization of key components is crucial to integration of all facilities into Central SCADA.
* Interface equipment to enable communication between water supply system field instruments, PLC's, RTU's, Local SCADA at WTP's, RTU's at Zonal DMA's and Local & Centralized Monitoring Control Center at DWASA.
* Supply, installation, testing commissioning of RTU's along with GPRS modem at DMAs to transmit flow, pressure and actuated pumps data to Locals and Central Monitoring and Control Centers (L&CMCC) for monitoring and control.
* The monitoring and control of all the DMAs in the Water Supply system shall be at Locals and Central Monitoring and Control Centers, for this purpose Bulk flow meters and pressure transmitters at strategic locations in the DMAs shall be provided along with RTU's, GPRS modem and shall be interfaced with the Local Monitoring and Control Center.
* The instrumentation provided at the DMAs shall be capable to measure and record reverse flow and uncommon flow shall be alarmed at the Locals and Centralized Monitoring and Control Centers.
* The communication equipment required to achieve this interfacing complete with all required accessories shall be supplied, installed, tested and commissioned under this contracts with vendors with performance guarantee.

**Data Processing:**

The data acquisition, processing and interfacing with the Locals and Centralized Monitoring and Control Centers of entire water supply scheme of Dhaka city is covered under Monitoring, Processing Software package. The future plan is that, domestic water meters data shall be collected and this data shall be fed into the Centralized Monitoring and Control Centre SCADA system for records and further analytical purposes.

**5.10 The minimum requirements of the SCADA Software:**

* Support situational awareness graphic development.
* Adherence to ISA 101 standards and guidelines.
* Support business system integration using industry accepted protocols (SNMP, OPC, etc).
* Support 3rd party systems and control vendors (SNMP, etc.). Simple Network Management Protocol (SNMP) is an Internet Standard protocol for collecting and organizing information about managed devices on IP networks and for modifying that information to change device behaviour. Devices that typically support SNMP include cable modems, routers, switches, servers, workstations, printers, and more. SNMP is widely used in network management for network monitoring. SNMP exposes management data in the form of variables on the managed systems organized in a management information base (MIB) which describe the system status and configuration. These variables can then be remotely queried (and, in some circumstances, manipulated) by managing applications.
* Provide a seamless and simple transfer of programming and configuration from a Development environment to the Production Environment.
* Support a modular object-based development environment with direct links between graphic elements and control elements as in the latest Industrial robust PLC systems
* Built in full featured Trending package. Built in Reporting capability. Built in Alarm / Event Analysis and Alarm Management tools.
* Support key performance indicators, dashboards and overview displays.
* As DWASA is integrating a very large water distribution network, it is not always possible to keep an eye on every condition on field so to provide decision support to DWASA Management and stakeholders regarding abnormal conditions or deviations smartly, package is offered with capabilities of alarms/incident/calibration/maintenance and asset management, so DWASA will not only able to monitor but also will be able to handle situations in more better way. Also DWASA will be able to justify return on investment with managing maintenance/calibration activities on time, managing complete life cycle of their asset, optimizing energy efficiency and water quality
* Now a days that trend is adopted in most of central command control platforms for water, smart cities and smart infrastructures globally to empower decision making for optimizing sources and justify ROI. So DWASA will be also able to set global benchmark.
* DWASA management have decided to go with the idea that - all monitoring and control will happen from Zonal SCADA and central platform will capture data from zonal SCADA, it must have redundancy and web clients for local monitoring and control operations. Also addition to that, historian storage up to 1 year is recommended, but it DWASA need it for 3 year, there will not be any license cost implication
* Central SCADA will not directly fetch data from PLC/RTU, but it will fetch data from Zonal SCADA, it should be like that only. But as zonal SCADA is responsible for monitoring and controlling. It should have remote access clients (Mobile/Web) for secured monitoring and control from field area and it must have redundancy. So continuous operations can be ensured at zonal offices also and there will not be any loss of data on central SCADA.
* Zonal SCADA must have web/mobile clients available for their local teams (field, maintenance, operations) to have easy remote operation, specific to their area, and advantage of it is also that local management of change and assignment from its respective authorities of Zonal SCADA office. Also it can have secured and limited access across respective zonal SCADA teams. However offered Central SCADA should have web clients/mobile clients for DWASA stakeholder in order to have situational awareness from complete water distribution network with required, analysis, reporting, monitoring and decision support.

**5.11 SCADA Historian:**

**Operations Data Management System (ODMS):**

* The historian will be a key source of data for the DWASA Integrated Intelligent Water Operations Center (IIWOC) to find data trends through analytics. The minimum requirements of the SCADA Historian include:
* A minimum of five years of real-time data must be actively available to be retrieved and displayed both on the SCADA Operator Workstations and on systems in the local offices.
* Archive data will be available for comparative historical trend analysis on the SCADA Operator Workstations and on systems in the local offices.
* SCADA systems reports will be capable of being generated on demand from SCADA Operator Workstations and on systems in the local offices. Does not need to be embedded in HMI Screens support data exchange with external SQL Databases.
* Capability to create dashboard without the need for third party software packages.

**SCADA Application Change Management:**

The SCADA System shall maintain a record of changes made to the software applications. The minimum requirements of the SCADA Software Systems include:

* Provide centralized software application configuration version control.
* Provide centralized patch management and platform version control.
* Provide a Disaster Recovery point for the HMI Applications.

**Remote and Mobile Access:**

IT support, Operators and Maintenance staff members may require remote access to SCADA System components, such as the SCADA Network equipment, HMI workstations, PLCs, Vendor Package Systems, and the Historian. The minimum requirements for SCADA Remote and Mobile Access include:

* On-call SCADA and Maintenance staff may require remote access to the SCADA systems from anywhere in the DWASA service area, both inside the SCADA network and outside of the SCADA network during normal business hours Operations and Support staff may require access to SCADA from remote water facilities.
* Secure remote access could be provided for access to the corporate network via Email authentication to network maintenance.
* IT staff will require remote access to networking equipment from a central location / IIWOC (Intelligent Integrated Water Operations Center) & IISOC (Intelligent Integrated Security Operations Center).

**5.12 Training and Support services:**

* Maintenance and Support with the Design Building Operation.
* The Contractor shall include maintenance support for all software components of the HMI and system software.
* The Contractor shall include maintenance support for all hardware.
* Training should include configuration interface, troubleshooting the SCADA system, display building, security and ongoing operation of provided hardware & computer software components.
* The Contractor will provide SCADA software service support, updates, and upgrades for a period of at least 5 years following completion of the Design and Build Phases of the DBO (Design, Build and Operation) Contract.

**5.13 Importance of proper installation and maintenance:**

* Increase Life expectancy of equipment
* Maintenance Cost reduction
* Safety of manpower and materials during operation.
* Safety Feature - Over Current, Under Current, Unbalanced. Current, Over Voltage, Under Voltage, Unbalanced Voltage. Over voltage in any phase Pumping low water level, Excess delivery pressure, Inverter Faults and Trips. Maintaining preset delivery pressure. Pump operation time scheduling for unmanned operation.
* Alarm Feature - Pump production efficiency Alarms, Low Flowrate Alarm, Over-current alarm, Phase-loss/unbalanced alarm, High water pressure alarm, Network fail alarm etc.
* SCADA and Maintenance - SCADA is a useful tool for monitoring and operation of the equipment. SCADA is providing detailed information about the running machine. This can be used to customize a maintenance plan.

**Importance of the site survey and pay attention to the detail:**

After equipment has been installed, a site survey visit needs to be conducted by DWASA specialist or external supervisors, to check if the equipment is installed properly. We have to check, is everything installed properly according to the contract by the vendor. The site acceptance test is of great importance. Wires and cables should be lined up, coated and tagged. Connections should be watertight. Inspection team should make sure that, the chamber is covered, proper channels are there, and tag numbers are there. Software tests can also be carried out by IT staff and supervised by senior staff members.

**The possible solution for simple computer problem can be:**

* Update Computer Operating system – Windows/Linux regularly.
* Using firewall using the antivirus system and update them regularly.