SECTION -2 , CHAPTER 2

DMS FUNCTIONS & Supporting functions

2.1 General Requirements

This Section describes the Distribution Management System (DMS) applications & Other supporting applications that are required for SCADA/DMS System . The DMS applications shall utilise the data acquired by the SCADA application. Distribution management System Software shall include the following applications. Utilities shall select /all or certain applications according to the need & characteristic / profile of the electrical network & future part of SMART GRID in the project area,

2.1.1 DMS functions

- Network Connectivity Analysis (NCA)
- State Estimation (SE)
- Load Flow Application (LFA)
- Voltage VAR control (VVC)
- Load Shed Application (LSA)
- Fault Management and System Restoration (FMSR)
- Loss Minimization via Feeder Reconfiguration (LMFR)
- Load Balancing via Feeder Reconfiguration (LBFR)
- Operation Monitor (OM)
- Distribution Load forecasting (DLF)

2.1.2 Other Supporting functions

- Dispatcher training Simulator (DTS)

2.1.3 Contractor's Standard product

The bidders are encouraged to supply standard, unmodified products that meet or exceed the Specification requirements. These products may be provided from the bidder's in-house baseline offerings as standard products from other established suppliers. Bidders shall describe all standard, unmodified products proposed and shall highlight those features that exceed the Specification requirements. Although the bidder is encouraged to use as much standard hardware and software as possible, the proposal will be judged by its conformance to the Specification. Hence, a minimum level of customisation in order functional requirement is permitted. The product CIM based interfaces to other enterprise applications shall be available & compliant of SMART GRID as specified in chapter 1.

2.1.4 Graphical & Tabular display requirements for DMS functions

A network overview display of the distribution system with substations, feeders colour coded by voltage shall be provided. This display shall present the distribution system in a graphic format. Telemetered and calculated values like active and reactive power flows etc shall be displayed with direction arrow. Lines, Loads, transformers etc that have exceeded their loading limits shall be highlighted. Stations shall be depicted by suitable symbols which reflect the presence of alarms. Cursor selection of a station symbol shall result in display of the associated Single line diagram for that station. " What if "analysis shall be included to visualise network & verify the impact before an action is taken by dispatcher. For all switching actions which dispatcher have to execute manually/step by step shall have the option to simulate switching operations in order to visualise the effect on the distribution network using what if analysis

All DMS result tabular displays shall have capability for sorting by name and calculated parameters.

The solution prescribed by DMS application shall consider & identify & sort the following as minimum

1: Remote controllable circuit breaker with capability to interrupt fault currents
2: Non-remote controllable circuit breaker with capability to interrupt fault currents
3: Remote controllable circuit breaker with no capability to interrupt fault currents
4: Non-remote controllable circuit breaker with no capability to interrupt fault currents .
5: Remote controllable disconnector
6: Non remote controllable disconnector .
7: Fuse
8: Ground/ Earth switch etc
9.Sectionizer

2.2 Network Model

The DMS applications shall have a common model for the project area comprising of primary substation feeders, distribution network and devices with minimum 10 possible islands, which may be formed dynamically. All DMS applications shall be able to run successfully for the total distribution system with future expandability as envisaged under the specification. The following devices shall be represented in the model as a minimum:

a) Power Injection points
b) Transformers
c) Feeders
d) Load (balanced as well as unbalanced)
e) Circuit Breakers
f) Sect ionizers
g) Isolators
h) Fuses
i) Capacitor banks
j) Reactors
k) Generators
l) Bus bars
m) Temporary Jumper, Cut and Ground
n) Meshed & radial network configuration
o) Line segments, which can be single-phase, two-phase or three-phase and make up a distribution circuit.
p) Conductors
q) Grounding devices
r) Fault detectors
s) IEDs
t) Operational limits for components such as lines, transformers, and switching devices

All DMS applications shall be accessed from graphic user interface through Operator consoles as defined in this specification. Reports, results and displays of all DMS application shall be available for printing at user request.

Population and maintenance of the distribution network model should be possible by using the database maintenance tools to build the database from scratch. In case the required data already exists within the Employer's corporate Geographic Information System (GIS) as a part of R-APDRP scheme or otherwise, the DMS database functions should leverage this effort by providing an interface/adaptor to extract GIS data using the CIM international standard IEC 61970/61968 and automatically generate the complete Network Operations Model. The data extracted should include network device information, connectivity, topology, nominal status and non-electrical data such as cable , landbase data etc . Further Land base data can be sourced from GIS in Shape files or DXF.

The extraction process should comply with the international standard CIM data descriptions. The CIM standard is maintained by the IEC (Technical Committee 57, Working Group 14) and is used for a wide range of purposes. The extraction process should be independent of the real-time network management system. Any GIS model should be extractable to build the network model regardless of the supplier or internal schema.

The extraction should also allow incremental updates & global transfer with no need to bring the system down or even fail over. The model should support extraction on a per-station basis and must be fully scalable from a single zone substation to the largest distribution networks. SCADA/ DMS should be able to present geospatial data even when the link to the source GIS at the data center/DR is not available
The user interface supporting the database will provide updated data directly to display geographic and/or schematic views of the network.

The model should support multiple geographic coordinate sets for each device so that, if available, the network can be displayed in custom geo-schematic formats. The network views may also include various levels of detail depending on the zoom level. Information such as land-base data (provided as a dxf file, shape file etc) may also be displayed as required.

An interface with the already existing Geographical Information Systems shall be developed using interoperability features between the DMS and the installed GIS.

Each of the two systems shall keep its own specificity, and shall be used for what it has been designed: the SCADA for the real-time data acquisition ,control and processing, the GIS for the maintenance of the network construction and geographic data.

The interface shall be developed in order to obtain a maximum benefit of the two systems use. It shall be implemented while maintaining the SCADA/DMS and GIS integrity as individual systems. It is of the utmost importance that the two systems remain able to operate separately.

The required functionalities for this interface shall cover the two following aspects:

The transfer of specific real-time data from the DMS into the GIS data-base
The possibility to navigate easily from one system to the other through the user's interface

Data exchanges shall be made through the Control Center LAN/WAN.. Bidder shall demonstrate its incorporation capability to the main GIS Vendors through a dedicated reference list or provide and support standard interfaces to GIS.

2.3 Network Connectivity Analysis (NCA)

The network connectivity analysis function shall provide the connectivity between various network elements. The prevailing network topology shall be determined from the status of all the switching devices such as circuit breaker, isolators etc that affect the topology of the network modelled.

NCA shall run in real time as well as in study mode. Real-time mode of operation shall use data acquired by SCADA. Study mode of operation will use either a snapshot of the real-time data or save cases.

NCA shall run in real time on event-driven basis. In study mode the NCA shall run on operator demand.

The topology shall be based on
(a) Tele-metered switching device statuses
(b) Manually entered switching device statuses.
(c) Modelled element statuses from DMS applications.

It shall determine the network topology for the following as minimum.
(a) Bus connectivity (Live/ dead status)
(b) Feeder connectivity
(c) Network connectivity representing S/S bus as node
(d) Energized /de-energized state of network equipments
(e) Representation of Loops (Possible alternate routes)
(f) Representation of parallels
(g) Abnormal/off-normal state of CB/Isolators

The NCA shall assist operator to know operating state of the distribution network indicating radial mode, loops and parallels in the network. Distribution networks are normally operated in radial mode; loops and/or parallel may be intentionally or inadvertently formed.

A loop refers to a network connectivity situation in which there exist alternative power flow paths to a load from a single power source. A parallel refers to a topological structure in which a load is fed from more than one power source. Parallel paths often result in circulating currents and such operating conditions need to be avoided. All loops/parallels in an electrical network shall be shown by different colours in such a way that each is easily identifiable.

Abnormal state of CB/Isolators means these devices are not in their Normal OPEN or CLOSED position.

Alarms shall be generated when presence of abnormal switches, De-energized components of network and of Network loops / parallels is detected.

2.3.1 Tracing

NCA function shall also have the capabilities of network tracing when requested by the dispatcher. Dedicated colours shall be used for feeder and circuit tracing and also when information available is not complete or inconsistent.. The trace shall persist through subsequent display call-ups, until the operator explicitly removes it or requests another trace. In addition, at the bottom of the geographic view the number of transformers and customers passed by the trace are shown.

(a) Feeder tracing - This feature shall aid dispatcher to identify the path from a source to all connected components by same colour.

(b) Circuit tracing- This feature shall enable operator to select any device and identify the source and path by which it is connected through the same colour.

(c) Between Tracing : This feature shall enable the operator to select any two components of the network and shall able to trace all components connected in between them.

(d) Downstream Trace – from a selected circuit element the trace identifies all devices that are downstream of the selected element. In the case where a downstream trace is performed on a de-energized section of the network, the trace highlights all devices electrically connected to the element.

2.3.2 Temporary Modifications:

The NCA will allow temporary modifications at any point in the distribution network to change the network configuration, to isolate faults, restore services or perform maintenance. A Summary shall list the jumpers, cuts and grounds that are currently applied. The function is performed by the NCA and is implemented locally within the client software and has no effect on the operations model or other clients viewing the network.

2.3.2.1 Cuts:

Cuts facilitated in any line segment in the network. The cut may be applied to one or more available phases of the conductor. The cut could also be applied as a temporary switch inserted in the line.

- The cut must be given a name or id number for identification, which is displayed as a label on the geographic network view.
- It should be possible to select the position of the label relative to the cut symbol.
- The position can be altered after the cut has been placed.

Once placed the cut symbol can be selected and switched on and off by the operator in the same way as a standard disconnect switch. Cuts can also be tagged.

2.3.2.2 Jumpers

Jumpers are a means of providing a temporary, switchable connection between two points on the network. The operator should be able to select two points and place the jumper with relevant details. The initial state of the jumper may be set to open or closed. The jumper popup automatically defaults to show the phases available for connection between the two points but other partial or cross-phase connections may be made if required. The popup shall warn the operator about abnormal connections such as not all phases being connected or the nominal voltage being different at the two connection points. Once the jumper has been placed the switch symbol in the center can be selected and switched open or closed. The topology of the network model is updated accordingly. There is no restriction on the placement of jumpers between lines connected to different feeders or different substations.

Temporary connections between phases on the same line segment, known as a phase jumper shall be supported. This can be used in conditions where one phase is deenergized and it is desired to restore customers by energizing the dead conductor from one of the live phases.

2.3.2.3 Temporary Grounds

Temporary grounds should only be placed, for obvious reasons, on de-energized sections of a line. These grounds represent the mechanical grounding of lines for safety purposes during maintenance or construction.

A temporary ground may be placed on one or more of the available phases. It must be given a name and addition information can be included in the description field.. If a line segment is re-energized while a temporary ground is still applied, the ground will be automatically removed.

2.3.3 Reports and Displays

The reports and displays shall be generated indicating the followings as a minimum:

(a) Abnormal switches in tabular display
(b) De-energized components of network in tabular display
(c) Presence of loops & parallels on network displays
(d) Un-served/ disconnected loads (loads affected due to tripping of CBs) in tabular displays
(e) List of temporary jumpers/cuts /grounds

2.4 State Estimation

The primary function is to determine network state where SCADA system monitoring is directly envisaged. The State Estimation (SE) shall be used for assessing (estimating) the distribution network state. It shall assess loads of all network nodes, and, consequently, assessment of all other state variables (voltage and current phasors of all buses, sections and transformers, active and reactive power losses in all sections and transformers, etc.).

Firstly, the symmetrical (per phase) and asymmetrical (three-phase) load of all nodes in the radial or weakly meshed MV network, which are not remotely monitored, that is not directly covered by the SCADA System shall be using evaluated Load Calibration . **SE** represents the basic DMS function, because practically all other DMS Analytical Functions are based on its results.

This is the unique function dealing with the unobservable load of the actual network, which is not directly covered by the SCADA System. Function is used for balanced and unbalanced networks.

The function is based on an algorithm specially oriented towards distribution networks, with low redundancy of real time, remotely monitored data, The deficiency of real time data has to be compensated with historical data.

Beside the parameters of network elements, the real time data consists of:

- Actual topology, transformers tap changer position, etc.
- Voltage magnitudes of supply point and other nodes in the network.
- Current magnitudes (active and reactive power) at feeder heads.
- Current magnitudes (active and reactive power) from the depth of the network.

The historical data of the network consists of:

- Daily load profiles – current magnitudes and power factors, or active and reactive powers for all load classes (types, for example: industrial, commercial, residential), for all seasons (for example: winter, spring, summer, autumn), for e.g. four types of days (for example: weekday, Saturday, Sunday and holiday).
- Peak-loads for all distribution transformers and/or consumers (peak-currents and/or peak powers) and/or monthly electric energy transfers across all distribution transformers (consumers).

SE function shall run in all cases from the range of networks where all historical data are known, but also in networks with no historical data available (based on parameters of the network elements).

Also according to users setting, the **SE** function shall be able to run:

- With or without verification of telemetered measurements.
- With manual or automatically processing unobservable parts of network.
- With or without fixed measurements.

This shall have real time & Simulation mode both . In the first one, the function shall be used for estimation of the current state. In the Simulation mode, the function is used for estimation of the desired state (e.g. any state selected from the saved cases).

The **SE** algorithm shall consider into account the non availability of real time data and compensates them with historical data, pseudo and virtual measurements, to achieve the minimal set of input data necessary for running a consistent Load Flow.

The **SE** algorithm shall consist of the next important steps:

- Pre-estimation – It shall be based on the historical data of the network: daily load profiles, peak-loads for all distribution transformers and/or consumers, etc. This step shall give pre-estimated states of considered MV networks.
- Verification of measurements– It shall be obtained from artificially redundancy of measurements (too small number of measurements and notable main number of pseudo measurements obtained from first approximation). This step shall consider two sub-steps: (a) in sighting evidence bad measurements, (b) verification and/or correction all permanent measurements. In this step, incorrect measurements shall be corrected or discarded.
- Load calibration – The function shall distribute the load to the busbars of the MV network on the basis of the set of verified measurements and historical data. Also, Load calibration shall deal with consumers specified directly through their current/time diagrams i.e. load curves as well as with consumers with constant consumption. The function shall run even any of these data are not available. It shall be designed in such a way that the quality of results of the function running increases directly with the amount of given data.
- Load Flow calculation – This shall be the next function in the specification based on the loads assigned in the previous step.

2.4.1 Input/Output

Beside the network element parameters, main inputs for the functions consist of above noted real time and historical data. In the case of the function running in the Simulation mode, the real time data must be replaced with the corresponding data from the saved cases or forecasted ones.

Main outputs of the function are estimation of:

- Voltage magnitudes in the entire network.
- Current magnitudes and power factors for all network elements.

- Loads of all MV and LV consumption buses.
- Losses of active and reactive powers in the entire network, by each supply transformer or feeder.

Beside those results, output of **SE** function is tabular report, also. In this report measurement verification results are presented those results are:

- Pre-estimated and estimated values of measurements.
- Minimal and maximal expected values of measurement.
- Quality of each measurement.
- Deviation measured values from estimated and pre-estimated values.

2.5 Load Flow Application (LFA)

The LFA shall utilize information including real-time measurements, manually entered data , estimated data together with the network model supplied by the topology function, in order to determine the best estimate of the current network state.

The Load Flow Application (LFA) shall determine the operating status of the distribution system including buses and nodes

The LFA shall take the following into consideration:

a. Real time data
b. Manual entered data
c. Estimated data
d. Power source injections
e. Loops and parallels
f. Unbalanced & balanced loads
g. Manually replaced values
h. Temporary jumpers/ cut/ grounds
i. Electrical connectivity information from the real-time distribution network model
j. Transformer tap settings
k. Generator voltages, real and reactive generations
l. Capacitor/reactor bank ON/OFF status value.
m. Save case data

2.5.1 General Characteristics of LF application:

The following general characteristics/ capabilities shall be provided as minimum:

- The LF model shall support the different kind of lines such as cable feeders, overhead lines and different kind of transformers having various vector groups & winding configurations.
- Unbalanced & balanced three phase loads connected in radial and non-radial modes.
- Compute voltages and currents and power factor for each phase for every node, feeder and network devices.
- Compute each phase active and reactive loads and technical losses for the distribution system as a whole, for individual substations and feeder wise with in telemetered zone.
- Use previous save-case to make new save case or use new snapshots to set the base case for LF.
- The results of the LF application shall reasonably match with the operating condition in which the distribution system is stable.
- The LFA function shall be executed in real time & study mode.
- It shall be possible to model load either as a percentage of system load or profile base load modelling
- It shall be possible to model individual component of load i.e. Active and Reactive parts

2.5.2 Real Time Load Flow Execution:

The Real-Time LF function shall be executed:

- on event trigger
- on periodic basis
- on demand basis
- on initiation by other DMS Applications functions
- On placement of Temporary Jumper, Cuts and Ground

The Event Triggered LF execution shall always have the highest priority. The study mode LF function shall be executed on a snapshot or save case with user defined changes made to these cases. The study mode execution of LF Function shall not affect the Real-time mode execution of LF function.

<u>(a) Event Triggered Real Time LF Execution:</u>

The LF function shall be executed by pre-defined events that affect the distribution system. Some of the events the dispatcher may choose for triggers shall include:

- Power system Topology Change i.e. Alteration in distribution system configuration.

- Transformer Tap Position Change / Capacitive/reactor MVAR Change
- Feeder Over loadings
- Sudden change in feeder load beyond a set deadband

(b) Periodic Real Time LF Execution:

The real-time distribution system load flow application shall be executed periodically as configured by the dispatcher. The function shall be executed periodically even if there are no significant changes in the operating conditions, as some of the power flow outputs shall be required to provide aggregate summaries (losses, etc.)

(c) On Demand Real Time LF Execution:

Dispatchers may initiate the real-time LF function at any time through dispatcher command.

(d) Real Time LF Execution initiated by other DMS Applications:

Other DMS functions may initiate the real-time LF function at any time as desired for the execution of the respective functions.

2.5.3 Study Mode Load Flow Execution:

It shall provide despatchers with estimates of kW, kVar, kV, Amps, power losses and the other information on the distribution system, but not necessarily reflecting its real-time state. In study mode the application should use the same data model and have direct access of the real time data as necessary. Study mode load flow shall be used to study contingency cases.

It shall be possible to prepare and store at least fifty cases along with the input parameters, network configuration and output results.

The dispatcher shall be able to select the saved Case to be used as a Base case for LF execution and modify the base case . Possible changes, which the dispatcher shall be permitted to make, shall include:

(a) States of individual power system elements
(b) Values of specific parameters including nodal loads, bus voltages, connected kVA, power factor etc.

The Study Mode shall calculate various values for each feeder and prepare summaries as LF output.

The Load Flow function shall provide real/active and reactive losses on:

- Station power transformers
- Feeders

- sections
- Distribution circuits including feeder regulators and distribution transformers, as well as the total circuit loss

2.5.4 Load Flow Output:

The following output capability shall be provided:

(a) Phase voltage magnitudes and angles at each node.
(b) Phase and neutral currents for each feeder , transformers, section
(c) Total three phases and per phase KW and KVAR losses in each feeder, section , transformer ,DT substation & for project area
(d) Active & reactive power flows in all sections, transformers List of overloaded feeder, lines, busbars, transformers loads etc including the actual current magnitudes, the overload limits and the feeder name, substation name
(e) List of limit violations of voltage magnitudes, overloading.
(f) Voltage drops
(g) Losses as specified above

2.5.5 Display and Reports

All input and output data shall be viewed through tabular displays and overlay on the one line network diagram. Tabular displays shall consist of voltages, currents (including phase angles), real and reactive powers, real and reactive losses as well as accumulated total and per phase losses for each substation, feeder and project area . All the overloaded lines ,busbars, transformers, loads and line shall start flashing or highlighted

The LF outputs shall be available in the form of reports. The report formats along with its contents shall be decided during detailed engineering.

2.5.6 Alarms

The LFA shall warn the Despatcher when the current operating limits are exceeded for any element or when lines are de-energized. It shall also warn the Despatcher when any abnormal operating condition exists.

Alarms generated during Study Mode shall not be treated as real-time alarms but shall be displayed only at Workstation at which the LF application is running in study mode.

2.6 Volt –VAR control (VVC)

The high-quality coordination of voltages and reactive power flows control requires coordination of VOLT and the VAR function. This function shall provide high-quality voltage profiles, minimal losses, controlling reactive power flows, minimal reactive power demands from the supply network.

The following resources will be taken into account for voltage and reactive power flow control:

- TAP Changer for voltage control
- VAR control devices: switchable and fixed type capacitor banks.

The function shall propose the operator solution up on change in the topology of the network switching. The function shall consider the planned & unplanned outages, equipment operating limits, tags placed in the SCADA system while recommending the switching operations. The functions shall be based on user configurable objectives i.e. minimal loss , optimal reactive flow , voltage limits, load balancing . These objectives shall be selectable on the basis of feeder , substation & group of substations or entire network. The despatcher shall have the option to simulate switching operations and visualise the effect on the distribution network by comparisons based on line loadings, voltage profiles, load restored, system losses, number of affected customers. The solution shall identify /sort the different type of switches that are required for operation i.e. remote /manual etc.

2.6.1 Modes of operation

The VVC function shall have following modes of reconfiguration process:

(a) Auto mode
(b) Manual mode

The despatcher shall be able to select one of the above modes. These modes are described below:

2.6.1.1 Auto mode

In auto mode, the function shall determine switching plans automatically and perform switching operations upon despatcher validation automatically.

2.6.1.2 Manual mode

In manual mode, the function shall determine switching plans automatically and perform switching operations in step-by-step manner.

A filter for remote operable & manual switches shall be provided with switching plan ,

2.6.2 Reports

Detailed reports of complete switching sequence for VVC operation , including voltage / VAR levels before switching & after switching shall be presented.

2.6.3 Displays

The User interface for VVC function shall have following summary displays as minimum:

(a) Network & tabular display to VVC switching
(b) Tabular display giving chronological sequence for VVC operation

2.7 Load Shed Application (LSA)

The load-shed application shall automate and optimise the process of selecting the best combination of switches to be opened and controlling in order to shed the desired amount of load. Given a total amount of load to be shed, the load shed application shall recommend different possible combinations of switches to be opened, in order to meet the requirement. The despatcher is presented with various combinations of switching operations, which shall result in a total amount of load shed, which closely resembles the specified total. The despatcher can then choose any of the recommended actions and execute them. The recommendation is based on Basic rules for load shedding & restoration

In case of failure of supervisory control for few breakers, the total desired load shed/restore will not be met. Under such conditions, the application shall inform the dispatcher the balance amount of load to be shed /restore. The load-shed application shall run again to complete the desired load shed /restore process. The result of any Load Shed operation shall be archived in Information storage and retrieval (IS&R) system.

2.7.1 Basic rules for load shedding & restoration

The load shall be shed or restored on the basis of following basic rules:

(a) **By load priority**

The LSA shall have a priority mechanism that shall allow the user to assign higher priorities for VIP or any other important load. The load assigned with the higher priorities shall be advised to be shed later and restore earlier than load with relatively lower priorities. Each load priority shall be user definable over the scale of at least 1-10.

(b) **By 24 Hrs load shed /restore history**

The loads of equal priorities shall be advised for restoration in such a way that loads shed first shall be advised to be restored first. The application shall ensure that tripping operations is done in a cyclic manner to avoid the same consumers being affected repeatedly, however, priority loads shall be affected least.

(c) **By number of consumers affected**

The consumer with equal priority and similar past load shed history shall be considered by the application in such a way that minimum number of consumers are affected during the proposed load shed. The data for number of consumers connected to a feeder /device shall be taken from computerised billing system.

2.7.2 Modes of operation

The load-shed application shall operate in the following modes:

(a) Manual load shed
(b) Manual load restoration
(c) Auto load shed
(d) Auto load restoration

Each mode of operation can be enabled or disabled by operator independently. The load can be shed & restore in possible combination i.e. manually shed & auto restore vice versa or both operations in the same modes.

2.7.2.1 Manual Load Shed

In this mode operator specifies a load to be shed in a project area The software shall determine & propose all the possible combinations of switches to be operated for the requested load shed considering the basic rules for load shed & restoration.

In case more than one options are possible, then the application shall identify all such options with the priority of consumers along with the number of consumers are likely to be affected for the particular load shed option. The despatcher shall select & execute one of these options for affecting the load shed.

2.7.2.2 Manual Load Restoration

In this mode operator specifies the desired load to be restored. The software shall determine the switches to be operated for the requested load restore considering the basic rules for load shed & restoration.

In case more than one options are possible, then the application shall identify all such options with the priority of consumers along with the number of consumers are likely to be restored for the particular load restore option if chosen by despatcher. The despatcher shall select & execute one of these options for effecting the load restoration.

The Load shed Application shall maintain a load restore timer, which shall automatically start after tripping of CB due to manual load shedding. An alarm shall be generated to remind the operator to restore the loads when this timer expires. For manual mode of operation the dispatcher shall enter the value of load restore timer.

2.7.2.3 Auto Load Shed

This shall have two modes namely frequency based load shed & time of day based load shed as described below.

(a) Frequency based Load Shed

The function shall execute the tripping of breakers based on the system frequency automatically considering the basic rules for load shed & restoration.

The software shall automatically execute the switching operations as soon as system frequency reaches at load shed start (LSS_str)frequency threshold and it shall continue to do so unless system frequency crosses the load shed stop (LSS-stp) frequency limit. The frequency limits shall be despatcher assignable up to single decimal points. Once frequency crosses below LSS_stp limit , then load shed can only be started again when frequency attains LSS_str. Limit LSS_str shall be lower than LSS_stp & suitable protection to ensure that shall be provided in user interface such as discard ,forbidden etc if user accidently enters LSS _str higher or equal to LSS_stp or LSS are entered higher than LSR .

(b) Time of day based Load Shed

The function shall operate to shed load at the predefined time of the day & load to be shed. The software shall automatically execute the switching operations considering the basic rules for load shed & restoration.

2.7.2.4 Auto Load Restoration

This shall have two modes namely frequency based load restoration & time of day based load restoration as described below:

(a) Frequency based restoration

The function shall execute the closing of breakers based on the system frequency automatically considering the basic rules for load shed &

restoration.

The software shall automatically execute the switching operations as soon as system frequency attains load restore start frequency limit (LSR_ str) and it shall continue to do so as long as system frequency is crosses below the mark load shed restore stop frequency limit (LSR_stp)_. The frequency limits shall be despatcher assignable up to single decimal points. Once frequency crosses below LSR_stp limit , then load shed can only be started again when frequency attains LSR_str. Limit LSR_str shall be higher than LSR_stp & suitable protection to ensure that shall be provided in user interface such as discard ,forbidden etc if user accidently enters LSR _stp higher or equal to LSR_str or LSR limits or LSS _str higher or equal to LSS_stp or LSR limits, lower than LSS . The sequence of frequency limits shall be permitted as LSR str>LSR_stp>LSS _stp >LSS_str . Adequate protection as mentioned above shall be given if user tries to violate the same.

(b) Time of day based restoration

The function shall operate to restore load at the predefined time of the day & load to be restored. The software shall automatically execute the switching operations considering the basic rules for load shed & restoration.

2.7.3 Alarms/Events

All Load shed & restore operations executed shall be logged in the system as events. In case the supervisory control fails during the operation in predefined time, an alarm shall be generated with the possible reason for the failure.

2.7.4 Summary Report

Load shed application shall generate Summary Reports for project area on daily basis. These reports shall be available online for minimum period of two days. The following reports shall be made.

(a) Daily Load shed report indicating, substation name, feeder/device name, date/time, duration of load shed and amount of load shed, Number of consumers affected based on consumer indexing information, mode of load shed including planned outages of feeders/network equipments.
(b) Daily Alarm summary pertaining to LSA, substation wise.
(c) Substation wise daily Served, un-served power & energy for every 5 minute time block
(d) Served & un-served power for last seven days for every 5-minute time block to calculate Load forecast for the next day. The report shall contain a column to define weightage factor (multiplier) by despatcher to calculate Load forecast for the next day. The weightage factor is

required to consider the type of the day such as holiday, festivals, rainy day, etc. Separate report for total load forecast of complete project area shall also be generated from above two reports.

2.8 Fault Management & System Restoration (FMSR) Application

The Fault Management & System Restoration application software shall provide assistance to the despatcher for detection, localisation, isolation and restoration of distribution system after a fault in the system. The FMSR function shall be initiated by any change in the network connectivity due to any fault. It shall generate automatic report on switching sequence depicting analysis of fault, location of fault & recommendations for isolation of faulty sections & restoration of supply.

2.8.1 Functional Requirement

The FMSR function shall include the following characteristics:

1) FMSR shall be capable of handling phase-to-ground and phase-to-phase faults and shall not be restricted by their time of occurrence on one or more feeders. Thus, the ability to handle multiple faults of different types, on multiple feeders, shall be provided. It shall be capable to carry out restoration of large area after a occurrence wide spread faults amounting to substantial outages in the town.

2) FMSR shall be capable of allowing the substitution of an auxiliary circuit breaker or line recloser that may temporarily function in place of a circuit breaker or line recloser that is undergoing maintenance.

3) The Operator shall be able to suspend FMSR restoration capabilities by activating a single control point. Otherwise, FMSR shall continue to operate for fault detection and isolation purposes. The Operator shall be able to resume FMSR's normal operation by deactivating the same point. 4) FMSR shall be capable of isolating faulty sections of network by opening any available line Circuit Breaker that may be necessary, however operating limitations on device such as control inhibit flag shall be respected.

5) FMSR application shall utilize the results of LF for recommendations of switching steps for restoration where in it should guide the operator for amount of overloading in lines ,bus voltage violations and amount of load that can be restored for various options of restorations ,the operator shall have the privilege of selecting the best restoration option suggested by FMSR before it starts restoration .The operator shall also be to simulate the LF for the recommended switching actions ,so that the necessary violations can be displayed on graphical display also.

If an overload condition is expected as a result of the proposed switching, it shall be displayed to the operator on a graphical display and proposed alternative switching sequence to avoid or minimize the overload.

6) FMSR shall be capable of using data derived from substation RTUs/FRTUs /FPIs to recognize faults in substation transformer banks , any fault on the primary side of these banks that cause loss of outgoing feeder voltage and current or any fault occurred on 11KV network.

7) FMSR shall be capable to make Restoration plans with identification name and respective merit orders & its execution of Restoration plan using network Display and single line diagram of substation.

8) FMSR shall be capable to find delay in the restoration of network beyond specified time (Despatcher configurable) and shall be able to report separately in the form of pending restoration actions.

2.8.2 **Detection of fault**

FMSR function shall detect the faulty condition of the network causing CB tripping due to protection operation or FPI indication. The Circuit breakers having auto-reclose feature, the FMSR application shall wait for programmer specified(setteable for individual feeders) duration before declaring the network as faulty. On detection of fault in the network, an alarm shall be generated to draw attention of the dispatcher.

Switching device tripping caused by SCADA/DMS applications shall not be considered as a faulty condition. FMSR application shall also not be initiated if the quality flags such as, manually replaced value, Out of scan are set for a switching device.

To avoid potential difficulties during severe storm conditions, the Operator shall be able to suspend FMSR switching sequence of restoration capabilities by activating a single control point. Otherwise, FMSR shall continue to operate for fault detection and isolation purposes. The Operator shall be able to resume FMSR's normal operation by deactivating the storm-mode control point. When this occurs, FMSR shall be ready to restore power as well as detect and isolate faults following the next outage event. The same shall be recorded as an event.

2.8.3 Localisation of Fault:

Wherever protection signal or FPI indication is not available , FMSR function shall determine the faulty section by logically analysing the telemetered data (status of CBs, , analog values etc) as acquired through SCADA system. Besides this, for such cases an iterative method for determining fault shall be used e.g. In case of fault, upstream breaker is tripped & long stretch of multiple sections are having no intermediate fault indicators & intermediate switches are not capable to trip on fault upto the closest NO(Normal open) point, the dispatcher can open the last switch before NO point & try to close breaker , if trips again fault is on further upstream & the same method is to be repeated else fault is located in the downstream section only. For the sections where protection signal or FPI indication is available , the same shall be derived through these telemeterd signals. Network diagram identifying the faulty sections/components shall be displayed identifying the relevant section. and various configurations of switch type etc) Minimum of following switch types shall be considered by FMSR system:

1: Remote controllable circuit breaker with capability to interrupt fault currents
2: Non-remote controllable circuit breaker with capability to interrupt fault currents
3: Remote controllable circuit breaker with no capability to interrupt fault currents
4: Non-remote controllable circuit breaker with no capability to interrupt fault currents.
5: Remote controllable disconnector
6: Non remote controllable disconnector .
7: Fuse
8: Ground/ Earth switch etc

2.8.4 System isolation & restoration

Once faulty section is identified, the FMSR function shall determine the switching plan to isolate healthy area from unhealthy area . FMSR function shall suggest switching plans for restoration of power to the de-energized healthy sections of the network. It may done be by closing NO switch to allow the power from alternate source. In case more than one feasible switching plans exist, the despatcher shall be guided for most optimum plan based on the merit order ie minimum switching operations, minimum loss path, system operation within the safe limits of various network elements. The despatcher shall have the option to simulate switching operations and visualise the effect on the distribution network by comparisons based on line loadings, voltage profiles, load restored, system losses, number of affected customers. The FMSR function shall have feature to attain the pre-fault configuration on despatcher’s request after repair of faulty sections.

The FMSR function shall have following modes of restoration process:

(a) Auto mode of restoration
(b) Manual mode of restoration

The despatcher shall be able to select one of the above modes. These modes are described below:

(a) Auto mode of restoration

In auto mode, the FMSR shall determine switching plans automatically upon experiencing fault & proper isolation of unhealthy network from healthy part of the network and perform restoration actions upon despatcher validation automatically.

(b) Manual mode of restoration

In manual mode, the FMSR shall determine switching plans upon experiencing faulty state & proper isolation of unhealthy network from healthy part of the network. The switching plans shall be presented to despatcher for step by step restoration. Despatcher shall be allowed to introduce new steps.

A filter for remote operable & manual switches shall be provided with switching plan ,

2.8.5 Reports

Detailed reports of complete switching sequence from outage to restoration, feeder-wise outage duration with Date & Time stamp, quantum of served & un-served load, number of consumers interrupted & restored and network parameters limits violations shall be generated by FMSR application

2.8.6 Displays

The User interface for FMSR function shall have following summary displays as minimum:

(c) Network & tabular display to identify faulty network
(d) Network & tabular display to identify remotely controllable devices
(e) Network Display to show plan for Isolation of faulty sections from the network using single line diagram of substation or network as selected by the despatcher.
(f) Tabular display for Restoration plans with identification name and respective merit orders & execution of Restoration plan using network Display,and single line diagram of substation
(g) Delay in the restoration of network beyond specified time (Despatcher configurable) shall be reported separately in the form of pending restoration actions in Tabular display.
(h) List of sections not restored with the reasons for non-restoration such as overloading and voltage limit violations etc shall be shown in tabular display.
(i)

2.9 Loss Minimization via Feeder Reconfiguration (LMFR)

This function shall identify the opportunities to minimize technical losses in the distribution system by reconfiguration of feeders in the network for a given load scenario. The technical losses are the losses created by characteristic of equipments & cable such as efficiency, impedance etc.

The function shall calculate the current losses based on the loading of all elements of the network. The telemetered values, which are not updated due to telemetry failure, shall be considered by LMFR application based on recommendations of LF Application.

Function shall advise the transfer of load to other elements of the network with an aim to minimize the loss. All such advises shall indicate the amount of loss reduction for present load condition. The LMFR application shall consider the planned & unplanned outages, equipment operating limits, tags placed in the SCADA system while recommending the switching operations. The despatcher shall have the option to simulate switching operations and visualise the effect on the distribution network by comparisons based on line loadings, voltage profiles, load restored, system losses, number of affected customers.

LMFR application shall run periodically at every 15 minutes and on demand. Short duration Power Interruption to the consumers during suggested switching operations may be permitted.

2.9.1 Modes of operation

The LMFR function shall have following modes of reconfiguration process:
(a) Auto mode
(b) Manual mode

The despatcher shall be able to select one of the above modes. These modes are described below:

2.9.1.1 Auto mode

In auto mode, the function shall determine switching plans automatically for minimal loss condition in the network and perform switching operations upon despatcher validation automatically.

2.9.1.2 Manual mode

In manual mode, the function shall determine switching plans automatically for minimal loss condition in the network based on which despatcher can perform switching operations in step-by-step manner.

A filter for remote operable & manual switches shall be provided with switching plan ,

2.9.2 Displays & Reports

At the defined periodicity or on demand, the despatcher shall be presented with the tabular & graphical displays indicating feeder-wise, substation-wise, project area wide technical losses in % before & after the feeder reconfiguration.

The summary report shall also be generated periodically to display technical losses and possible reduction in losses if despatcher follows the LMFR recommended switching operations. The report shall also highlight violations that are occurring in the network with display layers before and after reconfiguration.".

2.10 Load Balancing via Feeder Reconfiguration (LBFR)

The Load Balancing via Feeder Reconfiguration function shall optimally balance the segments of the network that are over & under loaded. This function shall help in better utilization of the capacities of distribution facilities such as transformer and feeder ratings.

The Feeder Reconfiguration Function shall be activated either by an overload condition, unequal loadings of the parallel feeders and transformers, periodically or on demand by the despatcher. It shall generate the switching sequence to reconfigure the distribution network for transferring load from some sections to other sections. The LBFR application shall consider the planned & unplanned outages, equipment operating limits, tags placed in the SCADA system while recommending the switching operations. The function shall distribute the total load of the system among the available transformers and the feeders in proportion to their operating capacities, considering the discreteness of the loads, available switching options between the feeder and permissible intermediate overloads during switching. The despatcher shall have the option to simulate switching operations and visualise the effect on the distribution network by comparisons based on line loadings, voltage profiles, load restored, system losses, number of affected customers.

2.10.1 Modes of operation

The function shall have following modes of reconfiguration process:

(a) Auto mode

(b) Manual mode

The despatcher shall be able to select one of the above modes. These modes are described below:

2.10.1.1 Auto mode

In auto mode, the function shall determine switching plans automatically for load balancing in the network and perform switching operations upon despatcher validation automatically.

2.10.1.2 Manual mode

In manual mode, the function shall determine switching plans automatically for load balancing in the network based on which despatcher can perform switching operations in step-by-step manner.

A filter for remote operable & manual switches shall be provided with switching plan ,

2.10.2 Displays & Reports

The summary report shall cover the followings:

(a) Loadings of feeders and transformers before and after reconfiguration.
(b) Voltage profile of the feeders before and after reconfiguration.

The report shall also highlight violations that are occurring in the network with display layers before and after reconfiguration.".

2.11 Load Forecast –

2.11.1 Short-Term Load Forecasting (STLF)

Short-Term Load Forecasting (STLF) analytical function will be used for assessment of the sequence of average electrical loads in equal time intervals, from 1 to 7 days ahead.

As noted above, the STLF function shall be based on different forecasting methods such as:

- Autoregressive.
- Least Squares Method
- Time Series Method.
- Neural Networks.
- Kalman filter
- Weighted Combination of these method

In the first step, training module is executed using load data series from the historical database and weather conditions. After appropriate training, Forecast module is executed for up to next 7 days including weather forecast. Results are available in tabular and graphical form. The user shall be able to make adjustments to the active forecast. The adjustments can also be done through weather conditional data parameters i.e. temperature, humidity, precipitation level, wind speed , wind direction acquired through telemetered sensors or manually .

STLF will be used for forecasting of loads for the next short-term period (up to 7 days), to provide planning of the (optimal) network operation at the daily level. in periodic time (15 min to 1hr) The user shall be able to save forecasts in save cases, one of which shall contain the active forecast that shall be available for study functions.

2.11.2 Similar day forecasting

A similar day forecast shall be used that is based on the normalized half-hourly load values stored for each of seven-day types. Provision shall be made for storing day types for the last 24 months. The storage shall be updated each day by replacing the oldest of the same day type with the most current actual load curve.

The similar day forecast shall search the 24-month file for the same day type whose weather conditions best match. It shall then present the user-entered and best-matched conditions, for user comparison, together with the chosen day's loads as the suggested forecast. The user shall be able to modify any of the forecast's loads manually. In addition, the user shall be able to scale the entire forecast by simply specifying an appropriate peak load value.

Multi-day forecasts shall be constructed by permitting the user to define the input data for each forecast day.

The results of the previous forecasts will be compared with the actual load realization. The performed differences will be used for updating the forecasting procedure parameters.

2.11.3 Long Term forecasting

In addition to the above , Long term load forecasting shall also be available for at least 1 year . The same shall be calculated based on the peak load values or energy consumptions on weekly/monthly basis for atleast two preceding years, Array of forecasted peak loads imported from STLF/ entered manually.

The user shall be able to print and display the forecasts in both tabular and graphical form. This shall include the ability to display the active forecast with the actual loads of current and past days superimposed ,energy consumption/peak load curves in the forecasting period . .

2.11.4 Results of Function

A) Main input data for the LF will be:

- Historical Load measurements for specified network points, associated with corresponding weather conditions.
- Daily load curves & energy consumption from the past, for all type of days and seasons.
- Weather prognosis for the forecasting period.

B) Main output data of the STLF will be:

- Forecasted load for the forecasting period
- SCADA/DMS should create reports for sending the demand to SLDC as per requirements of the utility.

2.12 Operation Monitor

The Operations Monitoring function shall track the number of operations made by every breaker, capacitor switch, recloser, OLTC , isolator and load break switch that is monitored by the System. Devices shall be identified by area of responsibility, substation, feeder, and device ID to provide the necessary information for condition-based maintenance of these devices.

Each monitored device shall be associated with a total operations counter. This counter shall be incremented whenever the associated device changes state. When a multiple change (such as a trip-close-trip sequence) is reported by an RTU/FRTU, each transition shall be counted separately. In addition, a fault operations counter is required. This counter shall be incremented only for uncommanded trip operations. The date and time of the last operation shall be saved for each device when one of the counters is incremented.
An Operator with proper authorization shall be able to enter a total operations and fault operations limit for each counter. An alarm shall be generated when a counter exceeds its limits. No additional alarms shall be generated if the

counter is incremented again before it is reset. For each counter, the System shall calculate the present number of operations expressed as a percent (which may exceed 100%) of the corresponding limit.
The ability to reset individual counters shall be provided. In addition, a user shall be able to inhibit operations counting for individual devices. Such devices shall be included in summaries based on areas of responsibility. Resetting and inhibiting counters shall be permitted only for devices that belong to the areas of responsibility and resetting shall require the console to be assigned to an appropriate mode of authority. The user info , date and time , when each counter was last reset shall be saved.

The counters and other related information shall be available for display and inclusion in reports. The user shall be able to view the date and time of a device's last operation together with its accumulated operations data by simply selecting the device on any display where it appear

2.13 Disptacher Training Simulator (DTS)

A Dispatcher Training Simulator (DTS) shall be provided for SCADA/DMS system for training of operators/ dispatchers during power system normal, emergency/ disturbance and restoration activities. The DTS shall be installed at the SCADA/DMS control centre where it shall be used to train employer and other utilities dispatchers. The major DTS features shall include:

(a) The DTS model shall simulate the distribution power system in a realistic manner, including its response to simulated events, Instructor actions, and Trainee actions. The response shall be identical to the response observed by the dispatcher in the actual computer system environment.

(b) The consoles shall be assignable as trainee or instructor consoles. The DTS shall support at least one instructor & two trainees

© Instructor control features shall include the ability to set up, control, participate in, and review the results of a training session.

(d) Dispatcher control feature shall facilitate dispatchers to train dispatcher to use all SCADA , dispatcher & DMS functions under normal & disturbed conditions.

(e) An ability to obtain data from the SCADA/DMS systems automatically for DTS initialization. The initialization data shall include save cases, predefined & instructor defined scenarios.

(f) It shall prevent actions & keep insulated the actions performed by the Instructor and Trainee using the DTS from affecting the real-time system database or the actual power system.

(g) An ability to simulate actual system disturbances from historical data "snapshots" stored by the real-Time database Snapshots .

(h) DTS function shall have ability to establish the following training conditions as a minimum:
(1) Normal steady state
(2) Disturbed network conditions for distribution network
(3) High & Poor Voltage conditions
(4) Poor VAR conditions
(5) Indiscriminate tripping
(6) islanding
(7) System blackout
(8) System restoration
(9) Conditions/functions included for SCADA/DMS real time system

(i) Following features as minimum:
(a) All SCADA/DMS functions as envisaged in the specification
(b) Cry wolf alarms
(c) Record/ Playback /slow/realtime/fast forward
(d) Record trainee actions

DTS Model features , functions & user interface shall be true replica of SCADA/DMS system model for that project area. The DTS can be used in the following modes as minimum :

1. Instructor Control
2. Trainee Control

2.13.1Instructor Control:

The Instructor shall be able to perform pre-session, session, and post-session activities. Each training session shall consist of executing a scenario (tailored to the simulated SCADA/DMS system) starting from a base case. The base case shall consist of a solved network output case from the NCA or load/power flow and one or more load curves..

Pre-session activities consist of scenario building and development of events that occur during the training scenario. A load/power flow function shall be provided in the DTS to support this feature.

Session activities performed by the Instructor include initiation, control, and participation in the training session.

Post-session activities shall consist of session review and evaluation of Trainee performance. The DTS shall maintain records of the training session so that the base case, scenario, Trainee actions, and other session activities may be reviewed. Instructor shall have all rights of trainee mode also as mentioned below:

2.13.2 Trainee control :

All activities ,features, functions, user interfaces, which dispatcher can perform or use in real time shall be available to trainee in trainee control mode.

2.13.3Pre-Session Activities

The Instructor shall be able to create a base case and to execute a power flow if desired to initialize the base case. The Instructor shall be able to build groups of events scheduled to occur during the training session. A training session shall be built by combining one or more event groups with a base case.

2.13.4 Scenario Construction

The following features shall be provided for building a training session:

(a) Base Case Construction: shall allow Instructor to set conditions, parameters, and limitation for equipment in the network database. It shall be possible to initialize a base case from the following sources:

(1) A stored base case created in the DTS
(2) A power flow solution obtained in the DTS
(3) A power flow or NCA /SE solution obtained from real-time system.
(4) Output of real time DMS executed functions

(b) Base Case Store: shall allow instructor to save a base case for future use. It shall be possible to transfer saved base cases to auxiliary memory (e.g., magnetic tape) and to reload saved base cases from auxiliary memory.

(c) Base Case Select: shall allow instructor to select a specific base case for modification or further processing. Base case selection may be indexed by title or subject.

(d) Base Case Review: shall allow instructor to display the contents of the base case.

(e) Base Case Editing: shall allow instructor to modify a base case and to store the updated version.

(f) Event Group Construction: shall allow instructor to construct event groups containing one or multiple events. The Instructor shall be able to define the events within the event group to occur simultaneously or according to other parameters of time or system conditions. Checks shall be performed to assure that each event entered is one of the predefined set of events and that the equipment and parameters associated with the event are valid for the event specified.

The system shall provide an interactive means for specifying the device or point associated with each event.

(g) Event Group Store: shall allow the Instructor to save the event group constructed for future use.

(h) Event Group Select: shall allow the Instructor to select one or more event groups for incorporation into a training scenario.

(i) Event Group Review: shall allow the Instructor to display events within an event group.

(j) Event Group Editing: shall allow the Instructor to modify an existing event group and to store the updated version.

2.13.5 **Event Types**

The Instructor shall be provided with a set of permissible event types that can be scheduled as part of a scenario. As a minimum, the following event types shall be included:

i. Change of bus load
ii. Change of system load
iii. Fault application/FPI indication
iv. Circuit breaker trip/close
v. Circuit breaker trip with successful reclosure
vi. Circuit breaker trip with unsuccessful reclosure
vii. Isolators switchings
viii. Supervisory control disable/enable for specific device
ix. Relay status enable/disable
x. Loss of RTU /FRTU due to telemetry failure for specified period of time
xi. Loss of single RTU /FRTU point
xii. Replace value of telemetered point
xiii. Messages to Instructor
xiv. Pause simulation
xv. Demand snapshot.
xvi. Cry wolf alarms

2.13.6 **Event Initiation**

Events shall be executed at an Instructor-specified time, when Instructor-specified conditions occur, upon Instructor demand, and when protective relays operate. Event initiation shall include:

(a) Time Dependent Events: These events shall be scheduled by the Instructor to occur at a specified simulated clock time or at time intervals relative to the start time of the scenario.

(b) Conditional Events: Conditional events shall be based on simulated power system conditions obtained from DTS model . The Instructor shall be able to specify a conditional event by specifying a permissible events and a boolean equation for the power system condition that will trigger the event. The boolean equation shall allow the following triggers to be incorporated separately or in combination:

(1) A status variable equal to a defined state

(2) An analog variable above or below a defined threshold

(3) Change in analog variable from one DTS cycle to the next by more than a defined amount (positive or negative).

(c) Demand Events: The Instructor shall be able to demand the immediate execution of an event without having to insert it in the events list.

(d) Relay Initiated: The operation of a relay shall result in the execution of one or more Instructor-specified events.

2.13.7 **Session Activities**

The Instructor shall be able to monitor the training scenario and guide it toward a specific objective by inserting new events omitting scheduled events, and performing other actions. The following commands shall be provided to control a Trainee scenario:

(a) Pause/Resume: Shall allow the Instructor to suspend or resume the training scenario without affecting the scenario. While in the Pause mode, the Trainee and Instructor shall be able to call all displays but perform no other functions. The Resume command shall resume the simulation from the point at which the pause occurred.

(b) Slow/Fast Forward: shall allow the Instructor to move a training scenario forward at a Instructor-specified speed slower/faster than real-time.

(c) Event Insertion: shall allow the Instructor to add new events when a training scenario is in progress without the need to interrupt the training scenario.

(d) Event Demand: shall allow the Instructor to demand the immediate execution of an event.

(e) Event Omission: shall allow the Instructor to omit a scheduled event from the training scenario in progress without interrupting the training scenario.

(f) Periodic Snapshot: shall allow the instructor to create a historical file that is periodically updated with session data necessary to resume simulation as it occurs during the simulation. The DTS shall not pause while the snapshots are being collected and saved. The snapshot save area shall be circular in nature where the oldest snapshot will be overwritten each time a new snapshot is saved when the save area is full.

(g) Demand Snapshot: shall allow the Instructor to create a historical file, identical to that created by a periodic snapshot, on demand during the simulation. The DTS shall not pause while the snapshots are being collected and saved.

2.13.8 **Post-session Activities**

The DTS shall provide the following capabilities to assist the Instructor in reviewing a training session with the Trainee:

(a) Snapshot Review: shall initialize the DTS with a snapshot saved during a training session. After a snapshot has been loaded, the Trainee and Instructor shall be able to call displays to examine any data available during a session.

(b) Snapshot Resume: shall resume the simulation from a snapshot in the same manner as it would resume from a Pause.

(c) Evaluation report : Based on the actions performed , timeliness & An evaluation report shall be created to review performance of trainee.

2.13.9 **DTS Performance and Sizing**

The DTS shall be sized the same in all respects as the SCADA/DMS control system. In addition, the capabilities of the DTS shall include the following items as minimum:

(a) 20 DTS base cases
(b) 20 scenarios
(c) 250 event groups
(d) 50 events per group
(e) 50 session snapshots
(f) 5-minute snapshot periodicity
(g) 100 conditional events
(h) 1000 variables in conditional events.
(i) 2 Trainee (according to no. of DTS consoles) & 1 instructor

2.13.10 **DTS Database and Displays**

The DTS SCADA and Network model database must have the same functionality & displays as the real-time system database & displays. It must be possible to initialize the DTS with a copy of the database of real-time system in addition creation of database locally.

End of Section 2, Chapter 2