PCS System Performance

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REV. 02

DOCUMENT APPROVAL PROCESS

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This table summarises what has been changed in the document so that it is easy to keep track of the effected changes.

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1. Introduction

1.1 Purpose

The operational performance of the new PCS as supplied from field I/O to operator HMI as applicable will be determined by its ability to meet several key performance criteria outlined in this document. These criteria can be measured and objectively analysed.

The objective of this document is to quantify overall PCS compliance required performance metrics required as part of the delivery of the project.

1.2 Scope

1.2.1 Requirements Included

1) System Architecture;
2) System Configuration;
   a. Local polling via Modbus;
   b. Data replication from the stations to the MCC;
3) Number of stations;
4) Average and maximum I/O per station;
5) Adhering to HMI graphics guidelines;
   a. Number of graphics per level (L1,L2,L3,L4)

1.2.2 Requirements Excluded

N/A

1.3 Terms and Definitions

1.3.1 Abbreviations

Term	Definition
ACE	Advanced Calculation Engine
AOR	Area of Responsibility
Active Ticket	An active ticket is one for which real-time data is being collected and volumes calculated in real-time. Active tickets can be remote (calculated in the flow computer); as used in this PCS or host (Calculated in LMS).
Benchmark	A benchmark is an AVEVA provided test result that describes the performance of the PCS system as a measured value. These benchmarks can be used as provided or extrapolated to TPL specific requirements. Benchmarks are identified as "Benchmark "
Custody metering	Custody metering functionality provided as part of Pipeline Operations – Liquids Applications.
Connection	Realtime Database instance representing a physical connection to the RTU
Console	The physical area at which the Operator sits and views the 4 monitors they use to supervise and control the SCADA system.
CPU	Central Processing Unit

DMZ	Demilitarized Zone
Display	A window that contains graphics and data. There will be multiple displays on a monitor.
Fast Scan	It is possible to fast scan, meaning scan a particular PLC at a faster rate than under normal conditions, using two methods: i. Manual - User initiated fast scan (or interrogation) of a PLC or flow computer. ii. Command (automated) - Software initiated fast scan (or interrogation) of a PLC after issuing a setpoint. The fast scanning duration is configurable on a per PLC basis. Default value is 30 seconds. Fast scanning causes the particular PLC to receive a scan every other poll cycle for a given polling process. Fast scanning temporarily sets the Minimum Poll Cycle time to 0.
Faceplate	Detailed display with information and controls for the device on a Display from where they are called.
GUI	Graphical User Interface
HMI	Human Machine Interface
H/W	Hardware
I/O	Input / Output
LAN	Local Area Network
LDS	Leak Detection System
LMS	Liquids Management System
MCC	Master Control Centre
Monitor	The physical hardware that is used at the console (27") with a maximum screen resolution of 3840 x 2160 pixels.
NMC	Network Management Console
NOC	National Operations Centre
OASyS	AVEVA's Open Architecture System
OASyS System	AVEVA's system for facilitating field device communication and system monitoring and control, as well as integration with utility enterprise software.
OASyS Service	AVEVA's service, a sub system of AVEVA's OASyS System, providing real-time, historical or HMI functionality
ODBC	Open Database Connectivity
omnicomm	OASyS polling engine
OpenRDA	Open Remote Database Access
PCS	The Process Control System (PCS) refers to the complete control system required for the operation of the TPL sites from the field interface to the operator interface. This includes the following sub-

	systems: PCS SCADA (including Replay), PCS PLC, LMS, LDS, HMI Trainer.
Pop-up	Pop-up is a display that is configurable to disappear from a console display after a period of inactivity. Pop-ups appear in intuitive locations. In general, pop-ups facilitate controller entry to the SCADA system. Following are examples of the functions that are available through pop-ups: a) Discrete controls; b) Setpoint controls; c) Communications control; and d) Setting Area of Responsibility.
PLC	Programmable Logic Controller
RCS	Remote Client Services
RDBMS	Relational Database Management System
RDP	Remote Desktop Protocol
Remote	Realtime database instance representing a physical remote terminal unit (RTU) or PLC.
RTDB	RealTime Database
RTDB object	A software written, pre-compiled display object showing a value on a display, analogue or digital. RTDB objects are linked to the database via publish / subscribe.
SCADA	Supervisory Control and Data Acquisition
Site / Station	The term site is used to indicate the local station.
SQL	Structured Query Language
SRM	Security Reference Monitor
SSCP	Systems Security Certified Practitioner
S/W	Software
TCP/IP	Transmission Control Protocol / Internet Protocol
VM	Virtual Machine
WAN	Wide Area Network
XE	eXtended Editor

2. Applicable Documents

2.1 TPL Applicable Specifications and Standards

No. and Title	Doc. No.	Rev.
[1] PCS Upgrade Project Works Information	H354086-00000-300-090-0001	01
[2] TPL-TECH-I-C-SPEC-012 [3] Control System URS	TPL-TECH-I-C-SPEC-012	03
[3] SCADA System Architecture	E354086-00000-271-256-0002	Latest
[4] FYN PLC System Architecture	E354086-00001-271-256-0001	Latest
[5] Typical Pump PLC System Architecture	E354086-00000-271-256-0006	Latest
[6] Typical Booster PLC System Architecture	E354086-00000-271-256-0005	Latest
[7] CBK PLC System Architecture	E354086-00017-271-256-0001	Latest
[8] PLC System Functional Design Specification	E354086-00000-271-078-0003	Latest
[9] SCADA System Functional Design Specification	E354086-00000-271-078-0018	Latest
[10] Custody Metering Functional Design Specification	E354086-00000-271-078-0020	Latest
[11] Leak Detection Metering Functional Design Specification	E354086-00000-271-078-0007	Latest
[12] SCADA/PLC Communication Plan	E354086-00000-271-078-0012	Latest
[13] HMI Style Guide	E354086-00000-271-078-0006	Latest
[14] LAN Network Standard	E354086-00000-271-078-0002	Latest
[15] ICD: WAN – Crude Oil Pipeline	H354086-00000-276-242-0001	0

2.2 Other Applicable Specifications and Standards

The following national and international standards are required to be complied with and shall be read in conjunction with this Specification.

No. and Title	Doc. No.	Rev.
[16] Nil		

2.3 Reference Documentation

The documents included in this section do not form part of the specification, but are included for background and context.

No. and Title	Doc. No.	Rev.
[17] Test Steps for Polling Performance	E354086-00000-271-050-0003	00

3. Loading – Normal, Heavy and High Latency

There are two aspects to the loading of the PCS:

1) Server processing throughput consisting of telemetry data acquisition, calculations on telemetry data, publishing of telemetry data and data replication to other systems; and
2) The user experience with the system including viewing of real-time data, periodic refresh of summary data and historic trend data.

"**Normal Load**" is the loading that would be found on the PCS with:

1) Pump stations operating in a typical steady state manner;
2) All designed operator consoles connected, with typical displays up and routine Operator activities taking place including opening and closing displays and sending commands;
3) All field remote devices that are configured being connected and polling at configured polling frequency, with all devices on-line and responding; and
4) All applications within the PCS functioning normally and all external applications requesting and/or sending data to / from the PCS in quantities typical for steady state facility operations.

"***Heavy Load***" is related to bursts of activity on the PCS related to abnormal conditions on the pipeline or within the system itself. These bursts may last for seconds or for several minutes and are unpredictable.

"***High Latency***" is related to higher than normal WAN latency on the PCS related to abnormal conditions within the telecom infrastructure. These periods of high latency may last for minutes or for several days and are unpredictable. High latency, as opposed to heavy loading increases the time for WAN activities to occur including poll requests, operator commands and application replication. The high latency test demonstrate that the system is functional during this time.

4. Database Sizing

The following tables list the sizing of the system and defines the absolute data points and other attributes of the system.

4.1 RealTime Database

The attributes listed in the following table are considered part of the RealTime Service and are replicated from the Hot RealTime servers to the Standby RealTime servers of a Station and to MCC. Replication will also be configured to the Decision Support Environment.

Refer to AVEVA's baseline SCADA documentation for more details on each attribute.

Attribute	Oil Pipelines
stations	50
remotes	50 stations X 1 PLC / station = 50 PLCs for multiple PLC stations = 50 Flow computers = 100 Total = 200
connections	200 remotes X 1 connection / remote = 200
modbus	200 remotes X 1 Modbus / remote = 200
analogues	50 stations X 750 analogues / station =37,500 flow computer analogues = 7,500 Total = 45,000
statuses	50 stations X 750 statuses / stations =37,500 flow computer statuses = 7,500 Total = 45,000
trend sets	50 stations X 40 trends / station = 2000
ACE routines (*)	10
ACE Routine Instances	50 stations X 10 ACE routines / station = 500
Areas of Responsibility	2 area / station = 100
groups (**)	50 stations X 20 groups / station = 1000

Table 4.1-1: RealTime Database

(*) AVEVA's provided application for user defined calculations is called the Advanced Calculation Engine (ACE). ACE is used to create custom calculations and controls for the RealTime service using .NET languages such as Visual Basic or C#. ACE procedures can be triggered periodically, manually, by exception, on alarm or on start-up. As AVEVA provided applications as licensed modules requirements for ACE are limited to small adhoc programs.

(**) Further testing required before group field can be increased from 20 to 40.

4.2 Pipeline Operations - Liquids Databases

The attributes listed in the following table are considered part of RealTime Liquids (LMS) and are replicated from the hot servers to the standby servers and from the Stations to the MCC. Replication will also be configured to the Decision Support System.

Refer to AVEVA's baseline LMS documentation for more details on each attribute.

Attribute	Station	MCC
tickets (active)	10 tickets	20 stations X 10 tickets / station = 200
tanks	20 tanks	5 stations X 20 tanks / station = 100
	TPL System	
pipelines	crude, multi-product, avtur = 3 (excluding extensions)	

Table 4.2-1: LMS Databases

4.3 Historical Database

Historical data is stored in the SQL Server Databases located on the Historical servers.

Attribute	Station	MCC
Collect Points – Time Series	1800	90,000
Collect Points – CommStats	4	200
Collect Points – Events	100 / hour	2400 / hour

Table 4.3-1: Historical Database

4.4 Consoles & Users

The attributes listed in the following table relate to the physical components of the system and the number of users (MCC and Stations).

Attribute	Station	MCC
Consoles	1, 2 or 3	6
Operator Workstations per Console	1	1
Physical Monitors per Workstation	4	4

Table 4.4-1: Consoles & Users

4.5 Displays and Reports

Displays are generated using the eXended Editor (XE) and the displays are stored in a display repository which is used to synchronize the displays across ezXOS workstations on the network.

Reports will be generated using Microsoft Reporting Services with output formats including Excel and .pdf.

Attribute	Stations
Displays – Total Number (*)	50 Stations X 25 Displays / Station = 1250
Global Trend Sets – per Console	200
Reports – SQL Reporting Services	30

Table 4.5-1: Displays & Reports

(*) These numbers are over and above the baseline displays supplied as part of the baseline OASyS system. These numbers are best-guess estimates based on the following assumptions:

- Common pump stations displays can be templated; and
- Dialog popups are not included.

If the above assumptions change, then the numbers in the table need to be re-assessed. Additional hardware resources, CPU, memory, hard drive space may be required.

5. Performance Criteria

5.1 General Metrics

	Station and MCC	
Criteria	**Normal Load**	**Heavy Load**
Availability	99.98%	99.98%
Failover – Planned	30 seconds	30 seconds
Failover – Unplanned	30 seconds	30 seconds
Mode Switch	30 seconds	30 seconds
Communication Path Switch	30 seconds	30 seconds

Table 5.1-1: General Metrics

5.1.1 Failover

A Failover to the Standby server(s) shall take less than the specified elapsed time. The elapsed time shall be calculated from the time the Failover command is given (in a planned Failover) or from the time control capability is lost on the currently hot server (in an unplanned Failover) until control capability is restored on the standby server (which has switched to hot status due to the Failover).

The declaration of "loss and restore of control capability" on each server shall be determined through consultation with AVEVA. This may be calculated through the examination of the time stamped entries in the event logs on each server.

5.1.2 Mode Switch

A Mode Switch switches control capability from Station to the MCC.

A Mode Switch shall take no more than the time specified from the time the command is issued until the SCADA system declares that the Mode Switch has completed.

The Mode Switch returns successful when the command has been accepted on the other System.

5.1.3 Communication Path Switch

The time that the host and field take to re-establish communications is based on communication path and bandwidth. Communication paths will switch between the Station (LAN connected) and the MCC (WAN connected).

5.2 TPL Real-time Performance and Loading

Note: These metrics are applicable to this PCS (refer to the separate columns for Normal and Heavy loading).

		Station		MCC		
#	**Criteria**	**Normal Load**	**Heavy Load**	**Normal Load**	**Heavy Load**	**High Latency**
1 [5.2.1]	Alarms per hour (peak)	20	75	600	1,000	600
2 [5.2.2]	Events per hour	100	300	2400	4000	2400
3 [5.2.3]	Data changes from Remotes - per second	15	30	750	1500	750
4 [5.2.4]	Historical data exception values collected in SQL – per second	15	30	750	1500	750
5	TPL: Minimum Poll Cycle	2 seconds	2 seconds	2 seconds	2 seconds	2 seconds
6	TPL: SCADA Modbus points per poll (analogue values i.e. 1 registers per value)	125	125	125	125	125
7	TPL: SCADA Modbus points per poll (Digital values i.e. 1 register per 16 values)	750	750	750	750	750
8 [5.2.5.1]	TPL: Maximum allowable time for a change in field status on the input card of the RTU to be displayed on the HMI graphic.– Station	1.5 seconds	2 seconds	---	---	---
9 [5.2.5.2]	TPL: Maximum allowable time for a change in field status on the input card of the RTU to be displayed on the HMI graphic. – MCC	---	---	2 seconds	4 seconds	2 seconds
10 [5.2.6]	TPL Scenario: Polls required per device – Modbus	7	7	7	7	7
11 [5.2.7]	TPL Scenario: Modbus expected poll cycle OASyS processing time. (*)	1.5 s for 7 polls	1.7 s for 7 polls	2.2 s for 7 polls	2.2 s for 7 poll	3.6 s for 7 poll

		Station		MCC		
#	**Criteria**	**Normal Load**	**Heavy Load**	**Normal Load**	**Heavy Load**	**High Latency**
12 [5.2.13]	TPL: Allowable time from command issue to the output of the PLC	1.5 seconds	1.5 seconds	---	---	---
13 [5.2.13]	TPL: Allowable time from command issue to the output of the PLC	---	---	2.0 seconds	2.0 seconds	2.0 seconds
14 [5.2.14]	TPL: Setpoint throughput (Operator or program sent to setpoint queue) per second	1	1	6	6	5
15 [5.2.15]	TPL: Maximum Setpoints (Operator or program sent to setpoint queue) per minute	15	15	60	60	50
16	TPL: WAN latency	---	---	50 msec.	50 msec.	150 msec.

Table 5.2-1: TPL Real-time Performance and Loading

(*) Based on benchmark test results, Table 5.2-2: Benchmark Scenario Details. Although the system is capable at the requested poll cycle time AVEVA recommends polling at the benchmark polling frequency of 1 / 5 seconds.

5.2.1 Alarms per Hour

The total number of alarms per hour across all consoles in the system. These are peak counts and include both alarms and alerts if alerts are being configured in the OASyS system.

5.2.2 Events per Hour

The total number of events per hour including alarms or alerts across all consoles in the system.

5.2.3 Data Changes from Remotes

The number of analogue and discrete points received and processed from field devices per second. This metric does not include any device or communications latency.

5.2.4 Data Values to Historical Database – per Second

This metric is related to the data interface between the real-time server and the historical SQL server.

5.2.5 TPL Allowable Times

5.2.5.1 Field to Station

TPL maximum allowable time for a change in field status on the input card of the RTU to be displayed on the HMI graphic. – Station.

5.2.5.2 Field to MCC

TPL maximum allowable time for a change in field status on the input card of the RTU to be displayed on the HMI graphic. – MCC.

5.2.6 Polls Required per Device

This is the number of polls required to gather all benchmark data. Number of polls required by Transnet will vary with the actual number of configured registers in each PLC. Stations with multiple PLCs will be polled in parallel.

5.2.7 Expected Poll Cycle OASyS Processing Time

This is the measured round time for one poll. The measured valued is dependent on the PLCs, LAN, server hardware and software provided.

5.2.8 Poll Time - LAN

This is the maximum time in seconds required to gather all configured data from a given PLC under normal condition using station polling and LAN connection to PLC. This is based on a poll / response communication architecture to and from PLCs. Benchmark testing is used as a reference for system throughput; network latency and TPL specific polling requirements are detailed in section 5.2.12.

5.2.9 Poll Time - WAN

This is the maximum time in seconds required to gather all configured data from a given PLC under normal condition using MCC polling and WAN connection to PLC. This is based on a poll / response communication architecture to and from PLCs. Benchmark testing is used a reference for system throughput; network latency and TPL specific polling requirements and are detailed in section 5.2.12.

5.2.10 Field Communications – Benchmark Scenario Details

5.2.10.1 Modbus

The table below indicates the results of an AVEVA internal benchmark test conducted to determine the Modbus expected poll cycle OASyS processing time. Results of this internal test are provided as reference as to available system throughput.

	Station		MCC	
Criteria	Normal Load	Heavy Load	Normal Load	Heavy Load
Maximum Modbus registers per poll	124	124	124	124
Maximum SCADA Modbus points per poll (Floating point values i.e. 2 registers per value)	62	62	62	62
Maximum SCADA Modbus points per poll (Digital values i.e. 1 register per 16 values)	1984	1984	1984	1984
Benchmark poll cycle – LAN	5 seconds	5 seconds	---	---
Benchmark poll cycle – WAN	---	---	10 seconds	10 seconds
Benchmark Scenario: Polls required per device – Modbus	14	14	14	14
Benchmark Scenario: Modbus expected poll cycle OASyS processing time	250 msec. / poll 3.5 s for 14 polls	325 msec. / poll 4.55 s for 14 polls	550 msec. / poll 7.7 s for 14 polls	625 msec. / poll 8.75 s for 14 polls

Table 5.2-2: Benchmark Scenario Details

The metrics in these rows are based on previous testing by AVEVA to confirm timing to gather 1500 registers worth of data representing 750 changing floating point values and 47 registers worth of data representing 750 changing digital values; raw results of this were:

- at LAN bandwidth, zero latency and zero loss (best scenario):

- Modbus takes average 3.5 seconds to complete one poll cycle (14 polls)

The following analysis is based on the "Modbus" results above.

Analysis:

A Modbus RTU configured with 750 floats and 750 digitals will take 14 polls:

Number of values X Number of Registers per value = Number of registers

750 floats X 2 registers per value = 1500 registers.

750 digitals / 1 registers per 16 values = 47 registers.

The max bytes per Modbus poll is 124 bytes.

Number of registers / Maximum bytes per poll = Number of polls

1500 analogue point registers / 124 bytes = 13 polls.

47 digital registers / 124 bytes = 1 poll

With zero latency, it takes 3.5 seconds to poll all the registers, which requires 14 polls (See raw data above).

Total host processing time / Number of polls = processing time / poll

3.5 seconds / 14 polls = 250 msec.

Therefore, the processing time is 250 msec.

With network latency added (150ms), polling from the MCC it would take 7.7 seconds to poll the same number of registers.

The Minimum Poll Cycle Time Delay is the minimum time delay between the beginning of one poll cycle and the start of the next poll cycle. The system will wait if a Minimum Poll Cycle Time delay is configured and the actual omnicomm poll cycle completes before the Minimum Poll Cycle time expires.

5.2.11 Poll Cycle TPL - LAN

TPL polling will be configured with minimum poll cycle time for high speed data acquisition.

The polling engine will wait after all polls for the cycle are completed until the Minimum Poll Cycle Time. When the polling cycle exceeds the Minimum Poll Cycle Time the polling will restart as soon as finished.

Multiple devices are queried in "parallel" via sockets, polls on a single device are serial in a query-response manner.

5.2.12 Field Communications - Transnet Scenario Details

5.2.12.1 Modbus

The requirements to gather 750 registers worth of data representing 750 changing analogue values and 47 registers worth of data representing 750 changing digital values are:

Frequency X Minimum Poll Cycle = Polling Frequency

Configuration:

PLC configured with 750 analogue and 750 digitals will take 7 polls:

Number of values X Number of Registers per value = Number of registers

750 analogues X 1 registers per value = 750 registers.

750 digitals / 1 registers per 16 values = 47 registers.

Number of registers / Maximum bytes per poll = Number of polls

750 analogue registers / 125 bytes = 6 polls.

47 digital registers / 125 bytes = 1 poll

The following configuration will be specifically configured for the PCS upgrade project.

Poll Number	Registers	Frequency	Minimum Poll Cycle Time (Seconds)	Polling Frequency (Seconds)
1	47	1	2	2
2	125	1	2	2
3	125	1	2	2
4	125	1	2	2
5	125	1	2	2
6	125	1	2	2
7	125	1	2	2

Table 5.2-3: TPL Scenario Details

5.2.12.2 TPL Configuration Options

Number of poll ranges will vary depending on the number of data values required from each PLC / flow computer. The following describes configuration options available to achieve the desired Performance Criteria:

1. Flow computer polling can be done simultaneously with PLCs;
2. Multiple PLCs / flow computers can be deployed at one Site, all polled simultaneously;
3. Multiple remotes can be configured for 1 PLC, all polled simultaneously;
4. Registers with statistical information can be polled in multiples of Minimum Poll Cycle (for example retrieve pump run time once / minute);
5. Rollup maintenance information into single registers (for example transmitter failed, pump failed, valve position error).

5.2.13 Command Issue Delay

The maximum time permitted between the Operator issuing the command from the SCADA Master and it being received at the remote device (e.g. PLC, flow computer). The time for the PLC to execute the command is independent of this time and cannot be controlled by the SCADA system.

This time includes any pre-processing required in OASyS prior to the issue of the command. This includes validation processing. (checking for Remote on scan, setpoint within limits, no pending setpoint).

This also applies to automated issue of commands by software applications running on OASyS, whether developed by AVEVA or Transnet.

5.2.14 Setpoints Throughput

The number of setpoints (analogue or digital) per second that can be issued by an operator using the operator HMI or by an application to be queued by the Omnicomm service. The setpoints are only received by Omnicomm and may or may not have been issued to the field device.

5.2.15 Maximum Setpoints

The maximum number of setpoints that can be issued by an operator using the operator HMI or by an application to be queued by the Omnicomm process. The setpoints are only received by Omnicomm and may or may not have been issued to the field device.

5.3 HMI Performance and Loading

The following sections relate to the performance of the HMI interface as used by the local station operators or from the MCC.

There shall be no noticeable lag on the ezXOS workstation whenever an operator uses the mouse or keyboard to move the cursor or select dynamic areas on the display. This applies to Normal and Heavy Loading conditions on the PCS.

Note: These metrics are applicable to this PCS (refer to the separate columns for Normal and Heavy loading).

5.3.1 Station / MCC HMI Access

#	Criteria	Station	MCC
01 [5.3.1.1]	Maximum time to re-boot a single Workstation from applying power to Windows Login	60 seconds	60 seconds
02 [5.3.1.2]	Maximum time from MS Windows Login until ezXOS displays are populated and Operator can issue command or navigate	90 seconds	90 seconds
03 [5.3.1.3]	Maximum time to shift change from one Operator to another on OASyS	60 seconds	60 seconds
04 [5.3.1.4]	Maximum update time on XOS workstation display after data updated in database – publish / subscribe	1 second	1.5 seconds
05 [5.3.1.5]	Maximum update time on XOS workstation displays after data updated in database – tabular / summaries (*)	5 seconds	5 seconds
06 [5.3.1.6]	Maximum time for new alarm to appear in Alarm Summary (**)	1 second	1 second
07 [5.3.1.7]	Benchmark: Maximum RTDB objects per Display	1548	1548
08 [5.3.1.8]	Benchmark: Display call up time – Average for Maximum RTDB object display (non-cached; average of first and subsequent call up times) (****)	2.0 seconds	2.5 seconds
09 [5.3.1.9]	Benchmark: Display call up time – Average for baseline OASyS analogue control panel (CNTL_ANALOG)	0.6 seconds	1.1 seconds
10 [5.3.1.10]	Benchmark: Event Summary Call up time – list of 500 events retrieved from the Historical database in a scrollable list.	2 seconds	3 seconds
11 [5.3.1.11	Benchmark: Average RTDB Objects per Console	2064	2064
12 [5.3.1.12]	Benchmark: Maximum number of 4 – pen, 60-minute light-weight trends (Spark lines) per Display	30	30
13 [5.3.1.13]	Benchmark: Display Call up time – Average for maximum light-weight trend display (PERF_TREND), 6 threads	5 seconds	6 seconds
14 [5.3.1.14]	Benchmark: Number of Displays per Console (excluding Pop-ups)	5	5
15 [5.3.1.15]	Benchmark: Display call up time for a RealTime trend: 1 pen, 0-60 days to a maximum of 1000 data points.	2 seconds	4 seconds
16 [5.3.1.16]	Benchmark: RealTime Queries for name, description from RealTime database via OpenRDA interface	Return in 30 seconds	Return in 60 seconds

#	Criteria	Station	MCC
17 [5.3.1.17]	TPL - Maximum Control objects per Display (***)	300	300
18 [5.3.1.18]	TPL - Time for the Maximum Control objects per Display graphic page to display after call-up	2.0 seconds	2.5 seconds
19 [5.3.1.19]	TPL: Button Selection Highlight time for feedback of a selection (e.g. border on a button)	0.2 seconds	0.2 seconds

Table 5.3-1: Station / MCC HMI Access

(*) This is the update time based on the retrieval of data using a query (SQL or compiled program) from the time the query is issued until the data is displayed on the Window. Tabular summaries can be configured to update on a periodic basis such as every 5 seconds. Actual execution time varies so metric is based on specific benchmark display "sum_analog".

(**) This time is independent of the number of alarms to be displayed. For example, if there are 40 alarms in the alarm queue then all 40 will be displayed within the time specified not 40 times the time specified.

(***) Control objects represent complex pipeline network equipment (i.e. pumps and valves). Control objects will be built using AVEVA RTDB objects.

(****) Non-cached means the displays are called from the display repository, Caching of displays is not used in display call up time measurements.

5.3.1.1 Workstation Reboot to Operator Login

This metric is related to starting up any one of the Operator HMI workstations on the network from a powered down state until the Operator can login to the workstation. This includes the time is takes to login into MS Windows. This time should be independent of the load on the system as the reboot is a local operation on the workstation.

5.3.1.2 Workstation Login to Command Issue

The time from entering the Operator's login until a command can be issued from the workstation. This does not include any additional time required to bring up a specific window but is used to determine when the workstation is in a state that would permit the issuing of a command.

5.3.1.3 Shift Change

The time between entering the new Operator's login on the Shift Change dialog on OASyS until a command can be issued from the workstation.

5.3.1.4 Maximum Update Time on Display – Pub/Sub Data

The time between an update of the data value in the database until it appears on the display. This is related to data that is updated through the pub/sub mechanism.

5.3.1.5 Maximum Update Time on Display – Tabular

The time between an update of the data value in the real-time database until it appears on a tabular display. Tabular displays use scheduled SQL queries to poll data from the real-time database and this is normally defaulted to 5 seconds.

5.3.1.6 Alarm Summary Updates

The maximum time between an alarm being generated by the OASyS system and it appearing in the "alarm summary" on the Operator's ezXOS workstation. Some variation in this is expected based on number of alarms in the table and the alarm input/output rates.

5.3.1.7 Benchmark: Maximum RTDB Objects per Display

Based on 516 dynamic display objects each consisting of three inner elements with individual RTDB attaches: value, units and data quality icons. Benchmark display consisting of tabular arranged "RTText"s with 30% whitespace (PERF_RTTEXT).

5.3.1.8 Benchmark: Maximum RTDB Objects' Display Call up Time

"Display Call up Time - Average for Maximum RTDB object display" is the average time to call up a new display on the XOS Workstation with the maximum number of RTDB objects on the display (refer to 5.3.1.7) from the time the Operator has executed the request until all data is displayed and updated with the current real-time data values. Table numbers for this metric are based on using benchmark displays "PERF_RTTEXT", "PERF_DEVICE"," PERF_DEVICE_SURROUND", "PERF_TREND", "PERF_HIST_TREND" and "PERF_REFRESH".

5.3.1.9 Benchmark: Display Call up Time – Analog Control Panel

"Display Call up Time - Average for CNTL_ANALOG display" is the average time to call up the display on the XOS Workstation from the time the Operator has executed the request until all data is displayed and updated with the current real-time data values.

5.3.1.10 Benchmark: Event Summary Call up Time

For a list of 500 events retrieved from the Historical Database in a scrollable list. On Call up the 500 most recent events will be populated in the event summary display.

5.3.1.11 Benchmark: Average RTDB Objects per Console

The average number of dynamic real-time data objects at a console. A full ezXOS workstation will have the, number of displays per console, times this average number of RTDB objects. For example, if the number of monitors per console is 4 and the number of RTDB objects per monitor is 516 then the console will have 2064 (4*516) RTDB objects.

5.3.1.12 Benchmark: Maximum Number of Lightweight Trends

The maximum number of Lightweight (Spark Line) Trends per display.

5.3.1.13 Benchmark: Display Call up Time – Lightweight Trends

"Display Call up Time - Average for Lightweight Trends display" is the average time to call up the display on the operator workstation from the time the operator has executed the request until all data is displayed and updated with the current real-time data values.

5.3.1.14 Benchmark: Number of Displays per Console

The maximum number of displays that can be displayed on console.

5.3.1.15 Benchmark: Display Call up Time – RealTime Trends

"Display Call up Time - Average for RealTime Trends display" is the average time to call up the display on the XOS Workstation from the time the Operator has executed the request until all data is displayed and updated with the current real-time data values.

5.3.1.16 Benchmark: RealTime Database Query

A query for all analogue, rate, status and remote current conditions from the RealTime database return data within the specified time.

5.3.1.17 TPL: Maximum Control Objects per Display

Based on 300 control objects (valves and motors) of the type developed on this project for TPL. Control objects will be developed using AVEVA RTDB objects.

5.3.1.18 TPL: Display Call up Time

Refer to TPL-TECH-I-C-SPEC-012 [3] Control System URS #202 bullet 3 and #204 bullet 3.

5.3.1.19 TPL: Button Selection Highlight

Refer to TPL-TECH-I-C-SPEC-012 [3] Control System URS #202 bullet 4 and #204 bullet 4.

5.3.1.20 Display Call Up Time– Meeting Performance Criteria

This section will be used by AVEVA / EOH for initial display development and also during system maintenance.

It is recognized that to meet the "Display Call up Time" this will require careful display design to ensure that high usage displays are developed in adherence to the Display Style Guide and performance tested before being used in the control centre. The following describes the display building guidelines to be followed to achieve the desired Performance Criteria:

1. Displays are built using primarily OASyS native RTDB objects, "RTText" and "Generic Device" as opposed to composites. Use of composites should be limited to low call up frequency, such as line, displays;
2. Displays are built using static objects, as opposed to dynamic or .NET objects;
   a. Static objects are the five object types provided by XOS which are created and rendered utilizing the graphics database. They consist of static polyline, static polygon, static ellipse, static text, static image and static arc.

b. These objects should be used whenever possible, for example: to display text that does not change on a display, display polylines which have no dynamic colouring or to display images which do not change.
c. While the same functionality is provided by their dynamic equivalents, dynamic polyline, bitmap / Generic Device and RTText / .NET label, the static objects are far more performant.
d. For example, piping depicted on displays will be drawn using a static line.

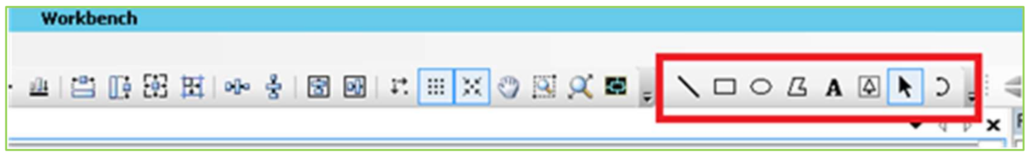

Figure 5.3.1-1: Static Line Selection

3. Displays are built using symbols, as opposed to bitmaps;
   a. In OASyS, an object can report a field value in the form of an image through either a file based bitmap or vector based symbol designed within XE.
   b. In XOS, the vector based symbols are scaled using the HOOPS rendering engine and drawn using the graphics database. With this form of pre-rendered staging, symbols are more efficient than bitmaps which are computationally scaled at call up. In general, the maintenance of bitmaps is simpler than symbols as they are resident on the file system and can be manipulated with any image editor versus the resign of a symbol within XE. Symbols are better at scaling to any dimension without rasterization given their vector nature and are less of a computational burden than bitmaps are.
   c. Symbols also support transparency similar to bitmaps.
4. Baseline provided objects, as opposed to programmer developed display coding logic is not used to determine the field device quality and / or alarming information shown near objects on a display;
5. There will be a small percentage of Level 1 displays (tabular summary, map, system wide trend, overview, tank summary, hydraulic profile), least frequently called up, maximum one to two times per shift, and often remain up for multiple shifts;
6. There will be a small percentage of Level 2 (line, manifold, valve) and a large percentage of Level 3 displays (station, meter, prover) that are called at moderate frequency and optimally up to 200, can be scripted for a unique list per console, of which will use display caching and / or pre-loading. Most Level 3 displays will have lower points counts, similar to Level 4, as many of them represent a 1 or 2 run meter station.
7. There will be a small percentage of Level 4 displays (faceplate, control panel, equipment detail panel, quick trend), containing average to low quantity of objects, most frequently used by Operators, and therefore with fast call up times;
8. Large displays that do not come up within the acceptable criteria would need to split into two or more smaller displays or be considered exceptional, and be managed separately in the averaging calculation (e.g. counted as 2 or more call-ups, in accordance with the magnitude of objects in relation to the criteria); and
9. Workstations are supplied to specifications for all operator consoles.

For example, of an inventory of 314 displays required for a liquids pipeline, below is the proposed distribution of each Level. Estimations were created before consideration given to consolidation via templates or redesign as detailed in the Display Style Guide. The distribution does not directly correlate to call-up frequency. Refer to Display Style Guide for more details on display Levels.

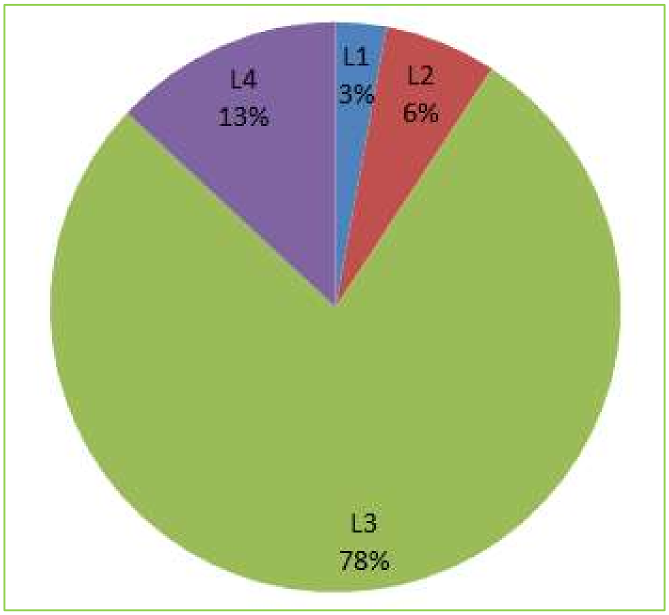

Figure 5.3.1-2: Proposed Transnet Display Distribution

5.4 Applications and Interfaces

Performance of applications and the interfaces between applications and servers can be measured using specific criteria:

- Bandwidth: characterized as points per second, separated into read and write operations,
  - This can also be characterized as messages per second, constituting a bulk read or write operation of multiple points within the message.
- Latency: characterized as the period between updates being processed by SCADA into its dependencies,
  - In OASyS, this can be characterized as the time between 'krunch' and the SCADA system's ability to process any dependencies that result.

Utilization is also an important factor, which can be measured as the load on which such applications impose performance demands of finite resources, being CPU, disk, memory, and network utilization. This measure is usually much more difficult to measure, since system specifications greatly affect the impact of applications on utilization. A well-behaved application should only have fractional usage of each resource on average, low when idle, but higher when dealing with heavy load. For the purposes of this section, utilization is only considered in so much that any application does not overwhelm (or starve) other applications in the system, even during events of heavy load. Section 4.5 has more information about utilization, so this section will not go into further detail.

Different applications have different requirements of each of these criteria, but the aggregate effect on the SCADA system is at least as important, and is included as a key specification metric below.

5.5 Start-up & Utilization

The criteria listed in the following table relate to the start-up of the system and to the utilization of the networks and the replication latency in the system. The validation of a number of these criteria will require the use of tools to monitor the throughput of data between the different networks in the system.

Criteria	Station	MCC
Server Start-up and Real Time Synchronization – Maximum	500 Seconds	500 Seconds
Server CPU Utilization Maximum– see notes below	25%	60%
Workstation CPU Utilization – Maximum	25%	70%
Historical Service Start-up time – Maximum	600 seconds	600 seconds
Disk Space – First Level Alarm	50% Full	50% Full
Disk Space – Second Level Alarm	80% Full	80% Full

Table 5.5-1: Start-up and Utilization

5.5.1 Server Start-up

This metric is related to starting up any one of the servers on the network (real time, historical etc.) from a powered down state until the server is deemed available for normal use in the SCADA system. This implies that the server has started to perform its synchronization processes. The elapsed time until the server is available in hot or standby mode is the addition of the server start-up and synchronization time. The metric above for this includes the time it takes to load the OS, start the OASyS common services, RealTime and synchronize with hot/standby servers.

5.5.2 Server CPU Utilization

Measuring system load is complicated and multifaceted and just recording one metric (total % CPU) is too high level for this discussion. The built-in windows tools exist to monitor performance. The Windows Performance monitoring tools will be used to monitor the CPU utilization during the performance testing. The tool can average the CPU usage over the duration of the test, which can be used to validate the metric provided in the table.

A recommended approach is to use the built in Performance Monitor and doing 60-second captures of the pre-defined 'System Performance' data collector set during normal and high load. The "start-up watermark" should be noted when a server is re-booted to provide a baseline value for these parameters.

The System Performance reports can then be analysed to look at the 'System / Processor Queue Length'. While this will not be a specification metric tested for, this is a much better single metric to look at load wise on multi-core servers and may be considered if system performance problems are being observed despite acceptable CPU utilization. The queue length should not be greater than two times the number of cores for extended periods of time; if it is that means code execution is being delayed.

Virtualization introduces more complexity, because allocation of work to cores is done by the hypervisor rather than the guest OS. If you want to view CPU utilization information via Performance Monitor, specific hypervisor-aware performance counters should be used. In the root partition of a Windows Server running Hyper-V, the "Hypervisor Root Virtual Processor % Total Runtime" counter can be used to track CPU utilization for the Virtual Processors to which a VM is assigned.

Memory Utilization also need to analysed and parameters such as Page Faults and Handle counts can be analysed to ensure the system is not thrashing. No Specification Metrics have been defined for these, but they may be considered if system performance problems are being observed despite acceptable CPU utilization.

5.5.3 Workstation CPU Utilization

This metric is related to the CPU utilization on the ezXOS workstation (refer to section 5.5.2 for more information on CPU utilization monitoring).

5.5.4 Historical Service Start-up

This is the maximum amount of time it takes to start the Historical database and associated OASyS services.

5.5.5 Disk Space

An alarm will be generated by the SCADA whenever the first level and second level utilization of the disks in the system are breached. This alarm may be configured to only alarm on the Supervisor's console or other SCADA support personnel's console by having the Supervisor consoles configured to receive these alarms while operator consoles have them disabled.

6. Data Loading Tests

The data loading tests summarize these Performance Specifications, including system benchmark and TPL specific requirements. The Summarized Data Loading Test criteria are used by the project teams to setup test loads for FAT load testing. Performance testing will include "Normal", Heavy Load" and "High Latency" tests.

For the data loading test the number of connections, PLCs / flow computers and the number of polls per cycle to be set to the values described in Table 4.1-1 and Table 5.2-1.

6.1 Normal Loading – Sustained 1 Hour

The normal load test represents the system load managed on a sustained basis. This table is used to determine performance when the WAN is available, and the stations are replicating to the MCC. WAN latency will be simulated at 50ms for the normal load test.

The SCADA system shall be loaded with the following:

Criteria	Station Load	MCC Load
Active Consoles	3	6
Active Displays per Console	5	5
Data changes from all Remotes combined	15 per second	750 per second
Historical Data – Update Rate	15 points per second	750 points per second
Alarms	1 per minute	10 per minute
Events	6 per minute	60 per minute
Setpoints throughput (discrete and analogue) to command queue	1 per second	6 per second
Maximum Setpoints (discrete and analogue) to command queue	15 per minute	60 per minute
Historical Database Queries	5 queries per hour returning 500 data points per query. Each query would execute in 40 seconds	30 queries per hour returning 500 data points per query. Each query would execute in 40 seconds

Table 6.1-1: Normal Loading Sustained

6.2 Heavy Loading – Burst 10 Minutes

The heavy load test represents the system load managed on a burst basis, for example in a pipeline upset with higher than normal data changes and alarm processing. This table is used to determine performance when the WAN is available, and the stations are replicating to the MCC. As this test requires higher than normal data throughput WAN latency will be simulated at 50ms for the heavy load test.

The SCADA system shall be loaded with the following:

Criteria	Station Load	MCC Load
Active Consoles	3	6
Active Displays / Console	5	5
Data changes from all Remotes combined	30 per second	1500 per second
Historical Data – Update Rate	30 points per second	1500 points per second
Alarms	3 per minute	30 per minute
Events	18 per minute	180 per minute
Setpoints throughput(discrete and analogue) to command queue	1 per second	6 per second
Setpoints (discrete and analogue) to remotes	15 per minute	60 per minute
Historical Database Queries	10 queries per hour returning 500 data points per query. Each query would execute in 40 seconds	60 queries per hour returning 500 data points per query. Each query would execute in 40 seconds

Table 6.2-1: Heavy Loading Burst 10 Minutes

6.3 High Latency – For 1 Hour

As opposed to the Heavy Load Test, the High Latency Test represents the system load managed during high WAN latency, for example when the network throughput is lower. This table is used to determine performance when the WAN is available, and the stations are replicating to the MCC. WAN latency will be simulated at 150ms for the high latency test.

Criteria	MCC Load
Active Consoles	6
Active Displays / Console	5
Data changes from all Remotes combined	750 per second
Historical Data – Update Rate	750 points per second
Alarms	10 per minute
Events	60 per minute
Setpoints throughput(discrete and analogue) to command queue	5 per second
Setpoints (discrete and analogue) to remotes	50 per minute
Historical Database Queries	30 queries per hour returning 500 data points per query. Each query would execute in 40 seconds

Table 6.3-1: High Latency