DEP SPECIFICATION

REAL-TIME OPTIMIZATION PROJECT STANDARDS

DEP 32.30.20.18-Gen.

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DESIGN AND ENGINEERING PRACTICE

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1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and provides recommendations for setting up the technology infrastructure for Downstream and Midstream online Real-Time Optimization (RTO) projects.

This DEP is intended to be used by those involved in designing, deploying, and upgrading RTO systems for Downstream and Midstream. It identifies generic functionality, standards and best practices, whilst allowing for differences in the time-line of when existing RTO systems were implemented, business requirements or local legislation that may require different implementations from one project to another.

This DEP provides:

- Specification of the key functionalities and supporting elements required from the infrastructure to support RTO.
- Specification of requirements for successful RTO project delivery.
- Specifications of requirements for sustaining RTO systems on Downstream and Midstream process units.

For additional clarification of requirements or guidelines regarding Real-Time Optimization, the RTO Subject Matter Expert (SME) should be consulted.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use primarily in downstream manufacturing, chemicals and mid-stream facilities. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorized to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

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1.3.2 Specific definitions

Term	Definition
General Process Management and Control System Model	Refer to ISA-99.00.01 Part 1 (2005). The model divides the architecture into a number of distinct levels as follows: • Level 5: Enterprise, Internet, Global Communications • Level 4: Desktop, Office Domain, Usually Site Wide. Site Production Scheduling. • Level 3: Process Control Network or Process Information Network, Optimizing Control. Real-Time Optimization. • Level 2: Distributed Control System, Operator Interface. • Level 1: Process Connected Sub Systems and I/O. Continuous Controllers. • Level 0: Field Devices The standard realization for the above within the Group is as per DEP 32.01.23.17-Gen., Appendix 2.
Office Domain (OD)	The Office Domain (OD) includes all devices, nodes, systems and networks required to provide a standardised enterprise-wide Information Technology environment, hence Levels 4 and 5 in the standard model. In Shell, the Shell Office Domain is standardised on GI and this DEP assumes that GI is fully implemented.
Process Control Access Domain (PCAD)	A Secure Cell consists of a Process Control Access Domain (PCAD) and one or more enclosed Process Control Domains (PCD). The Secure Cell ensures that Process Control Domains can work independently of the rest of the IT infrastructure (Office Domain). The PCD shall continue to function without losing its availability and integrity so that operation is not jeopardised even if there are problems in the Office Domain. Access to a Secure Cell shall be through one single entry point, the Process Control Access Domain (PCAD). PCAD is a Shell design. (Reference DEP 32.01.20.12-Gen.)
Process Control Domain (PCD)	Process Control Domain (PCD) covers Levels 1, 2 and 3 above, and has high level of security and availability, and a defined integrity level. Most PCD applications and systems are in direct communications with, and in control of, the operating units; where all field operations such as real-time process monitoring and control, safeguarding, validation of set points, equipment diagnostics and maintenance of the producing facilities are performed. The PCD shall be managed and engineered in accordance with DEP 32.01.20.12-Gen. and DEP 32.01.23.17-Gen.
Process Critical Data	Process critical data and documents are those which, when of good quality (accurate, consistent, accessible, available on time), improve the overall value derived from an asset, and when of poor quality (inaccurate, inconsistent, inaccessible or unavailable on time) may adversely affect the performance of key business processes at Levels 3 to 5. Safety and environmental data, while being critical in their own right, are not covered by this DEP.
Process Data Historian	System for the storage, archiving and retrieval of a broad range of process data (Plant Historian).
Process Enterprise Architecture	The Production Enterprise Architecture provides the Information Technology (IT)/Information Management (IM) framework to allow efficient delivery of information to support Process Control, Optimization and Engineering workflows. This architecture defines RTO IT requirements for Levels 4 and 5 of the General Process Management and Control System Model.

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Term	Definition
Real-Time Optimization (RTO)	Real-Time Optimization is used to determine a set of steady-state operating targets for the online control system to achieve the maximum profit possible within safe and practical limits of the process equipment while meeting all product stream specifications. RTO executes on the site's PCD.

1.3.3 Abbreviations

Term	Definition
APC	Advanced Process Control. In Shell, the standard APC controller is ExaSMOC.
CV	Controlled Variable. In APC, these are the process variables that are indirectly being controlled. In a simple base layer PID loop, the CV represents the variable that has an associated setpoint.
DACA	Data Acquisition and Control Architecture
DCS	Distributed Control System. For the purposes of this DEP, the abbreviation "DCS" is used interchangeably with other Process Control Domain data acquisition and control systems such as Programmable Logic Controllers (PLCs), Supervisory Control and Data Acquisition (SCADA) systems.
EDI	External Data Interface, the data I/O protocol RTO.
ESP	Ensure Safe Production
ExaSMOC	Shell Multivariable Optimizing Controller, Shell recommended APC application software licensed through Yokogawa
HMI	Human Machine Interface
KPI	Key Performance Indicator
MSDE	Microsoft Desktop Engine (SQL)
MV	Manipulated Variable. In APC, these are the base layer controllers or outputs that are being directly manipulated to achieve desired CV results.
ODBC	Open Database Connectivity
OLE	Object Linking and Embedding
OPC	OLE for Process Control. A group of standards, created by the OPC Foundation, which provides specifications for communicating data from devices and applications to provide current and historical data, such as databases.
OPC DA	OPC Data Access specification. OPC DA deals only with real-time data and not historical data.
OPC HDA	OPC Historical Data Access specification. OPC HDA deals with historical data and is used to exchange archived process data. RTO uses HDA data to capture average historical measurement inputs for the process model.
PACO M&O	In Shell, the RTO Center of Expertise group in the Projects & Technology organization. The engineering discipline is Process Automation, Control, and Optimization (PACO). The sub-team is Modelling and Optimization (M&O).
PFD	Process Flow Diagram

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Term	Definition
PI	Historian, an application by OSIsoft.
PIR	Post Investment Review
P&ID	Process and Instrumentation Diagram
ROMeo	Rigorous Online Modeling with equation-based optimization, RTO application software by Invensys SimSci-Esscor. Shell recommended RTO application software for continuous process units.
RTS	Real-Time-System, set of data flow control sequences required to execute RTO in an online environment
SCADA	Supervisory Control and Data Acquisition
SME	Subject Matter Expert
SMOCpro	Shell APC Design-time Tool
SQL	Structured Query Language
TaCIT PACO	Technical and Competitive Information Technology. In Shell, the TaCIT PACO (Process Automation Control & Optimisation) team develops and supports applications that span the real-time domain from measurement and instrumentation systems to real-time process optimization.
UniSim	Unified Simulation, RTO application software by Honeywell. Shell recommended application software for utility systems requiring mixed integer functionality.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets ( ). Other documents referenced by this DEP are listed in (5).

1.5 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using the DEP Feedback Form by:

- Entering comments directly in the DEP Feedback System on the Technical Standards Portal http://sww.shell.com/standards (mandatory for users with access to Shell Wide Web);
- Clicking on the DEP Feedback Form button on the DEPs DVD-ROM main page (for users without access to Shell Wide Web);
- Requesting a copy of the DEP Feedback Form from the Administrator at standards@shell.com (for users without access to Shell Wide Web).

For the last two options, the completed DEP Feedback Form can be attached to an email and submitted to the Administrator at standards@shell.com. Only feedback that is entered into the Feedback Form will be considered.

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2. SYSTEMS SUPPORTING RTO PROJECT DELIVERY

2.1 DATA SOURCES OVERVIEW

The RTO system shall reside on the PCD. RTO input and output data comes from various data sources as depicted in (Appendix 1). For example:

1. Real time process data input from the Process Data Historian (PI)
2. APC and DCS control status and limits input from the Process Data Historian (PI)
3. RTO model parameter inputs SQL database (MSDE)
4. Economic price inputs from Business Planning via ODBC (XLS)
5. APC controller information input from APC (SMOC)
6. RTO typically outputs data to the Process Data Historian (PI), SQL databases (MSDE) and directly to APC (SMOC)
7. In some cases, RTO is configured to input/output select data directly with the base layer distributed control system (DCS). This connection is not shown in (Appendix 1).

The operator interface to RTO shall be via a HMI on the PCD. The RTO support staff shall have a web based interface in the OD for general status monitoring and RTO output review.

2.2 PROCESS DATA HISTORIAN REQUIREMENTS

A Process Data Historian shall be provided for the medium and long term archiving of, and for near real-time access to, process data from process measurements and controls. As a minimum, data required by RTO to completely characterize the online process model and underlying APC and base layer control systems shall be captured and stored in the Process Data Historian. The Process Data Historian shall receive its data in real-time from various systems in the Level 2 and Level 3. The DCS and other systems in the PCD may have their own separate native data historians for operator graphics and trends. These will not be further discussed within this DEP and all references to Process Data Historians will refer to the long term Process Data Historian.

There should be redundancy at all levels of the historian architecture; the Shell global standard is a historian architecture that is fully redundant. The standard will be to have an L3 collective (at least two nodes, each with all tags and all data) and an L4 collective (all tags and all data but perhaps the data is less granular).

The Process Data Historian, residing in the PCD, interfaces to the L2 or L3 Process Control Domain data providers via the Process Control Network. The design and implementation of the Process Data Historian - L2 or L3 Process Control Data Sources link are critical for RTO and shall be subject to availability, redundancy and data-throughput considerations under supervision from the Principal's Process Data Historian focal point.

The Process Data Historian should be able to historize not just process data but also calculated results, including for example, calculated inputs required for APC and/or RTO and also results from those applications.

While data presentation is not its prime function, the Process Data Historian shall support at least one user interface to allow users in the OD to view both real-time and historical data trends. The Process Data Historian shall support data transfer interfaces to other applications, including downloads of process data into a spreadsheet.

The RTO Process Data Historian requirements for transmitting data from the process equipment, archiving data and performance standards shall include, as a minimum:

1. The Process Data Historian shall continuously store process data samples from the field at 1 minute intervals or less. Real-time data changes should appear in the Process Data Historian user interface within 2 minutes of actual process data change in the field. A minimum frequency of one value per minute should be targeted whenever possible. Data shall also be delivered at fixed intervals, at

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constant frequency.

2. Many of the process measurement inputs used by RTO are averages. The computation of these averages shall be done in the Process Data Historian.
3. The Process Data Historian may have time compression and resolution settings to allow reduction of storage capacity requirements, but these settings (resolution, time window size) shall be adjustable for individual signals. The party responsible for the configuration of the time compression and resolution shall propose settings for approval by Principal's APC and RTO representatives.
4. The Process Data Historian shall have availability in excess of 99.5 %.
5. The performance of the Process Data Historian in making data available to the PCD and OD shall be part of the commissioning testing of a facility. Performance of the Process Data Historian and its interfaces shall be demonstrated to and approved by the Principal's RTO representative.

2.3 RTO-APC INTERFACE REQUIREMENTS

In stand-alone mode, APC moves the MVs to keep the CVs within operated-entered limits or to achieve operator-entered targets. Alternatively, APC may use its available degrees of freedom to optimize an intrinsic, simplified objective function, which may have an economic flavor. When RTO is connected, it dictates operating targets for selected CVs and MVs to tie down up to all of the available degrees of freedom, thereby partially or fully supplanting the APC's intrinsic optimization capability.

The RTO-APC Interface is required to send each new set of operating targets from RTO to APC. The various parts of the RTO-APC Interface execute on the site's PCD. Based on the site's PCD configuration and desired operator RTO HMI location, the RTO-APC Interface may need to be customized at a site. However, the RTO-APC Interface functionality shall include, as a minimum:

1. Setup and configuration of the APC controllers to receive operating targets from RTO.
2. Addition of all new Process Data Historian points to support the data transfer and trending requirements.
3. Setup and configuration of RTO to receive APC and base layer controller information prior to running optimization case that determines new set of operating targets.
4. Steady-state detection and unit up/down determination so operator can monitor the state of the process unit via the RTO HMI.
5. Optimization solution (new operating targets) implementation management program.
6. Optimization target utilization statistics to track RTO KPIs.
7. Data transfer watch dog functionality to ensure data communications from RTO to APC and APC to RTO is working correctly.

RTO has the capability of to send operating targets to numerous destinations based on the specific configuration of a location's base layer DCS and/or APC controllers. If no APC control exists, RTO would send the targets to the base layer either directly (preferred method) or via the Process Data Historian. Normally APC will be in place and the targets will be sent directly to the APC controller or to the APC controller via the Process Data Historian.

The recommended best practice is to send all RTO targets directly to the APC controller for subsequent implementation. This includes "RTO-only" targets that are direct setpoints for base layer controllers that APC would otherwise not be using. These RTO-only targets are passed through the APC controller to the corresponding base layer controller. However, from the standard RTO-APC interface perspective, RTO-only targets are treated no differently than regular APC targets that are being set by RTO.

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2.4 PRESENTATION LAYER FOR RTO VISUALIZATION AND REPORTING

Means shall be provided for the visualization and reporting on user desktops in the OD of RTO results, real-time data and historical process data.

The visualized information should include, but not be limited to:

1. The steady-state and unit up/down status for the RTO process unit.
2. The current status of the RTO system.
3. A summary of the daily optimization target utilization statistics available for current day, past week, month to date, past month, year to date and past year.
4. Various presentation formats for the efficient analysis and review of data fit quality and optimization performance.
5. Historical trends for RTO targets and APC target limits.
6. RTO unit PFDs.
7. Historical trend of RTO implementation status from RTO-APC interface.

The reporting information should include, but not be limited to:

1. Data fit reports to assess the accuracy of the RTO process model's match to real-time process data.
2. Optimization reports to assess the optimization solution target moves, constraints and economic incentives.
3. Daily, weekly and monthly optimization target utilization report.
4. RTS sequence diagnostic logs to monitor the online status of the RTO.
5. Access to default reports and trace files that are generated as part of the standard RTO software platform.

2.5 BUSINESS PLANNING ECONOMIC INPUT

As a minimum, Business Planning shall provide RTO with the following input data at agreed upon time intervals; typically one week:

1. Marginal prices for all feeds, products and utilities in the RTO economic objective function.
2. Logistical constraints for feeds and products.
3. Product quality limits that are to be modelled in RTO that are not managed by the unit's APC system.

2.6 SITE PROCESS ENGINEERING TECHNICAL INPUT

Site Process Engineering should provide RTO with the following information:

1. The most recent version of any applicable Shell Models that are within the scope of the RTO project, i.e., SHARC model for fluidized catalytic cracking units, HxSTAR model for hydrocrackers, ECU model for ethylene cracking units, etc.
2. Input on any special modeling situations that need to be considered by the RTO project team.

2.7 CRITICAL SUCCESS FACTORS

The selection of an RTO project for a Downstream or Midstream process unit should be based on business requirements and identified economic benefits.

2.7.1 Prerequisites

As a minimum, the following prerequisites should be in place to ensure a successful RTO project:

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1. Adequate and reliable instrumentation (Levels 0, 1 and 2). The process must be observable; therefore there shall be sufficient instrumentation to completely specify the operation of the unit. If insufficient instrumentation exists, such instrumentation will be identified, justified, and included in the deliverables for the project where appropriate to do so.
2. Well-tuned Level 2 base layer control.
3. Functioning, stable Level 3 advanced process control, APC.
4. Key process equipment (valves, fans, pumps, etc.) must be reliable and functioning. Deficient equipment shall be identified and repaired, if justified.

In addition, it is important to minimize changes to the process unit during the RTO project. Process and/or instrumentation changes will require rework and slow down the project. Extended shutdowns during the latter half of the project will hinder online testing and commissioning of the RTO.

2.7.2 Principal site management

The RTO project/application should be supported by all of the Principal site management associated with the process unit to which it will be applied. This includes Business Planning, Production and Technical Management. The RTO project/application should be viewed as a team effort to improve the operation of the process unit. It shall be the responsibility of site management to provide the resources and define the roles and responsibilities necessary to make the RTO project/application successful. Site management should be visible in its support of RTO.

2.7.3 Core project team

The correct make up and organization of the RTO project team is critical to the success of the project. The project should be lead and executed by staff with sufficient expertise in the PACO M&O's RTO technology area. Key stakeholders who will eventually interact with the RTO system should be represented on the project team. The project team should be divided into core members and supporting members.

There are two options for the makeup and leadership of the core members of the RTO project team, depending on the level of optimization expertise at the Principle site, i.e., site.

1. Contractor lead turnkey project with site liaison.
2. Principal site lead project with Contractor consultant.

Recall that "Contractor" as defined in this DEP is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Contractor can be either an external company or Shell's RTO center of expertise group (i.e., PACO M&O).

Option 1 is designed for sites that do not have expertise or resources to execute an RTO project. In option 1, the Contractor provides the leadership and expertise to design, build and commission the RTO system. The standard RTO Project Delivery work process outlined in this DEP is employed to improve the efficiency of the project and ensure consistency across multiple RTO projects.

This option is complemented with a site liaison or focal point who will serve as the conduit for communication between the Contractor and the site. The site focal point supplies the Contractor with information required to design and build the RTO system (such as drawings, equipment detail sheets, control system design and data) and liaises with other site staff to ensure that the necessary infrastructure and work processes are in place to support the RTO system. The site focal point also participates in the build and commissioning phases of the project. The level of involvement in the build phase should depend on the site plans for developing the skills of its RTO engineers.

Option 2 is suited for sites that have both on-site RTO expertise and the resources necessary to execute the project. In option 2, the site RTO engineer leads the project and

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