



Employing Best Practices in Offshore Automation

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As Published in *Offshore*, November 2011

Automation projects for offshore production facilities are becoming more challenging. Tight schedules, new standards and technologies, a high degree of system integration and customization and complex execution environments are all common. Integrating Best Practices into a project is a proven approach for improving project outcomes. This is especially true for the Front End Engineering Design (FEED) phase of the project, a period when relatively low cost activities can create significant and positive results. Suggested FEED best practice examples are presented and their importance discussed.

Initial Activities

Figure 1 provides a conceptual FEED schedule for a Greenfield project. The initial phase of the project often begins by confirming the project scope, budget, studies, deliverables and schedule with the Client. A Main Automation Contractor (MAC), if employed, should be engaged and co-located with the Client’s technical team. Early activities often include a request to comment on the Client-provided Process Automation System (PAS) Philosophy and the topsides and hull Basis of Design (BOD) documents developed in the pre-FEED phase.

The PAS Philosophy is updated and FEED studies, if any, are clarified and confirmed. The BODs provide the technical frame and basis for the facility design, and are typically read by all disciplines and other contractors. The automation content in BODs, typically several pages in length, should summarize the major PAS subsystems and basic functionality, and the key concepts and technologies employed. Automation requirements that affect other disciplines and organizations should also be summarized.

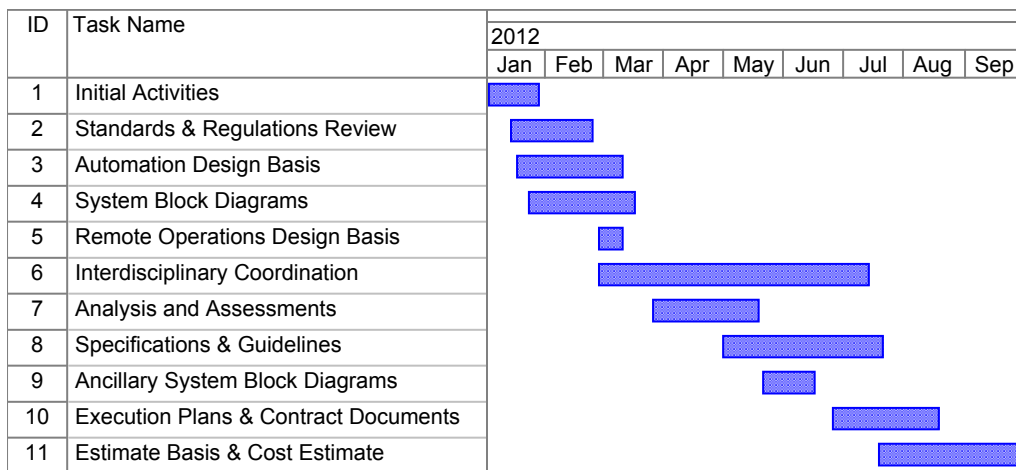


Figure 1: Conceptual FEED Schedule for a Greenfield Project

Standards and Regulatory Requirements

Early in the project the applicable regulations and standards (Client and industry) are reviewed and confirmed. When designing a facility in a new operating region, the environmental conditions, local design practices and regulatory requirements may differ from the Client standards and practices. Both should be reviewed and revised as needed to align with project requirements. Differences and discrepancies between documents should be reconciled, and a conflict-free set of project standards developed. The implementation approach for complex, multi-discipline standards like IEC 61511 and ISA S18.2, and regulatory requirements like API RP 75 are defined. Deferring this activity to the later Engineering, Procurement and Construction (EPC) phase can result in rework, unexpected change orders and potential design mistakes.

Automation Design Basis & System Block Diagrams

The Automation Design Basis (ADB) and System Block Diagrams are cornerstone documents that guide the development of all subsequent deliverables. Troubled automation projects that later experience frequent changes and significant design errors often begin with a missing, inconsistent or inadequate design basis. The ADB begins with a full listing of the regulatory requirements and the reconciled Client and industry standards. PAS subsystems and major components, interfaces to 3rd party systems, basic architecture and key technologies are described.

Basic requirements include control console design, monitoring and control functions, alarm management requirements, operator display types and the operating philosophy for controlling complex package equipment, e.g., compressors, from a Central Control Room (CCR). Basic hardware, power and electrical design requirements are defined. System wide topics such as PAS availability, reliability, performance, maintainability and sparring requirements are also defined. 'Lessons learned' are assessed and documented in a dedicated section to highlight their importance. Design studies are completed and the outcomes integrated into the document.

The PAS Block Diagrams should provide an accurate overview of the PAS architecture, major subsystems and equipment locations. Control consoles, engineering workstations, and PAS interfaces to packaged equipment, electrical systems, Fire and Gas Systems (FGS), the facility IT network and to a remote control location are shown. Indicating provisions for PAS future expansion may be appropriate. The diagrams should also provide an overview of the major networks including control, safety, 3rd party system and maintenance networks and the associated media types. Indicating the source power to critical equipment, e.g., 120 UPS or 24 VDC can be helpful during survivability assessments.

Selecting the appropriate drawing layout and density can simplify future changes and allows the drawings to be modified as needed for a network risk assessment process. Block Diagrams should also be provided for CCTV, power management, instrument asset management and machine condition monitoring systems to clarify major equipment components, architecture, location and scope of supply boundaries. The ADB and System Block Diagrams should provide a well thought out and consistent design concept that is fully aligned with the BODs and the Automation Philosophy documents.

Remote Operations Design Basis

A Remote Operations Design Basis (RODB) is an important tool for defining project requirements for monitoring and controlling an offshore facility from a remote location. This document should define the functional capabilities required at each location and the supporting infrastructure needed to support each capability. An example capability is a requirement to monitor and control an unmanned, producing facility from an onshore control room.

Another is a requirement for continuous and real-time access to facility integrity monitoring, weather, CCTV, and radar systems when the facility is not producing and abandoned in response to severe weather. Additional regulatory restrictions apply when operating in US waters.¹ Supplemental infrastructure may include alternate power systems, modified building HVAC systems, additional fuel and chemical storage, and telecommunications systems that provide the necessary network security, bandwidth and reliability.

Electrical Design Coordination

Working with electrical engineering, typical electrical schematics are developed that show the typical PAS hardwired, serial and network interfaces to common Motor Control Center (MCC) and Variable Frequency Drive (VFD) types. Authoring a mutually agreed VFD interface specification can be helpful. If a power management system is specified, decisions should be made on how this system connects to these and other electrical subsystems. Electrical one line drawings should include the major electrical support equipment identified in the ADB and RODB.

Process & Instrument Diagrams (P&IDs)

P&IDs identify most of the PAS I/O information needed to size the PAS system. Because of their high I/O contribution, P&ID 'typicals' should be developed for common control valve, MCC and VFD types that indicate PAS interface details and tagging conventions. PAS-connected fire and gas detectors, manual ESD stations and typical connections to packaged equipment, e.g., trip and trouble alarm status, are also considered when developing the PAS I/O counts. Presentation standards for alarms, complex controls, safety system functions and PAS interfaces to 3rd party and packaged systems are also agreed. A shutdown hierarchy logic tree may be included to provide an overview of the Safety Instrumented Functions (SIF). This document can be a valuable tool for Operations and used as a reference during hazard assessments.

Instrument Index and Tagging

A comprehensive guide covering instrument tagging, naming, character restrictions on tags and descriptors (inherent to some PAS) and standard abbreviations should be developed. Many corporate guidelines provide a good starting point, but seldom address the full range of tagging scenarios encountered. For computer aided design tools like Intergraph's SmartPlant Instrumentation (SPI), a project standard implementation guide, supporting standards, and SPI wiring module templates tailored to the selected PAS are essential. Custom SPI fields used to auto-configure PAS I/O should be identified

and implemented. The tagging guide and the SPI documents are issued to Vendors and contractors with a contractual obligation to follow these documents. Both contribute to achieving tagging and wiring consistencies across the facility. The SPI standards ensure the databases from different contractors can be merged into a single facility database at project completion.

Space and Weight

PAS space requirements can affect the topsides layout and the building and machinery space dimensions. Resistance to change in these areas often begins early. This information should be provided near the FEED midpoint for a project that has a major space and weight problem. The information needed to estimate cabinet counts and power consumption include the PAS equipment make and model, estimated I/O counts, equipment locations and spare I/O requirements.

Providing preliminary CCR and instrument rack room layouts ensures the proposed equipment fits correctly and provides the necessary egress spacing. The CCR layout is used to support the Operations and Human Factors review of the control room. PAS power consumption, used to size back-up battery systems, is needed to estimate battery weight and room size. Large, deck-mounted PAS panels are placed in the topsides 3-D layout model early to account for their space and weight affect.

Constructability

Minimizing PAS cables that cross module construction splits can reduce the offshore installation time and cost. By thoughtful selection of where PAS equipment is located, the cross-module interconnects are limited to fiber optic and network cables. A modular design enables the PAS to be commissioned in sections as construction progresses. UPS power-up is often delayed in fabrication yards. The quality of yard and temporary offshore power is often poor and can cause PAS damage and early aging.

Providing critical PAS equipment with a secondary power feed from a distribution panel sourced from the emergency bus and isolation transformers may be a prudent design. This design may be appropriate if the hull is installed and commissioned early and the electrical power is supplied from temporary generators. It may also apply if a shared backup generator is provided to support a Remote Operations mode when the main facility power systems are offline.

Specifications, Guidelines and Functional Safety

Developing technical specifications and guidelines is a significant FEED activity. The intended audience and use of each document should be assessed, and the content and level of detail thoughtfully determined. Completed documents must fully align with the ADB and Block Diagrams. All applicable standards and regulations listed in the ADB are referenced. Requiring deviations from a package equipment Vendor's standard design should be carefully weighed against the risk in terms of technical correctness, adherence to project standards, cost, quality and schedule. PAS interfaces to external systems, e.g., instrument asset management and machine condition monitoring systems, should be clearly and explicitly defined.

The Safety Requirements Specification (SRS) required by IEC 61511 and ANSI/ISA 84.00.01 is a special case because of its increased complexity and affect on other disciplines and organizations. (See Figure 2) Given the wide variance among contractors, the SRS content and detail should be agreed before work commences.² When the initial hazard assessments are complete, work on the SIF definition section can commence. Hazard assessments may be unclear, used incorrect assumptions or are missing important information. This triggers a return to the assessment process and hinders progress. To ensure timely completion, work in this area should begin early. Preliminary SIL calculations on common Safety Instrumented Function (SIF) configuration types are recommended to assure that FEED designs can meet SIL targets.

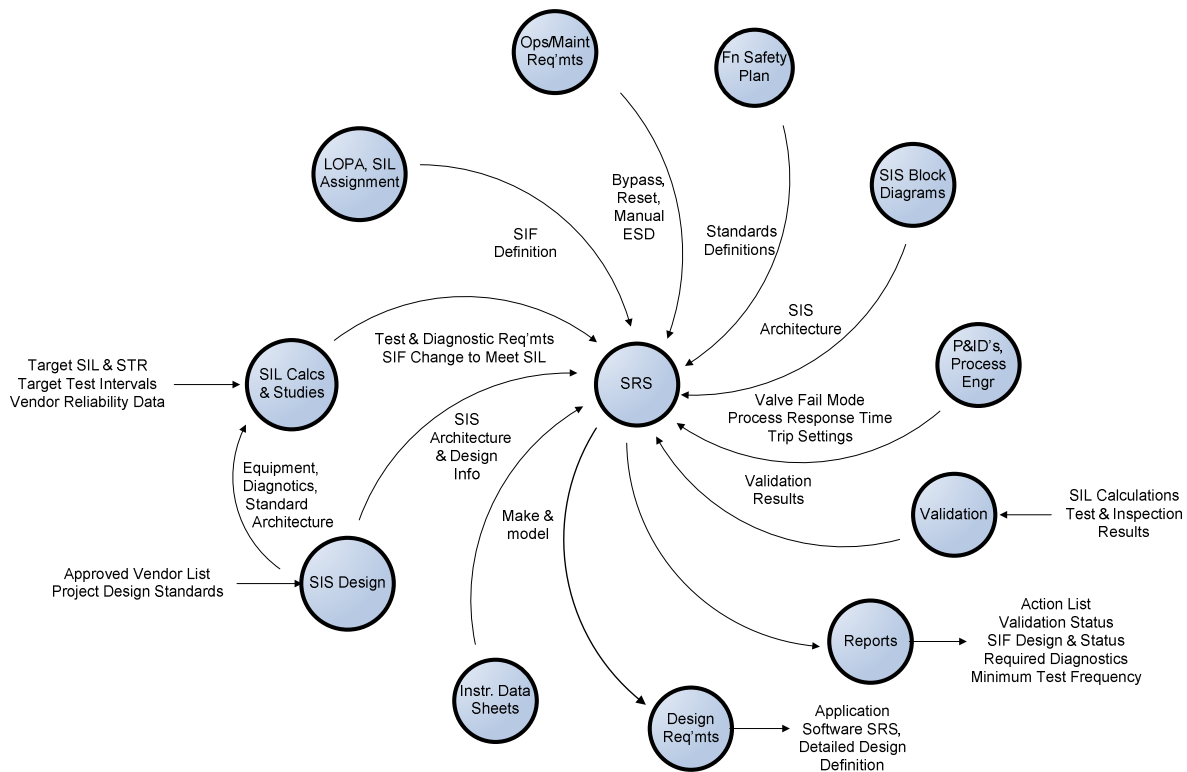


Figure 2: Safety Requirements Specification (SRS)

Package Equipment

A decision should be made early in FEED on which equipment packages are provided with embedded Packaged Equipment Control Systems (PECS). Contractual simplicity, warranty, project schedule and the span of control required from a CCR may be deciding factors. If a package is controlled directly from the PAS, a skid-mounted junction box is often the PAS interface point. Alternatively, an on-skid PAS panel that is prewired to skid instrumentation may be an appropriate option for a chemical injection skid given its increased tendency towards late design changes and high I/O counts.

If a PECS is specified, the PAS interface design may include a few hardwired signals supplied for critical alarms, control and safety functions, and a serial or network connection to manage the increased data exchange required to support remote monitoring and control. The remote capability tends to drive the

complexity of the PAS interface design. A software specification should be provided that defines the facility-standard 'handshake' protocol to detect interface failure and verify that network exchanged control commands are received and implemented. It also specifies the requirements for data exchange bit packing, use of floating and integer type points and scaling, local/remote control transfer switching and data needed to mimic the PECS HMI displays within the PAS.

PECS design and equipment selection can be affected if the package contains SIF components. Early identification of SIF requirements can prevent costly and late design changes. Industry and Client network security standards can place additional restrictions on the permitted PECS equipment and design and must be clearly defined.³ Critical packages may require redundant power feeds and on-skid power supplies. PECS interfaces to external instrument asset management, predicative machine monitoring and fire alarm systems are common. Package equipment vendors may have limited experience in some or all of these areas. Successful implementation requires clear and explicit requirements in procurement documents and specifications.

Design Coordination with Other Disciplines and Organizations

Achieving early design and schedule alignment with other disciplines and contractors can have a significant and positive impact on the FEED and EPC-phase work quality and productivity. When reviewing documents created by others it is often beneficial to insert technical clarifications and references to automation documents. This ensures that others have a shared and common understanding of a PAS interface requirement. The Instrument Design Basis should address partial stroke testing and safety transmitters if they are requirements in the SRS. The distribution of fire and gas alarming and executive actions is often unclear at this stage of the project.

A common FGS Cause and Effect Chart that summarizes the type of fire and gas detectors used in the facility, where they connect and which system initiates executive actions provides an invaluable coordination tool when issued to the topsides, hull and building contractors and package equipment vendors. The RODB should be referenced in the documents authored by other disciplines and organizations if they are charged with specifying systems that are affected by the requirements in this document. The topsides, hull, marine, subsea, and telecommunications design basis documents should reference the pertinent automation documents when there is a significant technical interface to PAS or an ancillary system, e.g., CCTV or asset management.

EPC Phase Execution Plan and Contract Coordination

The automation contracting and execution plan for the detailed EPC phase must be developed in time to support the cost estimate. The plan should be adjusted to reflect the contracting strategy employed. Critical path scheduling should identify the long lead and early need activities and equipment that may be needed before the EPC phase is sanctioned. Project and technology risk assessments should be performed to resolve areas of uncertainties that can significantly affect cost, schedule, quality or the technical design. When proposal requests for other contractors are being developed, an interface Roles and Responsibility matrix and a clear delineation of scope are both essential. Employing a MAC

contracting strategy changes the division of responsibilities between contractors. This must be included and detailed in their RFPs.

An aggressive PAS schedule can result if the project intends to float the hull early or requires early delivery of a high fidelity Operator Training Simulator (OTS). The OTS is often integrated with the PAS software to enhance operator training and to support design and verification studies. Other disciplines and organizations are affected if they provide information required to progress the early PAS design. The added cost and change in execution plans should be reflected in their proposals and contracts. The OTS vendor's proposal and execution plan should identify how they address the compressed schedule and staged and incremental deliveries of engineering information and PAS software. The overall goal is to logically distribute the schedule related risks between the affected parties.⁴

Cost Estimate

The scope of the Class 3 cost estimate and the methods used to develop the estimate is defined and agreed. Providing an 'Estimate Basis' document can be a useful approach. This document, issued early for Client review, lists the estimate assumptions and provides a narrative on how equipment and services costs are acquired or developed. The estimate process often has many sequential tasks of varying length and takes several months to complete. The work should be detailed and scheduled early to ensure a timely completion.

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2. Tom Shephard and David Hansen, "IEC 61511 Implementation – The Execution Challenge" (Control Magazine, May 2010)
3. Andrew Ginter and Walt Sikora, "Cybersecurity for Chemical Engineers" (Chemical Engineering June 2011)
4. Tom Shephard, "How to Develop a Project Execution Plan" (Control Engineering Magazine, December 2009)

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