+ PROCESS AUTOMATION

+ Main Automation Contractor and Electrical Consulting Services

PROJECT DESIGN AND IMPLEMENTATION GUIDE

sensia
Rockwell Automation + Schlumberger

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1. Executive summary

The main automation contractor (MAC) and electrical contractor services (ECS) approach is the most effective way to reduce cost overruns and eliminate schedule delays in heavy industry sectors. This approach has been demonstrated to lower the overall risks for both the owner/operator and the engineering procurement and construction (EPC) contractor, providing benefits in both capital expenditure (CAPEX) and operating expenditure (OPEX) savings and schedule reduction.

The savings from the reduction in schedule leads to early production and can yield benefits that often exceed the overall cost of the MAC/ECS contractor.

The Sensia approach to providing total lifecycle solutions for integrated control, power, and safety (ICPS) applications is to work with the plant designers to fully understand the plant operation our systems control and help protect, hence enabling Sensia to take full responsibility for the performance of those systems. The Sensia MAC/ECS group does not "build to print"; we apply our automation/electrical expertise and experience as necessary. We also challenge information we think is incorrect, inconsistent, or incomplete to avoid schedule overruns and expensive rework, thereby delivering fully fit-for-purpose solutions within schedule.

Sensia MAC/ECS teams proactively engage with the owner/operator and the EPC to achieve a "right first time" execution that minimizes both cost and schedule, while also addressing lifecycle OPEX benefits for the owner/operator. We maximize automation of the design and implementation phases using state-of-the-art toolkits and a set of best practices that are applied globally throughout Sensia. Sensia continually monitors and manages risk through a detailed and comprehensive project execution plan (PEP).

Our MAC/ECS model also addresses the control and safety aspects of cost and schedule, and optimized integration of third-party original equipment manufacturer (OEM) equipment and skids. This OEM package management engagement sees Sensia take full responsibility for the successful integration of the OEM equipment and the coordination of OPEX savings across all OEMs.

Sensia MAC/ECS teams engage early in the front-end engineering and design (FEED) phase to create the maximum value from our MAC/ECS expertise and experience. This allows us to work with the EPC(s) to align our best practices to further reduce schedule risk and lower costs. The FEED and MAC/ECS execution phases continuously consider the total cost of ownership (TCO) over the plant life. Throughout, the process, Sensia, with the operator and EPC, assesses the CAPEX costs versus OPEX benefits that may be achievable through design for minimum TCO over the lifecycle.

1.1 OVERVIEW OF CAPABILITIES

Sensia as a MAC can provide the following services:

1. Project management
2. Interface management
3. Control, shutdown, and fire and gas (F&G) systems
4. Design (instrument and electrical)
5. Construction support
6. Commissioning
7. Startup support
8. Lifecycle support

1.2 RESPONSIBILITIES

Sensia views their MAC/ECS project responsibilities as

+ Taking a proactive role in all aspects of the project
+ Being an integral part of the client's design and delivery teams
+ Supplying a functioning plant control, safety, communications, and information system, including risk responsibility
+ Supporting the entire instrumentation, automation, and electrical installation throughout each phase of the project
+ Managing data flow between the project management team, EPCs, package subsuppliers and the construction and commissioning teams
+ Developing the definitive basis of design (BOD) using the functional design specification (FDS) documents developed during FEED

2. Main Automation Contractor (MAC)

The Sensia MAC model provides for the following management, instrument, and commissioning services.

2.1 MAC MANAGEMENT SERVICES

By providing project management of the automation and controls, including field instrumentation engineering teams and vendors to maintain commonality of the delivery of goods and services, Sensia takes responsibility for the data transmission between parties.

When there are multiple vendors supplying the different process units, Sensia performs the interface-management function to help maintain a consistent and compatible control and shutdown solution. This relieves the burden on the client's project management contractor (PMC) to coordinate and pass information between many different parties.

Within the Sensia MAC/ECS model, Sensia's role when working with an EPC is a partnership – both parties benefit from the skill sets they bring to the project. In some cases, when required, the MAC/ECS role may be integrated into the EPC's project team, taking over the risk and responsibility for work packages from them. As part of any MAC/ECS project, Sensia provides complete end-to-end project management packages including support post plant handover and for facility startup. The package is tailored to the client's requirements and includes a full range of services from call-out to full-service agreements.

2.2 MAC INSTRUMENT SERVICES

Instrument services include the provision of engineering design and procurement of field instrumentation (measurement and analytical), metering, and associated scopes and specifications. The Sensia MAC instrument services are provided by the in-house engineering design services (EDS) group. The EDS instrument engineers take responsibility for the instrumentation that meets measurement and control needs of the plant process, as well as being compatible with, and interfacing to, the control and safety systems. The engineers in EDS realize that a thorough understanding of a well-defined work scope and application of relevant codes and standards in instrumentation/control analysis are critical for project success. The telecom services are included in the instrument services, and these are provided by Sensia via a third party.

Figure 1 illustrates the Sensia engineering design services. Sensia's areas of expertise include specification of field instruments (pressure, temperature, level, and flow) valves, metering systems, PID control, and calculations.

2.3 MAC COMMISSIONING SERVICES

Sensia provision of commissioning, final dynamic testing, and startup assistance is achieved by working with and alongside the EPC(s) and the construction services provider(s) on site. Thus, the integrated automation system is coordinated across the multiple process units.

As with the instrument services, the Sensia EDS group undertakes all activities associated with the commissioning of automation and instrument systems, including the production of commissioning procedures.

Sensia commissioning services are broken into three categories: precommissioning activities, commissioning activities, and startup.

Precommissioning activities begin after mechanical completion but prior to commissioning to prove and validate the functioning of the installed equipment. At the end of the precommissioning stage, systems should be fully compliant and capable of being referred to for full commissioning with any punch list items of a minor nature. Mechanical completion (or construction completion) is achieved when inspection and testing for workmanship and materials has been finalized. This helps validate and prove that the construction or modification work has been carried out in accordance with the scope and defined specification and has been correctly documented. The range of precommissioning activities includes factory acceptance testing, SAT punch listing, instrument loop testing, and electrical cable and motor testing.

Commissioning activities undertaken after precommissioning dynamically verify the functioning of the equipment and facilities forming part of a system is in accordance with specified requirements to bring that system safely into operation. During commissioning, the various systems and equipment are first put into initial operation using safe chemicals or fluids. Utility systems, instrument air, cooling water, and general-purpose water are completed, and the core process systems are first made operational typically with safe chemicals, air, or water. The units are leak tested, started up and shut down, and distillation columns and scrubbing columns are put into use, all to gain the confidence that when process chemicals are introduced, the plant operates as designed and intended.

Startup begins after all precommissioning and dynamic commissioning activities are complete and any remaining punch-list items are of a minor nature and have no impact on a fully functioning plant. The plant is ready to be brought into operation.

2.4 MAC AUTOMATION

Automation covers the control, shutdown, and information system(s) services scope, along with the engineering design and responsibility of verifying compatibility and interfacing of the automation system(s) with interconnected devices and intelligent systems within a project process package/skid.

The Sensia engineering services business provides value-added solutions through a combination of expertise and experience and the utilization of the latest technologies in areas areas including the following.

Advanced process control – Scalable model predictive control helps achieve optimal operation.

Distributed control systems (DCS) – The Rockwell Automation PlantPAx® DCS integrates modern plant automation to drive productivity, increase efficiencies, and reduce costs. Sensia offers both standard and safety chassis-based I/O to integrate with Allen-Bradley® controllers. Distributed I/O can be mounted in-cabinet or on-skid in both modular and block designs.

Design and operations software – The premier integration of Rockwell Automation software with our world class automation and control systems delivers a seamless process, from implementation to operation.

Human machine interfaces (HMI) – Visualization and HMI solutions provide productivity innovation, complying with high performance graphics industry standards. Sensia provides a consistent look and feel for electronic operator interface terminals, distributed client/server HMI, and information software.

Network solutions – Sensia offers industrial network solutions, including switches, routers, physical media, and connecting products.

Manufacturing execution system (MES) – MES solutions provide standardized workflows for operators to help sustain regulatory compliance. The MES supports continuous improvement initiatives by providing new ways to analyze process data.

Motion control – Our portfolio includes various industrial motion products and software and modular track systems.

Programmable logic controllers (PLCs) – Sensia provides Rockwell Automation PLCs and information-enabled programmable automation controllers (PACs).

Safety instrumented systems (SIS) – Sensia uses Rockwell Automation safety architectures that support fault tolerance for system components and scalable options including fail-safe, fault tolerant, and triple modular redundancy (TMR) options for applications with safety integrity levels (SIL) up to, and including, SIL 3. We also offer dedicated resources to support the design, implementation, and deployment of complete process safety solutions using certified functional safety engineers.

Industrial automation and control – The rapid evolution of technology in industrial automation systems requires tighter integration between devices on the plant floor and the rest of the enterprise. This integration requires a secure network infrastructure, smart devices for efficient data collection, and the ability to turn data into actionable information. The integration of Sensia control and information across the enterprise enables owner/operators to optimize their operations by connecting the plant, site, facility, and people. We deliver industrial automation and control through our control systems, motor control, and smart devices portfolios. The combination of these three platforms is architected and designed to help build the most efficient industrial automation system to meet project needs.

Intelligent operations solutions – The Sensia MAC approach to the connected enterprise is through smart process operations to enable a gateway to digital transformation. Connected, smart devices enable greater visibility into processes. Data and analytics enable better and faster decision making. Seamless connectivity spurs new collaboration. The connected enterprise converges plant-level and enterprise networks and securely connects people, processes, and technologies, delivering the right information to the right worker at the right time, which empowers plant operators to make better decisions.

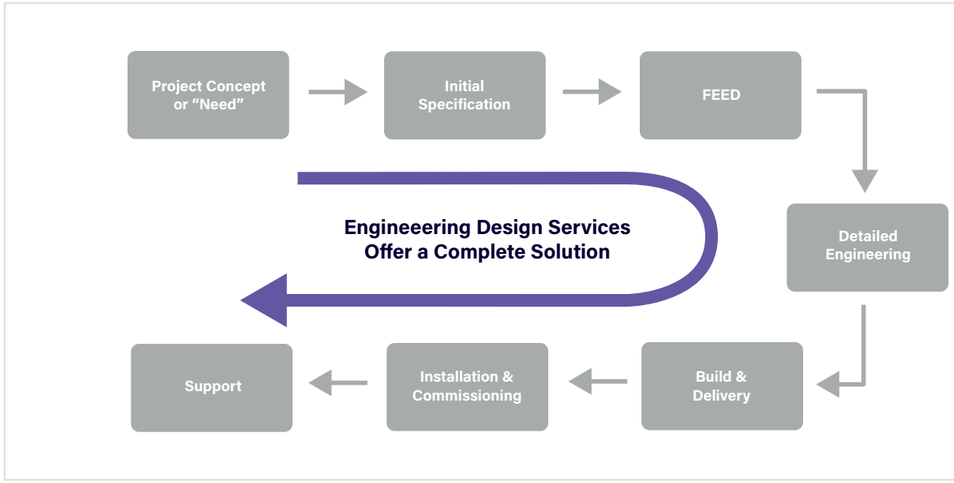


Figure 1 Sensia Engineering Design Services

Network design and cybersecurity – Sensia has long been engaged in industrial automation networks and security.

Additionally, Sensia has partnered with Cisco, an industry leader in network infrastructure, to provide industrialized Ethernet components using Cisco technologies and to co-author recommendations, tools, and best practices for deployment in the industrial space. Other notable companies in the cybersecurity field that Sensia works with are Symantec and Claroty.

Our dedicated networks and security service team is 100-percent focused on network design and cybersecurity.

+ The network and security services (NSS) team has extensive expertise in common industrial security standards/frameworks and best practices to provide strategic guidance to customers on how to implement risk management techniques catered towards ICS environments.
+ Our team consists of information technology/operational technology (IT/OT) security professionals that understand risks, threats, vulnerabilities, and mitigation techniques from both IT and OT disciplines.
+ The NSS team is solely dedicated to assessing, designing, and implementing security controls within an ICS environment.
+ We understand priorities of the ICS when conducting cybersecurity-related activities in the ICS environment.
+ Our delivery process is cognizant of the requirements of cybersecurity standards such as IEC 62443.

3. Electrical Consulting Services (ECS)

The Sensia ECS model provides for management services, electrical studies, electrical integration services, electrical design services, and commissioning services.

3.1 ECS MANAGEMENT SERVICES

Management services provide project management of the plant-wide electrical system, including supply and distribution engineering teams and vendors. This achieves commonality for the delivery of goods and services taking responsibility for the data transmission between parties. The management services team also takes responsibility for coordinating and integrating all electrical equipment and systems and managing the interfaces. Where there are multiple vendors, Sensia performs the interface management function to maintain a consistent and compatible solution. This includes the interfaces to the automation and shutdown systems. The success of a project largely depends on effective integration of electrical and automation systems.

3.2 ELECTRICAL STUDIES

Sensia's experienced engineers provide FEED studies and power system modeling and design services to support a project – whether it is a study to provide a bespoke solution for a new plant or making modifications/adding additional equipment to existing power systems.

Electrical studies related to the following areas can be provided:

+ Power system analysis and load flows
+ Protection grading studies
+ Power factor correction
+ Harmonic studies and analysis
+ Earthing and lightning protection
+ Energy and load management studies
+ Analysis of impact of variable frequency drives (VFDs) on a power system
+ Equipment replacement (motor control centers, MCCS, and transformers)

3.3 ELECTRICAL INTEGRATION SERVICES

Sensia has an extensive selection of Rockwell Automation motor control and power products to choose from, which facilitates the ECS role. For these products, the connectivity and integration provided by Rockwell Automation is best in class (i.e., Premier Integration).

In those instances where Sensia does not have a product, partners and consortium agreements to streamline third-party content are available.

Integration with management services, electrical studies, electrical integration services, electrical design services, and commissioning services is via IEC 61850 standards, making use of intelligent electronic devices (IEDs), microprocessor-based controllers with the capability of serial communication with equipment such as protection relays, circuit breakers, transformers, and voltage regulators.

IEC 61850 provides a standardized framework for substation integration that specifies the communication requirements, the functional characteristics, the structure of data in devices, the naming conventions for the data, and how applications interact and control the devices.

Sensia performs the electrical integration function to deliver a consistent, compatible, and integrated solution. This includes integration of the safety, protective, power, and automation systems. This integration is a key element in the success of a project.

3.4 ELECTRICAL DESIGN SERVICES

An electrical engineering design services team (EEDS) provides the engineering design and procurement of electrical equipment medium voltage (MV) and low voltage (LV) for associated scopes and specifications. EEDS electrical engineers take responsibility for the electrical supply and distribution needs of the plant, as well as verifying compatibility with, and interfacing to, the control and safety systems.

The design and procurement of electrical equipment related to the following areas can be provided:

+ Electrical reticulation design (LV and MV)
+ MCC design
+ MV protection and switchgear design
+ Lighting and small power design
+ Electrical and lighting protection design
+ Electrical equipment specifications preparation
+ Procurement vendor management
+ Construction design
  + Electrical equipment layout design
  + Lighting and small power layouts
  + Cable schedules
  + Cable racking and routing design
  + Interfacing design
  + Cable block diagrams
  + Termination schedules
  + Commissioning, startup, and handover documentation

3.5 COMMISSIONING SERVICES

Commissioning services encompasses commissioning and startup assistance. Final commissioning and startup assistance is achieved by working with and alongside the EPC(s) and construction services provider(s) on-site. Thus, the plant electrical system is coordinated across the multiple process units.

Within the Sensia MAC/ECS model, the role of an EPC is that of a partnership with both parties benefiting from the skill sets they can bring to the project. Where required, the ECS role can be integrated into the EPC's project team, taking over risk and responsibility for work packages from the EPC.

The EDS commissioning services are divided into several categories:

+ Mechanical completion (or construction completion)
+ Precommissioning (or cold commissioning)
+ Commissioning (or hot commissioning)
+ Startup, when the plant is brought into actual operation

4. Functional safety services

Our process safety team provides safety engineering and consultancy services to the oil & gas, petrochemical, and other process industries.

Safety standards take into consideration much more than just process functionality. They assist in achieving not only compliance, but also productivity and flexibility safely. Safety and productivity are not mutually exclusive goals.

Using the contemporary technologies and experience in automation, solutions are productive, flexible, compliant and cost-effective. Sensia has a global safety team to support the functional safety elements of a project, from training and standards assistance through validation and startup:

+ Functional safety management systems
+ Hazard and operability (HAZOP) study
+ SIL targeting
+ SIL assessment
+ Product certification
+ Quantified risk assessment (QRA)
+ Consequence analysis
+ General reliability/availability studies
+ Functional safety training including TÜV certification

5. Project support services

Sensia includes full planning and management support for a project in the following areas:

+ Overall execution strategy in the form of a project execution plan (PEP)
+ Resourcing
+ Detailed execution plan(s)
+ Detailed vendor schedule(s)
+ Project goals and objectives
+ Key performance indicators

6. Project interfaces

The Sensia project delivery/interface manager has overall responsibility for implementation of and maintaining the interface management process for the project lifecycle. The role requires implementing the Sensia project interface management work procedures (these may be project specific), capturing the necessary interface agreements, monitoring progress, confirming project schedule requirements are met, and identifying and/or initiating any design-change requests that may arise out of the discipline or management interfaces.

Depending on the size of the project, the Sensia MAC/ECS project interface manager is supported by a team of project interface engineers, who, if required, can be embedded in the offices or yards of other stakeholders and be the interface liaison with the client PMC, major vendors EPC interface representatives, or teams.

The objective of the interface management process is to facilitate interface agreements with other stakeholders regarding roles, responsibilities, battery limits, and timing for interface information and identification of critical interfaces early and throughout in the project lifecycle.

The interface agreement may typically include

+ Battery limits, as defined on project drawings such as P&IDs
+ Interface matrices
+ Interface register

The aims of the Sensia interface management team are

+ The early identification of issues with the potential for impact to budgets or project schedules and to mitigate against or remove the possible disruption scenario that may ensue
+ Working with others to promote clear, accurate, timely, and consistent communication between Sensia the owner/operator, client PMC, major vendors, and EPCs for the exchange of interface information.

The Sensia interface management process is designed to provide a method to formally document, track and monitor the interface flow of information between interface agreement entities to help verify information is available as and when agreed.

The process involves

+ Identification and interface agreement
+ Creating a vehicle to support an interface agreement
+ Agreeing/resolving conflict
+ Monitoring the status of the interface
+ Reporting the status

7. Brownfield MAC/ECS capabilities

Sensia has extensive experience in the assessment, engineering, and implementation of brownfield control, safety system extension, and full migration MAC/ECS projects. Our experience is most comprehensive with "live" migrations of control and safety systems where a methodical, meticulous, and thorough approach to all aspects of the job is required to help achieve a successful upgrade.

Sensia understands the drivers behind the need to extend or upgrade existing systems and the detailed engineering processes required to fully implement a project.

7.1 UPGRADE STRATEGY

Implementing a control or safety system upgrade or extension requires an in-depth analysis and risk assessment of the existing technology to obtain a solid understanding of the requirements needed for a new system. Any system upgrade should follow a systematic and well-documented process.

Sensia uses the following approach:

1. Establish a baseline
2. Evaluate the current plant and system architecture
3. Design the new system from the evaluation
4. Build and thoroughly test the new system in the factory
5. Meticulously plan and manage the system migration
6. Benchmark the existing functionality
7. Install the new system in its final location
8. Implement the migration strategy

8. Project phase: Sensia MAC/ECS involvement

In the oil & gas, petrochemical, and other heavy industries, such as mining and steel mill sectors, significant financial commitments are made for both

+ Commercial opportunities including business transactions, joint ventures, mergers and acquisitions and divestments
+ Capital projects (both greenfield and brownfield)

These investment commitments have wide-ranging and long-term implications, not only during design and execution of the project, but also during subsequent operation and maintenance, including abandonment and decommissioning of the assets or facilities.

Based on international best practices, a decision-based stage gate methodology has been developed by the industry to maximize value creation throughout the entire opportunity or project lifecycle. Details and terminology of this opportunity/project realization process may differ between individual businesses or companies, but fundamental principles are the same, including distinct maturation stages: identify and assess, concept select, define, execute, and operate.

Benchmarking results stress the importance of front-end loading, where significant resources and efforts need to be applied in the initial phases of the opportunity/project to maximize long-term value. Refer to Figure 2 for a typical large project stage flow.

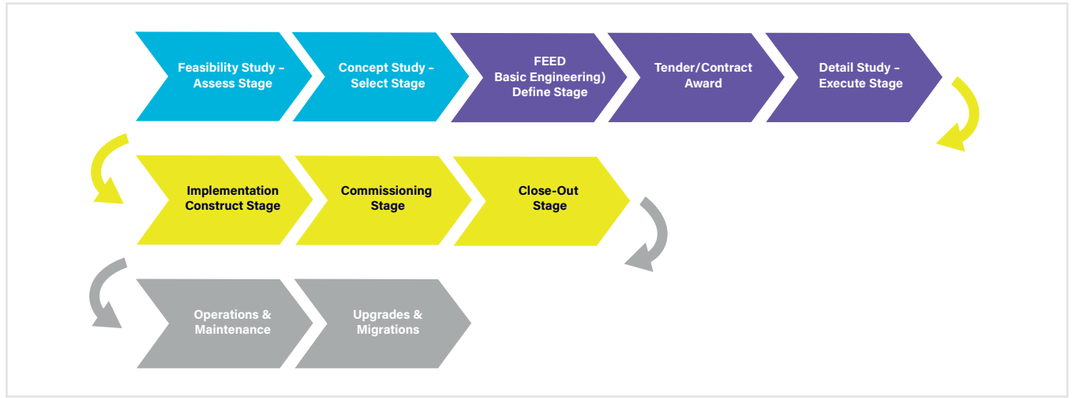


Figure 2 Typical Large Project Stage Flow

8.1 FEASIBILITY STUDY – ASSESS STAGE

The feasibility study is the first stage of a project during which the operator, generally supported by an engineering management company, investigates the most convenient technologies or processes to be used. This feasibility study also integrates all the corresponding cost aspects. The main objective of a feasibility study is to demonstrate technical and economic feasibility. The level of definition in the feasibility stage is limited; however, in some area, it may be necessary to develop the study in greater depth to demonstrate feasibility.

The conclusions of the feasibility study are not a straightforward recommendation of project go or no go, but a pragmatic list of conditions that can influence the project positively or negatively. Areas generally covered in the feasibility stage are the following:

+ Studies
+ Option identification
+ Construction methodology
+ Screening studies
+ Preliminary site investigation
+ Field development plan
+ Process requirements
+ Schedule and budget/costs development
+ Environmental considerations

8.2 CONCEPT STUDY – SELECT STAGE

From the feasibility stage, a project deemed to be economically viable moves into a conceptual study (select stage).
The objective of the concept study is to select and define the facilities concept and conclude the profitability and execution risk is satisfactory to operator requirements and business plans. This includes the selection, amongst a wider range of alternatives, of typically one technical concept as the basis for the FEED in the next project stage. The concept study may also be called pre-FEED.

During the conceptual study, the Sensia engineers

+ Investigate the multiple technologies to be used
+ Evaluate the costs of each solution, especially during the total lifecycle of the project, including capital expenditure for the construction (CAPEX) and operational expenditure (OPEX) to run the plant
+ Estimate construction challenges versus benefits in operations and vice versa
+ Measure the impact on the environment (footprint, water and energy consumption, CO_2 emissions, local acceptance, and decommissioning and restoration costs)
+ Draft a plan corresponding to each solution to identify critical items
+ Identify potential risks on the project and hazards for personnel
+ List all the required offsites and utilities
+ Determine all the infrastructures needed to bring in the feedstock and to export the production
+ Include local constraints about regulation, taxation, employment, and content
+ Complete concept selection
+ Perform site investigation
+ Compile maps, layouts, and geographical information
+ Select codes and standards
+ Evaluate environmental and social consequences
+ Assess risks
+ Determine project costs estimates and overall economics
+ Engage with other work groups and third parties to reduce uncertainties, for example drilling, reservoir engineering, tie-ins to other facilities, regulatory authorities, and/or buyers of products
+ Develop risk-mitigation plans
+ Complete a project execution plan and finalize contracting strategy
+ Update the basis of design
+ Begin the environmental and social impact assessment (ESIA) process

From the above activities, the development enters the FEED with a single, well-defined option. The major design issues have been decided; risks and uncertainties are understood; and the budgetary cost estimate, budgets, and schedules are clear and complete.

8.3 FEED (BASIC DESIGN) – DEFINE STAGE

The FEED may also be called basic design. This stage follows on from the feasibility study to expand in detail the different technical and financial options considered during the feasibility study. The FEED enhances the definition of the process, the plot plan, the long lead items, most of the key requirements, and the preliminary vendors list.

The Sensia MAC/ECS team understands that poor project definition can lead to cost and schedule overruns. The design basis is thoroughly reviewed and, if necessary, challenged, providing a springboard for the project. Design decisions based on too many assumptions and price estimates made in haste can haunt an organization during the project execution phase.

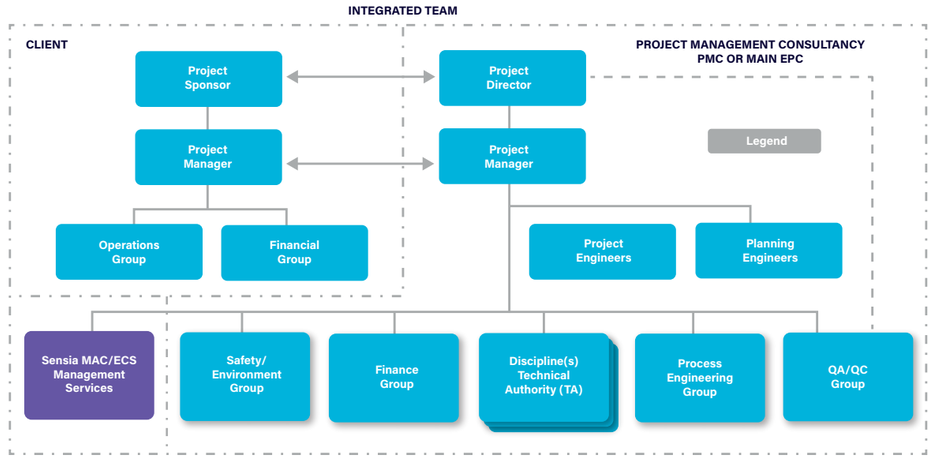
Because of our fundamental belief in the benefits of FEED, we verify any project in which the Sensia MAC/ECS team is involved is carefully planned and executed following a gated process, resulting in successful project completion within budget and on time.

For large projects involving multiple production units, breakdown of the different packages to be posted for bid to the engineering companies and contractors at the execution phase is prepared.

The objective of the FEED stage is to further develop and document the development opportunity based on the selected concept to such a level that a final project sanction can be made, application to authorities can be submitted, and the basis for contracts can be established. A full FEED uses budget quotes for both equipment and bulk materials.

The FEED is critical for all parties. For the owner/operator, the FEED conditions the profitability of the project and how flawless the future construction can be in anticipating potential risks. For the MAC/ECS, it is crucial to impose their processes or licenses. In some cases, the engineering companies performing the FEED are not involved in the next phase of the execution, whereas in other cases they are. This depends on the end user's policy and on their own engineering companies' strategy. Their respective decision must be made at the early days of the project announcement.

A well-executed FEED can deliver an increased accuracy of project costs. Poor project definition can lead to cost and schedule overruns, so the design basis should be thoroughly challenged before being accepted.



Organogram legend

Title	Client or project management consultancy
Title	Sensia role
Title	Sensia role that has been depicted in a previous organogram
Title	Joint venture or partner role. Communication is used as an example of a JV/partner (other JV/partners could include specialist services such as metering)
Common Services	Abbreviated form descriptor for services that are used on the project that do not have a role for a dedicated individual(s) such as project administrator, document
Title	EPC role

Figure 3 Team Organogam for FEED (BASIC DESIGN) – DEFINE STAGE

Risk and opportunity management: The Sensia risk and opportunity management plan is fully developed prior to the MAC/ECS contract award. The plan identifies the process used to evaluate and manage the range of business risks and opportunities facing the project. The risk and opportunity management plan also confirms the project has the correct controls in place to provide sufficient mitigation from risks, without stifling the opportunities to reduce project costs and timescales.

The Sensia risk and opportunity management plan provides many benefits benefits, including, but not limited to

+ Improved strategic, operational and financial management
+ Clear-cut decision making
+ Improved services
+ Excellent project outcomes
+ Effective use of resources
+ Taking advantage of key opportunities and mitigation of key risks
+ Identifying and controlling risks at an early stage so that the project and identified opportunities are more likely to succeed

Responsibilities

The Sensia MAC/ECS-specific responsibilities during the FEED are to produce the following documents:

+ Plot plans (e.g., instrument, F&G, telecom, electrical interfaces)
+ Architecture and networks
+ Preliminary I/O schedule
+ Base FDS for
    + PCS/DCS FDS
    + ESD FDS
    + F&G FDS
    + Metering FDS
    + Telecoms FDS
    + Power management system (PMS)
+ Vendor package interface FDS
+ Third-party work scopes
+ System philosophies
+ Requirement specifications
+ Package specifications
+ Advanced control and optimization specifications
+ Input to PFD, P&ID
+ Equipment general arrangements
+ Hazard identification (HAZID) reports
+ Basis of design (BOD)
+ Control narratives
+ Control, safety, and operational procedures
+ Network architectures
+ Validation strategy
+ Power system analysis and load flows study
+ Base electrical design criteria
+ Electrical equipment list
+ Single-line diagrams (SLD) – high level/overview
+ Layout drawings – high level/overview
+ Electrical schematic drawings (typical)

Integrated team deliverables

Sensia MAC/ECS, as part of the integrated delivery team (Sensia, PMC, EPC), has responsibility during the FEED to input to or produce the FEED documents listed (but not limited to) below:

+ Project specification
+ Strategic plan
+ Project execution planning (PEP)
+ Risk and opportunity management plan
+ Tender strategy document
+ Conceptual engineering
+ Risk register to track the risk mitigations
+ Schedule for the execution phase
+ A sound technical basis for the execution phase (detailed design, procurement, and construction) with minimal uncertainties
+ A basis for an accurate cost estimate
+ Feasibility studies (and bankable studies)
+ Process flow diagrams (PFDs)
+ Plot plans
+ Economic feasibility studies
+ Preparation of project financing
+ Managing the development risks
+ Identification of all the risks/opportunities and sensitivities
+ Verification that the risk levels are kept as low as reasonably practicable (ALARP)
+ TECOP model for risk evaluation
    + Technical risks
    + Economic risks
    + Commercial risks
    + Organizational risks
    + Political risks
+ Assurance reviews
    + HAZID
    + Design review
    + HAZOP
    + QRA
    + Finite element analysis (FEA)
    + Safety and operability (electrical systems) (SAFOP)
    + Instrumented protective functions (IPF)

Tender/contract award

Sensia in the role of MAC/ECS, and as part of the integrated delivery team, provides input to the tender contract award stage activities noted below.

+ **Planning and scheduling**: The integrated delivery team prepares the pre- and post-contract plan and schedule.
+ **Development of contracting strategy**: The development of an overall tender strategy document is the responsibility of the integrated delivery team. Support or representation (if required) is given by Sensia at the client procurement and contracting steering committee (PCSC) approval stage, or at the tender board presentation.
+ **The contracting strategy**: The contracting strategy objectives are the project drivers. The strategy document also deals with any alternative contract scenarios/options for delivering the project requirements. Workshops to identify the contract pricing structure may be beneficial.
+ **Selection of tenderers**: There are various options for selecting tenderers to participate in a tender, such as prequalification, registered contractors, preselection and unregistered contractors. The option selected is based on the preliminary cost estimate and risk profile of the contract.
+ **Tender document preparation**: The tender and contract documents are usually prepared by the integrated team contract engineering group. The contract engineering group is the single focal point for correspondence and discussions with the tenderers at the pre-contract award stage.
+ **Tender period**: The contract engineering group verifies all technical queries from tenderers are clarified. The contract engineer arranges for pre-tender submission meetings and site meetings if necessary.
+ **Tender evaluation**: The contracts engineer prepares the technical evaluation model and the commercial evaluation model. These models must be presented to the client tender board for endorsement.

8.4 DETAIL DESIGN – EXECUTE STATE

The objective of Sensia in the detailed design phase is to further develop and document the development opportunity based on the FEED to such a level that final project procurement and construction can commence.

Detailed design and engineering (automation): The architecture (networks such as Ethernet/IP and other field networks) is developed and the determination and collation of all I/O is confirmed to allow the hardware and software build for all systems.

Detailed design and engineering (instruments): This involves development of the required specifications/data sheets for field instruments and equipment (and procuring the same), construction documents and drawings up to approved for construction (AFC) stage for the construction, and detailed bill of materials (BOM) for the bulk material procurement based on the basic or FEED package.

Detailed design and engineering (electrical)

Develop all required detail design and construction documents and drawings up to the AFC. This typically includes the following

+ ECS electrical studies as required or specified during FEED
+ The compilation and acceptance (e.g., by the client and EPC) of the electrical design criteria document
+ Electrical design including all required single line diagrams, motor and load lists, electrical equipment list and specifications, electrical schematics, etc.
+ Procurement including bill of quantities, inquiries for technical procurement on behalf of the client/EPC, bid adjudication, and reports
+ Construction design including electrical equipment layout design, lighting and small power layouts, cable schedules, cable racking and routing design, interfacing design, and termination schedules
+ Construction work package including the construction work scope, drawings issued for construction, schedule, inspection, and testing requirements, etc.

Refer to Figure 4 MAC/ECS detail design stage organogram.

8.5 IMPLEMENTATION/CONSTRUCT STAGE

For instrument and electrical field construction activities, Sensia typically uses the services of the appointed electrical and instrumentation (E&I) site services contractor, using installation supervision expertise. The contractor's construction engineers are embedded in the Sensia project and design team from an early stage, thus achieving a smooth transition from design to construct. Sensia can, if required, produce construction work packs, job cards, and completions certification.

8.6 COMMISSIONING STAGE

The Sensia objectives during commissioning are to demonstrate and record equipment or control, shutdown, telecom, or electrical systems that have been modified or installed and are able to perform safely in accordance with specified requirements; bring the equipment or system safely into service; and hand it over to the asset owner/operator.

Fundamentally, commissioning is a series of checks and counter checks that confirm a newly constructed plant is fit for purpose and suitable for ongoing operation. The checks are made at all stages of the project's life, not just after construction is complete.

The Sensia MAC/ECS commissioning concept for all engineering projects follows a simple industry standard outlined below:

+ Preparation
+ Planning
+ Execution
+ Performance testing
+ Documented handover/closeout

Commissioning is best described split into three categories.

Precommissioning: Precommissioning activities that start during the construction phase of a project and prepare and enable the equipment or system to move to the main commissioning phase.

Commissioning: In this stage, the various systems and pieces of equipment are first put into initial operation. Utility systems, instrument air, cooling water etc., are made live, and the core process systems are first made operational, typically with safe chemicals/liquids, air, or water and first fills.

Startup: The plant is brought into operation.

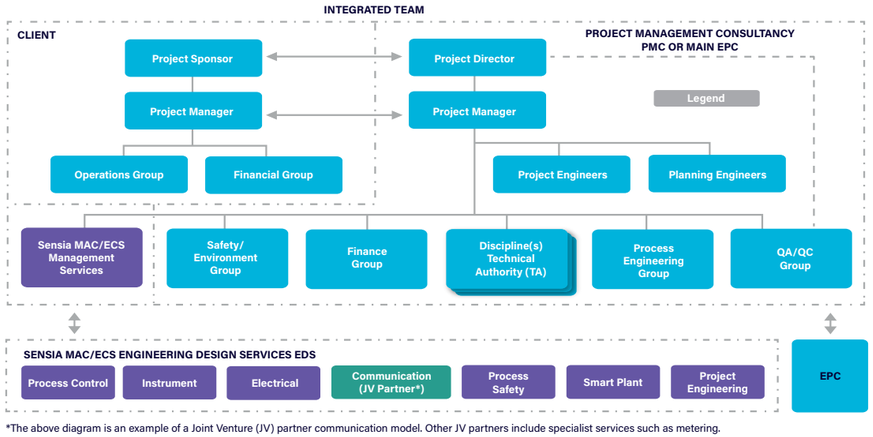


Figure 4 MAC/ECS Detail Design Stage Organogram (Refer to Figure 3 for Organogram legend)

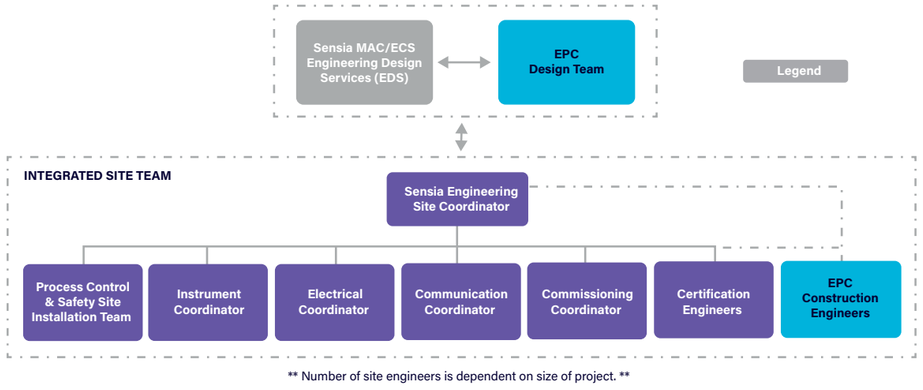


Figure 5 MAC/ECS Implementation/Construct Stage Organogram (Refer to Figure 3 for Organogram legend)

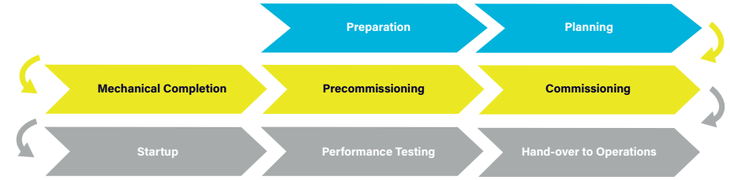


Figure 6 Typical Large Project Commissioning Flow

The Sensia MAC/ECS commissioning group can operate as an independent unit or as part of an integrated commissioning and startup (ICSU) team with responsibility for the following:

+ Automation/integrated control and safety system (ICSS), networks (fiber, wired, or wireless) and automation interface activities
+ Instrument field devices, valves, and control panels
+ F&G field devices
+ Information, security, and communication systems
+ Electrical equipment and associated systems

The Sensia MAC/ECS commissioning activities may, due to a project modular approach (plug and play), have the implementation split between the major project sites and the vendor yards.

The Sensia MAC/ECS precommissioning support activities are in the form of the following at vendors or on site:

+ Instrument loop checks
+ Remote I/O function tests
+ Attendance at factory acceptance test (FAT/site acceptance test (SIT)/site integration test (SIT)
+ Verification of any electrical equipment interfaces
+ Verification of systems
+ The precommissioning of electrical systems, which involves running equipment under no-load conditions.

As part of the commissioning deliverables, during detail design, the Sensia MAC/ECS commissioning group develop the systems commissioning procedures, plan the startup sequence and provide input to the operating procedures.

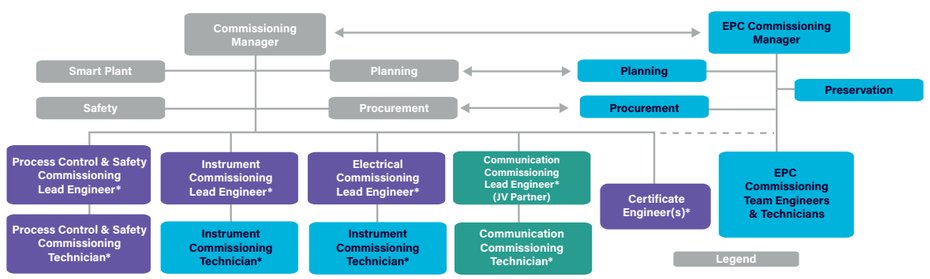


Figure 7 MAC/ECS Commissioning Stage Organogram (Refer to Figure 3 for Organogram legend)

8.7 OPERATION AND MAINTENANCE SUPPORT

On completion of the project, when the owner/operator takes possession of the plant/asset for continuous operations, the Sensia MAC/ECS regional technical support (RTS) teams can help sustain the plant with maintenance, support, and technical upgrades as needed and also as part of the operations and maintenance team on a service-contract basis. The Sensia MAC/ECS RTS can also store and supply spare parts and upgrades as needed, reducing lifecycle capital costs.

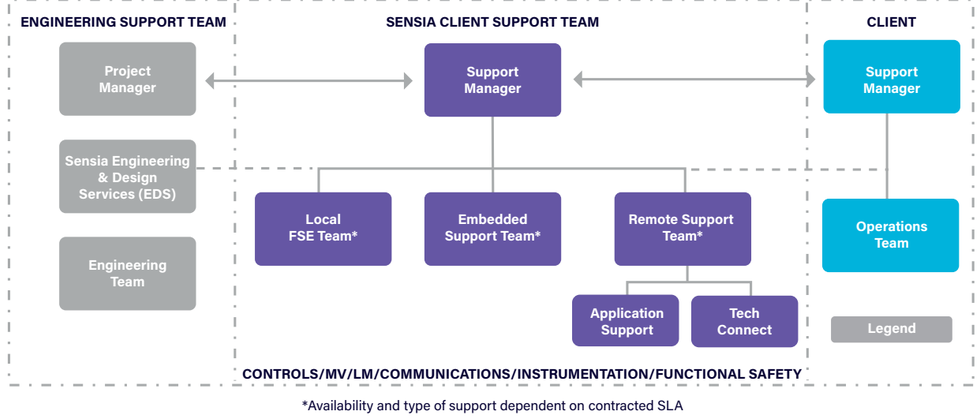


Figure 8 MAC/ECS Operations and Maintenance Stage Organogram (Refer to Figure 3 for Organogram legend)

8.8 CLOSE-OUT STAGE

Project close out is the formal process of recording the technical and commercial completion of a project. Some final project areas to be considered are

+ Documentation requirements
+ Complete drawings
+ Final report
+ Maintenance, procedures, routines, and plan(s)
+ Provision of people trained on operating product of facility
+ Customer training
+ Project audit
+ Updating of risk and work registers
+ Settling all invoices
+ Equipment and hire returns
+ Settling warranties and guarantees
+ Updating of financial systems
+ Documenting of lessons learned

The Sensia project director/manager responsible for a project initiates the project close-out process after completion of construction. It is the project director or manager's responsibility to work with the owner/operator, project management consultants (PMC) and the EPC to coordinate and maintain that all the activities identified in the project close-out procedure (PCOP) are completed and the project close-out certificate (PCC) is endorsed by all signatories. During this a stage both the systems applications and products (SAP) technical completion and transaction-technical (TECO) completion phases are of the project are checked and confirmed.

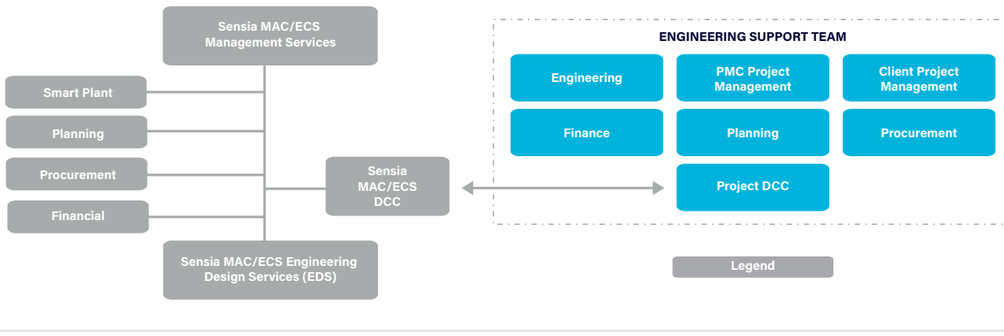


Figure 9 MAC/ECS Close-Out Stage Organogram (Refer to Figure 3 for Organogram legend)

9. Summary

The Sensia global solutions business capabilities, coupled with our best-in-class product range, technical expertise, and global manufacturing facilities, provides value-added solutions.

Through a combination of MAC/ECS expertise, experience, and the utilization of the latest technologies, we offer clients a range of project services from concept to operation, providing a right first-time correct, consistent, and complete solution that delivers fully fit-for-purpose solutions within schedule, avoiding schedule overruns and costly rework.

For more information on how we can help you

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