McGOUGH

Engineering, Procurement and Construction (EPC) Projects

ALIGNING ENGINEERING OPERATIONAL REQUIREMENTS WITH CONSTRUCTION, OPERATIONS, AND OWNER NEEDS IN EPC PROJECTS

The McGough Engineering Partner Requirements Approach

EPC projects succeed when engineering outputs are not only technically correct, but also operationally usable: buildable in the field, verifiable in controls, and maintainable for the Owner. When engineering requirements are written and managed in isolation, projects typically experience late design changes, constructability clashes, material and procurement churn, rework, claims, and commissioning delays.

This paper describes how aligning engineering operational requirements with construction, operations, and Owner needs reduces risk and increases value. It uses McGough's Engineering Partner Requirements (Subcontracted Engineering Specification and appendices) as a contract-ready model for:

- defining deliverables and maturity by phase (Front End Loading [FEL] 1/2/3 through Issued for Construction [IFC] and turnover);
- standardizing digital deliverables (3D model, registers, quantities) in open formats that connect directly to planning and project controls;
- enforcing metadata, QA/QC, and validation gates so engineering is usable for procurement, Advance Work Package (AWP), construction execution, and asset handover;
- integrating schedule, earned value, and change management with engineering progress and deliverables.

Finally, it summarizes industry evidence showing the cost of misalignment and provides an implementation roadmap that Owners, EPCs, and Engineering Partners can adopt on future projects.

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Why Alignment is the Defining Risk in EPC Execution

In EPC delivery, alignment means that every party is working from the same operational definition of:

- the Owner's performance, operability, maintainability, and safety requirements;
- scope boundaries and interfaces (inside/outside battery limits, tie-ins, vendor packages);
- deliverable content, maturity targets, and acceptance criteria;
- data standards (tags, systems, Work Breakdown Structures [WBS], cost codes) needed to link engineering to procurement, construction, and turnover;
- change control, including the baseline that changes are measured against.

Misalignment typically shows up as (1) engineering progressing without validated constructability or operability inputs, (2) procurement releasing before engineering is stable, (3) field rework driven by drawing/model conflicts or unclear interfaces, and (4) commissioning/turnover delays because asset data is incomplete or not formatted for the Owner's systems.

McGough Engineering Partner Requirements: Turning Alignment into Executable Requirements

McGough's partner requirements (issued as the Subcontracted Engineering Specification and supporting appendices) translate alignment into measurable deliverables, data standards, and governance expectations. At a high level they:

- define the minimum technical deliverables and the accepted software and exchange formats;
- tie acceptance of engineering deliverables to objective QA/QC and data validation;
- require routine, structured data deliveries that feed construction planning and project controls;
- require schedule integration (P6), earned value, man-hour tracking, and change control as part of engineering execution;
- define model content Level of Development (LOD) and metadata property sets so models and registers are usable beyond design, through construction and into turnover.

1 Deliverable Maturity by Phase (FEL 1/2/3 to Execution)

McGough aligns expectations early by defining what "good" looks like at each phase. Phase objectives (concept definition through FEED and execution) clarify what decisions can be made and which deliverables are intended for screening, feasibility, or execution support. **FEL-1** defines the business opportunity, **FEL-2** develops the selected concept, **FEL-3** produces sanction-quality FEED and execution planning, and **DETAILED ENGINEERING** converts that approved scope into complete IFC deliverables for procurement, construction, and startup.

ENGINEERING DELIVERABLES BY PROJECT PHASE

Phase	Typical Delivery	Delivery Intent
FEL 1 – Concept Definition	Screen options; establish business case and scope framing.	Preliminary deliverables: BOD, conceptual Process Flow Diagrams (PFD), early equipment and load lists.
FEL 2 – Feasibility / Preliminary Engineering	Confirm technical feasibility; evaluate alternatives and select basis.	Refined deliverables: updated PFDs/Heat and Mass/Material Balances (H&MB), preliminary Piping and Instrumentation Diagram (P&ID), plot plan, preliminary lists and criteria.
FEL 3 – Front-End Engineering Design (FEED)	Produce engineering deliverables suitable for EPC bidding and execution planning.	Full FEED package: approved PFDs/P&IDs, datasheets, specifications, FEED models, estimate inputs.
Detailed Design and Execution	Finalize design; support procurement, construction, and turnover.	IFC drawings, final models, calculations, vendor integration, as-built documentation.

A discipline-by-discipline deliverable map then connects each phase to the specific documents, models, and registers needed by construction and operations.

DISCIPLINE INVOLVEMENT PHASE

Discipline	FEL 1 – Concept Definition	FEL 2 – Feasibility / Preliminary Engineering	FEL 3 – FEED	Detailed Design and Execution
Process	BOD; Concept PFDs/H&MB	Updated PFDs; Prelim Equip List; Control Philosophy	Final PFDs/P&IDs; Flare Study; Datasheets	Line List; Process Manual; MOC Closure
Mechanical	Major Equipment List	Mech Design Criteria; Prelim Datasheets; Lifting Philosophy	Final Datasheets; Technical Bid Evaluations (TBE); Vendor Document Requirement List (VDRL)	Stress Analysis; Fab Drawings; Bill of Material (BOM)
Civil / Structural	Site Review; Concept Plot Plan	Geotech Plan; Foundation Concept; Access Plan	Design Basis; 60/90% Packages	IFC Foundations; Steel Details; As-Builts
Electrical	Power Concept; Prelim Load List	Prelim One-Lines; System Studies; Grounding/Area Class	Detailed One-Lines; ETAP/SKM (Electrical Engineering Software); Specs; Tray Concept	Cable Schedules; Plans; Protection Settings
Instrumentation	Control Philosophy; System Architecture; I/O Estimate	Instrument Index; Safety Instrumented Level (SIL) Assessment; Prelim C&E	Index/I/O List; Safe Charts; Datasheets	Loops; Schedule Performance Index (SPI) Files; FAT/SAT Reports

2 Digital Deliverables that Serve Construction and Controls (Appendix X)

To keep engineering connected to construction execution, McGough requires periodic engineering-to-construction data deliveries in structured formats (CSV, XLSX, PDF/A or agreed equivalents) suitable for direct import into planning and controls tools. These deliveries are expected to begin at approximately 30% model maturity and be updated routinely through execution. Datasets must carry the attributes needed for mapping to WBS, areas/systems, schedule activities, and cost codes.

Value created by this requirement:

- supports AWP and work packaging with reliable quantities and system/area breakdowns;
- improves procurement readiness and reduces late material substitutions driven by design changes;
- enables objective progress measurement (what is actually modeled/issued vs. what is planned);
- reduces manual reconciliation between design tools, P6 schedules, and cost systems.

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Cooper has over 35 years of EPC experience leading construction organizations from project conceptualization through the full engineering, procurement, construction, commissioning and startup phases of projects. His work spans across the energy, power generation, and renewable energy sectors. Cooper draws on his vast experience at various levels of EPC responsibility, from engineering through construction to execution in the field, to optimize construction processes.

3 Model Content and Metadata Governance (Appendix H - LOD 350)

McGough's LOD 350 requirements go beyond geometry. The specification defines mandatory property sets that make each model element traceable, schedulable, and turnover-ready. Common mandatory fields include tag, GUID (a unique ID that stays consistent across all revisions), discipline, system, description, status (Prelim/Issued for Review [IFR]/ Issued for Approval [IFA]/Issued for Construction [IFC]/As-Built), originating file, reference drawing, and revision.

MINIMUM BASIC MODEL INFORMATION

Mandatory Field	Type	Purpose	Examples / Notes
tag	string	Unique engineering tag; matches P&ID/one-line/ index	
guid	string	Persistent model GUID	
discipline	enum	{Process, Mechanical, Civil/Structural, Electrical, Instrumentation, Vendor}	
system	string	System (e.g., HRSG, CW, LP Steam)	e.g., HRSG, CW, LP Steam
description	string	Human-readable label	
status	enum	{Prelim, IFR, IFA, IFC, As-Built}	{Prelim, IFR, IFA, IFC, As-Built}
originatingFile	string	Native file path/name + version	
referenceDrawing	string	P&ID / GA / one-line reference	P&ID / GA / one-line
revision	string	Current revision code	

Discipline-specific required properties (process tags and design basis fields, line IDs, electrical tags/voltages, I/O types, etc.) ensure that models and registers remain consistent with P&IDs, one-lines, vendor data, and safety documentation.

4 QA/QC and Validation Gates Tied to Acceptance

McGough links engineering acceptance to QA/QC, including metadata completeness and reconciliation reporting. Engineering partners are expected to provide a quality control plan and submit periodic reports showing:

- metadata completeness against Appendix H requirements;
- reconciliation to P&IDs, one-lines, and vendor data;
- variance commentary explaining changes since the prior period and the expected impacts to cost, schedule, or constructability;
- corrective action for non-conforming datasets.

5 Project Controls Integration: Schedule, Earned Value, and Change

Alignment breaks down quickly when engineering progress cannot be measured consistently or translated into schedule impacts. McGough addresses this by requiring a resource-loaded Primavera P6 schedule, frequent updates, look-aheads, and monthly variance analysis. The specification also requires rules of credit, planned vs. earned reporting (PV/EV), and man-hour productivity tracking by discipline. Change control is integrated so approved changes are reflected in the schedule and cost forecasts, and baseline control is maintained with versioned P6 exports.

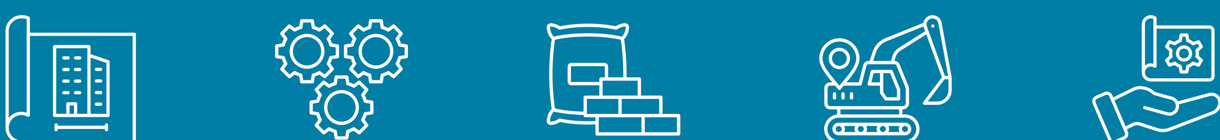
GENERAL COMMUNICATION CADENCE

Cadence	Minimum Controls Output
Bi-weekly	P6 update with percent complete, forecast dates, remaining hours; 6-week look-ahead; metadata KPIs
Monthly	Plotted schedule vs baseline and prior update; variance analysis; critical path narrative; PV/EV with CPI/SPI
Ongoing	Man-hour productivity trending; ETC/EAC forecasting; formal authorization before implementing changes; version-controlled schedule data

Understanding EPC

EPC stands for Engineering, Procurement, and Construction, a project delivery model where an EPC contractor is responsible for all stages of a project.

THE EPC PROCESS



Concept Design | Detailed Engineering | Materials Procurement | Construction + Assembly | Commissioning + Handover

BENEFITS OF AN EPC CONTRACT

Time Saving | Cost Control | Reduced Risk

What Happens When EPC Parties Are Not Aligned? Evidence from Industry

Research and public post-mortems show consistent failure patterns when requirements, interfaces, and hand-off expectations are not aligned early and maintained through execution.

RECURRING FAILURE MODES

- Unstable or poorly managed requirements leading to scope creep and late design churn;
- Interface mismanagement across multiple contractors and suppliers causing design conflicts, delays, and claims;
- Rework driven by incomplete or incorrect information flow between engineering and construction;
- Systems integration and commissioning delays when operational requirements and acceptance testing are not defined and traced;
- Baseline control breakdown (schedule and cost) due to uncontrolled change and weak progress measurement.

SELECTED DATA POINTS AND PUBLIC CASE EXAMPLES

Requirements Management: PMI reports that nearly half (47%) of unsuccessful projects fail to meet goals due to inaccurate requirements management. [1]

Interface Management: CII positions interface management as a practical response to project risk and complexity drivers, including poorly defined scope, condensed schedules, multiple engineering centers, and many suppliers/subcontractors. [2]

Mega/Complex Project Outcomes: McKinsey's analysis of 500+ large capital projects reports persistent schedule and budget overruns and under-delivery of outputs, supporting a push toward stronger pre-construction and front-end alignment. [3]

Crossrail (Elizabeth Line), UK: The NAO described how high numbers of interfaces and poor integration contributed to delays and change, and the UK Parliament's Public Accounts Committee cited poor integration of complex IT and operational systems and lack of a fully integrated plan to complete the programme. [4][5]

Construction Rework: Research cited by ASCE/CII indicates direct rework costs averaging about 5% of total construction cost, with higher impacts when indirect costs are included. [6]

Complex power and nuclear projects provide additional examples where long delays and major cost growth are tied to design changes, supplier coordination, and execution challenges across multiple parties (for example, Flamanville 3 in France and Olkiluoto 3 in Finland). [7][8]

A Practical Alignment Framework for EPC projects

The McGough requirements can be generalized into a simple, repeatable framework compatible with EPC, EPCM, or CM-at-risk delivery models.

ALIGNMENT PILLARS

Pillar	What Aligned Looks Like
Shared definition of success	Document and maintain Owner outcomes: capacity, efficiency, reliability, maintainability, safety, environmental constraints, and acceptance criteria.
Deliverable maturity and decision gates	Define which decisions are allowed at each phase and the deliverables required to support them (FEL 1/2/3 through IFC and as-builts).
Digital thread from engineering to field	Standardize models/registers with tags, systems, WBS, and cost code mappings; use open exchange formats; validate metadata routinely.
Integrated planning and controls	Tie engineering progress to P6 logic, earned value, and productivity; use look-aheads and critical path narratives; keep baselines controlled.
Interface and change governance	Assign interface owners, maintain interface registers, and enforce formal change authorization and configuration control.

IMPLEMENTATION ROADMAP (RECOMMENDED)

High-leverage actions that can be implemented without changing the delivery model:

- At notice-to-proceed: confirm Basis of Design (BOD), data dictionary (tags/systems/WBS/cost codes), model execution plan, and acceptance criteria for each deliverable type.
- During FEL and early design: run recurring constructability and operability reviews; explicitly track interfaces and tie-ins; align procurement release strategy to maturity gates.
- During detailed design: enforce metadata validation on every federation/submittal; publish look-aheads tied to deliverables and field needs; baseline schedule and manage constraints.
- During procurement and construction: keep engineering-to-construction data deliveries current; measure progress via deliverables issued and validated; integrate approved change impacts immediately.
- At turnover: deliver as-built models/drawings, registers, and required asset data in Owner-ready formats; close out Management of Change (MOC)/ Process Safety Management (PSM) documentation and acceptance testing evidence

Appendix: Deliverable–Based Scopes Support Objective Progress Measurement

A deliverable-based Schedule of Values (SOV) supports transparent progress reporting and earned value. The McGough template demonstrates how engineering deliverables can be organized by discipline and reported in percent-complete units.

SAMPLE SOV FOR CIVIL/SITEWORK PROJECT SCOPE

No	Description	Quantity	UOM
0.1	Project Support	52	WK
1.1	Site Plan	100	PCT
1.2	Geotechnical RFQ/RFP	100	PCT
1.3	Geotechnical Study	100	PCT
1.4	Building Conceptual Design	100	PCT
1.5	Civil/Structural Basis of Design Criteria	100	PCT
1.6	Civil Standards, Specifications & Datasheets	100	PCT
1.7	Deep Foundation (Piling) Design & Modeling	100	PCT
1.8	Existing Grading Drawings/Topographical Data	100	PCT
1.9	New Grading and Drainage Drawings	100	PCT
1.10	Storm Drainage Drawings	100	PCT
1.11	Process Drainage Drawings	100	PCT

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