

Get your E in to C – a seamless transition from Engineering design to efficient Construction

Executive summary

This article talks about the need to actively shift capital projects out of engineering design mode and into construction mode. It covers the pitfalls of not doing this proactively, and how to achieve this transition rapidly.

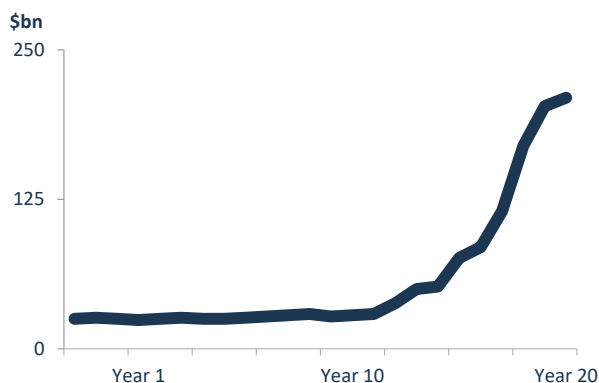
Many projects are slow to shift their focus from engineering design to construction (E to C). Four to five months can pass as the organisation moves out of design mentality and into construction mode, resulting in significant construction delays and a workforce that becomes used to low productivity levels. These tend to become entrenched behaviours which lead to long schedule over-runs. Shifting to a construction mindset early avoids costly delays and delivers the rapid ramp-up required to hit the overall construction schedule. We can diagnose problem areas which are holding your project organisation back, and provide tools to ensure that the transition is as quick and seamless as possible.

Why is E to C important?

Many countries are experiencing massive growth in construction, yet the total number of engineers hasn't increased, so the subset of engineers with major capital project experience remains small. Delivering capital projects safely to cost, quality and schedule targets is becoming increasingly difficult as projects become larger and more complex whilst the available skills base is diluted by the sheer volume of resources-based construction being undertaken.

We find that many engineering design teams lack direct commissioning and construction experience; unable to transition quickly (if at all) to a construction management approach. As such, construction disciplines and commissioning schedules are often poor. Inevitably, this leads to a slow start to construction whilst workable plans are created, resulting in costly delays to the project.

Australian pipeline of project



How to tell if E to C is a problem for you

The first step is to diagnose where you are at in the transition from E to C. An example analysis output from an E to C oil and gas diagnostic is shown below:

■ Exists and effective ■ Exists in part, but not effective ■ Does not exist		
Engineering-focus in construction <i>Reactive management</i>	Construction-focus <i>Proactive management</i>	Status
Drawings / designs are completed according to Engineering priorities, i.e. technical complexity	Sequence of drawing / design completion is aligned to critical path	
Land approvals not integrated with construction plan	Land approvals and construction plan are integrated and prioritised according to critical path	
Eng. still run by discipline as critical path not documented or understood by E/D firm	Critical path used to integrate civil, mechanical and electrical schedules	
Design and procurement priorities not aligned	Procurement driven by date required onsite, but dependent on availability of drawings and specs	
Sequencing for completion of designs not aligned with critical path timing	Focus of design team shifts to support project completion / commissioning / handover on time	
Contractors not involved in design	Contractors are regularly involved in design reviews to test constructability	
Commissioning and handover teams (including contractors) not consulted	Commissioning and handover teams are integrated into construction team	

This diagnostic is based on the typical symptoms of an engineering focus:

Symptoms of an engineering focus	Implications
<ul style="list-style-type: none"> → Drawings are completed according to 'engineering' priorities, i.e. technical complexity → Land approvals not integrated with construction plan → The project is still being run by engineering discipline and not area → The critical path is not documented/understood by E/D firm → Lack of mind-set around constructability → No appreciation of number of work fronts, when different skills are required → Design and procurement priorities not aligned → Sequencing for completion of designs not aligned with critical path timing → Contractors not involved in the design → Commissioning and handover teams not consulted 	<ul style="list-style-type: none"> → Drawings not ready when required for instruction → Fabricated items ordered and/or delivered late → Land access is granted late → Errors in construction due to incomplete drawings → Designs do not fully account for site conditions – on-site modifications needed → Insufficient time for proper response to Technical Queries → The construction approach doesn't adequately take into account constructability, access, accommodation levels, numbers of contractors leading to further delays

Commencing construction when your project is still in engineering mode will almost certainly result in significant delays to the schedule with associated cost overruns, diminishing project momentum and morale. Unless the wiring is fixed, wiring issues will persist throughout construction, magnifying schedule delays and cost overruns.

What to do about it – wire and coach

Wiring and coaching combine to quickly drive effective construction performance. Construction wiring (or management operating system) rapidly establishes the priorities, rhythms and routines of construction. Extensive coaching in the first few weeks accelerates the quality of construction management.

1. Getting the contract thinking and execution right

A key step for construction success is establishing the right partnerships. Many of the construction projects that we are brought in to assist with can trace their disappointing performance directly back to problems in this pre-contracting stage. The work here involves establishing which party is in the best position to manage key risks, understanding what type of relationship best reflects that position, how best to align motivations and create incentives that are indeed meaningful and focusing. We do not cover these aspects in this article, but are certainly very happy to share with you our experiences on this important foundation for construction performance.

2. Clarify roles

During the E to C transition the reporting lines and decision-making processes change. As a result it can be confusing for project team members, and accountabilities can be lost and misunderstood. Therefore it is critical to be crystal clear on who owns what, and when, before and after the transition takes place.

It should be noted that accountabilities differ depending on the engagement model undertaken by the owner's team. For example, an owner's team with a lump sum contract arrangement will have different accountabilities from those in an hourly-rate EPCM arrangement. Not all projects are the same, and accountabilities and their transition need to take into account both project deliverables and the contractual engagement model.

Responsibilities and accountabilities should be agreed upon between project teams using a RACI matrix. A RACI should include pre-construction, construction and commissioning steps as the roles of individuals change during these stages.

Example RACI matrix developed during an oil and gas E to C diagnostic



Wiring is the systems, processes, staff, competencies and behaviours (that you do and don't accept) and norms of an organisation which combine to determine how individuals behave and therefore how an organisation will perform.

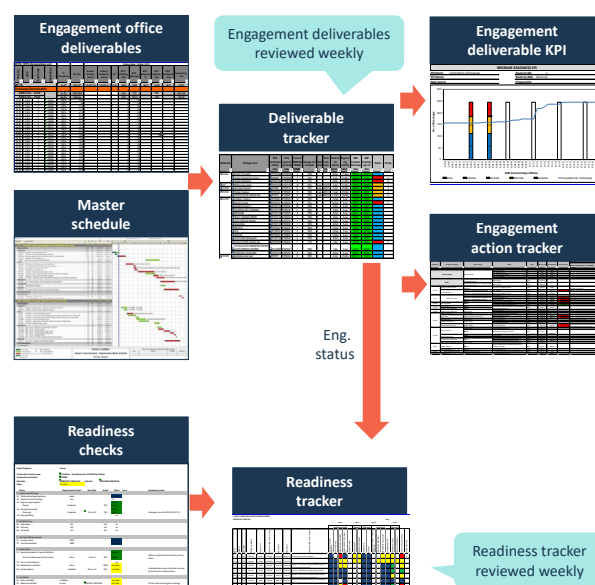
3. Install construction wiring

For construction projects to be managed efficiently, there is an interlocking system of simple, standard review charts (which can largely be updated manually and rapidly installed in weeks, not months). This is needed for construction to progress smoothly and on plan.

In Engineering mode, drawings are completed 'by number', but in Construction, drawings must be completed in the sequence supporting the project critical path. In the following example, the tracker clearly shows drawings as a looming problem.

Off-track performance is immediately visible at the daily or weekly review with the accountable people, enabling corrective actions to be agreed, and monitored.

Without the early warning system of the tracking and review process, unpleasant surprises inevitably occur. We help teams use techniques such as 'brown papers' (shown below) to identify the composition of essential meetings and reviews.



You cannot shift from Engineering to Construction without a commissioning plan which drives the construction schedule. It is critical that the commissioning plan is robust; the logic of the plan can be tested with a Construction and Commissioning Logic Block Diagram as described on the next page.

The Construction Readiness Tracker assesses the prioritised list of Construction Work Packages (CWPs)

Major Activity							Activity ID	Activity Name	Planned Duration	Start	Finish	Priority	<div> <div>Project Overview</div> <div>Project Charter</div> <div>Stakeholder Analysis</div> <div>Business Case</div> <div>Project Plan</div> <div>Communication Plan</div> <div>Risk Management</div> <div>Quality Management</div> <div>Resource Management</div> <div>Procurement Management</div> <div>Integration Management</div> </div>
Development Chapter Construction Early Works							A0000	Build 40 One-Bin Storage Units	12d	14-Sep-17	14-Sep-17	1	<div> <div>Project Overview</div> <div>Project Charter</div> <div>Stakeholder Analysis</div> <div>Business Case</div> <div>Project Plan</div> <div>Communication Plan</div> <div>Risk Management</div> <div>Quality Management</div> <div>Resource Management</div> <div>Procurement Management</div> <div>Integration Management</div> </div>
							A0070	Build 40 Chapter - Working Draw	14d	14-Oct-17	15-Mar-18	1	<div> <div>Project Overview</div> <div>Project Charter</div> <div>Stakeholder Analysis</div> <div>Business Case</div> <div>Project Plan</div> <div>Communication Plan</div> <div>Risk Management</div> <div>Quality Management</div> <div>Resource Management</div> <div>Procurement Management</div> <div>Integration Management</div> </div>
							A0070	Build 40 One-Bin Working	3d	14-Sep-17	15-Mar-18	1	<div> <div>Project Overview</div> <div>Project Charter</div> <div>Stakeholder Analysis</div> <div>Business Case</div> <div>Project Plan</div> <div>Communication Plan</div> <div>Risk Management</div> <div>Quality Management</div> <div>Resource Management</div> <div>Procurement Management</div> <div>Integration Management</div> </div>
							A0072	Build 40 One-Bin Station Clean	3d	21-Sep-17	21-Sep-17	1	<div> <div>Project Overview</div> <div>Project Charter</div> <div>Stakeholder Analysis</div> <div>Business Case</div> <div>Project Plan</div> <div>Communication Plan</div> <div>Risk Management</div> <div>Quality Management</div> <div>Resource Management</div> <div>Procurement Management</div> <div>Integration Management</div> </div>

4. Coach extensively

The tools and wiring outlined above are explicitly designed to be simple and relatively easy to manage. We then support rapid take-up of these tools through coaching of stakeholders – both in the owner's team and the contractors, so they are rapidly adopted and utilised effectively across the capital project.

Expected outcome

Your project will display the right focus at the right time; transition from Engineering to Construction will be clear and rapid, with all tools in place and roles and responsibilities understood. You will be set up well for the construction journey ahead, with an organisation wired to embrace the following characteristics:

- Activity sequencing driven by critical path
- Civil, mechanical, electrical schedules integrated or cross-referenced
- Focus on project completion / commissioning / handover
- Procurement driven by date required on-site and material lead times, but dependent on availability of drawings and specifications

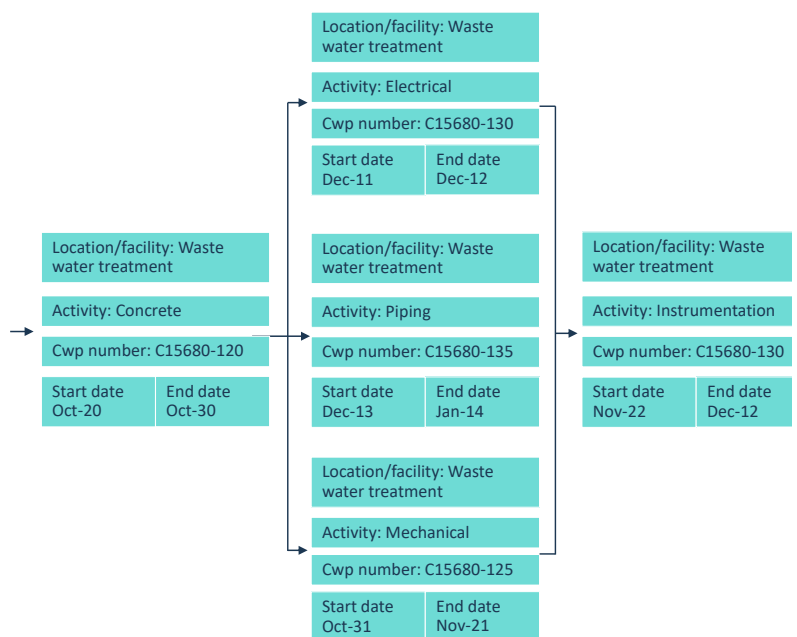
In Focus - Logic Block diagrams

In large complex projects the schedule / Gantt chart becomes the driving source of truth. However, the development of these schedules is often less than perfect. We've found numerous projects where the master schedule is unworkable, not optimised for real-life construction, has conflicts, is poorly sequenced, with poor staging of different work fronts etc. It is not easy to turn a project design (lots of drawings) into a master schedule with 1000 lines spread over almost 100 pages. It's like doing a 1000 piece Rubik cube in your head, while consulting with stakeholders (design, construction, operations, etc) to review and optimise the master schedule. A 1000 line Gantt chart is hard to interact with and facilitate, so many projects teams will leave it to the planning team to own and complete as it is just too hard to 'really think through and challenge the logic'.

Far better master schedules can be developed by initially using logic block diagrams to get the logic of construction right, then transferring this to the mega master schedule. A logic block diagram is a visual representation of the blocks of work that occur in order of construction, showing the flow of work and critical path.

Prior to launching into the Gantt chart, we can use the Logic block diagrams to force the thinking about what to construct and when. It is a very visual tool, thus easy to use across the whole team (not just planning). They can be used across different engineering groups (e.g. construction, operations, contractors) to come up with improvements to the overall plan. You can examine the interactions between the blocks of work (work faces, sequencing, interactions, constructability etc), and look for opportunities to optimise the schedule. They can also be used to track quantities by block during the design, identify variances and understand why and where they have occurred (e.g. earth has increased by 20% but it is all in the roadblock).

Some of the more experienced construction managers will recognise Logic Block Diagrams as similar to 'Pert Charts'. However, the use of Primavera and in particular P6 has made the use of Pert Charts extremely difficult and requiring specialised software technical knowledge. A more manual approach appears to give the best results before jumping into Primavera.





Case study

Construction and commissioning logic block diagrams for a greenfield iron ore project

Context

The owner's team of a \$2.5bn greenfield iron ore project was unable to get proper progress reporting and project plans from their EPCM, even though early works had already commenced onsite and final funding had been approved. The EPCM planning team was struggling to deliver a detailed Level 6 Primavera plan due to shortage of resources, and the inevitable, constant changes that occur as a result of onsite events. There were delays with onsite construction, approvals were late, and drawings were not provided in a timely fashion. Finally, the visual boards were not updated with relevant information, and morale across the project was low.

Client achieved

The project is now wired up well as construction progresses. The owner's team are aligned with the EPCM and contractors, with the common objective of meeting project milestones, on-time and on budget. The increasing construction focus is clear across the project team, with regular cascaded reviews of progress and budget requirements. There is full ownership of the process by the EPCM, and active management to improve on the targets. The project manager mentioned,

“ I’ve been thrilled to bits to have that level of commitment and drive: we couldn’t have done it ourselves.

What we did

After a short diagnostic, we facilitated workshops with the owner's team and EPCM to develop Construction and Commissioning Logic Block Diagrams.

This focused the combined team on ‘building the project’ through developing a high-level view of the future construction, with start and end dates. This enabled ‘ah-ha’ moments with Area Managers (“we seem to be missing a haul road”) and more importantly started engaging the broad stakeholder group of owner's team, approvals, and contractors, to revise and refine the overall plan, and enable a more realistic and aligned approach with construction-driven milestones. These Logic Block Diagrams commenced the transformation from an Engineering focus to a Construction focus, with clear prioritisation of work based on the construction sequencing and the critical path.

To assist in onsite works, the team developed and implemented a Readiness Tracker that focused on the key drivers for starting works onsite. A weekly meeting with area managers, engineers and functional heads drove clear prioritisation and actions to ensure each construction and commissioning work package was on track, and ready to not only start on time, but also finish on time. This allowed cross-area issues (such as accommodation) to be escalated up to the owner's team in a timely fashion, and drove quick resolution through innovative solutions.

Significant work was done to create a single source of information, both onsite and in the project centre, with clear output and leading KPIs to drive construction success. The KPIs around time, cost, and quality were cascaded across the owner's team, site and EPCM, through Lean Boards and weekly and daily meetings. Simple and clear targets were set that tracked daily and weekly adherence to the plan, and what measures were being taken to get back on track. This resulted in improved visibility of progress and ensured that any impediments to achieving objectives were escalated and communicated up the line.



Case study

On track and on time project deliver for unconventional oil and gas project

Context

A major oil and gas project, consisted of upstream, a 400km pipeline and construction of a major LNG plant on the coast. Construction delays in this area were estimated to have a cost of \$0.25m/day. The client was not happy with the rate of progress on the pipeline portion – it had started late and early progress was slow. In addition, they didn't feel there was any transparency on the actions being taken to recover the loss.

What we did

We worked with the parties to carry out a week-long diagnostic to identify what priority actions were required to rapidly get the project back on track for on time delivery.

We identified key meetings and reviewed materials from the Project Manager, Construction Manager, Planning and Scheduling Manager, Land Access Manager and Contracts Manager. The interviews were targeted to assess the degree of transition from Engineering to Construction and scored against 11 key criteria points mentioned below:

- Criteria 1-7: Characteristics of Engineering Focus versus Construction Focus
- Criteria 8-9: Transparency driving certainty on CWP readiness and rate tracking
- Criteria 10: Clear responsibilities and accountabilities for construction delivery
- Criteria 11: Clear and integrated communication between site and off-site project offices

The recommendations were prioritised on the highest impact areas and the team invited to stay and assist the team to install the wiring for high-performance construction and to coach the team on how to manage within this system.

