

OPERATIONS PREPARATION FOR START-UP OF A NEW ALUMINA REFINERY TO SUPPLY WORLD CLASS ALUMINA

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ABSTRACT

Emirates Global Aluminium (EGA), one of the world's largest 'premium aluminium' producers, is constructing the Al Taweelah alumina refinery, the company's first and first of its kind in the UAE. The primary customer of the alumina is EGA's neighbouring Al Taweelah smelter. The smelter produces high quality metal, and currently receives some of the world's best quality alumina. There is a clear requirement that the refinery will need to meet these same quality standards.

Building any greenfield alumina refinery is an ambitious project. There were further challenges for the refinery, both in terms of lack of availability of inherent operational systems and local expertise in alumina refining as the first in the country. Appreciating how this enhanced the challenges associated with successfully starting-up a greenfield operation for a complex process, and the quality expectations of their downstream customer, the refinery implemented a comprehensive Operations Readiness (OR) program.

Working in partnership with Hatch, EGA has pro-actively driven an inclusive and integrated OR program focussed on effective transition through commissioning, ramp up and sustainable operation of the plant. Leveraging off strong co-operative relationships formed between the refinery, smelter, corporate services and project organisations, teams worked together self-reporting in a unique and easy to use management system that encouraged ownership and accountability to manage change and mitigate risks before they became impactful to schedule. Acknowledging how the entire value stream and related support services contribute to the successful start-up of the refinery, not just operations and maintenance, the rigorous program ensured all aspects of the business operation would be prepared.

1. INTRODUCTION

In 2015, EGA made the investment decision to construct their 2mtpa Al Taweelah alumina refinery. The start-up of new refineries in more recent times have suffered significant erosion of business value as simulated in Figure 1. While construction and design quality certainly contributed, the authors contend that lack of preparation to operate the refinery is a significant factor driving failure to meet the operational performance expectations which underpin the investment decision.

Operations Readiness focusses on ensuring the business is prepared and equipped to operate. The program runs concurrently to the construction and work should be coordinated so that the business is ready when construction is complete.

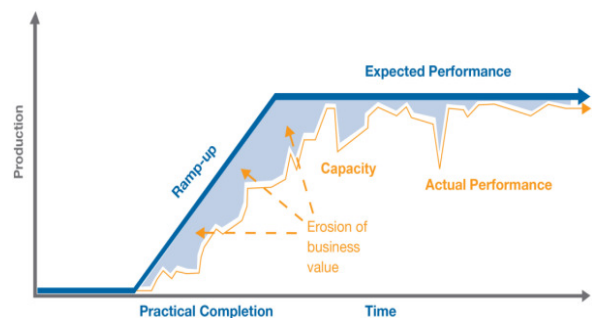


Figure 1. Typical impact of lack of preparation on business value

EGA's vision for OR execution was to build an operations organisation, ready and fully functional in both "people" and "systems" to inherit the constructed refinery and bring it to life through safe and efficient pre-commissioning, commissioning, ramp-up and on into stable operations.

2. APPROACH

As EGA's first refinery and the first in the country, the OR scope was extensive and inclusive of all aspects of the business

The scope covered the full process cycle:

- from global sourcing, recruitment, immigration and on-boarding through to completion of all required training and transition to site working in shift patterns
- Definition of business process to establishment and population of associated systems of management, work execution and reporting as part of the wider EGA organisation
- Specification and sourcing of material quantities to confirmation of readiness to issue warehouse items, refinery first fill and start-up
- Identification of operational contracts to contractor readiness to provide services
- Commissioning and ramp up planning to establishment of commissioning execution management systems ready for commissioning and start-up
- Ramp-up and quality management planning
- Issuing by the regulatory bodies all licenses required for operation

The OR execution strategy centred around three key principles.

Firstly, the refinery requires a workforce of around 650 combined operations and corporate shared services personnel. As the inheritors of the work in the long run, a strong drive for ownership, acceptance and commitment to the systems and practices for refinery operation was seen as necessary. As such, an imperative of the OR program was for the majority of the work to be completed by the EGA team who will ultimately operate the refinery.

Secondly, to engage operations readiness specialists that understand project execution and the refinery operation and able to work with the EGA team to achieve the target outcomes and alignment with EGA standards and quality objectives.

Thirdly, the structure of the OR Plans was fundamentally aligned with the organisational structure and responsibilities, creating clear lines of organisational ownership and accountability.

EGA engaged HATCH to provide this service and the provision of OR work execution management tools was a core requirement of the support.

2.1 OR Planning

The OR work commenced in earnest during the feasibility phase. At this point, all Stakeholders were identified and engaged to develop their OR strategy and preliminary execution schedule. The operations philosophy was also developed and the organisation chart, staffing ramp-up plan and budget prepared to enable the execution of the strategy. These were fundamental documents for informing and aligning supervisory team members as they were onboarded.

Detailed OR Planning started during the execution phase. The OR Plan effectively outlines the packages of work and associated deliverables and activities to be completed for operation to be undertaken in a consistent and sustainable manner. HATCH worked with the EGA refinery and corporate services senior leadership and utilised the OR framework (Figure 2) to scope the work ensuring all the building blocks for business establishment were incorporated into manageable packages.



Figure 2: OR Framework

As with any project, the schedule ensures the work identified can be achieved in the time and with the resources available. Many areas of OR work have a strong dependency on project information and as such scheduling is integrated with the asset delivery schedule. The staffing ramp-up plan was optimised in both utilisation and cost effectiveness through work allocation and resource levelling (Figure 3).

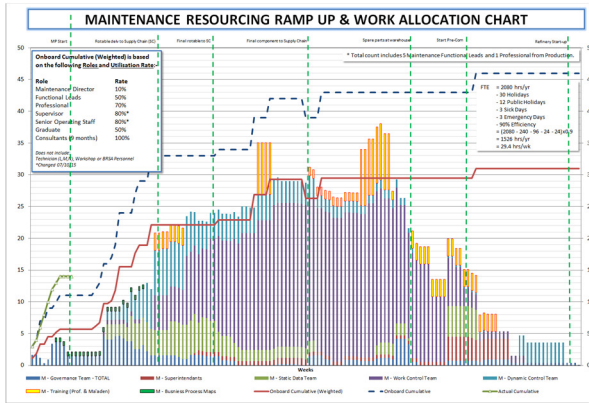


Figure 3: Example of OR Plan Resource Curve

The resulting plans were approved by Stakeholders and formed the baseline OR Plan for execution.

2.2 OR Execution Management

The detailed OR plans were uploaded into HATCH's Operational Readiness Management System (ORMS). The system provides managers and leaders with online, real time monitoring and reporting that tracks progress against plan and package health. The work breakdown structure (WBS) aligned with organisational functions to ensure clear lines of accountability. Deliverable progress is based on tollgate profiles that reflect the development workflow as defined in consultation with the scope owner.

During the execution phase, the approved baseline plans are continuously updated. OR work strongly follows the process of progressive elaboration where the completion of early work feeds the definition of further work, all of which must be resourced, managed & controlled. The inbuilt change management protocol enables package managers to submit change notices enabling the OR plan to fluidly adapt to the gradual expansion and evolution of the scope.

A document management system was established to control and store all of the documents developed. The configuration reflected the OR Plan WBS aiding intuitive navigation and self-learning. Document templates, supported by content and style guides were established to aid adherence to quality standards.

Several key processes were established to manage and drive the execution delivery. These included reporting, risk management, steering committee, war rooms and governance processes.

2.3 Reporting

Following the mantra that "schedule is king", a key objective of the management methodology is to be on schedule. Active management practices are utilised which focus on recognising where we plan to be and where we are, managing by exception and actively in a timely manner, rather than accidentally, mitigating risk. ORMS provides real time reporting which informs and best places the team to meet this objective.

Users are assigned with varying levels of authority to enable progress management and reporting to occur. Multi-level visual management dashboards and progress summaries (Figure 4) provide easy oversight by Managers and Stakeholders of performance against plan.

Progress is reported at a deliverable level. This aggregates to provide earned value at a package, sub function, function and project level.



Figure 4: ORMS Visual Report Samples

A range of other reports are available that enable package managers and organisational leaders to manage effectively. These include but are not limited to, work load assignment to resources, progress of their assigned work.

In addition, the OR Dashboard is used to communicate OR progress in a range of other forums throughout the organization up to Board level.

2.4 Risk Management

As with any project, the ability to manage arising risks often comes down to awareness of them. This does not just mean having the knowledge but also having awareness that they are becoming increasingly imminent. What turns a hazard into a risk is not just the consequence but the likelihood of it occurring. Being aware that there is emergent risk due to increasing likelihood is key to its successful mitigation.

The ultimate objective is to have reliable equipment, capable people and effective systems in place when the asset is ready to commission. OR risks are assessed and captured in a risk database (Figure 5). Any controls required to mitigate the risk are managed through the database and incorporated into the relevant OR plans in ORMS, where progress of their completion can be tracked.

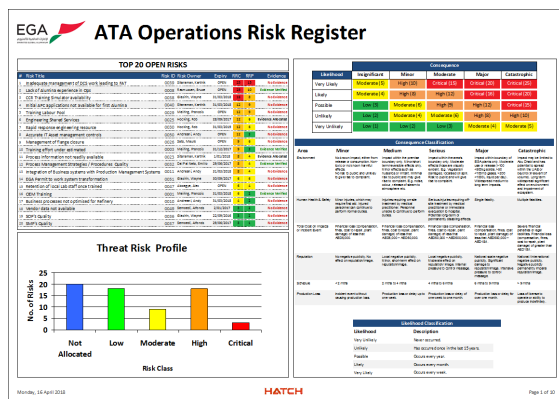
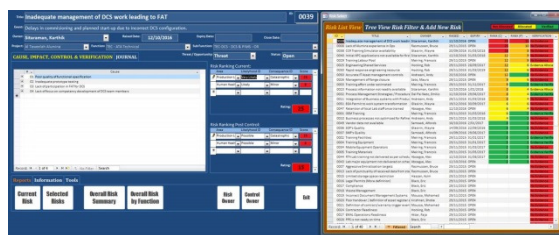


Figure 5: Risk Reporting

2.5 Commissioning Driven

Minimising the project timeframe is driven by aligning the asset construction and the operations readiness with the facility commissioning sequence requirements. Responsibility for commissioning rested with the refinery operations team. Rather than operations being at arms-length from the project, a key characteristic of the approach was instead close interaction, communication and coordination with the Capital Projects team.

Facility OR completion milestones were also aligned with the commissioning sequence. OR completion certificates form part of the commissioning execution stage gate process. OR deliverables are tied to the certificates. Similar to punch listing, certificates list incomplete OR deliverables ensuring sign-off is undertaken in full knowledge of the facility OR status.

2.6 Governance

Governance is a fundamental part of any well-developed system of management. Four levels of internal governance were established with the intent to ensure quality output, integrity of reporting and to support execution by enhancing co-operation. The governance program consisted of:

- Authorization protocols for OR Plan changes
- Random auditing of reported progress and completion status as well as compliance to document management processes
- Functional and cross-functional OR War Room meetings to facilitate face-to-face execution team discussion of progress, drive escalation, risk mitigation and accountability
- OR Steering Committee Meetings to facilitate active participation by organisational leaders in oversight of the OR effort and escalation and issue resolution

In addition, two separate quality assurance audits were undertaken by independent internal and external auditors as part of performance verification.

3. ESSENTIAL SUCCESS FACTORS

3.1 Organisational Culture

A key differentiator setting the EGA approach apart is recognition of the critical role cultural alignment plays in the performance of the organisation. This is a difficult to measure and often underestimated factor that contributes to success.

As the refinery is greenfield, the first in the United Arab Emirates (UAE) as well as the first for EGA, there was limited UAE or EGA based experience for the refinery to draw upon. As a result of global recruitment, the workforce is currently comprised of 18 different nationalities and for 80%, the language of the organisation – English – is not their first language. This represents a degree of workforce diversity

rarely experienced. People have moved around the world, bringing their home culture, to live within the local societal culture, and to work in line with the organisational culture. Defining and instilling an organisational culture that exemplified the EGA values and created an environment of operational discipline, technical excellence and community care was very deliberately and meticulously undertaken.

The refinery leadership team developed their Guiding Principles. This set of overarching principles more intimately connects the employees with the business and articulates what they need to do well in order to be successful. These principles became the underpinning foundation for all that they do and how they do it. The set of documents are broken into three categories:

- Why (have them): if people know the “whys” they can better connect with them and play their role in bringing them to life through their own actions, in their own job role, in their own area
- What (are they): the actual Guiding Principles
- How (are they): to be brought into action so as to make a difference

To support the roll out of the Guiding Principles, refinery senior leaders recognized that technically focused operations leaders also need to be encouraged and supported in their leadership obligations as their actions and behaviours influence the culture across the whole business, particularly with new starters joining on a weekly basis from many different cultural and experiential backgrounds.

An initiative was embraced where a customized Executive Leadership Program and Frontline Leadership Program was developed and deployed. This provided a consistent and standardized set of refinery leadership tools across all leadership roles in the organization.

Additional to this, the G20 team (the top 20 executives within the Operations organization) meet on a quarterly basis in a facilitated “Leadership Alignment Workshop”. This ensures all executive Leaders are working effectively, consistently and in a coordinated manner in relation to developing the organizational culture and the manner by which they cascade down the key messages to their teams and team members.

Along with continuously and consistently communicating the Guiding Principles,

expected accountability behaviours are clearly defined. Particular focus has been given to reinforcing the organisational cultural values when behaviours arising from personal culture conflicted with expectations.

3.2 Commitment to OR Accountability

EGA's expansive OR program represented the operational maturity required to maximise the ramp up potential of the refinery.

In early 2015, when the decision to construct was announced the organisation was in the early stages of recruiting senior leaders. By early 2016, all the baseline OR plans had been developed, the execution systems were in place and work execution was underway under the leadership of organisational managers and guidance of the OR team. Since that time, the progress has never deviated from plan by more than a few percent.

In line with the OR execution principles, the scope encompassed 15 organisational functions with clear accountability including the core functions of Production, Technical and Maintenance and the corporate shared services of HSE, Emergency Response and Security, Human Capital, Training, Supply Chain, Finance, ICT, Engineering and Rapid Response, Legal, Smelter, Strategic Raw Materials and 3 cross functional elements of Business Process Mapping, Contractor Readiness, Commissioning and Ramp Up.

The engagement strategy of the EGA refinery senior management focused on developing cohesive partnerships. This inclusive approach fostered a deep appreciation and commitment to the success of the refinery through all levels of the organisation.

Effective management for on time work completion was critical. The greatest opportunity of meeting this objective is provided by managing the work in line with project management principles. The challenge was to transition the largely operation centric team to a system development team following project management methodology. To accomplish this, team members were trained in the basic principles of project management.

Using the ORMS system, all users could easily update deliverable progress, view performance and raise change notices through the systems user-friendly interface. The concept of s-curves, planned versus earned values were easily understood and enabled package managers to constantly analyse package performance due the system being ‘live.’

The ease of work management encouraged active participation from team members and resulted in 150 package managers and 300 users regularly interacting with the system. These users have included personnel not only from EGA and Hatch but also Bechtel, Rio Tinto, Synergistics, McKinsey and Veolia. Whoever has a requirement to interface with the system is given access. It is the single point of truth for the project status. Increasing transparency and connectivity to the project and the performance results fosters engagement and accountability.

4. ACHIEVEMENTS AND OUTCOMES

The ultimate objective is to have reliable equipment, capable people and effective systems in place when the asset is ready to commission. This best places the refinery to produce alumina of the required quantity and quality. The EGA OR program encompassed all aspects of the business required to meet this objective.

The staffing ramp up plan was tailored to the OR work load requirements. Although the work evolved to become increasingly defined, the OR team provided experience based guidance so the approximate effort was understood from the outset and resourced accordingly. Figure 6 shows the relatively minor variation in OR Plan effort over the duration of the project versus the significant increase in deliverables arising from the ongoing definition of scope.

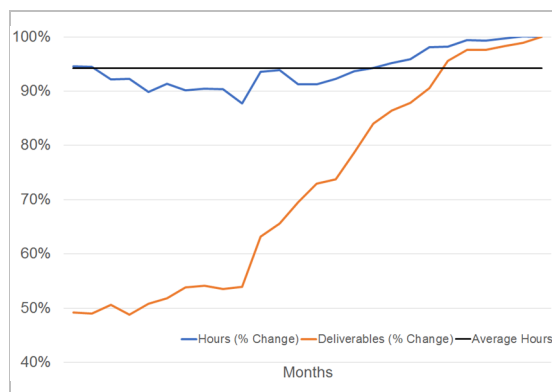


Figure 6: Progressive Evolution of Scope

Failure to understand the real effort required to complete the work, even in the early stages, would have led to late resourcing. The consequence would have been inability to complete the work in the time available, resulting in the EGA team being less than optimally prepared. A common challenge of new projects is the underestimation of the

effort required to prepare for operation, compromising their objective.

EGA invested in their team and had a comprehensive resourcing plan with multiple sourcing strategies. These strategies varied with position, included an Emiratization component and considered alumina and industrial experience requirements. A critical part of OR planning for resourcing was catering for the recruitment selection process which included candidate skill verification in some cases and had to take into account the rigorous UAE governmental approval processes.

The on-boarding was refined so that new employees arrived in two weekly batches. OR introduction sessions were regularly held so people quickly understood what was going on, what was expected of them and where to seek help. A key role of the OR team was to align people with the plan so effort was directed at completing the work, not changing the plan, and facilitating connections between existing personnel and new joiners, particularly across teams.

Defining and populating the plant operational management systems is a major undertaking for any new facility. The EGA system consisting of SAP modules, distributed control system, a plant information management system (PIMS), a laboratory information management system (LIMS) and document management system (DMS) required extensive levels of master data. In these systems alone, EGA created approximately 95,000 items consisting of, but not limited to, functional locations, maintenance tasks and plans, catalogued items, PIMS and LIMS plant input and calculation tags, job codes, employee codes, accounting codes.

Much of this data is inter-dependent and can be generated only after underpinning work has been completed. Understanding the development workflow and the dependencies between both OR and project deliverables aided the teams to understand the OR plan and manage schedule impacts between packages. This knowledge also benefited the teams understanding of the process of claiming progress.

The EGA refinery teams objective in operation is everyone working together to achieve a common goal with a high degree of commitment and compliance to the business system so there is operating discipline. A core component of the readiness work was to define the business system. EGA adopted advanced business process mapping as part

of their methodology. A specialist modeller assisted the EGA refinery teams to define the process pictorially and interactively. The outcome is an easy to access, workflow driven system comprised of 23 workflows supported by around 125 process maps. The maps capture the metadata that supports the performance of the process steps and connects the workforce to the necessary procedures and forms for execution of the process.

One of these processes was the Lock Out, Tag Out Verification (LOTOV) process. As a fundamental safety system underpinning the management of safe work within an operational facility it was an essential OR deliverable. As a greenfield refinery, the EGA refinery team had the unique opportunity to select and implement a benchmark system utilizing the latest available technologies. An e-Permitting (e-PTW) philosophy was embraced from the start. It was recognised this system of permitting management would assist staff towards doing the right thing while making it more difficult to do the wrong thing and naturally leading to improved standardization and error proofing.

The LOTOV process is an important and complicated process. The implementation had substantial requirements in relation to the system, field equipment and competency. There were around 2000 isolation plans alone, all of which require field verification towards the end of construction and prior to handover to commissioning. In excess of 300 personnel in the refinery required some form of permitting authorisation, this however represented only one aspect of the training program.

Commissioning is a complex time and will not forgive lack of skills. Success requires people who know their job role and responsibilities, equipment and processes very well. As such, the training philosophy adopted was “inch wide – mile deep” to ensure people had deep understanding of their patch. Training extended from core knowledge through to operational task competency. Around 3,500 training documents were developed along with foundational operations and technical manuals, standard operating & maintenance procedures, checklists, process management strategies & procedures.

Rigorous preparation for commissioning and ramp-up was a high priority for EGA. Significant effort was committed to not only developing a combined quantity of 650 risk assessed plans and procedures but also defining the execution management

methodology and establishing the management system. OR Completion Certificates form part of the stage gate system and as the OR plan culminates in readiness to operate at site, war room methodologies transitioned from organisational completion of bulk work, to milestone completion in preparation for first alumina. HATCH's OR Metro provided a visual connection to cross-functional critical plan activities, tracking the completion against milestone dates and float between milestones.

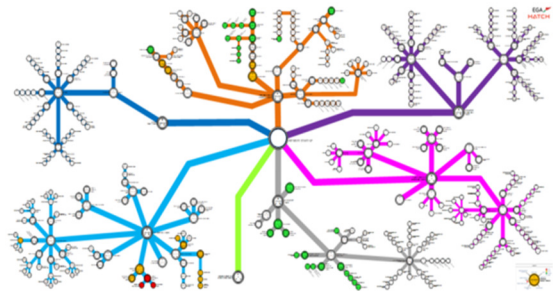


Figure 7: OR Milestone Metro

The high interconnectivity of work means that upstream work delays impact downstream milestones. The availability and consistency of real time data provided by ORMS and supported by various exception reporting methodologies created confidence to address issues with arising risk. The change management protocol safeguarded the plan, stopping changes being made when risks should instead be mitigated.

EGA instigated two independent audits over the course of the project. The second was performed by an external party. The audit was extensive with the objective being to validate the completeness of plan scope and the reported progress. Assessment was against the auditor's comprehensive evaluation matrix. In reporting back to EGA Management, the OR effort was deemed to be best practice with 94% of the attributes covered.

ORMS provided a well thought out and stable work management system that strongly engaged users and management. In the final stages of the project, the OR plan has around 2,300 work packages, 14,200 deliverables and 500,000 hours of work.

The EGA team acquired strong work management skills and supported by the various layers of reporting and governance, progress remained largely on plan. As shown in Figure 8, the variance, although small, did trend from above plan to below plan reflecting that as with any project, after the low hanging

fruit is gone, getting to the finish requires stamina and fortitude.

product quality parameters below the control limits and no long term operational performance issues.

The magnitude of the OR work is often only recognised and valued at the end. If the opportunity to prepare is not taken, operations often face an ongoing cycle of challenges that are costly but avoidable.

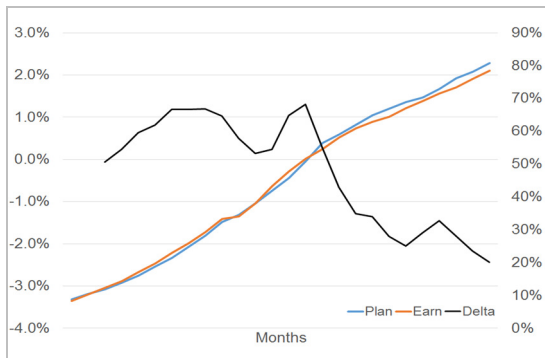


Figure 8: Performance against Plan

The strong commitment of the EGA team to their readiness, enabled them to push on uncompromisingly with their plan, demonstrating the true value of the culture and ownership.

5. CONCLUSION

EGA's approach to OR embodied the statement - proper preparation and planning prevents poor performance. Essential success factors differentiating the EGA preparation for the Al Taweelah refinery operation have been:

- Deliberate and careful establishment of organisational culture which is leadership driven and focused on effective engagement and ownership of accountability
- Commencement of OR planning and execution in a timeframe that adequately provides for strong stakeholder engagement and ownership of OR Plan scope and accountability for work execution
- Application of a clear management methodology that enables self-reporting against the owner defined stage gate profile, creating a strong sense of ownership in the data and transparency
- Focus on co-operative solution generation not blame when challenges and risks arise
- Effective governance and management of risks affecting plan performance and direct linking of OR deliverable completion to approval to start commissioning via OR Completion Certificates

For EGA, the final test of the operations readiness effort will be demonstrated by the successful ramp up refinery to full production capacity, in the planned timeframe, with all