**Light Metals 2014**
*Edited by: John Grandfield*
***TMS (The Minerals, Metals & Materials Society), 2014***

# SUCCESSFUL START-UP OF WORLD LARGEST GREENFIELD SMELTER

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Keywords: Operations Readiness Plan, A3 Initiative, CSU Management, Risk Management

## Abstract

Emirates Aluminium Company (EMAL) is the largest single site Greenfield smelter. It was started up on December 2nd, 2009 and reached full capacity of 750ktpa by early 2010. While the construction of the smelter commenced in 2007, at the same time, in parallel operation team established the Operations Readiness Plan (ORP). Core to ORP was development of "Systems", and establishing mechanisms to roll out these "Systems" and make contingency plans for workarounds with a clearly defined Future Desired condition (FDC).
The paper covers in detail the methodology adopted for initiating number of initiatives under ORP framework by Operations team and propelling EMAL from Concept to Completion.
As a result of the methodologies employed, EMAL achieved fastest, safest and uninterrupted startup of the biggest smelter in the world. The experience, knowledge & lessons learnt in Phase-1 was incorporated in the development, ORP commissioning & ramp-up of Phase-2 to achieve even better results.

## Introduction

The Emirates Aluminium smelter complex (EMAL) is a private joint stock company established and owned in a joint venture by Dubai Aluminium Company (Dubal) and Mubadala Development Company (Mubadala). It is located at the Khalifa Port & Industrial Zone in Al Tawila Abu Dhabi approximately 80km east of Abu Dhabi.
Construction of 1st Phase (Phase I) was commenced in November 2007 with 1st Aluminium metal in December 2009 and the commissioning of last reduction cell in January 2011. At an annual capacity of 750,000 tpa, it is the largest greenfield Aluminium Smelter project in a single phase.
EMAL has subsequently commenced the expansion of the smelter by adding another 444 pots of Dubal DX+ technology called Phase 2. As part of this expansion was to upgrade Phase 1 to increase the amperage from 340 to 380KA, which was commenced on early 2011 and completed in November 2012. This lifted Phase 1 capacity to 795,000 MT per annum, an increase of approximately 55,000 MT.
At the time of writing this paper, 1st pot in Phase 2 was cut in on 9th of September, 2013 with 1st metal on 15th September, 2013. The estimated time of completion of Phase 2 will be Q2, 2014 bringing total Aluminium capacity to 1.4 million tonnes/year.

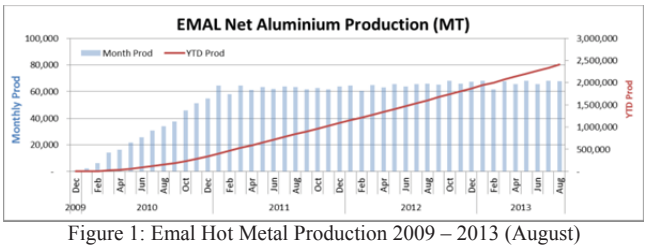


Figure 1: Emal Hot Metal Production 2009 – 2013 (August)

## Overview

EMAL Operations management consists of 4 core operations and 3 support area under the umbrella of Vice President Operations (VPO).

Table1. Classification of Emal Operations Management

| Operations area | Supporting area |
|---|---|
| Reduction | Engineering |
| Cast House | Business Systems |
| Carbon Lab & Port | Central Maintenance |
| Power | |

Management recognised that the start-up of such a state of art plant requires a highly focused and methodical approach.
Accordingly, a number of initiatives were launched under the heading of "Business Systems" by operation to manage its journey towards FDS (Future Desired Condition). These include;

- ORP Framework
- CEO Dashboard
- War room Concept
- Cross System Work Shops
- Living the core values
- CSU Management
- A3 Initiatives
- Risk Management

Although each of above concepts itself is a technical paper of its own however it was tried to summarized all in this document.

### 1. Operation Readiness Plan (ORP)

While construction of Phase-1 was in progress, an Operation Readiness Plan (ORP) framework was established to ensure that when the plant was handed over from project to operation, the start-up, ramp-up to steady state operation was achieved with minimal interruptions.

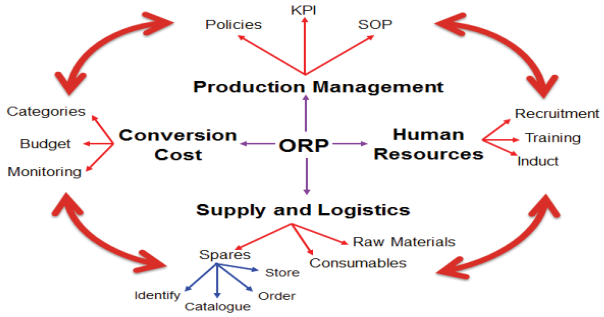


Figure 2: Operation Readiness Plan (ORP) Tree

Some of the key aspects of the ORP will be discussed in this paper.

1.1 Human Resources

1.1.1 Recruitment: Manpower ramp-up was established in 2008 to allow recruitment to bring the workforce based on plant start-up and ramp-up contractual dates with different vendors. Most of the recruitment was done overseas therefore the process took between 6-9 months from the initiation of the request for a person to bring him/her on EMAL seat. Approx. 2000 employees were recruited at different levels in management along with operator of various skills and grades.

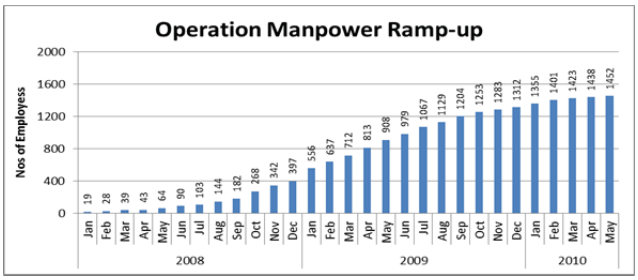
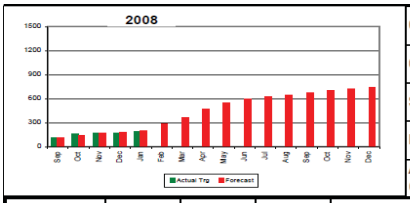


Figure 3: Manpower Ramp-up (Planned Vs Actual)

1.1.2 Training: The majority of operations workforce was recruited without or very limited smelter experience. All these employees had gone through extensive training, followed by onsite practice to achieve high level of competency and each of the skills required for smooth smelter operation. Majority of the training was carried out under an extensive training programme conducted by Dubal Training Department. The training coordination to ensure the quality training was carried out by the supervisory staff from each section of EMAL which was responsible for the operation of EMAL plant at later stage.

Practical and written tests were conducted on samples basis to ensure the effectiveness of the training. Subsequently each employee operated the selected plant and state of art equipment independently for a minimum 3 months to ensure high level of competency was achieved.




| OEM Training | TM | LM |
|---|---|---|
| OEM Trg Identified | 127 | 127 |
| Scope Written | 31 | 31 |
| PO Issued | 0 | 0 |
| Amount Commited (US$ M) | 0 | 0 |

| Dubai Trg | Reduction | Casthouse | Carbon | Smelter Maint | Power O/M | Total |
|---|---|---|---|---|---|---|
| Target | 351 | 192 | 102 | 203 | 72 | 1,017 |
| On Job Training | 97 | 61 | 69 | 22 | 2 | 227 |
| On Shift | TBA | TBA | TBA | TBA | TBA | 180 |

Figure 4: Training Status Overview

1.1.3 Induction: Induction of the employees was carried out at different stages of project development. Some of the supervisory staff was imbedded with project team to assist in layout, technical classification and preparation for start-up. A large number of employees were seconded to participate in POV (Pre Operational Verification) and different walk downs to identify deficiencies at an early stage of project. This not only helped the project but also added value to the knowledge of employees which were responsible for plant operation at later stage.

1.2 Supply/ Logistics

1.2.1 Raw Materials: Emal has its own dedicated port to bring major raw materials (Alumina & Coke), however the construction and availability of the port by ADPC (Abu Dhabi Port Company) was delayed for almost a year. A contingency plan was established with different workaround to enhance Dubal Port facility & unload Raw Materials at Dubal and transfer it to EMAL. A total of 900,000 MT material was transported to Emal site until Emal port was made operational in November 2010. The management of such a large fleet of Alumina and Coke handling was an enormous challenge however it was accomplished very well.

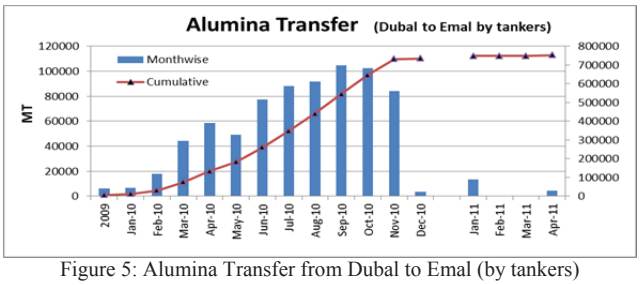


Figure 5: Alumina Transfer from Dubal to Emal (by tankers)

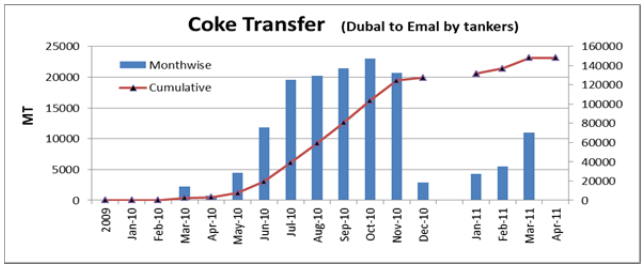


Figure 6: Coke Transfer from Dubal to Emal (by tankers)

1.2.2 Tools / Consumables: To operate a smelter, massive quantity of consumables, tools and equipment were required.

Each section of the plant prepared a comprehensive list of such items, establish consumption, find the suitable vendors and place the order based on plant start-up and consumption schedule.

This list includes items as small as a pencil to a front loader. Attention was adopted to manage and control over/under supply. Procurement of thousands of items was efficiently planned based on plant startup and ramp-up schedules to control and optimize the costs. The delivery, inspection and storage conditions were ensured throughout the process.

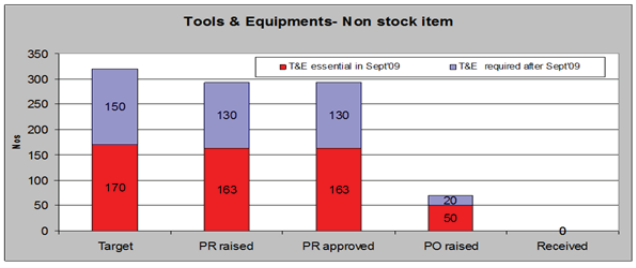


Figure 7: Tools & Equipment Management

1.2.3 Spare: As part of the Operational Readiness Plan (ORP), it was a challenging exercise to select an appropriate number of spares from very extensive lists produced by the vendors to keep a balance between need and cost. On time delivery was an issue and with the assistance of EMAL Procurement team, several items were expedited, thus did not face any plant interruption due to non-availability of spares.

| | Sr # | Package Numer | Spare Ordered (Line item) | Spare Received (Line item) | Received % | Pending | Pending % |
|---|---|---|---|---|---|---|---|
| PHASE 1 | 1 | TK-6691 | 3279 | 3269 | 99.7% | 10 | 0.1% |
| | 2 | TK-6692 | 1780 | 1779 | 99.9% | 1 | 0.1% |
| | 3 | TK-6692 (HBR) | 790 | 790 | 100.0% | 0 | 0.1% |
| | 4 | TK-6693 | 380 | 379 | 99.7% | 1 | 0.1% |
| | 5 | PM-6552( FTA+ASC) | 422 | 422 | 100.0% | 0 | 0.1% |
| | 6 | PM-6553 | 145 | 145 | 100.0% | 0 | 0.1% |
| | 7 | PM-6556 | 570 | 570 | 100.0% | 0 | 0.1% |
| | 8 | TK-5570 | 28 | 28 | 100.0% | 0 | 0.1% |
| | 9 | PM1029 | 600 | 600 | 100.0% | 0 | 0.1% |
| | 10 | TK-3201 | 350 | 350 | 100.0% | 0 | 0.1% |
| | 11 | PM-3203 | 93 | 93 | 100.0% | 0 | 0.1% |
| | 12 | PM-3205 | 49 | 49 | 100.0% | 0 | 0.1% |
| | 13 | PM-3223 | 94 | 94 | 100.0% | 0 | 0.1% |
| | 14 | TK-3232 | 350 | 350 | 100.0% | 0 | 0.1% |
| | 15 | PM 3204 | 230 | 230 | 100.0% | 0 | 0.1% |
| | | TOTAL | 9160 | 9148 | 99.9% | 12 | 0.1% |

Figure 8: Spares Management

1.3 Production Management

1.3.1 Standard Operating Procedure (SOPs) This was one of the crucial activities carried out by operations and maintenance teams to develop/write SOP for each state of art equipment/activity and upload in Quality Management System, Based on information available, SOPs were revised a number of times and efficacy of whole process can be judged by the fact that just prior to plant start-up majority of documented SOPs were almost correlating actual functions/activities being performed.

A number of (WOT) work observation teams (internal) were established to review the strength of SOP and to ensure the people of the shop floor were fully aware of them.

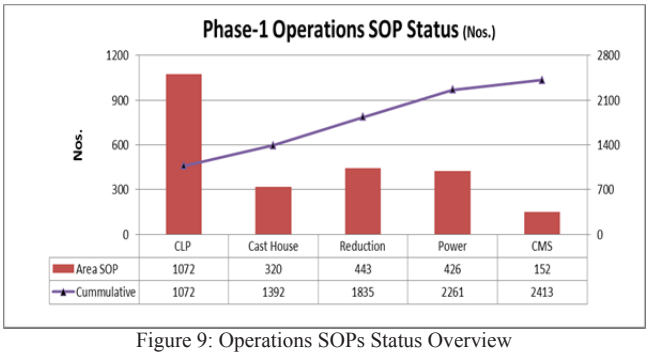



Figure 9: Operations SOPs Status Overview

1.3.2 Key Performance Indicators (KPIs): Being a Greenfield smelter EMAL had no historical data, hence KPI were established based on given industry practices and the expertise of experienced employees in the organisation. To establish business performance monitoring system, KPI were established as initiation of the process and with further usage of A3 concept for Future Desired Condition (FDC), extended improvement was achieved.

| KPIs | UOM | Target | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Internal Processes (Current) | uom | 2012 | Q1 | | | Q2 | | | Q3 | | | Q4 | | |
| | | | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sep | Oct | Nov | Dec |
| Minimum Inventory Level (Alumina) | Days | 20 | 32 | 21 | 28 | 41 | 32 | 31 | 24 | 36 | 34 | 39 | 40 | 43 |
| Minimum Inventory Level (Coke) | Days | 15 | 36 | 41 | 42 | 45 | 8 | 16 | 21 | 28 | 39 | 30 | 31 | 38 |
| Minimum Inventory Level (Green Anode) | Days | 19 | 23 | 18 | 16 | 13 | 15 | 13 | 19 | 20 | 19 | 19 | 17 | 11 |
| Inventory Level (Baked Anode) | Days | 12 | 13 | 13 | 14 | 14 | 11 | 8 | 11 | 11 | 12 | 12 | 11 | 11 |
| Inventory Level (Rodded Anode) | Days | 5 | 5 | 5 | 5 | 6 | 5 | 6 | 5 | 6 | 6 | 5 | 5 | 6 |
| Rejection Rate: Green and Baked | % | <4 | 1.1 | 1.8 | 1.6 | 1.7 | 2.2 | 2.3 | 2.2 | 2.3 | 1.0 | 1.9 | 2.1 | 2.0 |
| Anode Production - Green | Nos | 407537 | 45065 | 27017 | 32675 | 27068 | 31839 | 31793 | 39990 | 35231 | 33144 | 34605 | 30265 | 27320 |
| Anode Production - Baked * | Nos | 395204 | 30814 | 30240 | 34711 | 33432 | 30240 | 31010 | 34608 | 34944 | 33264 | 33600 | 32928 | 33768 |
| Anode Production - Rodded | Nos | 376190 | 31543 | 29526 | 31381 | 31669 | 31422 | 31381 | 30812 | 32613 | 30775 | 31193 | 30959 | 32182 |
| OA Rod shop | % | 69 | 78 | 73 | 74 | 74 | 75 | 76 | 73 | 75 | 75 | 74 | 74 | 75 |
| Standard 5S Walkarounds (JG13+) | No./Month | 5 | 7 | 8 | 5 | 9 | 10 | 11 | 10 | 9 | 7 | 7 | 1 | 2 |
| A3s Open | No./Month | 2 | 0 | 8 | 6 | 11 | 3 | 1 | 1 | 1 | 0 | 1 | 3 | 0 |
| A3s Closed | % of Open | 70 | 0 | 0 | 0 | 0 | 0 | 16 | 10 | 10 | 10 | 41 | 57 | 63 |
| WOT 2.0 (SOPs analyzed and improved) | No./Month | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Customer / Community (Current) | uom | 2012 | Q1 | | | Q2 | | | Q3 | | | Q4 | | |
| SLA Compliance | % | 90 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Customer meetings | Nos./ Qtr. | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| Customer satisfaction Index | % | >85 | N/A | N/A | N/A | N/A | N/A | 85 | N/A | N/A | N/A | N/A | N/A | N/A |
| Customer complaints / Month | # | 8 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |

Figure 10: Key Performance Indicators (KPIs)

2. CEO Dashboard

For such a gigantic Greenfield smelter, many stakeholders were involved;

- Projects
- HR Management
- Supply & Logistics
- Finance
- Production/Operations
- IT
- Marketing / Sales continuous
- EHS

The CEO Dashboard objective was to establish horizontal & vertical interface between each stakeholder. Based on 2nd December 2009 start-up, each stakeholder established KPIs which were reviewed weekly under the leadership of CEO. The Green (accomplished), Yellow (1st delay), Red (2nd delay) were adopted in a visual way to appreciate achievements and highlight the concerns.

The countdown started many weeks ahead of 1st hot metal which was planned on 2nd December 2009. The presence of all the key players under an umbrella for an hour/week significantly helped out to understand each other needs and move forward as a team.

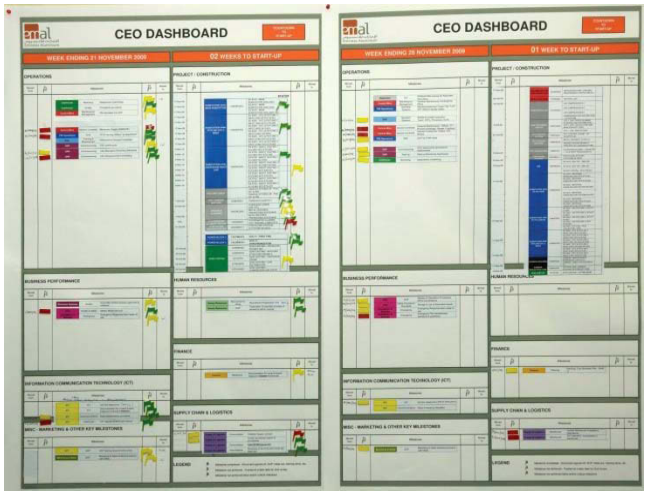



Figure 11: CEO Dashboard Overview

3. War Room Concept

Weekly review of the CEO Dashboard was being carried out in a meeting place named as "War Room". It was a combination of fun and actions and played a significant role to achieve the goal set by the management.

Figure 12: War Room Picture

4. Cross System Workshop

Another system adopted to bring all the key functions to one page was holding several workshops and brainstorming sessions to identify, design, roll out and cross check various business system development.

Figure 13: Cross Section Workshop Picture

5. Living the core values

Emal's mission of contribution to diversification and industrialization towards global economy by building such a largest Greenfield mainly consists of its five core value pillars which are as follows:

- Safety first, last & always
- Investing in today for tomorrow
- We respect the individuals and their difference
- Everything can be improved
- Protection of the environment

6. Commissioning and Start-up (CSU) Management

The principle of establishing CSU concept was to have direct interface with the counterpart in EPCM (Engineering, Procurement & Construction Management) contractor which was SNC Lavalin & Worley Parsons (SLWP) driven. The prime objective was to manage all commissioning and start-up activities of respective areas directly with SLWP POV team. They were also mandated to resolve "out of scope" or "out of plan" major issues and ensure that proper documentation was available to start and maintain the plant in an efficient manner. Each team of CSU was selected from respective departments, to ensure that they would accept a plant in such condition which they have to operate and manage at the later stage. This concept helps significantly to achieve safest, fastest and efficient plant ramp-up in most areas of operations.

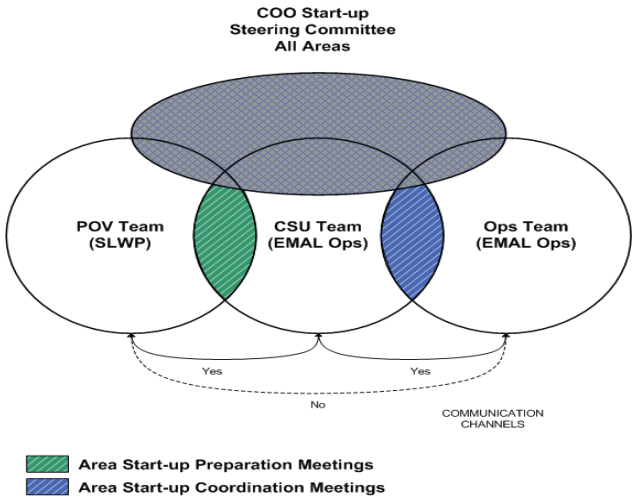



Figure 14: CSU concept diagram

7. A3 Initiative

Using balances score card dimensions, EMAL established and implemented A3 initiative at an early stage of plant start-up to establish Future Desired Condition (FDC) which clearly states the current conditions and the action plans to move towards FDC. Each action point was assigned to a Single Point of accountability (SPA).

All areas in operations developed their own A3 which was reviewed on a monthly basis by the area. This concept significantly helped to monitor, align and adjust the action plans based on any changed scenarios.

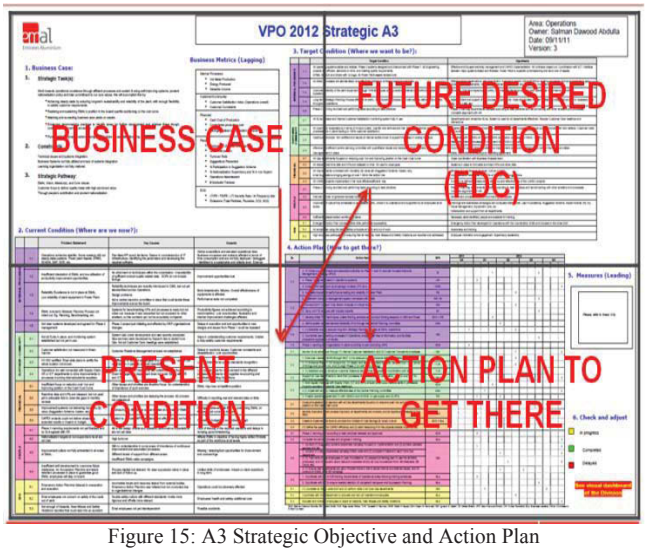



Figure 15: A3 Strategic Objective and Action Plan

8. Risk Management

The nature of risk during Project preparation phase, commissioning, ramp-up and steady state varies significantly. The Risk Management process at EMAL was established wherein relevant stakeholders underwent rigorous team exercises, well in advance, to identify risks associated with each phase Viz, Start Up, Ramp Up and Steady State Phase of Plant. Key focus of the Risk Management Process included

- Continuous monitoring of Project schedules & deviations
- Identifying the critical show stoppers
- Risk evaluation and impact assessment on business needs
- Identification of alternate solutions.

As a result, a number of workarounds were carried out in the absence or delayed availability of plant/equipment essential to continue ramp-up and mitigate overall impact on EMAL Objectives.

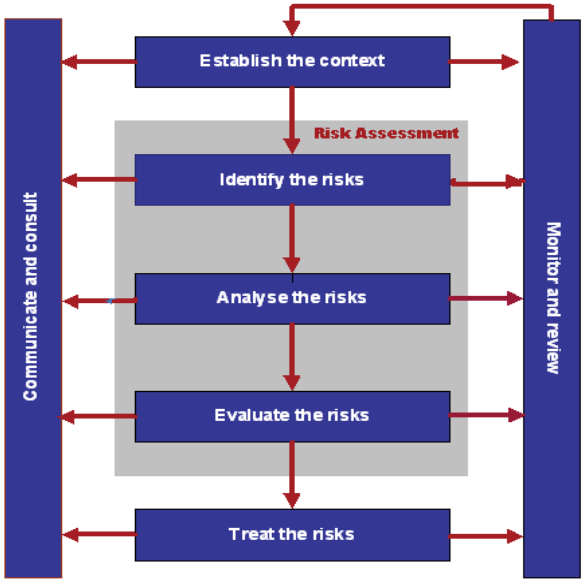



Figure 16: Emal Risk Management Hierarchy

## CONCLUSION

- World largest Greenfield smelter start-up took place in the safest, fastest and efficient manner. 13.3 pots/week or 396 days to complete 756 pots.
- Systems helped turn people intentions into reality and delivered business objectives based on predefined and agreed methodology.
- Systems allowed managers to focus on strategic issues rather than daily tactical issues.
- Systems reduced reliance on people and focus on process to action productive output with minimum follow-up.
- Lessons learnt from Phase-1 were incorporated in the development of Phase-2.


## Acknowledgement

We acknowledge the contributions of Mr. Majid Shafi, DS Kumar, Tahir Bashir, Ms. Nadia Brima & Liudmila Intabli's efforts for preparing this document.