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1. INTRODUCTION

It is recognized that business competition has shifted over time from a situation of individual enterprise versus individual enterprise to one of supply chain (SC) versus SC. This is perhaps more obvious for a project-oriented business, whereby large engineering projects have an edge in terms of scale and complexity, especially regarding the involvement of tiers in the project outcome delivery. In fact, large engineering projects are characterized by huge financial and resource effort as well as high probabilities of failure, and once finished, 'projects have little use beyond the original intended purpose' (Miller and Lessard). In addition, these projects are facing an ever-growing complexity, in both structure and context; this is mainly caused by the involvement of more and more diverse and strongly interrelated elements, and addressing the complexity is one of the major and most recurrent features of such projects.

In particular, when we focus on large projects delivering complex capital goods, they have economic significance, and the governance of their design and construction is a fundamental determinant of their outcomes. Large projects, such as those related to the delivery of buildings, airplanes and plants, typically involve many tasks that interact to create a complex solution landscape.

It is apparent, on the one hand, that an increasing trend towards adopting this kind of project is taking place (e.g. from construction to oil and gas to nuclear power industries); on the other hand, it seems there is another common feature characterizing them: large projects experience erosion of value during execution.

So, if it is clear that competition is now played on the field of the whole SCs, also for project-oriented business, it becomes clearer why project management and SC management scholars have increasingly focused their attention on the management of complex projects.

1.1 The relevance of large engineering, procurement and construction projects

Within the variety of project typologies, the importance of engineering, procurement and construction (EPC) projects is widely acknowledged in the fields of civil engineering, plant engineering, electrical engineering and so on, mainly because of the increasing requirements from the client in terms of reduced project cost and a shorter schedule. In EPC projects, the contractor has the responsibility for project cost, quality and schedule (usually) under a fixed price. This contractor is almost always selected by a client through a competitive bidding process based on such as bidding price, past experience, past performance, company reputation and the proposed method of delivery and technical solutions and, most of all, price.

The selected contractor undertakes a set of tasks including EPC by coordinating subcontractors and main suppliers within the limits of the predetermined budget and schedule. Given all that has been mentioned above, EPC projects can suffer from a number of issues, such as very high interdependence of activities with complex process relationships, overlaps, overall work fragmentation (vertical de-integration), complex organizational structure and uncertainty in prediction of desired outcomes. This is also aggravated by the fact that, by definition, each project is unique not only in terms of design but also in terms of manufacturing and technological requirements and constraints.

Because of this uniqueness and complexity, only the best contractors can still manage to fulfil the requirements of a large project successfully, supported of course by their whole Supply Chain. Thus, a greater integration or at least coordination between contractor, subcontractors and suppliers is necessary for EPC projects.

In particular, the most impacting set of tiers of the SC in the EPC industry is that operating in engineering to order fashion, which basically includes the contractor, its subcontractors and their main suppliers. This differing distribution of expenditure, particularly for the project materials, is symptomatic of a context in which the contractors ‘increasingly play the role of integrators and coordinators of the entire realization process, while on the other hand, subcontractors and main suppliers have to be able to design and produce the more and more complex items/systems needed.

As a result, very competitive subcontractors are vital for the success of the projects, of the contractors and of their whole SCs in cascade. In addition, local suppliers employed by the owner of the project are becoming more frequent, and socio-eco-political events and globalization are making the context riskier. Thus, a greater integration or at least coordination between contractor, subcontractors and suppliers is necessary for EPC projects. Still, the relevance of procurement management in the EPC sector is high: in fact, procurement can be exploited to leverage a project's performance and to reduce costs and, according to Yeo and Ning and Alarcon et al., the relevance (in both positive and negative sense) of procurement management is mainly related to the fact that;

(1) Procurement connects engineering and construction,
(2) Procurement is highly dependent on external companies,
(3) Procurement needs communication and negotiation with external parties,
(4) Project materials' cost represents a high proportion of the total costs of the EPC project, and
(5) complex supplies are very difficult to manage.

1.2 EPC Projects and Procurement

Experience in the EPC sphere confirms how, during project execution, considerable deviations may occur between the real performance and the planned one. The nature of these deviations is extremely variable and may depend on both external causes, of which the company has practically no control, and internal causes, related to the three EPC company business processes: EPC. Procurement, in particular, probably has the greatest impact on the project. Buying may account for up to 80% of the total value of a project and for up to 45% in the case of critical supplies. The high impact of procurement on project performance is just as evident with regard to time: consider the long lead-time item, whose buying process begins even before the actual beginning of the project activity. Lastly, the end quality of the system is highly influenced by the quality of the items purchased; EPC companies act by choosing a supplier capable of guaranteeing an adequate level of quality.

2. PROBLEM SETTING

The evolution of purchasing, from a mere buying function to a strategic function, has been accompanied by a growing interest among researchers in providing helpful methodological support. There are three main streams of research on the role of procurement: specific strategies employed by the purchasing function; purchasing's role in supporting the strategies of other functions and that of the firm as a whole; and purchasing as strategic function of the firm. Another stream of research appeared about the impact of purchasing strategy on firm performance. In particular, as regards companies mainly working on projects (such as EPC companies), the overall firm performance strongly depends on the performance of the projects. Within such projects, procurement has the task of identifying the most suitable buying strategy (or differentiated strategic actions for heterogeneous categories of objects or subjects or buying behaviour (i.e. the degree of effort in each step of the buying process) to satisfy the triple constraints of time, cost and quality.

The prime interaction between procurement and project performance could therefore be based, at first glance, on the relevant levers of procurement: strategy and process. It is precisely through the chosen positioning of these two levers that procurement may modify project performance, thus contributing to the creation of possible deviations from the planned performance both in a positive and in a negative way.

In general terms, it is considered that procurement may be associated with project deviations in the two dimensions (or 'levers') of purchasing strategies and purchasing process. In fact, these dimensions determine the contribution of procurement to project performance in terms of time, cost and quality and may be directly influenced by the same. On the other hand, the 'remedial actions' adopted by procurement to recover performance deviations can therefore be based on modifications made to purchasing strategies and processes. These changes can be considered as realignment actions between the desired performance and that obtainable through a specific positioning of strategy and process levers. More specifically, it is suggested that the positioning of the levers may be modified

for a single purchase, subsequent purchases within the scope of the same project or structurally for future projects (lessons learned).

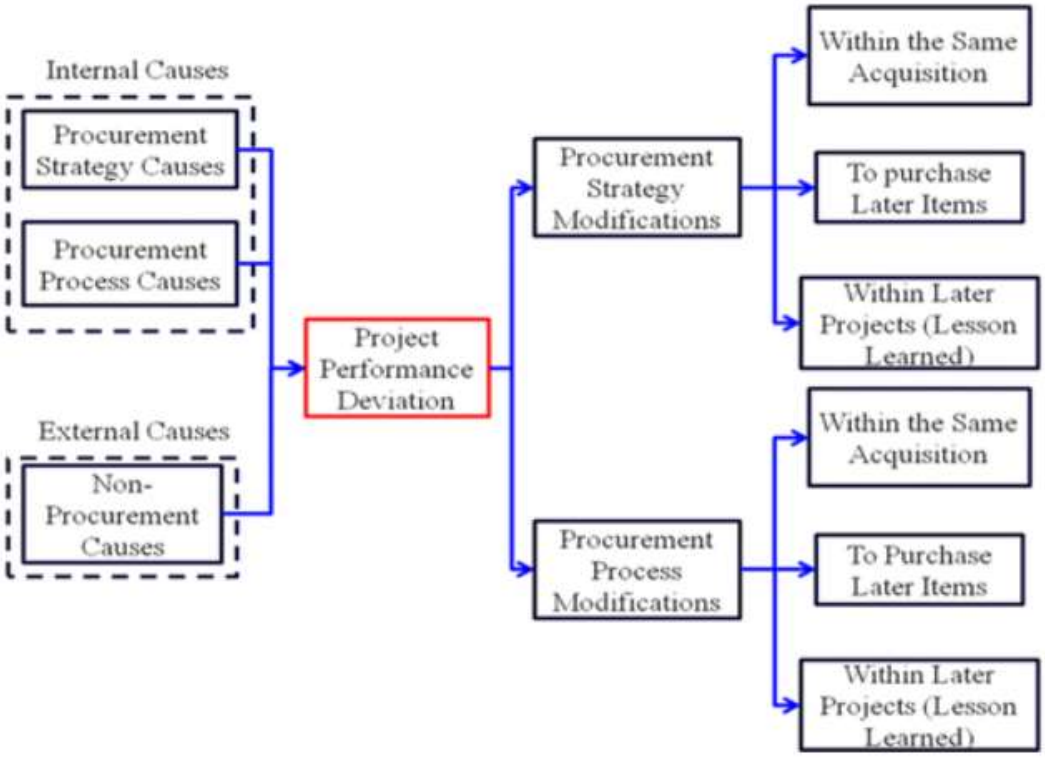


Figure 1: Positioning of the procurement levers

3. DESCRIPTION OF SCM PRACTICES

Process control and improvement	Use of fool-proof for process design, statistical techniques, automation, preventive equipment. Clarity of work or process instructions. Identification of problem easily.
Top management support	Offer of innovation and continuous improvement policies. Provision of necessary resources for processes. Promotion of partners' involvement in firm's activities. Participation of top management in supply chain improvement process. Review of supply chain issues in top management meetings Responsibility for operational performance.
Customer focus	Determination of customers' needs and wants. Use of information from customers in designing products and services. Understanding of products or services by employees. Commitment in satisfying customers. Relationship between company's goals and customers' expectations.
Supplier management	Reliance on a few suppliers. Selection of suppliers based on quality. Development of long-term relationship with suppliers. Clear of the specifications provided to suppliers. Assessment of suppliers' capabilities and performance.

4. PROCUREMENT PROCESS MAP

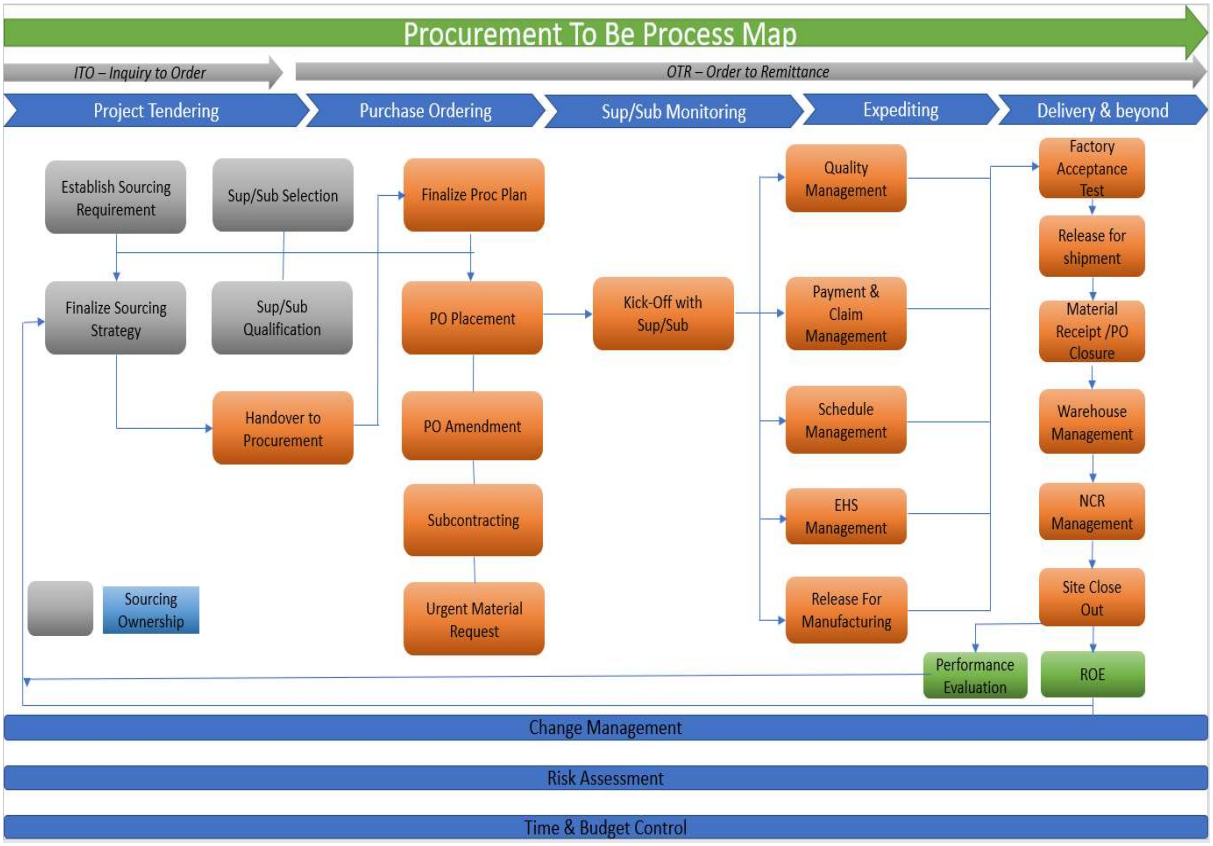
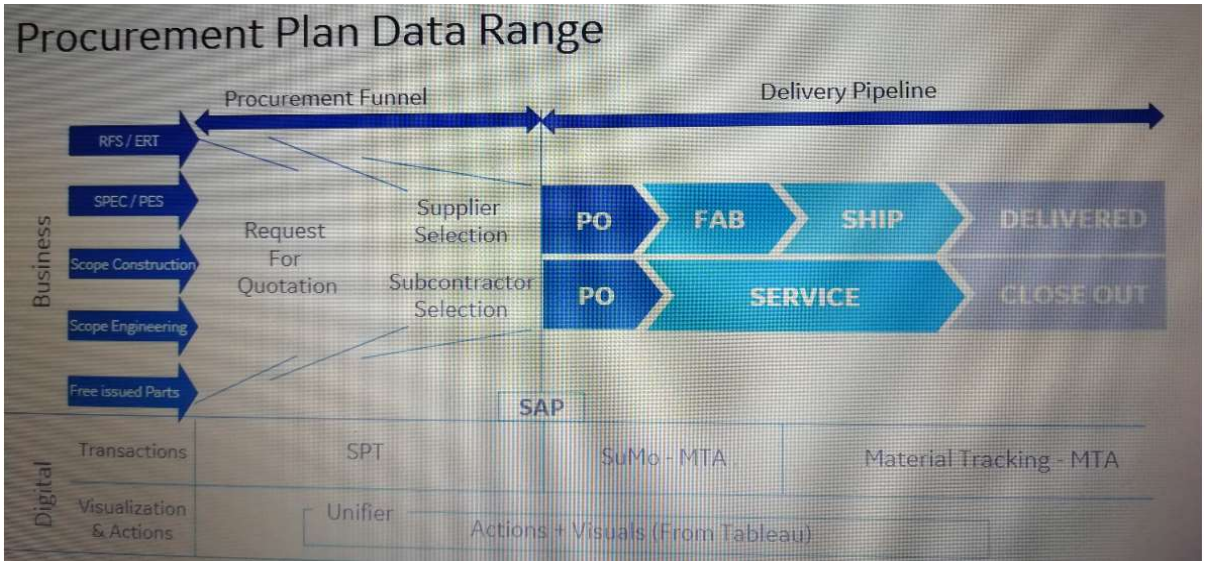


Figure 2: Procurement Process Flow Chart

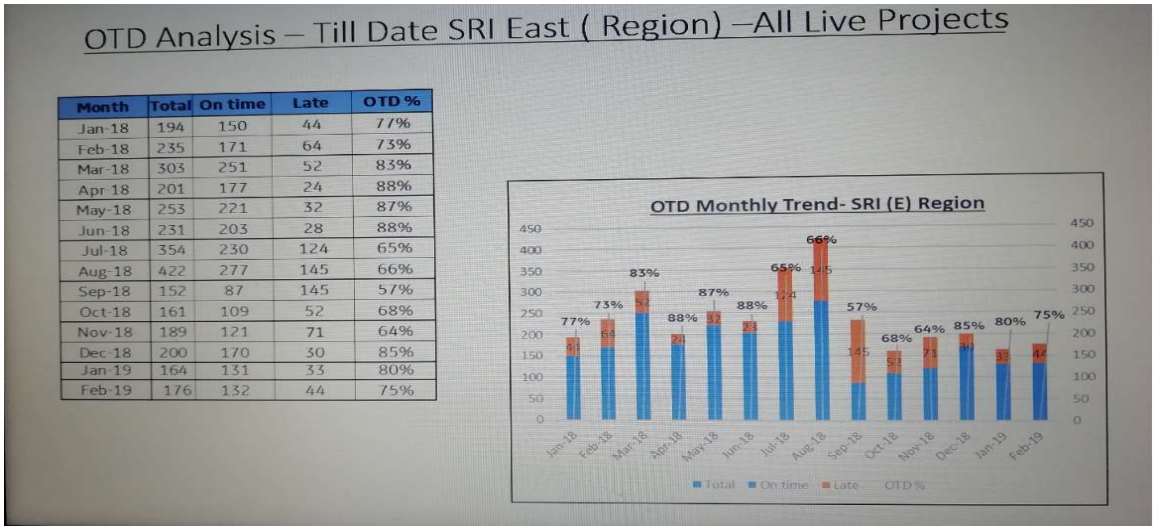


5. OBJECTIVES OF PROCUREMENT

- Lead Time Reduction by applying and using various tools for Information Flow
- Lead Time Reduction by following the Material Flow. Attached file to be referred

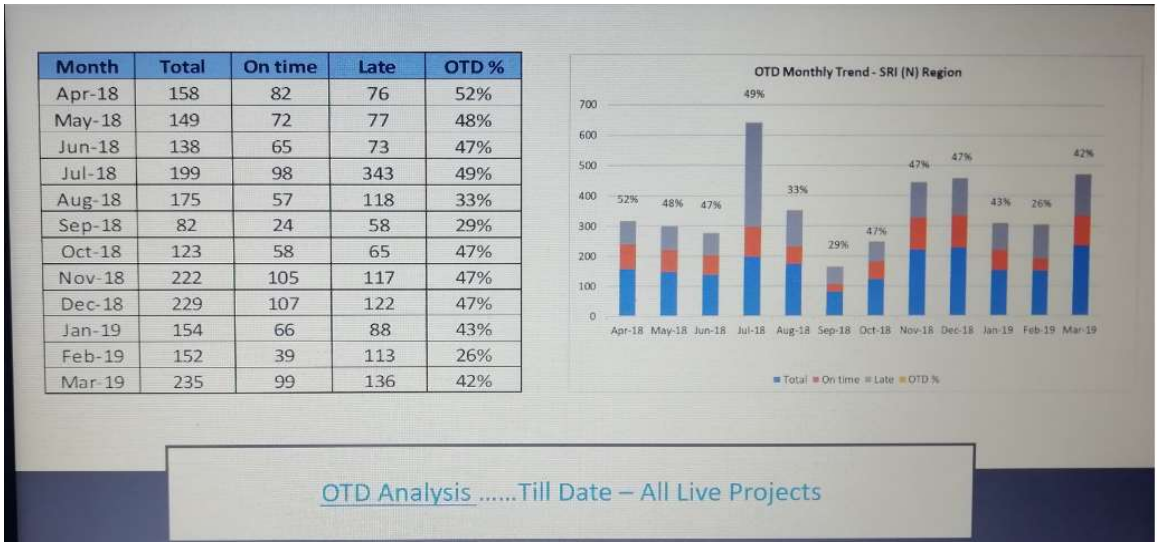
6. METHODOLOGY

6.1 Operating Rhythm: Continuous Rhythm of Review, and monitoring of outsourcing activities. Focus on Late Start Late Finish Report from Tableau.



Month	Total	On time	Late	OTD %
Jan-18	194	150	44	77%
Feb-18	235	171	64	73%
Mar-18	303	251	52	83%
Apr-18	201	177	24	88%
May-18	253	221	32	87%
Jun-18	231	203	28	88%
Jul-18	354	230	124	65%
Aug-18	422	277	145	66%
Sep-18	152	87	145	57%
Oct-18	161	109	52	68%
Nov-18	189	121	71	64%
Dec-18	200	170	30	85%
Jan-19	164	131	33	80%
Feb-19	176	132	44	75%

Figure 3: OTD Analysis



Month	Total	On time	Late	OTD %
Apr-18	158	82	76	52%
May-18	149	72	77	48%
Jun-18	138	65	73	47%
Jul-18	199	98	343	49%
Aug-18	175	57	118	33%
Sep-18	82	24	58	29%
Oct-18	123	58	65	47%
Nov-18	222	105	117	47%
Dec-18	229	107	122	47%
Jan-19	154	66	88	43%
Feb-19	152	39	113	26%
Mar-19	235	99	136	42%

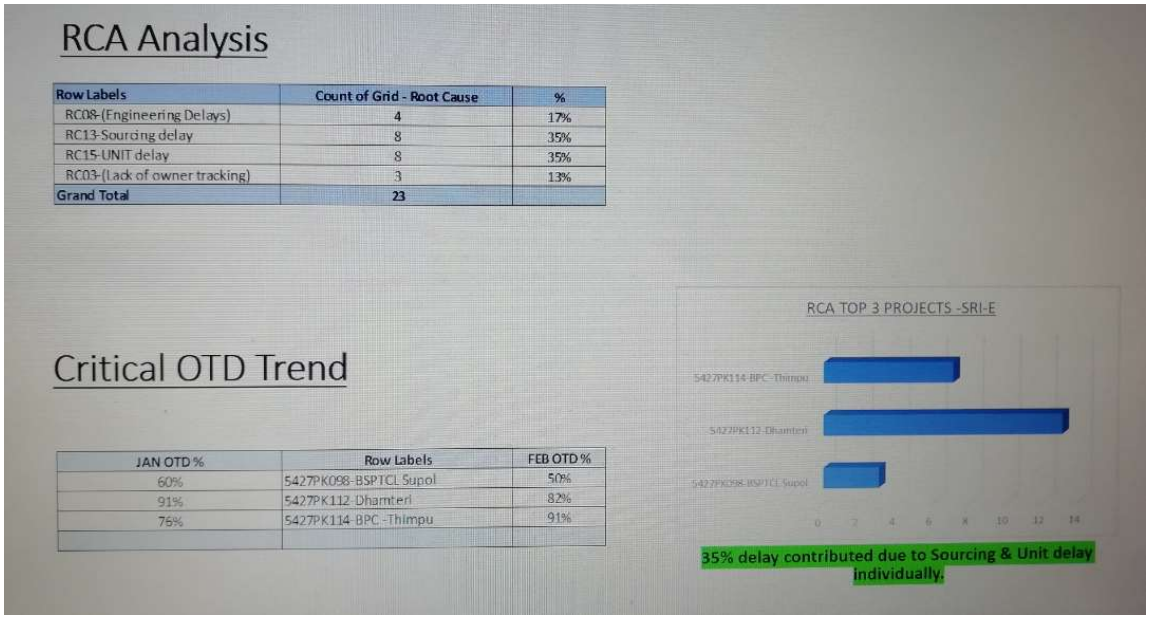
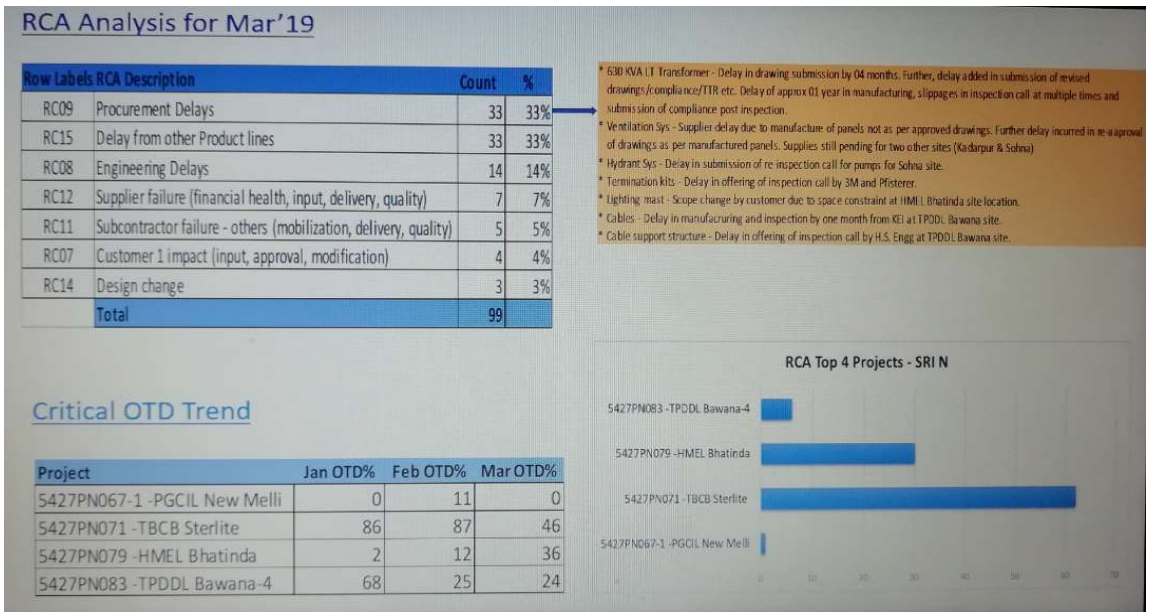


Figure 4: RCA Analysis



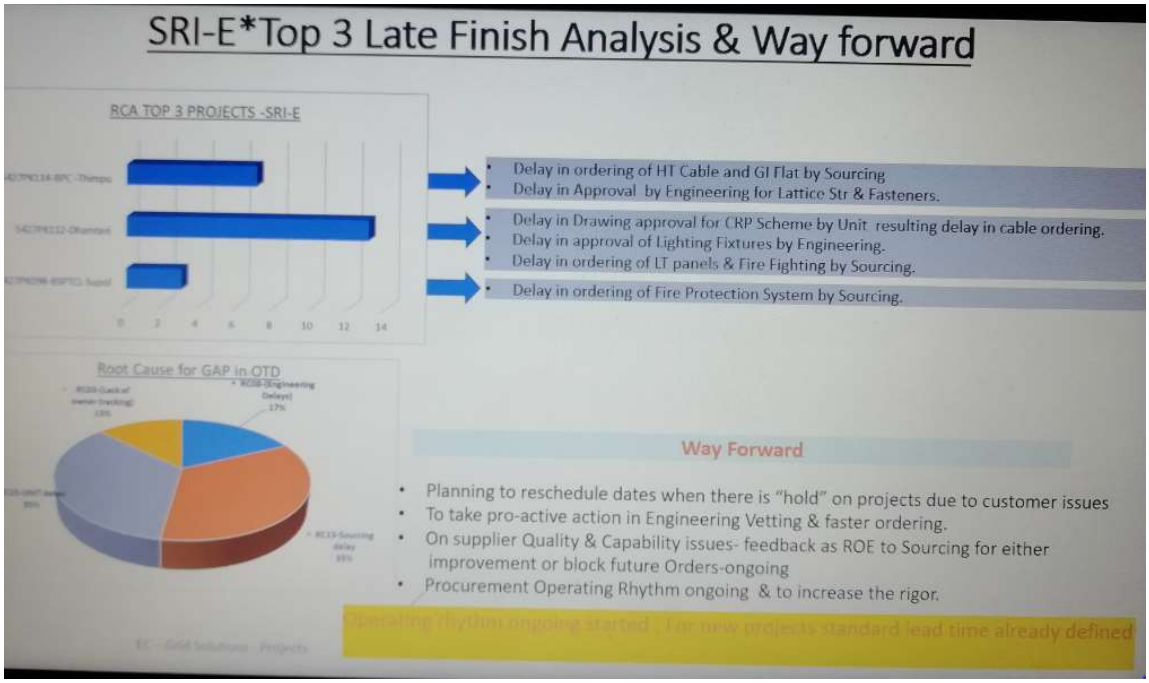
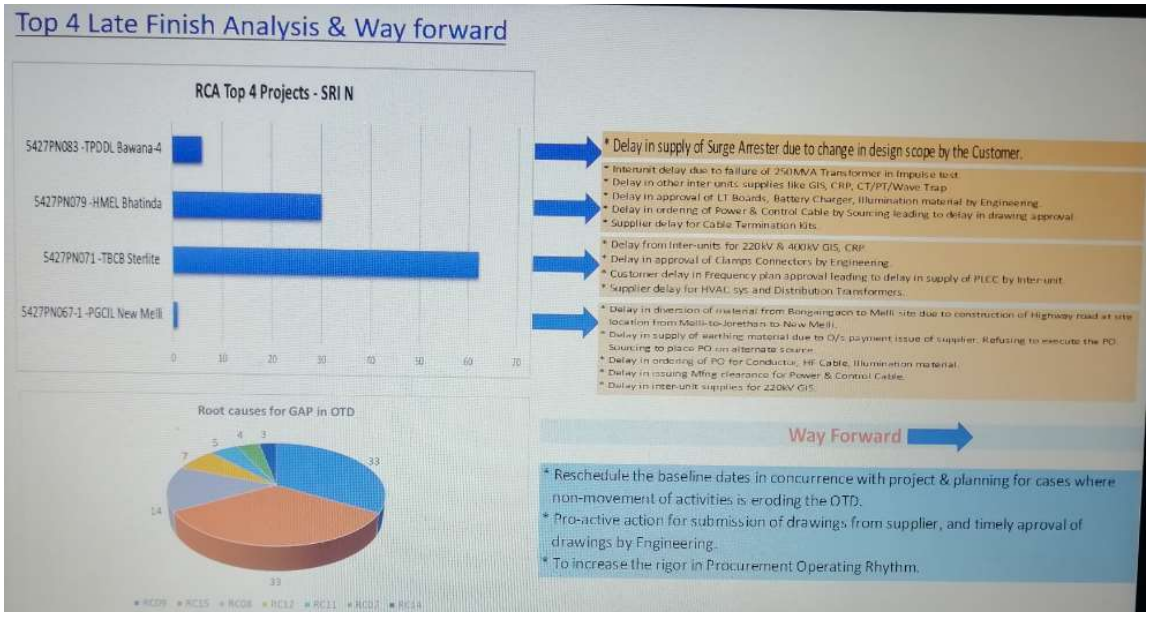


Figure 5: Late Finish Analysis



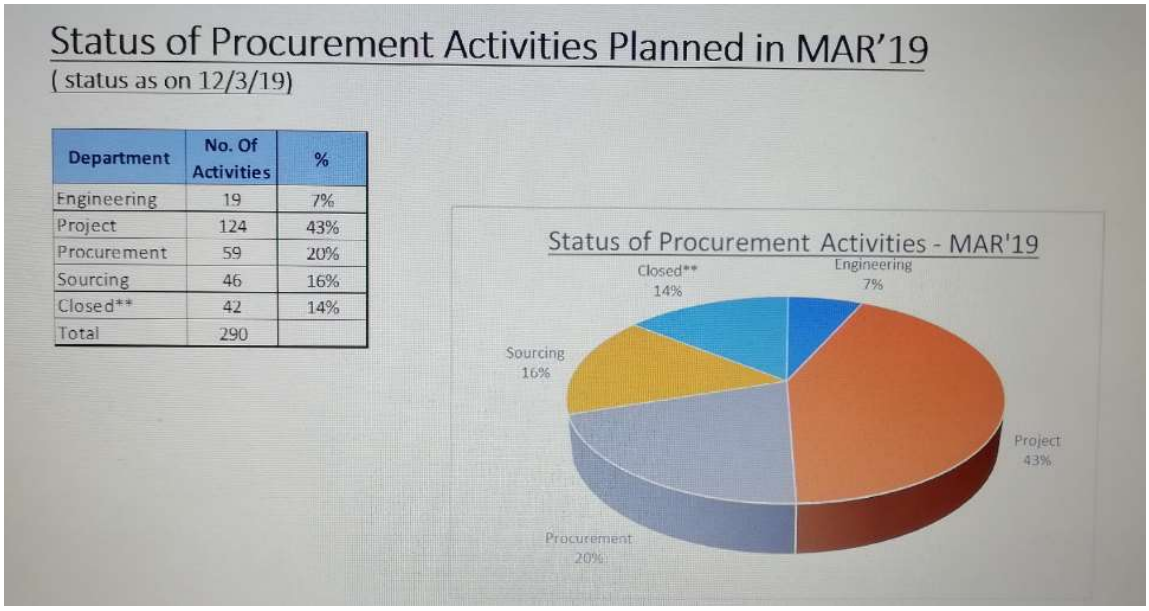
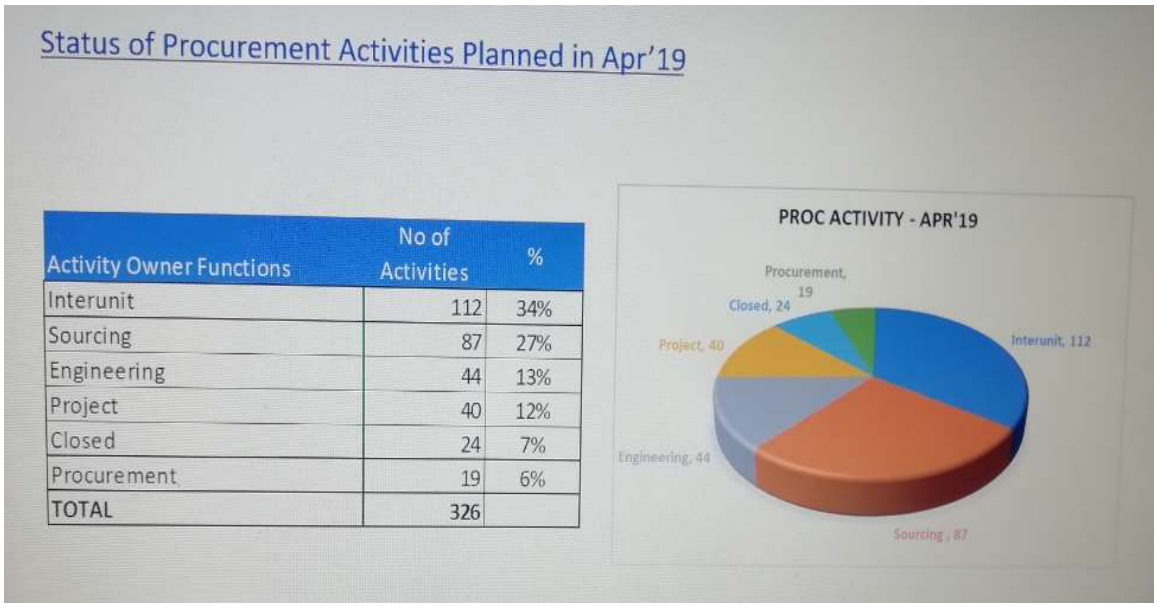
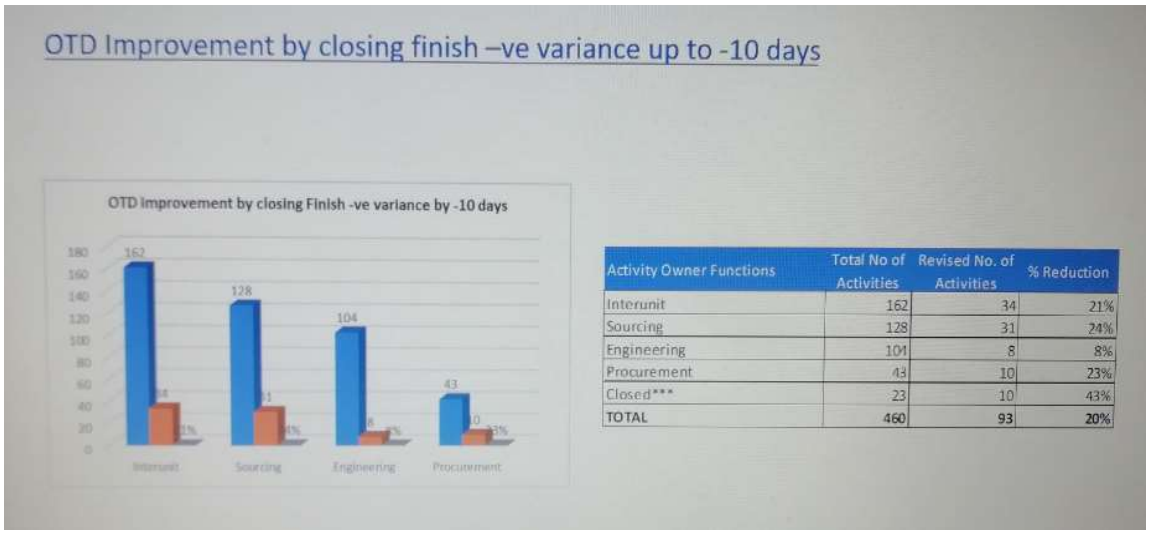


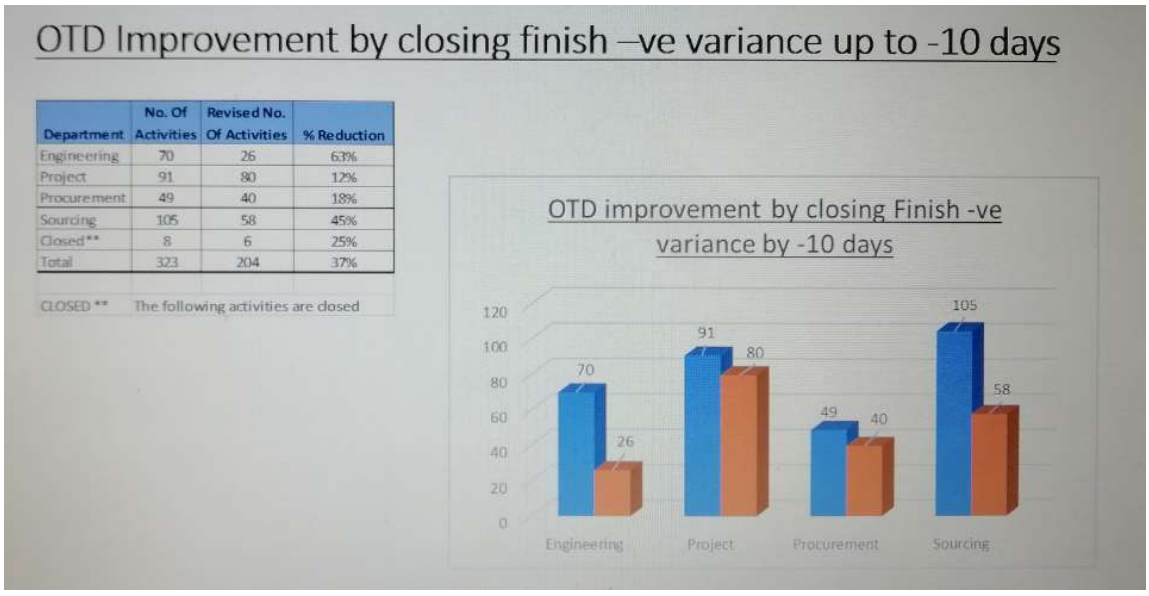
Figure 6: Planned activities in successive month





Activity Owner Functions	Total No of Activities	Revised No. of Activities	% Reduction
Interunit	162	34	21%
Sourcing	128	31	24%
Engineering	101	8	8%
Procurement	43	10	23%
Closed***	23	10	43%
TOTAL	460	93	20%

Figure 7: OTD Improvement by closing -10 days activities



Department	No. Of Activities	Revised No. Of Activities	% Reduction
Engineering	70	26	63%
Project	91	80	12%
Procurement	49	40	18%
Sourcing	105	58	45%
Closed**	8	6	25%
Total	323	204	37%

CLOSED ** The following activities are closed

6.2 PO Tagging: All Pos that are tracked in the project planning within Primavera P6 have to be tagged. This linkage activates the comparison of forecasted and actual dates with baseline dates. The target is 100% tagging all the time.

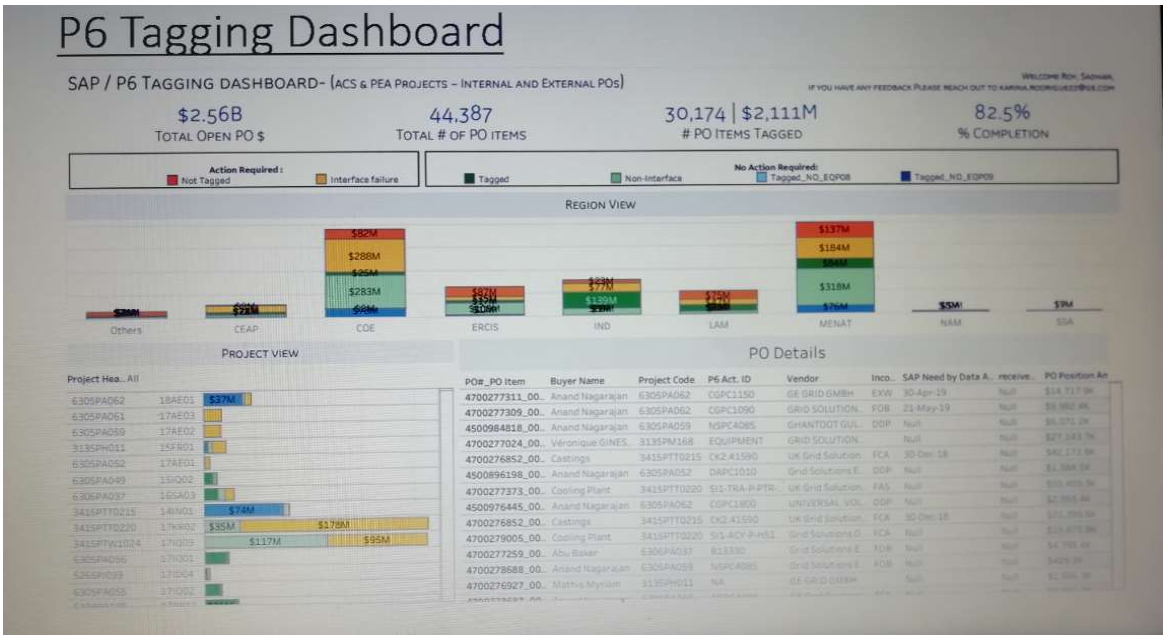


Figure 8: P6 Tagging Dashboard

6.3 PO Acknowledgement: All Purchase Orders have to be confirmed by the supplier by writing with a Confirmed Date of Delivery. In fact, Confirmed Delivery Date has to be filled on every PO line and updated when necessary to reflect reality. Review of Dashboard **weekly.**

6.4 Updates of Dates in ERP: Any changes in an order even limited to the date of delivery has to be reflected into the ERP. The most accurate dates are needed in the ERP at all time. The accuracy of Dashboard has to be reviewed weekly.

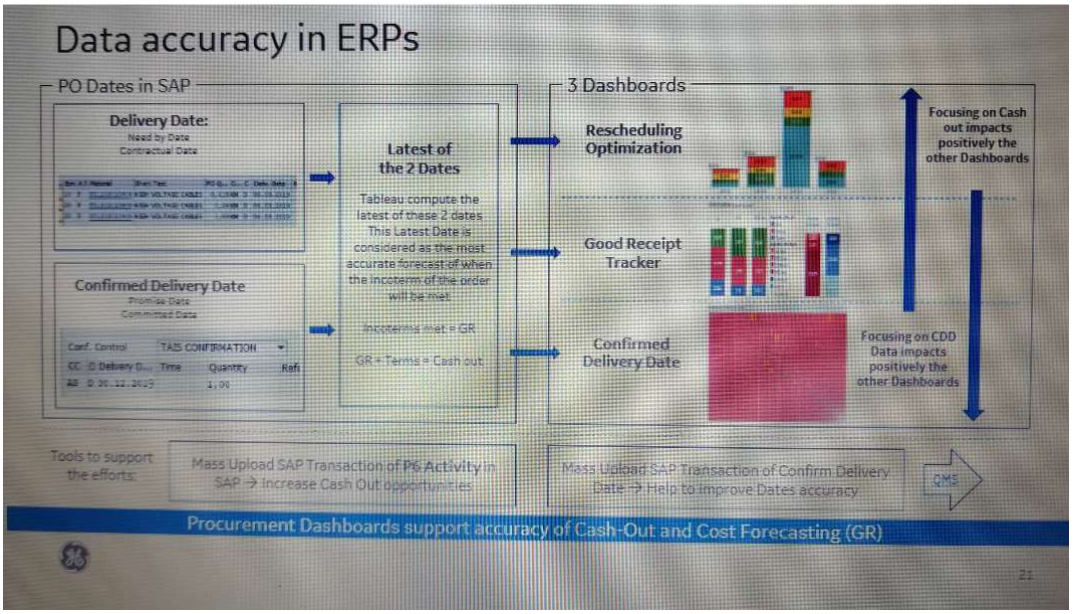


Figure 9: Data Accuracy in ERP

6.5 Drive Return of Experience: Return of Experience has to be consolidated between project to share awareness on issues with specific suppliers. A **quarterly review** is required to consolidate the findings and share.

6.6 Supplier Evaluation (Procurement): Supplier Evaluation has to be performed on all suppliers and consolidated and shared on **quarterly basis.**

6.7 Lead Time: Lead Times set have to be respected in Project Planning. Proactive actions are being taken to control discrepancies identified by Procurement and Logistics Teams. In addition, lead time have to be updated based on **Return Of Experience.** This has to be consolidated **every 6 months.**

6.8 Communications: **<u>On monthly basis</u>**, a Communication meeting has to be held to cascade the function information and news from Central Team. Based on this, an action plane is set and updated at every meeting to follow up on important information.

6.9 Invoices on hold: Permanent focus is required to clear the backlog of invoices waiting for validation. A **<u>monthly review</u>** held in this regard the streamline the process.

6.10 Non-Conformities: Focus on having the team to manage Non-Conformity in NCP tool. Tracking the Cost of Failure as well as recovery made from claiming the defective supplier has to be set in place.

6.11 CDD Updation: Confirmed Delivery Date to be updated in PO on regular basis every fortnight. This help in projecting the revenue figure more accurately,

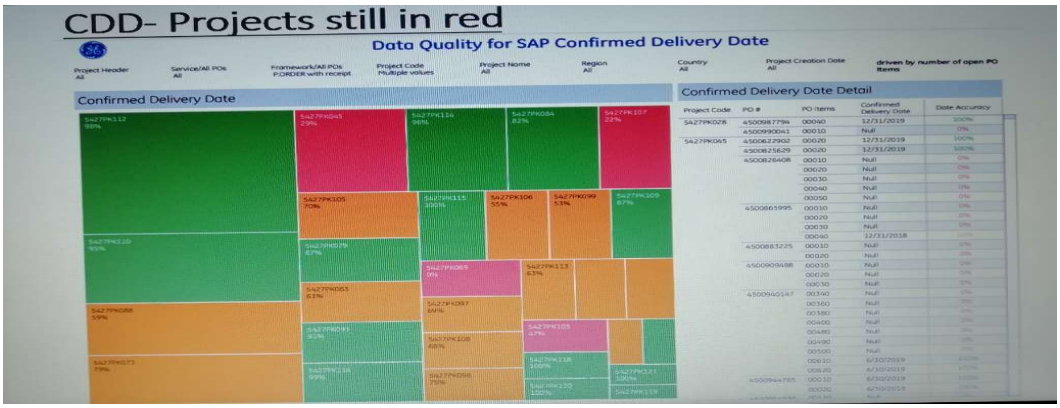
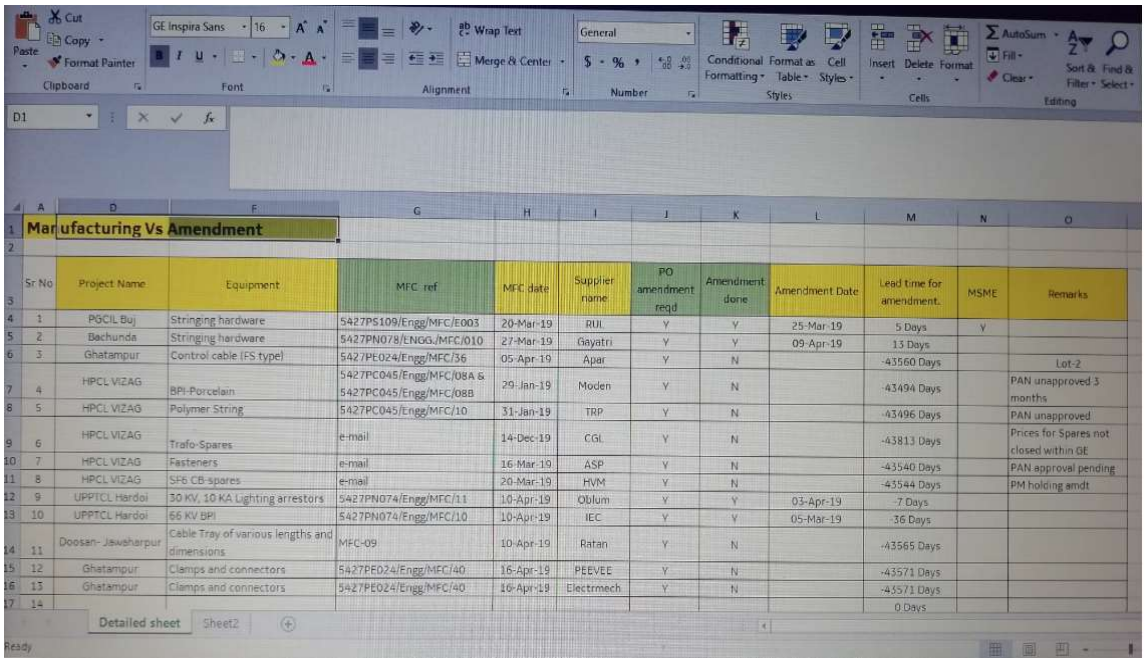


Figure 10: CDD Dashboard

6.12 Manufacturing Vs PO quantity: Closely monitoring and timely issuance of PO amendment to avoid holding back the dispatches of material at supplier end due to gap in manufacturing quantity and PO quantity causing delay in supplies.



Manufacturing Vs Amendment

Sr No	Project Name	Equipment	MFC ref	MFC date	Supplier name	PO amendment reqd	Amendment done	Amendment Date	Lead time for amendment.	MSME	Remarks
1	PGCIL Buj	Stringing hardware	5427PS109/Engg/MFC/E003	20-Mar-19	RUL	Y	Y	25-Mar-19	5 Days	Y	
2	Bachunda	Stringing hardware	5427PN078/ENGG./MFC/010	27-Mar-19	Gayatri	Y	Y	09-Apr-19	13 Days		
3	Ghatampur	Control cable (FS type)	5427PE024/Engg/MFC/36	05-Apr-19	Apar	Y	N		-43560 Days		Lot-2
4	HPCL VIZAG	BPI-Porcelain	5427PC045/Engg/MFC/08A & 5427PC045/Engg/MFC/08B	29-Jan-19	Moden	Y	N		-43494 Days		PAN unapproved 3 months
5	HPCL VIZAG	Polymer String	5427PC045/Engg/MFC/10	31-Jan-19	TRP	Y	N		-43496 Days		PAN unapproved
6	HPCL VIZAG	Trafo-Spares	e-mail	14-Dec-19	CGL	Y	N		-43813 Days		Prices for Spares not closed within GE
7	HPCL VIZAG	Fasteners	e-mail	16-Mar-19	ASP	Y	N		-43540 Days		PAN approval pending
8	HPCL VIZAG	SF6 CB spares	e-mail	20-Mar-19	HVM	Y	N		-43544 Days		PM holding amdt
9	UPPTCL Hardoi	30 KV, 10 KA Lighting arrestors	5427PN074/Engg/MFC/11	10-Apr-19	Oblum	Y	Y	03-Apr-19	-7 Days		
10	UPPTCL Hardoi	66 KV BPI	5427PN074/Engg/MFC/10	10-Apr-19	IEC	Y	Y	05-Mar-19	-36 Days		
11	Doosan- Jawaharpur	Cable Tray of various lengths and dimensions	MFC-09	10-Apr-19	Ratan	Y	N		-43565 Days		
12	Ghatampur	Clamps and connectors	5427PE024/Engg/MFC/40	16-Apr-19	PEEVEE	Y	N		-43571 Days		
13	Ghatampur	Clamps and connectors	5427PE024/Engg/MFC/40	16-Apr-19	Electrmech	Y	N		-43571 Days		
14									0 Days		

Detailed sheet | Sheet2

Ready

Figure 11: Manufacturing Vs Amendment

7. TECHNOLOGY FUNCTIONAL TOOLS

7.1 Tableau & Primavera: Using Tableau and Primavera planning tool for monitoring the project schedule thereby controlling Late Start, Late Finish activity by following Procurement Methodology. Also, Lookahead plan to be followed for 3 /4 months.

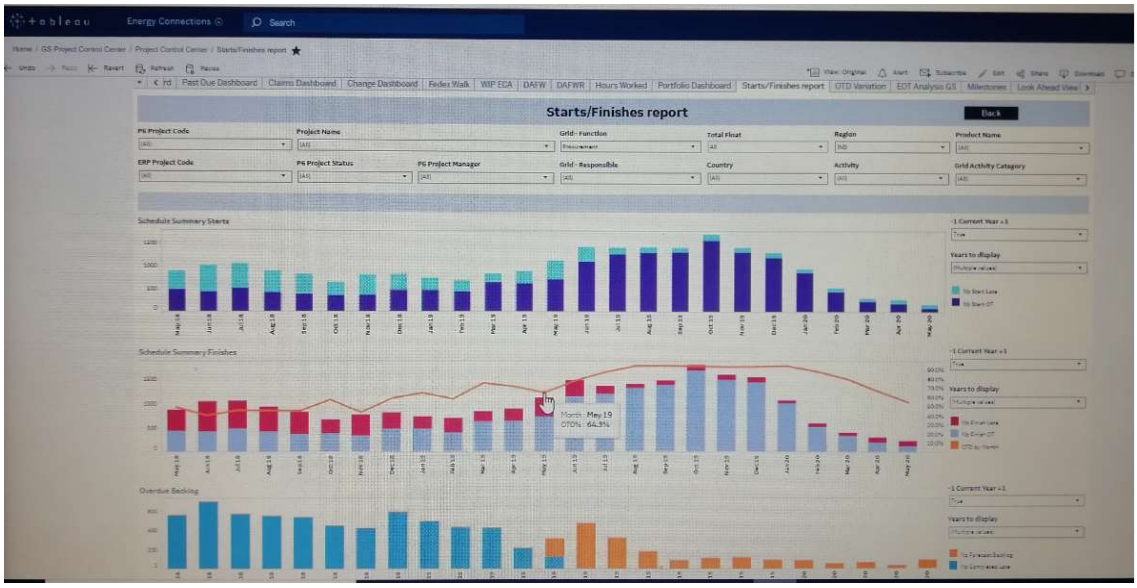


Figure 12: Late Start Late Finish Report

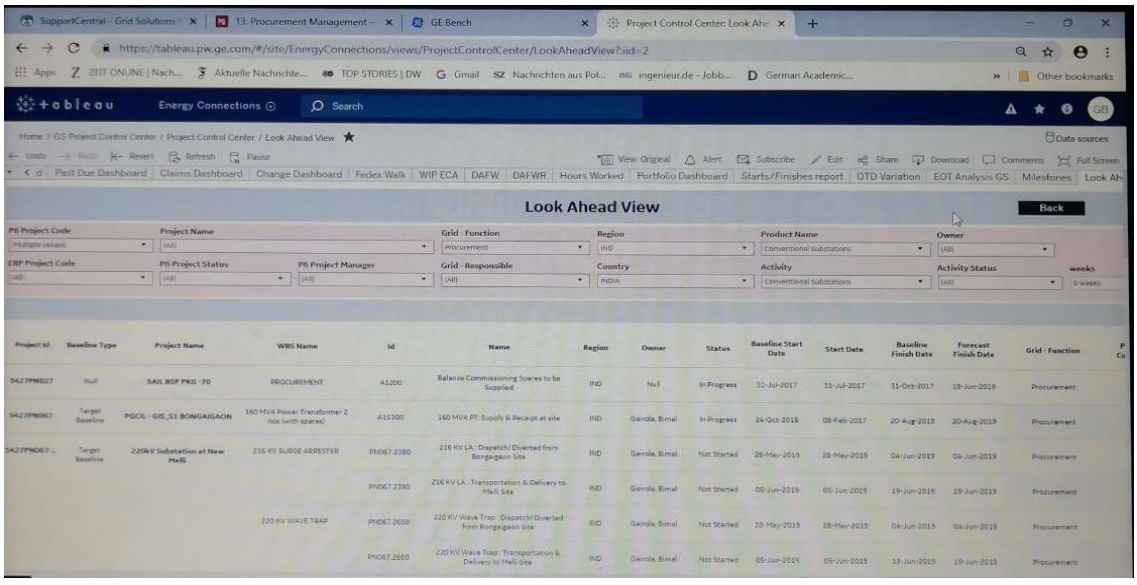


Figure 13: Look Ahead View

7.2 Procurement Plan: Excel Procurement Plan for Large and Complex projects. An excel template is available for tracking all progress of Procurement and Logistics activities.

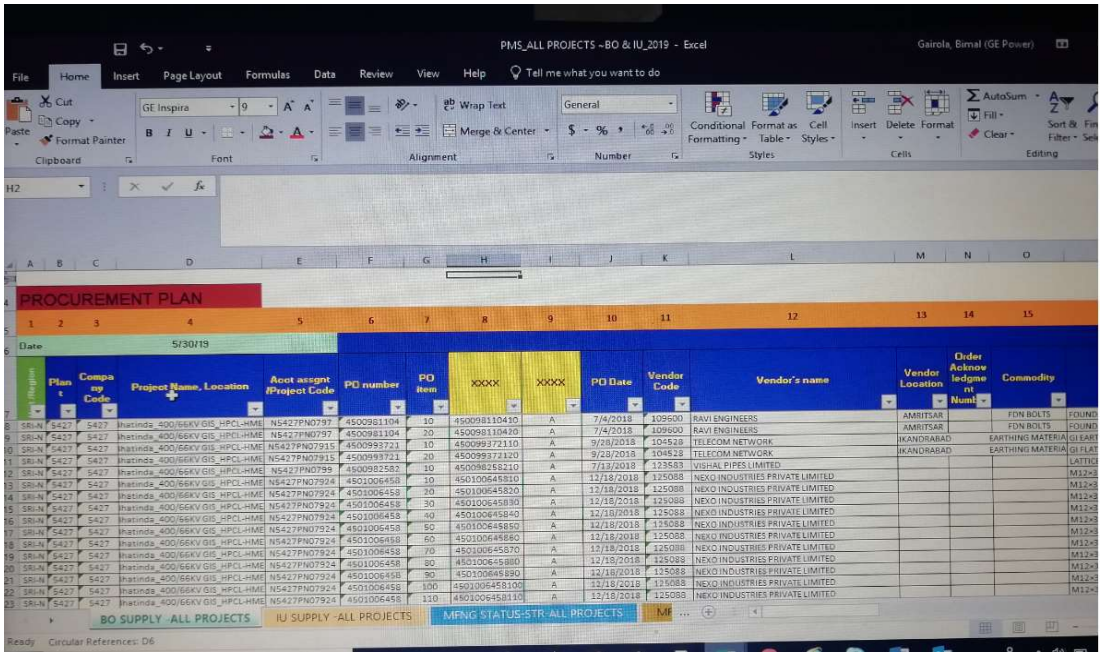


Figure 14: Procurement Plan Or Project Monitoring Sheet

7.3 Digital Procurement Plan: It is a concept build on the co-activity of 4 business tools. (Not Yet Ready)

- Sourcing & Procurement Tool (SPT) for all activity pre-Pos
- SAP for placing officially the orders and get them validated.
- Master Tracking Application (MTA) to track all activities post PO Placed.
- Primavera P6 for all Baseline dates of the project.

7.4 Master Tracking Application (MTA): To be tracked on **monthly basis**. This tool is being used for handling supplier documents and material receipt at site apart from

a. **Quality follow ups – ITTS:** It is a module of MTA that allows tracking of all manufacturing inspections on an order. The module can be deployed on any project already on the MTA platform.

b. **Bar Coding- Material Handling:** Bar coding helps in online receipt of material in MTA to close the material flow from supplier works to site locations. This is being done using scanner device or smartphone using MTA applications to be installed from Google play store.

c. **Supplier Documentation Follow-up:** Supplier Documentation module is a MTA module tracking all documentation communications between Company and its suppliers.

d. **Logistics Module:** Ship Module helps tracking all the shipments of commodities. This tracking takes place from PR to delivery at site.

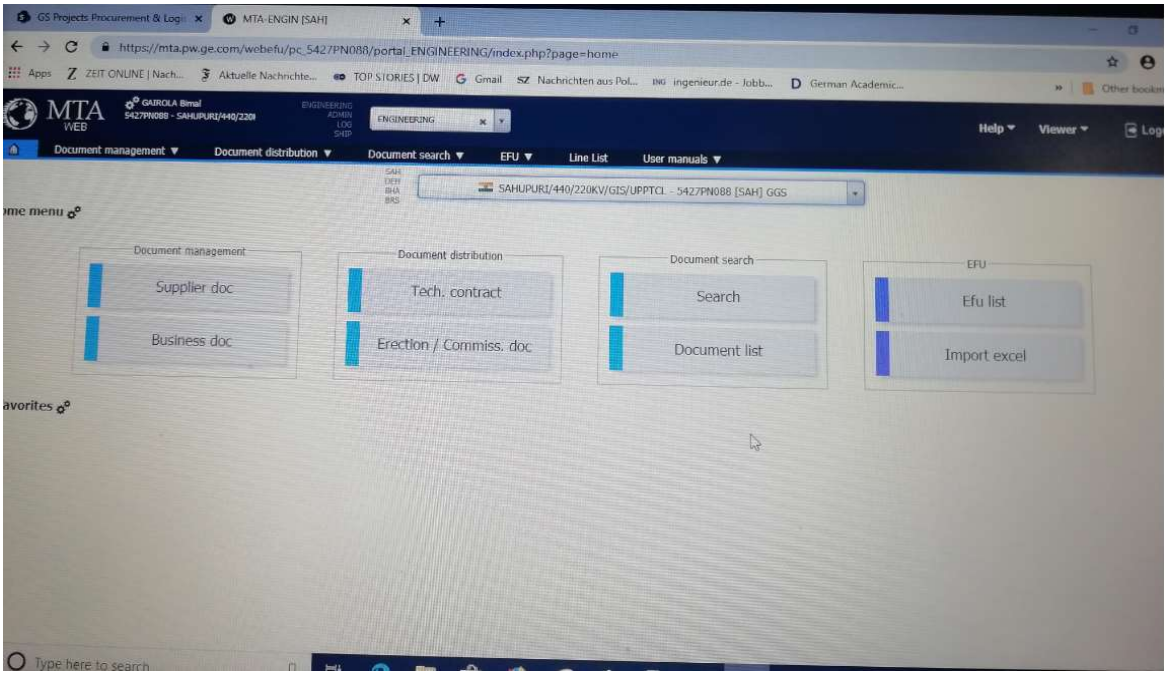


Figure 15: Master Tracking Application (MTA)

8. SUPPLIER PRE-SELECTION

The pre-selection of a new supplier for potential business in Customer projects leads to the inclusion of this supplier on the panel.

Process Step

a) RFI

RFI consists of collecting and analyzing information about suppliers and their processes.

b) Data Collection

The request for information forms must be used in order to collect all the requested information.

Following information to be provided by the suppliers

- General & Commercial information
- Supplier's production capacity and future growth capability (Including technology & logistics)
- Supplier's financial health
- Track record on past performance versus present needs (Quality, Delivery, EH&S)
- Tracking non-conformance processing and complaint handling, Sub-Contracting control.
- Compliance Due-Diligence – Know Your Supplier and third-party report. (for sub-contractors only)

c) Result analysis

Supplier result must be analyzed using pre-defined criteria. The output of the RFI is list of suppliers which will be assessed and potentially audited before final pre-selection.

This step is carried out for Key Commodities on a regular basis. In particular, supplier's financial health shall be performed. In addition, for large sub-contractors, compliance screening shall be performed.

- Initial price-quotation from supplier to be obtained to check competitiveness. Assessment must be conducted by Sourcing.
- Depending of the assessment result, an audit will be conducted by Supplier Quality.
- If all previous steps are satisfactory, pre-selected supplier will be added in the panel.

If a supplier failed pre-selection process may be supplier panel. pre-selected later, if situation improves.

A pre-selected supplier may lose its pre-selected status if:

- RFI has been re-performed and results are not satisfactory.
- Delivery & quality are not acceptable anymore.
- Supplier is not competitive anymore.
- Financial health is not adequate
- Compliance screen shows evidence of integrity misses.

Finally, the supplier is eliminated from the active panel.

Supplier Assessment

Assessment is performed for:

- Every new manufacturing supplier providing products falling into Critical Product category.
- Did not receive any purchase order for a period of 2 years.
- For existing suppliers, in case of bad performance and no audits done.

For Project suppliers providing commodities falling into critical commodity, a pre-assessment and a risk evaluation using scoring matrix will be performed to define the suitable way to evaluate the supplier.

Specific conditions of financial health assessment:

- The financial part of the risk assessment has to be done based on the following situations:
- Purchase order value is >$1M
- Sole source suppliers
- Critical commodity of Non-Repeat & Project scope.
- Early warning sign that Supplier may in financial distress.

9. SUPPLIER SELECTION PROCESS

The Supplier Selection Process comprises of 3 main steps, that are summarized in the below diagram.

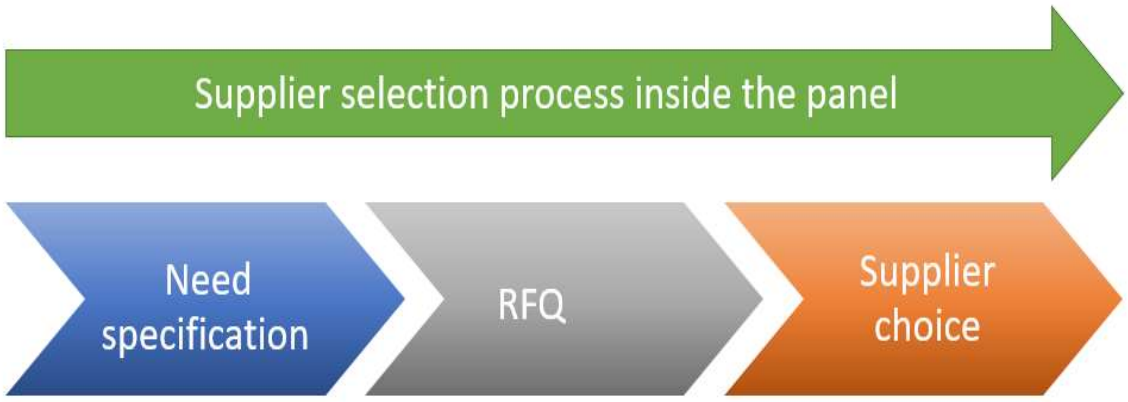


Figure 16: Supplier Selection Process

STEP 1: Description of the need through a specification

STEP 2: Request For Quotation to the potential suppliers

STEP 3: Offer Analysis, Negotiation and Supplier choice.

Note: In case of existing and valid price list, RFQ process is not required.

Project Launch

a) Need Specification

Selection of a supplier starts at the reception of specification by the process owner. Specification include technical information and supply chain requirement.

Description of a need through a **"Specification Package".**

Purpose: Specification and requirement collection

Output: Validated "Specification Package" of product /service.

The specifications of the product or services to be sourced must be gathered and understood by the process owner.

The Process owner must then build the **"Specification Package"** by collecting all the relevant information including

b) Request to Quotation (RFQ) to Potential suppliers

Purpose: get quotes from suppliers

Output: A list of further shortlisted suppliers for negotiation (if needed)

RFQ must be sent to the suppliers in panel.

Exceptions:

RFQ can be sent to new suppliers, only no supplier on the panel can be meet the requirement. In this case the pre-selection process must be launched in parallel.

A minimum of three suppliers shall be solicited to bid for each PO for any Direct Materials or Services greater than or equal to $25000 USD

c) Offer analysis, Negotiation and Supplier Choice

Purpose: Select the best possible supplier

Output: Selected supplier for business with firm requirement

In case of technical & commercially valid offer is available, the use is mandatory.

The offers received must be analyzed and compared using criterion defined before the reception of the offers.

- At a minimum, a Price Comparison Sheet must be filled
- Negotiation must be conducted using the adequate tools, including sourcing mentored negotiation when required.
- The cheapest supplier must be chosen.
- In case the supplier chosen is not cheapest one, the exception process must be followed

A final confirmation of the agreed price and conditions must be sent in writing to the selected supplier.

10. REFERENCES

1. Quality Control HandBook by JM Juran & Gryna

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3. Tools – FEMA (Failure Mode & Effect Analysis), Cause-Effect Diagram, Pareto Analysis, CTQ (Critical to Quality)

4. https://journals.sagepub.com

5. Procurement Game Plan: Winning Strategies and Techniques for Supply Management Professionals by Charles Dominick and Soheila Lunney