Chapter 8

Recommendations & Summary, Limitations and Further Scope

Overview: To the best of my knowledge, this is the first ever integrated attempt in a bulk ore industry for automaton of complete supply chain logistics through RFID and GPS deployment and the degree of its success could be gauged by the immediate acceptance of these systems by top management of case company and their appreciation of scholar’s efforts. It was heartening to know that top management of the company had given their in-principal approval for rolling out such implementation across all its Goa locations including mines in Karnataka.

Further I also gathered from the industry circles that even the Govt. of Goa had recently contemplated automation of trucks and barges through GPS in their recent notification in order to regulate industry better. This proves the importance of automation for industry, though RFID is yet to gain formal acceptance in state legislations due to prevailing obvious differences in variety of technology i.e. Active, Semi-active and Passive.

I hope this research would have implications for readers, both practitioners and academicians in terms of identifying challenges and mitigating them while executing automation of supply chain using modern technologies. The practical implementation has demonstrated the actual impact of automation expressed in quantitative values by way of improvement in performance indices and financial savings. Significant benefits have been reported for the company under implementation in their various business processes and performance measures as stated below:

The automation efforts could lead to significant improvements in overall equipment efficiency (OEE) of barges and overall fleet efficiency of trucks. The research study did present a lot of opportunities / scope available for the company management to tweak or fine-tune their facilities lay-out for higher and faster through-put of trucks and barges by improved turn-around from their premises. One can imagine the significant impact this would have across industry if it were to adapt such automation technology to explore newer ways for competition and collaboration.
The transit or handling losses have been reduced significantly in both road and river segment as compared to past, specifically in river segment from 4-5% to almost <1.2% and in road segment from 0.9% to 0.6%. This if translated in monetary terms, meant a huge financial impact on the bottom-line of the company (simply speaking the company now has scope to convert 3-4% of its revenue straight into profits at no additional cost. If we were to imagine such scope of benefit being available to whole industry, the financial numbers would mean a huge impact on Goan ore exporters’ financial performance and thereby also strengthening national exchequer by additional foreign currency inflows.

Let us discuss all of these benefits and a few others below, to recapitulate.

8.1 Barge Turn-Around Time (TAT):

Barge TAT was defined earlier as the time taken by a barge to complete its 2-way journey between jetty (source) and port or trans-shipper (destination). It consists of the total lapse of time right from reporting of barge at loading jetty, actual loading time together with waiting time, travel time to reach unloading destination (a port berth or TV), actual unloading time together with waiting time and finally the time it travels empty back to jetty for re-loading the next trip. Thus in short, it is total lapse of time for the intended to and fro voyage between jetty and port.

The baseline TAT was computed by extracting data from past manual records of the company (30 hours) for similar calendar months (as of study period) in order to keep the play (interference) of other variables or factors at minimum. Post implementation of new system, we compiled voyage data for the set of barges equipped with GPS system during 2 months and computed TAT. During implementation, care was taken to ensure that the particular mother vessels, once nominated for our study were being fed only from GPS-equipped barges and likewise only those barge trips were being considered for voyage TAT computation. Necessary user training was imparted to the operating personnel of barge control room which included mock sessions to train them for spontaneous action including coordination with inter-dependent functions like quality assurance and jetty loading teams.
It was found that under the new regime, barges had clocked TAT ranging from 18 hours to 28 hours during different trips of study-nominated vessels and the average time for all such trips was 22 hours as against 30 hours during baseline measurements. The variation in TAT was further analyzed to identify controllable and uncontrollable factors. Following key inferences were drawn after attempting sufficient fine-tuning of controllable factors:

The waiting time at tidal crossings of individual barge at the Miramar Sand Bar in Mandovi river and other sand bars of Zuari river played significant role and the fact that the events of entire supply chain of previous barge for similar source or destination was now visible / accessible to barge crew and control room desk together, weighed heavily on the faith of the crew to not waste time elsewhere and cross that hurdle spot (sand bar) to reach in time. It is important to note and appreciate the fact that the seriousness and sincerity with which this information were utilized by the crew and the whole river set-up worked in sync with new objective of trip completion as fast as possible. This was the key contributor of reduction in trip time to like 18 hours and even below 22 hours many times, which was earlier unheard of. Post-study period, the research scholar was informed by the river-fleet control desk that they have also been able to clock just 11.5 hours in a few trips to one particular trans-shipper (being the most efficient one in discharging cargo from barge), which is almost close to theoretically computed time with zero waiting at any place throughout the trip. This amply proves that real-time monitoring, coupled with synchronization of objectives of entire supply chain partners and stakeholders can make revolutionary achievements in a motivated people environment. Further it was not just one-time or only during study period improvement, rather an all-round sustainable performance improvement as is evident from the few 11.5 hour achievements later beyond study period as conveyed by control desk team.

The real-time dynamics of various events causing abnormal waiting time, some being beyond direct influence of barge crew or the control desk, e.g. like non-availability of particular grade of material at jetty arising from delays in stock arrival by road due to traffic congestion or jams en-route; or say due to break-down of a particular machinery in material handling at loading or unloading point, etc.
However despite all odds, it was still proved that barge TAT can be improved significantly by controlling the deviations through real-time monitoring and. The real-time monitoring also gave opportunity to the concerned control room members to make dynamic allocation of barges through flexibility of barge diversion en-route to those jetties (sources) or port / TV (destinations) which were performing better, while taking into account the other constraints and competing opportunities. The full visibility of entire supply chain to the operating personnel was the prime mover of improvement, as against earlier scenario when they were trying to catch up with every new situation after a considerable time lag by which time other variables of the problem would continue to play to bring in more complexity.

The fact that control desk members were aware of the exact barge location and were in constant communication with barge drivers, they now had better ability to take optimized decision at that point in time.

8.2 Reduction in Missing Trips:

As the name suggests such info was easily derived by the open entries of trips which had not been closed during the same month (however as a practice it did not include open entries of last day of the month as that was interpreted as In-transit trips for carry-over reconciliation to next month). However it would be worth noting that despite awareness and sensitivity of all supply chain executives, we found a relatively large number of missing trips in the past data. Considering that it was a huge manual effort to reconcile receipt of almost 4000-5000 trips happening daily across various company locations, we could not sight appropriate manpower to do such quantum of work, as was evident from the fact that the concerned executives always lagged by at least 2 months of pending reconciliation. It would also be anybody’s guess about the efficacy of such identification-cum-determination process of missing trips, given the fatigue caused to individuals while trying to match such massive digital data with physical paper acknowledgements as produced by transporters after constant follow ups.

However we were able to see instant pleasure and sigh of great relief in the eyes of executives when they started getting the list of missing trucks daily and cumulatively.
The company now had increased capability of instantaneous auto-reconciliation and quick identification (almost next day on practical basis) to know the ‘missing’ arrivals. The post-implementation data showed that no. of missing trips have gone substantially down from 804 in 1st month, 247 in 2nd month and just 5 nos. in 3rd month, as the company executives scaled their efforts to track missing arrivals almost next day. The executives took little time in 1st month to wake up to the new reality of availability of information same day and were still caught with follow up of old cases, keeping fresh cases of yesterday also pending, to be taken in sequence of date of occurrence. However it took escalation to higher-up authorities to make them realize the new reality and change the practice, by prioritizing yesterday’s cases in today’s follow up agenda and accordingly correcting their internal processes to exert pressure on transporters, without having to ask for acknowledgement, rather just ask whereabouts of trucks.

To sum up the overall experience of reduction in handling loss in road segment:

Transit loss in road segment had reduced from 0.93 % to 0.67 % average and even to 0.39% in 3rd month.

The no. of missing trips had come down drastically from 804 nos. in 1st month to just 5 nos. in 3rd month, thereby demonstrating that auto-reconciliation capability of new automated solution coupled with continuous monitoring had helped enforcing better delivery accountability amongst truckers and drivers. This benefited company not just monetarily but also from the point of view of business hygiene and higher certainty / reliability in committing daily arrival volumes at jetty.

8.3 Reduction in Transit or Handling Losses:

The term transit loss or handling loss is computed as the difference of weight recorded between source and destination points, expressed as percentage of source weight. If this difference is negative, it means there is a net gain, which of course is practically not possible for such loose bulk commodities and hence it only signifies a faulty method of determination or a likely measurement machine error resulting out of improper calibration. Let us now discuss these losses for each segment, road and river
8.3.1 Transit Losses in Road Segment:

Usually any loose powder material taken through trucks involving physical travel may give scope for escape or leakage of material through the gaps in flooring (of wooden planks or damaged steel sheet), besides escape of fine material through air while undergoing handling (loading / unloading). This would result in shortage which is computed as difference between weighment of source and destination, even when there is no human attempt to pilferage.

Exceptions, exclusions and assumptions: It was found in a few trips recording negative shortage, i.e. the destination weight was slightly higher than source weight, beyond machine error of 0.20% as explained in below paragraph (it used to be observed even in the past periods as confirmed by company executives) and it was apt to ignore such readings for our computation and focus only on shortages, as envisaged in our research objectives.

It is worth noting that weighbridges being electronic machines, although there is no repetitive error in any machine, but there was still a chance to find a difference (positive or negative) between weights taken in 2 different machines, as was the case in our company having multiple weighbridges. It is a known fact that different weighbridges were being used at source or destination for gross as well as tare weighment and hence a small error is likely to occur (around 0.20-0.25% between machine to machine as established through enquiry with weighbridge suppliers / manufacturers).

During the RFID implementation, we recorded gross weight of all trucks at source or destination for each trip, whereas the tare weighment was being recorded at least once every 10 days, if not for all trips at all destinations, which was also the system in the past, rather going as much as 15-20 days.

Further it would be worth mention here that the universe of trips’ data during study period did not include missing trips, just like the case of baseline data. The case of
missing trips is being discussed below separately due to the fact that the company’s contract stipulates recovery of more than 100 pct. cost of material cost from the trucks as penalty and hence it was desirable to have separate control on missing trips even from the point of view of overall business hygiene.

For arriving at the baseline figure, we relied upon past data from company for similar calendar months at 0.93% as conveyed by its executives from their MIS reports, as was not possible to dig up old records being not in well maintained condition.

Results obtained: The average shortage for a month was computed by taking sum total of differences of all trips between net weights of source and destination, divided by total source weight of such trips. This was found to be 0.97% in 1st month, 0.64% in 2nd month and 0.39% in 3rd month. Thus the weighted average of transit loss in road segment for all the months was found to be of the order of 0.67%, which was lower than baseline of 0.93%. This was a continuously reducing trend and 3\textsuperscript{rd} month data also proved further drop in losses to just 0.39% and one may expect similar or better figure for future months, assuming all care being exercised as in previous study months by way of making a SOP (standard operating procedure) of weighment.

**8.3.2 Transit Losses in River segment:**

To know the baseline handling loss figure, we sought access to past 3 years barge and ship loading data records of the company to witness the difference between total weight of all barges for a particular vessel as declared by jetties and the weight arrived through draft survey (as declared in bill of lading issued by vessel master), it was accounted as high as 4-5%. This in itself was a big motivation for this study to reduce it and a target was set to bring it below 1.5% basis internal tolerances of various processes and amount of multiple handlings involved till final vessel loading.

Similarly we have computed such difference between total loaded weights of all barges and vessel cargo weight as determined from 3 vessel’s draft survey jointly done by company team and external surveyor agency along with master of the vessel. The draft survey is a well-accepted scientific method of cargo weight determination across the globe in shipping industry forming basis of issuance of Bill of lading (B/L). Ideally this
difference should be negligible or a very small percentage depending upon the frequency of calibration and state of general upkeep of weighbridges.

As explained in methodology, the total weight data of all short-haul trips were acquired from Auto-Id software of new RFID system for a particular barge trip and then loaded weight of all such barge trips served for a particular vessel were summed up to arrive at dispatch or source weight for that particular vessel. The draft survey of that particular vessel was conducted jointly by a team from company and an external surveyor agency, with renewed process focus. There were 3 such mother vessels wherein such detailed focused exercise was carried out as given in appendix. The results of this exercise demonstrated handling loss in the range of 0.85% to 1.5%, which were way below the company’s baseline figure of 4-5%. The weighted average of handling loss of these 3 vessels was found to be 1.2%, however to achieve the same consistently in future, one would need to tighten many other dependent sub-processes and also ensure that the concerned team is taken care well to insulate from fatigue of working in moderately harsh sea condition.

It would be worth sharing here that due to export restrictions imposed by government, we could not conduct such exercise on more vessels despite our best intent and preparedness.

8.4 Visibility and Coordination

Visibility and ease of coordination are the qualitative attributes and hence it was considered apt to conduct a general perception survey of company executives at the end of such implementation and system stabilization. Besides the survey, this was also proved objectively through important KPIs like Truck Journey Time (TJT) in addition to Nos. of Missing Trucks etc. The significant objective improvements brought in by way of reduction in TJT to almost one-third level i.e. from 18:19 hours to 06:10 hours as well as reducing no. of missing trucks from > 800 to almost just 5 nos. a month, speaks louder than a survey, but nevertheless an attempt was made to seek general perception and feedback mandate from the actual users in the company, to get more insights on overall satisfaction level of larger mass as well.
The survey consisted of seeking response from executives across all levels (those who had some involvement or were at least concerned with this project) to filling an on-line questionnaire about the whole implementation process, its results and to check their commitment level to this new system for sustainable results in future. The questionnaire of survey was designed after referring to a no. of management literature to gain insights in to various dimensions and factors responsible for successful unbiased survey results. Due care was taken to bring common understanding and meaning of words (visibility and coordination) amongst the survey respondents by restricting the meaning of these words as quoted in the questionnaire. It was quite clear from survey results that such an implementation helped company in improving trust and transparency not only amongst employees but with all other supply chain partners (transporters, barge operators and vessel stevedores etc.).

A few other questions in survey also evoked positive responses as to whether the company would be able to sustain such automation efforts and their impact on business in near future and whether the automation has enabled them exercise higher control over supply chain processes. Likewise highly affirmative responses were received for questions such as whether automation has influenced the awareness levels of transporters in reducing handling losses or whether it has helped them in simplifying information capturing / gathering / sharing and whether automation would help the company in improving its fleet efficiency etc.

It would not be out of place to mention that throughout the implementation we came across a no. of process-simplifying opportunities and we had not only captured but also implemented the revised process so that not only data collection was made easier yet robust with concurrent process internal checks / controls, but were also benefited by way of faster transactions without compromising data integrity or accuracy e.g. mandatory periodical revalidations of tare weight of trucks with advance reminder to all concerned, Driver-In-situ updating of truck weights instead of driver getting down from trucks at weighbridge for every transaction, fixation and guidance in positioning of trucks on weighbridge platform through the use of marking as well as traffic lights installation on weighbridges, dynamic load balancing of unloading destinations by guiding /
diverting the trucks en-route to other nearby destination in case of temporary congestion or sudden emergencies as against rigid delivery option or no mid-route correction system during manual regime, etc. etc.

A few other efficiency and effectiveness improvement measures were also undertaken as given below during the evaluation of study findings:

**8.5 Increased Productivity**

- The productivity increased due to elimination of manual data entry operation of weighbridges at Loading and Unloading end. Automated weighbridge operations reduced time taken for transactions at both ends as seen by us. This helped queue move much faster than earlier.
- Eliminated manual truck reconciliation and associated errors in road segment while reporting missing trucks or taking corrective action.
- Eliminated manual written slip and manual feeding of truck data to ERP completely, even in case of data connectivity failures.
- Automated tracking of cargo from jetty through trans-shippers for barges.

Load Balancing for machinery and manpower

Post-implementation and system stabilization, we analyzed frequency distribution of primary truck arrival data at source and it was observed a fairly equal time-distribution of truck arrivals at source weighbridge, which in the past used to be highly skewed with significant peaks in early morning hours or troughs (>35-40% of daily truck arrivals in early morning wee hours and just about <10% arrivals post 0200pm). We tried to analyze the reasons of this shift of load and were pleasantly surprised that with successful RF implementation, truck drivers were smart enough to have observed company’s enhanced capability of faster transaction time and better dispatch planning to take advantage of not following herd psyche of me first’. Rather they were taking considered decisions basis past few days’ observed trend of loading times within a source. Hence it is clear that even the internal customers of the company i.e. truck drivers had perceived these benefits and were aligning themselves to new realities and thus offering opportunities for better load planning to company executives. Same is true for destinations, which were getting much advance info through the system to mobilize
required machinery and manpower to unload trucks. All these measures were being utilized to economize the operations coupled with better utilization of company’s resources.

8.6 Better Response System for Freight Payments

With RFID system in place, the company executives knew about exact real-time status of delivery, unlike in past where it used to take >2 months to know the missing trips. In turn this used to affect the freight payment cycles of transporters as company executives were resorting to split multiple advance payments basis advancement of missing trip reconciliation. But with auto-reconciliation, the overall echo system of the transporters and company improved greatly as confidence started building on the accuracy and reliability of new system. Hence this helped increase in trust and transparency with quality of response from supply chain partners i.e. transporters improving greatly in all other matters. This was true for long haul and short haul (in jetty) trucks as well as hired barges.

8.7 Improved Safety Conditions

At source and destination weighbridge points, the new automated process avoided the need for driver to get down from vehicle and weighment continued in-situ, thereby there was no scope for any accident compared to past, when some drivers while getting down, left the vehicle in running condition without applying hand brakes and posed serious life threats to themselves or supervisors standing nearby. Likewise in the unloading stockyard, we could eliminate the need for the supervisor to get very close to the truck by giving him a handheld device to the supervisor. The handheld would communicate wirelessly with the RFID tag installed in the truck within a range of up to 25 meters, which could improve the safety conditions for the supervisors.

Besides all above direct impacts on efficiency and effectiveness of supply chain, the following benefits of automation were achieved and were accepted by one and all for their visible change brought out in each of such factors:
**Better Security**

By installing RFID readers at the entry and exit security stations, we can help the security personnel monitor the movement of trucks in an efficient way. Audible alarms help the security in taking timely action against possible malpractices or wrong trips. Also time-stamps of entry / exit of trucks at site can be maintained in a log for future reference.

**Data integrity**

Since the trip data was captured automatically, the probability of manual errors got eliminated. This helped maintain integrity of data such as Number of trips, source and destination point of each specific trip.

**Increased morale and motivation of employees**

This would not be out of place to mention that such automation effort had a great influence on the morale and motivation of its employees through a no. of positive factors such as:

a). It was now much easier to enable job rotation amongst employees as a no. of employees were earlier stuck in their career either as weighbridge operators or traffic assistants as their job involved mainly field skills or skills in just one area (e.g. data entry in weighbridge cabins), but now involved analytical skills necessitated through constant monitoring of data / info available on their tips;

b). Further the result of their hard work was much easier to present to their seniors in the form of easy-to-compile objective reports as compared to vague subjective statements earlier without the support of logical numbers, which was not available same day;

c). the fact that executives were able to observe or get feedback faster of various challenges en-route or within a location and take timely corrective action, was also a huge satisfying factor for many as it gave them clues to possible interventions to resolve such hurdles / bottlenecks.
d). Employees were happy to be adding significant value to their company bottom-line by finding newer ways to attack reduction in transit or handling losses. We can go on and on with numerable examples of impacts on employee motivation as were evident from the vibrancy and keen interest shown by them through-out implementation and reflected through our post-implementation survey results. We are sure that such motivational effects would certainly help company attain transformation of its supply chain.

**Customer Satisfaction and leveraging the brand goodwill**

All above measures coupled with more customer-friendly administrative actions (such as setting up kiosks in company premises for truck operators to view or compare their truck performance with peer group could be utilized to create healthy competition amongst themselves. All such measures to boost their morale and zeal to work for mutual benefits could be planned in near future to leverage company’s goodwill and build a committed beneficial partnership with its all supply chain partners.

Further many other improvement opportunities were discussed / explored with company executives for harnessing full potential of automation efforts, but are not being detailed here to keep brevity.

**8.10 Limitations of Research and Scope for further work:**

Any technological intervention in industry or personal life is guided by some needs and it is these user needs which enable the system to get configured accordingly. The user needs or requirements thus drive the system development and deployment. It is difficult to imagine any technology invention or intervention without such need identification. However it is also true that once such technological intervention is deployed for a particular industry or a situation, it is natural for other users also to learn from such experience and make an attempt to apply such technology to other demanding situations or industries per se. To the best of knowledge of research scholar, the ore mining or export industry globally has not applied both technologies, RFID and GPS together across full supply chain, and it is probably the first such attempt.
This research study focusses only on RFID and GPS technology for automation of supply chain, whereas there are other multiple technological options and hence it is not necessary that all stages / components of the system study and software would be compatible with other options.

Further this research has been limited to the study of supply chain effectiveness of only bulk ore exporting industry and it has not compared the similarities or differences of this supply chain with any other supply chain of same (e.g. for domestic consumer supply) or any other industry. As such it would be pre-mature to imagine the applicability of such automation solution to any other case and one would have to study the system requirements in detail before applying this vanilla solution. As we have seen the information demands of road segment is different from that of river segment, even though both belong to same supply chain of ore export.

Accordingly we have seen how the technological options differed in terms of their suitability, i.e. RFID for road and GPS for river segment. It is also worth mention here that while it is easy to imagine that GPS technology would have also easily fit in for the road segment, however one must not forget that the weighment process being the heart of the road segment (contractual commitment for the transporters to deliver same quantity at destination as was picked by them at source), the GPS technology did not offer any integration opportunity with weighbridge, as was offered by RFID technology. Whilst river segment did not have any such physical weighment process (which was replaced by draft survey after Load-Line mark on barges was reached), and therefore it was perfect fit for GPS on barges as the focus here was on the route deviation controls and confirmation of arrival on right destination.

Hence we must clearly understand that in such technological interventions, it is utmost important to ensure the solution is tailor-made configured as per the user requirements, however standard it may be at design stage. It is this knowledge that would make the future researchers and practicing managers to not try to copy the solution, but rather learn to understand the framework and then see if there is good mapping of user needs with the standard or customized solution fit.
It would also be worth noting that the above research has been performed for a particular geographical territory i.e. Goa-India, which has a unique god-gifted inland waterways through navigable Mandovi and Zuari rivers connected with port in between. Hence this study may be relevant for any other similar supply chain but not for the other geographical territories if not similar to navigable channels /rivers of Goa.

All above limitations of this research study would provide scope for future scholars and practicing managers to apply the technological solutions to other industry or other supply chains for improving the effectiveness and efficiency of other supply chains. The most obvious study could be covering the domestic supply chain of ore industry of Goa for supply to steel industry as raw material. It would be also pertinent to examine and suggest whether any other future breakthrough technology could be deployed to the bulk Ore industry supply chain, which would be more user-friendly and would be less costly than the ones recommended here.

Last but not least, it would not be out of place to mention that any technological solution is as good as the people who implement it and use it in their daily working life. This is so because of our fundamental belief that it is humans who have quest to excel and only with such non-satiating hunger for something better, makes human species the longest surviving living creatures on the planet. With this belief, I hope my fellow research scholars would undertake further research work in this subject, especially in those areas where this study has faced limitations such as integrating information of weight of cargo independently in the water-borne journey or for example in those industry sectors where information and communication technology has still not made inroads for larger community benefits such as Pharmaceuticals (in controlling shelf-life of medicines) and Indian Railways etc. (in tracing the sick wagons or in arresting collisions / accidents etc.). In future, there could be sensor-based technological possibilities for gauging the technical parameters such as engine health through engine speed and oil pressure or temperature, etc. for barges to be integrated with BMS or some tyre-pressure sensor-based technology for road segment to integrate with OTS.

Hence I would like to finally conclude that if this research could serve as a reference for all fellow practitioners, and / or researchers to help them decide on framework,
guidance and the challenges ahead of any attempt on automation, my purpose of undertaking this academic journey would have fulfilled.

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