7.1 Overview:

As the performance of an enterprise becomes more closely linked to the performance of its supply chain, it is crucial that firms focus on the macro processes. While focusing on internal processes, a firm must also expand the scope beyond internal processes and look at the entire supply chain to achieve breakthrough performance. As discussed earlier, the goal should be to increase the total profitability of the supply chain (also referred earlier as supply chain surplus).

Figure 34: Macro Processes of Supply Chain management

Good supply chain management is not a zero-sum game in which one stage of the supply chain increases profit at the expense of another. Good supply chain management is instead a positive-sum game in which supply chain partners can increase their overall level of profitability by working together. Therefore, to increase the supply chain surplus (and therefore their firm’s own profitability) most effectively, firms must expand their scope beyond their enterprise and think in terms of all above three macro processes, to integrate meaningfully depending upon the value it would derive.
Here in this research our immediate first focus was on Transaction Management Foundation and its automation, thereby enabling exchange of information among all stakeholders in a collaborative manner to improve overall surplus by making positive changes to efficiency and ensuring effectiveness of supply chain functioning within the domain of each chain partner.

However none of the gains are possible without taking pains and I also faced my share of difficulties in data collection and investigative analysis of the same while executing this research.

It would be worth mention of a few major business Challenges and Difficulties experienced to give a true reflection of my efforts:

- One of the major hurdle faced was restrictions imposed by state govt. and Supreme Court that the ore cannot be mined or exported. With such ban imposition, we were apprehensive of actual roll-out of our application in the practical field as there was no clarity when such event would take place. Hence we were forced to shift our application roll-out to their steel plant (of same company in Goa) who were buying ore from nearby mines in Karnataka and whose supply chain logistics resembled to exactly with that of ore exporting industry i.e. the initial leg of journey consisted of road movement by tippers from mines to nearest river-loading jetty after their entry in South Goa (unload in the stack there). Thereafter the ore material would get loaded in barges at the jetty for travelling through Zuari River to their final destination in Mandovi River, to unload at their jetty located right at the plant site. Thus the truck tippers were tagged with RFID, weigh bridges were equipped with RFID readers/antenna, and the barges were fitted with GPS devices as well as sensors for capturing key physical data of health of barge engines.

- Enforcing user discipline to adhere to standard processes was the toughest part of implementation as it involved change of mindset of a large cross-section of the people through behavioral interventions without which such technological interventions would remain a half-baked cake. They have been hitherto accustomed to a certain way of working manually, whereas the new ways of automatic data capturing wanted them to
think beyond what they were so far thinking and focus on bringing action in to everything which had deviation as alarmed by system. This was possible by building in a no. of additional concurrent internal process controls for ensuring only valid data gets entered. E.g. validations / controls related to weighment such as periodical tare weighment, strict adherence to double weighment norms (source-destination) unlike single weight sufficiency of the past and a few additional alarms/controls like maximum permissible net weight or maximum permissible deviation between source and destination weights etc.

The automatic data capture had been attempted and the marriage of hardware-middleware had been appropriately fine-tuned for 2 sets of source-destination locations till + 95% auto-capture was achieved (by use of additional antenna, its orientation and fixing/marking the best capture zones to guide truck drivers to position their trucks on weigh bridge). Necessary validations were performed once again by upload utility programs company executives had coded themselves, to facilitate direct uploading the resultant required data to their ERP server to safeguard against any unintended errors. Huge efforts were made by our field teams in attempting data capture for next few months. Such data acquisitions were being subjected to some simple hygiene checks almost in parallel so that we are able to carry out due analysis.

- It is true that we had been zapped with the quantum of information these data were representing and we had to prepare ourselves for the corrective action, the logistics process were demanding in terms of no. of missing trips, extended journey durations, weight shortages, process intermediary bottlenecks, sequential de-bottlenecking of each of such sub-processes which hitherto went un-noticed. Likewise during the implementation, we came across opportunities of increasing flexibility e.g. with the decoding of data string of reader, one can easily find the location of that tipper truck (by the unique id / Code of that particular reader as assigned in the software and by knowing the set of readers vs. their location of installation).

This meant that in a multi-location company one can give freedom to tipper drivers to report to a particular destination if they witness any congestion for the intended destination as now they can reach anywhere (any nearby alternate permissible RFID-
enabled jetty location en-route) and system would automatically trace / update their actual reporting destination as given by unique id of the particular reader. This flexibility meant a lot for this company as it offered big opportunity to the logistics manager to balance the work load amongst various jetties and their weighbridges, even after trucks have left the source.

Now onwards in below discussions, we shall focus on key performance parameters of processes and later use them into deriving key performance indices (KPIs) for the overall supply chain efficiency and effectiveness. The first such process parameter in both segments is transaction time taken for capturing each transaction. In case of road segment, capture of weight for each allocated trip is the most significant parameter as had been explained in earlier discussions due to internal delay caused in completing the truck trip. Also this is fully controllable by better planning and right deployment of technological solution, as against the in-transit time to reach destination which is more or less beyond the control of transporters or the company. However same is not true in case of barge trip, wherein there are hardly much challenge for in-transit time, but significant challenges exist due to internal factors at source and destination (here it is not to be inferred that external forces do not exist, e.g., bad weather, break-downs in mother vessel, stock arrival delays at jetty etc. are a few out of multiple such external challenges. The point to be understood is given that there are no challenges externally, even then there are challenges of seeking internal coordination and performance commitment from internal teams at source / destination (trans-shipper).

As a consequence of this understanding, it is pertinent to further discuss Transaction time for RFID in road segment including Truck Journey Time (TJT) and Barge TAT (turn-around time) for GPS in river segment. The point to be noted is that there is hardly any capture effort in GPS (unlike RFID) as BM Unit starts sending data as soon as it is powered, no further effort is required to improve its capture or accuracy). Let us now first discuss all parameters and KPIs of road segment through RFID and then those of river trips through GPS technology.

7.2 Transaction time
Transaction time can be simply defined as the time taken to capture a transaction i.e. lapse of time between a truck arrives on weighbridge and it leaves the same after the transaction is saved or documents get printed and handed over.

As explained earlier and considering that company’s truck logistics model was always a ‘push’ type model involving long queues, it can be safely assumed that there would always be some trucks remaining in queue on source or destination weighbridge.

Hence **Transaction time for Road segment** can be further refined as the time interval between weighment capturing of 2 consecutive trucks at either source or destination. This in turn would mean the time taken to travel in and out of the WB platform which would include time taken to complete data entry by the WB operator post- stabilization of WB readings. This definition pre-supposes queue of trucks at weighbridge and otherwise in a non-queue scenario, measurement of the Transaction time could involve conduct of time and motion study from the time truck enters WB platform and leaves it. The average of multiple such readings would enable computation of transaction time in such a case.

However for our analysis purposes, the time stamp recorded in the computer system for each consecutive weighment was a readily available data, whether during baseline data study or post-RFID implementation. Hence the time elapsed between consecutive weighment readings was computed in the excel sheet for all trips. It was apparent from the data tables that the transaction time has reduced drastically for all trips during the 3 months of data acquisition. It was further inferred that the average transaction time has reduced from 65 seconds (baseline) to just around 35 seconds in 1st month, 29 seconds in 2nd month and finally to 23 seconds in 3rd month of implementation. It is important to highlight that prior to fixation of baseline during our As-Is study, this time used to be almost 120 sec (i.e. 2minutes), but had improved by now to 65 seconds during baseline study (i.e. without use of RFID solution) due to a no. of simplifying amendments made in the weighbridge software as well as practical activity level by removing wasteful non-value adding activities, like having to make truck driver alight from truck for wishful accuracy of weighment in the past was abandoned with in-situ system implemented, whether RFID or not. Further it was worth noting that the readings
of transaction time during the full-scale implementation period varied in a significantly close range across the month irrespective of peak or lean hours, as against wider variations observed during manual run and baseline study. Considering the large set of 3 months’ data in a closer range of values, a simple average was the right measure to depict the trend. We also instituted time and motion study in 3rd month to ascertain activity-wise break-up to ascertain whether scope exists for further reduction in transaction time. Wherein it was established that while RFID identification-cum-capture application takes only about 7-10 seconds (optimum) for identifying the truck and saving the WB weight reading in local PC system, the rest of the time is consummated by the driver to place the truck correctly on the weighbridge platform and leave after the traffic light turns to green, signifying wider variation from driver to driver depending upon his skill, alertness and similar other personal factors.

Purging of manual activities as listed below and replacement by automated process were responsible for such significant improvement in transaction time:

a). The weighbridge operator was no more required to enter the truck related identification and weighment data (either 1st time at source or repeatedly at destination to recall the particular transaction) due to auto-identification and capture by RFID.

b). Removal of the need for driver to get down from the truck to reach to weighbridge operator’s window for handing over the loading advice (LA) and collecting the delivery advice (DA) at source and likewise handing over the delivery advice (DA) and collecting the unloading advice (UA) at destination, being generated by the local computer system. These were now being given or distributed little later by the concerned security guards while the drivers were busy covering their trucks with tarpaulins in the parking yards next to the exit gate with the help of 3rd party laborers. The tarpaulin covering activity would take about 1-3 minutes by laborers being standard size and method for almost similar trucks (model / mfr. etc.). Thus a sequential activity was converted to parallel processing and time-critical activity (truck identification-cum-posting weight) was prioritized through use of technology by deferring non-critical activities (printing and distributing delivery documents).
c). This was further made user-friendly by installing a large font electronic display indicator (LED boards) placed at suitable location to facilitate easy in-situ reading by the driver for increasing his awareness for sanctity of weight. In the revised scheme of truck-flow at destination, auto-capturing of tag data of the truck was made further stricter through re-designing the lay-out i.e. conceiving a non-escape restricted route from Inward gate via Gross weighbridge to unloading yard and return via separate Tare weighbridge to Exit gate. All of above re-engineered business processes brought in the positive impact on throughput of trucks in terms of no. of trucks being handled per hour at any weighbridge. Or in other words, it helped in increasing the volume of material evacuation from source for achieving higher exports under same constraints as earlier, thus meeting the prime objective of our study.

7.3 Barge Turn-Around Time (TAT):

Barge TAT is defined 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 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.

7.4 Missing Trip Identification and Reporting for Road Segment

As explained earlier, the Ore tracking RF system allots one unique trip-id each time a truck appears on weighbridge, if the previous trip is closed. As the name suggests and as discussed earlier, such missing trip information is easily derived by the open entries of trips which have not been closed during the day / month (meaning absence of corresponding destination arrival weighbridge entries).

The fact that in earlier (pre-automation) days, just identifying such missing trips itself was a daunting task for the execution teams, leave apart follow-up required to know the whereabouts and take penal action for defaulter trucks. Reconciliation for missing trucks and / or shortage in delivery was a tedious manual process involving studying 2 slips of paper for each trip or comparing the source weight and destination weight manually. Trip wise reconciliation was many times attempted based on ERP data using MS Excel, but it lacked speed resulting in huge backlog piling up of pending follow-up action to reach to the stage of penal recovery from defaulters. Further safety for supervisors was not optimum as the old manual system involved the supervisor getting close to the truck to receive or handout slips of paper to the truck driver as mentioned earlier.
But now post-automation, such missing trips’ data were easily identifiable from the massive tracking data collected for each day through a simple pivot table viewing and they would be easily segregated for immediate follow-up action same day or at the most next day. Appendix 2 covers the list of trucks which had highest missing frequency during month 1 and 2, which were nailed down by the follow-up teams to just 5 trucks in month 3 (that too due to genuine en-route break-downs as per first information lodged by drivers and later verified by field teams). The defaulter (missing trucks’) owners were being chased by a separate focused group of people almost on daily basis for the previous day’s transactions, as against earlier time-lag of a week or even more.

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 had been able to scale up their efforts as explained below to track missing arrivals almost next day. The re-engineered process did not involve any handing over of slips by supervisors at receipt weighbridges also de-risked their safety aspects. Further re-engineered process of the ore receipt at the destination had built-in alarms in the software for weighbridge operators, in case of trips received beyond 24 hours and an appropriate dialog process was installed for the destination weighbridge operator to talk to concerned truck driver to know and record the reasons of late arrival in their log book. This was further strengthened by subsequent investigation of such cases by concerned security chiefs for possible clues to the motives behind. Thus an alert detection-cum-security system installed at the destination (without any additional manpower) helped instill a moral fear and changed behavior in truck drivers/owners. Due care was taken to ensure that security would exercise needed sensitivity in respecting the genuine cases (e.g. messages from them towards en-route break-down or any longer duration route blockage etc. etc.). Statistical analysis of such missing trips data has been attempted along with analysis of next section on Handling Loss. Prior to RFID implementation, such cases of late arrivals either used to go un-noticed or even consciously ignored many times due to heavy crowding of trucks at the weigh bridge (arising from more time taken in capturing the data manually).
Overall, it was an overwhelming experience for the execution team to note such drastic reduction in no. of missing trucks brought about by their constant efforts with increased awareness and attitudinal change in drivers. The reduction in missing trips also had positive implications on the company’s sales volume commitments, since jetty managers’ were now able to give commitment of arrivals to barge control desk and in turn improved their cargo planning and execution through better predictability of near future events in supply chain. Besides above, the overall business hygiene had improved significantly, thus raising the efficacy of internal business controls. It would have also helped company in avoiding so much non-productive work being done earlier by Logistics and Finance department teams in recovering the shortage amount from transporters, albeit also evading the trust of stakeholders.

7.5 Handling Losses in Road segment

The term transit loss or handling loss is computed as the difference of weight recorded between source and destination point, 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 commodities like iron ore and hence it only signifies a likely machine error resulting out of improper calibration or lack of weighbridge calibration at scheduled interval or some excess water spray on the cargo before covering with tarpaulin to avoid run-off of fine ore dust causing pollution en-route.

Usually any loose powder material taken through trucks involving physical travel may give scope for escape or leakage of material through the gaps in wooden planks, if any in the truck bottom, besides escape of fine material through air while undergoing handling (loading / unloading). This is computed as shortage between weighment of source and destination. However as discussed above sometimes it could be misleading due to relative machine error recording higher destination weight than loaded source weight. I have shown such trips also in the below tables labelled as ‘excess weight trips’.

<table>
<thead>
<tr>
<th>Type of Trip</th>
<th>Type of Handling Loss</th>
<th>Month 1</th>
<th>Month 2</th>
<th>Month 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missed Trips</td>
<td>Missed</td>
<td>5%</td>
<td>2%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Table 6: Distribution of Trips and Trend of handling losses

It is worth noting that any weighing machine has a tolerance limit and usually all manufacturers recommend a tolerance of +/- 0.5%, which means that the excess or shortage has to be brought down to this level. This can be seen that various efforts cited as above have yielded results in bringing down these losses month by month. The excess or shortage have been brought down from around 1% (0.99% excess and 0.97% shortage) in month 1 to around 0.6% (0.61% excess and 0.65% shortage) in month 2 and finally achieved below 0.5% (0.47% excess and 0.40% shortage) in Month 3.

We further found simple mean, median and standard deviation of all trips excess or short weight and separately checked the spread between mean and median, for each month, to see whether these values have come closer than earlier months. The table below gives these statistical measures of central tendency, thus confirming that there has been significant improvement in 3rd month in both excess as well as shortage, wherein mean, median and mode has almost same value and the standard deviation has also reduced significantly.

<table>
<thead>
<tr>
<th>EXCESS WEIGHT TRIPS ANALYSIS</th>
<th>Month 1</th>
<th>Month 2</th>
<th>Month 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of trips where Destn wt recorded in excess of source weight</td>
<td>4414</td>
<td>6333</td>
<td>7990</td>
</tr>
</tbody>
</table>
Table 7: Excess weight analysis- measures of central tendency

<table>
<thead>
<tr>
<th>% of total trips</th>
<th>32%</th>
<th>39%</th>
<th>60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of excess readings</td>
<td>2 to 3170</td>
<td>10 to 5140</td>
<td>10 to 1290</td>
</tr>
</tbody>
</table>

| Mean of excess readings | 121 | 67 | 50 |
| Median of excess readings | 70 | 40 | 50 |
| Mode of excess wt, readings | 10 | 10 | 50 |
| Standard Deviation | 161 | 99 | 38 |

Table 8: Shortage trips analysis- measures of central tendency

<table>
<thead>
<tr>
<th>SHORTAGE WEIGHT TRIPS ANALYSIS</th>
<th>Month 1</th>
<th>Month 2</th>
<th>Month 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of trips where Destn wt recorded in shortage of source weight</td>
<td>8510</td>
<td>8805</td>
<td>4276</td>
</tr>
<tr>
<td>% of total trips</td>
<td>58%</td>
<td>54%</td>
<td>32%</td>
</tr>
<tr>
<td>Range of shortage readings</td>
<td>10 to 2100</td>
<td>10 to 5400</td>
<td>10 to 970</td>
</tr>
<tr>
<td>Mean of shortage readings</td>
<td>115</td>
<td>73</td>
<td>42</td>
</tr>
<tr>
<td>Median of shortage readings</td>
<td>90</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Mode of shortage wt, readings</td>
<td>50</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>118</td>
<td>97</td>
<td>43</td>
</tr>
</tbody>
</table>

However for the purpose of loss computation, we have ignored such data as we believe same was also being neglected in the past computation of handling loss. Thus only those individual truck readings which represent shortage on daily trip basis were considered for computation of sum total of shortages over a month divided by total source weight of only such short trips. Due care has been taken to ignore missing trucks above i.e. those who have not reported at destination (as the same were also not considered in past baseline data and also because the company’s contract stipulates recovery of more than 100 percent cost of material from the truck owners in cases of missing trucks as penalty, thus cannot be interpreted as loss). These have been shown separately in missing trips record.

Further we have plotted list of trucks which have been habitual defaulters who were causing trip shortages (like we traced missing trips) in each month and the same was intensely discussed with truck owners / transporters, to sensitize them for the recovery of money by company through rigorous practice. Pl refer appendix 2. The below table
explains the frequency distribution of short weight trucks in different range of shortages observed.

<table>
<thead>
<tr>
<th>Min. Shortage Kg</th>
<th>Max. Shortage Kg</th>
<th>No. of Trucks-M1</th>
<th>% of Trucks-M1</th>
<th>No. of Trucks-M2</th>
<th>% of Trucks-M2</th>
<th>No. of Trucks-M3</th>
<th>% of Trucks-M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;501</td>
<td>&lt;751</td>
<td>527</td>
<td>39%</td>
<td>1525</td>
<td>76%</td>
<td>1594</td>
<td>80%</td>
</tr>
<tr>
<td>&gt;500</td>
<td>&lt;751</td>
<td>195</td>
<td>15%</td>
<td>247</td>
<td>12%</td>
<td>11</td>
<td>1%</td>
</tr>
<tr>
<td>&gt;750</td>
<td>&lt;1001</td>
<td>171</td>
<td>13%</td>
<td>99</td>
<td>5%</td>
<td>2</td>
<td>0%</td>
</tr>
<tr>
<td>&gt;1000</td>
<td>&lt;1501</td>
<td>260</td>
<td>19%</td>
<td>42</td>
<td>2%</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>&gt;1500</td>
<td>&lt;2001</td>
<td>85</td>
<td>6%</td>
<td>9</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>&gt;2000</td>
<td>&lt;2501</td>
<td>32</td>
<td>2%</td>
<td>1</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>&gt;2500</td>
<td>&lt;3001</td>
<td>10</td>
<td>1%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>&gt;3000</td>
<td></td>
<td>4</td>
<td>0.3%</td>
<td>2</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Trucks with shortage</td>
<td></td>
<td>1284</td>
<td>96%</td>
<td>1925</td>
<td>95%</td>
<td>1608</td>
<td>81%</td>
</tr>
<tr>
<td>Total Universe of Trucks</td>
<td></td>
<td>1337</td>
<td>Ref. Note</td>
<td>2018</td>
<td>Ref. Note</td>
<td>1990</td>
<td>Ref. Note</td>
</tr>
</tbody>
</table>

Table 9: Frequency Distribution of trucks causing shortages for M1, M2 & M3

Note: Analyzed data covers only trips with shortages and does not cover excess / zero /missing trips

From this table, one can easily infer that

- It has been possible to reduce population of trucks responsible for shortages from 96% in month 1 (M1) to 81% in month 3 (M3) out of total universe of trucks.

- Further maximum shortages (quantity in Kg) per truck have been reduced from >3000 Kg in month 1 to less than 1500 Kg in month 2 and finally to less than 750 Kg in month 3 as is evident from the above table that just 1% trucks had reported shortages above 500 Kg (in 14 trucks beyond allowed tolerance of 0.5% per trip of 10 MT), rest all trucks had either zero shortages or within the allowable
tolerance. This was a significant achievement and company management had greatly appreciated the results, the awareness in truckers and the confidence it had stilled in execution supervisory team.

The factors which contributed to this success in reduction of handling / transit losses are as follows:

- The re-engineering of weighment process as discussed earlier (consistent practice of in-situ driver weighment instead of earlier practice of him getting down from truck and marking of right location on weighbridge where the truck is supposed to be parked for exerting equal strain on all 4-6 load cells mounted below the platform corners / centers).

- The practice of mandatory updating of tare weight of trucks every 10 days, if not daily at some destinations. This minimized chances of error creeping in.

- The practice of taking tare weight compulsorily on at least one destination by dedicating one weighbridge exclusively for this purpose.

- Adherence to new SOP for periodical calibration of all weighbridges with a standard procedure incorporating inter-weighbridge error reduction.

- Incorporating a feature in weighbridge entry software to allow weighment even in ‘off-line’ mode whenever faced with connectivity failure. This helped avoiding manual entry of weights by operators and thereby eliminating possibility of their connivance and collusion with truck drivers.

7.6 Improving Visibility and Coordination in Supply Chain

A lot of management literature has pondered over various dimensions and factors responsible for better visibility and coordination. If all stages of the chain take synchronized actions to improve supply chain coordination and increase total profit of supply chain. Supply chain coordination demands every stage of the supply chain to consider the impact its actions would have on other stages. It would be interesting to understand what is commonly known as ‘bullwhip effect’ i.e. when each stage in a
supply chain forecasts demand basis the stream of orders received from the downstream stage, a small demand fluctuation at a few point of sales counters may result in higher magnification of fluctuations in orders as we move up the supply chain from the retailer to the manufacturer.

In our case of automation, we have seen how mutual exchange of information has made significant changes in the way business operates, particularly the coordination amongst different departments like Logistics, Quality Control, Marketing and Jetty Loading. This was brought about by open exchange of information through new software, enabling sharing same information with all.

If managers in a supply chain are able to identify the key obstacles, then they can take appropriate actions to help achieve coordination. When different stages in the supply chain start attempting either local optimization or increase delay, distortion, and variability in information within the supply chain, it is called as obstacle to coordination. We divide the major obstacles into five categories:

- Inventive obstacles
- Information-processing obstacles
- Operational obstacles
- Pricing obstacles
- Behavioral obstacles

A lack of coordination may creep in, either because different stages of the supply chain have conflicting objectives or due to information moving between stages is delayed and distorted. The chances that different stages of a supply chain may have conflicting objectives get aggravated when each stage has a different owner or a multiple of them. The phenomenon of lack of coordination becomes profound if each stage is allowed to optimize only its local objective, ignoring the impact on the complete chain. As a consequence, each stage tries to maximize its own profits, resulting in actions that often
diminish total supply chain profits. The foremost challenge today for all supply chains is to achieve coordination despite multiple ownership and higher product variety.

Let us briefly discuss some of the key ill-effects of lack of coordination in a supply chain. The lack of coordination increases manufacturing cost in the supply chain. As a result of the bullwhip effect, manufacturer (Mfr.) and its suppliers must fulfill a series of orders that are much more variable than customer demand itself. Mfr. in such a case would respond to the increased variability by either building excess capacity or holding excess inventory, both of which increase the manufacturing cost per unit produced.

The replenishment lead times in the supply chain also get increased due to lack of coordination. As a result of the bullwhip effect, increased variability makes scheduling at Mfr. and supplier plants much more cumbersome and difficult compared to a scenario with level demand. There may be frequent stock-outs whenever the available capacity and inventory cannot meet the demand through orders coming in. This would also then result in higher replenishment lead times in the supply chain form both Mfr. and its suppliers.

The lack of coordination surges transportation cost in the supply chain. The transportation requirements over time at Mfr. and its suppliers are correlated with the orders being filled. As a result of the bullwhip effect, transportation requirements fluctuate significantly over time. This raises transportation cost because transportation capacity needs to be maintained to cover high-demand periods. Further the labor costs associated with shipping and receiving increases due to fluctuating orders with an aim to fulfill orders whenever supply is available, irrespective of time or size of order. A similar fluctuation would then occur for the labor requirements for receiving at distributors and retailers.

Lack of coordination hurts the level of product availability and results in more stock outs in the supply chain. The large fluctuations in orders make it harder for Mfr. to supply all distributors’ and retailers’ orders on time. This increases the likelihood that retailers will run out of stock, resulting in lost sales for the supply chain.
Lack of coordination has a negative effect on performance at every stage and thus hurts the relationships between different stages of the supply chain. There is a tendency to assign blame to other stages of the supply chain because each stage feels it is doing the best it can. The lack of coordination thus leads to a loss of trust between different stages of the supply chain and makes any potential coordination effort more difficult.

The lack of coordination reduces the profitability of a supply chain by making it more expensive to provide a given level of product availability.

Table 10: Impact of the Lack of Coordination on Supply Chain Performance

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Impact of the Lack Of Coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing Cost</td>
<td>Increases</td>
</tr>
<tr>
<td>Inventory Cost</td>
<td>Increases</td>
</tr>
<tr>
<td>Replenishment Lead time</td>
<td>Increases</td>
</tr>
<tr>
<td>Transportation Cost</td>
<td>Increases</td>
</tr>
<tr>
<td>Shipping and receiving Cost</td>
<td>Increases</td>
</tr>
<tr>
<td>Level of product availability</td>
<td>Decreases</td>
</tr>
<tr>
<td>Profitability</td>
<td>Decreases</td>
</tr>
</tbody>
</table>

Having understood the theoretical effects of lack of coordination, let us now understand how coordination was improved in our research study between various supply chain components and stakeholders.

The example of significant reduction in missing trucks, discussed earlier is a classic example of how RFID has enabled integration of various stakeholders through increased awareness amongst drivers enabled by quick sharing of trip information. Similarly significant reductions in barge TAT as well as in handling losses in road and river segment provides ample objective evidence of having improved inherent processes, through better visibility and coordination.
To supplement it further, I would like to also discuss another classic example of Truck Journey Time (TJT) as to how visibility and coordination can impact results, even beyond imagination. Let us now discuss in detail Truck Journey Time (TJT).

### 7.7 Visibility and Coordination to improve Truck Journey Time (TJT)

Truck Journey Time for the purpose of our study is defined as the time taken by a truck to complete its journey from source weighbridge to destination weighbridge for gross weighment. It thus consisted of the total lapse of time right from leaving the source weighbridge before security outward gate, travel time to reach destination weighbridge (any jetty) and includes the waiting time in queue at destination weighbridge, if any. Thus in short, it is total lapse of time for the intended travel but as recorded between time stamps of our source and destination weighbridge.

For academic interests, it is worth noting that total turn-around time (TAT) was not found relevant parameter for such routes (measuring time interval between source exit to source enter, thus representing 2-way journey) as it was found that hardly any truck was able to do more than 1 trip a day for the particular source-destination combination and none were able to complete 2 trips a day. Hence most of the truck drivers were not returning to source same day for next loading trip and instead would return to their homes. This was due to travel time restriction of max 8 hours a day on road by traffic enforcement authorities.

Further the concept of internal turn-around time (internal TAT) i.e. time taken to enter source or destination and exit from these places, was only found to be controllable factor. This was so, because we could not see any systematic truck parking place outside the mines or jetty and it was customary in Goa to make the trucks wait inside the mines compound, before ore loading point, as otherwise the main public roads (including approach road, if any) would get jammed up by such queues, affecting general public movement. Hence although initially we decided to install RF readers at security inward and outward gate to consider using time stamps of these gates / readers, but we found hardly any waiting time between gates and weighbridges. Hence there was a special drive in the company to drastically reduce the internal TAT and the
results were successful. We later used weighbridge time stamps reflecting the true confirmation of arrival at destination and departure from source. However the readers installed at security gates of destination were continued, just to use their time stamp readings as emergency back-up option, in case of weighbridge breakdown or just to re-validate any data conflict in case of missing trips etc.

We therefore sharpened our focus on TJT computations (time interval of individual trips and average thereof) for the trips undertaken during months of our study. While it can be argued from above discussion that how automation through RF technology would have any impact on journey time of trucks between 2 reader points spread across different premises on public roads. Moreover journey time of trucks in Goa would depend a lot upon traffic congestion en-route specifically at all junction-points and waiting time at certain halting barrier points introduced by local traffic enforcement agencies to regulate traffic for ease of general public during school break times or start-stops timings of daily transport etc. Hence we performed time interval analysis of each and every trip to see if there are any particular time-slots when the TJTs are lower or higher substantially and shared the results with company executives to take advantage of same in their favor. It was evident from trip data given below as the company executives now leveraged this knowledge by re-asserting the observation of truck drivers.

![Figure 34: Trend data of Truck Journey Time plotted for 3 month](image)

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Average Time taken per trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month 1</td>
<td>Month 2</td>
</tr>
<tr>
<td>00-01</td>
<td></td>
</tr>
<tr>
<td>03-04</td>
<td></td>
</tr>
<tr>
<td>04-05</td>
<td>12:25:21</td>
</tr>
<tr>
<td>05-06</td>
<td>12:57:27</td>
</tr>
<tr>
<td>06-07</td>
<td>14:17:15</td>
</tr>
</tbody>
</table>

3:44:57
Table 11: Average time taken for trips during various time Interval of the day

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Average Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>07-08</td>
<td>12:10:10</td>
</tr>
<tr>
<td>08-09</td>
<td>11:49:15</td>
</tr>
<tr>
<td>09-10</td>
<td>11:40:07</td>
</tr>
<tr>
<td>10-11</td>
<td>13:38:22</td>
</tr>
<tr>
<td>11-12</td>
<td>17:32:21</td>
</tr>
<tr>
<td>12-13</td>
<td>18:30:34</td>
</tr>
<tr>
<td>13-14</td>
<td>23:54:22</td>
</tr>
<tr>
<td>14-15</td>
<td>24:17:54</td>
</tr>
<tr>
<td>15-16</td>
<td>23:48:00</td>
</tr>
<tr>
<td>16-17</td>
<td>24:25:01</td>
</tr>
<tr>
<td>17-18</td>
<td>24:38:10</td>
</tr>
<tr>
<td>18-19</td>
<td>26:15:07</td>
</tr>
<tr>
<td>19-20</td>
<td>26:25:25</td>
</tr>
<tr>
<td>20-21</td>
<td>24:21:27</td>
</tr>
<tr>
<td>21-22</td>
<td>19:11:47</td>
</tr>
<tr>
<td>22-23</td>
<td>23:40:34</td>
</tr>
<tr>
<td>23-24</td>
<td>15:02:00</td>
</tr>
<tr>
<td>Grand Total</td>
<td>18:19:02</td>
</tr>
<tr>
<td></td>
<td>11:19:58</td>
</tr>
<tr>
<td></td>
<td>6:10:19</td>
</tr>
</tbody>
</table>

This time interval-trip analysis proved very useful. As the time slot starts getting elapsed, say after 1100 am (considering 0800 am as scheduled open time of barrier points), the TJT was getting longer and longer till the schedule closure of barrier points to get early departure from these points ensured least traffic on roads and it is data support that early morning exit from source to queue up at barrier points almost sure shot to reduce the TJT. With highest TJT being clocked after 1500-1600 hours as there was no chance of crossing the barrier points being in queue and hence would have to wait till the start of next day time-slot. These results have been summarized in above table. It can be easily witnessed that there has been clear trend of reduction in average TJT for each time-slot over the 3 months. The TJT has reduced from 18 hours 19 minutes per trip in 1st month to 11 hours 19 min in 2nd month to just 6 hours 10 minutes in 3rd month as shown above. Further it can also be observed that with 3-months’ average TJT time came down to 11 hours 54 minutes and 3rd month average
coming down to just around 6 hours, thereby proving that it is possible to make 2 trips per day for most of the trucks, with consistent efforts in right direction.

This was made possible by a combination of multiple interventions, enabled by visibility of information exchange in real-time manner brought through digitization / automation efforts. Although we (including company executives) did not expect much improvement in TJT in the beginning of this exercise, since TJT was a measurement of almost all external time factors with miniscule factors under internal control. But having already optimized internal TAT of trucks within source and destination (transaction time and business process re-engineering), it was a natural challenge for us to try out and see if we could learn how to use / leverage availability of information for better monitoring of journey time.

A separate focused team was formed, whose only job was to constantly analyze daily trend in the quantum of data being flown in through RF intervention on various parameters in varied manner to see if there was any cause-effect relationship and whether actionable inference could be drawn out of such detailed analysis. This challenged everyone in the team to also come out with multiple interventions, manual or otherwise, in order to enable faster completion of trips (target given was to find ways and means for completion of 2 trips daily). The same team not only came forward with a no. of such interventions including daily follow-up with truck drivers / owners for the missing trips (being discussed later), but even implemented a no. of them in a short span, enabling an echo-system healthy for any creative resolution of challenges faced.

One of the most game-changer interventions worth mention here in bringing this improvement in TJT, which is not directly attributable to automation, but certainly it would be too difficult to ignore the indirect influence it reflected on thinking abilities of executive team, thanks to the visibility and transparent exchange of info for trust building amongst stakeholders. The field team mobilized an outsourced agency employing a no. of local people to supervise all traffic junctions and halting barrier-points en-route for maintaining lane discipline and orderly movement of trucks, specifically to ensure slow yet steady movement of traffic, rather than frequent long stoppage of traffic. This is easier said than done, but the consistent efforts and
cooperation of drivers and local villagers paved the way appreciated by all. The presence of these local traffic supervisors had become conspicuous as was witnessed whenever there were delay in their arrival at junctions and everyone had become used to it, as witnessed by the TJT computations in the 2nd and 3rd month, week after week.

This became a huge success amongst the various other efforts of automation and had been the most note-worthy role-setting effect of automation in this study as it helped the execution team win the trust and confidence of truck drivers, owners and traffic regulating government authorities. The trust-building also had a no. of consequent effects on other efficiency parameters including handling loss, missing trips and TAT of barges as discussed earlier. It was suggested to company executives to reinforce this positive development and make it sustainable by introducing a small direct incentive to the truck drivers for on-time delivery if they complete the journey within fixed time interval. This kind of benevolent schemes could pave the way for faster integration of all supply chain partners / stakeholders in to achieving common objectives.

However any management thinker would lay equal focus on those qualitative attributes which are crucial for building trust and transparency in all human interactions for long-term sustenance of benefits. While it is commonly more satisfying to prove quantifiable results in research studies as they are easier to interpret and convey. But Since these attributes were qualitative and subjective, hence it was considered apt to conduct an organization feedback survey from a cross-section of employees of the company who were directly or indirectly concerned with such automation efforts, e.g. executives from operations, marketing, road and river logistics, quality control, jetty, S&OP, etc. The feedback questionnaire was drafted after referring to various literature reviews of similar surveys performed earlier and subject matter experts for conformance to neutrality and other parameters.

I laid equal importance in building such foundation of trust and openness while working with all supply chain stakeholders through data gathering and analysis. The classic examples of TJT reduction of trucks or the barge TAT reduction or handling loss reduction in road and river segment are all worth re-examining from the perspective of supply chain collaboration and coordination. Without these ingredients, it was not
possible to achieve results in such short span of time. In any system, openness is welcome by one and all, as it gives level-playing field and equal importance to the ingenuity of all participants. It then fosters a will to cooperate and collaborate among all participants, while still competing with each other in their own sphere of excellence in order to achieve the common goal / objectives. The sharing of information in an open manner to the extent desired by each supply chain player helps him understand the same and its relevance to the achievement of common purpose. The information in an organization should not be privy to a select few and hence free exchange of right information is must for ensuring right coordination. The coordination activity is to seek an action from concerned stakeholder for a common objective, such that it synchronizes action from each stakeholder.

### 7.8 Hypothesis Testing

We would now test the hypothesis formed earlier basis our data collection and results obtained so far, using appropriate testing tools.

**Hypothesis #1-A: For Road segment**

H0r: Automation of logistics process does not result in reduction of truck transaction time.

Har: Automation of logistics process results in reduction of truck transaction time.

For proving this we used the time stamp recorded in the computer system for each consecutive weighment, whether for baseline data or for post-RFID implementation. Hence the time elapsed between consecutive weighment readings was computed in the excel sheet for all trips. It was inferred that the average transaction time has reduced from 65 seconds (baseline) to just around 35 seconds in 1st month, 29 seconds in 2nd month and finally to 23 seconds in 3rd month of implementation. The average transaction time thus was found reduced from 65 sec onds to 29 sec.

We performed One Tailed test (Z-test) on the sample data, chosen randomly from the batch of transaction times for a sample size of 31 (more than 30 prescribed) for the set of data in normal distribution, keeping in mind the central limit theorem. Since
improvement expected are reduction in TT numbers from historical trends, performing the Hypothesis test at 99% Level of significance, we obtain the rejection criteria of Null Hypothesis as

$$\text{Reject } H_0 \text{ if } X < X_{\text{critical value}}$$

Where, critical value is

In which case null hypothesis (H0r) would not hold good and it would be proved that Automation of logistics process resulted in reduction of truck transaction time.

The values of mean and standard deviation of the sample are shown in the below table:

<table>
<thead>
<tr>
<th>Sample Mean</th>
<th>Sample Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X = 33.45 \text{ Kg}$</td>
<td>$S = 8.06 \text{ Kg}$</td>
</tr>
</tbody>
</table>

The sketch of sampling distribution of sample mean approximately followed a normal curve as shown in graph above.

Performing the Hypothesis test at 99% Level of significance, we obtained the rejection criteria of Null Hypothesis as

$$\text{Reject } H_0 \text{ if } X < X_{\text{critical value}}$$

Where critical value is

Substituting the relevant values: $Z_\alpha = -2.33$, $n = 31$, $\mu_0 = 115$, $S = 118$, we get critical value as

$$X_{\text{critical value}} = 65.62$$

Clearly, $X = 33.45 < X_{\text{critical value}} = 65.62$

Hence null hypothesis (H0r) does not hold good and it is proved therefore alternate hypothesis stands good, i.e. Automation of logistics process results in reduction of truck transaction time.
Hypothesis #1-B: For River segment

H0w: Automation of logistics process does not result in reduction of barge turn-around time.

Haw: Automation of logistics process results in reduction of barge turn-around time.

As discussed in earlier findings, it was proved for 3 mother vessels loaded in the 2 months that GPS-enabled barges had clocked turn-around time ranging from 18 hours to 28 hours during different trips of study-nominated vessels and the average TAT for all such trips was 22 hours as against 30 hours of baseline data.

We performed One Tailed test (Z-test) on the sample data, chosen randomly from the batch of turn-around times. As the sample size is > 31 (more than 30 prescribed) for the set of data to be in normal distribution, as per the central limit theorem. Since improvement expected is reduction in TAT numbers from historical trends, performing the Hypothesis test at 99% Level of significance, we obtain the rejection criteria of Null Hypothesis as

Reject $H_0$ if $X < X_{\text{critical value}}$

Where, critical value is

Hence null hypothesis ($H_0$) does not hold good and it is proved therefore alternate hypothesis stands good, i.e. Automation of logistics process results in reduction of barge turn-around time.

Hypothesis #2-A: For Handling losses in Road segment

The average shortage for any 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 these 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 losses of 0.93%.

Further post-implementation data of road segment 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 against above 800 nos. consecutively historically. Besides the time to crack down such missing trips was brought down from almost above 2 months to just one day when the company escalated efforts to track missing arrivals almost next day basis spontaneous auto-reconciliation. The executives took little time in 1st month to accept and wake up to the new reality and accordingly correcting their internal processes to exert pressure on transporters, which yielded results in subsequent months as was evident from negligible missing trips in 3rd month.

Hypothesis Test Statement

H0r: Automation of logistics process does not lead to reduction in transit losses during cargo journey between source and destination.

Har: Automation of logistics process leads to reduction in transit losses during cargo journey between source and destination.

We performed One Tailed Hypothesis Test on Transit loss (TL) data of road segment. Estimating Population mean from Sample Mean, we compute

Null Hypothesis:

H0: Automation did not result in lower Transit Loss Avg. TL = µ₀

Alternative Hypothesis:

Ha: Improvements in efficiency resulted in Lower Transit Loss. Avg. TL < µ₀.

This is tested at 1% level of significance i.e.at 99% confidence level.

The sample size is large, n = 31. Therefore, central limit theorem was applied and the distribution of average transit loss was approximated as normal distribution.

The sample mean (X) and sample standard Deviation (S) were calculated from the transit loss data for Month 1 as collected. A summary of Sample means for the samples used are shown in Figure on next page.

If X is proved to be less than Xcritical value, then we would infer clearly that null hypothesis does not hold good.
Let us now look at the frequency distribution of transit losses as computed below:

### Road Transit Losses

<table>
<thead>
<tr>
<th>Sample Means</th>
<th>Range from</th>
<th>Range to</th>
<th>Frequency Range</th>
<th>No. of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>20.65</td>
<td>20 and lower</td>
<td>20 and lower</td>
<td>0</td>
</tr>
<tr>
<td>32.90</td>
<td>40.32</td>
<td>20 and lower</td>
<td>20-24</td>
<td>1</td>
</tr>
<tr>
<td>24.19</td>
<td>29.03</td>
<td>24.01</td>
<td>24-28</td>
<td>4</td>
</tr>
<tr>
<td>20.97</td>
<td>32.26</td>
<td>28.01</td>
<td>28-32</td>
<td>1</td>
</tr>
<tr>
<td>32.26</td>
<td>30.00</td>
<td>32.01</td>
<td>32-36</td>
<td>4</td>
</tr>
<tr>
<td>46.77</td>
<td>21.94</td>
<td>36.01</td>
<td>36-40</td>
<td>2</td>
</tr>
<tr>
<td>54.52</td>
<td>31.94</td>
<td>40.01</td>
<td>40-44</td>
<td>1</td>
</tr>
<tr>
<td>26.77</td>
<td>39.35</td>
<td>44.01</td>
<td>44-48</td>
<td>1</td>
</tr>
<tr>
<td>25.48</td>
<td>39.35</td>
<td>48.01</td>
<td>48-52</td>
<td>1</td>
</tr>
<tr>
<td>33.23</td>
<td>31.61</td>
<td>52.01</td>
<td>52-56</td>
<td>1</td>
</tr>
<tr>
<td>50.00</td>
<td>32.58</td>
<td>56 and above</td>
<td>56 and above</td>
<td>0</td>
</tr>
<tr>
<td>25.48</td>
<td>28.71</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>37.10</td>
<td>37.74</td>
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<tr>
<td>40.65</td>
<td>39.68</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>32.58</td>
<td>30.97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 12: Summary of sample means and samples used for road transit loss

Figure 35: Distribution of Sample Means of road transit losses

The values of mean and standard deviation of the sample are shown in the below table:

| Sample Mean | Sample Standard Deviation |
The sketch of sampling distribution of sample mean approximately followed a normal curve as shown in graph above.

Performing the Hypothesis test at 99% Level of significance, we obtained the rejection criteria of Null Hypothesis as

\[
\text{Reject } H_0 \text{ if } X < X_{\text{critical value}}
\]

Where critical value is

Substituting the relevant values: \( Z_{\alpha} = -2.33 \), \( n = 31 \), \( \mu_0 = 115 \), \( S = 118 \), we get critical value as

\[
X_{\text{critical value}} = 65.62
\]

Clearly, \( X = 33.45 < X_{\text{critical value}} = 65.62 \)

Hence, we reject null hypothesis \( H_0 \). Therefore alternate hypothesis is proved correct i.e. Automation of logistics process leads to reduction in transit losses during road cargo journey between source and destination.

**Hypothesis #2-B: For River segment**

\( H_0w \): Automation of logistics process does not lead to reduction in transit losses during cargo journey between source and destination.

\( Haw \): Automation of logistics process leads to reduction in transit losses during cargo journey between source and destination.

The results of exercise in river segment for 3 vessels 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%, which is much closer, in fact better than the target of 1.5% fixed prior to undertaking exercise.
Hence it is proved that Automation of logistics process leads to reduction in transit losses during cargo journey for barges between source and destination.

**Hypothesis #3 – Common for road and river segment**

H0: Automation of supply chain processes does not improve visibility and coordination amongst chain partners.

Ha: Automation of supply chain processes improves visibility and coordination amongst supply chain partners.

The objective evidence in support of above hypothesis stems from the previously discussed examples of finite reduction in missing trucks due to increased awareness (or visibility) amongst drivers in road segment as well as improvement in barge TAT and reduction in handling losses in road and river segment. The Truck Journey Time (TJT) was another classic example of how coordination between various agencies associated with the supply chain brings results far exceeding normal expectations.

It was observed that total turn-around time (TAT) was not a relevant parameter as it was observed that hardly any truck was able to do more than 1 trip a day for any route and none were able to complete 2 trips a day for a 2-way journey. It was therefore thought fit to focus on TJT computations during our study (time interval of individual trips between source exits to destination entrance). While it was argued that how RF technology would have any impact on journey time of trucks when there is no reader points installed on public roads. Moreover journey time of trucks in Goa would depend a lot upon traffic congestion en-route specifically at all junction-points and barrier points introduced by local traffic enforcement agencies to regulate traffic. Hence time interval analysis of each and every trip in 1st month was performed to see if there are any particular time-slots when the TJTs are lower or higher substantially and shared these results with company executives to take leverage the same in better planning of various stages of process of truck loading / source exit. The truck drivers were asserted with past data that it was best to exit from source early morning to queue up at barrier points to get early departure in least traffic times, a sure shot to make pitch for 2nd trip. After 1100 am, the TJT was getting longer and longer, with highest TJT being clocked after
1500-1600 hours as there was no chance of crossing the barrier points and one would have to wait till the start of time-slot next day.

It was witnessed that there had been clear trend of reduction in average TJT for each time-slot over the 3 months. The TJT has reduced from 18 hours 19 minutes per trip in 1st month to 11 hours 19 min in 2nd month to just 6 hours 10 minutes in 3rd month as shown earlier. Further it can also be observed that 3rd month average coming down to just around 6 hours, thereby proving that it was possible to make 2 trips per day for most of the trucks, with consistent efforts continued in right direction.

Whilst this could be argued that this was made possible by multiple interventions, which were not direct result of visibility of information exchange brought through automation efforts, but the underlying importance of ready availability of information cannot be under-estimated. A separate focused team was formed with only job to constantly analyze daily trend of data on various parameters to see if there was any cause-effect relationship and whether actionable inference could be drawn out to enable faster completion of trips (target of 2 trips daily). The team came forward with multiple such interventions and implemented a no. of them in short time. One of the most game-changer interventions, the indirect influence it had on TJT improvement was difficult to ignore. The field team had mobilized an outsourced agency employing a no. of local people to supervise all traffic junctions and halting barrier-points en-route for maintaining lane discipline and orderly movement of trucks, specifically to ensure slow yet steady movement of traffic. This is easier said than done, but the consistent efforts paved the way as witnessed by the TJT computations in the 2nd and 3rd month, week after week. This became a huge success and had been the most note-worthy role-setting effect of automation in this study as it helped the execution team win the trust and confidence of truck drivers, owners and traffic regulating government authorities. The trust-building also had a no. of consequent effects on other efficiency parameters.

**Hypothesis Test for TJT:**

H0: Automation of supply chain processes does not improve visibility and coordination amongst chain partners, thereby showing no improvement in TJT.
Ha: Automation of supply chain processes improves visibility and coordination amongst supply chain partners, thereby showing improvement in TJT.

One Tailed Hypothesis Test:

Estimating Population mean from Sample Mean:
Null Hypothesis (H0): Improvements in visibility and coordination did not result in faster TJT  
Avg. TJT in 1\textsuperscript{st} month = \mu_0.
Alternative Hypothesis (Ha): Improvements in visibility and coordination did not result in faster TJT to prove that Avg. TJT in 3\textsuperscript{rd} month < \mu_0.
This was tested at 1\% level of significance i.e. at 99\% confidence level.

Sampling Methodology: Simple Random

Calculations for One Tailed Hypothesis Test:

The sample size is large, n = 31. Therefore, central limit theorem was applied and the distribution of average hours was approximated as normal distribution.

The sample mean (X) and sample standard Deviation (S) are calculated from TJT data collected. A summary of Samples used are shown in Appendix 3. The values of mean and standard deviation of the sample are shown in the table below. The sketch of sampling distribution of sample mean approximately followed a normal curve as shown in graph below.

Table 13: Distribution of sample means and samples drawn for TJT

<table>
<thead>
<tr>
<th>Sample Means</th>
<th>Range from 16000</th>
<th>Range to lower</th>
<th>Frequency Range 16000 and lower</th>
<th>No. of Samples 0</th>
</tr>
</thead>
</table>
### Sample Mean and Standard deviation of Truck Journey Time-TJT

<table>
<thead>
<tr>
<th>Sample Mean</th>
<th>Sample Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( X = 22230 ) seconds</td>
<td>( S = 2860 ) Seconds</td>
</tr>
</tbody>
</table>

Figure 36: Normal Distribution of sample means of Truck Journey Time

Performing the Hypothesis test at 99% Level of significance, we obtained the rejection criteria of Null Hypothesis as

\[
\text{Reject } H_0 \text{ if } X < X_{\text{critical value}}
\]

Where, critical value is
Substituting the relevant values: \( Z_{\alpha} = -2.33, n = 31, \mu_0 = 48525, S = 27454 \) we get critical value as

\[ X_{\text{critical value}} = 37036 \]

Clearly, \( X = 22230 < X_{\text{critical value}} = 37036 \)

Hence, we reject null hypothesis \( H_0 \). Therefore it proved that Automation of supply chain processes improved visibility and coordination amongst chain partners, thereby showing improvement in TJT. Had it been possible for the trucks to make second trip in a day, it would have been easier to prove that the Turn-around time (TAT) of trucks also would be impacted in a similar logic.

### 7.9 Employee Feedback On-line survey for testing Hypothesis # 3

While we all readily accept quantifiable results for proving hypothesis, but any management thinker would lay equal stress on these qualitative attributes which are crucial for long-term sustenance of any organization i.e. trust and transparency in all human interactions. Hence to test this hypothesis, it was considered apt to undertake a feedback survey from the users of Logistics information across departments and hierarchy. A total 75 participants had responded out of 120 targeted, with their profile shown in figure 37. The target group was chosen by the concerned company executives in supply chain department to represent people across hierarchy and across departments who were using our information as available from automation systems, for example, from Production / Operations or Marketing or Logistics or S & OP dept. The survey was therefore administered through a common questionnaire framed of general questions equally applicable across road and river segment both, since the qualitative attributes of the impact of automation were equally relevant for all users, irrespective of road or river
segment. Due to ease of administration as well as to eliminate any scope for bias due to personal influence, it was agreed that on-line method of administering the survey would be the best medium and company IT department agreed to host the survey on their intranet for an agreed time-limit. The design of questionnaire was attempted by research proponent by referring to various literature available on the subject with due emphasis on various parameters like avoiding lead questions or creeping of human bias due to use of words or sentences (e.g. slangs) being commonly used without any specific meanings and hence meanings of such words were restricted by providing the most apt standard dictionary meanings to remove any ambiguity in the meaning, e.g. visibility and coordination, it was decided to freeze following simple and easy to understand meanings for the purpose of survey after a deep dive in to literature:

1. Visibility means ready availability of information as may be necessary for executing one’s job.

2. Coordination means making use of the available information to take action by self, or to solicit action from other team members for fulfilling the desired objective.

The above meanings were incorporated in the survey questionnaire form (please refer appendix 4 and were also explained to respondents before undertaking survey, in order to restrict their response within the ambit of above definition for ensuring uniformity. The results of feedback survey are being discussed here:

Question 4 - Whether automation efforts have influenced the visibility of information?

95% respondents have acknowledged that automation exercise has provided them easy and faster access for communication of events as compared to past, thus improving visibility of information related to various stakeholders including supply chain partners. The 5% participants who had difference in observation were almost equally spread amongst all 3 user groups i.e. full-time core team, part-time core team and not member of core team.

Figure 38: Impact of Automation on Visibility of Information
Question 5 - How have automation processes impacted your co-ordination with other stakeholders?

66% of total respondents have clearly acknowledged that automation helped them to achieve better coordination. Further 27% of respondents, almost all from non-core group, have conveyed that automation impacted in effective coordination to some extent.

Figure 39: Impact of Automation on coordination amongst stakeholders

Only about 7% of total respondents, in fact just about 10% of respondents from part time-core team and non-core team, perceived that automation did not have any effect on coordination. Further 88% of middle and senior executives participated have acknowledged that it was easier for them to achieve coordination after automation in place.

Other feedback points of survey:

Now we shall discuss the analysis of results of other questions of feedback survey, in order to gauge the effectiveness and impact of automation of export supply chain for the ore industry as follows:

Question 2 - How do you rate overall experience of automation implementation in company?

75% respondents have clearly acknowledged that their overall experience of automation has been satisfactory, while 19% respondents, again almost equally spread across core and non-core groups, felt that their overall experience was partly satisfactory and 6% felt that it was not satisfactory at all. It is further interesting to find that almost 50% of respondents not forming the core team at any time, have also acknowledged that the automation experience was highly satisfactory, which speaks of its acceptance of solution in industry. Even if we suspect any kind of bias in response due to any personal influence of the proponent of automation study, this particular group of non-core team
participants had no vested interests or so-called collision with proponents as these were a very random group of employees, who may not have had any association or acquaintance with proponents of study.

Figure 40: Overall Rating of Automation experience by respondents

Question 3: Has Automation influenced awareness level amongst transporters towards reduction in transit losses?

75% respondents have expressed affirmative i.e. positive influence on awareness amongst transporters to reduce transit losses (highly satisfactory and satisfactory), while 19% respondents in equal numbers across core and non-core groups felt that automation might have only partly influenced and balance 6% just from non-core group felt that it has not influenced at all.

Figure 41: Influence on awareness in transporters for reduction in losses

Question 9– How confident are you about the benefits achieved from automation efforts would be sustainable in near-term?

Almost 96% total respondents perceived that sustainable benefits of automation would continue to accrue to company. Just 4% respondents, to be precise 1 respondent each from full-time core group and non-core group did not foresee likelihood of accrual of benefits, whereas one respondent from non-core group remained neutral.

Figure 42: Confidence on Sustainability of automation benefits
Q 10- Has automation enabled you to exercise higher control over the supply chain processes?

Almost 85% total respondents have endorsed that automation led to exercising better control over supply chain, with almost equal members from both core groups and even 70% of non-core group members endorsing the same. However 1 respondent from each group has endorsed that he has not experienced better control.

Figure 43: Automation enables higher control over the supply chain processes

Question 6- Do you think automation process has simplified data capturing / gathering / sharing?

About 96 % of total respondents agreed that automation leads to simplified data capturing, gathering and sharing, with 73 % fully endorsing the view. It is quite revealing that while all non-core team members fully endorsed this view, whereas one or two members from each core group held view other than above. May be it reflects that these members believe that it is not an easy job to dig out relevant data after automation leads to flooding of data.

Figure 44: Automation simplifies data capturing / gathering / sharing

Q 7-- Do you think automation would help company improve its fleet efficiency in due course of time?

From below charts, it can be concluded that almost 88% of total respondents agreed that automation would help improve fleet efficiency in due course of time as stakeholders understand the power of trust and transparency, which drives individual accountability to impact performance positively. However it is interesting to note that
while core team members believed in this, but some of the part-time core members along with non-core members did not believe in.

Figure 45: Automation helps improve fleet efficiency in due course of time

It may be noted that Question 8 was added in the survey on the insistence of case company as their executive wanted to understand the user’s perception of the specific advantages obtained from the automation and same was analyzed on highest to lowest total score of all respondents. It may be noted that improving visibility of information figured highest, followed by advance planning of logistics operations and building higher degree of trust with senior management team, whilst least score was on enabling continuous and real-time monitoring of assets.

Hence we can summarize from above discussions on feedback survey of case company proving all the hypothesis framed at the beginning of our research study. The improvements achieved could have been of even greater impact in road segment, had there been a no throttling of time available for transport, as was in the past. Despite such severe restrictions imposed externally by local traffic regulators, it was still a decent attempt and the results obtained were sustainable as proved month after month, with proper monitoring of trips and maintaining overall surveillance, easily achievable now due to better visibility of trips and trained motivated manpower.