

<b>Project Title</b>	<b>Smart Solid Waste Management</b>
Executive Summary	<p>Surat Municipal Corporation is responsible for collection and disposal of Solid Waste across 326 sq.km city area.</p> <p>Solid Waste Management comprising of solid waste collection, transportation and disposal is a very critical activity for any ULB. SMC has taken various initiatives in the field of Solid Waste Management to make the city clean. The efforts of SMC has been acknowledged at various level.</p> <p>With a view to utilize the latest technology and IT system to further strengthen the Solid Waste Management practices, SMC has under taken a project on implementation of the Smart Solid Waste Management System as a PAN city IT project under Smart City Mission. The project got implemented on 21<sup>st</sup> March 2018.</p> <p>The goal of this project is to implement an Integrated and centralized Solid Waste Management monitoring and tracking solution. The solution is monitored centrally from Smart City Center (Command &amp; Control Center) of SMC. Below are primary objectives of the Solid Waste Management (SWM) monitoring &amp; tracking solution:</p> <ol style="list-style-type: none"> <li>1. To monitor the fleet involved in the Solid Waste Management activities in real-time, to improve per vehicle productivity, to reduce non-compliance and to optimize fleet utilization</li> <li>2. To have the real-time information with regards to waste collection activity</li> <li>3. To geocode and geo-fence stoppages/Point of Interest (POI) and routes</li> <li>4. Route planning and allocation</li> <li>5. Automate the transfer stations and disposal site for daily garbage inward and outward activities</li> <li>6. To utilise the technology to minimize human intervention and to improve the collection efficiency</li> <li>7. To full proof the system and prevent misuse of manual system and to induct transparency and accountability in operations</li> <li>8. To ensure complete coverage of waste collection across Surat city</li> <li>9. To have the system that helps monitor the performance and SLA for services</li> <li>10. To provide management with dashboard and detailed analysis reports for decision making</li> </ol> <p>SMC implemented the Smart Solid Waste Management System under Smart City Mission that helps overcome the challenges mentioned above. The Smart Solid Waste Management Solution broadly comprises of the following:</p> <ul style="list-style-type: none"> <li>• Vehicle Tracking System on the Primary Collection and Secondary Transport vehicles</li> <li>• RFID tags on waste collection vehicles</li> </ul>

	<ul style="list-style-type: none"> <li>• RFID readers at transfer stations and disposal site</li> <li>• Integration with cameras to capture image of vehicle (along with number plate) entering and exiting transfer station and disposal site</li> <li>• Integration with weighing scale to capture weight data of loaded and empty vehicles</li> <li>• Biometric system to authenticate user entering/capturing details of vehicle in and out at transfer stations and disposal site</li> <li>• Centralized web based system for monitoring of the complete Solid Waste Collection &amp; Disposal activities integrated with RFID readers, cameras, biometric and GPS devices.</li> </ul>
Background & Context	<p>Surat is a city located on the western part of India in the state of Gujarat. It is the eighth largest city in terms of population in India and the fastest growing city (as per Oxford Economics report). The city has witnessed decadal growth of over 60% since last 5 decades with city population increasing from 2.8 million (census 2001) to 4.5 million (census 2011). The current population is estimated to be 6 million.</p> <p>The upsurge in population and increasing urbanisation poses challenges to keep city clean. Surat Municipal Corporation with an aim to create world class civic infrastructure has been forerunner when it comes to Solid Waste Management.</p> <p>The following challenges were faced prior to the implementation of this project:</p> <p>The solid waste collection activity under primary collection comprises of door to door garbage collection, container lifting, day swiping, night scraping &amp; brushing activity, etc. The major activity under primary collection is that of door to door garbage collection. SMC has outsourced and engaged different vendors for each zone to carry out door to door garbage collection. The collected waste is disposed at the Primary Transfer Stations. From here, the MSW is transported to disposal site through secondary transport. The secondary transport activity is also outsources.</p> <p>Individual vehicles are assigned designated area with specified time to visit individual household to collect garbage. A vehicle traverses through the route and collects the garbage from individual households.</p> <p>The responsibility to equip each vehicle engaged with GPS was that of the vendor which resulted in different interfaces to track different vehicles.</p> <p>Some of the challenges faced by existing systems are as under:</p>

	<ol style="list-style-type: none"> <li>1. Different interface to track different vehicles leading to lack of holistic view of SWM operations.</li> <li>2. Non-standardised reports to ascertain KPIs.</li> <li>3. Difficulty in performance measurement of the vehicle/contractor, penalty and payment calculation.</li> <li>4. Difficulty in monitoring whether the assigned route is visited or not by a particular vehicle.</li> <li>5. Manual process for calculation of SLA, penalties and payments.</li> <li>6. Non-availability of on-demand reports of vehicles, total garbage collected etc.</li> <li>7. Different monitoring solution for different zones causing maintenance issues</li> <li>8. Independent system for vehicle tracking and weight collection process.</li> <li>9. Manual intervention at the time of registration of weight on entry and exit from Primary Transfer Station / Final Disposal Site. Vehicle numbers were required to be entered.</li> </ol> <p>With a view to overcome these challenges, the Smart Solid Waste Management project was undertaken. Further, it was required to have a full proof and transparent system in place as the payment to contractor is processed based on the weight of garbage collected and based on the field level compliance by the vehicles.</p>
Implementation Objectives	<p>The goal of this project is to implement an Integrated and centralized Solid Waste Management monitoring and tracking solution. Solution will be monitored centrally from existing Smart City Center. Below are primary objectives of Smart Solid Waste Management solution</p> <ol style="list-style-type: none"> <li>1. To monitor fleet involved in the SWM activities in realtime and optimise, to reduce non-compliance</li> <li>2. To have real-time information with regards to waste collection activity</li> <li>3. To geocode and geofence stoppages/Point of Interest (POI) and routes</li> <li>4. Route planning and allocation</li> <li>5. Automate transfer stations and disposal site for daily garbage inward/outward activities</li> <li>6. To utilise technology to minimize human intervention and improve collection efficiency</li> <li>7. To full proof the system and prevent misuse of manual system and to induct transparency and accountability in operations</li> </ol>

	<ol style="list-style-type: none"> <li>8. To ensure complete coverage of waste collection across Surat</li> <li>9. To have the system that helps monitor the performance and SLA</li> <li>10. To provide management with dashboard and detailed analysis reports for decision making</li> </ol> <p>The technology components are as under:</p> <ol style="list-style-type: none"> <li>1. GPS devices &amp; RFID tags installed on vehicles</li> <li>2. RFID readers at primary transfer stations and final disposal site</li> <li>3. Transfer Station Application integrated with RFID reader, Weigh bridge, CCTV Camera and Biometric device.</li> <li>4. Centralised application to monitor entire SWM activities</li> <li>5. Mobile App for field level monitoring and support</li> </ol> <p>Technology used:</p> <ul style="list-style-type: none"> <li>- Centralised application and transfer station application is developed in asp.net and C# respectively with backend as MS SQL.</li> <li>- Mobile app is available for android and iOS</li> </ul>
Scope of implementation	<p>The broad scope of work comprises of the following:</p> <ol style="list-style-type: none"> <li>1. All 600 vehicles involved in Solid Waste Management activity vehicles were fitted with GPS &amp; RFID Tag.</li> <li>2. Mapping of vehicles, RFID tags and vendor was carried out.</li> <li>3. Each D2D vehicle was assigned the trips and Point of Interest to be attended along with specific In-Time and Out-Time. A mobile app was developed for capturing the PoI under a specific trip and assign it to individual vehicles. In all 1300 trips and around 10,000 PoIs were created and assigned.</li> <li>4. At transfer station, application was integrated with RFID reader to auto identify the vehicle, with weigh bridge to auto capture weight, with CCTV to auto capture vehicle image and registration no. and with biometric device to authenticate the user.</li> <li>5. Transfer station system was implemented at all 8 primary transfer stations and final disposal site.</li> <li>6. The business rules to ascertain performance parameters were created.</li> <li>7. Centralised application comprising various features like Dashboard, live vehicle tracking, vehicle history playback, real-time D2D garbage collection activity overview comprising information on no. of vehicles on trip, trips initiated, PoI attended (in time, early, late), missed PoI along with Penalty &amp; payment reports developed.</li> <li>8. Mobile app for field staff to monitor and manage the activity is provided. It helps to assign spare vehicles in case of breakdown.</li> <li>9. Mobile app also helps to capture other penalties like, staff not wearing uniform, hanging of garbage bags, vehicle not in good condition, etc.</li> </ol>

Innovative characteristics of the proposal

Integration of various IT components in Solid Waste Management makes the solution smarter by reducing manual interventions and by providing a way to cross verify the field level compliance of the vehicles. Some of the components covered under this project as under:

1. **RFID Readers:** The RFID readers are installed at transfer stations and disposal site. These readers fetch vehicle details automatically from RFID tags placed on each vehicle in such a way that supervisor does not have to enter vehicle details manually.
2. **Cameras:** The cameras is placed at each transfer station and disposal site to monitor entry and exit of vehicles. The cameras are used to capture image of vehicle (with number plate visible) directly in the system at the time of saving record.
3. **Biometric devices:** This device is used to scan finger print of the supervisor stationed at Transfer Station and disposal site to authenticate user and ensure his/her availability.
4. **Weigh Bridge System:** This device is used to calculate weigh of the waste collected by vehicle entering and existing Transfer Station and disposal site
5. **Hardware Integration:** The hardware specified above is integrated with the software application. The application is completely integrated application and users are not required to access separate application to perform required task for specific hardware.

Further, to ensure field level compliance of each vehicles, for every vehicle's TPM's, each and every PoI (Point of Interest) locations are captured using Smart Phone GPS by SMC Employees. Each location captured with through GPS is also assigned a time slot indicating the time when the vehicle will visit respective location along with number of households covered by respective PoI. Capturing of GPS locations of all PoI has been done for more than 500 vehicles covering approximately 1300 trips with approximately 10,000 PoI across the city. When a vehicle is on trip for garbage collection, the GPS unit installed in the vehicle continuously sends the location of the vehicle using which, system cross verifies whether the vehicle is attending the designated PoIs during the trip or not. At the end of the day, systems generates a report clearly indicating the number of locations missed by the vehicle during the day. Based on the number of vehicle missed, contractor penalty is automatically calculated.

Apart from attending the PoIs on time, other penalties related to vehicles are also automatically calculated by the system.

	<p>For better monitoring and management of the system, a web based portal and a mobile app has been developed for SMC. The portal is useful for centralized monitoring through command and control center, while the mobile app is useful for field level monitoring and management. The mobile app also provides an option to replace a vehicle in-case the vehicle breaks down during operation.</p>
Results	<p>With the help of Smart Solid Waste Management System, number of complaints from citizens have been reduced by more than 81%. This also enables prompt action for garbage collection locations that have been missed. Real time monitoring leads to efficient route management and updating of routes as and when required. The availability of entire operations and its monitoring at the level of ward, zone and Command &amp; Control Center has helped to reduce the number of missed PoIs from 500 per day to less than 10 per day. Smart SWM system enables accurate and automated weighing at transfer stations. Automated system has minimized human errors and chances of malpractices. Penalty is also calculated automatically and payment is made accordingly. Door to door contractors, zonal and ward level sanitary inspectors are also able to monitor all vehicles over mobile app to manage the door to door system more efficiently.</p> <p>The smart city project of Smart Solid Waste Management implemented has helped SMC to effectively utilise its resources. It has also helped the stake holders i.e. SMC officers, employees and contractors to track various activities and monitor the abnormalities if any and take corrective actions. The manual interventions have been removed ensuring transparent system. The system is standardised across the vendors and operations. The citizens at large have benefited with improved service delivery and adherence.</p>
Replicability / Scalability	<p><b>Replicability</b> The Smart Solid Waste Management System is designed keeping the standard Solid Waste Management processes which are usually common across all cities. The solution designed does not contain any dependency on specific make or model of any hardware or software. This enables this solution to be replicable across multiple city. Further, the modular architecture of the solution allows respective department / organization to even monitor other vehicles apart from Door to Door Garbage Collection vehicles as well making it replicable within multiple departments within same organization.</p> <p><b>Scalability</b> The architecture and design principal of this system is defined in such a manner that it is flexible enough to be scaled up for monitoring more number of vehicles as well. The infrastructure required for Transfer Stations, vehicles and data center is developed in such a way that it can be scaled up in plug and play mode with minor configuration in centralized application.</p>

URL link for  
video

<https://www.youtube.com/watch?v=mrolEz5YEDU>