Using IT-based Solutions to Improve Logistic Operations of a Scrap Collection System

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Abstract

The study takes place at a steel production company in Mexico, where the market has a deficit for its collection capabilities. This project focuses on the redesign of the logistics system in charge of the collection of raw material, which is done by the company owned fleet. The initial diagnostic phases had the purpose of identifying the root causes of the problem at hand. They involved collecting and analyzing data regarding the providers, processing factories, costs and the process involved with the collection system. The key action taken was to establish a new venture of collaborative economy as a mean for scaling the collection capabilities. In addition, a new planning and operations scheme was implemented using a software application for better routing. It includes a prioritized provider selection based on performance, fleet management, and data gathering with integrated analytics. The results after a pilot period were a decrease in the logistics costs by 14.48%, a decrease in the average kilometers driven per ton by 27.4%, and an increase in collection capacity by 8%.

Keywords
Logistics, fleet management, steel production, lean transportation, collaborative economy

1   Introduction

Nowadays, technology and human life cannot be separated; society has a cyclical co-dependence on technology, since it has solved and facilitated many daily and operational tasks. Technology is constantly changing and updating, impacting the environment, people and the society alike; although the way people use it, determines if it impacts in a positive or negative way. In this case, it is known that transportation is one of the basic areas that has been implementing technological solutions, having benefited both the society and businesses with these updated practices. Transportation provides mobility for people and goods, and like all other technologies, can be viewed as a system, since it is composed of a series of parts that are interrelated that work together to meet a certain goal.

Technology has been key for creating the globalized world of today. Thanks to this, new business models are emerging and attracting the attention of investors and the public in general. More and more companies are replicating these different business models to adapt to society and survive as a profitable venture, as they try and keep up with technology, which each day, evolves faster than before. An example of a business model that is disrupting the market is the collaborative economy, which refers to an economic system in which goods and services are shared and exchanged through digital platforms, while the companies providing the business become only connection between third parties, that are in need for a network big enough to earn a living, with the clients. Such as the author Morgan (2014) says, "The digital revolution generates new productive relationships and transforms the economy, in a few years perhaps all we need to earn a living is a humble connection to the Internet". Each different industry may adapt the model to become the first company to apply something so different from competitors that may launch them to the next level.

The company in study is a world-class steel production company in Mexico founded in 1952. It has an integrated infrastructure for the collection and processing of scrap, steel mills, plants that manufacture finished products and

distribution centers. Its business is focused on construction, industrial, fences, hardware stores. The company has an operation of collecting the raw material by recycling different types of material and then processing them to transform these products into steel by a different process of foundry. The collection of raw material is made up of the operation of the company's internal trucks and the purchase of this material from trucks that obtain this material elsewhere. This project is focused in the reduction of the logistics costs, and capture of more raw material through the company´s transports.

2   Problem

Mexico's Steel Industry is currently in a deficietary state, creating strong competition between steel manufacturers that are in the hunt for the raw materials that are necessary for quenching their production necessities. Mexican steel production needs about eight million tons worth of scrap, but nevertheless, the country has a maximum supply capacity of seven million tons, leaving a deficit of a million tons that need to be brought in from foreign places. This state of the market, in which informality between companies' reigns, is promoting high competition between the biggest scrap buyers, one of which is the company in study. This high dispute over raw materials gives scrap collectors and sellers a higher bargaining power and creates a system where the providers that can sell in higher volumes, to also sell at a higher price point.

This project focuses in the redesign of the logistics system in charge of the collection of raw material done with the company owned fleet, which needs solutions to better attend this problematic environment in which the market resides and improve their efficiency throughout the system and the decision-making capabilities of the team in charge. The collection logistics system is composed of a fleet of 26 Roll Off trucks, 15 drivers, and five employees in charge of the logistics for more than 60 providers located in the city of Monterrey, México, and its surroundings. The system has been growing throughout the years in terms of its operation scale and is in the need of structure and control to keep up with today's standards.

3   Methodology

The methodology utilized for the development of the project is an eight-step methodology created by Dr. Tom Kuczmarski specifically for the company in study. The methodology is used internally for the development of its own projects, since it focuses on diagnosis, design and innovation. Dr. Kuczmarski constructed it by inspiring himself with his own methodology called *The Eight Disciplines*. "8D was created to represent the best practices in problem solving." Kuczmarski, T. (2018) This methodology focuses on innovation through the development of new projects, however, to better serve the project, the *Lean Transportation Management Methodology* has been integrated so that it could better adapt those principles to the company's methodology. This adaptation resulted in a better methodology focused on diagnosing problems and its root causes, and, proposing, developing, and implementing solutions for a logistics centered project in order to achieve and develop the project efficiently and correctly. The following figure 1 shows a complete visualization of the stages of the adapted methodology and the activities that where done in each step:
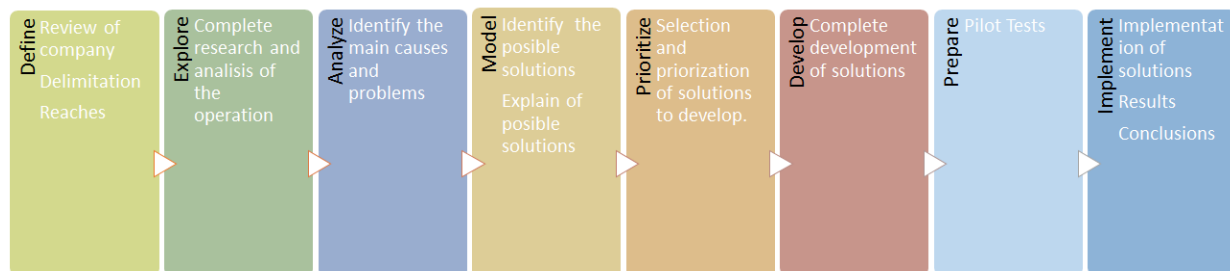

Figure 1. Methodology

3.1   Define

The project is limited to the logistic area that operates the scrap collection operation for their two main scrap yards (One being the biggest scrap collecting yard, and the other the headquarters for the logistic operations), for which a redesign, a simulation, an implementation and documentation will be made.

3.2 Explore

This stage has as its goal to begin the search for pertinent information that will be further analyzed in the third stage of the methodology.

3.3.1 The process

The logistics planning process is made by one employee who receives calls during the day from the providers that want to schedule a collection trip. The employee proceeds to generate a unique folio and manually schedules the trip in an Excel spreadsheet by assigning the truck, driver and time for each one in a calendar type look. Once the collection trips are scheduled, it is communicated to the drivers via text message and a printed sheet that is pasted in a window for all to view. The driver proceeds to make a visual and technical checkup for the truck that he will use and then heads off to the Scrap Yard's exit for the final weighing checkup and then to the first appointed trip. Each driver is assigned about two or three daily trips. When arriving to each provider, the driver needs to drop off its current crate and load up the one that the provider filled since the moment of their last collection. A driver can only collect the crate of a single provider at a time, because each one needs to be delivered in the company's scrap yard individually for two main reasons. First, the capacity of the Roll Off truck can only support a single box, and second, more scrap from another provider can't be loaded with a crane because the material needs to be weighted for further payment and mixing two loads would only dividing the scrap a complication and imprecise. Because of this, each crate needs to be fully loaded so that it can be eligible to receive a scheduled trip. The crates come fully loaded in volume capacity, but because of the nature of scrap, the weight of the load will never be the same. Once the driver finishes all his trips, and he is not located in the scrap yard that also serves as the logistics base, he heads back to it.

3.3.2 General stats from the operation

The following table represents the operation from the last four years in terms of tons collected, total trips made and the average load that was carried in average per trip.
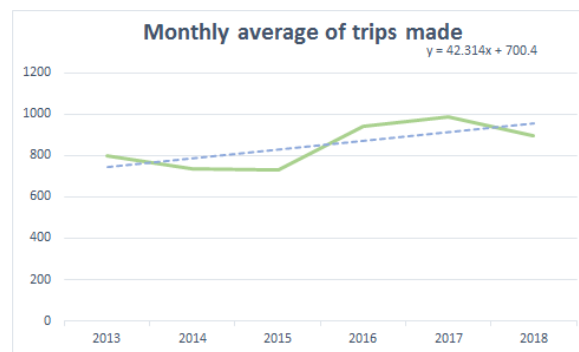

Figure 2. Monthly average of trips made

As seen in the figure 2, there has been a bigger increase in trips than the average tons collected, which translates in a lighter load per trip which affects its efficiency. The reason behind this extra effort in trips for the same amount of scrap is based in a previously implemented strategy that seeks scrap mainly from companies that are dedicated to scrap collecting, instead of companies that produce scrap residue from their operation. So, for the 2018 year the average of trips made by a Roll Off were 899 and the tons recollected for the same year were almost 6494.

3.3.3 Costs

There are two cost categories that have either a direct or indirect effect on the logistic system for scrap collection: Purchase cost and logistics cost. Purchase cost affects indirectly the logistic system in hand, and it is measured in tons. It depends on several variables: the type of provider and the type of material. For this project purposes, the purchase cost will be evaluated by the averages for each type of provider and all types of materials for each. A sample from the main Scrap Yard, called *Patio Guadalupe* was used to explore the distribution of tons provided by each type of provider and the average cost of each. After a deep investigation and analysis, it can be deducted that, the higher the rank, the bigger the cost. This happens in spite that the higher the rank, the more a provider can sell monthly to the company in study. This has a contrary effect to regular sales in which a single high-volume purchase

qualifies for a volume discount, but, since the scrap collecting market is in a deficietary state, as previously explained in the chapter regarding the problem in hand, it gives providers with high volumes of stock the opportunity to sell with a more expensive price.

The logistic cost is composed of six different variables: Maintenance, Diesel, Insurance, Comms, Depreciation and workforce. The project in hand can only, due to its limitations and scope, affect three out of these six variables; Maintenance, Diesel and Workforce. These three variables represent 64% out of the total integrated logistics cost as of 2018. Diesel alone represents 17%, Workforce a 20% and Maintenance a 28%. Taking into account the average monthly collection of scrap of 6,494 tons. Further exploring a loaded truck's journey, by using the average total collected tons of 7.22, the purchase cost accounts for approximately 97% of the total cost of a single trip while the logistics cost just 3%.

3.3.4   Distance travelled

One of the sections of the operation that heavily impacts the logistic cost is the amount of Diesel spent for sustaining the operation. This involves wait time and distance travelled. Over the course of July, August and September, the average distance in kilometers was of 28,655 for 3,410 tons of scrap, or 8.4 KM per Ton. These facts are only from the operations of the biggest Scrap Yard, *Patio Guadalupe*. Other factors included are the driving habits of the employees in charges of the routes and the amount of time that the truck is on but not moving. For this last variable, the trucks have a system installed that turns off the engine after 10 minutes of inactivity. For routing, the drivers only use empirical information, and they don't rely on a previously selected optimal route. All trucks are monitored in real time by a software called *Geotab* which gives the current location of the vehicle. The fleet makes about 36.2 daily trips, for which some are called *Fake Trips*, that happen anytime a provider schedules a trip, claiming he has filled the crate entirely, but when the driver arrives, he notices that it is not entirely full, and therefore the driver needs to return to the scrap yard without the material, or continue with the rest of the daily schedule. These *Fake Trips* represent a full trip of logistic cost which will be attributed to the company and not the provider, so it represents money loss, and happen about once per week, although there's no actual record of which provider made it.

3.3.5   Scrap Yards

The company for which this case study is being made has three different scrap yards distributed throughout the city of Monterrey, Mexico. Each one of them has a different capacity and process different types of scrap. The biggest one, called *Patio Guadalupe*, is where about 70% of the operations are held. This paper will focus on the biggest scrap yard, although the solutions will be developed with the scalability to apply them in the other scrap yards in the city and the country, since the company also has X more scrap yards that use the same inhouse logistics operation.

3.3.6   Maintenance and Workforce

Maintenance for the trucks is given either by the car company if the warranty is still valid, or in an inhouse workshop. The trucks receive maintenance each 12,000 kilometers or each six months, whichever comes first, although this rarely happens because of the moderate usage that each one gets. The monthly average maintenance cost is directly affected by the number of kilometers driven, and the balancing of the workload for each unit in the fleet. The workforce cost is composed of the monthly salaries that the drivers receive.

3.3.7   Providers

The company has 67 active providers as of August of 2018, which was the time where this section of the methodology was made. These 67 providers were in a total of 90 different locations all around the city of Monterrey and its surroundings. There are locations that request as much as 15 weekly trips and other ones with just a trip once per month. Out of the 90 locations, 27 belong to *Industries*, and 63 belong to *Collectors.* Information about each of these providers was scarce or distributed in different databases. Because of this, a homogenized database was made to better conduct the study. This was created with the help of five different database documents, interviews with the personnel, and a focus group with seven drivers. This last focus group revealed detailed information about several conditions and restrictions for certain providers. These include features like the escort of a custodian, unpropper facilities that hinder the driver's capabilities to perform the task or that may damage the truck. Others include, double weighing, double trip, or restrictions based on scheduling conflicts. 43% of the total locations contain at least one restriction or condition.

3.4   Analyze

Within this stage, what is sought is to make an analysis with all the information provided by the company to be able to find the possible root causes of the problem established during the project's early stages. It is also determined with the analysis if there is another problem which can be detected and further solved for the benefit of the project. An analysis about the two types of provider, *industry* and *collector,* was made. The comparison between these two providers has an impact on the logistic and purchase cost, the amount of restrictions that a provider may have or impose, the traveling distance and the tons per trip. The main variables that stand out are that in the case are the costs, for which the industry has a cheaper logistic cost per ton and in the case of collector, the purchase cost per ton less than its counterpart, having a 4.1% cheaper cost per trip. So, the conclusion from this analysis is that making collection trips from a *collector* is more convenient for the company.

After a complete analysis and investigation, it was possible to create a relationship diagram based on the *Ishikawa Diagram Model*, which allows us to observe the main root causes of the project and can then be observed through the relationship diagram. "Identifies many possible causes for an effect or problem. It can be used to structure a brainstorming session." Ishikawa, K (1986). The diagram started with the main variables of the case: Purchase cost and logistic cost. From there, the variables were broken down to their own components and then to the actual problems found for each. The following step was to question the root of each problem until the root cause could be found for each one. Thus, the analysis concluded were summarized in two main root causes: First, the lack of a specialized software or tool for handling the logistic operation and second, a reinforcement in the provider selection and commercial strategy.

3.5   Model

After finding the proper root causes, the next step is to model a possible solution or solutions for each one. The following are the three main solutions that will be developed in chapter 6. *Develop*. In total there were six proposals, however, chapter 5. *Prioritize,* will explain the reasons of why these were discarded.

3.5.1   Transportation Management System
The root cause that has an impact in the most problems is the lack of a specialized software or tool for handling the logistic operation, for better keeping track of the trip records, having real performance indicators in real time and thus have better decision-making fundamentals for improvement. This root cause is solved with the implementation of a Transportation Management System, or TMS for short, for managing the day to day operations.

3.5.2   Provider Prioritization
There are several factors that affect the actual cost that each provider brings to the company. These are distance, wait time, purchase cost, scrap quality, ton load per trip, fake trips, damage risk to truck. But there are also variables that measure the behavior that the provider has towards the company. These are congruency in the type of scrap delivered, demand, number of trips, ton load per trip, and seniority. If individually measured, these factors and with the appropriate decision-making process, savings can be made, and problems can be averted. With this in mind, the provider prioritization model will help to grade every single provider with their real performance so that the provider portfolio is better constructed, and savings can be made. These solutions attack the root problem found that consists in a reinforcement in the provider selection and commercial strategy.

3.5.3   Scrap Collecting App.
In order to also address the root cause involving the reinforcement in the provider selection and commercial strategy. This focus on the development of the functional and conceptual design of an application based on the collaborative economy model used by enterprises like Uber and Airbnb. This application focuses on the development of type F providers, so that they can have another tool for finding clients throughout the city, and then bring and sell all the scrap collected, either by means of the application or by themselves. This solution seeks to increase the collection capacity of the company and decreasing the purchase and logistic costs that would have been needed to be spent if this scrap was collected by their own fleet.

3.6   Prioritize

Once the root causes are identified and solutions were generated, the decision was made to prioritize these solutions so that when carried out, the flow of the process will be constantly improved. This was done due to the fact if a

solution works in the best way possible, the others also must be applied and working correctly, by aiming all applied solutions toward the same goal. Together with the client, a prioritization matrix was developed, this matrix is used by the company and consists of two axes: effort (Y) and impact (X), where the effort is measured in a matter of time and money invested and the impact in the reduction of time that each solution will have. The company use this matrix to prioritize the solutions for a project that is going to be developed. The matrix is sustained by a methodology of baseball and uses these terms for every quadrant. The matrix below represents the six possible solutions that were established at the beginning and that with the research and analysis of the information is that by the help of a brainstorming these solutions emerged. There are four quadrants, *Quick Hit, Strike, Long Hit & Home Run.* The best option is the lower left quadrant named Home Run, and this is because of the big impact it has and the low effort that it takes. And so, unlike this, the worst option it's the upper left quadrant where it belongs to a Strike
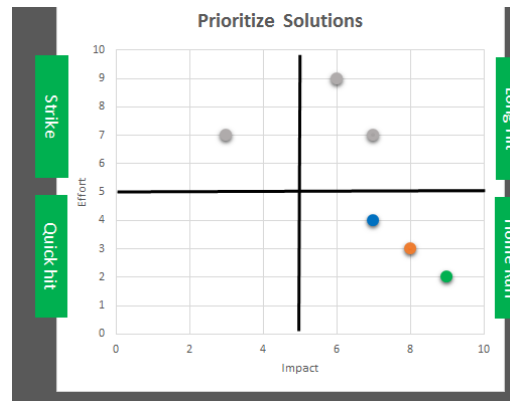

Figure 3. Prioritization results

On figure 3 you can see how the quadrant of Home Run is the best positioned with three solutions within it, which comply with the variables of impact and effort, this means that they are the solutions that best adapt to the project and can be develop in order to meet the expectations of the project.

4   Develop

4.3   Transportation Management System

Processes need to be standardized, and technology is key for achieving and ensuring this standardization. Managing manually the day to day operations can be a tedious job, since information may not be kept neither in order, nor in the same place, so keeping track of trips, accidents and indicators can be tough. A transportation management system is a solid solution that has been applied by leading industries to optimize their operations. For this case study, several different providers of TMS softwares, Mexican and international, were compared in order to make a solid decision that will better adapt to the needs of the company at hand. The main features that were searched for were: semi-automatic trips scheduling, on route monitoring, route planning and optimal suggestions, cloud syncing, syncing with the company's own scrap yards operations software, route and schedule viewer app for drivers with an attachment feature for reporting incidents, and trip customization so specifics that are key to the operation can be recorded and measured. The team selected a Mexican startup that provided the features needed for the operation at a lower cost. This, together with the fact that the response time from the customer service and the flexibility in the configuration of their technological modules, were key for the selection process; also, the company in study had strong confidence in supporting and boosting Mexican startups.

Apart from the operational features, it was important that the TMS included features that would help improve the decision-making process inside the collection system. The selected TMS included a Control Tower module, specifically created for measuring the Key Performance Indicators from the logistics operations. These are: the amount of trips made, collected tons, *Fake Trips*, kilometers covered, kilometers per liter driven and time spent in scrap yards, providers and on route. All of this from the point of view of the driver, vehicle or the operation as a whole.

4.4   Provider Prioritization

This solution is based in a study about the performance about each scrap provider, to measure how cost-effective the act of the collection is for each, and how well do they behave; considering specific variables that help measure each criteria. This solution is aimed for the scrap buying employees, so that they can have information to better take decisions for whom to buy scrap from.] The provider prioritization list is to be used in a monthly periodicity, so that the provider portfolio can organically improve, and overall costs can be decreased.

In order to develop the model, each variable needed a ponderation value to best describe the impact each one has on the final prioritization result. The developing process consisted in three main steps: Weighing the variables, evaluating the real results based on dynamic scales, and the development of the model together with the final display of results. The methodology used for weighing the variables was Analytic Hierarchy Process, created by Thomas Saaty in the 1970s. This process is utilized for assigning hierarchies to different criterias and variables to best choose an alternative. For this case study's purpose, AHP will be used until a weight is determined for each variable, since this solution focuses on prioritizing providers for further choosing, and not the selection of only one of them. First, a series of nine different variables where created and then assigned to their respective criteria so that a hierarchy diagram can be produced as shown in figure 4. (Vargas, 2010).
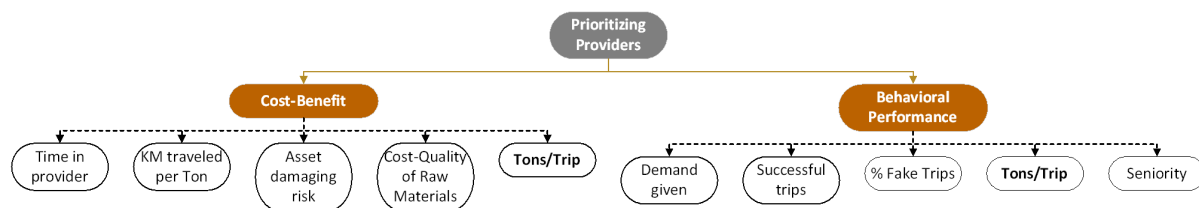

Figure 4. Hierarchy diagram

Once the diagram is finished, a matrix table needs to be made for the criteria and another for all the variables per criteria, so that each variable can be evaluated against each other by using the Saaty scale, which measures the importance that each variable has, and it needs to be answered by the key players that know best about the system under study. The three matrices were needed to follow the following example shown in table 1.

Table 1. AHP matrix example

Example	Criteria 1	Criteria 2	Criteria 3
Criteria 1	1	x	y
Criteria 2	1/x	1	z
Criteria 3	1/y	1/z	1

Once the results are in, an average needs to be made for each individual response, for further numerical processing. For example, an average for all responses of Criteria one versus Criteria two, another for Criteria one with Criteria three and so forth. This process needs to be made for the results of the criteria and the variables in criteria one and two, having as a result a new matrix for each. Once the results are in, a normalization process needs to be made in order to come up with a preliminary vector for each variable and criteria. This is made with the values of each average previously made, divided by the sum of its respective column. If done correctly, the results need to sum one for each column.

After the normalization, a new average needs to be made. Unlike the normalization process, this average needs to be made by variable by considering only the values in their respective row. For example, for *Average time in provider,* the average is made with the numbers *0.063, 0.302, 0.197, 0.143* and *0.046,* resulting in an average of 0.150. This process is repeated for all variables and criteria for further plotting in the hierarchy diagram as shown in the following image. And again, if all calculations are correct, all variable from each criteria needs to sum one. The last step of the process needed for this project is to multiply the coefficient from the criteria to each of its variable. This result in the final values for each variable that will be used in the prioritization model. Tables 2 and 3 show the average results for each variable, together with their respective final weights.

Tables 2 and 3. Final weighing results per variable

Weighing Final Values (Criteria: Cost-Benefit)		
Variable	Average	Final weight
Tons/trip*	0.326	0.225
Cost-Quality of Raw Material	0.190	0.131
KM traveled by Ton	0.189	0.131
Asset damaging risk	0.145	0.100
Time in provider	0.150	0.104

Weighing Final Values (Criteria: Behavioural performance)		
Variable	Average	Final weight
Confiability	0.234	0.072
Demand given	0.191	0.059
Tons/trip*	0.184	0.057
% Fake trips	0.144	0.044
Successful trips	0.139	0.043
Seniority	0.110	0.034
* Max value taken from criteria: Cost-Benefit		

Once the weighing process is made, the database for the scrap collecting trips was used to create a dynamic scale for each variable. The scales were made by following the methodology for creating histograms. A lock for only five intervals was set, where depending by factors like, sample size, range, and amplitude, an evaluation could be made, that would not only set a value to each variable but adjust scales every time new data is fed to the model. The amplitude is defined by dividing the range (maximum value in the sample minus the minimum value) by the number of intervals. The unit of measure is set so that all possible values, including the minimum, can fit in the scale, since this unit is then divided by two so that the inferior limit can be set. The ranges from the first limit, to the maximum value plus the unit divided by two and each interval is set up by adding the amplitude to each inferior limit (Putler, 2018).

Table 4 and 5. Scale example

Monthly Average of trips (Last 4 months)	
N	62.0
Range	193.5
Intervals	5.0
Amplitude	39.0
U	1.0
U/2	0.5
Li1	-0.5

Monthly Average of trips (Last 4 months)			
k	Li	Ls	Value
1	(0.50)	38.50	1
2	38.50	77.50	2
3	77.50	116.50	3
4	116.50	155.50	4
5	155.50	194.50	5

Table 4 shows an example of the calculations made for each variable in order to create the final scale (table 9). Once the process is done for each one, the next step is to evaluate each provider for all variables using these scales. After the evaluation is made, the results need to be multiplied by their respective weighting results that came up from AHP. Once the multiplication for all variables is made, the sum of it will become the final grade that each provider will get. This grade will determine the order in which employees in charge of buying scrap for further collection will call for setting up trips until the demand of the month is satisfied. An example showing only the top five providers is shown in the table below.

Table 6. Prioritization model results summary

Position	Provider	Grade	Tons/Trip (Last 4 trips)	Historic Tons/trip	Raw Material Confiability	Distance traveled per ton (KMs)	Purchase Cost per Ton	Average quality
1	* - MARTHA VERONICA OVIEDO POSADA	3.06	15.32	11.46	0%	1.9	$ 5,392.33	2.00
2	* - RAQUEL CASTILLO GONZALEZ	2.80	11.42	11.42	0%	1.9	$ 5,617.14	1.00
3	* - METALES FRAGMENTUM SA DE CV	2.79	3.40	3.58	0%	4.7	$ 5,338.63	2.00
4	* - FERNANDO GABRIEL CERVANTES ARTUZA	2.79	11.06	7.45	0%	6.9	$ 5,417.50	2.00
5	* - ROLANDO TELLEZ SALAZAR	2.68	7.11	7.11	0%	10.0	$ 4,648.33	4.00

The table 6 includes general information about the provider, the grade, and the top five variables that need to be shown in the main view, so that buyers can make better business decisions. The top five variables where selected from the AHP results.

4.5   Scrap Collecting App.

In order to determine if the solution of the application was feasible to be carried out, the information provided by the company was considered. A small market study was carried out by themselves and with the support of their own

research, it was possible to find the best way to present and develop this solution. The application seeks to intercept the chain of purchase that is currently available, where the main function of the application is to obtain the material at a cheaper price than the price it currently achieves. This application is aimed at anyone who wants to get rid of scrap or want to sell it. The logistic operation is carried out by collectors who have nothing to do with the company, and so the company diverts costs and new and strong investments such as new personnel and transport units. Likewise, the company does not have to decide on what type of transport or unit is convenient to go out to collect scrap. This idea or solution is based on the cooperative business model, which is the vast majority of service applications today, such as Uber, Airbnb and Booking. Also, there are benefits for the three parties involved within the project.

For this solution, it is necessary to mention that the agreement that was stipulated on this application, is not the development of a functional prototype, but the base and preparation of how to develop the application. all the necessary for the TI department so they just adapt it to their system and type all the algorithms That is why the deliverables are the explanatory manuals of the operation and operation of the tool and the design through illustrations of how the application would look. Therefore, it was created a standard operating procedure for the persons in charge of developing this application.

5   Prepare

In this stage what happens is the pilot tests of the solutions, during this stage the three solutions are prepared for the future implementation. For the TMS and the Provider Prioritization solutions, a pilot test was made, for the Scrap Collecting App, further design of concepts and functions were made by focus groups with the objective on improving the processes behind the app's core.

One important feature needed in the TMS, was the ability to serve as a database so that the Provider Prioritization solution can be feasible. While in the negotiating sessions with the TMS provider, the Provider Prioritization solution was included inside of it, so that it updates automatically without the need of an employee, assuring its continuous use and impact to the company. The previously formulated excel with the semi-automatic model for prioritization was given and thoroughly explained to the TMS provider for its successful implementation. Regarding the TMS, the pilot tests were implemented in *Patio Guadalupe,* with four drivers of confidence and were trained with the necessary equipment to carry out the pilot tests. The first requirement needed so that the pilot test could proceed, was that the drivers had an Android smartphone. A training session was held where all the basic and necessary aspects of the application for the drivers were explained, as well as an explanation of the TMS platform that was developed by the company. This training lasted two days and was performed with the help of some videos, brochures, and personal trainee to the drivers. This proceeded to a weeklong pilot test were, the logistic planners and four drivers continued to use the full features of the TMS and its applications. The pilot tests feedback was a good experience for all the person that were involved. They look excited and positive for the development for this solution. The best part was that they didn't show some resistance. They gave some feedback about which changes can be made for a better operation and some terms in the application that can be kind of confusing for them.

6   Implement

The last step of the methodology is to implement the previously prepared solutions for permanent use inside the company at hand. Thanks to negotiating efforts, the provider prioritization was fully integrated with the TMS. This gives several benefits: First, it removes human interaction with the update process for the list, so it helps assuring its full availability and completeness. The main benefits from the solution are the reduction of logistic costs by selecting the providers that better behave and have the most cost-effective qualities for a smooth operation. This solution ensures traceability for each provider that will organically better the provider portfolio based on real performance. This solution also provides a more precise way to calculate the personalized logistic cost that will be charged to each provider. A user's manual was given to the owners of the solution so that they learn how was it made, how to update it and how to use it.

The TMS brought order to the scrap collecting operation by allowing the company to trace each and every single trip made, monitor their trucks, having a more efficient scheduling tool, providing drivers with an application that shows them a suggested route, their daily agenda and a feature to record evidence from any possible event or accident that may happen while on a trip. The TMS centralized the operation's data, by gathering historical information, asset inventories and providers' profiles, all in one place. With these, key performance indicators can be created and

studied for the complete operation, or even by truck, driver or provider, helping have a better foundation for the decision-making process. The TMS provider oversaw the training sessions and the personalization of the software; this lasted a one month and a half.

For the scrap collecting app, a complete functional and conceptual manual was finished that includes the communication diagram of the process, a description of all processes, functions, modules and profiles. A simulation of all the possible functions and interactions was made specifically for the development team and to better show the correct behavior and functioning of the application. With this, the development team started the project to code the application and begin testing.

7   Results

7.3   TMS

The results from the solutions developed for this project were totally satisfactory, and as expected. For the first solution the TMS, the result was favorable and positive for the company. After the pilot tests and all the information dropped with its analysis, the results were as follow. The TMS had an impact on the logistics costs that made savings of 4% per ton. All this thanks to the tracking and better decision making in which route should take, the more agile way of planning and the tools given to the drivers to serve as assistants in daily operations. Although, the solution had a cost, so the final ratio of savings was of 0.82% during the first year, and then 1.98% afterwards. The reason behind this comes from the financial plan Suit as a Service, where the implementation costs are spread throughout the first year, and when completely covered, the monthly payments diminish.

7.4   Provider Prioritization

Apart from other benefits as, a better cost-quality collection of scrap, the diminishing of wait time with the provider and a portfolio with providers with a better behavioral performance, the prioritization solution provided the most impact in the kilometers traveled by ton because of two factors: the top variables that were weighted with AHP were Tons per Trip and Kilometers per Ton, Together, the variables made a more efficient portfolio (Tons per trip improved by 8.7%).

	Month 0	Month 1	Month 2	Month 3	Month 4
Real KM/Ton progress*	8.71	8.23	7.41	6.96	6.32
List incorporation progress	0%	20%	55%	73%	100%
Reduction of KM	0.0%	5.5%	15.0%	20.1%	27.4%
Savings to the logistics cost	0.0%	2.4%	6.6%	8.8%	12.0%
Considers the 8% deficit that the top of the list can not provide					

Table 11. Prioritization Solution Results

The table 11 shows the progress and the impact that the solution had on the total logistics cost. This progress took about four months because of the nature of the industry, since the provider rotation is slow but constant, and the company depends on certain compromises and also on the providers having a new collection trip to that provider that the list shows as inefficient, so that the company can pick up their collection boxes in a trip that is cost effective, and not make a trip for an empty box.

7.5   Scrap Collecting App

Since this solution's development objective is to deliver a conceptual and functional design, a Return of Investment simulation was done with four different scenarios in mind: An optimist (8% growth rate with 10% extra collection capacity), good (5%,5%), normal (5%,3%), and a bad (3%, 1%). The optimist and the good ones also considered an average purchase point higher than the normal and the bad (4.9% higher). The simulation considers constant purchase and logistic costs per ton, measured in savings (not corporate utility) generated by using the app instead of the Roll Off operation for collecting the extra scrap. The simulation considers the wages from the developers during the initial stages and the subsequent months were a specific operator needs to oversee maintaining the app, fixing bugs and launching updates.
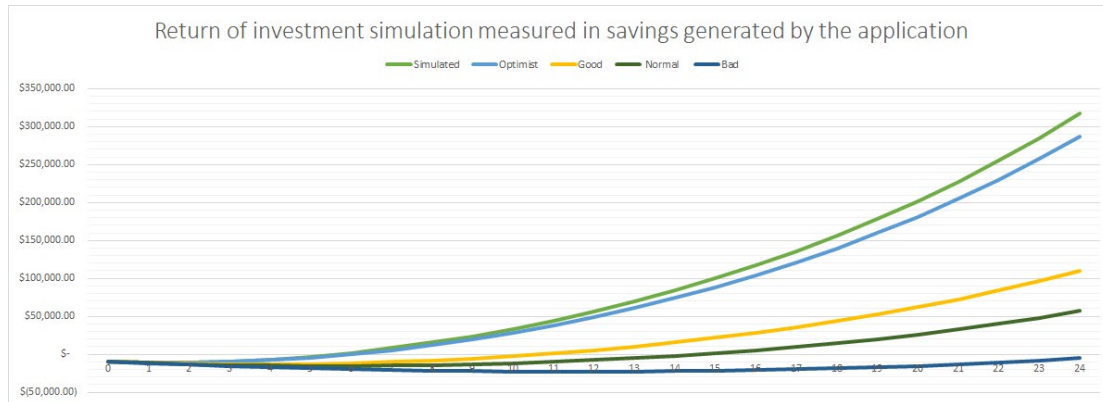
Figure 7. ROI simulation results

The figure 7 shows that the results were promising, considering that the best three scenarios had a ROI before the course of two years. The final ROI rates for two years of operations were: Optimist (3,031%), Good (1,165%), Normal (602%) and for the Bad scenario (-49%). This highly volatile rates are caused by the low development costs of the application, since it will be done by in house developers from the company in study.

Together the solutions provided a reduction of 13.32% the first year and later of 14.48% off the logistics cost and of 27.4% in the number of kilometers traveled. The Scrap Collecting App will also provide savings, as its scenario simulation showed, but these results are not taking directly into consideration for the reduction of logistic cost, since this affects mainly the purchase cost and the extra capacity that the company will be able to collect. The savings in cost logistics are measured in this solution, but this is an opportunity saving since, now these additional scrap tons won't require the Roll Off truck operations.

8   Conclusions

As conclusions of the project it can be observed that the results were positive and satisfactory for the company, the expected and the additional ones. There was a quite complex and interesting development which during this time it was possible to observe how interesting it was to carry out this project, in addition to all the knowledge acquired and put into development on our part. Although the project had a different approach at first, after the analysis and what was discovered as it was progressing is that you can conclude and observe that the company feels satisfied and happy with the work that has been done. The time invested, and the tools used were many, in addition to the interaction and communication with the staff of the company. The treatment and experience within the company was quite positive and has helped that the knowledge acquired and applied during this time in the project are very useful for the future that is coming. So much so that the same company has approached to make an offer on job offers to be able to give continuity to the project.

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