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Logistical Analysis for XYZ Corporation: Phase 1 Report

1. Problem Statement

A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of finished products to customers. Supply Chain Management (SCM) is the process of planning and management of materials, information and financial flow in a network consisting of manufacturers, distributors, suppliers and customers with the objective of reducing the costs, increasing the business and improving the customer service.[1] In this scenario, XYZ Corporation is a new, rapid-delivery transportation services provider. Similarly to the services offered by Amazon Prime Now, XYZ Corporation has been established to subcontract with large retail, online, and e-commerce companies to provide customers one-hour package delivery.

XYZ Corporation has seeked out the help of a third-party in efforts to set-up the end phase of their supply chain management. The end phase consists of the process of getting the order from the distribution center to the customers' shipping address. This end phase of the supply chain consists of three sub-phases:

1. Picking: Finding and selecting the ordered items from all items available in the distribution center
2. Packing: after selecting all items included in the order, XYZ must ensure that the items are put into proper packaging and labeled correctly for shipment
3. Delivery: lastly, XYZ takes the packaged items from the distribution center to the shipping address as provided by the customer upon the placement of their order

[1] http://lcm.csa.iisc.ernet.in/scm/supply_chain_intro.html

For this analysis, it is assumed that XYZ Corporation has already established and perfected sub-phase 1 and 2 of the process of getting the items from distribution center to customer (also known as the last-touch interaction). With the picking and packing steps using 40-minutes of the allotted one-hour delivery, that leaves us with 20-minutes of the total delivery time left to advise XYZ in. 20-minutes out of the entire logistical network may not sound like much, but it can be make-it-or-break-it when dealing with a logistical network. As GIS Analysts, this gives us a very specific focus consisting of the end phase of that one-hour delivery; taking the **packed** shipment **from the distribution center to the customer's address**. Since XYZ currently has zero leased space in the DFW market, our goal is to be advise XYZ on how to be as strategic as possible in the placement of each proposed distribution center within this very large market. A large chunk of that strategy would consist of identifying areas where these distribution centers would best serve the people likely to need this one-hour delivery service within Denton, Dallas, Tarrant, and Collin County. The delivery portion in logistics plays a huge part in the system - as it can be very costly if not planned out methodically. Having a poorly set up logistical network could not only increase transportation costs, but it could cause the entire company to fail if this last phase of the network does not meet that one-hour criteria. What good is an overall excellent logistical network if the last step of that network causes the entire operation to crumble? Not meeting that one-hour delivery time frame could be that one thing that causes the end of XYZ (or any delivery service) if not planned out with specific goals, best-case-scenarios, and worst-case-scenarios in mind. The goals laid out below will address how all of these factors will be individually assessed at each phase of the analysis.

2. <u>Specific Goals for Analysis</u>

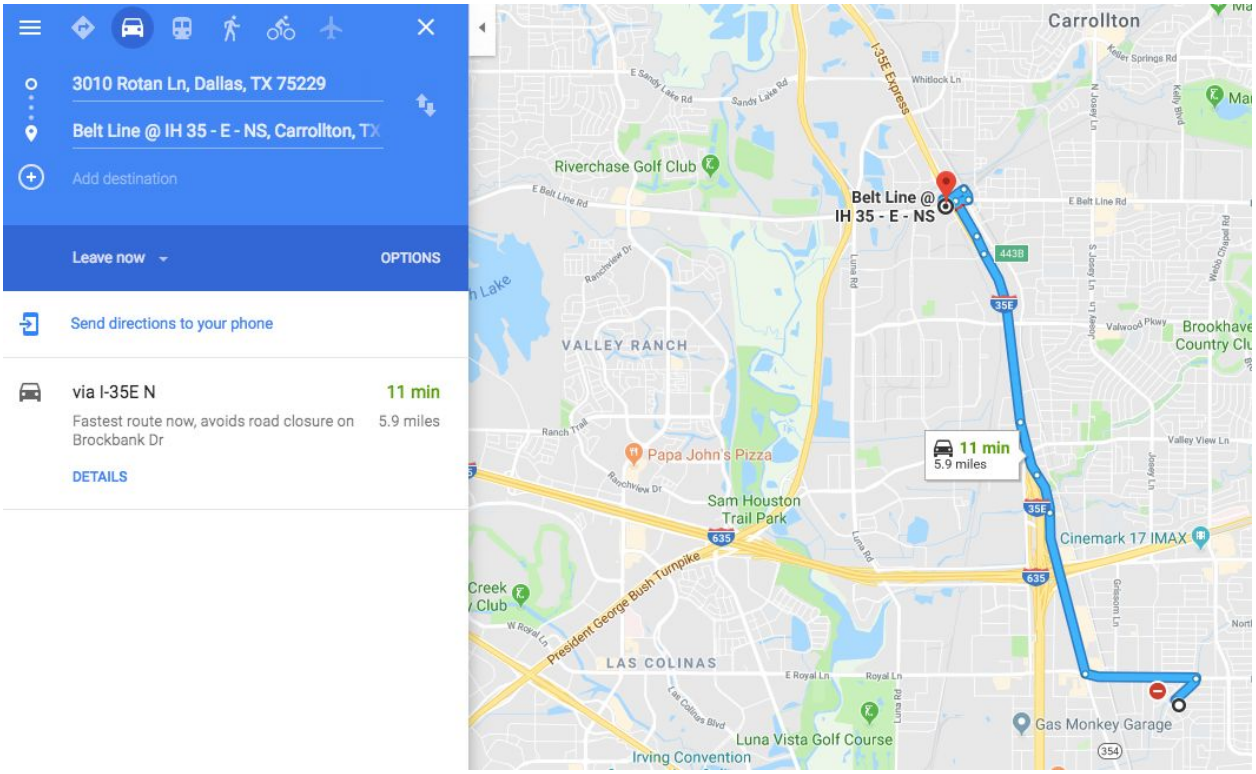
As mentioned in the problem statement, a logistics network consists of suppliers, warehouses, distribution centers, retail outlets, as well as raw materials, work-in-process inventory, and finished goods that flow between the different facilities which are part of the network. The particular focus in this logistical analysis lies at the end phase of this system; the process of taking the product from distribution center and delivering to the customer. Key strategic decisions pertaining to this final, but imperative, part of the logistical network followed to determine the best, most strategic, logistical network for XYZ include:

- Determining the optimal number of warehouses. Ideally, we'd keep it under 5 total distribution centers for the entire metroplex. Each distribution center has a cost affiliated with it, so it is important to not just get carried away with how much coverage having 5 distribution centers would provide. It's important to keep an eye on the amount of coverage both spatially and

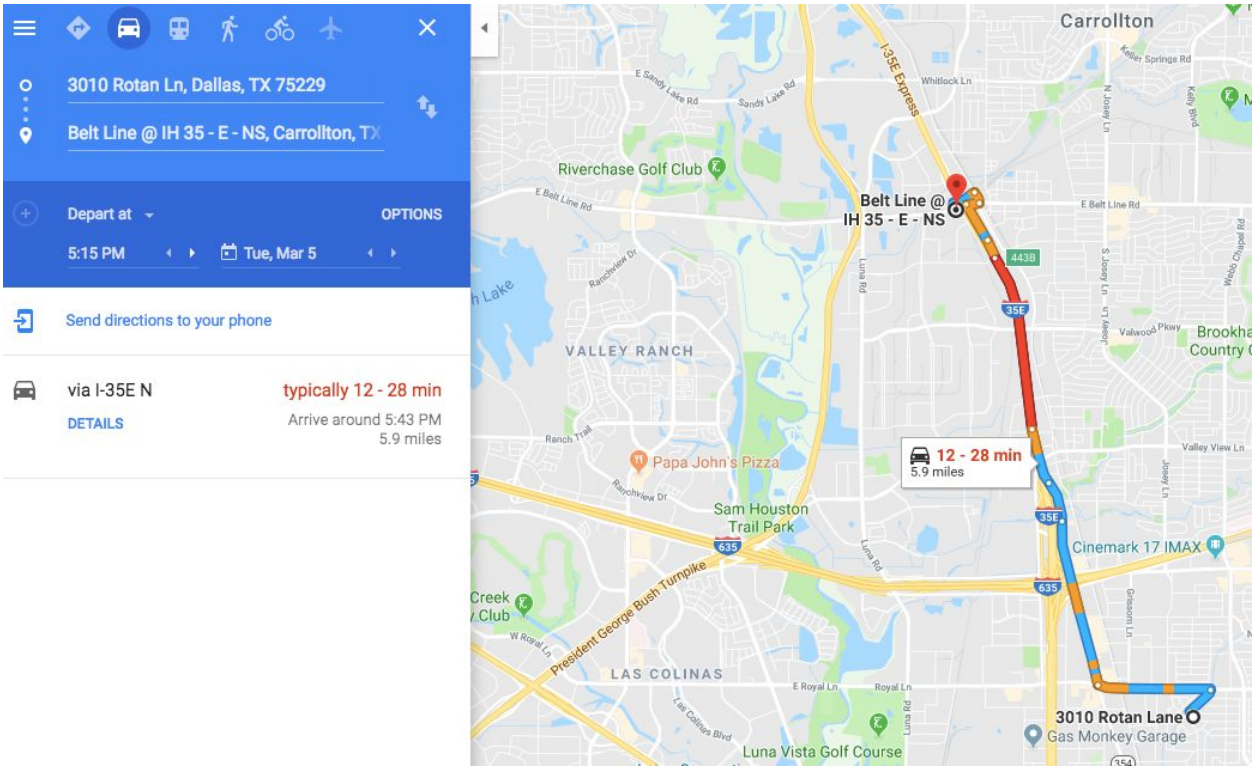
population-wise each distribution center provides in order to justify the existence of each one.

- Determining the location of each warehouse. Each distribution center should be located not only in an area that has a highway network nearby, but the specific building should also have **quick and easy access** to the near-most highway in order to maximize the use of the narrow 20-minute delivery window. This will be important both in choosing an area and when narrowing down to a specific building or site.
- Determining the size of each warehouse.
    - +/-50,000 square feet (SF) for each distribution center facility
        - Amazon has fulfillment centers ranging anywhere from 100,000 to 500,000 to 1,000,000 square feet
        - Amazon has sortation centers ranging from 100,000 to 500,000 square feet
        - Amazon has delivery stations as small as 60,000 to 100,000 square feet*

    * This is all to say that the size of each distribution center will not be prioritized by its individual size, but by the effectiveness of the total amount of square footage in all of the distribution centers combined. For example, if we have 3 distribution centers that are in total, a combined 200,000 square feet, preference will not be given to this method over having 5 distribution centers totaling 200,000 square feet. The logic behind the preference would defer to the effectiveness of the total accessibility and coverage provided by the total proposed network.
- Determining the best routes for a vehicle in a transportation network.
        - It is important to take note of which distribution center falls in areas with a consistent influx of traffic. This is why routes will be assessed based on best-case scenario traffic as well as worst-case scenario traffic. This could make the difference between locating on I-35 and Beltline versus I-35 and Valley View Lane if the target focus delivery area is North Dallas. For example, below, the two maps show the difference in time to reach an affluent neighborhood of Royal lane. Map A shows time at 8:28pm (usually out of business hours) versus Map B that shows peak hour traffic during 5 o’clock rush hour all starting from the same location.



Map A: Shows 11 minutes from point A to point B during normal conditions.



Map B: Shows up to 28 minutes from and to the same points seen on Map A, but during rush-hour traffic.

After answering the questions above, we will have narrowed down some of the desired physical characteristics of the distribution center buildings, a rough estimate of where to place these distribution centers, and desirable highways to locate near for quick access to many neighborhoods and towns. However, this is not the end of the search for desirable areas to place these distribution centers in. This information acts as a pre-qualification process before we judge the process of getting the product to customer. This includes factors such as:

- How much coverage does each distribution center provide within a 20-minute drive-time from each center? Coverage with best case scenario traffic (ideal conditions)? Coverage with worst case scenario traffic (rush hour traffic)?
- How much of the four counties are covered within the 20-minute total drive-time? What is the population in these coverage areas?
- Which routes will be used to provide this proposed coverage? How likely are these routes to fall under future construction projects?

Many of these questions require GIS applications and data containing demographics in order to be answered. I'll touch on how we answer these questions further down in section 3 that touches on our GIS techniques and methodologies.

Conquering the entire Dallas-Fort Worth metropolitan area with less than 5 distribution centers all within less than 20-minutes driving distance from any given point within our four focus counties is not an easy task. This is why another geographic layer has been added to the process. This layer acts as a filter to prioritize the areas into 'focus areas' where we categorize based on whether or not residents in each area are likely to have a high number of orders. Specifically, this will tell us how to place our distribution centers in order to make sure that even in the worst scenario, these areas are covered within our 20-minute deadline. A separate map will be made in Business Analyst Web App that consists of areas indicating areas that fall into the 'priority demographic'. The priority demographic consists of people who fall under a demographic that are most likely to order and need delivery services from XYZ. These demographics include, but are not limited to:

- High-income demographic
- Areas with high amount of spending in clothing
- Areas with high amount of spending in restaurants
- Areas with high luxury car ownership
- Areas with high amount of spending in travel
- Areas with high amount of spending in fitness/fitness accessories like Fitbits, Garmin watches, etc.
- Areas with a high percentage of college educated individuals

- Areas with a high percentage of people white-collar occupations

This is not an effort to exclude certain groups of people, but simply an effort to prioritize the zip codes that have residents who are most likely to become repeat customers needing one-hour delivery services from XYZ Corporation. Someone who has a high amount of spending money to use on leisurely online purchases is more likely to develop a relationship with a company who focuses on the niche service of one-hour delivery. If the goal of this relationship between the customer and business is to maintain a good track record by providing a consistent service that fulfills its promise of one-hour delivery *every time*, then the company should focus on placing themselves in the geographic locations where meeting this narrow deadline is most likely to occur and less likely to be prone to congestion (traffic) issues, unforeseen construction, etc. This is why the goal is not to exclude those who do not fit these demographics (because, afterall it is a service offered to **everyone** without a qualifying credit check or some sort of qualification filtering process) therefore the goal should be to provide an excellent delivery service to all, but since this is a logistical problem involving a very large metropolitan area, in order to make a spatial prioritization system to go by, certain demographics have to be put at the top of the lists as far as areas to make sure fall within that guaranteed one-hour total delivery time window.

An example of a priority demographic map was made and is shown below, highlighting priority demographic areas is shown below for our four counties: Denton County, Dallas County, Tarrant County, and Collin County. The four squares shaded in gray display these four counties. The areas shaded in blue in contain zip codes that fit the following demographics:

- Annual income above $80,000
- Fall in the national top 33% in the following spending categories:
    - Apparel
    - Restaurants
    - Fitness-related spending (fitness trackers, fitness watches like Fitbit, Garmin, etc)
- 33% or more own a luxury vehicle

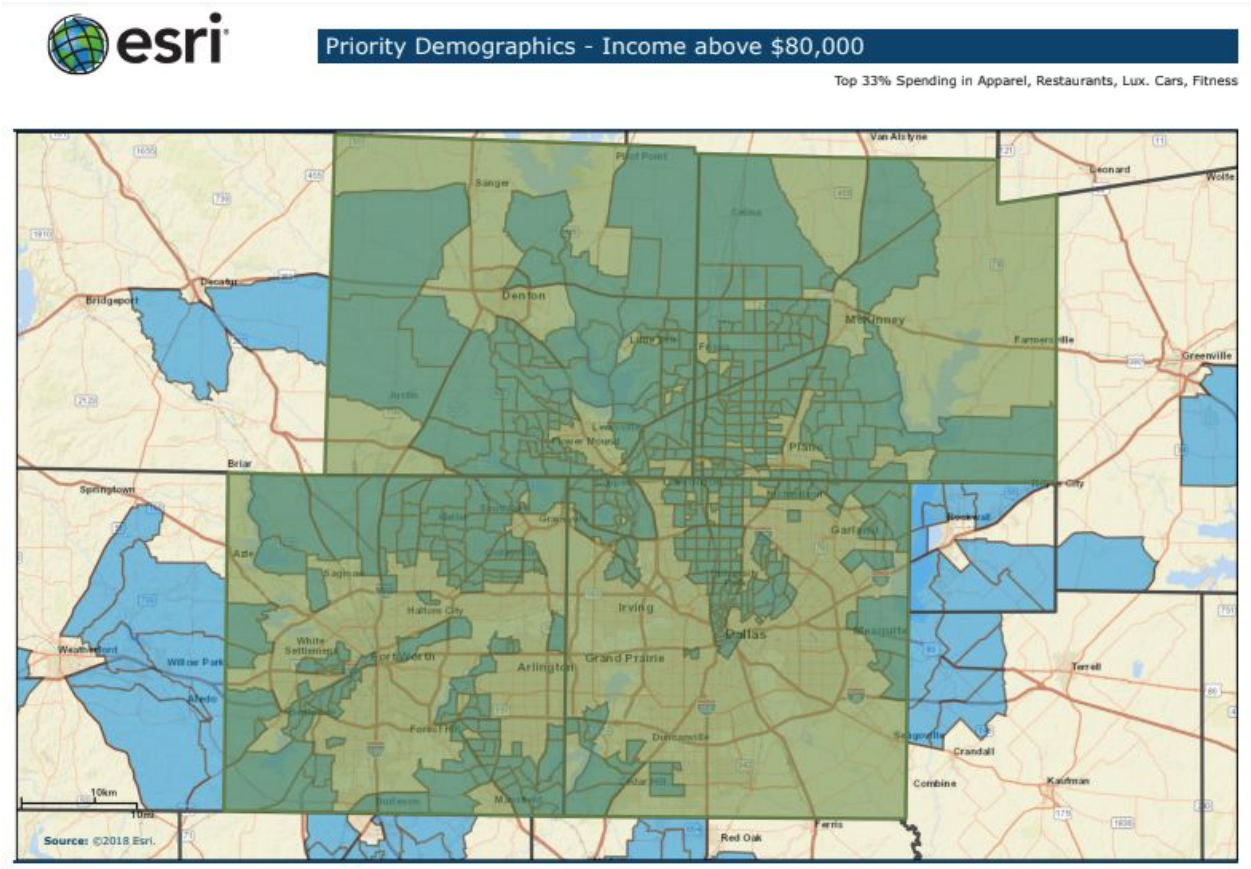


Figure 1: Priority Demographic made on Business Analyst Web App

Keep in mind this map is still being worked on. This criteria might be modified if the coverage seen within the four counties above is easily reached with two distribution centers or if more population information that seems fit for this analysis is found. Although this is still in its refinement process, this is a rough guide I will follow while browsing and grading potential areas and sites.

The map provides some truth obvious to someone familiar with the DFW metroplex. As seen on Figure 1, the zip codes immediately north of Dallas city-center are shaded in blue. Being a Dallas native, I know that these blue regions near the city center are Highland Park, Lake Highlands, and Uptown. Figure 3 below is a map produced by the Dallas Morning News displaying the "*best places for buyers for whom money is not an object*". Eleven measures of livability were calculated for each census tract in Dallas, Collin, Denton, Rockwall and parts of Tarrant counties. Scores indicate how far above or below average an area rated, and those ratings were combined according to their relative importance among those surveyed

who identified themselves as making more than $85,000 per year, the highest income group for which the poll produced statistically significant results. [2]

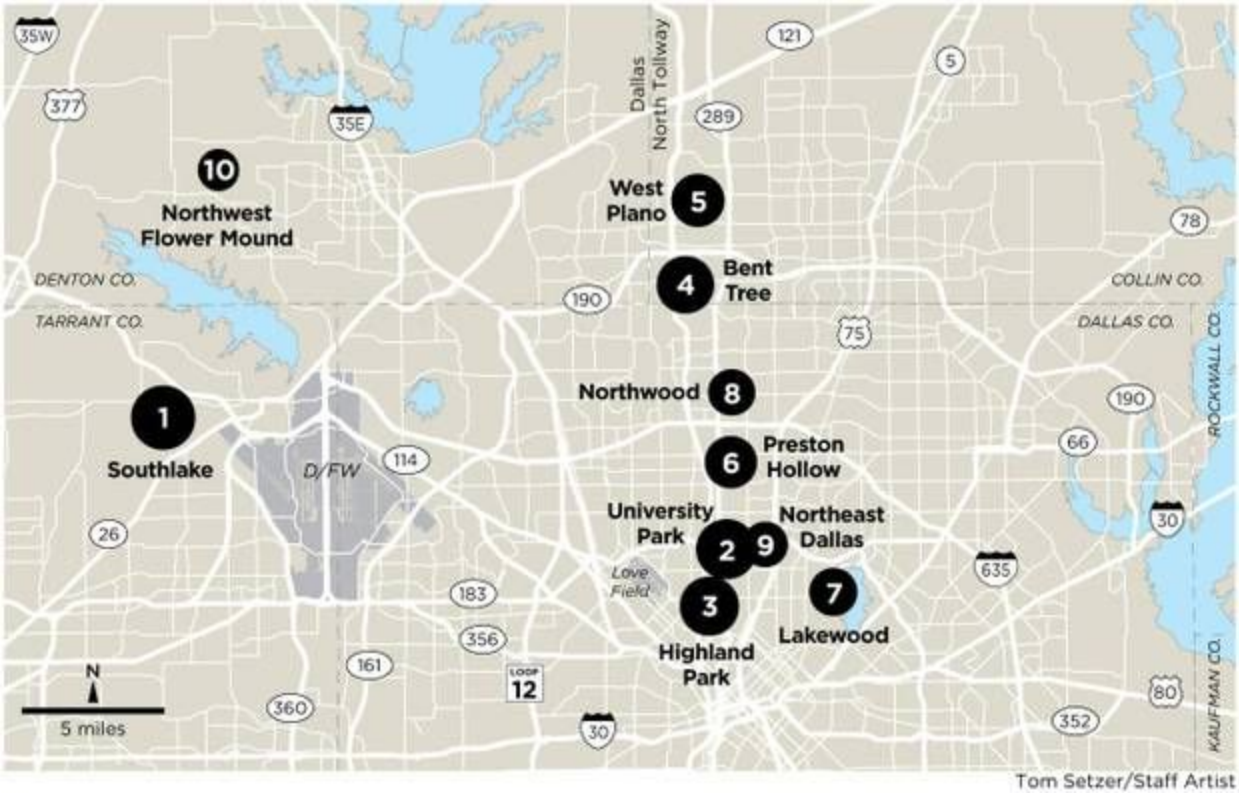


Figure 3: Best Neighborhoods: Top 10 places for wealthy Dallas-area homebuyers according to the Dallas Morning News

Using and creating maps like the two shown above in Figure 1 and 3 help display why prioritization is an important aspect of this analysis. There is no point in prioritizing areas that have low residence-levels, high-industrial areas, etc. because people will not be likely ordering from those areas. This helps us narrow down our focus in this large metropolitan area.

3. Summary of relevant GIS techniques and methodologies

In recent years, logistics distribution center location placement has become a popular research area as competition becomes more and more fierce amongst brick-and-mortar stores competing with online business. Grocery stores like Kroger and Brookshires now offer services like one-hour pickup, otherwise known as “curbside pickup” that offer customers the ability to place their grocery store order online and

[2] https://livinglargeindfw.wordpress.com/2013/05/20/best-neighborhoods-top-10-places-for-wealthy-dallas-area-homebuyers/

guaranteeing it ready within one-hour. This service also offers storefront parking to those who place orders through this one-hour service as another way to minimize the amount of time a customer has to spend at the store. This, many claim, is a way to combat the increasingly competitive market created by innovative services like Amazon Prime Now, which offer the free service of two-hour delivery for existing Amazon Prime members. Along with this, use of GIS towards superior delivery processes of business logistics is a relatively new phenomenon. More specifically, GIS has been used to answer several logistics-related business questions such as:

- What is the best route for delivery trucks?
- How should deliveries be scheduled?
- What mobile resources available are available?
- What is the best way to optimize territory?
- Where is the best site for a distribution center?
- How can the delivery vehicles be optimized to meet service goals and minimize costs?

GIS (Geographic Information Systems) can be used as a tool to map clients, distribution center locations, and routing of vehicles. A Geographic Information System (GIS) is an organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze and display many forms of geographically referenced information (ESRI, 1995).[3] GIS can also be used as a decision support for effective supply chain management. These tools ensure the flow of an efficient delivery system in order to stay quick and competitive. The route analysis tools optimize delivery routes and minimize logistics costs. With this location analysis, the goal is to provide an analysis for XYZ as a guide to choose best placement, type of building, and a time-effective method of transporting product to customers around the metroplex. I'll touch on the specific tools and criteria pertaining to that goal below.

The application of GIS in logistics distribution center location problem has a great advantage because of these kinds of tools. Since one of our main goals of this analysis is to find an effective placement of distribution centers, we will be using GIS to determine where to place these distribution centers by:

- Using Calipers 'Maptitude' to determine the type of coverage found within a 20-minute drive-time from each proposed distribution center location.
- Use Business Analyst Web App to insert the same proposed locations and perform an analysis of their drive-time reach in order to determine how

[3] ESRI. Understanding GIS: The ARC/INFO Method. ESRI; Redlands: 1990.

much coverage can be made within 20-minutes under ideal driving conditions. An example of that map is shown below:

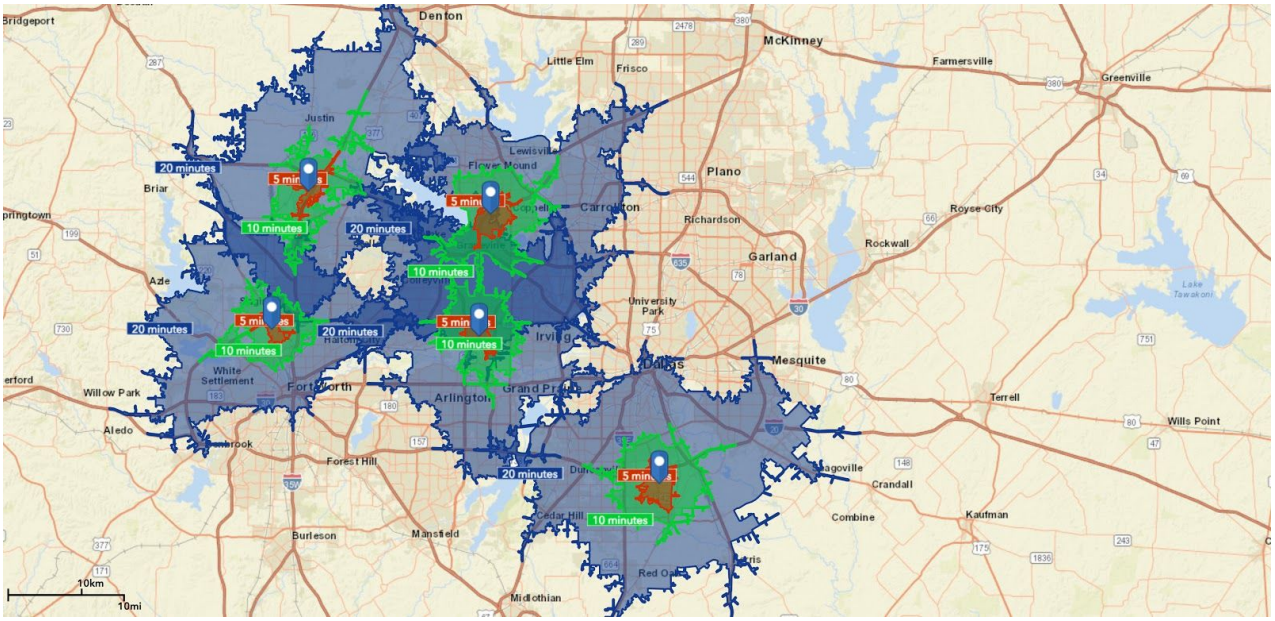


Figure 2: Drive-time Rings in Caliper's Maptitude

After using Business Analyst Web App to further determine where the priority demographic areas are, Maptitude will be used to alter the locations seen in Figure 2 to best cover the areas we find should be priority as seen in Figure 1. Clearly the role of geographical information in logistics network management can be a very innovative and useful tool for business. It is often claimed, that according to a generally believed statistic in scientific literature is that 80% of business data has a geographical element[4]. Along with that, it makes sense that geographical information systems (GIS) are becoming an increasingly important role in any area of business.

Business Analyst Web App also has a plethora of demographic data integrated into its user interface that allows us to create the priority demographic maps as shown in Figure 1. This is all spatially connected data which enforces the relevance of GIS in an issue like this.

4. Data Needs

Part of evaluating each proposed site will consist of using satellite imagery and information found on CoStar to rate each site by physical characteristics. As mentioned earlier in the goals, one of the key strategic decisions pertaining to any

[4] https://pdfs.semanticscholar.org/aca6/9107fc46a8138434715a3fda50d541dd57fa.pdf

logistics network configuration includes site selection. For example, site selection is critical for planning a real estate development project. A point system is currently the proposed way to rate each proposed site. This point system would evaluate both the area of the distribution center and the physical attributes of the specific site in question. Things factored into this point system would consist of things like the following for analyzing the proposed distribution site location **area**:

- Accessibility to highway: how fast can a delivery vehicle access highway in either direction
    - If time is under 1 minute in either direction: 10 points
    - If time is 2 minutes in either direction: 8 points
    - If time is 3 minutes in either direction: 6 points
    - If time is between 4-5 minutes in either direction: 2 points
    - If time is more than 5 minutes in either direction: 0 points
- Often times, if a distribution center is part of a multi tenant building, there could be unanticipated congestion while attempting to leave or arrive the facility if there are a large amount of other tenants arriving or leaving at the same time. This explains the grading below for a stand-alone building versus being part of a multi tenant building:
    - Stand-alone building: 10 points
    - Multi-tenant: 0 points
- Construction is often a problem to people no matter where they are located. It is a factor that most often affects traffic negatively. Although construction can only be foreseen for a certain amount of time in the near future, the idea followed below is that if there has been construction done in the past to the area, it may indicate how likely it is for that street or area to have construction again. This would be analyzed for the stretch of the main, most accessible highway near a specific area or location. For example:
    - Last construction completed 2 months ago or less: 10 points
    - Last construction completed 2-6 months ago: 9 points
    - Last construction completed 6-12 months ago: 8 points
    - Last construction completed 12-18 months ago: 7 points
    - Last construction completed 18-24 months ago: 6 points
    - Last construction completed 2-4 years ago: 4 points
    - Last construction completed more than 4 years ago: 3 points
    - No construction done in the past to account for: 0 points
        - Unless this is due to being a newly built or established road or highway, in which case the points would defer to the date of completion

- Evaluating routes. Each proposed site will also be analyzed based on both the shortest path and the fastest routes. In Maptitude, the drive-time ring tool can be used to determine both the fastest route within a given time, and the shortest distance able to be traveled in that same given time-frame. Traffic can be unforeseen and have a tremendous impact on the narrow 20-minute delivery time-frame. A route that under ideal conditions takes 10-minutes can be turned into a 30-minute nightmare at any time of day or night. Similarly, when basing distance on miles opposed to time, there is no guarantee that traffic will not stop a short 5-mile route from becoming a 40-minute route. This is why it is important to look both into the ideal conditions as well as the unfavorable. While looking at these different routes, it is important to note the complete urban road network may not be a realistic route. For example, if these routes contain tolls (adding costs to the overall logistical network) but they only save 1 minute of time, then the free route is likely the better option since that 1 minute is not a very large amount of time expected to be saved. Another advantage of using GIS for this analysis is that obstacles, which may reduce the effectiveness of analytical approximations, can be incorporated explicitly in the reduced network.[5] This explains the logic in the following point system for the worst case scenario routes and best case scenario routes. The points depend on the amount of difference made to the coverage. Since this is difficult to analyze, the specific demographic to base this off of is the total population within the coverage area. To determine the points for this, the difference of population that falls under a 20-minute drive-time with the best case scenario route and the worst case scenario route will be converted to a percentage and fall into these categories:
    - % Difference 0-.05% : 10 points
    - % Difference .05-.1% : 8 points
    - % Difference .1-.2% : 6 points
    - % Difference .2-.3% : 6 points
    - Anything above .3% gets 0 points.
- Parking:
    - All types of vehicle parking (normal car parking spots for employees, dock-loading space for 18-wheelers bringing in items, and plenty of up-front parking for delivery vehicles): 10 points
    - Normal amount of employee parking, some dock-loading space, no up-front parking for delivery vehicles: 8 points

[5] https://pdfs.semanticscholar.org/5841/cf5a366bc442415c9fdd2728696f1d0cdf25.pdf

- Light amount of employee parking, little delivery vehicle up-front parking (meaning they have to park further than 40 feet from the door) and normal 18-wheeler dock space: 5 points
- Limited parking space in general: +0 points

The data needed to complete this grading criteria will be obtained again through CoStar, openly available satellite imagery, Google Earth, Google Maps, and any available demographic data available through any GIS application such as Business Analyst Web App, Maptitude, or through shapefiles downloaded from the US Census Bureau containing demographics by zip code. Business Analyst Web App contains a high amount of data pertaining to demographics, and Esri has even made 'tapestry segments'. According to Esri, *"Tapestry segmentation provides an accurate, detailed description of America's neighborhoods—U.S. residential areas are divided into 67 distinctive segments based on their socioeconomic and demographic composition—then further classifies the segments into LifeMode and Urbanization Groups."*[6] This feature will be used when beneficial to the analysis. Examples of tapestry segmentations to be considered for use in this project are:

A) <u>LifeMode 1 Affluent Estates</u>

- Established wealth—educated, well-traveled married couples
- Accustomed to "more": less than 10% of all households, with 20% of household income
- Homeowners (almost 90%), with mortgages (65.2%)
- Married couple families with children ranging from grade school to college
- Expect quality; invest in time-saving services
- Participate actively in their communities
- Active in sports and enthusiastic travelers

B) LifeMode 3 Uptown Individuals

- Young, successful singles in the city
- Intelligent (best educated market), hard-working (highest rate of labor force participation) and averse to traditional commitments of marriage and home ownership
- Urban denizens, partial to city life, high-rise apartments and uptown neighborhoods
- Prefer credit cards over debit cards, while paying down student loans
- Green and generous to environmental, cultural and political organizations
- Internet dependent, from social connections to shopping for fashion, tracking investments, making travel arrangements, and watching television and movies
- Adventurous and open to new experiences and places

[6] https://doc.arcgis.com/en/esri-demographics/data/tapestry-segmentation.htm

These are just examples of segments that might seem appealing to XYZ to cater to, as mentioned above when mentioning priority demographics. This, combined with all the other grading criteria of both areas and buildings will make a very specifically catered map for XYZ, containing areas where these likely-buyers live, and where the best fitting distribution center sites are located. I recognize that the distribution center selection decision is not merely the question of choosing an area that appears a good candidate to focus on. It also involves a very specific comparison of the physical and spatial characteristics of a building with the overall effectiveness of the business and the network as a whole. Different buildings have different characteristics that will either benefit or detract from the system as a whole. The point system used above will help grade a specific site while the priority demographic data will indicate an area to focus on and those to detract from. The grading criteria above will be modified if needed to find the site that best fits the needs of this analysis for XYZ. None of these rough drafts are final; the demographic data, the priority demographic maps, and the point system are all bound to change as this analysis is further explored, but this serves as a general guideline to go by. Criteria could be taken off, or added, if additional research finds another dimension needed to best complete the analysis. Logistics has a spatial scale and spatial characteristics as does the nature of GIS technology and logistics technology integration. With the final analysis, the goal is to best integrate the two in order to provide the most current and innovative method of placing these distribution centers.