IOWA STATE UNIVERSITY

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Automated Guided Vehicles for Material Handling Applications

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1 Problem Statement

Problem Statement

ORBIS Corporation is a plastics manufacturer located in Monticello, Iowa. They have constructed a new 100,000 sq. ft warehouse and distribution center connected to the main plant. ORBIS wants to conduct an Automated Guided Vehicle (AGV) study to understand the benefit versus the cost of implementing this technology instead of using their current personnel on forklifts. The AGVs would travel from the stretch wrapper to the double-depth warehouse racking. Another task is to retrieve materials from storage and place it in the proper truck staging area.

This newer technology is being looked at by many companies as an option to reallocate manual labor to more complex tasks instead of material transport. When a completed return on investment report is completed, this can be applied to other businesses and their desires to implement this technology. Our proposed solution aims to provide ORBIS with a clear list of the costs versus benefits of implementing this AGV technology with an estimated Return on Investment (ROI) for multiple vendors. This return on investment shows ORBIS how the initial investment of the Automated Forklifts is absorbed by cost savings over a time period.

Business Case Statement

A. ORBIS is currently using manual labor on forklifts to conduct the task of transporting materials back and forth between the stretch wrapper and the warehouse. This currently costs them around $39 per hour. There is expressed interest in allocating this task to automation in order to save money and allow personnel to be focused on other areas of need. The personnel only work at a 50% productivity rate in forklift tasks currently. By placing AGVs in this area, their productivity will be 100% focused on the material handling task.
B. While there is not a major problem with using manual labor, there is potential for more efficiency in other areas of production if the personnel is moved away from the transporting task.
C. The Monticello, Iowa plant is a 24-hour operation. If automation was implemented for this material handling task, it would help provide consistent, valuable work at all hours of the day without breaks.
D. This problem makes sense to address because there is room to save ORBIS both time and money on the process. It would be paired with an upgraded inventory system to ensure the right materials are transported to the right place on time.
E. The plant manager at ORBIS first addressed this problem and introduced it to our group. If they are able to implement this technology for the material handling task, they could also implement it in other operations such as loading material for plastic injection or placing parts into their rack storage in the warehouse.

2 Main Objective

The main objective of this project is to find 3-4 AGVs to implement in ORBIS's new 100,000 square foot warehouse to provide the benefits vs. the costs. This will help ORBIS decide if it will be advantageous to implement the new AGVs. In doing so, we will be able to remove a tedious job where an employee sits on a forklift for a 12-hour shift to move a pallet full of materials to the new warehouse to store it. The possible improvements made by this project will be measured by finding:

- The annual savings per year in personnel-hours
- The estimated cost of capital
- Finding the path, the AGVs would travel, with distances, known as a spaghetti diagram
- Finding all capital investment options identified with full costs over a 3-year period
- All pros and cons listed, tangible and intangible

ORBIS will be able to keep these autonomous vehicles running at all times to move products from a stretch wrapper to the storage racks in the new facility and to a staging area to get ready for distribution. They will be able to better utilize the potential of the employees who were driving forklifts to do this and place them where their skills will benefit the company. Along with this, they will eliminate

the possibility of human error when placing the pallets in the wrong spot in the warehouse, which causes confusion and wastes time.

Implementing AGVs would only apply to the distribution warehouse of the company. It will help ORBIS be more efficient in the process of storing and staging materials. Also, it will eliminate human error in the process. It will not make any changes to how ORBIS manufactures its products on a day to day basis.

3 Methods/Approach

Reference Materials

- See Section 7 and the Appendix for specific references

Data collection:

Data for this project was received from multiple sources. This included the current costs of operation under the current work system, which was provided by ORBIS. Data was also collected from Associated Solutions, Dematic, and Balyo, which included price points and specifications. We used their price points and specifications to create an ROI. We also collected data on-site with representatives to ensure price points could be accurate.

Skills:

We used a collection of techniques, procedures, and skills that we learned from Industrial Technology classes. Some of the classes that provided us with the tools and references to complete the project are listed below in the Appendix under Helpful Classes.

Solutions:

After meeting with the client, we created criteria for what ORBIS was looking for. They wanted a spaghetti diagram and ROI for all AGV solutions. The solutions were measured through networking and company outreach. Some metrics that were used included: aisle width and height, load capacity, AGV battery life, worker costs, and total costs of AGVs specific to the supplier (See the Appendix for this specific data). Client input was always considered and was the primary focus of our project. As of now, our proposed solutions are consistent with the objectives and scope that was proposed.

Organization:

We communicated with the client bi-weekly at the beginning of the project. Towards the end of it, we started to communicate weekly with multiple site visits. Each week we would decide what needed to be done to meet project goals and standards. We divided out the work evenly within the group. Site visits provided us with the ability to see the lines and warehouse firsthand, so we get a better understanding of the project. They also allowed for suppliers to get a first look at the site where they could visually see any problems that could arrive with their proposed solution. Milestones for the project included in the Appendix.

4 Results

During this project, we were able to identify two suppliers, Balyo and Associated, that can provide a solution for our project. Balyo was able to provide the quickest ROI (16 months) and boasts 15 years without an accident. Safety was a top priority for our clients. Going forward, we recommend that ORBIS works with Balyo and implements its AGV system in a two-phase project. This AGV system will integrate with the existing Warehouse Management Software. The AGVs will utilize opportunity charging and come with 360-degree lidar sensors for positioning and safety.

When discussing with our client and Balyo, we decided a two-phase approach is best for this project. Phase 1 includes bringing a product from the stretch wrapper to a staging location in the

warehouse. The second phase incorporates bringing a product from the warehouse staging location and placing it into the proper storage rack for that product. This phase includes incorporation with warehouse management software, as mentioned above. This warehouse management software helps track the product location and provides live data on inventory levels.

5 Broader Opportunity Statement

In this new age of technology, automation has become commonplace in manufacturing. Technology such as AGVs has allowed for greater efficiencies and reduced costs. AGVs also have the benefit of improving workers' quality of life, making processes more ergonomic, or eliminating mundane and difficult tasks. Many companies within all corners of the industry could benefit from AGV technology. Large transportation companies, medical facilities, and airport material handling could benefit from this technology. AGVs can provide effective transportation and task completion that can be easily tracked and managed from a central location. AGVs are focused on being custom-tailored to the customer's needs. By looking into the many options, there should always be at least one that will work for the problem at hand. Other companies with AGV technology have gone about multiple ways of implementation. There are multiple ways to guide the technology around the plant, such as in-ground wiring, laser-Based Systems (our proposed method), and cloud-based guidance systems.

How much a company will spend on this technology is highly dependent on both the ROI and cost-effectiveness of the solution. If the product will payback within two years and is less expensive than using manual labor with lower risk, they will implement the technology and reallocate the manual labor to needed areas. Automation is a long-term investment that can provide short term efficiency and cost savings.

6 Graphical Abstract

An Automated Guided Vehicle (AGV) is performing a material handling task.

7 References

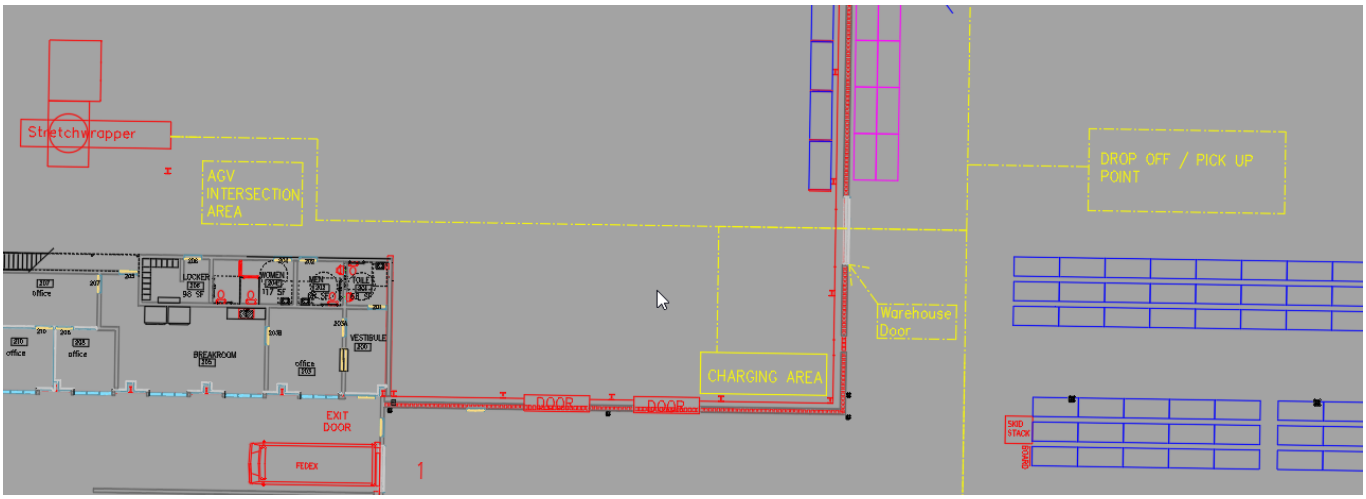
- Company Representatives
  - Associated Solutions (Doug Roth, droth@associated-solutions.com, December 11, 2019)
  - Dematic (Chase Turkstra, chase.turkstra@dematic.com, December 6, 2019)
  - Balyo (Geoff Butler, geoff.butler@Balyo.com, February 20, 2020)
- "Smart and Flexible: Automation for Intralogistics." *Automation*, 10 Dec. 2019, www.linde-mh.com/en/Solutions/Automation/.
- "AGV Manufacturers and Companies." IQS Directory, Automatic Guided Vehicles, www.iqsdirectory.com/agv/agv-2/.

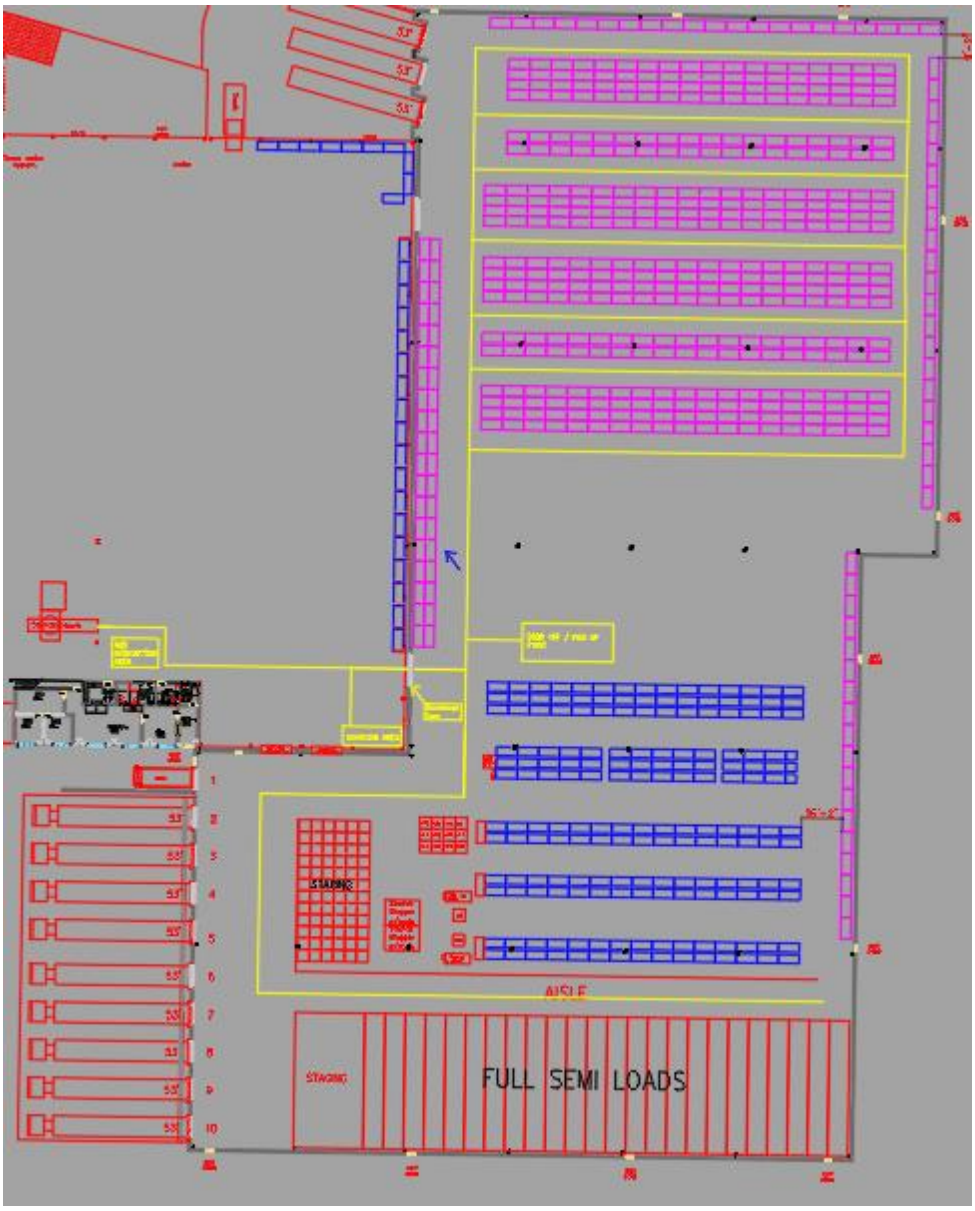
8 Appendix

- ORBIS Fixed Data:
  - Aisle Width of 10 ft of and Rack height of 28 ft
  - Maximum load of 3500 lbs.
  - AGV Battery Life to support 30-45 minutes of work per hour
  - Worker costs of $39/hour

- Relevant coursework
  - TSM 444 Facility Planning
  - TSM 465 Automated Systems
  - TSM 310 Total Quality Improvement
  - TSM 340 Advanced Automated Manufacturing Processes
  - TSM 415/416 Technology Capstone

- Spaghetti Diagram:





Above: Two top-down CAD drawings showing the path the AGV would take from the stretch wrapper (red) located on the left side of the drawing, to the warehouse located on the right side of the drawing. The yellow line demonstrates the AGV path.

- Balyo ROI Data:

BALYO

	MANUAL OPERATION	ROBOTIC OPERATION
TRUCK & ENERGY (UNIT PRICE)	$0.00	$110,000.00
NUMBER OF TRUCKS	0.5	1
Number of Hours Equipment in Use annually	5997.6	5998
Maintenance Rate Per Hour Per Truck	$1.50	$3.00
Maintenance / YEAR / Per Truck	$8,996.40	$17,992.80
NUMBER OF SHIFTS	4.2	4.2
NUMBER OF OPERATORS PER SHIFT	0.5	0
TOTAL NUMBER OF OPERATORS (MANUAL & ROBOTIC)	2.1	1
MANUAL LABOR COSTS / DRIVER (YEARLY)	$79,560.00	$0.00
One time Installation/Engineering/Peripheral Hardware	$0.00	$75,000.00

Start of Payback

15.5 Months

1.29 Years

$185,000.00 *Initial Robotic Investment*

ESTIMATED SAVINGS

$582,907.00 In Savings after 5 Years

68% **Overall Cost Reduction** without inflation

212% **Return on Overall 5 year Investment**

Cost Of Ownership

	YEARLY	CUMULATIVE	SAVINGS	YEARLY	CUMULATIVE
YEAR 1	$171,574.20	$171,574.20	-$31,418.60	$202,992.80	$202,992.80
YEAR 2	$171,574.20	$343,148.40	$122,162.80	$17,992.80	$220,985.60
YEAR 3	$171,574.20	$514,722.60	$275,744.20	$17,992.80	$238,978.40
YEAR 4	$171,574.20	$686,296.80	$429,325.60	$17,992.80	$256,971.20
YEAR 5	$171,574.20	**$857,871.00**	$582,907.00	$17,992.80	**$274,964.00**

Return on Investment data provided by Geoff Butler of Balyo demonstrating the personnel vs. AGV cost over five years.

- Reference Materials
  - Floor Layout of Warehouse and Manufacturing area
  - Associated Solutions Representative
  - Spaghetti Diagram (CAD file provided by ORBIS)
  - Dematic Representative
  - IQS Industrial directory
  - Balyo Representative

- Milestone Schedule

Milestone Performance				
Work Breakdown Structure		Summary/Measurable	Verification Date	On / Off Schedule
1.0	**Determine project needs and details**	Summary	10/18/19	ON
1.1	Face to face meeting with the client	Summary	10/18/19	ON
1.2	Layout and logistics	Summary	10/11/19	ON
2.0	**Research and Development**	ummary/Measurab	12/13/19	ON
2.1	Determining multiple applicable AGV/AMR	Measureable	11/29/19	ON
2.1.1	Cost Analysis	Measureable	12/13/19	ON
2.1.2	Company Outreach	Summary	11/15/19	ON
3.0	**AutoCAD Layout**	Summary	2/28/20	ON
3.1	Measuring distances/delivery times	Measureable	1/24/20	ON
3.2	Spaghetti diagram	Measureable	2/28/20	ON
4.0	**Project Deliverables**	Summary	Apr-20	ON
4.1.1	Draft Poster	Summary	Mar-20	ON
4.1.2	Final Poster	Summary	Apr-20	ON
4.2.1	Final Report Semester 1 Draft	Summary	Nov-20	ON
4.2.2	Final Report Semester 1	Summary	Dec-20	ON
4.3.1	Final Report Semester 2 Draft	Summary	Jan-20	ON
4.3.2	Final Report Semester 2	Summary	Apr-20	ON
4.4	Oral Presentation	Summary	Apr-20	ON

Milestones and project schedule followed by the ORBIS AGV capstone group.