Drones in Warehousing: Our Recommendations for the Apollon Company

A market research paper compiled by Wendy Obispo, Alex Lam, Allyson Ramirez-Garay, Liz Fischer, and Zacharias Beck. With a focus on different industries with drone applications for The Apollon Company.

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**Industry Summary**

**Disaster Management**

According to the article, “Emergency drones market forecast to grow at a CAGR of 13.1% between 2023-33 – Fact.MR report,” drones can help get accurate data and pictures in order to help the military. Also, the article mentions that a market study mentions that emergency sales is expected to gain market share of around 25.4% in 2023. In addition, “The global emergency drone market is projected to expand at an impressive CAGR of 13.1% and be valued at USD16,729.8 million by 2033.” Europe and North America dominated this market in 2022.

According to the article “The drone market for environmental monitoring: trends and growth opportunities,” the drone market for environmental monitoring is estimated to reach around $14.5 billion by the year 2027. The article also states that there is a growing demand for drones in the agriculture, forestry, and even the oil and gas industries. It is expected to grow at a rate of about 15% to 20% over the next few years.

In disaster management, an issue is that not all drones can fly through various weather conditions. This could be detrimental as it is faster to use a drone and less threatening to human life. Some drones also have a limited battery life which is very inconvenient for disaster situations. In disaster management, timely information is extremely important. Traditional methods of disaster management are timely. With drones, real-time data can be gathered and given to emergency responders. Oftentimes, disasters may disrupt communication. Drones could be equipped with communication technology to serve as communication hubs. Another issue with this is privacy issues as people may be more vulnerable to exploitation in disaster moments.

**Environmental Monitoring**

Multispectral imaging is one of the actions that makes drones very popular in the Environmental Monitoring and Conservation Industry. Multispectral imaging allows drones to capture various images in different bands of the electromagnetic spectrum which in turn allows for an analysis of the environment. The use of drone technology for environmental monitoring is increasing in both developing and developed countries. In developed countries, the technology is being used to supervise deforestation, land, and resources of water. While in developed countries, the technology is used to monitor the quality of air and water, as well as wildlife, and even how the land is being used. In addition, drones provide the ability to collect data on wildlife in ways that make it easier to monitor. Drones can be used to, “monitor the effects of climate change on ecosystems, as well as to detect and monitor sources of greenhouse gas emissions [and] drones can also be used to monitor the effects of climate change on human populations, such as the impact of rising sea levels on coastal communities.”

One of the biggest issues with drones in this sector is that drones may have a negative environmental impact. This is because drones can be quite noisy which could lead to disruption of different species, etc. Also, collisions can potentially damage and disrupt wildlife.

A problem in this industry is that some habitats and ecosystems may be located in areas that are dangerous or inaccessible to humans. Due to this, many of the traditional methods to collect data in areas such as these are expensive, time consuming, and can often disrupt the environment. Drones could therefore help this problem by being a way to access and monitor these areas in a cost effective way. Due to the advancement in technology, many drones are now equipped with various cameras and sensors which can help with navigating through dangerous areas. Poaching is another significant threat that wildlife conservation may go through. Poachers may appear in protected areas. It can be hard to monitor these poachers as traditional surveillance may not be enough to do so. Drones that contain technology such as thermal imaging or night vision could help with catching poachers as drones could cover areas in a quick way.

**Insurance and Risk Assessment**

According to Deloitte, drones allow us to assess property features in a safe way. Drones are also said to help save the insurance industry nearly $7 billion per year. Between 2022 and 2030, drones within the insurance industry are expected to rise at a quick rate. It is estimated that the drone industry in the insurance market will reach a million USD by 2028. By 2027, drones in the insurance and risk assessment industries are expected to grow at a rate of about 8.4%. The growth is driven by their role in evaluating risk, quickening property assessment, and by reducing costs and improving efficiency within this section of the industry.

One of the main issues with drones in this industry is that low-flying drones can cause bodily injuries. This could be caused due to having limits in flight altitude. Another issue is that, of course, technological malfunctions could lead to unintentional landings which could cause property damage. There are also concerns about privacy invasions. Since drones could gain access to areas that are hard to reach, many think that this could lead to pilots doing this in an irresponsible way.

**Discussion of the Disaster Management, Environmental Monitoring, and Insurance and Risk Assessment Industries**

The Apollon Company could use some of their mentioned sensors in the drones. These sensors could help with navigating through challenging areas in order to provide safety for humans by helping with obstacle avoidance. These sensors could also include different cameras such as thermal imaging cameras, and light detecting sensors. These types of sensors could help with monitoring the health of forests, monitoring water quality, and even with detecting different changes in the environment. Sensors could also help with detecting threats in real-time which could not be done quickly with traditional methods. Overall, sensors could help with improving the accuracy and reliability of data collection. With these sensors, there could be automated takeoff, flights, and landing in order to have quick response times in disaster management. A big issue in insurance and risk assessment is time efficiency, using sensors to streamline the capture of data could help with processing claims at a faster rate and overall improving satisfaction with customers.

In addition, the Apollon company could solve the main issues faced by each sector by not limiting the flight of their drones. Companies that manufacture their drones can geofence their drone models. By providing sensors that can help maneuver through obstacles could help limit property damage, human injury, and the disruption of the environment. By using bigger batteries, the company could make drones that have a higher battery life which could create a competitive drone. To tackle the privacy concerns, the Apollon company could use geotagging on certain locations. This could limit any privacy concerns people may have. Drones are also very expensive but researching ways to create affordable, yet powerful drones can help the Apollon company stand out from competitors.

Competitive Landscape

**Insurance and Risk Assessment**

For this sector, Yuneec provides precise flight, rapid change of imaging systems, and clean and accurate images. This is useful as Precision is important when flying to avoid obstacles but also to get accurate and reliable information (which is another issue that this tackles). The rapid change of imaging systems allows users to capture data at a quicker rate.

PrecisionHawk uses cutting-edge geospatial science which sets their drones apart from the competition. Drones use geospatial science to collect, analyze, and use spatial data for many things such as obtaining data, mapping and surveying, and more. Another thing that they offer is that they keep up with the newest artificial intelligence technology which helps with machine learning. It takes information collected from drone flights to do a better job each time. The biggest thing that sets them apart, however, is that they are the only service provider that is authorized by the FAA, federal aviation administration, to fly drones above the visual line of sight.

SkyCatch provides mapping that has a high accuracy which can help with mapping properties and administering risks. They also have proprietary photogrammetry technology which is, “a method of approximating a three-dimensional (3D) structure using two dimensional images.” They also have automation in drone capture and processing which helps with speeding up the process of capturing images.

**Environmental Monitoring**  
 In this sector, Wingtra provides accurate and multispectral images with their drones which helps to monitor landscapes, etc. Their drones also help with mapping large areas safely and quickly. Something that sets them apart is their long flight time that the drones have of 59 minutes.

SenseFly has an even longer battery life which is 90 minutes. This helps with being able to monitor areas for a longer time, which is more efficient. senseFly also allows their users to work virtually. Plus, they also provide built-in management software which can help with data capture.

DJI has drone models that use multispectral sensors which can help with mapping forests. These sensors also help with mapping around surface water. DJI drones can also classify water bodies, estimate water coverage, and monitor sewage. They are one of the most popular and used brands for drones.

**Disaster Management**

In this sector, DJI uses high resolution digital and thermal cameras which helps with getting more accurate images and information. Plus, they also provide technology that users can use to see at night or low-light situations which could be crucial in disaster situations. With their high-resolution cameras, users can also gain another perspective which allows scanning for people and other emergencies.

Parrot does not have any geofencing which allows them to reach areas that may be limited to other brands of drones. They also have a 180-degree tilt on their cameras which allows the users to see from more angles . Parrot created easy-to-use drones which can help get reliable data.

Aeryon Labs also creates drones that are easy to operate. Something that sets them apart is that they have all-weather drones. They can withstand cold temperatures and hot temperatures which would be crucial for disaster management. Their drones can also withstand higher wind speeds, which again, helps with disaster management.

**Discussion of the Competitors**

Each competitor in the drone sector for different applications which includes insurance and risk assessment, environmental monitoring, and disaster management, showcases distinct strengths and offerings. In terms of imaging systems and precision, the Apollon company could differentiate itself by introducing innovative technologies that enhance precision even further, ensuring a safer and more accurate data collection process. This could be done through sensors and an improved software for drone usage and data collection. In terms of artificial intelligence technology and geospatial science, the Apollon company could try and further enhance data analytics as PrecisionHawk stands out for using geospatial science and for incorporating the latest artificial intelligence technology in their tech for machine learning. Research and development could be done in battery technology in order to try and extend drone flight times. Each competitor has something that makes them stand out but the Apollon company could focus on innovating these existing features to try and solve the limitations and issues that exist with the competitive products.

**Search and Rescue**

**Definition**: Use of drones in search and rescue operations by conducting aerial reconnaissance, quickly covering large areas, and providing real-time imagery and thermal imaging to locate missing persons or survivors. They can assess hazards, establish communication relays, and drop life-saving equipment, enhancing the efficiency and effectiveness of search and rescue efforts. Drones also contribute to post-disaster assessment and documentation, making them indispensable tools in modern search and rescue missions.

**Financials:** According to a report from FactMR in 2022, the global search and rescue drone market had a market size of 2.8 billion, with a Compound Annual Growth Rate (CAGR) of 13.6% ("Title of the Report" FactMR, 2022).

**Competitive Landscape:**

* **DJI:**
  + Pioneering modular drones and attachment system that caters to specific situations, offering flexibility to operators.
  + Allows operators to attach various sensors and tools, making it adaptable for a wide range of applications.
  + Wide product range and extensive ecosystem, providing a comprehensive solution for diverse user needs.
  + Strong emphasis on innovation and technology leadership in the drone industry.
* **Aerotronics:**
  + Innovative modular design with a focus on product durability and sturdiness.
  + Weathiner-tested for extreme conditions, ensuring reliable performance in challenging environments.
  + Equipped with impressive lifespan enhancements, reducing the need for frequent replacements.
  + Known for producing robust and dependable drones tailored for demanding situations.

**Recommendations:** The Apollon Company can leverage its expertise in control technologies to develop software facilitating drone "swarms" capable of efficiently covering larger areas per operator or autonomously. Additionally, they can implement safeguards to enhance user-friendliness and promote safer operating environments. However, similar to many other drone applications, the primary constraints in this sector remain limited battery life and connectivity capabilities.

Public Safety, Security, Surveillance

**Definition:** Utilizing drones provides a unique aerial perspective, making them valuable for police and security operations, such as crowd monitoring, traffic control, and border surveillance. In public safety, drones play a critical role in search and rescue missions, disaster response, and firefighting, where they can access hard-to-reach areas and provide real-time data. Their ability to cover large areas quickly and transmit live footage makes them essential for enhancing situational awareness and improving response times.

**Financials:** According to a report published by MarketsandMarkets in 2023, the global public safety drone market was estimated to have a market size of 1.1 billion, with a projected Compound Annual Growth Rate (CAGR) of 13.0% ("Public Safety Drone Market by Application (Law Enforcement, Firefighting, EMS), Component (Hardware, Software, Services), Type (Multi-Rotor, Fixed Wing, Hybrid), Product (Firefighting, Law Enforcement), and Region - Global Forecast to 2023")

**Competitive Landscape:**

* **Draganfly/Lufthansa Industry Solutions Merger:**
  + Extensive experience in maritime cargo inspections, leveraging AI for precise and efficient operations.
  + The merger creates a powerful synergy, offering comprehensive solutions for various industries, including maritime logistics.
* **Iron Drone:**
  + Leading-edge automated security drones that can intercept rogue drones without the need for frequency jamming, enhancing safety.
  + Robust security measures provide effective defense against unauthorized drone intrusions, making it a trusted solution for airspace protection.
* **Skydio:**
  + Versatile drones equipped with multi-frequency capabilities, enabling seamless use by various departments like fire, police, and emergency services.
  + A strong focus on cybersecurity ensures the confidentiality and integrity of the data collected, bolstering trust in drone operations.

**Recommendations:** Similar to the "search and rescue" sector, many of the same principles apply here. The emphasis should be on reducing the skill requirements, enabling a wider range of operators to harness drone technologies. Additionally, the development of software for coordinated drone "swarms," where multiple drones can work together under the guidance of a single operator, is crucial. Efficiently accomplishing these tasks will open up diverse applications across this expansive sector.

Agriculture

**Definition:** Drones used to enhance crop management and efficiency. They are equipped with various sensors and cameras to collect valuable data such as crop health, moisture levels, and pest infestations. This information helps farmers make informed decisions about irrigation, fertilization, and pesticide application, ultimately leading to higher yields and reduced operational costs. Drones also enable farmers to monitor large fields quickly and easily, making them a valuable tool for modern precision agriculture.

**Financials:** According to a report by Fortune Business Insights in 2022, the global agriculture drones market reached a market size of 4.2 billion with a Compound Annual Growth Rate (CAGR) of 20.30% ("Title of the Report" Fortune Business Insights, 2022).

**Competitive Landscape:**

* **AeroVironment:**
  + Hybrid Drone Technology: Develops hybrid drones designed for autonomous scanning and data collection in predefined areas.
  + Data-Driven Recommendations: Utilizes collected data to provide valuable field change recommendations through their software.
  + Impressive Coverage: Can efficiently cover areas exceeding 45 acres during a continuous 45-minute flight, enhancing data collection capabilities.
* **DJI:**
  + Fertilizer Spreading Capability: DJI's drones excel in efficient fertilizer spreading, with a capacity of up to 1.5 Tonnes per hour.
  + Versatility: In addition to fertilization, DJI drones are adaptable for diverse operations, including mapping and surveying.
  + Established Reputation: DJI is a reputable and well-established brand in the drone industry, known for reliability and versatility.
* **AgEagle:**
  + Fixed-Wing Aircraft: Specializes in the development of fixed-wing drones tailored for precise agricultural data collection.
  + Comprehensive Data Use: Collected data supports the creation of detailed models, including various types of maps, and aids in water management, crop monitoring, yield prediction, and plant counting.
  + Holistic Agricultural Management: Enables effective management of multiple facets of agricultural operations, enhancing overall efficiency and decision-making.

Inspection and Monitoring

**Definition:** Accumulate visual data, aid avoiding hazardous areas (chemical spills, tall, lean towers). With features, they can detect any future dangers and movements within the facility.

**Financials:** According to a report published by MarketsandMarkets in 2022, the global inspection and monitoring market was estimated to have a market size of 11.6 billion, with a projected Compound Annual Growth Rate (CAGR) of 14.6%

**Top 3 Issues**:

* Endurance capacity (limited battery)
* Climate and weather (the drone adaptation to these conditions)
* object scales, angle variations, truncation, and occlusion

**Competitive Landscape:**

* **Maverick Inspection LTD:**
  + Detect any methane leaks
  + Create maps and models as a blueprint for visualization on infrastructures (bridges, manways, decks)
* **GarudaUAV Soft Solutions Pvt. Ltd.:**
  + Gather data with urban planning to understand current and future state of urban areas
  + Analyze movements of people and have immediate response for emergency
* **Dronedeploy, Inc:**
  + Strong detections on any dangers that may put the worker’s life at risk
  + Creations on analysis and validations for quality work of structural elements and sharable edit reports with the team in real-time

**Mapping/Surveying/GIS**

* **Industry Summary**
* Site topography including inspection surveying and others that cover various Industries such as agriculture construction Public Safety Etc.
* The global market size is 1 billion as of 2023 and CAGR 17.10% <https://www.marketsandmarkets.com/Market-Reports/drone-inspection-monitoring-market-99915267.html>
* The primary issues in this industry are FAA regulations and it is a fragmented Market.
* Construction uses a lot of very expensive equipment and drones can be used to track and monitor that the equipment is being used and stored properly along with employee activities. In agriculture drones can map out fields for planting, track the continued health of crops and the health of livestock. In public safety you can use the information accumulated to gather Road information and recreate the scene of an accident using 3D imaging.
* **Competitive Landscape**
* Maverick Inspection Ltd.
  + Infared Thermography to Inspect and  
    Identify equipment Issues  
    Maverick Inspection Ltd. ensures  
    compliance with the Canadian Aviation  
    Regulations that govern Canadian airspace  
    through its RPAS Operations Program.  
    topographic surveys, 3D modeling,  
    orthophoto production, vegetation  
    analysis, or any other geomatics-related  
    services
* GarudaUAV Soft Solutions Pvt. Ltd.  
  BlueHawk provides a digital platform for a  
  complete life cycle of a project i.e., survey  
  & mapping, monitoring, inspection,  
  surveillance, O&M services and perform  
  various analytics
* Dronedeploy, Inc.  
  Easily create maps, 3D models,  
  panoramas, and videos  
  Walk your jobsite and capture continuous  
  360 footage  
  Generate maps in real-time, entirely  
  offline, with Live Map
* 3D Drone Mapping
  + Long range drones
  + custom built for African weather conditions
  + vertical landing and takeoff
* ABJ Drones
  + 2500 Pilots globally in North America, Europe and Asia
  + Accommodate both large and small companies
  + Inspect infrastructure like building cell towers power line solar and wind farms from the way land surveying is done to 3D modeling of construction sites advances in drone technology are pushing boundaries and enabling innovation
  + Generate terrain models that extend under water
* Aerial Robotix
  + Specialized in low altitude aerial photography with a geometrically calibrated camera
  + Extremely fast and efficient calculations

All 3 companies offer 3D modeling and infrared using Livar technology to monitor the productivity of devices and safety on the job. Each of these drone functions are focused on differently within each company. Maverick focuses on equipment issues, Garuda on the start to finish of a construction project and Drone deploy can create real time maps with 360-degree footage. Maverick is the only company that mentioned Canadian Airspace clearance. Garuda has a digital platform. Drone deploy offers offline live mapping.

Mapping:  
All 3 companies seemed like their dissimilarities would make them appealing. The drone functions and developed technology were focused on greater in separate ways. 3D drone Mapping was the only company that mentioned its long-range capabilities. This was due to the vast openness of the African terrain. Vertical landing and takeoff are essential due to weather conditions, but the market is limited to a specific region. ABJ drones are mapping underwater terrain with more advanced technologies. Their product and services are global, and the training and professional standards set them apart as a very large competitor. Due to there being over 2500 drone management professionals they are able to service different size companies. Aerial robotics focuses more on the efficiency of calculations after mapping is completed. Each of these companies have different specialties they cater to with mapping drone services.

Construction and Infrastructure

**Definition:** Secure and monitor materials, people, and equipment for safety and security purposes

**Financials:** According to a report published by Straits Research in 2021, the global construction drone market was estimated to have a market size of 4.9 billion, with a projected Compound Annual Growth Rate (CAGR) of 15.57%

**Top 3 Issues**:

* limited flight time and range as battery life
* low battery life
* Costly in terms of features of a drone (lasers)

**Competitive Landscape:**

* **Leptron Unmanned Aircraft Systems, Inc.** **:**
  + Accumulates and creates highly accurate site data for construction work
  + The merger creates a powerful synergy, offering comprehensive solutions for various industries, including maritime logistics.
* **DJI:**
  + Can easily takeoff and fly over complex worksites with the collected highly accurate data
  + Creates 3D models with accurate positioning data to visualize data and generate better route designs with most softwares

Photography and Cinematography Services

**Definition:** The use of drones within this industry involves two sectors. The first and main sector is filming and taking photographs for content purposes within the film industry. The second sector is used for location scouting and aerial mapping prior to filming content. Drone requirements for this industry include weight bearing drones, high quality images, and high-flying speeds without heavily impacting image quality. Additionally, this industry is privileged with FAA exemptions that allow for more flexibility to use drones within set operations.

**Financials:** The overall drone camera market size for 2022 was about $5.9 billion, this specific industry made up a little over $600 million within that market size, therefore this industry held 10% of the entire drone camera usage revenue. This industry also had a Compound Annual Growth Rate (CAGR) of 18.7% in 2022.

**Top 3 Issues:** The first main issue involves the loss of focus and quality when reaching high flying speeds to keep up with scenes. Subject focus is lost the pilot controlling the drone must rerecord, costing time and money during filming. The second main issue within this industry is the disturbance of natural wildlife due to drone noise and bulky equipment. This is especially dangerous for both the subject and for the drone and requires subtlety without loss of quality. The third main issue is the loss of connectivity that limits the range and control of the drone that prevents certain areas to be photographed or filmed because the drone loses connection to the remote, even if the drone is still within sight of the pilot.

**Discussion of Solutions:** The Apollon company has had experience with sound control of aerial vehicles and can help suppress any further noise made by the drone as well as keep high camera quality while still providing subtle hardware that would not interfere with wildlife. Apollon’s previous work with satellites can help improve drone connection and accuracy of location by pinpointing an area or even a device to help with autopilot controls. This can allow a drone to focus on either an object or person and use autopilot technology to “track” it if there is connectivity issues. The newest talk on the use of drones in cinematography is the incorporation of AI. This sort of technology can increase the range of angles and optimal film locations, keeping up with image quality without the need for constant reshoots because the AI technology can anticipate needed changes and modify its camera settings accordingly.

**Competitive Landscape: Yuneec** software controls allow locations and movement to be stored and replicated to take a series of complex shots. Their drones allow their payloads to be interchangeable to allow flexibility and choice while also providing two independent controllers, one for the drone and the other for the camera payload. **Helinet** is another drone company that is a high competitor due to their expansive camera integration while maintain high speeds of up to 58mph. Furthermore, functions of the drones include preplanned coordination and flight paths that maintain efficiency as well tracked maneuvers that help decrease battery usage. Lastly, we have **Freefly**, this drone company also works with cinematographers to design drones that have the functions, capabilities, and quality needed for filming. Their drones have intelligent autopilot sensors to aid in position accuracy; they are also weight bearing which allows for heavy high-quality cameras.

Package Delivery

**Definition:** Drones being used to revolutionize the way goods are transported and delivered. They can swiftly navigate through urban and remote areas, avoiding traffic and delivering packages directly to a designated location. Drone delivery has the potential to reduce delivery times, lower costs, and minimize the environmental impact associated with traditional delivery methods, making it an exciting development in the logistics and e-commerce sectors.

**Financials:** According to a report from Fortune Business Insights, the global drone package delivery market had a market size of 1 billion in 2020. Furthermore, the market is expected to grow significantly, with a projected Compound Annual Growth Rate (CAGR) of 53.93% ("Title of the Report" Fortune Business Insights).

**Competitive Landscape:**

* **Matternet Inc.**
  + Matternet drones feature automated payload and battery exchange, improving delivery efficiency and speed.
  + The company has developed a proprietary software platform for operating Matternet networks, enabling autonomous drone operation, flight route generation, and comprehensive drone monitoring.
  + Matternet achieved the world's first delivery drone Type Certification from the Federal Aviation Administration (FAA), signifying compliance with FAA regulations and approval of the drone's design and components.
* **Wingcopter GmbH**
  + Wingcopter employs a fail-safe power train with 8 motors, 8 electronic speed controllers, and two batteries for operational safety.
  + Their drones feature multiple cameras for obstacle detection and integrated artificial intelligence for real-time risk assessment.
  + The Wingcopter 198 can deliver three packages to multiple locations in one flight, utilizing forward flight and hover modes to lower packages quickly and reduce delivery costs.
* **Zipline Inc.**
  + Zipline offers a simple software infrastructure for easy integration into business operations, enhancing efficiency.
  + Their latest drone combines lift and cruise propellers with a fixed-wing design for precise and quiet operation in various weather conditions.
  + The Zipline P2 Zip drone can deliver packages weighing up to 8 pounds from an altitude of 300 feet with precision, including delivery to small spaces like tables.

Warehousing (part of General Logistics)

**Definition:** Drones are increasingly used in warehousing for tasks such as inventory management, surveillance, and inspection. They navigate storage facilities efficiently, automate tasks like cycle counting, and enhance security through real-time surveillance, contributing to streamlined operations and improved accuracy

**Financials:** According to Fortune Business Insights, the global drone package delivery market reached a market size of 1.0 billion in the year 2020. Furthermore, this market is expected to experience a substantial Compound Annual Growth Rate (CAGR) of 53.94% in the coming years ("Title of the Report" Fortune Business Insights).

**Competitive Landscape:**

* **Skydio**
  + Skydio offers fully automated drones designed to enhance inventory accuracy and efficiency within warehouses.
  + The drones are capable of mapping the warehouse and following designated routes to manage inventory effectively.
  + Rapid data capture enables quick environmental mapping, allowing operators to schedule specific areas for the drone to cover.
  + Skydio drones utilize an artificial intelligence-driven navigation system that can identify barcodes and other objects while avoiding obstacles, preventing crashes and ensuring safe operation.
* Doks
  + Doks drones are equipped with powerful sensors for accurate reading of labels and documentation, aiding in warehouse inventory management.
  + They feature a night flight mode for efficient operation in low-light or dark conditions while still capturing essential information like labels.
  + Using these sensors, the drone can create images of captured objects and generate digital replicas of shelves, facilitating data organization and precise item location on the user interface.
* Verity
  + Verity's drones can create precise digital models of warehouse racking environments using cameras, extracting shelf dimensions, and enhancing inventory management accuracy.
  + They operate autonomously, allowing for online scan scheduling to check specific areas or the entire warehouse as needed.
  + Drones are capable of detecting when items have been moved, generating reports, and capturing images of misplaced or mismarked inventory, ensuring efficient warehouse operation.
  + Accessible inventory data on the Verity cloud software enables real-time monitoring and management.

Recommendations: Our group's assessment indicates that this sector aligns best with The Apollon Company, considering their expertise and the sector's anticipated high growth. The warehousing industry boasts a substantial number of facilities, with many seeking technological solutions to optimize their operations. Drones, particularly for cycle counting, remain largely unexplored in this sector. Further details regarding our recommendations will be outlined in this report.

Utilities and Renewable Energy

**Definition:** Drones utilized for inspecting and maintaining critical infrastructure like power lines, wind turbines, and solar panels. Additionally, drones collect essential data, such as environmental conditions and equipment performance, aiding in resource management. Their use enhances safety, minimizes operational downtime, and contributes to the growth and sustainability of these industries.

**Financials:** According to a report on Yahoo Finance, the global utility drone market had a value of 0.26 billion in the year 2022, and it is expected to grow at a Compound Annual Growth Rate (CAGR) of 28.7% ("Global Utility Drones Market Report 2022" Yahoo Finance)

**Competitive Landscape:**

* **DJI**
  + DJI drones, like the Matrice 210 RTK V2 with an XT2 thermal payload, are used for solar farm inspections. They collect high-resolution and thermal images to detect faults in solar panels efficiently.
  + The Mavic 2 Enterprise Advanced and Matrice 300 RTK enable automated flight routes for wind turbine inspections. This reduces safety risks for personnel and eliminates the need to shut off turbines during inspections.
  + Drones such as the Matrice 210 RTK V2 and Matrice 300 RTK can perform leak detection and repairs in utility operations without interrupting ongoing processes. They can also utilize gas detector attachments, reducing the need for additional detection equipment and cutting costs.
* **BRAQ Industries**
  + BRAQ Industries offers trained pilots skilled in drone operation, particularly in challenging or hard-to-reach environments.
  + Their comprehensive software simplifies picture management, annotations, sensor control, and autonomous flight planning.
  + Corridor mapping services are provided to assist companies in expanding and building new facilities in areas where critical infrastructure, such as power lines, is required.
* **Skydio**
  + Skydio has introduced 3D Scan technology, enabling drones to automatically create flight paths around assets and perform onboard modeling for real-time processing on-site.
  + They have unveiled the Skydio X10 drone with Skydio Night Sense, a video-based navigation and obstacle avoidance system for nighttime operations, extending operational capabilities.
  + Skydio has developed the VT300-L attachment, equipped with three cameras ranging from 50-60 MP, including a narrow camera, a 1" wide camera, and a radiometric thermal camera. Additionally, it features a built-in flashlight with 2800 lumens of illumination.

**Forestry**

**Definition:** Drones are used in forestry to overlook and predict any future fire dangers, identify pests and disease that might be created within a forest and identify opportunities for Harvest planning. The forestry industry manages wildlife conservation, biodiversity, and vegetation conservation, the balance of ecology, and similar aspects of forestry. Forestry is expected to continue growing, and drone technology is essential to meet forestry needs. There is not enough workforce or boots on the ground to cover all the forest terrain. Drones will promote the health and wellbeing of our forests by quickly identifying the presence of smoke and preventing a potentially catastrophic fire. Important to forestry is wildlife management but the risk to humans is significant. Drones allow for monitoring with no potential harm to forestry staff. If there is illegal logging taking place the drones can identify the affected areas and have police personnel come address the situation quickly.

**Financials:** The global market is approximately 1 billion as of 2022 and the CAGR is 37% <https://bekryl.com/>

**Top 3 Issues**

1. Forest areas can be extremely large and vast. There is simply not enough workforce to effectively search an entire Forest Area. When an individual is lost, and search and rescue is sent out there is a lot of missed territory. Without regular monitoring of the forest areas many potential fire hazards could get perpetually worse.
2. Deforestation and urbanization can have a negative impact on wildlife and may encourage migration. From this we may see a decline in certain species of a specific environment.
3. If disease begins to ravage a forest it can have a significant economic impact on foresting Industries and can impact commercial businesses That may require logging. This problem can translate into the agricultural industry and disease can spread and destroy crops.

Drone Technologies can help improve the number of lives we can save through thermal imaging. They can cover a larger area with more accuracy in a shorter time. Regular aerial Imaging and mapping of the forest can allow for wildlife monitoring that might indicate potential deforestation. All this information can be relayed in real time through data processing. In addition, drones can through lidar sensors detect disease in trees and plants.

* . Life Saving through Thermal Imaging - Drones that have thermal imaging cameras can identify wildfires before they become too large and prevent exhaustive damage. If there is someone lost, they can cover a larger region and view areas that cannot be covered by someone that is walking. This can identify someone who may be trapped in a hard-to-reach area and who may be unconscious but alive.
* Wildlife Monitoring through Regular Aerial Imaging Mapping and Data Processing - Through regular monitoring we can track the impact of deforestation and urbanization on important populations of wildlife. Logging can be planned out more strategically and with data illustrating the impact on wildlife
* Wildlife migration and monitoring of how each species is continuing to develop. If there is a shift in location of wildlife or size of species, then there may be a potential threat that can be identified through constant monitoring of areas that may not be accessible to humans.
* Tree Disease Detection through LiDAR Sensors - Light detection and ranging sensors can identify early if there is disease forming in diverse types of trees and vegetation within a forest. Early detection has significant economic impact not only in the forest but extending to crops and agriculture

<https://www.autelpilot.com/blogs/faq/how-drones-are-being-used-in-forestry>

<https://www.equinoxsdrones.com/how-drone-technology-is-becoming-essential-for-forestry/>

**Competitive Landscape**

* **Elios 3**
* Drone allows for the inspection of damp areas without damaging the UAV
* Lidar scanning Technologies help to gauge the distance depths and shapes of surfaces
* The sensors on their drones are equipped to create 3D models of any landscape
* **DJI**
* Their drones are equipped with powerful infrared and thermal sensors.
* Their drones have a fixed Wing function to the Drone which does allow for more cameras and sensors on the UAV to optimize your data collection.
* They run longer than normal flight times, so they can cover a much larger area.
* **WingtraOne**
* Only a small area is needed for takeoff and Landing with their vertical takeoff technology (VTOL)
* Durability and difficult regions that have more Rocky or difficult Terrain or even high winds
* versatile to move into smaller areas that humans cannot go
* top of the line aerial mapping cameras

**Mining**

**Mining Definition:**

Mine or quarry monitoring and operation planning, and Stockpile volumetrics. Mining is the process of extracting valuable minerals, ores, or other geological materials from the Earth to be repurposed for commercial use. This practice involves various methods and techniques including drilling, blasting, digging, and transportation, to access and recover natural resources found beneath the Earth's surface like oil and gasses making it an extremely labor intensive and dangerous line of work. Mining encompasses a wide range of minerals and materials, including metals like gold, silver, copper, and iron, as well as non-metallic resources like coal, limestone, salt, and gemstones. The extracted materials are typically processed and refined to obtain valuable commodities used in various industries, including manufacturing, construction, energy production, and technology. Mining operations can vary in scale, from small-scale artisanal mining to large-scale industrial mining, and they often have significant economic, environmental, and social impacts on the regions where they are carried out. Effective mining practices require careful planning, safety measures, and environmental stewardship to mitigate negative effects while maximizing resource extraction. Drones are an effective technology in improving and assisting in these mining activities.

**Financials:** According to PWC in 2017 one of the four major global industries for drone Solutions is mining and the potential market value could be upwards of 4.3 billion dollars (about $13 per person in the US). <https://www.pwc.com/gx/en/communications/pdf/communications-review-july-2017.pdf>

**Top 3 Issues:**

1. When you are moving a lot of materials in stockpiling it as you scoop it out of the earth there is potential for a lot of waste.
2. Materials mined out of the Earth are very often valuable like gold silver and Gem so 24-hour real-time surveillance is critical Due to high rates of theft
3. Underground mining can be extremely dangerous because conditions can be wet, full of unsafe gasses, or unstable debris where people are too large to inspect the area drones can navigate to those hard-to-reach places.

A common mining application is calculating the amount of material left in a stockpile. The piles can often become huge and overwhelming. There is volumetric software integrated into drones used for mining so they can obtain accurate reads on the actual amount of material that is left. They can read how much material was moved and how much is left so there can be a waste reduction. Mining is an intensely dangerous job and there are a lot of risks. Sending a drone into these hard-to-reach areas and ahead to determine potential emissions and hazards protects the employees and provides maximum efficiency. Regular monitoring will protect human lives. Mining is often very rough terrain and drone technology is developing vertical take-off and landing gear to assist with the durability and ease of use with the drones. This will prevent damage to the drone if it is landing on rocky terrain. Drones used for mining can develop some added durability. Some drones can go underground amidst wet and rocky terrain. Equipment Inspection to improve worker safety is crucial in these environments and drones can perform thorough equipment inspections. It is extremely cost effective to have these items routinely checked via drone servicing. Drones provide 24-hour monitoring to help prevent the theft and destruction of property on a job site. They can identify early the release of any gases should mining cause any additional environmental concerns.

**Three Major Players**

* **DJI** 
  + a Chinese drone manufacturer offers advanced imaging capabilities
  + Powerful Infrared and thermal sensors
* **Sensefly EbeeX** 
  + The fixed wing function of the drone allows for more cameras and sensors to optimize data collection.
  + Longer flight times so they can cover a much larger area.
* **Wingtra One** 
  + Only a Small Area is needed for take-off and landing using vertical take-off technology.
  + Durability in difficult regions that have more difficult terrain or even high winds. - Versatile to move into smaller areas that humans cannot go - Better aerial mapping cameras

Plane inspection

**Definition:** The use of drones is revolutionizing plane inspections by offering a safer, faster, and more efficient alternative to traditional manual checks. Equipped with high-resolution cameras and sensors, drones can closely examine aircraft exteriors for damage or wear, capturing detailed images of hard-to-reach areas like the upper fuselage and tail. This technology significantly reduces the inspection time, allowing for more frequent and thorough checks without the need for scaffolding or lifts. The data collected by drones can be analyzed using advanced software, leading to more accurate and timely identification of potential issues.

**Financials:** According to a report by MarketsandMarkets, the global drone inspection and monitoring market had a market size of 11.6 billion in 2022, with a Compound Annual Growth Rate (CAGR) of 11.6% ("Title of the Report" MarketsandMarkets).

**Competitive Landscape:**

* **Boeing:**
  + Established reputation and credibility as a major player in the aerospace industry.
  + They already have drones in active service and undergoing testing on military bases, displaying their technological expertise.
  + While their commercial market plans are not widely known, their military background suggests a solid foundation for future innovations.
* **Mainblades:**
  + Offers a comprehensive drone service bundled with user-friendly software, providing a hassle-free solution for customers.
  + Ready-to-use off-the-shelf package makes drone adoption more accessible to a wider range of businesses.
  + Focuses on ease of use and accessibility, making it a user-friendly choice for commercial applications.
* **Donecle:**
  + Utilizes machine learning and advanced image processing, enabling precise damage assessment down to the millimeter.
  + Claims to significantly outperform traditional inspection teams, boasting a 75% faster inspection process.
  + Offers a disruptive solution by automating and streamlining inspection tasks, potentially reducing costs and improving efficiency for customers.

Oil and Gas

**Definition:** This industry uses drones to oversee any mishaps such as spills, damage, and pipelines for oil and gas companies. These drones are required to capture minute details with accuracy and use infra-red cameras with thermal imaging technology. The data and images collected from these drones are used for analysis of efficiency as well as preventative measures needed for safety.

**Financials:** According to Market, Research, Future the market size for the year 2022 was of $10.3 billion. It also has a CAGR of 39.1% due to advancements in AI technology integration.

**Top 3 Issues:** The first main issue concerning this industry regards the surveying of hazardous areas involving the batteries used for drones. Their low life span is a limiting factor that prevents long term data collection because they only last 15-20 minutes, additionally locations of inspection are often far and require long travel times which also consumes battery life, limiting the battery life available for actual data collection. Another issue within this industry concerns the vibrations caused by winds/harsh climate conditions. These vibrations cause issues with the sensors required to collect data, making the data unreliable at best or completely corrupt the sensors at worst. Lastly, rough terrains and remote locations are an issue for drones due to the short bandwidth available for connection.

**Discussion of Solutions:** Longer battery life can significantly improve data collection and analysis and an option for a battery saving mode can during the hovering and gathering of data can also extend how long a drone is present in the location of concern. The need for additional hardware and sensor malfunction alerts is also essential for the care and protection of the complex sensors needed for data collection. Ensuring the hardware does not get in the way of the sensors is also important. Lastly, other companies have provided AI integration and predetermined mapping/GPS pathways for the drones to follow even if they are disconnected, allowing them to continue the data collection without the need for direct connection with pilot, thus increasing the availability of data.

**Competitive Landscape:** The first main competitor to consider is DJI, because it is the main competitor in all applications and industries regarding drones, they have advanced technology that allows them to accommodate each industry. For gas and oil inspections they provide specialized sensors that can detect leakages as well as provide a digital 2D/3D map model of the inspected structures. The following competitor is Aerial Production Services, Inc., they have high resolution imagery and video of the data captured which helps with accuracy and prediction analysis. Last is American Robotics who continuously monitors the structures with long lasting batteries, this helps in long term data collection.

Meteorological Drones and Sensors

**Definition:** Drones within this industry allow for assessment of weather conditions; specifically, wind speed and direction due to climate change. The data these drones collect also aids in weather prediction and accurate forecasting.

**Financials:** The estimated market size for the year 2021 was roughly $2.3 billion. This was found by multiplying 1.4 billion registered drones by the market size of anemometer sensors $164 million (which are the primary sensors used on all meteorological drones). The CAGR for that same year was 24.5%.

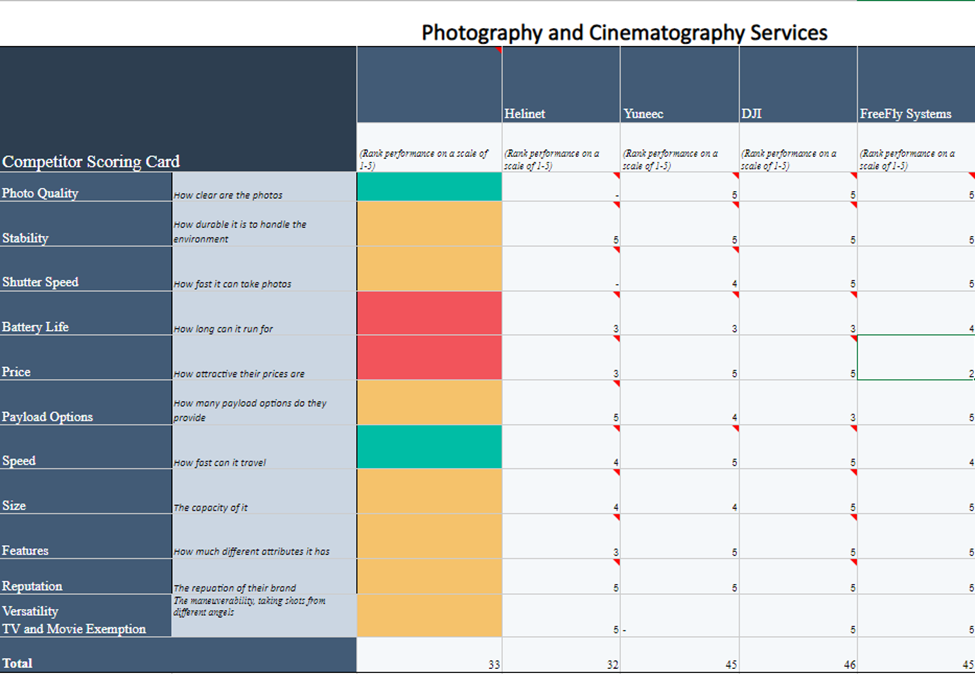
**Top 3 Issues:** The first main issue concerning meteorological drones is that they cannot maintain a long enough battery life to complete the long-term data tracking needed to create an accurate forecast. The second main issue is that some anemometers do not work well with the drone’s hardware and functions. This gap creates inaccuracies in the data collected as well as a drain on the battery life of the drone, more advanced anemometers are required. Lastly, these drones must be designed with proper hardware and sensors that are not heavily affected by harsh weather conditions while at the same time not getting in the way of the anemometer sensors.

**Discussion of Solutions:** Although cameras are necessary for operation of drones, during extreme weather conditions vision of cameras may be impaired, additional sensors for obstructions and spatial awareness can allow for other forms of “visibility.” In addition to this AI features can monitor GPS paths to ensure it can return to the same location it was receiving data from without manual control, thus cutting flight time when possible and conserving energy. In addition to the AI, pinpointing of “subject” whether it’s a hurricane or clouds to generate forecasting of path of storms can also allow for accurate data collection. During severe weather it’s important to receive data as quickly as possible. Even basic data and/or AI generated forecasting based on data being collected can assist in required actions from those on the ground. Having the drone send information can prove valuable when there’s limited time to send the drone up to collect data and bring it back down to download and review data. Any real time view of data received by the sensors can allow for a better understanding of what actions may need to be taken. Lastly, long running batteries are essential for these drones, but more importantly the drones must have optimal hardware encasing and protecting both sensors and battery from harsh weather conditions.

**Competitive Landscape:** The first main competitor in this industry we must take a look at is **MeteoMatics** which has a deicing function in order to melt ice that could accumulate on blades due to severe weather and/or high altitudes. Their drones are also waterproof, so they are safe to use in rain or snow. Additionally, their drones are autonomous so that they can continue to survey and receive data without an operator during sever weather or obstructions that makes it difficult for an operator to view and maneuver drone, and they can reach high altitudes and maintain high speeds to keep up with strong winds that may break connection. The second company to consider is **Black Swift Technologies.** They incorporated AI to aid in system failures as well as learning algorithms placed to provide preventative maintenance measures that can improve operations for data collection. Their drones also have field swapable payload systems in case sudden changes occur that require different sensors for different data entries, as well as long battery life with quick swapable batteries to allow change in batteries and have the drone be back in the air in no time. Lastly is **Anemoment LLC**, their drones are lightweight, but highly accurate weather reporting sensors; lightweight allows for more optimal battery life. They also have sensitive sensors that can be tethered to adjacent towers in order to share data immediately and no moving parts to provide accurate data but also prevent system failures due to external weather impacts.

**Top 3 Industries: (not sure how to format score card for this but we need to include the information as to why each company is scored, if there is any recommendations that would be great)**

Photography and Cinematography Services



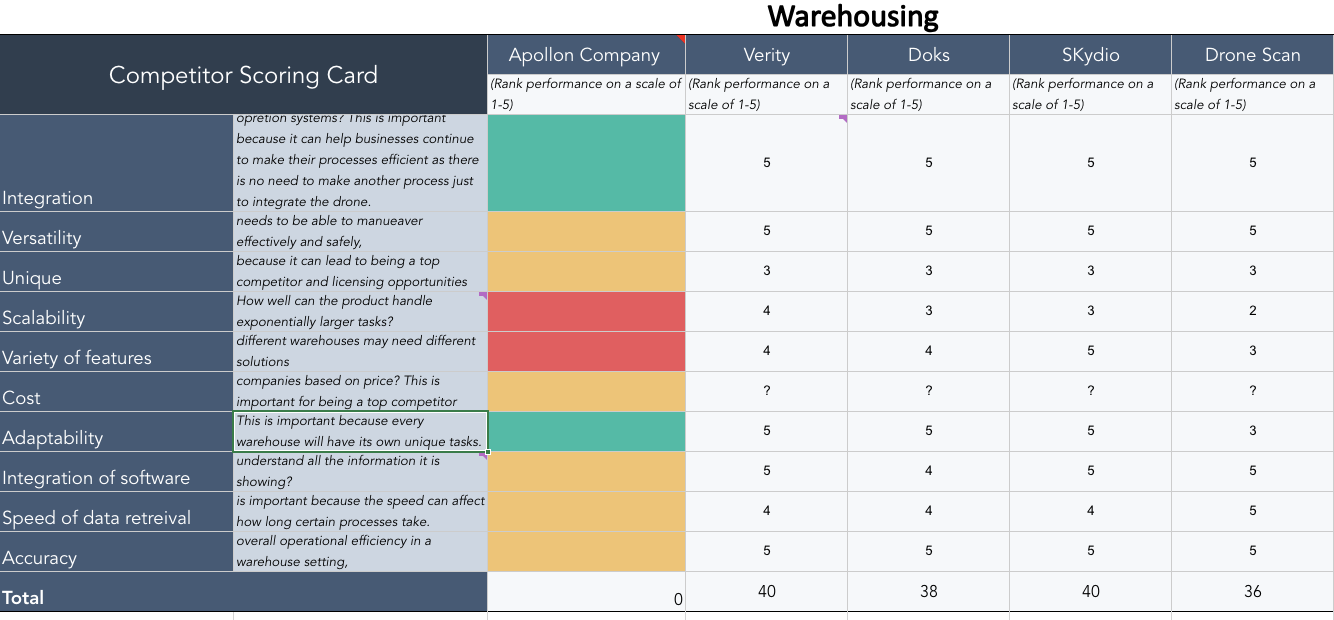
The companies Helinet, Yuneec, DJI, and FreeFly Systems were scored on a scale of 1-5 on the following criteria: photo quality, stability, shutter speed, battery life, price, payload options, speed, size, features, reputation, versatility, and TV/Movie exemptions.

All companies received a score of 5 on stability due to their use of stabilizers and sensors throughout the hardware of the drone to ensure that weather conditions did not affect hovering stability.

* All companies, except Yuneec, also received a 5 on their TV/Movie exemptions. They are widely used in the film and production industry and have good standing with the FAA and therefore are given exemptions easily.
* Helinet received the lowest score, 32, because they do not promote use of their own payloads (unknown if they even make payloads). Instead, they use the payloads of other companies such as DJI and FreeFly. Therefore, Helinet received a score of 0 for the criteria of photo quality and payload options. Additionally, their battery life and price received a score of 3 because they are not appealing to production companies with limited budgets. It should also be noted that Helinet mainly focuses on providing aerial vehicles for news broadcasting systems and not as much for film productions they way the other companies do.
* DJI received the highest score of 46. They received a score of 5 on all criteria except 2 (battery life and payload options). This is due to their extensive work with production companies and crew, this results in drones and payloads that provide high quality images with low prices. Despite not having many payload options that are easily interchangeable, the few that they do have surpass that of other companies with integrated AI technology that appeals to film production companies.
* Yuneec and Freefly Systems have a tied score of 45, right behind DJI. Yunnec had balanced scores all throughout the criteria, having a lot of versatility amongst its drone and payload capabilities. Yuneec only fell short in its battery life with a score of 3, however this is not uncommon as all other companies also struggled with this criterion. Freefly Systems had very high scores all throughout the criteria. Like DJI they also work intensively with production companies and crew to obtain feedback on how to better improve their drones for this specific industry. The only reason it fell short and behind DJI is due to their prices. Freefly Systems received a score of 2 because it has the highest prices out of all the other companies, making it inaccessible for small production companies.

Warehousing

Top 3 Industries for Apollon Company



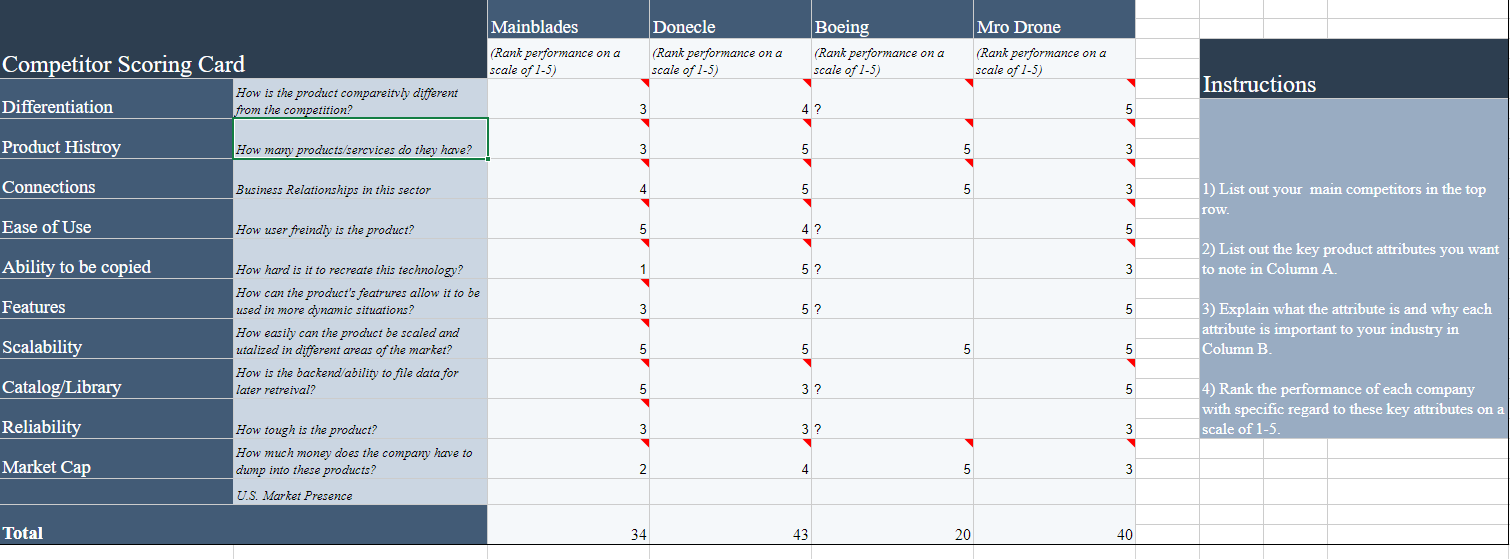
The ten attributes that we chose to focus on are integration, versatility, uniqueness, scalability, variety of products, cost, integration of software, ease of use, speed of data retrieval, and accuracy. The ease of integrating a drone into an already existing process helps with ensuring minimal description on ongoing operations. This allows for a more efficient transition to incorporating the drone technology into the operations which again helps with a seamless process. Versatility is important because every warehouse has different tasks. A versatile drone could be used for many reasons such as inventory management, inspections, surveillance, and more. If a drone is versatile, a single drone could address multiple tasks and needs which makes it a cost-effective purchase for warehouses. The uniqueness of a drone is also important as it can help distinguish itself from traditional tools used within warehousing such as warehouse pickers which are extremely unsafe. Being able to maneuver effectively or execute specific tasks adds to the value of a drone. Scalability is important because if drone manufacturers plan to offer drones with more features, then creating a scalable drone solution can help with adapting to the increasing demands of warehouse operations. This in turn could turn into a long-term investment for consumers that may align with their own warehouse expansion ideas and/or strategies. Having a variety of products with a variety of sizes, weight, shape, etc. is important for a drone’s adaptability and applicability in different warehouse environments, as they all vary. The cost of technology is arguably one of the most important considerations for any purchase decision, providing a good return on investment to clients is key to being a top competitor. Adaptability allows drones to be used for more than one task. The ease of use of drones can be very crucial for integrating itself successfully into the already existing workflow of the warehouse operations. Interfaces that are user-friendly, controls that are intuitive, and even training requirements that are minimal may contribute to the ease of adding a drone to the daily operations of a warehouse. Speed of data retrieval is important within a drone because warehouses are fast paced environments where the data retrieval process is an important factor as it can help make operations more efficient. If personnel require certain data to complete tasks, a slow retrieval of data may slow down that process. Lastly, accuracy helps with tasks such as inventory management, inspections, and quality control of a warehouse. If there is high precision with the data retrieval, then this will ensure that there are reliable and even actionable insights. Overall, this improves the quality of the processes and operations in a warehouse.

The four competitors we chose are Verity, Doks, Skydio, and Drone Scan. Verity ended with a score of 40. This is because the drones have the ability to create a digital model of the warehouse using the cameras within the drone. This adds to the accuracy and adaptability of the drones from Verity. It is also very easy and convenient to schedule specific checks on areas within the warehouse or even the entire facility. The drone also features its own software named verity cloud which helps with integration of operations. Doks ended with a score of 38 in the competitor scoring card. Although their drones contain powerful and accurate sensors, their drones do not contain much uniqueness of features compared to the other competitors listed. Although, a cool feature they have is that their drones have a night flight mode which allows for easy use in a dark environment. Doks also create images of every object that is captured which helps with organization and accuracy of location. Skydio obtained a score of 40. Skydio is very unique as it uses an artificial intelligence-driven system of navigation. This helps with staying on top of the curve with new technology that is on the rise. This artificial intelligence increases their accuracy with obstacle avoidance and data retrieval. The drone also captures data in a fast and efficient manner which helps with mapping out the environment of the warehouse. Similar to Verity, Skydio can also be scheduled to map out certain areas. Finally, Drone Scan received a score of 36. This is because the Hummingbird from Drone Scan is an attachment to a specific drone. Meaning it does not add more variety of features for warehouse tasks. It is pretty easy to attach to a drone and it can be used for inspection. The rate of the attachment is about 2 seconds per barcode for inventory management and 5 seconds per pallet.

Based on this information, we recommend the Apollo company to focus on ease of use, adaptability, integration, and variety of features. Focusing on these will allow the Apollon company to stand out from the four main competitors mentioned above. Integrating artificial intelligence will help with their accuracy and overall addition of adaptable and applicable features on the drone.   
**Why the Warehouse Drone Industry is the Best Fit for the Apollon Company**

The warehouse industry is the best fit for the Apollon Company as they can be a powerful competitor in the market. The market is continually growing, which can help the Apollon Company insert itself into the industry. Apollon's dedication to innovation is a key asset in a rapidly evolving industry. If they introduce new features like the ones mentioned (enhanced battery life, precise navigation in confined spaces, and advanced data analytics) they can distinguish themselves from competitors and ultimately gain a competitive edge in this market.

Plane Inspections:



The Plane Inspection industry is highly competitive, with major players like Donecle, Boeing, and Mro Drone having a strong presence. These companies have already secured contracts and their technologies are operational in airports globally.

Mainblades stands out with a standard product but places a strong emphasis on training and implementation. Based in the EU, Mainblades has numerous contracts with airports. Their focus on training and user-friendliness, coupled with a scalable business model, sets them apart. The strength of Mainblades lies in its software and backend systems, positioning them as a smaller-cap company in the market.

Donecle distinguishes itself with patented sensors, a key differentiator for their products. They have a long-standing presence in the industry and are well-established in the aerospace sector worldwide. Although specifics about their backend technology are not widely known, it appears to be plug-and-play. Donecle's unique features, particularly their advanced sensors, enable them to generate data beyond the capabilities of their competitors. Their product focus and backend integration with various technologies contribute to their global footprint, though their market cap remains unspecified.

Boeing, a giant in the aerospace sector, has limited public information regarding their specific offerings in this area. However, they are known to have contracts and products under testing with the U.S. Air Force. Boeing's strong, established connections in both public and private markets worldwide, along with a substantial market cap, allow them significant investment potential in new technologies.

Mro Drones, a newer entrant in the market, has developed a unique product and accompanying software. Despite being a recent player, they have carved a niche with an integrated approach where each component, though simple individually, works synergistically, outperforming similar-sized competition. Focusing primarily on smaller airfields and customers, Mro Drones is still growing in market value and experience and has a small market cap.

**Recommendations for Apollon Company**: Given the high level of competition, regulatory hurdles, and substantial startup costs in this market, it might be advisable to focus on developing a patentable product or a unique product feature. Such innovation could attract interest from larger companies like Boeing for licensing or acquisition, presenting a strategic entry point into the market. However, overall, the market does not seem to be a suitable fit for Apollon Company at this stage.

**Warehouse Drone Industry**

Constraints and Technical Requirements (Include the Research Question findings here)

**Technical Requirements**

In the United States, the average warehouse is a bit over 15,000 square feet. Due to this, small warehouses are considered to be under 15,000 square feet and those over 15,000 square feet are considered large warehouses. Typically, smaller warehouses are used as storage facilities and larger warehouses provide easy access to highways and loading docks. For this exact question there was no direct answer when conducting research online, therefore by looking at the clients of different drone companies and seeing what the size usually is, one can infer that an average size and large warehouse are the adequate size for drones.

In North America, the largest ports are in Los Angeles, Long Beach, New York and New Jersey, Georgia (more specifically Savannah and Brunswick), Seattle-Tacoma, Houston, Oakland, South Carolina, Port Metro Vancouver, and Virginia. Therefore, these cities could serve as an answer to where warehouses that could use drones are generally located. This is because these cities serve as epicenters of global trade and supply chain connectivity, meaning that warehouses in these locations can play pivotal roles in handling large quantities of goods and materials. By targeting warehouses near major ports, Apollon can tap into a plethora of logistical activity, and can offer advanced drone solutions that cater to the evolving needs of warehouses.

The prices of drones and the services are not public information. However, after further research it could be seen that Skydio drones cost around $999, but this does not include the monthly drone services if any fixing needs to be done. Therefore, the Apollon Company should consider Skydio’s prices as a benchmark for prices but the overall cost can extend beyond the initial purchase price. There are different costs and services that can be provided such as maintenance, repairs, and software updates. In addition, the lack of published pricing information may mean that the Apollon company could go through a different approach and emphasize tailored solutions and flexible service models that align with diverse client needs as any industry that has to do with fulfillment, picking, packing, and fulfilling orders may benefit from drones. As an example, the Canadian DSV offices focus on air freight and sea freight services. Something important to add is that inventory accuracy is important in any industry but more specifically those in, “supply chain management and retail, as it directly impacts the efficiency of operations, customer satisfaction, and financial performance.”

**Constraints**

In terms of regulations, the FAA does not regulate the usage of drones in an indoor setting as indoor spaces are not part of the national airspace system. Due to this there are no indoor regulations or laws for drones. However, the Apollon company should still practice safety indoors. To add, in order to use drones autonomously beyond the visual line of sight, operators need to have a waiver from the FAA.

There are many things that may make a drone considered safe in an indoor setting. The drone scan website states that, “Mechanical features such as propeller guards are fitted to reduce the risk of damage. Electronic safety measures such as fuses and emergency cut-off switches are recommended to prevent electrical fires when a drone motor stalls or draws a high current after crashing.” In terms of propellers, they should always be plastic as they can potentially hurt people or items. To protect the public, there should be signs that state there is a drone flying in the area. Therefore, the Apollon company should try and make their drones as safe as they can. This is because there are different safety issues related to operating drones indoors. For example, if the drone is operated when there are people in the warehouse also working then there is a risk of flying into people. Not only that but if there are other machinery being used then the drones may damage the machinery and vice versa. In addition, knocking over any boxes/pallets may bring damage to the material but may also hurt people if the materials fall ons someone. There can also be interference between signals that are exchanged between the drone and the remote controller. Large industrial equipment can emit a stronger magnetic field.

Repetitive Injury Reduction:

* Using drones for cycle counting can significantly decrease the number of workers required to perform repetitive tasks. Since injuries from repetitive motion are among the most common, reducing this number not only enhances operational efficiency but also results in substantial cost savings
* In 2012, the incident rate for repetitive motion injuries was 3.0 incidents per 10,000 workers. Overexertion accounted for a higher rate of 12.5 incidents per 10,000 workers. Notably, repetitive motion is often a contributing factor in overexertion cases. (OSHA Statistics)

Warehouse Requirements

* Many drone companies that supply warehouses require a minimum 100k square footage warehouse. This was specifically stated by the company Ware AI who also partners with Skydio. Although they did not outright say they only work with warehouses that meet this requirement they made it clear these are the type of warehouses they prioritize. Therefore, leaving a large middle market that could be filled with the Apollon company. Providing smaller companies with trials/demos could allow them to satisfy their need for quick inventory intake without the need for a significant initial investment.
* Warehouses that are relatively adaptive to high/common technology are required to effectively integrate the use of drones. This does not necessarily mean that smaller local warehouses cannot use drones, however, they do need to be able to have a warehouse management system (WMS) that can work well with the drone’s software system without causing too many issues. Or it must be capable of switching entirely to a system that is compatible with drones. If the data is manually uploaded it also poses the issue of human error that often occurs when inventory is collected manually. Additionally, it can take a lot of time for a person to manually upload this data into the company’s WMS, versus it being done automatically by the drone or a more advanced WMS which can take a few minutes.

**Customer Discovery Findings**

The following is a script that I used use when contacting the warehousing companies in order to conduct research about the market:

* “Hi. My name is Wendy and I am a college student at Cal Poly Pomona. I am taking a course named Global Entrepreneurial Marketing and I am completing a research project based on the use of drones in the warehouse industry. Is it okay if I ask you quick questions regarding this?”
* “Does your warehouse use drones?”
* Why not?
* “What would make you get drones for your warehouse”
* “How much would you be willing to pay”
* “What features would you want the drones to have?”

In the pursuit of information regarding drone usage in warehouses, outreach was made to several companies, including Exxtra Express Warehouse and Distribution in Pico Rivera. Unfortunately, no response was received despite two phone calls. Similarly, attempts were made to contact SFE Logistics Two Inc at their Commerce location, but it was found that the number listed on both their website and Google Business was incorrect. I finally obtained a reply from Gallop Warehouse & Distribution INC. However, there were language barriers which made many of the answers difficult to understand and a lack of complexity within them. The replies I got were one or two words, however, this does provide information for our research. The lady stated that their warehouse does not use drones because they are too expensive. I asked how much they would be willing to pay and they either said not too much or none at all. Someone at Fulfillment World in Pico Rivera answered my questions as well. This was by far the best reply I have received on a call. She was very eager to answer my questions. She mentioned that their warehouse does not use any drones and she suspects that money may be an issue. However, she expressed that drones would be very, very, helpful for her warehouse! She even brought the idea up to her managers before but they said no therefore she said that they would be willing to pay $0. She said the racks are really high up so if they ever want to check what is in a pallet, they have to wait for someone to wait for someone to bring the pallet down and manually check them. Also, the workers have to climb a long ladder which could bring safety issues to the warehouse. Drones would help with safety and efficiency. The FedEx Freight warehouse in Gardena does not use drones as they have no use for them due to the fact that the company is trying to obtain RFID tagging which is a tracking system that uses radio frequency to identify, search, and track items.

Then I reached out to Cal Poly Pomona students and alumni. For the first current student, Daniel, I asked if the warehouse he worked at uses drones. He let me know that the warehouse does not use any drones. He was unsure as to why the warehouse did not use them. However, he says that he thinks that it may be due to the cost of the drone services and that the company would not be willing to spend more money. As an example, he states that the warehouses used conveyor belts. However, these conveyor belts were not electric, autonomous, or automatic. Rather, the conveyor belts in the warehouse were manual rollers. With this information, one can infer that the warehouse does not want or have enough finances to invest in technology for their warehouse. After discussing this, I asked Daniel if he thinks that drones would benefit his warehouse in any way. He said that he does think they would benefit warehouses. He stated that every year, there are some days where their licensed forklift drivers could only come in on the weekends to look at the inventory they had on top of shelves and count them. This, of course, could delay warehouse operations and be costly in terms of time. Daniel mentioned that due to this, he thinks that drones could help save time and make warehouse operations more efficient.

Esther, a Cal Poly Pomona TOM alum, let me know that her specific Target warehouse does not use drones. She believes that the reason why her building does not use drones is mostly due to safety, costs, and even due to training. In terms of safety, the warehouse has a limited amount of space which they want to maximize the capacity of the building. Due to this, drones may lead to spaces in the warehouse that may not be used. This could lead to using drones in conditions that are not safe as there are cramped spaces and low ceiling. The company may also have to spend money in order to expand the warehouse to create more space for the drones to fly freely and safely. There would also be more expenses with hiring people who are certified to fly the drones or to invest in any sort of drone services such as repairs, etc. Time would also be a factor as the drones would have to be implemented into a new process at the warehouse. By replacing the old process that already exists, Target would have to invest more time and money. Esther, however, believes that drones would benefit her warehouse. Drones could help save ground space as the warehouse used different equipment on a daily basis. However, she mentions that by getting more ground space on the warehouse the warehouse may need more vertical space instead to accommodate the drones. A big help that the drones would provide is being able to reach spaces that cannot be typically reached without machinery or human input as well as safety issues such as using a ladder. In terms of cost, Esther is unsure how much the company would be willing to spend for drone services. She says that they would not only need to consider the costs of the drones but also the services, the space expansion, and finding or training appropriate staff. Due to this, Esther thinks that the cost would be too expensive and may be one of the largest reasons as to why the business does not have any drones in the warehouse.

With these examples, one can see that cost is a big factor on whether or not warehouses have drones. But warehouses may benefit time wise and efficiency wise with drones.

Source: Interview with David Ardolino (<https://www.linkedin.com/in/david-ardolino-3855438/>)

Understanding the increasing importance of RFID in modern warehousing practices, it's evident that innovative solutions like a drone-based product are critical for the future of inventory management. Retail giants such as Walmart and Macy's are moving towards mandating RFID technology in their warehouses, a trend that underscores the necessity of adapting to these advanced systems.

Dave's enthusiasm about the integration of drones in warehouse operations, particularly for cycle counting, is a testament to the potential of this technology. His surprise at the novelty and effectiveness of such a solution highlights a significant gap in the current market offerings, which a product like this aims to fill.

The ideal product leverages drones equipped with RFID technology to revolutionize the process of cycle counting. Cycle counting, an essential aspect of inventory management, typically requires significant manpower. Traditional methods involve multiple employees dedicated full-time to this task. By utilizing drones for cycle counting, our product not only automates this process but also introduces unparalleled efficiency and accuracy.

The cost-effectiveness of a drone-based solution is particularly notable. With an initial installation cost of $50,000 and a subscription fee of $200 per drone, the overall expenditure is considerably lower than the annual salary of a cycle counter. This makes the product a financially viable alternative to traditional methods and comparable technologies in the market, such as Locus Robots.

It's essential to consider this type product within the broader context of technological advancements in warehousing. While technologies like Libiarobot and Kardex ASRS have their own applications in material handling and storage optimization, a drone-based cycle counting solution stands out for its unique approach to inventory management.

Source: <https://www.linkedin.com/company/american-western-distribution>

* When discussing in team meetings, it can be seen that drones are never mentioned and may be a reason why they do not incorporate new technologies into their warehouses
* Some industries do not require having a drone and is not seem as useful for the jobs the workers are doing
* They would like drones that would keep track of inventory because of the industry they are working in
* Price plays a major factor if they are willing to invest their funding on items that can help their company grow

Source: Interview with JCT Logistics (<https://www.linkedin.com/company/jct-logistics/> )

Based on the interview with the inventory manager of the Ontario, CA location for JCT Logistics the following information was gathered:

* The major reason for why these independently owned companies have not switched to using drones is because they already find that their current software systems are efficient and effective. The inventory manager that spoke to us, mentioned that they had previously attempted to introduce drones in their warehouse, however, despite the low cost initially being a benefit the systems were not easy to use for their employees or their customers which he noted was a big reason for why they like their current system. Because it allows their customers to view the inventory as well without hassle.
* Additionally, he mentioned that the technical and customer support for their current system is really great, something that was lacked by the company they tried working with when introducing the drones. They did not have help from the company to make the transition easy or a system that allowed their own customers to also see the inventory.
* Although no specific features were mentioned, it was stated that the lack of additional features was also a reason for why they did not continue with the drone services. He did not mention any issues regarding the drones themselves however, nor did he disclose what company they used at the time of their initial attempts.

Source: Sean Mitchell (<https://www.linkedin.com/in/seantmitchell/> )

During the interview with Sean Mitchell I was able to gather several bits of information regarding their company priorities for Gather AI.

* Previously, they had Ware AI as a competitor, however, Gather AI bought them out and was able to establish new company priorities and services. Prior to being bought, Ware AI determined what warehouses they were willing to work with based on the square footage of the warehouse, they prioritized warehouses with 100k sqft. However, they have now shifted to prioritize number of pallets, rather than square footage. Their smallest warehouse holds up to 500 pallets and their largest warehouse holds over 65,000 pallets, additionally they are interested in warehouses that stack their pallets because this allows them to store more inventory.
* Their drone battery last up to 20 minutes and one operator can oversee up to 3 drones at a time. Each battery time allows for a warehouse employee to register 100-150 pallets at a time. Therefore, if a warehouse employee is working with 3 drones, they are able to register up 900 pallets within one hour.
* Additional features included with the drone are autonomous flying and AI integration. Mr. Mitchell shared that their drones do not work with barcode scanners, rather they take pictures of the pallets, and the AI will read the text and barcode of each pallet and register the time the photo was taken as well as pinpoint the location of the pallet. This allows for easy traceability in case the pallet needs to be located afterwards, the data will inform the employee of what aisle and level the pallet was scanned.
* Gather AI does not provide a Warehouse Management System (WMS) of their own. The data that is obtained by the drones is uploaded to a web dashboard, and an employee must manually transfer the data onto their company’s WMS. This can cause issues on the accuracy of the data transferred because it allows for human error.
* Mr. Mitchell was not able to share their prices for their drones, however he was able to share that it is based on a tier system depending on the warehouse’s needs, such as features, amount of drones, and system needs.

**Conversations and Interviews**

I, Liz Fischer, was able to have conversations with several different companies. First was Marcel with Bayer. His responses were as follows for a warehouse that does utilize drones in warehouses:

1. Current Use - cataloging and warehouse mapping; monitor stock and inventory; less forklift drivers=less injury
2. Pain Points - data/inventory accuracy
3. Improvement Suggestions - better obstacle detection and avoidance, more advanced data integration with inventory management systems
4. Willingness to Pay - unsure but would assume based on how effectively it improved operations
5. Satisfaction - (1-5) 4 because always room to improve
6. Reason for company choice - unknown
7. Cost of Drone Service - assumed/guessed 10k annually but completely unknown
8. Reason for Possible Switch - better value for investment; solutions with competitive pricing

Additionally, after several attempts to reach other warehouses, I was able to get an email response from Giant Eagle. “Currently they are not using drones due to costs and union ramifications.”

**Analysis of Findings**

After many discussions completed by me and the team from our warehouse direct research we were able to deduce some common themes and similarities. A lot of the organizations were dismissing the use of drones in their warehouses due to expense. In our research we did not find the cost associated with drones readily available. It was clear there was interest, but to determine the cost for a specific business/warehouse, they would need to request a quote related to their needs. The more we dug deeper into this topic we found most of these companies were unaware of the costs associated with UAV, the limited regulations, and the usability and functionality for drone use in daily business activities. These warehouses have an extremely specific need to reduce work related injuries due to forklift, falling from ladders, falling inventory, etc. There is an opportunity to market drones for inventory management/cycle counting to the warehouse sector based on our research. There is very little awareness and currently this industry could be considered as an untapped market. Below is some additional research we conducted based on these findings to help determine a possible cost benefit to implementing drone usage to reduce injury. The following data is a high-level average for warehouses within the United States. It will need to be drilled down further on a case-by-case basis as you present options to an organization based on their warehouse size and number of employees acting in these potentially hazardous roles. From there you can determine the targeted warehouse size needed for there to be a significant cost benefit.

**High Level Cost Benefit Analysis**

**Time/Staffing Savings in Cycle Counting**

**3 Types**

* ABC Cycle Counting
  + Most Used and most complex
  + Highest Value (dollar amount, demand, turnover) Counted More Frequently
    - A = Highest and counted every month
    - B = Mid counted every quarter
    - C = Low Counted 2 x’s a year
* Random Sample Cycle Counting
  + A select # of items are chosen to be counted at random because there is a large number of similar items
  + Generally done daily
  + Can be done 1 of 2 ways: same # of items counted each time or items counted are excluded from the following days counted to decrease over time the total # of items
* Control Group Cycle Counting
  + Small set of items repeatedly to see if any counting errors

It is advised that inventory management be done at the beginning and the end of each work day using one of these methods. ABC Cycle counting has been determined the most effective. “Better [inventory control](https://dclcorp.com/blog/inventory/inventory-control/) is one of the easiest ways to improve revenue, but many companies focus their attention elsewhere.” Physical inventories are lengthy and often require warehouse closure. Cycle counting can be done more regularly and during normal operations. Currently cycle counting requires multiple teams to manually confirm and enter data into a warehouse management and inventory management system. It is our position via our research that cycle counting completed by drones that are seamlessly integrated with these management systems will have significant time savings due to the efficiency and accuracy.

<https://dclcorp.com/blog/inventory/inventory-cycle-count/> Accessed - 11/13/2023

**Reduced Injury and Cost Benefit Analysis**

**Work-related Fatalities, Injuries, and Illnesses**

**This section presents data for the warehouse industry on the number of workplace fatalities and the rates of workplace injuries and illnesses per 100 full-time workers in warehousing and storage. An injury or illness is considered to be work-related if an event or exposure in the work environment either caused or contributed to the resulting condition or significantly aggravated a pre-existing condition.**

**Warehouse Sector Includes**

1. Industrial Truck and tractor operators
2. Laborers and freight, stock, and material movers, hand
3. Shipping, receiving and traffic clerks
4. Stock clerks and order fillers
5. Transportation storage and distribution managers

**Based on Bureau of Labor and Statistics Warehousing Industry Injury Data**

Total # of Fatalities in 2021 was 46

Total Recordable Cases of Injury in 2022 was 69,307 in the warehouse sector alone

[**https://www.bls.gov/iag/tgs/iag493.htm#fatalities\_injuries\_and\_illnesses**](https://www.bls.gov/iag/tgs/iag493.htm#fatalities_injuries_and_illnesses)

It has been determined by the bureau of Labor and Statistics that Warehousing is one of the 4 most dangerous occupations. According to NSC “**Transportation and warehousing**– experienced the highest injury and illness rate involving days away from work per 10,000 workers”

<https://injuryfacts.nsc.org/work/industry-incidence-rates/most-dangerous-industries/>

**According to the National Security Council as of 2021…**

The cost per worker with days of work lost is $1,080

The cost per death is $1,340,000

The cost per medically consulted injury is $42,000

<https://injuryfacts.nsc.org/work/costs/work-injury-costs/>

**What is the Bottom Line Cost Industry Wide?**

Warehouse industry fatalities totaled approximately $61,640,000

Warehouse injuries cost a minimum of approximately $74,851,560

We can add industry wide approximately $291,089,400 to the cost of injuries for every 10% of accidents that ended up with medical consultations.

If we assume that 30% of these total warehouse injuries ended up in medical consultations (total annual industry expense $1,009,759,760) which is conservative based on the high injury and illness rates. We then take the total number of warehouses in the US of approximately 21,000 and can assume the average cost per warehouse is $48,083 annually.

It is clear that the cost will be relative to the size of the warehouse and will be subjective to each companies % market share and how many of these injuries were specific to the warehouse itself, however as a general calculation this supports the probability that there is a market share for dangerous manual and machine labor to be replaced by drone technologies to significantly reduce the # of industry related injuries and in turn the cost in medical legal and lost wages expenses.

For Census Data surrounding Fatal Occupational Injuries as of December 16, 2022 please reference the link below from the bureau of labor and statistics

<https://www.bls.gov/news.release/archives/cfoi_12162022.htm>

For Additional Research on Ladder Specific Related Injuries

<https://www.bls.gov/opub/ted/2022/fatal-injuries-from-ladders-down-in-2020-nonfatal-ladder-injuries-were-essentially-unchanged.htm>

**Discussion and Recommendations (I am thinking we all should do this part individually and then we can come together a create a final copy that includes all our opinions)**

Zach’s response:

The warehousing drone industry presents a promising opportunity for The Apollon Company, particularly considering Dr. Anhdoh's interests and the industry's current landscape. This sector, still in its early stages, is projected for significant growth, making it an ideal time for entry.

One of the key factors bolstering this opportunity is the current market composition. With only a few major players in the drone warehousing industry, there's a substantial opening for new entrants. This scenario is further enhanced by the already recognized need for drone technology in warehouse operations, signaling a receptive market.

In the United States alone, there are tens of thousands of warehouses, many of which are yet to fully integrate advanced technologies. This gap presents a vast potential customer base for drone technology, especially for applications like cycle counting and inventory tracking. The implementation of drones in these areas is not only straightforward but also seamlessly integratable with existing warehouse operations, making it an attractive proposition for potential clients.

The focus on utilizing RFID technology in our drone solutions is particularly strategic. RFID offers numerous advantages in terms of efficiency, accuracy, and data management, which are crucial in inventory management and cycle counting. By leveraging RFID, our drone solutions can offer more value than traditional methods, positioning our product as a superior alternative in the market.

It's noteworthy that while many companies are exploring various aspects of warehouse operations, the specific sector of drone technology for inventory management remains largely untapped at a large scale. This situation presents a unique niche for The Apollon Company to capitalize on.

Market research indicates that major warehouse brands are not fully aware of the benefits and capabilities of drone technology for their operations. This lack of awareness represents both a challenge and an opportunity. The challenge lies in educating the market about the potential and advantages of drone technology. However, it also presents a significant opportunity for market penetration and establishing a strong brand presence.

Given these insights, The Apollon Company's main focus should be on two key areas: developing a robust, user-friendly, and efficient drone product tailored for warehousing needs, particularly in cycle counting and inventory tracking; and executing an effective marketing strategy. This strategy should not only highlight the product's unique benefits but also educate potential customers on how drone technology can revolutionize their warehouse operations. With the right approach, The Apollon Company has the potential to become a leading player in this emerging and lucrative market.

Alex’s response:

* Focus on marketing because some companies are unaware of the benefits and lack the acknowledgment
* Most warehouses are outdated and lack the integration of new technology
* Focusing on how the new technology can be incorporated into old warehouses
* Using AI to automate drone operations may be great due to how AI has improved throughout the years

**Discussion and Recommendations**

Based on the Information provided and discussed about, it is recommended that the Apollon company enters the drones in warehouses market. There is a lot of potential in this sector, as it is expected to grow. They can definitely integrate the technology they have already helped develop into the drones they create. In a way, this gives them an advantage as they have the experience with entering different market segments within different technology sectors.

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