**Review of Related Literature**

**Weather Stations**

Weather stations are devices used by several weather-related companies that, as the name implies, collect data that are related to the weather and environment. These weather stations use multiple sensors to be able to forecast and analyze weather. The sensors that are usually included in a weather station are barometers that measure the atmospheric pressure, thermometers to measure the temperature, hygrometers that measure the percentage of water vapor in the air or humidity, wind vanes that could tell the direction of where the wind is blowing, anemometers that measures current, peak, and average wind speeds, rain gauges that measures rainfall, and several other sensors depending on the manufacturer. Weather stations aren’t just for professional use, there are also weather stations being sold for home use. (Acurite, 2010)

Weather stations also come in two main types, manual and automatic stations. Manual weather stations are the traditional weather stations which are analog when measuring certain weather data. On the other hand, automatic weather stations, or AWS, have two main parts which are outdoor and indoor. The outdoor components of an AWS are the sensors that collect weather data, which then is sent to the indoor component of an AWS that displays the measurements and readings of the AWS. Many people, up to this day, still use the traditional manual weather stations, while many companies have migrated to the usage of an automatic weather station. One difference between a manual weather station and an automatic weather station is cost, with the latter being more expensive. (Moore, 2016)

**Barcode and RFID**

Barcoding, or barcode system, is a form of collecting data and an identification tool which does not require the use of physical keys. Barcodes are the black bars with gaps which are parallel that hold data contained in binary coding. Barcodes nowadays also come in other shapes such as rectangular ones. Each individual barcode has a unique pattern or shape that can correspond to an item or object. These barcodes are read using optical lasers which can interpret numerical and alphanumerical characters. According to Zebra Technologies, several forms of manual data collection and data entry has been replaced by the barcoding system. This is because the speed, as well as the accuracy, at which data is retrieved by barcoding is extremely quick and accurate. Zebra Technologies state that these barcoding systems are accurate 99% of the time. This is important due to the fact that data entry errors could cause negative effects on a business such as a wrong input of data within a manufacturing company could cause a decrease in production due to wrong values. (Zebra Technologies, 2013) Barcode technology could greatly impact the back-end of a business for numerous reasons. One of which is an improvement of the accuracy of data. This alone could possibly be the main intention for implementing a barcode system. The reason for its accuracy is due to the fact that the information are kept within the individual barcodes itself in which almost no human error could occur. According to BarCode ID Systems, the implementation of barcoding could greatly decrease operating expenses and have a noticeable return of investment with 6 months. Research also shows that barcode could increase warehouse operations inventory accuracy to about 99%. (Barcoding Inc., n.d.)

RFID, or Radio Frequency-Identification technology, is another type of tool used for data collection and uniquely identifying an item, similarly to barcodes. RFIDs contains a tiny chip and an antenna. As the name implies, RFIDs use radio frequencies to communicate with an RFID tag, or a transponder that contains information, which is interpreted using a transceiver that could interpret data. On paper, RFID is more sophisticated than barcodes with features such as farther read distances, faster read and write speeds, larger data capacity, higher levels of security, and many more. RFID systems also have their downsides though. Its drawbacks include higher pricing since it contains a computerized chip, and reader and tag collision errors when multiple readers and tags could cause errors to one another. (adaptalift, 2012)

**Preventative Maintenance**

Preventative maintenance is maintenance that is regularly performed on a piece of equipment to lessen the likelihood of it failing. Preventative maintenance is performed while the equipment is still working, so that it does not break down unexpectedly.

According to Stuart Smith of MINTEK, many companies still do not consider applying preventive maintenance to their equipment and only acting when the actual equipment has broken down or failed, causing expenses to rise for the company for the replacement of the broken equipment. Preventive maintenance has several advantages, one of which is that preventive maintenance could decrease the expenses of the company. Even though preventive maintenance is also expense for the company, the cost of preventive maintenance is lower, compared to the actual replacement of the same equipment. The second advantage is the increase of efficiency of the equipment, making the equipment run more cost effectively. Equipment that has 100% health would utilize energy or power resources better than low health equipment. Preventive Maintenance could also indirectly increase the reputation of the company. Since the goal of preventive maintenance is to reduce the likelihood of a failure to occur, the company's history or track record of failure in their equipment would be minimal to none. (Smith, 2012) Preventive maintenance lessens the number of large-scale repairs as well as improves the safety and quality conditions of the people working with and around the area of the said equipment.

According to Ken Staller of Daniel Penn Associates, there are six steps to devising a preventive maintenance program. The first step of preventive maintenance is by reverse engineering what the company want to achieve by designing the procedures and identifying the possible problems or failures that may occur to the equipment. Also, the architects of the preventive program must be knowledgeable of the equipment or machines, they must know how it works and what to do at failure of the equipment. The second step of devising a PM program is to know how to efficiently handle the use of people and resources. First, the company must have a Computerized Maintenance Management System, or CMMS, in order to effectively handle the data about the people and resources, and the procedures. Next, the right procedures must be written and sent to the CMMS. After that, these procedures must be scheduled. The 3rd step is proper preventive maintenance lubrication engineering. This step is basically proper maintenance of lubrication of the equipment, and handling oils and grease as well as proper disposal of these oils and greases according to the environmental rules depending on the area. The fourth step is to train the staff for correct and proper preventive maintenance. Make sure the staff knows how to operate, repair, and maintain equipment according to how they were trained. The 5th step is having a management plan for the PM program. A proper management plan is effectively attaining information that could be useful for future analysis. Such information includes labor-hours, quantity of materials, reason for specific Work Order, etc. Lastly, the sixth step is to make sure communication to the workers is present. Communication is key in almost all programs and systems. Not having communication to the workers could cause misunderstandings to as why they are required to do such tasks. Communication must be present so that the workers of the PM program would know what exactly should be done, who will do this certain task, and when it should be done. Also, they must know what quality of work must be done.

**Asset Management**

Asset management is basically organizing the assets of a company in order to improve efficiency and productivity as well as maintenance of the assets. According to jinisyssoftware, asset management systems make tracking assets easier and contain details which make assets more organized since this information about the assets are located inside a database which is seen in the web application of the asset management system if ever present. Benefits of implementing an asset management include improved asset tracking, improved productivity, and efficient in time handling. (Jinisys Software Inc. , n.d.)

According to the Federal Highway Administration, the proper definition of asset management, defined by Organization of Economic Cooperation and Development (OECD), is as follows:

*“[Asset Management is] a systematic process of maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing tools to facilitate a more organized and flexible approach to making the decisions necessary to achieve the public's expectations. (OECD 2000)”*

FHWA explains that there are different decision levels of asset management which may interconnect and overlap because communication between the levels is important for the management process. The first and most broad is the strategic decisionmaking level wherein its concern is with broad and generic resource allocation and utilization decisions. The next level is the network decisionmaking level. This level is similar to the strategic level but is narrower since overall budget allocation is a focus area here and is broken down into the other lower levels such as program level and project selection level. After that level is the program decisionmaking level which pertains to the policy decisions and focuses on the optimization of funds in the system. The next level is the project selection level which has to do with the funding for specific projects. This level needs more specific and detailed information compared to the program and network level. The last level is the project level which is the most specific of all levels due to the fact that it has to do with the design of the project which is part of the overall work plan. It is also known as the ‘field level’ or ‘operational level’. This level also shows the actual work which is needed to be done. (FHWA, 2015)

