ABSTRACT

FINK, J KINGSLEY JR. Process Improvement of a MRAP (Mine Resistant Ambush Protected) Vehicle Production Line. (Under the direction of Thom Hodgson.)

The MRAP, or Mine Resistant Ambush Protected, vehicle is a new military armored vehicle with the intent to sustain minimal or survivable damage due to the enemy's use of roadside bombs, mines, and IEDs, or Improvised Explosive Devices. BWW is a competing vendor for a contract to be a provider of MRAP vehicles. The United States government has stated that it has decided to fill its vehicle inventory with approximately 20,500 of the MRAP vehicles over the next five years. BWW tasked North Carolina State University to assist with the layout, resource allocations, and process of transforming a former automobile facility to produce these vehicles. Due to the deadlines imposed by the government, this needed to be completed promptly. After this analysis was complete, BWW decided, instead, to use their current manufacturing facility. BWW again turned to North Carolina State University to assist with the overall process at the facility. Using this manufacturing facility, BWW set an optimal output goal of 1 MRAP vehicle per day.

The production output of an assembly line can be optimized through the scheduling of the process through the use of Gantt Charts. To compare the different models with the revisions, we ran simulations to predict the change of the production output of the MRAP vehicles. The overall emphasis of the process improvement for this assembly line was performed on Station 9 to Station 12, which caused the largest lag in the overall assembly process. Using the simulation output, we can determine the number of vehicles produced per day.

Throughout this project, North Carolina State University personnel were in constant contact with the production company, BWW, in order to obtain the most updated and current information for this analysis.

Process Improvement of a MRAP (Mine Resistant Ambush Protected) Vehicle Production Line

by
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Biography

I was born in Honolulu, HI on August 11, 1975. While growing up, I lived throughout the state of Florida. After graduating high school in 1994, I enrolled in the United States Military Academy Preparatory School at Fort Monmouth, NJ. After this course, I attended the United States Military Academy in West Point, NY where I received a Bachelors of Science degree in Operations Research in May 1999.

In May 1999, I was also commissioned as a Second Lieutenant in the Field Artillery of the United States Army and after a brief leave reported to Fort Sill, OK to begin the Field Artillery Officer Basic Course. In January 2000, shortly after the completion of this course, I was assigned to my first duty station at Fort Benning, GA with the 3rd Brigade, 3rd Infantry Division (Mechanized). During this time, I was assigned in multiple positions of authority and responsibility as both as a Second and First Lieutenant. Also, during this time, I was also married to my beautiful and understanding wife, the former Donna Marie Lapczynski.

In November 2002, I was promoted to Captain and reported to Fort Sill, OK to begin the Field Artillery Captains Career Course. In May 2003, I was further assigned to Fort Sill, OK as my permanent duty station and successfully completed two company level commands. The first was the command of Charlie Company (Infantry), 1st Battalion, 78th Field Artillery. The second was the battery command of Bravo Battery (MLRS), 2nd Battalion, 4th Field Artillery.

Near the completion of my second command, I was offered the opportunity to instruct in the Department of Mathematics at the United States Military Academy. I agreed and enrolled in the North Carolina State University graduate program for Operations Research in July 2006. In August 2008, I will graduate with a Masters of Science degree in Operations Research and begin teaching in the Department of Mathematics at the United States Military Academy.

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Glossary

Body: The middle portion of the vehicle. Within this portion of the vehicle is where all passengers, minus the driver, ride while in the vehicle. Also, the turret is installed on the top of the body.

Figure 1. Example completed body portion of a MRAP vehicle.

Cab: The front portion of the vehicle. Within this portion of the vehicle is where the driver sits. It also contains all controlling panels for the vehicle.

Figure 2. Example partially completed cab portion of a MRAP vehicle.

Clamshell: The rear portion of the vehicle which contains the rear door. Referred to as a "clamshell" because of its distinct shape. The shape also assists in deflecting blasts from direct or indirect blasts to the rear of the vehicle.

Figure 3. Example completed clamshell portion of a MRAP vehicle.

Fibertec: Fabricated composite panels used as ballistic armor. This ballistic armor uses a solid resin and fiberglass woven roving construction without a core. This coreless material allows for ballistics to be absorbed but not allow penetration through the panel.[1] These panels are used, with Gold Shield, as ballistic protection for all passengers inside the MRAP vehicles.

Figure 4. Pre-trimmed pieces of Fibertec ready for installation in the MRAP vehicle.

Gantt Chart: The standard format for displaying a schedule graphically. Individual operations are displayed as horizontal bars in the chart, indicating the time at which the operation begins and ends. Many variations on the Gantt chart exist to display additional kinds of information. Gantt charts can be drawn physically on paper, but for the purpose of this analysis, Microsoft Excel was used to display the information.

Gold Shield: "Gold Shield® anti-ballistic composite enhances the bullet-resistance capability of aramid fibers compared to woven material. It is created by laying parallel strands of aramid fiber side by side and then bonding them in place with an advanced resin system."[2] These panels are used, with Fibertec, as ballistic protection for all passengers inside the MRAP vehicles.

Figure 5. Example piece of Gold Shield which is installed in the MRAP vehicle.

IED: Improvised Explosive Device. "An IED can be almost anything with any type of material and initiator. It is a "homemade" device that is designed to cause death or injury by using explosives alone or in combination with toxic chemicals, biological toxins, or radiological material. IEDs can be produced in varying sizes, functioning methods, containers, and delivery methods. IEDs can utilize commercial or military explosives, homemade explosives, or military ordnance and ordnance components."[3]

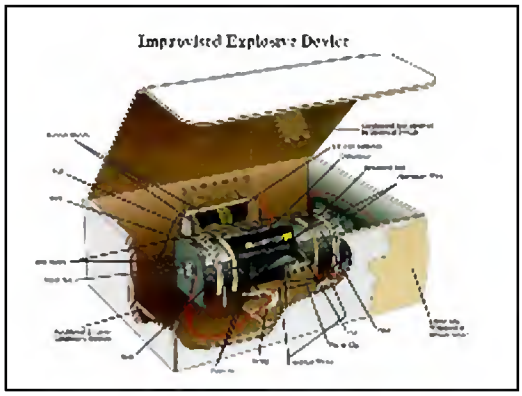

Figure 6. Example of an Improvised Explosive Device (IED).[4]

MRAP: Mine Resistant Ambush Protected vehicle. The design of this vehicle is a wheeled vehicle using a slanted or V-shaped hull to deflect the impact of a blast from the side or beneath of a vehicle by the use of explosives.[5]

Figure 7. Example of a MRAP vehicle portraying the slant on the front and side of the vehicle.

1 Introduction

A challenge faced by any manufacturing facility is producing in the most cost and time efficient manner as possible. This is especially true with an assembly, or production line, for a very large heavily armored vehicle like the MRAP, or Mine Resistant Ambush Protected, vehicle. The MRAP vehicle is a new armored vehicle with the intent to sustain minimal or survivable damage due to the enemy's use of roadside bombs, mines, and IEDs, or Improvised Explosive Devices. These bombs, mines, and IEDs have become a daily and deadly threat used by insurgents in both Iraq and Afghanistan. In fact, according to the Department of Defense military casualty statistics compiled from October 2001 to Feb 2008, IEDs and such explosives have accounted for nearly 50% of the deaths and 67% of wounded United States military personnel.[6] This is the primary reason that this type of vehicle is so necessary for the United States and its ally forces. As such, the United States government has decided to pursue a new armored vehicle named the MRAP vehicle. The overall design for the vehicle calls for a wheeled vehicle with the use of a slanted or V-shaped hull to deflect the impact of a blast from the side or beneath of a vehicle by the use of explosives.

Figure 8: A front and left side view of the MRAP vehicle produced by BWW.

BWW is a competing vendor for a contract to be a provider of MRAP vehicles. The United States government has stated that it has decided to fill its vehicle inventory with approximately 20,500 of the MRAP vehicles over the next five years. In order to find the best vehicle, the United States government tasked multiple vendors to produce such a vehicle for testing and fielding to its forces. After BWW had conducted its own research through development and testing of several

prototype models, they submitted their vehicle for testing by the United States government. After receiving positive feedback regarding their vehicle, they decided to move onto conducting resource analysis for the continued production of this vehicle. This analysis was extremely important because it would also be included within the bid proposal for the United States government's MRAP contract.

Originally, BWW realized that they could receive none, some, or all of the contact; however, they needed to plan as though they would receive the full contract for the bid proposal. In order to fulfill the entire contract requirements at maximum capacity, they initially planned to lease an old automobile facility. Using this facility, they planned for the manufacturing process to provide a daily output of 16 MRAP vehicles. To assist with the layout, resource allocations, and process of this facility, they tasked North Carolina State University to provide a feasible solution to their problem. In September 2007, North Carolina State University provided BWW with a capacity analysis and preliminary layout for this updated facility based on the company's requirements including an output of 16 MRAP vehicles produced per day. This initial report can be found in Appendix 1.

However, after further analysis was completed by the United States government, they decided that it would be more beneficial to spread the contract for the MRAP vehicle throughout multiple vendors. This would allow for multiple versions of the MRAP vehicle to be incorporated throughout the military in differing capacities. For example, the Marines would need a much different vehicle than would the Army because, generally, their missions are typically different in scope. Using this new information, BWW decided to revise their initial plan to lease an old automobile facility; instead, they would use their current manufacturing facility.

BWW again turned to North Carolina State University to assist with the overall process at the facility. Using this manufacturing facility, BWW set an optimal output goal of 1 MRAP vehicle per day. Using the current information that BWW had on hand, North Carolina State University provided BWW with a capacity analysis and preliminary layout based on the company's requirements.

2 Project Description

2.1 Objective

The objective of this project is to improve the overall process for the production of the MRAP vehicle in a BWW facility that is constrained on the space, equipment, and people. Limited historical data is available to determine the best course of action due to the limited number of vehicles that have been produced; however, using the most current production data and times, a more productive system will be determined to produce the maximum number of vehicles in the least amount of time possible with 1 MRAP vehicle produced per day being the optimal goal.

The production data and times will be obtained from the vehicles currently being produced at the BWW facility. This will act as a basis for the analysis involved in the process improvement of the system.

2.2 Assumptions

The assumptions involved to complete this project can be summarized by the following:

- All production time averages at each of the assembly stations, collected and provided by BWW, are both accurate and reliable.
- The current vehicle specifications will not change due to improvements, requirements, etc. Thus, each task at each station will remain the same and unchanged.
- Assume that the vast majority of processes will remain constant over time and will not improve as personnel are trained and process improvements are implemented.
- Each of the trim stations (i.e. Stations 9 – 12) will have a minimum of 2 people with a maximum of 4 people at each of the stations.

2.3 Overview

The remainder of this report is organized in the following order. Section 3 of this report explains the overall description of the processes involved with the production within the BWW's current facility. Section 4 discusses the methods used to improve the process involved in the production of the MRAP vehicles within the BWW's current facility. Section 5 discusses the sensitivity analysis. Section 6 reviews recommendations. Section 7 discusses conclusions and Section 8 discusses avenues for further research.

3 Production at the BWW Manufacturing Facility

BWW has the ultimate production output goal of manufacturing 1 vehicle every day within the BWW Manufacturing Facility. Initially, the layout of the facility was not conducive in order to achieve this output. Even with some alterations to the facility, it was still a lofty goal in order to achieve such an aggressive output rate. However, using this goal as a basis, process improvements were made to the manufacturing system that would attempt to meet that goal.

The manufacturing system involved maximizing the number of personnel assigned to a processing area. This would minimize the time it would take for the task at that processing area to be completed. However, one important constraint to take into account is that only 1 vehicle can be at a station at a time, with no queuing areas between stations. This, in turn, will cause a considerable slow down in the assembly at some of the stations due to a higher station assembly time.

A schematic of the overall BWW production facility for the MRAP vehicles can be found in Appendix 2. It depicts the current BWW production facility in its entirety with all areas or stations. BWW has provided North Carolina State University with the assembly times broken down at each of these different areas or stations. At this time, this data is the most recent information for use in this analysis. The facility can be broken down into the following areas as seen on the flowchart on the following page.

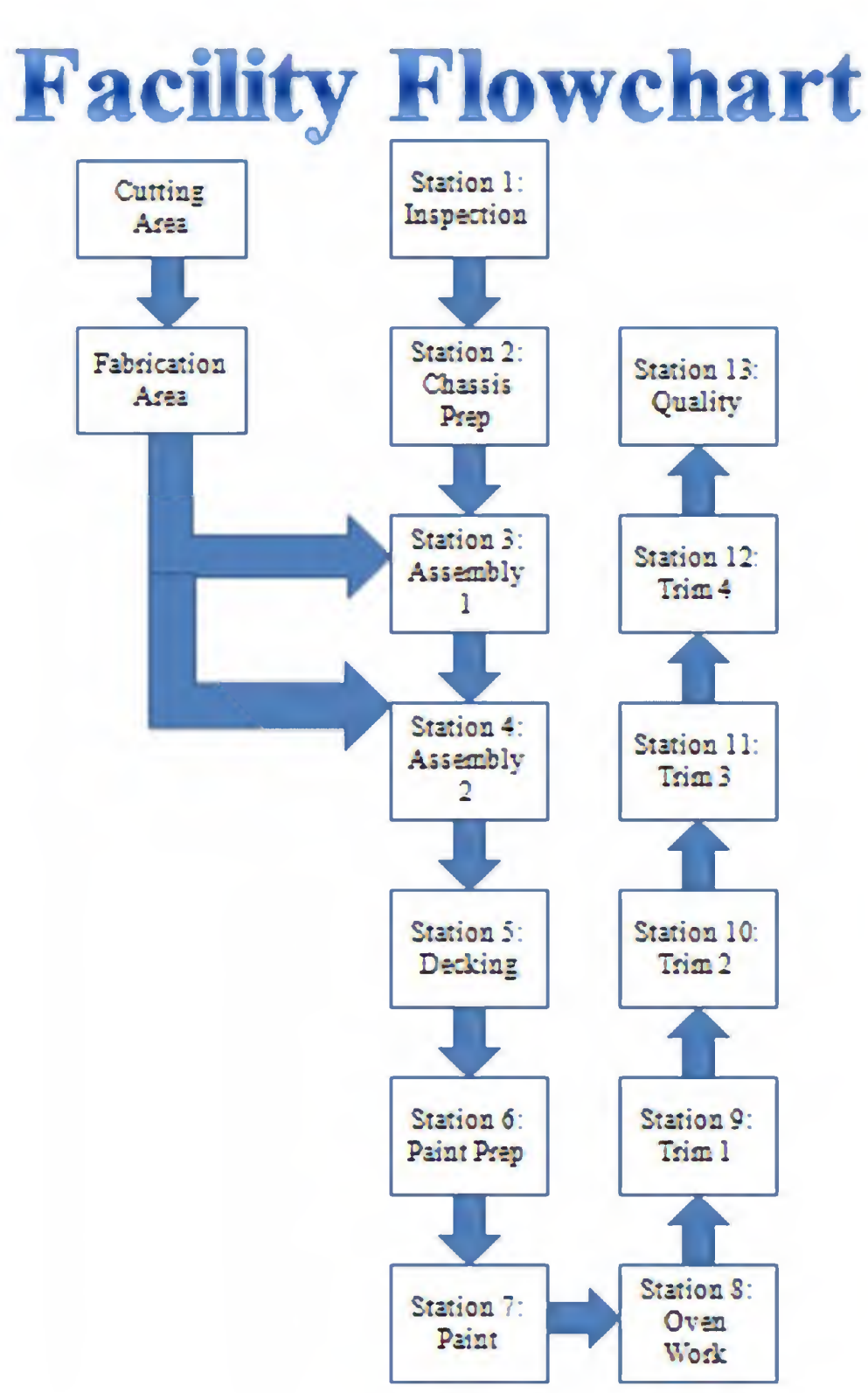

Figure 9. BWW Facility flowchart demonstrating the assembly flow of the MRAP vehicles.

The Cutting Area is composed of one large plasma cutter and two small plasma cutters. The larger plasma cutter is able to cut 24' x 8' sheets of steel. This area cuts all of the steel provided to the plant. It takes an average of 8 hours to cut the steel required to build one of the MRAP vehicles.

The Fabrication Shop enables the welders to weld the large parts that compose the MRAP vehicle. This shop contains the fixtures and jigs necessary. Within this same area is the MRAP Fabrication Area. This area takes cut steel directly from the Fabrication Shop and welds it into cabs, bodies, and front end parts. This section is a direct feed into Station 4 where the parts are welded together. The Small Parts Area fabricates smaller parts for the MRAP vehicle, which feeds parts directly to Station 3. Within this entire area, it takes an average of 8 hours to fabricate the parts required to build one of the MRAP vehicles.

The first station in the assembly process is Station 1, or the Inspection Station. At this station, several tasks are completed in succession. The tasks are the following: electrical inspection, air conditioner inspection, chassis inspection, the installation of the brake rod, vehicle test drive around the building, the disconnecting of the batteries and ECUs, and overall final chassis prep. Within this station, it takes an average of 8 hours to complete all of these tasks in order to push the vehicle to the next station.

Figure 10. Beginning of a test drive at Station 1.

The second station in the assembly process is Station 2, or the Chassis Preparation Station. At this station, six main tasks are completed in succession. These tasks are the following: installation of brake release rods, gas pedal horn pad, surge protector, electrical functions, engine compartment, and fuel tank. Within this station, it takes an average of 8 hours to complete all of these tasks in order to push the vehicle to the next station in the assembly line, which is Station 5.

Figure 11. Starting work on the engine compartment at Station 2.

The third station is Station 3, or the Assembly 1 Station. This is an important station because it takes all of the fabricated smaller parts and welds the "Front End Parts" together. The "Front End Parts" of this vehicle consist of the following: gas tank covers, hood, grill, GOR, head light boxes, rear blast skirts, front blast skirts, fenders, and the airbox. It takes an average of 18 hours to complete all of these tasks. After completion, all of these parts are installed onto the MRAP vehicle used in Station 5, except the Blast Skirts which are installed in Station 10.

Figure 12. Beginning work on the Front End Parts at Station 3.

The fourth station is Station 4, or the Assembly 2 Station, which is divided up into two substations. This is another important station because it uses the larger cut steel in order to construct the cab and body of these vehicles. One substation focuses on the cab assembly and the other substation focuses on the body assembly of the MRAP vehicles.

Initially, the process of cab assembly was taking 96 man-hours for completion with 3 welders working on the cab which brought the total time of work on the cab to 32 hours per MRAP vehicle. However, since the initial estimate was done, BWW has now begun to outsource the construction of the door on the cab. This, in turn, brought the total work time on the cab to an average of 20 hours.

Figure 13. Beginning work on a cab assembly at Station 4.

Initially, the process of body assembly was taking 128 man-hours with 4 welders working on the body which brought the total time of work on the body to 32 hours per MRAP vehicle. However, as with the cab assembly, the total work time was also decreased because of the outsourcing of the door for the body as well. This, in turn, brought the total work time on the body to 22 hours. Both the cab and body can be worked on simultaneously. This enables the total overall time of Station 4 to be an average of 22 hours before moving on to Station 5.

Figure 14. Beginning work on a body assembly at Station 4.

The next station in the assembly is Station 5, or Decking Station. At Station 5, the chassis of the MRAP vehicle is completely assembled with the cab, body, and "Front End Parts". This decking included the installation of cab, body, and "Front End Parts" minus Blast Skirts onto the chassis of the vehicle. This procedure can only be completed on one vehicle at a time due to spacing constraints. The average time that it takes for a vehicle to be completely decked is an average of 4.0 hours before movement to the next station.

Figure 15. In the process of decking the vehicle with cab, body, & Front End Parts at Station 5.

The next station in the line is Station 6, or Paint Preparation. This station is comprised of 3 tasks which are the following: sand blasting, metal washing, and the taping and sanding of the entire MRAP vehicle. These procedures can also only be completed on one vehicle at a time. Within this station, it takes an average of 8.0 hours before movement into the next station.

Figure 16. The picture on the left depicts a body prior to sandblasting. In comparison, the picture on the right depicts a cab after sandblasting.

The next two stations can be included together. Station 7, or Paint, is the station where the entire vehicle is painted. Station 8, or Oven Work, is the station where the freshly painted MRAP vehicle is dried before moving on to the trim stations. The total for the two stations is an average time of 16.0 hours.

Figure 17. The picture above depicts the painting of a vehicle part.

Station 9, or Trim 1 Station, is the next station in the assembly line. This station is composed of 14 tasks that must be completed according to their order of precedence. The tasks in order are: install Goldshield floor panels, run wires for exterior lights and interior blue/white lights, run passenger side wire harness, install go-light wiring, install side fuel tanks, install fire suppression system, install driver's side Goldshield, install Fibertec in rear clamshell, install rear blowers, install ceiling panels, install blackout front lights, and install brake release. The total time that it takes to complete all of these tasks is an average of 13.8 hours.

Figure 18. The picture on the left depicts the installation of Gold Shield in the floor of the vehicle. The picture on the right depicts the installation of a side fuel tank on the vehicle.

Station 10, or Trim 2 Station, is the next station in the assembly line. This station is composed of 5 tasks that must be completed according to their order of precedence. The tasks in order are: install blast skirts, install turret, install spare tire, install exhaust system, and install right side Goldshield panels. The total time that it takes to complete all of the tasks at Station 10 is an average of 6.4 hours.

Figure 19. The picture on the left depicts the rear blast skirt. The picture on the right depicts the installation of a turret on the vehicle.

Station 11, or Trim 3 Station, is the next station in the assembly line. This station is composed of 10 tasks that must be completed according to their order of precedence. The tasks in order are: install raceway, install left side air conditioner duct, install exterior DOT wiring and lights, install fender mirrors, install interior lighting, install door rubbers, install wiper arm, hose, and front exterior lights, install exterior utility lighting on the side and rear, install the antenna box, and install the front floor plate and gas pedal. The total time that it takes to complete all of the tasks at Station 11 is an average of 7.5 hours.

Figure 20. The picture on the left depicts a DOT light box prior to installation. The picture on the right depicts the installation of a mirror onto the vehicle.

Station 12, or Trim 4 Station, is the next station in the assembly line. This station is composed of 8 tasks that must be completed according to their order of precedence. The tasks in order are: install final electrical wiring, adjust wiper arm, install inverter, air conditioner evacuation and fill the rear lockers, electrical testing, install control rack, mount dash items and right IP, install body floor plates and seats. The total time that it takes to complete all of the tasks at Station 12 is an average of 9.0 hours.

Figure 21. The picture on the left depicts the wiper arm that would be adjusted at Station 12. The picture on the right depicts how the seats are installed inside of the vehicle at Station 12.

The last station in the line is Station 13, or Quality Station. The tasks that must be completed are quality assurance, 20 minute water test, and functionality test. All of these tests are vitally important because it tests all functions of the vehicle ensuring its capabilities and safety. The total time that it takes to complete all of the tasks at Station 13 is an average of 8.0 hours.

4 Methods of Process Improvement

4.1 Initial Use of Simulation

A helpful tool for this analysis is the use of simulation. Simulation allows for minor changes to be made to a current production setup without actually implementing them on a production floor. This prevents a change in the process causing an issue within the overall production system. In the case of this model, Arena was used to depict the system and its characteristics. The data that was used as the main conditions at each of the stations was the following:

Table 1: Overall Station Breakdown for the MRAP Manufacturing Assembly Line.

OVERALL STATION BREAKDOWN		
STATION NO.	DESCRIPTION	WORK TIME (HRS)
1	Inspection Station	8.0
2	Chassis Preparation Station	8.0
3	Assembly 1 Station	18.0
4	Cab/Body Assembly Station	20.0/22.0
5	Decking Station	4.0
6	Paint Prep	8.0
7	Paint	8.0
8	Oven Work	8.0
9	Trim Station 1	13.8
10	Trim Station 2	6.4
11	Trim Station 3	7.5
12	Trim Station 4	9.0
13	Quality Station	8.0

All of the work hours above are considered to be averages obtained from historical data from vehicle construction at the BWW manufacturing facility. There would typically be some play in these work hour numbers; however, for the simulations, the work hours will be accepted as fact and considered constants with no deviation. The actual model itself will start with no fill in the line; in other words, the line will only have the workers at each of their stations awaiting the vehicle frame to arrive to complete their portion of the MRAP vehicle build.

The next aspect of this model is the actual model replication parameters which will guide the simulation. The first, and arguably the most important, is the number of hours that the plant will conduct manufacturing business. At the time of the analysis, the facility and its assembly line worked

an 8-hour work day. An increase or decrease in assembly time will have a direct impact on the number of vehicles produced during a given time span.

Using the information from above, this initial simulation will vary in its replication length from 5 to 60 days. Also, each of these simulations will be run a minimum of 30 replications to account for any deviation in the data. The data that was produced is displayed in the table below.

Table 2: MRAP Vehicles produced over time given the original data provided by BWW.

MRAP Vehicles Produced Over Time	
REPLICATION LENGTH (DAYS)	NUMBER OF VEHICLES PRODUCED
5	0
10	0
15	0
18.55	0
21.35	2
29	4
35	6
40	8
45	10
50	12
55	14
60	16

Using the simulation data in the table above, the figure on the following page was produced which demonstrated the trend of the vehicle build over time.

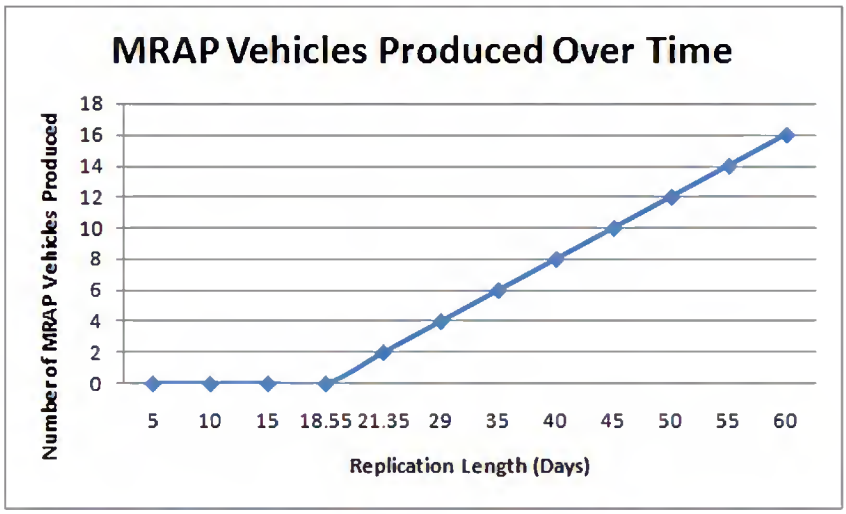

Figure 22: MRAP vehicles produced over time using the original data provided by BWW

As seen above, in the first 18.55 days, no vehicles even reach the end of the assembly line. However, after that mark in time, the vehicle production output gradually increases as the time is increased. This shows that it takes approximately 18.55 days for the line to be filled. In order to determine what the rate of production is the slope of the line in Figure 1 needs to be calculated. By taking (16-0) vehicles/ (60-18.55) days = 16 vehicles/ 41.45 days = 0.386 vehicles / 1 day. This tells us that there is 0.386 of a MRAP vehicle produced every day in the current layout of the MRAP manufacturing facility. However, this does not meet the optimal goal of the production of 1MRAP vehicle every day.

4.2 Simulation Improvement

In order to achieve the production goal of 1 MRAP vehicle every day, analysis needed to be completed to improve the overall assembly process. The first tool that was used to improve this process was visual inspection of the process times at each of the assembly stations. Through visual inspection of the average times at each of the stations, it was apparent that Station 3 and Station 4 were the largest two causes of the inefficiency of the system. However, there is a simple fix to solve this problem.

Through examination of this simulation model, it is apparent that Station 3 was waiting on Station 1 and Station 2 to be completed prior to starting the respective tasks at its station. However, this station did not need to wait on either Station 1 or Station 2 to complete its work. It could actually start work on its tasks as soon as the cut parts of metal were received from the fabrication areas.

Station 4 had a very similar issue in the simulation model. It was apparent that Station 4 was waiting on Station 1, Station 2, and Station 3 to complete prior to starting the tasks at its station. Again, this station did not need to wait for completion of the other assembly stations either. It could actually begin work on its tasks as soon as the cut parts of metal necessary for the station build arrived from the cutting and fabrication areas. Both Station 3 and 4 received the cut metal from the fabrication area, which in the case of the simulation was seamless and did not cause any lag in the work at either of these stations.

Using the revisions that were discussed above, the simulation was rebuilt producing the table below:

Table 3: MRAP vehicles produced over time given the corrected times for Stations 3 & 4.

MRAP Vehicles Produced Over Time	
REPLICATION LENGTH (DAYS)	NUMBER OF VEHICLES PRODUCED
5	0
10	0
11.8	0
13.6	2
20	5
25	8
30	11
35	14
40	17
45	20
50	23
55	26
60	29

Using the simulation data in the table on the previous page, the figure below was produced which demonstrated the trend of the vehicle build over time with the revised data.

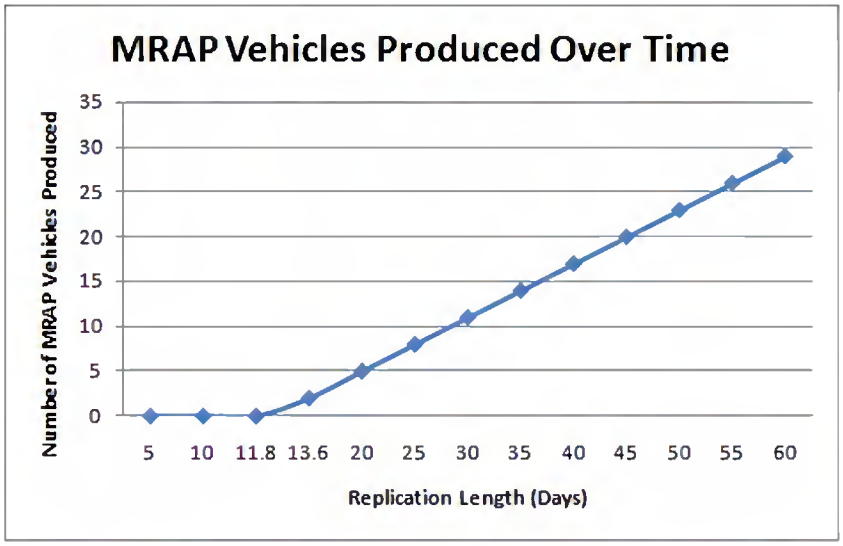

Figure 23: MRAP vehicles produced over time using the corrected times for Stations 3 and 4.

As seen above, in the first 11.8 days, no vehicles reach the end of the assembly line. However, after that mark in time, the vehicle production output gradually increases as the time is increased. This shows that it takes approximately 11.8 days for the line to be filled. In order to determine what the rate of production is the slope of the line in Figure 1 needs to be calculated. By taking (28-0) vehicles/ (60-11.8) days = 28 vehicles/ 48.2 days = 0.581 vehicles / 1 day. This tells us that there is 0.581 MRAP vehicles produced every day in this revised layout of the MRAP manufacturing facility, and this does not meet the optimal goal of the production of 1MRAP vehicle every day. However, there are additional areas where a change could possibly cause a higher production output.

4.3 Use of Gantt Charts

The next station that seemed to cause some drag in the assembly time of the MRAP vehicles is Station 9, or Trim Station 1. Originally, this station took 13.7 hours. This station took the longest work time after the previous revisions were completed. Since Station 9 has multiple tasks that could

be scheduled, a Gantt chart could be used to minimize the amount of time that each of these vehicles spends at this station.

If time is spent scheduling out one of the trim stations, which are Station 9 – 12, it would only make sense to use the scheduling tool throughout the rest of the trim stations as well. The trim stations were the only stations that BWW provided a more detailed time and procedure breakdown and precedence chart because of the multiple, detailed tasks at each of the stations. The stations breakdown as follows:

Table 4: Overall Trim Station Breakdown for the MRAP Manufacturing Assembly Line.

TRIM STATION BREAKDOWNS			
STATION 9	STATION 10	STATION 11	STATION 12
Install Goldshield floor panels	Install Blast Skirts	Raceway	Final Electrical Wiring
Run wires for exterior lights and interior blue/white lights	Install turret	Install left side A/C duct	Adjust wiper arm
Run passenger side harness	Install spare tire	Exterior DOT wiring and lights	Install Inverter
Install Go-light wiring	Install exhaust system	Fender mirrors	A/C evacuation and fill (rear lockers)
Install side fuel tanks	Install right side Goldshield panels	Interior lighting	Electrical testing
Install fire suppression system		Door rubbers	Control Rack
Install driver's side Goldshield		Install wiper arm, hose, and front exterior lights	Mount Dash Items and Right IP
Install Fibertec in rear clamshell		Exterior Utility lighting side and rear	Body floor plates and seat
Install rear blowers		Antenna box	
Install wiper motor (fitting)		Install front floor plate and gas pedal	
Install rear door Goldshield			
Install ceiling panels			
Install blackout front light			
Brake Release			

By looking at the above breakdown, there is a significance or precedence to the order in which each of the tasks are placed. Some of the steps cannot be completed until a step in front of it is completed. For example, in Station 12, the "Final Electrical Wiring" must be completed prior to the "Electrical Testing" being completed as this order seems logical. The table on the previous page demonstrates the order of precedence for Stations 9 – 12.

However, there are also steps that can be completed in conjunction with another step due to its installation proximity on the vehicle or some other allowing factor. For example, in Station 10, the "Install Blast Skirts" can be completed at the same time as "Install Turret" because of the locations of

these installations. While the "Install Blast Skirts" is along the exterior bottom of the vehicle, the "Install Turret" is completed at the exterior top of the vehicle and inside ceiling of the vehicle.

According to the information provided by BWW, it is a fact that each of these trim stations will have a minimum of 2 people, with a maximum of 4. This is an important point because it allows two operations to be completed at the same time, with the order in the process, the equipment, and the location dependent as stated earlier. By incorporating these important factors into the scheduling at each station, it would allow for the overall time at each of the stations to be minimized tremendously.

At Station 9, if the current Sequence of Operations provided by BWW was followed without any adjustments, it would take an average time of 13.7 hours total hours with 2-4 personnel working at the station as shown below.

Table 5: Station 9 Sequence of Operations.

STATION 9 SEQUENCE OF OPERATIONS		
SEQUENCE NO.	DESCRIPTION	AVERAGE TIME (HRS)
1	Install Goldshield floor panels	1.5
2	Run wires for exterior lights and interior blue/white lights	0.7
3	Run passenger side harness	0.6
4	Install Go-light wiring	0.6
5	Install side fuel tanks	2.0
6	Install fire suppression system	0.8
7	Install driver's side Goldshield	1.5
8	Install Fibertec in rear clamshell	1.0
9	Install rear blowers	1.0
10	Install wiper motor (fitting)	0.3
11	Install rear door Goldshield	0.7
12	Install ceiling panels	2.5
13	Install blackout front light	0.3
14	Brake Release	0.2
	TOTAL TIME	13.7

Taking the Sequence of Operations, we incorporated it into a Gantt chart to see if we could minimize the amount of time that it would spend at Station 9. We knew that each job took a minimum of 1 individual with some taking a maximum of 2 personnel (this is an important assumption to understand). Additionally, we know that at most two jobs can be completed at the

same time without competing for equipment or space, where both are limiting factors. Using this information, a Gantt chart for Station 9 was completed which can be seen on the next page.

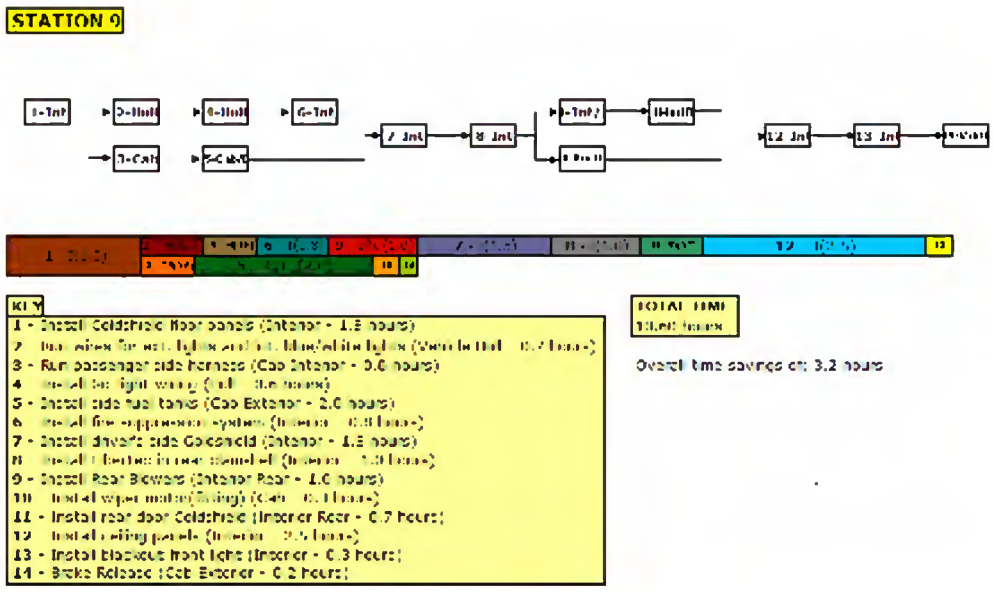

Figure 24: Gantt chart for Station 9.

The first diagram on the page demonstrates the precedence diagram with respect to station tasks that can be completed simultaneously which can conserve the overall time at the station. The next diagram on the page demonstrates the scheduling that can be performed using the Gantt chart. Task 1, or "Install Goldshield floor panels", is only an interior task but since both Task 2, "Run wires for exterior lights and interior blue/white lights", and Task 3, "Run passenger side harness", are interior tasks, Task 1 can only be performed by itself. As soon as Task 1 is complete, both Task 2 and Task 3 can be completed simultaneously even though they are both interior related tasks because of their installation vicinity.

Once Task 3 is completed, Task 5, "Install side fuel tanks", can be performed while Task 2 is still being performed. This is because Task 5 is a completely exterior task. As soon as Task 2 is completed, Task 4, "Install Go-light wiring", Task 6, "Install Fire Suppression System", and Task 9, "Install Rear Blowers" can be performed consecutively while Task 5 is still being performed because both Task 4, Task 6 and Task 9 are interior tasks and will not interfere with Task 5. Once Task 5 is completed, Task 10, "Install wiper motor (fitting)", and Task 14, "Brake Release", can be performed consecutively because they both can be completed on the exterior of the vehicle.

At the completion of Task 9, Task 7, "Install driver's side Goldshield", Task 8, "Install Fibertec in rear clamshell", Task 11, "Install rear door Goldshield", Task 12, "Install ceiling panels", and Task 13, "Install blackout front light", are performed consecutively because they are all tasks involved in the interior of the vehicle. By completing this scheduling using the Gantt chart, the overall time that a vehicle will spend at Station 9 has dropped from 13.8 hours to 10.6 hours. Appendix 3 has a thorough breakdown of each of the steps with pictures demonstrating the tasks.

At Station 10, if the current Sequence of Operations provided by BWW is followed without any adjustments, it would take an average time of 6.4 hours total hours with 2-4 personnel working at the station as shown below.

Table 6: Station 10 Sequence of Operations.

STATION 10 SEQUENCE OF OPERATIONS		
SEQUENCE NO.	DESCRIPTION	AVERAGE TIME (HRS)
1	Install Blast Skirts	1.0
2	Install turret	3.0
3	Install spare tire	0.5
4	Install exhaust system	0.4
5	Install right side Goldshield panels	1.5
	TOTAL TIME	6.4

Using the Sequence of Operations, we incorporated it into a Gantt chart to see if we could minimize the amount of time that it will spend at Station 10. We knew that each job took a minimum of 1 individual with some taking a maximum of 2 personnel (this is an important assumption to understand). Additionally, we know that at most two jobs can be completed at the same time without competing for equipment or space, where both are limiting factors. Using this information, a Gantt chart for Station 10 was completed which can be seen on the next page.

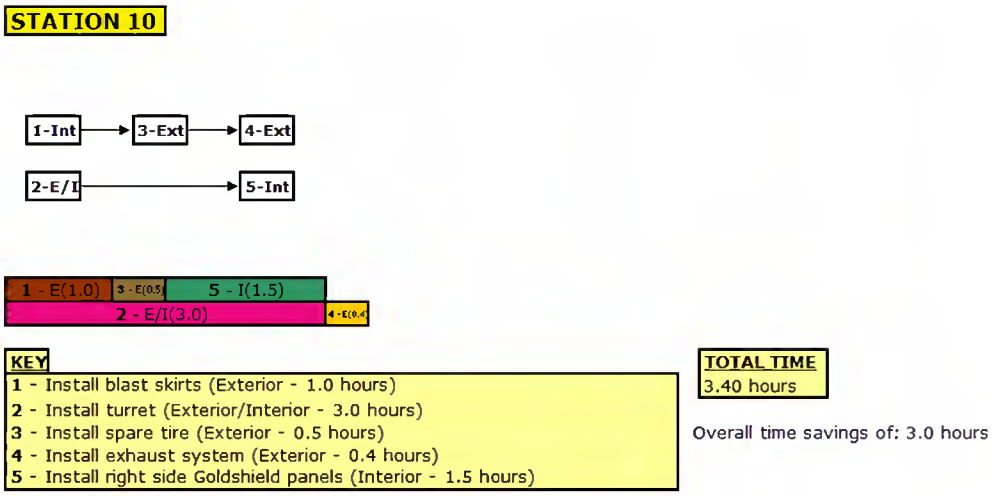

Figure 25: Gantt chart for Station 10.

The first diagram on the page demonstrates the precedence diagram with respect to station tasks that can be completed simultaneously which can conserve the overall time at the station. The next diagram on the page demonstrates the scheduling that can be performed using the Gantt chart. Task 1, or "Install blast skirts", is an exterior task on the bottom of the vehicle so Task 2, "Install turret" can be performed simultaneously because it is on the exterior top and interior of the vehicle. As soon as Task 1 is complete, Task 3, "Install spare tire", can be completed because it is an exterior task on the bottom of the vehicle.

As soon as Task 3 is complete, Task 5, "Install right side Goldshield panels", can be performed because it is an interior task in the cab of the vehicle and will not interfere with the completion of Task 2. Tasks 2 and 5 will complete simultaneously leaving only Task 4, "Install exhaust system", to be performed. By completing this scheduling using the Gantt chart, the overall time that a vehicle will spend at Station 10 has dropped from 6.4 hours to 3.4 hours.

At Station 11, if the current Sequence of Operations provide by BWW is followed without any adjustments, it will take an average time of 7.5 hours total hours with 2-4 personnel working at the station as shown on the following page.

Table 7: Station 11 Sequence of Operations.

STATION 11 SEQUENCE OF OPERATIONS		
SEQUENCE NO.	DESCRIPTION	AVERAGE TIME (HRS)
1	Raceway	0.3
2	Install left side A/C duct	1.0
3	Exterior DOT wiring and lights	1.5
4	Fender mirrors	0.3
5	Interior lighting	0.8
6	Door rubbers	0.6
7	Install wiper arm, hose, and front exterior lights	0.6
8	Exterior Utility lighting side and rear	0.8
9	Antenna box	0.6
10	Install front floor plate and gas pedal	1.0
	TOTAL TIME	7.5

Using the Sequence of Operations, we incorporated it into a Gantt chart to see if we could minimize the amount of time that it will spend at Station 11. We knew that each job took a minimum of 1 individual with some taking a maximum of 2 personnel (this is an important assumption to understand). Additionally, we know that at most two jobs can be completed at the same time without competing for equipment or space, where both are limiting factors. Using this information, a Gantt chart for Station 11 was completed which can be seen on the next page.

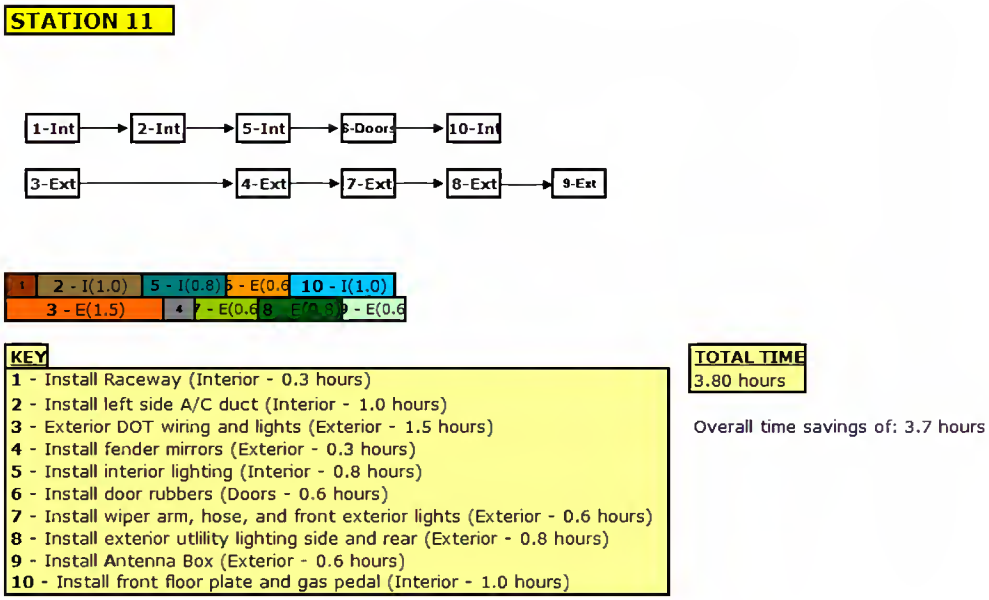

Figure 26: Gantt chart for Station 11.

The first diagram on the page demonstrates the precedence diagram with respect to station tasks that can be completed simultaneously which can conserve the overall time at the station. The next diagram on the page demonstrates the scheduling that can be performed using the Gantt chart. Task 1, or "Install raceway", is an interior task that can be performed simultaneously with Task 3, "Exterior DOT wiring and lights", which is an exterior task. As soon as Task 1 is complete, Task 2, "Install left side A/C duct", can be completed because it is an interior task that will not interfere with Task 3. As soon as Task 2 is complete, Task 5, "Install interior lighting", can be performed because it is an interior task in the cab of the vehicle and will not interfere with the completion of Task 2. At the completion of Task 3, Task 4, "Install fender mirrors", can begin on the exterior. After Task 4 is complete, Task 7, "Install wiper arm, hose, and front exterior lights", can perform its exterior task will not interfere with Task 5.

At the completion of Task 5, Task 6, "Install door rubbers", can begin its task because it is focused primarily on the doors and will not interfere with Task 7. Once Task 7 is complete, Task 8, "Install exterior utility lighting side and rear", will begin on the exterior of the vehicle. At the close of Task 6, Task 10, "Install front door plates and gas pedal", can begin on the interior of the vehicle.

Lastly, at the completion of Task 8, Task 9, "Install antenna box", can be performed. By completing this scheduling using the Gantt chart, the overall time that a vehicle will spend at Station 11 has dropped from 7.5 hours to 3.7 hours.

At Station 12, if the current Sequence of Operations provide by BWW is followed without any adjustments, it will take an average time of 9.0 hours total hours with 2-4 personnel working at the station as shown below.

Table 8: Station 12 Sequence of Operations.

STATION 12 SEQUENCE OF OPERATIONS		
SEQUENCE NO.	DESCRIPTION	AVERAGE TIME (HRS)
1	Final Electrical Wiring	3.5
2	Adjust wiper arm	0.2
3	Install Inverter	0.4
4	A/C evacuation and fill (rear lockers)	1.0
5	Electrical testing	1.0
6	Control Rack	0.6
7	Mount Dash Items and Right IP	0.8
8	Body floor plates and seat	1.5
	TOTAL TIME	9.0

Using the Sequence of Operations, we incorporated it into a Gantt chart to see if we could minimize the amount of time that it will spend at Station 12. We knew that each job took a minimum of 1 individual with some taking a maximum of 2 personnel (this is an important assumption to understand). Additionally, we know that at most two jobs can be completed at the same time without competing for equipment or space, where both are limiting factors. Using this information, a Gantt chart for Station 12 was completed which can be seen on the next page.

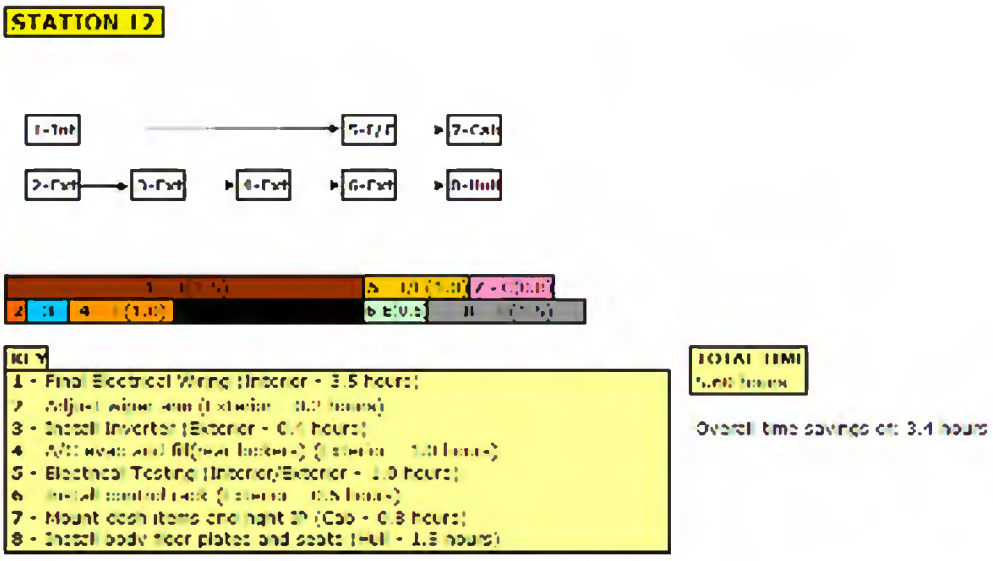

Figure 27: Gantt chart for Station 12.

The first diagram on the page demonstrates the precedence diagram with respect to station tasks that can be completed simultaneously which can conserve the overall time at the station. The next diagram on the page demonstrates the scheduling that can be performed using the Gantt chart. Task 1, or "Final Electrical Wiring", is an interior task so Task 2, "Adjust wiper arm", can be performed simultaneously because it is on the exterior of the vehicle. As soon as Task 2 is complete, Task 3, "Install inverter", can be completed because it is an exterior task. As soon as Task 3 is complete, Task 4, "A/C evacuation and fill (rear lockers)", can be performed because it is an exterior task and will not interfere with the completion of Task 1. Once Task 4 is complete, Task 6, "Install control rack", can begin its exterior task. After Task 1 is complete, both Task 5, "Electrical testing", and Task 8, "Install body floor plates and seats", can perform their tasks simultaneously because they will not interfere with the others progress. Lastly, after Task 5 is complete, Task 7, "Mount dash items and right IP", will perform its interior task. By completing this scheduling using the Gantt chart, the overall time that a vehicle will spend at Station 12 has dropped from 9.0 hours to 5.6 hours.

Prior to the use of the Gantt charts, our total time for each of the stations and overall time through the trim stations was the following on the next page.

Table 9: Trim Station Overall Time Savings through the use of Gantt Charts to Schedule the Stations.

TRIM STATION OVERALL TIME SAVINGS			
STATION NO.	DESCRIPTION	ORIGINAL TIME (HRS)	NEW TIME (HRS)
9	Trim Station 1	13.8	10.6
10	Trim Station 2	6.4	3.4
11	Trim Station 3	7.5	3.8
12	Trim Station 4	9.0	5.6
	TOTAL TIME	36.7	23.4

However, after using the Gantt charts, the overall time through Station 9-12 has reduced from 36.7 hours to 23.4 hours.

The next step is to simulate the model again using the new station times for Stations 9 – 12. This will demonstrate how, if any, the refinements will help to increase production over time. Using the revisions that were discussed above, the simulation was rebuilt producing the table below:

Table 10: MRAP vehicles produced over time given the corrected times for Stations 9-12.

MRAP Vehicles Produced Over Time	
REPLICATION LENGTH (DAYS)	NUMBER OF VEHICLES PRODUCED
5	0
10	0
10.15	0
11.5	3
16.8	6
22.1	10
27.4	14
32.7	18
38	22
43.35	26
48.65	30
55	34
60	38

Using the simulation data in the table above, the figure on the following page was produced which demonstrated the trend of the vehicle build over time with the newly revised data.

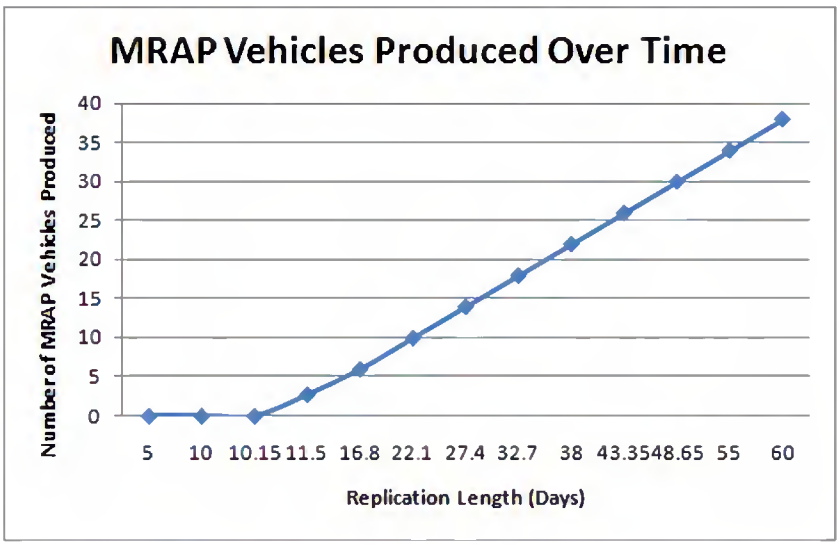

Figure 28: MRAP vehicles produced over time using the corrected times for Stations 9-12.

As seen above, in the first 10.15 days, no vehicles even reach the end of the assembly line. However, after that mark in time, the vehicle production output gradually increases as the time is increased. This shows that it takes approximately 10.15 days for the line to be filled. In order to determine what the rate of production is the slope of the line in Figure 27 needs to be calculated. By taking (38-0) vehicles/ (60-10.15) days = 38 vehicles/ 49.85 days = 0.762 vehicles / 1 day. This tells us that there is 0.762 MRAP vehicles are produced every day in this revised layout of the MRAP manufacturing facility, and still does not meet the optimal goal of the production of 1MRAP vehicle every day. However, there is one remaining area where a change could possibly cause a higher production output.

After examining the scheduled trim stations, Station 9 is still causing a lag in the assembly of the MRAP vehicle. The next possible refinement that can be made is line balancing. The purpose of line balancing is to level out some of the tasks across the line. In this case, the balancing of the line would be achieved by trimming some of the tasks from Station 9 that will lower the overall station time under 8 hours and move these tasks to Station 10. Making this adjustment at Station 9 will allow 1 vehicle to pass through the station every day and, in turn, should promote the output of 1 vehicle per day out of the system.

By looking at the Gantt chart for Station 9, on page 23, it would be necessary to move Task 12 and Task 13. This will trim 2.8 hours of work time off of Station 9 reducing the overall station work time to 7.8 hours. This should have only a minimal impact on Station 10 by increasing the overall station work time to 6.2 hours which is well under the 8 hour maximum at the trim stations. The new precedence diagrams and Gantt charts can be seen on the following page.

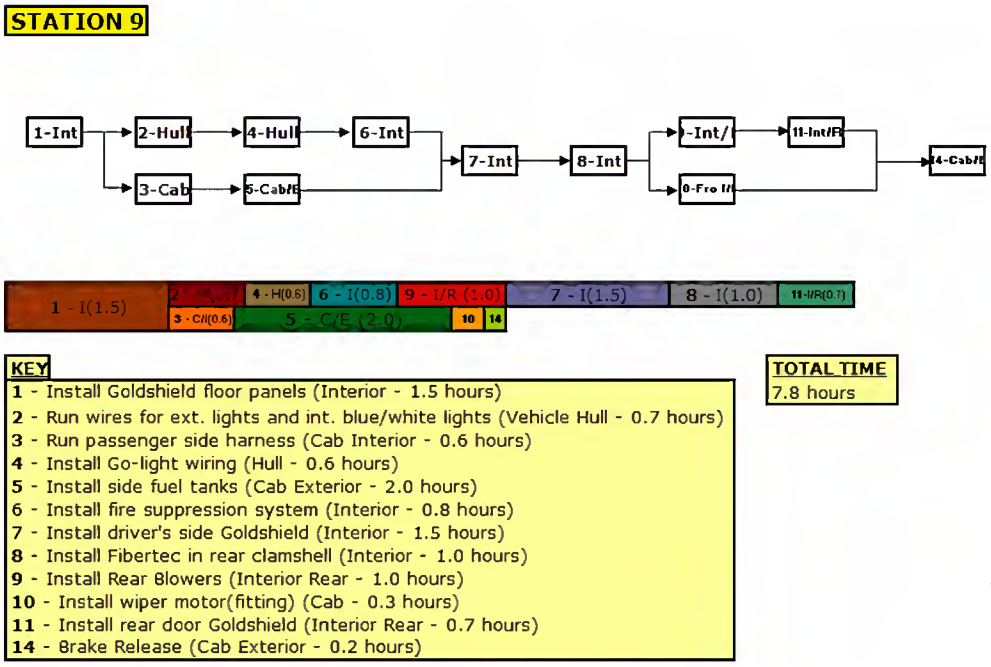

Figure 29: Gantt Chart for Station 9 after moving some tasks to Station 10.

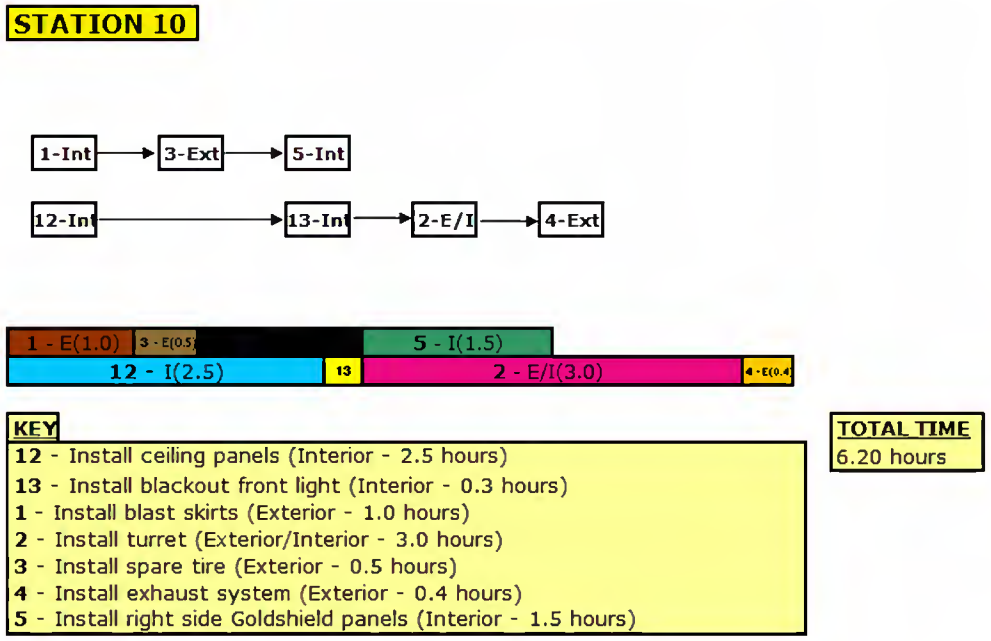

Figure 30: Gantt Chart for Station 10 after moving some tasks from Station 9 to Station 10.

The chart below depicts the new trim station times that will be used in the next simulation.

Table 11: Trim stations time savings after moving selected tasks from Station 9 to Station 10.

TRIM STATION OVERALL TIME SAVINGS AFTER STATION 9 AND STATION 10 SHIFT			
STATION NO.	DESCRIPTION	SCHEDULED TIME (HRS)	NEW TIME (HRS)
9	Trim Station 1	10.6	7.8
10	Trim Station 2	3.4	6.2
11	Trim Station 3	3.8	3.8
12	Trim Station 4	5.6	5.6
	TOTAL TIME	23.4	23.4

The next step is to simulate the model again using the new station times for Stations 9 – 12. This will demonstrate how, if any, the refinements will help to increase production over time. Using the revisions that were discussed above, the simulation was rebuilt producing the table below:

Table 12: MRAP vehicles produced over time given the task shift from Station 9 to Station 10.

MRAP Vehicles Produced Over Time	
REPLICATION LENGTH (DAYS)	NUMBER OF VEHICLES PRODUCED
5	0
10	0
10.15	0
15	5
20	10
25	15
30	20
35	25
40	30
45	35
50	40
55	45
60	50

Using the simulation data in the table above, the figure on the following page was produced which demonstrated the trend of the vehicle build over time with the newly revised data.

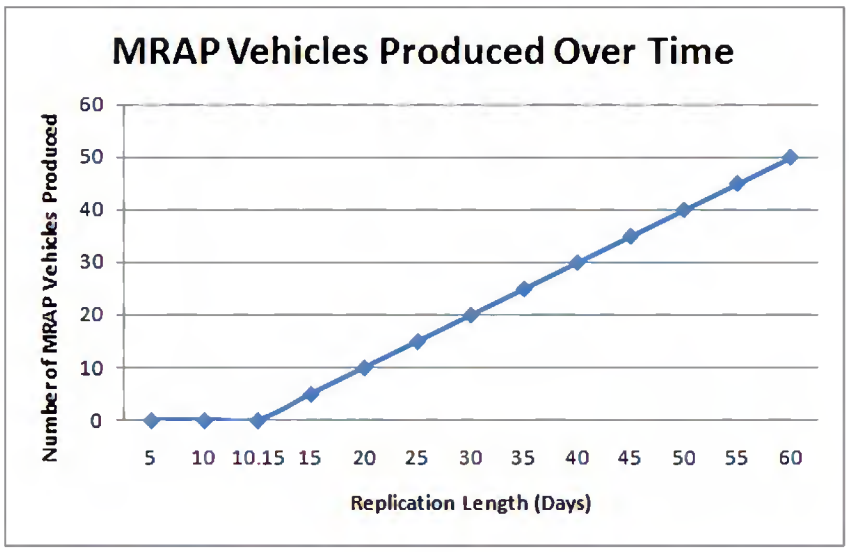

Figure 31: MRAP vehicles produced over time given the task shift from Station 9 to Station 10.

As seen above, in the first 10.15 days, no vehicles even reach the end of the assembly line. However, after that mark in time, the vehicle production output gradually increases as the time is increased. This shows that it takes approximately 10.15 days for the line to be filled. In order to determine what the rate of production is the slope of the line in Figure 30 needs to be calculated. By taking (50-0) vehicles/ (60-10.15) days = 50 vehicles/ 49.85 days = 1.003 vehicles / 1 day. This tells us that there is 1.003 MRAP vehicles produced every day in this revised layout of the MRAP manufacturing facility, and this does meet and exceed the optimal goal of the production of 1MRAP vehicle every day. Thus, this latest revision has now made the process streamlined enough that there is an output of 1.003 MRAP vehicles produced every day.

5 Sensitivity Analysis

In order to streamline the system of 1.003 MRAP vehicles produced every day, we simulated a deterministic model using the average station times to balance out the stations. Now, let's take a different view of this data. Assuming a normal distribution with the average service time being the mean, let's look at the production decay that will occur. We will evaluate this with six different standard deviations. The standard deviation will be based off of the average service time that was

provided by BWW. The first standard deviation will be at 5%. Using the standard deviation of 5%, the simulation was rebuilt producing the table on the following page:

Table 13: MRAP vehicles produced over time given a 5% standard deviation at all stations.

MRAP Vehicles Produced Over Time	
REPLICATION LENGTH (DAYS)	NUMBER OF VEHICLES PRODUCED
5	0
10	0
10.2	0
15	4
20	9
25	14
30	19
35	24
40	29
45	34
50	39
55	44
60	49

Using the simulation data in the table above, the figure on the following page was produced. This shows that it now takes approximately 10.2 days for the line to be filled. Using the same calculations used previously, we find that the production output now drops to 0.984 vehicles per day ((49-0) vehicles/ (60-10.2) days = 49 vehicles/ 49.8 days = 0.984 vehicles / 1 day).

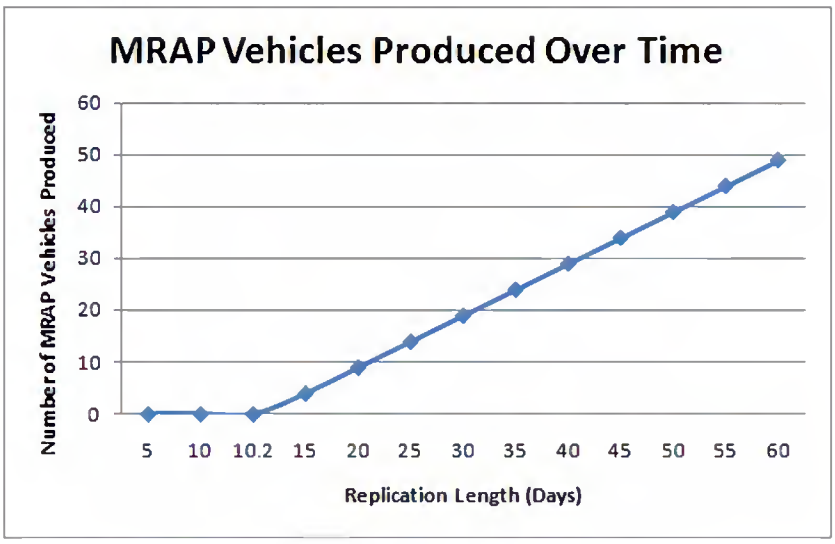

Figure 32: MRAP vehicles produced over time given a 5% standard deviation at all stations.

Now, let's evaluate the standard deviation at 10%. Using the standard deviation of 10%, the simulation was rebuilt producing the table below:

Table 14: MRAP vehicles produced over time given a 10% standard deviation at all stations.

MRAP Vehicles Produced Over Time	
REPLICATION LENGTH (DAYS)	NUMBER OF VEHICLES PRODUCED
5	0
10	0
10.1	0
15	4
20	7
25	12
30	17
35	22
40	27
45	32
50	37
55	42
60	47

Using the simulation data in the table above, the figure on the following page was produced. This shows that it now takes approximately 10.1 days for the line to be filled. Using the same

calculations used previously, we find that the production output now drops to 0.942 vehicles per day ((47-0) vehicles/ (60-10.1) days = 47 vehicles/ 49.9 days = 0.942 vehicles / 1 day).

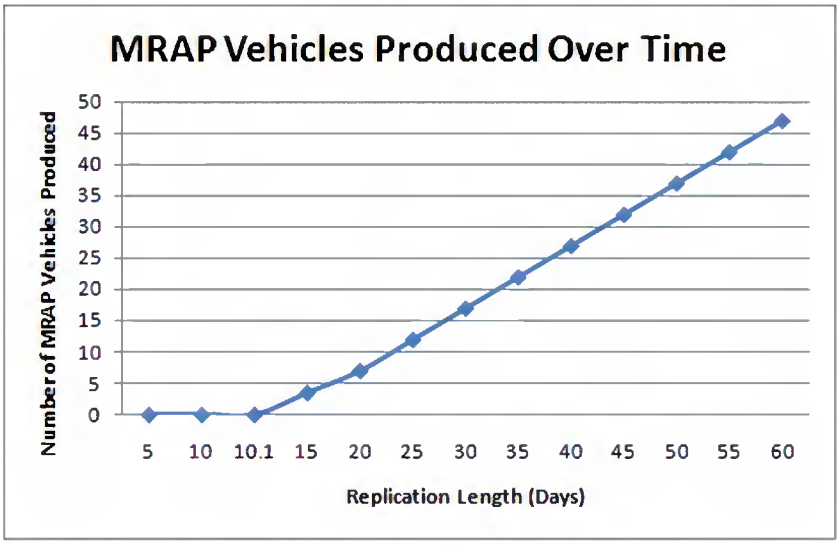

Figure 33: MRAP vehicles produced over time given a 10% standard deviation at all stations.

Continuing on, let's evaluate the standard deviation at 15%. Using the standard deviation of 15%, the simulation was rebuilt producing the table below:

Table 15: MRAP vehicles produced over time given a 15% standard deviation at all stations.

MRAP Vehicles Produced Over Time	
REPLICATION LENGTH (DAYS)	NUMBER OF VEHICLES PRODUCED
5	0
10	0
10.05	0
15	3
20	7
25	11
30	16
35	21
40	26
45	31
50	36
55	41
60	46

Using the simulation data in the table above, the figure below was produced. This shows that it now takes approximately 10.05 days for the line to be filled. Using the same calculations used previously, we find that the production output now drops to 0.921 vehicles per day ((46-0) vehicles/ (60-10.05) days = 46 vehicles/ 49.95 days = 0.921 vehicles / 1 day).

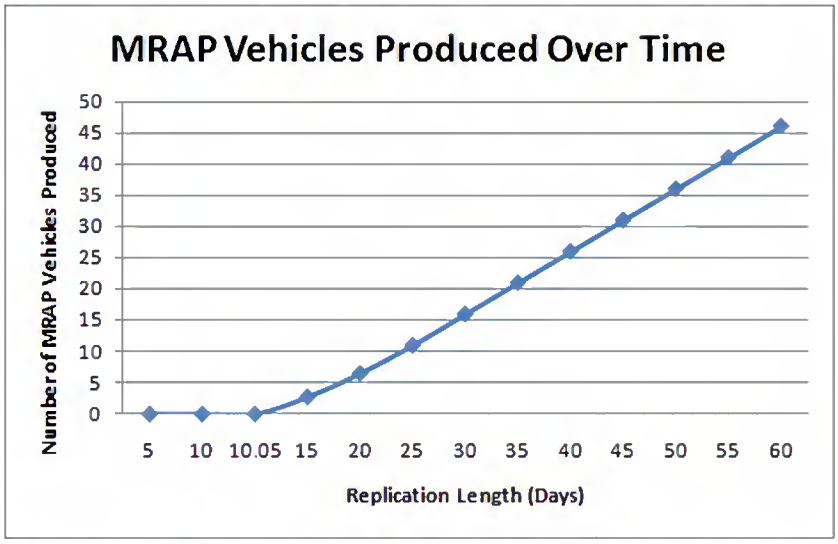

Figure 34: MRAP vehicles produced over time given a 15% standard deviation at all stations.

Next, let's evaluate the standard deviation at 20%. Using the standard deviation of 20%, the simulation was rebuilt producing the table below:

Table 16: MRAP vehicles produced over time given a 20% standard deviation at all stations.

MRAP Vehicles Produced Over Time	
REPLICATION LENGTH (DAYS)	NUMBER OF VEHICLES PRODUCED
5	0
10	0
10.5	0
15	3
20	6
25	10
30	15
35	20
40	25
45	30
50	35
55	40
60	45

Using the simulation data in the table on the previous page, the figure below was produced. This shows that it now takes approximately 10.5 days for the line to be filled. Using the same calculations used previously, we find that the production output now drops to 0.909 vehicles per day ((45-0) vehicles/ (60-10.5) days = 45 vehicles/ 49.5 days = 0.909 vehicles / 1 day).

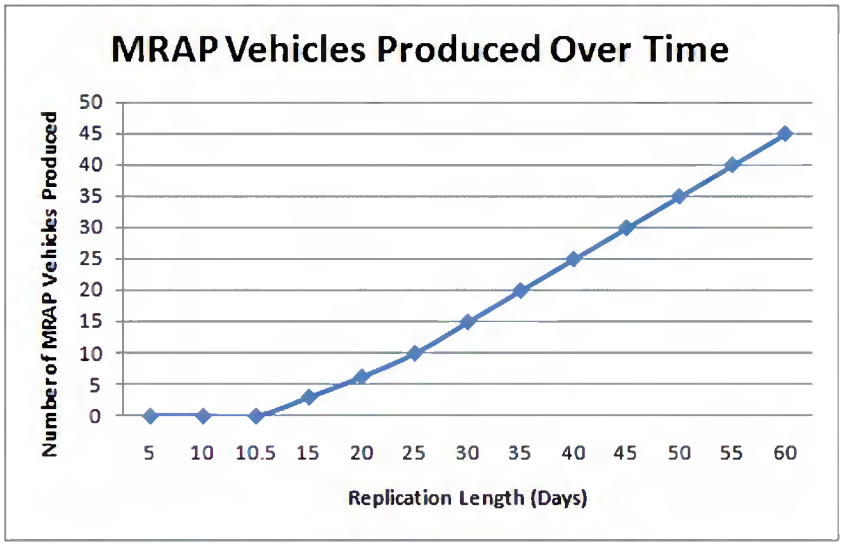

Figure 35: MRAP vehicles produced over time given a 20% standard deviation at all stations.

Next, let's evaluate the standard deviation at 25%. Using the standard deviation of 25%, the simulation was rebuilt producing the table on the following page:

Table 17: MRAP vehicles produced over time given a 25% standard deviation at all stations.

MRAP Vehicles Produced Over Time	
REPLICATION LENGTH (DAYS)	NUMBER OF VEHICLES PRODUCED
5	0
10	0
10.65	0
20	4
25	8
30	13
35	18
40	23
45	28
50	33
55	38
60	43

Using the simulation data in the table above, the figure below was produced. This shows that it now takes approximately 10.65 days for the line to be filled. Using the same calculations used previously, we find that the production output now drops to 0.871 vehicles per day ((43-0) vehicles/ (60-10.65) days = 43 vehicles/ 49.35 days = 0.871 vehicles / 1 day).

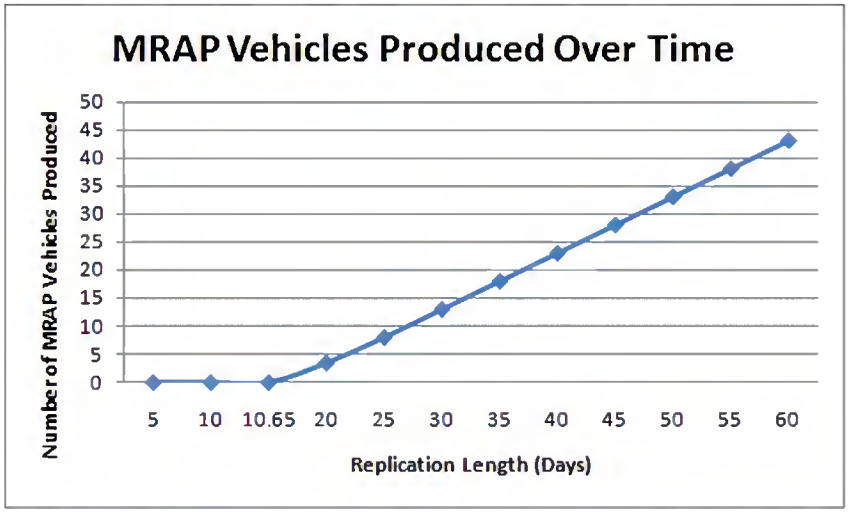

Figure 36: MRAP vehicles produced over time given a 25% standard deviation at all stations.

Lastly, let's evaluate the standard deviation at 30%. Using the standard deviation of 30%, the simulation was rebuilt producing the table on the following page:

Table 18: MRAP vehicles produced over time given a 30% standard deviation at all stations.

MRAP Vehicles Produced Over Time	
REPLICATION LENGTH (DAYS)	NUMBER OF VEHICLES PRODUCED
5	0
10	0
10.65	0
15	4
20	9
25	13
30	17
35	21
40	25
45	29
50	33
55	37
60	41

Using the simulation data in the table above, the figure below was produced. This shows that it now takes approximately 10.65 days for the line to be filled. Using the same calculations used previously, we find that the production output now drops to 0.871 vehicles per day ((41-0) vehicles/ (60-10.65) days = 41 vehicles/ 49.35 days = 0.831 vehicles / 1 day).

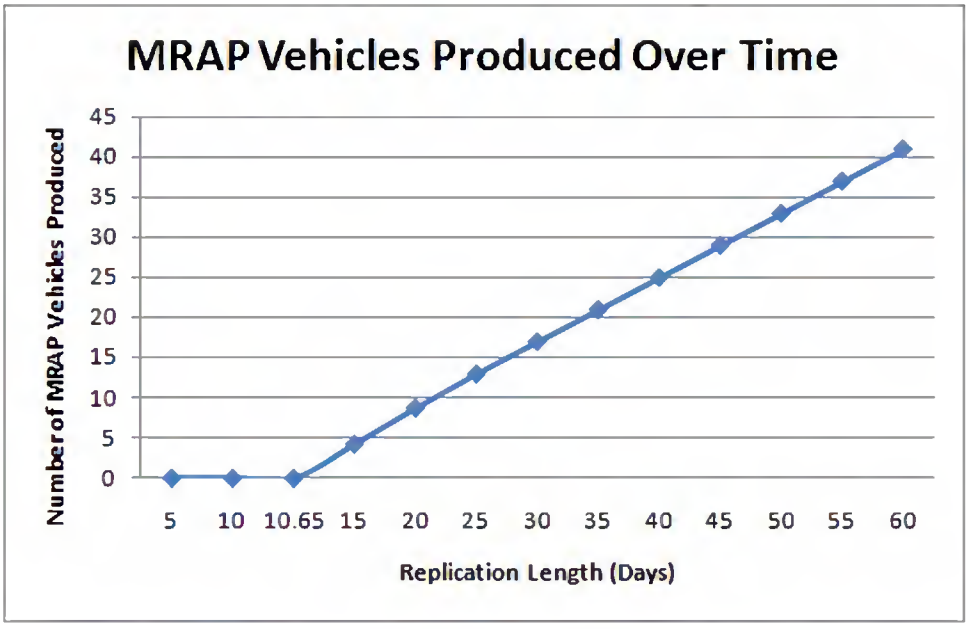

Figure 37: MRAP vehicles produced over time given a 30% standard deviation at all stations.

By assuming a normal distribution on the assembly line with average station times as the mean and varying the standard deviation, we see how the line production decays over time. This can be seen in the table below:

Table 19: Production output comparisons of MRAP vehicles with respect to varying standard deviations.

Production Output Comparisons	
STANDARD DEVIATION (%)	OUTPUT (VEHICLES PER DAY)
0	1.003
5	0.984
10	0.942
15	0.921
20	0.909
25	0.871
30	0.831

This analysis demonstrates how the production output of the assembly line is not very sensitive with respect to the varying times at each of the stations. Depending on the standard deviation at each of the stations, you could produce as many as 1.003 MRAP vehicles per day or as little as 0.831 MRAP vehicles per day. This is only a small decrease in the output and even at the largest standard deviation, the output of 0.831 MRAP vehicles per day is significantly larger than the original system that was only producing 0.386 MRAP vehicles per day.

6 Recommendations

Through the research conducted on this product, a noticeable increase in the production output of MRAP vehicles at the BWW Manufacturing Facility. The original layout of this facility only yielded 0.386 MRAP vehicles per day. The recommended revisions increase the yield to 1.003 MRAP vehicles per day. This improves the overall yield at this plant per day by approximately 260%. This is a staggering improvement over the current layout and should be implemented in order to optimize the output from the facility.

7 Conclusions

Using historical data, we have found the most efficient system for incorporation into this facility. We were able to achieve this through the use of Gantt Charts to optimize the production schedule at each of the most time intensive stations, which were Stations 9 – 12. Taking the updated data, we implemented it into a simulation through the use of Arena. This allowed us to continually revise the stations and their corresponding Gantt Charts until we found the layout that produced not only the highest production output, but also exceeded the goal of 1 MRAP vehicle per day, which BWW had set as their optimal goal.

After these revisions were completed, the updated yield became 1.003 MRAP vehicles per day. This increased output was is in comparison to the current production output which is yielding only 0.386 MRAP vehicles per day. This is based upon the average station times provided by BWW. As stated previously, this improves the overall yield per day at this plant by approximately 260%.

8 Avenues for Further Research

Various avenues of continued research are the following:

1. **Expansion of the current BWW Manufacturing Facility:** One limitation that constrained this project was the size of the facility that is used. There are many other possible improvements if there was an increase in the space. Some of these are the following:

    a. increase in the number of assembly lines

    b. allowing for more space at each station for more than one vehicle at a time

    c. installation of an additional paint and drying booth to speed up the paint process

2. **Outsourcing of more vehicle parts:** Currently there are few parts that are outsourced and do not require total assembly. A good example of an outsourced part that saved time was the outsourcing of the doors. That change made a significant impact on the assembly time at that station. There are other vehicle parts that could be outsourced that could also save the both time and money to BWW. Some of these are the following:

    a. assembly/painting of the cab

    b. assembly/painting of the body

3. **Production scheduling of other stations:** This project's focus of scheduling was only on the Stations 9 – 12, or trim stations. This was primarily because the trim stations were originally the most time intensive stations. After the scheduling at these stations has been completed, there are other stations that, with additional information from BWW could also be more efficient. Some of these stations are:

a. Station 1 (Inspection)

b. Station 2 (Chassis Preparation)

c. Station 13 (Quality)

9 References

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Appendices

Appendix 1: Initial Capacity Analysis & Preliminary Layout

Capacity Analysis and Preliminary Layout

for the

BWW Armored Vehicle Manufacturing Facility

by

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Executive Summary:

Time estimates for each of the process associated with the construction of the Grizzly have been provided. They are based on BWW's experience in producing approximately 6-10 Grizzly armored vehicles. We would expect that the actual time to perform the vast majority of the processes will decrease over time as personnel are trained and process improvements are implemented. In terms of the trim line, we have performed line balancing using only a single feasible ordering of the jobs as a precedence network for the jobs has yet to be developed. This is also true of each of the manufacturing processes. Working off of the current scenario of producing 16 vehicles per day, we have developed a manufacturing process plan that will meet the desired output. This process uses the manufacturing stations used in the current production of the vehicle with altered personnel and station numbers. Throughout this document, one assumption that continues is a decrease in the time it takes to complete a process with an increase in the number of personnel assigned to that process.

CUTTING: The 1st manufacturing process is the cutting of the steel used to build the vehicle. There are two different cutting operations. One cutting operation utilizes plasma cutters. It takes 8 hours for one plasma cutter to complete the steel required to build one vehicle. To meet output requirements, we need to use $8/8 \cdot 16 = 16$ plasma cutters.

For more dimension critical pieces, a laser cutter is used. It takes 2.5 hours for one laser cutter to complete the steel required to build one vehicle. To meet output requirements, we need to use 5 laser cutters.

WELDING: The 2nd manufacturing process is the fabrication (welding) of the vehicle body parts. Welding is divided into 4 areas: engine compartment, cab, body, and sub-assemblies.

It takes 24 man-hours to weld one engine compartment. It then takes 3 man-hours to bolt on the components. Therefore, we require $24/8 \cdot 16 = 48$ engine compartment welding stations and $3/8 \cdot 16 = 6$ engine bolting stations to meet production.

The cab requires 40 man-hours to weld. It is possible to use two welders to work on each cab. Using 80 welders at $40/8/2 \cdot 16 = 40$ stations, cab welding output can be met.

Each body requires 80 man-hours to complete welding. It is possible to use up to 3 workers per body to decrease the time as needed. Therefore, using 160 welders, we can meet production needs with $80/8/3 \cdot 16 = 53.33 \cong 54$ body welding stations.

Sub-assemblies require 80 man-hours to complete enough for one vehicle. The number of sub-assembly welding stations and the exact welding time at each depends on the number of actual sub-assemblies. Welding of the sub-assemblies requires $80/8 \cdot 16 = 160$ welders to meet production. We have used 3 welders on each sub-assembly station resulting in 54 stations.

QA: Each chassis used to create the vehicle goes through a QA process prior to decking. A portion of the QA process will take place outside of the manufacturing facility. As a result, it is not clear whether QA needs its own specific station. However, we know that, with a 2.5 hour completion time, it will take $2.5/8 \cdot 16 = 5$ QA workers to meet the required output rate.

DECKING: The decking process is the first in the assembly line operation. Decking is divided into the following 3 assembly operations: front end, cab, and body. The entire decking process needs to

produce 1 vehicle every 0.5 hours to meet the output rate. It takes 1.5, 1, and 1.5 man-hours to complete front end, cab, and body decking, respectively. Therefore, using one decking line, we need 3 workers on front end decking, 2 workers on cab decking, and 3 workers on body decking for a total of 8 workers decking (this does not include material handling people).

QC: We are unaware of what the QC process prior to paint prep entails. However, we know that it takes 4 hours to QC one vehicle. We recommend 8 QC stations with 1 worker at each to meet production.

PAINT PREP: The paint preparation rate is dictated by the paint process. It takes 5.5 man-hours to prepare a single vehicle for painting. We will need 3 workers at each of 4 paint-prep stations (total 12 workers) to output an average of 1 vehicle every 0.5 hours. 4 separate stations are required to enable the batching necessary to feed our two 2 vehicle paint booths described in the next section.

Assuming a time of 1.5 to prep 1 vehicle worth of sub-assemblies, we determined the need for 3 workers at 1 prep station to feed the sub-assembly paint booth.

PAINT: The concept of paint process is comprised of a four cell (prime, dry, paint, dry - in series) operation taking place in one paint booth/oven housing. We determined it necessary to construct 3 paint booths (2 for vehicle and 1 for sub-assemblies). During the paint process, vehicles will be batched so that 2 vehicles enter each stage simultaneously. The first cell in the process is for priming the vehicle. It takes 2 hours to complete this priming process on one vehicle. We will need one worker priming each of 4 vehicles for a total of 4 workers priming. The vehicles will then enter the next cell, drying, where no man power is necessary for approximately 2 hours (minimum 1.5). Following the drying of the primer, the vehicles will move to be painted. It takes 3.5 hours to paint a single vehicle. In the paint booth, we will need to assign 2 painters per vehicle for a total of 8 painters (to maintain a cycle time of less than 2 hours). Finally, the vehicles will move into the paint drying cell of the booth where they will remain for 1.5- 2.0 hours before moving into the queue for the trim station. The entire vehicle paint process produces, on average, 2 vehicles per hour.

It takes 6 and 8 hours to prime and paint, respectively, the sub-assemblies for one vehicle. To meet the required production rate, we will need to push 4 vehicles worth of sub-assemblies through the sub-assembly paint booth every 2 hours. This requires 12 painters priming and 16 painting. The parts will spend 2 hours in each of the four cells. Since the hours include material handling, and it is expected that the pieces will be suspended from an overhead conveyor, we assume that some of these people will not be in the paint booth. In addition, it is expected that these numbers will decrease due to efficiencies accrued from the material handling system.

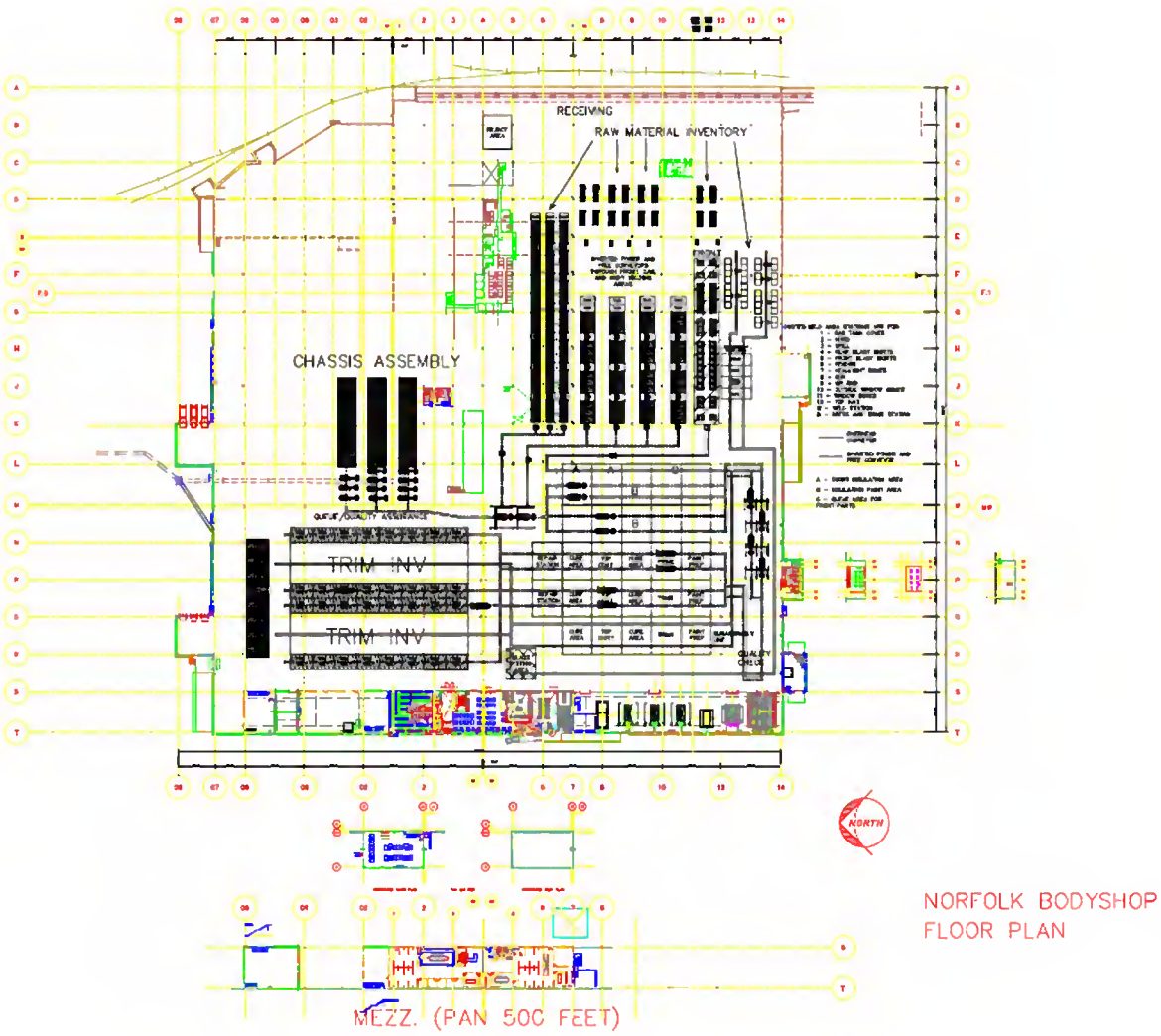
TRIM

Our original assumption, when working with the trim line processes provided by BWW, was that each process had precedence over the next. We then ordered each of the 51 trim operations sequentially and divided them into interior and exterior operations. Once divided into interior and

exterior operations, we applied a logical approach to determining what operations had to remain sequential while trying not to disturb the given order. Due to the space constraints on the inside of the vehicle, we assumed that, in most cases, a maximum of two workers could work on interior tasks simultaneously.

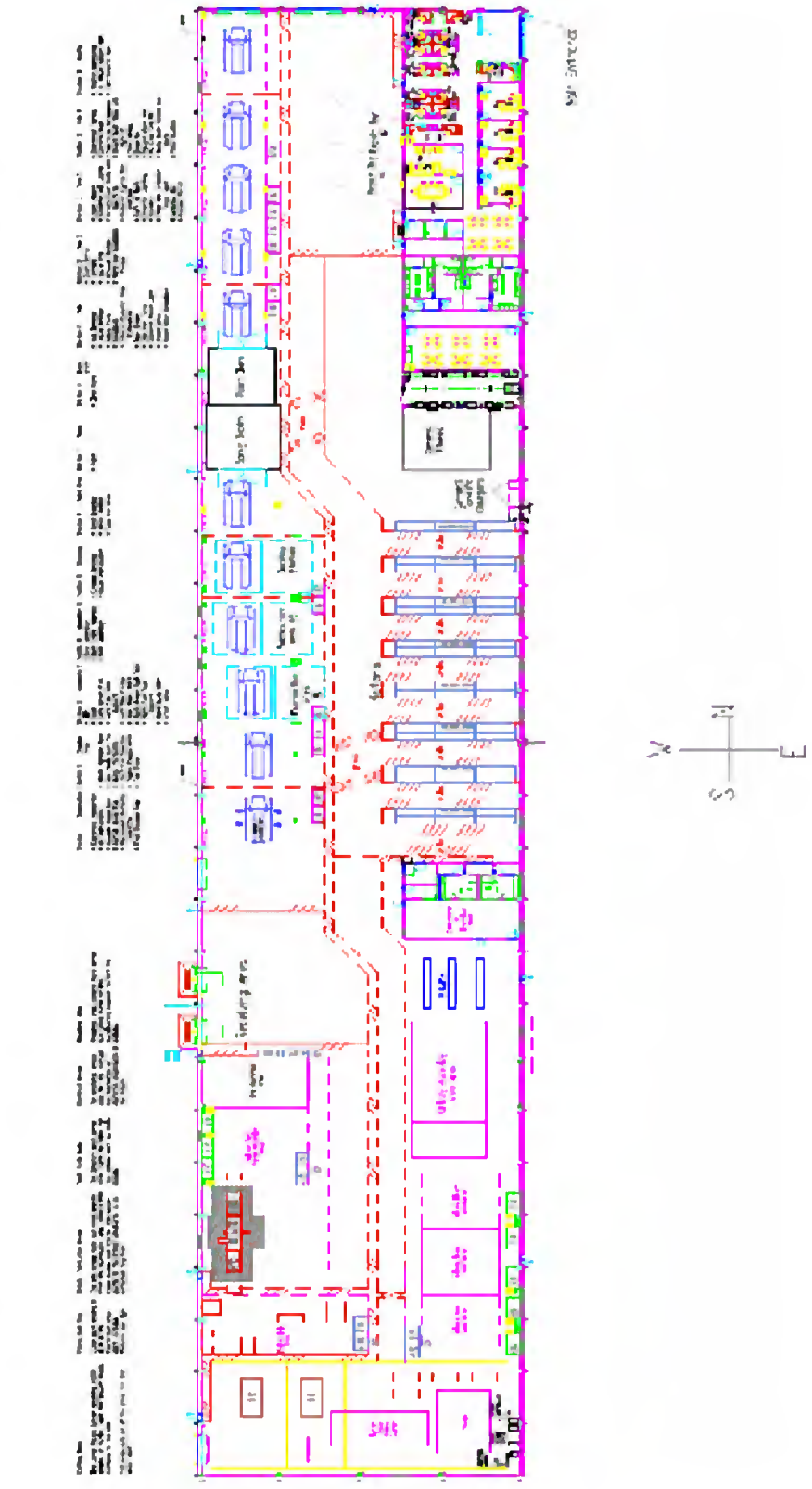
The total time to complete the trim operation is 53.3 hours. We determined it optimal to divide trim into 8 stations and run 4 trim lines. Each station will take no longer than 2 hours to complete. It takes 9 man-hours to complete the task of fabricating the harnesses alone and, as a result, it is necessary to add harness fabrication as its own separate at the end of the trim process. We will need 2 harness stations, operating in parallel, for every 1 trim line for a total of 8 harness fabrication stations. The breakdown of 1 trim line (stations 9 – 16 followed by 2 harness fabrication stations) is attached as Appendix A. The total time, in hours, is documented next to each task and Station.

Operation Number	Description	Allocated Time (hrs)	Interior/ Exterior	Operation Number	Description	Allocated Time (hrs)	Interior/ Exterior
Station 9 (1.9 hrs)							
Person 1 (1.9 hrs)				**Person 2 (1.9 hrs)**			
1	Run wires for Ext. lights	0.4	Int	6	Run Int. wires	0.4	Int
3	Install Fibertec in panels	1.5	Int	12	Inner panels, Fibertec	1.5	Int
Person 3 (1.4 hrs)							
2	Install Fibertec in lockers	0.5	Ext				
4	Hook up gas tank hoses/Fillerpipe	0.5	Ext				
7	Install Wiper motor (fitting)	0.4	Ext				
Station 10 (1.85 hrs)							
Person 1 (1.75 hrs)				**Person 2 (1.85 hrs)**			
9	Install Wall Panels	1.25	Int	9	Install Wall Panels	1.25	Int
5	Install rear blowers	0.5	Int	8	Run Cab Harness (gps,go-light)	0.6	Int
Person 3 (1.4 hrs)				**Person 4 (1.6 hrs)**			
17	Install Blasts skirts	1	Ext	10	Install Front Bumper/Winch/Emble	1	Ext
18	HVAC Engine	0.4	Ext	11	Blackout front lights	0.3	Ext
				19	Washer pump	0.3	Ext
Station 11 (2 hrs)							
Person 1 (1.9 hrs)				**Person 2 (2 hrs)**			
13	Ceiling and Side panels	1.5	Int	14	Interior wires (swivel)	0.3	Int
15	Right Hand Harness	0.4	Int	16	Dress DOT wiring	1.7	Int
Person 3 (1.95 hrs)				**Person 4 (1.95 hrs)**			
22	Install Exhaust System	0.2	Ext	22	Install Exhaust System	0.2	Ext
25	Windshield and Fibertec	1	Ext	25	Windshield and Fibertec	1	Ext
30	Exterior DOT Wiring	0.75	Ext	30	Exterior DOT Wiring	0.75	Ext
Station 12 (1.8 hrs)							
Person 1 (1.8 hrs)				**Person 2 (1.8 hrs)**			
21	Install Gun ports	1	Int	24	Install right and left IP	1	Int
27	Install R/S AC Duct	0.8	Int	29	Install L/S AC Duct	0.8	Int
Person 3 (1.75 hrs)				**Person 4 (1.75 hrs)**			
31	Side Glass	0.5	Ext	31	Side Glass	0.5	Ext
32	Windshield Glass	0.35	Ext	32	Windshield Glass	0.35	Ext
33	Door Glass/Mirrors	0.4	Ext	33	Door Glass/Mirrors	0.4	Ext
36	Door Latches	0.5	Ext	23	Air intake Fender	0.5	Ext
Station 13 (2 hrs)							
Person 1 (1.95 hrs)				**Person 2 (1.95 hrs)**			
26	Wall Panels/Raceway	1.25	Int	26	Wall Panels/Raceway	1.25	Int
28	Front Blower/Left Console	0.7	Int	35	Interior Lighting	0.7	Int
Person 3 (2 hrs)				**Person 4 (1.75 hrs)**			
20	Air Horn	0.3	Ext	31	Side Glass	0.5	Ext
34	Install Battery Cables	0.3	Ext	32	Windshield Glass	0.35	Ext
37	Door Rubbers	0.8	Ext	33	Door Glass/Mirrors	0.4	Ext
38	Washer Bottle Wire	0.6	Ext	23	Air intake Fender	0.5	Ext
Station 14 (2 hrs)							
Person 1 (2 hrs)				**Person 2 (2 hrs)**			
41	Install Flooring and Seats	0.75	Int	41	Install Flooring and Seats	0.75	Int
43	Mount Dash Items	0.35	Int	43	Mount Dash Items	0.35	Int
39	Exterior Utility Lighting	0.75	Ext	39	Exterior Utility Lighting	0.75	Ext
40	Install Wiper Arm and Hose	0.15	Ext	40	Install Wiper Arm and Hose	0.15	Ext
Station 15 (2 hrs)							
Person 1 (2 hrs)				**Person 2 (2 hrs)**			
44	Final Electrical Wiring	1.5	Int	44	Final Electrical Wiring	1.5	Int
45	Electrical Testing	0.5	Int	45	Electrical Testing	0.5	Int
Person 3 (1.8 hrs)							
42	A/C Evac and Fill	1.2	Ext				
47	Adjust Wiper Arm	0.3	Ext				
48	Wind Wire On Winch	0.3	Ext				
Station 16 (1.9 hrs)							
Person 1 (1.9 hrs)							
46	Button Up All Dash and Ducts	1.3	Int				
49	Headlight Cover Brush Bar (rear)	0.3	Ext				
51	Install Inverter	0.3	Ext				
Harness Station 1 (3 hrs)				**Harness Station 2 (3 hrs)**			
Person 1				**Person 1**			
50	Fabricate Harnesses	3	Int	50	Fabricate Harnesses	3	Int
Person 2				**Person 2**			
50	Fabricate Harnesses	3	Int	50	Fabricate Harnesses	3	Int
Person 3				**Person 3**			
50	Fabricate Harnesses	3	Int	50	Fabricate Harnesses	3	Int



NORFOLK BODYSHOP
FLOOR PLAN

Appendix 2: BWW Manufacturing Facility



Appendix 3: Station 9 Illustrated Sequence of Operations

Station 9 Overall Sequence of Operations

Sequence of Operation	Description	Alloted Time(hrs)	Actual Time	Operator Initals	Supervisor Initials	Remarks
1	Install Gold Shield floor panels	1.5				
2	Run wires for Ext. lights and int blu/wht lights	0.7				
3	Run passenger side harness	0.6				
4	Install Go-light wiring	0.6				
5	Install side fuel tanks	2.0				
6	Install fire suppression system	0.8				
7	Install driver's side Gold Shield	1.5				
8	Install Fibertec in rear clamshell	1.0				
9	Install rear blowers	1.0				
10	Install wiper motor (fitting)	0.3				
11	Install rear door Gold Shield	0.7				
12	Install ceiling panels	2.5				
13	Install blackout front light	0.3				
14	Brake Release rods	0.2				
	Total Hours	13.7				

Vin # _____

Station 9

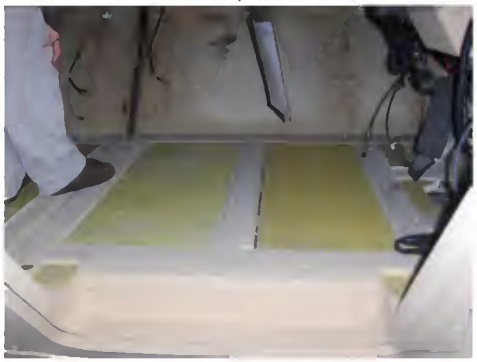
Sequence of Operations Form

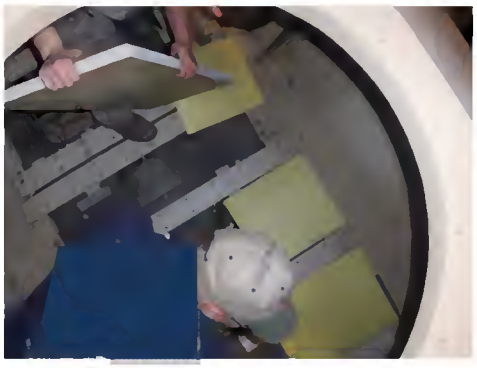
Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Floor Goldshield									
		1	Obtain floor Goldshield panels from Material Handling	Receiving				Forklift	
		2	Install all floor goldshield panels except three axis panels						

Station 9 Process 1 – Floor Goldshield

Step 1: Obtain floor panels from Material Handling

Step 2: Install all floor Goldshield panels except for the three access panels





Station 9 Process 1 – Floor Goldshield

Vin # _____

Station 9

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Exterior and Interior Light Wiring									
		1	Obtain Wires, Velcro from Material Handling	Receiving				Stock Cart Drawings	
			Obtain Wire, Camera, Visual Aide, Locators from Material Handling	Receiving	3SP0144AA	Dakota Micro		Stock Cart Drawings	
			Obtain Velcro, from Material Handling	Receiving	32P003AA	Waytek		Stock Cart Visual Graphics	
		2	Visually inspect vehicle for non-conformities, missing parts from Station #1starting at the back left of the vehicle				1		
		3	Visually inspect assemblies from Material Handling prior to mounting them to the vehicle				1		
		4	Grasp 3 exterior spot light wires off stock rack, route 2 of the wires through stuffer tube and down the inner wall using velcro to locate and secure the wire. The 3rd wire goes in rear locker right side panel (passenger side) and reoutes out of stuffer tube in right side roof				1		
			NOTE: The stuffer tubes for exterior spot lights are behind panels 33P10S9B)						
		S	Grasp camera wire from stock rack (3SP0144AA 36in extension) and route through left side stuffer tube in roof of rear left side locer (driver side) and secure with sticky back locators/Velcro (male pins should be on outside of truck)				1		
		6	Grasp 4 interior wires from stock rack, route down left and right side of inner walls per drawing. Secure to wall with velcro verify a foot of wire is left hanging at top to go through Gold shield and that 1in or 2ins are left at the bottom to go into trough				1		

Station 9 Process 2 – Exterior and Interior Light Wiring

Step 1: Obtain Materials (Wires, Velcro, Camera, and Locators)

Step 2&3: Visually inspect vehicle and materials received

Step 4: Route wires through inner wall and attach with Velcro

Step 5: Run camera wire through left side stuffer tube and secure with Velcro

Step 6: Grab 4 interior wires, route and secure with Velcro

Station 9 Process 2 – Exterior and Interior Light Wiring

Vin # _____

Station 9

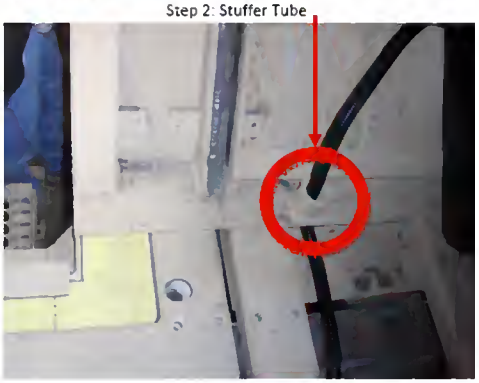
Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Passenger Side Harness									
		1	Obtain right hand side harness wires						
		2	Run harness under door through stuffer tubes located on both sides of the door						
		2	Pull enough wire to be able to connect to control box						

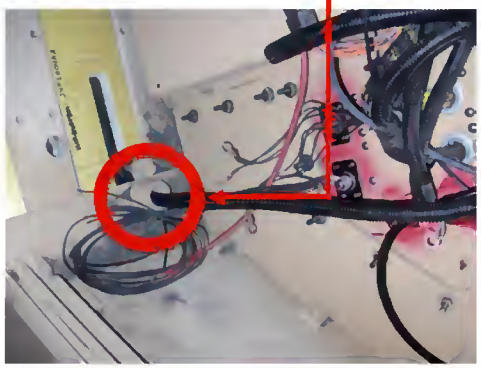
Station 9 – Passenger Side Harness

Step 1: Obtain right hand Side harness wires

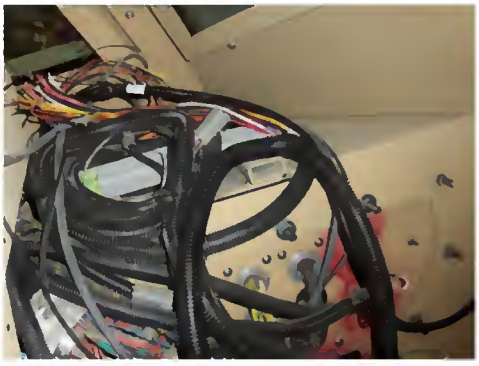
Step 2: Stuffer Tube



Step 2: Run harness under door through stuffer tubes located on both sides of the door



Step 3: Pull enough wire to be able to connect to control box



Station 9 – Passenger Side Harness

Vin # _____

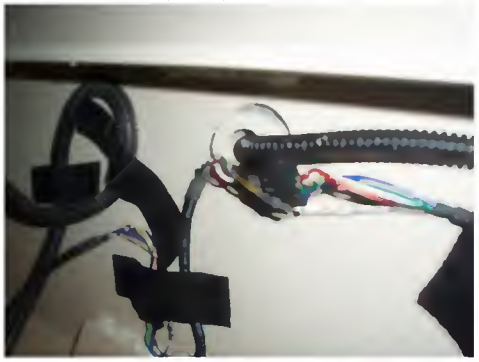
Station 9

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Go-Light Wiring									
		1	Run Go-Light control wire and power wire from cab harness through center stuffer tube, located directly above center windshield						
		2	Mount Go-Light control in bracket and secure to ceiling						
		3	Finalize Go-Light connections						

Station 9 Process 4 – Go-Light Wiring

Step 1: Run Go-Light control wire from cab harness through center stuffer tube, directly above the center stuffer tube



Step 2: Mount Go-Light control in bracket and secure to ceiling

Step 3: Finalize Go-Light connections

Station 9 Process 4 – Go-Light Wiring

Vin # _____

Station 9

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Side Fuel Tanks									
		1	Obtain tanks from Material Handling	Receiving				Forklift	
			Obtain Kit from Material Handling		34P0064AA	Seagrave			
		2	Visually inspect vehicle for non-conformities, missing parts from Station #1starting at the back left of the vehicle						
		3	Visually inspect assemblies from Material Handling prior to mounting them to the vehicle						
		4	Route #6 (33P70S3AA)and #10 (33P70S4AA)fuel lines down frame rails and thru the transfer case tubeing (31p0015AA)and hook up to the valve and then run hose out to the tank from the other side						
		5	Obtain fuel tank straps and rubber. align and seat rubber over strap			Seagraves		Visual Aid	
		6	Measure fuel tank on bottom and then bend strap accordingly to form strap to tank					Visual Aid	
			Seat strap studs with a nut and washer to the inner most hole of bracket , do not tighten all the way					Visual Aid	
		7	Obtain floor jack to lift fuel tank(34P0064AA) into place. Wrap straps around tank and insert studs of strap thru outer most holes and install washer and nut but do not tighten		34P0064AA	Seagraves		Visual Aid	
		8	Put a # 6 jic fitting onto end of hose and connect to top of fuel tank .						
		9	Tighten tank up and connect bottom hose with #10 JIC fitting						
		10	Obtain left and right fuel tank armor boxes from material handling					Forklift	

Vin # _____

Station 9

Sequence of Operations Form

		11	Install door seal in "crescent" on box						
		12	Jack box into place with floor jack					Floor Jack	
		13	Install bolts (8) first hand tighten, then tighten with impact wrench						
		14	Repeat for other side.						

Station 9 Process 5 – Side Fuel Tanks

Step 1: Obtain materials from Material Handling

Step 2-3: Visually inspect vehicle and materials for flaws

Step 4: Route #6 and #10 fuel lines then hook up to valves

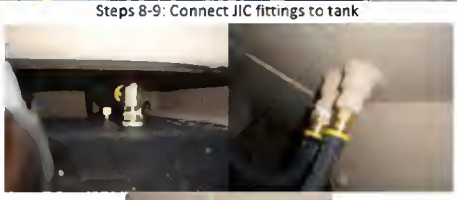
Step 5-6: Measure fuel tank on bottom, bend strap accordingly

Station 9 Process 5 – Side Fuel Tanks

Station 9 Process S – Side Fuel Tanks

Step 7: Obtain floor jack, lift tank into position, then attach straps

Steps 8-9: Connect JIC fittings to tank



Step 10: Obtain left and right fuel tank armor boxes from MH

Step 11: Install door seal in "crescent" on box

Step 12-13: Use jack to put box in place, install bolts and tighten

Step 14: Repeat for other side

Station 9 Process S – Side Fuel Tanks

Vin # _____

Station 9

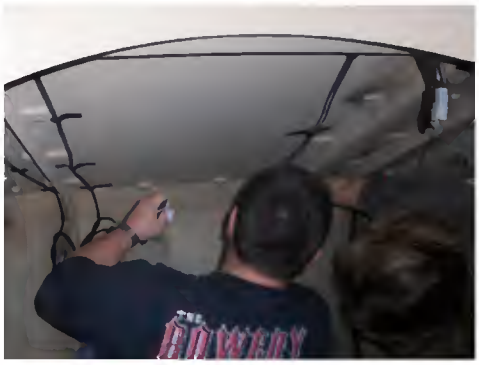
Sequence of Operations Form

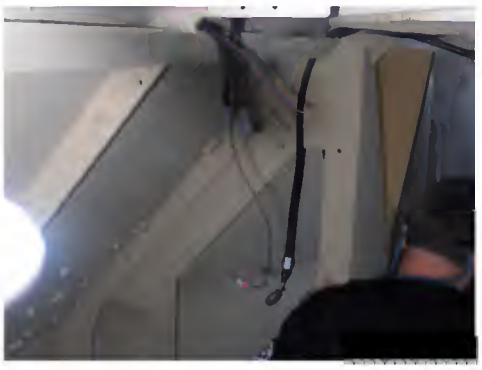
Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Fire Suppression System									
		1	Obtain 4 fire supression wires						
		2	Obtain Velcro						
		3	Obtain wire layout schematics						
		4	Run horizontal harness from rear to cab						
		5	Run wires per layout, attaching with velcro straps						

Station 9 Process 6 – Fire Suppression System

Steps 1-3: Obtain 4 Fire Suppression wires, Velcro, and wire layout schematics

Step 4: Run horizontal harness from rear to cab, attaching with Velcro





Station 9 Process 6 – Fire Suppression System

Vin # _____

Station 9

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Driver Side Goldshield									
		1	Obtain M12 x 40mm from Material Handling	Receiving	390037AA	Superior		Stock Cart Drawings	
			Obtain Nut, M12 from Material Handling	Receiving	39P0004151	Superior		Stock Cart Drawings	
			Obtain Goldshield from Material Handlling	Receiving		Honeywell		Forklift	
		2	Visually inspect vehicle for non-conformities, missing parts from Station #1starting at the back left of the vehicle				1		
		3	Visually inspect assemblies from Material Handling prior to mounting them to the vehicle				1		
		4	Chase wall blocks with drill and tap down all of left (Driver side)					Drill and Tap	
		5	Obtain Goldshield studs and secure into wall blocks down all of left side (Driver side)				1		
		6	Get Goldshield (33P1053B)install upper shield to wall aligning with studs place 1/8 gauge sheet metal over left and right sides handstart nuts and run down with right angle motor.						
		7	Get Goldshield (33P1054B)install lower shield to wall aligning with studs place 1/8 gauge sheet metal over left and right sides handstart nuts and run down with right angle motor.						
		8	Grind off stud ends flush with nut using angle grinder					Angle Grinder	
		9	Repeat process for each panel listed . See visual aid				5	Visual Aid	
		10	For a Mark 3 the panels are 5 panels #33p1063b and 5 panels #33p1059b				1		
			NOTE: The number of panels will be differnet for a Mark 1 and Mark 2						

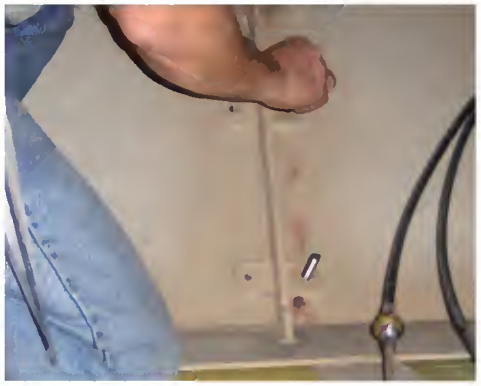
Station 9 Process 6 – Driver Side Goldshield

Step 1: Obtain materials from Material Handling

Steps 2-3: Visually inspect vehicle and panels for flaws

Step 4: Chase wall blocks to remove paint from threads

Step 5: Obtain studs and screw them into wall blocks



Step 6-7: Place upper and lower panels, tighten with nuts

Step 8: Grind off stud ends flush with nut using angle grinder

Station 9 Process 6 – Driver Side Goldshield

Vin # _____

Station 9

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Clamshell Fibertec									
		1	Obtain Fibretec panels from material handling						
		2	Obtain washers and 1/2" nylock nuts from material handling						
		3	Layout panels						
		4	Fit panels on studs in clamshell						
		5	Install washer and 1/2" nylock nut on each stud and tighten					Wrench	

Station 9 Process 7 – Clamshell Fibertec

Steps 1-2: Obtain Fibertec and washers from Material Handling

Steps 3-4: Fit panels on studs in clamshell, tighten with nuts

Station 9 Process 6 – Driver Side Goldshield

Vin # _____

Station 9

Sequence of Operations Form

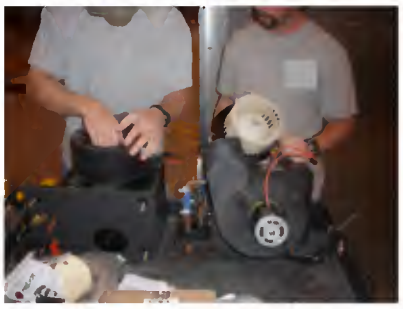
Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Rear Blower									
		1	Obtain Nut, M8 x 1.2S from Material Handling	Receiving	3900043S1A	Fastenal		Stock Cart Drawings	
			Obtain Bolt, M8 x 30 from Material Handling	Receiving	39P00044S1	Fastenal		Stock Cart Drawings	
			Obtain Washer from Material Handlling	Receiving	39P0109AA			Forklift	
			Obtain Nut from Material Handlling	Receiving	39P0102AA				
			Obtain Blower, Left and Right Kit from Material Handling	Receiving		Williams		Forklift	
		2	Visually inspect vehicle for non-conformities, missing parts from Station #1starting at the back left of the vehicle				1		
		3	Visually inspect assemblies from Material Handling prior to mounting them to the vehicle				1		
		4	Remove and realign blower vents. With blowers sitting on 4 studs and vents facing worker, rotate left (Driver side) blower vent 180 degrees. Rotate right (Passenger side) blower vent 30 degrees (this requires drilling 4 new holes in the blower to receive the vent)						Drill
		S	Mount bracket into rear locker with 8mm nuts and bolts see visual aide and repeat for other side (left-94p900SAA) right (94p9006AA)				1		
		6	Align 4 pia studs on blower to slots on bracket (verify proper side to blower),handstart 4 nuts and washer .Secure with right angle nut runner.						
		7	Repeat for other side				S	Visual Aid	
		8	Obtain heater and a/c hoses laying in bottom of locker and secure to blower unit				1		
		9	Obtain drain hoses and install to bottom of unit then run out of bottom belly pan						

Station 9 Process 9 – Rear Blower

Step 1: Obtain Materials (nuts, bolts, washers, left and right blowers with kits) from Material Handling

Steps 2-3: Visually inspect vehicle and assemblies for flaws

Step 4: Remove and blower vents, realign at correct angles, drill new holes on one then reattach blowers



Steps S and 6: Align and secure blower brackets in vehicle

Step 7: Mount other blower

Steps 8-9: Obtain and secure heater, a/c, and drain hoses

Station 9 Process 9 – Rear Blower

Vin # _____

Station 9

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Wiper Motor									
		1	Obtain Bolt, 6mm from Material Handling	Receiving	390021S3	Fastenal		Stock Cart Drawings	
			Obtain Wiper Motor from Material Handling	Receiving	3SPO14SBA	Sprague		Stock Cart Drawings	
			Obtain Thru Skin Fitting from Material Handlling	Receiving	3SPO148AA	Sprague		Stock Cart Drawings	
			Obtain Hose, Washer from Material Handlling	Receiving	3SPO1S0AA	Sprague		Stock Cart Drawings	
			Obtain Velcro from Material Handling	Receiving	32P0003AA	Waytek		Stock Cart Drawings	
		2	Visually inspect vehicle for non-conformities, missing parts from Station #1starting at the back left of the				1		
		3	Visually inspect assemblies from Material Handling prior to mounting them to the vehicle				1		
		4	Obtain wiper motor and 6mm bolts to secure at the top of left windshield opening and secure with 6mm				1	Visual aid	
		S	Obtain thru skin fitting , hold outer nozzle piece and stick from outside in thru hole place washer and nut and tighten.				1	visual aide	
		6	Hook washer hose to fitting and route per visual down a-pillar verify no pinch points.				1	visual aid , velcro	
		7	Obtain drain hoses and install to bottom of unit then run out of bottom belly pan						

Station 9 Process 10 – Wiper Motor

Step 1: Obtain Materials (bolts, Wiper Motor, Thru Skin Fitting, hose, Velcro) from Material Handling

Steps 2-3: Visually inspect vehicle and assemblies for flaws

Step 4: Secure Wiper Motor

Step 5: Obtain thru skin fitting, attach outer nozzle piece

Steps 6: Hook washer hose to fitting and route per visual down a-pillar verify no pinch points

Step 7: Obtain drain hoses and install, then install protective box

Station 9 Process 10 – Wiper Motor

Vin # _____

Station 9

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Rear Door Goldshield									
		1	Obtain Rear Door Goldshield from Material Handling						
			Obtain studs, nuts, and washers from Material Handling						
			Obtain Door Mount Panels from Material Handling						
		2	Insert studs into door and tighten						
		3	Place upper Goldshield panel, secure with washers and nuts						
		4	Place middle Goldshield panel, secure with washers and nuts						
		5	Place lower Goldshield panel, place lower door mount panel over it, tighten nuts over studs						

Station 9 Process 11 – Rear Door Goldshield

Step 1: Obtain materials (Rear Door Goldshield, studs, nuts, washers, Door Mount Panel) from Material Handling

Step 2: Insert studs into door, tighten

Step 3: Place upper Goldshield plate around window, secure with washers and nuts

Step 4: Place and secure middle Goldshield panel

Station 9 Process 11 – Rear Door Goldshield

Station 9 Process 11 – Rear Door Goldshield

Step 5: Place lower Goldshield panel, place lower door mount panel over it, tighten nuts over studs

Station 9 Process 11 – Rear Door Goldshield

Vin # _____

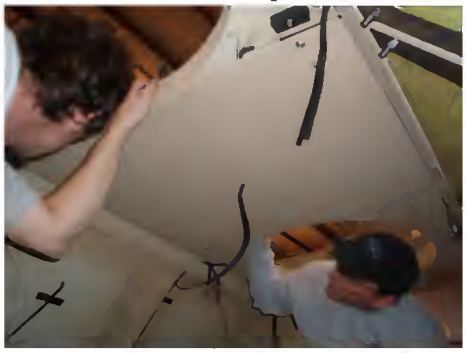
Station 9

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty.	Tools Needed	Time of Task
Station 9 - Ceiling Panels									
		1	Obtain Bolt, 8 x 30 from Material Handling	Receiving	39P0043S1	Go Light		Stock Cart Drawings	
			Obtain Bolts 8 x 40 from Material Handling	Receiving	39P0044S1	Waytek		Stock Cart Drawings	
			Obtain Block, Wall Old Style from Material Handling	Receiving	34P0046AA				
			Obtain Panels, Ceiling from Material Handling	Receiving			1		
							1		
		2	Visually inspect vehicle for non-conformities, missing parts from Station #1starting at the back left of the vehicle				1	Visual aid	
		3	Visually inspect assemblies from Material Handling prior to mounting them to the vehicle				1	Visual aide,velcro	
		4	Obtain mounting blocks , nuts and bolts(short and long bolts)attach to ceiling ribs so that panels can be installed from front to back .				1	go-light cable	
		S	Align holes in panels to ceiling blocks using line-up bar if neccesary and hand start bolts first panel(33p0056AB)					Visual aid	
		6	Repeat for panels ,(33p0069BA), (33p0066BB), (33p0068BA), (33p0066CB), (33p0067CA), (33p0068CA), (33p0069CA), (33p1067CA)					Visual aid	

Station 9 Process 12 – Ceiling Panels

Step 1: Obtain Materials (bolts, blocks, and panels) from Material Handling

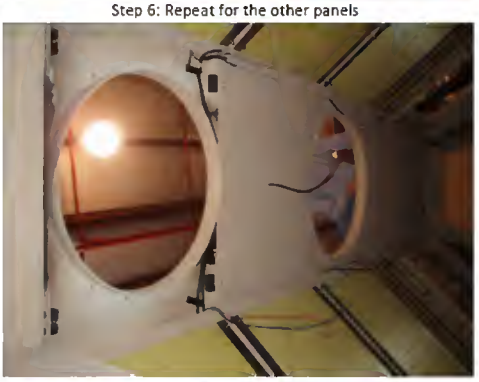


Steps 2-3: Visually inspect vehicle and assemblies for flaws

Step 4: Attach mounting blocks on ceiling

Steps 5: Align holes in panels, start attaching bolts

Step 6: Repeat for the other panels



Station 9 Process 12 – Ceiling Panels

Appendix 4: Station 10 Illustrated Sequence of Operations

Station 10 Overall Sequence of Operations						
Sequence of Operation	**Description**	**Alloted Time(hrs)**	**Actual Time**	**Operator Initals**	**Supervisor Initials**	**Remarks**
1	Install blast skirts	1.0				
2	Install turret	3.0				
3	Install spare tire	0.5				
4	Install exhaust system	0.4				
5	Install right side Gold Shield panels	1.5				
	Total Hours	6.4				

Vin # _____

Station 10

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 10 - Blast Skirts (rear BS not in MRAP vehicle because of exoskeleton)									
		1a	Obtain right side rear blast skirt	Receiving	33P0282AA	8W Small Parts	1		
		1b	Obtain M12 x 40mm bolts from the blue Fastenal hardware tree located in Station 9	Receiving	39P0014S1	Fastenal	4		
		1c	Obtain M12 - 1.7S nut from the blue Fastenal hardware tree located in Station 9	Receiving	39P004S1	Fastenal	4		
		2	See visual aid to determine how the blast skirt will sit on the mounting brackets attached to the truck						
		3	Obtain additional workers from other stations to assist in lifting the blast skirt						
		4	Lift the blast skirt and line it up with the brackets on the truck. Rest the blast skirt on the mounting brackets so the the holes in the blast skirt are alighned with the holes in the mounting brackets. Have someone go under the blast skirt, insert the M12 x 40mm bolts in the holes, and hand start them. Secure the bolts using a 18mm impact socket and impact gun.					18mm impact socket and impact gun	
		5a	Obtain the left side rear blast skirt	Receiving	33P0283AA				
		5b	Obtain M12 x 40mm bolts from the blue Fastenal hardware tree located in Station 9	Receiving	39P0014S1	Fastenal	4		
		5c	Obtain M12 - 1.7S nut from the blue Fastenal hardware tree located in Station 9	Receiving	39P004S1	Fastenal	4		
		5d	See visual aid to determine how the blast skirt will sit on the mounting brackets attached to the truck						
		6	To install the blast skirt repeat step # 4						

Vin # _____

Station 10

Sequence of Operations Form

		7a	Obtain the right side front blast skirt	Receiving	33P0284AA				
		7b	Obtain M12 x 40mm bolts from the blue Fastenal hardware tree located in Station 9	Receiving	39P0014S1	Fastenal	4		
		7c	Obtain M12 - 1.7S nut from the blue Fastenal hardware tree located in Station 9	Receiving	39P004S1	Fastenal	4		
		7d	See visual aid to determine how the blast skirt will sit on the mounting brackets attached to the truck						
		8	To install the blast skirt repeat step # 4						
		9a	Obtain the left side front blast skirt	Receiving	33P028SAA				
		9b	Obtain M12 x 40mm bolts from the blue Fastenal hardware tree located in Station 9	Receiving	39P0014S1	Fastenal	4		
		9c	Obtain M12 - 1.7S nut from the blue Fastenal hardware tree located in Station 9	Receiving	39P004S1	Fastenal	4		
		9d	See visual aid to determine how the blast skirt will sit on the mounting brackets attached to the truck						
		10	To install the blast skirt repeat step # 4						

Station 10 Process 1 – Blast Skirts (Steps 1-6: no rear blast skirts because of exoskeleton)

Steps 7&9: Obtain materials (front blast skirts, fasteners) from MH

Steps 8,10, and 11: Hoist, align, and secure blast skirts

Station 10 Process 1 – Blast Skirts

Vin # _____

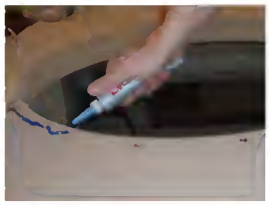
Station 10

Sequence of Operations Form

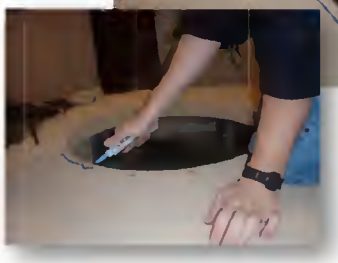
Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 10 - Rear Turret									
		1a	Obtain the rear hatch cover from material handling	Receiving		Platt	1		
		1b	Obtain the blue Locktite from the work bench in Station 11	Receiving			1		
		2	Place a even bead of blue locktite around the hole in the roof of the truck an inch inisde the holes in the roof.						
		3	Have material handling bring the fork lift to Station 10. Attch the rear hatch cover to the fork lift using two qualified weight nylon straps. Loop the straps around the hatch cover and around the forks on the forklift. Have 2 people go onto the roof of the truck. Hoist the rear hatch cover over the truck aligning it with the hole in the roof.						
		4	Align the holes in the hatch cover with the holes in the roof of the truck. Hand tighten the S/16th bolts and secure using a 13mm ratchet wrench.						
		5a	Obtain the turret from material handling						
		5b	Obtain the spacer ring from material handling	Receiving		AMT	1		
		6	Align the holes in the spacer ring with the holes in the turret. Attach the spacer right to the turret using the ??mm bolts. Hand start the bolts and secure using a ??mm ratchet wrench.						
		7	Attach the turret to the the forlk lift using two qualified weight nylon straps. Loop the straps around the turret						
		8	Align the holes in the turret with the holes in the roof of the truck. Hand tighten the S/16th bolts and secure using a 13mm rachet wrench.						

Station 10 Process 2 – Small Turret

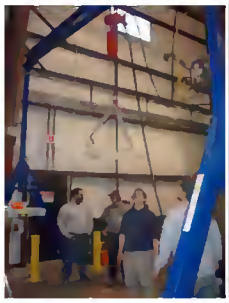
Step 1: Obtain materials



Step 2: Place loctite bead an inch from hatch opening



Step 3: Hoist rear turret, line up with holes, secure



Station 10 Process 2 – Small Turret

Vin # _____

Station 10

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 10 - Motorized Turret									
		1a	Obtain the geared front hatch and geared hatch ring	Receiving		Platt	1		
		1b	Obtain bolts, rubber bushings, and sealant foam	Receiving			1		
		2	Place rubber bushings and sealant foam in holes surrounding the hatch opening						
		3	Place geared turret ring in hatch opening, line up holes						
		4	Hoist hatch, lower onto geared ring						
		5	Place bolts upwards through rubber bushings, secure hatch						

Station 10 Process 3 – Motorized Turret

Step 1: Obtain materials

Step 2: Place rubber bushings and sealant foam in holes surrounding the hatch opening

Station 10 Process 3 – Motorized Turret

Station 10 Process 3 – Motorized Turret

Step 3: Place geared turret ring and line up holes

Step 4: Hoist hatch, lower onto geared ring

Step 5: Place bolts up through rubber bushings, secure hatch

Station 10 Process 3 – Motorized Turret

Vin # _____

Station 10

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 10 - Spare Tire									
		1a	Obtain the spare tire from material handling using the fork lift	Receiving			1		
		1b	Obtain crank and cable from material handling in row 7 section c and d	Receiving			1		
		1c	Obtain spare tire carrier parts kit from the Station #10 staging area	Receiving		BW Small Parts	1		
		2	Bolt the crank to the side of the truck using the bolts that are in the holes. (Note: Be sure to put locktite on bolts)						
		3	Obtain pulley from the Station #10 staging area						
		4	Mount the pulley to the truck by placing it between the the two mounts located 8 - 10 inches below the crank. (See Visual Aid)						
		5	Obtain arm from Station #10 staging area						
		6	Using the 1 inch pin holding the arm at the bottom bracket line up the holes in the bracket with the holes in the arm and insert the pin. Then secure with 2 carter pins to either side of the one inch pin.						
		7	Obtain the other pulley from the Station #10 staging area						
		8	Repeat the pulley process attaching it above the arm						
		9	Obtain the cable from the Station #10 staging area						
		10	Attach the cable to the arm by inserting the cable wire lock through the shackle.						
		11	Take the other end of the cable and run it up the side of the truck and behind the 2 pulleys. Attach the cable						

Vin # _____

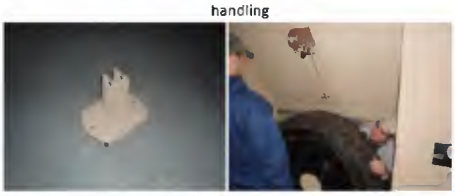
Station 10

Sequence of Operations Form

		12	Obtain the spare tire stud plate from the Station #10 staging area						
		13	Align the studs on the plate through the holes in the rim. Secure the stud plate to the spare tire using ???						
		13	Walk the tire to the arm and attach the spare tire stud plate to the spare tire arm using the other pin.						
		14	Hoist the tire to the side of the truck by turning the crank using the impact wrench.						

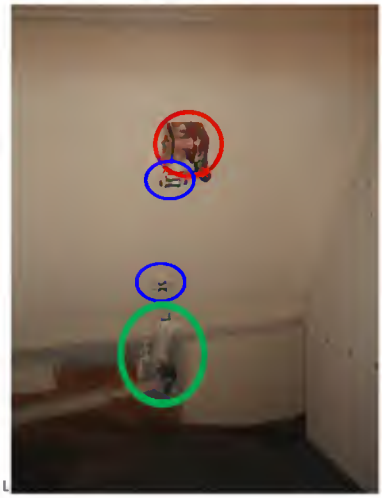
Station 10 Process 4 – Spare Tire

Step 1: Obtain materials (tire, crank, cable, kit) from material handling



Step 2: Bolt crank to truck

Steps 3, 4 and 7, 8: Obtain 2 pulleys and attach to truck

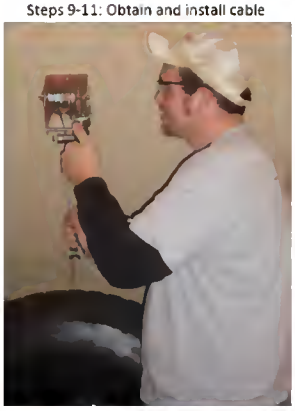


Steps 5 and 6: Obtain and install tire arm

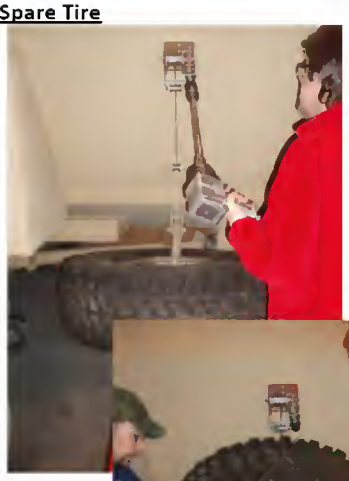
Station 10 Process 4 – Spare Tire

Station 10 Process 4 – Spare Tire

Steps 9-11: Obtain and install cable



Steps 12-14: Obtain stud plate, secure to tire and hoist tire using crank to the side of the vehicle



Station 10 Process 4 – Spare Tire

Vin # _____

Station 10

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 10 - Exhaust System									
		1a	Obtain exhaust pipe kit from the Station 10 staging area	Receiving			1		
		1b	Obtain exhaust clamp kit from Station 10 staging area	Receiving			1		
		2	Align the 90 degree pipe that is exiting the right fender of the truck to the long end of the s pipe that comes in the kit. Secure the pipes together by sliding the end of the s pipe inside the 90 degree pipe.						
		3	At the joint between the s pipe and the 90 degree pipe apply the u bolt over the pipe. Place the clamp under the pipe and align the holes in it with the holes in the t bar. Insert the threaded ends of the u bolt through the holes in the t bar. Hand start the nuts on the threaded end of the u bolt under the t bar and secure using a ratchet wrench.						
		4	Attach the straight pipe to the s pipe the same way using the clamp and u bolt from the exhaust kit and the t bar attached to the truck.						
		5	Attach the muffler to the straight pipe the same using the clamp and u bolt from the exhaust kit and the t bar attached to the truck.						
		6	Attach the tail pipe to the muffler the same way using the clamp and u bolt from the exhaust kit and the t bar attached to the truck.						
		7	Obtain the cover shield kit from the Station 10 staging area	Receiving		BW Small Parts	1		
		8	See the visual aid to determine which cover shields will go in what locations on the exhaust pipes.						
		9	Center the cover shield on the section of pipe that you are covering.						

Vin # _____

Station 10

Sequence of Operations Form

		9	Secure the cover shield to the exhaust pipe by placing the u bolt around the exhaust pipe and sliding on the						
		10	Hand start the nuts to the threaded end of the u bolt and secure using a ??mm ratchet wrench (Note: The						

Station 10 Process 5 – Exhaust System

Step 1: Obtain materials (muffler, pipes, paint, fittings)

Step 2: Paint pipes and muffler black

Steps 3-4: Align and secure 90º pipe through front into engine

Step 5: Attach single curve pipe, secure

Step 6: Attach muffler

Station 10 Process 5 – Exhaust System

Station 10 Process S – Exhaust System

Step 7: Attach S-Pipe and attach muffler tail pipe, finalizing exhaust

Steps 8-9: Obtain and secure exhaust cover shields

Station 10 Process S – Exhaust System

Vin # _____

Station 10

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 10 - Passenger Side Goldshield									
		1a	Obtain the M12 - 1.75 x 60mm studs from the blue Fastenal hardware tree located in Station 9	Receiving	39P001SS1	Fastenal	125		
		1b	Obtain the 19mm hex head nuts from the blue Fastenal hardware tree located in Station 9	Receiving	39P01S9AA	Fastenal	125		
		1c	Obtain Goldshield panels from material handling	Receiving					
		1d	Obtain 1/8 x 2 inch metal strips from material handling	Receiving					
		1e	Obtain 5/16 washers from the blue Fastenal hardware tree located in Station 9	Receiving		Fastenal	44		
		1f	Obtain inverter bracket from "Jack's Brackets" in Row 288 in material handling	Receiving	34P9038AA	BW Small Parts	1		
		1g	Obtain 10mm bolts from blue Fastenal hardware tree located in Station 9	Receiving		Fastenal	4		
		2	Thread the studs into the blocks on the wall by turning the studs counter clockwise (Note: some of the holes in the blocks will need to be tapped to ensure that the stud treads all the way to the inside wall).						
		3	Align the holes in the Goldshield panels with the threaded studs. Slide the goldshield panel into the space between the ribs so that the studs are going through the Goldshield panel.						
		4	On the top 2 and bottom 2 center studs slide a washer onto the stud and hand start a 19mm hex head nut on the stud. Secure the nut using a 19mm ratchet wrench.						

Vin # _____

Station 10

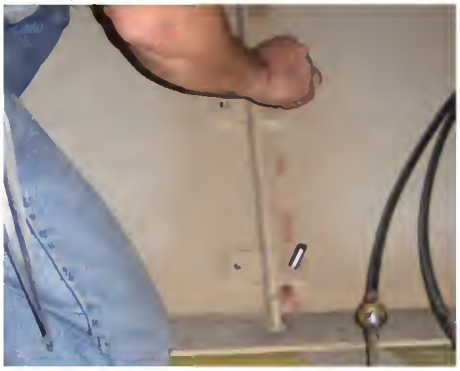
Sequence of Operations Form

		5	Line up the holes in the metal strip with the studs going through the Goldshield panel. Slide the metal strip on so the studs go through the metal studs. Hand start a 19mm hex head nut on the stud and secure using a 19mm ratchet wrench.						
		6	On panel place the inverter bracket over the studs and secure with a 19mm ratchet wrench (see visual aid).						

Station 10 Process 6 – Passenger Side Goldshield

Step 1: Obtain materials from Material Handling

Step 2: Obtain studs and screw them into wall blocks



Chase any wall blocks that threads are painted in

Steps 3-6: Place upper and lower panels, tighten with nuts

Station 10 Process 6 – Passenger Side Goldshield

Vin # _____

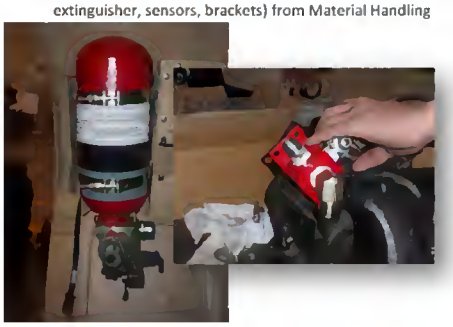
Station 10

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 10 - Front Blower and Left IP									
		1a	Obtain front blower from material handling	Receiving			1		
		1b	Obtain blower brackets from material handling	Receiving		BW small parts	1		
		1c	Obtain left instrument panel from material handling	Receiving		BW small parts	1		
		1d	Obtain A/C vents from material handling	Receiving			2		
		1e	Obtain fire supression manual discharge panel from material handling	Receiving		kidde	1		
		1f	Obtain IR control panel from material handling	Receiving			1		
		1g	Obtain sheet metal panel insert from matrial handling	Receiving		BW small parts	1		
		1h	Obtain flex light from material handling	Receiving			1		
		2	Mount front blower onto mounting bracket and install assembly into cab					socket wrench	
		3	Connect blower to wiring harness						
		4	Install A/C vents (2) onto left IP and connect to A/C ducts					Screw driver	
		5	Install left instrument panel in cab over front blower assembly					socket wrench	
		6	Insert manual fuel shut off pull rods (2) through left IP						
		7	Mount Fire supression manual discharge panel onto panel insert and connect to wire harness					Screw driver	
		8	Mount IR control panel onto panel insert and connect to wire harness					Screw driver	
		9	Mount sheet metal panel insert to left IP					Screw driver	

Station 10 Process 7 – Fire Suppression System

Step 1: Obtain materials (manifold, hoses and fittings, extinguisher, sensors, brackets) from Material Handling



Step 2: Cut S hoses to length, attach to manifold

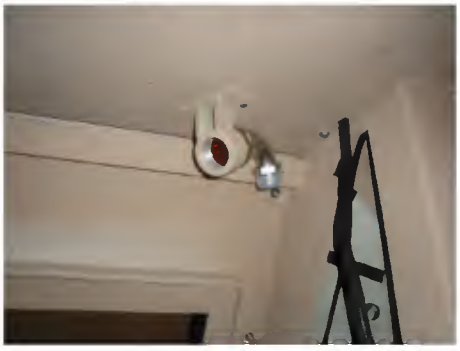
Steps 3-6: Install extinguisher manifold and nozzle brackets in engine bay

Station 10 Process 7 – Fire Suppression System

Station 10 Process 7 – Fire Suppression System

Step 7: Install fire detection sensor in engine bay

Step 8: Install extinguisher mounting brackets and nozzles in body



Station 10 Process 7 – Fire Suppression System

Vin # _____

Station 10

Sequence of Operations Form

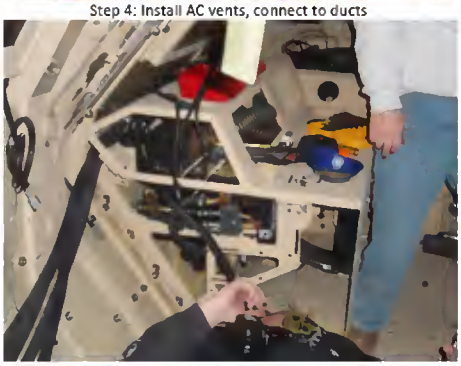
Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 10 -Fire Supression (Interior and Exterior)									
		1a	Obtain engine bay fire supression manifold from material handling	Receiving		Kidde	1		
		1b	Obtain hoses and proper fittings from material handling	Receiving		Kidde			
		1c	Obtain fire extinguisher from material handling	Receiving		Kidde	3/4		
		1d	Obtain mounting brackets for manifold, hoses and extinguisher from material handling	Receiving		BW small Parts	6		
		1e	Obtain fire sensors from material handling	Receiving		Kidde	S/6		
		2	Manufacture S hoses (1 inlet & 4 outlets) and attach to manifold					bench vice, hose cutter	
		3	Install extinguisher mounting bracket in engine bay and then extinguisher in bracket					Socket Wrench	
		4	Install manifold bracket onto manifold and install in engine bay					Socket Wrench	
		S	Install mounting bracket on each of 4 outlet hoses and install in engine bay					Socket Wrench	
		6	Attach inlet hose from manifold to extinguisher					Wrench	
		7	Install sensor onto sensor bracket and install into engine bay. Connect sensor to wiring harness					Socket Wrench	
		8	Install fire extinguisher mounting brackets (2 in MARK I, 3 in MARK III) in the cab and body					Socket Wrench	
		9	Install fire extinguishers into mounts					Socket Wrench	
		10	Using fittings and hoses provided in kit, assemble extinguisher exhausts as shown in pictures					Wrench	
		11	connect sensor wires to wiring harness and mount sensors					Socket Wrench	

Station 10 Process 8 – Front Blower and Left Instrument Panel

Step 1: Obtain materials (brackets, IP, fasteners, etc.) from MH

Steps 2 and 3: Mount blower in brackets, install into vehicle, connect to wiring harness

Step 4: Install AC vents, connect to ducts



Steps 5-9: Install driver side instrument panel over blower, finalize all connections, including sheet metal insert

Station 10 Process 8 – Front Blower and Left Instrument Panel

Vin # _____

Station 10

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 10 - Door Parts									
		1	Obtain Door Parts removed prior to paint process in Station #6	Receiving			1		
		2	Install locking mechanism (door handle on interior and exterior) and check for proper fit, friction, and funtionality					Rubber mallot	

Vin # _____

Station 10

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 10 - Side Door Goldshield									
		1	Obtain Side Door Goldshield from Material Handling						
			Obtain studs, nuts, and washers from Material Handling						
			Obtain Door Mount Panels from Material Handling						
		2	Insert studs into door and tighten						
		3	Place upper Goldshield panel, secure with washers and nuts						
		4	Place middle Goldshield panel, secure with washers and nuts						
		5	Place lower Goldshield panel, place lower door mount panel over it, tighten nuts over studs						

Station 10 Processes 9&10 – Door Parts and Side Door Goldshield

Process 9 Step 1: Obtain materials (door parts)
Process 9 Step 2: Reassemble parts on door

Process 10 Step 1: Obtain materials (Goldshield, studs, etc.)

Process 10 Step 2: Insert studs, tighten

Process 10 Steps 3-5: Install panels from top to bottom

Station 10 Processes 9&10 – Door Parts and Side Door Goldshield

Appendix 5: Station 11 Illustrated Sequence of Operations

Station 11 Overall Sequence of Operations

Sequence oI Operation	Description	Alloted Time(hrs)	Actual Time	Operator Ioitals	Supervisor Ioitials	Remarks
1	Install raceway	0.3				
3	Install l/s ac duct	1.0				
4	Exterior DOT wiring and lights	1.5				
5	Fender Mirrors	0.3				
6	Interior Lighting	0.8				
7	Door Rubbers	0.6				
8	Install Wiper Arm,hose and front ext lights	0.6				
9	Exterior Utility Lighting side and rear	0.8				
10	Antenna Box	0.6				
11	Install front floor plate and gas pedal	1.0				
	Total Hours	7.5				

Vin # _____

Station 11

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - Raceway									
		1	Obtain a 3 foot section of raceway from material handling	Receiving	3SP0114AA	Newark	1		
		2	Peel adhesive from the back of the raceway section						
		3	Using a pair of snips cut the convelent casing off of the wires so they can be properly inserted into the raceway					snips	
		4	Lay the wires into the raceway, close the raceway cover, and adhere the raceway to the interior panel.						

Station 11 Process 2 - Raceway

Step 1: Obtain 3' raceway section from MH

Steps 2-4: Insert wires into raceway and attach to wall

Station 11 Process 2 - Raceway

Vin # _____

Station 11

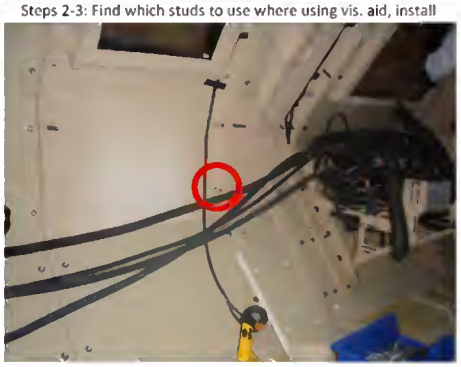
Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - Left AC Duct									
		1a	Obtain 19mm nuts from blue Fastenal hardware tree located in Station 9	Receiving	39P001SS1	Southeastern	3		
		1b	Obtain #8 x 1/2in screws from the blue Fastenal hardware tree located in Station 9	Receiving	39P0007S1	Fastenal	20		
		1c	Obtain trough from the electrical shop	Receiving	35P0173BA	AMT	1		
		1d	Obtain the S0mm studs from the blue Fastenal hardware tree located in Station 9	Receiving		AMT	3		
		1e	Obtain a 4in hose clamp from the WW Williams kit	Receiving		WW Williams	1		
		2	Inspect the visual aid to determine which blocks will require the longer length studs to be inserted into them					visual aid	
		3	To install the studs thread it into the block by turning it clockwise until it is fully hand tightened						
		4	Insert the wires hanging out the bottom of the goldshield panels into the trough.						
		5	Locate the camera wire in the the trough. Run the wire out of the trough in the rear of the truck and up						
		6	Locate the hardshell flex pipe in the trough and attach it to the fixture on top of the blower in the rear locker. Secure the pipe with a 4in hose clamp and tighten using a 8mm nut driver.						
		7	Connect all wires from the wall panel to the properly labeled hardshells in the wire harness						
		8	Using the #8 x 1/2 screws install the cover on the trough by lining up the holes on the cover with the						

Station 11 Process 3 – Driver Side AC Duct

Step 1: Obtain materials (screws, nuts, trough, studs, hose clamp) from Material Handling

Steps 2-3: Find which studs to use where using vis. aid, install



Steps 4-5: Run wires through Goldshield, separate and route camera wire

Steps 5-8: Install trough, effectively covering hoses, secure to wall

Station 11 Process 3 – Driver Side AC Duct

Vin # _____

Station 11

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - External DOT Light Wires									
		1a	Obtain 1/4 - 20 x 1 stainless steel bolts from the electrical shop	Receiving	3P008752	Fastenal	12		
		1b	Obtain headlight ring from material handling	Receiving	34P9024AA	AMT	2		
		1c	Obtain headlight assembly from material handling	Receiving	35P0217AA	Grote	2		
		2	See visual aid to find proper location of the headlights						
		3	Connect the hardshell from the proper wires to the connection on the headlights						
		4	To install the headlights push the light into the opening on the truck body						
		5	Position the light so the holes on the light line up with the holes on the truck body. Hand tighten the 1/4 - 20 x 1 bolts and secure using a 10mm rachet wrench.					10mm rachet wrench	
		6	Place the headlight ring over the headlight and line up the holes in the ring with the holes in the truck body. Hand start the bolts and secure using 10mm rachet wrench.					10mm rachet wrench	
		7	To install the headlights push the light into the opening on the truck body						
		8a	Obtain the red marker lights from the electrical shop	Receiving	RT35P0214A	Grote	2		
		8b	Obtain the orange marker lights from the electrical shop	Receiving	RT35P0215A	Grote	2		
		8c	Obtain 10/24 screws from the electrical shop	Receiving	39P0024S2	Fastenal	30		
		9	See visual aid to find the proper location of the side marker lights						
		10	To install the red and orange marker lights align the holes in the light with the holes in the truck body.						

Vin # _____

Station 11

Sequence of Operations Form

		11a	Obtain the front turn signal assembly from electrical shop	Receiving	35P0209AA	Grote	2		
		11b	Obtain the rear turn signal assembly from the electrical shop	Receiving	35P0210AA	Grote	2		
		12	See visual aid to find the proper location of the front and rear turn signals						
		13	Connect the hardshell on the truck to the hardshell connection on the turn signal. Secure the turn signal to the truck using\ the 10/24 screws.						

Station 11 Process 4 – DOT Light Wiring

Step 1: Obtain materials (bolts, lights, boxes) from MH

Step 2: Obtain and utilize station visual aid to properly place headlight

Steps 3-7: Line up and insert headlight on vehicle, hand start bolts, securing headlight to vehicle

Steps 8-10: Obtain and install orange (front) and red (back) marker lights using visual aid for their placement

Steps 11-12: Obtain and secure turn signals

Station 11 Process 4 – DOT Light Wiring

Station 11 Process 4 – DOT Light Wiring

Step 13: Finalize headlight box installation by securing the box to the vehicle, finalizing connections

Station 11 Process 4 – DOT Light Wiring

Vin # _____

Station 11

Sequence of Operations Form

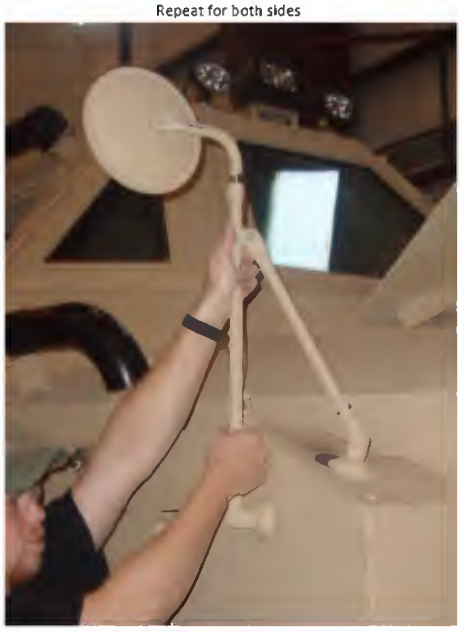
Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - Fender Mirrors									
		1	Obtain the fender mount mirror kits from material handling	Rec.	34P0034AA	Tidewater Fleet Supply	2		
		2	To install the fender mount mirrors lossen the bolts on the mirror kit and align it with the holes on the fender. Remove the nut from the bolt and insert it into the hole in the fender. From the outside of the fender person #1 will hold a 14mm rachet wrench on the bolt. From the inside of the fender panel person #2 will secure the nut using the 14mm rachet wrench.					2 14mm rachet wrench	
		3	tighten all the nuts on the mirror once it has been adjusted and positioned correctly.					14mm rachet wrench	
		4	repeat previous steps for the other side					14mm rachet wrench	
		5a	Obtain the right side hummer mirror kit from material handling	Rec.	34P0018AA	Roscoe	1		
		5b	Obtain the left side hummer mirror kit from material handling	Rec.	34P0019AA	D	1		
		5c	Obtain 4 M8 x 1.25 flange nut from the blue Fastenal hardware tree located in Staation 9		39P0116AA	Fastenal	4		
		5d	Obtain 4 M8 x 30 flange bolt from the blue Fastenal hardware tree located ibn Station 9		39P0044S1	Fastenal	4		
		6	To install the hummer mirrors see the provided visual aid to locate which of the window studs the mirrors will						
		7	To assemble the mirrors to the mirror brackets line up the holes on the mirror with the holes on the mirror brackets. Thread a flange bolt through the hole and secure using the flange nut on the threaded end of the bolt. Using a 13mm rachet wrench secure the nut to the bolt.						
		8	Using the air rachet and 16mm socket remove the nuts from the studs that will require the mirrors to be					air rachet and 16mm socket	

Station 11 Process 5 – Fender Mirrors

Step 1: Obtain fender mirror kit from MH

Steps 2-4: Install fender mirror by securing with nuts under fender panel

Repeat for both sides



Step 5: Obtain Hummer mirror kit

Steps 6-8: Install Hummer mirror by utilizing studs and nuts on the side mirror

Repeat for both sides

Station 11 Process 5 – Fender Mirrors

Vin # _____

Station 11

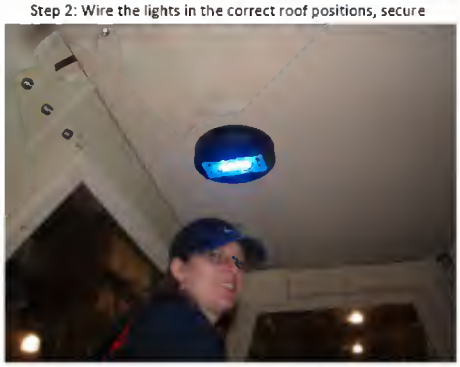
Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - Interior Lighting									
		1a	Obtain 2 blue and white interior roof lights from material handling	Receiving	33P0271AA	Grote	2		
		1b	Obtain 4 M6 x 40 bolts from the blue Fastenal hardware tree located Station 9	Receiving	39P0021S3	Fastenal	4		
		2	To connect the wires for the interior roof lights line up the colored wire on the light to the same color wire coming out of the ceiling panel. Insert the coordinaing colored wire into the same color wire that has the wire connector on the end of it. Using a crimper crimp the colored wires together. Heat the wire connector using a lighter. Align the holes in the light with the holes in the roof and secure using the M6 x 40 mm bolts. Tighten the bolts with a 6mm rachet wrench .						
		3	Obtain 4 interior wall lights from material handling	Receiving	2JA343680277	Grote	4		
		4	Obtain 8 x 1/2 screw from the blue Fastenal hardware tree located in Station 9	Receiving	39P0007S1	Fastenal	16		
		5	See visual aid to determine where the interior lights will be positioned						
		6	Connect the wires coming out the back of the light to the wires coming mout the back of the interior panels.						
		7	To install the interior wall lights line up the holes on the light with the holes on the interior panels. Insert a 8 x 1/2 screw through the hole in the light and the hole in the interior panel. Hand start screws and secure with a phillips head screw driver.						
		8	Repeat steps 6 and 7 to install the 3 remaining interior lights.						

Station 11 Process 6 – Interior Lighting

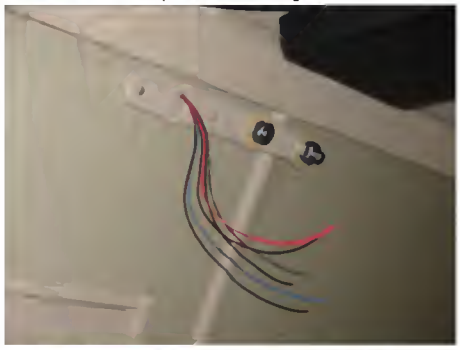
Step 1,3,&4: Obtain 6 blue and white interior lights from MH

Step 2: Wire the lights in the correct roof positions, secure



Step 5: Use visual aid to determine wall light placement

Step 6: Wire the first light



Steps 7-8: Secure light, repeat for the rest of the wall lights

Station 11 Process 6 – Interior Lighting

Vin # _____

Station 11

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - Door Rubber									
		1	Obtain door rubber from material handling	Receiving	34P00S1AA	Trimlok	400"		
		2	Using a pair of snips cut the door into 2 200 inch pieces.						
		3	To install the door rubber start in the lower right hand corner 1 inch above the bottom. Open the channel on the door rubber by bending it backwards. Place the open channel over the edge of the door opening. Working towards the top of the door opening tap the door rubber with a rubber mallet and work your way around the door opening (Note: ensure that the door rubber is properly placed over the door opening and has not been pinched).						
		4	Repeat the previous steps for rear door opening						

Station 11 Process 7 – Door Rubbers

Step 1: Obtain materials (door rubber) from material handling

Step 2: Cut rubber to size

Step 3: Install rubber in front door

Step 4: Repeat for rear door

Station 11 Process 7 – Door Rubbers

Vin # _____

Station 11

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - Wiper Arm, Exterior Spotlights									
		1	Obtain wiper arm kit from material handling	Receiving	3SP0146AA	Sprague	1		
		2	See visual aid to ensure wiper will be located in the correct position						
		3	Cut 2" off each side of the wiper arm.						
		4	To install the wiper arm position the arm on the windshield so it is in the up position. Slide the wiper arm onto the stud at the top of the window. Hand tighten the bolt onto the stud and secure using a 18mm rachet wrench.					18mm rachet wrench	
		5	Attach the washer hose to the thru skin fitting on the nozzle						
		6a	Obtain the Go Light kit from material handling	Receiving	3SP0050BA	Go Light	1		
		6b	Obtain 10 x 24 1 inch screws from the blue Fastenal hardware tree located in Station 9	Receiving		Fastenal	4		
		6c	Obtain nylon lock nut from the blue Fastenal hardware tree located in Station 9	Receiving		Fastenal	4		
		7	Remove the Go Light mounting bracket from the kit.						
		8	Locate the 2 wires that are exiting the roof of the truck through the front stuffer tube. Insert the 2 wires through the hole in the Go Light mounting bracket. Attach the mounting bracket to the roof of the truck using the 10 x 24 screws. Secure the screws using a battery operated drill and phillips head bit. Attach the 2 wires that were threaded through the mounting bracket to the 2 wires that are located on the back of the Go Light.					battery operated drill and phillips head bit	
		9a	Obtain the spot lights from material handling (Note: The front spot lights have clear lenses because they are long range lights).	Receiving	3SP0121AA	Grote	2		

Vin # _____

Station 11

Sequence of Operations Form

		9b	Obtain 10mm lock washers from the blue Fastenal hardware tree located in Station 9	Receiving		Fastenal	1		
		10	Remove the nut from the bottom of the bolt on the spot light. Line the bolt on the bottom of the spot light up with block that is mounted on the roof of the truck. Turn the spot light clockwise to thread the bolt into the block. Once the light has been tightened to the truck ensure that the light is facing forward. Connect the hardshell wire that is exiting the truck through the stuffer tube to the hardshell connection on the back of the spot light.						

Station 11 Process 8a - Wiper Arm, Exterior Front Light

Steps 1&2: Obtain wiper arm, use visual aid to ensure correct positioning

Step 3: Cut 2" off each side of the wiper arm

Steps 4&5: Install the wiper arm, secure, attach hose to fitting

Step 6: Obtain Go-Light Kit and Fasteners

Step 7: Remove mounting bracket

Station 11 Process 8a - Wiper Arm, Exterior Front Light

Station 11 Process 8a - Wiper Arm, Exterior Front Light

Step 8: Wire and secure Go-Light on roof on mounting bracket

Steps 9: Obtain spot lights and fasteners from MH

Steps 10: Install spotlights

Station 11 Process 8a - Wiper Arm, Exterior Front Light

Vin # _____

Station 11

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - Exterior Side and Rear Spotlights & Tophat									
		1a	Obtain 10mm lock washers from the blue Fastenal hardware tree located in Station 9	Receiving		Fastenal	3		
		1b	Obtain the side spot lights from material handling (Note: the side spot lights have frosted lenses because they are short range lights)	Receiving	35P0122AA	Grote	2		
		1c	Obtain the rear spot light from material handling (Note: the rear spot light has a frosted lense because it is a short range light	Receiving	35P0122AA	Grote	1		
		1e	Obtain tophat from material handling	Receiving	BW small parts		1		
		2	Remove the nut from the bottom of the bolt on the spot light. Line the bolt on the bottom of the spot light up with block that is mounted on the roof of the truck. Turn the spot light clockwise to thread the bolt into the block. Once the light has been tightened to the truck ensure that the light is facing forward. Connect the hardshell wire that is exiting the truck through the stuffer tube to the hardshell connection on the back of the spot light.						
		3	To install the rear spot light repeat the installation instructions for the front spot light (Note: once installation of the rear spot light in complete direct the light so that is angled towards the ground)						
		4	Once installation of the side and rear lights are complete direct the lights so that they are angled at the ground						
		5	Install tophat on roof of cab and tighten nuts on each of the eight studs					Ratchet	

Station 11 Process 8b – Side and Rear Spotlights and Tophat

Step 1: Obtain materials (lights, tophat, fasteners) from MH

Step 2: Secure lights to side of truck, connect to wire

Step 3: Repeat for rear light

Step 4: Position lights to shine on the ground

Step 5: Install Tophat

Station 11 Process 8b – Side and Rear Spotlights and Tophat

Vin # _____

Station 11

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - Antenna Box									
		1a	Obtain the silicone caulk from blue Fastenal hardware tree located in Station 11	Receiving	82P0126AA	Sherwin Williams	1		
		1b	Obtain antenna box from material handling	Receiving	34S9048AA	BW small parts	S		
		1c	Obtain 10mm allen head bolts from the blue Fastenal hardware tree located in Station 9	Receiving	39P007SS3	Fastenal	3S		
		1d	Obtain 6mm bolts from the blue Fastenal hardware tree located in Station 9	Receiving	39P0064S3	Fastenal	20		
		1e	Obtain the antenna box plate cover from material handling	Receiving		BW small parts	S		
		1f	Obtain the antenna box plate cover from material handling	Receiving		BW small parts	S		
		2	Run a bead of silicone caulk along antenna box edge						
		3	Line up the 7 holes in the box with the 7 holes in the truck body. Insert a 10mm allen bolt through the hole in the antenna box and into the hole in the truck body. Hand start the bolt and secure using a battery operated drill and a 10mm allen head drill socket. Repeat the process to install the remaining 6 bolts on the antenna box.					drill, 10mm allen head drill socket	
		4	Repeat the previous step to install the 4 remaining antenna boxes					drill, 10mm allen head drill socket	
		S	Run a bead of silicone caulk along antenna box cover plate edge						

Vin # _____

Station 11

Sequence of Operations Form

		6	Line up box cover plate over 4 holes in the plate cover with the 4 holes in the antenna box. Insert a 6mm bolt through the plate cover and into the hole in the antenna box. Hand tighten the bolt and secure using a rachet wrench. Repeat bolt process for the remaining 3 bolts to secure the antenna plate cover.						
		7	Repeat the previous step to install the 4 remaining antenna box plate covers						

Station 11 Process 9 – Antenna Box

Step 1: Obtain materials (antenna box, fasteners, silicon) from MH

Step 2: Run a bead of silicone caulk around antenna box edge

Steps 3-4: Secure boxes to vehicle by lining up holes on studs and tightening nuts over them

Step 5: Run silicone caulk around antenna box cover edge

Step 6: Bolt down cover plate

Step 7: Repeat for other antenna boxes

Station 11 Process 9 – Antenna Box

Vin # _____

Station 11

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - Front Floor Plate & Gas Plate									
		1a	Obtain the front floor plate from material handling	Receiving	33P0048AA	AMT	1		
		1b	Obtain M10 x 40 bolts from material handling	Receiving	39P0016S1	Fastenal			
		2	Place the floor plate on the floor in the cab portion of the truck. Using a line up bar position the holes in the floor plate so they line up with the holes in the cross member. Hand start all the M10 x 40 bolts (Note: See visual aid to determine which hole will not get a bolt so the accelerator pedal can be installed). Secure all the bolts using a battery operated drill and a 6mm allen head drill socket.						
		3	Obtain 8mm 1/2 inch long self tapping screws from the blue Fastenal hardware tree located in Station 9.	Receiving	39P0023AA	Fastenal	2		
		4	See visual aid to determine the location of the pilot holes that will need to be drilled						
		5	Align the hole in the gas pedal with the hole that was drilled in the floor plate during the previous step.						
		6	Using the self tapping screw attach the accelerator pedal to the floor plate. Secure the screw using a battery operated driver.						

Station 11 Process 10 – Front Floor Plate and Gas Pedal

Step 1: Obtain materials (front floor plate, bolts) from MH

Step 2: Place front floor plate, line up holes, secure with bolts

Steps 3&4: Obtain fasteners and visual aid for gas pedal, drill pilot holes for self tapping screws

Step 5: Secure pedal

Station 11 Process 10 – Front Floor Plate and Gas Pedal

Vin # _____

Station 11

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - Exo-Skeleton									
		1a	Obtain upper 3/8" steel plates from material handling	Receiving			6-10	Forklift	
		1b	Obtain upper exo-skeleton hanger brackets from material handling	Receiving			8-12	Forklift	
		1c	Obtain upper hanger bracket top plates	Receiving			8-12	Forklift	
		1d	Obtain upper aluminum plates from material handling	Receiving			16-24	Forklift	
		1e	Obtain upper Exo-Scale plates from material handling	Receiving			8-12	Forklift	
		1f	Obtain upper Goldshield plates from material handling	Receiving			8-12	Forklift	
		1g	Obtain lower 3/8" steel plates from material handling	Receiving			6-10	Forklift	
		1h	Obtain lower exo-skeleton hanger brackets from material handling	Receiving			8-12	Forklift	
		1j	Obtain lower hanger bracket top plates	Receiving			8-12	Forklift	
		1k	Obtain lower aluminum plates from material handling	Receiving			16-24	Forklift	
		1m	Obtain lower Exo-Scale plates from material handling	Receiving			8-12	Forklift	
		1n	Obtain lower Goldshield plates from material handling	Receiving			8-12	Forklift	
		2	Install lower exo-skeleton hanger brackets					Ratchet	
		3	Slide in lower Goldshield plates in pockets closest to cab						
		4	Slide in lower Exo-Scale plates in pockets closest to Goldshield						
		5	Slide in lower first layer of aluminum plates in pockets closest to Exo-Scale						
		6	Slide in second layer of aluminum plates in pockets closest to first layer of aluminum						

Vin # _____

Station 11

Sequence of Operations Form

		7	Bolt on lower exterior steel plates					Ratchet	
		6	Repeat steps 2-7 for upper exo-skeleton						

Station 11 Process 11 - Exoskeleton

Step 1: Obtain materials (brackets, plates, fasteners) from MH

Step 2: Install brackets

Steps 3-6: Slide proper plates in, secure

Station 11 Process 11 - Exoskeleton

Vin # _____

Station 11

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 11 - Rear Camera									
		1a	Obtain the camera kit from material handling	Receiving	35P0144AA	Dayota Micro	1		
		1b	Obtain a 10mm bolt from the blue Fastenal hardware tree located in Station9	Receiving		Fastenal	1		
		2	Connect the camera wire that is exiting the truck through the rear stuffer tube to the back of the camera.						
		3	Using the 10mm bolt bolt the camera to the block that is placed above the rear door of the truck.						

Station 11 Process 12 – Rear Camera

Step 1: Obtain materials (camera, fasteners) from MH

Step 2: Connect the camera to the wire coming out of the vehicle

Step 3: Fasten camera with nut

Station 11 Process 12 – Rear Camera

Appendix 6: Station 12 Illustrated Sequence of Operations

Station 12 Overall Sequence of Operations

Sequence of Operation	Description	Alloted Time(hrs)	Actual Time	Operator Initals	Supervisor Initials	Remarks
1	Final Electrical Wiring	3.5				
2	Adjust Wiper arm	0.2				
3	Install Inverter	0.4				
4	A/C evac and fill(rear lockers)	1.0				
5	Electrical Testing	1.0				
6	Control Rack	0.6				
7	Mount Dash Items and Right IP	0.8				
8	Body Floor Plates and Seats	1.5				
	Total Hours	9.0				

Vin # _____

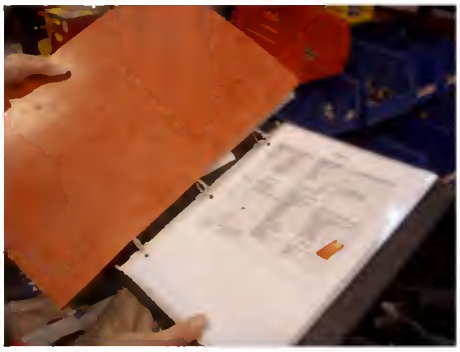
Station 12

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 12 - Final Wiring									
☐	☐	1	Get schematics and wiring pic ,work bag with tools					wire pic	
☐	☐	2	Get schematic for engine harness and terminate accordingly					wire strippers	
☐	☐	3	Get schematic for cab harness and terminate accordingly					crimpers,butt splices,heat gun	
☐	☐	4	Get schematic for R/h harness and terminate accordingly					wire ties	
☐	☐	5	Get schematic for L/h harness and terminate accordingly						
☐	☐	6	Get Wago(wire terminal) print out and terminate accordingly.						

Station 12 Process 1 – Final Wiring

Step 1: Get schematics and wiring pic ,work bag with tools



Steps 2-6: Utilize wiring schematics to properly wire harnesses

Station 12 Process 1 – Final Wiring

Vin # _____

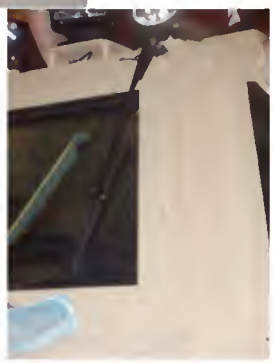
Station 12

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 12 - Adjust Wiper Arm									
☐	☐	1	Once electrical connections are made check range of wiper .		34A003AA				
☐	☐	2	If wiper swoops within range and does not hit window frame tighten down.						
☐	☐	3	If wiper swoops within range and does hit window frame remove and adjust accordingly.						

Station 12 Process 2 – Adjust Wiper Arm

Step 1: Once electrical connections are made check range of wiper



Steps 2-3: Based on wiper position, adjust accordingly If wiper swoops within range and does not hit window frame tighten down; If wiper swoops within range and does hit window frame remove and adjust accordingly.

Station 12 Process 2 – Adjust Wiper Arm

Vin # _____

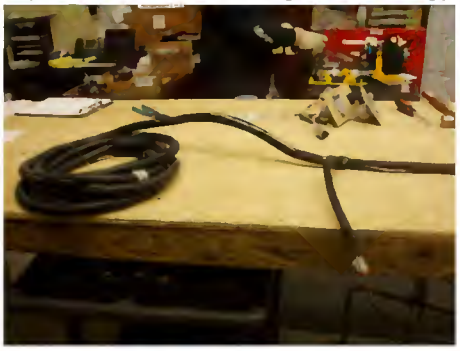
Station 12

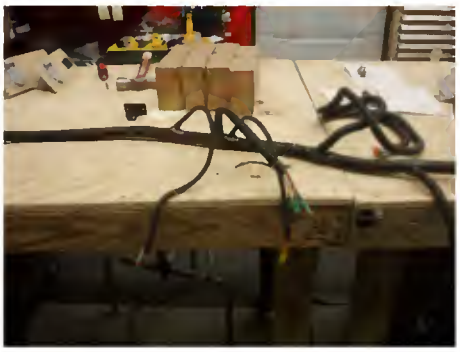
Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 12 - Fabricate Harnesses									
☐	☐	1	Obtain all wire harness drawings and build accordingly					wire strippers, cutters, crimpers,	
☐	☐	2	Obtain all Brady wire labels for wires.					deutsch connectors, convulet	
☐	☐	3	Fabricate , label and store properly until installed					wire ties, electrical tape	

Station 12 Process 3 – Fabricate Harnesses

Steps 1-3: Obtain all wire harness drawings and build accordingly





Station 12 Process 3 – Fabricate Harnesses

Vin # _____

Station 12

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 12 - Inverter									
☐	☐	1	Align inverter with bracket on back two 6mm bolts and then handstart 6mm bolts on outside.		3Sp0073CA				
☐	☐	2	tighten with 10mm wrench						
☐	☐	3	verify battery switch is in off position						
☐	☐	4	take red wire(4 awg) and secure to 100amp fuse block						
☐	☐	5	take black wire(4awg) and secure to negative lug . 19mm wrench to loosen and tighten lug.						
☐	☐	6	take small #8 black wire and secure to chassis ground bolt of triangle plate at firewall.						
☐	☐	7	take control wire (red) #16 to wago for on /off switch at Instrument panel.						

Station 12 Process 4 – Install Inverter

Steps 1&2: Align inverter with bracket, secure

Steps 4-7: Wire Inverter

Step 3: Turn power switch to off position

Station 12 Process 4 – Install Inverter

Vin # _____

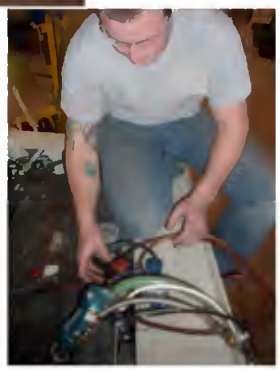
Station 12

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 12 - AC Evac and Fill									
☐	☐	1	Open hood connect the coupler. Select the recipe						
☐	☐	2	Press start cycle for pcu(production control unit)password 5150					PCU machine	
☐	☐	3	Evacuation of lines will start					leak detection light	
☐	☐	4	If successful PCU will automatically fill						
☐	☐	5	Machine will tell you if it passed. If passed your are done						
☐	☐	6	If it does not pass you get your leak detection light and proceed to find leak. Checking each connection first .find leak and repair it.						
☐	☐	7	Repeat from step one till successful						
☐	☐	8	If successful install rear lockers with 12mm bolts. (verify striker plate has been installed)					171414(bolt)	

Station 12 Process 5 – AC Evac and Fill

Step 1: Open hood, connect the coupler. Select the recipe



Step 2: Press start cycle on PCU (production control unit) password: 5150

Steps 3-8: Evacuation of lines commences, if passed, install rear locker plate, if not, find leak and repeat

Station 12 Process 5 – AC Evac and Fill

Vin # _____

Station 12

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 12 - Electrical Testing									
☐	☐	1	Start unit and verify all lights and buttons function properly						
☐	☐	2	Check Inverter					Multimeter	
☐	☐	3	Check Go-Light					Multimeter	
☐	☐	4	Check DOT Lights					Multimeter	
☐	☐	5	Check 12V power points					Multimeter	
☐	☐	6	Check 120V Outlets					Multimeter	
☐	☐	7	Check 25' cord light and spotlights					Multimeter	
☐	☐	8	Check Camera					Multimeter	
☐	☐	9	Check A/C blowers						

Station 12 Process 6 – Electrical Testing

Step 1: Start unit and verify all lights and buttons function

Step 3: Check Go-Light

Step 2: Check Inverter

Step 4: Check DOT Lights

Station 12 Process 6 – Electrical Testing

Station 12 Process 6 – Electrical Testing

Step 5: Check 12V power points

Step 6: Check 120V outlets

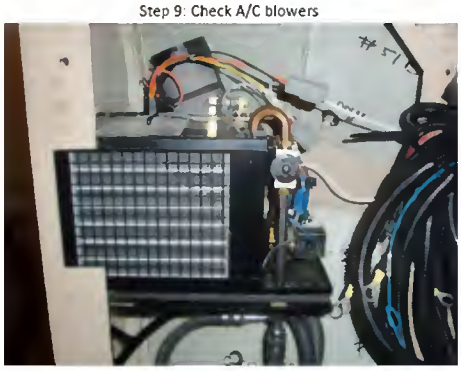
Step 7: Check 25' cord lights and spotlights

Step 8: Check camera

Station 12 Process 6 – Electrical Testing

Station 12 Process 6 – Electrical Testing

Step 9: Check A/C blowers



Vin # _____

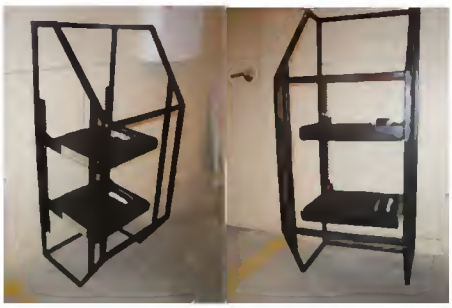
Station 12

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 12 - Control Rack									
☐	☐	1	Obtain rack and place at left side of truck right behind left IP						
☐	☐	2	Get bolts 10mm bolts(4) hand start them into track. 2 go into track and 2 go into floor next to wall panel. See visual					6mm hex head ratchet	
☐	☐	3	Obtain trays and mount 2' from top . Bolt tray to rack with bolts and nuts						
☐	☐	4	Second tray goes 1' below the first tray .Bolt tray to rack .					wrench	

Station 12 Process 7 – Control Rack

Step 1: Obtain rack and place at left side of truck behind left IP



Step 2: Secure to vehicle

Steps 3-4 (possible to do before placement in vehicle): Insert racks

Station 12 Process 7 – Control Rack

Vin # _____

Station 12

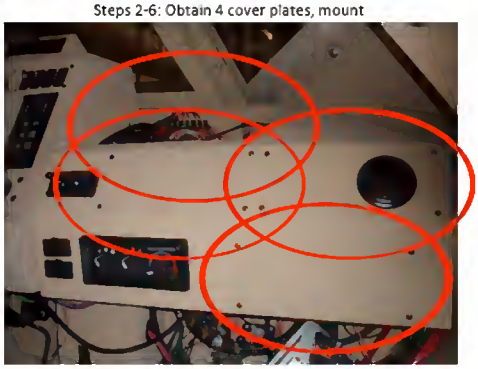
Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 12 - Mount Dash Items & Right IP									
☐	☐	1	Obtain r/h instrument panel(IP)align to right side of center ip . Holes should line up handstart 10/24 screw and nut and align bottom brace to bolt stud under right side of IP hand start S/16 nut and then tighten all down .						
☐	☐	2	Obtain 4 cover plates					battery motor	
☐	☐	3	Mount according to visual					screwdriver	
☐	☐	4	The left plate has camera mount on it. It will only fit one way						
☐	☐	5	Align fixture and secure with 4 black 10/24 screws						
☐	☐	6	Repeat each fixture , all take 4 black 10/24 screws.						

Station 12 Process 8 – Dash Items and Right IP

Step 1: Obtain, align, and secure Right Instrument Panel

Steps 2-6: Obtain 4 cover plates, mount



Station 12 Process 8 – Dash Items and Right IP

Vin # _____

Station 12

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 12 - Body Floor Plates and Seats									
☐	☐	1	Obtain floor plates for rear of truck						
☐	☐	2	Place rear plate just inside of rear door (verify that v shape notch is facing front of truck to line up with next plate. using line up bar to adjust handstart 10mm bolts						
☐	☐	3	Repeat for next plate until all plates are fitted and secure completely					adhesive spray	
☐	☐	4	Obtain mats for floor and place according to visual						
☐	☐	5	Obtain rear seats and gold track studs(fasteners)					ratchet	
☐	☐	6	Space seats 33" from back of seat to next. Align with studs and obtain 14mm nuts to secure seats.		34p00S3AA				
☐	☐	7	Obtain Driver's seat and mat						
☐	☐	8	Spray adhesive on back of mat lay in cab of truck . Verify holes for seat .						
☐	☐	9	Obtain four S/16 bolts and seat. Align seat and handstart bolts secure down with ratchet		34A00S2AA				

Station 12 Process 9 - Body Floor Plates and Seats

Step 1: Obtain floor plates

Step 3: Repeat with all plates, moving forward through the vehicle

Step 2: Place rear plate, align, secure with bolts

Steps 4: Obtain Mats, insert into floor

Station 12 Process 9 - Body Floor Plates and Seats

Station 12 Process 9 - Body Floor Plates and Seats

Step 5: Obtain seats

Steps 7-9: Obtain driver's seat and mat, install and secure

Step 6: Place seats in vehicle, 33" apart, secure to floor

Station 12 Process 9 - Body Floor Plates and Seats

Vin # _____

Station 12

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 12 - Stud Acorn Nuts									
☐	☐	1	Obtain painted acorn nuts from material handling	Receiving			200		
☐	☐	2	Tighten acorn nut on end of each exposed Goldshield stud.					Ratchet	

Station 12 Process 10 – Attach Acorn Nuts

Step 1: Obtain painted acorn nuts from material handling

Step 2: Tighten acorn nut on end of each exposed Goldshield stud.

Station 12 Process 10 – Attach Acorn Nuts

Vin # _____

Station 12

Sequence of Operations Form

Checked	Lead Verify	#	Description of Task	Process Name	Part #	Parts Supplier	Qty	Tools Needed	Time of Task
Station 12 - Final Touches									
☐	☐	1	Obtain Air Conditioning (AC) Fluids from Material Handling	Receiving				Forklift	
☐	☐		Obtain Public Address (PA) System from Material Handling	Receiving			1	Secured Cage	
☐	☐		Obtain Rear View Camera from Material Handling	Receiving			1	Secured Cage	
☐	☐		Obtain Global Position System (GPS) from Material Handling	Receiving			1	Secured Cage	
☐	☐		Obtain 12mm washers from Material Handling	Receiving				Stock Cart	
☐	☐		Obtain 12mm nuts from Material Handling	Receiving				Stock Cart	
☐	☐		Obtain Structual Wire from Wench Kit (Station 9)	Receiving				Stock Cart	
☐	☐	2	Visually inspect vehicle for non-conformities, missing parts from Station #11 starting at the back left of the vehicle						
☐	☐	3	Pull vacumn on AC System and refill with proper refrigerant					Measuring equipment	
☐	☐	4	Test AC by checking for leaks and proper temperature					Meter	
☐	☐	5	Mount rear locker covers by securing them to the mounted bolts with 12mm washers and 12mm nuts					14mm Wrench	
☐	☐	6	Finalize the installation of electrical wiring and components	Electrical				Wire Cutters	
☐	☐	7	Verify the voltage of the electrical wiring	Electrical				Voltage Meter	
☐	☐	8	Mount componets to Dash Assy (GPS, Rear View Camera Screen, PA System)				3	Drawings Wire Cutters	
☐	☐	9	Verify the voltage of the electrical systems mounted to the Dash Assy are working	Electrical			1	Voltage Meter	
☐	☐	10	Close up all covers on the Dash Assy by screwing all the mounted S/6mm screws flush into the panel				12	Drawings Phillips Screw Driver	

Vin # _____

Station 12

Sequence of Operations Form

☐	☐	11	Close up all covers within the Air Conditioning Ducts by screwing all the mounted S/6mm screws flush into the panel				4	Drawings Phillips Screw Driver	
☐	☐	12	Mount structural wire to the wench using wire cutters for initial mounting				1	Wire Cutters	
☐	☐	13	Adjust Windshield Wiper Arm per the configuration of the windshield						
☐	☐	16	Move vehicle to Station 13						

Station 12 Process 11 – Final Touches

Step 1: Obtain materials (AC fluids, PA system, GPS equipment, rear view camera, fasteners, winch cable)

Step 2: Visually inspect vehicle for any flaws

Steps 3-4: Finalize AC

Step 5: Mount rear locker covers

Station 12 Process 11 – Final Touches

Station 12 Process 11 – Final Touches

Steps 6-7: Finalize wiring

Steps 8-10: Install dash components (GPS, Camera, PA System)

Step 11: Finalize AC duct installation

Steps 12-14: Finalize and move vehicle to station 13

Station 12 Process 11 – Final Touches