May 2011

Ambulatory Storage

Joshua David Bernier  
Worcester Polytechnic Institute

Steven Thomas Knapp  
Worcester Polytechnic Institute

Follow this and additional works at: https://digitalcommons.wpi.edu/iqp-all

Repository Citation

This Unrestricted is brought to you for free and open access by the Interactive Qualifying Projects at Digital WPI. It has been accepted for inclusion in Interactive Qualifying Projects (All Years) by an authorized administrator of Digital WPI. For more information, please contact digitalwpi@wpi.edu.
THE STORAGE OF AMBULATORY SUPPLIES

by

Steven Knapp and Joshua Bernier

An Interactive Qualifying Project

Submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirements for the

Degree of Bachelor of Science

in Mechanical Engineering

___________________________  _______________________
Steven Knapp                Joshua Bernier

APPROVED:                  APRIL 2011

_______________________________
Professor M. S. Fofana, Major Advisor
Mechanical Engineering Department
Abstract

The objective of the Efficient Ambulance Storage project is to investigate the methods currently in place and implement a system that can improve the methods. The goal is to optimize the space within the ambulance. The outcome should be an efficient way to store ambulatory supplies and accessories required by law. Through effective storage means, improved patient care and paramedic safety can be achieved. As it is now, the ambulance is not set up in a very efficient manner as far as storage is concerned. Much of the interior space is unused. The inability to utilize this space leads to a cluttered and unorganized storage area. Paramedics must frequently stand to get equipment while working on a patient. A prolonged period of this places a strain on the paramedics, and often leads to back injuries. The accomplishments of this project are due to the help and guidance of the staff of the UMass Memorial ambulance services and our WPI advisor, Professor Mustapha Fofana. The beginning of the project consisted of investigating various forms of storage used by other disciplines such as NASA and US military services. This investigation and feedback from UMass EMTs helped us to understand ambulatory supplies and their storage classifications. We modify the shelves inside the cabinets that store ambulatory supplies. The ambulatory cabinets now have grid-like shelves to increase storage space. The doors to the storage units are modified so that they lift upwards, keeping them out of the way while paramedics access the storage space. We remove the seat and counter on the left side of the ambulance to increase storage area. The final design is a modification to the paramedics’ chair. This chair is modified so that it can rotate on a track around the stretcher. We believe that these improvements will enhance the safety of paramedics, practices of EMS and higher quality of patient care.
Table of Contents

Abstract .............................................................................................................................................. i

Table of Contents ............................................................................................................................. i

List of Figures ................................................................................................................................. ii

List of Tables .................................................................................................................................. iii

Acknowledgments ........................................................................................................................... iv

Chapter 1 EMS and Life Saving Practices ....................................................................................... 1

  1. Introduction ............................................................................................................................... 1

Chapter 2 EMS and Patient-Centric Quality Care .......................................................................... 3

  2. Introduction ............................................................................................................................... 3
    2.1.1 Inefficient Storage Use .................................................................................................... 3
    2.1.2 Paramedic Safety ............................................................................................................. 12
    2.2: Background Research ......................................................................................................... 13
      2.2.1: Case Studies ................................................................................................................. 13
      2.2.2 Equipment Location ....................................................................................................... 16
      2.2.3 NASA ......................................................................................................................... 18
      2.2.4 Airlines ....................................................................................................................... 23
    2.3 Materials List ....................................................................................................................... 29

Chapter 3 Concepts for Improvement ............................................................................................ 33

  3. Introduction ............................................................................................................................... 33
    3.1.1 Visit to UMass .................................................................................................................. 33
    3.1.2 Existing Ambulance Model ............................................................................................ 39
    3.2 Design Iterations ................................................................................................................... 44
      3.2.1 Grid Pattern Shelf Units .............................................................................................. 45
      3.2.2 Rolling Chair .............................................................................................................. 47
      3.2.3 Improved Storage Model ............................................................................................ 59

Chapter 4 Concluding Remarks ..................................................................................................... 69

References ......................................................................................................................................... 69

Appendix A: Administrative Requirements Manual ......................................................................... 73

Appendix B Federal Specifications .................................................................................................. 82

Appendix C: AMD Standards .......................................................................................................... 96

Appendix D: Solid Works Models .................................................................................................. 101
List of Figures

Figure 1: Approximation of cabinet dimensions on the left side of the ambulance .................. 4
Figure 2: Cabinet C .................................................................................................................... 6
Figure 3: Closer look at Cabinet C ............................................................................................ 6
Figure 4: Cabinet B .................................................................................................................... 9
Figure 5: Cabinets A, D, E ..................................................................................................... 10
Figure 6: Cabinets D, E, F ..................................................................................................... 11
Figure 7: Lights on ceiling of ambulance .............................................................................. 11
Figure 8: Seat on left side ...................................................................................................... 12
Figure 8a: Ambulance Transport Statistics ....................................................................... 18
Figure 9: NASA storage lockers .......................................................................................... 21
Figure 10: NASA storage bins ............................................................................................ 22
Figure 11: Equipment inside storage unit ........................................................................... 23
Figure 12: Cockpit of 747 commercial airliner .................................................................... 26
Figure 13: Over head storage inside commercial jet .............................................................. 26
Figure 14: Storage cabinets in ambulance .......................................................................... 27
Figure 15: Sliding door tracks ............................................................................................. 35
Figure 16: Door above bench which opens upward ............................................................. 36
Figure 17: Bench with non-removable cushion ................................................................. 37
Figure 18: Counter next to the main chair .......................................................................... 38
Figure 19: Solidworks section view of the right side of the ambulance ......................... 40
Figure 20: Solidworks screenshot of the left side of the ambulance .............................. 41
Figure 21: Solidworks section view from the back of the ambulance ............................ 42
Figure 22: Solidworks sliding doors over the counter ......................................................... 43
Figure 23: Solidworks doors over the bench which opens up ........................................ 43
Figure 24: Shelf unit ........................................................................................................... 46
Figure 25: Example of shelving units for each cabinet ..................................................... 47
Figure 26: Paramedic seat .................................................................................................. 49
Figure 27: Chair track .......................................................................................................... 50
Figure 28: Track in locked position ..................................................................................... 51
Figure 29: Close up of ribs .................................................................................................. 52
Figure 30: Dimensions of track .......................................................................................... 53
Figure 31: Seat on track inside ambulance ...................................................................... 54
Figure 32: Caster ball ......................................................................................................... 56
Figure 33: Example of chair sliding down track ................................................................. 57
Figure 34: Section view of seat at end of track ................................................................. 58
Figure 35: Section view of the left side of the improved storage ambulance ............... 61
Figure 36: Section view of the left side of the new ambulance from a different angle .... 62
Figure 37: Section view of the new ambulance showing the extra storage ................. 63
Figure 38: The counter in the existing ambulance which takes up a lot of space .......... 64
Figure 39: Increase storage replacing counter ................................................................. 65
Figure 40: Section view of the chair on a track in the new ambulance ....................... 67
Figure 41: Section view of the chair on a different part of the track ............................. 68
List of Tables

Table 1: Paramedic Injury Statistics ................................................................. 14
Table 2: ALS Ambulance Materials List .......................................................... 29
Acknowledgments

We would like to thank our project advisor Professor Mustapha Fofana, PhD for directing and mentoring us through this project.

A special thanks to Steve Hayes, UMASS Memorial EMS Chief, and all of the paramedics at UMass Memorial for all of their helpful input and for allowing us to tour their facilities.
Chapter 1 EMS and Life Saving Practices

1. Introduction

The current ambulance model, specifically the GMC 3500 chassis with a Braun box, has several design flaws that do not promote the safety of the paramedics who work within it. The motivation of this project comes from the danger that these paramedics face in saving lives every day. The rear of the ambulance where the paramedics work contains constant potential for injury. The fact that EMT’s working on a patient in the ambulance must often stand to reach certain items, exposes them to possible injury. An ambulance with a patient inside is trying to reach the hospital as soon as possible and this can sometimes mean taking fast turns or going over large bumps at high speeds. For someone standing in the back of this vehicle, who cannot anticipate what is about to happen, this poses the obvious threat of falling. For paramedics to perform their duties of saving lives, their lives should also be safe.

The ambulance is often an unsafe environment for paramedics and the objective of this project is to change that. It is important for the paramedics to be safe while they are in the ambulance because this affects the safety of the patients whom they are working on. A common injury among paramedics is lower back pain from bending and lifting and the success of this project relies on a solution that minimizes this kind of paramedic injury. Ideally, a paramedic should never have to stand while on the way to the hospital. This means the engineering of a new ambulance model in which the paramedic can reach everything that he needs from a seated and buckled position. For this to happen, the current storage capabilities will need to be altered.
The wasted space in the ambulance needs to be utilized so that there is no need to walk from place to place. This will mean that in the event of a crash or even a fast sharp turn, the paramedic will stay seated and not fly about the cabin.

The rest of this project contains the analysis, research, and possible solutions for the storage problem in the modern ambulance. Chapter 2 shows other methods of storage discovered in the background research. It will also have case studies of paramedic injuries within the ambulance and a list of the materials that are lawfully required to be in the ambulance (acquired from the UMass Memorial paramedic staff). Chapter 3 will contain what we learned from the paramedic staff in our trip to UMass Memorial, that is, what changes they would like to see in the ambulance. It will also contain a description of a SolidWorks model that we created of the existing ambulance and the possible solutions to the storage problem. A liberal use of figures, tables, and SolidWorks screenshots are employed throughout to thoroughly illustrate what is being explained.
Chapter 2 EMS and Patient-Centric Quality Care

2. Introduction

The issues that this project will focus on are the storage and efficiency shortcomings of ambulances. Although there are several makes and models of ambulance frames and boxes, this project concentrates on only one, a Braun ambulance on a GMC 3500. One major area of improvement to consider is the storage methods currently in use. More specifically, the side and overhead cabinets where equipment and supplies are kept will be looked at. The way that supplies are stored inside the cabinets is not as efficient as it could be. Most of the actual cabinet space is under unutilized. Small items such as gauze and other prepackaged materials are placed in bins at the bottom of the cabinet. This system works; however, it is wasting the space already available.

2.1.1 Inefficient Storage Use

To demonstrate how much space is actually unused, look at the area of the entire storage space versus the area used in Figure 1. The area rather than the volume will be considered. The reasoning behind this is due to the fact that it is often difficult and impractical to store supplies behind one another. To show the greatest effects in insufficient storage, we will calculate the unused storage space in the smallest as well as the largest storage cabinets. This will cover both the maximum and minimum space available. To start, examine the area of cabinet B. The dimensions are 27 in. x 9.5 in. This would give a total area of 256.5 in$^2$. Approximately one third of this space is not being used with the current set up.
Figure 1: Approximation of cabinet dimensions on the left side of the ambulance

There is a patient vacuum that occupies about one third of space, and in the other two thirds available, only about half is being used. This leaves about one third of the total area that is not being used. This means that of the 256.5 square inches available, only 171 square inches are being used effectively. A large part of this inefficiency is the method of storing items in plastic bins. These bins secure the supplies, but they also take up a significantly larger amount of space than the supplies themselves. Now take a look at the largest cabinet. The dimensions of the largest cabinet, C, are 47.5 inches long by 14.5 inches wide. This cabinet is actually divided up into two sections with a sliding door covering each half. All of the supplies kept in this cabinet
are stored in plastic bins to keep them separated. In each half of the cabinet, a divider shelf holds supplies above other supplies set on the bottom of the cabinet. Approximately two fifths of the storage in these cabinets goes to waste. The top section is about three fifths of the total space. Of this section, about half of the space is unused. The bottom section uses about three quarters of its capacity. When combined, this adds up to around two fifths of the space being inefficiently used. This equates to 413.23 in² being occupied by equipment. The other 275.5 in² are not being utilized.

Figure 2: Cabinet C

Figure 2 shows cabinet C. This is the storage unit above the countertop. This area contains supplies for airway and ventilation treatment.
Figure 3: Closer look at Cabinet C

Figure 3 takes a closer look at cabinet C. Notice the clutter and the disorganization of the plastic wrapped supplies at the top. The plastic bins do not very successfully separate and organize supplies within the unit.

The major issue that needs to be worked around is the width of the ambulance. It is not possible to increase this width because doing so would decrease its maneuverability while driving through narrow passageways. This could include difficult areas to navigate, such as busy city streets. In larger cities, the complication of driving and fitting through narrow gaps becomes more common. The ambulance must also fit within the average street lane. Otherwise the ambulance would become a hazard to other vehicles on the road, causing an unsafe situation. Therefore, the ambulance width should not be increased. The problem with the space inside becomes clear when you look at what must fit inside the allotted space. Storage spaces extend
out on both the left and ride sides of the ambulance, the stretcher sits in the middle of the aisle way, a bench where another stretcher may be laid is against the right wall, and a seat and counter space extend from the left wall. This leaves very little room for the paramedic to move and access the patient safely. If the paramedic does need to stand or walk to reach needed supplies while the ambulance is in motion, it is very easy to fall or stumble. This can be a very serious issue as the patient on the stretcher is left in a vulnerable position. The paramedic can easily fall on the patient. Also, due to the close proximity of the patient to the sides of the ambulance, supplies could potentially fall and further injure the patient as the EMT reaches up to grab an item.

Cleaning the ambulance after a call is an area that might go unnoticed, but it is an essential part of the paramedics’ duty. If they fail to clean, or do not do a thorough job, pathogens and disease can easily spread from patient to patient. Although it might appear to be clean, small cracks or difficult spots to reach may be missed. Sharp edges surrounding or connecting two surfaces are nearly impossible to get completely clean. Fluids such as blood can work its way into these edges. The fluid can becomes confined in this tight space, posing health and hygienic issues for paramedics and other patients. Making the ambulance easy to clean would improve the health factors inside the ambulance. Any sharp corners should be eliminated. Also, smooth curved edges would reduce the threat of disease spreading due to the fact that smooth finishes are much easier to clean. Even the lights on the ceiling are susceptible to contamination. The light fixtures have open spaces where fluids can seep through making it nearly impossible to clean. To clean this, the paramedics have to take the entire fixture off in
order to clean inside where the fluids may have leaked. This is a painstaking process. The time spent doing this is wasted, whereas the paramedics could be doing something more important. Any time saved cleaning, means that the EMT’s are available to take more calls.

Figure 4: Cabinet B

Figure 4 pictures cabinet B. It is located above the seat on the left side of the ambulance. Again it is visible of how easily one item could fall out while reaching for another. Since this unit is located above patients, falling objects are hazardous.
Figure 5 shows cabinet A (top), cabinet D (bottom left) and cabinet E (bottom right). These are located at the back of the ambulance near the rear door. These units show the varying sizes and shapes of the storage cabinets. These differing sizes allow for uniquely shaped EMT supplies and equipment to be stored.
Figure 6: Cabinets D, E, F

Figure 6 depicts units D (top left), E (top right), and F (bottom right).

Figure 7: Lights on ceiling of ambulance

Contaminates can leak into space between light fixture and ceiling.
Figure 7 shows the lights running down the length of the ceiling. Notice the space located between the light fixtures and the surface of the ceiling. Fluids can breach this area contaminating the inside of the fixture. This is a serious problem because it is such a difficult area to clean and sterilize.

Figure 8 shows the seat on the left side of the ambulance. Either a patient or the paramedics use this seat. It is padded heavily as a precaution to avoid injury. However, this padding has the potential to be exposed to contaminants.
2.1.2 Paramedic Safety

Paramedic safety is an integral part when considering the system and functions related to the ambulance. The paramedics try to ensure safety to the patient as much as possible, so they too must also be safe. There are two papers that are specifically geared towards the specifications needed in an ambulance, keeping paramedic safety in mind. The first was published on August 1, 2007 by the U.S. General Services Administration. It is the Federal Specification for the Star-of-Life Ambulance KKK-A-1822F document (6. GSA). The other was put out by the Ambulance Manufacturers Division (AMD). It was published in August of 2007 and is titled “AMD STANDARDS” (7. AMD). The AMD actually documents and states its affiliation with the General Services Administration. It recognizes the KKK-A-1822 as the minimum specification for the ambulance industry (7. AMD). It goes on to give its own specifications for ambulance and paramedic/patient safety. One thing to note about both publications is that neither requires dynamic testing of the ambulance. This is unlike the automotive industry in that every vehicle model must pass a rigorous serious of testing before it can be put into production. This is not so in the ambulance industry. There are static loading tests which check the structural integrity of the cab under a certain load weight. However, they are lacking any sort of testing requirements for an ambulance in motion, which as far as the crew and patients are concerned, is the most important aspect of safety. If the box can hold 55,000 static pounds (7. AMD), but crumbles during the force of an impact from an accident, it becomes a serious concern and the required testing means nothing.
2.2: Background Research

2.2.1: Case Studies

By looking into the back of an ambulance it is easy to see that some improvements could be made to increase safety and efficiency. However, it is important that there are studies and outside information that supports this, otherwise there would be no need to make any change. Looking at case studies and statistics that are relevant to the subject is a good place to start gathering vital information. The following example of paramedic injury illustrates the need for a safer ambulance. In July 2001, an EMT died when her ambulance struck a train track support column. She was attending to a patient in the patient compartment without a seatbelt on. Upon collision, the EMT struck the front bulkhead of the patient compartment. The driver of the ambulance and the patient being transported were restrained at the time of the accident and survived the impact. However, the paramedic in the back of the ambulance was pronounced dead at the hospital. An incident like this truly demonstrates the need for safer medical transport. Had the EMT been seated and restrained, she too may have survived the crash. With efficient storage utilization, she could have been seated and restrained.

The following table shows injury statistics from ambulance crashes from 1991-2000. It was taken from cdc.gov which is the government funded centers for disease control and prevention website. Table 1 shows the number of persons injured in ambulance crashes, by severity and seating position. It gives insight into the injuries sustained in ambulance crashes based upon where the passengers were seated. Such a table can help in understanding where the
The most dangerous part of an ambulance is in the event of an accident. One can notice that as the severity of the injury increases, so does the percentage of the injuries that occurred in the back of the ambulance. 58.5% of the fatalities that occur in ambulance crashes happen in the patient compartment (3. Proudfoot). The fact that most serious injuries take place in the back of the ambulance truly demonstrates that more safety measures should be taken in order to allow everyone in the ambulance to be seated and buckled in, including all EMT’s. This could certainly be achieved with a new, more efficient interior.

Table 1: Paramedic Injury Statistics

<table>
<thead>
<tr>
<th>Injury severity/ seating position</th>
<th>% within injury severity group</th>
<th>% of all ambulance occupants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Possible</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front left</td>
<td>70</td>
<td>41.7%</td>
</tr>
<tr>
<td>Front right</td>
<td>50</td>
<td>29.8%</td>
</tr>
<tr>
<td>Other enclosed*</td>
<td>34</td>
<td>20.2%</td>
</tr>
<tr>
<td>Other/unknown</td>
<td>14</td>
<td>8.3%</td>
</tr>
<tr>
<td>Total</td>
<td>168</td>
<td>20.6%</td>
</tr>
<tr>
<td><strong>Nonincapacitating</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front left</td>
<td>81</td>
<td>36.5%</td>
</tr>
<tr>
<td>Front right</td>
<td>54</td>
<td>24.3%</td>
</tr>
<tr>
<td>Other enclosed*</td>
<td>63</td>
<td>28.4%</td>
</tr>
<tr>
<td>Other/unknown</td>
<td>24</td>
<td>10.8%</td>
</tr>
<tr>
<td>Total</td>
<td>222</td>
<td>27.2%</td>
</tr>
<tr>
<td><strong>Incapacitating</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front left</td>
<td>43</td>
<td>32.8%</td>
</tr>
<tr>
<td>Front right</td>
<td>20</td>
<td>15.3%</td>
</tr>
<tr>
<td>Other enclosed*</td>
<td>50</td>
<td>38.2%</td>
</tr>
<tr>
<td>Other/unknown</td>
<td>18</td>
<td>13.7%</td>
</tr>
<tr>
<td>Total</td>
<td>131</td>
<td>16.0%</td>
</tr>
<tr>
<td><strong>Fatal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front left</td>
<td>14</td>
<td>17.1%</td>
</tr>
<tr>
<td>Front right</td>
<td>10</td>
<td>12.2%</td>
</tr>
<tr>
<td>Other enclosed*</td>
<td>48</td>
<td>59.5%</td>
</tr>
<tr>
<td>Other/unknown</td>
<td>10</td>
<td>12.2%</td>
</tr>
<tr>
<td>Total</td>
<td>82</td>
<td>10.0%</td>
</tr>
<tr>
<td><strong>None†</strong></td>
<td>201</td>
<td>24.6%</td>
</tr>
<tr>
<td><strong>Unknown‡</strong></td>
<td>12</td>
<td>1.9%</td>
</tr>
</tbody>
</table>

* Inside the patient compartment.
† Seating positions irrelevant or unavailable.

The Annals of Emergency Medicine is a journal whose aim is to improve the quality of emergency care through the publication of emergency medicine related science. Within this
This research paper analyzes the occupational fatalities among EMS providers. The authors of the paper took their data from three fatality databases; the Census of Fatal Occupational Injuries, the National EMS Memorial Service, and the National Highway Traffic Safety Administration’s Fatality Analysis Reporting System (all from 1992-1997). Using the information that they got from these sources, the authors were able to estimate the fatality rate among emergency medical services. They estimate that within these six years, 114 EMS deaths occurred, 67 of which were ground transportation related fatalities. They estimate a rate of 12.7 deaths per 100,000 EMS workers. This includes only deaths and not injuries. This death rate is nearly as high as that of police officers and firefighters.

This journal publication talks about the dangers of being in the back of a moving ambulance. One of the authors, Brian J. Maguire, MSA, EMT-P, talks about the issue of paramedics buckling up, “They can’t take care of the patient if they’re seatbelted in, though they’ll still need to be unbelted at times to work on the patient, if they pay attention, there can be more times where they can wear the seatbelt. The other thing is recognizing the dangerous items in the ambulance—oxygen ports sticking out from the walls, IV poles that hang from the ceiling, sharp corners, loose things that need to be strapped down.” This quote perfectly describes the problem that the ambulance storage IQP is looking to solve. The paramedics need to stand and be unbuckled in order to effectively care for patients. This exposes them to the dangers of sharp corners of storage compartments and loose items in the event of an accident, bump, or even a sharp turn.
2.2.2 Equipment Location

The paramedics need to move around in the ambulance based on where specific supplies and medical materials are located. For instance, a burn victim would need to be treated with supplies made for burn treatment and, depending on where they are located; the paramedic must get up and retrieve them. In the current ambulance, the items are broken up into groups based on what injury they treat and stored accordingly. This means that all of the airway equipment is in one section of the ambulance; burn treatment is in another, etc. This is an effective way of storing materials because it is easy to know exactly where to go for specific items. However, this also means that there are a lot of items that are too far away for the paramedic to reach while seated.

In a trip taken to the UMass Memorial hospital ambulance headquarters, we learned that the paramedics here keep the airway equipment closest to the main chair. This is so it will be close to the head of the patient which is where airway treatment will take place. With the current storage system, this is a reasonable method. The down side is that almost anything besides airway equipment is too far from the chair to reach and will require moving around. This is unavoidable with the current storage setup of the ambulance. To avoid having to stand up, paramedics might also consider storing the items used most often closer to the chair. This would mean that they would have to move around less and could spend more time on the patient. Any new design of ambulance storage should take into consideration where items should be stored based on classification and how much it is used.
Figure 8a above is taken from the cdc.gov website. The ten diagnoses shown above accounted for approximately one third of the ambulance transports in the year 2003 according to an analysis of the sixteen million ambulance responses in that year (1. Mcaig). In an ambulance with more accessible storage, the location of tools and materials could be decided according to this kind of information to allow for easier access and less moving around.
2.2.3 NASA

After establishing that there can and should be changes made to the current ambulance storage, one can look into the storage capabilities of other transportation vessels. There are many modes of transportation that utilize all of the space provided out of necessity. A good example of this would be the space shuttles that NASA sends into space. NASA is a good place to start looking for engineering solutions because they employ thousands of engineers who work to solve problems such as inadequate storage. Some of the brightest engineering minds have worked for NASA, which is evident when one looks at the accomplishments in space travel. For this reason, what better place is there to look than NASA as a reference for engineering solutions? Especially in the way that items are transported.

Storage must absolutely be considered in space missions for many reasons. Astronauts are being sent into space for months at a time in a relatively small craft that needs to carry all of their supplies. The shuttle must contain all of the food, clothing, tools, and equipment that the astronauts will need on their mission. This ship must travel long distances for long periods of time while using as little fuel as possible in an effort to keep energy usage as well as cost down. Since the astronauts have to live and function in this ship, the resources that they bring aboard cannot become obstrusive or taking up too much space. The solution could be to make the shuttle larger and more accommodating but that just leads to a need of more funds and resources. The obvious solution is to use every free square foot of space in the storage setup. This is what the engineers at NASA had to do and this is why the space shuttle is such a good reference for storage.
The solution that NASA devised is to have storage lockers with insert able trays. These trays can store a variety of equipment such as food and tools. The lockers can be installed or removed during flight by the crew. The inside dimensions of the trays are 10x17x20 inches (4. Nasa.gov). The trays are packed in such a way that no items overlap each other. This will allow for easier access to items and less confusion in finding loose tools. This is a good solution to the storage problem because it fits everything that the astronauts need into the spaceship, while allowing neatness, even without any gravity. The storage in the shuttle even utilizes the floor as a means of storage which can be seen in Figure 9. There are several figures that show the storage in a space shuttle and a couple that show some of the storage in an ambulance. While the space shuttle does not have any overlapping items in its lockers, the ambulance has cluttered items tightly packed in bins with several different types of items on one shelf.
Figure 9 above shows the storage lockers present in a NASA space shuttle. This figure shows the complete optimization of space, utilizing even the floor for storage. Such a system is ideal for traveling a long distance, for an extended period of time, in a small space.
Figure 10 is another example of the lockers in the spaceship. Here the astronauts are using the storage in a weightless environment. The staple of a good design is its adaptability and these storage lockers can function properly in zero gravity. The storage in an ambulance should also be safe and efficient in every environment that it experiences, like bumps and sharp turns.
Figure 11 shows a storage compartment in the current ambulance. The materials within the space are cluttered and close together. If something was to be taken out very quickly, it could cause another item to fall out, possibly onto someone. There is also space in this cabinet above some of the items that is not being used for anything.

The NASA storage lockers are a good source of inspiration for improvements that can be made in ambulance storage. For instance, the clutter in the storage cabinets of the ambulance is both impractical and unsafe. A paramedic trying to pull one item out of a cabinet can easily pull many out, possibly causing them to fall onto the patient. A system where all of the tools of the same kind are in the same place and easily accessible one at a time would be ideal. Organization
is extremely important when someone’s life is on the line and every second counts. Another feature of the spaceship that the ambulance should employ is the use of all of the space in a cabinet. The lockers in the shuttle are meant to eliminate any open air in the storage unit. Ambulance cabinets have bins full of supplies on the shelf and then nothing above them where there could be more item storage. The use of the floors as storage in the spaceship is inspiration for the idea that ambulances could use ceiling space for storage. For the paramedics, reaching straight up might be easier than reaching over the patient for something small. Looking at the engineering from NASA’s spaceships is an excellent source of ideas. Even if the design for new ambulance storage is not exactly like that of the space shuttle, the concept allows for new ideas and possibilities.

2.2.4 Airlines

Equally important to what equipment should be stored in, is where and how it can be stored in the vehicle. The current ambulance model has a very simple cabinet system built into the walls. There are many places where there could or should be more storage areas and it is important to locate these areas with the help of existing storage usages. This is not to say that there should be storage compartments everywhere in the ambulance including under the floor, as in the NASA space shuttles. That would be entirely impractical for use en route to the hospital while carrying a passenger. However, there is unused space that can be found by looking at other modes of transportation. The airplanes of commercial airlines are a good place to look for
information regarding how and where things are stored, since commercial airplanes are constantly being upgraded and optimized.

The first thing that we looked at in the airplane was the cockpit, not for the storage but because of the number of levers, buttons and gages as well as their location. The way that this cockpit is setup, allows the pilot and co-pilot to reach anything that they need from the seated position. There are even buttons on the ceiling so that they are literally surrounded with what they need to fly. It would be very impractical if the pilot constantly had to stand up to press a button, pull a lever, or check a gage. The same logic should be extended to the ambulance. The paramedics are exposed to constant danger and this is only exacerbated by constantly having to stand to reach what they need. The paramedics should be able to do their jobs from a seated position for both efficiency and safety. For this reason, the storage in the ambulance should be changed accordingly.
Figure 12 depicts a 747 airplane cockpit. It illustrates to what extent the pilot and co-pilot are surrounded by lights, buttons, and gages. There is no need to stand up while flying the plane since everything is within reach. During an emergency, the pilots do not have to frantically rush about the cockpit. Similarly, paramedics should not have to run around the back of the ambulance to get what they need in an emergency.

Another aspect of the commercial airplane that is useful to look at is the storage within the passenger cabin. The carry-on luggage of all of the passengers aboard the plane needs to be
efficiently stowed away during flight. The most important thing that needs to be taken into consideration is the safety of the passengers. In the event of turbulence, the luggage needs to be safely secured to avoid falling bags that could result in injury. The overhead compartments of the average commercial airplane do a very good job of keeping bags in their place during flight. The compartments are still very easy to open even though they stay securely shut when they need to be. The ambulance could definitely benefit from a similar setup that opens easily but stays securely shut when it needs to be.

![Over head storage inside commercial jet](image)

*Figure 12: Over head storage inside commercial jet*
Figure 13 shows the overhead compartment of a commercial airplane. The door of the compartment opens up rather than to the side. This allows easy access to luggage just by pulling a handle. The spring assisted mechanism that opens the door controls the speed at which it opens so that now extra mechanical strength needs to be exerted to open it. When the door is closed, the lock keeps it from opening even in the event of turbulence.
Figure 14 is of a cabinet door in the ambulance. These double doors open and close from side to side. Unlike the doors of the overhead compartments in the airplane, these doors are opened using only the mechanical power of the paramedic.
## 2.3 Materials List

### Table 2: ALS Ambulance Materials List

<table>
<thead>
<tr>
<th>Item</th>
<th>Sizes</th>
<th>Quantity</th>
<th>EMT-I</th>
<th>EMT-P</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Intubation Kit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endotracheal tubes:</td>
<td>2.0-5.0 uncuffed</td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.5-9.0 cuffed</td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Magill Forceps</td>
<td>Adult</td>
<td>1</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pediatric</td>
<td>1</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Lubricant (water soluble)</td>
<td></td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Tape or Tube Restraint</td>
<td>One roll or 2 restraints</td>
<td></td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Styllette</td>
<td>Adult 14F</td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pediatric 6F</td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>10 cc Syringe</td>
<td></td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Handles with batteries:</td>
<td>Standard</td>
<td>1</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pediatric</td>
<td>1</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Spare Batteries</td>
<td></td>
<td>2 each size</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Spare Bulbs</td>
<td></td>
<td>1 each size</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Blades (disposable or stainless)</td>
<td>Curved # 2,3,4,5</td>
<td>1</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Straight # 1,2,3,4</td>
<td>1</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Size/Type</td>
<td>Quantity</td>
<td>Required</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>----------------------------</td>
<td>----------</td>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Nasogastric Tubes</td>
<td>5F, 8F, 10F, 14F</td>
<td>2 each</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>2 oz. Catheter-tip syringe</td>
<td></td>
<td>1</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Hemostat</td>
<td></td>
<td>1</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Rescue Airway</td>
<td></td>
<td>1</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Intubation confirmation device</td>
<td></td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>As authorized by Statewide Treatment Protocols and approved by the service's Medical Director</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Intravenous Administration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catheters</td>
<td>14ga, 16ga, 18ga, 20ga, 22ga</td>
<td>5 each</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Administration sets</td>
<td>Macro (10gtt)</td>
<td>4</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Micro (60gtt)</td>
<td>4</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Constricting bands</td>
<td></td>
<td>4</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>padded arm boards</td>
<td></td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>syringes</td>
<td>1cc, 3cc, 10cc</td>
<td>3 each</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 cc</td>
<td>3</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>blood draw setups</td>
<td>Vacutainer</td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leur lock adapter</td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lab tubes per local hospitals</td>
<td>2 sets</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antiseptic wipes</td>
<td>12</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safety catheters recommended Adjustable rate set acceptable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td>Quantity</td>
<td>Requirement</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------</td>
<td>----------</td>
<td>-------------</td>
<td>---------------------------------</td>
<td></td>
</tr>
<tr>
<td>Needles</td>
<td>(18ga, 21ga, 23ga, 25ga)</td>
<td>5 each</td>
<td>18 ga</td>
<td>Required only</td>
<td></td>
</tr>
<tr>
<td>Needles-butterfly</td>
<td>25ga and 23ga</td>
<td>2 each</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Intraosseous Needles</td>
<td>15ga or 18ga</td>
<td>2</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>IV extension set with stop cock</td>
<td></td>
<td>2</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Biocclusive IV dressing</td>
<td></td>
<td>4</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>NaCL (0.9%)</td>
<td>1000mL</td>
<td>6</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>500mL</td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>250mL</td>
<td>2</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100mL</td>
<td>2</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Lactated Ringer</td>
<td>1000mL</td>
<td>2</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Buretrol</td>
<td></td>
<td>1</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Monitor/Defibrillator</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defibrillator</td>
<td></td>
<td>1</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Monitor</td>
<td></td>
<td>NR</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Pacing</td>
<td></td>
<td>NR</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Cardioversion</td>
<td></td>
<td>NR</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Adjustable joule setting</td>
<td></td>
<td>NR</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>12 lead capability</td>
<td></td>
<td>NR</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pediatric paddles/hands free pads</td>
<td></td>
<td>2</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Cables: Spare set for all necessary cables</td>
<td></td>
<td>1</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Conduction medium or hands free pads</td>
<td></td>
<td>1 tube or 4 sets of pads</td>
<td>NR</td>
<td>R</td>
<td>2 year phase in period. Effective date: 11/1/2003</td>
</tr>
</tbody>
</table>
## Electrode and Monitoring Equipment

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Required Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrodes</td>
<td>24</td>
<td>R</td>
</tr>
<tr>
<td>Pediatric monitoring electrodes</td>
<td>6</td>
<td>NR</td>
</tr>
<tr>
<td>Razor</td>
<td>2</td>
<td>R</td>
</tr>
<tr>
<td>Rolls of EKG paper</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>Spare batteries (if applicable)</td>
<td>2</td>
<td>R</td>
</tr>
</tbody>
</table>

## Other Equipment

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Required Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. Pulse Oximeter</td>
<td>1</td>
<td>NR</td>
</tr>
<tr>
<td>E. Multi patient glucometer</td>
<td>1</td>
<td>NR</td>
</tr>
<tr>
<td>F. Nebulizer</td>
<td>4</td>
<td>NR</td>
</tr>
<tr>
<td>Adult Nebulizer mask</td>
<td>2</td>
<td>R</td>
</tr>
<tr>
<td>Pediatric Nebulizer mask</td>
<td>2</td>
<td>R</td>
</tr>
<tr>
<td>G. Pediatric length based tape</td>
<td>1</td>
<td>NR</td>
</tr>
<tr>
<td>H. Catheters; Needle decompression</td>
<td>2</td>
<td>NR</td>
</tr>
</tbody>
</table>

### Legend:
- NR = Not Required
- R = Required
Chapter 3 Concepts for Improvement

3. Introduction

To familiarize ourselves with the layout of the ambulance, we were able to take a trip to UMass Memorial Hospital ambulance headquarters in Worcester, Massachusetts because of the connections of our advisor, Professor Mustapha Fofana. This allowed us to take pictures of the ambulance and ask the paramedics for their input. We were also able to take measurements of the interior of the ambulance. This allowed us to make a Solidworks model of the existing ambulance so that new ideas could be later implemented. Seeing the inside of the ambulance and hearing what the paramedics had to say enabled us to brainstorm new ideas for practical solutions. This chapter contains the information about our visit to UMass and what we learned as well as information about the resulting solidworks model. It also contains three iterations which are meant to solve the problem of paramedic safety.

3.1.1 Visit to UMass

The best way to pinpoint all of the problems with the current ambulance model is to ask the people who work in it every day. Paramedics know everything that is right and wrong with the ambulance because they experience it firsthand. These are the people who are subject to injury every time that they get a call. For this reason, their input is crucial in locating all of the problem areas in the back of the ambulance. Professor Mustapha Fofana has connections with the paramedic team of the UMass Memorial Hospital in Worcester Massachusetts, and because of this we were able to take a trip to their ambulance headquarters. Here we gained valuable
insight into how the paramedics worked in the ambulance and the problems that they had with the setup.

Talking to one of the veteran paramedics we learned that the rear of the ambulance is very difficult to clean due to all of the nooks and crannies in between seat cushions, light fixtures, etc. As a result, there are many places in the ambulance that are contaminated with traces of blood or other bodily fluid which are not washed away during routine cleaning. This poses an obvious health risk to the paramedics who work in the ambulance and the patients who are transported in it. The bacterial growth from the residue in these hard-to-clean places could cause a paramedic who touches it to become susceptible to disease. Furthermore, if the person whose blood is contaminating these areas had a serious disease, it could infect anyone who might touch it.
Figure 15 shows the tracks along which the cabinet doors slide on the average ambulance cabinet. The cabinet doors are by no means liquid resistant and it is clear from this figure that it would be a painstaking process to try to clean anything out of these tracks. Especially considering the fact that this is such a small part of the ambulance and the entire thing needs to be cleaned in a timely manner. It might seem that there is a slim chance of any bodily fluid reaching the cabinet doors but the horror stories of the UMass Memorial paramedics suggest otherwise. A surprising amount of fluid can be projected from an injured person to all corners of the ambulance. When this is the case, fluid resistant cabinets seem all but unnecessary.
Figure 15: Door above bench which opens upward

Figure 16 shows the storage cabinet over the large bench inside of the ambulance. These cabinets open up rather than to the side. There is a piston connected to the door that can be seen to the far side of this figure. This allows the door to open all the way without shutting. This does make accessing materials easier than sliding a door but having a door like this one at waist level would get in the way. When this door is opened, it is out in the open and someone could easily bump into it. For this reason, the doors should open up into themselves like they do in airplance overhead bins.
Figure 17 is a photograph showing the bench in the ambulance where family members of a patient or EMT’s will ride on the way to the hospital. The cushion on this bench is not removable which means that there are a lot of places for fluids to seep. Disinfecting this entire bench by hand in a timely manner seems borderline impossible if it has been contaminated by a bodily fluid. A removable cushion or one that seamlessly connects to the bench would be more suitable.

The paramedics from UMass mentioned that, to them, one of the most important things that an ambulance can have is enough head room to stand up straight. The ambulance that they
currently use is approximately six feet high in the back which gives most of them enough room to stand up comfortably. This is something that the new model cannot take away. Chronic lower back pain is a common injury among EMT’s from constantly bending over and picking things up. To have to bend over or lean while standing in the back of the ambulance will only cause more muscle and joint injuries. If there is to be overhead storage in the new ambulance model, it should not hinder the paramedics’ ability to stand up straight or the paramedic should not have to stand up at all.

Figure 17: counter next to the main chair

Figure 18 shows a counter in the ambulance right next to the paramedics’ main chair. The UMass paramedics informed us that this table is rarely utilized by them and when it is, they only use it to write on. Something that takes up so much vital space should also have a vital
purpose. Rather than having a countertop that does the job of a clipboard, there could be more storage in that area. The items that are located several feet from the paramedic could be stored right next to this paramedic, saving the EMT a trip to the other side of the ambulance and the potential injury in getting there. Keeping all of the most important tools at the paramedics’ level and not over his head is another benefit of turning this counter space into shelves.

### 3.1.2 Existing Ambulance Model

An effective way of illustrating design solutions is through the use of computer aided design software. For the purposes of this project, we are using SolidWorks. Before any design solutions are realized in a computer program, it is important to have a reference. For this reason, we decided to use SolidWorks to create a model of the existing ambulance. This way, we could have something to build off of when implementing our new ideas. Due to time constraints and only a two person group, the model is very basic but still representative of the storage situation in the ambulance. A simple model is much easier make changes to, while accurately illustrating what needs to be demonstrated.
Figure 18: SolidWorks section view of the right side of the ambulance

The SolidWorks screenshot above shows a section view of the left side of the ambulance from the back. The seat and counter can be seen in Figure 19. The stretcher goes toward this side of the ambulance with the head of the patient toward the front. Most of the storage on this side of the ambulance is closer to the back than the front than the back, farther from the patient. The counter takes up a lot of space where the paramedic is working on the patient even though it often goes unused.
Figure 9: SolidWorks screenshot of the left side of the ambulance

The SolidWorks screenshot in Figure 20 shows a section view of the right side of the ambulance from the back. The bench on which family members of the patient sit en route to the hospital is on this side. Directly adjacent to the bench are the open spaces where trash is thrown. The side door can also be seen along with extra storage above the bench and above the door. These places are also unreachable by paramedics if they remain in a seated position.
In figure 21 the SolidWorks screenshot is a section view of the front part of the back of the ambulance. The cabinet close to the door is used for the heating of medicine that needs to stay warm. An example of an EMT supply that requires a controlled climate is the IV drip. These IV bags often freeze during the winter and must be stored in this heated compartment to maintain a liquid state. The door that leads from the cab to the back of the ambulance can also be seen in this figure. There is storage on this wall of the ambulance but it is above the door and out of reach of the seated paramedic.
Figure 11: SolidWorks sliding doors over the counter

Figure 22 shows the cabinet above the countertop. This is an example of most of the cabinet doors and handles in the ambulance. The handles allow the glass doors to slide toward each other so that half of the cabinet can be accessed at one time. As mentioned in the previous section, the doors slide on a track that is not liquid proof and is often hard to open and close.

Figure 12: SolidWorks doors over the bench which opens up
Figure 23 shows the cabinet that is located over the bench on the right side of the ambulance. These cabinet doors open up rather than to the side. This design is a good idea because it is easier to open and close. However, the door opens straight up rather than up into the cabinet itself, like it does in airplane overhead bins.

3.2 Design Iterations

After talking with the UMass EMT’S we began thinking of ways to modify the inside of the ambulance in ways which would provide a more efficient way of storing equipment. The feedback from the paramedics directed our focus into three directions. The first involved optimizing the space to maximize the amount of usable space inside the storage compartments. This also included the arrangement of certain supplies so that the most commonly used are easily within reach of the paramedic while they are seated. The second area of focus was developing a system that reduced the need for paramedics to stand while treating a patient while in route to the hospital. It was determined that the best way to do this was to create a seat which could rotate around the stretcher in order to have access to any supplies that are needed to treat the patient. This concept would also allow the paramedic to treat any area of a patient while being safely seated. Lastly, reducing the amount of corners and sharp edges would make the ambulance safer and much easier to clean. This idea came about after speaking with one of the paramedics. He described the difficulty of cleaning once contaminates breach these areas. The idea is to have as many smooth, rounded surfaces as possible. We want to eliminate gaps between adjacent surfaces.
3.2.1 Grid Pattern Shelf Units

Space inside the ambulance is a difficult problem to work around. Since there is no easy or practical way to increase the space of the ambulance, it was decided to use what space there was as efficiently as possible. Paramedics are acclimated to using the storage cabinets currently in place. The cabinets themselves are a good way to store things; therefore they became the base for our design. The focus turned to creating a shelving system that held a greater amount of supplies. Most of the materials commonly used are relatively small and do not take up a great deal of space. This led to the idea of making a grid like shelving unit that could be placed inside the storage cabinets. The current cabinets usually have one shelf running horizontally across the width of the unit. Some do not have any shelves at all. By having a grid system it would vastly improve on the usable space. Not only would it increase how many things could be stored, but it would also create a more organized method. As it stands now, smaller supplies are kept in plastic bins. These bins take up unnecessary space. Also, the bins do not hold supplies in place very thoroughly. The plastic surrounding some supplies can easily cause more than one item to come out at a time. This leads to a messy and unorganized area.

An advantage to the grid shelving system is that it can be customized to fit any size compartment. The spacing of the shelves themselves could also be customized. This is beneficial for cabinets with varying shapes and sizes of supplies. Standardizing the way every ambulance is set up would help in the cause of organized equipment storage. This task is unfortunately impossible. The numerous styles and sizes of ambulances don’t allow for a standardization of the
layout of materials. Therefore, the advantage of flexibility in design and manufacturing of the new shelving units is invaluable.

![Figure 13: Shelf unit](image)

Figure 24 above shows an example of a new shelf unit. The individual squares make it much more efficient for storing smaller items. These smaller items become easier to sort and therefore the paramedic can access them more easily. This is a much more efficient and organized way compared to the current conditions.

The shelves themselves would ideally be made out of a lightweight plastic. They could, however, be made from a composite wood or aluminum. These materials would be very cost effective. Also, they would be lightweight. It is very important that these components are as lightweight as possible. The ambulance already carries thousands of pounds of equipment, on top of its own weight. Fabricating bulky, heavy components into the ambulance fails in
practicality. The weight of the new system of shelves would be trivial, as to not introduce more nonessential weight.

Figure 14: Example of shelving units for each cabinet

Figure 25 shows the left side of the ambulance. The new shelving system can be adapted to any size or shape of storage cabinet. It shows how customizable these units can be. The versatility of being able to change the size of each section of the cabinet is vital for storing various materials.

3.2.2 Rolling Chair

The second aspect that we concentrated on was the seat. This seat, referred to as the “captain’s chair”, is located at the back of the ambulance, near the separation between the back of the ambulance and the cab where the driver sits. It is completely stationary and faces towards
the rear of the ambulance. A patient on a stretcher would have their head right in front of a paramedic seated in the chair. Also, the restraints, or seatbelt, for the chair is rarely worn as it restricts the movement of the paramedic and makes it difficult to treat the patient. Because the chair is static, the EMT’s sit there, on the bench, or the seat on the left side of the ambulance depending on the injury of the patient.

The goal of the new design was to create one seat that could travel in an arc around the patient. This would eliminate the need for the seat against the left wall of the ambulance. The chair would allow for the tending paramedic to reach both sides of the patient while remaining seated. They would also have access to both sides of the ambulance. Being able to reach either side would provide a tremendous advantage in safety for the paramedics. They would no longer have to stand up to reach supplies. By reducing the amount of time that paramedics need to stand, the chance for paramedic injury is reduced. As practicing EMT’s are prone to back problems from the demands of the job, reducing any further physiological stress would have a great impact.

The base for the design was the chair that is already in place. The most important part of the design was to ensure that the paramedic could safely travel from one side of the patient to the other without obstruction. They must be able to comfortably reach and treat the patient. The space in the floor where the chair will revolve around must also not be a threat to safety. The slot for the track should not be a tripping or any other kind of hazard. This track should also be accessible for maintenance and cleaning.
Figure 26 shows the basic seat that would be used inside the ambulance. It resembles and was modeled after the chair that is already used inside the ambulance. It would be made out of leather and would offer proper back support for the attending paramedics.

The assembly for the track and rollers that the chair will use to revolve on is based on the sliding track inside motor vehicles that allows drivers and passengers to move. This either brings the seat forward or backward. These mechanisms are safe and reliable, making them a good fit for the ambulance. With little maintenance these devices work continuously without jamming or other malfunctioning. Because of the larger seat and increased usage, a heavier duty material is needed for an ambulance model.
The track itself is made out of a curved pipe-like feature where a ball bearing can smoothly roll. The ball bearing will be attached to the bottom of the chair. These bearings would provide the smoothest motion while also providing continuous performance. The most challenging part of the assembly is determining a way in which the paramedic can lock the chair in place so that it does not move about the track. The simple solution would be to have a lever attached to the seat which could be pulled to mechanically stop the chair somehow. The problem with this solution is that the seat moves in an arc about the stretcher, making a simple lever unrealistic, as it could not easily translate with the chair.

Figure 16: Chair track
Figure 27 shows the track that the chair will roll on. This view shows the track in the unlocked position. The curved section at the top of the figure is located by the head of the stretcher. The straight section would run between the stretcher and the bench.

The solution that we came up with involves a motor pushing up slots as wide as the ball bearings themselves so that when activated, the bearings would be locked in between these slots, preventing motion. When the track is not locked, these slots would lay flat at the base of the track. When activated, they would rise up, essentially locking the ball bearings in place. A small electric motor could be mounted to drive the slots up and down. This motor could be controlled by a one simple button on the chair. Basically it would be an on/off switch controlling whether the chair is locked in place or free to rotate about the track.
Figure 28 shows the track in the locked position. The spacing between the slots or ribs would prevent the caster wheel from rolling. This would effectively lock the chair in place. The ribs would rise to lock the chair in place or lower to allow it to have free movement around the track.

Figure 18: Close up of ribs

Figure 29 shows a zoomed in view of the ribs that hold the chair stationary. These raised slots in the tube of the track rise and fall through the aid of a motor controlled on the chair by the paramedic. When the slots are positioned up, the chair becomes immobile.

The dimensions of the track are not exact but rather, are conjectured roughly from the known dimensions. The track should have a radius of about ten inches away from the stretcher at all times. There are two reasons for this. First, the limited space inside the ambulance will not
allow for the rotating chair to be very far from the stretcher. There is just not enough clearance from the bench and anything else inside the ambulance. The second reason is that the paramedic should be close enough to work comfortably on the patient. Ten inches is close enough that the average EMT should be able to reach and effectively treat a patient. Ten inches also allows a comfortable amount of leg room for the paramedic. This gap is also wide enough that a person may walk between the stretcher and the seat.

![Diagram of dimensions of track]

*Figure 19: Dimensions of track*
Figure 30 shows the dimensions of the track. The numbers are not exact and can be changed according to the size and shape of the ambulance. Note the size of the width and spacing between the slots. These dimensions will rely completely on the size of the caster balls that the chair rolls on. Our example uses a caster ball of about one inch in diameter.

The seat will be mounted on two tracks rather than just one. Two legs in the front of the chair will attach to the first track. A single leg from the back of the chair will attach to the rear track. This dual track system will allow for extra stability of the seat. If only one track was used, the seat would be less stable and therefore unsafe and unreliable. The two tracks will be the same shape only with the rear one having a larger radius from the stretcher.
Figure 31 gives a view of the seat inside the ambulance. It shows the track wrapping around a rough representation of the stretcher. The chair will be able to follow the track along its length in order to be able to treat various parts of a patient as well as reach items throughout the ambulance.

The whole system will work by attaching a caster ball to each leg of the chair. This caster ball is perfect for this setup because of the freedom of motion that it has. The ball will be able to freely rotate along the track. Other systems were rejected because of the specific path the track has. Wheels and other methods did not have the degrees of freedom necessary. Also this caster ball approach fits in perfectly with the locking mechanism. The end of the caster ball meshes well with the slots that push up to lock the chair in place. Having wheels would not work with this system. If wheels were used, it would be much more difficult to have the chair follow the correct path around the stretcher. This is due to the fact that wheels are not a practical idea when using a set pathway. Locking a normal set of wheels would pose another challenge. Wheels tend to be bulky and cumbersome. In the case of the ambulance, this awkward shaping would get in the way. The caster ball on a track is its own self-contained unit. As a result of being self-contained, it does not get in the way or pose a safety issue. It can turn smoothly and reliably, allowing the paramedics to do their jobs more efficiently.
Figure 32 shows a caster ball. A mechanism similar to this is used for the design for the chair. The quasi enclosed ball bearing is free to rotate along the path of the track. The other end would attach to the legs of the seat. The caster ball is the best choice for the chair to move safely and smoothly through the ambulance. With the caster ball system, the locking mechanism becomes almost failsafe as long as the motor operates correctly. The paramedic does not need to worry about the chair locking incorrectly. The ribs will be spaces apart just far enough for the caster ball to fit into. Should the ball be positioned on top of one of these ribs while locking the chair, the system will still work. This is due to the physics of the ball over the thin flat surface of the rib. The ball will simply slide off into the correct slot even if it is directly over one of the rising ribs.
The material that the track will be made out of must be very wear resistant. It should be able to stand up to the stress and forces of the chair seating a paramedic rolling over it. It should keep its rigidity, meaning that it should resist plastic deformation. The caster ball will be made of some sort of metal encased in either plastic or another metal. It is for this reason that the track should not be made out of aluminum. Aluminum would wear out much too quickly from the metal on metal grinding. Some type of steel would be a sensible choice of material for the track. Specifically, high carbon steel would be the best choice. High carbon steel has very high fatigue strength. This means that it can go through a large number of cycles of use without wearing out.

Figure 22: Example of chair sliding down track
Figure 33 demonstrates the path and motion that the chair takes through the ambulance. The paramedic would have the room to move down the side of the stretcher. This particular example shows that the paramedic can reach the medicine cabinet as well as some of the storage above the bench. The chair should also have the ability to swivel. This means that the paramedic would easily be able to turn the chair and treat a less severely injured patient on the bench if needed. All of this would be accomplished while remaining seated.

Figure 23: Section view of seat at end of track

Figure 34 shows the chair at the end of the track. Not shown in the figure is the storage behind the seat, above the bench, that the paramedic can reach. This further demonstrates the ability for the paramedic to increase their range without standing. By eliminating instances where the paramedic needs to stand, the safety of the crew and patient increases.
3.2.3 Improved Storage Model

Paramedic safety is the most vital thing to consider in this project and all of the possible solutions to the storage problem must reflect this. It is important to keep the background research and EMT input in mind in order to come up with suitable ideas for improvement. Even though safety is imperative in the creation of new storage, it should not go so far as to compromise the work that the paramedics are doing, i.e., saving lives. This would entirely defeat the purpose of having ambulatory services. The following iteration is of an entirely new ambulance. For it to be realized there would need to be an overhaul of the existing ambulance or a completely new production. Even so, this solution would theoretically solve a lot of the problems that the paramedics have with the existing ambulance.

We have extensively talked about the dangers that the paramedics face in the ambulance. If they need to stand up to reach something, a bump or turn could cause them to fall. This is something that needs to be addressed. The paramedics should be able to remain seated as they work on a patient. For this reason, the things that they need most should be easily within arm length. The cockpit of an airplane shows us that the pilot never has to stand to fly the plane and the same should go for paramedics. The cockpit even utilizes space above the pilots and there is no reason why an ambulance cannot do the same. If there is storage directly next to and perhaps even above the paramedics, they will never need to leave the chair. For this to be accomplished, the space previously used for a countertop and chair would have to be turned into storage space.

Another problem with the current ambulance is the cabinet corners that hang over the seat and counter area. These corners cause the same problem for paramedics in a moving ambulance
that a coffee table causes for a wobbly toddler; there is a possibility of head injury in the event of a fall. Even if the paramedics barely stumble, they could hit their heads and cause serious injury. For this reason, the walls of the ambulance should contain no sharp corners at all. Perhaps the safest and most efficient way to make the ambulance is with the entire wall as a storage cabinet. This wastes no space and also means that there are no dangerous corners that could lead to potential injury. Even where the ceiling meets the wall could be curved to allow for more storage space close to the paramedic. The design for this iteration can be thought of as a somewhat parabolic ambulance with walls that meet the ceiling with a gradual curve that can act as storage.

A major issue that one of the paramedics at UMass Memorial had was the difficulty in cleaning the ambulance. All of the small corners are easily accessed by bodily fluids but not by those who have to clean them. The best way to do away with gathering areas for bacteria is to do away with all of the ninety degree angles where they tend to gather. The ambulance in this solution will have no corners at all. Every place where there would normally be corners has rounded edges. The bench on the right side of the ambulance can have a removable cushion for easy cleaning. Ideally the entire thing can be made water proof and simply be sprayed down from top to bottom when all of the cabinet doors are closed.
In the SolidWorks screenshot above, a simple model of this iteration is shown. The view in Figure 35 shows the left side of the ambulance from the back. This is the side towards which the stretcher is oriented. Normally there is a seat and counter on this side of the ambulance, but this model has replaced these with storage space. The chair where the paramedic sits next to the stretcher is close to this spot. Because the storage is located in this area, a seated paramedic will be able to access what he needs to treat the patient.
Figure 25: Section view of the left side of the new ambulance from a different angle

This section view of the SolidWorks model shows the same side of the ambulance as the last figure. It can be seen in Figure 36, that there is a curved cabinet connecting the wall of the ceiling. This cabinet will have a glass door to keep its contents in. Due to the danger of items falling out of the cabinet when these doors are open, there could be holes that would allow paramedics to grab one item at a time. Things like towels could be put into this space and work like a tissue dispenser. With a curved area like this, there are fewer sharp corners and potential for injury. It will also be easier to clean because there is nowhere for liquid to stagnate.
Figure 26: Section view of the new ambulance showing the extra storage

Figure 37 is another screenshot of the SolidWorks model. It shows the extra storage area on the far side of the ambulance. Right next to the door that leads to the cab is a few more shelves where important items can be stored. By replacing the rarely used countertop and seat with storage space, paramedics will be able to remain seated while treating the patient. Furthermore, the lack of corners makes a safe clean environment for paramedics and patients alike.
Although it is not shown in the SolidWorks model, this iteration has doors that open up rather than to the side. Due to time constraints, it would be very difficult to make a SolidWorks model of the doors and opening mechanisms. However, these doors and their hinges would look very similar to those in an airplane overhead compartment. The door opens up into itself so that it will not get in the way of a working paramedic. The door will be hinged such that it will open by itself when the door handle is pulled and the door is unlocked. When the door is closed, it will be locked into place such that it will form a virtually waterproof seal. This waterproof seal can be accomplished through the use of a rubber weather-stripping similar to what can be found in a car. This will allow for easy cleaning and prevent liquid from seeping into any cracks. If each cabinet has a door like this, the paramedics will be able to reach whatever they need quickly and easily from a seated position.

Figure 27: The counter in the existing ambulance which takes up a lot of space
Figure 38 shows the counter which has been replaced by storage in this iteration. There are several things that are on or above this counter space that need to be in the ambulance. The shelves that are next to the door that leads to the cab (which can be seen in the SolidWorks screenshots) could be fitted to house these devices so that they are still within reach. The large device above the cabin could even be moved to the cabinets that are on the other side of the door that leads to the cabin.

Figure 28: Increase storage replacing counter
The screenshot in Figure 39 illustrates the wall that is closest to the cab. The door in the middle leads to the cab and there are storage cabinets on either side. The shelves to the left of the door are where the items currently on the counter may go. The shelves to the right of the door could house any of the larger items. Even though this might put a device a little farther away, the paramedics said that the counter space was rarely used. Often times, it was only used for writing. Writing something down does not require a large counter however, and can be just as easily done on a clipboard. Having considered all of these things, this iteration has many positive aspects and very few negatives. It promotes the safety of the paramedics and patients and even allows for efficient cleaning.

An earlier iteration was of a chair that ran on a track so that the paramedic sitting in it could move without having to stand up. If that iteration was combined with the one in this section, it could make all of the needed materials even more accessible. A moving chair in this case would make accessing tools even easier. For instance, if the patient had an injury on his or her leg, the paramedic could swivel the chair to an appropriate position to work on the patient’s leg. If he or she needed more materials from the storage compartments, he or she could slide to where he could reach them and then back again. The paramedic could work on any part of the patient from this seat.
Figure 40 shows a section view of the left side of the ambulance. The chair can be seen in a position close to the front of the compartment and the table in front of it is a crude stretcher “stand-in”. When the chair is at this point on the track, the paramedic can grab whatever he needs from the adjacent storage bins. The patients head would be directly in front of the EMT so that any head trauma, trouble breathing, etc, could be treated by the paramedic from this position.
Figure 30: Section view of the chair on a different part of the track

Figure 41 above is another SolidWorks section view of the left side of the ambulance. Here the chair is in a different location on the track. If the patient was not experiencing some kind of head injury, the paramedic could move the seat to the appropriate place on the track without standing. In the interest of efficiency, the items most needed for treating certain parts of the body could be stored on shelves that are close to that part of the body. Any supplies used to treat a leg injury, for example, could be stored close to the area on the stretcher where the legs would be (all the way to the left in the figure above). This way, the paramedic can simply reach over and get it.
Chapter 4 Concluding Remarks

During the duration of this project, we came up with three successful iterations that would improve the ambulance as it is. After inspection of the current system, it was decided that these three concentrations could be feasibly achieved. The reason for focusing on these areas was that, if properly done, they could vastly improve on the conditions that are currently in use. The amount of storage, the type of storage, and paramedic mobility were the three areas of interest. The solution for the amount of storage comes in two parts. The first involves the obvious solution of simply adding more storage area. To do this, the chair and counter top on the left side of the ambulance were removed. The second aspect of implementing more storage space consists of optimizing the amount of usable storage space inside existing storage units. This was accomplished through insert able fabrications of shelves. These shelves have a grid-like appearance. They can be modified to fit any cabinet and store any various sized materials.

The type of storage was changed with respect to how the paramedic accesses the equipment. In the current model, the doors are often difficult to open especially while seated or moving. If the paramedic is on a call the doors should be easy to open for fast effective patient care. The new doors on the storage units are secure when locked, but easy to open. They open upwards like the storage bins inside commercial jets, so that they do not get in the way while in use. This means that a paramedic can easily access any necessary materials without the door getting in the way. A spring system will allow the door to remain raised once open, so that the EMT does not have to worry about the door slamming down while accessing the storage unit.
While the door is closed, the spring is in tension. When the door is unlatched, the spring pulls the door up and keeps it in place.

The final phase of the modification process includes improvements to the paramedics’ chair. As it is now, this chair is stationary. Also, the position that it is in is often out of reach of important medical supplies. This causes hazardous conditions when the paramedic needs to stand in order to obtain supplies. Lower back problems that develop in paramedics over the span of their career are often attributed to standing while working on a patient during a call. Reducing this need to stand could greatly decrease the number of injuries to paramedics and patients alike. To eliminate the need to stand, the chair will rotate around a track on the floor of the ambulance. This gives the paramedic the range to be able to acquire any materials that they might need during a call. This also gives the ability to work on any part of the patient. The legs of the chair will have caster balls attached to them. These caster balls allow the chair to smoothly move around the track. To lock the chair in place ribs, or slots, will raise up in the track. These ribs prevent the caster ball from moving around the track, thus locking the chair in place. This system will be driven by a small motor located under the track and will be controlled by a single button located on the chair.

Some of the limitations to the project deal with the sizing constraints of the ambulance, as well as the regulations of the ambulance. The size of the ambulance is unable to be altered. This means that the interior space is set. This makes it difficult to make modifications or to increase the amount of space where items may be stored. Also, there are governmental laws and regulations that any design and modification must meet. Each of the iterations must be safe and
reliable. Otherwise, they would not meet the government regulations and would not be acceptable to be placed inside the ambulance. Since the goal is to improve the current system in place, it is very important that these designs be up to code.

Some room for improvement in the future includes further refinement of the presented iterations. The details of some mechanisms still need to be worked out. Also, more computer aided models of iterations should be looked into. The real test and fulfillment of the project would be to manufacture prototypes of afore mentioned designs. These prototypes could then be implemented in an ambulance. The system could be tested in real world applications. Feedback from paramedics and other medical personnel could be collected and used to further improve on the designs. This would all eventually culminate into the launching of a new system of storage inside new ambulances.
References:

1. Burt CW, McCaig LF, Valverde RH. *Most Common Diagnoses in Patients Transported by Ambulance to Emergency Departments, by Primary Diagnosis Group* 2003
   http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5519a8.htm

2. Maguire, Brian J. et al, 2002 “*Occupational Fatalities in Emergency Medical Services: A Hidden Crisis*” From the Department of Emergency Health Services, University of Maryland, Baltimore County, MD (Maguire); the Department of Environmental and Occupational Health, The George Washington University, Washington, DC (Hunting); the Center for Safety Research, Liberty Mutual Research Center for Safety and Health, Hopkinton, MA (Smith); and Harlem Hospital, Columbia University, New York, NY (Levick)

3. SL Proudfoot, NT Romano, MS, TG Bobick, PhD, PH Moore, Div of Safety Research, National Institute for Occupational Safety and Health, CDC.
   http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5208a3.htm


7. AMD Standards. Ambulance Manufacturers Division of the National Truck Equipment Association. August 2007
Appendix A: Administrative Requirements Manual

Basic Life Support (BLS) Ambulance

General Principles

A. AUTHORIZED EQUIPMENT: Ambulance services must carry equipment and medications as required by Statewide Treatment Protocols. Ambulance services should not equip ambulances with equipment that is outside of scope of practice of its EMT employees, or outside of the service’s level of licensure.

B. PERFORMANCE STANDARDS: All equipment must be designed and constructed to meet medical performance objectives and must not endanger patients.

C. MAINTENANCE: All equipment and supplies must be maintained according to manufacturers’ specifications with regard to maintenance, storage, expiration date, replacement, etc.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Name</th>
<th>Class</th>
<th>Description &amp; Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ambulance Cot</td>
<td>I, II</td>
<td>• One 4-wheeled, multi-level ambulance cot.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Standard cot mattress with waterproof cover.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Patient restraining devices at chest (commercial shoulder harness or equal) hip, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>knee to prevent lateral or longitudinal displacement of the patient during transport.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Dual I.V. holder, capable of being cot mounted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Padded wrist and ankle restraints, minimum one complete set.</td>
</tr>
<tr>
<td>2</td>
<td>Bag Valve Mask Ventilation Unit</td>
<td>All</td>
<td>One (1) hand-operated bag/mask ventilation unit with adult mask(s), capable of use with</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>oxygen supplies (disposable, single use units recommended). Unit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>must be accessible within the patient compartment, and include, at minimum:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(a) One (1) each child and infant size bag/mask ventilation units</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>with appropriate mask(s), capable of use with oxygen supply (disposable, single</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>use units recommended); (b) Two (2) oxygen connector tubes, minimum 84 inches long;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(c) One (1) oxygen supply reservoir for each bag/mask ventilation unit.</td>
</tr>
<tr>
<td>3a</td>
<td>Portable Oxygen Unit</td>
<td>All</td>
<td>Portable positive pressure resuscitator/ inhalation unit designed to operate in</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>conjunction with external cardiac compressions and deliver nearly 100% oxygen.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>All components must be stored together. Unit must be equipped with:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(a) One (1) bag/Valve/mask ventilation unit. The Addition of a flow restricted,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>oxygen powered ventilation device (demand valve) is optional;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(b) Oxygen cylinder with minimum capacity of 300 liters;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(c) Oxygen cylinder pressure gauge and regulator capable of delivering a range of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>zero (0) to fifteen (15) liters per minute;</td>
</tr>
</tbody>
</table>
### Office of Emergency Medical Services

**Administrative Requirements Manual**

**Effective:** 03/01/2000

**AR Title:** Ambulance Equipment List

**Supercedes:** BLS List Effective March 1, 2000

<table>
<thead>
<tr>
<th>Item #</th>
<th>Item Name</th>
<th>Class</th>
<th>Description and Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a</td>
<td>Cont'd (Port. Oxygen Cont.)</td>
<td></td>
<td>(d) Two (2) different sizes of resuscitator face masks;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(e) Two (2) Each child and adult size transparent, disposable, high concentration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>oxygen masks with delivery tubes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(f) Two (2) adult nasal cannula with delivery tube;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(g) Oxygen connecting tubing;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(h) Cylinder wrench or wheel secured to unit;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>One (1) full spare oxygen cylinder, minimum 300 liters. All spare cylinders</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>to be maintained in vehicle, but not part of the kit. All spare cylinders must</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>be stored in a crash stable devices per KKK-A-1822, and any amendments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>thereto.</td>
</tr>
<tr>
<td>3b</td>
<td>Installed Oxygen</td>
<td>I, II</td>
<td>An installed oxygen system conforming to Applicable sections of the Federal</td>
</tr>
<tr>
<td></td>
<td>System</td>
<td></td>
<td>Specification for Ambulances KKK-A-1822, and any amendments thereto, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>equipped with the following:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(a) Two (2) Flowmeters, capable of delivering a range of zero (0) to 15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>liters per minute, at minimum;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(b) Unbreakable oxygen humidifier, disposable, for single use only;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(c) Sterile water for use with oxygen humidifier;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(d) Four (4) each adult and child size, transparent, disposable, high</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>concentration oxygen masks with delivery tubes;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(d) Four (4) Each adult and child sizes of disposable nasal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>cannulae with delivery tubes;</td>
</tr>
<tr>
<td>4</td>
<td>Installed Suction</td>
<td>I, II</td>
<td>[required by KKK-A-1822 s.3.12.3; but not previously itemized on equipment list]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Electrically powered suction aspirator system shall be furnished with an</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>illuminated switch, and panel mounted, to include:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(a) One (1) non-breakable, transparent collection bottle or bag,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>minimum 1,000 ml capacity;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(b) One (1) suction rinsing water bottle;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(c) Two (2) semi-rigid pharyngeal suction tip with thumb suction control</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>port;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(e) Two (2) transparent or translucent, non-kinking suction tubing min. 1/4 inch</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>in diameter;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(f) Two (2) Each 5, 8, 14 French suction catheters; and ten (10) spare</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>collection bags when bag type system is furnished.</td>
</tr>
<tr>
<td>5</td>
<td>Portable Suction</td>
<td>All</td>
<td>One (1) adjustable gas or battery powered portable suction apparatus, capable</td>
</tr>
<tr>
<td></td>
<td>Unit</td>
<td></td>
<td>of delivering a minimum vacuum of 600 millimeters of mercury and equipped</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>with the following:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(a) Wide bore, non-kinking tube;</td>
</tr>
</tbody>
</table>

---

**Page 2**
<table>
<thead>
<tr>
<th>Item #</th>
<th>Item Name</th>
<th>Class</th>
<th>Description and Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Cont'd</td>
<td>Pharyngeal suction tip; (b) Non-breakable, transparent collection bottle, minimum capacity 550 cc (disposable container recommended); (d) One (1) pair disposable exam type gloves; (e) One (1) combination face mask/eye shield or one (1) each facemask and protective eye wear.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 First Aid Kits I, II</td>
<td>Two (2) portable first aid kits.</td>
<td>IV, V</td>
<td>One (1) portable first aid kit. Kits may be incorporated into other kits (i.e., portable oxygen kit.) Each first aid kit to be supplied and equipped with the following equipment: (a) Three (3) wrapped oropharyngeal airways, one (1) each, infant, child and adult sizes; (b) Twelve (12) small dressings (sterile gauze pads, minimum size 4&quot;x4&quot;); (c) Four (4) medium dressings, sterile, minimum size 5&quot; x 9&quot;; (d) Two (2) large dressings (sterile universal dressings, minimum size 10&quot;x 3 0'); (e) Six (6) rolls soft roller, self-adhering bandage, minimum 4&quot; x 5 yds; (f) Four (4) cravats or triangular bandages, minimum 40&quot; wide; (g) Two (2) arterial tourniquets for control of arterial bleeding, commercial or equivalent; (h) Two rolls 2&quot; adhesive tape, minimum 5 yards; (i) One (1) 7&quot; bandage scissors or equivalent; (j) One (1) adult size sphygmomanometer; (k) One (1) stethoscope; (l) One (1) penlight-type flashlight; (m) One (1) unbreakable container of sterile water or saline solution, minimum one pint (500 cc); (n) One (1) wrapped 3 ounce bulb syringe for irrigation purposes; (o) Two (2) cold packs; (p) One (1) tube glucose based paste or equivalent; (q) Two (2) wrapped tongue depressors for glucose administration; (r) Six (6) band-aids, minimum 3/4&quot;; (s) One (1) mouth-to-mouth resuscitator mask with one way valve and an oxygen port (disposable type recommended); (t) Two (2) combination face mask/eye shield or two (2) each facemask and protective eye wear; (u) Two (2) pair disposable exam type gloves.</td>
</tr>
<tr>
<td>7 Traction Splints I, II</td>
<td>• One (1) hinged Thomas-type half ring lower extremity splint or equivalent; • One (1) child-sized hinged Thomas-type half ring lower extremity type with ankle hitch and leg ties or equivalent, with ankle hitch and leg ties. All accessory items to be stored with splints.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item #</td>
<td>Item Name</td>
<td>Class</td>
<td>Description and Quantity</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------------</td>
<td>-------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>Padded Board Splints</td>
<td>All</td>
<td>Covered padded board splints or equivalent impervious to saturation by fluids, minimum two (2) each of the following sizes: (a) 3 feet by 3 inches; (b) 15&quot; inches by 3 inches; (c) 4 1/2 feet by 3 inches.</td>
</tr>
</tbody>
</table>
| 9     | Spine Boards and Accessories   | All   | • One (1) half spine board meeting AAOS standards, with three (3) torso straps and head strap (2" tape or functional equivalent), or equivalent (i.e., KED);  
• One (1) full spine board meeting AAOS standards;  
• Accessories for each full spine board carried, stored together, as follows: (a) Four (4) straps of 9 foot length or functional equivalent; (b) Four (4) adult rigid cervical collars of various sizes (e.g. no-neck, small, medium, and large). or one (1) adult adjustable collar, and three (3) child size rigid cervical collars of various sizes (e.g. infant, toddler, and child), or one pediatric adjustable collar at a minimum; (c) Sufficient padding material to maintain in-line head and cervical spine support and stabilization (i.e., foam blocks, rolled blankets, and/or towels). |
<p>| 10    | Stair Chair                    | I, II | One (1) stair chair with patient restraint straps                                                                                                                                                                       |
| 11    | Auxiliary Stretcher            | I, II | One (1) auxiliary stretcher with patient restraint straps, or equivalent (i.e., orthopedic &quot;scoop&quot; stretcher, &quot;Reeves&quot; type stretcher, long spine board)                                                                                                 |
| 12    | Transfer Sheet                 | I, II | One (1) transfer sheet with a minimum of six (6) handles, or equivalent.                                                                                                                                                 |
| 13    | Airways                        | I, II | Six (6) Wrapped oropharyngeal airways (2) Each infant, child, and adult [in addition to those listed in the first aid kit]; (a) Eight (8) adult size nasal airways, one (1) each 20F, 22F, 24F, 26F, 28F, 30F, 32F, and 34F; (b) Four pediatric nasal airways, One (1) Each 12F, 14F, 16F, 18F; (d) One disposable package water soluble lubricant per nasal airway. |
| 14    | Small Dressings                | I, II | Twenty-four (24) sterile gauze pads, minimum 4&quot; x 4&quot;                                                                                                                                                                   |
| 15    | Medium Dressings               | I, II | Twelve (12) sterile, individually packaged dressings, minimum 5&quot; x 9&quot;, or equivalent (i.e., sterile sanitary napkins)                                                                                                  |</p>
<table>
<thead>
<tr>
<th>Item #</th>
<th>Item Name</th>
<th>Class</th>
<th>Description and Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Large Dressings</td>
<td>I, II</td>
<td>Six (6) sterile, individually wrapped universal dressing, Minimum 10&quot; x 30&quot;.</td>
</tr>
<tr>
<td>17</td>
<td>Soft Roller Bandage</td>
<td>I, II</td>
<td>Twelve (12) rolls soft roller, self-anchoring bandage, either 3&quot; or 4&quot; size.</td>
</tr>
<tr>
<td>18</td>
<td>Triangular Bandage</td>
<td>I, II</td>
<td>Twelve (12) triangular, commercial or equivalent, of unbleached muslin, minimum 40&quot; wide.</td>
</tr>
<tr>
<td>19</td>
<td>Adhesive Tape</td>
<td>I, II</td>
<td>Four (4) rolls of 1&quot; x 5yd, one of which must be hypoallergenic.</td>
</tr>
<tr>
<td>20</td>
<td>Bandage Shears</td>
<td>I, II</td>
<td>One (1) pair bandage shears.</td>
</tr>
<tr>
<td>21</td>
<td>Burn Sheets</td>
<td>All</td>
<td>Two (2) sanitary, wrapped burn sheets, linen or disposable.</td>
</tr>
<tr>
<td>22</td>
<td>Obstetrical Kit</td>
<td>All</td>
<td>One (1) sterile commercial obstetrical kit; OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>One (1) sterile obstetrical kit containing the following:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(a) One (1) large towel;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(b) One (1) receiving blanket, or equivalent;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(c) One (1) pair sterile disposable plastic or rubber gloves;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(d) Six (6) sterile gauze pads, minimum 3&quot; x 3&quot;;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(e) Two (2) Kelly clamps or sterile ties;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(f) Six (6) sanitary napkins;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(g) One (1) infant bulb syringe;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(h) One (1) pair scissors (bandage or surgical blade);</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(i) One (1) container with lid for carrying placentas;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(j) One (1) newborn swaddler system, i.e. space blanket, foil swaddler, or equivalent to retain body temperature.</td>
</tr>
<tr>
<td>23</td>
<td>Poison Antidote Kit</td>
<td>All</td>
<td>One (1) poison antidote kit, containing:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(a) Activated charcoal;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Measuring device.</td>
</tr>
<tr>
<td>24</td>
<td>Irrigation Fluid</td>
<td>I, II</td>
<td>Three (3) liters of sterile water or saline solution, in unbreakable containers, in a minimum of three (3) containers.</td>
</tr>
<tr>
<td>25</td>
<td>Aluminum Foil</td>
<td>I, II</td>
<td>One (1) roll of aluminum foil, minimum 12 inches by 25 feet, or adult size space blanket.</td>
</tr>
<tr>
<td>26</td>
<td>Polyethylene Film</td>
<td>I, II</td>
<td>One (1) roll of polyethylene film.</td>
</tr>
<tr>
<td>Item #</td>
<td>Item Name</td>
<td>Description and Quantity</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>-----------------</td>
<td>---------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Bed Pan</td>
<td>I, II, One (1) adult bed pan.</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Motion Sickness</td>
<td>I, II, IV, Two (2) motion sickness bags, or equivalent, capable of being sealed.</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Pillows</td>
<td>I, II, IV, V, Two (2) pillows with waterproof plastic covers, and four (4) pillow cases. One (1) pillow with waterproof plastic cover, and two (2) pillow cases.</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Sheets</td>
<td>I, II, IV, V, Eight (8) sheets, disposable or linen; Two (2) sheets, disposable or linen.</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Blankets</td>
<td>I, II, IV, V, Four (4) blankets; Two (2) blankets.</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Towels</td>
<td>I, II, Four (4) towels.</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Tissues</td>
<td>I, II, Two (2) packages of disposable paper tissues.</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Drinking Cups</td>
<td>All, Two (2) or more disposable drinking cups.</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Cold Packs</td>
<td>I, II, Four (4) cold packs</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Glucose</td>
<td>I, II, Two (2) glucose based paste or equivalent, and wrapped tongue depressors for glucose administration. <em>(other than what is in first aid kits).</em></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Infection Control Kit</td>
<td>All, One (1) infection control kit, containing two (2) each of disposable, fluid resistant gowns, masks, caps, protective eye wear, and two (2) different sizes of gloves.</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Ring Cutter</td>
<td>I, II, One (1) ring cutter.</td>
<td></td>
</tr>
<tr>
<td>Item #</td>
<td>Item Name</td>
<td>Class</td>
<td>Description and Quantity</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------</td>
<td>-------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>39</td>
<td>Adult Sphygmomanometer</td>
<td>I</td>
<td>One (1) adult, sphygmomanometer.</td>
</tr>
<tr>
<td>40</td>
<td>Large Adult</td>
<td>All</td>
<td>One (1) large adult, or thigh size sphygmomanometer.</td>
</tr>
<tr>
<td>41</td>
<td>Child Size Sphygmomanometer</td>
<td>I, II</td>
<td>One (1) child size sphygmomanometer.</td>
</tr>
<tr>
<td>42</td>
<td>Infant Sphygmomanometer</td>
<td>All</td>
<td>One (1) infant size sphygmomanometer.</td>
</tr>
<tr>
<td>43</td>
<td>Stethoscope</td>
<td></td>
<td>One (1) stethoscope to be a component of patient compartment stocks. (other than what is in first aid kits.)</td>
</tr>
<tr>
<td>44</td>
<td>Plastic Bags</td>
<td>I, II</td>
<td>Two (2) large plastic bags with ties.</td>
</tr>
<tr>
<td>45</td>
<td>Contaminated Trash</td>
<td>All</td>
<td>Two (2) disposable &quot;Bio-Hazard&quot; bags, with ties.</td>
</tr>
<tr>
<td></td>
<td>Container</td>
<td></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Eye Shields</td>
<td>I, II</td>
<td>Two (2) combination face mask/eye shield or two (2) each face mask and protective eye wear.</td>
</tr>
<tr>
<td>48</td>
<td>Gloves</td>
<td>I, II</td>
<td>Six (6) pairs of disposable exam type gloves in three (3) different sizes.</td>
</tr>
<tr>
<td>49</td>
<td>Hand Cleaner</td>
<td>I, II</td>
<td>One (1) dispenser antiseptic hand cleaner, or 25 individually wrapped antiseptic hand wipes.</td>
</tr>
</tbody>
</table>
| 50    | Latex-free Equipment      | ALL   | One (1) commercial latex-free kit; OR one (1) labeled latex-free kit containing the following: (a) latex-free examination gloves, two (2) pairs each, small, medium and large; (b) latex-free tourniquet; (c) latex-free adult BVM and masks; (d) latex free high concentration, disposable, oxygen masks with delivery tubes, two (2) each, adult and child; (e) latex-free nasal cannulae and delivery tubes, two (2) each, adult and child; (f) latex-free B/P cuff, and (g) latex-free stethoscope.
51 CPR Board | I, II | CPR board or functionally equivalent (i.e., short board) hard surface for patient torso accessible to patient compartment.

52 Automatic Defibrillator | I, II, V | One automatic external cardiac defibrillator (AED) appropriate to ambulance staffing configuration, with appropriate accessories. Effective date: March 1, 2002.

53 Epi-Pens | ALL | Two (2) each, child and adult Epi-Pens. Effective June 30, 2002.

54 Aspirin | ALL | 30 tablets of chewable pediatric-strength (81 mg/tablet) aspirin, or 30 tablets of adult-strength (162-325 mg/tablet) aspirin. Effective June 30, 2002.

---

**EQUIPMENT TO GAIN ACCESS**

<table>
<thead>
<tr>
<th>Item #</th>
<th>Item name</th>
<th>Class</th>
<th>Description and Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equipment to Gain Access</td>
<td>I, II</td>
<td>(a) One (1) screwdriver, minimum 8&quot; regular blade&lt;br&gt; (b) One (1) hacksaw with six (6) wire (carbide) blades&lt;br&gt; (c) One (1) pair of pliers, 10&quot; vice grip&lt;br&gt; (d) One (1) short handled sledge hammer, minimum 3 pounds&lt;br&gt; (e) One (1) rope, synthetic, minimum 50 feet by 1/2 inch diameter or functional equivalent&lt;br&gt; (f) Two (2) pairs of gloves (leather gauntlets)&lt;br&gt; (g) Two (2) pairs of goggles (clear eye protective)</td>
</tr>
</tbody>
</table>
VEHICLE EQUIPMENT

<table>
<thead>
<tr>
<th>Item #</th>
<th>Item Name</th>
<th>Class</th>
<th>Description and Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Warning Lights</td>
<td>V</td>
<td>Emergency warning beacon, visible 360 degrees, as permitted by M.G.L. c.90, s.7, or as</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>required under KKK-A-1822 and any amendments thereto.</td>
</tr>
<tr>
<td>2</td>
<td>Audible Warning Devices</td>
<td>V</td>
<td>A siren, audible 500 feet to the front.</td>
</tr>
<tr>
<td>3</td>
<td>Maps</td>
<td>I, II</td>
<td>Street directories and road maps for primary and backup areas served.</td>
</tr>
<tr>
<td>4</td>
<td>Fire Extinguishers</td>
<td>I, II</td>
<td>Two (2) adequately charged fire extinguishers, five (5) pound C02 or dry powder.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Underwriter's Laboratory approved, one of which shall be mounted in the patient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V</td>
<td>compartment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>One (1) adequately charged fire extinguisher, five (5) pound C02 or dry</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>powder, Underwriter's Laboratory approved.</td>
</tr>
<tr>
<td>5</td>
<td>Handlights</td>
<td>I, II</td>
<td>Two (2) 6-volt handlights, bulb type, or two bulb type handlights with rechargeable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V</td>
<td>battery of 4.5 volts minimum.</td>
</tr>
<tr>
<td>6</td>
<td>Chock Blocks</td>
<td>I, II</td>
<td>Two (2) vehicle chock block.</td>
</tr>
<tr>
<td>7</td>
<td>Road reflectors</td>
<td>I, II</td>
<td>Six (6) DOT approved triangular reflectors, or equivalent.</td>
</tr>
<tr>
<td>8</td>
<td>Hazardous Material</td>
<td>I, II</td>
<td>One (1) U.S. Department of Transportation Emergency Response Guidebook, current edition;</td>
</tr>
<tr>
<td>Material Guidebooks</td>
<td></td>
<td>V</td>
<td>One (1) National Institute of Occupational Health and Safety (NIOSH) Pocket Guide to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chemical Hazards, current edition.</td>
</tr>
<tr>
<td>9</td>
<td>Binoculars</td>
<td>I, II</td>
<td>One (1) pair of binoculars minimum 7x35 mm.</td>
</tr>
<tr>
<td>10</td>
<td>Triage Tags</td>
<td>I, II</td>
<td>Twenty five (25) triage tags.</td>
</tr>
<tr>
<td>11</td>
<td>Protective Equipment</td>
<td>I, II</td>
<td>Personal protective equipment adequate to safeguard crew from anticipated exposures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V</td>
<td>as defined by the licensee.</td>
</tr>
<tr>
<td>12</td>
<td>Reflective Garment</td>
<td>All</td>
<td>One (1) set reflective vest or reflective garment, or equivalent, per crew member.</td>
</tr>
<tr>
<td>13</td>
<td>Protective Masks</td>
<td>All</td>
<td>Two (2) respirators, conforming to OSHA Bloodborne Pathogens Standard 29 CFR 1910.1030</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(HEPA).</td>
</tr>
</tbody>
</table>
Appendix B Federal Specifications

Federal Specifications for the Star-of-Life Ambulance

These are excerpts from the KKK-A-1822F written by the U.S. General Services Administration on August 1, 2007

1. SCOPE, PURPOSE, AND CLASSIFICATION

1.1 SCOPE.
This specification identifies the minimum requirements for new automotive Emergency Medical Services (EMS) ambulances (except military field ambulances) built on Original Equipment Manufacturer's Chassis (OEM) that are prepared by the OEM for use as an ambulance. The ambulances are front or rear wheel driven (4x2) and minimally warranted as specified in Section 6. Refurbishing and remounted vehicles are not covered by this standard. This standard applies to new vehicles only.

By definition an ambulance is a vehicle used for emergency medical care and patient transport. This specification is for the construction of ambulances, not for vehicles intended for use as fire apparatus. National and international standards exist for automotive fire apparatus. These standards can be obtained from organizations such as the National Fire Protection Association (NFPA).

Section 3 of this specification contains:
• Optional configurations.
• A worksheet to assist the purchaser in developing their procurement requirements.

1.1.1 DEFINITION OF AMBULANCE.
The ambulance is defined as a vehicle used for emergency medical care that provides:
• A driver’s compartment.
• A patient compartment to accommodate an emergency medical services provider (EMSP) and one patient located on the primary cot so positioned that the primary patient can be given intensive life-support during transit.
• Equipment and supplies for emergency care at the scene as well as during transport.
• Safety, comfort, and avoidance of aggravation of the patient’s injury or illness.
• Two-way radio communication.
• Audible and Visual Traffic warning devices.

1.1.2 PURPOSE.
The purpose of this document is to describe ambulances that are authorized to display the “Star of Life” symbol. It establishes minimum specifications, performance parameters and essential criteria for the design of ambulances and to provide a practical degree of standardization. The object is to provide ambulances that are nationally recognized, properly constructed, easily maintained, and, when professionally staffed and provisioned, will function reliably in pre-hospital or other mobile emergency medical service.

1.1.3 “STAR OF LIFE” CERTIFICATION.
The final stage ambulance manufacturer (FSAM) shall furnish to a purchaser an authenticated certification and label stating that the ambulance and equipment comply with this specification and applicable change notices in effect on the date the ambulance is contracted for. FSAMs making this certification are permitted to use the “Star of Life” symbol to identify an ambulance as compliant with the Federal specifications for ambulances. Use of the symbol must be in accordance with the purpose and use criteria set forth in published guidelines (Document Number DOT HS 808 721, Rev. June 1995) by the National Highway Traffic Safety Administration, an operating administration of the U.S. Department of Transportation.
3.1 GENERAL VEHICULAR DESIGN, TYPES, AND CONFIGURATION.

3.1.1 DESIGN.
The ambulance and the allied equipment furnished under this specification shall be the OEM’s current model year commercial vehicle of the Type and Configuration specified. The ambulance shall be complete with the operating accessories, as specified. The design of the vehicle and the specified equipment shall permit accessibility for servicing, replacement, and adjustment of component parts and accessories with minimum disturbance to other components and systems. The term “heavy duty,” as used to describe an item, shall mean in excess of the standard quantity, quality, or capacity and represents the best, most durable, strongest, etc., part, component, system, etc., that is commercially available on the OEM chassis.

3.1.2 TYPE I AMBULANCE (10,001 TO 14,000 GVWR).
Type I vehicle shall be a cab chassis furnished with a modular ambulance body.

3.1.2.1 TYPE I - AD (ADDITIONAL DUTY) AMBULANCE (14,001 GVWR OR MORE).
Type I-AD shall be a Cab-Chassis with modular ambulance body, increased GVWR, storage, and payload.

3.1.3 TYPE II AMBULANCE (9201 – 10,000 GVWR).
Type II ambulance shall be a long wheelbase Van, with Integral Cab-Body.

3.1.4 TYPE III AMBULANCE (10,001 TO 14,000 GVWR).
Type III shall be a Cutaway Van with integrated modular ambulance body.

3.1.4.1 TYPE III - AD (ADDITIONAL DUTY) AMBULANCE (14,001 GVWR OR MORE).
Type III-AD shall be a Cutaway Van with integrated modular body, and increased GVWR, storage, and payload.

3.1.5 CONFIGURATION OF PATIENT COMPARTMENT.
Primary cot shall be loaded to position the patient’s head forward in the ambulance. The primary cot shall be mounted to provide maximum access from the EMSP seat.

3.2 VEHICLE, AMBULANCE COMPONENTS, EQUIPMENT, AND ACCESSORIES.
The emergency medical care vehicles; including chassis, ambulance body, equipment, devices, medical accessories, and electronic equipment shall be standard commercial products, tested and certified to meet or exceed the requirements of this specification. The ambulance shall comply with all Federal Motor Vehicle Safety Standards (FMVSS) and other Federal and state regulations applicable or specified for the year of manufacture. The chassis, components, and optional items shall be as represented in the OEM’s current technical data. The ambulance body, equipment, and accessories shall be as represented in their respective FSAM’s current technical data. The FSAM shall provide total standardization and interchangeability between similar vehicles, equipment, items, and accessories specified for all ambulance units under each contract.

3.2.1 MEDICAL DEVICES.
All medical devices furnished must be marketed in compliance with Food and Drug Administration (FDA) regulatory requirements.

3.4 VEHICLE OPERATION, PERFORMANCE, AND PHYSICAL CHARACTERISTICS.

3.4.1 OPERATION AND PERFORMANCE.
All requirements in Section 3.4 shall be met with the ambulance loaded at curb weight plus total usable payload. The vehicle shall be capable of operating safely and efficiently under the environmental conditions outlined.

3.4.2 TEMPERATURE CONDITIONS.
3.4.2.1 EXTERIOR.
The ambulance and equipment shall be operable in ambient temperature ranging from 0°F to 95°F.
3.4.2.2 INTERIOR.
The interior of the ambulance patient compartment must be maintained at a minimum temperature of 50°F when the ambulance is prepared for immediate response. This requirement does not apply to ambulances that are fully operational but being held in reserve or ambulances that are not fully operational.

3.4.3 NOISE AND SOUND LEVEL LIMITS, EXTERIOR.
Unless more stringent sound levels are regulated by the states and municipalities where the ambulance will be based, the exterior noise level produced by the vehicle, except siren, shall not exceed federal regulations.

3.4.4 VEHICLE PERFORMANCE.
The ambulance shall provide a smooth, stable ride. When available from the OEM, automatic vehicle stability control (AVSC) shall be furnished.

3.4.5 SPEED.
The vehicles shall be capable of a sustained speed of not less than 65 mph over dry, hard surfaced, level roads, at sea level, and passing speeds of 70 mph when tested under normal ambient conditions.

3.4.6 ACCELERATION.
Vehicle shall have a minimum average acceleration, at sea level, of 0-55 mph within 25 seconds. Test shall be performed under normal ambient conditions.

3.4.7 GRADEABILITY.
The vehicle shall be capable of meeting the following performance requirements. The determination shall be made by actual test or OEM’s certified computer prediction.

3.4.7.1 GRADEABILITY AT SPEED.
Minimum gradeability at speed shall be 55 mph on a 3% (1.72°) grade.

3.4.7.2 MINIMUM LOW SPEED GRADEABILITY.
The minimum low speed gradeability shall be 5 mph on a 35% (19.3°) grade.

3.4.8 FUEL RANGE.
The ambulance shall be capable of being driven for at least 250 miles without refueling.

3.4.9 FORDING.
The vehicle shall be capable of three fordings, without water entering patient and equipment compartments while being driven through a minimum of 8” of water, at speeds of 5 mph, for a distance of at least 100’.

3.4.10 VEHICLE PHYSICAL DIMENSIONAL REQUIREMENTS.

3.4.10.1 LENGTH.
Overall length of the ambulance (OAL) shall be specified by the purchaser, including bumpers, rear step and bumper guards.

3.4.10.2 WIDTH.
The overall width of ambulance bodies having dual rear wheels shall be a maximum of 96”, excluding mirrors, lights, and other safety appurtenances. The ambulance body sides, on a chassis with dual rear wheels, shall be symmetrical and within +/- 2.5” of the overall width of the tires (outside sidewalls). The 2.5” allowance is not cumulative; it applies individually to each side. Tires shall not extend beyond the fenders.

3.4.10.3 HEIGHT.
The purchaser shall specify the overall height of the ambulance when loaded to curb weight. This includes roof-mounted equipment, but excludes two-way radio antenna(s).

3.4.10.4 ANGLE OF APPROACH, RAMP BREAKOVER AND DEPARTURE.
With the exception of the OEM’s furnished and installed components, the ambulance shall provide not less than the following clearance, measured in accordance with SAE J689.

Approach angle 20°
Ramp breakover 10°
Departure angle 10°

3.4.10.5 TURNING RADIUS.
Turning radius shall not be greater than the OEM standard.

3.4.10.6 FLOOR HEIGHT.
The finished floor (loading) height shall be a maximum of 34”.

3.5 VEHICLE WEIGHT RATINGS AND PAYLOAD.

3.5.1 CURB WEIGHT.

Non-permanently mounted equipment is considered to be part of the payload, not the curb weight.

3.5.2 PAYLOAD CAPACITY.

Each ambulance’s payload capacity shall be determined by completing the payload calculation form in Figure 2. The payload value of Figure 2, item 9 shall be displayed on the certification and payload signage as shown in Figure 1. The label shall be located in a conspicuous location in the ambulance. The required minimum payload per vehicle without optional equipment shall be as follows:

1. Single rear wheeled, van ambulances (Type II)—1500 lbs.
2. Dual rear wheeled, modular ambulances (Type I or III)—1750 lbs.
3. Additional duty modular ambulances (Type I AD or III AD)—2,250 lbs.

The ambulance shall not be operated in an overloaded condition. EMSPs should determine that the actual load, to be placed on the vehicle, does not exceed the total usable payload as manufactured. Any additional items attached to, or carried on the vehicle by the EMSP will reduce the combined weight of occupants and cargo that comprise the total usable payload. Additional weight added, resulting from specified options, will reduce the available minimum payload per vehicle.

Occupant weight shall be accommodated at 150 lbs. for each designated seating position and the primary patient.

3.6 CHASSIS, POWER UNIT, AND COMPONENTS.

3.6.1 CHASSIS-FRAME.

The chassis shall include the OEM’s ambulance preparation package when available. The chassis-frame and components shall be constructed to withstand the strains of on-off road service and any special service and equipment requirements specified. All chassis (including cab) components shall be as represented in the OEM’s technical data.

3.6.2 VEHICLE LUBRICATION.

The chassis components, devices, accessories, and added equipment requiring lubrication shall be fully equipped with lubrication fittings, as provided by the OEM or equipment manufacturer.

3.6.3 POWER UNIT, ENGINE.

3.6.3.1 POWER UNIT.

The power unit shall meet or exceed the required vehicle performance specified at not more than the engine manufacturer’s recommended operating engine speed. The OEM’s diesel engine and power train shall be provided. The OEM’s block heater shall also be furnished.

3.6.3.2 ENGINE LOWTEMPERATURE STARTING.

The engine shall start satisfactorily without the aid of engine block preheating devices (except glow plugs) or combustion air preheater at 0°F. The determination shall be made by actual test or OEM’s certification.

3.6.4 POWER UNIT COMPONENTS.

3.6.4.1 OIL FILTER.

The oil filter shall be the OEM’s standard for the engine offered.

3.6.4.2 AIR FILTER.

The air filter shall be the OEM’s standard for the engine offered.

3.6.4.3 AIR POLLUTION CONTROL.

Vehicles destined for the 50 states, the District of Columbia, Puerto Rico, the Virgin Islands, Guam and American Samoa shall comply with the Environmental Protection Agency (EPA) regulations governing Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines in effect on date of manufacture of the engine.

3.6.4.4 FUEL SYSTEM.

The fuel system shall conform to all applicable FMVSS, FMCSR, CARB, and EPA requirements. The fuel system components shall be installed, connected, and routed in accordance with all OEM’s guidelines. A permanent label at the fuel filler opening shall be furnished specifying the specific type
3.6.4.5 COOLING SYSTEM.
A coolant overflow recovery tank and compensating system shall be furnished. The cooling system shall be protected with an OEM solution of extended life antifreeze/coolant. Coolant to be the OEM's recommended type and mixture. The FSAM shall provide the OEM maximum size cooling system for the engine provided. The cooling system design shall maintain the engine at safe operating temperatures at all drivable altitudes and grades encountered during on and off road vehicle use.

3.6.4.6 EXHAUST SYSTEM.
The exhaust shall discharge at the vertical side(s) of the ambulance at a maximum distance of 1" beyond the side of the module and be angled /positioned to project the exhaust away from the door(s) to minimize fumes and contaminants entering the interior. On modular vehicles, the tailpipe outlet shall not terminate within 12" of the vertical axis of the fuel tank filler opening(s) when located on the same side. Modifications or extensions made to the OEM exhaust system shall meet or exceed OEM's requirements in terms of backpressure, components, design, and workmanship.

3.6.5 DRIVE TRAIN.
3.6.5.1 DRIVE TRAIN COMPONENTS.
The drive train and component's torque capacity shall meet or exceed the maximum torque developed in the lowest gear ratio by the engine.

3.6.5.2 AUTOMATIC TRANSMISSION.
The OEM’s automatic transmission shall be provided. The transmission shall provide not less than four speeds forward and one reverse and shall be equipped with the OEM's heaviest duty transmission fluid cooler.

3.6.5.3 DRIVELINE.
The driveline (driveshaft, U-joints, etc.) shall be balanced and supported to perform throughout the design speed range without whipping or vibrating.

3.6.5.4 BRAKE SYSTEMS, SERVICE AND PARKING.
OEM’s heaviest duty, power assisted brakes, linings, and parking brake shall be furnished on the OEM chassis offered. Antilock brake systems shall be furnished when available from the OEM.

3.6.5.5 SPECIAL TRACTION (REAR END) DIFFERENTIAL.
All ambulances shall have a positive traction, limited slip differential or automatic, locking type differential, unless not furnished with the OEM’s AVSC system.

3.6.5.6 SUSPENSION.
Vehicle shall be equipped with laterally matched sets (front and rear) of spring, torsion, or air suspension system components. Components shall have a rated capacity in excess of the load imposed on each member. Only corrections permitted by the OEM to compensate for lean due to normal spring tolerance variations are permitted. Correction of lean due to imbalance is not permitted.

3.6.5.7 SPRING STOPS.
The OEM’s standard spring bumpers and axle stops shall be furnished. The stops/bumpers shall prevent the wheel and axles from striking the engine, oil pan, fenders, and body under all conditions of operation.

3.6.5.8 SHOCK ABSORBERS.
Shock absorbers, double-acting type, heaviest duty available from OEM for model offered, shall be furnished on the front and rear axles.

3.6.6 STEERING.
The OEM’s standard, power assisted steering shall be furnished.

3.6.7 WHEELS.
Types I, I AD, III & III AD ambulances shall be equipped with dual rear wheels and single front wheels. Type II ambulances shall be equipped with single, front and rear wheels. Wheels shall conform to the recommendations of the Tire and Rim Association, Inc., and shall be identical in type, size, and load rating for all wheels on the ambulance.

3.6.8 TIRES.
Tires shall be as furnished by the OEM and shall be OEM tubeless, steel belted radials.

3.6.9 TIRE CHAINS AND CLEARANCE.
Tire chain clearance on the furnished body shall be provided for all driving wheels per SAE J683.
Sufficient chain clearance shall be provided to permit off road operation with the ambulance loaded to the maximum payload.

3.6.10 WHEEL TIRE BALANCING.
Wheel/tire, hubs, and brake drum assemblies of the vehicle shall be dynamically balanced to a minimum of 70 mph.

3.6.11 HUBCAPS.
When available from the OEM standard hubcaps or wheel covers shall be furnished on Type II ambulances.

3.9 CAB-BODY DRIVER COMPARTMENT AND EQUIPMENT.
3.9.1 DRIVER’S COMPARTMENT, CAB-BODY STRUCTURE.
All cab compartments shall be of sufficient size to accommodate a driver and passenger, with space to perform driving and control activities. The cab shall be organized and designed with the specified and required equipment and accessories for ease of operation and safety. There shall be a console convenient to driver in the drivers cab. The console shall contain all added switches for operation of the ambulance.

3.9.2 CAB-BODY PROVISIONS.
An OEM two door cab shall be furnished that is suitable for the subsequent mounting of various ambulance equipment and bodies.

Driver’s cab section shall provide:

a. Forward hinged doors.
b. Opening side windows.
c. Door stops.
d. External key operated door locks with two sets of keys.
e. Trim or closed panels and headliner (washable vinyl upholstery, or flooring type materials).
f. Floor covering (OEM’s heat, noise and appearance trim packages).
g. Panel mounted instruments.
h. All exposed interior surfaces shall be painted.
i. Armrests, mounted on each side door.
j. Key operated ignition/starter switch.
k. Oil pressure gauge.
l. Engine temperature gauge.
m. Speedometer with odometer.
n. Environmental controls (heater-defroster/air conditioner, etc.).
o. Type II Seatbelts and shoulder harness for driver and passenger.
p. Cab lighting and controls.
q. Tinted windshield.
r. Dual electric horn(s).

3.9.3 CAB COMPARTMENT DRIVER AND PASSENGER SEAT.
The driver’s compartment shall be OEM two individual bucket-type seats (driver and passenger). The seats shall be frame constructed with cushioned springs or foam rubber, padded and upholstered to provide riding comfort. The seats shall be covered with fire-retardant, washable, nonabsorbent material. Driver’s seat shall have the OEM’s full, unobstructed seat track travel range of longitudinal adjustment, and a minimum of 30% of the range of inclination, but not less than the angle furnished on the OEM’s standard non-reclining high back seat.

3.9.4 CONTROLS AND OPERATING MECHANISM.
All controls and operating mechanisms shall be located for left-hand drive. Lever controls, equipment, items, and devices shall be installed, located, and stowed for the convenience of the purpose intended and shall not interfere with the EMSP or patient’s ingress or egress of respective compartments.

3.9.5 OUTSIDE REARVIEW MIRRORS.
Dual rearview OEM mirrors having a combination flat/convex mirror system, shall be furnished. The mirrors shall be the largest available from the OEM. When available from the OEM, all four mirror head faces shall be independently adjustable. Hardware and mirror heads shall have a corrosion resistant exterior finish.
3.9.6 BUMPERS AND STEPS.
OEM’s standard chrome bumper shall be furnished in the front of the chassis. The rear of the ambulance shall be furnished with a sturdy, full-width, rear bumper, with step secured to the vehicle’s chassis-frame. The bumper-step shall be designed to prevent the accumulation of mud, ice, or snow and made of anti-skid open grating metal. These steps shall not be located or exposed to the interior of the ambulance when the door(s) are closed. All necessary steps shall be at least the width of the door opening for which they are provided. The step’s tread shall have a minimum depth of 5” and a maximum depth of 10". If the step protrudes more than 7" from the rear of the vehicle, a fold up step shall be furnished. The rear bumper and step shall be adequate to support a test weight of 500 lbs. without flexing. The height of the rear step shall not exceed 22”.

3.9.7 BODY PROTECTION.
3.9.7.1 FENDERS.
Fenders and wheel housings shall be provided to cover all tires.

3.9.7.2 MUD FLAPS.
Mud flaps, at least as wide as the tire(s), shall be provided behind the front and rear wheels and shall be reinforced at the point of attachment to the vehicle. Mud flaps may be incorporated into the running boards.

3.9.7.3 FUEL FILL SPLASH PLATES.
The painted surface of the ambulance body shall be protected from discoloration due to spilled fuel during refueling. Protection shall be provided by a drain in the fuel fill housing(s) or by splash plate(s) under the fuel fill opening.

3.9.8 ENGINE HOOD.
Engine hood and cowl shall be fitted to prevent precipitation, heat, odors, and noise from entering the interior of the cab and body. Cab compartment engine covers shall be removable for easy access to engine and components.

3.9.9 CAB CONNECTING BELLOWS FOR TYPE I & I AD VEHICLE.
A flexible, weather-tight bellows, fabricated from EPDM, Hypalon, sheet or molded rubber, or other durable materials that meet the temperature requirements herein and resist ozone, sunlight, oil, fungus, and will not crack, rot or deteriorate, shall be provided between the cab and the modular body. Bellows shall be designed for proper fit and finish and be able to absorb lateral, vertical, and torsional displacement due to body/cab movement.

3.10 AMBULANCE BODY AND PATIENT AREA.
3.10.1 BODY ACCOMMODATIONS.
The ambulance body and patient compartment shall be sufficient in size to transport occupants and all specified stretchers, cots, and litters. There shall be space around the patient(s) to permit an EMSP to administer life support treatment to the primary patient during transit.

3.10.2 CAB/PATIENT COMPARTMENT ACCESS WINDOW.
The ambulance and body bulkheads shall have an aligned window opening of at least 150 sq. in., for visual checking and voice communications between the cab and the patient’s compartment for nonwalk through vehicles. The window in the cab or body shall be of the sliding type, shall be aligned, and connect with the modular body window opening and shall conform to requirements of the partition. The window shall be latchable from the cab side and shall be an adjustable, transparent, shatterproof panel.

3.10.3 EMERGENCY MEDICAL SERVICES PROVIDER (EMSP) SEATING.
The EMSP shall be provided with a seat conforming to all applicable FMVSS Standards, and be equipped with a safety belt and a padded back and a padded headrest. The seat shall be not less than 15" deep by 18" wide and a minimum distance of 43" from the top of the padded seat to any overhead obstruction. The EMSP seat shall be located to allow for the care of the primary patient.

3.10.4 PATIENT COMPARTMENT INTERIOR DIMENSIONAL PARAMETERS.
The patient compartment shall provide a minimum of 325 cubic feet of space (275 cubic feet of space for a Type II), less volume for cabinets, while complying with the following:

a. The length measured from the partition to the inside edge of the rear loading doors at the floor, shall be at least 122”. The compartment configuration shall provide at least 25" of unobstructed space at the head of the primary patient, measured from the face of the backrest of the EMSP
seat to the nearest edge of the cot. A minimum of 10” shall be provided, from the rear edge of the
cot mattress to the rear loading doors, to permit clearance for traction or long board splints.
b. The compartment shall provide a minimum of 12” of clear aisle walkway between the edge of the
primary patient cot and base of the nearest vertical feature measured along the floor.
c. The patient compartment shall provide at least 60” height, over the primary patient area, measured
from floor to ceiling panels.

3.10.5 BODY, GENERAL CONSTRUCTION.
For modular construction, the body shall be all welded aluminum or, other lightweight, inherently
corrosion resistant materials of equal, or greater, strength. The exterior of the body shall be finished
smooth with symmetrically radius corners and edges, and shall include doors and windows specified
herein. Ambulance body, as a unit, shall be designed and built to provide impact and patient compartment
penetration resistance and shall be of sufficient strength to support the entire weight of the
fully loaded vehicle on its top or side, if overturned, without separation of joints or permanently
deforming roof bow or reinforcements, body posts, doors, stringers, floor, inner linings, outer panels,
rub-rails, and other reinforcements. Wood, or wood products, shall not be used for structural framing.
As evidence that the ambulance body meets the above criteria, the FSAM’s body (fabricated, modified,
or converted), excluding the conventional cab, shall furnish for each body model (Type) a certification
that the ambulance body meets AMD Standards No. 001, 020 & 007. Additionally, the roof
structure, liner, and outer skin or cap shall be designed and constructed to prevent separation.
Any absorbent material such as carpeting, fabric, or inside/outside plastic type carpeting, etc. That
resists cleaning and decontamination shall not be used.

3.10.6 AMBULANCE BODY STRUCTURE.
All parts of the ambulance body and attachments shall be fastened in a manner that will preclude
loosening. All fasteners shall be of the corrosion resistant type. Cabinets, benches, partitions, oxygen
cylinder holders, guide rails, and cot holders shall be attached to metal tapping plates and/or framing
welded to the body structure. These components shall be fastened by welding, bolting, or self-tapping
(threading) machine screws, on a minimum of 18” centers. Sheet metal, self-tapping wood/metal
screws, nails, staples, etc. shall not be used in assembling the ambulance structure, except for
selfthreading
sheet metal screws used for light trim panels and for retention of wood or composite subflooring.
Ambulance bodies with an extended roof shall have the roof structural members permanently
fastened to structural members of the body. Drip rail(s) shall be provided around the entire modular
body and have drain points at each corner. Drip rails shall also be furnished over each entry and
compartment
doors. The body, roof, and panel joints shall be watertight. All openings between the chassisbody
and occupant carrying compartments shall be sealed to prevent intrusion of water, dust, and
exhaust gases.

3.10.7 BODY MOUNTING.
On modular ambulance bodies, to reduce stress on body and frame, minimize height above the frame,
and isolate the patient compartment from noise and vibration, full floating, automotive style, rubber
body mounts shall be furnished. A minimum four body mounts per frame rail not to exceed the
mechanical properties of the body mounts and fasteners shall be furnished. Fasteners shall be a
minimum
of Grade 8.

3.10.8 DOORS.
Two patient compartment door openings shall be provided.
1) There shall be a door opening on the right forward side and at the rear of the body for loading a
patient on a cot.
a) The side opening shall have a single forward hinged door for modular bodies.
b) Double hinged doors for Type II, shall be furnished.
c) Door(s) shall provide a minimum right side clear opening of 30" wide and of 63" high for modular
bodies.
d) The OEM’s standard opening for Type II vehicles.
2) There shall be a door opening at the rear of the body for loading a patient on a cot.
a) Rear loading door(s) shall cover a clear opening of not less than 46” in height for modular bodies.
b) Minimum width of 44” for modular bodies.
c) The OEM’s standard rear door width opening for Type II vehicles.
3) All ambulance body doors shall be equipped with not less than 250 sq. in. of safety glass area per door.
4) Each door shall have effective compression or overlapping seals to prevent leakage of exhaust fumes, dust, water, and air.
5) Patient compartment doors, on modular bodies, shall be flush or near flush style.
a) Shall be full box type construction.
b) Have removable inner panel.
c) Inner panel shall be finished with a durable, washable type material.
d) Shall include trim moldings around all unfinished, exposed edges.
6) A reflective device shall be furnished in any color meeting the reflector or conspicuity systems requirements of FMVSS 108.
a) Have at least 60 sq. in. of total reflective area.
b) Shall be installed on the interior of all patient compartment entry doors.
c) The reflective device shall be so positioned as to provide maximum visibility when the doors are in the fully open position.

3.10.8.1 PROTECTION OF PATIENTS AND CREW.
Upholstered padding/cushions shall be provided at the upper interior areas of the doorframes.

3.10.9 DOOR LATCHES, HINGES, AND HARDWARE.
1) Door latches, hinges, and hardware furnished by OEM and FSAMs shall comply with FMVSS 206.
2) When doors are open, the hinges, latches, and door-checks shall not protrude into the access area.
3) All doors shall have hardware or devices to prevent inadvertent closing.
4) To facilitate entry and exit from the vehicle, a minimum 6”, tubular or semi-oval, minimum 3/4” wide (diameter), grab handle shall be provided on the inside of each door or the adjacent body structure (in addition to a door operating handle).
5) Door shall be equipped with hold opens or stops.
6) One external operated lock, with key per door opening, shall be provided.
7) All patient compartment door locks shall be identically keyed.
8) Hardware shall be weather resistant.

3.10.10 FLOOR.
1) The floor shall be flat, except when the area near the rear entrance door is sloped for a lower entering height.
2) With the exception of cot related hardware, shall be unencumbered in the door(s) access and work area.
3) Shall support a “Distributed Loads” Medium footprint of 400 lbs.
4) Metal floors shall be reinforced to eliminate “oil canning.”
5) Floors shall be insulated against outside heat and cold.
6) The sub floor of the modular body patient compartment shall be water resistant.
7) When plywood is utilized, it shall be water resistant.
a) Not less than 1/2” thick, 5 ply minimum.
b) Shall be supported by body framework.
8) Under the sub floor of the modular body shall be an aluminum heat shield/splash pan, minimum 0.050”, sealed with silicone or other non-hardening sealant evenly distributed around its perimeter.
9) The sub floor of the Type II patient compartment shall be not less than 1/2” thick density, marine or exterior grade plywood.
10) fiberglass, aluminum, or other non-hydroscopic composites, with at least the equivalent strength of plywood may be used as the sub floor.
11) Particleboard or equivalent type materials are not acceptable.
12) Voids or pockets, where water or moisture can become trapped to cause rotting and unsanitary conditions, are not acceptable.
13) Voids and pockets shall be filled with sealer or caulking compound.
14) Flooring shall extend the full length and width of the patient compartment or body (including
space under the cabinets, unless otherwise insulated) or prevented by exterior compartment bodies or wheel wells that extend above floor level.

3.10.11 FLOOR COVERINGS AND COLOR.
Floor covering shall be easily cleaned, sanitized, and harmonize with the interior color and décor of the patient compartment. The floor covering shall be seamless, one piece, no wax type, solid linoleum, vinyl, or poured epoxy or acrylic not less than 1/16" thick and permanently applied to the sub floor. The floor material shall cover the entire length and width of the compartment's working area. The covering of joints (corners, etc.), where the sidewalls and covering meet, shall be sealed and bordered with corrosion resistant cove molding or the covering shall extend at least 3" up the sidewalls.

3.10.12 STEP WELL (SIDE DOOR).
Steps shall be provided in the door openings. Step well shall be the enclosed two-step type. Height of the bottom step shall not exceed 22". Step wells shall be lighted, and all step surfaces shall be constructed with anti-slip material.

3.10.13 WHEEL HOUSINGS.
Wheel housings of modular bodies shall include metal or plastic splash shields between the body wheel housing and the wheels extending over the top of the tires to the bottom of the body side skirting. Wheel house openings shall allow for tire chain usage and easy tire removal and service. OEM's standard wheel housings will be acceptable.

3.10.14 BULKHEAD/ PARTITION FOR TYPE II, III, AND III AD VEHICLES.
A full height and width partition or bulkhead (with or without compartments), with a walkthrough opening with a door shall be placed between the driver and patient’s compartment. This partition shall be located directly behind the driver and companion seats when in the rearmost position. The partition shall be secured on the sides, ceiling, and floor by welding or bolting to tapping plates.

3.10.14.1 DOOR / WALKTHROUGH FOR TYPE II, III, AND III AD VEHICLES.
The door opening shall be at least 17” wide and 46” high and shall provide an aisle between the compartments.

3.10.15 INSULATION.
The entire body, sides, ends, and roof of the patient’s compartment shall be completely insulated to enhance the performance of the environmental systems and prevent external noise from entering the vehicle interior. The insulation shall be a non-settling type, vermin-proof, mildew-proof, fire retardant, non-toxic, and non-hygroscopic. If fiberglass insulation is used, it shall not be exposed to water, e.g. door panels.

3.10.16 INTERIOR SURFACES.
The interior of the body shall be free of all sharp projections. All hangers or supports for equipment and devices shall be mounted as flush as possible with the surrounding surface. Interior body lining and cabinetry materials, excluding the cab compartment, shall be selected to minimize dead weight. The finish of the entire patient compartment, including interiors of storage cabinets, shall be:
1. impervious to soap, water and disinfectants.
2. mildew resistant.
3. fire resistant.
4. easily cleaned/disinfected (carpeting, cloth, and fabrics are not acceptable).

3.11 STORAGE COMPARTMENTS.
Storage compartments shall be furnished for all items required by this specification and/or specified by the purchaser and include storage for, but not be limited to; backboards, portable cots/litters, stair chairs, and any other specified patient handling devices. Any absorbent material such as carpeting, fabric, or inside/outside plastic type carpeting, etc. that resists cleaning and decontamination shall not be used in any storage or patient compartment.

3.11.1 INTERIOR STOWAGE ACCOMMODATIONS.
The interior of the patient compartment shall provide a minimum volume of 35 cubic feet of enclosed stowage cabinetry, compartment space, and shelf space which shall be conveniently located for
medical supplies, devices, and installed systems as applicable for the service intended. The 35 cubic feet of enclosed stowage cabinetry requirement does not apply to type II ambulances. Enclosed compartments and spaces shall be located at, in, or on the partition, sidewalls, overhead, seating areas, and doors. Compartment(s) under the floor, with opening panel(s) inside the patient compartment, shall not be acceptable. When furnished, top opening squad bench lids shall be fitted with an automatic hold open device and a quick release slam type latching device when closed.

3.11.1 LOCATION OF MEDICAL EQUIPMENT AND SUPPLIES.
Supplies, devices, tools, etc., shall be stored in enclosed compartments and drawers designed to accommodate the respective items. All medical devices and equipment shall be stowed or properly fastened in/on the action area according to the medical device manufacturer’s directions.

3.11.1.2 WASTE AND SHARPS DISPOSAL.
The following shall be furnished: A trash receptacle compartment, with closure over opening, for general waste shall be furnished with a plastic/rubber trash can and disposable plastic liners, with 12 spare liners. The trash compartment shall be accessible to the EMSP seat. A sharps receptacle compartment/storage or a commercially available container mounted in a convenient area shall be furnished for retention of a sharps container that meets OSHA requirements.

3.11.2 EXTERIOR STORAGE ACCOMMODATIONS.
Ambulance exterior storage compartments shall be weather resistant Exterior compartment doors and hardware shall be flush or near flush style construction. All doors shall have spring or gas tube type, hold open devices that permit one hand closure. Hardware (hinges, locks, latches, etc.) shall be rust resistant. All exterior compartments shall have latches with locks and shall be keyed alike. All exterior compartments shall be automatically lighted when opened.

3.11.3 STORAGE COMPARTMENTS AND CABINETS DESIGN.
Storage cabinets, drawers, and kits shall be easily opened but shall not come open in transit. For rapid identification of contents, medical supply cabinets above the litter patient shall have shatterproof, transparent or lightly tinted, sliding doors.
1) Doors shall be provided with near flush grip, or low profile handles.
2) Storage compartments shall be divided into sections.
   a) Drawers shall be marine style slide or tilt.
   b) All shelves shall be removable.
3) Sliding doors for cabinets designed to carry lightweight items such as dressings, bandages, etc. shall be furnished.
   a) Shall automatically latch or be fitted with friction holding devices when in a closed position.
4) Doors shall have positively locked latches that are bolted to the door and the door frame structure and are designed to remain closed during transports.
5) All cabinets shall be firmly anchored (bolted or welded) to tapping plates of the body structure.
   a) Use of sheet metal or wood screws is not acceptable.
6) Tops of the cabinets and shelves shall be surrounded by a lip of not less than 1/2" in height covered in a soft, pliable molding.
7) Storage for the main oxygen cylinder shall be accessible for replacement from an outside position.
8) The oxygen compartment shall be provided with at least a 9 sq. in. of open vent to dissipate/vent leaking oxygen to the outside of the ambulance.
9) Oxygen cylinder compartment shall not be utilized for storage of any other equipment.
10) Oxygen cylinder(s) shall be mounted with a restraining device(s).

3.11.4 PATIENT COMPARTMENT SEATING.
All seats in the patient compartment shall conform to applicable FMVSS Standards, will be padded and have the largest practical padded back and headrests. Padding material shall be rubber or polyester urethane foam of a medium to firm density, with a minimum finished thickness (padding and upholstery) of 2.5” for seat pads, and 2” for head and backrests. All padding and upholstery shall be fire retardant. The upholstery shall be non-absorbent, washable and impervious to disinfectants. Non-OEM seats shall have 40 oz. (minimum) reinforced vinyl upholstery. To facilitate cleaning and disinfecting, all seats furnished and installed by the FSAM shall be cleanable to OSHA standards, and all exposed surfaces shall be free of vent devices that would permit the entrapment of biological
contaminates.
All seating positions in the patient compartment shall be provided with a vertical overhead clearance measurement of 43”.

3.11.4.1 PATIENT SEATING.
The seats shall provide seating space for two persons and shall not be less than 15” deep by 18” wide (per seating position), and the seat backs shall be a minimum of 18” wide by 7” tall. The requirement to provide patient seating space for two persons shall not apply to Type II ambulances.

3.11.5 SEAT SAFETY BELTS AND ANCHORAGES.
All designated seating positions in the patient compartment shall be equipped with safety restraint systems appropriate for each type of seating configuration.

3.11.6 LITTER FASTENERS AND ANCHORAGES.
A cot fastener assembly with quick release latch shall be furnished. The installed cot fastener device(s) for wheeled cots shall be installed per the manufacturer’s directions. At a minimum, the litter retention system, anchorages, and litter fastener(s) shall not fail or release when subjected to a force of 2,200 pounds applied in the longitudinal, lateral, and vertical direction. Should the manufacturer of the cot fastener assembly specify a greater force, the litter retention system, anchorages, and litter fastener(s) shall be tested to that greater force.

ALL COTS AND INFANT TRANSPORTERS SHOULD ONLY BE USED WITH THE REQUIRED FASTENER ASSEMBLY AS PRESCRIBED BY THE COT/TRANSPORTER MANUFACTURER.

3.11.7 IV HOLDER FOR INTRAVENOUS FLUID CONTAINERS.
One ceiling mounted “hook” style device specifically designed for holding IV containers shall be provided, including Velcro type straps to adequately secure an IV bag/bottle. The device shall not protrude more than 1”, and shall be located adjacent to, or on the cabinetry near the head of the primary patient. Swing down IV hangers with rigid support arms that can cause injury shall not be specified or furnished.

3.12 OXYGEN, MAIN SUPPLY AND INSTALLATION.
The ambulance shall have a piped medical oxygen system capable of storing and supplying a minimum of 3,000 liters of medical oxygen. The installed medical oxygen piping and outlet system shall be leak tested to 200 PSI. After the successful completion of tests, the system shall be capped then tagged with date and signature of person and firm performing the tests.
The main oxygen supply shall be from a single compressed gas cylinder that the consignee will provide and install at the time the vehicle is placed in service. A cylinder changing wrench shall be furnished. The wrench shall be chained and clipped within the oxygen cylinder compartment.
The cylinder controls shall be accessible from the inside the vehicle. A device shall be visible from the EMSP’s seat that indicates cylinder pressure. The use of remote high pressure lines and gauges are not allowed. The oxygen cylinder shall be accessible for changing from the exterior of the body.
The purchaser shall specify the type of quick disconnect, to be used. The FSAM shall install all other components and accessories required for the piped oxygen system which shall include as a minimum:
- A pressure regulator.
- Low pressure, electrically conductive, hose approved for medical oxygen.
- Oxygen piping concealed and not exposed to the elements, securely supported to prevent damage, and be readily accessible for inspection and replacement.
- Oxygen piped to a self-sealing duplex oxygen outlet station for the primary patient with a minimum flow rate of 100 LPM at the outlet.
- Outlets shall be adequately marked and identified and not interfere with the suction outlet.

3.12.1 OXYGEN PRESSURE REGULATOR.
The medical, oxygen pressure reducing, and regulating valve with inlet filter at the cylinder shall have line relief valve set at 200 psi maximum, and a gauge or digital monitor with a minimum range of 0 to 2,500 psi with the gauge or display scale graduated in not more than 100 PSI increments. The regulator shall be easy to connect and preset, with a locking adjustment, at 50 +/- 5 psi line pressure, permitting a minimum 100 LPM flow rate at a bottle pressure of 150 psi.

3.12.2 SUCTION ASPIRATOR, PRIMARY PATIENT.
An electrically powered suction aspirator system shall be furnished with an illuminated switch and a panel mounted, labeled, quick disconnect inlet device on the EMSP panel. The electric type aspirator
system shall be connected per Figure 3. The suction pump shall be located in an area that is accessible but sound and vibration insulated from the patient compartment.

1) The pump shall be vented to the vehicle’s exterior.

2) A vacuum control and a shut-off valve, or combination thereof, shall be provided to adjust vacuum levels.

3) A vacuum indicator gauge of 3” +/-0.5” in diameter, with numerical markers at least every 100 mm Hg and a total range of 0 to 760 mm Hg, shall be provided.

4) The collection bottle or bag shall be non-breakable and transparent with a minimum 1,000 ml capacity.

5) The minimum inside diameter for the suction tubing connectors shall be at least 1/4”. The end user shall provide any suctioning catheters desired.

6) The suction aspirator system shall provide a minimum of 30 LPM flow at the catheter tip.

3.13 ENVIRONMENTAL: CLIMATIC AND NOISE PARAMETERS.

3.13.1 ENVIRONMENTAL SYSTEMS.

All ambulances will be equipped with a complete heating, ventilating, and air conditioning system(s) (HVAC) to supply and maintain clean air conditions and specified level of inside temperature in both driver and patient compartments. The system(s) may be separate or a combination system, which will permit independent control of the environment within the driver’s cab and patient compartment. All ambulances will be equipped with HVAC that can be made to collectively operate using re-circulated air and outside ambient air and will be capable of maintaining a patient compartment temperature of 68°F to 78°F while patients are in the patient compartment. The air systems will be high volume capacity with low velocity delivery for minimum draft circulation. Environmental system components will be readily accessible for servicing at the installed location(s). Connecting hoses for heating and the air conditioning system will be supported by rubber-insulated metal clamping devices at least every 18”.

3.13.2 HEATING CRITERIA.

The heating system(s) will have sufficient capacity to maintain the temperature in the patient compartment at a minimum dry bulb temperature of 68°F. Heater(s) will, to the maximum extent possible, be connected to the OEM’s furnished interconnection points.

3.13.3 AIR CONDITIONING CRITERIA.

The air conditioning system(s) will have sufficient capacity to maintain the temperature in the patient compartment at a maximum dry bulb temperature of 78°F. When available, OEMs’ interconnection points will be utilized.

3.13.4 VENTILATION CRITERIA.

Ventilation system(s) of the driver and patient compartments will provide a complete change of ambient air within both compartments at least every two minutes with the vehicle stationary. Ventilation will be separately controlled within the cab and patient compartments. Fresh air intakes will be located towards the front of the vehicle and exhaust vents will be located on the upper rear of the vehicle. Exhaust vents may be located on the rear lower half of the module/body, provided the vent/device incorporates a reverse flow damper to prevent back draft and intrusion of vehicle engine exhaust, dust, dirt, or road spray. The patient compartment will be ventilated by the air delivery system of the environmental equipment (heater-air conditioner) or by separate system(s), such as power intake, exhaust ventilator(s).

3.13.5 ENVIRONMENTAL CONTROLS.

Adjustable, manual or thermostatically operative controls will permit heating and/or air conditioning and ventilation in either compartment without affecting the other compartment. Switches and controls will be located in “action area” panel and/or remote panel and identified for function and operating position. Blower or fan system will have at least three speeds (excluding “OFF”). Separate non-corroding brass, bronze, stainless steel, plastic or other inherently corrosion proof shutoff valves, for the patient compartment hot water heating system, will be provided. The use of vacuum or electrically operated shutoff valves is acceptable provided it will meet the above criteria and the valve provides inherent sealing when vacuum is removed. This sealing will prevent engine cooling system pressure and water pump pressure from causing any leakage when vacuum is removed. Air systems will have adjustable louvers to direct the flow of air.
3.13.6 PATIENT COMPARTMENT SOUND LEVEL CRITERIA.
The patient compartment sound level shall not exceed 80 dBA at any time.

3.14 COMMUNICATIONS.
3.14.1 COMMUNICATION EQUIPMENT.
Any two way radio equipment shall be installed by a licensed installer approved by the radio manufacturer. Communications equipment will meet the applicable FCC rules and required state and local area EMS radio communication protocols.

3.14.2 RADIO (MOBILE) PROVISIONS.
All ambulances will be provided with sufficient ventilated space for a two-way radio (including convenience features), antenna openings, ground plane, terminal wiring for 12V power and ground.

3.14.3 ANTENNA CABLE, AND ACCESS.
The FSAM shall provide each ambulance with a ground plane, and coaxial lead-in wire from the ventilated radio storage area/compartment to the centerline of the patient compartment roof. An antenna wiring access/port shall be provided in the patient’s compartment directly under the coaxial leads. The port shall provide at least a 16 sq. in. clear access. All nonmetallic roofs will be equipped with at least a 40” x 40” metal ground plane molded into the roof. The ground plane then shall be properly grounded to the chassis ground. The antenna cable (lead-in) shall be provided and clearly labeled with RG/58U or equal cable. Approximately 18” of extra cable shall be provided at the roof and approximately 36” at/in the radio area/compartment.

3.14.4 SIREN – PUBLIC ADDRESS SYSTEM.
A combination electronic siren with integral public address system including radio interface capability shall be provided. A “Horn/Siren” switch shall be provided on the driver’s console. When on shall activate or change the siren tone when the horn button is pushed. The “Horn/Siren” switch shall be illuminated (in siren mode). Dual speakers shall be installed, outside the vehicle, in the bumper/hood area. Speakers shall not protrude beyond the face of the bumper or bumper guards. The siren shall be capable of producing a continuous warning sound at a minimum level of 123 dB, A-weighted, at 10’.

3.15 ADDITIONAL SYSTEMS, EQUIPMENT, ACCESSORIES, AND SUPPLIES.
3.15.1 ADDITIONAL AND OPTIONAL EQUIPMENT.
This specification provides the minimum technical requirements that new ambulances are required to meet. Some purchasers will require features in excess of these minimum requirements to complete their mission(s). Completing the worksheet in this section will assist purchasers in determining the optimum type, configuration and optional equipment required. Purchasers may wish to consider some of the following criteria before completing the worksheet:
1. Operating environments such as inner city, rural areas, length of responses
2. Exposure to extreme ambient temperatures
3. Size of ambulance crew
4. State and/or local jurisdiction required medical equipment
5. State licensure requirements
6. Vehicle size and weight limitations in the response area
7. Expected service life of the ambulance
8. Additional non EMS equipment that must be carried on the ambulance
9. Future equipment requirements
10. Additional state or local requirements
11. Export requirements
In no event shall the specified or furnished optional item(s) reduce the quality and intent of the ambulance but shall enhance its design and purpose.

3.15.2 STANDARD MANDATORY MISCELLANEOUS EQUIPMENT.
Each ambulance shall be equipped with, but not limited to the following:
1. Fire extinguishers: Two, (ABC dry chemical or carbon dioxide) minimum 5 lb. unit, in a quickrelease bracket, one mounted in the driver/cab compartment or in the body reachable from outside the vehicle and one in the patient compartment.
3. Overhead grab rail, minimum 60" long, maximum 4" depth, on the ceiling over the primary patient. Grab rail shall be stainless steel, aluminum, or other corrosion resistant material, and have padded or curved up ends, and rounded corners. Mounting brackets shall be chromed, stainless steel, polished cast aluminum or other corrosion resistant materials. The grab rail shall be tested to 300 lbs.
4. Backup alert alarm, (audible warning device) activated when the vehicle is shifted into reverse. Device shall be rated (SAE) for 97 dB-a at 4'.

Appendix C: AMD Standards

The following is an excerpt from the Ambulance Manufacturers Division Standards document written in August 2007.

Ambulance Manufacturers Division (AMD)

An Industry Division of the National Truck Equipment Association

37400 Hills Tech Drive, Farmington Hills, MI 48331-3414 • 248/489-7090 • Fax 248/489-8590

INTRODUCTION

For more than 30 years, the emergency medical services in the U.S. has been represented by an association dedicated to the production of safe, state-of-the-art ambulances. That organization is the Ambulance Manufacturers Division (AMD) of the National Truck Equipment Association (NTEA).

The NTEA is the only trade association representing the nation’s manufacturers and distributors of commercial trucks, truck bodies, truck equipment and accessories. NTEA members include companies that produce highly specialized vehicles, such as ambulances, towing and recovery vehicles, small school buses and mid-size buses. The Association provides its nearly 1,800 members with resource materials, technical assistance, education and training and business improvement programs. Headquartered in Detroit, the NTEA interacts directly with the major truck chassis manufacturers on product compatibility issues. From its government relations office in Washington, DC, the Association keeps its members advised of changing regulations affecting commercial trucks and lobbies on the industry’s behalf.

Before affiliating with the NTEA, the AMD was a division of the Truck Body and Equipment Association. In 1986, the AMD became a division of the NTEA to further enhance its credibility and depth of professionalism. The organization has grown dramatically over the past 20 years as more and more ambulance manufacturers and industry-related companies have realized the value and significance of being an AMD member. Currently composed of approximately 45 companies, the AMD has consistently maintained representation of more than 90% of the ambulance production in North America. Since its founding in 1976, the AMD has worked closely with all state and federal regulatory agencies and has been directly involved in activities that benefit the general public as well as the industry. These activities include:
• Recognition of the Federal Specification for the Star-of-Life Ambulance, KKK-A-1822, as the minimum specification for the ambulance industry.
• Partnership with the General Services Administration (GSA) in further development and revision of KKK-A-1822.
• Active involvement with truck chassis manufacturers in the development of new models and options that make their chassis more compatible for ambulance service.

• Support of the Ford Qualified Vehicle Modifier Program.
  • Continued development, improvement and updating of AMD Standards.

Federal laws and regulations require that all motor vehicles, including ambulances, operated on public highways conform and be certified to all applicable Federal Motor Vehicle Safety Standards (FMVSS). The FMVSS set the performance requirements for the safety of new motor vehicles and motor vehicle equipment. The National Highway Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation oversees these Standards that were established by the National Traffic and Motor Vehicle Safety Act of 1966. All AMD Standards are in addition to, and in no way substitute for, FMVSS and other federal requirements that apply to motor vehicles and other regulated aspects of ambulances and their intended functions.

Most AMD members maintain staff engineers to keep their companies abreast of technological advances applying to the manufacture of ambulance bodies, electrical systems, environmental systems and other ambulance components. These advances are incorporated into new ambulance models thereby continuously improving the industry through competition. No governmental agency dictates that AMD members make these improvements; they are done voluntarily to upgrade the product, make it more reliable, and provide even more dependable life support capabilities.

Development of AMD Standards began almost 30 years ago by AMD members, in conjunction with the GSA, and are currently cited in Federal Specification for the Star-of-Life Ambulance (KKK-A-1822). AMD Standards are meant to work in tandem with the KKK-A-1822 Specification by providing ambulance purchasers and users with performance standards specific to ambulances. AMD Standards provide a verifiable means to help assure that ambulatory vehicles comply with certain performance requirements of the KKK-A-1822 Specification.

AMD Standards are developed and revised with input from the GSA, ambulance manufacturers and component suppliers, emergency medical technicians, paramedics, vehicle maintenance personnel, the Emergency Medical Service community at large and other interested parties through public comment. All proposed changes received during periods of public comment that may enhance the quality of the Standards within their respective context are considered, and appropriate revisions are made before a standard is adopted. All of the enclosed AMD Standards have been incorporated into the latest revision of KKK-A-1822. These documents and others are available for download through the NTEA Web site at www.ntea.com

Ambulance Manufacturers Division of the NTEA
37400 Hills Tech Drive,
Farmington Hills, MI 48331-3414

ii
S1. SCOPE AND PURPOSE. This standard establishes guidelines for accurately measuring the volume of interior cabinets and exterior compartments of an ambulance. This is a type test.

S2. APPLICABILITY. This standard applies to all ambulances.

S3. DEFINITIONS.

S3.1 “Cabinet depth” is the measured depth from the cabinet inside back wall to the outside cabinet face.

S3.2 “Compartment depth” is the measured depth from the compartment inside back wall to the outside compartment face.

S3.3 “Door OD” is the door overall outside thickness (dimension).

S3.4 “Depth ID” is the actual interior depth either measured or figured by subtracting the Door OD from the cabinet or compartment measured depth.

S3.5 “Height ID” is determined by measuring from interior bottom surface to the interior surface of the cabinet or compartment top.

S3.6 “Width ID” is determined by measuring from one interior surface to the next interior surface of the cabinet or compartment.

S3.7 “Sliding window track” is the track used for sliding cabinet windows.

S3.8 “Sliding cabinet windows” is the sliding doors used on interior cabinets.

S4. TEST CONDITIONS.

S4.1 Remove any loose or mounted removal able equipment from interior cabinets or exterior compartments. Examples would be fire extinguishers, portable oxygen mounts, spare tires and tools.

S5. TEST PROCEDURE.

S5.1 Interior cabinet with sliding doors or roll-up doors (Figure 1).

a. Measuring from the back of the rear wall to the back of the sliding window track, record that dimension for Depth ID.

b. Measuring from cabinet interior wall to wall, record that dimension for Width ID.

c. Measuring from the interior top to bottom, record dimension. This is the Height ID.

d. Multiply Height ID x Width ID x Depth ID = then divide by 1,728 to get cubic feet.

S5.2 Interior cabinets with hinged doors (Figure 2).

a. Measure from the back of the door to the face of the door and record that dimension for Door OD.

b. Measure from the back of the rear wall to the cabinet face and record that dimension for cabinet depth.

c. Subtract the Door OD from the cabinet depth to get Depth ID.

d. Measure from cabinet interior wall to wall and record that dimension for Width ID.

e. Measure from the interior top to bottom and record dimension. This is the Height ID.

f. Multiply Height ID x Width ID x Depth ID = then divide by 1,728 to get cubic feet.

S5.3 Exterior Compartments with hinged doors (Figure 3).

a. Measure from the back of the door to the face of the door and record that dimension for Door OD.

b. Measure from the back of the rear wall to the cabinet face and record that dimension for cabinet depth.
c. Subtract the Door OD from the cabinet depth to get Depth ID.
d. Measure from cabinet interior wall to wall and record that dimension for Width ID.
e. Measure from the interior top to bottom and record dimension this is the Height ID.
f. Multiply Height ID x Width ID x Depth ID = then divide by 1,728 to get cubic feet.

**NOTE:** Subtract any notches for spring shackles or fuel systems from the total to get the correct total cubic feet.

*Figure 1*
© 2007 Ambulance Manufacturers Division of the National Truck Equipment Association Orig. 8-07

*Figure 2*

*Figure 3*
© 2007 Ambulance Manufacturers Division of the National Truck Equipment Association Orig. 8-07

---

**Figure 1**

![Figure 1 Diagram]

- Height ID.
- Depth ID.
- Sliding windows
- Sliding Window Track
Appendix D: Solid Works Models

Below are an assortment of miscellaneous screenshots of sketches and rough drafts of models

Chair

track
Rotating chair in new ambulance