DESIGN EXPLORATION OF ATLANTA APPARATUS INSTRUMENT PANEL

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DESIGN EXPLORATION OF ATLANTA APPARATUS INSTRUMENT PANEL

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GLOSSARY

All professions have there own language or list of terms that are commonly used. Refer to list below to see a list of common words used in the firefighter lexicon and throughout this thesis.

Aerial: (synonym; Truck) Fire Apparatus designed to allow firefighters to gain access to multiple story structures. Usually characterized by ladders.

Apparatus: pl. apparatuses, the vehicle based fire equipment used by the fire department.

Battalion Chief Vehicles: Modified Sport utility vehicles, used by the Battalion Chief, featuring utility draws with marker boards, and model pieces of various apparatus to illustrate a “bird’s eye view” of the fire attach scenario allowing the Battalion Chief to make informed decisions regarding how to address the emergency.

Driver: Operator, Driver, Technician

EMT: emergency medical technicians or paramedics

Fire Engine: (synonym; Pumper) Fire Apparatus designed to allow firefighters to pump water or foam using an onboard water supply sometimes replenished with fire hydrants or other sources of water to suppress fires.

Fire Truck: (Aerial) Usually equip with long ladders, hydraulic platforms and heavy rescue gear. Designed to support the fire engine when attacking a fire.

Hazmat: Hazardous Material

SUMMARY

Design research captures the voice of the expert to aid in the design process. The expert users of the municipal fire apparatus are firefighters. An immersive study of the Atlanta Fire Department firefighters was conducted along with a literature review. Data collected in the study reflected how the apparatus instrument panels are actually used. Results indicated the both the driver and the captain use the instrument panel. Instrument panel related tasks were compared with similar systems as a benchmark. Firefighter feedback provided a basis for concept development. The possible impact of the findings on future research and urban apparatus product development are discussed.

CHAPTER 1

INTRODUCTION

1.1. Introduction

The Atlanta Georgia Fire Department faces many challenges while protecting the lives and property of the Atlanta residents and visitors. One of the largest investments that the Atlanta Fire Department makes is its fleet of fire apparatuses. The apparatuses, are used to facilitate the firefighting department in saving lives and property.

This research explores the design of the fire apparatus instrument panel. The task of driving heavy equipment in emergency situations will also be studied and analyzed. Satisfying the various customer requirements will be investigated since the driver is not the only customer. By investigating these and other factors through the design process, some viable concepts will be developed that will augment the fire crew, manufactures' costs, improve the ability to save lives, and save purchasing municipalities money.

1.2. Motivation

The motivation to explore the usage of the fire apparatus instrument panel stems from an interest in automobiles. My professional experience is in engine design, automotive manufacturing, and automotive product development. A decision matrix, Table A1. Decision Matrix, was made to capture interesting automotive topics and what knowledge I have of them based on a few criteria. A decision was matrix was started by preparing a list of different types of vehicles. The vehicles were evaluated based on interest, room for innovation, opportunity to add new knowledge to the field**,** and my access to such vehicles for user research.

Preliminary research revealed a limited amount of information on firefighter usage of the instrument panel interface in the apparatus. The apparatuses firefighters often use are unique compared to other vehicles on the road. The Atlanta Fire

Department is conveniently located nearby and provided a sizable population to research.

CHAPTER 2

PROBLEM DEFINITION AND SCOPE

2.1. Problem Statement

Currently, Atlanta Georgia fire apparatus instrument panel designs do not adequately support the fire crews' role.

2.2. Purpose of the Study

Purpose of the study is to research the usage of the fire apparatus instrument panel**,** and to provide recommendations to be utilized in urban environments that will support the role of the firefighters protecting the people and property of Atlanta Georgia.

2.3. Design Objectives

Obtain and utilize firefighter feedback to provide design recommendations that manufacturers can apply to aid fire apparatus instrument panel design.

2.4. Delimitations and Limitations

This thesis is limited to the municipal fire apparatuses, engines and trucks, operated by the Atlanta Fire Department in Atlanta**,** Georgia.

CHAPTER 3

BACKGROUND

3.1 Atlanta Fire Department

3.1.1. Overview

The mission of the Atlanta Fire Department is “To prevent or mitigate harm of life, property, and the environment.” (http://www.atlantaga.gov/Government/Fire.aspx) Currently, the Atlanta Fire Department is based in City Hall East and serves a city of over four-hundred thousand people (http://www.city-data.com/city/Atlanta-Georgia.html). The fire department is composed of thirty municipal fire stations in the Atlanta area and four stations at Atlanta Hartsfield-Jackson Airport. Within the city of Atlanta**,** each station has an approximate range of one hundred thirty-two square miles. (Captain Bickford) On average, Atlanta Fire Department receives one hundred twenty-five to one hundred fifty incident calls per day. Incident calls include fires, hazardous material, rescues and emergency medical services alarms, and Homeland Security Responses/Planning.” (http://www.atlantaga.gov/government/fire.aspx) Approximately eighty percent of the calls that the Atlanta fire department responds to are medical emergencies.

“Applicants for municipal firefighting jobs generally must pass a written exam; tests of strength, physical stamina, coordination, and agility; and a medical examination that includes drug screening. Workers may be monitored on a random basis for drug use after accepting employment. Examinations are generally open to persons who are at least eighteen years of age and have a high school education or the equivalent. Those who receive the highest scores in all phases of testing have the best chances for appointment. The completion of community college courses in fire science may improve an applicant’s chances for appointment. In recent years, an increasing proportion of entrants to this occupation have had some postsecondary education.

As a rule, entry-level workers in large fire departments are trained for several weeks at the department's training center or academy. Through classroom instruction and practical training, the recruits study firefighting techniques, fire prevention, hazardous materials control, local building codes, and emergency medical procedures**,** including first aid and cardiopulmonary resuscitation. They also learn how to use axes, chain saws, fire extinguishers, ladders, and other firefighting and rescue equipment. After successfully completing this training, they are assigned to a fire company where they undergo a period of probation." (http://bls.gov/oco/ocos158.htm)

The fire department is organized in a hierarchical structure similar to the military. The rank system in descending order is:

- Fire Chief
- Deputy Chief
- Assistant Fire chief
- Battalion Chief
- Fire Captain
- Fire Lieutenant
- Fire Prevention/Code Inspector
- Engineer or Driver
- Firefighter

In Atlanta, firefighters based in the stations are on one of three shifts. The firefighters that are based in fire stations throughout the city are on call for the entire twenty-four hour work shift. Firefighters have twenty-four hours on duty and forty-eight hours off. Work hours are seven am to seven-o-clock the next morning.

Atlanta firefighters are constantly getting their training updated. Beginning next year, physical fitness requirements will be enforced. Firefighter training includes apparatus and equipment training, emergency medical technician training, hazardous material education, and fire behavior.

3.1.2. Apparatus Crews

Apparatus operation protocol reflects firefighter hierarchy. Seating position, Figure. 1 Atlanta Georgia Firefighting Crew Seating Position, in the apparatus is dictated by rank. The driver sits in the driver seat of the apparatus. The driver is responsible for driving the apparatus, preventative maintenance, and if needed controlling the ladders on a truck, or the water pumps on an engine during an emergency. The captain**,** or superior ranked firefighting officer, rides as co-driver in the right front seat of the vehicle. The captain is ultimately responsible for the apparatus. This includes making sure it gets to the emergency in time, communicating with incident command, and the apparatus speed. In a three man crew, the firefighter sits in the back behind the captain. In cases of a four person crew, the additional firefighter will sit behind the driver. Anytime the apparatus is driven, the whole crew must be aboard. Trips an apparatus may complete while on duty include responding to emergencies, filling fuel tanks, or getting groceries for the fire station. Having the entire crew in the vehicle allows the group to be ready respond to an emergency anytime during the trip.

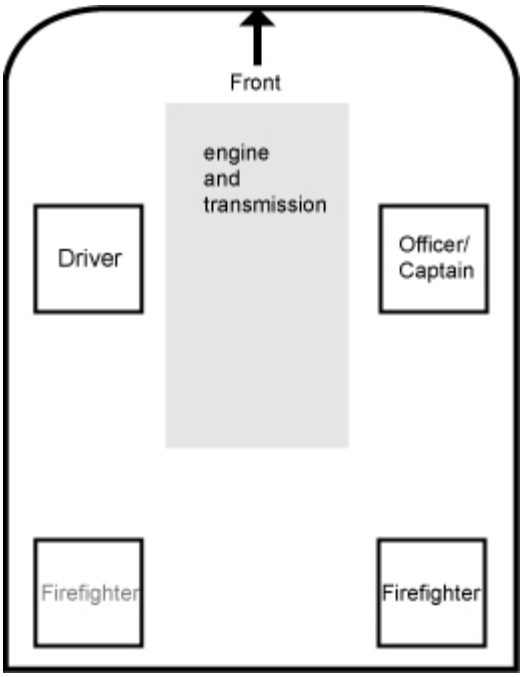

Figure 1. Atlanta Georgia Firefighting Crew Seating Position

3.1.3. Municipal Apparatus

Atlanta Fire Department uses various types of fire apparatuses due to the different situations the fire department responds to in the city. An apparatus is the vehicle based fire equipment used by the fire department. The truck, or aerial, is used to haul ladders, and supporting equipment, Figure 2. Atlanta Fire Department Aerial.

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Figure 2. Atlanta Fire Department Aerial

The engine, or pumper, is used to haul and/or pump water to put out the fire, Figure 3. Atlanta Fire Department Engine.

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Figure 3. Atlanta Fire Department Engine

Currently, in 2005, Atlanta Fire Department operates thirty engine companies and seventeen truck companies. (http://www.firetruckleasing.com/leasing2fire-newsletter1.htm) The vehicles are based on the Spartan Gladiator chassis and

manufactured by Quality Manufacturing Inc. The current truck and engine instrument panels are common to each other. There are a few differences in gauges and controls corresponding with the vehicle type.

Apparatuses are kept in service for ten years. The apparatuses in the best condition are kept five more years as reserve vehicles to backup the new fleet. Reserve apparatuses are used to replace the new apparatus during service and maintenance.

Along with the trucks and engines, other service vehicles are used by the Atlanta Fire Department. Other vehicles include a Hazmat Squad, a Decontamination unit, Battalion Chief Vehicles, and soon to be in service, a parking deck apparatus.

3.1.4. Tactics

Much like the military, tactics are important as they organize people and other resources to address the various emergencies around Atlanta. Firefighter response is based on the emergency. Atlanta Fire Department uses Incident Command to coordinate resources. Incident Command receives a call, or alarm, and then it allocates resources to resolve the situation. Incident Command uses large maps of Atlanta. On the maps**,** fire station locations are marked. Apparatus movement is noted manually as they move around the city and are called to various locations. Incident Command uses models on the map to keep up with the apparatus locations.

When an emergency call is received by the system via a call or electronic alarm**,** incident command is notified. Beginning with incident command, fire department resources are assessed and coordinated to deal with the emergency situation. There is a list of prescribed responses to common emergencies, refer to Appendix B. Incident Responses of the Atlanta Fire Department. In general**,** stations closest to the scene of the emergency are contacted via radio to respond. Based on the incident**,** there are prescribed responses from the fire department.

Radio communication is critical to firefighter tactics. All apparatuses are equipped with radios. Currently**,** radios are carried by captains, drivers, and medics. There are plans to equip all Atlanta firefighters with radios. There are six tactical radio channels used by the Atlanta Fire Department along with radio channels dedicated to arson, maintenance, inspections, and training.

3.1.5. Summary

The apparatus is a multifunction tool. The apparatus is used to transport personnel to scenes of emergencies and to errands, such as groceries. It is used as a mobile toolbox, carrying equipment such as ladders, hoses, medical gear, turnout gear, and flashlights. The apparatus is also used as a command post, or a mobile extension of the Fire Department. In some cases, at the scene, the apparatus is used to pump water if it is an engine, or to deploy ladders if it is an aerial unit.

The apparatus also has many drivers. Each apparatus at a station has three drivers not including substitute drivers. Multiple users will adjust things like mirrors and seats. Product adjustment facilitates many users but, it can increase wear on parts.

CHAPTER 4

BENCHMARKING

4.1. Competitive Benchmarking

There are numerous fire apparatus manufacturers in the United States. When looking for a new apparatus, fire departments develop committees to analyze factors such as budget restrictions, performance needs, maintenance capabilities, terrain, and building types within service territory.

Spartan Chassis Incorporated designs and manufactures the instrument panel used by the Atlanta Fire Department, Figure 4. Spartan Chassis Gladiator Instrument Panel Photo used by Atlanta Fire Department.

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Figure 4. Spartan Chassis Gladiator Instrument Panel Photo used by Atlanta Fire Department

The Spartan chassis is the basis of the Quality Manufactured apparatuses employed by the Atlanta Fire Department. It is common in the apparatus industry for one company to design and build the custom chassis. Then another company will buy the chassis and customize it per customer request. The Spartan Gladiator chassis is considered a

custom chassis. Custom chassis are made specifically for apparatus applications. Custom chassis cabs are often larger and offer more space for the crew and equipment in comparison to commercial cab chassis. Custom chassis allow the use of larger, more powerful powertrains and custom mounted equipment. Like many custom chassis manufactures Spartan Chassis Inc., employs the “cab over engine” design. The engine is located between the driver and captain. Advantages of this design include a lower roofline and the shorter overall length of the apparatus. The “cab over engine” design also increases driver visibility. Exposed fasteners and a panel design allow the Spartan Chassis instrument panel to be easily customized. The panels can be modified to fit various gauges and controls based on the customer ordered options.

A new feature is a Weldon Technologies manufactured electronic multiplex unit. According to Spartan Chassis Inc., the multiplex unit is a display that allows user to monitor vehicle performance via a screen mounted in the center bin of the instrument panel. (http://www.spartanchassis.com/ft/ft_products.asp)

American LaFrance is a competitor of Spartan Chassis Inc., and is one of the oldest fire apparatus manufacturers in America. The American LaFrance Eagle chassis serves as the primary chassis for the American LaFrance’s product line. The instrument panel is common throughout the various cab configurations. The Eagle chassis also make use of the “cab over engine” layout.

Another option a municipal fire department has is to purchase/lease an apparatus based on a commercial cab chassis. Commercial cabs chassis are made by manufactures such as Ford and Freightliner. Commercial cab chassis are most often used as vehicles made to haul freight or large equipment. Commercial cab chassis based apparatus are less expensive than custom chassis since they are produced in much larger numbers for a multitude of applications. The instrument panels are usually

more oriented to the driver. The Atlanta Fire Department doesn't consider commercial cab chassis based apparatuses since they have proven to be less safe than custom chassis.

Airport Rescue and Fire Fighting, ARFF, requires a different type of apparatus. Airport Rescue and Fire Fighting apparatus are used to suppress fires at the airport. They are primarily used around aircraft on the runways. Colet SVD, Special Vehicle Design, manufactures airport rescue and firefighting apparatuses used by the military and various civilian airports. A Colet SVD Jaguar K-15 and K/R40 Airport Rescue Fire Fighting apparatus, Figure 5. Atlanta Fire Department Colet Jaguar K-15 SVD Apparatus and Figure 6. Atlanta Fire Department Colet Jaguar K/R40 SVD Apparatus, is at each of the Atlanta's Hartsfield-Jackson Airport fire stations.

Figure 5. Atlanta Fire Department Colet Jaguar K-15 SVD Apparatus

Figure 6. Atlanta Fire Department Colet Jaguar K/R40 SVD Apparatus

Both the Colet SVD Jaguar models are designed for high speed. This high speed allows airport fire crews to quickly get to emergencies involving aircrafts on the runway. Both are designed to pump water or foam to suppress fires. The cab is designed for a two person crew of the driver and officer. The driver is seated in the center of the vehicle. The officer sits behind right shoulder of the driver. The instrument panel, Figure 7. Colet SVD Instrument Panel and Figure 8. Atlanta Fire Department Colet SVD Jaguar K15 Instrument Panel, is centrally mounted in front of the driver.

Figure 7. Colet SVD Instrument Panel

Figure 8. Atlanta Fire Department Colet SVD Jaguar K15 Instrument Panel

To save space, one gauge face houses four gauges. An indicator light near the gauge draws the driver's attention if at a critical level. The canopy design resembles and an aircraft to facilitate driver visibility. Colet SVD offers a heads-up display as an option. Inside the cab, there are numerous screens with vision enhancing cameras. The Colet apparatuses are equipped with infrared cameras to facilitate driving the apparatus in low visibility conditions. A rear facing camera helps the driver see behind the apparatus while reversing. A joystick in the cab allows the driver, or officer, to control the water turrets to suppress fires.

There are a few observable design differences between freight hauling commercial cab based truck and fire apparatus. Commercial cabs used for hauling freight instrument panels are biased toward the driver. In comparison, fire apparatus controls are for two person operation. Designers take advantage of the expanse of space above the engine and between the driver and captain. The automatic transmission is prevalent in fire apparatuses. The push button transmission gear selector is the observed trend. Commercial cabs apply a transmission lever for both the automatic and manual transmissions.

4.2. Parallel platforms

The primary goal of the fire apparatus driver is to drive the apparatus quickly and safely to the scene of emergencies. Aided by the co-driver, the driver operates and navigates the apparatus. Similar tasks employing a two person operation of a vehicle is the control of a rally car and the piloting of a Lockheed C-130 aircraft.

The competitive rally driving team is composed of two people. Competition rally cars compete on various terrains. Teams race against the clock as they drive the car in pre-set stages. The driver is responsible for vehicle control, monitoring vehicle status, and negotiating the terrain. The co-driver, or navigator, is responsible for directing the driver and monitoring time. In general, rally events proceed as follows; the day before the driver and co-driver drive the preplanned race course. The co-driver makes notes. The day of the event the driver and co-driver enter the team prepared race car. In some cases, a map is given to the co-driver. The driver moves the car to the starting line. Rallies are timed events. Therefore, a car is launched every five minutes negating the need to negotiate traffic. The driving crew is told to start by the officials at the starting line. The driver controls the vehicle and the co-driver tells the driver where to go, while also warning of obstacles. Some drivers and co-drivers develop codes between them to describe the terrain. A headset is worn by both the driver and co-driver to aid communication. The headset silences the engine noise, and it allows the team to speak to each other clearly.

The instrument panel is usually loosely based on the instrument panel of a passenger car available to the public. In many cases, the instrument panel is stripped of down to reduce weight. The transmission lever is often mounted in the instrument panel to help the driver make faster gear changes. The tachometer is emphasized in the

instrument cluster for the driver to take better advantage of the engine power throughout the range of speed. Between the driver and the co-driver, some teams have a brake lever to allow the driver to manually lock the rear wheels in order to sweep the rear of the car around corners. In some vehicles, the driver can adjust differentials and turbocharger boost within the vehicle. The co-driver, or front passenger, part of the instrument panel often has a trip computer in the area traditionally reserved for the glove box on a passenger car. The interface can be modified. The screen often is used to reflect the distance the vehicle has covered and the trip time.

The current Lockheed Martin C-130J flight crew is composed of two people. The C-130 Hercules was designed for airlift operations for the United States military in the 1950's. This aircraft has been a versatile and durable platform now in service for fifty years in a multitude of countries. The airframe has numerous variations for specific missions. The Lockheed C-130 now serves roles including troop carrier, unmanned drone launcher, front line supply delivery, medical evacuation and air tanker.

A general mission of the C-130 aircraft is to fly in supplies. The aircraft is loaded by the ground crew. Then the pilot and copilot get into the cockpit. Headsets are worn to aid in communication between pilot, copilot, and ground control. The pilot takes control of the plane for take off, flight, and landing.

The cockpit is symmetrical allowing either pilot or copilot to fly the aircraft. Avionics advancements have allowed the flight crew required to pilot the C-130 to be reduced from the five to two. Fifty years of product evolution has simplified the cockpit layout. Earlier models had a multitude of gauges providing information to the crew. The latest incarnation of the aircraft employs a glass cockpit. The numerous gauges have been replaced by flat panel color screens which simplify the layout assisting the pilots.

The glass cockpit reduces the weight and power consumption of the cockpit. The use of screens allows new features to be added, such as moving maps. The new C-130 also uses holographic heads-up display, H.U.D., allowing pilots to obtain information without looking in the cockpit. Lockheed Martin uses the dark cockpit system. Gauges and some indicators appear on screen only when pilot attention is needed. Controls have been simplified along with the advancement in technology. Simplifications include a single engine power control lever and an auto throttle to control the four engines.

Both the rally car and the Lockheed C-130 reflect a simplification of the instrumentation panel layout. The screen display is becoming prevalent in automobiles and aircraft allowing the interface to be more flexible easily adding new features. Driving a municipal apparatus is more like driving a rally car than flying a Lockheed C-130. The rally car driver and co-driver work cooperatively but their controls are independent from each other. The Lockheed C-130 pilot and co-pilot work cooperatively and their controls are more symmetrical allowing for redundancy.

CHAPTER 5

RESEARCH

5.1. Research Methodology

5.1.1. Methods

Research methods applied to obtain data about the fire apparatus interface were a literature review, qualitative observation, questionnaire, and a design critique.
A literature review was conducted to understand the instrument panel interface. Observation based research provided an opportunity to see how the instrument panel is used. The questionnaire that was developed allowed the firefighters to record how they use the instrument panel. Lastly, the design critique allowed firefighters to express their ideal instrument panel configurations.

First, a literature review was conducted to gain insight and understanding of existing fire apparatus instrument panel design. Since driving is involved, much of the literature obtained was about the driving of passenger vehicles. Sources are reflected in the bibliography.

The National Fire Protection Association, NFPA, provides a handbook defining the requirements and guidelines for fire protection including firefighter training, investigation, apparatus construction, and fire codes. The National Fire Protection Association handbook reflects the knowledge and experience of firefighters and apparatus manufacturers across the United States.

National Fire Protection Association 1901, NFPA 1901, is a required guideline for fire apparatus manufactures to follow in order to sell their products to municipalities. ”NFPA 1901 defines the requirements for new automotive fire apparatus designed to be used under emergency conditions to transport personnel and equipment, and to support the suppression of fires and mitigation of other hazardous situations.”

(http://www.normas.com/NFPA/PAGES/NFPA-1901(03).html) National Fire Protection Association 1901 states what instruments, controls, and features are required to be on the apparatus instrument panel.

Next, to better understand what Atlanta firefighters face as they work in the various communities in the city**,** a ride-along was scheduled. This was an ethnographic observational pilot study. The ride-along involved staying at a fire station in Atlanta for five hours during the day. Questions were then developed for a questionnaire. The questionnaire, Appendix C. Questionnaire, is a mix of closed answer, short answer, and Likert-type scale based questions to capture the firefighter's level of agreement. The questionnaire was used to get a general understanding of gauge and control usage of the apparatus drivers. The questionnaire was also used to understand what new equipment is in demand from the various drivers and captains in the city.

Lastly, a design critique was completed with apparatus drivers and captains. This critique of the current system allowed drivers and captains to describe what they would do differently if they designed the instrument panel layout. This was primarily used as a way for apparatus drivers and captains to tell where they want various gauges and controls located.

5.1.2. Significance of Research

The significance of the research is to understand the work environment of the Atlanta firefighter**,** and to directly observe how the firefighters interact with the instrument panel. The research also aided the understanding of what the drivers and captains would consider to be an ideal instrument panel.

5.1.3. Site and Sample Selections

The population of interest was the Atlanta Fire Department apparatus drivers and captains. With the help of Captain Bickford of the Atlanta Fire Department, the researcher was able to contact many firefighters.

For the ride along, the site sampled was a station located in downtown Atlanta. The site was chosen due to central location and convenience. The territory of the station includes the expressway, residential homes, commercial buildings, high rise buildings, and pedestrian traffic.

The questionnaire was sent to all Atlanta Fire Department apparatus drivers with the help of Captain Bickford. This sample method provided the potential to receive feedback from all drivers and captains. Participants volunteered to take the survey.

The design critique participants were chosen with the aid of Captain Bickford. Various station drivers and officers were met. The sample selection provided a broad scope of experience and station locations. A few drivers have driven the previous model apparatuses. Station locations were both downtown and outside of downtown.

Steps were taken to maintain participant confidentiality. Names are removed from any notes or returned documentation such as the questionnaire. Participants in pictures were cropped out to hide their identity.

5.1.4. Researcher's Role

The researcher was involved in all aspects of the research performed. Literature reviews were conducted by the researcher. The researcher contacted the Atlanta Fire Department Chief, Chief Dennis Rubin, and received authorization to conduct surveys and directly observe firefighters. The researcher filled out the required waiver and participated in a ride-along with an engine crew. During observations**,** the researcher took all notes and photographs. All survey materials were developed by the researcher.

5.1.5. Research Strategies

The primary strategy was to respect the firefighter's time. First was to do as much background research as possible before meeting the firefighters. This literature review involved numerous sources; periodicals, manufacturers' literature, and various publishings of organizations, such as Society of Automotive Engineers.

There are many possible interruptions that can occur when speaking with on duty firefighters. At any time**,** they can be dealing with an emergency and must quickly respond. At all times radio dispatch can be heard in the background during meetings. Time had to be used as constructively as possible. At City Hall**,** many times during interviews someone called or came by the office to get a few questions answered. At the fire stations, firefighters were engaged in some work activities**,** such as preventative maintenance. A few times while talking to the firefighters, they had to respond to an emergency call.

During the ride along, the researcher made sure not to disrupt work flow by staying out of the way of the firefighters.

The questionnaire was written to be as concise as possible. Quick check boxes are used as well as short answer questions. Two very similar forms were made. One was designed to be filled out on paper allowing participants to circle answers and check boxes. The other form was to be filled out on the computer. This was an excel spreadsheet based form. The participant could simply type in an “x” into specific cells. The spreadsheet based form was sent by Captain Bickford using the Atlanta Fire Department intranet system.

The design critique was originally developed based on a Velcro model. A Velcro model is the use of a model that allows the participant to illustrate their ideal product design. A kit is made of blank substrate allowing the participant to stick components of model features. Participants develop various configurations.

The Velcro model had to be modified since participants would be on duty. Participants sat in their apparatus and expressed where they would ideally want controls, gauges, and new features to be located. The researcher made models of the various gauges and controls to be put on the existing instrument panel. Markers were

supplied for participants to write down what the various model pieces represented to allow it to be identified in pictures after being photographed.

5.1.6. Data and Collection

A copy of the National Fire Protection Association 1901 was obtained with the help of Lieutenant Hill, since it contained information regarding apparatus guidelines.

Notes were taken by the researcher at meetings and while making observations. Digital pictures of the apparatuses were also taken for documentation.

5.1.7. Data

Raw data collected is in data section of the Appendix.

Appendix D. Observation Ride-Along Notes

Appendix E. Questionnaire Raw Data

Appendix F. Design Critique Notes

5.2. Research Analysis

5.2.1. Task and Function Analysis

The literature data obtained from the National Fire Protection Association 1901 guidebook provided the basis for a function analysis of the apparatus instrument panel. The prime function of the instrument panel is to be the main interface between the driver/co-driver and the vehicle. The instrument panel is a myriad of interfaces. The instrument panel can be broken down into the following:

1. Provide Vehicle Status Information via Gauges

The instrument panel reflects vehicle status to the driver and captain. The instrument panel contains many gauges and indicators reflected in the NFPA 1901. Gauges such as the speedometer reflect the vehicle road speed at that instant; other indicators reflect upcoming maintenance needs.

Multimedia screen is being employed in some vehicles to be a single focal point to be used by the driver and officer. The screen can show maps, vehicle diagrams, and

the location of other vehicles. Currently, the Atlanta Fire Department does not use the multimedia screen option in their vehicles.

Some vehicles have an onboard diagnostic connection allowing service technicians to obtain vehicle information to diagnose current issues, as well as prevent vehicle problems. Current passenger vehicles use an on-board diagnostic connection of OBD II required by the federal government.

2. Provide Vehicle Control Interfaces

The vehicle control interfaces include direction control and powertrain control interfaces.

Apparatus direction control is primarily the steering wheel. The steering system is powered via engine driven hydraulics to reduce driver effort.

The powertrain control interfaces for engine and transmission management. There is an ignition switch to turn the engine on and off. The engine controls include an accelerator pedal for the engine throttle, and an engine brake switch allowing the driver to incorporate engine compression to assist the airbrakes to slow or stop the apparatus. The transmission interface is to manage the gear selection. Current apparatus are primarily automatic transmission units that allow selection of reverse, neutral, drive, and gear up and down. On the Spartan Gladiator the park and parking brake occur at the same time via one switch.

3. Auxiliary Power Control

As mentioned in NFPA 1901 guidelines this depends on the type of apparatus. For example a pumper truck has a pump to be powered, or an aerial has hydraulics that requires power. Auxiliary power equipment usually requires engine power via a power take off. For the power take off to operate, the engine has to be running at a specified speed.

4. Climate Control

The HVAC controls of the Spartan Gladiator chassis are located on ceiling above the instrument panel. The controls are for the fan, air conditioning, heating, and ducting. The fan speed controls are for managing the air circulation in the cabin. The heating controls allow the driver/officer to manage the amount of heated air that enters the cabin. The heat is often taken from the coolant of the engine as it is heated by combustion. The air conditioning controls are for cooling the cabin as well as dehumidifying the air to remove any fogging on the windows. The ducting in the instrument panel directs airflow.

Beyond looking at the HVAC option on a vehicle as a comfort item, the HVAC option can help the firefighters recover after working on a scene. For example, if the firefighters were working at highly elevated temperatures especially in the summer months, the air conditioning in the cabin can be used to aid recovery by cooling the firefighters down.

5. Communication Control

The primary source of communication for the firefighters in the apparatus is the CB radio. The officer has the radio on at all times to hear from dispatch. There is an instrument panel mounted CB radio that the driver uses on the scene. The driver can scan tactical channels and adjust volume.

To communicate with those outside of the vehicle**,** an audio/optical system is used. This is the familiar lights and sirens of the fire apparatus telling traffic to move out of the way. The control panel is used by both the driver and the officer.

6. Ensure Passenger Safety

The NFPA 1901 dictates the labels and plaques for warnings in the cabin for safety. The instrument panel is a possible location.

In case the apparatus is involved in a traffic accident**,** the instrument panel is to prevent injury. Passive safety measures include an energy absorbing geometry and

materials. Energy absorbing geometry allows parts of the instrument panel to break away, or absorb the impact if someone hits the instrument panel. Padding distributes the load reducing the chance of injury.

Since fire apparatus are usually larger and heavier than many vehicles on the road, containment is employed to aid safety. The instrument panel helps to enclose the driver and officer in a cell.

7. Storage/Organization

The instrument panel can provide some storage and organization for the firefighters. There are miscellaneous items that are carried by firefighters. Items such as writing utensils, paper, and clipboards are carried to take notes. Some of the papers are forms to be filled out, such as fire hydrant maintenance forms. Atlanta Fire Department has roster cards on all apparatuses. Roster cards are given to the Battalion Chief at the scene of an emergency. The cards are plastic plaques with the names of the crew at the scene. If the unit is the first on the scene, the roster cards are displayed on the instrument panel. The various items found in the makeshift baskets in the front of few apparatuses are listed in Appendix G. Console Items.

Observations during the ride along provided the basis of a task analysis reflecting how firefighters interact with the instrument panel. The primary task of the fire apparatus is to support the firefighters to protect the community lives and property. In general, the firefighters perform a multitude of tasks. Below is a sample task analysis mapped out, assuming the apparatus is leaving from the fire station:

1. Dispatch call

Call from dispatch. Firefighters hear all dispatch calls. The dispatch calls the actual station or squad number and then provides the location and any pertinent known information.

2. Jump into Cab

The driver goes into the driver seat, the officer occupies the front passenger seat, and the firefighter goes into the jump seat behind the officer. All put on their headsets which are hanging on the roof of the cabin.

To ingress the apparatus quickly**,** access to the seats must be unobstructed. In some stations visited**,** the parked apparatus driver's door is left wide open.

3. Start up, Leave Station

Driver starts engine. NFPA 1901 specifies that if keys are used to start vehicle, countermeasures are taken to insure that they can't be removed from the ignition. Atlanta Fire Department Spartan chassis engine and trucks use an ignition switch. The driver ensures all passengers are aboard and that everything is secure. NFPA 1901 mentions indicators for making sure bin and cabinets are closed. A red light indicator on the roof notifies crew if a bin, or cabinet, on the apparatus is open. An indicator on the instrument panel displays what bin is open using text.

4. Drive to Scene

The optical/auditory system is activated. The apparatus is pulled out of the garage. The officer gives directions, if needed, to the location. The driver negotiates traffic. The officer, or driver**,** honks the horn. The horn is to be used prudently**,** since it uses the pressurized air that is also used to operate the pneumatic braking system.

5. Arrive on Scene

Fire crew arrives on scene. The driver parks the apparatus. Auditory warning is turned off. The flashing lights remain on. Officer and firefighter get out of apparatus to evaluate the scene.

6. Work on Scene

Driver remains in apparatus, headset is off, and listens to the dash mounted CB radio. Driver looks around to observe what is going on around the scene.

Depending on the situation, auxiliary power is needed based on the apparatus in service. The driver may have to man the pump controls, aerial controls, or other controls outside of the cabin of the apparatus. Some of the exterior controls are in the cabin mounted on the instrument panel as dictated by NFPA 1901 regulation.

7. Leave Scene

Driver checks all auxiliary systems are off. Driver confirms all bins are secure. Driver makes sure all are in the cabin. Crew puts on their headsets.

8. Drive from Scene to Station

Optical warning system is turned off. The driver negotiates through traffic

9. Station Arrival, Park

Depending on station layout**,** the driver stops the apparatus in the middle of the street**,** and the officer and firefighter get out. The officer and firefighter stop traffic on both sides of the street. The driver then backs the apparatus back into the fire station garage. Some stations drive apparatus around the back and pull it through the garage.

The vehicle is then parked by the driver. The park gear and brake are applied simultaneously by one switch.

10. Vehicle Maintenance

This is a separate task performed by the driver. The Atlanta Fire Department protocol requires a maintenance check to be completed at the beginning of each shift. The driver checks if the fluid levels and pressures are within specifications. The station has some fluids on hand to top off amounts. Fluids such as engine oil, transmission oil, and windshield washer fluid.

Major maintenance is completed at a centralized location. For Atlanta Fire Department and the maintenance for all city vehicles such as police car and garbage trucks, service is done at a central location. This is where repairs are made, fluids are changed, and problems are diagnosed.

11. Outside Maintenance

The Atlanta Fire Department uses the smaller of their fire apparatus**,** the engine**,** to perform low demand tasks. Such tasks are fire hydrant check and getting groceries. It is required the full crew driver, officer, and firefighter are onboard for such tasks since no one knows when dispatch will call them.

One of the tasks that firefighters perform is fire hydrant maintenance. There is a set of fire hydrants assigned to each fire station that has to be periodically checked. The officer and firefighter get out of the vehicle. The firefighter opens the valve on the hydrant and makes sure the hydrant can be opened with a specified wrench. The officer uses a clipboard and pen to note which hydrants have been checked. The driver slowly drives the apparatus following the officer and firefighter.

The fire station has a kitchen and dining area. The firefighters on shift are responsible for buying there own groceries. They go for a grocery run for the entire station.

In some cases**,** the officer calls dispatch/incident command to take the fire apparatus out of service. This may occur if the apparatus is getting fuel. The entire crew goes on the trip. When the fuel tank is full and the apparatus is back on the road**,** the officer calls dispatch/incident command and puts the apparatus back into service.

5.2.2. Survey Analysis

Ninety-nine percent of the Atlanta Fire Department drivers responded to the questionnaire. Twenty-eight of the surveys were missing some data and therefore disregarded. The resulting useable response rate was at a seventy percent response rate.

First question was regarding equipment usage while driving the apparatus. The fire department most frequently uses the headphones, or headsets, for communication. Turnout gear was the second most frequently used equipment. Turnout gear is the

protective equipment firefighters wear on the emergency scene to fight fires. Turnout gear is composed of boots, pants, an overcoat, gloves, hood, and helmet. Equipment worn while driving, graph, Figure. 9, reflects headphones are most frequently used by apparatus drivers.

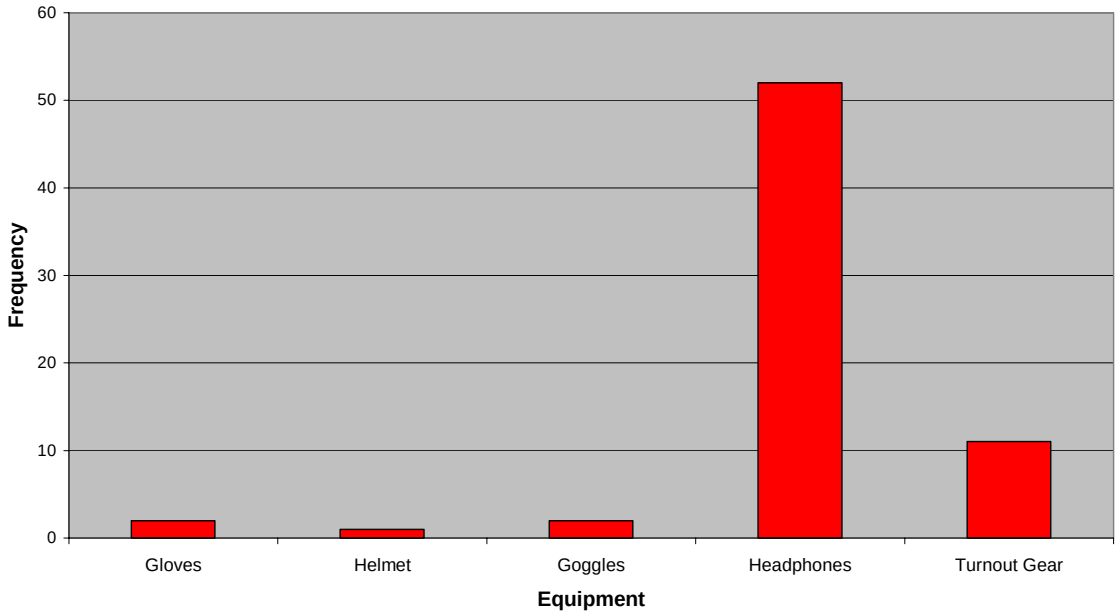

Figure 9. Equipment Worn While Driving

Next the drivers rated the following; comfort, seat adjustment, visibility, instrument panel organization, instrument panel view, reach, control usage, and control indication. The drivers agreed with the statements in the questionnaire. Refer to Appendix H. Level of Agreement**,** for charts reflecting the results of each statement.

Gauge usage was then rated. The order of usage frequency is ranked below based on the average of the most used gauges from highest to lowest**;**

1. Speedometer
2. Front Air Pressure
3. Rear Air Pressure
4. Fuel Level

5. Engine Oil Pressure
6. Engine Oil Temperature
7. Tachometer
8. Battery Voltage Level, Transmission Oil Temperature (tie)
9. Transmission Oil Pressure

Gauge usage charts are in Appendix I. Gauge Usage.

Controls usage was then rated. The order of usage frequency is ranked below based on the average of the most used controls from highest to lowest.

1. Turn Signal
2. Brake Controls
3. Headlight
4. Warning Lights
5. Siren
6. Transmission Gear Selector
7. Windshield Wiper/Washer
8. CB Radio
9. Heating/Cooling
10. Other

Gauge usage charts are in Appendix J. Controls Usage.

Drivers evaluated new features they would want on the apparatus they are driving. Features were found in the literature analysis used in other applications such as military vehicles.

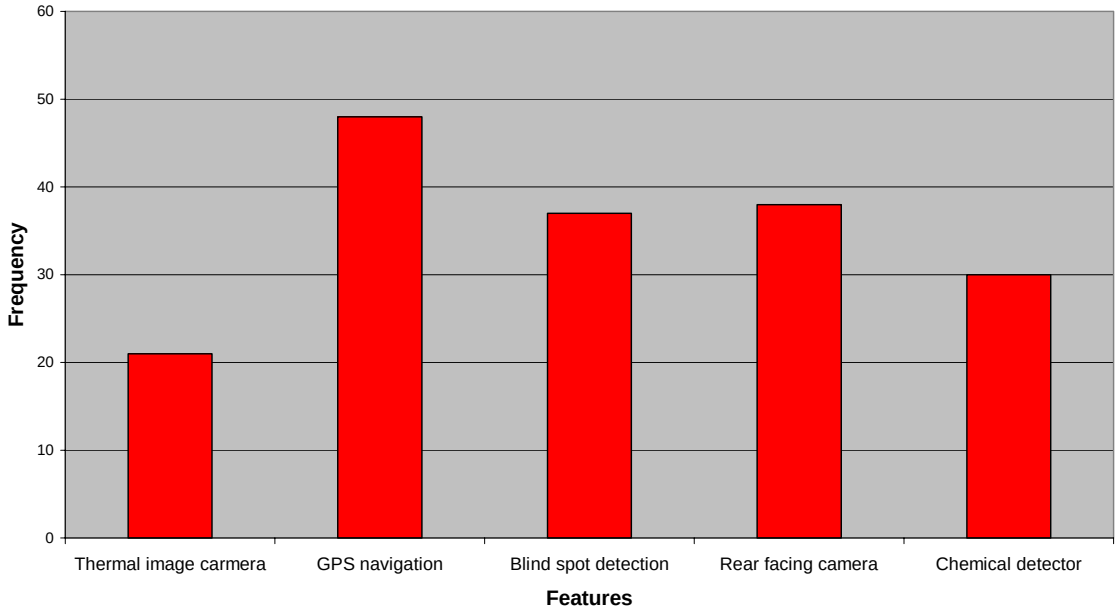

Figure 10. New Features

Digital mapping or GPS navigation was the most wanted feature. Drivers commented it would be easier to find hidden locations. One driver commented the "GPS system can show hydrant and Fire Department connections at the scene."

5.2.3. Design Critique Analysis

Ten percent of the Atlanta Fire Department apparatus drivers participated in the design critique of the instrument panel.

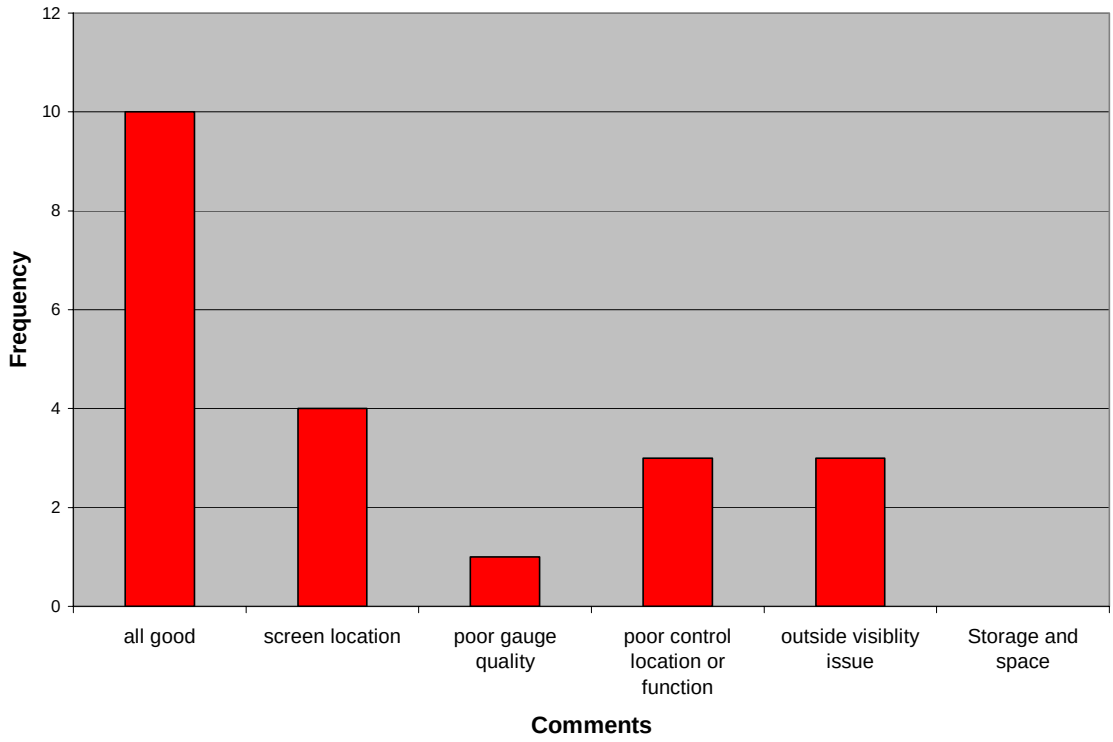

Figure 11. Driver Design Critique Responses

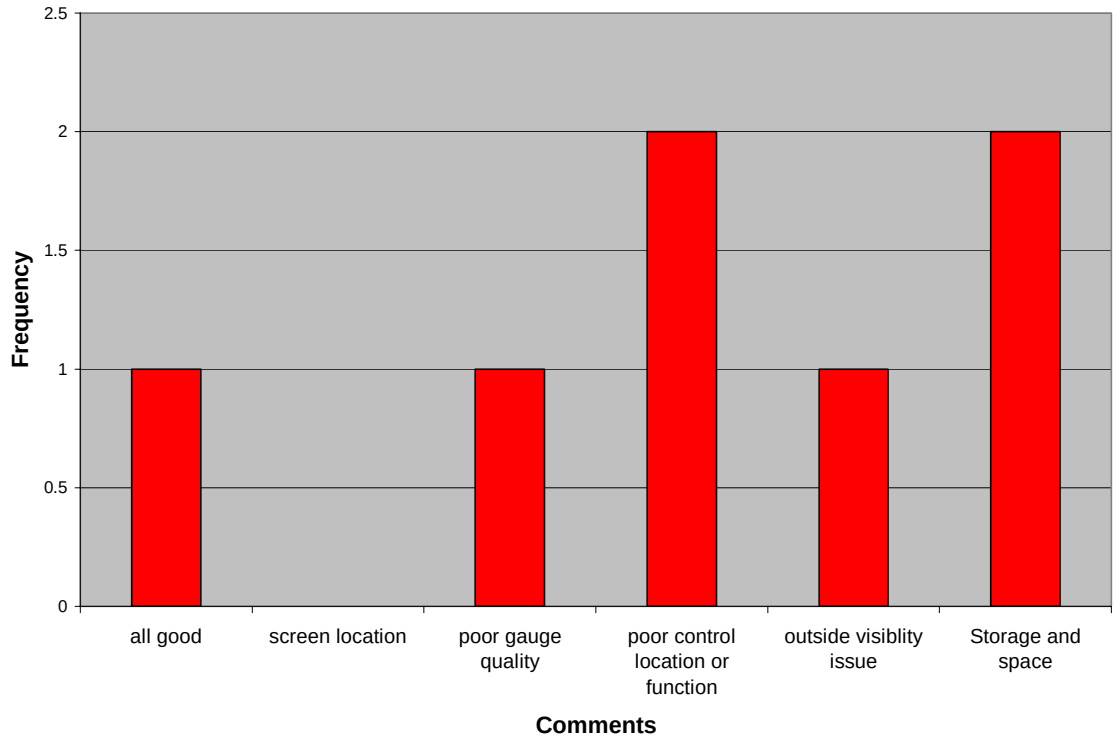

Figure 12. Captain Design Critique Responses

Three captains participated in the design critique. The poor controls location was related to the shared optical/audio warning switches.

Drivers and captains that operated the previous model apparatuses commented the current Spartan chassis instrument panel is a huge improvement. The older units required a longer reach to manipulate the warning controls. Drivers would have to lean forward to operate many of the siren and warning light controls now located in the center panel area of the newer Spartan Gladiator chassis. The push button transmission gear selector of the new Spartan Gladiator chassis is preferred to the lift and switch lever of the older vehicles. The area biased to the driver with the transmission gears select buttons is also a welcomed improvement.

Appendix K. Photo Collage of Design Critique

Figure L1. Design Critique Screen Locations

5.3 Conclusions

The research reflects how the instrument panel of an apparatus is really used. The research illustrates the driver is not the only user of the instrument panel. The captain also uses the instrument panel. Driver center zone control usage is based on the captain. Some drivers stated they are responsible for controlling the sirens and optical warning systems. Some captains prefer to control the horn and sirens. This difference was also indicated when drivers illustrated the ideal location of a screen to display mapping.

Some of the gauges do not work on the apparatus reflecting a quality issue. A few participants mentioned the air filter restriction gauge is useless. Atlanta uses preventative maintenance schedule and this is therefore not an issue.

Drivers indicated the instrument panel design is suitable for their needs. A few expressed “I like it how it is.” This fact is reflected in the overall level of agreement chart, Figure 13. Overall Satisfaction.

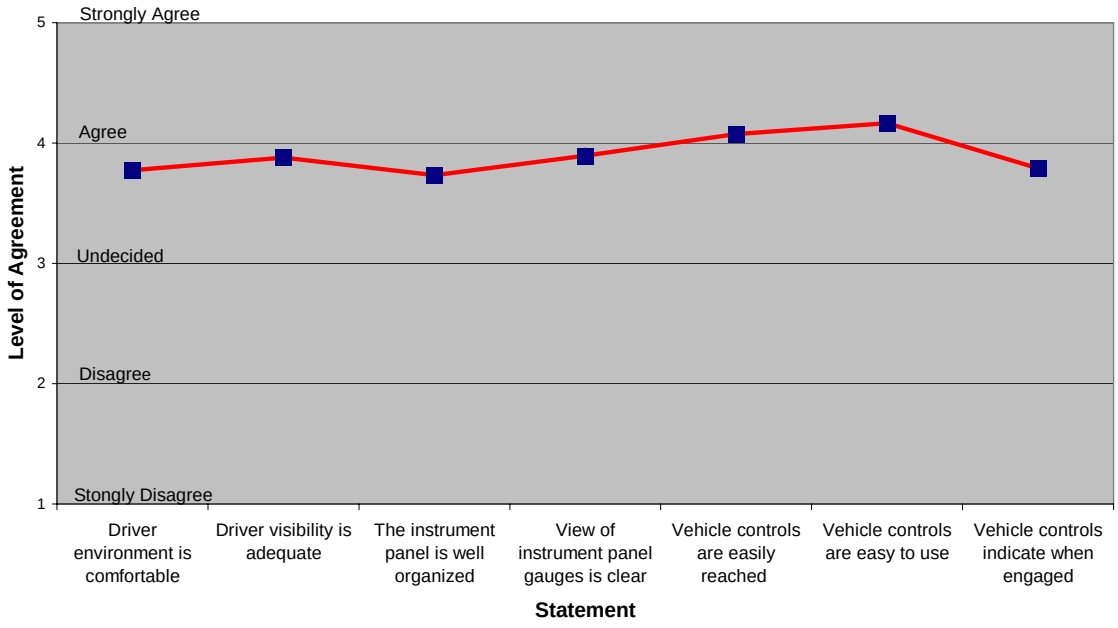

Figure 13. Overall Satisfaction

A possible reason for bias is that the trucks and engines are relatively new. Many have used the previous model and have stated the current newer Spartan chassis is a vast improvement. Many design evolutions can occur in ten years.

5.4. Recommendations

Fire apparatus manufacturing is very competitive. In order to get a market advantage, manufactures should not just rely on what is dictated by the NFPA 1901. Manufacturers need to ride with current fire crews in various cities to get a broader understanding of what occurs.

The questionnaire could gain more detailed information. First a questionnaire should be developed for drivers and another for officers. The two questionnaires could capture the instrument panel usage from the points of view of both users. There should be gauge and controls usage questions developed to reflect driving during an emergency and a non-emergency. For example, a driver commented he looks at the speedometer when driving on errands but during an emergency he doesn't use the gauges at all. More usage data can aid the layout of the instrument panel. A current sign of usage dictating design is the size and position of gauges in the driver binnacle. For example, the speedometer is larger and much more centralized than the fuel gauge.

More time was needed with the participants. Working with off duty firefighters in a simulator or using a Velcro model would help gain more insight into an ideal instrument panel layout. Both the driver and the captain should be evaluated together. It seems the background and personality of the captain dictates the overall usage of the instrument panel center panel.

The dynamic of performance under pressure was not fully explored. Firefighters, like many emergency responders, can be at a state of relaxation then suddenly they must respond to an emergency call. Measurements of heart rates and eye movements in the apparatus could be obtained to enhance the design layout of the instrument panel.

CHAPTER 6

DESIGN PROCEDURE

6.1. Human Factors

People are an integral part of instrument panel design. Operation of the apparatus integrates many aspects of human factors. It involves more than one person to operate an apparatus. Atlanta Fire Department has a minimum set of physical and cognitive standards to become a firefighter that narrows the scope of the population of users. Within the population of acceptable applicants remains variation in the physical and mental abilities of potential apparatus operators. For the city of Atlanta, the apparatus is used by three work shifts and substitute users. During the ten year service lifecycle, the apparatus will be used by various people with different levels of experience.

The physical demands of the job require a minimum physical requirement to be considered for the Atlanta Fire Department. Physical requirements for driving the apparatus requires the ability to manipulate the steering wheel, pedals, press buttons, pull knobs, and rotate knobs. There is a vision requirement that allows for corrected vision to needed levels. Operators need to be able to see objects at a distance and focus on objects closed to them. Peripheral vision is required to observe gauges and indicators from “corner of the eye” while focusing on something else. A person’s vision is affected by the vibration of apparatus due to the engine and terrain. Although both genders may be firefighters, males dominate the field. A concern of this is the fact males are most often color blind. Special attention is needed when selecting colors or color combinations for indicator and gauges.

Driving an apparatus requires a certain skill set. Since firefighters are over eighteen and are trained to drive the vehicle, they acquire and perfect the ability to drive quickly. Sign recognition is required to obey traffic laws and follow driving norms. Driving requires hand-eye coordination and distance judgment as the driver negotiates

traffic. The driver must be able to multitask as they drive, as they are receiving auditory input from the officer helping them locate the scenes.

Situational disabilities occur due to the environment and the use of necessary protective equipment. There is a hearing requirement to qualify for firefighting. Survey results reflect headphones are used by most of the apparatus drivers. The headphones allow the crew within the apparatus to communicate with each other and listen to Incident Command while on the road. At the same time, headphones can hamper the hearing of the user. Headphones are useful for quieting the din of the motor.

Apparatus drivers wear personal protective equipment while driving the apparatus. Some drivers wore gloves which reduce the hand dexterity of the user. Depending on the type and condition of the glove, user grip can be reduced on some surfaces. Gloves also reduce tactile feedback possibly making it more difficult to feel the switch or button engage. Turnout gear restricts mobility when worn, especially when seated in an apparatus.

There are numerous risks associated with operating an apparatus. Many times when the firefighters are using the apparatus to respond to a call from dispatch, life and or property is at risk. The squad can be responding to a medical emergency or a building on fire. There is a rush to get to the scene as quickly as possible. The driver must avoid vehicle accidents as they race to the scene. Risks include traffic and/or severe weather and may hamper rescue. Traffic can be slow moving in the mornings and evenings. Being in southeastern United States, the city of Atlanta does see thunderstorms, extreme heat, light snow/ice, hail, and tornados. Weather changes cause the driver to react differently. Risk increases with vehicle speed as reaction time to compensate for maneuvers or mistakes is reduced. Depending on the type of apparatus, there is a chance of jack-knifing the trailer due to abrupt maneuvers.

Sometimes death can result due to traffic accidents, slow response, or failure to respond.

While parking the vehicle, the crew must contend with spectators on the scene or those trying to help. The driver must read the terrain to park the apparatus in a suitable location that is most helpful for all on the scene. In some cases, there is a risk of hazardous chemicals being in the air as the fire crew arrives.

The call response time demands an apparatus require speed. The fire crew is on duty for twenty-four hours at a time. At a moments notice they are required to be ready to go. The driver performs maintenance checks at the beginning to the shift. Upon receiving a call, the crew must quickly get to the location of the emergency. The crew must quickly size up the situation while on the scene. Dispatch tells a limited amount of the actual situation emergencies, and they are often dynamic, it can be intensifying or subsiding.

Firefighters live in a hierarchical city government agency. There is a set series of rank and all have a list of responsibilities. They serve the public protecting community lives and property. Firefighter activities are often public.

A psychological factor that affects the firefighter is stress. The training firefighters receive help to offset the effects of stress. Through training, muscle memory is obtained. A firefighter can go from a relaxed state at the station to be rushing to an emergency.

6.2. Design Objectives

From the NFPA 1901 guidelines and Atlanta firefighter feedback objectives can be defined.

Objectives:

Durability (“firefighter proof”)

Reliability

Modular (easily modified or customized)

Easy to manufacture

Easy to repair

Safety

Intuitive Use

Customizability

Cost conscious (Fire Department, Manufacturer, Municipality)

The durability of the instrument panel is important since the Atlanta Fire Department purchases new apparatus every ten years. The reliability of the instrument panel is important due to the lives and property at risk. To ensure durability and reliability moving parts must be minimized. The modular layout will be maintained to ease manufacturing, customization, and maintenance. Safety will be aided by avoiding sharp angles. The layout will be intuitive following the standards of the industry. Clear layout can aid the firefighters to save lives.

6.3. Idea Generation

The concepts are driven by the data gathered by the research. In general, firefighters are satisfied with the current instrument panel. The previous apparatus model and the current model follow a standard gauge and controls placement method observed in fire apparatus design of numerous companies reflecting NFPA 1901 guidelines.

A radical design change can alienate potential customers and cause a longer learning curve for firefighters with experience. Changes must occur incrementally, driven by function. The apparatus along with the instrument panel is a tool to facilitate the firefighters to perform their job efficiently.

A new fire apparatus is not the place to put experimental technologies. Rugged and tested technologies are to be applied to the instrument panel. Private consumer

technology advancement occurs faster then the United States military funded projects. The advantage of this is a plethora of new products and technologies that have been tested by consumers in the market and the military.

6.4. Concepts

Concepts below take advantage of existing parts used by apparatus companies. The huge amount of parts currently existing makes it easer for suppliers to procure parts and customize customer apparatus orders.

Below, Figure 14. is the current Spartan Gladiator Chassis instrument panel used by the Atlanta Fire Department in the fire engine and fire truck.

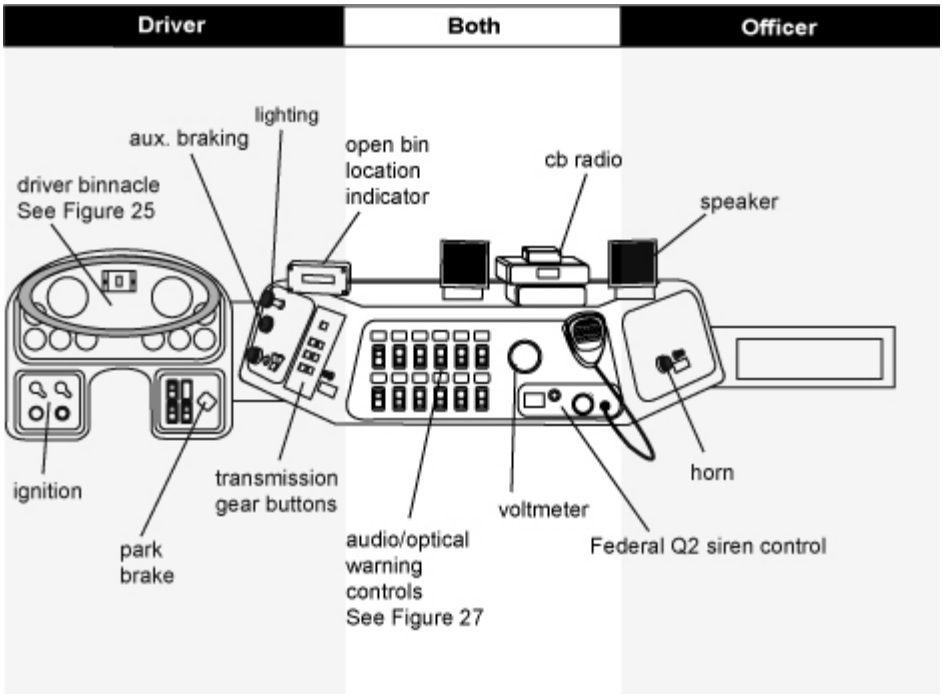

Figure 14. Current Spartan Instrument Panel

The layout is dictated by function. Referring to Figure 15. Current Spartan Instrument Panel Zones, The driver sits directly behind his or her primary control and feedback location. This includes the driver binnacle constantly updating the driver of the apparatus status. The tachometer and the speedometer gauge dominate the highest position and are the larges of the gauges. All other gauges are common in size.

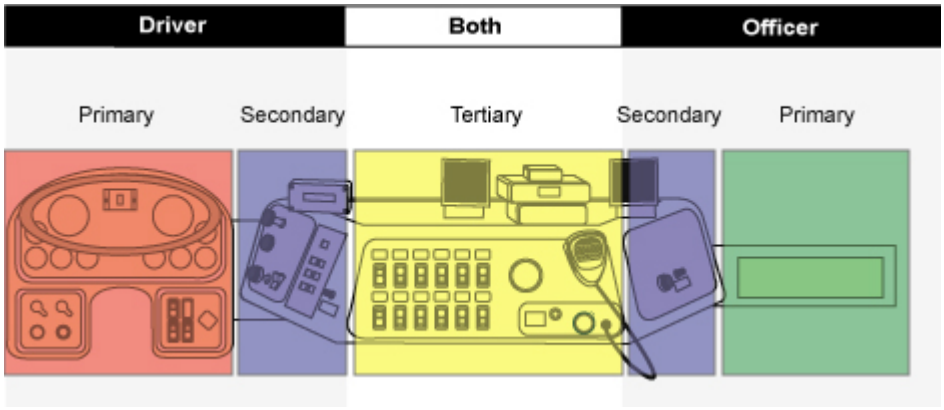

Figure 15. Current Spartan Instrument Panel Zones

The driver's secondary zone contains the open door indicator gauge and lighting, auxiliary braking, and transmission controls. The tertiary zone is use by both the driver and the captain or officer. The captain secondary zone contains a "press to talk button" and a horn. The officer sits directly behind a shelf.

Evolutionary concept 1, Figure 16., is based on the Spartan Gladiator Chassis instrument panel**.**

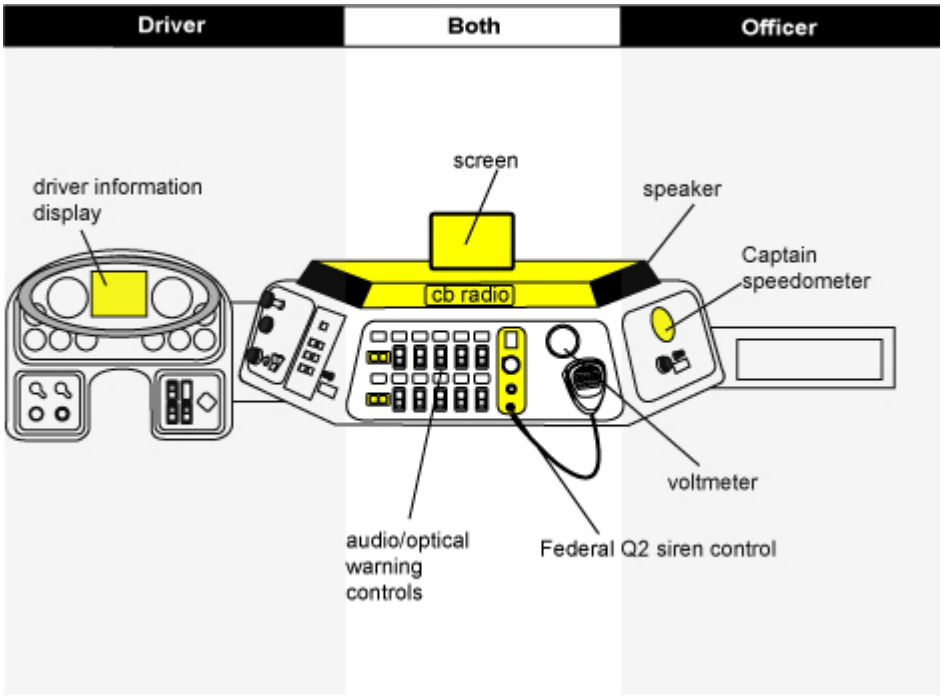

Figure 16. Evolutionary Concept 1

Changes begin with the driver binnacle, or combimeter, area, Figure 17. Driver Binnacle Changes. A screen is added between the speedometer and tachometer.

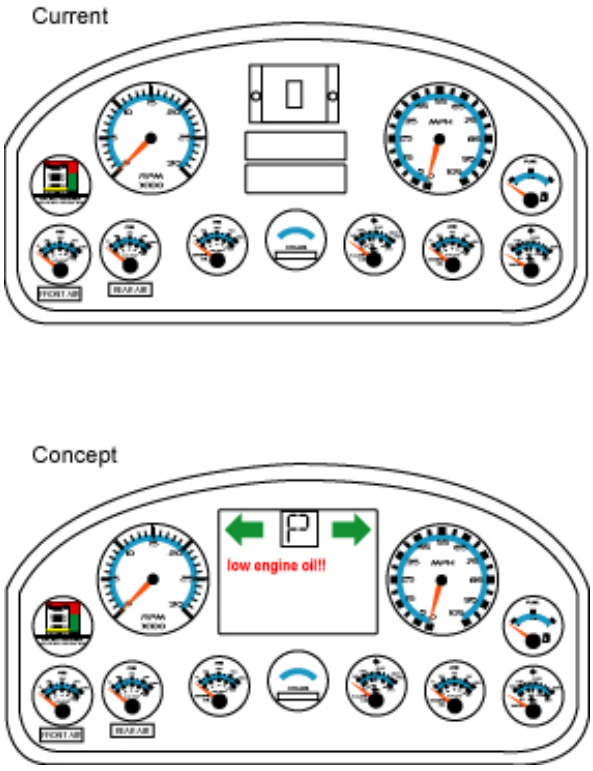

Figure 17. Driver Binnacle Changes.

The screen allows an opportunity to fulfill a multitude of functions using one part;

1. An open cab door or equipment compartment location indicator replacing the unit currently in place.
2. Show the gear the transmission is in.
3. Alert driver to situations that need their attention such as low oil level.
4. Show preventive maintenance information such as engine hours.
5. Show the turn signal indication.

Based on the research, drivers liked where the gauges are currently located. Analog gauges are maintained similar to the current model so the driver can obtain information instantly without input such as toggling through menus.

The reduction in the equipment on top of the instrument panel aids driver visibility. The radio and speakers are integrated into the instrument panel. The

instrument panel height is increased approximately two inches in height. The cb radio and speakers are integrated in a panel similar to the installation of radios in passenger vehicles.

The clearance provided space for a possible small display screen. The screen can potentially create a blind spot depending on its size. The screen can be mounted on a pivot to allow it to be biased toward the captain or the driver. The screen provides an opportunity to include the multiplex display features currently being offered by Spartan Chassis Incorporated and other apparatus companies. A possible scenario is when the apparatus transmission is set into reverse. The rear camera can activate transmitting the image to the instrument panel mounted screen. When drivers are reversing the apparatus, they look at the right and left door mounted external mirrors. As they rotate their head left and right, the screen would be in that same path easing use.

The screen can also display map information, Figure 18. Display Screen. A map of the street can be shown as the apparatus is driven to the scene of the emergency. This will be helpful to crews traveling to locations they are not familiar with such as responding to aid another station in a major fire. As the crew arrives at the scene the display can show fire hydrant or fire department connection locations to the driver.

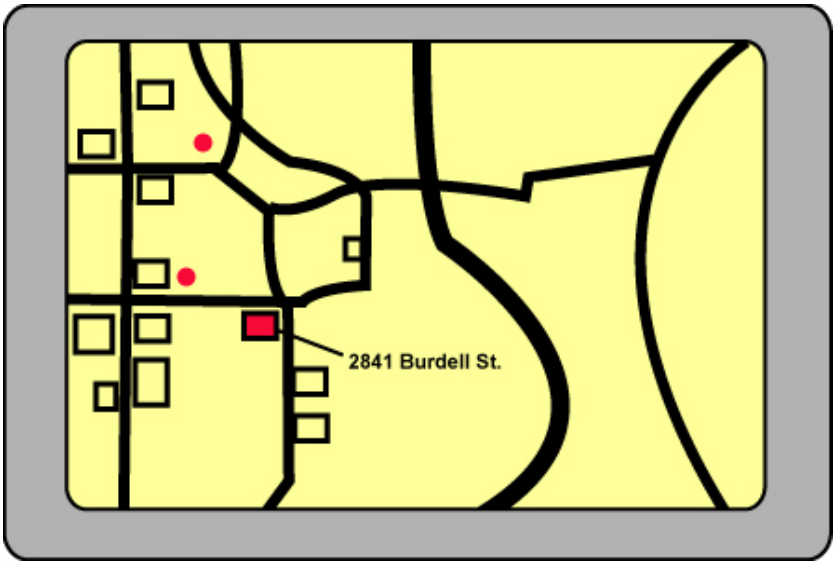

Figure 18. Display Screen.

The center panel changes ease driver use, Figure 19. Optical/Audio Warning Switches.

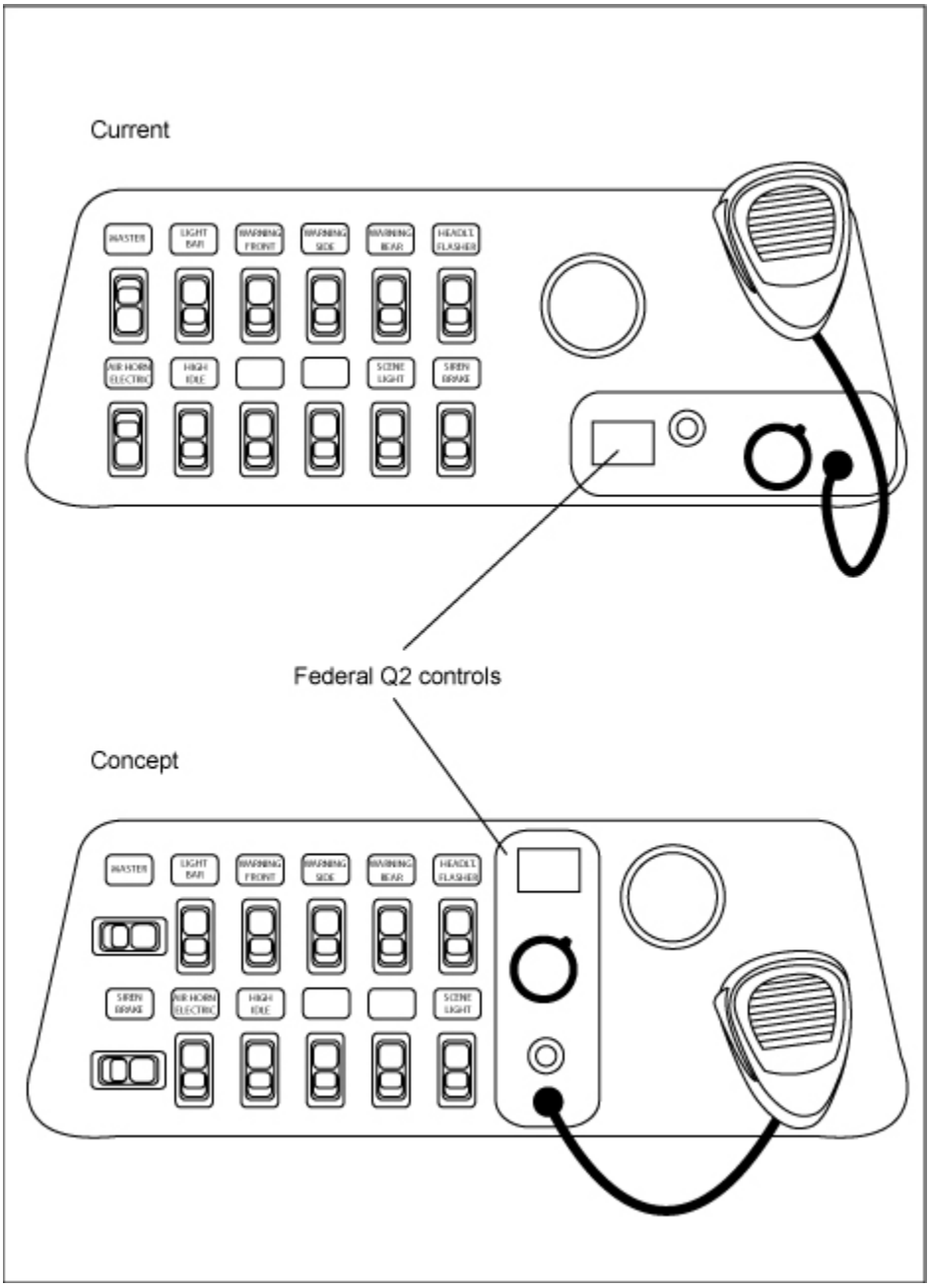

Figure 19. Optical/Audio Warning Switches.

It was articulated by a couple drivers that it was difficult to maneuver the apparatus and then reach for the siren brake when they are at the scene. The warning controls for the siren and lights are arranged to allow the driver to start and stop the lights and siren quickly. A similar technique is used on the keyboard on a computer. The home row is marked with small bumps on letters “f” and “j” on a “qwerty” keyboard. The master

switch and siren brake switch are closest to the driver and turned ninety degrees. The master switch controls all of the optical/audio warning switches and the siren brake stops the spinning of the siren in front of the apparatus. The siren is in front of the apparatus with a cylindrical shape is the Federal Q2, Figure 20. Federal Q2 Siren.

Figure 20. Federal Q2 Siren.

This change in position is to help drivers to find the switches quickly as they go around a corner on a medical call. Other possible orientations include staggering the switches or clustering the switches based on there function. Since a majority of the calls Atlanta firefighters respond to are medical calls, the driver will be able to silence the apparatus to avoid startling the victim needing medical attention. The change would be for the engine since it is sent on more emergencies.

The proposed concept illustrates a possible location for the captain speedometer. Atlanta Fire Department will soon be putting speedometers on the captain's side of the apparatus. The captain is ultimately responsible for the condition and performance of the apparatus he or she is in charge of. The new location avoids taking more space in the captain seat area and takes advantage of the easy to remove panel.

Additional configurations were developed to explore more possibilities. Some drivers and captains reported the captain would primarily use the screen as reflected in Figure 21. Evolutionary concept 2.

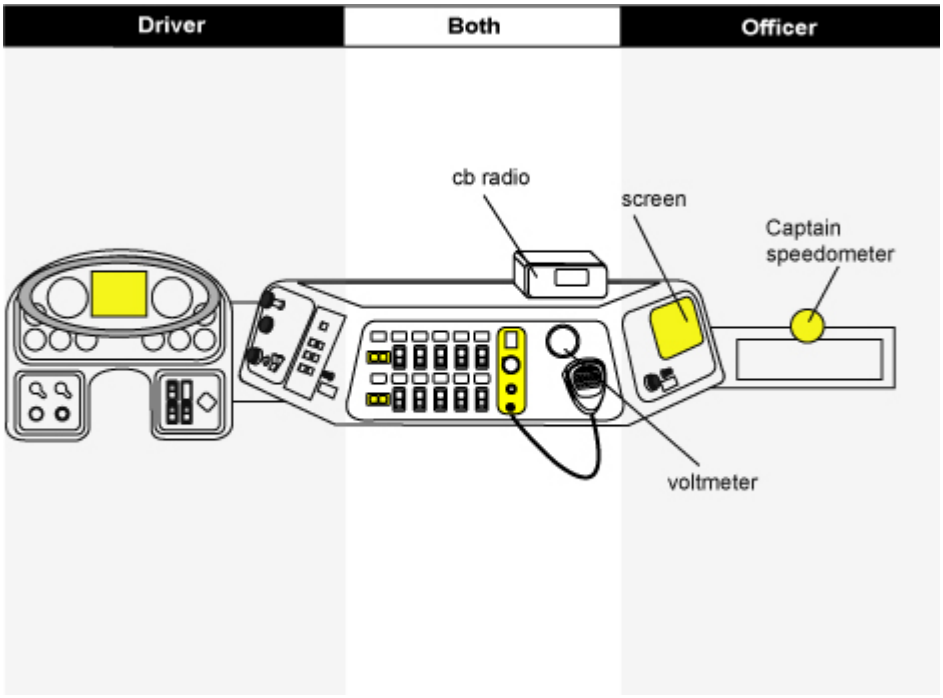

Figure 21. Evolutionary concept 2

Evolutionary concept 2 reflects the influences of the rally car instrument panel layout. The captain is like the co-driver of the rally car. Map information as well as building information could be on the screen. The captain can direct the driver to the location if needed. This layout allows the driver to focus on the road as they drive.

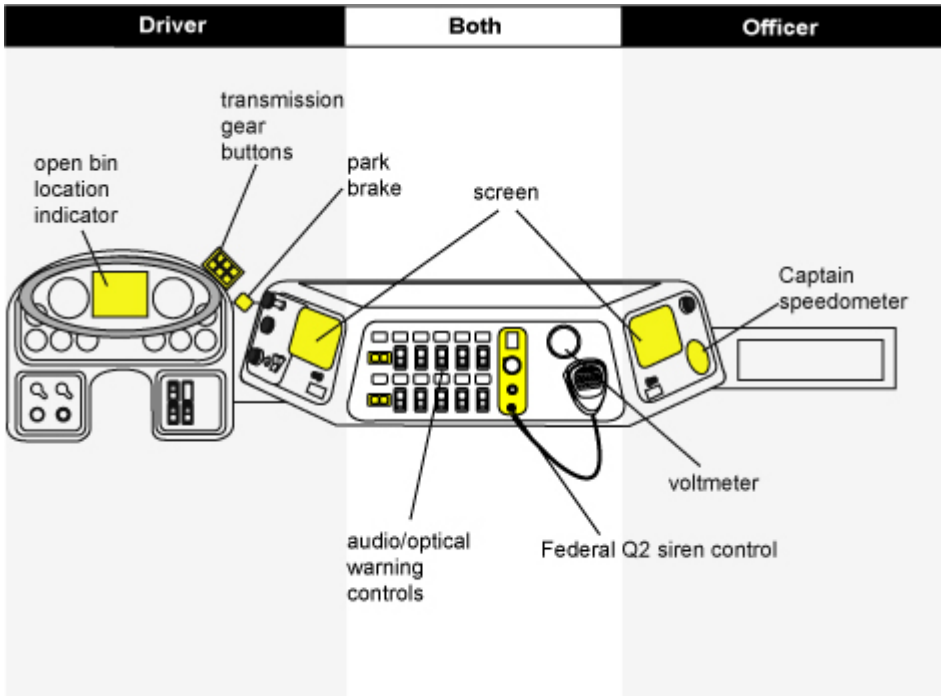

Figure 22. Evolutionary concept 3

Evolutionary concept 3 reflects the cockpit of a Lockheed C-130, Figure 22. Evolutionary concept 3. Two screens are used. One is dedicated to the driver and the other is for the captain. Controls for the transmission gear selection are mounted high to allow the driver to quickly manipulate them. The parking brake is mounted higher to avoid contact with the knee and to provide visual feedback if engaged.

On a smaller scale mapping can be use to simplify the layout of controls making them more intuitive to use. The optical/audio warning switches are identical switches in two rows. This layout requires the use of labels to reflect what each switch controls. It is possible to have the shape the switches to be shaped like a top view of the apparatus. The shape won't indicate what the switch is for.

6.5. Concepts beyond the scope of the instrument panel

There are issues that can be addressed by design beyond the scope of this thesis. Storage in front of the cab is an issue. Some of the stations have made

makeshift console bins to store items like clipboards and writing utensils. One station made a cover for their infrared camera-gun that allowed them to store pens on it.

Some of the drivers commented on the need for blind spot indicator. The A-pillars on the Spartan Gladiator make a blind spot making the apparatus more challenging to drive in traffic. A possible countermeasure is to have an indicator on each pillar that can indicate when someone is near the apparatus. The driver would be looking in the direction of the pillar therefore an indicator on the instrument panel would be useless.

A 12V accessory jack similar to those found in passenger vehicles could allow an area to charge equipment batteries. The batteries could be for walkie talkies or flashlights, therefore, firefighters will always have charged batteries ready. It will gain importance as more portable devices are carried by all firefighters.

6.6. Summary

Concepts were evolutionary steps reflecting firefighter feedback. The prime concerns were screen placement and center panel usage. The concepts were biased to the driver to keep their eyes on the road. The captain can look longer at the instrument panel since their tasks, as the apparatus is driven to the emergency, do not require them to react to rapidly changing dynamics such as traffic. The concepts reflect the different zones of the instrument panel. The zones illustrate the hierarchy of use.

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CHAPTER 7

FINAL RECOMMENDATIONS

7.1 Future Exploration

Advancements in technology and Atlanta's urban dynamics are changing and the fire department will evolve and adapt. Currently in Atlanta there are many large construction projects changing the city. In the past four years there have been dynamic changes to the cityscape. More high-rise condominiums, refurbishment of old urban neighborhoods and many large scale venues like an aquarium will put more demand on the Atlanta Fire Department's services.

There is an opportunity to propose concepts that are considered blue-sky now but can be commonplace in ten to twenty years. Technologies that will be tested by the time Atlanta is ready to purchase new apparatuses will include hybrid powertrains, drive by wire controls, and environment sampling for toxins. At the same time the instrument panel designs must balance standardized features with these newer technologies since firefighters will continue to respond to many of the same emergencies.

More features are being designed into the apparatus. The increase in features is resulting in more controls and gauges being placed in the instrument panel. The amount of gauges and controls will begin to have a crowded layout. Instrument panel designers in passenger automobiles are dealing with the increasing features by reducing the amount of controls and employing menus for the driver to select what function they want to activate. This is illustrated in systems like the BMW i-Drive interface or voice controlled systems found in a few model. Aircraft cockpit designers are dealing with the same dilemma of increasing features by simplifying the controls and reducing the amount of gauges by adding more display screens producing the glass cockpit.

Develop more concepts looking at technologies in commercial and military markets. Utilize mapping of various switches to decrease the need of labels. The NFPA

may need to consider standardizing icons to replace labels. As concepts are refined a model or a series of models would be helpful to illustrate new layout possibilities to the firefighters. It would be easier for firefighters to evaluate and comment on.

There are various vehicles in the fire department. Some interesting vehicles that provide plenty of opportunity to research human machine interface include:

Battalion Chief Vehicle: Provides many design opportunities. There is mapping, situational updates via radio, and coordination of resources. Currently there is a magnetic mapping system used similar to a navy war room map displaying apparatus and personal location with magnets and using dry erase markers to show firefighter movement while tackling a situation on the emergency site.

Airport Rescue Fire Fighting Apparatus: The vehicle is mentioned but not explored. In Atlanta the municipal firefighters with urban experience are assigned to the airport fire stations. It is a change in environment. The apparatus is made to respond quickly with the added element of dealing with aircrafts.

7.2 Recommendations

Expand research and work with fire departments nationwide. Fire departments all over the United States are dealing with common issues in fire fighting. Fire departments also communicate with each other nationwide comparing notes about training and equipment usage. Major incidents or catastrophes are studied by the fire department to see what can be learned from the situation. At the same time various city environments place different demands on the firefighter and the fire equipment.

Questionnaires need to be developed for the driver and captain. Each uses the instrument panel differently. Capturing feature usage of each would add insight in designing the instrument panel.

7.3 Final Statement

Design research allows the expert to voice their experience. In this case the firefighters are the experts of the apparatus. The captains and drivers are trained to operate the apparatus and use it every work shift. A designer working on the design of the instrument panel must try to immerse themselves in the experience and talk to the experts. A designer can't learn about how a current product is actually used from literature reviews or websites.

The designer must look for how people make accommodations and may not even notice it. An Atlanta Fire Department apparatus driver can be trained to drive the current apparatus and may never drive another brand therefore may not have anything to compare his or her experience too. This means drivers know the layout since in many cases it is the only type they have used.

The research illustrated how the gauges and controls are used by the driver and captain. Over all drivers agree the instrument panel performs satisfactorily. There is drastic improvement in instrument panel designs comparing the previous model apparatus to the current models.

Many contacts were made to public officials that were interested in the research. Companies contacted illustrated a new field; designing for first responders. There are numerous companies specializing in designing and manufacturing equipment for firefighters, police, and paramedics.

APPENDIX A

DECISION MATRIX

Table A1. Decision Matrix

	Add to body of knowledge	Room for innovation	Interesting	Accessible	Total
Vehicles					
Sports Car GT	0	0	1	1	2
Compact Sports Car	0	0	1	1	2
Luxury Car	0	0	0	1	1
Family Sedan	0	0	0	1	1
Minivan	0	0	0	1	1
Sports Utility/Pickup	0	0	1	1	2
					0
School Bus	1	1	0	1	3
Ambulance	1	1	0	1	3
Mini Ambulance (SUV)	1	1	0	1	3
Police Car	1	1	1	1	4
Firetruck	1	1	1	1	4
Bomb Squad Vehicle	1	1	1	0	3
Armored Truck	1	1	1	1	4
Commercial Truck	1	0	1	1	3
Catering/delivery Truck	0	1	0	1	2
Tow Truck	1	1	0	1	3
In town Delivery Truck	1	0	1	1	3
Mining Haul Truck	1	0	1	0	2
Dump truck	0	0	0	0	0
Back Hoe	0	0	0	1	1
Bobcat	0	1	1	1	3
Timberjack	1	1	0	0	2
Wildfire Truck	1	1	1	0	3
					0
Fork Lift	0	0	0	1	1
Tow Hauler	1	0	0	1	2

APPENDIX B

INCIDENT RESPONSES OF THE ATLANTA FIRE DEPARTMENT

High rise >75ft

- 4 engines
- 3 trucks
- 2 Battalion Chiefs (command of fire and safety)
- 1 Medical Command
- 1 additional engine, with the confirmation of a working fire.
- Squad
- Customer service van

Low rise <75ft

- 3 engines
- 2 trucks
- 2 Battalion Chiefs
- 1 Medical Command
- 1 additional engine, with the confirmation of a working fire.
- Squad
- Customer service van

Auto Accident:

- 1 engine

Auto Accident w/ entrapment

- 1 Engine
- 1 Truck
- Battalion Chief

Wood Fire

- 1 Engine (level 1, 2, or 3)
- 2 Engine (level 4 & 5)

Alarm Bell

- 1 Engine
- 1 Truck
- Battalion Chief

2nd Alarm +

- all that is sent to a low rise situation

Hazmat

- 3 Engine
- 2 Trucks
- 1 Medical Command
- 1 Squad
- De-Contamination Unit
- Both Battalion Chiefs

Squad: heavy rescue unit with a captain, a driver, and four fire fighters

Customer service van: puts people of business in livable situation and collects salvageable belongings. Also helps put businesses back into business.

Battalion chiefs coordinate the movement of personnel and equipment at the scene. One battalion chief is responsible for the command of the fire, and the other is responsible for safety. Medical command provides medical attention to the injured. A squad is a heavy rescue unit with a captain, a driver, and four firefighters. This is for additional manpower. A customer service van helps put people in temporary living situations if their dwelling was damaged and also collects salvageable belongings. Also, customer service facilitates businesses by putting them back into business.

The following actions are to occur at the scene of an emergency. The first unit arrives at the emergency is to give an initial report. An initial report is a short radio report specifying name of command, location confirmation, and building or environment. The building or environment information reported is building height, construction type, overall dimensions, critical factors, any actions taken, and exposures.

Staging occurs during situations requiring a number of units to respond. Staging is the coordination of resources at the scene. Other units stay back and gather in an empty parking lot or on the street to prepare to react. The scene is divided into sectors or areas of operation. Resources are assigned to each sector. As ranking officers arrive to the scene and the transfer of command occurs. The officer assuming command is to be updated on the general situation status, phase of operation, critical factors, sector assigned, and resources deployed/requested. Officers in command monitor work progress, direct activities, coordinate performing related activities, and monitor the safety of personal.

APPENDIX C

FIRE APPARATUS DRIVER QUESTIONNAIRE

Fire Apparatus Driver Questionnaire

Purpose: This is a Georgia Institute of Technology research study. It will take less than 10 minutes to complete the following questionnaire. This voluntary survey has no risk and no compensation.

Comments: Any comments or concerns please contact:

Taro Walcott
Georgia Institute of Technology
Email: gtg522d@mail.gatech.edu

Survey:

What equipment do you wear while you drive?

Gloves Helmet Goggles Headphones Turnout Gear

In the following section, please mark answer:

SD = Strongly Disagree
D = Disagree
U = Undecided
A = Agree
SA = Strongly Agree

Driver environment is comfortable	SD	D	U	A	SA
Driver visibility is adequate	SD	D	U	A	SA
The instrument panel is well organized.	SD	D	U	A	SA
View of instrument panel gauges is clear	SD	D	U	A	SA
Vehicle controls are easily reached	SD	D	U	A	SA
Vehicle controls are easy to use	SD	D	U	A	SA
Vehicle controls indicate when engaged	SD	D	U	A	SA

In the following section, please mark all that are applicable:

What gauges do you look at the most on while you drive?

☐Speedometer (vehicle speed) ☐Tachometer (engine speed)
☐Battery Voltage Level ☐Fuel Level
☐Engine Oil Temperature ☐Engine Oil Pressure
☐Transmission Oil Temperature ☐Transmission Oil Pressure
☐Front Air Pressure ☐Rear Air Pressure

What gauges do you look at the least while you drive?

☐Speedometer (vehicle speed)	☐Tachometer (engine speed)
☐Battery Voltage Level	☐Fuel Level
☐Engine Oil Temperature	☐Engine Oil Pressure
☐Transmission Oil Temperature	☐Transmission Oil Pressure
☐Front Air Pressure	☐Rear Air Pressure

What controls do you use the most while you are driving?

☐Transmission gear selector	☐Windshield wiper washer
☐Walkie Talkie/Radio/CB	☐Heating/Cooling Controls
☐Headlights	☐Siren
☐Warning Lights	☐Braking Controls
☐Turn signals	☐Other_____

What controls do you use the least while you are driving?

☐Transmission gear selector	☐Windshield wiper washer
☐Walkie Talkie/Radio/CB	☐Heating/Cooling Controls
☐Headlights	☐Siren
☐Warning Lights	☐Braking Controls
☐Turn signals	☐Other_____

What items would you want on the fire truck instrument panel?

☐Thermal image camera screen: Displays hot spots such as fires or people in buildings

☐GPS satellite navigation: Screen with maps to aid the driver locate place in city

☐Blind spot detection: Warning to let driver know when a motorist is in the blind spot

☐Rear facing camera: Displays what is behind the apparatus

☐Chemical detector: Warns firefighters in the cab what chemical, biological, or radioactive toxins are in the air in an immediate area

☐Other: -

_____

_____

_____

Comments:

_____

_____

_____

_____

Thank you for taking the time to fill this survey out. Please feel free to contact me with any comments or concerns regarding this survey.

Any comments or concern can be sent to:

Taro Walcott
Georgia Institute of Technology
Email: gtg522d@mail.gatech.edu

APPENDIX D

OBSERVATION RIDE-ALONG NOTES

Ride Along Notes

Shift begins at 7am and has duration of 24 hours. Then the firefighters are off for 48 hours.

7:30am Met with the captain signed wavier form

7:31 am Alarm. Rode in Engine (Pumper) behind the driver.

Engine driver door is left open. In the front passenger seat sits the captain/lieutenant/most seniority and behind him sits a firefighter with gear (boots with overalls & helmet) at his side. The back seats are on back wall of cab and are folding movie style jump seats. Crew puts on earphones. Through the earphones crew with in cab can talk to each other, hear communications from dispatch, and the earphones reduce the noise of the siren to lower levels. The siren and lights are put on as they truck leaves the station. The windows of the truck were left open it was a clear day at about 70 deg F.

Senior officer of vehicle crew always carries cb radio. It always has dispatch on. The series of tones are used to tell when a squad is being told where to go.

On the way:

Senior officer in passenger seat gives directions (Location is given over the radio from dispatch)

Both the truck (aerial) and the engine (pumper) where driven to the scene. An officer from the other truck walked over to driver of the engine and said something is happening on the sixth floor.

The siren was turned off when the vehicle was parked. The flashing lights were left on.

The co-driver (captain/lieutenant/senior) officer and the firefighter sitting behind him took off earphones and left to go into the building. The driver remained took of his earphones and turned a couple dials of the cb radio mounted on the dashboard. The diesel engine is left running. The dash mounted radio had speakers on top to the instrument panel.

Co-driver radios driver from inside the building. The driver turns around the engine. The co-driver and firefighter get into truck.

8:00 Engine back to station

Driver pulls engine up to station stops and co-driver and rear ff get out and stop traffic one at each end of the engine. The driver reverses the engine into the station driveway. The driver doesn't pull engine into the bay. The driver parks vehicle leaving the engine on and turns a few dials and move a couple levers on panel behind the cab.

The driver tells me it is routine at the beginning of each shift equipment is checked. He was checking the water pump of the engine and confirming the pressures and controls are working.

The apparatus will be checked: necessary fluid levels are confirmed (e.g. engine oil, transmission, windshield washer…)

8:15 Run to the grocery store.

Vehicle crew (Driver, Co-driver, and rear ff) always rides together. New driver is driving (he is a substitute from another station getting overtime)

8:20 On the way to grocery store

Call from dispatch. To aid non-respondent person at dialysis center. Dispatch provides situation and location, the address.

Some issue finding location. Co-driver led driver the street location. Addresses on building were used.

8:27 Crew called away by dispatch. Grady got to the location before the Engine.

Back to going to the grocery store. The engine crew is buying breakfast for the station. The radio someone was carrying had a dead battery.

9:10 Back at the station.

Had a chance to talk to a driver. He is the substitute driver.

He states a navigation system is a good idea it is used in other locations. "Atlanta usually lags behind. They're smaller communities the much better equipment." He tells me about a navigation system not only for street mapping, but has building blueprint information. He stated this would be helpful in large buildings and high rise offices. A few battalion cars in Fulton County may have it.

9:30 Left to do errands

Engine crew always travels together. No siren /lights on. All in cab wear earphones to communicate. They stopped at another station but no one was there (they were on call).

Stopped at another station further away to get fuel. The driver puts fuel in the truck.

The co-driver tells dispatch weather the engine is in or out of "service" When in service truck is ready for a call.

10:30 Breakfast.

Earlier the station radioed co-driver breakfast was ready. Engine crew got back in time.

11:30 Flush Hydrants

One of the fire fighters duties is to flush fire hydrants and check they are working as part of preventative maintenance. "It is one of the mundane tasks. The water department dumped it on us." Each station is assigned a set of fire hydrants to check monthly.

The fire hydrant list with locations is on paper. Each fire hydrant has a piece of paper with a chart so firefighters can list any issues and check of they checked the hydrant. Any hydrants with issues are reported to the water department for them to be repaired.

Driver stays in engine moving it down the street as co-driver and rear fire fighter are outside. Rear fire fighter is turning wrench checking the hydrant valves and flushing some of the water out.

APPENDIX E

QUESTIONNAIRE RAW DATA

Table E1. Questionnaire Raw Data

What equipment do you wear while you drive?							
Gloves	2						
Helmet	1						
Goggles	2						
Headphones	52						
Turnout Gear	11						
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree		
Driver environment is comfortable	1	4	9	48	5		
Driver visibility is adequate	1	7	4	42	13		
The instrument panel is well organized	1	4	14	41	7		
View of instrument panel gauges is clear	2	4	5	44	12		
Vehicle controls are easily reached	1	4	5	36	21		
Vehicle controls are easy to use	1	1	2	45	18		
Vehicle controls indicate when engaged	1	6	6	47	7		
gauges used the:			most		least		
Speedometer (vehicle speed)			53		2		
Battery Voltage Level			5		29		
Engine Oil Temperature			10		18		

Transmission Oil Temperature					4		22		
Front Air Pressure					26		12		
Tachometer (engine speed)					9		23		
Fuel Level					23		21		
Engine Oil Pressure					18		5		
Transmission Oil Pressure					5		18		
Rear Air Pressure					24		18		
controls used the:					most		least		
Transmission gear selector					16		10		
Walkie Talkie/Radio/CB					6		35		
Headlights					30		2		
Warning Lights					25		1		
Turn signals					39		2		
Windshield wiper washer					10		28		
Heating/Cooling Controls					4		34		
Siren					22		4		
Braking Controls					34		3		
Other					1	horn	1		
					3	steering wheel			
What Items would you want on the fire truck instrument panel?									
Thermal image camera screen							21		
GPS satellite navigation							48		
Blind spot detection							37		
Rear facing camera							38		
Chemical detector							30		
Other:									
OUTSIDE TEMPERATURE GAUGE									1
COFFEE CUP HOLDERS									1
LIGHTING NEED TO BE IMPROVED OF COLET CRASH TRUCK									1
ON BOARD DASH CAMERA FOR ACCIDENTS INVOLVING APPARATUS/Video camera(s) to record traffic, and conditions similar to Police Dash									2
BETTER WINDOW DEFROSTERS,									1
AM/FM RADIO/CD with pre-empt for FD Radio.									1
Comments:									
KEEP TRUCK AS SIMPLE AS POSSIBLE BUT WITH COMFORT									

APPENDIX F

DESIGN CRITIQUE NOTES

Observations Notes March 17, 2005

D1

- All gauges and controls are in a good location
- Want a larger screen than 6 in by 5 in

D2

- Controls and Gauges are in good location no need to change.

D3

- Problem with gauges is they don't work well. They are not accurate so I don't use some of them. For example the air filter restriction gauge.

D4

- Nothing should be put higher than the dashboard.
- The current radios and fans
- Produce blind spot making things hard to see in traffic.
- It would be nice to have a flip down screen from the ceiling of the cab on a swivel so driver and captain can use it.

D5

- Too many blind spots. A-Pillar blind spots are huge, making it difficult to driver apparatus in traffic.
- The emergency/parking brake should be relocated. The button (bright yellow diamond) is easily to hit with you right knee.

Five responses including a captain

- It would be nice to have a flip down screen from the ceiling of the cab on a swivel so driver and captain can use it.
- A-pillar blind spots are large.
- GPS system can show hydrant and Fire Department connections at the scene.
- Someone at station made a box over the infrared camera tool. Since space is so tight the box has an area for pens
- There needs to be space around the captain for notebooks/clipboards, map, extra batteries for radios, and pens.
- The driver also needs space for a notebook.
- The navi screen can also show the back of the apparatus when transmission is shifted into reverse
- Panel/Door ajar indicator is sensitive to objects loose in cabins sometimes provide false readings causing crew to leave later since they must try address the loose panel or door.
- No space for Roster Cards (plastic cards w/ names reflecting crew at scene). Required to give to chief reflecting the crew on a scene.
  -possible to electronic link so the Chiefs knows the actual people that went onto the scene.
- No room in apparatus to put on turnout gear but we get in trouble for putting on gear on site because a civilian will complain to the city the firefighters were not ready at the site.
- We (captains) are to get a speedometer? There is nowhere to put it.

- Need a bin in center console area

Capt.1

- The bouncing of the truck makes it difficult to read a map.

D1

- Move locker box from back of apparatus. It make it hard to learn the territory as a firefighter if you can't see outside the apparatus.
- Easy to mess up sequence of Pumping. It is with engine on switch transmission to neutral, engage PTO, then place into drive (transmission) goes to fourth gear. If in wrong sequence you can tear up transmission
- Screen on drive side can be helpful.

D1

- Screen should be on officer side. Driver is too busy to use it on route to the scene.
- Radio location is good I often tuning to the various stations.

C

- Federal Q2 is the big cylinder on the front of the apparatus it spins to make noise. Pitch and be controlled at panel by driver or officer.
- Need a lighting system so people can see apparatus at night at an accident scene

D

- Master switch and siren brake need to switch positions so you know where the brake is it would be the first one.
- E-siren switches are a bit out of reach and difficult to see.
- Sometimes the captain operates the switches and sometimes the driver operates the switches based on personality of officer.
- Blind spot detector is good, blind spots are a huge issue

APPENDIX G

CONSOLE ITEMS

Pens and pencils
Note pads
Walkie talkie
Roster Cards
Spray bottle (lens cleaner)
Cleaning rag
Phone, base
Gloves
Phone in base
Face mask
Keys
Maps
Papers
Notebooks
Turnout jacket
Helmet
Flashlight
3 ring binder
Spiral notebook
Book
Infrared scanner (MSA Evolution 5000)

APPENDIX H

LEVEL OF AGREEMENT

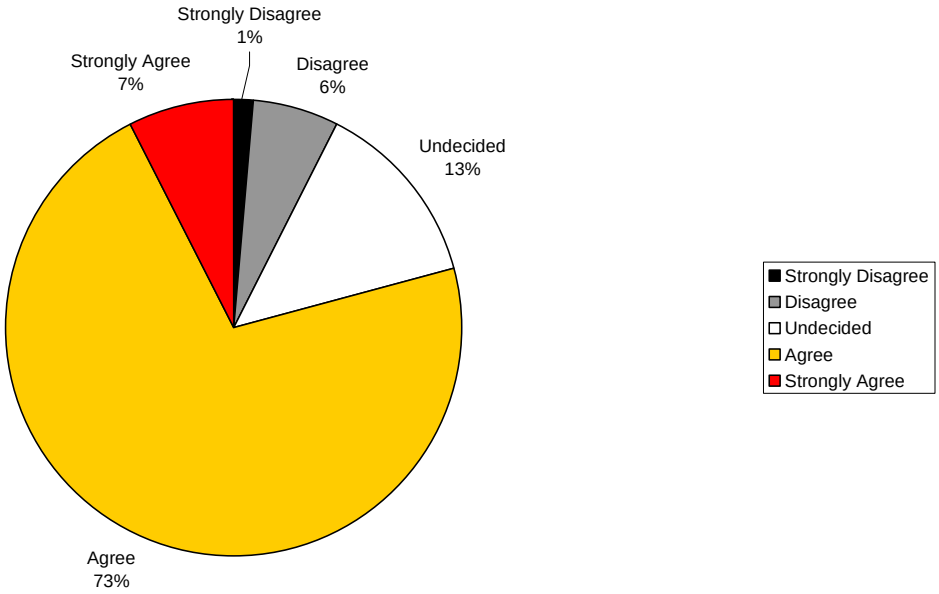

Figure H1. Driver environment is comfortable

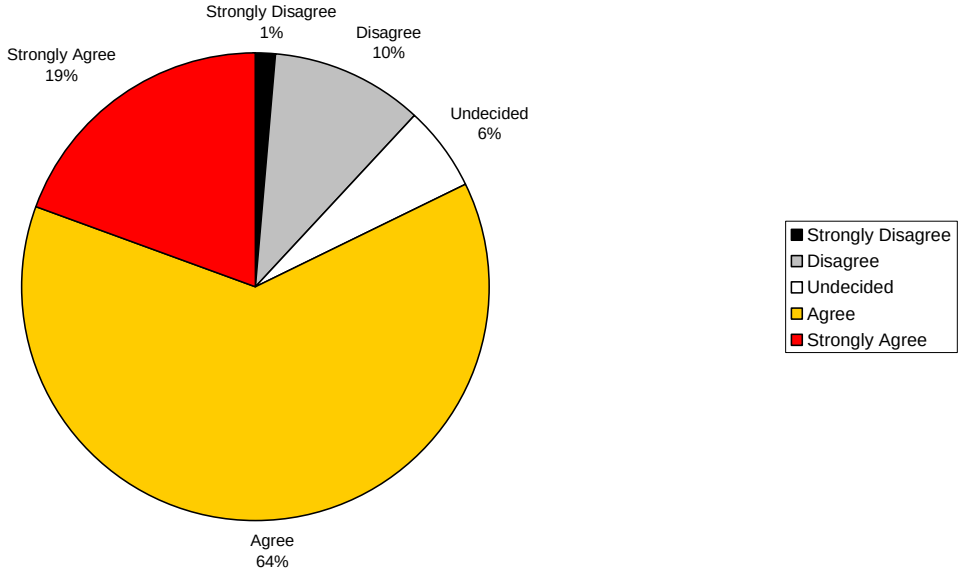

Figure H2. Driver visibility is adequate

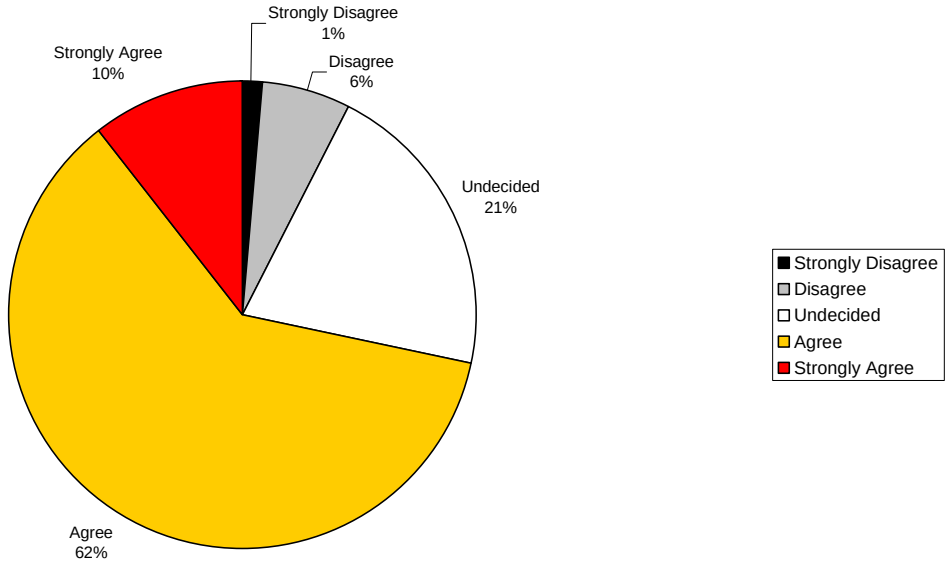

Figure H3. The instrument panel is well organized

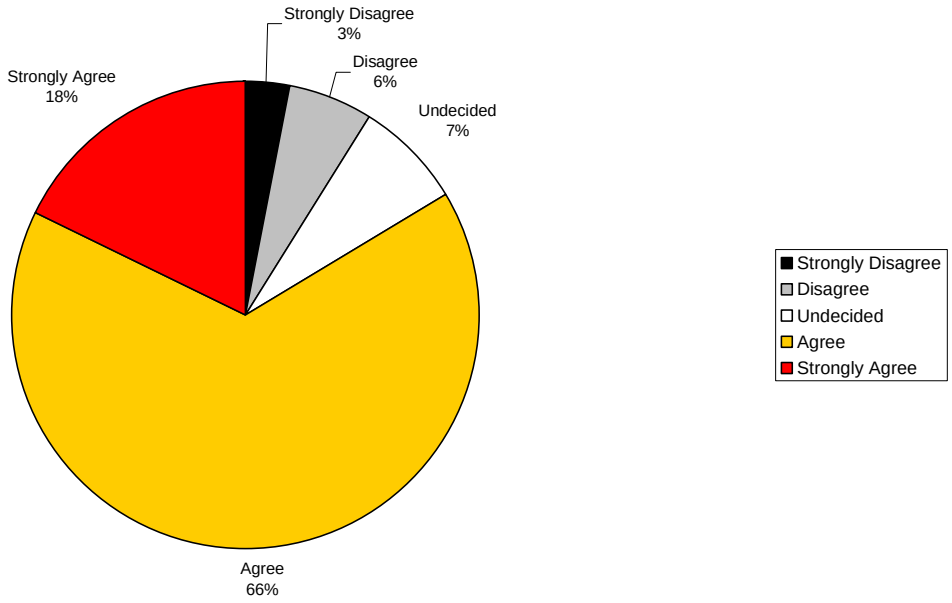

Figure H4. View of the instrument panel is clear

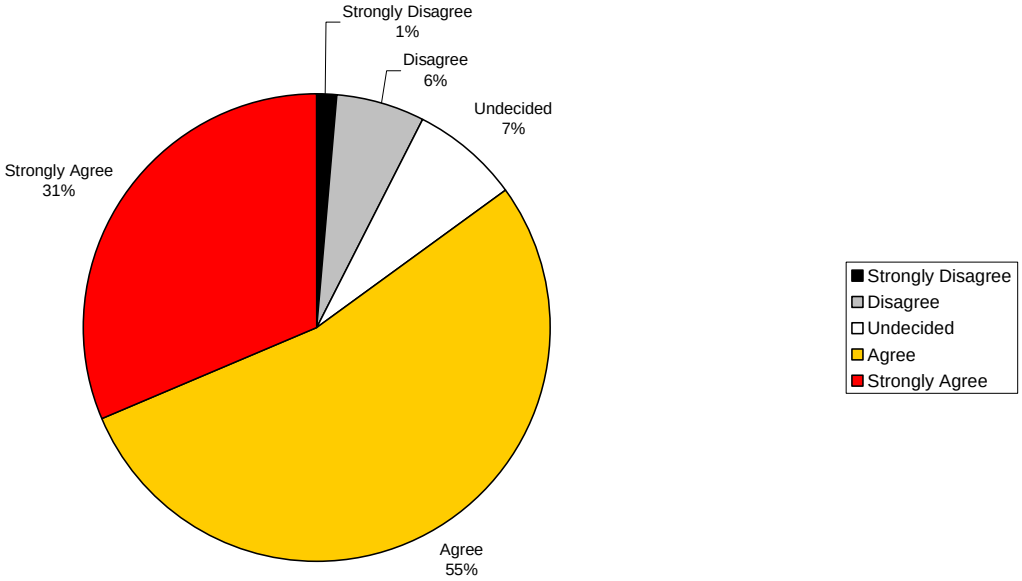

Figure H5. Vehicle controls are easily reached

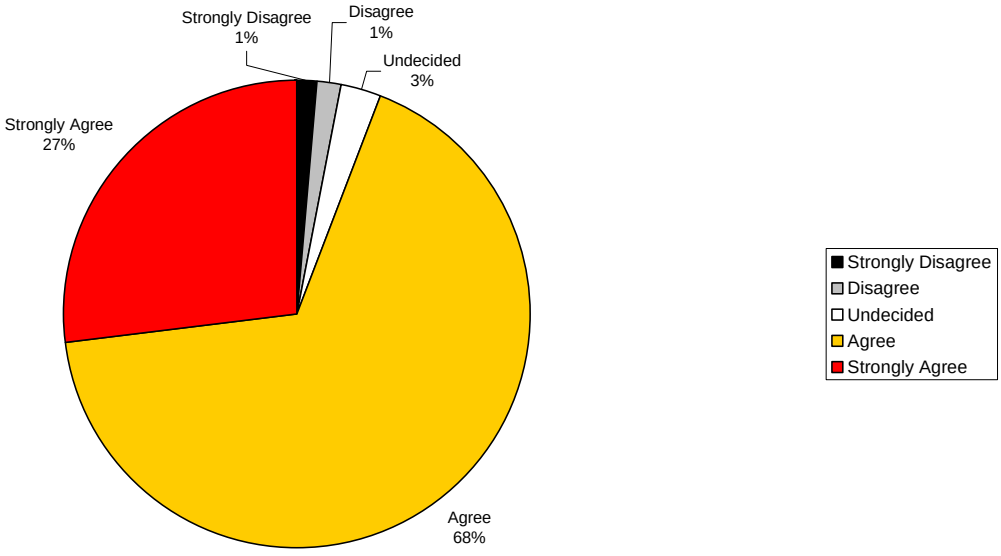

Figure H6. Vehicle controls are easy to use

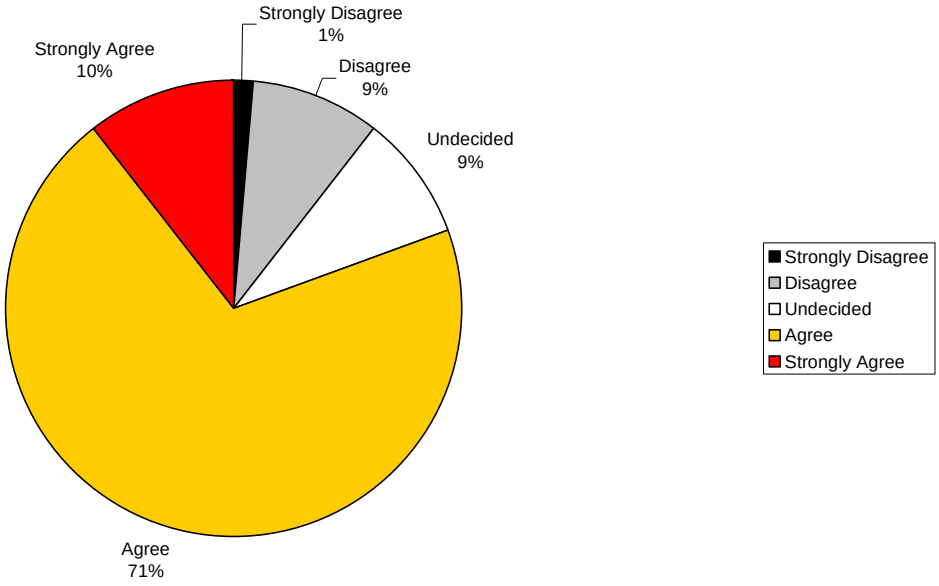

Figure H7. Vehicle controls indicate engaged

APPENDIX I

GAUGE USAGE

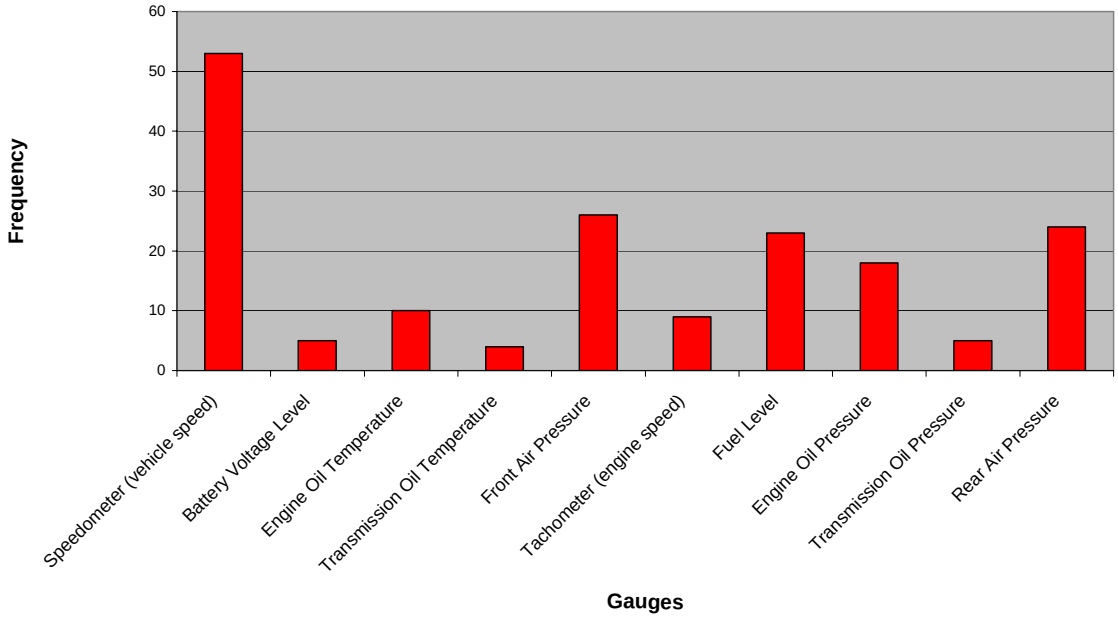

Figure I1. Most Used Gauges

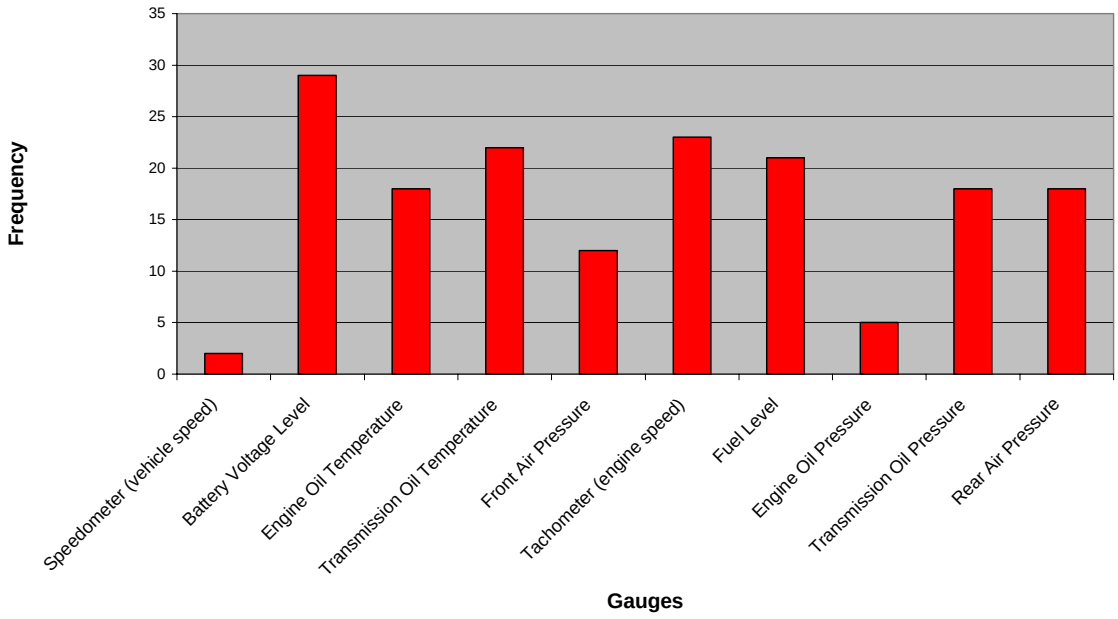

Figure I2. Least Used Gauges

APPENDIX J

CONTROLS USAGE

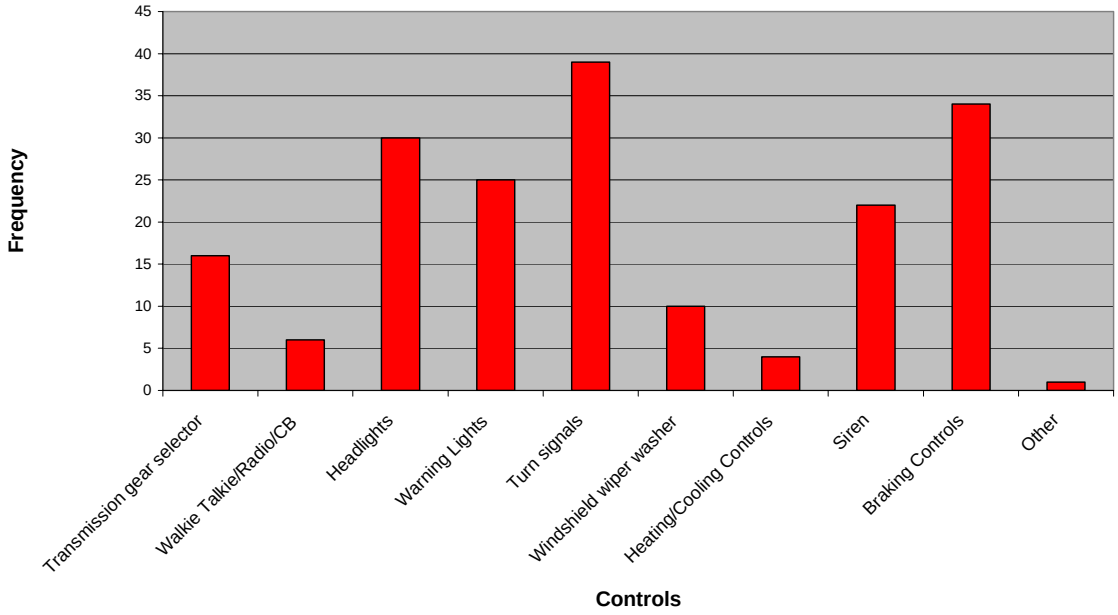

Figure J1. Most Used Controls

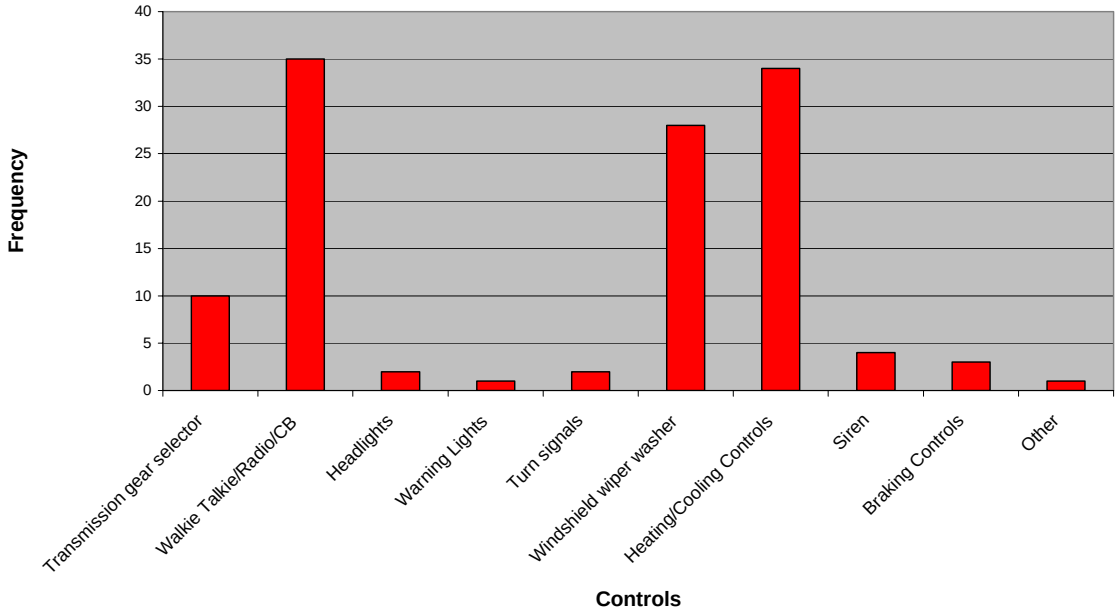

Figure J2. Least Used Controls

APPENDIX K

PHOTO COLLAGE OF DESIGN CRITIQUE

Figure K1. Photo Collage of Design Critique

APPENDIX L

DESIGN CRITIQUE SCREEN LOCATIONS

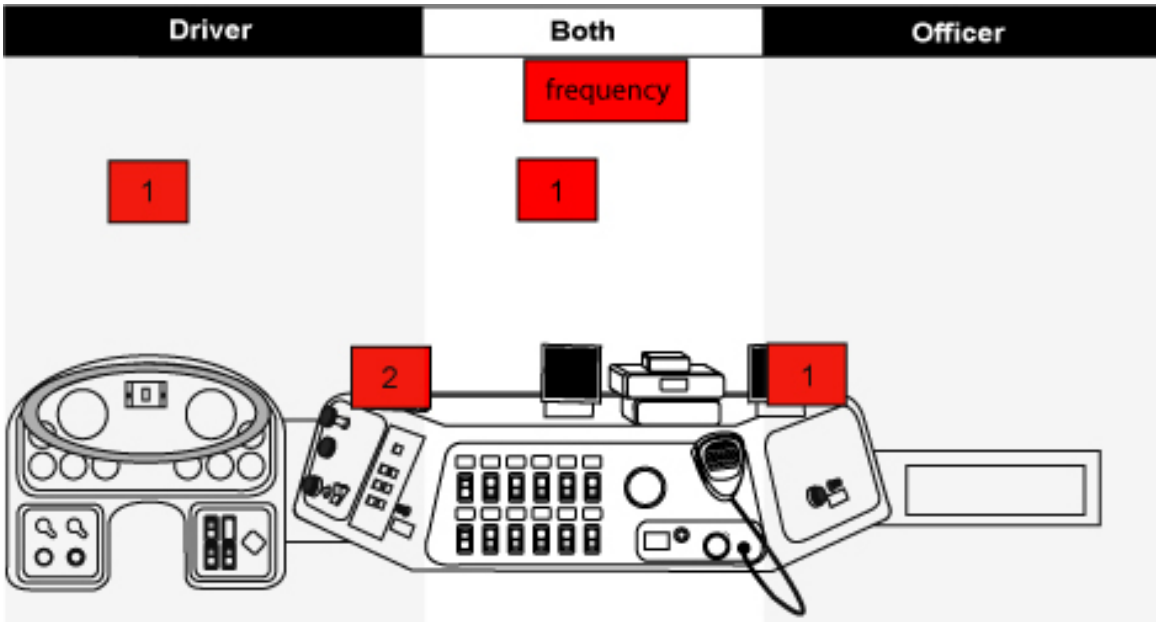

Figure L1. Design Critique Screen Locations

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