Secondary Display Unit

University of Wisconsin – Madison
College of Engineering – Biomedical Engineering
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Our client would like to reproduce the image on his Welch Allyn Propaq Encore machine that records blood pressure. Acceptable reproduction methods include a small video screen such as those found in vehicle entertainment centers, or preferably, in the form of a wearable CRT. This latter approach projects an image in the user's peripheral vision. Contacting the manufacturer only leads to financial problems and lack of a network acuity port on the machine means a solution consisting of a number of custom devices. We have developed housing for the Propaq that allows a reproducible image onto any monitor via a small camera that is placed directly in front of the screen.

§1 Problem Statement

Dr. Abernethy and the UW Med Flight team must be able to view the status of the patient whenever desired; however, the vital signs monitor, a Propaq Encore, must be placed on the floor of the helicopter's cabin. This makes it very difficult to access important statistics during flight. The goal of this project is to obtain the output signal from this small monitor and have it reproduced on an ergonomic prototype that may be placed in the helicopter, allowing the information to be readily accessed.

§2 Client Requirements

Several requirements must be considered when designing a client's project. These necessities will aid our group when developing ideas for a final design. This device allows the Med Flight team to view their patient's status in the helicopter whenever desired. When operating in the helicopter, the proposed prototype must not interfere with the output of the Propaq monitor. Furthermore, the product must not interfere with the portability of the Propaq monitor. However, the prototype may also require a cable extension from the Propaq that connects the two monitors and allows for visual reproduction within the helicopter.

Because the space inside of the helicopter is limited, it must be organized for safe and efficient patient delivery. Thus, the final product must not contain any loose wires that may interfere with the normal treatment of a patient in the helicopter. Weight must also be taken into consideration during prototype design because the client does not want a product that is as bulky as the Propaq. Also, the patient must not be endangered from this proposed design by electromagnetic radiation or excessive cables. Our client does not want to deal with an additional power source other than the Propaq. Thus he has requested that the device have its own power supply. This machine will be stored in a facility that operates at 25 degrees Celsius and must not malfunction due to helicopter heights or cabin temperature.

Finally, one must take cost into consideration during the brainstorming process. Our client has requested that the final device does not exceed the price of a Propaq. These monitors from Welch Allyn can cost up to $5,000 and Dr. Abernethy would like a total expected cost much less than this value.

§3 Background

The med-flight team at UW-Hospital uses the Propaq Encore model 206-EL from Welch Allyn to monitor a patient's vital signs such as electrocardiogram, respiration, heart rate and blood pressure. Each Propaq costs approximately $8,000 and weighs 2.8 kg. The dimensions of the monitor are 17x 21x13 cm. The Propaq Encore 206-EL is certified for use in rotary and fixed wing aircraft by the U.S. Air Force Armstrong Laboratories. The Propaq boasts an intuitive monitor with a high resolution, long battery life and bright display.

Dr. Abernethy, a doctor at the UW-Hospital working in the med-flight department, has encountered some problems with this monitor. The way the Propaq monitors the patient is not the problem, but rather how it fits into their helicopter. Because the Propaq allows the med-flight technician to monitor the vital signs, it is necessary that the technicians have unobstructed visual access to the display. However, there is nowhere in the helicopter to safely secure the Propaq with the display in the visual field of the technicians.

If the Propaq is placed in a high spot within the helicopter, it will be available for the technicians to reference whenever needed; however, if there are any sudden movements within the helicopter, there is a good possibility that the Propaq will displace itself and possibly injure either the patient or the technicians. A possible solution for this would be to lock it into a holster of some kind; however, this would impede the immediate use of the monitor in an emergency situation. Because it is impossible to display the monitor in the helicopter safely and efficiently, the technicians must place the Propaq on the ground where it is in a safe position within the helicopter as well as easily accessed for movement of the patient.

To account for the technicians not being able to see the monitor display while it is on the ground, a secondary monitor is required to output the data from the Propaq at eye level. This is necessary for the convenience as well as the safety of the flight crew and the patient. Only one of the med-flight technicians is required to see the secondary monitor. That technician can then alert the other technician of proper procedures according to the vital signs on the display.

§3.1 Competition

Other monitors are used to unscramble, reconstruct and reproduce images on a secondary screen. A patent search yields a few such devices. Patent 5,751,341 displays high resolution video images from a primary signal. Patent 6,558,321 monitors a medical device and allows for remote treatment of a subject with that device. Patent 6,633,658 requires an interference bar moving across an image display. The position and velocity of the interference bar within a scrambled image frame are used to compute the position of the corresponding image on a secondary monitor without the noise. None of these designs are plausible for the situation of the UW-Hospital Med-Flight team because they do not do the correct function necessary to monitor a patient's vital signs.

§4 Video Output Alternatives

Outputting video/data from the Propaq was one of the major dilemmas encountered during the design process. We devised three possible solutions to this dilemma. The first of which was to use the Network Acuity that is available on some Propaq monitors. Outputting data directly from the Propaq and interpreting it with a PDA is another option. The last idea was to splice the wire leading to the current display into two, which would lead to the creation of a second connector for video outputting.

§4.1 Direct Video Output (Network Acuity)

Welch Allyn's Propaq Encore 206-EL comes with an option for a Network Acuity port (Figure 1). It is simply an RJ-11 connector (phone cable connector) that allows the Propaq to transmit data. This design would use Vidco's Netviewer MDP2040-0100 to attach to the Network Acuity port. The Netviewer would take the data that is transmitted from the Propaq and converts it into video. It would then output this video using a standard DV-15 connector, also known as a VGA monitor port.

One of the advantages to this design was that the data conversion would have already been accomplished, and that this converter is reliable. As a result, we would have been able to focus on the display aspect of this project, which was the primary goal. At a total expense of over $3,500, the cost of this design was a major drawback. Additionally, the Netviewer is excessive, as it can connect to up to 16 Propaqs simultaneously for use in hospital settings, but only one connection is necessary in this situation.

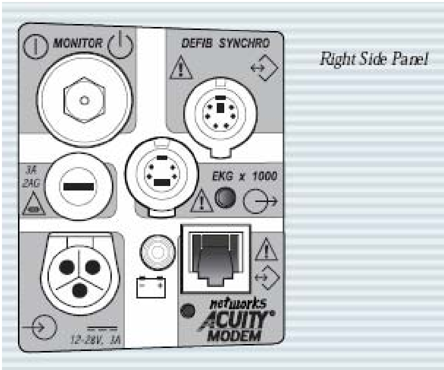

Figure 1: Diagram of right side panel on Welch Allyn's Propaq Encore 206-EL (left). Picture of Vidco's Netviewer (right).

§4.2 Direct Video Output (Video Camera)

Another method of obtaining standard video output would be to "film" the Propaq screen with a small video camera (Figure 2). This would involve mounting a camera centered on the Propaq monitor at a distance equal to its focal length, thereby allowing the entire screen to be reproduced on a secondary monitor.

Figure 2: Small video camera suitable for high resolution and standard video output.

Advantages to this design are similar to those provided by the Network Acuity proposal. Any type of device that uses standard video input could be used as a secondary monitor. This allows the user to customize the monitoring system to meet individual preferences based on power supply, space availability, and any budget restrictions. In order for this design to function properly, the camera must be securely mounted to eliminate any vibrations that could arise from in-flight turbulence experienced by the helicopter. These could potentially cause poor resolution and a distorted image displayed on the secondary monitor.

§4.3 Serial Data Output to PDA

This design called for the output of data from the Propaq, and subsequent interpretation and output of that data using a personal data/digital assistant (PDA). The data received would be interpreted by a customized program on the PDA. The screen of the PDA would display all the necessary measurements such as blood pressure, blood oxygenation, heart rate, etc.

An advantage of this design was that it will allow total customization of the display. This would ensure that the user would not have to fumble around with complicated controls and strain their eyes to read small numbers. The necessary information would already be displayed for the technician. The cost of this design would have been fairly low, between $200 and $400. The PDA would receive, interpret, and display data. One of the problems that could have occurred with this design is that the complexity of the program and the specifications of the PDA might have caused significant lag in the interpretation step. Another concern that was associated with this design was that methods of implementation are still unknown. The reason being, there is currently no data output port on the Propaq that can be connected to a PDA. Also, the members of this design team are not proficient in programming with Graphical User Interface (GUI).

§4.4 Splicing

Splicing wires is a process in which one can separate one wire into two independent wires (Figure 3). This design would have utilized this principle; it called for the splicing of the wire leading to the liquid crystal display (LCD) currently in the Propaq. Thus, there would have been two video outputs from the Propaq. One of these outputs would go to the built-in screen, while the second would be converted to a standard DV-15 connector. This connector would be placed alongside the various existing connectors located on the exterior of the Propaq.

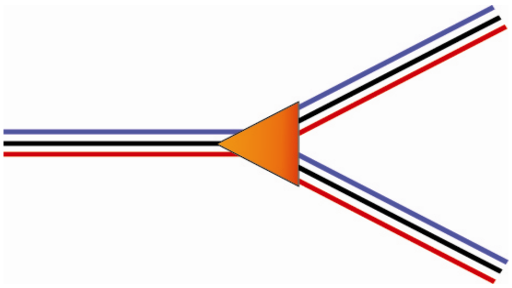

Figure 3: Graphical representation of a wire being spliced into two.

One of the advantages of this design was that the secondary display will be identical to the primary display. Hence, the operators would already be accustomed to the display. Additionally, all of the conversions would be made within the Propaq. This will leave the only extra device in the helicopter to be the secondary screen. Splicing would also be inexpensive because the vast majority of the expense would be the secondary screen. One of the drawbacks was that users may be skeptical about the reliability of the altered Propaq. Also implementing a splice could have increased current flow from the Propaq, which may have caused damage to the internal circuitry. Additionally, the current from each of the two new wires may not have been enough to display an image simultaneously on both displays.

§5 Monitoring Alternatives

An important part of the design is the type and accessibility of a secondary monitor. Each type of video output received from the Propaq is best used with a specific type of monitoring system. As previously stated, ability to maintain minimal clutter, portability, feasibility, and cost are all important factors that must be taken into consideration when choosing a secondary display.

§5.1 Wearable CRT (Eyetop Sunglasses)

Figure 4: The Eyetop glasses project an image in the user's peripheral vision (above). Close-up of the imbedded screen (below).

The client's preferred method of monitoring involves a wearable cathode ray tube (CRT). The Eyetop sunglasses use a screen imbedded in the glasses' lens to project an image into the user's peripheral vision (Figure 4). A wire connecting a control unit to the glasses transmits any type of standard video input (i.e. RCA, S-Video) to this imbedded screen (Figure 5). The control box is powered by four "AA" alkaline batteries and weighs less than half a pound (6.34 oz.). This type of monitoring option works best in conjunction with direct video output from the Propaq monitor, or through a small image capture device mounted on the face of the Propaq. The glasses provide both audio and video capabilities, come in a wide variety of styles, and cost anywhere between $400 and $600.

The main advantage provided by the Eyetop glasses is the ability to monitor the output from the Propaq without needing to glance away from the patient. This allows the flight physician to maintain focus on the operation being performed. Connecting to the control box

Figure 5: A wire connecting the control box to the glasses transmits images to the user.

to the glasses via a wire is the only foreseeable setback to this monitoring option. This creates a potential safety hazard in the limited working space of the helicopter. This physical connection reduces the portability, but is required since radio frequencies are restricted from use in helicopters.

§5.2 LCD

As with the Eyetop sunglasses, the LCD monitoring system provides a secondary display option in conjunction with standard video output. While LCD monitors provide multiple display options, the proposed method involves mounting a flip-down screen attached to a pivoting arm to the ceiling of the helicopter (Figure 6). This provides a wide range of viewing angles while eliminating any additional clutter caused by unnecessary wiring. LCD monitors are available in an extensive range of prices based primarily on screen size, resolution, and model type. This allows for the best choice to be made when deciding which monitor to implement regarding the functional needs and available budget.

Figure 6: The flip-down LCD monitor (above) would be attached to a pivoting arm (below) to create a wide range of viewing angles

While increasing the viewing angles and visual range, this design does not eliminate the need for the flight physician to glance away from the patient in order to view the monitor. The LCD is also constricted to the mounting hardware in the helicopter and is therefore not portable.

§5.3 PDA

The final monitoring option comes in the form of a PDA. The PDA serves a dual function as both a video display screen and a data processor. As previously mentioned, this data conversion capability would be extremely useful in converting serial data output from the Propaq to a viewable image. These small, handheld devices could be utilized at the user's discretion. Possibilities include attaching a PDA to the physician's kneeboard, or using a wristwatch PDA operated by voice recognition (Figure 7). As with the LCD monitors, the PDA is available for a broad range of prices and is offered in an assortment of styles, sizes, and functional capabilities.

Figure 7: Wristwatch PDA controlled by voice recognition.

Similar to the Eyetop glasses, the PDA must be provided with a physical connection to the Propaq monitor in order to receive the serial data output. This limits portability and creates a potential safety hazard with loose wires. The major downfall to this design is the software required to convert the data output from the Propaq monitor to a visual image has yet to be written.

§6 Results & Discussion

The final design must take into consideration two crucial factors – obtaining video output from the Propaq and designing an accessible secondary monitor. Since these two aspects are dependent on one another (i.e. the monitoring option depends on the type of video output). This inter-dependency is displayed in the flow chart below (Figure 8).

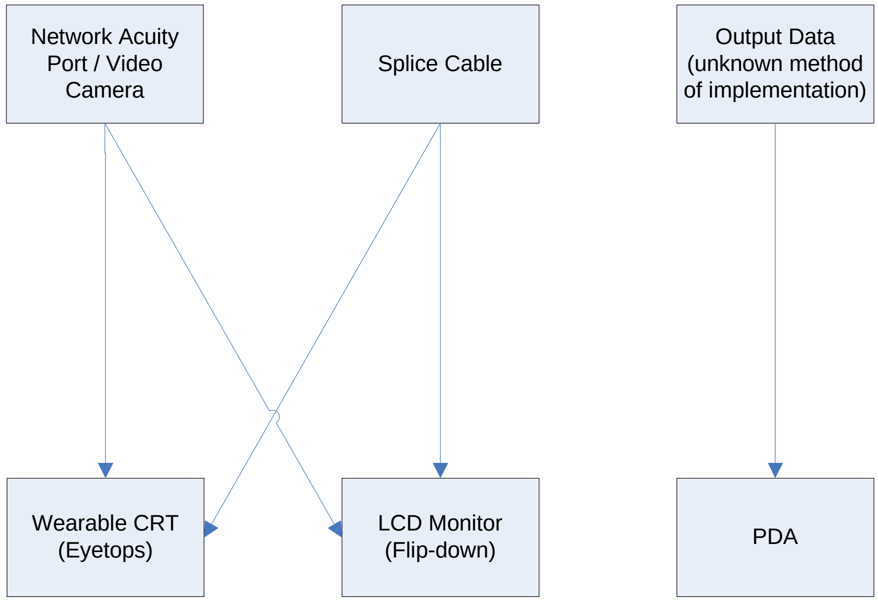

Figure 8: Flow chart summarizing the different types of video output from the Propaq and the corresponding monitoring options.

The two design matrices (Figures 8 & 9) on the following page rank the video output and secondary monitoring alternatives in the areas of monitoring options, current feasibility, cost, and minimal clutter. We found that by mounting a small video camera directed at the Propaq monitor will supply the most realistic method of obtaining usable video output. Converting the data from the Network Acuity port to video output using the Network converter, as previously discussed, will not be practical due to its substantial cost. This type of video output produced by either the camera or supplied by the Network Acuity port would then be compatible for use with either the Eyetop glasses or any type of LCD monitor using standard video input.

Video Output Alternatives

	Network Acuity	Output Data	Splicing
Monitoring Options	8	9	8
Current Feasibility	8	5	6
Cost	1	7	9
Minimal Clutter	5	8	8
Total	**22**	**29**	**31**

Figure 8: Design matrix comparing video output alternatives

Secondary Monitor Alternatives

	Eyetop Sunglasses	LCD	PDA
Monitoring Options	**7**	**9**	**8**
Current Feasibility	**6**	**6**	**1**
Cost	**8**	**4**	**7**
Minimal Clutter	**5**	**6**	**8**
Total	**26**	**25**	**24**

Figure 9: Design matrix comparing secondary monitor alternatives

§7 Final Design

The constructed prototype combines the method of obtaining direct video output with any type of secondary display using standard video input to effectively reproduce the Propaq monitor. While the technique involving converting data from the Network Acuity port could not be established, a video camera filming the Propaq monitor was used to achieve an equivalent effect. This allows the user to select an appropriate secondary display based on personal preference, space constrictions, power availability, and budget limitations.

§7.1 Propaq Housing

The material used to construct the housing for the Propaq is 0.5588 cm thick Plexiglas. Each side (left/right) is custom-fitted to allow external components to remain connected to the Propaq while the prototype is in use, and the top lid is hinged permitting the Propaq unit to be easily placed in, or removed from, the housing (Figure 10). When in use, the top lid latches to locking mechanisms located on each side of the housing securing the Propaq in place. Foam padding (1.91 cm) has been added to the top lid, each side, and the back of the housing unit in order to stabilize the Propaq and provide protection from any potentially damaging external forces.

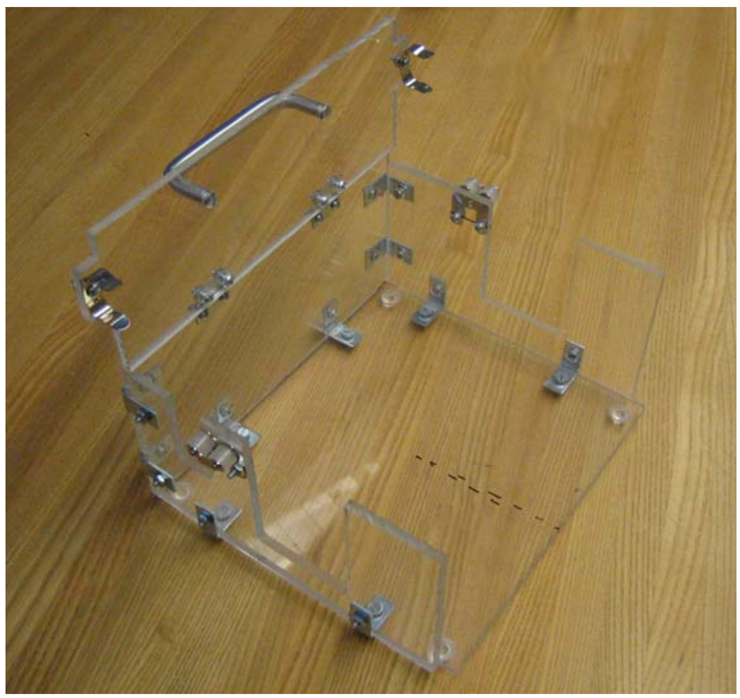

Figure 10: Plexiglas housing for Propaq monitor.

§7.2 Camera Mount/Housing

The video output is provided by a snake-camera mounted to a copper L-Bracket, which is fastened to a metal arm extending from the underside of the Propaq housing unit (Figure 11). The camera is firmly secured by surrounding foam padding, which also offers protection from any external forces or vibrations that may dislodge the camera from its focal point. The metal arm extends a distance of 24.13 cm from the Plexiglas housing to the location of the camera mount, allowing the camera viewing angle to encompass the entire Propaq monitor.

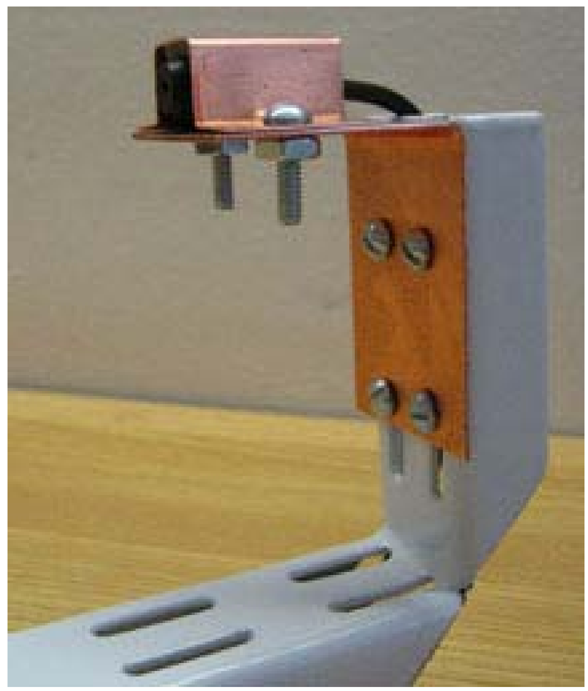

Figure 11: Mounting system for camera.

§7.3 Spring System

Working in conjunction with the Propaq housing, the spring system allows the set-up to function in either a horizontal or vertical position. Eyehooks located on either side of the housing provide attachment points for two 9.55 lb springs. These springs allow the Propaq to remain suspended in the vertical position while in operation and do not require an excessive amount of force to adjust. A hinge located on the base of the Plexiglas housing supplies a fixed point of rotation upon which the Propaq may be repositioned. In order to provide even more viewing angles of the original monitor, this hinge may be attached to a swivel base providing a 360° plane of rotation.

This permits the attending physician(s) to quickly and easily view the original Propaq screen if needed.

§7.4 Monitoring System

The video output produced by the prototype is extremely flexible in that it allows for any type monitoring system using standard video input to be utilized. This includes both the Eyetop glasses and LCD devices previously discussed. Because of this flexibility, the design is not constrained to a specific set-up, and may be formatted to fit the specifications and preferences of each individual user. Suggested monitoring set-up systems, including those for LCD displays and Eyetop glasses are discussed in Future Work.

§7.5 Advantages & Disadvantages

The most important attribute provided by this design is the flexibility permitted in the area of monitoring options. By providing a standard video output, a wide variety of secondary displays may be utilized. This allows the user to customize their set-up to the appropriate operating environment (i.e. helicopter, ambulance, hospital room, etc.) instead of implementing modifications into their workspace in order to support a specific type of monitoring system. The intuitive operation of the design is also another key advantage. Obtaining a secondary image can be accomplished by simply placing the Propaq in its Plexiglas housing and turning on the camera and the chosen display. Connections between the external monitoring components (BP, ECG, pulse oximetry) may remain intact, minimizing the time spent setting up the secondary monitoring system. This is crucial when the physician’s attention must be focused on attending to the health of the patient.

One disadvantage that arises with this design is the need for permanent placement of the Plexiglas housing in order to utilize the multiple operating positions provided by the spring system. Despite this shortcoming, the ability to provide video output of the Propaq monitor remains unaffected and a secondary image may still be produced.

§7.6 Cost Analysis

The materials used in the construction of the prototype along with the supplier and component price are displayed in Table 1. Each of these products is readily available at any hardware store, and may be obtained in a variety of standard sizes and colors. Ultimately, material expenses remained under $50, excluding the price of the provided video camera and the purchase of an LCD monitor. Mass production of the design would unquestionably reduce the price on a per unit basis due to less material waste produced by construction and bulk quantity purchases.

Table 1 – Materials used for prototype construction

Item	Supplier	Quantity	Price
3/8” Foam Tape	Home Depot	1	$2.37
3/4” Foam Tape	Menards	1	$2.78
1” Corner Brace	Home Depot	4 @	$1.69
25” Upright Bar	Home Depot	1	$4.97
3” Round Hinge	Home Depot	1	$1.29
Plexiglas	Home Depot	1	$12.99
Handle	Home Depot	1	$2.39
Springs	Home Depot	1	$2.67
Mounting Hardware	Home Depot	8 @	$0.98
	Menards	2 @	$0.67
Roller Catch	Home Depot	2 @	$0.69
1” Hinge	Menards	1	$1.48
LCD Monitor	N/A	1	$70 - $500
Snake Camera	Supercircuits	1	$220
Total			**$338.26 – $768.26**

§8 Future Work

The main obstacle of obtaining data output from the Propaq has been successfully accomplished. However, in order to make this device fully functional, more work must be done. The following criteria were unable to be addressed due to time and budget constraints.

One of the most important remaining tasks is to add functionality to the Propaq housing so that it can attach to the floor of our client's helicopter. The proposed method of implementing this is to use existing rails located on the helicopter floor. These rails are conveniently located alongside the seat of the flight physician, and support custom made clips allowing the Propaq housing to be held in a variety of different positions.

If our client wishes to permanently place an LCD monitor in the helicopter cabin as a secondary video display, a way of attaching it needs to be constructed. The client's helicopter has rails, similar to the ones on the floor, that allow for the attachment of custom clips in a variety of locations, such as the back wall. As previously suggested, a rotating arm could be implemented to allow multiple viewing angles of the monitor. In this scenario, an LCD monitor would also have to be purchased based on the client's preferences. One suggestion is the Pyle PLVWR840 flip-down model for $110 (Figure 12). If the client decides on using Eyetops sunglasses, then he can simply connect his existing pair to the video output from the Propaq holder.

Figure 12: Flip-down LCD monitor suggested for secondary display.

§9 Ethics

Our goal is to ensure that there are no hazards that may interfere with daily operation of the helicopter and interaction with the patient. The safety, health and welfare of the people around the Propaq and secondary monitor must be held paramount. To achieve this, it is vital that any extraneous wires are restrained in such a way to avoid electrocution or entanglement. Also, it is essential that the secondary display has no lag time from the original Propaq display to ensure that the proper actions are taken immediately to ensure that the patient's health is not compromised. No parts of the prototype will possess excessive cables or emit signals that could interfere with the medical equipment and harm to the patient's safety. Finally, the design must not have any electrical or frequency interference with the helicopter, which can cause malfunctions.

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Secondary Video Monitor Display

Product Design Specifications

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Date Last Updated: April 26, 2006

Abstract: The Welch Allyn Propaq Monitor (Model #206 – EL) is used to record a patient's vital signs (EKG, pulse oximetry, BP) during an emergency transport by helicopter. Med-Flight team technicians rely on the monitor's output during flight transportation while attempting to stabilize the patient. Currently, the monitor lies on the helicopter floor causing the attention of the Med-Flight team members to be split between their work on the patient and the output of Propaq Monitor. Because of this, output information displayed by the monitor must be reproduced on a readily accessible secondary screen. Acceptable reproduction methods include a small video screen such as those found in vehicle entertainment centers, or preferably, in the form of a wearable CRT. This latter approach projects an image in the user's peripheral vision.

Function: The expected device must reproduce the output of the Welch Allyn Propaq Monitor on a readily accessible secondary display monitor.

Client Requirements:

- Device must not interfere with output of Propaq Monitor
- Preferred method of visual reproduction would be in the form of a wearable CRT
- Device must be portable since Propaq Monitor will be transported along with patient
- Any loose wires/material must be kept to a minimum in order to prevent tangling with other medical equipment and allow for maximum portability
- Secondary monitor must provide its own power source
- Total product cost must not exceed that of the Propaq Monitor from which output is originally produced

Design Requirements:

1. Physical and Operational Characteristics

a. *Performance requirements*: The device will be used in a medical helicopter in emergency situations. Thus, any controls on the device must be easy to find and easy to operate to minimize time wastage. The device could potentially be used several times daily. It needs to be sturdy in case it is dropped, and must be resilient when exposed to water or bodily fluids.

b. *Safety*: The device must comply with the same safety standards as the Propaq, such as: all relevant AAMI, IEC, EN, CSA and UL standards, USAF approval for rotary, small and large bodied fixed wing aircraft.

c. *Accuracy and Reliability*: The Propaq Encore is one of the leaders in its vital signs monitoring, providing very accurate vital signs monitoring. If the secondary display is to be successful, it must be just as precise as the primary display. Additionally, there must not be a noticeable lag between the two displays.

d. *Life in Service*: The secondary display's battery life should be comparable to that of the primary display – approximately 5 hours. Propaq monitors are kept in service for several years, thus the secondary display unit must also be functional for this amount of time.

e. *Shelf Life*: While the secondary display unit is being stored, it will be kept in either a dry storage room or in a helicopter unit prepared for dispatch. The unit will be kept in a dry 25°C facility while in storage. While in the helicopter, the unit will be protected from weather elements. The batteries of the unit should be rechargeable but last approximately 6 hours between recharges.

f. *Operating Environment*: During operation, the unit will be in the helicopter with the Med-Flight team and the patient. Significant activity could occur during use, causing disturbances to the unit. The unit could be temporarily exposed to climate changes such as rain, snow or heat, although these conditions would be momentary. The vibrations from the helicopter must be considered as well. If Bluetooth technology is used, it must not interfere with the radio frequency used by the helicopter pilot. The unit must be secured so that it is not easily thrown from its position in the case of sudden movements within the helicopter.

g. *Ergonomics*: The unit must have as few wires as possible, if any. The wires may interfere with the Med-Flight team's interaction with the patient. The unit should be able to be kept on a knee board of one of the team members for easy access.

h. *Size*: The unit should be relatively small, but large enough to convey all of the necessary information from the Propaq Encore. The unit should be portable to be handed from one Med-Flight team member to another. It should be compact for easy storage and use within a limited space such as a helicopter.

i. *Weight*: Since the device is to be portable, the weight should be no more than half the current weight of the Propaq Encore for easy maneuverability. If the image is to be displayed on an LCD monitor, the weight should be light enough so that the display can be mounted onto the inside of the helicopter without complications.

j. *Materials*: No electronics may be embedded into the prototype that would interfere with certain frequency signals on the helicopter.

k. *Aesthetics, Appearance, and Finish*: The prototype should have no loose material and not be considered bulky by any means. An ideal design will incorporate a single wire connecting the project to a secondary monitor, of which may be chosen at the client's discretion.

2. Production Characteristics

a. *Quantity*: One sufficient prototype is required.

b. *Target Product Cost*: The cost of the final product should be considerably less than an actual Propaq Encore which has costs estimated in the thousands of dollars.

3. Miscellaneous

a. *Standards & Specifications*: Any device must not interfere with frequencies utilized by helicopter electronics and/or frequency signals.

b. *Customer*: Preferred method of video display is wearable CRT with image projected in user's peripheral vision.

c. *Patient Related Concerns*: Any incorporated design must not interfere with the output (BP, pulse oximetry, EKG) of the Propaq Monitor. Design must not be cumbersome as it will need to be transported along with primary monitor when transferring the patient from the helicopter.

d. *Competition*: A patent search yields Patents: 5,751,341; 6,558,321; 6,633,658 describing comparable devices. Each of these patents describes a device which, in one form or another, unscrambles, reconstructs, or reproduces images on a secondary screen.