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Technology Review of Head Mounted Tactors for SIHS TD

by:

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Abstract

In the context of the SIHS-TD project, the Speech/Comms Sub-system Team (SST) has proposed considering the integration of a haptic display in the concept helmets to be developed by the Industrial Team (IT). A study of the state of the art of commercially available haptic interfaces, aimed at being integrated to a helmet, was conducted to fill the knowledge gap identified by this SST.

After reviewing existing technologies in the field of haptic interfaces (tactile display), it becomes evident in light of SIREQ-TD trial results that the Vibro-Mechanical Electromagnetic tactors are in general too bulky and heavy for helmet integration. Furthermore, there are two other technologies that at this time cannot be used without packaging even if studies and research programs have used them: the Piezoelectric and the Memory Shape Alloy devices. These technologies need to be covered with some material to keep out dirt, water, etc… Their properties and form factor make them attractive, but no pre-packaged tactors have been found yet.

The field of haptic display is growing and new devices are bound to appear on the market. The advent of smaller computerized systems integrated with haptic interfaces can be another means to improve the ability to face a more complex battle space and improve safety in many areas.

Résumé

Faisant partie du projet SIHS-TD, l’équipe du sous-comité appelé *Speech/Comms* a proposé d’évaluer la possibilité d’intégrer un senseur tactile dans les concepts de casque qui seront développés par l’équipe d’industriels travaillant aussi sur le projet. Une étude des interfaces tactiles disponibles commercialement et pouvant s’intégrer sur le casque a donc été approuvée dans le but de combler le manque de connaissance identifié par l’équipe *Speech/Comms*.

Suite à cette recherche et à la lumière des travaux du projet SIREQ-TD, il semble évident que les senseurs électromagnétiques mécaniques tactiles sont trop encombrants pour être intégrés sous un casque. Deux autres technologies pourraient cependant être intéressantes du point de vue de leurs propriétés et formes, à la condition de trouver une méthode efficace de protection contre la saleté, l’eau et autres ; il s’agit des Piézo-électriques et des dispositifs à mémoire (*Memory Shape Alloy Devices)*.

Le domaine des senseurs tactiles est en plein essors et de nouvelles technologies apparaîtront certainement très bientôt sur le marché. L’utilisation d’ordinateurs de plus en plus petits dans des systèmes intégrés en plus des senseurs tactiles peut aussi être un bon moyen d’améliorer l’efficacité des intervenants dans un champ de bataille plus complexe qu’avant et peut même d’augmenter la sécurité dans plusieurs autres domaines.

Executive Summary

In the context of SIHS-TD project, the capability to provide soldiers with complete situational awareness faces the problems of information overload and cluttering of the visual and audio senses. One way to limit the amount of information to be displayed visually or through audio is to exploit other channels (senses) of communication. The sense of touch or haptic system is a good candidate to fulfill this role.

The SIREQ-TD study and trials on tactile displays for Wayfinding experiments held in previous years arrived to the following main conclusions:

1- The haptic or tactile display is a good way to provide navigation information to the wearer,
2- Torso mounted tactors were favored by the majority of participants,
3- The optimal number of tactors was 8,
4- A head mounted tactile display was not the best way to provide information. This should be interpreted by taking into account that the tactors used in these experiments were large and vibrated too intensely for use on the head. A different kind of tactor could have changed the results in this case.

Taking these findings into accounts, and after a brief review of the haptic field, the Speech/Comms Sub-system Team (SST) of the SIHS-TD project has proposed considering the integration of a haptic display into the concept helmets to be developed by the Industrial team. A study of the state of the art of commercially available haptic interfaces, aimed at being integrated into a helmet, was conducted to fill the knowledge gap identified by the SST.

The scope of this report is to complete a technology search to identify devices and systems currently available that could be used in the development of a head-mounted tactile display. This technology search provided a detailed review of devices and systems found and a documentation base for further studies.

After reviewing existing technologies in the field of haptic interfaces (tactile display), it becomes evident in light of SIREQ-TD trial results that the Vibro-Mechanical Electromagnetic tactors are in general too bulky and heavy for helmet integration. Furthermore, there are two other technologies that at this time cannot be used without packaging even if studies and research programs have used them: the Piezoelectric and the Memory Shape Alloy devices. These technologies need to be covered with some material to keep out dirt, water, etc… Their properties and form factor make them attractive, but no pre-packaged tactors have been found yet.

During the survey, we found out that expertise in that field is growing in Canada: the vest used by the TSAS experiment (in USA) was designed and fabricated by DRDC, and DRDC-Valcartier has a Distributed Synthetic Environment group that is interested in the Haptic interfaces for use in virtual environment.

The field of haptic display is growing and new devices are bound to appear on the market. The advent of smaller computerized systems integrated with haptic interfaces can be another means to improve the ability to face a more complex battle space and improve safety in many areas.

Sommaire

Dans le contexte du projet SIHS-TD, la volonté de donner au soldat une vue complète de la situation fait face au problème de surcharge des sens de la vue et de l'audition par une trop grande quantité d'informations. Une façon de limiter la quantité d'information visuelle et auditive est d'exploiter ses autres sens. Le sens du touché, par des systèmes dits tactiles, semble un bon candidat.

Les études SIREQ-TD et les essais sur les senseurs tactiles durant les expériences Wayfindings des dernières années ont démontré les points suivants :

1- Les senseurs tactiles sont un bon moyen de transmettre des informations de directions.
2- Les senseurs situés sur le torse sont plus efficaces et mieux tolérés par les participants.
3- Le nombre optimal de senseurs est 8.
4- Les senseurs situés sur la tête n'ont pas donné de bons résultats. Cependant, il faut tenir compte que les senseurs utilisés étaient gros et vibraient trop fort pour être utilisé vraiment sur la tête. Un différent type de senseur aurait pu donner de meilleurs résultats.

Considérant ces résultats, l'équipe du sous-comité appelé *Speech/Comms* a proposé d'évaluer la possibilité d'intégrer un senseur tactile dans les concepts de casque qui seront développés par l'équipe d'industriels travaillant aussi sur le projet. Une étude des interfaces disponibles commercialement et pouvant s'intégrer sur le casque a donc été acceptée dans le but de combler le manque d'information technologique identifié par l'équipe *Speech/Comms*.

Le but de ce rapport est donc de faire une recherche des technologies tactiles existantes pouvant être intégrées à l'équipement de tête. Le rapport présente un résumé de ces technologies ainsi que des recommandations pour des études plus poussées sur ces technologies.

Suite à cette recherche et à la lumière des travaux du projet SIREQ-TD, il semble évident que les senseurs électromagnétiques mécaniques tactiles sont trop encombrants pour être intégré sous un casque. De plus, deux autres technologies, les Piézo-électriques et des dispositifs à mémoire (*Memory Shape Alloy Devices),* pourraient être intéressantes du point de vue de leurs propriétés et formes, à la condition de trouver une méthode efficace de protection contre la saleté, l'eau et autres.

Durant la recherche, nous avons pu constater que cette expertise progresse au Canada : la veste utilisée par les Américains pour l'expérience TSAS a été conçue et fabriquée par le RDDC, tandis que le groupe *Distributed Synthetic Environment* au RDDC – Valcartier s'intéresse déjà au sujet des senseurs tactiles pour les environnements virtuels.

Le domaine des senseurs tactiles est en plein essors et de nouvelles technologies apparaîtront certainement très bientôt sur le marché. L'utilisation d'ordinateurs de plus en plus petits dans des systèmes intégrés en plus des senseurs tactiles peut aussi être un bon moyen d'améliorer l'efficacité des intervenants dans un champ de bataille plus complexe qu'avant et peut même d'augmenter la sécurité dans plusieurs autres domaines.

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Annex

1. Introduction

In the context of SIHS-TD project, the capability to provide soldiers with complete situational awareness faces the problems of information overload and cluttering of the visual and audio senses. One way to limit the amount of information to be displayed visually or through audio is to exploit other channels (senses) of communication. The sense of touch or haptic system is a good candidate to fulfill this role. The sense of touch is not a sense that accesses the higher cognitive process on a continuous basis; most of the information processing for touch is done at a lower level in the spinal cord and in the somatosensory cortex. So a good portion of the sense of touch is "instinctive" and information passed through this channel will not significantly increase the cognitive workload. [1][2][3][4]

The SIREQ-TD study and trials on Tactile Displays for Wayfinding arrived to the main following conclusions:

1- The haptic or tactile display is a good way to provide navigation information to the wearer,
2- Torso mounted tactors were favored by the majority of participants,
3- The optimal number of tactors was 8,
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Taking these findings into accounts, and after a brief review of the haptic field, the Speech/Comms Sub-system Team (SST) has proposed considering the possibility of integrating a haptic display in the concept helmets to be developed by the Industrial team. A knowledge gap was identified in the field of haptic interfaces. A study of the state of the art of commercially available haptic interfaces, aimed at being integrated to a helmet, was proposed and accepted.

The scope of the present document is to complete a technology search to identify devices and systems currently available that could be used in the development of a head-mounted tactile display. This technology search will provide a detailed review of devices and systems found and a documentation base for further study.

2. Document Structure

This report is organised along the following lines:

1- Introduction
2- Document Structure
3- Existing Application of Haptic Interfaces
4- Other Tactor Related Products
5- Commercially available haptic display systems (refer to Appendix A)
6- Recommendations
7- Conclusion.

[1] File ResponseToTouchIsInstinctive.doc and Website link "WEL-Systems Newsletter ChoicePoints August 2003"
[2] File TouchFeedback_page2.doc and Website link "TouchSense_TouchFeedback"
[3] File TouchSenseTech_page3.doc and Website link "TouchScreen_apr05_v1_LR"
[4] File TSAS_Abstract.doc and Website link "Tactile Situation Awareness System"

3. Existing application of haptic interfaces

3.1 General Survey Projects

3.1.1 Virtual Environment and Sensori-Motor Activities: Haptic, Audition and Olfaction [5]

This paper, focusing on Virtual Reality, was written by the Distributed Synthetic Environment Group from DRDC-Valcartier and the Computer Vision and Systems Lab from the Department of Electrical and Computer Engineering at Laval University.

This paper quickly reviews the (1) olfactory, (2) auditory, (3) haptic sensori-motor activities and focuses on the hardware/software components that are currently available, either as commercial products or as academic prototypes

Summary of listed Issues with Haptic Devices

- Physical Stability:
  - It is a major concern: it is affected by the reaction rate of the device, and by the quality of reaction. It can destroy the user sense of immersion and can also be potentially dangerous for the user.
  - *Solutions*:
    1. Consider the haptic controller and the controller of the object modeled by the haptic device as a whole. The stability will then depend on the design of the whole application.
    2. The haptic controller can be separated from the rest of the application.

- The perceptual capabilities and limitations of human users:
  - They impose requirements on the design of haptic interfaces. Those requirements shall cover force sensing, pressure perception, position sensing resolution, stiffness, viscosity, and mass perception, human force and position control, temperature perception, texture perception, and ergonomics and comfort requirements.

Conclusion

"Despite the enthusiasm surrounding VR, a substantial gap exists between the technology available today and the technology needed to bring Virtual Environments (VE) closer to reality. The current state of specialized hardware necessary to support VE applications is not satisfactory in most of the cases, and true consumer-grade, high performance VR technology is not yet currently available. Haptic interfaces are still in a primitive phase of development, (…)"

3.1.2 Tactile Interfaces: a State-of-the-Art Survey [6]

Researchers at CEA LIST SRSI (France) and Laboratoire Systèmes Complexes- University of Evry (France) have written this paper.

This paper presents existing tactile stimulators, their physical, spatial, and frequency characteristics. They are classified in terms of application domains. The different technologies are fixed on the finger of the user and are part of research projects.

3.1.3 Review of Virtual Environment Interface Technology[7]

This survey is somewhat dated, presented by the Institute for Defense Analyses, March 1996. But the researchers: Christine Yougblunt, Rob E. Johnson, Sarah H. Nash, Ruth A. Weinclaw and Craig A. Will did

[5] File wscg2004-2_UnivLaval_WithDRDC-Valcartier.pdf
[6] File ISR2004_Khoudja_tactile_Interfaces_State-of-the-artSurvey.pdf
[7] File HAPTIC1.pdf in ReviewOfVirtualEnvironmentInterfaceTechnology sub-directory.

a good review on the haptic technology. More importantly, the first sections of chapter 6 pertaining to haptic interfaces have good information on this channel of communication.

3.2 Tactile Vest

We have found many projects that use vests to integrate tactile technology. Reference documents to those projects are contained in the OtherResearchPapers sub-directory. The following sections present only some of them.

3.2.1 Tactile Situation Awareness System (TSAS) [8]

Project Overview

Joint Strike Fighter (JSF) -TSAS project originated at the NASA Johnson Space Center and the Naval Aerospace Medical Research Laboratory. The project integrated an array of 22 pneumatic tactors from Carleton Technologies (model 2856-A0), F-22 cooling vest, and GPS/INS technologies into a single synergistic system in a UH-60 helicopter. According to the magazine The Maple Leaf, the vest was provided by DRDC[9] (Figure 1)

Figure 1 Extract from the Maple Leaf Magazine.

The Carleton Technologies pneumatic tactor, model 2856-A0, consists of a hemispherical shaped molded plastic shell with a diameter of 31 mm (see Figure 2). A strong tactile sensation is achieved when the tactor membrane vibrates at 50Hz. Tactor weight was 2g.

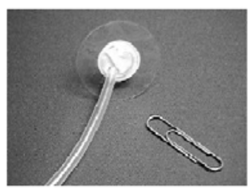

Figure 2. Carleton Technologies model 2856-A0 pneumatic tactor

Summary of Results

- Most of the pilots reported improved situation awareness during TSAS ON.
- They could feel tactors before they could detect visual cues.
- They felt safer during reduced visual conditions.
- They also reported reduced workload.
- The tactor intensity was strong enough even in the vibration environment of a helicopter, but where there is sensory overload, or with high threat situations, stronger tactile sensations would be more appropriate.
- All pilots found the tactile information very intuitive; no thinking.
- All the pilots said the tactile sensation was not annoying or distracting.

"By using the appropriate tactile algorithm (tactor location with maximal separation and strong tactile intensity) intuitive 3D direction and magnitude information can be provided."

"The F-22 cooling suit was a vest that provided a good fit around the torso (…) To expand the role of the vest to include orientation information during forward flight (perhaps presented as a single tactor or a collection of tactors in the direction of down, (…)) an expanded coverage vest is required to include the upper torso region. The current vest does not provide a snug fit sufficient to maintain tactor contact with the body in the upper torso (chest and back)."

[8] File USAARL_TSAS_Report.pdf
[9] File Maple Leaf Magazine 803-19.pdf

"To achieve a complete solution to the problem of spatial awareness mishaps, tactile instruments must be integrated with advanced visual displays and audio systems into a synergistic situation awareness instrument. (…) The mode-switching software must be adaptive and "smart" about which information to present; and how, when, and where to provide that information."

Improvements and future development

- Integration of tactile instruments with helmet mounted displays and 3D audio displays.
- Significant improvement in tactor technology.
- Tactor integration with flight garments.
- Miniaturization of all TSAS components.
- Development of "smart" software to enable intelligent switching between various modes of situation awareness information.

3.2.2 Design of a Wearable Tactile Display (Carnegie Mellon University (CMU)) [10]

Project Overview

Their work is in the area of tactile information display. The aim of this project is to give a better understanding of the difference between the different kinds of information that can be presented through touch and how that information can be presented.

Summary of Results

- In the first tactile display vest, the tactors were contained inside hemispheres on the harness. These tactors were modified piezo buzzers from Radio Shack and were wired to a belt-worn infrared receiver. " This design was loud, bulky and consumed too much power. For these reasons, it was not a reasonable tactile display."
- The second tactile display vest contained customized tactors, which are smaller, silent and used less power. A wireless infrared kit allowed them to create a testable vest that did not require any programming. Moreover, the vest design can be customized for testing purposes. The tactors contain a modified miniature vibrating electric motor (from Alcom –Figure 3).
  Three problems were found with the original miniature vibrating electric motor:
  - o The original vibrating electric motor is designed for a specific application where tabs (allowing connection) are required and placed at an angle from the motor (the current vest design didn't need these tabs).
  - o They are soldered directly on the circuit board and difficult to connect to a power source.
  - o The motors are easily obstructed; the rotating weight on the shaft is stopped with minimal resistance from fingers or fabric.

  Solution: A custom housing for the tactor module was designed to address these problems. This design meets the criteria established for this project. Despite its small size, the initial tests indicate that this tactor can be felt through one layer of clothing.

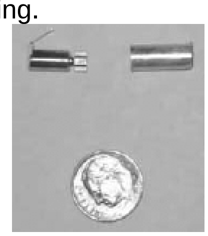

Figure 3 – Customized tactors

- Another concept: the Sprout conceptual earpiece. It couples tactile notification with a simple speaker and microphone earpiece for audio interfacing. An array of 5 micro tactors would provide various notifications to the user. (Figure 4)

[10] File tactile-display_CMUniv.pdf, tactile-display_NEAR-Ear.pdf, and TactileVestPaper.doc and gemperle01design_WearableTactor.pdf

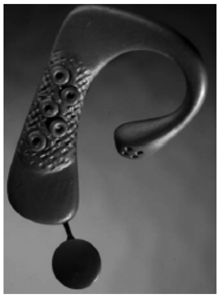

Figure 4 The Sprout Conceptual Earpiece

Improvements and future development

- The third generation design will be a USB device that will be plugged into the wearable computer, running Linux. This computer will allow them to program more complex sequences of vibrations and connect vibration sequencing to spatial information. They want to test the usability of the tactile display when used alone or in conjunction with a head-mounted display and audio information.

3.3 Wristband Technology

3.3.1 Multimodal Machines Makes Military Move [11]

Project Overview

The PalpEye Project, by J.Andersson, and A.Lundberg from the Department of Computing Science, IT University of Götebong, Sweden.

" (…) Through the development and testing of a prototype for such a tactile interface thought to augment some of the present communicative ways, we have tried to answer the question if tactile information is usable within the military context."

Summary of Results

- Different placements of tactors on the body were evaluated: on the shoulder, around the neck, on the back of the arm, or on the legs (but not on the head). When feeling a movement on the skin, a natural reaction is to glance in the direction of the sensation. The test plan included three parts: one functionality test in a laboratory environment, one body storming with the mock-up version and a posttest survey. More detailed results are presented in the referenced document[12].
- They have combined tactors with a SMA-"ribbon" around the forearms. The conical shape of the forearm makes it difficult to sustain its position for a long period of time.
  They have added electromagnetic vibrators: the smallest and most protected vibrator they found was a pancake vibrating motor[13].
  The sheer size of the vibrators limited the amount of vibrators embedded onto the forearm. They also added a small display. (Figure 5)
- Ten standard pancake vibrators were used to create the vibrating symbols on the arm.
- Without display aid, all subject had an average of 51,25% correct reactions. The perception of the vibrations was generally very good. Only 54% of the subjects found the symbols as clear. PalpEye's individual vibrators were considered distinguishable by 73% of the subjects.

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[11] File Multimodal Machines Makes Military Move.pdf
[12] File Multimodal Machines Makes Military Move.pdf
[13] Pancake motors have a diameter of more than 10mm, thickness ranges from 3mm to 6mm, and they are encapsulated (without visible moving parts). Small pancake vibrating motor can be easily found on Internet. One example: http://www.maxonmotorusa.com/newproducts/article.cfm?id=20021101&title=Brushless%20'Pancake'%20Motors

6. Iteration 5-version ready

Figure 5 –Integrated Tactors and PalpEye Last Prototype

Improvements and future development

- The size of the vibrators was a large constraining factor of the total size of PalpEye. If the size can be reduced, and have a pointing tip, the vibrations could get more exact.
- The ideal tactor needs to stimulate more types of skin receptors than vibrators, in order to create a reliable stimulus. MMES technology shows a great potential for the future. Development and manufacturing technologies are obstacles right now.

4. Other Tactor Related Products

4.1 Gel Technology

4.1.1 Acoustic Sensor for Health Status Monitoring [14]

Figure 1: Acoustic sensor.

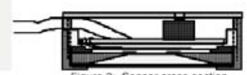

Figure 2: Sensor cross section.

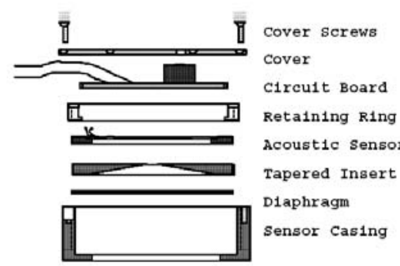

Figure 3: Sensor assembly drawing.

Project Overview

"The U.S. Army Research Laboratory (ARL) has developed sensor technology to monitor the soldier's physiological variables and motor activities by gathering and analyzing acoustic data. The sensor consists of a fluid contained within a small rubber bladder or pad that also includes a hydrophone. (…) When the sensor pad is in contact with patient's thorax, neck, or temple region, sounds can be immediately and continuously monitored."

This project did not look at the possibility of using the gel-sensor as a tactor. Mr. Michael V. Scalon from USARL's opinion on this possibility, (obtained through a phone conversation), was that the gel-sensor could act as a tactor. But he cautioned that the signal strength could be too weak for use. He offered to send gel-sensors to Oerlikon to do some testing. This will have to be taken into consideration and may warrant further investigation to test the concept. He further said that a researcher at Aberdeen had mapped the head region for sensitivity in the context of haptic display.

4.2 Gloves Technology

4.2.1 CyberTouch[15]

"CyberTouch is the vibro-tactile feedback option for CyberGlove. It features small vibrotactile stimulators on each finger and the palm of the CyberGlove. Each stimulator can be individually programmed to vary the strength of touch sensation. The array of stimulators can generate simple

[14] File Acoustic Sensor Health Monitoring98.pdf in Gel_Technology sub-directory
[15] Website http://www.immersion.com/3d/products.

sensations such as pulses or sustained vibration, and they can be used in combination to produce complex tactile feedback patterns. Software developers can design their own actuation profiles." It also needs a 3D tracking device from Polhemus or Ascension to provide its absolute (x,y,z), yaw, pitch, roll position and orientation information.

4.2.2 5Dt Data Gloves[16]

This product is put here only to give information about this kind of technology. This is not to transmit the vibro-tactile feedback to the user: it transmits only motion data to the computer: "The 5DT Ultra Wireless Kit is a plug-and-play kit for the 5DT Ultra series of data gloves. Each belt-worn wireless kit is designed to transmit the data for 2 gloves simultaneously. This means that a single wireless transceiver and battery pack is used for both gloves, saving both space and power. Up to 4 wireless kits (8 gloves) can be used at the same time."

4.3 Force Feedback Computer Mouse and Trackball

There is no detailed documentation about the TouchSense Technology.
Many manufacturers develop peripherals (mouse and trackballs) with Immersion TouchSense technology:

- HP (Force Feedback Web Mouse)
- Belkin (Belkin Nostromo n30)
- Logitech (iFeel™ Mouse)
- Saitec (Touch Force™ Optical Mouse)
- Kensington (Orbit® 3D Trackball)

5. Commercially Available Haptic Display Systems

The appendix A presents the technical information of commercially available haptic display systems:

- Vibro-Mechanical Electromagnetic devices
- Skin Simulator model VBW32
- Electrocutaneous Stimulation devices
- Pneumatic devices
- Shape Memory Alloy devices
- Piezo-Electric devices
- Mechanical rotating devices
- Gel Based devices

6. Recommendations

The following recommendations could change with new information to be received from suppliers.

After reviewing existing technologies in the field of Haptic interfaces (tactile display), it became evident in light of SIREQ-TD trial results that the Vibro-Mechanical Electromagnetic tactors, e.g. from Engineering acoustics Inc, are, in general, too bulky and heavy for helmet integration. Furthermore, there are two technologies that at this time cannot be used without packaging even if studies and research programs have used them: the Piezoelectric and the Memory Shape Alloy devices. These technologies need to be covered with some material to keep out dirt, water, etc… Their properties and form factor make them attractive, but we have found no prepackaged tactors. The Electrocutaneous Stimulation devices have interesting properties (form factor, low power, large

[16] Website http://www.5dt.com/hardware.html#glove.

devices array) but are too expensive and have a shallow threshold between usability and pain. But again, this is an emerging technology and may warrant further investigation. The Pneumatic devices are light, small and provide good tactile sensation, but are difficult to integrate in a soldier's helmet because of the required pump and control valves. The advent of MEMS [17] pump and valves could put this technology in reach for integration. The following paragraph presents two other technologies that could prove more promising than pneumatic devices in the Dismounted Soldier context, even if they may still be an option for Drivers and Gunners in fighting vehicles.

We are left with two technologies that may be more suitable for the purpose at hand:

- The Mechanical Rotating devices with the form factor of the Steadfast Technologies R-1 product would seem appropriate. The only concern is the length of the device may limit the numbers of tactors, but again most of the tactors surveyed have one of their dimensions in the range of 25,4 mm (1 inch). The only technologies that have a smaller form factor are the Piezoelectric, the Memory Shape Alloy and the Multichannel electrotactile array, and these have all been rejected for the reasons stated above.
- The Gel based technology has never been used as a tactile display. But the construction and form factor warrant an investigation of the possibility of operating an array of Gel based sensors as tactors. This concept needs to be validated before being rejected.

During the survey, we found two links of interest for the Tactile Display Survey. First, the vest used by the TSAS experiment was designed and fabricated by DRDC, according to the Maple Leaf magazine. Secondly, we found out that DRDC-Valcartier has a Distributed Synthetic Environment Group that is interested in the Haptic interfaces for use in Virtual Environment (see their report entitled “Virtual Environment and Sensori-Motor Activities: Haptic, Audition and Olfaction”).

Based on these finding, we recommend that the Speech/Comms Sub-system group, through its Chairman, invite the TSAS vest designer and the Valcartier team to validate this report and to work on the next phase of this project, if it goes forward.

A final recommendation is to move rapidly in putting together a one or two-day workshop on Tactile Display and inviting researchers from Natick Soldier System Center and US Army Research Laboratory and from the US Army Aeromedical Research Laboratory, initiator of the TSAS flight demonstration program.

7. Conclusion

Mr Micheal V. Scalon from The US Army Research Laboratory, Acoustic division, inventor of the Gel sensors technology has offered to collaborate with us in trying to use the Gel-sensors as a tactile display. According to him the signal strength may be on the low side but it could work. Furthermore, he told us that a researcher in Aberdeen Proving Ground has mapped the head skin sensitivity and that the Natick Soldier System Center has at this time a project to put tactile display into a helmet or will start such a program. Contact was made with the Canadian exchange scientific at Natick, Mr. Gilles Pageau. Mr. Pageau has agreed to contact Mr. Scalon to try to find the name of the researcher in Aberdeen. Moreover, Mr. Pageau will try to contact the Scientists responsible for the helmet-based tactile display program. SIHS-TD has everything to win in establishing cooperation with their US counterpart.

This report could have included more technologies like ferromagnetic-based devices or Peltier effect based devices. The field of haptic display is growing and new devices are bound to appear on the market. The amount of learned work and experiments done in this field is large and growing larger. The improvement and increased used of Virtual Environments for training is pushing the technology of Haptic Display. The interest demonstrated by the military (Air Force, Navy, and Army) is increasing partly because the technology permits it but also because of the advent of smaller computerized systems integrated with haptic interfaces that can improve the ability to face a more complex battlespace and improve safety in many areas.

[17] MEMS: Micro Electro Mechanical System

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(U) In the context of the SIHS−TD project, the Speech/Comms Sub−system Team (SST) has proposed considering the integration of a haptic display in the concept helmets to be developed by the Industrial Team (IT). A study of the state of the art of commercially available haptic interfaces, aimed at being integrated to a helmet, was conducted to fill the knowledge gap identified by this SST.

After reviewing existing technologies in the field of haptic interfaces (tactile display), it becomes evident in light of SIREQ−TD trial results that the Vibro−Mechanical Electromagnetic tactors are in general too bulky and heavy for helmet integration. Furthermore, there are two other technologies that at this time cannot be used without packaging even if studies and research programs have used them: the Piezoelectric and the Memory Shape Alloy devices. These technologies need to be covered with some material to keep out dirt, water, etc… Their properties and form factor make them attractive, but no pre−packaged tactors have been found yet.

The field of haptic display is growing and new devices are bound to appear on the market. The advent of smaller computerized systems integrated with haptic interfaces can be another means to improve the ability to face a more complex battle space and improve safety in many areas.

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(U) tactile displays; tactors; SIHS; Soldier Integrated Headwear System; communications; haptic displays; display modalities; helmet displays