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The Low Vision Enhancement System:

A Decade Long Technology Transfer Project

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INTRODUCTION

There are approximately 2 million people in the United States who cannot function normally in society due to vision impairment. Yet, most of these people retain some sight. Until recently available treatments were essentially unchanged from those available 50 years ago. Options included various hand magnifiers, colored lenses, and telescopes mounted to glasses. The one recent innovation was the development of a stand-mounted, closed-circuit television. Collectively, these aids were often of limited utility. For example a hand lens is of little value when walking, watching television or shopping.

As the result of a conscience decision the Wilmer Eye Institute, a part of The Johns Hopkins University, contacted NASA. They wished to learn if NASA had new technology that could help low vision patients. As a result in 1985 the two parties began working together, developing an aid for the vision handicapped.

Their efforts, along with that of many other organizations that subsequently joined, have created a system of technology that will have impact far beyond the original target population.

LOGIC

The requirements presented by the low vision patient and the state of medical knowledge posed an interest problem. The original analysis identified three major problem areas that had to be addressed. First, the patients are highly variable by almost any measure. They vary in age, size, medical condition, individually with time, and functional need. One who is reading has different requirements from someone who is walking. Second, there was a basic lack of understanding about how the vision of the patient was affected by the disparate medical conditions. Vision is in the brain

1

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as well as the eye, and it was well known that what happened in the processing of the nerve signals had major impact on vision. It was also known that the patients adapted to their optical problems with a host of strategies, both conscience and un-conscience. Thus, if a change was made in what the patient saw, would it help? Third, there was relatively little knowledge about the epidemiology. Who were the patients, how many with what medical conditions, and what were their functional needs?

The solution that was developed was based on three technologies. Two were provided by NASA's work in image processing at National Space Technology Laboratories[2] in Mississippi and head mounted displays at Ames Research Center in California. The third was commercial developments in frame rate image processors. Basically the idea was to take video imagery from head mounted cameras, simultaneously acquire eye tracking information, convert the imagery to digital form, process the data at frame rates and display the results on head mounted displays. The use of flexible image processing software would allow the researchers to quickly test ideas. The epidemiology would be handled along classic lines. It was clearly recognized that the technology simply did not exist to do all that was envisioned. Further, the technology was evolving very rapidly. The proposed approach was recognized as having the advantage that it was highly adaptable.

With further development more explicit requirements were developed. We give a partial list of some of the considerations. These are presented without attaching much significance to their order or groupings. Many of the factors had multiple impacts.

- Cost: of any product and the cost of development

As most medical costs in the United States are not borne directly by the patient creating something that would be covered by existing insurance was a consideration.

- Physiological variation

The system would have optical components. Optical systems are sensitive to angles and distances. Head size, shape, an interocular distance all vary between patients and change as children grow.

- Visual requirements change with task.

Reading, conversation, shopping, walking, fixing a meal, and watching television all have distinct visual requirements.

- Weight:

Both the total and its distribution were major considerations.

- Appearance:

Any aid had to be cosmetically acceptable. There are many medical aids available which are not used simply because of social factors.

- Ease of use

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Any controls had to be usable by someone with controls work for arthritic hands. Contamination of system by dirt and sweat due to normal use was expected

- Engineering:

The system would have to be shock resistant at least able to withstand a drop from a table to a floor. Power requirements would be limited by the weight and performance characteristics of batteries. Can the design be manufactured?

RESULTS

The project has resulted in two discrete products. The commercial system (Figure 1), termed the Low Vision Enhancement System (LVES) is now commercially available across the nation. It is flexible in configuration and multi-functioned. It can capture video imagery from either one or two cameras which are built-in or link to other NTSC or PAL sources. The video imagery is processed, and displayed in a head's up display. The entire unit is generally cosmetically acceptable and light weight.

Figure 1 From brochure "Announcing the Availability of the Low Vision Enhancement System" by the Lions Vision Center, Johns Hopkins Wilmer Eye Institute

The LVES is the commercial expression of the Low Vision Research System (LVRS). This is a suite of hardware and software devices capable of capturing imagery at frame rates, digitally processing this input and displaying the results to various output devices. The hardware core of this system is a Silicon Graphics 340 VGX. Software allows the researcher to manipulate imagery according to research and test protocols. Example operations include various band pass filters and image warps. Some of the system's capabilities include:

. accept color video imagery with 512x480 resolution at 30 Hertz,

. store or recall from real-time digital disks,

. geometrically warp the imagery in a completely arbitrary manner,

. adjust processing based on the user's eye position.

The LVES and LVRS are inherently adaptable. They can be used for research, simulation, as well as a vision aid. For example the LVRS can help the researcher find the most effective correction for a patient's problem, duplicate the problem and give it to a "normal" user, such as the researcher, and apply the correction for the patient. Applications of the technology to scientific work other than vision, primarily utilize three of the system's capabilities: the ability to integrate disparate data, process the data at very high rates, and display the result in an "Enhanced Reality". To illustrate, one proposed application would integrate visible, thermal and radar imagers to allow an archaeologist literally "see" into the ground while walking across the surface.

LESSONS LEARNED

In hindsight the development of the low vision systems has taught its participants several points relevant to technology transfer in general. First, there is often a need for long term commitment on the part of all parties, not just as organizations but as people. Ten years was needed to bring the original idea into a commercial reality. A retention of key personnel and some fiscal stability is essential. Delays were usually the result of NASA's problems in one of these areas. We also found a large number of people and organizations wished to contribute to the overall effort. Our open management structure readily allowed incorporation of their efforts.

There is a clear desire on the part of NASA to have an effective technology transfer program. But, there are several issues that often make this difficult. Possibly the common factor is that much of the technology is simply not at a point where it can be moved out into the commercial world without significant investments of time.

First, NASA's funding cycle is yearly. Any agreement covering a multi-year project will carry a caveat or escape clause concerning availability of funds. When a prospective partner asks what makes funds available or not the first answer given is Congressional authorization. Probing farther they learn that personal decisions by many individuals at multiple levels within the NASA system can all change the level of funding available for a specific project. The former is not a significant problem for most companies; the latter is. The lack of a strong, readily enforceable contract inherently makes NASA's partners very tentative about committing resources. The net result is an overly cautious product development.

Second, accomplishing a transfer is often a major time burden for one or more of NASA's civil servant staff. For most personnel there is little, long term benefit or career enhancement for such work. The people who have the intimate knowledge of a technology do not work for the Technology Utilization Office. They work for other codes (organizations), and those codes receive little or no benefit for successful technology transfer projects. Thus there is a clear disincentive for both the individual civil servant and the organization to not spend significant time on technology transfer work.

Third, the methods used and the strictures which civil servants must use are often foreign to others. This affects items as diverse as travel arrangements, procurements, planning, funding processes, an individual's responsibilities and authority, publications and public affairs activities.

With such impediments success requires a personal dedication on the part of the civil servants and the outside personnel.

CONCLUSIONS

NASA"s Low Vision Project is a clearly successful technology transfer. It has resulted in an aid for those who have largely become invisible in society due to vision handicaps and the creation of a basic research tool. The former is practical, effective and commercially viable. Although NASA's role in this effort is over, development will continue for the foreseeable future because of the inherent merit of the technology and the strength of the organizations created around it. Accomplishing this has required a decade of work. From the NASA side the largest difficulties were consistently not the technical issues, rather they were management related. Lack of confidence in budgets, man power and other resources for periods longer than 6 months resulted in serious delays. Flexible organization, a freedom and a willingness to change plans as the situation evolved, and a dedication to reaching the overall goal has been central to success..