

Florida Space Research & Education Grant Program (2000/2001)
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PROPOSAL COVER PAGE

Name of Project: Advances in Networked Video to Improve Safety, Effectiveness, and Security
of Florida Spaceport Operations

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Budget Request:

Grant	\$30,000 *** revised on April 30, 2001 ***
Matching Contribution	from Bionetics Photo Services (see letter in Appendix A)
Total Project Cost	\$30,000 *** revised on April 30, 2001 ***

Note: A detailed budget justification is required.

Please identify which categories are applicable to your project (check as many as are appropriate):

- Spaceport Technology Development
- Space-Based Research & Payload Development
- Space Education & Training Programs
- Space Research Infrastructure Programs

Please identify whether your project fits within one of the following sponsored initiatives (optional):

- Remote Sensing
- Leveraging Major Opportunities
- Florida Express
- LiteStar
- Parabolic Microgravity
- Teacher Fellowship Program

Beginning Date: 9/1/2001 Ending Date: 8/31/2002

___ *** See original for signature *** ___
(Signature) Faculty PI / Date

___ *** See original for signature *** ___
(Signature) Department Head / Date

Name Kenneth J. Christensen
Title Associate Professor

Name Dewey Rundus
Title Associate Chair of Computer Sci and Eng.

Revision Note

This proposal is a revised version to reflect a funding level of \$30,000 reduced from \$43,897. The budget changes (the revised budget is in Section 8) from the original proposal are:

1. Support of two graduate students at half-time is reduced to support of one graduate student at half-time and one undergraduate student at quarter-time . Tuition does not need to be requested for undergraduate student support (and hence tuition support is shown for only one student). The undergraduate student is supported at about \$8 per hour, a reasonable rate for an undergraduate Computer Science and Engineering students.
2. The travel costs from USF to Cape Canaveral have been removed (PI to cover)
3. The equipment costs have been reduced to \$347 from \$500. It is hoped that the price of components has dropped since the proposal was first submitted and that Bionetics Photo Services can provide some equipment.

The technical changes from the original proposal are:

1. The primary change is in focus #1 where we address how to handle “down” links for the case of video transmission. The original proposal addressed as-soon-as-possible updating of stored video when a link returns to an up state following a down state. In this revised proposal, we relax this requirement. Instead we will explore means of locally storing video and then at a later time forwarding it to a distant “home” server to update any lost video transmissions. Section 4.2, 5.0, and 6.0 reflect these changes. There are no revisions to focus #3 (new technology development in Section 4.3).
2. The final deliverables are one prototype video enabled computer, one report, one conference paper, and one technical report. This consolidates three reports into one report and eliminates one conference paper.
3. The student recruiting plan has been changed to reflect the new support of one graduate and one undergraduate student (the original proposal supported two graduate students). These changes are in Section 8.2.

Executive Summary

Imagine if *every* aspect of Florida Spaceport operation - from payload and vehicle preparation to launch - could be monitored and captured on video. Imagine if spaceport technicians could wear video cameras that viewed and recorded everything they did. Real-time monitoring of the video streams would make possible real-time decisions improving safety and effectiveness. Playback of stored video could be used to confirm that procedures have been completed correctly and could enable less expensive, faster, and more reliable analysis of incidents. Stored video could also be used for training and time-and-motion study purposes. Modern technology has dropped the cost of video cameras to below \$50 and has made possible the emerging field of wearable computing.

This project will address open problems in increasing the use of video for improving Florida Spaceport operations safety, effectiveness, and security. A unique requirement to spaceport operations is that no video data ever be "lost" due to network connectivity problems. In other words, degraded video quality, which may be acceptable in other business and entertainment applications, is not acceptable for spaceport operations. This project will address this unique requirement. This project will also evaluate the feasibility of having spaceport technicians wear video cameras as part of their clothing to record and allow for live viewing, via wireless links, of everything they do in an operational procedure. The three inter-related tasks of this project are:

- 1) Prototyping a video-enabled technician using off-the-shelf components. The deliverable is a prototype.
- 2) Prototyping methods of locally storing video transmissions when network connectivity is down or degraded. The deliverable is a prototype.
- 3) Investigating technology development to improve video quality, reduce costs, and better meet stringent spaceport technical requirements. The deliverables are a conference paper and a technical disclosure.

This project will be conducted at the University of South Florida with the assistance of two students. The results will be demonstrated and presented to Florida Spaceport officials. The principal investigator for this project is Dr. Ken Christensen in the Department of Computer Science and Engineering at the University of South Florida. A funding level of \$30,000 (revised down from \$43,897 on April 30, 2001) for one year is required to support two students and enable course release for the principal investigator. Course release is at a reduced rate with support from the Department of Computer Science and Engineering at the University of South Florida. At the completion of the project, the students will be well prepared to be employed by the space industry in the state of Florida. The direct benefits from this project are to, 1) improve the safety, effectiveness, and security of spaceport operations, 2) develop technology for transfer to the private sector, and 3) train two students in an area of value to Florida Spaceport. Dr. Ken Christensen was a summer faculty fellow at NASA/KSC for 1998 and 1999 and performed capacity planning work related to MPEG video distribution throughout KSC. This proposal includes a letter of support from Leonard Erickson, General Manager of Bionetics Photo Services. Bionetics is offering both use of equipment and their photo editing facilities in support of this project.

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Project Narrative

1. Introduction

Safety and security of technical operations can be improved by monitoring at many levels. Video monitoring is increasing in use as the cost of video technology drops. Launch facilities are currently equipped with multiple cameras [3] and recent launches from Cape Canaveral have included on-board “rocketcams” [23]. Thus, video is nothing new for Florida Spaceport operations. Real-time video is useful for making go/no-go decisions. Recorded video is useful for later analysis. As a tragic example from the aerospace field, the recent Concorde accident could have been better analyzed, and possibly prevented, if large scale video monitoring had been implemented. An amateur, low-quality video, has been a significant analysis tool in the accident investigation.

An emerging field of computing is “wearable computing” [17, 20]. Wearable computing was pioneered by Steve Mann while at MIT and is currently the subject of research at several universities [11, 18]. Vendors of wearable computing equipment include Xybernaut [24], Genesis Technology Group [9], and Circus Systems [7]. Wearable computing exploits the very high levels of miniaturization of computing technology. It is now easily possible to wear computing equipment of sufficient capability for projection of documents on a floating video screen, voice input of simple commands, and video recording. Using wireless technology, the wearable computer is connected to the rest of the world for receiving and/or sending of information including video streams. The Department of Defense has explored, and funded, the use of wearable computers for future generations of soldiers [1]. Boeing is a pioneer in the use of wearable computing by aircraft technicians [10].

This project proposes to investigate the use of low-cost video to improve Spaceport operations safety, effectiveness, and security. There are many “dark” areas that could benefit from having video monitoring. This project will address how to implement large-scale video infrastructures that would enable “putting a camera” in many new areas. This project will demonstrate new applications of video including the use of video-enabled wearable computing for aerospace technicians. Specifically, this project will have three distinct focuses:

- 1) Prototyping a video-enabled technician using off-the-shelf components. The deliverable is a prototype.
- 2) Prototyping methods of locally storing video transmissions when network connectivity is down or degraded. The deliverable is a prototype.
- 3) Investigating technology development to improve video quality, reduce costs, and better meet stringent spaceport technical requirements. The deliverables are a conference paper and a technical disclosure.

The overall goal of this project is to investigate technologies for extensive video monitoring to improve spaceport operational safety and effectiveness.

2. Technology Background

2.1 Wearable computers

Computing technology has dropped in price, size, and power-consumption and increased in performance all at the same time. Wearable computing is an emerging field with its own conferences, research groups, and companies. Steve Mann, now at the University of Toronto [16], is often credited with inventing the field while a graduate student at MIT. The MIT Media Lab [18] continues to explore both wearable computing technologies and new paradigms of social interaction made possible by wearable technology. Georgia Tech [11] is exploring manufacturing, and other pragmatic applications of wearable computing. Significant computing power can now be comfortably worn in, or on, clothing. Wireless links make possible tether-free communications between the wearable computer and the rest of the world. Display technology has improved to the point where a full-screen monitor can be delivered via a “floating” heads-up display. Video camera technology has improved to where a camera and video display can all be readily hidden in a pair of eyeglasses. Figure 1, taken directly from [17], shows the evolution of wearable computers from bulky “contraptions” in the early 1980’s to a hidden appliance in the late 1990’s. The camera and floating display are hidden in the sunglasses in the fourth image showing a late 1990’s wearable computer (the computer is worn on the belt and is about the size of the original Sony Walkman). In 2000, the NFL approved “ump cams” for professional football [8]. This is an example of video-enabling a human with low-cost and highly portable video cameras and wireless links.

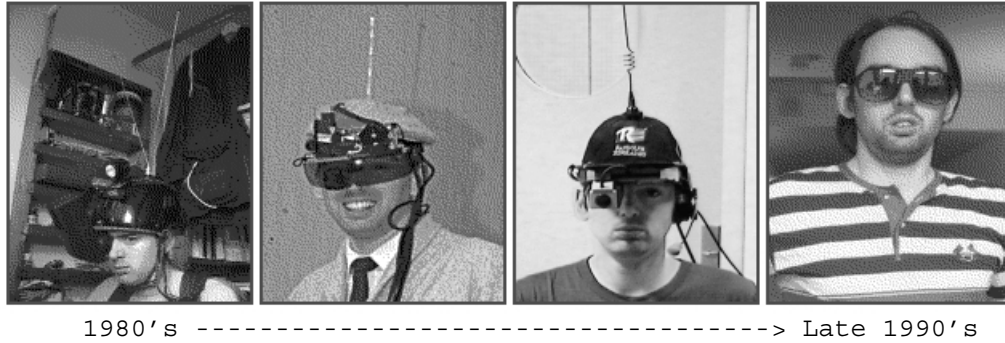


Figure 1 - Photograph of Steve Mann showing wearable computing technology (copied directly from [17])

The military is exploring wearable computing in the Maintenance and Repair Support Systems (MARSS) [1]. MARRS is an integration of soldier and machine optimized for maintenance. The wearable computer is designed to be worn as a vest. Input and output is via a head mounted microphone and flat-panel display. The goal for MARRS is to be able to meet Army requirements for test, fault isolation, repair procedures, and so on. Of direct relevance to Florida Spaceport operations, Boeing [10] has pioneered the use of wearables for integrating support technicians with a surrounding support system to reduce both costs and turn-around times. In [10], the development of a Portable Maintenance Terminal (PMT) is described. The PMT includes wireless LAN, storage, speech recognition, audio I/O, personal displays, input devices, portable computer, and a battery. In [10] the following is stated with regards to input devices,

“Video camera technology has also merged with wearable. The wearable computer can be used to capture or transmit color video. This enables a mechanic to record his process to help train others, provide inputs to time and motion studies, document repairs and defects, or provide quality documentation for remote quality control functions. Video camera technology enables multimedia collaboration such as video conferencing or a real-time remote contractor logistics support function with the realized benefits of reduced time and cost.”

2.2 Low-cost video cameras

Video cameras continue to drop in cost and size. Off-the-shelf technology for consumers support “hidden cameras” in everyday items including wearable ties and faux household items [19]. The applications of this technology are often for personal surveillance. The National Institute of Standards and Technologies (NIST) recently funded a private company to pioneer new technologies for low-cost, low-light cameras [15]. The expected application is for nighttime security. Camera technology is now sufficiently advanced that a wide-field camera can be integrated into a set of normal-sized eyeglasses and worn while performing physically strenuous duties (e.g., as for NFL ump cams [8]).

2.3 High-speed network technologies

Network technology has also advanced very rapidly in the past five years. From 1980 to about 1995, the most common local area network data rate was a shared 10-Mbps (i.e., 10-Mbps Ethernet as 10BASE5, 10BASE2, or 10BASE-T). Higher-speed 100-Mbps Fiber Distributed Data Interface (FDDI) was, and continues to be, used but at relatively high cost. FDDI is typically used for wide-area backbones interconnecting smaller Ethernet and Token Ring Local Area Networks (LANs). NASA-KSC makes extensive use of FDDI technology in their backbones. FDDI technology is considered “legacy” with little new technology development. This limited development limits the future for this technology.

Between 1995 and 2000, data rates have increased by two orders of magnitude and switching has enabled this much greater bandwidth to be dedicated, as opposed to shared. Costs have stayed about the same (e.g., a 1000-Mbps Ethernet adapter today is only slightly more expensive than a 100-Mbps adapter in 1995). Technologies

such as ATM at 155-Mbps and 622-Mbps and Ethernet at 100 and 1000-Mbps are now off-the-shelf, easily obtainable, and widely deployed. For example, NASA-KSC deploys a wide range of ATM and Ethernet technologies to meet both local and wide area networking requirements. Work has been done at NASA-KSC to determine how the existing infrastructure can best be used to transport digitized MPEG space shuttle video [4]. Dynacs Engineering is the primary contractor responsible for this work [12].

3. New Applications of Video Monitoring for Florida Spaceport

Florida Spaceport already uses video in many place for monitoring of operations. Launch pads are “wired” for video for launch support. Launch pads that are not directly wired can use mobile “van based” cameras [3]. Even the rockets themselves now carry cameras in the form of “rocketcams”. These rocketcams have resulted in spectacular launch footage available on the Web. Florida Spaceport certainly understands the value of video and the difficulties associated in transmitting and storing large quantities of such video. However, there still exist “dark places” within Florida Spaceport that could benefit from video. One such dark place is the workspace of the technician. This workspace, and the activities that he or she perform, are (obviously!) of vital importance to launch operations. Thus, one new application of video in Florida Spaceport is with the technicians themselves. Other dark places may include storage areas, maintenance shops, and other facilities of less primary importance than the launch pads. Video monitoring of these areas would increase security and may thus also reduce “manned” security costs.

With wearable computing for Spaceport technicians, many new applications of video can be envisioned. Immediate applications that we envision include:

1. Recording of operations for later confirmation that tasks were performed correctly. In other words, “Was the bolt tightened?”
2. Real-time monitoring and audio two-way conversation for consulting with remote engineers and/or other technicians. In other words, “Which bolt should I tighten?”
3. Recording of operations for training purposes and time-and-motion studies. In other words, “Let me show you which bolt to tighten and how to do it.”

In the long-term, having a video camera as part of a technician’s clothing or toolkit could change how tasks are performed. For example, it may be possible to integrate visual inspection of a part (with a video recording of it) with its installation. This would reduce two steps into one step. It is reasonable to expect that many new ways of performing operational tasks will emerge in similar fashion that the wearable computing research community is finding many new forms of social interaction are enabled by wearable computer technology. The only way to find these new applications is to experiment with wearable computing technology in the context of spaceport operations.

4. Project Tasks

The project will have three distinct focuses. The first and second focus is supported by one student (student #2 - undergraduate), the third by a second student (student #1 – graduate). Both students will assist each other in their tasks. The first focus area will be on building and demonstrating a video-enabled technician using wearable computer technology. The second focus area well be on local storage of video when network connectivity is down or degraded. The third focus area will be on technology development to support large-scale video infrastructures.

4.1 Focus #1 - Prototyping a video-enabled technician using wearable computers

We will build and demonstrate a video-enabled technician using off-the-shelf components. We envision that the computer system unit is belt mounted, the microphone is a standard head-mount unit, and the video camera is mounted on the brim of a baseball-type cap or the brim of hardhat, as appropriate for the specific technician’s job. A key technical problem to be solved is how should disconnections of the wireless link best be handled - this is the subject of focus #2 described in Section 4.2. Since local storage of video will be required when network disconnections occur, a wearable computer will be needed. This focus will explore integrating existing ump cam type of technology with wearable computers for video transmission and storage.

Evaluation of the video quality will include viewing of fine detail work (e.g., putting in small half-inch screws into a panel) and large-detail work (e.g., stacking large components in a correct order). Both artificial and natural lighting conditions will be used. It may be necessary to include spotlighting with the camera for sufficient quality video for fine-detail work with artificial lighting. We will evaluate these types of video quality issues as pertinent to a video-enabled technician.

4.2 Focus #2 - Storing video transmissions when network connectivity is down or degraded

What happens when network connectivity is down or degraded (e.g., if a video enabled technician goes out of range from a base-stations)? Video transmissions must not be lost during these periods of time. This problem has not been previously solved. We propose that the video be stored locally if the wireless link is unusable and otherwise (if and when the link is “up”) be transmitted on the wireless link. A real-time approach to this problem is:

- 1) Design and implement a method of reliably detecting when a wireless link is unusable or “down” due to distance or obstacles affecting the channel.
- 2) Design and implement a method to quickly (without losing video frames) transition from network transmission to local storage when the link goes “down”.
- 3) Design and implement a method to transmit as much as possible of any backlogged (locally stored video) and otherwise quickly resume transmission of video when the link is “up”.
- 4) Develop a method to assemble a single and complete video stream from two sources, the live streaming video stored at a remote computer and the locally (on the wearable computer) stored video. Any lost video frames must be clearly marked.

As a result of the April 30, 2001 revision, we intend to explore a limited version of the above. Our developed system will:

- 1) Locally store all video transmission
- 2) Send, via a wireless link, video transmission to a local (local to the technician) server that contains both wireless (e.g., IEEE 802.11) and wired network cards (e.g., Ethernet).
- 3) Periodically update a distant “home” server (via a wired link) of all video stored in the local server.
- 4) At the end of a task be able to update the final archived video using the locally stored video.

We will implement video transmission using the TCP/IP or UDP/IP protocol and the sockets programming interface [22]. The programming environment will be either Microsoft Windows, or Linux, whichever is best suited for wearable computing technology. Both TCP/IP and sockets are open standards and are equally supported in Windows and Linux environments.

4.3 Focus #3 - New technology development to support large-scale video infrastructures

In the third and final focus of this project, we will explore new networking technologies to support very high densities of network-attached video cameras. All existing high-speed networking technologies (e.g., ATM and Ethernet) are based on a dedicated medium (see [5] for a history of network evolution from shared to dedicated medium). In a dedicated medium network, each network device (e.g., desktop PC) has its own physical wire to a centralized network “wiring closet”. This is also called star wiring. Dedicated medium networks evolved from shared-medium networks for two significant reasons:

- 1) Fault detection and isolation is much easier
- 2) Higher total data-rates can be supported

Figure 2(a) shows a shared-medium network with direct-wiring (daisy-chaining) between devices, Figure 2(b) shows a dedicated-medium network with star-wiring. Note that in the star-wired case, the amount of cabling exceeds that of direct-wiring. Star-wiring also requires a hub unit that is a repeater (in the CSMA/CD Ethernet case), a concentrator (for FDDI), or a switch (for switched Ethernet or ATM). In all cases, the network of Figure 2(b) will be more costly than that of Figure 2(a). Our challenge is to be able to build a shared-medium, direct-wired network with acceptable performance and reliability compared to a dedicated-medium, start-wired network.



Figure 2 - Examples of shared-medium and dedicated-medium networks

For a dedicated network to be cost-feasible, the cost of a “wire” must be less than the network device. This is typically the case for desktop PC’s (where the PC will cost about \$2000 and the labor and material cost of a network drop from office to wiring closet is between \$150 and \$300). As the cost of network devices continues to drop (and copper/fiber and cable costs do not drop), wireless technologies increase in interest and application. However, wireless networks can only go “so far” in terms of bandwidth, distance, and low packet loss. Wireless technologies are excellent for short distances (e.g., from a technician with a wearable computer to a nearby base station) and where the density of devices is not very high (a high density of devices will overwhelm the available “shared” wireless bandwidth in, for example, a single cell). Controlling packet loss in wireless networks is an open challenge. Both distance and obstructions (e.g., walls, metal beams, etc.) affect packet loss in a wireless link.

We propose to investigate if, and how, shared-medium networks may again make sense in light of a very high density of network devices and where the devices 1) cost very little, 2) require moderately large amounts of bandwidth (e.g., several Mbps each), and 3) the applications are not tolerant of packet losses. We will investigate both Medium Access Control (MAC) layer protocols and Physical (PHY) layer connection issues required to build a reliable and predictable (performance) shared-medium networks. In particular, we will investigate two methods:

- **FDDI-Lite** - This is a stripped-down FDDI protocol that will result in a cost-effective adapter design. For example, FDDI requires an adapter to have a microprocessor to support “SMT” functions that are rarely, if ever, used in a production environment. The complex timed-token protocols of FDDI are also rarely used and contribute to complexity and cost. We will also investigate methods of direct attachment of an FDDI-lite device to a network cable and thus not require star-wiring and costly concentrator (hub) units.
- **Extended CSMA/CD** - This is an “extended CSMA/CD” that combines both CSMA and CSMA/CD operation for less efficiency, but very low complexity and the ability to utilize very high data rates (e.g., 10-Gbps). For very high-speeds and large-span networks, collision detection will be usable for large packets, but for small packets entire packets will be lost to a collision (this is pure CSMA operation). The decreased efficiency of CSMA will “rob” considerable bandwidth from the network, but if the amount of bandwidth that we can start with is high, the resulting usable bandwidth will still be significant.

Both of these proposed MAC-level protocols will be simulated for performance evaluation. Trace files of real video streams will be used to drive the simulations to allow conclusions to be made on video performance for these new technologies. Reliability will be addressed by PHY layer methods enabling the devices to physically remove from the medium in case of failure. Current IEEE 802.5 Token Ring contains mechanisms to enable adapters to remove from a network. We will study these methods and how they may apply to a shared fiber-optic medium. We will not pursue actual technology development, but we will write an appropriate technical disclosure to guide future development. The design and its performance will be described in a conference paper. As a result of the April 30, 2001 revision, other methods than FDDI-lite and Extended CSMA/CD will also be investigated.

5. Schedule of Activities

This project will be conducted in one year beginning on September 1, 2001 and completed on August 31, 2002. Figure 3 shows the schedule with milestones (milestones are described on the following page).

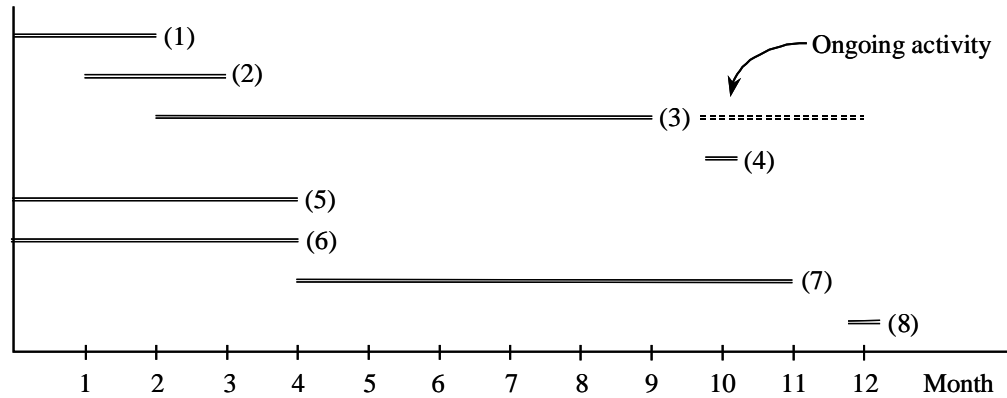


Figure 3 - Schedule of activities with milestones

The milestones in Figure 3 are:

- (1) Completion of video-enabled wearable computer using a wired link and without software features to handle disconnected links.
- (2) Addition of a wireless link to wearable computer.
- (3) Completion and evaluation of advanced software features to wearable computer prototype to handle disconnected links with non-realtime updates to a distant “home” server.
- (4) Demonstration of a wearable computer with video to appropriate Florida Spaceport principals
- (5) Education on existing network infrastructure at Florida Spaceport
- (6) Completion of literature research in shared-medium technologies
- (7) Completion of technology investigation into new shared-medium networks for high-density video
- (8) Final delivery of one prototype video-enabled wearable computer, three reports, two conference papers, and a technical disclosure

6. Deliverables

There are two major deliverables (each with sub-deliverables) from this project, they are:

- 1) A demonstration of a prototype wearable computer with video camera. The prototype will demonstrate the ability to adaptively transmit video when a transmission link is usable and store video locally when no link is available.
- 2) A report on possible future technology development for network technologies better suited for supporting large-scale video infrastructures. A conference paper and a technical disclosure will be submitted.

An overall final report will also be submitted.

7. Benefits to Florida Spaceport

7.1 Tangible and short term benefits

The short-term benefits are to introduce new technologies to the “toolkit” of Florida Spaceport to improve command, control, and monitoring. We believe that video monitoring of critical technician implemented procedures can increase safety and improve effectiveness of operations. Case studies by wearable computing vendors have shown productivity increases when wearable computers are used in manufacturing. Security can clearly be improved by added video monitoring. This project addresses the technologies needed for large-scale video infrastructures to support large number of safety and security related video cameras. The emerging low-light camera technologies [15] need to be carefully followed.

7.2 Long term research and proposal activity

We intend to pursue further funding in this area from the National Science Foundation (NSF) ITR program. Thus, this project will serve as the springboard, or lever, to bring federal funding into Florida. In particular, we wish to investigate image processing aspects of large scale video. When you have 1000's of cameras, how do you best "watch" all this video? Other faculty in the department will be involved in this much larger grant proposal.

For Spaceport Florida we hope to get industry partners (both spaceport contractors and wearable computing vendors) "plugged in" to continue exploring and adopting new video-related technologies. Technology transfer is possible via the technical disclosure for new shared-medium network technologies.

8. Budget

This section shows the budget for this project. Appendices A and B contain supporting material for the budget. The total requested funding is \$30,000. An in-kind match of use of facilities and equipment from Bionetics Photo Services is shown in the budget.

1) Student salaries	
Student #1 (half-time, 9 months)	\$13,500
Student #2 (quarter-time, 9 months)	3,000
2) Fringe rate for student salaries	
1% for students	165
3) Student in-state tuition (required by USF rules for graduate student support)	
Student #1 (18 hours, \$166 per hour)	2988
5) Equipment (\$500 is maximum allowed by program)	
Video cameras and wireless cards	347
6) Course release for Principal Investigator (Christensen)	
Release from one course for Spring 2002	10,000
7) USF indirect cost	
0% rate per Florida Space Grant Consortium agreement	0
Total budget request: \$30,000	

1) Use of Bionetics Photo Services facilities and equipment	
Use of video editing facilities and Sony cameras	---
Total project cost: \$30,000	

8.1 Budget justification and explanation of matching

The budget is justified as follows. The majority of the funding is for two students and a course release for the principal investigator. The two students will perform the described work as the basis of their M.S. thesis, or as part of a larger scope Ph.D. dissertation (or, as the basis of an undergraduate honors thesis, see Section 8.2 for the recruiting plan). The undergraduate student will tackle the relatively easier focus #1 and #2 and the graduate student will tackle the more difficult focus #3. The course release enables the principal instructor to have the necessary time to supervise the students. The equipment money will be used to buy miniature cameras and wireless equipment to prototype the wearable components that are the key components of the overall system that will be made wearable. Partnering arrangements with wearable computing vendors and/or corporate supporters will be pursued to purchase an actual wearable computer at about \$5,000 cost.

Bionetics has committed use of their photo editing facilities and of two Sony cameras. While there is no assigned value for this support, this support will make the project possible. This support will significantly allow for a review by a commercial vendor heavily involved in providing launch and payload processing image services for Cape Canaveral launches.

8.2 *Recruiting of students*

This project will require two students. These students will be recruited from those students already in the graduate program at the University of South Florida. A high priority will be to recruit students from under-represented populations. To do this, we will advertise the open positions to SBE, SHPE, SWE, and similar student groups that support under-represented populations. Encouraging our own undergraduate students to pursue graduate degrees and spaceport-related careers is of high importance.

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*** Revised version (April 30, 2001) ***

Biographical Sketch

- Not included in revised version (on file in original version)

**** Revised version (April 30, 2001) ****

- **Appendix A - Letter of Support from Bionetics Photo Services**

Attached is a letter of support from Leonard Erickson, general manager of Bionetics Photo Services in Cape Canaveral. This letter describes use of facilities and cameras.

- Not included in revised version (on file in original version)

**** Revised version (April 30, 2001) ****

Appendix B - Letter of Support from the Department

Attached is a letter of support from Dewey Rundus, Associate Chair of the Department of Computer Science and Engineering. This letter describes departmental support for a course release.

- Not included in revised version (on file in original version)