TECHNOLOGY REQUIREMENTS

SOE technology requirements are categorized into the following areas:

1. Video Conferencing and Distance Learning – Expand and Upgrade Capabilities
2. Copying, Scanning and Printing
3. Telephones
4. Computer Resources
    - A. Networking Infrastructure
        - i. Improve campus connection to the internet (CENIC HPR Initative)
        - ii. Silicon Valley Center internet connection (CENIC HPR + SOE VPN)
        - iii. SOE internal network operations
        - iv. Main SOE building cable plant standards and improvements
    - B. Wireless Computer Networking
    - C. Virtual Private Network (VPN); SOE & Silicon Valley Center
    - D. Enterprise Computing Services – Email, Webserver, Filestorage
    - E. Computational Computing
    - F. Physical Infrastructure – Data Centers
5. Special Class Instructional Laboratories
    - A. Addition & Expansion of Undergraduate Laboratory Space
    - B. Dedicated Computer Science Laboratories
6. Research and Instructional Laboratory Support
    - A. Machine Shop Requirements
    - B. Fabrication Space
    - C. Outside Shop & Research Vehicle Storage
    - D. Receiving Operations
7. Silicon Valley Center – Requirements
    - A. Server Room
    - B. Video Conferencing
    - C. Virtual Private Network (VPN) connection to SOE network
8. Physical Security, Electrical Infrastructure and Environmental Monitoring
    - A. Card Key Access
    - B. Electrical Infrastructure Modernization and Monitoring
    - C. Environmental Monitoring

1. Videoconferencing and Distance Learning, - Expand and Upgrade Capabilities

Present videoconferencing and distance learning facilities are too few for future requirements. Presently all of these are located in general assignment classrooms, which are operated by campus media services and scheduled by the registrar. These locations although useful for larger undergraduate courses, are nearly impossible to schedule for low enrollment graduate courses and research collaborations.

The School is actively participating in numerous remote site research and instructional activities, some examples include the Silicon Valley Center, UCSC Extension Sites in Silicon Valley and a new initiatives at Los Alamos National Labs in New Mexico. In addition, due to limited main

campus space and local housing costs, additional growth will need to occur at remote sites such as 2300 Delaware Street, NASA- Ames Research Facilities, Monterey Bay Science and Technology (MBEST) and at an expanding number of UCSC Extension sites.

Presently there are four distance learning classrooms spread among the Jack Baskin Engineering and Engineering 2 buildings. All of these are located in sizable general assignment classrooms which are normally scheduled for classes throughout the quarter. At present there exists no general purpose video conferencing facilities for research groups and short-term needs. Easy to operate video conference facilities will be required to accommodate not only off campus initiatives but to enable principal investigators to collaborate in a far more efficient and effective manner. A goal should be to equip each conference room with a moderate level of video teleconference equipment.

The School should have an inventory of desktop video conference equipment available for checked out by SOE community members as needed. Desktop video conference systems are relatively inexpensive and would reduce travel to off-site locations providing additional time for SOE community members to be more productive. Some form of training community members in the use of desktop video conference equipment and use would be highly beneficial as well.

2. Copying, Scanning and Printing

SOE faculty members require expanded copying, printing and scanning capabilities. As of December 2005, two copiers in the School (one in Baskin, one in Engineering 2) provide scanning services and none are connected for printing. The School should work towards expanding the numbers of scanners available, so that every floor of each building has a combination copier, scanner and printer. Scanning serves to reduce the amount of paper and energy used, reduces the load on the environment and provides for increased efficiencies of faculty, staff and students.

3. Telephones

Investigations at improving the existing telephone system should be initiated. SOE community members are often roaming between laboratories, classes and meetings. The telephone system should have wireless capability that does not interfere with wireless networking. It should also provide the ability to forward calls immediately to wherever the client is located, whether that be in their office or at our remote sites. As of December 2005, many SOE members are relying upon personal cell phones to compensate for the inadequacies of the campus telephone system. This should be remedied.

4. Computing Resources

A. Networking Infrastructure

The computing network infrastructure is the life blood of any modern advanced research facility. SOE has recognized this and has invested heavily in the fastest, most reliable and robust networking system. These investments far exceed any other division or unit on campus. Still, SOE computer networking requirements traditionally exceeded our most expansive predictions. As of December 2005, our 10/100Mb and limited Gb switched computer network to the desktop is doing reasonably with some room for additional capacity. However this is immediately after a

redesign that coincided with the opening of the Engineering 2 building. Over $500K of improvements were made to provide expanded conduits between buildings, install fiber optic trunk cabling and replace main routers and switches.

Since the computing network is so vital to the School, this section is segmented into 5 main areas; (i) campus internet connection (UCSC - CENIC HPR initiative); (ii) Silicon Valley Center internet connection (SVC - CENIC HPR initiative); (iii) SOE Network Operations; (iv) SOE Building cable plant and network equipment stardards; (v) Network robustness and reliability standards and improvements.

(i) Campus Connection to the Internet (UCSC to CENIC HPR or Dark Fiber Initiative)
As of December 2005, the UCSC connection to the internet is provided via two 2.5 Gb/s connections, one of which is leased. These connections serve the entire campus and are considered by senior managers in ITS and by faculty in SOE, PBSci and Lick Observatories to be inadequate and constrictive to research.

Campus research initiatives and the demands of network video conferencing will require the campus to rapidly and drastically improve data connections to educational network in California. This network is operated by the Corporation for Educational Network Initiatives in California (CENIC). Two networks UCSC should be connected to;

(a) CENIC CalRen High Performance Research (CalRen HPR) network
(b) CENIC CalRen Experimental/Development Network.

Presently UCSC is one of the few UC campuses not connected to either the CENIC HPR nor Experimental networks. This must be recognized by campus leaders as a major roadblock to future growth on the UCSC campus and should be considered a top priority for funding. ITS Director for Core Technologies, Brad Smith, has made achieving these connections a top goal for the campus. SOE must support this initiative in whatever way possible.

(ii) Silicon Valley Center Connection to the Internet (SVC to CENIC CalRen HPR)
Networking requirements that the Silcon Valley Center also require a direct connection to CENIC CalRen HPR and Experimental networks. There are state initiatives to bring the CENIC network to the NASA Ames complex. However additional effort by campus will be required to bring that connection perhaps 1 mile to the buildings that house SOE community members. SOE members need to have the same level of networking and computing system access whether they are located in one of the Engineering Buildings or at the Silicon Valley Center. Therefore a Virtual Private Network (VPN) is required for connections between SOE facilities on the main campus and those at the Silicon Valley Center.

(iii) SOE Internal Network Operations
Engineering and Computers Science schools run their own networks because requirements of the researchers are not yet considered needed for other campus units and sometimes the services are not scalable. It is vitally important that local control and management of the SOE internal networks be maintained.

As of December 2005, the technical staff of SOE has been consolidated into the ITS organization. Historically the ITS Networking group has needed to maintain a consistent set of networking service levels that typically funded far below the minimum requirements of SOE. There is significant concern by faculty and technical staff that should NTS attempt to pick up networking for SOE, then our non-scalable service levels cannot be maintained. Thus SOE must maintain network operation and management within the local IT specialists for SOE.

(iv) SOE Building Cable Plant and Network Switching Improvements
During the December 2001 writing of this document, network delays were present due to a bottleneck in our single main router and backbone trunks and because SOE only had a single Gb/sec connection to the main campus. When the Engineering 2 building was outfitted for networking, vast improvements were made to the network cable plant backbone and main routers. These improvements now allow all network closets (switch locations) to be optically trunked (dual homed) to two modern Cisco 6500 main routers (be-g and e2-g). Trunking on these main switch closets is using 1Gb/sec multimode and single mode fibers and we anticipate that higher throughputs may be obtained. These throughputs may require the use of jumbo frames and higher bandwidths, something our networking investments can scale into. Therefore recent improvements provide a capable network backbone that can handle increased traffic from the larger numbers of systems.

Networking at the edge (switch to desktop) is using 100Mb/s switch gear with a limited capability to provide 1Gb/s to the desktop. Due to expanded desktop videoconferencing and collaboration tools, desktop installations should take the form of the highest data rate possible within reasonable cost. We anticipate increased requirements for Gb/s Ethernet to the desktop. Gb/s service levels are currently required for any SOE servers receiving central tape backup services. We anticipate that by AY2007, all SOE servers (with or without tape backup) will require Gb/s connections. Network edge requirements will drive replacements of 10/100MB/s network switches or augmented with addition Gb/s switches.

Applied Sciences Alternations Phase I project made use of wall mounted wire moldings for many instructional and research labs. These wire moldings allow for easy upgrades, alternations of both networking and power wiring at reduced costs. Engineering 2 did not use wall mounted wire molding and subsequently we later needed to install more network connections. Additional alternation projects should incorporate wiremolding for lab spaces as our networking and power requirements are always increasing and changing. This configuration allows us to make those changes rapidly and at reduced costs.

(v) Network Robustness and Redundancy
SOE Networking has been designed to allow continued operations through the most common single points of failure. These include loss of power, disconnection of network trunk, loss of a power supply and even loss of a main router. As of December 2005, most SOE switch closets are dual homed to two routers; all switch closets have local UPS support; all switches are purchased and installed with redundant power supplies and both routers have two UPS units with different sources of power. The e2-g router is connected to backup generator power, however the be-g router is not.

Continuous improvements in network robustness and redundancy are required to make the network a resilient as possible. As of December 2005, the following actions should be taken:

- Connect backup generator power to be-g router.
- Continue to install UPS units for all network switches.
- Ensure two UPS units are working for each main router.
- Continue to dual home all new switch closets including those in the new PSB Building.

B. Wireless Computer Networking

Uniform wireless communications for voice and data throughout the engineering complex is considered a necessity that provides enhanced productivity for faculty, students and staff. At present there is a spotty coverage of 802.11b wireless coverage using both the existing School's wireless system (Tsunami) and the Campus Enterprise wireless system (CruzNet). The school is in the process of installing a 802.11b/g wireless network to provide uniform coverage through Engineering 2 and the Baskin Engineering Building. We envision this system to provide coverage for both the SOE mac addressed authentication system and the more restrictive and secure CruzNet system.

The CruzNet system in place on much of the UCSC campus meets a low level need for wireless, however SOE faculty and students require a less restrictive and more flexible wireless system. CruzNet policies are set to protect campus administrative users and systems and do not account for many research and instructional requirements which faculty and graduate students in the School require. Thus the ability to provide multiple wireless systems, some enterprise level (such as CruzNet) and others more aligned with research and instructional needs must be available. This can be provided for by allowing multiple wireless systems to coexist by using different service set identifiers (SSIDs) for different services. Local ITS specialists and CruzNet personnel should work together to achieve a system that accommodates multiple levels of service.

C. Virtual Private Networks

Increasing requirements of SOE community members for access to services from non-SOE managed networks will require the use of a secure means to connect to shared resources. A Virtual Private Network (VPN) should be installed and maintained so that faculty, students and staff members can securely use computing resources at the School from any location in the world.

A second VPN is needed to extend SOE networking and services to the Silicon Valley Center. The SOE Silicon Valley Center VPN would allow SOE members at SVC to receive the same computer services that they currently receive when on site in Baskin Engineering or Engineering 2.

D. Enterprise Computing Services – Email, Webserver, Filestorage

The School of Engineering has since the beginning operated its own email system, web server, file storage and backup. As of December 2005, the UCSC campus is consolidating IT support under a single organization reporting to the Campus Vice Provost of Information Technology.

Engineering Schools need to implement rapid advances on their email, web and filestorage systems. Quite often these rapid advances have benefits associated with them that other units on campus do not immediately require, appreciate or even comprehend.

SOE must retain a separate email, web and file storage with backup that can be rapidly modified without the extensive budget, project and change management processes the remainder of the campus requires. The School recognizes a need for extensive governance and configuration management processes for campus-wide enterprises systems, however those processes inhibit risk taking and the adoption of bleeding edge technologies. SOE requires rapid advancement and adoption of bleeding edge technologies to obtain excellence in our programs. Many of these technologies are common place in other research engineering schools but are often considered ill-suited for the remainder of the campus.

E. Computational Computing,

As of December 2005, SOE operated four shared general purpose unix login servers, 2 computational servers and a graduate computing lab (BE-340). These systems are currently inadequate for support of research and graduate instructional in the School. The computing infrastructure committee (CIC) has recommended the following projects be implemented:

- General purpose computational cluster computing system

  For use only by SOE students, this would provide a multi-system general purpose login server. At times the system would also permit, multiple job processing to various computers as well.
- Secure Computing System

  For use by faculty and students involved with proprietary data, such as the MOSIS research program.
- General Purpose Login Servers

  Multiple Linux, Sun Solaris on Sparc, Sun Solaris on X86, Mac OS10 servers are required to compile, test and run various instructional and research efforts under these different operating systems.
- Graduate Computing Laboratory Expansion

  Currently BE340 is available for general purpose graduate computing. Department faculty in Computer Engineering and Computer Science have setup department labs in the Engineering 2 building. Those new labs along with labs for the AMS, BME and EE departments should be equipped to allow new students without research sponsorship a place to work with appropriate computing resources.

F. Physical Infrastructure Improvements – Data Centers

The School has research work and services that is critical to researchers throughout the world (for example Genome Data). Some of this data and computational capability must remain operational 24/7/365. As such, the School needs to have data center facilities and support that is robust and can operate through power outages, earthquakes and individual system failures. The School should partner with ITS on a multi-faceted approach towards improving and developing data centers with as much redundancy and robustness as possible. These plans should take into

account short-term needs and abilities along with the longer term view that a major campus data center will be built at the 2300 Delaware Street building.

As of December 2005, the School (including CBSE) operates out of four datacenters (BE213, BE250, E2-208, E2-594). Short term plans include relocating all critical core computing services to the E2-208 data center as E2-208 has modern data center infrastructures for fire suppression, backup generator power, main UPS support with emergency power off, redundant air conditioning and seismic isolation rack mounting. The acknowledged single point of failure for E2-208 is the lack of air conditioning during a power outage. That problem must be address immediately as well as backup power air conditioning for the E2-594 data center.

Longer term plans should include a through review of the facilities in BE213, 250 and 252 with the intent to develop a prioritized improvement list that would bring these facilities to the highest reliability status as possible. Some of these improvements may include the following:

- Backup generator power to BE213, BE250, to include backup power to air conditioning.
- Install FM200 fire extinguishing systems to BE213, 250, 252.
- Increase the size of UPS systems for BE250.
- Install seismic "iso-base" plates for racks in E2-594, BE213, BE250
- Ensure all network routers and switches connecting these data centers to the internet have UPS, redundant power supplies and connections to backup generator power.

5. Special Class Instructional Laboratories –

A. Addition and Expansion of Existing Labs,
As of December 2005, the School has 10 special class instructional labs primarily used by the Computer Engineering and Electrical Engineering Departments. A list of these labs is as follows:

- BE-104 Digital Logic Lab
- BE-111 Signals Lab
- BE-113 Circuits Lab
- *BE-115 Robotics Lab (new since December 2001)*
- *BE148 Laser/Optics Lab (new since December 2001)*
- BE150 Advanced Digital Logic Lab
- BE161 Electromagnetics & RF Lab
- BE162 Semiconductor Materials Lab
- *BE168 Networking Lab (new since December 2001)*
- *E2-592 - Advanced Networking Lab (new since December 2001)*

Several additional labs will likely be established after December 2005. Instructional labs are in various states of planning or investigation include:

- Senior Projects Labs, two each (for CMPE-EE123A/B)
- Biomolecular Engineering Labs, two each

- Computer Gaming Lab
- Silicon Valley Center Lab

B. Dedicated Computer Science Instructional Labs

As of December 2005, the Computer Science department uses the UCSC Campus instructional computing (IC) laboratories. The IC laboratories are general-purpose computing environments arranged to serve a wide variety of courses from all campus departments and divisions. Computer Science undergraduate studies require far more access to hardware and software than is physically obtainable from these campus open labs. Also many CS courses would like their undergraduate students to install, administer, experiment with and maintain software as part of the curriculum. This is especially true for operating systems, E-Commerce, internet and database software. Many of our Junior Colleges transfer students had these resources at their JC Campus only to find it lacking at UCSC.

In the December 2001 version of this document, it was said
"the School plans to investigate providing a few specialized Computer Science computing labs principally for upper division courses. These labs would not be open to the general campus population and could be configurable depending upon the sole needs of the CS Department. Many CS courses would likely continue to utilize the campus IC labs when possible, especially for lower division courses where requirements for unimpeded access are not required."

As of December 2005, the School has not identified space or funding to provide dedicated Computer Science undergraduate computing labs.

6. Research and Instructional Laboratory Support

A. Machine Shop Requirements

Presently the Division of Physical and Biological Sciences (PBSci) operate a machine shop with a single machinist. The machine shop has two areas; a staff operated machine shop and an area where students, after considerable training, are allowed to use. The availability of the PBSci machine shop facilities to SOE community members historically has been spotty at best. The shop is only available when the PBSci machinist is present and not deeply involved in his own projects.

SOE researchers and especially students working on senior projects require less restricted access to the shop. Quite often they are working round the clock on projects and require after hours access to the shop. SOE faculty requested the School either develop its own machine shop or provide resources and means to expand the PBSci Machine Shop access for after hours use.

B. Fabrication Space

A shop area to do fabrications of circuit boards, simple hardware and to house our new laser cutter system is needed. This fabrication space previously existed within the BELS group, however that space was reallocated when the BELS group was relocated for the Nanotechnlogy lab (BE64).

C. Outside Shop and Research/Robotic Vehicle Assembly Area
SOE faculty have requested work space for larger robotic vehicles. Gabriel Elkheim of the Computer Engineering Dept currently has a robotic sailboat and may receive a robotic land vehicle used in DARPA's autonomous land vehicle challenge. Shop space to house, assemble and test these vehicles is necessary to continue this research.

7. Silicon Valley Center – Requirements
A number of faculty and students will be working out of the Silicon Valley Center at NASA Ames Research Park. This location will need to support instruction, research work and faculty working intermittently between this site and the main UCSC campus. As of December 2005, it is expected SOE members will be working out of Building 19 at the NASA Research Park. At some point in the future two new buildings may be constructed. An instructional classroom and office building may be commissioned by Foothill-De Anza College District. UCSC may lease instructional and office space in the proposed building. The other building is expected to be a wetlab nanotechnology research building.

A. SVC Server Room
As of December 2005, it is expected that over the next two years, up to 3 racks of research servers may be installed at the SVC Building 19 site. When the new buildings are programmed and designed for NASA-Ames Research Park, an important part is to include a Tier III or IV data center as part of that construction.

B. Video Conferencing
It is expected that the campus will provide a most amount of video conferencing and distance learning equipment at the Building 19 site. This is required to permit faculty to teach simultaneously to students at SVC and the UCSC main campus. It is also necessary for researchers collaborating between the two sites and elsewhere in the world.

C. SVC-SOE Virtual Private Network (VPN)
A VPN is needed to extend SOE networking and services to the Silicon Valley Center. The SOE Silicon Valley Center VPN would allow SOE members at SVC to receive the same computer services that they currently receive when on site in Baskin Engineering or Engineering 2. Presently the campus runs two separate VPNs to the SVC site, however neither will permit SOE networking services to operate. In December 2005, campus networking personnel acknowledge a need to setup a third VPN to provide SOE members at SVC this access.

8. Physical Security, Infrastructure and Environmental Monitoring Infrastructure
The campus should invest in remote camera systems, omnilocks, card-key access to rooms and hard-wired doors for sensitive areas such as laboratories containing expensive equipment. Electrical and environmental monitoring is needed to ensure laboratory facilities are receiving proper utilities and that problems are noted before significant research work has been adversely affected.

A. Building and Laboratory Physical Security

The Engineering 2 building was built using centrally monitored and controlled card-key access system. Jack Baskin Engineering building uses hard keys for most labs and individual combination cipher locks (omnilocks) for instructional lab spaces. Often hard keys are not returned or are lost by various students. Physical security to many of these lab spaces cannot be controlled to a reasonable level. Nearly all of these labs contain very expensive test equipment and computers. It is imperative that a robust physical security system that can quickly lock out undesired individuals be implemented. It is recommended the card key system installed in Engineering 2 be extended to the Jack Baskin Engineering building outer doors. For Baskin Engineering, all lab doors should be equipped with the card key system (optimum solution) or with omnilocks.

B. Electrical Power Monitoring and Improvements

Since December 2001, the electrical grid serving Baskin Engineering and Engineering 2 has failed with seemly increasing and lengthy occurrences. Some of these failures are attributed to PG&E electrical distribution problems; however an increasing number of failures have been due to campus electrical grid shortcomings, either in capacity or in maintenance.

Campus Electrical Engineers have expressed concern about the deteriorating shape of the University owned electrical distribution system. Most of this system is over 40 years old and is close to absolute capacity. In some cases, a single failure may cause the campus to go dark for days. For a research campus, this is unacceptable and must be remedied. The campus must should install a second feeder to the core of campus and provide electrical capacity and reducancy that is needed for new buildings on campus.

While these grid failures have occurred, SOE and other units on campus have experienced a higher than normal rate of failure of computer, UPS and electronic test equipment components. SOE faculty feel these failures are due to noisy line power, power surges and potential currents on neutral and ground wires. Sometime after December 2005, SOE expects to bring on line several nanotechnology and Biomolecular Engineering Labs. These labs will be far more sensitive to “dirty” electrical power than computer systems. Monitoring of the electrical systems serving Baskin Engineering will be necessary to ensure proper filtering and conditioning of power is applied when needed. Monitoring of the electrical systems serving the Engineering 2 building is recommended to reduce the possibility of system failures due to long term dirty electrical power.

C. Environmental Monitoring

Several areas of Baskin Engineering and Engineering 2 require monitoring of environmental parameters such as temperature, humidity, and air flow. This is needed to ensure laboratory work proceeds without disruption and/or destroying results of sensitive fabrications and experiments. These monitoring systems should be tied back to an automated reporting system to immediately alert facilities and laboratory personnel to environmental problems.