Report of the Information Infrastructure Task Force
March 3, 1997
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1. Introduction
Infrastructure is defined as "an underlying base or foundation, especially for an organization or a system." It consists of "the basic facilities, services, and installations needed for the functioning of a community or society..." Transportation, communication, water, power, education, public health and safety contribute to the infrastructure of our society. All are key elements. In today's society, information, defined as the communication of knowledge, must be added to this list as it affects all of the other elements.

While information is an essential piece of the larger societal infrastructure, it has its own infrastructure as well. At WPI, the information infrastructure is the base or foundation upon which faculty members teach and conduct research, students learn, and all of us do our jobs. It is composed of basic facilities, services, and installations: the campus network; hardware devices including computers, printers, scanners, modems; software enabling everything from electronic mail, to course registration, to the delivery of scholarly electronic articles to the desktop; laboratories; and computer classrooms. Our infrastructure includes every academic, administrative, and support department and office on campus. All are key elements of the infrastructure and all depend upon it.

If information is the communication of knowledge, and the infrastructure is the underlying base or foundation, then WPI's information infrastructure is vital to...
its mission as an institution committed to an "... educational process true to the founders' directive to create, to discover, and to convey knowledge at the frontiers of academic inquiry for the betterment of society."  

In order for WPI's information infrastructure to support the university's mission, careful and continuous planning and coordination must be an essential component so that the great variety of needs are met and resources are expended wisely. This process of planning and coordination will assume greater importance as WPI seeks its place "... as a world leader among small, private engineering, science, and technology-based universities."  

The Information Infrastructure Task Force has been charged with examining the development of a process for planning the infrastructure for information at WPI. The Task Force report that follows consists of the following: the current situation regarding the infrastructure and planning; implementation of a planning process; specific issues, both near-term and longer-term; financial resources; and a conclusion.

2. Current Situation
Currently, WPI has both centralized and decentralized information infrastructures, with some self-supporting departments and others relying on the College Computer Center (CCC). This approach creates interoperability problems between the various departments whether they are academic or administrative. In academic departments, this has created a 'have' and 'have not' division for information infrastructure resources such as equipment budgets and computer system personnel. In administrative areas, the CCC staff spends much of their time simply maintaining outdated systems rather than creatively applying their expertise to innovation.

The CCC is the central information and computing resource on campus and provides many of the basic, low-level infrastructure needs of the entire WPI community. It provides public access lab equipment to various departments as well as having two of its own public labs. The CCC maintains the software and hardware for student, faculty and administrative common needs, i.e. those common to all departments, as well as offering some department educational software. These offerings include the Novell servers which serve the PC
software for most of the PCs on campus, the UNIX servers including the university's world wide web (WWW) presence and the campus mail and news servers, and the administrative cluster of "mainframe" computers.

The CCC also provides and maintains fundamental infrastructure needs such as the campus network, including both the on-campus and residence network, WPI's link to the Internet, and the dial-up modems for remote access. This past year, the CCC has also begun offering training for Microsoft Windows, Microsoft Office, Basic UNIX, and Electronic mail from their new trainer. For researchers who may not have grant money for purchasing computer equipment, the CCC offers three UNIX machines for research and compute-bound jobs. Two of these three machines actually belong to Digital Equipment Corporation but have been left at WPI for an unspecified duration due to our external field test work for Digital. The CCC provides only minimal assistance to researchers who choose to manage their own computing equipment instead of using CCC management.

Like many other departments on campus, the CCC has both budget and personnel limitations that affect the amount of support they can provide. For example, the CCC has lost staff in several recent years. Last year was the first year in which the staff did not shrink. At the same time, the workload on the remaining staff has grown. For example, the CCC was put in charge of installing, coordinating, and maintaining the residential network, currently at 729 connections, without any additional staffing to support the increased needs in network and PC support.

Other departments are able to provide for their own information infrastructure needs in one or may ways. For example, the Mechanical Engineering (ME), Electrical and Computer Engineering (ECE), and Computer Science (CS) departments each have their own systems manager. The ME and ECE departments manage their own workstations and PCs, with the exception of the PCs found in public labs. The CS department manages their faculty and graduate lab machines, but the undergraduate machines are managed by the CCC. The Mathematical Sciences department has also hired a systems person to assist users within the department but uses CCC station management. The same decentralized approach can be found in computer equipment purchasing.
Some departments have a budget for equipment while others submit equipment requests to the CCC.

While there is currently no organized group at WPI whose purpose is to plan and provide for WPI's information infrastructure needs, this idea was once embodied by the Chief Information Officer (CIO) position held by Professor David Cyganski from 1987 to 1989. Under his role as CIO, and later Vice President of Information Systems (1989 - 1991) and Vice Provost (1991-1992), he was given the task of creating a unified approach to computing across campus. At that time, the CCC handled mainframe oriented computing and the Office of Academic Computing (OAC) handled the campus PC needs.

Prof. Cyganski describes his job as having three phases. His first objective was a campus-wide telecommunications upgrade, which included both a new telephone system, creation of a high-speed campus network, and a connection to the Internet. The next phase he described as "dragging the campus into the future." This meant introducing the campus to using the Internet, electronic mail, and individual desktop personal computers. This task was difficult due to the natural tendency to resist change, the difficult decisions that needed to be made regarding computers, and the budgetary requirements involved. Due to the compatibility problems between PCs in the industry at this time, centralized acquisition was required to maintain a compatible computing base across campus. After WPI had caught up with computing needs, the last phase was to provide for long term maintenance of its position. This included developing vendor contacts through grant and gift proposals and planning for future needs.

The issue of planning has been studied in various committees and task forces since the CIO position was discontinued, but the recommendations of their reports were not generally implemented. For example, the Academic Computing Advisory Committee (ACAC) spent approximately two years studying academic needs on campus and recommended an increase budget for CCC and better organization across campus.

The current planning group is the Computer Advisory Committee organized by Associate Provost Durgin. However, this group only fills an advisory role to assist him in making capital budget purchasing decisions and concentrates
mostly on academic computing, generally ignoring administrative computing. Although its goal at creation was to assist with long term planning, it is occupied mostly by current issues and problems.

3. The Information Infrastructure Planning Process
The most crucial change WPI could make in its information infrastructure is to change the way planning is accomplished. As noted in Section 2, long-term planning is currently the responsibility of the Computer Advisory Committee, organized by the Associate Provost for Academic Affairs.

We believe that there must be a fundamental change in this planning process. Long-term planning should be the responsibility of an individual, a Chief Information Infrastructure Planner, who devotes at least 50% of his or her time to information infrastructure planning. This person would be responsible for tracking trends in computer and network technology, and for keeping up to date on what other universities are doing in this area. He or she would also be responsible for leading the development of specific implementation plans for WPI, and for pursuing funding opportunities to support the implementation of those plans.

A key element of the planning process will be to determine which information infrastructure resources should be centralized and which should be decentralized. This planner should address this issue, with the understanding that any such plans will change over time as technology and campus needs change.

Another key element of the planning process should be to ensure that information resources are fairly distributed across campus. While different departments and offices have different computing needs, the current situation of have and have-not departments must be corrected.

Of course, a one-person effort could never succeed in such a diverse environment as a university. Thus it would be crucial for the Chief Planner to seek out advice from a variety of campus constituencies: students, faculty, administration, and staff. A structure such as the current Computer Advisory
Committee may be helpful or other methods of involving the campus community may be more appropriate.

The Chief Planner could be a member of the administration, a member of the faculty with released time, or a member of the CCC. An opportunity exists to create this position as an endowed chair at WPI by soliciting information infrastructure companies. No matter who assumes this position, we feel it is crucial that this person have the necessary time to study, plan, and dream. Without a carefully considered vision of where WPI's information infrastructure should be moving, we will be unable to identify and act on the opportunities that this fast-moving technology presents to us.

4. Near-Term Issues
This section describes some issues concerning the information infrastructure that need to be addressed in the near term: six months to a year. The time frame available to the Task Force does not allow us to decide on a particular solution for each of these issues, but we are convinced that they need to be addressed quickly.

4.1 Network Access from off campus
The decision to "wire the dorms", that is to provide network access to students living on campus, can be seen in retrospect as a crucial infrastructure decision. WPI was starting to lose students to competing colleges that offered better network access, and, for some students, network access from their residence halls is an important aspect of how they accomplish their academic work.

Now, the Task Force sees the issue of providing good quality network access for students and faculty off campus as an increasingly crucial infrastructure issue. Students become accustomed to good network access in their first years at WPI when they live on campus. If they move off campus in their later years at WPI, they still want to have good network access. Faculty and staff, too, are increasingly dependent on the computing environment at WPI, and they want to have access to these resources from off campus. Similarly, the needs of students and faculty involved in the Waltham campus and at distance learning sites require improved access to campus resources.
The current system of providing dial-up access to our system is not adequate since it does not support a graphical interface to the systems. In the past, WPI has encouraged members of the community to purchase graphical access from independent Internet providers, such as Point-to-Point Protocol (PPP) access, which allows full graphical access to the Internet over telephone lines. However, the quality of these Internet providers is highly variable, and they have not always met the needs of members of the community.

A special concern arises because of new on-line resources provided by Gordon Library. Their licensing prohibits access by users off-campus, so that users connecting to WPI through an external Internet provider cannot access these resources. As such on-line resources become more common and more central to our teaching and research, this problem will become more severe.

A similar issue involves the new Web-based registration system, which will be available soon. This system will be based on a graphical user interface, so may not be accessible to students connecting to WPI through the current modem bank.

We see a need for a graphic-based Internet access for students, faculty and staff, arranged so that users dialing in would be directly connected to the campus network, and would carry network addresses that are part of the WPI domain. Several methods are available to address this need: an external Internet provider could supply the service for a fee to be paid by users, or WPI could provide this service for free, for a fee based on a flat monthly amount or for a fee based on usage. In any case, a significant improvement to the computing environment could be provided with a minimal impact on the WPI operating budget.

The following is an estimate of one-time hardware costs for providing PPP access through modems at WPI.

<table>
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<tr>
<th>Qty</th>
<th>Description</th>
<th>Each</th>
<th>Total</th>
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<tr>
<td>4</td>
<td>US Robotics 16 line modem bank</td>
<td>$8000</td>
<td>$32000</td>
</tr>
<tr>
<td>1</td>
<td>Annex Terminal Server (72 port)</td>
<td>$12390</td>
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Given time, the popularity of the PPP access would grow and expansion would be necessary requiring another round of one-time costs as well as more telephone lines.

4.2 Replacement of Desktop Computers
WPI recognizes the importance of desktop computers for faculty and staff and has expended considerable funds to purchase such computers. However, no process appears to be in place for replacing aging desktop computers.

The replacements could be provided through a leasing arrangement or through purchase with a definite plan to replace the computers on an appropriate schedule.

The Task Force estimates the lifetime of a typical desktop computer to be three years or less. Sufficient funds should be set aside to permit the replacement of desktop computers on this schedule.

4.3 Integration of Computing Environments
Currently many individuals have multiple passwords and home directories depending upon the systems they are on. There definitely is a need for making connections between these systems transparent.

4.4 Continued Upgrade of the Network Infrastructure
As student, faculty, and staff use of the campus network increases, there is a clear need to provide additional capacity to this network. The need to support new applications, such as multimedia applications or network conferencing makes this issue even more critical.

4.5 Administrative Computing

The current computing environment in administrative offices consists of several mutually incompatible systems. While the current systems serve the needs of individual departments reasonably well, the lack of compatibility between systems leads to inefficient operations. For example, the Task Force was surprised to learn that records of admitted applicants must be re-typed in order to be transferred from the Graduate Admission Office computer system to the Registrar's.

A unified computing environment for these offices would allow their operations to be more efficient and less expensive. Such a system would also allow us to learn more about our students and how we educate them. For example, it would be easier to compare students' academic success with characteristics of their application for admissions, and thus potentially improve our admissions process.

Such a system must be selected and implemented only after extensive discussions with the affected offices, to make sure that the system supports each office’s mission, and to ensure that the transition from the current systems to the new system is as painless as possible.

An integrated administrative computing system should meet the following criteria: utilize a single shared database (e.g. Oracle), provide distributed access and control to users, and employ a graphical user interface. In this environment users and CCC staff would be freed from spending time on "work-arounds," batch interfaces, and redundant data entry. The estimated cost of implementing a fully integrated administrative system is $2 million, plus $50,000 per year for maintenance fees.

4.6 User support from CCC
As more and more members of the campus community come to depend on the information infrastructure to complete their courses or do their jobs, the demand on CCC staff to provide help to these users will continue to grow. Several members of the community remarked on the difficulty of obtaining timely help from the CCC staff when they had problems. This is not a reflection on the skill of the CCC staff, but rather a result of the small number of staff members available. The increase in training courses on campus has helped, but additional help to users is required. Large-scale changes in information infrastructure resources should be accompanied by sufficient training for those affected.

Some departments have their own department staff to help with support issues while other departments do not. Departments with their own support staff in general obtain better attention to their computing needs. A method should be found to provide a comparable level of support to those departments without their own staff.

5. Longer Term Issues
Some of the issues identified during the Task Force study are long-term issues. WPI should certainly be paying attention to these issues, and should be prepared to act on them at the appropriate time.

We believe that WPI should be a leader in educational uses of information technology. We probably can not devote the resources necessary to developing experimental systems, but we should be prepared to adopt the best solutions of proven value as they become available.

5.1 Use of Notebook PCs
We should consider the increased use of notebook computers on campus and should consider encouraging students to purchase notebook computers through the university. Given the number of units involved, substantial savings should be possible. Such a policy would also introduce an element of uniformity in the computing environment on campus. Another added benefit would be the reduction of the need for computer labs and making available more computer classrooms.
5.2 Campus-wide Wireless Network
We are currently developing a wireless local area network that is expected to cover five buildings on campus. It should not be too expensive to provide wireless access to the entire campus. Other universities have already installed similar networks. A wireless network would minimize the cost of providing network access for notebook computers, if we adopt that strategy.

5.3 High-speed Network Connections
The next generation of network applications, like real-time video conferencing and network meetings, will require higher-speed networks than those generally installed on campus now. Such applications could be used for on-line advising of students at distance learning sites or participation in seminars and research meetings by people off-campus. There are many competing technologies being proposed to provide such services, and we should be tracking their development with a view towards selecting an appropriate technology.

5.4 Archiving Electronic Documents
As more of WPI's record keeping is carried out electronically, there is a need to plan for the archiving of these electronic documents. This would include official publications now published in paper format, but which will probably go totally electronic in the years to come such as catalogs and Newspeak, and records that are already in electronic format, like student records and financial information. Most faculty committees now keep electronic records; are these being archived? Student life information is increasingly published electronically -- club records and activities and campus events. Much of this goes on through e-mail and the web. We need to be concerned with how researchers in 2050 will know what WPI was like in 2000.

A related issue is that of publishing projects and theses electronically and archiving them. During the past year questions have been raised about why all past MQP's and IQP's are not available (or even existing) and how an electronic archive could be created. A daunting and expensive project would be to try to archive the past 25 years' of projects in electronic format. At a minimum, we could start with current projects and theses. This would greatly reduce space
and time requirements for the library as well as making these project reports more widely available.

5.5 Gordon Library
As WPI approaches the 21st century, Gordon Library’s place in the information infrastructure continues to move ever more rapidly from the traditional library role of information warehouse to that of information provider, with the purpose of enabling users to access the information regardless of its location or the users' location. Electronic journals and databases, with full-text and full-image, are here now, however they do not come without cost. Services that provide full-text and full-image can cost anywhere from $20,000-35,000 annually, with individual subscriptions also costing thousands of dollars. As more electronic resources are added, the library’s role as guide or teacher continues to expand as well. The Gordon Library of 2010 should contain a state-of-the-art electronic classroom, suitable for instruction and orientation by library reference staff. Current cost for such a facility could run from $50,000-80,000. While there will be a decreasing emphasis placed on Gordon Library as the primary physical location of materials and users, the library still will need to provide a location for individual study and group work, with access to physical and virtual collections. Network drops for laptop computers, access to the wireless network, and appropriate user space will all continue to be needed in the library of the future. Recent estimates for renovations to the existing Gordon Library have ranged from 3-5 million dollars.

6. Financial Resources
6.1 Financial History
Financial resources for the information infrastructure at WPI are part of both the operating and capital budgets of the institution. Operating funds are those of CCC, the central source of support for computer services to the community, and in specifically identified line items in departmental budgets. The level of funding for these areas is set annually as part of the budget development process and has historically been determined by making incremental adjustments to prior year budgets. The Capital Budget is used each year to fund major projects and the purchase of computer equipment. The institution maintains a five-year plan for capital investments.
Funding for the CCC has remained essentially level during the past five years. Total expenditures ranged, as can be seen in the table below, from $1.5 to $1.6 million with a decline in the number of budgeted staff positions. During this same time period institutional operating expense exclusive of financial aid grew from $49.2 to $56.4 million. Expenditures for CCC are roughly equivalent to those of the library ($1.6 million in FY1996) or an academic department of average size.

### College Computer Center Financial Summary

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<tr>
<td>Compensation</td>
<td>1,038,743</td>
<td>1,036,970</td>
<td>1,052,069</td>
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<td>Other Expense</td>
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<td>Total Expense</td>
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<td>$1,519,621</td>
<td>$1,667,375</td>
<td>$1,621,917</td>
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<td>23</td>
<td>22</td>
<td>22</td>
<td>23</td>
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Expenditures by academic and administrative departments on computer hardware have come from a variety of sources over the most recent two fiscal years. Academic departments and project centers spent from their operating budgets $166,000 for computer hardware in Fiscal 1995 and $203,000 in Fiscal 1996. At the same time administrative departments spent a total of $79,000 in each of these fiscal years. Continuing Education purchased $30,000 in computer hardware in Fiscal 1995 and with the advent of its Westboro campus a total of $164,000 in Fiscal 1996. In addition, in Fiscal 1996 the institution cost shared equipment purchased through grants and contracts at a cost of $90,000. Some departments have had access to institutional capital funds for the purchase of personal computers but others have charged their departmental operating budgets by drawing on financial resources originally intended for other purposes. Computer hardware has also been purchased through departmental restricted funds ($80,000 in FY1995 and $119,000 in FY1996) as well as sponsored research grants and contracts ($350,000 in FY1995 and $444,000 in FY1996).

The capital budget is intended to fund the cost of major projects at the institution. This includes the cost of new buildings through purchase or construction, building renovations, and purchases of equipment and software...
with an expected useful life of three years or more and a cost greater than $500. Funding comes either from gifts, debt, or internal financing.

The total allocation for equipment was $500,000 in Fiscal 1995, $520,000 in Fiscal 1996, and $668,000 in Fiscal 1997. In each of these years the amount available for equipment to meet the needs of academic computing was $250,000 despite requests for departmental computer labs and from faculty that far exceeded this amount. Administrative hardware needs have been funded to a limited extent from the General Institutional Equipment Fund ($100,000-$140,000) and have to compete with new vehicle requests from Plant Services and Campus Police. The remaining segment of the capital equipment budget is the allocation to the Provost Office and is intended to cover the cost of laboratory equipment as well as computer hardware for new faculty.

Another source of funding for laboratories and equipment has been matching gifts from both IBM and Digital Equipment. In the past these donations of equipment were used for many of the lab upgrades such as the first and second generations of the ADP Lab. IBM support ran as high as $150,000, a significant supplement to the $250,000 capital equipment budget, while DEC's contributions were at the $30,000 level. These corporate gifts are presently at substantially reduced amounts thus putting additional pressure on the equipment budget.

The funding level of the institutional capital budget in recent years has varied, depending on the major building projects in process, from $12.4 million in Fiscal 1995 to $3.1 million in Fiscal 1996 to $7.8 million in Fiscal 1997. The Residence Halls Networking was a part of the Fiscal 1995 Capital Budget with the $995,000 cost funded by debt to be repaid over time through student connection fees. In the late 1980's the cost of new administrative system software for financial records, human resources, and student information systems was funded through the capital budget.

6.2 Current Funding
For Fiscal 1997 the institution allocated $1.8 million in resources for operation of the CCC. Of this amount $1.2 million is for staff salaries, staff fringe benefits, and student wages while the remaining $600,000 is for nonsalary
expense. Included in nonsalary expense is $21,000 for academic enhancement and $21,000 for administrative enhancement to cover such things as disk drives and printers. Maintenance costs associated with the administrative software systems are also charged to the CCC budget rather than directly to the areas which use the various systems. The budget for CCC currently represents 2.5% of the budgeted expense for the Academic Affairs Division and 1% of budgeted institutional expense exclusive of financial aid, debt service, and depreciation.

There are 23 budgeted full-time staff positions of which 17 are considered exempt or salaried and 6 are hourly positions.

There is a modest level of funding provided for computer hardware in other areas of the institution. In Fiscal 1997 there are line item amounts totaling $94,000 in the academic departments, $83,000 for Continuing Education, and $15,000 spread among various administrative areas. Departments can choose, however, to transfer funds from other nonsalary lines in order to increase their level of spending for computer hardware needs.

The Capital Budget for Fiscal 1997 contains the same $250,000 level of funding for academic computing needs that has existed historically. It covers the first $2,200 of cost for computer equipment for each new tenure-track faculty member. In addition the Provost Office has available an equipment fund of $318,000 for Fiscal 1997 that is intended to cover commitments to new faculty members for laboratory and additional computer needs. The institution also allocated $360,000 for replacement of the network infrastructure on campus. Specifically, this project entailed putting ATM switches in the network hub and Fuller Labs capable of feeding fast Ethernet and/or Ethernet to satellite buildings as well as replacement of satellite building equipment throughout the campus.

6.3 Future Financing

The institution should be developing a financial plan to fund the information infrastructure needs of the next five to ten years. After capital requirements are identified and prioritized in accordance with the outcomes of the strategic planning process, the estimated costs of proposed computer system upgrades, network improvements, and computer hardware should be made an integral part of the long-range Capital Budget for the institution. Items that have the
right appeal to interest donors can be funded through the Capital Campaign. Otherwise, funding for proposals will need to be covered by debt or internal financing in the same way as the institution plans for "bricks and mortar" projects.

As WPI prepares a five-year operating budget, thought should be given to the proper allocation and appropriate level of resources for computers and computer support on campus. Technology may become cheaper over time but the demand for more and better technology negates the opportunities for reduced expenditure. The College Computer Center may warrant significant increases in funding and staff in order to provide the level of service demanded by the community. Also, there needs to be consistency throughout the institution as to the means of purchasing personal computers. An institutional plan for replacement, whether it be through purchase or leasing, would ensure that all areas receive equal consideration for funding and that the necessary upgrades of equipment occur on a timely basis.

7. Conclusions
If one word could be used to describe the current information infrastructure at WPI, it would be "fragmented". On the academic side, there are widely varying levels of hardware, software, and support. On the administrative side, there is a proliferation of separate databases and software systems. Some departments are still using "home grown" software written more than a decade ago. The resulting redundancies and re-work cost WPI tens of thousands of dollars each year.

We see the institution of an effective planning process, led by a Chief Information Infrastructure Planner, as the most important change that could be made in WPI's information infrastructure. Effective planning would lead to significant savings from a rational, planned approach to the information infrastructure, and would also allow us to eliminate the current inequities in the level of information resources available to different area of the campus. Furthermore, a planning process would allow us to prepare, both financially and technically, for necessary technological changes in the computing environment on campus.
We have identified some specific short-term and long-term infrastructure issues for the Chief Planner to address. Some of these issues will require substantial additional resources, but we see the opportunity for significant savings through greater efficiencies in other areas.

We have identified the following specific giving opportunities:

- Full graphical Internet access (PPP access) for off-campus computer users. Costs: $48,565 initial cost plus $26,800 per year operating costs.
- Administrative computing system, to provide a common computing environment for administrative offices. Costs: $2,000,000 acquisition cost, plus $50,000 yearly maintenance costs.
- Gordon Library, renovations for the library of 2010. Costs: $3,000,000 to $5,000,000.
- An endowed chair in information technology
- Campus-wide wireless networking

1 The American Heritage Dictionary of the English Language, 3rd edition.
2 "The Mission of WPI," WPI Undergraduate Catalog, 1997-98, p.1
3 Stephen J. Weininger. "Vision Statement from the SPSC" (Strategic Plan Steering Committee). 18 Dec. 1996. Announcement to steercom-announce@wpi.edu.