To: Engineering Chairs, Directors, and Associate Directors
From: Charlie Van Loan (CS)
Subject: Core Requirements and Other Things
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I would like to comment on two issues that bring up related concerns: the idea of having a more flexible set of core requirements and the proposed information science major. Thoughtful colleagues are wondering if these developments square with the traditions of Cornell Engineering. The discussion is challenging because the genome is so complex:

AEP-BEE-CBE-CEE-CS-EAS-ECE-MAE-MSE-ORIE-TAM

How can this varied sequence of "nucleotides" simultaneously code for breadth of education and regulate life in the "cell" with forward-looking degree programs? Let's go back one hundred years and trace its evolution.

A freshman visiting Sibley Hall in 1900 would come away with the idea that engineering was simply the art of applying physics to build useful things, e.g., a generator, a bridge, a pump. The faculty in Electrical, Civil, and Mechanical engineering embodied the "practical half" of the Andrew D. White / Ezra Cornell vision—a brilliant vision that included the liberal arts <u>and</u> the practical arts.

In the 1920s chemical engineering was added to the mix because by then engineers realized that chemistry had just as many practical ramifications as physics. Around that time Cornell Engineering transitioned from a loose confederation of academic units to a genuine college with deep roots in the physical sciences.

The next generation of postwar/cold war engineering students found richer connections to the sciences and tighter couplings to mathematics and business. The College discovered four new ways to deliver the goods: A&EP, MS&E, OR&IE, and T&AM.

Nowadays, undergraduates thinking about majors leaf through glossy university publications and discover that A&S, A&LS, and CIS have shared academic missions with Engineering. Cornell encourages interdisciplinary research and backs it up with flexible administrative arrangements that bring opportunities to students: EAS, BEE, and CS.

The Engineering genome with its eleven codons is a marvel to behold. But the environmental factors that directed its evolution—science and mathematics—are still at work tugging away at the college's intellectual heart. <u>And that heart is the design process</u>. We are struggling with a diversity of fields each of which uses science and mathematics in its own unique way to support its brand of engineering design.

Nano-engineers build objects at the molecular level and use physics in a different way than their colleagues in structural engineering who work on a scale that is a billion times larger. The design of a pharmaceutical requires chemistry, but a different kind of chemistry than what underpins the design of a low-emissions engine. The biology required to build an effective proteomic database has very little in common with the biology required to build an effective artificial limb. Different kinds of engineering connect to different kinds of science. *The core science requirement should make it possible for each field to develop an alloy of physics, chemistry, and biology that maximizes the strength of its major.*

There is also wide variation in the College with respect to the kind of mathematics that is used support the design process. To build a communication network that maximizes the flow of information requires an understanding of discrete mathematics and statistics. To build an artificial heart that maximizes the flow of blood through a network of arteries and veins requires partial differential equations. To build a secure and reliable computer system requires number theory and mathematical logic. To make that system physically secure requires calculus and more advanced continuous mathematics. Different kinds of engineering connect to different kinds of mathematics. *The core mathematics requirement should make it possible for each field to develop an alloy of differential equations, statistics, and discrete math that maximizes the strength of its major.*

By granting the fields a measure of flexibility in choosing core courses <u>and</u> by enforcing a high standard of rigor for the allowable options, the College can accentuate further the strong math/science base that is the hallmark of our undergraduate programs. We must remember that Cornell engineers are sought by industry and graduate schools because of their creative design instincts and superb problem-solving ability, not because they are able to recall a particular syllabus item from a required course. The freshman-sophomore common curriculum is terribly important, but it should be evaluated in terms of how well it enables the fields to produce great engineering alumni.

While the core requirement issue prompts us to consider what's important for our students, the proposed Information Science and Technology (IS&T) major raises an even more fundamental concern: What is Engineering? To me, the IS&T major is yet another presentation of the design process, one that revolves around information and unimaginable complexity. Let me explain why I believe that the IS&T major has all the credentials that we expect of an engineering major.

The trend of increased complexity throughout engineering is obvious. Instead of being concerned with individual generators, bridges, and pumps, our colleagues in ECE, CEE, and M&AE now deal with power systems, transportation systems, and hydraulic systems. In OR&IE, it is more about manufacturing networks than about individual production centers. In CS the concern is more with making computer networks reliable and secure than about doing the same thing for individual processors. Etc. Etc. The IS&T major will educate students about the design and management of very complex information systems. Just as structural engineers and nanofabricators use physics at radically different scales, so also will there be a scale difference between the focus of the IS&T graduate and the graduates of the more look-under-the-hood majors in CS and OR&IE. The emphasis will be about engineering in broad application contexts where information science, technology, and management are the central concerns.

It is important to stress that effective engineering in the IS&T area involves more than just dealing with technical complexity. Ambiguous social issues and messy human factor concerns prevail. The design, analysis, and management of large complex information systems require as much psychology and social science savvy as it does mathematics and technical know-how. The engineering problems in this arena are so large and complex that practitioners need a wide range of problem solving methodologies, some of which are new to the engineering landscape and naturally engender skepticism. But there <u>is</u> a science of human-computer interaction--it straddles the Departments of Psychology and Communications. There <u>is</u> a science of information management—it involves statistics, mathematical optimization, and yet more psychology. In the curriculum area, there are S&TS courses that are just as vital to the IS&T design process as are T&AM courses to mechanical engineering. The IS&T major will give our undergraduates the opportunity to apply a very broad range of skills in areas that are critical to the nation's infrastructure.

Proponents of liberal education in the College of Arts and Sciences have long since widened their circle to include more than Latin and Greek. Perhaps it is now Engineering's turn to think more broadly about its commitment to the practical half of the Andrew D. White / Ezra Cornell vision.