So what is it that engineers do, anyway?

or
How to answer all those "What are you studying at school?" questions at Thanksgiving dinner...

by
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Read the passage below and then work with your group to list at least five parts of the Intelligent Highway System. When all groups are finished, someone from each group will have a chance to comment on their group's list.

Part 1: The Intelligent Transportation System

In today's society, traffic accidents and congestion take a heavy toll. Many highway accidents are caused by human error, such as failing to yield the right of way, improper passing, or running stop lights. Additionally, there is heavy traffic congestion in many urban areas, and current patterns of suburban growth and job movement to suburban areas will only lead to more and more traffic problems, both in transit from suburb to city and suburb to suburb travel.

To address these problem, a multi-million-dollar research initiative--the Intelligent Transportation System--is being undertaken by corporations, universities, and federal and state agencies (e.g., the Federal Department of Transportation). One part of this system, the Automated Highway System (AHS), involves automatically controlled cars, specially designed highways, management of traffic flow, automatic alerting of traffic congestion, and in-car computerized navigation systems. For example, the number of cars allowed on any section of highway--and their speed--will be automatically controlled by a central traffic control center, similar to the way planes are controlled by air traffic control centers.

One method for automatically managing traffic flow is the "platoon" concept. In certain areas of the highway, vehicles will be grouped into a multiple car platoon, automatically traveling at high speeds close together. Another idea is to construct special lanes on the highway for use by cars whose steering, speed, and braking systems are automatically controlled to avoid accidents with other cars.

Researchers of this system believe that the AHS will reduce accidents due to driver error and increase the capacity of the highways by allowing more cars to travel at higher speeds, thus reducing traffic congestion.

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Read the descriptions below, and listen to the engineers describe their work. With your group, list at least three things in the ITS that you would ask each engineer to design. When all groups are finished, someone from each group will have a chance to comment on their group's list.

Part 2: Systems and Sub-systems

Whenever you design a whole system, what happens is that different kinds of engineers end up working together as a team and the work gets divided up among the team members. Here it is your job to divide up the work. The following engineers need to be assigned to design various components of the ITS. What do you think would be most appropriate for each engineer to design?

Amy: Amy is an industrial engineer, specializing in the area of human factors engineering. Industrial engineers work in very diverse areas, such as manufacturing, transportation, and service industries (e.g., health care, banking) to analyze, design, and improve complex systems so that they operate efficiently and effectively. For example, industrial engineers use mathematical techniques and computer programs to decide how airlines should best organize their planes and schedules, so that planes around the country arrive on time, don't sit too long between flights, have just enough seats to hold the passengers who purchased tickets, and have enough fuel and crew members. Other industrial engineers design and lay out equipment and jobs in manufacturing plants, so that goods can be produced efficiently, according to quality standards. Human factors engineers concentrate on designing and analyzing the components of systems that humans (for example, workers or customers) must use, to insure that people can use those systems effectively, without injury, and with few errors. For example, some human factors engineers design workstations, jobs, and tools in manufacturing plants to ensure that workers can perform their jobs well (e.g., meet quality standards), without threat of injury. Other human factors engineers design parts of the computer software systems that are used to control things such as manufacturing equipment or vehicles (e.g., airplanes) so that people can find and understand the information they need on the computer screen display, make the right decisions with that information, and give the computer system the correct commands.

Alex: Alex is an electrical engineer specializing in communications and display systems. Specifically, his work involves the design and implementation of systems that can display information to users and allow communications between humans, computers and humans, and computers and computers. These two areas do not encompass the entire spectrum of electrical engineering. The governing body of electrical engineering is the Institute of Electrical and Electronics Engineers, Inc. This group includes representatives of all majors areas of EE, from more applied physics areas such as lasers and photonics (using light instead of electricity to communicate) to traditional areas like the design of electrical circuits, control systems, and the communication of information. Electrical engineering also includes the development of materials -- for instance, compounds that are similar to glass or sand that include the element silicon and can conduct electricity -- that can be used for the development of advanced circuits and computer components for the next generation of information transfer systems. It is important to understand that electrical engineering should be distinguished from computer science: Computer scientists develop complex computer systems which use building blocks -- such as integrated circuit chips -- developed by electrical engineers. Traditionally, electrical engineers have been responsible for the development of an extensive set of products, such as radio equipment, CD players, control systems (e.g., automated feedback through a circuit to control the speed of an automobile), circuits for electrical products, antennas, radar systems, electrical power distribution systems for homes (e.g., power plants, power lines, and transformers), and materials development (e.g., silicon based semiconductors).

Amjad: Amjad is a civil engineer specializing in structural engineering. To explain what civil engineers do, it is helpful to know that there are five specialized areas in civil engineering: namely, structural, geotechnical, construction, transportation, and environmental engineering. A structural engineer has the responsibility to design structural systems -- things like buildings, bridges, structural parts in automobiles, aircraft structures, and even small objects like a computer chip. The common denominator in all these systems is that all of them will undergo some loads -- or forces, like weight, pressure, or tension -- while in service. Having to resist the loads applied to each system, a structural engineer designs the components to sustain a set of loading conditions that could occur, taking into account certain margins of safety and reliability. For large structures such as buildings and bridges, such forces include normal service conditions (e.g., the weight of cars driving over the bridge or the pressure of normal winds on tall buildings) as well as extreme forces such as earthquakes and hurricane force winds. The design of things like automobile components and aircraft structures also includes considering the effects of fatigue and temperature. For small structures such as electronic devices, temperature and vibration are major design issues. Just by turning your computer on and off, you subject these devices to cycles of temperature-induced loads. Moreover, when electronic devices are mounted on an airplane or an automobile, vibration and temperature are of great concern as they affect the length of time these devices will operate. Other types of civil engineers focus on other types of design problems. A geotechnical engineer deals with soil mechanics (how strong is that clay soil?) and foundation design, while a construction engineer is responsible for coordinating the construction tasks and contracts, organizing the construction sequence, estimating the amount of materials needed, and ensuring that the project is following a construction schedule and is going according to design plans. Transportation engineers design roads and highways, including traffic lights and other controlling traffic signs based on traffic patterns studies. A transportation engineer is also responsible for designing the routes and frequency of various means of public transportation such as buses and trains. Finally, environmental engineers deal with the design of water supplies (where is the water source? How will it be delivered?), air quality, and preventing hazardous materials from harming the environment.

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Read the following passage. What are the different things the designers and companies that used the Galaxy IV did that they thought would prevent such a failure? Why didn't these things work? How does the passage relate to the safe operation of the IHS?

Part 3: Reliability and Redundancy

At 6:00 EST on Tuesday May 19, 1998, there was a failure of a major communication satellite, Galaxy IV, operated by PanAmSat. Press releases from PanAmSat identified the problem as one which affected the on-board spacecraft control processor, which is the primary system used to orient, or point the spacecraft. The automatic switch to a backup control unit also failed. Due to these failures, the satellite no longer maintained the necessary fixed orientation with respect to the earth, disrupting its ability to transmit video and telecommunications information.

The New York Times (May 22, 1998) reported that approximately 80 percent of the nearly 50 million pagers in use in the United States lost service because of the satellite failure, affecting everyone from physicians and salespeople to parents checking up on their teenagers. While some corporations, such as CBS or HBO, reserve capacity on other satellites or utilize a set of satellites and therefore can shift programming transmissions to other satellites, smaller companies such as many pager companies cannot afford the cost of maintaining the reserve capacity (*New York Times*, May 21, 1998).

To solve the problem, PanAmSat rerouted communications data to other satellites which had excess capacity. This necessitated engineers and field technicians to redirect several hundred thousand satellite dishes in order to pick up data from the other satellites. According to the *New York Times* (May 22, 1998) due to the urgency of the situation and the limited number of technicians available, one company, Wall Street on Demand, redirected its satellite using an interesting combination of old and new technology--they found the position of the Galaxy IV and the new satellite by looking on the World Wide Web, and then repositioned the satellite dish guided by a string and protractor.

The majority of customers were receiving service via alternative satellites by Friday, May 22.