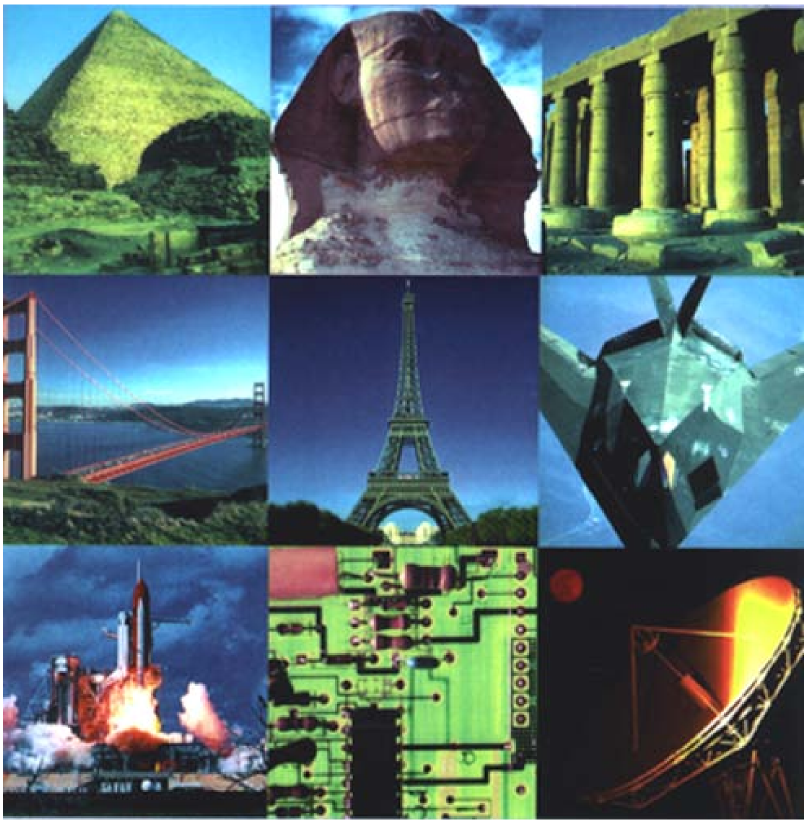
# CHAPTER 1

# THE ENGINEER

## 1.1. INTRODUCTION



The root of the word "engineer" derives from "engine" and "ingenious" both of which come from the Latin root "ingenerate" meaning "to create".

"Mühendis" in Turkish derives from "hendese" which means "geometry" and thus mühendis is the one who makes dimensional calculations. "Hendesehane" means "School of Engineering".

**Engineers are individuals who *combine knowledge of science, mathematics and economics* to solve technical problems that confront society. Main difference between scientists and engineers is the cost analysis.**

Early in human history, there were no formal schools to teach engineering. Early engineers were those, "Alaylı" in Turkish, who had a gift for manipulating the physical world to achieve a practical goal. Often, it would be learned through apprenticeship with experienced practitioners.

Current engineers are educated, "Okullu" in Turkish, in mathematics, science and economics. According to ABET (Accreditation Board for Engineering and Technology, USA) engineers must demonstrate that they have:

(a) an ability to apply knowledge of mathematics, science, and engineering,
(b) an ability to design and conduct experiments, as well as to analyze and interpret data,
(c) an ability to design a system, component, or process to meet desired needs,
(d) an ability to function on multi-disciplinary teams,
(e) an ability to identify, formulate, and solve engineering problems,
(f) an understanding of professional and ethical responsibility,
(g) an ability to communicate effectively,
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context,
(i) a recognition of the need for, and an ability to engage in life-long learning,
(j) a knowledge of contemporary issues,
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

## 1.2. ENGINEERING DISCIPLINES

Figure 1.1 shows when the major engineering disciplines were born. Nearly all engineering disciples are thought to have evolved from civil engineering. Note that all engineering disciplines require extensive knowledge of physics, whereas chemical and materials engineering require extensive knowledge of physics and chemistry. Some recent disciples require extensive knowledge of physics, chemistry and biology.

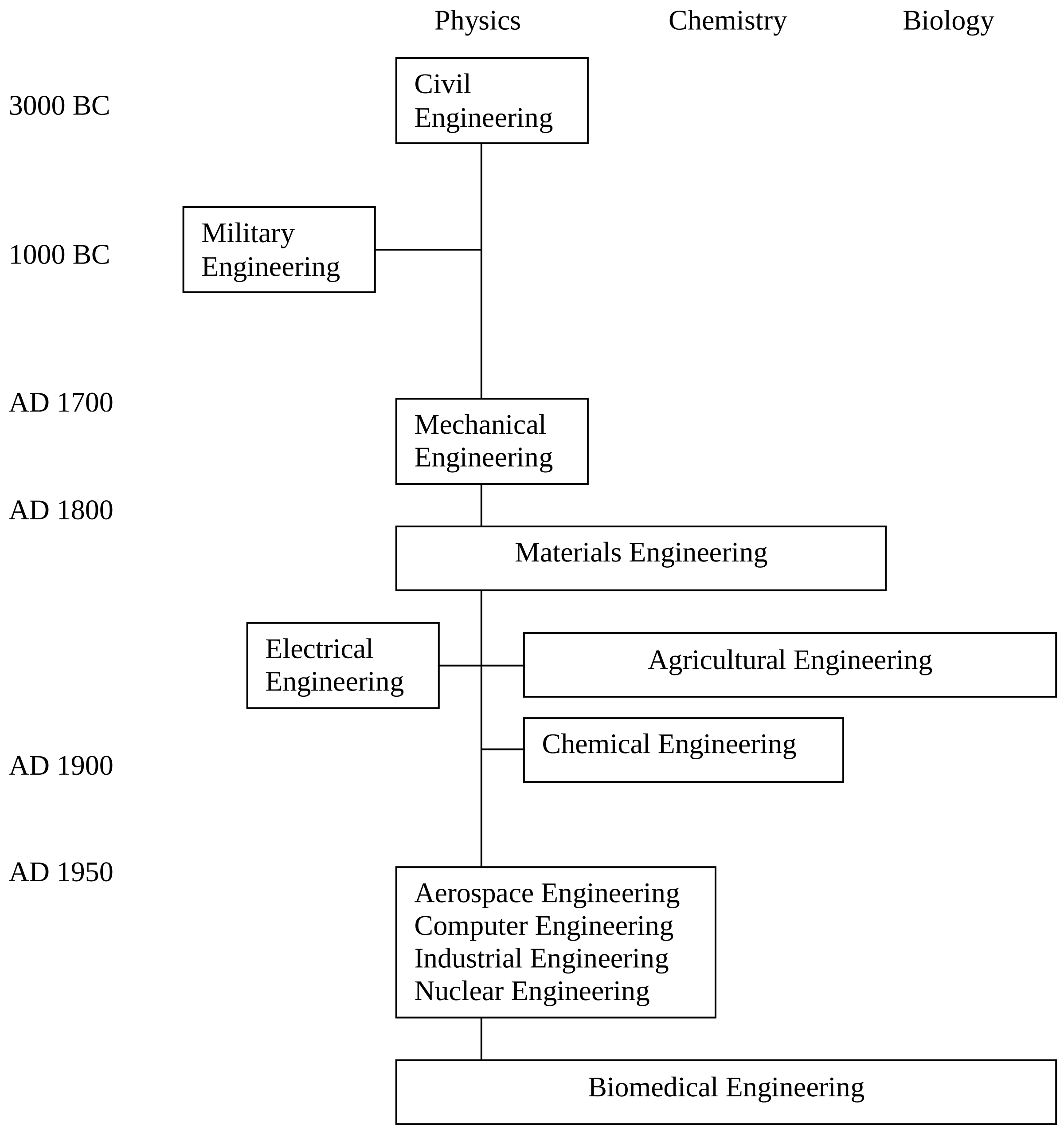



Figure 1.1. Birth of engineering disciplines

**(A) Civil Engineering:** Civil engineering is generally considered the oldest engineering discipline-its works trace back to the Egyptian pyramids and before. Many of the skills possessed by civil engineers (e.g., building walls, bridges, roads) are extremely useful in warfare, so these engineers worked on both military and civilian projects.

Civil engineers are responsible for constructing large-scale projects such as roads, buildings, airports, dams, bridges, harbors, canals, water systems, and sewage systems.

**(B) Mechanical Engineering:** Mechanical engineering was practiced concurrently with civil engineering because many of the devices needed to construct great civil engineering projects were mechanical in nature. During Industrial Revolution (1750-1780), wonderful machines were developed: steam engines, internal combustion engines, mechanical looms, sewing machines, and more. Thus, the birth of mechanical engineering took place as a discipline distinct from civil engineering.

Mechanical engineers make engines, vehicles (automobiles, trains, planes, ships), machine tools, heat exchangers, industrial process equipment, power plants, consumer items, and systems for heating, refrigeration, air conditioning, and ventilation.

**(C) Electrical Engineering:** Soon after physicists began to understand electricity, the electrical engineering profession was born. Electricity has served two main functions in society: the transmission of power and of information. Those electrical engineers who specialize in power transmission design and build electric generators, transformers, electric motors, and other high-power equipment. Those who specialize in information transmission design and build radios, televisions, computers, antennae, instrumentation, controllers, and communications equipment.

Modern life is largely characterized by electronic equipment. Daily, we rely on many electronic devices-televisions, telephones, computers, calculators, and so on.

**(D) Chemical Engineering:** Chemical engineering was born in 1880s as a combination of mechanical engineers and industrial chemists. Chemical engineering is characterized by a concept called *unit operations*. A unit operation is an individual piece of process equipment (chemical reactor, heat exchanger, pump, compressor, distillation column). Chemical engineers assemble chemical plants by combining unit operations together.

Chemical engineers process raw materials (petroleum, coal, ores, corn, trees) into refined products (gasoline, heating oil, plastics, pharmaceuticals, paper, detergents, foods, sugar).

**(E) Industrial Engineering:** Beginning of assembly lines in 1900s for mass production of cars and many other types of equipment resulted in *time-motion studies* for increasing the efficiencies of workers. Today industrial engineers develop, design, install, and operate integrated systems of people, machinery, and information to produce either goods or services.

**(F) Aerospace Engineering:** Aerospace engineers design vehicles that operate in the atmosphere and in space. They design and built high performance flight vehicles (aircraft, helicopters, missiles, and spacecrafts).

**(G) Materials Engineering:** Materials engineers are concerned with obtaining the materials required by modern society. Metals and their alloys, plastics, ceramics, composites, rocks, concrete, and many others are commonly used engineering materials.

**(H) Agricultural Engineering:** Agricultural engineers help farmers efficiently produce food and fiber. They develop many farming machines (tractors, plows, combined harvesters, milking machines), and buildings (silos, green houses, barns).

**(I) Computer Engineering:** Computer engineering evolved from electrical engineering. They understand both from hardware and software. They design and build various computers, operating systems, networks, and similar information processing systems. Computer engineering is the fastest growing engineering discipline all over the world.

**(J) Biomedical Engineering:** Biomedical engineers combine traditional engineering fields (mechanical, electrical, chemical, industrial) and medical professions. They develop prosthetic devices, artificial kidney, pacemakers, and artificial hearts.

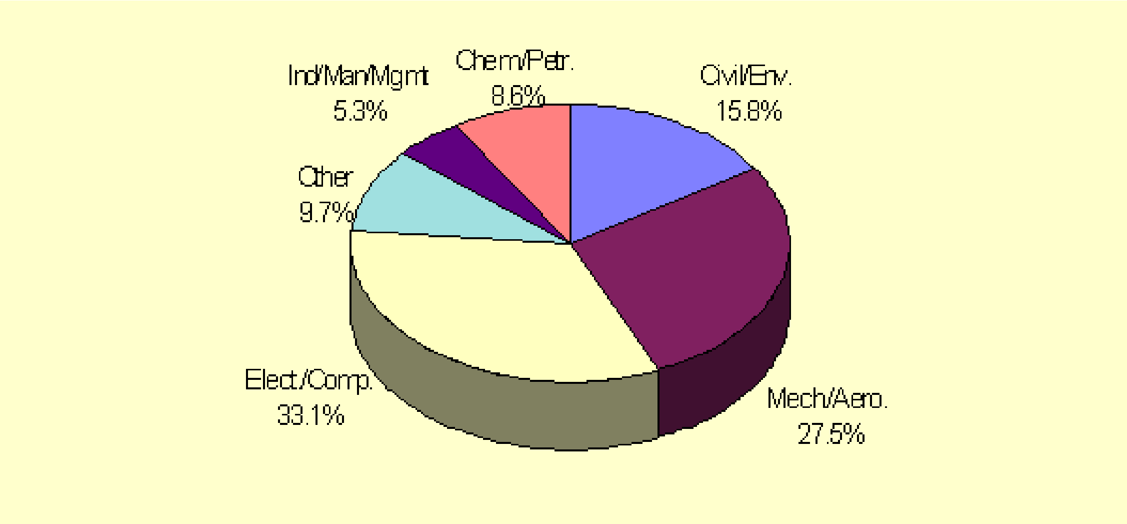



Figure 1.2 Engineering degrees awarded in USA universities in 1993-94 academic year.

### 1.3. ENGINEERING FUNCTIONS

Regardless of their disciplines, engineers can be classified by the function they perform:

- *Research engineers* search for new knowledge to solve difficult problems that do not have readily apparent solutions. They require the greatest training, generally an MS or PhD degree.
- *Development engineers* apply existing and new knowledge to develop prototype of new devices, structures, and processes.
- *Design engineers* apply the results of research and development engineers to produce detailed designs of devices, structures, and process that will be used by the public.
- *Production (construction) engineers* are concerned with specifying production schedules, determining raw materials availability, and optimizing assembly lines to mass produce the devices conceived by design engineers.
- *Testing engineers* perform tests on engineered products to determine their reliability and suitability by design engineers.
- *Operations engineers* run and maintain production facilities such as factories and chemical plants.
- *Sales engineers* have the technical background required to sell technical products.
- *Managing engineers* are needed in industry to coordinate the activities of the technology team.
- *Consulting engineers* are specialists who are called upon by companies to supplement their in-house engineering talent.

| Sector of Employment | Aero | Chem | Civil | Elec | Ind | Mech |
|---|---|---|---|---|---|---|
| Industry | 63.3 | 74.0 | 48.9 | 69.6 | 76.7 | 75.8 |
| Self | 11.1 | 12.7 | 14.4 | 12.2 | 11.5 | 11.4 |
| Education | 3.5 | 5.0 | 3.0 | 4.9 | 3.6 | 3.9 |
| Non-profit | 2.4 | 1.7 | 0.5 | 1.5 | 1.7 | 1.1 |
| Fed. Govt. | 4.7 | 4.6 | 9.3 | 9.3 | 4.6 | 6.1 |
| Military | 4.3 | 0.3 | 1.3 | 0.9 | 0.3 | 0.4 |
| Other Govt. | 0.4 | 1.3 | 22.1 | 1.1 | 1.4 | 0.9 |
| Other | 0.3 | 0.4 | 0.5 | 0.5 | 0.2 | 0.4 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Figure 1.3 Employment records of various engineering disciplines in USA (1993-94)

## 1.4. CREATIVITY

Rarely is creativity directly addressed in the engineering classroom. Some of the professors think that creativity is a talent students are born with and cannot be taught. Instead, the primary goal of engineering education is the transfer of knowledge to future generations that was painstakingly gained by past generations. Further, engineering education emphasizes the proper manipulation of knowledge to correctly solve problems. These activities support analysis, not synthesis. However, engineers are expected to combine knowledge together, synthesis, for developing a new product or a process. Both analysis and synthesis are part of the creative process.

Table 1.1 lists some creative professions, of which engineering is one. Although the goals of authors, artists, and composers are many, most have the desire to communicate.

Table 1.1 Creative professions

| Profession | Goals | Constraints |
|---|---|---|
| Author | Communication, exploration of emotions, development of characters | Language |
| Artist | Communication, creation of beauty, experimentation with different media | Visual form |
| Composer | Communication, creation of new sounds, exploration of potential of each instrument | Musical form |
| Engineer | Simplicity, increased reliability, improved efficiency, reduced cost, better performance, smaller size, lighter weight, etc. | Physical laws and economics |

The creative thinker is a combination of organized and disorganized thinkers. The creative mind is ordered and structured, but information is stored in multiple places so that when the information is needed, there is a higher probability of finding it. The disorganized thinker has no structure. Although the information may be stored in multiple places, his mind is so disorganized that the information is hard to retrieve when needed.

**1.5. ENGINEERING WONDERS**

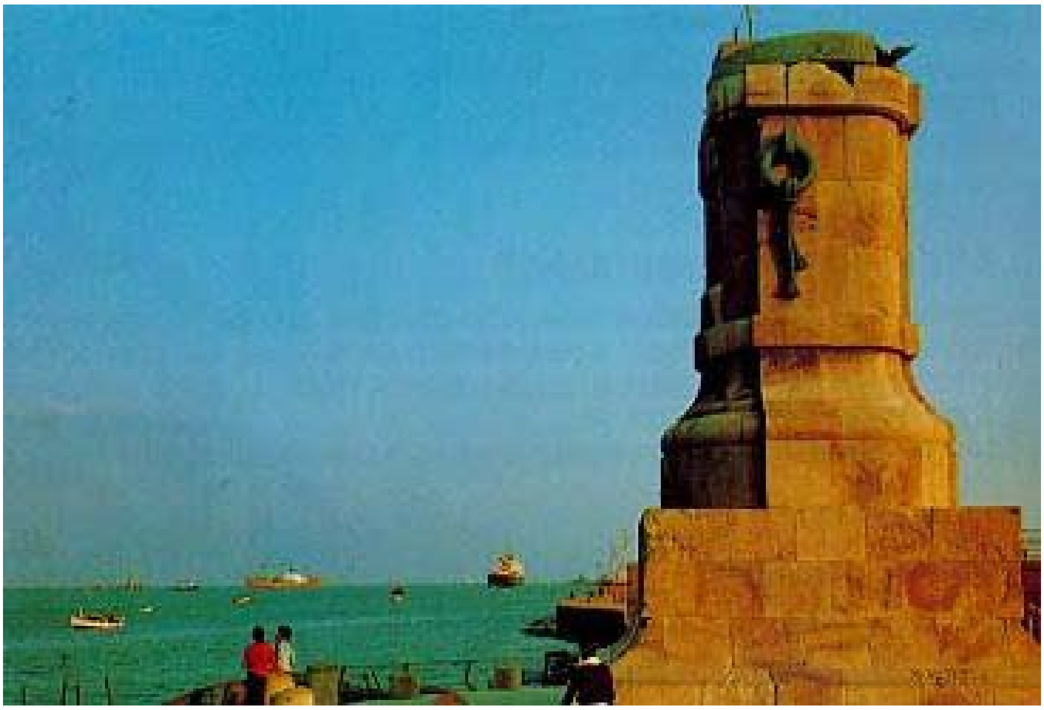
**(A) CANALS (TUNNELS)**

**SUEZ CANAL**

The idea of a canal linking the Mediterranean to the Red Sea dates back to ancient times. Unlike the modern Canal, earlier ones linked the Red Sea to the Nile, therefore forcing the ships to sail along the River on their journey from Europe to India. It has been suggested that the first Canal was dug during the reign of Tuthmosis III, although more solid evidence credits the Pharaoh Necho (Sixth Century BC) for the attempt. During the Persian invasion of Egypt, King Darius I ordered the Canal completed. The Red Sea Canal, consisted of two parts: the first linking the Gulf of Suez to the Great Bitter Lake, and the second connecting the Lake to one of the Nile branches in the Delta. The canal remained in good condition during the Ptolemaic era, but fell into disrepair afterwards. It was re-dug during the rule of the Roman Emperor Trajan, and later the Arab ruler Amr Ibn-Al-Aas. Over the years, it fell again into disrepair, and was completely abandoned upon the discovery of the trade route around Africa.

It was Napoleon's engineers who, around 1800 AD, revived the idea of a shorter trade route to India via a Suez Canal. However, the calculation carried out by the French engineers showed a difference in level of 10 meters between both seas. If constructed under such circumstances, a large land area would be flooded. Later, the calculations showed to be wrong, and the final attempt to dig the Canal was undertaken by former French Consul in Cairo and famous Canal digger **Ferdinand de Lesseps**. He was granted a "ferman" or decree by the khedive Said of Egypt to run the Canal for 99 years after completion.

In 1859, Egyptian workers started working on the construction of the Canal in conditions described by historians as slave labor, and the project was completed around 1867. On November 17, 1869, the Canal was officially inaugurated by Khedive Ismail in an extravagant and lavish ceremony. French, British, Russian, and other Royalty were invited for the inauguration which coincided with the re-planning of Cairo. A highway was constructed linking Cairo to the new city of Ismailia, an Opera House was built, and Verdi was commissioned to compose his famous opera, "Aida" for the opening ceremony. Ironically, Verdi did not complete the work in time and "Aida" premiered at the Cairo Opera a year later.



Statue of Liberty was produced to be located in place of this monument

**Statue of Liberty** (produced for locating at the exit of Suez Canal)


Sculptor Frederic **Auguste Bartholdi** was commissioned to design a sculpture with the year 1876 in mind for completion, to commemorate the centennial of the American Declaration of Independence. The Statue was a joint effort between America and France and it was agreed upon that the American people were to build the pedestal, and the French people were responsible for the Statue and its assembly here in the United States. However, lack of funds was a problem on both sides of the Atlantic Ocean. In France, public fees, various forms of entertainment, and a lottery were among the methods used to raise funds (statue was ready and the money was paid by the Ottoman Empire!). In the United States, benefit theatricalevents, art exhibitions, auctions and prize fights assisted in providing needed funds. Meanwhile in France, Bartholdi required the assistance of an engineer to address structural issues associated with designing such as colossal copper sculpture. **Alexandre Gustave Eiffel** (designer of the Eiffel Tower) was commissioned to design the massive iron pylon and secondary skeletal framework which allows the Statue's copper skin to move independently yet stand upright.

**PANAMA CANAL**


The French got the first crack at digging a trench from the Atlantic Ocean to the Pacific in 1878 when a committee of the Geographical Society of Paris signed a treaty with Colombia (of which Panama was then a province) to build a canal from Limon Bay to Panama City, closely following the Panama Railroad. In retrospect, the French effort probably was doomed from the start because **Ferdinand de Lesseps**, builder of the Suez Canal in 1869, insisted on a sea level canal requiring a massive 7,720-meter long tunnel through the Continental Divide at Culebra. The builders also had no idea how to cope with the frequent horrific outbreaks of malaria and yellow fever. Ten years later and after at least 20,000 deaths from disease the French gave up, but not before one last effort was made to switch from a sea level canal to a waterway that crossed the Continental Divide along the isthmus's central highlands using a series of locks. **Lucien N.B. Wyse**, the French navy lieutenant who surveyed the canal's course and negotiated the treaty with Colombia, tried once more beginning in 1894. Wyse's company settled on a canal with a pair of lakes and eight sets of locks, but it was grossly under-capitalized and would clearly never finish the job.

U.S. President Theodore Roosevelt settled on the Panama route after some friendly persuasion by the powerful Ohio Republican senator, Mark Hanna, himself lobbied heavily by French interests whose assets were in Panama, not in Nicaragua. When Colombia refused to sell the rights to dig the canal, Roosevelt threw U.S. power behind a Panamanian uprising and supported Panama's 1903 declaration of independence. Roosevelt instigated a treaty with Panama that gave the United States the right to build the canal and created a 10-mile wide Canal Zone of what amounted to sovereign American territory surrounding the waterway. The United States bought the French rights and properties, and construction of a lock canal commenced in 1904. The Americans took no chances. The Army dispatched surgeon Col. William Gorgas to Panama to tackle malaria and yellow fever. Gorgas was fresh from Havana where he had helped eradicate yellow fever, following discoveries by his colleague Maj. Walter Reed and others that the disease was carried by a mosquito. Malaria also had recently been discovered to be transmitted by mosquito bites. Once Gorgas's efforts had quickly eradicated yellow fever and reduced the incidence of malaria, two principal obstacles to the canal had been removed. The third obstacle was the terrain. The lakes and locks proved to be the right idea at the right time. Indeed. The Panama Canal was not just a magnificent feat of engineering; it was the cornerstone, in a sense, of the American Century. After 10 years, during which 70,000 people worked on the project, $400 million and 5,600 deaths, the Panama Canal officially opened on August 15, 1914, just as World War I was getting under way.

| | PANAMA | SUEZ |
|---|---|---|
| LENGTH | 80 km | 163 km |
| MAX. SHIP WIDTH | 32 m | 70 m |
| MAX SHIP LENGTH | 294 m | 500 m |
| COST | 400 million dollars (1914) | 114 million dollars (1869) |
| NO OF LOCKS | 3 | NONE |

## SEIKAN TUNNEL

The Seikan Tunnel construction was started on September 1971 and was opened in March 1988 and runs beneath the seabed of the Tsugaru Strait, which separates the southern edge of Hokkaido from Aomori Prefecture on the northern edge of the mainland. This tunnel is a part of a railway that runs between Aomori City and Hakodate City in just two and a half hours, and was named by combining the two characters and pronunciations of Aomori City's "Ao (Sei)" and Hakodate City's "Hako (Kan)". The length of 53.85 kilometers (33.5 miles) makes it world's longest, though its 23.3 kilometers (14.5 miles) of submarine portion was outdistanced by the 37.5-kilometer (23.3-mile) Euro Tunnel which opened in 1994. The railway track runs 240 meters (787 feet) below the sea surface, and is the deepest railway line in the world. The advanced civil engineering technologies have been rated highly that made it possible for the tunnel to run below 140-meter-deep (459-foot-deep) water as well as 100 meters (328 feet) below the seabed.

The tunnel was designed with gentle curves and slopes for possible future use by Shinkansen (bullet train). In addition, high-strength rails suitable for Shinkansen have been used.

There are two stations inside the tunnel: Tappi Kaitei Station on the Aomori side, and Yoshioka Kaitei Station on the Hokkaido side. They are both located just under the coastal line. In these two station buildings-which are rare submarine stations-tour courses have been established with reference displays of the Tsugaru Strait and the Seikan Tunnel.

## CHANNEL TUNNEL

The **Channel Tunnel**, (French: *le **tunnel sous la Manche***; once popularly nicknamed the **Chunnel** in English) is a 50-km-long rail tunnel beneath the English Channel at the Straits of Dover, connecting Cheriton in Kent, England and Coquelles near Calais in northern France. A long-standing and hugely expensive project that saw several false starts, it was finally completed in 1994. It is the second-longest rail tunnel in the world, surpassed only by the Seikan Tunnel in Japan. It is operated by Eurotunnel company.


Channel Tunnel


The English terminal at Cheriton,

***Historical attempts or proposals for a tunnel***

A link between Britain and France had been proposed on many occasions.

- 1802 Albert Matthieu-Favier, a French engineer, put forward a proposal for a tunnel. Passengers would travel through the tunnel in horse-drawn coaches; the road would be lit by oil-lamps; and a mid-tunnel island would have provided a fresh-air respite for the horses. The cost would have been one million pounds even then.
- 1875 Peter Barlow, builder of London's first Underground railway, suggested a floating steel tube across the Channel. The idea was rejected.
    - French & English Parliamentary bills passed to build the tunnel. Insufficient funds raised and the concession ran out a year later.
- 1876 Extensive geological survey carried out; French sink two shafts.
- 1880 The South Eastern Railway (SER) arranges trial borings on English side.
- 1881 Patented (Beaumont) boring machine drive a tunnel 897 yards (820 m) parallel to cliffs on English side.
    - Work begins on Channel Tunnel by (SER); again insufficient funds & *Submarine Continental Railway Company* set up.
- 1882 Rival *Channel Tunnel Company* causes a rift in proceedings; adverse comments by media and an influential group (including Robert Browning and Alfred Lord Tennyson). Eventually work was halted by the Board of Trade because of military objections: the ease with which invaders could attack from the Continent was cited.
- 1922 Workers started boring a tunnel from Folkestone: after 128 meters of tunnel had been completed, political objections again brought the project to an end.

It was not until the 20th century that engineers came to believe that the necessary technical ability was available. After World War II the concept of the tunnel began to receive serious attention.

***Planning***

In 1957 le Tunnel sous la Manche Study Group was formed. It reported in 1960 and recommended two main railway tunnels and a smaller service tunnel. The project was launched in 1973 but folded due to financial problems in 1975 after the construction of a 250 m test tunnel.

In 1984 the idea was relaunched with a joint United Kingdom and French government request for proposals to build a privately funded link. Of the four submissions received, the one most closely resembling the 1973 plan was chosen and announced on 20 January 1986. The Fixed Link Treaty was signed by the two governments in Canterbury, Kent on 12 February 1986 and ratified in 1987.

The planned route of the tunnel took it from Calais to Folkestone (a route rather longer than the shortest possible crossing) and the tunnel was to follow a single chalk stratum, which meant the tunnel was deeper than the previous attempt. For much of its route, the tunnel is nearly 40 m (130 ft) under the seafloor, with the southern section being deeper than the northern.

***Construction***

Digging the tunnel took 15,000 workers over seven years, with tunnelling operations conducted simultaneously from both ends. The prime contractor for the construction was the Anglo-French TransManche Link, a consortium of ten construction companies and five banks of the two countries. Engineers used large tunnel boring machines (TBMs), mobile excavation factories that combined drilling, material removal, and the process of shoring up the soft and permeable tunnel walls with a concrete liner. After the British and French TBMs had met near the middle, the French TBM was dismantled while the British one was diverted into the rock and abandoned. Almost 4 million $m^3$ of chalk were excavated on the English side, much of which was dumped below Shakespeare Cliff near Folkestone to reclaim 90 acres (360,000 $m^2$) of land from the sea.

The Channel Tunnel consists of three parallel tunnels: two primary rail tunnels, which carry trains north and south, and a smaller access tunnel. The access tunnel, which is served by narrow rubber-tyred vehicles, is connected by transverse passages to the main tunnels at regular intervals. It allows maintenance workers access to the tunnel complex and provides a safe route for escape during emergencies.

***Completion***

When the two tunnels met 40 m beneath the English Channel seabed on 1 December 1990, in what was to become one of the "crossover halls" that allow diversion of trains from one main tunnel to the other, it became possible to walk on dry land from Britain to mainland Europe for the first time since the end of the last ice age, over 13,000 years ago. The British and French efforts, which had been guided by laser surveying methods, met with less than 20 mm of error. The tunnel was officially opened by Queen Elizabeth II and French President François Mitterrand in a ceremony held in Calais on 6 May 1994.

***Statistics***

The Channel Tunnel is 50 km (31 miles) long, of which 39 km (24 miles) are undersea. The average depth is 45 m (150 ft) underneath the seabed. It opened for business in late 1994, offering two principal services: a shuttle run for vehicles, and the Eurostar passenger service linking London with Paris and Brussels.

In 2004, 7,276,675 passengers travelled through the tunnel on Eurostar while in the same year Eurotunnel carried 2,101,323 cars, 1,281,207 trucks, and 63,467 coaches on its shuttle trains. Rail freight carried through the Channel Tunnel increased by 8% to 1,889,175 t in 2004.

A journey through the tunnel lasts about 20 minutes; from start to end, including a large loop to turn the train round, a shuttle train journey totals about 35 minutes. Eurostar trains travel considerably more slowly than their top speed while going through the tunnel, in part to fit in with the shuttle trains.

At completion, it was estimated that the whole project cost around £10 billion.

***Operation***

The tunnel is operated by Eurotunnel plc. Four types of train services operate:

- *Eurostar*, a high speed passenger service. This connects London's Waterloo station (named for the Napoleonic battle between the UK and France) with the Gare du Nord station in Paris and with Brussels Midi/Zuid station, with stops at Ashford, Calais-Frethun and Lille. All Eurostar services will switch from Waterloo to St Pancras railway station when the new Channel Tunnel Rail Link railway line is completed between the tunnel and London in 2007.
- *Eurotunnel Shuttle*, a rail ferry service. These carry cars, coaches and vans between Sangatte (Calais/Coquelles) and Folkestone. Enclosed rail wagons with minor amenities, some double-deck, permit drive-on and drive-off operation; passengers stay with their vehicle. Formerly marketed as *Le Shuttle*.
- Eurotunnel freight shuttle trains. These carry lorries on open rail wagons, with the lorry drivers travelling in separate passenger coaches.
- Rail freight service. These trains carry conventional rail freight or container loads between a special transfer yard in France to destinations in England.

Eurostar trains travel at high speeds in France, where the tracks are modern and custom-made for the standard TGV cruising speed of 300 km/h (186 mph), and within the tunnel at up to 160 km/h (100 mph), their speed in Kent once they leave the Channel Tunnel Rail Link is limited by the relatively low-speed tracks over which they must run. The project, a partly government-funded scheme to build a dedicated high-speed line from London to the tunnel entrance, is expected to be completed in 2007. The first stage of the link, running from the tunnel to North Kent, was opened in 2003.

There have been proposals for local passenger rail services linking Kent with towns in the Pas de Calais, along the lines of the local trains that run between Zealand and southern Sweden across the Oresund Bridge, but such a service remains unlikely.

**(B) DAMS**

**HOOVER DAM**

Viewing this magnificent, massive man made structure creates a respect for man's accomplishments. The strong desire to harness nature's power drove the human mind and body to build a dam in the hottest, driest area of the United States. People wanting to irrigate low lying plains, known as low desert areas, without suffering from flooding and the battle over water made it obvious to the United States government that the Colorado River was part of the solution. Geologists and Hydrologists who surveyed to determine the best area to dam the mighty Colorado River waters initially determined that Boulder Canyon was going to be the site for the dam. The government pursued bids for the building project. This project was so demanding that one construction company would not be capable enough to solely build the dam. Therefore, six of the largest United States construction companies worked together to acquire the bid. This sealed the deal and construction started in 1931 with the arrival of dam builders from all over the country.

Hoover Dam: One of the "Seven Engineering Wonders of the United States"
(Arizona-Nevada Border, USA)

At the onset of construction the dam location had been changed from Boulder Canyon to Black Canyon. Men in the need of work came to this desolate, wild, and hot area to earn a living during the United State's great depression. Arriving with families, a tent community was born. The life was rugged with no electricity, an average temperature of 119 degrees Fahrenheit (48 degrees Celsius) during the day, poor sanitary conditions and poor water set the stage for communities know as "Ragtowns." In order to improve their quality of life and to save people from disease, electricity came to the area and Boulder City was established. A school, church, post office and other supporting facilities where created for the families.

Before the concrete arch-gravity type dam construction could begin, the Colorado River needed to be diverted through diversion tunnels. This would allow the water to by pass the dam foundation site and later on to be used for the electric plant generators. Building tunnels directly through the canyon rock walls required dynamite, rock removal and structure for support to be built. The use of machinery within these tunnels created just as great a hazard, carbon monoxide poisoning, as drilling and blasting the rock. Once the first two tunnels where in place, cofferdams were built to divert the Colorado River. This allowed the dam construction to begin. As in any construction project, the dam's base was a major factor in building an enduring structure. This required the men to excavate the mud and muck at the river bottom. With the aid of power shovels the men removed over half a million cubic yards to reach bedrock 40 feet below. Simultaneously the "high scalers" worked the canyon walls. Earning $5.60 a day, this was one of the highest paying jobs at the site. These men would blast the walls to create a smooth joining surface for the dam. After much preparation on June 6, 1933 concrete began to be poured at the dam's base. The men poured 230 individual gigantic blocks of concrete to complete the base. This pouring process was necessary to allow the concrete to properly dry. On May 29, 1935 the last block was constructed, making the total concrete used for construction to be 3.25 million cubic yards. (This is enough concrete to pave a 16 feet wide highway from San Francisco to New York City!) With the completion of the dam's main construction the diversion tunnels were closed to start filling Lake Mead. With the dam's building process complete, in 1935 Hoover Dam became the largest dam in the world.

On September 17, 1930, Secretary of the Interior, Ray L. Wilbur, named the dam "Hoover Dam" at the spike driving ceremony. This announcement came as a surprise to reporters. On May 8, 1933 Harold Ickes, Secretary of the Interior changed the name back to "Boulder Dam." After 14 years congress felt compelled to pass a joint resolution to change the name back to "Hoover Dam" in honor of the United States 31st president, Herbert Hoover. Some of the Hoover Dam statistics are:

726.4 feet **high** (221m), 1,244 feet **wide** (379 m), 660 feet (203 m) **thick** at the base, 45 feet (13 m) **thick** at the top, $165 million dollars to build, 4.5 **years** to build, 4.4 million yards of concrete used for construction, March 1931 building **began**, September 30, 1935 President Franklin D. Roosevelt dedicated the **completed** dam.
**Powerhouse:** 17 generators, 4+ billion kilowatt hours produced each year.
**Power used by:** 56% California, 25% Nevada, 19% Arizona.
**Lake Mead:** 6.5 years to fill (A slow filling process was required to lessen the pressure change on the dam and to help prevent small earthquakes due to land settlement.) 589 feet (181 m) at the deepest point. 247 square miles in size 110 miles (176 km) long. Named after Dr. Elwood Mead, Commissioner of the Bureau of Reclamation (1924 - 1936) largest manmade reservoir in the United States.

## KARAKAYA DAM

| | |
|---|---|
| Location | Diyarbakır |
| River | Fırat |
| Purpose | Energy |
| Construction year | 1976 -1987 |
| Type | Concrete arch |
| Dam volume | 2 000 000 $m^3$ |
| Height (from river bed) | 158.00 m |
| Reservoir volume at normal water surface elevation | 9 580.00 $hm^3$ |
| Reservoir area at normal water surface elevation | 268.00 $km^2$ |
| Capacity | 1 800 MW |
| Annual generation | 7 354 GWh |

## ATATÜRK DAM

| | |
|---|---|
| Location | Şanlıurfa |
| River | Fırat |
| Purpose | Irrigation+Energy |
| Construction year | 1983 -1992 |
| Embankment type | Rockfill |
| Dam volume | 84500 $hm^3$ |
| Height (from river bed) | 169 m |
| Reservoir volume at normal water surface elevation | 48700 $hm^3$ |
| Reservoir area at normal water surface elevation | 817 $km^2$ |
| Irrigation Area | 872385 ha |
| Capacity | 2400 MW |
| Annual Generation | 8900 GWh |


## KEBAN DAM

| | |
|---|---|
| Location | Elazığ |
| River | Fırat |
| Purpose | Energy |
| Construction year | 1965 - 1975 |
| Embankment type | Rockfill |
| Dam volume | 16679 $hm^3$ |
| Height (from river bed) | 210 m |
| Reservoir volume at normal water surface elevation | 31000 $hm^3$ |
| Reservoir area at normal water surface elevation | 675 $km^2$ |
| Irrigation Area | ha |
| Capacity | 1330 MW |
| Annual Generation | 6000 GWh |


**(C) BRIDGES**

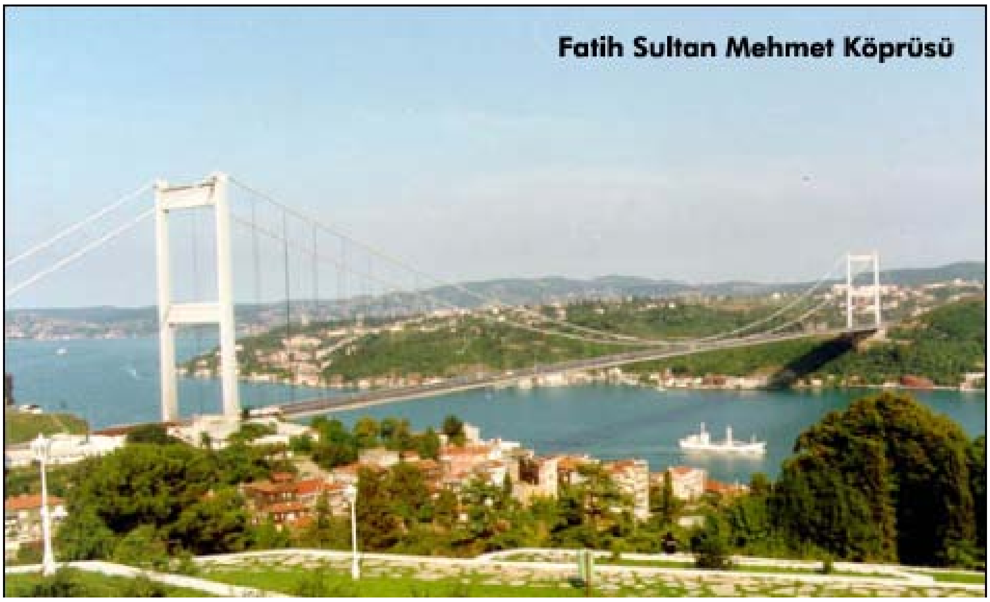
## GOLDEN GATE BRIDGE

The Golden Gate Bridge at San Francisco, completed after more than four years of construction at a cost of $35 million, is a visitor attraction recognized around the world. The bridge opened to vehicular traffic on May 28, 1937 at twelve o'clock noon, ahead of schedule and under budget. The Golden Gate Bridge's 4,200 feet (1280 m) long main suspension span was a world record that stood for 27 years. The bridge's two towers rise 746 feet (227 m) making them 191 feet (58 m) taller than the Washington Monument. The Golden Gate Bridge crosses Golden Gate Strait which is about 400 feet or 122 m deep.

**Joseph Baerman Strauss** had a dream of building a bridge across the Golden Gate. Though Strauss only lived a year beyond completion of the Golden Gate Bridge he disproved the conventional wisdom of the time that "no one can bridge the Golden Gate because of insurmountable difficulties which are apparent to all who give thought to the idea."

The design of the Golden Gate Bridge echoes an Art Deco Theme. Wide, vertical ribbing on the horizontal tower bracing accents the sun's light on the bridge. The towers that support the Golden Gate Bridge's suspension cables are smaller at the top than at the base, emphasizing the tower height of 500 feet (152 m) above the roadway. Linking San Francisco with Marin County the 1.7 mile (2.8 km) long suspension bridge can be crossed by car, on bicycles or on foot.

## ISTANBUL BRIDGES


| **Bosporus Bridge** | **Property** | **Fatih Sultan Mehmet Bridge** |
|---|---|---|
| 1560 m | Bridge Total Length | 1510 m |
| 1074 m | Main Suspension Span | 1090 m |
| 165 m | Tower Height | 111 m |
| Box (5.2x7 m, 3x7 m) | Tower Geometry | Box (5x4 m, 3x4 m) |
| 33.4 m | Bridge Width | 39.4 |
| 2x3 | Number of Lanes | 2x4 |
| 64 m | Clearance from Sea Level | 64 m |

**CHESAPEAKE BAY BRİDGE-TUNNEL**

## The Chesapeake Bay Bridge-Tunnel is considered to be "One of Seven Engineering Wonders of the Modern World."

The Chesapeake Bay Bridge-Tunnel opened as a two-lane highway in 1964. Thirty-five years later, the southbound side opened, making it a four-lane highway. The 20-mile road cuts 95 miles from the trip between Virginia Beach, Virginia and Wilmington, Delaware. It is made of two high bridges, two, one-mile tunnels, four man-made islands, and 12 miles of trestle. Each island is 10 acres in size and has almost 1.2 million tons of rock armour. The 12 miles of trestle are supported by more than 5000 concrete piles.

**(D) TOWERS AND TALL BUILDINGS**

**EIFFEL TOWER**

The Eiffel Tower was built for the International Exhibition of Paris of 1889 commemorating the centenary of the French Revolution. The Prince of Wales, later King Edward VII of England, opened the tower. Of the 700 proposals submitted in a design competition, **Gustave Eiffel's** was unanimously chosen.

However it was not accepted by all at first, and a petition of 300 names - including those of Maupassant, Emile Zola, Charles Garnier (architect of the Opéra Garnier), and Dumas the Younger - protested its construction.

At 300 metres (320.75 m including antenna), and 7000 tons, it was the world's tallest building until 1930. Other statistics include:

- 2.5 million rivets.
- 300 steel workers, and 2 years (1887-1889) to construct it.
- Sway of at most 12 cm in high winds.
- Height varies up to 15 cm depending on temperature.
- 15,000 iron pieces (excluding rivets).
- 40 tons of paint.
- 1652 steps to the top.

It was almost torn down in 1909, but was saved because of its antenna - used for telegraphy at that time. Beginning in 1910 it became part of the International Time Service. French radio (since 1918), and French television (since 1957) have also made use of its stature.

During its lifetime, the Eiffel Tower has also witnessed a few strange scenes, including being scaled by a mountaineer in 1954, and parachuted off of in 1984 by two Englishmen. In 1923 a journalist rode a bicycle down from the first level. However, if its birth was difficult, it is now completely accepted and must be listed as one of the symbols of Paris itself.

## WORLD'S TALLEST BUİLDİNGS

| Rank | Building, City | Year | Stories | Height (m) |
|---|---|---|---|---|
| 1. | Taipei 101, Taipei, Taiwan | 2004 | 101 | 509 |
| 2. | Petronas Tower 1, Kuala Lumpur, Malaysia | 1998 | 88 | 452 |
| 3. | Petronas Tower 2, Kuala Lumpur, Malaysia | 1998 | 88 | 452 |
| 4. | Sears Tower, Chicago | 1974 | 110 | 442 |
| 5. | Jin Mao Building, Shanghai | 1999 | 88 | 421 |
| 6. | Two Int. Finance Centre, Hong Kong | 2003 | 88 | 415 |
| 7. | CITIC Plaza, Guangzhou, China | 1996 | 80 | 391 |
| 8. | Shun Hing Square, Shenzhen, China | 1996 | 69 | 384 |
| 9. | Empire State Building, New York | 1931 | 102 | 381 |
| 10. | Central Plaza, Hong Kong | 1992 | 78 | 374 |
| 11. | Bank of China, Hong Kong | 1989 | 72 | 369 |
| 12. | Emirates Tower One, Dubai | 1999 | 54 | 355 |
| 13. | Turntex Sky Tower, Kaohsiung, Taiwan | 1997 | 85 | 348 |
| 14. | Aon Centre, Chicago | 1973 | 80 | 346 |
| 15. | The Center, Hong Kong | 1998 | 73 | 346 |
| 16. | John Hancock Center, Chicago | 1969 | 100 | 344 |
| 17. | Ryugyong Hotel, Pyongyang, N. Korea | 1995 | 105 | 330 |
| 18. | Burj al Arab Hotel, Dubai | 1999 | 60 | 321 |
| 19. | Chrysler Building, New York | 1930 | 77 | 319 |
| 20. | Bank of America Plaza, Atlanta | 1993 | 55 | 312 |
| 21. | U.S. Bank Tower, Los Angeles | 1990 | 73 | 310 |
| 22. | Menara Telekom Headquarters, Kuala Lumpur | 1999 | 55 | 310 |
| 23. | Emirates Tower Two, Dubai | 2000 | 56 | 309 |
| 24. | AT&T Corporate Center, Chicago | 1989 | 60 | 307 |
| 25. | JP Morgan Chase Tower, Houston | 1982 | 75 | 305 |
| 26. | Baiyoke Tower II, Bangkok | 1997 | 85 | 304 |
| 27. | Two Prudential Plaza, Chicago | 1990 | 64 | 303 |
| 28. | Kingdom Centre, Riyadh | 2002 | 41 | 302 |
| 29. | First Canadian Place, Toronto | 1975 | 72 | 298 |
| 30. | Wells Fargo Plaza, Houston | 1983 | 71 | 296 |
| 31. | Landmark Tower, Yokohama, Japan | 1993 | 70 | 296 |
| 32. | 311 South Wacker Drive, Chicago | 1990 | 65 | 293 |
| 33. | SEG Plaza, Shenzhen | 2000 | 71 | 292 |

| | | | | |
|---|---|---|---|---|
| 34. | American International Building, New York | 1932 | 67 | 290 |
| 35. | Cheung Kong Center, Hong Kong | 1999 | 63 | 290 |
| 36. | Key Tower, Cleveland | 1991 | 57 | 289 |
| 37. | Plaza 66, Shanghai | 2001 | 66 | 288 |
| 38. | One Liberty Place, Philadelphia | 1987 | 61 | 288 |
| 39. | Sunjoy Tomorrow Square, Shanghai | 2003 | 55 | 285 |
| 40. | Bank of America Center, Seattle | 1984 | 76 | 284 |
| 41. | Chongqing World Trade Center, Chongqing | 2005 | 60 | 283 |
| 42. | The Trump Building, New York | 1930 | 71 | 283 |
| 43. | Bank of America Plaza, Dallas | 1985 | 72 | 281 |
| 44. | United Overseas Bank Plaza, Singapore | 1992 | 66 | 280 |
| 45. | Republic Plaza, Singapore | 1995 | 66 | 280 |
| 46. | Overseas Union Bank Centre, Singapore | 1986 | 63 | 280 |
| 47. | Citigroup Center, New York | 1977 | 59 | 279 |
| 48. | Hong Kong New World Building, Shanghai | 2002 | 61 | 278 |
| 49. | Scotia Plaza, Toronto | 1989 | 68 | 275 |
| 50. | Williams Tower, Houston | 1983 | 64 | 275 |
| 51. | Wuhan World Trade Tower, Wuhan | 1998 | 60 | 273 |
| 52. | Renaissance Tower, Dallas | 1975 | 56 | 270 |
| 53. | Dapeng International Plaza, Guangzhou | 2004 | 56 | 269 |
| 54. | 21st Century Tower, Dubai | 2003 | 55 | 269 |
| 55. | Al Faisaliah Center, Riyadh | 2000 | 30 | 267 |
| 56. | 900 North Michigan Ave., Chicago | 1989 | 66 | 265 |
| 57. | Bank of America Corporate Center, Charlotte | 1992 | 60 | 265 |
| 58. | SunTrust Plaza, Atlanta | 1992 | 60 | 265 |
| 59. | Triumph Palace, Moscow | 2004 | 61 | 264 |
| 60. | Shenzhen Special Zone Daily Tower, Shenzhen | 1998 | 42 | 264 |
| 61. | Tower Palace Three, Tower G, Seoul | 2004 | 73 | 264 |
| 62. | Trump World Tower, New York | 2001 | 72 | 262 |
| 63. | Water Tower Place, Chicago | 1976 | 74 | 262 |
| 64. | Aon Center, Los Angeles | 1974 | 62 | 262 |
| 65. | BCE Place–Canada Trust Tower, Toronto | 1990 | 53 | 261 |
| 66. | Post & Telecommunication Hub, Guangzhou | 2002 | 66 | 260 |
| 67. | Transamerica Pyramid, San Francisco | 1972 | 48 | 260 |
| 68. | G.E. Building, New York | 1933 | 70 | 259 |
| 69. | Bank One Plaza, Chicago | 1969 | 60 | 259 |
| 70. | Commerzbank Zentrale, Frankfurt | 1997 | 56 | 259 |

| | | | | |
|---|---|---|---|---|
| 71. | Two Liberty Place, Philadelphia | 1990 | 58 | 258 |
| 72. | Philippine Bank of Communications, Makati | 2000 | 55 | 258 |
| 73. | Park Tower, Chicago | 2000 | 67 | 257 |
| 74. | Messeturm, Frankfurt | 1990 | 64 | 257 |
| 75. | Sorrento 1, Hong Kong | 2003 | 75 | 256 |
| 76. | U.S. Steel Tower, Pittsburgh | 1970 | 64 | 256 |
| 77. | Mokdong Hyperion Tower A, Seoul | 2003 | 69 | 256 |
| 78. | Rinku Gate Tower, Izumisano | 1996 | 56 | 256 |
| 79. | The Harbourside, Hong Kong | 2003 | 74 | 255 |
| 80. | Langham Place Office Tower, Hong Kong | 2004 | 59 | 255 |
| 81. | Capital Tower, Singapore | 2000 | 52 | 254 |
| 82. | Highcliff, Hong Kong | 2003 | 73 | 253 |
| 83. | Osaka World Trade Center, Osaka | 1995 | 55 | 252 |
| 84. | Jiali Plaza, Wuhan | 1997 | 61 | 251 |
| 85. | Rialto Tower, Melbourne | 1985 | 63 | 251 |
| 86. | One Atlantic Center, Atlanta | 1987 | 50 | 250 |
| 87. | Wisma 46, Jakarta | 1995 | 46 | 250 |
| 88. | Korea Life Insurance Company, Seoul | 1985 | 60 | 249 |
| 89. | CitySpire, New York | 1989 | 75 | 248 |
| 90. | One Chase Manhattan Plaza, New York | 1961 | 60 | 248 |
| 91. | State Tower, Bangkok | 2001 | 68 | 247 |
| 92. | Bank One Tower, Indianapolis | 1989 | 48 | 247 |
| 93. | Conde Nast Building, New York | 1999 | 48 | 247 |
| 94. | MetLife, New York | 1963 | 59 | 246 |
| 95. | Bloomberg Tower, New York | 2004 | 55 | 246 |
| 96. | JR Central Towers, Nagoya | 2000 | 51 | 245 |
| 97. | City Gate Tower, Ramat-Gan | 2001 | 67 | 244 |
| 98. | Shin Kong Life Tower, Taipei, Taiwan | 1993 | 51 | 244 |
| 99. | Chifley Tower, Sydney | 1992 | 50 | 244 |
| 100. | Menara Maybank, Kuala Lumpur | 1988 | 50 | 244 |


1. Taipei101

2 & 3. Petronas

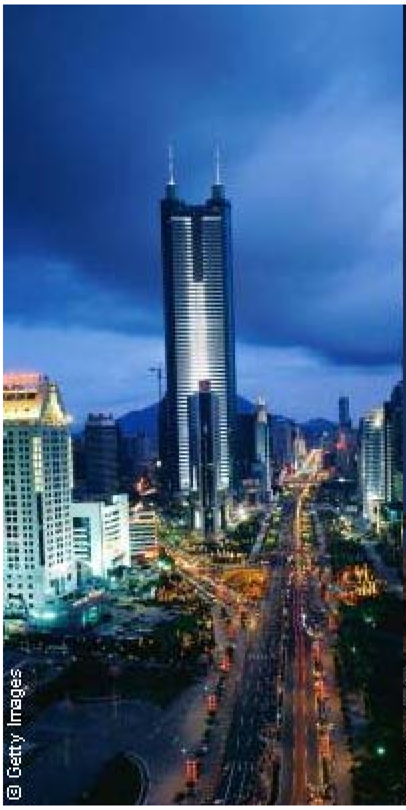
4. Sears



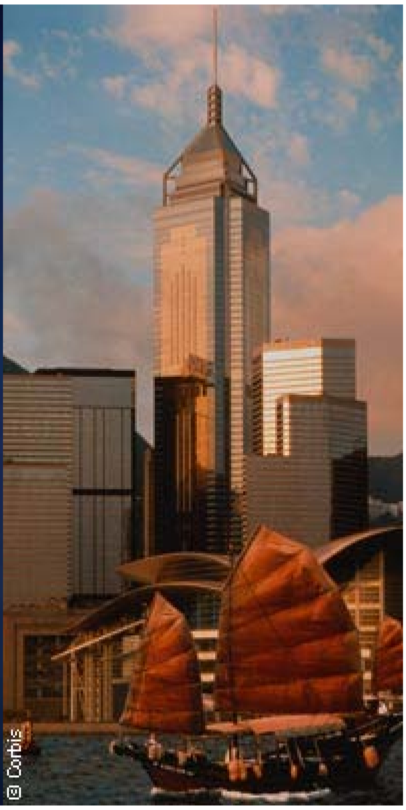

5. Jin Mao

6. Two Int. Finance Centre

7. Citic Plaza








8. Shun Hing Square 9. Empire State 10. Central Plaza

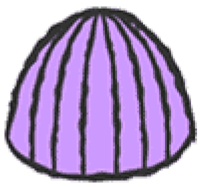
## (E) DOMES

They have been called "the kings of all roofs," and they cover some of our most important buildings. Domes are curved structures -- they have no angles and no corners -- and they enclose an enormous amount of space without the help of a single column. Despite their thinness, domes are some of the **strongest** and **stiffest** structures in existence today.

**Before domes, there were rectangular buildings (**Columns and roof)**.**

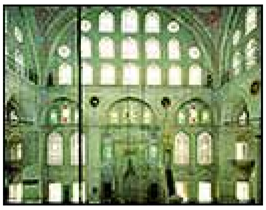
Almost all ancient buildings had roofs supported by forests of **columns**. The columns prevented the heavy roofs from collapsing, but they left very little open interior space.

**Soon, ancient engineers began experimenting with arches.**
Around 100 A.D., Roman builders rotated an arch in a circle and discovered that it created a strong three-dimensional shape -- the monolithic dome. In time, they were capping churches and mosques with this new and brilliant design.

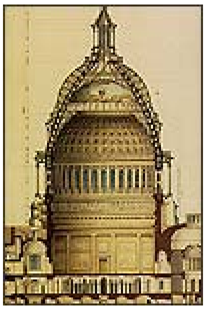


**The earliest domes were made of stone.**
The earliest **masonry** dome, the Pantheon, was so heavy that engineers carved intricate shapes, called coffers, along the walls to reduce the weight of the enormous structure. They also gouged a hole, called an oculus, at the top, which created a daily light show for which the Pantheon is still famous.

**As domes grew taller and taller, they became heavier and heavier.** By 532 A.D., ancient engineers realized that they could lighten their domes by scooping out the spaces between the arches. This design allowed sunlight to pour into the dome without weakening the structure. The Mihrimah Mosque, built in 1555 by the great architect, Sinan, is pierced with 161 windows!



**Sometimes, they become too heavy.**
When the dome on St. Peter's Basilica began cracking in the early 18th century, Vatican engineers tied several **iron** rings, called **tension rings**, around the structure to prevent it from collapsing. Fortunately, their emergency fix stood the test of time.



**In the quest for height, engineers came up with a few tricks.**
By the early 1400s, Roman engineers began building two domes in one to create the illusion of even greater height. The U.S. Capitol dome, built in 1793, gets its height from this engineering sleight of hand. The large outer dome is a thin shell, held up by a ring of curved **iron** ribs. Underneath it all is a smaller, self-supporting dome, visible only from the inside.

The U.S. Capitol dome is also one of the earliest domes made of pre-fabricated **cast-iron** ribs. The switch from heavy **masonry** to lightweight metal ribs in the late 18th century greatly reduced the weight of domes being built around the world.

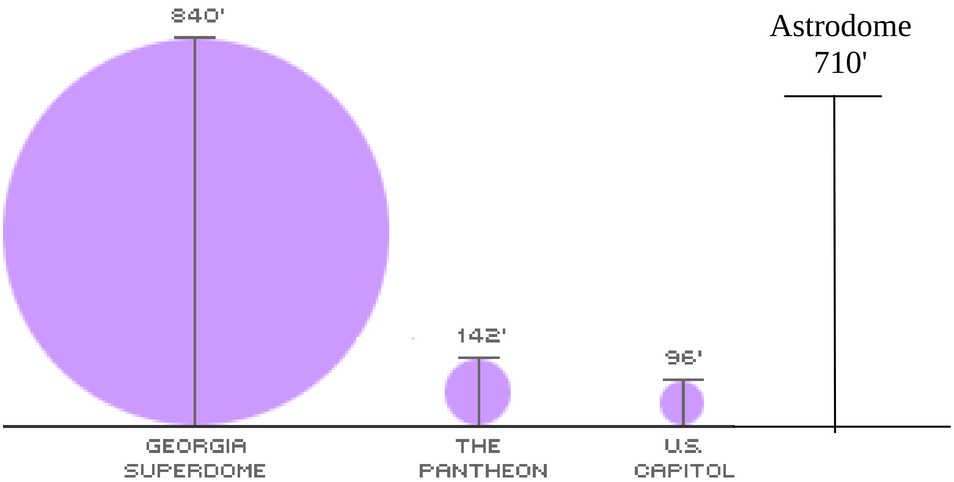
**But a 20th-century invention would change dome engineering forever.**
In the 1950s, a radical new design -- the geodesic dome -- changed the way engineers looked at domes for the first time in 2,000 years. Invented by American engineer and architect Buckminster Fuller, the geodesic dome is a partial sphere shape structured from a series of triangles, rather than a series of arches.

**ASTRODOME**

**Vital Statistics:**
**Location:** Houston, Texas, USA
**Completion Date:** 1966
**Cost:** $35 million
**Diameter:** 710 feet
**Type:** Ribbed
**Purpose:** Recreational
**Materials:** Concrete, steel
**Engineer(s):** Walter P. Moore; Lockwood, Andrews and Newman; John G. Turney; Robert J. Cummins Office

The summers in Houston, Texas, are grotesquely hot and sticky -- too hot to play or watch baseball. But in 1965, Judge Roy Hofheinz, the owner of the Houston Astros, found a way to do the impossible: play baseball in air-conditioned comfort. It was Hofheinz's idea to build a gigantic dome, large enough to cover a baseball field and grandstands for 50,000 people without a single column obstructing the players' or the spectators' view. The Houston Astrodome was the first ballpark in the world to have a roof over its playing field. Upon its completion, Judge Hofheinz dubbed his creation "the Eighth Wonder of the World." But there were problems with indoor baseball that no one had ever anticipated.

The 4,007 skylights in the Astrodome acted like a lens, smearing the sun into a blinding wall of light. It was almost impossible to catch a fly ball! Work crews painted the skylights to block the sun, but then the grass died from lack of sunlight. This led to the installation of plastic grass, which later came to be known as Astroturf. From then on, generations of ballplayers complained about the Astroturf ruining their knees.




Less than two decades after the Astrodome was built, a revolutionary new design led to the introduction of the retractable domed roof. Domes with retractable roofs gave players and spectators the best of both worlds: the ability to play in air-conditioned comfort when necessary and under the open sky when possible. By the 1990s, the Houston Astros and their spectators were longing for their own retractable roof.

The Astrodome lasted just 35 years as a working ballpark. On March 30, 2000, the Astros began playing in Enron Field, their new retractable-roof stadium.

Here's how this dome stacks up against some of the biggest domes in the world.
(diameter, in feet)

**GEORGİA DOME**

**Vital Statistics:**
**Location:** Atlanta, Georgia, USA
**Completion Date:** 1992
**Cost:** $214 million
**Diameter:** 840 feet
**Type:** Cable-supported roof (tensegrity)
**Purpose:** Recreational
**Materials:** Steel, Teflon-coated Fiberglas
**Engineer(s):** Matthys Levy; Weidlinger Associates

On March 1, 1992, as workers placed the last fabric roof panel in place, the Georgia Dome became the largest **cable**-supported fabric roof in the world. Stretching more than 395,000 square feet, the Teflon-coated Fiberglas fabric roof is quite an engineering marvel. The roof weighs just 68 pounds, but it is strong enough to support a fully loaded pickup truck. How? The answer lies with a fundamental engineering breakthrough, one that architect-engineer Buckminster Fuller dubbed "tensegrity."

Put simply, tensegrity is a complex sequence of triangles. Short, vertical posts carry the weight of the Georgia Dome roof. The posts are held in place by pre-stretched cables, attached to the top and bottom of each post with **steel** pins and welded connections. The cables pull on the posts with equal force in all directions to form **strong**, taut triangles. The cable roof is secured to a **reinforced concrete** ring along the **perimeter** of the dome. The 2,750-foot **concrete** ring rests on slide-bearing Teflon pads that allow the roof to flex slightly during high winds.

It is this precise dance of pulling and pushing that allows tensegrity roofs like the Georgia Dome to soar far above the stands and the playing field below.

**Fast Facts:**

- The Georgia Dome contains 110,000 cubic yards of concrete, enough to build a sidewalk from Atlanta to Cincinnati.
- The dome is as tall as a 29-**story** building, as tall as an average redwood tree, and three feet taller than the United States Capitol building.
- At a rate of 750,000 gallons of water per second, Niagara Falls would take 12 minutes to fill the Georgia Dome.
- The Georgia Dome contains 8,300 tons of reinforced steel -- more than the weight of **iron** and steel used in the Eiffel Tower.

**MINUTE MAID PARK**

**Formerly Enron Field/Astros Field**

**Houston, Texas**

**Tenant:** Houston Astros (NL)
**Opened:** March 30, 2000 (exhibition against the New York Yankees)
**First regular season game:** April 7, 2000 (against the Philadelphia Phillies)
**First regular season indoor game:** May 27, 2000 (against the Atlanta Braves)
**Construction began:** November 1, 1997
**Style:** Retractable roof
**Capacity:** 42,000 (March 2000); 40,950 (April 2000)
**Surface:** Burmuda (2000); Seashore Paspalum (August 2001)

**Architect:** HOK Sport (Kansas City)
**Construction:** Brown & Root (Houston), Barton Malow (Southfield, MI) and Empire Construction
**Owner:** Harris County-Houston Sports Authority
**Cost:** $250 million
**Public financing:** $180 million, or 68 percent, from a 2 percent hotel tax and a 5 percent rental-car tax
**Private financing:** $52 million, or 20 percent, from Astros owners; $33 million, or 12 percent, from no-interest loan
**Lease:** 30 years (2000-2029); $7.1 million annually ($4.6 million rent; $2.5 million to capital improvements fund)

**Location:** On the east side of downtown Houston at the corner of Crawford and Texas Streets, adjacent to Union Station and near the George R. Brown Convention Center. Left field (NW), Crawford Street; third base (SW), Texas Avenue; first base (SE), Hamilton Street; right field (NW), Congress Avenue.

**Dimensions:** Left field: 315 ft.; left-center: 362 feet; center field: 435 feet; right-center: 373 feet; right field: 326 feet; backstop: 49 feet.

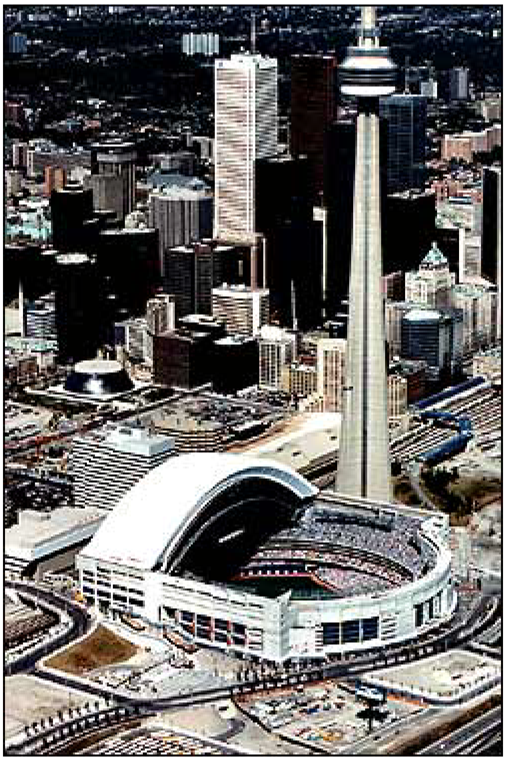
**Fences:** Left field: 21 feet; center field: 9 feet; right field: 7 feet.

**Materials:** Concrete and steel structure clad in brick and limestone.

## TORONTO SKYDOME

**Vital Statistics:**
**Location:** Toronto, Ontario, Canada
**Completion Date:** 1989
**Cost:** $500 million
**Diameter:** 674 feet
**Type:** Retractable
**Purpose:** Recreational
**Materials:** Steel, plastic
**Engineer(s):** Ellis-Don Limited

On fair weather days, the Toronto SkyDome can do something no other domed stadium in the world can: open its roof completely. Constructed in 1989, the SkyDome is the first and only stadium to have a fully retractable roof. Unlike any other sports stadium, the roof of the SkyDome separates into pieces and disappears from sight in less than 20 minutes, completely uncovering the playing field and more than 91 percent of the seats. How does it work?



The roof is made of four massive **steel** panels; one panel is fixed, and the other three slide on a system of steel tracks. Each panel is made from a pattern of steel **trusses** with a corrugated steel shell and a weatherproof **plastic** membrane. Opening the roof requires that two panels slide over each other and under a fixed panel behind center field. A third panel, which starts behind home plate, rotates on a circular rail. Despite its enormous weight -- the whole roof weighs more than 11,000 tons -- the roof panels slide at a whopping rate of 71 feet per minute!

Today, the SkyDome is home to the American League's Toronto Blue Jays and the Canadian Football League's Toronto Argonauts. The retractable roof was closed twice in the Blue Jays' first year in the dome and has closed four or five times a year since then.

**Fast Facts:**

- The SkyDome JumboTron is a 115-foot-by-33-foot video display board that has 420,000 light bulbs, making it the largest scoreboard in the world.
- A 348-room hotel is located in center field. Seventy of those rooms have views of the field.
- When the roof is open, the closed end of the stadium causes a downdraft in the outfield that tends to prevent home runs.

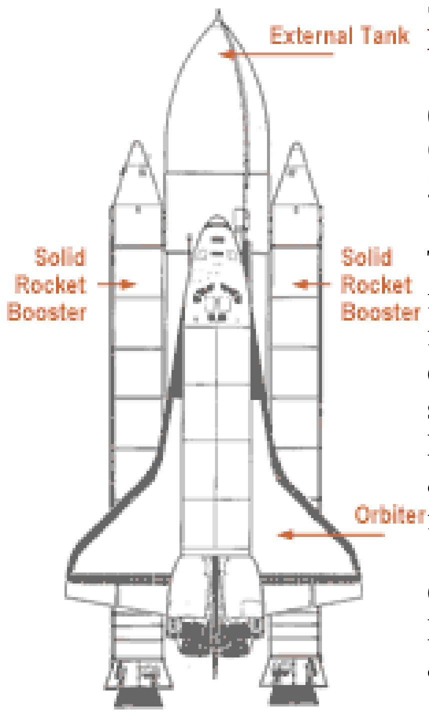
**516 elephants could fit on the SkyDome field**

## (F) AIR AND SPACE VEHICLES

### SPACE SHUTTLE



**Length** Space Shuttle: 56.14 meters (184.2 feet), Orbiter: 37.23 meters (122.17 feet)
**Height** Orbiter on runway: 17.27 meters (56.67 feet)
**Wingspan** 23.79 meters (78.06 feet)
**Weight** At lift off: 2,041,166 kilograms (4.5 million pounds), End of mission: 104,326 kilograms (230,000 pounds)
**Maximum cargo to orbit** 28,803 kilograms, (63,500 pounds)



Space Shuttle (launch configuration)

**SRB Separation** Two minutes after launch
**External Tank Separation** 8.5 minutes after launch, Altitude: 109.26 kilometers (59 nautical miles), Velocity: 28,067 kph (17,440 mph)
**Orbit** 185 to 643 kilometers, (115 to 400 statute miles), Velocity: 27,875 kph (17,321 mph)

The space shuttle is the world's first reusable spacecraft, and the first spacecraft in history that can carry large satellites both to and from orbit. The shuttle launches like a rocket, maneuvers in Earth orbit like a spacecraft and lands like an airplane. Each of the three space shuttle orbiters now in operation -- Discovery, Atlantis and Endeavour -- is designed to fly at least 100 missions. So far, altogether they have flown a combined total of less than one-fourth of that.

Columbia was the first space shuttle orbiter to be delivered to NASA's Kennedy Space Center, Fla., in March 1979. Columbia and the STS-107 crew were lost Feb. 1, 2003, during re-entry.

The orbiter Challenger was delivered to KSC in July 1982 and was destroyed in an explosion during ascent in January 1986. Discovery was delivered in November 1983. Atlantis was delivered in April 1985. Endeavour was built as a replacement following the Challenger accident and was delivered to Florida in May 1991. An early space shuttle orbiter, the Enterprise, never flew in space but was used for approach and landing tests at the Dryden Flight Research Center and several launch pad studies in the late 1970s.

The space shuttle consists of three major components: the orbiter which houses the crew; a large external fuel tank that holds fuel for the main engines; and two solid rocket boosters which provide most of the shuttle's lift during the first two minutes of flight. All of the components are reused except for the external fuel tank, which burns up in the atmosphere after each launch.

The longest the shuttle has stayed in orbit on any single mission is 17.5 days on mission STS-80 in November 1996. Normally, missions may be planned for anywhere from five to 16 days in duration. The smallest crew ever to fly on the shuttle numbered two people on the first few missions. The largest crew numbered eight people. Normally, crews may range in size from five to seven people. The shuttle is designed to reach orbits ranging from about 185 kilometers to 643 kilometers (115 statute miles to 400 statute miles) high.

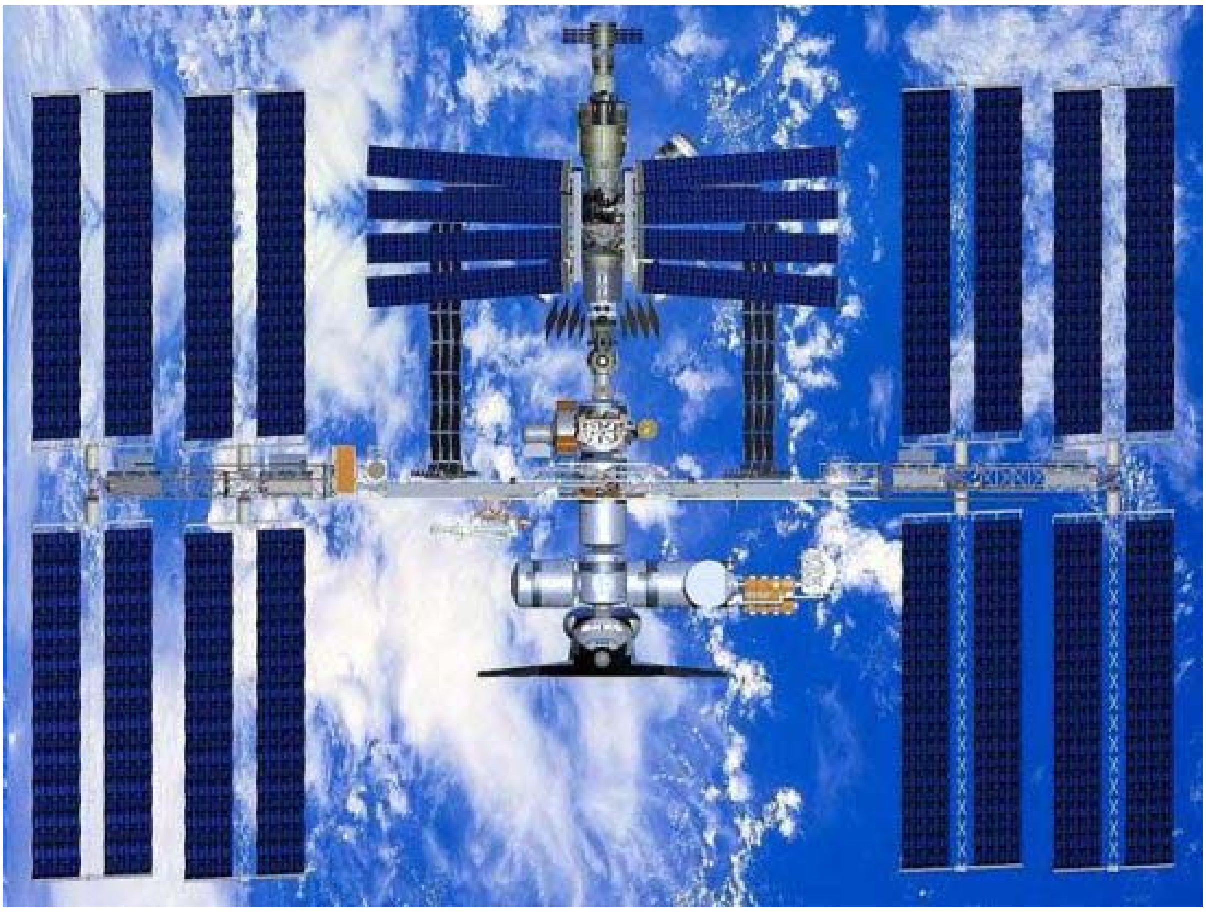
The shuttle has the most reliable launch record of any rocket now in operation. Since 1981, it has boosted more than 1.36 million kilograms (3 million pounds) of cargo into orbit. More than than 600 crew members have flown on its missions. Although it has been in operation for almost 20 years, the shuttle has continually evolved and is significantly different today than when it first was launched. NASA has made literally thousands of major and minor modifications to the original design that have made it safer, more reliable and more capable today than ever before.

Since 1992 alone, NASA has made engine and system improvements that are estimated to have tripled the safety of flying the space shuttle, and the number of problems experienced while a space shuttle is in flight has decreased by 70 percent. During the same period, the cost of operating the shuttle has decreased by one and a quarter billion dollars annually — a reduction of more than 40 percent. At the same time, because of weight reductions and other improvements, the cargo the shuttle can carry has increased by 7.3 metric tons (8 tons.)

NASA is prepared to continue flying the shuttle for at least the next decade and plans to continue to improve the shuttle during the next five years, with goals of increasing its safety by improving the highest-risk components. NASA will also be working with the Columbia Accident Investigation Board to correct any problems the board may find as it works to determine the cause of the Columbia accident.

## INTERNATIONAL SPACE STATION

The first proposal for a manned station occurred in 1869, when an American novelist told the story of how a "Brick Moon" came to orbit Earth to help ships navigate at sea. In 1923, Romanian Hermann Oberth was the first to use the term "space station" to describe a wheel-like facility that would serve as the jumping off place for human journeys to the moon and Mars. In 1952, Dr. Werner von Braun published his concept of a space station in Collier's magazine. He envisioned a space station that would have a diameter of 250 feet, orbit more than 1,000 miles above the Earth, and spin to provide artificial gravity through centrifugal force.



The Soviet Union launched the world's first space station, Salyut 1, in 1971 - a decade after launching the first human into space. The United States sent its first space station, the larger Skylab, into orbit in 1973 and it hosted three crews before it was abandoned in 1974. Russia continued to focus on long-duration space missions and in 1986 launched the first modules of the Mir space station.

In 1998, the first two modules of the International Space Station were launched and joined together in orbit. Other modules soon followed and the first crew arrived in 2000.

The International Space Station, or ISS, represents a global partnership of 16 nations. This project is an engineering, scientific and technological marvel ushering in a new era of human space exploration. The million-pound (450 tons) space station will include six laboratories and provide more space for research than any spacecraft ever built. Internal volume of the space station will be roughly equal to the passenger cabin volume of a 747 jumbo jet.

More than 40 space flights over five years and at least three space vehicles — the space shuttle, the Russian Soyuz rocket and the Russian Proton rocket — will deliver the various space station components to Earth orbit. Assembly of the more than 100 components will require a combination of human spacewalks and robot technologies.

ISS expansion continued with the arrival of the Russian Docking Compartment on September 16, 2001. The docking Compartment is called Pirs, which is the Russian word for pier. The next flight to visit the space station was STS-108. It arrived at the station in early December 2001 and delivered the Expedition Four crew. Expedition Three returned to Earth on STS-108. The first shuttle mission to visit the station in 2002 was STS-110. The seven-member STS-110 crew installed the S0 (S-Zero) Truss onto the station. The S0 was the second piece of the 11-piece Integrated Truss Structure delivered to the station. The second shuttle mission of 2002 to visit the station was STS-111 in mid-June. STS-111 delivered the Expedition Five crew and the Mobile Base System to the orbital outpost. Also, STS-111 returned the Expedition Four crew to Earth. Flight Engineers Carl

Walz and Dan Bursch set the record for the longest U.S. space flight with 196 days in space during Expedition Four.

The last shuttle mission to visit the ISS during 2002 was STS-113, which delivered the Expedition Six crew and the P1 (P-One) Truss. The STS-113 crew performed three spacewalks to activate and outfit the P1 after it was attached to the port side of the S0 Truss. Expedition Five returned to Earth on Endeavour, wrapping up a six-month stay in space.

The United States and Russia have partnered together since 1994 performing nine Shuttle-Mir dockings. That experience provided valuable insight and team work necessary for building and maintaining the International Space Station. When the space station is completed an international crew of up to seven will live and work in space between three and six months. Crew return vehicles will always be attached to the space station to ensure the safe return of all crewmembers in the event of an emergency

What in the world are we doing in space? Why spend the time and resources to build a laboratory in space when we have plenty of them on Earth? The answer is a unique tool called microgravity. Microgravity (also called zero-g) opens a new universe of research possibilities. It unmasks phenomena that gravity on Earth can obscure. Research in microgravity has enabled new insights into what happens inside a fire, how soil grains shift during an earthquake, why certain thick fluids flow easily under pressure, and what is the best way to spray water onto a fire. In this relatively new microgravity environment, experiments continue to yield surprising effects for researchers. Scientists are putting microgravity to work to understand the growth of proteins as near-perfect crystals (often not possible on Earth), allowing them to decode the protein's role in health or disease. Cells grown in space can also produce longer-lived cultures to help us understand the growth of tumors and perhaps give insight into how we might control this growth process. Microgravity also causes subtle changes in the structure and functions of the brain, nerves, muscles, bones, the immune system, and other parts of the body. Studying these may help us improve health care on Earth while protecting the lives of astronauts in space.

# Internal combustion engine

From Wikipedia, the free encyclopedia.

A colorized automobile engine

An **internal combustion engine** is an engine that is powered by the expansion of hot combustion products of fuel directly acting within an engine. A *piston internal combustion engine* works by burning hydrocarbon or hydrogen fuel that presses on a piston; and a *jet engine* works as the hot combustion products press on the interior parts of the nozzle and combustion chamber, directly accelerating the engine forwards. The rotary combustion engine uses a rotor instead of reciprocating pistons.

By way of contrast, an external combustion engine such as a steam engine, does work when the combustion process heats a separate working fluid, such as water or steam, which then in turn does work.

Jet engines, most rockets and many gas turbines are classed as internal combustion engines, but the term "internal combustion engine" is often loosely used to refer specifically to a **piston internal combustion engine** and **rotary combustion engine** in which combustion is intermittent and the products act on reciprocating machinery, the most common subtype of this kind of engine.

## History

Early internal-combustion engines were used to power farm equipment.

In the broadest sense of the term, the internal combustion engine can be said to have been invented in China, with the invention of fireworks during the Song dynasty (some sources put the invention a thousand years earlier still). English inventor Sir Samuel Morland used gunpowder to drive water pumps in the 17th century. For more conventional, reciprocating internal combustion engines the fundamental theory for two-stroke engines was established by Sadi Carnot in France in 1824, whilst the American Samuel Morey received a patent on April 1, 1826 for a "Gas Or Vapor Engine".

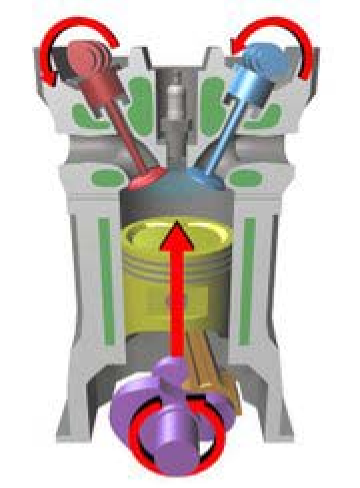
The Italians Eugenio Barsanti and Felice Matteucci patented a first working efficient version of an internal combustion engine in 1854 in London (pt. Num. 1072). Jean Joseph Etienne Lenoir produced in 1860 a gas-fired internal combustion engine not dissimilar in appearance to a steam beam engine. Nikolaus Otto working with Gottlieb Daimler and Wilhelm Maybach in the 1870's developed the four-stroke cycle (Otto cycle) engine.

## Applications

Internal combustion engines are most commonly used for mobile propulsion systems. In mobile scenarios internal combustion is advantageous, since it can provide high power to weight ratios together with excellent fuel energy-density. These engines have appeared in almost all cars, motorbikes, many boats, and in a wide variety of aircraft and locomotives. Where very high power is required, such as jet aircraft, helicopters and large ships, they appear mostly in the form of gas turbines. They are also used for electric generators and by industry.

For low power mobile and many non-mobile applications an electric motor is a competitive alternative. In the future, electric motors may also become competitive for most mobile applications. However, the high cost and weight and poor energy density of batteries and lack of affordable onboard electric generators such as fuel cells has largely restricted their use to specialist applications.

### *Parts*



An illustration of several key components in a typical four-stroke engine

The parts of an engine vary depending on the engine's type. For a four-stroke engine, key parts of the engine include the crankshaft (purple), one or more camshafts (red and blue) and valves. For a two-stroke engine, there may simply be an exhaust outlet and fuel inlet instead of a valve system. In both types of engines, there are one or more cylinders (grey and green) and for each cylinder there is a spark plug (darker-grey), a piston (yellow) and a crank (purple). A single sweep of the cylinder by the piston in an upward or downward motion is known as a stroke and the downward stroke that occurs directly after the air-fuel mix in the cylinder is ignited is known as a power stroke.

A Wankel engine has a triangular rotor that orbits in an epitroichoidal (figure 8 shape) chamber around an eccentric shaft. The four phases of operation (intake, compression, power, exhaust) take place in separate locations, instead of one single location as in a reciprocating engine.

A Quasiturbine has a four face articulated rotor that rotates inside a quasi-oval shaped chamber, as with the wankel the four phases take place in separate locations but differs in that a complete revolution of the output shaft is a complete four stroke cycle.

### *Operation*

All **internal combustion engines** depend on the exothermic chemical process of combustion: the reaction of a fuel, typically with air, although other oxidisers such as nitrous oxide may be employed. Also see stoichiometry.

The most common fuels in use today are made up of hydrocarbons and are derived from petroleum. These include the fuels known as diesel, gasoline and liquified petroleum gas. Most internal combustion engines designed for gasoline can run on natural gas or liquified petroleum gases without modifications except for the fuel delivery components. Liquid and gaseous biofuels of adequate formulation can also be used.

Some have theorized that in the future hydrogen might replace such fuels. The advantage of hydrogen is that its combustion produces only water. This is unlike the combustion of hydrocarbons which also produces carbon dioxide, a major cause of global warming, and, as a result of incomplete combustion, carbon monoxide and nitrous oxides ($NO_x$). The big disadvantage of hydrogen in many situations is storage; liquid hydrogen has extremely low density- 14 times lower than water and requires extensive insulation, whilst gaseous hydrogen requires very heavy tankage. Whilst hydrogen is light and therefore has a higher specific energy, the volumetric efficiency is still roughly five times lower than petrol.

All internal combustion engines must have a means of ignition to promote combustion. Most engines use either an electrical or a compression heating ignition system. Electrical ignition systems generally rely on a lead-acid battery and an induction coil to provide a high voltage electrical spark to ignite the air-fuel mix in the engine's cylinders. This battery can be recharged during operation using an *alternator* driven by the engine. Compression heating ignition systems (Diesel engines and HCCI engines) rely on the heat created in the air by compression in the engine's cylinders to ignite the fuel.

Once successfully ignited and burnt, the combustion products (hot gases) have more available energy than the original compressed fuel/air mixture (which had higher chemical energy). The available energy is manifested as high temperature and pressure which can be translated into work by the engine. In a reciprocating engine, the high pressure product gases inside the cylinders drive the engine's pistons.

Once the available energy has been removed the remaining hot gases are vented (often by opening a valve or exposing the exhaust outlet) and this allows the piston to return to its previous position (Top Dead Center - TDC). The piston can then proceed to the next phase of its cycle (which varies between engines). Any heat not translated into work is a waste product and is removed from the engine either by an air or liquid cooling system.

### *Classification*

There is a wide range of internal combustion engines corresponding to their many varied applications. Likewise there is a wide range of ways to classify internal-combustion engines, some of which are listed below.

Although the terms sometimes cause confusion, there is no real difference between an "engine" and a "motor." At one time, the word "engine" (from Latin, via Old French, *ingenium*, "ability") meant any piece of machinery. A "motor" (from Latin *motor*, "mover") is any machine that produces mechanical power. Traditionally, electric motors are not referred to as "engines," but combusion engines are often referred to as "motors."


A 1906 gasoline engine

## Principles of operation

Reciprocating:

- Two-stroke engine
- Four-stroke engine

Rotary:

- Wankel engine
- quasiturbine

Continuous combustion:

- gas turbine
- jet engine
- rocket engine

## Engine cycle

Engines based on the two-stroke cycle use two strokes (one up, one down) for every power stroke, relying on the action of the bottom of the piston within the crankcase to help move the fuel-air mixture, and are used where small size and weight are important, such as snowmobiles, lawnmowers, mopeds, outboard motors and some motorcycles. Gasoline two-stroke engines are generally louder, less efficient, more polluting, and smaller than their four-stroke counterparts, although large two-stroke diesel engines are not subject to these complaints and are used in many applications, for instance some locomotives built by EMD.

Engines based on the four-stroke cycle or Otto cycle have one power stroke for every four strokes (up-down-up-down) and are used in cars, larger boats and many light aircraft. They are generally quieter, more efficient and larger than their two-stroke counterparts. There are a number of variations of these cycles, most notably the Atkinson and Miller cycles. Most truck and automotive Diesel engines use a four-stroke cycle, but with a compression heating ignition system it is possible to talk separately about a diesel cycle. The Wankel engine operates with the same separation of phases as the four-stroke engine (but with no piston strokes, would more properly be called a four-phase engine), since the phases occur in separate locations in the engine; however like a two-stroke piston engine, it provides one power 'stroke' per revolution per rotor, giving it similar space and weight efficiency.

## Fuel type

Diesel engines are generally heavier, noisier and more powerful at lower speeds than gasoline engines. They are also more fuel-efficient in some circumstances and are used in heavy road-vehicles, some automobiles, ships and some locomotives and light aircraft. Gasoline engines are used in most other road-vehicles including most cars, motorcycles and mopeds. Note that in Europe, sophisticated diesel-engined cars are far more prevalent, representing around 40% of the market. Both gasoline and diesel engines produce significant emissions. There are also engines that run on hydrogen, methanol, ethanol, liquefied petroleum gas (LPG) and biodiesel. Paraffin and Tractor vaporising oil (TVO) engines are no longer seen.

One-cylinder gasoline engine (c. 1910).

## Cylinders

Internal combustion engines can contain any number of cylinders with numbers between one and twelve being common, though as many as 28 have been used. Having more cylinders in a engine yields two potential benefits: First. the engine can have a larger displacement with smaller individual reciprocating masses (that is, the mass of each piston can be less) thus making a smoother running engine (since the engine tends to vibrate as a result of the pistons moving up and down). Second, with a greater displacement and more pistons, more fuel can be combusted and there can be more combustion events (that is, more power strokes) in a given period of time, meaning that such an engine can generate more torque than a similar engine with fewer cylinders. The down side to having more pistons is that, over all, the engine will tend to weigh more and tend to generate more internal friction as the greater number of pistons rub against the inside of their cylinders. This tends to decrease fuel efficiency and rob the engine of some of its power. For high performance gasoline engines using current materials and technology (such as the engines found in modern automobiles), there seems to be a break point around 10 or 12 cylinders, after which addition of cylinders becomes an overall detriment to performance and efficiency, although exceptions such as the W-16 engine from Volkswagon exist.

- Most car engines have four to eight cylinders, with some high performance cars having ten, twelve, or even sixteen, and some very small cars and trucks having two or three. In previous years some quite large cars, such as the DKW and Saab 92, had two cylinder, two stroke engines.
- Radial aircraft engines, now obsolete, had from five to 28 cylinders. A row contains an odd number of cylinders, so an even number indicates a two- or four-row engine.
- Motor cycles commonly have from one to four cylinders, with a few high performance models having six.
- Snowmobiles usually have two cylinders. Some larger (not necessarily high-performance, but also touring machines) have four.
- Small appliances such as chainsaws and domestic lawn mowers most commonly have one cylinder, although two-cylinder chainsaws exist.

## Ignition system

Internal combustion engines can be classified by their ignition system. Today most engines use an electrical or compression heating system for ignition. However outside flame and hot-tube systems have been used historically. Nikola Tesla gained one of the first patents on the mechanical ignition system with U.S. Patent 609250, "*Electrical Igniter for Gas Engines*", on 16 August 1898.

## Fuel systems

Often for simpler reciprocating engines a carburetor is used to supply fuel into the cylinder. However, exact control of the correct amount of fuel supplied to the engine is difficult.

Car engines have mostly moved to Fuel injection systems, and Diesel engines essentially always use this technique.

Other internal combustion engines like Jet engines use burners, and rocket engines use various different ideas including impinging jets, gas/liquid shear, preburners and many other ideas.

## Engine configuration

Internal combustion engines can be classified by their configuration which affects their physical size and smoothness (with smoother engines producing less vibration). Common configurations include the straight or inline configuration, the more compact V configuration and the wider but smoother flat or boxer configuration. Aircraft engines can also adopt a radial configuration which allows more effective cooling. More unusual configurations, such as "H", "U", "X", or "W" have also been used.

Multiple-crankshaft configurations do not necessarily need a cylinder head at all, but can instead have a piston at each end of the cylinder, called an opposed piston design. This design was used in the Junkers Jumo 205 diesel aircraft engine, using two crankshafts, one at either end of a single bank of cylinders, and most remarkably in the Napier Deltic diesel engines, which used three crankshafts to serve three banks of double-ended cylinders arranged in an equilateral triangle with the crankshafts at the corners. It was also used in single-bank locomotive engines, and continues to be used for marine engines, both for propulsion and for auxiliary generators. The Gnome Rotary engine, used in several early aircraft, had a stationary crankshaft and a bank of radially arranged cylinders rotating around it. Technically this is a "rotary piston engine", to distinguish it from Wankel "rotary combustion engines".

## Engine capacity

An engine's capacity is the displacement or swept volume by the pistons of the engine. It is generally measured in litres or cubic inches for larger engines and cubic centimetres (abbreviated to cc's) for smaller engines. Engines with greater capacities are usually more powerful and provide greater torque at lower rpms but also consume more fuel.

Apart from designing an engine with more cylinders, there are two ways to increase an engine's capacity. The first is to lengthen the stroke and the second is to increase the piston's diameter. In either case, it may be necessary to make further adjustments to the fuel intake of the engine to ensure optimal performance.

An engine's quoted capacity can be more a matter of marketing than of engineering. The Morris Minor 1000, the Morris 1100, and the Austin-Healey Sprite Mark II all had engines of the same stroke and bore according to their specifications, and were from the same maker. However the engine capacities were quoted as 1000cc, 1100cc and 1098cc respectively in the sales literature and on the vehicle badges.

## Engine pollution

Generally internal combustion engines, particularly reciprocating internal combustion engines produce moderately high pollution levels, due to incomplete combustion of carbonaceous fuel, leading to carbon monoxide and some soot along with oxides of nitrogen & sulphur and some unburnt hydrocarbons depending on the operating conditions and the fuel air ratio

Diesel engines produce a wide range of pollutants including aerosols of many small particles that are believed to penetrate deeply into human lungs.

- Many fuels contain sulphur leading to sulphur oxides in the exhaust, promoting acid rain.
- Net carbon dioxide production is not a necessary feature of engines, but since most engines are run from fossil fuels usually occurs. If engines are run from biomass, then no net carbon dioxide is produced as the growing plants absorb as much, or more carbon dioxide whilst growing.
- Some engines run on hydrogen, and in those cases no direct carbon dioxide is produced, however hydrogen is not found naturally in the environment, and production usually, but not necessarily, involves production and release of reasonably large quantities of carbon dioxide to the environment.

**CONCORDE**

At the time it was introduced, the Supersonic Concorde was expected to revolutionize long-distance air travel. It holds the record for the fastest crossing of the Atlantic Ocean from New York to London in 2 hours, 54 minutes, and 45 seconds. It flies at 60,000 feet above the earth, which allows you to see the curvature of the earth. The only thing that goes higher than the Concorde is the space shuttle. Because the cost remains astronomical compared to regular coach seats, the jets remain for the select few.

In total 20 Concordes were built between 1966 and 1979. The first 2 Concordes were prototype models, one built in France and the other in England.
Another 2 pre-production prototypes were built to further refine design and test out ground breaking systems before the production runs, of only 16 aircraft in total, commenced in both countries.

The first production aircraft off each production line did not enter service but acted as a test bed for production techniques, airline training and further development work. They also paved the way for the granting of airworthiness certification as well as providing extensive route proving information.

In the end only British Airways and Air France purchased Concordes, with the airlines initially purchasing 5 and 4 aircraft respectively. The 5 surplus models were placed with the airlines in 1980 and eventually purchased for a nominal cost of £1 / 1 Franc each at the end of the Concorde programme a few years later, as part of a multi million pound support costs deal. British Airways acquired the 2 unsold UK built aircraft, while Air France bought the 3 unsold French built craft.

British Airways have a fleet of 7 aircraft while Air France had 5 aircraft. The British Airways Concordes have nearly 150,000 hours of flight time so far, which equates to roughly 52,000 flights,while Air France have over 105,000 hrs of flight time. The two prototypes, two pre production and one first production model are now on show in museums on both sides of the channel. The first British production Concorde is now owned by BA and used for spares.

Air France returned 4 aircraft to service after the Paris accident in July 2000, of the others; one was retired for spares use in 1982, one never completed a D check (due to retirement) and the final one was the aircraft lost in the accident. The 4 servicable aircraft were retired to museums in France, Germany and the US.

British Airways operated 5 aircraft, after the accident with a further 2 in storage at London Heathrow, that were not modified post accident. All 7 have now been retired, and are on display around the world.

**F16**

**Primary Function:** Multirole fighter, **Builder:** Lockheed Martin Corp., **Power Plant:** F-16C/D one Pratt and Whitney F100-PW-200/220/229 or one General Electric F110-GE-100/129, **Thrust:** F-16C/D, 27,000 pounds(121,500 N), **Length:** 49 feet, 5 inches (14.8 m), **Height:** 16 feet (4.8 m), **Wingspan:** 32 feet, 8 inches (9.8 m), **Speed:** 1,500 mph (Mach 2 at altitude), **Ceiling:** Above 50,000 feet (15 km), **Maximum Takeoff Weight:** 37,500 pounds (168,750 N), **Range:** Over 2,100 nm (2,425 mi; 3,900 km), **Armament:** One M-61A1 20 mm multibarrel cannon with 500 rounds; external stations can carry up to six air-to-air missiles, conventional air-to-air and air-to-surface munitions and electronic countermeasure pods.

## AN-225 MRİYA (DREAM) WORLD'S BIGGEST PLANE

Currently the world's largest airciaft, the An-225 Mrilya (dream) stemmed from the need to transport large items for the Soviet space programme. Previously a converted Myasishchev Mya-4 'Bison' bomber had been used to carry outsize items on its back. but this had a limited payload capacity. meaning many components had to be disassembled or not carried at all.

In mid-1985 Antonov was entrusted with the design of a new aircraft able to carry the Buran shuttle orbiter, large components of the Energiya launch vehicles and other outsize items for construction and mining industries. Construction of the An-124 provided the basis for the new aircraft, Antonov using many of the same components to keep cost and development effort down. The prototype made its first flight on 21 December 1988, and in March 1989 setup no fewer than 106 world and class records in one flight from Kiev, at a maximum take-off weight in excess of 5,000,000 N (1,100,000 lb). Only two have been completed so far, and the first flew with Buran on 13 May 1989. This combination made a dramatic appearance in the West for the first time a month later at the Paris Air Salon.

**An-225Mriya** (Dream) World Biggest Plane (used for Cargo). Above carrying space shuttle.

**Type:** heavy transport, **Powerplant:** six Lotarev D-18T turbofans, each rated at 229.5 kN (51,590 lb) thrust, **Performance:** (estimated) cruising speed 800 km/h (497 mph); take-off run carrying Buran 2500 m (8,200ft); turning radius about nosewheels 50 m (164 ft),
**Weights:** maximum take-off 6000000 N (1,322,750 lb), maximum payload (internal or external) 2500000 N (551,150lb), **Dimensions:** span 88.4 m (290 ft); length 84.0 m (275 ft 7 in). height 18.1 m (59 ft 43/4 in); tailplane span 32.65 m (107 ft 11/2in); length of freight hold 43 m (141 ft).

## B2 SPIRIT BOMBER

The B-2 Spirit is a multi-role bomber capable of delivering both conventional and nuclear munitions. A dramatic leap forward in technology, the bomber represents a major milestone in the U.S. bomber modernization program. The B-2 brings massive firepower to bear, in a short time, anywhere on the globe through previously impenetrable defenses. Along with the B-52 and B-1B, the B-2 provides the penetrating flexibility and effectiveness inherent in manned bombers. Its low-observable, or "stealth," characteristics give it the unique ability to penetrate an enemy's most sophisticated defenses and threaten its most valued, and heavily defended, targets. Its capability to penetrate air defenses and threaten effective retaliation provide a strong, effective deterrent and combat force well into the 21st century. The revolutionary blending of low-observable technologies with high aerodynamic efficiency and large payload gives the B-2 important advantages over existing bombers. Its low-observability provides it greater freedom of action at high altitudes, thus increasing its range and a better field of view for the aircraft's sensors. Its unrefueled range is approximately 6,000 nautical miles (9,600 kilometers).

**Primary function:** Multi-role heavy bomber, **Prime Contractor:** Northrop Grumman Corp. **Contractor Team:** Boeing Military Airplanes Co., General Electric Aircraft Engine Group and Hughes Training Inc., **Power Plant:** Four General Electric F-118-GE-100 engines, **Thrust:** 17,300 pounds each engine, **Length:** 69 feet (20.9 m), **Height:** 17 feet (5.1 m), **Wingspan:** 172 feet (52.12 m), **Speed:** High subsonic, **Ceiling:** 50,000 feet (15,152 meters), **Takeoff Weight (Typical):** 336,500 pounds (152 tons), **Range:** Intercontinental, unrefueled, **Armament:** Conventional or nuclear weapons, **Payload:** 40,000 pounds (18 tons), **Crew:** Two pilots, **Unit cost:** $1.157 billion **Date Deployed:** December 1993, **Inventory:** Active force, 21.

## V-22 OSPREY

The V-22 tiltrotor Osprey is a revolutionary, vertical and short take-off and land, multi-purpose aircraft with excellent high-speed cruise performance. This advanced technology rotorcraft performs a wide range of missions as effectively as a conventional helicopter, while equally capable of achieving the long-range cruise efficiencies of a twin turboprop aircraft.

Missions that cover large distances and that require vertical takeoffs and landings have challenged aeronautical pioneers since helicopters first proved their worth almost 50 years ago. The challenge has been to devise a vehicle that is faster, has more range, and is more cost effective than conventional helicopters.

The V-22 Osprey is a revolutionary change. It has recently been acknowledged by the Department of Defense as one of only four truly Transformational systems. It brings capabilities not found in any helicopter – twice the speed, three times the payload and five times the range of the legacy helicopters that it replaces. Add the ability to fly two and a half times higher than those helicopters and you have an aircraft that is truly a leap ahead. These capabilities recognized in 18 major studies and analyses, including seven Cost and Operational Effectiveness Analyses performed by the U.S. Government. All these studies have shown that the Osprey is more cost effective than any helicopter, compound helicopter, or combination of helicopters. The Osprey will bring interoperability and vastly increased mission effectiveness to armed forces around the globe.

Designed to the most stringent set of requirements ever imposed on a rotary wing aircraft, the V-22 successfully demonstrated that it was both effective and suitable for the Marine Corps mission during Operational Evaluation Phase I. After two years of additional, detailed flight testing, it will undertake Phase II, and enter into Full Rate Production in 2005. The V-22 is currently in Low Rate Initial Production. V-22 design criteria answered questions about safety, reliability, readiness, all weather, survivability, crashworthiness, and performance; shipboard compatibility was designed in at the outset. The modern avionics suite of communication, navigation and penetration aids are fully integrated and redundant, where necessary, to ensure successful mission completion. Other design considerations include meeting guarantees for weight and performance, graceful handling of engine failures, crashworthiness, emergency egress, and maintenance or repair accessibility. The V-22 uses proven technology to meet all of these requirements and more.

## (G) SEA VEHICLES

### Queen Elizabeth 2

The *Queen Elizabeth 2*, or *QE2* as she is commonly known was the flagship of the Cunard Line for over 30 years. *QE2* made her maiden voyage in 1969 and is one of the last great Transatlantic liners. At 70,327 tons and 963 feet (293 m) long with a top speed of 32.5 knots she is also one of the largest and fastest passenger vessels afloat.

**BIGGEST OIL TANKER:**
To carry a large amount of oil, tankers are designed to be quite large. The *Exxon Valdez* was considered a midsized oil tanker measuring 967 feet (294 m) long and 166 feet (50 m) wide. In comparison, the largest tanker in the world, the *Jahre Viking "Avar"*, formally known as the *Seawise Giant*, is 1504 feet (460 m) long and 226 feet (70 m) wide. These vessels are so large that crew members often use bicycles to travel from one point to another on the ship. Such a tanker carries about 400 000 tons of oil.

## (H) RAIL VEHICLES

**SPEED TRAIN**

In the 19th Century and early 20th Century, railway trains had a vital role. In the latter half of the 20th Century, the motor car and the aircraft have eroded the importance of railway travel. However, new technology, high-speed rail, has enabled some train services to be faster and more convenient than the motor car and aircraft. Services started in 1964. The Shinkansen (*Bullet Train*) Top Commercial Speed, variable: see below. Speed Record. 443 km/h or 277 mph. Best average speed 262km/h or 164mph. Japan was one of the first countries to realise the problems of the car. The Bullet train could be thought of as the worlds first high speed train.

Along the Tokaido line series 300 trains operate at a top speed of 270 km/h or 168 mph (since 1992). Along the Sanyo line series 500 trains operate at a top speed of 300 km/h or 186 mph (since 1997). Along the Tohoku line series 200 E2 + E3 trains operate at 275 km/h or 170 mph (since 1997), the rest at 240 km/h or 150 mph (since 1988). Along the Joetsu line series 200 "F9x" sets operate at 275 km/h or 170 mph (since 1990). Along the Hokuriku line E2 trains operate at 260 km/h or 162 mph (since 1997).

Between Hiroshima and Kokura the bullet train covers the 192 km or 120 mile distance in only 44 minutes. It averages a speed of 262 km/h or 164 mph which is the fastest scheduled train service in the world.

**(I) GROUND VEHICLES**

**ABRAMS M1A1 MAİN BATTLE TANKS**

The M1A1/2 Abrams main battle tank is manufactured by General Dynamics Land Systems (GDLS). The first M1 tank was produced in 1978, the M1A1 in 1985 and the M1A2 in 1986. 3,273 M1 tanks were produced for the US Army. 4,796 M1A1 tanks were built for the US Army, 221 for the US Marines and 555 co-produced with Egypt. Egypt has ordered a further 200 M1A1 tanks with production to continue to 2005. 77 M1A2 tanks have been built for the US Army, 315 for Saudi Arabia and 218 for Kuwait. For the M1A2 Upgrade Program, over 600 M1 Abrams tanks are being upgraded to M1A2 configuration. Deliveries began in 1998.

The main armament is the 120mm M256 smoothbore gun, developed by Rheinmetall GmbH of Germany. The 120mm gun fires the following ammunition: the M865 TPCSDS-T and M831 TP-T training rounds, the M8300 HEAT-MP-T and the M829 APFSDS-T which includes a depleted uranium penetrator. The commander has a 12.7mm Browning M2 machine gun and the loader has a 7.62mm M240 machine gun. A 7.62mm M240 machine gun is also mounted coaxially on the right hand side of the main armament. The M1A1 tank incorporates steel encased depleted uranium armour. Armour bulkheads separate the crew compartment from the fuel tanks. The top panels of the tank are designed to blow outwards in the event of penetration by a HEAT projectile. The tank is protected against nuclear, biological and chemical (NBC) warfare.

The commander's station is equipped with six periscopes, providing 360 degree view. The Raytheon Commander's Independent Thermal Viewer (CITV) provides the commander with independent stabilised day and night vision with a 360 degree view, automatic sector scanning, automatic target cueing of the gunner's sight and back-up fire control. The M1A2 Abrams tank has a two-axis Raytheon Gunner's Primary Sight- Line of Sight (GPS-LOS) which increases the first round hit probability by providing faster target acquisition and improved gun pointing. The Thermal Imaging System (TIS) has magnification x10 narrow field of view and x3 wide field of view. The thermal image is displayed in the eyepiece of the gunner's sight together with the range measurement from a laser rangefinder. The Northrop Grumman (formerly Litton) Laser Systems Eyesafe Laser Rangefinder (ELRF) has a range accuracy to within 10m and target discrimination of 20m. The gunner also has a Kollmorgen Model 939 auxiliary sight with magnification x8 and field of view 8 degrees. The digital fire control computer is supplied by General Dynamics - Canada (formerly Computing Devices Canada). The fire control computer automatically calculates the fire control solution based on: lead angle measurement; bend of the gun measured by the muzzle reference system; velocity measurement from a wind sensor on the roof of the turret; data from a pendulum static cant sensor located at the centre of the turret roof. The operator manually inputs data on ammunition type, temperature, and barometric pressure. The driver has either three observation periscopes or two periscopes on either side and a central image intensifying periscope for night vision. The periscopes provide 120 degrees field of view. The DRS Technologies Driver's Vision Enhancer (DVE), AN/VSS-5, is based on a 328 x 245 element uncooled infrared detector array, operating in the 7.5 to 13 micron waveband. A Raytheon Driver's Thermal Viewer, AN/VAS-3, is installed on the M1A2 Abrams tanks for Kuwait.

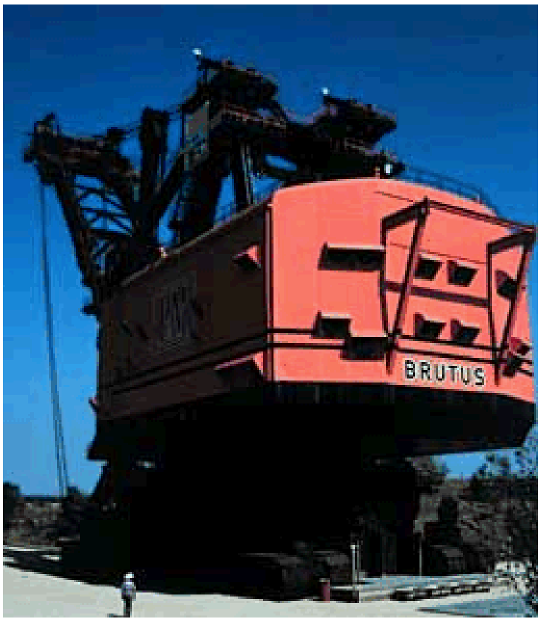
## ROLLS ROYCE

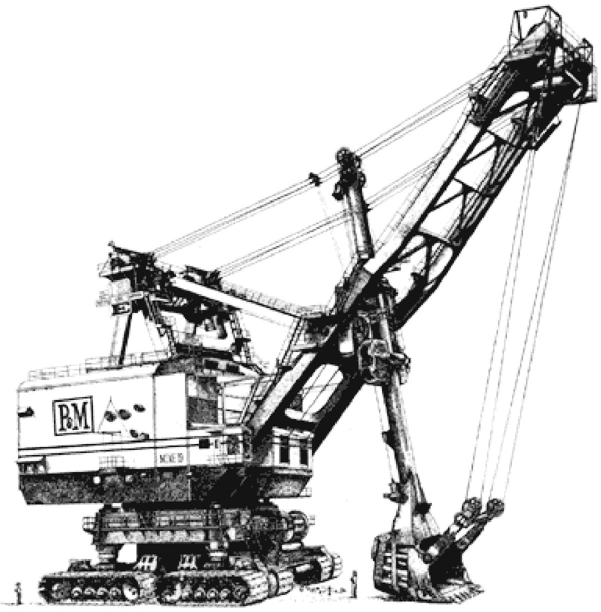

The **Rolls Royce** is world renowned for class. Ranging in price from $100,000 to $500,000, the Rolls Royce car is designed for those with a discriminating taste.

## BİG BRUTUS

Big Brutus is the largest electric shovel in the world **(**overshadowed by his big sister, Big Bertha, but she was dismantled and sold as scrap).

In May 1963, Big Brutus came alive. After taking more than 150 railroad cars and over a year to build, Big Brutus was in operation. Engineers designed the 15,000 horsepower shovel to revitalize the strip-mining industry. It is 16 stories (160 feet) tall and has a boom 150 feet long. At 11 million pounds, Big Brutus' bucket can lift up to 150 tons of coal - enough to fill three railroad cars. It ran 24 hours a day at a maximum speed of 0.22 mile per hour. It used as much electricity in one day as town of 15,000 people. In 1974, Big Brutus had to be shut down because its cost of operation was twice that of the value of coal it recovered.



**Located at West Mineral, Kansas**

Cost $6.5 million (in 1962)

On July 13, 1985, Big Brutus was dedicated as "a Museum and Memorial Dedicated to the Rich Coal Mining History in Southeast Kansas."

In September 1987 The American Society of Mechanical Engineers (ASME) designated Big Brutus a Regional Historic Mechanical Engineering Landmark, the 10th since 1971 to be so designated.

**(J) COMMUNICATION DEVICES**

**RADIO ASTRONOMY**

Until the development of radio astronomy in the 1940's, our view of the Universe was confined to the narrow visible-light window. However, there is more to the Universe than meets the eye. In addition to the light emitted by stars, galaxies, quasars and other celestial objects, there is invisible energy - infrared and ultraviolet light, x-rays and radio - that our eyes cannot detect. Special telescopes are needed to “see” this invisible radiation. Unfortunately, other than optical light, only radio waves are easily seen from the Earth's surface.

To detect radio waves, scientists use large parabolic "dishes", similar to the much smaller scale dishes commonly used in many households to pick up satellite television. Currently, the largest parabolic radio dish in the world is the 305 m diameter Arecibo Radio Telescope.

The Arecibo Observatory is part of the National Astronomy and Ionosphere Center (NAIC), a national research center operated by Cornell University under a cooperative agreement with the National Science Foundation (NSF). The NSF is an independent federal agency whose aim is to promote scientific and engineering progress in the United States. NSF funds research and education in most fields of science and engineering. Additional support is provided by the National Aeronautics and Space Administration (NASA)

The Observatory operates on a continuous basis, 24 hours a day every day, providing observing time, electronics, computer, travel and logistic support to scientists from all over the world. All results of research are published in the scientific literature which is publicly available.

As the site of the world's largest single-dish radio telescope, the Observatory is recognized as one of the most important national centers for research in radio astronomy, planetary radar and terrestrial aeronomy. Use of the Arecibo Observatory is available on an equal, competitive basis to all scientists from throughout the world. Observing time is granted on the basis of the most promising research as ascertained by a panel of independent referees who review the proposals sent to the Observatory by interested scientists. Every year about 200 scientists visit the Observatory facilities to pursue their research project, and numerous students perform observations that lead to their master and doctoral dissertations.

The Observatory had its origins in an idea of Professor William E. Gordon, then of Cornell University, who was interested in the study of the Ionosphere**.** Gordon's research during the fifties led him to the idea of radar back scatter studies of the Ionosphere. Gordon's persistence culminated in the construction of the Arecibo Observatory which began in the Summer of 1960. Three years later the Arecibo Ionospheric Observatory (AIO) was in operation under the direction of Gordon. The formal opening ceremony took place on November 1, 1963.

From the beginning there were certain requirements for the site. It had to be near the equator, since there, a radar capable of studying the ionosphere could also be used to study nearby planets which pass overhead. The Arecibo site offered the advantage of being located in Karst terrain, with large limestone sinkholes which provided a natural geometry for the construction of the 305 meter reflector.

In addition an Optical Laboratory with a variety of instrumentation used for the passive study of terrestrial airglow is located at the Observatory. A lidar (Light Detection And Ranging) together with a Fabry-Perot interferometer is primarily used to measure neutral winds and temperatures of the middle atmosphere This capability complements that of the incoherent scatter radar, and gives Arecibo a unique capability in the world in terms of aeronomic research.

On October 1, 1969 the National Science Foundation took over the facility from the Department of Defense and the Observatory was made a national research center. On September 1971 the AIO became the National Astronomy and Ionosphere Center (NAIC).

In 1974 a new high precision surface for the reflector (the current one) was installed together with a high frequency planetary radar transmitter. The second and major upgrade to the telescope was completed in 1997. A ground screen around the perimeter of the reflector was installed to shield the feeds from ground radiation. The gregorian dome with its subreflectors and new electronics greatly increases the capability of the telescope. A new more powerful radar transmitter was also installed.

About 140 persons are employed by the Observatory providing everything from food to software in support of the operation. A scientific staff of about 16 divide their time between scientific research and assistance to visiting scientists. Engineers, computer experts, and technicians design and build new instrumentation and keep it in operation. A large maintenance staff keeps the telescope and associated instrumentation as well as the site in optimal condition. A staff of telescope operators support observing twentyfour hour per day.

## GSM TECHNOLOGY


- Integrated digital camera with zoom
- Video recorder with audio support
- Streaming video and audio
- Wireless connectivity with Bluetooth and infrared
- 6 MB internal memory
- Memory card slot for additional user memory and appls.
- Supports Java™ MIDP 2.0 applications
- Data synchronization with PC via PC Suite
- Tri-band operation in GSM E900/1800/1900 networks

## FIBER-OPTICS

In recent years it has become apparent that fiber-optics are steadily replacing copper wire as an appropriate means of communication signal transmission. They span the long distances between local phone systems as well as providing the backbone for many network systems. Other system users include cable television services, university campuses, office buildings, industrial plants, and electric utility companies.

- Transmit and receive light instead of electric signals
- Digital coding of data and reduced error rate
- Easy multiplexing to transmit and receive many phone or TV lines over a single fiber optic cable
- High bandwidth
- Cheap and hi-performance solutions for communications

A fiber-optic system is similar to the copper wire system that fiber-optics is replacing. The difference is that fiber-optics use light pulses to transmit information down fiber lines instead of using electronic pulses to transmit information down copper lines. Looking at the components in a fiber-optic chain will give a better understanding of how the system works in conjunction with wire based systems.

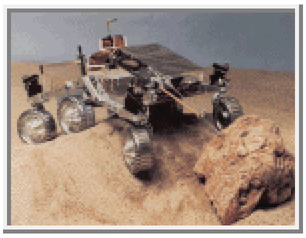
At one end of the system is a transmitter. This is the place of origin for information coming on to fiber-optic lines. The transmitter accepts coded electronic pulse information coming from copper wire. It then processes and translates that information into equivalently coded light pulses. A light-emitting diode (LED) or an injection-laser diode (ILD) can be used for generating the light pulses. Using a lens, the light pulses are funneled into the fiber-optic medium where they transmit themselves down the line.

Think of a fiber cable in terms of very long cardboard roll (from the inside roll of paper towel) that is coated with a mirror. If you shine a flashlight in one you can see light at the far end - even if bent the roll around a corner.

Light pulses move easily down the fiber-optic line because of a principle known as total internal reflection. "This principle of total internal reflection states that when the angle of incidence exceeds a critical value, light cannot get out of the glass; instead, the light bounces back in. When this principle is applied to the construction of the fiber-optic strand, it is possible to transmit information down fiber lines in the form of light pulses.

## SPACE ROBOTICS AND TELEOPERATION






The rover, which has been named "Sojourner" is a six-wheeled vehicle, 280 mm high, 630 mm long, and 480 mm wide with a ground clearance of 130 mm, mounted on a "rocker-bogie" suspension. The rover was stowed on the lander at a height of 180 mm. At deployment, the rover extended to its full height and rolled down a deployment ramp at about 05:40 UT on 6 July 1997 (1:40 a.m. EDT). The rover was controlled by an Earth-based operator who used images obtained by both the rover and lander systems. Note that the time delay was between 10 and 15 minutes depending on the relative position of Earth and Mars over the course of the mission, requiring some autonomous control, provided by a hazard avoidance system on the rover. The on-board control system is an Intel 80C85 8-bit processor which runs about 100,000 instructions per second. The computer is capable of compressing and storing a single image on-board. The rover is powered by 0.2 square meters of solar cells, which will provide energy for several hours of operations per sol (1 Martian day = 24.6 Earth hours). Non-rechargeable lithium thionyl chloride (LiSOCl2) D-cell batteries provide backup. All rover communications were done through the lander.

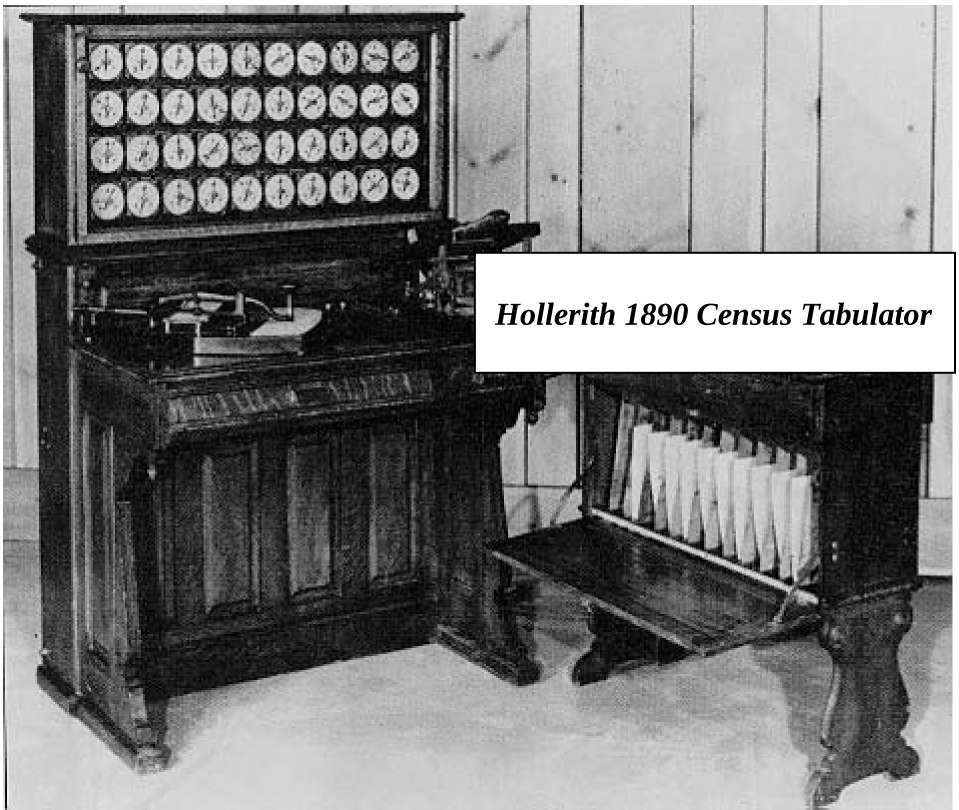
The rover is equipped with black and white and color imaging systems which were used to image the lander in order to assess its condition after touchdown. The goal was to acquire three black and white images spaced 120 degrees apart of the lander. Images of the surrounding terrain were also acquired to study size and distribution of soils and rocks, as well as locations of larger features. Imaging of the rover wheel tracks will be used to estimate soil properties. Imaging of the rover by the lander was also done to assess rover performance and soil and site properties. The rover's performance was monitored to determine tracking capabilities, drive performance, thermal behavior, and sensor performance. UHF Communications between the rover and lander were studied to determine the effectiveness of the link between the rover and lander. Assessments of rock and soil mechanics will be made based on abrasion of the wheels and adherence of dust. An alpha-proton-X-ray spectrometer (APXS) is on-board the rover to assess the composition of rocks and soil. Images of all samples tested are transmitted to Earth. The primary objectives were scheduled for the first seven sols, all within about 10 meters of the lander. The extended mission included slightly longer trips away from the lander, and even longer journeys were planned. Images were taken and experiments performed by the lander and rover until 27 September 1997 when communications were lost for unknown reasons.

## (K) COMPUTERS AND NANO TECHNOLOGY

### CENSUS MACHINE

Herman Hollerith (1860-1929),
Columbia University School of Mines EM 1879,
Columbia University PhD 1890.
*Photo:* IBM.

Herman Hollerith is widely regarded as the father of modern automatic computation. He chose the punched card as the basis for storing and processing information and he built the first punched-card tabulating and sorting machines as well as the first key punch, and he founded the company that was to become IBM. Hollerith's designs dominated the computing landscape for almost 100 years.



***Hollerith 1890 Census Tabulator***

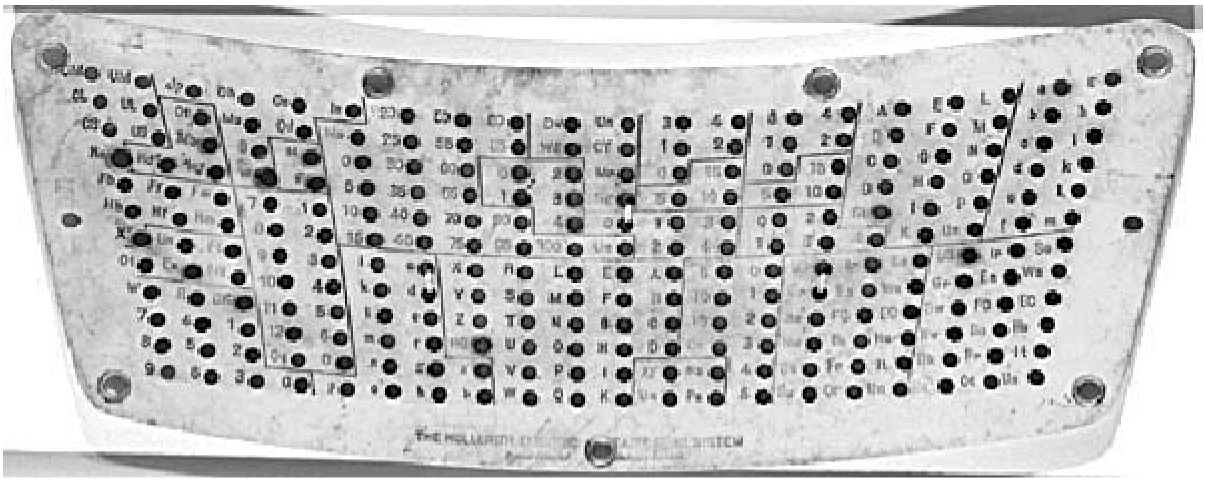
After receiving his Engineer of Mines (EM) degree at age 19, Hollerith worked on the 1880 US census, a laborious and error-prone operation that cried out for mechanization. After some initial trials with paper tape, he settled on punched cards (pioneered in the

Jacquard loom) to record information, and designed special equipment - a tabulator and sorter - to tally the results. His designs won the competition for the 1890 US census, chosen for their ability to count combined facts. These machines reduced a ten-year job to three months *(different sources give different numbers, ranging from six weeks to three years)*, saved the 1890 taxpayers five million dollars, and earned him an 1890 Columbia PhD. This was the first wholly successful information processing system to replace pen and paper. Hollerith's machines were also used for censuses in Russia, Austria, Canada, France, Norway, Puerto Rico, Cuba, and the Philippines, and again in the US census of 1900. In 1911 Hollerith's company merged with two others to form the Computing-Tabulating-Recording Company (CTR), which changed its name to International Business Machines Corporation (IBM) in 1924.

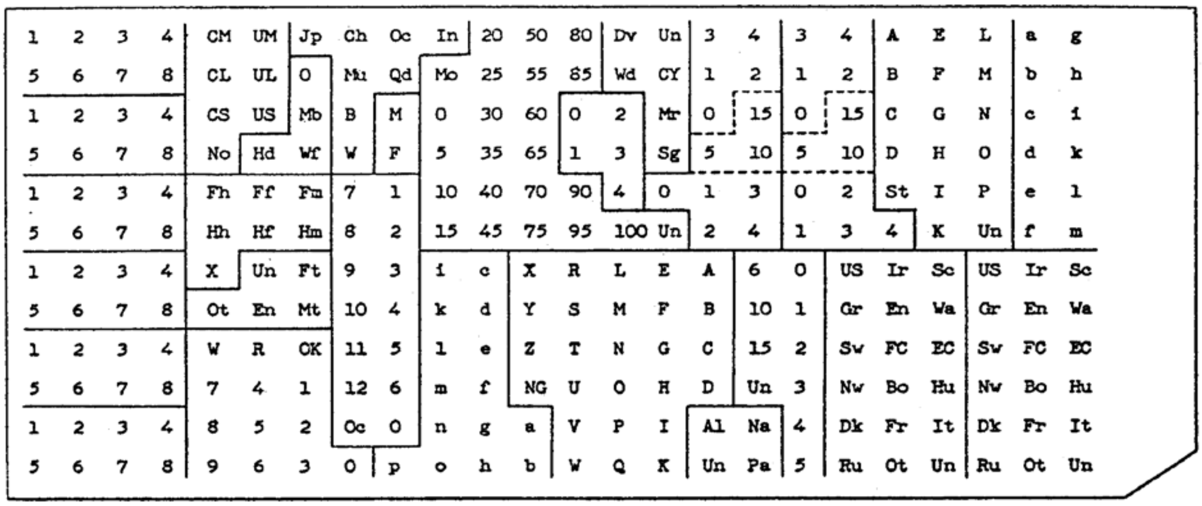
Hollerith's ideas for automation of the census are expressed succinctly in Patent No. 395,782 of Jan. 8, 1889: "The herein described method of compiling statistics which consists in recording separate statistical items pertaining to the individual by holes or combinations of holed punched in sheets of electrically non-conducting material, and bearing a specific relation to each other and to a standard, and then counting or tallying such statistical items separately or in combination by means of mechanical counters operated by electro-magnets the circuits through which are controlled by the perforated sheets, substantially as and for the purpose set forth."

Hollerith's contributions to modern computing are... "incalculable" :-) He did not stop at his original 1890 tabulating machine and sorter, but produced many other innovative new models. He also invented the first automatic card-feed mechanism, the first key punch, and took what was perhaps the **first step towards programmin**g by introducing a wiring panel in his 1906 Type I Tabulator, allowing it to do different jobs without having to be rebuilt! (The 1890 Tabulator was hardwired to operate only on 1890 Census cards.) These inventions were the foundation of the modern information processing industry.

The 1890 tabulator was capable only of counting. Subsequent models, developed by Hollerith himself, were also able to add, thus broadening their scope to accounting, warehousing, and shipping applications. Between 1902 and 1905, Hollerith also developed an automatic card feed and a method for reading cards in motion and settled on a standard card format. In 1928, IBM produced its first tabulator (the Type IV) with both addition and subtraction capability.



Above: A punch-card template from a Pantographic punch used the 1890 US census (image: US Library of Congress). Notice there are 12 rows (as in modern punch cards), of which only the bottom 10 were used, and only 20 columns; the curved shape is due to the Pantographic mechanism, an early ergonomic device allowing operators to punch 500 cards per day with good accuracy and minimal physical strain (compared to the handheld "train conductor" punches used in previous trials, which could cause near paralysis with prolonged use -- carpal tunnel syndrome did not start with PCs! -- and with which correct placement of holes was problematic). The Pantographic punch operator positioned a stylus over the desired hole in the template and pressed it to punch a hole in the corresponding position of the rectangular card. The template has areas marked off for various demographic categories.




Above: A punched card from the 1890 census Note that one corner is cut diagonally to protect against upside down and/or backwards cards that might not otherwise be detected. The card measures 3.25 by 7.375 inches, the same size as the 1887 US paper currency because Hollerith used Treasury Department containers as card boxes (pictures not actual size, but all to the same scale):

The modern, standard, corner-cut, 80-column general-purpose IBM punch card, introduced in 1928, and popularly known as the "IBM card". Holes in the 80-column card are rectangular, rather than round as in earlier models. The bottom ten rows are labeled with digits; the top two rows are unlabeled and are used in an alphanumeric character code first standardized (by IBM) in 1931 as BCDIC, a 40-character set that included digits, uppercase A-Z, space, minus sign, asterisk, and ampersand, eventually expanded to a large family of 256-character Extended BCDIC (EBCDIC) codes, IBM's Country Extended Code Pages.

This type of card was a mainstay of data processing and computing from 1928 through the 1980s and was still in use in voting machines through the 2000 USA presidential election, in which they were discredited when the number of swing ballots might have been less than the number questionably-punched cards and therefore contested ballots (we'll never know, since they weren't counted). Although the poorly punched cards were due primarily to unmaintained machines (many of them more than 40 years old), most localities resolved to replace punched-card technology with something more modern, like optical scanners. Whether the new technology is more reliable, accurate, cost effective, durable, and resistent to fraud and tampering remains to be seen. In any case, punched cards are still used in data processing today -- or at least as late as 1999, when THIS ARTICLE was written -- and the last remaining manufacturer of punched-card equipment, Cardamation Company, is still in business.

## INTEL PENTIUM

It is a very well known fact that the contemporary advancements in many engineering disciplines benefited from the emergence of microcomputing facilities. The development of microprocessors is therefore a landmark in the engineering culture.

See the example below:

| **Processor**  | Intel® Pentium® 4 Processor Supporting HT[†] Technology | | Intel® Pentium® 4 Processor |
|---|---|---|---|
| **Processor Number**[Δ] | 560, 550, 540, 530, 520 | NA | NA |
| **Architecture** | 90 nm process technology | 90 nm, 130 nm process technology | 90 nm, 130 nm, 180 nm process technology |
| **L2 Cache** | 1MB | 512KB, 1MB | 256KB, 512KB, 1MB |
| **Clock Speed** | 2.80 to 3.60 GHz | 2.40 to 3.40 GHz | 1.30 to 2.80 GHz |
| **Front Side Bus** | 800 MHz | 800 MHz | 400, 533 MHz |
| **Chipset –; 800 MHz system bus** | Intel® 925X Express, 915G Express, 915GV Express, 915P Express chipsets | Intel® 875P, 865PE, 865G, 865GV, and 848P chipsets | NA |
| **Chipset –; 533 MHz system bus** | Intel® 910GL chipset | Intel® 865P, 850 chipset family, 850E, 845PE, 845GE, 845GV, 845E and 845G chipsets | Intel® 865P, 850 chipset family, 850E, 845PE, 845GE, 845GV, 845E and 845G chipsets |
| **Intel® Desktop Boards** | Compatible with Intel Pentium 4 processor | Compatible with Intel Pentium 4 processor | Compatible with Intel Pentium 4 processor |
| **Hyper - Threading Technology**[†] | Yes | Yes | NA |

| | | | |
|---|---|---|---|
| **Recommended Applications** | • Digital Photography<br>• Digital Music<br>• Digital Video<br>• Gaming<br>• Digital Home apps<br>• Business Productivity and Solutions | • Multimedia applications | |
| **Features** | Intel NetBurst microarchitecture | | |

**MOUSE**

> "It would be wonderful if I can inspire others, who are struggling to realize their dreams, to say 'if this country kid could do it, let me keep slogging away'." - **Douglas Engelbart**

In 1964, the first prototype computer mouse was made to use with a graphical user interface (GUI), 'windows'. Engelbart received a patent for the wooden shell with two metal wheels (computer mouse U.S. Patent # 3,541,541) in 1970, describing it in the patent application as an "X-Y position indicator for a display system." "It was nicknamed the mouse because the tail came out the end," Engelbart revealed about his invention. His version of windows was not considered patentable (no software patents were issued at that time), but Douglas Engelbart has over 45 other patents to his name.

Throughout the '60s and '70s, while working at his own lab (Augmentation Research Center, Stanford Research Institute), Engelbart dedicated himself to creating a hypermedia groupware system called NLS (for oNLine System). Most of his accomplishments, including the computer mouse and windows, were part of NLS.

In 1968, a 90-minute, staged public demonstration of a networked computer system was held at the Augmentation Research Center -- the first public appearance of the mouse, windows, hypermedia with object linking and addressing, and video teleconferencing.

Douglas Engelbart was awarded the 1997 Lemelson-MIT Prize of $500,000, the world's largest single prize for invention and innovation. In 1998, he was inducted into the National Inventors Hall of Fame.

Currently, Douglas Engelbart is the director of his company, Bootstrap Institute in Fremont, California, which promotes the concept of Collective IQ. Ironically, Bootstrap is housed rent free courtesy of the Logitech Corp., a famous manufacturer of computer mice.

In 1964, the first prototype computer mouse was made to use with a graphical user interface. Douglas Engelbart's computer mouse received patent # 3,541,541 on November 17, 1970 for a "X-Y Position Indicator For A Display System"

## ETHERNET CARD AND INTERNET

Personal computers hadn't even hit the mass market when researchers started working on what would later prove to be the second phase of the PC revolution: linking these machines to a network. 1977 is widely seen as the year of the PC's big arrival, but Ethernet - the technology that today ties tens of millions of PCs into LANs - was invented four years earlier, in the spring of 1973.

The source of this foresight was Xerox Corp.'s Palo Alto Research Center (Parc). In 1972, Parc researchers were working on both a prototype of the Alto computer [Flashback, June 14] - a personal workstation with a graphical user interface - and a page-per-second laser printer. The plan was for all Parc employees to have computers and to connect the entire computer to the laser printer.

The task of creating the network was assigned to Bob Metcalfe, an MIT graduate who had joined Xerox that year as the self-described "networking guy." As Metcalfe says, the two novel requirements of this network were that it had to be very fast to accommodate the laser printer and it had to connect hundreds of computers.

Metcalfe's previous experience as a student gave him a great head start in networking. "My Harvard Ph.D. dissertation, based on my research at MIT, was about the Arpanet and the Alohanet," which was a packet radio network at the University of Hawaii, he says.

By the end of 1972, Metcalfe and a number of other Parc researchers had completed an experimental 3M bit/sec. PC LAN. The following year, Metcalfe defined the general principles of what he called Ethernet, the technology that made the first PC LAN possible. That same year marked the birth of the first Ethernet board, which you could place in a PC to create a network.

Ethernet defines the wires-and-chips aspects of PC net-working as well as the software aspects of how data is transmitted. A key concept is its system of collusion-detection and recovery, called CSMA/CD, or Carrier Sense Multiple Access with Collision Detect.

With this protocol, devices transmit only after finding the data channel clear. If two devices transmit simultaneously, causing a collision, they delay their retransmissions for a random length of time.

Metcalfe first called the network the "Alto Aloha Network." When he changed the name, he based it on the idea of "lumeniferous ether," the medium that scientists once thought carried electromagnetic waves through space.

Xerox produced hundreds of Ethernet boards that it used internally to access the lab's central minicomputer, access the Arpanet, send and receive e-mail, play games and share files, Metcalfe says.

It wasn't until 1979 that momentum gathered for Ethernet to become a widely agreed upon 10M bit/sec. commercial standard. At that point, Metcalfe had left Xerox and was meeting with Gordon Bell at Digital Equipment Corp. about helping Digital create its own LAN. Instead of coming up with something new, they decided to propose to Xerox that the two companies work together to make Ethernet a standard.

By June, Metcalfe had gotten Intel Corp., Digital and Xerox to agree to work on using Ethernet as the standard way of sending packets in a PC network. "Only then did it dawn on me that Ethernet would be a successful standard worth building a company around," Metcalfe says.

Thus 3Com Corp. was born. Now a $54 billion company, 3Com introduced its first product, EtherLink - the first PC Ethernet network interface card, in 1982. Early 3Com customers included Trans-America Corp. and the White House.

Ethernet gained popularity in 1983 and was soon named an international standard by the Institute of Electrical and Electronics Engineers Inc. But one major computer force did not get on board: IBM, which developed a very different LAN mechanism called Token Ring. Despite IBM's resistance, Ethernet went on to become the most widely installed technology for creating LANs. Today there's Fast Ethernet, which runs at 100M bit/sec., and Gigabit Ethernet, which promises 1G bit/sec. rates.

Looking back, Metcalfe says he would have used different methods to convince IBM of Ethernet's merits.

"I would have recruited major IBM customers to help me demand it from IBM," he says. "And it didn't help that I routinely attacked IBM as being a slow-moving monopoly - much as I now attack telephone companies and Microsoft - so I have not learned my lesson entirely."

## COMPACT DISC (CD)


Image of a compact disc (pencil included for scale)

A **compact disc** (or **CD**) is an optical disc used for storing digital data. It was originally invented for digital audio and is also used as a data storage device, a CD-ROM. CD-ROM reading devices are a standard component of most modern personal computers. In general, audio CDs are distinct from CD-ROMs, and CD players intended for listening to audio cannot make sense of the data on a CD-ROM, though personal computers can generally play audio CDs. It is possible to produce composite CDs containing both data and audio with the latter capable of being played on a CD player, whilst data or perhaps video can be viewed on a computer. Lately, with the advent of MP3 technology, audio player devices have been developed that can load and play MP3-formatted files from CD-ROM discs. The advantage of MP3 is that it reduces the amount of space required to store audio by around ten times, thereby increasing maximum playback time per disc from around 74 minutes to more than 700 without significant degradation in sound quality.

The compact disc was developed in 1979 by Philips and Sony. Philips invented the general manufacturing process, based on their earlier Laserdisc technology, whereas Sony contributed the error-correction method. 1982 saw its mass production in Langenhagen near Hanover, Germany. Microsoft and Apple Computer were early enthusiasts and promoters of CD-ROMs. John Sculley, CEO of Apple at the time, said as early as 1987 that the CD-ROM would revolutionize the use of personal computers.

Compact discs are made from a 1.2 mm thick disc of polycarbonate plastic coated with a much thinner aluminum (originally gold) layer which is protected by a film of lacquer. The lacquer can be printed with a label. Common printing methods for compact discs are silk screening and offset printing. CDs are available in a range of sizes but the most commonly available is 120 mm (about 5 inches) in diameter. A 120 mm disc can store about 74 minutes of music or about 650 megabytes of data. Discs that can store about 700 megabytes (80 minutes of music) have become more common however. There are also less common 90, 99 and 100 minute discs, but they are not compatible with all CD writers or readers. The mini-CD (not to be confused with the similar MiniDisc) is 80 mm (about 3 1/8 inches) in diameter, holds about 184MB of data or 21 minutes of audio, and has the exact same data format as the larger one. Yet another version of the CD has a mini-CD trimmed down to fit in with business cards.

The data format of the disc, known as the 'Red Book' standard, was laid out by the Dutch electronics company Philips, who own the rights to the licensing of the 'CDDA' logo that appears on the disc. In broad terms the format is a two-channel (left and right, for stereo) 16-bit PCM encoding at a 44.1 kHz sampling rate. Reed-Solomon error correction allows the CD to be scratched (to a certain degree) without degradation of the contents.

The information on a standard CD is encoded as a spiral track of *pits* molded into the top of the polycarbonate layer. Each pit is approximately 125 nm deep by 500 nm wide, and varies from 850 nm to 3.5 µm long. The spacing between the tracks is 1.5 µm. A CD is read by shining light from a 780 nm wavelength semiconductor laser through the bottom of the polycarbonate layer, and monitoring the light reflected by the aluminum coating. The light from the laser forms a spot of approximately 1.7 µm diameter on the metal surface. Since the CD is read through the bottom of the disc, each pit appears as an elevated *bump* to the reading light beam. The areas without bumps are known as *land***.** The spiral begins at the center of the disc and proceeds outwards to the edge. This allows the different size formats available.

To grasp the scale of the pits and land of a CD, if the disc is enlarged to the size of a regular stadium, a pit would have approximately the size of a grain of sand.

Light striking the land areas is reflected normally and detected by a photodiode. Light striking a bump, however, undergoes destructive interference with light reflecting from the land surrounding the bump and no light is reflected. This occurs because the height of each bump is one quarter of the wavelength of the laser light (in the polycarbonate medium), leading to a half-wavelength phase difference in light reflecting from the land to that of light reflecting from the bump.

The compact disc specification does not include any copy protection mechanism and discs can be easily duplicated or the contents "ripped" to a computer. Starting in early 2002, attempts were made by record companies to market so-called 'copy-protected' compact discs. These rely on deliberate errors being introduced into the data recorded on the disc. The intent is that the error-correction in a music player will enable music to be played as normal, while computer CD-ROM drives will fail with errors. This approach is the subject of an evolutionary arms race or cat-and-mouse game - not all current drives fail, and copying software is being adapted to cope with these damaged data tracks. The recording industry then works on further approaches.

Philips has stated that such discs, which do not meet the Red Book specification, are not permitted to bear the trademarked *Compact Disc Digital Audio* logo. It also seems likely that Philips' new models of CD recorders will be designed to be able to record from these 'protected' discs.

Injection molding is used to manufacture compact discs. A 'stamper' is made from the original media (audio tape, data disc, etc.) by writing to a photosensitive dye with a laser. This dye is then etched, leaving the data track. It is then plated to make a positive version of the CD. Polycarbonate is liquefied and injected into the mold cavity, where the stamper transfers the pattern of pits and lands to the polycarbonate disc. The disc is then metallized with aluminum and lacquer coated.

However there are also CD-recordable discs, which can be recorded by a laser beam using a CD-R writer (most often on a computer, though standalone units are also available), and can be played on most compact disc players. CD-R recordings are permanent and cannot be recorded more than once, so the process is also called "burning" a CD.

CD-RW is a medium that allows multiple recordings on the same disc over and over again. A CD-RW does not have as great a difference in the reflectivity of lands and bumps as a pressed CD or a CD-R, so many CD audio players cannot read CD-RW discs, although the majority of standalone DVD players can.

Recordable compact discs are injection molded with a "blank" data spiral. A photosensitive dye is then applied, and then the discs are metallized and lacquer coated. The write laser of the CD burner changes the characteristics of the dye to allow the read laser of a standard CD player to see the data as it would an injection molded compact disc.

## 1.7. ENGINEERING DISASTERS

### (A) NUCLEAR DISASTERS

#### Three Mile Island

At 4:00 AM on March 28, 1979, a reactor at the Three Mile Island nuclear power facility near Harrisburg, Pennsylvania suddenly overheated, releasing radioactive gases. During the ensuing tension-packed week, scientists scrambled to prevent the nightmare of a meltdown, officials rushed in to calm public fears, and thousands of residents fled to emergency shelters. Equipment failure, human error, and bad luck would conspire to create America's worst nuclear accident.

It was never supposed to happen. In the predawn hours of March 28, 1979, a pressure valve suddenly malfunctioned at the Three Mile Island nuclear power plant near Harrisburg, Pennsylvania. What occured next--a combination of technical failure, human error, and bad luck--would result in the worst nuclear accident in American history. For five nerve-wracking days, engineers struggled to control a runaway reactor, government officials debated whether to evacuate the area, and residents contemplated the ultimate horror of a nuclear meltdown.

Meltdown at Three Mile Island carefully re-examines step-by-step this national disaster which still haunts many Americans, and which dealt a crippling blow to the nation's nuclear power industry. Meltdown at Three Mile Island is produced by Chana Gazit (Surviving the Dust Bowl and Chicago 1968) and David Steward, and narrated by Liev Schreiber.

For nearly a year the nuclear plant had been quietly generating electricity in the middle of the Susquehanna River. Located just ten miles from the state capital of Harrisburg, Three Mile Island was within 100 miles of Philadelphia, Baltimore, and Washington, DC. People in the surrounding communities had grown accustomed to the concrete fortress with its giant cooling towers. "I was just amazed, wide-eyed looking at the thing, and it was just neat," says Mike Pintek, a local resident and journalist. "It was high technology and this was going to be power that was too cheap to meter."

The accident started at the plant's Unit 2 reactor when a small valve failed to close, causing cooling water to drain from the nuclear core. The core quickly began to overheat. Confronted by baffling and contradictory information, plant operators shut off the emergency water system that would have cooled the core. Within minutes, the mammoth control console was "lit up like a Christmas tree," one operator recalls. Hundreds of flashing lights were accompanied by piercing horns and sirens.

By early morning Wednesday, March 28, the exposed part of the core was beginning to cook as temperatures in the reactor reached 4,300 degrees Fahrenheit--dangerously close to meltdown. Yet operators remained convinced that the core was covered and safe. "We had a mindset that said we had these marvelous safety systems which had back-ups of back-ups," says Bob Long, a supervising engineer at Three Mile Island. "It was hard for people to really come to grips with the reality that severe damage had occurred."

But when contaminated water leaked into an adjoining building and started to release radioactive gases inside the plant, Three Mile Island's supervisor declared the first general emergency ever to arise at a nuclear power plant in the United States.

Word of the accident first reached the public in a radio report. Lieutenant Governor William Scranton assured everyone that the owner of the plant, Metropolitan Edison, had the situation under control, and no radiation had been released outside the plant. As Scranton left the podium, he learned that a release had in fact occurred; he had been misled. "It was at that point I realized," says Scranton, "that we could not rely on Metropolitan Edison for the kind of information we needed to make decisions."

Frightened residents didn't know whom to believe either. Just days earlier, Hollywood had released The China Syndrome, a film about a potential meltdown at a nuclear power plant. In it, an area the size of Pennsylvania is threatened with annihilation. For residents, life was now imitating art. "My sister called from LA," remembers Robin Stuart, "saying `Get out, hurry up and get out.'" More than 500,000 people now faced a decision: pack up and evacuate the area, or stay and stick it out.

The evacuation plans that Governor Dick Thornburgh had inherited were almost useless; one would have sent residents of two counties racing toward each other across a bridge. Thornburgh feared setting off public hysteria, but by Friday, March 30, he felt he had no choice but to advise pregnant women and school-age children to leave the area. His announcement unleashed a wave of panic as residents tossed a few belongings into their cars and sped off. More than 140,000 would eventually flee.

Friday also brought a new, more terrifying revelation: a hydrogen bubble had formed above the reactor core. Over the weekend, scientists from the Nuclear Regulatory Commission argued about whether the bubble might explode at any minute. Now even the journalists covering the story were on the verge of hysteria. During Sunday Mass, one Roman Catholic priest offered general absolution. "This is a sacrament reserved when death is imminent," recalls Victor Stello, a senior NRC engineer who was in the congregation. "What we had done to these people was just outrageous. We had frightened them so bad, they thought they were going to die."

A few hours later, President Jimmy Carter arrived. As his motorcade made its way to Three Mile Island, emotionally drained residents lined the street. "They stood there and cheered," relates journalist Mike Gray, "because he was with them."

Carter's visit would mark the end of the crisis. That afternoon, scientists finally determined that the hydrogen bubble posed no immediate threat, and that the reactor core had stabilized. Gradually, residents began returning to their homes. Although they were told that an insignificant amount of radiation had been released during the accident, they would be plagued by doubts for years to come.

Three years after the accident, a robotic camera was lowered into the Unit 2 core, providing the first look at what really had happened. Roger Mattson, a senior NRC engineer, describes what was revealed: "We had a meltdown at Three Mile Island. Fifty percent of the core was destroyed or molten and something on the order of twenty tons of uranium found its way to the bottom head of the pressure vessel. That's a core meltdown. No question about it."

**Chernobyl**

On April 25th -26th, 1986 the World's worst nuclear power accident occurred at Chernobyl in the former USSR (now Ukraine). The Chernobyl nuclear power plant located 80 miles north of Kiev had 4 reactors and whilst testing reactor number 4 numerous safety procedures were disregarded. At 1:23am the chain reaction in the reactor became out of control creating explosions and a fireball which blew off the reactor's heavy steel and concrete lid.

*A monument to the victims of the Chernobyl disaster at Moscow's Mitino cemetery, where some of the firefighters who battled the flames and later died of radiation exposure are buried.*

The Chernobyl accident killed more than 30 people immediately, and as a result of the high radiation levels in the surrounding 20-mile radius, 135,000 people had to be evacuated.

The Chernobyl power plant is about 7 km from the border with Belarus, while about 100 km to the south lies Kiev, the capital of Ukraine, with a population of 3.1 million. The reactor complex, which has been inactive since 12 December 2000, stands by the river Pripyat, which joins the Dnieper at the town of Chernobyl, 12 km away.

In the night of 25 to 26 April 1986, the explosion of the reactor in Chernobyl, the greatest industrial disaster in the history of humankind, released one hundred times more radiation than the atom bombs dropped over Hiroshima and Nagasaki. In addition to the reactor's immediate surroundings - an area with a radius of about 30 km - other regions were contaminated, particularly in Belarus, Russia and Ukraine.

The contaminated territories lie in the north of Ukraine, the south and east of Belarus and in the western border area between Russia and Belarus. International estimates suggest that a total of between 125 000 and 146 000 km$^2$ in Belarus, Russia and Ukraine are contaminated with caesium-137 at levels exceeding 1 curie (Ci) or 3.7 x 1010 becquerel (Bq) per square kilometre. This is an area greater than that of the neighbouring countries of Latvia and Lithuania combined. At the time of the accident, about 7 million people lived in the contaminated territories, including 3 million children. About 350 400 people were resettled or left these areas. However, about 5.5 million people, including more than a million children, continue to live in the contaminated zones.

Caesium-137 (half-life 30 years) was the most widely distributed long-lived radioactive element after the accident. Maps and descriptions of the contaminated territories therefore usually refer to caesium-137, giving the contamination per square kilometre either in the old unit, curies (Ci), or in becquerels (Bq). Both units indicate how much radiation is measured by Geiger counters in these areas. A becquerel is equivalent to one radioactive disintegration per second. 1 Bq = 27 trillionths of a curie (picocuries).


*A photograph of one of the lava-flows formed by corium Fuel containing mass in the basement of the Chernobyl plant. 1 is the lava flow, 2 is concrete, 3 is a steam pipe and 4 is some electrical equipment.*

The value "over 1 Ci/km2 caesium-137" does not in itself indicate how much radiation is absorbed by the people living in these areas. The authorities responsible for managing the disaster in the three countries affected estimate that people living in an area contaminated with 1 to 5 Ci/km$^2$ absorb an average of less then 1.0 millisieverts per year. Sieverts (Sv) or millisieverts (mSv) are the internationally recognised units used to measure the harmful effects of radiation on the human body (biologically effective dose).

Only when soil contamination is over 5 Ci/km$^2$ are people likely to absorb more than 1 to 5 mSv per year. As a comparison: Within the European Union, 1 mSv per year is the dose limit specified for people living near a nuclear power station.

Most of the contaminated territory lies in Belarus, since up to 70 per cent of the total fallout was deposited here. Of the total area of Belarus, 22 per cent was contaminated with more than 1 Ci/km$^2$ caesium-137. At the time of the accident, 2.2 million people lived in these areas, one fifth of the population of Belarus. 7.25 per cent of Ukraine's territory was contaminated following the accident, and 0.6 per cent of the Russian Federation.

Because of variable weather conditions in the days following the accident, radiation also spread over large parts of Scandinavia, Poland and the Baltic states, as well as southern Germany, Switzerland, northern France and England.

### Causes of the Chernobyl Accident

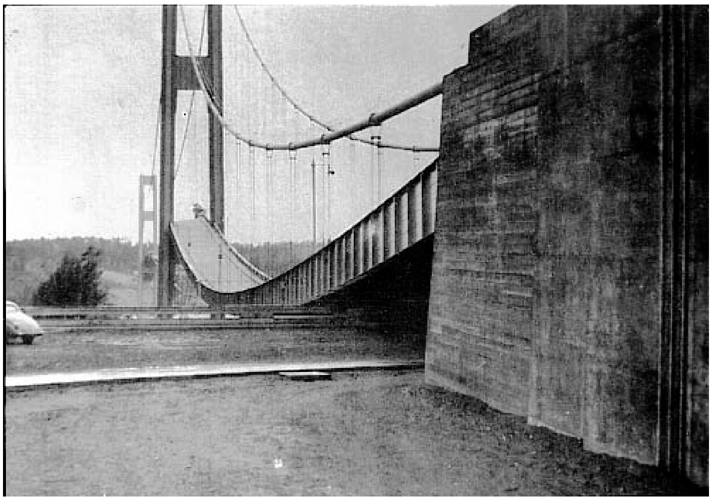
- **Lack of a 'Safety Culture'** - The organisations responsible for the Chernobyl Nuclear Power plant lacked a 'safety culture' resulting in an inability to remedy design weaknesses despite being known about before the accident. A secret USSR memorandum in the Russian archives "Chernobyl Construction Weaknesses" clearly illustrates this fact.
- **Design Fault In The RBMK Reactor -** The RBMK reactor type used at Chernobyl suffers from instability at low power and thus may experience a rapid , uncontrollable power increase. Although other reactor types have this problem they incorporate design features to stop instability from occurring. The cause of this instability is:

  - Water is a better coolant than steam
  - The water acts as a moderator and neutron absorber (slowing down the reaction) whilst steam does not.

  Excess steam pockets in the RBMK design lead to increased power generation this is known as a positive void coefficient. This excess power causes additional heating thus producing more steam and means less neutron absorption causing the problem to escalate. This all happens very rapidly and if it is not stopped quickly it is very hard to stop as it supplies itself.
- **Violation Of Procedures -** While running a test of the reactor numerous safety procedure were violated by the station technicians.
  - Only 6 - 8 control rods were used during the test despite there been a standard operating order stating that a minimum of 30 rods were required to retain control.
  - The reactor's emergency cooling system was disabled.
- **Communications Breakdown -** The test was carried out without a proper exchange of information between the team in charge of the test and personnel responsible for the operation of the nuclear reactor.

### (B) EARTHQUAKE AND SIMILAR

#### Tacoma Suspension Bridge



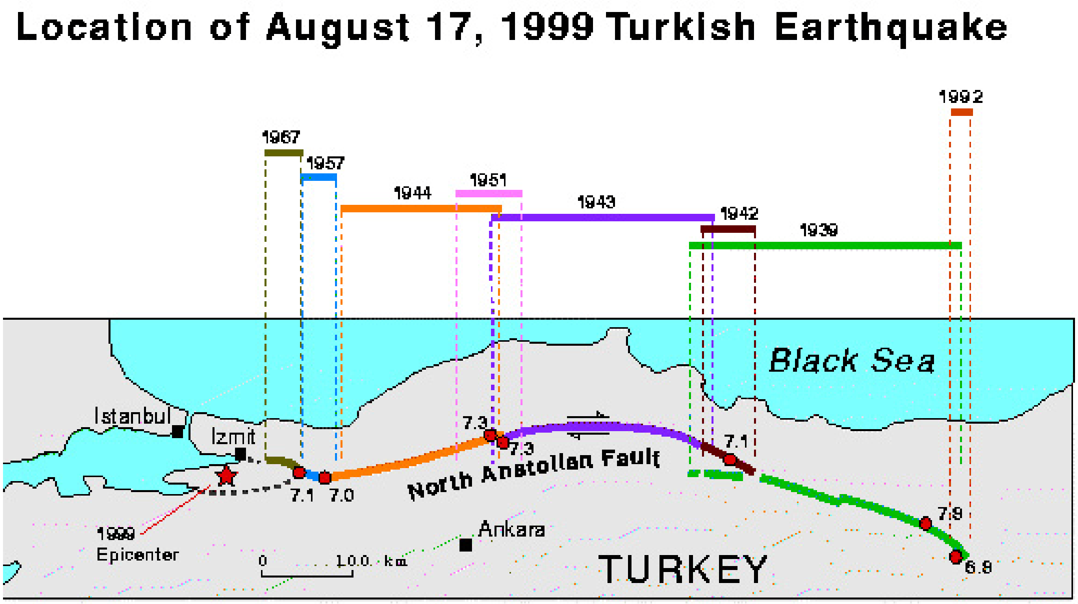
At approximately 11:00 AM, November 1940, the first **Tacoma** Narrows **suspension bridge** collapsed due to wind-induced vibrations ... near the city of **Tacoma**, Washington, USA.

**See video.**

**17 August 1999 Earthquake in Turkey**

On August 17, 1999, a devastating earthquake struck Western Turkey with an epicenter in the Gulf of Izmit. This was the strongest earthquake to strike Northern Turkey since 1967. Official estimates indicate that almost 15,000 people lost their lives. The death toll estimates are expected to rise as the earthquake occurred in a densely populated region of the country.

There were associated tsunamis. According to a Washington Post Foreign Service article by Lee Hockstader: BURSA, Turkey, It was just past 3 a.m. last Tuesday [17 August 1999] when Yuksel Er shuffled from his bedroom to extinguish the bathroom light. Er, who lives in Yalova, just south of Istanbul on the eastern shore of the Sea of Marmara had just come from the bathroom when the quake struck with a deafening roar that lasted 45 seconds. "It was awful," he said. "It was like a science fiction movie when a fireball rushes toward you and blows open your doors. I saw it coming clearly through the window in my son's room. It looked like a red fireball."




Earthquake Epicenter, Origin Time, Magnitude and Aftershocks

The epicenter of the earthquake was at 40.702 N, 29.987 E (USGS) near the town of Gölcük on the western segment of the North Anatolian Fault. It occurred at 00:01:39.80(UTC), 03:01:37 a.m local time. Surface Wave Magnitude was 7.8 (USGS); Moment Magnitude: 7.4 (USGS, Kandilli); Duration Magnitude: 6.7 (Kandilli). Body Wave Magnitude: 6.3 (USGS) . Its focal depth was 17 km (USGS).

Numerous aftershocks with magnitude above 4 were recorded. More aftershocks can be expected. Some of the aftershocks could be further damaging. A powerful aftershock struck the Izmit area on Tuesday, 31 August , killing one man, injuring at least 166 others and knocking down quake-weakened buildings. This strong tremor was followed by another 4.6 magnitude aftershock, 20minutes later. According to the USGS and Kandilli most of the aftershock activity is confined to the region bounded by 40.5-40.8N and 29.8-30.0E, which covers the area between Izmit and Adapazari to the east of the epicenter.

The excessive seismicity of this particular region can be explained by current geophysical knowledge of its structural development. The North Anatolian fault is a major fracture that transverses the Northern part of Asia Minor and marks the boundary between the Anatolian tectonic plate and the larger Eurasian continental block. Because of this unstable tectonic system the area is considered as one of the most seismically active zones of the world.

The earthquake of August 17, 1999 occurred along the long, east-west trending, great North Anatolian fault zone (NAFZ) in Northwestern Turkey. The North Anatolian Fault Zone is the most prominent active fault system in Turkey along which numerous large earthquakes have occurred throughout history. NAFZ has many similarities to the San Andreas fault system in California. As with the San Andreas, earthquakes along the Northern Anatolian Fault involve primarily horizontal ground motions. The earthquake of August 17, 1999 occurred on the northern branch of NAFZ which passes through Izmit Bay and traverses Marmara Sea and reaches to the Saros Gulf to the southeast. This a major strike-slip type of fault. This particular earthquake occurred along a section of a previously identified seismic gap where an earthquake had been expected. The earthquake occurred sooner than statistical studies had anticipated.


A team of Turkish and international scientists conducting field surveys in the area reported the earthquake's surface rupture to extend approximately 100 km east of Golcuk. Their preliminary observations indicate that the rupture from the 1999 earthquake does not appear to continue southeast and to join the rupture zone of the last 1967 earthquake. According to the preliminary reports the rupture turns northeast to near Akyazi, where there has been a cluster of earthquake aftershocks and ground displacements of about 1.5 m. On the average, field surveys show right lateral ground displacements which ranged from 2.5-3 m up to 4 m, with a maximum of 4.2 m measurement made east of Sapanca lake. Ground displacements between Sapanca Lake and the Izmit Gulf were reported to be 2.60 m. However, vertical downthrusting of about 2 meters has also occurred along the north block of the faulting couple, as indicated by subsidence and water inundation at Golcuk. Such vertical tectonic ground movement is typical of major earthquakes along the North Anatolian Fault and has been responsible for the generation of tsunami waves in the past.

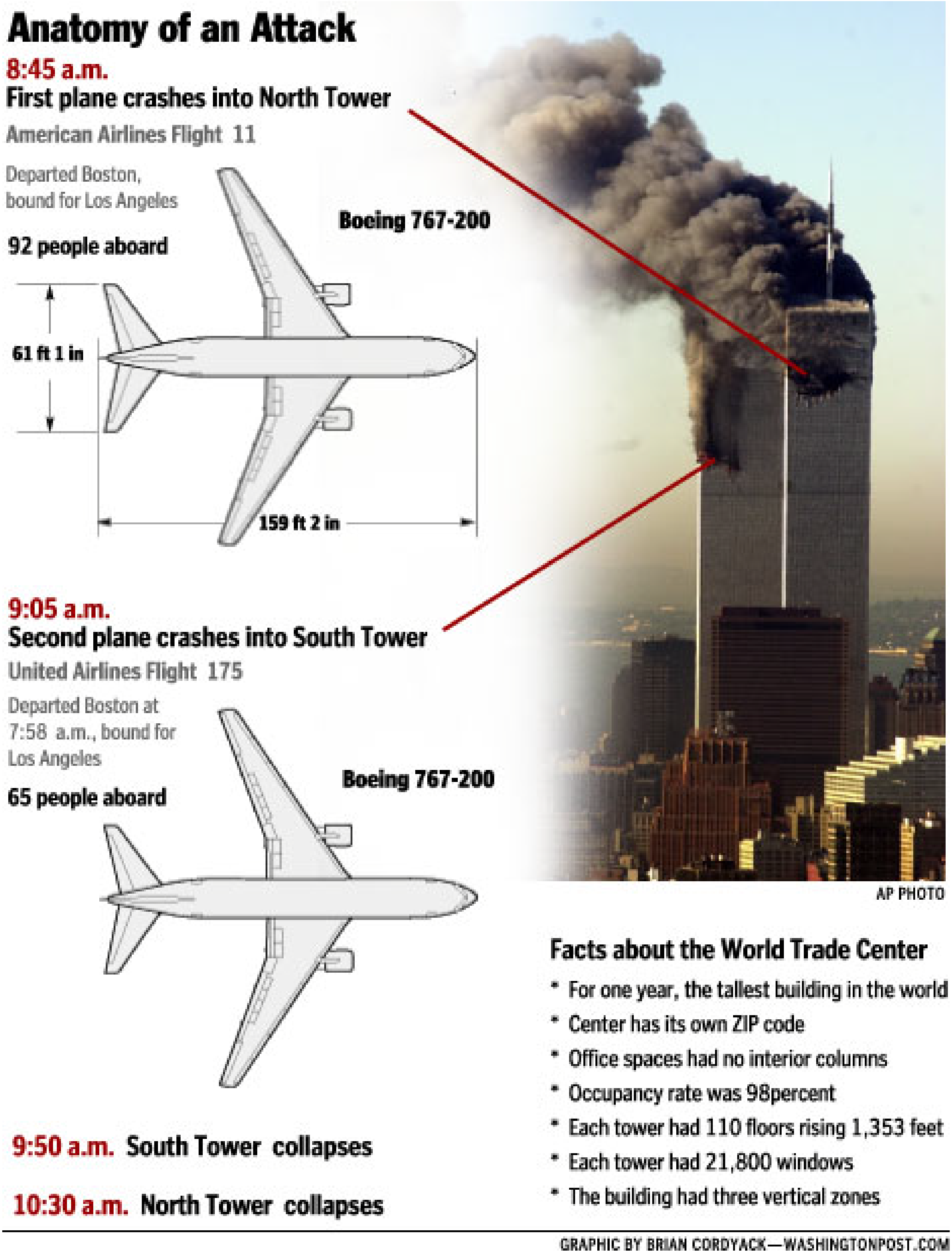
There have been numerous large earthquakes in western Turkey along the Northern Anatolian Fault in the 20th century. Beginning in 1939, large earthquakes with Richter magnitudes of over 6.7, have struck in progression along adjacent segments of the fault. The August 17, 1999 earthquake is the eleventh in the series of such events occurring in progression. Starting with the 1939 event, these series of earthquakes have broken segments of the Northern Anatolian Fault fault in both eastward and westward direction. Review of the historical seismic data shows that between 1939 and 1944 there was an active westward trend in the seismic activity with a resulting surface rupture of 600 km of adjacent fault. Subsequently, the westward trend of earthquakes slowed down. Earthquakes occurring in 1957 and 1967 ruptured an additional adjacent 100 km of fault but there was separated activity further west during 1963 and 1964. There was a long seismic gap separating the 1967 quake and the 1963 and 1964 quakes. This was the fault segment where the 1999 quake predictably occurred.

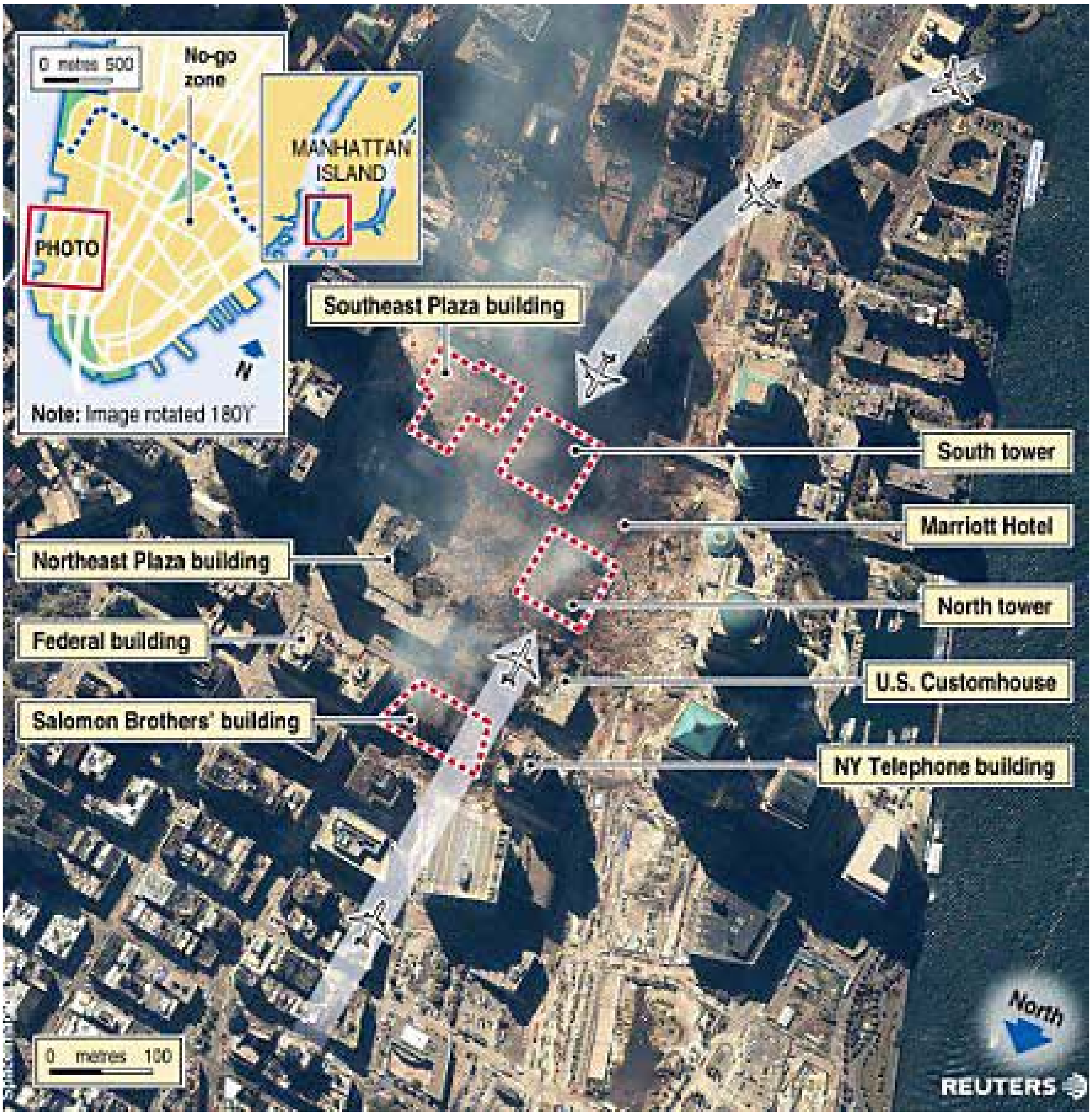
The August 17, 1999 earthquake fills in the 100 to 150 km long gap which existed between the 1967 event and the 1963 and 1964 quakes. As early as 1979, this gap was readily identified by numerous scientists as a potential site for a future earthquake. A subsequent evaluation in 1997 estimated a 12% statistical probability of an earthquake occurring in the 30 year period, from 1996 to 2026, in this region. Obviously, the statistical probability was underestimated as the earthquake occurred sooner than expected.

It appears that most of the seismic strain along this section of the North Anatolian fault was released by the August 17 earthquake. However there has been a cluster of aftershocks near Akyazi and more recently near Izmit. Many more aftershocks can be expected near Akyazi, Izmit and elsewhere along the fault area that ruptured. Most of these aftershocks will be small but occasionally a larger one could be expected. Given the preliminary measurements of 1.5 meter ground displacements in the Akyazi area, versus the larger displacements elsewhere, it is quite possible that all the seismic strain was not released by the August 17 event and that some future seismic event will release the remaining strain. This however may not happen for many more years.

It is believed that earthquakes occuring along the Western portion of the Northern Anatolian fault zone can generate destructive tsunami waves in the Sea of Marmara. A number of grabbens, fault offsets and other structural topomorhological features at the bottom of the Sea of Marmara indicate that seismic activity and movements of branches of the North Anatolian fault extend under the sea. Even an earthquake on land or a large aftershock could trigger a landslide in unconsolidated deposits or sediments along the coast. The tsunami danger is more pronounced in the eastern region of the Sea of Marmara and particularly in the Gulf of Izmit. The tsunami risk for the Sea of Marmara needs to be carefully evaluated. Obviously, government authorities will have to do some serious review of what measures must be taken to mitigate the effects of future earthquakes and possible tsunamis in the area. Better construction and building codes will definitely help.

**9/11 Twin Towers**

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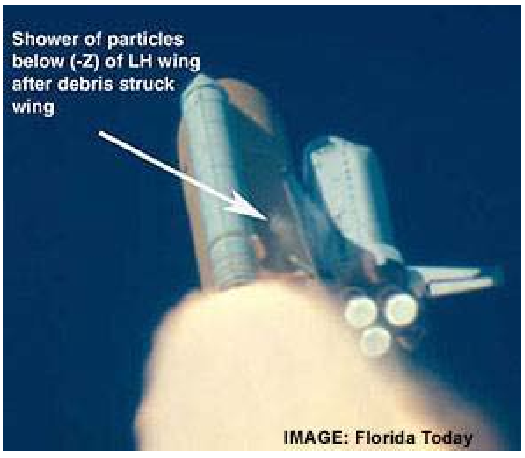
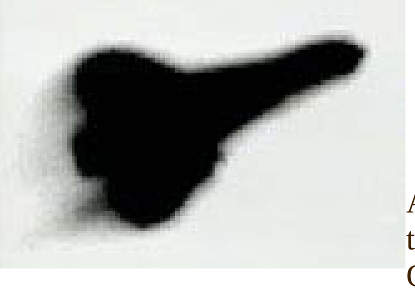
## (C) OTHERS

### Space Shuttle Columbia



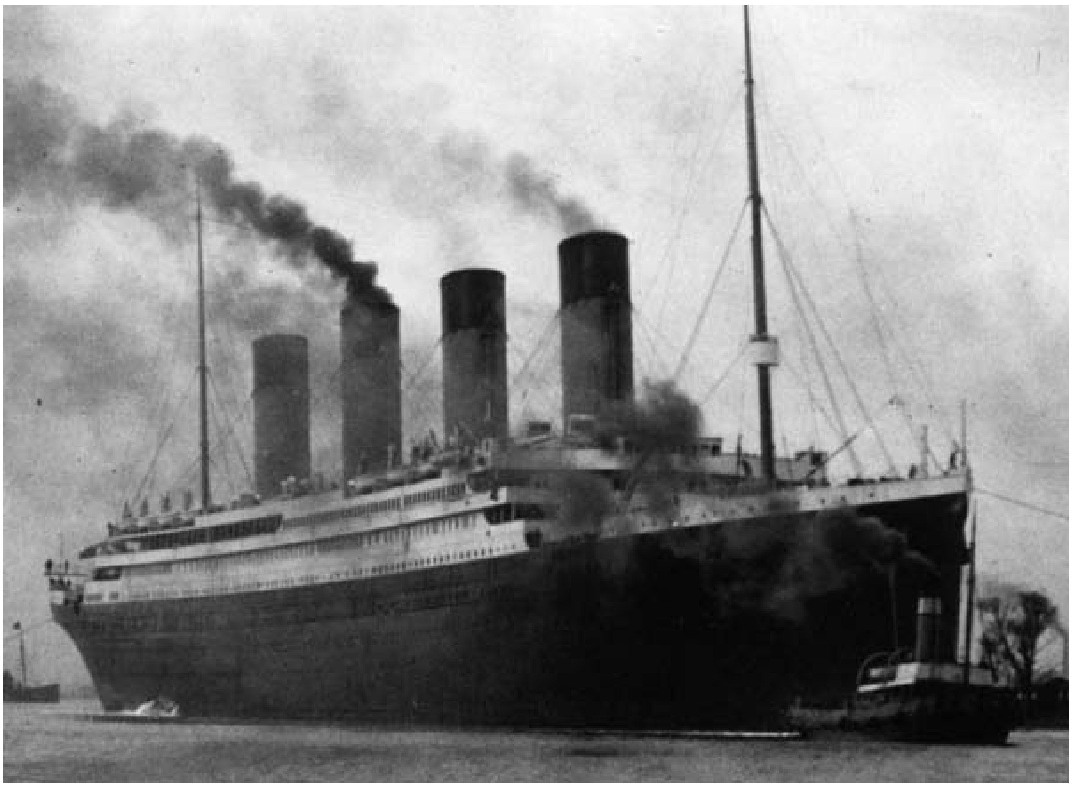

The cause of the accident was not immediately apparent. By the time the board concluded its five-month investigation, their was little, if any, doubt among investigators about the physical cause of the accident: Columbia attempted to re-enter and land the morning of Feb. 1, 2003 with a breach in its left wing inflicted some 16 days earlier by a breakaway chunk of **foam** 81.7 seconds after liftoff. Foam insulation is sprayed onto the the external fuel tanks in a gooey form and then becomes hard as a brick but light, like Styrofoam. It keeps the liquid hydrogen and the liquid oxygen fuel super cold. Shuttles ride these 15-story tanks during liftoff, then the tanks separate.



A photo of Columbia taken from the Starfire Optical Range shows what might be a jagged leading edge of the left wing and a plume behind it. Contrary to early reports, the photo was not taken with any sort of advance military technology.

**Titanic**

Titanic was the biggest moving object ever build. She was not only biggest but also backed with superior quality and performance. Titanic was the property of Whitestar corporation, based in Britain. unfortunately this company doesn't exist anymore.




At the turn of the twentieth century Great Britain was pre-eminent; her largest shipping companies, Cunard and White Star, since the earliest days of transatlantic travel, battled for the greatest share of passenger business. By 1902 White Star had been purchased by J. Pierpont Morgan's International

Mercantile Marine Company (IMMC) whose dream was to monopolize North Atlantic shipping, eliminating competition and standardize the cost of travel and freight.

The reason for building these enormous floating palaces is easy to understand. Economy of size meant a steamship line operating two big ships would save more money than three or even four smaller, older vessels. The company profited in time and money benefiting wages, turnaround time, cargo and passenger receipts.

With White Star and other British lines in the hands of the American-owned IMMC, the British Mercantile Marine[1]s reputation and national pride were at stake. The Cunard Line was unable to build new ships without financial help. The British Government rewarded the company with a $10 million low interest loan repayable over twenty years provided the company remained in British hands. The loan led to the construction of Lusitania and Mauretania, technological triumphs of the Edwardian era, when they entered service in 1907.

Without Cunard, the IMMC lost the ability to fix prices and eliminate competition, however a price war broke out in the Morgan Combine of shipping lines and by 1908 an emigrant could book passage to America for as little as $10. The situation became so serious that talks were forced among the companies forming the Atlantic Conference which led to the situation Morgan had initially planned price stability. The price war cost the IMMC dearly; Ismay believed the solution to the threat of competition, notably Cunard, was to build larger and finer ships. He decided to replace the older ones operating between Southampton and New York with a new class of ocean giants. The first Olympic, would begin a new era of luxury travel; Titanic was next incorporating various improvements learned from the operation of her sister. A third, as yet unnamed sister which became Britannic would complete an incomparable trio.

At the shipyards of Harland & Wolff at Belfast, Ireland the new liners were protected with a double-bottom and sixteen watertight compartments formed by fifteen bulkheads running across the ship. (A deficiency of those compartments was not closing them off at the top, a major factor in Titanic's sinking.) Watertight doors in the bulkheads could be closed instantly by an electric switch on the bridge. Should any two of the largest compartments become flooded, the liner could remain afloat indefinitely. The system of divided compartments, double-bottom and sheer size led the White Star Line and their builders to boast that Olympic and Titanic were "practically unsinkable" It's interesting to note, the 1908 Souvenir edition of "The Shipbuilder", Mauretania was advertised: "Practically Unsinkable owing to the Watertight Bulkhead Doors being hydraulically controlled by the Stone-Lloyd System" and when Mauretania was first commissioned, she carried only sixteen lifeboats. However the Titanic disaster is what people remember and in the process of editing company literature in newspapers and other publications, the word "practically" was dropped and the myth of "unsinkable" was born.

Famous buildings were compared with their height and length of the new ships. At 882 feet, they were longer than New York's mammoth skyscraper, the Woolworth Building by one hundred and thirty feet. The floating palaces surpassed anything on the North Atlantic in size and luxury. Passenger entertainment and diversion were provided by a squash racquet court, a Turkish bath, a fully equipped gymnasium, a plunge (swimming) pool, a Parisian style café and libraries. There were four electric elevators (three in first and one in second class) and, for the wealthiest passengers there were deluxe suites with a private promenade.

Only the privileged could take advantage of these luxurious accommodations which cost as much as $4,350 in high season (Summer) for the six day crossing. On board ship meals are included in the ticket price; the first class passengers' dining (saloon) room was styled in magnificent Jacobean surroundings. For those who wanted to dine in an exclusive setting where meals were charged extra and served on fine china, silverplate and glassware, the à la carte restaurant in Louis Seize motif, French walnut paneling and richly gilded carvings was for the select few.

On Wednesday, April 10, 1912, the four buff-colored funnels of the Royal & United States Mail Steamer Titanic glistened in the bright spring morning. Gathered along the quayside was merry crowd of well-wishers bidding farewell to friends and relatives. Among those boarding was nine year old Frank Goldsmith from Strood, Kent, who was leaving England with his parents and some neighbors to live in Detroit Michigan. People standing on the pier gazed in awe at the giant liner towering over them; she was the largest liner in the world.

None of the passengers or bystanders realized the preparations for Titanic's maiden voyage had been laden with difficulties. A national coal strike left the new ship without enough coal for the voyage to New York. Other liners had the same problem but gave up their meager reserves for Titanic. The laborious work of removing coal by hand, from one ship into Titanic's bunkers was a dirty business and it was necessary to clean the new liner from stem to stern.

Despite the extra work, shortly after noon the "all ashore" whistle sounded, and among goodbyes and bon voyages, gangplanks were removed and soon the sleek liner inched her way from the White Star Dock to begin her passage down Southampton Water across the Channel to Cherbourg, then a stop at Queenstown before finally heading to the open sea.

As Titanic was getting underway, she passed the American liner, S. S. New York moored at the quay, the smaller ship began straining at her lines drawn by the invisible suction from the Titanic's three mammoth propellers, driven by a power plant capable of 55,000 horsepower. Abruptly, loud reports shattered the lighthearted mood. The three-inch steel hawsers securing New York to her moorings snapped, recoiling through the air landing within a few feet of startled onlookers. New York's stern swung out towards the passing White Star liner. Captain Edward J. Smith, Titanic's master who was retiring after completion of this voyage, immediately ordered the port propeller reversed. Crew members rigged collision mats and an uneasy hush fell upon the spectators. The quick action of Captain Smith and the prompt attention of the tugboats prevented the Titanic's maiden voyage ending at Southampton.

On Thursday, April 11, Titanic dropped anchor late morning off Queenstown, Ireland. The tenders Ireland and America brought more passengers, picked up mail and a few people got off including Father Frank Browne, an amateur photographer who took snapshots of shipboard activity during his one day voyage. As she weighed anchor for the last time and headed out into the Atlantic the 2,200 passengers and crew prepared themselves for the journey to New York. In terms of numbers on board this was hardly a record sailing; Titanic could carry a maximum of 3,500. Many passengers preferred to sail during the summer months especially wealthy first class passengers who did not like to travel out of season.

On the North Atlantic there were defined sea lanes or tracks which all passenger liners followed. The northern track, taken during the months of August to December was approximately 200 miles shorter than the southern track taken during the months of January to July. The winter of 1911-1912 in the Arctic had been very mild; ice floes had drifted to the Gulf Stream further south then anyone could remember and the number of icebergs was larger than normal.

Sunday, April 14th, dawned with the promise of another glorious day of bright sunshine, a calm sea and mild weather. Most passengers were settled into their shipboard routine. Besides a bracing stroll on deck there were plenty of distractions to keep passengers occupied in her splendid interiors. After breakfast in the dining saloon a Church of England service was held presided over by Captain Smith. Most passengers did not seem to notice that the lifeboat drill that morning had been canceled. In 1912 there were no mandatory rules for lifeboat rehearsals or crew musters. The British Board of Trade's regulations were outdated, failing to keep pace with the ever increasing size of passenger liners. Lifeboat capacities tonnage; as it stood the number of boats carried by Titanic exceeded the Board of Trade's requirements.

At 1:40 pm the operators' working routine was disturbed by an incoming message from the White Star liner Baltic: "Captain Smith, Titanic. Have had moderate variable winds and clear fine weather since leaving. Greek steamer Athinai reports passing icebergs and large quantities of field ice today in latitude 41.51 N. longitude 49.11 W...Wish you and Titanic all success. Commander." This particular message was handed directly to Captain Smith, who, instead of posting it in the chart room, gave it to Bruce Ismay who casually put it in his pocket. Later in the day Smith asked for it back. Smith was very aware of the danger from ice. On Friday he had received ice warnings from the French Line vessel La Touraine and on Saturday Furness, Withy & Company's steamer Rappahannock reported having passed through heavy field ice. Titanic steamed on and had passed this area without spotting any ice but messages from Baltic and the Cunard liner Caronia indicated that ice would continue to pose a threat during the voyage. Smith altered course steaming sixteen miles further south before making the turn, at the so-called "corner" and headed due west towards the Nantucket Lightship.

Approaching the iceberg danger zone, Titanic remained on course, her powerful quadruple-expansion engines and single low pressure turbine drove the liner smoothly through the water at a moderate 22.5 knots. The temperature was falling fast and by 8.55 PM it was only one degree above freezing. Second Officer Charles Lightoller sent word to the ship's carpenter John Hutchinson to see that the fresh water supply did not freeze. Soon afterwards Captain Smith entered the bridge and together with Lightoller discussed the conditions.

They noted the lack of wind and the unruffled sea. Up in the crow's nest lookouts Frederick Fleet and Reginald Lee had been told to keep a "sharp eye peeled" for small ice and growlers. The night was crystal clear; there was no moon and the sky was filled with stars. The sea looked as smooth as plate glass, paradoxically, a disadvantage for the lookouts. Without waves breaking around an iceberg's base leaving a wake, it would be hard to spot without reflective moonlight, especially if a berg was showing its dark side.

At ten o'clock, First Officer William Murdoch relieved Lightoller. The two men chatted briefly about the falling temperature, now down to 32 degrees and the emphatic reminder to the lookouts to be on their toes for any signs of icebergs. Lightoller then went below leaving Murdoch to the darkness and freezing night air. By 11:30 PM most passengers had gone to bed, but a few night owls were gathered around a card table in the first class smoking room. In the main dining saloon, stewards preparing for Monday morning breakfast, carefully arranged gleaming silverplate and fine china edged in 22k gold on immaculate damask linen. As her passengers slept or relaxed, Titanic in a blaze of light from her sidelights illuminating the ambient darkness, forged steadily ahead, speed unabated, a white wave of foam curling around her bow. The clock on the first class grand staircase decorated with a carved panel of two classical figures representing Honor and Glory crowning Time showed 11:40 PM

Sixth Officer James Moody answered the telephone; "What did you see?" "Iceberg, right ahead!" shouted Fleet. Without emotion in his voice Moody said "Thank you." replaced the receiver and called loudly to Murdoch "Iceberg, right ahead." By now the First Officer had already seen the iceberg and rushed to the engine room telegraph moving the handles to "Stop" then "Full Speed Astern" and immediately ordered "hard a starboard." Moody standing behind the helmsman, Quartermaster Robert Hitchens, replied, "hard a starboard. The helm is hard over, sir."

The 46,000-ton liner seemed to take a prolonged length of time, gradually responding to her helm and began to turn to port. Murdoch intended to order "hard a port" to bring the stern away from the iceberg but it was too late; she struck. And as the iceberg glided by, breaking iron rivet heads fastening the steel shell plates causing massive leakage below the waterline, tons of ice fell onto the deck. Murdoch closed the electric switch controlling the watertight doors. Deep inside the ship's alarm bells rang as the massive watertight doors sealed each of the liner's sixteen compartments.

Captain Smith rushed onto the bridge; "What have we struck?" he asked. "An iceberg, sir'" replied Murdoch. Then the First Officer explained what he had done. After receiving an initial report that no damage was found, Smith ordered the carpenter to go down and "sound" the ship. When he returned he had bad news that Titanic was taking on water. Soon passengers began noticing the lack of vibration from the engines and worried about the impact from the collision.

By 2:10 am Titanic's stern had risen out of the water to an upright angle. Lights still blazing, there was pandemonium below decks where inanimate objects came to life; crockery, furniture and whatever else not fastened crashed towards the bow. In the engine spaces the massive boilers tore loose from their foundations and crashed through the bulkheads. For the hundreds of terrified passengers clinging to the stern the noise must have been unimaginable. Finally, under the incredible forces the hull was being subjected to, gave way and split in two just forward of the fourth funnel. The bow section quickly sank; the stern settled back for a few moments before it rose again vertically for the final time. The stern remained motionless against the starlit sky for a few moments before it began descending two miles to the ocean floor. As the Atlantic closed over the words on her stern - TITANIC LIVERPOOL - hundreds of passengers struggled in the icy waters.

Large numbers of icebergs were all around the ship as the crew began to pick up survivors from boats scattered over several miles of ocean. Rostron reported that there was very little wreckage when he got near to the scene of the disaster; a few steamer chairs, cork lifejackets and only one body. Titanic's boats were hauled up and stowed on deck. The rescue operation had taken four hours and as the Carpathia briefly searched the area for more survivors, two memorial services were held. The first, a short prayer, for the 705 who had been rescued, the second, a funeral service for those that had died.


When Dr. Robert Ballard's expedition found the wreck on September 1, 1985 he decided to leave the area in peace, recording the discovery with photographic images. In 1986, he returned and placed a bronze memorial plaque on her stern for the Titanic Historical Society honoring those who died. He kept his promise, but since then the wreck site, considered by most a mass grave, has been stripped and several exhibitions staged in Europe and the United States have displayed an odd assortment of twisted, torn and broken objects; even personal items and clothing. We now know the motive was profit and the pettiness shown by various individuals was proven; the gravesite had been violated.

Over 1,500 lives were lost, frozen or drowned in the frigid North Atlantic. The statistics are appalling enough to read let alone the reality of such a magnificent ship sinking on her maiden voyage. Of the 1,324 passengers and 899 crew on board, at the time of the collision, only 706 survived the disaster. Approximately 320 bodies were recovered, many buried in Halifax, Nova Scotia, but no trace was ever found of the Rice family. Margaret and her five young children;

Albert, George, Eric, Arthur and Eugene all perished, their only memorial - RMS Titanic.

Titanic's loss dismayed and infuriated the brave new world of 1912. Faith in the omnipotence of technology was badly shaken. But good did come from the terrible as so often happens. Ships would no longer be permitted to sail without enough lifesaving equipment for everyone; an International Ice Patrol was formed to warn ships at sea against wandering icebergs; the transatlantic tracks were shifted farther south during the critical winter and spring months and passenger liners were required to keep operators on a twenty-four hour wireless watch.

The White Star Line, contrary to myth, recovered from the disaster. The great tide of immigration from Europe filled their ships and the Company, in 1913, announced record profits despite the loss of their flagship.

As for the Titanic, her story will be told again and again, proven by the interest in the Titanic Historical Society formed in 1963 and still growing, and the success of Jim Cameron's film, despite the fictional screenplay, serves as a poignantly appropriate requiem.

### Airplane

**Date of Accident:** 12 November 1996
**Airline:** Saudi Arabian Airlines
**Aircraft:** Boeing 747-168B
**Location:** Chaki Dahdri, India
**Flight Number:** 763
**Fatalities:** 351:351
**Engine Manufacturer:** Rolls Royce, RB211-524C2
**Accident Description:** The aircraft crashed after colliding with a Kazakistan Airlines Ilyushin that had not maintained its assigned altitude. Error on the part of the Ilyushin crew. Deadliest mid-air collision in aviation history.

## 1.8. FAMOUS ENGINEERS

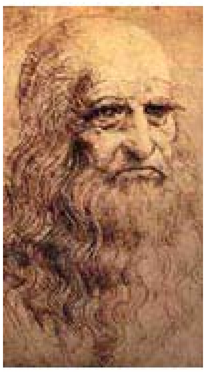
Many fascinating people have been engineers or have an engineering background. As the list below shows, engineers are not just researchers, designers, and inventors. They are also artists, Super Bowl winners, astronauts, Olympians, heads of state, and even Academy Award recipients! Famous people who are also engineers or have an engineering background:

- **Scott Adams** - Cartoonist and creator of "Dilbert" - read an interview with him in Prism Magazine.

- **Paul G. Allen** - is an entrepreneur who first established himself by co-founding Microsoft Corporation with Bill Gates. Allen was born in Seattle, Washington. At Lakeside School, Paul Allen (14 years old) and friend Bill Gates (12 years old) became early computer enthusiasts. Allen went on to attend Washington State University, though he dropped out after two years to pursue his and Gates's dream of writing software commercially for the new "personal computers".

- **Neil Alden Armstrong -** Became the first man to walk on the moon on July 20, 1969, at 10:56 p.m. EDT. He and "Buzz" Aldren spent about two and one-half hours walking on the moon, while pilot Michael Collins waited above in the Apollo 11 command module. Armstrong received his B.S. in aeronautical engineering from Purdue University and an MS in aerospace engineering from the University of Southern California.

- **Edwin Howard Armstrong** - His crowning achievement (1933) was the invention of wide-band frequency modulation, now known as FM radio. Armstrong earned a degree in electrical engineering from Columbia University in 1913.
- **Rowan Atkinson -** A British comedian, best known for his starring roles in the television series "Blackadder” and "Mr. Bean," and several films including Four Weddings And A Funeral. Atkinson attended first Manchester then Oxford University on an electrical engineering degree.
- **Alexander Graham Bell** , Inventor of the telephone. He also worked in medical research and invented techniques for teaching speech to the deaf. In 1888 he founded the National Geographic Society.
- **Henry Bessemer -** English inventor and engineer who invented the first process for mass-producing steel inexpensively - essential to the development of skyscrapers.
- **Frank Capra** - Film director - "It Happened One Night", "Mr. Smith Goes to Washington", "It's a Wonderful Life" - college degree in chemical engineering.
- **William D. Coolidge**'s name is inseparably linked with the X-ray tube - popularly called the 'Coolidge tube.' This invention completely revolutionized the generation of X-rays and remains to this day the model upon which all X-ray tubes for medical applications are patterned. Coolidge, born in Hudson, Mass., graduated from the Massachusetts Institute of Technology in 1896, majoring in electrical engineering. At General Electric, he invented ductile tungsten, the filament material still used in lamps, and worked on high-quality magnetic steel, improved ventilating fans and the electric blanket.
- **Roger Corman -** Film director, industrial engineering degree from Stanford University. He started direct involvement in films in 1953 as a producer and screenwriter, making his debut as director in 1955. Between then and his official retirement in 1971 he directed dozens of films, often as many as six or seven per year, typically shot extremely quickly on leftover sets from other, larger productions. His probably unbeatable record for a professional 35mm feature film was two days and a night to shoot the original version of "The Little Shop of Horrors".
- **Seymour Cray -** After a brief service during World War II, he went to the University of Minnesota where he studied engineering. In 1951 he joined Engineering Research Associates, which was developing computers for the Navy. Later he co-founded Control Data Corporation, and in 1972 he founded CRAY Research. Seymour Cray unveiled the CRAY-1 in 1976, considered the first supercomputer.



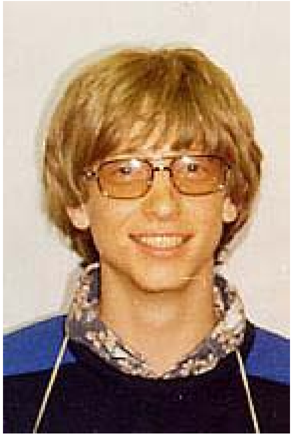
- **Leonardo Da Vinci -** Florentine artist, one of the great masters of the High Renaissance, celebrated as a painter, sculptor, architect, engineer, and scientist. His profound love of knowledge and research was the keynote of both his artistic and scientific endeavors. His innovations in the field of painting influenced the course of Italian art for more than a century after his death, and his scientific studies - particularly in the fields of anatomy, optics, and hydraulics - anticipated many of the developments of modern science.
- **Rudolf Diesel** -Though best known for his invention of the pressure-ignited heat engine that bears his name, the French-born Rudolf Diesel was also an eminent mechanical engineer.

- **Thomas Edison** - Edison patented 1,093 inventions in his lifetime, earning him the nickname "The Wizard of Menlo Park." The most famous of his inventions was an incandescent light bulb. Besides the light bulb, Edison developed the phonograph and the kinetoscope, a small box for viewing moving films. He also improved upon the original design of the stock ticker, the telegraph, and Alexander Graham Bell's telephone. Edison was quoted as saying, "Genius is one percent inspiration and 99 percent perspiration."

- **Henry Ford** held many patents on automotive mechanisms but is best remembered for helping devise the factory assembly approach to production that revolutionized the auto industry by greatly reducing the time required to assemble a car. Born in Wayne County, Mich., Ford showed an early interest in mechanics, constructing his first steam engine at the age of 15. In 1891, Ford became an engineer with the Edison Illuminating Company in Detroit. He became Chief Engineer in 1893 and this position allowed him to devote attention to his personal experiments on internal combustion engines. In 1893 he built his first internal combustion engine, a small one-cylinder gasoline model, and in 1896 he built his first automobile. In June 1903, Ford helped establish Ford Motor Company. He served as president of Ford from 1906 to 1919 and from 1943 to 1945.

- **Jay W. Forrester** was a pioneer in early digital computer development and invented random-access, coincident-current magnetic storage, which became the standard memory device for digital computers. He received a B.S. degree in Electrical Engineering in 1939 from the University of Nebraska and a M.S. degree from the Massachusetts Institute of Technology in 1945.

- **William Henry Gates III -** commonly known as **Bill Gates**, is the co-founder and current Chairman and Chief Software Architect of Microsoft. According to Forbes magazine in 2004, Gates is the wealthiest person in the world, a position he has held steadily for many years. Gates went to Lakeside School, Seattle's most exclusive prep school, and later on went to study at Harvard University, but dropped out without graduating. While he was a student at Harvard, he co-authored with Paul Allen the original Altair BASIC interpreter for the Altair 8800 (the first commercially successful personal computer) in the mid 1970s. It was inspired by BASIC, an easy-to-learn programming language developed at Dartmouth College for teaching purposes.



Aged 21, police photo for a minor traffic violation, Dec 13, 1977. Microsoft used this photo in a German advertisement with the slogan "Good that there are no speed limits for software"

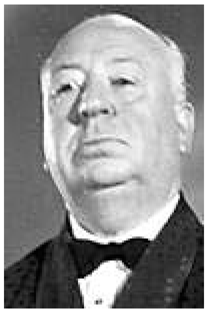
- **Lillian Gilbreth** - is considered a pioneer in the field of time-and-motion studies, showing companies how to increase efficiency and production through budgeting of time, energy, and money. Dr. Gilbreth received her Ph.D. in psychology from Brown University and was a professor at Purdue's School of Mechanical Engineering, Newark School of Engineering and the University of Wisconsin. She is "Member No. 1" of the Society of Women Engineers. She and her husband used their industrial engineering skills to run their household, and those efforts are the subject of the book and family film "Cheaper by the Dozen."

- **Robert Hutchings Goddard** pioneered modern rocketry and space flight and founded a whole field of science and engineering. Goddard's interest in rockets began in 1899, when he was 17. He conducted static tests with small solid-fuel rockets at Worcester Tech as early as 1908, and in 1912 he developed the detailed mathematical theory of rocket propulsion. In 1915 he proved that rocket engines could produce thrust in a vacuum and therefore make space flight possible. He succeeded in developing several types of solid-fuel rockets to be fired from handheld or tripod-mounted launching tubes, which were the basis of the bazooka and other powerful rocket weapons of World War II. At the time of his death Goddard held 214 patents in rocketry.

- **Roberto C. Goizueta** - Former chairman and chief executive of Coca-Cola. Chemical engineering degree from Yale University.

- **Andrew Grove** - co-founder, Intel, chemical engineer.

- **Alfred Hitchcock -** British-born American director and producer of many brilliantly contrived films, most of them psychological thrillers including "Psycho", "The Birds", "Rear Window", and "North by Northwest." He was born in London and trained there as an engineer at Saint Ignatius College. Although Hitchcock never won an Academy Award for his direction, he received the Irving Thalberg Award of the Academy of Motion Picture Arts and Sciences in 1967 and the American Film Institute's Life Achievement Award in 1979. During the final year of his life, he was knighted by Queen Elizabeth II, even though he had long been a naturalized citizen of the United States.



- **Grace Murray Hopper,** a computer engineer and Rear Admiral in the U.S. Navy, developed the first computer compiler in 1952 and the computer program language COBOL. Upon discovering that a moth had jammed the works of an early computer, Hopper popularized the term "bug." In 1983, by special presidential appointment, Hopper was promoted to the rank of Commodore. Two years later, she became one of the first women to be elevated to the rank of Rear Admiral. In 1986, after forty-three years of service, RADM Grace Hopper ceremoniously retired on the deck of the USS Constitution. At 80 years, she was the oldest active duty officer at that time. She spent the remainder of her life as a senior consultant to Digital Equipment Corporation. Hopper received numerous honors over the course of her lifetime. In 1969, the Data Processing Management Association awarded her the first Computer Science Man-of-the-Year Award. She became the first person from the United States and the first woman to be made a Distinguished Fellow of the British Computer Society in 1973. She also received multiple honorary doctorates from universities across the nation. The Navy christened a ship in her honor. In September 1991, she was awarded the National Medal of Technology, the nation's highest honor in engineering and technology.

- **Lee Iacocca** - Former chairman and CEO of Chrysler Corp. Iacocca graduated from Lehigh University, Bethlehem, Pa., in 1945 and received a master's degree in engineering from Princeton University in 1946. Best known for his helmsmanship at Chrysler Motors, Iacocca started out as a sales manager at the Ford Motor Co. in 1946 and by 1970 was president of the company. Joining Chrysler in 1978, Iacocca helped drag the troubled company from the brink of extinction by helping secure $1.5 billion in government loans. Iacocca's legendary status in the automobile industry is reinforced by his role in the introduction of that American icon: the Ford Mustang. He was also one of the first CEOs to proselytise his company's products on national television with the K car campaign.

- **Bill Joy** - co-founder of Sun Microsystems, electrical engineer. He received a B.S.E.E. in electrical engineering from the University of Michigan in 1975, after which he attended graduate school at U.C. Berkeley where he was the principal designer of Berkeley UNIX (BSD) and received a M.S. in electrical engineering and computer science. The Berkeley version of UNIX became the standard in education and research, garnering development support from DARPA, and was notable for introducing virtual memory and Internet working using TCP/IP to UNIX. In 1997, Joy was appointed by President Clinton as co-chairman of the Presidential Information Technology Advisory Committee.

- **Jack Kilby** - inventor of the integrated circuit. Kilby received a B.S.E.E. degree from the University of Illinois in 1947 and an M.S.E.E. from the University of Wisconsin in 1950. In 2000, he received the Nobel Prize in Physics for his work with the integrated circuit.
- **Jair Lynch -** 1992 and 1996 Olympic gymnast. Civil Engineering degree from Stanford University.
- **Elijah McCoy** was a Black inventor who was awarded over 57 patents. The son of runaway slaves from Kentucky, he was born in Canada and lived there as a youth. Educated in Scotland as a mechanical engineer he returned to Detroit and in 1872 invented a lubricator for steam engines. His new oiling device revolutionized the industrial machine industry by allowing machines to remain in motion while being oiled. This device, although imitated by other designers, was so successful that people inspecting new equipment would ask if it contained the real McCoy.
- **Guglielmo Marconi** - The "Father of Radio" - Marconi received many honors including the Nobel Prize for Physics in 1909.
- **James Morgan** - CEO, Applied Materials, mechanical engineer. In 1996 he received the National Medal of Technology for his industry leadership and for his vision in building Applied Materials into the world's leading semiconductor equipment company, a major exporter and a global technology pioneer which helps enable the Information Age.
- **George Simon Ohm -** Ohm became a professor of mathematics at the Jesuit College of Cologne in 1817. In 1827, Ohm showed experimentally that there was a simple relationship between resistance, current and voltage. This is his famous law $V = IR$.
- **Kevin Olmstead** - world-record game show payoff winner - $2,180,000 winner, "Who Wants to be a Millionaire?" - and environmental engineer. After acquiring chemical engineering degrees from Case Western Reserve University and the Massachusetts Institute of Technology, Olmstead earned a doctorate degree in environmental engineering from the University of Michigan. He also taught civil and environmental engineering and is currently a senior project engineer with Tetra Tech MPS, an international consulting firm specializing in infrastructure and communications systems.
- **Kenneth Olsen** - inventor of magnetic core memory, co-founder, Digital Equipment Corporation. After serving in the Navy between 1944 and 1946, he attended the Massachusetts Institute of Technology, where he earned a B.S. (1950) and an M.A. (1952) in electrical engineering.
- **Arati Prabhakar** - director, National Institute of Standards and Technology (NIST), U.S. Department of Commerce. Prabhakar was appointed the 10th NIST Director in May 1993. NIST promotes U.S. economic growth by working with industry to develop and apply technology, measurements, and standards. Previously, Prabhakar served as director of the Microelectronics Technology Office in the Defense Department's Advanced Research Projects Agency (ARPA). She holds the distinction of being the first woman with a doctorate from the California Institute of Technology, and was also the youngest director of the institute.
- **Ludwig Prandtl** - the father of fluid mechanics, mechanical engineer.
- **Hyman G. Rickover** - the "Father of the Nuclear Navy" he led the development of the Navy nuclear submarine fleet. Masters in electrical engineering from Columbia University. During World War II, he headed the electrical section of the Navy's Bureau of Ships, and in 1946 was enlisted into the U.S. atomic program. The next year he returned to the Navy to manage its nuclear-propulsion program. Regarded as a fanatic by his detractors, he completed the world's first nuclear submarine--the USS Nautilus--ahead of schedule in 1955. While continuing his

work with the Navy, he helped build the first major civilian nuclear power plant at Shippingport, PA. Always an outspoken advocate of U.S. nuclear supremacy, he was promoted to the rank of vice admiral in 1959 and admiral in 1973. He retired from the Navy in 1982 after serving as an officer for a record 63 years. Throughout his long naval career his decorations included the Distinguished Service Medal, Legion of Merit, Navy Commendation Medal, two Congressional Gold Medals, as well as the title of Honorary Commander of the Military Division of the Most Excellent Order of the British Empire. In 1980, President Jimmy Carter presented him the Presidential Medal of Freedom, the nation's highest non-military honor.

- **Norbert Rillieux** - revolutionized in the sugar industry by inventing a refining process that reduced the time, cost, and safety risk involved in producing sugar from cane and beets. His inventions protected lives by ending the older dangerous methods of sugar production. As the son of a French planter/inventor and a slave mother, Norbert Rillieux was born in New Orleans, LA. He was educated at the L'Ecole Central in Paris, France in 1830, were he studied evaporating engineering and served as an educator.

- **Washington Roebling** - completed the Brooklyn Bridge which was started by his father, civil engineer.

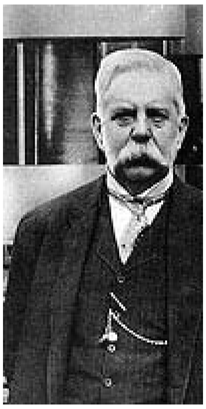
- **Nikola Tesla** - invented the induction motor with rotating magnetic field that made unit drives for machines feasible and made AC power transmission an economic necessity.

- **Stephen Timoshenko** - the father of engineering mechanics, engineering scientist.

- **Theodore von Karman** - Dr. von Karman was one of the world's foremost aerodynamicsts and scientists and is widely recognized as the father of modern aerospace science. He was a professor of aeronautics at the California Institute of Technology and was one of the principal founders of NASA's Jet Propulsion Laboratory, Pasadena, California.

- **Tom Scholtz** - Leader of the rock band Boston. Master's degree from MIT in mechanical engineering.

- **John F. Welch, Jr**. - Received his engineering undergraduate degree in his home-state at the University of Massachusetts. After he earned his Ph.D. in chemical engineering from the University of Illinois, he accepted a job offer from General Electric. The rest is history -- he became chairman and CEO of General Electric in 1981.

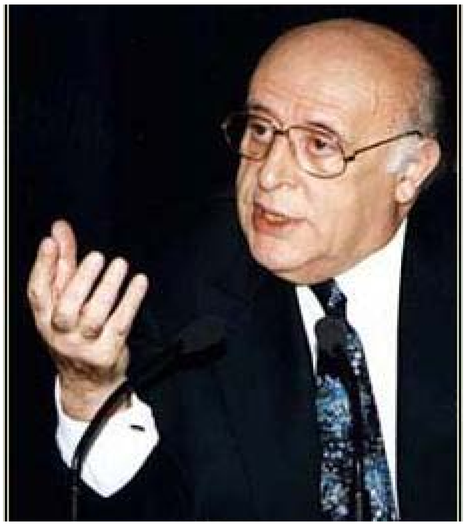


- **George Westinghouse** - invented a system of air brakes that made travel by train safe and built one of the greatest electric manufacturing organizations in the United States. In 1886, he founded the Westinghouse Electric Company, foreseeing the possibilities of alternating current as opposed to direct current, which was limited to a radius of two or three miles. Westinghouse enlisted the services of Nikola Tesla and other inventors in the development of alternating current motors and apparatus for the transmission of high-tension current, pioneering large-scale municipal lighting.

- **Eli Whitney** - American inventor, pioneer, mechanical engineer, and manufacturer Eli Whitney is best remembered as the inventor of the cotton gin. He also affected the industrial development of the United States when, in manufacturing muskets for the government, he translated the concept of interchangeable parts into a manufacturing system, giving birth to the American mass-production concept.

- **Steve Wozniak** cofounded Apple Computer, Inc. in 1976 with the Apple I computer. Wozniak's Apple II personal computer - introduced in 1977 and featuring a central processing unit (CPU), keyboard, floppy disk drive, and a $1,300 price tag - helped launch the PC industry. In 1980, just a little more than four years after being founded, Apple went public. Wozniak left Apple in 1981 and went back to Berkeley and finished his degree in electrical engineering/computer science. Since then, he has been involved in various business and philanthropic ventures, focusing primarily on computer capabilities in schools, including an initiative in 1990 to place computers in schools in the former Soviet Union.

- **Süleyman Demirel**



(1924- ) Turkish politician and prime minister 1965-1971
In his politics, Demirel was active in forging closer ties with NATO, and he instituted development programs for the peasantry. He was much concerned with aiding economical growth, but faced huge problems with inflation and trade deficit, as well civil violence and terrorism.
During his time as president, Demirel opposed a plan for a customs union with the European Union.
He had to find a balance between his politics and the interests of the military, but was removed from power twice. Another problem of his was that some of the governments he formed were too weak to allow proper implementation of his politics.

**BIOGRAPHY**

**1924:** Born in Islamsköy into a peasant family.
**1948:** Graduates from the Technical University of Istanbul as engineer.
**1961:** Is elected to the National Assembly as a member of the Justice Party (JP).
**1964:** Becomes leader of JP.
**1965 *October 27:*** Following the general elections, Demirel becomes the youngest ever prime minister in Turkey's history.
**1969:** Demirel wins the elections, and continue as prime minister.
**1971 *March:*** Demirel is forced to resign by the military commanders, who were dissatisfied with his low profile in combatting terrorist actions around the country.
**1975 *March:*** JP and a coalition of small parties called Nationalist Front wins the general elections. Demirel returns to the position as prime minister.
**1977 *June:*** Demirel's government falls.
**— *July:*** Demirel forms a new government.
**— *December:*** The government falls after just half a year in power.
**1979 *November:*** Demirel forms his 6th government.
**1980 *September:*** Demirel's 6th government is dissolved by the military.
**1982:** With a new Turkish constitution, Demirel is banned from politics for 10 years.
**1991 *November:*** Following the defeat of the Motherland Party in the general elections, and the success of Demirel's True Path Party, he returns to politics and forms his 7th government.
**1993 *May:*** President Turgut Özal dies, and Demirel steps down from his position as prime minister in order to become the new president.
**1996 *January:*** Demirel asks the Islamist politician Necmettin Erbakan to form a new government.
**— *May:*** Demirel escapes assassination by a militant Islamist.
**1999 *December:*** Demirel appeals to the parliament to suspend the death sentence passed on the

Kurdish leader Abdullah Öcalan.
**2000** ***May:*** As his constitutional allowed period as president comes to an end, Demirel steps down. He is succeeded by Ahmet Necdet Sezer.
— ***December:*** Is appointed to the Mitchell Committee to investigate the wave of violence in the Middle East.

- **Turgut Özal** (1927-1993) Turkish politician, deputy prime minister 1980-1982, prime minister 1983-1989, president 1989-1993. Özal's entry into Turkish politics came much by chance. He met Demirel during his years as student, and Demirel made him his advisor when he formed government.

Özal was active in opening up Turkish economy, orienting it towards Western patterns. He worked for Turkish membership in the European Union in th 1980's, but didn't succeed. Özal also worked for increased rights for the Kurdish population. Özal is also accredited for smoothing the military's disengagement from day-to-day politics.

But his politics didn't lead to the expected results, as Turkey was struck hard by high inflation and increasing unemployment. His regime also allowed continued breaches to human rights.

During his presidency, Özal tried to increase the power of the president — which to a large degree was a non-political position. This lead to clashes between him and prime minister Demirel.


**1927** ***October 13:*** Is born in Malatya, as son of a teacher.
**1940's:** Starts studying electrical engineering, where he met future prime minister Süleyman Demirel.
**1967:** Becomes an undersecretary at the Turkish State Planning Organization, and works close to prime minister Demirel.
**1971:** Starts working as an economist for the World Bank.
**1979:** Becomes advisor to Demirel's government.
**1980** ***September:*** The military overthrows Demirel's government, and Özal is appointed deputy prime minister.
**1982** ***July:*** Özal has to resign as deputy prime minister after a banking scandal.
**1983:** Özal's new party, the Motherland Party (ANAP) wins a majority in the parliament, and Özal can form a proper government.
**1987:** ANAP wins a majority in the parliament for a second time, but now with a smaller margin.
**1989:** Özal uses the parliament majority to appoint himself president.
**1993** ***April 17:*** Dies from a heart attack in Ankara.

- ## Al-Jazari (El-Cezeri) - the Mechanical Genius

Al-Jazari was the most outstanding Mechanical Engineer of his time. His full name was Abul-Ezz Ismail Bin Al-Razzaz Al-Jazari and he lived in Cizre (in Turkey) during the 12th century (1153-1233).

He was called Al-Jazari after the place of his birth, Al-Jazira (Cizre). Like his father before him he served Artuk kings of Diyarbakir, from 570-597 AH (1174-1200) as a Mechanical Engineer. In 1206 he completed an outstanding book on engineering entitled "Al-Jami Bain Al-Ilm Wal-Amal Al-Nafi Fi Sinat'at Al-Hiyal" in Arabic. It was a compendium of theoretical and practical mechanics. Writes Sarton (1884-1956):
*"This treatise is the most elaborate of its kind and may be considered the climax of this line of Muslim achievement."* Sarton vol.2; page 510.

Al-Jazari's book is distinctive in its practical aspect because the author was a competent engineer and skilled craftsman. The book describes various devices in minute detail hence an invaluable contribution in the history of engineering. British charter engineer Donald Hill (1974) who has a special interest in Arab technology writes:

**"It is impossible to over emphasize the importance of Al-Jazari's work in the history of engineering, it provides a wealth of instructions for design, manufacture and assembly of machines."**

Al-Jazari describes fifty mechanical devices in six different categories, including water clocks, hand washing device (wadu machine) and machines for raising water etc. Following the "World of Islam Festival" held in the United Kingdom in 1976 a tribute was paid to Al-Jazri when the london Science Museum showed a successfully reconstructed working model of his famous "Water Clock."

Hill translated Al-Jazari's work in 1974, seven centuries and 68 years after it was completed by its author. Al-Jazari's book includes six main categories of machines and devices. Several of the machines, mechanisms and techniques that first appear in this treatise, later entering the vocabulary of European mechanical engineering, including double acting pumps with suction pipes and the use of a crank shaft in a machine, accurate calibration of orifices, lamination of timber to reduce warping, static balancing of wheels, use of paper models to establish a design, casting of metals in closed mould boxes with green sand etc. Al-Jazari also describes methods of construction and assembly in scrupulous detail of the fifty or so machines in it to enable future craftsmen to reconstruct them.

And he was successful in that, for many of his devices were constructed following his instructions. The work by al-Jazari is also unique in the way that other writers often fail to give sufficient details, because amongst others, they are not craftsmen themselves, or kept their secrets, or if they were craftsmen, they could have been illiterate. Al-Jazari in this respect was unique, and this gives his work immense value. His book, Hill states, is an absolute wealth of Islamic mechanical engineering.

In their paper in the charter Engineer of the I.Mech.E., Ludlow and Bahrani have raised the important point that it is more than likely that there is more on the subject in some of the thousands of Arabic manuscripts in the European and North American libraries which have been inspected closely, and obviously require looking into.

Hill, too, and constantly raises the two major issues with respect to the history of engineering in general, and that of fine technology in particular. He first states the fact that the field, which is absolutely immense, is yet totally unexplored.

The other issue is related to fine technology. One of his concluding points states that `it is hoped that, as research proceeds, firmer evidence for the transmission of Islamic fine technology into Europe can be provided.' Hill also offers some hints for such transmission. The most likely route being Spain. Such fine technology could have followed the same route as the astrolabe (itself part of this fine technology.) Apart from Spain, there was Sicily, another land of transfer, Byzantium, and Syria during the Crusades. And Hill is also right on a further account, that what will be seen in this work is just a fraction of the whole process, which, as with much else has hardly been explored.

The animation shows a virtual model of one of al-Jazari's water raising pumps. The details of this unique pump were obtained from his manuscript and Hill's diagrams. We see two suction pumps in synchronous motion driven by a paddle wheel, which is driven by a water stream.

The other animation is for a 3D model recreated from the description of the elephant clock as described by Al-Jazari. Full details of this animation are given in the book by Prof. S T S Al-Hassani on "The History of Muslim Engineering", to be published.