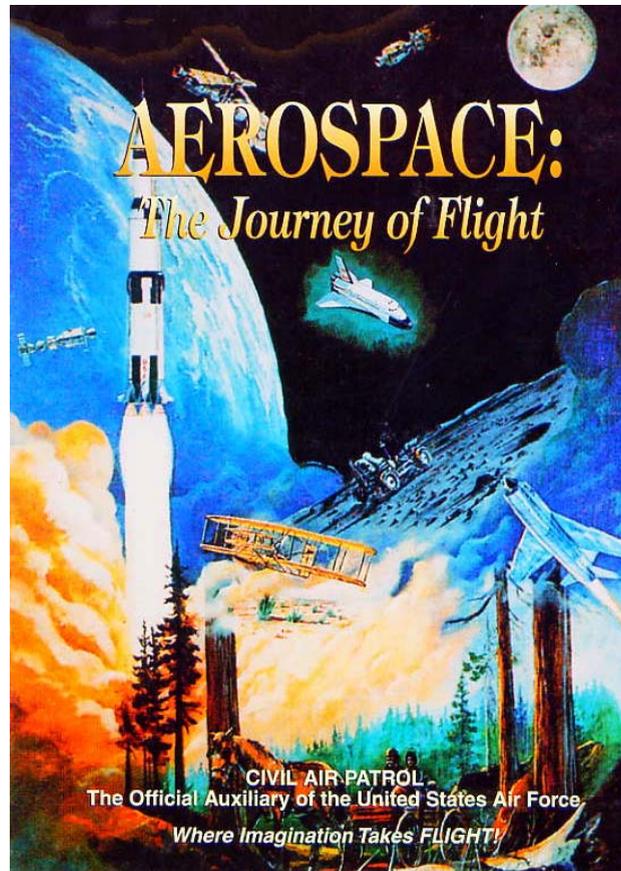




Civil Air Patrol - Ohio Wing



Aerospace Education Program for Senior Members (AEPISM)



Sky Harbor Composite Squadron 301 AEO, 1LT Tom Lodge
Revised June, 2002



Agenda

- **Introduction**
- **Part 1 - The Rich History of Air Power**
- **Part 2 - Principles of Flight & Navigation**
- **Part 3 - The Aerospace Community**
- **Part 4 - Air Environment**
- **Part 5 - Rockets**
- **Part 6 - Space**
- **Testing**



Introduction

- **Aerospace Education Program for Senior Members (AEPSM)**
- **Self paced study based on text *Aerospace: The Journey of Flight***
- **Open book, untimed exam correctable to 100%**
- **Charles E. “Chuck” Yeager Aerospace Education Achievement Award**
- **Approximately 8 hours, 3 evenings**



Part 1 The Rich History of Air Power

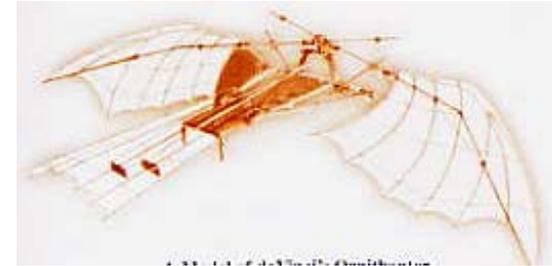


- Chap. 1- Introduction to Air Power**
- Chap. 2- Adolescence of Air Power: 1904-1919**
- Chap. 3- The Golden Age: 1919-1939**
- Chap. 4- Air Power Goes to War**
- Chap. 5- Aviation: From the Cold War to Desert Storm**
- Chap. 6- Advances in Aviation**



1 Introduction to Air Power

- **Desire to fly dates back 4000 years - China**
 - **Invented kite 100 BC, Gun Powder 900 AD, Rockets 1100 AD**
- **Leonardo da Vinci (1452-1519) Artist, Architect, Man of Science**
 - **First scientific experiments in field of aviation**
 - **160 pages of descriptions & sketches of flying machines**
 - **1st design of parachute and helicopter**
 - **Wrote about principles of CG, CP, Streamlining**
- **Lighter-than-air: Balloons**
 - **1783 Montgolfier brothers first balloon experiment with sheep, rooster, duck**
 - **Nov 21, 1783 - Pilatre de Rozier & Marquis d'Arlandes were first humans to fly lighter-than-air. Flight lasted 25 minutes and 5 miles.**
 - **First balloon flight in US: Jan 9, 1793 in Philadelphia**
 - **1st US military use in Civil War-observation, aerial reporting**



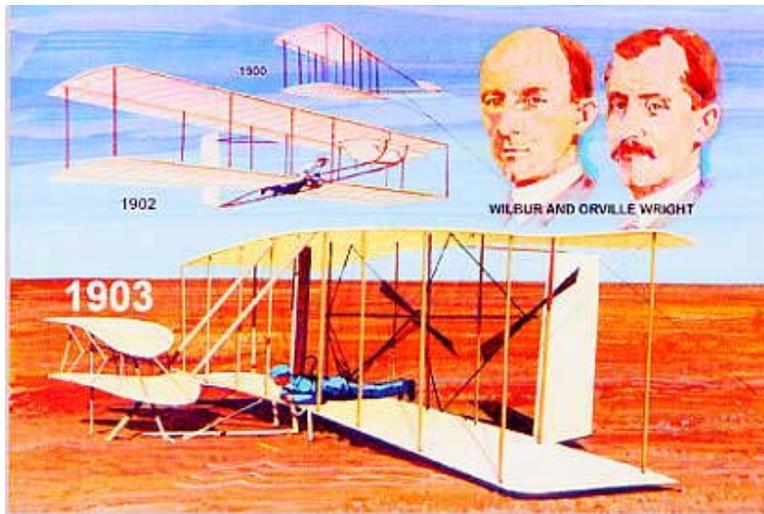
1 Introduction to Air Power

Dirigible: Lighter-than-air craft that can be propelled and steered

- Paul Haenlein - 1st dirigible powered by an internal combustion engine
- Ferdinand von Zeppelin - built and flew the world's first rigid dirigible LZ-1.



Wright Brothers



- First to achieve controlled, sustained, powered heavier than air flight.
- Learned from previous pioneers an observing birds in flight
- Utilized “wing-warping technique” for control
- Utilized gas powered engine; built gliders
- December 17, 1903-1st powered flt-120' 12 seconds at Kitty Hawk, N.C.
- Completed 3 flights that day, longest 852 feet, 59 seconds.



2 Adolescence of Air Power: 1904-1919

Wright Brothers

- Poor press, No enthusiasm
- No gov't interest until T. Roosevelt
- Contracted w/ Board of Ordnance & Fortifications to train 2 pilots
- Demonstrations in France
- Sept 17, 1908-Killed Lt. Thomas Selfridge, 1st death in powered aircraft

Aviation Gains Recognition

- Vin Fiz Flyer - 1st aircraft to fly across US coast to coast, built by Wright Bros.
- Harriet Quimby - 1st licensed female pilot in US.
- Louis Breguet - 1st helicopter to lift man
- World's 1st regularly scheduled airline - St. Petersburg - Tampa Airboat, 1914

Europe

- Frenchman Robert Esnault-Pelterie 1st aileron application and enclosed fuselage
- Alberto Santos-Dumont-flew 1st powered airplane in Europe 1906.



- Louis Bleriot-Built/flew 1st powered monoplane.



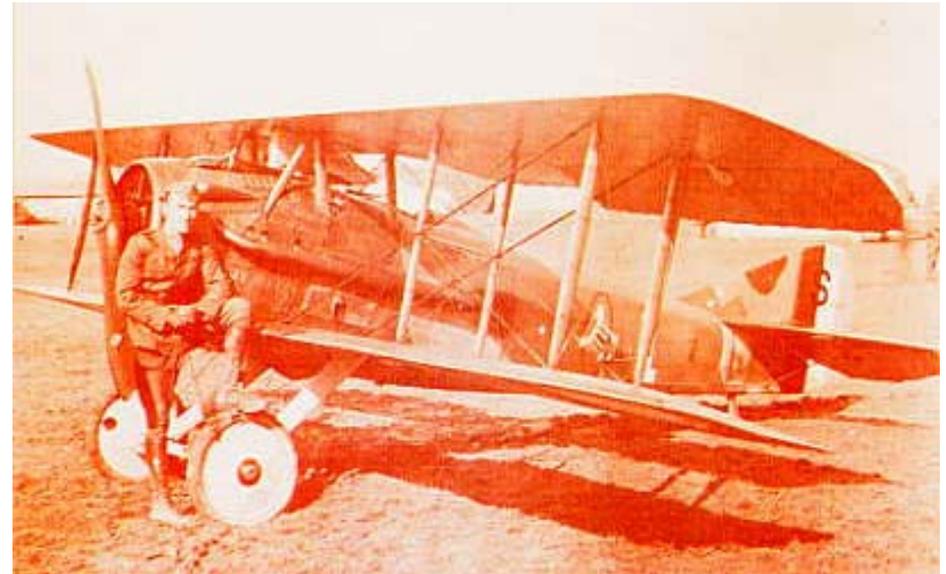
2 Adolescence of Air Power: 1904-1919

World War I

- Airplane not recognized as important at beginning WW1
- Germans had dirigibles as bombers (filled w/ hydrogen)
- Germans developed bombers
- Fighters developed to shoot down bombers
- Eddie Rickenbacker - American WW1 ace-16 kills in 5 months. Only living American to receive Medal of Honor in WW1
- US didn't recognize aircraft as "game changer" - used English/French built aircraft
- Lafayette Escadrille - American group of flyers serving the French

Gen. Billy Mitchell

- Recognized that the airplane is an offensive weapon
- Air service should be separate service than Army
- Air power can be effective against ground troops





3 Golden Age 1919-1939

US Aviation after WW I

- US had built 15,000 airplanes during war
- US front-line strength: 750 combat aircraft, 800 pilots
- 3 days after war ended, US gov't cancelled \$100M airplane contracts
- 175,000 workers laid off, production dropped 85%, military aviation cut 95%

Barnstormers

- Ex-military pilots, flew to attract attention
- Most people in US had not seen an airplane
- 1st licensed African-American pilot - Bessie Coleman



Billy Mitchell and airpower

- Air power could strike industrial targets, attack troop supply routes, shorten war
- Stressed importance of airpower in strategic warfare
- Ostfriesland “unsinkable” battleship
- Demolished by 200 lb. bombs
- Navy recognized importance and within 8 months had first aircraft carrier
- Organized 1st around the world flight with 4 Douglas World Cruisers - *Boston, Chicago, Seattle, New Orleans*



3 Golden Age 1919-1939

National Air Races

- Pulitzer Trophy - 29 mile closed course
- Bendix Trophy Race - West coast to Cleveland, OH - 1931

Air Mail

- First service by US Post Office May 15, 1918 between Washington DC and New York City.
- May 20, 1926 - Air Commerce Act, first attempt to regulate commercial aviation
- President Roosevelt signed Civil Aeronautics Act of 1938 creating Civil Aeronautics Authority (CAA) - one independent agency to regulate law and safety



1st non-stop Atlantic crossing

- July 1919-John Alcock and Arthur Brown
- St. Johns Newfoundland to Ireland 16 hrs, 1880 miles.

1st solo non-stop Atlantic crossing

- May 20, 1927 - Charles Lindbergh in the Spirit of St. Louis, built by Ryan





4 Air Power Goes to War

New Type of War

- Germany had terrible losses in WWI from trench warfare
- Blitzkrieg - “lightning war” combination of army and air forces
- Germany focused on small/medium sized aircraft to support Blitzkrieg tactics
- Allies (US, England, France) had cut back aircraft production - weakened air power

Germany Advances

- 1940 - Italy & Germany declared war on Great Britain
- Italy & Germany attacked western Africa
- Axis invaded Greece, Russia
- Russia used heavy defenses including woman pilots for combat sorties.
- Germany forces spread too thin on 3 fronts

Battle of Britain August 1940

- Luftwaffe focused on gaining control of air over Britain
- Germany did not have long range bombers
- Britain focused on defensive warfare with fighters
- Britain used radar
- Britain won by having the right aircraft for battle





4 Air Power Goes to War

US Enters WWII

- December 7, 1941 - Japanese attack Pearl Harbor, Hawaii. Purpose was to cripple the US naval fleet.
- Allied strategy -
 - Defensive to offensive
 - Recapture territory occupied by Germany & Japan
 - Force both Germany & Japan to unconditional surrender
 - European campaign had priority over Pacific
 - Focus on strategic bombing



Lessons in North Africa

- Centralize control of air forces
- Gain air superiority - attack airfields, aircraft
- Interdiction - cripple enemy supplies
- Close ground support - bomb enemy troops
- Hitler defeated in North Africa



4 Air Power Goes to War

Europe

- US declared war on Germany/Axis 12/11/41
- 8th Air Force formed in 1/42, 8/42 1st bombing mission
- US strategy-precision daytime bombing
- RAF strategy-Night blanket operations
- 6/6/44 - Normandy invasion
- 5/7/45 - Germany surrenders

Lessons Learned

- Airplane became prominent weapon of war
- Aircraft carrier became primary naval weapon
- 20 Million killed, 4 million civilians
- Warfare-no one wins or loses
- Sensible solution is to prevent war rather than fight one.

Pacific

- Japan rapidly advancing throughout the pacific
- 1942 -Battle of Coral Sea & Midway-entirely by airpower, no surface ship engagement
- Established strategy for subsequent naval battles
- Stopped advance of Japan
- 4/42 Doolittle Raid on Tokyo
- 8/6/45 Atomic bombing of Hiroshima - B-29
- 8/9/45 Atomic bombing of Nagasaki
- 9/2/45 Japan surrenders





5 Aviation: From the Cold War to Desert Storm



Political Climate

- Postwar years (after WWII) were called “Cold War”.
- Soviet Union tried to spread communism, US tried to stop it.
- Antagonistic relationship, not a “hot” war.
- Cold War shaped many developments in aviation.
- 7/26/47 - National Security Act - USAF was formed.
 - Primary mission - deterrence with atomic bombs by Strategic Air Command



Korean War

- 6/25/50 North Korea invaded S. Korea-ended 7/53
- 1st Priority to stop advance of N. Korean Army
- 1st all jet battle-F-80 shot down MIG-15
- Lessons learned: atomic arsenal not enough to prevent war, multiple levels of conflict



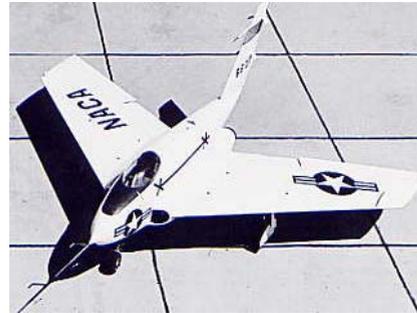
5 Aviation: From the Cold War to Desert Storm



Research & Development



- Bell X-1 1st plane to exceed Mach 1
- 10/14/47 Chuck Yeager



- Northrop X-4
- Tailless research
- Led to XB-35, YB-49 and B-2 stealth bomber



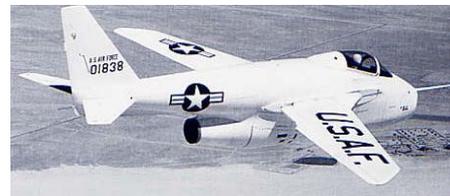
- Douglas D558-II
- 1st plane to exceed Mach 2
- 11/20/53 Scott Crossfield



- Bell X-2
- Swept wing research
- 1st plane to exceed Mach 3
- 9/27/56 Milburn Apt



- Douglas X-3
- High speed flight materials & aerodynamics testing
- Never exceeded speed of sound



- Bell X-5
- Variable geometry wing research
- Led to F-111, F-14, B-1

The X-Planes: X-1 to X-45
Jay Miller



5 Aviation: From the Cold War to Desert Storm



Vietnam Conflict

- Americas Longest War - 25 years
- Phase I-1950-1954-Aid and advisors for French
- Phase II 1954-1964-French defeated, troops sent to train S. Vietnamese
- Phase III-1964-1969-US Naval ships attacked. 8/64 Tonkin Gulf Resolution- empowered Johnson “take all necessary measures to repel armed attack against forces of US and prevent further aggression.”
- Operation Rolling Thunder: 1965-1968
 - 3 year bombing campaign to force N. Vietnam to surrender. Limited targets
- Operation Linebacker I & II
 - President Nixon’s method to get N. Vietnam to negotiate. Linebacker II was the only true strategic bombing campaign of Vietnam War
- Phase IV-1969-1975-Nixon withdrew troops, Saigon captured by N. Vietnamese in 1975.

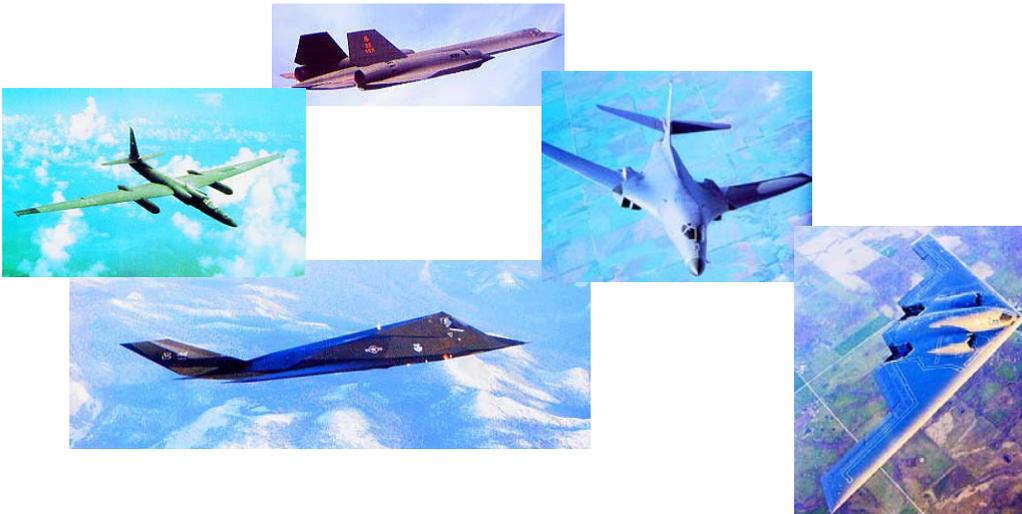




6 Advances In Aeronautics

Aeronautical Research

- X-15 joint USAF, Navy, NASA program to build aircraft to fly 4500 mph at 250k feet.
- XB-70-Mach 3 high altitude supersonic bomber prototype to replace B-52
- Composite materials-Strong, lightweight, non-metallic
- Oblique wing-Pivoting wing-optimum lift under different circumstances
- Winglets-Reduce vortices off wingtips reducing drag
- Canards-Horizontal surfaces forward of main wing
- Supercritical wing-Delay point at which air reaches supersonic speeds, delaying increased drag.
- Forward-swept wing: X-29



Military Advancements

- U-2: High altitude reconnaissance
- SR-71: Mach 3+ high altitude reconnaissance
- B-1B: Low altitude, high speed strategic bomber
- F-117 Nighthawk: 1st stealth fighter-bomber
- B-2: Stealth bomber



6 Advances In Aeronautics

Civil Jet Aviation-the Beginning

- 1st commercial jet Boeing 707, 1957
- Douglas' answer to 707, the DC-8
- Defined global air travel through the 1960's



- Short/medium range: 727, DC-9, 737
- 737 most produced jetliner in history



6 Advances In Aeronautics

Civil Aviation-The Wide body's

- 1st wide-body and largest commercial aircraft in service - Boeing 747, 1968
- Douglas entered with DC-10 trijet
- Lockheed entered with L-1011 trijet
- Airbus enters with A-300 twinjet



- First supersonic transport: Concorde
- The advanced twins: 757, 767
- DC-9 grows into MD-80
- Airbus enters the narrow body market with A320



6 Advances In Aeronautics

Civil Aviation-Modern Transports of the 1990's

- Boeing MD-11, 777, 737-700 series
- Airbus A330, A340



Civil Aviation-The Future....

- Boeing Sonic Cruiser
- Airbus A380





Part 2 Principles of Flight & Navigation



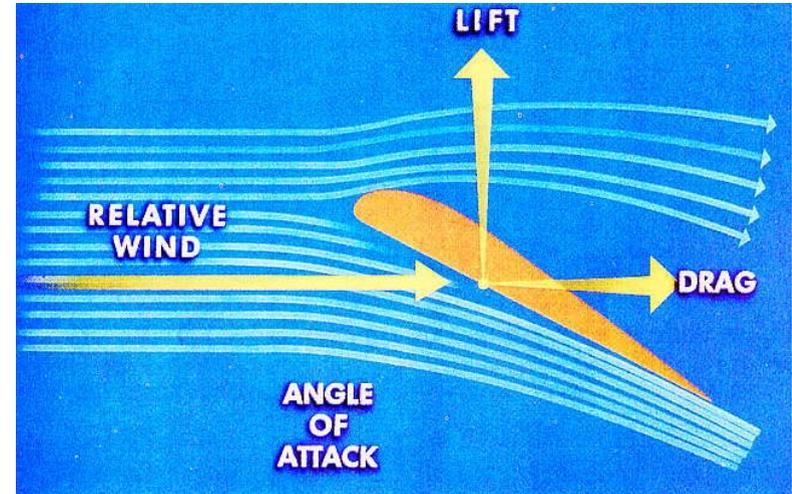
- Chap. 7- Basic Aeronautics & Aerodynamics**
- Chap. 8- Aircraft in Motion**
- Chap. 9- Flight Navigation**

7 Basic Aeronautics & Aerodynamics

Airfoil Design



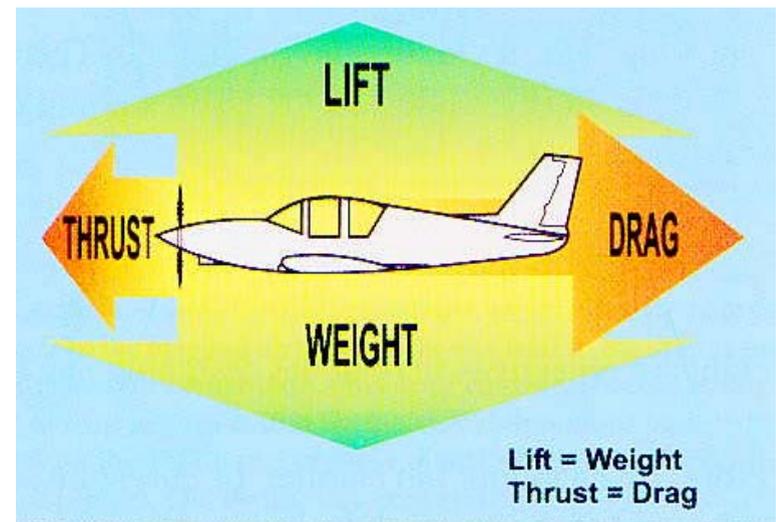
Lift & Angle of Attack



Daniel Bernoulli

- Dutch physicist, 1738
- Discovered relationship between the pressure and speed of fluid in motion
- Bernoulli's Principle: "As the velocity of a fluid increases, the pressure decreases"

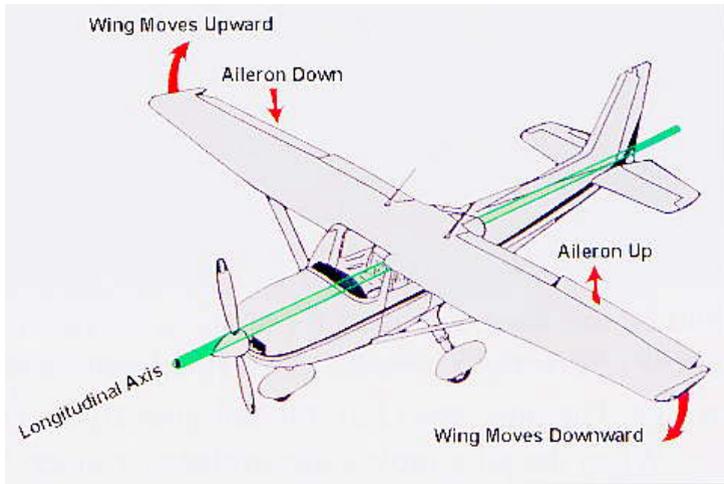
4 Forces of Flight



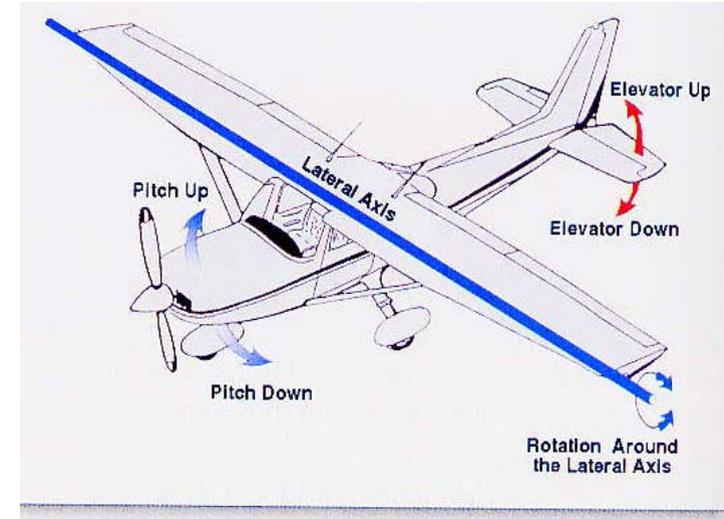
8 Aircraft in Motion

The Axes of An Aircraft

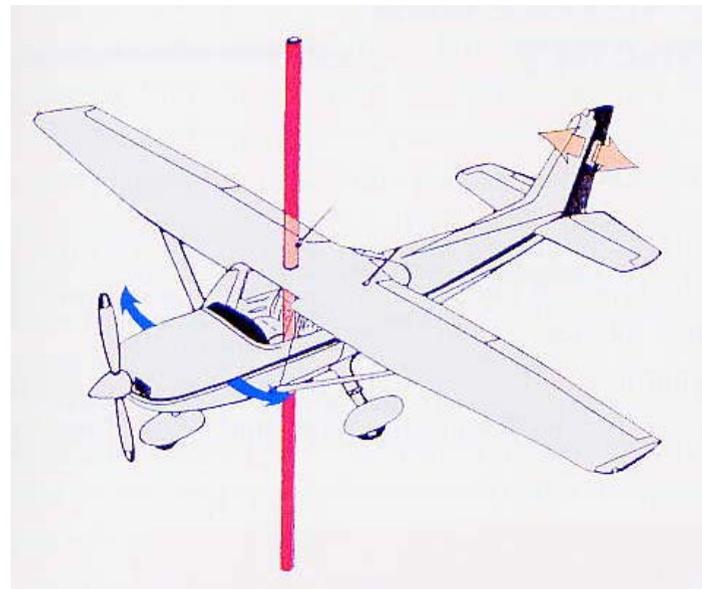
Longitudinal Axis



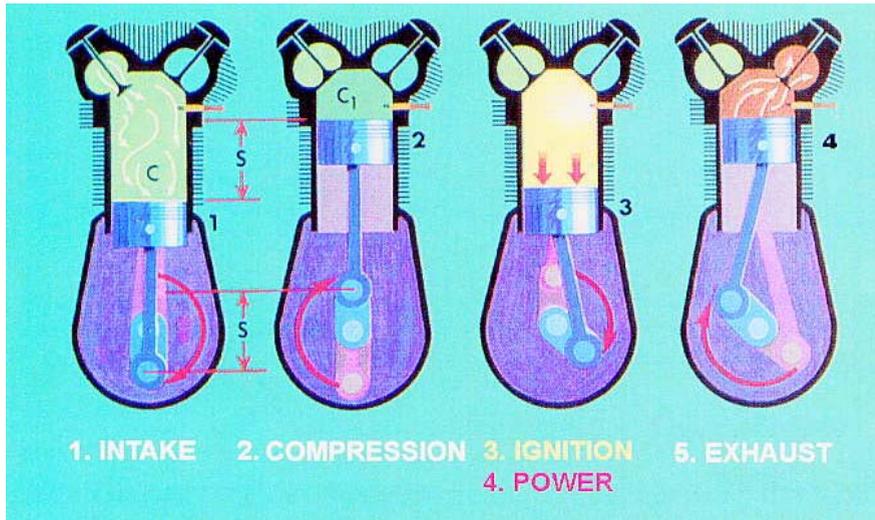
Lateral Axis



Vertical Axis



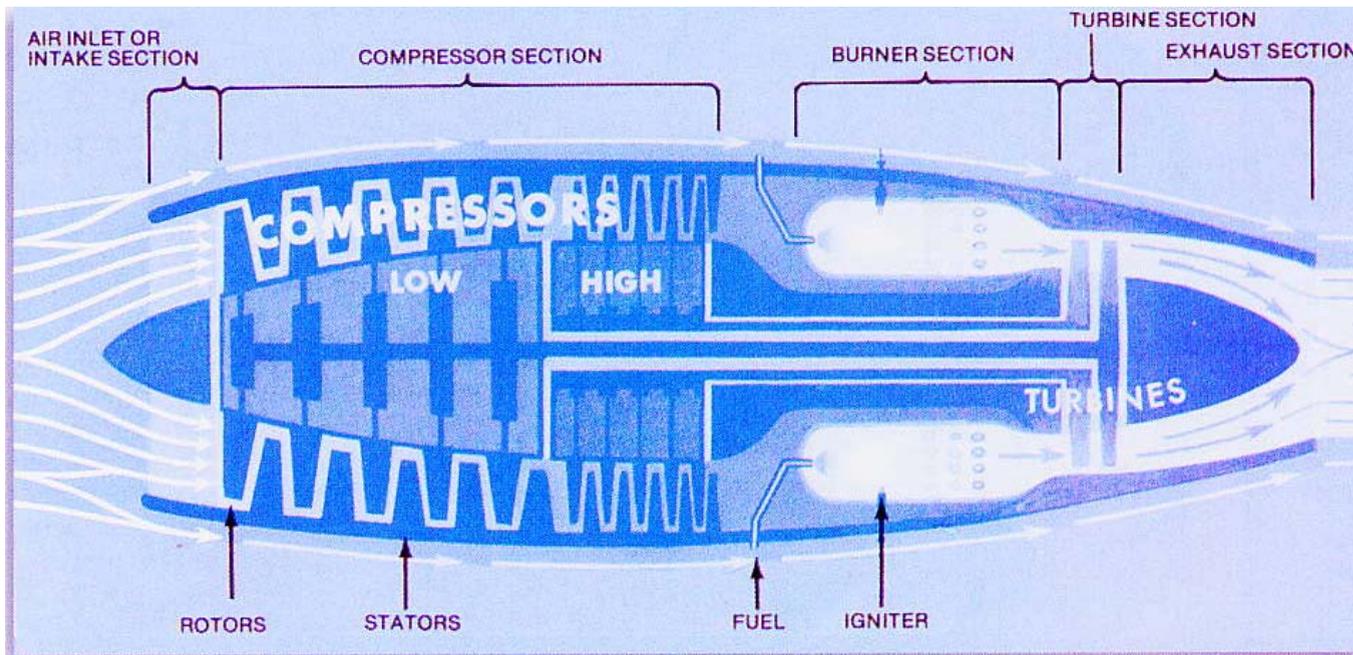
8 Aircraft in Motion



Engines

Reciprocating

- Fuel converted to energy in cylinder



Turbine

- Turbojet
- Turbofan
- Turboprop
- Turboshaft



8 Aircraft in Motion

Aircraft Instruments

- Performance - How aircraft responds to our commands
- Control - Current state of aircraft devices

Instrument Types

Engine

Tachometer

Oil Press.

Oil Temp.

Manif. Press.

Carb. Temp.

Exhaust Gas Temp.

Flight

Airspeed Ind.

Altimeter

Turn/slip ind.

Vert. Speed. Ind.

Attitude Ind.

(Artificial Horizon

Navigational

Mag. Compass

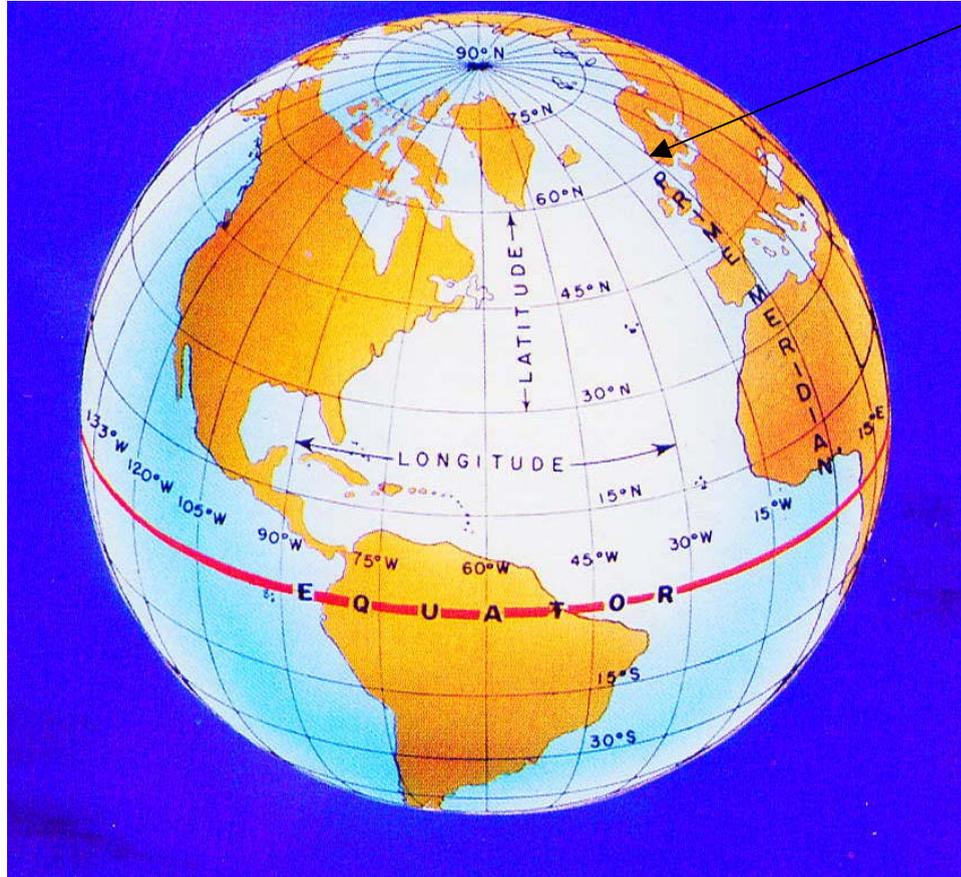
Heading Ind.

VOR Ind.



9 Flight Navigation

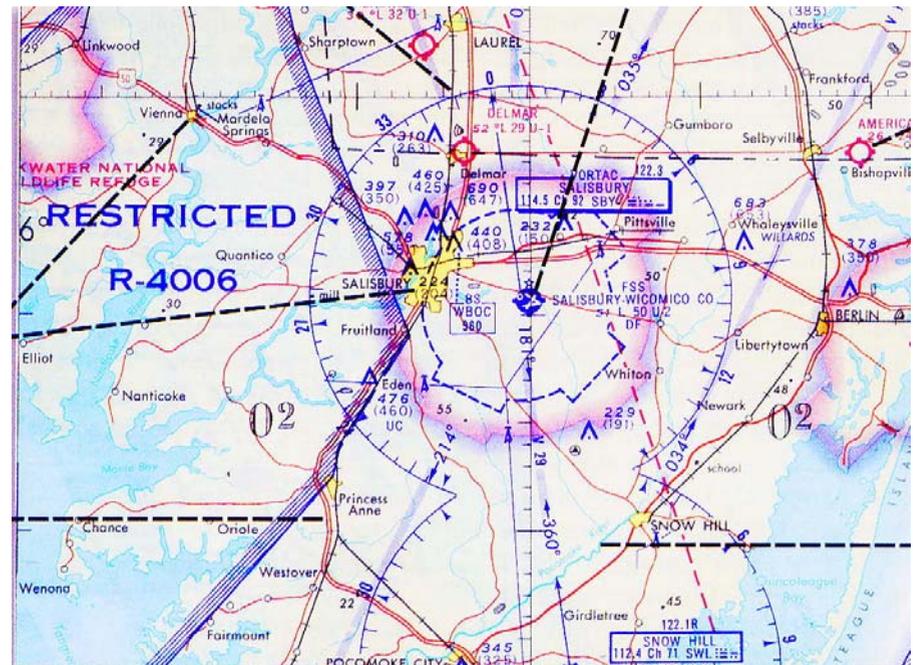
Global Coordinate System



Greenwich, England

Sectional Charts

- Relief - Elevations
- Hydrographic - Bodies of water
- Cultural - Cities, towns
- Airports - Civil & Military
- Airspace & Airways - Navigation



Basic Navigation Techniques

- Pilotage - Reference to visible landmarks
- Dead Reckoning - Systematic consideration of all factors that could effect the flight



Part 3 The Aerospace Community



Chap. 10- The Airport

Chap. 11- Air Carriers

Chap. 12- General Aviation

Chap. 13- Business & Commercial Aviation

Chap. 14- Military Aircraft

Chap. 15- Helicopters, STOL, VTOL, UAVs

Chap. 16- Aerospace Organizations

Chap. 17- Aerospace Careers & Training



10 The Airport

Runway

- Most important part of an airport.
- Can be made of grass, gravel, concrete, or asphalt.
- Identified by number corresponding to compass direction
 - 90 degrees “09”, opposite end 270 degrees “27”
- White lights at edges and sometimes in middle at night, during day are dashed white line down middle
- End of runway are red lights

Control Tower

- Primary function to control runway
- Controls movement of aircraft on ground
- Most airports are uncontrolled (no control tower)



11 Air Carriers

Major Air Carriers

- Regularly scheduled service (commercial airlines, cargo carriers, regional air carriers - All regulated by FAA)

Modern Airliners

- Boeing 707-1st commercial jet used in US. Flew 1958, built until 1979
- Douglas DC-8-Entered service 1 yr after 707, ended 1972
- DC-9-Twin jet short/medium range competitor to 737. MD-80/MD-90 are new versions.
- Boeing 727-Most successful tri-jet
- 737-Twin engine, short/medium haul, most successful jetliner
- Boeing 747-Largest commercial jet produced, 1st wide-body, Series 400-heaviest commercial aircraft 892K lbs (Antonov An-225-1,322K lbs)
- Douglas DC-10-2nd jumbo jet-3 engines, MD-11 next generation version
- Lockheed L-1011-1st commercial aircraft since Electra.
- Airbus A-300-1st commercial aircraft by Airbus
- 767-1980's technology small wide-body



11 Air Carriers

Major Airliners Continued

- **757-Designed with 767, standard body, same fuselage diameter as 707, 727, 737, intended to replace 727 however created its own market.**
- **A320 - Airbus entry into narrowbody market**
- **MD-11 - 1990's version of DC-10**
- **777-1990's technology twin-engine long range**
- **A330/A340-1990's technology medium/long range**
- **A380-New double deck 600 passenger long range - service 2006**
- **Boeing Sonic Cruiser - Near supersonic long range medium sized (767) twin engine transport. Probable service 2008**

Air Cargo Carriers

- **Only carry cargo, no passengers**
- **Boeing 747F, DC-10, MD-11, A300, 757, 727, DC-8**

Regional Aircraft

- **Metro III, Beech 99, ATR 72, Dash 8- all turboprops**
- **Regional Jets**
 - **Bombardier CRJ, Embraer 145, Dornier 328,**





12 General Aviation

General Aviation - All civil aviation other than flying by scheduled air carriers and government agencies

Instructional Aviation

- Aircraft specifically use to teach someone to fly. C-152, Piper Tomahawk, Beech Skipper



Personal Aviation

- Use of aircraft other than business or commercial use, 24% all hours flown.
- Beech - Sundowner, Sierra, Bonanza



- Cessna - largest builder of GA 179,500 - 172 Skyhawk, 182 Skylane, 185 Skywagon, 210 Centurion





12 General Aviation

- Mooney - Mooney 201
- Piper - Malibu, Cherokee, Cruiser, Arrow, Super Cub, Archer

Sport Aviation

- Home builds, ballooning, soaring, antique aviation, racing, aerobatics, ultralight
- First unrefueled nonstop flight around the world - December 14-23, 1986, Dick Rutan & Jeana Yeager





13 Business & Commercial Aviation

Business Aviation - Major areas of concern in aviation today: 1) Fuel efficiency; 2) Noise; 3) Cost effectiveness

Executive Aircraft

Multi-engine piston



Turboprops

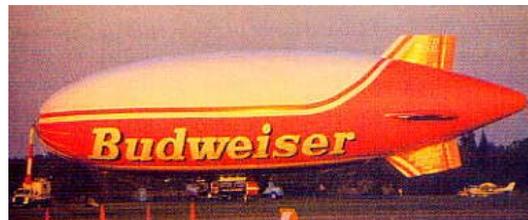


Turbofans



Business Aircraft

Transportation (air taxis, charter), agricultural ,
aerial Advertising, aerial Photography, fire
fighting, fish & wildlife, patrol, industrial uses



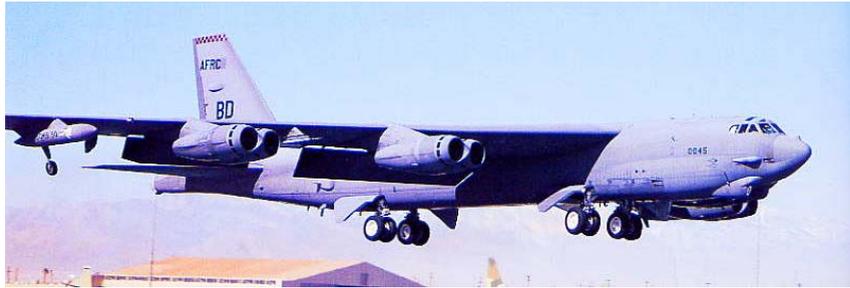


14 Military Aircraft

Combat Aircraft

Bombers - Reach enemy's homeland and destroy ability to wage war

- Boeing B-52, B-1, Northrop Grumman B-2 Stealth Bomber



Fighters - Destroys other aircraft, small ground targets

- Boeing F-15, F/A-18, Northrop Grumman F-14, Lockheed Martin A-10, F-22, F-35 (JSF), F-16, F-117





14 Military Aircraft

Noncombat Aircraft

Reconnaissance & Observation - Watch an enemy to keep track of what they are doing

- Lockheed U-2, SR-71, Boeing E-3A AWACS, E-4B, E-8 J-STARS, Lockheed P-3C, S-3A, Northrop Grumman E-2C



Transports & Tankers - Unarmed to support combat aircraft & military assets

- Lockheed C-5, C-141, C130, Boeing C-17, KC-135, KC-10, VC-25





14 Military Aircraft

Training Aircraft

US Air Force

- Raytheon T-6 Texan II, Cessna T-37 Tweet, Northrop T-38 Talon, Raytheon T-1 Jayhawk



US Navy

- Raytheon T-34C Mentor, Boeing T-45 Goshawk, Raytheon T-44 Pegasus





15 Helicopters, STOLs, VTOLs, UAVs

Helicopters - In use since end of WWII, very resourceful with limitations: high maintenance costs, vibrations, high noise levels. Turbine engines, composite materials advanced helicopter development

Attack

- Bell AH-1 Cobra (Army & Marines), Boeing AH-64 Apache (Army)



Heavy-Lift

- Boeing CH-47 (Army), CH-46 (Navy, Marines), Sikorsky CH-53 (USAF, Navy, Marines), Bell/Boeing V-22 Osprey (Hybrid), Sikorsky H-3 - 1st nonstop flight across Atlantic Ocean 1967



Utility

- Bell UH-1 Huey, Sikorsky UH-60 Blackhawk (Army, Navy, AF)



Civilian

- Bell 206 Jetranger, Bell 222, MD 500, Sikorsky S-76

Foreign

- Aerospatiale Puma, Dauphin, Agusta 109, MBB 105



15 Helicopters, STOLs, VTOLs, UAVs

Short-takeoff-and-landing (STOL) - Defined as ability of an aircraft to clear a 50-foot obstacle within 1500 feet after takeoff and to stop within 1500 feet after passing over a 50-foot obstacle when landing.

Vertical-takeoff-and-landing (VTOL) - Significant design differences to achieve VTOL from STOL. V-22 Osprey is propeller VTOL. AV-8B Harrier only VTOL aircraft put to common use in multiple countries. F-35 JSF Marines VTOL version to replace Harrier.



Unmanned Air Vehicles (UAVs) - Pilotless aircraft used for reconnaissance, electronic warfare, or combat operations. Used during WWII, widely used in Vietnam. Computer technology has renewed significant interest today.



RQ-1A Predator



RQ-5A Hunter



RQ-4A Global Hawk



16 Aerospace Organizations

Federal Aviation Administration

- Air traffic regulation began with Air Commerce act of 1926. Bureau of Air Commerce formed within Dept. of Commerce
- Civil Aeronautics Act 1938 - Regulation placed under Civil Aeronautics Authority (established safety & economic policies), Administrator of Aviation (execute safety policies), and Air Safety Board (investigated accidents).
- Federal Aviation Act 1958 - FAA formed
 - Air Traffic Control
 - Airway Facilities
 - Flight Standards
 - Research & Development
 - Aeronautical Center

National Transportation Safety Board (NTSB)

- 5 member board appointed by President
- Responsible for determining cause of any transportation accident.

National Aeronautics & Space Administration

- Earth Science, Aero-Space Technology, Space Science, Human Exploration & Development of Space

International Civil Aviation Organization (IACO)

- 1947 - International organization dedicated to standardization of aviation functions.

Civil Reserve Air fleet (CRAF)

- Commercial airliners which have been designated by DoD for use in time of emergency.

Civil Air Patrol

- Emergency Services, Aerospace Education, Cadet Programs

Aircraft Owners & Pilots Association (AOPA)

- Supports the views and rights of aircraft owners and pilots.

Experimental Aircraft Association (EAA)

- Formed to help builders safely construct and fly homebuilt aircraft.

Industry Organizations

- Aerospace Industries Association (AIA)
- General Aviation Manufacturers Association (GAMA)



17 Aerospace Careers & Training

Aptitudes and Aerospace Careers

- Special talents and natural abilities which a person possesses are called aptitudes.
- Mechanical, verbal, scientific, manipulative, numerical, administrative, social, artistic.

Academic Institutions

- Junior or community colleges - Associate degree
- Technical/Vocational School - technical education courses
- Four year college/University - BA, BS, MS, Phd
- Air Force Schools
 - Air Force Reserve Officer Training Corps. (ROTC)-Bachelors
 - Air Force Academy-Bachelors, Masters
 - Must be 17
 - US Citizen
 - Good moral character, physical condition, scholastic record
 - Unmarried and no dependent children
 - Demonstrated potential for leadership, desire to become a cadet
 - Community College of the Air Force - Associate Degrees



Part 4 Air Environment



Chap. 18- The Atmosphere

Chap. 19- Weather Elements

Chap. 20- Aviation Weather



18 The Atmosphere

Atmospheric Regions

- Troposphere - Region where we live. “Tropo” means change “sphere” means layer. Temperature decreases with altitude, region where weather occurs.
- Stratosphere - Stable weather region, temperature increases with altitude
- Mesosphere - Temperature increase then decrease to -130F
- Thermosphere - 50 miles to 300 miles, temperature increases

Water in Atmosphere

- Evaporation - liquid molecules turn to gas or vapor state.
- Humidity - amount of water in air
- Relative Humidity - indicates amount of water vapor that can still enter air mass before being saturated
- Dew Point Temperature - Temperature at or below which water vapor will be saturated and condense.

Methods of Heat Transfer

- Conduction - Heating by direct contact
- Convection - Heating by vertical motion of fluid (thermals)
- Advection - Heating by horizontal motion of fluid (wind)
- Radiation - Method of heating without changing temperature of medium in between (sun)
- Insolation - Rate Earth’s surface is heated by solar radiation

Pressure Gradient

- Pressure gradient - slope of high-pressure mountain
- Isobars - lines of constant pressure
- Jet Stream - “River” of high speed air moving from West to East at speeds up to 450MPH



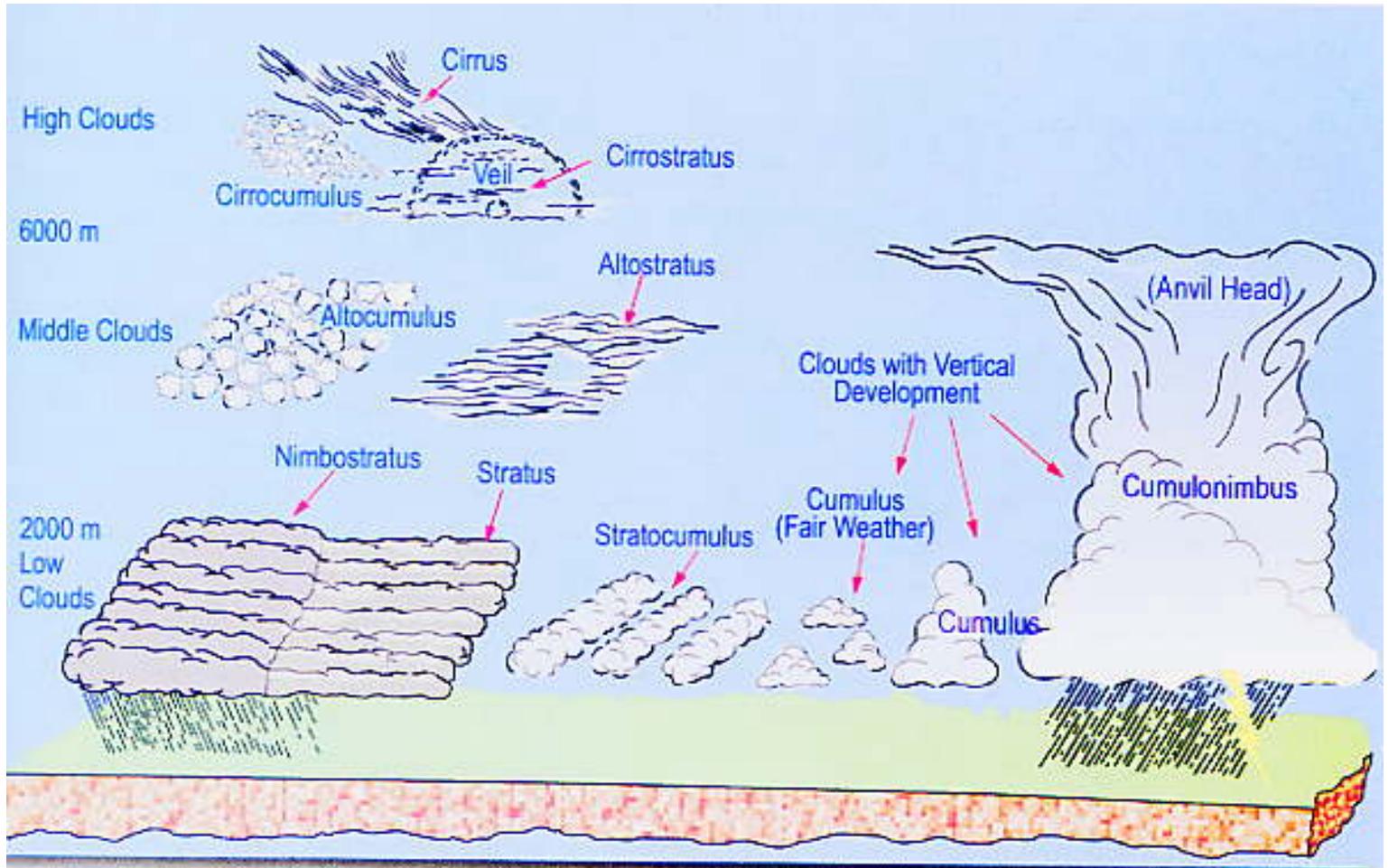
19 Weather Elements

Air Masses & Fronts

- Cold Front - Pushes warm air upward and can create thunderstorms
- Warm Front - Warm air covers cold air, usually high, thin wispy clouds develop
- Stationary Front - When air masses lose their “punch” and do not replace each other
- Occluded Front - Warm air mass, lying between two cold masses is lifted by cold mass behind
- Polar - Cold
- Tropical - Hot
- Maritime - Humid
- Continental - Dry

Clouds

- Cumulus - Piled up
- Stratus - Layered
- Cirrus - High, thin appearance
- Low - 300-6500 ft, stratus, cumulus, stratocumulus, cumulonimbus, nimbostratus
- Medium - “Alto” high but not highest, 6500 - 20000 ft
- High - Cirrus - wispy





20 Aviation Weather

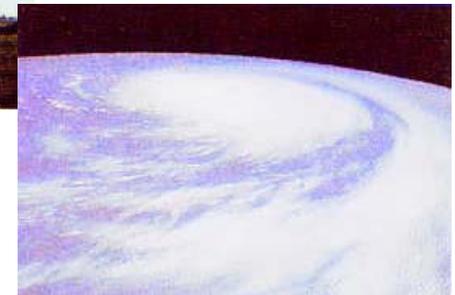
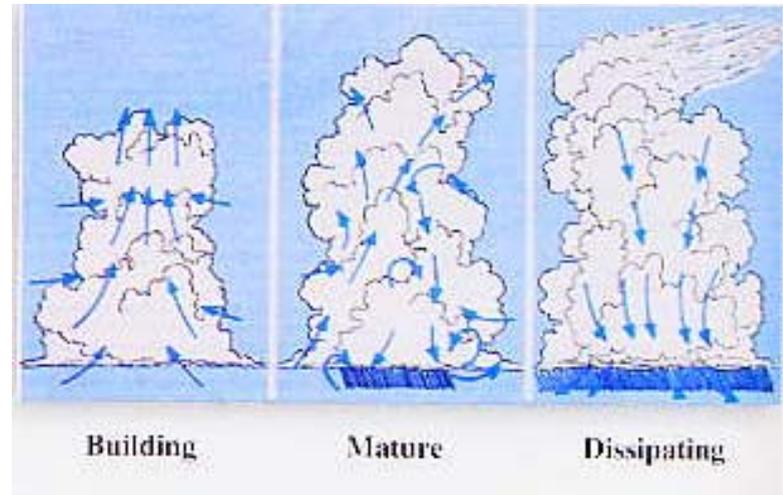


Weather Hazards

- Visual Flt Rules (VFR) - Cloud ceiling > 3000 ft and visibility > 3 miles
- Instrument Flt Rules (IFR) - Cloud ceiling >500 and <1000 ft and visibility >1 mile and <3miles
- Clouds, rain, snow, fog, haze, smoke, blowing dust, sand, snow
- Icing - Carburetor, glaze, rime, frost

Severe Weather

- Thunderstorms
 - Cumulus stage - updraft of warm moist air
 - Mature stage - Rain, strong downdrafts
 - Dissipating stage - Downdrafts produce heating, drying, ceasing rain
- Tornadoes
 - Funnel cloud that touches ground - violent energy in small area
 - Occur most often in N. America & Australia
- Hurricane
 - Strong tropical cyclone that occur around world
 - Eye of hurricane is calm low pressure core
- Hail
 - Frozen rain pellets that circulate in thunderstorm





Part 5 Rockets



Chap. 21- Rocket Fundamentals

Chap. 22- Chemical Propulsion

Chap. 23- Orbits & Trajectories



21 Rocket Fundamentals



History of Rocketry

- Rocketry is based on the propelling of a vehicle by a reactive force.
- Chinese developed rockets in 1220 and were first to use in war.
- 1405 - German engineer Konrad Kyeser von Eichstadt devised rocket propelled by gunpowder
- 1800 - Britain's William Congreve developed flight-stabilizing guide sticks and built first viable launching pad.
- William Hale (English) developed spin stabilization with angled exhaust tubes.
- WW I - rockets used as signal flares and to carry messages, not used as primary weapon.
- Dr. Robert H. Goddard - Developed and launched first liquid propelled rocket. Recognized as the "Father of Modern Rocketry".
- Germany developed liquid rocket as weapon in WW II know as the V-2.

21 Rocket Fundamentals

Fundamental Physics

- Gravitation-Force of attraction between all matter within the universe
- Gravity- Gravitation force with a body or mass on or near the Earth (Galileo)

- Newton's Law of Universal Gravitation:

$$F = \frac{Gm_1m_2}{d^2}$$

- Newton's Three Law's of Motion:

- 1) Inertia
- 2) $F=ma$
- 3) Action=Reaction

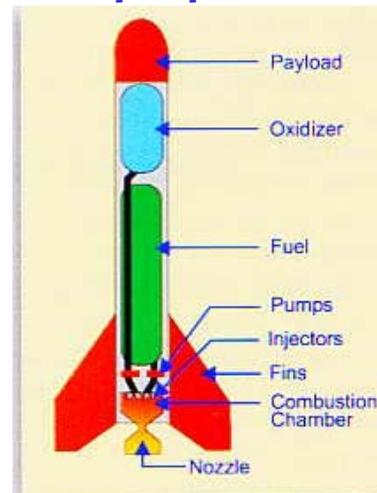
Momentum = m x V

Acceleration = rate of change of velocity

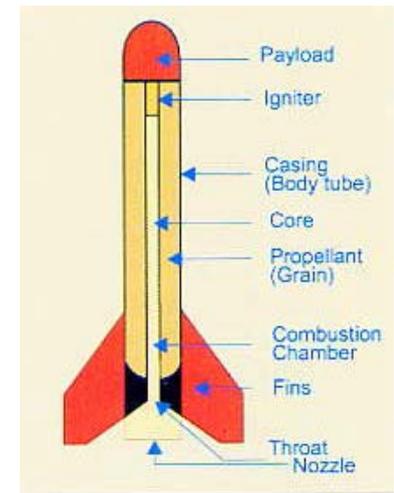
Rocket Systems

Specific Impulse (Isp) = lbs of thrust delivered by consuming 1 lb of propellant in 1 second

- Airframe-Structure
- Propulsion
 - Engines - Liquid Propellant
 - Motors- Solid Propellant
- Guidance Systems - "Brain", inertial platform, star tracking
- Control Systems - "Steering", thrust vector control, reaction control



Liquid Fuel Propulsion System



Solid Fuel Propulsion System



22 Chemical Propulsion



Oxidizers & Reducers

- Oxidation - combination of oxygen with another substance. Time it takes for this process determines if substance rusts, corrodes, burns, or explodes
- Combustion - Rapid oxidation
- Oxidizer - Chemical element of Oxygen used to facilitate oxidation
- Reducers - Fuel used to combine with Oxygen to produce combustion.
- Propellant - Common reference to both oxidizer and fuel
 - Bipropellant - Propellant with separate storage of oxidizer and fuel.
 - Monopropellant - Oxidizer and fuel stored in same container.

Solid Motors-Oxidizer and fuel are mixed together in solid state

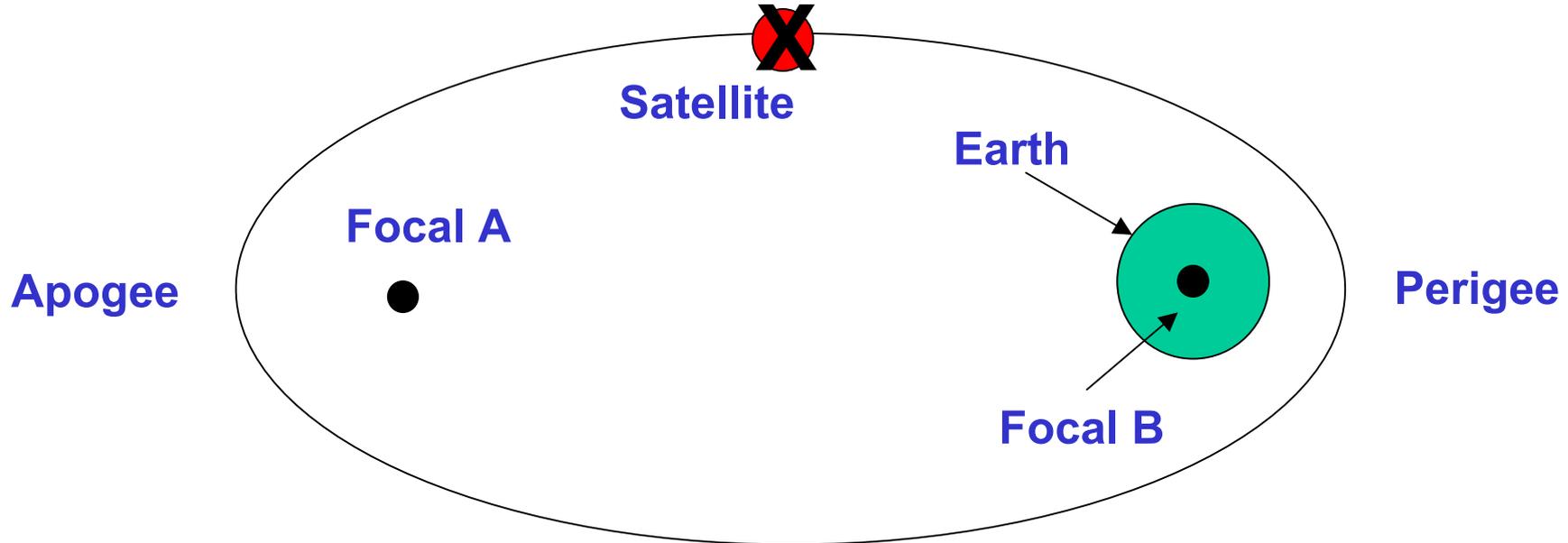
- Storable
- No thrust control
- Cannot stop or throttle

Liquid Propellant

- Hard to store/handle
- Can stop or throttle

23 Orbits & Trajectories

Orbit - Path described by one body in its revolution about another body.



Circular Orbit - Constant altitude above Earth's surface

Elliptical Orbit - Not circular

Equatorial - West to East over Equator

Geostationary Orbit - Equatorial orbit of period of 24 hours

Polar Orbit - Crosses North and South poles

Sunsynchronous Orbit - Constant exposure to sunlight

Sounding Rocket - Straight up trajectory, never reaches orbit



23 Orbits & Trajectories

Velocity Requirements

- **Burnout - Moment a rocket engine ceases to produce thrust.**
- **Satellite in circular Earth orbit - 17,856 MPH**
- **Minimum velocity to Moon - 24,409 MPH**
- **Escape velocity of Earth - 25,560 MPH**
- **Escape velocity of Solar System - 36,000 MPH**

Launch Vehicles

- **Rocket - Power plant used to propel a payload.**
- **Missile - Rocket propelled vehicle used to deliver a weapon.**
- **Launch Vehicle - Rocket propelled vehicle use to deliver payload other than a weapon.**
 - **Expendable - Vehicles used only once and do not return to Earth.**
 - **Reusable - Space Shuttle is only reusable launch vehicle.**



Part 6 Space



Chap. 24- Space Environment

Chap. 25- Our Solar System

Chap. 26- Unmanned Space Exploration

Chap. 27- Manned Spacecraft



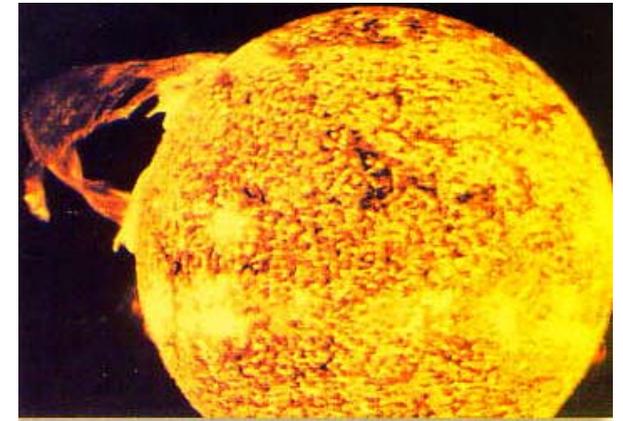
24 Space Environment

Space

- Definition - Altitude of 50 miles and beyond Earth's surface.
- Cislunar Space - Space between Earth & Moon.
- Interplanetary Space - Center of Sun to outermost planet, Pluto.
- Interstellar Space - Distance between solar systems.

Sun

- Strongest gravitational force in the solar system.
- 864,000 Miles in diameter, surface is plasma, fusion process
- Photosphere - Thin shell that gives light.
- Chromosphere - Sphere of Color.
- Corona - "Crown" outermost part of sun's atmosphere



Environmental Effects on Space Operations

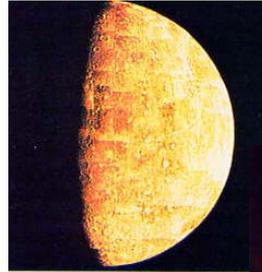
- Communications - Magnetic storms, ionosphere, solar flares
- Radiation, Electrostatic charging, vacuum
- Weightlessness - Damaging physical effects on Human body. Astronauts use NASA's "Vomit Comet" to train for weightlessness or free fall.



25 Our Solar System

Mercury

- Closest planet to Sun; 36 million miles
- Temperature ranges from -350F to 750F



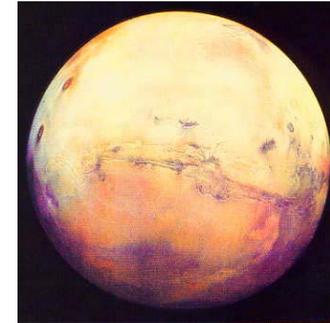
Venus

- Second planet from Sun; 67 million miles
- Nearest to Earth in size and distance
- Only planet to rotate about its axis in a clockwise (east to west) direction
- Hottest planet of 900F, 240 days to complete one rotation



Mars

- Fourth planet, the Red Planet, slightly longer than 1 Earth day
- Highest mountain in solar system: 400 miles wide 17 miles high
- Pathfinder mission landed 1997. Small rover called Sojourner analyzed rocks and soil.



Jupiter

- Fifth planet, largest in solar system
- Gas giant, hydrogen, helium, methane, ammonia
- 11 times larger than Earth
- Rotates every 10 hours

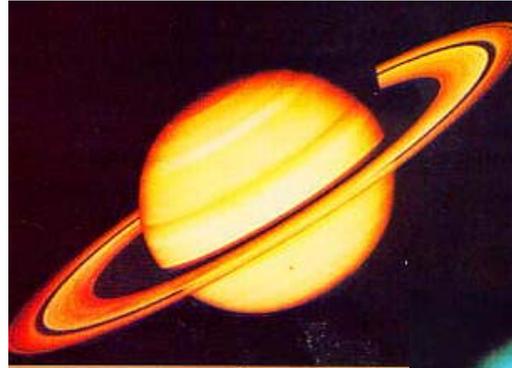




25 Our Solar System

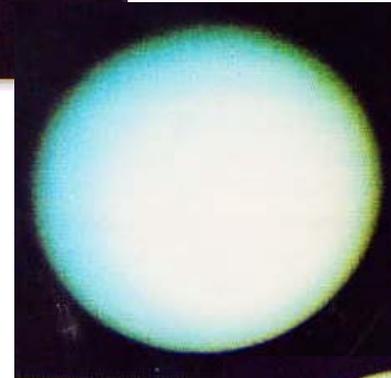
Saturn

- 2nd largest planet and sixth from Sun
- Rotates every 10 hours



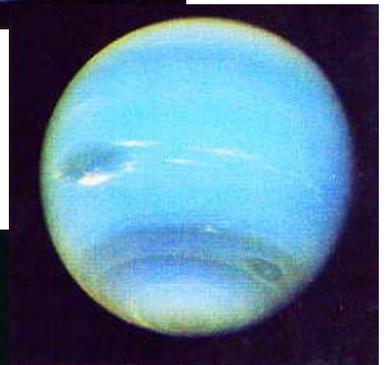
Uranus

- 3rd largest planet in solar system
- Rotates on side every 18 hours.
- 2 billion miles from Sun, -340F on surface



Neptune

- Outermost of gas planets, 4th largest in solar system
- Rotates every 19 hours
- Most windy planet, up to 1500 MPH



Pluto

- About size of Mars
- Rotates every 6.4 Earth days
- Ranges from 2.9 to 4.6 billion miles from Sun





25 Our Solar System

The Asteroids

- Rocky and metallic objects orbiting the Sun too small to be planets
- Over 15,000 asteroids have been found



Comets

- Small irregular shaped body with nucleus made of water, ice, rock, and frozen gas
- Identified by a coma (diffuse material surrounding nucleus) with a long trailing tail
- Highly elliptical orbit around the Sun



Meteoroids

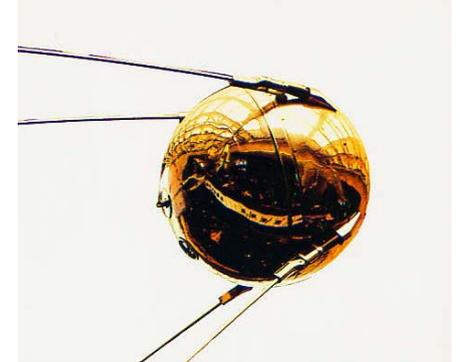
- Bits and clumps of matter that orbit the Sun and cross cislunar space
- Meteor - meteoroid that enters Earth's atmosphere
- Meteorite - meteor that collides with Earth's surface
- Most meteorites are size of basketball or smaller



26 Unmanned Exploration

The Space Race Begins

- Former German scientists worked with V-2 rocket derivatives to explore rocket research for US and Russia.
- Soviet Union launched first successful artificial satellite, Sputnik 1 on Oct. 4, 1957



- Explorer I - US first satellite launched Jan 31, 1958.
- October 1, 1958 - National Aeronautics & Space Administration (NASA) developed.

Space Treaties

- 1967 Outer Space Treaty - Approved in UN General Assembly states that space is providence of all mankind and space exploration should benefit all countries.
- AMB Treaty - 1972, Anti-Ballistic Missile Systems - agreement not to develop systems to defend against ballistic missiles.
- Commercial Space Launch Act (CSLA) - Single regulatory agency for commercial space in US.



26 Unmanned Exploration

Satellites - Unmanned Spacecraft

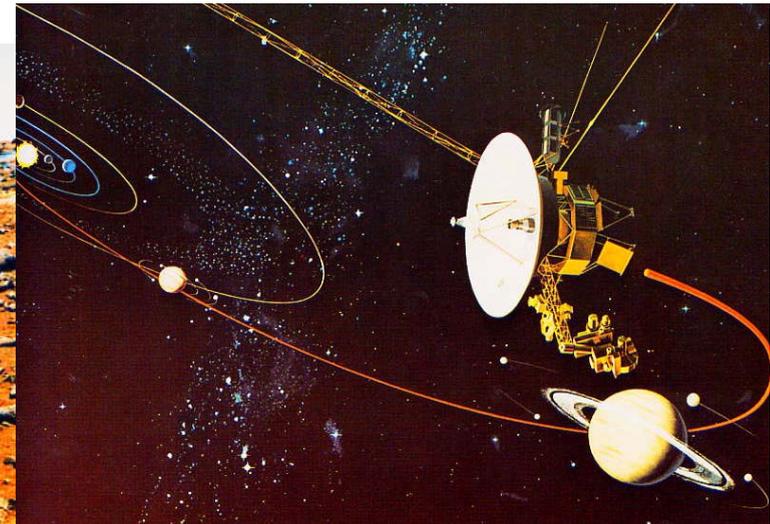
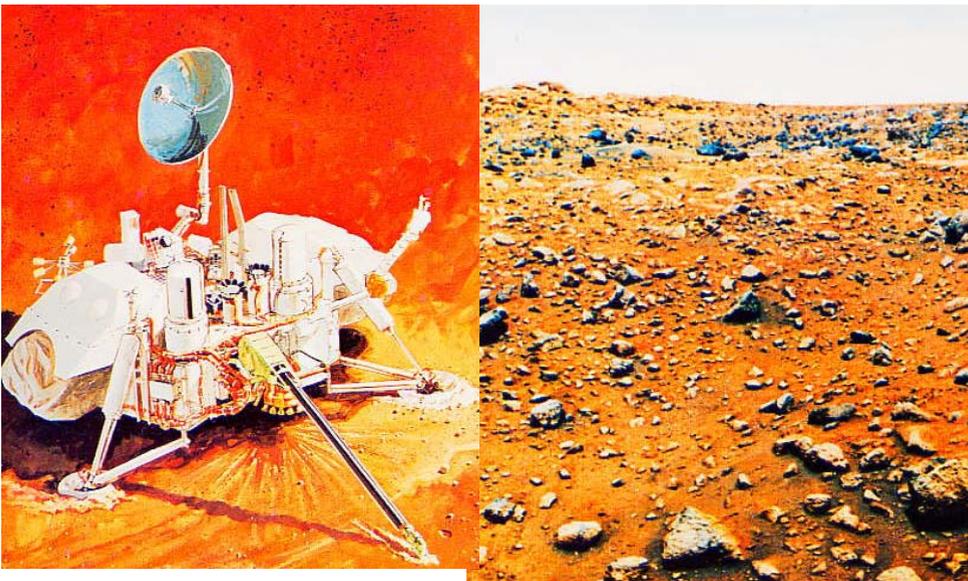
- **Communications Satellites - relay and amplify signals**
 - Echo 1, Telstar, INTELSAT, TDRSS, Milstar
- **Navigation Satellites - Send positional data to specific receivers**
 - Transit, NAVSTAR (GPS)
- **Observation Satellites - Look at Earth and relay information.**
 - Weather (Tiros 1960), multi-spectrum imaging, reconnaissance
- **Scientific Satellites - Orbit for sole purpose of gaining information**
 - Explorers - first of series to orbit Earth
 - Orbiting Solar Observatory (OSO)
 - Orbiting Astronomical Observatory (OAO)
 - Hubble Space Telescope
- **Probes**
 - Rangers - first probes to investigate the Moon
 - Surveyors - landed on Moon's surface



26 Unmanned Exploration

- Probes

- Mariners - flyby of Venus, Mercury, and Mars
- Pioneers - Outer planet probes, first look at Jupiter and Saturn
- Vikings - Two probes that landed on Mars
- Voyagers - explored Jupiter, Saturn, Uranus, Neptune
- Mars Pathfinder - 1997 landing of rover Sojourner
- Galileo - Inserted probe into Jupiter
- Cassini - To reach Saturn in 2004





27 Manned Space Explorations

Project Mercury - First American Manned Space Program

- Determine if man can survive in space and effects on human body.
- Original Seven: Carpenter, Cooper, Glenn, Grissom, Schirra, Shepard, Slayton
- 1961-1963: 6 flights
- May 5, 1961 - First American in space, Alan Shepard, suborbital flight
- February 20, 1962 - First American to Orbit Earth, John Glenn



Project Gemini

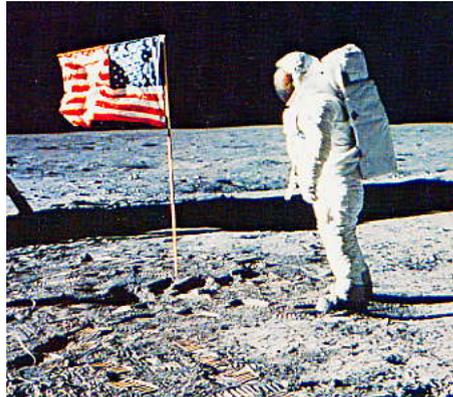
- Improve techniques needed for lunar mission: 2 people in space, rendezvous, and docking with another spacecraft, walk in space.
- June 3, 1965 - Ed White first American to walk in space.
- 1965-1966: 10 flights



27 Manned Space Explorations

Project Apollo - The Moon Missions

- 1968-1972: 11 missions, 6 landed on Moon
- Apollo 8 - December 24, 1968 - First Moon orbit
- Apollo 11 - July 20, 1969 - First Moon landing. Neil Armstrong & Edwin Aldrin

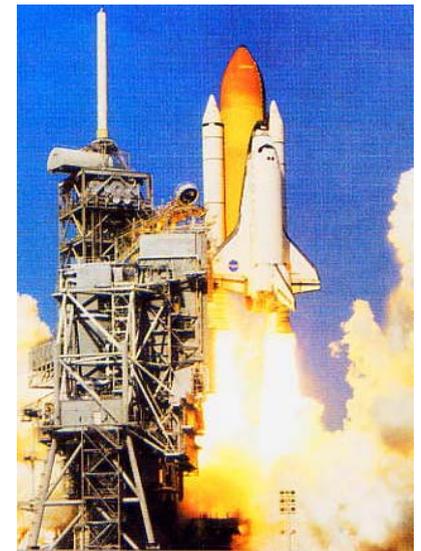


Project Skylab - Our First Space Station

- 1973-1974: 3 Missions, longest mission 84 days

Space Shuttle

- April 12, 1981 - first flight with John Young & Bob Crippen, Columbia
- Vehicles built: Enterprise (atmospheric test vehicle), Columbia, Challenger (lost Jan 28, 1986), Discovery, Atlantis, Endeavour
- June 18, 1983 - first American woman in space





27 Manned Space Explorations

Soviet Manned Space Program

- April 12, 1961 - First human enter space and orbit Earth - Yuri Gagarin
- June 1963 - First woman in space - Valentina Tereshkova
- March 1965 - First human to walk in space - Alexei Leonov
- July 1975 - Apollo-Soyuz Test Project - docking in space
- Mir - 1986-2001

