A

A-4 The original engineering designation for the **V-2**. See **V-2**.

ablation The erosion of a surface, usually of a spacecraft **heat shield** on **re-entry**, due to friction with the molecular constituents of the **atmosphere**. A surface designed to ablate in such circumstances is known as an 'ablative surface' or 'ablative coating'.

ABM An abbreviation for:

(i) **apogee boost motor** – see **apogee kick motor (AKM)**.

(ii) anti-ballistic missile, a missile designed to destroy another ballistic missile in flight and the subject of the 1972 ABM Treaty, designed to limit the development and deployment of ballistic missiles.

abort The termination of a space **flight** or **mission** (used both as a verb and a noun). As an illustration, the **Space Shuttle** has four abort alternatives which can be used during the launch phase in the event of a **Space Shuttle main engine** failure:

(i) Return To Launch Site (RTLS). Available from separation of the **solid rocket boosters (SRBs)** to the time when the next alternative (AOA) becomes available. The Shuttle flies on to burn the remaining **propellant**, turns back towards the **launch site**, jettisons the **external tank** and glides back to the launch site runway for a landing.

(ii) Abort Once Around (AOA). Available from about 2 minutes after SRB separation to when the next alternative (ATO) becomes available. The vehicle attains a **sub-orbital** trajectory, circles the Earth once and returns to the launch site.

(iii) Abort To Orbit (ATO). Available when the Shuttle has passed the AOA-point and can attain orbit. Although the orbit attained may be lower than originally intended, the **de-orbit**, **re-entry** and landing would be similar to a normal mission.

(iv) Transatlantic Landings (TAL). An additional abort alternative which overlaps the latter part of the RTLS option, added when emergency runways became available on the eastern side of the Atlantic.

absolute temperature Temperature measured on the 'absolute scale'. See **kelvin (K)**.

absolute zero The lowest temperature theoretically attainable; the temperature at which all molecular motion ceases (−273.15 °C). See **kelvin (K)**.

AC power A source of electrical power supplied with alternating current. See **power**. The great majority of spacecraft power systems use direct current (DC), AC being used only for special applications in scientific satellites and spacecraft payloads. The **Hubble Space Telescope**, for instance, uses a 20 kHz AC supply.

[See also **regulated power supply**]

acceleration due to gravity – see **gravity**

accelerometer A device for measuring acceleration.

[See also **inertial platform**]

access arm A projection from a launch vehicle **service structure** which can be rotated towards the vehicle for access, either for general maintenance or the loading of a **crew**. If the arm is swung away from the vehicle at the moment of **launch**, usually when it carries **umbilical**s for **propellant** or electrical services, it is also known as a **swing-arm**.

[See also **white room**]

access panel – see **closure panel**

access tower – see **service structure**

acoustic test chamber A ground-based test facility which simulates the acoustic environment experienced by a spacecraft during **launch**.

[See also **thermal-vacuum chamber**, **vibration facility**, **anechoic chamber**]

activated charcoal canister – see **environmental control and life support system (ECLSS)**

active A term applied to any device or system involved in mechanical or electrical action, or capable of a productive reaction to external stimuli; the opposite of **passive**. For example, an **amplifier** is an active device in a **communications system**, since it makes an active contribution to the input **signal**; a connector is a passive component. Similarly, a **heater** is an active device in a **thermal control subsystem**, while **thermal insulation** provides passive thermal control. While most spacecraft **sensor**s or remote sensing **payload**s are passive, the **synthetic aperture radar (SAR)** is an active device.

active satellite An archaic term for a satellite with an active payload, typically a **communications payload** (see, for comparison, **passive communications satellite**). The first satellite to carry an active radio repeater was Courier 1B – see **repeater**.

actuator Any device which produces a mechanical action or motion; a servomechanism that supplies the energy for the operation of other mechanisms.

Spacecraft actuators forming part of a spacecraft **attitude and orbital control system** include **reaction control thrusters**, **reaction wheels** and **momentum wheels**.

[See also **nutation damper**, **solar sailing**, **orbital control**, **attitude control**]

ADCS – see **attitude determination and control system**

aerial – see **antenna**

aerobraking Aerodynamic braking, an orbital **injection** technique which uses frictional forces generated within a planetary **atmosphere** to decelerate a **spacecraft**, thereby reducing the amount of **propellant** required. Aerobraking typically begins in the higher levels of the atmosphere and lowers the **apoapsis** in a gradual process (e.g. as performed by the Mars Global Surveyor spacecraft in 1997/98); the spacecraft may attain an **orbit** or conduct a **re-entry**. Contrast: **aerocapture**.

[See also **atmospheric drag**]

aerocapture Aerodynamic capture, an orbital **injection** technique which uses frictional forces within a planetary **atmosphere** to decelerate a **spacecraft** in a single pass (as opposed to **aerobraking**, which is a gradual process). In aerocapture, the spacecraft penetrates more deeply into the atmosphere and must be fitted with a **heat shield** to dissipate the higher levels of **aerodynamic heating**.

[See also **re-entry corridor**, **atmospheric drag**]

aerodynamic heating An increase in the **skin temperature** of a vehicle due to air friction, particularly at supersonic or hypersonic speeds [see **Mach number**]. Sometimes called 'kinetic heating', although this can be caused by other forms of friction due to motion.

[See also **re-entry**, **aerocapture**]

aerodynamic stress A generic term for the forces to which a **launch vehicle** or **spacecraft**, etc., is subjected during its passage through an **atmosphere** (during **launch**, **re-entry**, etc.). See **aerodynamics**.

aerodynamics The study of air flow over a body and the resultant aerodynamic forces. See **lift**, **drag**, **thrust**.

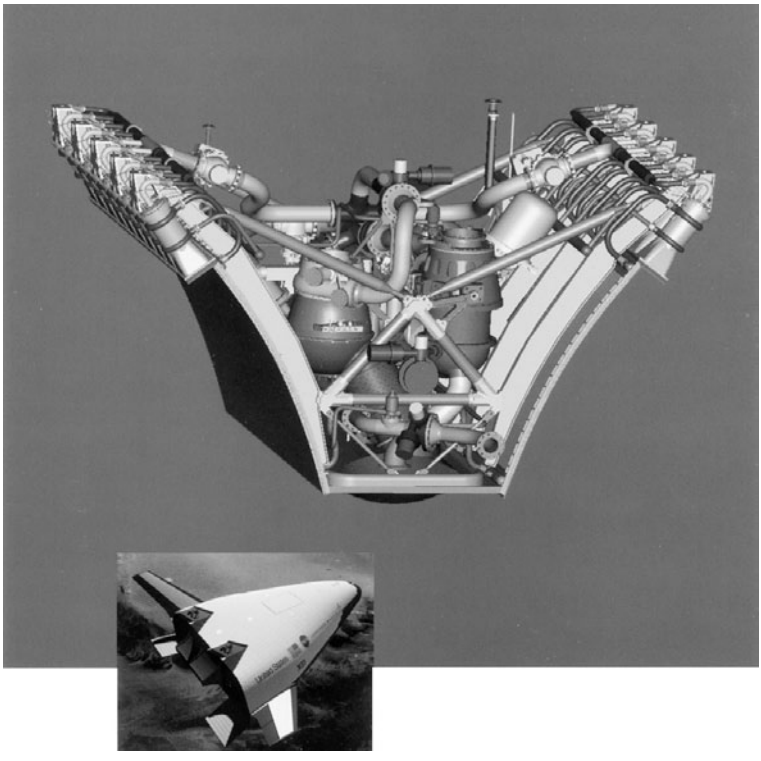
[See also **aerospace vehicle**, **lifting body**, **lifting surface**, **fairing**, **dynamic pressure**]

aerospace A modifier describing a relevance to both air and **space**: e.g. aerospace industry, **aerospace vehicle**.

aerospace vehicle A term used for a space vehicle which, as part of its **launch** or **re-entry** phase, is also capable of flight in the **atmosphere** using a **lifting surface** (namely a wing) as well as conventional rocket propulsion. [See also **spacecraft**, **single stage to orbit**, **reusable launch vehicle (RLV)**, **Hotol**]

aerospike A system of shock-waves (an 'aerodynamic spike') formed in the stream of exhaust gases from a **rocket engine** using a **plug nozzle**, as opposed to a bell-shaped **exit cone**. An abbreviated name for the engine itself: see **aerospike engine**.

aerospike engine An alternative to the bell-shaped **exit cone** used in the **nozzles** of contemporary **rocket engines**, whereby a number of small **combustion chambers**, with accompanying **nozzle** outlets, discharge combustion gases



A1: XRS-2200 linear **aerospike engine** designed for the **X-33** technology demonstrator. [Boeing]

against the outer surface of a truncated wedge or cone [see figure A1]. The system of shock-waves formed below the engine is known as an **aerospike**. In the case of the wedge (or ramp) design, the nozzle-outlets are arranged in a line and the device is known as a linear aerospike engine; in the conical design, where the nozzles are arranged in a ring, it is termed a plug nozzle or annular nozzle.

The aerospike engine is more efficient than the conventional bell nozzle in that it offers an automatic adjustment to the variation in atmospheric pressure between ground level and the upper **atmosphere** [see **plug nozzle**]. The linear engine design formed the basis for **NASA**'s **X-33** programme to develop the technology for a **reusable launch vehicle (RLV)**.

aerozine-50 A **liquid propellant** comprising 50% **hydrazine** and 50% **UDMH** (unsymmetrical dimethylhydrazine).
[See also **liquid propellant**]

Agena A rocket **stage** used with the **Thor**, **Titan** and Atlas **launch vehicle**s. See **Atlas**.

AI An abbreviation for **artificial intelligence**.

airborne support equipment (ASE) Equipment flown on a **spacecraft** or **launch vehicle** to support a **payload** (physically or in terms of electrical supplies, etc.); for example, a **cradle** (and its associated systems) designed to support a spacecraft in the **payload bay** of the **Space Shuttle**, or a Spacelab **pallet**.
[See also **flight hardware**, **ground support equipment (GSE)**]

air-breathing rocket – see **combined cycle engine**

airframe The supporting structure and aerodynamic components of a **launch vehicle** or **aerospace vehicle**. The term, borrowed from aviation technology, tends to be applied only to space vehicles which have some contact with the Earth's **atmosphere** during their launch phase, and not to **satellite**s and other similar **spacecraft**.
[See also **thrust structure**, **inter-tank structure**, **inter-stage**, **fairing**, **fin**, **skin**, **longeron**, **stringer**, **ogive**, **skirt**, **shroud**, **SYLDA**, **SPELDA**, **SPELTRA**]

airlock An airtight chamber which allows **astronaut**s and/or equipment to leave and/or enter a **spacecraft** without depressurising the entire vehicle. Most early space **capsule**s were far too small to include a separate airlock so any **extra-vehicular activity (EVA)** required all crewmembers to don their **spacesuit**s before the capsule was depressurised. However, the Space Shuttle **orbiter** has a removable airlock which can be installed in one of three

different positions dependent on the mission: inside the crew compartment, allowing maximum use of the **payload bay**; inside the payload bay attached to the aft cabin bulkhead; or on top of the pressurised 'tunnel adapter' which links a **Spacelab** payload to the orbiter **cabin**. Two spacesuits are stored in the airlock and, during EVA, it can supply oxygen, cooling water, electrical power and communications services to the suited astronauts.

AIT – see **assembly, integration & test**

AKM – see **apogee kick motor**

albedo The ratio of the intensity of light reflected from a body to that received from the Sun (in the 'visible **spectrum**' unless otherwise specified).

The fraction of the incident solar radiation returned to space by reflection from a planetary surface (solid or gaseous) is called 'planetary albedo', the average value of which for Earth, for example, is 0.34. In contrast, the thermal energy re-radiated by the Earth is known as 'earthshine'. Although important to the thermal design of spacecraft in **low Earth orbit**s, albedo and earthshine are only significant for geostationary spacecraft carrying devices at **cryogenic** temperatures.

[See also **thermal control subsystem**, **geostationary orbit**]

Alcantara The location of a Brazilian **launch site** (at approximately 2° S, 44° W), used mainly for its domestic small satellite launcher, **VLS** (Veiculo Lancador de Satellites).

ALH84001 The designation of a **meteorite** found in the Allan Hills region of Antarctica but believed to originate from Mars. In 1996, NASA announced that the 'Martian meteorite' appeared to contain fossilised lifeforms, thereby suggesting that there was once life on Mars. Less well known is the 'lunar meteorite' designated ALH81005, which, among others, is believed to have reached Antarctica from the **Moon**.

Alpha A former designation of the **International Space Station (ISS)**.

ALSEP An acronym for Apollo Lunar Surface Experiments Package. The ALSEP, carried on all **Apollo** landing missions except Apollo 11, was stored in the **descent stage** of the lunar module and powered by a plutonium-238 **radioisotope thermoelectric generator (RTG)**, designated **SNAP**-27 (an acronym for systems of nuclear auxiliary power). The package contained **seismometer**s, a **magnetometer**, and **solar wind** and lunar heat flow experiments.

altimeter An instrument designed to measure **altitude** (sense (i)).

[See also **radar altimeter**]

altitude
(i) The vertical height of a body above the surface of a planet (typically above sea level for Earth).
(ii) In astronomy, navigation, etc., a measure of the angle above the horizon. See **elevation** (**angle**).

altitude-azimuth mount A structure for the support and guidance of an astronomical telescope or a satellite **earth station** which uses the 'horizon system' of celestial coordinates – see **azimuth**. In satellite applications it is referred to as an **elevation**-over-azimuth mount if its lower axis is perpendicular to the ground, and 'X–Y' if its lower axis is parallel to the ground. The term 'Az-El mount' is also sometimes heard. The major alternative to the 'Alt-Az' mount for telescopes is the **equatorial mount**, known as a **polar mount** for earth stations.
[See also **kinetheodolite**]

aluminium (Al) A low-density metal, widely used (when alloyed with other metals) in the aerospace industry. Historically, aluminium was alloyed with only a few elements close to it in the periodic table: magnesium, zinc, copper, silicon, manganese and lithium. However, later techniques, including rapid solidification technology, have trebled this number. Typical applications: spacecraft body-panel **face-skins**, mounting-brackets and fittings (machined), launch vehicle **adapter ring**s (forged).
[See also **honeycomb panel**, **materials**]

AM – see **amplitude modulation**

Ames Research Center – see **NASA**

AMF – see **apogee motor firing**

ammonium perchlorate (NH_4ClO_4) A solid **oxidiser** used in **rocket motors**. See **solid propellant**.

amplifier An electrical device which increases the strength of an input signal and presents a magnified replica of the signal at the output.
[See also **amplifier chain**, **HPA**, **LNA**, **SSPA**, **TWTA**, **linearity**]

amplifier chain A general term for a number of amplifiers, and associated hardware, linked together in series. In a practical amplification device (for instance a spacecraft **communications payload**) a number of discrete, specialised amplifiers (e.g. pre-amplifiers, **low noise amplifiers** and **IF amplifiers**) are commonly linked together to form a chain. Within the communications payload one finds equipment divided, by function, into a **receive chain** and a **transmit chain**.

amplitude modulation (AM) A transmission method using a modulated **carrier** wave, whereby the **amplitude** of the carrier is varied in accordance with the amplitude of the input signal; the **frequency** of the carrier remains unchanged.
[See also **modulation**, **frequency modulation (FM)**, **phase modulation (PM)**, **pulse code modulation** (**PCM**), **delta modulation** (**DM**)]

Andoya The location the Andoya Rocket Range (at approximately 69° N, 16° E), a Norwegian **launch site** used mainly for **sounding rocket**s.

anechoic chamber A ground-based test-facility for the evaluation of **radio frequency (RF)** equipment on a spacecraft, which simulates the RF propagation characteristics of **free space**. The walls and all service equipment and mounts are covered with RF absorbing material to reduce reflections (or 'echoes') to a minimum [see figure A2]. The larger chambers admit the whole spacecraft, but it is quite common to test only the **communications payload** (**antenna**s and **transponder**s) at an earlier stage in the design process.
[See also **thermal-vacuum chamber**, **acoustic test chamber**, **vibration facility**]

Angara A Russian **launch vehicle** developed in the late 1990s, in a number of variants, to replace the **Zenit** and **Proton**. Its smallest version was designed to lift about 2200 kg to **low Earth orbit (LEO)**, while medium and heavy-lift versions had approximate payload capabilities of 14 and 24.5 tonnes, respectively, to LEO (2.5 and 6.8 tonnes to **geostationary transfer orbit**).

angle modulation – see **modulation**

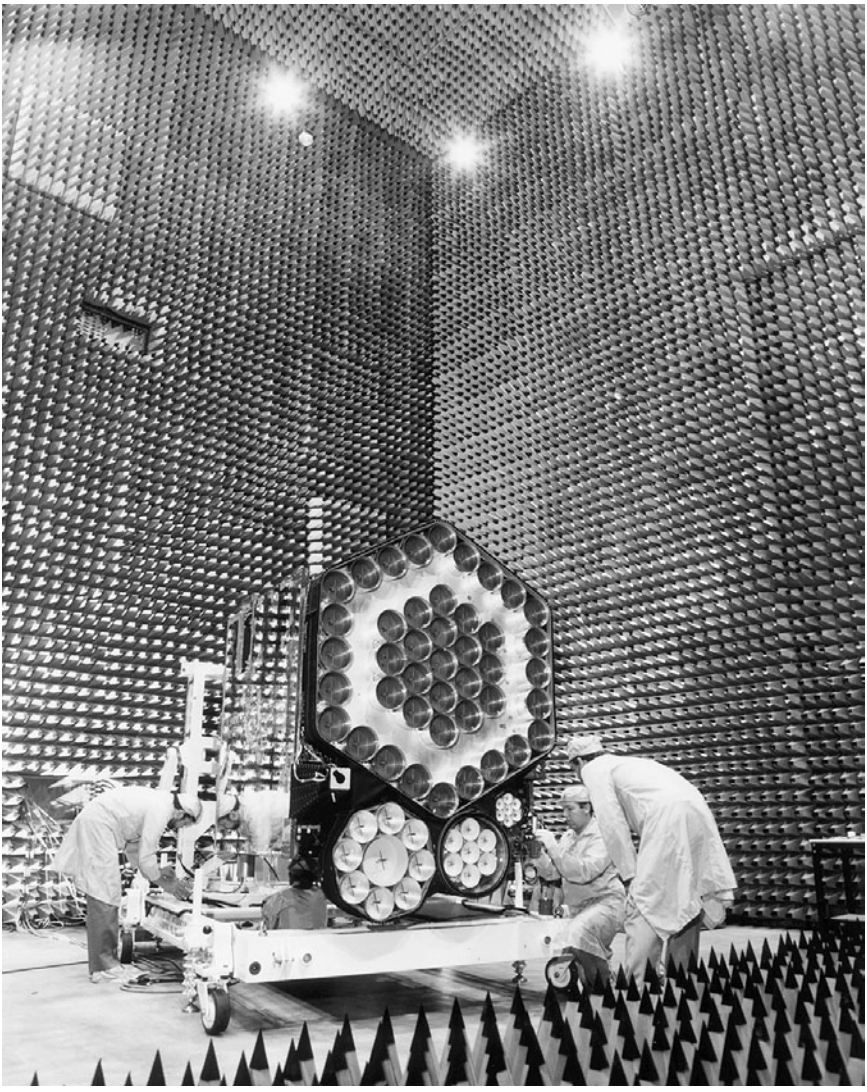
announcement of opportunity – see **AO**

annular nozzle – see **plug nozzle**

anoxia A lack of oxygen. See **hypoxia**.

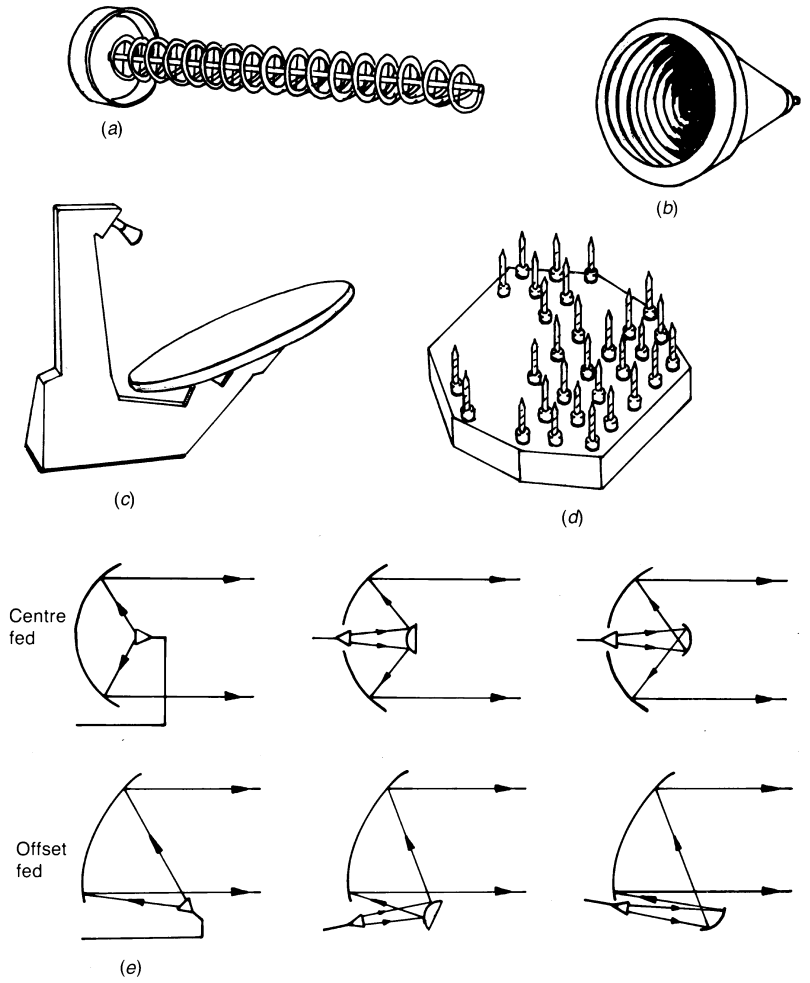
antenna The part of a radio system that enables a radio signal to be transmitted and/or received; the 'interface' between the radio equipment and the environment, between a '**free space**' RF wave and a guided wave. A radio **transmitter** 'excites' electric currents in the conductive surface layers of an antenna leading to the propagation of an electromagnetic wave; conversely, an incident radio wave 'excites' similar currents which are conducted to the **receiver**.

There are many different types of antenna, but using one method of categorisation four main types can be identified: wire, horn, reflector and array antennas [see figures A3, A4]. For spacecraft applications, wire antennas operate chiefly at VHF and UHF frequencies, often taking the form of a helix, conical spiral or simple dipole. The other types operate mainly at **microwave**



A2: Inmarsat-2 **communications satellite** in an **anechoic chamber**. Note the cupped dipole array **antennas**. [British Aerospace]

frequencies. Horn antennas are used by themselves on spacecraft to provide wide coverage of the Earth [see **global beam**], and as **feedhorns** to illuminate reflector antennas. Both horns and reflectors are known as 'aperture antennas'. Another type of aperture antenna is the microwave lens, or 'dielectric lens', which, like an optical lens, can be designed to convert a



A3: **Antenna** types and reflector-antenna configurations: (a) wire antenna (helix); (b) horn antenna (conical corrugated); (c) reflector antenna (offset fed); (d) array antenna (phased array helices); (e) reflector antennas (from left to right): single reflector, **Cassegrain reflector**, **Gregorian reflector**.

spherical wave to a plane wave, thereby improving **directivity** [see **lens antenna**].

The limited **gain** and relatively wide **beamwidth** of horn antennas has led to the widespread use of reflector antennas, particularly on **communications satellites** where high gain and narrow **spot beams** have become increasingly desirable. Array antennas consist of a number of radiating elements designed