business conditions of the last decade of the twentieth century led inexorably to a consolidation of the producers of titanium alloys. Further consolidations may be expected in the alloy specifications that govern the use of titanium. Common specification agreements are in the works whereby a single specification may serve as a buying for a given composition. Single specification requirements for a given alloy should not be considered to grant a common design data base for a material, however. Actual design data will continue to be within the purview of titanium users such as gas turbine engine and airframe manufactures. Commonality of purchasing requirements via common specifications should eventually drive design data to a more common framework.

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Active Orientation Systems, Stabilization of Artificial Satellites

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INTRODUCTION

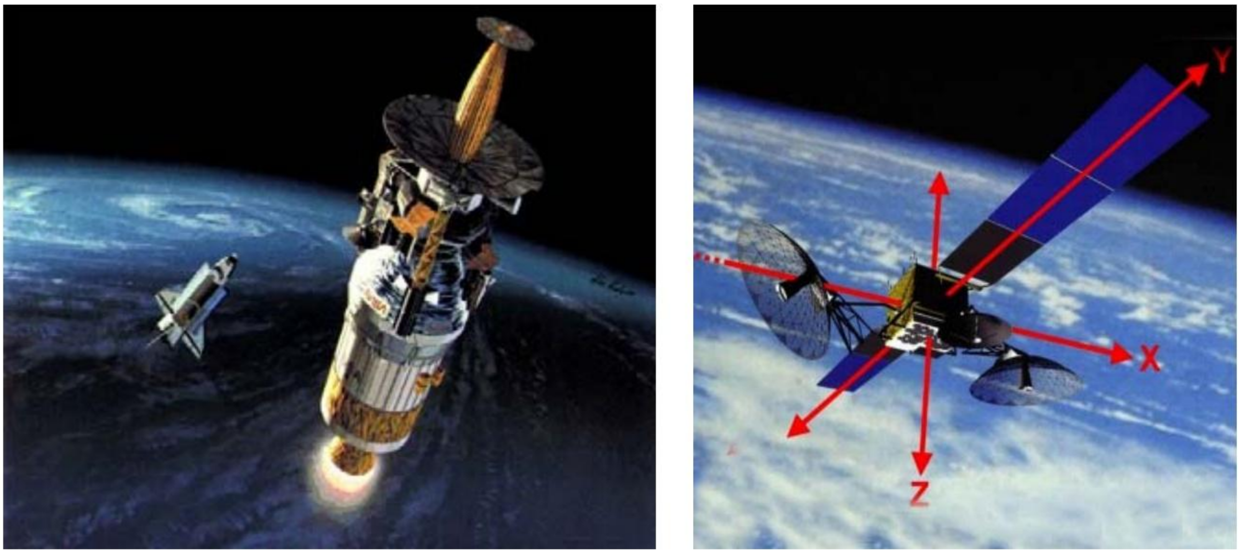
Artificial bodies, such as satellites, are used to study the Earth, other planets, to help us communicate, and even to observe the distant Universe. The first artificial satellite was the Soviet Sputnik 1 mission, launched in 1957.Satellites are launched into different orbits depending on their mission. One of the most common ones is geosynchronous orbit. This is where a satellite takes 24 hours to orbit the Earth; the same amount of time it takes the Earth to rotate once on its axis. This keeps the satellite in the same spot over the Earth, allowing for communication sand television broadcasts. Another orbit is low-Earth orbit, where a satellite might only be a few hundred kilometers above the planet. This puts the satellite outside the Earths atmosphere, but still close enough that it can image the planets surface from space or facilitate communications. Artificial satellites can have a range of missions, including scientific research, weather observation, military support, navigation, Earth imaging, and communications. Some satellites fulfill a single purpose, while others are designed to perform several functions at the same time [2].

ATTITUDE AND ORBIT CONTROL

In order to control an autonomous vehicle, it is fundamentally important to know its attitude. For manned aircraft, roll, pitch and yaw can be obtained through orientation by an inertial reference, usually the ground, or instruments such as an artificial horizon or a compass. Still all of them are dependent on pilot interaction. For unmanned platforms, it becomes necessary to use an electronic device capable of measuring physical quantities related to that goal. A device that aggregates these sensors is called IMU (Inertial Measurement Unit). An IMU contains inertial sensors that measure linear acceleration and angular rate, among other physical data. Through reading and fusing these data it is possible to obtain attitude information which, applied to flight history, can help to determine the position relative to an initial position in a way that allows an aircraft to be stabilized or maneuvered to follow a predetermined trajectory, fulfilling the role of replacing a pilot. Attitude control is essential to prevent the satellite from tumbling in space. Attitude of a satellite is its orientation as determined by the relationship between its axes (yaw, pitch and roll) and some reference plane [3].

SATELLITE STABILIZATION

The satellite once placed in its orbit, experiences various perturbing torques. These include gravitational forces from other bodies like solar and lunar attraction, magnetic field interaction, solar radiation pressure, etc. Due to these factors, the satellite orbit tends to drift and its orientation also changes. The satellite's position thus needs to be controlled both in the east-west as well as the north-south directions. The east-west location needs to be maintained to prevent radio frequency (RF) interference from neighboring satellites. It may be mentioned here that in the case of a geostationary satellite, a 10 km drift in the east or west direction is equivalent to a drift of about 735 km along the orbit. The north-south orientation has to be maintained to have proper satellite inclination. The attitude and orbit control system maintains the satellite position and its orientation and keeps the antenna correctly pointed in the desired direction. The orbit control is performed by firing thrusters in the desired direction or by releasing a jet of gas. It is also referred to as station keeping. Spin stabilization (**shown in Figure 1a**) and three-axis stabilization (**shown in Figure 1b**) are two methods that are used to orient satellites.



(a) Spin stabilization (b) Three - axis stabilization

Figure 1 - Satellite stabilization (a) and (b)

SPIN STABILIZATION: SOME FACTS

With spin stabilization, the entire spacecraft rotates around its own vertical axis, spinning like a top. To maintain stability, the moment of inertia about the desired spin axis should be at least 10% greater than the moment of inertia about the transverse axis. The advantage of spin stabilization is that it is a very simple way to keep the spacecraft pointed in a certain direction. The spinning spacecraft resists perturbing forces, which tend to be small in space, just like a gyroscope or a top. Designers of early satellites used spin-stabilization for their satellites, which most often have a cylinder shape and rotate at one revolution every second. A disadvantage to this type of stabilization is that the satellite cannot use large solar arrays to obtain power from the Sun; thus, it requires large amounts of battery power. Another disadvantage of spin stabilization is that the instruments or antennas also must perform «despin» maneuvers so that antennas or optical instruments point at their desired targets. Spin stabilization was used for NASA's Pioneer 10 and 11 spacecraft, the Lunar Prospector, and the Galileo Jupiter orbiter [3, 4].

THREE-AXIS OR BODY STABILIZATION

The stabilization is achieved by controlling the movement of the satellite along the three axes, i.e. yaw, pitch and roll, with respect to a reference. The system uses reaction wheels or momentum wheels to correct orbit perturbations. The stability of the three-axis system is provided by the active control system, which applies small corrective forces on the wheels to correct the undesirable changes in the satellite orbit. Most three-axis stabilized satellites use momentum wheels. The basic control technique used here is to speed up or slow down the momentum wheel depending upon the direction in which the satellite is perturbed. The satellite rotates in a direction opposite to that of speed change of the wheel. For example, an increase in speed of the wheel in the clockwise direction will make the satellite rotate in a counterclockwise direction. The momentum wheels rotate in one direction and can be twisted by a gimbal motor to provide the required dynamic force on the satellite. An alternative approach is to use reaction wheels. Three reaction wheels are used, one for each axis. They can be rotated in either direction depending upon the active correction force. The satellite body is generally box shaped for three-axis stabilized satellites. Antennae are mounted on the Earth-facing side and on the lateral sides adjacent to it. These satellites use flat solar panels mounted above and below the satellite body in such a way that they always point towards the sun, which is an obvious requirement. Voyagers 1 and 2 stay in position using 3-axis stabilization. An advantage of 3-axis stabilization is that optical instruments and antennas can point at desired targets without having to perform despin maneuvers [3, 4].

CONCLUSIONS

The accuracy with which the required attitude must be maintained depends on the purpose the satellite has to serve. This accuracy largely dictates the choice of the method of attitude control. Several ways can be followed to describe the different control methods used in the past or contemplated for future use. A division according to the reference-system with respect to which the satellite's attitude must be constant, has been mentioned in the Section 4. Another useful manner to describe the various methods, distinguishes between passive and active control methods. The characteristic difference is, that passive methods - such as spin-stabilization - require no energy from the satellite, whereas systems based on active control methods have to be supplied with some kind of energy from the satellite [4, 5].

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