ATMOSPHERIC DRAG ON ARTIFICIAL SATELLITES

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The acceleration caused on a satellite by air drag may be expresed by

$$\frac{1}{2} C_D \rho \frac{S}{m} v^2$$

where C_D is a dimensionless aerodynamic drag coefficient, S is the effective cross section of the satellite in its interaction with the atmosphere, m is the satellite mass, v is the velocity of the satellite relative to the atmosphere, and ρ is the atmospheric density. Then it is possible to show that the rate of change of the anomalistic period P of the motion of the satellite in its orbit is given by an expression of the form

$$\frac{dP}{dt} = K / (\frac{m}{SC_D})$$

The factor K is a certain integral computed along a complete revolution of the satellite in its orbit, and it depends essentially on the orbital elements and on the values of the air density along the point of the orbit. To evaluate such an integral it is usually assumed that the density can be expressed in the form

$$\rho = \rho_o \exp(-(Z-Zo)/H),$$

where ρ_o is the atmospheric density at the height of the perigee Z-Zo is the height above perigee and H is the density scale height. In this paper we have used Sterne's (1959) formula whic takes into account the effects of the rotation of the atmospher and the dependence of the density on the distance from the flattened planet.

Sterne also assumes that the scale height is constant at heights inmmediately above perigee, which of course is not true. However, Jacchia (1960) has shown recently that for typical artifical satellites, the assumption that H is either constant or is a linear function of height gives results that differ at most by 10 percent.

Sterne's expression relating the rate of change of period to the atmospheric density may be written in the form

$$\frac{dP}{dt} = f \rho_0 H / \left(\frac{m}{SC_D} \right),$$

where f is a rather complicated function of the elements of the orbit, the flattening of the Earth, and the angular speed of rotation of the atmosphere, which we assume here as equal to that of the rotation of the Earth.

By using observed values of dP/dt and a convenient model to represent the variable density (ρ) and the scale height (H) of the atmosphere, we calculate mean values for the effective cross-section (S) of a non-spherical satellite at every day during a period of about two and half months. For that calculation we assume in advance that the satellite tumbles around an axis perpendicular to the longest axis of symmetry.For Satellite 1958 Epsilon (Explorer IV) the orientation of the axis of rotation has been determinated by an analysis of the variation in intensity of the measured radio-transmission from the satellite (Naumann,1961).A similar analysis has been carried out for the rocket of Sputnik III (Satellite 1958 δ1) based on its variations of visual brightness (Notni and Oleak,1959). Our results on the effective drag area show a good agreement with those obtained from both analysis.