DEPARTMENT OF SPACE WAR
ASW DETACHMENT, WATERS ABOVE DETACHMENT
EARTH, MI 48820

ASW-Z2 2 April 2023

MEMORANDUM FOR: Space Tactics

SUBJECT: Satellite Velocity

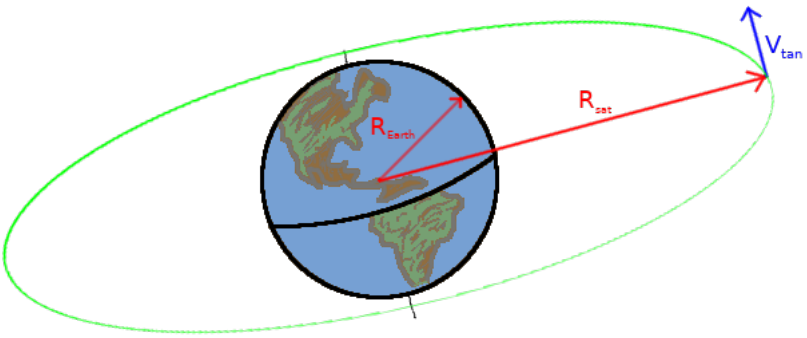
1. Orbital Velocity of a Satellite

In order to maintain a circular orbit any satellite needs to achieve and maintain a certain velocity. This velocity is denoted as $V_{tangental}$ and can quickly be calculated using Newton's 2nd Law and his Law of Gravitational Force.

a. Simple Physics

Newton's Law of Gravitation

$$F = G \cdot \frac{M_e M_{sat}}{R_{sat}^2}$$



Using Newton's 2nd Law with the law of gravitation

$$\begin{aligned} F &= ma \\ G \cdot \frac{M_e M_{sat}}{R_{sat}^2} &= m \cdot \frac{v^2}{r} \\ G \cdot \frac{M_e M_{sat}}{R_{sat}^2} &= M_{sat} \cdot \frac{V_{tan}^2}{R_{sat}} \\ G \cdot M_e &= R_{sat} \cdot V_{tan}^2 \end{aligned}$$

$$V_{tan} = \sqrt{\frac{G \cdot M_e}{R_{sat}}} \tag{1}$$

b. From the simple physics the tangential velocity of a satellite is given by equation (1). Note the mass of the satellite is not included in this formula and the

main driver of a satellite's orbital velocity is the distance from the center of the Earth at which it is positioned.

$$V_{tan} = \sqrt{\frac{G \cdot M_e}{R_{sat}}}$$

c. The height is an easier quantity to measure and is give by

$$R_{sat} = R_{Earth} + H_{sat}$$
$$H_{sat} = R_{sat} - R_{Earth} \tag{2}$$

2. Changing the H_{sat} of the satellite results in a change of V_{tan}. If the satellite moves to a lower orbit, its velocity will increase. And a move to a higher orbit will slow its velocity.

a. Knowing this trade off between H_{sat} and V_{sat} is important for performing spacewar tactics in orbit.

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La Professor