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Tsander's Work and Conclusions on Determining the Minimum Launch Energies Required for Travelling to Other Planets

by

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Although Tsander recognized the fact that any free-fall space vehicle passing a planet will have its orbit changed by the resulting gravitational influence and that this change will involve a change in orbital energy, he did not view this fact as a means for reducing the basic energy requirements for traveling to other planets below the direct-transfer Hohmann energies.

This is an indisputable historical fact that can be easily proved by examining a paper Tsander wrote in 1924-25, entitled Flights to Other Planets which contained 9 sections (pages 237-302, ref. 1). Although sections 5 and 6 (pages 278-289, ref. 1) indicated that he was aware of the fact that the orbital energy of a space vehicle could be changed by a close planetary encounter, (and provides a considerable amount of analysis in determining the maximum possible energy changes for the various planets) he states in section 1 (page 246, ref. 1) that a Hohmann trajectory to another planet represents the minimum energy trajectory. Moreover, Tsander must have believed in this assertion quite deeply because, unlike other researchers, he cast the statement in the form of a law for traveling to another planet.

The fact that this paper did indeed consist of the 9 contiguous sections where section 1 was written with the full knowledge of sections 5 and 6 is proved by Tsander's own statement made in section 1 (first paragraph subsection e, page 240, ref. 1).

Additional Evidence

In a book proposed by Tsander for publication (October 1926) entitled Flights to Other Planets: The First Steps Into the Vast Universe (Theory of Interplanetary Flight) he gives a Table of Contents where he summarizes the contents of the chapters and subsections (page 379, ref. 1). In Chapter V entitled "Theory of Interplanatary Flight" he indicates that section 8 will contain "Calculations of flight trajectories, additional velocities and times required for trips to other planets" and gives 6 subsections (a) - (f) (page 383, ref. 1). In subsection (f) he states his intention to calculate the minimum possible velocities required to reach Mercury and Neptune from Earth via Hohmann trajectories. Although he was aware of the fact that planetary perturbations can change the orbital energy of a free-fall vehicle, he does not indicate or hint at, or suggest the possibility that the minimum energies required to go to Mercury or Neptune can be reduced by detouring around a nearby intermediate planet (such as Venus or Jupiter) and letting the gravitational influence of the intermediate planet propel the vehicle to the more distant planet.

Since Tsander did not utilize planetary perturbations for reducing the minimum propulsion requirements for interplanetary space travel below that of Hohmann trajectories, a natural question arises. Why did Tsander investigate the effect planetary perturbations can have on a passing space vehicle if he did not intend to utilize the effect ? The answer to this question can be found by examining Tsander's own statements made in his 1924-25 paper (ref. 1).

It is apparent that Tsander's concern for planetary perturbations involved the effect perturbations of a target planet had on an arriving space vehicle after traveling to the target planet via a traditional direct-transfer trajectory. In particular, Tsander noted that the perturbations of a target planet could result in a major deflection of the vehicle's flight path out of the Solar System or into the sun which he regarded as a very undesirable event. Quoting directly from Tsander himself he states: "Such [gravity-deflected] trajectories should be avoided as far as possible as it will be difficult to catch up with a vehicle having already flown far from the sun and one may not succeed in rescuing a vehicle flying towards the sun" (paragraphs 1 and 2, subsection e, page 240, ref. 1).

In Section 2 entitled "Determination Of Take-Off Moment To Another Planet Ensuring Additional Velocity Close To Minimum" (page 263, ref. 1), Tsander considers approach trajectories to Mars and concludes with the following statement: "For example, if correction of the trajectory becomes impossible due to damage to the rocket by meteors, or if the control system fails, then the deviation caused by the attraction of Mars (if the spaceship flies near it) may modify the flight trajectory in such a way that the vehicle will escape from the Sun forever. It will be very hard to overtake such a vehicle with another spaceship" (page 266, ref. 1).

These statements clearly indicate that Tsander regarded the effect of planetary perturbations <u>not as a benefit to space travel but rather as a definite hindrance</u> "to be avoided as far as possible".

It should be noted, however, that Tsander did recognize that satellite perturbations could, in special situations, be utilized to help accelerate or decelerate a vehicle beginning or ending an interplanetary journey (pages 290-292, ref. 1). But his conception of interplanetary space travel through the Solar System to a target planet was definitely based upon direct-transfer trajectories with Hohmann trajectories representing the minimum energy trajectories.

In the early years of interplanetary space travel, the vehicles were assumed to be <u>manned vehicles</u> which had to bring the occupants back to earth. Tsander regarded (quite naturally) the effect of strong planetary perturbations as forcing the vehicle to go to a region of the Solar System far from earth where recovery would be difficult or impossible with the inevitable loss of life. He did not foresee interplanetary space travel by unmanned instrumented vehicles designed to explore regions of the Solar System far from earth via radio communication.

These remarks are not intended to detract from the outstanding contributions of Tsander, but, rather, to focus detailed examination of Tsander's work on interplanetary space travel and planetary perturbations to show that the concept of gravity-propelled interplanetary space travel did not originate with, or was anticipated by Tsander.

Reference

1. Tsander, A.F., Problema poleta pri pomoshchi reaktivnykh apparatova: Mezhplanetnve polety (Problems of Flight by Jet Propulsion: Interplanetary Flights --NASA Technical Translation F-147, 1964).