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Guidance, Navigation and Control Concepts in Armament Design

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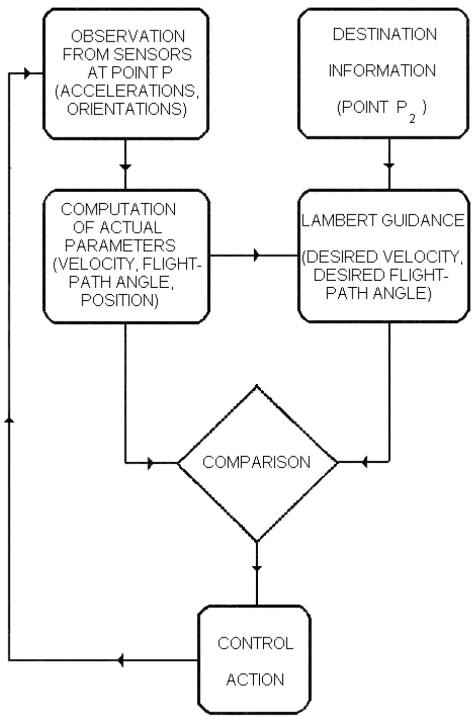

Fig. 1. Flow chart of the Lambert scheme

This lecture elaborated guidance, navigation and control concepts employed in armament design and development. Spacecraft dynamics is involved with correct and timely answers of questions like, where the spacecraft is currently located in space (*navigation*), in which orbit the spacecraft is desired to be (*guidance*), and, what action is needed to bring the spacecraft to the desired orbit (*control action*). If a spacecraft or a satellite were not in its proper orbit, it would not serve its purpose. Hence, it is very important to take the spacecraft to the desired orbit and keep it there, for the entire duration of its flight. In order to accomplish this, one may need to employ control systems. In the *open-loop control system*, one does not check the output against the reference after taking the control action. Regular of a fan may be cited as an example of such a system. In the *closed-loop control system*, one does check the output against the reference after taking the control action. Voltage stabilizer is a good example of such a system. Control laws are needed, on the basis of which autopilots are designed. It must be borne in mind that every control law is valid under certain conditions. It is not possible to devise a universal control law. On Monday, October 8, 2012, 'Astro-mathematics' https://www.ngds-ku.org/Presentations/ISPA.pdf was introduced by the speaker during *the First National Conference on Space Sciences* as a branch of mathematics focused on geometrical aspects to study orbits from a kinematical perspective, in which force expressions did not appear, explicitly. Force interactions were expressed as space-time-curvature equivalents. Such a formulation could deal with accelerated frames, which are governed by 'geometrodynamics' https://www.ngds-ku.org/Presentations/GenRelGrav.pdf based on general relativity[¥]. On March 20, 2014, the speaker delivered Opening Lecture of *the Second Conference on Mathematical Sciences*, https://www.ngds-ku.org/Presentations/Astromathematics.pdf 'Astromathematics**:** A New Branch of Mathematics'. Astrodynamics is a branch of mathematics, which deals with designing orbits to reach a target planet. The term is attributed to Samuel Herrick (1911-1974). The plane-polar coördinates are not the natural choice for setting up two-body problem. According to the Strong Noether's Theorem https://www.ngds-ku.org/Presentations/Noether.pdf put forward by the speaker, if one sets up problem close to natural symmetries of the system, one discovers additional constants-of-motion. Planetary orbits were modeled using the elliptic-astrodynamical-coördinate mesh https://www.ngds-ku.org/Presentations/Planetary.pdf that yielded 3 constants of motion. In 2015, the two-body problem was set up in the hyperbolic-astrodynamical-coördinate mesh to reduce transfer time, significantly https://www.ngds-ku.org/Presentations/Hyperbolic.pdf — new control laws were devised, the extended-cross-product steering, the normal-component-cross-product steering https://www.ngds-ku.org/Papers/C56.pdf as well as the dot-product steering, the normal-component-dot-product steering https://www.ngds-ku.org/Papers/C55.pdf and the ellipse-orientation steering https://www.ngds-ku.org/Presentations/Ellipse.pdf — cross-range error was incorporated in the Lambert scheme https://www.ngds-ku.org/Papers/C67.pdf as well as the multistage- and the inverse-Lambert schemes proposed https://www.ngds-ku.org/Papers/C72.pdf for course-plotting of SLV (Fig. 1). In addition, the multistage and the inverse-Q systems https://www.ngds-ku.org/Papers/C66.pdf were devised for steering a satellite-launch vehicle. Extended-Q system was proposed on March 20, 2014 in Richard H. Battin memorial lecture. In the extended-Q system, both position and velocity vectors are managed, simultaneously, through extended-cross-product steering to put a satellite in the desired location https://www.ngds-ku.org/Presentations/ExtendedQ.pdf with the recommended velocity.

*Keywords***:** Dot-product steering • Ellipse-orientation steering • Elliptic- and hyperbolic-astrodynamical-coördinate meshes • Extended-cross-product steering • Multistage- and inverse-Lambert schemes • Multistage-, inverse- and extended-Q systems • Strong Noether's theorem • Two-body problem

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