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INERTIAL/MULTISENSOR NAVIGATION

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The purpose of any Navigation System is to determine a vehicle's position while the vehicle is moving or it is stationary. There are many different kinds of Navigation Systems, each one based on a different principle. These principles include Radio Navigation (LORAN-C), Satellite Navigation (GPS), Inertial Navigation (INS), Low-Frequency Radio Navigation (OMEGA), etc. For Terminal Area Guidance systems such as the Microwave Landing System (MLS) or the Instrument Landing System (ILS) a combination of principles is used. Each navigation system provides different navigational accuracies. For example, the Global Positioning System provides high accuracies for long-term navigation but low accuracies for short-term navigation. On the other hand Inertial Navigation provides high accuracies for short-term navigation but low accuracies for long-term navigation. The Multi-sensor Navigation System incorporates several different Navigation Systems in one. In this configuration the combination of several systems can provide higher navigational accuracies and better system reliability.

The Inertial Navigation System makes use of the vehicle's accelerations in all directions. By integrating these accelerations once, the vehicle's velocity is determined, by integrating twice, the vehicle's position is determined (see Fig. 1). The Inertial Navigation System establishes a three axes reference frame and measures the vehicle's accelerations along these axes. Then a double integration determines the vehicle's relative position and a relative position vector is established. Finally, the Inertial Navigation System has to determine the vehicle's position with respect to Earth. For this purpose the inertial axes have to be constantly aligned with the Earth's pre-established axes. Therefore since the Earth rotates, the Inertial axes have to rotate too. Figs. 1-2 show a simplified Inertial Platform on which three accelerometers are sensing accelerations in three dimensions. The Inertial Platform is supported by the gimbals which serve the purpose of maintaining the precise orientation of the Platform. The Platform gimbals receive information from the System's Gyroscopes and the System's Computer and make sure that the Platform is always level to the Earth's surface and aligned towards a specified direction. Fig. 3 shows the block diagram of a system mechanized in spherical coordinates, in which longitude (ϕ), latitude (λ) and height (R) are supplied. It should be noted that gravity introduces unwanted components in the measured accelerations and these have to be accounted for and cancelled by the System otherwise positional errors will occur and the navigational accuracy will degrade significantly. Another form of the Inertial Navigation System is the Strap-Down system (see Fig. 4), in which the accelerometers are mounted on the vehicle's frame. In this configuration the Navigation Computer plays the role of the gimbals, therefore all the unwanted gravity components are computed and canceled by the Computer. The Computer is also responsible for rotating the pre-established reference frame according to the Earth's rotation.

Fig. 5 shows a Multisensor Navigation System as proposed by the Ohio University Avionics Engineering Center. The proposed system incorporates Radio (LORAN-C), Satellite (GPS) and Inertial (INS) Navigation. The Inertial part of the system will be of low grade since the INS will be used primarily for filtering the GPS data and for short term stability. LORAN-C and GPS will be used for long term stability. Fig. 6 shows different Navigation Systems and their characteristics.

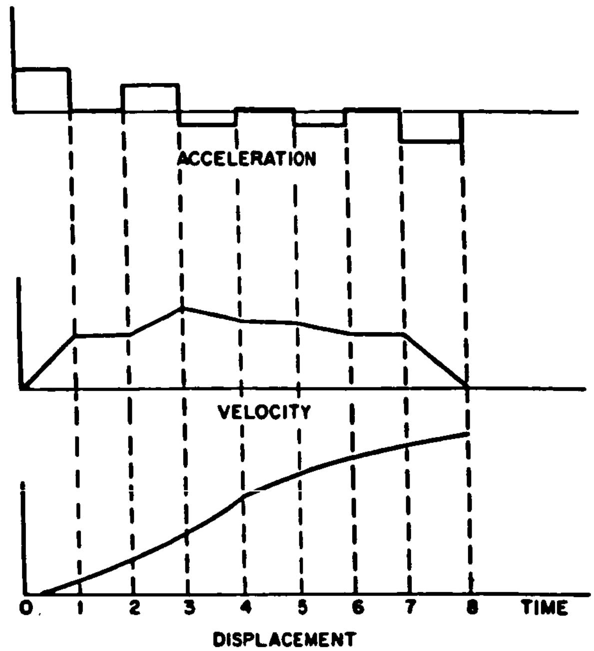

Figure 1. Integration of acceleration.

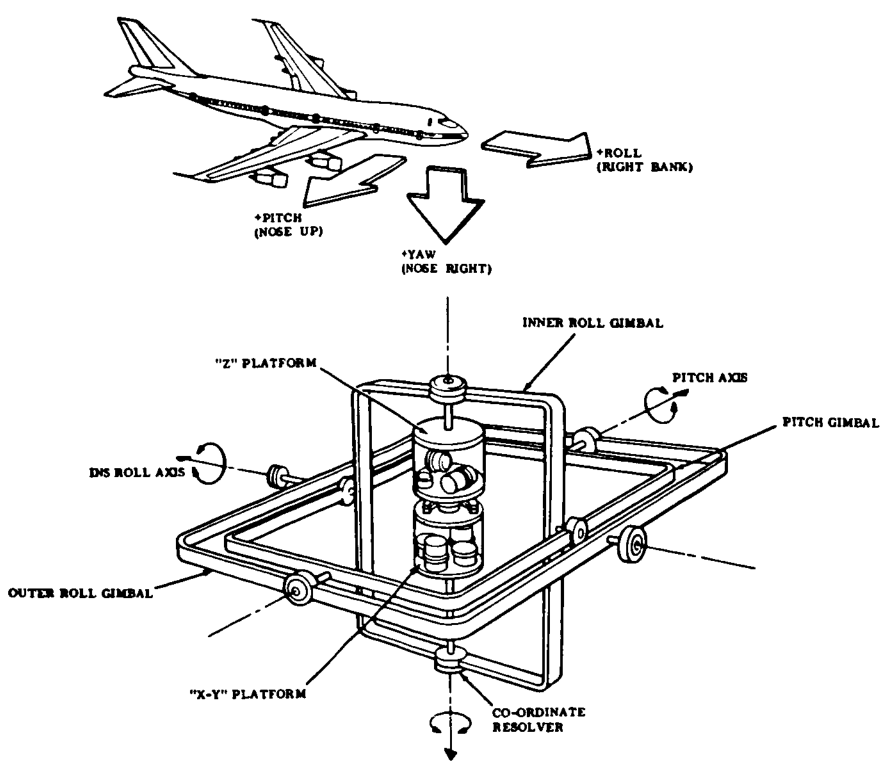

Figure 2. Carousel IV model platform.

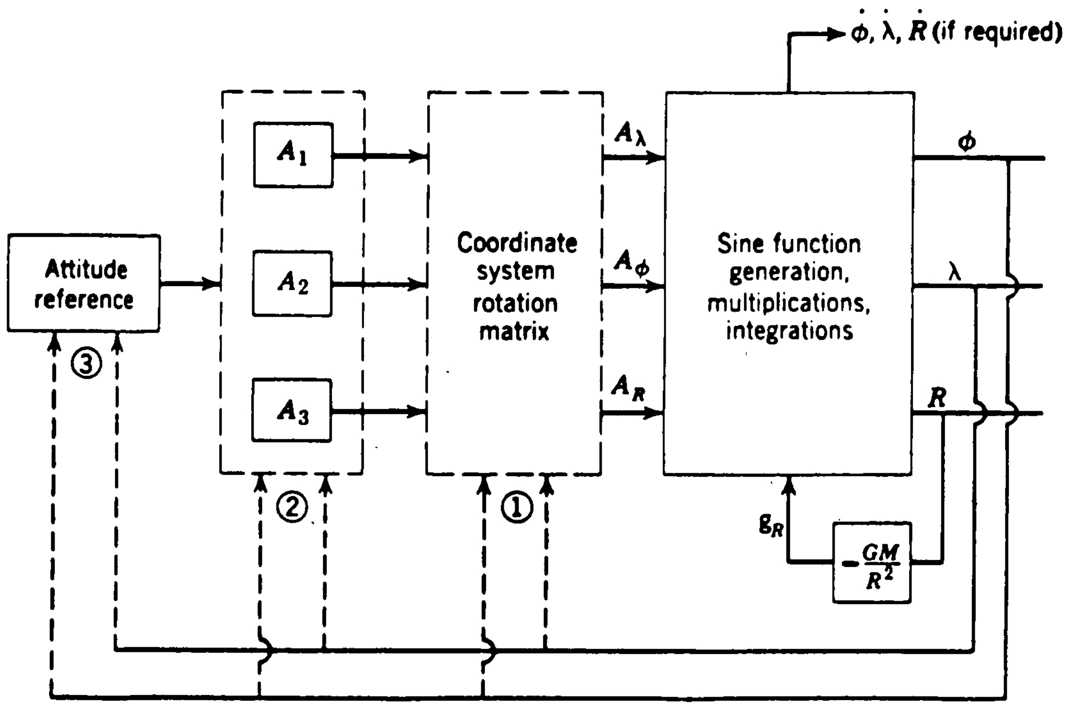

Figure 3. Functional block diagram of an inertial navigation system mechanized in spherical coordinates.

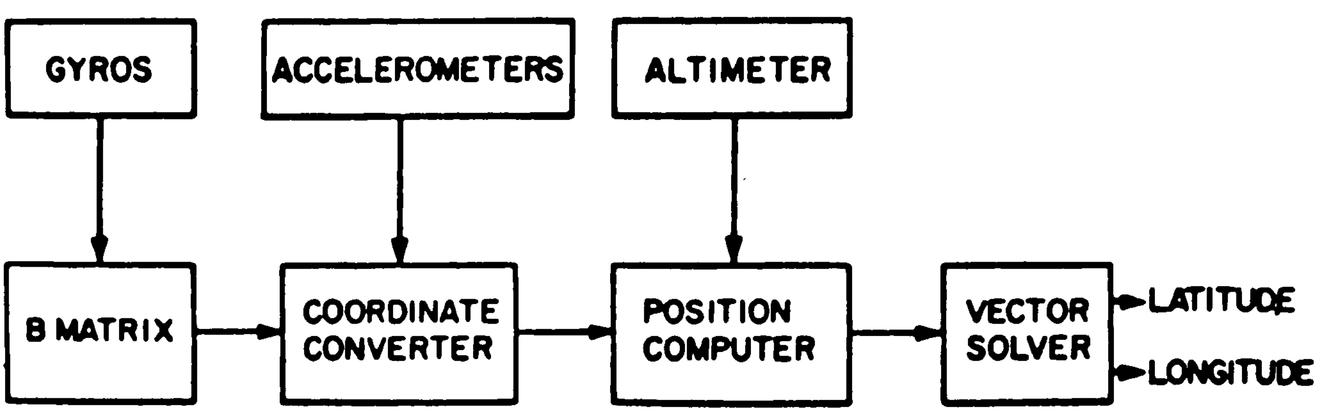

Figure 4. Simplified strap-down inertial navigation system.

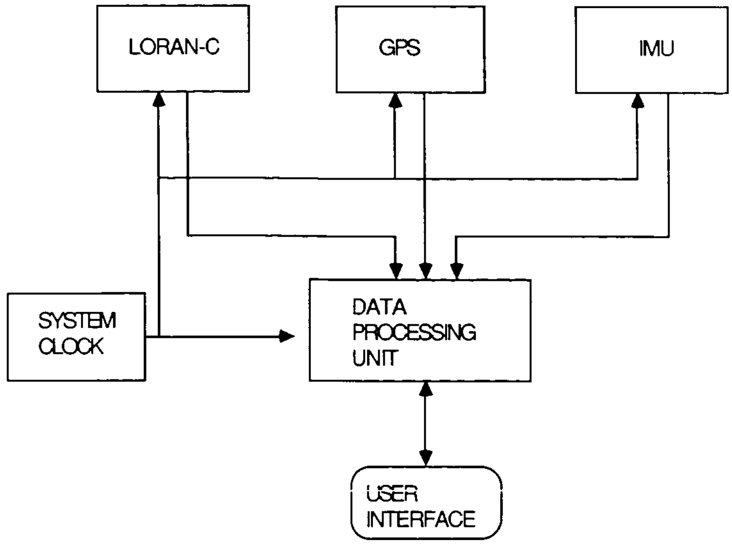

Figure 5. Integrated multisensor navigation system.

	NAVIGATION ACCURACY	
	SHORT TERM	LONG TERM
INS	GOOD TO EXCELLENT	POOR TO FAIR
GPS	FAIR TO POOR	EXCELLENT (VERY STABLE)
LORAN-C	FAIR TO POOR	GOOD (STABLE)
OMEGA	POOR TO BAD	FAIR
MLS	VERY GOOD	-------
ILS	GOOD	-------

Figure 6. Navigation system characteristics.