A COMPARISON OF MODELS IN INERTIAL SURVEYING *

Abstract

The output of an inertial measuring unit contains the combined effect of vehicle acceleration, accelerations due to the reference system, gravitational attraction, calibration and alignment errors, and measuring noise. The separation of individual effects from the total output is the task of modelling. Differences in the existing models are mainly due to the treatment of system errors and of the anomalous gravity field.

The paper discusses the state space formulation as a general approach to represent errors of a dynamic system and describes its application to the modelling of an inertial system. Complications due to the effects of the anomalous gravity field are discussed and possible solutions are indicated. Finally, the models in the existing inertial survey systems are compared and implementation requirements for survey applications are outlined.

1. Modelling Measurement Processes

Eykhoff (1974) has defined a model as "a representation of the essential aspects of an existing system which presents knowledge of that system in a usable form". When applying this definition to an engineering problem, three questions come immediately to mind:

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1. Which knowledge should be extracted from the system output?
2. Which aspects of the system are essential to do this?
3. Which representation does result in a stable and efficient algorithm?

Answers to these questions basically explain the differences between various models of the same process. They are therefore especially important in a comparative study and are underlying most of the discussion in this paper. By way of introduction, let us look at these general questions in the context of modelling the output of an Inertial Measuring Unit (IMU). Figure 1 gives a simplified presentation of the problem as an input–output scheme.

![Diagram of IMU components and model](image)

**Fig. 1 — Components of an IMU — Model**

Answers to the first question depend mainly on the specific application considered. The right-hand side of fig. 1 shows some uses of an IMU for geodesy, photogrammetry, and surveying. The positioning problem usually requires the knowledge of system derived velocity and position. In land operations the velocities are used for error control and the positions are the wanted quantities, in offshore applications discrete position fixes would normally control the error growth while both velocities and positions are desired as output. Photogrammetric positioning can be made independent of ground control if the orientation of the camera axes (attitude angles) and the camera