Attitude Determination of a Land Vehicle Using Inertial Measurement Units

By:

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and

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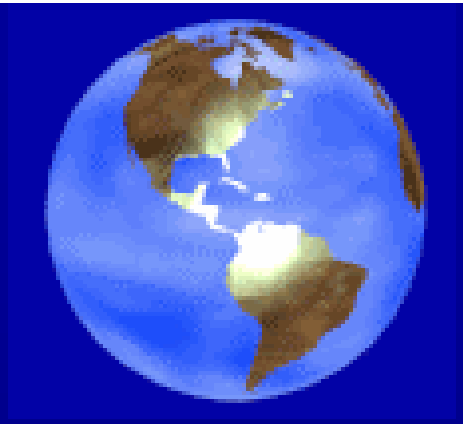


Introduction

- Determine attitude of land vehicle with respect to local navigation coordinates.
- Supplement Global Positioning System.

IMU Inputs

Inputs

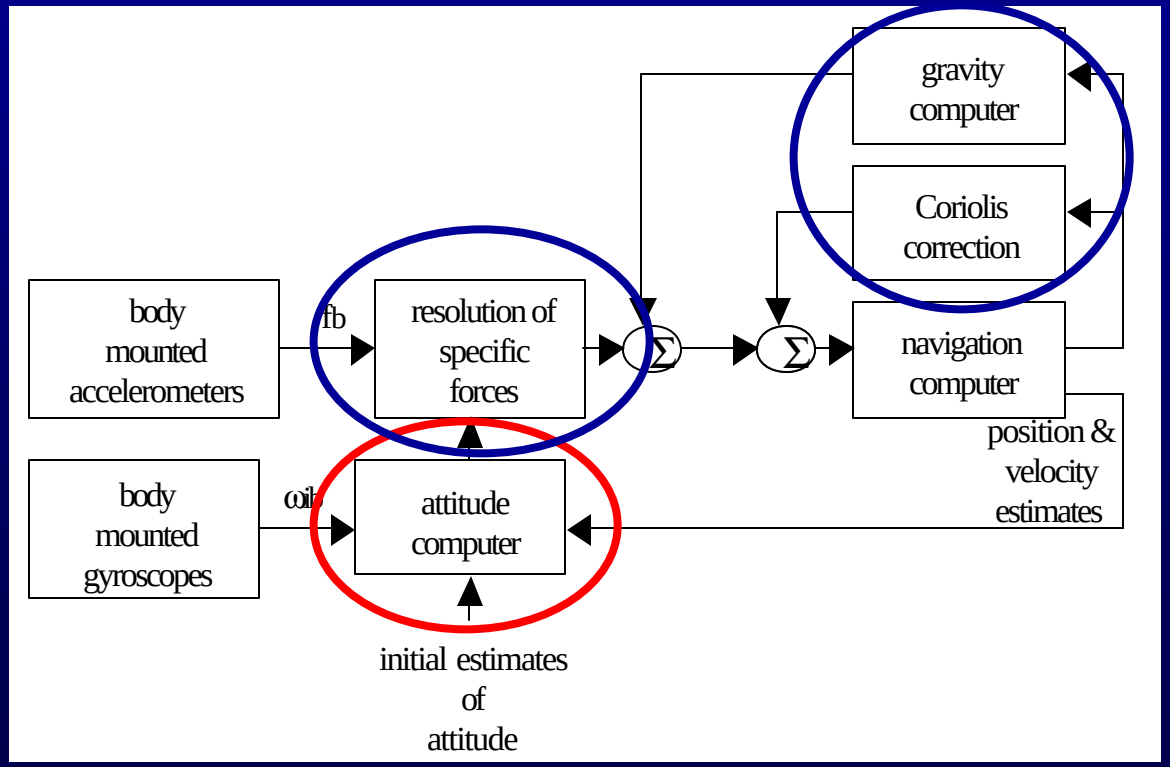
- Three inputs from accelerometers which provide accelerations in the x, y, z directions
- Three inputs from the inertial gyroscopes which provide attitude angles with respect to the body of the land vehicle
- Initial estimates of attitude which is the the initial position and angles of the vehicle

IMU Outputs

Outputs

- Position in the local navigation coordinates (Latitude, Longitude and Altitude)
- Velocity in the local navigation coordinates
- Acceleration in the local navigation coordinates
- Euler angles with respect to the local navigation coordinates

Overall System Block Diagram



Product Research

- Crossbow
  - IMU300CC
  - IMU400CC
  - IMU700AA
- BEI Systron Inertial Division
  - MotionPak
  - MotionPak II
- Other companies

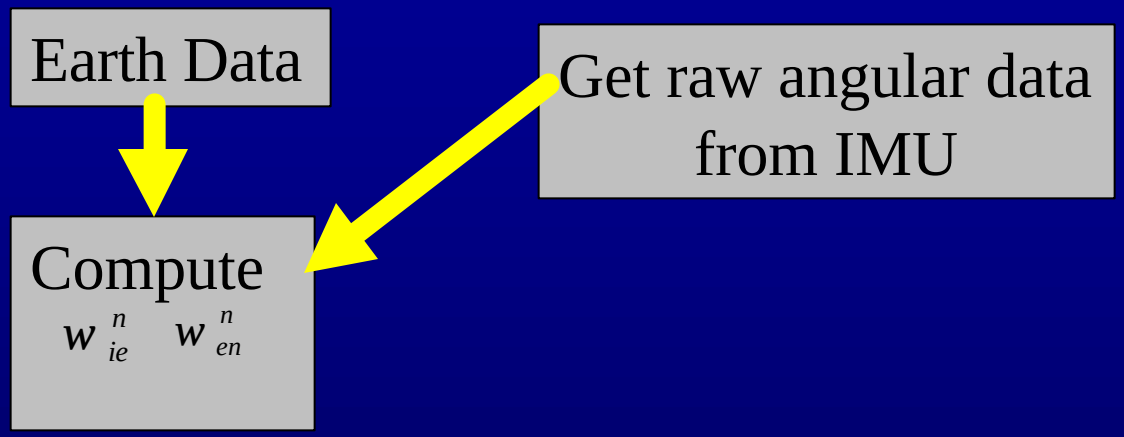
Crossbow Products

Product	Angular Rate Bias (Deg/sec)	Random Walk (deg/hr^(1/2))	Price
IMU300CC	(+/-) 2	<2.25	$2995.00
IMU400CC	(+/-) 1	<2.25	$3995.00
IMU700AA	(+/-) .03	<.4	$11500.00

BEI Systron Products

Product	Angular Rate Bias (Deg/sec)	Random Walk (Deg/hr^(1/2))	Price
MotionPak	(+/-) 2	-----	$10000.00+
MotionPak II	(+/-) 5	-----	$2500.00

Software Flowchart



Software Flowchart

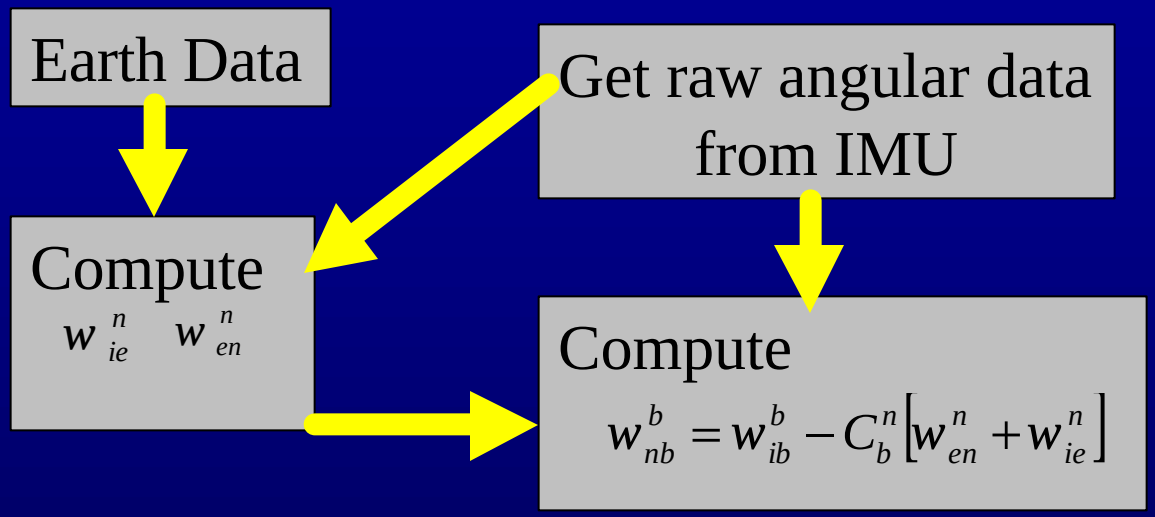
w_{en}^{n}

The turn rate of the local navigational frame with respect earth in the navigation frame

w_{ie}^{n}

Turn rate of the earth with respect to the inertial frame in the navigation frame

Software Flowchart



Software Flowchart

$$w_{nb}^{b}$$

The turn rate of the body with respect to the navigation frame in the body frame

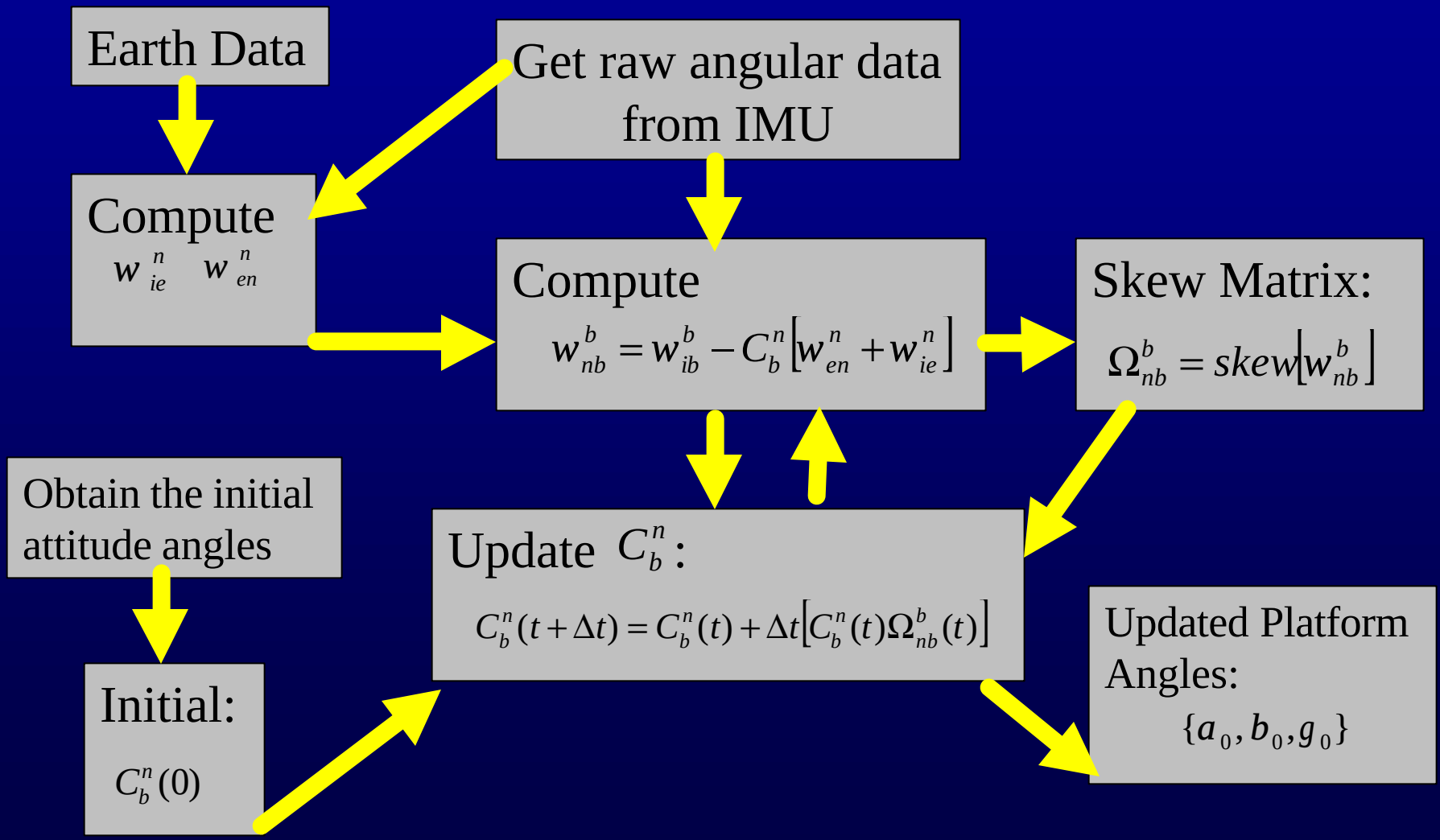
$$w_{ib}^{b}$$

Raw angular data from the Inertial Measurement Unit

$$C_{b}^{n}$$

The directional cosine matrix converting body frame angular rates to navigation frame

Software Flowchart



Software Flowchart

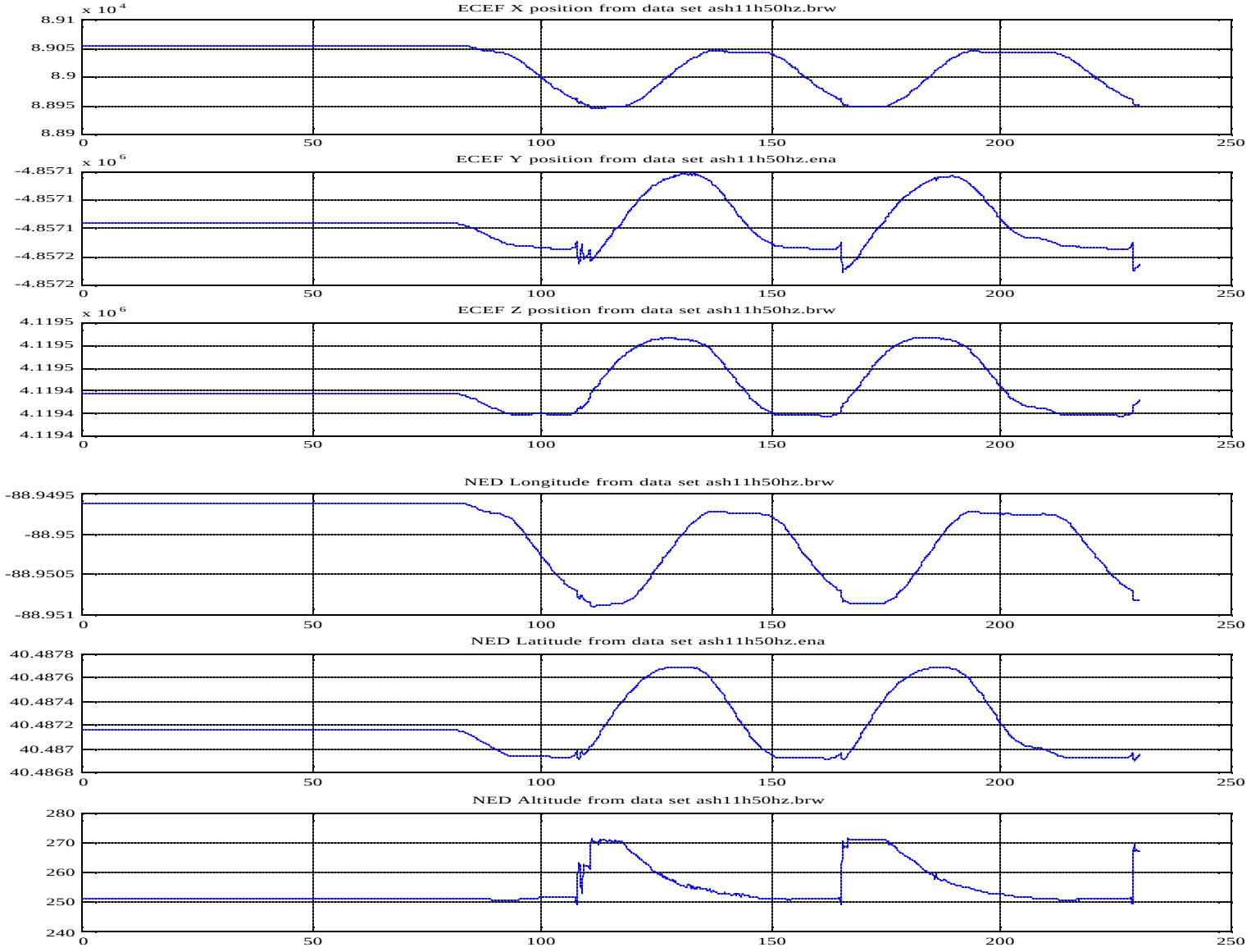
$$w_{nb}^{b} = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

$$skew\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 0 & -z & y \\ z & 0 & -x \\ -y & x & 0 \end{bmatrix}$$

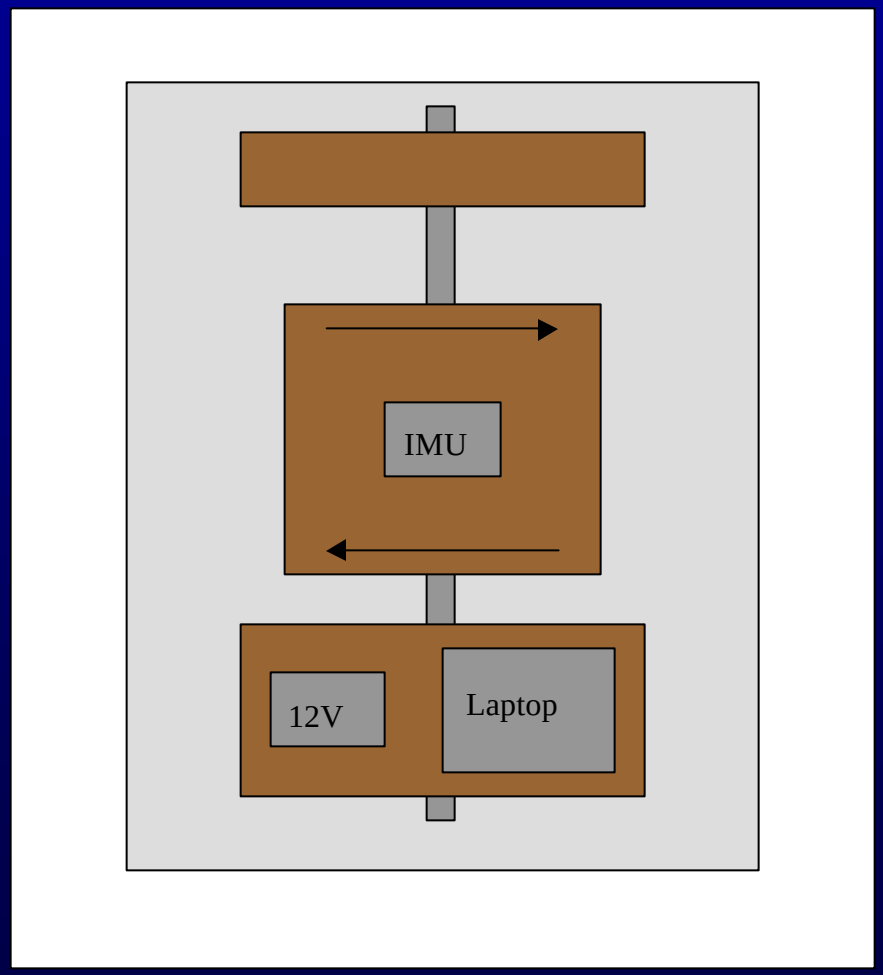
Completed Work

- Product Research
- Matlab code for attitude computer
- Matlab code for coordinate transformation using sample inertial measurement unit data
  - Converted earth centered earth fixed coordinates to local navigation coordinates
  - Converted local navigation coordinates to earth centered earth fixed coordinates

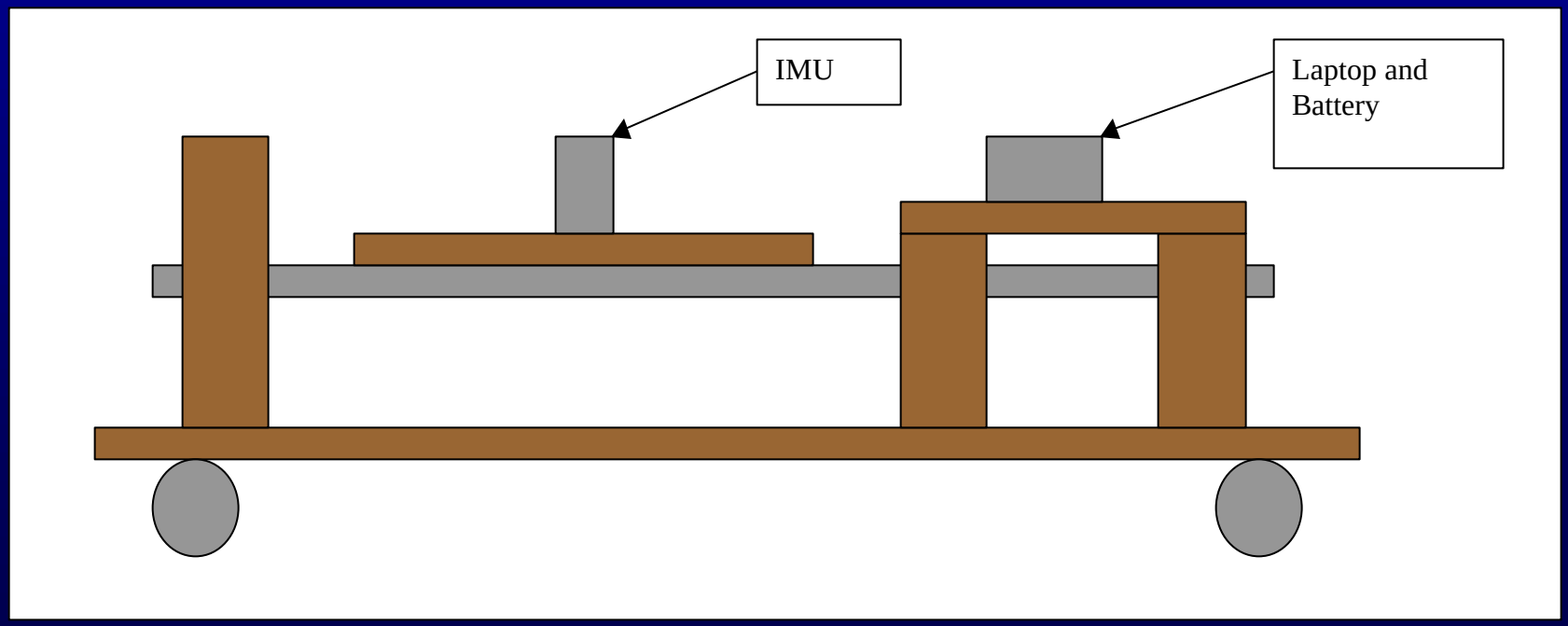
Completed Work



Testing Platform - Top View



Testing Platform - Side View



Time Table

- Winter Interim and January
  - Testing Platform
- February
  - Code finalized for the attitude computer
  - Collect data using testing platform
- March / April
  - Eliminate bias error from collected data using Matlab
  - Complete attitude computer
  - Determine accelerations, velocity, and position from accelerometers
- Remaining Time
  - Coding for Coriolis effect and the effect of gravity