LAB 3 – Inertial Navigation in 2D / realistic signal (1 week)

Objective:

Determine the position, velocity, and attitude (PVA) of a rigid body undergoing uniform circular motion using "2D" strapdown inertial navigation system with realistic inertial measurements.

Task:

1. Simulate realistic measurements for a gyro and 2 orthogonal accelerometers by adding the following noise structure (stochastic values are listed in table below) to the nominal measurements (LAB 2) obtained earlier:

   Gyro errors: *random-const. (RC) + 1st order Gauss-Markov (GM) + white noise (WN)*
   Accelerometer errors: *random-const. (RC) + white noise (WN)*

2. Perform strapdown inertial navigation (**use trapezoidal integration at 100 Hz**) with the simulated realistic signal. Study the effect of the individual error sources on trajectory determination and identify the predominant influences.

   Hint*:* apply error sources first separately then study their combined effect. Use your study to answer the questions and make synthesis in a report.

Questions:

For each of the quantity being asked to be analyzed, make separate tables to answer the questions

I. Which of the three error sources influence azimuth estimation *the **least***?
II. Which error source influences velocity estimation *the **most***?
III. Which error source influences position estimation *the **most***?

Numerical data:

- Circle radius: 500 m.
- Angular speed $\omega = \pi/100$ rad/s
- Initial position: on North axis
- Initial azimuth: 90˚ (measured from North axis in clockwise direction)
- Initial velocity: north-axis: 0, east-axis: $\omega \cdot$ radius
- Acceleration due to gravity, $g = 9.81$ m/s^2

!!! IMPORTANT!!!

Simulated errors **must be re-scaled** to correct units with respect to sampling freq.

Error type	Notation	Stochastic value			Note
		Provided units	Needed (SI) units	Value (SI)	
Gyro bias (random constant)	b_G	150 deg/h	rad/s		1σ
Gyro correlated noise (1st order Gauss-Markov)	$\sigma_{G_{GM1}^{PSD}}$	0.007 deg/s/√Hz	rad/s/sample		PSD level (scale for simulation!)
	$1/\beta_G$	100 s	s	100 s	correlation time
Gyro white noise	$\sigma_{G_{WN}^{PSD}}$	0.10 deg/√h	rad/s/sample		PSD level
Accelerometer bias (random constant)	b_A	1.3 mg	m/s^2		1σ
Accelerometer noise (white)	$\sigma_{A_{WN}^{PSD}}$	57 μg/√Hz	m/s^2/sample		PSD level

Table 1

Deliverables:

A REPORT SHOULD CONSIST OF ONLY THE FOLLOWING ELEMENTS. PLEASE DO NOT PROVIDE DETAILS THAT ARE NOT ASKED!

1. **Table 1** filled with converted units for stochastic error values.
2. **Plot** trajectory **errors** (i.e. in azimuth; position – N, E; velocity – N, E) with respect to *time* along one revolution for the case when all noise sources are present.
3. **Answers** to the questions
4. Your **code**

Lab weight: 5%
Deadline: 06.04.2025