NavLab
Navigation Laboratory

KONGSBERG

What is NavLab?

NavLab (Navigation Laboratory) is flexible and generic aided inertial navigation software running in post-processing. NavLab consists of a Simulator and an Estimator, as shown in figure A.

NavLab Simulator

The Simulator can simulate any vehicle trajectory in the vicinity of Earth, with a chosen set of sensor measurements.

NavLab Estimator

The Estimator calculates optimal estimates of a vehicle's position, orientation and velocity, based on available sensors, such as GPS/ acoustic positioning, Doppler velocity log and inertial measurement unit (IMU). It can process data from the Simulator or from a real vehicle.
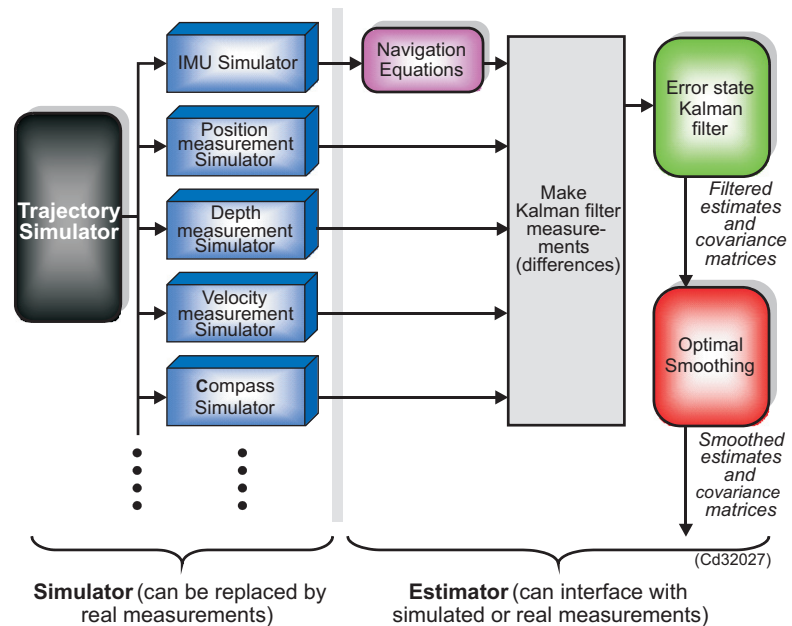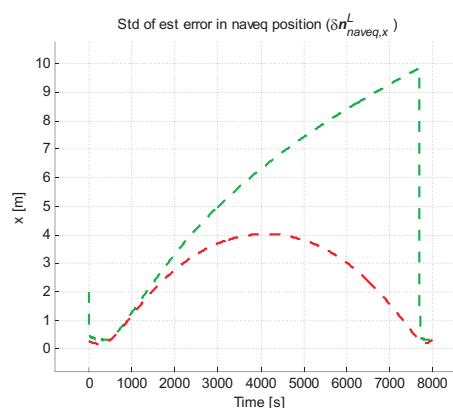
Optimal Smoothing

The Kalman filter is the optimal real-time estimator, but for post-processing the best algorithm is Optimal Smoothing, also benefiting from future measurements. The smoothed estimate of position, attitude and velocity, has several important advantages compared to the real-time solution, such as:

- The navigation results are **more accurate**. An example in case of a 2 hours position measurement drop-out, is shown in figure B. Even in cases where position measurements are continuously available, the position accuracy improves significantly.

- No measurements are unexpected, and thus there are **no jumps in the data** (hence the name smoothing). An example is shown in figure C.

A - NavLab principles

- Even in cases of sensor degradation or failure, accurate navigation can often be obtained (no need for a new mission). This is due to the increased robustness of the smoothing.

- The navigation results have **maximum reliability** (critical sensor errors are detected).

When using NavLab with smoothing, lower quality navigation sensors may be used, while still obtaining satisfactory navigational accuracy.

B - Position estimation uncertainty with a 2 hours position measurement drop-out (Green: real-time, Red: Optimal smoothing)
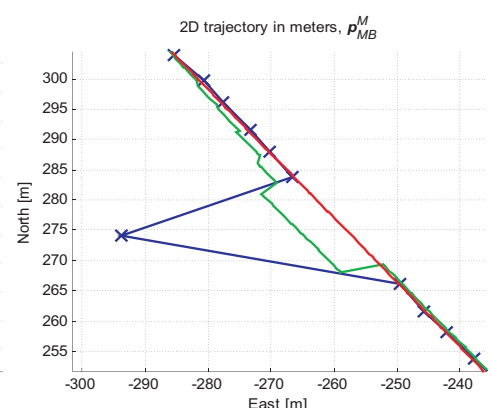
C - HUGIN 1000 position estimates: Blue: acoustic position measurement with outlier and drop-outs, Green: real-time, Red: Optimal smoothing.

Can NavLab be used for your application?

NavLab is readily integrated with the Kongsberg Maritime HUGIN and Hydroacoustic Aided Inertial Navigation (HAIN) products, but can due to its modularity easily be adapted to any application as long as raw sensor data are stored. NavLab has accurately positioned AUVs, ROVs, ships and aircrafts.

NavLab is always more accurate than a real time navigation system with comparable sensors. Optimal smoothing is the key technology providing maximum accuracy, robustness and integrity.

In some applications only real-time navigation results are of interest, however, **NavLab is still useful for:**

- **Verification of position quality -** As an example, the HUGIN AUV or the HAIN navigation data can periodically be verified by NavLab.
- **Tuning of real-time navigation system, and calibration of the sensors** - Optimal tuning and correct calibration is determined by NavLab.
- **Mission planning** - Vehicle operation and use of navigation sensors to get desired navigation accuracy can be investigated and planned in NavLab simulations.
- **Consideration of acquiring more sensors** - The effect of sensor accuracies on resulting navigation performance can be simulated in NavLab.

For advanced scientific users, NavLab has been extensively used for navigation system research and development (for which it was originally developed).

NavLab program modules

Figure D illustrates the NavLab program modules.
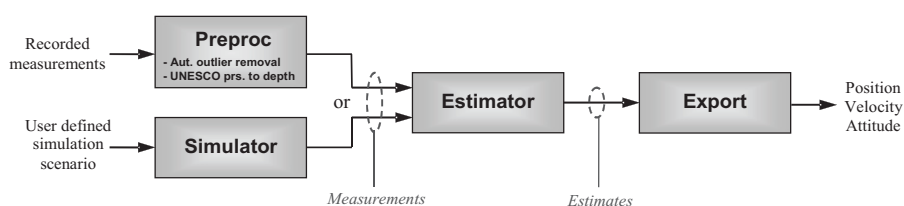
D - *NavLab program modules*

NavLab is delivered in 3 different packages with different program modules:
1 NavLab post-processing tool: Preproc, Estimator and Export
2 NavLab post-processing tool with Simulator: Preproc, Simulator, Estimator and Export
3 NavLab simulation tool: Simulator, Estimator and Export

Preproc does the necessary preprocessing of recorded data, including automatic outlier removal. In underwater navigation, vertical position is deduced from pressure measurements. **NavLab converts pressure measurements to depth using the internationally standardized UNESCO formula**. In shallow waters the pressure field is dynamic due to irregular ocean waves. This can cause a dynamic depth sensor error which is observed and filtered by the NavLab Estimator. **Export** exports the result on a desired format.

Flexible user interface

NavLab comes with a simple user interface with minimal operator interaction for robust and automated navigation data post-processing. In addition, it is also possible for advanced users to control a large amount of parameters and options, to make NavLab solve exactly their specific problems.

Software compatibility

NavLab can run under Matlab on any platform or as a stand alone Windows program.

Theoretical basis/technology

NavLab is developed as a general research tool by the Navigation group at the Norwegian Defence Research Establishment (FFI), where the main focus has been a solid theoretical foundation to maintain statistical optimality throughout the system.

The performance has been extensively tested through simulations and real data trials. The result is a tool that is very reliable, robust and has a high performance every time it is run.

Kongsberg Maritime has the selling rights of NavLab into the commercial maritime market, and has adapted NavLab to various vehicles and applications. NavLab is a supplement to the HUGIN AUV navigation and HAIN systems.