A tool for accelerometer modeling

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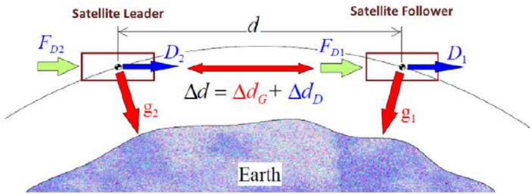
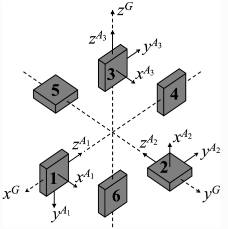
Accelerometers in gravimetry

Accelerometers (ACCs) are part of science payload in gravimetry missions. Can be used to measure forces impacting spacecraft (SC), or as test mass (TM) following a geodesic. Also gradiometers to measure local Δg.

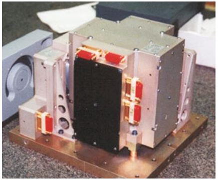


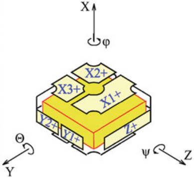


Left: scheme of GRACE-type gravimetry mission [9].
Right: accelerometer placement in GOCE (gradiometry mission) [8].

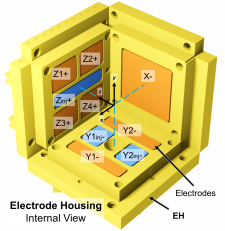
Accelerometer design challenges

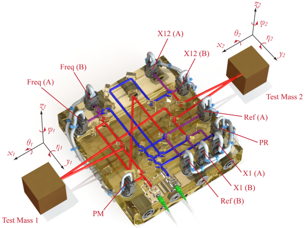
Different geometries depending on application and constraints;
Sensors can be capacitive, optical, cold atom (in future).
Actuation of TM is electrostatic repulsion;
TM may have charge build up and needs UV light or gold wire to discharge;





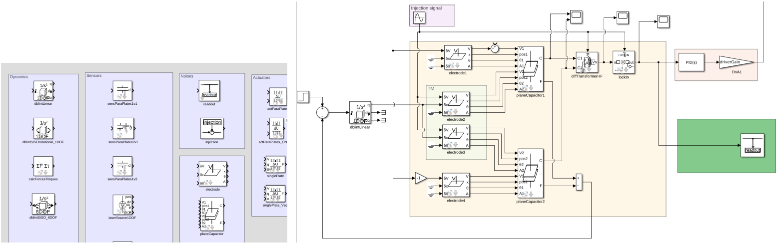
Top: GRACE accelerometer [3]. Left: S-GRS proposal [1]. Right: LPF optical table [2]





Accelerometer modeling

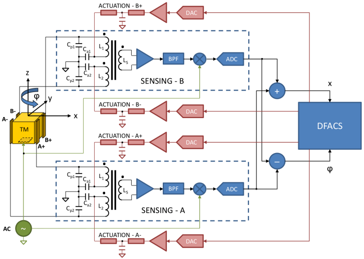
Need a tool to estimate the performance of the instruments and indicates scenarios w/ best science return. A mission can have one or more ACCs (of the same or different designs) per SC.
ACME - *Accelerometer Modeling Extended*. Programmed in Matlab/Simulink environment. Designed to be modular, parametrizable, instantiable, integration with XHPS [7];

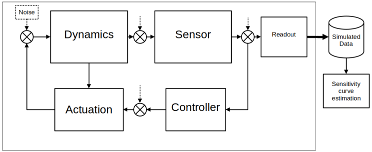


Simulink block library and example application model

Accelerometer modeling

The simulator is independent of geometry, sensor technique, noise model, control loop, etc. To simplify, assume independent DoFs, linearized terms and a generalized ACC.

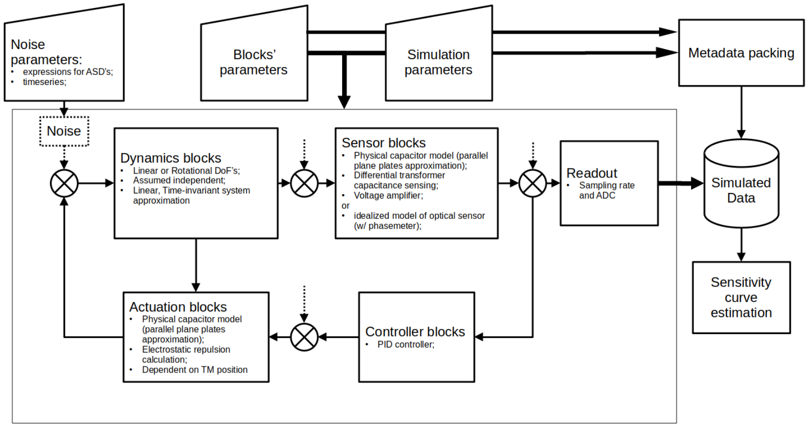




Left: Block diagram of LPF actuation circuit [5]. Right: generic block diagram representing an ACC

Accelerometer modeling

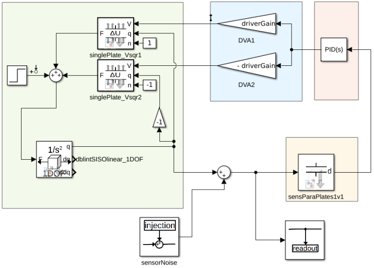
Each module can contain a variety of implementation options and parameters, as we try to cover most ACC designs.

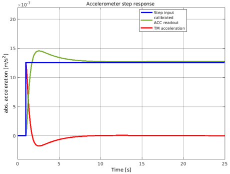


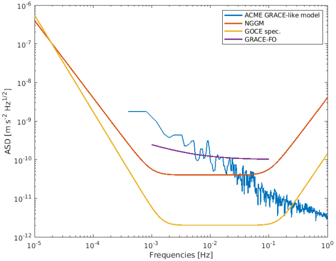
Block diagram with options and parameters

Standalone simulation

Able to simulate a instrument with a model for dynamics, sensors, actuation and noises. Produces both time and frequency domain results.



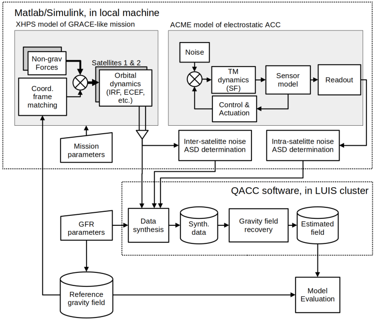


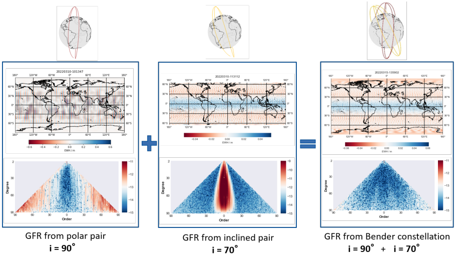


Left: Screenshot of a GRACE-FO-like ACC model. Top: time-domain response of an ACC to a step input. Bottom: comparison of the ASD of an illustrative model with the literature [4, 6]

GFR simulation

Simulate a Gravity Field Recovery mission scenario using tools developed within the TerraQ collaborations ACME + XHPS + QACC:
XHPS = multibody orbital dyn. on hi-fi gravitational field [7];
QACC = GFR data synth. from orbital and ACCs simulation [10].





Left: ACME+XHPS+QACC workflow. Right: map of EWH produced in 3 mission scenarios

Thank you!

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