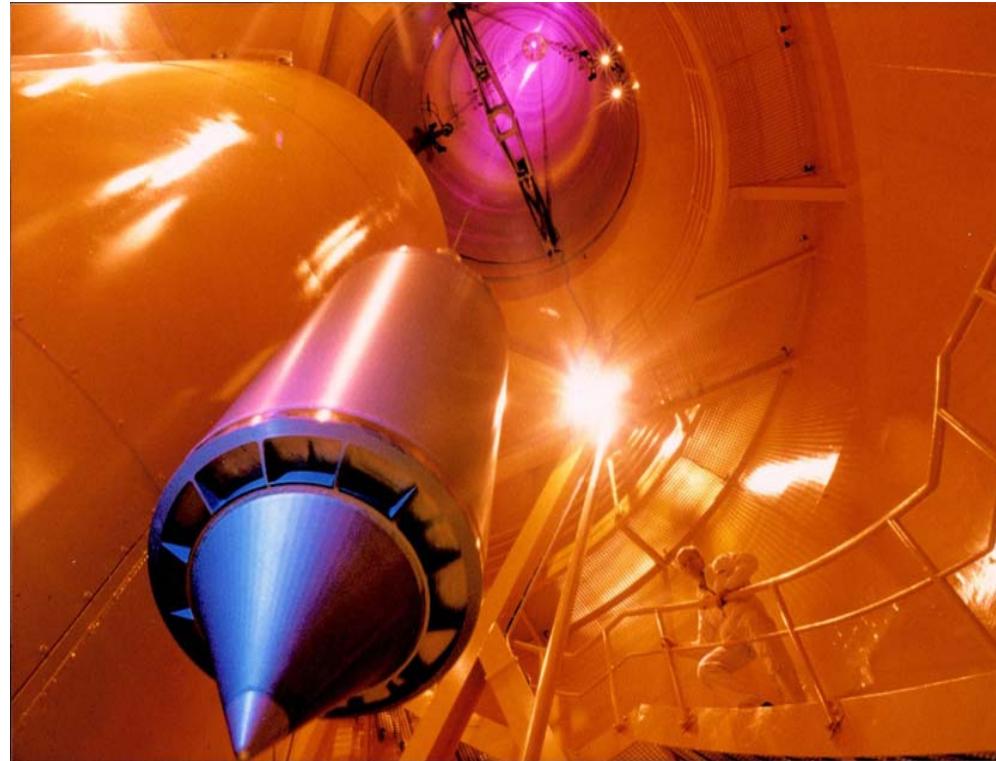
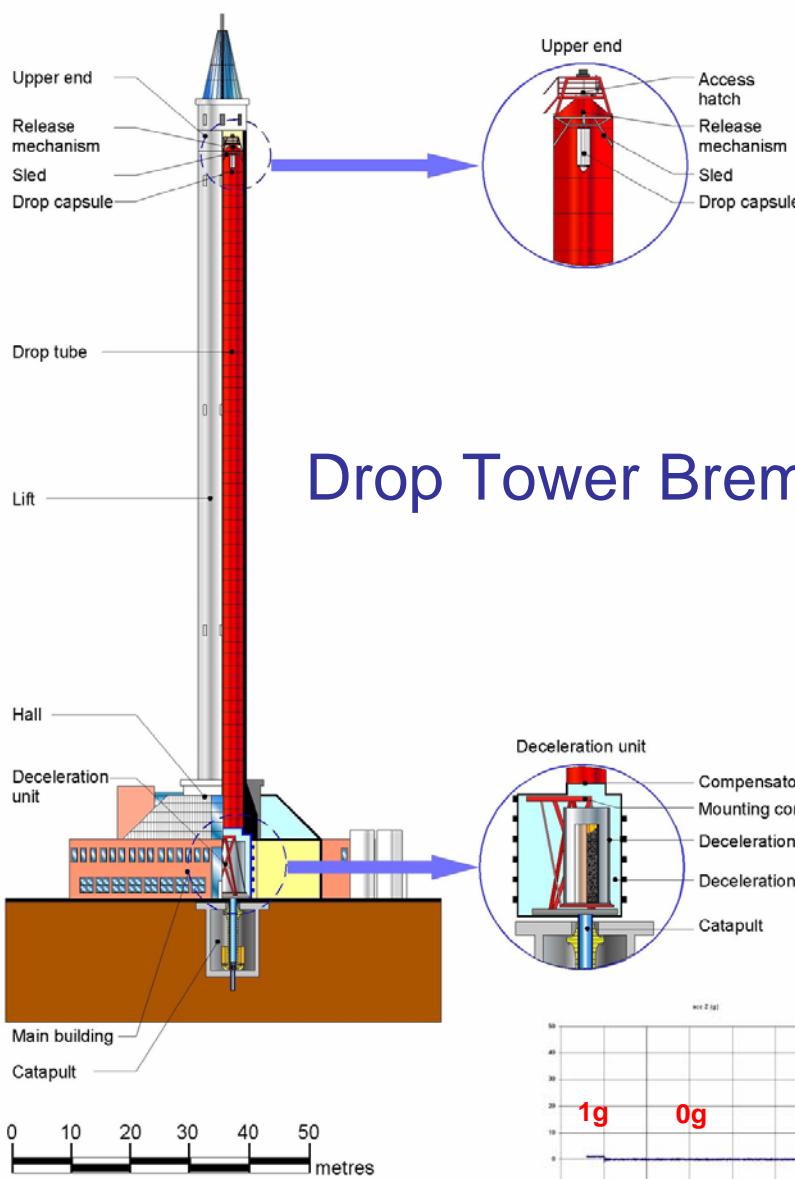


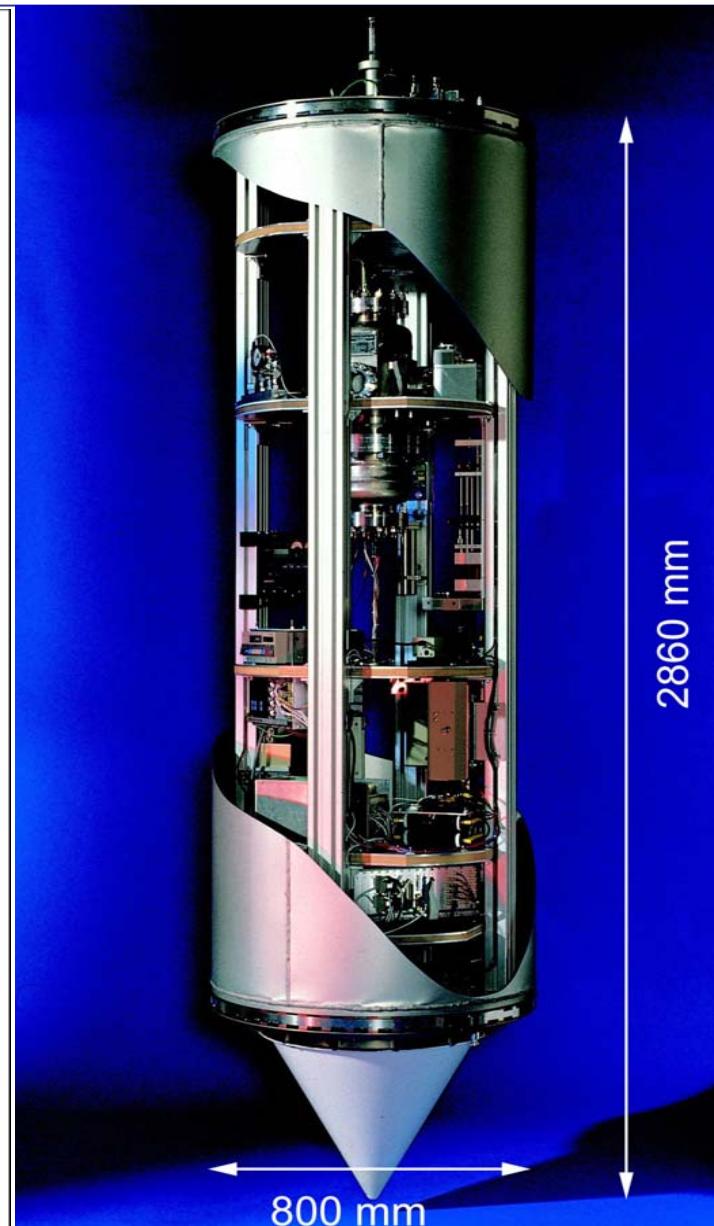
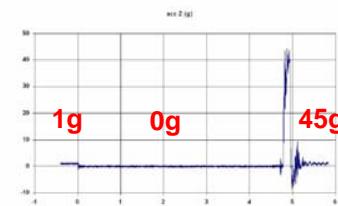
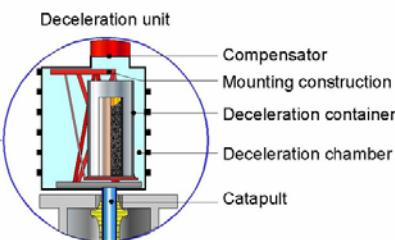
Free fall payload test environment and mission simulation



- Drop Tower Bremen
- Free flyer concept
 - μg-quality
- Catapult system
 - μg-quality
- MICROSCOPE test configuration baseline
- Mission simulation



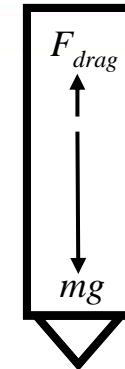
Drop Tower Bremen



Air drag - air friction

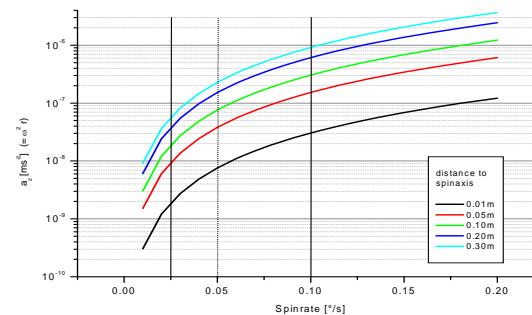
$$ma(t) = mg + F_{drag}(t)$$

$$F_{Newton}(t) = \beta v(t)^2 = \frac{\rho \cdot A \cdot c_w}{2} \cdot v(t)^2$$



Centrifugal acceleration

$$a_c = r \cdot \omega^2$$



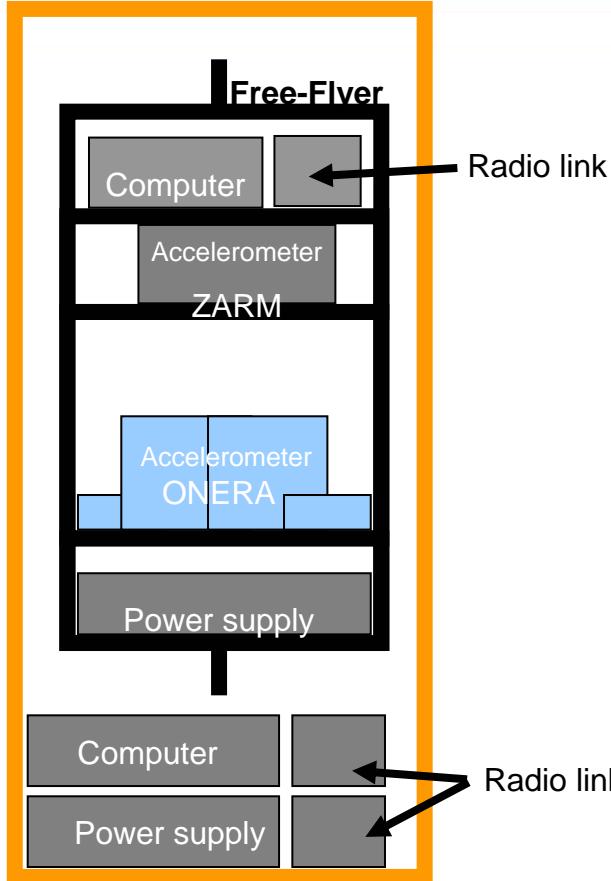
Vibration

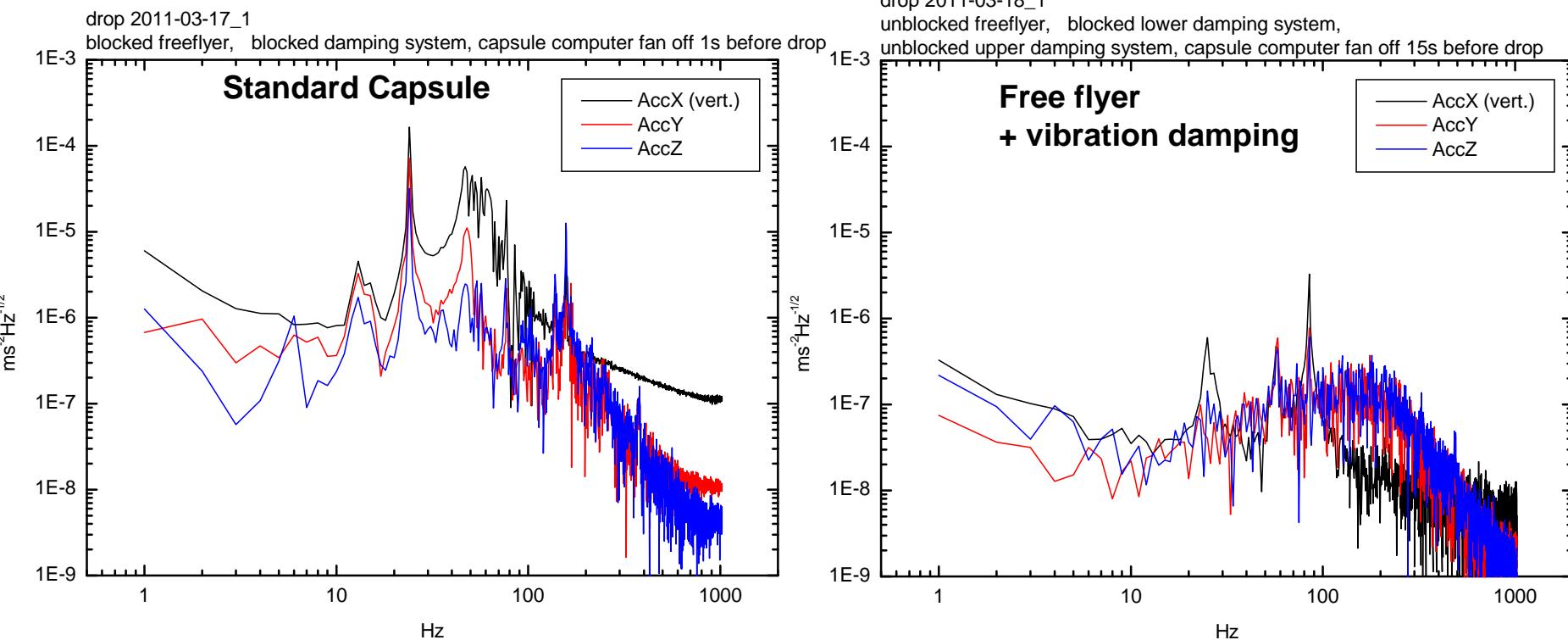
payload (fans, harddisks, etc.), transition 1g-0g

⇒ vibration damping, no vibrating payload components!

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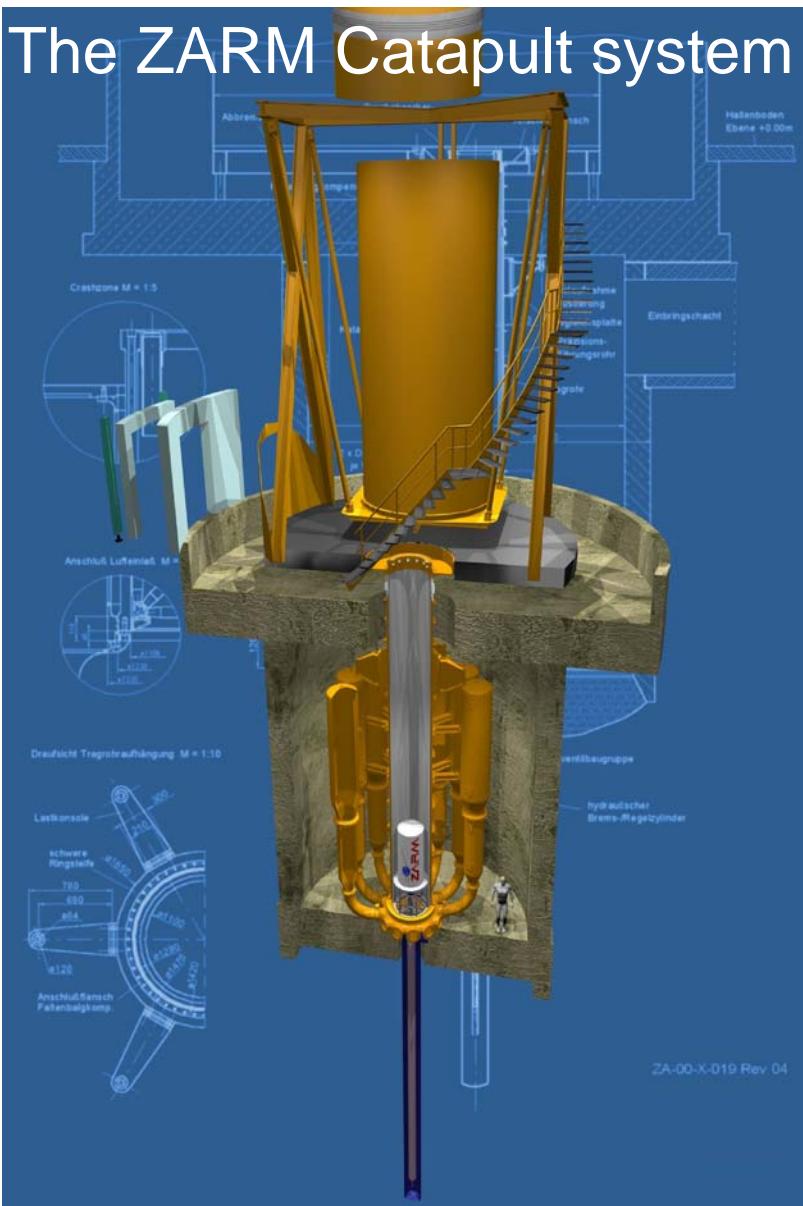
Drop capsule



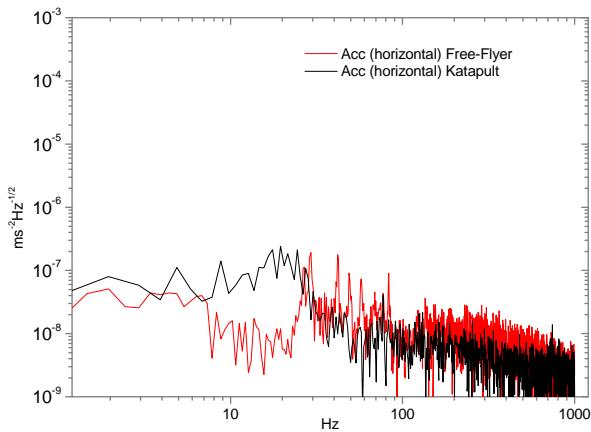
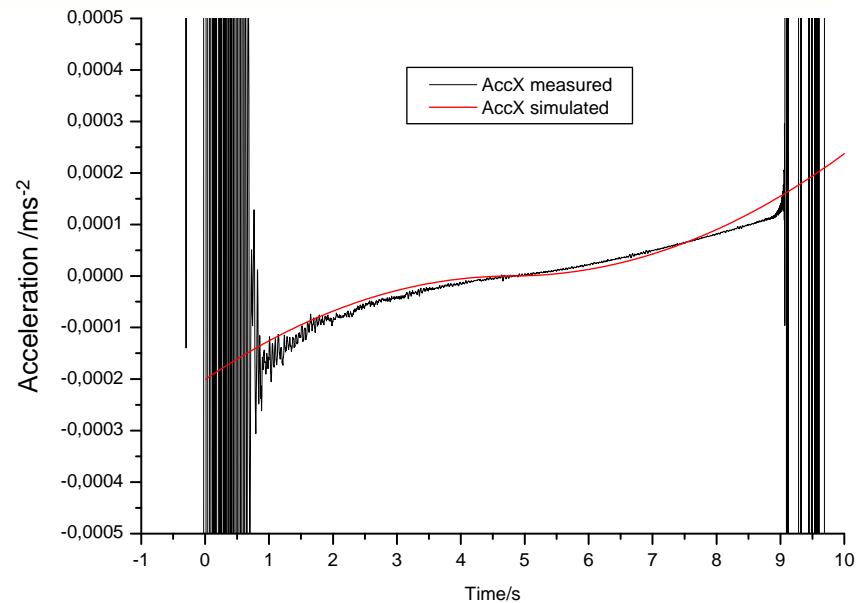


- Drop Tower Bremen
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μg-quality
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μg-quality
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The ZARM Catapult system



$$F_{Newton}(t) = \beta v(t)^2 = \frac{\rho \cdot A \cdot c_w}{2} \cdot v(t)^2$$



	Standard drop Free-flyer	Standard drop	Catapult shot
μg duration	2-3 s	4 s	7-8 s
present μg -level	$10^{-7} - 10^{-8} g$	$10^{-5} - 10^{-6} g$	$10^{-5} - 10^{-6} g$ ($10^{-7} g$ around apex)
advantage	best μg-level	low spin rates	long experiment time
disadvantage	short experiment time	lower μg-level	lower μg-level higher spin rates



better for High-Resolution-Mode
HRM

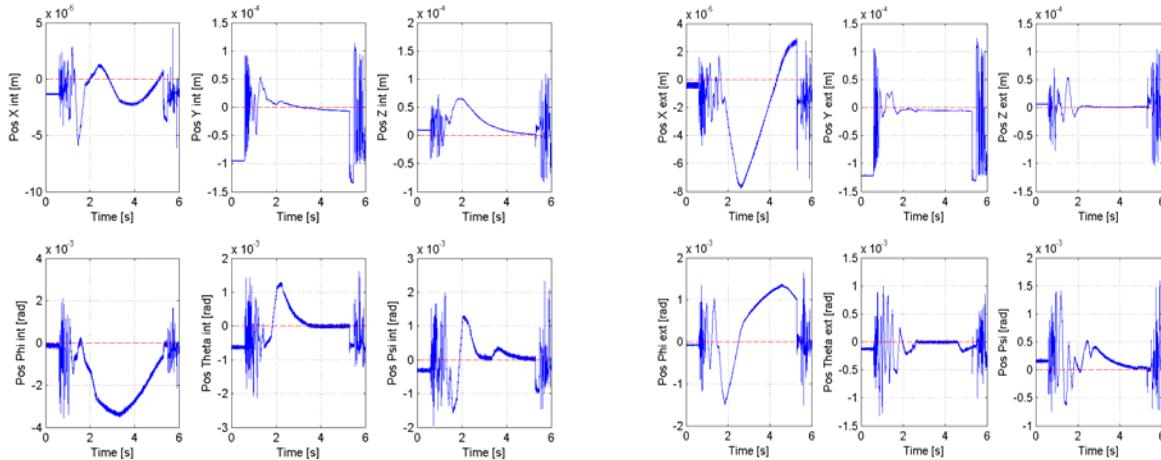


better for Full-Range-Mode
FRM

- Drop Tower Bremen
- Free flyer concept
μg-quality
- Catapult system
μg-quality
- MICROSCOPE test configuration baseline
- Mission simulation

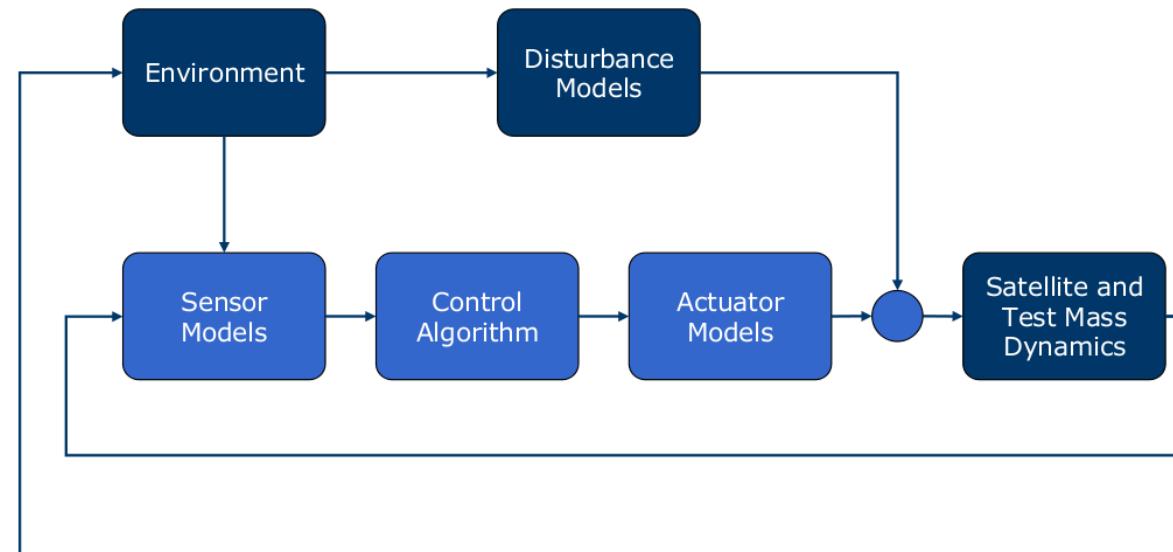
Test configuration baseline

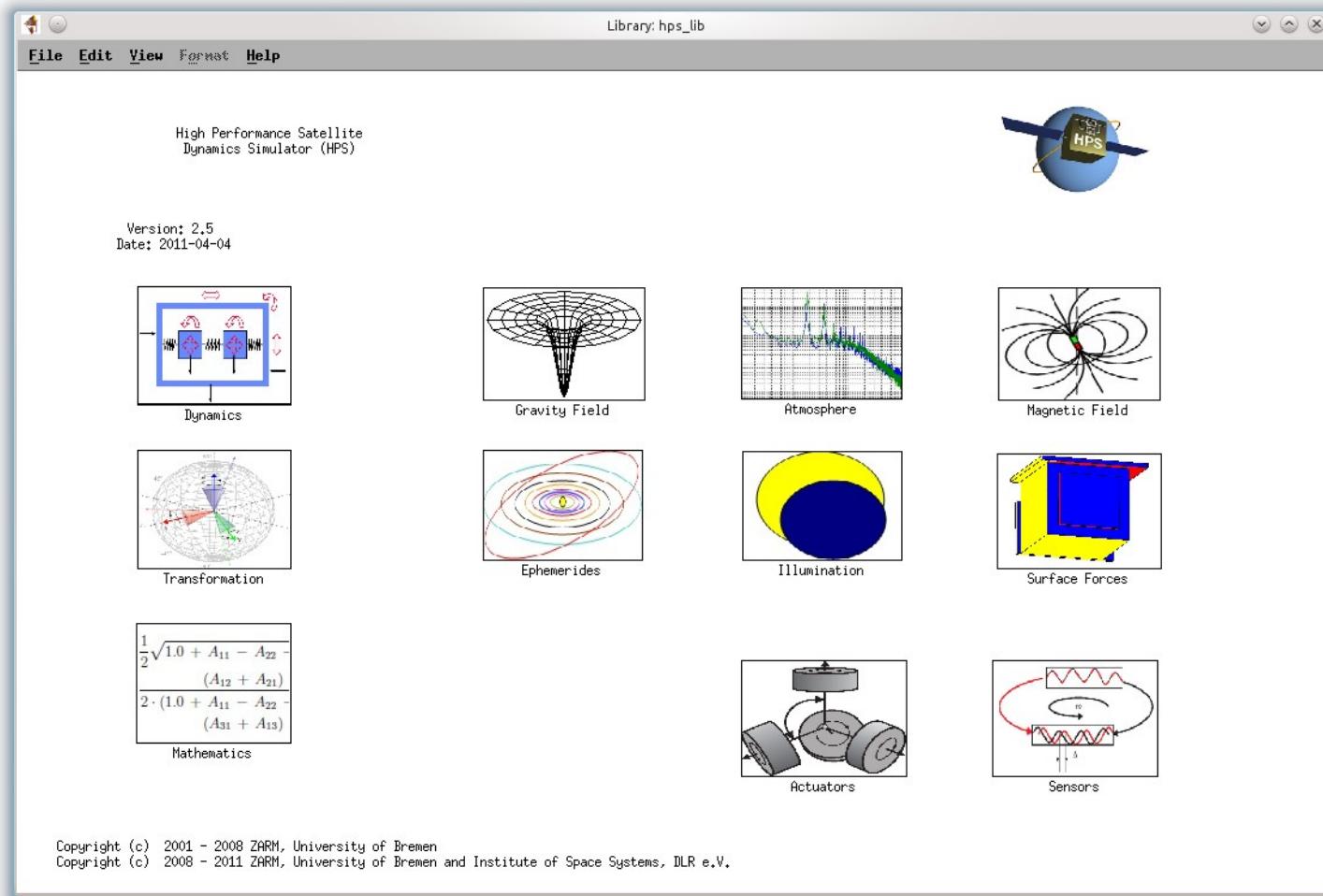
- **Pre qualification tests SU QM2 : 2011**
Several drops in order adjust the parameters
- **Qualification tests SU QM2 : 2011**
Qualification purpose: drop before and after environmental tests
- **Functionnal tests SU FM : 2011/2012**
control the PM for all axis
- **Test SU FM : 2011/2012**
Flight configuration

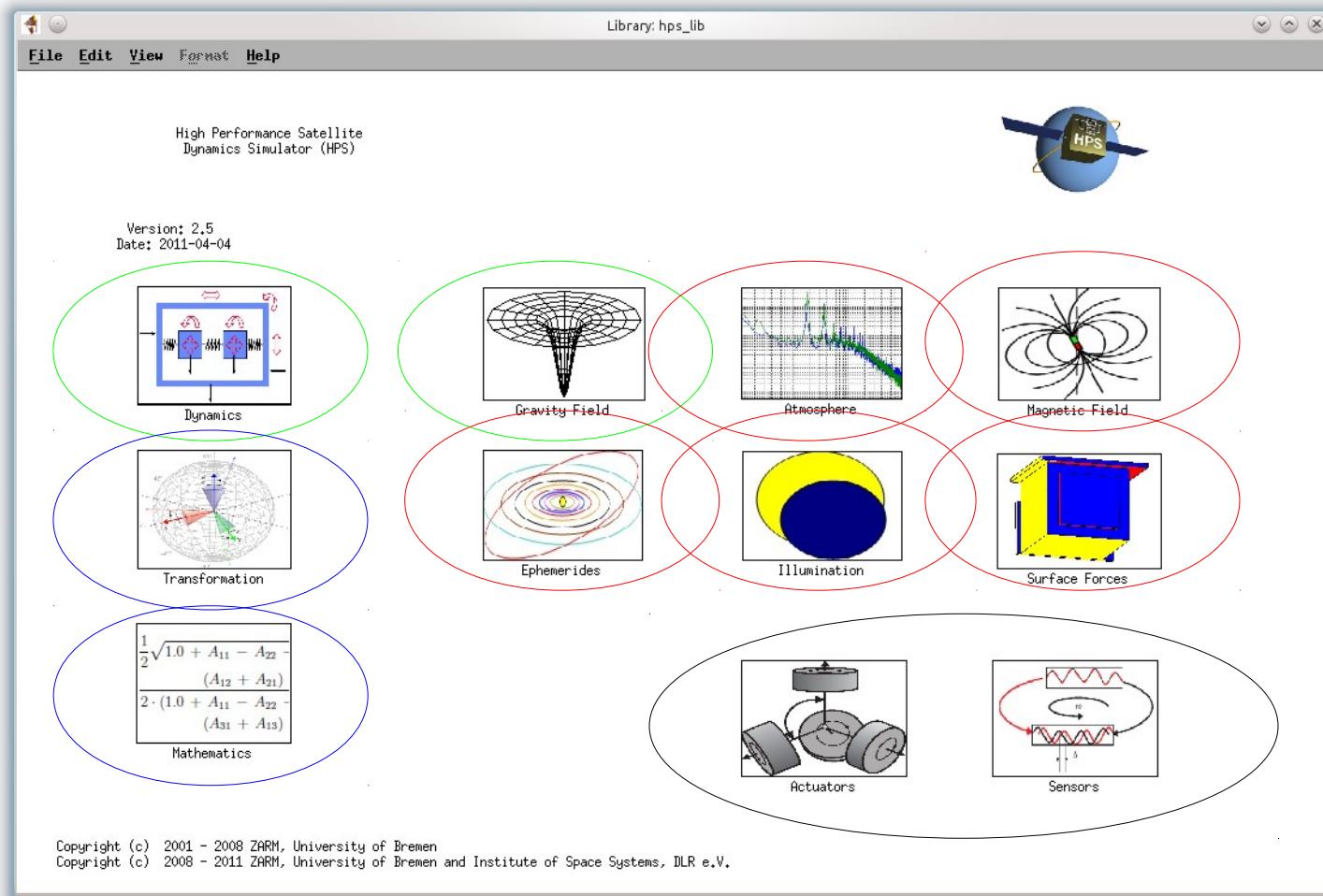


- Drop Tower Bremen
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μg-quality
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μg-quality
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- Processing of MICROSCOPE data – data reduction methods
 - High performance satellite dynamics simulation tool
- Comprehensive simulation of the real system including the science signal and error sources
- By means of mission simulations data is generated to test the reduction and processing methods





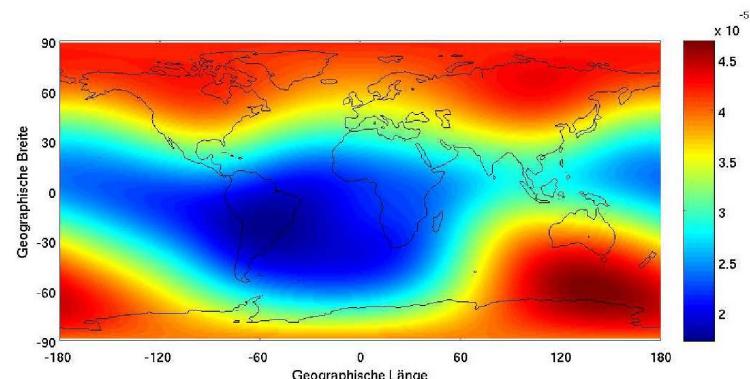


- **Models of Earth Gravity Field:**

- > **Simple Gravity Model** (spherical potential including zonal harmonic coefficients J_n up to degree n is approximated)
- > **Higher order Gravity Model:** Spherical harmonic model of the Earth's gravitational potential (complete to degree and order 360, based on GRACE data: EGM2008, EIGEN-5C, GGM03)
 - all effects of the Earth's non-symmetric mass distribution can be described
- > **Higher order Gravity Model:** Method of Pines (based on Grace data, zero-tide system: includes permanent tidal deformation due to external bodies)

- **Earth Magnetic Field:**

- > **The International Geomagnetic Reference Field (IGRF-11)**
- > External magnetic field: **Tsyganenko Model**
 - Internal magnetic field (IGRF-11)
 - Distortion of the internal magnetic field in high altitudes because of the solar wind



- **Ephemerides:**

- > Sun, the planets and Pluto
- > Based on the **algorithm of Montenbruck & Pfleger**
- > **better**: JPL ephemeris (based on n-body-calculations of approx. 300 solar system objects including the PPN of GR)

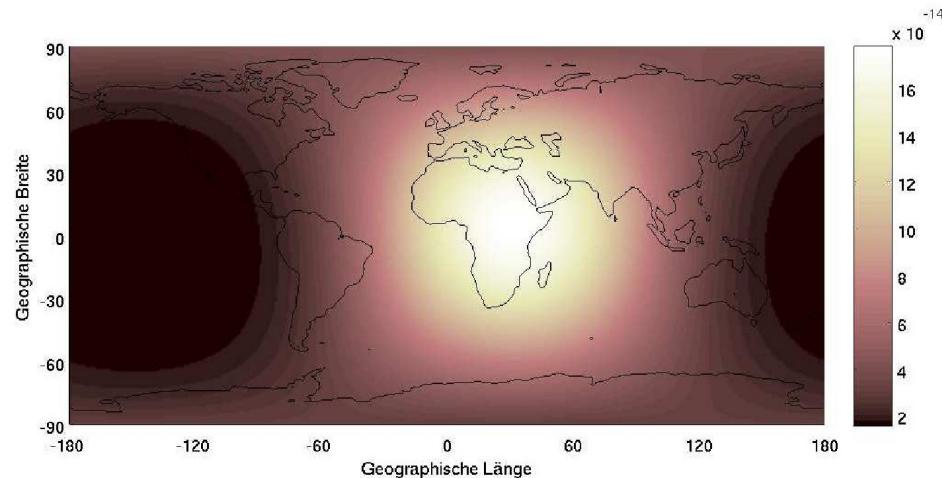
- **Atmospheric Density:**

- Empirical model for the atmosphere extending from the ground to the exosphere (**NRLMSISE-00**):
 - associated with the NRLMSIS data base
 - models the temperatures and densities of the atmosphere's components

- **HWM93 atmospheric wind Models**

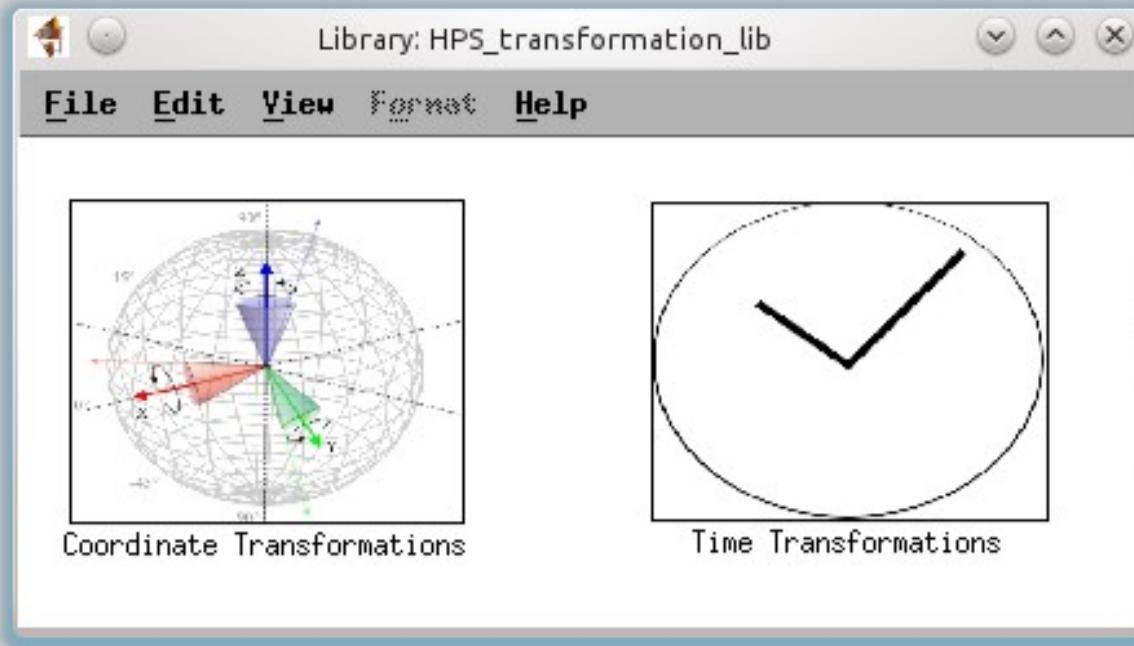
- Model of **Harries-Priester**

- based on the properties of the upper atmosphere as determined from the solution of the heat conduction equation under quasi hydrostatic conditions

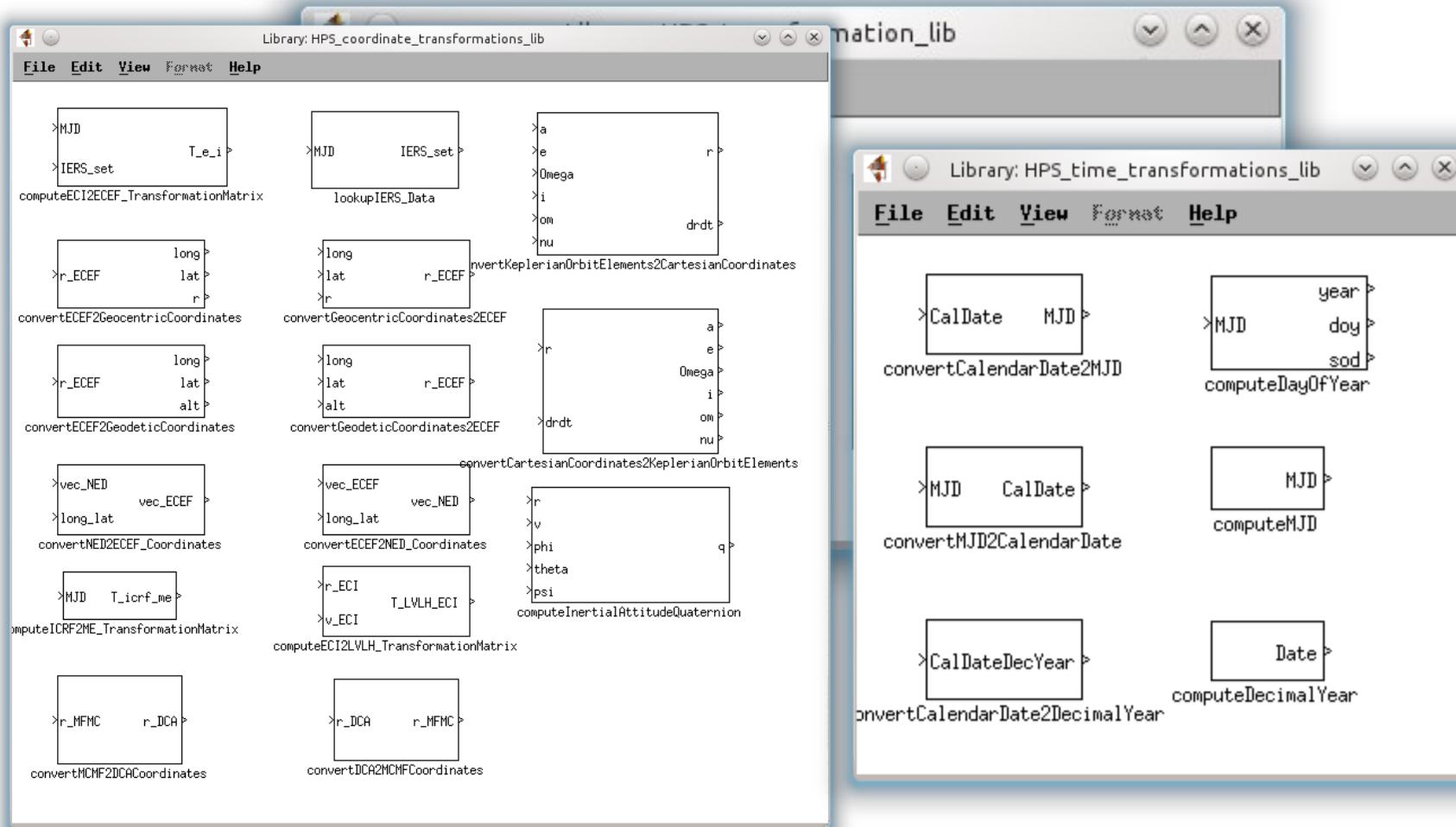


- **Eclipse Model**
- **Solar Pressure Model:**
 - > Point-like source
 - > Finite disk source
- **Albedo Irradiance Model:**
 - > Reflectivity data taken from
 - Total Ozone Mapping Spectrometer (TOMS):
22. July 1996 – 14. December 2005
 - Aura Mission: 1. January 2005 - 30. June 2009
 - Monthly mean data sets can be used (generated from TOMS data)

- **Transformations**



• Transformations



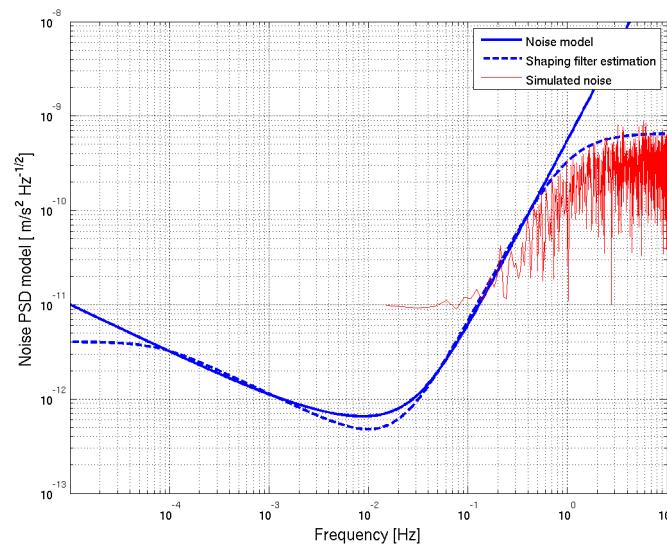
- **Surface Forces:**

- Calculation of surface forces and resulting torques by means of Finite Elements
- Dependence of the disturbance force on the geometry of satellite

- **Space Debris:**

- Under Construction!!!
- Uses data obtained with the help of ESA-tool **MASTER**
(Meteoroid and Space Debris Terrestrial Environment Reference)

- **Test mass and satellite dynamics**
- **Noise Model of MICROSCOPE instrument**



Noise model and filter estimation with simulated noise sampled at 1000 Hz
for 100s



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