Comments on System Requirements of Advanced LIGO SUS Alignment

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System Alignment Requirements on SUS

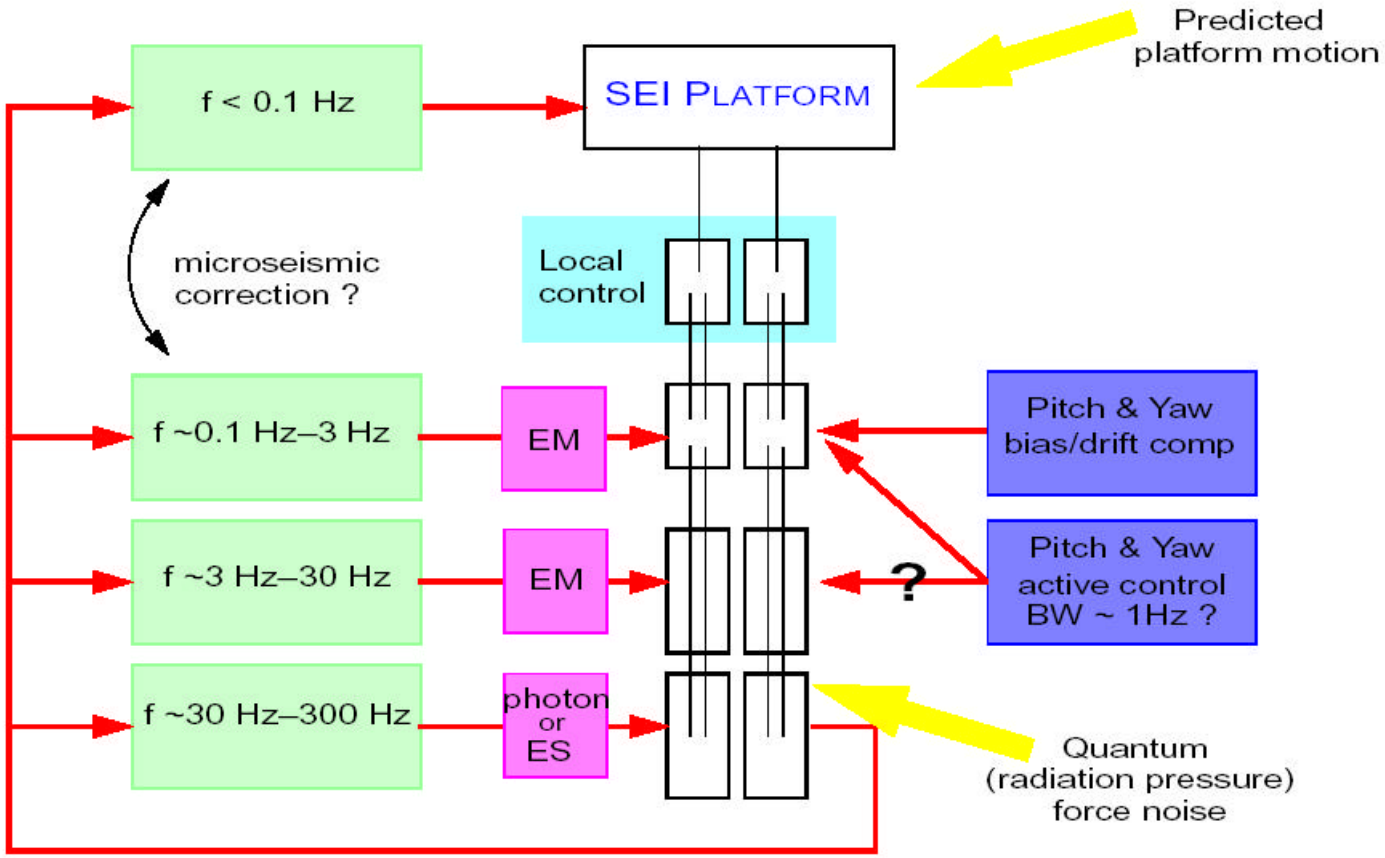
- Comments are for Quads (one per SEI platform)
  - » Triples, which share an SEI platform, have tighter tolerances
- Alignment Sensors:
  - » Initial Alignment System (IAS): theodolite total station, laser ranging, laser autocolimators, optical transit square, reference monuments, …
    - – Coarse-x,y,z and coarse-pitch,yaw (roll is set in SUS assembly)
    - – Accuracy of roll angle (wedge relative to flats and to crystaline axes (sapphire)) are TBD by COC, but order of ~mrads
    - – Angular accuracy is <= 50 microrad (pitch, yaw), resolution ~5 microrad
    - – Positional accuracy is ~1 mm
  - » Wavefront Sensing
    - – Low bandwidth: DC to ~few Hz (TBD pending further investigation of the cavity angular optical stability at high power)
    - – For initial LIGO, WFS accuracy ~10 nrad rms (pitch and yaw)
      - For advanced LIGO, WFS accuracy is TBD

System Alignment Requirements on SUS

- DC Alignment ‘actuators’:
  - » SUS design/assembly tolerance (dead reckoning) for coarse-z (vertical)
    - – Required to be << SEI EPI static positioning range (+/- ~5 mm)
    - – So tolerance from optics table interface to the center of the optic is +/- 0.5 mm
  - » Seismic Isolation (SEI) static positioning
  - » Tooling to statically position/align the SUS on the optics table (coarse-x,coarse-y,coarse-yaw)
    - – Should be commensurate with the ab initio alignment sensing accuracy, or +/- 0.5 mm and +/- 25 microrad
  - » Seismic Isolation (SEI) External Pre-Isolation (EPI) (fine-x, fine-y, fine-z, fine-yaw)
    - – Range is +/- 1 mm over a baseline of of 2.9 m (i.e. +/- 0.7 mrad yaw)
  - » SUS upper mass EM actuators (fine-pitch)
    - – Used to set fine-pitch alignment
    - – Also used to set fine-x,y,z and fine-yaw,roll – if needed; for example for suspensions in which more than one are on an optics table (FM & ITM), where the SEI EPI cannot independently align each suspension/optic

LIGO

CONTROL HIERARCHY



System Alignment Requirements on SUS

- Other system derived requirements on SUS alignment:
  - » Cross-hair reference marks on the SUS assembly indicating the center of the optic (above, below, left and right)
    - – Accuracy +/- 0.5 mm in positional knowledge (I.e. the reference marks do not have to be on-center, but the deviation from on-center must be known)
  - » Reference flats on structure at base (interface with the optics table) with known yaw angle to optic (accuracy +/- 25 microrad) to be used for mechanical registration for R&R (repair & replacement)
    - – Is this practical? Difficult?
    - – Desired when a SUS assembly is removed & replaced with a re-hung optic