Ideal Order/Contents of HAM Triple Testing/Commissioning

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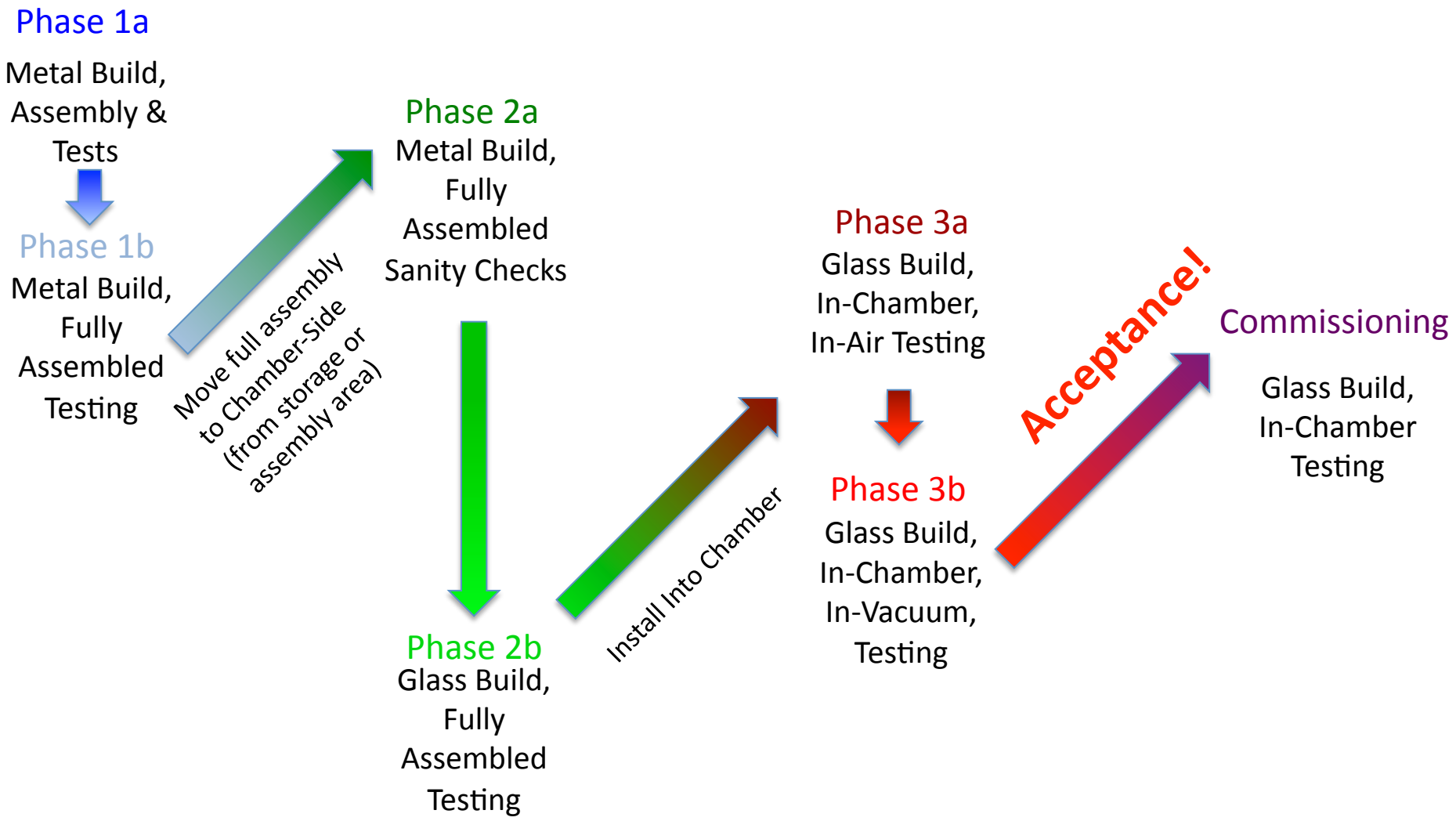
Driving Principles

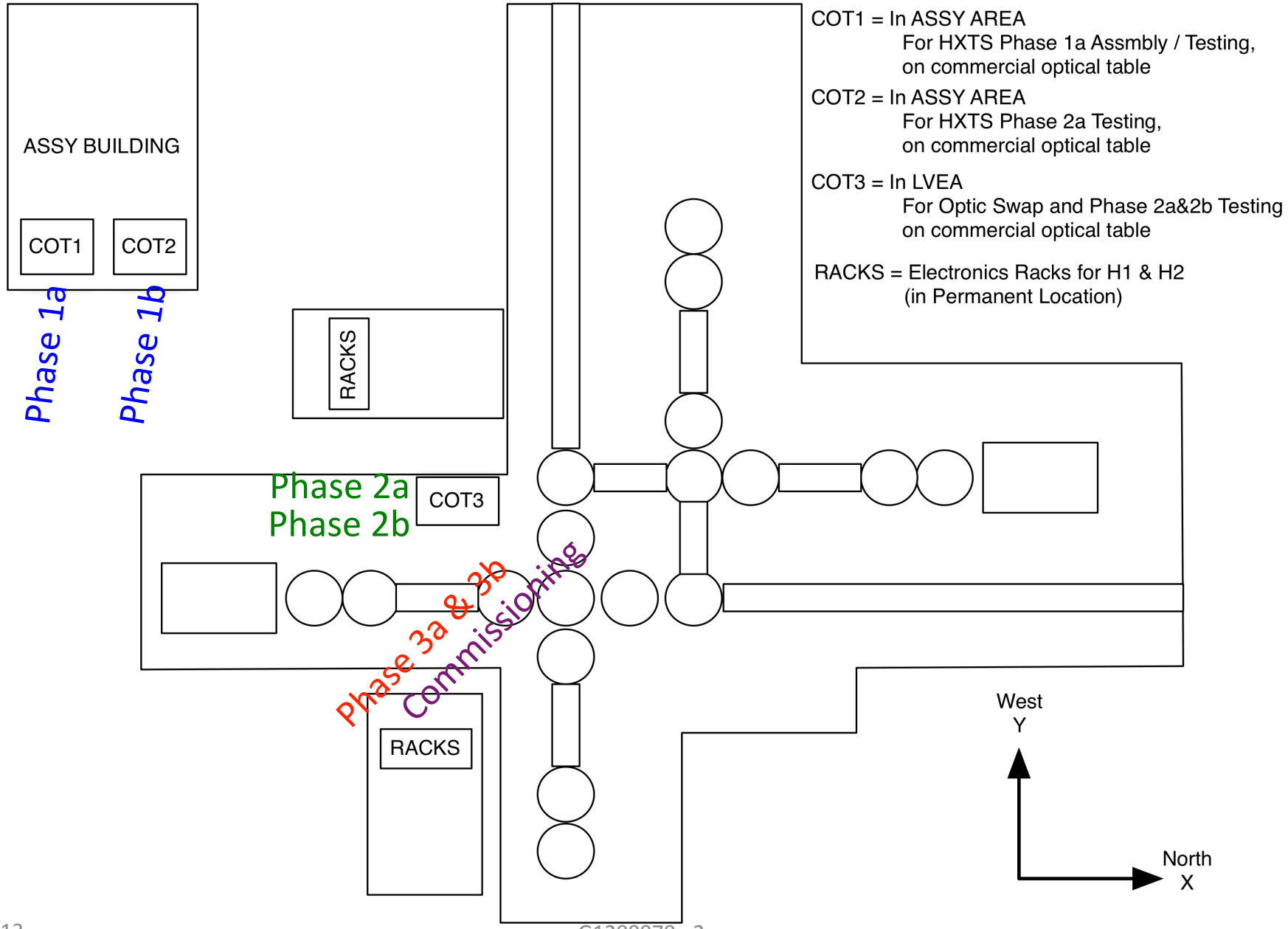
- This document was written with the HSTS and HLTSs in mind. In principle, the same procedure can be applied to the BSFM, replacing the mounting type (Hanging vs. Upright), and ignoring references to M3 sensors and resonant cavities
- Learn as much as you can about the systems, as early as possible
- Assembly and Testing are synonomous, not separate, as should be the teams
- Test simple cases first, then your understanding of the full thing will be more clear
- Test report should contain everything you need to *prove* it works, but does not contain every test you've done to *make* it work (Results vs. Tests vs. Sanity Checks)
- We're still developing the production line – not all tests that we've [done in the past / will do in the future] are useful, but we don't know until we try
- This is an ideal list. Reality maybe force us to measure less. We need not go back and get results, if the oppurtunity has passed.

⇒ We care about the performance / response / reports in the final configuration (glass build, fully assembled, in-vac) the most

Order of Operations - LINGO



LINGO – Stages of Testing



Phase 1a

Metal Build, Assembly and Testing

Tests

- DC Alignment (from Optical Levels and Levers)
- Magnet Polarity Check
- Ensure appropriate model infrastructure has been restored
- Determine M1, M2, M3 OSEM Open Light Current

Results

- Suspended mass' mass – specifically M1, M2, and M3 (ICS)
- Trim mass allocation at all stages (ICS)
- Blade Characterization Data (Stiffness Pass/Fail) (DCC)
- M1, M2, and M3 Magnet Strength Data (Strength Pass/Fail) (Manufacturer's Spec)
- M1, M2, and M3 OSEM Inventory; S/N, Configuration, Open Light Current (Open Light Current Level Pass/Fail) (Update ICS, Updated OSEM Chart E1200343)
- M1, M2, and M3 Coil Resistance and Inductance (Tolerance Pass/Fail)
  (Merely ensure that all data is in hand)
- M1, M2, and M3 OSEM sensor noise assessment (Noise Floor Pass/Fail)
  (Merely ensure that all data is in hand)
- Individual Vibration Absorber Characterization (Resonant Bandwidth Pass/Fail)
  (Merely ensure that all data is in hand)

Phase 1b

Metal Build, Fully Assembled Testing

Tests

- DC Alignment (from Optical Levels and Levers)
- Rough M1 OSEM Alignment
- Ability to Actuate M1 ← Use Speedometers
- M1 Sensor Sign Checks ← DC Offsets
- Expected Watchdog behavior
- Rubbing Checks (EQ Stops, etc)
- M1 Actuator Sign Check ← DC Offsets
- Rough M2, M3 OSEM Alignment ← Take a set of M1 to M1 TFs
- M2, M3 Sensor Sign checks ← Use Speedometers
- Damping Loop Closure ← DC Offsets at M1

Results

- Final alignment assessment (Tolerances Pass/Fail)
- Final Calibrated OSEM Spectra of M1, M2, M3 Motion (Resonances & Noise Floor Pass/Fail)
  - Comparison Set (Euler and OSEM Basis ASDs, compared with single Reference Measurement)
- Final Calibrated M1 to M1 Transfer Functions, Euler and OSEM basis, Damping Off, (Model and Ref. Meas. Comparison Pass/Fail)
  - Individual Set (Euler and OSEM Basis TFs, compared with Model)
  - Comparison Set (Euler Basis only, compared with Reference Measurements and Model)
- Final Calibrated M1 to M1 Transfer Functions, Euler and OSEM basis, Damping ON (Model and Ref. Meas Comparison Pass/Fail)
  - Individual Set (Euler and OSEM Basis TFs, compared with Model)
  - Comparison Set (Euler Basis only, compared with Reference Measurements and Model)

Phase 2a

Metal Build, Fully Assembled Sanity Checks

Tests

- Ensure front-end model infrastructure in place
- Determine M1, M2, M3 OSEM Open Light Current
- Center M1, M2, M3 OSEMs
- Rubbing Checks (EQ Stops, etc)
- Expected Watchdog behavior
- M1 Sensor Sign Checks
- Coil Driver BIO switches' functionality confirmed
- Ability to Sense/Actuate M1
- Ability to Sense M2, M3
- Damping loop closure

DC Offsets
Take a set of M1 to M1 TFs
Take M1, M2, M3 OSEM Spectra

Results

- M1, M2, and M3 OSEM Open Light Current (Open Light Current Level Pass/Fail) (Updated OSEM Chart E1200343)
- Final Calibrated OSEM Spectra of M1, M2, M3 Motion (Resonances & Noise Floor Pass/Fail)
  - Comparison Set (Euler and OSEM Basis ASDs, compared with single Reference Measurement)
  - Comparison Set (Euler and OSEM Basis ASDs, compared with previous stage)
- Final Calibrated M1 to M1 Transfer Functions, Euler and OSEM basis, Damping Off, (Model and Ref. Meas. Comparison Pass/Fail)
  - Individual Set (Euler and OSEM Basis TFs, compared with Model)
  - Comparison Set (Euler Basis only, compared with Reference Measurements, Previous Stage Results, and Model)
- Final Calibrated M1 to M1 Transfer Functions, Euler and OSEM basis, Damping ON (Model and Ref. Meas Comparison Pass/Fail)
  - Individual Set (Euler and OSEM Basis TFs, compared with Model)
  - Comparison Set (Euler Basis only, compared with Reference Measurements, Previous Stage Results, and Model)

Phase 2b

Glass Build, Fully Assembled Testing

Tests

- DC Alignment (from Levels and Optical Levers)
- IAS Bottom Mass Height Assessment
- Center M1, M2, M3 OSEMs
- Rubbing Checks (EQ Stops, etc.)
- Ability to Sense/Actuate M1
- Ability to Sense M2, M3
- Expected Watchdog behavior
- Damping Loop Closure

Take a set of M1 to M1 TFs

Take M1, M2, M3 OSEM Spectra

Results

- Final SUS alignment checkout (Tolerances Pass/Fail)
- Final Calibrated OSEM Spectra of M1, M2, M3 Motion (Resonances & Noise Floor Pass/Fail)
  - Comparison Set (Euler and OSEM Basis ASDs, compared with single Reference Measurement)
  - Comparison Set (Euler and OSEM Basis ASDs, compared with previous stage)
- Final Calibrated M1 to M1 Transfer Functions, Euler and OSEM basis, Damping Off, (Model and Ref. Meas. Comparison Pass/Fail)
  - Individual Set (Euler and OSEM Basis TFs, compared with Model)
  - Comparison Set (Euler Basis only, compared with Reference Measurements, Previous Stage Results, and Model)
- Final Calibrated M1 to M1 Transfer Functions, Euler and OSEM basis, Damping ON (Model and Ref. Meas. Comparison Pass/Fail)
  - Individual Set (Euler and OSEM Basis TFs, compared with Model)
  - Comparison Set (Euler Basis only, compared with Reference Measurements, Previous Stage Results, and Model)

Phase 3a

Glass Build, In-Chamber, In-Air Testing

Tests

- Assess absence of Ground Loops in Cabling Routing
- Assess Cable Routing stiffness/compliance from optical table, through ISI, to feedthrough
- Determine M1, M2, M3 OSEM Open Light Current
- Ability to Sense/Actuate M1
- Ability to Sense M2, M3
- DC Alignment (from Levels and Optical Levers, Full IAS Blessing)
- Final Alignment/Centering of OSEM Sensors at M1, M2, M3
- Expected Watchdog / Damping Loop behavior, including interaction with HAM-ISI
- Assess Table Mounting / Dog Clamping with B&K Hammer & Accelerometer
- Assess Vibration Absorber Functionality with B&K Hammer & Accelerometer
- Assess coupling to ISI with HAM-ISI ST1 transfer function and/or B&K Hammer
- Final Setting of EQ Stop Distances
- Final Rubbing Checks (EQ Stops, etc.)
- Damping Loop Closure

Take a set of M1 to M1 TFs

Take M1, M2, M3 OSEM Spectra

Take a set of M1 to M1 TFs

Install Vibration Absorbers

Take a set of M1 to M1 TFs

Results

- Final IAS Alignment Checkout (Tolerances Pass/ Fail)
- M1, M2, and M3 OSEM Open Light Current (Open Light Current Level Pass/Fail) (Updated OSEM Chart E1200343)
- Final Calibrated OSEM Spectra of M1, M2, M3 Motion (Resonances & Noise Floor Pass/Fail)
  - Comparison Set (Euler and OSEM Basis ASDs, compared with single Phase 3a Reference Measurement)
  - Comparison Set (Euler and OSEM Basis ASDs, compared with previous stages)
- Final Calibrated M1 to M1 Transfer Functions, Euler and OSEM basis, Damping Off, (Model and Ref. Meas. Comparison Pass/Fail)
  - Individual Set (Euler and OSEM Basis TFs, compared with Model)
  - Comparison Set (Euler Basis only, compared with Reference Measurements, Previous Stage Results, and Model)
- Final Calibrated M1 to M1 Transfer Functions, Euler and OSEM basis, Damping ON (Model and Ref. Meas. Comparison Pass/Fail)
  - Individual Set (Euler and OSEM Basis TFs, compared with Model)
  - Comparison Set (Euler Basis only, compared with Reference Measurements, Previous Stage Results, and Model)
- Vibration absorber / HAM-ISI (de-)coupling Confirmed (Pass/Fail)
  (encompasses Vibration Absorber OFF/ON test and ISI Transfer Functions)
- [For MC HSTSs Only] In-air Cavity Lock

Bonus:

(Environment may be too noisy, but it has been possible with purge air down/off and C3 covers on)

- Confirm ability to actuate M2 and M3 (using OSEMs or OpLev if available)

Phase 3b

Glass Build, In-Chamber, In-Vacuum Testing

Tests

- Ability to Sense/Actuate M1, M2, M3
- Rubbing Checks via Transfer Functions

Take a set of M1 to M1 TFs

Results

- Final Calibrated OSEM Spectra of M1, M2, M3 Motion (Resonances & Noise Floor Pass/Fail)
  - Comparison Set (Euler and OSEM Basis ASDs, compared with single Reference Measurement)
  - Comparison Set (Euler and OSEM Basis ASDs, compared with previous stage)
- Final Calibrated M1 to M1 Transfer Functions, Euler and OSEM basis, Damping Off, (Model and Ref. Meas. Comparison Pass/Fail)
  - Individual Set (Euler and OSEM Basis TFs, compared with Model)
  - Comparison Set (Euler Basis only, compared with Reference Measurements, Previous Stage Results, and Model)
- Final Calibrated M1 to M1 Transfer Functions, Euler and OSEM basis, Damping ON (Model and Ref. Meas. Comparison Pass/Fail)
  - Individual Set (Euler and OSEM Basis TFs, compared with Model)
  - Comparison Set (Euler Basis only, compared with Reference Measurements, Previous Stage Results, and Model)
- Final Calibrated M2,M3 to M1,M2,M3 Transfer Functions, Euler Basis, Damping Off (Model and Ref. Meas. Comparison Pass/Fail)
- M1, M2, M3 Actuation Range Test using OSEMs (or OpLev if available)

ACCEPTANCE!!

Commissioning
In-Chamber, as a Part of IFO

Goals

- OSEM Spectra of M1, M2, M3 Motion, compare with Phases 2c, 3a, 3b, with HAM-ISI/ HEPI in various states (ON/OFF, Damping ON/OFF, Low/High Perf, etc. etc.)
- M3 Motion measured by IFO, compare with Phases 2c, 3a, 3b, OpLev, with HAM-ISI/ HEPI in various states (ON/OFF, Damping ON/OFF, Low/High Perf, etc. etc.)
- Calibrated M1,M2,M3 to M3 transfer functions, measured by IFO
- Calibrated M2 to M3 transfer functions using triple acq. driver, measured by IFO
- Calibrated M3 to M3 transfer functions using triple acq. driver, measured by IFO
- Calibrated HAM-ISI STG1 to M3 Transfer Functions measured by IFO
- Length – to – Angle measurements / decoupling
- Violin Mode identification (Frequency and Q)
- Design/Install High performance Damping Filters, performance measured with IFO
- Heirarchical Control
- Study SEI/SUS interactions using projected Sus. Point Motion
- Offloading to ISI if necessary
- Experiment with Modal Damping