Ideal Order of QUAD Testing

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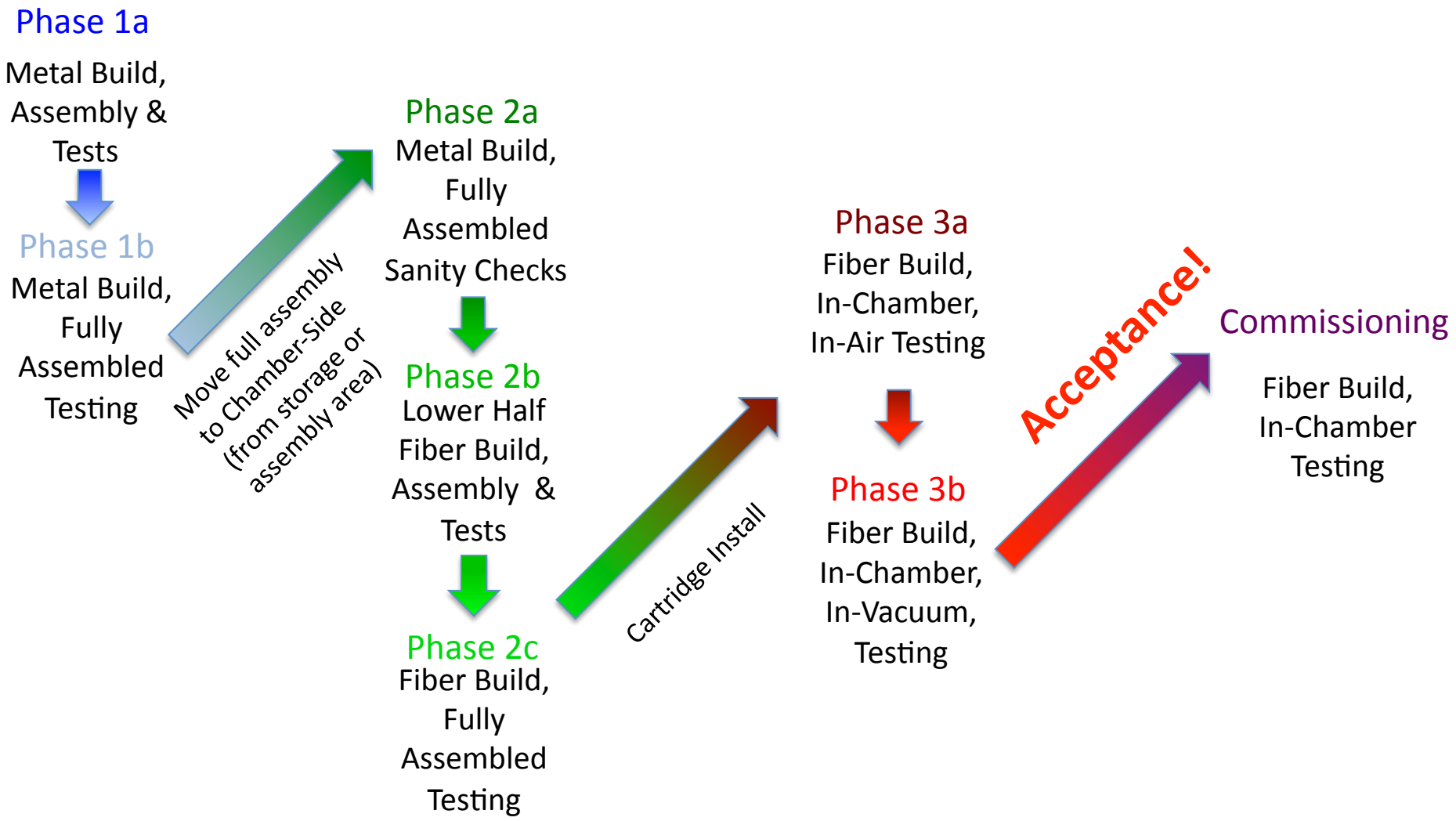
G1100693-v5

Driving Principles

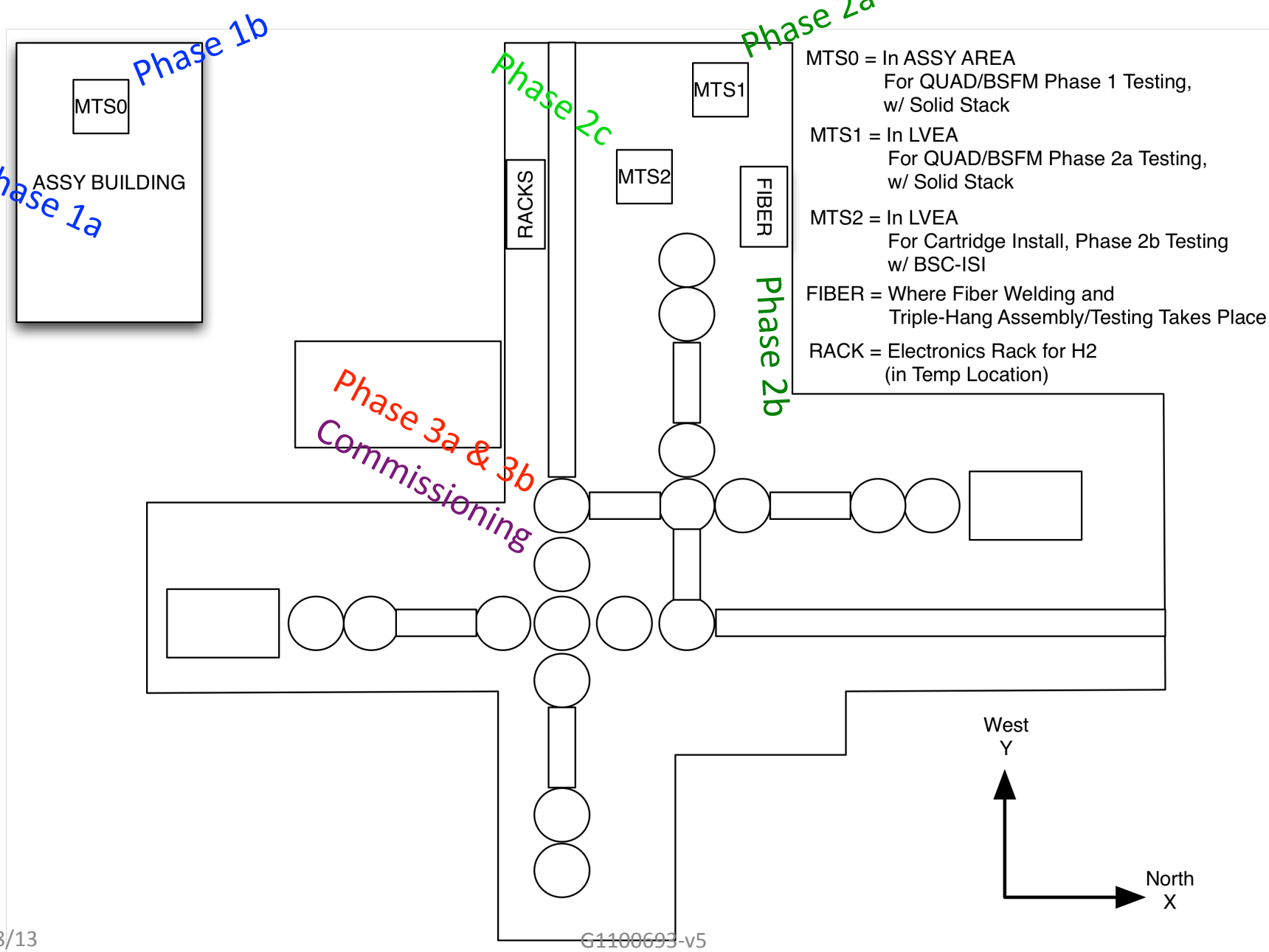
- Learn as much as you can about the systems, as early as possible
- Assembly and Testing are synonomous, not separate, as should be the teams
- Test simple cases first, then your understanding of the full thing will be more clear
- Test report should contain everything you need to *prove* it works, 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 (fiber build, fully assembled, in-vac) the most

Order of Operations - LINGO



LINGO – Stages of Testing



Phase 1a
Wire Build, Assembly and Testing

Tests

- DC Alignment (from Levels and Optical Levers)
- Magnet Polarity Check
- Ensure appropriate model infrastructure has been restored
- Determine M0, R0, L1, L2 Open Ligh Current

Results

- Main Chain (MC), Reaction Chain (RC) suspended mass' mass (ICS)
- Trim mass allocation at all stages (ICS)
- Blade Characterization Data (Stiffness Pass/Fail)
- M0, R0, L1, L2 Magnet Strength Data (Strength Pass/Fail) (Manufacturer's Spec)
  (Merely ensure that all specs are in hand)
- M0, R0, L1, L2 OSEM Inventory; S/N, Configuration, Open Light Voltage (Open Light Voltage Pass/Fail) (Update ICS, Update OSEM Chart E1200343)
- M0, R0, L1, L2 OSEM Coil Resitance and Inductance (Tolerance Pass/Fail)
  (Merely ensure that all data is in hand)
- M0, R0, L1, L2 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)

"Top to Top" = M0 to M0 & R0 to R0

Phase 1b

Wire Build, Fully Assembled Testing

Tests

- DC Alignment/Balancing (from Optical Levels and Levers)
- Ability to Sense M0, R0
- M0, R0 OSEM Centering
- M0, R0 OSEM Sensor Diagonalization / Perpendicular Alignment
- M0, R0 Sensor Sign Checks
- Expected Watchdog behavior
- Ability to Actuate M0, R0
- M0, R0 Actuator Sign Checks
- Reaction Chain Cable Dressing
- Rough L1, L2 OSEM Centering and alignment
- L1, L2 Sensor Sign Checks
- Rubbing Checks (EQ Stops, etc)
- Damping Loop Closure

← Physically Move M0,R0
← Use speedometers
← Take single-frequency V & Y Top to Top TFs
← Physically Move M0,R0

← DC Offsets
← Take a set of Top to Top TFs
← Take a set of Top to Top TFs
← Use speedometers
← Top DC Offsets
← Take a set of Top to Top TFs

Results

- Phase 1 SUS alignment assessment (Tolerances Pass/Fail)
- Final Calibrated OSEM Spectra of M0, R0, L1, L2 Motion (Resonances & Noise Floor Pass/Fail)
  - Comparison Set (Euler and OSEM Basis ASDs, compared with single Reference Measurement)
- Final Calibrated Top to Top 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 Top to Top 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)

"Top to Top" = M0 to M0 & R0 to R0

Phase 2a

Wire Build, Fully Assembled Sanity Checks

Tests

- DC Alignment/Balancing (from Optical Levels and Levers)
- Ensure front-end model infrastructure is in place
- Determine M0, R0, L1, L2 OSEM Open Light Current
- Center M0, R0, L1, L2 OSEMs ← Use speedometers
- Ability to Sense M0, R0 ← Take a Spectra
- M0, R0 Sensor Sign Checks ← Physically move the Suspension
- Expected Watchdog behavior
- Coil Driver BIO switches' functionality confirmed
- Ability to Actuate M0, R0 ← DC Offsets
- Rubbing Checks (EQ Stops, etc)
- Ability to Sense L1, L2 ← Take a set of Top-Top TFs
- Damping loop closure ← Take a Spectra

Results

- M0, R0, L1, L2 OSEM Open Light Current (Open Light Current Level Pass/Fail) (Updated OSEM Chart E1200343)
- Final Calibrated OSEM Spectra of M0, R0, L1, L2 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 Prior Stage Results)
- Final Calibrated Top to Top 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, Prior Stage Results, and Model)
- Final Calibrated Top to Top 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, Prior Stage Results, and Model)

"Top to Top" = M0 to M0 & R0 to R0

Phase 2b

Fiber Build, Assembly and Testing

Tests (Before install of Fiber Protection)

- PUM/TST DC alignment in Wire Hang
- Check/Record (single) fiber profile
- 15 kg load (single) fiber proof test
- DC Alignment (from Optical Levels and Levers)
- Rubbing checks (EQ Stops, etc.)
- Single-hang (PUM Locked) modal frequency assessment (see T1100594)

Results

- Fiber Characterization Data (Metrology and/or Profile, Load Pass/Fail)
  (Merely ensure that all data is in-hand)
- Ear Characterization Data (Metrology Pass/Fail)
  (Merely ensure that all data is in-hand)
- ESD Characterization (Continuity, Mapping, Metrology Pass/Fail)
- Ring Heater Characterization (Continuity Pass/Fail)
- Calibrated L, V, P, Y Single Pendula (PUM->TST) Spectra (Resonances Pass/Fail)

"Top to Top" = M0 to M0 & R0 to R0

Phase 2c

Fiber Build, Fully Assembled Testing

Tests

- DC Alignment (using Optical Levels and Levers, full IAS Blessing)
- Full IAS Alignment Checkout (Test Mass Height, Test Mass/Reaction Mass Gap check, Chain Alignment, etc)
- Center M0, R0, L1, and L2 OSEMs ← Use Speedometers
- Ability to Sense M0, R0, L1, L2 OSEMs ← Take Spectra
- Expected Watchdog behavior, including interactions with BSC-ISI
- Ability to Actuate M0 and R0 ← Take a set of Top-Top TFs
- ESD Continuity, Ring Heater resistance ← Use Digital Multimeter
- Assess absense of Ground Loops in Cable Routing
- Reaction Chain Cable Dressing
- Rubbing Checks (EQ Stops, etc.) ← Take a set of Top-Top TFs
- Assess Table Mounting / Dog Clamping with B&K Hammer & Accelerometer (Vibration Absorbers OFF)
- Assess Vibration Absorber Functionality with B&K Hammer & Accelerometer (Vibration Abosorbers ON)
- Damping Loop Closure
- Assess Coupling to ISI with BSC-ISI ST2 transfer function ← Take a set of Top-Top TFs

Results

- Final IAS alignment checkout (Tolerances Pass/Fail)
- Watchdog connection with BSC-ISI, Damping Loop Functionality (Expected Protection Pass/Fail)
- Final Calibrated OSEM Spectra of M0, R0, L1, L2 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 Top to Top 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 Top to Top 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)
- Assess Vibration Absorber Performance (Suitable Reduction of Resonances, Decoupling from ISI Pass/Fail)

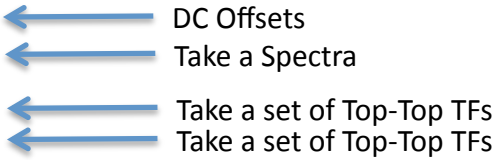
"Top to Top" = M0 to M0 & R0 to R0

Phase 3a

Fiber Build, In-Chamber, In-Air Testing

Tests

- Assess electronics chain continuity through feedthrus (ESD continuity, Ring Heater resistance, etc)
- Assess cable routing stiffness/compliance from Optical Table, through ISI, to Feedthrough
- Determine M0, R0, L1, and L2 Open Light Current
- Final Centering of M0, R0, L1, L2 OSEMs (including bouyancy compensation for vertical OSEMs)
- Final Setting of EQ Stop Distances (including bouyancy compensation for vertical stops)
- Ability to Sense / Actuate M0/R0
- Ability to Sense L1, L2
- Final Rubbing Checks (EQ Stops, etc.)
- Damping Loop Closure
- Assess coupling to ISI with BSC-ISI ST2 transfer function (if Phase 2c test was polluted by ambient noise)



Results

- M0, R0, L1, and L2 OSEM Open Light Current (Open Light Current Level Pass/Fail) (Updated OSEM Chart E1200343)
- Final Calibrated OSEM Spectra of M0, R0, L1, L2 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 Top to Top 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 Top to Top 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)

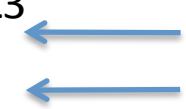
"Top to Top" = M0 to M0 & R0 to R0

Phase 3b

Fiber Build, In-Chamber, In-Vacuum Testing

Tests

- Ability to Sense/Actuate M0, R0, L1, L2, L3
- Rubbing Checks via Transfer Functions



Take OSEM/Oplev Spectra

Take a set of Top-Top TFs

Results

- Final Calibrated OSEM Spectra of M0, R0, L1, L2 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 Top to Top 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 Top to Top 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 L1, L2 to L1, L2, L3 Transfer Functions, Euler Basis, Damping Off (Model and Ref. Meas. Comparison Pass/Fail)
- M0, L1, L2 Actuation Range Test using OSEMs (or OpLev if available)
- L3 Actuation Range Test using OpLev

ACCEPTANCE!!

"Top to Top" = M0 to M0 & R0 to R0

Commissioning
In-Chamber, as part of IFO

Goals

- OSEM Spectra of M0, R0 Motion, compare with Phases 2c, 3a, 3b, with BSC-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 BSC-ISI/HEPI in various states (ON/OFF, Damping ON/OFF, Low/High Perf, etc. etc.)
- Calibrated M0 to TST transfer functions, measured by IFO
- Calibrated L1 to UIM, PUM, and TST transfer functions using UIM driver, measured by IFO
- Calibrated L2 to PUM and TST transfer functions using PUM driver, measured by IFO
- Calibrated L3 to TST transfer functions, using ESD driver, measured by IFO
- Calibrated BSC-ISI STG2 to M3 Transfer Functions measured by IFO
- Measure Fiber Violin modes with IFO
- Measure Acoustic Modes with IFO
- Length – to –Angle measurements / decoupling
- Test Mass Charging/Discharging measurements with ESD
- Ring Heater Performance
- Design/Install High performance Damping Filters, performance measured with IFO
- Experiment with Heirarchical Control / Offloading to BSC-ISI
- Experiment with Modal Damping