Prototype Testing
Generalities

- ALL subsystems must perform prototype & final article testing to assure fit, function & performance (to a practical extent).
- Most subsystems will perform prototype testing for design optimization.
- Material or device development tests are of course required (e.g. sapphire absorption, detector characteristics, etc)
- QA tests on components (COC metrology, device testing, etc.) are also required
- Research tests are required for high development risk areas
- Subsystem Testing:
  What are the key component tests needed?
  (tests that may affect a design choice)
  - » Focus here is on prototype testing to resolve design issues which could influence major subsystem design choices, impact other subsystems or effect the system design or requirements trade-offs.

Prototype Testing
Subsystem Testing: PSL

- Prototype laser testing to support a design selection?
  (e.g. MOPA or an injection-locked, unstable resonator, etc.)
  - » Is development risk low enough that design decision is based solely on contractor proposals?
  - » … or is a Contractor “horse race” needed?
  - » … or should the LSC prototype a design approach?
- PSL prototype development
  - » initial prototype (in parallel with LIGO-2 laser development), to prove out basic design -- field test at LASTI
  - » second generation prototype at developer’s institution -- suitable to be fielded as first article
  - » Is in-the-loop measurement of frequency noise sufficient, or is a long suspended analyzer cavity needed? (e.g. 40 m, LASTI, …)

Prototype Testing
Subsystem Testing: IO

- Modulation & Isolation
  - » High power testing to qualify materials/design
- Mode Matching & Input Mode Cleaner
  - » no significant issues
  - » suspensions developed & tested under SUS subsystem
  - » length & alignment controls tested under ISC subsystem

Prototype Testing
Subsystem Testing: SOS

- Prototype & first article testing of any new designs for fit and QA mostly:
  - » Beam dumps, baffles, pick-off mirrors, telescopes
  - » no issues to be resolved via testing
  - » need layout -- may justify larger BSC optics table?
- Output Mode Cleaner
  - » ~~no~~ significant issues
  - » suspensions developed & tested under SUS subsystem
  - » length & alignment controls tested under ISC subsystem? (or not?)

Prototype Testing
Subsystem Testing: SOS

- Adaptive Optics for Thermal Distortion
  - » Can one do a useful test in LASTI?
  - » Should we consider a test in LIGO-1?

Prototype Testing
Subsystem Testing: SUS

- Comments apply to Quad, Triple & Double
- R&D tests: fiber, ribbon, bonding development, thermal noise, electrostatic actuation
- Lab Tests: demonstrate acceptable components, assembly technology (Qs, reliable connections, etc.)
- Full Scale lab demonstrator @ Glasgow
  - » first check of fit & function in air
  - » develop methods & fixtures for assembly, installation & repair

Prototype Testing
Subsystem Testing: SUS

- Initial Prototype test in LASTI
  - » transfer design to LIGO Lab?
  - » prove out design approach; address key technical design issues (damping control, electrostatic actuation, etc.)
  - » demonstrate fit, function, assembly, installation
  - » develop diagnostics
  - » test global control interface
  - » measure cross-couplings, transfer functions, modes, Qs

Prototype Testing
Subsystem Testing : SUS

- Final design test in LASTI
  - » Acceptance Tests: prove out design implementation
  - » demonstrate fit, function, assembly, installation, repair
  - » demonstrate diagnostics
  - » demonstrate global control interface
  - » measure cross-couplings, transfer functions, modes, Qs
  - » set upper bound on isolation performance and thermal noise (a little bit of “heroics”?)

Prototype Testing
Subsystem Testing : SEI

- Lab Demonstrator
  - » demonstrate robust active isolation
  - » measure transfer functions
  - » prove out design approach ; address key technical design issues (sensing/actuator geometry, structural dynamic interaction, cross-coupling, etc.)
  - » explore design trades (sensor selection, structure modifications, …)
- Prototype test in LASTI
  - » full scale
  - » prove out design approach; address key technical design issues
  - » demonstrate fit, function, assembly, installation procedures & tooling
  - » develop diagnostics
  - » test global control interface
  - » measure cross-couplings, transfer functions, modes, Qs

Prototype Testing
Subsystem Testing: SEI

- First Article test in LASTI
  - » Acceptance Tests: prove out design implementation
  - » demonstrate fit, function, assembly, installation, repair
  - » demonstrate diagnostics
  - » demonstrate global control interface
  - » measure cross-couplings, transfer functions, modes, Qs
  - » measure isolation performance in conjunction with SUS

Prototype Testing

Subsystem Testing : DAQ, PEM, COC

- Subsystems which do not require prototype testing
  (to resolve design issues which could influence major subsystem design choices, impact other subsystems or effect the system design or requirements trade-offs)
  - » DAQ?
  - » PEM
  - » COC
    - – requires material testing program (mechanical & optical)
    - – polishing and coating development program
    - – metrology as QA

Prototype Testing
Subsystem Testing: ISC

- Configuration issues:
  - » sensing & control scheme
  - » gw readout option
  - » output mode cleaner
  - » variable recycling mirrors?
- R&D Tests:
  - » Glasgow 10 meter RSE experiment
  - » CIT benchtop RSE experiment (Jim Mason)
  - » UFL benchtop DR experiment
  - » TAMA benchtop experiment
  - » GEO 600 Suspended Interferometer

Prototype Testing
Subsystem Testing : ISC

- Global Controls Engineering Testbed:
  40 meter Suspended Interferometer
  - » Refinement of sensing & control topology
  - » Integrated system test of Electronics
  - » measure noise coupling mechanisms, frequency responses, sensing & actuation matrices
    (verify modeling & extrapolate to LIGO-2)
  - » no “heroics” for displacement noise sensitivity
- Isolation System Controls Interface Testbed:
  LASTI
  - » Integrated test of the SUS and SEI controls with ISC subset
  - » Mode Cleaner length & alignment controls

Prototype Testing
Noise Testing

What noise mechanisms do we want to do testing on, and at what level of sensitivity?

- Defer noise floor testing of final systems to first LIGO-1 interferometer to be upgraded?
  - » … or be “heroic” (or semi-heroic) on one of the suspended interferometers?
- Test Mass thermoelastic noise measurement
  - » Sufficient to have Syracuse's anelastic measurements & the TNI measurements?
  - » ... or do we need a measurement on a suspended interferometer?
- Photo-elastic noise measurement?