Advanced LIGO Risk Registry LIGO-M080359-v28

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Risk Value	Probability
5	Extremely Likely – 90% probability of occurrence over the project life
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Risk Value	Scope Consequence	Cost Consequence	Schedule Consequence	Performance Consequence
5	Unacceptable	> $3M	> 4 mos.	Unacceptable
4	Major overall Consequence	$500K to $3M	2 - 4 mos.	Doesn't meet SRD
3	Some major areas Consequenceed	$250K to $500K	1 - 2 mos.	Doesn't meet SRD in some areas
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RR-001	P. Willems	If Test masses require aggressive thermal compensation for arm mode control, additional cost and schedule delay may occur.	AOS	1	2	3	2	2	Low	N	Purchase of additional Hartmann sensors for permanent installation on test masses completed	1	1	1	1		Low	N	Accept Risk
RR-002	P. Willems	If thermal lensing is both highly inhomogeneous and rapidly varying, then scanning laser compensation is required	AOS	1	2	4	3	2	Low	N	Maintain R&D backup plan for scanning laser compensation	1	2	2	2	2	Low	N	Continue to develop plan; implement R&D backup plan for scanning laser compensation
RR-003	P. Willems	If thermal compensators inject noise into system, power stability for heater and laser will be required.	AOS	3	2	3	2	2	Med	N	Have characterized noise of Ring Heaters and determined them to be well below minimum requirements	2	2	2	2	2	Low	N	Characterize noise of a CO2 laser.
RR-004	P. Willems	If thermal compensator sensors inject noise into system, power stability of sensor lasers will need enhancement.	AOS	1	2	2	3	1	Low	N	Have backup plan to enhance power stability of sensor lasers.	1	2	2	3	1	Low	N	Implement backup plan to enhance power stability of sensor lasers.
RR-005	P. Willems	If thermal compensation sensors inadequately sensitive, performance will be degraded.	AOS	2	2	3	2	1	Med	N	Added to baseline: multiplicity of installed TCS sensors	2	1	1	1	1	Low	R	Risk Retired.
RR-006	M. Smith	If optical spring effect in RSE is ignored in calculating the scattered light noise, then ADLIGO may not meet SRD	AOS	2	1	3	3	2	Med	Y	Models do not indicate a problem	1	1	1	1	1	Low	R	Risk Retired.
RR-007	M. Smith	If the sole-source vendor for expensive, long lead time, off-axis parabolic mirrors is unable to produce the PO telescope mirrors, the cost and schedule would be impacted	AOS	2	3	5	5	5	Med	Y	Risk retired: Stable recycling design eliminated PO mirrors.	0	0	0	0	0	Low	R	Risk retired: Stable recycling design eliminated PO mirrors.
RR-008	D. Shoemaker	Unanticipated scattering or 'ghost beam' path found once system assembled	AOS	2	2	4	2	1	Med	N	eLIGO has improved baffling design/implementation, demonstrated to be successful, and consistent with AdL designs	1	2	4	2	1	Low	N	None.
RR-009	P. Willems	If core optic or coating absorption is too large, the thermal lens at full power will be larger than TCS can compensate, reducing sensitivity or forcing Advanced LIGO to run at lower power.	AOS COC	3	2	3	4	3	High	Y	TCS designed with 2x power margin; higher powers possible with incremental changes. Cleaning procedure sketched out for core optics in place; suspension etc. compatible. Enhanced LIGO TCS tests give experience in AdL approach. More in-spec and near-spec absorption seen in completed optics. See T1300354	1	2	3	4	3	Low	N	None
RR-010	P. Willems	If core optic or coating absorption is too inhomogeneous, thermal microroughness will limit arm power via high power scattering.	AOS COC	3	2	3	4	3	High	Y	Measured absorption on average lower than requirements, and few point scatterers.	1	2	3	4	3	Low	N	None
RR-011	P. Willems	If electrostatic actuator introduces noise through electronic or thermal coupling, will need to re-instate photon drive.	AOS SUS	2	3	4	4	3	Med	Y	Units received and meet requirements; Analysis of dynamic range shows current actuators acceptable for early astrophysics; further refinement will come with more experience with the complete interferometer and its noise performance.	1	2	3	2	1	Low	N	Complete modifications of DAC to ESD interface for whitening; ensure complete set of ESD on hand and tested; extract data from absolute motion from DRMI and complete IFO test to improve estimates for post-project activities

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RR-012	H. Armandula	If specialized coatings vender is lost, then set-up for another vender will add significant schedule and cost to project schedule.	COC	2	3	5	1	2	Med	Y	Contracts let with technically competant vendors.	1	3	4	1	2	Low	N	Maintain discussion with backup vendors in case of difficulties.
RR-013	H. Armandula	If suprasil 311 supplier chooses to optimize market, then costs for ITM mirror blanks could significantly increase.	COC	2	3	2	1	1	Med	N	Substrates in house	1	1	2	1	1	Low	R	Risk Retired
RR-014	C. Wilkinson	If sole-source COC vender is lost, then delays to schedule occur for long lead procurement items and costs are increased.	COC	3	3	5	2	1	High	Y	Most optics delivered, last few in production	1	1	1	1	1	Low	R	Risk Retired
RR-015	G. Billingsley	If the exchange rate for euro or Australian dollar increases by more than 20%, significant cost increases for the majority of COC procurements will occur	COC	5	4	1	1	1	High	N	Contracts in place, optics in production, costs lower than cost book; risk is not retired completely until all effort invoiced	3	1	1	1	1	Low	N	None
RR-016	G. Billingsley	If manufacturers cannot meet radius of curvature tolerances, performance will suffer unless a redesign effort eases requirements	COC	3	2	5	4	2	High	Y	Two vendors have demonstrated ability to reach requirement. Capable vendor selected.	1	1	1	1	1	Low	R	Risk Retired
RR-017	G. Billingsley	If polishing vendor cannot meet overall COC specs, then performance will suffer.	COC	2	4	4	4	1	Med	Y	Vendor selected who has met (and exceeded) requirements in pathfinder process	1	4	4	2	1	Low	R	Risk Retired
RR-018	G. Billingsley	That coating vendor cannot deliver suitable ITM COC optics.	COC	2	4	4	4	1	Med	Y	Installed AR coatings high but workable. Last AR 'milky' coatings very good.	1	4	4	3	1	Low	R	Risk Retired
RR-019	G. Billingsley	If optics damage exceeds spares allowance, then delays to schedule occur for long lead procurement items and costs are increased.	COC, IO	1	2	5	3	1	Med	N	1) Procure and replace in-process spares according to spares plan 2) Implement training for personnel who handle optic components	1	2	1	1	1	Low	N	None
RR-020	A. Lazzarini	If computer space requirements exceed projected space, then facility modifications may be required	DCS	4	4	1	1	1	High	N	Discussions with Caltech indicate will to place computing on campus. XSEDE potential reduces overall infrastructure burden.	1	3	1	1	1	Low	N	Act on outcome of XSEDE/DCS review.
RR-021	G. Billingsley	If sensitivity of optics to particulates is greater than anticipated, additional clean environmental costs required or performance suffers	FMP	2	4	2	3	3	Med	N	Found low power threshold for damage in test setup; limited input power to MC	2	4	4	2	3	Med	N	Continue characterization of damage, and relationship to observed eLIGO/high-power testing
RR-022	C. Wilkinson	If facility staging space is determined insufficient late in the project, then new facilities (or modifications to existing facilities) will be required.	FMP	2	2	3	1	1	Med	Y	FMP complete, all types of installations exercised	1	2	1	1	1	Low	R	Risk Retired
RR-023	C. Wilkinson	If the site facility is not ready for assembly or installation, then installation will be delayed.	FMP	2	1	3	1	1	Med	N	Facility modifications complete in timely fashion	1	1	3	1	1	Low	R	Risk Retired
RR-024	C. Wilkinson	If unplanned facility modifications or vacuum chambers and beam pipes are identified, then significant delays and cost increases to the project could occur.	FMP	2	3	3	1	1	Med	Y	Installation well underway; no new needs identified.	1	3	3	1	1	Low	R	Risk Retired
RR-025	C. Wilkinson	If clean room space is inadequate for assembly needs, schedule delay and or costs will increase.	FMP	2	2	4	1	1	Med	Y	Clean rooms adequate for work undertaken, covers all situations	1	2	2	1	1	Low	R	Risk Retired
RR-026	D. Shoemaker	If BSC vacuum chamber damaged during move from 2km to 4km, then long schedule delay could occur and cost to replace/repair high.	FMP	1	4	5	1	1	Med	N	Both BSC moved successfully	1	1	1	1	1	Low	R	Risk Retired

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RR-027	D. Shoemaker	Redundant with RR-030.																	
RR-028	D. Coyne	That subsystems not ready for deliveries when needed, schedule/cost impacts.	INS	3	4	4	1	3	High	Y	Subsystem deliveries effectively complete, and remaining parts available	1	3	3	1	3	Low	N	
RR-029	D. Coyne	That personnel or machine safety incident occurs during project	Project	3	3	2	1	3	Med	Y	Safety engineering and procedures required and reviewed in the design phase. All personnel undergo safety training. Safety personnel hired and engaged in all project activities. Facility operating plans already include laser and machine safety and personnel training.	1	3	2	1	3	Low	Y	Ongoing.
RR-030	C. Wilkinson	Outgassing contamination to the ultra-high vacuum system.	INS	1	4	5	5	5	Med	N	RGA measurements show ok levels. Pumpdown rate is reasonably fast.	2	2	2	3	3	Med	N	Complete improvement of ring-down tests to provide better limits on acceptable levels.
RR-031	D. Coyne	That excessive particulate contamination to the chambers occurs	INS	4	4	3	5	3	High	Y	Chamber cleaning completed. Particulate monitoring program in place. Revised cleaning and garbing. CC committee active. Significant improvement seen.	1	3	3	3	3	Low	Y	Ongoing; continue with present practice.
RR-032	D. Coyne	key staff loss for the installation tasks, i.e. experts on critical installation procedures/operations such as fiber welding, alignment procedures, etc.	INS	3	3	4	1	2	High	Y	Peak installation level underway and team is adequate.	1	3	4	1	2	Low	N	Continue with training process, aggressively including new staff in procedures.
RR-033	D. Coyne	key staff loss for the integrated test tasks, i.e. experts on subsystem test procedures/operations and especially troubleshooting.	INS	3	3	4	1	2	High	Y	Integrated test in motion at both observatories, and teams are adequate.	1	3	4	1	2	Low	N	Continue with training process, aggressively including new staff in procedures.
RR-034	D. Coyne	Installation steps take longer than expected and/or unforseen install procedures or tooling.	INS	5	4	4	1	2	High	Y	Most things installed once or many times. Installation did take longer than the original plan, but the plan is changed to reflect reality.	1	3	4	0	0	Low	N	continue to monitor rate of progress, adjusting schedule as appropriate.
RR-035	D. Coyne	Interface issues, e.g. physical interfaces problems (subsystem assemblies interfere) or signal interface mis-matches	INS	5	5	5	5	3	High	Y	All components installed at LLO, and they fit and interface.	1	3	3	3	3	Low	N	Continue integration, ensuring that lessons learned are propagated.
RR-036	D. Coyne	If resource/space conflicts occur, esp if delays occur (e.g. clean rooms, cranes, chambers, etc.), then work will be delayed.	INS	5	4	4	1	3	High	Y	Installation complete at LLO, mostly at LHO. Peak needs and stress already managed.	1	3	2	1	3	Low	N	Continue to dynamically allocate staff to optimize the remaining work at LHO

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RR-037	P. Fritschel	If lock acquisition takes longer than expected, delay to project end results.	INS	3	2	5	1	1	High	Y	LLO Locked quickly desipite ALS coating discrepancy. LHO partial locking under control.	3	2	5	1	1	High	Y	Continue with integrated testing.
RR-038	P. Fritschel	If initial alignment error(s) occur, requiring vacuum incursions to achieve alignment, then schedule delays may result	INST	2	1	4	1	1	Med	N	Arms all satisfactory, vertex at LLO and most of vertex at LHO ok	1	1	4	1	1	Low	N	Continue with alignment, carefully.
RR-039	C. Wilkinson	Premature in-vacuum instrumentation failures	INST	2	3	4	2	1	Med	N	Reliability is part of design QA for in-vacuum components. History growing on trouble-free in-vacuum instrumentation.	1	3	4	2	1	Low	N	Continue QA on in-vacuum component reliability
RR-040	D. Coyne	Adaptive telescope design uses CO_2 laser heating to MMT mirrors. Risks are 1) If system technology proves to be overly complex, then other designs may be needed; and 2) If there is insufficent space for	IO	4	1	4	3	3	High	NR	Retired - Alternative design with ring heaters eliminates the CO2 Laser.	0	0	0	0	0	Low	R	Retired - The CO2 Laser is no longer going to be used.
RR-041	P. Fritschel	If faraday rotator does not meet AdvLIGO vacuum requirements, then alternative designs may be required.	IO	3	1	2	1	2	Med	N	eLIGO Faraday Rotator (AdL prototype) met vacuum requirements.	1	1	1	1	1	Low	R	Risk Retired
RR-042	C. Wilkinson	Based on current knowledge of PSL pointing stability, there is no need for active jitter suppression. However, see jitter due to water-induced vibration which must be addressed.	IO-PSL	1	1	4	3	3	Low	N	Completed refit for lower cooling-water-induced vibration. Periscope payload changed for the better.	2	1	1	2	2	Low	N	continue with modifications of periscope etc. to reduce motion
RR-043	D. Coyne	If modulation depths (all TBD) don't support final modulation scheme, then significant consequence to schedule, performance, and scope will ensue.	IO	1	2	4	4	5	Med	NR	Risk Retired	0	0	0	0	0	Low	R	Risk Retired
RR-044	C. Wilkinson	If sole-source vender is lost, then delays to schedule occur for long lead procurement items and costs are increased.	Project	2	2	4	3	1	Med	N	have visited, and put into place future plans, for close in-situ oversight of LMA	1	2	2	2	1	Low	N	follow through with close LMA oversight.
RR-045	C. Wilkinson	If the exchange rate for euro or Australian dollar increases by more than 20%, significant cost increases for instruments and other non-optical components will occur.	COC	2	2	1	1	1	Low	N	Accept risk. Remains until all effort invoiced.	2	2	1	1	1	Low	N	Accept risk.
RR-046	C. Wilkinson	If NSF funding does not arrive as planned, then significant schedule delays and cost increases will be incurred.	Project	2	2	4	-	3	Med	N	All funding received, thank you.	1	1	3	-	2	Low	R	Risk Retired
RR-047	C. Wilkinson	If damage to optical components occurs (due to misalignments and exposure of high power density lasers), then schedule delays will result.	Project	4	3	3	2	2	High	N	Procured spares for optical components which could be damaged.Baffles designed to catch beams. High-power testing in Mode Cleaner (most intense beams) successful. However, limiting power input to MC	1	3	2	1	1	Low	N	Accept risk.
RR-048	D. Reitze	If choice of recycling cavity architecture (stable vs. unstable) negatively affects design of mode matching telescope, layouts, payloads, sensing and control, then significant Consequences to the project will ensue.	Project	3	1	3	4	4	High	Y	Risk retired: Stable recycling cavities chosen by TRB. Layout fits and costs are lower.	0	0	0	0	0	Low	R	Risk Retired

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RR-049	C. Wilkinson	If taxes and import duties are higher than expected for CA, WA, LA, and MA purchases/installed equipment and foreign materials, then cost will increase.	Project	2	4	1	1	1	Med	N	Most equipment received.	1	3	1	1	1	Low	R	Risk Retired
RR-050	D. Shoemaker	Redundant with RR-056																R	
RR-051	D. Shoemaker	If Observatory is damaged (e.g., hurricane, earthquake, vacuum failure), significant unplanned costs, schedule, and performance impacts will ensue	Project	1	4	5	4	1	Med	N		1	4	5	4	1	Med	N	Accept risk.
RR-052	P. Fritschel	If cabling problems occur (e.g., mis-wiring, failures), then significnat rework will be required.	Project	4	1	3	3		High	Y	Cables now all installed.	1	1	3	3	1	Low	N	Continue testing on cabling in install
RR-053	P. Fritschel	If Connectors don't function properly (i.e., contacts aren't made), then re-work to fix will be required.	Project	4	1	2	3	1	High	Y	Most stuff works reliably.	2	1	2	3	1	Med	N	Continue with tightening and wiggling cables to identify problems.
RR-054	P. Fritschel	If parts get lost at a site (before installation), time and money will be wasted to find and/or re-order.	Project	4	2	3	1	1	High	Y	Inventory effectively complete. BarCode system for 3rd interferometer in place.	1	1	1	1	1	Low	N	Vigilance.
RR-055	P. Fritschel	If foreign funding is lost or delayed, then schedule delays and cost increases will be incurred.	PSL	1	5	3	-	4	Med	N	All equipment received.	1	3	3	-	4	Low	R	Risk Retired
RR-056	P. King	If pre-stabilized lasers are limited to operating at less than 200W, then final sensitivity and performance will be lowered.	PSL	3	-	1	4	2	High	Y	After fabrication and testing of the 3 lasers, each demonstrating the 200 W output power requirement, this risk event is now highly unlikely.	1	-	1	3	2	Low	R	Risk retired.
RR-057	P. King	If pump diode manufacturer goes out of business or discontinues the current pump diode model, then there may be consequences	PSL	3	1	3	1	1	Med	N	The design involving coupling the pump power to the laser rods via optical fibres does not depend on the particular hardware interface used by the pump diode manufacturer.	2	-	-	-	-	Low	N	Investitgating second sources.
RR-058	P. King	If key staff leave Laser Zentrum Hannover, then there will be a lack of vital knowledge.	PSL	3	-	5	1	1	High	Y	Training sessions for LIGO personnel included in plan. 35 W front ends installed, in use by many LIGO staff. AEI staff also a repository of experience now.	2	-	2	1	1	Low	R	Risk retired. We have enough communal knowledge about the 200 W laser.
RR-059	P. King	If damage occurs to a laser component (either the laser rods, pump beam homogenizers, pump fibers or laser mirrors), then negative Consequences to the project will ensue.	PSL	4	2	3	2	1	High	N	Keep sufficient numbers of spare components on hand, especially those most prone to damage. Design of laser rooms consistent with needs identified by AEI/LZH.	1	2	1	-	-	Low	N	None
RR-060	P. King	If beam and mode quality do not meet requirements, then modifications to system may be required.	PSL	2	1	2	1	1	Low	N	The use of a spatial filter cavity reduces the likelihood of this event. LLO measured to be satisfactory.	1	1	-	1	-	Low	R	Risk retired.
RR-061	P. King	If cooling water for the pump diodes fails, then negative project Consequences ensue.	PSL	2	2	2	1	1	Low	N	Install temperature sensors and monitoring to automatically shutdown the laser if the temperature gets too high.	1	1	1	1	-	Low	N	Accept risk.
RR-062	P. King	If facility electrical power fails, then damage will occur due to improper shutdown or mains glitches.	PSL	3	2	2	1	1	Med	N	UPS on computing equipment; Laser survived many power outages at LLO	2	2	2	1	-	Low	R	Risk retired.

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RR-063	P. King	If project cannot transport the required pump power over the proposed distances (100 m) by optical fibers, then negative project Consequences ensue.	PSL	3	2	2	2	1	Med	N	Extensive prototyping at LZH indicates chosen fibers can carry power.	1	2	2	2	1	Low	R	Risk retired.
RR-064	P. King	If staff from LZH or MPG encounter visa problems to enter the US, then negative project Consequences ensue.	PSL	3	2	4	-	2	High	Y	Frequent travel by LZH and MPG staff without difficulties.	1	2	4	-	2	Low	R	Risk retired.
RR-065	P. King	If pre-modecleaner cannot handle the high power for long periods of time, then negative project Consequences ensue.	PSL	4	1	2	2	1	Med	N	Keep sufficient numbers of spares on hand. Spares in plan.	1	2	1	1	-	Low	N	Accept risk.
RR-066	P. King	If frequency noise does not meet the design specification.	IO-PSL	2	1	2	3	1	Med	N	Cooling water path changed to reduce excitation.	3	1	1	1	-	Low	N	IO to address periscope and optic mount resonances, then re-measure
RR-067	P. King	If intensity noise does not meet the design specification, then specification will not be met.	PSL	5	1	4	3	1	High	N	Intensity noise demonstrated to very nearly meet requirements in stand-alone experiment. Errors in initial implementation identified, and plans in place to rectify. LLO noise well below shot noise	1	1	2	2	-	Low	N	Correct matching into in-vac ISS array. Debug electronics. Demonstrate as-installed acceptable performance.
RR-068	P. King	If the high power photodetector is damaged, significant rework and repairs will be required.	PSL	4	1	3	2	1	High	N	Keep sufficient numbers of spares on hand. Spares included in plan.	1	1	1	1	-	Low	N	Accept risk.
RR-069	P. King	If the high power photodetector fails vacuum qualification, then performance of the system will be reduced.	PSL	3	1	2	-	1	Med	N	Risk Retired: No electronics in vacuum.	0	0	0	0	0	Low	R	Risk retired.
RR-070	P. King	If mix up occurs over metric or imperial units, then parts will not interface and significant rework will be required.	PSL	1	1	1	-	1	Low	N	Equipment built; no problem found.	1	1	1	-	-	Low	R	Risk retired.
RR-071	P. King	If the reference cavity is contaminated during assembly into its vacuum chamber, then reassembly will be required.	PSL	2	1	1	2	1	Low	N	Activity completed without incident.	1	1	1	-	-	Low	R	Risk retired.
RR-072	P. King	If the pre-modecleaner is contaminated during use then reinstallation will be required.	PSL	2	1	1	2	1	Low	N	Add schedule contingency to plan. Keep sufficient assembly instructions and handling procedures.	1	1	1	-	-	Low	N	Continue to monitor absorption.
RR-073	P. King	If pump diode optical fibres get damaged after installation, spares will be required.	PSL	2	2	2	2	1	Low	N	Fibres installed in a protective conduit	1	1	1	-	-	Low	N	Accept risk.
RR-074	P. King	If Incompatibility of laser controls arises due to differences in mains frequencies, I & C modifications may be required.	PSL	1	1	2	-	1	Low	N	Equipment installed and powered up.	0	0	0	-	0	Low	R	Risk retired.
RR-075	P. King	If laser safety related incident, as opposed to an injury, occurs, then significant delay and cost increases will occur.	PSL	4	1	1	-	1	Low	N	SOP, extended use of 35 W laser and use of 200 W laser without incident	4	1	1	-	1	Low	N	Ensure proper training and procedures are maintained and reinforced.
RR-076	P. King	If items are either lost or damaged during shipping, then negative Consequences to the project will ensue.	PM	2	3	3	-	1	Med	N	Shipping largely completed; only some COC and some SEI to go.	1	1	1	-	1	Low	N	None
RR-077	K. Mason	If Sercel L-4C Geophones failure rate increases, new design may be required.	SEI	3	2	3	3	2	Med	N	All L4-C units have been received and appear to be robust.	1	1	1	1	1	Low	N	Risk is low.
RR-078	K. Mason	If Hydraulic actuator assembly problems occur, then redesign and/or rework will be required.	SEI	2	3	3	2	2	Med	N	Assembly and testing complete with no major problems.	1	2	2	2	2	Low	R	Risk retired.

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Last Reviewed/Updated: 2015-01-23

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Risk Value	Scope Consequence	Cost Consequence	Schedule Consequence	Performance Consequence
5	Unacceptable	> $3M	> 4 mos.	Unacceptable
4	Major overall Consequence	$500K to $3M	2 - 4 mos.	Doesn't meet SRD
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RR-079	K. Mason	If Parker sevo valves become unavailable or fail during bench testing, then alternative design may be required.	SEI	3	3	4	3	2	High	N	25% spares ordered with only a couple failing in incoming inspection.	2	1	2	1	1	Low	N	Still possibility of failures during 1st two months of operation. Accept risk.
RR-080	K. Mason	If Hydraulic plumbing leak occurs, then repairs will be required.	SEI	2	1	2	1	1	Low	N	Design in plenty of valves and purge plugs to isolate any potential leak	1	1	2	1	1	Low	N	Thoroughly leak check manifolds and tubing before adding fluid.
RR-081	K. Mason	If Steckheisen STS-2 seismometers are discontinued, then replacements may be required (STS-3); that may cause interface problems.	SEI	4	2	3	1	1	High	Y	Nanometrics Trillium selected for baseline, all received. No interface difficulties.	1	2	3	1	1	Low	R	Risk retired.
RR-082	K. Mason	If Pod assemblies leak and require replacement, costs will be increased.	SEI	3	2	3	1	1	Med	N	Production run to date, including installation, demonstrates success to date	1	2	1	1	1	Low	N	Accept risk.
RR-085	D. Shoemaker	If BSC isolation does not meet requirements (e.g., excess LF noise from tilt-horizontal coupling, or subspecification performance of sensors, additional R&D or lowered performance may result.	SEI	3	5	5	3	2	High	Y	Satisfactory performance in GW band achieved. Tuning of ISI to address specific problems in integrated test demonstrated.	1	4	3	3	2	Low	N	Keep R&D going on suppressing chamber modes, feedforward, tilt sensors. Focus on horizontal-tilt coupling.
RR-086	D. Shoemaker	If HAM isolation does not meet requirements, then additional R&D or lowered performance may result.	SEI	3	5	5	3	2	High	Y	In-situ integrated testing show that the platform peforms well and is flexible through controls programming.	1	4	4	3	2	Low	N	Continue working on low-frequency sensor-induced motion.
RR-087	P. Fritschel	If HAM1 (ISC chamber) needs seismic isolation beyond commercial components, then additional costs and schedule delay could occur.	SEI	2	4	4	1	1	Med	N	Decision to use HEPI. Costs appear to be affordable. Isolation appears to be sufficient via modeling.	1	3	3	1	1	Low	N	Accept risk.
RR-088	C. Wilkinson	If GS-13 instrument vender is lost, then delays to schedule occur for long lead procurement items and costs are increased.	SEI	2	2	4	2	-	Med	N	All GS-13 seismometers received with 20% spares.	1	2	4	2	-	Low	R	Risk retired.
RR-089	C. Wilkinson	If foreign funding is lost or delayed, then schedule delays and cost increases will be incurred.	SUS	1	5	3	-	4	Med	N	Non-US SUS work completed.	1	1	3	-	3	Low	R	Risk Retired.
RR-090	C. Wilkinson	If suspension fibers and attachments do not meet requirements (breakage, noise, damping issues, etc), alternatives may be required and/or performance reduced.	SUS	3	3	4	2	1	High	Y	Succcessful fabrication and installation of complete suspension. Initial characterization consistent with requirements; suspension fiber Q measurements fit model.	1	3	4	4	1	Low	N	Further information requires low-noise complete interferometer sensitivity.
RR-091	J. Romie	If the quad osem requirements change, then redesign/rework/refab may be necessary to match most recent requirement.	SUS	2	3	4			Med	N	Testing development and damping loop design with present performance meets all current understanding of requirements.	2	2	2	-	-	Low	N	Accept risk.
RR-092	J. Romie	If requirements regarding front-end electronics (delivered from UK) change after delivery, then redesign and rework will be required.	SUS	3	2	4	2		High	Y	All front-end designs except ESD complete and tested to be satisfactory after minor rework.	2	1	2	-	-	Low	N	Understand frequent ESD shutdowns, and make modifications as needed
RR-093	C. Wilkinson	If vendor is lost, then delays to schedule occur for long lead procurement items and costs are increased.	Project	2	2	4	2	1	Med	N	Add schedule and cost contingency to plan.	1	2	1	1	1	Low	N	Accept risk.
RR-094	C. Wilkinson	If subsystem personnel need to be supported due to gap between subsystem finish and install start, then labor costs will increase.	Project	3	4	1	1	1	High	N	Include contingency in project risk calculation; deliveries keeping up with installation	2	2	1	1	1	Low	N	Let contractors go early and backfill with LIGO personnel on continuing tasks.
RR-095	D.Coyne	Viewport Failure	FMP	2	4	2	1	4	Med	N	TRB/VRB review resulted in improved protocols & procedures. TCS viewport evaluated and risk retired. 100% testing.	1	4	2	1	4	Low	N	Accept risk.
RR-096	D. Coyne	Parametric Instability	SYS	2	4	4	3	1	Med	N	Have observed in LLO, and addressed with heating of TM.	2	4	4	3	1	Med	N	Complete trade studies & experiments

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RR-097	D. Coyne	Risk that Electrostatic Charge Noise is unacceptable	SYS	2	3	3	3	0	Med	N	Design of in-vac charge completed and out for procurement. Tests on discharging done. Research into charging sources (ion pumps) done.	4	3	3	3	0	High	Y	Complete the instalation of the Weiss In-vacuum discharge system. Pursue alternative pumps. Shield Ion Pumps.
RR-098	D. Reitze	Contamination on the PSL injection viewport may lead to absorption, runaway heating, and damage/implosion to the viewport window	IO	1	5	5	5	5	Med	N	The PSL beam path injection into the vacuum system has been designed to go through a double viewport system. A failure of the injection viewport would vent HAM1(7), but not the main vacuum.	1	1	3	1	2	Low	N	Accept risk.
RR-099	B. Lantz	Lockers are weak point in reliability	SEI	3	1	3	0	0	Med	N	Trillium substituted for STS-2: eliminates one locker. More robust flexures adopted for GS-13, eliminates other locker.	1	1	3	1	1	Low	R	Risk retired.
RR-100	B. Lantz	Wandering plant resonances in combined SEI-SUS system limiting performance in SEI	SEI	3	1	4	3	3	High	Y	Resonances determined to be in counterbalance masses. Re-designing masses and attachments.	1	1	3	3	3	Low	R	Risk retired.
RR-101	Romie/ Robertson	UK schedule delayed	SUS	1	5	3	-	4	Med	N	UK fab work completed.	1	2	4	1	3	Low	R	Risk Retired
RR-102	Romie/ Robertson	Potential shortage of engineering and skilled touchlabor skills -- solidworks drafters; Conflict with S6 run operators being unavailable	SUS	3	2	2	1	1	Med	N	Additional Labor is in place, can retain for longer if needed	1	2	1	1	1	Low	R	Risk Retired
RR-103	Romie/ Robertson	OSEMs are complicated to make; cost or schedule overruns, difficult to find vendors	SUS	2	3	2	1	1	Med	N	All engineering complete. Production underway.	1	1	2	1	1	Low	R	Risk Retired.
RR-104	Romie/ Robertson	Blade procurement: difficulty in identifying vendor, fabrication process	SUS	2	3	2	1	1	Med	N	Blade material has been ordered for all US suspensions, processes established, vendors qualified	1	2	3	1	2	Low	R	Risk retired.
RR-105	Romie/ Robertson	Blade nickel plating: looking for vendor, suitable process	SUS	2	2	2	1	1	Low	N	Prototyping complete, vendor identified	1	1	1	1	1	Low	R	Risk retired.
RR-106	Romie/ Robertson	Quad Structure and welding: Vacuum, structural requirements cannot be simultaneously met	SUS	1	3	3	3	1	Low	N	Structures meet first resonance requirements. Vibration Absorbers have been developed and integrated for damping. Extra stiffening which improves coupling to vibration absorbers has been added to BS/FM structures	1	3	3	3	1	Low	R	Risk retired.
RR-107	Romie/ Robertson	OSEMS: reliability, handling issues	SUS	1	2	2	1	1	Low	N	Extensive burning in of OSEMS, use in prototypes; good statistics to date. Tools are in place for sys-id	1	2	2	1	1	Low	N	Work on this will continue as the commissioning proceeds
RR-108	P. Fritschel	Risk lost time during installation and commissioning if real-time CDS controls and DAQ systems not operating robustly	INS	3	3	3	0	3	Med	N	Configuration control implemented Code review done, recommendations in action. System operating. ER6 successful	1	3	3	0	3	Low	N	None.
RR-109	S. Anderson	Risk that campus administrations choose to remove support for on-campus computing clusters in out-years	DCS	3	2	0	0	0	Med	N	MIT cluster center coming on line well before need. Caltech firmed campus plans.	1	4	1	1	3	Low	R	Risk retired.
RR-110	D. Reitze	May learn from E-LIGO commissioning that the tri-mod EOM phase and amplitude noise performance (eg, piezo-electric resonances) is unsatisfactory	IO	2	1	3	3	2	Med	N	No evidence of problems of this nature in eLIGO. Will continue to monitor.	1	1	3	1	2	Low	N	Investigate passive damping through impedance matched electrodes.

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RR-111	D. Reitze	Tight polishing tolerance of the stable recycling cavity mirrors. Space constraints on the layout of the IO in the folded interferometer coupled with manufacture tolerance limits in PR mirrors radii of curvature could lead to delays in installation or possible modifications or additions to the HAM ISI	IO	3	1	4	3	5	High	Y	Layout established that does not stress SEI; installed, tested, works.	1	2	4	2	3	Low	R	Risk retired.
RR-112	D. Shoemaker	Find that the drawings that the project was working off of for the HAM and BSC vacuum envelopes do not reflect the as-built conditions	Project	1	4	4	0	3	Low	N	Designs leave margin to accommodate as-built differences. eLIGO instantiation of SEI and SUS and ISC elements fit. Have lived through several cases of mismatch.	1	4	4	3	3	Low	N	Accept risk.
RR-113	B. Willke	If cooling water of laser crystals get contaminated the laser performance might degrade. Cooling tubes and Xtals have to be replaced.	PSL	2	2	2	-	1	Low	N	Many hours of use without problems.	1	1	1	1	1	Low	N	Continue to monitor cooling water quality
RR-114	B. Willke	If laser pump fibers or cooling tubes get damaged during refurbishment or movement of HAM1 they need to be renewed.	PSL	1	2	2	-	1	Low	N		1	1	1	1	1	Low	R	Risk retired.
RR-115	C. Wilkinson	If procurement process is not sped up, project will not meet critical milestones	PM	3	4	5		3	High	Y	New procurement staff hired. More experience has led to faster processing. Procurement phase drawing to a close.	1	4	4		3	Low	R	Risk retired.
RR-116	N. Robertson	If the UK are unable to deliver all of their electronics due to their tight funding schedule, then schedule delays and cost increases will be incurred by the US.	SUS	3	2	4	2	1	High	Y	Production complete.	1	2	4	2	1	Low	R	Risk retired.
RR-117	D. Shoemaker	Premature or frequent in-vacuum instrumentation installation or lifetime failure may impact instrument availability during commissioning or operation	SYS	3	4	4	4	1	High	Y	In-house electronics guidance for high-reliability parts established and used in design of in-vacuum parts. eLIGO shows no in-vacuum instrumentation failures. Simplification of in-vacuum instrumentation.	1	4	4	4	1	Low	N	Accept risk.
RR-118	D. Carter	Delays in completion of designs could delay the Project schedule to the point that the NSF contract dates would be missed.	PM	3	3	4		3	High	Y	Design phase completed.	1	3	4		3	Low	R	Risk Retired.
RR-119	D. Shoemaker	Optic table motion excites suspension cages leading to modulation of wide-angle scattered light and thus to excess noise	SYS	2	3	3	3	3	Med	N		2	3	3	3	3	Med	N	Once instrument locked, perform tests to characterize scattered light, and proceed from there if needed.
RR-120	D. Shoemaker	Decommissioning may require more time and other resources if 'clean' removal is needed	SYS	3	3	3	1	2	Med	N	Initial LIGO Decommissioned.	1	2	2	1	2	Low	R	Risk Retired.
RR-121	P. King	If the cleanliness of the Laser Area Enclosure is insufficient then contamination of, or damage to, the PSL's optical components will occur.	PSL	3	2	2	2	2	Med	N	PSLs have now run for months without indication that the rooms are insufficient.	1	3	1	1	2	Low	R	Risk Retired

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RR-122	N. Robertson	Noise performance of test mass suspensions may be compromised by increased gas damping due to small gap between test mass and reaction mass	SYS	3	5	2	3	2	High	Y	Calculations and measurements complete. Several feasible conceptual designs for pumping mitigation sketched out. Costs of pumping added to potential calls on contingency. TRB concluded with firm plan to thin CPs and add increased space between ETMs and their RMs, the latter post-Project.	1	3	2	3	2	Low	N	Detailed design of TEM RM geometry Modification of Test Mass reaction chain for reduced mass of the Compensation Plate.
RR-123	D. Reitze	TCS and ISC requirements for multi-wavelength design of SR2 and PR2 mirror coatings may require development work by coating vendors which could impact the schedule.	SYS	3	2	3	2	3	Med	Y	Simplification of design by TCS to eliminate need for tri-chroic performance on small PRMs	1	2	2	2	1	Low	R	Risk Retired
RR-124	C. Wilkinson	The cleaning and baking of vacuum parts may be underscoped or susceptible to breakdown	FMP	3	4	3	1	1	High	Y	Only 3rd ifo parts remain in production clean/bake, and negligible amount there.	1	2	2	1	1	Low	N	Risk Retired
RR-125	D. Reitze	Polishing contractor for IO and COC has problems in the fabrication of IO and COC substrates; delay is the net impact	COC/IO	5	3	3	4	4	High	Y	Careful quality assurance monitoring of contractor (telecons, visits). Many optics received, and accepted.	1	3	3	1	1	Low	R	Risk Retired
RR-126	G. Billingsley	Metrology optics may be delivered late	COC	5	3	1	1	2	High	Y	Metrology system delivered.	1	3	1	1	2	Low	R	Risk Retired
RR-127	S. Anderson	Risk that total data rate is considerably greater than cost book estimates, requiring larger data archives	DCS	4	2	1	1	1	Med	N	First cut channel count made, net rate compatible with data processing and storage design. Stable numbers over time.	1	2	1	1	1	Low	N	Risk Retired.
RR-128	K. Mailand	If the current vendor for the TMS telescope off Axis Parabolas fails to produce a correct set of optics we will have to rework or acquire them from an alt. vendor.	AOS	2	1	4	4	3	Med	N	Mirrors received and satisfactory.	1	1	4	4	3	Low	R	Risk Retired
RR-129	K. Mason	If we are unable to detect welds or other hidden defects in internal machined parts we risk contaminating the vacuum system.	SEI	4	5	4	4	3	High	Y	Rejected suspect parts. Intensive QA of materials and processes across the project implemented.	1	1	3	3	3	Low	N	Risk Retired.
RR-130	M. Jacobson	If the Hartmann Sensor probe beam cannot be made effectively incoherent and cross-sampling between ITMs is not linearizable, then HWS performance will suffer.	AOS	3	2	2	3	3	Med	N	Modeled and measured in bench-top systems to scope problem and devise more robust solution. Characterized as-installed system on OAT, ok.	1	2	2	3	3	Low	R	Risk Retired.
RR-131	M. Jacobson	If new Hartmann Sensor R&D activities do not yield timely conclusions,in support of the nominal plan to procure Dalsa 1M60 cameras, then our collaborators in Adelaide will not be able to commit ~$500k this fiscal year (for that procurement activity) and those costs will return to aLIGO	AOS	3	3	2	3	3	Med	N	Completed evaluation of wavelengths and cameras; suitable solutions found. Adelaide procured all required and desired equipment.	1	3	2	3	3	Low	R	Risk Retired
RR-132	C. Wilkinson	Removed equipment requires unexpected rework due to damage or incompatibility of design	SYS	3	2	3	3	3	Med	N	Activity completed without incident.	1	2	3	3	3	Low	R	Risk Retired.

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RR-133	C. Wilkinson	Risk that pre-full-lock testing of any of the integrated systems takes longer than planned, either because we haven't defined a crisp, measurable end or because of too many gremlins	INS	3	3	3	3	3	Med	N	All integrated test to date performed on time, and full process moving forward well. Some Gremlins in H1	3	2	2	3	3	Med	N	Carry through with testing on H1
RR-134	B. O'reilly	- Risk of damage to vacuum flanges, bellows, or envelope during de-install, rearrangement of the vacuum envelope and removal /installation of new input/output tubes.	INS	3	4	5	5	4	High	Y	Completed installation with no damage	1	4	1	1	4	Low	R	Risk Retired.
RR-135	B. O'reilly	- Chamber cleaning procedure does not work as expected and contaminant levels increase rather than decrease.	INS	2	3	5	3	3	Med	N	Production cleaning nearing completion; FTIR indicate success in cleaning, and RGA test confirms on BSC	1	3	1	3	3	Low	R	Risk Retired.
RR-136	B. O'reilly	That there are Intermittent electronic problems with an installed component, sensors, actuators, cables etc.	INS	3	3	3	3	3	Med	N	Some initial problems found and repaired; see improving reliabilty, good enough to retire	1	3	3	3	3	Low	R	Risk Retired
RR-137	C. Wilkinson	risk that utilities will not be adequate to the job, due to poor estimation of needs - (HVAC, local chillers, electrical power, etc.)	FMP	2	4	2	3	4	Med	N	Increased capacity for a number of systems completed. Critical systems tested.	1	4	2	3	4	Low	R	Risk Retired.
RR-138	B. O'Reilly	Risk of electrical or magnetic cross-coupling between systems in the vacuum	DAQ	3	3	3	3	3	Med	N	Tests in LASTI of complete suspensions and seismic isolation systems. Mu-metal shields added to seismometers.	2	3	3	3	3	Med	N	Include cross-coupling tests in early integration testing
RR-139	D. Shoemaker	Late delivery of the vacuum modifications could impede general progress	FMP	3	2	3	1	4	High	Y	All parts received, installed, leak checked. Ok.	1	2	3	1	4	Low	R	Risk Retired.
RR-140	N. Robertson	Cross-coupling in suspension modes could lead to difficulty in control and delays in integration	SUS	3	2	3	1	3	Med	N	Testing to date shows manageable cross-coupling for control purposes	1	2	3	1	3	Low	N	Risk Retired.
RR-141	D. Reitze	FEA shows that the IO REFL parking beam dump will heat HAM ISI table to temperatures well in excess of safe operating temperatures when illuminated at full power	IO/SEI	5	1	3	5	4	High	Y	The parking REFL beam dump has been moved outside the vacuum	1	1	3	1	1	Low	R	Risk Retired.
RR-142	D. Reitze	Delay in procurement of reference spheres for recycling mirror metrology may delay of measurements of ROC needed for installation	IO	4	1	3	2	2	High	Y	Delivered and in use.	1	1	1	2	3	Low	R	Risk Retired.
RR-143	D. Reitze	Delays in HSTS fabrication and test may delay HSTS assembly and installation	SUS/IO	5	1	4	1	3	High	Y	Have all structures in house.	1	1	4	1	3	Low	R	Risk Retired.
RR-144	D. Shoemaker	Chamber cleaning introduces other contamination	FMP	3	4	4	3	5	High	Y	Completed cleaning. Remaining contamination from other sources.	1	4	1	3	1	Low	N	Risk Retired.
RR-145	D. Shoemaker	Over-extended staff results in setbacks for Project and people	SYS	3	4	4	3	5	High	Y	Many persons added through contingency use; schedules adjusted.	2	3	3	1	5	Med	N	Use of cost contingency and social engineering to push to the finish, using staff from all four Lab sites
RR-146	N. Robertson	Lessons learned from initial quad assemblies has led to a review of potential re-work. Outcome of review may have consequences for schedule and cost which are still being assessed	SUS	5	2	3	3	3	High	Y	A collection of small changes have been made. Quads in use in One-Arm test and HIFO; issues addressed with these fixes resolved.	1	2	3	3	3	Low	R	Risk Retired.

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Risk Value	Scope Consequence	Cost Consequence	Schedule Consequence	Performance Consequence
5	Unacceptable	> $3M	> 4 mos.	Unacceptable
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Risk ID	Risk Contri-butor	Risk Event	Affected System or WBS Level	Prob-ability	Consequence				Risk Score	Major Threat List	Completed Mitigation Actions	Prob-ability	Consequence				Resi-dual Risk Score	Major Threat List	Open Mitigation Actions
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RR-147	N. Robertson	Discussions with ISC group has highlighted the need for more sys-id on quad assemblies, may have schedule impact	SUS/ISC	5	2	3	3	3	High	Y	Test results from DRMI, 4km arms indicate a workable system.	1	2	2	3	3	Low	N	Risk Retired.
RR-148	R. Bork	Number of EPICs channels may exceed the ability of the current system, requiring additional hardware and some software development. Guess ~300k channels.	DAQ	3	2	2	2	3	Med	N	High rates demonstrated with success.	1	2	2	3	3	Low	N	Risk Retired.
RR-149	N. Robertson	Blades rusting between receipt from the first vendor and processing by the Ni plating vendor	SUS	5	2	3	1	2	High	N	All parts received.	1	2	3	1	2	Low	R	Risk Retired.
RR-150	D. Reitze	Delays in procuring SiC for the IO baffle material may impact installation schedule	IOO	3	2	3	2	3	Med	N	All SiC procured.	1	2	2	2	2	Low	R	Risk Retired.
RR-151	D. Shoemaker	LIGO-India could delay H1 or incurr costs due to a technical complication	SYS	2	3	3	1	3	Med	N	Storate activities laid out and placed in the schedule. Equipment costed.	1	2	2	2	2	Low	R	Risk Retired.
RR-152	D. Shoemaker	LIGO-India could delay the project through distraction of technical staff	PM	3	3	3	1	3	Med	N	Clear guidance from Leader and PI to prioritize aLIGO-US and obtain prior permission to spend time on LIGO-India. Instructions to clear requests with Whitcomb and Shoemaker.	1	2	2	2	2	Low	N	Continued vigilence.
RR-153	D. Shoemaker	LIGO-India could delay the project through lack of proper communication to technical staff	PM	3	3	3	1	3	Med	N	Monday meetings used to regularly update; examples used to help train the staff intuition. Scope limited to storage.	1	2	2	2	2	Low	R	Risk Retired.
RR-154	D. Shoemaker	LIGO-India could lead to 'color of money' difficulties	PM	3	2	3	2	3	Med	N	Technical and Procurement staff deeply involved in planning and fist-cut costing. Interface well defined and simple.	1	3	2	1	2	Low	R	Risk Retired
RR-155	D. Shoemaker	Integrated testing reveals weakness in subsystem/system design	SYS	3	4	4	3	5	High	Y	LLO success shows this is not a near term problem	1	1	1	3	1	Low	N	Continue with the program.
RR-156	D. Shoemaker	LIGO-India change in plan requires later installation of H2 in integration period	SYS	3	4	4	3	4	High	Y	NSF Direction is to store H2.	1	4	4	1	4	Low	R	Risk Retired.
RR-157	D. Shoemaker	LIGO-India training program distracts from US Installation	SYS	3	3	3	3	3	Med	N	Removed from Project scope.	1	2	2	1	1	Low	R	Risk Retired.
RR-158	D. Shoemaker	LIGO-India planned activities in conflict with US installation due to US technical difficulty	SYS	3	3	3	1	3	Med	N	LIGO-India tasks moved after H1 tasks. Priority correctly set for LHO/LLO detectors. Program well underway.	1	3	3	1	2	Low	R	Risk Retired

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RR-159	D. Shoemaker	That Beam Tube Leak at LLO interrupts aLIGO	SYS	3	3	4	1	3	High	Y	Expert evaluation of leak done by Ops. Repair undertaken, successfully.	1	3	3	1	2	Low	N	None
RR-160	D. Shoemaker	Magnetic coupling in quad suspension leads to the need for rework of the suspensions	SUS	3	3	3	1	3	Med	Y	Determined that the coupling observed is not in the seismic isolation system or an active component, or ECD magnets. Installed slit OSEM holders. Each better measurment indicates smaller coupling.	1	3	3	1	2	Low	N	Measurements on an end station with full interferometer in place.
RR-161	D. Shoemaker	Layout inconsistent with subsystem plans	SYS	3	3	3	1	3	Med	Y	Addressed the issue of compensation plate handedness, and misplaced BS.. Established review committee and chair for Layout review. Everything now installed at LLO, looks ok	1	3	3	1	2	Low	N	Complete LHO installation, continue to check for beam interference and scatter.
RR-162	B. Levine	That Pilot End Test Mass neeed for Installation at LHO	COC	4	2	3	3	3	High	Y	TMs suitably coated for at least Pilot if not final use.	1	1	1	1	1	Low	R	Risk Retired.
RR-163	D. Shoemaker	That Repolish and recoat End Test Masses needed	COC	3	4	3	3	3	High	Y	H1 and L1 coatings complete and probably acceptable. QA imposed on coating vendor	1	4	3	3	3	Low	N	Complete 3rd interferometer coatings
RR-164	Guido Mueller	That beam pointing jitter between PSL table and IMC is larger than expected	IO	4	2	2	3	3	High	Y	Levels of jitter meet requirements at most frequencies, with further mitigation already implemented.	2	2	2	3	3	Med	N	Propagate solutions from LLO to LHO; iron out remaining excess at acoustic frequencies.
RR-165	Guido Mueller	If fluctuations in modulation index generate RIN in carrier field beyond the 2e-9/rtHz requirement at 10Hz.	IO	2	2	2	2	2	Low	N	None	2	2	2	2	2	Low	N	Characterize Radiation pressure noise at low frequencies when IFO reaches sufficient sensitivity below ~30Hz.
RR-166	Guido Mueller	Problems (vacuum compatibility, beam distortion) with the optical elements used to maintain mode matching between IMC and Core interferometer. Potential issue at high laser powers or if static ROCs are off.	IO	2	2	2	2	2	Low	N	Matching of red in HIFO acceptable.	2	2	2	2	2	Low	N	Test in each HIFO, and full lock.
RR-167	Mike Landry	That Complacency and over-familiarity with INS tasks leads to errors and accidents	INS	4	3	3	3	3	High	Y	Several good catches and near-misses noted and used as training for teams. Almost completed in Installation	1	3	3	3	3	Low	N	Continued vigilence.
RR-168	Mindy Jacobson	Limited longevity of TCS CO2 lasers in storage	Storage	3	3	1	1	2	Med	N	Storing as prescribed by Manufacturer	2	3	1	1	2	Med	N	None.
RR-169	Mindy Jacobson	Possible aging/deterioration of coatings on large copper substrates for TCS	Storage	3	2	1	1	2	Med	N	Storing according to past experience with these coatings.	3	2	1	1	2	Med	N	None.
RR-170	John Worden	Additional handling for Storage increases risk of damage	Storage	3	2	1	1	1	Med	N	All kinds of parts now stored, and much of it already done.	1	2	1	1	1	Low	N	Continued vigilence.
RR-171	John Worden	Loss or malfunction of purge gas for 3rd ifo storage	Storage	2	1	1	1	1	Low	N	Concern added at beginning of design process	2	1	1	1	1	Low	N	Carry through with N2 design and monitoring plan
RR-172	John Worden	Components in open environment suffer unanticipated damage (e.g., electronics and rodents/insects)	Storage	2	2	1	1	1	Low	N	Frequent inspections specified in plan	1	2	1	1	1	Low	N	None.
RR-173	David Shoemaker	Particulate or hydrocarbon contamination during storage could take place without us being aware	Storage	3	4	1	1	1	High	N	Planned witness plate placement/measurements	2	4	1	1	1	Med	N	Complete execution of witness plate placement and sampling plan

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RR-174	Hiro Yamamoto	At the high power operation, if the (re-)locking of IFO to the full sensitivity mode takes long due to various time constants of thermal-related issues, the duty cycle with high sensitivity could be compromised.	SYS	3	2	2	2	2	Med	N	Seismic isolation designed to give long lock periods	2	2	2	2	2	Low	N	Determine locking times possible with HIFO-XY once SEI is commissioned to confirm long locks. If not, elaborate Seismic control.
RR-175	Garilynn Billingsley	If thermal asymmetry in the beamsplitter is too large it may increase the contrast defect and/or cause excess noise in the signal recycling cavity - affecting interferometer control.	COC	3	3	1	3	3	Med	N	LLO success indicates that this is not a problem	1	3	1	3	3	Low	N	
RR-176	David Shoemaker	Failure of vertex or end pumping systems can introduce delay or contamination or damage	SYS	3	3	4	3	3	High	Y	Cause of Sept 2013 failure understood; triggered systematic check of vacuum pump systems	1	3	4	3	3	Low	N	Continued vigience.