LIGO-India: Opportunities and challenges - from perspective of the LIGO Laboratory

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Opportunity lives in the home of Risk

Perspective: Elements of LIGO's success

- One team, many mail codes.
  - » High person-to-person communication rate.
  - » Includes sharing; "how's it going?" or "what keeps you awake at night?" or "I screwed up …; how do we fix it?"
  - » Frequent reviews of sub-projects by diverse stakeholders across multiple mail codes.
- Distributed decision making, as close to the work as possible & as fast as possible.
  - » LIGO O&M spends $123K/day; LIGO Construction peak spending was ~ $2M/week. Time = Money.
  - » Use of "cognizant engineer" & "cognizant scientist" partnerships to lead teams on sub-projects whenever practical.
  - » Management establishes clear requirements, rules of engagement and constraints (budget/schedule) and hands down authority with responsibility.

Risks to LIGO-India: LIGO Lab Perspective

From an October 2018 Risk Assessment to NSF:

- LIGO perceives the primary risks to the LIGO-India project to be:
  - » Failure to acquire the observatory site → can't build LIGO-India (*NOW ALMOST RETIRED*)
  - » Insufficient training of the LIGO-India staff → LIGO-India detector won't work
  - » Logistics problems encountered by India in shipping the stored detector equipment → LIGO-India components are irreparably damaged
- Secondary risks (to schedule) to project include:
  - » Further delays in acquiring the observatory site (*NOW ALMOST RETIRED*)
  - » Delays in Atomic Energy Commission *(NOW RETIRED)* and/or GoI Cabinet approval of the Detailed Project Report
  - » Difficulties in constructing the LIGO-India Observatory vacuum system
  - » Minor damage to detector components during storage and installation
  - » Substandard contamination control and safety practices
  - » Delays in procurements due to excessive bureaucratic procedures.

Need to catch a moving target because the rest of the world keeps turning.

- The detector stored for LIGO-India was completed before March 2015.
- Modifications were made to H1 and L1 afterwards that India needs to perform as updates:
  - » Modifications for O1,
  - » Modifications for O2,
  - » Modifications for O3,
  - » Modifications for O4,
  - » A+ modifications completed for H1, L1 by 2024.
- By 2025, there will have been a quantity of order 1000 BBH detections and 100 BNS detections.
- More important than quantity will be quality, high SNR for parameter estimation, GR tests.

Observatory Staffing

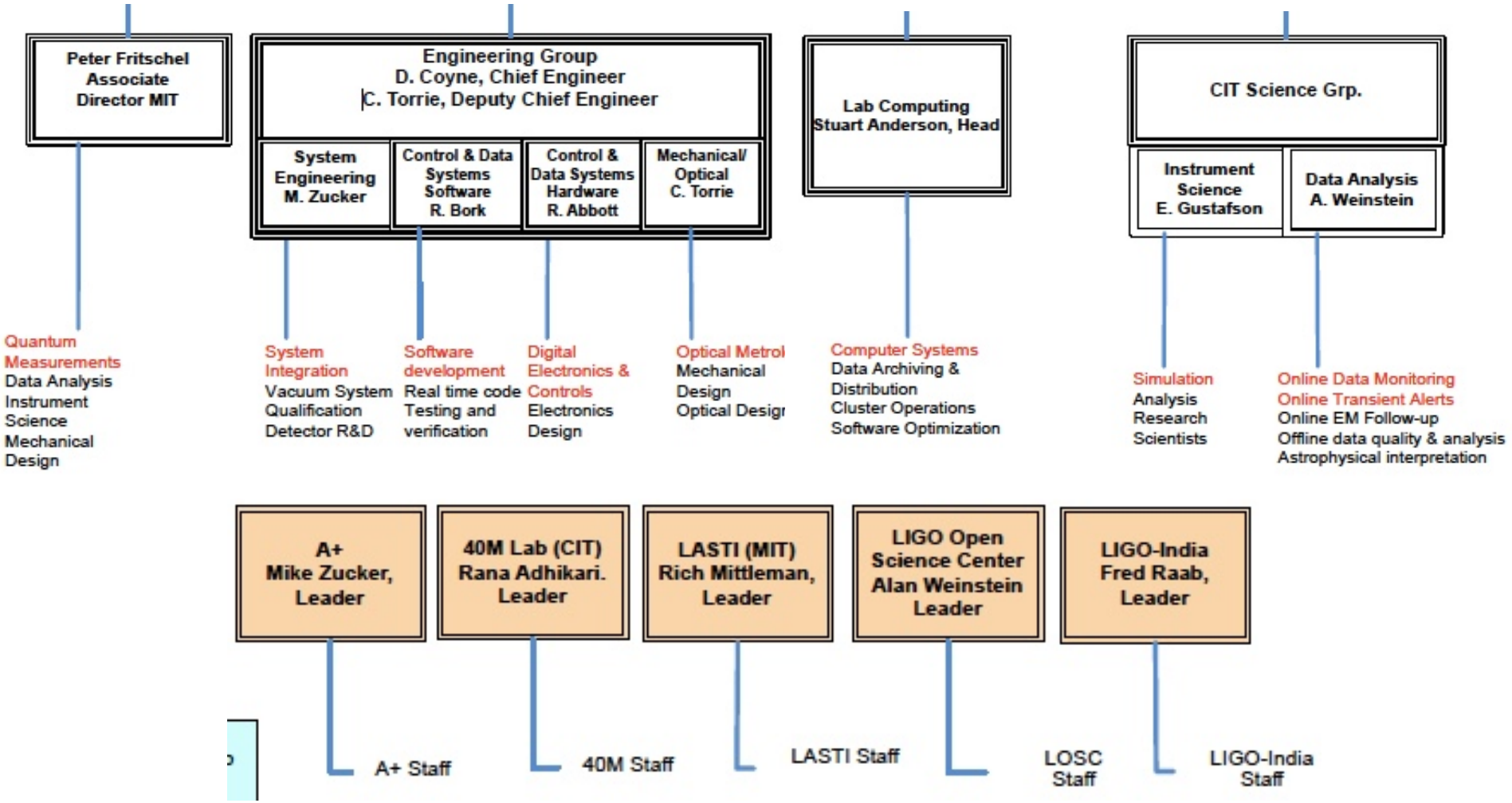
GW Detections Rock Astronomy!

- Meeting demands of multi-messenger astronomy after GW170817
  - » Multi-messenger astronomy was baked into the LIGO Construction Proposal (1989) and actions since to make investments in infrastructure, collaborations, data structures, etc., to enable the successful science coming from GW170817.
  - » But we now serve a much larger community cutting across astronomy, cosmology, particle astrophysics, nuclear theory, etc., needing ***RAPID*** dissemination of ***FREQUENT*** MMA results.
  - » The Open Public Alerts era beginning in O3 will begin to respond to this greater demand.
  - » Observing coordination, robustness, speed and agility will become increasingly important for GW observatories.
  - » Observing coordination includes advance communication of observing run start/stop dates that are planned with increasing sensitivity to new EM capabilities coming online.

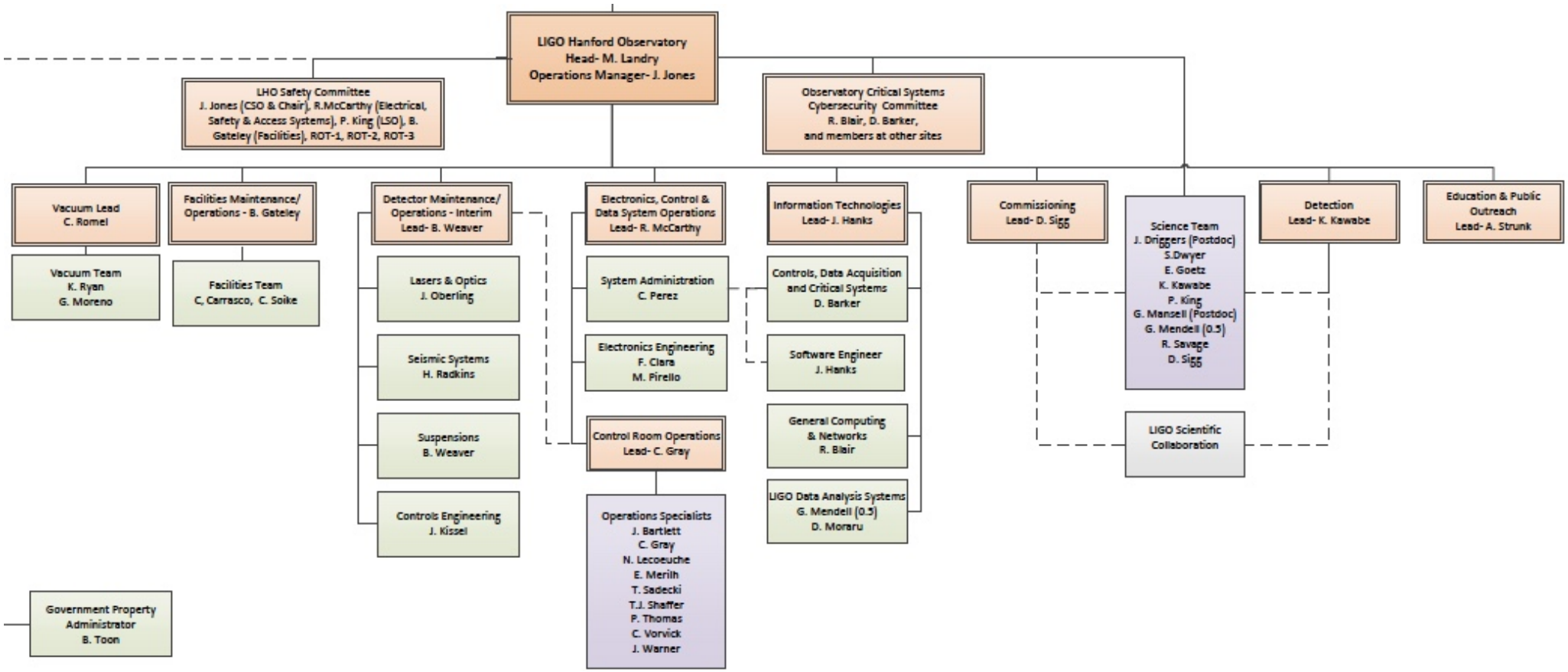
Observatory staffing is determined by required response times

- On site – ability to respond to issues that compromise observing time or present hazards in minutes to hours
- On call – ability to respond within an hour
- Remote – carry on support tasks (e.g., lab-based research, engineering development, procurement, etc.) and can travel to support on-site activities

Remote operations



On-site technical staff at a LIGO observatory – LHO example, but LLO is similar



Transition from Construction Project to Operations

- Not an instantaneous phase transition (like launching a satellite), but a long ramp-down/ramp-up transition.
- Transition needs a plan to ensure correct people are recruited into correct positions at the correct times with the correct training.
- As soon as construction delivers first deliverables, need some operations staff to accept, operate and maintain them.
- Deliverables increasing over time requires operations staff increasing over time; can be optimally achieved by integrating operations staff into construction and installation activities or transitioning construction staff into operations staff.
- Careful planning is needed to match operations labor to needs of construction project.

“Need by” dates for “Operations” labor

- 2025 – year of observing
- 2024 – achieve 1st lock and sensitivity improvement
- 2024 – complete installation & testing
- 2022 – start installation & testing
- 2021 – unpack, inventory & check out 1st detector hardware in staging building
- 2020 – LIGO-India Operations Director needed to ramp up recruiting and hiring of operations staff; should have strong precision measurements background, preferably in gravitational wave detectors or prototypes

LIGO Opportunities seen by LIGO Laboratory

- The LIGO Global Network – LHO, LLO and LIO – will be the premier observatories operating in the decade 2025-2035 or later, providing the most sensitive data, with the strongest contributions to localization and polarization resolution for events detected in all three observatories.
- Due to their common facility designs, all three observatories will have comparable facility limits, although the LIGO-India seismic profile may be more conducive to providing better low-frequency sensitivity than at the US sites.
- A future detector upgrade path available to the LIGO Global Network detectors, referred to as the Voyager detector, can extend the reach of these three observatories to their common facility limits using much of the existing Advanced LIGO detector equipment.
- We expect that the vast majority of gravitational-wave sources discovered before the onset of 3G facilities will be found by the LIGO Global Network, assisted by the Virgo and KAGRA observatories.