aLIGO Guardian
Status and Plans

Jameson Graef Rollins

Fall 2014 LSC-Virgo Collaboration Meeting
Joint Instrument Science session
August 25, 2014

LIGO-G1400995

Overview

This is an overview of the development and deployment status of the aLIGO automation infrastructure, also known as "Guardian".

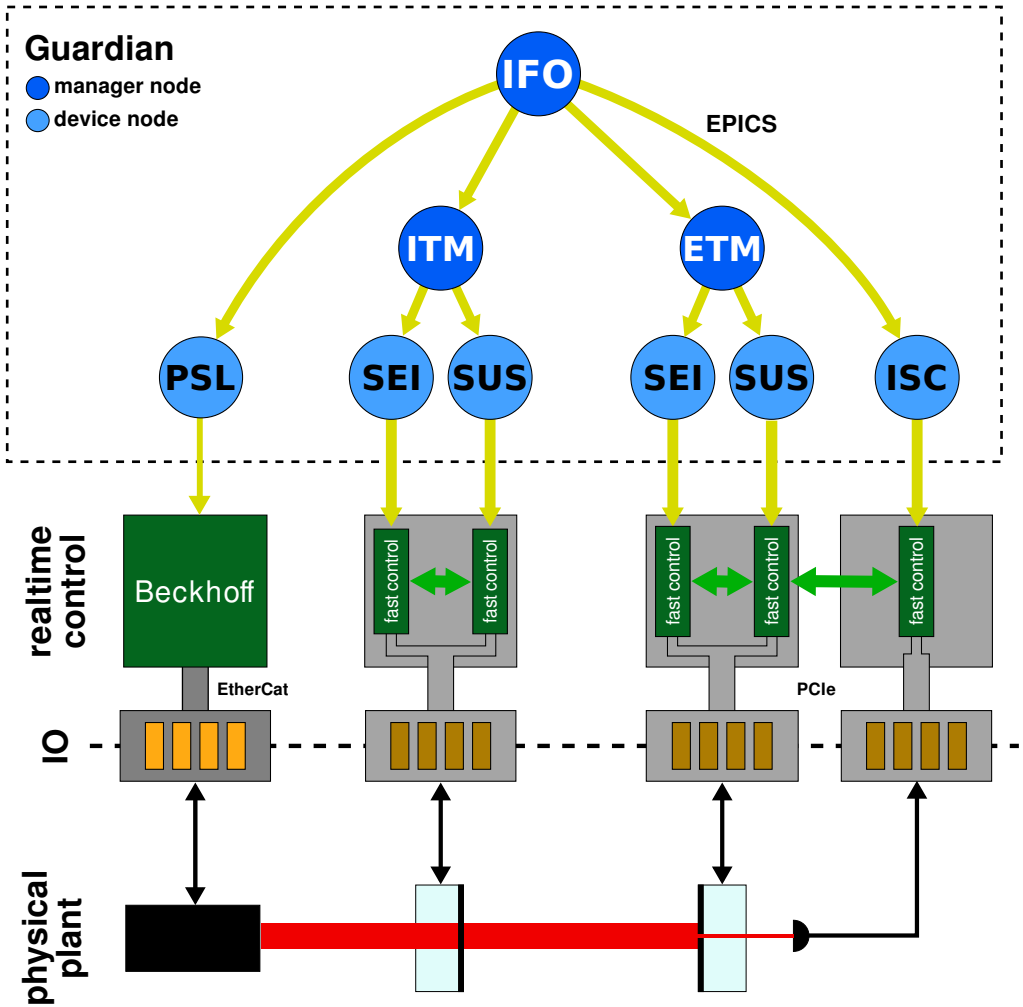
Guardian controls the global state of the interferometers by managing the states of all subsystems and handling the full lock acquisition process.

Guardian is also designed to be a useful tool for interferometer commissioning. It is easily reconfigurable, and its distributed nature allows us to build up the automation piecemeal.

Overview

The Guardian architecture is that of a distributed, hierarchical, state machine.

Control is divided among independent automation processes known as **nodes**. The lowest level nodes talk directly to the fast front end system, and their state is coordinated at the global level by "manager" nodes.

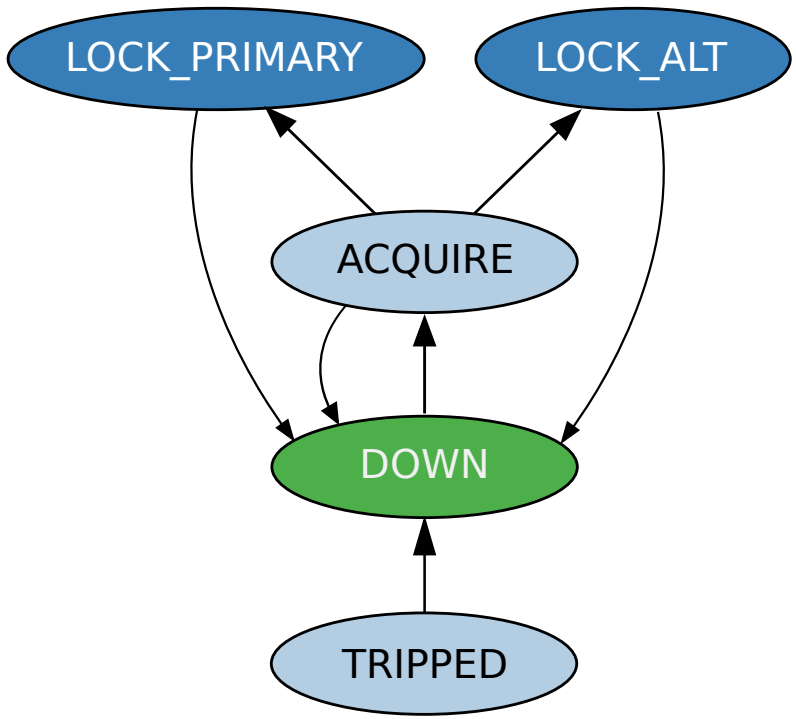


System behavior

Each node is programmed as a **directed graph**.

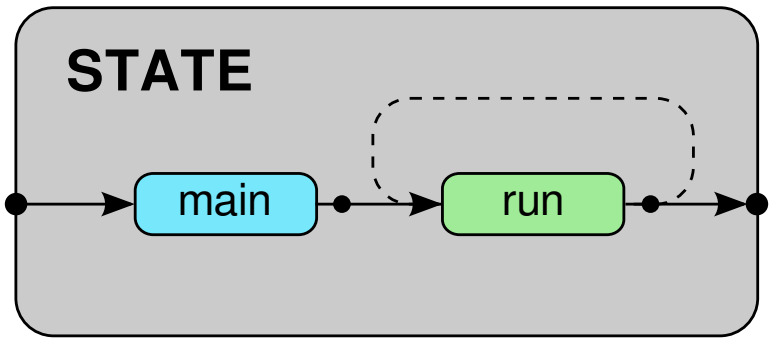
States of the system, which are represented by nodes in the graph, are distinct pieces of automation logic. They handle both monitoring the state of the system and responding to stimuli to change the physical configuration.

Edges represent possible transitions between states, and have zero content.



State behavior

The states themselves have a very simple structure and behavior.



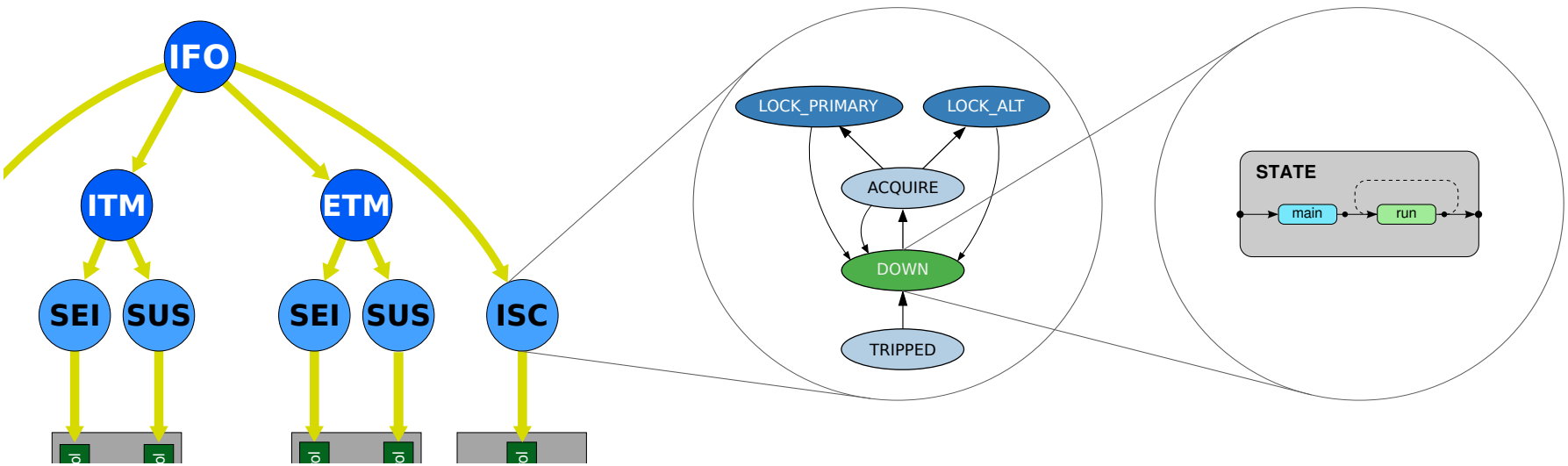
There are two state *methods* (i.e. functions) of executable code:

main
: executed **once** immediately upon entering state.

run
: executed **in a loop** until the state exit condition is achieved.

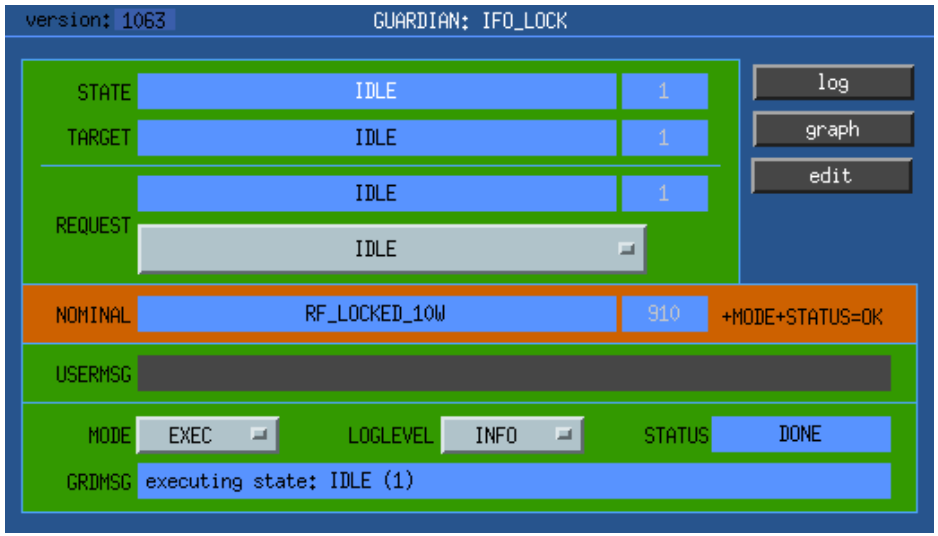
Overview

Distinct systems in the full IFO are divided into sets of independent nodes, each node programmed with their own state graph.



Guardian core

The Guardian "core" state machine engine is now quite mature and feature-full. The behavior and interfaces have stabilized.



The two core packages are installed at both sites and all supporting facilities:

guardian Core graph and state execution system and libraries, command line interface, helper utilities, MEDM control interface, supervision interface, etc.

ezca/cdsutils Ezca customized EPICS client library and other useful CDS interaction utilities (servo, step, avg, etc.)

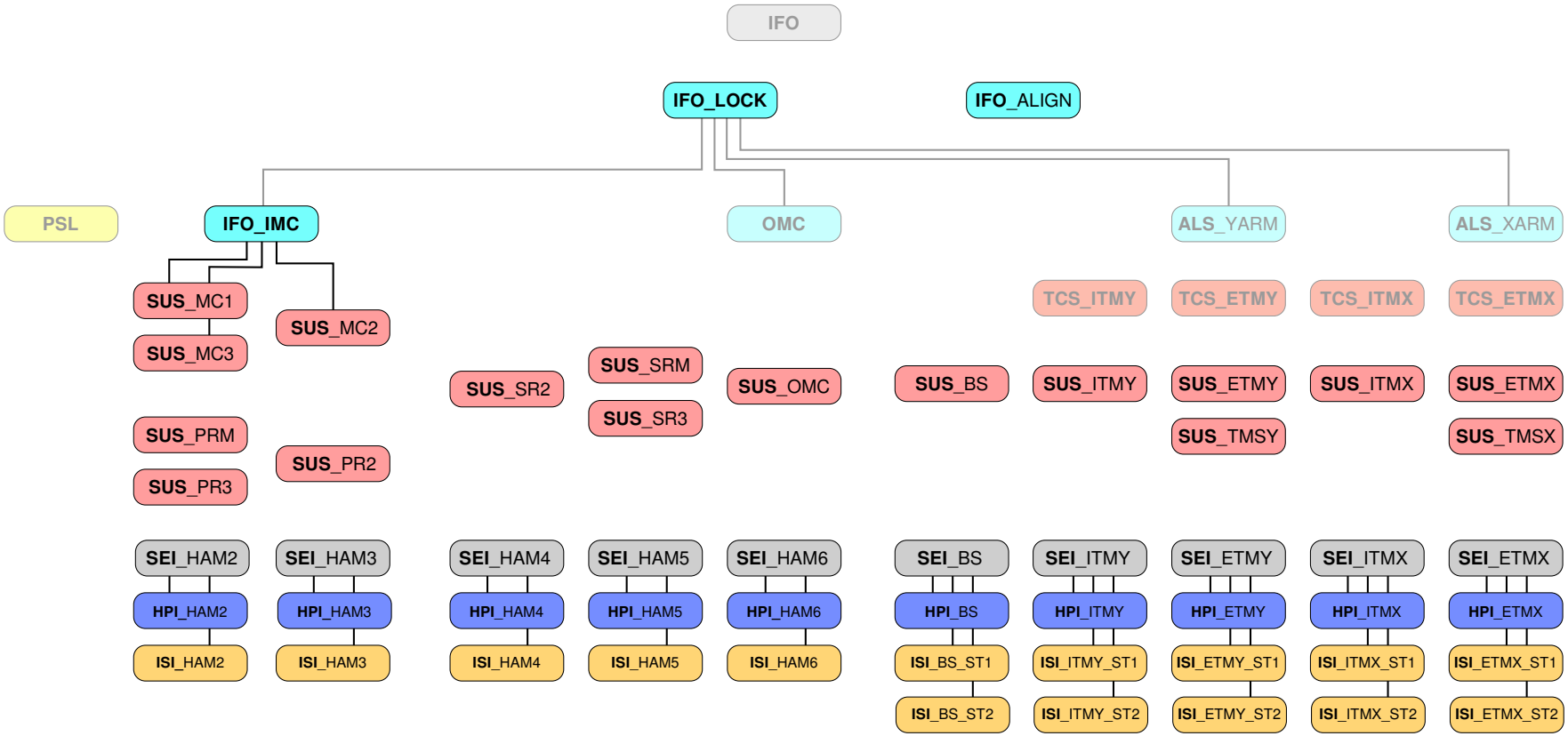
Site infrastructure

Guardian node supervision infrastructure is in place at both sites on dedicated machines. `guardctrl` interface is used for controlling nodes (creating, starting, stopping, listing, etc.), as well as viewing node logs.

```
jameson.rollins@opsportal:~ 0$ guardctrl list
node         s k m vers  state                                message
----         - - - ----  -----                                -------
HPI_BS       * * M 1060  READY
HPI_ETMX     *   P 1060  WATCHDOG_TRIPPED_FULL_SHUTDOWN       WATCHDOG TRIP: FULL_SHUTDOWN (4)
HPI_ETMY     * * M 1060  READY
HPI_ITMX     * * M 1060  READY
HPI_ITMY     * * M 1060  READY
IAS_INPUT    *   E 1060  INIT
IAS_MICH     *   E 1060  INIT
IAS_PRC      *   E 1060  INIT
IAS_SRC      *   E 1060  INIT
IAS_XARM     *   E 1060  IDLE
IAS_YARM     *   E 1060  IDLE
IFO_ALIGN    *   E 1060  IDLE
IFO_DRMI     *   E 1060  DOWN
IFO_IMC      * * E 1060  LOCKED
IFO_LOCK     *   E 1063  IDLE
IFO_OMC      *   E 1060  DOWN
ISI_BS_ST1   * * M 1060  HIGH_ISOLATED
ISI_BS_ST2   * * M 1060  DAMPED
ISI_ETMX_ST1 *   P 1060  WATCHDOG_TRIPPED_FULL_SHUTDOWN       WATCHDOG TRIP: FULL_SHUTDOWN (4)
ISI_ETMX_ST2 *   P 1060  WATCHDOG_TRIPPED_FULL_SHUTDOWN       WATCHDOG TRIP: FULL_SHUTDOWN (4)
```

Full system node projection

Current projection of the full constellation of guardian nodes:



Usercode deployment

Deployment of "usercode", i.e. the specific system automation logic, is progressing nicely:

- SUS and SEI subsystems essentially complete at both sites
- IMC auto-lockers working at both sites
- RF IFO lock at LLO, under active development
- prototype of initial alignment system

SUS and SEI systems are well parameterized, with ability to customize individual systems as needed.

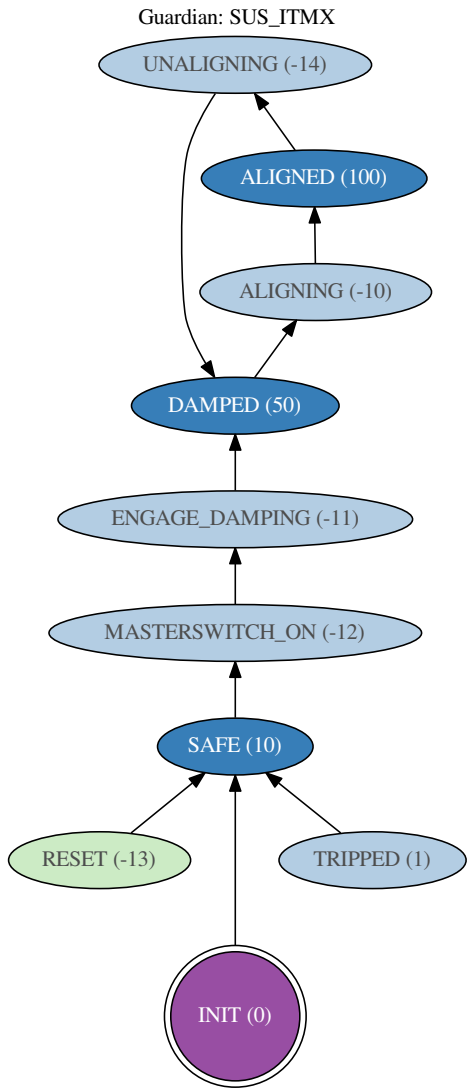
Focus now on **full lock acquisition** automation.

SUS fully deployed

Suspension subsystem was the first to be fully automated (also the simplest). All suspensions nodes have identical guardian structure, using a common library interface and base state graph description.

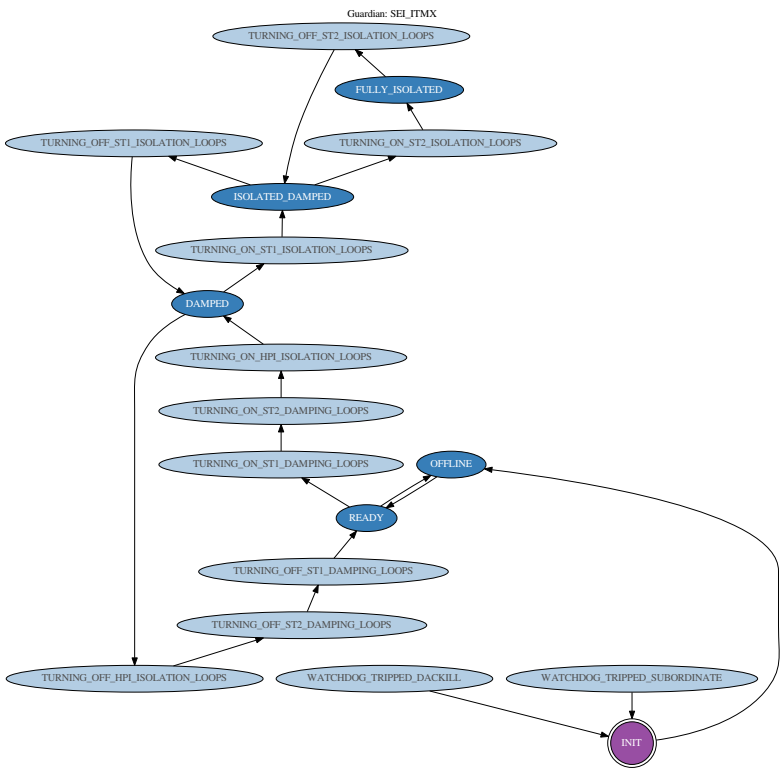
Handles full recovery to aligned state from watchdog trips.

Handling of alignments still needs refinement. Currently *not* touching alignment offset values, just enabling outputs (thus currently no "misaligned" state).

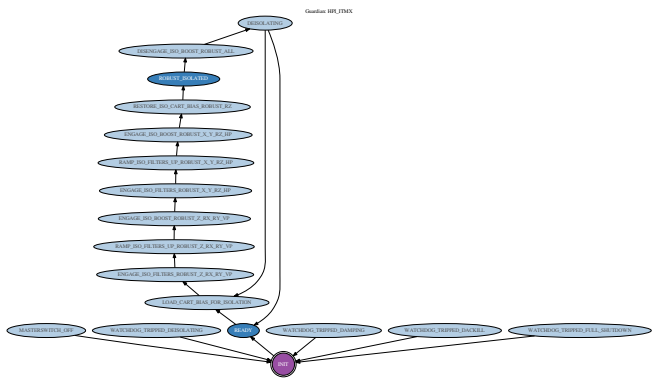


SEI fully deployed

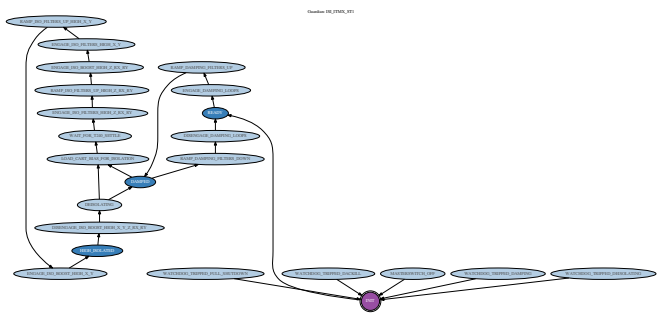
Seismic isolation subsystem fully automated, also with automatic watchdog trip recovery to full isolation. Various isolation levels supported. “Chamber managers” coordinate isolation between HPI and ISIs nodes.



SEI_ITMX (manager)



HPI_ITMX

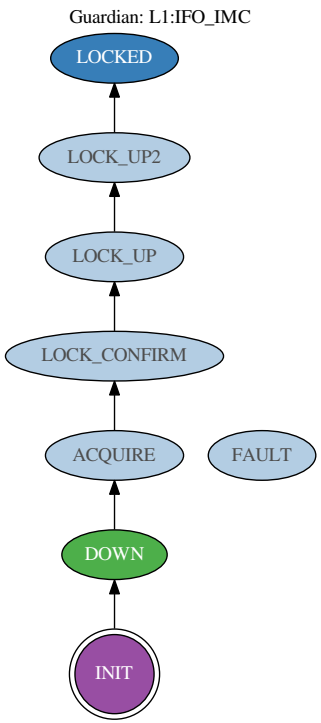


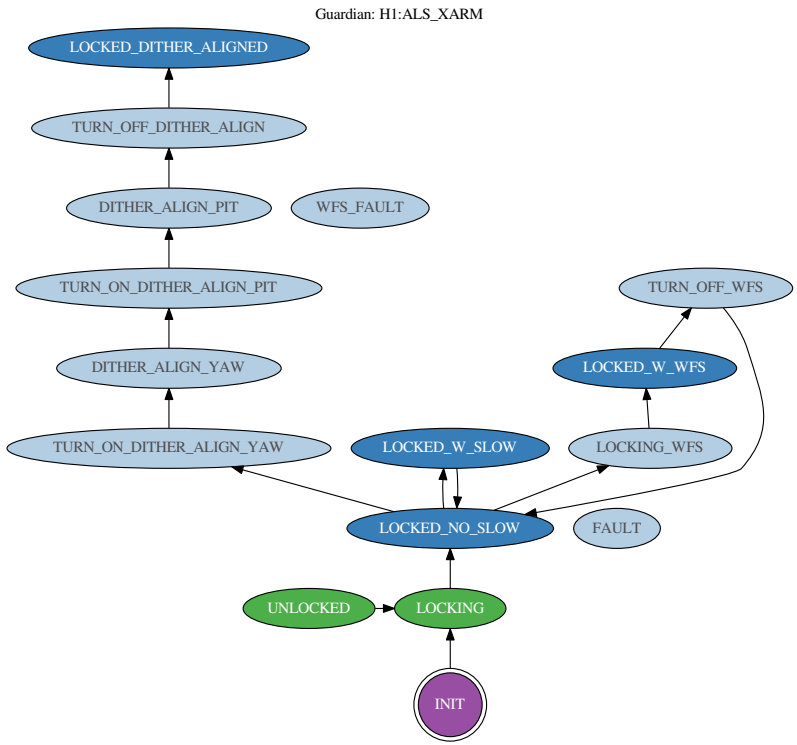
ISI_ITMX_ST{1,2}

IMC and ALS

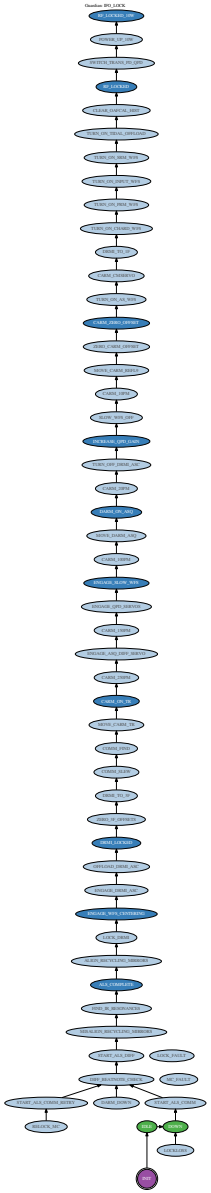
Input mode cleaner (IMC) auto-locker (first cavity control) deployed at both sites.

Arm length stabilization (ALS) automation being developed at LHO.





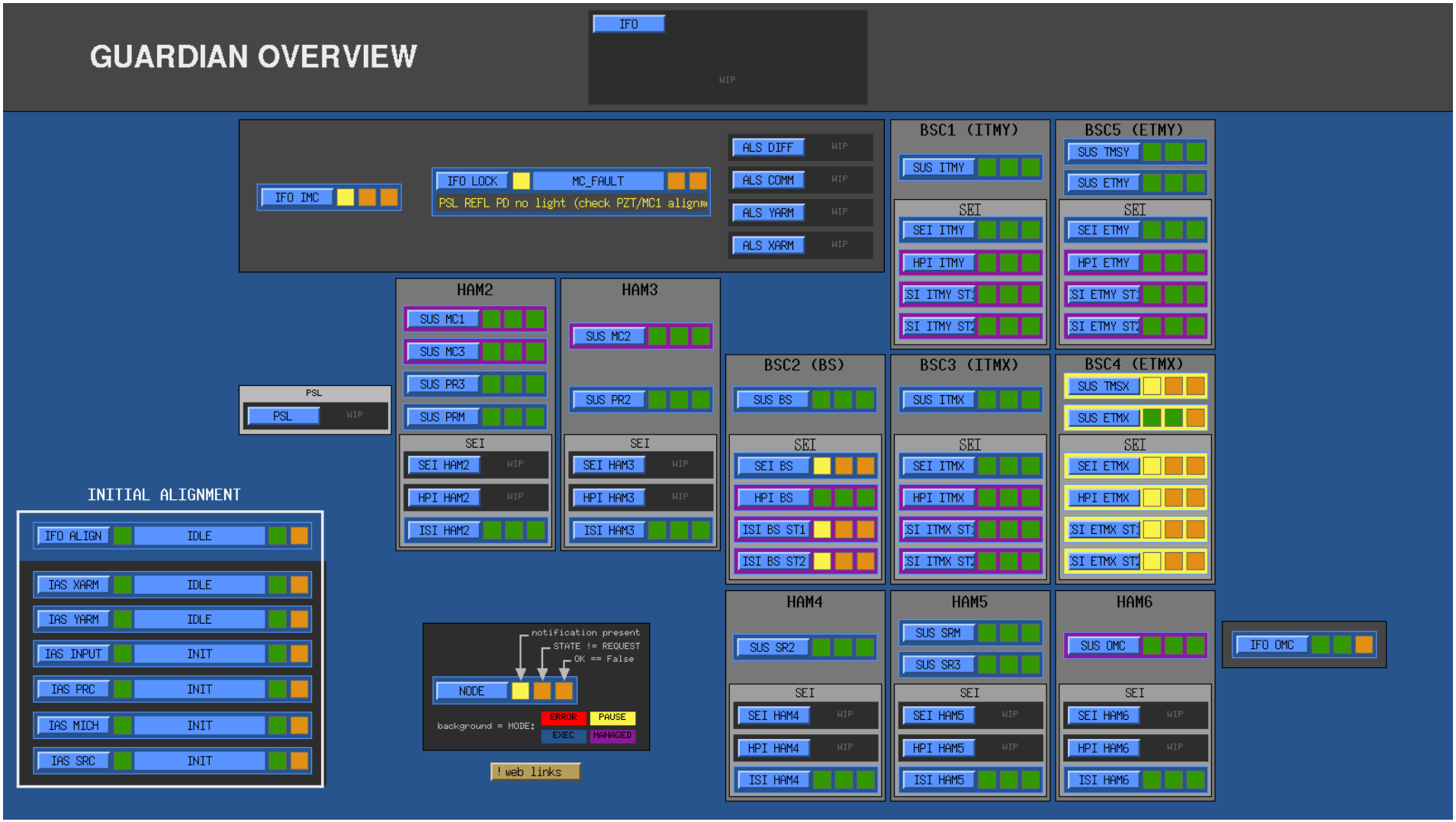
Full IFO locking



Full IFO lock acquisition now being handled by guardian at LLO. Handles full RF lock acquisition, including ALS control of the arms, DRMI lock, and CARM and DARM transitions, and some amount of ASC integration. DC readout transition now being integrated.

This node is still under heavy development, but starts to give a sense of what the full lock acquisition procedure will look like.

Full system overview



Remaining tasks

Still a lot left to be done.

Remaining tasks: parameter tracking

improved parameter tracking

We need a better way to track the state of $\mathcal{O}(100\text{k})$ setting channels in the digital system. We're currently developing a more unified and comprehensive tracking of system settings/parameters at the front end level. Hope to roll out something in the next month or so.

Remaining tasks: alignment and locking

initial alignment

We have begun working on a set of initial alignment nodes to get all suspension offsets to their nominal values. These will likely be commissioned at LHO over the next couple of months.

better ALS integration

ALS automation is under development at LHO, and needs to be integrated with (managed by) the lock acquisition nodes.

OMC node and DC readout transition

An OMC node is under development at LLO, and needs to be integrated with (managed by) the lock acquisition nodes.

Remaining tasks: suspensions

SUS optical lever damping

The op-lev damping loops are a bit tricky as they need to be turned on and off depending on the state of the op-lev beams on the QPDs. Some handling of this has been integrated at LLO, but it needs to be refined and transferred to LHO.

SUS alignment offsets

Tracking of suspension alignment offsets is currently difficult and clunky. We need a better way to track/manage alignment offsets, with better guardian integration.

small optic suspensions

No guardians yet for small optic suspensions (HSSS).

Remaining tasks: seismic

SEI respond to changing seismic environment

The seismic environment is constantly changing (earthquakes, high microseism, high winds, etc.). Frequently the changes leak into the IFO, affecting performance or breaking lock. We would like to be able to better respond to the changing environment by changing the SEI state on-the-fly.

earthquake early warning/response

An earthquake early warning system is under development. We will hopefully be able to use this to preemptively put the SEI systems into more robust configurations to help the locks ride out the earthquakes.

Remaining tasks: other subsystems

thermal compensation

TCS system has not been automated yet, although work has begun.

pre-stabilized laser

PSL not yet integrated into guardian yet.

Remaining tasks: full integration

fully integrate all automation code

We still have some automation logic encoded in external scripts, written mostly before guardian was fully deployed. We're working on moving all automation logic into "guardian native" code, eliminating all external script calls. This will make everything much more robust.

full management integration

Node management, whereby one node controls one or more other nodes, is currently only used in SEI. The full management hierarchy needs to be commissioned, from top node down. The core manager interface will likely need more development to unsure robustness.

Remaining tasks: full integration

support alternative IFO configurations

Want to be able to easily transition between various IFO configurations, e.g. DRMI only, single arm only, PRMI+arm, etc. Still working out how best to integrate these options into the larger structure.

high power operation

Transition to high power operation, and locking at various IFO thermal states, will be very tricky.

Remaining tasks: full integration

tasks

Better support for specific measurement tasks, such as calibration measurements.

reconcile site differences

As much as possible, we would like all sites to be running the same automation code. This is achievable, to the extent that the operational configurations of the instruments are commensurate, if the code is well parameterized. Keeping sites in sync is an ongoing struggle.

core improvements

Better interface, support more requestable states, better code tracking, better EPICS write performance, etc.

Links

- Guardian awiki
- Guardian Overview and User Manual (G1400016)
- Guardian Progress and Remaining Tasks (T1400461)