The aLIGO Guardian

Jeff Kissel, for the ISC, SEI, SUS, etc. teams

Motivation

- iLIGO Experience: Operators/Commissioners had to manage many control systems, but many components were passive
- aLIGO has many more control loops/sensors/actuators – "modules" – of which to keep track; too difficult for one operator to manage
- BUT many aLIGO modules are will be controled/managed identically
- Design modular control systems to be in well-defined and verifiable states, which can then be managed hierarchically
- Inspired by the VIRGO and GEO experience
- Natural evolution from operation "by-hand," to low-level scripts, to an organized well-tought-out infrastructure
- Not a necessary deliverable for aLIGO, but essential for long term, robust, repeatable operation – particularly by non-experts

Guardian Principles

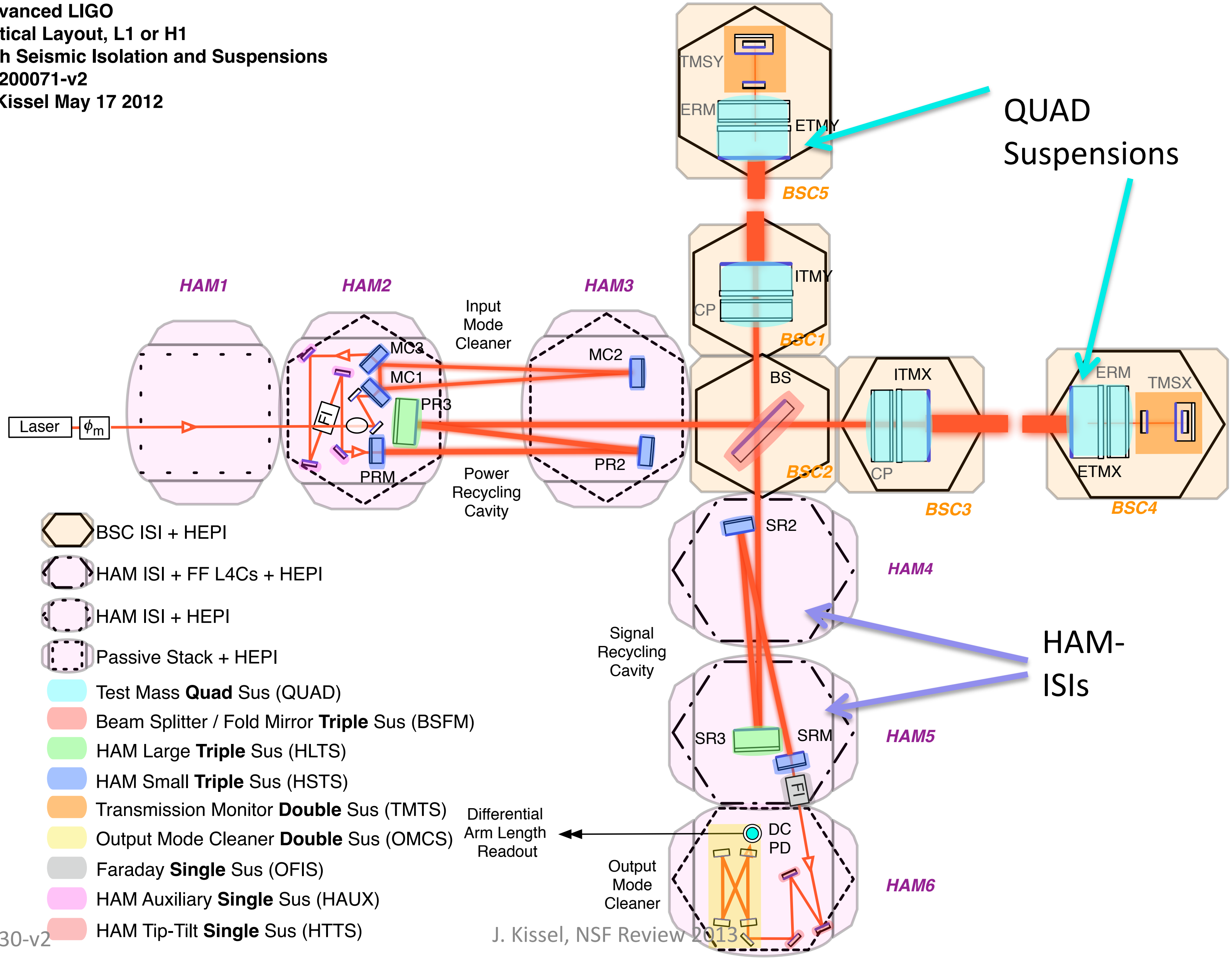
- **NOT** responsible for protection, only reporting, verifying, and transistioning between states ("Guardian" is a mis-nomer)

- **Module Guardian**: the lowest level state machine, directly controls a given component that can be treated identically (e.g. a Triple Suspension, or HAM-ISI)

- **Manager Guardian**: the "puppet master" that merely demands modules be in a given state, based on upper level manager or human requests

Module Examples

Advanced LIGO
Optical Layout, L1 or H1
with Seismic Isolation and Suspensions
G1200071-v2
J. Kissel May 17 2012

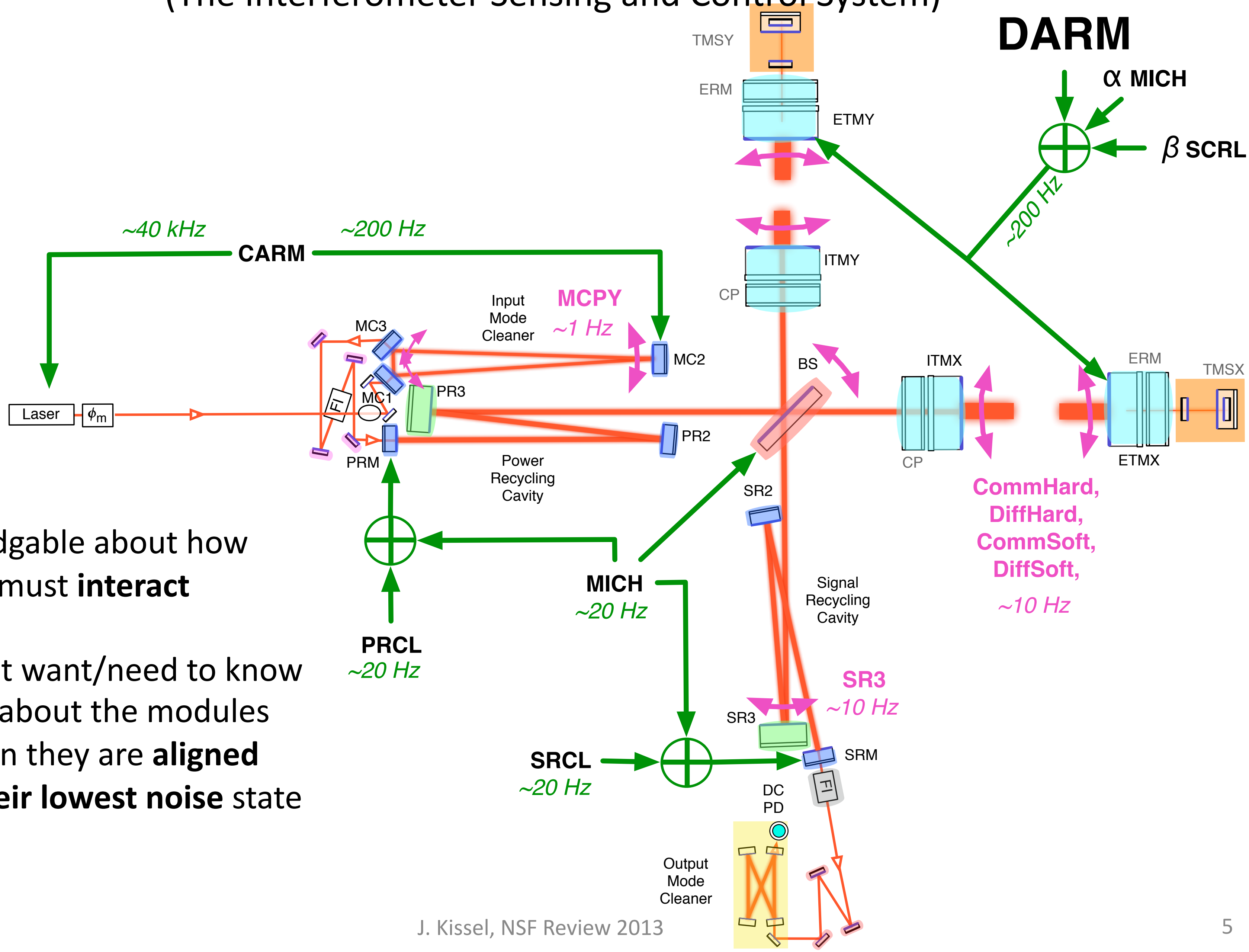

TMSY
ERM
ETMY
BSC5
ITMY
CP
BSC1
HAM1
HAM2
HAM3
Input
Mode
Cleaner
MC3
MC1
MC2
PR3
FI
Laser
ϕ_m
PRM
PR2
Power
Recycling
Cavity
BS
BSC2
ITMX
CP
BSC3
ERM
TMSX
ETMX
BSC4
SR2
HAM4
Signal
Recycling
Cavity
SR3
SRM
FI
HAM5
DC
PD
Differential
Arm Length
Readout
Output
Mode
Cleaner
HAM6
BSC ISI + HEPI
HAM ISI + FF L4Cs + HEPI
HAM ISI + HEPI
Passive Stack + HEPI
Test Mass **Quad** Sus (QUAD)
Beam Splitter / Fold Mirror **Triple** Sus (BSFM)
HAM Large **Triple** Sus (HLTS)
HAM Small **Triple** Sus (HSTS)
Transmission Monitor **Double** Sus (TMTS)
Output Mode Cleaner **Double** Sus (OMCS)
Faraday **Single** Sus (OFIS)
HAM Auxiliary **Single** Sus (HAUX)
HAM Tip-Tilt **Single** Sus (HTTS)

QUAD Suspensions

HAM-ISIs

Manager Examples

(The Interferometer Sensing and Control System)



- Knowledgable about how modules must **interact**

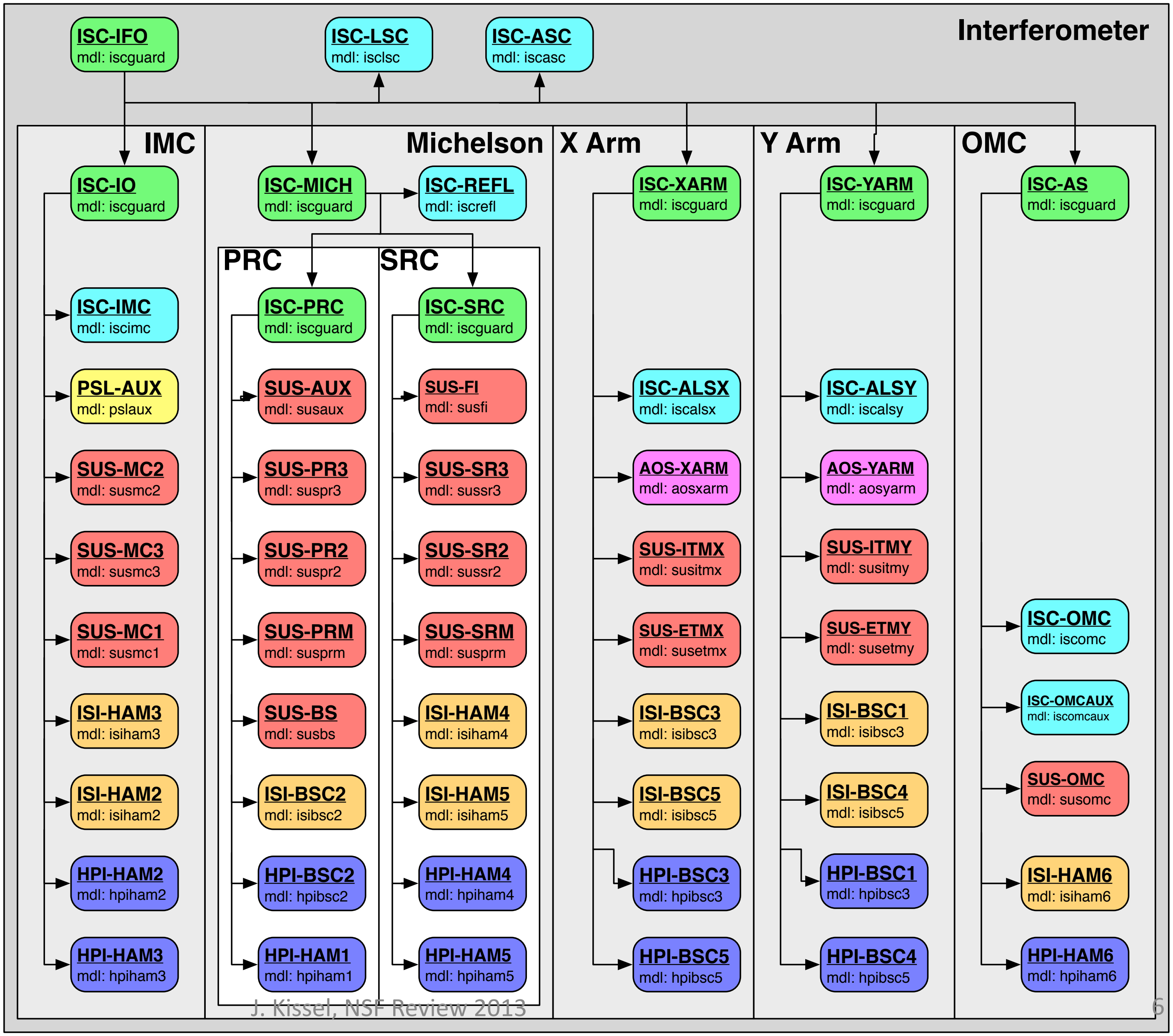
- Does not want/need to know anything about the modules other than they are **aligned** and in **their lowest noise** state

The Highest Level Organization

aLIGO Guardian Overview Diagram

D1101755-v3
Sep 02, 2011

S. Waldman



Interferometer

ISC-IFO
mdl: iscguard

ISC-LSC
mdl: isclsc

ISC-ASC
mdl: iscasc

IMC

ISC-IO
mdl: iscguard

ISC-IMC
mdl: iscimc

PSL-AUX
mdl: pslaux

SUS-MC2
mdl: susmc2

SUS-MC3
mdl: susmc3

SUS-MC1
mdl: susmc1

ISI-HAM3
mdl: isiham3

ISI-HAM2
mdl: isiham2

HPI-HAM2
mdl: hpiham2

HPI-HAM3
mdl: hpiham3

Michelson

ISC-MICH
mdl: iscguard

ISC-REFL
mdl: iscrefl

PRC

ISC-PRC
mdl: iscguard

SUS-AUX
mdl: susaux

SUS-PR3
mdl: suspr3

SUS-PR2
mdl: suspr2

SUS-PRM
mdl: susprm

SUS-BS
mdl: susbs

ISI-BSC2
mdl: isibsc2

HPI-BSC2
mdl: hpibsc2

HPI-HAM1
mdl: hpiham1

SRC

ISC-SRC
mdl: iscguard

SUS-FI
mdl: susfi

SUS-SR3
mdl: sussr3

SUS-SR2
mdl: sussr2

SUS-SRM
mdl: susprm

ISI-HAM4
mdl: isiham4

ISI-HAM5
mdl: isiham5

HPI-HAM4
mdl: hpiham4

HPI-HAM5
mdl: hpiham5

X Arm

ISC-XARM
mdl: iscguard

ISC-ALSX
mdl: iscalsx

AOS-XARM
mdl: aosxarm

SUS-ITMX
mdl: susitmx

SUS-ETMX
mdl: susetmx

ISI-BSC3
mdl: isibsc3

ISI-BSC5
mdl: isibsc5

HPI-BSC3
mdl: hpibsc3

HPI-BSC5
mdl: hpibsc5

Y Arm

ISC-YARM
mdl: iscguard

ISC-ALSY
mdl: iscalsy

AOS-YARM
mdl: aosyarm

SUS-ITMY
mdl: susitmy

SUS-ETMY
mdl: susetmy

ISI-BSC1
mdl: isibsc3

ISI-BSC4
mdl: isibsc5

HPI-BSC1
mdl: hpibsc3

HPI-BSC4
mdl: hpibsc5

OMC

ISC-AS
mdl: iscguard

ISC-OMC
mdl: iscomc

ISC-OMCAUX
mdl: iscomcaux

SUS-OMC
mdl: susomc

ISI-HAM6
mdl: isiham6

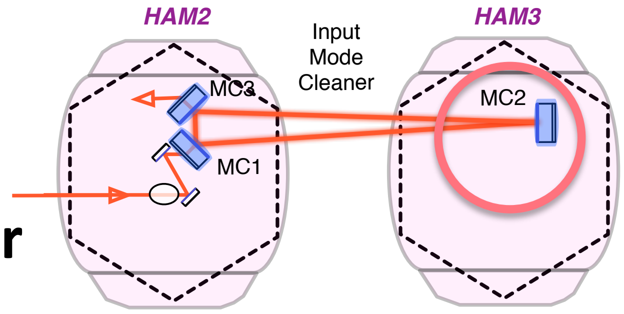
HPI-HAM6
mdl: hpiham6

LEGEND

HPI-xxxx mdl: xxxxx	HEPI Guardian
ISI-xxxx mdl: xxxxx	ISI Guardian
SUS-XXX mdl: xxxxx	SUS Guardian
PSL-AUX mdl: pslaux	PSL Guardian
AOS-xxxx mdl: aosxarm	AOS Guardian
ISC-XXX mdl: xxxx	ISC Guardian
ISC-XXX mdl: xxxxx	Manager Guardian (note: managers are hosted in a single EPICS DB)

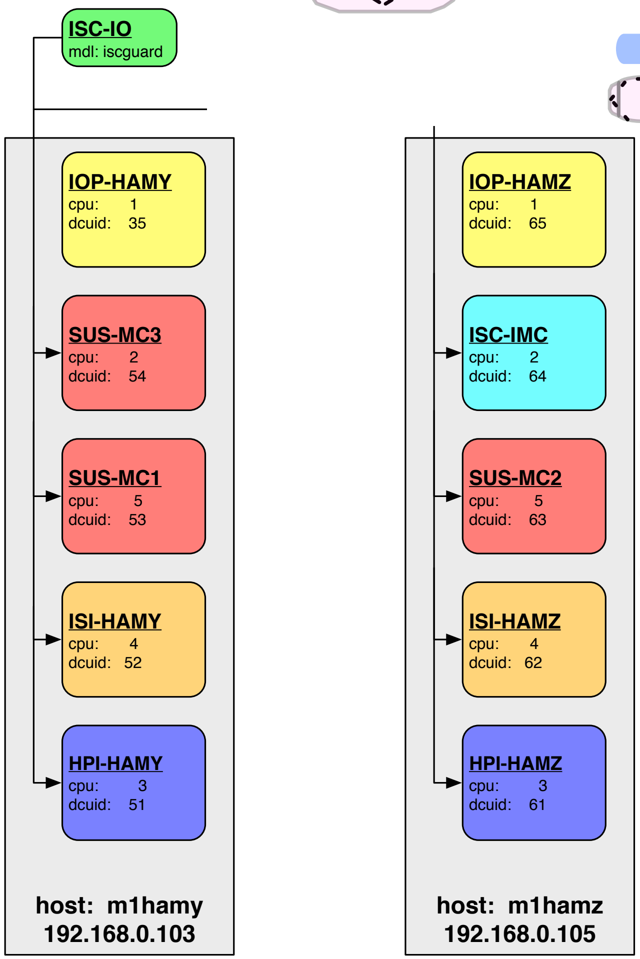
Modules

Manager



🟦 HAM Small Triple Sus (HSTS)

HAM ISI + HEPI



ISC-IO
mdl: iscguard

IOP-HAMY
cpu: 1
dcuid: 35

SUS-MC3
cpu: 2
dcuid: 54

SUS-MC1
cpu: 5
dcuid: 53

ISI-HAMY
cpu: 4
dcuid: 52

HPI-HAMY
cpu: 3
dcuid: 51

host: m1hamy
192.168.0.103

IOP-HAMZ
cpu: 1
dcuid: 65

ISC-IMC
cpu: 2
dcuid: 64

SUS-MC2
cpu: 5
dcuid: 63

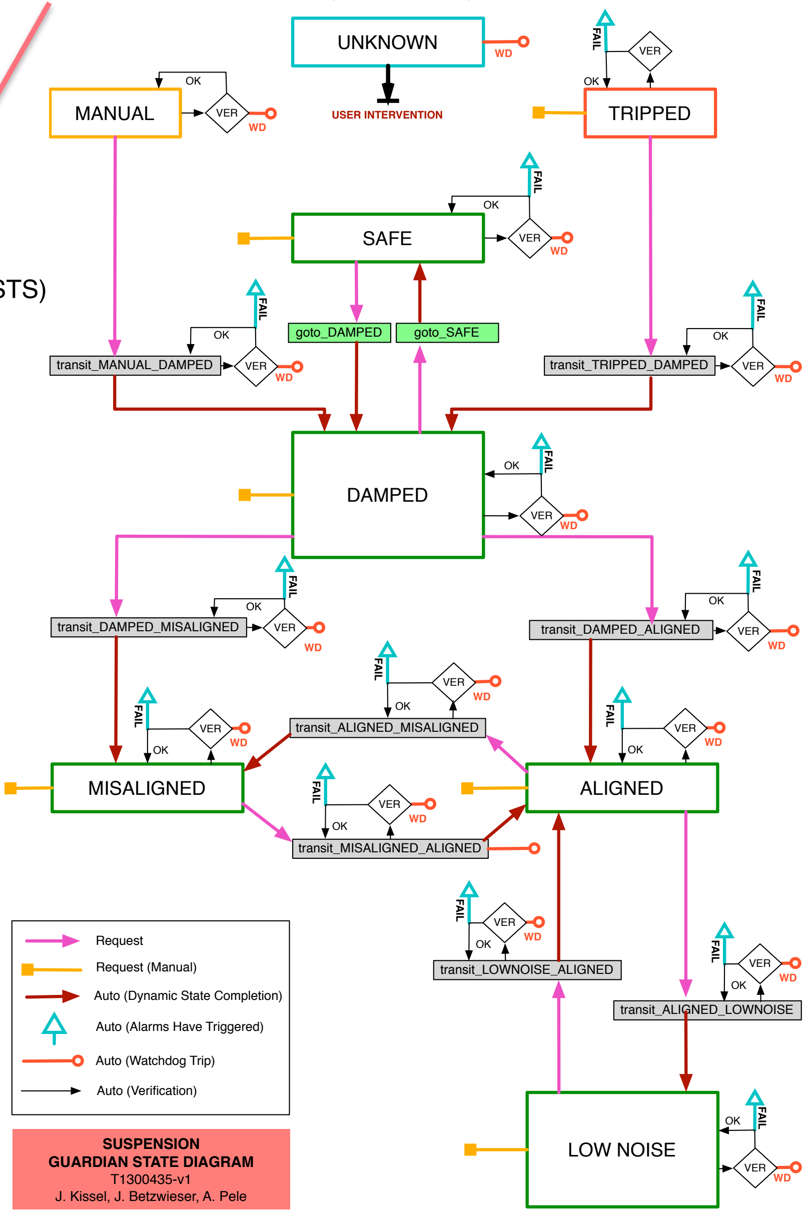
ISI-HAMZ
cpu: 4
dcuid: 62

HPI-HAMZ
cpu: 3
dcuid: 61

host: m1hamz
192.168.0.105

(CPU and DCUID allocations are somewhat arbitrary)

Module
(HAM Triple Suspension)



SUSPENSION GUARDIAN STATE DIAGRAM
T1300435-v1
J. Kissel, J. Betzwieser, A. Pele

Progress Thus Far…

- First article infrastructure created at MIT
- Prototype module systems developed at MIT (SUS) and Stanford (SEI) using representative hardware
- L1 Input Mode Cleaner Integrated Test Phase included prototype of IMC Manager Guardian
- Very new (last week!): face-to-face meeting of subsystem leaders on the Guardian

  We've had enough prototyping that we can now really:

  - Define Requirements
  - Define common goals and infrastructure
  - Software infrstructure can begin to be absorbed by CDS / Software Engineers
  - Establish "czar" to ensure commonality and smooth interactions at the manager level

  All of which we accomplished/has begun