An Efficient Hardware Maintenance Capability for the National Ignition Facility Computer Control System

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NIF operations is supported by multiple maintenance facilities

- Optics Processing Facility
- CIM Facility
- NIF Supporting Facilities
- Incoming new or refinished equipment from vendors
- Equipment going back to vendors
- B490
- Warehouse
- NIF Controls Maintenance
- The NIF Building
- Laser
- Maintenance Facility
- Tour starts here
The controls system contains 1,800 processors that operate the NIF laser and target devices.

- Processor locations

Controls 66,000 actuators, triggers, cameras, digitizers, pulse power and a variety of digital & analog I/O.
ICCS hardware technology designed to meet NIF controls functional requirements

ICCS Architecture
COTS and Specialized

ICCS Workstations

Servers

Front End Processors

Field Bus

Embedded Controllers

Smart Devices or Control Points

Instrument Based Controllers

Instrument (digitizers, power supplies, cameras)

Target Diagnostic Control Points

Supervisory Layer

Front End Layer

I/O Layer

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M.G. Miller - ICALPICS, October 6, 2013
Hardware responsibilities cover systems life cycle

- **Engineering**
  - System and circuit design
  - Configuration and inventory management
  - Reliability, Availability, Maintainability (RAM) improvement and technology refresh

- **Production**
  - Assembly and test
  - Installation & qualification testing

- **System Maintenance**
  - Unplanned & preventative maintenance
  - Calibration
  - Online/offline troubleshooting

Team has focused on maintenance processes the last two years
Maintainability is governed by many factors

- Strong configuration control
- Reduce software development tools
- Improve reliability
- Improve performance
- Decrease software development efficiencies
- Minimize hardware maintenance resources
- Technology advancements

Diverse Controls Architecture (established pre 1996)
- 10 Device Bus types
- 6 Operating Systems
- 5 CPU types

Evaluate system design
- Standardize & consolidate

Develop enhanced maintenance plans and processes

Continuous refresh process

Homogeneous Architecture (continuous effort)
- Improve availability
- Reduce maintenance costs
## Maintenance strategy has focused on a few key areas

<table>
<thead>
<tr>
<th>Maintenance Facility</th>
<th>Maintenance Policy</th>
<th>Sparing Plan</th>
<th>Refresh</th>
<th>Process Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>• Optimize for test and repair rigor as well as efficiency</strong></td>
<td><strong>• Update predictive and unplanned policies and procedures</strong></td>
<td><strong>• 24/7 access to large inventory of tested hardware</strong></td>
<td><strong>• Hardware approaching EOL</strong>&lt;br&gt;Continuous process. Major upgrades planned for 2014</td>
<td><strong>• Automate and integrate tools to increase rigor and efficiency</strong>&lt;br&gt;80% Complete of two year effort</td>
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<tr>
<td>30% Complete of multiyear effort</td>
<td>Largely complete. Continuous effort</td>
<td>Completed in 2013 with ongoing effort</td>
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Maintenance Facility incorporating specialized test stations to test and repair controls hardware

- Test standards are defined and repeatable
  - Written test procedures
  - Documented calibration specifications
  - Trained and qualified staff
- Scheduled “verification” of station functionality

Improved test and repair capability increases our controls reliability
Predictive maintenance minimizes unplanned impact and downtime

• Calibration insures and maintains device performance and accuracy
  — In situ onsite calibration by trained staff
  — Offsite calibration by instrument vendors
  — LRU devices tested onsite

• Preventative Maintenance (PM) minimizes unplanned outages
  — Determine replacement schedule before predicted EOL
  — Periodic equipment inspections
Spares strategy for unplanned maintenance

• Critical spares storage area for rapid facility failures
  — Certified replacement units
  — 24/7 access
  — Inventory tools trigger reorder

• Guiding principles
  — Number units deployed
  — Failure rates
  — Unit availability
  — Expansion needs

Inventory of 1,100 different assemblies assures timely repairs
Refresh strategy to replace aging HW is based on product availability and modern technologies

- Analyze inventory to identify refresh candidates

- Guiding principles identify replacement hardware based on:

<table>
<thead>
<tr>
<th>Current industry standards</th>
<th>• Maturity level</th>
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<tbody>
<tr>
<td>Leverage technical base and experience</td>
<td>• Use existing personnel experience where feasible</td>
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</table>
| Hardware replacement costs          | • Units cost  
|                                     | • Spare costs  
|                                     | • Cabling                 |
| Software replacement effort         | • Software conversion  
|                                     | • Additional coding  
|                                     | • Language change  
|                                     | • New board support package |

Tight integration with the CIS software team delivers an integrated cost effective solution
Understanding inventory highlights areas to target for refresh which improves our RAM.

**Processors by Subsystem**

**By Device Bus**

**By Operating System**

**By CPU Type**
Consolidation of compute platforms and software languages is an active project focus for the Controls team

**Now**

**AccuRev, Apex Code Repository**
- Rational Ada, GNAT Ada
- OrbExpress, Java, Jacorb

**Operating Systems**
- VxWorks, Linux, Solaris, Windows

**Platforms**
- Sun, X86, PPC, VME, field buses

**Future**

**Accurev Code Repository**
- Java, Jacob

**Operating Systems**
- Linux, Windows, Virtual Machines

**Platforms**
- x86, VME, field buses

**Technology Refresh**
Reduction of required inventory will help minimize maintenance and spares costs
Transition to current/future OS’es will increase reliability and minimize software support required
Maintenance work processes are assisted by a variety of tools and procedures

- **Inventory management tools**
  - Multi-level bill of materials
  - Warehouse inventory
  - Shortage reports
  - Configuration

- **Maintenance training and tools**
  - Qualification cards
  - Rack layout and cabling database
  - Document retrieval tools specific to control systems

- **Work control tools**
  - Maintenance work orders
  - Preventative maintenance plan
  - Improvements in process

Tools help manage the work, assure quality control and maintain inventory
In summary, our experienced team has proven capable of maintaining and expanding NIF’s controls

• Maintenance facility fully established
  — Fabrication and assembly work centers complete
  — Motor test and evaluation station operating in clean environment
  — Ready spares warehouse and tactical logistics in place
  — Dedicated test stations continue to come online

• Adequate resources are planned to be available
  — Engineering and tech support
  — Instrumentation and troubleshooting aids
  — Spare parts and hot spares

• Maintenance processes and procedures are maturing
  — Work control, inventory and configuration management