

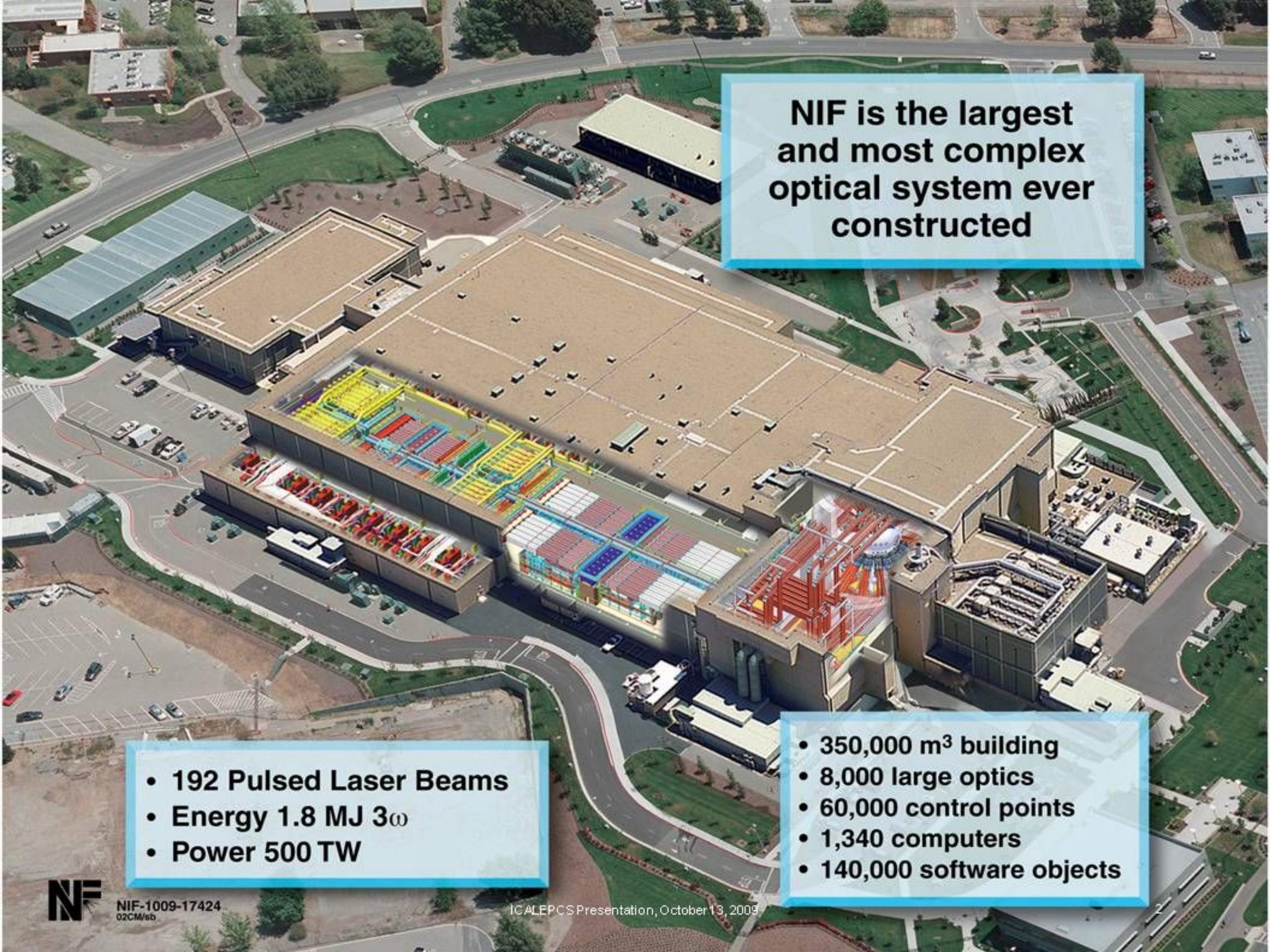
# National Ignition Facility Control & Informational Systems Operational Tools

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October 13, 2009  
Lawrence Livermore National Laboratory, USA

IM-379392



**NIF is the largest  
and most complex  
optical system ever  
constructed**

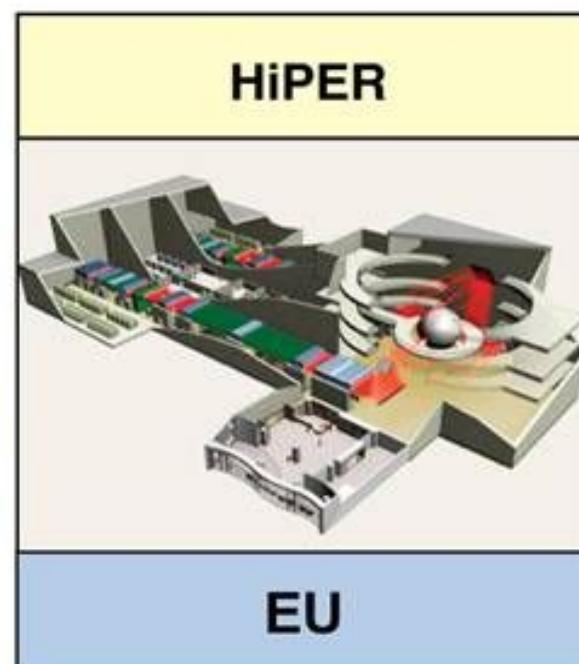
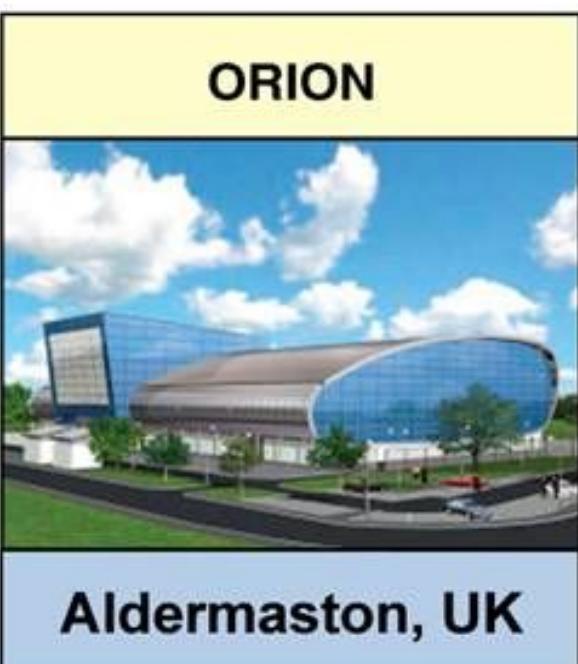
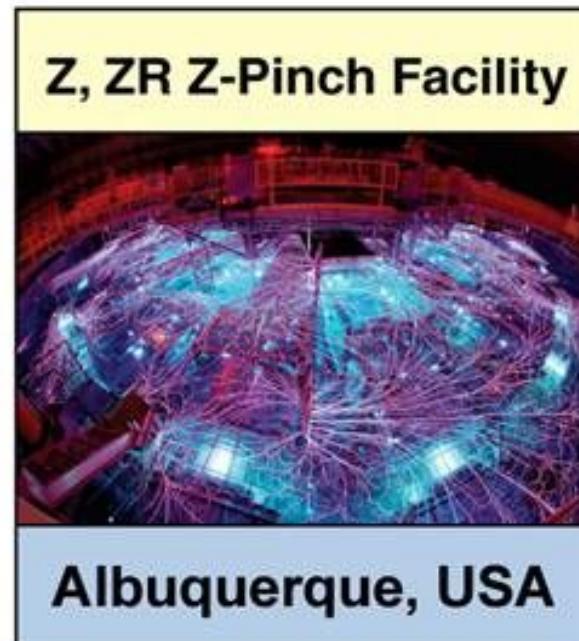
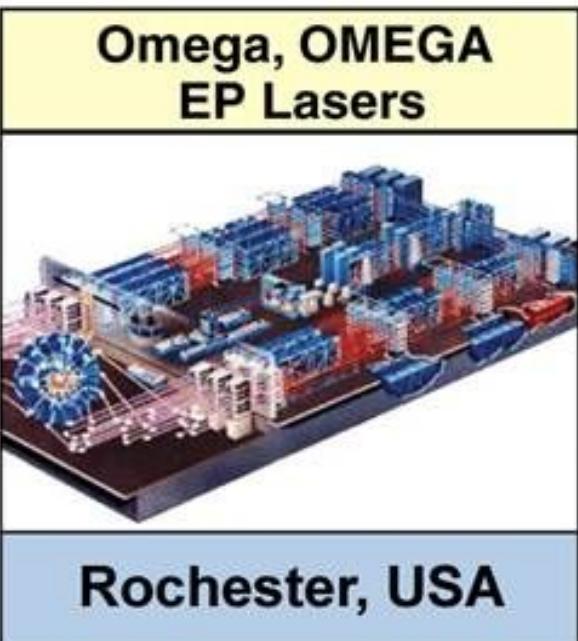
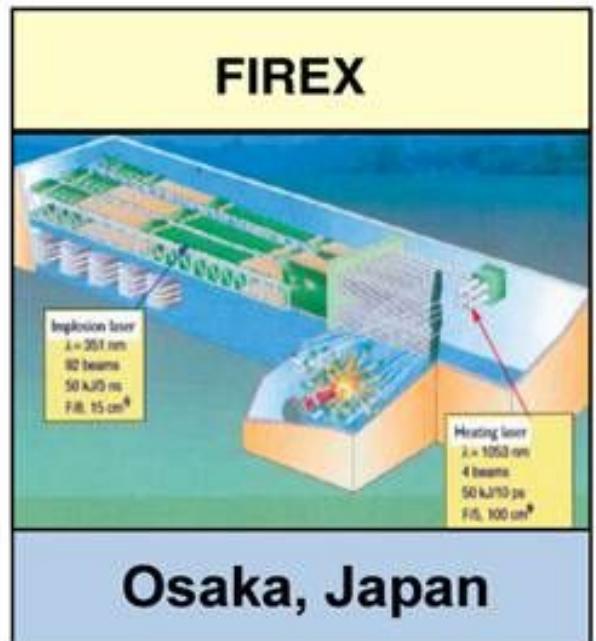
- 192 Pulsed Laser Beams
- Energy 1.8 MJ  $3\omega$
- Power 500 TW

- 350,000 m<sup>3</sup> building
- 8,000 large optics
- 60,000 control points
- 1,340 computers
- 140,000 software objects

# NIF is part of a growing international community of inertial fusion and high energy density science facilities



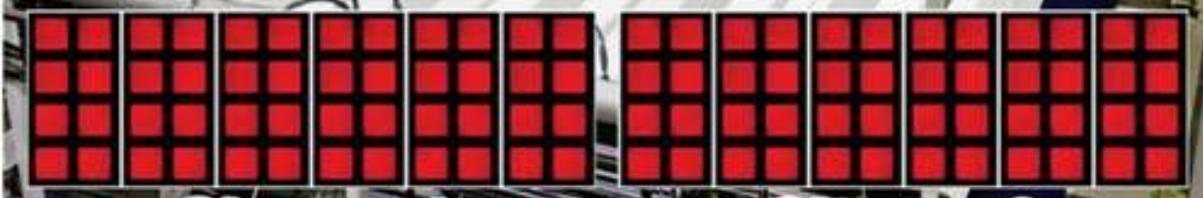
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The NIF laser system consisting of 192 beams was operationally qualified in September 2008

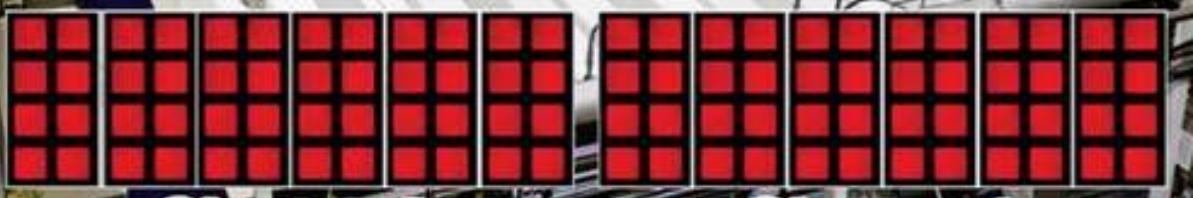
World's highest energy laser — 4 MJ 1  $\mu\text{m}$  light



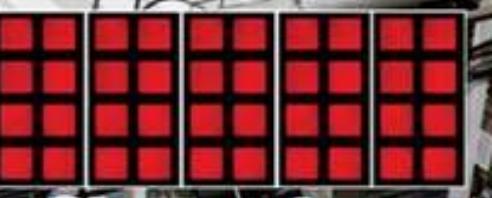
Cluster 4



Cluster 3



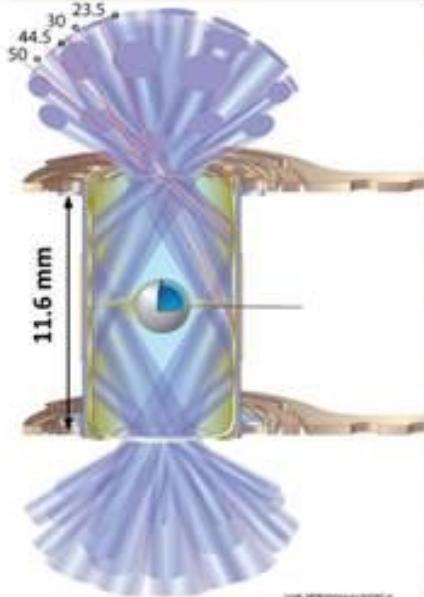
Cluster 2



Cluster 1

Initial fusion experiments with neutron yield were conducted with 200 diagnostic data channels in September 2009

Cryogenic target surrounds spherical capsule with hydrogen

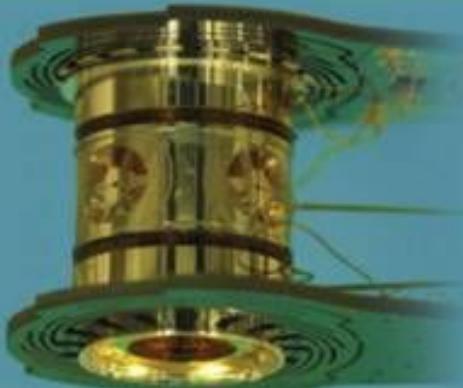


# NIF core operational tools\* are utilized during the entire experiment from conception to execution



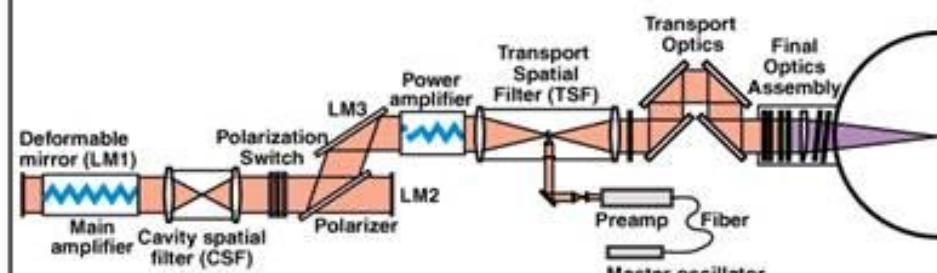
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## Experiment setup (t-10 to 1 days)



- End user input
- Laser Optimization

## Shot cycle “turn-on” in progress (t-8 to 0.5 hours)



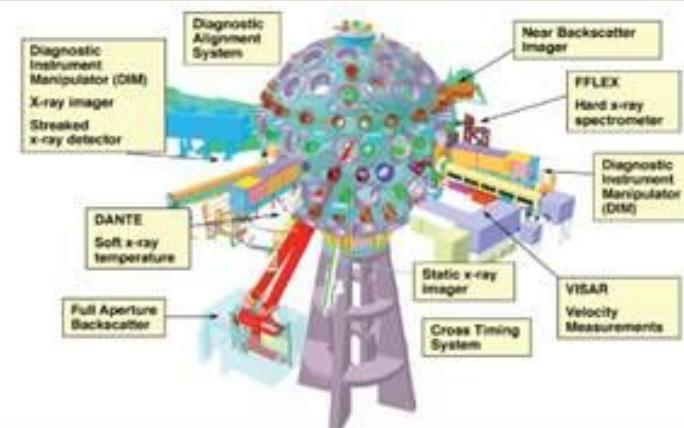
- Experimental goal change management

## Pre-shot cycle Readiness (t-24 to 8 hours)



- Laser and Diagnostic HW Configuration
- Operational Restrictions

## Final countdown (t-5 to 0 minutes)



- Critical device status verification redundant to main control system

# Campaign Management Tool performs experimental setup for multiple shots



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The screenshot shows the NIF Campaign Management Toolset (CMT) interface. The main window displays a 'Campaign: Hohl\_Energetics\_PartIA' table with columns for Experiment Type, Action, and various System Shot parameters (e.g., 1.76471, 1.76471, 1.76471). The interface includes a menu bar (File, Edit, Format, Experiment, Analyze, Options, Help) and a toolbar with icons for file operations.

**Laser**: An inset image showing the complex optical infrastructure of the laser system.

**Target**: An inset image showing a target capsule being positioned for a shot.

**Pulsed Power**: An inset image showing the pulsed power facility, which provides the energy for the lasers.

**Diagnostics**: An inset image showing the diagnostic equipment used to monitor and analyze the experiments.

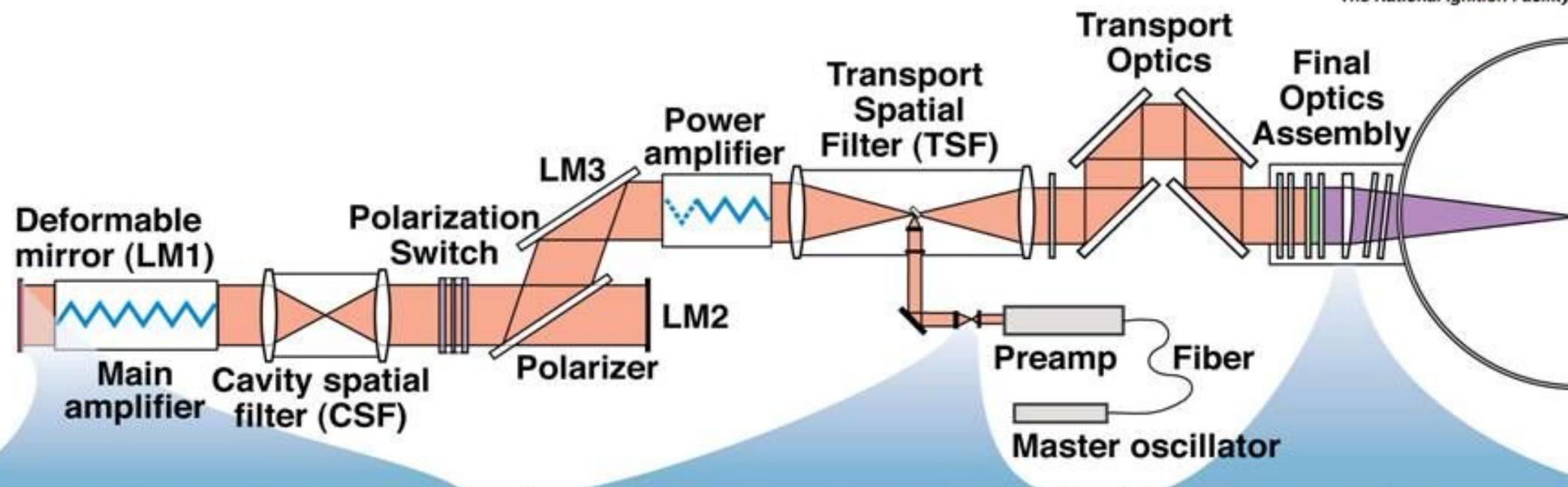
**Key Features:**

- Template shots
- Derived setup
- Rule enforcement
- Apply defaults
- Visual setup aids

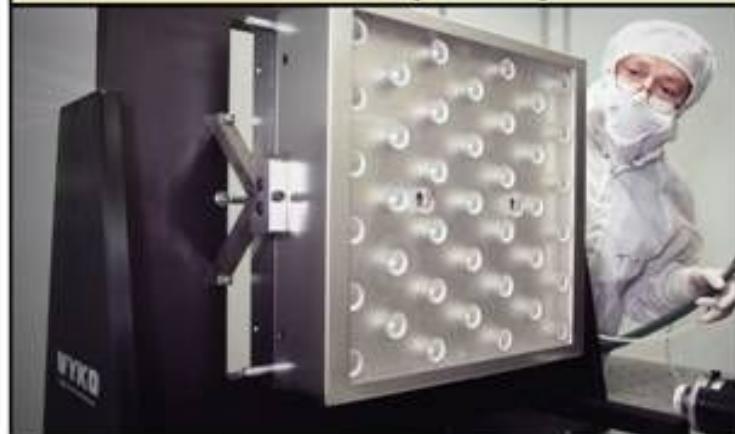
# Laser Performance & Optimization Model (LPOM)



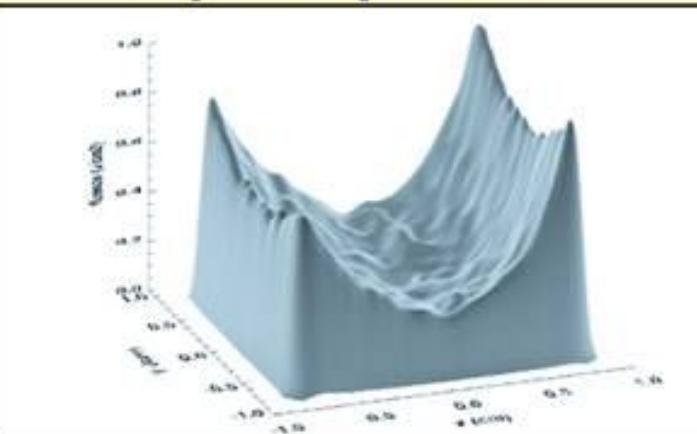
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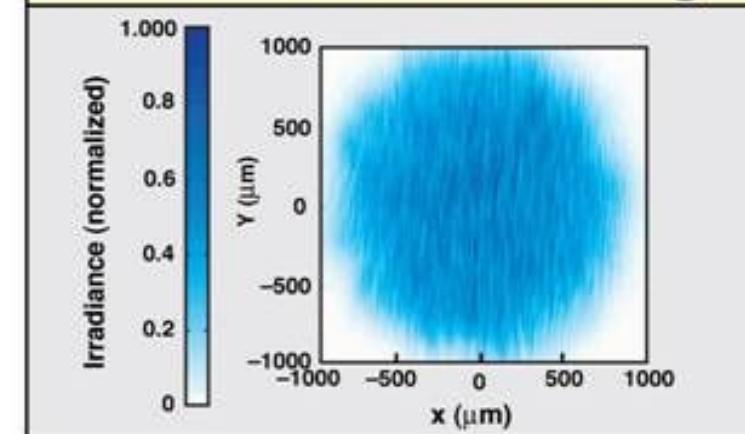
**Deformable mirror (LM1)**



**Typical requested spatial profile**



**UV light focused with diffractive conditioning**

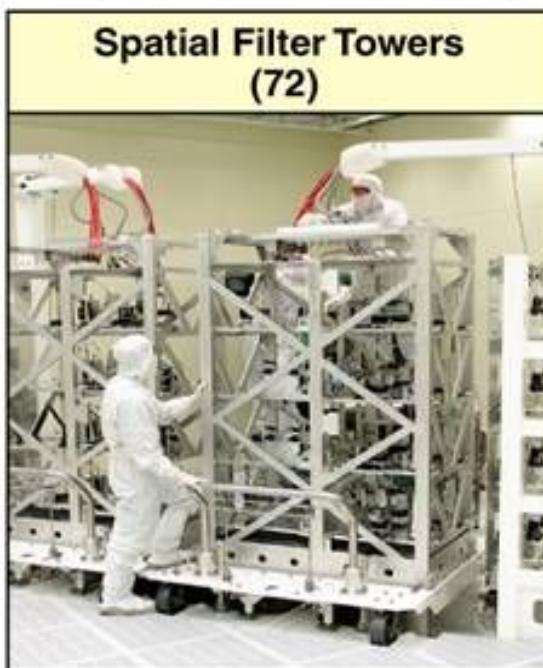
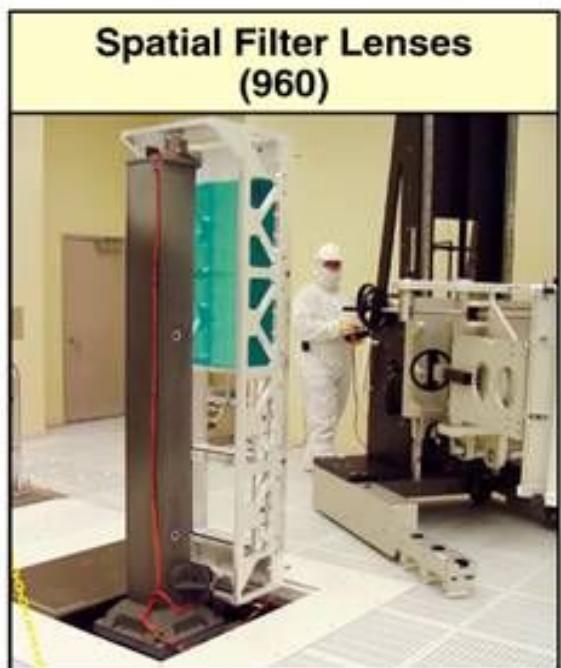
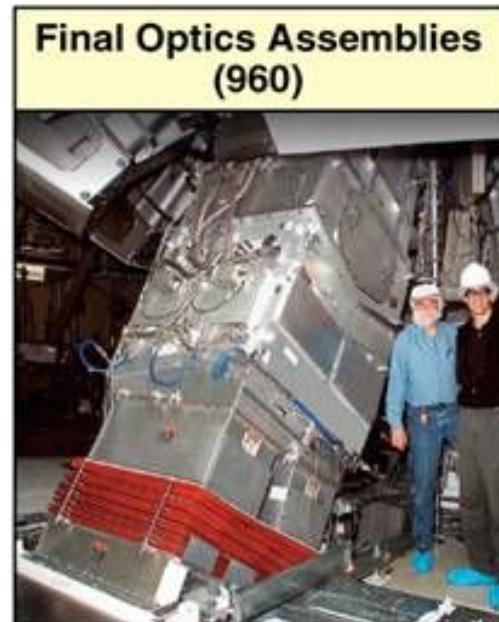
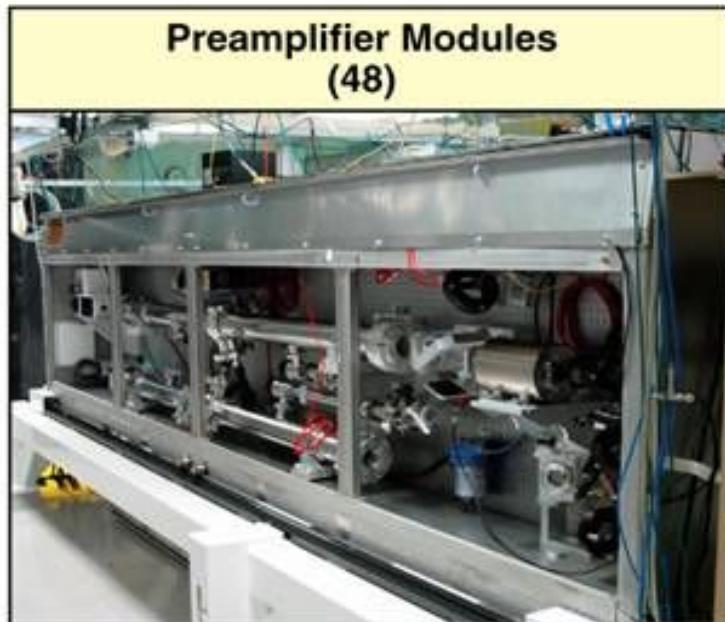


- Laser performance is optimized to meet experimental goals for each shot
- Independent machine safety verification

# NIF is comprised of 6,200 Line Replaceable Units (LRUs)

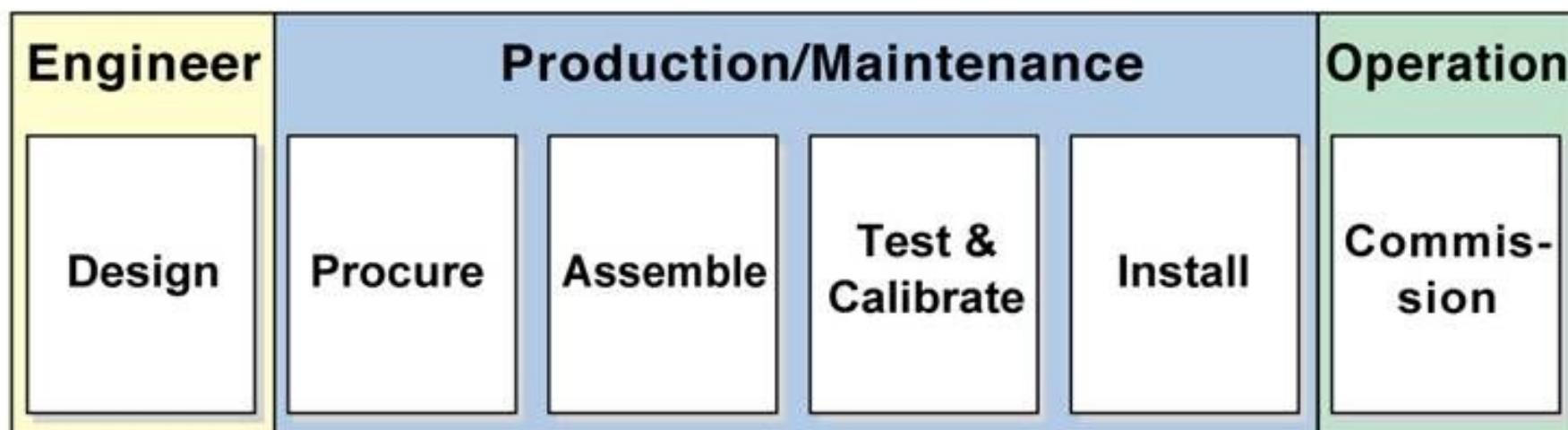


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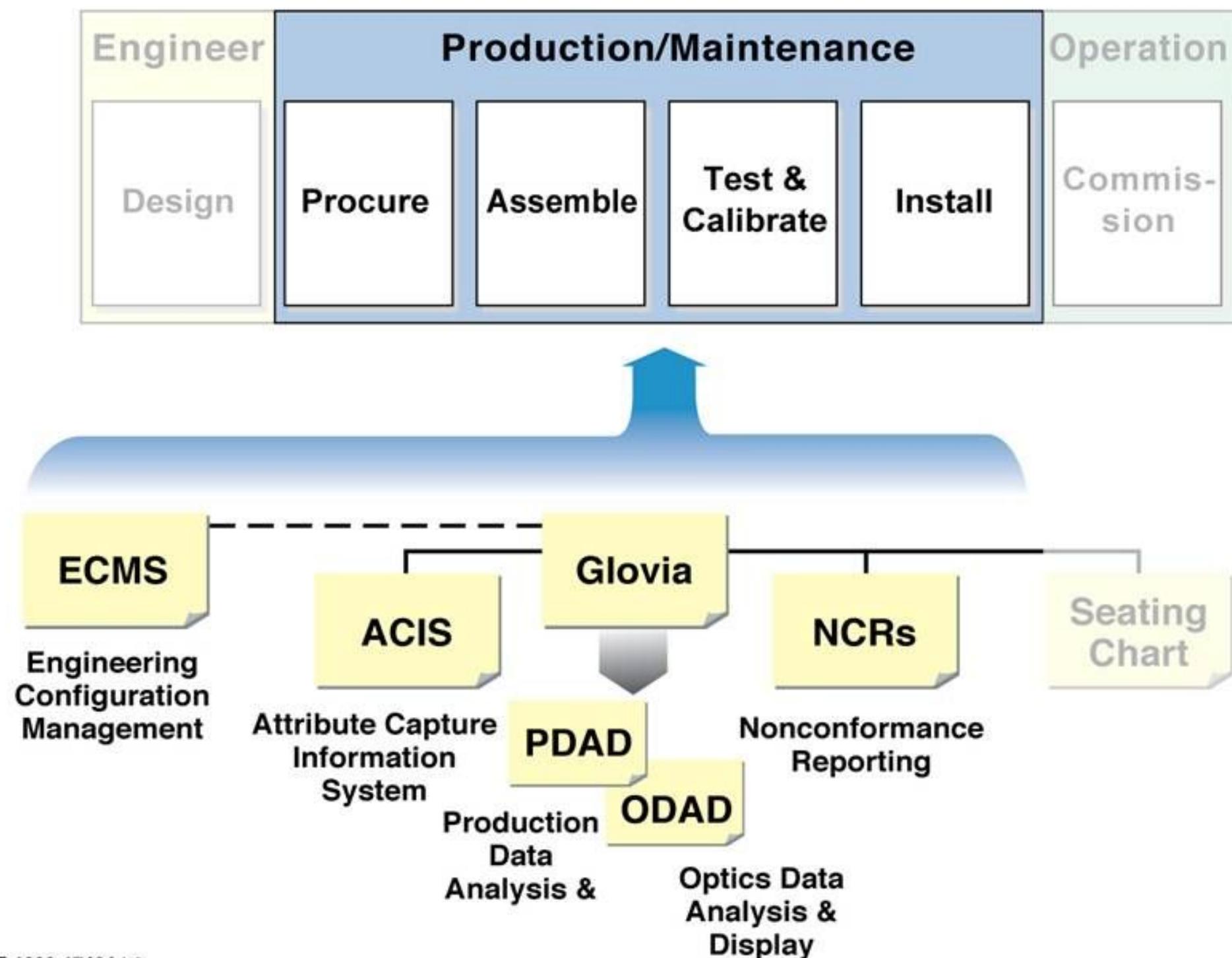


Managing the installation and operational status of LRUs requires information tools

# LRU process life cycle



# LRU Information Technology Tools



# Information tools help manage configuration and work flow processes



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A screenshot of a web browser window titled "Internet Explorer provided by NIF". The browser interface includes a toolbar, address bar, and menu bar. Below the toolbar, there are tabs for HOME, APPLICATIONS, SUPPORT, and COMPUTER SECURITY. The date displayed is Wednesday - September 30, 2009.

The main content area shows a navigation menu on the left and several functional modules:

- Commissioning Activity**: Includes links for Create New Log, All Issues, Actions, Problems, NCRs, Restrictions, Ops, and Notes.
- Work Authorization**: Includes links for Create New Work Permit, Work Permits, Loto Configuration, IWS Administration, NIF Site Forms, and Unified System Hierarchy.
- Work Activity**: Includes links for Create New Order, Service Orders, Work Orders, Install Orders, and Remove Orders.
- Datasets**: Includes a link for Add Calibration Data.
- Reports**: Includes a link for LoCoS Reports.

On the right side of the screen, there is a facility status map showing the layout of the NIF site with various buildings and laser bays labeled. A blue arrow points from the "Commissioning" module to the "Commissioning" section of the map. Another blue arrow points from the "Reporting" module to the "Facility Status" map. A third blue arrow points from the "Work Control" module to the "Work Authorization" and "Work Activity" sections of the left sidebar.

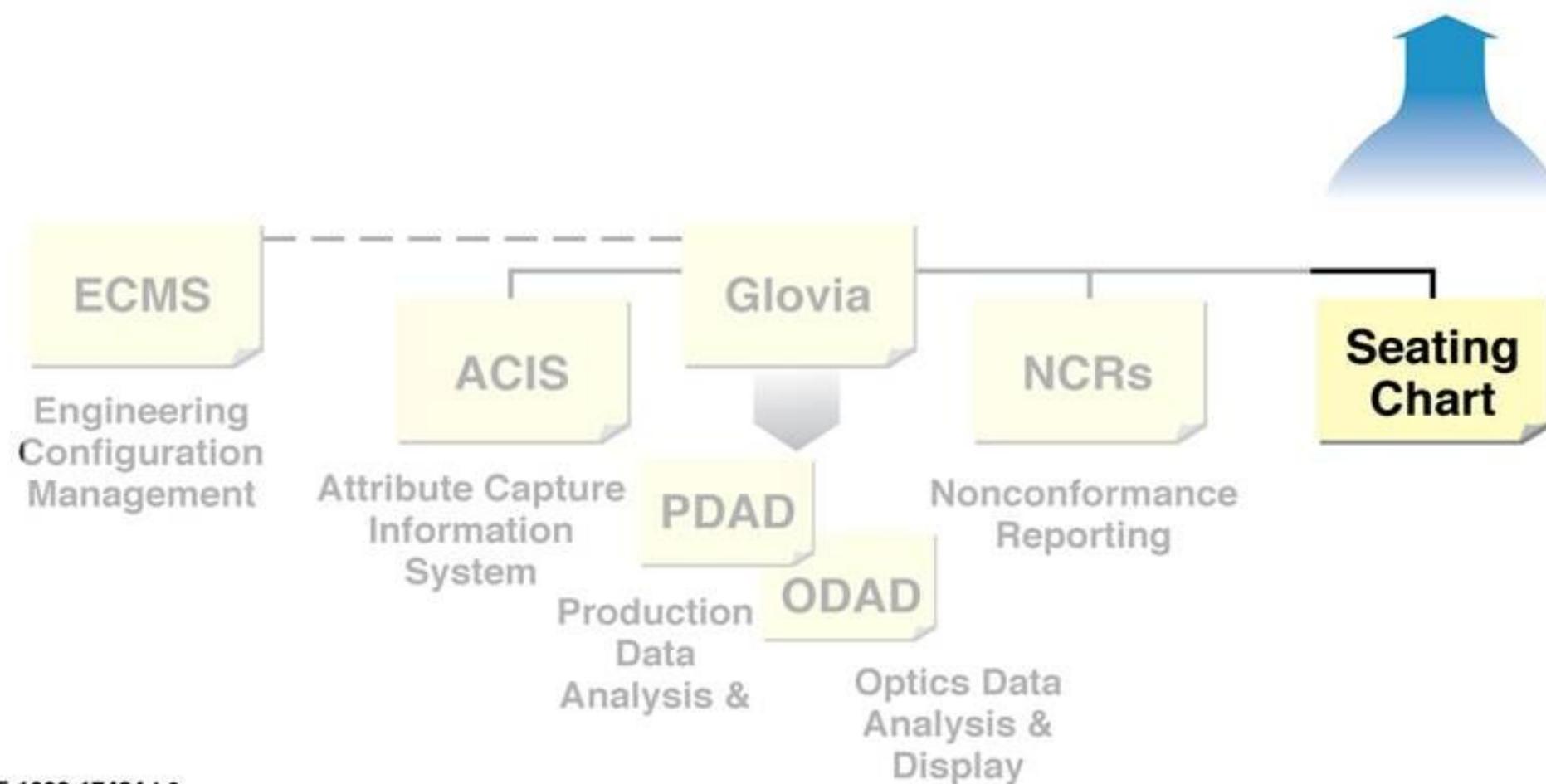
**Commissioning**

**Work Control**

**Reporting**

NIF-1009-17433  
06CMtr

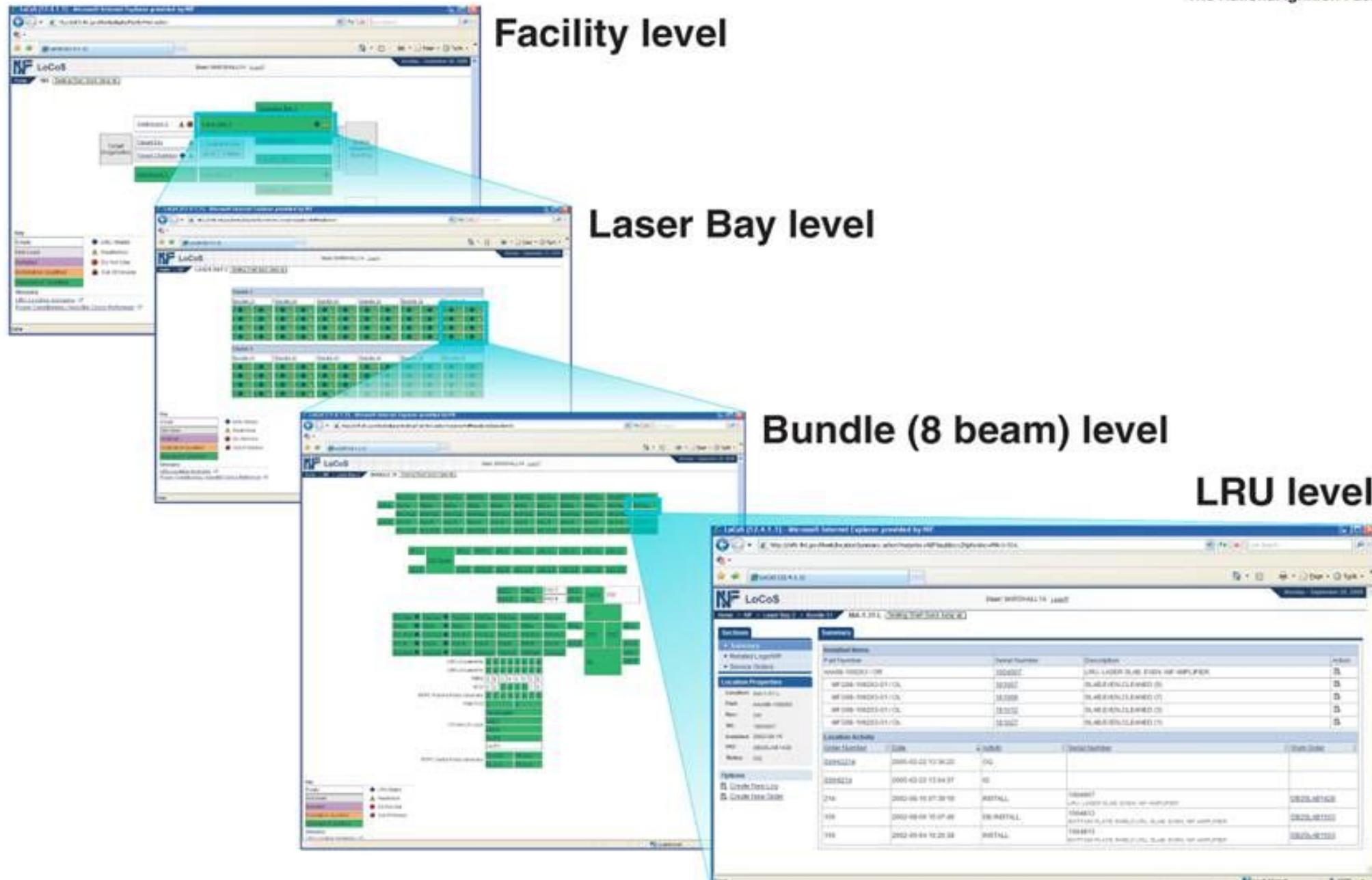
# LRU Information Technology Tools



# Location and Component System (LoCoS) tool tracks the status of all 6,200 LRUs



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**LoCoS is a hierarchical web-based application with extensive drill down from facility level to individual parts**

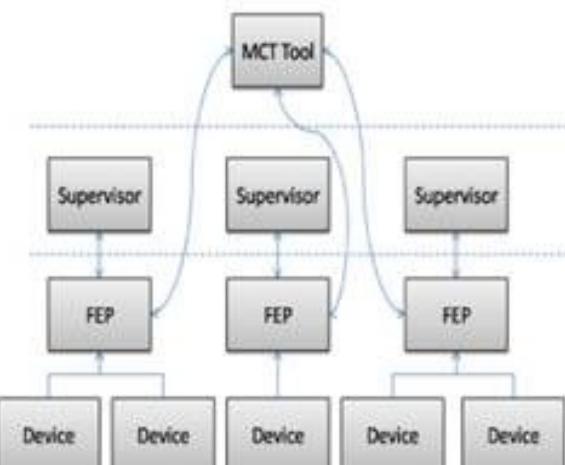
**LRUs are commissioned & maintained with tools that update calibration, alignment, imaging, & timing**



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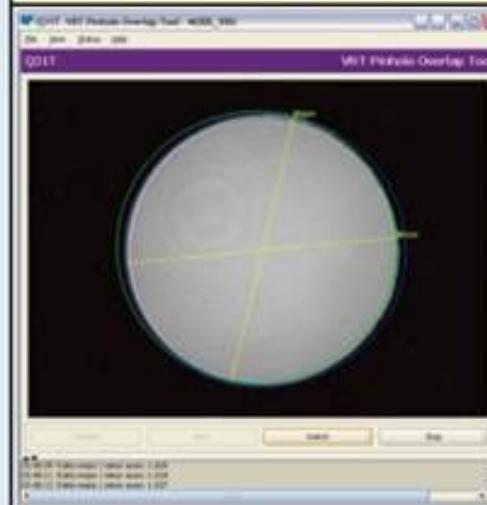
## Architecture

Tools are linked below Supervisory shot control



## Examples

Pinhole overlap tool



Injection laser pointing stability tool



- **25 Automated Maintenance and Commissioning Tools in use**
  - Substantial time savings
  - Reduced operator error
  - Reduced operator subjectivity
  - Codified verifiable algorithms
  - More frequent use
  - Consistent detailed logs

# Pre-shot Experiment Readiness Checker compares requirements with current configuration



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ExRA Version 1.0.0 - Microsoft Internet Explorer provided by NIF

ExRA  
Experiment Review & Approval

Home Experiments List EXPERIMENT REPORTS

Configuration CHECKER

- High Level Shot Plan
- Beam Control
- Power Conditioning
- MOR
- ILS
- Laser Diagnostics
- POS
- Target Area

Approval

- Approval Status

Experiment Properties

ID: RT\_GreenPhotography\_301  
Title: De-Zeroing without Beamways  
Description: Pulse RadThru\_B rms<=RT\_GP\_Cut\_0.5G21%\_Tgt\_VIV's closed w/Beams to Roger  
Status: READY  
RI: Copper\_Amp  
LPOM: 3rd2009  
Run:

Laser Diagnostics PAETS Beams Pinhole Wheels Wavefront Controls

Participation & Fates

Cluster 1	Cluster 2	Cluster 3	Cluster 4
SHUTTER	SHUTTER	SHUTTER	SHUTTER
DMP_DAL	DMP_DAL	DMP_DAL	DMP_DAL
PAETS	PAETS	PAETS	PAETS
Beams	Beams	Beams	Beams
Pinhole Wheels	Pinhole Wheels	Pinhole Wheels	Pinhole Wheels
Wavefront Controls	Wavefront Controls	Wavefront Controls	Wavefront Controls

FOC Reflection

Cluster 1	Cluster 2
Y	Y
N	N
NC	NC

Pinhole Check

Cluster 1	Cluster 2
Y	Y
N	N
NC	NC

OSP Hartmann Coarse - Main Shot

Cluster 1
Y
N
NC

OSP Hartmann Fine - Rod Shot

Cluster 1
Y
N
NC

OSP Hartmann Fine - Main Shot

Cluster 1
Y
N
NC

Real-time control room tool

Facility Readiness verification

- Laser filtered by beam fate
- Target Diagnostics
  - Hardware installation
  - Operational Status
  - Timing
  - Filters

Restrictions

- Optical Power / Energy
- Beam Pointing

# Shot in progress experimental goals are optimized with shot operations change management



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LPOM Experiment Info - Microsoft Internet Explorer provided by HIR  
http://lpo.mll.gov/0034e/system/1expd/nif\_Energ\_P1\_Clone\_518a.html?subview=Q31T

NF LPOM  
Laser Performance Operations Model

Experiment Info

ExpID: Hohl\_Energ\_P1\_clone\_518a MISAR

PI: Dixit, Shailendra Quad: Q11T Date: 10/13/2009

Desc: Cryo Hohlräum Energetics Emulator: 60 GHz SSD, Diam = 1.5 A, cf = 0.33; clone of S16\_Q36T and Q31B PR reconfig

Status: READY

Setup Equipment Protection | Projects | Model Summary | Reports | Near Field | Debug |

Hohl\_Energ\_P1\_clone\_518a\_Q31T

PREDICTED REQUESTED

Region	ISP	DSP	DRM	3rd TCC	Energy	Location	TRANSMISSION
(mJ)	L1	(mJ)	(mJ)	(mJ)	(mJ)		
0.00422	0.751364	0.00519	2.727324	B311	2.712568	TCC	0.98 0.961 8311
	0.81547	2.334495	B312	2.712568	TCC	0.975 0.963 8312	
	0.30582	2.720202	B313	2.712568	TCC	0.98 0.954 8313	
	0.30167	2.709152	B314	2.712568	TCC	0.98 0.937 8314	

MOR Output (Q11T)

MOR: PAM Input sensor Beam Path

Pulse Length (ns): 10.9

Gap (ns): 10.9

Post Pulse (ns): 2.0

MOR Energy (J): 0.002

Conversion Ratio: 0.003

SSD Grating of 550.0 Modulation of 1.0

Equivalent SSD Bandwidth of 1.0 (CH) 60.0 Outer Wavelength: 10530.5A

PAM Gain Attenuators PAPTS

SHG THG SHG THG PH

B311	1.4	0.98	105.0	30.0
B312	1.101	1.0	-229.0	30.0
B313	1.4	0.99	105.0	30.0
B314	1.19	0.900	220.0	30.0

Q31T Aperture Beam Config: 0.25%

Shots 1-8: M1-M2, M3-M4, M5-M6, M7-M8, M9-M10, M11-M12, M13-M14, M15-M16, M17-M18, M19-M20, M21-M22, M23-M24, M25-M26, M27-M28, M29-M30, M31-M32, M33-M34, M35-M36, M37-M38, M39-M40, M41-M42, M43-M44, M45-M46, M47-M48, M49-M50, M51-M52, M53-M54, M55-M56, M57-M58, M59-M60, M61-M62, M63-M64, M65-M66, M67-M68, M69-M70, M71-M72, M73-M74, M75-M76, M77-M78, M79-M80, M81-M82, M83-M84, M85-M86, M87-M88, M89-M90, M91-M92, M93-M94, M95-M96, M97-M98, M99-M100

NF Laser Performance Operation Model Faux Shot Supervisor

Configuration: Experiment ID: 0.01\_J204\_Der-3\_518a  
Shot ID: 00002440-000  
Shot Type: Not Defined

Countdown: Countdown: 0  
Time Held: 0

Shot Log: Shot Configuration: Steps: Collaboration SL: Change Manager: Critical Devices: Setup Power:

Note: Note adding change request  
Select All: Hold Selected: Approve Selected Requests  
Deselect All: Un-select All  
Select Sub: Type: Level: Location: Time: Value: Shot Type: Pad: U/D: Calc.: Change Shot: Status: Time: Copy: Delete: Approve:  
CH\_CHANGE\_SETTING: Q40: Q31: DP\_CAL\_SABN: G4P1: All: NO: NO: NONE: REQUESTED: 10:50:15:3: Copy: Delete: Approve:  
CH\_CHANGE\_DIAGNOSTIC\_REL: Q40: Q31: DP\_DIAG1\_NODE: 1000E: All: NO: NO: NONE: REQUESTED: 10:50:15:3: Copy: Delete: Approve:  
All Request: View Participants:

- Laser Performance and Optimization analysis is performed during shot setup

- Derived setting update requests are automated (manual also supported)

- Requests are approved or rejected by Shot Director using change management GUI

**Status Verifier Tool independently verifies the machine safety and device lock-out of 6,600 devices at shot time**



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