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Office of Facilities & Property Management

NIST FACILITIES NEEDS

NIST
National Institute of Standards and Technology

October 18, 2016

VCAT Presentation

NIST

- NIST's Enterprise Risk Management
  - Number One Risk: Facility deficiencies

- NIST Three Year Programmatic Plan 2017 – 2019
  - GOAL: Strengthen NIST's Laboratories and Facilities to ensure U.S. Leadership in Measurement Science.
    - To push beyond the limits of today's advanced technology require stability.
    - Aging facilities and the extensive backlog of deferred maintenance put research at risk.

Facilities

Overall NIST has over 1,200 acres across its four sites. Consisting of 97 buildings and structures totaling over 4.5 million square feet.

The Gaithersburg site is comprised of 579 acres with 61 buildings and structures totaling 3.6 million GSF.

The Boulder site covers 206 acres with 30 buildings and structures totaling 896,000 GSF.

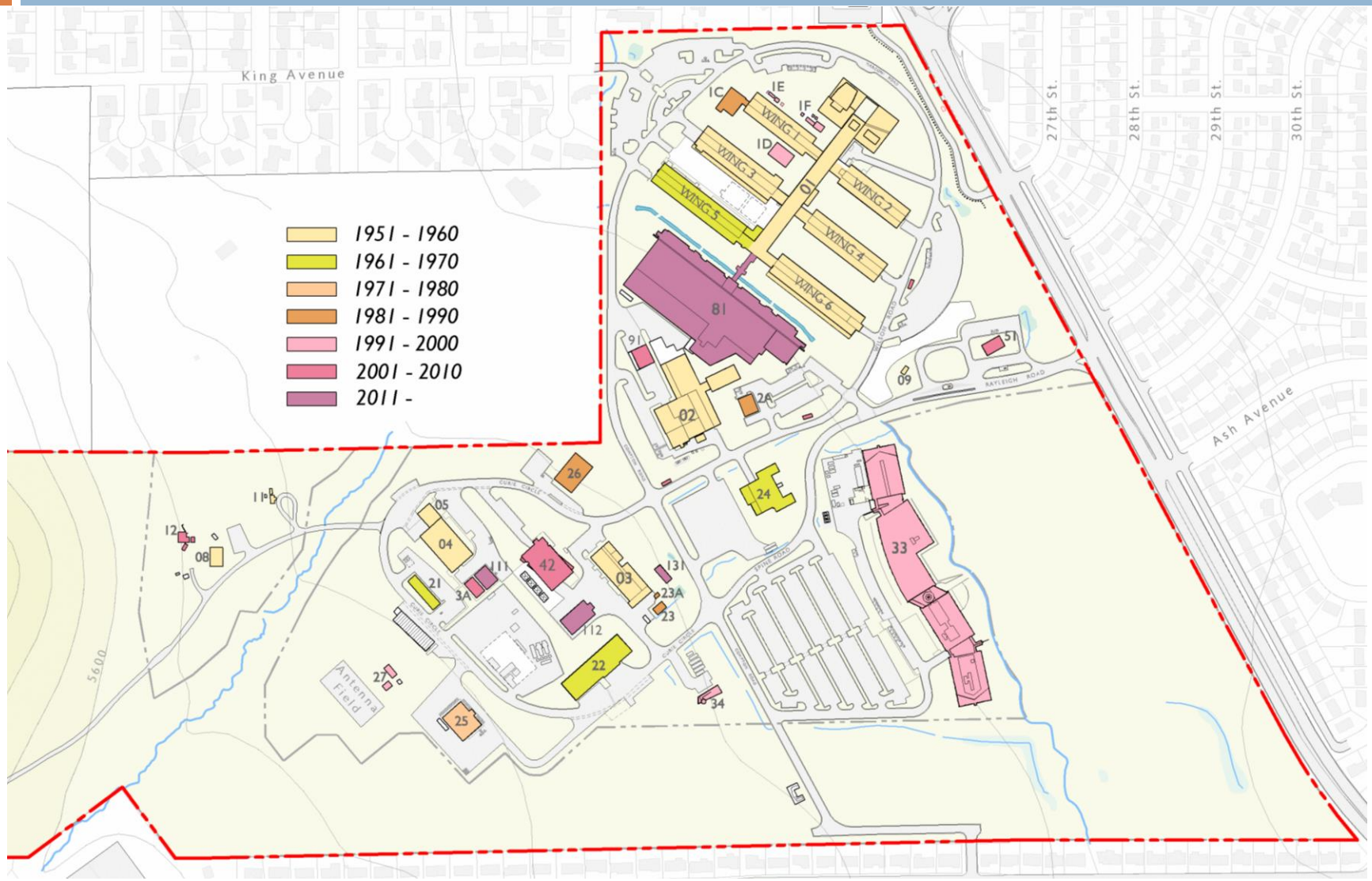
Facilities

Fort Collins Field site covers 390 acres with 5 buildings and structures totaling 19,000 GSF.

Kauai Field site is located on the Barking Sands Pacific Missile Range Facility; the site covers 31 acres and has 1 building totaling 6,000 GSF.

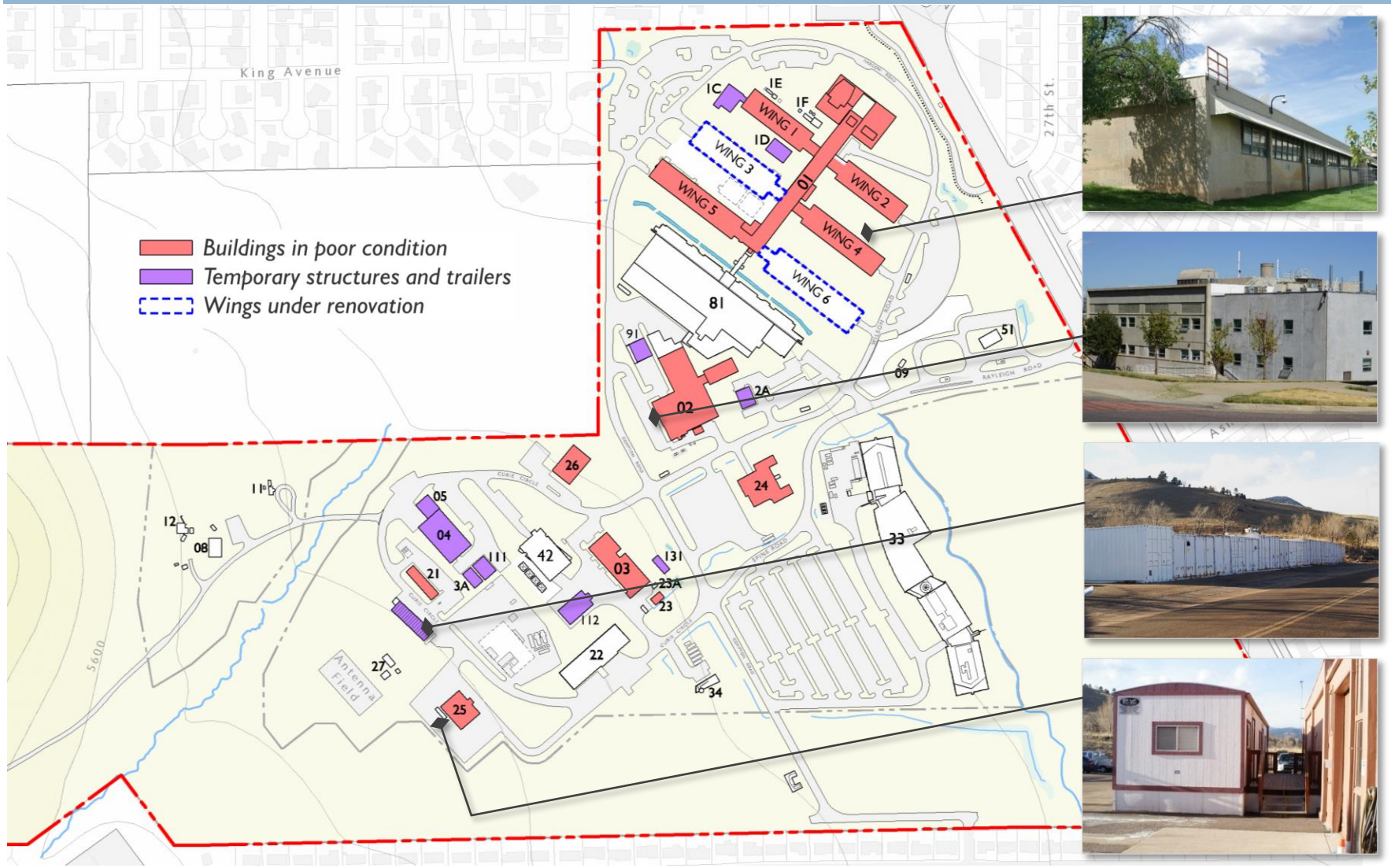
Facilities Construction History

(Boulder)



Facilities Conditions

(Boulder)



Facilities Construction History

(Gaithersburg)

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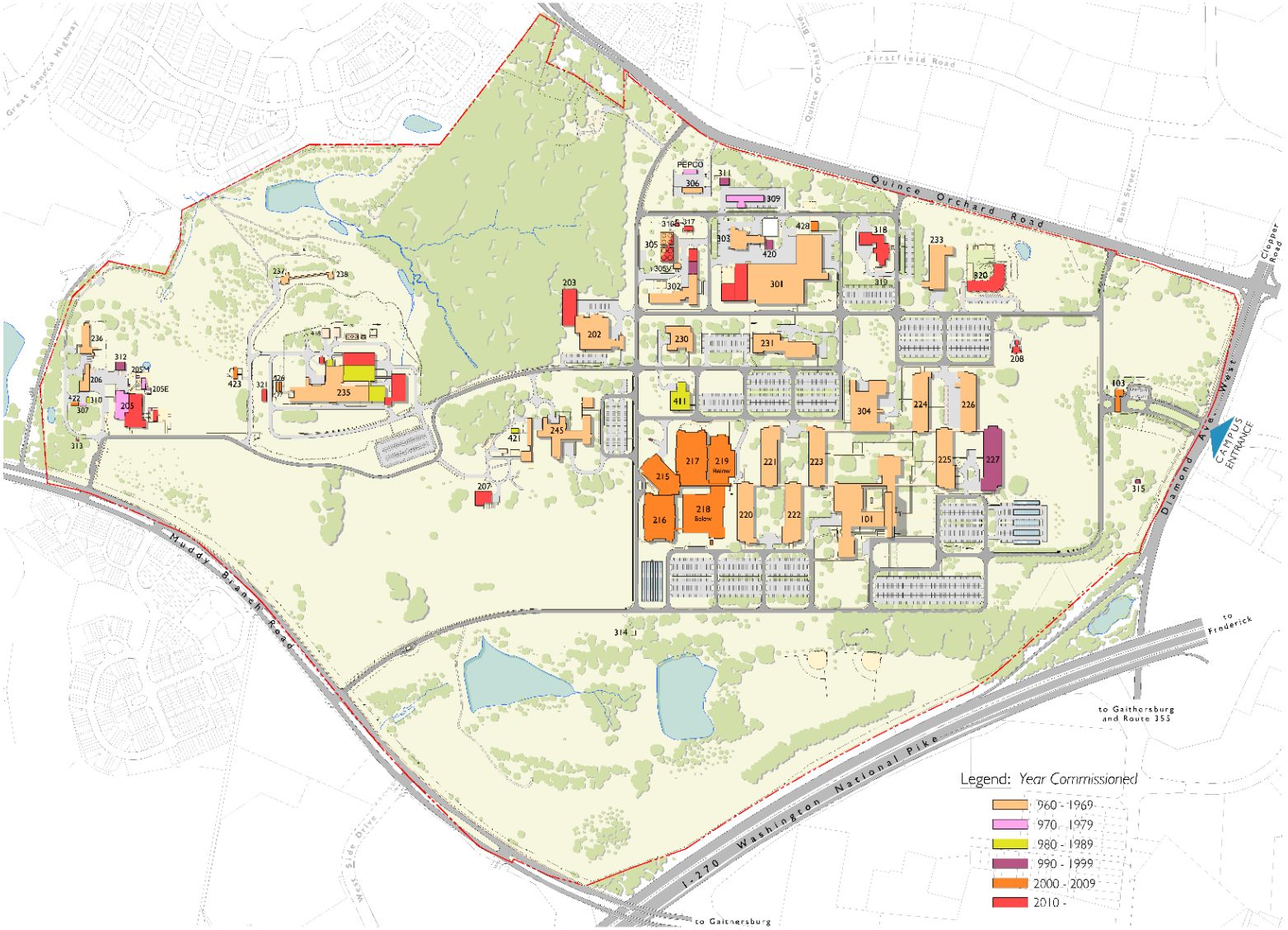

Facilities Conditions

(Gaithersburg)

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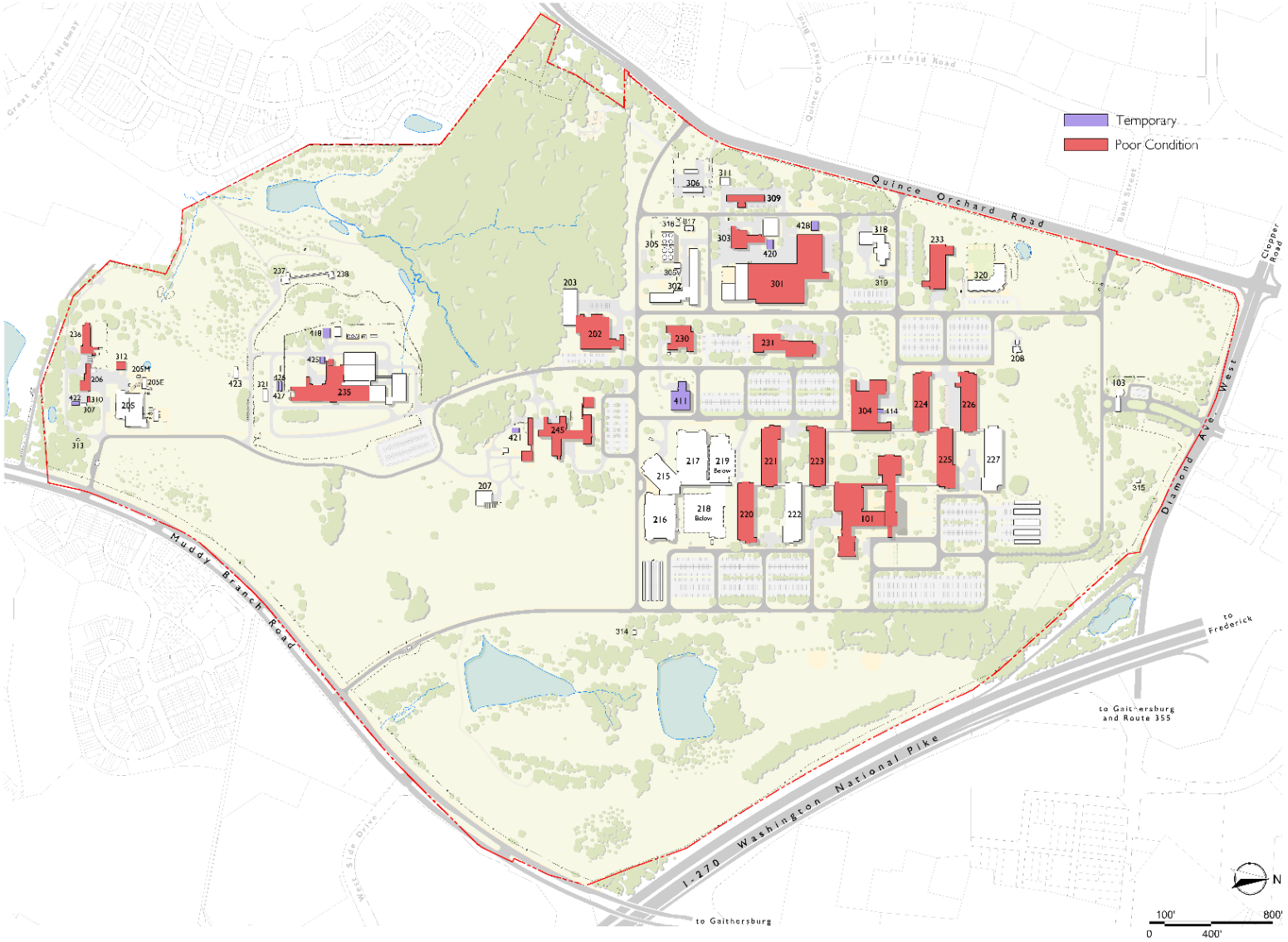

Facility Deficiencies

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- Lack of temperature stability
- Lack of humidity control
- Lack of vibration control
- Inadequate quality & quantity of power
- Deficiencies in piped services to labs
- General degradation in infrastructure equipment & distribution
- No redundancy of infrastructure systems
- Components for legacy equipment are difficult to obtain

Facility Condition Assessment (FCA)

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- Facility Condition Index (FCI)
  - Is an industry standard parametric tool used to relatively compare building conditions.
  - Comparison of Deferred Maintenance Backlog to Current Building Replacement Value.
    - Excellent > 95
    - Good 90 - 95
    - Fair 85 - 90
    - Poor < 85
- Gaithersburg – Overall FCI = 84.0
  - Conducted site-wide FCA and building sustainability assessments in 2011 and partial FCAs and sustainability assessments (i.e., 1/3 of site per year) in 2013 and 2014.
  - Conducting partial FCA and building sustainability assessments in Fiscal Year 2015.
  - Awarding new multi-year FCA contract in 2016 for all NIST sites.
- Boulder – Overall FCI = 82.0
  - Conducted site-wide FCA and building sustainability assessments in 2013.
  - Conducting partial FCA and building sustainability assessments in 2015.
  - Future partial assessments will be conducted under the new NIST FCA contract.

Facility Condition Assessment (FCA)

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- Current Backlog of FCA Projects:
  - Gaithersburg: $271.0 M (3.6 M GSF; $75 per square foot)
  - Boulder (including Kauai & Ft. Collins): $75.2 M (0.92 M GSF; $82 per square foot)
- Federal Facilities Council, Report Number 131: Budgeting for Facilities Maintenance & Repair Activities, 1996, Recommends:
  - Annual Funding of 3% to 4% of Current Replacement Value
- NIST Buildings & Structures Current Replacement Value: $2.670 B
  - Gaithersburg
  - Boulder
  - Kauai radio station
  - Ft. Collins radio station
- Current Funded Percentage – just under 2% ($50M/$2.670B)
- Recommended Annual Funding Level for Facilities Maintenance & Repair Activities: $80 M to $107 M

Facility Condition Assessment (FCA)

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Project Backlog by Category $346.2 M

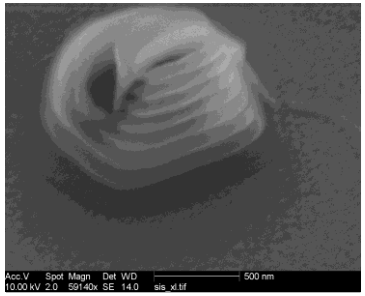
- Architectural Repairs/Replacements..... $ 13.4 M
- Central Utility Plant Expansion/Replacement..... $ 1.3 M
- Civil/Site Environmental Repairs/Replacement..... $ 14.6 M
- Conveying System Repairs/Replacements..... $ 2.1 M
- Energy/Water Conservation..... $ 36.6 M
- Exhaust & Air Filtration System Repairs/Replacements..... $ 13.1 M
- Hazardous Material Removal..... $ 22.1 M
- Mechanical-Electrical System Repairs/Replacement ..... $209.8 M
- Site Alarm & Fire Safety Repairs/Replacements..... $ 3.1 M
- Site Utility System Repairs/Replacements/Upgrades..... $ 12.8 M
- Structural Repairs/Replacements..... $ 17.3 M

Facility Condition Impact on Research

	General Lab Level 1 (L1)	General Lab Level 2 (L2)	General Lab Level 3 (L3)	High Performance Lab (L4)	Instrument Lab (L5)	Precision Metrology Lab (L6)
Temperature Control (°C)	+/- 2	+/- 1	+/- 0.5	+/-0.5 +/-0.25 in enclosure	+/-0.25	+/-0.1
Relative Humidity Control	NA	+/- 20%	+/- 20%	+/- 10%	+/- 5%	+/- 5%
Air Filtration Class	100,000	100,000	10,000	10,000	100	100
Vibration Control (micrometers / second)	Insensitive	12.5	<12.5	6	3	<3

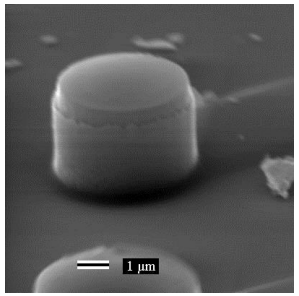
Current Laboratories Do Not Support Critical Technical Needs

"Quantum dot" – controlled source of single photons for quantum communications, telecommunications, laser measurements, etc.



Non-functioning quantum dot due to poor lab conditions.

Good fabrication result.



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Construction of Research Facilities (CRF) Future Plans

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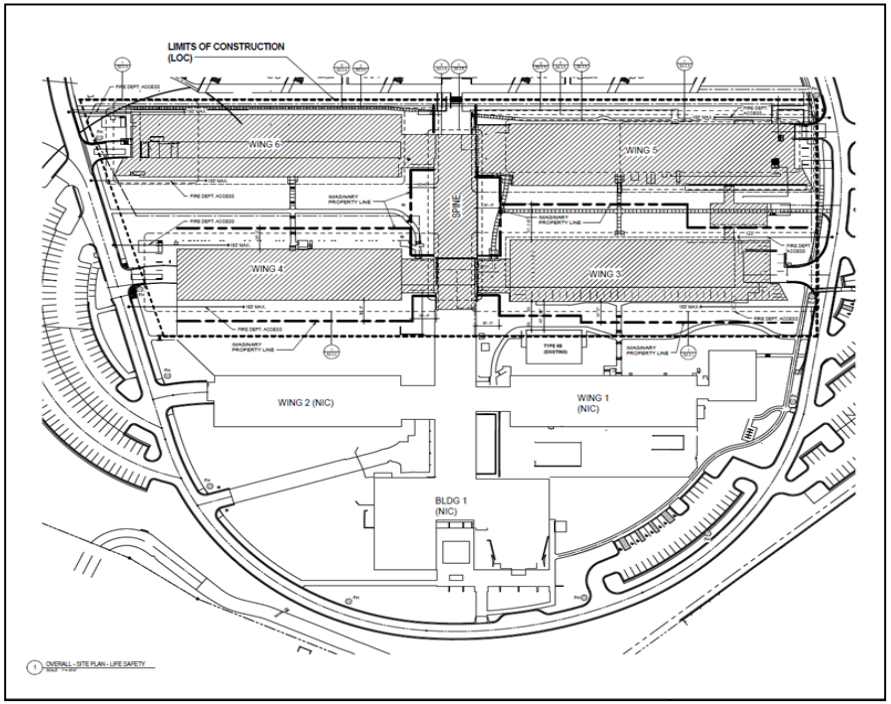
- Complete B1R in Boulder
- Start major renovations in Gaithersburg
  - Building 245 Modernization
    - Oldest research facility on campus with significant mechanical and code deficiencies; Program of Requirements developed & Preferred Alternative identified.
  - General Purpose Labs (GPL) Revitalization
    - Research Facilities Strategic Plan complete; provides basis for assessing current and future space needs. Identified a modernization & implementation strategy.
  - Building 101 Revitalization
    - Mechanical and exterior walls systems study complete; Functional relationships and efficiencies of administrative functions study complete
- Safety, Capacity, Maintenance and Major Repair (SCMMR)
  - Using Facility Condition Assessments to plan and track Facility Condition Index (FCI)
- Energy Savings Performance Contract
  - Gaithersburg: Combined Heat-Power Plant-8MW unit, supplying 40% of electricity and 80% of steam needed with significant reductions in Green House Gas

Boulder Master Plan Concept

Building 1 Renovation (B1R)

(Boulder)

- Current Estimated Project Budget: $195.5 M
- Currently Funded (thru FY16): $91.5 M
- Projected Project Completion: FY2023
- Total Renovation Area: 214,900 GSF
- Exterior Renovation of Wings 3 & 6 is complete with the interior build-out of Wings 3 & 6 in progress. Projected completion – October 2016.
- Project includes renovation of Building 1, Wings 3, 4, 5, 6, and a limited portion of the Center Spine; includes construction of service corridors.
- Project also includes renovation of Building 3 for the Communications Technology Laboratory (CTL).
- Replaces obsolete & inadequate facilities; significantly improves control of temperature, humidity, and air cleanliness.



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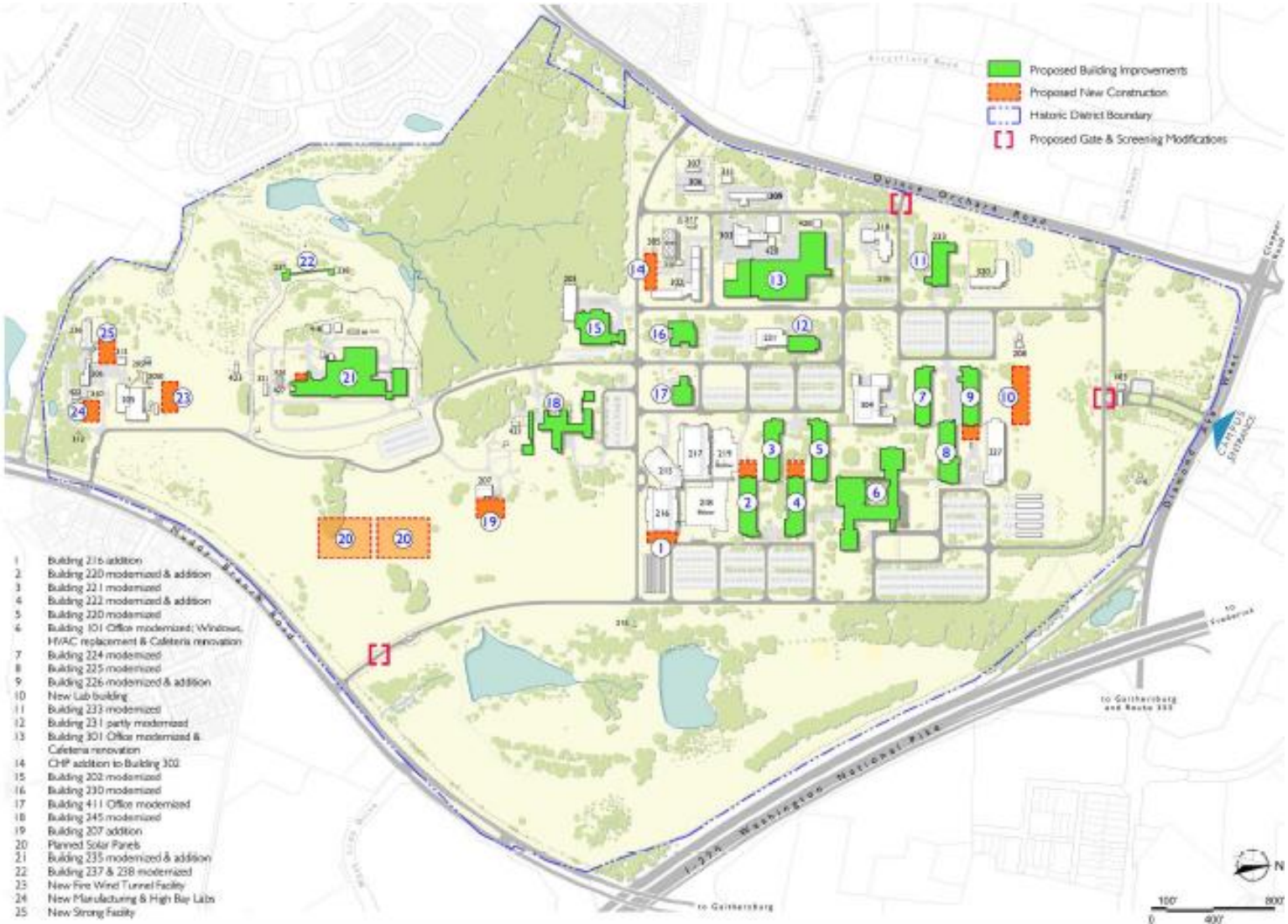
Building 3 Renovation

(Boulder)

Communications and Technology Laboratory (CTL)

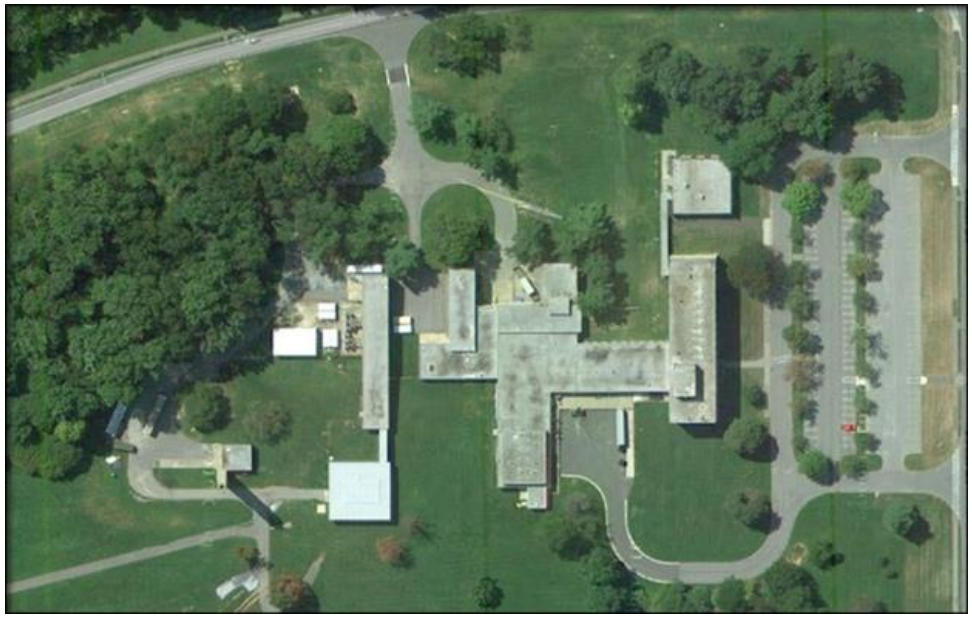
- Liquefier Building – constructed in 1952
- Design-Build contract awarded February 2016
- Office & Computer Laboratory Space for 105 staff
- Estimated Project Budget $18.0 M
- Projected Completion – September 2017

Gaithersburg Facilities Strategic Plan



Building 245 Modernization

(Gaithersburg)



- Design-build Indefinite Delivery Indefinite Quantity contract w/first task order (lab addition) awarded September 30, 2016

Radiation Physics Building

- Completed in 1964, oldest research facility on Gaithersburg campus
- Purpose-built for research - contains concrete shield walls up to 10 ft. thick
- FCI of 35.54 with more than $68.0 M in deferred maintenance
- Current Estimated Project Budget: $322.5 M
- Currently Funded (thru FY16): $60.0 M
- Research program vital to NIST mission & priorities in the areas of:
  - Nuclear Medicine Program
  - Standards for Electromagnetic Radiation and Radioactivity
  - Radiometry Measurement & Calibration
  - Metrology related to: Nuclear Medicine, Environmental Radioactivity, Medical Imaging, Advanced Manufacturing & others

CRF Funding

Construction of Research Facilities
Strategic Facilities Funding Plan ($M)

	2007 Approp	2008 Approp	2009 Approp	2009 ARRA Oblig	2010 ARRA Oblig	FY 2010 Approp	2011 Full Year CR	2012 Approp	2013 Approp	2014 Approp	2015 Approp	2016 Approp	2017 Pres. Request	Future Budget Requests	Total Cost
New Construction:															
BOULDER															
Building 1 Extension - Design and Construction (PML	10.1	23.6	-	2.8	40.7	-	-	-	-	-	-	-	-	-	77.2
Building 1 Extension - Enhanced Performance (PML)	-	-	-	1.7	39.7	-	-	-	-	-	-	-	-	-	41.4
JILA Expansion	-	-	22.5	-	-	-	-	-	-	-	-	-	-	-	22.5
Helium Recovery System	-	-	-	0.1	2.4	-	-	-	-	-	-	-	-	-	2.5
Time-Code Radio Broadcast Stations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal, BOULDER	10.1	23.6	22.5	4.6	82.8	-	-	-	-	-	-	-	-	-	143.6
GAITHERSBURG															-
Radiation Physics Building 245 Modernization - B/C Wing Addition (Phase I)	-	-	-	-	-	-	-	-	-	-	-	60.0		-	60.0
Radiation Physics Building 245 Modernization - A & D Wing Additions (Phase II)	-	-	-	-	-	-	-	-	-	-	-	-	40.0	100.0	140.0
Radiation Physics Building 245 Modernization - Future Construction														122.5	122.5
NCNR Expansion	12.0	19.0	-	1.2	9.6	8.0	-	-	-	-	-	-	-	-	49.8
Child Care Center	-	-	7.2	-	-	-	-	-	-	-	-	-	-	-	7.2
National Structural Fire Resistance Laboratory	-	-	-	1.5	19.9	-	-	-	-	-	-	-	-	-	21.4
Net-Zero Energy Resistance Laboratory	-	-	-	-	2.7	-	-	-	-	-	-	-	-	-	2.7
Robot Test Facility	-	-	-	0.3	2.2	-	-	-	-	-	-	-	-	-	2.5
Consolidated Logistics Center	-	-	-	0.6	5.7	-	-	-	-	-	-	-	-	-	6.3
Emergency Services Consolidated Station	-	-	-	0.7	6.3	-	-	-	-	-	-	-	-	-	7.0
Helium Recovery System	-	-	-	-	8.7	-	-	-	-	-	-	-	-	-	8.7
Subtotal, GAITHERSBURG	12.0	19.0	7.2	4.3	55.1	8.0	-	-	-	-	-	60.0	40.0	222.5	428.1
Total New Construction	**22.1**	**42.6**	**29.7**	**8.9**	**137.9**	**8.0**	**-**	**-**	**-**	**-**	**-**	**60.0**	**40.0**	**222.5**	**571.7**
Renovation Projects:															
BOULDER															
Building 1 Selective Renovation: **(B1R)**															
Design & Limited Renovations of Building 3, Relocate Instrument Shop, & Building 1 Exterior Renovations (Wings 3, 5, 6, & Spine) (Phase I)	-	-	-	-	-	12.0	-	-	-	-	-	-	-	-	12.0
Building 1 Exterior Renovations (Phase I)							12.0	2.9							14.9
Swing Space	-	-	-	-	-	-	-	-	-	3.9	-	-	-	-	3.9
Wing 3 Renovation (Phase II)	-	-	-	-	-	-	-	11.0	-	4.0	-	-	-	-	15.0
Wing 6 Renovation (Phase III)	-	-	-	-	-	-	-	-	11.8	3.9	-	-	-	-	15.7
Wing 5 (Phase IV)	-	-	-	-	-	-	-	-	-	-	-	12.0	10.0	38.0	60.0
Wing 4 and Center Spine (limited) Renovations (Phase V)	-	-	-	-	-	-	-	-	-	-		-	-	56.0	56.0
Building 3 Renovation for CTL	-	-	-	-	-	-	-	-	-	-	15.0	3.0	-	-	18.0
Subtotal, BOULDER	-	-	-	-	-	12.0	12.0	13.9	11.8	11.8	15.0	15.0	10.0	94.0	195.5
GAITHERSBURG															-
Radiation Physics Building 245 Modernization	-	-	-	-	-	-	-	-	-	-	2.0	-	-		2.0
Space Study	-	-	-	-	-	2.0	-	-	-	-	-	-	-	-	2.0
Subtotal, GAITHERSBURG	-	-	-	-	-	2.0	-	-	-	-	2.0	-	-	-	4.0
Total Renovations	**-**	**-**	**-**	**-**	**-**	**14.0**	**12.0**	**13.9**	**11.8**	**11.8**	**17.0**	**15.0**	**10.0**	**94.0**	**199.5**
General Safety, Capacity, Maintenance, Major Repair Projects:															
SCMMR	**36.6**	**36.6**	**68.3**	**5.0**	**28.2**	**58.0**	**57.9**	**41.5**	**44.2**	**44.2**	**33.3**	**44.0**	**45.0**		
CRF Grand Total	**58.7**	**79.2**	**98.0**	**13.9**	**166.1**	**80.0**	**69.9**	**55.4**	**56.0**	**56.0**	**50.3**	**119.0**	**95.0**	**316.5**	**771.2**

Facility Condition Impacts

- Research & Personnel
  - Efficiency
  - Effectiveness
  - Asking the bigger questions

- April 2016 article in New Scientist on Sydney's nanoscience lab a researcher that was doing nanoscience research at NIST said:
  - "When I was doing nanoscience research at NIST, we were all perpetually frustrated." He says his team would have to spend four to five hours a day realigning laser beams that had moved because of temperature changes or other environmental factors.
  - Now, we hope to be able to focus on the science and ask the big questions instead of doing the same things over and over again just to get things running.

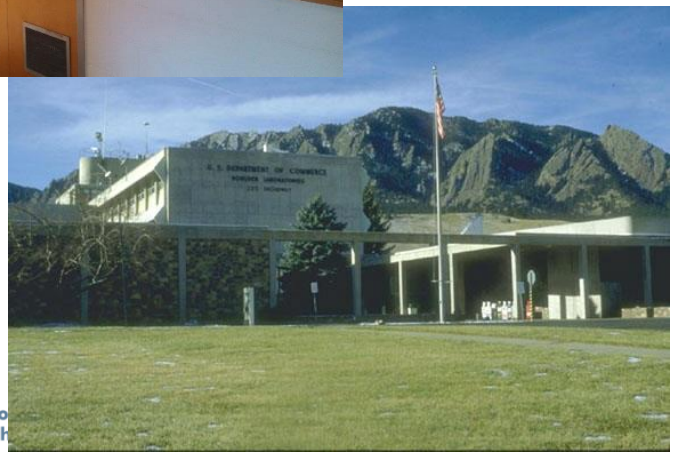
Facility Condition Impacts (cont'd)

- Productivity loss of at least 20%
- $13M - Estimated direct annual cost of lost productivity for NIST due to forced lab downtimes
- $130M – Estimated yearly impact to nation due to facility conditions.
- Since 2006 economic impact conservatively estimated at over $1B
  - NIST Boulder Facilities Review Team, Report on NIST Boulder Laboratory Facilities: Findings and Recommendations on Possible Renovation of Existing Facilities and Possible Construction of New Laboratory Facilities, January 31, 2006

Research on Next-Generation Atomic Clocks

Andrew Ludlow
Optical Frequency Measurements Group
Time and Frequency Division

2008-2012
NIST Boulder, Building 1 (1954)



2012-present
Katherine Gebbie Laboratory (2012)

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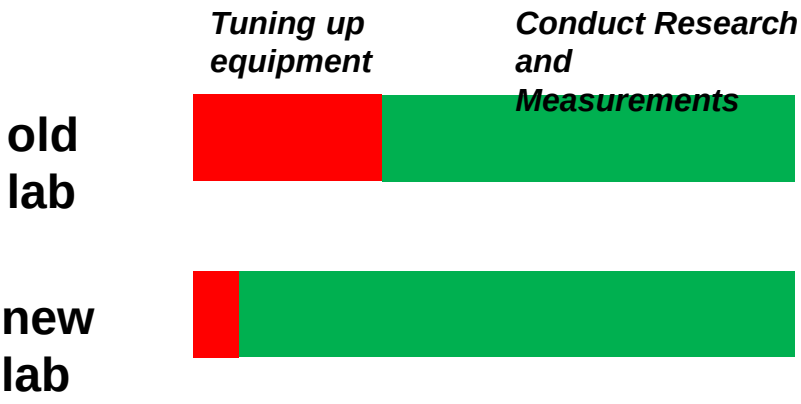
1. We spend **more time each day** doing research

Temperature and Humidity Fluctuations

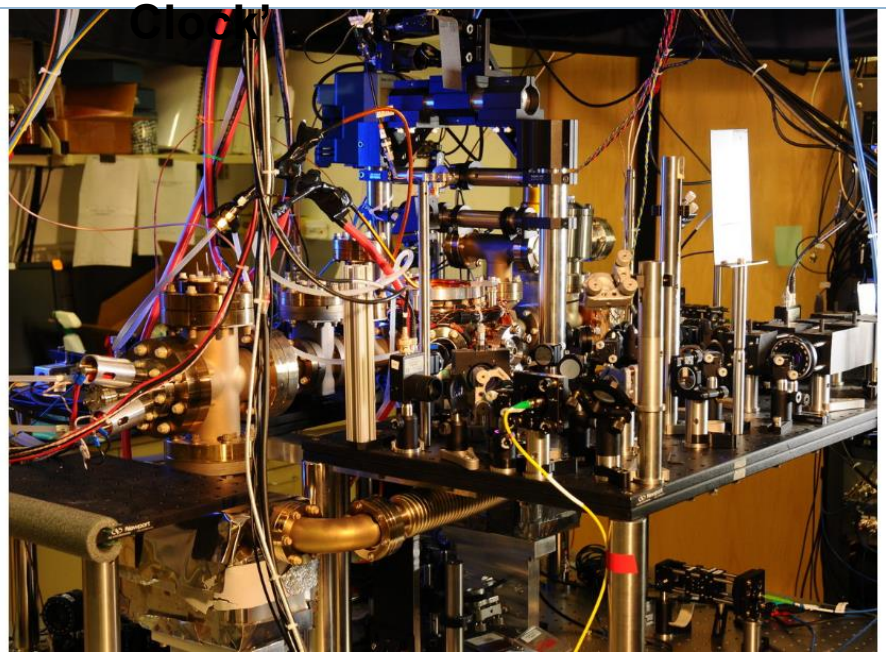
Laser and optical misalignments

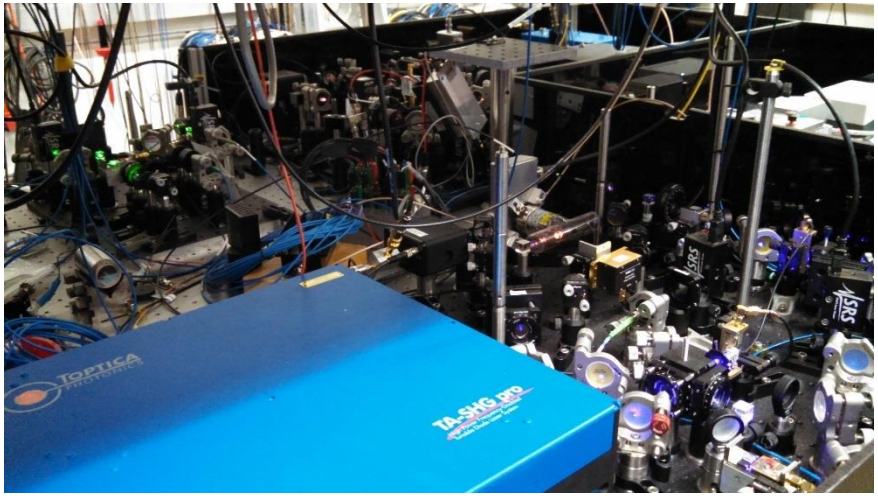
Time Spent Each Day



Time Savings: ½ hour to several hours per day

'Ytterbium Optical Lattice Clock'





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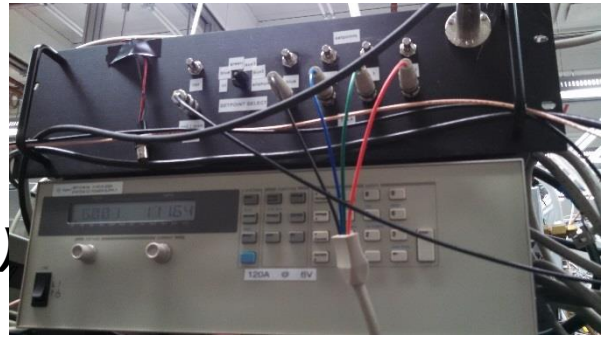
2. We spend more **days per year** doing research

Infrastructure System Failures and Maintenance Shutdowns

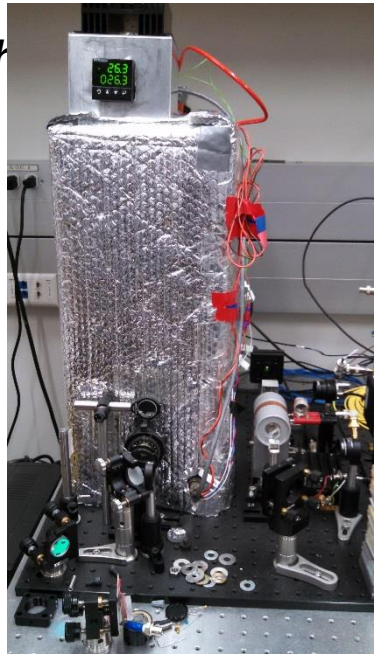


- ***Electrical power***
  - ***Equipment shutdown***
  - ***Long recovery times (e.g. thermal systems)***
  - ***Equipment damage***

- ***Chilled water lines***
  - ***Cannot sufficiently cool equipment requiring safety sh***

- ***Lab temperature and humidity***
  - ***Significant misalignment of laser equipment***
  - ***Failure of thermal sub-systems***

- ***Leaking pipes***
  - ***Equipment damage, loss of laboratory notes/archives***



old lab. While no single type of failure/shutdown repeated frequently, together these events caused regular interruptions to research, often many times per

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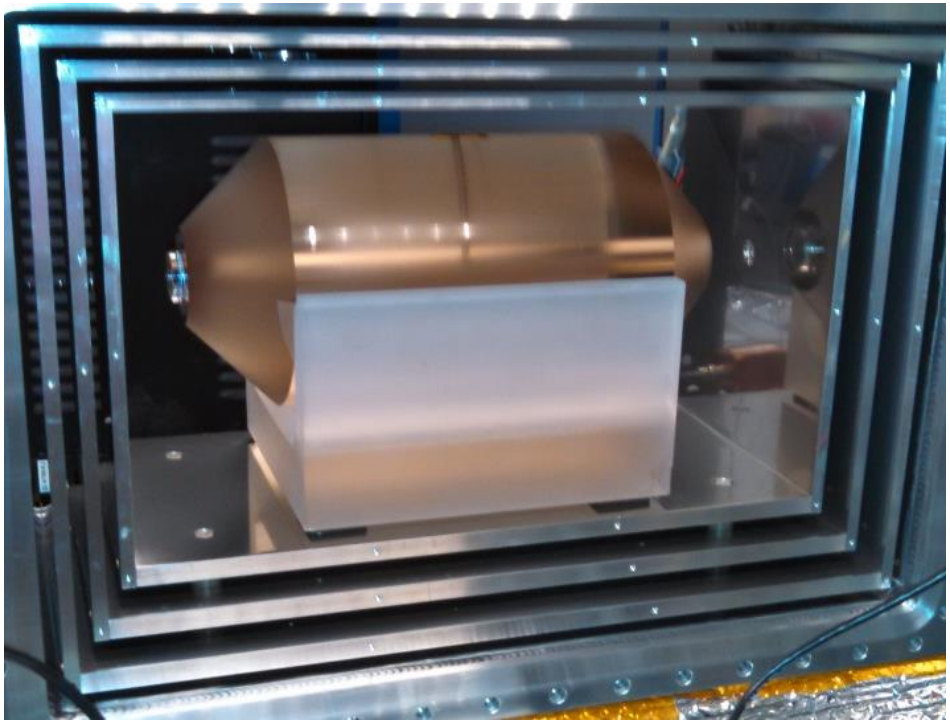
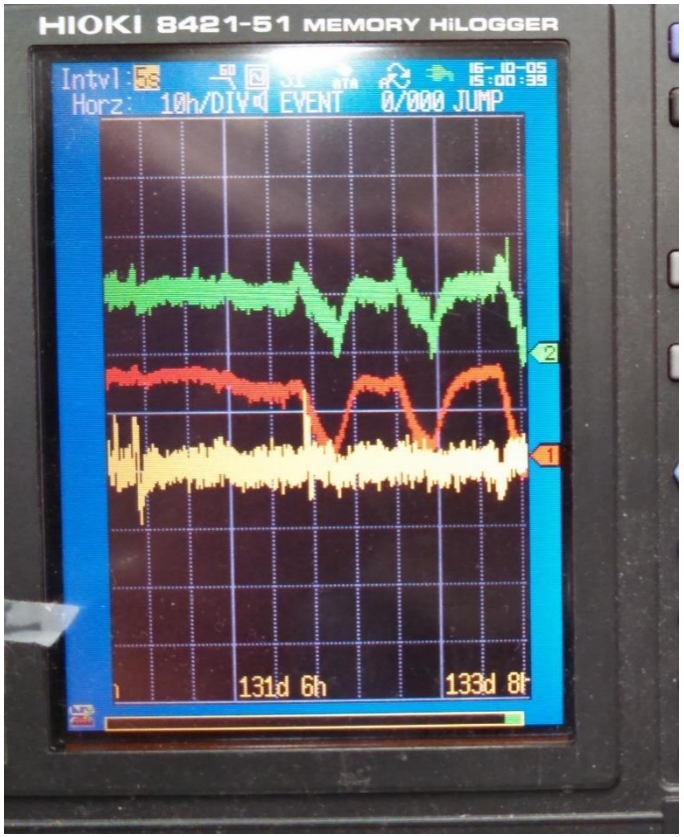
3. We can achieve performance we couldn't before

Ultra-stable optical interferometers for laser frequency stabilization





Resulting stabilized laser played a critical role in recent demonstration and development of world's most precise atomic clock.

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