



# Ames Collaborative Support Facility/Sustainability Base



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Glenn Research Center  
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# Sustainability Base

- 50,000 sq. ft. high-performance office building
- ~220 occupants
- LEED Platinum certified



# Outline

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- Overview of Sustainability Base
  - Introduction
  - Awards
  - Accomplishments
  - Research objectives and thrust areas
- Motivation for researching two Sustainability Base use case scenarios
- Integration of Building Systems - IT Challenges
  - Approach
  - Recommendations
  - Research areas to benefit
- Wrap-up

# Sustainability Base

- Reduce impact on environment
- Minimize energy use
- Minimize potable water use
- Create an evolving sustainability research testbed
- Apply NASA + Partner technologies to improve performance



# Sustainability Base

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## Awards

- 2013 California Governor's Environmental and Economic Leadership Award (GEELA)
- 2013 Acterra Business Environmental Awards – Large Project
- 2012 LEED Platinum Certification (U.S. Green Building Council)
- 2011 “Leadership in Innovation Award” (Center on Environmental Innovation and Leadership)
- 2011 White House “Lean Green and Mean” GreenGov Award
- 2011 Engineering News Record California “Best Green Building Award”
- 2010 “Real Property Innovation Award” (Government Services Agency )
- 2010 “Green Project of the Year” Structures Award (San Jose Business Journal)

# Sustainability Base

## Accomplishments

### ■ Partnering

- Intra-Organizational: Facilitation of close working relationship between Facilities (Code J) & Intelligent Systems (Code TI) Divisions
- Inter-Organizational: CMU-SV, Autodesk, Verdigris Technologies, EPRI, etc.

### ■ Research

- Invitation to publish a Springer-Nature Monograph Series
- Ph.D. research, 1 M.S. Thesis, 10 undergraduate internships

### ■ Acknowledgements

- Steve Zornetzer, Code D
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- Scott Poll, Code TI
- Dougal Maclise, Code TI
- Mike Flynn, Code SCB
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- Ray Schuler, Code JCE
- Dave Wong, Code JCE
- Kevin Fedor, Code JCM
- Robert Cormia, FDACC
- Darlene Wiedemann, Code B

# Sustainability Base

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## Systems Health Management

- Investigate methods to determine
  - ✓ Anomalous conditions (“Detection”)
  - ✓ Faulted state (“Diagnostics”)
  - ✓ Time to failure (“Prognostics”)
  - ✓ Response to take (“Mitigation”)
- Hypothesis: Systems health management leads to more cost effective building maintenance and operations (e.g. CBM – Condition-Based Maintenance)

## Data Mining

- Use computer algorithms to find anomalies
- Build knowledge bases of system behavior
- Hypothesis: Data mining identifies subtle changes in building performance missed by simple threshold-based detection schemes

## Intelligent Integrated Control

- Apply integrated intelligent, advanced control techniques to the built environment
- Hypothesis: Overall building performance can be improved, energy usage can be reduced, and individual occupant comfort can be better achieved

# ACCEPT



## (Adverse Condition and Critical Event Prediction Toolbox)

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### Provides Open, Special-Purpose Functionality

- Goal is to provide an ***open-source*** tool which can be used ***specifically for the prediction or forecasting of adverse events in time series data***
- Provides a single, unifying framework in which to compare a variety of combinations of algorithmic approaches addressing this problem
- Provides a platform whose intention is to act as a catalyst in advancing the state of the art in technologies related to this problem
- MSET (Multivariate State Estimation Technique) and variations thereof is the current defacto industry gold standard for these technologies
- Originally developed at Argonne National Laboratories
- Has since been adapted for myriad applications spanning a broad range of disciplines

# Uses of the ACCEPT Framework for Sustainability Base



- Problems related to temperature fluctuations and subsequent thermal sensation complaints
- Leaking groundwater return/supply piping connections to heat pump
- Heat pump failures
- Critical alarms (e.g. hot water pump differential pressure)



# ACCEPT

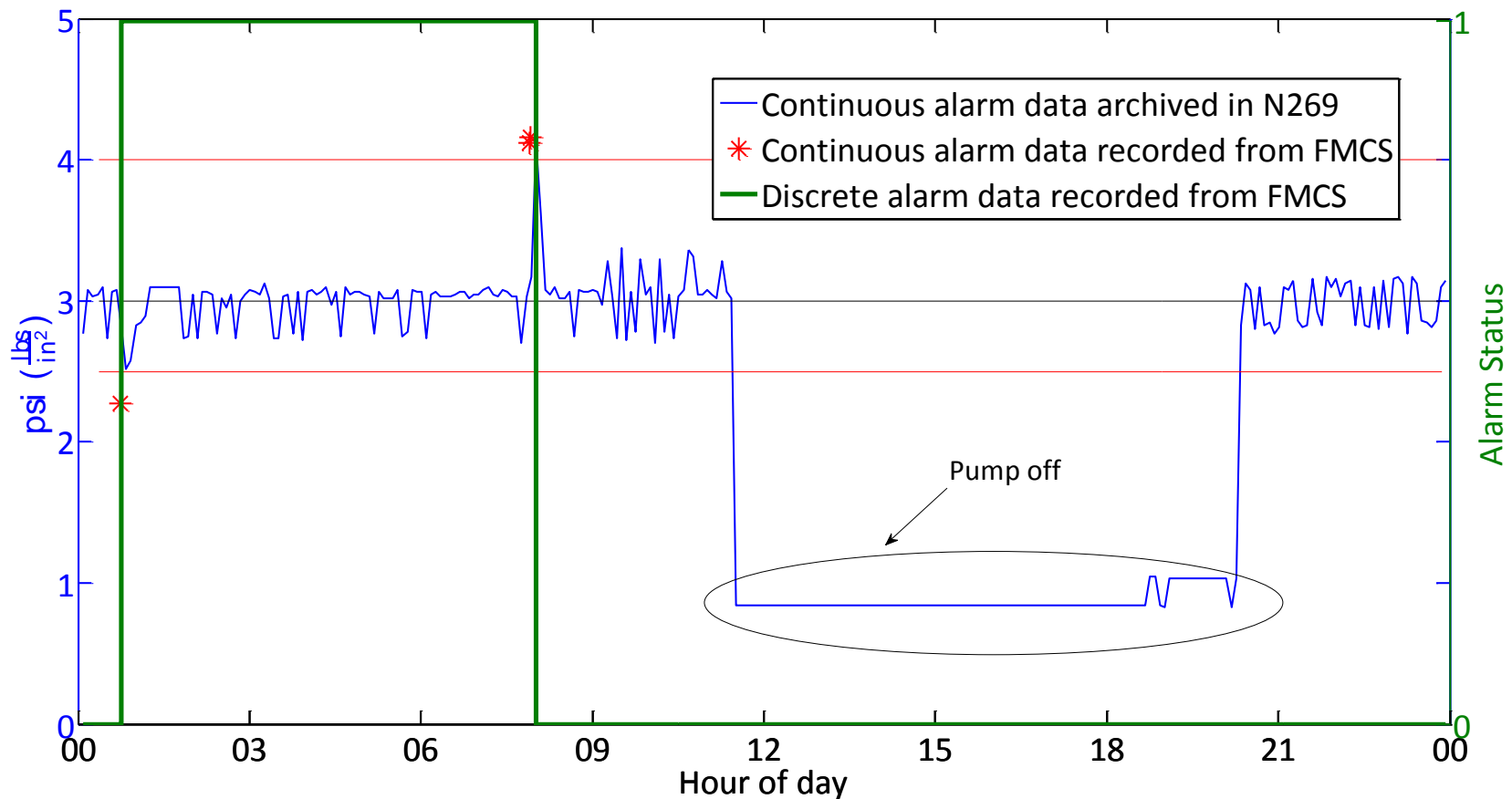


## (Adverse Condition and Critical Event Prediction Toolbox)

### Current Use Cases/Scenarios for ACCEPT

- Advance prediction of critical FMCS alarms in buildings

Hot Water Differential Pressure (Current Sensor) in N232, Sustainability Base on Feb. 13, 2014



# ACCEPT

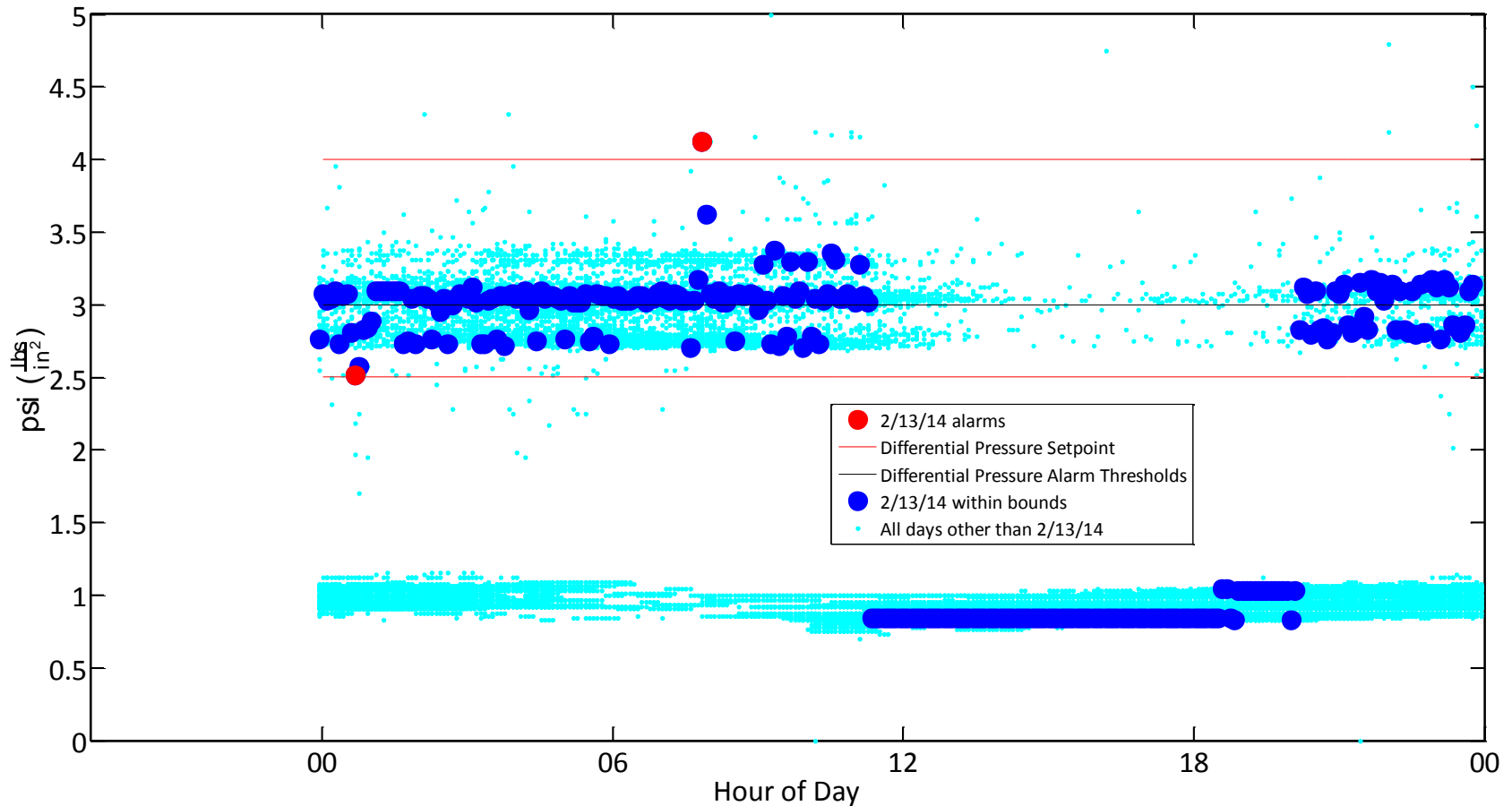


## (Adverse Condition and Critical Event Prediction Toolbox)

### Current Use Cases/Scenarios for ACCEPT

- Advance prediction of critical FMCS alarms in buildings

Hot Water Differential Pressure (Current Sensor) in N232, Sustainability Base from 02/12/14 to 05/06/14



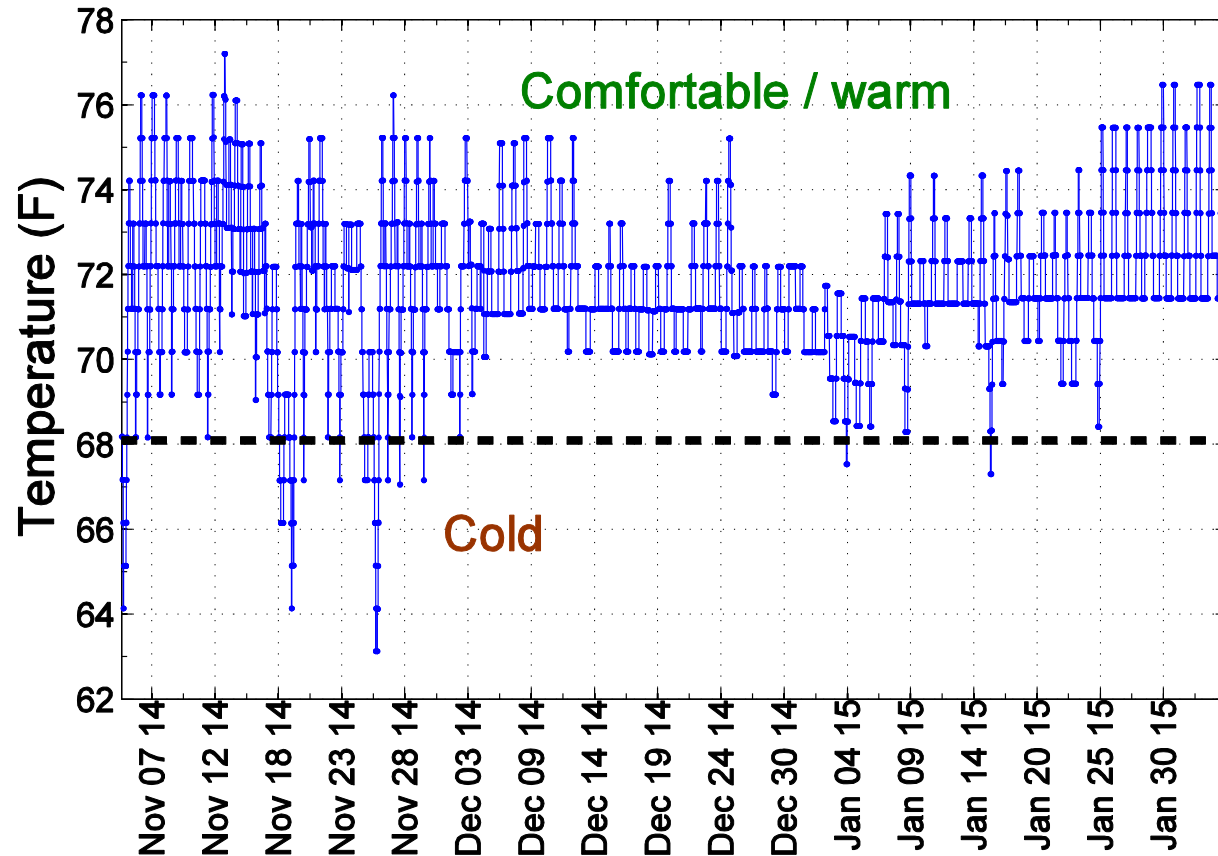
# ACCEPT



## (Adverse Condition and Critical Event Prediction Toolbox)

### Current Use Cases/Scenarios for ACCEPT

- Cold Complaints in buildings



# ACCEPT



## (Adverse Condition and Critical Event Prediction Toolbox)

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### Current Use Cases/Scenarios for ACCEPT

- Sensors intended to characterize thermal comfort are based on the Wet Bulb Globe Temperature (WBGT) index
- The WBGT sensors compute a weighted average of the following:
  - Dry bulb temperature
  - Wet bulb temperature (based on %RH – relative humidity)
  - Mean radiant (“black bulb”) temperature
- Hypothesis of facilities staff: notoriously “biased high,” and not necessarily representative of actual thermal comfort, resulting in building running cold
- We can roughly approximate this hypothesis with a simple experiment
- We’d like to test other hypotheses using an empirical data-driven approach (CMU-SV), for research purposes and enhanced isolation capability

# Proposed Solution to IT Challenges

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## Problem definition

- Lack of easy access to integrated data generated from various building systems
- Deficiencies exist with current infrastructure
  - Direct access to native software interface (Siemens Apogee Insight)
  - Polling procedure using a standard building-specific communication protocol (BACnet)

## Background

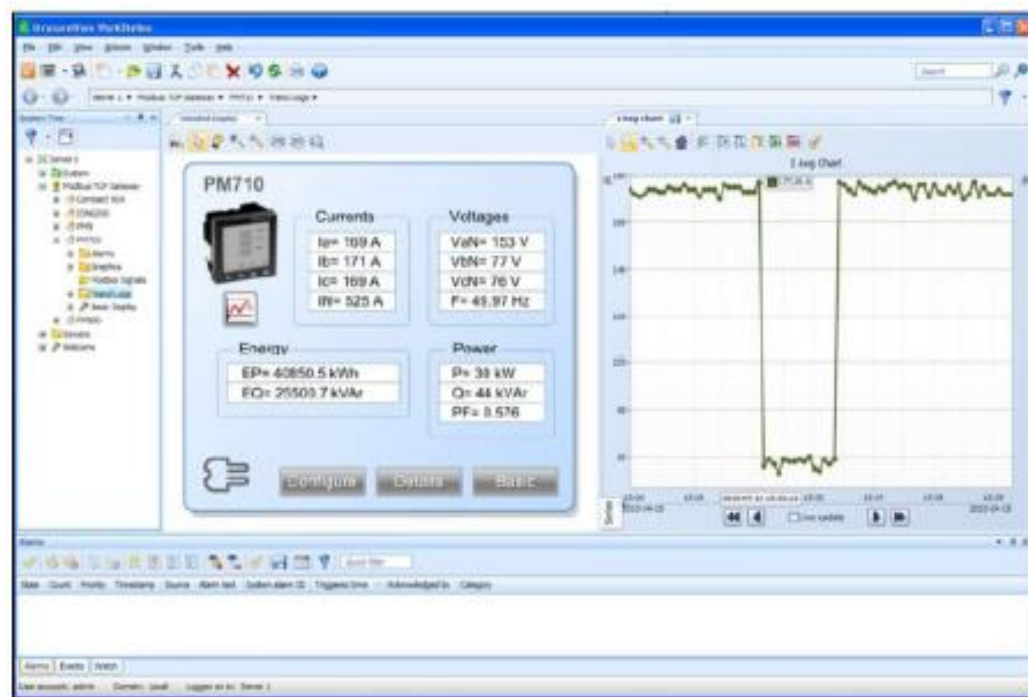
- Lack of alignment of IT resources necessary to enable research vision of Sustainability Base's charter
- Lesson learned - IT integration concepts addressed during design stage would have been beneficial

## Expected Benefits

- Would directly benefit high performance Agency buildings
- Incorporate findings & recommendation into plans during the design and construction phases

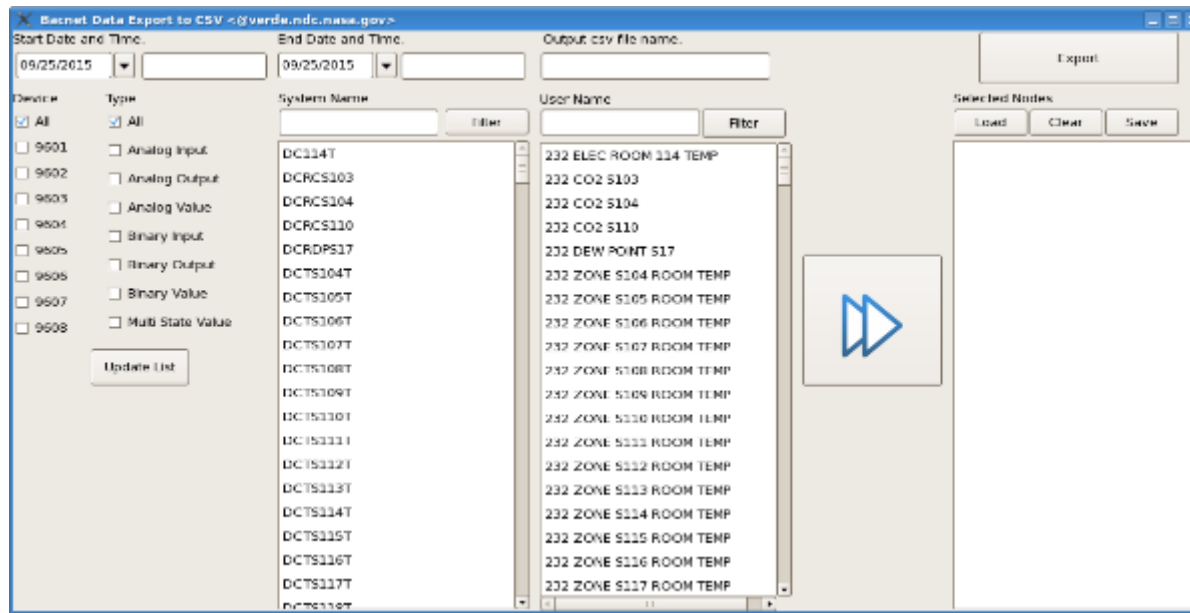
# Approach

- Investigated two parallel solutions aiming to deliver a tool enabling near real-time or real-time access to a comprehensive suite of synchronized time series data stored in various databases
- Approach #1: Schneider Electric's StruxureWare turnkey solution.



# Approach

- Investigated two parallel solutions aiming to deliver a tool enabling near real-time or real-time access to a comprehensive suite of synchronized time series data stored in various databases
- Approach #2: Continued extension of the original in-house tools that were previously developed.





# Recommendations

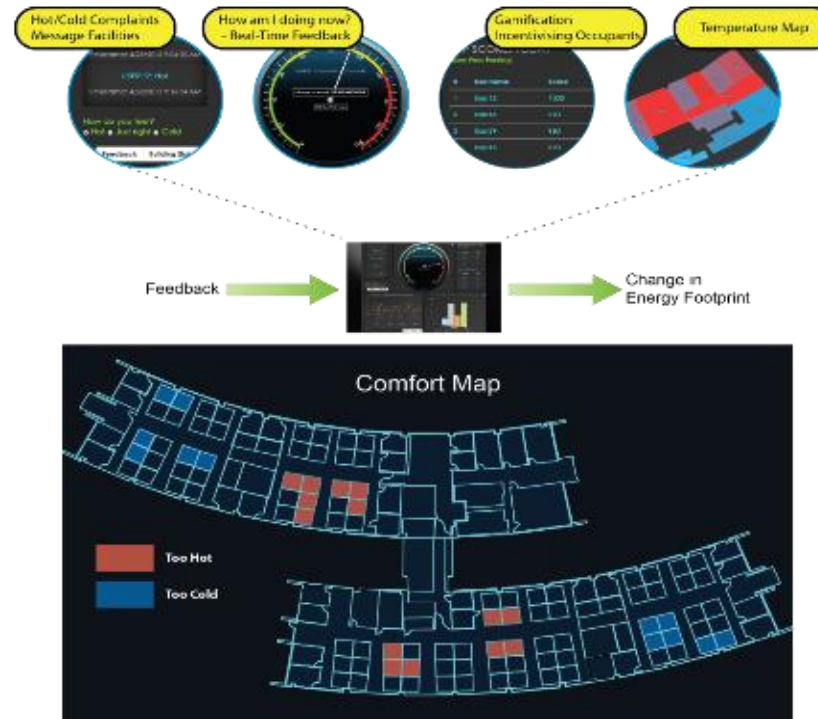
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- There is a clearly delineated path to addressing fundamental requirements that lends itself well to moving forward and building a prototype that is flexible and extensible
- Recommend investment using outsourced solution
  - Submit solicitation to be formally competed through the procurement process. Possible vehicles:
    - SBIR/STTR
    - RFI
- Recommend continuation of development of in-house integrated tool development, leveraged by other projects and CMU-SV CA
- Verdigris Technologies has agreed to deploy sMAP solution has part of NRSAA
  - Systems to be integrated yet to be negotiated

# Research Areas to Benefit: Energy, Occupant Feedback

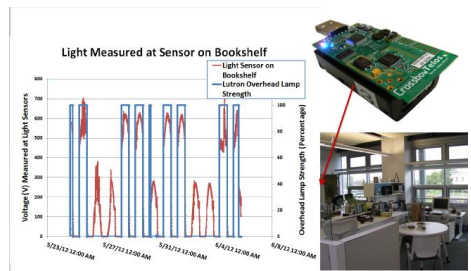


- CMU-SV
  - Energy dashboard study to raise awareness of workstation plug load consumption habits for building occupants
  - Will incentivize occupants with best reductions in consumption on weekly basis
  - Can collect occupant feedback on other issues (comfort, temperature , etc.)



# Other Research Areas to Benefit HVAC, Occupant Feedback

- Verdigris Technologies
  - CTs can be used to disaggregate loads
  - Visibility into plug loads via coordination w/CMU on labels
  - Dedicating circuits for larger loads (lighting, HVAC, etc.) can also be monitored
- Occupant Satisfaction
  - Mechoshades
  - Cold Complaints
- HVAC Equipment problems
  - Groundwater pipe leaks
  - Heat pump failures
  - Critical alarms (e.g. hot water pump differential pressure)
- New sensors (UCB)
  - Lighting
  - PECS



# Wrap-up/Take-home

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- Opportunities exist to using current technology derived from existing NASA research areas to make dramatic improvements in managing our built environment
  - Occupant satisfaction and comfort
  - Water & energy consumption
  - Improved/Streamlined building operations & maintenance activities
- Integration of Building Systems will enable
  - Deeper insights into latent, unknown problems
  - Better visibility into known problem areas
    - Increased predictive capability
    - Ability to assist with isolation of contributing factors, facilitating a more streamlined diagnostics process
  - Enable seamless deployment of novel sensing capabilities/technologies

# Questions ?

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