SWARM

Small Workplace Automation & Remote Monitoring

Global Campus Energy Manager's Workshop

Thursday, October 24th

Rhys Davis & Devon Schmidt, Graduate Student Researchers

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What is SWARM?

Problem – Solution – Goals & Benefits – Savings at UC Davis

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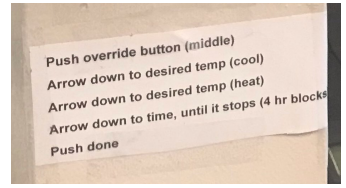
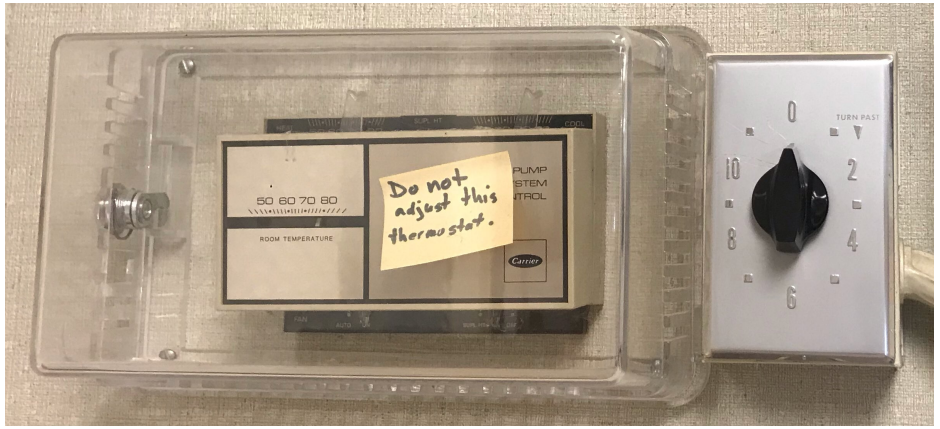
What is SWARM? – *Problem:*

- **Hundreds of small buildings** on campus with **isolated HVAC systems** that are not connected to the centralized HVAC scheduling system
- **No way to monitor** the HVAC use in these buildings remotely to see if everything is running as it should
- These buildings often **struggle to maintain comfortable temperatures** during occupancy and **do not cycle off when not in use**





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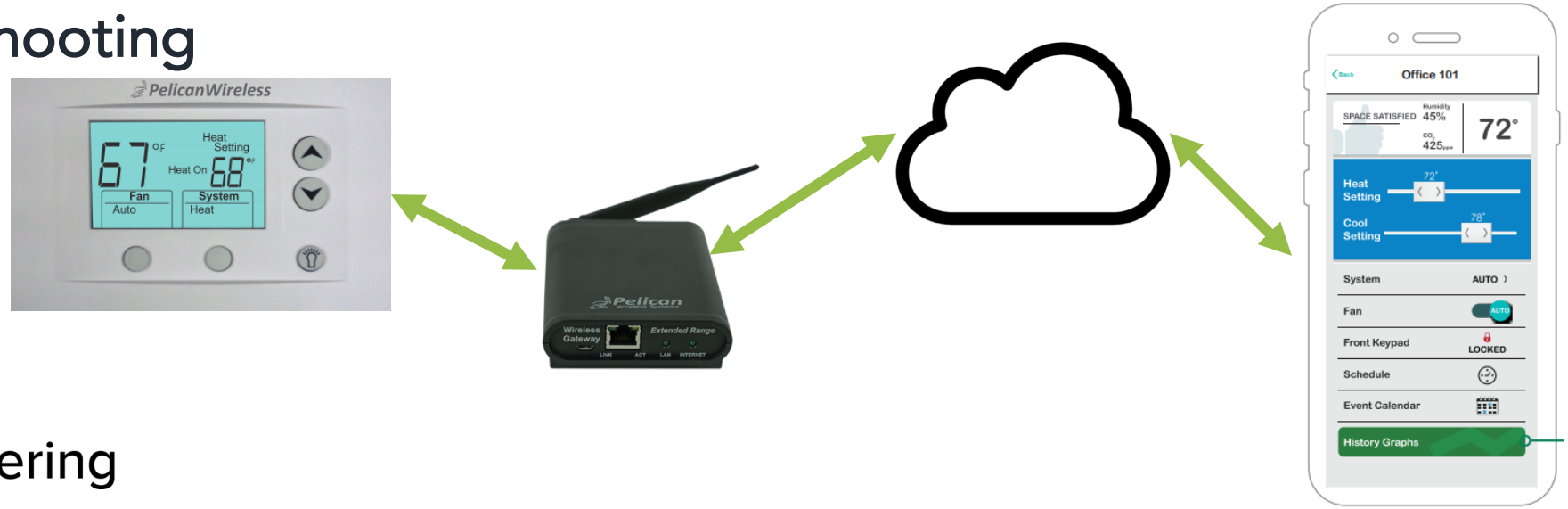
What is SWARM? – *Solution:*

- **Connect** these isolated units to a secure network to allow for **remote HVAC scheduling**
- Create an o**ccupancy-based** schedule with help from the **building manager**
- Give HVAC monitoring information to the **facilities team for troubleshooting**



What is SWARM? – *Goals & Benefits:*

- Improve the **comfort** of occupants
  - **Set schedules** based around building occupancy
  - Give select users the ability to adjust schedules for **special events**
  - **Ramp up** conditioning hours before occupancy to reach set point on time
- Reveal building **HVAC use**
  - Give HVAC maintenance team access to data to **discover and diagnose HVAC issues**
  - Enable a better understanding of **building temperature history** and cool and hot calls
- **Trim energy use** when building is not in use
  - Turn off HVAC systems on **holidays and weekends** for most buildings
  - **Quantify savings** using data from scheduling and set backs

What is SWARM? – *Savings at UC Davis*

1,650+	830 MWh	$65,000	>40%
TONS OF HEATING & COOLING CONTROLLED	ANNUAL ELECTRICITY SAVINGS	ANNUAL ENERGY COST SAVINGS	PERCENT DECREASE IN HVAC RUNTIME

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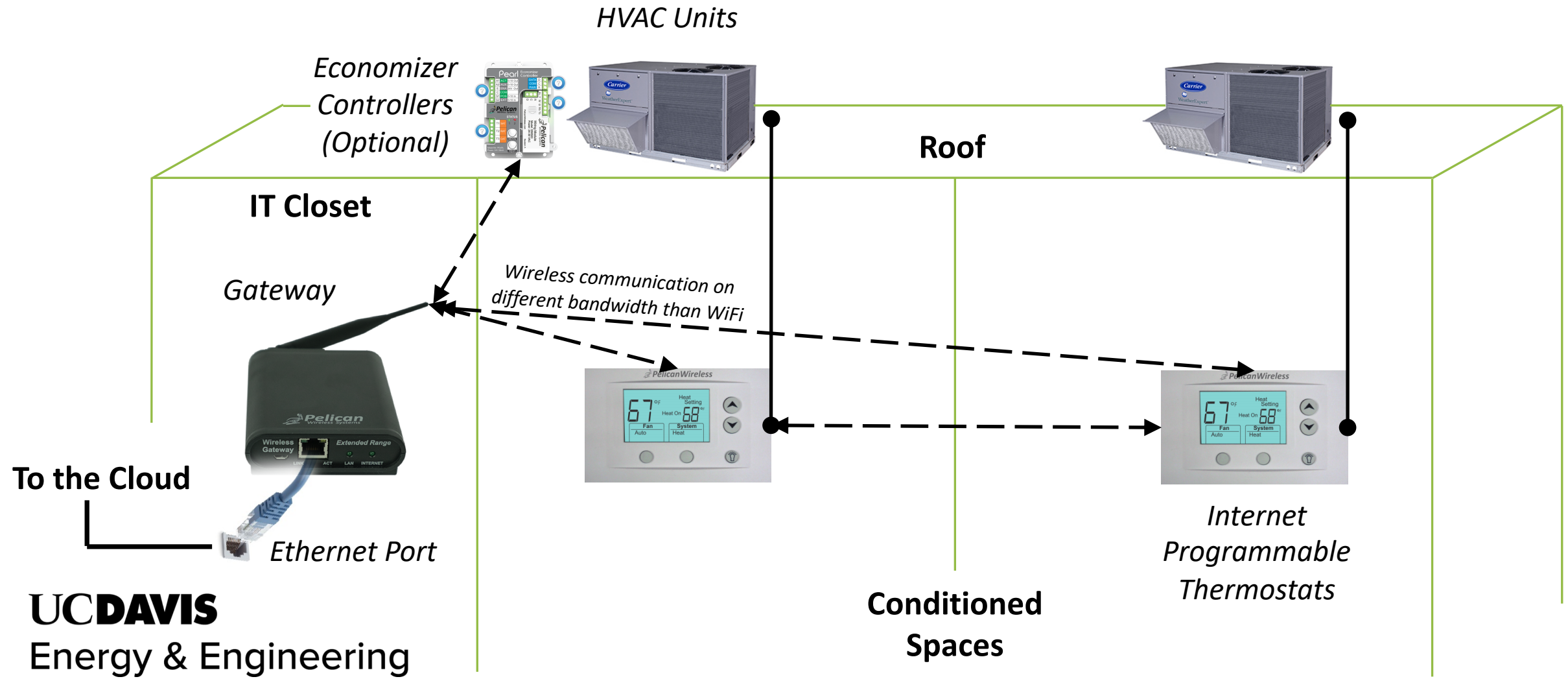
How Does SWARM Work?

Technology Options – Network Level – Building Level – Requirements

How Does SWARM Work? – *Technology Options*

- The UC Davis SWARM program uses **Pelican Wireless** technology and web interfaces
  - Using **one company** for the hardware, data storage, and web interface has been very convenient for **compatibility and customer service** purposes
  - Pelican's thermostats and website have worked very well for SWARM's purposes here at UC Davis and are **supported by our IT team**
- **Other options** for wireless enabled thermostats include Venstar and Sensi
  - We have **not assessed** these technologies or others for **security or ease of use**
  - SWARM will work with **any wireless thermostats** that can be controlled from a central database, but we have had a lot of success with **Pelican Wireless**

How Does SWARM Work? – *At the Building Level*



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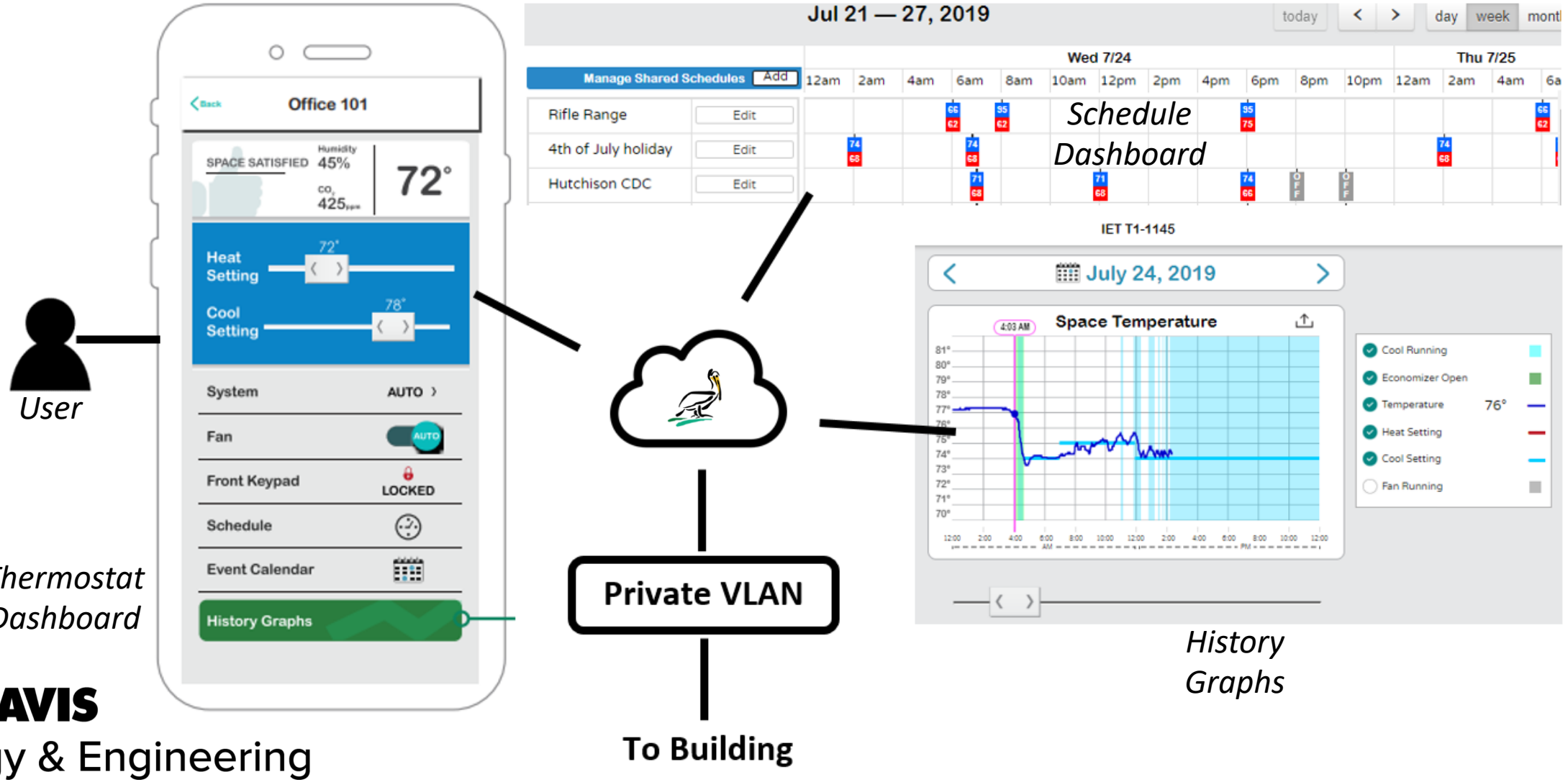
How Does SWARM Work? – *At the Virtual Level*



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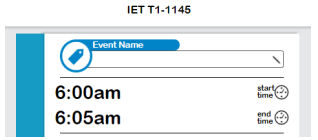
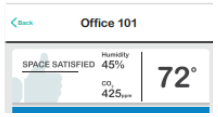
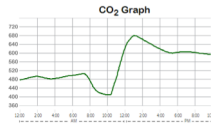
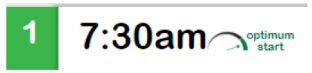
How Does SWARM Work? – *Requirements*

- If you plan to use **a different technology** for SWARM, here are the key **requirements**:
  - Connect to a **centralized scheduling interface**
  - Assign building operators **remote access** to **individual thermostat** controls
  - **View and control HVAC equipment** status (Cool/Heat/Fan, economizer position, etc.)
  - **Group** thermostats by cluster/building
  - Utilize **API capabilities** to pull **trended data** to analyze
  - Measure **CO_2** and utilize **demand control ventilation** with **economizer**
  - Physical thermostat **override** of pre-set schedule
  - Utilize **Optimum Start** to ramp up building conditioning **prior to occupancy**







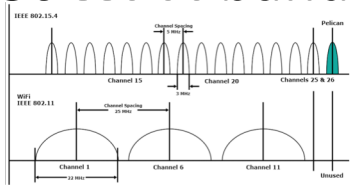


How Does SWARM Work? – *IT Requirements*

- Additionally, these are the **security requirements** for UC Davis (these may **change by campus**):

  - **Wired** network connection for the **gateway**
  - **Proxy server** for the **gateway-to-web server** connection

  - **Wireless mesh** network (**not Wi-Fi** bandwidth) for **thermostat-to-gateway** connection



  - Thermostats can **ping server** to **ask for changes** (avoids outside system making changes on campus network)
  - Ability to set **static external IP address** for **gateways**

Buildings in SWARM at UC Davis

Current Buildings – IETCR Building Case Study

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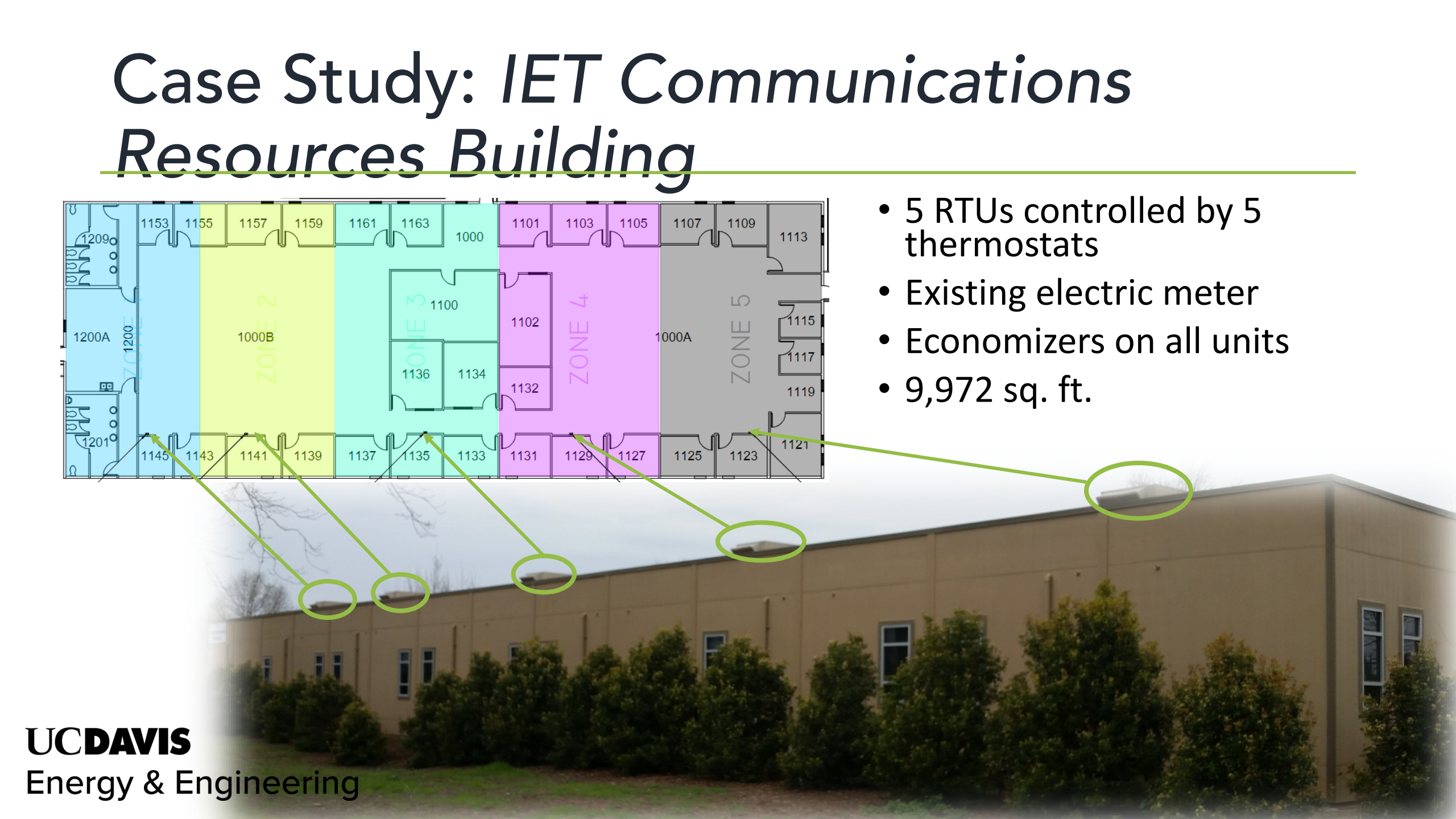
Buildings in SWARM at UC Davis

- Currently, there are **25 buildings/complexes** in SWARM with over a dozen in progress
  - Largest: 28,187 sq. ft.
  - Smallest: 1,184 sq. ft.
- These include
  - temporary buildings
  - trailers
  - isolated labs
  - annexes
  - rooms within larger buildings
  - athletic facilities

Case Study: *IET Communications Resources Building*

- 5 RTUs controlled by 5 thermostats
- Existing electric meter
- Economizers on all units
- 9,972 sq. ft.



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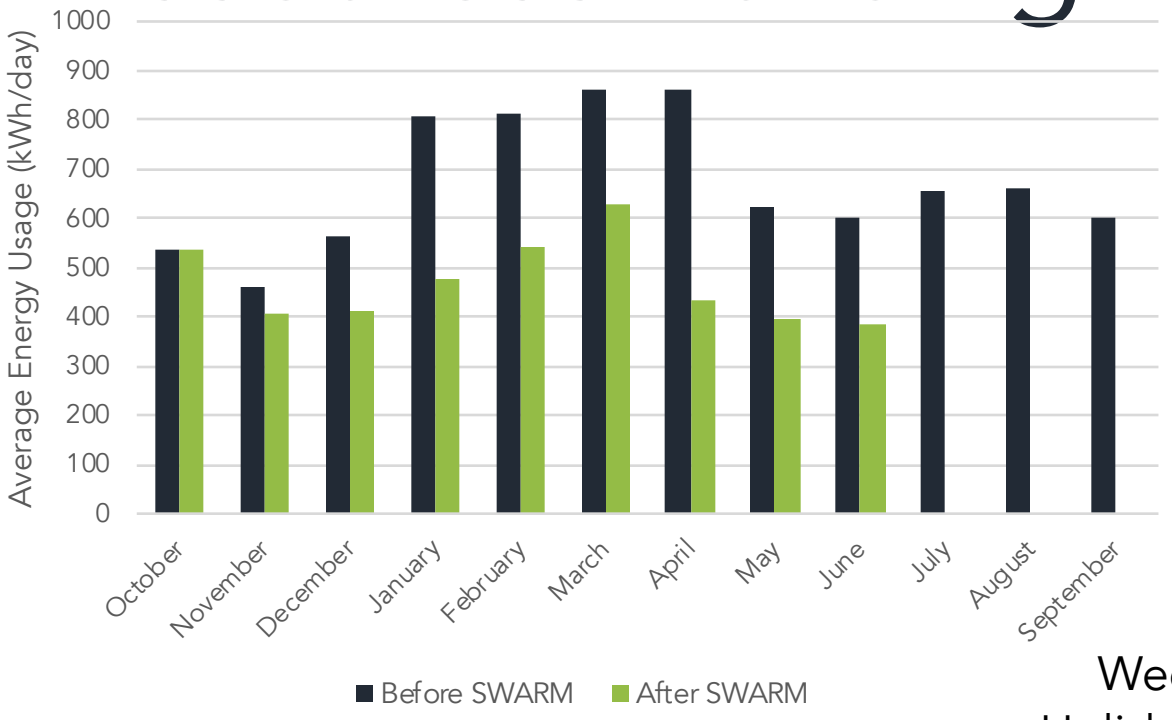
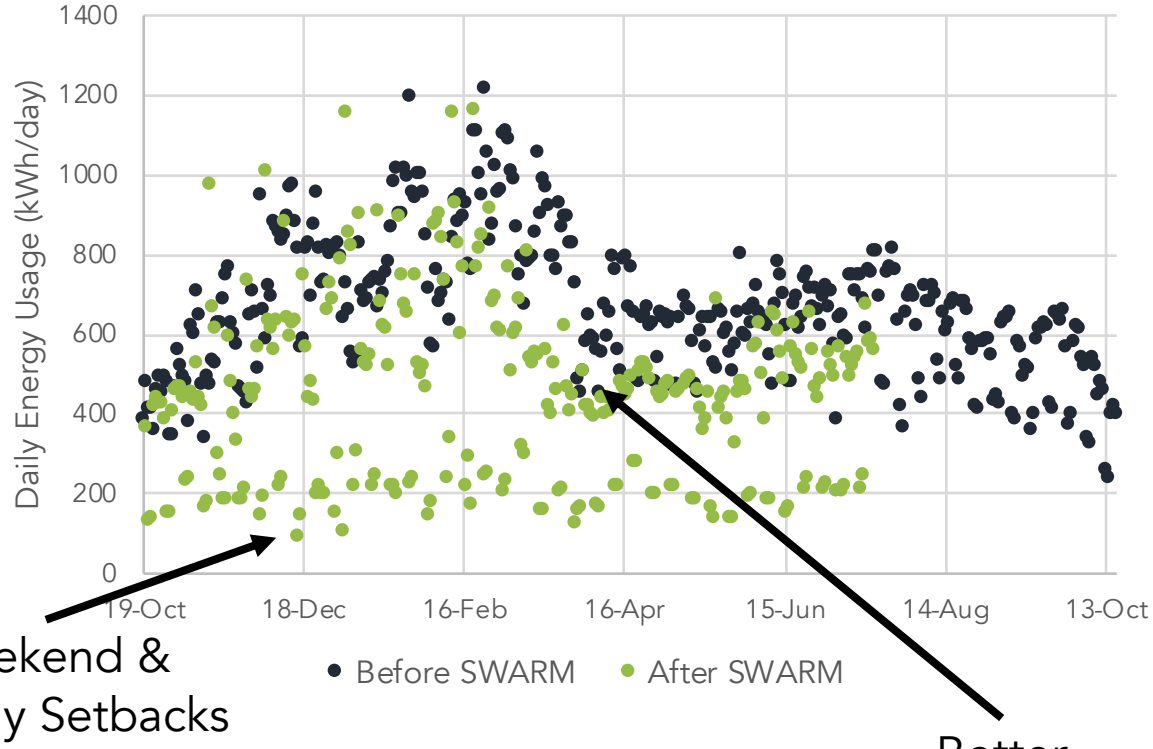
Case Study: *IET Communications Resources Building*





- Annual savings of **78,500 kWh/year** and **$5,400/year**
  - **32% reduction** from the previous year
  - 2017-18 EUI = 84 kBtu/ft^2.
  - 2018-19 Projected EUI = 57 kBtu/ft^2

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SWARM Process at UC Davis

Tom Ryan, Project Manager

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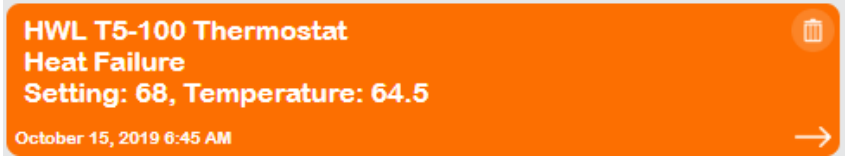
SWARM Team Roles

- Staff
  - Admin
  - Materials
  - General Project Support
  - Direction when needed
- Students
  - Program Development
  - Modeling
  - Site Research
  - Customer interaction
  - Holiday scheduling
  - Documentation

Airtable

- Facilities Maintenance
  - Installations
  - Commissioning
  - Site Monitoring and Maintenance



SWARM Process

ONGOING

0-3+ MONTHS

MONTHS

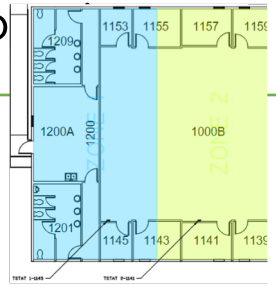
1-6 MONTHS

ONGOING

Determine buildings eligible for SWARM and contact building managers

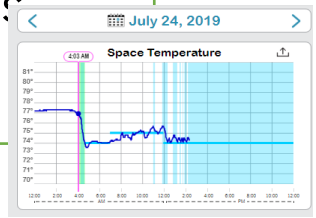
Collect baseline energy usage data; install meters if necessary

Determine existing HVAC equipment and thermostat lo



Order & install equipment, request Ethernet port, determine sche & set p

HVAC team monitors equipment, SWARM team monitors energy saving



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Planning SWARM for the Whole Campus

- Find Potential for SWARM at Campus buildings
  - Energy Savings
  - Maintenance
- Future planning – Where does SWARM make sense? (and who pays for it?!?)
- Campus Standards – Design Construction and Management
  - Performance Specification

Common Issues & Solutions

- Occupant expectations – SWARM will NOT fix everything!
- Geography of buildings – Making one gateway go a long way
- An ever-changing team – Document everything!
- Shop coordination and navigating the bureaucracy

Questions?

SWARM for HVAC Technicians

Nathan Cardoza, Lead Refrigeration Technician

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Benefits of SWARM for HVAC

- *Benefits*
- *Case study/examples?*

Using Pelican Equipment

- *DCM?*
- *Process of choosing clusters, etc.*

How to Get SWARM Started

Identify Buildings – Create a Budget – Present to Stakeholders – Setting Up a Building in SWARM

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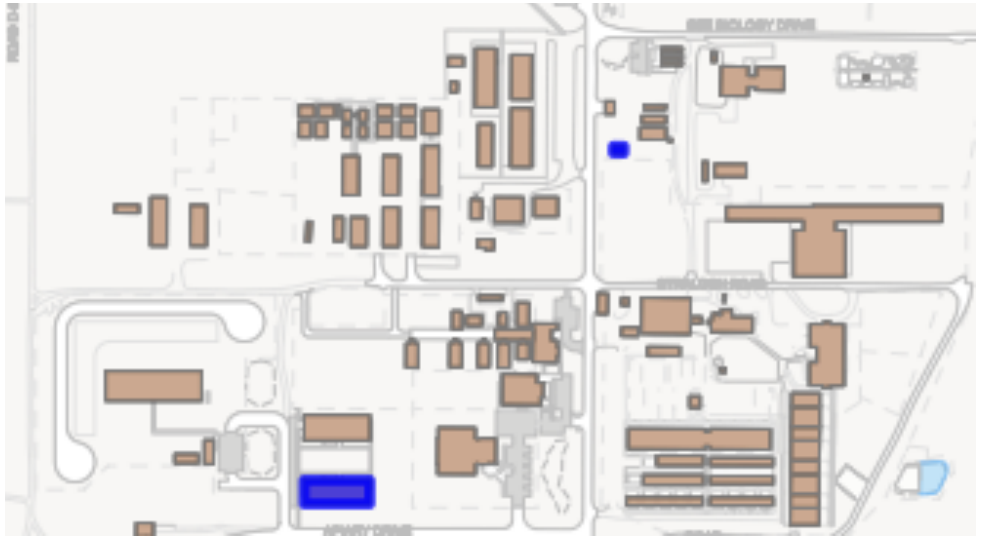
How to Get SWARM Started – *Identify Buildings*

- SWARM Buildings **cannot be connected** to the central building automation system
- From that criterion, find buildings that fit most or all of these:
  - **Metered**, with access to one year of utility data
  - **Flexible** HVAC requirements (offices & classrooms are better than labs)
  - History of occupant **HVAC complaints**



How to Get SWARM Started – *Create a Budget*

- To obtain funding for SWARM, the campus administration will want to see the **financial prospects** of the program
- Double click on **payback estimation table** below and change **yellow boxes**
- See Itemized budget in Technical Reference Manual for more in-depth look

Average Cost/building	*$3,400*
Average Cost/sqft	*$0.71*
Energy Savings/building/year	*$1,065*
Energy Savings/sqft/year	*$0.12*
How many buildings do you see eligible for SWARM?	10
Average square feet of these buildings? (Optional)	5000
Do the buildings have economizers? (Y/N)	Y
Average tons of cooling in these buildings (optional)?	10
Cost of Install	$35,500
Rebate for economizer controller + CO2 sensing t-stat	$10,000
Cost Savings from Energy Reduction/year (Estimate)	$6,000
Maintenance Cost Savings/year (Estimate)	$2,500
Payback (Years)	**3.0**

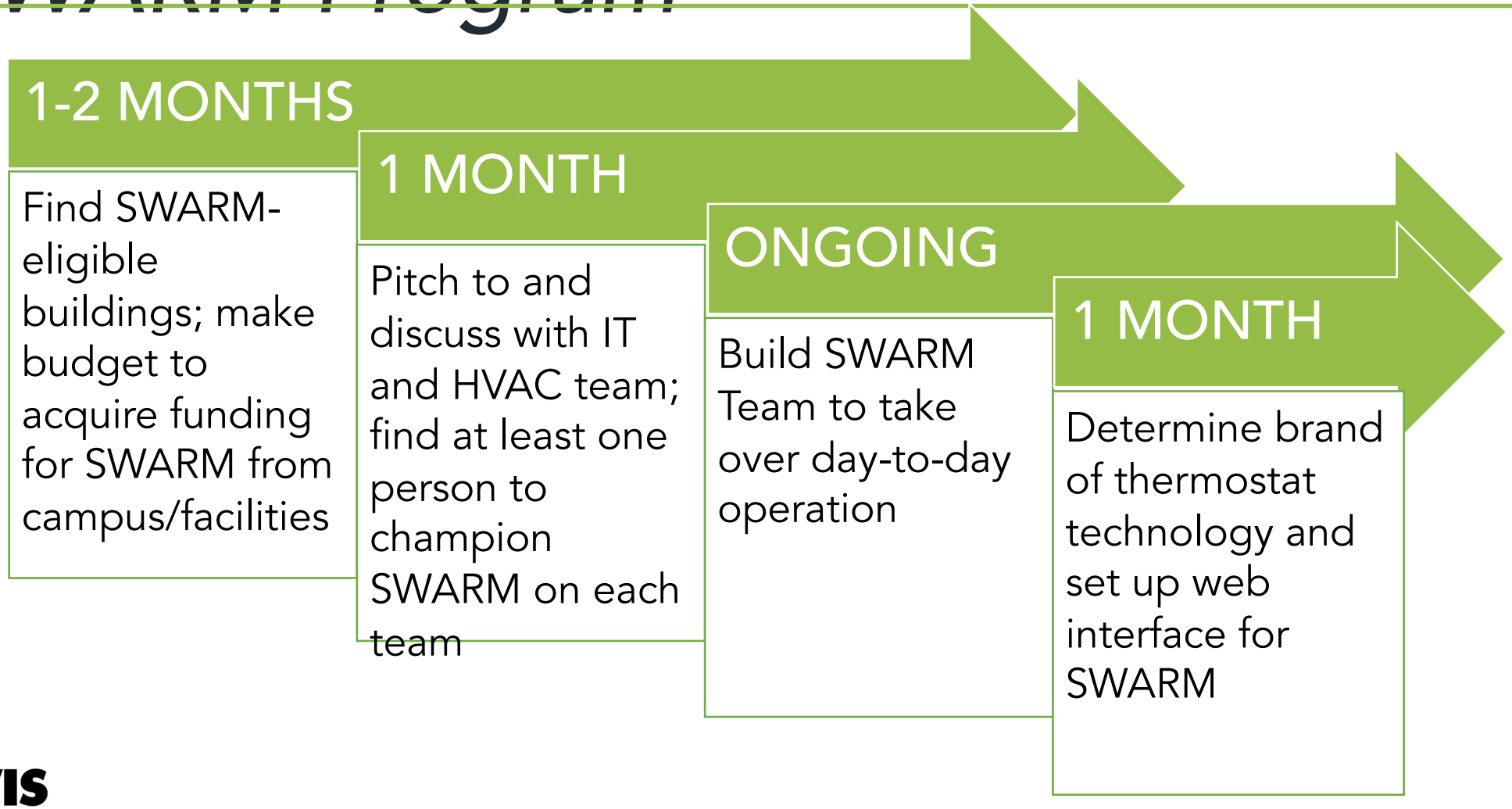
How to Get SWARM Started – *Present to Stakeholders*

- Crucial to **discuss** SWARM process and networks with **IT team** at the outset
  - See **SWARM IT Team Module** for discussion of SWARM security, network, and technology
- Provide **in-person** presentation and **hands-on** training of SWARM for **HVAC maintenance team**
  - The more comfortable the HVAC team is with SWARM, the more effective the program will be
  - See **SWARM HVAC Team Module** for equipment spec sheets, training materials, and installation guides
    - *At UC Davis, the maintenance team is a huge proponent of SWARM*

How to Get SWARM Started – *Assemble a Team*

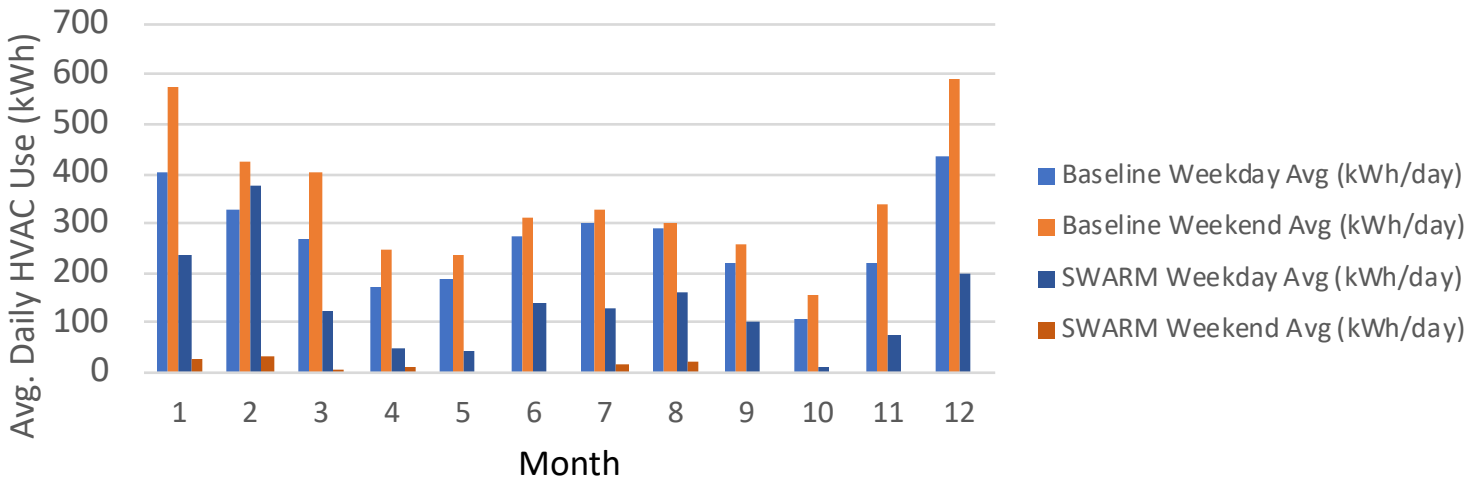
- Having **one main** contact and **SWARM proponent** from both the **HVAC team** and **IT team** is huge help
- Once SWARM is started, having a **SWARM team** to deal with **day-to-day operation** helps move program along
  - UC Davis has had success using **student interns** for SWARM legwork and correspondence and a **facilities staff member** for planning and guidance

How to Get SWARM Started – *Developing SWARM Program*



How to Get SWARM Started – *Measurement & Verification*

- For the pilot program, try to use buildings with **baseline energy usage data** to determine **savings** from SWARM
  - This will help **justify expanding SWARM** and help **estimate savings** for buildings without baseline data
  - Try to determine average savings for **weekdays/weekends, months, and temperatures (CDD / HDD)**
- No perfect method for doing M&V
  - We suggest creating a method for **estimating use in buildings without baselines** by using **percent savings** from buildings **with baselines**
  - **See our *Building Energy Data Analysis Module* for more information**



Thank you!

For questions, contact UC Davis SWARM Team at swarm@ucdavis.edu

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