Reliability Centered Maintenance

APPA Institute
for Facilities Management

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SPEED
LIMIT
24


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ON THE ESCALATOR.
PLEASE USE THE ELEVATORS.
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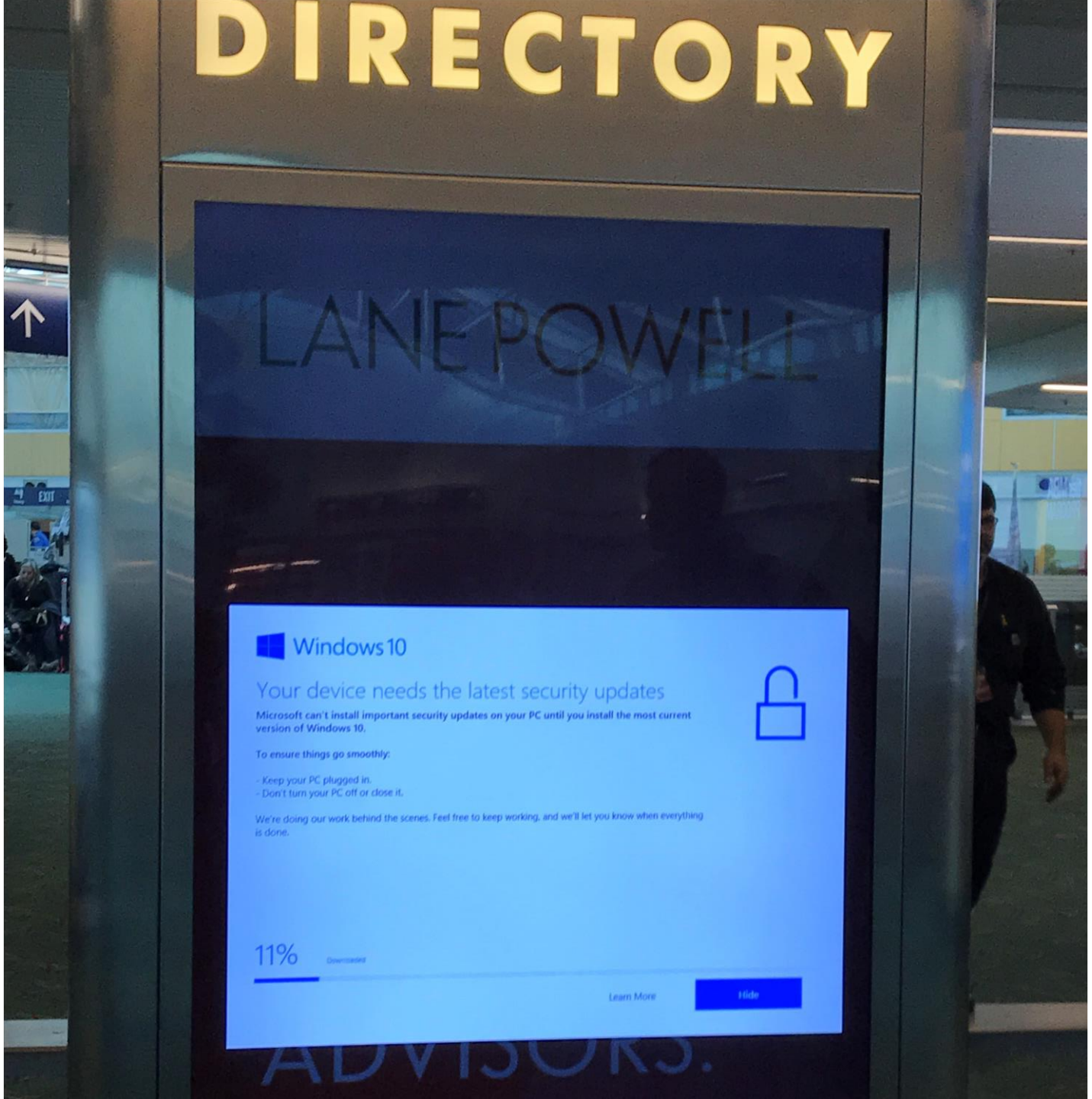
PUSH HERE TO OPEN COVER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Free Bacon with
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Technically...
ALCOHOL
is a
Solution!

Credit(s) earned on completion of this course will be reported to American Institute of Architects (AIA) Continuing Education Session (CES) for AIA members.

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AIA Approved Continuing Education

Course Description

Reliability Centered Maintenance is a strategic approach that combines various maintenance practices to ensure that equipment and facilities function optimally over their lifecycle. This course will cover topics such as preventive, predictive, and proactive maintenance techniques and delve into the role of maintenance management in supporting the institutional mission, increasing cost-effectiveness, and contributing to sustainability goals. The course concludes by considering case studies and best practices that illustrate the application of RCM principles in a campus setting.

AIA Continuing Education Provider

Learning Objectives

- Philosophy of Reliability Centered Maintenance
- Discuss Reliability Centered Maintenance in a Higher Education Setting
- Review Case Studies of RCM in Higher Ed

Have a question or comment?

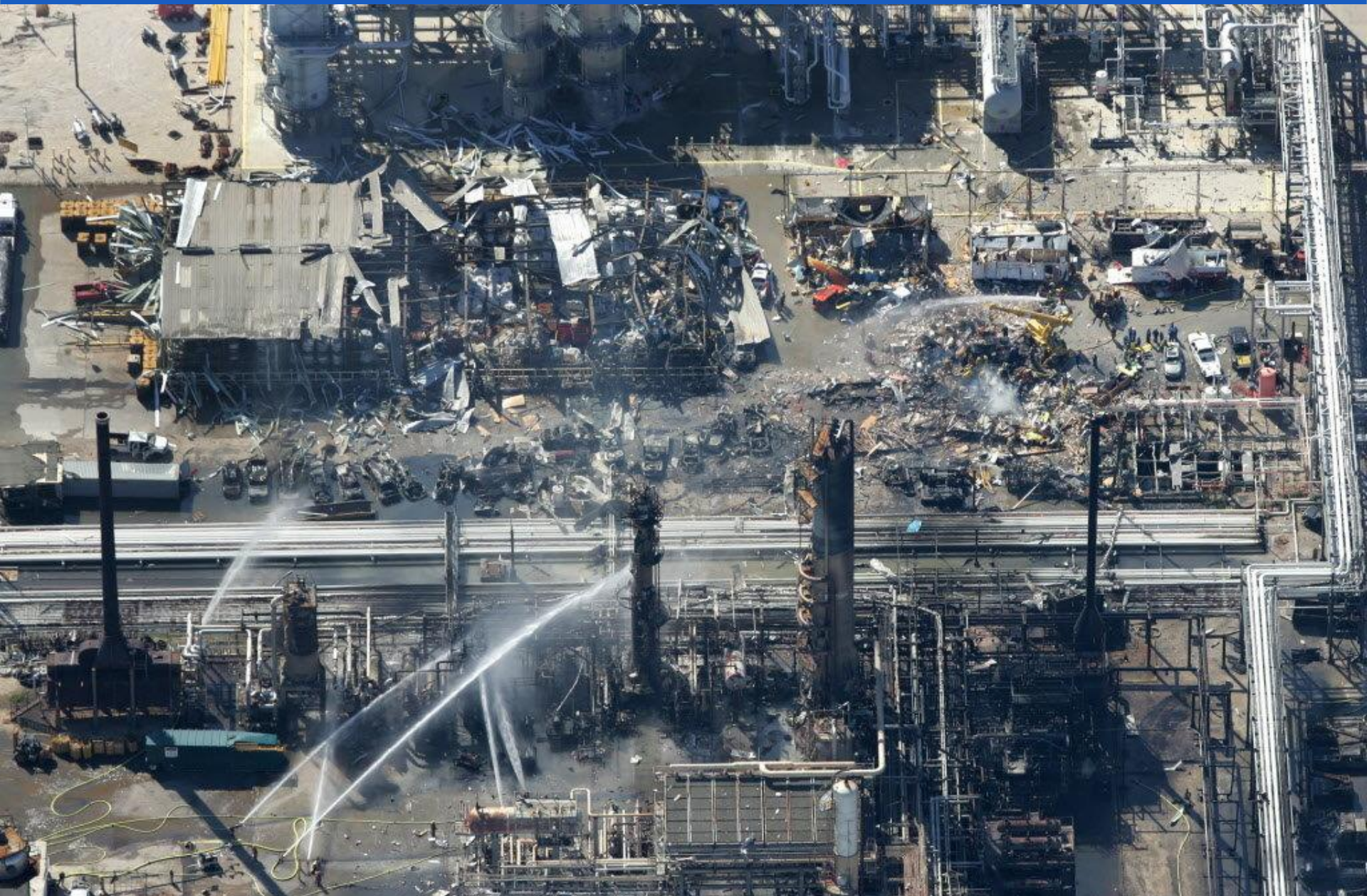
Feel free to ask or share during the presentation

This is ***your*** session…

We all need to do maintenance – 1.0

We all need to do maintenance – 2.0

2005 Texas City refinery explosion



2005 Texas City refinery explosion

- 15 workers killed
- 170 workers injured
- The pressure wave was so powerful it shattered windows off site up to ¾ miles away
- An area estimated at 200,000 square feet was burned

- "Technical failings included … **a lack of preventive maintenance on safety critical systems…**"

  (Report by Chemical Safety and Hazard Investigation Board)

1997 University of Virginia balcony collapse

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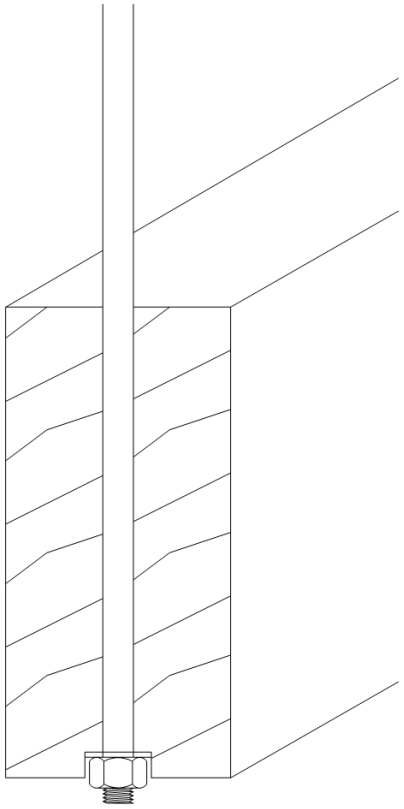
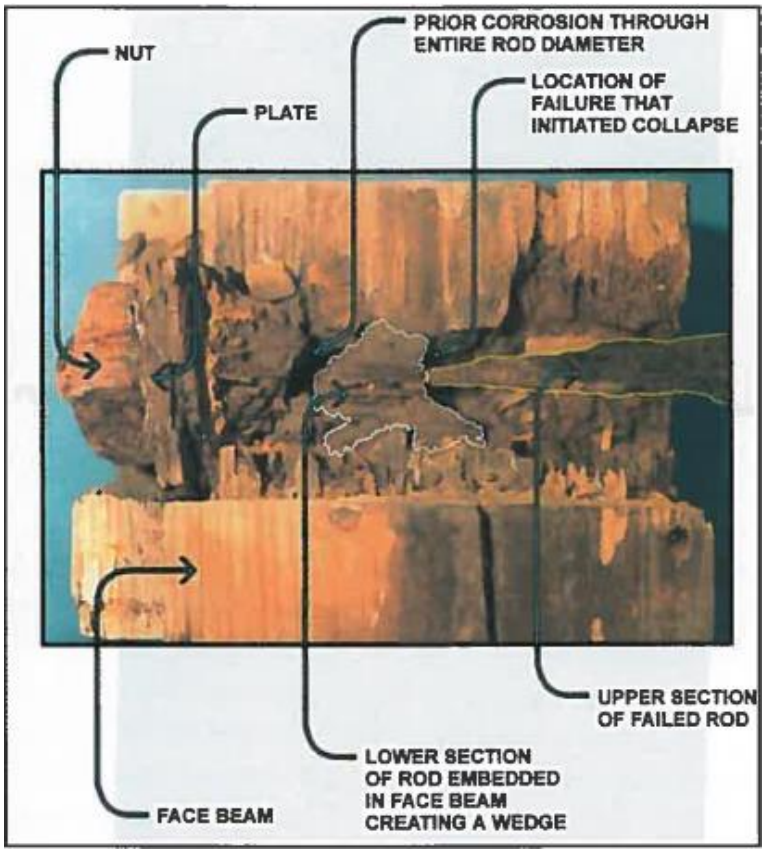
1997 University of Virginia balcony collapse





What is the **cost of a maintenance failure**?

- Health & life safety
- Property damage / loss
- Compliance
- Reputation
- Loss of use (mission) = occupant (customer) impact
- Increased / additional cost
- Unplanned work / emergencies / crises
- Environmental impacts

What are the objectives of a preventive maintenance program?

- Reduce frequency of unscheduled breakdowns and downtime of critical equipment and systems
- Extend service life of equipment
- Reduce energy consumption (sustainability)
- Improve safety
- Compliance
- Improve overall appearance of facilities
- Reduce overall maintenance costs
- Reduce occupant impact
- Liability
- Improve service level

Options for maintenance

Reactive or Demand Maintenance

(a.k.a. No maintenance just repairs!)

Preventive Maintenance

Proactive Maintenance

Predictive Maintenance

Reactive/Demand Maintenance

Do not maintain an asset to prevent failure. Instead, run it to failure and replace/repair it when it fails.

Reactive/demand maintenance forgoes the cost/effort of routine maintenance *on non-critical or low-impact assets* and accepts the cost/impact of asset failure. Also referred to as run-to-failure (RTF).

For example, this typically involves non-critical or low-impact assets such as changing a general use light bulb when it burns out. (NOTE: Can also be effective for redundant equipment.)

Reactive/Demand Maintenance Pros and Cons

Advantages

- Low cost.
- Less staff.

Disadvantages

- Increased cost due to unplanned downtime of equipment.
- Increased labor cost, especially if overtime is needed.
- Cost involved with repair or replacement of equipment.
- Possible secondary equipment or process damage from equipment failure.
- Inefficient use of staff resources.

DoE Operations & Maintenance Best Practices Guide 3.0: https://www1.eere.energy.gov/femp/pdfs/OM_5.pdf

Preventive Maintenance

Maintain an asset to prevent failure, instead of reacting to it.

Preventive maintenance encourages a planned and controlled program of time- or cycle-based continuous inspections and corrective actions taken to ensure peak efficiency and minimize deterioration.

For example, changing the oil in a motor according to manufacturer's recommendations or inspecting belts and pulleys on a recurring basis.

Preventive Maintenance Pros and Cons

Advantages

- Cost effective in many capital-intensive processes.
- Flexibility allows for the adjustment of maintenance periodicity.
- Increased component life cycle.
- Energy savings.
- Reduced equipment or process failure.
- Estimated 12% to 18% cost savings over reactive maintenance program.

Disadvantages

- Catastrophic failures still likely to occur.
- Labor intensive.
- Includes performance of unneeded maintenance.
- Potential for incidental damage to components in conducting unneeded maintenance.

DoE Operations & Maintenance Best Practices Guide 3.0: https://www1.eere.energy.gov/femp/pdfs/OM_5.pdf

Proactive Maintenance

MAINTAIN AN ASSET TO PREVENT FAILURE, INSTEAD OF REACTING TO IT.

PROACTIVE MAINTENANCE ENCOURAGES MAINTENANCE OF ASSETS *BASED ON CUMULATIVE DATA.*

FOR EXAMPLE, THE BUSHINGS ON MACHINE X GET REPLACED EVERY Y NUMBER OF DAYS BECAUSE HISTORICAL DATA SHOWS THEY EXPIRE AFTER Z AMOUNT OF TIME, ON AVERAGE.

Predictive Maintenance

Maintain an asset to prevent failure, instead of reacting to it.

Predictive maintenance encourages maintenance of assets *based on monitoring conditions.*

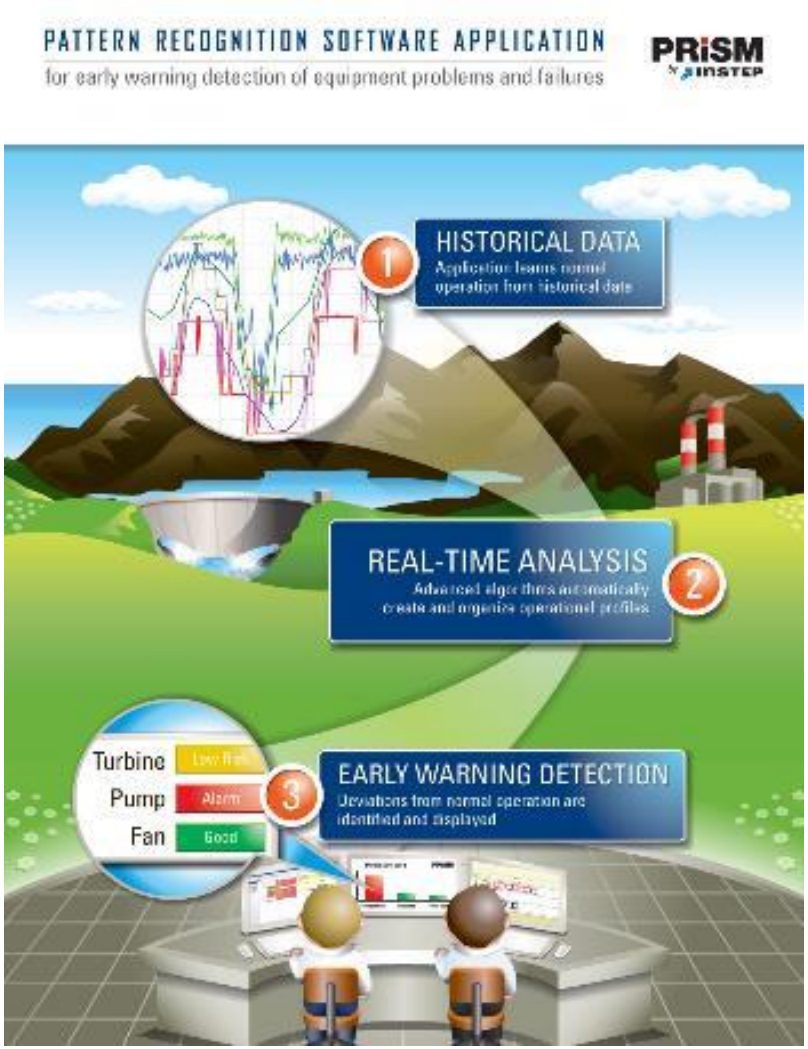
For example, infrared thermographic studies and vibration analysis of electric motors to identify possible problems before they become serious problems requiring an unplanned (reactive) work.

Predictive & proactive maintenance techniques

Inspections
- Visual
- Noise
- Thermal
- Vibration
- Fluid analysis
- Performance analysis (flow across a filter)

- Monitoring
  - Automated BAS system monitoring

Data-based
- Real-time data from building systems
- Fault Detection and Diagnosis (FDD)
- Trending & Modeling
- Machine learning/Artificial Intelligence



Predictive/Proactive Maintenance Pros and Cons

Advantages

- Increased component operational life/availability.
- Allows for preemptive corrective actions.
- Decrease in equipment or process downtime.
- Decrease in costs for parts and labor.
- Better product quality.
- Improved worker and environmental safety.
- Improved worker morale.
- Energy savings.
- Estimated 8% to 12% cost savings over preventive maintenance program.

Disadvantages

- Increased investment in diagnostic equipment.
- Increased investment in staff training.
- Savings potential not readily seen by management.

DoE Operations & Maintenance Best Practices Guide 3.0: https://www1.eere.energy.gov/femp/pdfs/OM_5.pdf

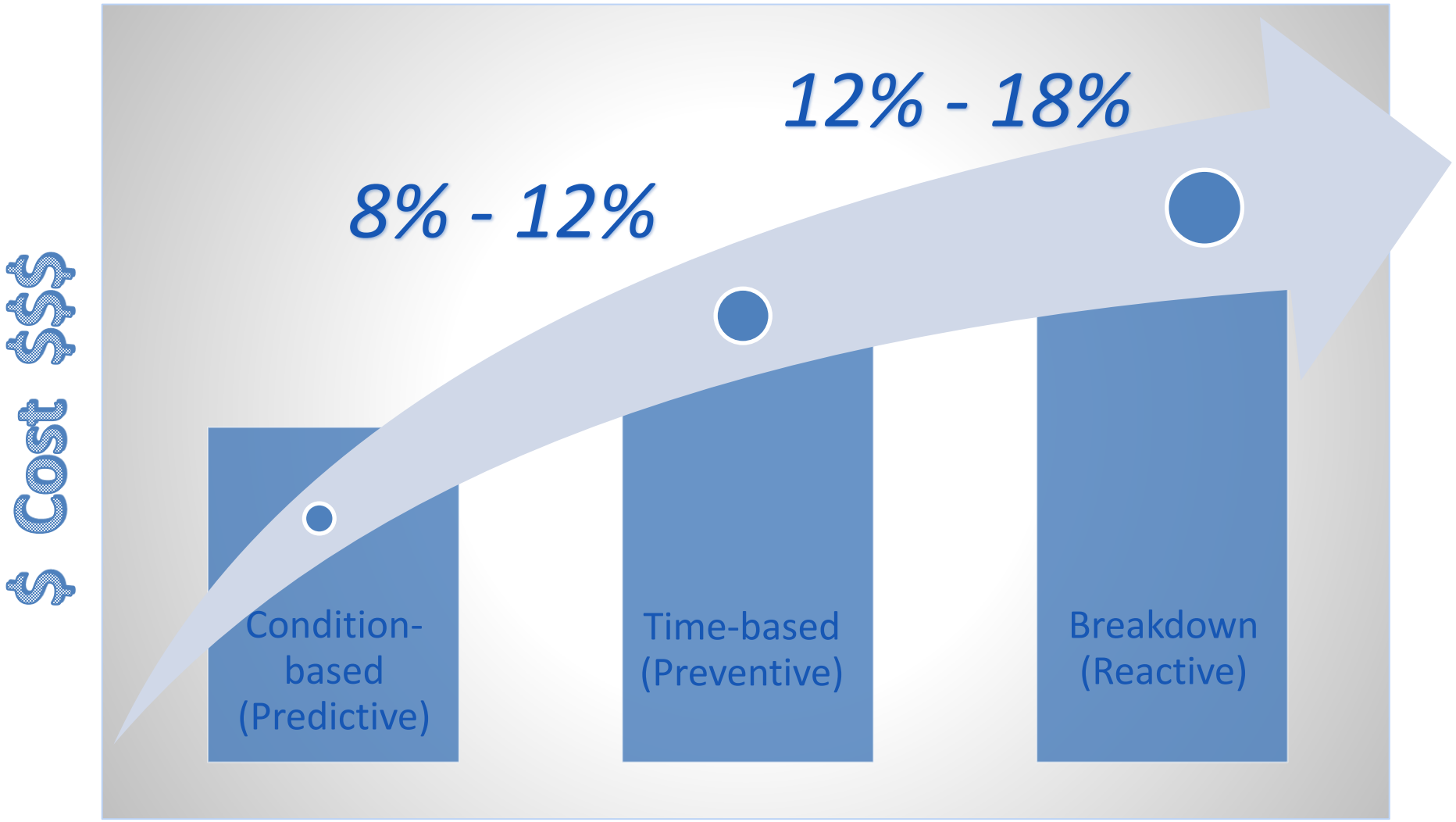
Predictive & proactive maintenance techniques

CIO JOURNAL

‘Predictive-Maintenance’ Tech Is Taking Off as Manufacturers Seek More Efficiency

Pepsi, Colgate and other firms are populating their plants with sensors from AI startup Augury to ‘listen’ for machinery problems. And other up-and-coming ‘machine-health tech’ firms are offering similar wares

The cost of maintenance



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How do you prioritize maintenance?

How do you prioritize maintenance?

	URGENT	NOT URGENT
IMPORTANT	I ACTIVITIES: Crises, pressing problems, deadline-driven projects	II ACTIVITIES: Exercise, long-range planning, preparation, preventive maintenance, relationship building, personal growth activities, some leisure
NOT IMPORTANT	III ACTIVITIES: Interruptions, some calls, some mail, some reports, some meetings	IV ACTIVITIES: Trivia, busy work, some mail, some calls, time wasters, some pleasant activities

APPA's Maintenance Levels of Service include PM

Level	1	2	3	4	5
Description	**Showpiece Facility**	**Comprehensive Stewardship**	**Managed Care**	**Reactive Management**	**Crisis Response**
Customer Service & Response Time	Able to respond to virtually any type of service, immediate response.	Response to most service needs, including non-maintenance activities, is typically in a week or less.	Services available only by reducing maintenance, with response times of one month or less.	Services available only by reducing maintenance, with response times of one year or less.	Services not available unless directed from top administration, none provided except emergencies
Customer Satisfaction	Proud of facilities, have a high level of trust for the facilities organization.	Satisfied with facilities related services, usually complimentary of facilities staff.	Accustomed to basic level of facilities care. Generally able to perform mission duties. Lack of pride in physical environment.	Generally critical of cost, responsiveness, and quality of facilities services.	Consistent customer ridicule, mistrust of facilities services.
vs. Corrective Maintenance	100%	75-100%	50-75%	25-50%	<25%
Maintenance Mix	All recommend preventive maintenance (PM) is scheduled and performed on time. Emergencies (e.g. storms or power outages) are very infrequent and are handled efficiently.	A well-developed PM program: most required PM is done at a frequency slightly less than per defined schedule. Occasional emergencies caused by pump failures, cooling system failures etc.	Reactive maintenance predominates due to systems failing to perform, especially during harsh seasonal peaks. The high number of emergencies causes reports to upper administration.	Worn-out systems require staff to be scheduled to react to systems that are performing poorly or not at all. PM work possible consists of simple tasks and is done inconsistently.	No PM performed due to more pressing problems. Reactive maintenance is a necessity due to worn-out systems. Good emergency response because of skills gained in reacting to frequent system failures.
Aesthetics, Interior	Like-new finishes.	Clean/crisp finishes.	Average finishes.	Dingy finishes.	Neglected finishes.
Aesthetics, Exterior	Windows, doors, trim, exterior walls are like new.	Watertight, good appearance of exterior cleaners.	Minor leaks and blemishes, average exterior appearance.	Somewhat drafty and leaky, rough-looking exterior, extra painting necessary.	Inoperable windows, leaky windows, unpainted, cracked panes, significant air and water penetration, poor appearance overall.
Aesthetics, Lighting	Bright and clean, attractive lighting.	Bright and clean, attractive lighting.	Small percentage of lights out, generally well lit and clean.	Numerous lights out, some missing diffusers, secondary areas dark.	Dark, lots of shadows, bulbs and diffusers missing, cave-like, damaged, hardware missing.
Service Efficiency	Maintenance activities appear highly organized and focused. Service and maintenance calls are responded to immediately.	Maintenance activities appear organized with direction. Service and maintenance calls are responded to in a timely manner.	Maintenance activities appear to be somewhat organized, but remain people-dependant. Service and maintenance calls are variable and sporadic, without apparent cause.	Maintenance activities appear somewhat chaotic and are people-dependant. Service and maintenance call are typically not responded to in a timely manner.	Maintenance activities appear chaotic and without direction. Equipment and building components are routinely broken and inoperable. Service and maintenance calls are never responded to in a timely manner.
Building Systems' Reliability	Breakdown maintenance is rare and limited to vandalism and abuse repairs.	Breakdown maintenance is limited to system components short of mean time between failures (MTBF).	Building and systems components periodically or often fail.	Many systems are unreliable. Constant need for repair. Backlog of repair needs exceeds resources.	Many systems are non-functional. Repair instituted only for life safety issues.
Facility Maintenance Operating Budget as % of CRV	>4.0	3.5-4.0	3.0-3.5	2.5-3.0	<2.5
Campus Average FCI	<0.05	0.05-0.15	0.15-0.29	0.30-0.49	>0.50

Does a preventive maintenance program prevent failures?

- Is 0% failure ideal?
- Is more maintenance better?
  - What is the cost/impact of downtime for maintenance?
  - “70% failures are self-induced” ??
- Is 100% PM completion ideal?
  - Code compliance = 100%World class: > 95% PM completion
  - Reality: 60% (20-30% properly done)!
  - What is your PM completion %?
- Is time-based better?
- Is cycle frequency better?

Fundamentally, a good maintenance program is an exercise in risk management

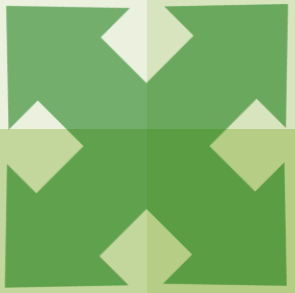
- Understand the risks
  - Identify risks
    - **Failure Modes & Effects Analysis (FMEA)**
  - Probability of risk
- Risk management balances:
  - Cost of failure / How much failure can you afford?
  - Cost of maintenance / How much maintenance can you afford?
- Most likely, varies across your portfolio

Reliability Centered Maintenance

Reactive or Demand Maintenance

(a.k.a. No maintenance just repairs!)

Preventive Maintenance



Proactive Maintenance

Predictive Maintenance

Reliability Centered Maintenance

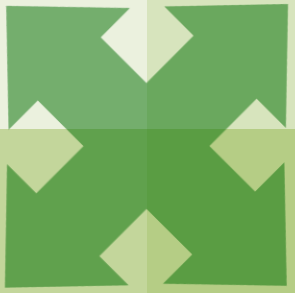
< 10%

Reactive or Demand Maintenance

(a.k.a. No maintenance just repairs!)

25-35%

Preventive Maintenance



Proactive Maintenance

Predictive Maintenance

45-55%

Case study: Culture change

“The best service is no service.”

UVA McCormick Rd. Zone

Air filter’s impact on customer service – not just a bunch of hot air!

Case study: Staffing/Resourcing

The impact of planning work at UVA

Meet the Coordinators:

Mike Jessee – North Grounds

Eric Luedeking – West Grounds

Jerry Schwartz – Newcomb

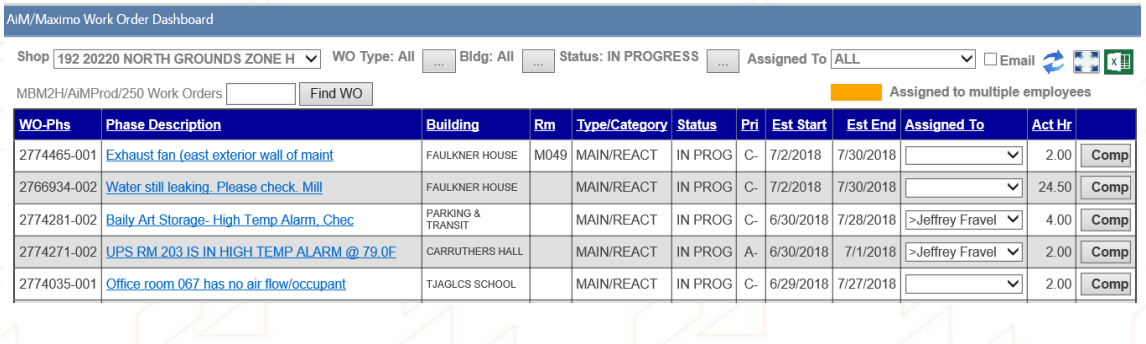
Paige Herndon – Fire & Life Safety

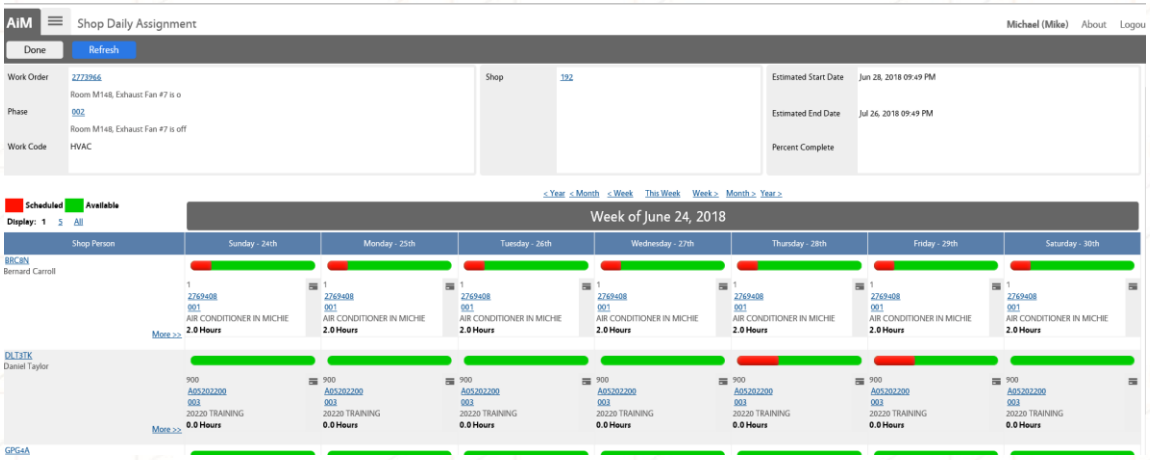
John Quinn – Central Grounds

Jason Falls - McCormick

The Maintenance Coordinator Initiative

Improve ‘wrench time’ through planning & scheduling:



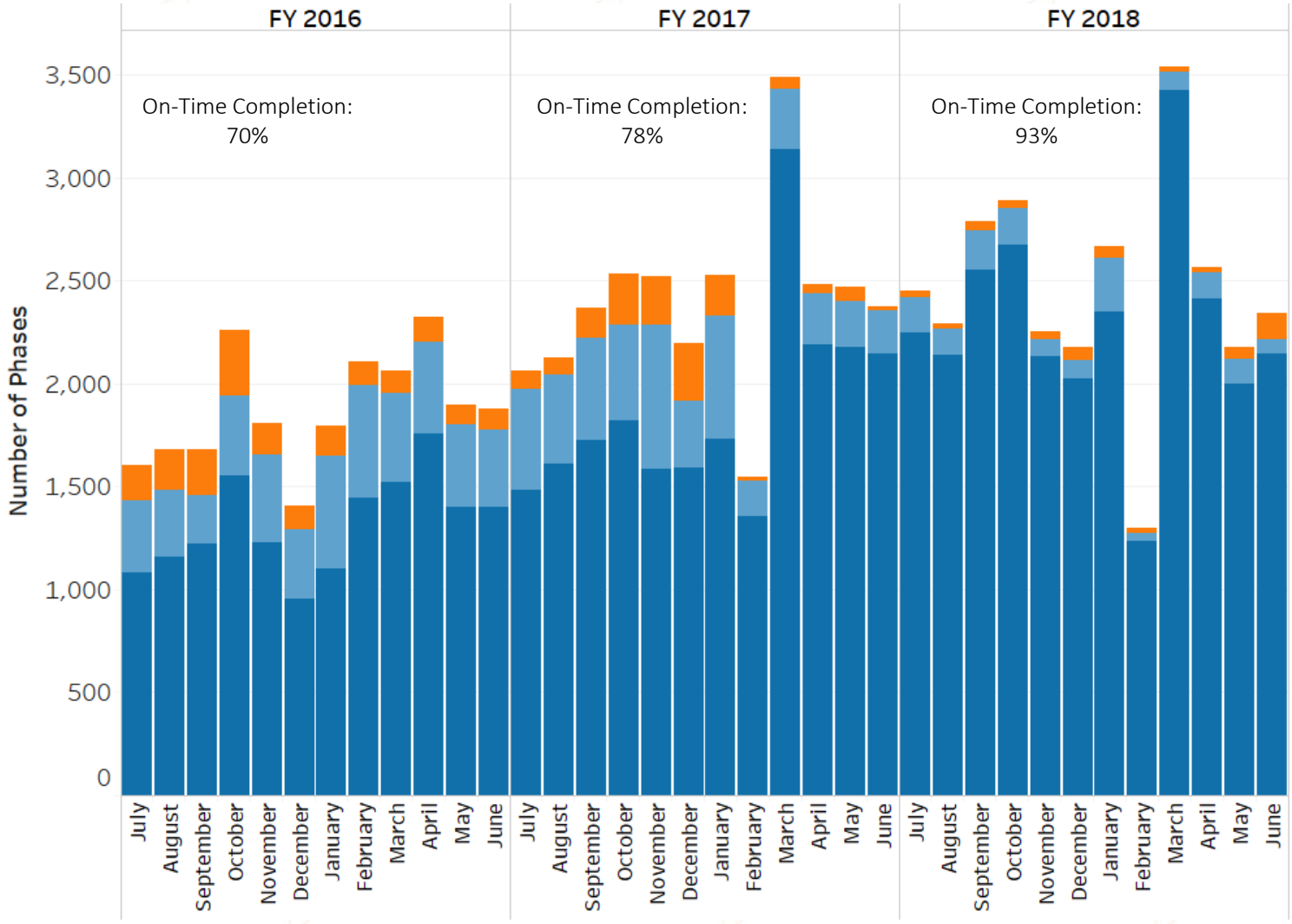


PM Completion Rates

- improved in coordinator maintenance shops

31%

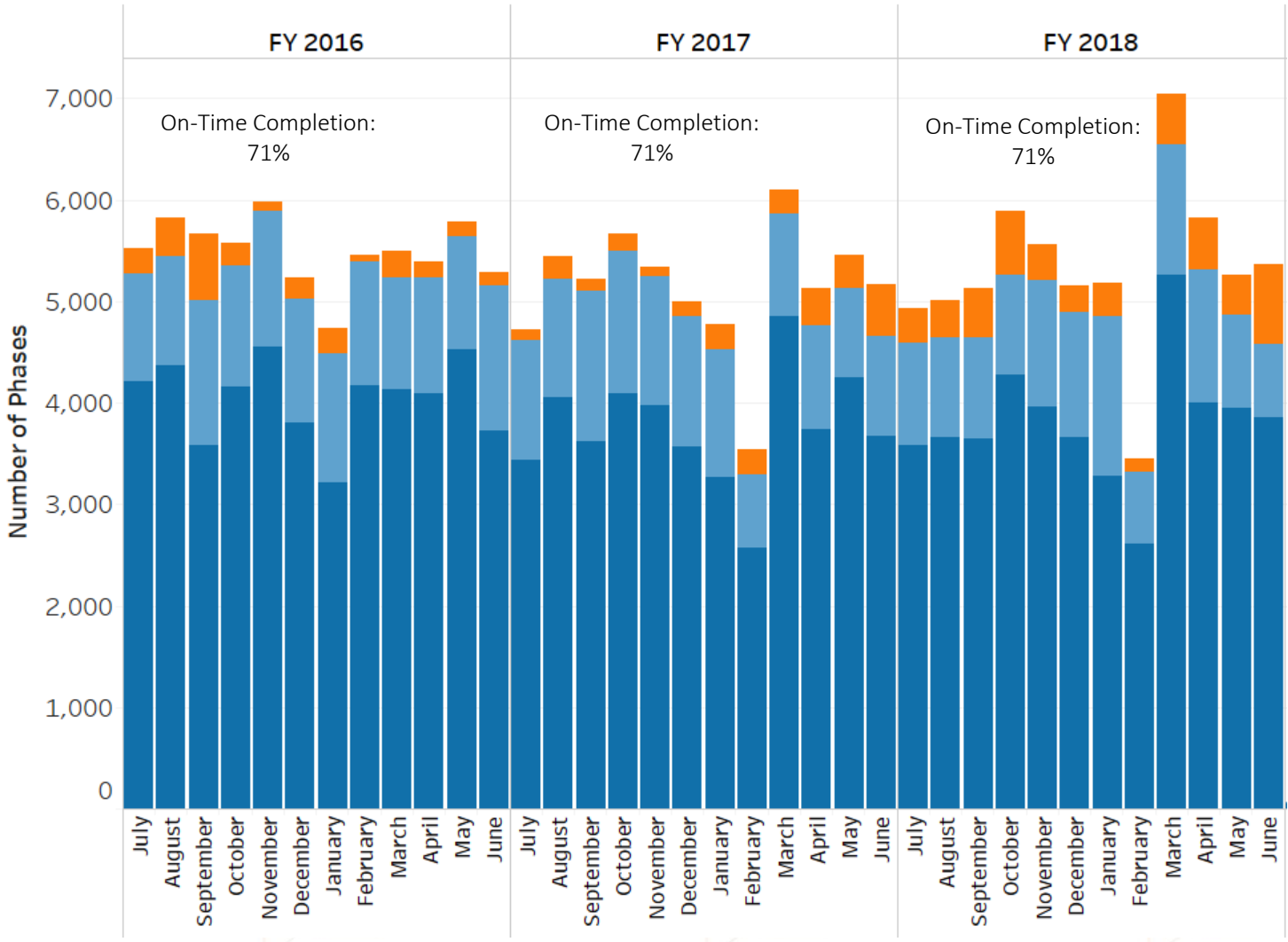
Increase in # of PM phases FY16 to FY18



PM Completion Rates – all other non-coordinator shops combined

3%

Decrease in # of PM phases FY16 to FY18



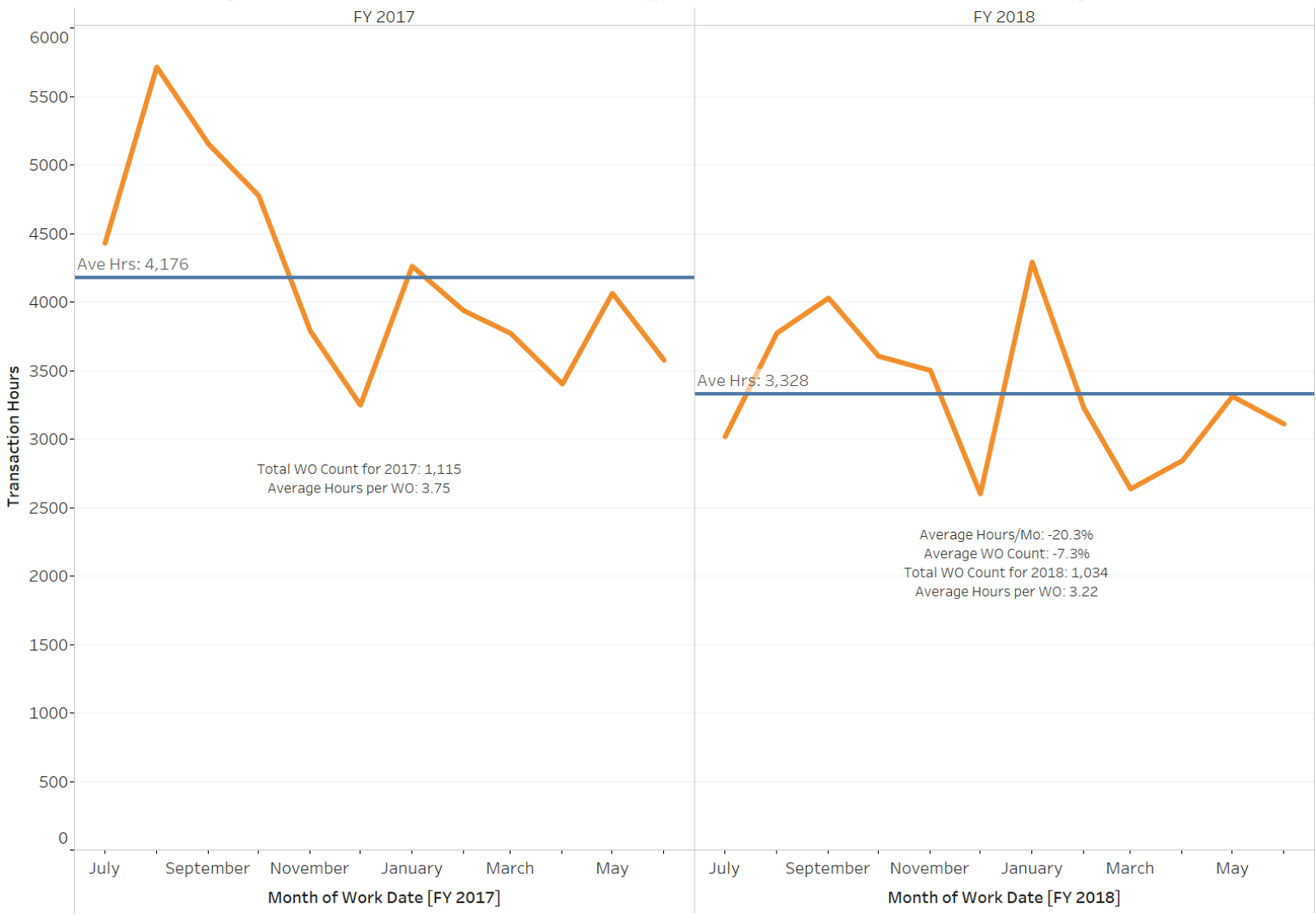
Reactive Work – decreases in coordinator maintenance shops from FY17-18

7%

Decrease in # of WOs

20%

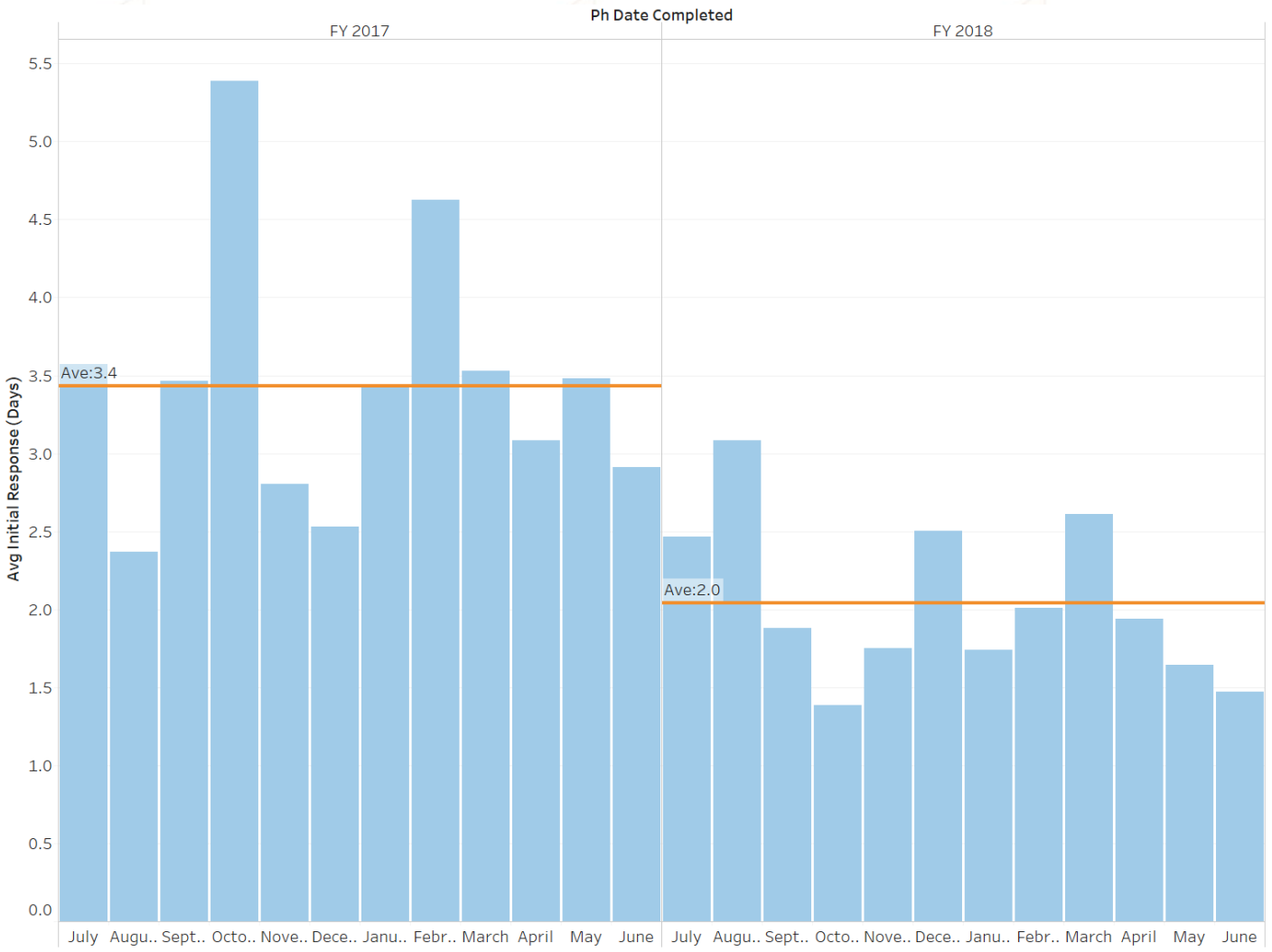
Decrease in labor hrs charged per month



Initial Response Time – to reactive WOs in coordinator maintenance shops improve in 2018

41%

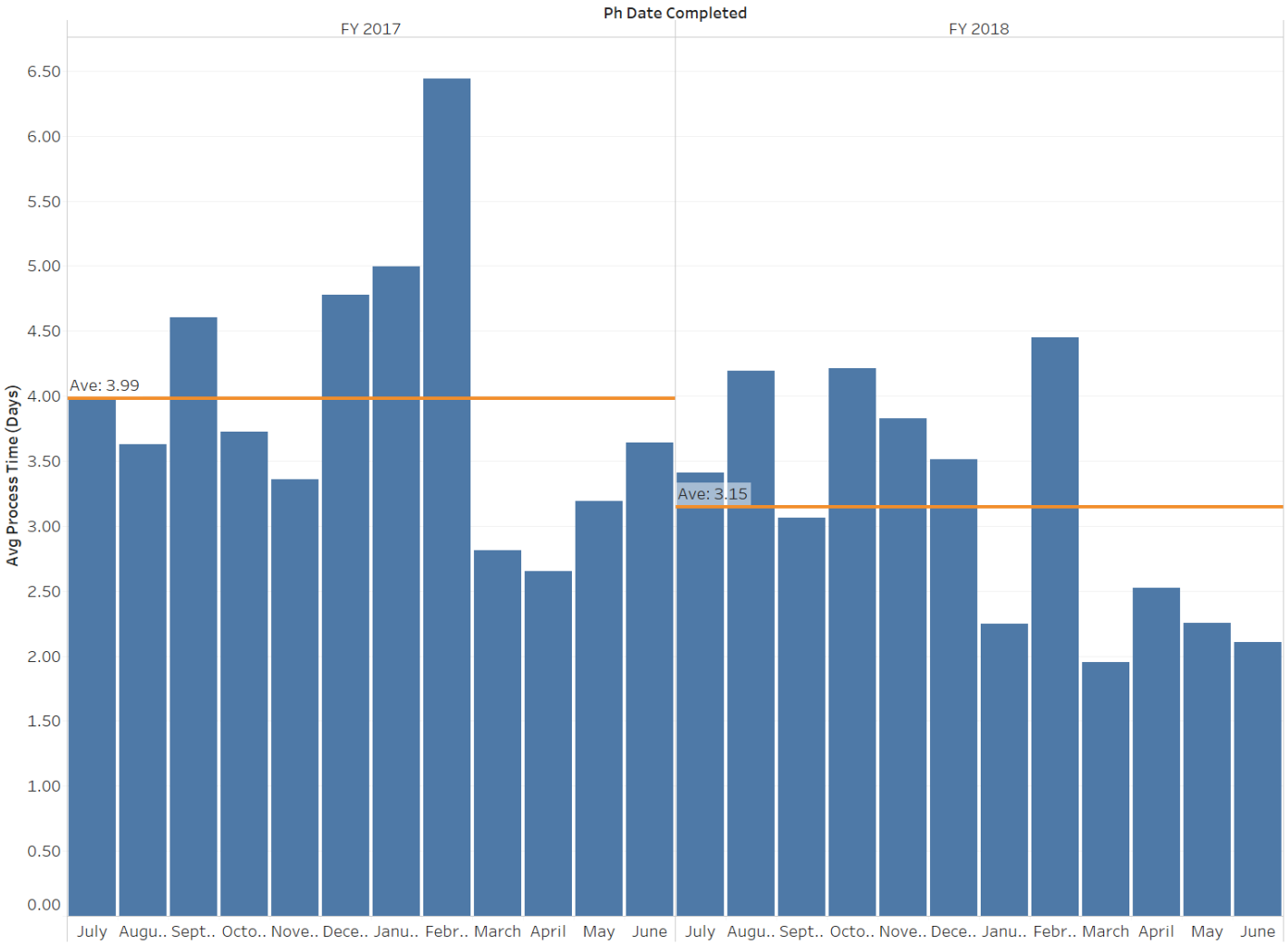
Improvement in time taken to begin work on a reactive WO



Reactive Process Time – work is being completed more quickly once started in coordinator maintenance shops

21%

Improvement in time spent on reactive work



Additional staffing/organization considerations for a PM program

Who has ownership/responsibility?

- Preventive Program Manager?
- Zone/shop responsibility?

Who performs PM?

- Dedicated crew? All technicians?
- Off-hours?

Case study: Using your data

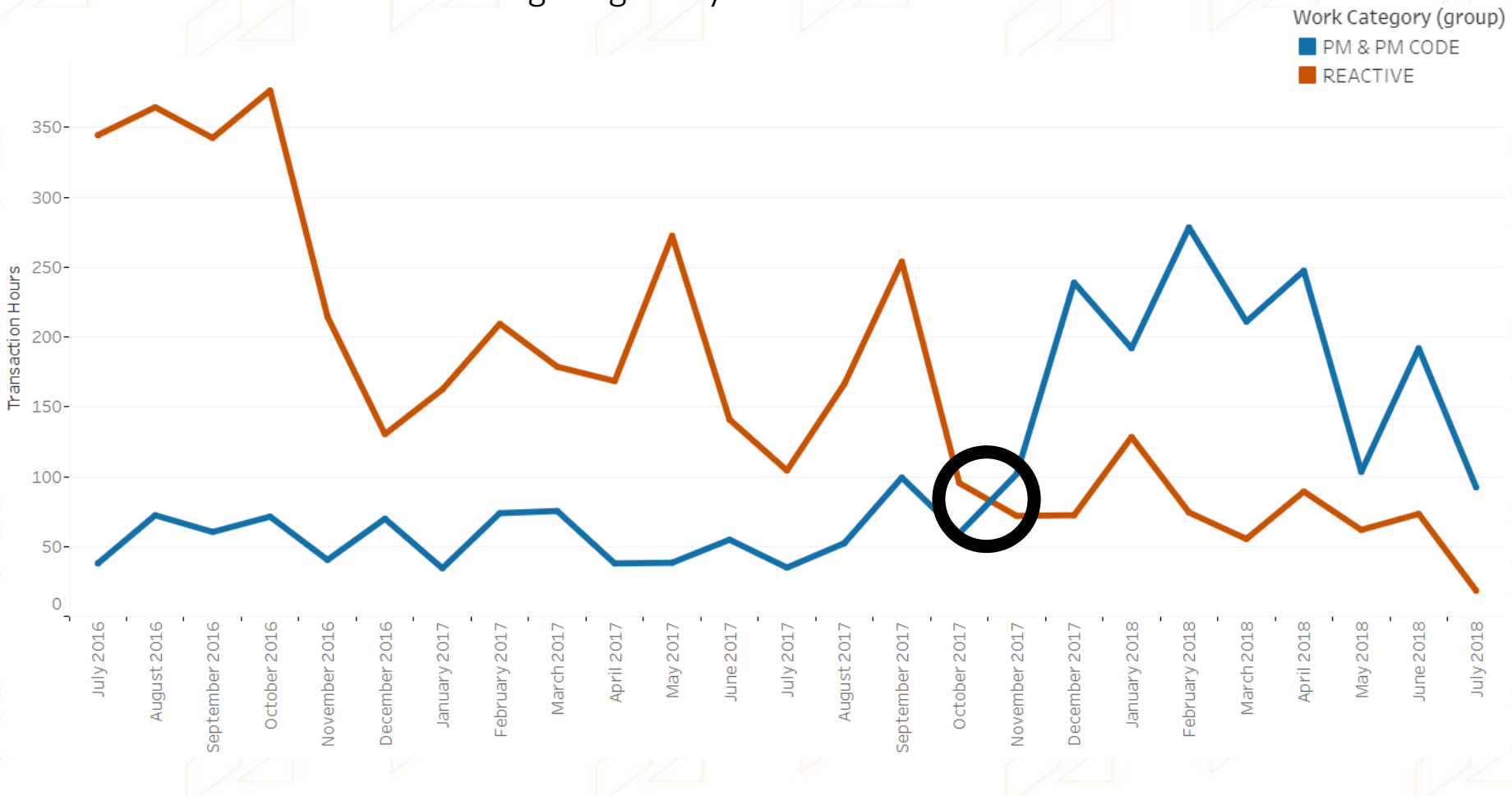
How many people does it take to change a light bulb at UVA?

Central Grounds Zone Maintenance Analysis

Lighting Frequency Analysis for Central Grounds

Building	Total Hours	Reactive Hours	Percentage Reactive	Original Frequency	New Frequency
RANDALL HALL	16	2.5	15.63%		Bi-Monthly
GARRETT HALL	99.5	14.5	14.57%	Monthly	Bi-Monthly
VARSITY HALL	4	2	50.00%	Semi-Annual	Quarterly
ROBERTSON HALL	641	8	1.25%	Semi-Weekly	Monthly

Lighting Analysis Reactive to PM

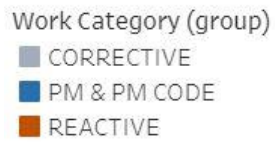


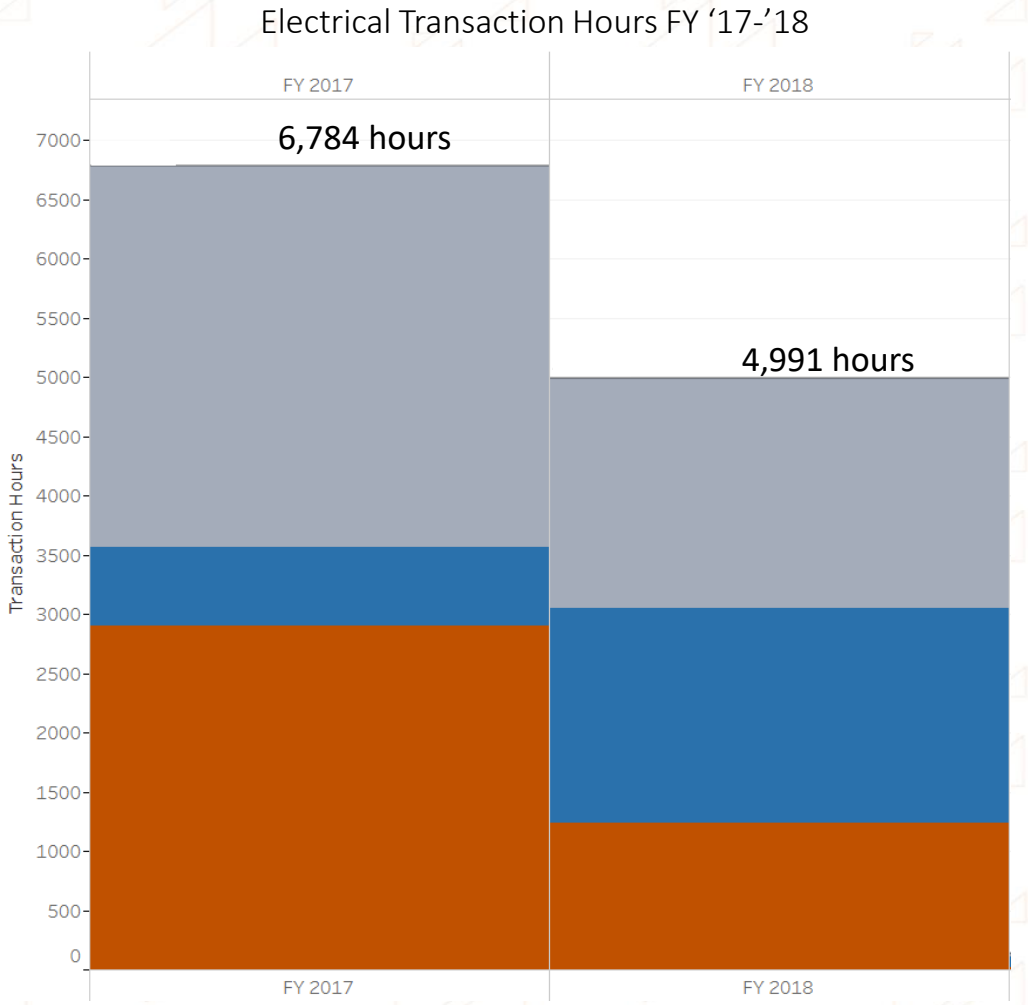
Reactive to Proactive

- Reduced the total amount of hours spent maintaining assets
- Improved customer service

35%

less hours spent
on electric assets





Take-aways and keys to a successful maintenance program:

It starts with culture change

Staff your maintenance program

Use your data to tell your story

Thank you!

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