# Controller Cognitive Workload Levels and Fatigue

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# Presentation Objectives

- Illustrate why controller workload is measured and how we measure it
- Discuss relationship between cognitive workload and fatigue

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# Why measure?

Operators of hazardous liquids, gas transmission, and gas distribution control rooms

- are required by the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration to monitor
  - the general activity of their controllers to make sure they have enough time to analyze and to react to alarms.

# Why measure?

- Controllers are responsible for the operation, monitoring and control of high risk operations.
- Controllers, because they are human, have Human Capabilities and Limitations.


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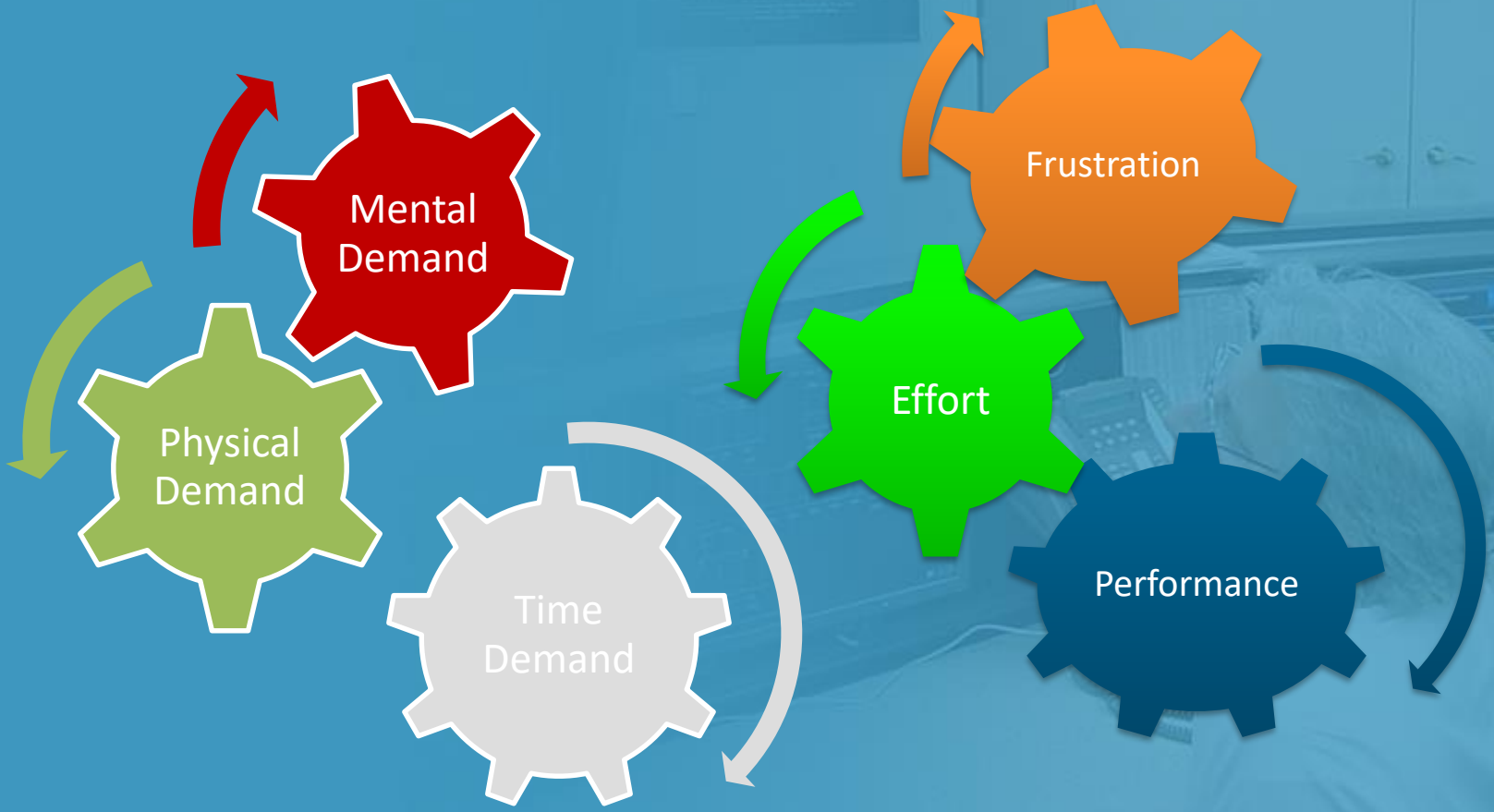
# Our Methodology

- Over the past six years we have conducted over 180 workload assessments with controllers in over 60 control rooms in the United States and Canada.
- Our methodology is based on:
  - modified NASA Task Load Index (NASA-TLX)
  - measures of task percentages.
- In 2015 we added an alertness measure to the workload assessments.
- Industry benchmarks for:
  - controller workload,
  - alertness
  - controller general activities (particular attention to responses to alarms and abnormal and emergency conditions)

# Workload Ratings

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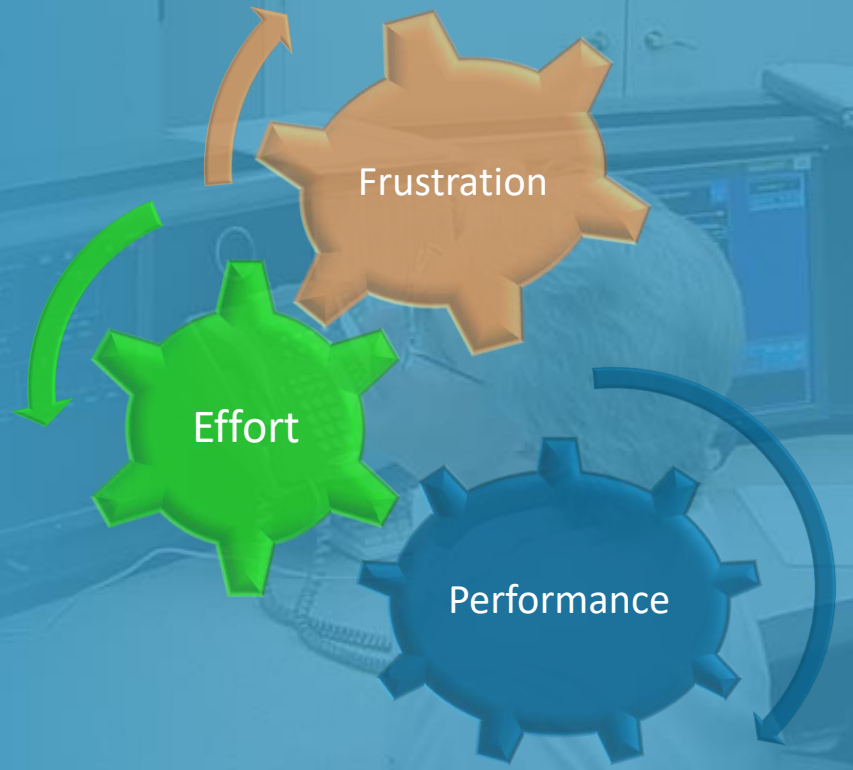
# Workload Ratings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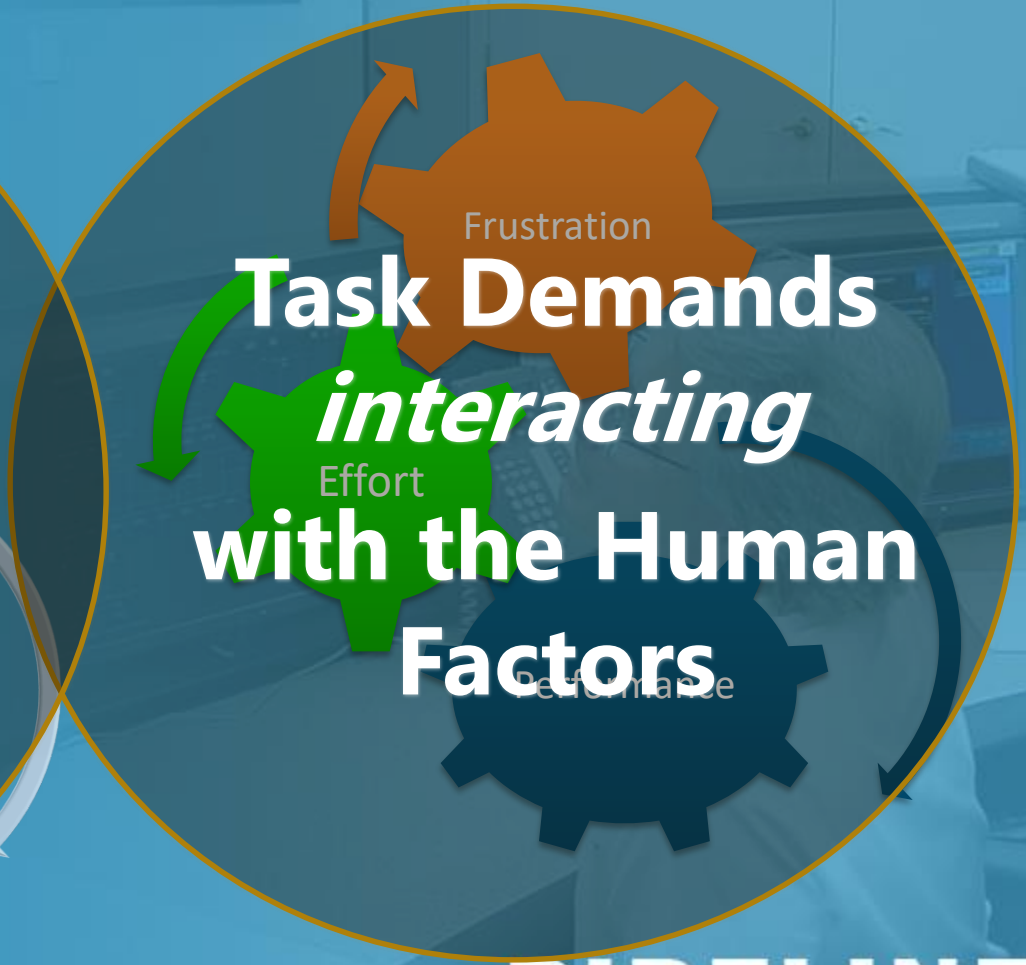
# Workload Ratings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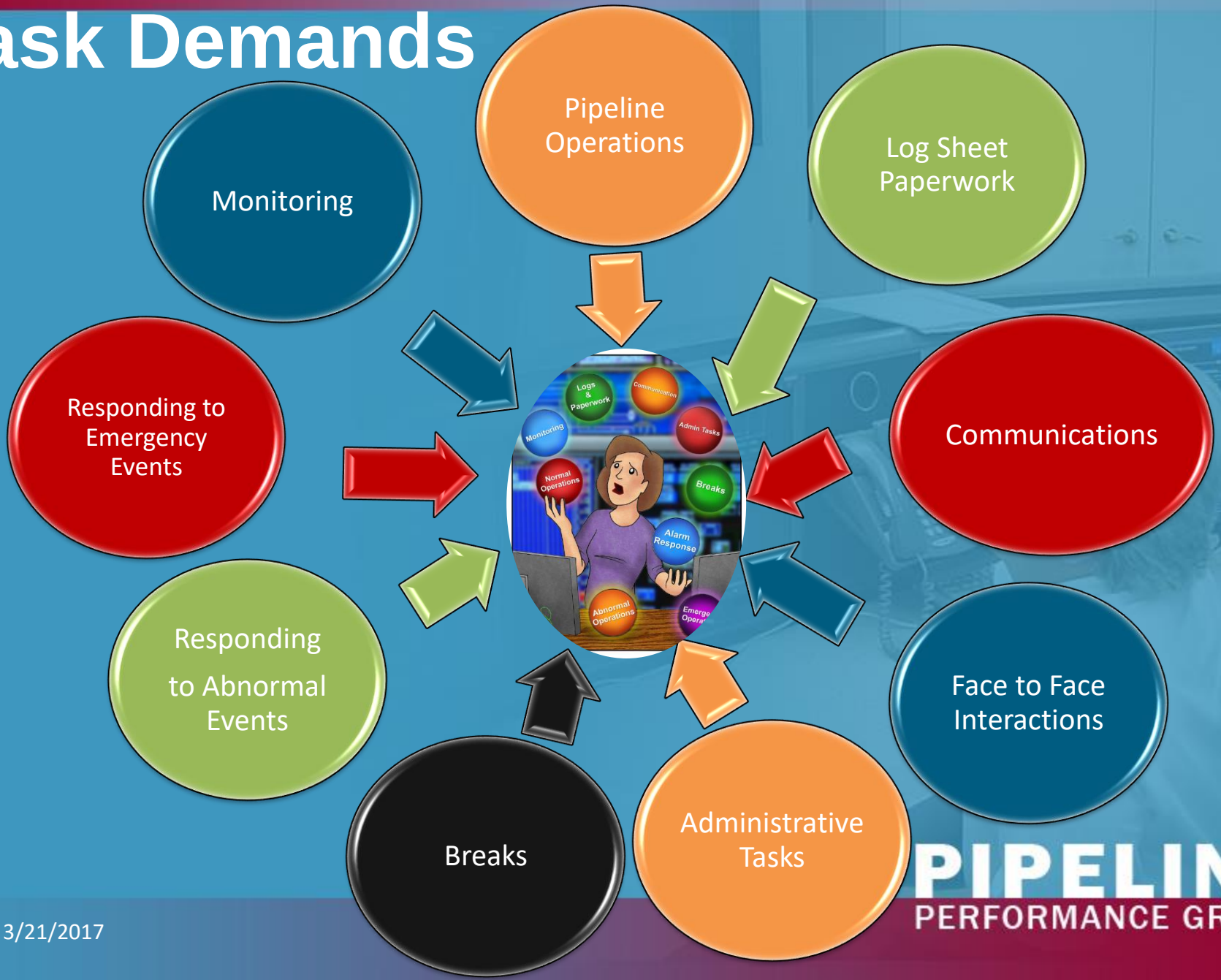
# Task Demands

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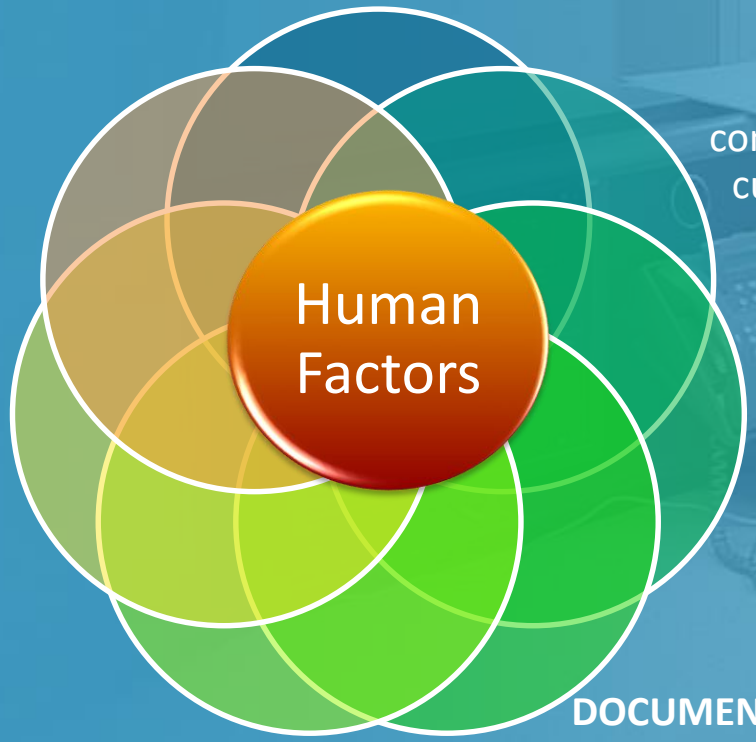
# Factors that impact Task Demands

**CONTROLLER CHARACTERISTICS**

health, habits, attitude, home, age, experience, previous experience, self assessment

**ENVIRONMENT**

windows, seating, air, heat, clean, lighting, TV




**OTHER PEOPLE**

controllers, field personnel, customers, management

**THE COMPANY**

culture, leadership, resources

**TECHNOLOGY**

SCADA displays, phones, radio

**DOCUMENTATION**

procedures, manuals, email

Training



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# Pipeliner Alertness Measure

- The 9-point scale was adapted from the Karolinska sleepiness scale (KSS) developed by the Karolinska Institute in Sweden.
- This is a self-report scale that measures drowsiness:
  - extremely alert
  - very alert
  - alert
  - rather alert
  - neither alert nor sleepy
  - some signs of sleepiness
  - sleepy, it's no effort to stay awake
  - sleepy, some effort to stay awake
  - very sleepy, great effort to stay awake, fighting sleep

# Workload Assessments: Conducted 2010-2016

| Control Center Type | Number of Assessments | Number of Consoles | Number of Controllers |
|---|---|---|---|
| Hazardous Liquid | 88 | 153 | 847 |
| Gas Transmission | 47 | 75 | 395 |
| Gas Distribution | 20 | 37 | 175 |
| Both HL & Gas | 24 | 35 | 181 |
| **Total** | 179 | **300** | **1598** |

60 Control Rooms in U.S. and Canada/58915 hours assessed

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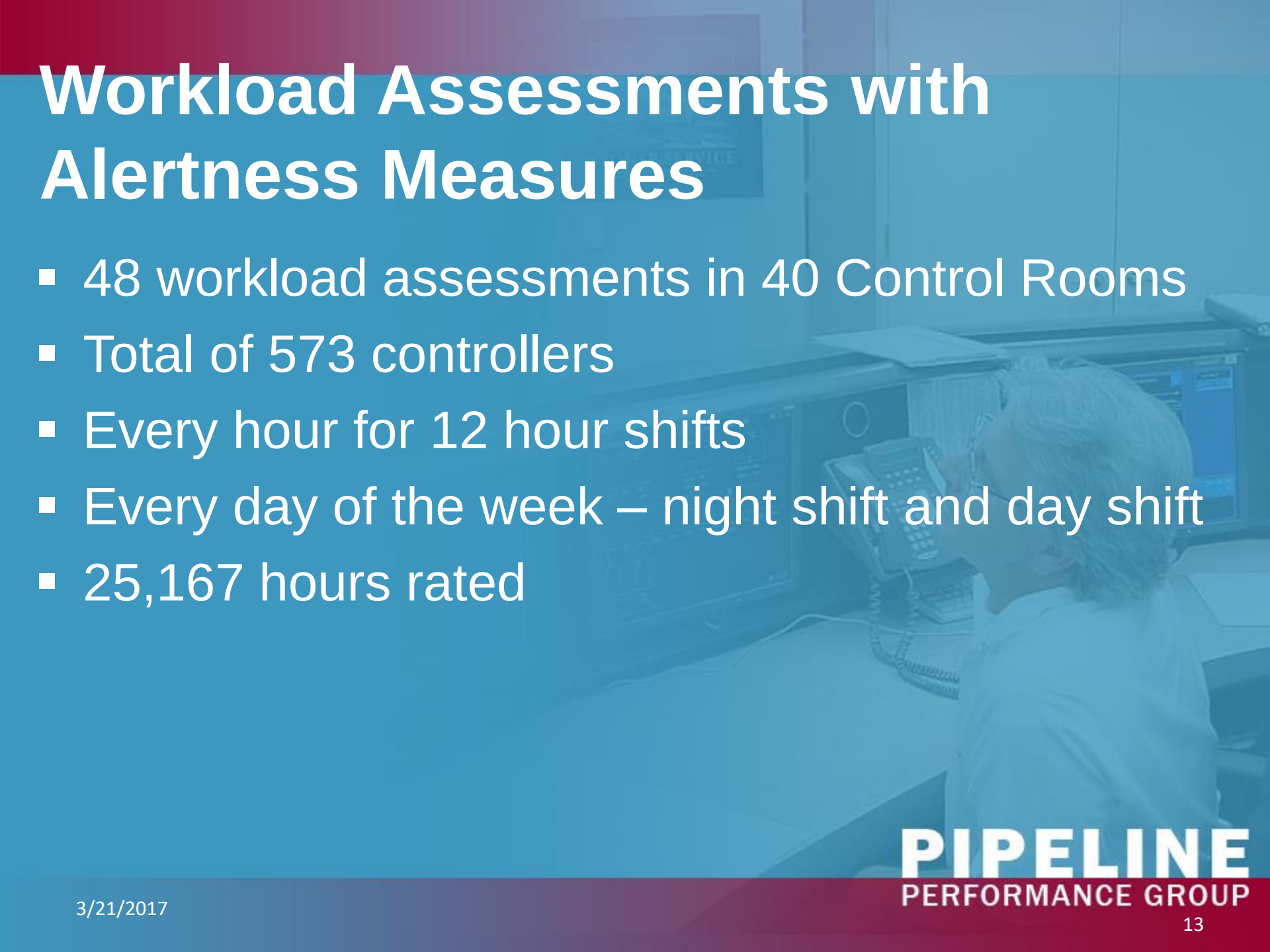
# Workload Assessments with Alertness Measures

- 48 workload assessments in 40 Control Rooms
- Total of 573 controllers
- Every hour for 12 hour shifts
- Every day of the week – night shift and day shift
- 25,167 hours rated



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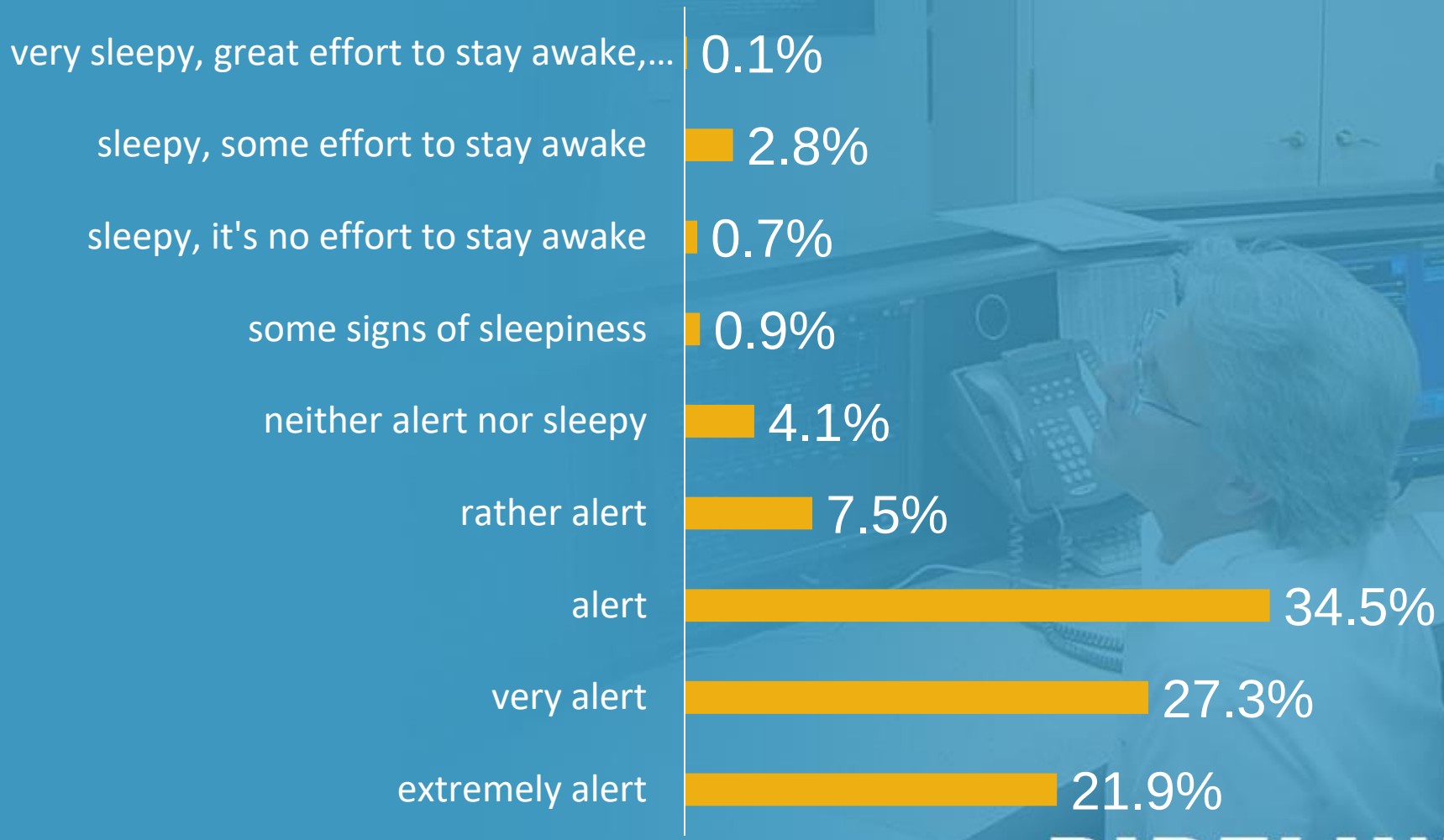
# Alertness Ratings

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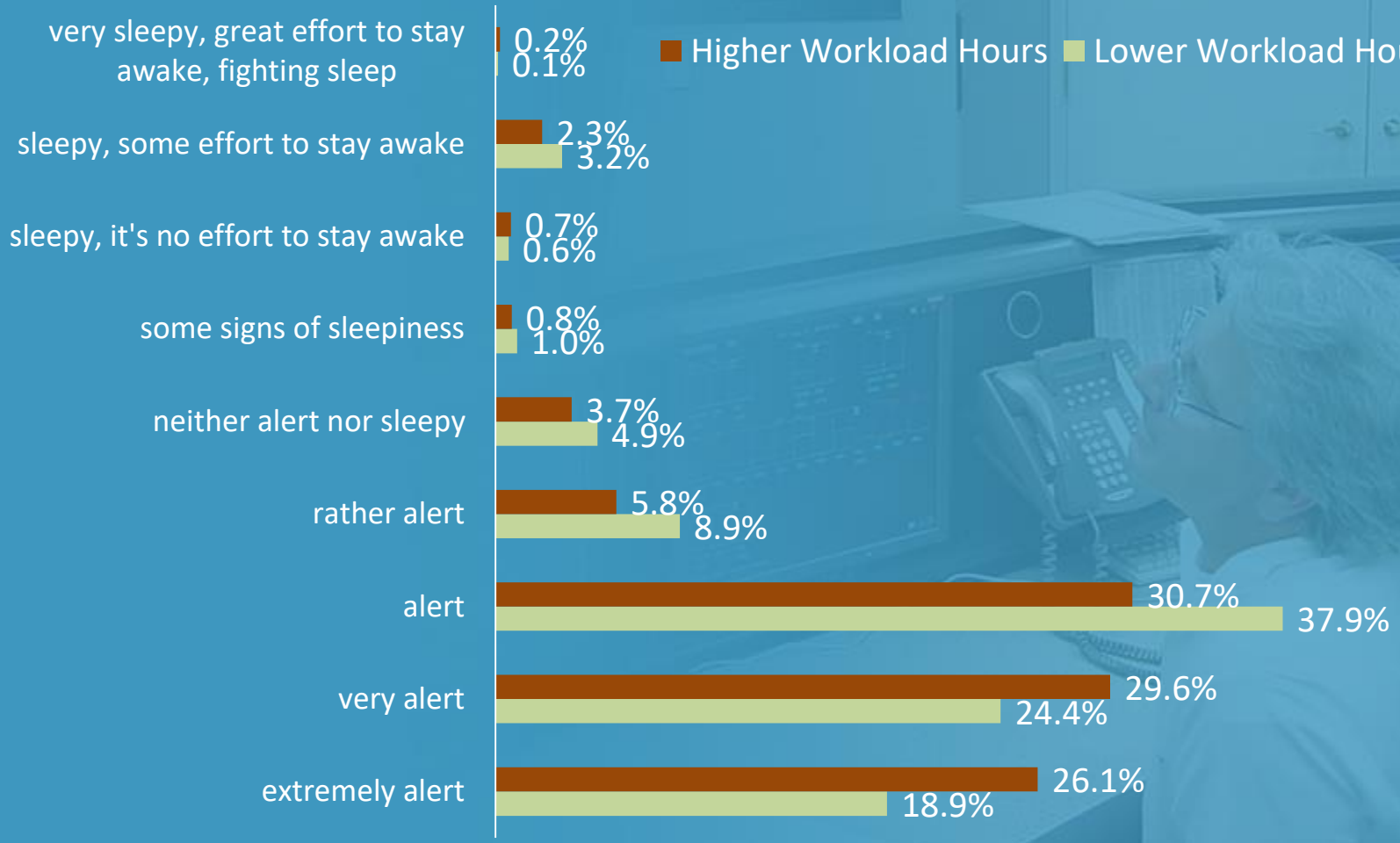
# Alertness Ratings
# During Higher and Lower Workload Hours

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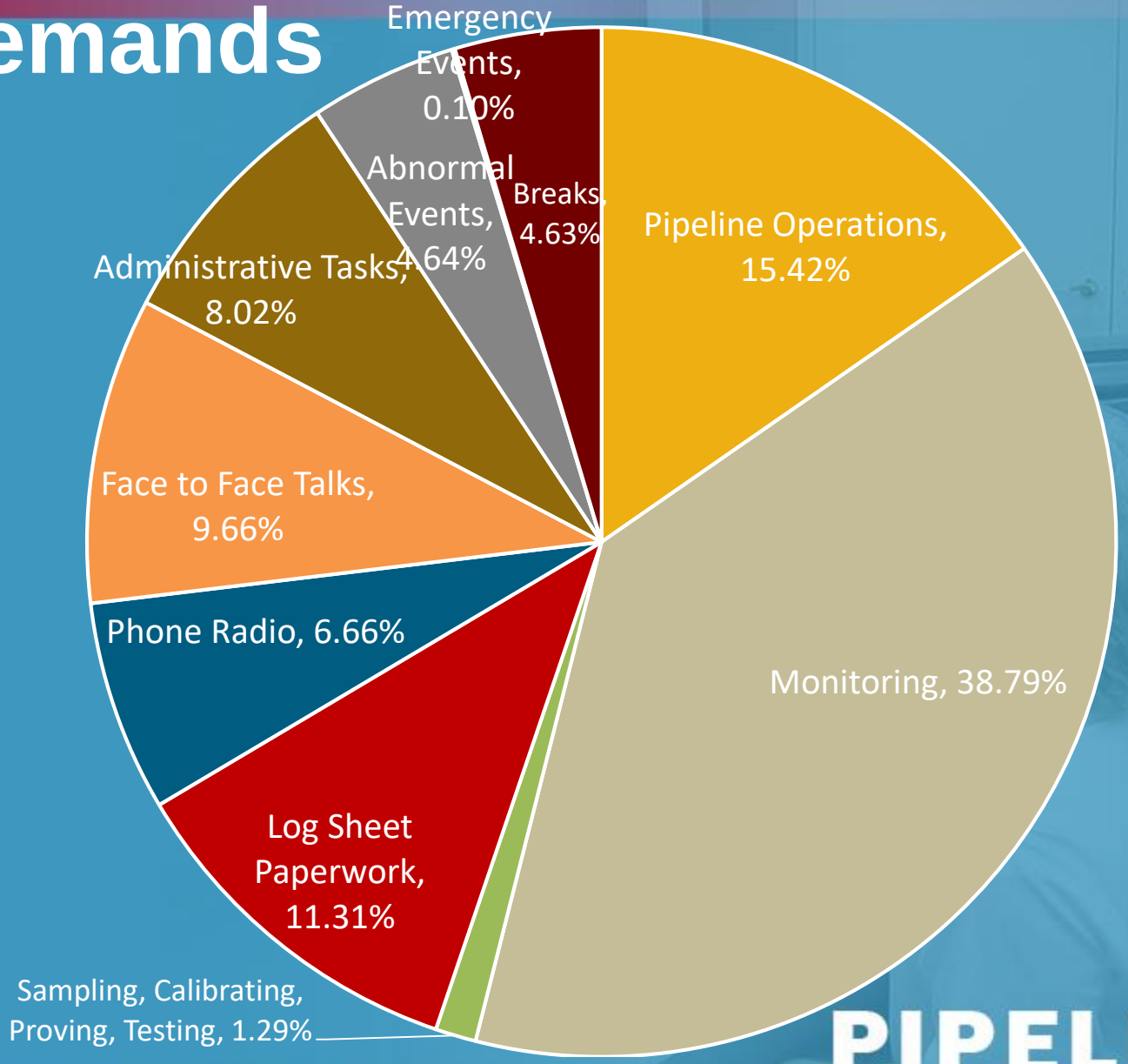
# Alertness Ratings

| Pipeliner Alertness Percentages | Lower Workload Hours | Higher Workload Hours | All Hours |
|---|---|---|---|
| extremely alert | 18.9% | 26.1% | 21.9% |
| very alert | 24.4% | 29.6% | 27.3% |
| alert | 37.9% | 30.7% | 34.5% |
| rather alert | 8.9% | 5.8% | 7.5% |
| neither alert nor sleepy | 4.9% | 3.7% | 4.1% |
| some signs of sleepiness | 1.0% | 0.8% | 0.9% |
| sleepy, it's no effort to stay awake | 0.6% | 0.7% | 0.7% |
| sleepy, some effort to stay awake | 3.2% | 2.3% | 2.8% |
| very sleepy, great effort to stay awake, fighting sleep | 0.1% | 0.2% | 0.1% |

# Workload Benchmarks

- Average workload during all hours (n=25,167)
  - Day Shift 5.2
  - Night Shift 4.9
  - Overall 5.0
- Average workload during “higher” hours (n= 4029)
  - Day Shift 8.1
  - Night Shift 8.1
  - Overall 8.1

# Task Demands

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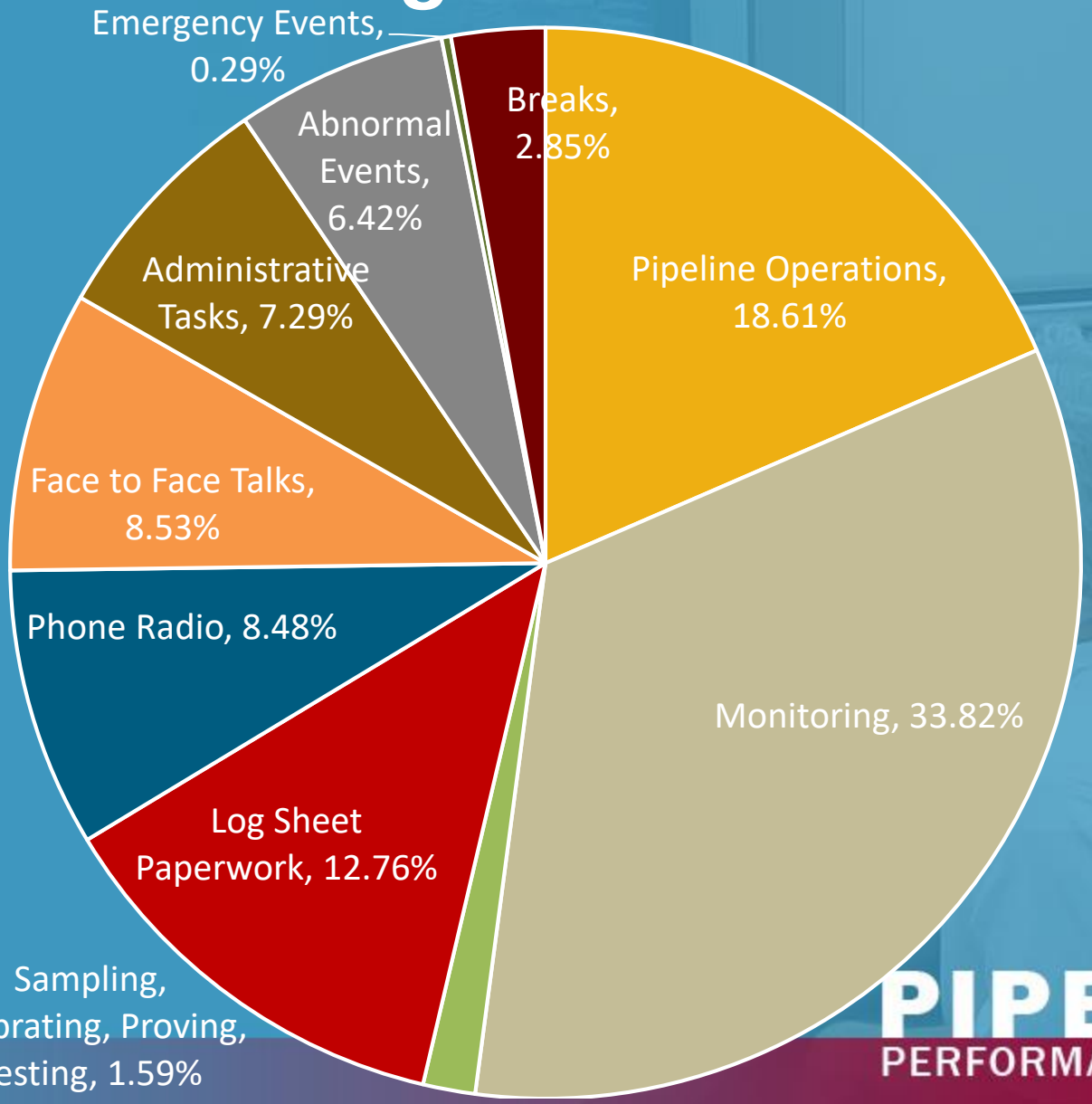
# Task Demands Higher Workload Hours

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# Task Demands Higher Workload Hours

| | All Hours | Higher Workload Hours | Change |
|---|---|---|---|
| Pipeline Operations | 15.42% | 18.61% | ↑ |
| Monitoring | 38.79% | 33.82% | ↓ |
| Sampling, Calibrating, Proving, Testing | 1.29% | 1.59% | |
| Log Sheet Paperwork | 11.31% | 12.76% | ↑ |
| Phone Radio | 6.66% | 8.48% | ↑ |
| Face to Face Talks | 9.66% | 8.53% | ↓ |
| Administrative Tasks | 8.02% | 7.29% | ↓ |
| Responding to Abnormal Events | 4.64% | 6.42% | ↑ |
| Responding to Emergency Events | 0.10% | 0.29% | |
| Breaks | 4.63% | 2.85% | ↓ |

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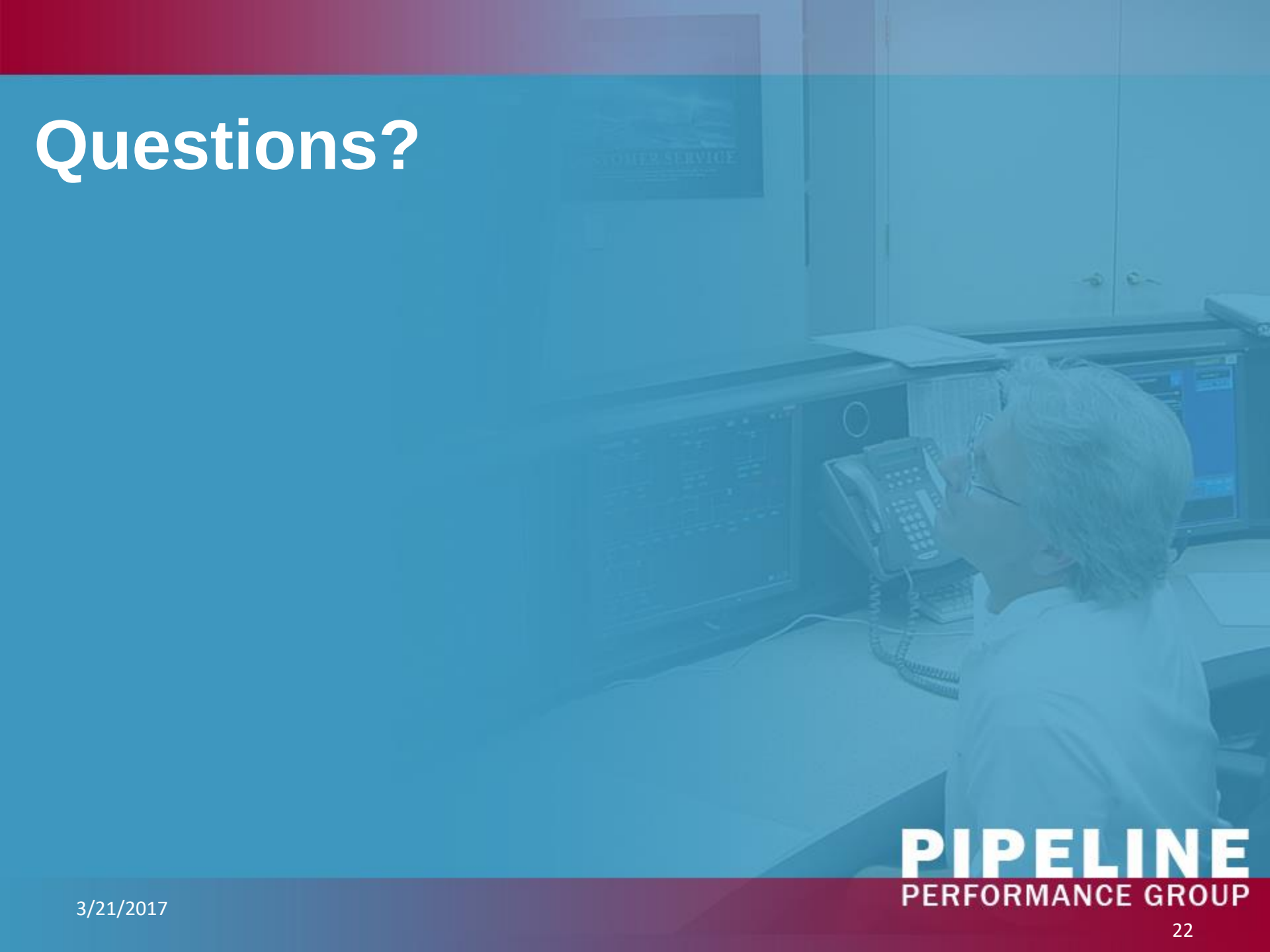
# Discussion

- Alertness
  - The greatest percentages of the alertness ratings were at the top of the alertness scale: “extremely alert”, “very alert” and “alert” (84%)
  - During higher workload hours, the percentage of “extremely alert” ratings (26%) increased as compared to lower workload hours (19%). This is expected due to higher levels of stress associated with higher workload hours.

- Workload
  - The results show a relationship between controller alertness and workload levels.
  - The higher averages were at the lower and higher end of the alertness scale but there was not much variability.

- Task Demands
  - Monitoring takes up the majority of controllers’ time, this is followed by Pipeline Operations and then administrative work
  - During higher workload hours the task demands change somewhat:
    - Increases
      - Operations
      - Log Sheet/Paperwork
      - Phone and Radio Communications
    - Decreases
      - Monitoring
      - Face to face communications
      - Administrative tasks
      - Breaks

# Questions?



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