Why Workload Matters in Pipeline Control Rooms

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Pipeline control rooms are mentally demanding, safety-critical environments. Controllers juggle multiple tasks and carry heavy responsibilities for safe and efficient operations while also managing the challenges of long hours and rotating work shifts. For a highly skilled and dedicated group, such as Controllers, performance failures are rarely caused by a lack of skill or motivation; more often, failures occur when cognitive workload exceeds mental capacity. Excessive or poorly managed workload can degrade situation awareness, delay responses, and increase the likelihood of errors during normal, abnormal, and, especially, emergency operations. For this reason, measuring Controller workload is an essential element of effective control room management (CRM) programs and provides critical data for optimizing operations, staffing sufficiently, and managing fatigue.

While PHMSA's CRM regulations (49 CFR 192.631(e)(5) and 49 CFR 195.446 (e)(5)) do not prescribe a specific workload methodology, an operator must demonstrate that Controller workload is identified, evaluated, and managed in a manner that supports safe pipeline operations. A repeatable and structured methodology is recommended.

In a pipeline control room, workload is multi-faceted, so it is not simply how busy a Controller appears or a simple calculation of how many alarms, SCADA movements, or phone calls occur during a specified period. Workload is the complex interaction of operational demands, system design, staffing and scheduling, environmental and organizational factors, and human factors. Because workload is multidimensional, no single or static metric captures it completely. For mentally demanding work, multidimensional self-reported workload ratings consistently outperform single objective measures in predicting performance breakdowns.

Over the past 15 years of measuring Controller workload, we have observed a wide range of approaches used by operators to assess workload. Our standardized, repeatable methodology has remained consistent through 540 assessments and has been refined through collected data and extensive on-site control room experience. Our methodology relies on Controllers to self-report workload. The measure captures cognitive load, not just activity. It is a sensitive and realistic

measure of workload because it incorporates human factors influences such as frustration, perceived effort, and performance success. The use of a multidimensional tool with proven and established validation and reliability is essential. Since Controller shifts are typically 12 hours with wide variations in demands, we collect Controller input at regular, hourly intervals. In a dynamic control room environment, a lot can change in an hour.

Along with workload levels, there are also fatigue-related workload considerations. Fatigue may reduce cognitive capacity, impede reaction time, and increase individual effort requirements. Measuring fatigue alongside workload provides a more comprehensive and holistic understanding of operational demands.

Workload and fatigue measures tell part of the story. Including the operational context that impacts workload and fatigue provides practical information for reassigning assets between consoles, scheduling personnel, or automating tasks. Task-based analysis documents how Controllers divide their time at the console and the percentage of time devoted to these tasks. We have benchmarked task distribution related to monitoring, operations, communications, logging activities, administrative tasks, breaks, and responding to abnormal and emergency events. This extensive data set allows us to compare console activity against industry benchmarks, identify operational peak hours and days, and support informed decisions related to staffing, scheduling, and fatigue management.

Subjective measures are often the earliest and most sensitive indicators of overload because performance errors may not appear until workload is already excessive. Alarm counts alone do not accurately reflect cognitive complexity, and Controllers may feel cognitively overloaded before it becomes externally visible. Self-report measures capture how workload is perceived and managed by Controllers, including effort, frustration, time pressure, mental load, and performance success. When collected frequently and confidentially, they offer a reliable picture of operational demand in the control room.

Supplementing self-report measures with system-based indicators, such as alarm activity, SCADA movements, phone volume, abnormal operating conditions (AOCs), management of change (MOCs), and other Controller demands, including required readings, strengthens workload evaluations. The most defensible workload assessments integrate multiple data sources, combining self-reported workload and fatigue ratings with task-based and system-generated measures. This comprehensive approach supports identification of peak hours and days, periods of high cognitive demand, overload conditions that increase operational risk, and long-term workload trends.

Workload measures should be captured during real operational periods in a manner that is nonintrusive, protects confidentiality, and uses discrete time windows (e.g., hourly) to detect workload peaks. Methods should avoid oversimplifying workload into a static estimate of time per task and instead reflect the dynamic nature of control room operations. Any tool used in the control room must be practical, easy to administer, and non-disruptive to Controllers and ongoing operations.

Controller workload is dynamic, cognitive, and context-dependent, and no single metric can fully capture its complexity. Establishing industry benchmarks is essential for distinguishing normal from elevated workload conditions; our benchmarks for workload, alertness, and task activity are informed by 540 workload assessments conducted across the pipeline industry in the U.S., Canada, and Australia. The most defensible approach integrates structured Controller input with objective task and operational data collected during real work. When embedded within CRM programs, comprehensive workload assessment becomes a practical mechanism for identifying risk, informing system and schedule design, and strengthening training and human performance under pressure.