A Methodology for Assessing Pipeline Operator Workload and Job Complexity

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In 2009, the Pipeline and Hazardous Materials Safety Administration (PHMSA) issued the new control room management (CRM) regulations to address human factors and other aspects of control room management for pipelines where controllers use supervisory control and data acquisition (SCADA) systems. As part of the final rule, affected pipeline operators must annually monitor the content and volume of general activity being directed to and required of each controller to ensure controllers have sufficient time to analyze and react to incoming alarms. Actual workload is a function of the amount of cognitive, emotional and physical energy expended. Workload typically will vary as a function of the type of work being conducted, the level of stress, the time constraints, and familiarity with the task as well as other factors and thus, is difficult to measure directly. Human Centered Solutions (HCS) has long been engaged in research on staffing requirements for safe refinery and petrochemical plant operation, as well as applying the knowledge gained from that research into a structured methodology for conducting staffing assessments that it has applied at control room operations around the world for over 10 years (Bloom, Barreth, & McLain, 2007). Based on that experience, HCS was contracted to develop a measurable and replicable method of assessing and monitoring this volume of activity to ensure pipeline operators have adequate time to react to alarms and potential upset conditions for the purposes not only meeting--but exceeding--the requirements of the PHMSA regulation.

Control Room Workload Assessment Methodology

The methodology developed has two main components. The first component – the *Control Room Utilization Assessment* – involves an observational assessment of control room operator activities to determine base utilization (as measured by percent time engaged) for all activities in addition to the activities of monitoring the SCADA system and responding directly to SCADA alarms. In this context, the term utilization is used as an indicator of workload because the observations capture time involved in work-related activity. The utilization data collected is then further analyzed to understand the relative time spent in different types of work interactions, such as incoming and outgoing phone communications, SCADA alarm response, data monitoring or set point changes, reading or writing activities and work orders in the daily electronic log, face-to-face communications between control room personnel, and any and all other interactions, such as the use of specialized PC applications and reading or writing with paper documents.

The reason for conducting the direct observation of control room activities was to identify realistic average time estimates for work-related activities that are easily counted from electronic logs and similar objective 'metrics' of activity. Together, the objective counts and the realistic average time estimates form the basis for determining a trigger for initiating a Change Management review of the gas pipeline control room staffing.

The methodology for conducting the control room observations consisted of direct observations of each of the control room operators for a given shift. Observation data was collected for both day and night shifts. To score the minute-by-minute activity, observations sheets were developed to capture each occurrence of the activities discussed above. This observation sheet recorded interactions that the individuals were observed having, such as a face-to-face communication or log or SCADA system usage. In addition, a notation was made as to the overall activity of which the interaction was a part (e.g., maintenance work, alarm/upset handling, or gas provisioning).

The recorded data can be thought of characterizing two independent dimensions of observable work—interactions vs. activities. Activities (such as maintenance support, incident reporting, or gas provisioning) are comprised of the interactions the operator performed to achieve the activity (such as interaction with the SCADA system, communicating over the phone or face-to-face, logging their activities, and interacting with other applications on their PC). The total 'workload' for a given activity is the sum of all the (observed) interactions required to perform that activity. Similarly, the total workload for a given type of observed interaction category (e.g., PC) would be 'summed' across the various activities.

The observation data is then analyzed in a number of ways. First, there is the Average and Peak Utilization – an aggregate accounting of total time that each control room position was observed performing an interaction, as a percentage of the total time observed on either the day shift or night shift. Second, there is the Interaction Analysis – an accounting of what percentage of time the control room personnel were observed conducting a specific interaction when the personnel were engaged in a work activity; that is, how much time was spent performing the various interactions. Third, there is the Activity Analysis – an accounting of what percentage of time the control room personnel were observed conducting a specific work activity when the personnel were engaged in a work activity. Finally, there is the Base Utilization Analysis – an accounting of what percentage of the time control room personnel were observed conducting specific work activities other than the SCADA/Log/Phone notification activity; the purpose of this analysis is to determine whether, on the average, the operators have sufficient time available for monitoring and responding to notifications and conducting proactive monitoring.

The second component – the *Average Control System Interaction Complexity Assessment* – is an objective complexity metric calculated by analyzing the SCADA, log, and phone data associated with each control room operator position. In this analysis, the utilization rate is characterized by identifying the console systems interactions in terms of three different operating conditions:

- Managing – operating condition defined as 2 or less console system interactions in a 10-minute period;
- Coping – operating condition defined as more than 2 console system interactions but no more than 10 console system interactions in a 10-minute period; and
- Upset – operating condition defined as more than 10 console system interactions in a 10-minute period.

Then, the Console Systems Interaction Complexity score is calculated as a weighted sum metric. The percent time spent in a specific operating condition (i.e., managing, coping, or upset) is multiplied by the average utilization rate for that specific operating condition. Hence, the Console Systems Complexity Score is the sum of the three products for each operating condition.

To apply this metric, 10-minute counts are generated for each of the data sources (SCADA Alarms, SCADA Actions, log entries, Incoming phone calls, and Outgoing phone calls) for each operating position. The SCADA actions, log entries, and Incoming and Outgoing calls are then combined into a single Action category—not inclusive of SCADA alarms. The respective 10-minute counts for Alarm and Combined Actions are then analyzed to identify both the utilization and time spent in each of the three operating conditions (Managing, Coping, and Upset).

A second component of the console systems complexity analysis involves a deeper analysis of the alarm system. An effective alarm system can be characterized in terms of the rate at which alarms are presented to an operator. Alarm system performance can be characterized in terms of its impact on operators through metrics of average and peak alarm rates as established by EEMUA and refined by Campbell-Brown (Campbell-Brown, 2002; EEMUA, 1999; Campbell-Brown, 2003).

Table 1 below depicts Campbell-Brown's alarm system performance levels in terms of the differing quantitative performance seen on each of three key metrics at each level: Average alarm rate, Peak alarm rate, and Percent Time in Upset. In general, the higher the alarm system performance level, the higher process availability and safety.

Initial studies examining the maximum rate at which operators could read new alarm information were 30 per minute while the preferred rate was 15 per minute (Hollywell & Marshall, 1994). This study only suggests that operators can **read** 300 alarms in a ten-minute period. However, the study did not take into account potential operator actions in response to an alarm such as analyzing, investigating or correcting process conditions associated with the alarm.

A more comprehensive study that modeled all of the operator activity associated with different alarm scenarios demonstrated that operators, on average, can handle 1 alarm per ~50 seconds or about ~12 alarms per 10 minute window (Reising, Downs & Bayn, 2004). This research finding supports the EEMUA Publication No. 191 recommendation of not more than 10 alarms in the first ten minutes following an upset. Consequently, an effective alarm system that presents alarms at a rate that operators can effectively handle in normal and abnormal operations is one that is at least at the "Robust" level of alarm system performance (see Table 1).

The level of alarm performance that a site should target is dependent upon a number of factors, including the complexity of the equipment and process under control, the severities associated with an operator's failure to act, the speed of response required in order to avoid the consequences of missing or failing to respond to an alarm, the interrelationships and

impacts between the impacted area and other process areas, and the level of automation implemented and the impact loss of that automation has on fallback control by operators.

Table 1: Alarm performance levels

Performance Level	Alarm Rates	Characteristics
1-Overloaded: alarm rates are high in normal conditions	• Average: > 100/10 min ▪ Peak: > 1000/10 min ▪ Upset %: > 50%	▪ Continuously high alarm rates ▪ High number and duration of standing alarms ▪ Important alarms are hard to discriminate from crowd ▪ Many alarms do not initiate an operator action
2-Reactive: alarm rates are acceptable in normal conditions but excessively high in peak conditions	▪ Average: 10-100/10min ▪ Peak: 1000/10 min ▪ Upset %: 25 - 50%	▪ More useful during normal / stable operation ▪ Often unusable during process upset ▪ Operator reacts to the rate of alarm generation rather than to the alarm detail ▪ Some prioritization but known to be unreliable ▪ Many nuisance and disabled alarms
3-Stable: alarm rates are reasonable in normal and peak conditions	▪ Average: 1-10/10 min ▪ Peak: 100-1000/10 min ▪ Upset %: 5 - 25 %	▪ Reliable during normal / stable operation ▪ Provides early warning of process upset ▪ Less useful during upset ▪ Operator confident of priorities and consistently takes action ▪ Control system has been enhanced with alarm historian & alarm applications (e.g., grouping, contact cutout)
4-Robust: alarm rates are low in normal and peak conditions	▪ Average: 1-10/10 min ▪ Peak: 10-100/10 min ▪ Upset %: 1-5%	▪ Reliable during all operations modes ▪ Operators have time to read and address all alarms ▪ High confidence in alarm system ▪ Control system has been enhanced with alarm historian & alarm applications (e.g., grouping, contact cutout)
5-Predictive: operators demonstrate the ability to make process changes before an alarm occurs	▪ Average: < 1/10 min ▪ Peak: < 10/10 min ▪ Upset %: < 1%	▪ Operator is aware of process situation at all times without relying on alarm system ▪ Alarm system is stable at all times

While this characterization of alarm performance levels was originally applied to the refining and petrochemical domains, since pipeline control is similar in objectives to refining process control, it seems logical to assume a goodness of fit of this characterization to pipeline alarm performance as well.

Use of these two assessment components, *Control Room Utilization* and Average *Control System Interaction Complexity* enables gas pipeline companies to demonstrate their ability to

assess their performance against the CRM regulations pertaining to control room operator workload monitoring.

Example Results

In this section we provide examples of the typical results expected through application of this methodology, as well as example interpretations of the results.

Example Control Room Utilization Assessment Results

Table 2 below shows an example of an average and peak utilization summary aggregated across all operators taken during three separate assessment periods. The utilization % is calculated as the % of time during observations excluding break time away from the console that individuals were involved in work-related activities. The day mean and peaks are comparable for all three assessment periods approximately six months apart, indicating consistent workloads for both Average and Peak over time. The Night/Weekend means are also comparable for all three assessment periods. In addition, it is likely that the increase in variability across the night/weekend shift percentages is probably due to their being less activity, hence fewer observations at those times. In general, the utilization percentages, though different, do not show any clear trend up or down at this point.

Table 2: Summary of utilization findings by assessment period

Summary of Utilization By Assessment Period			
Shift	Assessment 1	Assessment 2	Assessment 3
Day Mean	55%	57%	59%
Day Peak	87%	85%	90%
Night/Weekend Mean	50%	44%	56%
Night/Weekend Peak	52%	50%	59%

Further analysis of the hourly utilization data can be conducted to better understand the relative time spent in different types of *interactions* during the observation periods. The data can be analyzed with respect to six types of interactions noted while control room personnel performed work-related activities: (1) Incoming and outgoing phone communications (Phone); (2) SCADA alarm response, data monitoring or set point changes (SCADA), (3) Reading or writing log messages (a means of maintaining a persistent record of actions taken and the time taken) (Log), (4) Face-to-Face communications at the desk or away (Face-to-Face); (5) PC applications (PC); and (6) All other interactions such as reading or writing with paper documents (Other).

Table 3 shows the contribution of interaction type to the work-related activities for each of the six interaction types. Specifically, the data represents the percentage of time involved in work-related activity engaged in specific interaction types for each position and shift period. In other words, the data shows what individuals were interacting with when observed performing control room work-related activities. With regard to percent interaction time, operators on days spent the most time interacting with the SCADA system and on the phone handling inbound and outbound calls; while on nights they spent the most time interacting with PC applications, and slightly less time interacting with the SCADA system. The other difference had

to do with phone interactions, which would be expected to be busier on days because of normal work hours.

Table 3: Percentage of interaction time and average utilization as a function of interaction type

	Operators			
Interaction %	Day		Night/Weekend	
Interaction Type	Interaction %	Utilization %	Interaction %	Utilization %
Phone	25%	15%	5%	2%
SCADA	25%	15%	25%	15%
Log	18%	11%	15%	7%
Face-to-Face	13%	7%	20%	12%
PC	13%	7%	30%	18%
Other	6%	4%	5%	2%
Total	100%	59%	100%	56%

Further analysis of the hourly activity data can also be done to better understand the nature of the *activities* that control room personnel were involved in during the observation periods. Table 4 shows the contribution of activity type to the work-related utilization of control room personnel during Day and Night observation periods. Specifically, the data represents the percent of the time involved in work related activity engaged in specific work activity types for each shift. In other words, the data indicate what individuals were working on when being observed in control room work-related activities.

For operators, on days their time is predominantly spent on maintenance support- (19%) and notification-related (22%) activities, with notification (14%) activities taking up the next largest amount of their time. On nights, operators spent most of their time on administrative-related activities (28%), followed by notification (13%) activities. However, as expected, there is relatively more time spent on maintenance-related activities on Days as compared to Nights. In addition, given the less hectic nature of off-hours (nights and weekends), it is not unexpected to find operators have more time for administrative tasks.

Table 4: Percentage of work-related activity and average utilization as a function of activity type

Work Related Activity % by Position	Operators			
	Day		Night/Weekend	
Activity Type	Activity%	Utilization%	Activity%	Utilization%
Gas Provisioning	8%	4%	5%	3%
Maintenance Support	32%	22%	15%	8%
Notification	25%	14%	20%	13%
Incident Reporting	10%	5%	0%	0%
Proactive Monitoring	10%	5%	10%	4%
Administrative	15%	9%	50%	28%
Total	100%	59%	100%	56%

The base utilization analysis examines the percentage utilization associated with monitoring and responding to notifications. Notifications represent the time spent responding to a SCADA alarm, phone calls or a log messages that not associated with a maintenance activity or gas provisioning order – in other words, associated with a potential or emerging abnormal situation. The purpose of this analysis is to determine whether operators have sufficient time available to monitor and respond to notifications via phone, SCADA or log. Table 5 shows the relative contribution of SCADA, phone and log notifications to the control room average utilization to indicate the impact of SCADA alarms, phone notifications and log notifications.

Table 5: Percentage of average utilization for notification versus all other work related activity types

Utilization %	Operators: Day	Operators: Nite/Wkd
Notification	14%	13%
All other work-related activity	45%	43%
Total	59%	56%

The operators had total utilization of 59% on day shift and 56% on Night/Weekend shift indicating additional time available for work-related activities. Note the utilization percentage represents the time during observations excluding break time. Hence, the data suggests there is additional time available to monitor and respond to notifications.

Table 6: Comparison of the percentage of average utilization as a function of notification versus all other activity types across the three assessment periods

Utilization % By Position	Assessment 1		Assessment 2		Assessment 3	
	Day	N/Wkd	Day	N/Wkd	Day	N/Wkd
Notification	10%	7%	12%	8%	14%	13%
All other work-related activity	45%	43%	45%	36%	45%	43%
Total	55%	50%	57%	44%	59%	56%

As depicted in Table 6, in the third assessment period, the notification-related activity accounts for 14% utilization during the day shift and 13% utilization during the night shift. The level of notification related activity was the highest in this most recent assessment period in comparison to the prior two assessments. The data indicates that as notifications increase the overall % utilization tends to increase rather than other activities decreasing at the current workload levels.

Example Console System Interaction Complexity Results

The Console System Interaction Complexity score is calculated as a weighted sum metric. The percent time spent in a specific operating condition (i.e., managing, coping, or upset) is multiplied by the average utilization rate for that specific operating condition. Hence, the Average Complexity Score is the sum of the three products for each operating condition.

Table 7 below contains the results of all three assessment periods. From an overall complexity perspective, data from the third assessment shows that the interaction with the SCADA, Phone and logging systems accounts for about 22% to 36% of the time for two operators workload on shift (i.e., 2.6 to 4.3 hours on the average for 12 hr. shift); with the day shift workload being slightly higher than the night/weekend workload. From a peak workload perspective, the amount of time spent in Upset operating conditions is quite low from 0.5 to 2% of the time on shift (i.e., ~3 to 15 minutes on the average for 12 hr. shift). Moreover, even during the upset periods, the average workload is less than 100% utilization for both operator positions.

Table 7: Example of balanced console system interaction complexity results

Position	Managing Utilization	Coping Utilization	Upset Utilization	% Managing	% Coping	% Upset	Overall Complexity
Assessment 3							
Operator 1 Days	24	50	82	68	30	2.0	33
Operator 2 Days	25	55	78	65	33	2.0	36
Operator 1 Nights-Weekends	17	46	80	84	16	0.5	22
Operator 2 Nights-Weekends	15	52	82	75	24	1.1	25
Assessment 2							
Operator 1 Days	21	55	94	76	23	1.5	30
Operator 2 Days	24	53	88	72	27	1.2	33
Operator 1 Nights-Weekends	16	47	88	85	15	0.1	21
Operator 2 Nights-Weekends	18	49	85	81	18	1.5	25
Assessment 1							
Operator 1 Days	24	52	88	82	17	1.0	29
Operator 2 Days	23	55	92	75	23	2.0	32
Operator 1 Nights-Weekends	14	52	84	88	12	0.5	19
Operator 2 Nights-Weekends	15	56	80	82	18	0.5	23

The comparison of the three assessment periods shows fairly consistent findings. The data shows a slightly increasing trend from assessment 1 to assessment 3. The night/weekend data showed an increase from the first to the second assessment, then remained consistent between the second and third assessments. Examination of the % time in operating modes shows that the difference is due to ~10% increase in the Coping condition for both operator positions. Consequently, this slight difference in workload for the two periods might represent seasonal differences in workload.

Error! Reference source not found. below shows some examples of the impact of different levels of utilization and percent time in period on the Overall Complexity. Increases in utilization and/or percent time in period consequently increase the overall complexity, while decreases in utilization and/or percent time in period result in reductions in overall complexity. The take away here is that using this methodology should reveal opportunities for reducing complexity.

The console system interaction complexity methodology can also be applied to evaluating different divisions of responsibilities among operators. Table 8 shows how the methodology could be used to assess different control room staffing scenarios. The upper portion of Table 8 shows the complexity results for a three operator day shift which did not show an even distribution of responsibilities. Based on the analysis results, their perception was validated, showing large differences in overall complexity. In addition, it was felt that a target complexity of approximately 30 was where the workload should be.

The bottom portion of Table 8 shows the complexity results for a two operator day shift that contained significant areas of realignment of responsibility. As can be seen, the two operator complexity results were fairly balanced and in line with overall workload expectations.

Table 8

The console system interaction complexity methodology can also be applied to evaluating different divisions of responsibilities among operators. Table 8 shows how the methodology could be used to assess different control room staffing scenarios. The upper portion of Table 8 shows the complexity results for a three operator day shift which did not show an even distribution of responsibilities. Based on the analysis results, their perception was validated, showing large differences in overall complexity. In addition, it was felt that a target complexity of approximately 30 was where the workload should be.

The bottom portion of Table 8 shows the complexity results for a two operator day shift that contained significant areas of realignment of responsibility. As can be seen, the two operator complexity results were fairly balanced and in line with overall workload expectations.

Table 8: Division of responsibility analysis using console system interaction complexity methodology

Position	Managing Utilization	Coping Utilization	Upset Utilization	% Managing	% Coping	% Upset	Overall Complexity
Operator A Days	20	50	80	91	9	0.4	23
Operator B Days	12	45	80	95	5	0.2	14
Operator C Days	24	55	90	78	21	1.5	32
Operator A Nights-Weekends	15	48	88	92	8	0.3	18
Operator B Nights-Weekends	18	57	80	82	17	0.8	25
Operator 1 Days	24	52	88	82	17	1.0	29
Operator 2 Days	23	55	92	75	23	2.0	32
Operator 1 Nights-Weekends	14	52	84	88	12	0.5	19
Operator 2 Nights-Weekends	15	56	80	82	18	0.5	23

Refining alarm system performance has been characterized in terms of its impact on operators through metrics of average and peak alarm rates as established by EEMUA (1999) and refined by Campbell-Brown (2002). These same metrics can be used to assess the effectiveness of the pipeline console system. Table 9 and Table 10 contain average and peak rate results from all three assessment periods for days and nights/weekends respectively.

Table 9: Console systems performance metrics for day shift across three assessments

Interaction Rates per 10 Minutes	Assessment 1 Operator 1 Days	Assessment 1 Operator 2 Days	Assessment 2 Operator 1 Days	Assessment 2 Operator 2 Days	Assessment 3 Operator 1 Days	Assessment 3 Operator 2 Days
Average Rate	1.9	2.1	2.0	2.3	2.7	3.0
SCADA Alarms	0.4	0.5	0.5	0.4	0.3	0.5
SCADA Actions	0.4	0.8	0.5	1.1	0.4	0.8
Log Entries	0.5	0.4	0.4	0.4	1.2	1.2
Phone Calls	0.6	0.4	0.6	0.4	0.8	0.5
Peak Rate	32	45	41	32	34	35
SCADA Alarms	31	46	25	21	28	33
SCADA Actions	12	24	36	25	15	19
Log Entries	6	4	5	3	12	9
Phone Calls	25	15	10	8	10	9

Table 10: Console systems performance metrics for night/weekend shift across three assessments

Interaction Rates per 10 Minutes	Assessment 1 Operator 1 N/Wkd	Assessment 1 Operator 2 N/Wkd	Assessment 2 Operator 1 N/Wkd	Assessment 2 Operator 2 N/Wkd	Assessment 3 Operator 1 N/Wkd	Assessment 3 Operator 2 N/Wkd
Average Rate	1.2	1.8	1.6	1.9	1.6	2.0
SCADA Alarms	0.3	0.4	0.5	0.4	0.4	0.4
SCADA Actions	0.2	0.8	0.3	0.8	0.3	0.8
Log Entries	0.3	0.2	0.4	0.4	0.4	0.5
Phone Calls	0.4	0.4	0.4	0.3	0.5	0.3
Peak Rate	28	33	31	36	24	30
SCADA Alarms	28	31	31	35	21	30
SCADA Actions	20	18	28	22	21	24
Log Entries	6	4	5	4	6	7
Phone Calls	26	16	10	7	14	8

The pattern of results is consistent with the findings in the overall complexity scores. The average rates for day shift show slight trending up from the second assessment to the third assessment. The main contributor to this increase was in log entries. The other data sources remained stable and consistent with the first assessment. However, it should be pointed out that although the log entry metric increased during this last observation period, it was only from approximately one entry every 20 minutes to one entry every 10 minutes, not an overwhelming workload increase. The average and peak rates for the night and weekend shift are stable and consistent across all analysis periods.

The comparison between the two operator positions on average interaction rates also shows a consistent pattern. Moreover, operator 2 position has more SCADA Actions per 10-minutes than the operator 1 position, while the operator 1 position has slightly more telephone interactions per 10-minutes than the operator 2 position.

The console performance metrics show both of the operator positions are in the ***Robust*** performance level with an average rate of 1-10 per ten-minute period, peak rate of 10-100 per 10-minute period and percent time in upset of 1-5% (see Table 1).

At the robust level of performance, two operators have sufficient time to respond to the SCADA alarms, log notifications, and phone calls**.** Even in peak times, there is minimal impact on the operators' ability to maintain situation awareness of all process areas needing attention.

Conclusions

In conclusion, this methodology has been successfully applied to the measurement of pipeline control room operator workload as a replicable method of assessing and monitoring the volume of activity to ensure pipeline operators have adequate time to react to alarms and potential upset conditions as a means of demonstrating the ability to meet or exceed the requirements of the PHMSA regulation.

The first component – the *Control Room Utilization Assessment* –involves an observational assessment of control room operator activities to determine base utilization (as measured by percent time engaged) for all activities. This assessment can be been used to identify realistic average time estimates for work-related activities that are easily counted from electronic logs and similar 'metrics' of activity, which in turn can be used as a trigger for initiating a Change Management review of the gas pipeline control room staffing.

The four parts of the assessment enable pipeline management to view several different aspects of operator workload. First, the Average and Peak Utilization Analysis shows the total time each control room operator was observed performing an interaction, as a percentage of the total time observed. Second, the Interaction Analysis shows how much time was spent performing the various interactions. Third, the Activity Analysis shows what percentage of time the control room personnel were observed conducting a specific work activity. Finally, the Base Utilization Analysis shows whether, on the average, the operators have sufficient time available for monitoring and responding to notifications and conducting proactive monitoring.

The second component – the *Average Control System Interaction Complexity Assessment* – is an objective complexity metric calculated by analyzing the SCADA, log, and phone data associated with each control room operator position. The percent time spent in a specific operating condition (i.e., managing, coping, or upset) is multiplied by the average utilization rate for that specific operating condition, resulting in a score that represents the sum of the three products for each operating condition. For each time the assessment is applied, the results can show whether the complexity is balanced across operating positions, and whether period utilizations are in line with one another. When examined across assessments, the results can show whether any of the operating positions are experiencing a change in complexity and if so, the direction of that change. The console system interaction complexity methodology can also be applied to evaluating different divisions of responsibilities among operators.

The additional alarm performance assessment enables examination of how the different console systems average and peak rates impact the effectiveness of the pipeline console operators. If the goal is to achieve a robust performance level on all console systems, this

analysis can identify points of divergence from this performance level, which in turn identifies areas for console system improvement.

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