Discussion about Measurement of Console Workload & CRM Plan

Controller Work

It is important to determine the purpose of a workload measurement project. In this case, the impetus is the statement in the CRM Rule that a company shall "monitor the content and volume of general activity being directed to and required of each controller…that will assure controllers have sufficient time to analyze and react to incoming alarms." PHMSA representatives have remarked that "general activity" refers to all tasks for which a controller is responsible. Job postings include items that could be considered "general activity."

A Trainee Liquids Pipeline Controller will have responsibilities to include:

- **Monitoring and controlling the movement of product** using a SCADA system and by direct communication with field personnel, interconnecting pipelines, and other customers.
- **Analyzing changing conditions** and alarms on the pipeline and **making appropriate adjustments** in operating parameters.
- **Implementing daily operational plans** to provide safe and reliable operation of liquid pipelines within regulatory requirements.
- **Closely monitoring pipeline integrity** using software, pressure, and volume indicators; and **coordinating maintenance, construction, outages and repairs** with field operations.
- **Monitoring** Company owned and operated **tank and cavern storage levels**.
- **Making important decisions concerning startup and shutdown of mainline pumps** to maximize system efficiency.
- **Preparing routine daily operating records**, **communicating current operating conditions** to management, and **maintaining a complete log** of events
- **Monitoring quality parameters** and **notifying appropriate individuals** when material is "off-spec."

A Trainee Liquids Pipeline Controller will have these qualifications [describes general activities]

- The ability to **perform basic mathematical calculations** and basic computer skills such as **opening, creating and updating content** in MS Word documents and Excel spreadsheets is required.
- Must have excellent **writing and verbal communication skills** and be able to **interface with employees, customers, and suppliers** in a **professional manner**; both in person and by telephone.
- Must be able to **work a rotating 12-hour shift schedule** including weekends, nights, and holidays; as well as unscheduled overtime.
- Must be able to **visually distinguish multi-color panel alarms**.
- Must be **able to sit or stand at the console for a 12-hour shift, or longer**, with the exception of occasional breaks.
- Must **have sufficient mobility** to evacuate the control center in an emergency and immediately transport self to an alternate control center in other cities.

The Gas Pipeline Controller will:

- **Receive on-the-job training**; **working along side various Control personnel**.
- The training will include safety procedures, regulatory requirements, and various other procedures that are related to the pipeline industry.
- This position will **be responsible for the monitoring and controlling the movement** of material through pipelines by **remotely starting/stopping pumps** and **operating valves**, **analyzing changing conditions and alarms** and **making necessary adjustments**, **monitoring pipeline integrity and coordinating pipeline maintenance**, **monitoring tank and cavern storage levels**, **maintaining communication** with field personnel, customers, and suppliers to **maximize efficiency, safety, quality, and customer service.**

A Trainee Gas Pipeline Controller will have these qualifications [describes general activities]:

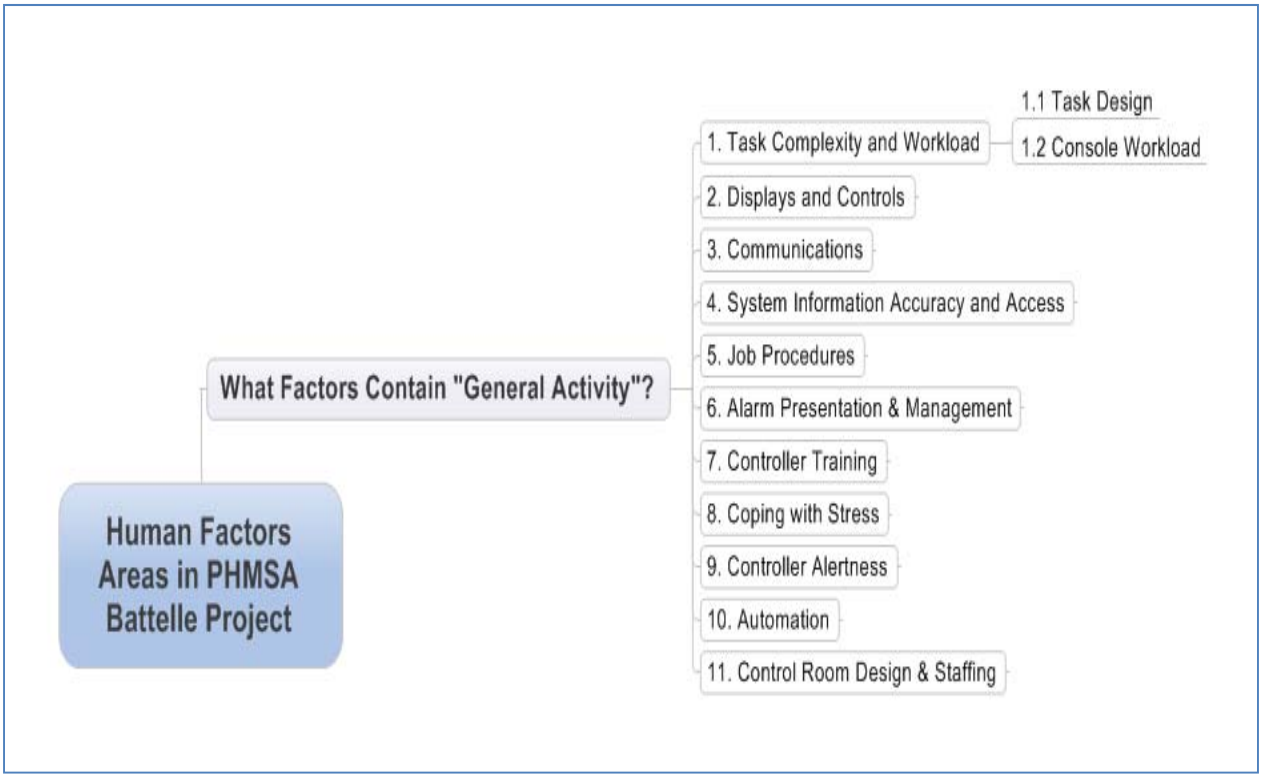
- Must have experience in basic computer use including the use of **word processing, spreadsheet, and email software.**
- Great team player who **interacts effectively** with co-workers, customers and the public, whether in a group or in independent cooperative activities.
- **Good communication abilities (verbal and written)** and **desire to represent the Company effectively** will result in excellent service to customers and the community.
- Must be **accountable and self-driven to learn**, and to **continuously develop and improve** his/her skills through both formalized and on-the-job **training**.
- Must be willing to **comply** with all company policies and regulatory requirements.
- Must be **willing and able to perform essential functions** of this position in an indoor, office environment and be **able to work unscheduled overtime**.
- Must be **able to demonstrate**, through previous job experience, training, and activities, his or her **ability to understand the operation of various mechanical and technical equipment or systems**.
- Must be **able to quickly learn and become proficient** with new skills, technologies, procedures and processes.
- Be **able and willing to work a rotating 12 hour shift schedule**, to include weekends and holidays.

Workload and CRM Rule

The statement from the rule is "monitor the content and volume of general activity being directed to and required of each controller." That appears to indicate that an accounting of tasks and time might be sufficient. These are items that can be observed and measured. This accounting can be improved by taking a risk-based approach to frequency of performance, complexity of tasks, consequences and severity of errors in performance, and priority of tasks.

Workload (Physical & Mental)	=	Demands of All Tasks & Requirements	+	Individual's Physical & Mental Resources

The rest of the statement in the rule is "assure controllers have sufficient time to analyze and react to incoming alarms." This indicates that the workload, excluding alarm response, should not require 100% of a controller's attentional resources. Some pipeline companies have asked us to perform a quantitative workload assessment and not to address any qualitative or subjective issues such as individual differences in the capabilities of controllers. In our experience, both are necessary for a useful workload measurement report. To the best of our knowledge, the only work that PHMSA has done related to workload was the Battelle-led project: Human Factors Analysis of Pipeline Monitoring and Control Operations. While this project was not specifically about workload, the figure below illustrates that task complexity and workload was the factor that was rated first of the 11 human factors areas that affected performance of controllers. PHMSA might use this information in their assessments of CRM plans.



Some Methods We Could Use for Measurement of Workload

There are several workload measurement methods that are appropriate for applying to control room monitoring and control. As previously mentioned, a time and task analysis is one approach that can be done of tasks on each console for each line. With the tasks, we would use a method to determine task complexity, task goals, task duration, task allocation, and the mental and physical activities required during each task. Since the number of tasks and the duration of tasks of "general activity" appear to be important, any time pressure and the time of day tasks are performed should be considered.

The analysis would include performance of primary tasks and secondary tasks. This is important, in the context of the CRM rule statements. A primary task, for example, would be the normal startup of a pipeline or pipeline segment. A secondary task could be response to an abnormal operating condition that occurs during the normal startup. The measure of primary and secondary tasks is valuable for providing an indication of spare capacity.

The "time and tasks" observations would need to be done on shift for each line controlled from the control center. These quantitative measures of number of tasks performed by controllers, combined with the time required for each primary and secondary task, will provide data on the amount of time being used, and an estimate of available time.

A preferred method for mental or cognitive workload measurement is the NASA TLX (task load index) method. The NASA TLX is a multi-dimensional rating procedure that provides an overall workload score based on a weighted average of ratings on six subscales:

- Mental demand
- Physical demand
- Temporal demand
- Effort
- Performance
- Frustration level

Controller mental workload, related to their tasks, can be described with these terms:

- Information Access (how difficult is it to get information to perform task?)
- Mental Loading (how great is the "mental workload" to complete the task?)
- Action Loading (how complex are the physical actions required?)
- Communication Loading (how complex and demanding are communication requirements?)
- Stress (how great is the psychological stress due to time demands, abnormal conditions, or exposure to hazardous conditions?)

Potential Deliverables and Plan for a Workload Measurement Project

1. Assessment of current controller workload, with a focus on cognitive workload: State whether or not the current workload is too little, too much, or appropriate on the console, with recommendations on how to improve operations on those consoles.

2. Control room management (CRM) "tools": Provide the CRM essential resources to plan for future additions to the control centers and perform regular reviews of the "general activity" required of controllers.

    - The methodologies of the task analysis, the "time and tasks" observations,
    - The cognitive workload study results,
    - An analysis of current SCADA and alarm records for a baseline will provide tools.
    - Controller "subject matter experts" and managers can be trained on the basics of what we are doing while doing it.

Phase 1: The goal is to understand workload in the normal control and monitoring of the pipeline and refinery processes. Workload will be assessed in the actual operating environment of the control center during all shifts. The primary data collection materials will be the NASA TLX (Task Load Index) rating scales.

Task analysis will be conducted first in order to get a full list of the controller tasks. The task analysis would be based on these procedures and records, assembled and provided by the Client:

1. Normal Console or Pipeline System Operating Procedures
2. Abnormal Operating Procedures
3. Alarm Response Procedures
4. Emergency Operating Procedures
5. Administrative Procedures and tasks
6. Required training and meetings that are conducted during off-console time
7. A "typical" schedule or description for the daily activities on each console during one
8. Operating data from each console for a "typical" period of time
9. Alarm records from each console for a "typical" period of time
10. Phone records from each console for a "typical" period of time
11. Records of errors, near misses, abnormal and emergency events on the console for 2010-2011.
12. Records of changes, additions, deletions of lines and/or equipment in 2010 or 2011
13. Additional information from gap analyses, needs assessments, controller feedback, etc. that has identified high workloadtasks
14. Records of actual hours worked during 2010 on each console for every controller who worked on the console. If those controllers worked on other consoles, the records of those hours worked are also necessary.
15. Description of roles and responsibilities of controllers and shift supervisors.
16. Control Room Management Plan.

A “typical period of time” will be selected, after determination of times of day, week, month, or season when an average console workload exists. This data needs to be collected and provided before the onsite work so that the team from PPG can organize and analyze the data. Rating scales from the NASA TLX will be customized based on actual controller tasks. This pre-work reduces the amount of disruptions from the onsite work.

Using our methodology, observations will be made on shift of each console to track amount of time for controlling, monitoring, communication, and interaction with peopleand SCADA, etc. In addition, the data from SCADA system on number of startups, shutdowns, deliveries, and alarms per line and interview results per console will be analyzed. This enables an examination of the work processes.

The “time and tasks” observations would need to be done on shift for each line controlled from the five consoles. These quantitative measures of number of tasks performed by controllers, combined with the time required for each primary and secondary task, will provide data on the amount of time being used, and an estimate of available time. When the data analysis and observations are complete, the findings will be validated by controllers and representatives.

At this time, we will introduce the NASA TLX method to controllers and work with them at specific times of a shift. This “sampling” will take place at different times during the day, the night, and the weekends in order to get representative periods of times when workload is high, low, and optimal. Controllers, working with the consultants, will complete data sheets related to cognitive workload. Data sheets will be completed online, using a secure site provided by Pipeline Performance Group.

Analysis of the workload data will include:

- Individual controller workload
- Workload fluctuations during shifts
- Workload measures for specific tasks
- Workload differences between shifts
- Contributors to workload.

Phase 2: The goal will be to determine the five most common tasks from Phase 1 and introduce abnormal and emergency events into the system and measure controller reaction time. This will be conducted in a controlled and planned environment of the training simulator where infrequent abnormal events can be programmed to occur. If a simulator is not available, tabletop scenario can be developed from abnormal and emergency procedures.

Another consideration that affects workload is the workspace and environment and the number of hours worked. The method for this study would include an assessment with appropriate evaluation methods of environmental, ergonomic, and spatial factors. These factors affect controller workload, situation awareness, vigilance, and attention. The information from these assessments would be valuable as the Client addresses other areas of the CRM Plan. Pipeline Performance Group will provide recommendations in these areas to provide additional value in this project.

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Typical Project Schedule

Project Schedule:	*This project schedule and fees are for one pipeline console.*	Fees for Professional Services and Expenses
Preparation	• Client provides electronic copies of procedures and other records about operational workload(list in Phase 1) • PPG does off-site preparation and integration of Client information into assessment tools and workload analysis planning	
Week 1	• Project kickoff meeting, initial interviews, information gathering • Validation of tasks, tools, and plans by Client • On-site observation and data collection on shifts	
Weeks 2 - 5	• PPG off-site data analysis and report preparation • Controllers complete online rating sheets and surveys	
Weeks 6 - 7	• PPG completes report with recommendations • Client reviewsreport	
Week 8	• Onsite review of report and recommendations • Edits to the reports and recommendations	
	FEES FOR PROFESSIONAL SERVICES	$ TBD
	Estimated travel expenses plus 15% for handling and processing of invoices	$ TBD
	FEES & ESTIMATED EXPENSES	$ TBD

Consulants Who Could Be Involved

Charles Alday Charles has 45 years experience in pipeline construction, operations, maintenance, management and consulting. He has a Masters degree in Business, with a focus on Management. For the last six years of his 30 year career with Colonial Pipeline Co. he worked with people and teams in all parts of the organization as leader of Colonial's Operational Excellence program – designed to eliminate pipeline leaks, spills, and errors. A human factors program was a critical component of Operational Excellence. Charles has provided human factors and organizational consulting with many pipeline companies, including comprehensive analyses of pipeline control centers. He has led or participated in task analyses, time and task workload studies, cognitive workload studies, and alarm studies. In 2011, the company is developing CRM plans for six control centers, providing fatigue management services for over 20 clients, working on alarm management plans, and performing workload analyses.

Michele Terranova Michele holds a Ph.D. in Industrial/Organizational Psychology with a major in Human Factors from Old Dominion University. Michele, with 20 years experience in Human Factors and User Interface Design, has worked in a vast array of environments, in nuclear, military, aviation, and process control. Michele has held previous positions as the Director of Human Factors Research at Concord Associates, Inc. and Senior Research Scientist at The Oak Ridge National Laboratory. Michele has been involved in analysis, design, and evaluation of web sites and interactive systems in transportation (public and commercial), nuclear, military, and government. She has done human factors consulting and training with nine pipeline companies. This includes the ergonomic design of a new control center, alarm management analysis and plan for reduction of alarms, SCADA display evaluations, and workload studies for Colonial Pipeline Co.

Sarah Acton holds a Masters degree in Experimental Psychology with a focus on Human Factors Engineering. She has 11 years of experience in Human Factors designing for situation awareness and transportation safety in both the Military and Transportation Industry. Sarah has completed several fatigue, alarm, and workload studies for the US Coast Guard, the Army and the Federal Railroad Administration. .

Pipeline Performance Group has other partners who work with us on projects. This includes former pipeline controllers, engineers, procedure writers, and trainers.

Other Services

We can provide assistance for any or all parts of the development and implementation of the CRM plan, control room design, and other services described in the provided brochures.