Utilization Of Handheld Computing To Enforce Procedural Compliance

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Abstract

Elevating human performance and minimizing non-compliance errors is an ongoing challenge for owners and operators of nuclear facilities. Enforcing procedural compliance in the workplace with a new set of processes that simplify communication to and from the field, and improve information flow, will be a key to addressing the issue.

This paper will provide an overview of the factors contributing to human performance non-compliance, the development of current industry practices with a focus on the existing gap, and the impact of handheld technology on effective communication with the field and its resultant impact on improving procedural compliance.

1. Introduction

Standards and procedures are necessary and vital in any industrial setting. With ongoing public scrutiny and the severe consequences of failure, nuclear contractors must be particularly rigorous in monitoring and documenting the outcomes of all work. Employees at the workface are expected to be intimately familiar with procedures governing practices and it is often the expectation that procedures are followed verbatim with a completed work record tracked and signed off, including independent verifications at key junctures.

What is the fundamental source of non-compliance?
When procedures are not followed, questions are raised as to how the work was conducted and why the procedures were not followed. Human performance deficiencies are the fundamental source of non-compliance and the need perpetually exists to evaluate new alternatives to increase compliance.

What are the real costs of non-compliance?
Typically increased costs and time to deliver are the key indicators most projects are concerned with. While the cost and schedule impacts are immediately visible and tangible, there are many other significant risks propagated by non-compliance issues, including:

- Risk to License to Operate (This is equally true for Contractors and Operators)
- Penalties assessed by Regulators
- Mandated Inspection Frequency Increases
- Potential removal from bid lists
- Decreased workplace morale

Will more procedures help?
A common misconception is that more procedures at the workface will increase compliance. Business processes require procedures, however when excessive, they may actually lead to increased non-compliance. What is truly required is an overarching set of processes to communicate information from and to the field, which rapidly reveal non-compliance or preferably demonstrate compliance.

What are ideal processes?
The ideal process communicates clear instructions in a timely fashion to a properly trained, qualified and equipped work force. These processes allow rapid communication, of concerns and objective evidence of compliance back to the owners and regulators. Additionally the processes assist with proper checks and balances to ensure suspected non-compliances are immediately identified and resolved.

How can handheld technologies improve processes?
Handheld technologies have the ability to empower the worker in the field and elevate human performance with:

- embedded and enforceable procedural requirements
- rapid and clear communication of achieved status, work force concerns and suspected non-compliance
- transparent objective evidence of compliance

This paper will focus on three key questions:

1) What known factors contribute to non-compliance?

2) What current practices can and should be optimized to increase procedural compliance, empower the workforce and reduce rework?

3) How can the utilization of handheld or mobile computing at the workface increase procedural compliance?

2. Factors Contributing to Non-Compliance

As discussed in Section 1, a key contributor to non-compliance at the workface is negative human performance. This can encompass any number of categories of human behaviour based on the chosen categorization method. We will discuss a variety of these in the following sections.

2.1 Cognitive Reliability and Error Analysis Method (CREAM)

This process developed by Hollnagel [1], identifies a number of general categories of human performance and their impact on non-compliance at the workface. This study focuses on operational aspects of a nuclear facility, however, the same factors are observed in maintenance and construction.

The categories identified through CREAM are as follows:

- Maintenance failure,
    - e.g. equipment (controls, resources) does not function or is not available due to missing or inappropriate management.
- Inadequate quality control,
    - e.g. lack of resources or supplies.
- Management problem,
    - e.g. the line of command is not well defined and control of the situation may be lost.
- Design failure,
    - e.g. the interface is inadequate, and the cause is clearly a design failure.
- Inadequate task allocation,
    - e.g. the organisation of work is deficient due to the lack of clear rules or principles.
- Social pressure,
    - e.g. the individual's understanding of the situation is guided or controlled by the group. [2]

Hollnagel's categories are important to the discussion on human performance and its role in non-compliance; these methods place a specific focus on the cognitive aspects of human behaviour. It can be seen from each of the 6 categories defined that an overall lack of appropriate processes in place to manage the information flow is a root cause for each of the breakdowns in a given event.

2.2 Measurement and Classification of Rework

The direct result of non-compliance incidents at the workface is rework – examples of rework as defined in this study, include re-engineering a part that did not meet specifications or re-performing a task that was not completed according to the defined procedures. Love et al. (1997) proposed a rework classification system from preliminary study findings of two construction projects: residential development and industrial development. They classified rework into three principle groups: (1) People, (2) Design, and (3) Construction [3], as illustrated in Figure 1.

They demonstrated that a number of causes were encountered for each group. The majority of rework causes are common causes, which can be attributed to the system (process). They further conclude that some causes are interrelated due to complexity of construction operations [3].

Figure 1 illustrates that a focus on improved processes and communication methods can have a significant impact on reducing the amount of rework in the field. Timely and effective communication of goals, abilities, responsibilities and challenges as encountered would address or mitigate the majority of "People" based issues as well as identify and minimize the effects of the construction and design issues.

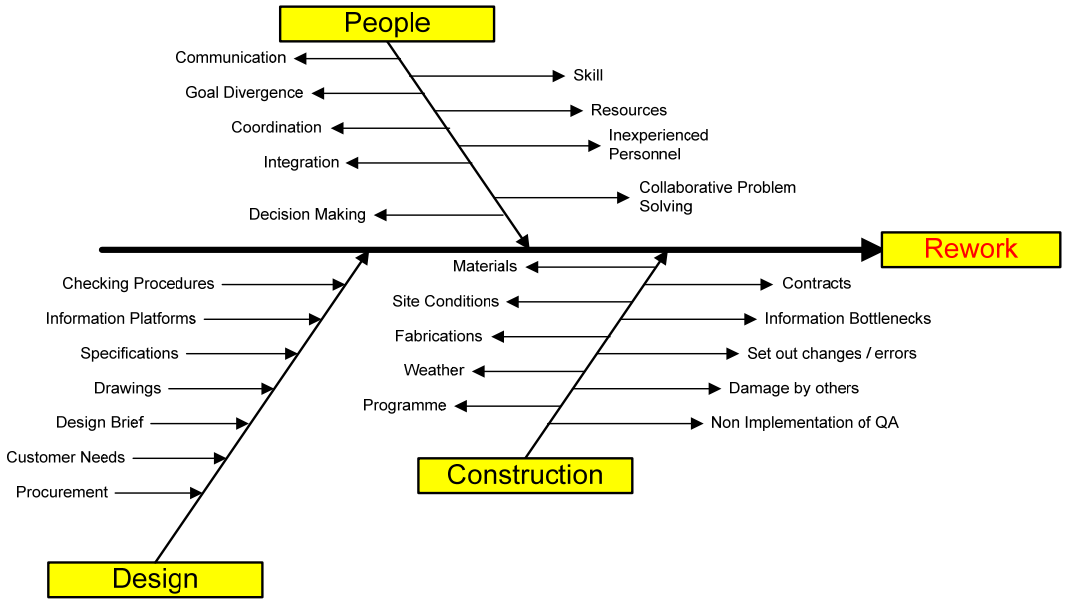

Figure 1 - Generic Cause and Effect Rework Diagram
Derived From Qualitative Data, [3]

Figure 2 expands upon the framework of rework contributors defined by Figure 1. This diagram provides a more detailed view of the three general groupings provided. The 'People' grouping can be divided further into two sub-groupings: Human Resource Capability and Leadership & Communications. There is a gap between the capability of resources in the field and the communication of requirements by the leadership team.

Figure 2 further illustrates improved information flow processes between engineering and the field provides a similar improvement opportunity. There is a gap between communicated changes in work and the ability of resources in the field to react – the result being increased rework. The information flow gap, shown here, needs to be closed.

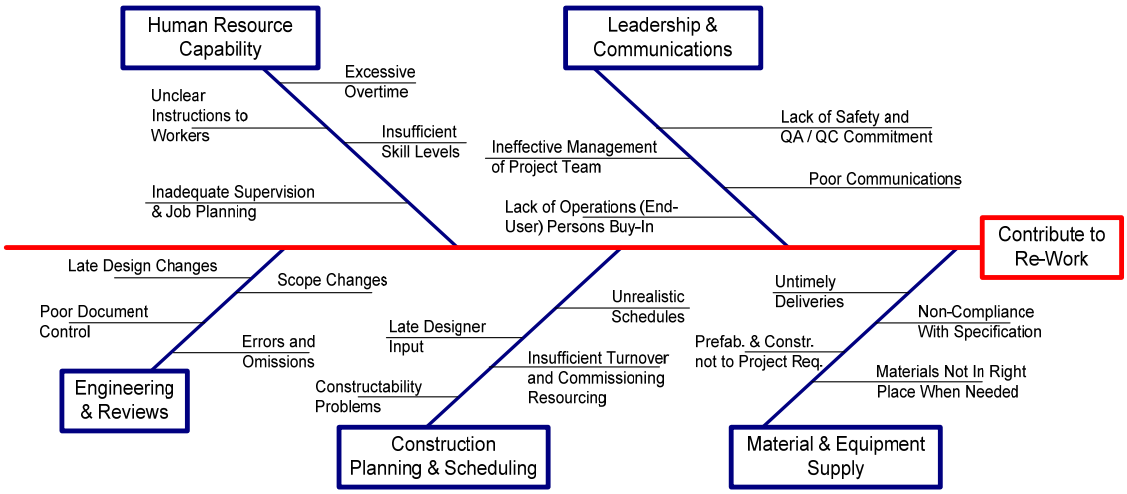

Figure 2 – Fishbone on Rework Cause Classifications (updated in 2002), [3]

3. Development of Industry Practices

The origins of quality processes
Early quality control efforts were self-imposed sets of rules; if you were making a product or tool, it was most likely for yourself and the only requirement was for it to perform as intended. The arrow point you were chipping had to be fit for your intended purpose or you might well starve. When craftsmen entered the picture, they started to create goods and provide services to customers for fair retribution – this led to the formation of Guilds. These Guilds managed to self-police and institute minimum standards of training and quality.

Quality problems resulting from more complex items being assembled by an unskilled or under- trained work force in World War I necessitated the introduction of Quality Control Inspectors (QCI). At present, the process of ensuring conformance and gathering results has changed little in the past 80 years with the QCI figuring prominently in the process.

Current processes for ensuring compliance
The primary evolution in the processes has occurred in how the efforts of the QCI are directed. The following methods have grown in industry:

- Written Standards assist in defining acceptance and rejection criteria or fitness for purpose
- Statistical Quality Control methods allow us to detect when a process is "going off the rails"
- Advances in inspection technology allow us to more completely examine a given item for which consequences of failure are high
- Management processes governing organizational structures, training, qualifications, procedures and documentation establish "laws" which the QCI can then "police"

The effect of these improvements has been to dramatically improve the quality of goods and services available, which allows industries like Nuclear Power Generation to exist.

Information Overload
While these improvements have allowed very complex critical activities to be completed, the drawback to these advancements has been a steady surge in information and requirements being pushed to the workface with a corresponding increase in required documentation of objective evidence of compliance.

The information required to perform and document maintenance and construction tasks in the nuclear industry is growing to such an extent the ability of the performer to comply with the defined process has become severely compromised. Construction and maintenance personnel will be expected to comply with hundreds of instructions or procedures, many of which are considered "continuous in-hand" - meaning to be followed implicitly with specified independent verification activities during the activity.

With sufficient skilled labour the existing processes can manage the workflow and attendant documentation, however it is clear the current situation at the workface is not ideal and improvements must be made.

Skilled labour shortage
With a greying trade population and the resurgence of large complex projects, we are looking at a workforce in their 20's and their 50's. One group has minimal experience; the other has no legs. The American Welding Society predicts that by 2010 demand for skilled welders may exceed supply by about 200,000. With the current age of welders averaging 54, and climbing, welding schools and on-site training programs are not producing replacements fast enough. This is true for all skilled trades.

Statistics Canada predicted skilled-labour shortages in Western Canada five years ago based solely on the country's biggest demographic trend: the aging of the baby boomers [4]. This was without knowledge of the soon to be overheated Alberta economy. Currently, quality control inspectors in Alberta with minimum qualifications are billing as much as $10,000.00 weekly in Fort McMurray. Even taking into account the $300,000 mobile homes, this is a significant inducement for tradespersons especially when factored against the nuclear industry's favored 40 hour workweeks.

4. Handheld Technology and Procedural Compliance

With the resurgence of the nuclear industry, technological innovation will be necessary to assist operators in achieving cost effective compliance. The identified growth in the complexity of procedures at the workface calls for processes that reduce the impact of human performance-related non-compliance incidents and improve communication and information flow.

Handheld technologies at the workface show a significant opportunity to meet both objectives. Implementing new technologies at the workface to streamline and simplify existing processes, without further straining project budgets, will become a fundamental necessity for all nuclear projects.

It is important that any new technology introduced meet these key requirements:

- Reduces process complexity
- Has a short learning curve for field workers
- Is a cost effective solution

There is evidence that procedural compliance is more likely when staff view procedures as being useful and describing the "quickest and most efficient way of doing the job" [5]. Any new technologies introduced that are difficult to learn will be viewed as more complex and inefficient than current methods and will be met with resistance.

4.1 Impact of Handheld Technology on Effective Communication

Key developments in Technology Allowing Mobile Computing
Mobile computing and handheld technology has made significant strides towards closing the gap between the current and the expected level of human performance. In 1965 Gordon Moore postulated computers of a given size and price would double in performance every 2 years. Since then the prediction has held true with an even shorter interval of 18 months and is just one of the technological advancements allowing the workforce of today to be equipped with these tools.

Areas Benefiting From the Utilization Handheld Technology
Handheld technologies can aid in supplementing management processes. Inserting simple applications to improve current processes directly into the existing workflow can achieve a net benefit of significantly improved communication. These applications can assist field workers remain compliant through a number of mechanisms such as:

- Ensuring key information is in hand
- Utilizing forms with detailed instructions embedded
- Gating forms to enforce required actions
- Allowing worker to take credit for completed work
- Date and time stamping operations
- Automating detection of and highlighting suspected non compliance
- Elimination of transcription errors
- Easing document revision control concerns
- Facilitating remote review of results
- Speeding results archiving

Non-Compliance Indicators Addressed With Handheld Technology
Recall the categories defined in Section 2.1 relating to human cognitive behaviour and its effect on non-compliance. An analysis of each category shows opportunities to improve process management and human resource capabilities through handheld technology:

1) **Maintenance failure, e.g. equipment (controls, resources) does not function or is not available due to missing or inappropriate management:**

   Handheld technology can identify these issues earlier in the process during detailed walk downs of work conducted utilizing forms equipped with required reference material and easily populated responses to anticipated variables. Walk down personnel take ownership of the process by accepting all of the attributes they have verified. Unverified or unacknowledged attributes prompt immediate follow-up.

   Management is alerted to problems with resources or controls during the planning phase when it is possible to reassess the work as opposed to during the execution. The status of walk down activities is easily formatted to provide progress reporting to determine actual state of readiness leading into the execution phase.

2) **Inadequate quality control, e.g. lack of resources or supplies:**

   Documentation can be gathered electronically, through intelligent forms, bar code readers, RFID, digital cameras or other handheld technology by performer, peer reviewer or QCI at the work face.

   This information can be screened for acceptability through automated processes or remote reviewers, significantly reducing the amount of time and effort spent on QC checks. This same information can be used to provide true status reporting on accepted work.

3) **Management problem, e.g. the line of command is not well defined and control of the situation may be lost:**

   Senior management can communicate requirements simultaneously throughout the organisation to supervision and trades at the workface receiving repeat backs and providing documented evidence of three way communication. Eliminate stand-downs.

4) **Design failure, e.g. the interface is inadequate, and the cause is clearly a design failure:**

   Handheld technology can identify these issues earlier in the process through a detailed walk down of work conducted utilizing forms equipped with required reference material and easily populated responses to anticipated variables.

5) **Inadequate task allocation, e.g. the organisation of work is deficient due to the lack of clear rules or principle:**

   Inequities in task allocation are readily detected due to transparent real time reporting. With reporting slaved to accepted and documented task completions or by peer reviewed reporting senior management is looking right at the workface

6) **Social pressure, e.g. the individual's understanding of the situation is guided or controlled by the group:**

   Utilizing smart forms with embedded procedural requirements and detailed explanations of expectations available in picture, sound or video, culminating in individuals signed acceptance or questioning of the assigned task allow individuals the freedom truly exercise a questioning attitude.

Reducing Rework Resulting From Non-Compliance
Beyond the impact on human performances leading to non-compliance, the utilization of handheld technology can greatly reduce the communication gap between the project leadership and the field resources. Streamlined information transfer reduces confusion at the source and supports staff by putting the needed information at the workface. Controlled back-end processes allow the Leadership team to focus on putting the correct up-to-date procedures with supporting documentation, into the hands of field resources directly at the source of the workflow.

Further, the utilization of handheld technology can significantly reduce the information flow gap between engineering and the field. Implementing a workface process to notify the project management team of design-related issues, such as non-compliance with defined procedural specifications when they are discovered eliminates, the time spent tracking down issues that are often lost in the paperwork chain.

Addressing the communication and information flow gaps found in existing procedural operations will significantly impact the contribution of human performance non-compliance to rework performed in the field.

Managing Information Output
Managing the information flow from the field is a key to process improvement and successfully reducing non-compliance long-term. Proper document management systems and ongoing records are a necessity to reduce memory loss on a project. Records of work are maintained indefinitely; a process must be in place to ensure proper tracking of all operations and a record must exist to show all procedures were properly adhered to.

Handheld technology managing output at the workface improves the overall information management system by putting records directly into the system. This has intangible benefit of reducing the time spent tracking and filing paperwork, reducing the stress on the organization to monitor records and ensuring if issues arise, the documents are readily accessible. By funneling documentation from the workplace directly into the organization's database, project scheduling can be improved and deficiencies in management procedures can be quickly identified.

5.0 Conclusion

Opportunities exist for improvement within existing methods that handheld technology can supplement. With the documented challenge to ensure project compliance, the opportunity exists for new technologies to augment and aid the compliance efforts.

The surge of handheld technology into the mainstream combined with the maturity of software available for such systems in recent years have increased the accessibility to your project as a cost-effective solution.

The ideal process meets the following criteria:

- Communicates clear instructions to the workface in a timely fashion
- Remains flexible with the ability to adapt to change immediately
- Reduces process complexity for the field resources
- Reduces the time spent on management checks and reviews
- Places ownership of quality process in the hands of field personnel
- Provides objective evidence of compliance for key stakeholders
- Communicates between stakeholders, to ensure key expectations are understood before work is conducted
- Provides consistent means to measure, audit and communicate all field activities
- Reduces paperwork and improves the efficiency of document turnover
- Creates searchable records for usable OPEX
- Minimizes archiving costs and effort

Utilizing handheld technologies to aid clear, concise communication at the workface will help mitigate non-compliance spurred by negative human performance.

6.0 References

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