

Exploring Fit to Improve Mine Safety: A NIOSH Project on Mobile Proximity Detection Systems

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What makes people engage in unsafe behaviors? Thanks to our understanding of human behavior imparted by the experience of mine safety managers and decades of published research, we can now identify several factors that may explain why people engage in unsafe behaviors. As our awareness of the effects of factors such as personality, fatigue, and mine culture continues to grow, we may also consider one less commonly discussed factor that could influence unsafe practices. That factor is *fit*.

This article briefly summarizes how NIOSH researchers are using an instrument called *task-technology fit* to better understand the fit between proximity detection systems for mobile machines (mobile PDS) and underground coal mining.

The Current State of Mobile PDS

Mobile PDS is an automated collision avoidance system intended to decrease pinning, crushing, and striking injuries. According to MSHA, “from 1984 through 2014, 42 fatal and 179 non-fatal pinning, crushing, or striking injuries occurred in underground coal mines that may have been prevented by the use of proximity detection systems on coal hauling machines and scoops.”^[1] MSHA proposed a rule in 2015 that would require underground coal mine operators to install mobile PDS on scoops and hauling machines on all working sections.^[1] At this point, the proposed rule has not been enacted. However, due its potential safety benefits, some mine operators may be interested in adopting mobile PDS.

The Task-technology Fit Instrument

In 1995, Goodhue and Thompson introduced task-technology fit to help decision makers evaluate how information systems fit organizational tasks.^[2] Fit can be defined as a suitable quality, standard, or type that meets a required purpose. Further, task-technology fit can be described as the degree to which one finds a technology to be useful in helping with task completion.^[2] For example, consider a shuttle car operator who is focused on safely and efficiently transporting coal. If mobile PDS helps the worker to safely and efficiently transport coal, then the worker’s evaluation of mobile PDS would be more favorable than if the technology makes transporting coal more hazardous or difficult.

As shown in Figure 1, the user’s evaluation of the technology is based on three characteristics: (1) task, (2) mine, and (3) system. This figure represents a modified model of the task-technology fit instrument—the original instrument introduced by Goodhue and Thompson includes individual characteristics instead of mine characteristics. Table 1 further describes each of the characteristics.

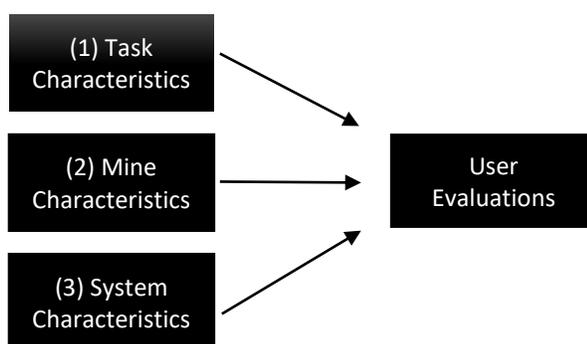


Figure 1: Characteristics of task-technology fit

Table 1. Explanation of the modified task-technology fit characteristics

Characteristic	Description	Example
(1) Task characteristics	Features of the job or responsibility	Cutting coal
(2) Mine characteristics	Attributes or conditions of the mine	Seam height
(3) System characteristics	Features of the system or technology	Accuracy

User evaluations are also an important part of Goodhue and Thompson’s task-technology fit.^[2] As a part of the current NIOSH study, researchers collected user evaluations by asking mine leaders to evaluate mobile PDS based on nine factors. Table 2 gives a description for each of the nine factors.

Table 2. Descriptions of task-technology fit factors for the NIOSH study

Task-technology Fit Factor	Description
(1) Training and ease of use	It is easy to use the system and get quality training
(2) Locatability	It is easy to identify system information
(3) System quality	The system gives accurate information that keeps workers safe
(4) Authorization	It is easy to get authorization to access the necessary functions of the system
(5) User experiences	Workers have positive experiences with mobile PDS in the mining environment
(6) System reliability	The PDS is dependable and consistent
(7) Safety	The system is effective and keeps workers safe
(8) Compatibility	PDS works well with other machines, systems, and the conditions of the mine
(9) Task completion	The system gives accurate information that keeps workers safe

These nine factors were developed from Goodhue and Thompson’s [2] original eight dimensions of task-technology fit.

What We Have Learned from Mine Leaders about Mobile PDS, Safety, and Fit

With the introduction and adoption of new mining technologies that boast improved efficiencies and safety, the concept of *task fit* becomes even more critical and fundamental questions emerge. How well do these new technologies aid in the completion of mining tasks? More importantly, what are the health and safety consequences of poor task-technology fit?

To begin to explore these questions, NIOSH researchers asked mine leaders at two underground coal mines to complete surveys and participate in guided group discussions. The study included nine mine leaders, who were foremen, dust coordinators, superintendents, general managers, and automation specialists.

Preliminary results from the study provide two key findings. First, the study results show ways that mobile PDS may either fit or present challenges in the underground mining environment. Second, the study reveals task, mine, and system characteristics that may influence the way mobile PDS fits with mining.

Ways That Mobile PDS May Fit or Present Challenges

First, preliminary results show that mine leaders evaluated five of the task-technology fit factors favorably: training and ease of use, locatability, system quality, authorization, and user experiences. This finding suggests that these are areas where mobile PDS may fit well with underground coal mining. Conversely, safety, compatibility, task completion, and system reliability were evaluated less favorably, which may indicate that these areas present some challenges.

Characteristics That Influence the Fit of Mobile PDS

Second, the study results also help to describe task, mine, and system characteristics that may influence the fit between mobile PDS and coal mining. For task characteristics, results show that mobile PDS has made miners more aware of “red zones”—those areas where they might be in danger of being struck or pinned by a machine—while working. However, mine leaders report that the mobile PDS has made some tasks such as

loading, dust sampling, or working near other equipment or machines more difficult or hazardous. Some of the challenges related to specific mining tasks have caused frustration for miners.

Results for mine characteristics reveal that specific mine conditions may have an influence on the performance and implementation of mobile PDS. Conditions such as seam height, humidity, amount of metal in the mine, and floor conditions seem to have an impact on how the system has performed. Both participating mines reported having to tailor the system to meet their specific mining conditions and environment. In addition, policies, resources, training programs, and existing culture at a mine may influence implementation efforts.

Lastly, results for system characteristics show that mobile PDS has helped to keep miners safe. However, issues related to electromagnetic interference, system alerts and feedback, and the wearability of the miner-wearable components have created several safety concerns.

Note: The above findings are based on preliminary data and should not be considered as general knowledge.

Using Fit to Improve Safety

The task-technology fit method may be an effective evaluate for preliminary design prototype criteria testing to point to design deficiencies before manufacturing. For the current NIOSH study, it was assumed that the technology was appropriately designed and usability was a part of the design process. Preliminary findings from this study may help mine leaders better understand the fit between mobile PDS and underground coal mining. If mine leaders are more aware of situations where mobile PDS can support miners in safely completing tasks, then they may be more interested in adopting the technology to help prevent human-machine collisions. It is also beneficial to understand situations where mobile PDS is more challenging to use. Understanding these challenges can help leaders to make informed decisions about mobile PDS adoption and implementation as well as help manufacturers improve design features. Finally, this understanding could also help mine leaders to address and prevent unsafe behaviors such as miners removing or disabling the miner-wearable component through training, policies, and practices.

Disclaimer

The findings and conclusions in this paper are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

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Authors Biographies

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