Exploring the complexities of cane rail operations in Tropical Far North Queensland

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ABSTRACT

Rail-based transportation is the backbone of agriculture in the raw sugar supply chain. A high-pressured industry, rail-based service delivery corresponds with mill productivity, but the nature of this environment renders it prone to derailment and conflicting moves. Despite the pace at which cane operations are evolving to accommodate rising industry growth, there is little to no published literature of the human factors in cane rail operations, or a common understanding of how the peculiarities in this system impact risk and the way that drivers work. A total of five focus groups were conducted with locomotive crew (*n* = 19) from an organisation in tropical Far North Queensland. Data was collected using a scenario-based technique which involved the creation of challenging everyday scenarios. Data analysis examined features of challenging scenarios, and specific categories of risk. Preliminary results illustrate cane-rail operations as a highly complex, dynamic and opaque system with a myriad of inherent risks that make the work undertaken by locomotive crew particularly challenging. Future research directions are given.

KEYWORDS

Cane rail, safety, risk perception, cognition, agriculture

Introduction

Australia is the world's third largest supplier of raw sugar (BITRE, 2015). However, estimates of cane sugar production and yield show a steady decline over the last decade (BITRE, 2015; Sugar Research Australia, 2013). The cane industry is actively stimulating growth to address this issue with corresponding signs of recovery; land under cane is now projected to increase by 3 per cent over the coming years as companies continue to incentivise growers to bring new areas into production, purchase land from retiring neighbours, and undertake earlier harvesting (BITRE, 2015). This is being accompanied by increases in the demand for cane rail service. Comprising some 4000km of track, Australia's cane rail system is integral to its milling supply chain; from 2011-2012, rail movements of cane from farms to mills represented 73 percent of total sugar cane volume movements (~462.9 million tonne km) (BITRE, 2015). Service delivery of cane rail correlates with mill productivity in that there is a very small window to transport the cane once it's been cut to preserve its sugar juice content.

While the locomotives and speed of operations are respectively smaller and slower than many other forms of rail, cane rail still has all the hallmarks of a complex system. The two main sub-systems (locomotive crew/drivers and traffic officers) work together to balance performance needs with safety requirement in effort to optimise service delivery. In an environment as complex as cane rail, the system is prone to failure from derailments and conflicting moves, and given the openness of the environment, altercations with other systems actors. Recent incidents on the cane rail network have necessarily impacted milling efficiency, and raised public concerns implicating driver competencies and effective communication (Steger and Haupt, 2018; Stevenson, 2013).

In Australia, general Rail Safety National Law (Department of Transport and Main Roads, 2017) governs cane rail operations, but the specific idiosyncrasies of the system make it a unique environment. Cane train drivers do not only drive, and the traffic office does not only coordinate traffic—there is an equal share in these tasks as they work together to pursue a common goal. In order to deliver empty bins and return harvested cane to the mill, drivers and traffic officers must strategise complex manoeuvres over infrastructure that is defined by constraint. The systems used by traffic officers may not always reflect the driver view of the world and the emergence of remote control operations (operating the locomotive from outside with a remote unit, for example when shunting at paddocks) has had the effect of removing the "Fireman" (i.e. the Driver's Assistant), changing the way that tasks, information, and social channels are communicated on these trips.

Despite the pace at which operations and technology is evolving to accommodate growth in the cane rail industry, there is no published literature of the safety-related human factors in its operations, or a common understanding of how the inherent risks impact upon the way drivers work. In an effort to fill some of this research gap, this study aimed to generate knowledge and understanding of risk in this rail mode, beginning with the locomotive crew perspective. The research question was: *what specific features of cane rail driving are perceived to create the most challenging scenarios by locomotive crew?* This paper presents preliminary findings.

Methods

A qualitative research design comprising focus groups was undertaken. Focus groups were scheduled according to rostering needs and incorporated a Scenario Invention Task Technique (SITT) (Naweed *et al*., 2012; Naweed, Rainbird & Dance, 2015; Naweed, Rainbird & Chapman, 2015). This method has been used to collect data from rail drivers on safety-related topics, and maximized knowledge elicitation by identifying critical themes associated with risk, and specific sources of risk in challenging everyday scenarios.

Five focus groups were conducted with a total of 19 participants (all male, M_{age} = 45, age range 21–63) working at a cane mill in tropical Far North Queensland. Three to four participants were involved in each group with nearly half (47.3%) unemployed during the off-season (i.e. when there is no cane harvesting), either by circumstance or through choice. The most frequent educational qualification in the cohort (52.6%) was the fulfilment and subsequent exit from formal education at Year 9 (i.e. three years before completing high school at Year 12).

Participant recruitment was facilitated by a Cane Supply Manager in conjunction with the Traffic Office, by nominating groups based on rostering and availability during a full week of data collection. Each participant was provided with an information sheet and verbally briefed before giving consent. Focus groups were voice recorded and low-risk ethics clearance was obtained from the University Human Research Ethics Committee (*Approval no. left intentionally blank*).

The procedure for the focus groups broadly followed the following five steps:

1. Briefing about the nature of the study, obtain signed consent

2. Initiate semi-structured focus group protocol, starting with background ice breaker questions and elicitation of attitudes and behaviours to the role
3. Progressive deepening of rapport and questions associated with understanding of risk to locomotive crew, other individuals in the chain, and non-rail people
4. Initiate the SITT: Create an everyday driving scenario with conditions that would make it very challenging for cane rail drivers to manage risk, even for those most experienced. Use of A3 paper and coloured felt-pens.
5. Debrief participants

Creation of the scenario during the SITT was a dynamic process and involved participants explaining their drawings to the rest of the group and questions/probes from the researcher to verify meaning of content. Transcribed data was analysed using inductive coding (i.e. without use of preformed themes) using principles of qualitative content and thematic analysis (Saldaña, 2012) to identify features and characteristics of the sources of risk. The analysis was performed in four stages consistent with this process and included: (1) line-by-line reading and open-coding of the transcriptions associated with each focus group; (2) identification and refinement of central codes to preserve and respect the expression of participants, where any codes deemed to contain similar meanings arranged into more abstract categories; (3) determining connections and identifying relationships between categories and subcategories through axial coding. In this stage, scenarios were also coded and tallied into frequencies according to their features, types, and categories of risk; (4) selective coding to link all foregoing codes and categories.

Results & Discussion

A total of 24 scenarios were collected and identified in the study (some participants created more than one). Table 1 summarises the scenarios and their frequency within the data.

Table 1. Overall list of challenging scenarios identified

Scenario type	**Number**
Level crossing collision/strike	6
Harvester/farmer collision/strike	3
Bridge incident/collapse	3
Loss of train control	2
Sighting issues	2
Public recklessness	2
Difficult driving conditions	1
Derailment	1
Traffic Office error/failure potential	1
Complicated shunts	1
Collision potential near school	1
Communication breakdown	1
Total	24

Based on analysis performed using the methods at the end of the foregoing section, underlying features of challenging cane rail scenarios linked with system risk are presented in Figure 1, including their individual frequencies. Collisions risk and potential invariably dominated, featuring in 17 of the 24 scenarios (70%). Line of sight issues or constraints, for example blind corners, featured in 11 of the 24 scenarios (45%), downhill grades in the track centreline featured in nine scenarios (37%), and loss of train control, event rate, and asset/infrastructure issues all featured in eight (33%). Derailment and/or derailment risk featured in seven (29%).

An unscheduled halt (not directly associated with a collision) featured in six (25%) whilst unauthorised track entry and abrupt braking actions featured in five (20%). Less frequently referenced but equally important elements included the weather (four, 16%), shunting delay (two, 8%), and clearance and call point anomalies (both with one, 4%). Some connections between these features can be drawn, for example, sighting constraints, downhill grades, weather and loss of train control may all converge to create derailment and/or collision risk depending on the circumstances.

Figure 1 is suggestive of a myriad of different environmental and technical features in the cane domain. Many are broadly typical of those found in any rail system, though the presence as an "everyday scenario" for some (e.g. Train out of control; collision; derailment) creates alarm. Indeed, a set threshold of derailments was found to be treated as a key performance indicator (i.e. "KPI") in this domain, indicating that this type of failure mode was a weekly if not daily occurrence.

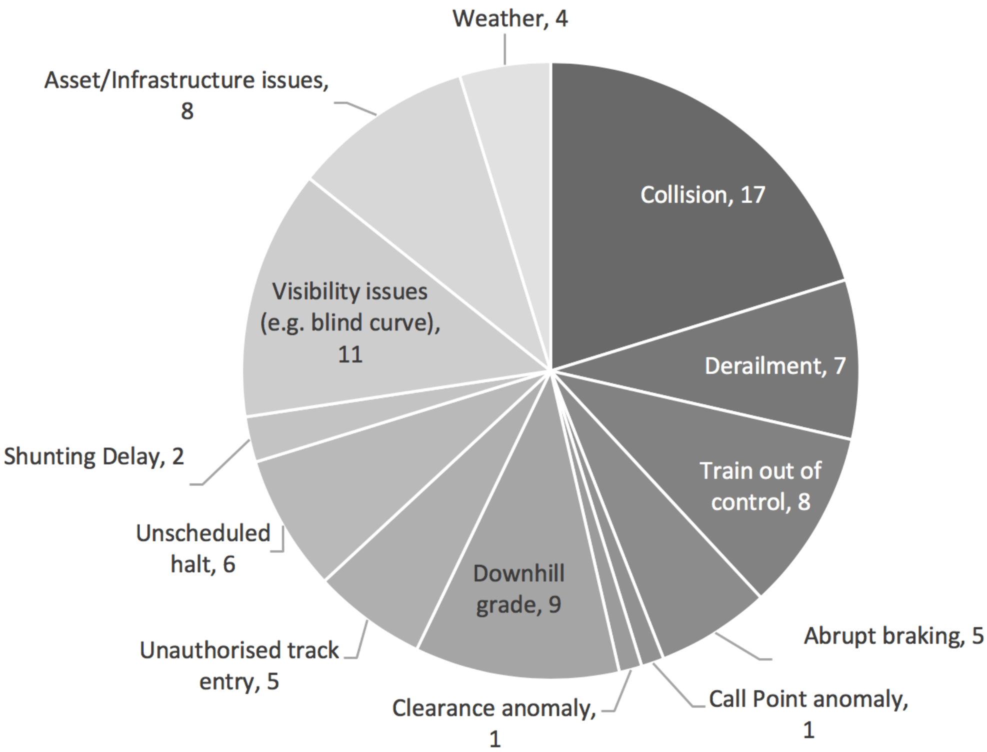

Figure 1 – Features of challenging cane rail scenarios across the scenarios

Figure 2 provides more context to the foregoing results and discussion by indicating, through greater specificity, the categories of risk that were coded across the scenarios. From this it can be seen that in 20 of the scenarios (77%) the combination of features created significant failure potential, where an unsafe outcome was simply difficult to mitigate (e.g. a scenario where a bridge has been improperly maintained). Ten of the scenarios (41%) included a direct non-compliance event of some type, such as departure from established road rules (e.g. a level crossing user driving through an active crossing) or a trespasser (e.g. unauthorised track entry).

Nine of the scenarios (37%) included some form of distraction where locomotive crew were distracted by a task or activity not critical to safety, and eight scenarios (33%) incorporated a high-event rate, which is to say that the driver was faced with multiple sources of information, some of which competed for their attention. A physical obstruction (e.g. a car or pedestrian on the track), and communication issues between various actors (e.g. driver and traffic officer, driver and harvester) was present in seven scenarios (29% respectively). Lastly, a technical error of some kind (e.g. train brakes not working) was present in three (12%) of scenarios. These results emphasise not only the highly dynamic properties of the cane rail domain, but also its inherent complexity.

The presence of communication issues, high event rate, and propensity for distraction are all evocative of problems in how information flows in these sub-systems and how cognition is distributed in the system. It also suggests that, in order for the system to continue functioning, locomotive crewmembers and those in the connected system (e.g. Traffic Officers) must find strategies to cope with the complexity. The next sections provide short vignettes from three representative scenarios to contextualise a little more of the perceived risks from the locomotive crew member perspective. Excerpts from the data are used to the support the points being made where relevant.

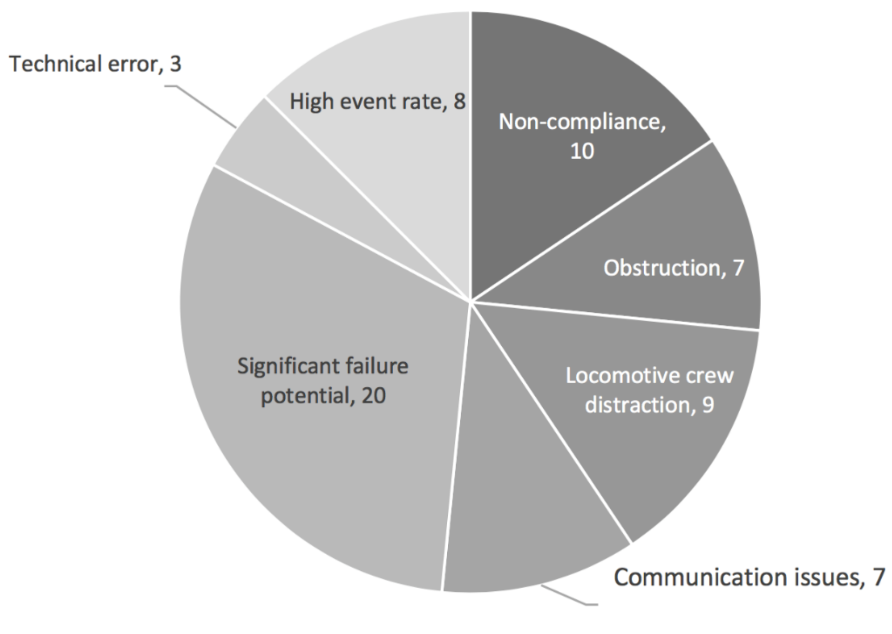

Figure 2 – Specific categories of risk across the scenarios

Figure 3(a) conveys a simple example of a defining feature of cane rail underpinning most of the scenarios created, and contributes to the overall risk profile in this domain. The drawing is an interpretation of sighting issues inherent to driving from the cane itself:

"That's what it's like out there at the beginning of the season."

The cane rail driving task was described as one that required high situational awareness at all times to maintain operational integrity, *"we've got to look backward and forward."* This emphasised the unpredictability of the work, collision potential with a variety of system actors, and need to maintain a high level of awareness owing to the inherent difficulty of knowing what is ahead:

"When you go around the corner you can't see if the points are against you or not […] sometimes there's harvesters around the corner that you can talk to and you can call them up and they might be at the points there and they'll tell you that it's all clear because they can see."

While sighting restrictions were a staple of the environment, the issue was considered to be exacerbated by working practices of others in the system:

"[Farmers] plant right up to the railway line […] at the start of the season, you know, when the cane is 7-foot high, it's just hopeless and you can't see anything. The cane's over like that [motions with hand] on the line and we're just bulldozing through it."

Figure 3(b) relates a common scenario associated the rail-public interface. In this scenario, members of the public are trespassing on a bridge; while these structures are commonly treated as walkways, on this occasion it has been created as a platform for fishing. The issue was compounded by a variety of perceptions (note: each quote originates from a different participant):

"Some people are of the opinion that cane trains don't operate on weekends"

"People ignore the signs [No Fishing on Bridge] anyway"

"[People will] cut the wire to climb over [a fence], they'll go around it, they'll do anything to get on the bridge."

"I come up to that one day, got across the highway just at the top of the hill and there's a guy sitting on the bridge fishing. So, I stop and [I'm] hitting the horn, hitting the horn and he was just ignoring me, giving me the finger."

"The company has done the right thing by putting signage up […] but the problem they're having, the kids go and pull the signs out and throw them in the water or down the bank…"

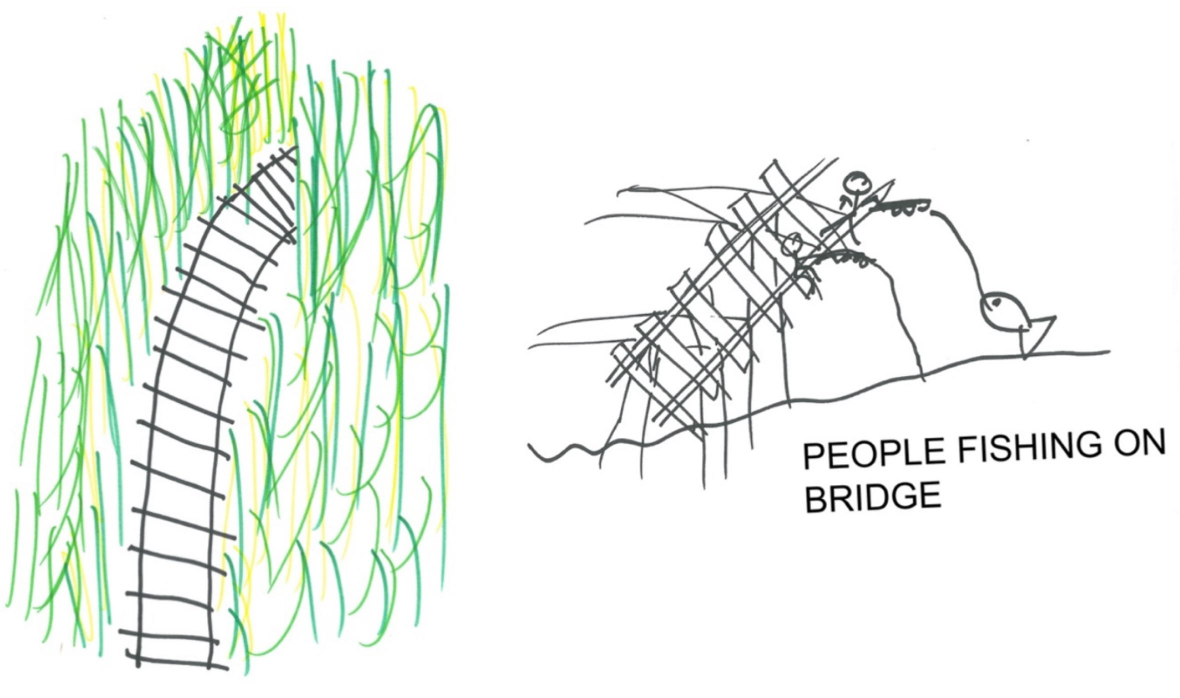

Figure 3 – (a) Sighting issue (left) and bridge incident (right) scenarios

The foregoing results and discussion is suggestive of social norms, ineffective or ignored signage, serious collision risk, as well as pre-existing driver anxiety issues associated with bridges, and other corresponding concerns or pressures associated with unscheduled delays. Participants indicated that they had been *"lucky because [people] have been sitting on the end of the bridge where they can move, but if they were sitting in the middle of the bridge…"* There is also precedence for safety risk in this particular scenario:

"[Once] the bins got off and someone got hurt on that river bridge […] the kid was crushed under a bin."

Finally, Figure 4 depicts another common scenario, but one involving a different system actor. In this scenario, a locomotive with full bins has entered a paddock under protocol—that is to say that the crew have stopped at a call sign and received the *"all clear"* from the contractor to go through, but the contractor has turned around irrespectively, and embarked on a collision course:

"This has happened to me about 4 or 5 times […] so I'm coming through, I've got a big load home, I've got the clearance, he finishes loading and he crossed in front of me […] nearly had a head-on on a curve."

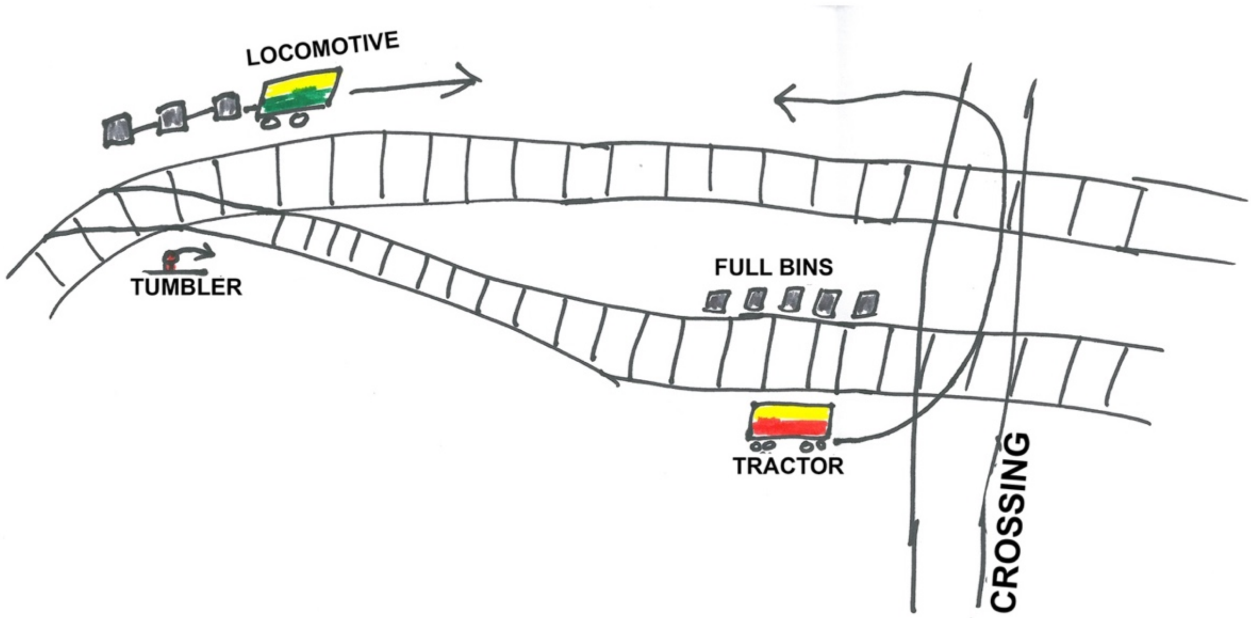

Figure 4 – Harvester/farmer collision scenario

This issue may be due to a variety of factors associated with breaks in shared situation awareness and relaying messages between harvesters and haul out trucks, but it appears to have become normalised:

"I got a clearance one day from this [other driver], he was loading, 30 seconds later he comes across right in front of me."

The issue may also be compounded by a lack of standardisation in the way that the signs which notify cutting going are managed, so much so that the absence or the presence of the sign may not be overriding issue:

"You're supposed to put signs out but traffic office doesn't enforce it [...] there is no sign sometimes. Sometimes they leave their signs out and there's no harvester ever though they've been gone 2 weeks."

Signs may also reportedly be in the *"wrong places."*

Finally, by way of comprehensively addressing the research question in the study, Figure 5 provides a summative abstraction of the specific features of the rail system observed in the study. Much of this is what may be found in other broadly analogous agricultural systems, but the interface with rail-based transportation in the supply chain, particularly in the context of seasonalised light rail, is relatively peculiar to this transport mode.

The key operational challenges (Figure 1) and main areas of risk (Figure 2) all point to a highly complex and dynamic system, where many of these a normative feature of the environment (e.g. visibility issues, downhill grades, high event rate) with others created by issues with process and systems integration (e.g., non-compliance, communication issues).

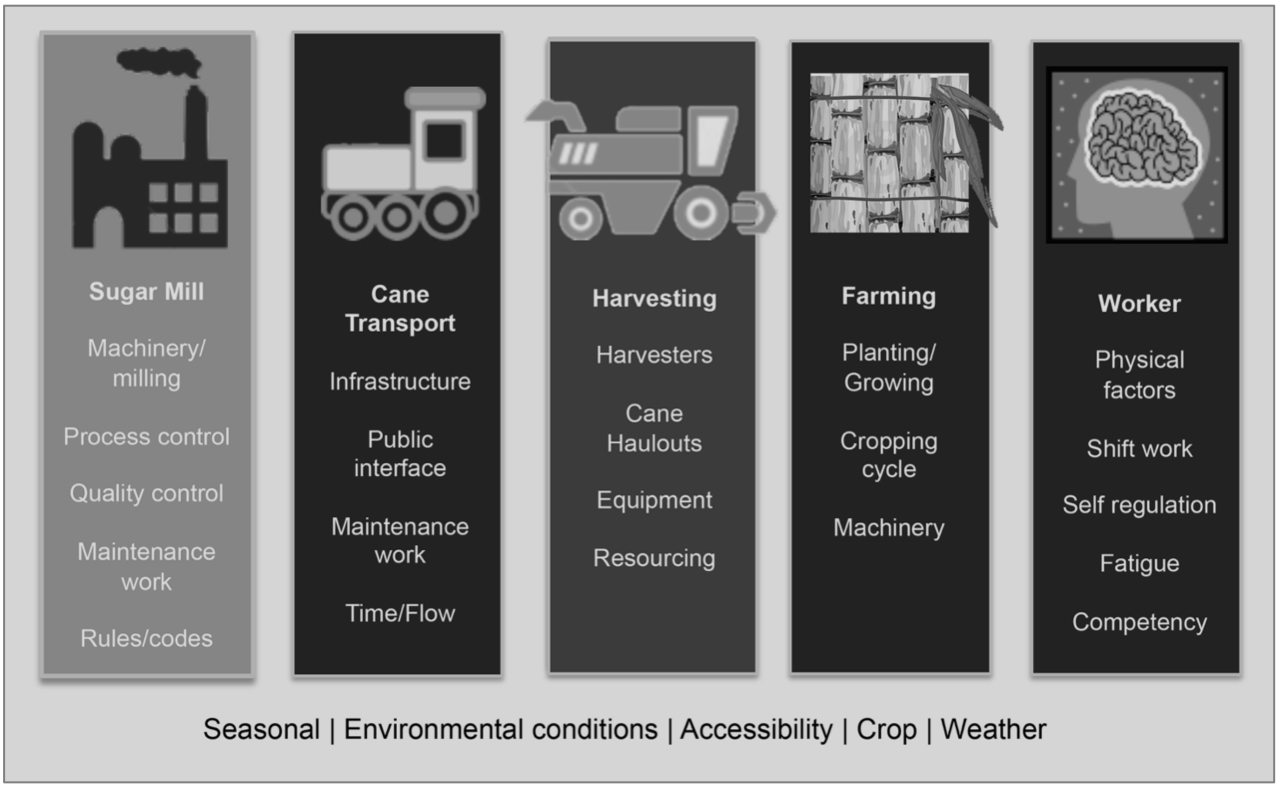

Figure 5 – Specific features across the layers of the Sugar Milling system

Future research should build on these findings with a more comprehensive analysis, and further concrete examples of challenges/safety risk that support the scenarios extracted, for example through structured observation. As a fundamentally distributed system that involved a number of actors, research that looks at the barriers and/or enablers in the system (e.g. in teaming aspects) and investigates exactly how information flows is also warranted. While the uniqueness of the features in cane rail have become abundantly clear from this research, investigating how cane operations differ in their attempts to address risks compared to other rail systems (e.g. freight, passenger) may lend further understanding in terms of comparisons with risk management maturity. Lastly, as this research has only scratched the surface of operational performance and risk in cane rail driving, research should explore other human factors and ergonomics issues. This may further contribute and enhance substantive mainstream literature in other rail settings, particular on topics such as fatigue (Filtness & Naweed, 2017), mentoring and training (Naweed & Ambrosetti, 2015), and impacts to driver health (Naweed, *et al.* 2017).

Conclusions

This study aimed to generate knowledge and understanding of risk in Australian cane rail operations and to understand what specific features of cane rail driving were perceived the create the most safety-risk by locomotive crew. While only a preliminary account of the types of challenges and risks encountered, the findings paint a compelling picture of the complexity, dynamism and opacity in the system in a way that warrants further investigation.

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