APPENDIX E: Traffic safety report

UNIVERSITY OF WASHINGTON

SMR

Traffic Analysis and Safety Recommendations Proposal

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Executive Summary

This study identifies the three main traffic features that affect pedestrian safety at the SMR facility and proposes recommendations to increase pedestrian safety.

The three main traffic features in the facility are as follows: potential crashes from intersecting vehicular flows, unknown variability on truck arrival rates, and circulation of internal vehicles close to pedestrian.

Two types of recommendations are proposed: operational improvements and facility-level improvements.

Operational improvements are inexpensive measures that cause minimal disruption on the company's daily operations. They seek to reduce unexpected conditions on the facility's roads. These recommendations are as follows:

- **Marking and signaling:**
  - Isolate pedestrians from vehicular traffic by marking where pedestrians can circulate.
  - Mark the locations of unloading areas.
  - Identify areas where vehicles can make U-turns.
  - Mark parking areas for vehicles.
- **Employees Clothing**
  - Provide reflective clothing to employees working at the main facility and ensure its use.
  - Provide reflective police-like gloves and whistles to increase the visibility of traffic controllers and their ability to guide traffic and ensure their use.
- **Traffic Management**
  - Hold vehicles by the main entrance to avoid congestion in the facility.
  - Increase the coordination among the traffic controllers.
  - Review the area where internal vehicles work.

Facility-level improvements require more investment and coordination. These types of recommendations address the source of the problematic traffic patterns observed at the facility. These recommendations are as follows:

- **Management**
  - Reduce incoming-material flow variability by evenly distributing the incoming flow of materials during the day.
  - Reduce the arrival time variability by a partial appointment system.
  - Certify traffic controllers.
- **Road Size**
  - Decrease the piles' diameter by increasing throughput.
  - Eliminate bidirectional traffic flows.
  - Change configuration or location of the scrap machine in zone #6 to allow relocation of piles.

About this Document

This document presents the effects of vehicular traffic on pedestrian safety at the SMR's facility. Main traffic characteristics in the facility are identified as well as their impact on people circulating in it. Recommendations are proposed to increase pedestrian safety.

The document is organized as follows. First, a description of the site visit, interviews, and main observations is presented. Second, the most used pedestrian routes in the facility are identified. Thirdly, three consecutive sections describing the three main traffic features respectively are described: internal vehicular routes and location of potential crashes, sources of traffic flow variability, and internal vehicles' service areas. Finally, operational recommendations are presented based on the previous features and observations.

Sources of Observation

The authors of this study have obtained the necessary observations from two sources: a site visit and interviews.

The site visit to the facility took place on January the 4th, 2011. During this visit, it was possible to obtain information about on-site operations, equipment, customers, and traffic behavior.

The interviews were done on February the 25th, 2011. Seven people participated in this activity: a front loader driver, a forklift driver, a crane operator, main gate's traffic controller, zone #6's traffic controller, zone #2's traffic controller, and the company's director of health and safety. This array of people covers key functions for the daily operations. Their answers provided a first-hand opinion of the effects of traffic on people's safety in the facility.

i. Description of the observations from the on-site visit

SMR is a company that scraps and recycles ferrous and non-ferrous materials. The input materials arrive mainly by truck every week day. These trucks are run by both the company and independent owners. The trucks freely arrive to the facility during business hours.

The facility has a unique entrance where vehicles are weighed both when entering and leaving. Also, documentation checking is done at this location. Vehicles can be held immediately after the entrance or on the local roads to avoid an increase in internal congestion. It is important to note there is no clear internal coordination or policy to decide when vehicles need to be held. If there is enough space in the facility, vehicles can enter and drive to the area where they need to unload.

There are three supervisors directing traffic: one at the main gate and two on the south part of the facility. These last two supervisors wear proper safety clothes and work in the same space where vehicles circulate. Their visibility is reduced by traffic itself and noise level is high. These two constraints can affect the supervisors' knowledge of the vehicles surrounding them. They communicate by radio and they share instructions regarding traffic.

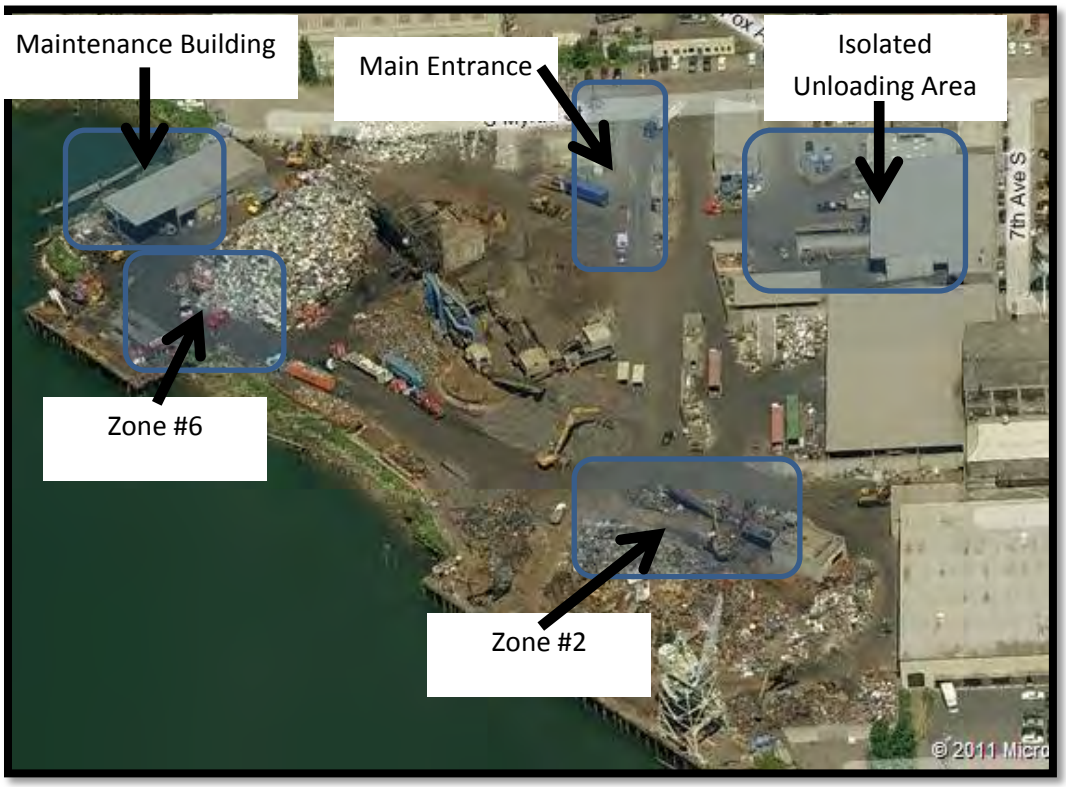
The main areas to unload products are located in what are called zone #2 and zone #6. In these places, customers unload the incoming products and internal vehicles pile them up. A crane takes these products and feeds scrap machines, one in each zone.

Additionally, there is a separate building east of the main gate where incoming nonferrous materials are unloaded and processed. All the related activities happen isolated from the main traffic area. This isolation increases safety for the customers and staff working in this area.

On the southwest corner of the facility, there is a maintenance building. Staff frequently walks in this area and company-owned vehicles enter and leave this building. Sometimes, these vehicles cannot access this area immediately surrounding this building because high volumes block its access.

An image presenting the areas described above is shown in Figure 1.

Figure 1: SMR Facility



Source: Image provided by Microsoft Bing

ii. Description of observations from the interviews

Seven employees from SMR were interviewed. They perform a wide range of daily activities in the facility. These people are: a front loader driver, a forklift driver, a "crane" operator, main gate's traffic controller, zone#6's traffic controller, zone #2's traffic controller, and the company's director of health and safety. They were asked questions about their perceptions about safety in regards to vehicular movement in the facility and improvements opportunities.

The common answers to this interview are summarized below:

- Roads are narrow providing little space to drivers to maneuver. This increases accident risks to pedestrian circulating near these vehicles;
- Sizeable vehicles operating in this constrained space reduce visibility to other drivers, pedestrian and internal operators;
- Objects can fall from the piles in zone #2 and #6 potentially injuring people and reducing even more the road space;
- Internal roads' conditions affect drivers' behavior and vehicular movement. Customers are sometimes afraid to cross potholes with water because metal scraps in them can damage their vehicles' tires;
- Non-defined procedures to manage incoming and internal traffic. Traffic controllers have developed some guidelines to improve mobility but these are only based on their experience;
- Employees connected by radio sometimes talk in languages different than English. This can reduce the effectiveness of future communication strategy;
- Opportunity to systematically learn from daily experiences regarding safety. There are periodic safety meetings (almost monthly) that can be used for that purpose.
- Opportunity to increase safety by implementing small changes. Providing whistles to some traffic controllers have increased their ability to guide vehicles. Newly-painted walkways have helped to guide pedestrian and isolated them from traffic;
- Opportunity to prioritize efforts and resources by developing comparative analysis between cost of accidents (production disruptions and personnel health costs) and the cost of implementing safety measures (from operational to strategic changes)

Pedestrian Corridors

Employees and customers walk in the facility. Pedestrians do not have isolated sidewalks and they share the same space with vehicles. A portion of the road connecting the main entrance with zone #2 has been painted to clearly separate pedestrian and vehicular flows. Sizeable vehicles are driving in the facility so these simple visual measures provide information to drivers regarding where to expect pedestrian. An image with the main pedestrian corridors in the facility is shown in Figure 2.

Figure 2: Main pedestrian corridors in the facility

Source: Image provided by Microsoft Bing

Traffic Features at the Facility

Three traffic features were identified in the facility. These features relates to how vehicles move and interact. Identifying main traffic features helps focusing the analysis of vehicle-pedestrian interactions.

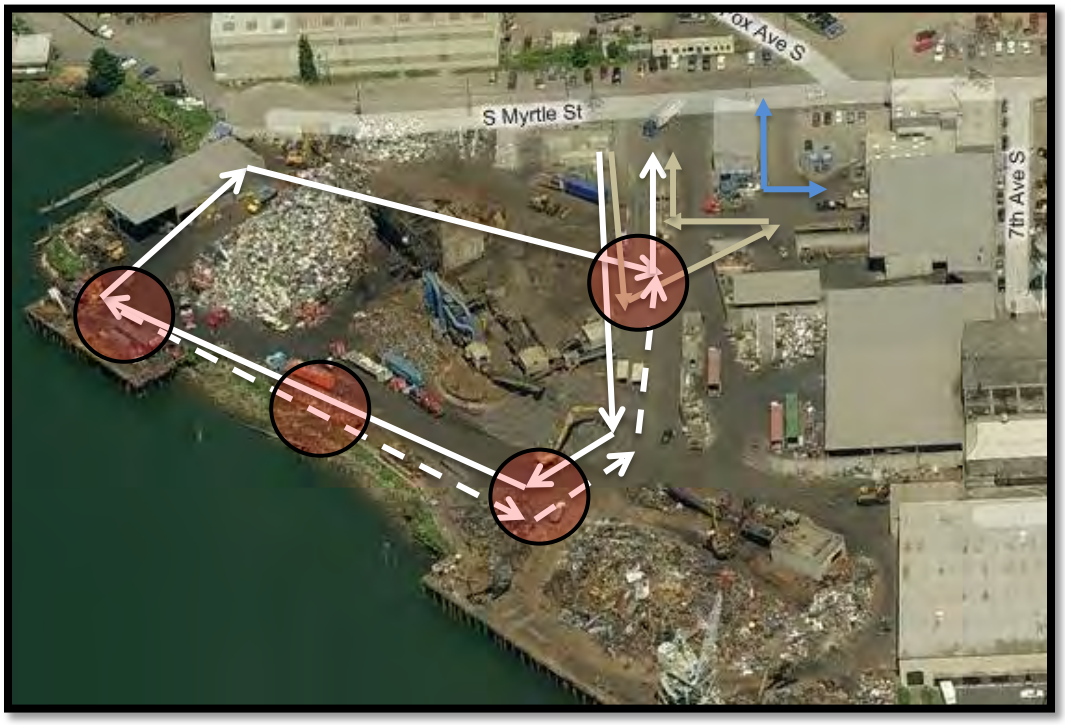
i. Main Routes and Potential Spots for Crashes

The main routes vehicles follow and conflicting spots are shown in Figure 3. Places where routes intersect are potential spots for crashes in addition to the areas where vehicles do U-turns.

The continuous blue line represents the route customers normally follow to go to zone #2 and zone #6. Vehicles come directly from the entrance and leave the facility by doing a U-turn and following the discontinuous blue line. Vehicles at zone #6 can return to the main entrance by going around the pile but this road is frequently too narrow because of excess of material. The purple line represents the route customers follow when they unload directly to the company's facilities. Finally, the four red circles show potential areas where vehicles can crash because of intersecting routes or vehicles driving in opposite directions.

It is worth noticing that pedestrian walk next to vehicles on these routes. In addition to this danger, narrow road space, U-Turns maneuvers, and bidirectional flow increase the likelihood of accidents for both drivers and pedestrians.

Figure 3: Frequent vehicle routes in the facility and spots of crossing routes



Source: Image provided by Microsoft Bing

ii. Variability

In this study, variability is understood as the range of vehicle flows visiting the facility and volumes loaded/unloaded during a period of time. This variability has negative consequences on pedestrian safety because it creates an uncertainty in the number of vehicles circulating in the facility during the day as well as the routes these vehicles follow.

At SMR, variability has not been formally studied. Therefore, the company does not have key information to create comprehensive plans to manage changing traffic flows patterns. The variable number of customers coming to the facility creates congestion which blocks internal roads and changes the internal routing in the facility. This uncertainty is unsafe for pedestrians because vehicles can come from different directions during the day.

We found seven areas in the facility facing important degrees of variability. These areas are shown in Figure 4. The details of the variability occurring in these areas are listed below:

1. Number of vehicles entering the facility
2. Number of vehicles using unloading area
3. Vehicles unloading immediately after the entrance
4. Vehicle unloading area
5. Vehicle unloading area
6. Maintenance area. Vehicles entering and leaving facilities
7. Vehicle unloading area

Figure 4: Location of processes that present variability during a day

Source: Image provided by Microsoft Bing

iii. Internal Vehicles

The company operates vehicles to help unloading trucks and to place the input materials on the piles. Their movement is shown in Figure 5. Some of these vehicles work in the same areas where customers are circulating (two red lines on the left) and some of them work in isolated areas from the customers (two green lines on the right). The company can add or reduce the number of vehicles doing such activities during the day, which allows it to adapt to the demand.

Additionally, it appears that the only crane operator at zone #6 has constant access to a radio and regularly communicates with the traffic controller in this zone. The traffic controller indicates to him when vehicles and pedestrian are far enough to make it safe to operate. However, some material can fall from the crane and the rotation of the crane is a constant safety risk for internal vehicles and pedestrians in the surrounding area.

Figure 5: Movement of internal vehicles

Source: Image provided by Microsoft Bing

Proposed Recommendations

Pedestrians and vehicles share narrow unmarked roads. Traffic patterns change during the day because of variability in the arrival rates, demand volumes, internal routing, and U-turn frequency. These conditions create an uncertain environment for people walking in the main facility in terms of where to expect vehicles and what maneuvers drivers are allowed to make. Additionally, the number of traffic controllers is not sufficient and they cannot assist all vehicles when demand is high. This leaves some drivers with no instructions or unmarked areas where pedestrian can be hit.

In order to increase safety for pedestrians in the facility two types of recommendations are proposed: operational improvements and facility-level improvements. The former are inexpensive measures that do not or minimally disrupt normal day-to-day operations. The latter require more investment and coordination. These safety recommendations are based on the observed pedestrians' patterns, traffic features and answers from the interview. These two groups of recommendations are not exclusive and they can be combined.

i. Operations improvements

Reducing uncertainty in vehicular flows and drivers' maneuvers increases safety because pedestrians can expect where vehicles will be coming and what maneuvers drivers will perform. The following recommendations seek to reduce unexpected conditions on the facility's roads by reducing pedestrian-vehicle interactions, variability, and the risks from the internal vehicles' flows:

- **Marking and signaling:**
  - **Isolate** pedestrians from vehicular traffic by marking where pedestrians can circulate and safely move. The use of physical separation such as fences should also be considered.
  - **Mark** the locations of unloading areas. These signs can aid navigation especially to new customers.
  - **Identif**y areas where vehicles can make U-turns. These areas can be marked on the pavement or by using other visual signs.
  - **Mark** parking areas for vehicles. These areas need to be located at a safe distance from the traffic and objects potentially falling from the scrap piles. These parking areas can also provide isolation for pedestrians.
- **Employees Clothing**
  - **Provide** reflective clothing to employees working at the main facility and ensure its use.
  - **Provide** reflective police-like gloves and whistles to increase the visibility of traffic controllers and their ability to guide traffic and ensure their use.
- **Traffic Management**
  - **Hold** vehicles by the main entrance to avoid congestion in the facility. Heavy traffic in the facility reduces the available space for drivers to maneuver. Limited space can increase the risk of accidents and reduces the ability to serve customers fast.
  - **Increase** the coordination among the traffic controllers. Communication has to be bidirectional among them. They need to inform of unexpected circumstances to avoid accidents. Coordination between controllers is a key component of a holding policy.

- **Review** the area where internal vehicles work. The internal vehicles (front loaders and forklifts) carry materials from the customers to the scrap piles. These drivers have reduced visibility because of the material carried in front in front of them. This is a hazard for pedestrians especially in the proximity of the maintenance building where there is a high-volume of pedestrian (staff and customers).

ii. Facility-Level Improvements

The facility-level improvements address the source of the problematic traffic patterns observed at the facility. These improvements reduce traffic variability, internal vehicular routing uncertainty, and the pedestrian-vehicle interactions. This is done by demand-management techniques and operational improvements. The recommendations below may require further analyses of the current operations and financial commitment. It is worth considering that a national average cost per injury or illness of an employee is US$85,848[1].The facility-level improvements are as follow:

- **Management:** the below recommendations seek to spread incoming material volumes, arrivals rates more evenly during the day as well as improve traffic management in the facility.
  - Reduce incoming-material flow variability. Despite the dynamic nature of the business, it is worth looking for opportunities to increase certainty in the incoming material flows. Based on the workers' interview answers, several customers are frequent visitors. Identifying those who bring the major percentage of material and allocating them during off-peak periods is an effective way flatten out the incoming demand.
  - Reduce the arrival time variability. Both trucks operated by SMR and external customers arrive at the facility without early notice. A partial appointment system would help to spread the arrivals during the day and reduce congestion. This system can be first implemented with those trucks operated by SMR and service providers as waste collection.
  - Certify traffic controllers. The average two-day certification program for traffic controllers can increase their ability to manage the internal traffic and reduce accident risks for pedestrians.
- **Road Size:** the limited roads space can be increased by reducing the piles' diameter or relocating them.
  - Increase throughput to decrease the piles' diameter. Throughput can be increased in three ways: improving the coordination between the existing equipment, reducing the equipment' failure rates, and acquiring additional equipment.
  - Eliminate bidirectional flows. The restoration of the previous northwest exit or the creation of a permanent loop around the piles at zone #6 would allow vehicles to continue moving in the same directions and reduce U-turns at zone #2 and #6. The above recommendation is a good complement to this one because smaller piles can provide the require road space.
  - Change configuration or location of the scrap machine in zone #6. Such a change can allow relocating piles and provide additional adjacent surface. This additional surface can be used as additional road space and extra buffer area for when the pile diameter increases. This alternative requires an understanding of demand history, service rates, and related costs.

[1] Jeffery L. Campbell, (2005) "Significantly reducing facility maintenance costs through innovative custodial safety", Journal of Facilities Management, Vol. 3 Iss: 3, pp.203 - 214