Exploring the systematic causes of Beijing subway PSD accident

Shijie Zhang, Ph.D. student
State Key Laboratory of Rail Traffic Control and Safety
Beijing Jiaotong University
Outline

Background and Motivation
- Background Beijing subway
- The application of platform screen doors
- Overview of the accident

Beijing subway PSD accident analysis with CAST
- Physical and Operational Level
- Management level
- Passenger’s role as context & controller

Changes & Conclusions
Outline

◆ Background and Motivation
  – Background Beijing subway
  – The application of platform screen doors
  – Overview of the accident

◆ Beijing subway PSD accident analysis with CAST
  – Physical and Operational Level
  – Management level
  – Passenger’s role as context & controller

◆ Changes & Conclusions
Background

◆ The Beijing Subway is a rapid transit rail network that serves the urban and suburban districts of Beijing municipality. The network has 18 lines, 334 stations[a] and 554 km (344 mi) of track in operation.

◆ The subway is the world’s busiest in annual ridership, with 3.41 billion trips delivered in 2014, averaging 9.2786 million per day, with peak single-day ridership reaching 11.5595 million.

People fell off platform

From “House of cards” S02

Beijing subway, 2016

<table>
<thead>
<tr>
<th>Time</th>
<th>line</th>
<th>station</th>
<th>consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.28, 2016</td>
<td>line 1</td>
<td>Yuquanlu</td>
<td>one death</td>
</tr>
<tr>
<td>Feb.14, 2016</td>
<td>line 2</td>
<td>Dongzhimen</td>
<td>one death</td>
</tr>
<tr>
<td>Feb.28, 2016</td>
<td>line 1</td>
<td>Yuquanlu</td>
<td>one death</td>
</tr>
<tr>
<td>Mar.2, 2016</td>
<td>line 1</td>
<td>Wanshoulu</td>
<td>one death</td>
</tr>
</tbody>
</table>
The application of platform screen doors (PSDs)

**The purpose**

- **Safety**: Train piston wind & Fall off platform
- **Energy conservation**: Air condition
- **Prevent suicide**

**The system become more complicated**
The gap

Hazard:
Train start with people between train doors and PSDs.

About 300mm in width
Historical accident

1. Run to the train when doors were closing

2. Could not get onboard because it’s crowded

3. PSDs already closed

4. The man got killed by the departing train

Shanghai metro line 1, Nov.6, 2007
Overview of the accident

The location

- On November 6, 2014 at 18:57
- Beijing subway line 5 Huixinxijie Nankou station
- A woman fell out the train and got trapped between the train door and the PSD and train departed
- The women died in hospital at 20:20
Passenger volume at peak

- Beijing subway has serious “tidal phenomena”.
- Huixinxijie Nankou —— Important interchange station
Outline

◆ Background and Motivation
  – Background Beijing subway
  – The application of platform screen doors
  – Overview of the accident

◆ Beijing subway PSD accident analysis with CAST
  – Physical and Operational Level
  – Passenger’s role as context & controller
  – Management level

◆ Changes & Conclusions
Hazard: Train start with people between train door and PSD.

Safety constrain: There must be no person between train doors and PSDs when the train start.
Measures

- Driver’s check
- Plate on PSD
- Emergency tools
- Handle on PSDs
- Platform staff’s assist
<table>
<thead>
<tr>
<th>Time</th>
<th>Victim</th>
<th>Train doors</th>
<th>PSDs</th>
<th>Driver</th>
<th>Platform staff</th>
<th>other passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>18:57</td>
<td>fell out of train</td>
<td>start to close</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>got trapped</td>
<td>closed</td>
<td>closed</td>
<td>forgot to check the gap</td>
<td>didn't find the emergency</td>
<td>looked for staffs and emergency tools</td>
</tr>
<tr>
<td></td>
<td>got hurt</td>
<td></td>
<td></td>
<td>started the train</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>stopped the train</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sent to hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20:20</td>
<td>died in hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Safety Control Structure

Driver

Human got stuck?

Platform Staff

Passenger nearby

Depart the train, Open/close PSDs

Condition of doors, starting signal

Emergency break

Open/close train doors

Open Condition of Enable train doors

Signal system

Open Condition of train doors

Train door controller

Train doors

GAP

PSDs

Open/close PSD

PSD controller

Condition of train doors

Condition of PSD

Condition of PSDs

Condition of door area
Physical Level

Deficiencies in system design:

- Safety constrain not allocated to a controller.
- PSDs closed, no equipment can detect gap.
- Sequence: Train doors close after PSDs.

No sensor in the gap.
Deficiencies in system design:

- Assist: Drivers may neglect the check especially on rush hour with the assist of equipment.
Operational level

Driver

**Safety responsibilities**
Supervise passenger transfer, ensure safe starting conditions

**Unsafe control actions that occurred**
Start the train with a passenger trapped

**Contextual reasons for the behavior**
In rush hour, driver worked under the pressure of the busy timetable;
Equipment provided unreliable assist.

**Mental model flaws that contributed to it**
The driver was too dependent on preventing equipment;
Neglect the importance

---

Condition of doors, starting signal

Human got stuck?

Platform Staff

Depart the train, Open/close train doors & PSD

Emergency break

Passenger nearby the doors

Condition of door area

Emergency break

Physical Controllers

Train door

PSD

Passengers getting on or getting off

Door area
Dysfunctional Interaction

- Passengers cannot find platform staffs to report the emergency.
  Reason: The platform was crowded, vision was blocked, and the environment was noisy.
- Platform staffs find it hard to supervise all the doors.
- Passengers cannot reach emergency tools.
  Reason: No handy emergency break or emergency call device. Cannot get to tools nearby due to the crowds.
Emergency button on platform

Emergency button upon train doors
Only set on 2 middle doors of each carriage

Accident spot

Platform track

Car 1  C 2  C 3  C 4  C 5  C 6

Platform track

Platform
Operational level

- **Train door**
- **PSD**
- **Passengers getting on or getting off**

**Physical Controllers**

- **Driver**
- **Platform Staff**
- **Passenger nearby the doors**

- Condition of doors, starting signal
- Depart the train, Open/close train doors&psd
- Emergency break

- Human got stuck?

**Door area**
Operational level

Passengers nearby

Safety responsibilities
Report to platform staffs or the driver, or use the stop the starting.

Unsafe control actions that occurred
Start the train with a passenger trapped

Contextual reasons for the behavior
Crowded station & No handy tool

Mental model flaws that contributed to it
No enough knowledge to cope with this situation
Not prepared so panicked

Passengers are instable as volunteer controllers of door system
Passengers

It’s hard to get onboard without push and squeeze. People often been kidnapped by passenger flow.

Contextual reasons & Mental model

- Passengers’ mental model could be greatly influenced by passenger flow.

Passengers as controllers of themselves

Role: controller
Safety responsibilities
- Stop getting onboard when the car is full
- Stop at the alarm.
Unsafe control actions that occurred
- Be the last one to get on a packed car
- Did not obstruct the closing train doors
Contextual reasons for the behavior
- It’s hard to get onboard without push and squeeze.
- People often been kidnapped by passenger flow
- Hope to get home soon
Mental model flaws that contributed to it
- People overlooked the importance of order at rush time

Passenger system
Signal system
Train door controller
PSD controller
alarm
Train door
PSD
Closed & locked
Starting signal
Condition between train door & PSD
Pull open

Human-machine interaction
Passengers’ role

- Volunteer controllers of the door system — the instable controller
- Controller of themselves when during transfer — make advisable decision with crowds
- Context of interaction and of other controllers — the crowds block interactions
Passenger flow not been controlled effectively. Lack of regular and efficient approach to feedback when the station/individual are out of capacity.
Suggestions

◆ A specific physical controller should take this safety constrain in charge. And there should be a stable feedback to monitor the gap.

◆ More propaganda should be carried out by public education and the operation corporation not only about behaving in order but coping with emergency.

◆ Subway operation cooperation should use tidal control strategy and control the passenger flow if it’s beyond the capacity.
Outline

**Background and Motivation**
- Background Beijing subway
- The application of platform screen doors
- Overview of the accident

**Beijing subway PSD accident analysis with CAST**
- Physical and Operational Level
- Management level
- Passenger’s role as context & controller

**Changes & Conclusions**
Changes

Train doors and PSDs close at the same time

Longer & louder alarm
Changes

Passenger limiting

Volunteers at peak time

Lookout stage
Conclusion

- A CAST analysis was made and gave us some systematic suggestions.
- Passengers should be thought from different roles within subway system.
- Control structure should be designed dynamically with different passenger flow.
Q&A!

State Key Laboratory of Rail Traffic Control and Safety
Beijing Jiaotong University

Email: sjzhang@bjtu.edu.cn