



轨道交通控制与安全

国家重点实验室(北京交通大学)

STATE KEY LAB OF RAIL TRAFFIC CONTROL & SAFETY

Exploring the systematic causes of Beijing subway PSD accident

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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

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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.

"Beijing 2015 and "twelfth five-year" period for national economic and social development statistical bulletin". Beijing Municipal Statistics Bureau. 2016-02-15. Retrieved 2015-02-18

People fell off platform



From "House of cards" S02

Beijing subway, 2016

Time	line	station	consequence
Jan.28, 2016	line 1	Yuquanlu	one death
Feb.14, 2016	line 2	Dongzhimen	one death
Feb.28, 2016	line 1	Yuquanlu	one death
Mar.2, 2016	line 1	Wanshoulu	one death

The application of platform screen doors(PSDs)

◆ The purpose

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

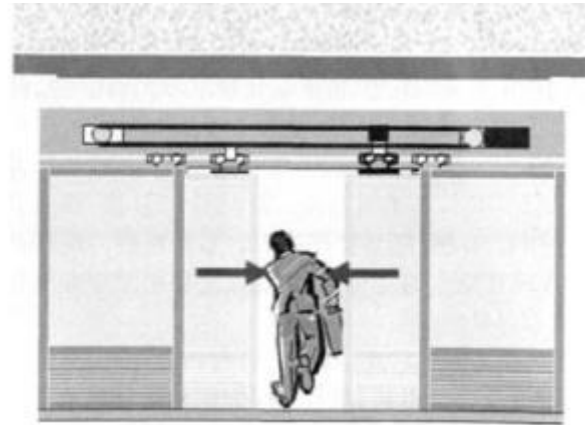


◆ The system become more complicated

The gap



About 300mm in width



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

Historical accident



2. Could not get onboard because it's crowded

3. PSDs already closed

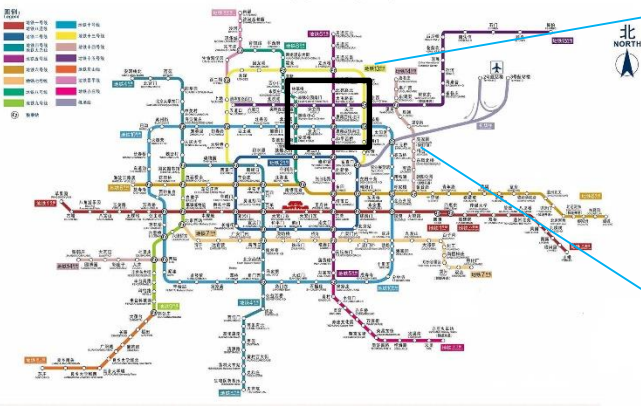
1. Run to the train when doors were closing

4. The man got killed by the departing train

Shanghai metro line 1, Nov.6, 2007

Overview of the accident

北京地铁线路图
Beijing Subway Map



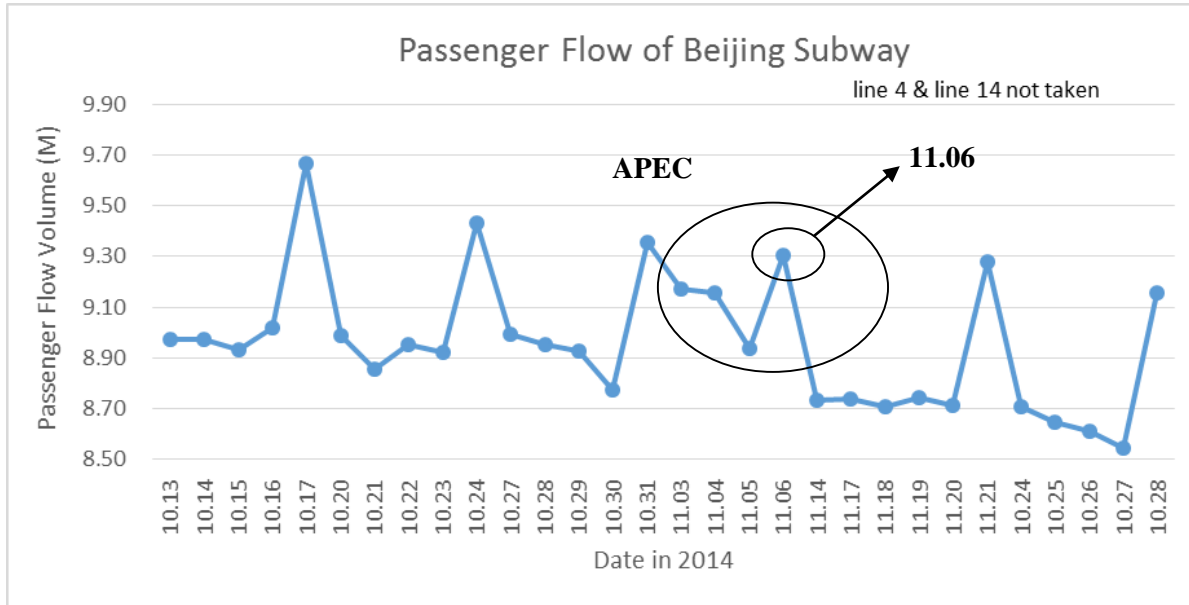
The location



Accident spot

- ◆ 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

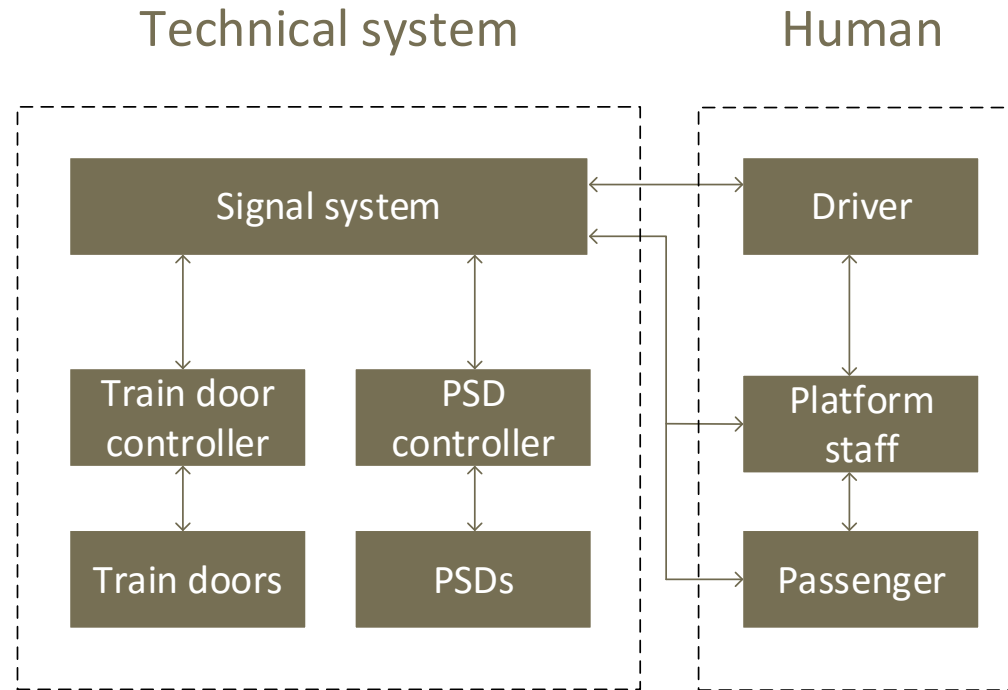
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Train & station system



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



Plate on PSD



Driver's check



Emergency tools



Handle on PSDs

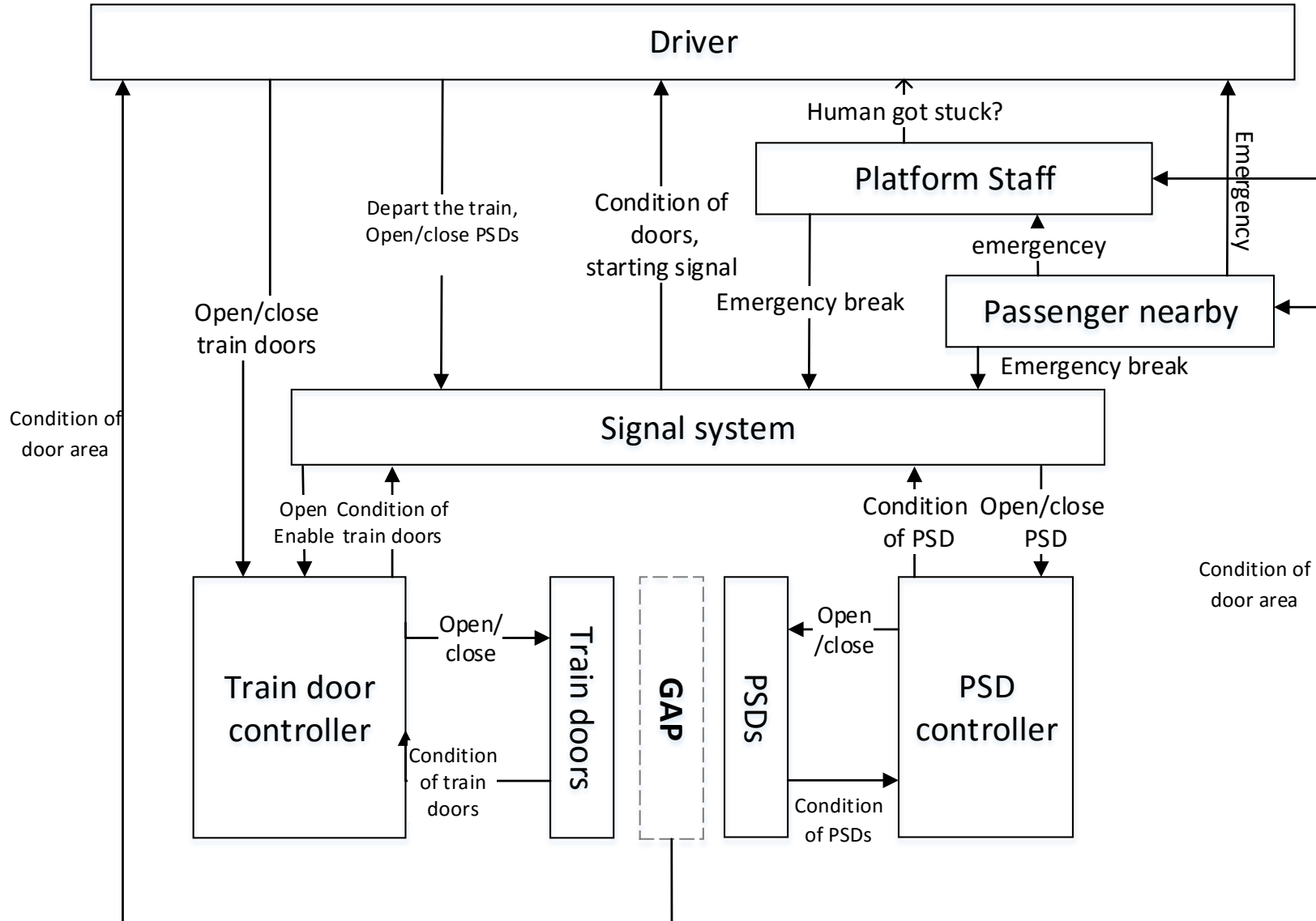


Platform staff's assist

The Proximate Events

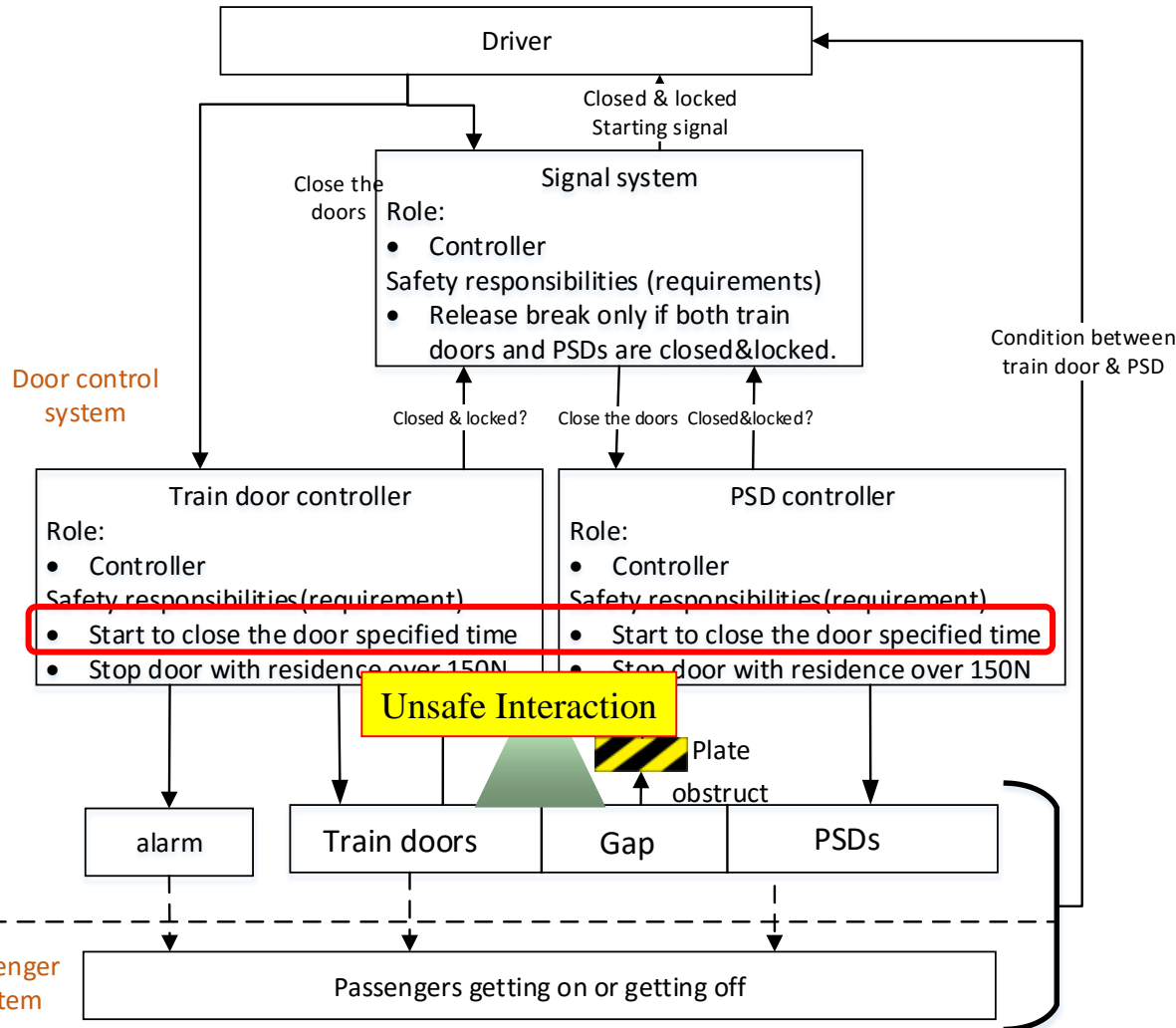
Time	Victim	Train doors	PSDs	Driver	Platform staff	other passengers
18:57			start to close			
	fell out of train					
		start to close				
	got trapped	closed	closed			
				forgot to check the gap	didn't find the emergency	looked for staffs and emergency tools
				started the train		
	got hurt					
				stopped the train		
	sent to hospital					
20:20	died in hospital					

Safety Control Structure



Physical Level

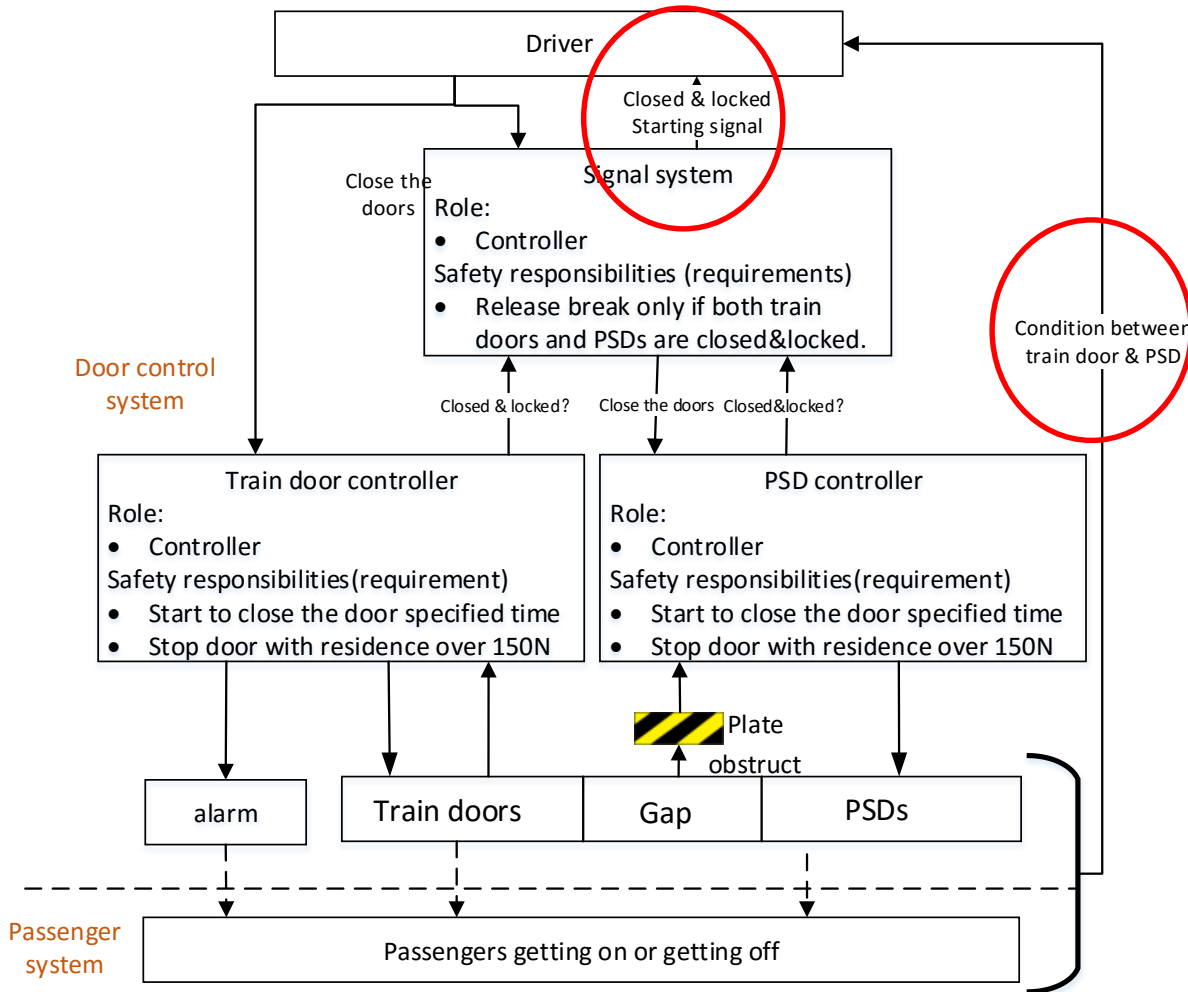
No sensor in the gap.



Deficiencies in system design:

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

Physical Level

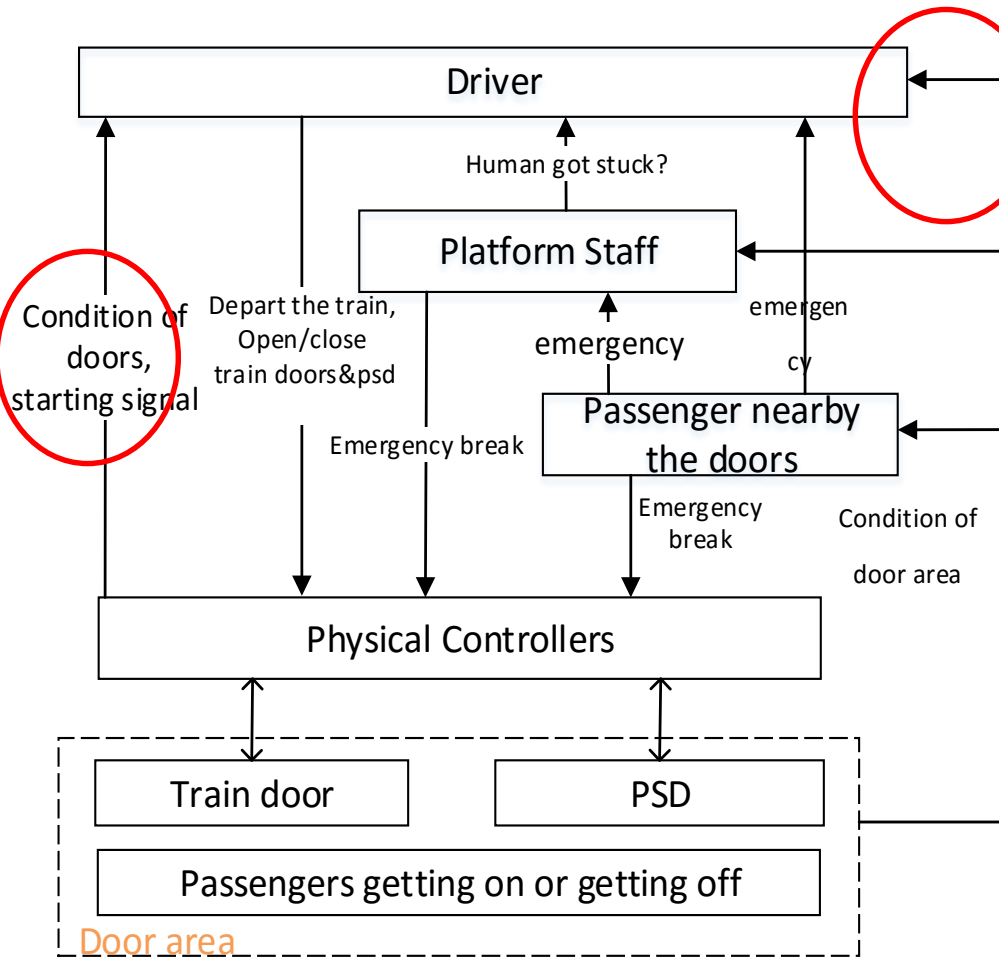


Deficiencies in system design:

- ◆ 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

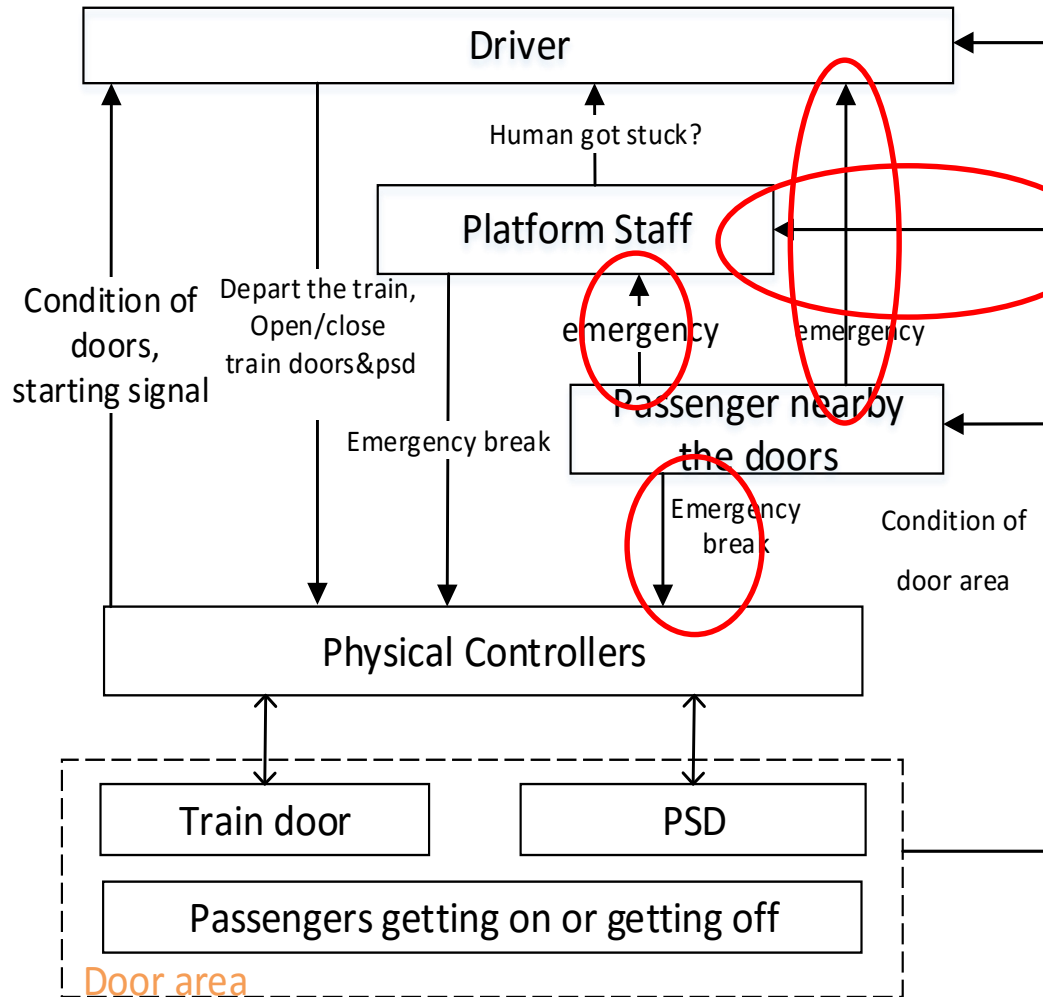
Contextual reasons for the behavior

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

Operational level



Dysfunctional Interaction

- ◆ Passengers cannot find platform staffs to report the emergency
 Reason: The platform was crowded, vision was blocked and 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

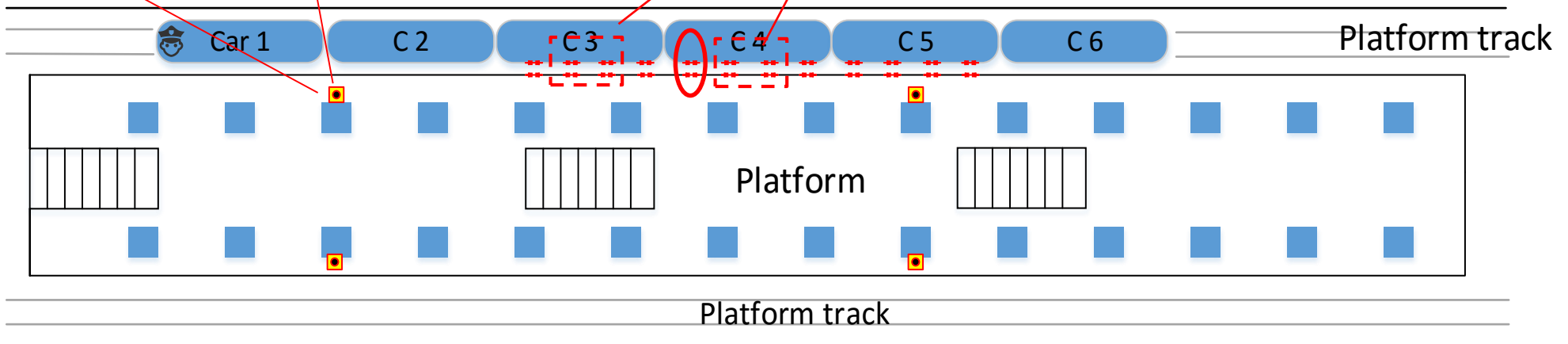
Emergency button on platform



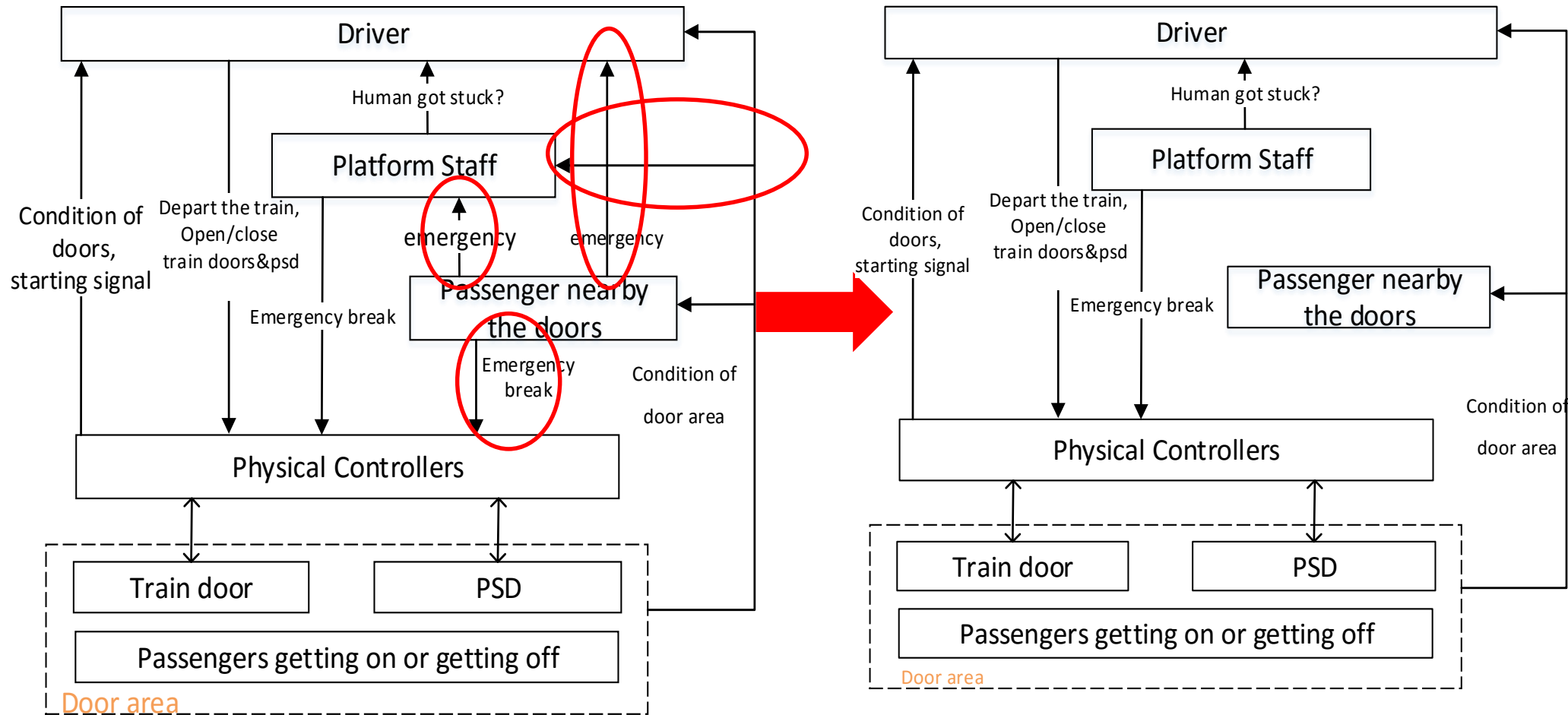
Emergency button upon train doors

Only set on 2 middle doors of each carriage

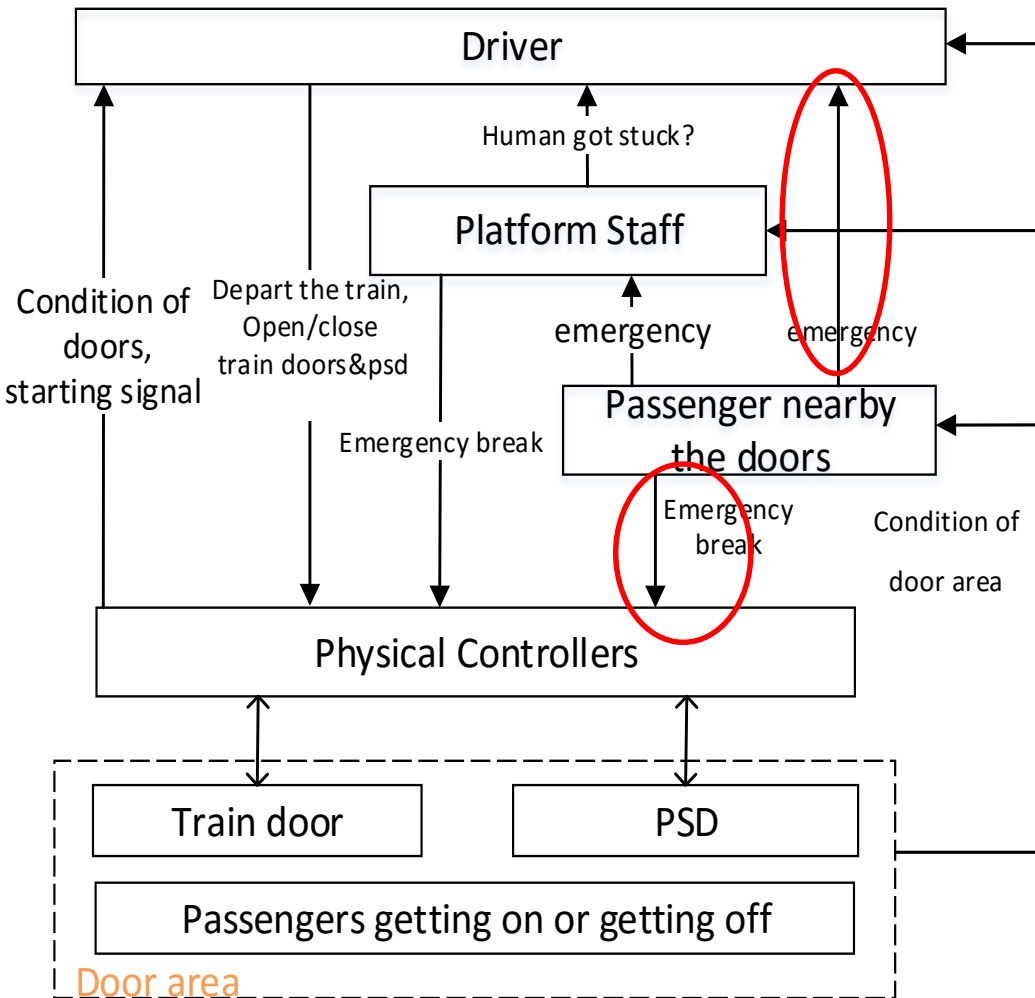
Accident spot



Operational level



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

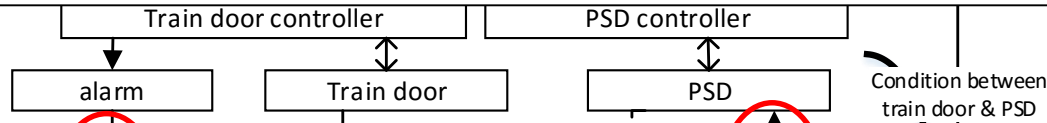
No enough knowledge to cope with this situation

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



Passengers getting on or getting off

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

Human-machine interaction

Contextual reasons & Mental model

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

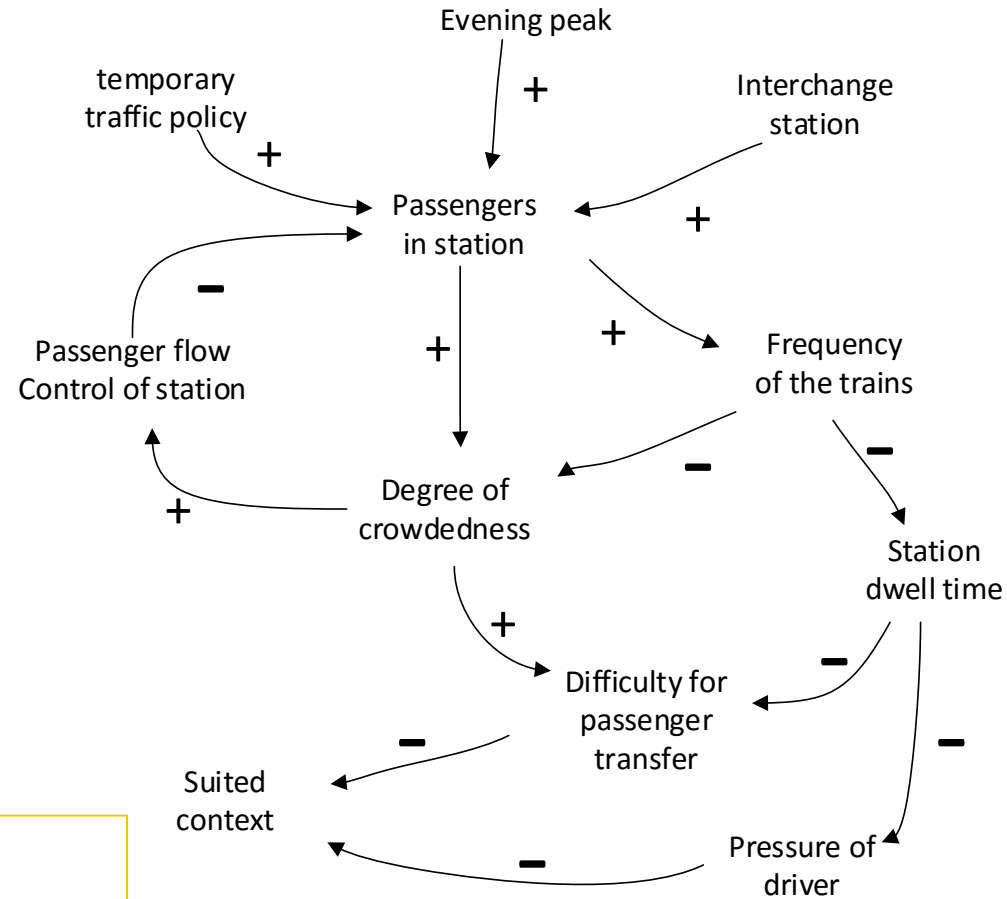
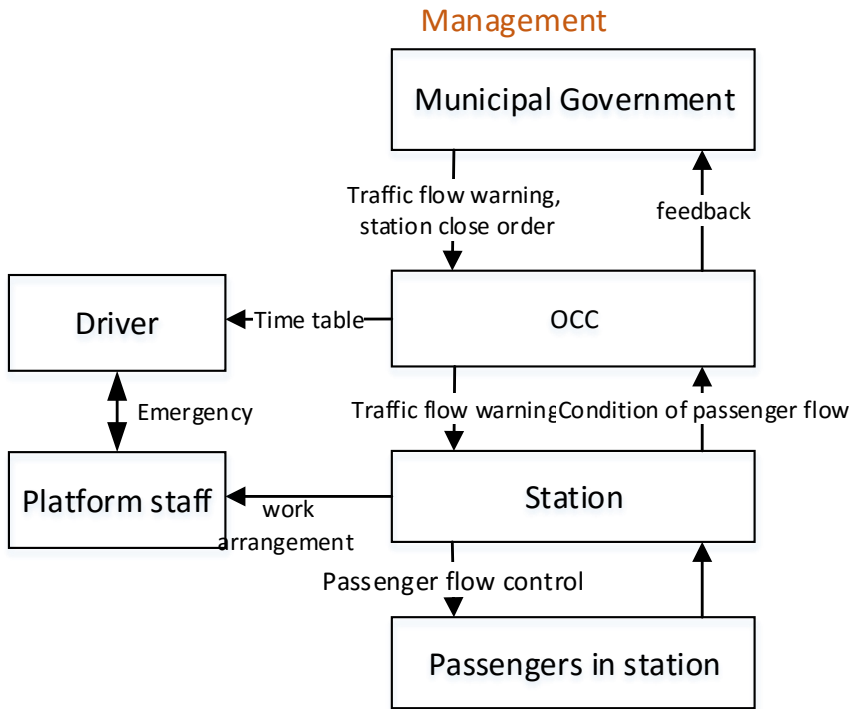
Passengers as controllers of themselves

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

Management level

Coordination and Communication



Tidal with passenger flow

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.

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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.



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Q&A!

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