Using STAMP to analyze serious accidents in China railway system

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China railway system

• Total railway operating length: 98,000KM (At the end of 2012)
• Passenger: 1.61 billion (2012)
• Goods: 3.3 billion tons (2012)
• High-speed rail: 13,000KM, about 300km/h
## China railway accidents

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Train</th>
<th>Fatalities</th>
<th>Injuries</th>
<th>Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>04/11/2006</td>
<td>Linzai - Dongshui</td>
<td>T159, 1017</td>
<td>2</td>
<td>18</td>
<td>Collide</td>
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<tr>
<td>02/28/2007</td>
<td>Zhenzhuquan - hongshanqu</td>
<td>5807</td>
<td>3</td>
<td>34</td>
<td>Derail (Wind)</td>
</tr>
<tr>
<td>01/23/2008</td>
<td>Anqiu - Changyi</td>
<td>D59</td>
<td>18</td>
<td>9</td>
<td>Collide Workers</td>
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<tr>
<td>04/28/2008</td>
<td>Zhoucun - Wangcun</td>
<td>T159, 5034</td>
<td>72</td>
<td>416</td>
<td>Derail, Collide</td>
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<tr>
<td>07/23/2011</td>
<td>Yongjia - Wenzhounan</td>
<td>D301, D3115</td>
<td>40</td>
<td>192</td>
<td>Rear-end, Derail</td>
</tr>
</tbody>
</table>
STAMP-based analysis on the railway accident and accident spreading: Taking the China–Jiaoji railway accident for example

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China-Jiaoji railway accident

- A serious railway accident on April 28, 2008. The accident caused 72 fatalities and 416 injuries.
- 04:38, Train T195 derailed on the inside track because of over speed. (The first stage)
- 04:41, Train 5034 collided T195 from the other direction on the outside track. (The second stage)
**System Hazard:** Train derails.

**System Safety Constraints:** The safety control structure must prevent derailment of the train.

1. Train must run within limited speed.
2. Driver must know the correct limited speed through different kinds of ways (e.g., IC cards and the scheduler).

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**Control Structure**
The spread of the first accident

Event sequences for the collision after the derailment of train T195
The hierarchical control structure of trains in China
Difficulty

• We need more elaborate control structures to analyze based on STAMP.
• It is hard and heavy workload to describe all the control structures of each subsystems. Not all the control structures will be used during the analysis.
• How to organize the reasons found through STAMP and propose corresponding improvement methods?
STEP

• STEP: the Sequentially Timed Events Plotting method (Hendrick & Benner, 1987);
• a multi-linear event sequence models and methods;
• STEP provides a comprehensive framework for accident investigation from the description of the accident process.
Graph based on STEP

<table>
<thead>
<tr>
<th>ACTORS</th>
<th>TIME LINE</th>
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<tbody>
<tr>
<td></td>
<td>12:24</td>
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<tr>
<td>LEVEL 1</td>
<td></td>
</tr>
<tr>
<td>actor1</td>
<td></td>
</tr>
<tr>
<td>LEVEL 2</td>
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<tr>
<td>actor2</td>
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<td>LEVEL 3</td>
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<tr>
<td>LEVEL 4</td>
<td></td>
</tr>
<tr>
<td>actor5</td>
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</table>
STEP - STAMP

(1) Collecting data, and use natural language to record the process of an accident.

(2) Use graph to describe the accident, and mark the wrong events in the graph (STEP).

(3) Construct control structures based on wrong events and use STAMP to analysis.

(4) Classify the reasons of the accident, and propose the preventions and improvement methods.
Yongwen (7.23) railway accident

• Another serous railway accident on July 23, 2011. The accident caused 40 fatalities and 192 injuries.

• 20:30, Train D301 from Beijing to Fuzhou rear-ended train D3115 from Hangzhou to Fuzhou.

• The two trains derailed, and four cars fell off the viaduct.
Yongwen railway accident
Collecting data

- Internet portal feature reports (Sina, Yahoo.cn)
- Railroad experts interviews in TV (CCTV, Phoenix Chinese Channel)
- The process of the accident.docx
Graph based on STEP

Management level
- Work Branch
  - Schedule maintenance
  - Maintenance without stopping railway
  - Dispatcher find error and give instruction
  - Dispatcher warn the driver of D3115
  - Dispatcher give an special instruction to driver of D3115
  - Dispatcher communicate with station controller

Operation Level
- Driver of D3115
  - Arrive station
- Driver of D301
  - Start off
  - Lightning stroke destroy the line, ATP works
  - Fail to switch the mode and fail to communicate
  - Fail to communicate, switch the mode later
  - Moving at the speed of 16km/h
  - ATP works and drive
  - Report the situation
  - Wait signal
  - Start off
  - Monitor the train in front, the driver brake

- Warn driver be cafe of the train in front
- Communicate control center
Dispatcher

Control Center of TDCS

Station Controller

Extension of TDCS

LKD2-T1

Computer supervisor
maintenance without stopping railway
Classification of the reasons

- Human sources
- The rail (infrastructures)
- Power network (over power)
- Trains
- Electric signs
- Switch problems
- Electric equipment
- Passenger and cargo
- Natural disasters
- Third people
- Other factor

UIC (International Union of Railway)
## Classification of the reasons

<table>
<thead>
<tr>
<th>Human sources</th>
<th>The rail (infrastructure)</th>
<th>Power network (over power)</th>
<th>Trains</th>
<th>Electric signs</th>
<th>Switch problems</th>
<th>Electric equipments</th>
<th>Passenger and cargo</th>
<th>Natural disasters</th>
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<th>Other factor</th>
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<tbody>
<tr>
<td>MOR</td>
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THANK YOU!
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