The latest Developments of transport safety in China and its future

Xinpeng YAN

Intelligent Transport System Research Center
National Engineering Research Center for Water Transport Safety
Wuhan University of Technology

Aug 10, 2017
Merged on 27th May 2000 by the authorization of the State Council from three former universities:
- Wuhan University of Technology (1948)
- Wuhan University of Transportation (1946)
- Wuhan Automotive Polytechnic University (1958).

- A Chinese key university under the direct administration of Ministry of Education, China.

- Located at Wuhan, the largest city in central China and a Chinese famous “River City”
Wuhan University of Technology

Four disciplines were listed in ESI world's top 1% ranking since 2015:

- Materials
- Engineering (including Naval Architecture and Ocean Engineering, Transportation Engineering, Mechatronic and Automotive Engineering, Civil Engineering, Resources and Environmental Engineering, etc.)
- Chemistry
- Physics
Wuhan University of Technology

Disciplines:

- Engineering
- Natural Sciences
- Management
- Economics
- Literature & Arts
- Law
- Philosophy
- Education

- 8 state key subjects
- 87 specialties for undergraduates
- 226 master-degree programs
- 77 doctoral degree programs
- MBA, MPA, MFA
Wuhan University of Technology

School of Materials Science and Engineering
School of Automotive Engineering
School of Transportation
School of Mechanical Engineering
School of Energy and Power Engineering
School of Resources and Environmental Engineering
School of Information Engineering
School of Computer Science and Technology
School of Automation
School of Civil Engineering and Architecture
School of Navigation
School of Logistics Engineering
School of Chemistry, Chemical Engineering and Life Science
**Wuhan University of Technology**

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
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<tbody>
<tr>
<td><strong>Academic Staff:</strong></td>
<td>3201</td>
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<td><strong>Professors:</strong></td>
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<td><strong>Associate Professors:</strong></td>
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<td><strong>“One Thousand Talent” Program Experts:</strong></td>
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<td><strong>Registered Students of Continuing Education:</strong></td>
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National Engineering Research Center for Water Transport Safety (WTS Center), MOST, China

ERCTS, July 2006

WTS center September, Sept., 2014

National Engineering Research Center for Water Transport Safety, MOST

Engineering Research Center for Transportation Safety, MOE

Intelligent Transportation Systems Research Center, Wuhan University of Technology

ITSC Established in Sept., 2000
Outlines

1. Current Situation of China’s Transportation
2. Current Situation of Transport Safety in China
3. Research projects of Transport Safety in China
4. How to Improving the Transport Safety in the Future
Outlines

1. Current Situation of China’s Transportation
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China's comprehensive transport network

- High-speed railway coverage of cities with a population of over one million each has 65%.
- International waterway transport routes connect over 1,000 ports in more than 100 countries and regions.
- Scheduled civil aviation flights operate on 3,326 routes, reaching 204 cities in China, as well as 137 cities in 55 foreign countries and regions.
China’s expressway network in the 13th Five-year plan

By the end of 2015, the total highway traffic length was 4.58 million km. Expressway length was 123,500 km, ranking first in the world.
By the end of 2015 the total railway operation length reached 121,000 km, ranking the world's second, including 19,000-km high-speed railway, ranking the world's first.
Inland waterway navigable length was 127,000 km, with graded waterways accounting for 52.2 %, and formed an inland waterway system composed of two horizontal trunk waterways.
By the end of 2015 China had 210 civil transport airports which secured 8.57 million takeoffs and landings in 2015.
Transportation infrastructure construction

Qinghai–Tibet Railway, the total mileage of 1142 kilometers, is the world's highest altitude plateau railway, 2013 selected "Global Hundred Years Project", is the world's railway construction in the history of a monument.
Hong Kong-Zhuhai-Macao Bridge is connected to Hong Kong, Zhuhai, Macao's large cross-sea channel, it integrate the bridge, island and tunnel, a total length of 55 km.
High-performance railway equipment technologies

New-energy road transport equipment has realized preliminary industrialization.

Feeder liners, general aviation aircraft and helicopters independently developed and the C919 airliner has rolled off the assembly line.
Transportation Information and intelligent technologies

- Railway passenger transport online booking system
- Nationwide Expressway transport Electronic Toll Collection (ETC) network
- Port Electronic Data Interchange (EDI), Vessel Traffic Services (VTS), Vessel Automatic Identification System (AIS)
- China's civil aviation business information system
- The Beidou Navigation Satellite System has become the third GNSS applied in international navigation.
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Three safety indexes decreased and one safety index significantly improved in 2015

- Number of accidents decreased
- Minor accident (three fatalities) decreased
- Relative safety indexes decreased
- Safety level significantly improved
- Number of accidents and fatalities decreased by 4.6% and 1.2%, respectively.
- Minor (3 fatalities) and major (10 fatalities) accidents decreased by 7.1% and 10.3%, respectively.
- Fatalities of road and maritime transportation decreased by 0.9% and 10.1%, respectively.
Transport safety situation in China (road)

- Fatalities stay steady in the recent years, the number of fatalities is **58022** in 2015.
- The number of accidents and fatalities reached the peak in 2002, and then decreased owing to the road safety law has been enforced since 2003.

![Graph showing number of accidents and fatalities from 1996 to 2015](image)

Number of accidents and fatalities of road transportation from 1996 to 2015

Data source: National Bureau of Statistics
China’s public service platform for commercial vehicles

In order to improve the safety of commercial vehicles, all the passenger vehicles and dangerous goods transport vehicles must be installed the GPS device in China since 2012, and all the data from those vehicle access to the public service platform.
Dangerous driving regulations and laws in China

• China’s constitution, has been amended in 2011, shows that dangerous driving, such as motor racing and drunk driving will be detained and fined.

• The new law is already seeing results. The first two weeks saw the number of drunk driving cases fall 35 percent compared with the year before.
Transport safety situation in China (railway)

- The catastrophic and major accident rarely occurred recently
- Minor accidents occasionally occurred
- Fatalities caused by accident are around 1000 per year
- Mortality rate of billion ton-kilometers is around 0.3

Statistic of railway accidents from 2011 to 2016

<table>
<thead>
<tr>
<th>Year</th>
<th>Catastrophic and major</th>
<th>Minor accidents</th>
<th>Fatalities caused by accident</th>
<th>Mortality rate of billion ton-kilometers</th>
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<td>0</td>
<td>1566</td>
<td>0.401</td>
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<td>2012</td>
<td>0</td>
<td>0</td>
<td>1463</td>
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<td>2013</td>
<td>0</td>
<td>8</td>
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<td>2014</td>
<td>0</td>
<td>6</td>
<td>1232</td>
<td>0.315</td>
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<td>2015</td>
<td>0</td>
<td>6</td>
<td>1037</td>
<td>0.290</td>
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<td>2016</td>
<td>0</td>
<td>3</td>
<td>932</td>
<td>0.256</td>
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Data source: National Railway Administration
Mortality rate of billion ton-kilometers = fatalities/converted turnover (billion ton-kilometers)
The number of accidents, fatalities and wreck stay steady in maritime transportation in the recent years.

All these three indexes decreased, which means the maritime safety situation is improved.

Statistic of maritime accidents from 2010 to 2016

Data source: China Maritime Safety Administration
Ten year rolling value of major accidents rate per million hour is 0.04 during the period from 2006 to 2015, while the same time the world average level is 0.47, and the USA is 0.10.

Ten year rolling value of fatalities per million person-kilometers is 0.001, while the same time the world average level is 0.010.
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Investment of scientific research in China

Nearly ten years of research funding (Billion)

0 500 1000 1500 2000 2500

<table>
<thead>
<tr>
<th>Year</th>
<th>Funding (Billion)</th>
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<tr>
<td>2007</td>
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</tr>
<tr>
<td>2008</td>
<td>678</td>
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<td>2009</td>
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<tr>
<td>2015</td>
<td>2083</td>
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<td>2016</td>
<td>2270</td>
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# The Transportation Safety Science and Technology Program - Representative Issues and Achievements (Taking Road Traffic and Waterway Traffic as an Example)

<table>
<thead>
<tr>
<th>Topic</th>
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<tbody>
<tr>
<td>Navigation condition monitoring and real-time management</td>
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<tr>
<td>Risk control technology for waterway transportation in Yangtze River</td>
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<tr>
<td>Intelligent ships--Navigation brain system (NBS)</td>
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<tr>
<td>Early warning technologies of driving behaviors for the vehicle</td>
</tr>
<tr>
<td>Key technologies of IVICS (Intelligent Vehicle Infrastructure Cooperative Systems)</td>
</tr>
</tbody>
</table>
1 Navigation condition monitoring and real-time management

Development of Maritime data collection technologies

- Integrated ship traffic monitoring system, RFID
- Center Control Television (CCTV)
- AIS, VTS
- Man-made waterway infrastructure
- Ship traffic information
- Monitoring elements
- Current mapping modelling
- Man-made waterway infrastructure
- Current
- ADCP sensors
- Man-made waterway infrastructure
- Convention al nav-aids
- Multi-function nav-aids
- Automatic water depth measuring ship
- Artificial water depth measuring ship
- Ship draft
- Water depth
- Manually measurement
- Advanced sonar technology
- Fibre Optic Sensor
- Current
- Multi-function nav-aids
1 Navigation condition monitoring and real-time management

Develop series of navigation monitoring devices
1 Navigation condition monitoring and real-time management

Design the Automatic surveying ships to collecting water depth data
1 Navigation condition monitoring and real-time management

Establish the real-time Ship monitoring system

Aids to navigation system  Shipborne radar
2 Improvement on safety navigation and emergency response

Development of ship maneuvering simulator for inland water transportation
2 Improvement on safety navigation and emergency response

Development of Emergency maritime simulation system

- Wind
- Current
- Visibility
- Ship length
- Failure mode
- Fuzzy box for the natural environment evaluation
- Natural environment
- Traffic flow
- Restricted area
- Fuzzy box for the traffic environment evaluation
- Traffic environment
- Fuzzy box for the vessel condition evaluation
- Vessel condition
- Tug
- Anchorage
- Fairway
- Exception for safety control option AI
- Available rescue resources

Mechanism of maritime transportation system

- Pre-accident
- Post-accident
- Data log and replay module

Scenario

- Geometric model
- OGRE engine
- Condition model
- Numerical simulation
- Maritime accident environment and data
- Training Control Module
- Training Evaluation Module
- Real-time virtual reality
- Human-computer interaction module
- Mouse and Keyboard
- Rudder and Propeller
- Projector and VGA
- Hardware-in-the-loop
- Emergency rescue team
- Navigator in rescue boat
- Commander
- Human-in-the-loop
Multiple factors coupling mechanism under complex conditions in inland waterway

- A modified model is established based on FSA and BN to describe the coupling mechanism of multiple influencing factors

Formal safety assessment

Bayesian network
Quantification of maritime safety based on both historical data and subjective knowledge

- The proposed model has advantage in making quantitative risk assessment with higher precision, which is 15%-30% higher than the conventional BNs model.
NBS is composed of self cognitive, environment cognitive, and decision making and control

NBS is connected with ship control system, navigation equipment, and navigational aids
4 Intelligent ships--Navigation brain system (NBS)
4 Intelligent ships--Navigation brain system (NBS)
4 Intelligent ships—Navigation brain system (NBS)
5. Early warning technologies of driving behaviors for the vehicle

- Data Collecting
- Multifarious Warnings
- Unsafe Driving Detecting
- Car Following
- Lane keeping
- Dangerous Driving Detecting
5. Early warning technologies of driving behaviors for the vehicle

Experimental design

Timing model

Unsafe driving behaviors recognition technology

Threshold determination

Correlation analysis
5. Early warning technologies of driving behaviors for the vehicle

- Lane Recognition
- Vehicle Trajectory Recognition
- Traffic Sign / Light Recognition
- Obstacle Recognition
- Pedestrian Recognition
- Driver Behavior Recognition
5. Early warning technologies of driving behaviors for the vehicle

- Driving behavior collecting system
- Simulation system for Real vehicle operation
- Simulated driving technology
- 3 Degrees of Freedom Motion Platform for Miniature Vehicle
- 3 Degrees of Freedom Motion Platform for Truck/Coach Bus
6. Key technologies of Intelligent Vehicle Infrastructure Cooperative Systems

- **Architecture**

- **IVICS**
  - V-V Interactive Safety Control Systems
  - V-I Interactive Safety Control Systems
  - Full Simulation Test
  - Field Test
  - V-V/V-I based Traffic Control Systems
  - Multimode Information Exchange Platform
6. Key technologies of Intelligent Vehicle Infrastructure Cooperative Systems

Task 1
Vehicle-Infrastructure Cooperation system architecture design and field test

Task 2
Key technologies of Vehicle-Infrastructure Interacted Control System

Task 3
Key technologies of Vehicle-Vehicle Interacted Control System

Task 4
Key technologies of V-V/V-I based Cooperated Traffic Control System

Task 5
Simulation test of Vehicle-Infrastructure Cooperation system
6. Key technologies of Intelligent Vehicle Infrastructure Cooperative Systems

- **On-Board Unit**
  - Radar
  - DSRC/3G
  - CCD
  - Lidar
  - Infrared

- Data Acquisition System
- Central Processing System
- Nav
- CAN Instrument
6. **Key technologies of Intelligent Vehicle Infrastructure Cooperative Systems**

- **Road-Side Unit**
  - Power
  - Weather Detecting
  - Road Surface Condition Detecting
  - Signal Control System
  - Variable Message Sign
  - Video Processor
  - Main Processor
  - Data Exchange Platform

Connections:
- RS232
- RJ45
- USB
- GPS/Beidou
- WLAN
- WAVE
- 3G
6. Key technologies of Intelligent Vehicle Infrastructure Cooperative Systems

IVICS Testbed, Longfang, Hebei, China
6. Key technologies of Intelligent Vehicle Infrastructure Cooperative Systems

<table>
<thead>
<tr>
<th>Moving Cluster</th>
<th>Contour</th>
<th>Trajectory</th>
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</thead>
<tbody>
<tr>
<td>State Cluster</td>
<td></td>
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</table>

Point Cloud after Scan Matching and the Cluster Tracking

Panorama Image of Local Scenarios

The Autonomous vehicles in WUT
6. Key technologies of Intelligent Vehicle Infrastructure Cooperative Systems

The Autonomous vehicles in WUT
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4、How to Improving the Transport Safety in the Future

Introduction of consulting project of CAE

PI: Professor Zhihuan FU, Academician of CAE
Background — mission and task

- Both the CAE and MoT declared that China must firmly grasp the historical opportunities to carry out the study of the strategy of developing a new transportation system, and to reach the goal of more safety, green, efficient, convenient in the field of transport.
Contents of the project---ten topics

Topic 1: Demand forecast and future analysis of passenger and freight transport
Topic 2: Strategic objective and evaluation criteria system for a traffic and transport power
Topic 3: Optimization strategy of transport infrastructure
Topic 4: Innovation strategy of transport technology
Topic 5: Strategy of improving the service level of passenger and freight transport
Topic 6: Development strategy of green and intelligent transport

**Topic 7:** Development strategy of traffic safety

Topic 8: Improvement of the international influence (competitive) power of transport
Topic 9: Development strategy of urban transport
Topic 10: Development strategy of the security system for transport power
The results of the project

1. General report on this project
2. 10 research reports for the ten topics
3. 1 recommendation for strategy of developing the transportation system in the 2035 and 2045

- The research findings will be submitted to the state council, national development and reform commission, CAE and MoT, etc.
Transportation development trend- vehicles

Unmanned and Intelligent:

- McKinsey & Bloomberg New Energy News released a report that the 2030 high-level automatic driving car will reach 50% of the overall sales, electric vehicles will account for 2/3; In addition, around 2045 will be fully unmanned.
Unmanned and Intelligent:

◆ The level of intelligence for maritime transportation will be significantly improved in the upcoming years, and the unmanned ship technology will be merging to its mature stage in around 10 years.
The situation of the transport infrastructure will deteriorate. The future of transport infrastructure disaster resilience will be significantly improved. In recent years, China attaches great importance to the capacity of transport infrastructure and service level. Transportation infrastructure development, service level improvement and transformation, will form a safe, convenient, efficient, green, economic integrated transport system.
Transportation development trend- Operational management

◆ Internet + traffic travel, Internet + cargo transport, is rebuilding the entire transport system.
◆ Anytime, anywhere to provide personalized, diversified information services, information sharing and business collaboration.
◆ Shared traffic will occupy, the future development of traffic is conducive to multi-person ride a car, a car service multiplied by the shared mode of transport.
**Safety management**

- Features: People involved in a small degree of automation; the higher the degree of participation, the more the accident.

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**Safety control**

- Features: Reducing human operation and achieving safety control.

  - **Vehicle Operation Control**
    - Safe and reliable advanced technology
  
  - **Management System Control**
    - Legal perfection, standard promotion, process coordination, decision science
  
  - **Human Factors Control**
    - Teaching system, public propaganda, and comprehensively enhance
  
  - **Infrastructure**
    - Dynamic real-time monitoring, system coordination
  
  - **Accident Process Control**
    - Timely response, controllable visual
Five National Projects

1. Project for modern transport safety Management and optimization
2. Project for transport safety technologies innovation
3. Project for national attainment improvement to transport safety
4. Project for improvement on resilience of transportation system
5. Project for transport safety emergency system

Five key R&D Plans

1. Civil aviation transport safety cost and optimization
2. Full-life security of rail transit
3. Water transport safety comprehensive promotion
4. Rural road transport safety control
5. Urban integrated transport hub safety
Project for modern transport safety Management and optimization

✓ Transport safety law perfection
✓ Transport system standard upgrade
✓ Traffic safety management collaboration
Project for transport safety technologies innovation

- Data Acquisition and Storage Technology
- Analysis and Mining Technology of Transportation Data
- Transport safety equipment technology development
- Transport safety training equipment technology
Project for improvement on resilience of transportation system

- Reliability improvement of transport facilities, vehicles, and control equipment
- Accessibility improvement of critical transport infrastructures network
- Interconnected of urban and regional traffic
Thank you

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