INSTITUTE of PUBLIC SAFETY RESEARCH

April 30, 2018

With dedication, with wisdom, for a safer world!
In the past
- Founded as a preparatory school in 1911
- Established university section in 1925
- Became a polytechnic university in 1952
- Restored science, economics, law…etc in 1978.

At present (top 3 in China)
- 7800 of faculty and staff
- 13,000 undergraduates
- 12,800 Master students
- 5,700 Ph.D students

Goal for the future
…into a world-class university
IPSRI (Institute of Public Safety Research)

- ★ Institute of Safety Science and Technology (Engineering Physics)
- ★ State Administration of Work Safety Key Lab on Fire Safety (Eng. Physics)
- Laboratory of Particle and Radiation Imaging (Engineering Physics)
- Center for Nuclear Safety (Nuclear Technology)
- Institute of Disaster Prevention and Mitigation (Civil Engineering)
- Department of Construction Safety Management (Civil Engineering)
- Institute of Hydraulic and Hydropower Engineering (Civil Engineering)
- Center for Crisis Management Research (Public Policy & Management)
- Center for Chemical Processing Safety (Chemical Engineering)
- Laboratory of Control and Simulation of Power Systems (Automotive Eng.)
- Center for Safety Eng. and Technology Research (Aeronautic & Aerospace)
- Institute of Thermal Engineering (Thermal Engineering)
- Institute of building Environment and Facility Eng. (Architecture Science)
- Institute of Software Theory and System (Software)
Commendation from Chinese President Xi Jinping:
“A key research base for strategically crucial issue of national safety, which is a fitting undertaking for the prestige of Tsinghua University.”

President Xi visited IPSR
- “IPSR has already been the national base for public safety research and engineering…”

President Xi visited ECU911
- Ecuador public safety management system, using IPSR technologies

Premier Li visited C2 centre
- Command and control center, using IPSR technologies
Chairman/secretary general of Asia-Pacific Association of Public Safety Science and Technology
Chairman/secretary general of Chinese Association of Public Safety
Beijing Key Laboratory of Comprehensive Emergency Response Science
Key Laboratory of Work Safety State Administration of Work Safety
Risk & Resilience, Disaster Modeling

Vulnerability Analysis

Chain-event modeling

Forest fire

Crime hotspot

Risk Analysis

Water pollution

Human evacuation

Hazmat spill
Large Experiment Facility

Human behavior and safety protection

Disaster coupling wind tunnel

Wind spd: 1-80 m/s;
Temp: -40-70ºC;
Humidity: RH 10%-95%;
Shake freq: 0.1-100 Hz;
Shake acc: 6g;
Rain: 0-250mm/h;
Snow: 0-150mm/h;
Sun: 500-1200W/m2;
Safety Technology Provider for Disaster Response & Rescue - Command & Coordination

- Dynamic command & control
- Real-time feedback
- Interdisciplinary
- Trans-regional
- Cross-agency

- National Centre
- District / Department Platform
- Field Task Force

- Disaster scene
- Emergency shelter & housing
- Resource dispatch station
- Critical Infrastructure

- Text
- Voice
- Video
- Collaborative plotting

- Force Dispatch
- Disaster Development
- Disaster Site
- Rescue & Relief
- Resource Allocation
Safety Technology Provider for Disaster Response & Rescue - Command & Coordination
Safety Operation System for All Nuclear Plants in China
Smart Safe City

Application Layer
- Safe Community
- Safety Campus
- Smart Firefighting
- Safe Lifeline
- Smart Health
- Safe Transportation
- Flood Protection

Awareness Layer
- Risk Analysis
- Forecast and Early-waning
- Consequence Analysis
- Safety Management
- Decision Making

Transmission Layer
- Communication Network
- Internet
- IoT

Sensing Layer
- Mobile Phone
- Visual Telephone
- Call Center
- Wireless Gateway
- Internet
- Camera
- RFID
- Sensor Network
Smart Firefighting

Advantages
- Sophisticated Management
- Situation Prediction
- High-efficiency of Accident Rescue

Data Management
- BIM
- GIS
- 3D Model
- Inflammable Goods Info

Monitoring Data
- Fire Detectors

External Data
- Meteorology
- Personnel Location

Analysis Model
- Structure Fire Model
- Fire Spread Model

Command & Control Centre

Fire Scene
- Fire Situation

Feedback
- Schedule
- Fire Fighter
Infrastructure Safety – Gas Pipeline, Bridge, Water Pipeline
Social Security

Intelligence Sources

Analysis & Decision

Command & Control Centre

Advantages
- Intelligence Integration
- Intelligent Decision-making Assistance

Data Center

Intelligence Sources
- Surveillance video
- Telecom
- Network behavior
- Bank consumption
- Traffic record
- Accommodation

Crime Hotspot
Social Relationship
Terrorist Network
Network Relationship
Crowd Gathering Detection

Telecom Network behavior
Bank consumption
Traffic record
Accommodation

Surveillance video
Telecom
Network behavior
Bank consumption
Traffic record
Accommodation
Safe Petroleum & Petrochemical Industry Park

- Full coverage of crucial safety “hot spots”
- Combination of routine monitoring and emergency response
- Grade-based safety management

Key Areas
- Crucial Operation
- Key Areas
- Surrounding

Core Capabilities
- Surveillance & Monitoring
- Operation Safety Management
- HSE Management
- Simulation & Training
- Predictive Analysis & Early-warning
- Information Collection
- Emergency Response Capability Evaluation
- Decision Support
- Digital Contingency Plan
- Collaborative Consultation
Fire Safety
KangDing High Altitude Fire Testing Laboratory

KangDing Airport - Altitude 4290m

Simulated Cargo Compartment

Heat Release Rate Calorimeter
Full-Scale Standard Simulated Cargo Compartment

(a) Simulated cargo compartment

(b) Internal pressure control system

Main Technical Parameters

Pressure variable range:
24 KPa ~ 110 kPa (30000 ft ~ sea level)

Pressure variable rate: 3 ~ 30 kPa/min

Door: 2 m(W) × 1.67 m(H)

Inner dimension: 8.11 m × 4.16 m × 1.67 m

Volume: 56.6 m³
Weight: 20 t
Liquid Pool Fire Behavior

Mass burning rate under different static pressures (6 and 10 cm pool fire)

Turbulent to laminar
Flame base turned blue
Polyhedral and swirled flame

Plume temperature correlated with axial height and pressure

\[
\frac{T_p - T_\infty}{T_\infty} = C_f \left( \frac{1 - X_f}{c_p \rho T_\infty} \right)^{2/3} \left( \frac{Z + Z_0}{Q^{2/5}} \right)^{5/3}
\]

\[
\sim \left( \frac{Z + Z_0}{Q^{2/5}} \right)^{-5/3}
\]

Liquid Pool Fire - Depressurization and Pressurization

- Liquid fire could not be put out
- Near-Real pressure environment

- Lower pressure, higher evaporation capacity and diffusion rate. Higher flame height and temperature, greater potential risk.

Maximum external temperature 754°C.
Radiative heat flux identify with pressure.
Dynamic Pressure Effect on Solid Fire

- Depressurization suppress fire, but cannot eliminate smoldering
- Re-ignition with increasing air pressure

- Contribute to insufficiency combustion
- Increase the flammable gas concentration
- Additional flashover possibilities
Vulnerable Area during Cargo Fire

- **Cargo liners** -- effective and practical burn-through barrier
- **Cheek area** -- likely pathway for fire penetration
- **Cargo smoke detection** -- decreased soot formation, high false detection rate

Timothy R. Marker, 1999 (FAA)

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Flame Morphology and Post-fire Panels

Flame Morphology

Panels Structural Variation under Fire

- Dilation and Delamination
- Comprised of fiberglass encased in film bagging
• Low pressure, wider dilation area and carbonization area
• Low pressure, cargo liners burn through more easily

➢ Depressurization could not put out the flammable liquid fire, and increases the potential burn through threat.
Low Pressure Two-fluid Water Mist

**Water Mist Nozzle**

**Particle Size Distribution**

Case 1  
$N_2$: 0.3 MPa  
Water: 0.2 MPa, 180 ml/min

Case 2  
$0.4$ MPa

Case 3  
$0.5$ MPa
Smoke Permeate into Passenger Cabin

Air Crash Investigation, Getting Out Alive, S13E11, 2014
Next Steps

Cargo Smoke Detection

Lithium Battery Thermal Runaway

MPS Fire Test Scenarios

Halon Replacement: Onboard Water Mist System
Campus Safety
Background Analysis of Campus Safety

- Hazard
  - Natural disasters
  - Unsafe behavior
  - Unsafe state
  - Unsafe environment

- Vulnerability
  - Material vulnerability
  - Human vulnerability
  - Vulnerability of operational system
  - Vulnerability of buildings

- Risk
  - Organizational structure and competence
  - Rules and regulations
  - Resources
    - Training and drills

- Management
  - Equipment equipping
  - Unit use and maintenance
  - Monitoring system
  - ...
Campus Safety Information Collection and Database

"Information islands" joined together

Administration office

Department of logistics management

Local street office

Public security department

Housing management company

Property management company

Laboratory and equipment

Information centre

Laboratory and equipment

Canteen service centre

Students affairs office

Housing management service centre
Campus Safety Information Collection and Database

- Systematically review campus risk and identify the key problems
- Establish monitoring and warning system using new technologies, e.g., video/camera, smart phone, face/license plate recognition system
- Connect to the neighborhood and to the city
- Establish campus safety protection system
Campus Safety Information Collection and Database

Full control of the school situation

Campus security comprehensive protection platform

Fire extinguishing system
- fire extinguishing mainframe
- fire extinguishing water supply monitoring system

Information monitor and reporting system
- IoT monitor
- crowds collect image and report
- voice call
- public opinion monitor
- related organization information system

security system
- Video monitoring
- grid patrol
- door access system

Fire extinguishing system
- fire extinguishing mainframe
- fire extinguishing water supply monitoring system
System Userage

Intuitive understanding of campus operation
Quickly respond campus emergency decision

Enhanced public security awareness
Easy access to security information

Public safety knowledge training
Conveniently report security information

Intuitive understanding of campus operation
Quickly respond campus emergency decision
System Framework

Campus BIM, GIS modeling

Dynamic risk information collection
- Identification of risk assessment index
- Classification of monitoring elements
- Sensors installation and deployment
- Information collection and access

Campus risk prevention, control and emergency coordination platform
- Campus security platform
- Front platform

Identification of risk assessment index
Classification of monitoring elements
Sensors installation and deployment
Information collection and access

Campus BIM, GIS modeling

risk identification and analysis
- Identification of campus security risk incident
- Complete risk index system construction

multi-source information access technique
- Classification of monitoring information
- Multi-source heterogeneous information integration and access

information integration and analysis technique
- Combination of IoT and GIS/BI
- Cross impact chain analysis
- Real-time risk assessment and visualization

emergency coordination
- Situation comprehend
- Emergency coordination and command
- Resource management and scheduling
System Framework

Phase I
- Smart firefighting subsystem
- Risk prevention and warning subsystem
- Campus security grid management subsystem

Phase II
- Campus emergency management subsystem
- Comprehensive control subsystem
- Event information base
- Component information base

Use
- Basic GIS and a graph system
- Three-dimensional visualization system
- Data exchange and sharing platform

Know
- basic information base
- Geo-database
- IoT database
- Event information base
- Component information base
- Emergency knowledge base
- Case base
- Security Resource base

Spread
- outer net
- Education private net
- internet
- wireless net
- satellite
- intranet

Sense
- Sensing means
- Infrared sensing
- Dangerous chemicals detection
- Video supervision
- Quick Mark
- Gridman
- Interior and Exterior environment
- Comprehensive security
- Production equipment
- Underground pipe network

Campus security comprehensive security and emergency command center

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Campus security comprehensive security and emergency command center
Scenario Development

Mission → Plan → Scenario/Exercise → Gap/Improving steps → Implementation

**Targeting**
- Initial objectives
- Latent objectives
- Target revising

**Planning**
- Risk/opportunity analyzing
- Objective setting
- Lessons learning

**Scenario/Exercise**
- Fit/gap analyzing
- Exercise testing
- Lessons learning

**Internal/external assessment**
- Planning
- Data collecting/analyzing
- Lessons learning
- Recommendations

**Implementation**
- Person preparation
- Material preparation
- Monetary preparation
- Implementation

New Mission → Capability Assessment Report
Daily Supervision

- Daily inspection
- Instant sign in
- Information collection
- Information reporting
- Incident report
- Mobile video
Daily Supervision and Early Warning

School teachers & students photo upload

**road manhole cover lost

Photo upload

Report

Repair

Campus Security Comprehensive Protection Platform

On-campus speed monitoring

50km/h

License plate recognition

Leave

License plate recognition
Important Event Management and Early Warning
Emergency Management

Comprehensive management

- Monitoring, early warning and emergency coordination platform
- Implement campus emergency response
- One-touch calling
- Video conference
- One-click SMS, fax

- Digital plan
- Information collection
- Resource scheduling
- Emergency coordination
Emergency Management

All stakeholders involved in emergency prevention and closed-loop information

- Personnel monitoring
- Equipment monitoring
- On-site command

Emergency information

- Event information (Location, Disaster, Measures Taken)
- Live feedback (audio, video, pictures)
- Monitoring information (event progress)

Monitoring information

- Personnel monitoring
- Equipment monitoring

Emergency disposal scheme

- Emergency information

Emergency disposal scheme

- Event information (Location, Disaster, Measures Taken)
- Live feedback (audio, video, pictures)
- Monitoring information (event progress)

Emergency response team

- One-touch calling, text messaging, fax
- Verification of the information, notification of the emergency response team

Relevant leaders and responsible persons

- Remote power off, open access control system
- Early warning information release (large screen mobile broadcast, etc.)

Preplan automatic extraction

- Level confirmation
- Accident type confirmation

Information confirmation and prior disposal

Platform system

- Command
- Rescue
- Protection
THANK YOU