



**With dedication, with wisdom, for a safer world!**

# **INSTITUTE of PUBLIC SAFETY RESEARCH**

**April 30, 2018**

# Tsinghua University

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



# IPSR (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**)

# Government Think Tank

## 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



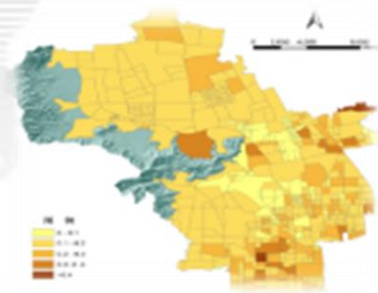
# Academic Influence



- ❑ 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



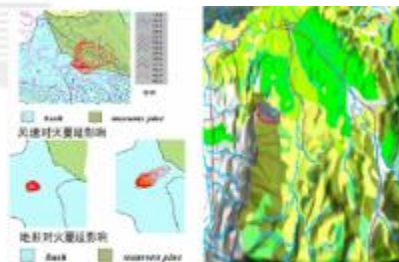
# Risk & Resilience, Disaster Modeling



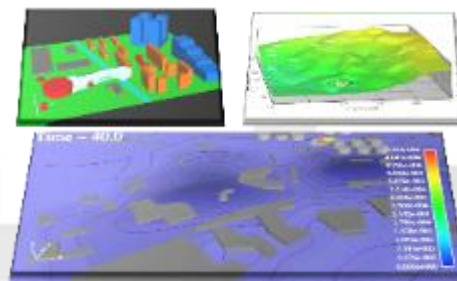
Vulnerability Analysis



Chain-event modeling



森林火灾蔓延态势分析  
Forest fire



危化品泄漏蔓延态势分析  
Hazardous chemical spill



Risk Analysis



长江水污染模拟态势分析  
Water pollution



奥运会场馆人员应急疏散模拟  
Human evacuation

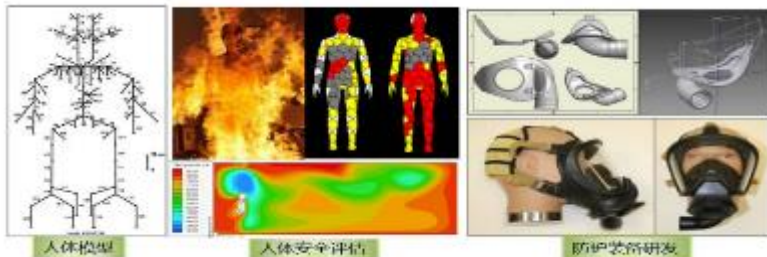


警情空间热点分析  
Crime hotspot

# Large Experiment Facility

## 人员行为与人员防护实验系统

研究高温、低温冰冻、火灾浓烟、危化品事故、爆炸及其复合作用等灾害环境下人体损伤防护装备的研制和评价。



Human behavior and safety protection



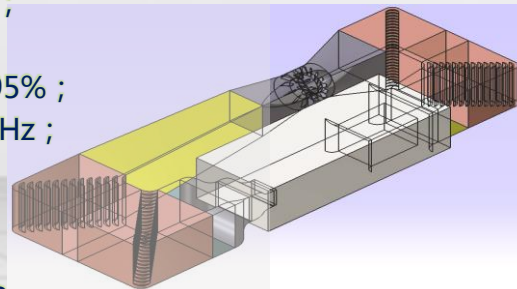
## 多灾种耦合作用多尺度实验平台

- 模拟典型突发公共事件（大风、强降雨、洪水、火灾、气体泄漏、火灾、建筑物破坏、基础设施破坏等）
- 揭示各种突发事件之间的衍生和耦合规律



Disaster coupling wind tunnel

Wind spd : 1-80 m/s ;  
Temp : -40-70°C ;  
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;



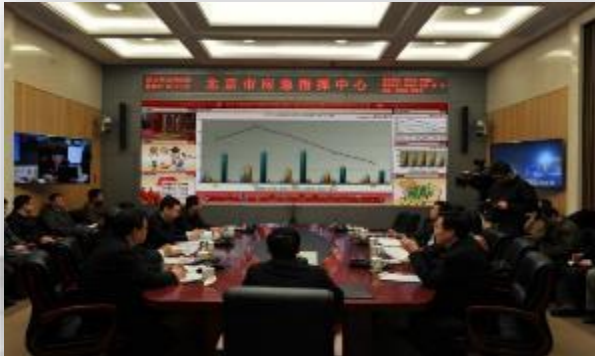


# Safety Technology Provider for Disaster Response & Rescue - Command & Coordination





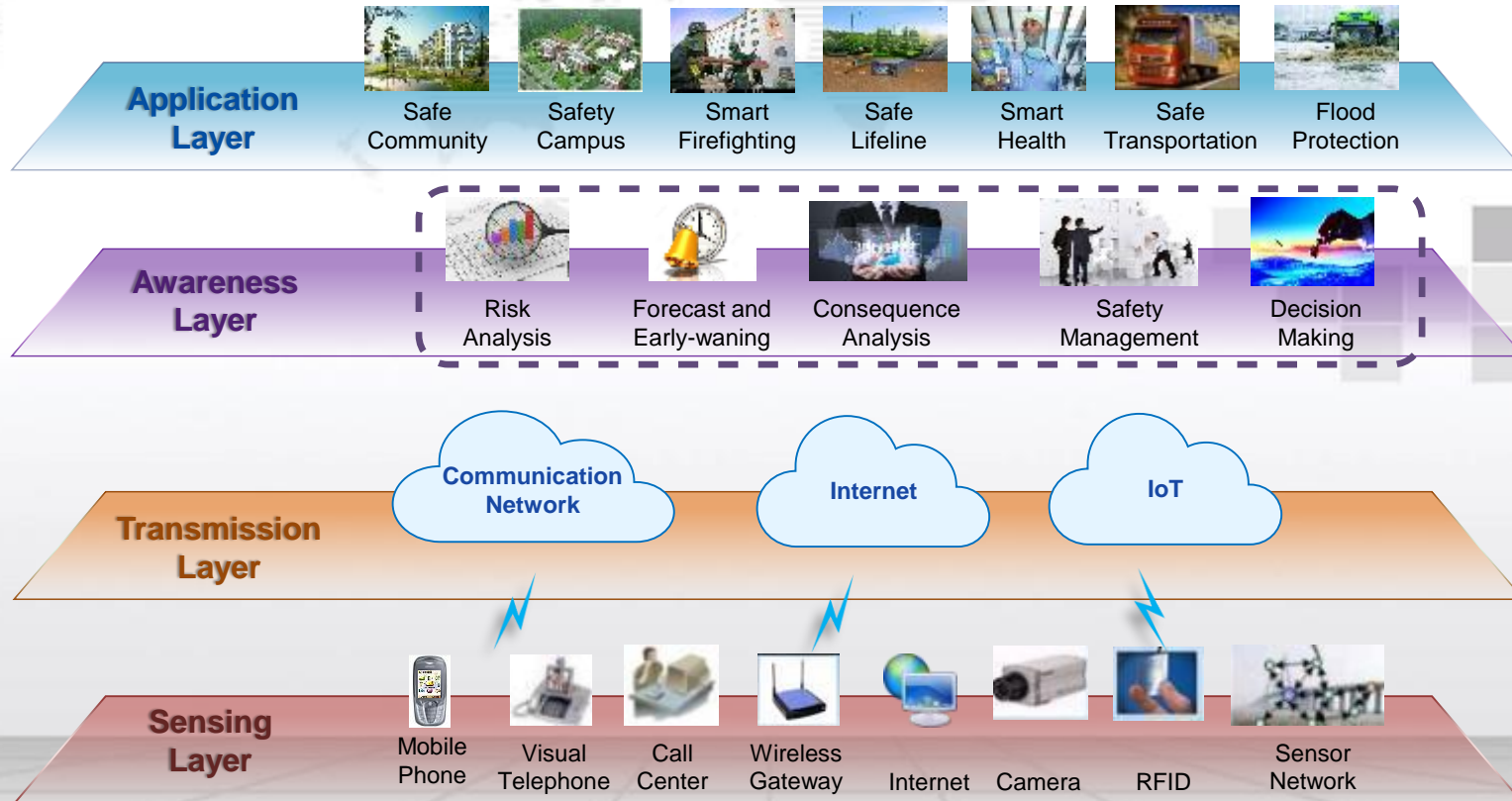
# Safety Technology Provider for Disaster Response & Rescue - Command & Coordination



# Safety Operation System for All Nuclear Plants in China

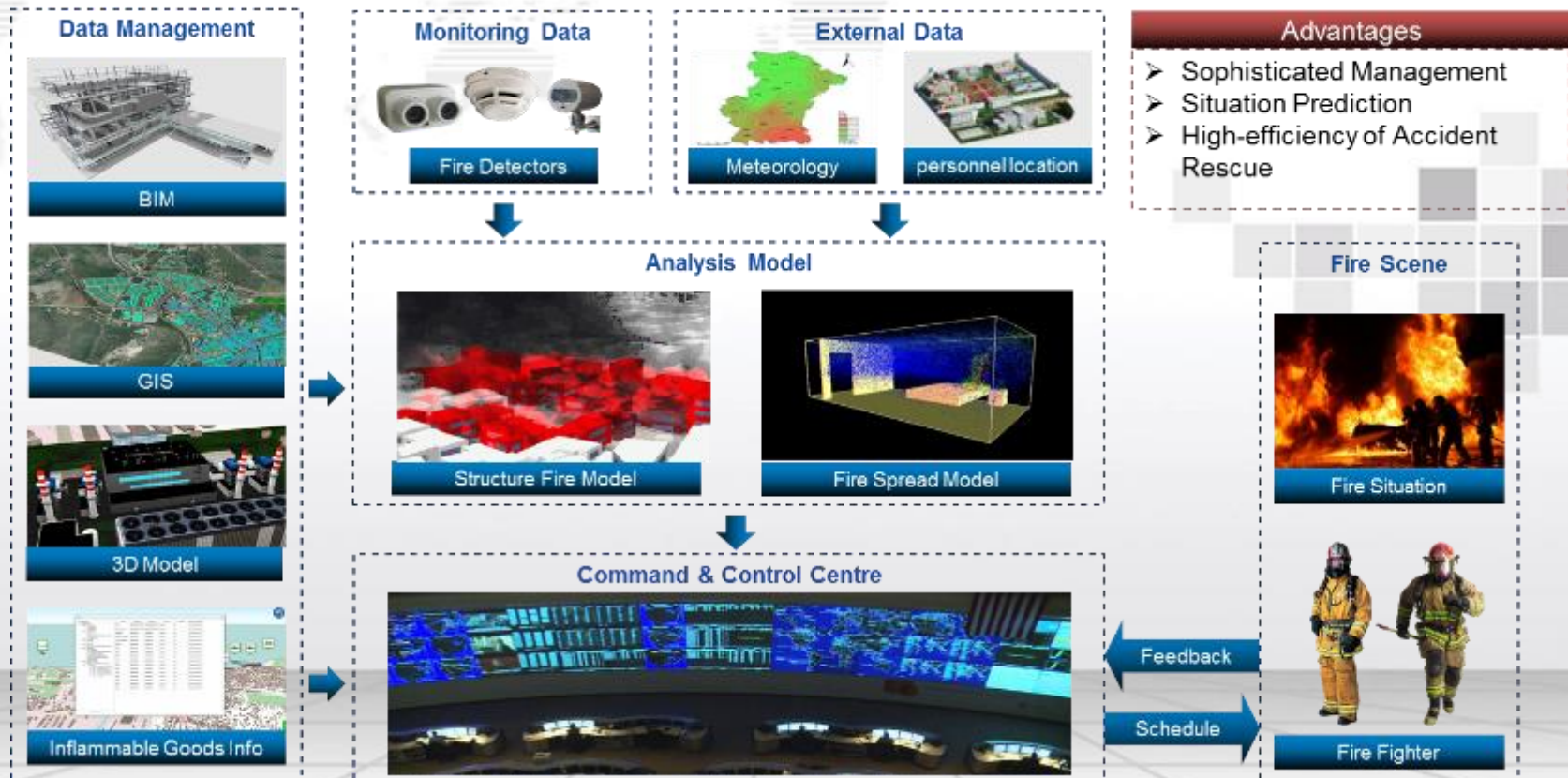


# Smart Safe City





# Smart Firefighting



# Infrastructure Safety – Gas Pipeline, Bridge, Water Pipeline



# Social Security

## Analysis & Decision



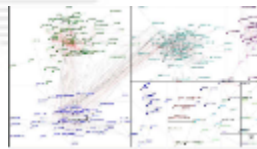
Crime Hotspot



Social Relationship



Terrorist Network



Network  
Relationship



Crowd Gathering  
Detection



Data Center

## Command & Control Centre



## Advantages

- Intelligence Integration
- Intelligent Decision-making Assistance

## Intelligence Sources



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

Surveillance & Monitoring

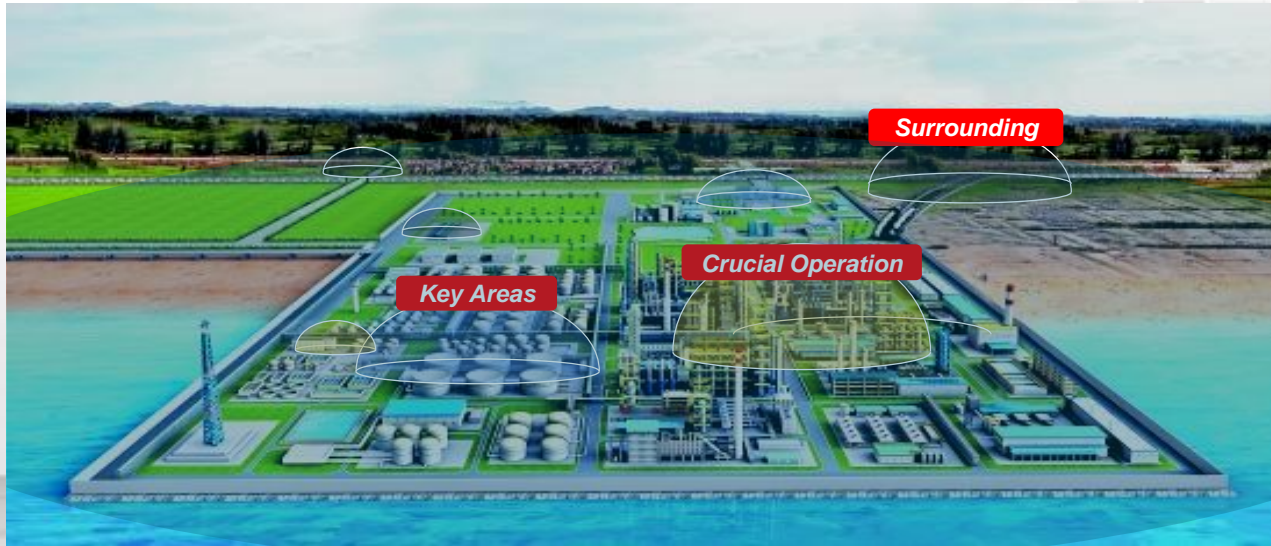
Operation Safety  
Management

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





[illegible]

(b) Internal pressure control system

**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 m<sup>3</sup>      Weight: 20 t

# Liquid Pool Fire Behavior



89 KPa  
Turbulent



68 KPa  
More laminar



35 KPa  
Blue base



32 KPa  
Swirl

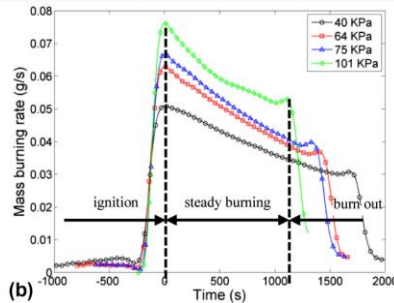
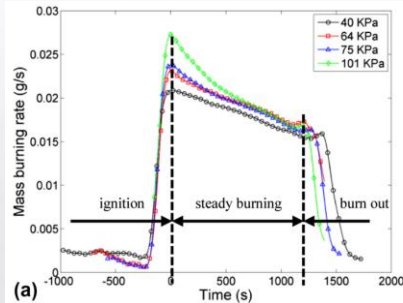


32 KPa  
Extinguish

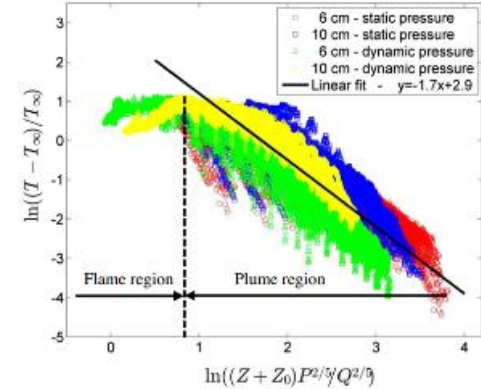
Turbulent to laminar

Flame base turned blue

Polyhedral and swirled flame



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

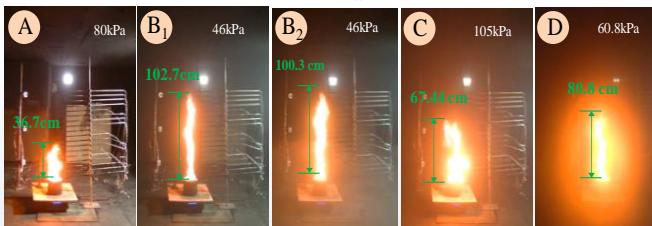
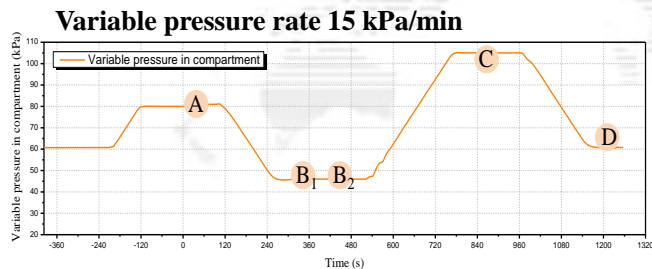


$$\frac{T_p - T_\infty}{T_\infty} = C_T \left( \frac{1 - X_r}{c_p T_\infty \sqrt{g}} \right)^{2/3} \left( (Z + Z_0) \frac{\rho_\infty^{2/5}}{Q^{2/5}} \right)^{-5/3}$$

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

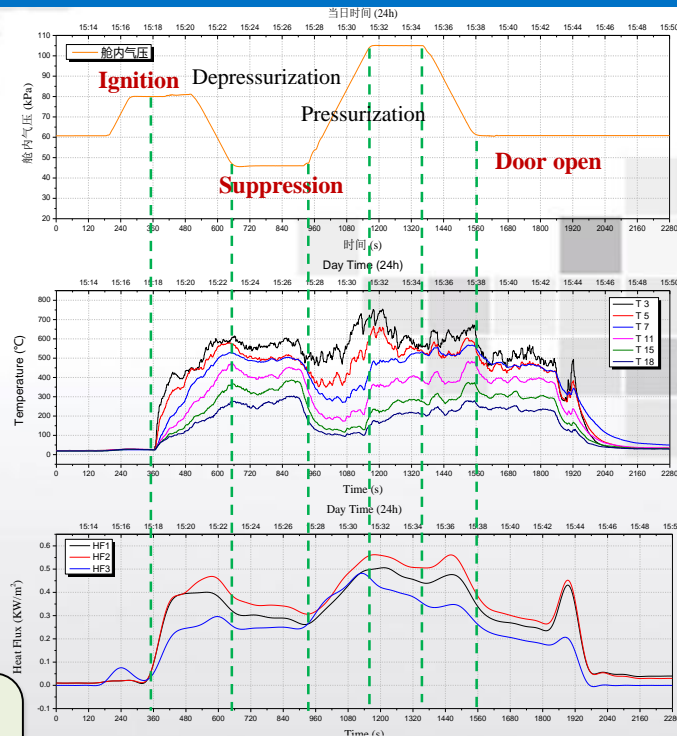
Plume temperature correlated with  
axial height and pressure

# 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.**

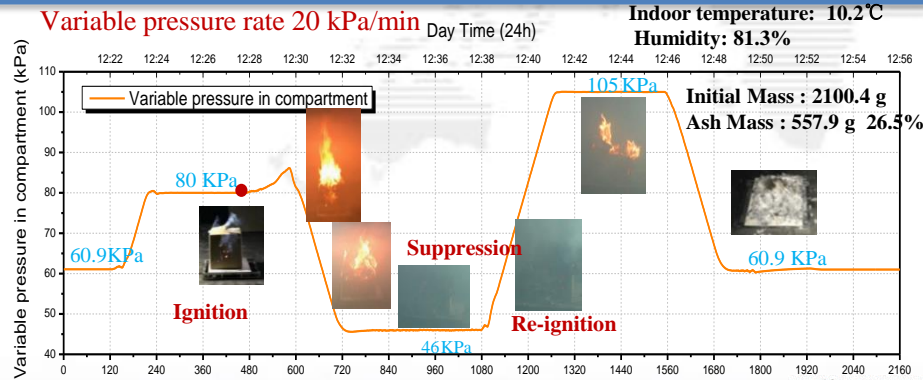


Maximum external temperature 754°C.

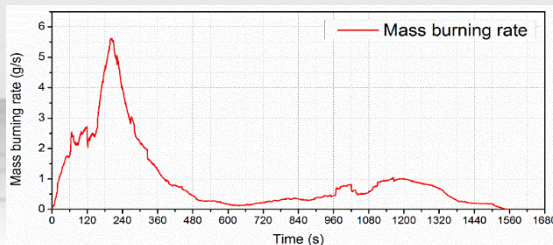
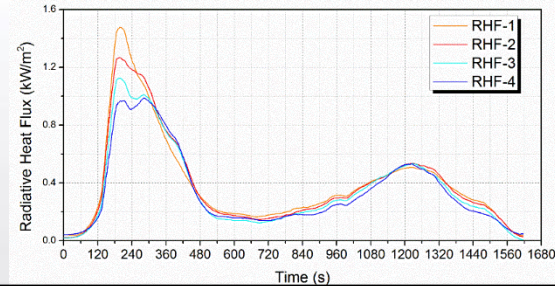
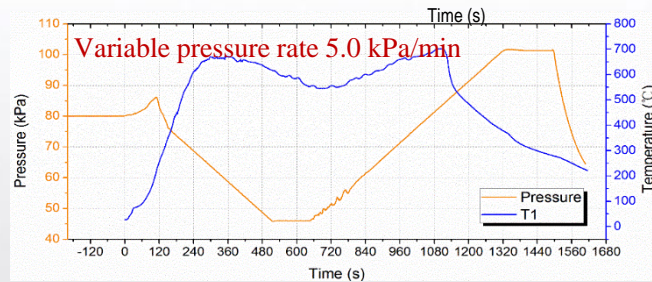
Radiative heat flux identify with pressure.



# Dynamic Pressure Effect on Solid Fire

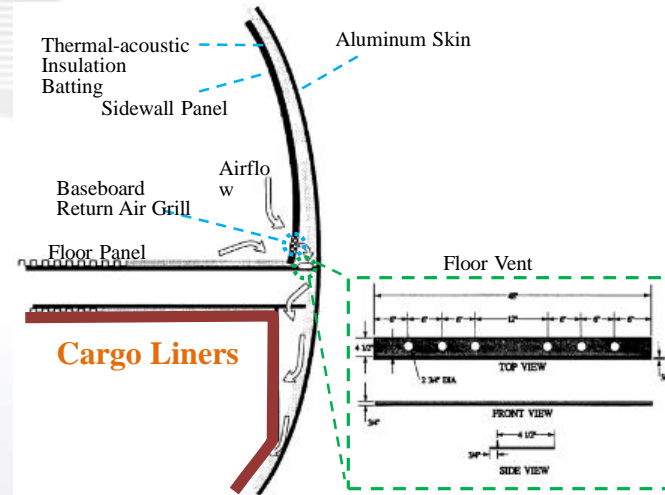
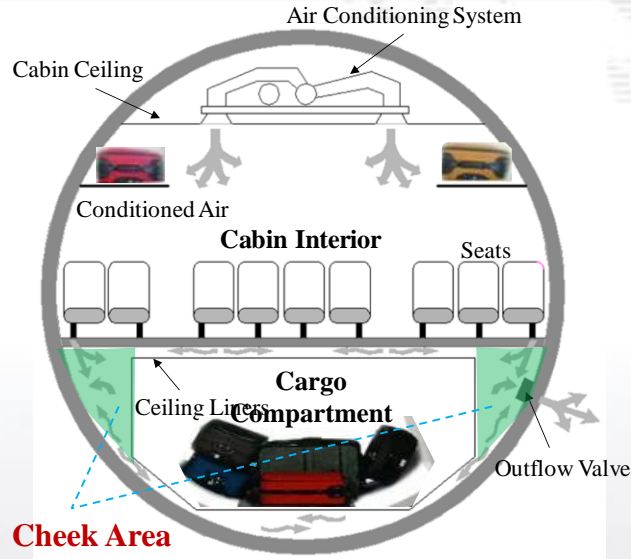


- Depressurization suppress fire, but cannot eliminate smoldering
- **Re-ignition** with increasing air pressure



- ❑ Contribute to insufficiency combustion
- ❑ Increase the flammable gas concentration
- ❑ Additional flashover possibilities

# Vulnerable Area during Cargo Fire



Timothy R. Marker, 1999 (FAA)

- **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

# Flame Morphology and Post-fire Panels

## *Flame Morphology*



76 kPa

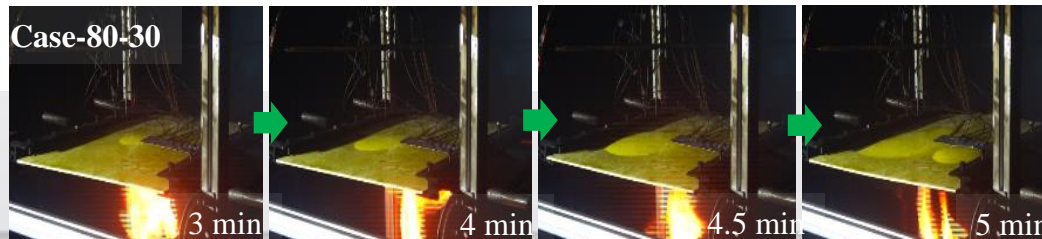


46 kPa

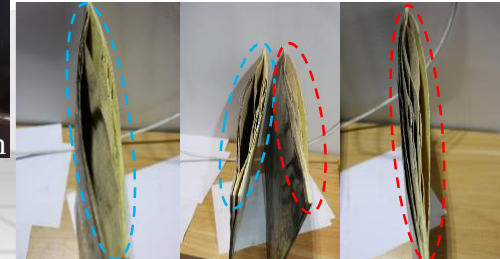


30 kPa

## *Panels Structural Variation under Fire*

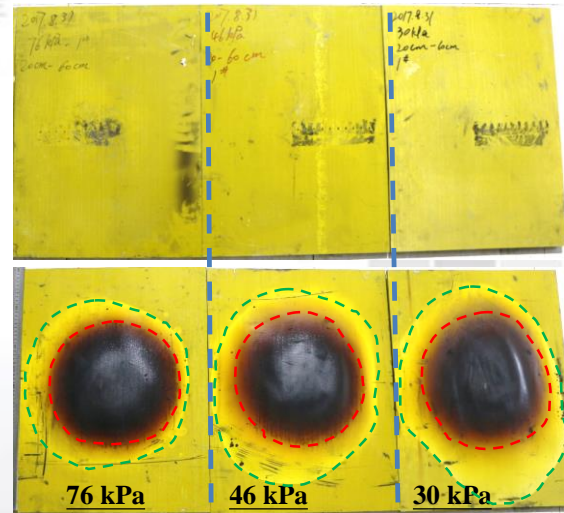
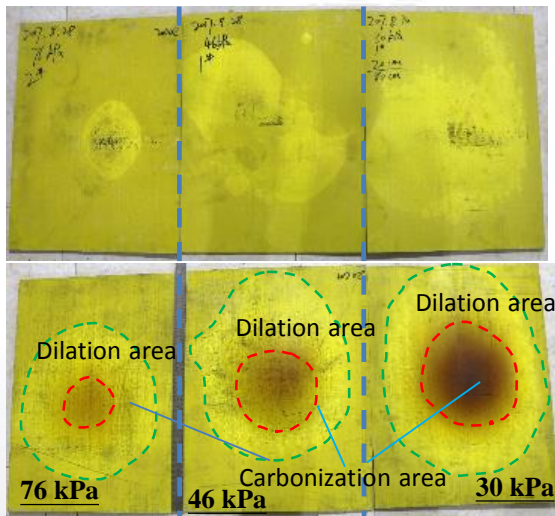


- Dilation and Delamination
- Comprised of fiberglass encased in film bagging





# Post-fire Panel



- Low pressure, wider dilation area and carbonization area
- Low pressure, cargo liners burn through more easily

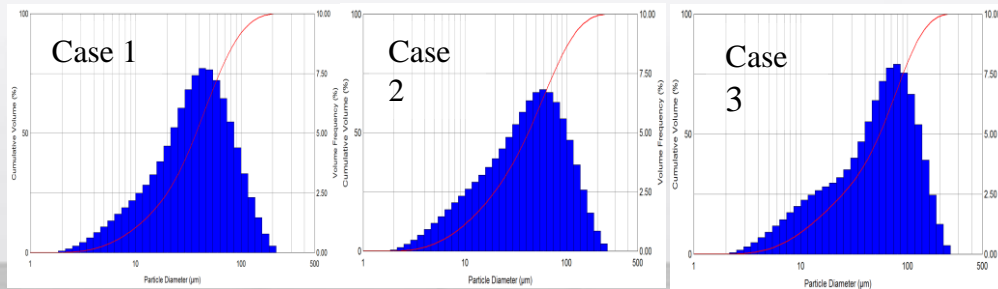
➤ Depressurization could not put out the flammable liquid fire, and increases the potential burn through threat.

# Low Pressure Two-fluid Water Mist

## Water Mist Nozzle



## Particle Size Distribution



$N_2$  0.3 MPa

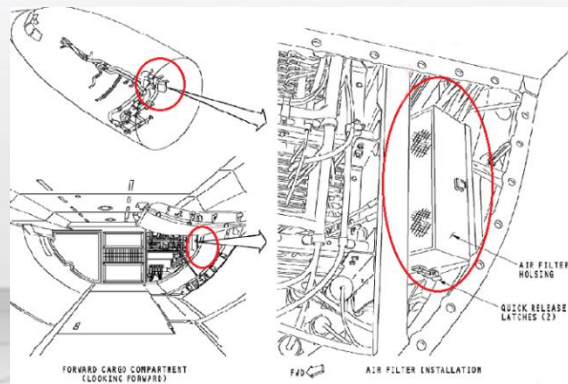
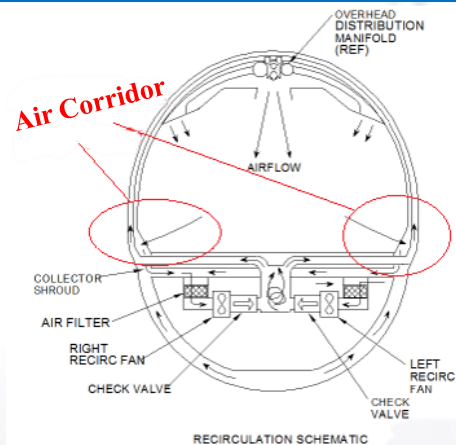
0.4 MPa

0.5 MPa

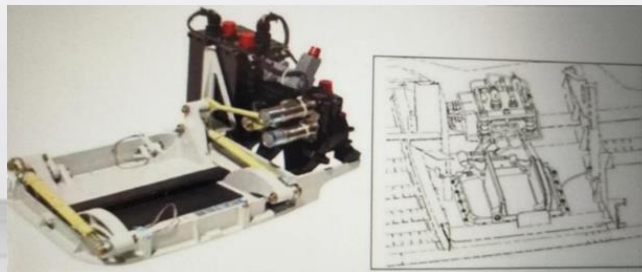
Water; 0.2 MPa, 180 ml/min



# Smoke Permeate into Passenger Cabin

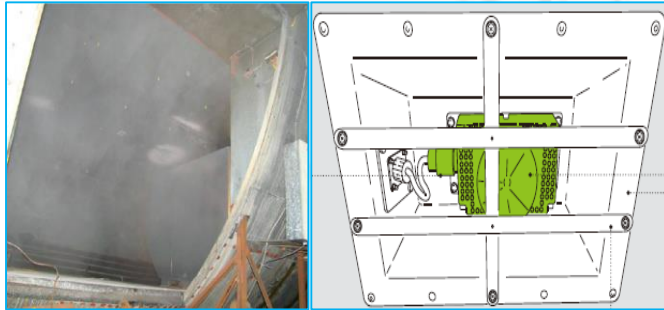


*Air Crash Investigation, Getting Out Alive, S13E11, 2014*

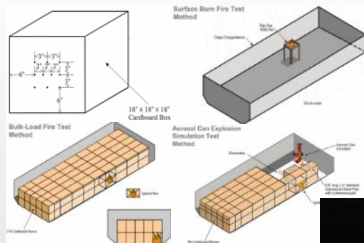




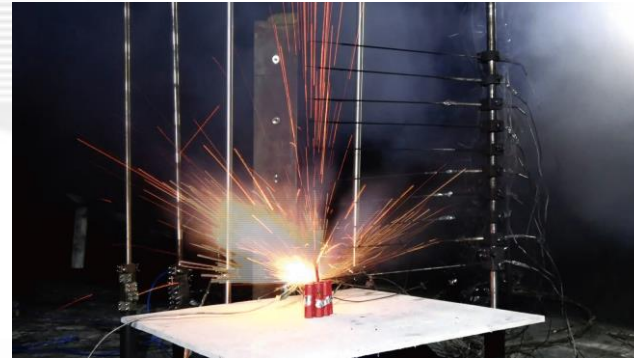
# Next Steps



**Cargo Smoke Detection**



**MPS Fire Test Scenarios**



**Lithium Battery Thermal Runaway**

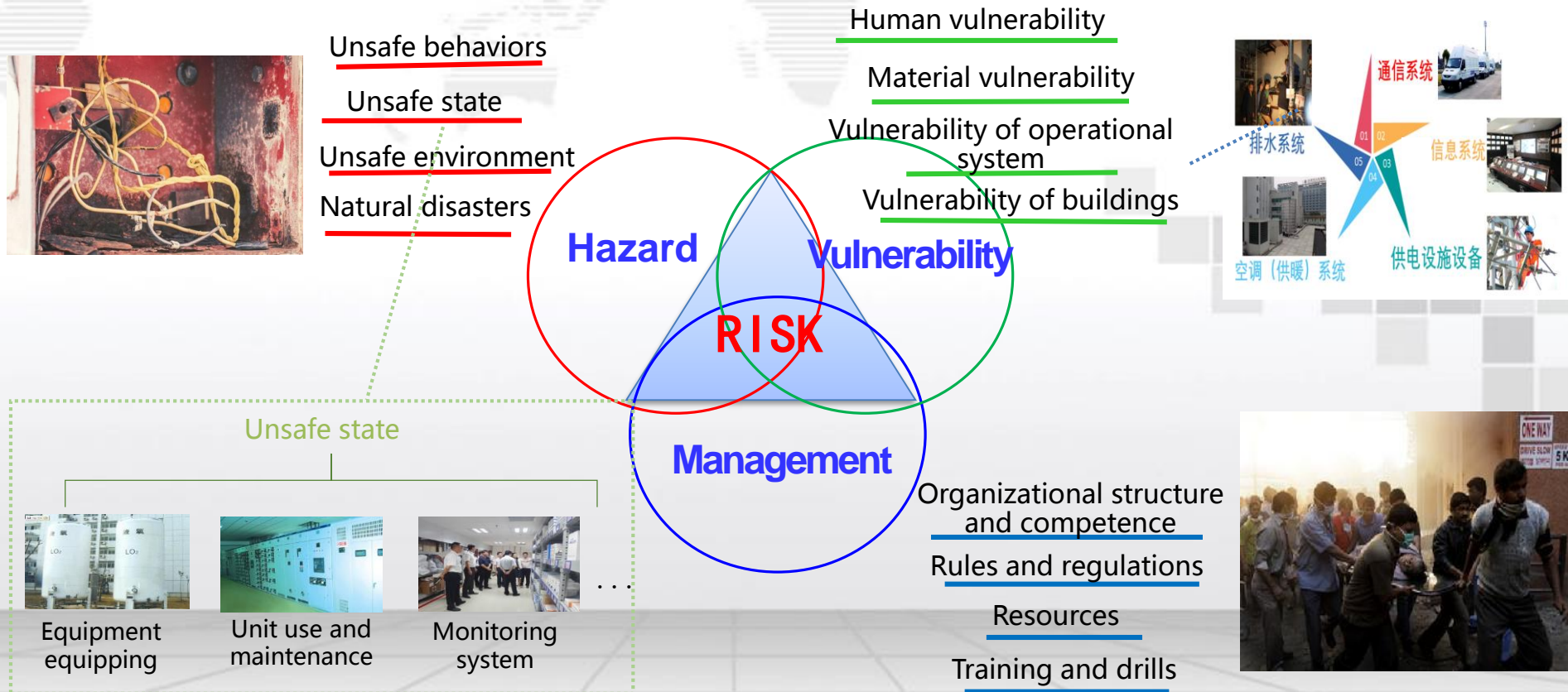


**Halon Replacement: Onboard Water Mist System**

The background of the slide features a faint, stylized world map in the upper left corner. To the right of the map, there is a decorative graphic consisting of a grid of squares in various shades of gray, arranged in a pattern that resembles a stylized 'X' or a cluster of data points. The overall aesthetic is clean and modern.

# Campus Safety

# Background Analysis of Campus Safety





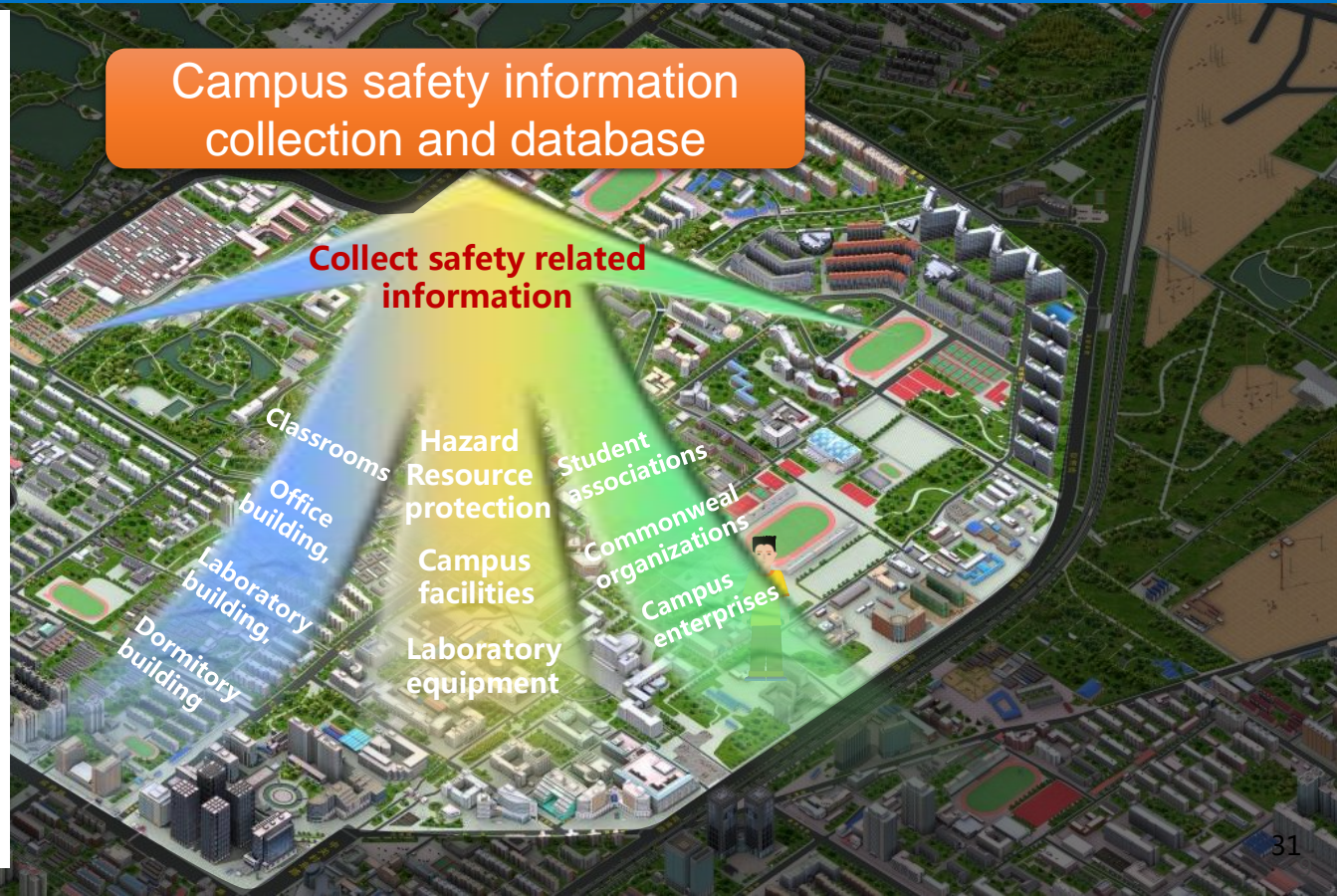
# Campus Safety Information Collection and Database



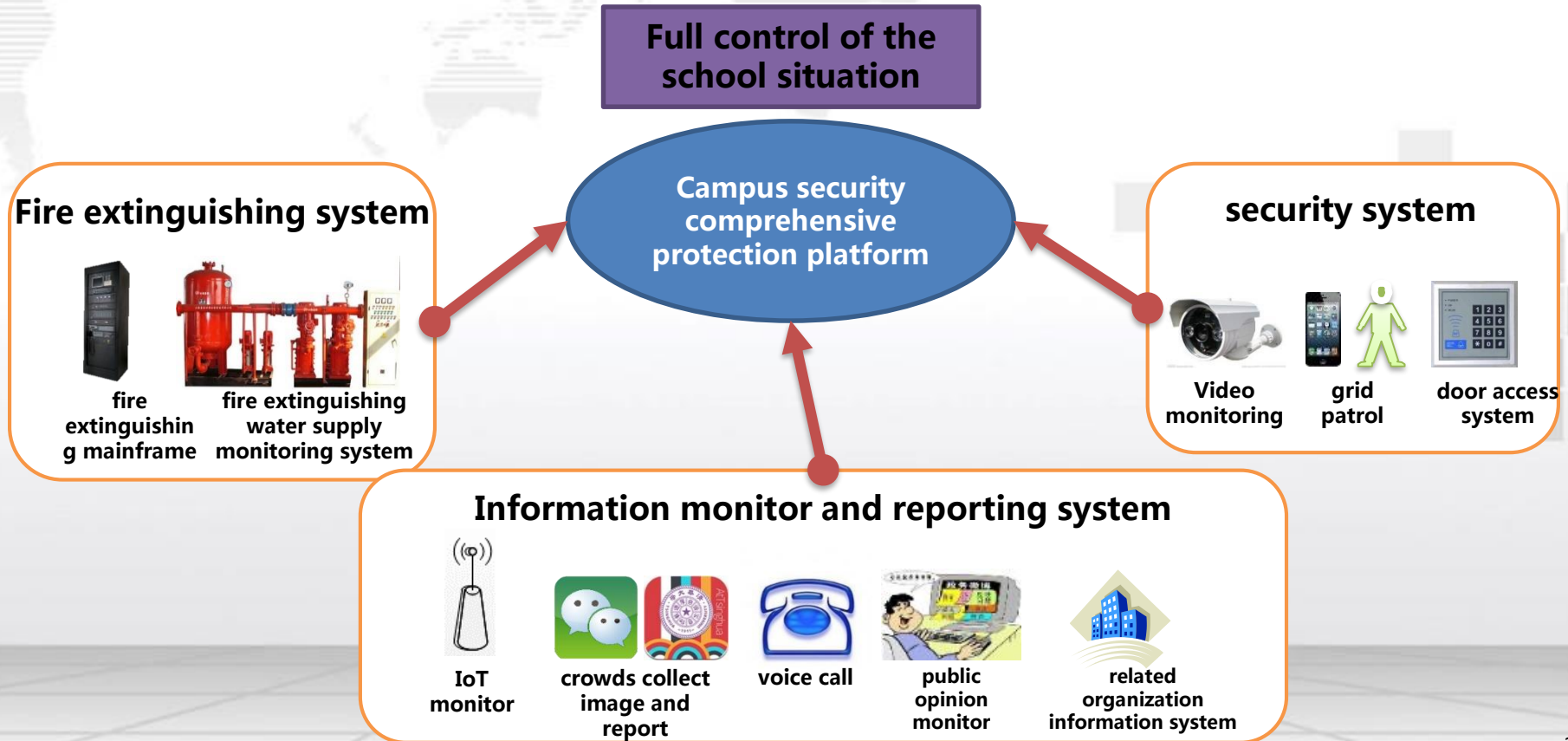


# Campus Safety Information Collection and Database

- ❑ 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



# System Usage

**school  
leadership**



**Intuitive understanding of campus operation**  
**Quickly respond campus emergency decision**

**student  
and staff**



**Enhanced public security  
awareness**  
**Easy access to security  
information**



**Public safety knowledge training**  
**Conveniently report security information**

**safety grid  
manager**



**routine  
patrol**



**monitoring  
warning**



**emergency  
response  
coordination**



**resource  
management**



# System Framework

## Campus BIM、GIS modeling



building  
information  
modelling



function  
information  
modelling



geographic  
information  
modelling

## risk identification and analysis

identification of campus security  
risk incident

complete risk index system  
construction

## Dynamic risk information collection



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



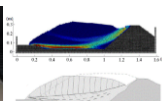
hazard  
factor  
detection



human  
behaviour  
monitor



logistic  
equipment  
monitor



environment  
elements  
monitor

## 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

## Campus risk prevention, control and emergency coordination platform



campus security platform



front platform



dynamic  
risk  
monitoring



situation  
of incident  
analyzed



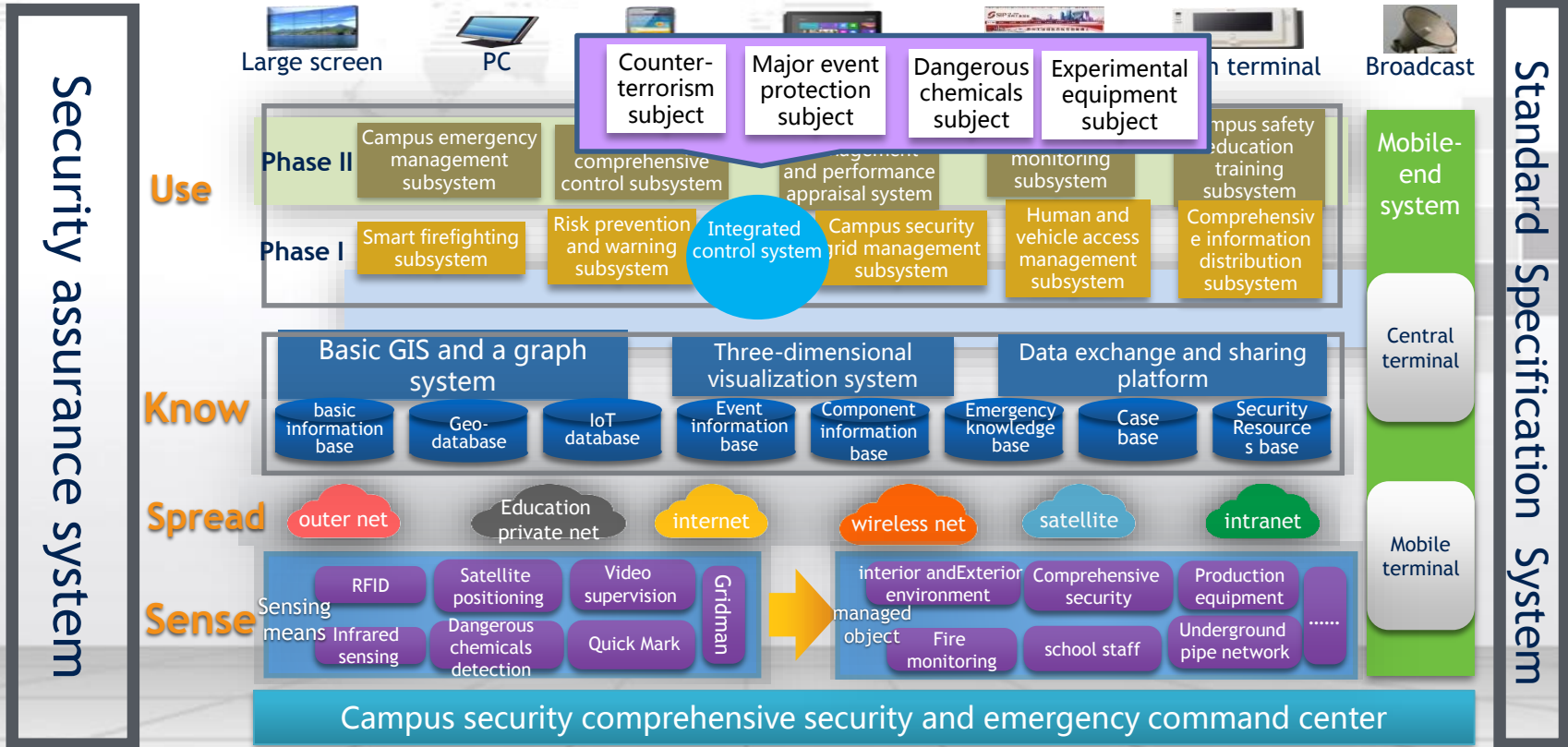
emergency  
coordination  
on scheme

## emergency coordination

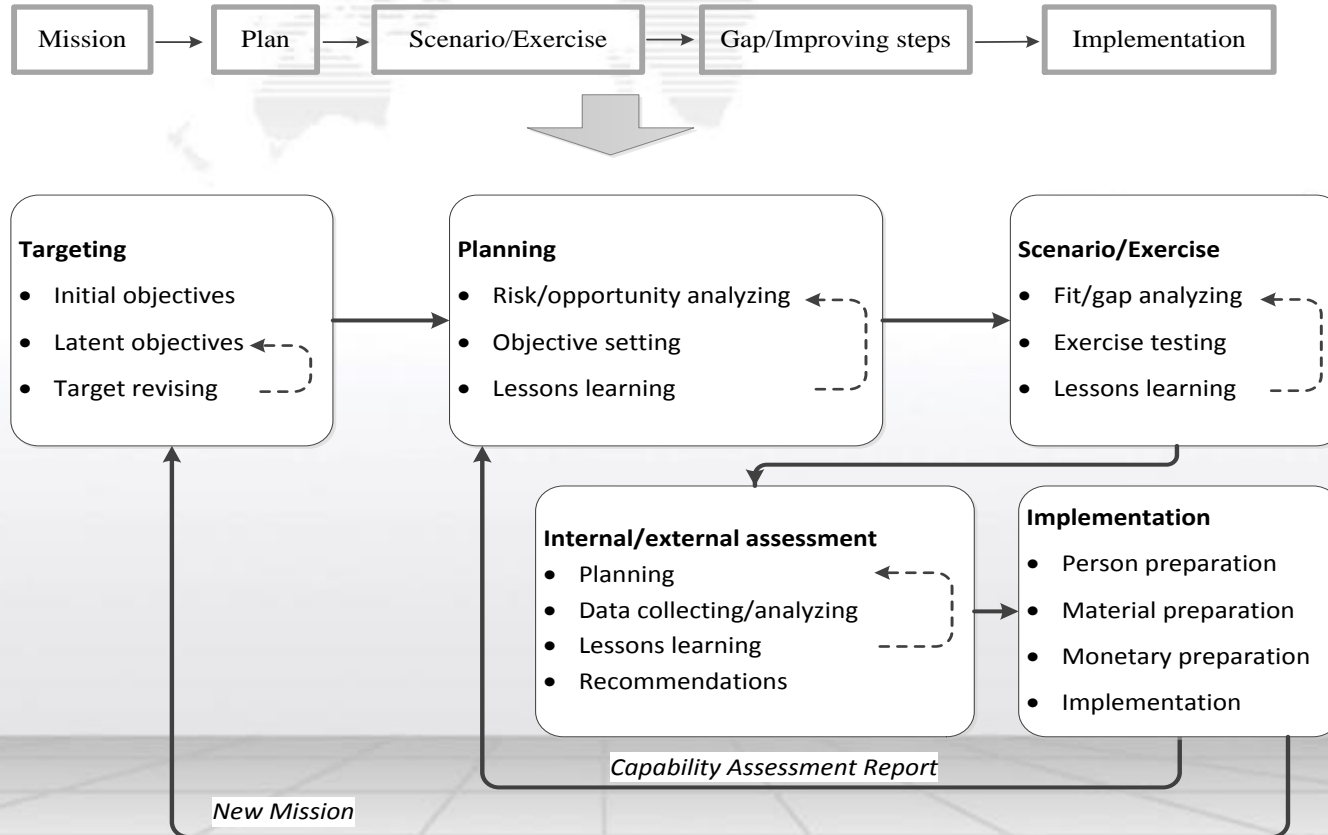
situation comprehend  
emergency coordination  
and command

resource management and  
scheduling

# System Framework

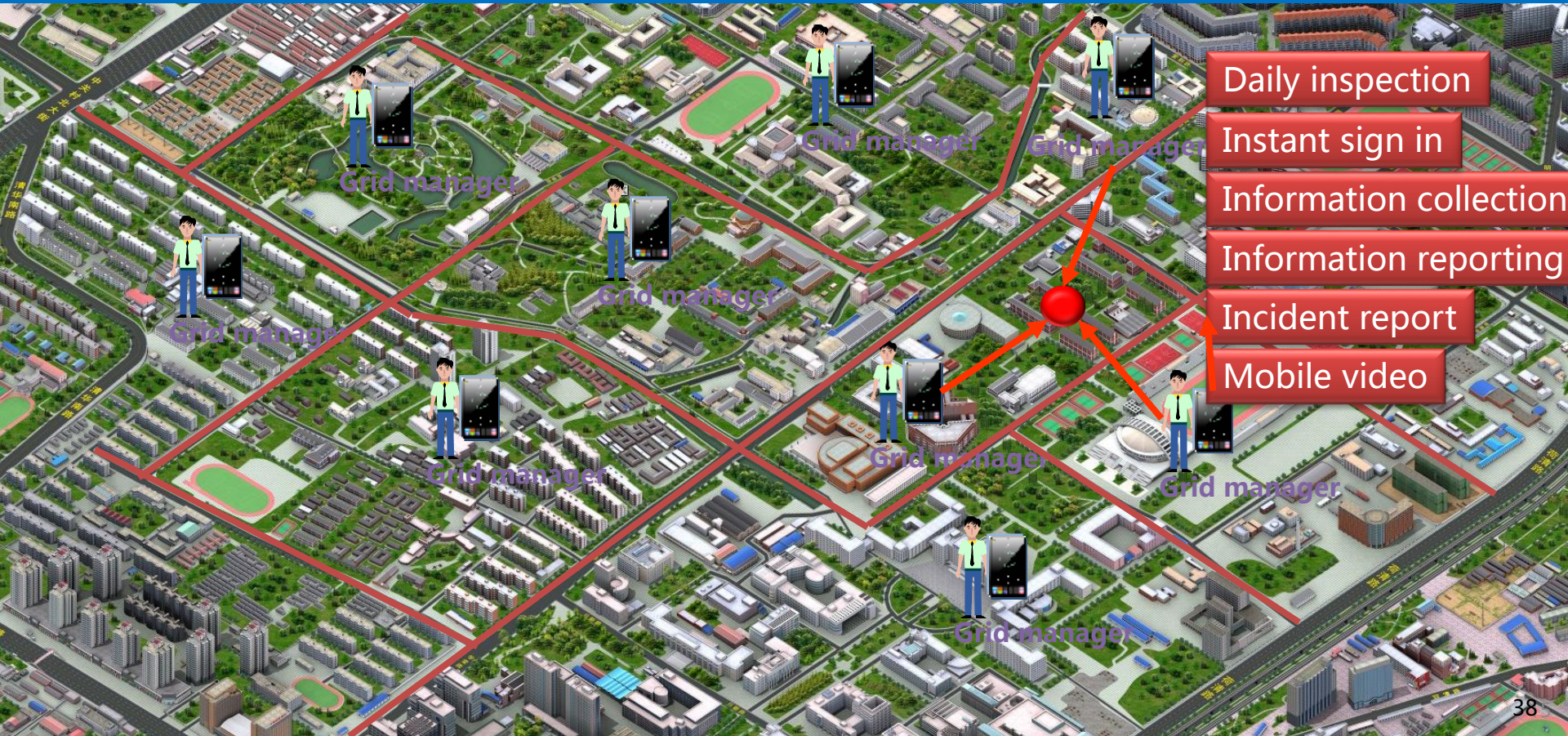


# Scenario Development





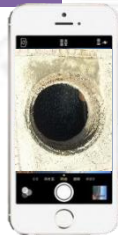
# Daily Supervision





# Daily Supervision and Early Warning

School teachers & students photo upload



\*\*road  
manhole  
cover lost

Photo  
upload



Report

Campus Security  
Comprehensive Protection  
Platform



Repair



On-campus speed monitoring



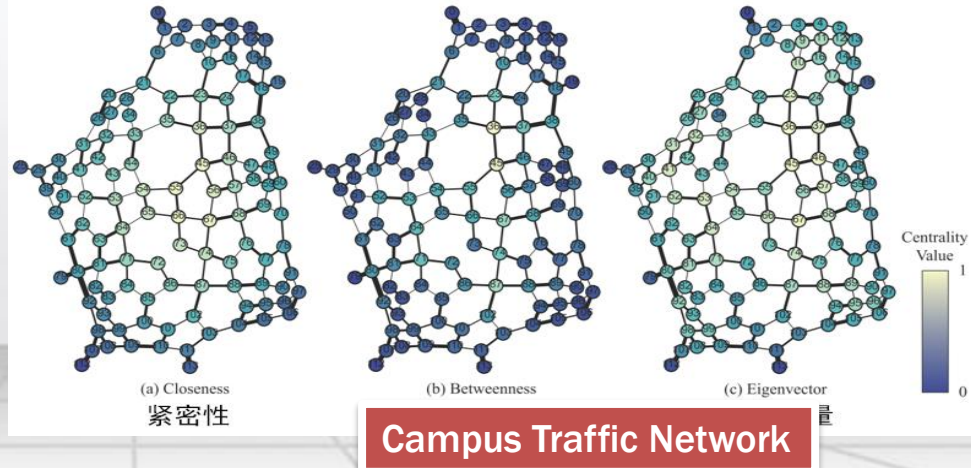
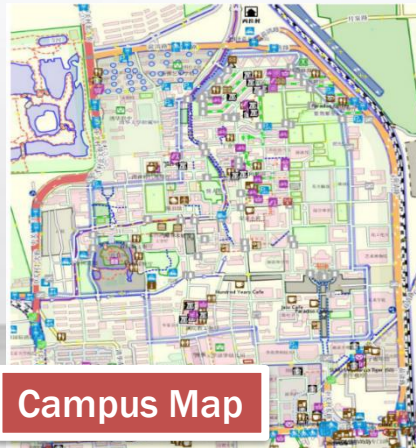
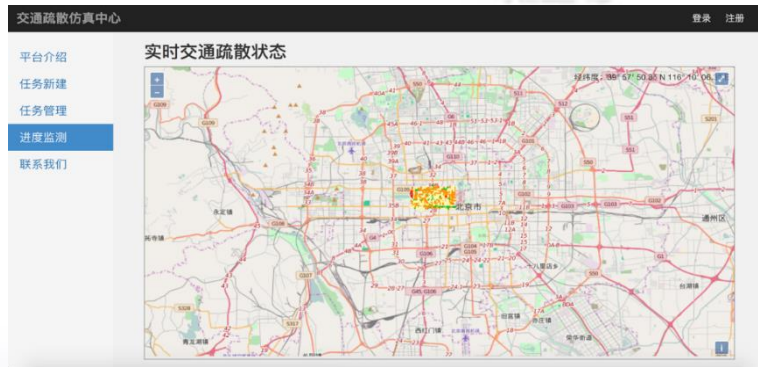
License plate recognition

Leave



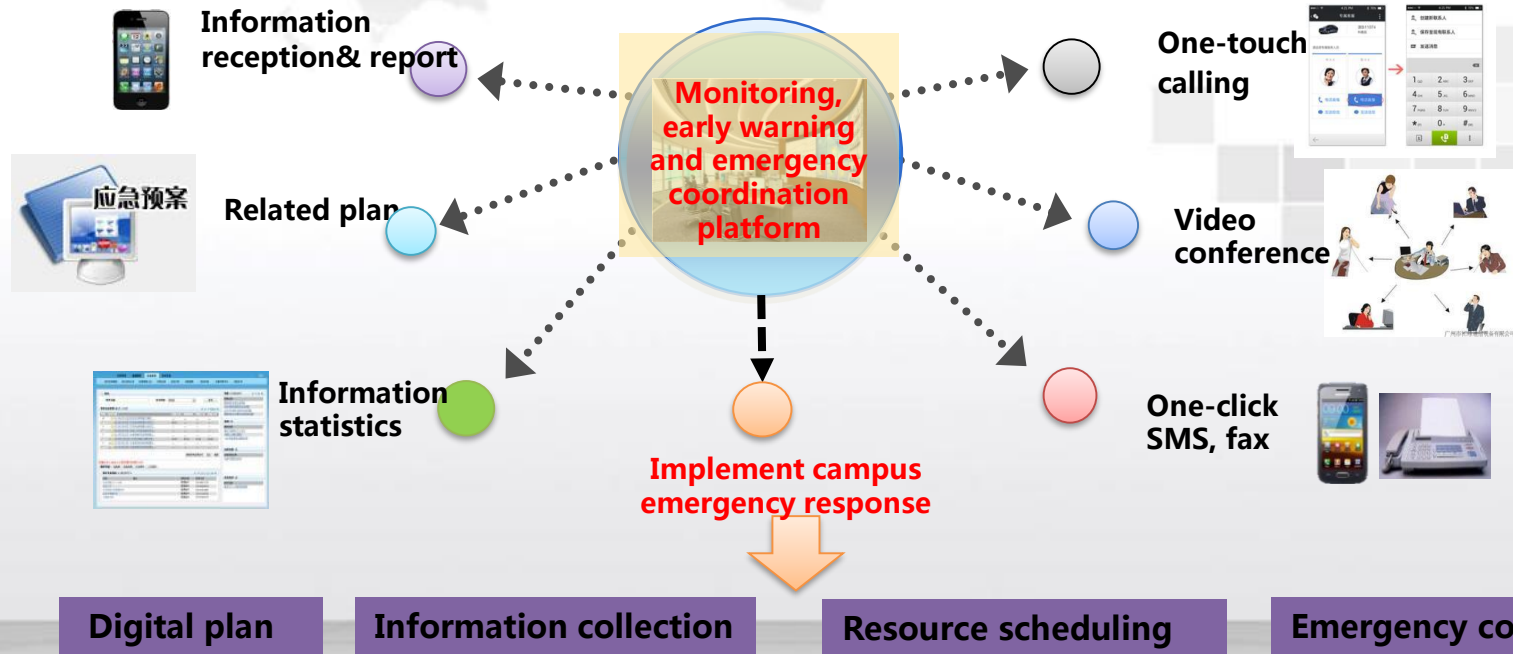
License plate recognition

# Important Event Management and Early Warning



# Emergency Management

## Comprehensive management



# Emergency Management

All stakeholders involved in emergency prevention and closed-loop information





# Campus Safety Information Client

## Cellphone APP



## Leadership exclusive page



## Info portal





**THANK YOU**