UN GEONOW 2024
首届联合国地信周

Emergency Spatiotemporal Knowledge Ecology Framework and Think Tank Research Suggestions

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Climate Change and Disaster Risk Reduction Forum

01

Emergency Spatiotemporal Information

Goals, Tasks, Technical Framework and Applications

Conception: Emergency Spatiotemporal Information

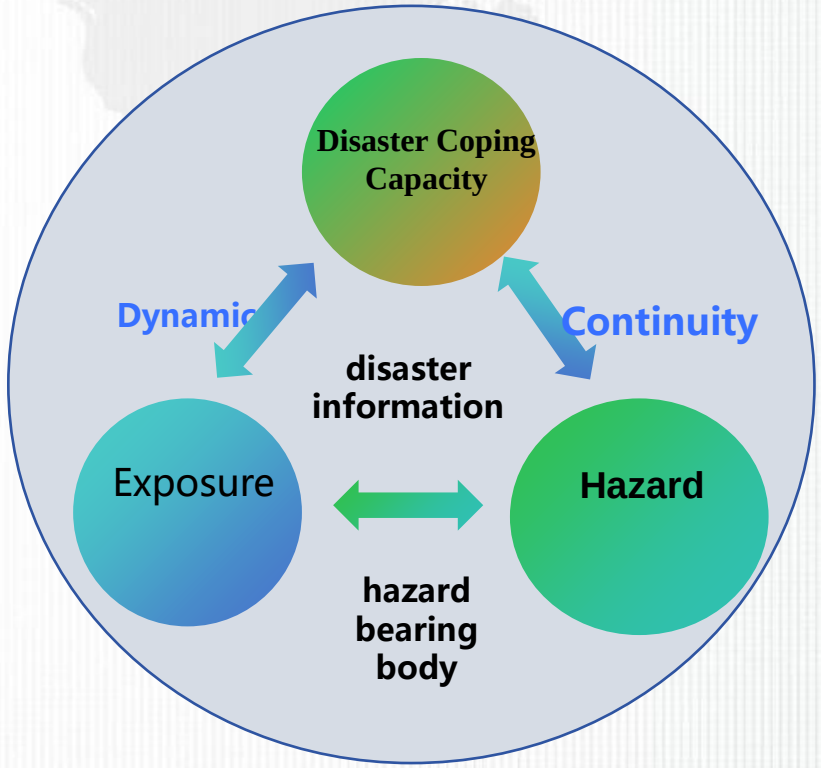
Emergency spatiotemporal information: Based on disaster events, carriers, and disaster reduction capabilities. Disaster events include **the start time, duration, and evolution process of the disaster**, carrier information includes (information such as the time, spatial scale, state, and abnormal changes in state of the carrier)

Hazard : **Occurrence and Development ,including start time, duration, evolution process, etc.**

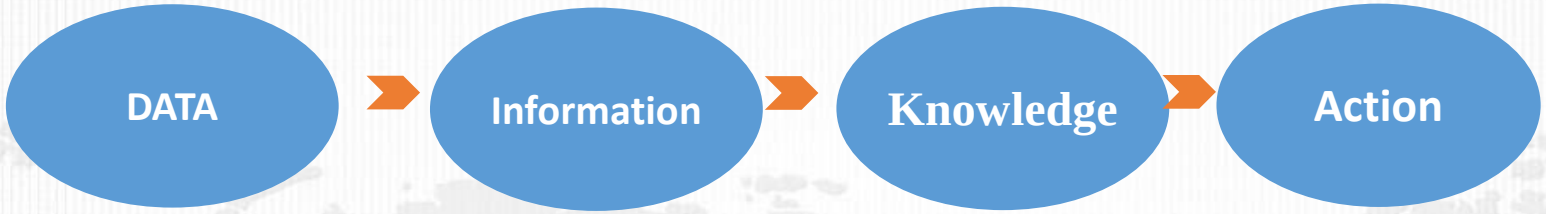
Disaster-formative environment : **Information on terrain, landforms, vegetation, personnel, economic distribution, etc.**

Exposure : **Information on the spatiotemporal, structural characteristics, state, and abnormal changes in the state of the carrier itself.**

Disaster Coping Capacity : **Information on the spatial distribution and attribute status of human and material resources for emergency rescue.**



Development: Emergency Spatiotemporal Information



- **Data —— Risk Perception**

Collect, process and integrate risk data such as infrastructure, environmental monitoring, and traffic conditions in real time to build a comprehensive emergency perception network.

- **Spatiotemporal information —— Anomaly analysis**

By real-time monitoring and analysis of data, potential risks and issues can be quickly identified and responded to, ensuring the security and stability of various systems in society.

- **Spatiotemporal Knowledge —— Analysis and Prediction**

Combining "data" and "mechanism" to reveal the complex evolution laws of disaster events, and achieve dynamic analysis and accurate prediction of risks.

- **Action——Intelligent emergency decision-making**

Deep analysis and rapid response to complex disaster events, optimization of decision-making processes, and improvement of emergency response efficiency.

Target： Emergency Spatiotemporal Information

The six informational elements of emergency event

- Where
- What
- Which
- Who
- When
- How

Spatiotemporal information integration empowers emergency management

Risk Perception

- Risk Assessment and Analysis
- Multi-Hazard Risk Map
- Resource Distribution and Vulnerability
- Disaster Exposure Assessment

Monitoring and Early Warning

- High-timeliness data update, collection and distribution
- Comparative analysis of status change data
- Emergency simulation and scenario deduction

Emergency Response

- Rescue Decision and Dynamic Dispatch
- Disaster situation awareness
- Disaster damage data analysis, assessment and dynamic monitoring
- Emergency communication network construction

Post-disaster Recovery

- Loss assessment and recovery planning
- Post-disaster environmental monitoring
- Post-disaster human migration and resettlement

Framework： Emergency Spatiotemporal Information

Framework of ESI: gather data based on Satellite and monitoring； collect data from industry management , process and analyze based on offline and real-time computes ， to monitoring、 assessment and reponse.

Data

- Satellite data
- National monitoring data
- Emergency specialized data
- Social data

Industry management

- Construction Bureau
- Ecological Construction Bureau
- Urban Management Bureau
- National Health Commission
- ...

Comprehensive

- Meteorological Bureau
- Geological Bureau
- ...

Company

- Gas Company
- Water Supply Company
- ...

Safety supervision | Disaster prediction | Safe production

Data processing

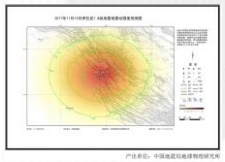
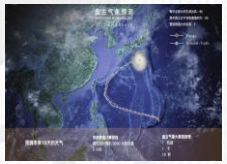
Artificial Intelligence

Safe production
Natural disasters

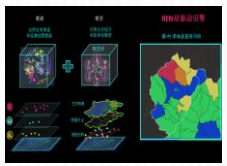
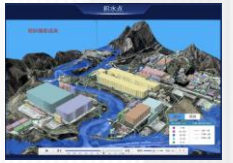
Risk identification
Pattern Discovery
Predictive warning

Compute	Analyze	Service
Offline computing	Image Visual Analysis	Algorithm Services
Real-time computing	Intelligent Voice Interation	Algorithm Warehou

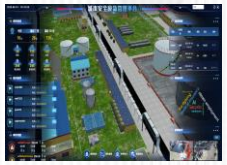

Monitoring Early Warning

Disaster Prediction

Risk Assessment

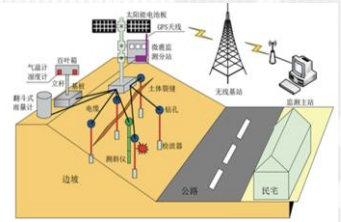



Emergency Response

Practical Cases：Earthquake Precursory Anomaly Monitoring

Monitoring target： Monitoring and measurement of earthquake precursor anomalies and seismic activity before and after the earthquake

➢ Process

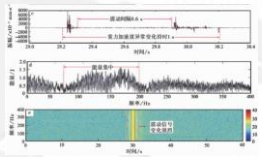


Seismic Monitoring Stations

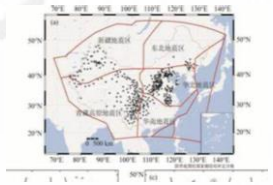
Data transfer

Data Center

Analytical processing

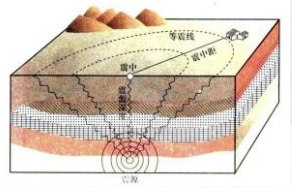


Seismic signal processing



Earthquake Recognition Algorithm

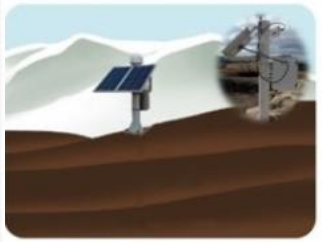
Earthquake location



Seismograph

Earthquake Early Warning

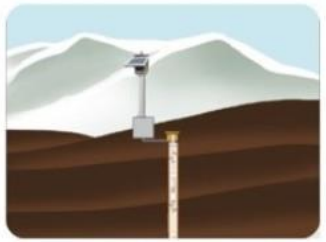
➢ Contents 监测内容



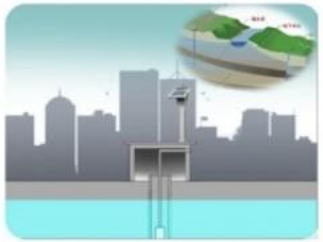
GNSS displacement

Rainfall

Surface displacement



Dislocation displacement



Ground water level

Soil moisture gradient

Practical Cases: Active fault detection

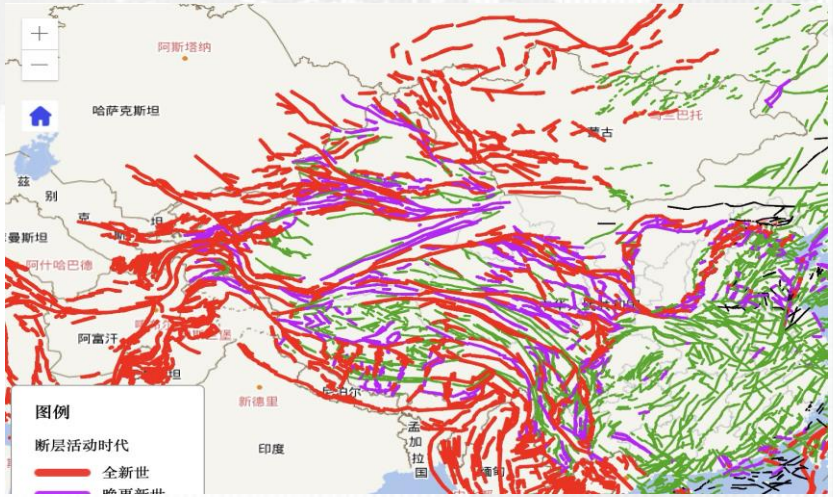
Determine the location and attitude of active faults, and obtain parameters such as the nature, magnitude, age, and slip rate of their late Quaternary activity, as well as the recurrence interval of large earthquakes.

➢ Detection Content:

- ☐ Fault Location: Determine the geographic location and strike of the fault
- ☐ Fault Activity: Assessing Fault History and Potential for Future Movement
- ☐ Fault Structures: Fault Geometry and Structural Properties

➢ Probe Target:

Active faults covers : existence, activity, depth, seismic potential, and displacement.



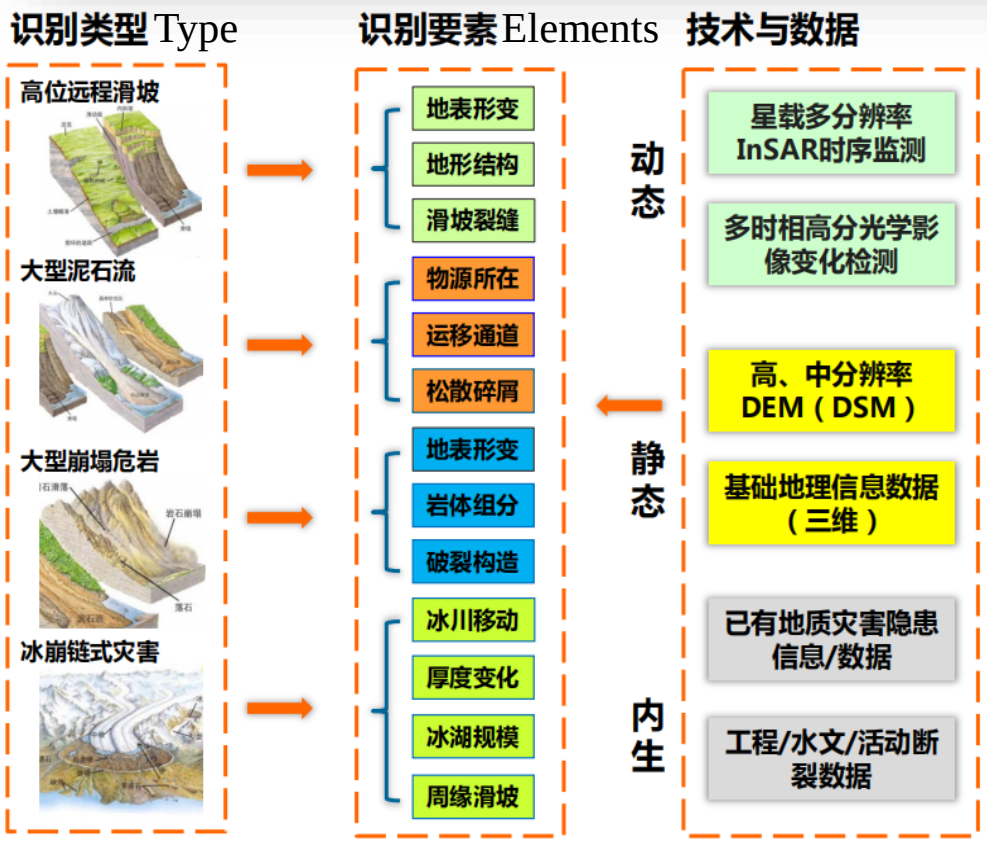
Activity Fault Database
Geology China Earthquake Administration

Data collection → Field investigation → Geophysical exploration → Trench excavation → Sample analysis → Fault activity assessment

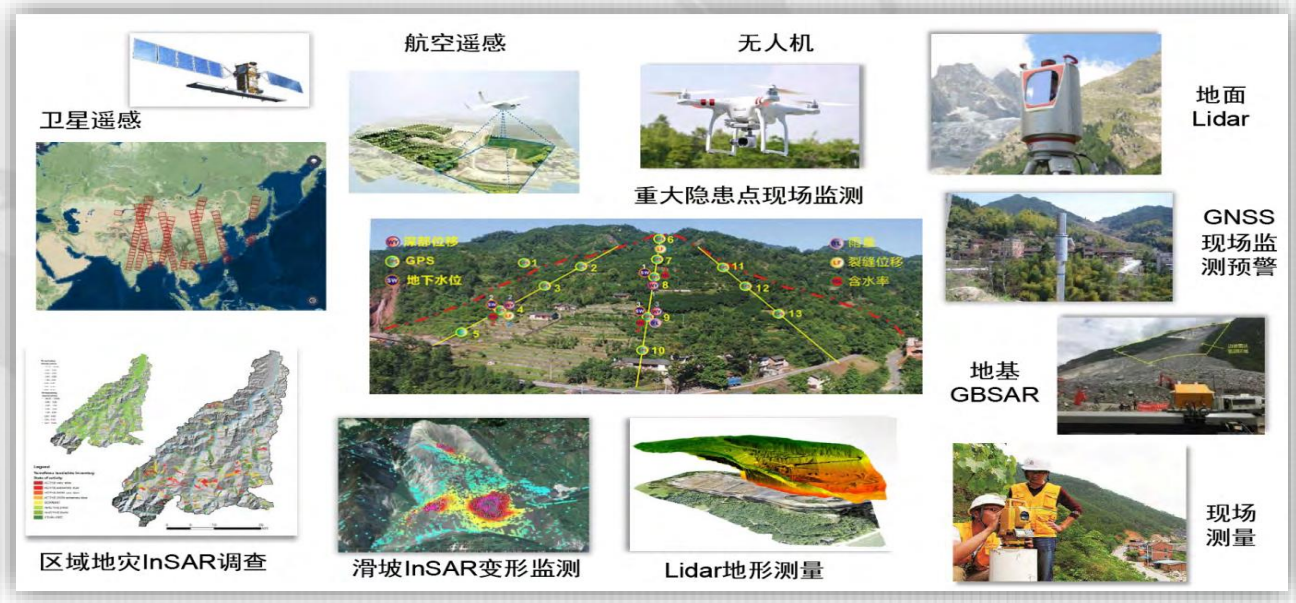
Practical Cases： Geological hazard (landslide) monitoring

Identify:discover where to

Monitor:track its changes

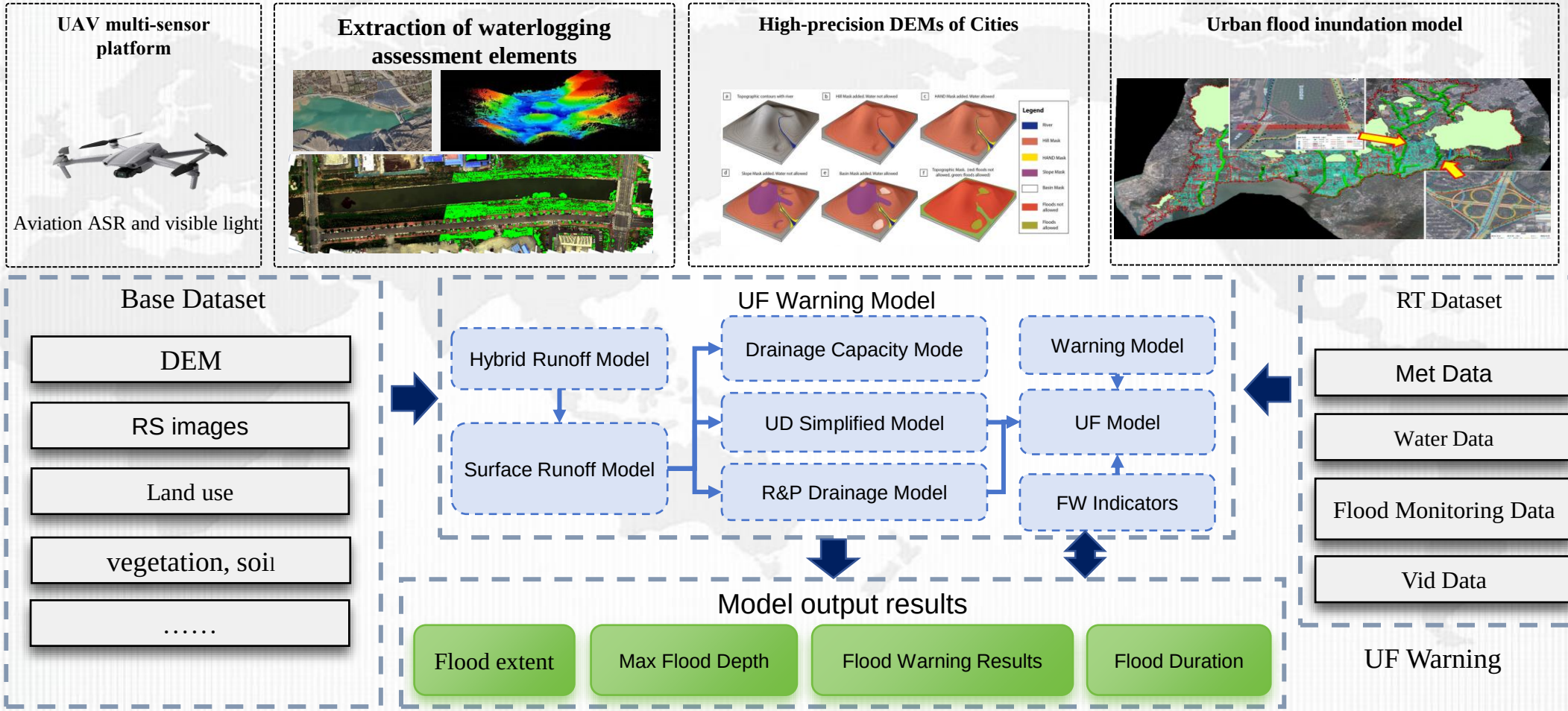


- **Morphology** (signs of damage in progress): High resolution optical remote sensing + Lidar
- **Deformation** (slip size, activity stage and development trend) : InSAR
- **Situation** (deforion status and potential situation) : remote sensing mat+ ground measurement



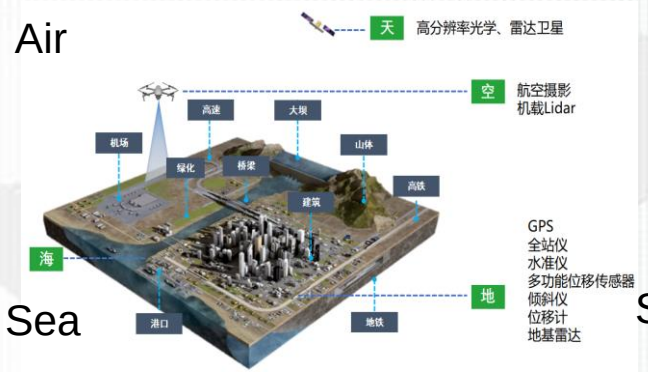
Practical Cases: Flood monitoring

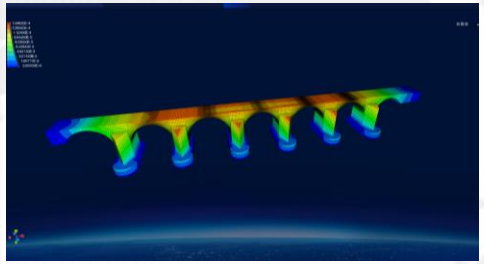
Flood disaster: river flood, waterlogging and mountain flood caused by rainfall, melting snow and ice, etc., and secondary disasters caused by it.

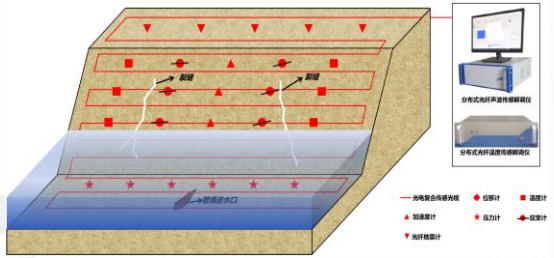


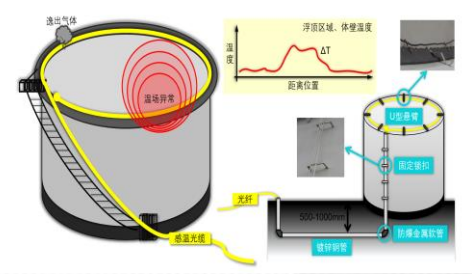
Practical Cases: Urber safety Monitoring and Warning

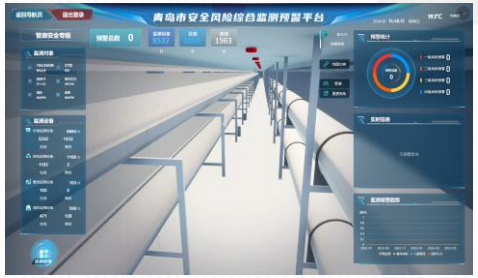
Construct a comprehensive, three-dimensional perception and monitoring early warning system for multiple types of disaster-bearing bodies such as high-rise buildings, tunnels, bridges, dams, subways, industrial parks, etc.

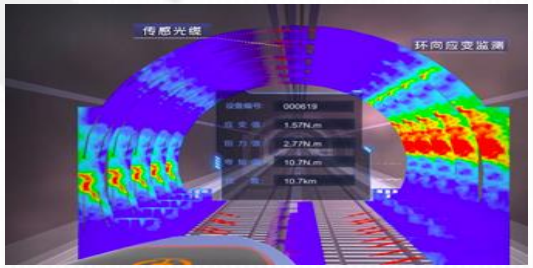












Knowledge Mining: Prediction and Early Warning Models

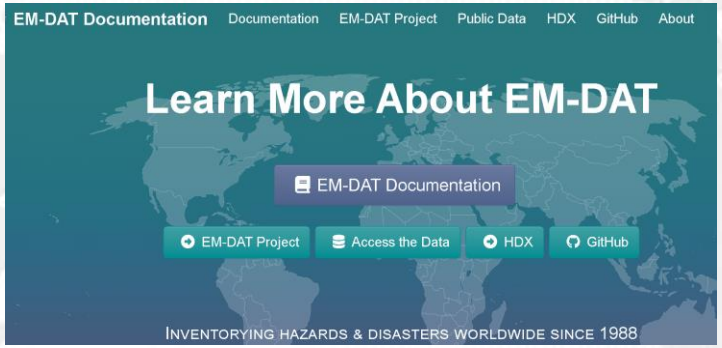
The basic algorithm model for solving the spatiotemporal information analysis needs in the entire emergency process.

Scenario	Model type	Application scenario	Specific models
Disaster prediction and early warning	Deep learning models	Earthquakes, typhoons, floods...disaster prediction	- CNN - LSTM
	GAN	Satellite,meteorological data...Generation and Enhancement	- GAN
Risk assessment and decision support	Mechine learning models	Disaster risk assessment, resource allocation and scheduling	- SVM - XGBoost、LightGBM
	Deep reinforcement learning	Emergency response strategies and Optimize resource allocation	- DQN
Data processing and analysis	NLP	Social media data analysis and public opinion monitoring	- BERT、GPT,etc
	GNN	Data analysis of spatial relationships in urban infrastructure	- GNN
Disaster response and recovery	Deep Learning and Computer Vision	Post-disaster , building damage identification, trapped people	- YOLO、Faster R-CNN - DeepLab、FCN
	Reinforcement learning and simulation	Simulation and optimization of rescue operations	- MARL
Intelligent IoT and sensing	Sensor data analysis	Changes in soil moisture and meteorology	- LSTM、GRU
	Edge Computing & Internet of Things	Real-time data processing, low-latency decision support	- Edge computing models
Data visualization	Data visualization tools	GIS maps, disaster heat maps, decision support interfacesGIS地图、	- Interactive visualization platform

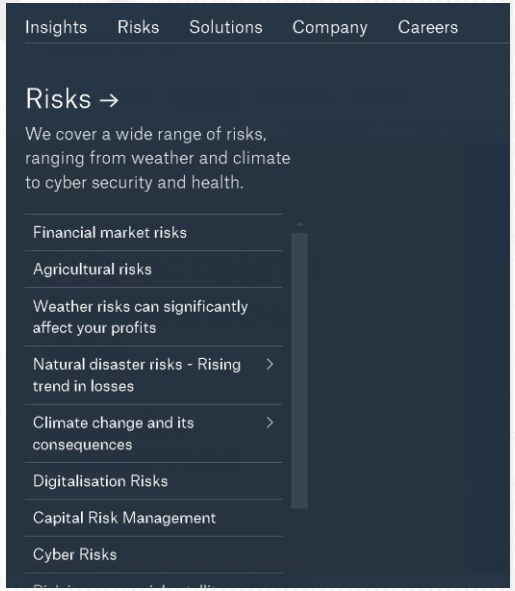
Data Sharing:

It is great importance to the construction of disaster databases， there are 50 disaster databases available online, 30 disaster databases built and maintained by foreign organizations, and 15 disaster databases in China

- **Emergency Events Database（EM-DAT）**
- **NatCat of Munich Re（NatCat）**
- **Sigma of Swiss Re（Sigma）**



Project	EM-DAT	NatCat	Sigma
Time	Since 1900	Since 1980	Since 1970
Coverage	Global	Global	Global
Types	Natural, Technological Disasters	Natural Disasters	Natural, Technological Disasters
Inclusion Criteria	≥ one of three conditions	No	≥ one of seven conditions
Owner	KU Leuven, Belgium	Munich Re Group	Swiss Re Group
Accessibility	Free	Limited	Limited
Website	emdat.be	munichre.com	SWissre.com



Data Sharing：

Earthquake Science Data Sharing System： national earthquake science data sharing center:1, specialized data sharing:10 ; sub-centers, and regional subnetworks:6 have integrated, transformed, and updated 54 databases. The accumulated scientific resources have exceeded 260TB, comprising a total of 103 datasets.

Name	Data
Observation Data	Observational data on earthquakes, geomagnetism, gravity, etc., which account for the largest quantity
Detection Data	Data from artificial earthquakes, electromagnetic surveys, and seismic flow arrays
Survey Data	Data on seismic geology, earthquake disasters and seismic remote sensing, etc
Experimental Data	Data on structural physical experiments, neotectonic age testing, seismic resistance experiments for buildings, and geotechnical earthquake engineering experiments
Thematic Data	Comprehensive data mainly serves important research topics, major engineering projects, and specific regional integrated research objectives

Data Sharing：

Meteorological Observation Platforms and Data Center： A comprehensive meteorological observation system composed of 7 atmospheric background stations, 25 climate observatories, over 70,000 ground-based automatic weather stations, 120 upper-air weather stations, 236 new-generation weather radars, and 7 Fengyun meteorological satellites in orbit; along with 8 national climate observatories and 7 atmospheric background stations

Type	Dataset
Drought	1：中国自动站与CMORPH降水融合逐时降水量网格数据 2：中国地面国际交换站气候资料年值数据 3：中国地面气温日值0.5°×0.5°格点数据 4：中国地面气候资料日值数据 5：区域性干旱事件监测产品 6：中国地面国际交换站气候资料月值数据 7：中国地面降水月值0.5°×0.5°格点数据 8：中国地面气温月值0.5°×0.5°格点数据 9：中国气象局陆面数据同化系统实时产品数据 10：中国地面降水日值0.5°×0.5°格点数据
Rainstorm and flood	中国暴雨灾害洪涝、热带气旋灾害、 干旱灾害数据集

Data Sharing：

The Hydrological Intelligence and Forecasting Center, under the Information Center of the Ministry of Water Resources： The number of national flood reporting stations has decreased from 102,000 in 2017 , with 2,290 new hydrological (water level) stations and 2,866 new rainfall stations established. Developed and completed business systems such as the "Flood Control and Drought Relief Hydrological and Meteorological Comprehensive Business System", "China Flood Forecasting System", "National Hydrological and Drought Business System", "Rainwater Information Handheld Query System", "Water Situation Warning Collection and Release System", etc

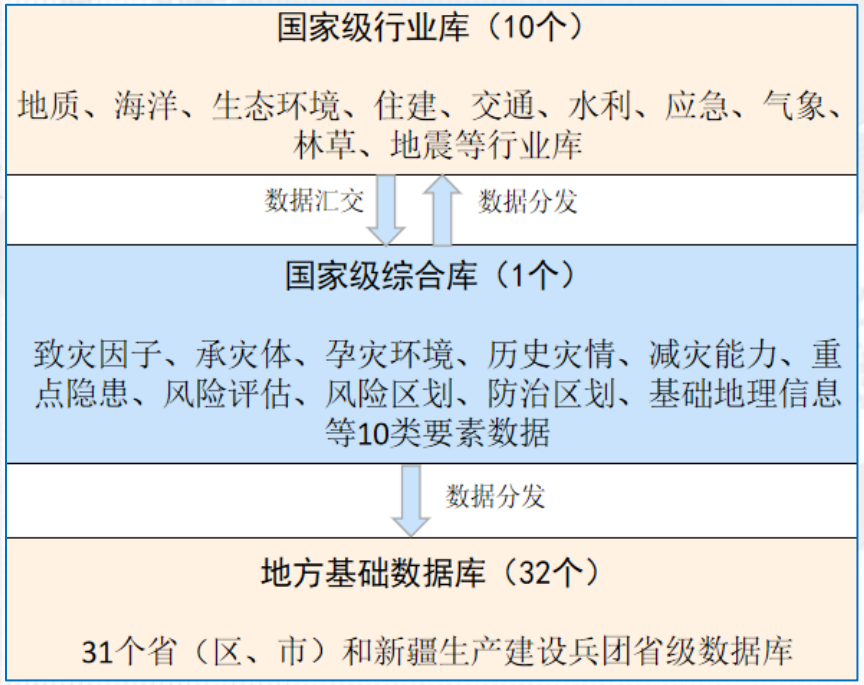
The Information Center of the Ministry of Water Resources （xxzx.mwr.gov.cn）

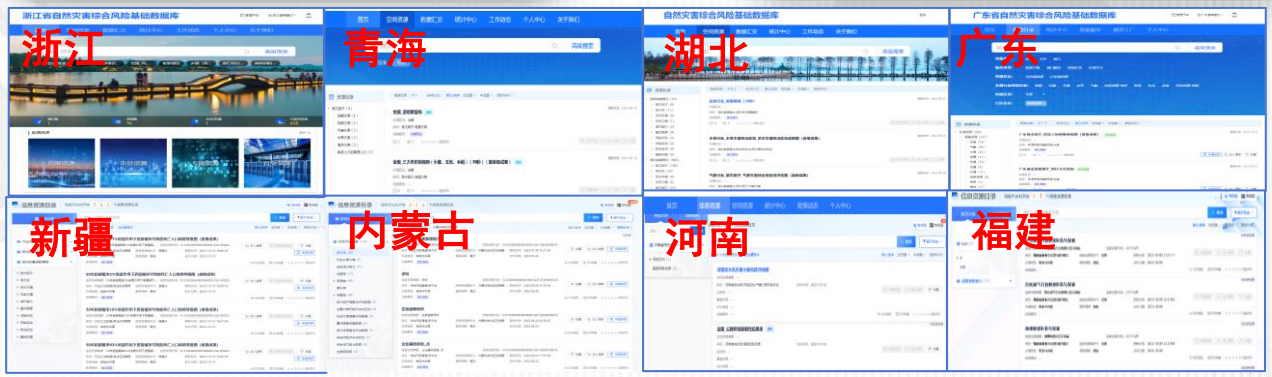
National Water and Rain Information Monitoring and Early Warning Platform （xxfb.mwr.cn）

National Water Situation Early Warning Public Service System （hfc.mwr.cn）

Data Sharing：

Have formed a unified technical standard, classified and graded management, vertical and horizontal connectivity, co construction, sharing, and shared data sharing service platform, 1.7 billion pieces of various risk data.





Climate Change and Disaster Risk Reduction Forum

02

Opportunities and Challenges

Opportunities：3S，Large Language Model (LLM), Digital Twin, Intelligent Robot；Problem and Challenges

Opportunity 1: Devlopment of Equipment and Technology

• GNSS

- Beidou navigation system
- GPS
- GLONASS
- Galileo

•Surveying and mapping

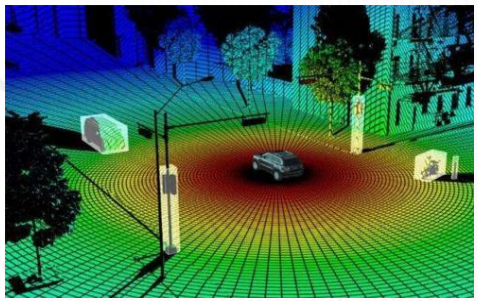
- Global CORS SBN
- Hexagon HxGN SmartNet
- Trimble VRS NOW Network
- Australia AllDayRTK
- The SAPstring SAPA service

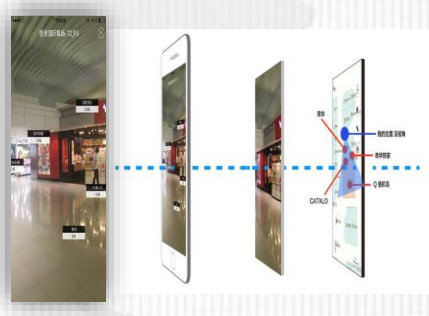
• Remote Sensing

- Radar and video satellites
- Small satellites and nanosatellites
- UAV applications
- Microsatellite clusters

• Social Sensing

- Social network
- Twitter
- Wechat
- Mobile location data





Opportunity 2: Drones has entered large-scale application

Characteristics:

Flexible, man-machine separation, low cost

A variety of payloads such as visible light, aviation SAR, communication module, and LIDAR

Scenarios:


Live aerial photography


Anti-terrorism drills


Cluster firefighting


Dike Emergency Rescue


Plateau logistics operation


Delivery of supplies


Topographic survey


Fire rescue


Water rescue


Exercise support


Unmanned system fire extinguishing


Earthquake rescue

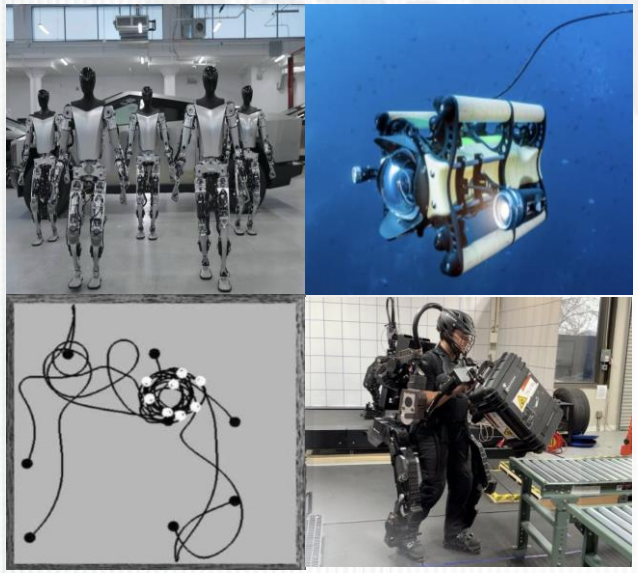
Opportunity 3： Intelligent robots replace high-risk occupations

Highly autonomous and intelligent

Artificial intelligence, bionic sensors, soft materials, group collaboration, autonomous navigation.

Characteristics： Extreme environment, fast response, multi-load, high efficiency

Healthcare, industry, agriculture, disaster relief, and public services

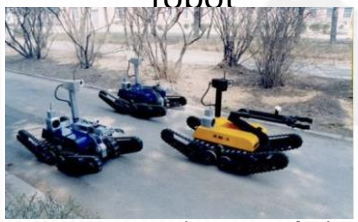


Intelligent patrol robot

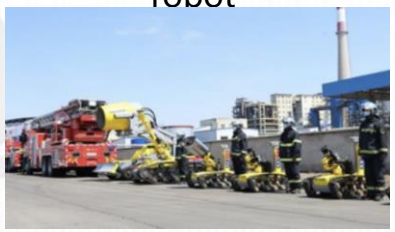
Track inspection robot

Key Space Inspection Robot

Bridge maintenance robot

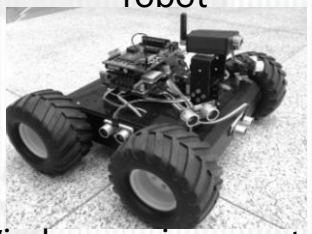


Counter terrorism and riot control robot



Firefighting robot

Early warning collision avoidance robot



Wireless environmental monitoring intelligent robots

Opportunity 4: Risk Prevention and Control with Digital Twins

Synchronization(virtual vsreality)

Application On Risk Prevention and Control

- Real time risk monitoring and warning 实时风险监测预警
- Disaster scenario simulation and rehearsal 灾害场景模拟与演练
- Dynamic emergency resource scheduling 动态应急资源调度
- Risk assessment and decision support 风险评估与决策支持
- Collaborative Emergency Response 协同应急响应

Before

Simulation of disaster chain evolution and intelligent identification of risks

During

Synchronized operation, mid-term consultation and decision-making analysis

After

Twin reproduces historical flooding scenes and achieves post attribution analysis

Opportunity 5: Large Models make it possible for everyone

Google, Amazon, and Microsoft are leading the way in large model technology.

Baidu, Alibaba, Tencent, 360, etc., with over 300 currently in use.

Alibaba Cloud Tongyi Large
阿里云通义大模型

It can simulate human thinking, achieving smarter and more flexible natural language processing, and is applied across 8 industries

Huawei PanGu Large
华为盘古大模型

It is a multifunctional AI model covering NLP, CV, multimodal, and scientific computing, applied in medical, industrial, transportation, and meteorological fields

Large Model ERNIE
百度文心大模型

ERNIE, a knowledge-enhanced model, spans NLP, CV, and multimodal fields, powering internet products and industries like search, smart speakers, manufacturing, energy, finance, and education through PaddlePaddle and Baidu AI Cloud

Jiu'an Large Model
久安大模型

- Video feature extraction
- Image risk identification
- Industry knowledge Q&A
- Voice Rapid Group Meeting
- Recommended historical cases
- Scheduling scheme

Problems and Challenges

Technical application

1 Unclear

Technologies can be applied in emergencies

2 Incompetent

data processing is highly professional to users.

3 Unintelligent

intelligent technology is not enough for emergency

Industrial development

1 Unsystematic

systematic theory and integrated technical equipment are lack

2 Untimely

Emergency needs are difficult to be transformed into industries .

3 Unstable

Dynamic and the stability of the industry cannot be guaranteed

Standardization

1 Unaware

where to find emergency

2 Inflexible

The management mechanism cannot meet emergency needs.

3 Unstandardized

lacks standards and specifications

4 Indirect

knowledge cannot directly assist emergency decision-making

Challenges: Data Governance and Security

Data dimension	Data type
Meteorological	Temperature, humidity, precipitation, wind speed, air pressure
Geology	Fluid data, deformation data, electromagnetic data, GNSS
Hydrology	Rivers, lakes, reservoirs, water levels, flow rates, water quality,
Environment	Air quality index, pollutant concentration, noise level
Infrastructure	The status and usage of infrastructure such as roads, bridges, buildings, and transportation systems.
Population	Information on resident distribution, population density, population mobility, etc.
Remote sensing	Images and data obtained through remote sensing technologies such as satellites or drones.
Historical disasters	Disaster event records, including disaster type, occurrence time, impact range, response measures, etc.

Global monitoring

multi-dimensional data

multi-dimensional scenarios

Challenges: Data Governance and Security

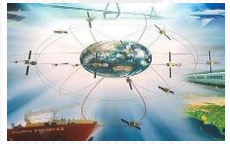
Intelligent processing of multi-modal data such as sound data、optical image data，electromagnetic data and hologram data from air, space, ground and sea.

Deep space

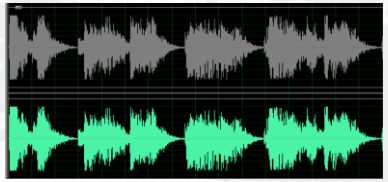
Deep ground

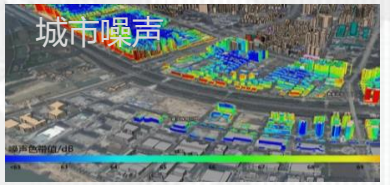
Deep sea

Deep Blue

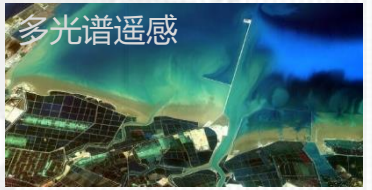


Sound data

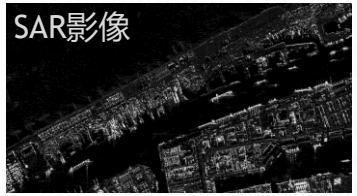


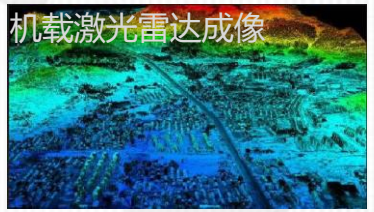


Optical image data

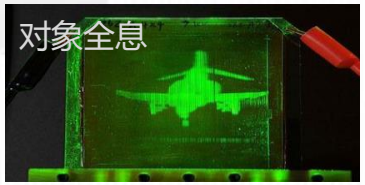


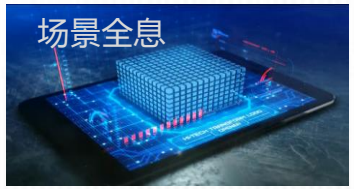
Electromagnetic wave data





Hologram data





Source: Wang JiangHao, China Institute of science and Geographical Sciences and resources

Climate Change and Disaster Risk Reduction Forum

03

Emergency spatiotemporal knowledge ecosystem and Think Tanks

Ecosystem: Frameworks, strategies, themes

Think Tank: Work plan、Implementation

Emergency spatiotemporal knowledge ecosystem

Based on the ecological foundation of spatiotemporal big data and combined with the spatiotemporal information needs throughout **the entire emergency management process**, a knowledge generation, sharing, application, and iteration network driven by emergency spatiotemporal information is formed, with **the development core** of mining and realizing the value of emergency spatiotemporal information.

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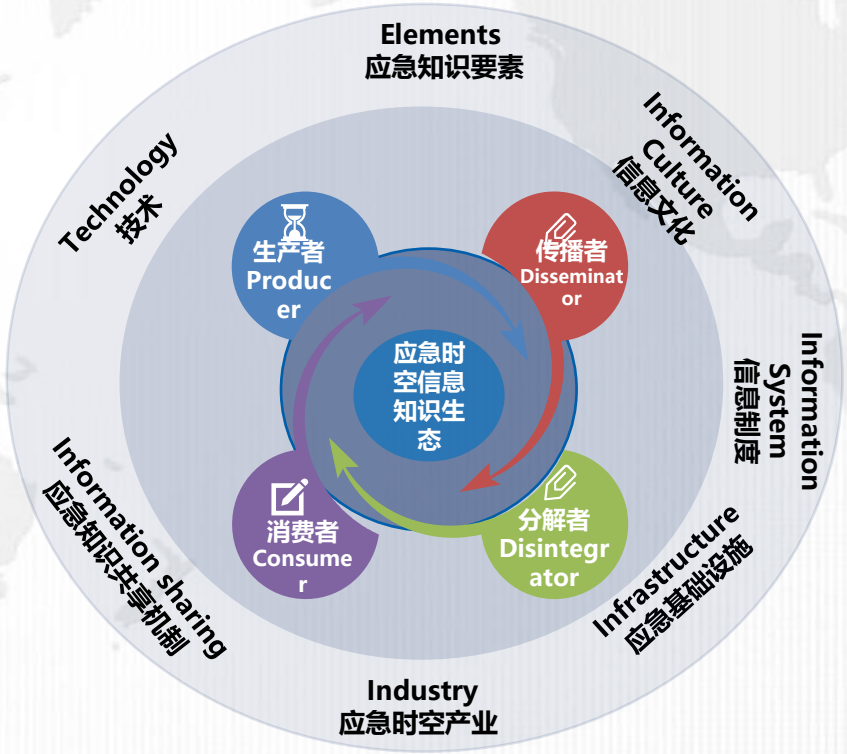
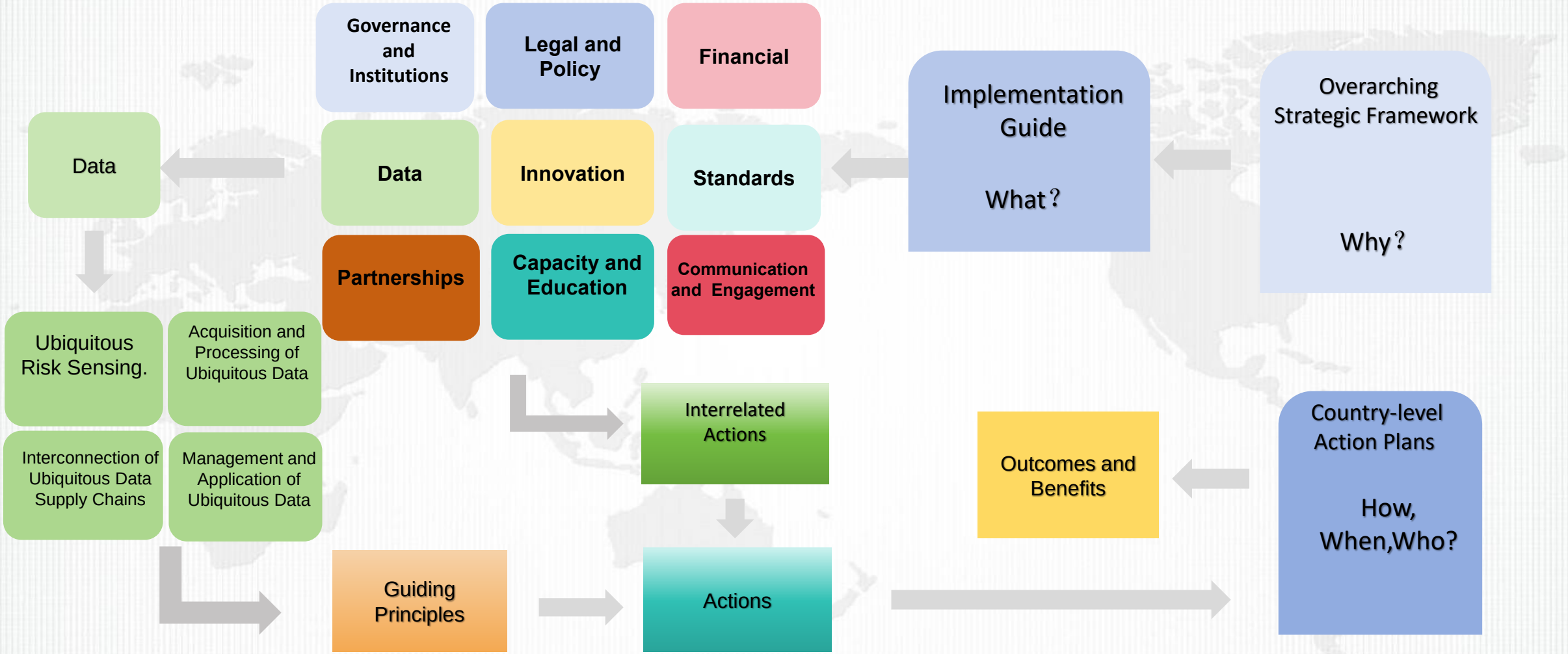
- **Elements**
- **Techniques**
- **Sharing**
- **Application**
- **Industrial**
- **Ecological environment**



Implementation Path Suggestions



Implementation Path Suggestions: Think Tank

Development Goals: **To promote innovation, exchange and sharing of global emergency spatio-temporal knowledge, enhance the capacity of countries in emergency management and data analysis, enhance the comprehensive capacity of global disaster response, and provide important support and guidance for the realization of the United Nations Sustainable Development Goals.**

Third Stage

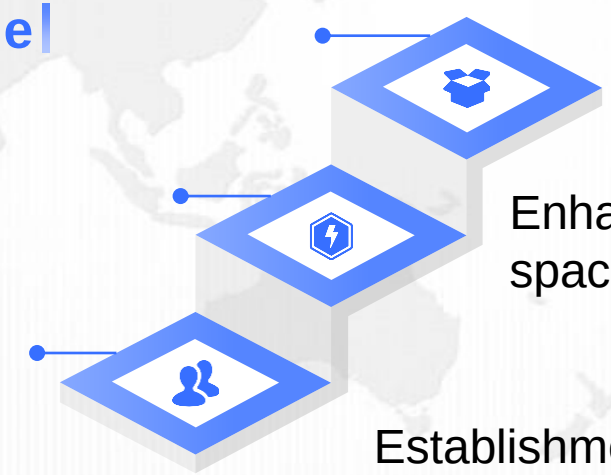
Implementing the Sendai Disaster Prevention and Reduction Framework and SDGs 2030 、

Second Stage

Enhancing the construction of emergency time and space support capabilities in various countries

First Stage

Establishment of think tank working group and preliminary formation of think tank



Emergency Spatial-Temporal Think Tank Work Plan

1 Establish the Global Emergency spatial-temporal workgroup

- Determine the expert requirements and selection criteria for the working group
- Build the organizational structure of the workgroup
- Develop work mechanisms and communication channels
-

2 Formulate Research Guide for Think Tanks

- Research the current situation and needs of emergency spatiotemporal research in various countries
- Clarify the research objectives and scope of emergency time and space
- Develop guidelines for emergency spatiotemporal research
-

Key points

Comprehensive scope
Clear requirements
Multi-hazard response

Emergency Spatial-Temporal Think Tank Work Plan
应急时空智库工作规划

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3 Draft Global Emergency White Paper (Case Collection)

- Research the current situation, challenges, and needs of various countries in emergency response space-time
- Collect typical emergency space-time cases from countries to form a case library and knowledge base
- Extract globally targeted strategies and plans for reference by countries
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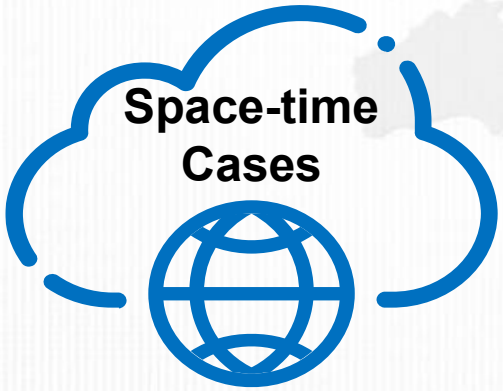

4 Formulate Emergency Spatial-Temporal Standard Specifications

- Collect existing relevant standards from various countries, analyze their advantages, disadvantages, and applicability
- Clarify the objectives and requirements of emergency space-time standards, and propose a standard system plan
- Propose standard project proposals, initiate and organize the preparation work

Emergency Spatial-Temporal Think Tank Work Plan
应急时空智库工作规划

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5 Establish Talent Training and Cooperation Mechanism

- Set talent development goals and requirements
- Conduct training on emergency spatiotemporal applications
- Establish emergency spatiotemporal research projects and cultivate researchers
- Establish a multi-party cooperation mechanism involving government, research institutions, enterprises, etc
-

6 Guide the Construction of Spatial-temporal Emergency Support Capabilities

- Analyze the current situation and needs of emergency space-time support capabilities in various countries
- Develop an implementation plan for emergency space-time support capacity building
- Provide customized guidance for the construction of emergency space-time support capabilities

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THANK YOU

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