ETRI CONSORTIUM DT R&D LAb.

Disaster Safety Management Technology based on Digital Twin

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Ministry of Science and ICT
Ministry of the Interior and Safety
Ministry of Land, Infrastructure and Transport
Ministry of Trade, Industry and Energy
IITP Institute of Information & Communications Technology Planning & Evaluation

01 Digital Twin and Disaster & Safety

Acceleration of disaster complex and large-scale

"Due to climate change and urban complexity and overcrowding changes,"

Accelerating the complexity of disaster occurrence

local disaster	Diversification of disaster occurrence	Linked Disaster Occurrence	Increase in large-scale disaster cases	Complexity of disasters
Individual	Individual and partial linkage	Associations and Integrations	Expansion of Associations and Integrations	Compounding <Representative example> March 11, 2011 Great East Japan EarthquakeEarthquake → Tsunami (tsunami) → Nuclear accident → Radioactive leak

Current

Composite Disaster Acceleration

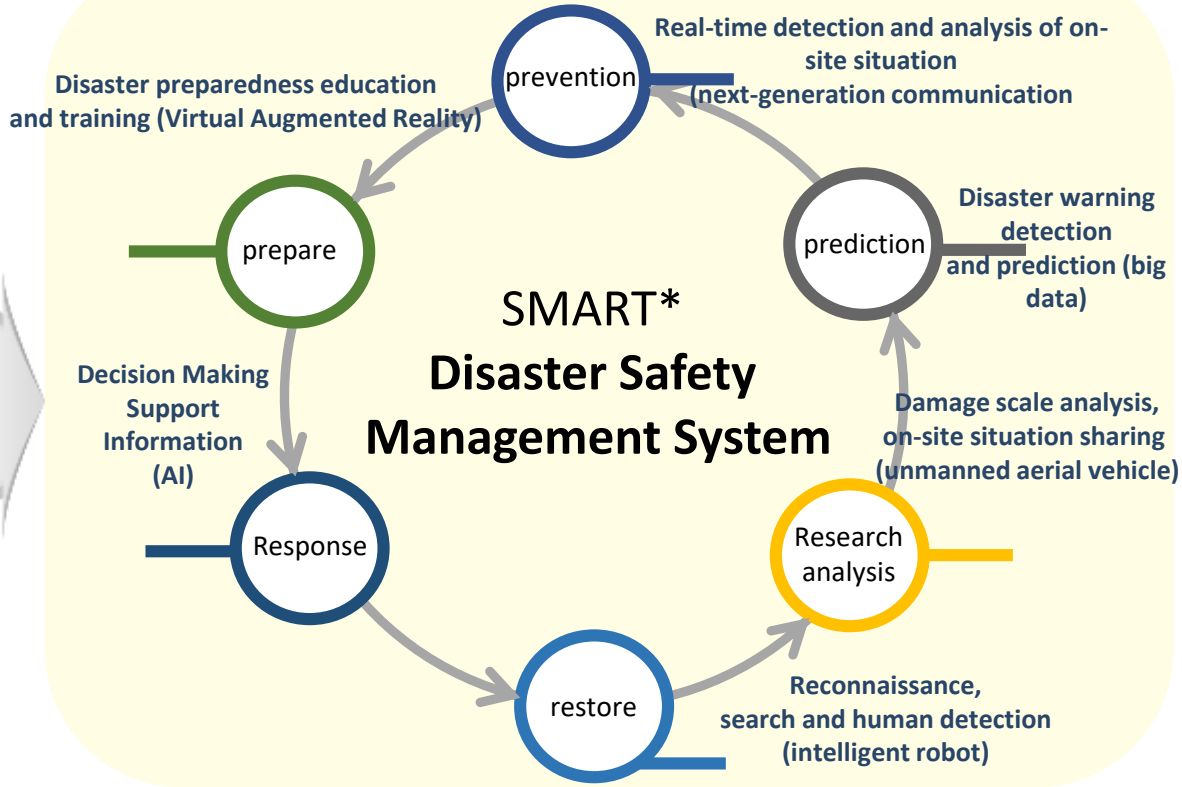
simple disaster	Diversification of disasters according to the complexity of society	Increase in connection with disasters	Climate change and large-scale natural disasters (earthquakes, etc.)	Chain of Complex disasters
• local disaster • limited damage area	• Diversification of disasters due to differentiation of social functions	• occurrence of a chain of disasters	• Increased possibility of large-scale disasters due to climate change and revitalization of earthquake zones	• Frequent complex disasters • The necessity of joint response as a chain reaction of disasters

Digital Twin and Disaster & Safety

Full-cycle disaster management system

4Steps of Disaster Safety Management

6 Steps of Disaster Safety Management



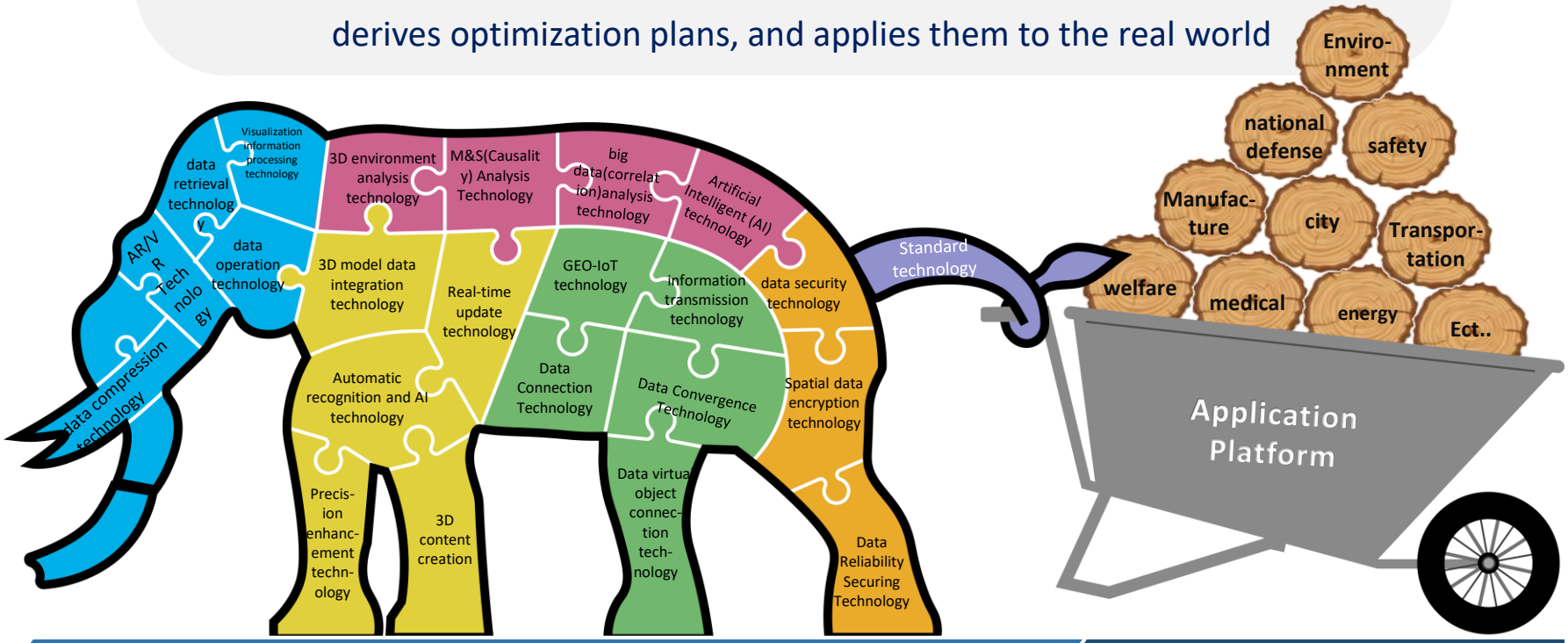
*S(uitablility)-customized service, M(arket)-disaster safety industry nurturing and foundation, A(dvance)-advanced technology development, R(eality)-demonstration/participation type, T(ogether)-collaboration type

* Source: The 3rd Comprehensive Plan for Disaster Safety Technology Development, National Scientific Deliberation Committee

Definition of a digital twin

Intelligent convergence technology

that analyzes various information collected in the real world in the virtual world, derives optimization plans, and applies them to the real world



3D Modeling Construction/Renewal Technology

Visualization/Operation Technology

security technology

analytical skills

connection technology

*Source: Digital Twin Technical Report, ETRI, 2021.01

1 Stages of digital twin technology development

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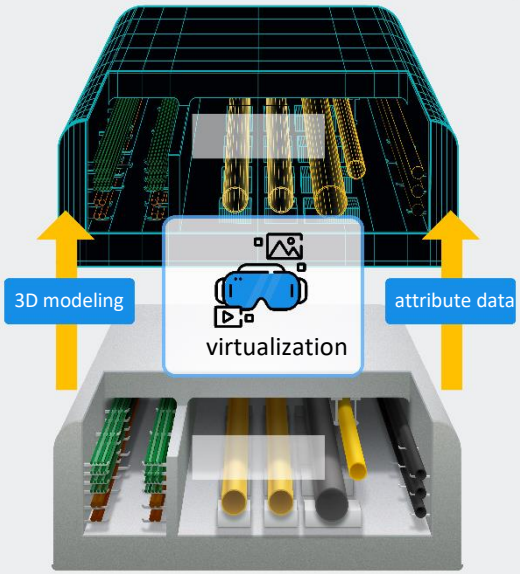
Stage 1 Digital Twin

3D virtual world creation

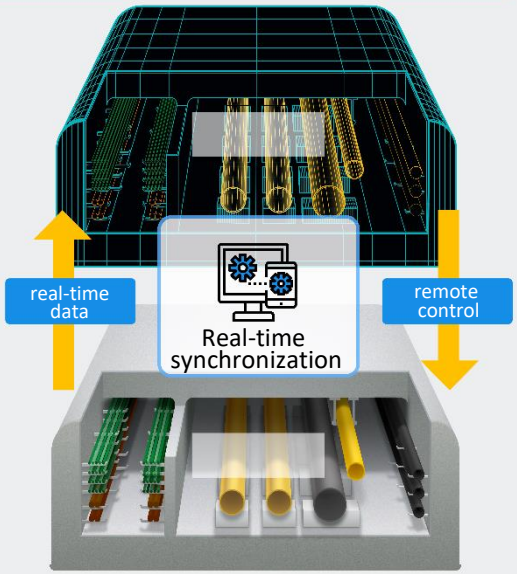
3D CAD, GIS, BIM, public data, historical data etc.



Stage 2 Digital Twin

Real-time monitoring and control service

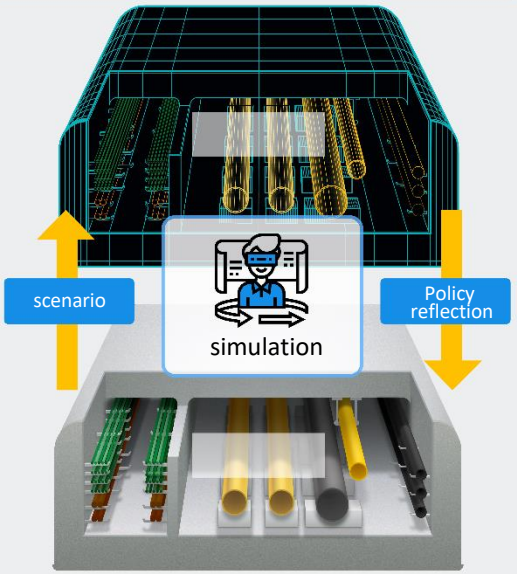
Connected to CCTV, etc. Real-time data, video information, remote control, etc.



Stage 3 Digital Twin

Analysis, prediction, optimization, training services

Big data, machine learning, AR/VR/MR, 5G, cloud, edge computing, etc.



Duplicated Virtual twin
(connection between the real world and the virtual world)

Monitoring and Control twin
(real world remote management)

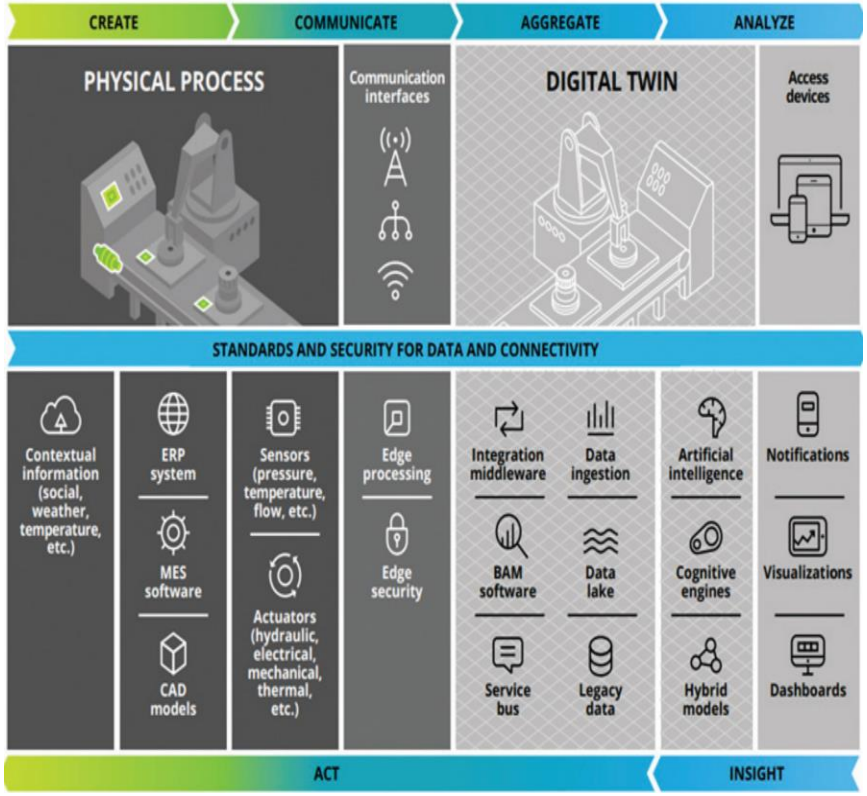
Modelling and Simulation twin
(Real World Prediction and Optimization)

Source: Gartner data corrected

Digital Twin Service

Real-time vs Importance of finding compromises for accuracy

Digital twin Operation: Real-world information Produce → Transmission → Synthesis → analysis → Insight → Act



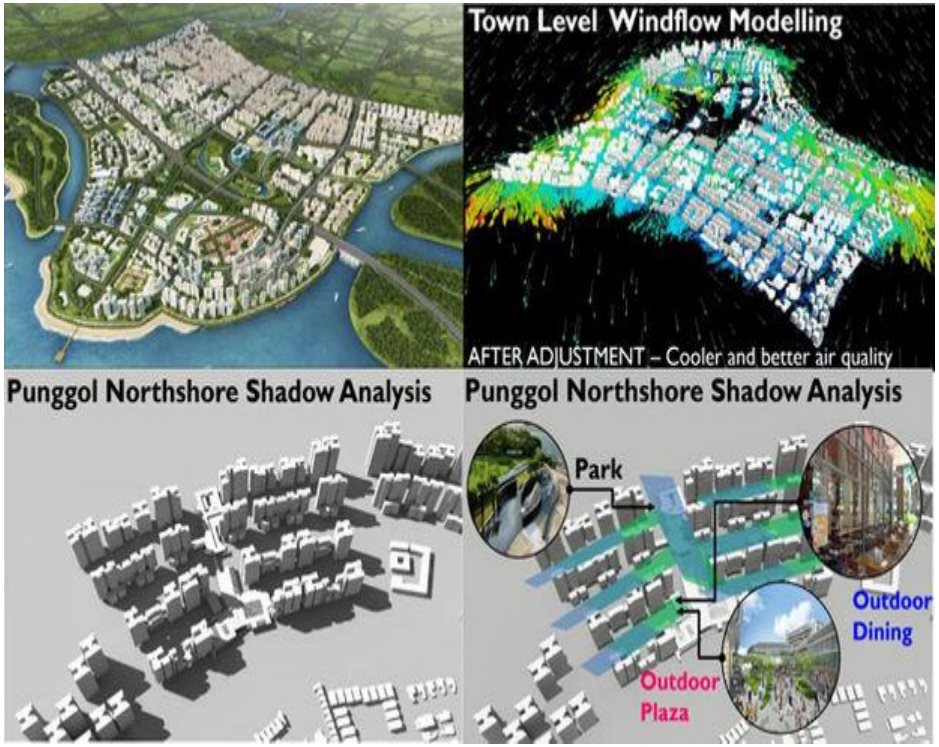
Source: DilloitUniversityPress

Create	Leverage sensors to collect and model external data from physical processes and the environment that can influence measurements and operations
Comm.	Real-time bidirectional integration/connection support between physical processes and digital platforms
Aggregate	Preprocessing and integration for data analysis
analysze	Analyze and visualize preprocessed data to create models that support decision making
Insight	Visualize analysis results and display them on a dashboard Highlight the unacceptable performance gap between the digital twin and the real world, and indicate where it needs to be investigated and changed
Act	Apply actionable feedback from previous steps to physical assets and digital processes

Digital Twin Application Case: Virtual City

Using digital twin technology
to build twin cities and solve current problems

Virtual Singapore



Virtual Seoul

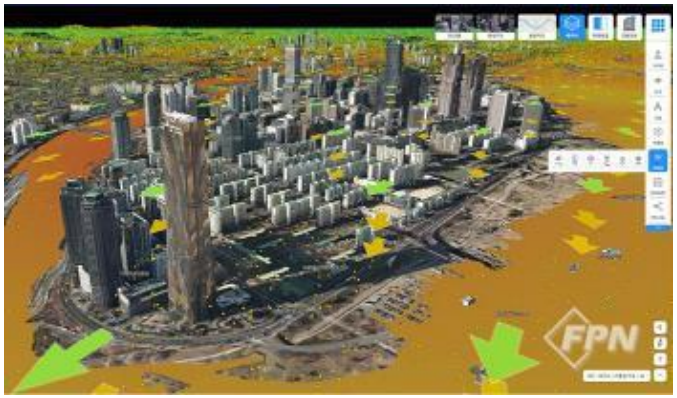
Digital Twin Application Case: **S-Map**

(Seoul) S-Map : " city problem solving simulation "

• Solving various urban problems such as fire by combining information such as administration and environment in a virtual space

• Building a digital twin that can analyze and simulate urban problems for the entire city

- 3D realization of about 600,000 buildings and facilities including the topography of Seoul Establishment of ground/underground/indoor spatial information integration
- Urban planning decision support, real-time fire monitoring for fire prediction, implementation of urban wind roads, etc. Equipped with analysis models for each field to solve urban problems
- Firefighting that can check whether the fire sensor is working or not with a 3D map without going to the site IoT sensor technology monitoring technology mounted on S-Map
- 'Real-time IoT Fire Management System', combined with 'Fire Safety Map', detailed information of the building and check the exact location of the fire in advance and Equipped with a model that can respond quickly to fire without going out

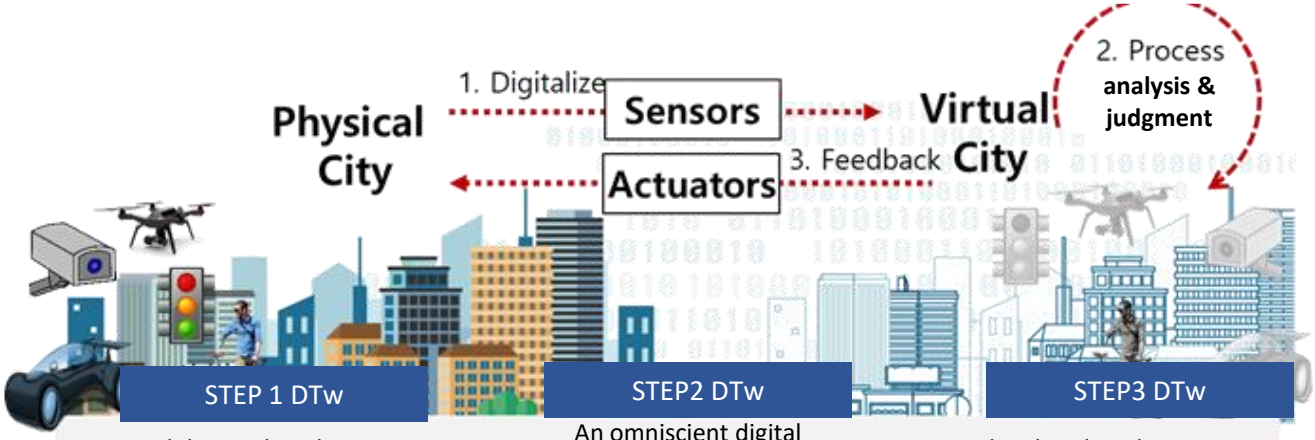


Digital Twin Application Case: Digital Twin City

Transition to an all-time , omniscient and omnipotent digital twin city

- 3D urban space map-based exhibition/blind zone zero urban phenomenon reproduction and real-time intelligent control
- Realization of an omnipotent digital twin city that enables organic and autonomous interaction between digital twin objects inside and outside the city through a digital twin city

A sustainable smart city based on an omnipotent, omnipotent and omnipotent digital twin city



Digital twin city construction, renewal, and virtualization technology	Digital twin city data life cycle management technology	Digital twin city intelligence and optimization technology	Digital twin city exhibition visualization technology	Digital twin city autonomous intelligent execution technology

02 Management of underground infrastructure based on digital twins

Underground infrastructure – underground tunnel

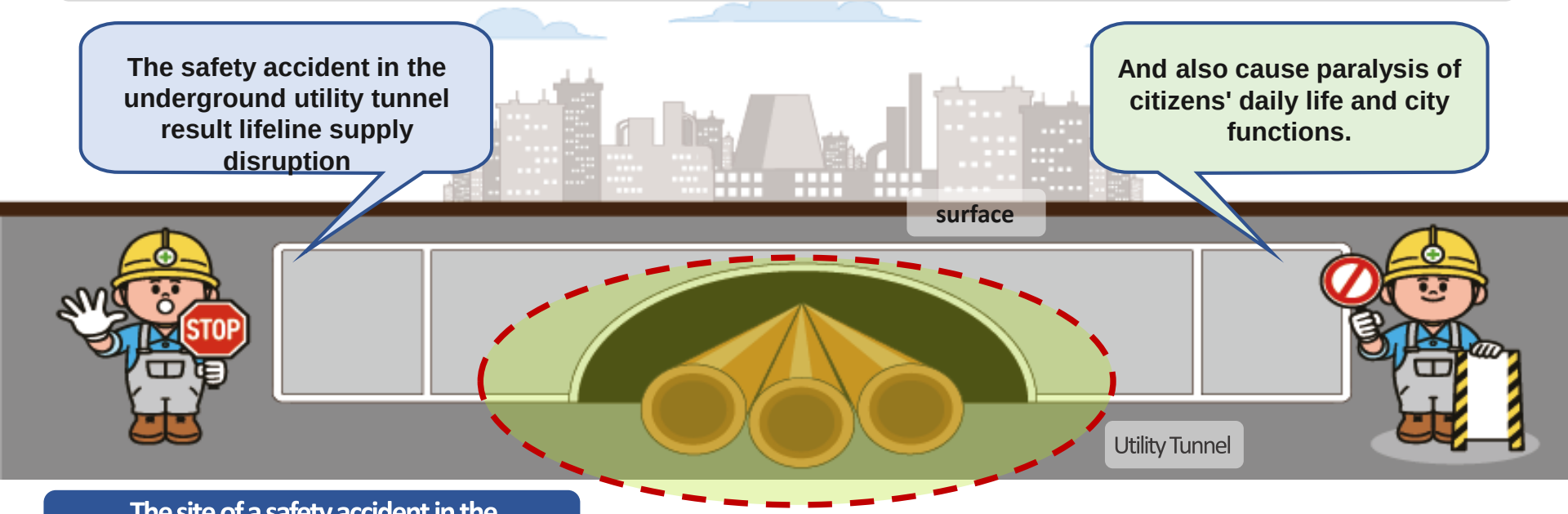
Types of Disasters Caused by Underground Infrastructure

Spread of disaster complexity damage increase

- Spread of fire disaster to ground buildings by lifeline dependency
- Spread of fire disaster to underground shopping malls due to subway facilities (flame, smoke, etc.)
- Traffic facilities paralyzed due to loss of lifeline function (ex. Daegu subway fire)
- Lifeline fire disaster : power, communication infrastructure failure

Underground infrastructure – underground tunnel

Utility tunnel is a facility for jointly accommodating underground facilities
such as supply facilities (electricity, gas, water supply), communication facilities, and sewage facilities.



The site of a safety accident in the underground utility tunnel

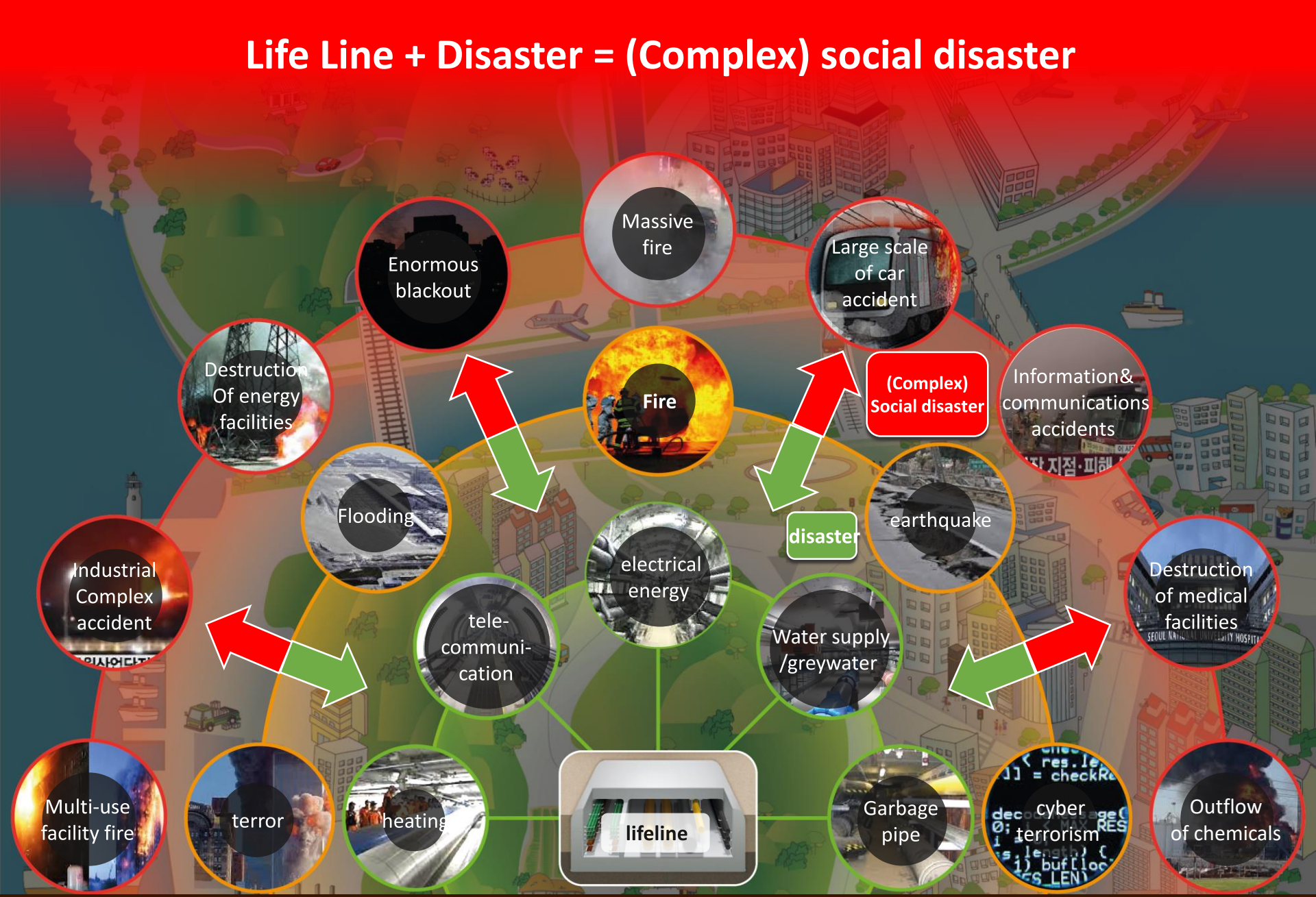
Fire in underground utility tunnel, Yeouido, Seoul('00.02)

Fire in KT telecommunication area in Ahyeon-dong, Seoul ('18.11)

Ilsan Baekseok Station hot water pipe rupture ('18.12)

Source : https://www.sisul.or.kr/open_content/safety/conduit/intro.jsp correction

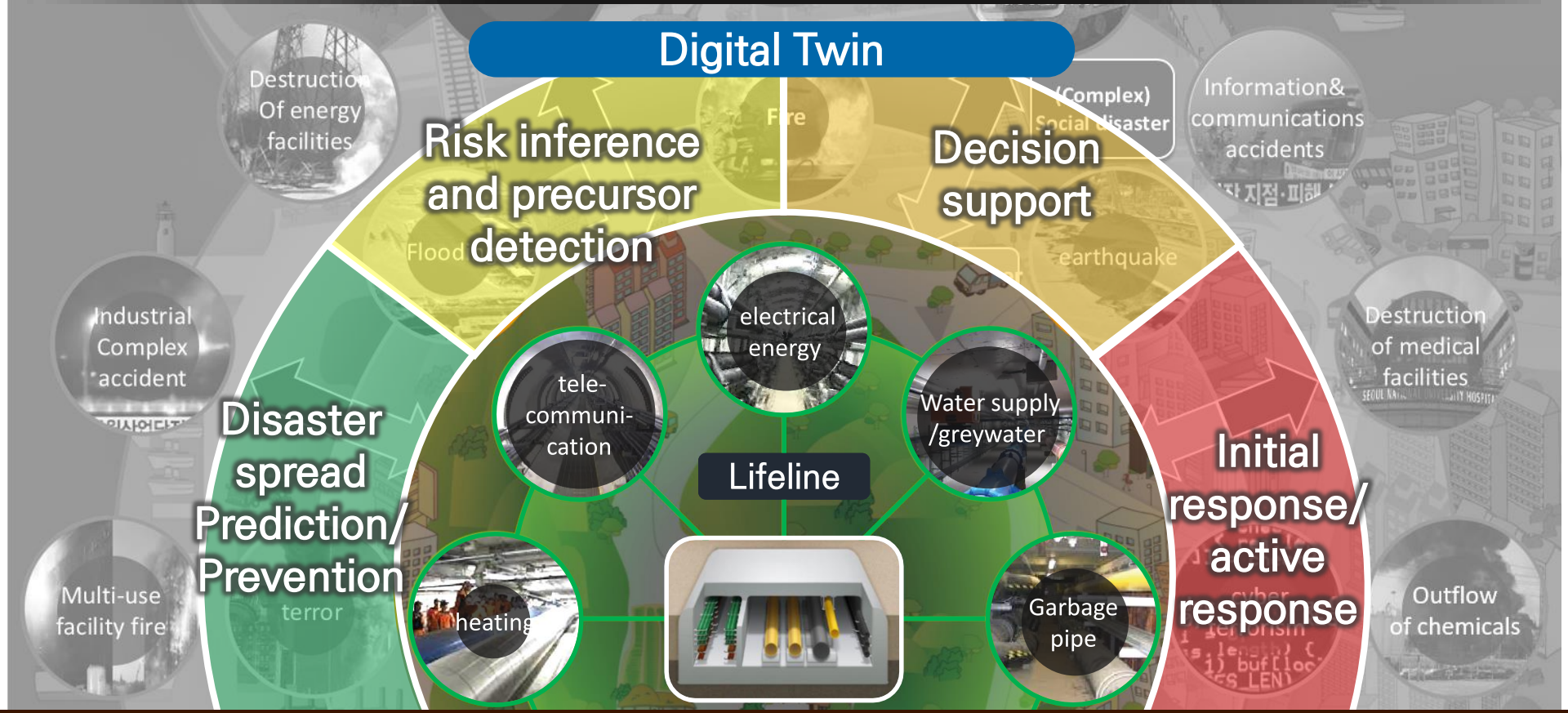
Life Line + Disaster = (Complex) social disaster



Social disasters: damage exceeding the scale prescribed by the Presidential Decree caused by fire, collapse, explosion, traffic accident, CBRN accident, environmental pollution accident, etc. The spread of infectious diseases under the Prevention and Management Act of Livestock Contagious Diseases or livestock Contagious Diseases under the Act on the Prevention and Management of Infectious Diseases, and damage caused by fine dust under the Special Act on the Reduction and Management of Fine Dust, etc.

What is the (combined) social disaster damage reduction technology?

Development of digital twin core technology for disaster management centered on disaster spread prediction and prevention



- Digital twin: Dynamic software that supports decision-making by analyzing problems through modeling and simulation of heterogeneous information (sensor information, spatial information, attribute information, etc.) in order to recognize the state of the physical world, changing behavior, etc. It can be used for all-cycle disaster management centered on disaster spread prediction and prevention)

2 Disaster Safety Management Platform based on Digital Twin

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General Research Objectives

Research Objectives

Development and demonstration of integrated platform technology Disaster Safety Management Platform based on Digital Twin capable of early prediction and proactive response

1 Ministry of Science and ICT

Disaster Safety Management Technology development based on digital twin

2 Ministry of Interior and Safety

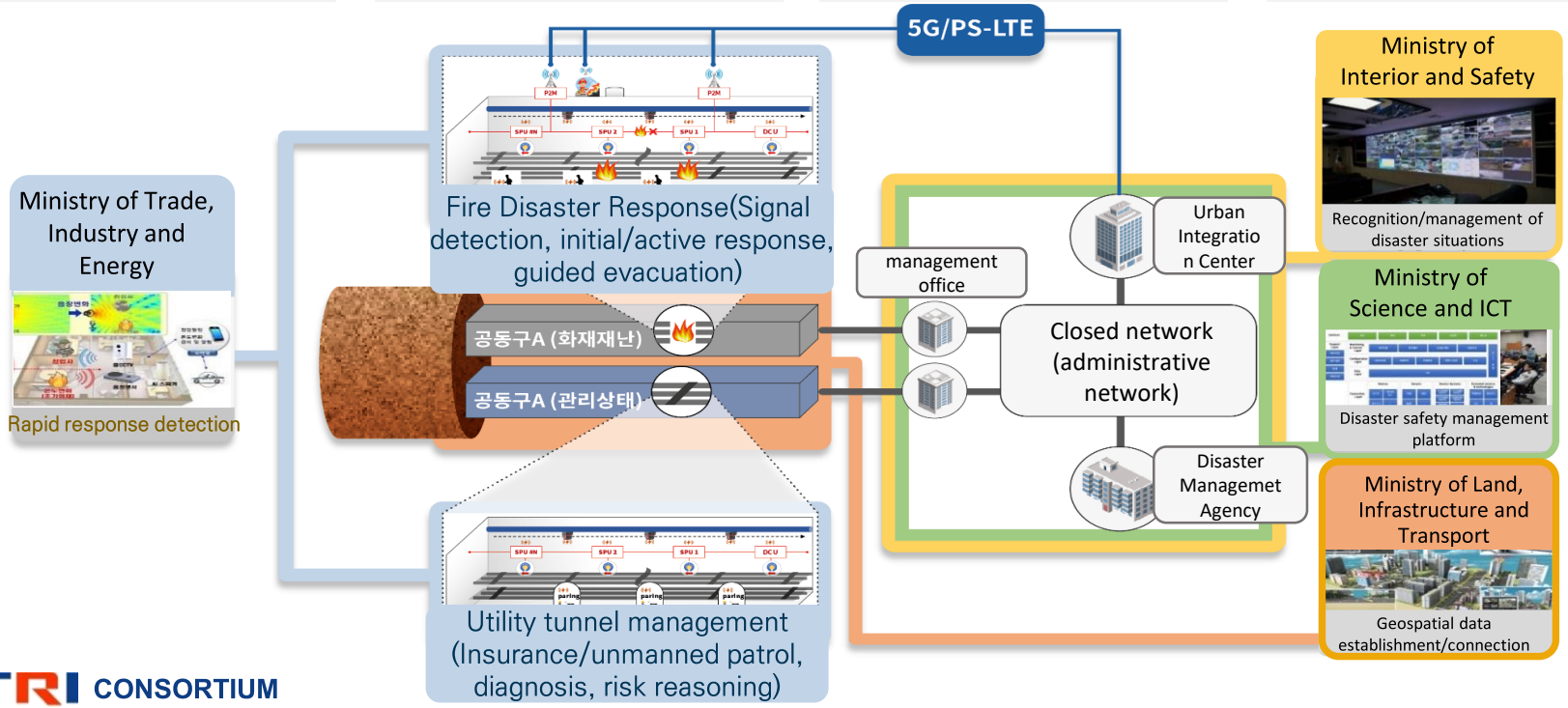
Disaster prediction and field-oriented prevention / preparation / response technology development and demonstration

3 Ministry of Land, Infrastructure and Transport

(Existing) Real-time underground utility tunnel 3D spatial information generation and update technology development

4 Ministry of Trade, Industry and Energy

Development of intelligent multi-sensor and relief technology for fire and disaster detection in underground utility tunnel



2 Disaster Safety Management Platform based on Digital Twin

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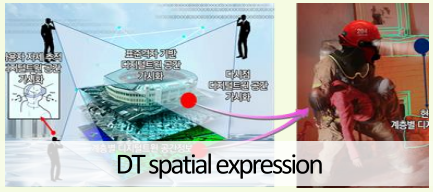
DT infrastructure facility

DT disaster safety management platform

DT space generation management

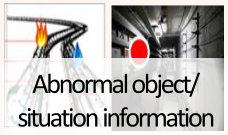
Presence detection/decision making



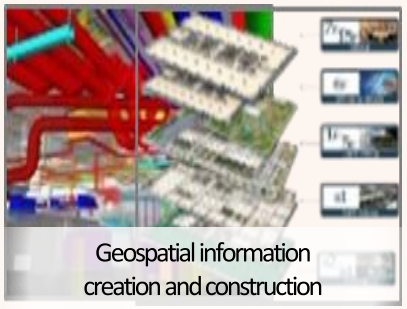
DT spatial expression

DT space server

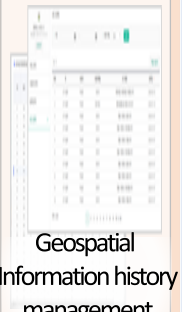
Create standard gap



Abnormal object/ situation information



Geospatial information creation and construction



Geospatial Information history management

DT operation system

DT-based intelligent situation control

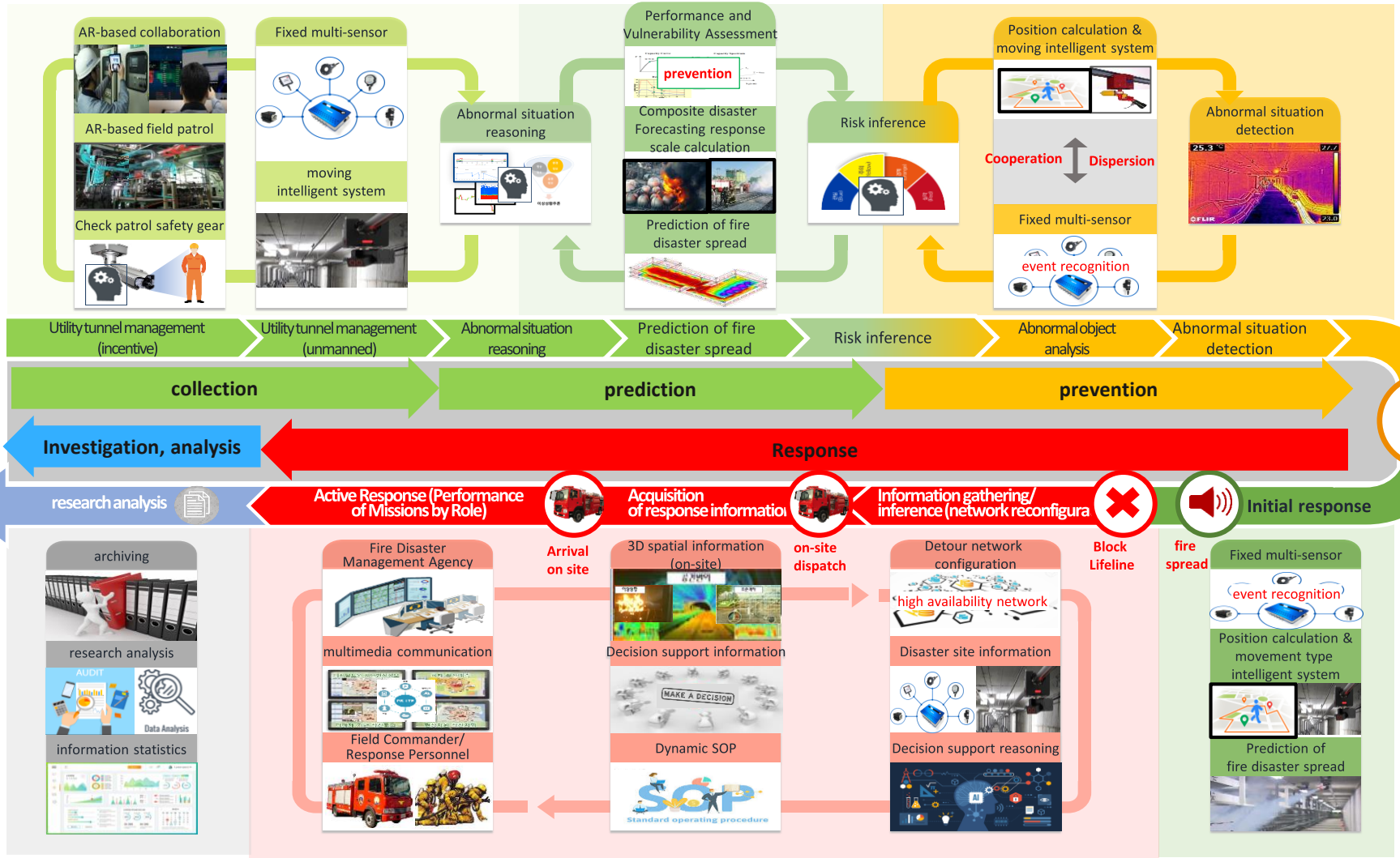
Facility monitoring, crime prevention, control

Patrol Safety check

DT-based on-site response

Disaster Safety Management Platform based on Digital Twin

One-Stop Service from fire and disaster prediction to response and investigation analysis

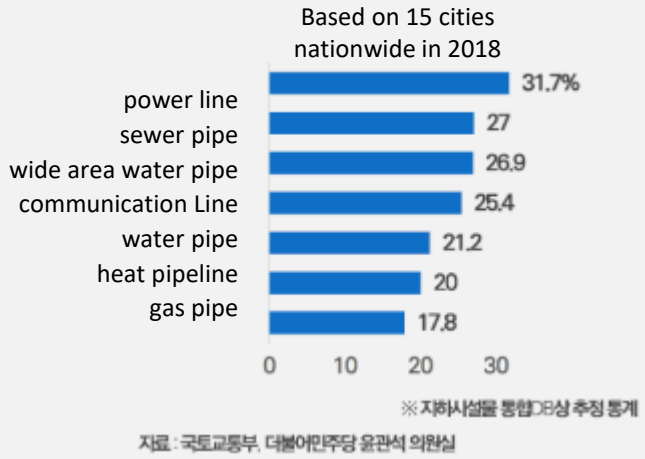


Disaster Safety Management Platform based on Digital Twin

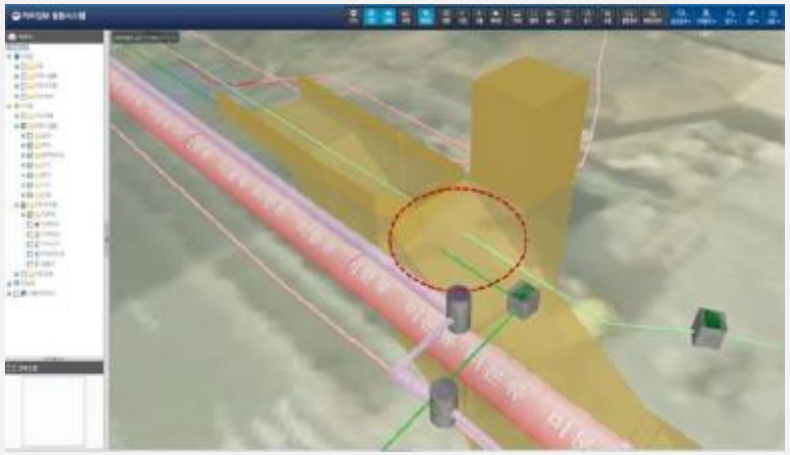
The importance of data quality for digital twins

Spatial information and facility data error serious: power line depth error rate 62%, error rate by facility type 18~32%

Data error rate for each facility in the integrated underground spatial map



Case of data error in communication line buried at exit 6 of National Assembly Station



< Data reliability by facility >

("Estimated statistics on the integrated database of underground facilities in 2018)

division	Electric Power	Heat Transport	Wide Area **constant**	Communication	Gas	Constant	sewer
Depth error (%)	61.9	28.4	18.4	40.1	4.2	20.3	11.3
Building overlap error (%)	6.8	3.2	4.7	10.6	13.3	12.2	3
Road non-overlapping error (%)	26.5	28.6	57.8	25.6	36	31.2	24
Average(%)	31.7	20.0	26.9	25.4	17.8	21.2	27

How to measure distance by finger

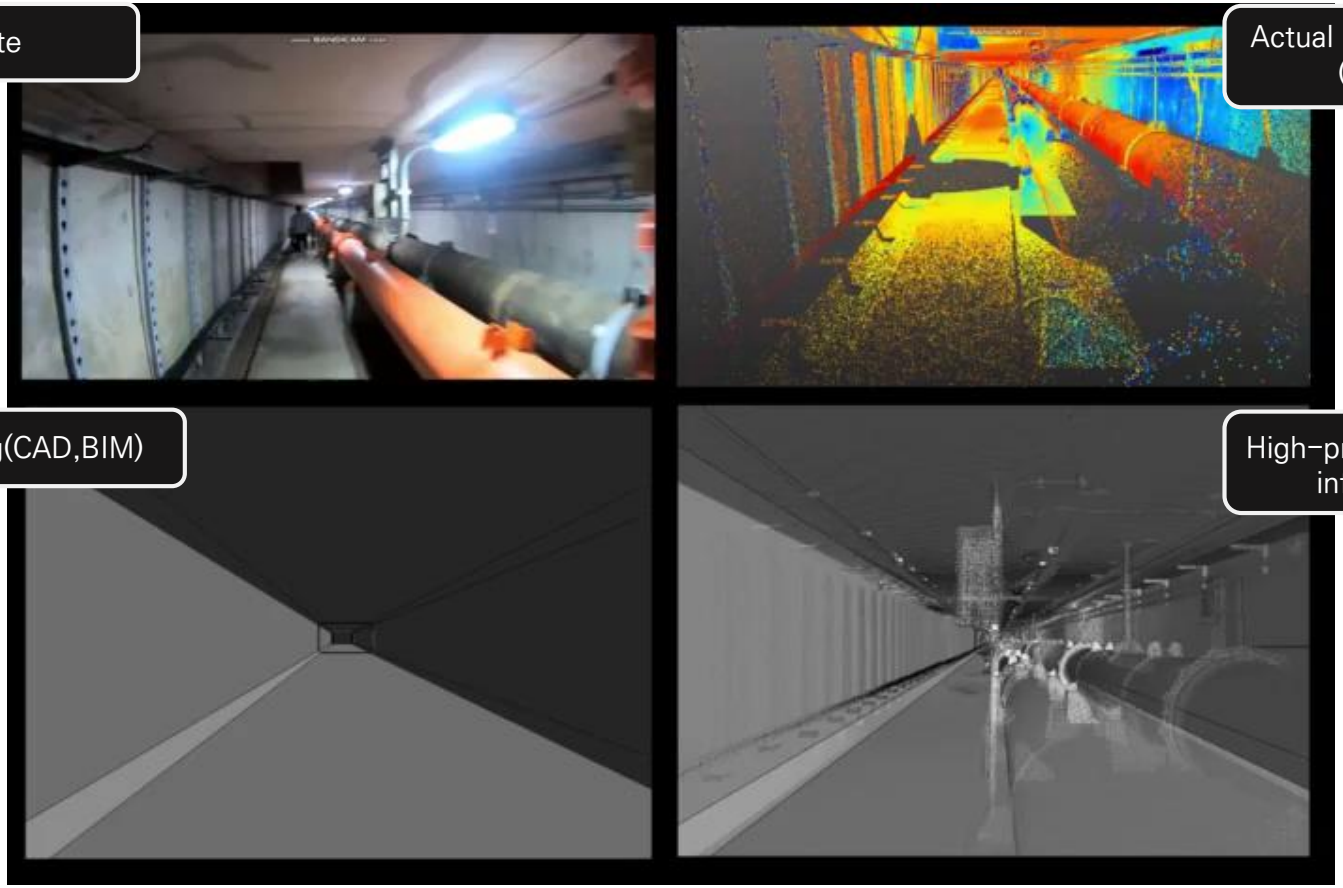
division				
actual measurement		8cm	16cm	20cm
scale	1:25,000	2km	4km	5km
	1:50,000	4km	8km	10km

Disaster Safety Management Platform based on Digital Twin

Create(Virtual World)

Create high-precision 3D spatial information that integrates CAD, BIM, and LiDAR information

(vertical and horizontal error less than 5cm)



Disaster Safety Management Platform based on Digital Twin

Create and Act

Collecting on-site information in the underground common area and executing decision-making information

Rail Robot

Video analysis

Operation management

Ochang Underground Utility Tunnel application model (K530)

Type	Bar Type
Weight	20Kg
Size	200mm
position error	Within 0.01m
battery capacity	Within 3hours/10km
fire extinguishing	Within 3m of the site (automatic, manual)

Maximum speed

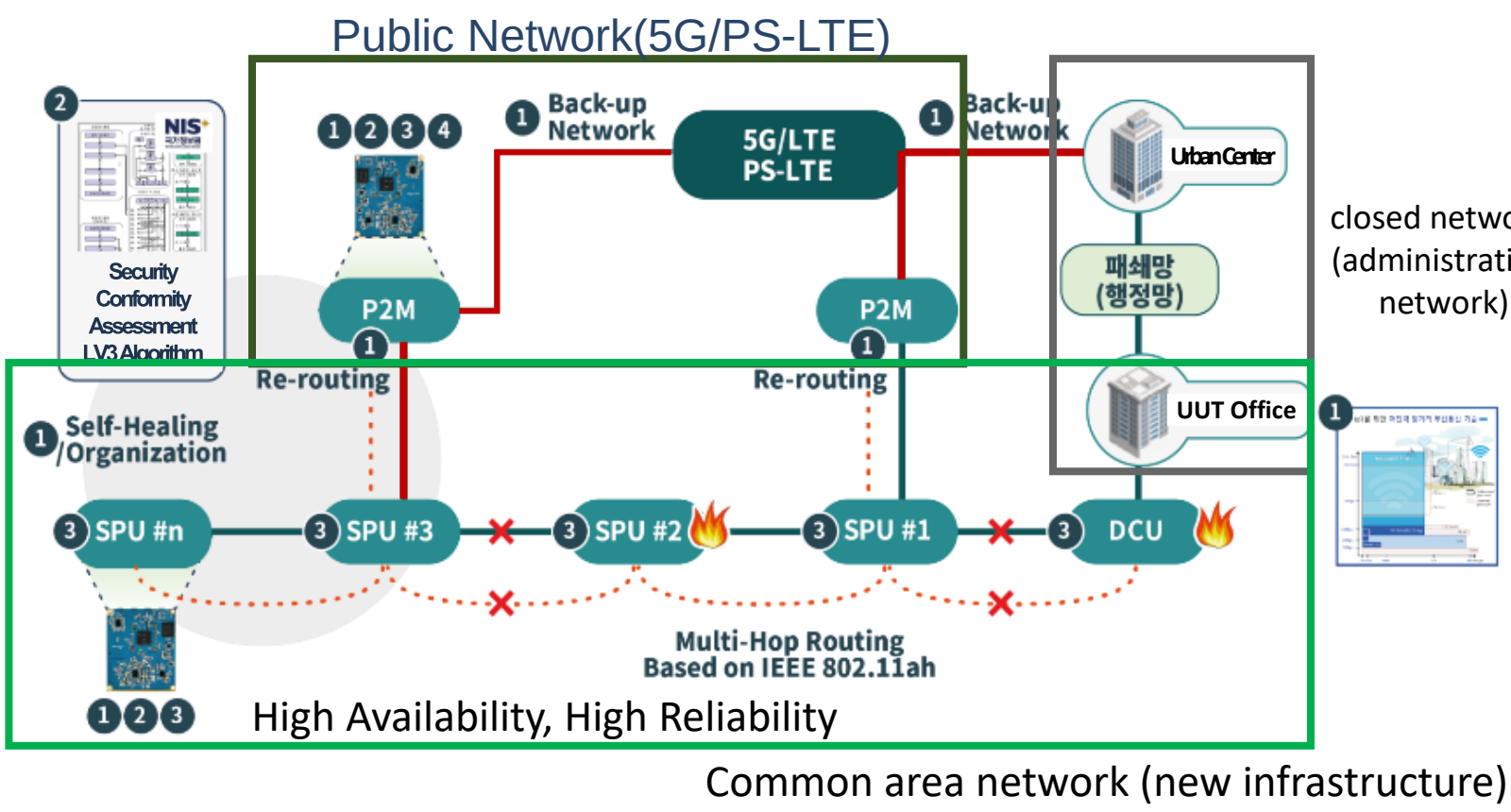
straight section	10m/s
Linear operation	5m/s
Curve operation	2m/s
Optimum average operating speed	1m/s

Disaster Safety Management Platform based on Digital Twin

communication

-Requirement of network infrastructure with strong survivability considering the characteristics of underground utility tunnels

-Security function requirement according to national infrastructure management regulations

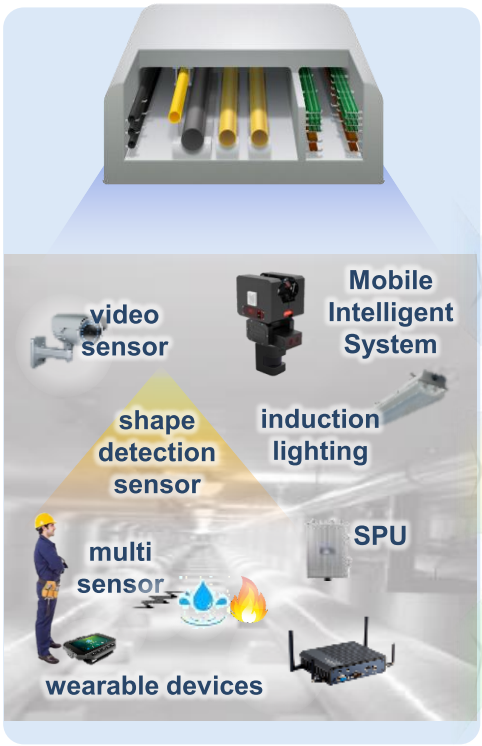


Disaster Safety Management Platform based on Digital Twin

Aggregate(Sync.)

Information integration based on a unified system for analyzing integrated field information

Underground utility tunnel DT infrastructure facilities

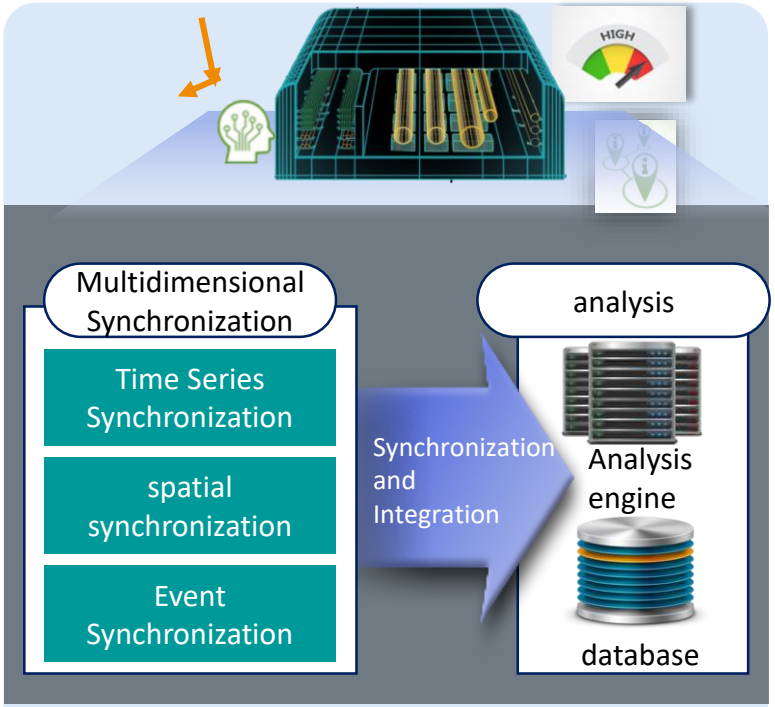


Sensor information (numerical)

Video information (stream)

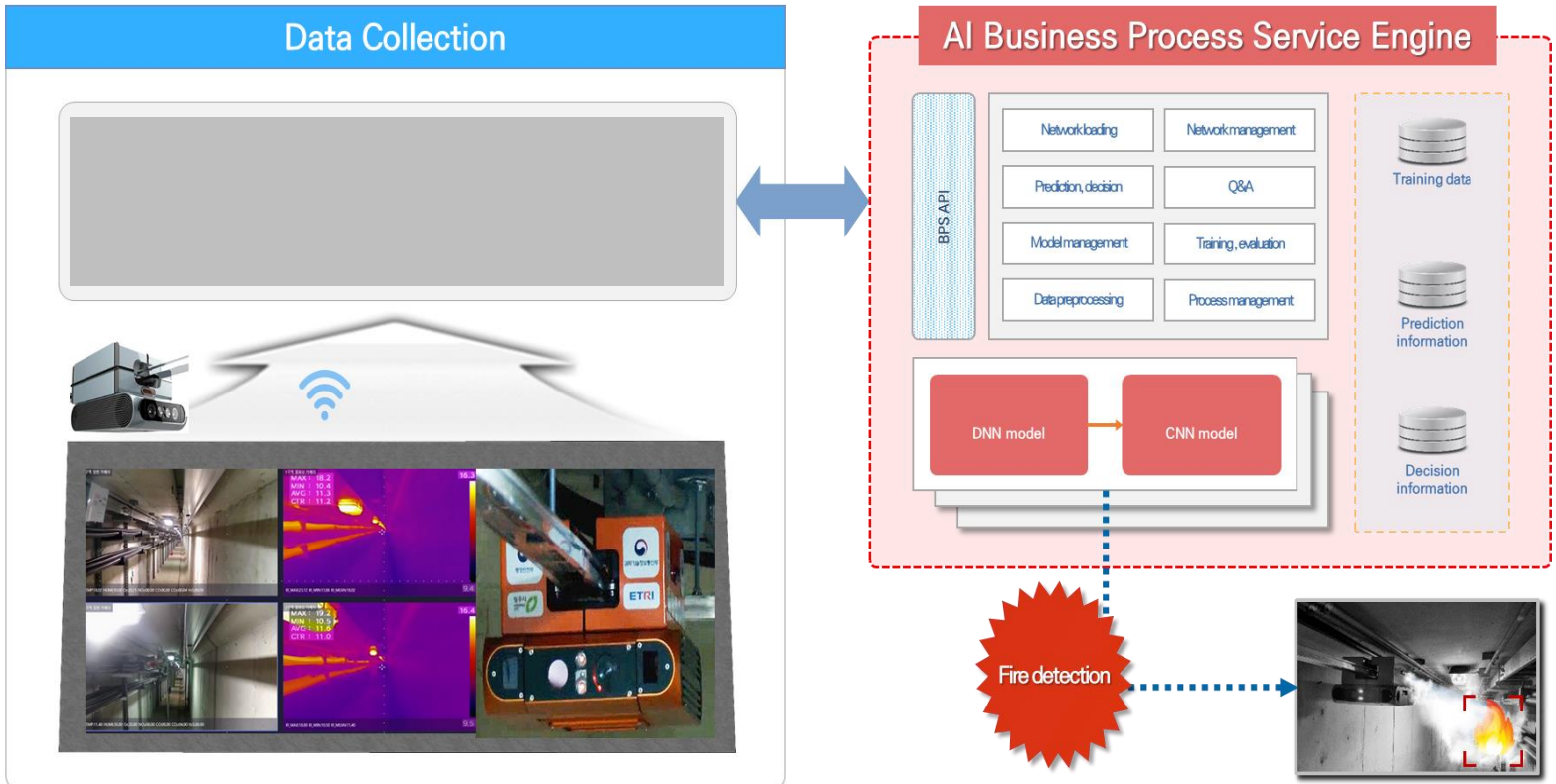
Sound information (stream)

Digital twin underground utility tunnel



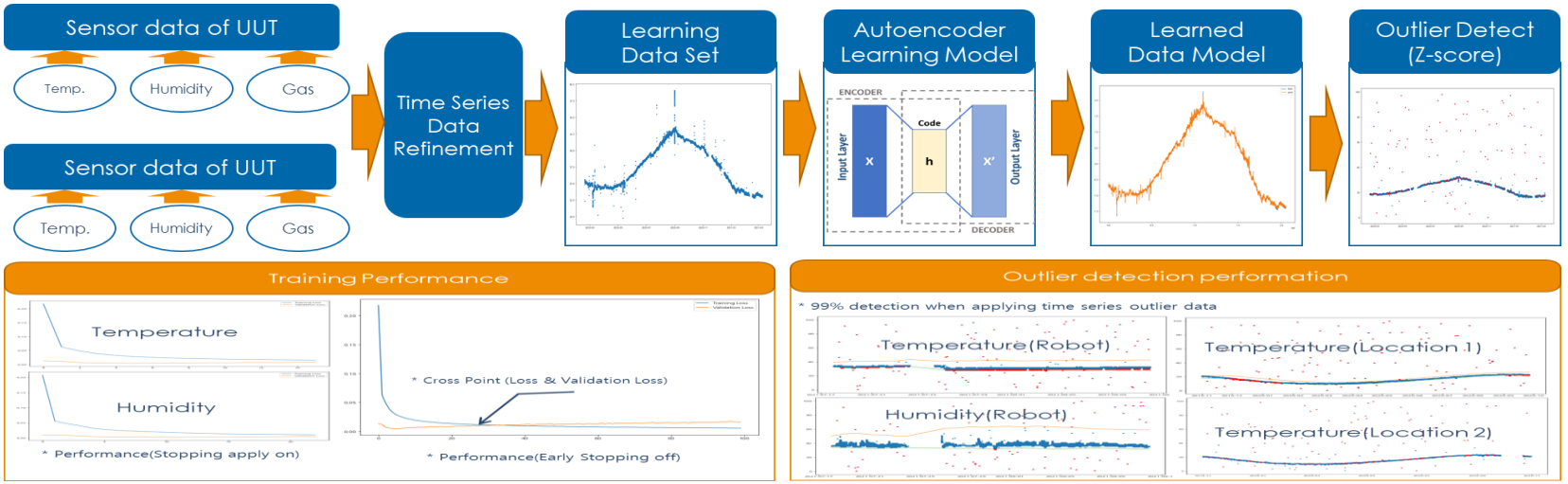
Analysis

Prediction of disaster safety situation for underground facilities throughout the entire cycle through on-site information collection and analysis using BAS (Bigdata, AI, M&S) technology



Analysis

Importance of establishing risk standards for managed facilities



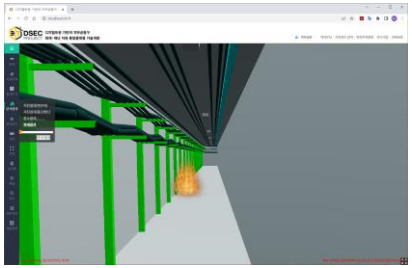
Level	Status	Condition
Blue	- the frequency of use of heating and fire in winter - Dryer outside the summer, new/replacement of power lines, construction using firearms - Detection in case of fire, data detected meets general conditions	- Normal Condition
Yellow	- Detects against fire in the underground utility tunnel causing abnormalities in the detected data	- Alert Level 1(Abnormal appearance criteria)
Orange	- High probability of ignition/spreading while the detected data shows an outlier	- Alert Level 1(fire diffusion standard)
Red	- Emissions of fire and high concentrations of hazardous gases	- stop function

Disaster Safety Management Platform based on Digital Twin

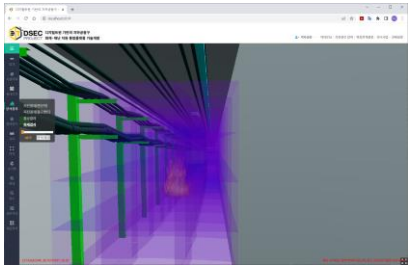
Analysis

Time series disaster safety simulation according to scenario

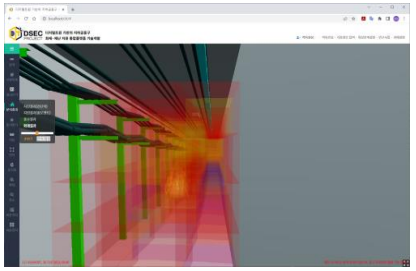
Example of visualization using standard grid for fire M&S support



< Example of ignition point screen >



< Example of ambient temperature screen after 40 seconds of fire >

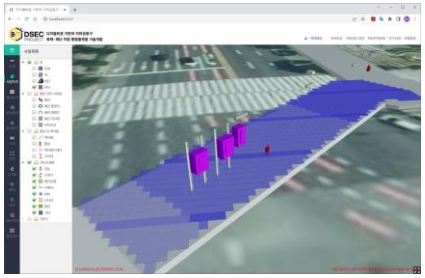


< Example of ambient temperature screen after 310 seconds of fire >

Example of visualization using standard grid to support flood M&S

< Example of initial flood (0 seconds) analysis result >

< Example of flood (1 to 5 seconds) analysis result >

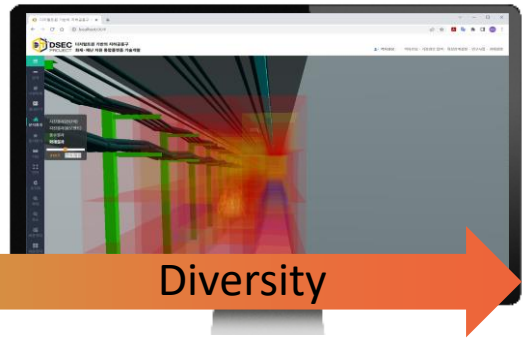


< Example of floor only view >

Disaster Safety Management Platform based on Digital Twin

Insight

Visualization considering the intuition and diversity of information according to service needs

Basic control screen (dashboard)	2nd stage DTw control	3 stage DTw control
		
Intuition	Information	Diversity

- **Peacetime control**
  - Graph/table rather than text control
  - Administrative work and patrol support
- **Disaster control**
  - Text-based situation control rather than graphs/tables
  - Active response procedures by disaster type and disaster control

- **2D/3D conversion method information display**
  - Flat map-based underground tunnel situation information expression
  - Provision of information for quick situation exdetermination
- **Real-time 3D spatial information display**
  - pression of 3D virtual information in the underground communal area
  - Representation of moving objects (patrols, robots, unauthorized persons, etc.)
  - Display of moving and fixed object information

- **Digital twin model display**
  - Display of digital twin model information for each stage
  - Display of user interest layer information
  - Disaster prevention information such as preventive measures expression

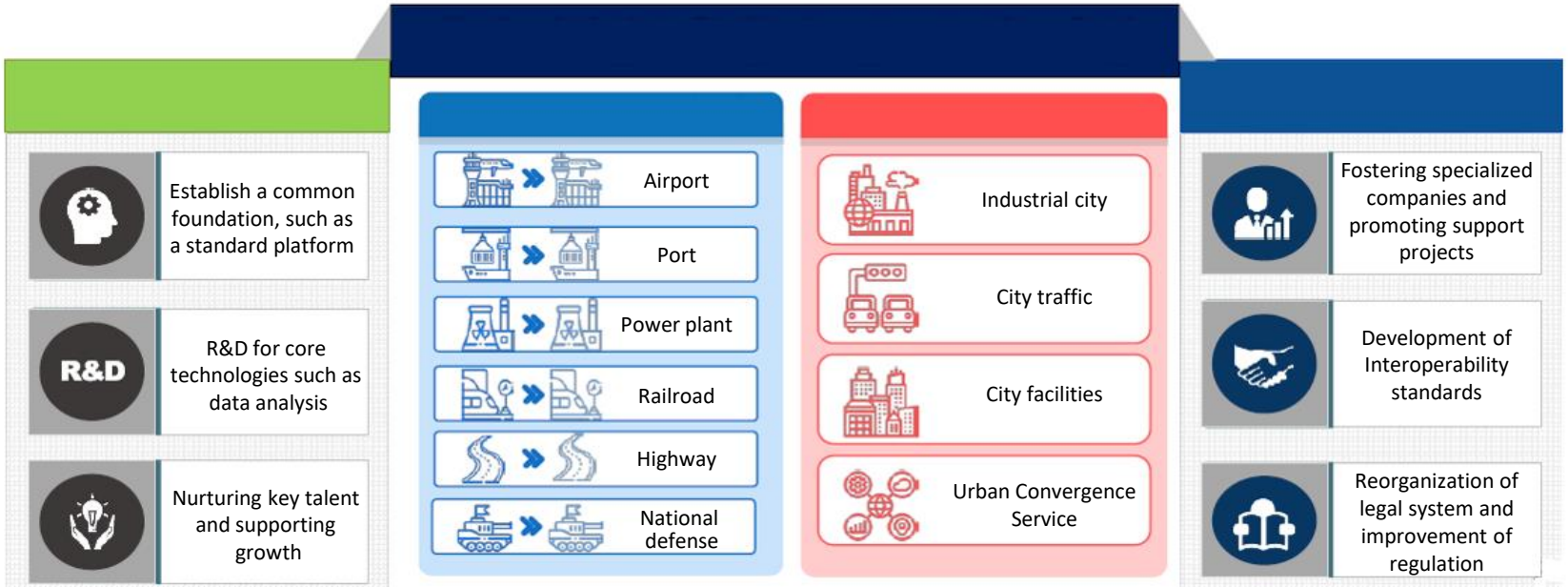
03 Utilization plan

Representative Performance and Utilization Plan

Reinforcement of national competitiveness based on digital twin for digital economy innovation

4 Strategic Goals

- Strengthening the foundation for national economic growth
- Massive job creation
- Fostering new digital industries
- Strengthening public safety



Digital Twin Forum in Korea

https://www.digitaltwinforum.kr/

DT.Forum 디지털트윈포럼

- Law/Institution
- Technology/Platform
- Smart City
- Smart Factory
- Smart Port
- Smart Farm
- Smart Safety
- Smart Building

ETRI 컨소시엄 DT DT연구단

Disaster Safety Management Technology based on Digital Twin

Thank You

And we will do our best.