[ADB Workshop on Building NSDI]

Nov. 7, 2024

Daejong Kim(Ph.D)

djkim@krihs.re.kr

{Geospatially Enabled Society Research Center}

KRIHS 국토연구원

CONTENTS

I

Introduction

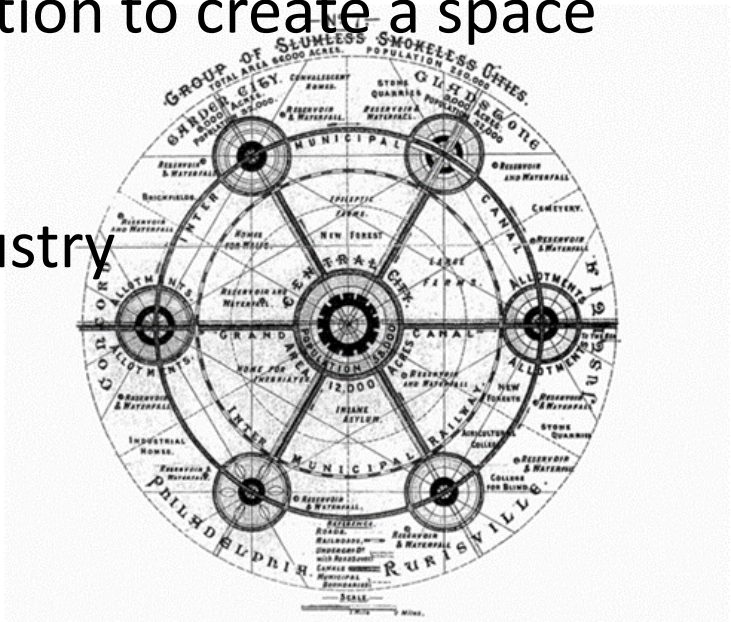
Why do we need spatial information?

- Navigation and exploration for survival(resources)

- Spatial planning, design and construction to create a space
  Building / road → city…
  CAD/BIM…

- City operation/management and industry
  GIS/Digital Twin…

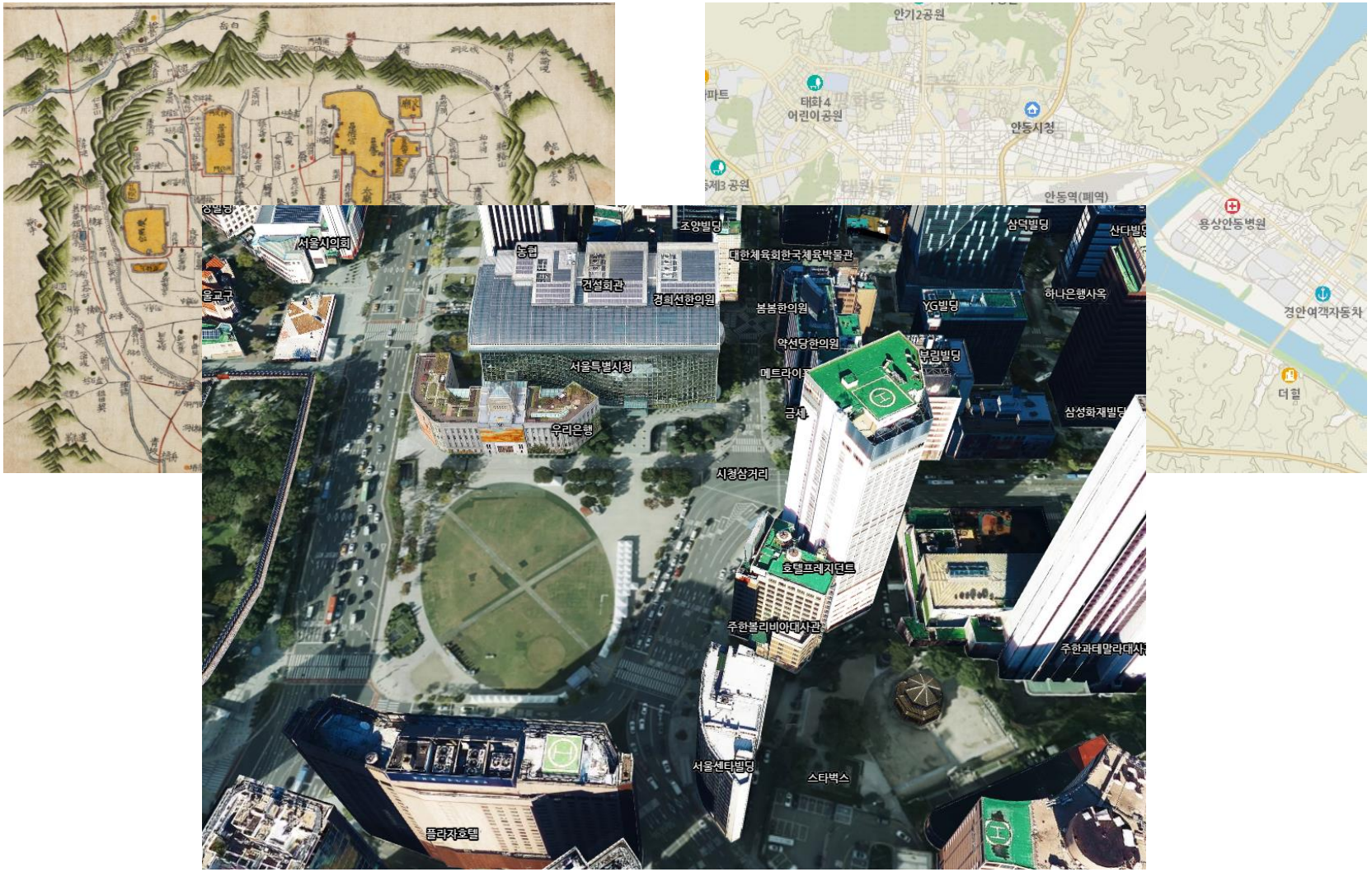
- Solving urban/spatial problems
  GIS/Digital Twin…



Ebenezer Howard, Garden City model, 1898

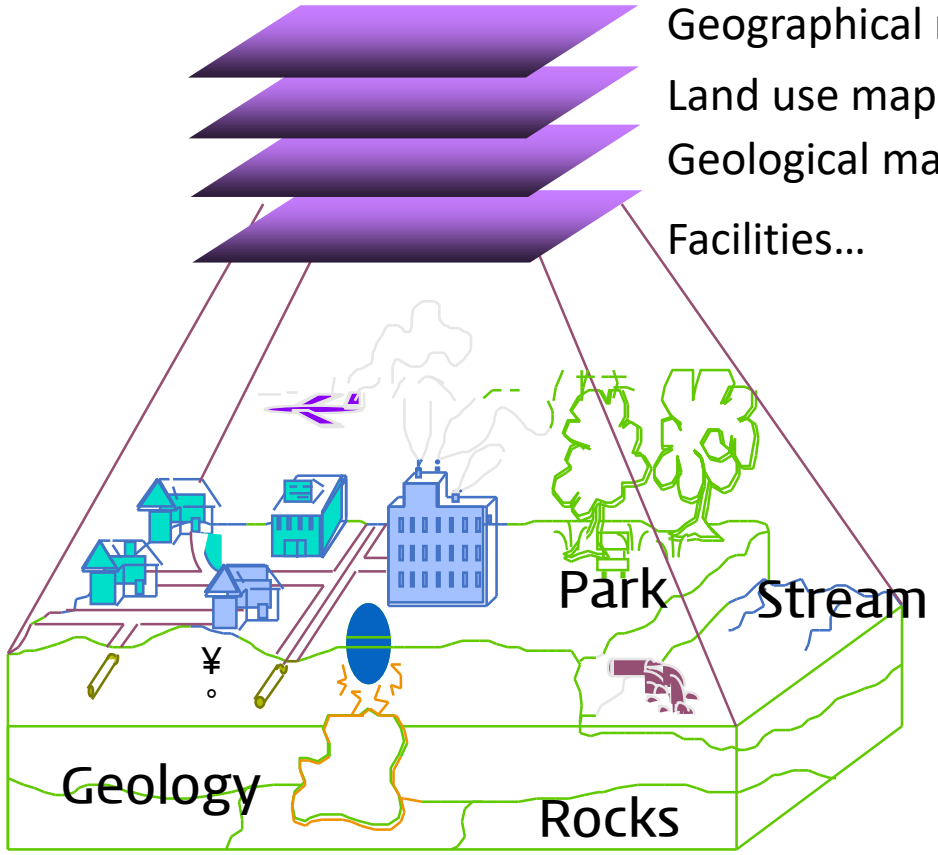
Evolution of geospatial data

Digital transformation of space: Analog → Digital(2D → 3D, + Attribute + Sensing)



Abstracted spatial data in analog era

Representation of real world with map/geographical visualization



Abstraction

With geometry(point/line/polygon)

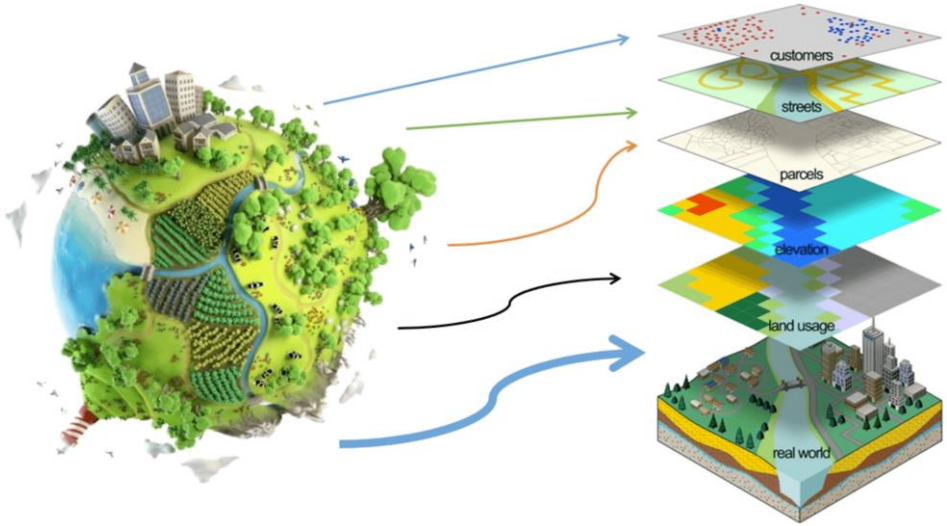
Real world

Big advancement in geospatial technologies?

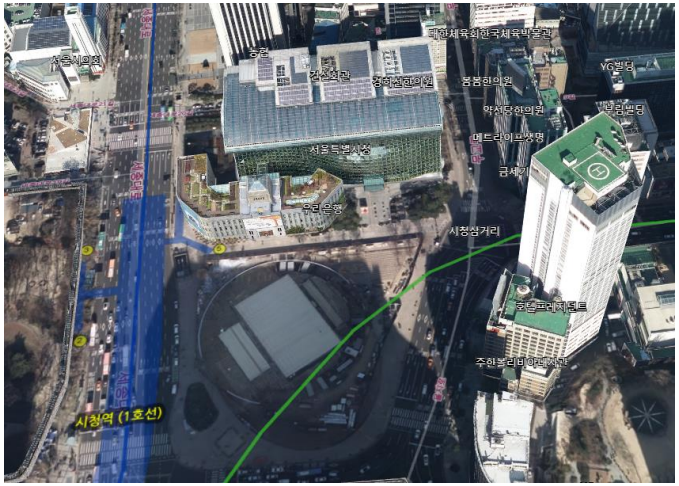
Getting synchronized b/w real world and data world

As it was (abstracted) :: past → As it is (fidelity):: real time

ICT being advanced,
Mapping sensors, communication, edge & cloud computing, AI…

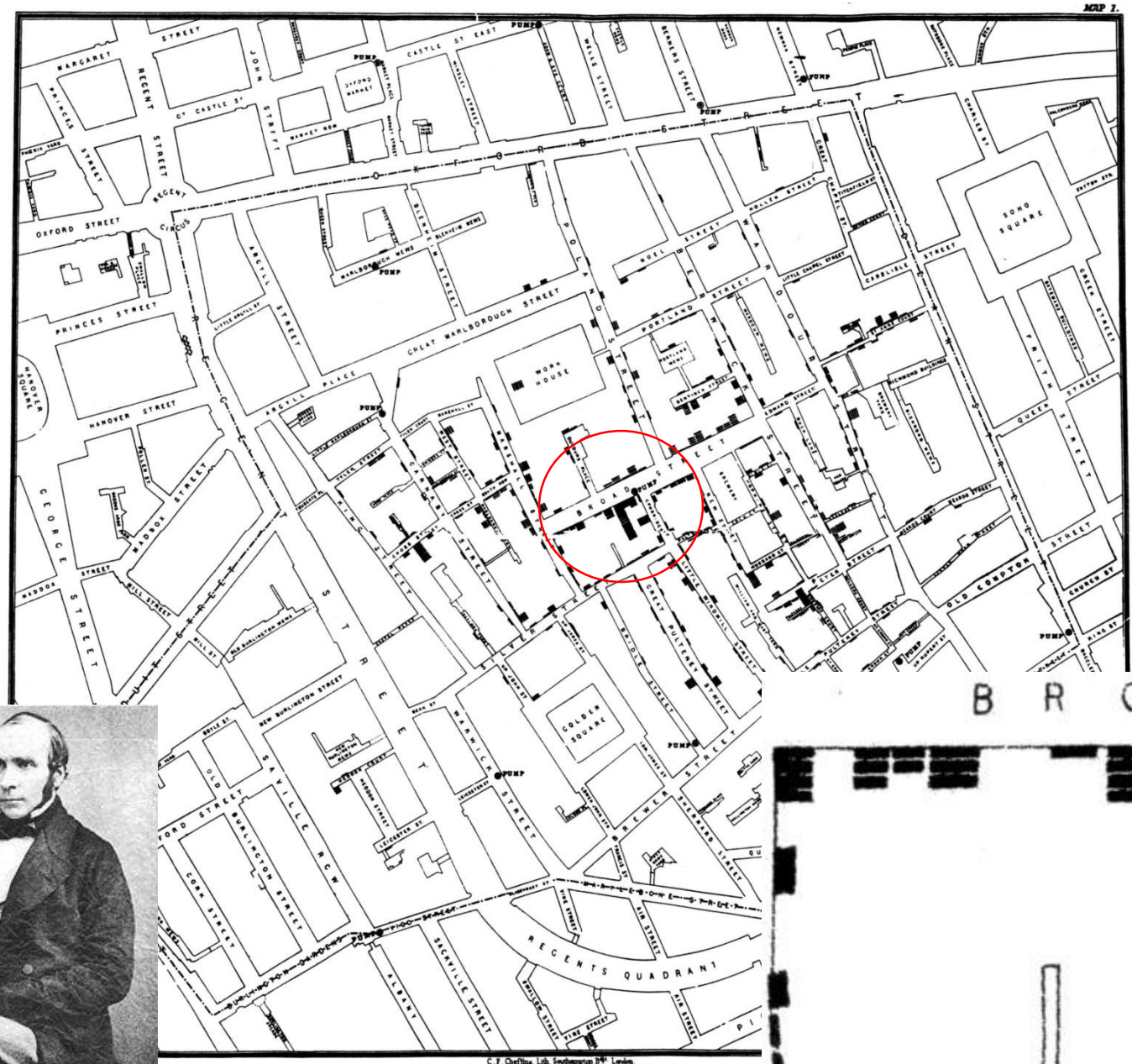


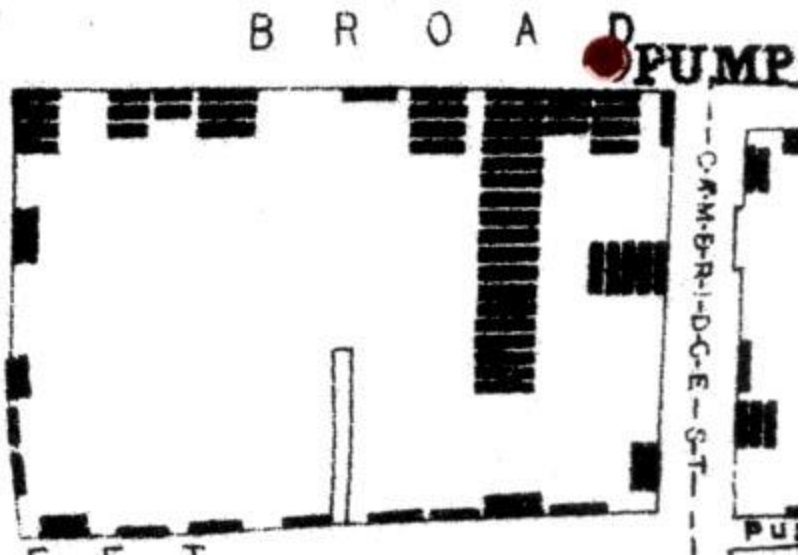
https://www.geo.university



https://smap.seoul.go.kr


Over 500 mortalities for some weeks
OUTBREAK!
In Soho, England in 1854


MAP 1.
OXFORD STREET
REGENT STREET
REGENT'S CIRCUS
PRINCES STREET
HANOVER STREET
GEORGE STREET
MADDOX STREET
ARGYLL PLACE
GT MARLBOROUGH STREET
MARLBOROUGH MEWS
WORK HOUSE
POLAND STREET
PORTLAND MEWS
BROAD STREET
BROAD STREET PUMP
HARDWICK STREET
SOHO SQUARE
NOEL STREET
LITTLE CHAPEL STREET
CARLISLE STREET
GREEK STREET
FRITH STREET
QUEEN STREET
OLD COMPTON
CHURCH ST
RICHMOND BUILDINGS
NEW BURLINGTON STREET
SAVILLE ROW
OLD BURLINGTON STREET
CORK STREET
GOLDEN SQUARE
REGENTS QUADRANT
SACKVILLE STREET
ALBANY
C. F. Cheffins, Lith. Southampton Bldgs London.


B R O A D
PUMP

Approaches to solve problem (ex. Health)

Diagnosis

- What/where is a problem?
- Causes?
- *Effective?*

Prescription

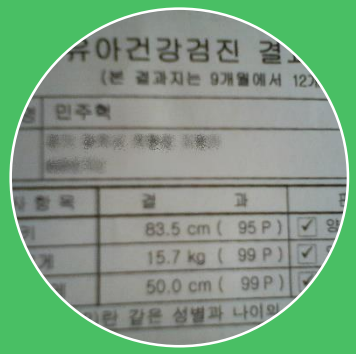
- Alternatives
- Choice of best alternatives
- Implementation

Data types in hospital

Picture

Video

Text



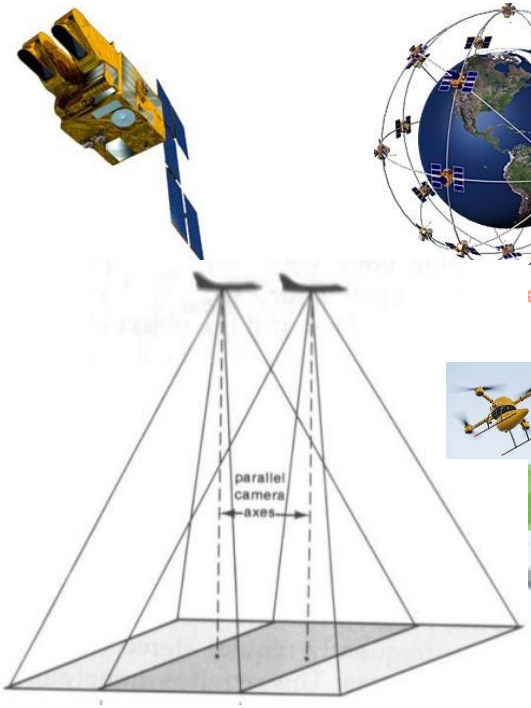
Number

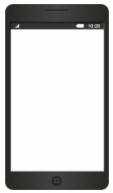
Map

(X-ray etc.)

Structured vs Unstructured | Small vs Big | Spatial vs Aspatial

Data collection in urban space





출처: 김대종 외 (2016), 여성안전붕야의 공간빅데이터 활용방안, p.11

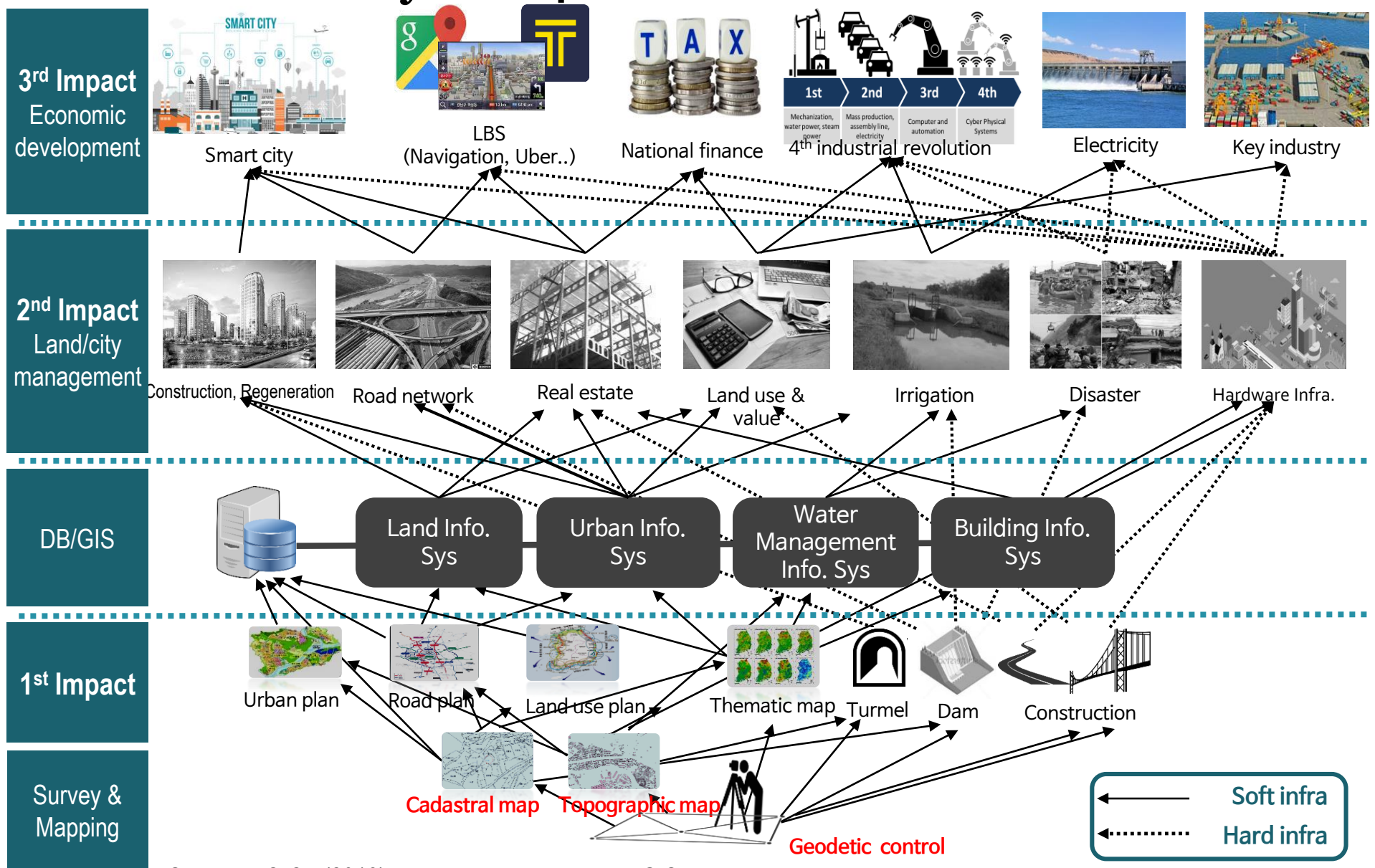
Creation

Planning
Operation

GCP
Place names
Orthophoto
DEM
3D
Land use
Greenbelt
Urban plan
Land price
Forest type
Under. facilities
•
•
Floating pop.
Credit card
SNS

Framework data Thematic map Geo-bigdata

Root industry for 4th industrial revolution



Source: KOICA (2018), Integrated evaluation on GIS projects

II

Understanding NSDI policy

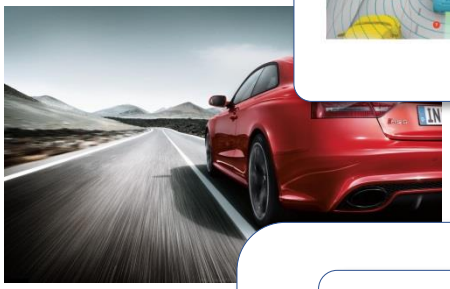
What is National Spatial Data Infrastructure

"… the technology, policies, criteria, standards, and employees necessary to promote geospatial data sharing throughout the Federal, State, Tribal, and local governments, and the private sector (including nonprofit organizations and institutions of higher education)" Section 755, Geospatial Data Act of 2018, USA

"shall ensure that geospatial data from multiple sources (including the covered agencies, State, local and tribal governments, the private sector, and institutions of higher education) is available and easily integrated to enhance the understanding of the physical and cultural world

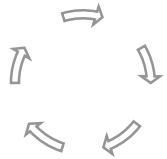
Road is a hardware infrastructure to transport people and goods. Spatial data is a software infra to develop and manage hardware infra. This means that software infra should go first to develop hardware infra. SDI should be national because most data are owned by government. Government needs geospatial data to protect and manage people, land and infrastructure. The data should be accessible by all people.

Components of NSDI

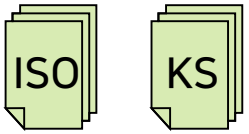


Applications

Framework Data



Clearinghouse

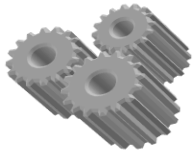


Standards

Human Resources

Institutions

Organization



Technology

National **S**patial **D**ata **I**nfrastructure

Partnership

History of NSDI policy in Korea

Background of National GIS(NGIS)

Dec. 7, 1994(Seoul)

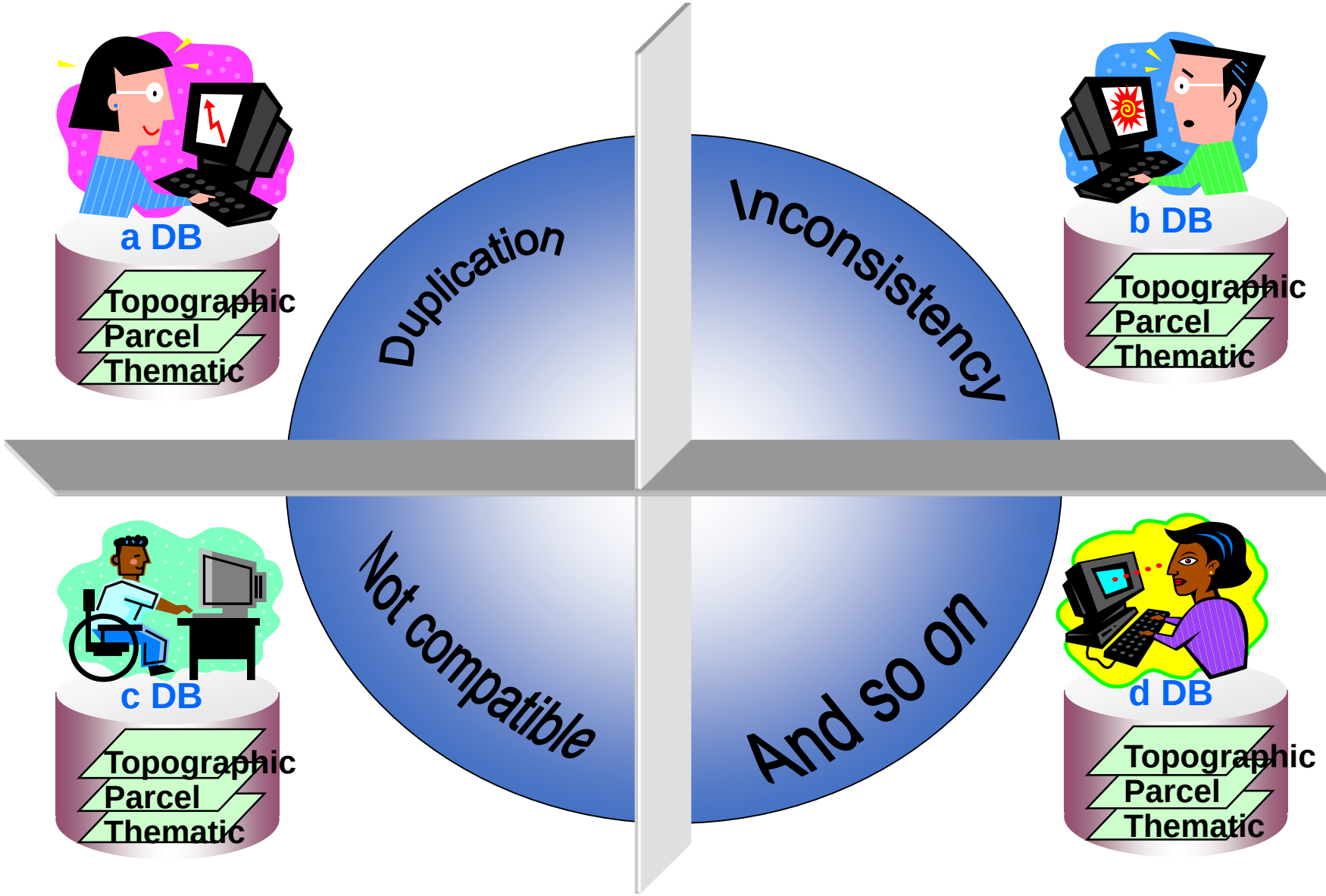
hankookilbo.com

April 29, 1995(Daegu)

www.ehistory.go.kr
db.history.go.kr

History of NSDI policy in Korea

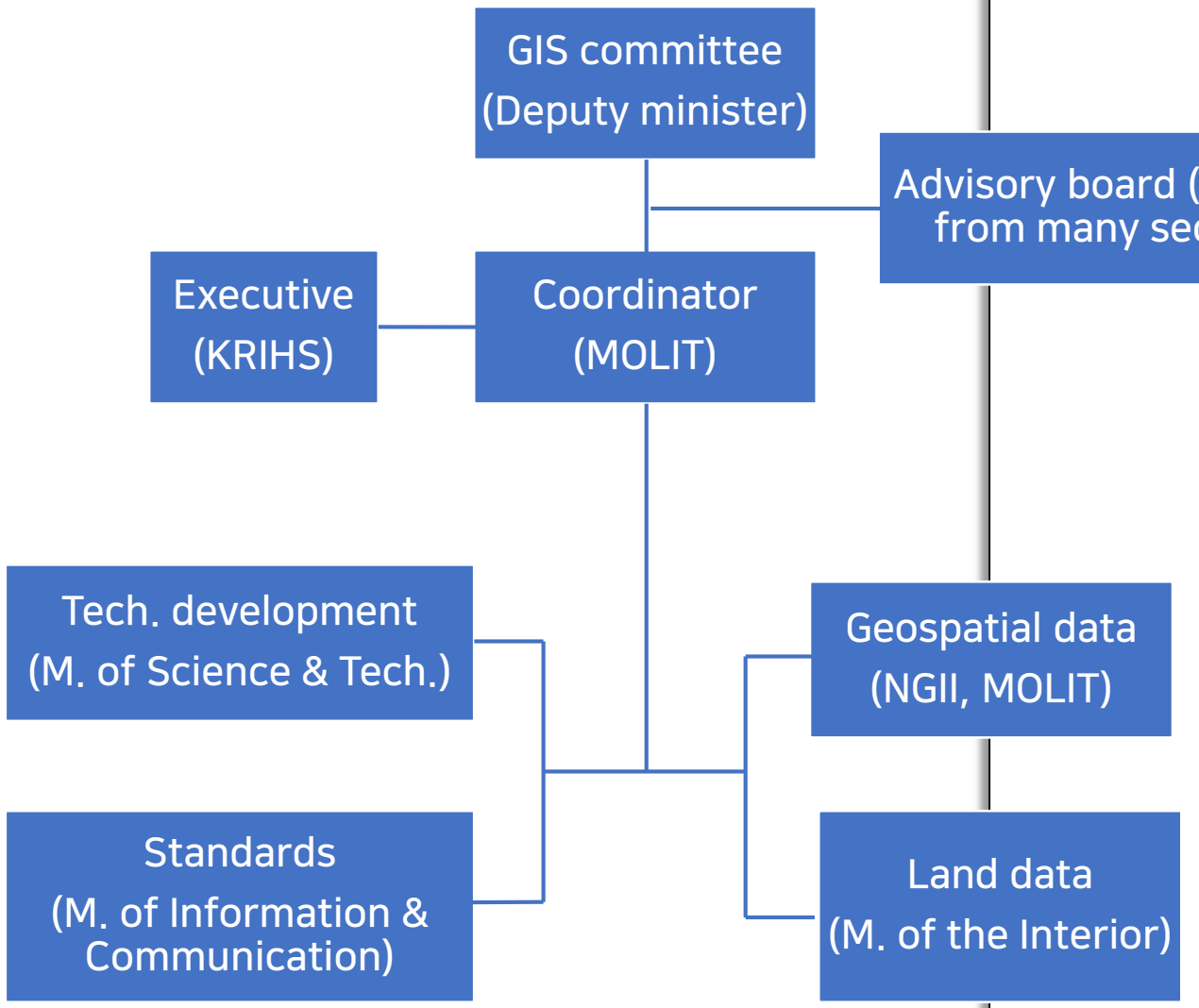
Background of National GIS(NGIS)



History of NSDI policy in Korea

The first master plan for NGIS(1995-2000)

國家地理情報體系(NGIS) 構築 基本計劃

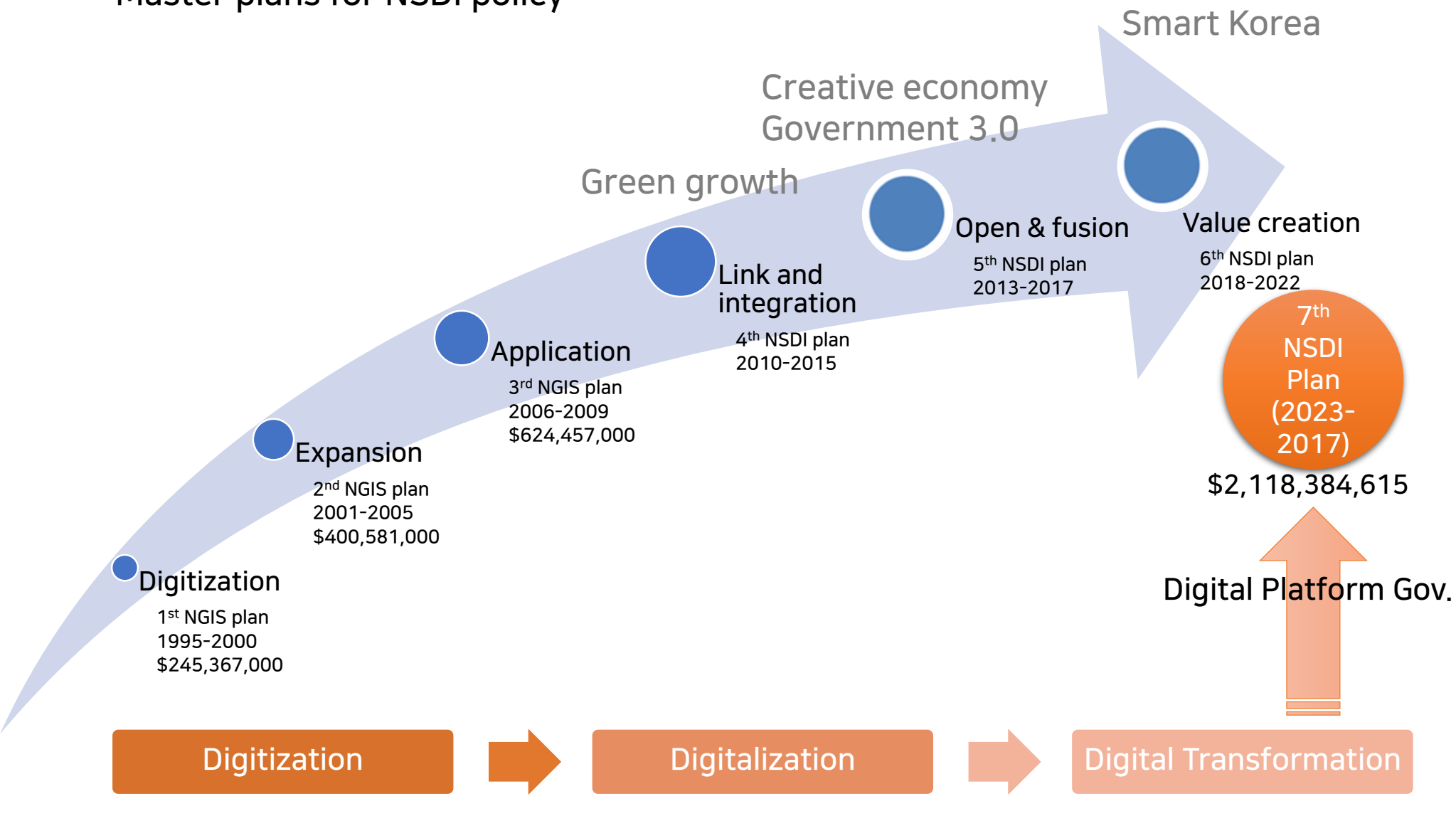


1997. 10

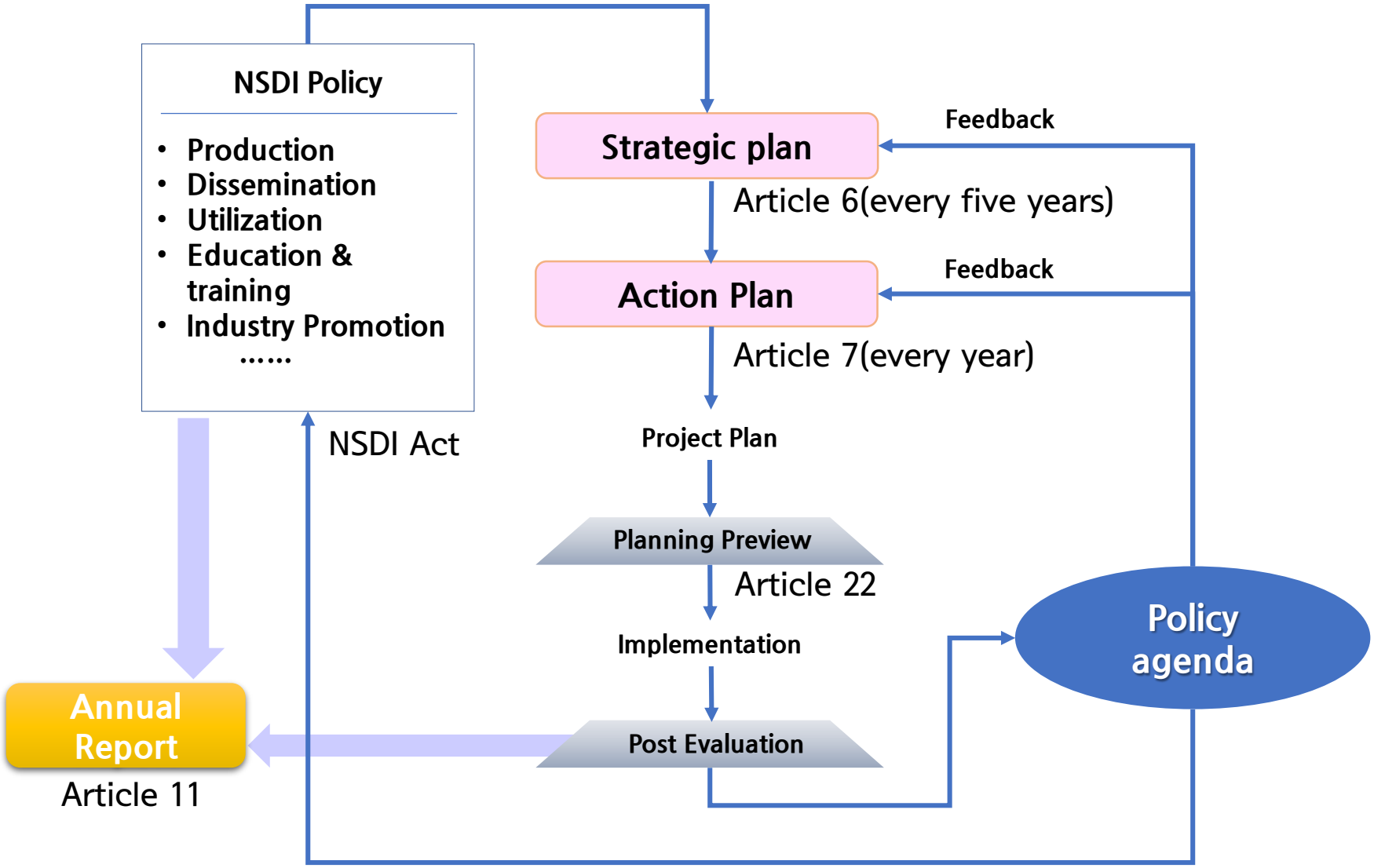
NGIS 總括分科委員會

History of NSDI policy in Korea

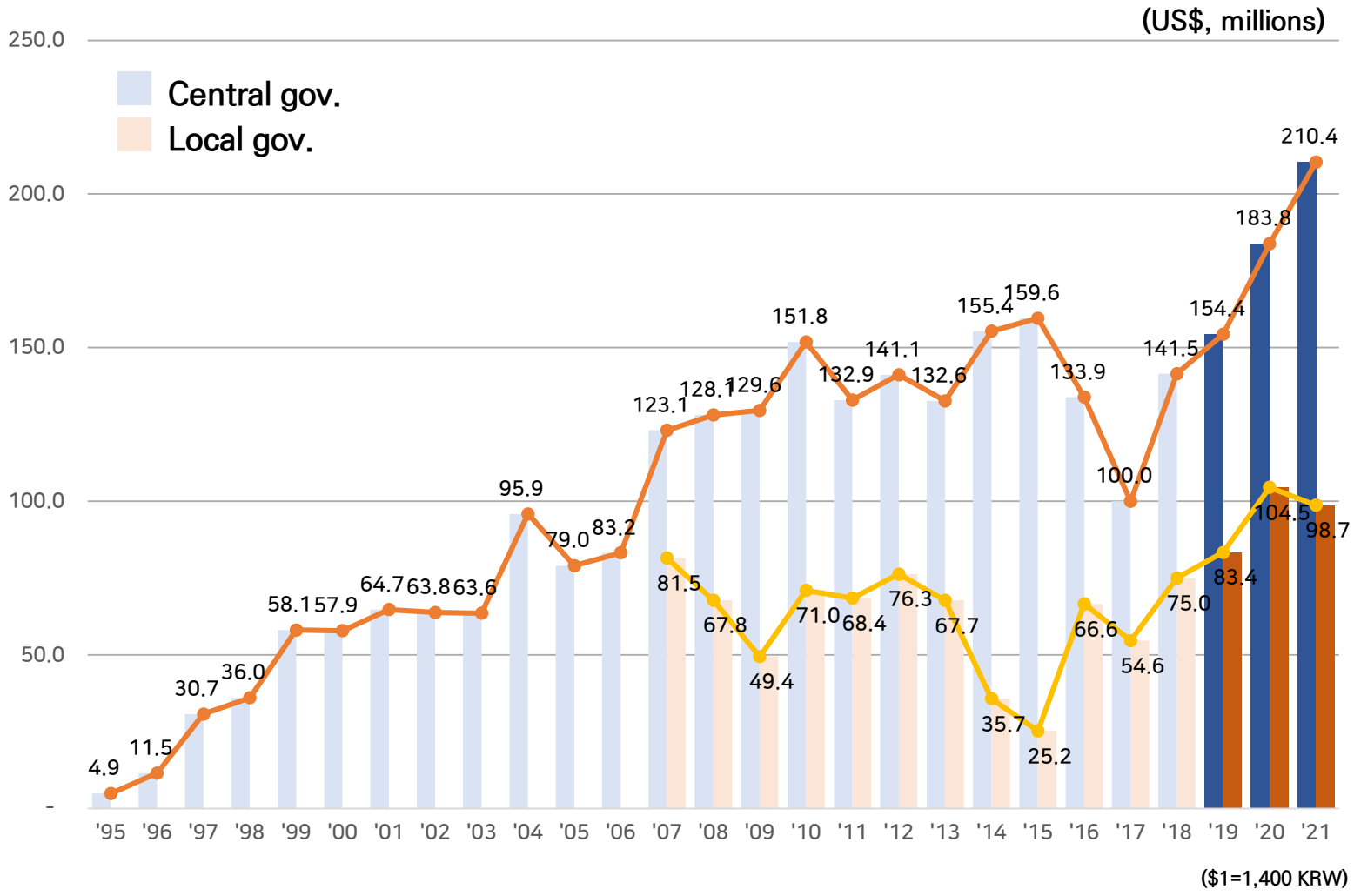
Master plans for NSDI policy



NSDI policy framework in Korea

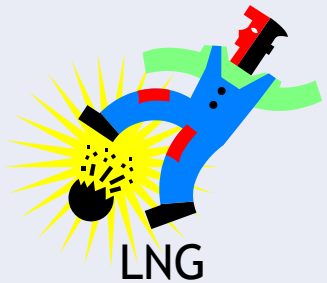


Investment trend in building NSDI



Main projects by MOLIT

Too many regulations for land use



LNG explosions

1st NGIS Master Plan | 2nd | 3rd | 4→5th

National land planning and utilization act

Act on the est. and use of NGIS | NSDI Act | F. Act

Framework act on land use regulation

F. act on the N. Land

(1996) Underground facility information management system

(1998) LMIS

(2003) KLIS

(1996) PBLIS

(1999) NSIC

(2009) Vworld

Digitalization of topographic maps

Framework data

3D image

National Spatial Data Integrated Sys.

(2001) UPIS

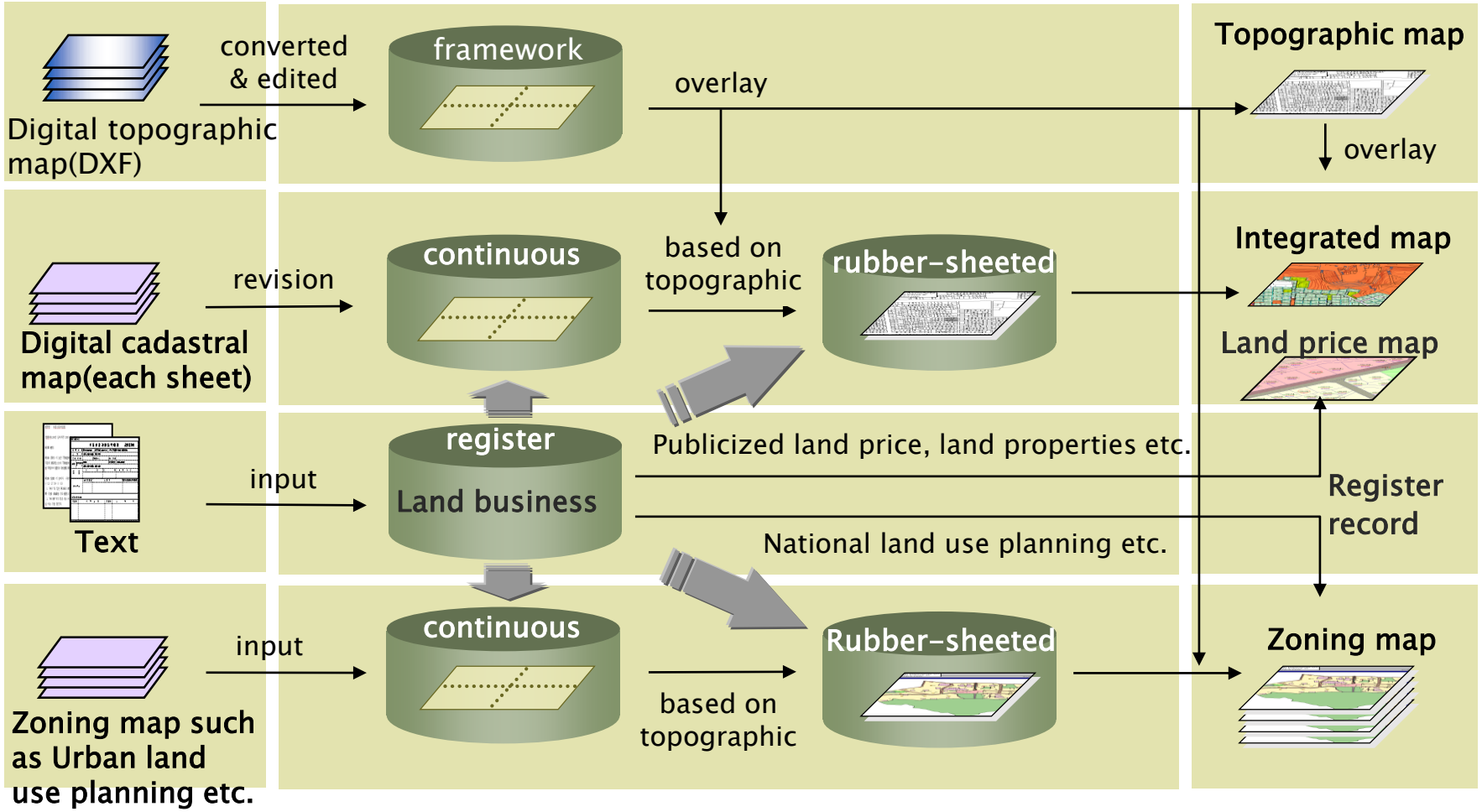
(2006) KOPSS

(2007) LURIS

LMIS: Land Management Information System
PBLIS: Parcel-Based Land Information System
KLIS: Korea Land Information System
NSIC: National Spatial Information Clearinghouse
NSDI: National Spatial Information System
UPIS: Urban Planning Information System
KOPSS: KOrea Planning Support System
LURIS: Land Use Regulation Information System

1995 2001 2005 2010

Korea Land Information System

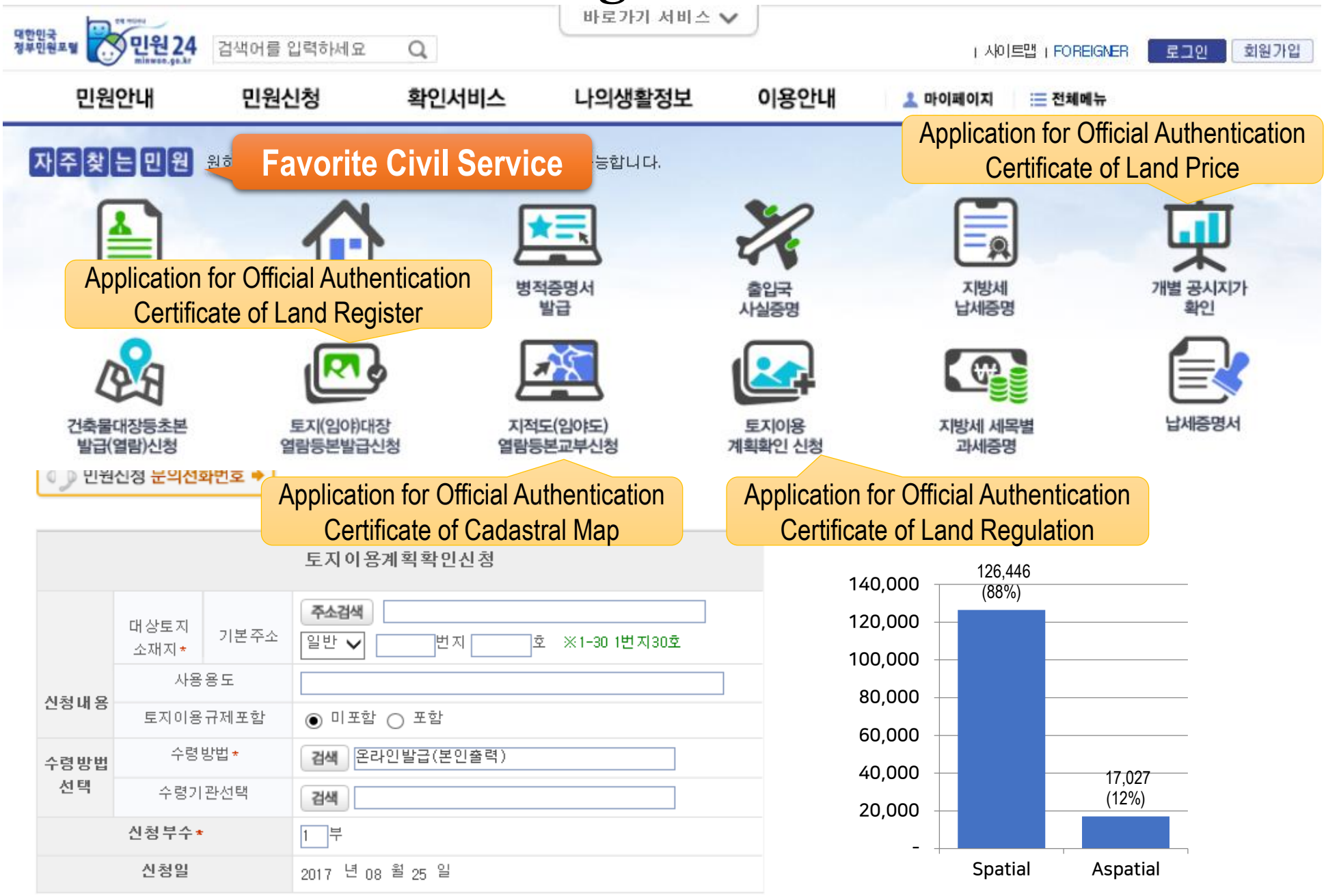


Source: Ministry of Construction and Transport, 2000, Guideline for Land Management Database

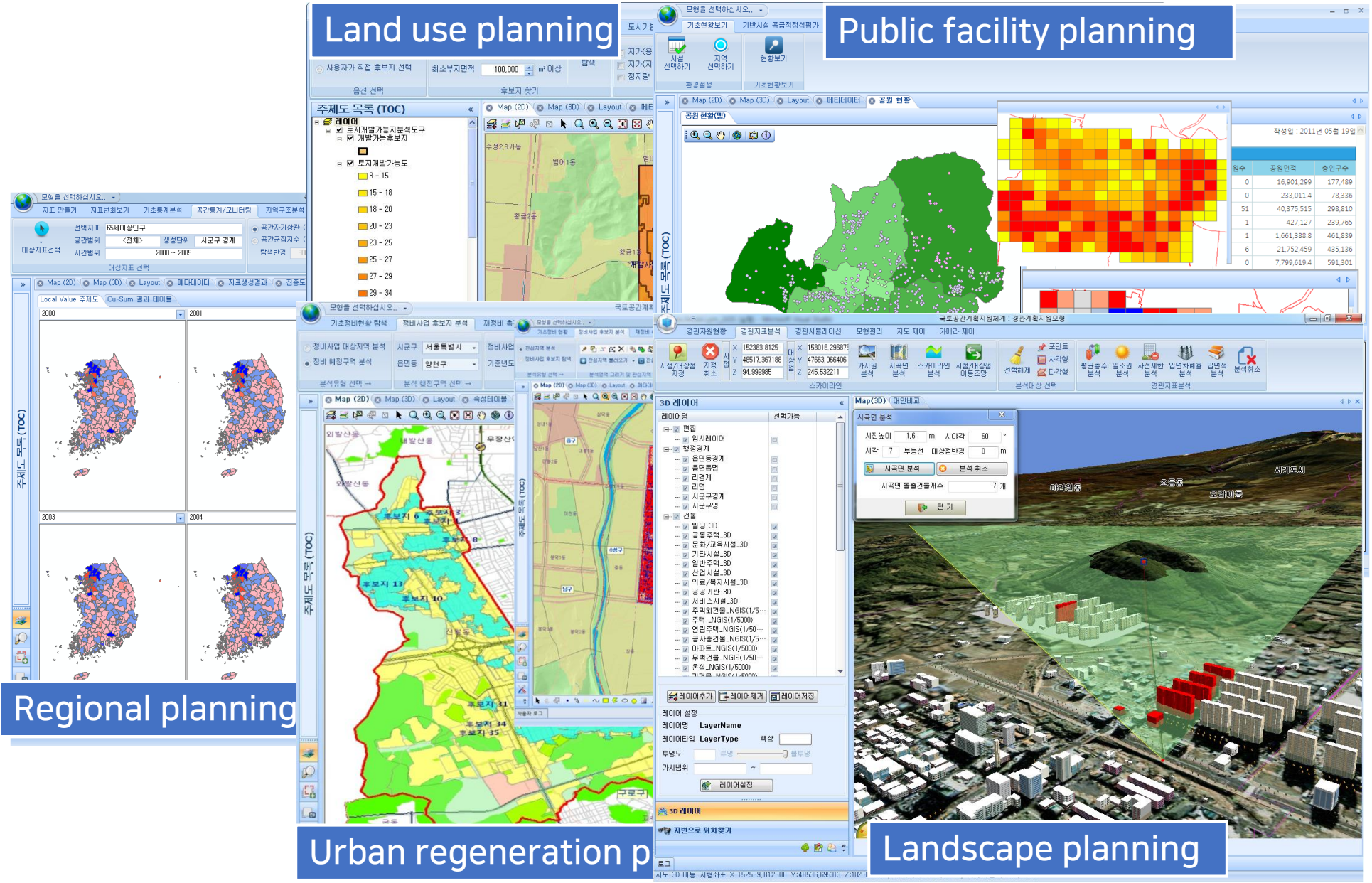
Vworld.kr for sharing geospatial data

3D data-based open platform service with many other spatial data, past areal photos, indoor data, visual analytics tools and OpenAPIs

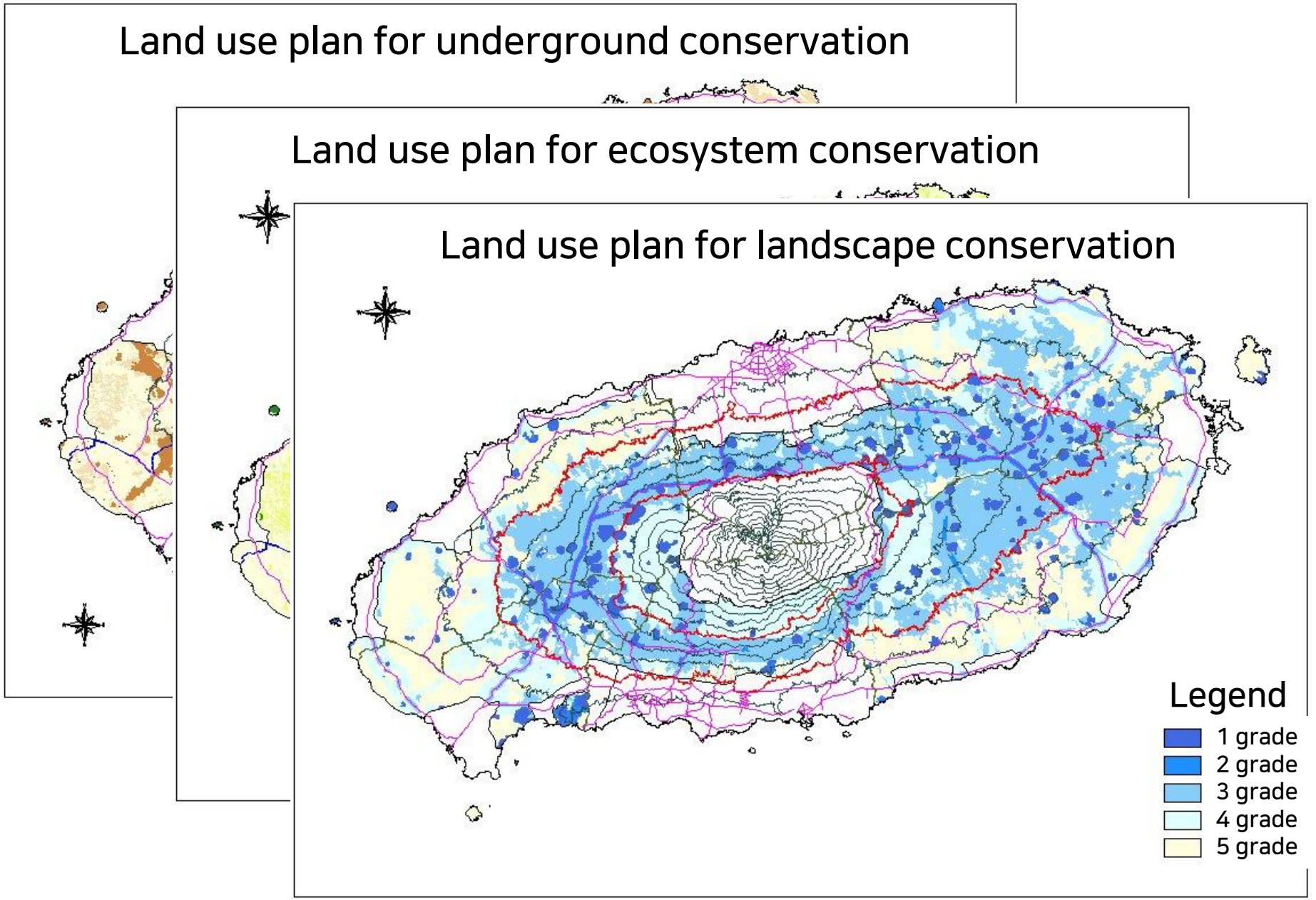
Public services through e-Gov.



KOrea Planning Support System

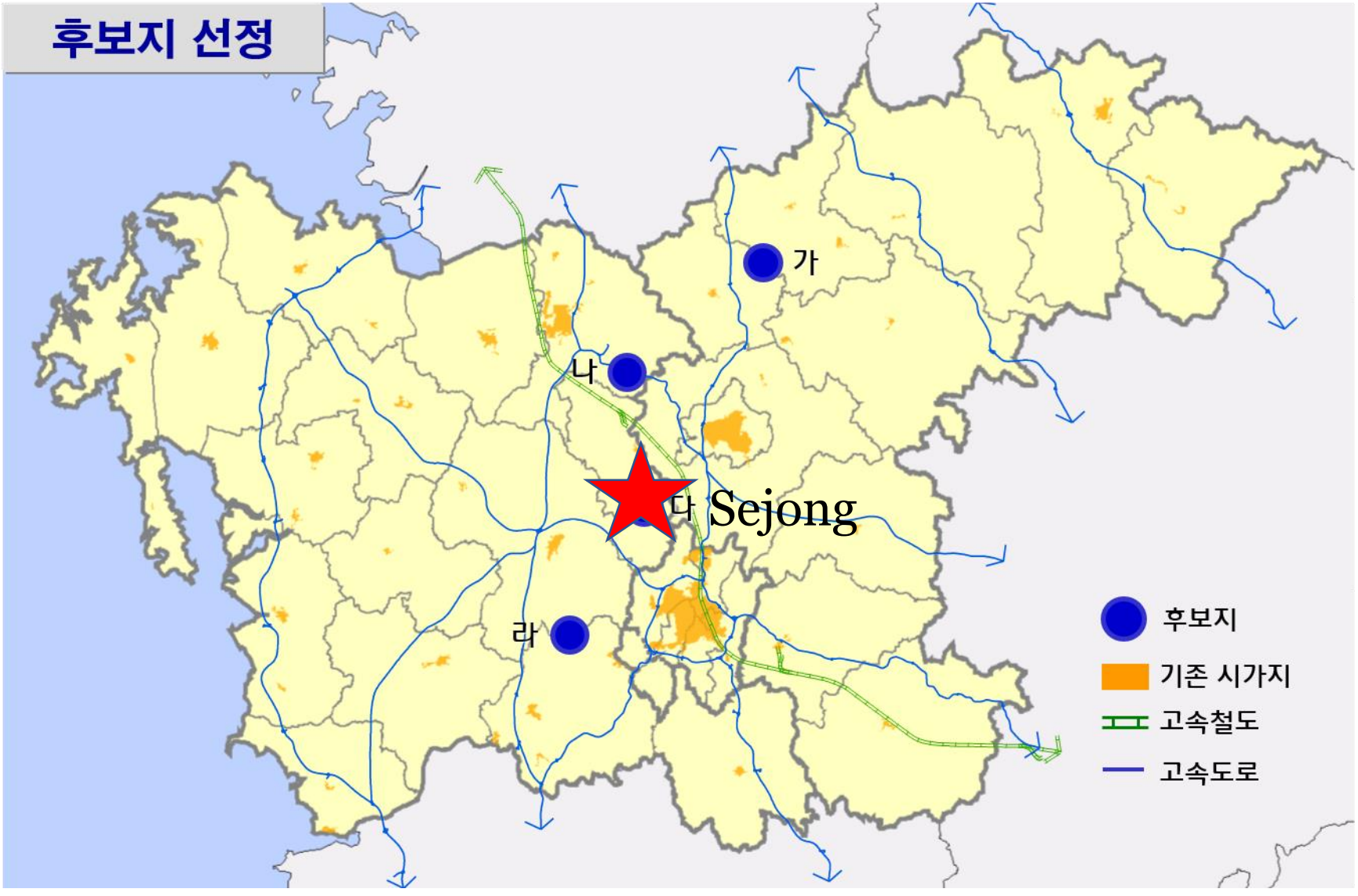


Land use planning with geospatial data



Site selection for new administrative capital

A Study on Site Selection and Assessment for a New Administrative Capital(2004)



Smart city integrated platform of Anyang city

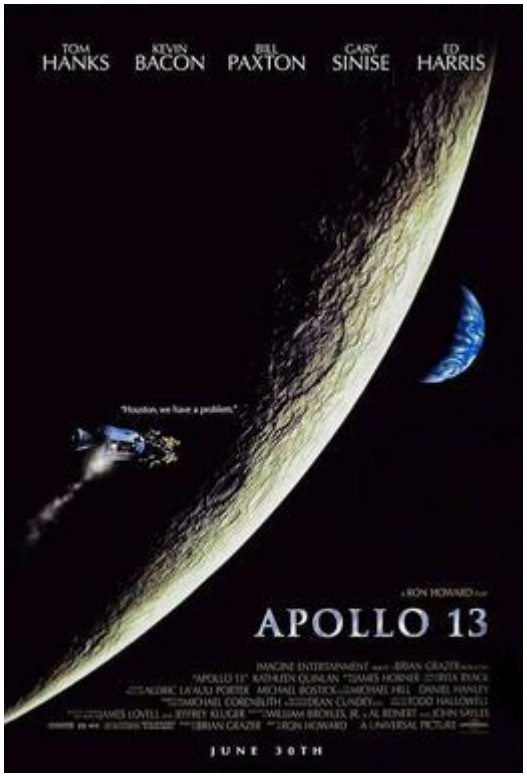
https://smartcity.go.kr :: https://post.naver.com/

VI

Digital Twin: The Next Frontier

The origin of digital twin?

1970. 4



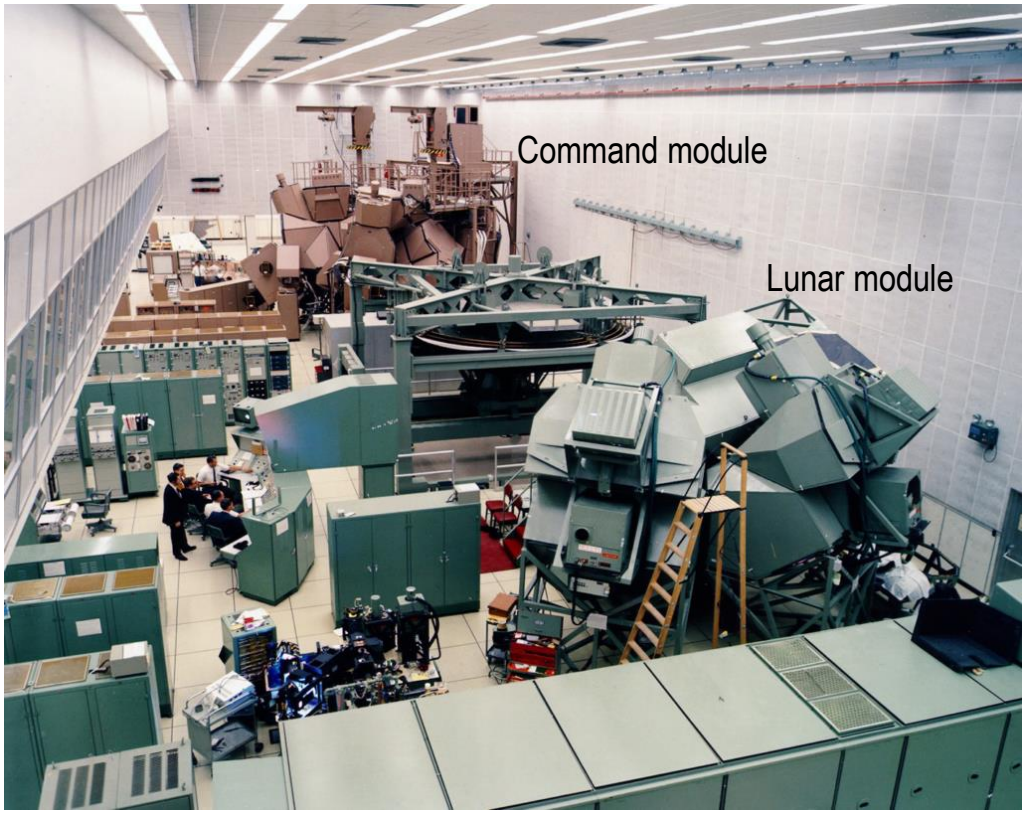
Physical

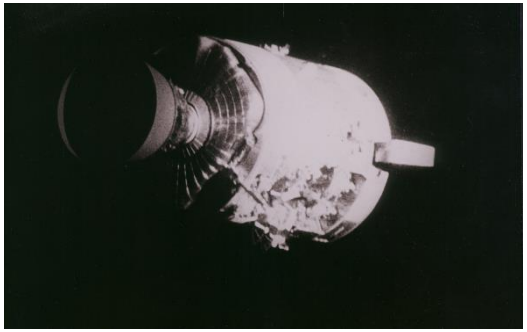
Connected

Adaptable

Threaded

Responsive

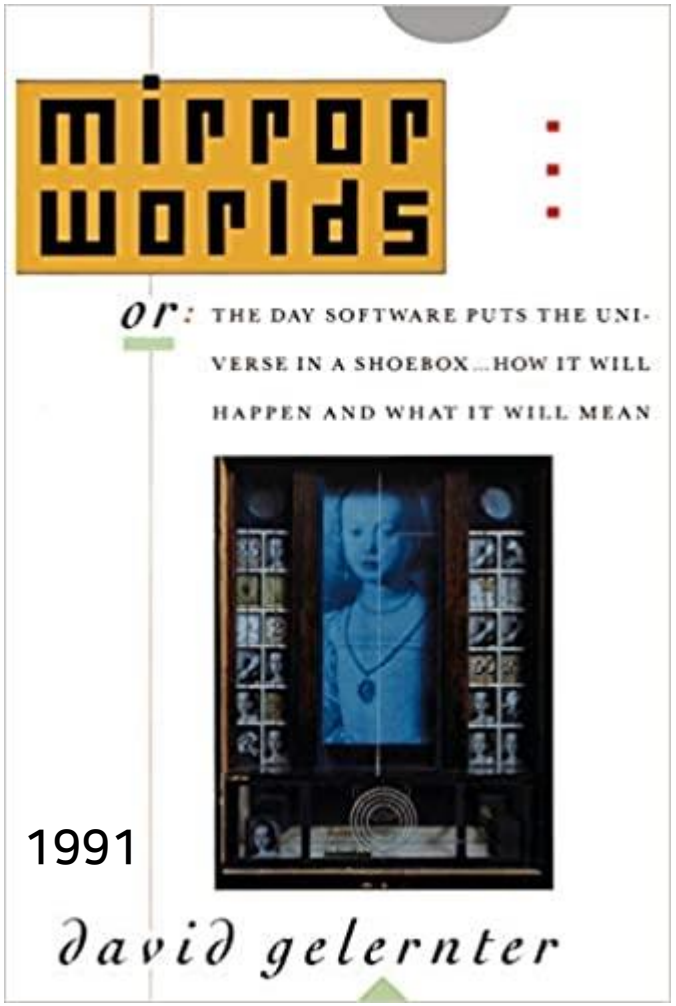




"The simulators were some of the most complex technology of the entire space program: the only real things in the simulation training were the crew, cockpit, and the mission control consoles, everything else was make-believe created by a bunch of computers, lots of formulas, and skilled technicians".

Gene Kranz, NASA Chief Flight Director for Apollo 13

The origin of digital twin!



"The Mirror World will be a digital twin of reality, a crystal ball through which we can observe and interact with the world in unprecedented ways. Imagine a world where real-time traffic flows are displayed on a map, and every corner of a city can be monitored through CCTV cameras. This is the future I envision, a future where the physical and digital worlds merge seamlessly."

Daejong Kim(2021), The concept of national digital twin and policy directions, Planning and Policy(Vol. 474)

The first appearance of DT in academic paper

a) Actual view

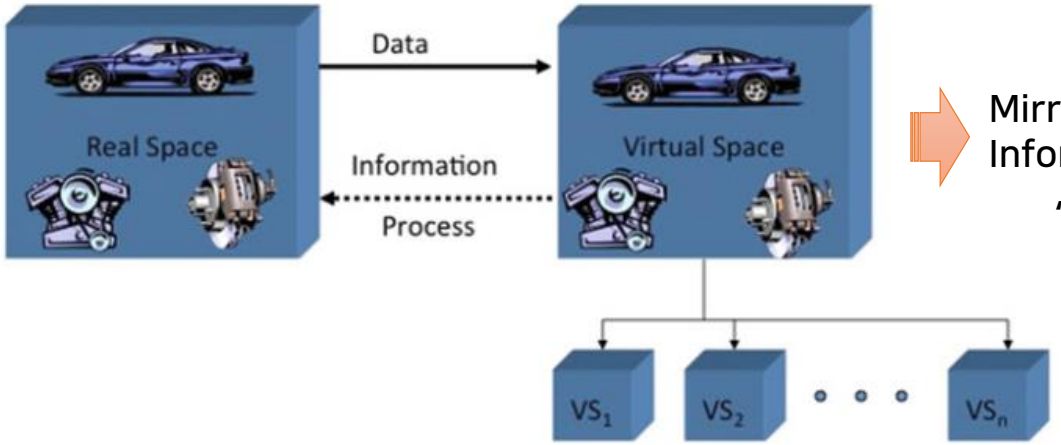
b) Future view

"…This was the time when the first profits appeared, and several modifications were made on the construction project based upon the results of the geometrical building of its digital twin. This modifications were again carried to the digital version, then checked and so on…"

Hernández, L. A. and Hernández, S. 1997. Application of digital 3D models on urban planning and highway design. Trans Built Environ 33: 391–402.

The emergence of lifecycle-based digital twin

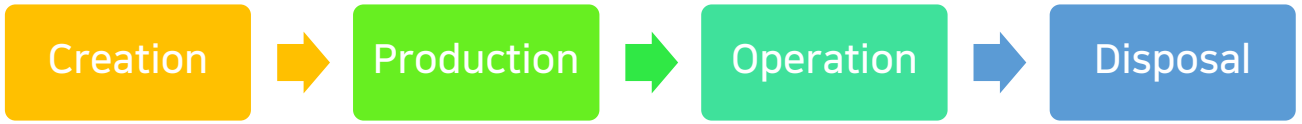
Conceptual ideal for PLM(Product Lifecycle Management)



Mirrored Spaces Model
Information Mirroring Model

'Digital Twin' coined

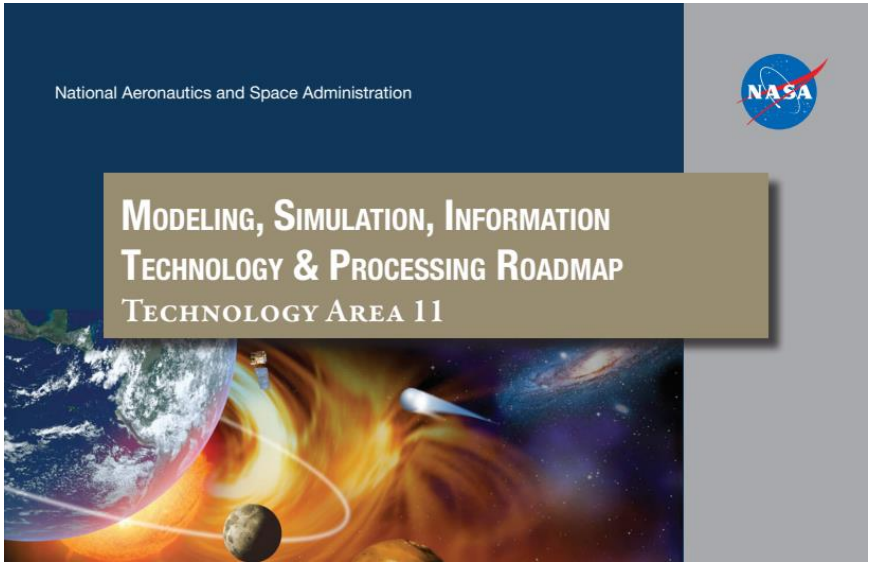
presented by Michael Grieves @ University of Michigan (Lurie Engineering Center), Dec 3, 2002



Grieves, M. and Vickers, J. 2017. Digital twin: mitigating unpredictable, undesirable emergent behavior in complex systems. In Transdisciplinary perspectives on complex systems: 85-113. Springer, Cham.

Definition of digital twin

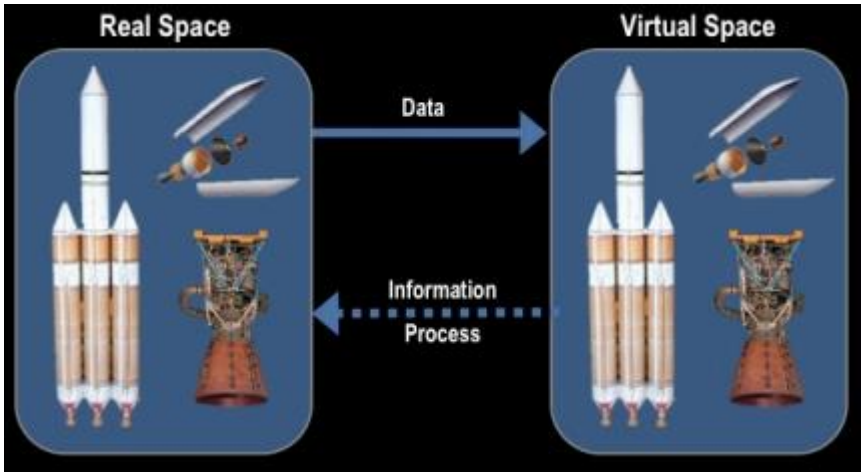
- NASA(2012)



- "…integrated multi-physics, multi-scale, probabilistic simulation of a vehicle or system that uses the best available physical models, sensor updates, fleet history, etc., to mirror the life of its flying twin…"

Definition of digital twin

- Grieves (2015), “Digital twin: manufacturing excellence through virtual factory replication”: White paper
  - Physical product + virtual product + data & information
  - Geometry + Behavioral and status characteristics → Visualization and performance test
  - Reduction in communication time and cost
  - For product lifecycle management



Information Mirroring Model

Gartner Top 10 Strategic Technology Trends

순위	2017년	2018년	2019년
1	AI and Advanced Machine Learning	AI Foundation	Autonomous Things
2	Intelligent Apps	Intelligent Apps and Analytics	Augmented Analytics
3	Intelligent Things	Intelligent Things	AI-Driven Development
4	Virtual and Augmented Reality	Digital Twin	Digital Twins
5	Digital Twin	Cloud to the Edge	Empowered Edge
6	Blockchain and Distributed Ledgers	Conversational Platforms	Immersive Technologies
7	Conversational Systems	Immersive Experience	Blockchain
8	Mesh App and Service Architecture	Blockchain	Smart Spaces
9	Digital Technology Platforms	Event-Driven Model	Digital Ethics and Privacy
10	Adaptive Security Architecture	Continuous Adaptive Risk and Trust	Quantum Computing

Definition of digital twin

Time	Definition of Digital Twin	key points
2010.11	A digital twin is an integrated multi-physics, multi-scale, probabilistic simulation of a vehicle or system that uses the best available physical models, sensor updates, fleet history, etc., to mirror the life of its flying twin.	integrated simulation
2014.4	Digital twin is a life n	eling
	other vehicle-specific	
2015	Very realistic models	del
2016	Digital twins are virtu	itutes
	nodes inside the inter	
2017	The term digital twin	
	well as being globally	
2017	Faster optimization al	ntrol and optimization
	products and product	
2017	Digital Twin is a set	mation
	geometrical level.	
2018.1	Digital Twins stand fo	lection
2018.2	A digital twin is a on	ca
2018.5	The digital twin mod	
2018.7	DT is a multi-domain	el
2018.8	Digital twin represent	lica
2018.9	This rich digital repre	sentation
2018.11	Digital Twin is essenti	l
	and cloud service, etc	
2018.12	BIM (Building Inform	
2018.12	Digital twin represent	resentation
2019.1	The new technology,	del
	"Digital Twin".	
2019.1	A digital twin is a virt	ual instance
	physical system's life	
2019.2	DT refers to a virtual object or a set of virtual things defined in the digital virtual space, which has a mapping relationship with real things in the physical space.	mapping
2019.6	DT is defined as a digital copy of a physical asset, collecting real-time data from the asset and deriving information not being measured directly in the hardware.	real-time data
2019.8	Digital twin can be regarded as a paradigm by means of which selected online measurements are dynamically assimilated into the simulation world, with the running simulation model guiding the real world adaptively in reverse.	Dynamic, bidirectional

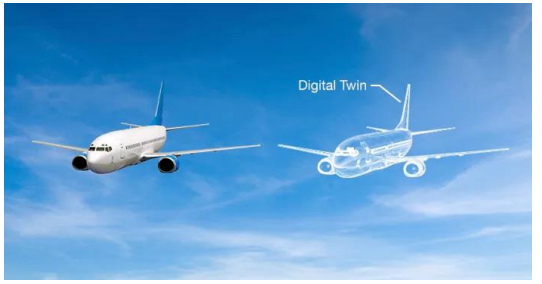
Integrated simulation
Fidelity modeling
Realistic model
Virtual substitutes
Digital copy/Virtual replica/Cyber copy/Dynamic replica
Digital representation/Dynamic representation
Updated virtual instance
Real-time data
Dynamic, bidirectional
Living model
Real-time control and optimization

Liu, Mengnan, Shuiliang Fang, Huiyue Dong, and Cunzhi Xu. "Review of digital twin about concepts, technologies, and industrial applications". *Journal of Manufacturing Systems (2020)*.

Conclusion of DT definition

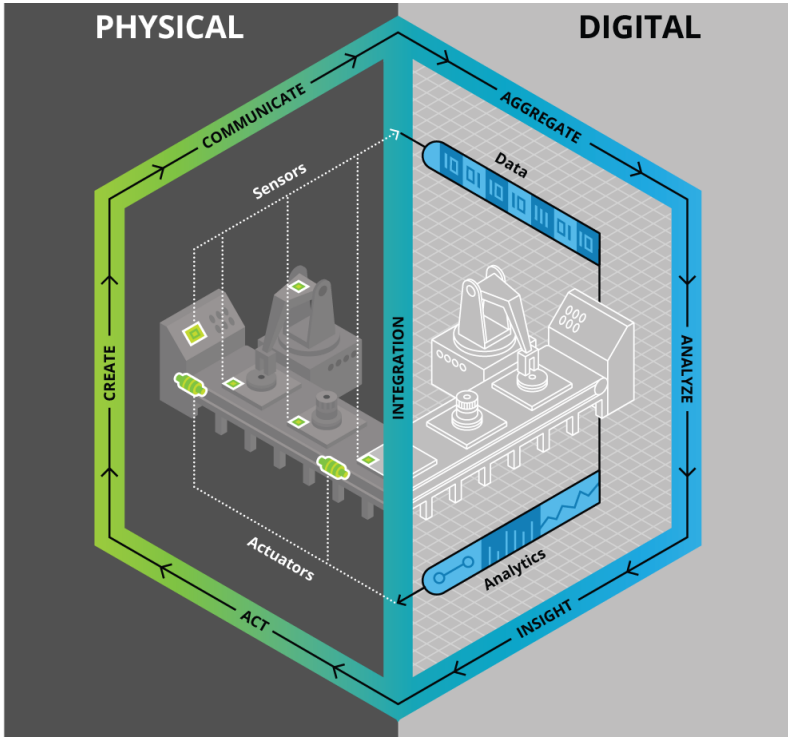
- Using technology to make an exact digital copy of something from the real world, just like identical twin
  - Form
  - Behavior
  - Property
  - Status/Situation)
  - Etc….

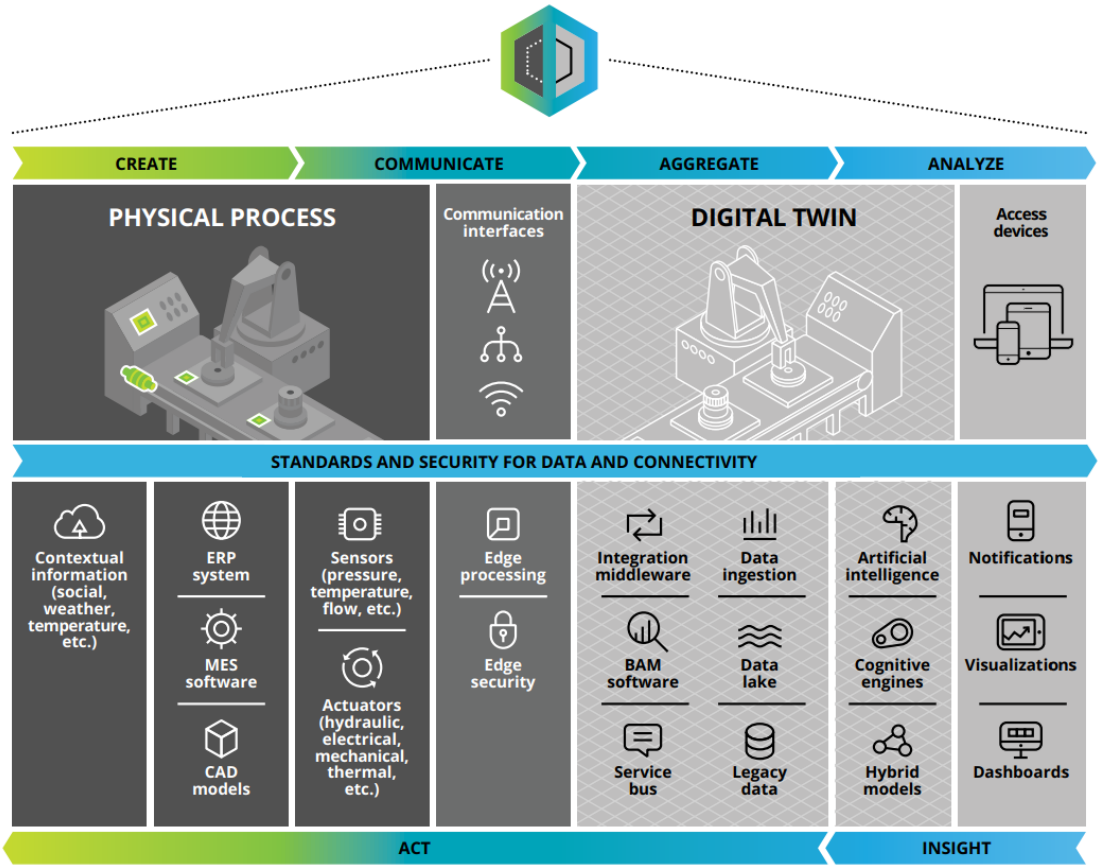
Static or dynamic



- Solution to real world problems
  - Design/Production/Circulation/Operation
  - Heath
  - Optimization
  - …

Conceptual Model by Deloitte





Parrott, Aaron, and Lane Warshaw(2017). "Industry 4.0 and the digital twin." In Deloitte University Press, pp. 1-17.

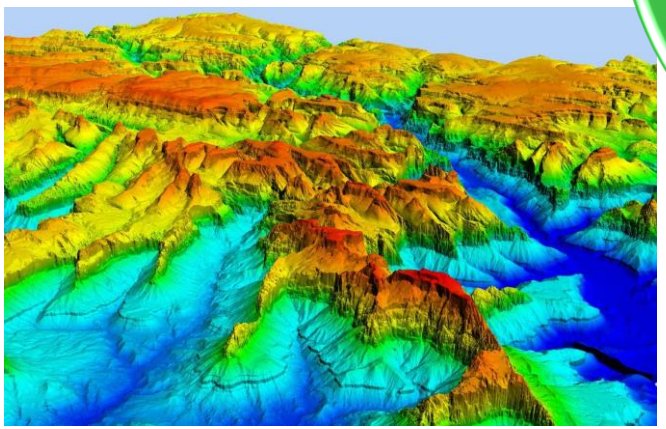
Components of 3D geospatial data base digital twin

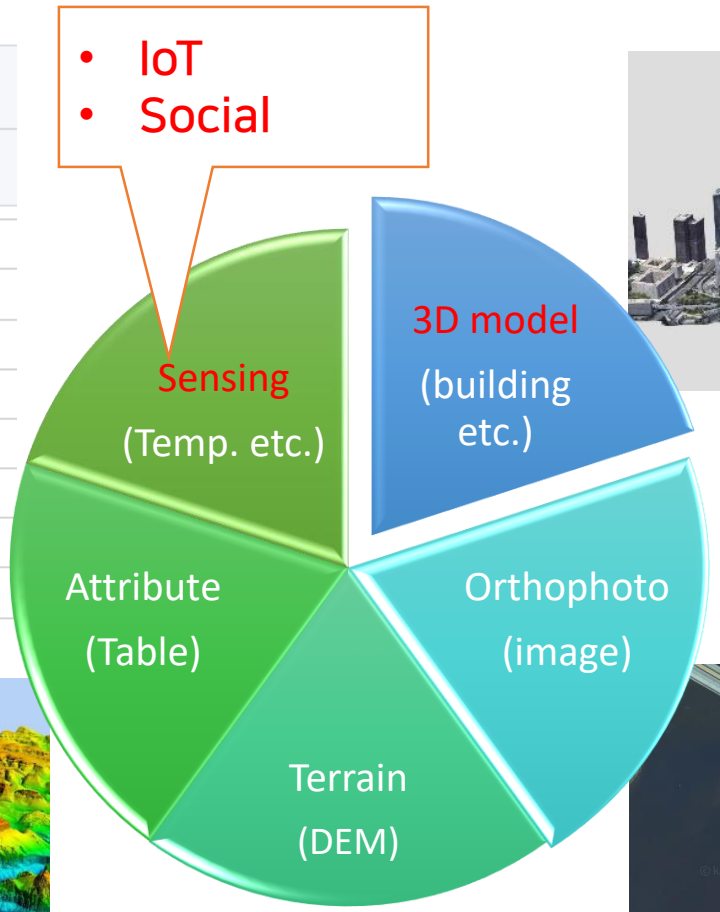
행복도시 대통령기록관

세종특별자치시 다솜로 250
(지번 : 세종특별자치시 어진동 614)

250, Dasom-ro, , Sejong-si, Republic of Korea
(지번 : 614, Eojin-dong, Sejong-si, Sejong-si, Republic of Korea)

건물명칭	행복도시 대통령기록관		
건물동명칭	-		
건물용도	-	구조	-
지상층수	4	지하층수	2
건물면적	.00 ㎡	건물높이	.00 m
용적률	-	건폐율	-
연면적	.00 ㎡	대지면적	.00 ㎡
사용승인일자	-		





Digital Elevation Model

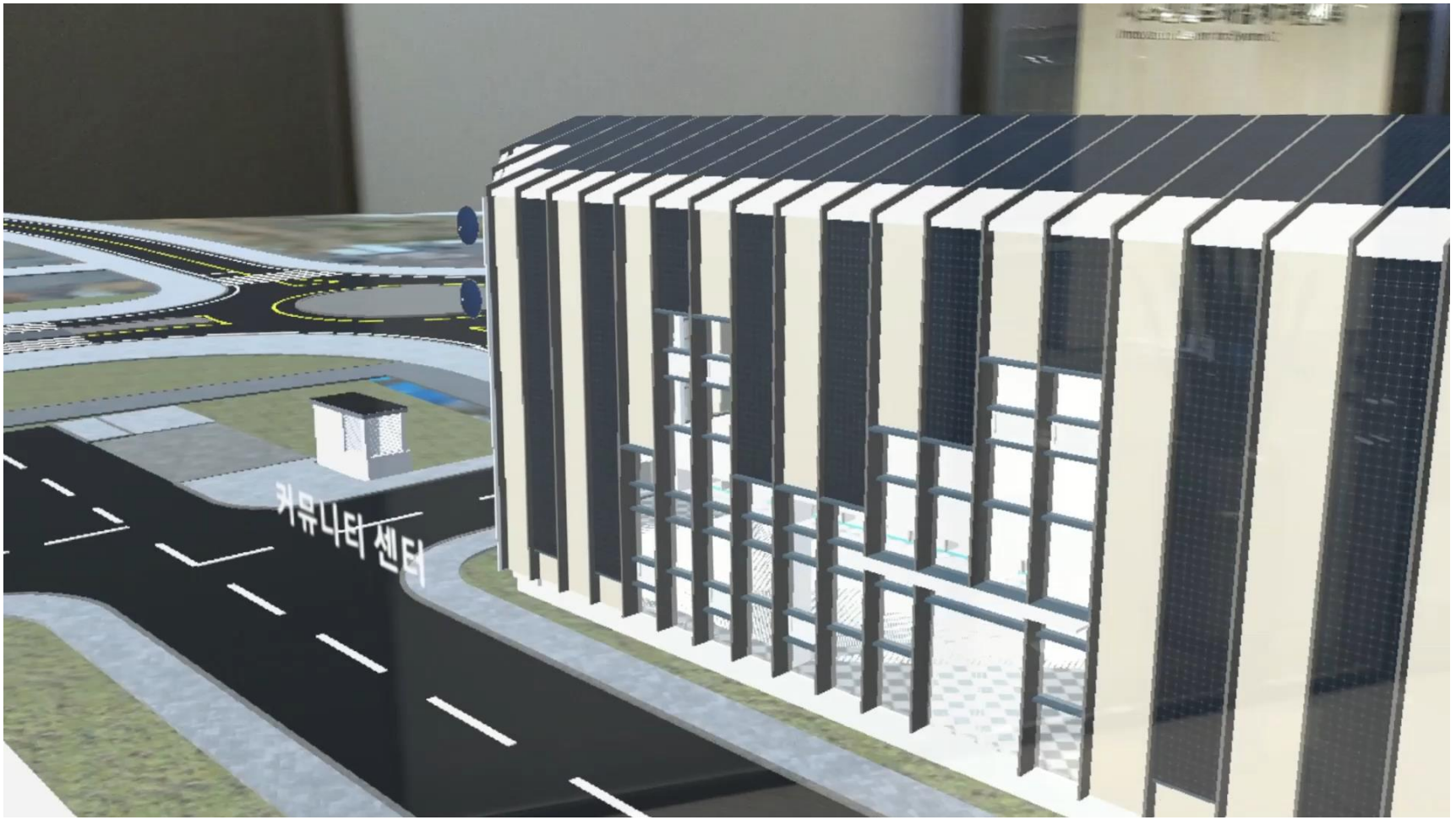
Digital twin of Seoul

Seoul Institute of Technology & STLogic(2021)

Self-learning virtual robot in DT

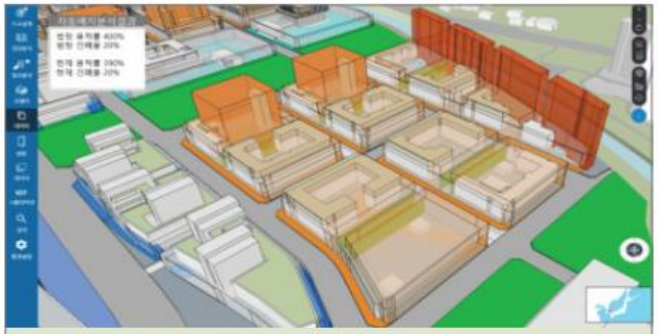
Seoul Institute of Technology & STLogic(2021)

Utilization of BIM data in R&D project



MOLIT/MSIT/MOTIE/MOIS, Development of high-fidelity 3D city models (2018-2022)

Development of the third-phase new city by LH



룰 기반 계획요소(용적률 · 높이) 정합성 검증

용적률 · 높이 · 세대수 변화 연동 분석

주요 조망점 분석

원경 · 중경 · 근경 스카이라인 분석

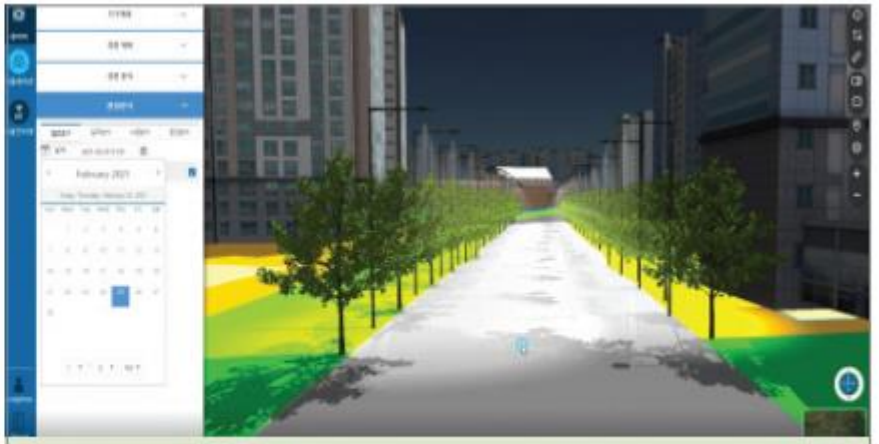
IoT 기반 실외 미세먼지 모니터링

IoT 기반 실내 재실자 모니터링

Lee, Kwonhan(2021), Digital twin utilization case for the new city and future plan, Planning and Policy: Vol. 474

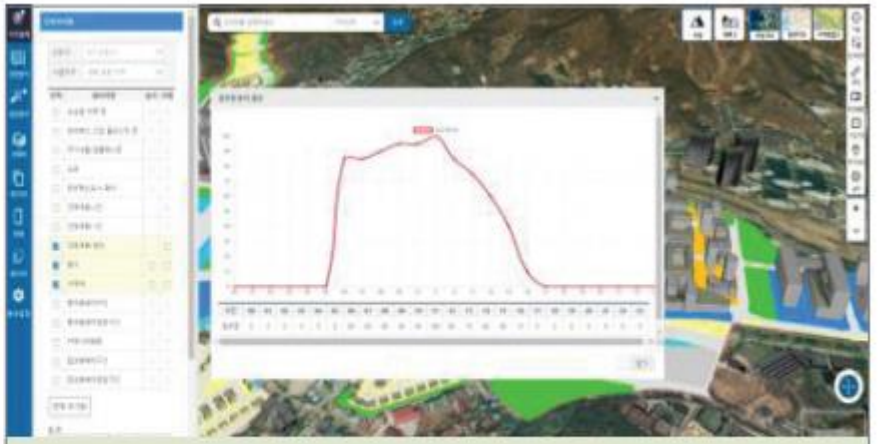
Development of the third-phase new city by LH

신도시 건설 전후 바람길 변화 예측 시뮬레이션



가로등, 가로수 시설물 가상 배치 시뮬레이션

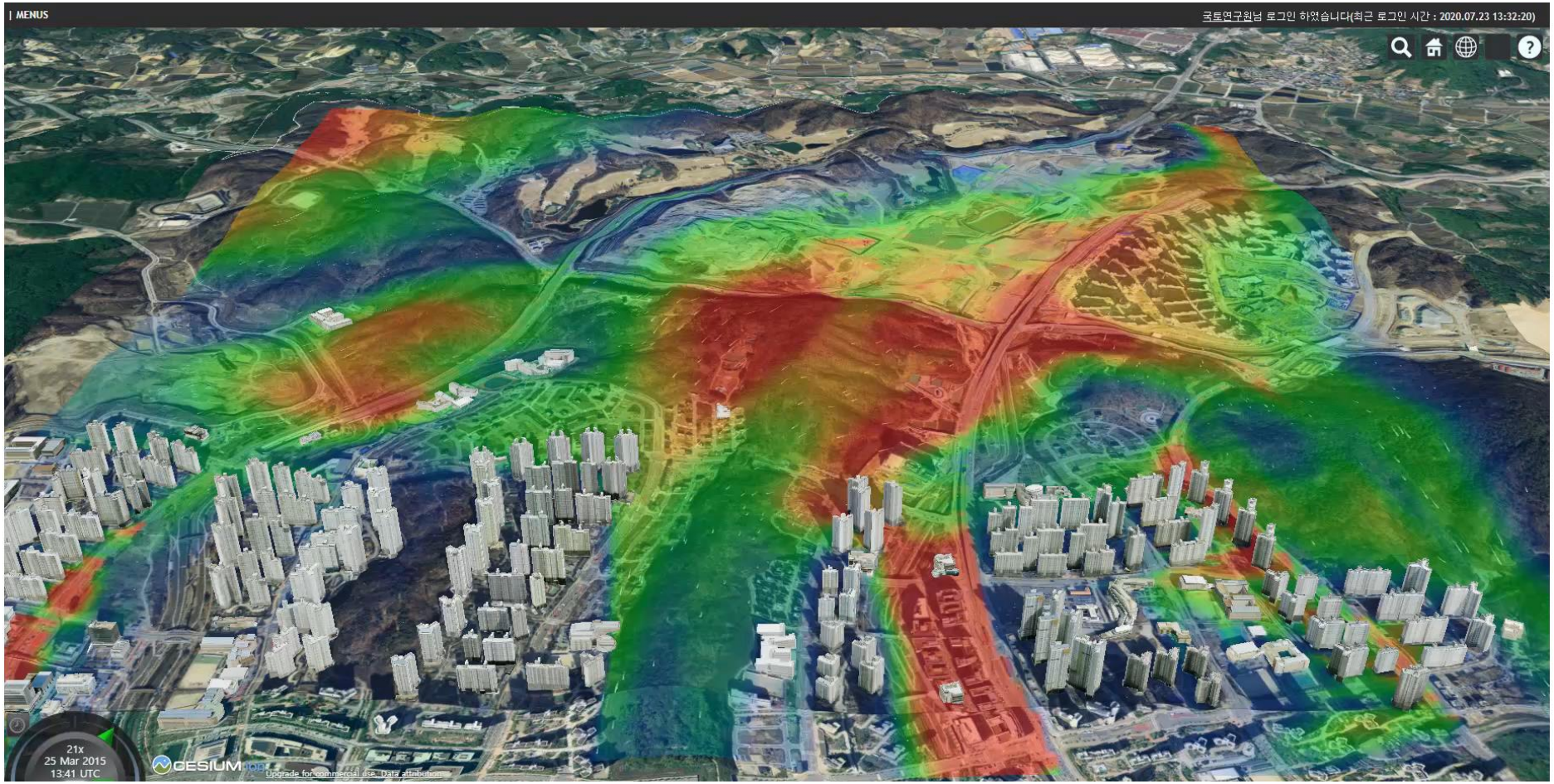
인접대지 영향 검토 일조분석



인접대지 영향 검토 일조결과

Lee, Kwonhan(2021), Digital twin utilization case for the new city and future plan, Planning and Policy: Vol. 474

POC: Real-time visualization of air pollutant

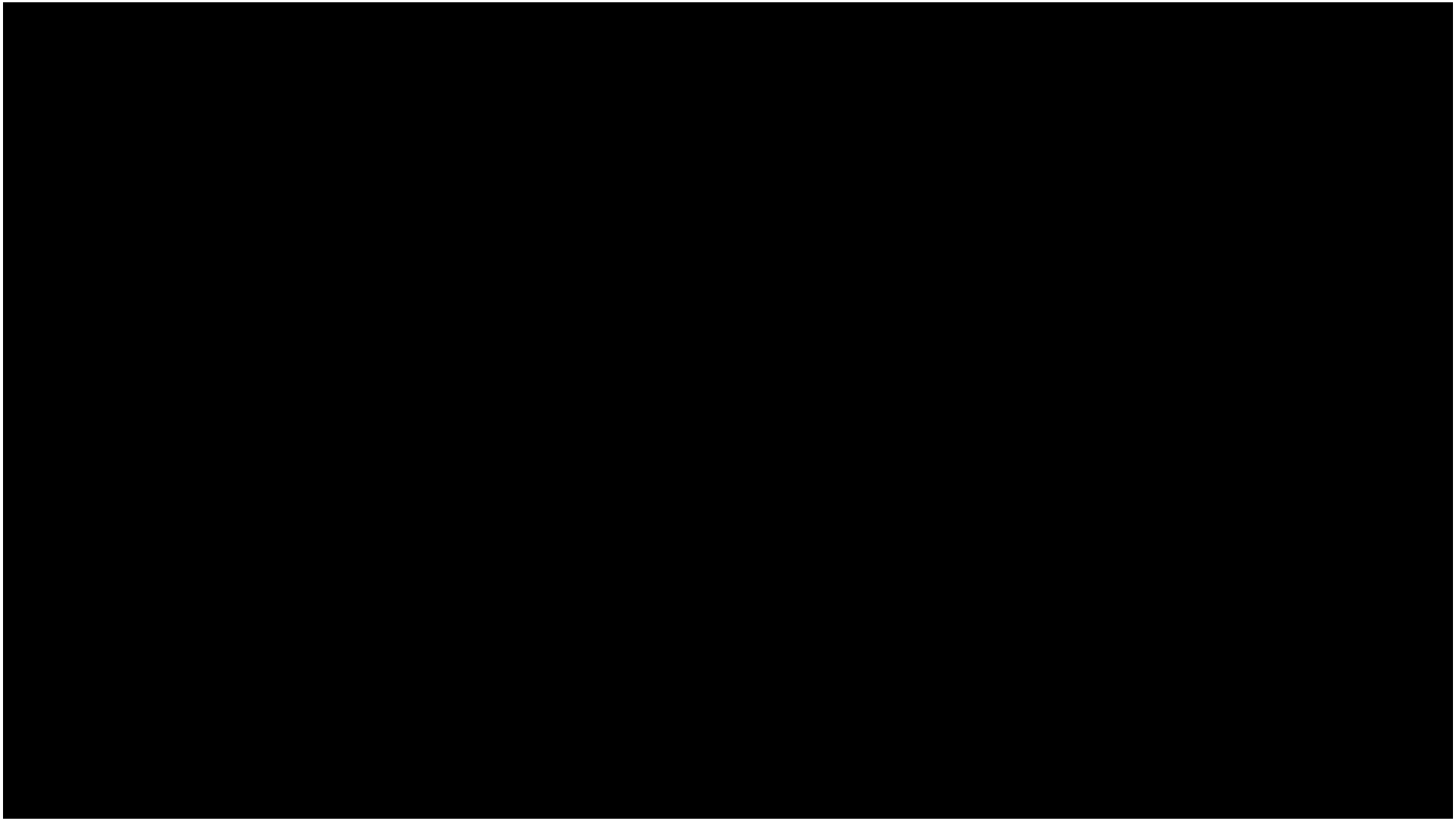


출처: 국토연구원(2020), 3기 신도시 특화 디지털트윈플랫폼 구축을 위한 마스터플랜수립연구 최종보고회

POC: Simulation of traffic policy

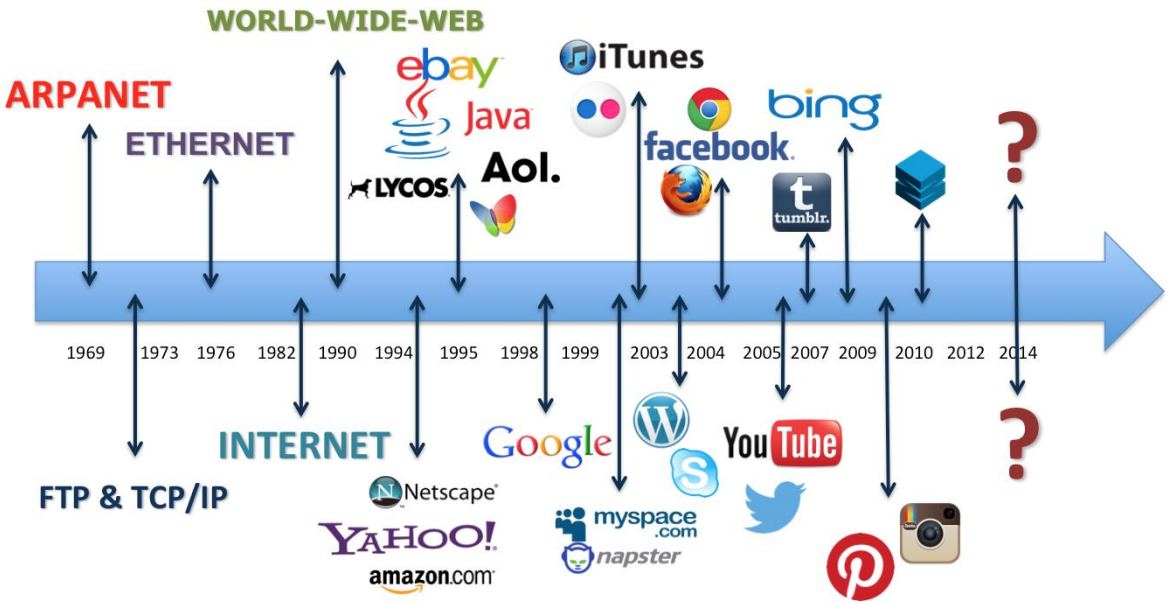
출처: 국토연구원(2020), 3기 신도시 특화 디지털트윈플랫폼 구축을 위한 마스터플랜수립연구 최종보고회

DT based game

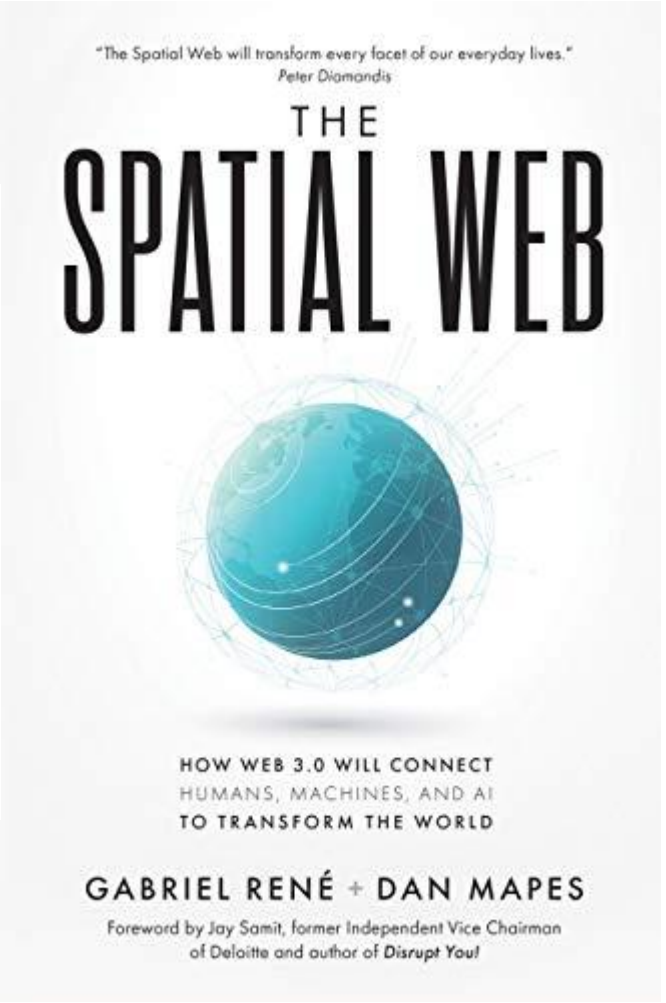


https://www.youtube.com/watch?v=rxhLg2mAIfc

Web 3.0 = spatial web



Source: http://pykorry.com/25-years-of-the-internet/



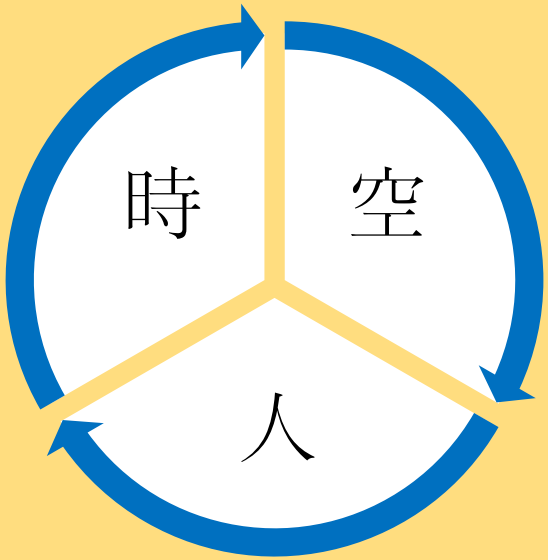
Convergence of real world and digital world

Offline

空
間
時　人

Limited by space and time

Online → Digital/virtual World → Digital parallel universe



Eased limitations

Sharing info.
Resources
Hyper-connected
Interaction
⋮

Source: uploadvr.com/10-most-important-vr-developments-of-2015/

Digital parallel universe

국토교통부/과기부/산자부/행안부, 실감형 3D 도시모델 기술개발(2018-2022)

The future of NSDI

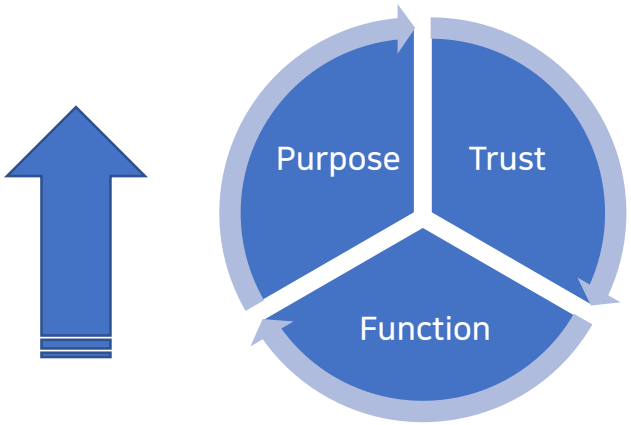
GEMINI Principle

Public good Must be used to deliver genuine public benefit in perpetuity	**Value creation** Must enable value creation and performance improvement	**Insight** Must provide determinable insight into the built environment
Security Must enable security and be secure itself	**Openness** Must be as open as possible	**Quality** Must be built on data of an appropriate quality
Federation Must be based on a standard connected environment	**Curation** Must have clear ownership, governance and regulation	**Evolution** Must be able to adapt as technology and society evolve

https://www.cdbb.cam.ac.uk/

NDTI

National Digital Twin Infrastructure

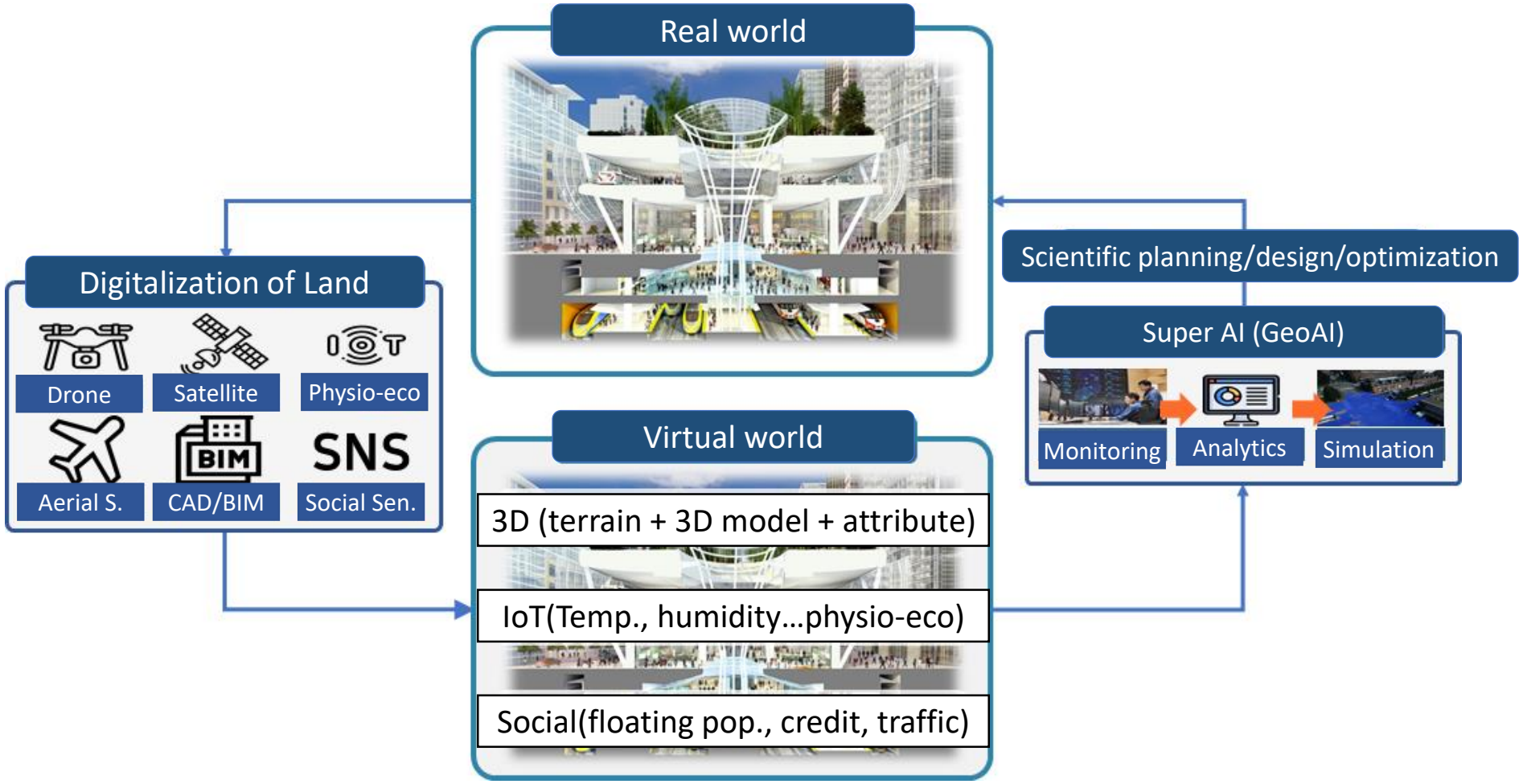


국가공간정보기반(NSDI)

National Spatial Data Infrastructure

Establishing a nationwide system for building and utilizing DT

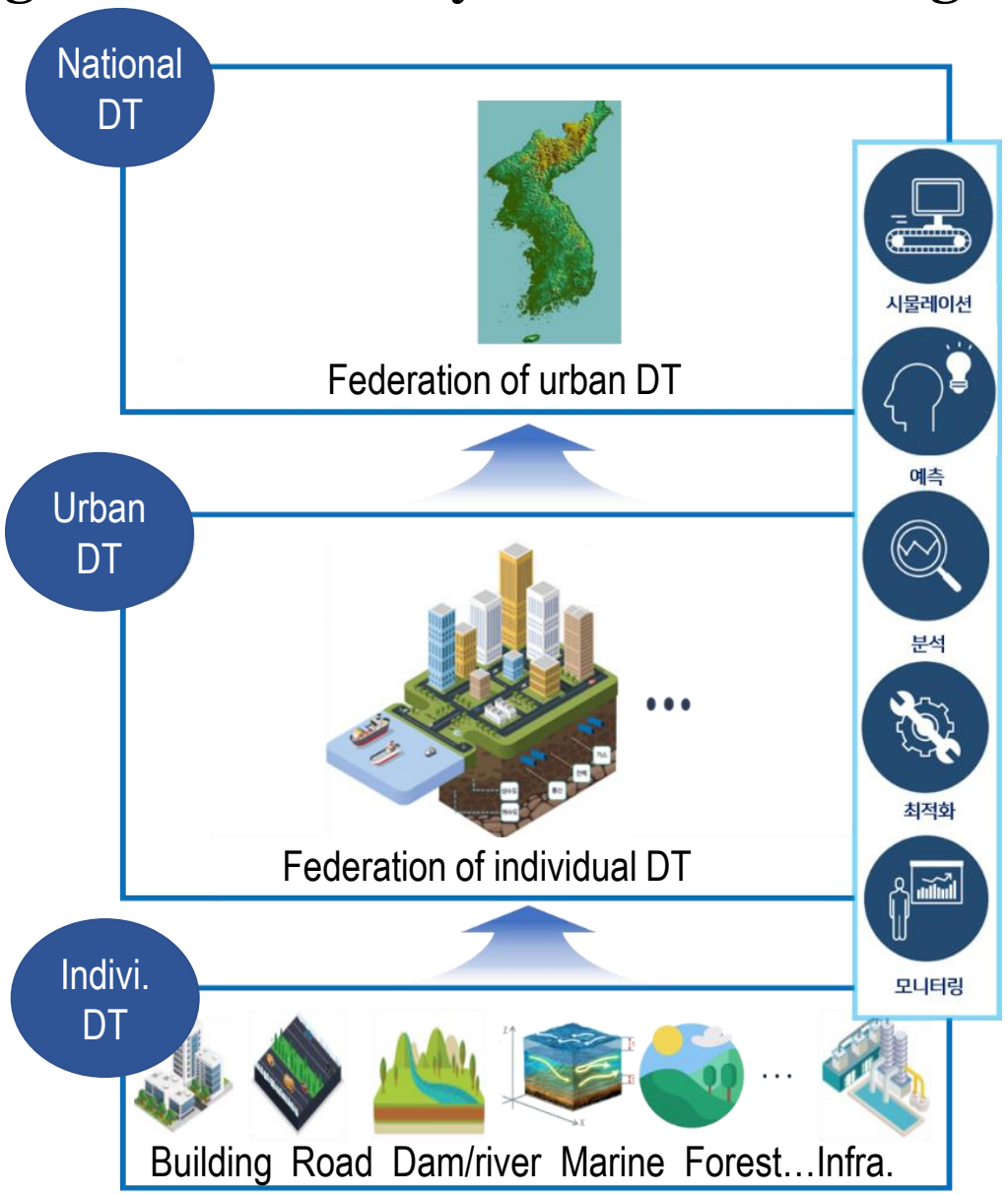
in 7th Master Plan



National spatial data based Digital Twin

Establishing a nationwide system for building and utilizing DT

in 7th Master Plan



V

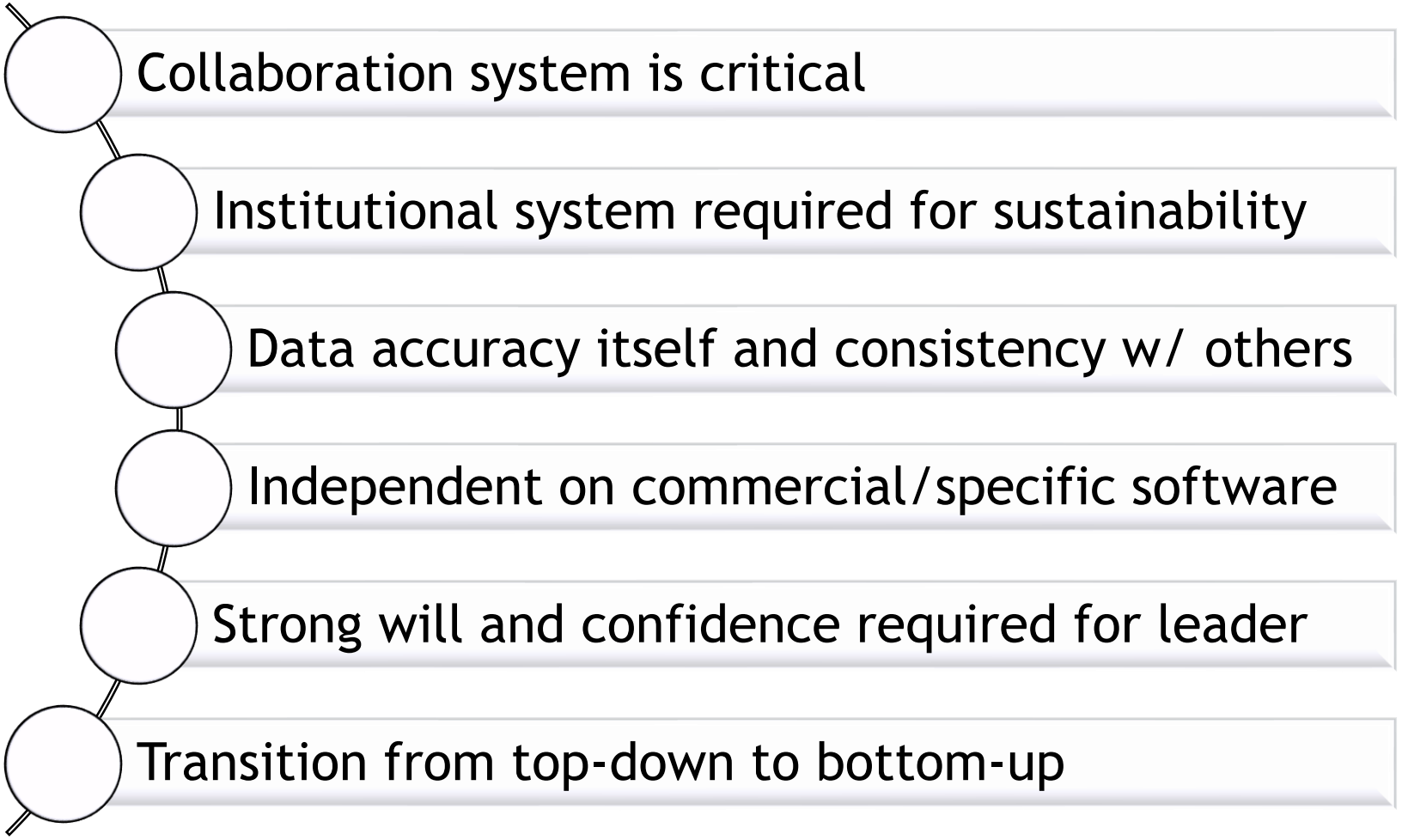
Lessons learned and policy directions

for NSDI and digital twin

Limitations of NSDI

- Low quality(accuracy, precision, fusion)
- High resolution data now opened
- No utilization of individual data(building/road…)
- Low consistency of legal systems
- No big but small companies
- Narrow ecosystem focused on data production

Lessons learned from the past



Thank you!

Any questions are welcomed!!

KRIHS 국토연구원