ADB-LX Corp Joint Workshop on National Spatial Data Infrastructure

Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

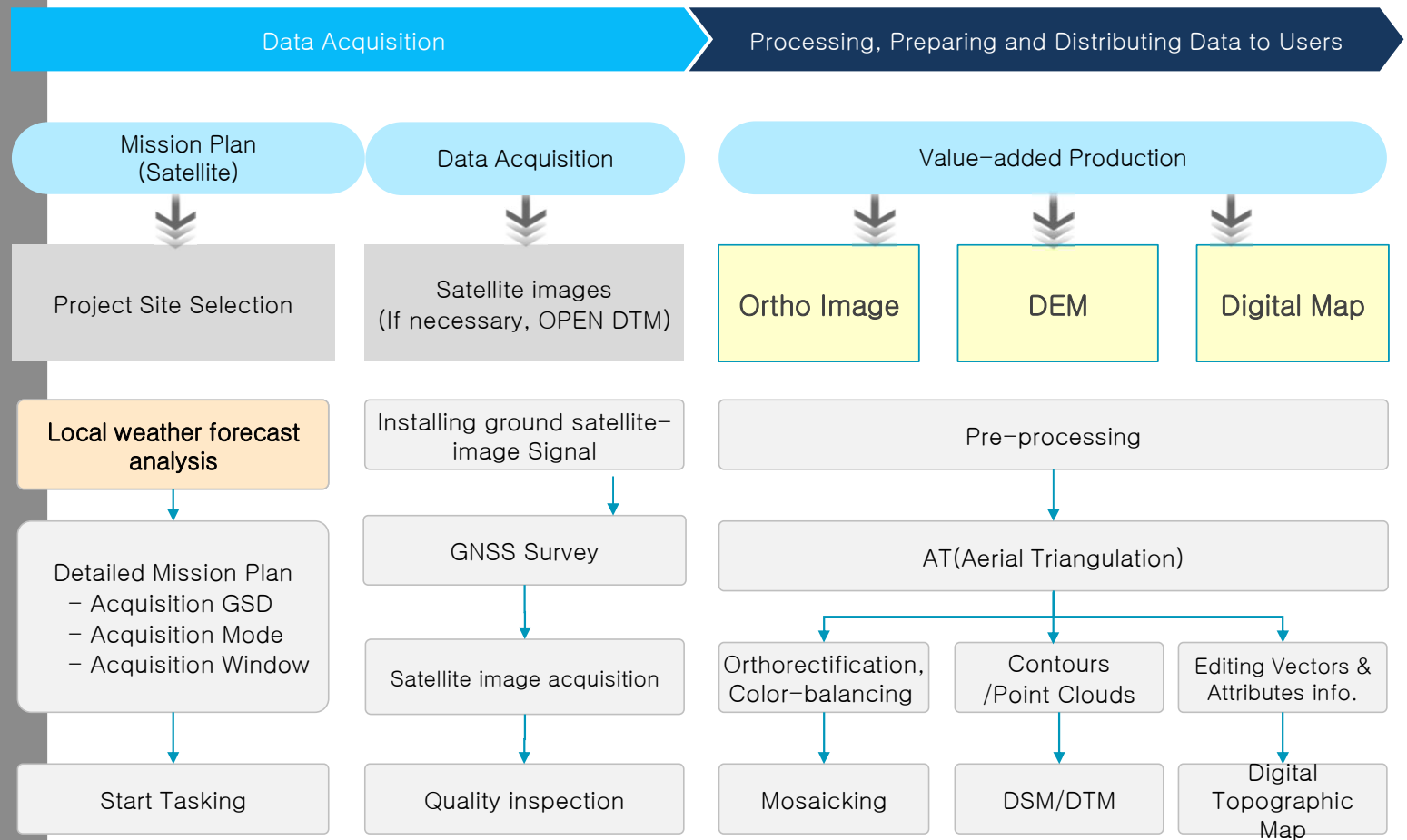공간 정보 업무 의사 결정을 위한 위성영상 선택 시 고려사항

2024-11-06

Abbreviation

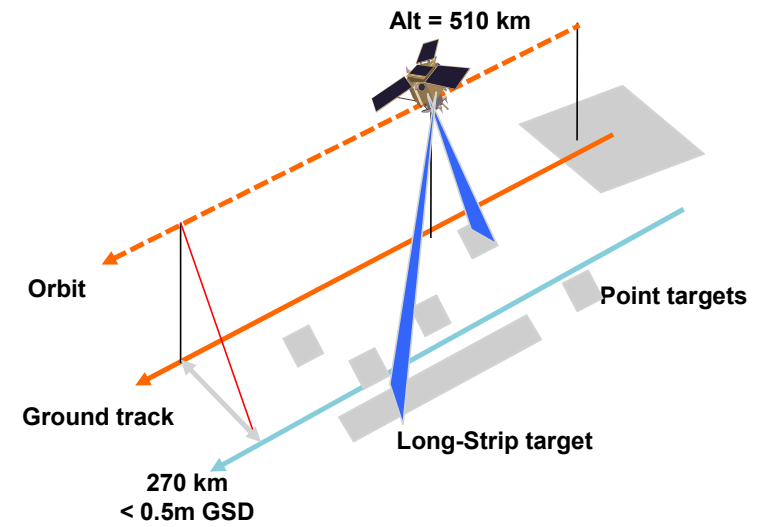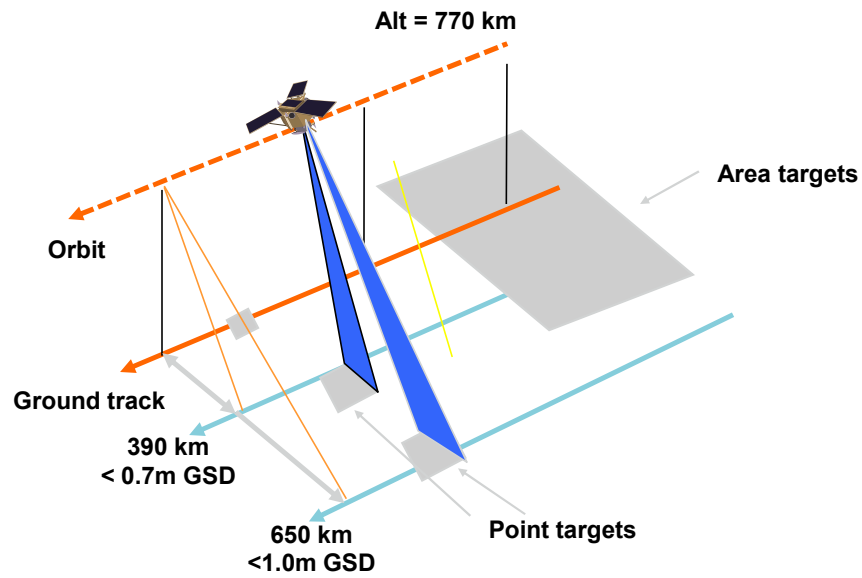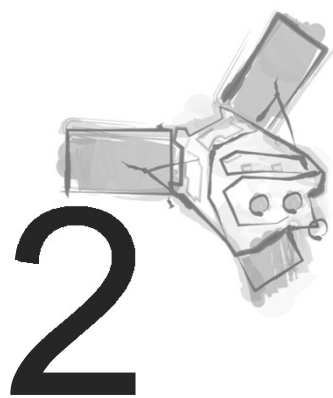|	
AT	**A**erial **T**riangulation
DEM	**D**igital **E**levation **M**odel
DPW	**D**igital **P**hotogrammetry **W**orkstation
DTM	**D**igital **T**errain **M**odel
GCP	**G**round **C**ontrol **P**oint
GIS	**G**eospatial **I**nformation **S**ystem
GNSS	**G**lobal **N**avigation **S**atellite **S**ystem
GPS	**G**lobal **P**ositioning **S**ystem
GSD	**G**round **S**ample **D**istance
KARI	**K**orea **A**erospace **R**esearch **I**nstitute
KOMPSAT	**KO**rea **M**ulti-**P**urposes **SAT**ellite
COTS	**C**ommercial **O**ff-**T**he **S**helf
RPC	**R**ational **P**olynomial **C**oefficients
QC/QA	**Q**uality **C**ontrol / **Q**uality **A**ssessment
UAV	**U**nmanned **A**erial **V**ehicle
VHR	**V**ery **H**igh **R**esolution

1

위성영상의 획득과 배포 과정의 이해
Understanding the Process of Acquisition and Distribution of Satellite Data

Acquisition and Distribution Workflow in general

**Data Acquisition** → **Processing, Preparing and Distributing Data to Users**

Mission Plan (Satellite)	Data Acquisition	Value-added Production		
Project Site Selection	Satellite images (If necessary, OPEN DTM)	Ortho Image	DEM	Digital Map
Local weather forecast analysis	Installing ground satellite-image Signal	Pre-processing		
Detailed Mission Plan – Acquisition GSD – Acquisition Mode – Acquisition Window	GNSS Survey	AT(Aerial Triangulation)		
	Satellite image acquisition	Orthorectification, Color-balancing	Contours /Point Clouds	Editing Vectors & Attributes info.
Start Tasking	Quality inspection	Mosaicking	DSM/DTM	Digital Topographic Map

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

Concept of data acquisition

Alt = 770 km

Area targets

Orbit

Ground track

390 km
< 0.7m GSD

650 km
<1.0m GSD

Point targets

Alt = 510 km

Orbit

Point targets

Ground track

Long-Strip target

270 km
< 0.5m GSD

2

위성영상의 주요 SPEC 의 이해
Understanding the key SPECifications of Satellite Imagery

Sample Specifications
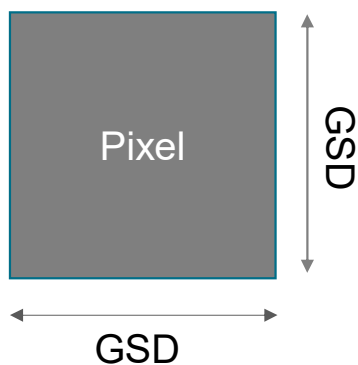
SPOT-6/7 >>
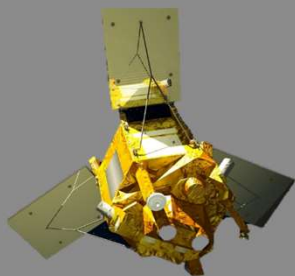
Number of Satellites	2 satellites (SPOT-6 & SPOT-7)
Launch	SPOT-6 : 2012-09-09 / SPOT-7 : 2014-06-30
Orbit, Altitude	Sun-synchronous, 694 km, 98.79 minutes/pass
Inclination	98.2°
1_Spatial Resolution	Panchromatic : 1.5 m + Multi-spectral : 6.0 m
2_Spectral Bands	Panchromatic + 4 Bands (BGRN)
3_Swath Width	60 km @nadir
4_Revisit Time	Daily, anywhere
5_Acquisition Mode	Mono & Stereo
Dynamic Range	12 bits/pixel
Location Accuracy	< 18m CE90 (@nadir, without GCPs)
Acquisition Capacity	600,000 ㎢/day
Mission Lifetime	10 years minimum

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

Spatial Resolution

Selection Key 1

= **G**round **S**ampling **D**istance

- The more pixels and the smaller the GSD, the higher the spatial resolution and the easier to identify geographical features.
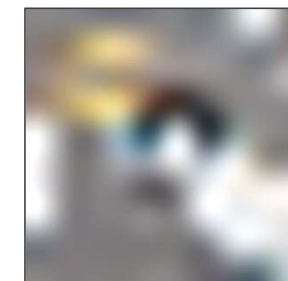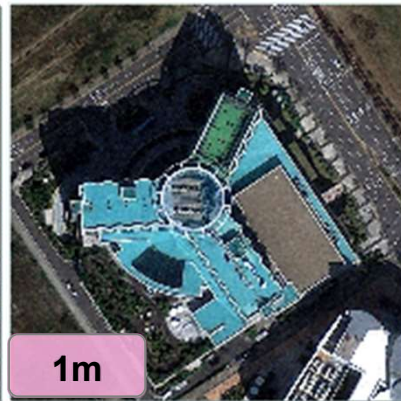- Most important consideration when evaluating the performance of optical observation satellites.

Pixel — GSD (vertical) × GSD (horizontal)

5 cm

30 cm

50 cm

1 m

Spatial Resolution Samples

16m

4m

2m

1m

50cm

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

Medium Resolution Samples

4.0 m	5.0 m	6.0 m

Road/Rail route feasibility study

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making
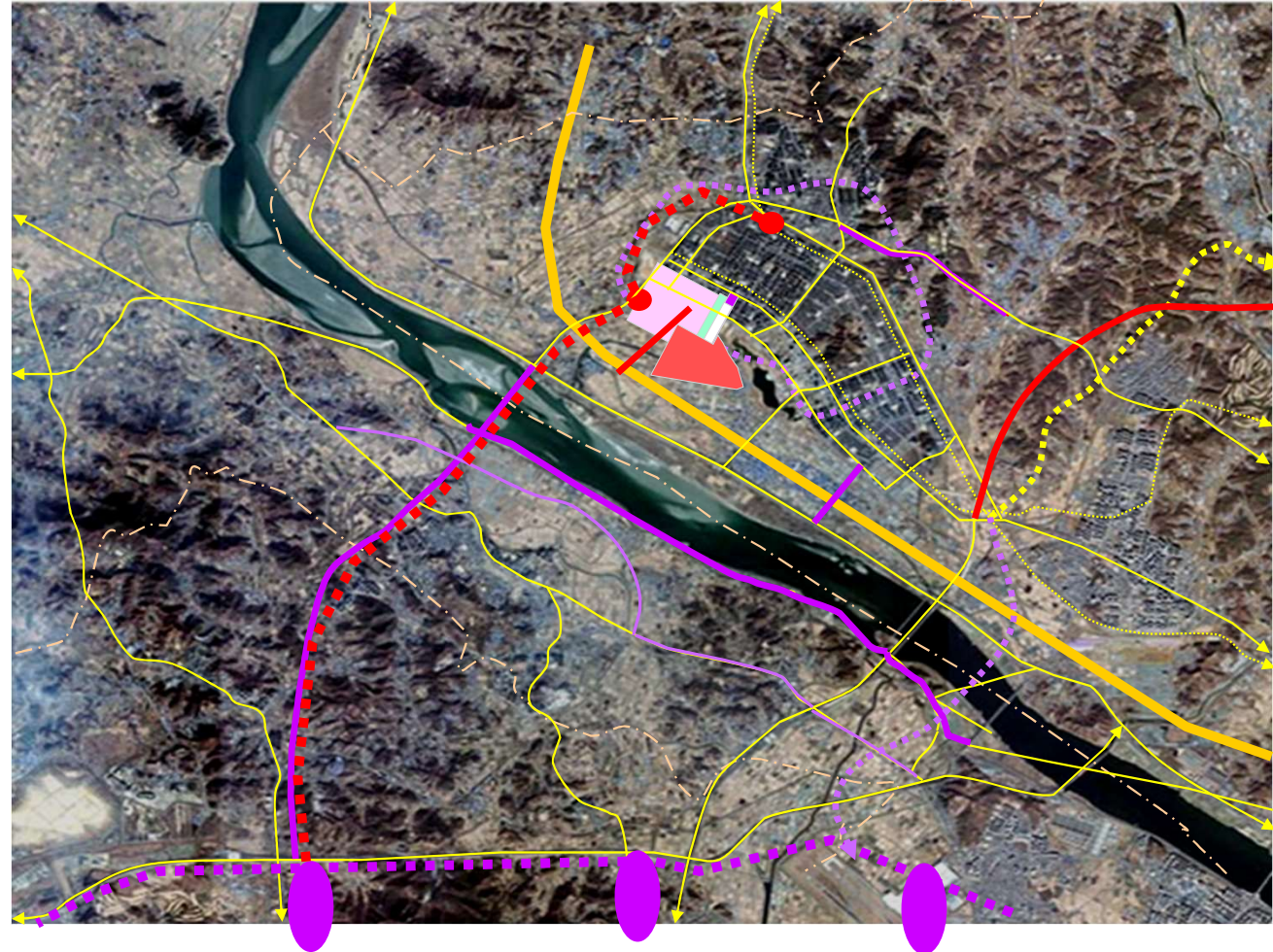
Environment / Disaster monitoring covering wide area

Wildfires burning west of Yellowknife (Sentinel-2 satellite image; August 16, 2023)

WildFire @Canada

Yellowknife Residents Prepare to Evacuate Due to Wildfires | Yellowknife, Canada | August 15, 2023 | WorldView-3 Satellite Image | Location: 62.439, -114.409

Hurricane @USA

Pollution

Oil

1 m GSD

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

0.5 m GSD

14 |

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

30cm (Pleiades Neo)

15cm (re-Sampled)

VHR
(Very High Resolution)

KARI/SIIS

KOMPSAT-5
Design lifetime : 5 years
2013.10.22 ~
1.0 m SAR Payload
LTAN : 6:00 (18:00)

KOMPSAT-2
Design lifetime : 3 years
2006.7.28 ~
1.0 m EO Payload
LTAN : 10:50

KOMPSAT-3
Design lifetime : 4 years
2012.5.18 ~
0.7 m EO Payload
LTAN : 13:30

KOMPSAT-3A
Design lifetime : 4 years
2015.3.26 ~
0.55 m EO & 5.5 m IR
Payload
LTAN : 13:30

KOMPSAT-1
(Resolution 6.6m)
1999~2008

KOMPSAT-2
(Resolution 1m)
2006~
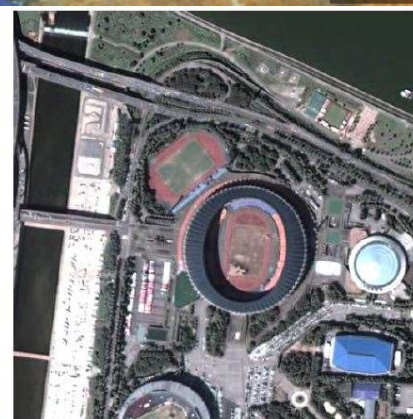
KOMPSAT-3
(Resolution 0.7m)
2012~
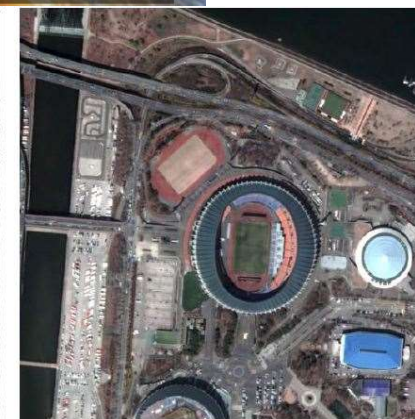
KOMPSAT-3A
(Resolution 0.55m)
2015~
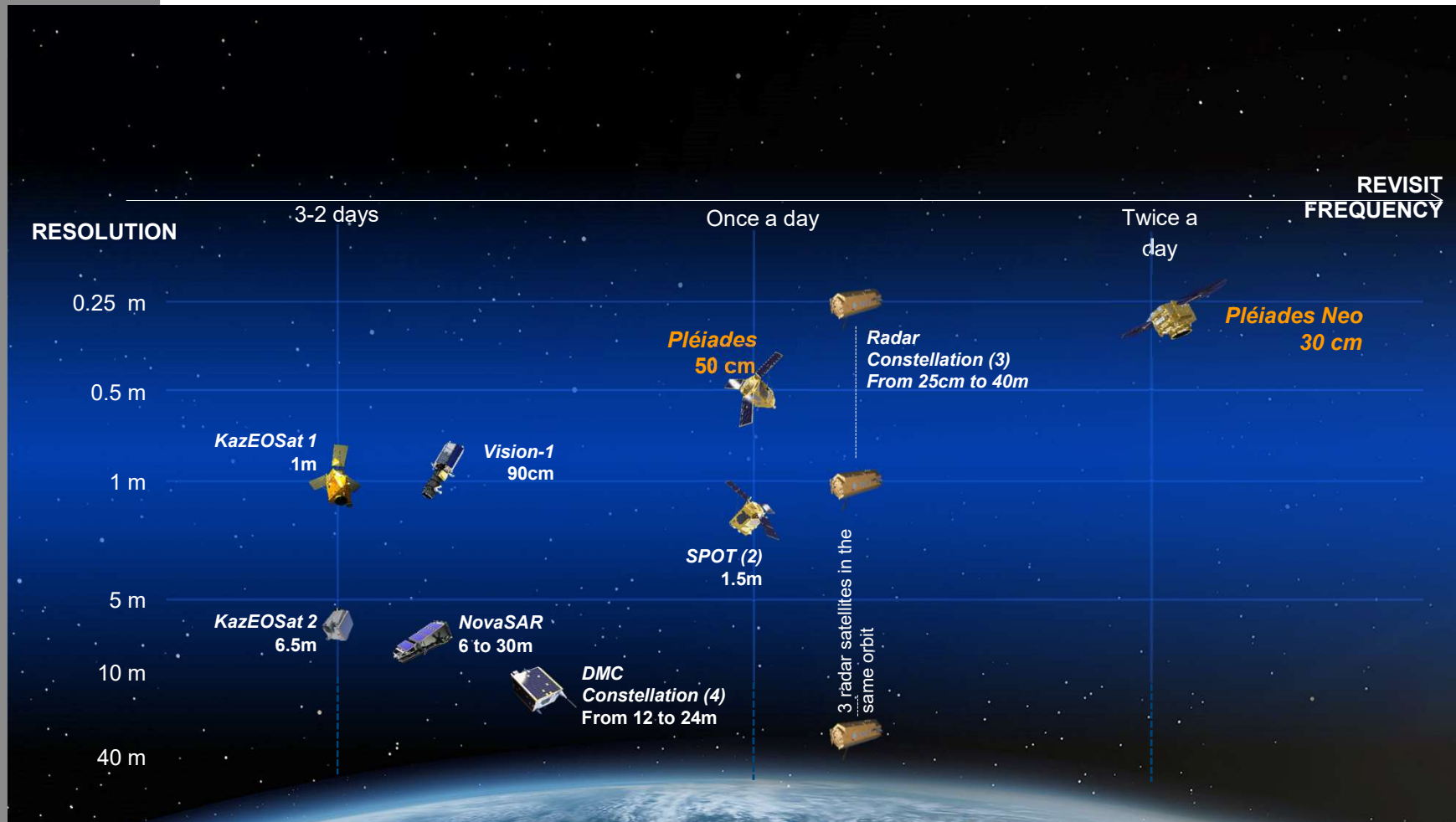
| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

VHR

Airbus

RESOLUTION

REVISIT FREQUENCY

3-2 days

Once a day

Twice a day

0.25 m

Pléiades Neo 30 cm

Pléiades 50 cm

Radar Constellation (3) From 25cm to 40m

0.5 m

KazEOSat 1 1m

Vision-1 90cm

1 m

SPOT (2) 1.5m

3 radar satellites in the same orbit

5 m

KazEOSat 2 6.5m

NovaSAR 6 to 30m

10 m

DMC Constellation (4) From 12 to 24m

40 m

VHR

Maxar
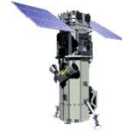
1999	2001	2016	2007	2008	2009	2014	2024
IKONOS®	**QuickBird®**	**WorldView-4®**	WorldView-1®	GeoEye-1®	WorldView-2®	WorldView-3®	WorldView Legion
82-cm resolution	65-cm resolution	31-cm resolution	50-cm resolution	41-cm resolution	46-cm resolution	31-cm resolution	34-cm Resolution
9 m CE90	23 m CE90	5.0 m CE90	<5.0 m CE90	<5.0 m CE90	<5.0 m CE90	<5.0 m CE90	<5.0m CE90

In Archive   **On Orbit**

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

SuperView-1 (01/02/03/04)

Satellite details

Orbit	Altitude: 530 km
	Type: Sun-synchronous
	Period: 97 minutes
Design life	8 years
Mass	560 kg
Sensor bands	Panchromatic: 450-890 nm
	4 Multispectral:
	Blue: 450-520 nm
	Green: 520-590 nm
	Red: 630-690 nm
	Near-IR: 770-890 nm
Spatial Resolution	PAN: 0.5 m
	MS: 2 m
Dynamic range	11 bits
Swath width	12 km
Onboard storage	2.0 TB
Revisit time	2 days by twin satellites
Positioning accuracy	9.5 m CE90
Data transmission	2 * 450 Mbps
Daily Capacity	900,000 km²

Associated satellite programme and related satellites

- SuperView
  - SuperView-1 (2016 - 2021)
  - SuperView-2 (2016 - 2021)
  - SuperView-3 (2017 - 2022)
  - SuperView-4 (2017 - 2022)

Satellite Payload

All known Instruments flying on SuperView-1

Acronym	Full name
PMC-3	Panchromatic and Multi-spectral CCD Camera - 3

Show instrument status and calibration
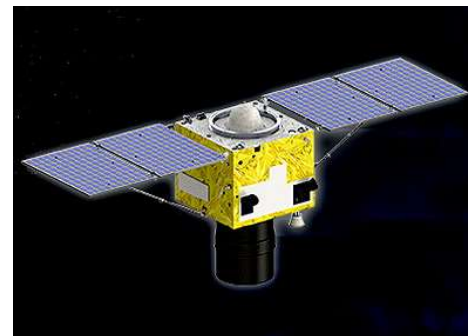
VHR SPEC.

Satellite		Spatial Resolution		Swath	Spectral Resolution (Bands)	Radiometric Resolution (bits/pixel)	Remarks
Operator	Name	GSD	Product				
Airbus (France)	**Pleiades Neo**	0.3 m	0.15 / 0.3 m	14 km	PAN + 6 Multi	12	2 Satellites
	Pleiades-1A/1B	0.7 m	0.5 m	20 km	PAN + 4 Multi	12	2 Satellites
Maxar (USA)	**WorldView Legion**	0.34 m	0.15 / 0.3 / 0.4 / 0.5m	10 km	PAN + 8 Multi	11	6 Satellites
	WorldView-4	0.31 m	0.15 / 0.3 / 0.4 / 0.5m	13.1 km	PAN + 4 Multi	11	Mission ceased
	WorldView-3	0.31 m	0.15 / 0.3 / 0.4 / 0.5m	13.1 km	PAN + 8 Multi	11	
	WorldView-2	0.46 m	0.4 / 0.5m	16.4 km	PAN + 8 Multi	11	
	WorldView-1	0.5 m	0.5m	17.7 km	PAN	11	
	GeoEye-1	0.41 m	0.4 / 0.5m	15.3 km	PAN + 4 Multi	11	
KARI (South Korea)	**KOMPSAT-3**	0.7 m	0.5 m	16 km	PAN + 4 Multi	14	
	KOMPSAT-3A	0.55 m	0.4 m	13 km	PAN + 4 Multi + 1 IR	14	
SpaceWill (China)	**SuperView Neo**	0.42 m	0.4 m	15 km	PAN + 6 Multi	12	
	SuperView-1/2/3/4	0.5 m	0.5 m	12 km	PAN + 4 Multi	11	4 Satellites

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

Optimal route planning for power station sites
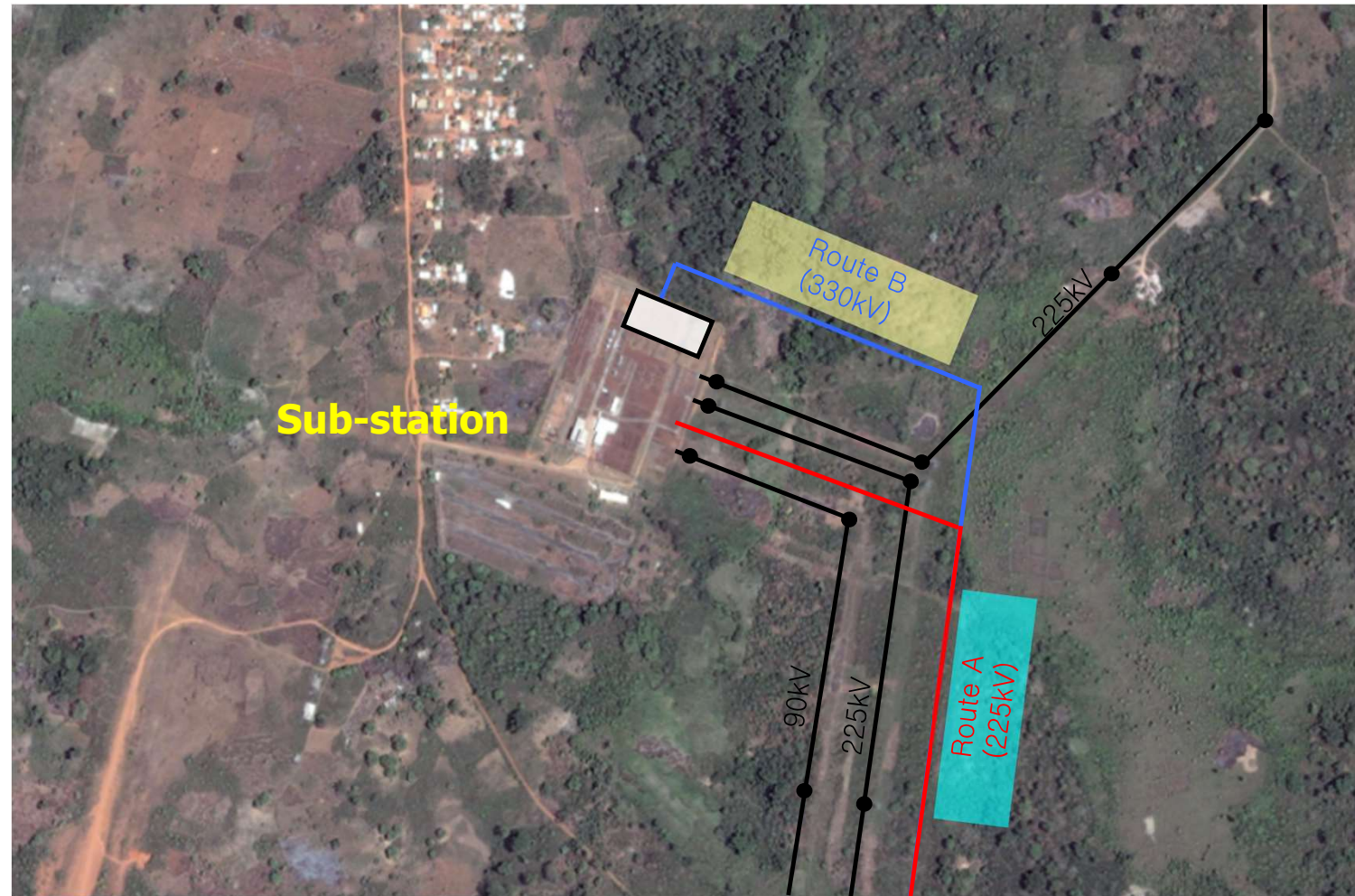
Generating and updating digital cadastral maps
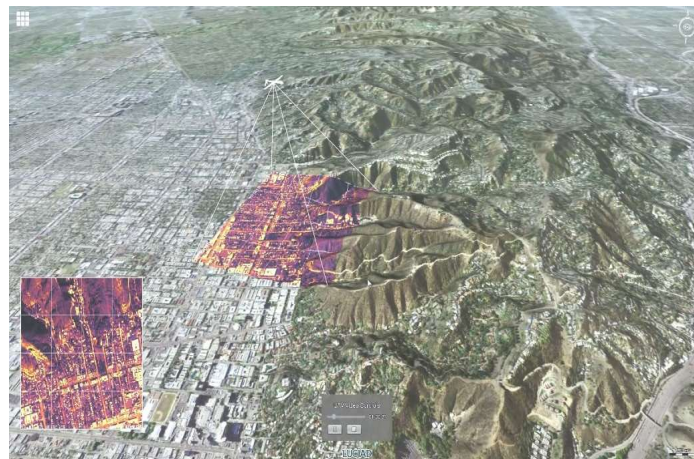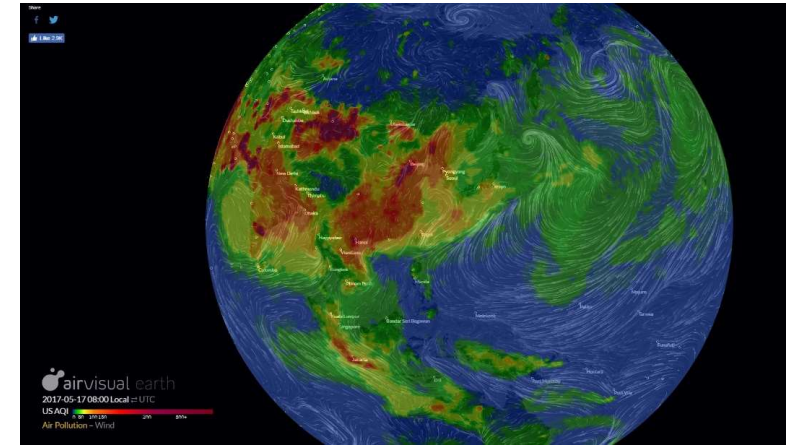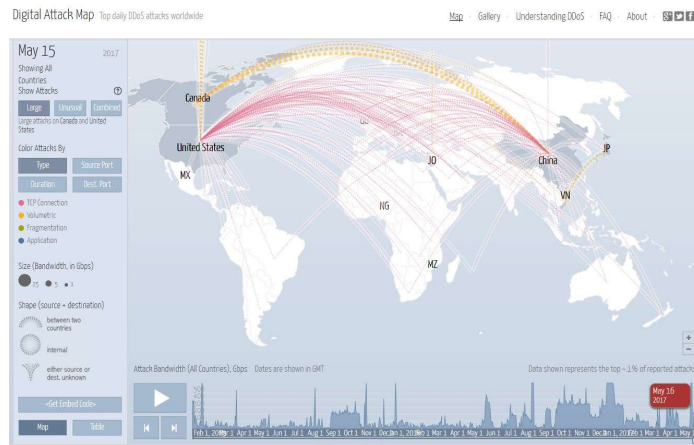
On-line Map Services

- ❖ **2D / 3D Viewing**
- ❖ **Vector Map/Satellite Images**
- ❖ **Time Series**
- ❖ **Split Display**
- ❖ **Overlay with information**
- ❖ **Metadata Display**
- ❖ **Street View**
- ❖ **3D Terrain View**
- ❖ **Satellite Image + 3D Buildings**
- ❖ **Distance/Area/Height calculation**
- ❖ **Navigation**
- ❖ **Public Transportation / CCTV**
- ❖ **Weather Information**
- ❖ **Security / Accommodation / Tours**
- ❖ **OPEN Source API**

Google Earth | V-World | NGII
DAUM | NAVER | Bing
Web Catalogue | Navigation | Infra Management
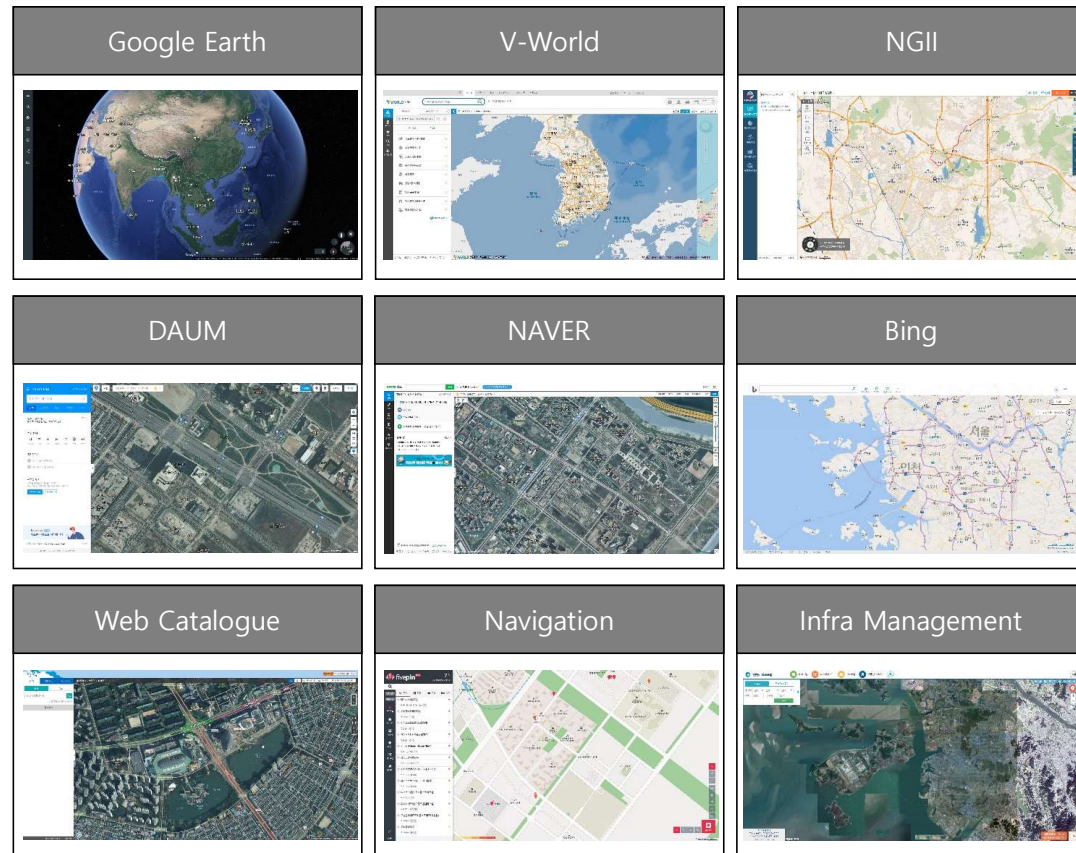
Traffic & Safety Management by using CCTV
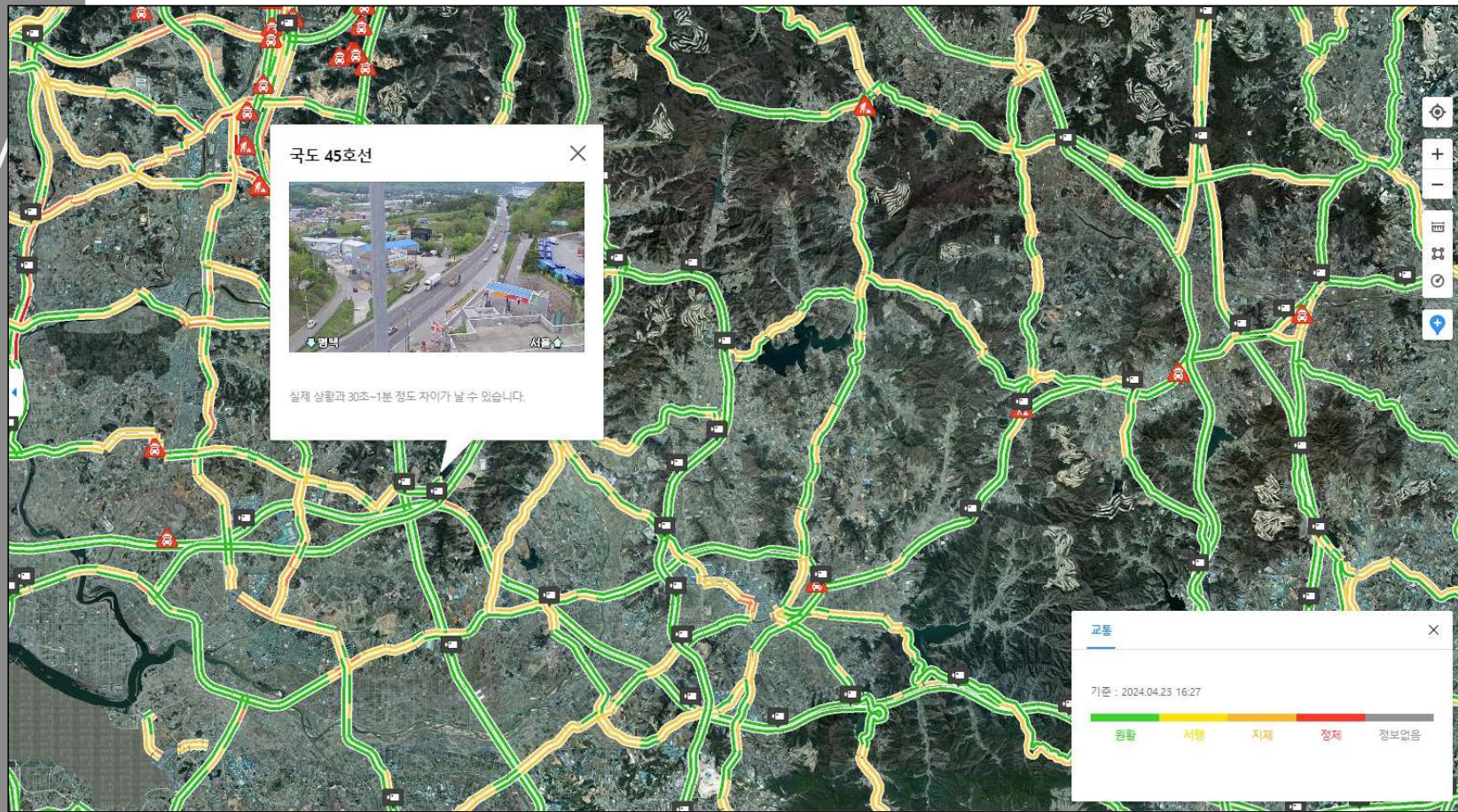
On-line Real-Time Platform

Spectral Resolution

Selection Key 2

Multi-Spectral
- Widely available for Remote Sensing
- # of bands : several ~ tens of bands
- able to detect Solids/Liquids, Artificial/Natural by combining multiple bands
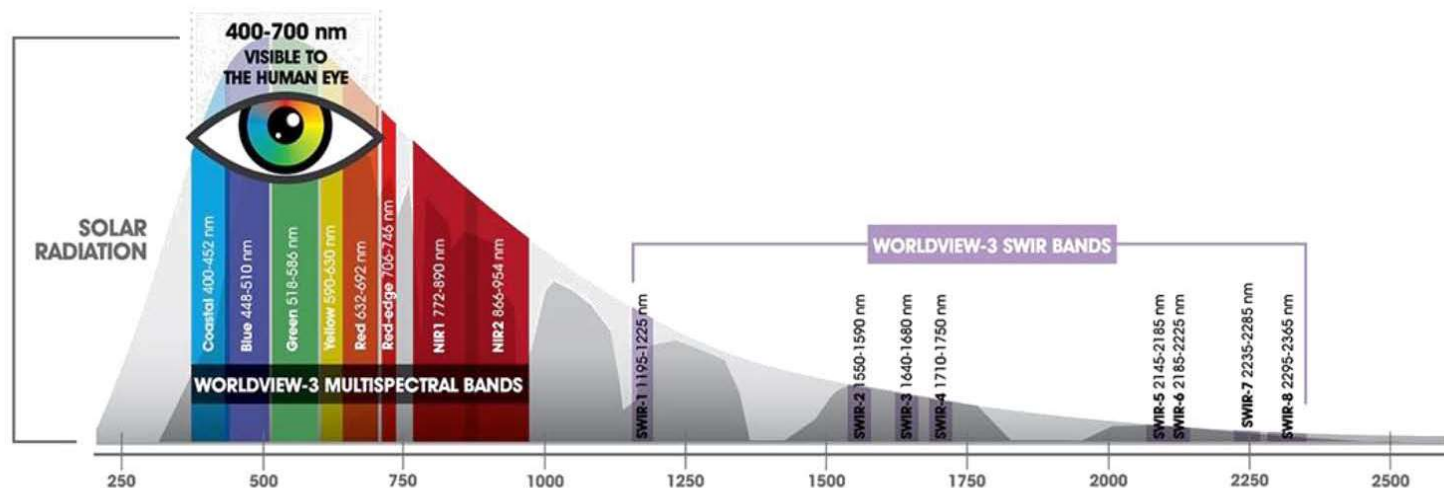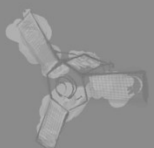

Spectral Resolution of WorldView-3

Bands Composite

RGB
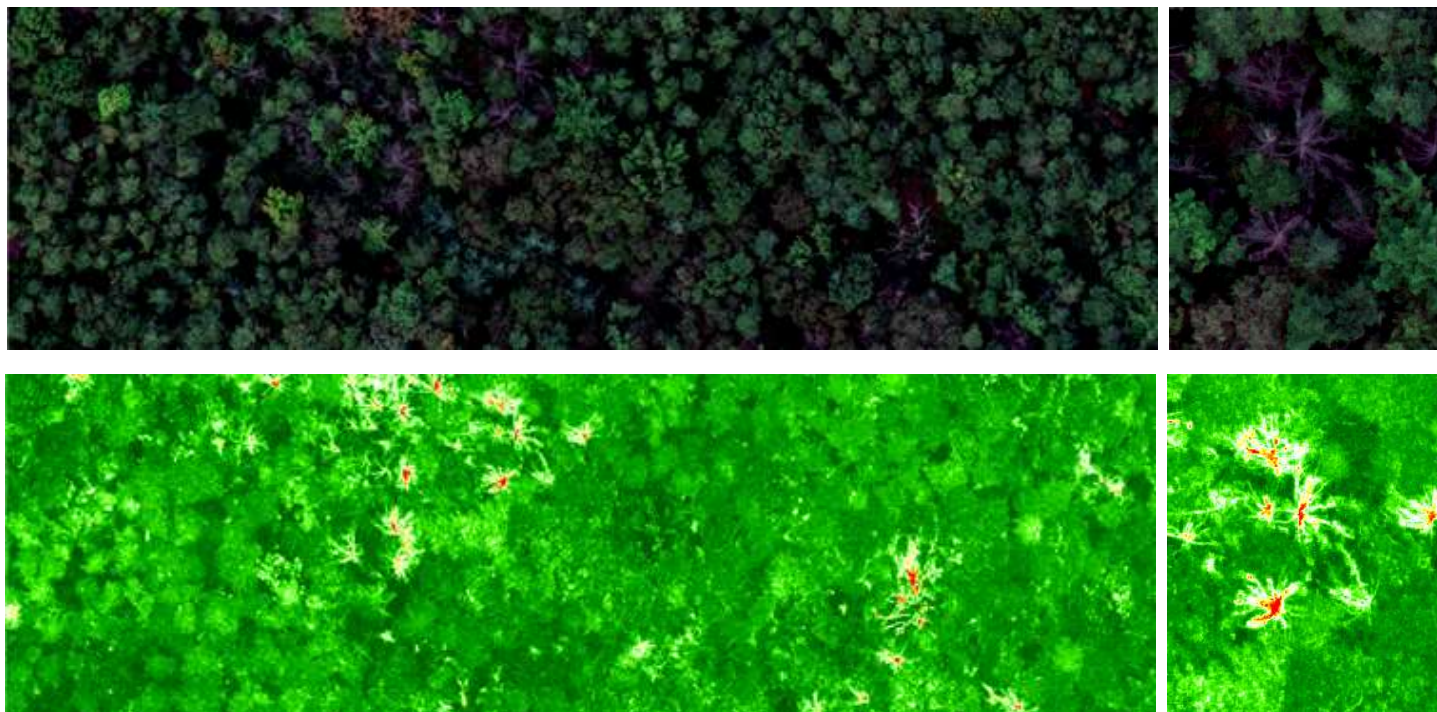
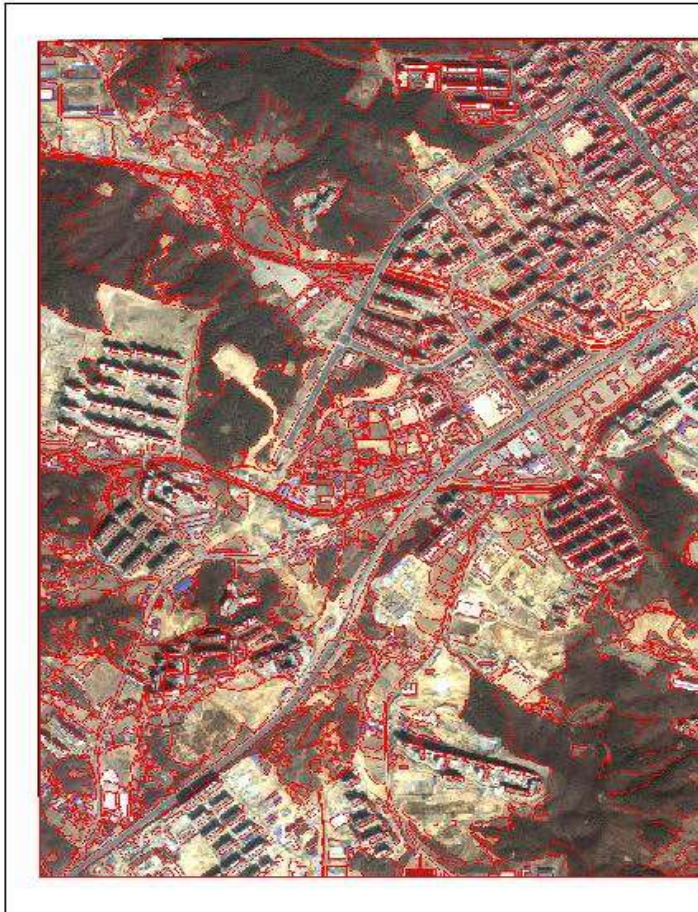
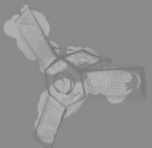$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Monitoring
Land usage

Swath Width

Selection Key 3

Width of the area that can be taken at once as a satellite passes through orbit.
 - various range from tens to hundreds of kilometers
 - The satellite's orbit is designed to cover all areas of the Earth's surface in general.
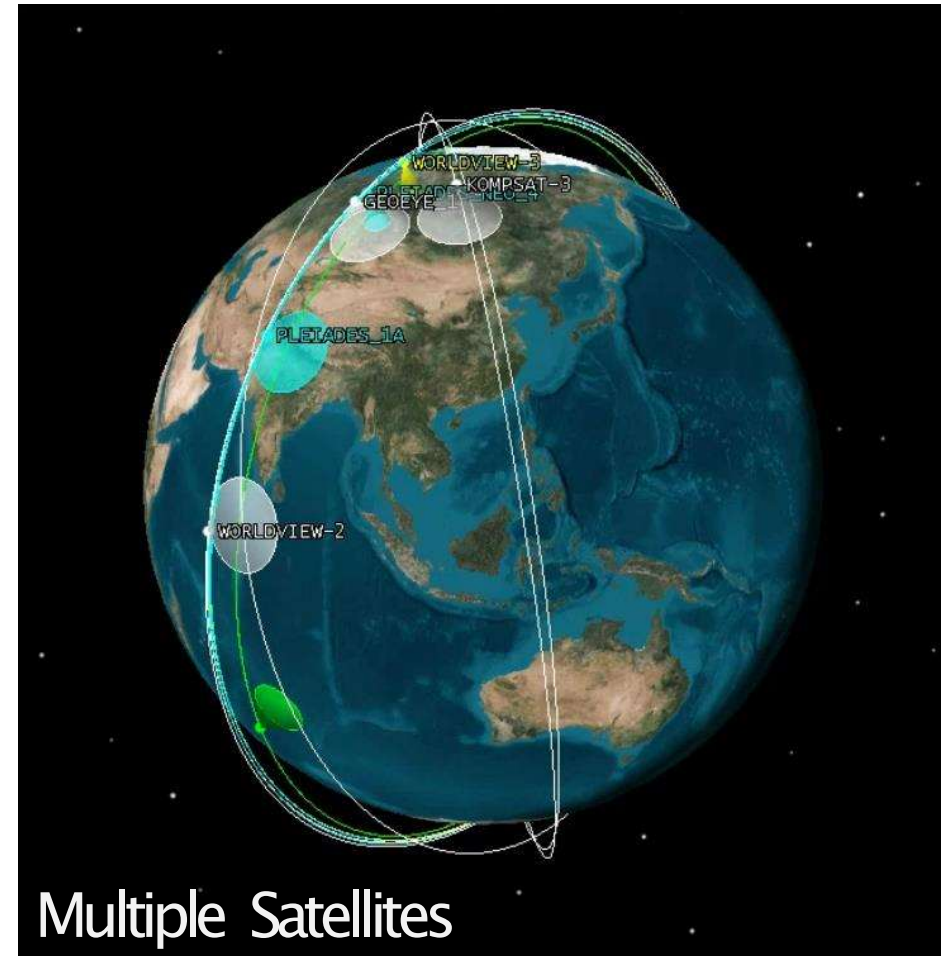

Nadir

Swath

Swath comparison
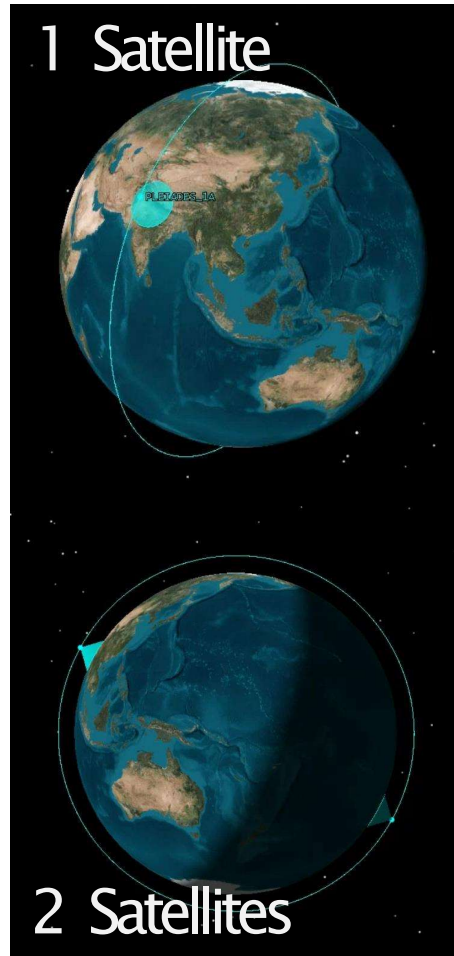

SPOT-6/7
(60Km x 60Km)

KOMPSAT-3
(15Km x 15Km)

KOMPSAT-3A
(12Km x 12Km)
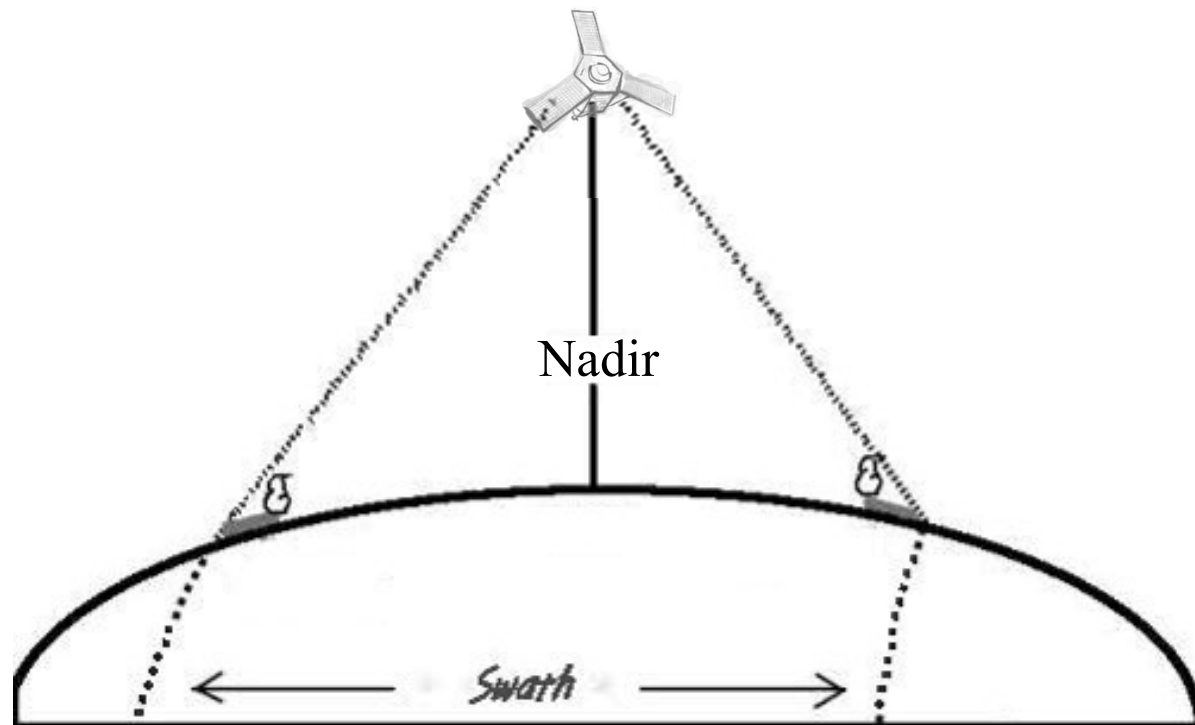
Revisit Time

Selection Key 4

1 Satellite

2 Satellites

Multiple Satellites

Monitoring Land changes

y1990

y1992

y1995

y2000

y2022

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

Acquisition Mode

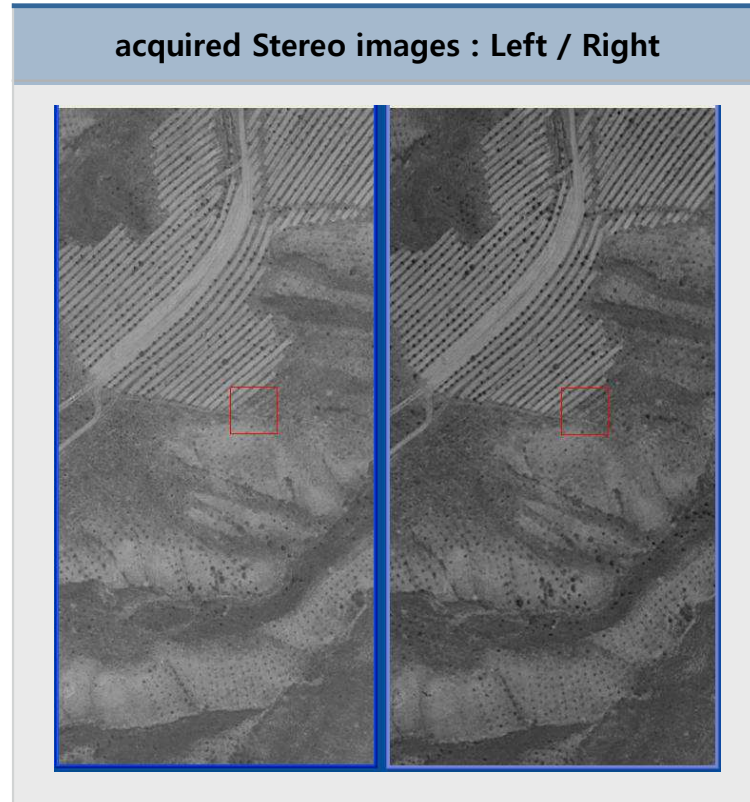## Selection Key 5

☐ Stereo images are mandatory for digital mapping.
☐ Stereo images : 2 or more images acquired on same area with geometric convergence angle.
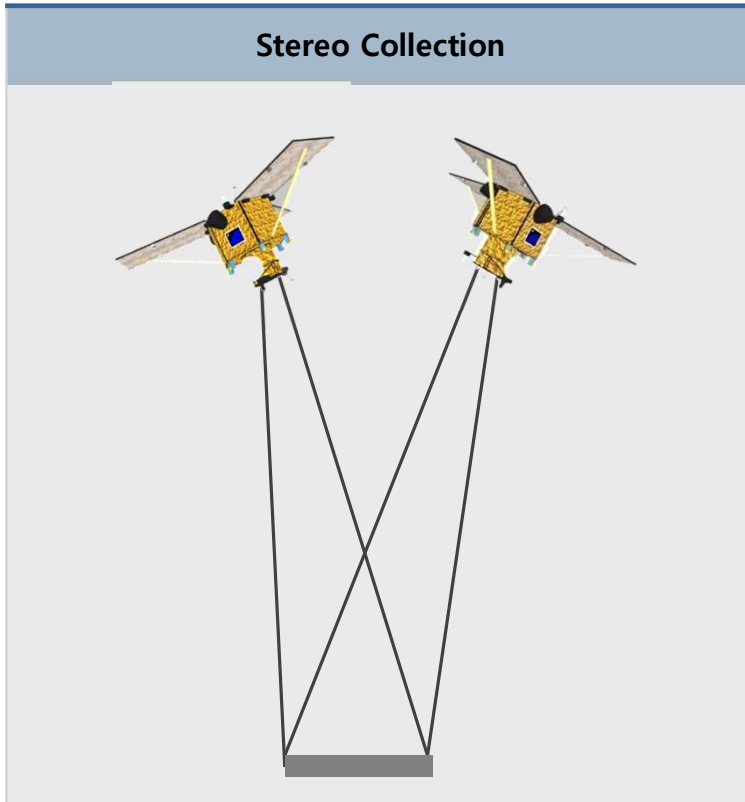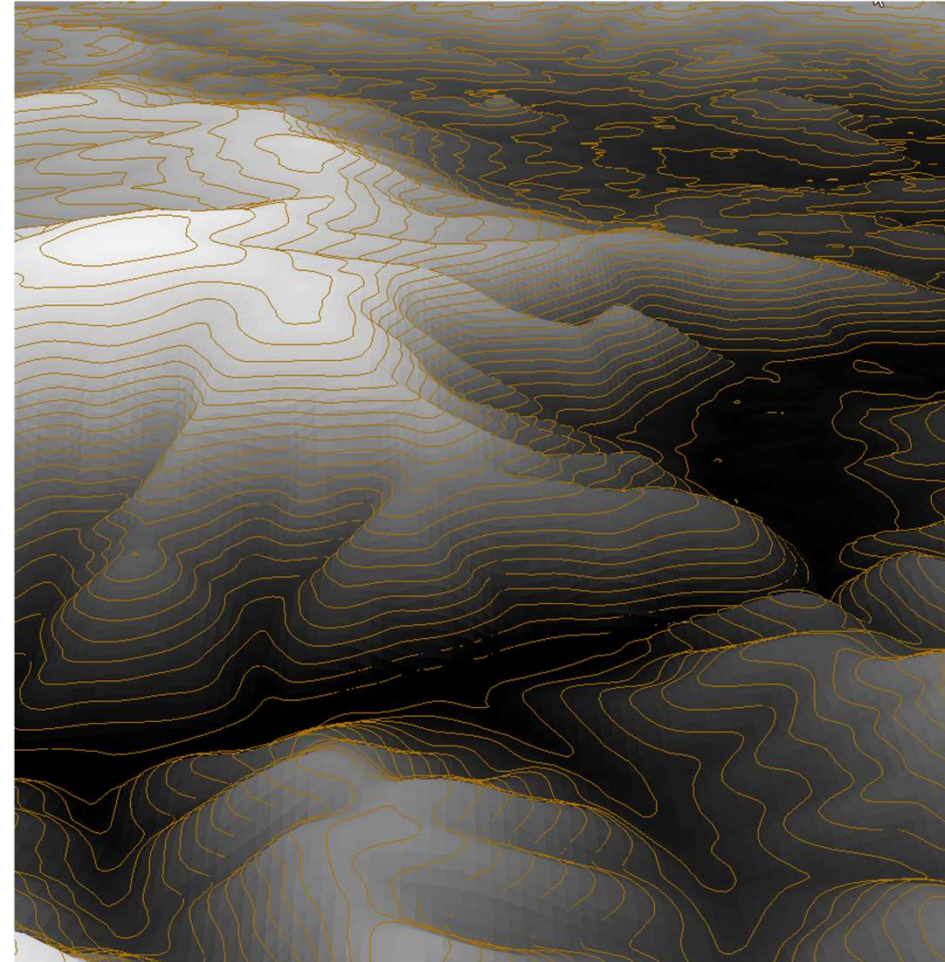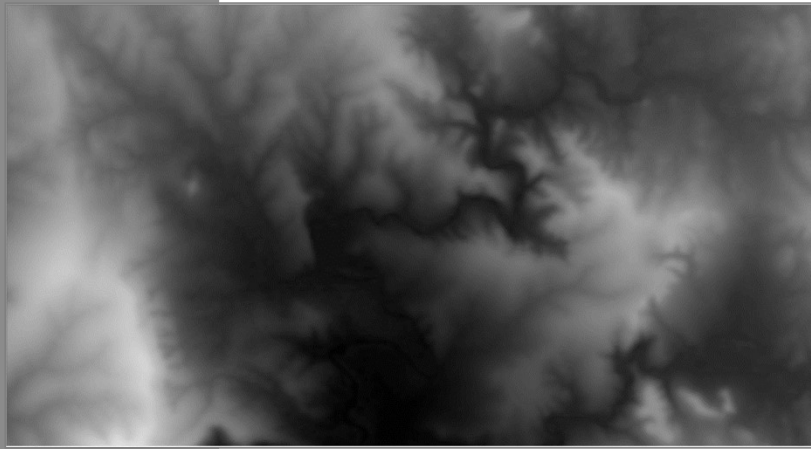
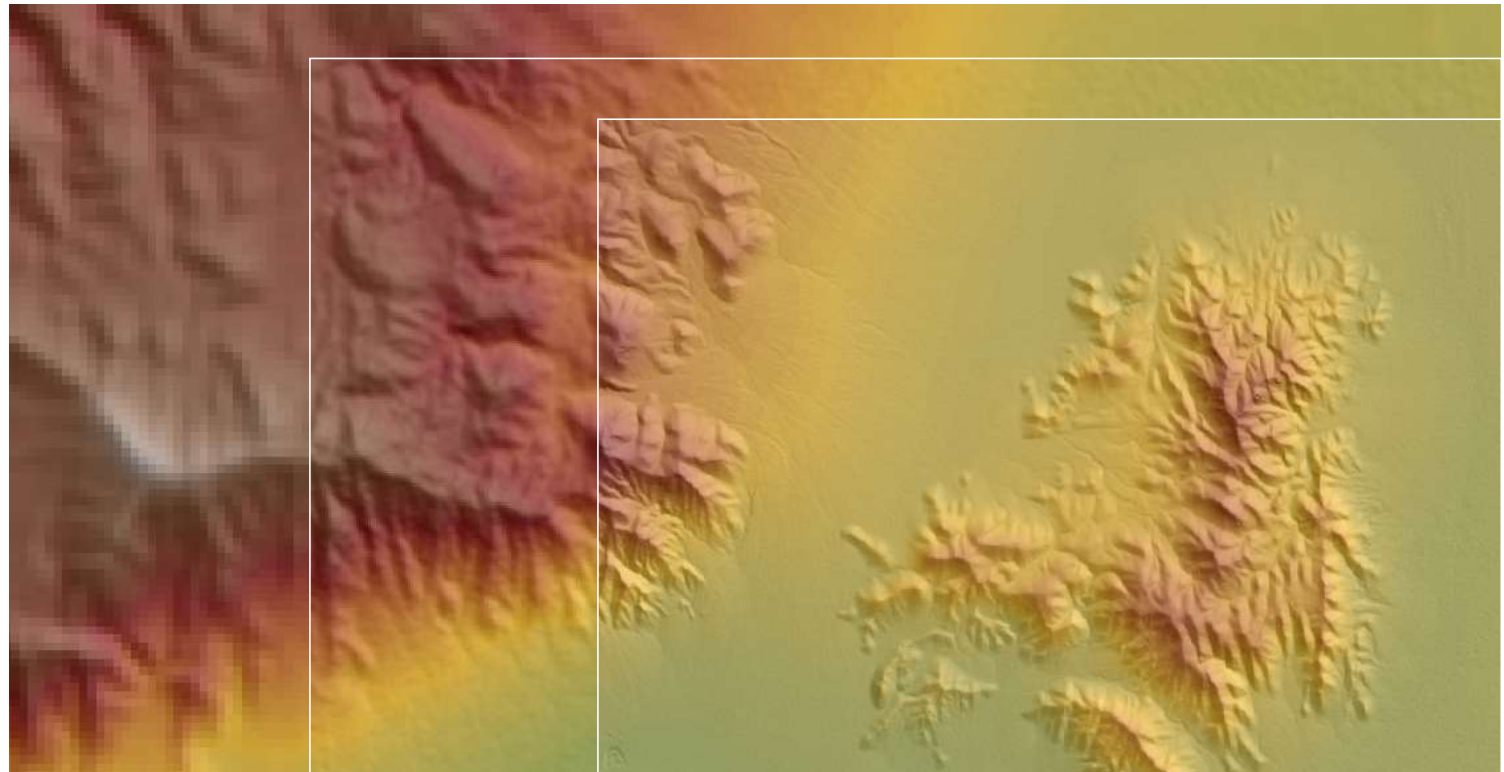| Stereo Collection	acquired Stereo images : Left / Right

DTM & Contours

DEM generation

Space Shuttle / Satellite — Aerial — UAV

90m   30m   10m   5m   1m   0.1m

3D
Terrain analysis

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making
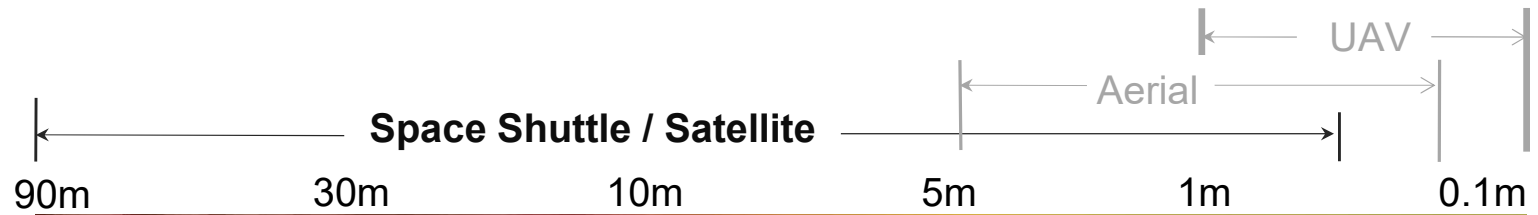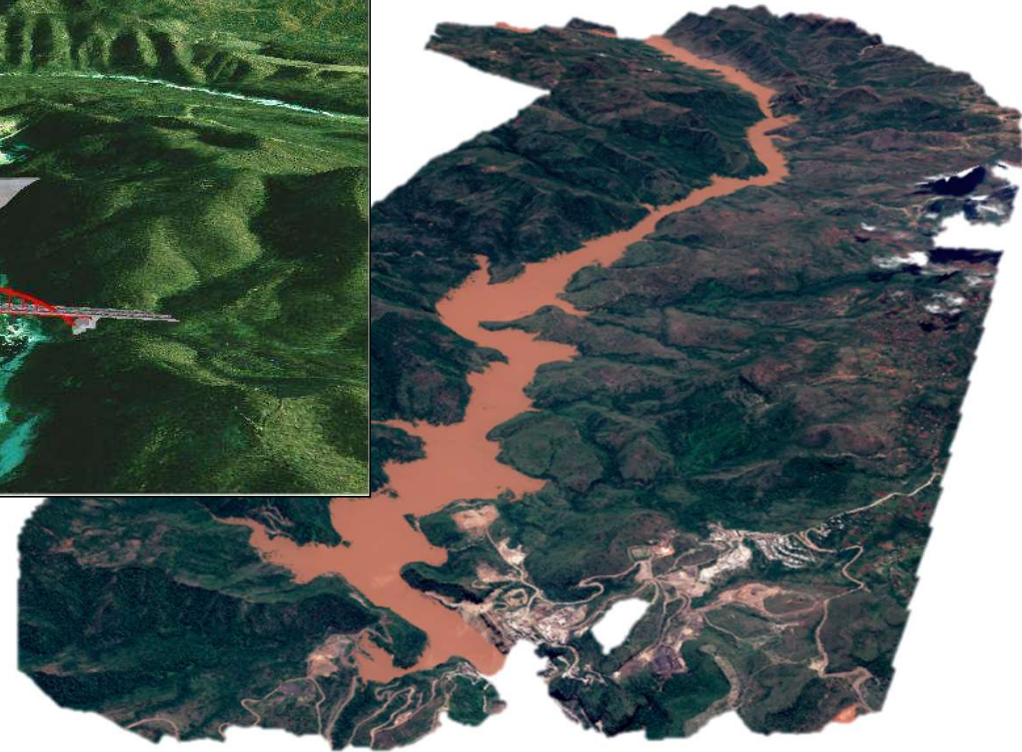
Route plans for Power tower sites
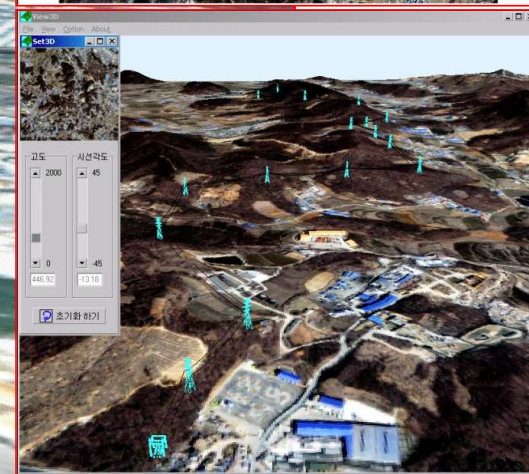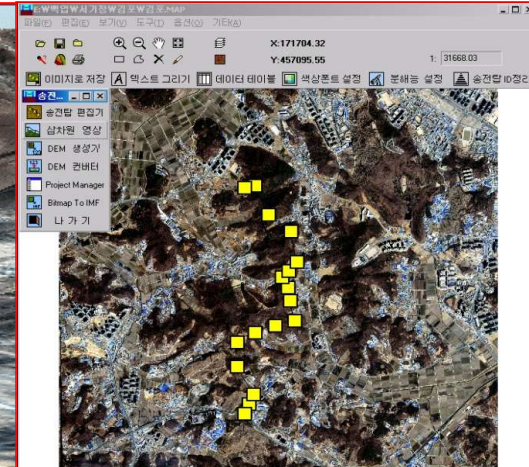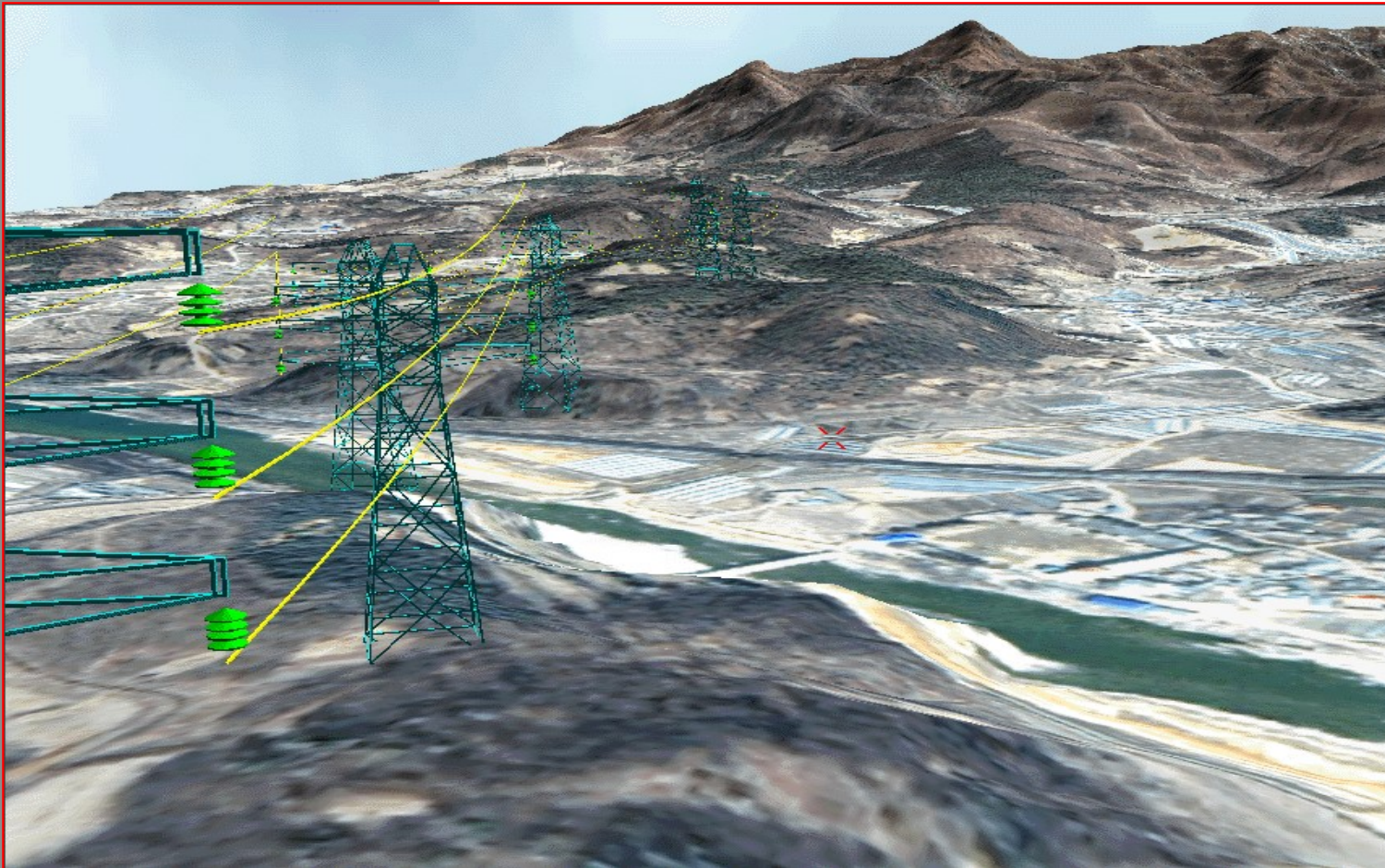
Extracting 3D layer information by using DPW

Digital Topographic Mapping

Procedure for Digital Topographic Mapping

Acquisition images
(Stereo)

GCPs
(Local Surveys)

3D AT
(Accuracy Adjustment)

Extracting
Topographic Information

Editing Topographic Map

Final Digital Map

3D AT(Aerial Triangulation)	
1	Sensor Modeling with RPC
2	Analyzing Stereo images with GCPs
3	Estimating the Accuracy
4	Repeat (2), (3) until the accuracy meets the best result
5	Verifying final accuracy is within the requirement
	Starting to digitize

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

Mapping

with KOMPSAT−3A Stereo Images
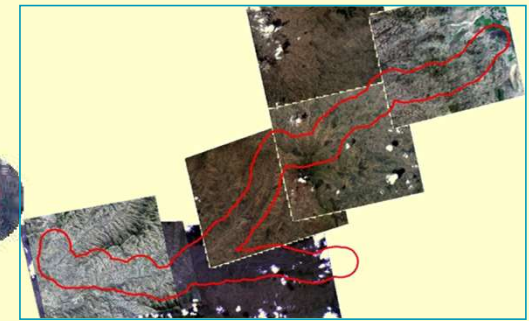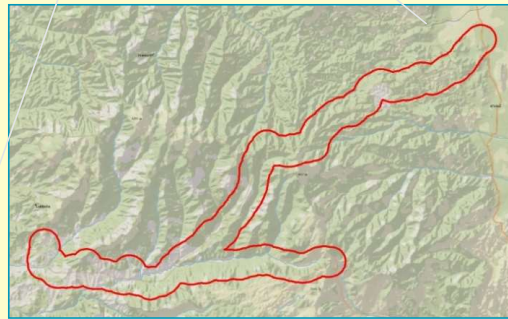
7 Stereo Satellite Images were acquired

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

Spatial Resolution vs. Mapping Scale

Elevation
- < 1m DEM
- 1~4m DEM
- 8~10m DEM
- 30 ~ 90m DEM

Map generating / updating (3D editing)

Satellite Survey ~ 0.5m Stereo

1.5m Stereo

Aerial / UAV Survey 3cm ~ 25cm

Map generating / updating (2D editing)

VHR Satellites < 1m mono

1.5 Mono

2 ~ 10m mono

Mapping scale

1/500 1/1,000 1/5,000 1/10,000 1/25,000 1/50,000 1/100,000 1/200,000

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

3 위성영상 처리
Processing satellite imageries

General WorkFlow for processing satellite images

1   **Acquiring satellite images**

2   **Pre-Processing**

3   **Accuracy Enhancement by AT**

4   **3D Editing / DEM Preparation**

5   **Ortho-Rectification**

6   **Accuracy/Quality Assessment**

7   **Ready for Application**

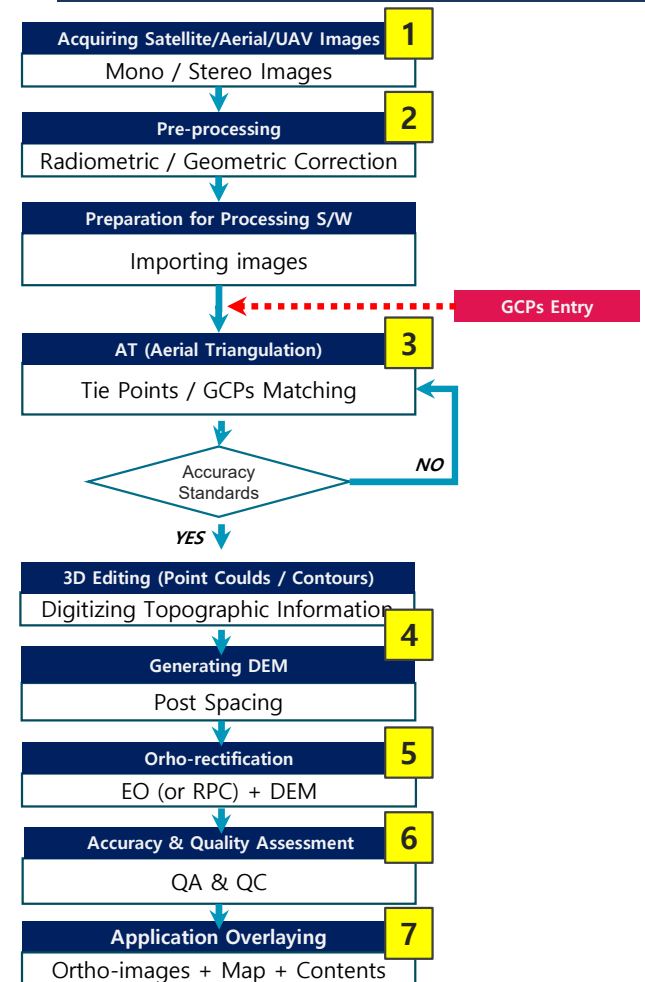| **Acquiring Satellite/Aerial/UAV Images** | **1** |
| Mono / Stereo Images | |

| **Pre-processing** | **2** |
| Radiometric / Geometric Correction | |

| **Preparation for Processing S/W** | |
| Importing images | |

← ⋯ **GCPs Entry**

| **AT (Aerial Triangulation)** | **3** |
| Tie Points / GCPs Matching | |

Accuracy Standards — *NO*

YES

| **3D Editing (Point Coulds / Contours)** | |
| Digitizing Topographic Information | **4** |

| **Generating DEM** | |
| Post Spacing | |

| **Orho-rectification** | **5** |
| EO (or RPC) + DEM | |

| **Accuracy & Quality Assessment** | **6** |
| QA & QC | |

| **Application Overlaying** | **7** |
| Ortho-images + Map + Contents | |

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

COTS Softwares for data processing

Photomod	ENVI	ERDAS	Catalyst	PIX4Dmatic
Socet Set/GXP	Cesium	CADMAP	ArcGIS	Metashape
Geographic Imager MAPublisher	Photoshop/illustrator	GlobalMapper	eCognition / Inpho	QGIS

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making
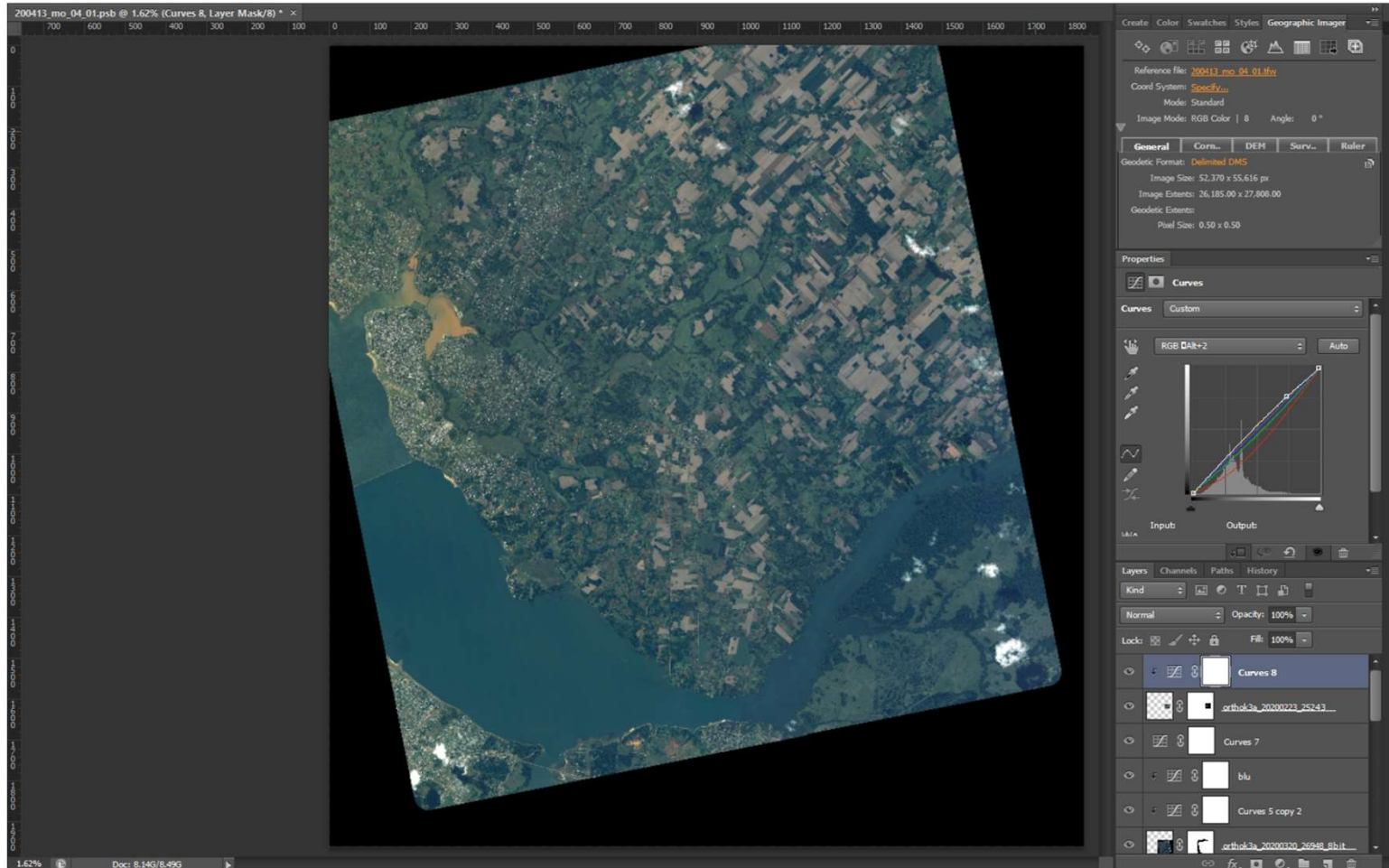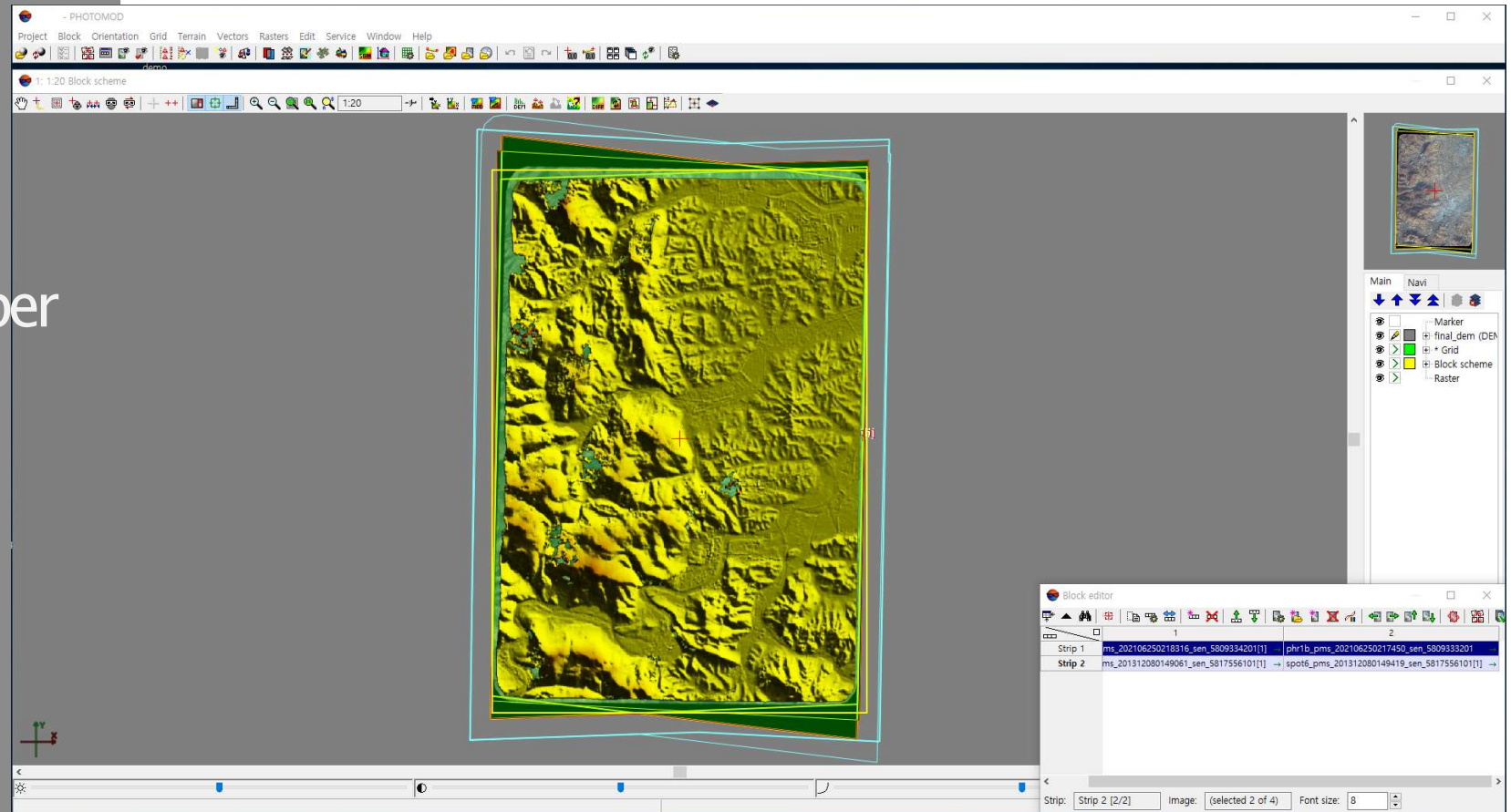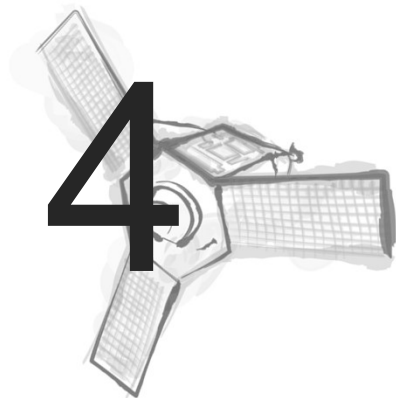
Graphic
re-touching

ERDAS Imagine +
Photoshop +
Avenza

DEM & Map generation

Photomod + ArcGIS + Global Mapper

4 위성영상 일상 업무 활용 제언
Suggestions for utilizing satellite images everyday

Basic processing skills increase work efficiency

Basic
Manipulate : Zoom in/out, move, histogram
Import / Export
Layer Stack : spectral bands composite
Rescale : change radiometric resolution
Degrade : change spatial resolution
Reproject : change coordinate system
Batch Processing

- Opening images and checking quality
- Changing file format
- Combining bands
- Dynamic Range (Histogram) Adjustment
- Resampling, Subsetting
- Changing pixel size
- Changing coordinate information
- Overlaying Vectors over Images

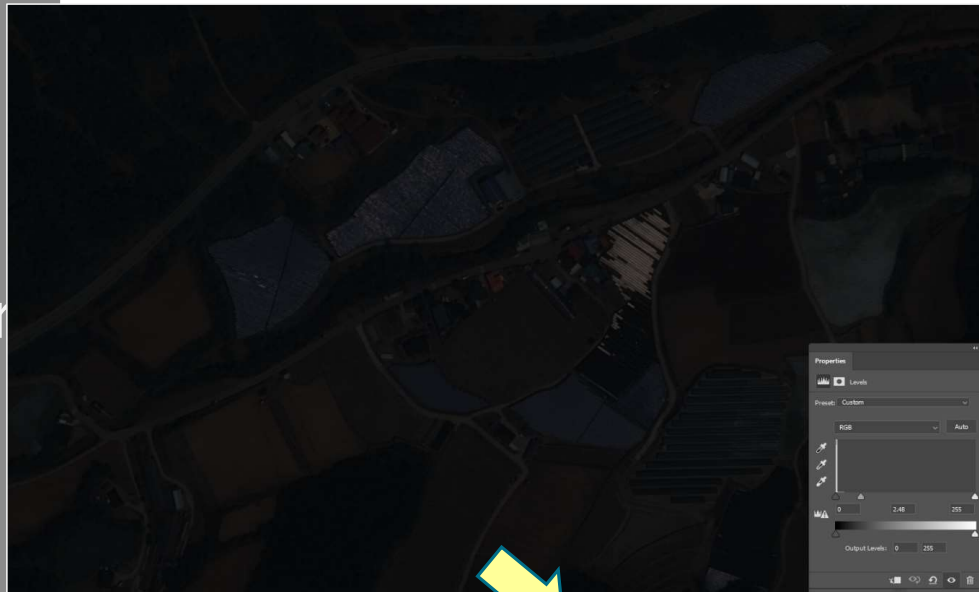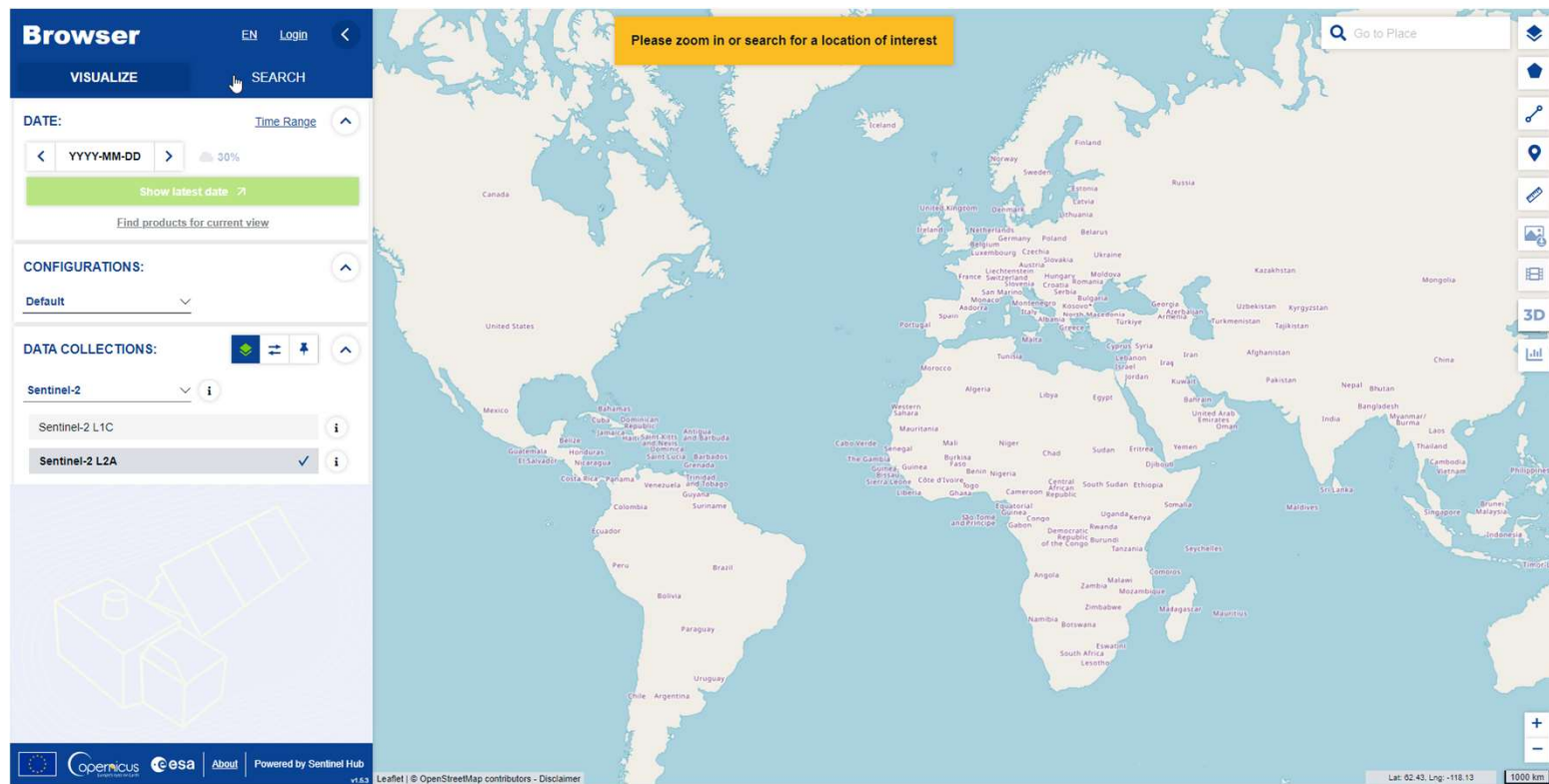| |
|---|
| Georeferencing / Geocoding |
| Rectification |
| Ortho-rectification |
| Fusion / Pan-sharpening |
| Subset / Mosaic |
| Classification |
| Digitizing |
| 3D visualization |
| **Advanced** |

Basic processing skills increase work efficiency

- Dynamic Range Adjustment helps you to see images clearly and dramatically.

Before DRA

After DRA

OPEN Source

10m resolution Sentinel–2

- Free Access at any time
- Easily check the latest satellite images
- Country-level monitoring
- 10m ortho-images

↓ access to Sentinel-2

https://browser.dataspace.copernicus.eu/
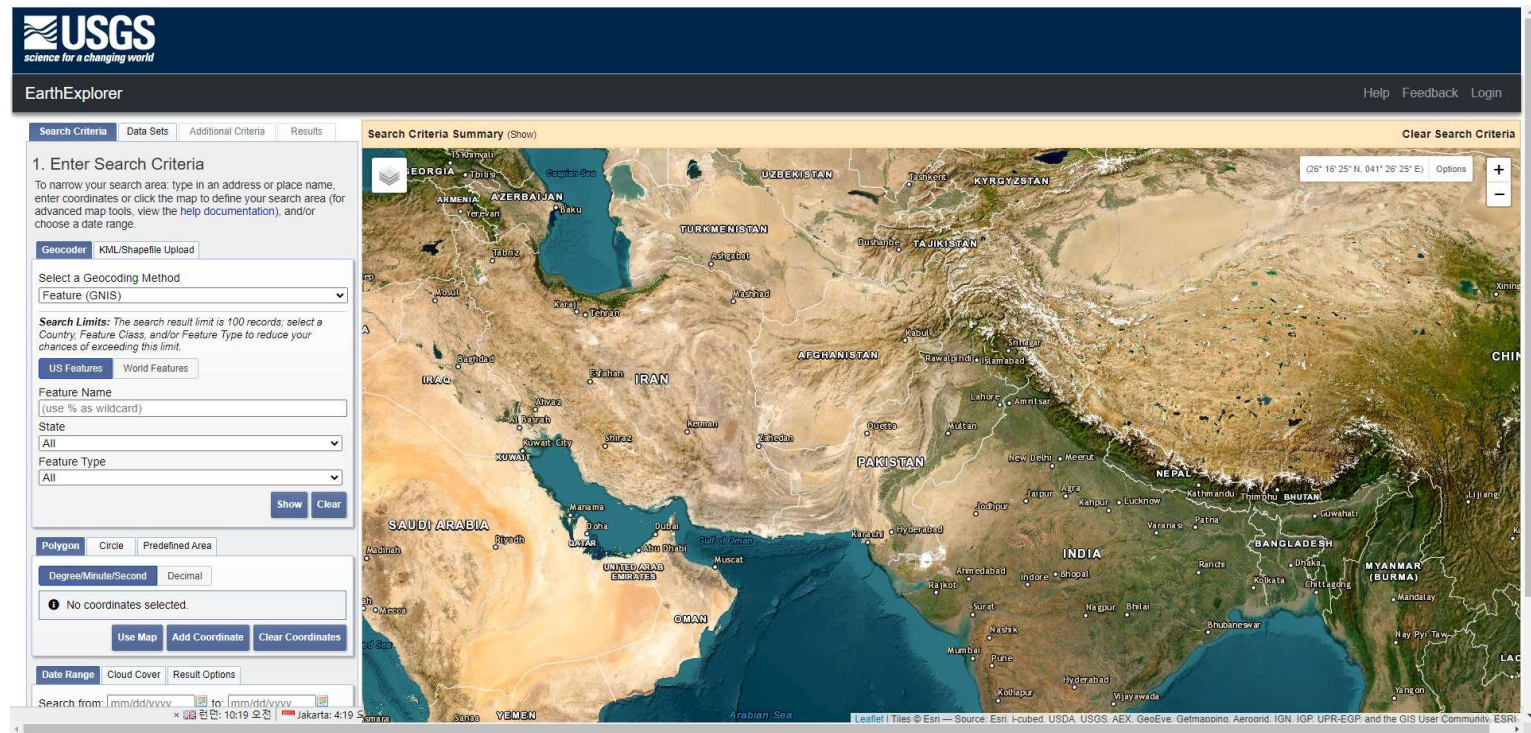
OPEN Source

30m Post Spacing DTM (SRTM)

- Free Access at any time
- NASA/USGS
- Global coverage
- 90m / 30m post-spacing
- Pre-topographic analysis on the interested area

↓ access to SRTM

https://earthexplorer.usgs.gov/

OPEN Source

VHR2021 Coverage

- Free Access for Gov't sectors
- Covering whole EU acquired in vegetation seasons
- Country-level monitoring
- 2m / 4m ortho-images

Coverage	Country	39 countries (EEA-39)	
	Area	~ 6M ㎢ (buffer: 500m borders , 4Km coastlines)	
Optical Satellite Imagery	Acquisition Window	Vegetation Seasons in 2020, 2021, 2022	
	Satellites	Primary : Pleiades-1A/1B, WV-2/3, GE-1, K-3/3A, SuperView-1	Secondary : SPOT-6/7, TripleSat GeoSat-2, SuperView-2
	GSD	2m / 4m	Multi-spectral (RGBN)
	Product	Level 1 (System Corrected) - Sun Elevation > 26° - Off-Nadir < 29° - 16 bits/pixel - DRA off	Level 3 (Ortho) - DEM : Copernicus GLO-30 - GCPs : Airbus SRPs - full RPC processing - ETRS89-LAEA, EPSG 3035
	File format		GeoTIFF version 6.0

OPEN Source

VHR2021 Coverage

REF COMPOSITION

provider	mission	resolution	number	area	ref %	cov %
AIRBUS	PHR	2	23243	1 820 668.45	28.78 %	28.68 %
SPACEWILL	SUPERVIEW-1	2	21396	934 174.07	14.76 %	14.71 %
EUSI	WORLDVIEW	2	11365	856 947.83	13.54 %	13.50 %
SIIS	KOMPSAT-3	2	11200	451 751.97	7.14 %	7.12 %
EUSI	GEOEYE	2	3492	241 910.93	3.82 %	3.81 %
SPACEWILL	SUPERVIEW-2	2	3288	166 446.62	2.63 %	2.62 %
AIRBUS	SPOT	4	13948	1 692 562.35	26.75 %	26.66 %
DEIMOS	DEIMOS-2	4	1832	62 497.66	0.99 %	0.98 %
AIRBUS-UK	VISION-1	4	1053	59 751.94	0.94 %	0.94 %
21AT	TRIPLESAT	4	398	40 244.14	0.64 %	0.63 %

resolution	number	area	ref %	cov %
2	73984	4 471 899.88	70.68 %	70.44 %
4	17231	1 855 056.08	29.32 %	29.22 %

year	number	area	ref %	cov %
2022	8909	176 798.89	2.79 %	2.78 %
2021	59816	5 033 120.61	79.55 %	79.28 %
2020	22490	1 117 036.46	17.66 %	17.59 %

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making

Searching for archived commercial satellite images

KARI
(https://ksatdb.kari.re.kr/map/map.do, Korea)

Airbus
(https://www.intelligence-airbusds.com/en/4871-ordering, France)

Maxar
(https://discover.maxar.com, USA)
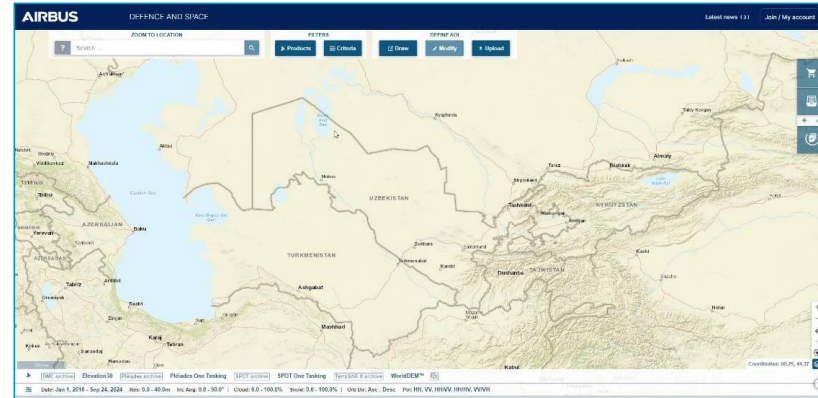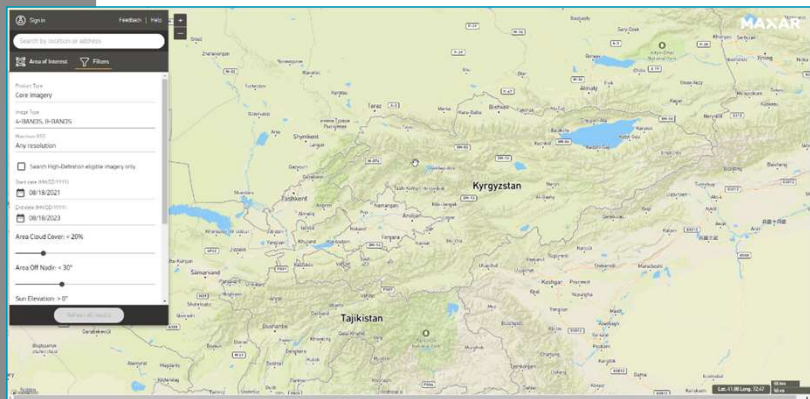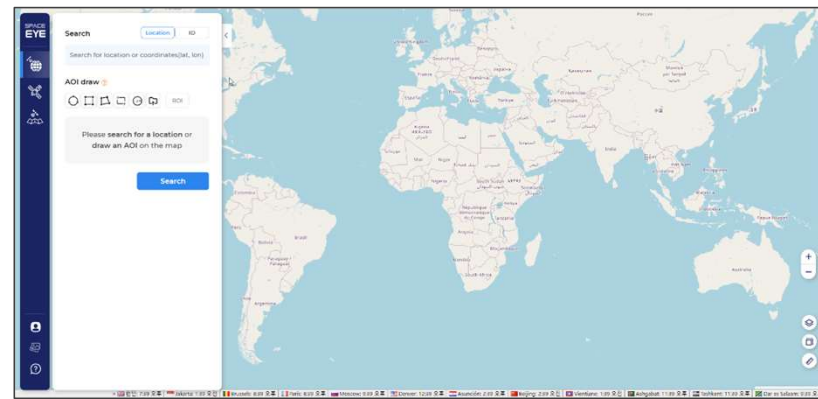
SIIS
(https://spaceeye.si-imaging.com/search, Korea)
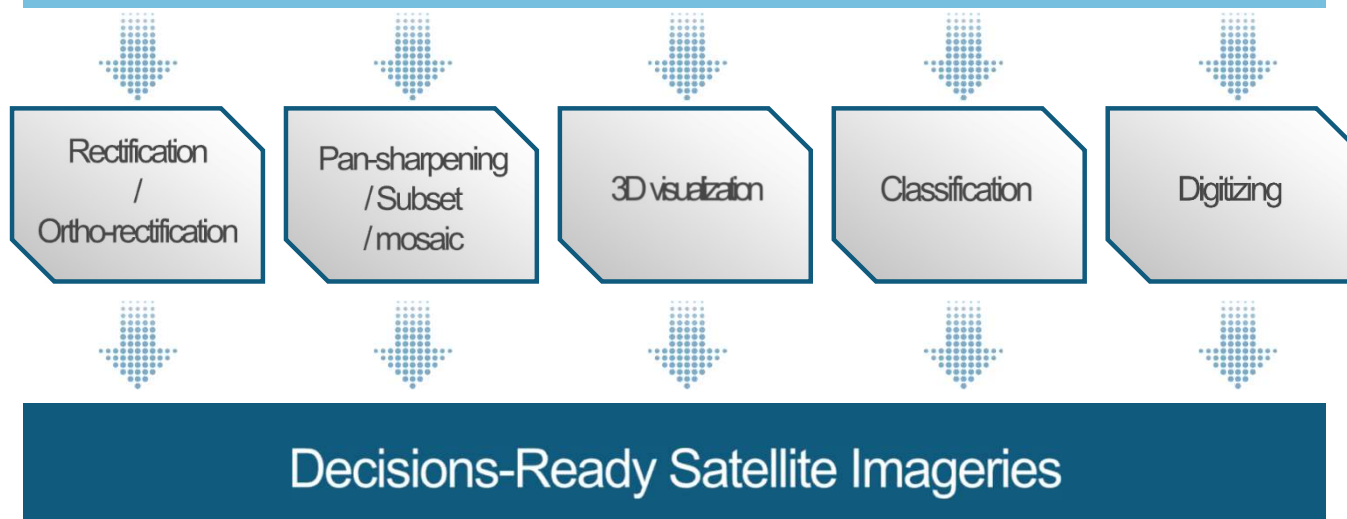
Closing

▪ **Collecting GIS information: paper/electric data**
▪ **Processing images**
▪ **Considering : purposes, scope, targets**

| Rectification / Ortho-rectification | Pan-sharpening / Subset / mosaic | 3D visualization | Classification | Digitizing |

Decisions-Ready Satellite Imageries

Summary

Selection KEYs		Questions for Selecting Satellite Imagery	
1	Spatial Resolution	Requirements on identifying features that are necessary for analysis ?	
		Select **an appropriate level of resolution**. However, **be budget-sensitive**.	
2	Spectral Resolution	Need Vegetation (Land Use, Mineral) Status Assessment ?	
		(Necessary) **Multiple Bands including NIR**	(Not important) **RGB**
3	Swath Width	Need quick information gathering for a wide area in a short period of time ?	
		(Necessary) **> 60 Km**	(Not important) **10 ~ 20 Km**
4	Revisit Time	Need monitoring regularly ?	
		(Necessary) **Multiple Satellites**	(Not important) **1 or 2 Satellites**
5	Acquisition Mode	need 3D information ?	
		(Necessary) **Stereo**	(Not important) **Mono**

| Considerations when Selecting Satellite Imagery for Spatial Information-based Decision Making