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Using Artificial Satellite Data in High-Low Mix Design Environment

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Learning Objectives

- Gain a basic understanding of GIS and satellite data so that you can “google” to find what you need when you need it.
- Discover GIS support functionality in Autodesk products and why you may need to know workarounds in some cases.
- Remember some web resources where you can find free and paid geospatial data
- Learn about when and why you need to associate Autodesk products (AutoCAD Plus, Civil 3D, and InfraWorks) in terms of handling geodata.

Description

Many professionals have started using satellite-based data in their design process to mitigate the risks from global warming, negative environmental impacts, Covid-19, low-intensity/large-scale conflicts, and other unforeseeable events. There are many types and a wide range of data format variations of 2D and 3D data derived from satellites, and their coverage and ability are growing rapidly. But the truth is that it is not always straightforward to "read" satellite-based data from your Autodesk design environment. In this case study, we will cover the following satellite-data-related topics: satellite data 101, benefits and limitations, examples of successful ACE projects, and some common pitfalls you may encounter. We will then cover how to cleanse and manage satellite data for three levels of design toolsets, namely AutoCAD software, AutoCAD Plus software, and the Architecture, Engineering & Construction Collection. Lastly, we will show several of the latest open/free, global-scale, satellite-based geodata that could be maximized in the large-scale conceptual/overall planning of architecture, engineering, and construction (AEC) projects.

Speakers

Sami Harada:
He is a long-time Autodesk product user since AutoCAD version 2.6 (1989~). He works for RESTEC as a senior specialist in the satellite data distribution section. One of his interests is helping people via bridging between GIS and CAD industries.

Mariko Morioka:

She has more than 10 years' experience in the remote-sensing industry. She is introducing and promoting various Japanese space data to the people in the world. She is in foreign sales team and supporting infrastructure projects with satellite-based solutions.

Both main-speaker: Sami Harada & co-speaker: Mariko Morioka currently work for Remote Sensing Technology Center of Japan (RESTEC), a Tokyo-based non-profit organization.

Introduction – why we want to use satellite data from Autodesk product?

More than ever, many organizations need a way to obtain updated information for every person who makes a design decision. This is because the world is constantly changing, and its speed has been accelerating. We have countless reasons why we cannot continue with the old way of doing things.We need to think about how individuals can get the access to the data that they need - Empowering everyone in your organization, no matter what kind of design decision they are trying to make, and at any scale.
And that's where satellite data come in. We also want to make sure it will be available at any level of the design workplace. That is the reason I am giving this presentation.

Satellite 101 – how it works

Demystifying satellite data acquisition

Unlike what you see in TV shows/movies, satellites will not change their flying direction. The orbit is determined during the launch operation. They will keep the same orbit for their entire life, and the orbit will determine where they can see and how often they will revisit the same place.

Sun-synchronous orbits: Pros-Cons

The most used orbit type is "Sun-synchronous orbits." A satellite in this orbit can visit anywhere in the world, but the effective revisit time is 5 days or more.

Increasing temporal resolution

One way to shorten the revisit time is putting multiple spacecraft in the orbit (= make a constellation), which requires a large amount of capital.
Another way is to title a spacecraft to point to the target (off-nadir viewing).
However, this decrease ground sample distance (GSD), image clarity, and accuracy.

Limitation

One of the biggest limitations of a satellite-based solution is its accuracy due to its high altitude. Typical (raw) satellite imagery comes with up to 3m RMSE, which is not greater than traditional approaches such as airborne / UAV-based solutions. You may want to request to calibrate the data using ground control points (GCP correction) to enhance the accuracy if the provider supports it.

Figure 1 Altitude

When satellite-based solution works

Moderate accuracy but high scalability is required

- Size of area of interest (AOI): larger than 25 sq. km (= 10 sq. mile)
- Raster resolution: 0.3m to 2.5m or larger
- Horizontal / Vertical accuracy: 1m to 5m RMSE

Accessibility to the target area is limited

- Remote location, no-fly-zone (airport), etc.

Agility is critical

- For short turnaround time and/or periodical update

Table 1 Satellite solution vs. others

Pros	Cons
• Satellite ○ Universal, Ultra-scalable & Homogeneous ○ Low setup/arrangement cost	• Satellite ○ Not best-in-class accuracy & resolution ○ Not ideal for small AOIs (≦ 25 km^2)
• Airborne ○ Accurate, high-resolution (cm) ○ Scalable	• Airborne ○ Expensive setup (prior flight permission etc.) ○ no-fly-zone (airport) etc.
• UAV ○ Low initial-cast / setup ○ High resolution	• UAV ○ (difficult to access some target areas) ○ Limited Scalability
• Ground Survey ○ “cm” accuracy (thanks to GPS/GNSS) ○ Flexible to unexpected target characteristics	• Ground Survey ○ (difficult to access some target areas) ○ Inconsistent (quality <= surveyor's skill)

Two essential functionalities to handle satellite data

Your design environment (CAD) must handle satellite data gracefully to consume them since they come with various CRS & data format

Coordinate Reference System (CRS)

* CAD: (almost) always cartesian coordinates (X, Y, Z)
* Satellite Data: varies, e.g., geographic coordinate system GCS (polar coordinate system)

In order to show an object at the correct scale & location on your screen, CAD must understand the CRS of the source data. Not all Autodesk products directly support this.

Data Format

A satellite data file format, even when they share the same file extension, varies in terms of data compatibility with Autodesk products. For example, a GeoTIFF, a raster data format, can be compatible with Infraworks but cannot be read from Civil 3D. This is because one file format

supports many variations. It also depends on how each application handles an error and anomaly.

Autodesk design tools: Functionality

Different Autodesk products offer different levels of satellite-data support. If you need maximum data interoperability, consider converting satellite geo-data to vanilla AutoCAD data so that all vertical product users can access them, even from DWG TrueView, Autodesk Viewer, and AutoCAD Web on Mobile. See AU2020 class = CES468698 if you are interested in this direction.

InfraWorks

- 3D native & built-in excellent CRS handling
- Comprehensive & robust data interoperability

Civil 3D

- Read raster (DEM) to create a 3D surface
- All Map 3D functionality

AutoCAD Map 3D (extension)

- Extended CRS support
- GIS data support, including DEM handling (MapWSpace)

AutoCAD (without extension)

- Limited CRS support (GEOGRAPHICLOCATION)
- Limited data import

Autodesk design tools: bundle configuration

Suite configuration varies from country to country. Ask your IT manager/reseller if what you have includes what you need.

AEC collection

Offers all functionality for satellite-data but managing multiple binary (app & data) costs.

Civil 3D & Map 3D

Supports superb functionality for satellite-data

AutoCAD

May or may *__not__* include Map 3D extension!

AutoCAD LT

May or may *__not__* available in your country / region

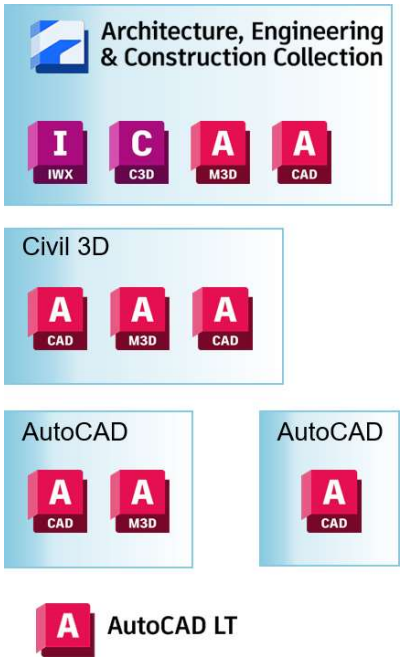

Figure 2 ADSK products

Data Compatibility

Raster Data

GeoTIFF file that is the best for GIS analysis does not necessarily mean the best for CAD consumption. MPIIMPORT/ATTACH implementation is not as robust as what InfraWorks offers (as of Sep/2022, using version 2023 products)

Table 2 2D GeoTIFF Compatibility Test Result

	InfraWorks	Civil 3D (Map 3D)	(Vanilla) AutoCAD
PCS GeoTIFF (projected, 8-bit, RGB)	✓ Drag & Drop	✓ MapIInsert / MapWSpace	? ATTACH (metadata ignored)
16-bit color GeoTIFF (16-bit-depth / band)	✓ Drag & Drop	✗ Not Supported	✗ Not Supported
64-bit address / 4+GB (BIG GeoTIFF)	✓ Drag & Drop	✗ Not Supported	✗ Not Supported
Pan + MS bundle (not Pansharpened)	✗ Not Supported	✗ Not Supported	✗ Not Supported
Revered band Order (e.g. B-G-R-IR)	✗ Not Supported	✗ Not Supported	✗ Not Supported

Raster Data

Vanilla AutoCAD does not support consuming satellite-based 3D data directly – it requires 3rd party solutions or some pre-processing, as you see in CES468698 from AU2020. (as of Sep, /2022, using version 2023 products)

Table 3 Compatibility Test Result (3D data)

	InfraWorks	Civil 3D (Map 3D)	(Vanilla) AutoCAD
PCS GeoTIFF (Projected)	✓ Drag & Drop	✓ Grid Surface / MapWSpace	✗ Not Supported
GCS GeoTIFF (Lat/Lng)	✓ Drag & Drop	? "Z" is stretched 11,120x to "XY"	✗ Not Supported
64-bit address /4+GB (BIG GeoTIFF)	✓ Drag & Drop	✗ Cannot Read	✗ Not Supported
Contour Lines in Esri Shape File	✓ Drag & Drop	✓ MAPIIMPORT	✗ Not Supported
3D Building in Esri Shape File	✓ Drag & Drop	? No 3D Support (read footprint)	✗ Not Supported

Consuming 2D Imagery

Need to know the best data format specification for the best result. Try a sample first.

Resolution

We need 2 x 2 to 5 x 5 pixels at least to identify an object
Pay attention to the GSD (not only from the sensor resolution but also from the off-nadir angle)

Color

3 bands (R, G, B) would be sufficient for CAD visualization purposes
16-bit color is good for ML but may not work in AutoCAD-based product
GeoTIFF file that is the best for GIS analysis does not necessarily means the best for CAD

Geolocation

Georeferenced GeoTIFF or JPEG200 file should be sufficient (world-file is not necessary)
Drag-&-drop will not work. Use proper command/procedure
You may want to ask for orthorectification and/or GCP correction for the best accuracy

Other consideration

“True-ortho,” which is synthesized multiple images, can be used for digitizing ground objects
Sun-elevation to avoid deep shadows from tall buildings

Consuming 3D Data

Terminology: Digital Elevation Model

DEM can be used for either Digital Surface Model (DSM), which includes ground objects like buildings and trees, or Digital Terrain Model (DTM), which describes the bare surface of the ground. For example, NASADEM is a DSM, not a DTM.

CRS

Pay attention to the CRS & projection of each data you will use in your design. Even when the same projection (e.g., “UTM 10N”) is used, using different ellipsoids leads to misaligned locations. Check “EPSG” code of each geo-data you use in your design.

Vertical Datum (Elevation)

Two types of elevation are commonly used – make sure you are using the “right” one

- Orthometric elevation = height above sea-level (e.g., EGM2008)
- Ellipsoidal elevation = height above ellipsoid (e.g., WGS84)

Conclusion

Satellite-based data

- Increasingly, satellite-based solutions are getting more popular
  from imagery, greenhouse-gas emission, detecting geo-hazard, 3D terrain & building
- Be aware of the limitation – when you can use it and when you cannot

Consuming satellite data from ADSK products

- 2 key features: CRS & data compatibility
- Each product offers a different level of support
- Managing errors can be tricky

Best practice

- Make most out of what you have
- The best file format varies depending on your work environment
- Ask the provider to deliver the data in a “right” data format

Additional Web Resources

(Commercial) Service Provides referred in the presentation

Following is the list of commercial service providers that are referred to the presentation. You can directly contact them for questions/inquiries, or ask me (RESTEC data@restec.or.jp) if you want to know more about their products / services.

BlackSky

A unique satellite operator who offers easy new-tasking & ultra-quick delivery of satellite imagery
<URL> https://www.blacksky.com/

GHGSat

Capturing greenhouse gas emissions (methane/CH_4) from space in the best-in-class high resolution (25 meter)
<URL> https://www.ghgsat.com/en/

3vGEOMATICS

Semi-real-time ground-movement monitoring with unmatched accuracy (cm/year) for mitigating risks of geohazard
<URL> https://3vgeomatics.com/

AW3D

Supplying Digital Elevation Model (DSM/DTM), and 3D building vector data of anywhere in the world
<URL> https://www.aw3d.jp/en/

(Free) GIS Tools

Following are some of GIS tools you may want to use when you work with satellite data to consume from Autodesk environment. You will find some usages of them in a context of AutoCAD workflow in the following AU2020 class = CES469698:
https://www.autodesk.com/autodesk-university/class/Bring-Geospatial-Data-Your-Workspace-Alternative-Way-AutoCAD-LT-2020

QGIS

QGIS offers a broad range of GIS functionality you might need. The current version (as of Sep. 2022) is 3.2x. The latest build could be unstable, also the newly implemented features would not be directly relevant to your workflow, thus I would suggest that you should examine Long Term Release (LTR) version first.

Note: Unfortunately, look and feel (UI) in Ver 2.x and Ver 3.x can be vastly different. Following aged video instructions/demos (on YouTube etc.) may not be very intuitive from time to time.

<URL> https://www.qgis.org/en/site/forusers/download.html

GDAL (from OSGeo4W)

QIGS is a great tool to handle satellite data interactively in a GUI environment, however, you may prefer to use CUI to massage/process satellite-based data. Geospatial Data Abstraction Library (GDAL), more precisely its binary executables, can be handy when you want to process a multiple set of satellite data or automate your pre-processing procedure using a command-line/text interface. You can access most “GDAL commands” via OSGeo4W, which is a part of QGIS installation.

Note: You may not have an access to python script-based GDAL commands (e.g., gdal_edit.py) from OSGeo4W Shell. Find the right target script file (*.py) from your QGIS installation folder and pass its full-path to “Python” command if necessary.

<URL> https://gdal.org/index.html

Google Earth

From time to time, you need to deliver your area of interest (AOI) or other geo-related information to other people. Google Earth is a great tool to define an AOI and save it as KMZ (compressed-zip) or KML (plane text) file. You can use Google Earth to identify the UTM (Universal Transverse Mercator) / MGRS (Military Grid Reference System) zone, as well as access historical imagery, etc.

Note: You can directly import an Esri Shapefile to Google Earth; however, a conversion from non-WGS84 ellipsoid geometry to KML/KMZ may not be perfectly accurate (depending on the version you are running).

<URL> https://www.google.com/earth/versions/#earth-pro

(Open & Free) Satellite and other geo-data

Please refer each website to ensure your usage will be covered by their license scheme.

USGS / 3DEP products

Web search using keywords “USGS” or/and “3DEP” will give you more than sufficient information. There are several ways to access their data, and the following is one of my favorites:
<URL> https://apps.nationalmap.gov/downloader/

AW3D30

Worldwide 30m resolution DSM from JAXA – the Japan Aerospace Exploration Agency. There are serval sites that you can access this dataset. The data has been constantly refined and updated – you may want to access their original source website to get the most up-to-date data.
<URL> https://www.eorc.jaxa.jp/ALOS/en/dataset/aw3d30/aw3d30_e.htm

SRTM / NASADEM
Shuttle Radar Topography Mission, known as SRTM, is one of the most famous global-coverage DSM data. It offers void-less coverage between +/- 60° latitude in 30m resolution. NASADEM is an enhanced DSM dataset derived from SRTM with better accuracy.
<URL> ("google" to find how to access "them")

GSI data (Japan)
Geospatial Information Authority of Japan offers Lidar-based 5m DTM (partial coverage) and photogrammetry-based 10m DTM (full coverage) of Japan.
<URL> https://fgd.gsi.go.jp/download/menu.php

EO Browser
Satellite data ESA/Copernicus program, such as Sentinel-1 (SAR) and Sentinel-2 (Optical), as well as Landsat data can be found here.
<URL> https://apps.sentinel-hub.com/eo-browser/

ASF
Alaska Satellite Facility: ASF, is one of the most useful sites to access various free satellite data.
<URL> https://asf.alaska.edu/

Global Surface Water
This is a reliable source to understand the surface water body over the large target area (AOI). (size of 30m block = pixelation can be seen in a small area)
<URL> https://global-surface-water.appspot.com/

EPSG
You can look up an EPSG code and a coordinate system that is used worldwide.
<URL> https://epsg.io/

Tutorials on Web
There are countless online tutorials and "how-to" information.

Importing GIS Data into AutoCAD Civil 3D
A great YouTube tutorial by Jason Porter. "*… they've all been imported wherever they land according to their files … What most people do is they import this data then they move it around, scale around up or down however they need to so it can fit properly into their drawing however Civil 3D will do this for you automatically….*"
<URL> https://youtu.be/g7HW6apnh3g

AutoCAD Geographic Location | New Features 2015

This is a great introduction of GEOGRAPHICLOCATION command in AutoCAD.
<URL> https://youtu.be/gZzrLJQpFuk

GIS to CAD using ogr2ogr -Part 1- SHP to DXF with Contour Data

If you want to consume 3D terrain data from AutoCAD without an extension, you can generate contour lines in QGIS and then convert it to DXF. This article by Heikki Vesanto explains how to make 3D contours for AutoCAD consumption.
<URL> https://gisforthought.com/gis-to-cad-using-ogr2ogr-part-1-shp-to-dxf-with-contour-data/

Adding base-maps from Google or Bing in QGIS

This is not related to ADSK products but adding base maps to QGIS is one of many things that make your GIS-related work easier and faster.
<URL> https://gis.stackexchange.com/questions/20191/adding-basemaps-from-google-or-bing-in-qgis

Contact US (RESTEC)

https://www.restec.or.jp/en/contact.html