CES468698

Bring Geospatial Data into Your Workspace: An Alternative Way for AutoCAD LT

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Learning Objectives

- Reaffirm the strong GIS supports and capabilities in Autodesk's industry-specific products
- Establish a basic understanding of GIS concept and terminology so that you can "google" info you need on your own
- Translate GIS data to an AutoCAD native data and open them in AutoCAD model-space
- Examine some cases when some GIS data cannot be consumed from Autodesk products – and how to resolve them

Description

In the early stage of a project, collecting and organizing baseline data is essential and the key to the successful result. Satellite, aerial, or UAV based geospatial data, such as imagery and digital elevation model (DEM) , could be one of the most critical foundations of your initial design decision, but it's not always straightforward if you are not familiar with the GIS industry and community.
In this class, I will demonstrate how easy and simple we can import various GIS data into your design environment using InfraWorks and Civil 3D. Then I will delve into how it can be done with vanilla AutoCAD/AutoCAD LT.
Several practical techniques to make various GIS data to AutoCAD-readable format will be shared. Some GIS concepts, basic terminology, and how to use widely used open-source toolset such as GDAL (Geospatial Data Abstraction Library) and QGIS, also related tips & tricks, will be explained with Google Earth Pro.

Speakers

Sami (Hisamitsu) Harada is a longtime fan and enthusiast of Autodesk products. The first Autodesk product he encountered was version 2.6 (called “EX2” in the Japanese market) running on MS-DOS, then Release 10 (a.k.a. AC1006/GX3) was used while he wrote his master thesis. After spending 15 years in several west coast-based US companies, including Autodesk, inc., he returned to Tokyo and joined a general incorporated foundation named RESTEC who is promoting satellite technology among the general public. One of his current interests is democratizing satellite-based geospatial data and lowering the boundary between GIS and CAD communities.
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Mariko Morioka has spent more than 10 years in the remote-sensing industry as a sales representative. In 2016, she joined Remote Sensing Technology Center of Japan ("RESTEC"), promoting satellite technology for 45 years. Her responsibility is to develop and support the projects using AW3D, a 3D Map/Digital Elevation Model (DEM) derived from artificial satellite imageries for overseas partners and customers. AW3D is a GIS-ready comprehensive data including GeoTIFF and DWG/DXF and was used over 130 countries for more than 1,600 projects, mainly for urban planning, civil engineering, disaster mitigation plan, etc.
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LinkedIn: https://linkedin.com/company/aw3d-global-highresolution-3dmap/

1. GIS 101 – UTM projection

From time to time, you need to work in 2-dimensional space even you have to deal with 3D objects. Working with a 2D drawing/paper map is one of these occasions, and it might not straightforward as you can easily imagine.
GIS data often comes in 3D format since Earth is spherical shape, and you often have to transform 3D positions into 2D points – this is why we need a process so-called "projection." Projection, however, comes with tradeoffs in shape, distance, direction and/or size. This means that each projection method always has pros and cons, and you have to pick one that works the best for your need.

Universal Transverse Mercator (UTM) projection

One of the most frequently used projection is the "Universal Transverse Mercator" (UTM) coordinate system. It's from a relatively simple transformation method, and the result is very human friendly.
See: https://en.wikipedia.org/wiki/Universal_Transverse_Mercator_coordinate_system

In this class, we will see how we can bring GIS data into 2D DWG using UTM projection. Once you know the principle, you can apply the same technique with other "local" coordinate system that is suitable for your project.

2. Free GIS tools

Three free GIS Tools used in this class

GIS data comes with various formats with sub/local "dialects"/sub-formats. Because some formats are not fully compatible with Autodesk toolsets, you may need to massage data to make it readable. In this class, we will see the following free 3 tools that have been popular among satellite-based data communities(installation tips can be found in the class video) :

QGIS

This is the most commonly used open-source GIS GUI tool. Avoid the latest release and pick LTR (or try the latest version 2.x) instead if stability is more important than experimental new functionality.
https://qgis.org/en/site/

GDAL

This is an X/MIT licensed translator library for raster & vector GIS data. You can bind the library in your code, and some command-line tools are also provided.
https://gdal.org/

Google Earth Pro

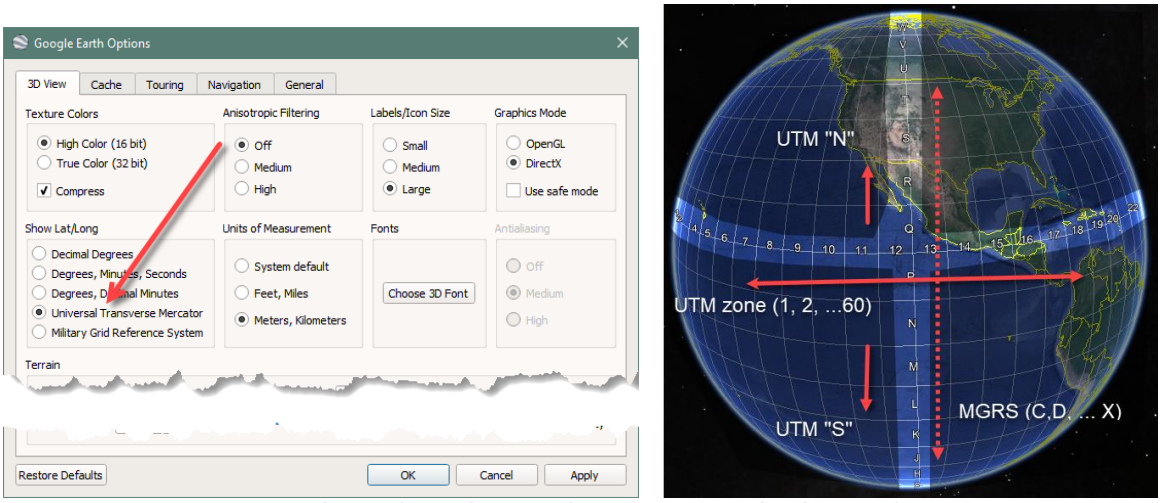
This a free tool that is extremely popular among the satellite data community. You can draw a point/line/polygon on "Earth" and save it as a KML/KMZ file.

https://en.wikipedia.org/wiki/Google_Earth

Visualize / identify UTM zone in Google Earth Pro

There are 120 (= 60 x 2) UTM zones and you need to know the corresponding zone ID of your target area. One of the easiest ways to find a zone ID is using Google Earth Pro.

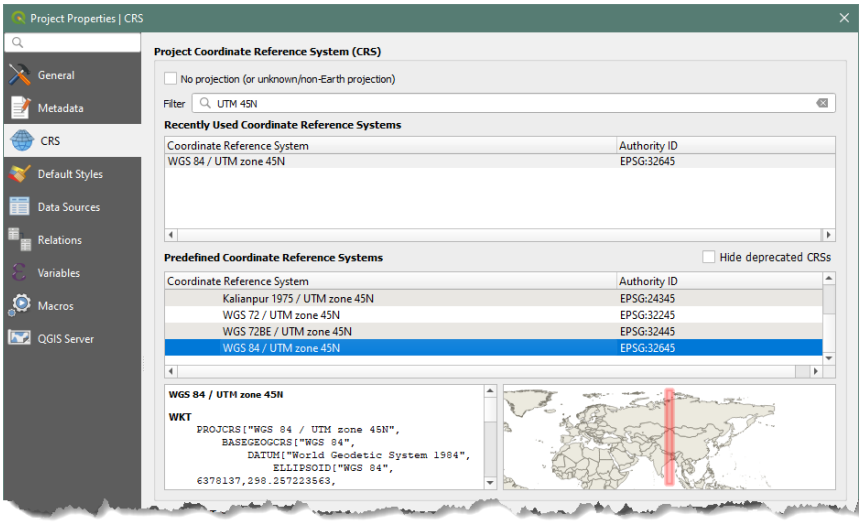
> Menu: Tools > Options… > [3D View] tab > Show Lat/Long group box. Select “Universal Transverse Mercator” then zone IDs are visible on the screen canvas (and the toolbar).



Google Earth Settings to show UTM zone (and MGRS)

Find an EPSG code for the target UTM

EPSG code is the ID that is used to identify the coordinate system and projection type. To reproject data to another system using GDAL, you will use an EPSG code. EPSG codes can be searched in QGIS - Menu: Project > Properties… > CRS tab.



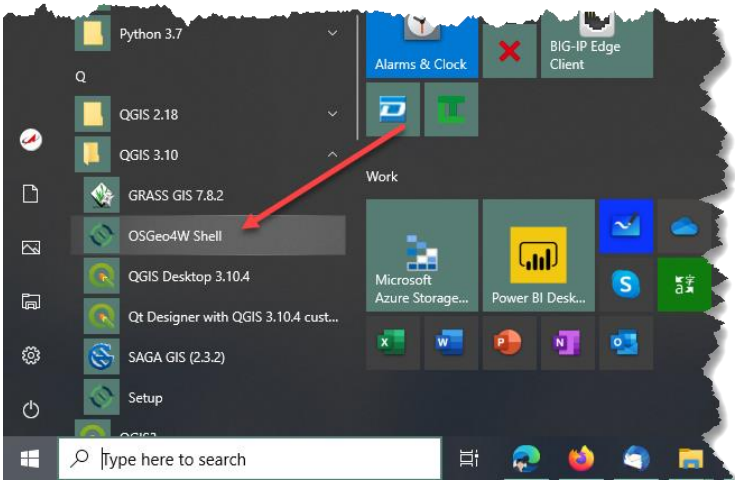
Find an EPSG code for the UTM zone

Accessing GDAL command-line tools

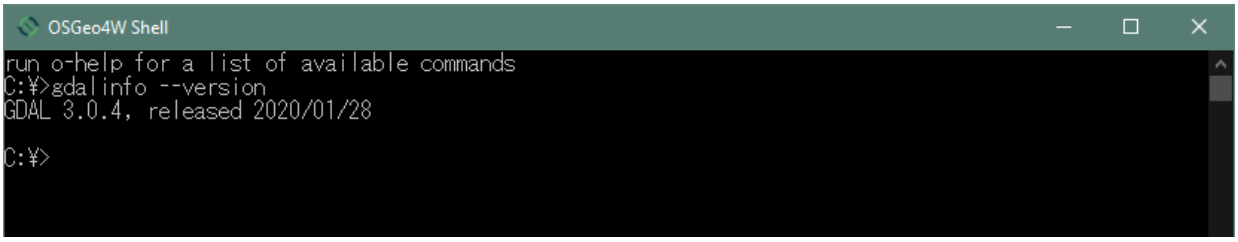
GDAL command-line tools come with QGIS installation, and they can be accessed via Windows Start menu > QGIS {version} > OSGeo4W Shell. Type any GDAL command, for example,

gdalinfo --version

to see if your installation is healthy.



Accessing GDAL command-line tools via OSGeo4W Shell



GDAL commands can be executed in the “OSGeo4W Shell” window

Placing GIS data in DWG at the right position w/ the right scale

Preparation – make the data consumable first

Before you place GIS data, check the projection/coordinate system of the data first. If it's not properly projected, reproject it using the ***gdalwarp*** command.

Check the coordinate system/projection

Examine your GeoTIFF file using the ***gdalinfo*** command. For an Esri shape file (vector), ogrinfo command with "-al" option can be used.

```
gdalinfo      target-file.tif
ogrinfo  -al  target-file.shp
```

If it's already UTM projected, you can skip the rest of the following preparation section.

Find the corresponding UTM zone ID

Locate your target in Google Earth Pro. See the zone number and S / N designator.

Find the corresponding EPSG code for the UTM zone ID

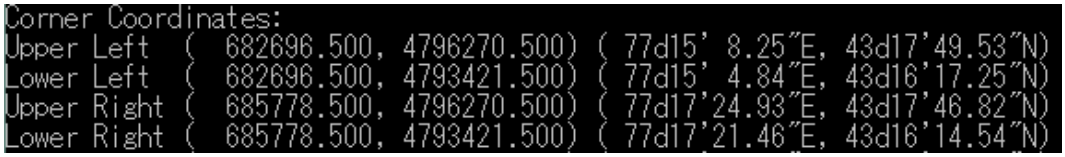
Open QGIS > Project > Properties… > CRS tab, and search the UTM zone ID

Reproject the data using EPSG code

For a raster file (GeoTIFF file), open OSGeo4W Shell window then

```
gdalwarp -r cubic  -t_srs EPSG:{nnnnn}   input-file.tif    output-file.tif
```

then "***gdalinfo output-file.tif*** " to get the positions of the "lower-left" and "upper-right" corners of the generated image. We will use these X-Y coordinates when placing the file inside DWG



Example: comer coordinates in gdalinfo output

For a vector file (*.shp), type the following then open the generated DXF from AutoCAD.

```
ogr2ogr  -t_srs EPSG:{nnnn}  temp-file.shp   input-file
ogr2ogr  output-file.dxf   temp-file.shp
```

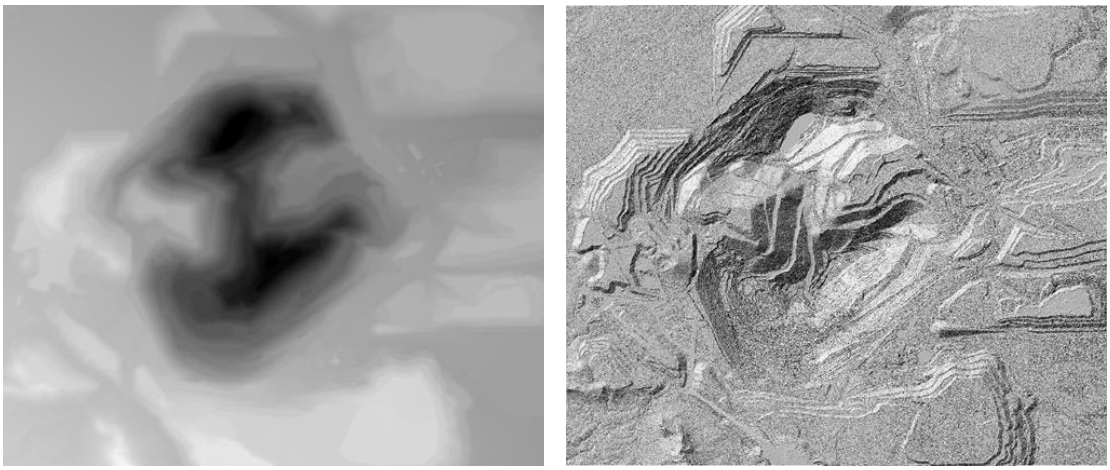
Place GIS data inside DWG

Raster files (GeoTIFF)

Make sure your drawing unit is "meter." Then draw a rectangle using two coordinates you get from "gdalinfo" in the previous step. Place an image using that rectangle.

Using Digital Elevation Model (DEM) to DWG

DEM (either Digital Surface Model – DSM, or Digital Terrain Model – DTM) can be placed into DWG since it usually comes in a raster file format (GeoTIFF), but simply placing it doesn't much make sense.



Left: DSM bitmap / Right: Hillside image (San Xavier Mine Site, AZ) from AW3D Enhanced 0.5m DSM credit

Hillshade image

You can generate a hillshade image, which is a more human-friendly form than a raw DEM raster, from DSM/DTM raster data.

Generate hillshade image using a gdal tool

Examine your GeoTIFF file using the ***gdalinfo*** command first to make sure your source data is properly projected (UTM or your preferred coordinate system). Then

gdaldem hillshade input-file.tif output-file.tif

Once you get a hillshade image, "gdalinfo output-file.tif" to get the lower-left & upper-right coordinates (X/Y), open a new drawing, set the drawing unit = meter, draw a rectangle using the Coordinates you got from gdalinfo command, then attach the image and make it fit the rectangle.

Contour lines

Another way to bring terrain elevation into an engineering drawing is to generate contour lines.

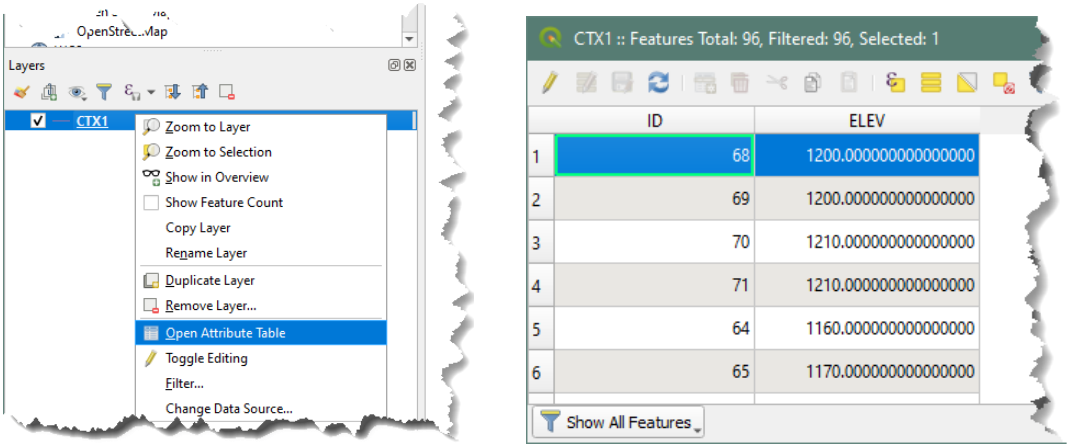
Generating contour lines

Examine your GeoTIFF file using the ***gdalinfo*** command first to make sure your source data is properly projected (UTM or your preferred coordinate system). Then try the following:

gdal_contour -i {interval} -a ELEV input-file.tif output-file.shp

Example: (10m interval contour lines from c:\AU20\aaa.tif file)
gdal_contour -i 10.00 -a ELEV c:\AU20\aaa.tif c:\AU20\bbb.shp

Thanks to the option "***-a ELEV***", the actual height (elevation) values are assigned to each line in the attribute table in the generated Esri shape file. To verify this, open the shape file from QGIS, select the layer, right-click mouse > select Open Attribute Table.



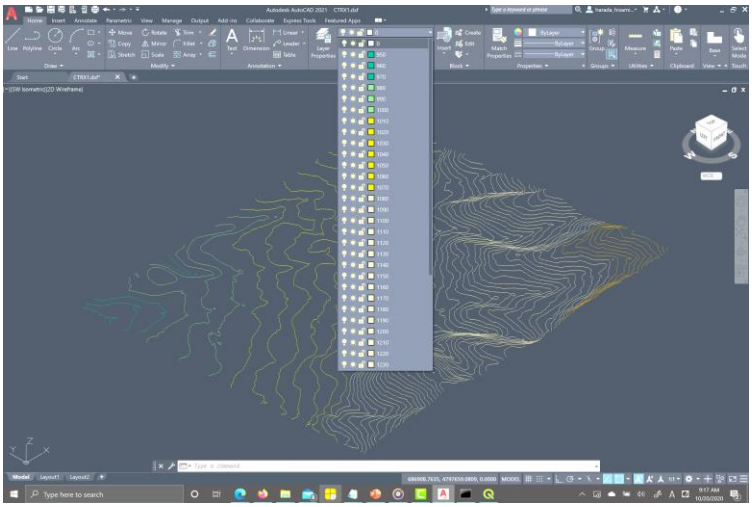
"ELEV" column is created in the attribute table in the SHP file

Convert an Esri Shape file to a DXF file

Once you create contour lines in an Esri shape file format, you can convert it to a DXF file. The format should look something like:

gr2ogr output-file.dxf name.shp -zfield ELEV -sql "SELECT ELEV Layer, * FROM name"

"***ELEV***" is the column name in the attitude table in the shape file. "***name***" is the file name of the source Esri shape file (without file extension). Avoid using as special characters, symbols, or/and any non-plain-ASCII character that may confuse SQL syntax.
Open the DXF file from AutoCAD, then you will see 3D contour lines are generated.



3D contour lines generated from a GeoTIFF file

Massaging GIS data for Autodesk products

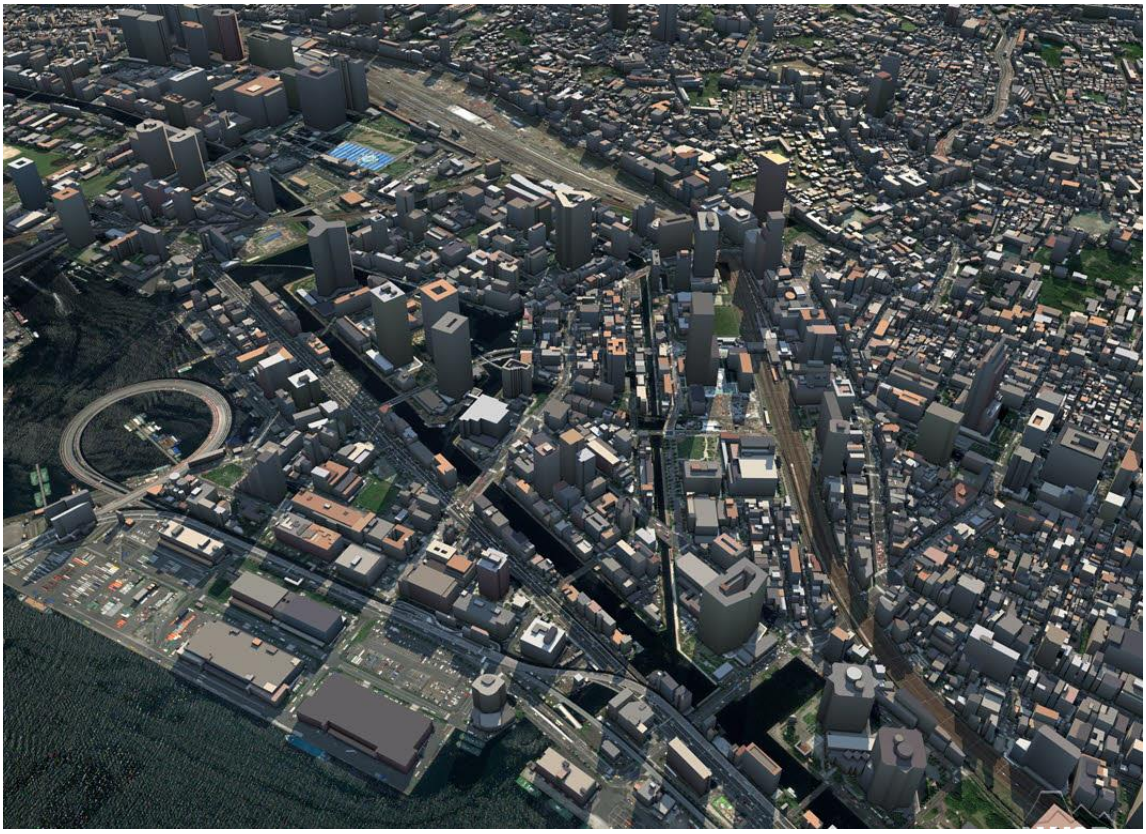
From time to time, opening GIS data from your platform won't work as you expected, because there are many sub-formats / dialects and you need to tweak before you use it.

16-bit data type GeoTIFF

As far as I have experienced, InfraWorks offers the most robust interoperability in terms of consuming GIS data.

Example

You can simply drag & drop DTM (Digital Terrain Model) in GeoTIFF format, Ortho-imagery, and 3D building vector data as well. Within a few mouse clicks, you will be able to generate a photo-realistic 3D virtual city model.



3D city model created in Autodesk InfraWorks (Minato City, Tokyo)
AW3D DTM, Orhto-image, & 3D building data, ©NTT DATA Corporation, Included © Maxar Technologies,Inc.

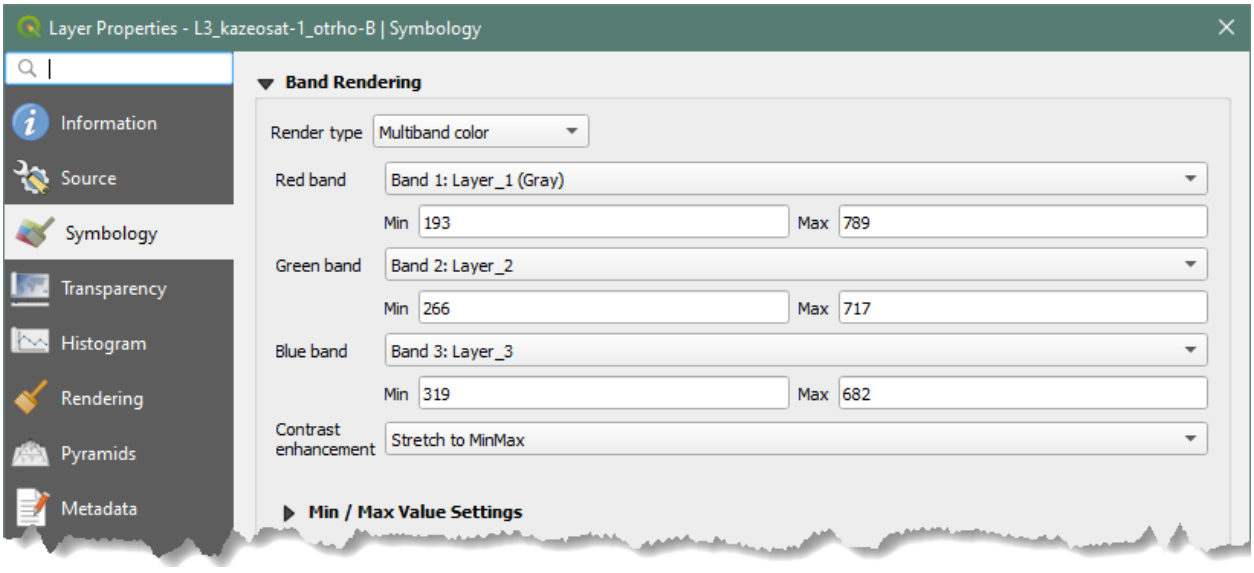
The only issue I currently have with InfraWorks is that it won't read 16-bit data type GeoTIFF correctly. When you take a look inside a GeoTIFF using the "***gdalinfo***" command, you will find that the data type of R/G/B band is UInt-16 (16-bit unsigned integer) in some satellite imageries.

This kind of 16-bit data type GeoTIFF is not shown correctly in AutoCAD either when it's attached from a DWG. To fix this, you need to convert the data type from UInt-16 to Byte. This can be done using the ***gdal_translate*** command with "-**ot Byte**" option.

```
Band 1 Block=3082x1 Type=UInt16, ColorInterp=Gray
  Description = Layer_1
  NoData Value=65535
  Metadata:
    LAYER_TYPE=athematic
    OVERVIEWS_ALGORITHM=ErdasBino3
Band 2 Block=3082x1 Type=UInt16, ColorInterp=Undefined
  Description = Layer_2
  NoData Value=65535
  Metadata:
    LAYER_TYPE=athematic
    OVERVIEWS_ALGORITHM=ErdasBino3
Band 3 Block=3082x1 Type=UInt16, ColorInterp=Undefined
  Description = Layer_3
  NoData Value=65535
  Metadata:
    LAYER_TYPE=athematic
    OVERVIEWS_ALGORITHM=ErdasBino3
```

"Type=UInt16" in gdalinfo command output

When we convert a data type from UInt-16 to Byte, we need to know the proper scaling / stretching setting on each R/G/B band. We can refer to the auto-scaling settings in QGIS. Open a GeoTIFF file from QGIS, then right mouse button click on the layer, properties…, then open Symbology tab. You can copy & paste these min/max values.



QGIS Layer Properties > Symbology tab

The command you will use should look something like this:

gdal_translate -ot Byte -b 1 -b 2 -b 3 -scale_1 193 789 -scale_2 266 717 -scale_3 319 682 -r cubic input-file.tif output-file.tif

(this mimics the scaling/stretching settings you saw in the QGIS Symbology dialog.)

64-bit offset GeoTIFF (BIG TIFF)

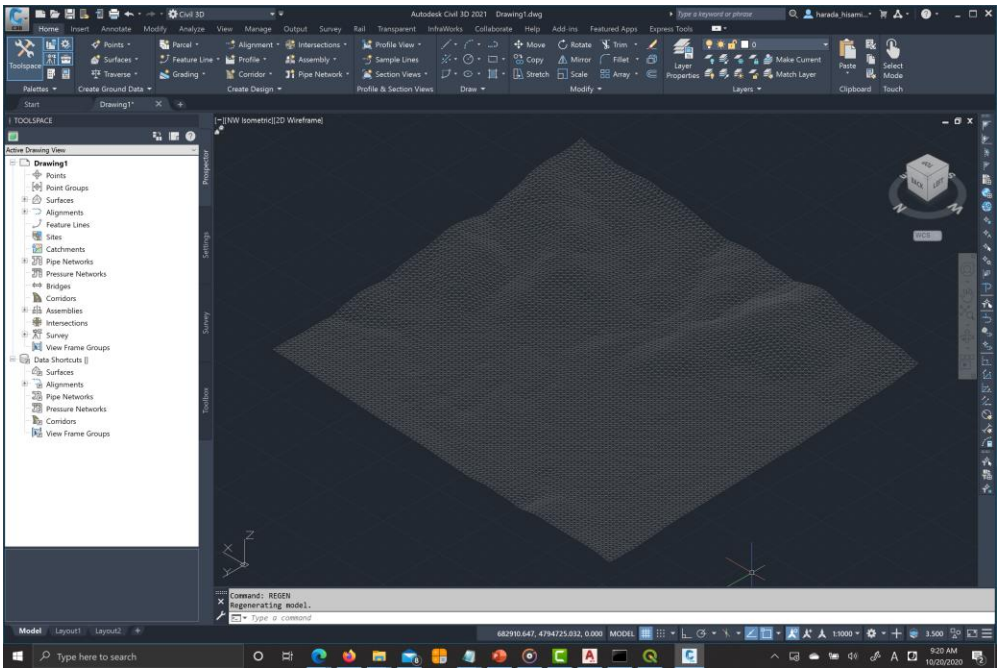
When a satellite image cannot be opened from AutoCAD (but it can be opened from InfraWorks or GIS software), try to convert it to 32-bit GeoTIFF using gdal_translate command with -co option. The syntax should look like:

gdal_translate -co BIGTIFF=NO input-file.tif output-file.tif

If the size of the area is large and the resolution is fine, you may need to clip a TIFF. This can be done via QGIS menu: Raster > Extraction > Clip Raster by Mask Layer…

Horizontal & vertical scale of a surface in Civil 3D

This typically happens when you create a grid surface from a DEM but DEM is not properly projected. Find a suitable UTM zone number for your Area of Interest (AOI), get a corresponding EPSG code for the UTM zone, then reproject a GeoTIFF using that code before you create a grid surface.



Grid Surface from DEM (Talgar, Kazakhstan)
DEM: KazEOSat-1 L-4 data / Courtesy Kazakhstan Gharysh Sapary (KGS)

Appendix: Online Resource

Once you understand the concepts of what I demonstrated in this class, you should be able to find necessary information quite easily via your favorite online search service.
The following are just some examples of where you should look into when they don't appear at the top of your search results.

Free GIS data

Free data would be a good option when your financial constraint doesn't allow you to use commercial data, even though you may have to compromise some aspects of the data quality, such as vintage, resolution, and/or accuracy.

USGS

You can find a wide range of GIS information and downloadable data including free high-resolution DTM of the United States. Search "USGS National elevation Dataset (NED)"
https://www.usgs.gov/

AW3D30

This is basically a downsampled version of commercial AW3D Standard DSM products (5m and 2.5m global coverage) + some additional treatments by JAXA (The Japan Aerospace Exploration Agency). It comes with a standard GeoTIFF file format, but you may need to add a no-data value definition to its metadata. Try:

gdal_translate -a_nodata -9999 input-file.tif output-file.tif

There are several sites where you can download AW3D30, but please watch the version of the data (Ver 3.1 is the latest as of Nov/2020).
https://www.eorc.jaxa.jp/ALOS/en/aw3d30/index.htm

SRTM

SRTM is the most well-known and widely accepted global-scale DSM. It comes with *.hgt file format. You should be able to convert them into GeoTIFF file format using:

gdal_translate input-file.hgt output-file.tif

It comes with a 1-degree x 1-degree tile in the geographic coordinate system (lat/long), so you may need to reproject the data into a suitable UTM zone.
I usually use this wrapper site to locate my target tile.
http://dwtkns.com/srtm30m/

GADM maps and data

This is a great site to obtain vector GIS data, such as the country, state, county boundaries for non-commercial users.
https://gadm.org/index.html

Documentation / Information / Tutorial Video

Here are some links I'd like to recommend to you. You will also find many tutorials that cover GIS-to-AutoCAD / AutoCAD-to-GIS workflows on YouTube and other online spaces.

GDAL official documents

There are many GDAL and OGR commands that you can massage GIS data to fit them for Autodesk products. I only scratch the surface of them in this class. Find a suitable command you need, then google it if it doesn't work as you expected.
https://gdal.org/index.html

Generate good looking hillshade in QGIS

If you need a good looking hillshade image with a proper color ramp for the background image of your project drawing, you can try the steps in this article.
https://ieggis.wordpress.com/2015/04/04/create-great-looking-topographic-maps-in-qgis-2/

Creating 3D contour lines and assign them to the corresponding layer

This article explains the detailed usage of ogr2ogr when you convert contour lines in an Esri shape file to a DXF.
https://gisforthought.com/gis-to-cad-using-ogr2ogr-part-1-shp-to-dxf-with-contour-data/

Importing GIS Data to AutoCAD Civil 3D

This YouTube video explains how to use GIS data from Civil 3D / Map 3D in the way it should be. He is not using UTM in his example, but you will see that a local coordinate system just works just fine as long as it's 2D drawing friendly.
https://youtu.be/g7HW6apnh3g

Adding Bing aerial image /Google satellite image to QGIS

You can bring Bing aerial images, which are the same online image you get through AutoCAD GEOMAP command, into QGIS as well. Please refer to the settings of Tile Server (XYZ) settings in this article.
https://gis.stackexchange.com/questions/20191/adding-basemaps-from-google-or-bing-in-qgis

Zoom Earth (vintage info)

You can find the vintage information (observation date) of the satellite image of the Bing/Esri online map/image. FYI - Bing aerial image is the one you see in the AutoCAD GEOMAP command.
https://zoom.earth/

I hope this gives you some new ideas about using GIS data from Autodesk products. Do not hesitate to contact me (RESTEC) if you have any questions about the dataset I used in my demos, any workflow that doesn't work for you, etc.
Thank you!