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

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Introduction: GIS data in DWG

Situation awareness is the most crucial factor in your construction/civil and other projects.

Wide range of free public GIS data are available / commercial data is getting more and more affordable

- **Aerial/Satellite imagery**
- **Digital Elevation Model (DEM): DTM & DSM from UAV/Satellite, and more…**

They are not always fully utilized!

- **Vanilla AutoCAD/LT: GIS data is not easily consumed with off-the-shelf toolset (need InfraWorks / Civil 3D)**

Through this class you will see

- **How to transform GIS data (image & DEM) to make them consumable from AutoCAD/LT**
- **How to place GIS data to the correct location in the correct size in AutoCAD model space**
- **A tip to “fix” GeoTIFF data that cannot be read from Autodesk products**

About the speaker

Sami HARADA – senior expert at RESTEC

A long time Autodesk product user since AutoCAD version 2.6.

Currently work for a general incorporated foundation: Remote Sensing Technology Center of Japan - RESTEC http://www.RESTEC.or.jp

RESTEC was founded in 1975 to promote artificial satellite technology and data. Since then, RESTEC has been receiving and processing data from satellites, and providing the data to users and researchers entrusted by the Japan Aerospace Exploration Agency (JAXA) and other related agencies.

Class Objective

✓ **We will explore following:**

- **Basic GIS 101**
  - a) Map projections, b) Popular GIS data file formates, c) Essential free GIS tools
- **How to massage GIS data and place them in AutoCAD/LT**
  - Identify projection and re-project to UTM
  - Manage raster & vector data using GDAL tools
  - Transform DEM (Digital Elevation Model) data to a consumable form for AutoCAD

✕ **This class does not cover:**

- **Advanced GIS-CAD integration workflow**
  - ~~Map 3D toolset, Autodesk-Esri integration, Convert CAD data to GIS data~~
- **Detailed GIS software GUI operation**
  - ~~ArcGIS / QGIS UI operations~~

Target Audience / Scope

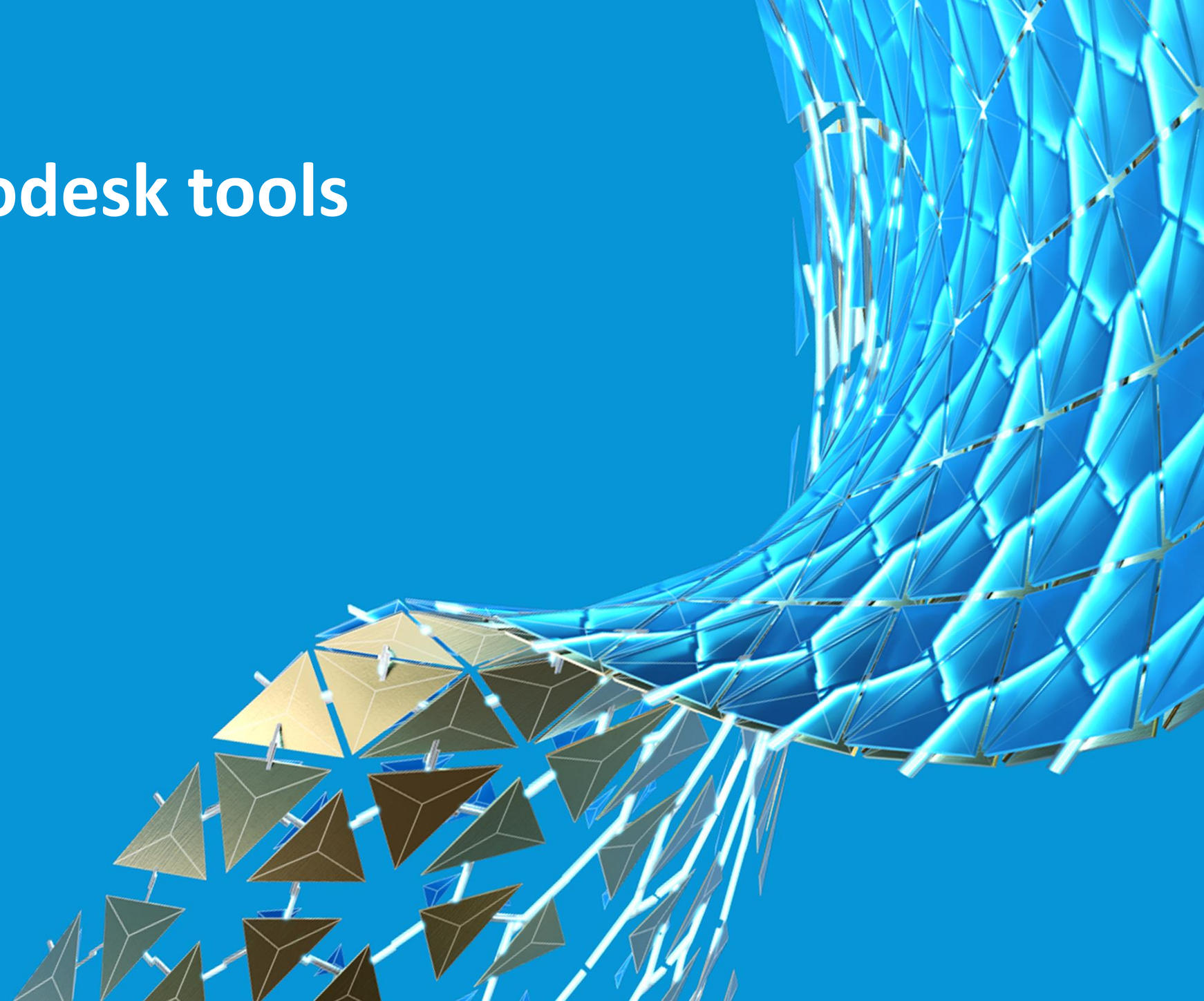
✓ **This class is for people who would like to:**

- Learn basic GIS concepts that are relevant to GIS to CAD workflow
- Use satellite-based data (image / terrain) into a design workspace
- (develop a feature to handle GIS data for AutoCAD environment)

✕ **This class is NOT for:**

- ~~GIS engineers~~
- ~~Esri product users (ArcMap / ArcScene / ArcGIS Pro)~~
- ~~AutoCAD Map 3D expert users~~

Demo-1: Autodesk tools and GIS data



Demo-1

DTM, Satellite Image, 3D building data - Courtesy AW3D

Examples that will work

- Read DTM, Ortho-image, then 3D buildings from Infraworks
- Create a surface from DEM in Civil 3D
- GEOMAP / aerial image in AutoCAD

Things that doesn’t work well

- GEOMAP = aerial image is not up-to-date (Shibuya, Tokyo)
- DEM data – horizontal/vertical scale doesn’t match in Civil 3D
- GeoTIFF – satellite image won’t be shown in InfraWorks / AutoCAD

I cannot make a part of this demo data available for free-download on an Autodesk site. Contact data@restec.or.jp if you want to try them out

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Photo credit goes here

Demo-1: recap

✓ **Autodesk professional toolset offer wide range of GIS related workflows:**

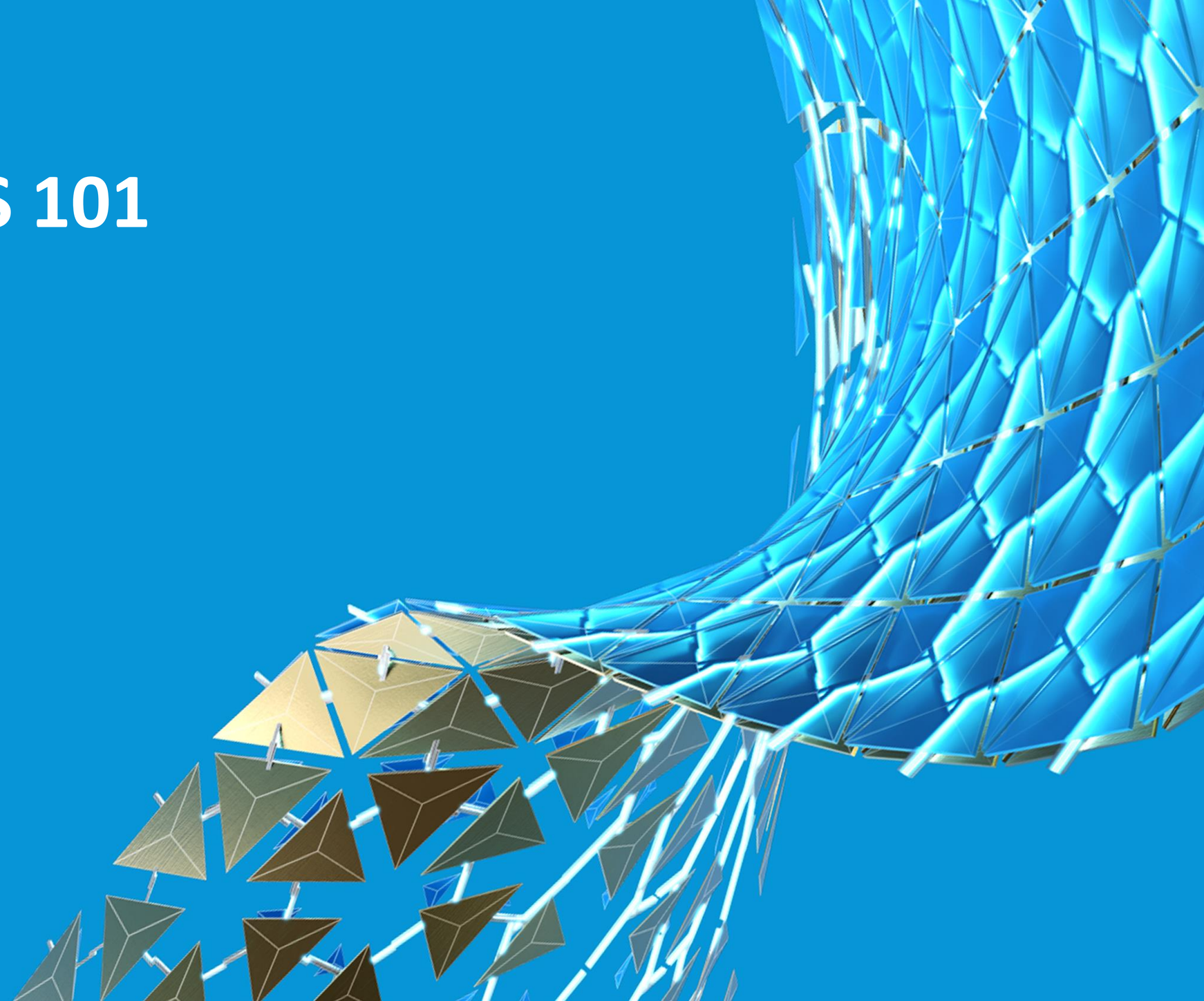
- Infraworks, Civil 3D, Map 3D
- AutoCAD / AutoCAD-LT: geographic location & online map through GEOMAP command

✕ **Sometime things do not work as you expected:**

- Online aerial image isn’t always up-to-date
- Horizontal / Vertical scale doesn’t match after creating surface from some DEM data in Civil 3D
- Some satellite image isn’t shown in InfraWorks / AutoCAD

We will revisit these issues later and see how to resolve them – but let’s dive in GIS basics first

Section-1: GIS 101



Section-1: GIS-101

What we will cover:

- **Map projections**
  - Local coordinate system, Geographic (lat-long), UTM, and EPSG code
- **File Formats in GIS**
  - Raster data: GeoTIFF
  - Vector data: KML/KMZ and Esri Shape
- **Free GIS Tools**
  - QGIS and GDAL (comes with QGIS installation)
  - GoogleEarth Pro

About the co-speaker

Mariko Morioka – AW3D sales in RESTEC

Mariko 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

AW3D

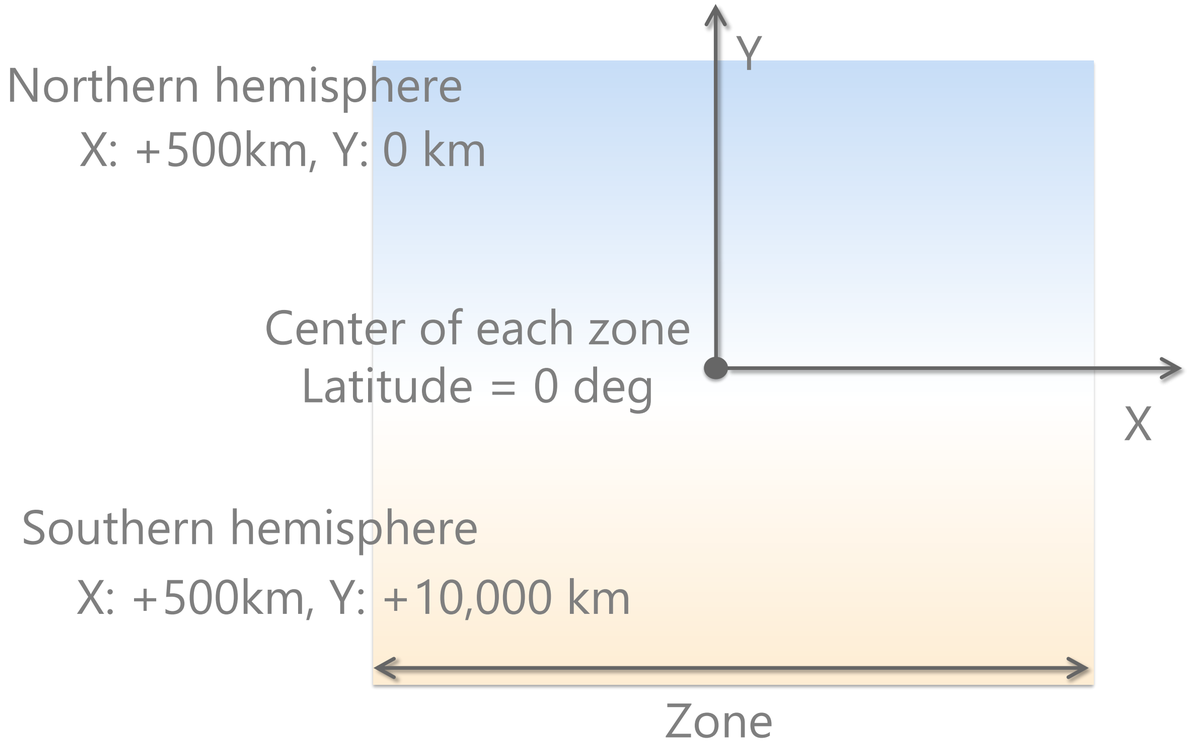
1-1: Map Projections

Since Earth is spherical shape, we have to transform the location into cartesian coordinate system (X/Y/Z)

- **Why project? Earth = sphere -> flattened out to X-Y plane map on the drawing panel**
- **Commonly Used Projection / Coordinate Systems**
  - Various local coordinate systems (e.g. NAD27/Texas North…)
    - Common in construction projects, but very “local”
  - Geographic coordinate system (latitude & longitude)
    - Scale to states and larger, precise, code/machine friendly but no human friendly
  - UTM: Universal Transverse Mercator coordinate system
    - Versatile, suitable for small-mid size region, ***CAD friendly***

Illustrative

Simplified view of contiguous US UTM zones, projected with Lambert conformal conic. – Wikipedia



UTM Zone

UTM - divides the globe into 60 zones (6 degrees of longitude each)

Each zone: 666.66… km width (40,000 km ÷ 60)

UTM X/Y coordinate

Unit: meter

The origin of each zone: the center of each zone

To avoid minus values, we add:

- **+ 500km (500,000 m) to X-value**
- **+10,000 km to Y-value in Southern hemisphere**
  - "**S**" and "**N**" identifier is used (e.g. 18N, 18S, etc.)

UTM, MGRS and EPSG code

2 additional things to know about UTM

- **MGRS Latitude Bands = Military Grid Reference System with UTM**
  - 20 latitude bands (each 8 degrees), starting from C, to X is used with UTM
  - Do not confuse N/S (Nouth/South) notation with latitude band S/N

    e.g. Baltimore, MD is in UTM zone **19N** (N=North), also in **19S** (S=lat band / 32 – 40 degree North)
- **EPSG code**
  - EPSG registry: defines projection systems, earth ellipsoids, etc.
  - Most GIS codes rely on EPSG code – you “have to” use EPSG to specify your desired coordinate system
    - EPSG:4326 - WGS 84, geographic (latitude/longitude) coordinate system – this is used in most GPS systems
    - EPSG:3857 – Web Mercator Projection – you will see this in most on-line maps (including Google/Bing map)

1-2: File Formats

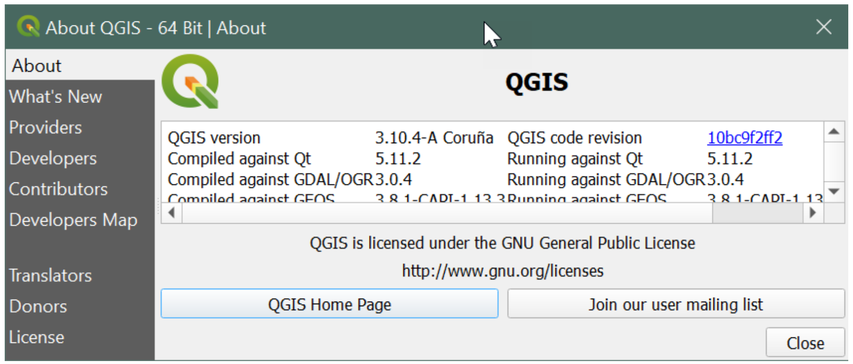
3 most commonly used GIS file formats (in satellite-based data industry)

- **GeoTIFF files**
  - Raster format: image TIFF + geolocational meta data
  - File Extension: *.TIF // used for satellite imagery and digital elevation model (DEM/DSM/DTM)
  - Uniform horizontal increments = resolution
- **KML / KMZ files**
  - Vector format: geometrical properties (points, polylines, polygons) + additional data in XML
  - File Extension: *.KML / *.KMZ (KML = plain-text , KMZ = zipped) // used to describe Area of Interest (AOI)
  - Fixed WGS84 geographic coordinate system
- **Shape files**
  - Vector format: geometrical properties + table data
  - Extension: *.SHP, *.SHX, *.DBF (mandatory) / *.PRJ, *.CPG, … (optional) // used for GIS (statistic) data

1-3: Free GIS tools

What we will cover:

- **QGIS**
  - Free and Open-source desktop GIS application platform
  - Visualize and manipulate 2D/3D GIS data
  - Supports various GIS file formats including GeoTIFF, Shape, KML/KMZ
- **GDAL**
  - Pronounce (“gee-dal”) = Geospatial Data Abstraction Library
  - Manipulate and convert various GIS data
  - command line tools comes with QGIS installation
- **Google Earth Pro**
  - Free desktop application that renders 2D/3D representation of Earth
  - Visualize GIS data in 3D environment
  - Supports KML/KMZ/Shape



Demo-2: GIS 101 & Free GIS tools

Demo-2

Installation

- **QGIS**
  Install Long Term Release: LTR, 3.x, 64-bit
  Install 2.18.28-2 as well
- **GDAL**
  open OSGeo4W shell from Windows Start menu -> 「gdalinfo --version」
- **Google Earth Pro**
  Install Google Earth on desktop

Quick Demo

- **GDAL:** Access GDAL commands from OSGeo4W Shell
- **QGIS:** Very basic UI operations
- **GE-Pro**: UTM settings in Google Earth, how to identify UTM zone & S/N

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Demo-2: recap

Two major free GIS tools to visualize and “cook” GIS data

- **QGIS**
- **GDAL (from QGIS installation)**
- **Google Earth Pro**

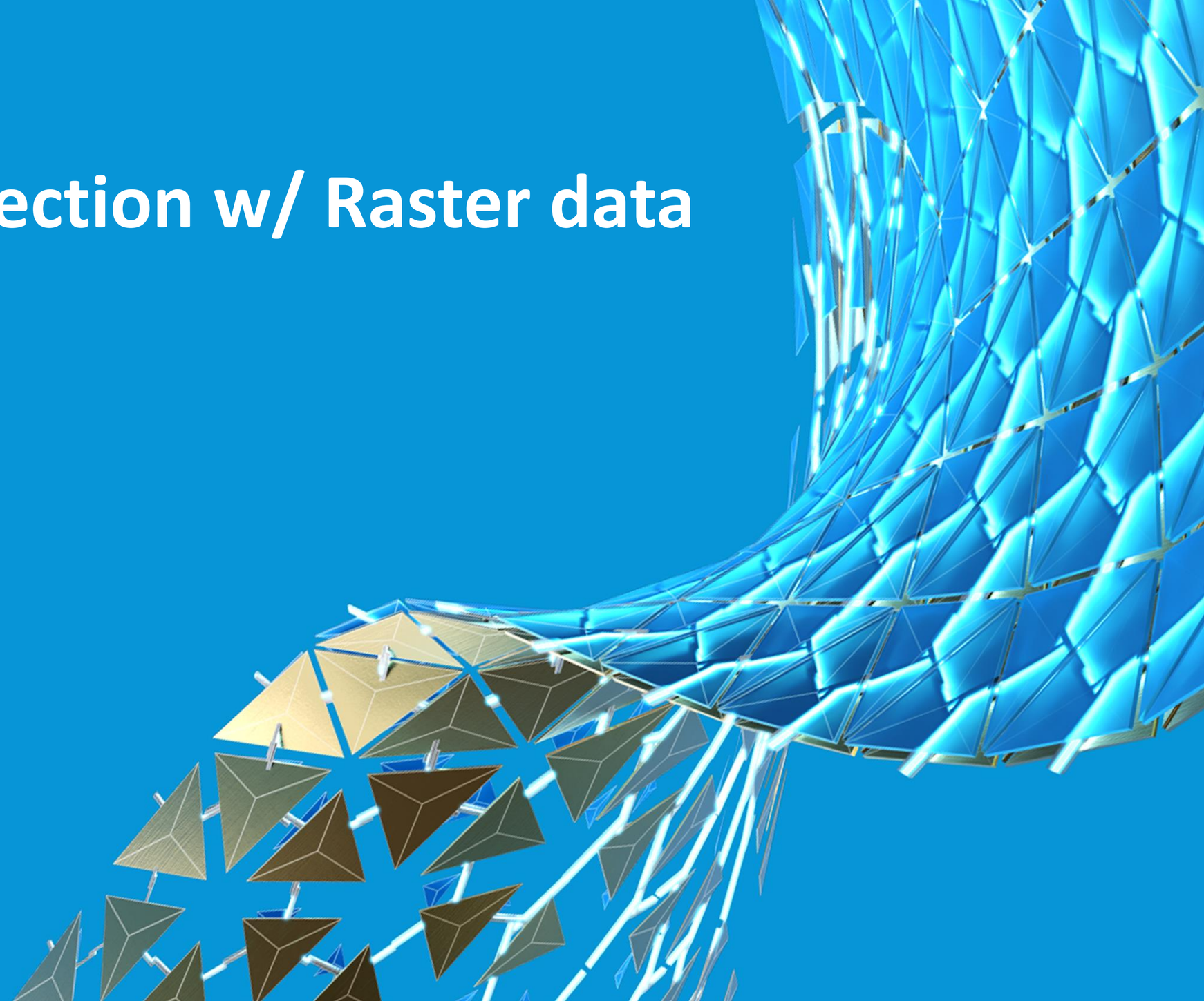
Now we have covered following:

- **Basic concept (projection / UTM)**
- **File types (GeoTIFF, Shape, KMZ/KML)**
- **Tools (QGIS, GDAL, Google Earth Pro)**

Next, we will take a close look at projection with raster data

- **How to check the projection type**
- **How to re-project GIS data (satellite imagery / Digital Terrain Model (DTM), Digital Surface Model (DSM))**

Demo-3: Projection w/ Raster data



Demo-3

Satellite image – KazEOSat-1 / Courtesy KGS

How to check the projection/coordinate system in a GeoTIFF file

- gdalinfo target-file.tf

How to know the UTM zone # of the target location

- Google Earth
  menu: Tools > Options… > [3D View] – Universal Transverse Mercator)
  UTM-zone # is shown on the screen
  Do not confused with UTM N/S (North/South) identifier from N/S from MGRS latitude bands

How to reproject a GeoTIFF file to your desired UTM zone

- gdalwarp -r cubic –t_srs EPSG:xxxxxx input-file.tif output-file.tif

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Demo-4: Place GIS Raster in DWG how to make position & scale right

Demo-4

Satellite image – KazEOSat-1 / Courtesy KGS

How to place a satellite image into a DWG with the “correct” location and size

- Know the UTM zone number and N/S of your target (use Google Earth)
- Check if the image (GeoTIFF) is correctly projected using above UTM zone #
  if not
    get the corresponding EPSG code (using QGIS: menu project > Properties…)
    reproject it using: gdalwarp -r cubic -t_srs: nnnnnn input-file.tif output-file.tif
- Check the lower-left & upper-right coordinates
    gdalinfo target-file.tif | more
- Open a drawing in AutoCAD. Set the drawing unit = meter
- Draw a rectangle, using two points from previous gdalinfo output
- Attach your image – origin = the lower-left corner > scale it to the upper-right corner

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Demo-3 & 4: recap

How to place raster data (satellite image) into AutoCAD canvas correctly

- **Reproject data to UTM if not yet**
- **Get the X/Y coordinates of two diagonal corners of the image**
- **Place the image using above coordinates**

Next, we will take a look at a workflow with DEM (Digital Elevation Model) & AutoCAD

- **Hillshade**
- **Contour lines**

Demo-5: Bring DTM in DWG transform to a consumable form

Demo-5

DEM data – KazEOSat-1 / Courtesy KGS

DTM = raster data -> use gdalwarp to UTM projected first

- DEM (raster data) is not very useful if you place it into your drawing
  monochrome image (dark = lower / bright = higher elevation)
- Make hillshade image first
  gdaldem hillshade input-file.tif
- Place a rhillshade image into DWG
  refer previous demo

Create contour lines

- Generate contour lines
  gdal_contour –a ELEV –i 10.00 input.tif tmp.shp

- Convert shape to DXF w/ 3D information and layer-assignment
  ogr2ogr -f DXF outf.dxf tmp.shp -zfield ELEV -sql "SELECT ELEV AS Layer, * FROM tmp"

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Demo-5: recap

How to utilize DEM (Digital Terrain Model / Digital Surface Model) in AutoCAD

- **A) Hillshade graphics for background image**
- **B) Contour lines**

A) Hillshade:

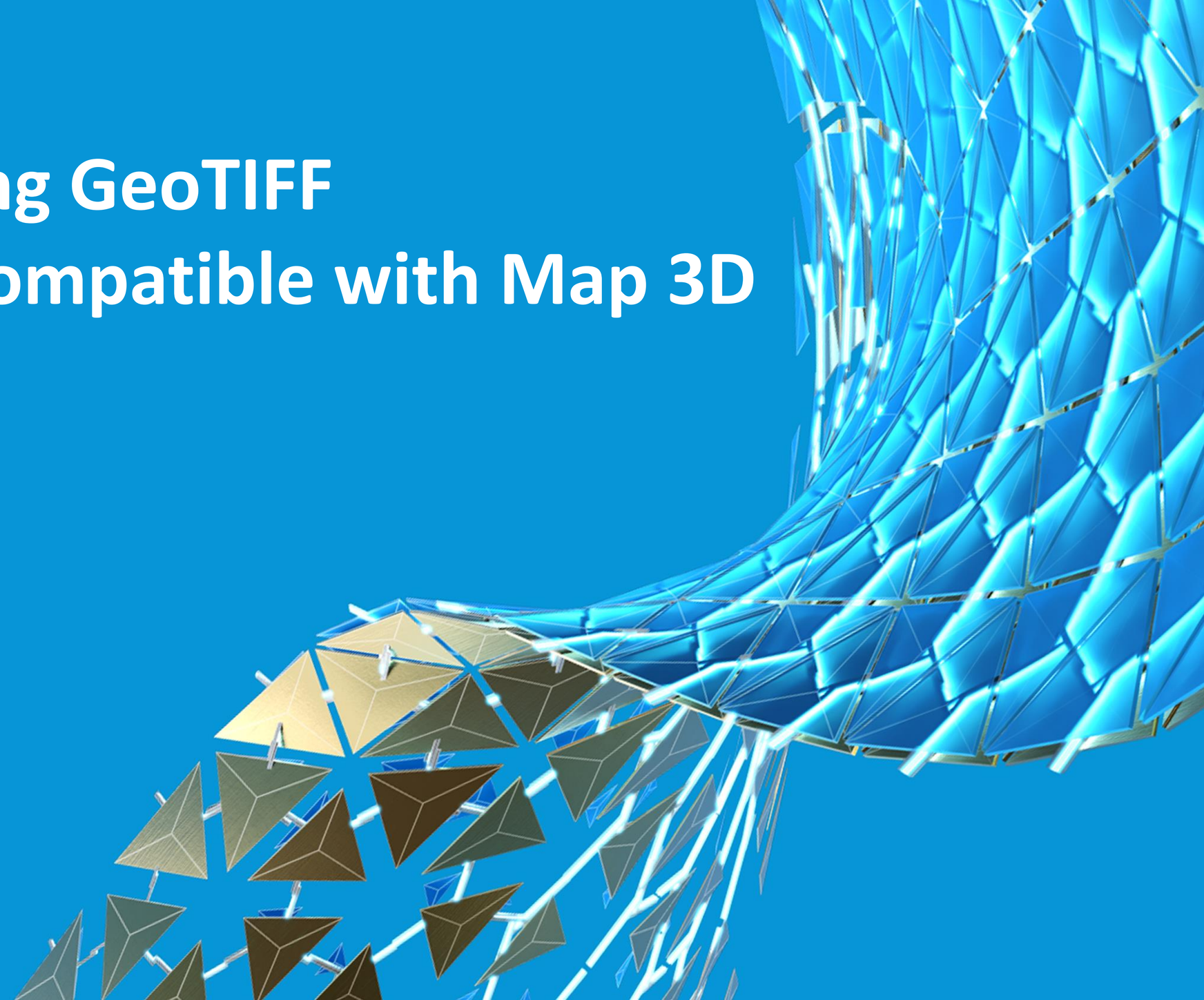
- **Command: *gdaldem hillshade infile.gif***
- **Make sure UTM-projected already, place it to the right spot / scale it right**

B) Contour lines:

- **Command: *gdal_contour –i {interval} infile.tif tmp.shp*** **, then gor2ogr to convert it to DXF**
- **Command: *ogr2ogr outfile.dxf tmp.shp FROM.tif -zfield ELEV -sql "SELECT ELEV AS Layer, * FROM tmp"***

Lastly, let's "fix" the GeoTIFF file that won't be opened from Civil 3D / Map 3D properly

Demo-6: Fixing GeoTIFF that is not compatible with Map 3D



Demo-6

Courtesy KGS / KazEOSat-1

When the horizontal and vertical scaling is way off after a grid surface is generated from DEM

- Check the projection/coordinate system of the source DEM (GeoTIFF)
- Reproject to UTM (or your preferred local coordinate system) first

When a satellite image cannot be read from AutoCAD (but works with InfraWorks)

- Try to convert GeoTIFF from 64-bit “big” tiff to 32-bit “normal” tiff
- gdal_translate -co BIGTIFF=NO input-file.tif output-file.tif

When a satellite image is not shown properly in AutoCAD or InfraWorks

- Check the data type
- If data type = Uint-16, try to convert from Uint-16 to Byte (8-bit) with proper scaling
- Scaling / Stretching settings can be taken from QGIS layer properties
- gdal_translate –ot Byte –b 1 –b 2 – b 3 –scale_1 {min} {max} –scale_2 {min} {max} –scale_3 {min} {max} -r cubic input-file.tif output-file.tif

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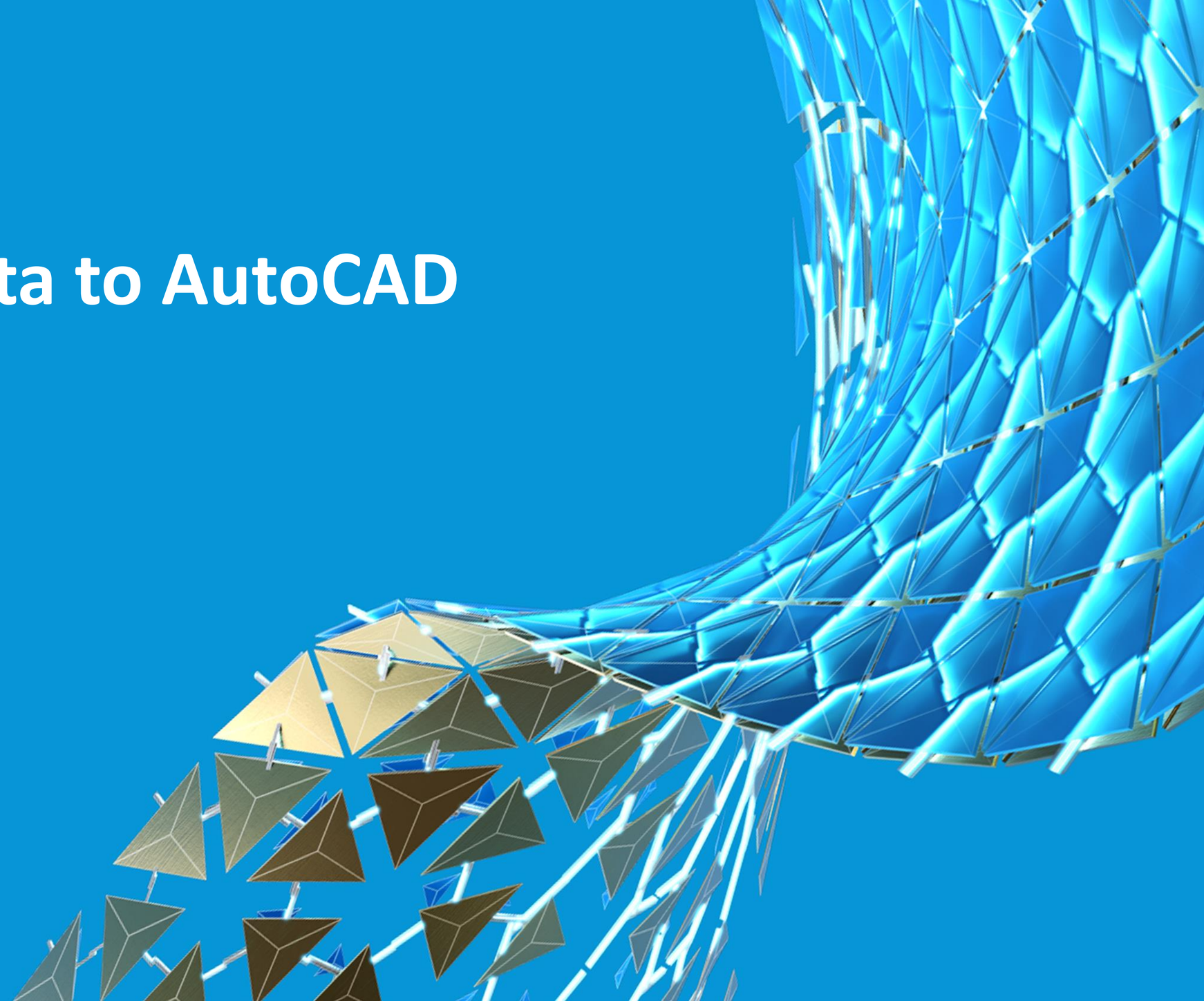
Demo-6: recap

When you have a trouble with reading GIS data

- **Diagnose a file using gdalinfo (for raster) / ogrinfo (for vector)**
- **Try to re-project data to UTM**
  - Geographic coordinate system (lat/long) won't work well with Civil 3D
- **AutoCAD cannot read a 64-bit GeoTIFF image (BIGTIFF)**
  - Clip a raster data if necessary
  - Convert it to 32-bit "normal" GeoTIFF (***gdal_tanslate –co BIGTIFF=NO file-in.tif file-out.tif***)
- **InfraWorks / AutoCAD cannot read 16-bit depth GeoTIFF image**
  - Change the data type from Int16 to Byte
  - Need to scale / stretch (check stretch values using QGIS)
  - ***gdal_translate -ot Byte -b 1 -b 2 -b 3 -scale_1 {min} {max} -scale_2 {min} {max} -scale_3 {min} {max} -r cubic in.tif out.tif***

Summary:
Bring GIS data to AutoCAD



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

What we've covered in this class:

- **Basic GIS 101**
  - a) Map projection & UTM, b) Popular GIS data file types, c) Essential free GIS tools
- **Ways to massage GIS data**
  - Reproject data to UTM using gdal command-line tools
  - Generate hillshade image & contour lines from DEM (DTM/DSM)
- **How to place a satellite image to the right location with the right scale**
- **How to "fix" GeoTIFF for Autodesk products**

Thank you!

RESTEC 

There are many free/open and commercial satellite-based GIS data you can use in your projects. Do not hesitate to try and discover what you can do with them in your design workspace.

I hope you have found something new / interesting in this presentation.

Questions / Full-samples of this presentation?
Contact data@restec.or.jp