Managing Lidar (and other point cloud) Data

Lindsay Weitz

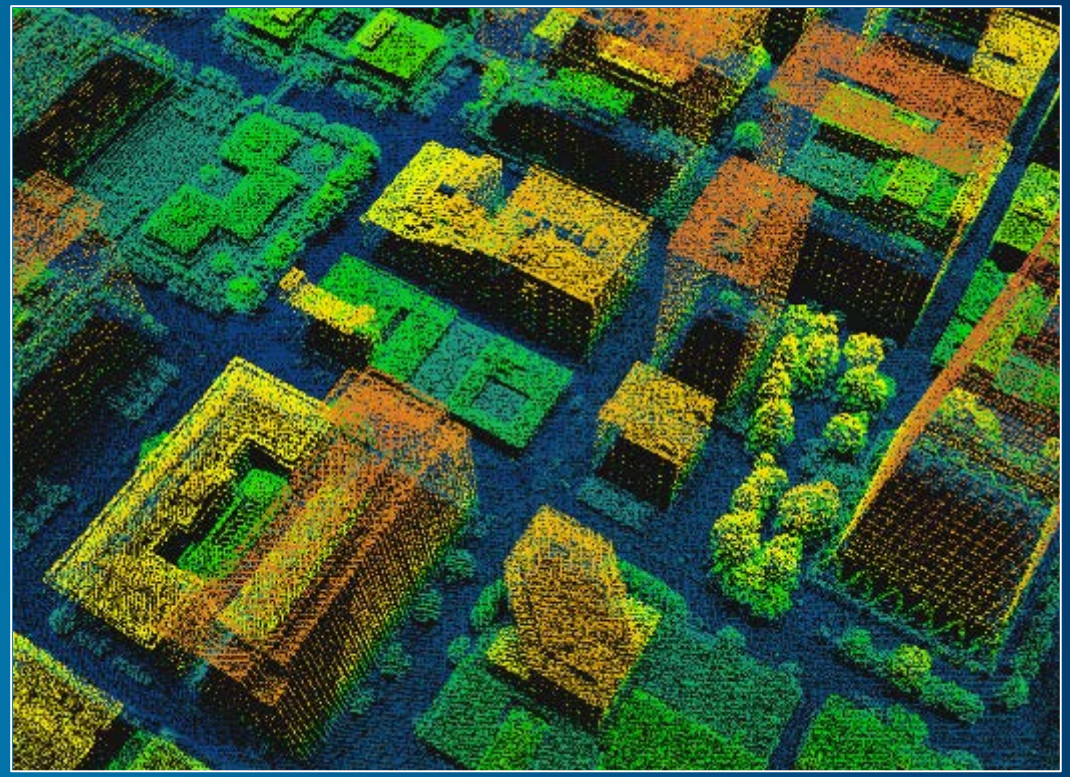
Cody Benkelman

Presentation Context

- **What is lidar, and how does it work? → *Not this presentation!***
- **What can you do with lidar in ArcGIS?**
- **What does Esri recommend as best practices for processing and managing lidar data?**
- **What about other point clouds (from photogrammetry)?**

Presentation Outline

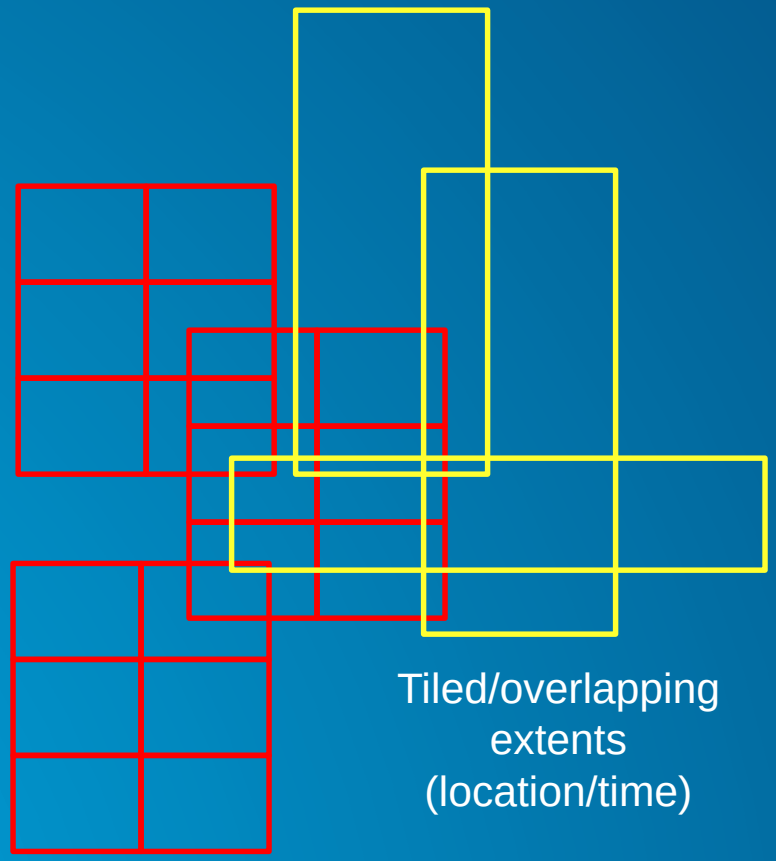
- Data structures
  - LAS and zLAS formats
  - LAS Dataset – for lidar & surface constraints
  - Terrain Dataset – for lidar & surface constraint
  - Mosaic Dataset – for lidar & raster data management
- Data management
  - QC & Derived products
  - Automation & Sharing



Data Structures for Lidar support in ArcGIS

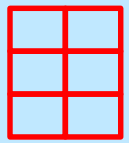
File01.las
File02.las
…
File99.las

Multiple files/folders

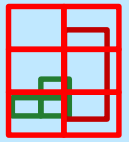


Tiled/overlapping extents (location/time)

Analyze and update



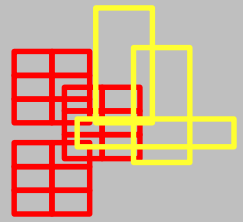
LAS dataset



Terrain dataset

LAS dataset / Terrain dataset

Manage, serve, share

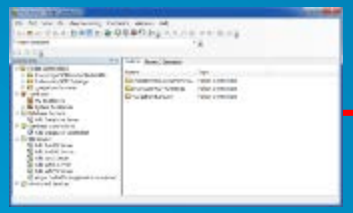


Mosaic dataset

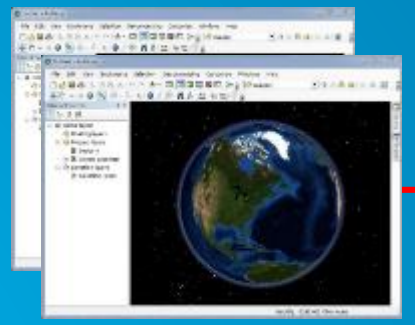
Application Fusion: ArcGIS Pro

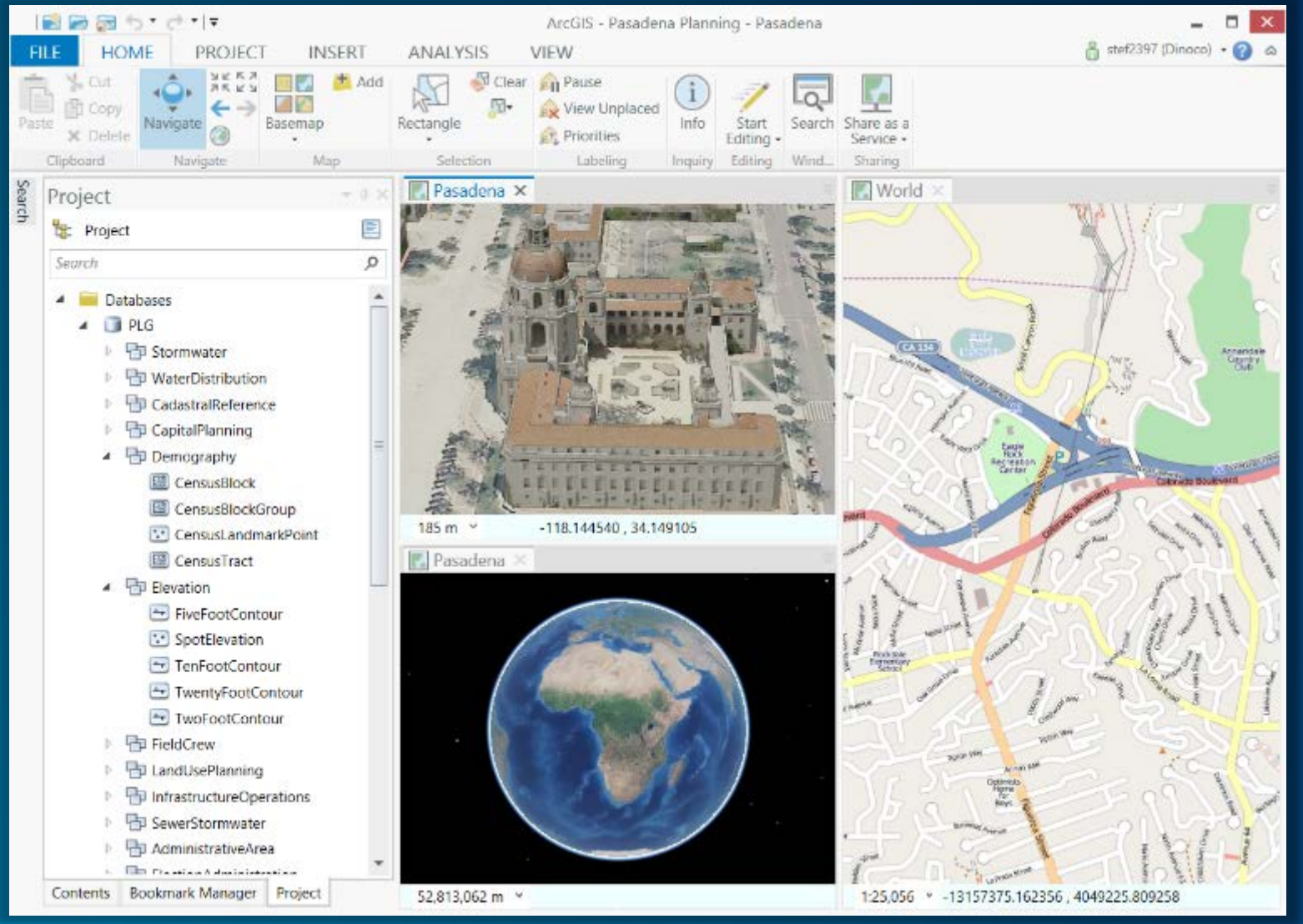
ArcMap

ArcCatalog



ArcGlobe / ArcScene





Lidar in ArcGIS Pro

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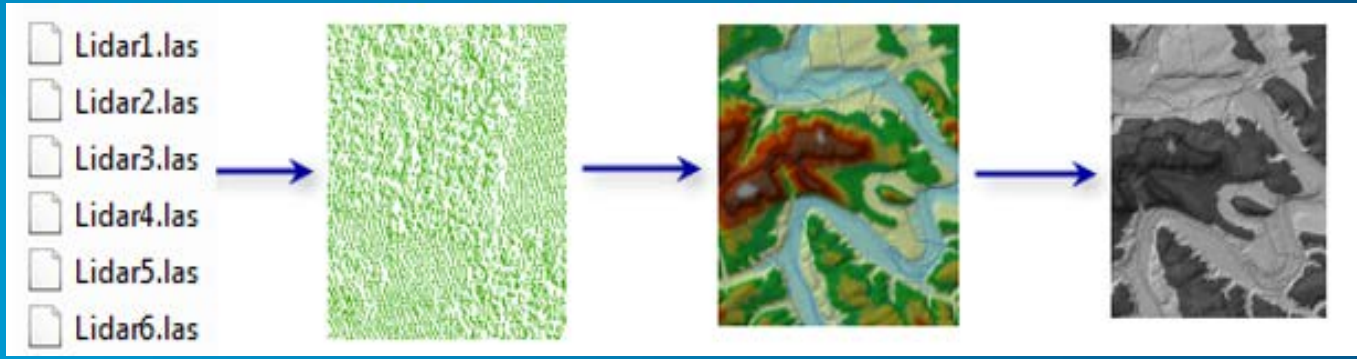
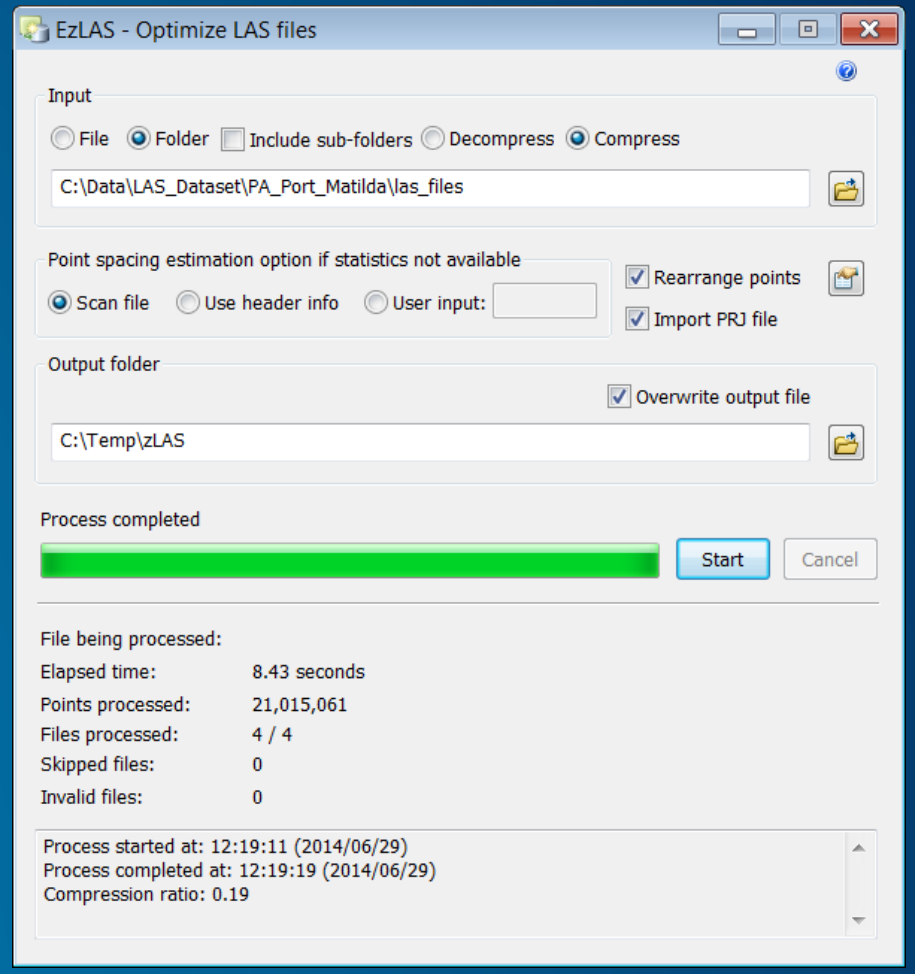
Lidar data storage – LAS files

- Binary file format developed by ASPRS
- Metadata in a header block
- Individual record for each laser pulse recorded
- Directly readable by ArcGIS
- Most common format for lidar and other point clouds (e.g. from photogrammetry), but designed as an exchange/archive format, not optimized for operational use…



Lidar data storage – zLAS

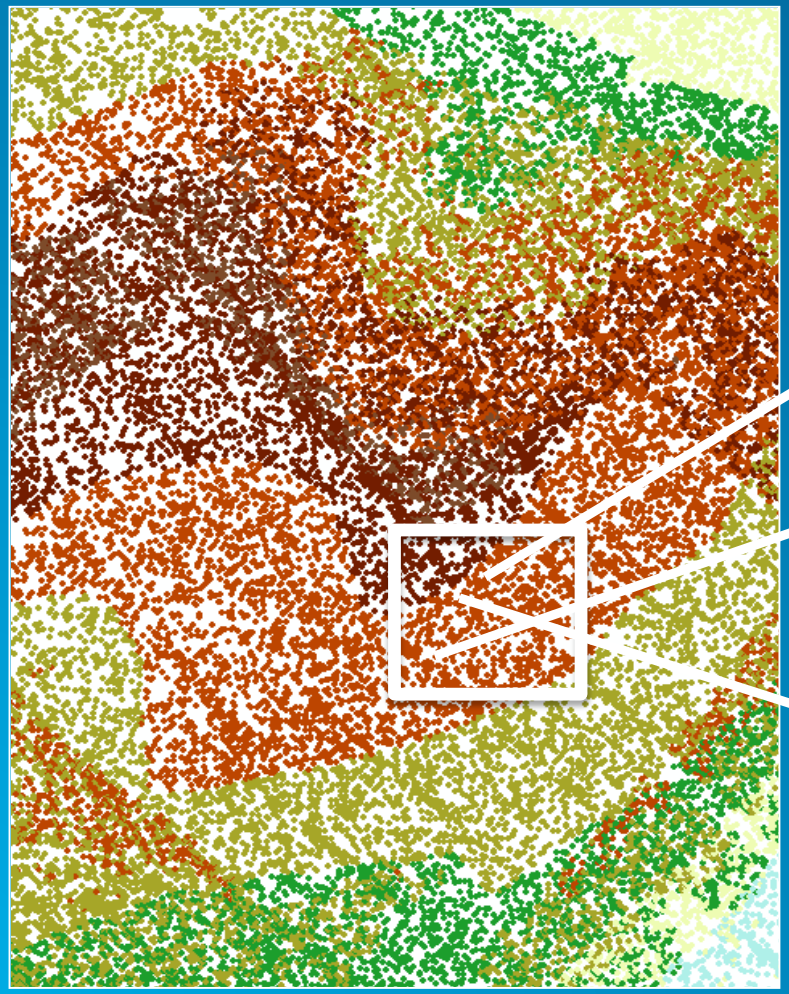
- Introduced January 2014
- Compression, sorting, and indexing
- Direct read
  - Parallel decompression added to ArcGIS apps in 10.3
- Features & Benefits
  - Re-sequence points w/ geospatial index
  - Optimized for random access
  - Lossless compression
  - Transparent integration with LAS dataset



zLAS

- Free!! Does not require ArcGIS
- Support added in 10.2.1
- Standalone application “EzLAS” on Resource Center
  - http://esriurl.com/zLAS
- API available for developers
  - https://github.com/Esri/esri-zlas-io-library
- For more info:
  - http://blogs.esri.com/esri/arcgis/2014/01/10/esri-introduces-optimized-las/
  - http://www.lidarnews.com/content/view/10214/2/

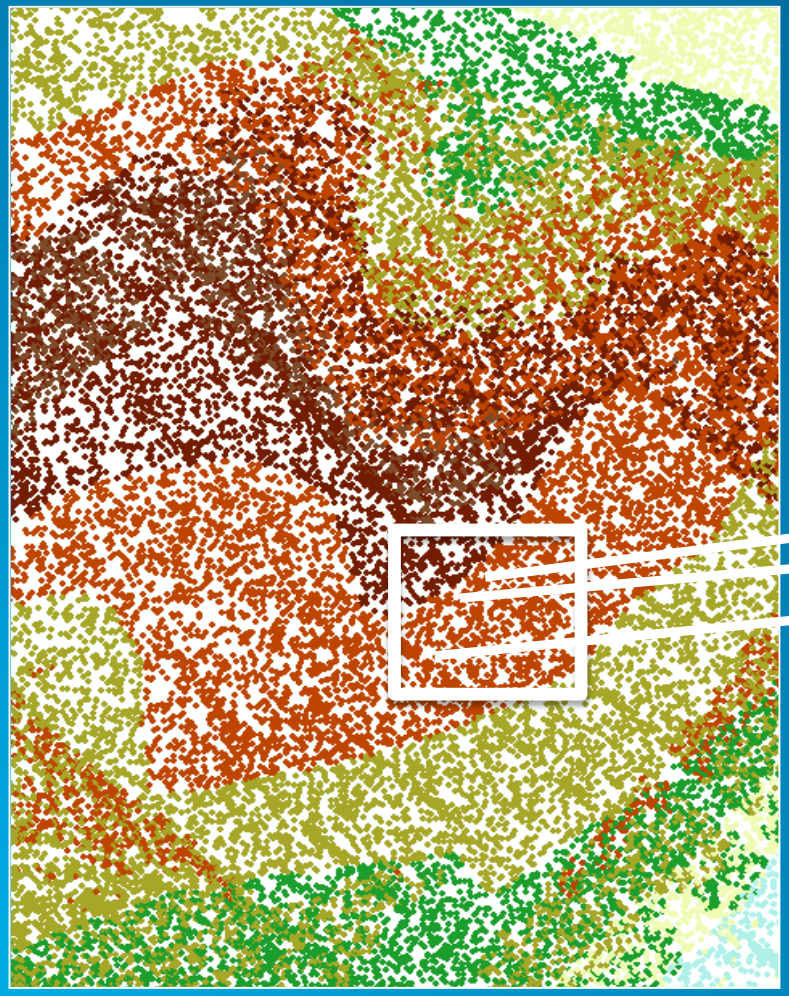
Rearranging Point Records



Spatial distribution of points

Physical location in file

Rearranging Point Records



Spatial distribution of points

Physical location in file

LAS dataset

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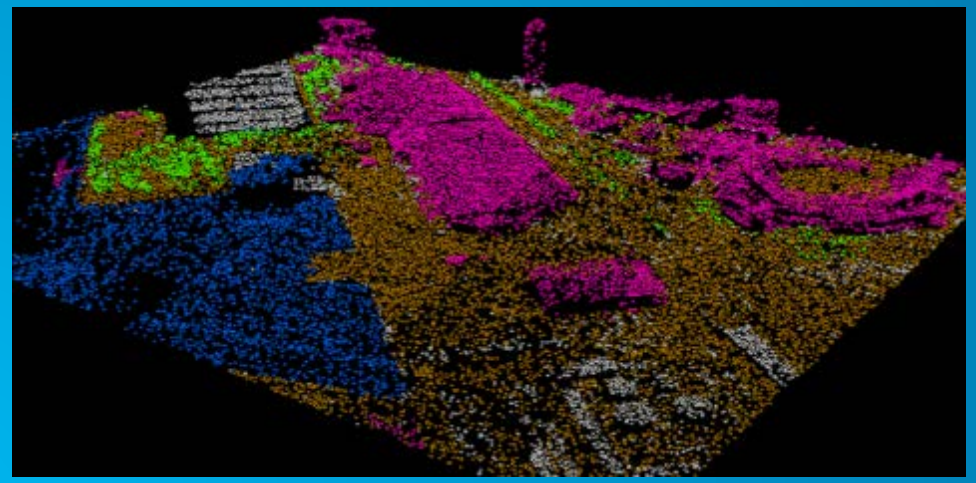
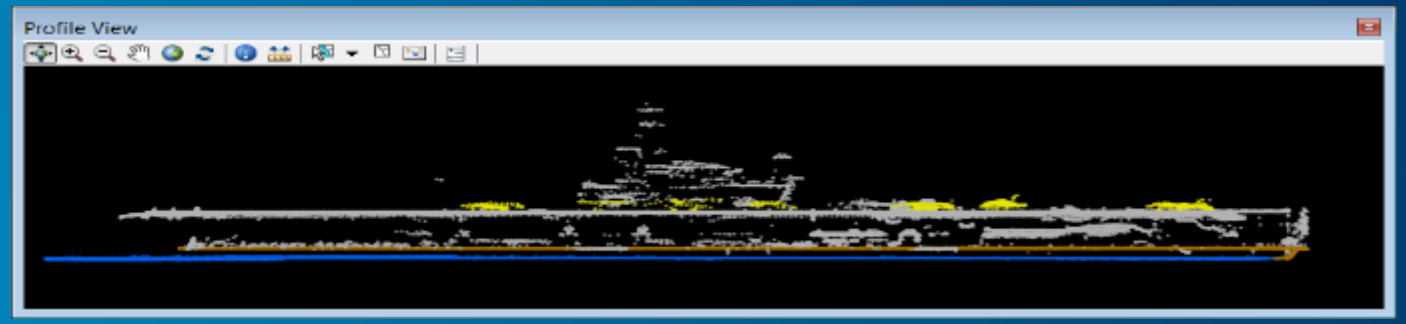
Lidar data with a LAS dataset

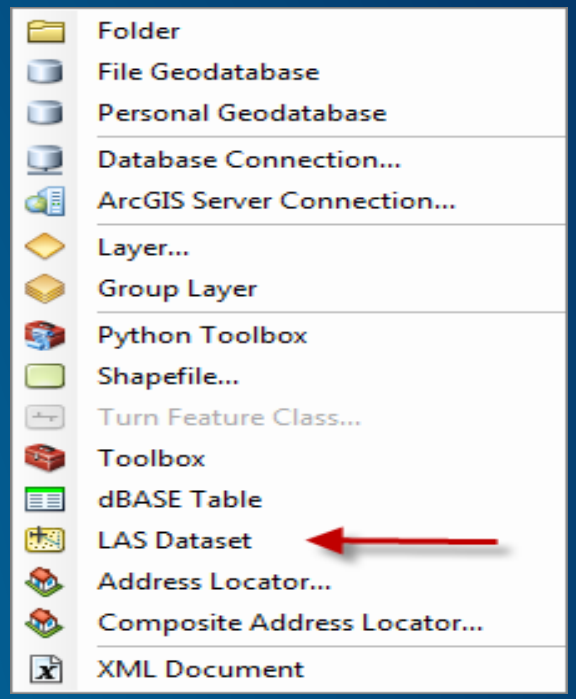
- Direct read of LAS or zLAS format lidar
- File based
- QA/QC tools
- Stores references to LAS/zLAS files on disk
- Optionally reference breakline and control point data
- Treats a collection of LAS/zLAS files as one logical dataset (“Project”)



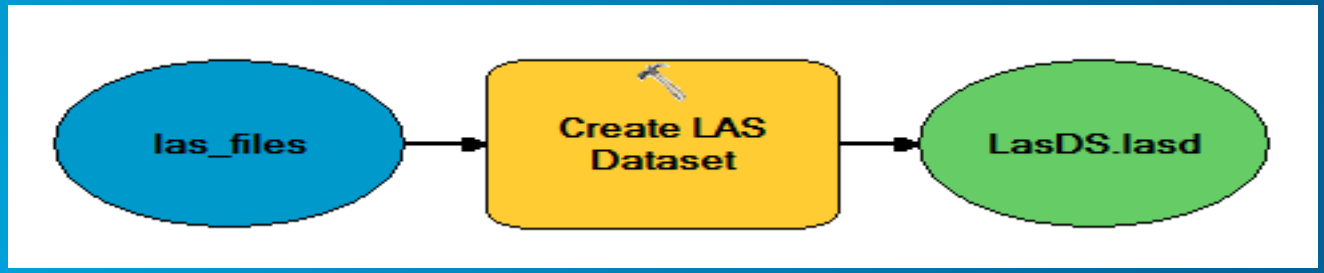


Create a LAS dataset

- **Interactively through ArcCatalog**
  - **Use the file folder context menu**

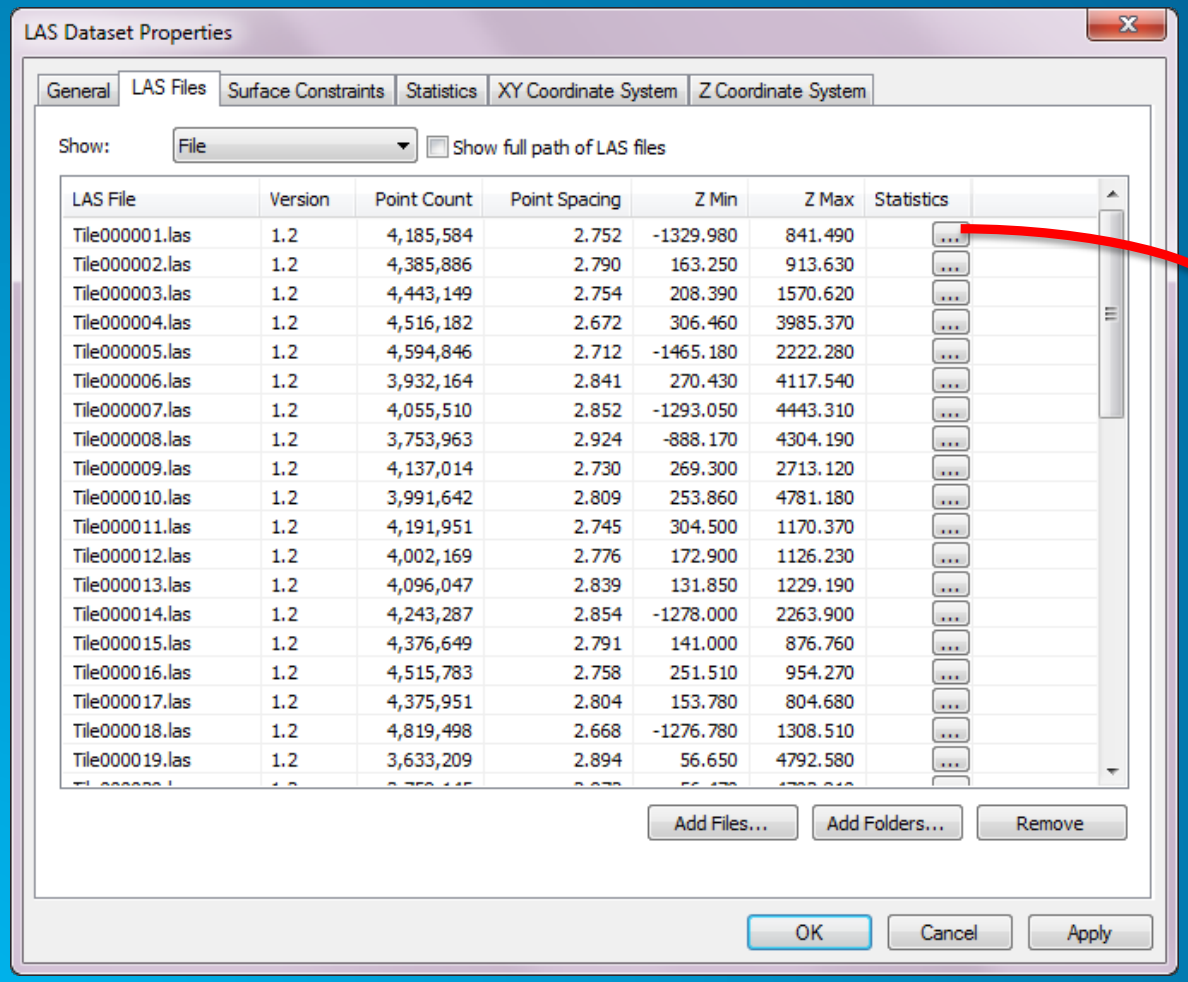


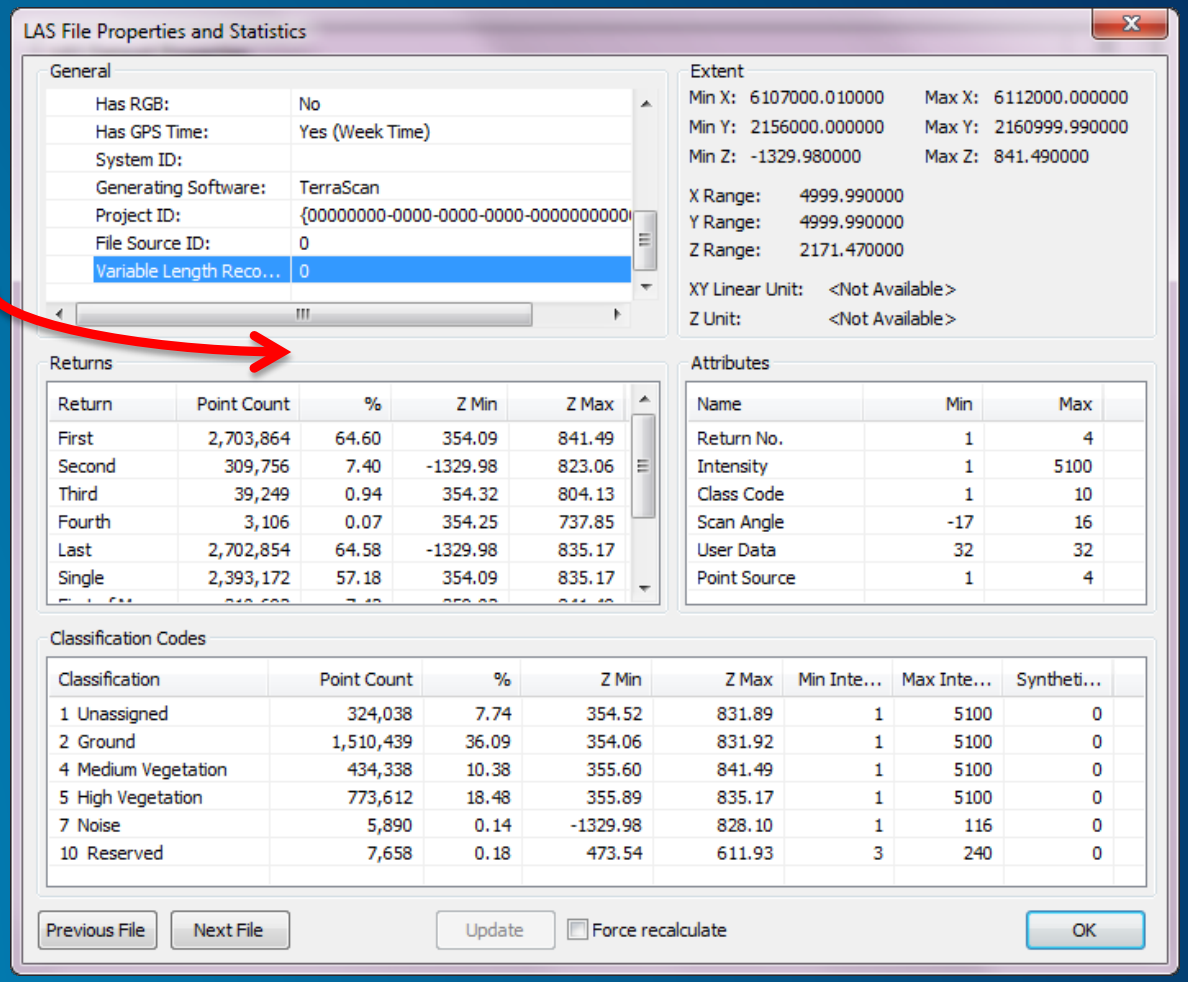
- **Using scripts and models with geoprocessing tools**



QA\QC: LAS file based statistics

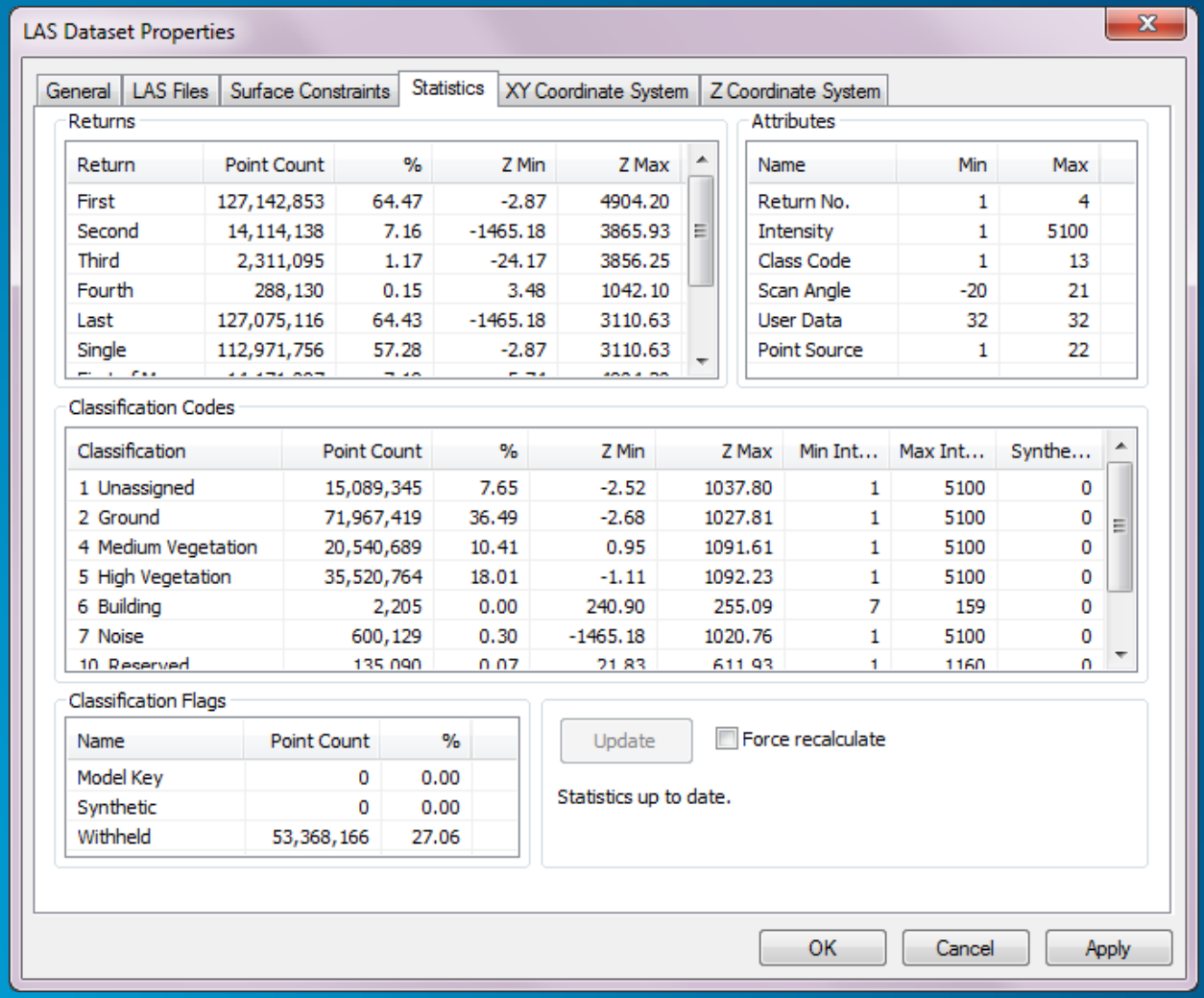
- **LAS Dataset Properties: LAS File Statistics**





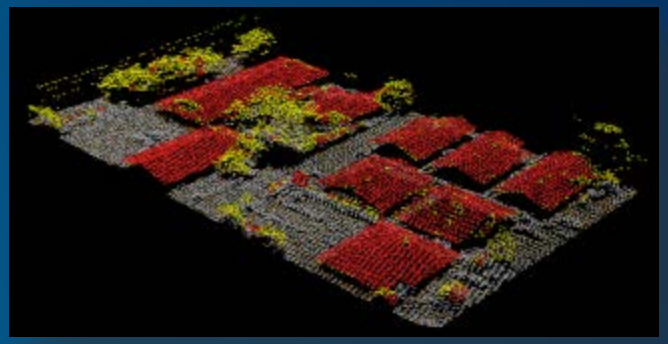
QA\QC: LAS dataset based statistics

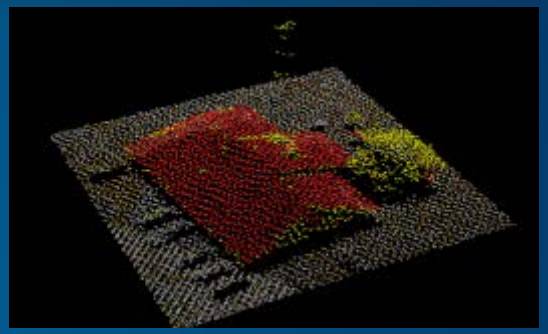
- LAS Dataset **Properties**: LAS Dataset Statistics



Edit classification codes

- Interactive
  - Fixing data anomalies and misclassifications via point profile window
- Automated (GP tools)
  - Classify relative to feature data
  - Reclassify to standard LAS specification





DEMO

LAS dataset demo

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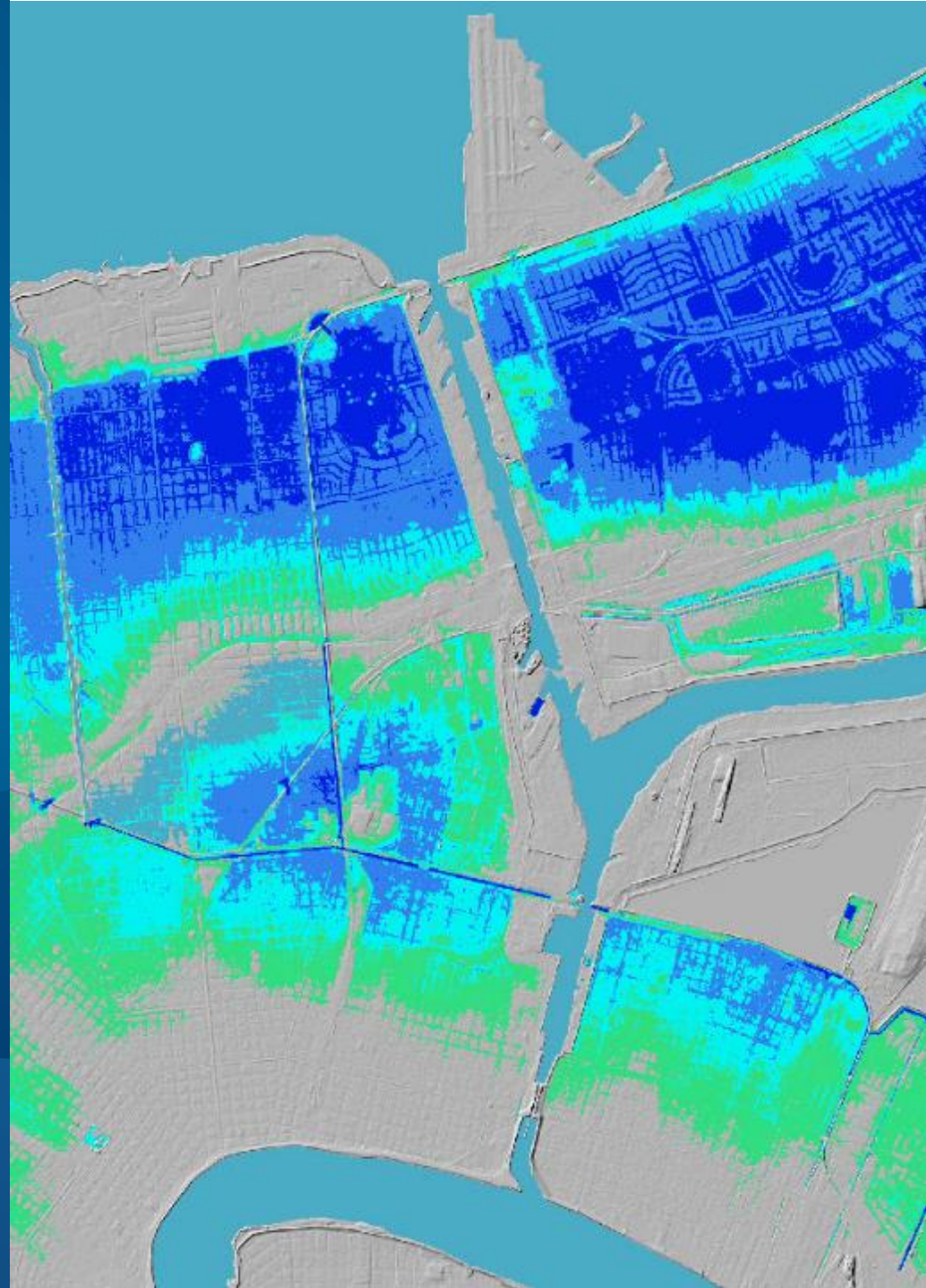
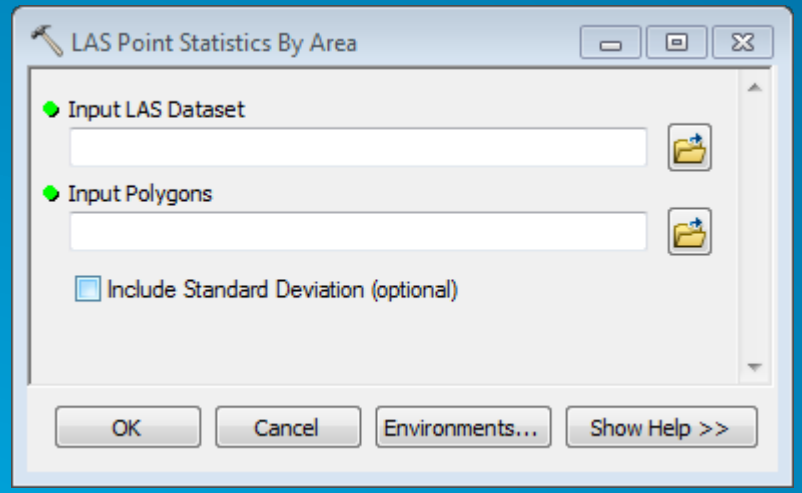
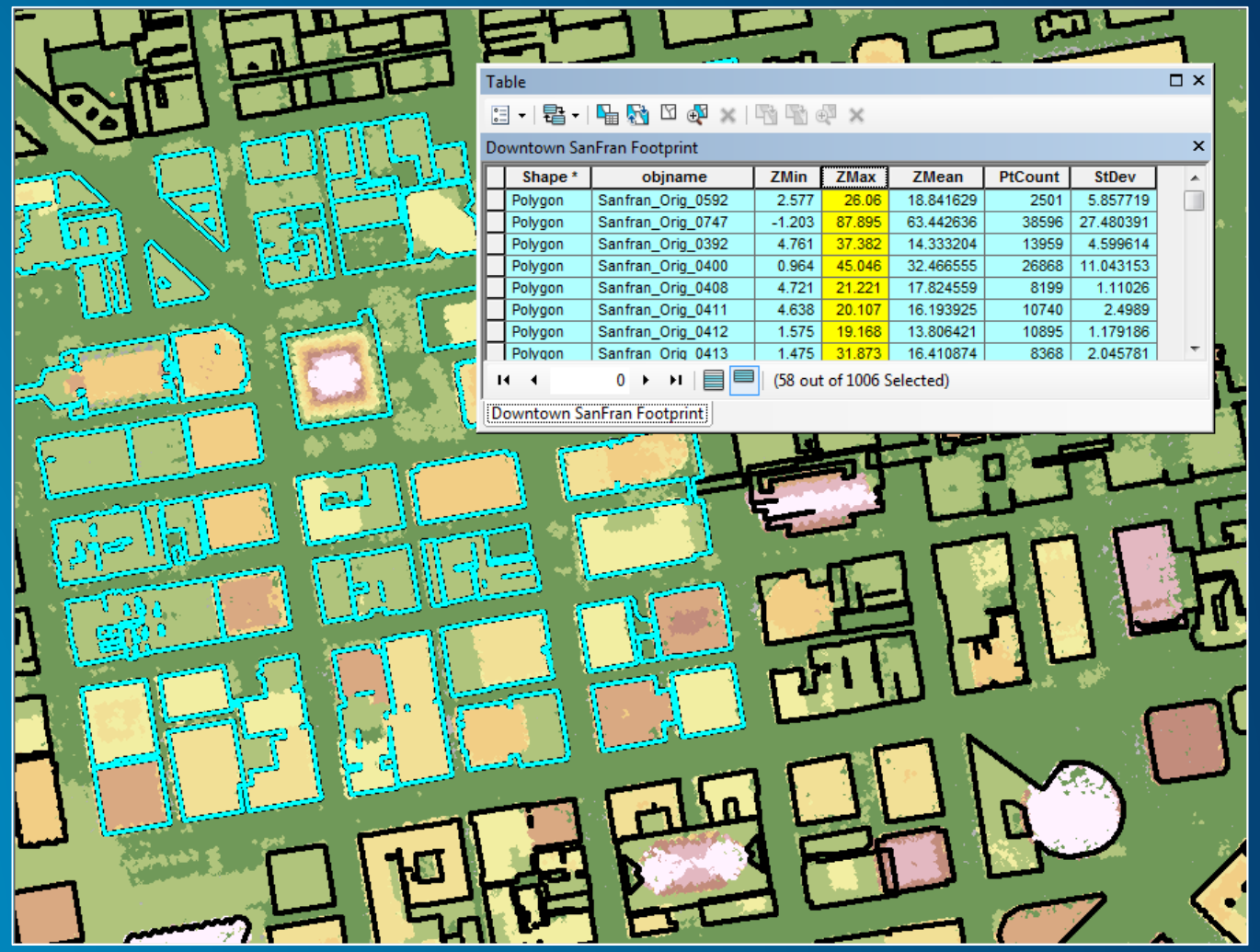
Lidar Related Analysis Tools

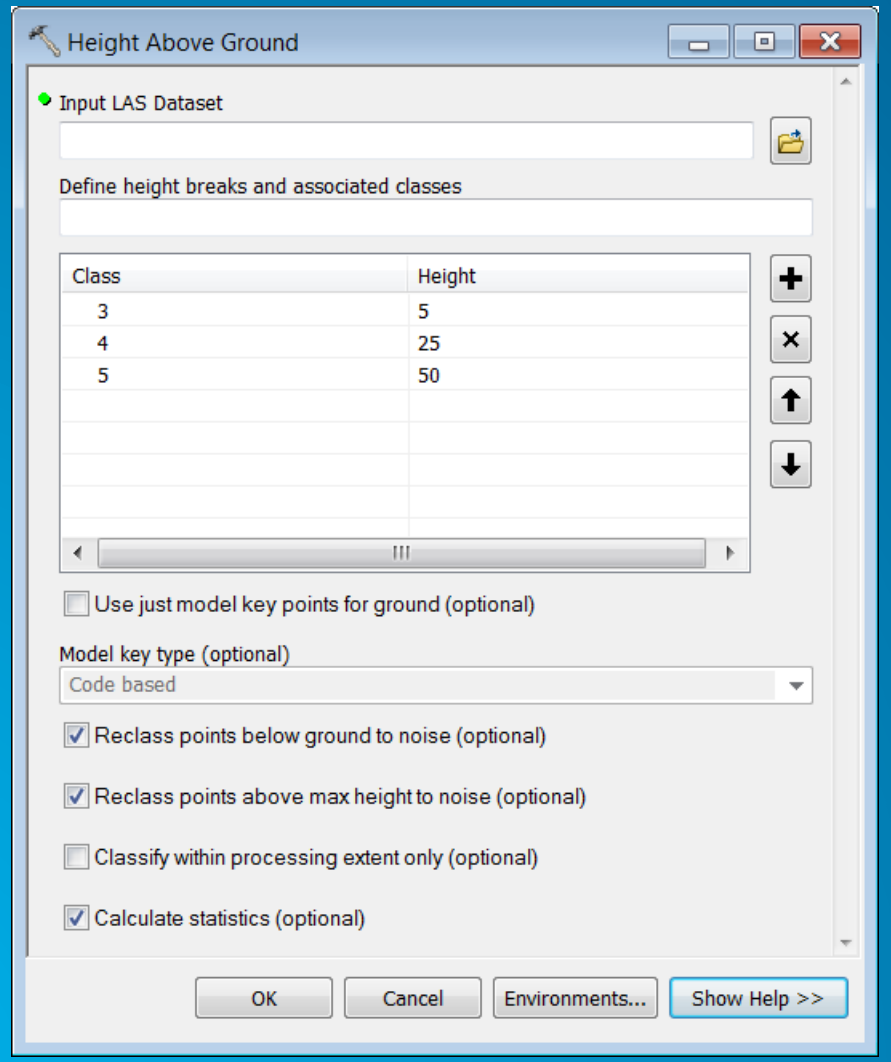


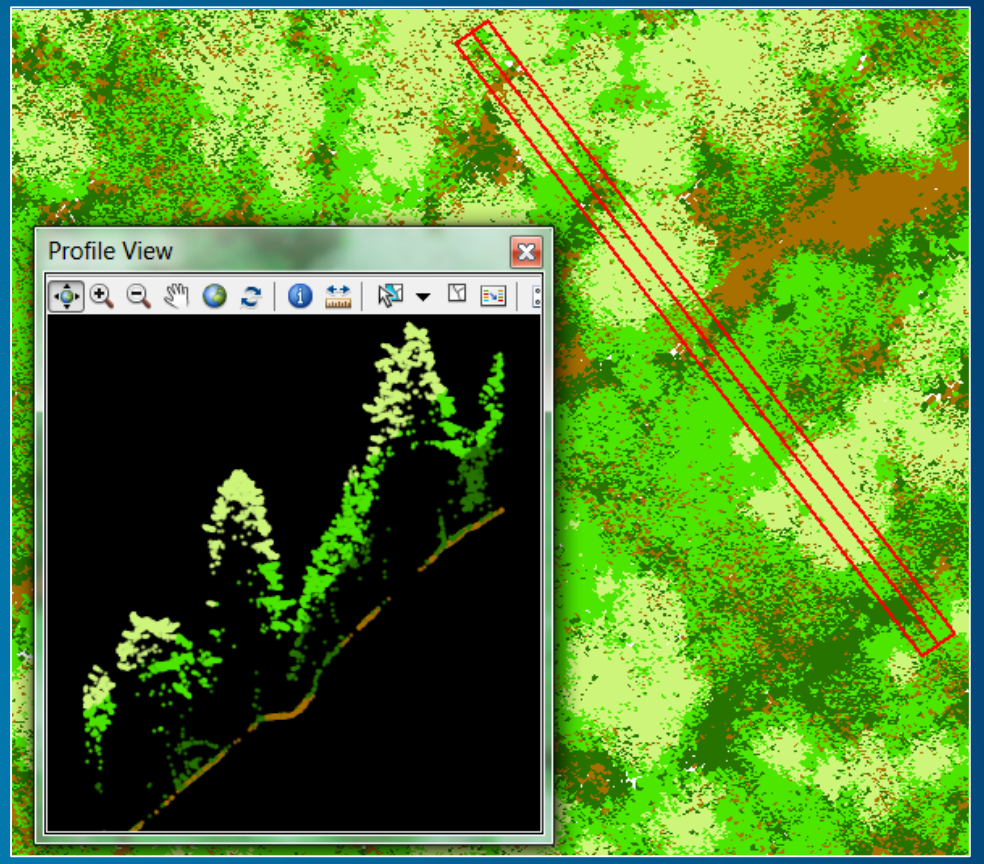
LAS Point Statistics By Area



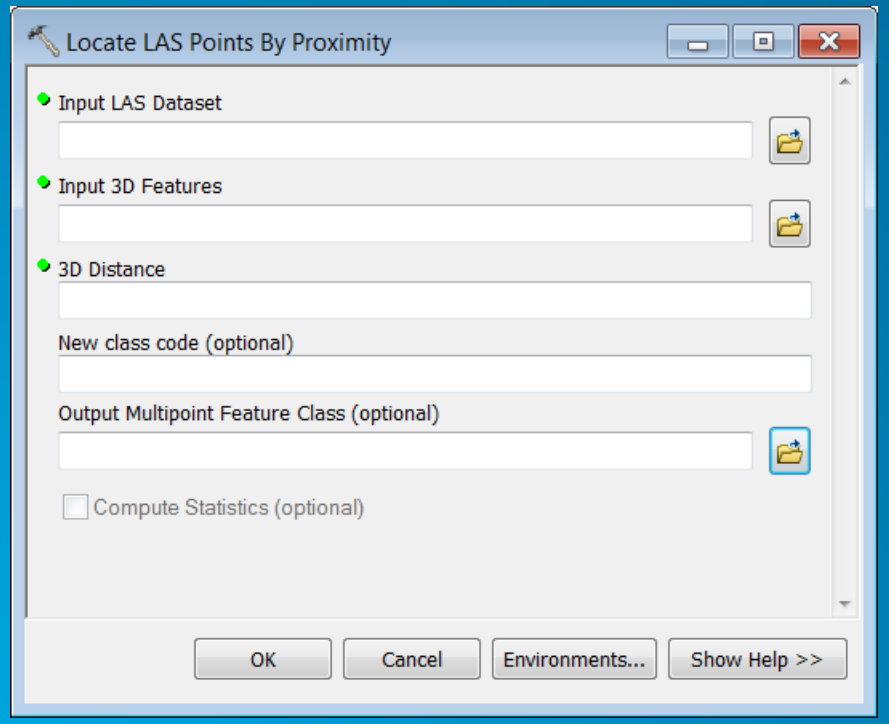


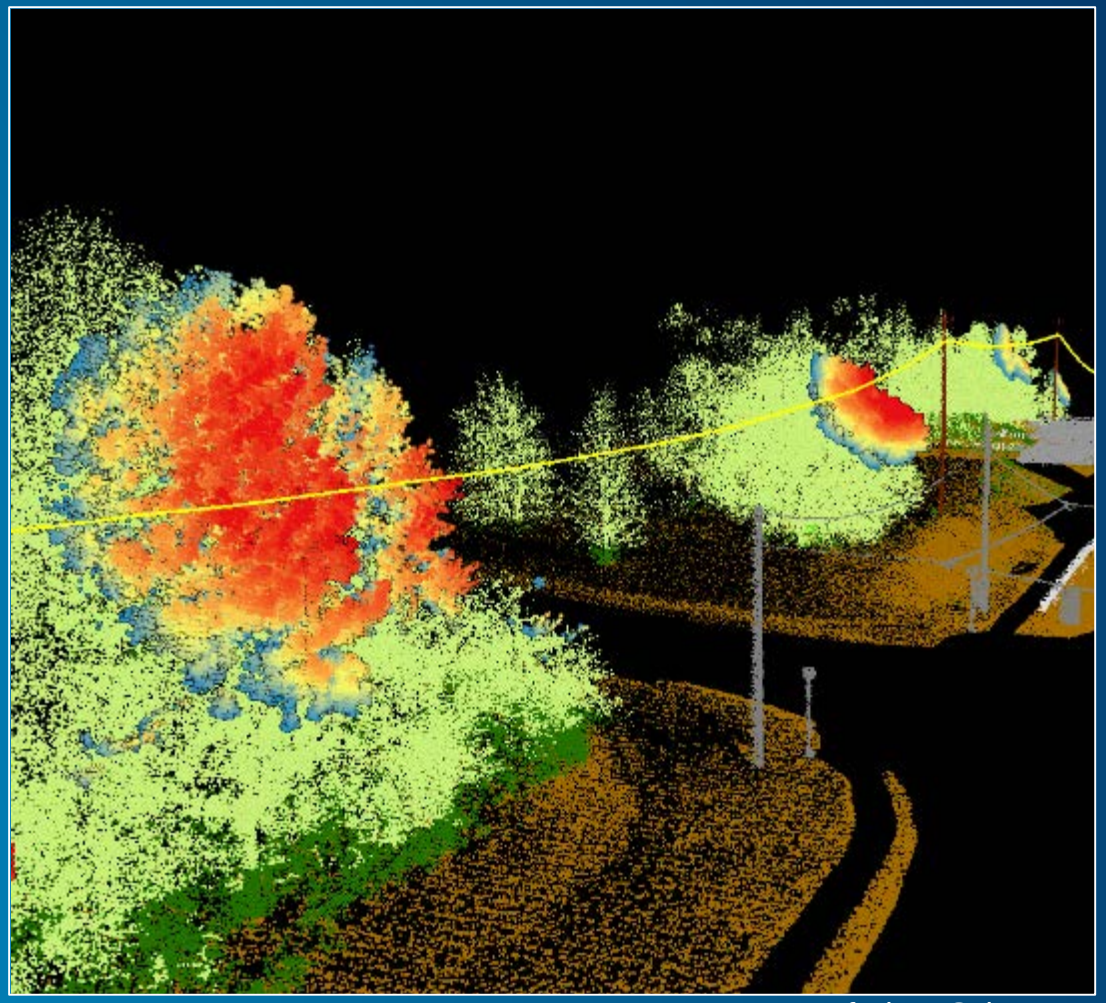
Classify LAS by Height





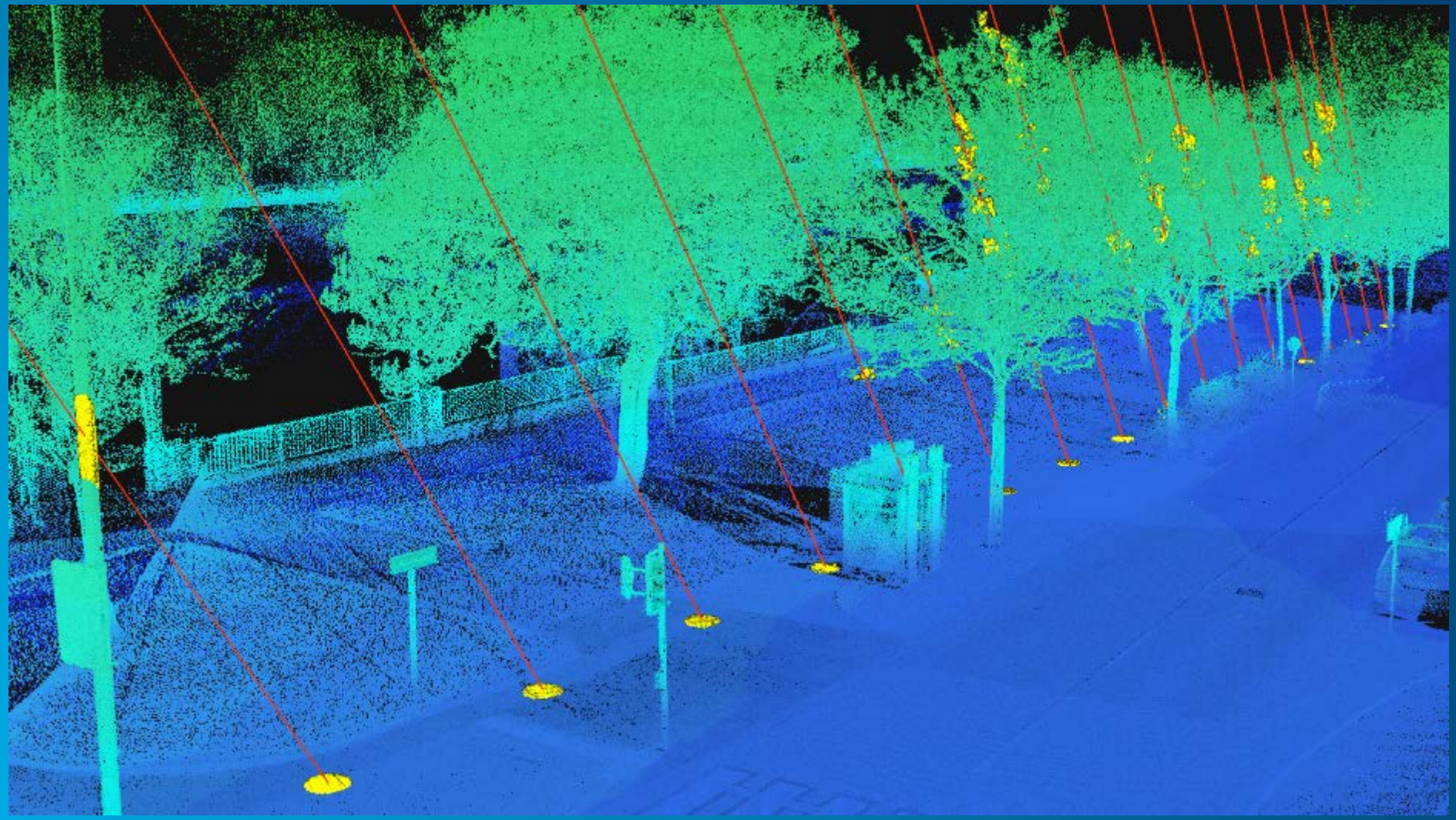
Locate LAS Points By Proximity





Data courtesy of PhotoScience

Locate LAS Points By Proximity

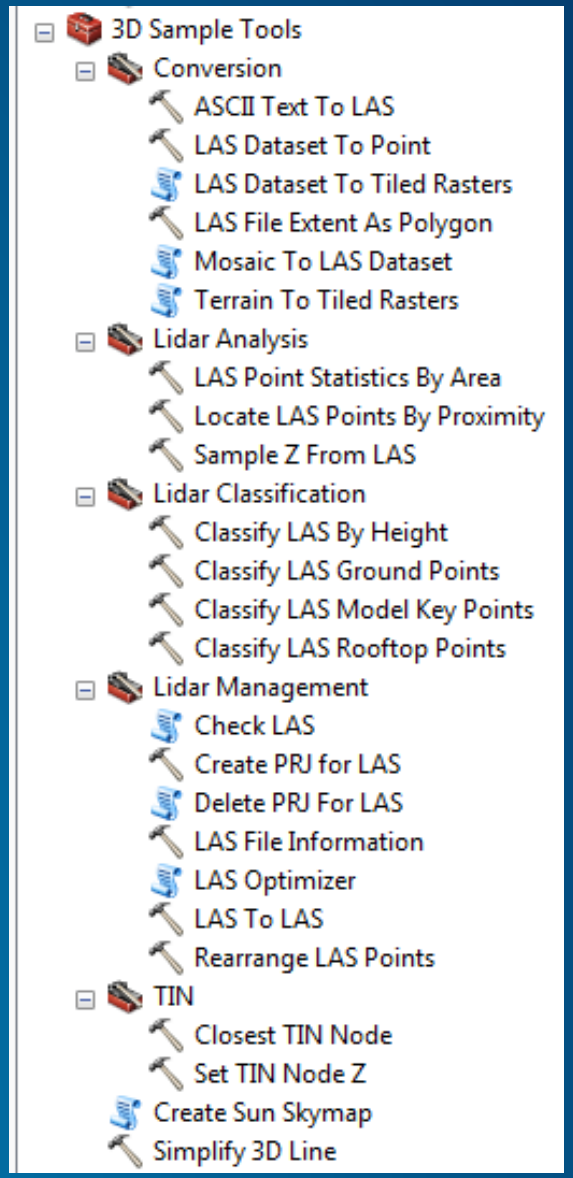


Extract LAS

Data courtesy of Optech

Lidar/3D Sample Tools

- **Available in ArcGIS 10.2 and 10.3**
- **Sample geoprocessing tools**
  - **Esri 3D Resource Center**
  - **http://links.esri.com/3dSamples**



Best Practices

- Tiled LAS, v1.1 or higher
- Projected, rearranged, indexed
  - zLAS
- File size: 1 – 2 GB or less (<500 MB if not rearranged)
- Keep file I/O local, avoid network
- Study area boundary included as constraint
- Airborne lidar
  - Classified (bare earth, non-ground)
  - Breaklines for hydro enforcement
- Terrestrial lidar
  - RGB & intensity values, classified

* Also applies to photogrammetric point clouds

Terrain dataset

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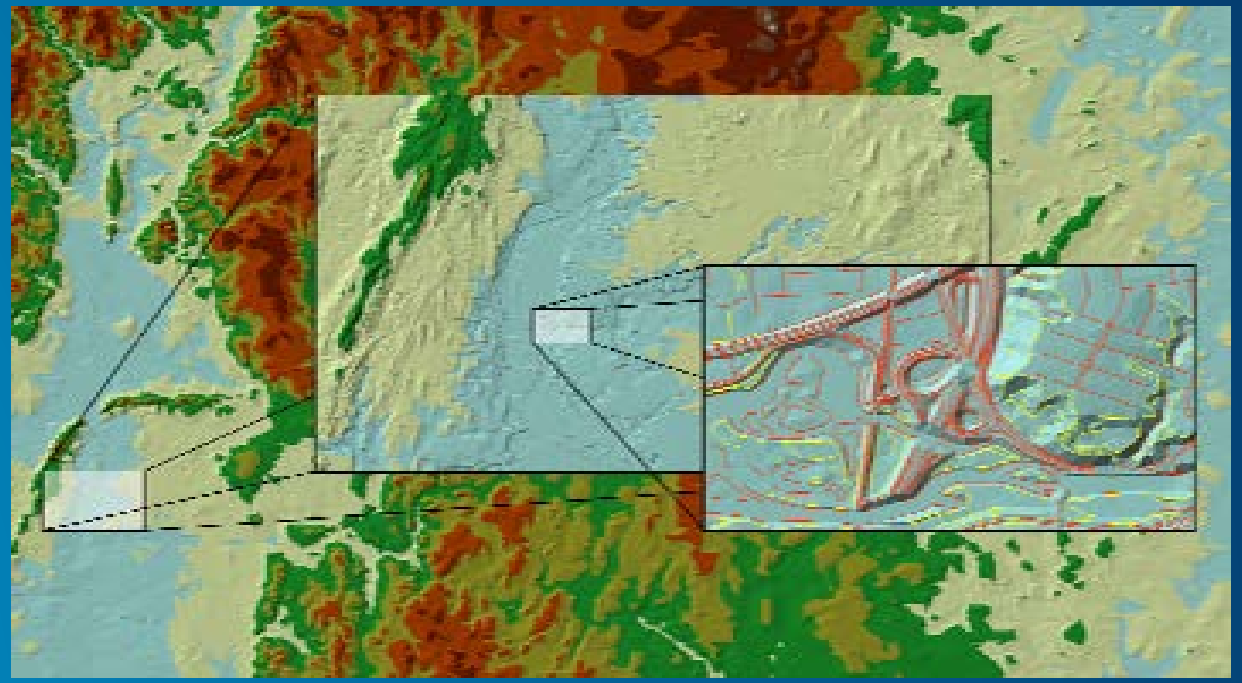
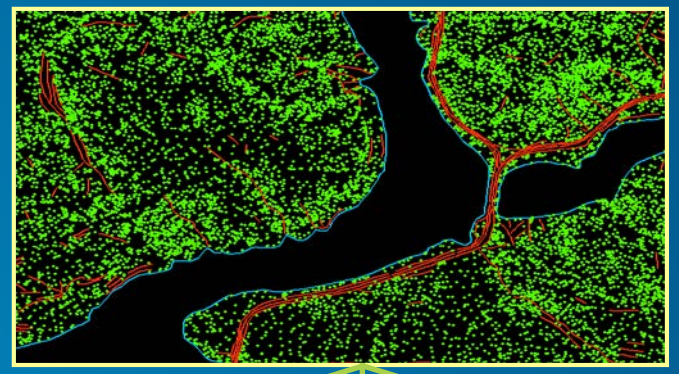
Managing lidar data in a terrain dataset

- A Terrain dataset is a multi-resolution surface created from measurements stored in feature classes
- Typical applications:
  - Topographic mapping
  - Bathymetric mapping
- Typical data sources:
  - Photogrammetric data
  - Lidar
  - Sonar

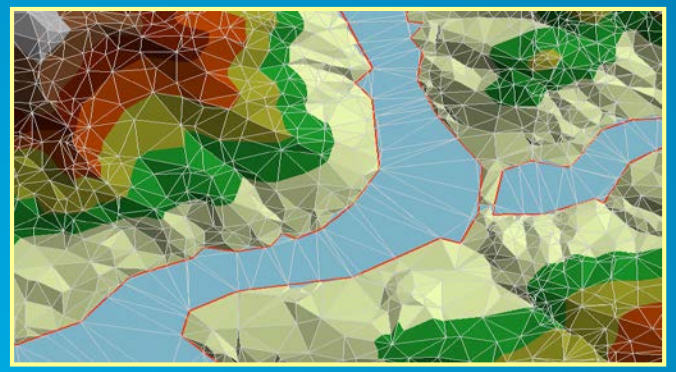


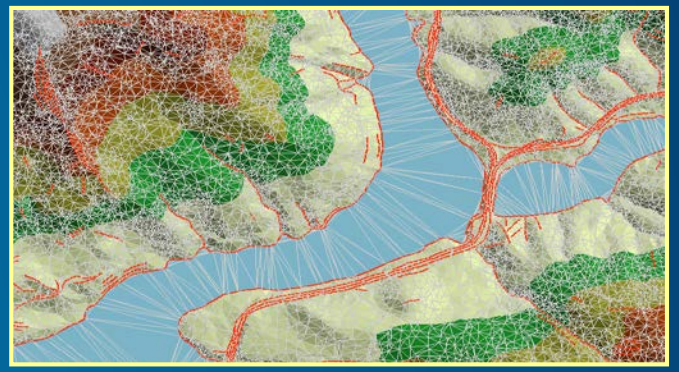
Multiresolution surface model

Points and breaklines



Terrain Pyramids





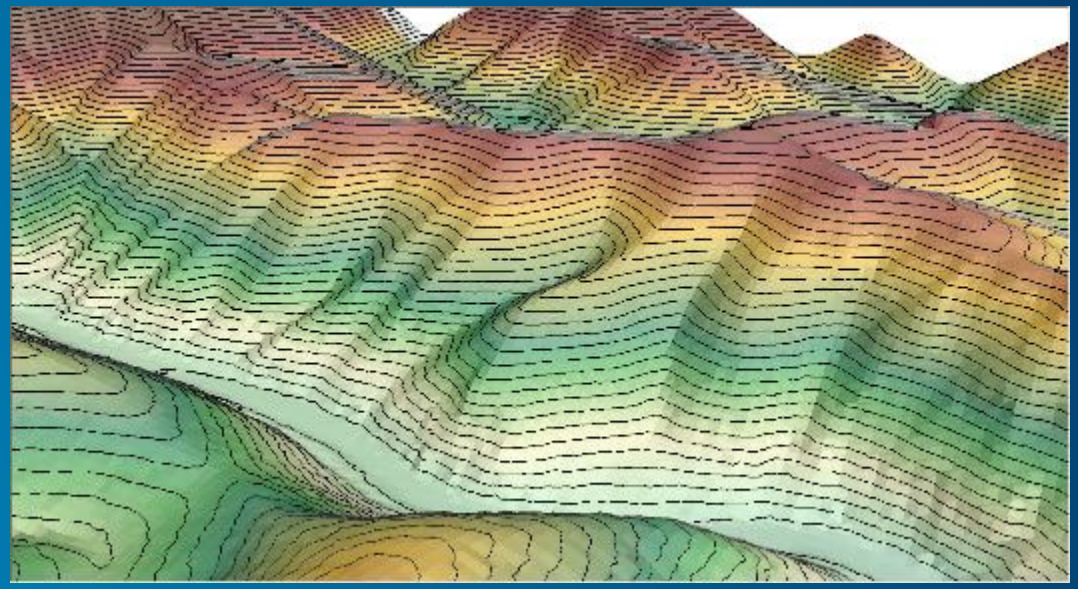
Thinned lidar point set

Full **resolution lidar point set**

Multiresolution terrain dataset (TIN structure)

Terrain dataset advantages

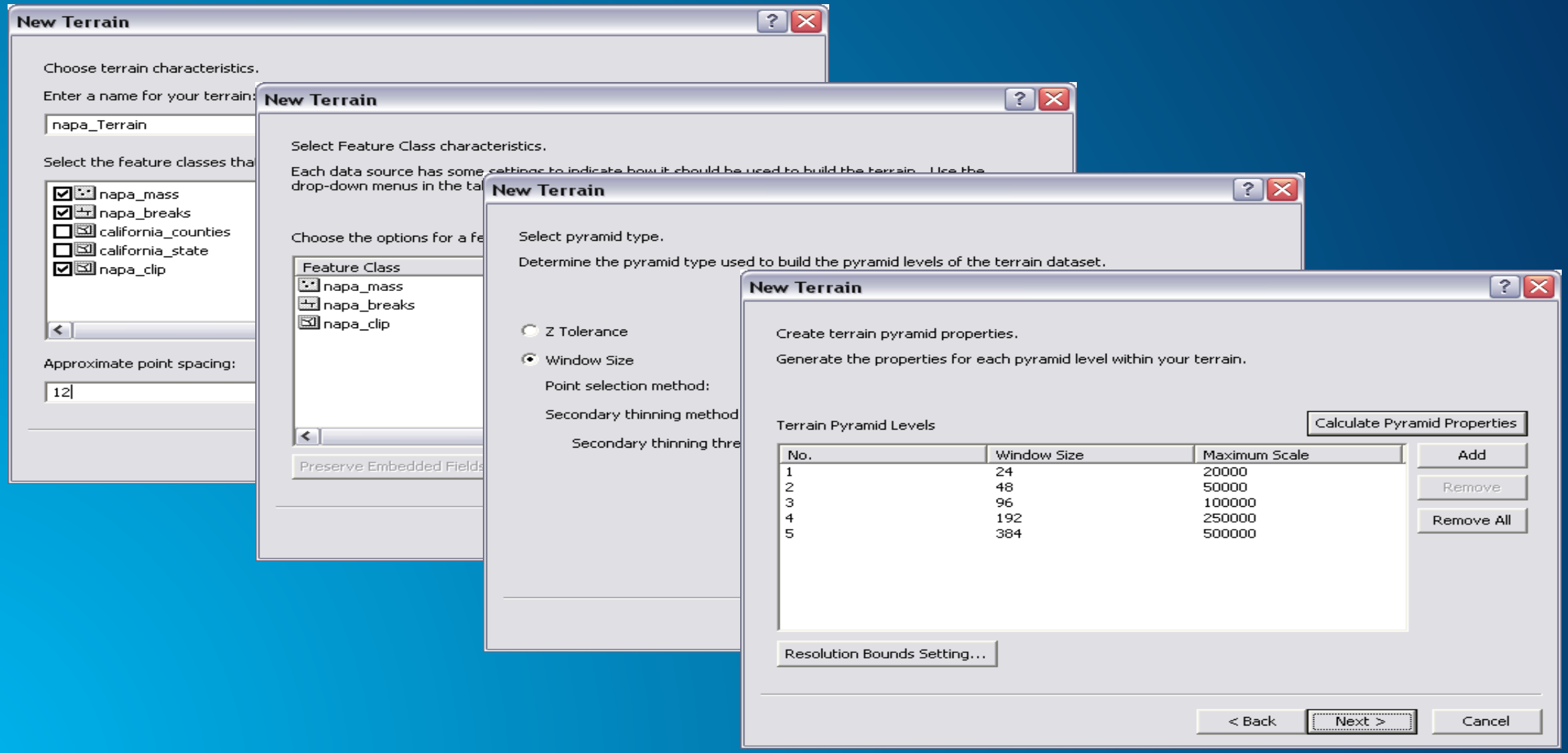
- Scalability
  - Large collections of mass point data (e.g. LIDAR)
  - have been a problem
- Data integration
  - Need surface to live with source data
- Data management
  - Database tools
  - Editing/update
  - Multi-user



Terrain dataset editing

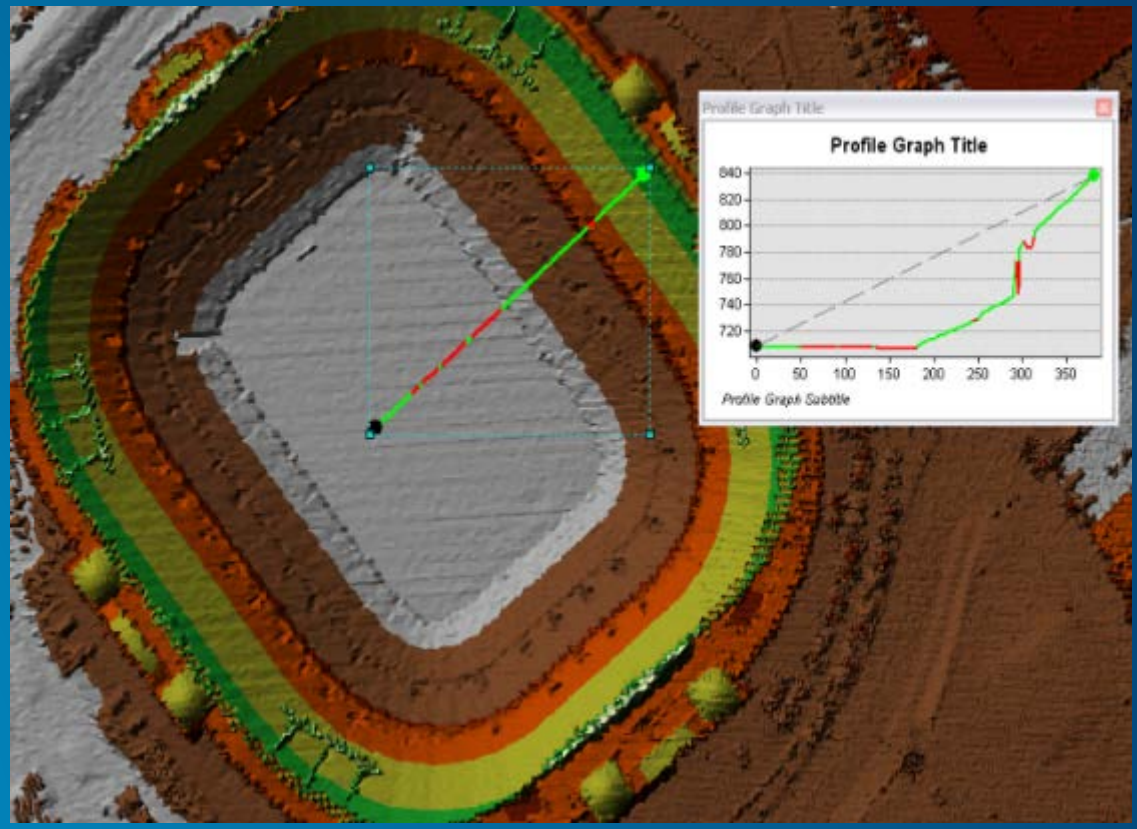
- Updating via editing of source measurements
  - Appending, removing, replacing mass points by area
  - Standard and custom edit tools for modifying polylines, polygons, spot heights
  - Terrain rebuild based on dirty areas
- Support for versioning in SDE

Creating a terrain dataset



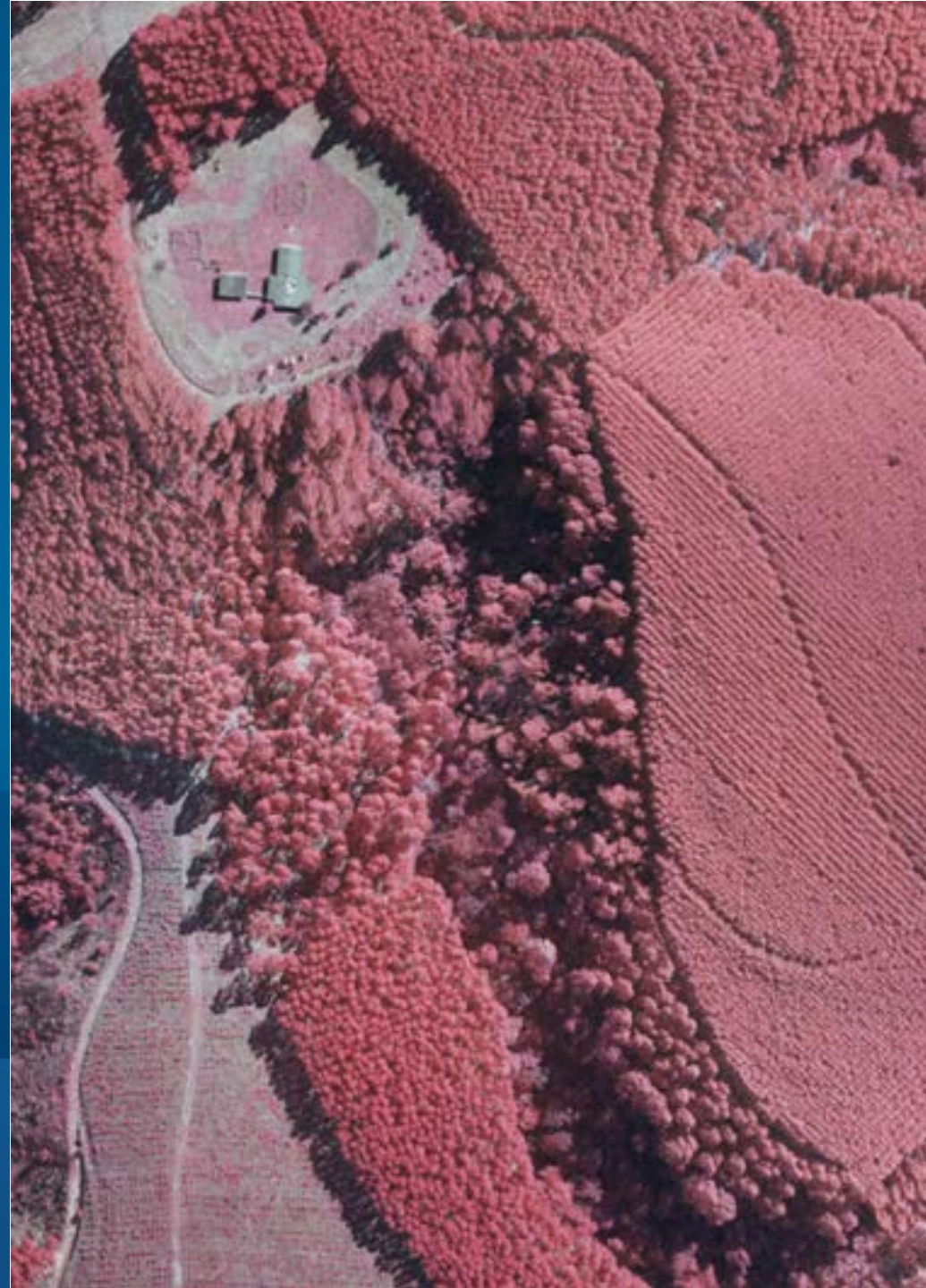
Analysis capabilities for terrain datasets

- QA/QC data
- DTM, DSM
- Slope
- Aspect
- Contours
- Surface differencing
- Intensity image
- Forest canopy estimation
- Data area delineation
- Thinning, reducing noise
- Spot interpolation
- Profiling



Mosaic Dataset

Cody Benkelman

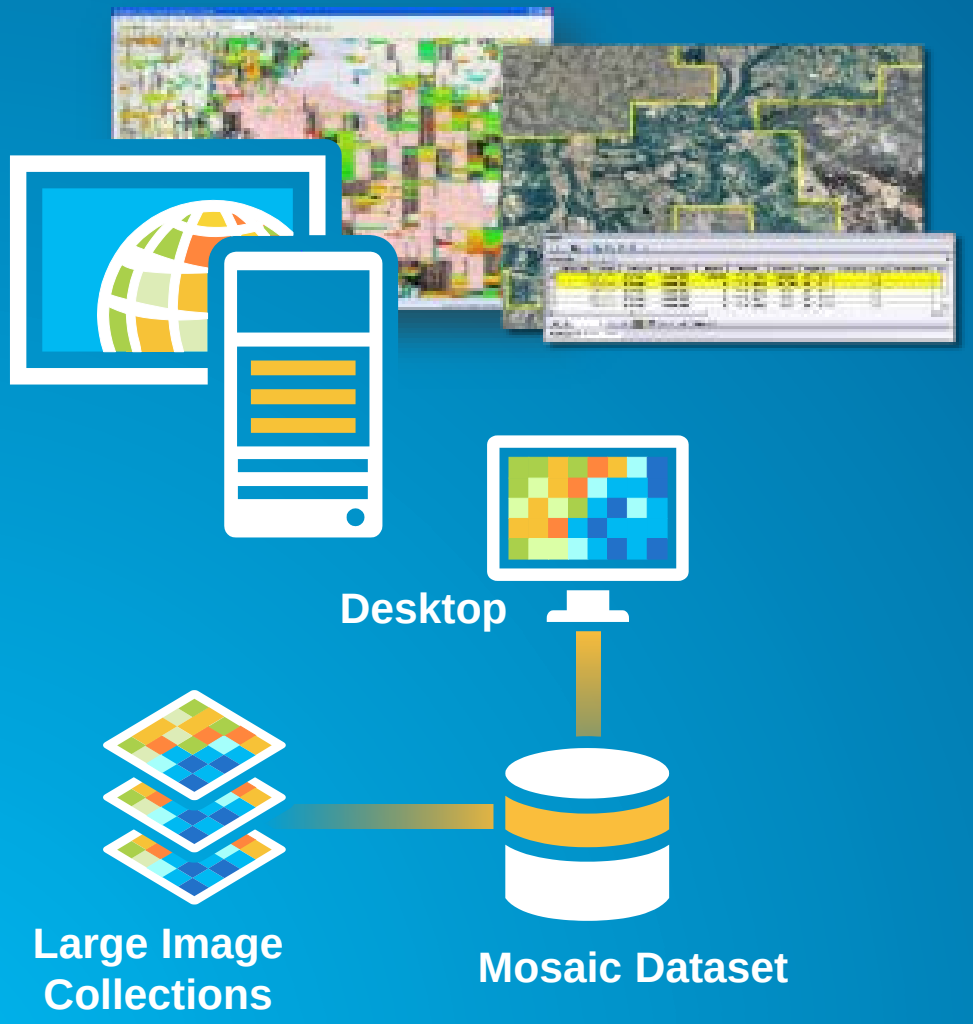


Introduction / Review

- LAS Datasets
  - For individual projects; support access to 3D points, w/ filtering, toward analysis
- Terrain datasets
  - For organizations creating, editing, & maintaining authoritative DTM
- For managing multiple projects, and accessing 3D surfaces (DTM, DSM), Mosaic Dataset is recommended
  - Post QC, organized by project via LAS Datasets *or*
  - Managed within a Terrain Dataset

Image Management Workflow Using Mosaic Datasets

Highly Scalable, From Small to Massive Volumes of Imagery



Create Catalog of Imagery

- Reference Sources
- Ingest & Define Metadata
- Define Processing to be Applied

Apply:

- On-the-fly Processing
- Dynamic Mosaicking

Access as Image or Catalog

Image Dissemination

Integrating with / and in The Cloud

- **Dynamic Image Services**
  - **Processing & Analysis**
  - **Catalog of Metadata**
- **Geoprocessing Services**
  - **Processing Tasks**

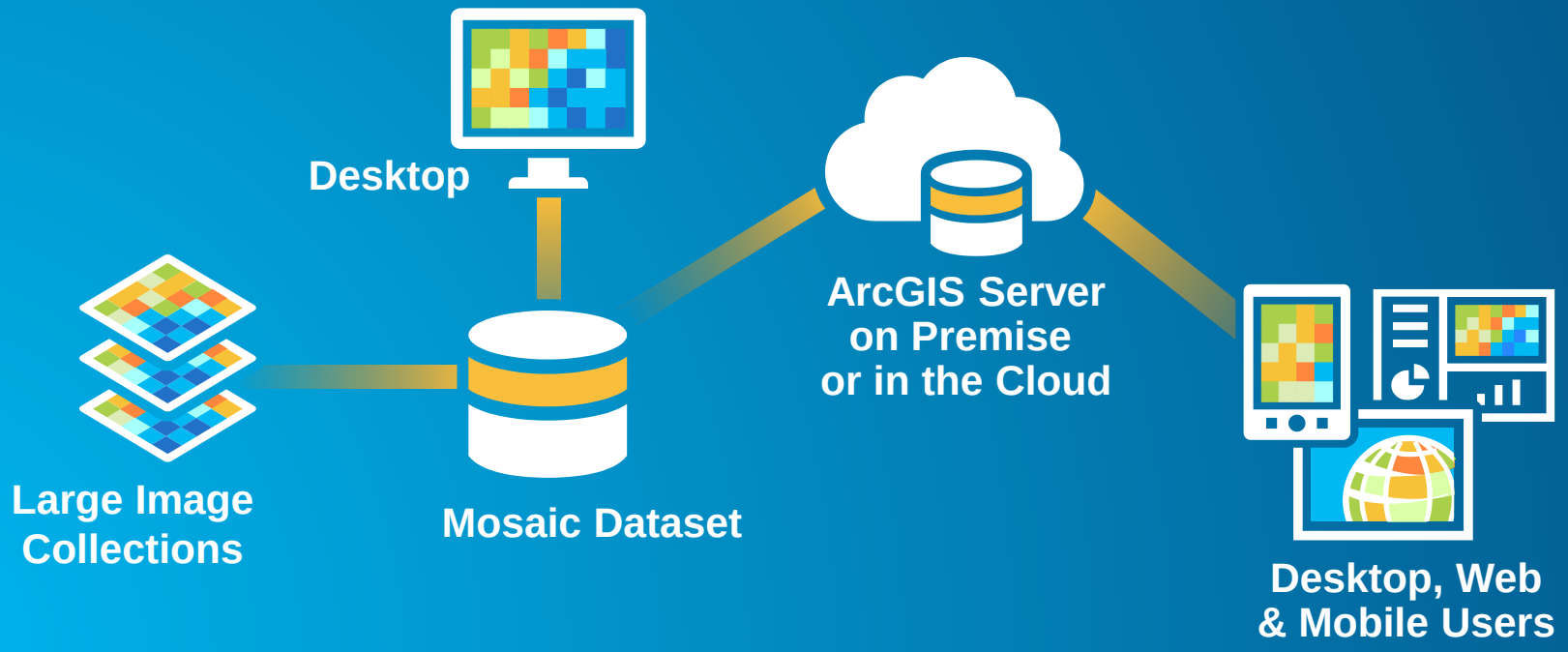
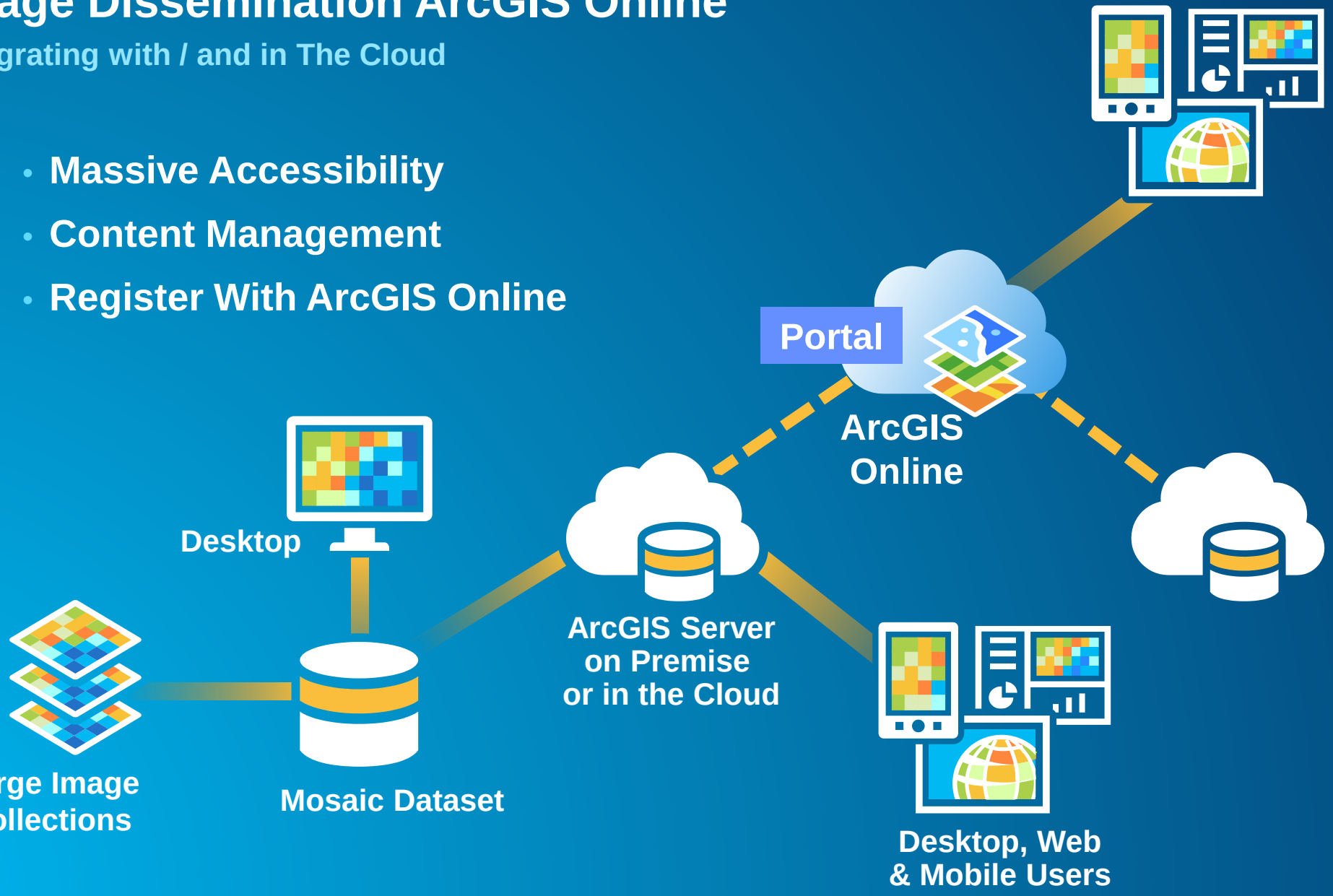


Image Dissemination ArcGIS Online

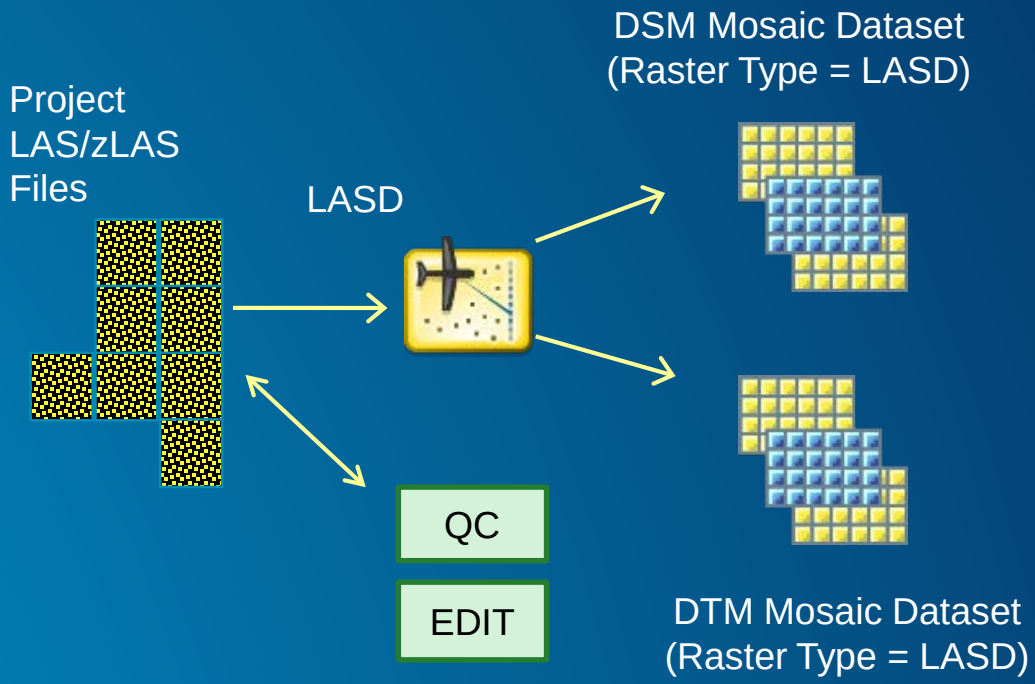
Integrating with / and in The Cloud

- Massive Accessibility
- Content Management
- Register With ArcGIS Online



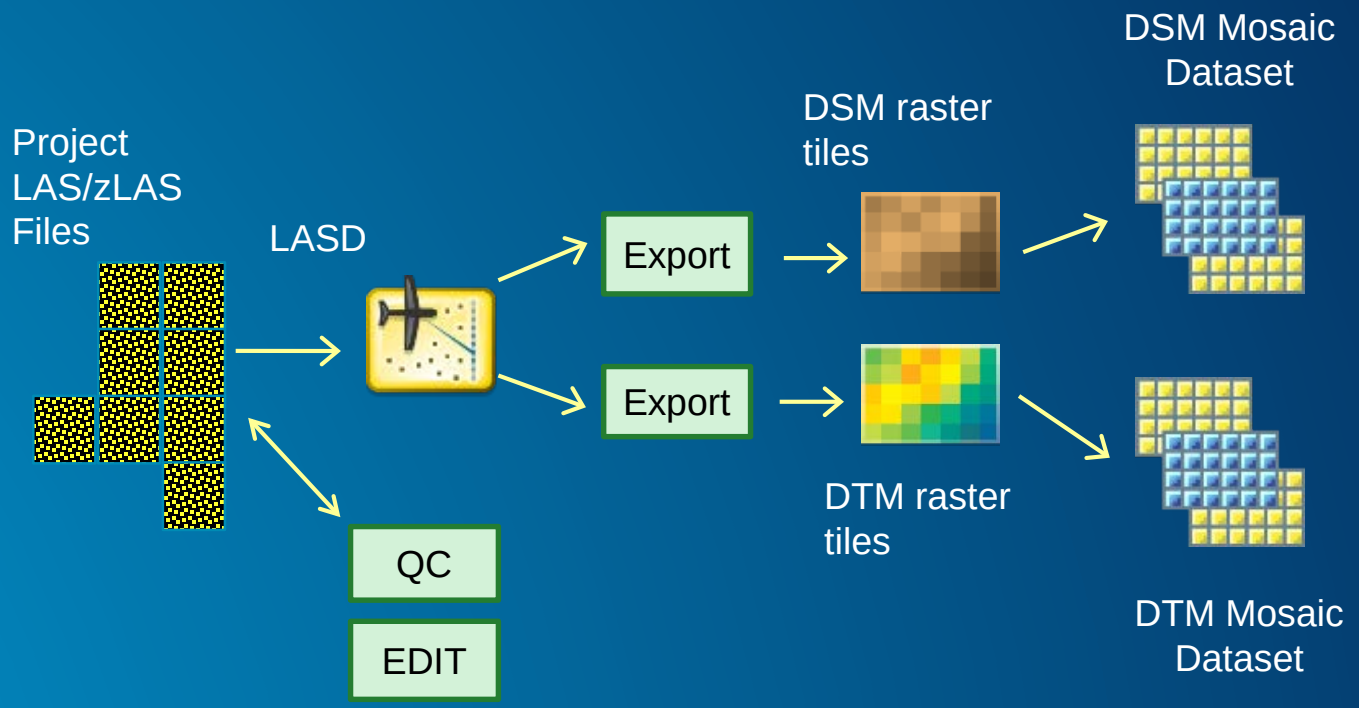
Adding lidar data to a mosaic dataset (Method 1)

- **Advantages**
  - **Fastest method to begin using & sharing raster surfaces**
  - **Filter to create custom surfaces (e.g. buildings & DTM, remove vegetation)**



Adding lidar-derived data to a mosaic dataset (Method 2)

- **Advantages**
  - **Most scalable**
  - **Best performance**

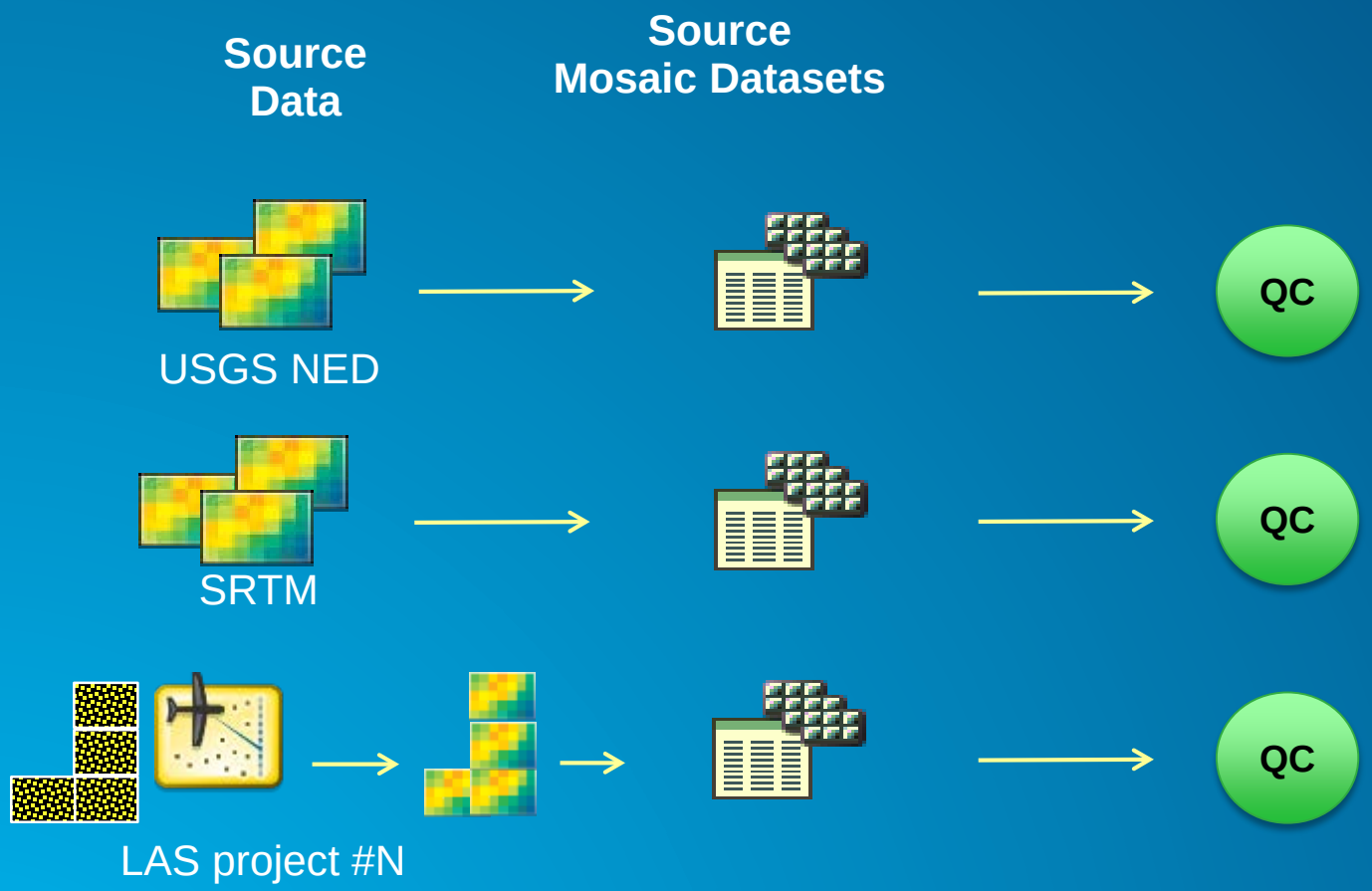


Lidar data management using Mosaic Datasets

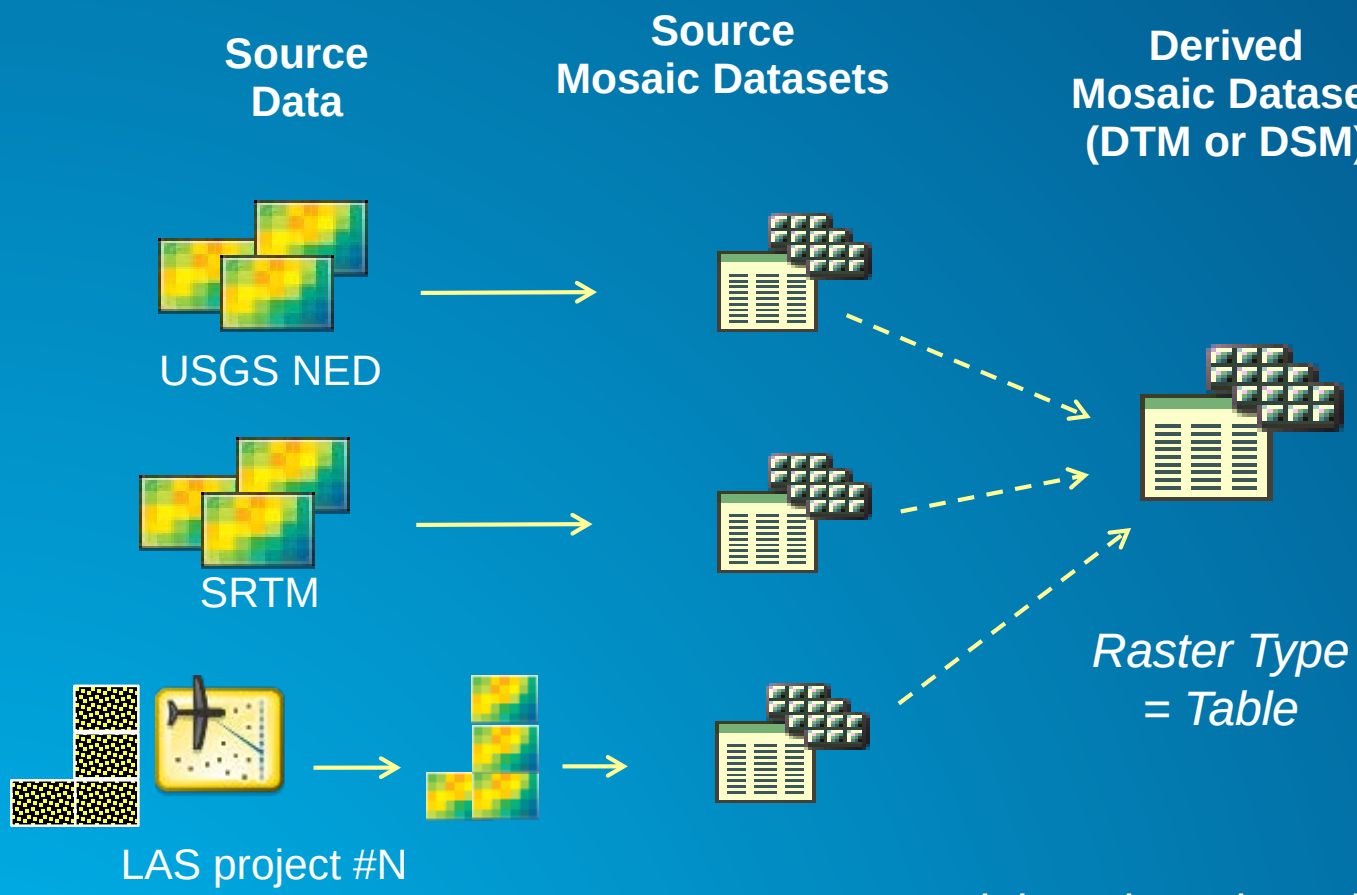
- **Design**
  - **Begin with Elevation data management**
    - **In most organizations, DTM & DSM supports the majority of users**
  - **Support download for 3D point data users**
- **Build & Maintain**
  - **Automation (see *Image Management Workflows*)**
- **Share**
  - **Within an organization**
  - **With external users**

Elevation data management using Mosaic Datasets

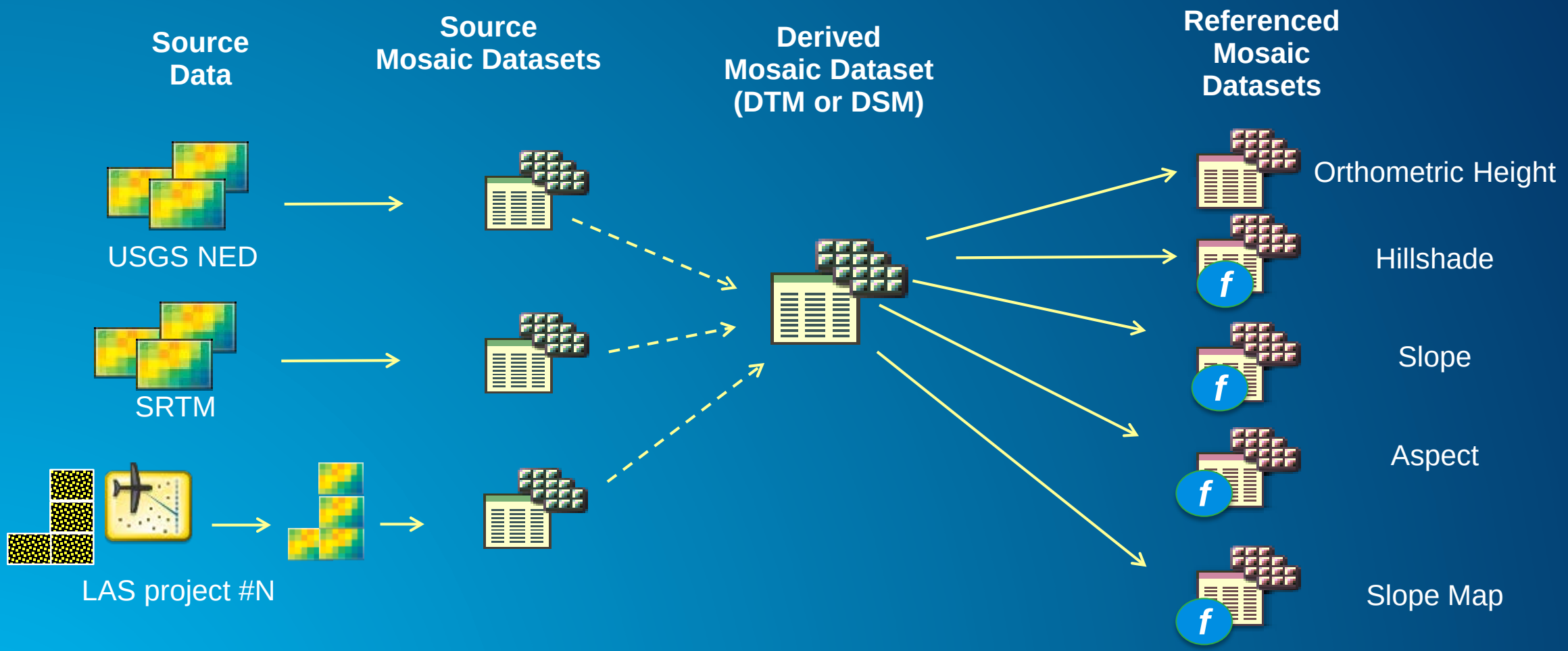
- Manage each project separately (LASD)
- Create tiled DTM and DSM for ingestion into Mosaic Dataset
- Combine multiple projects into single repository
- Manage DTM and DSM as base data, provide other products on demand
  - hillshade, slope, ellipsoidal height, etc.
- For users needing source 3D points (lidar/photogrammetry), allow data download

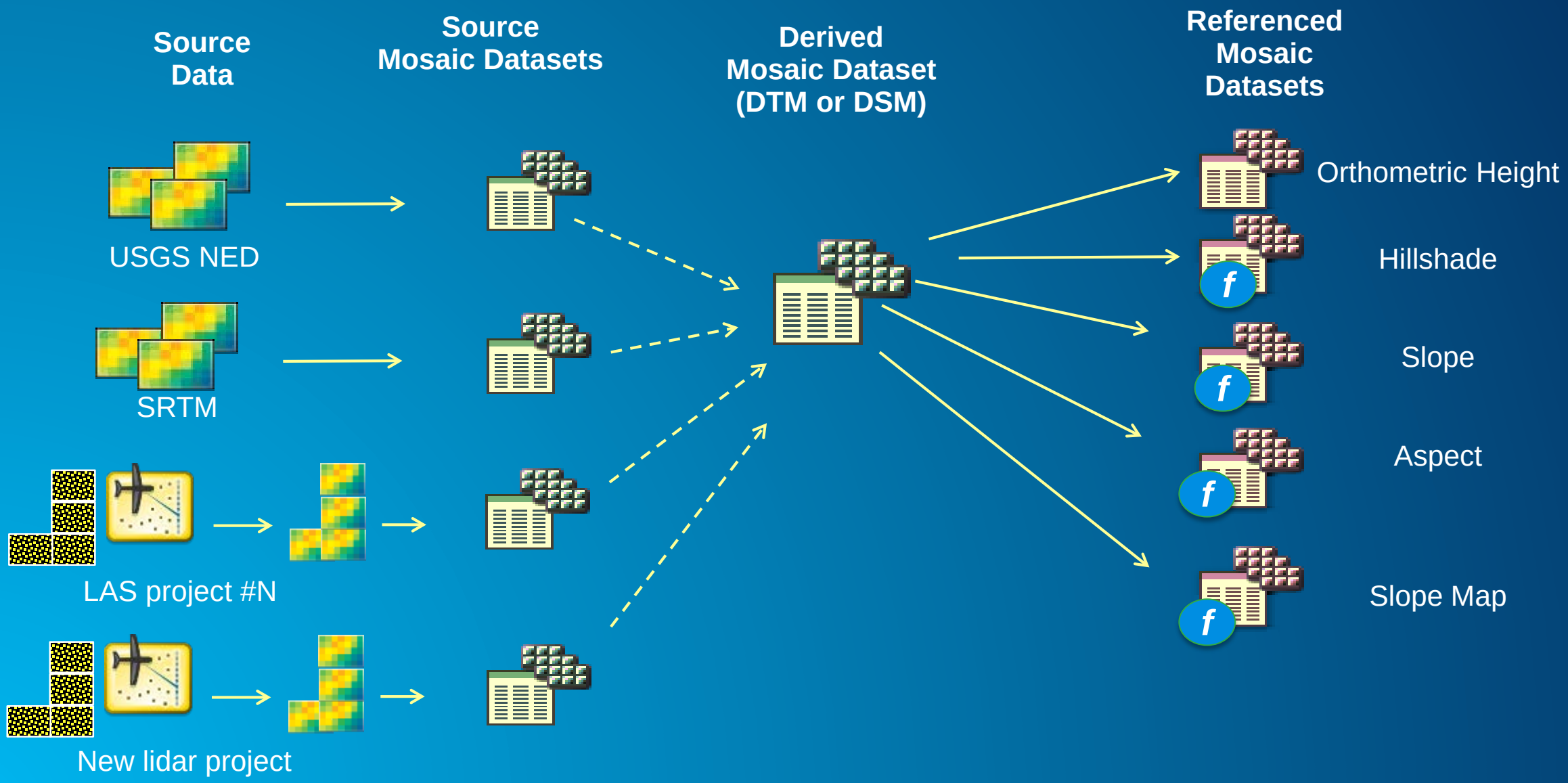


Manage each project separately



Link projects into single repository


Source Data
Source Mosaic Datasets
Derived Mosaic Dataset (DTM or DSM)
Referenced Mosaic Datasets
USGS NED
SRTM
LAS project #N
Orthometric Height
Hillshade
Slope
Aspect
Slope Map
Link projects into single repository


Source Data
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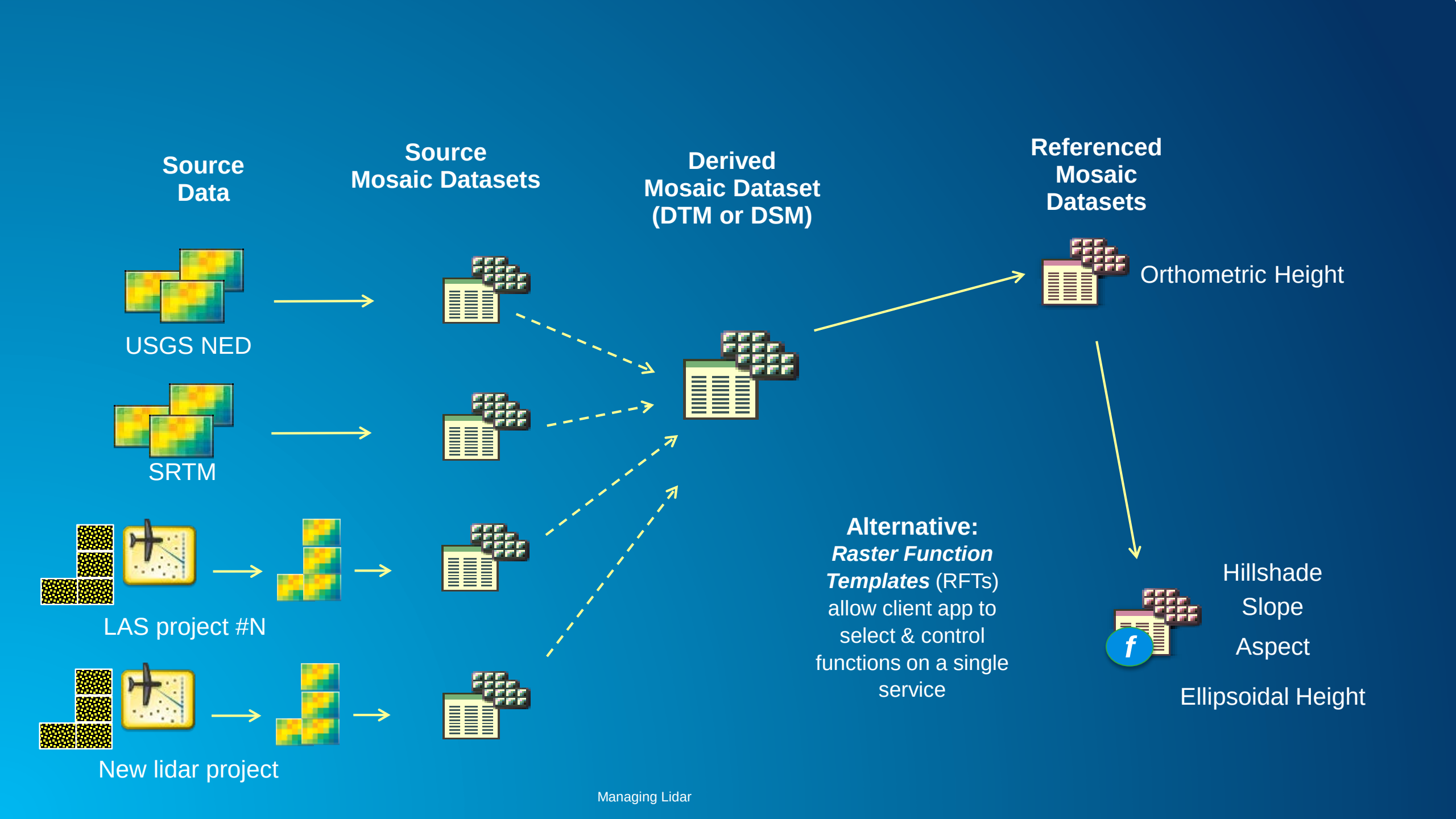
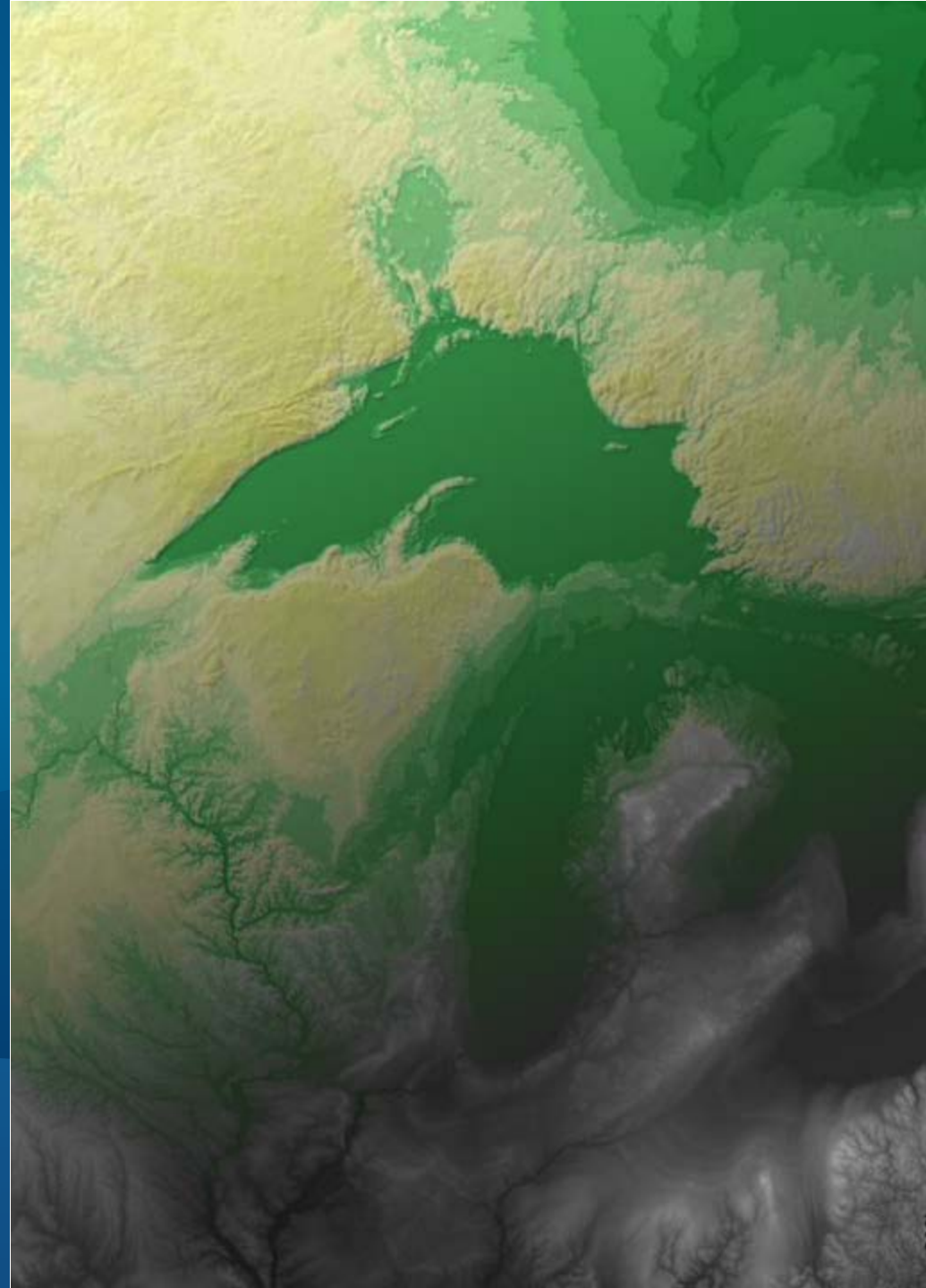
USGS NED
SRTM
LAS project #N
New lidar project
Orthometric Height
Hillshade
Slope
Aspect
Slope Map


Source Data
Source Mosaic Datasets
Derived Mosaic Dataset (DTM or DSM)
Referenced Mosaic Datasets
USGS NED
SRTM
LAS project #N
New lidar project
Orthometric Height
Alternative:
Raster Function Templates (RFTs) allow client app to select & control functions on a single service
Hillshade
Slope
Aspect
Ellipsoidal Height

DEMO

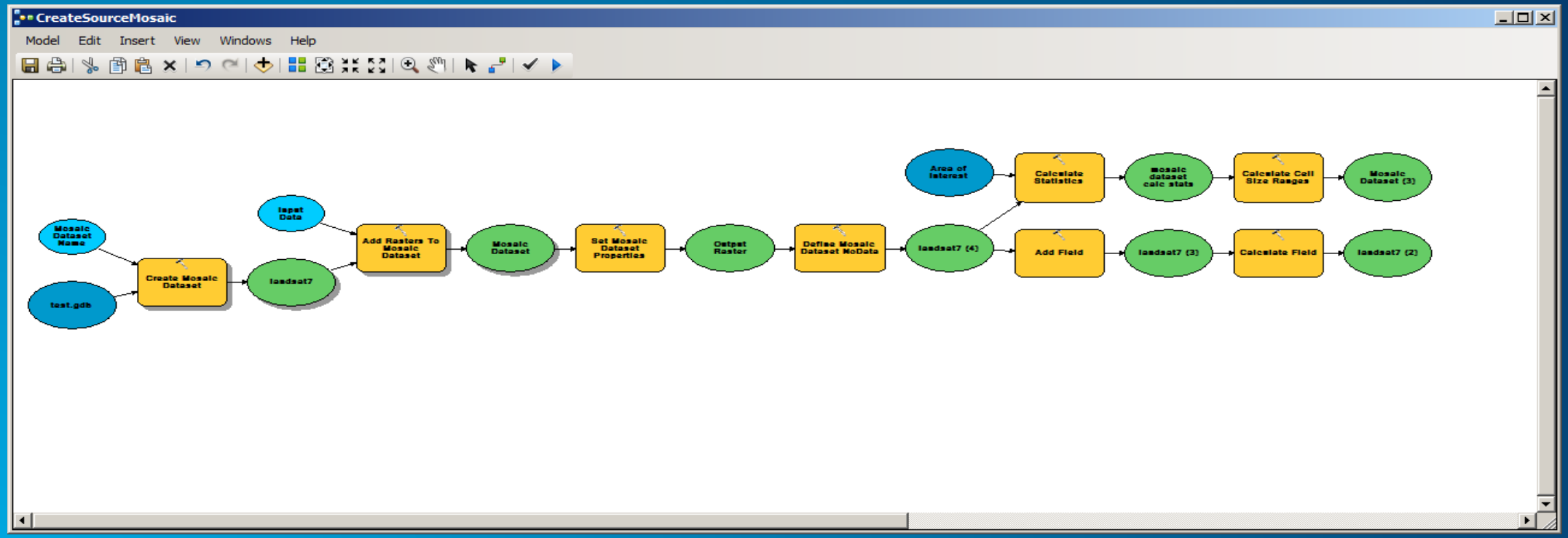
Multiresolution Elevation Data



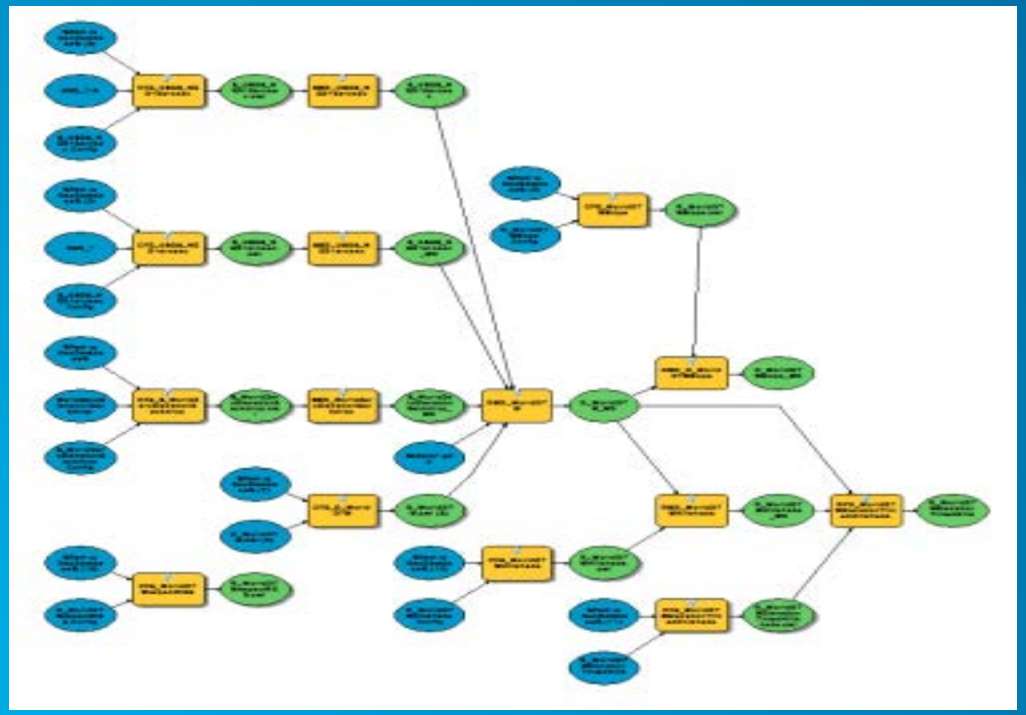
Advantages/Objectives of Automation

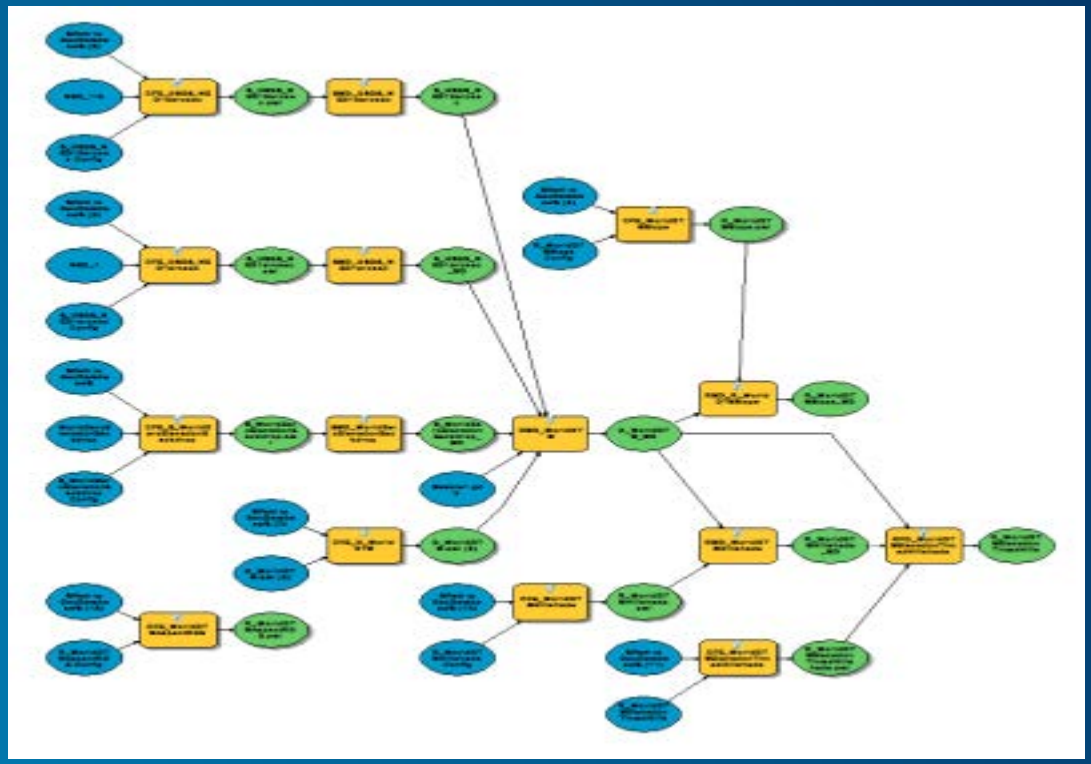
- Productivity
  - Repeatability, Scalability, Maintainability
  - System Documentation → to facilitate QA & QC, Design Review
- Training/Examples
  - Encapsulate best practices
  - Reusable templates
- Simplicity
- Options for creating Mosaic Datasets:
  - Manual
  - ModelBuilder
  - Python

Create Simple Mosaic Dataset - ModelBuilder



Comparing Models





Python example tools - *Mosaic Dataset Configuration Script (MDCS)*

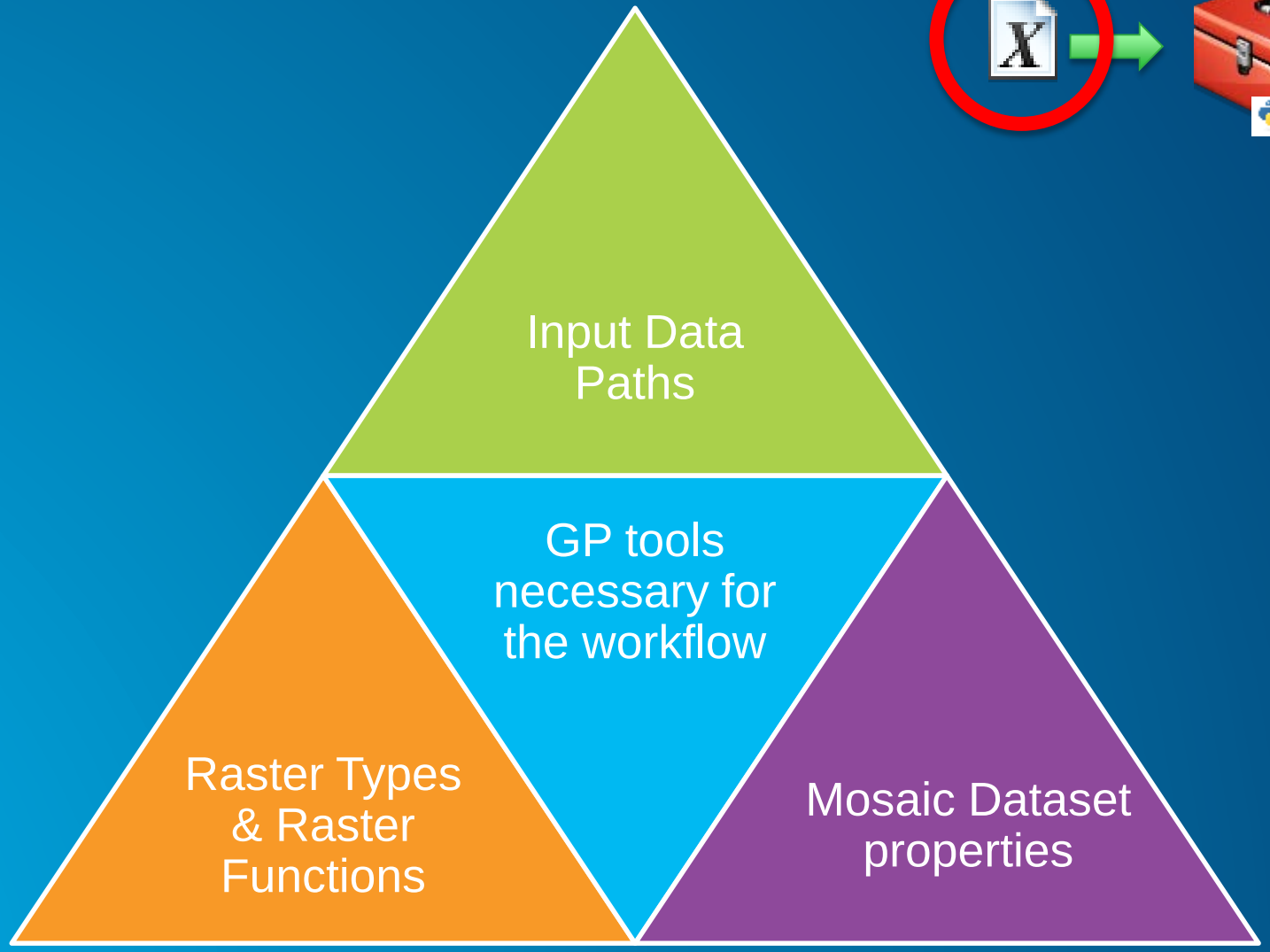
- Calling standard Geoprocessing tools from a single script
- Input configuration file contains complete information to:
  - Create,
  - Populate, and
  - Configure one mosaic dataset

  - Also generates detailed log files

Advantages of MDCS

- Configuration file encapsulates “Best practices” (mosaic dataset properties) based on image type
- “Self Documenting” –
  - Template is reusable for different image types, or multiple mosaic datasets within a more complex system
  - Compare versions (difficult with ModelBuilder)
- Automated Log files – Simple Review
- Based on 10.2, but compatible with upcoming ArcGIS Pro App

Configuration file contents

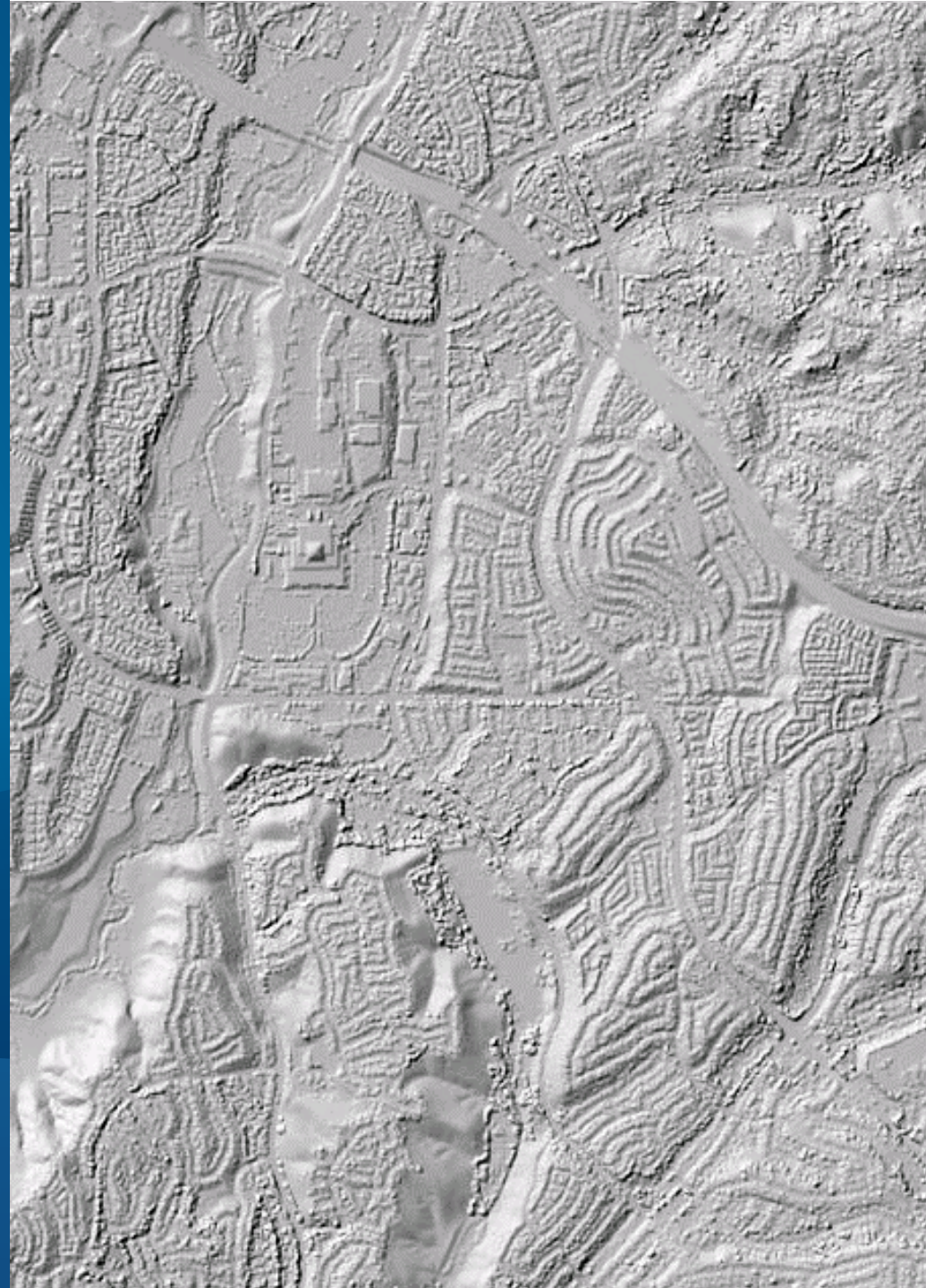


Configuration file contents

Demo - Automation

Adding Lidar to World Elevation

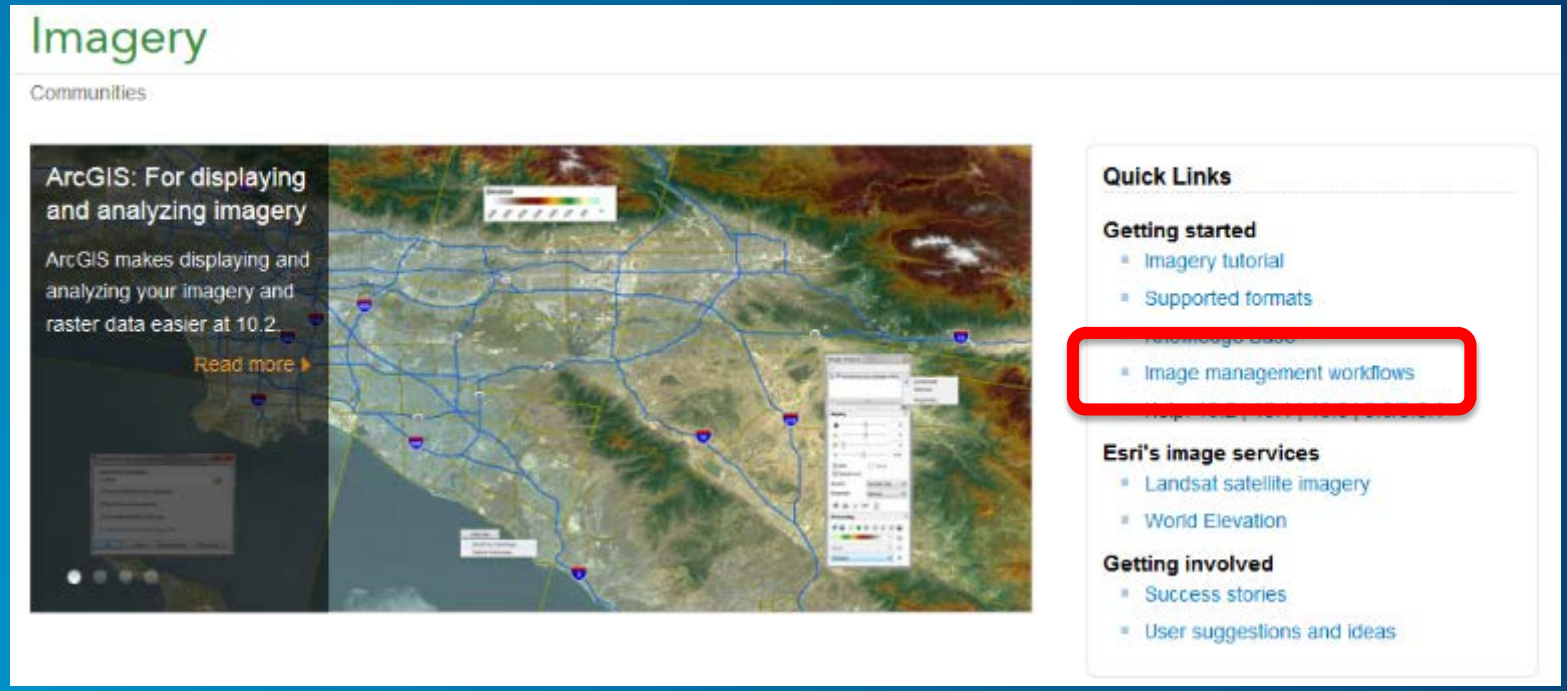
If you want to follow on a mobile device:
http://esriurl.com/AddLidar



Finding MDCS and related resources

http://resources.arcgis.com/en/communities/imagery

Imagery Community on the ArcGIS Resource Center



Finding MDCS and related resources

…to the Landing page on Resource Center

Finding MDCS and related resources

Image Management Guidebook

in ArcGIS Help System for detailed advice

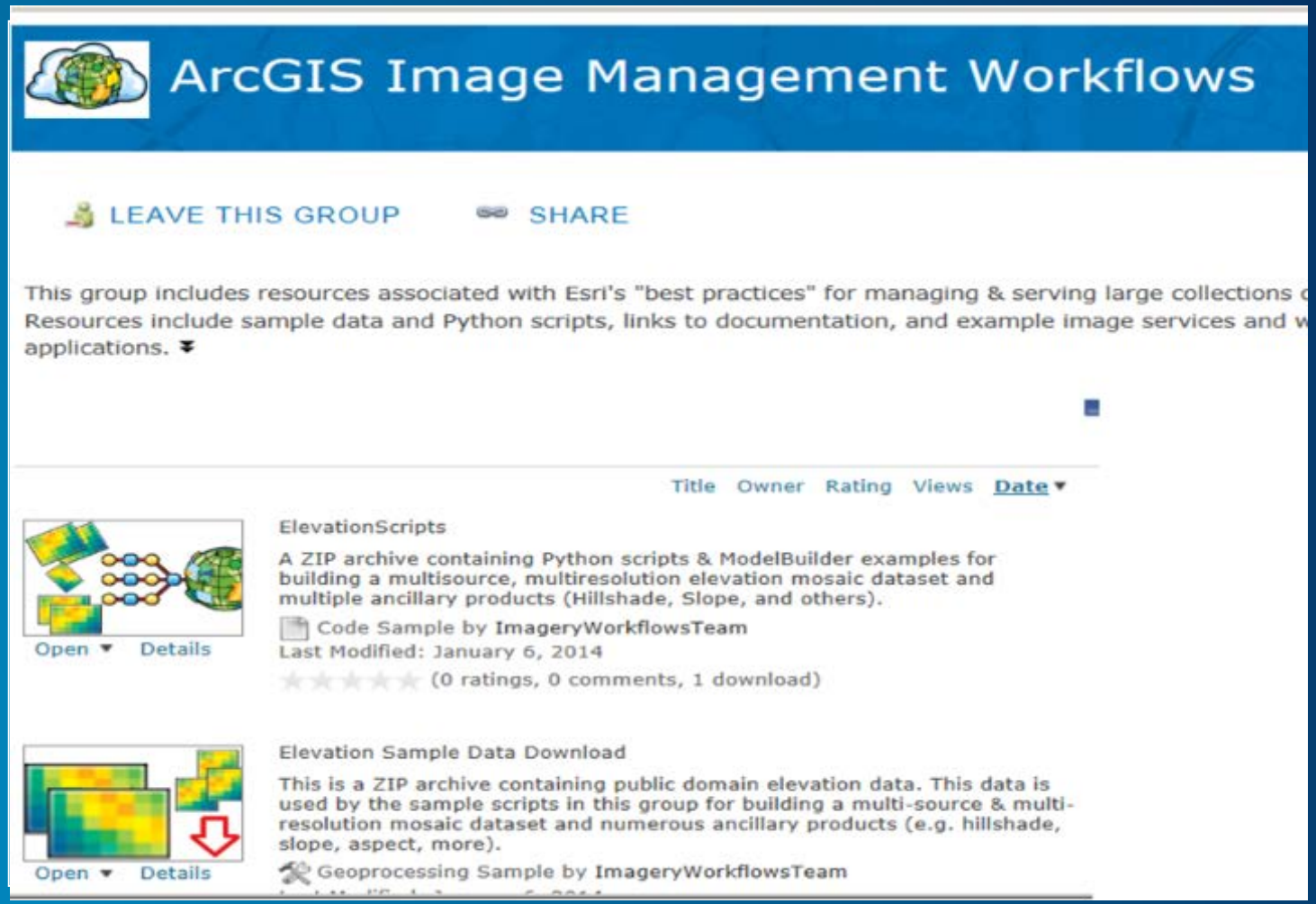
General workflow,

Elevation workflow,

& Lidar workflow

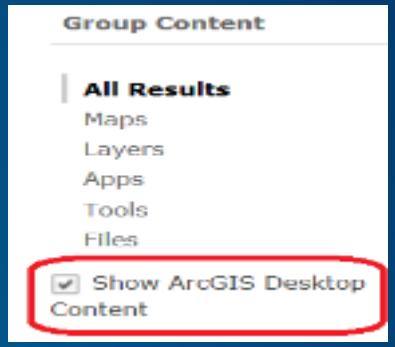
ArcGIS Online (AGOL) group

- **Downloadable examples**
- **More workflows/templates to be added over time**



Resources: “Imagery Management Workflows”

- **Imagery Resource Center : http://esriurl.com/6005**
- **Image Management Workflows: http://esriurl.com/6550**
- **Guidebook in ArcGIS Help: http://esriurl.com/6007**
- **ArcGIS Online Group: http://esriurl.com/6539**



- **Recorded Webinar on lidar data management: http://esriurl.com/LTSLidarMgmt**
- **Optimized LAS tool: http://esriurl.com/zlas**
- **Tools from 3D Team: http://links.esri.com/3dSamples**

- **Contact information:**
  - Cody Benkelman cbenkelman@esri.com
  - Lindsay Weitz lweitz@esri.com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