



# Managing Lidar (and other point cloud) Data

Lindsay Weitz

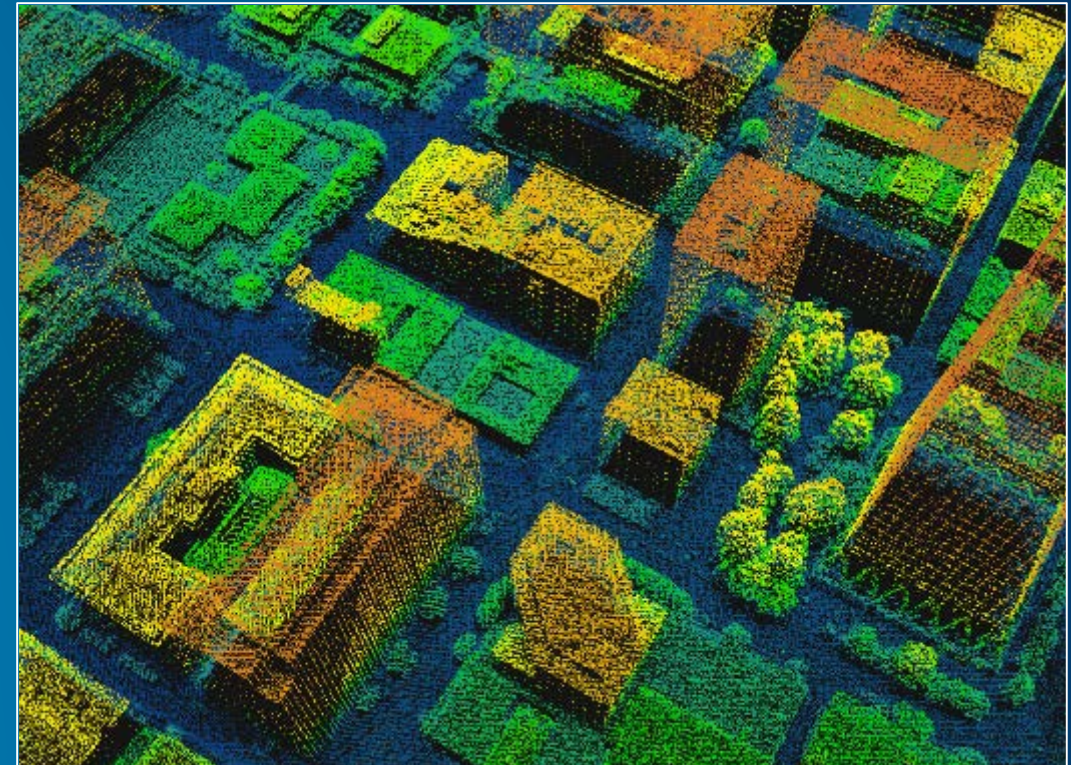
Cody Benkelman

## Presentation Context

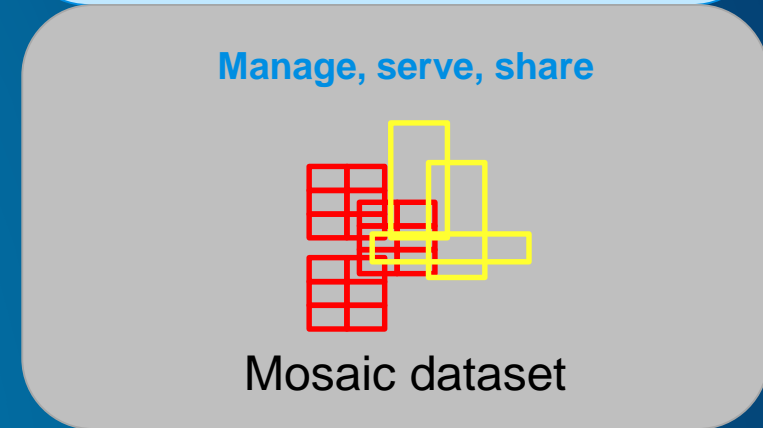
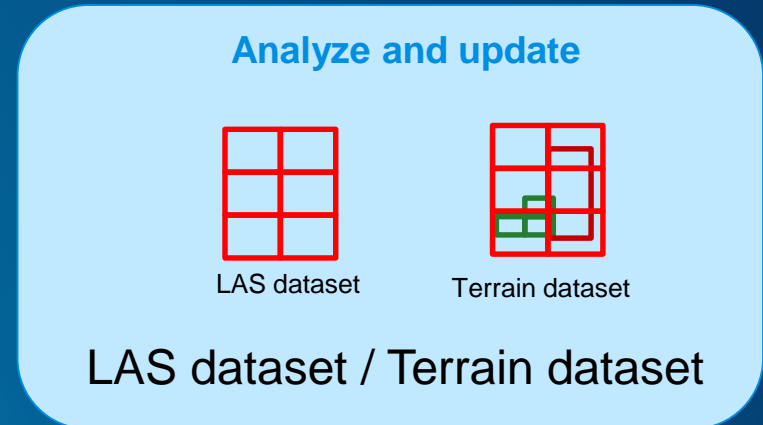
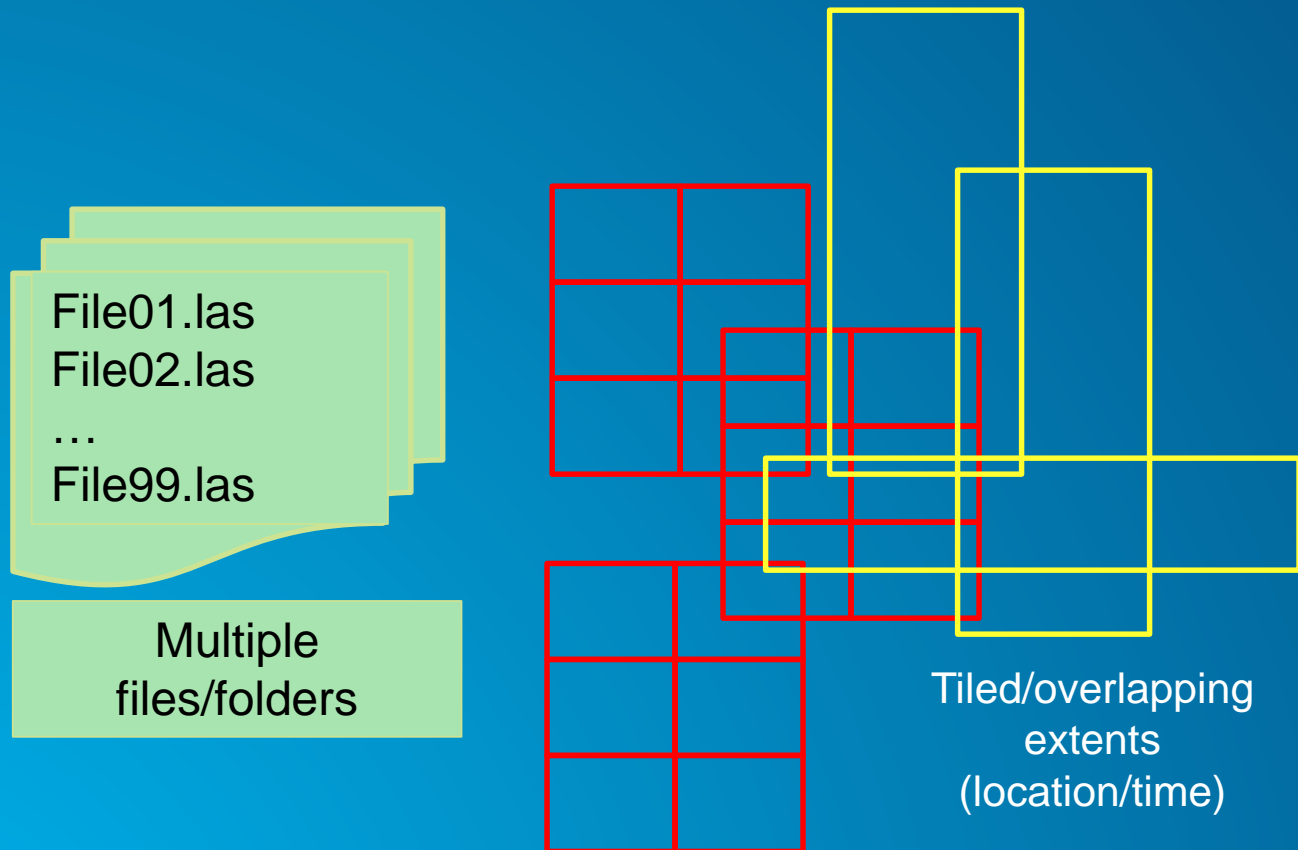
- What is lidar, and how does it work? → *Not this presentation!*
- What can you do with lidar in ArcGIS?
- What does Esri recommend as best practices for processing and managing lidar data?
- What about other point clouds (from photogrammetry)?

# 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

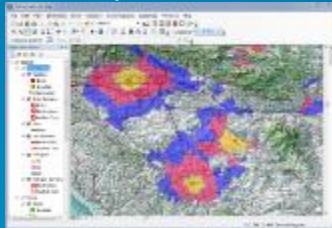


# Data Structures for Lidar support in ArcGIS

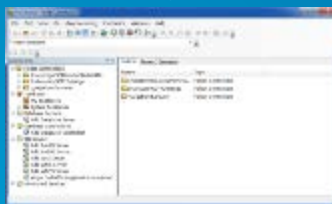


# Application Fusion: ArcGIS Pro

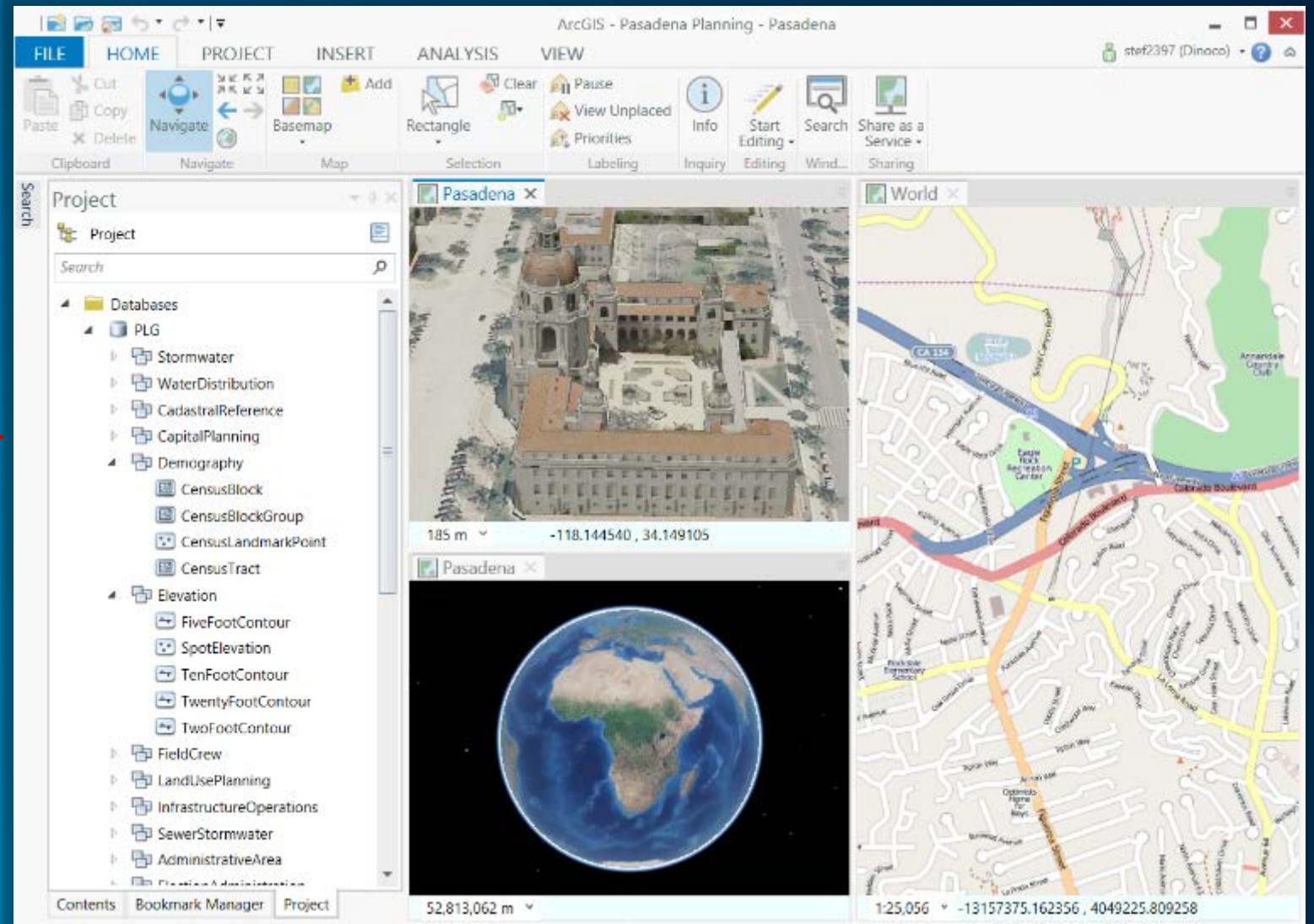
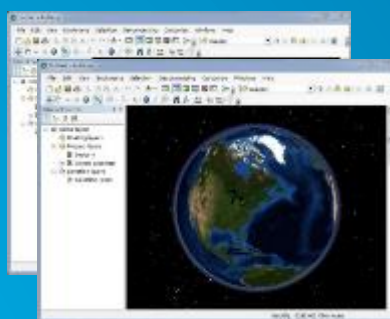
ArcMap



ArcCatalog



ArcGlobe / ArcScene



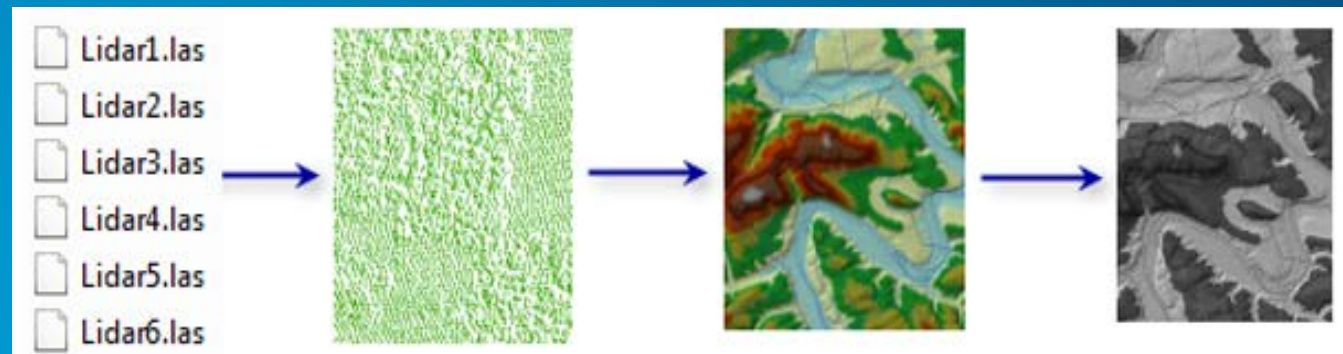
# Lidar in ArcGIS Pro

Lindsay Weitz



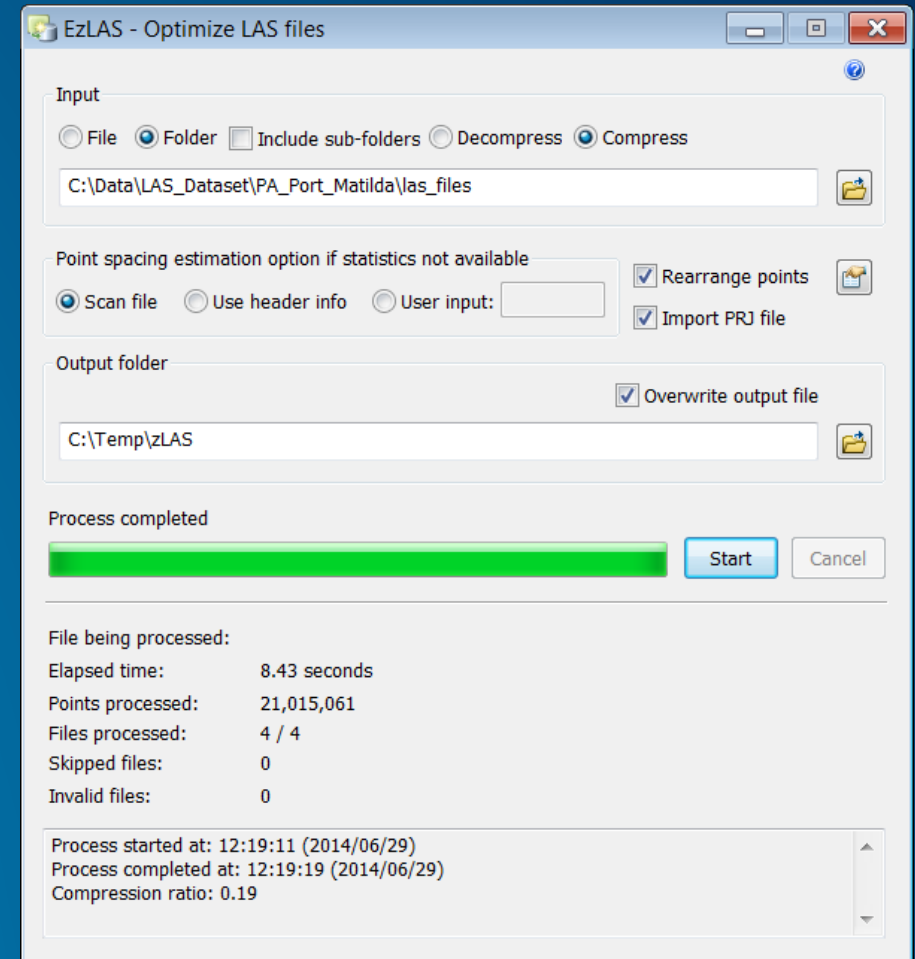
# Lidar data storage – LAS files

- 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

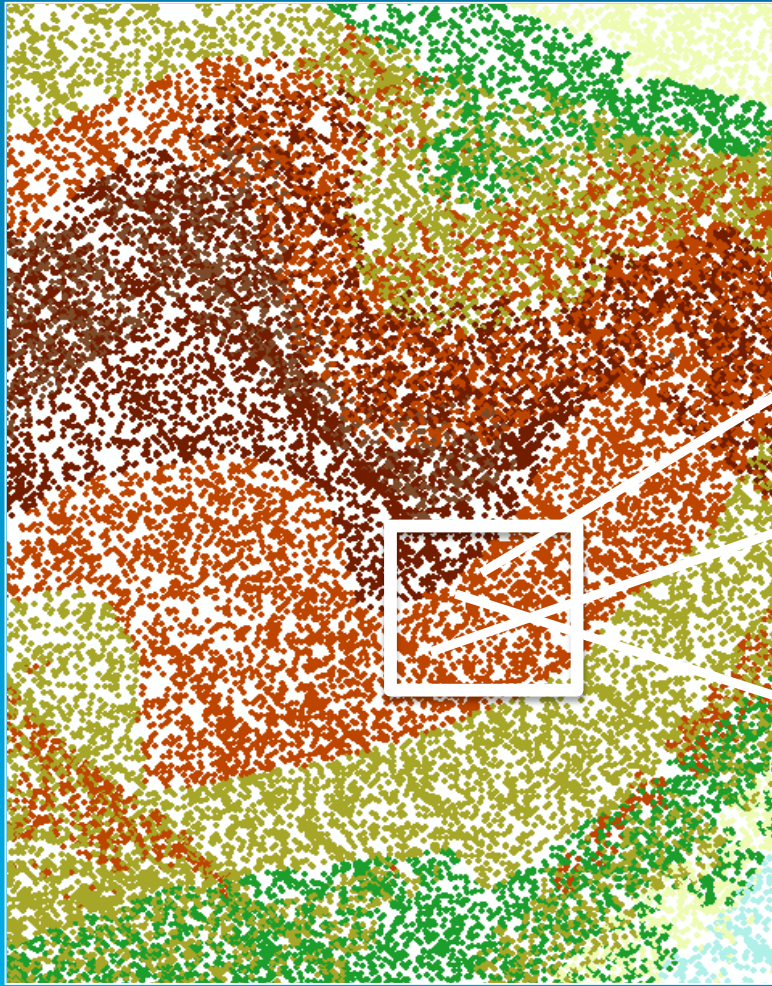




# zLAS

- **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

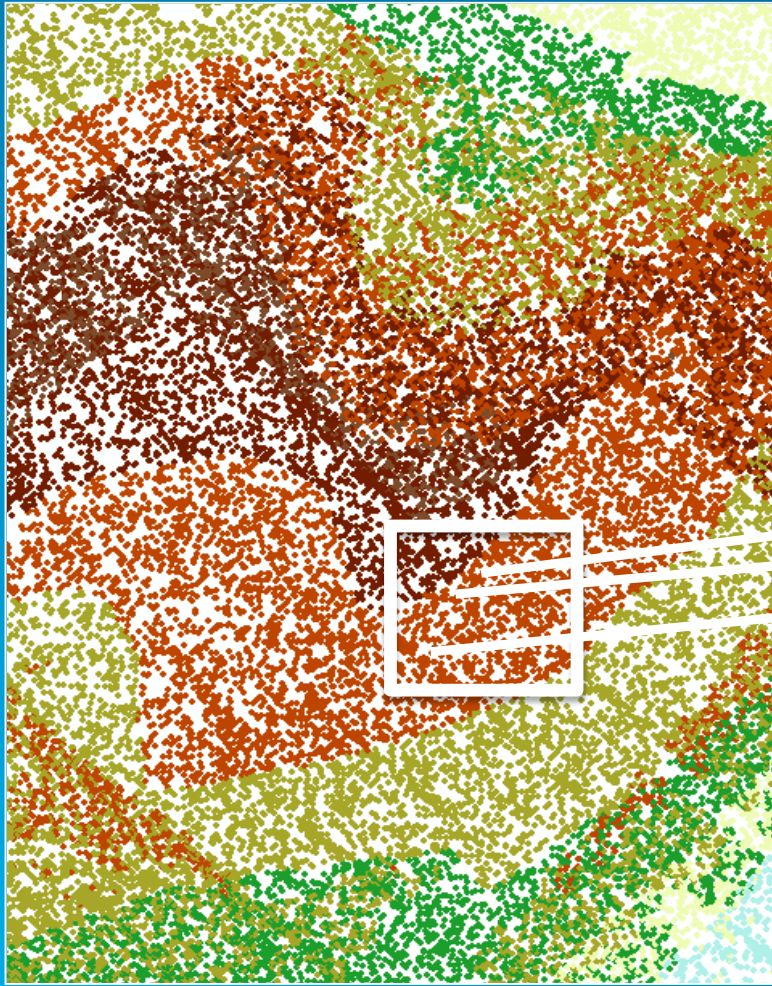


Spatial distribution of points



Physical location in file

# Rearranging Point Records



Spatial distribution of points



Physical location in file

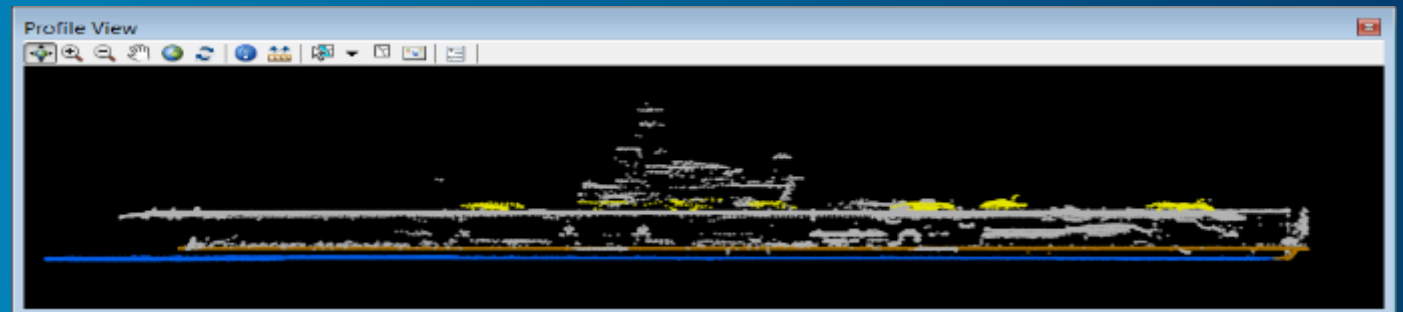
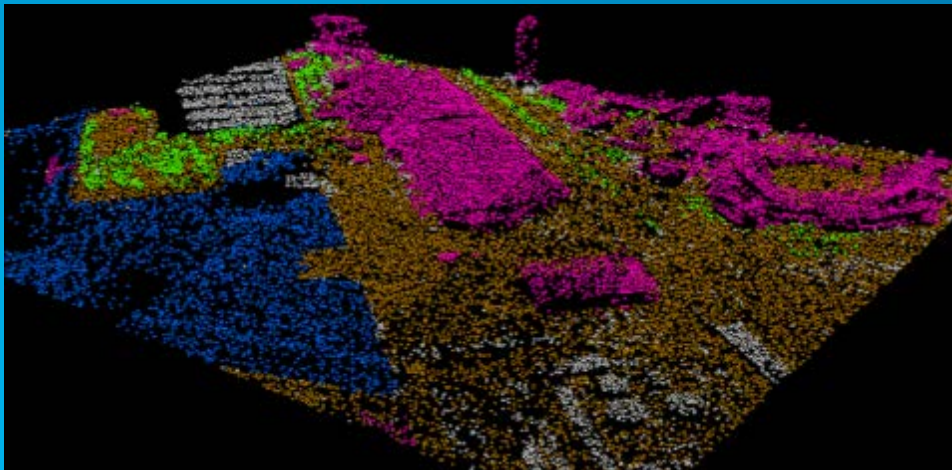
# LAS dataset

Lindsay Weitz



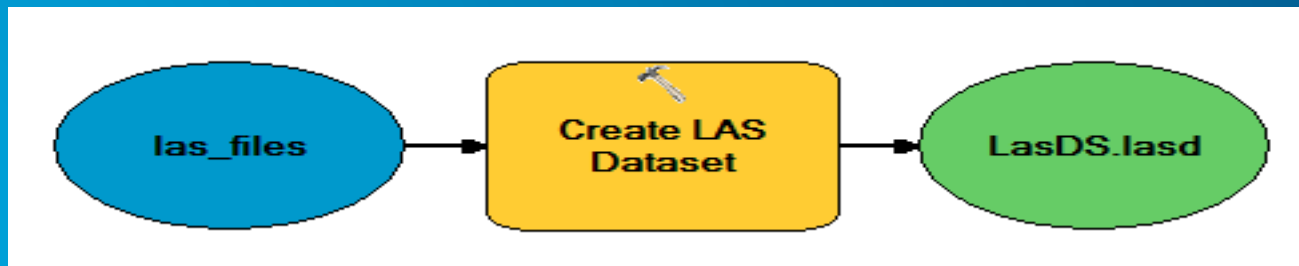
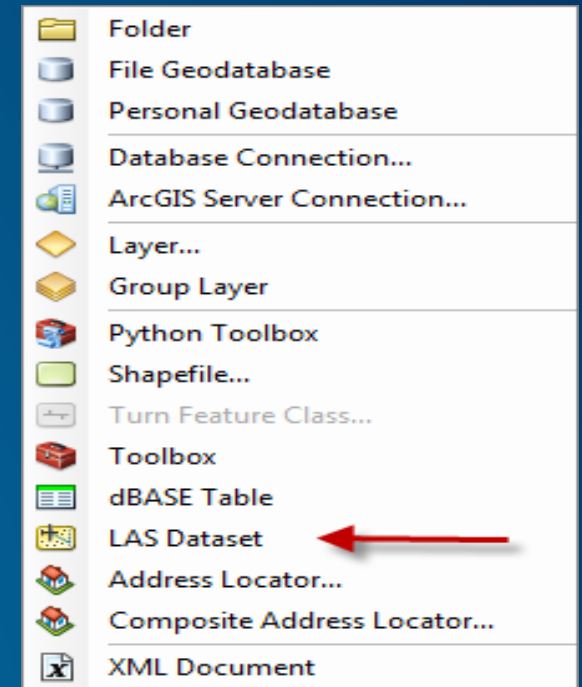
# Lidar data with a LAS dataset

- 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

LAS Dataset Properties

General | **LAS Files** | Surface Constraints | Statistics | XY Coordinate System | Z Coordinate System

Show:   Show full path of LAS files

LAS File	Version	Point Count	Point Spacing	Z Min	Z Max	Statistics
Tile000001.las	1.2	4,185,584	2.752	-1329.980	841.490	...
Tile000002.las	1.2	4,385,886	2.790	163.250	913.630	...
Tile000003.las	1.2	4,443,149	2.754	208.390	1570.620	...
Tile000004.las	1.2	4,516,182	2.672	306.460	3985.370	...
Tile000005.las	1.2	4,594,846	2.712	-1465.180	2222.280	...
Tile000006.las	1.2	3,932,164	2.841	270.430	4117.540	...
Tile000007.las	1.2	4,055,510	2.852	-1293.050	4443.310	...
Tile000008.las	1.2	3,753,963	2.924	-888.170	4304.190	...
Tile000009.las	1.2	4,137,014	2.730	269.300	2713.120	...
Tile000010.las	1.2	3,991,642	2.809	253.860	4781.180	...
Tile000011.las	1.2	4,191,951	2.745	304.500	1170.370	...
Tile000012.las	1.2	4,002,169	2.776	172.900	1126.230	...
Tile000013.las	1.2	4,096,047	2.839	131.850	1229.190	...
Tile000014.las	1.2	4,243,287	2.854	-1278.000	2263.900	...
Tile000015.las	1.2	4,376,649	2.791	141.000	876.760	...
Tile000016.las	1.2	4,515,783	2.758	251.510	954.270	...
Tile000017.las	1.2	4,375,951	2.804	153.780	804.680	...
Tile000018.las	1.2	4,819,498	2.668	-1276.780	1308.510	...
Tile000019.las	1.2	3,633,209	2.894	56.650	4792.580	...

Add Files... Add Folders... Remove

OK Cancel Apply

LAS File Properties and Statistics

General

Has RGB: No  
Has GPS Time: Yes (Week Time)  
System ID:  
Generating Software: TerraScan  
Project ID: {00000000-0000-0000-0000-000000000000}  
File Source ID: 0  
Variable Length Reco... 0

Extent

Min X: 6107000.010000 Max X: 6112000.000000  
Min Y: 2156000.000000 Max Y: 2160999.990000  
Min Z: -1329.980000 Max Z: 841.490000

X Range: 4999.990000  
Y Range: 4999.990000  
Z Range: 2171.470000

XY Linear Unit: <Not Available>  
Z Unit: <Not Available>

Returns

Return	Point Count	%	Z Min	Z Max
First	2,703,864	64.60	354.09	841.49
Second	309,756	7.40	-1329.98	823.06
Third	39,249	0.94	354.32	804.13
Fourth	3,106	0.07	354.25	737.85
Last	2,702,854	64.58	-1329.98	835.17
Single	2,393,172	57.18	354.09	835.17

Classification Codes

Classification	Point Count	%	Z Min	Z Max	Min Inte...	Max Inte...	Syntheti...
1 Unassigned	324,038	7.74	354.52	831.89	1	5100	0
2 Ground	1,510,439	36.09	354.06	831.92	1	5100	0
4 Medium Vegetation	434,338	10.38	355.60	841.49	1	5100	0
5 High Vegetation	773,612	18.48	355.89	835.17	1	5100	0
7 Noise	5,890	0.14	-1329.98	828.10	1	116	0
10 Reserved	7,658	0.18	473.54	611.93	3	240	0

Previous File Next File Update  Force recalculate OK

# QA/QC: LAS dataset based statistics

- LAS Dataset Properties: LAS Dataset Statistics

The screenshot shows the 'LAS Dataset Properties' dialog box with the 'Statistics' tab selected. The dialog is divided into several sections: Returns, Attributes, Classification Codes, and Classification Flags. The 'Returns' table shows data for five return types. The 'Attributes' table shows statistics for seven attributes. The 'Classification Codes' table shows data for ten classification codes. The 'Classification Flags' table shows data for three flags. There are also 'Update' and 'Force recalculate' buttons, and a status message 'Statistics up to date.' at the bottom.

**Returns**

Return	Point Count	%	Z Min	Z Max
First	127,142,853	64.47	-2.87	4904.20
Second	14,114,138	7.16	-1465.18	3865.93
Third	2,311,095	1.17	-24.17	3856.25
Fourth	288,130	0.15	3.48	1042.10
Last	127,075,116	64.43	-1465.18	3110.63
Single	112,971,756	57.28	-2.87	3110.63

**Attributes**

Name	Min	Max
Return No.	1	4
Intensity	1	5100
Class Code	1	13
Scan Angle	-20	21
User Data	32	32
Point Source	1	22

**Classification Codes**

Classification	Point Count	%	Z Min	Z Max	Min Int...	Max Int...	Synthe...
1 Unassigned	15,089,345	7.65	-2.52	1037.80	1	5100	0
2 Ground	71,967,419	36.49	-2.68	1027.81	1	5100	0
4 Medium Vegetation	20,540,689	10.41	0.95	1091.61	1	5100	0
5 High Vegetation	35,520,764	18.01	-1.11	1092.23	1	5100	0
6 Building	2,205	0.00	240.90	255.09	7	159	0
7 Noise	600,129	0.30	-1465.18	1020.76	1	5100	0
10 Reserved	135,090	0.07	21.83	611.93	1	1160	0

**Classification Flags**

Name	Point Count	%
Model Key	0	0.00
Synthetic	0	0.00
Withheld	53,368,166	27.06

Update  Force recalculate

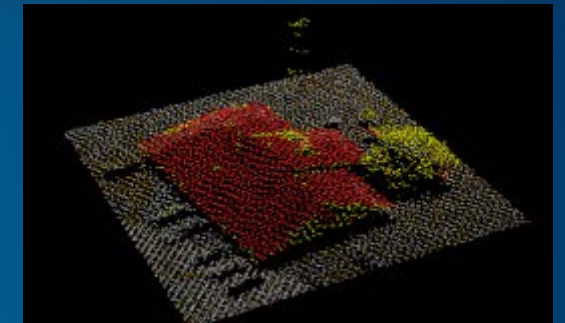
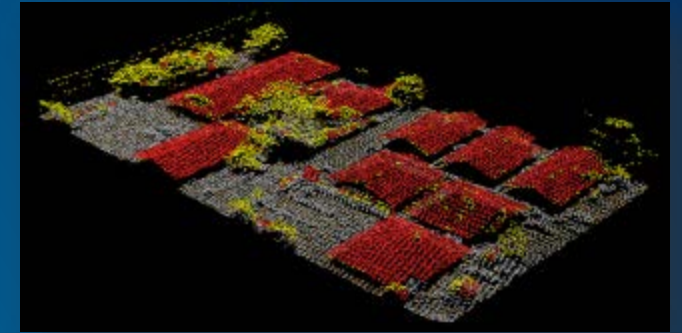
Statistics up to date.

OK Cancel Apply



# 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



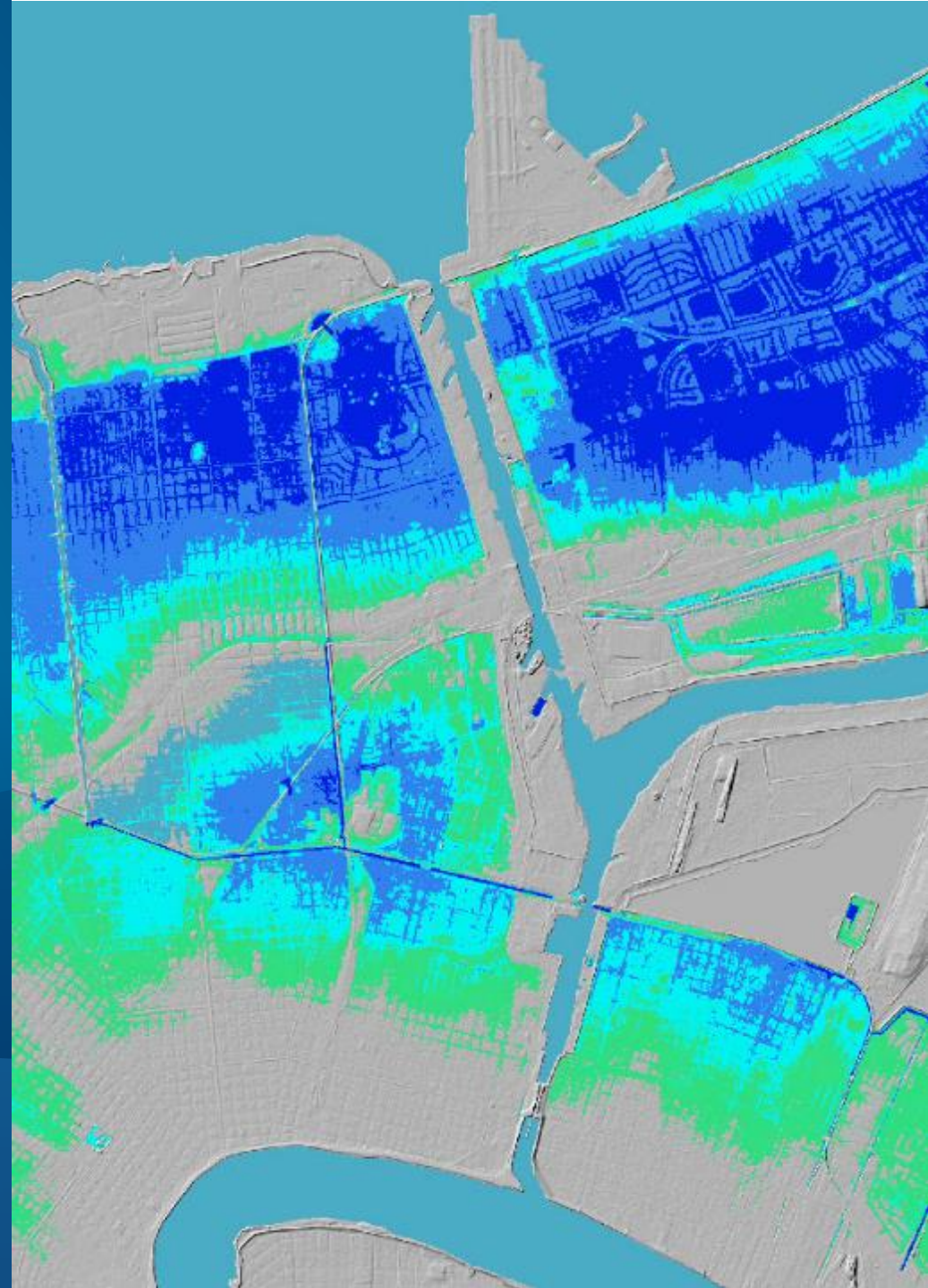
DEMO

# LAS dataset demo

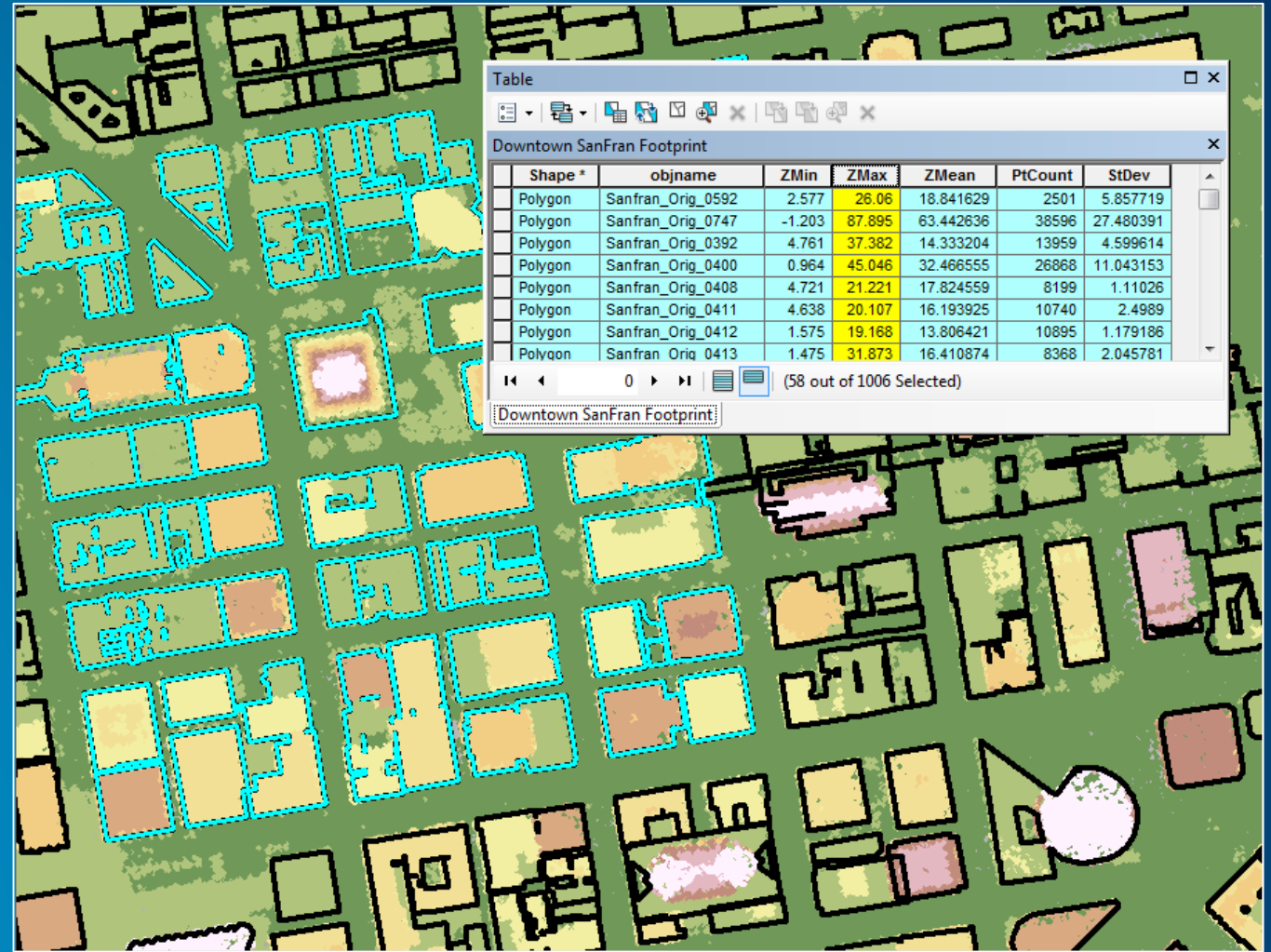
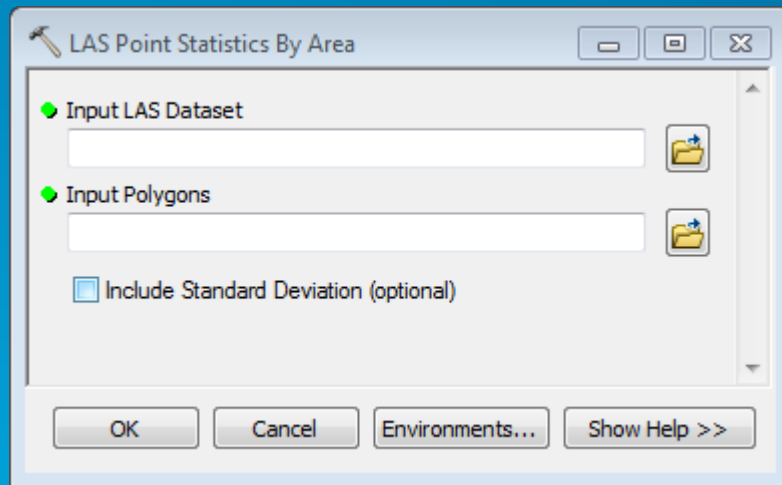
Lindsay Weitz



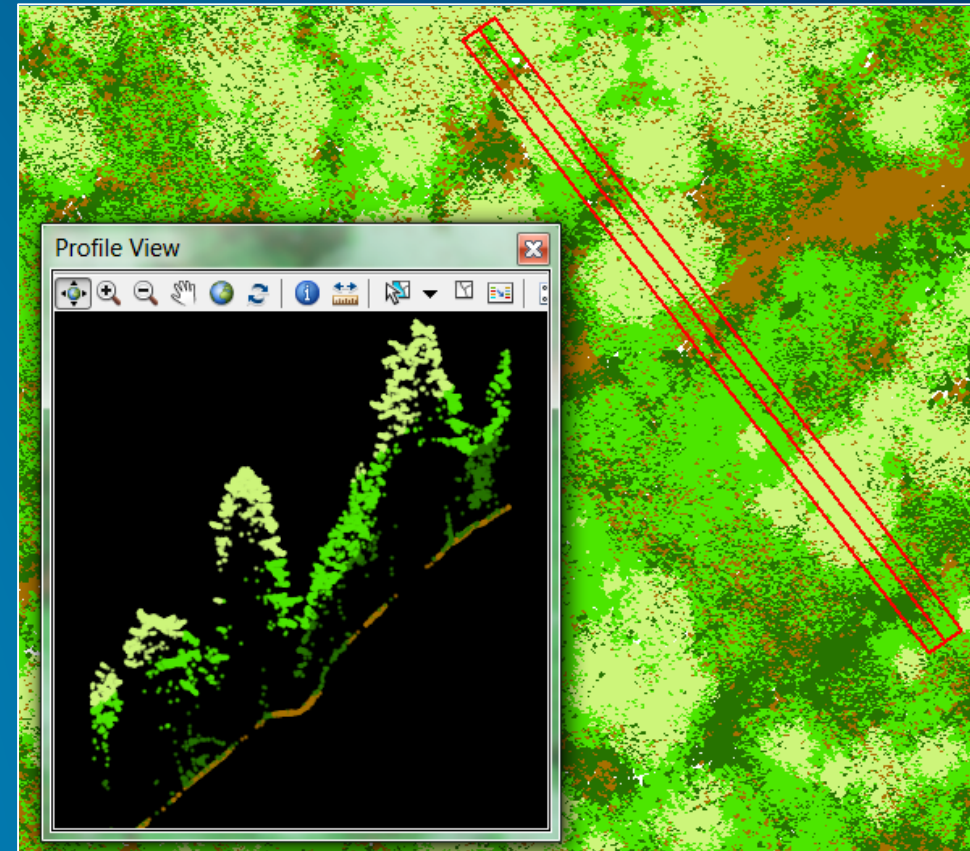
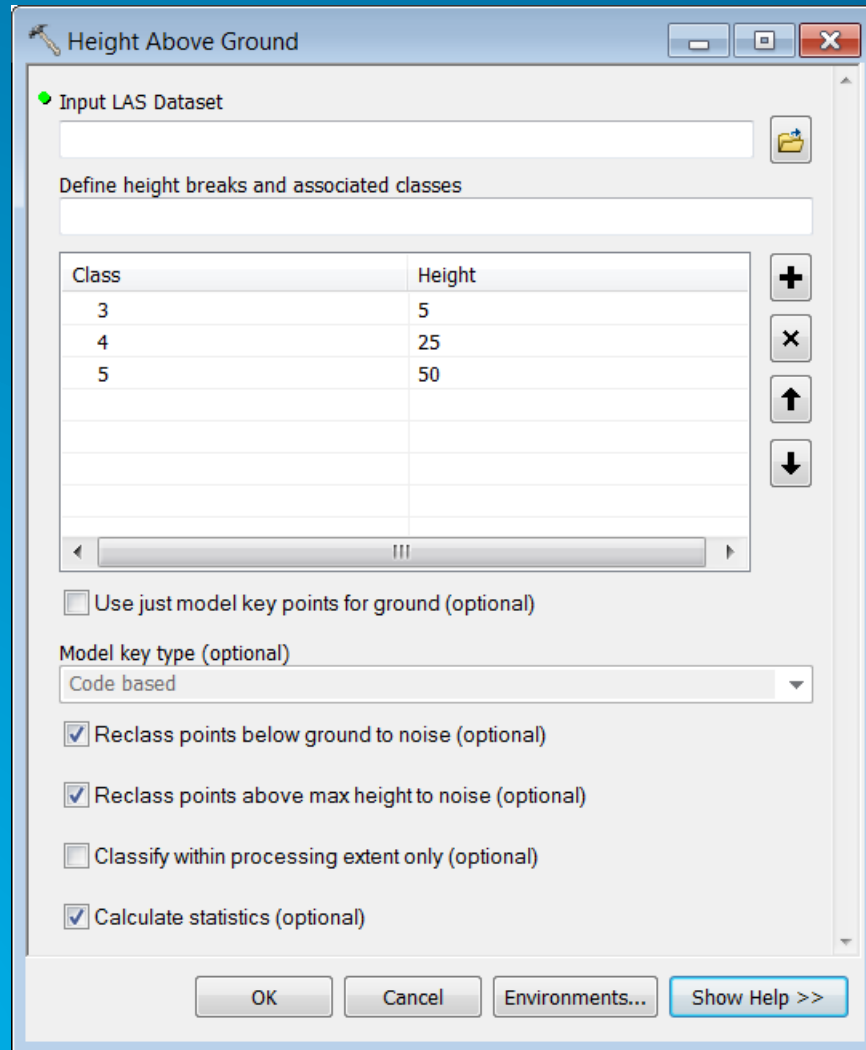
# Lidar Related Analysis Tools



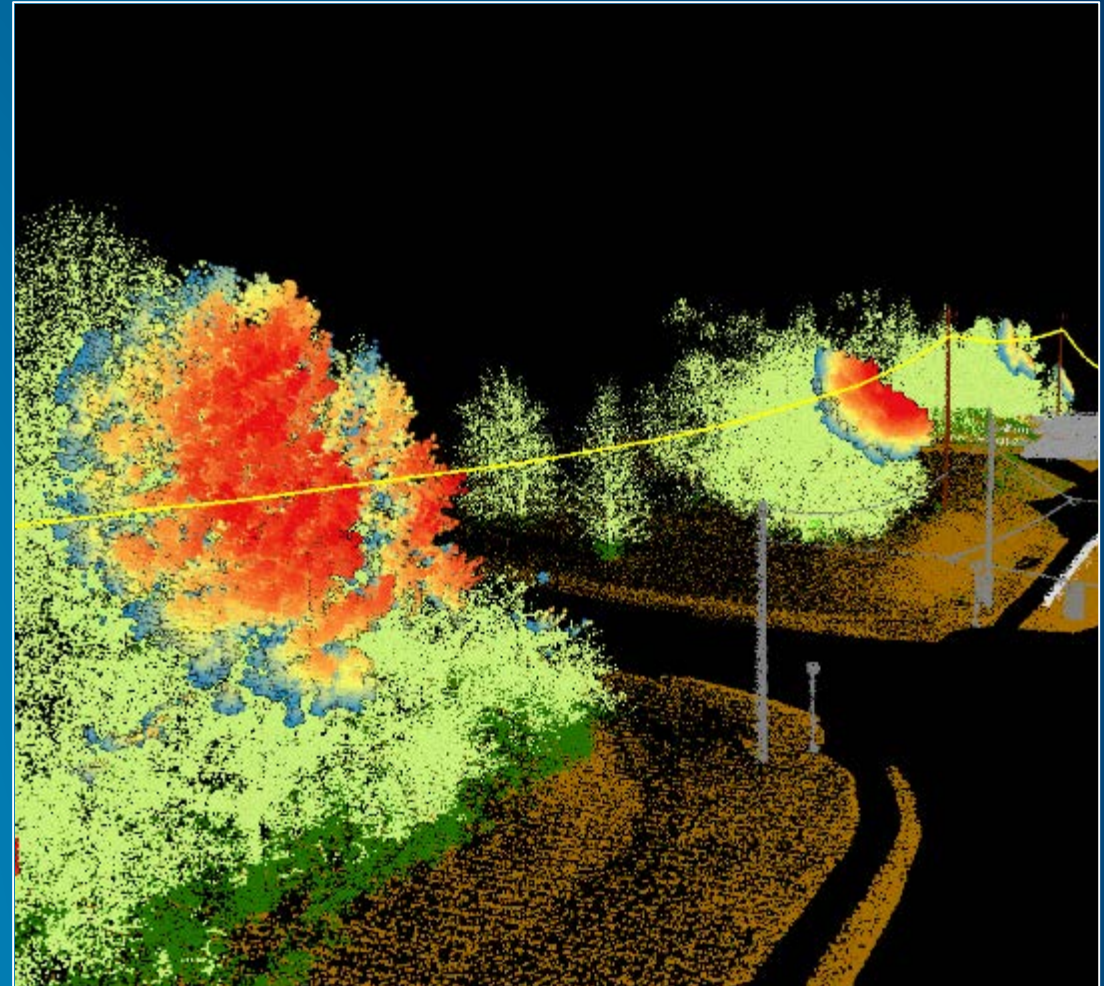
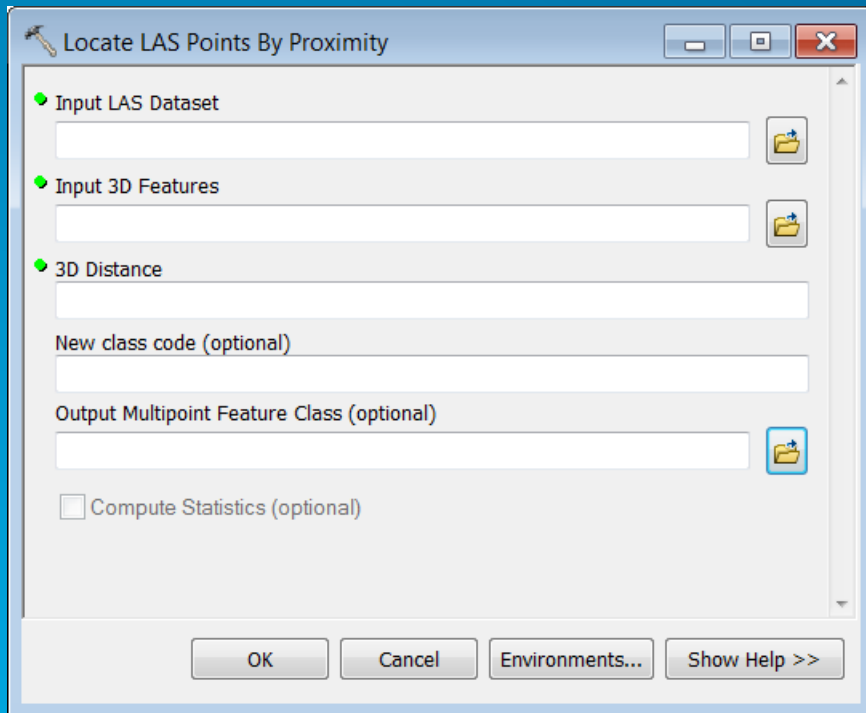
# LAS Point Statistics By Area



# Classify LAS by Height

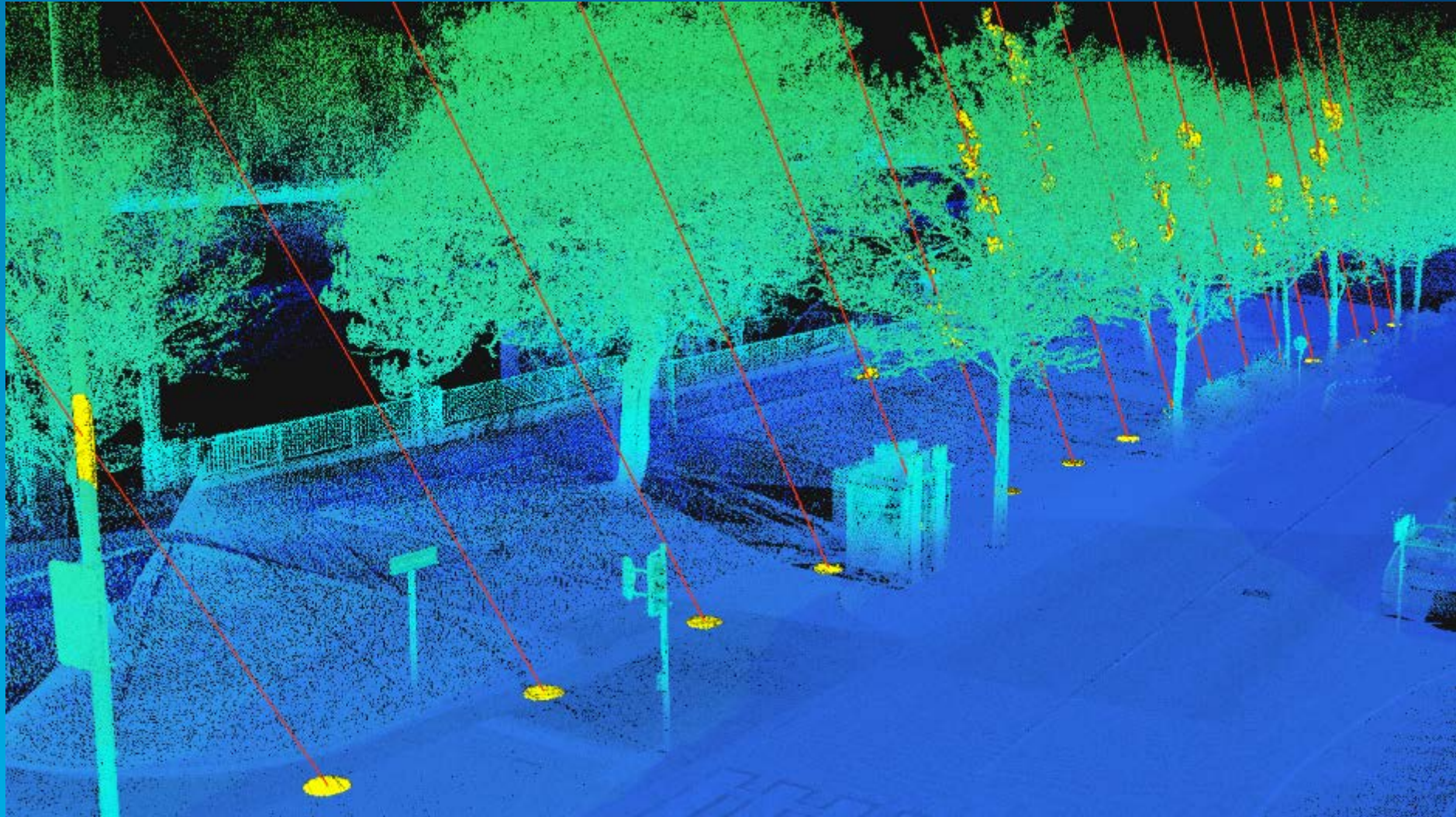


# Locate LAS Points By Proximity

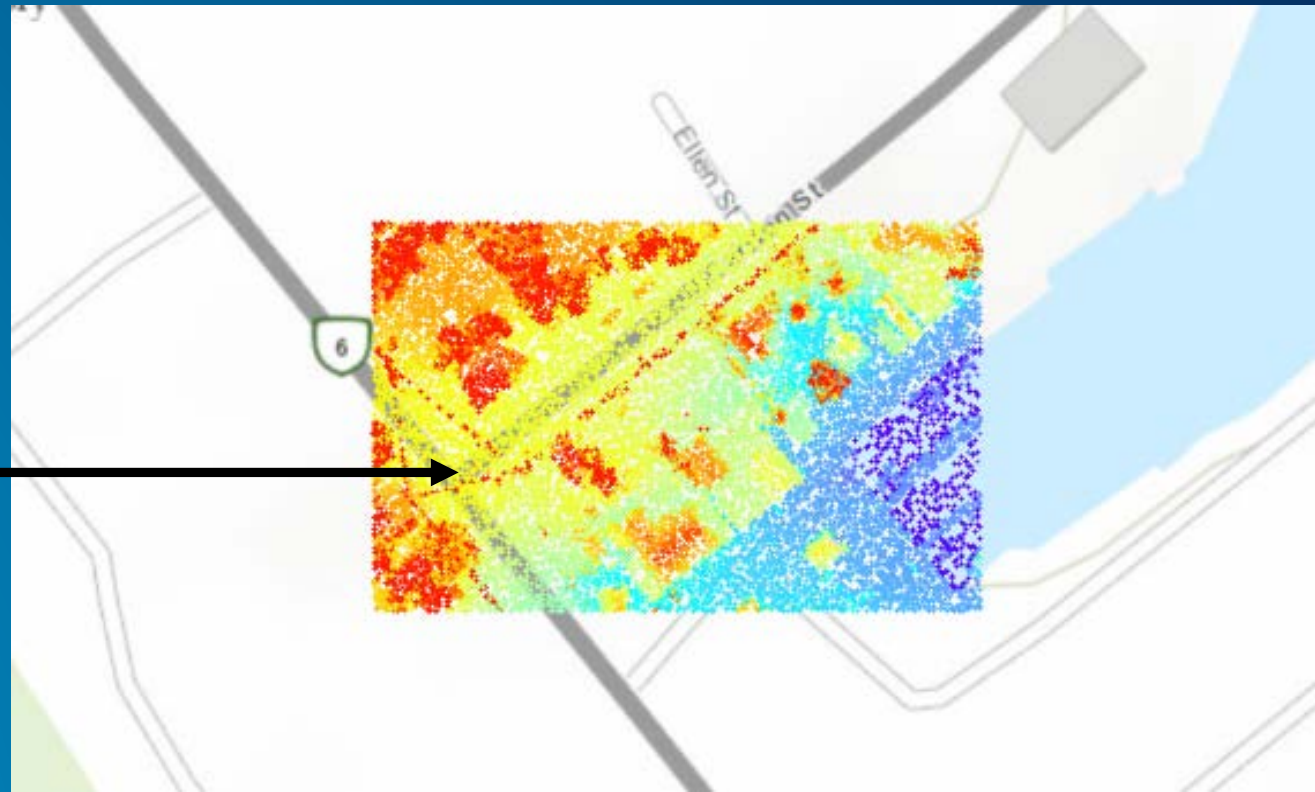
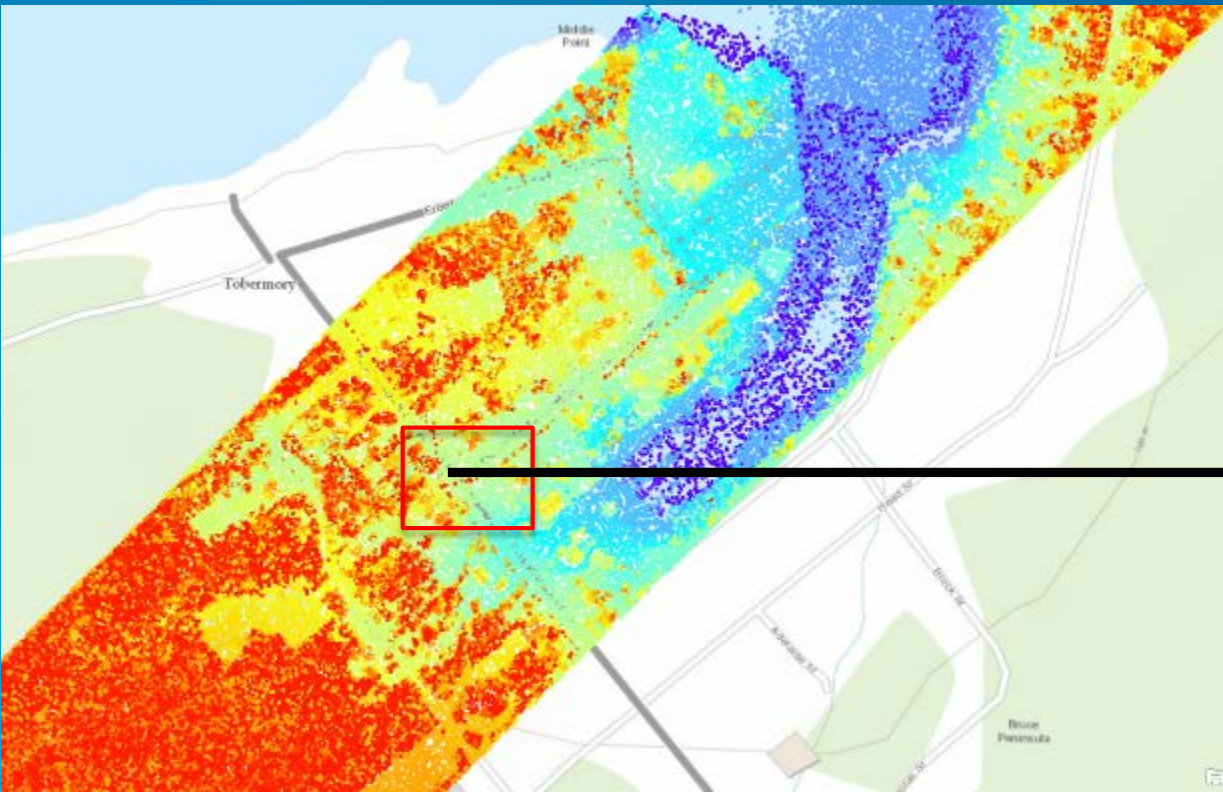


Data courtesy of PhotoScience

## Locate LAS Points By Proximity



# Extract LAS

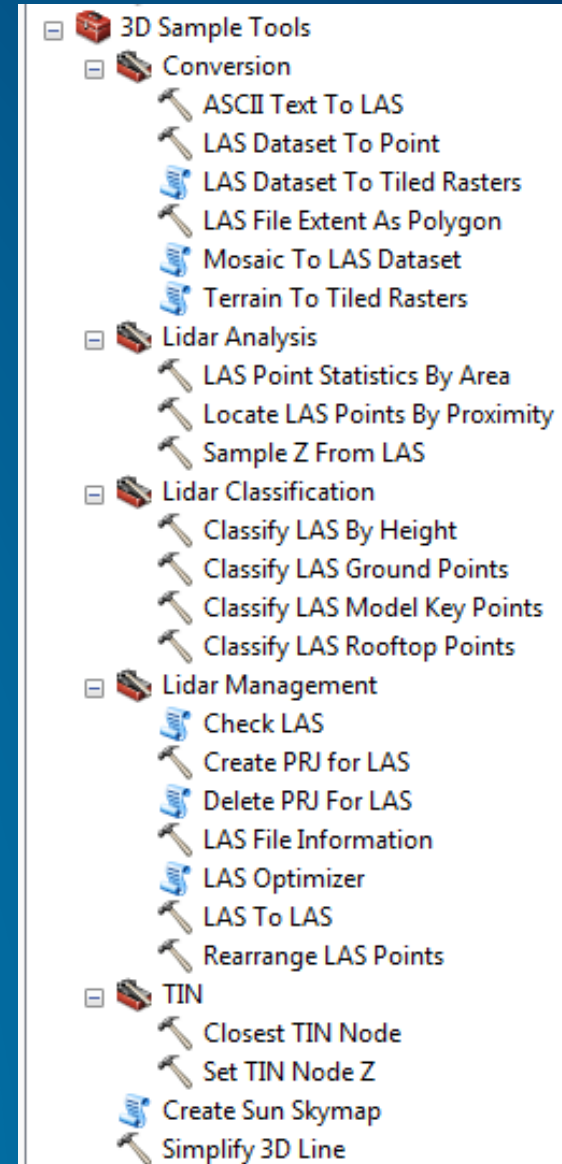


Data courtesy of Optech



# 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

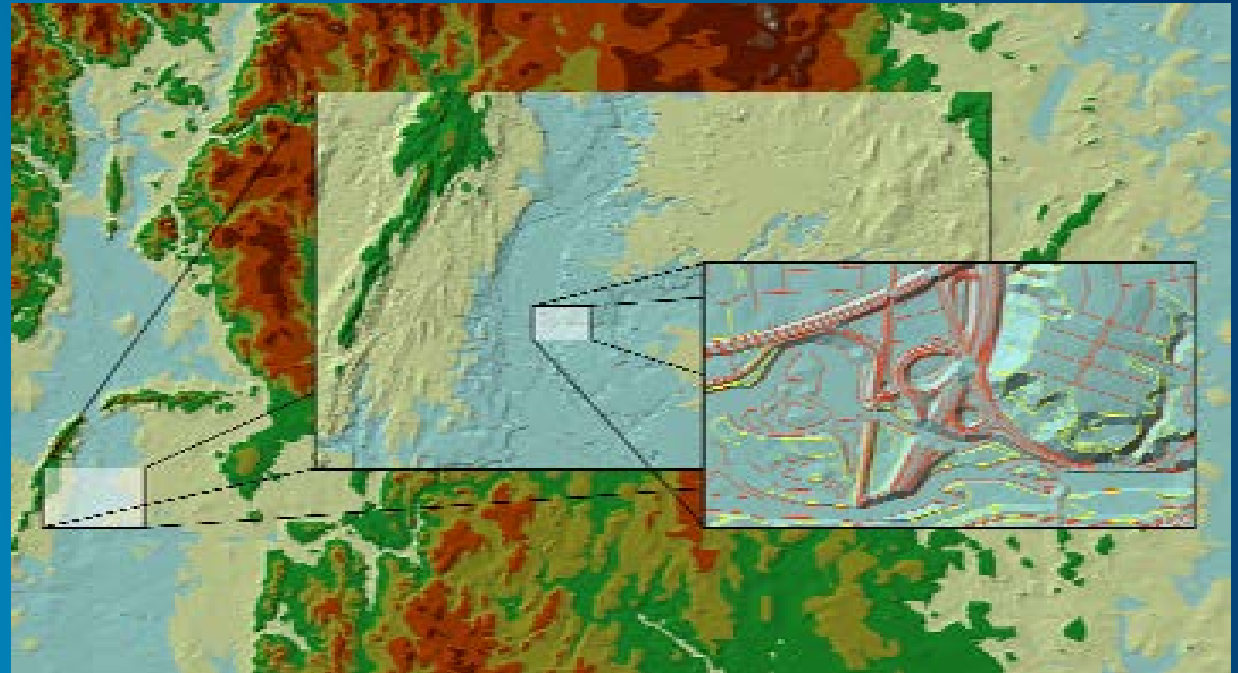
# Terrain dataset

Lindsay Weitz



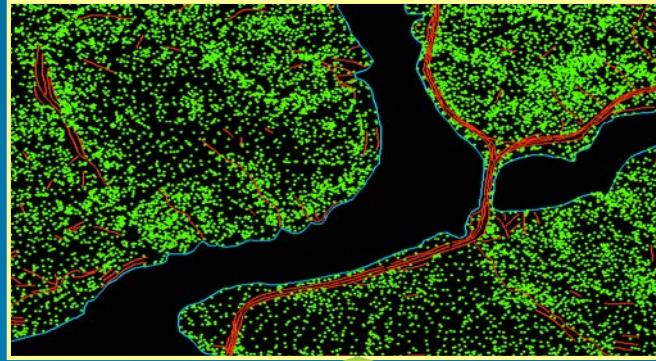
# Managing lidar data in a terrain dataset

- 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

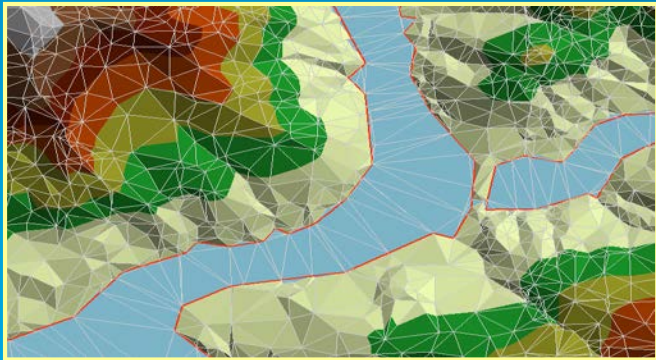


# Multiresolution surface model

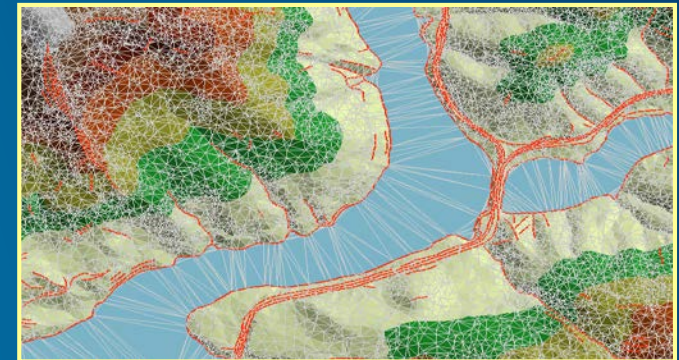
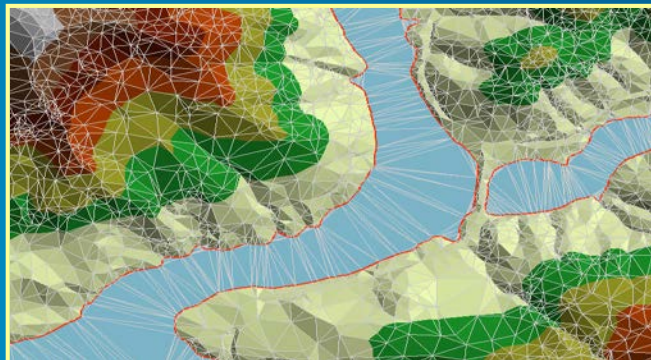
Points and breaklines



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

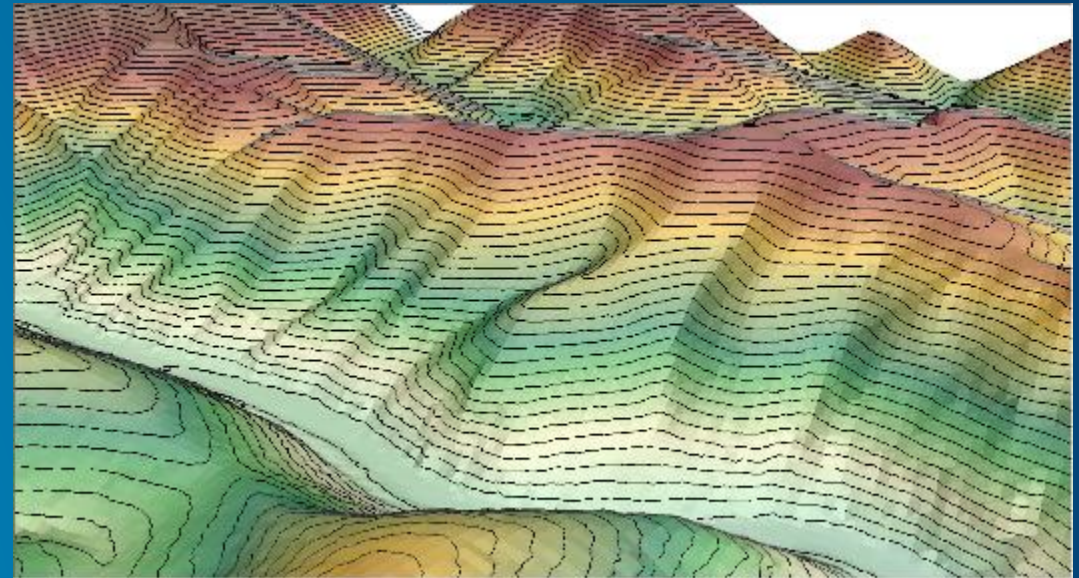
Need surface to live with source data

## Data management

Database tools

Editing/update

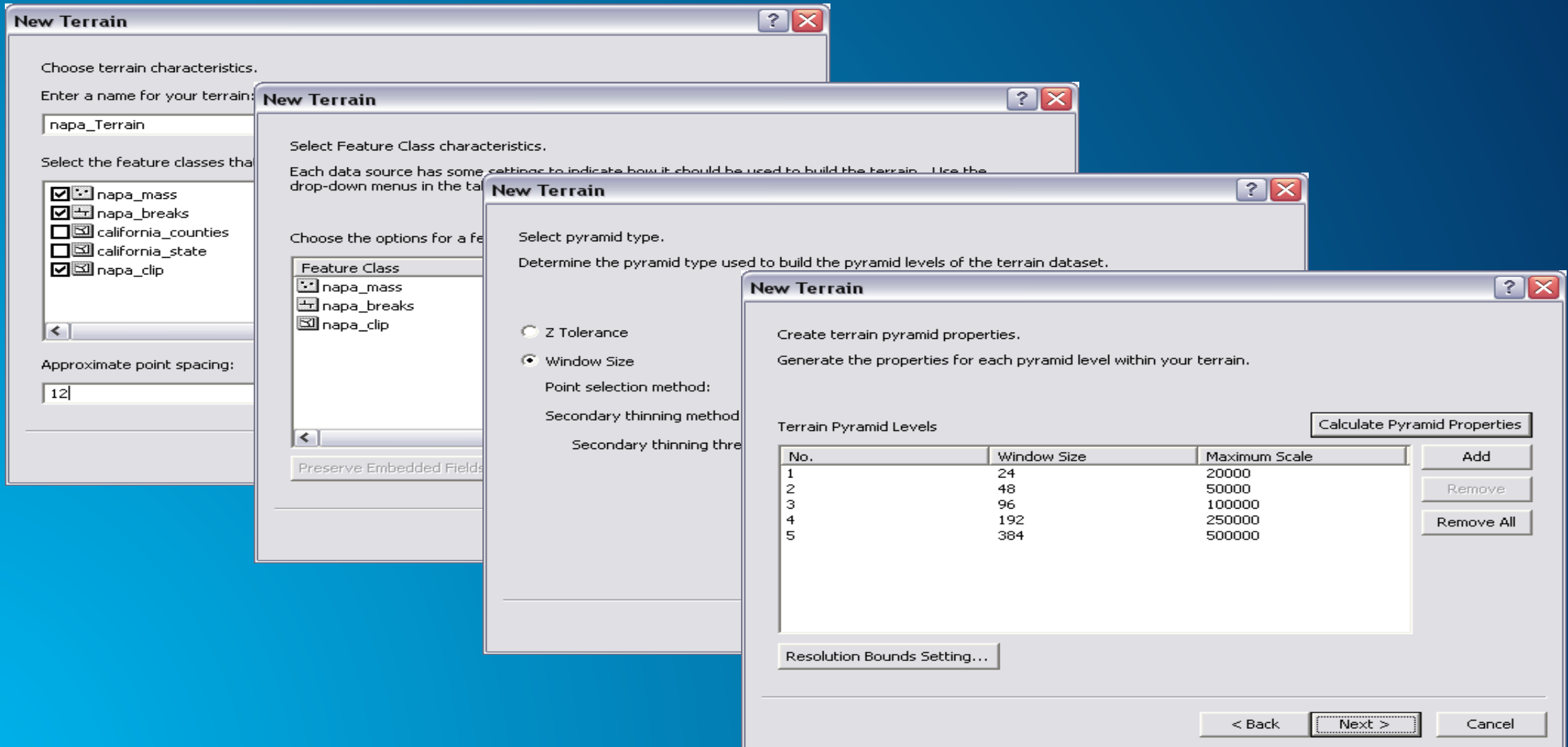
Multi-user



# 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**

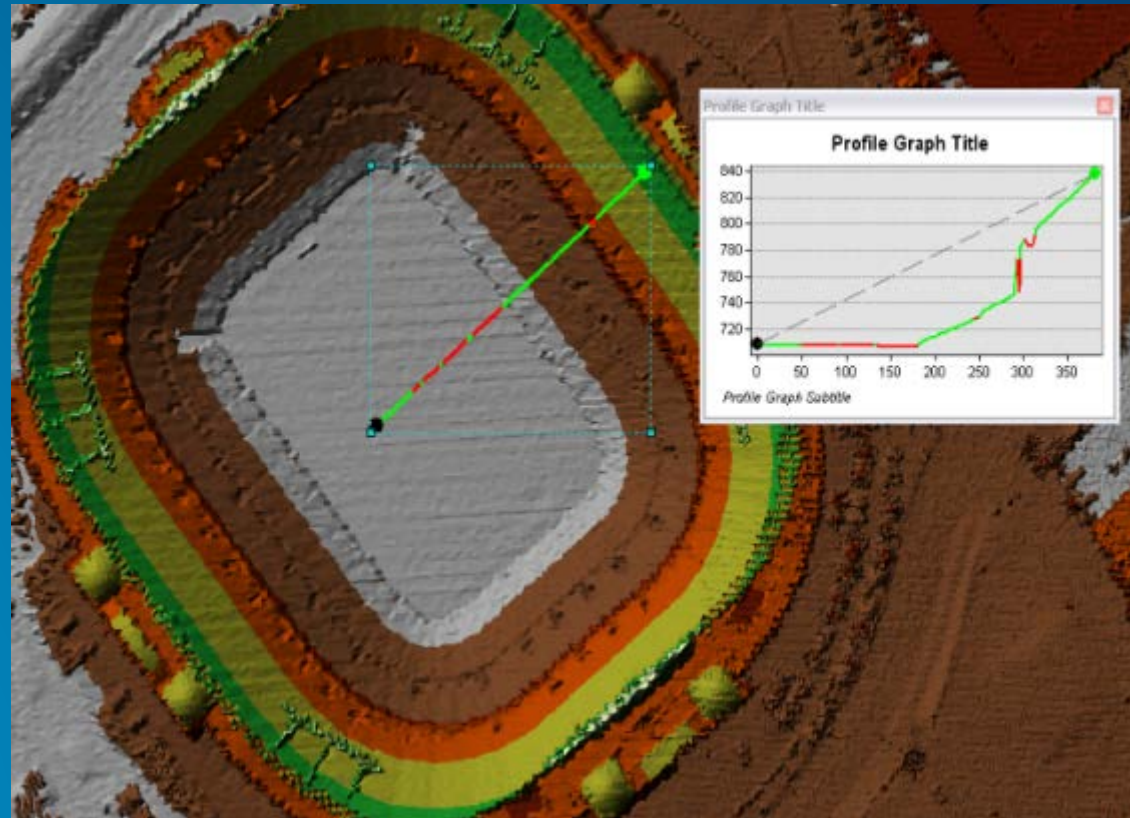
# Creating a terrain dataset





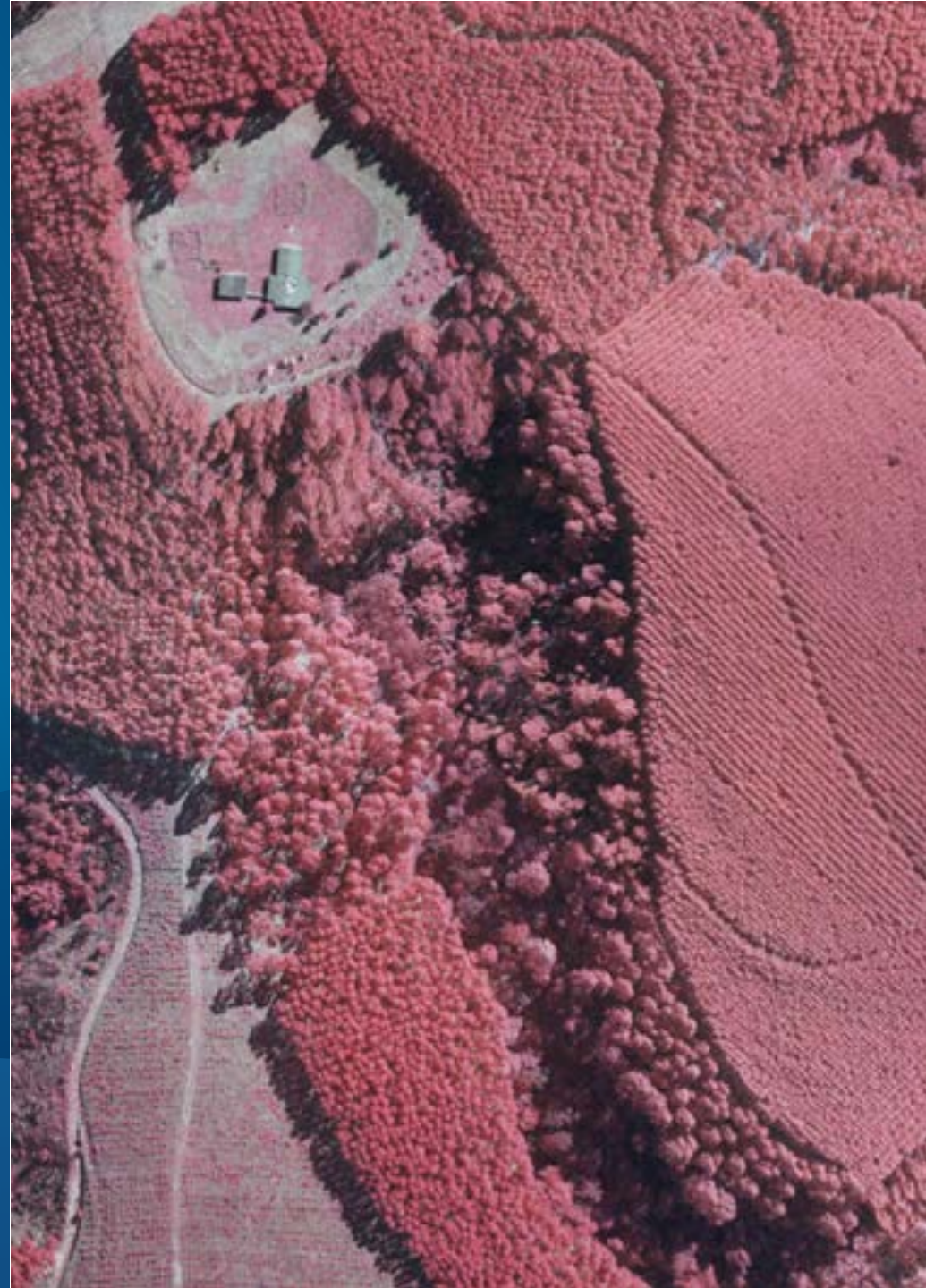
# Analysis capabilities for terrain datasets

- 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

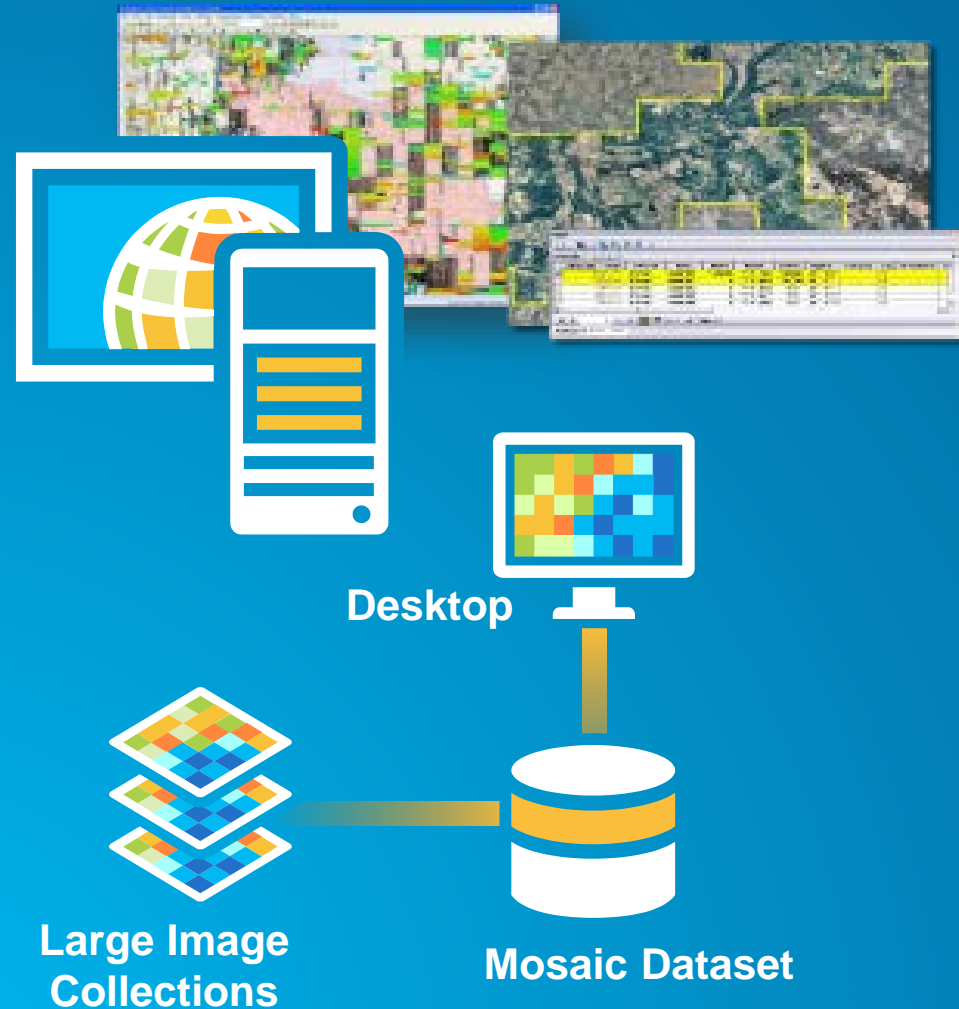


# Introduction / Review

- 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:

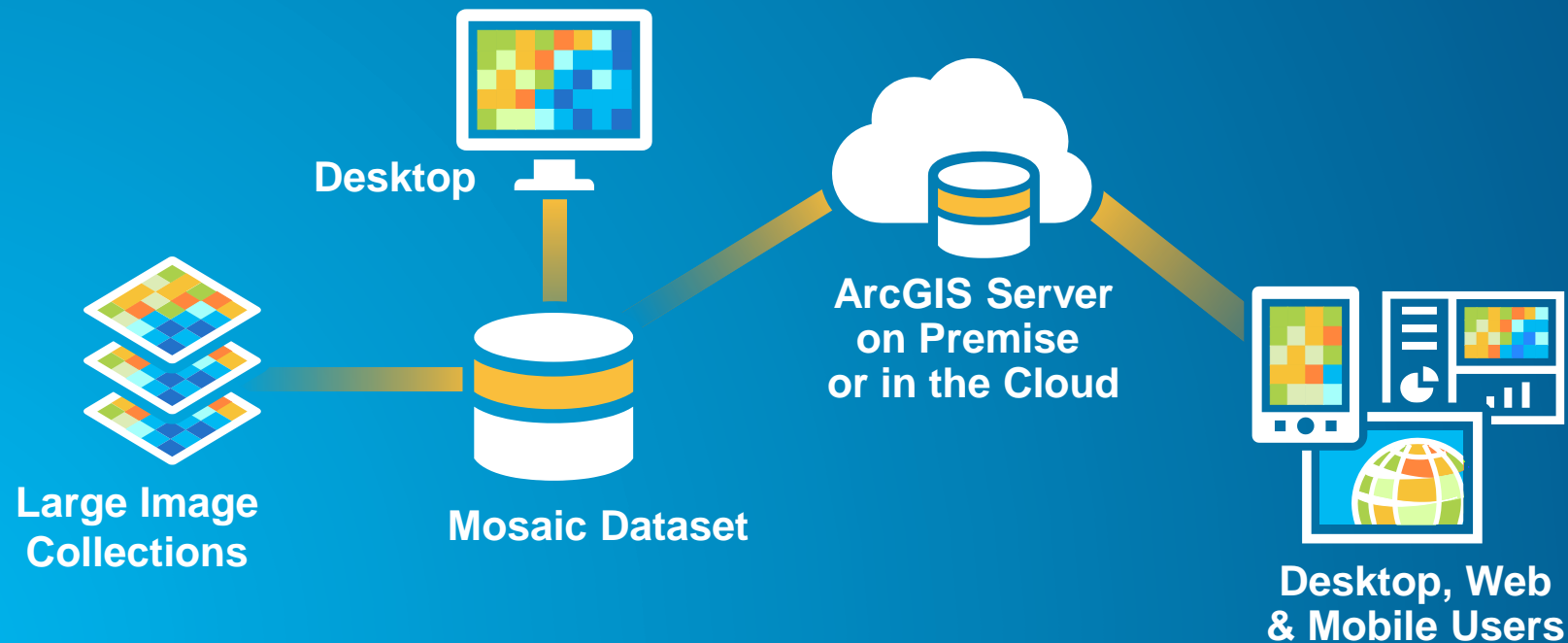
- On-the-fly Processing
- Dynamic Mosaicking

Access as Image or Catalog

# Image Dissemination

Integrating with / and in The Cloud

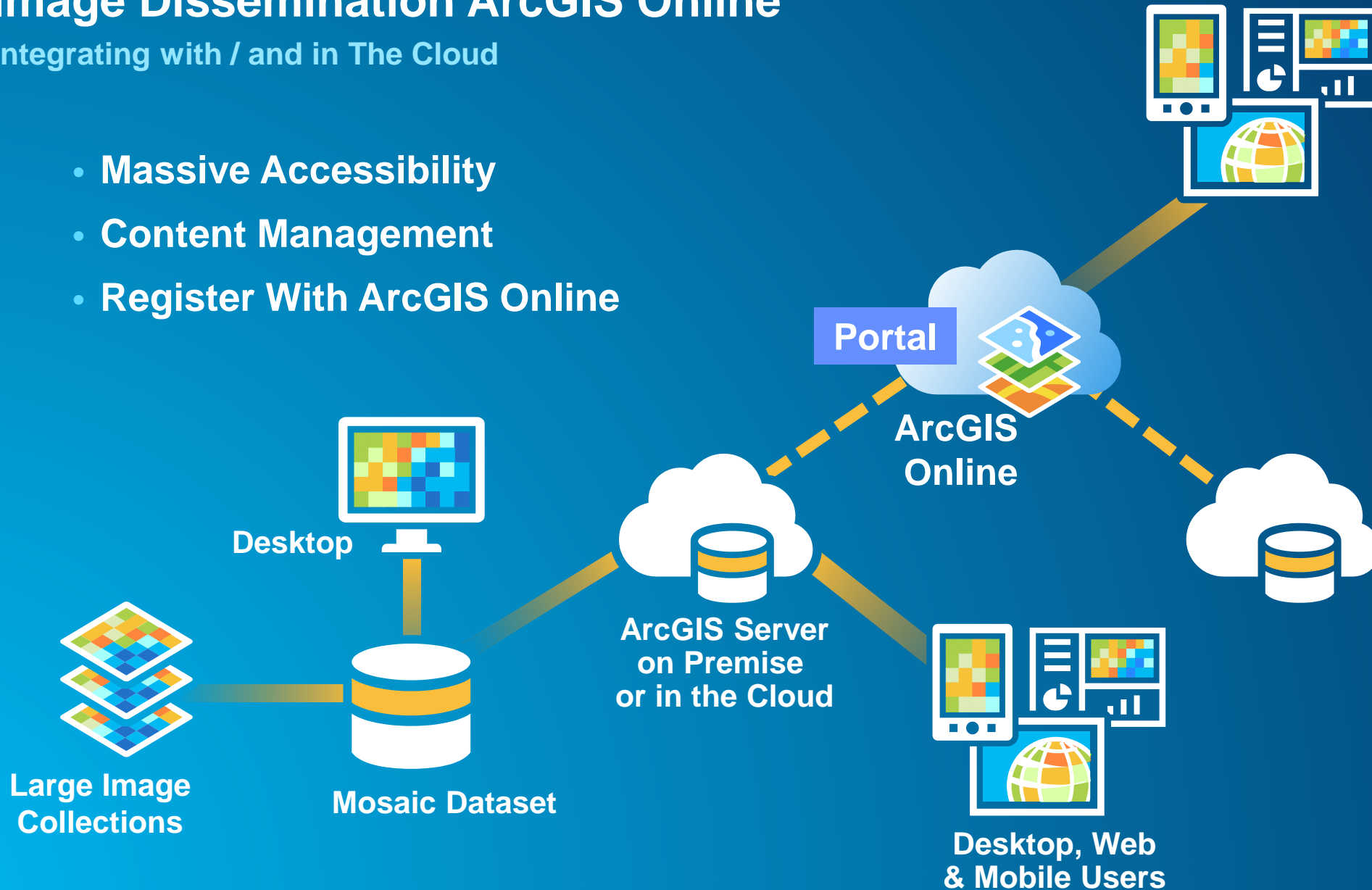
- **Dynamic Image Services**
  - Processing & Analysis
  - Catalog of Metadata
- **Geoprocessing Services**
  - Processing Tasks



# Image Dissemination ArcGIS Online

Integrating with / and in The Cloud

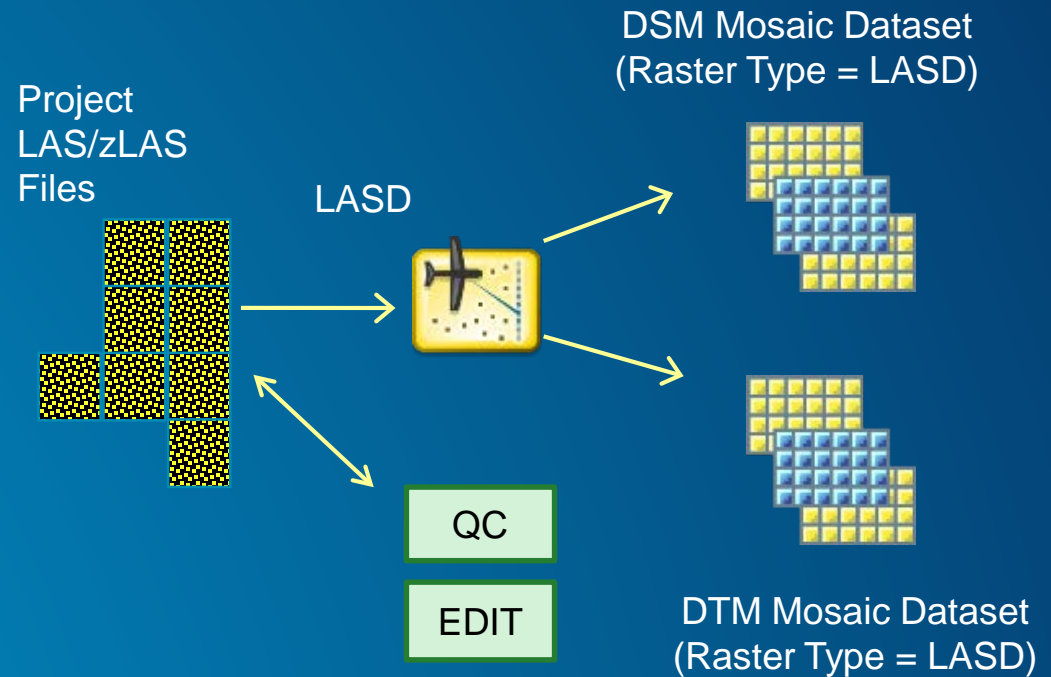
- Massive Accessibility
- Content Management
- Register With ArcGIS Online



# Adding lidar data to a mosaic dataset (Method 1)

- **Advantages**

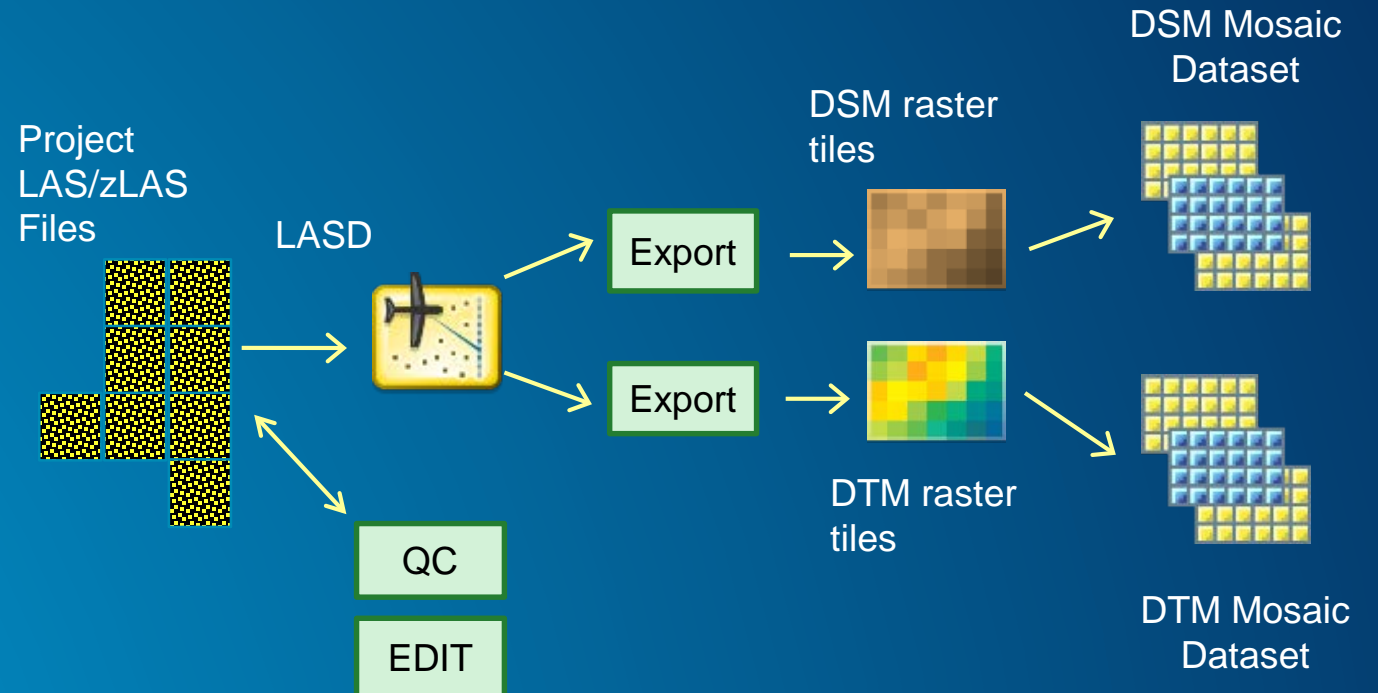
- **Fastest method to begin using & sharing raster surfaces**
- **Filter to create custom surfaces (e.g. buildings & DTM, remove vegetation)**



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

- **Advantages**

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



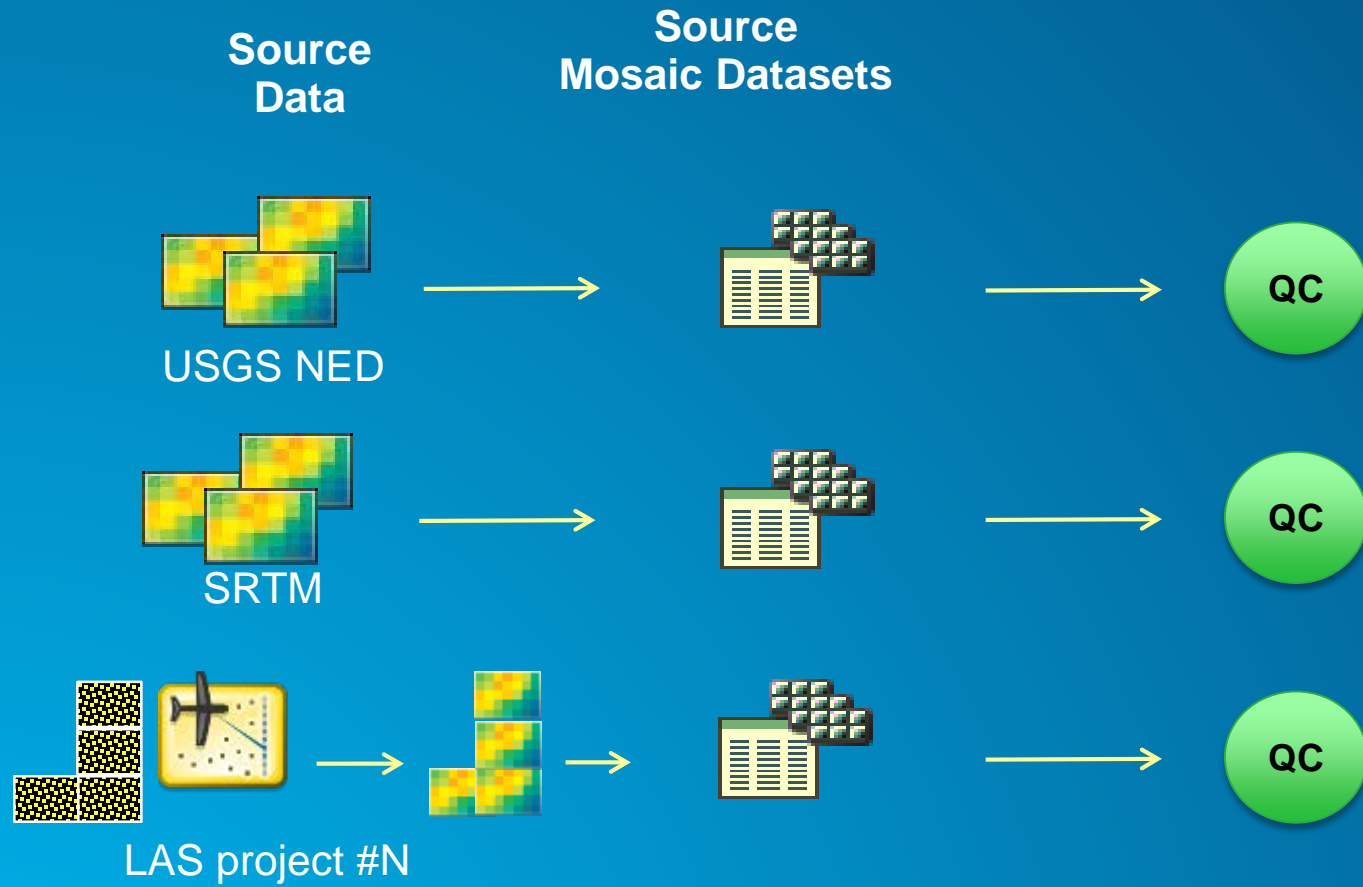


# Lidar data management using Mosaic Datasets

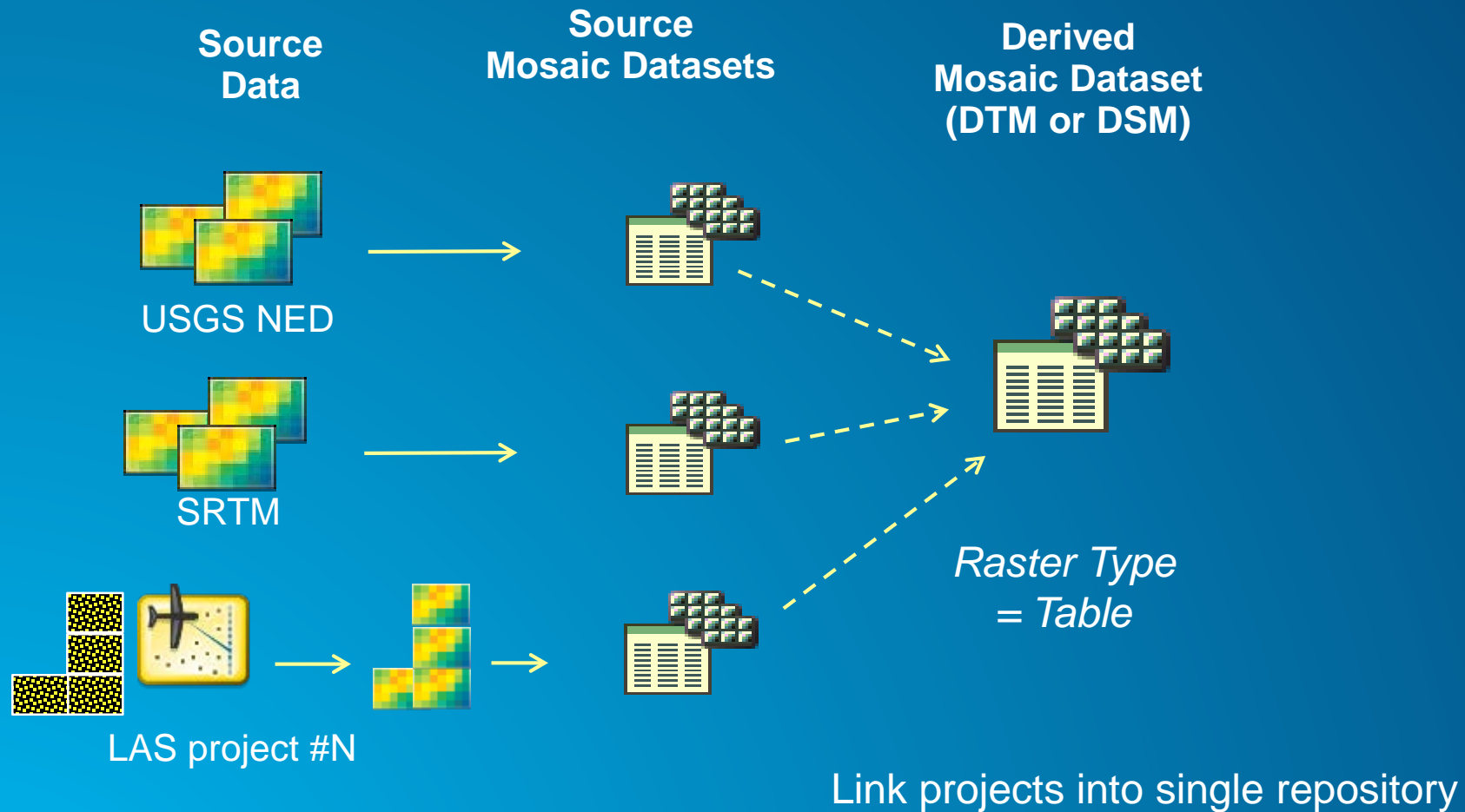
- **Design**
  - **Begin with Elevation data management**
    - In most organizations, DTM & DSM supports the majority of users
  - **Support download for 3D point data users**
- **Build & Maintain**
  - **Automation (see *Image Management Workflows*)**
- **Share**
  - **Within an organization**
  -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

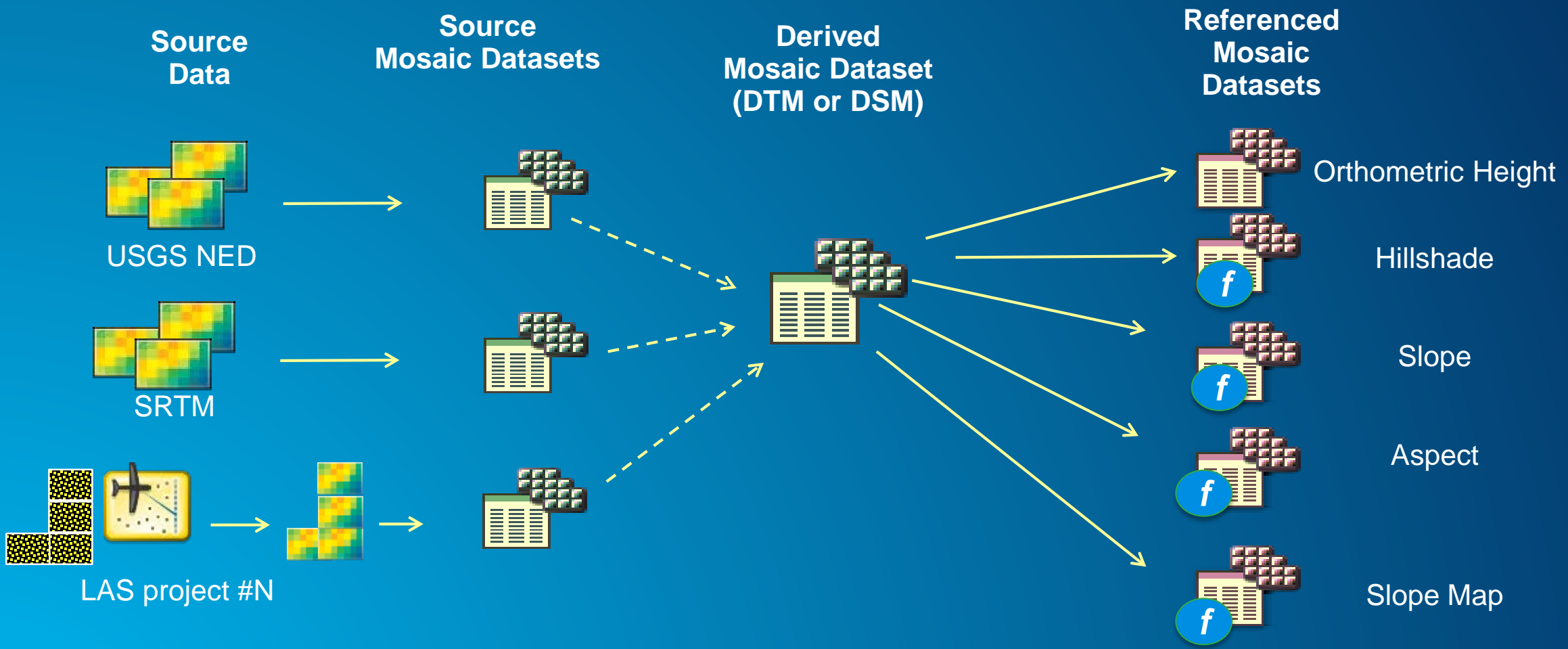
# Elevation data management using Mosaic Datasets

- **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**

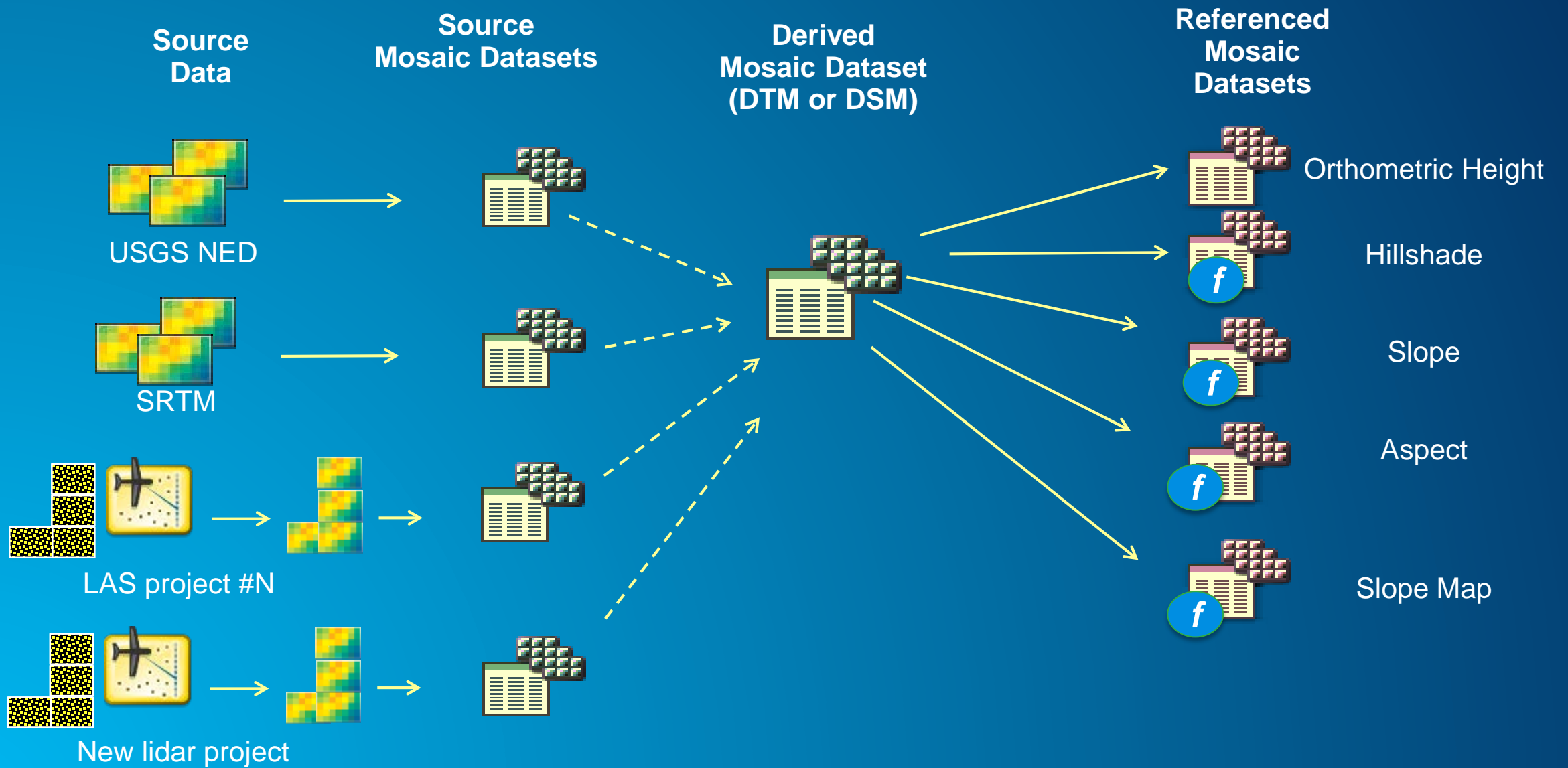


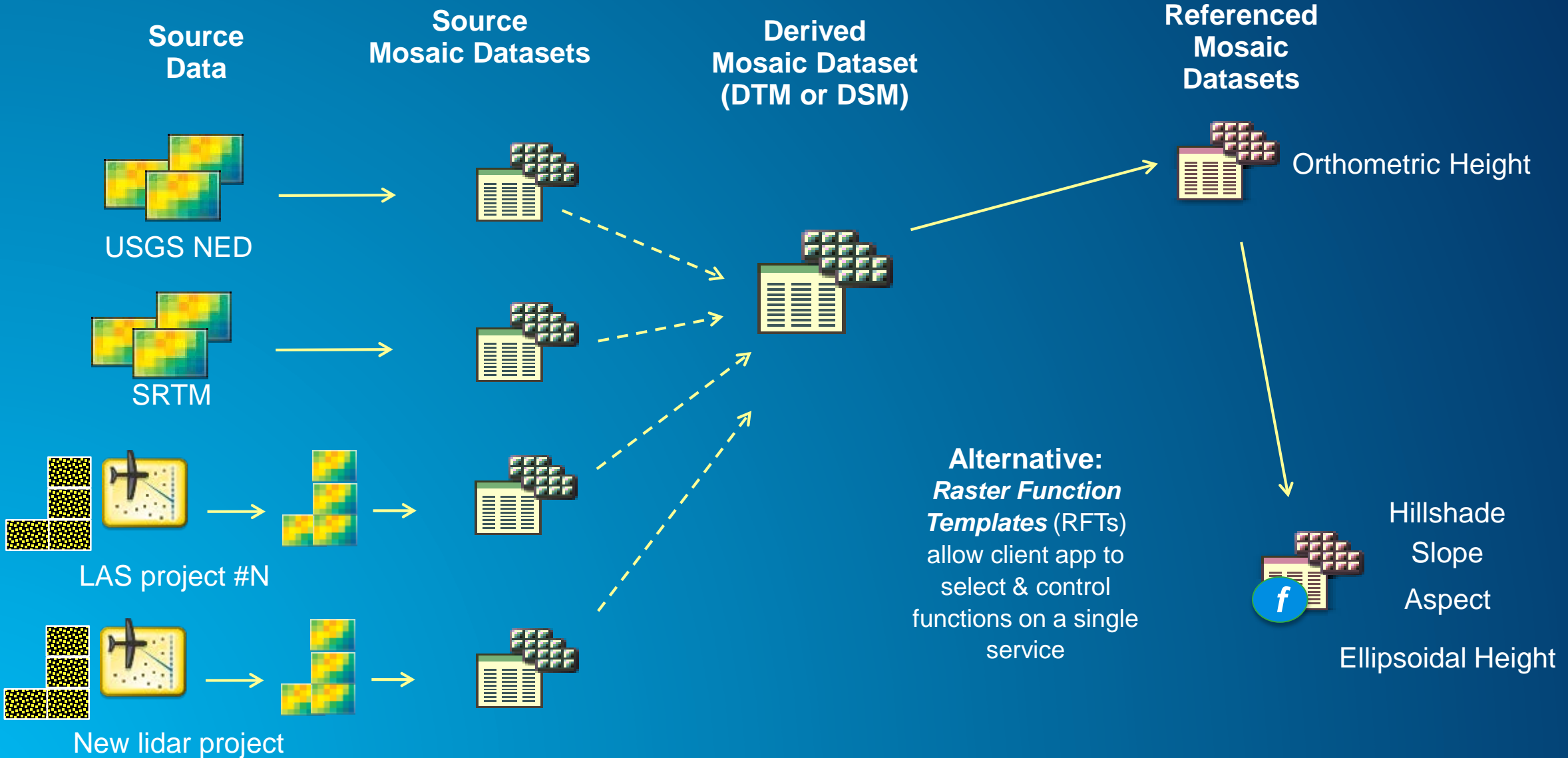
Manage each project separately





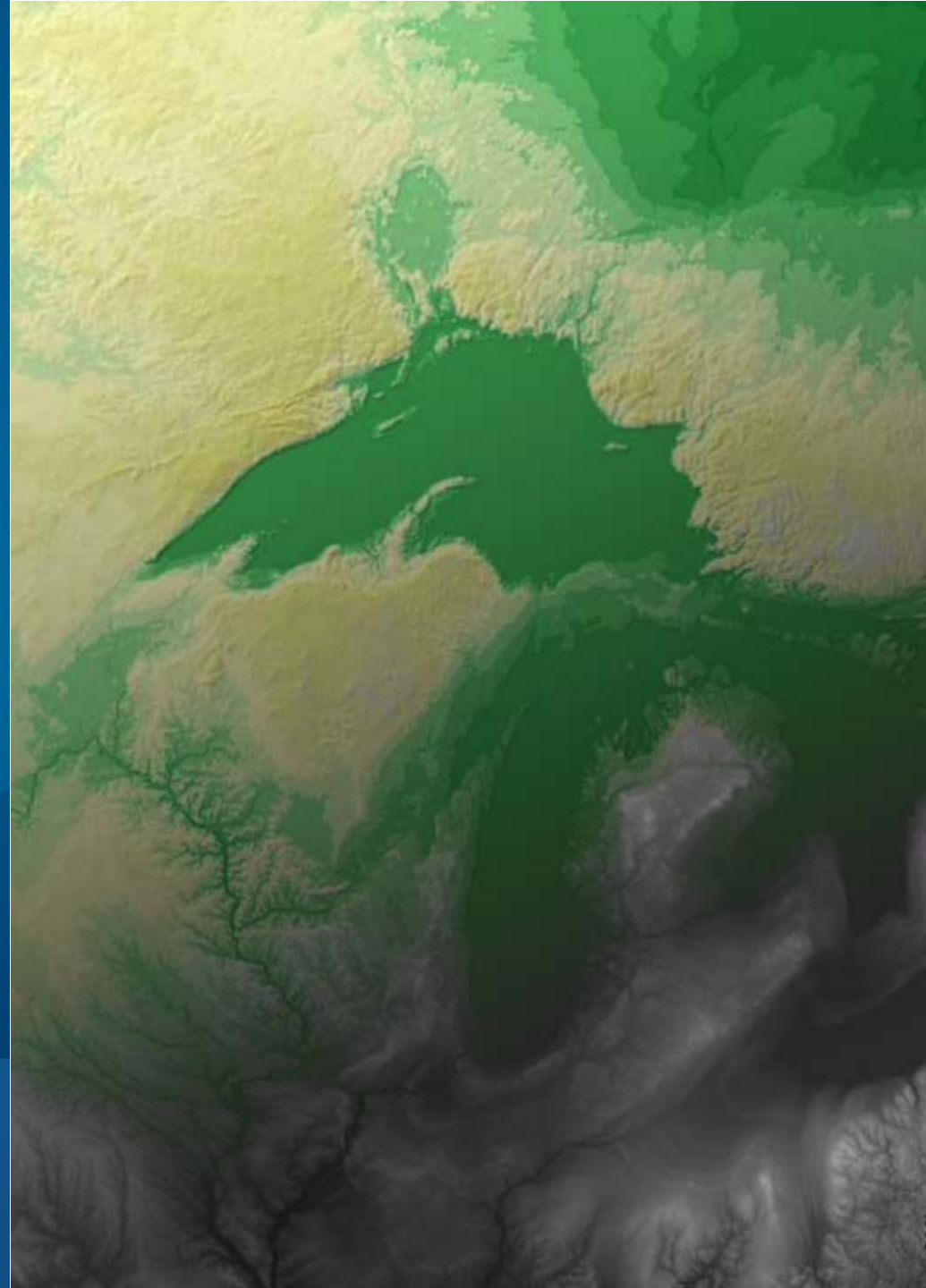
Link projects into single repository





DEMO

# Multiresolution Elevation Data

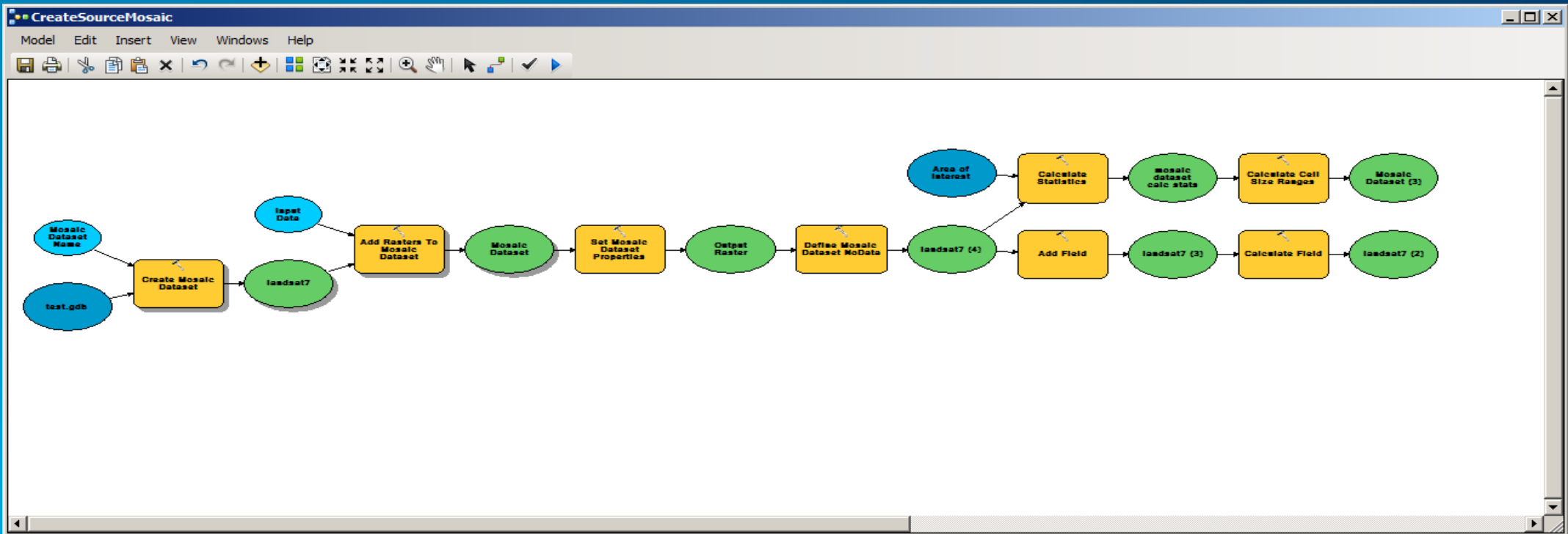




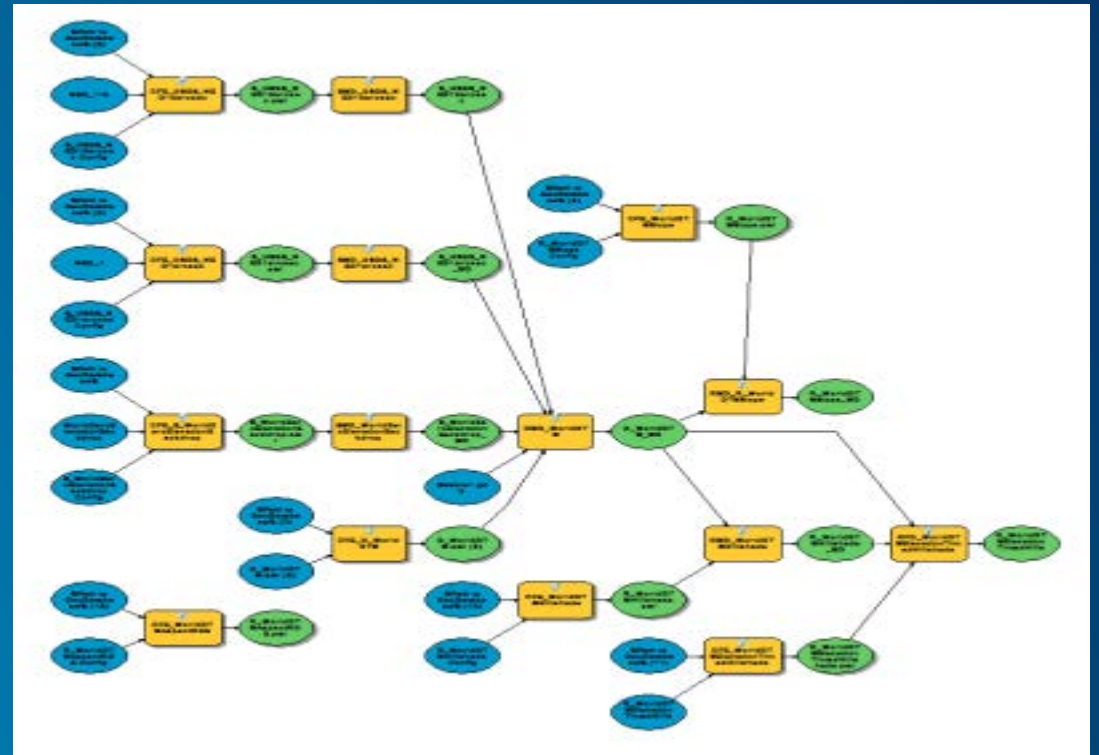
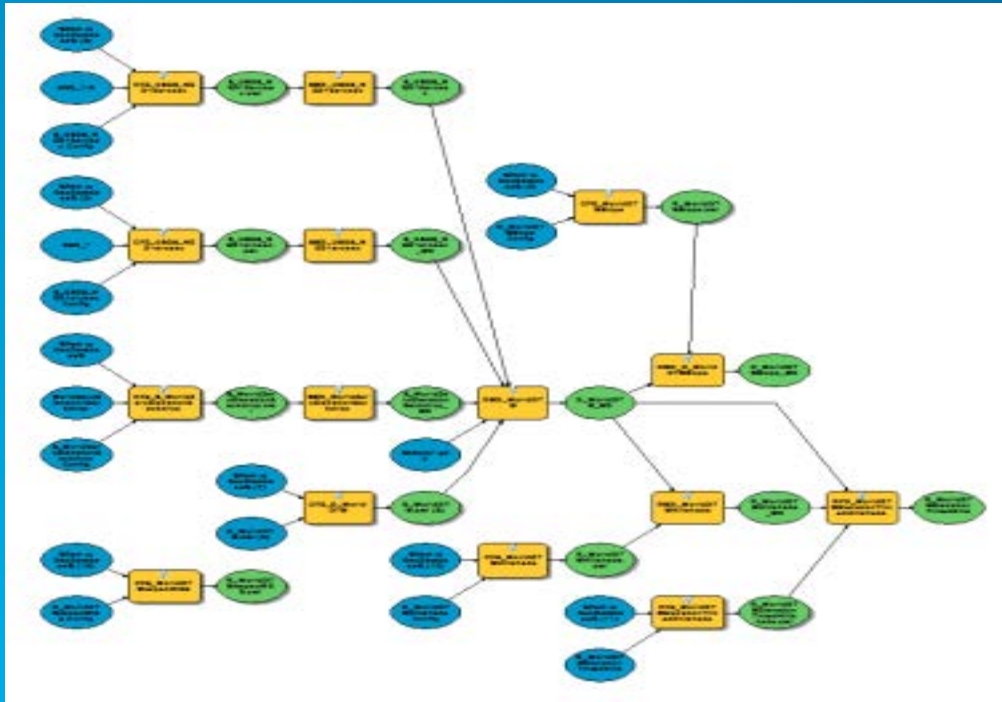
# Advantages/Objectives of Automation

- **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

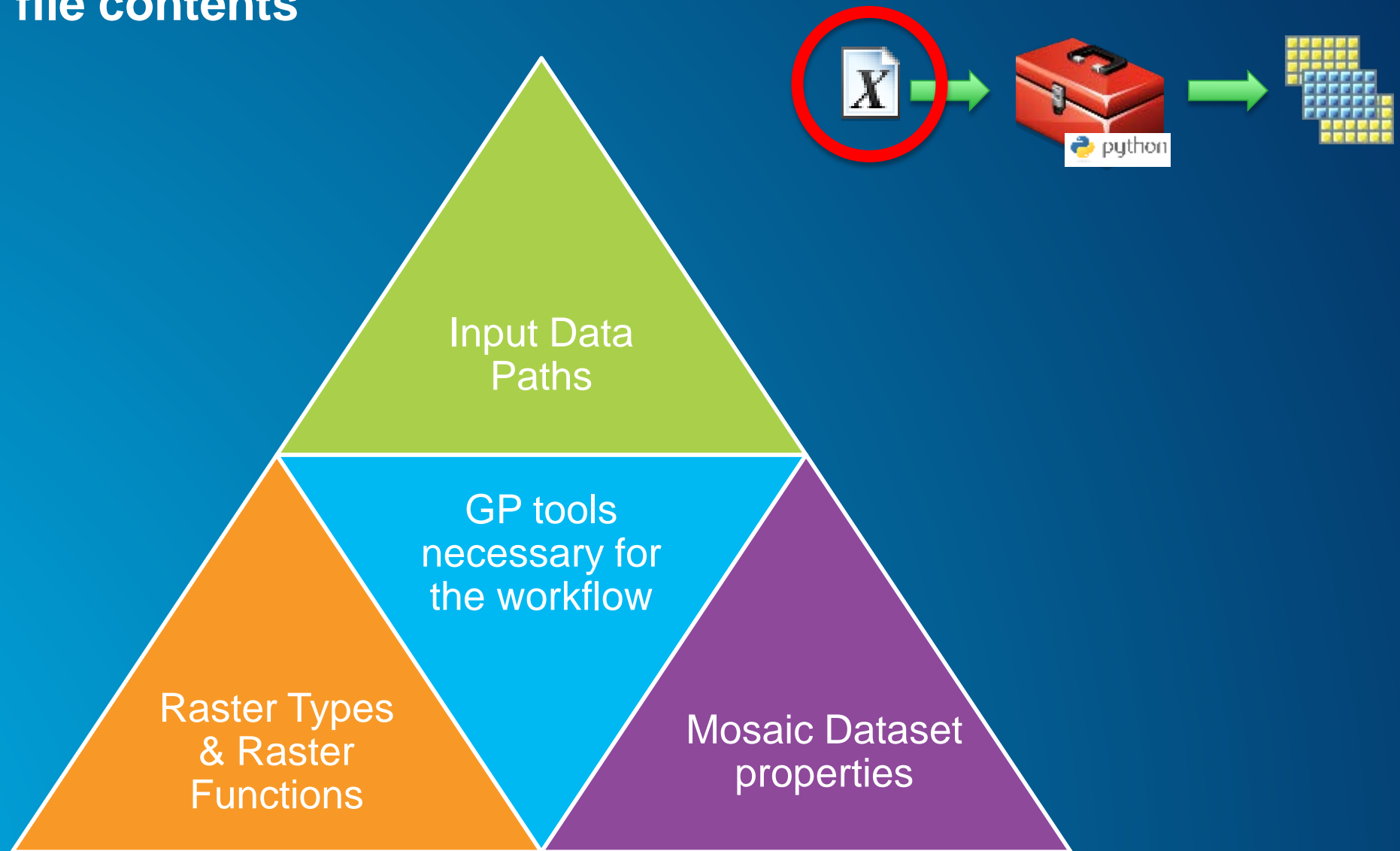


- Also generates detailed log files

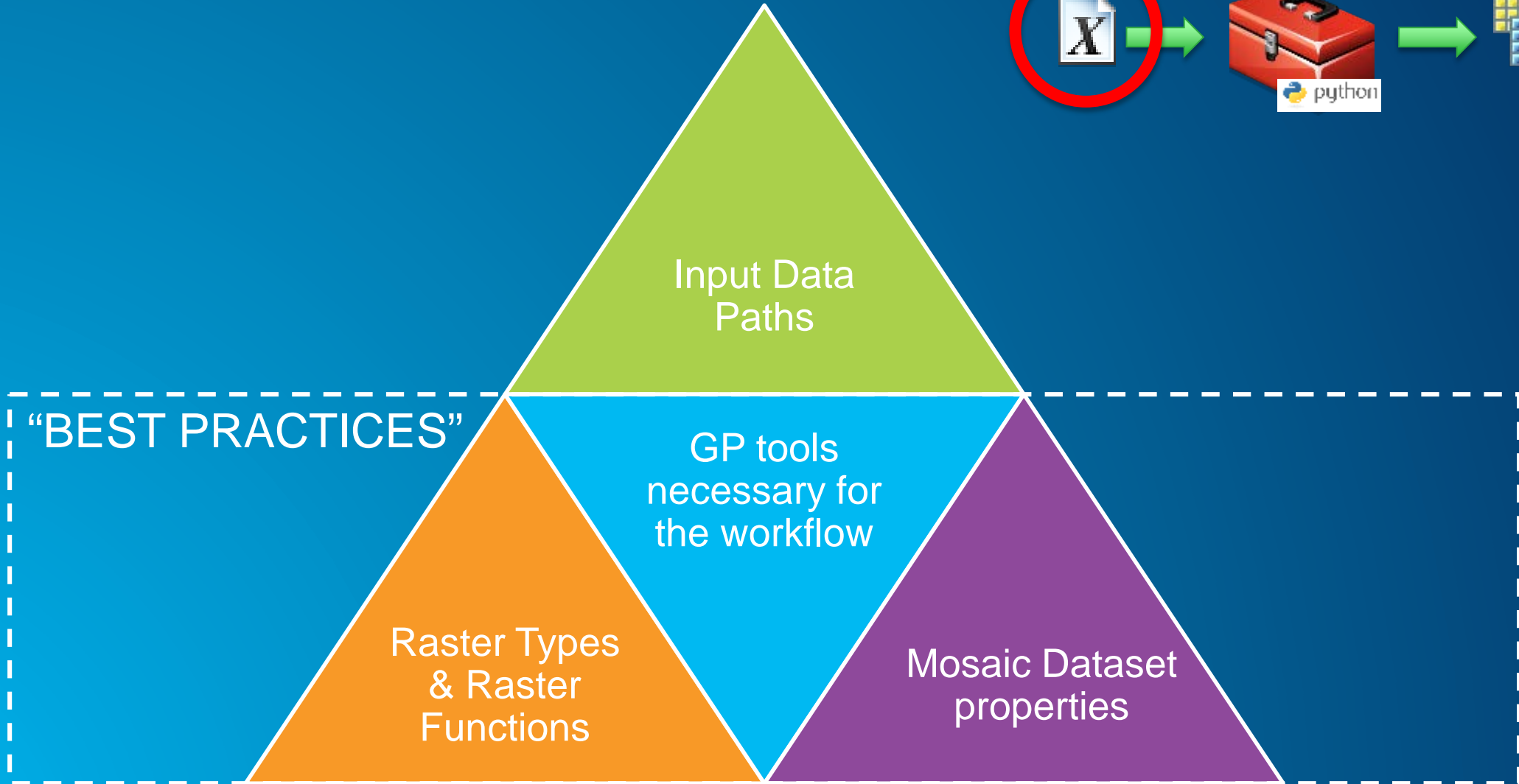
## Advantages of MDCS

- **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



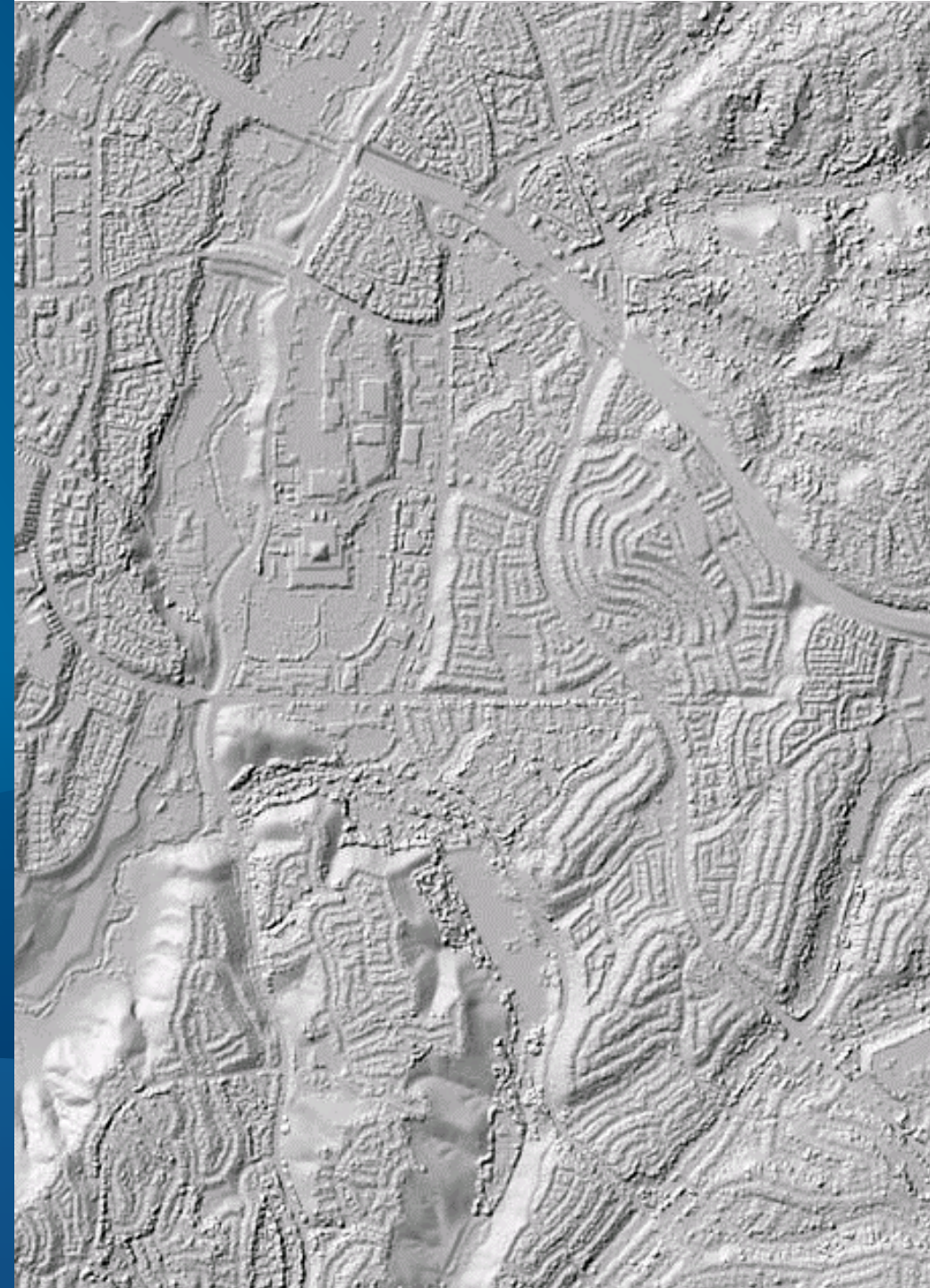
# Configuration file contents



# 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

**Imagery**  
Communities

**ArcGIS: For displaying and analyzing imagery**  
ArcGIS makes displaying and analyzing your imagery and raster data easier at 10.2.  
[Read more](#)

**Quick Links**

**Getting started**

- Imagery tutorial
- Supported formats
- Image management workflows**

**Esri's image services**

- Landsat satellite imagery
- World Elevation

**Getting involved**

- Success stories
- User suggestions and ideas

# Finding MDCS and related resources

...to the Landing page on Resource Center



ArcGIS Resources

ArcGIS Online Sign In English

Home Communities Help Blog Forums Videos Search Imagery

## Image Management Workflows

Communities / Imagery

Manage collections of imagery in ArcGIS using a mosaic dataset.

Share your collections online as image services.

ArcGIS enables you to work with a wide variety of imagery acquired from different sources. These image management workflows provide best practices for managing large collections of imagery to make the imagery quickly and efficiently accessible. The image management workflows are described in the [Image Management Guidebook](#) which begins with a general overview of all aspects related to image management, followed by workflow-specific sections regarding best practices for all workflows listed below.

The following additional components unique to each workflow are referenced below:

- Scripts and associated documentation for the automation of workflows.
- Sample data to be used with the scripts to create sample mosaic datasets and image services.
  - See [this Group](#) on ArcGIS Online for workflow-specific example scripts and data, as well as the underlying **Mosaic Dataset Configuration Script (MDCS)** which is used for all workflows.
- Links to live example services on ArcGIS Online.
- Links to other resources such as Forums, Blogs, and Help system.

Following are the workflows that are currently being documented. If you have questions, please do check out the corresponding FAQs and post questions (and answers) to Forums, and alternatively let our team know by sending email to [ImageManagementWorkflows@esri.com](mailto:ImageManagementWorkflows@esri.com).

### Multispectral Satellite Imagery

This workflow addresses management of imagery from medium (5-30m) and low resolution (>30m) satellites, such as RapidEye, SPOT, Landsat & ASTER. This imagery is commonly used for regional or country-wide assessment and monitoring. Typical applications include agricultural or environmental monitoring. A significant value of images from these satellites are multispectral that support a wide range of applications, which rely on analysis utilizing the different spectral bands. Aspects such as atmospheric correction are of higher importance. By



# Finding MDCS and related resources

## Image Management Guidebook

in ArcGIS Help System for detailed advice

General workflow,  
Elevation workflow,  
& Lidar workflow



The screenshot shows the ArcGIS Resources website. The main heading is "ArcGIS Resources" with navigation links for Home, Communities, Help, Blog, Forums, and Videos. The "Image Management" section is highlighted in green. Below the heading, there is a "Help" link and a list of topics. Two red arrows point to "Elevation data" and "Aerial Lidar Data". The "Aerial Lidar Data" section is expanded, showing a list of sub-topics: Overview, Preparation, Manage lidar collections with LAS datasets, Determine parameters to generate DTM and T, Create derived rasters, Alternatives to create derived rasters, Create mosaic datasets and serve the raster, Share 3D point files for user download, and Build and share geoprocessing services. The main content area on the right contains the "Image Management" title and introductory text.

ArcGIS Resources

Home Communities Help Blog Forums Videos

## Image Management

Help

- Image Management
  - Standard Workflow
  - Elevation data
  - Browse Imagery
  - Preprocessed Orthophotos
  - Aerial Lidar Data
    - Overview
    - Preparation
    - Manage lidar collections with LAS datasets
    - Determine parameters to generate DTM and T
    - Create derived rasters
    - Alternatives to create derived rasters
    - Create mosaic datasets and serve the raster
    - Share 3D point files for user download
    - Build and share geoprocessing services

# ArcGIS Online (AGOL) group

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

**ArcGIS Image Management Workflows**

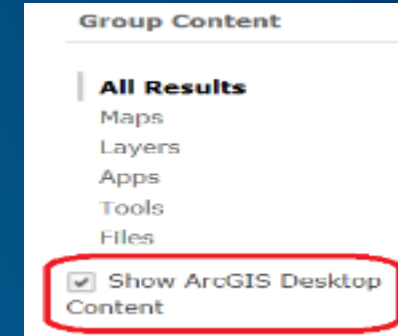
[LEAVE THIS GROUP](#) [SHARE](#)

This group includes resources associated with Esri's "best practices" for managing & serving large collections of data. Resources include sample data and Python scripts, links to documentation, and example image services and web applications. ▼

	Title	Owner	Rating	Views	Date ▼
	ElevationScripts				
	A ZIP archive containing Python scripts & ModelBuilder examples for building a multisource, multiresolution elevation mosaic dataset and multiple ancillary products (Hillshade, Slope, and others).				
	Code Sample by ImageryWorkflowsTeam				
	Last Modified: January 6, 2014				
	★★★★★ (0 ratings, 0 comments, 1 download)				
	Elevation Sample Data Download				
	This is a ZIP archive containing public domain elevation data. This data is used by the sample scripts in this group for building a multi-source & multi-resolution mosaic dataset and numerous ancillary products (e.g. hillshade, slope, aspect, more).				
	Geoprocessing Sample by ImageryWorkflowsTeam				

## 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](mailto:cbenkelman@esri.com)
  - Lindsay Weitz      [lweitz@esri.com](mailto:lweitz@esri.com)





Understanding our world.