Using Remotely Sensed Data and ArcGIS to Automate and Improve Census Bureau Geographic Update Activities

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No Title 13 data in this presentation

Goals & Benefits

- To improve data quality for the U.S. Decennial Census and survey operations.
 - Validate existing collection of housing units and roads (MAF/TIGER).
 - Detect change (new roads/buildings) to identify areas for more intensive study.
- Reduce the amount of in-field work needed, focus on-going update work.



Block Assessment Research and Classification Application (BARCA)

- An in-office data review system using visual inspection of high resolution imagery to identify Census blocks in need of update
- Estimated that BARCA will be able to identify around 75% of the blocks needing active updating



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BARCA Interface





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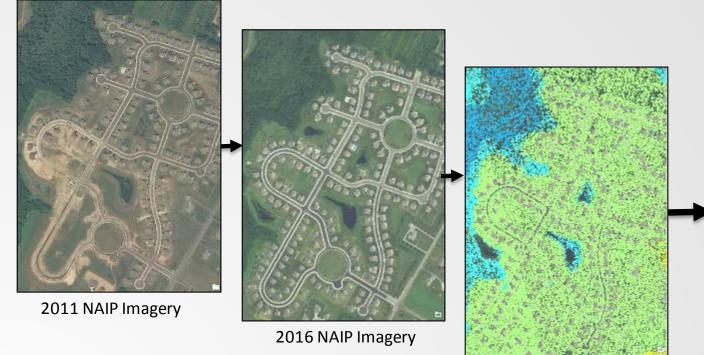
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Interactive Review Automation

• Create a Geoprocessing tool that will utilize a combination of aerial imagery, LiDAR, and existing Census GIS data to identify Census blocks that have experienced change in the built environment since the last update and prioritize the blocks by amount and type of change for editing by a human analyst.



Imagery + LiDAR = Buildings



2016 LiDAR Point Cloud

New Building Footprints





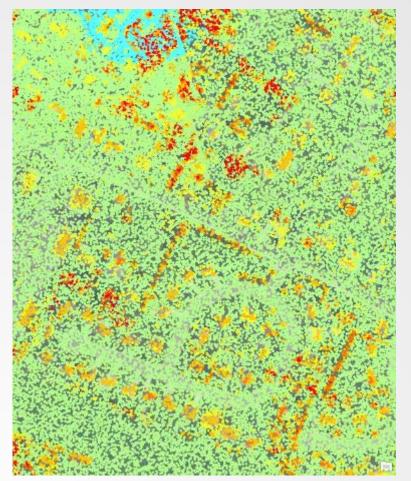
Python Processing Flow

CHANGE DETECTION PROCESS Arthur Desch | October 23, 2016 Threshold each Image Combine Represents Change since Select County to NDIV image into Service 2010 updates NOVITI Process 2 classes: queried for Vegetation and NOVITE Raster layer with 2 NDVI layers Built-up within extent Boundary classes: 1) Built area NOVI TE gains, 2) Built area Clean losses Census blocks image within County fost recent, Service Reclass boundary sorted NDVI raster Segment queried for in descending Mean Shift layer most recent RGB order by area. **RGB** image **Process blocks** within extent Mergered sequntially. Zonal NDVI/segment layer Statistics reclassed to Built-up and Vegetation Expand Built-up Extent of largest Threshold all ground unprocessed LIDAR Point points to '1' all other block buffered to frocessed LAS Dataset -**Cloud filtered to** Null include 3 Census Yes-r include only **LIDAR** point Shrink **Building layer** unprocessed ocks' 'Ground' points cloud neighboring Ground Layer removed from blocks and Built-up Built-up layer Raster layer layer merged to Smoothed create Building representing Ground' raste LASToRaster LIDAR ground layer layer points. Query for No Housing Unit points and Road Geodatabase Spatial Join Buildings Expand polylines **Housing Unit** within extent Points Misaligned features ID'd Geodatabase Spatial Join Shrink Roads **Road Polylines** End Misaligned features ID'd Built environment **Census Block** Product gains and Geodatabase losses



Processing Inputs

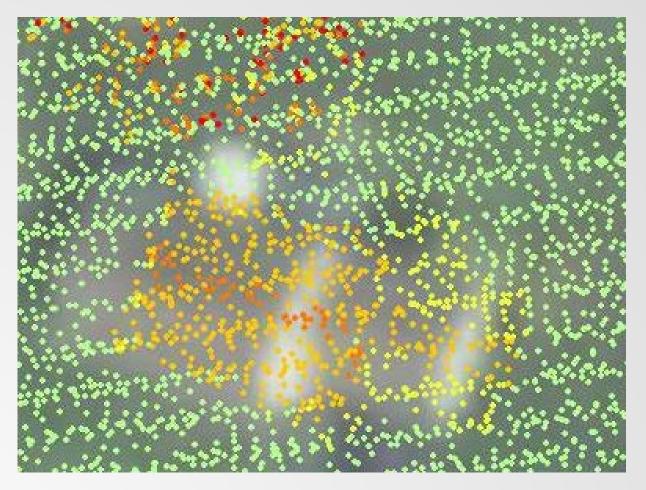
LiDAR Point Cloud



NAIP Imagery – 4 band





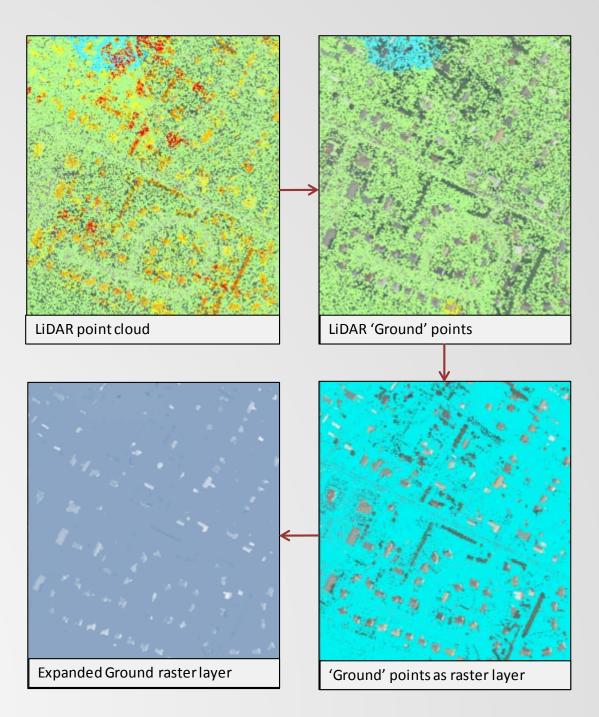


LiDAR point cloud – full sample



Processing - LiDAR

- LiDAR point cloud queried for ground points
- Points converted to raster
- Expanded to fill small gaps





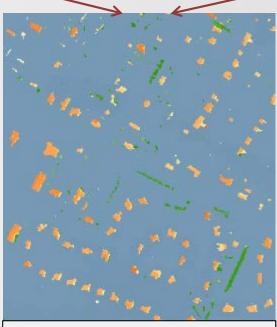
 The resulting Ground Mask layer is 'transparent' where higher objects exist.
 Overlaying this layer on a Normalized Difference
 Vegetation Index (NDVI) of
 NAIP imagery highlights which spaces are buildings and which are trees.



NDVIlayer



Ground Mask layer



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Ground Mask over NDVI

• The NDVI layer is converted to a Built/not Built layer





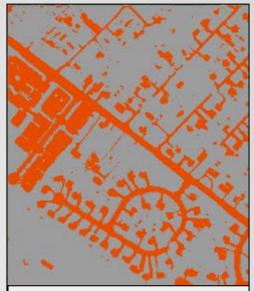
2015 Builtlayer



- Expanded Ground raster used as mask to remove low areas of Built/Not Built layer
- Resultant raster layer represents primarily buildings



'Ground' points as raster layer



2015 Builtlayer





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'Buildings' raster layer

- Building raster converted to polygons
- Small polygons deleted, other noise filtered





- Building polygons spatially joined to housing unit points to identify points that do not intersect building footprints
- Misaligned points written to output geodatabase
- Building footprints and approximate heights written to output geodatabase





Validating roads





Start with buildings raster layer

Subtract buildings raster layer from Built/Not Built layer



Small road segments eliminated and intersected with existing road vectors.

Misaligned road segments identified and saved.



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layer

Block Product

- Number of misaligned features, total features found by tool, and total from MAF/TIGER for each Census Block within the extent are tallied and written to output geodatabase
- Total and relative amount of area change per Census Block written to output geodatabase
- Total and relative amount of change can be used to prioritize assignment to human editor



Interactive Review Comparison

- 95% agreement for blocks identified as 'Active' —Most disagreements result from older LiDAR
- 65% agreement on 'Passive' blocks
 - -Tool IDs more buildings
 - -Tool can't differentiate residential vs commercial
 - -Multi-unit buildings difficult to flag correctly
- Human ~90 sec/block
 Program ~90 sec/block



Data Currency is Problematic





Similar Datasets Available



'Building' Polygons – Census Tool



'Building' Polygons-ORNL

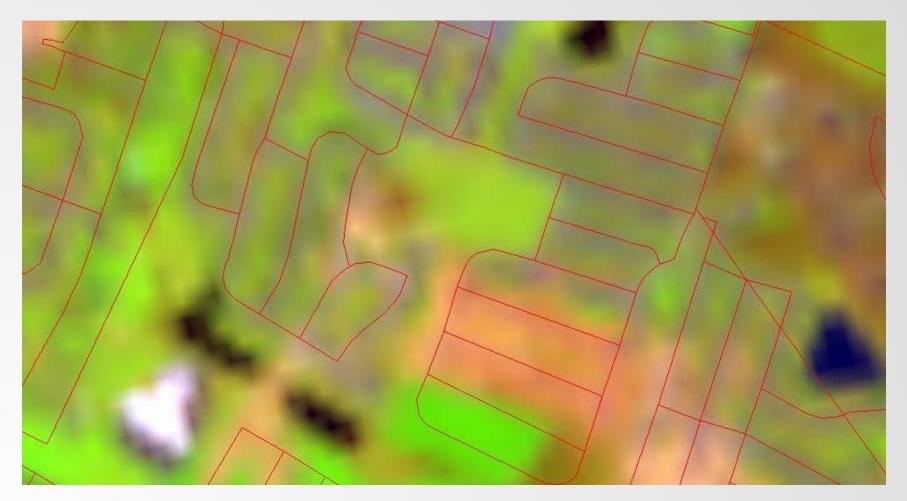


Developing Approaches to Identifying Change

- Needs to utilize data that is current enough to be relevant to Census needs
- Needs to be at fine enough resolution to identify building level change
- Need to be able to process data for entire country quickly
- Needs to be cost effective



Landsat – Not enough spatial resolution





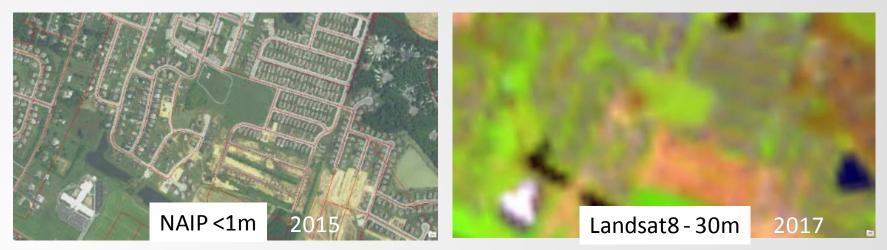
Sentinel 2

- 13 spectral bands
- Four bands at 10 m, six bands at 20 m and three bands at 60 m spatial resolution
- Orbital swath of 290 km, product provided as 100 km² tiles
- Level-1C tiles are orthorectified and corrected to TOA reflectance
- Tools available to correct to BOA
- <u>5 day repeat</u>
- FREE Available from ESA and USGS



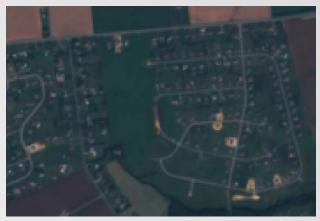
Sentinel 2 – 10m Change Signal?







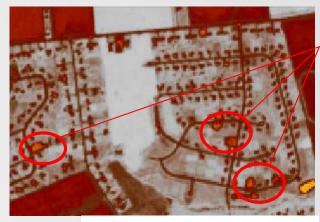
Sentinel 2 – 10m Change Signal!



September 2017

New

housing



NDVI September 2017



May 2016



NDVI May 2016



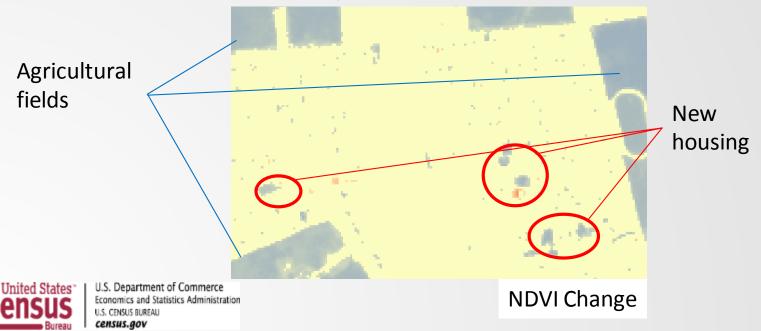
Sentinel 2 – 10m Change Signal



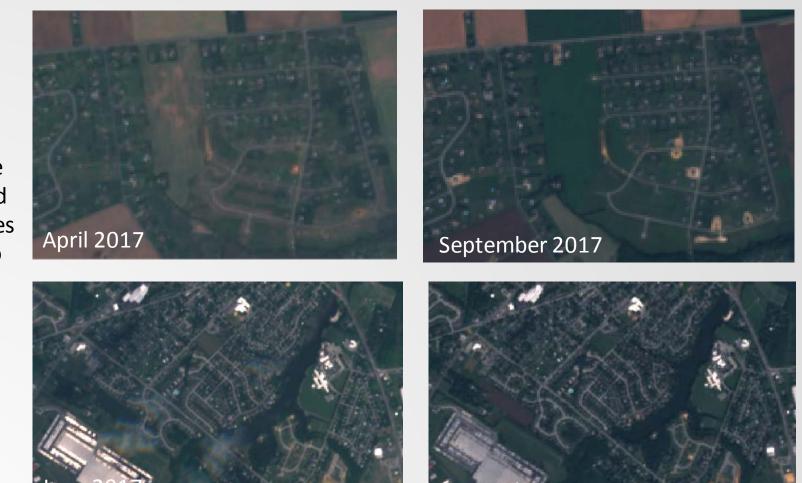
NDVI May 2016



NDVI September 2017



Sentinel 2 – 10m Change Signal



September 2017

Detectable at time and space scales relevant to Census needs?

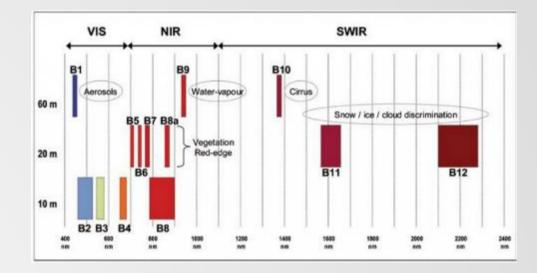




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Challenge: Image Data Are Huge!

- Multiple dimensions to consider:
 - Spatial resolution
 - Spectral resolution
 - Temporal resolution
- Example numbers using Sentinel-2 (10m² spatial resolution):
 - ~80 trillion pixels of entire planet.
 - ~98 billion pixels of the U.S.
- Each pixel has 13 bands
 - 10-60m² resolution
- And that's just for a single pass!
 - Updated every 5 days.





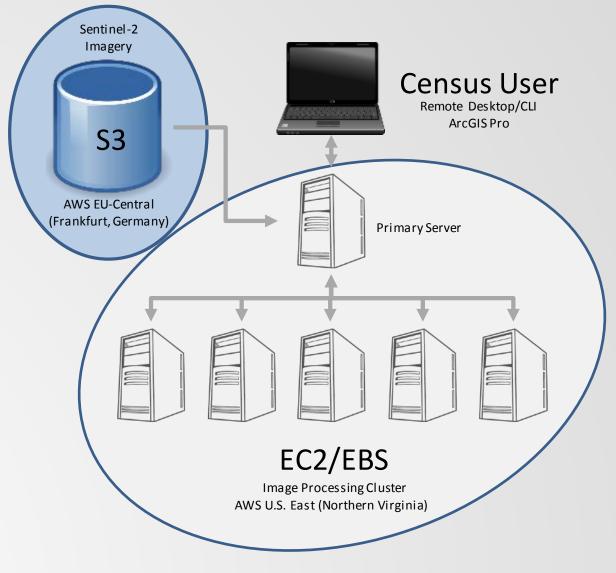
Prototype Architecture



- Amazon Web Services (AWS)
 - Elastic Compute Cloud (EC2)
 - Simple Storage Service (S3)
 - Elastic Block Store (EBS)
- Commercial Cloud vs. GovCloud

Image processing tools:

- ArcGIS Pro
- ArcGIS Enterprise
 - ArcGIS Server
 - ArcGIS Image Server





Processing Pyramid

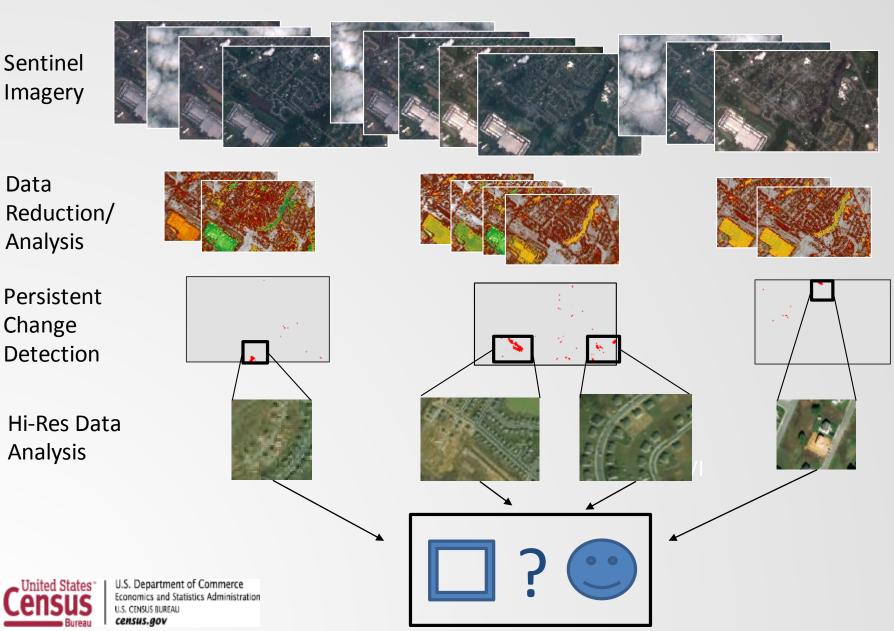


Data

Analysis

Change

Analysis



Inited States

Thank you!



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