Census Bureau Automated Change Detection

A key mission of the Geography Division is to update and maintain the Census Bureau's national geospatial database — the Master Address File/Topologically Integrated Geographic Encoding and Referencing (MAF/TIGER) System. Historically, this task was undertaken by field canvassers and through data-sharing partnerships with tribal, state, local, and federal partners, such as the U.S. Postal Service.

What we did in 2020:

- Built a Block Tracking Database.
- Conducted a complete review of all blocks in the nation, some of which were reviewed multiple times to evaluate ongoing change. In total, we conducted more than 13 million block reviews.
- Identified growth, decline, and built-out areas.
- This effort required nearly 150 full-time staff over a four-year period.

Results:

- Reduced the number of housing units requiring a field visit by 65 percent.
- Reduced field staff for canvassing (32,000 in 2020 vs. 150,000 in 2010).
- Cost avoidance of approximately $674 million (versus visiting all housing units in the field).

2000

100 PERCENT In-Field Address Canvassing through Address Listing and Block Canvassing operations.

Paper based operation.

2010

100 PERCENT In-Field Address Canvassing.

Digital data collection including GPS.

2020

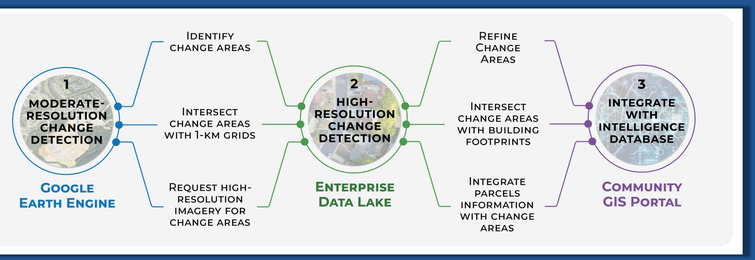
100 PERCENT In-Office Address Canvassing.

Only 35 PERCENT needed In-Field Address Canvassing.

Digital data collection including GPS.

What we want to do:

- Automate manual change detection methods used leading up to the 2020 Census.
- Automate methods to capture housing unit changes from source data to more efficiently update the MAF/TIGER System.
- Increase quality, coverage, and spatial accuracy of the MAF/TIGER System.
- Increase efficiency and optimize resource allocation.



Step 1: Identify areas of change from vegetated to non-vegetated using moderate-resolution imagery.

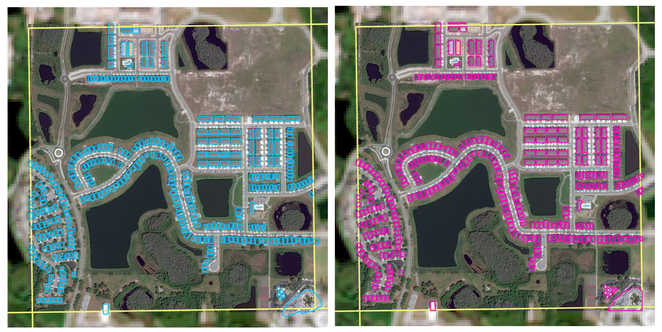
- Calculate difference between Sentinel-2 recent image and long-term normal NDVI/Artificial Surface Index to detect areas of change at 10m resolution.
- Use the Observational Products for End-Users from Remote Sensing Analysis (OPERA) DIST_ALERT product for finding persistent disturbance and for validation.
- Use Dynamic World to detect areas of change between the built classification.
- Conduct time series analysis against training areas that have been created within the Census Bureau.

These methods will be used in an ensemble model to have higher confidence in change areas.

Left: The underlying image is Sentinel-2 from 04/03/2020 and the yellow grid is the MGRS 1km; Center: The underlying image is Sentinel-2 from 11/04/2023. The red polygons represent change areas from Google Dynamic World; Right: The underlying image is Sentinel-2 from 11/04/2023. The purple and blue polygons represent change areas detected from OPERA's Vegetation Disturbance layer from 09/30/2023. The blue areas represent a shorter duration and the pink polygons longer duration from the detection of initial change.

Step 2: Object extraction process

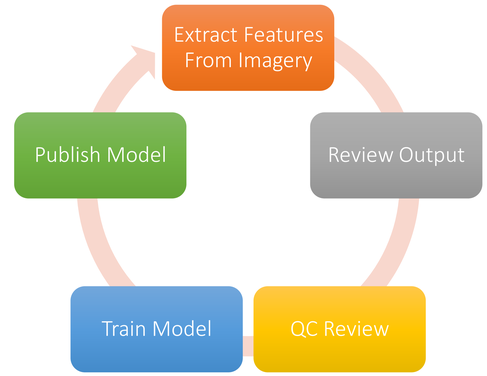
- Acquire high-resolution imagery based on Military Grid Reference System (MGRS) grid cells containing change polygons.
- Use Building Footprint Extraction – USA and the Multi-Task Road Extractor deep learning models for extraction of buildings and roads, respectively. Instance segmentation will occur using mask region-based convoluted neural networks (R-CNN) and Faster R-CNN architecture.

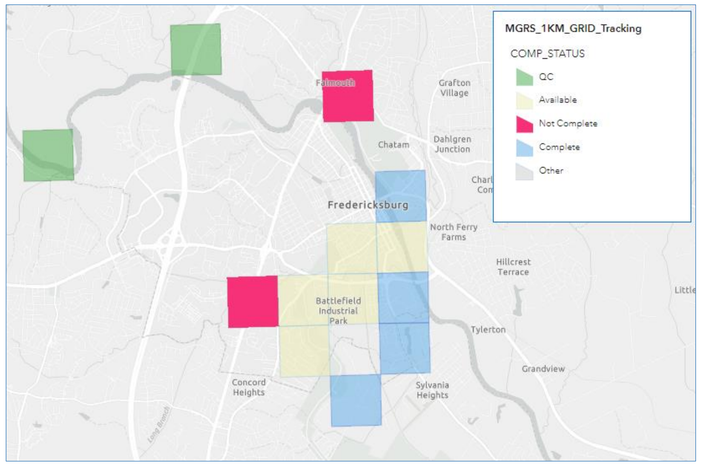


Left: The underlying high-resolution image is from 03/12/2023, ©2023, Maxar, USG Plus. The cyan polygons are our model output. Right: The pink polygons have been reviewed and corrected by staff. This edited data will be used to further train the model.

Step 3: Object extraction review

- Staff review 1km MGRS grid cells identified using moderate-resolution change detection. Building footprints were generated in these grid cells from an R-CNN model using high resolution imagery.
- Staff also review the footprints generated for accuracy and completeness and create footprints in areas that were missed by the model.
- Edited data is transformed into training data and used to improve the model's accuracy and robustness for future runs.





Fredericksburg, VA is a pilot for building footprint extraction. The grid represents MGRS cells where change was detected using moderate resolution imagery. The various colors represent the stage of the review process. The object extraction results are reviewed twice before being used to refine the model.

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