Business Plan for Building Footprints in North Carolina

Statewide Mapping Advisory Committee

Working Group for Building Footprints

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North Carolina
Geographic Information Coordinating Council

Contents

EXECUTIVE SUMMARY

This business case outlines the importance of an up-to-date statewide building footprint GIS dataset and a recommended technical approach on how to efficiently maintain it to represent current building geometry and populate relevant attributes with sufficient accuracy to support business needs. The official sponsor of this business case and subsequent charter is the Geographic Information Coordinating Council (GICC). The Statewide Mapping Advisory Committee (SMAC), acting through the GICC, initiated the Working Group for Building Footprints (WGBF) to create this plan and outline a realistic approach to achieve an updated and maintainable framework dataset. Appendix A, Table 8 summarizes the members and represented agencies. This data would not only meet the business needs for many different state agencies, local governments, and private businesses, but would also support and supply other framework datasets with necessary information.

This plan documents the strategic importance to state, local, and federal stakeholders. In doing so, it justifies the investment and effort required to develop this data set. It outlines a common base framework of attributes and geometry that will then enable additional attribution of the building footprints to meet individual business needs. Finally, the case aligns with the Sponsor's directives to develop and support, update, and maintain framework datasets to ensure it meets the needs of stakeholders.

<table>
<tr><th colspan="3">PRIORITY USE CASES</th><th>BENEFICIARIES</th></tr>
<tr><td>Disaster relief damage estimation and recovery assistance, accurate risk assessment, disaster recovery and resiliency planning</td><td>Identifying, inventorying, analyzing, and managing real property assets, including historic preservation</td><td>Targeted state, federal, and local grant funding opportunities including NC Broadband</td><td rowspan="3">12 State Agencies

All Local Government

3 Framework datasets

3 Federal Agencies

4 Programs/Applications</td></tr>
<tr><td>Insurance assessments and fire risk visualization, mitigation, response, and ratings assessments</td><td>Election confidence and voter information</td><td>Tax assessment & planning</td></tr>
<tr><td>NextGen 911 completeness assessment & 911 initial unit response plans</td><td>NCDOT Early Right of Way Relocation/Acquisition cost feasibility, Project prioritization, project planning potential impacts and visualizations</td><td>U.S. Census validation of housing units for 2030 Census & Annual State & Federal Population Estimates</td></tr>
</table>

Table 1: Use Case Summary

The GICC recognizes the integration potential between building footprints and other framework datasets including parcels, addresses and municipal boundaries. This plan initially identifies 17 organizations, including federal agencies, state agencies, local governments, and private enterprises, that would benefit from this data set. Each of their use cases, along with their set of core attributes, has been documented. Appendix A, Table 6 provides details for each agency. Table 1 summarizes the priority use cases.

Building footprints have been identified as a framework GIS dataset that can serve many different business cases across both government and the private sector. Previously, North Carolina Emergency Management (NCEM), within the Department of Public Safety, created a statewide building footprints layer to meet the needs of the Floodplain Mapping Program and to perform damage assessments following hurricanes and other events. The dataset was initially derived from orthoimagery and was not updated for more than five years after creation. Recent attempts to update the dataset involved incorporating new buildings extracted from LiDAR, community provided updates, and any available building footprint data available from Microsoft. Keeping this data current has been an ongoing issue due to a lack of funding and the absence of a structured maintenance plan. Therefore, the SMAC discussed the need to develop a plan for updating and maintaining an authoritative building footprint dataset that can be leveraged by all stakeholders.

This plan assumes a collaborative effort of joint responsibility for developing geometry, core attribution, tools, best practices, and standard operating procedures for continual maintenance to prevent the data from becoming obsolete. The plan leverages artificial intelligence (AI) and deep learning models for extraction of features from orthoimagery products that facilitate continued maintenance compared to manually intensive past efforts. Constraints include statewide end-user support for continual maintenance, potential funding, staffing, and a lack of methods for mass attribution.

The primary and most fundamental assumption is that the North Carolina 911 Board's Orthoimagery Program (Ortho Program) will continue. The Ortho Program collects new imagery on a four-year refresh cycle. This consistent refresh creates an opportunity to update the building footprints from the imagery products each year and establishes a maintenance schedule for keeping this valuable dataset current.

BUSINESS CASE AND PURPOSE

North Carolina's existing building footprint data layer was produced by NCEM and therefore focuses on emergency recovery and response. It was used for the first-time during Hurricane Fran (2014) to analyze damages from wind and flooding. The extensive damage estimates from Hurricane Matthew (2016) were used to justify the fastest federal disaster declaration in FEMA history (to that date). Additionally, the Flood Inundation Mapping and Alert Network (FIMAN) relies on accurate building footprints to provide advanced flood warning, thus saving lives. However, extensive growth within the state in the last decade has resulted in missing data and outdated attributes. While the FIMAN system remains functional, its reliability continues to decrease due to the lack of consistent building footprint maintenance. This single reason alone provides justification for new investment.

The existing dataset has approximately 5 million features, but it is estimated that between 400,000 and 900,000, or up to 18%, of buildings are missing statewide from the original dataset due to new development, expansion of buildings, and changes in the landscape since the original data collection. In addition, existing attributes fail to meet the needs of all stakeholders, including the original data producer. These data gaps not only reduce the accuracy of damage estimates, thereby potentially reducing the expediency of recovery funds distribution, they also endanger lives by decreasing the reliability of the predictions of the FIMAN system. However, the need for this data extends beyond emergency response into other programs and industries such as broadband expansion, resiliency analysis, transportation, and addressing. Addresses and building use type are examples of updates needed by a broad coalition of stakeholders. Appendix A, Table 6 documents the set of stakeholder use cases for a complete inventory of current needs.

Advancements in technology, such as AI and deep learning models have enabled more efficient feature extraction from imagery and/or lidar and should greatly reduce the amount of labor required to maintain a building footprint dataset. However, certain implementation risks would remain. **The WGBF has made a preliminary conclusion that funding and labor to perform QC on the data and compile attributes are the immediate risks to project success.** If any of the following items are not defined by a plan, do not have commitment or backing, or diminish over time, they should be considered as risks, and methods and workflows must be put in place to mitigate these risks.

- Local government engagement is necessary for attribute accuracy, and additional engagement through building permits and flood certificates could improve geometry and attributes.
- A coordinated effort involving agreements with each party involved in maintenance on a regular schedule, or consistently across all geographic areas (e.g., a single county).
- Guidelines must be clear for attribute requirements, maintenance methodology, and task assignment.
- Adequate funding or staffing develop and maintain a comprehensive data set with standardized attributes. Revisions must be maintained or transferred from the existing dataset to the updated dataset to include:
    - Maintenance of existing building unique identifier
    - Defined methods to crosswalk a new footprint against existing in terms of attribution and geometry
    - Confidence of mass existing attributes transfer
    - Accountability for assigning an address to the correct footprint where multiple footprints exist on any given property

TECHNICAL APPROACH

As the capabilities of AI and deep learning models have continued to advance, so have opportunities to use these technologies to complete tasks that were once labor intensive. The extraction of building footprints is one such example. The expectation is that by using AI and deep learning models, the level of effort required to maintain this data set will be greatly reduced relative to previous maintenance efforts and is the recommended approach for this effort.

This plan identifies an AI deep learning approach to extract building footprints from either orthoimagery or LiDAR products as the means to accomplish the goals of this effort. Due to the consistent cycle of updates from the Ortho Program, the focus of the technical processes will be to use these imagery products instead of LiDAR. However, if a regular LiDAR collection becomes available in the future, the plan could also be applied to those products to achieve the same result. Nonetheless, LiDAR serves as a value-added means for quality control as well as a source to derive elevation and height attributes. The plan assumes the Ortho Program collects 6-inch, 4-band (RGBIR) orthoimagery products for approximately a quarter of the state per year. This enables a consistent refresh cycle of new orthoimagery for every region in the state every four years. This creates an opportunity to update the building footprints from the imagery products each year and establishes a maintenance schedule for keeping this valuable dataset current.

Figure 1 demonstrates the workflow for extracting new building footprints from orthoimagery products from the Ortho Program. This workflow includes steps for updating training samples and fine-tuning the deep learning model using the existing footprint dataset and the most recent orthoimagery. Performing these steps to fine-tune the model to North Carolina, instead of using out of the box models, will ensure the model is tailored to the resolution, radiometry, and geography of the North Carolina orthoimagery. The expected result is better initial object detection.

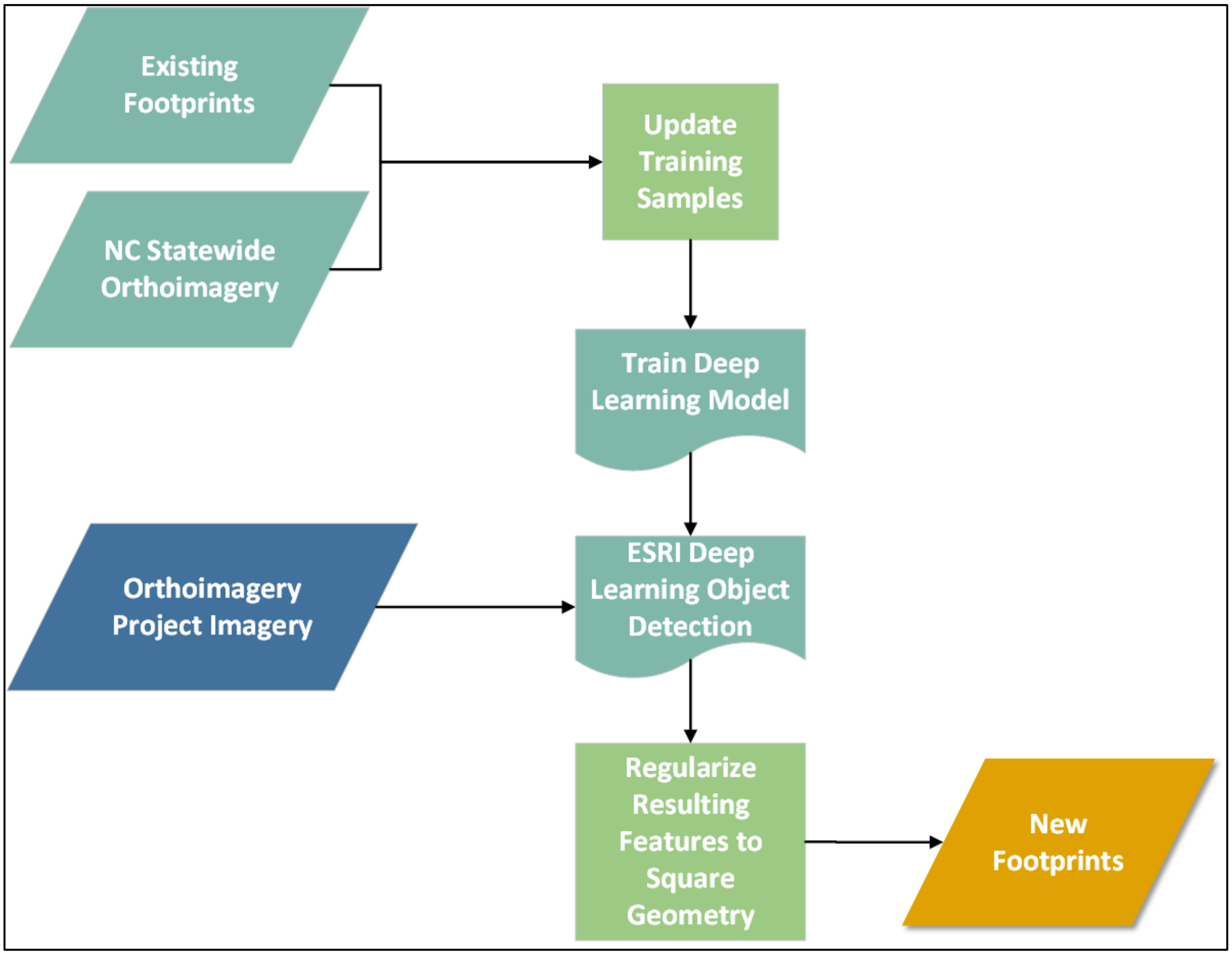

Figure 1: Process diagram for creating new building footprints from the NC Orthoimagery Program

However, with many AI and deep learning solutions, manual quality control and data cleanup tasks will still need to be implemented to ensure that a high-quality and complete dataset is ultimately produced. The level of effort for these manual tasks will present the biggest challenge for successfully completing the work outlined in this plan. Figure 2 outlines a workflow to identify change in the existing statewide building footprint dataset by using the outputs from Figure 1. In summary, Figure 2 considers at least four significant workflows:

1. Identifying new structures
2. Modifying existing structures
3. Removing demolished structures
4. Providing attribution for new or modified footprints

The workflow for modifying existing structures requires analyzing specific thresholds for identifying change. These thresholds change based on the original size of the structure. A smaller structure will require a larger percentage of change to necessitate an update, but a larger structure will require a smaller percentage since a small percent of a large original number will still represent a large structural change. These thresholds will also need to be large enough to account for slight differences in the extracted footprints due to building lean being present in different years of orthoimagery. The exact figures to use for the diminishing size thresholds that will identify change in the existing footprints will need to be determined through a thorough proof of concept.

The WGBF also assessed a minimum square footage threshold for inclusion in the primary building footprint dataset. This will improve usability and performance for most use cases outlined in this document. Structures smaller than 800 square feet would be converted into a point layer to reduce the volume of outbuildings and other structures that are non-essential to most business uses. However, this secondary layer could be leveraged by any organization needing to satisfy additional requirements.

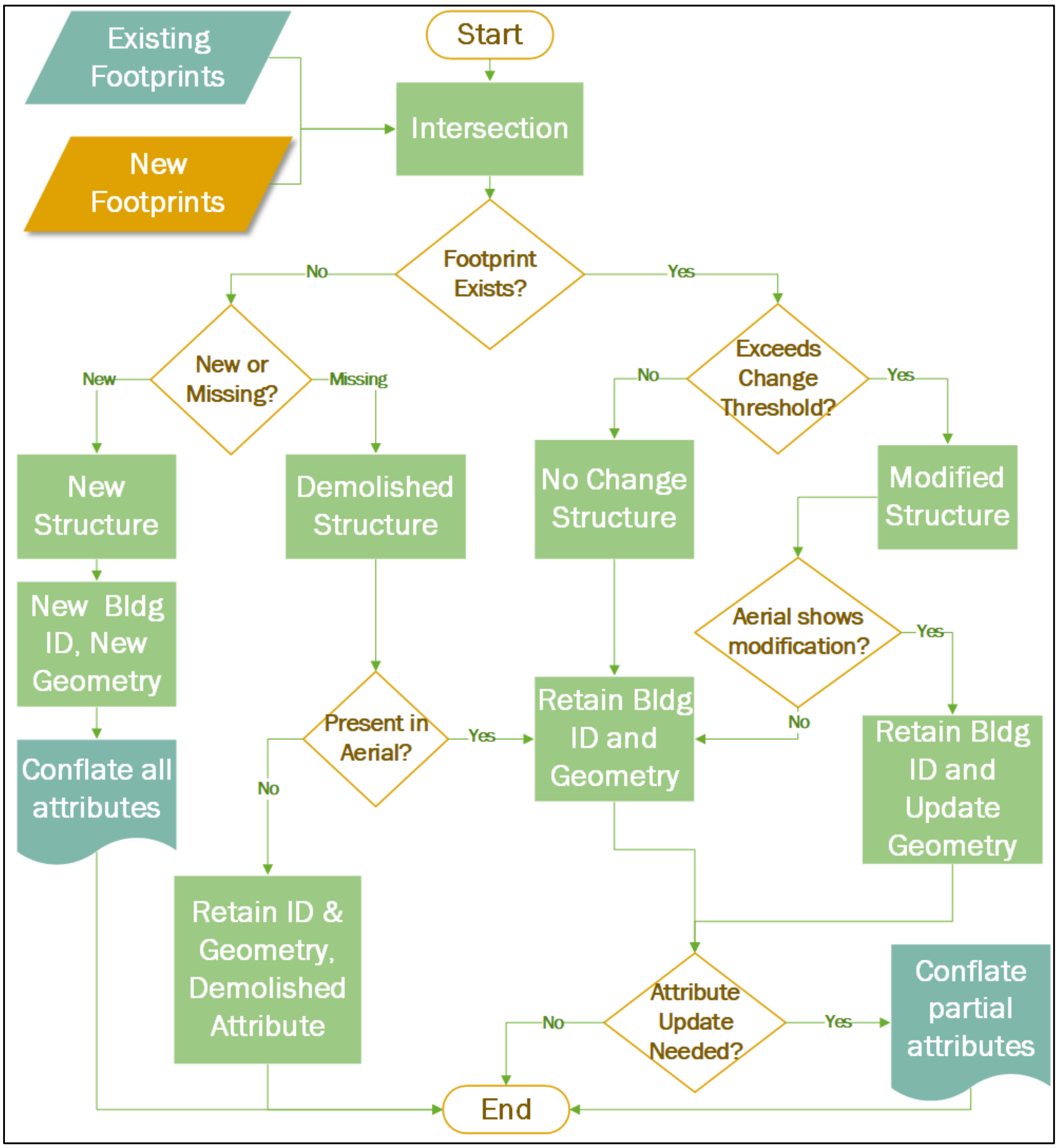

Figure 2: Process diagram for using new footprints to update the existing statewide building footprints dataset.

Table 2 outlines primary attributes of the statewide dataset required by most business uses. Structures that have been demolished or are no longer present in the imagery should not have their geometry removed but should have the [REMOVED] and [REMOVED_YR] attributes updated to reflect that it is no longer visible in the imagery and what year this occurred. Other attributes, such as occupancy type, year built, square footage, etc. can be derived from the county tax records or statewide parcel dataset. The address for the structure should be derived from the AddressNC dataset since it is the authoritative statewide address dataset and is maintained through the NextGen 911 systems across the state. Optional attributes identified by the business use cases are outlined in Appendix A - Table 6. These additional attributes are based on individual business uses and demonstrate the fully attributed data that might be required by any given agency. The working group recommends the proposed building footprint dataset be limited to a core set of common attributes required by all stakeholders that would also allow agencies to leverage their business-specific data using relational databases or other data sources. It should be noted the bulk of attributes would be required by NCEM for hazard risk, FIMAN, Flood Risk Information System (FRIS), etc.

Field	Potential Source	Data Type	Description
BLDG_ID	Generated	Text	Primary key
PID	Statewide Parcels	Text	Tax Parcel Identification Number.
OCCUP_TYPE	Statewide Parcels	Text	Occupancy Type e.g., single family, religious, industrial, mobile, multifamily, etc.
BUILD_TYPE	Statewide Parcels	Text	HAZUS Building Construction Type i.e., wood, steel, concrete, etc.
YEAR_BUILT	Statewide Parcels	Text	Year the structure was built.
HTD_SQ_FT	Statewide Parcels	Long	Heated square footage.
NUM_STORY	Statewide Parcels	Text	Number of stories.
IMAGE_YEAR	NC Orthoimagery	Text	The year that the imagery was flown from which the building footprint was derived.
REMOVED	Generated	Integer	Has this building been removed (i.e., a demolished structure)? 0 = No, 1 = Yes.
REMOVED_YR	Generated	Integer	If the REMOVED field contains a 1, this field denotes the year in which the structure was removed.
ADDRESS	AddressNC	Text	911 Address

Table 2: Primary attributes identified by most use cases

IMPLEMENTATION REQUIREMENTS

Implementation of this business plan must consider various technical aspects of the data, as well as workflows for creating and maintaining it. North Carolina is well situated to undertake this effort due to an established high resolution Ortho Program along with the existing statewide building footprint layer. Both data sets can be used as a starting point for this work. Improvements in AI and deep learning models represent a major improvement in the ability and speed with which this type of work can be completed and a proof of concept for implementing these models at a county-wide scale will validate the approach.

The approach described thus far is comprised of two components: geometry updates and attribution. Populating the required attributes and consistently maintaining the data are critical to meeting the business uses outlined by this document and represent the highest project implementations risks. **The quality control and manual editing of the data that continues to be required, even when using automated feature extraction processes, represents the largest obstacle to completing the work outlined in this plan**. Contracting or additional staffing will be needed to address this specific workflow.

<table>
<tr><th colspan="2">IMPLEMENTATION RISKS</th><th>REQUIREMENTS</th></tr>
<tr><th colspan="2">RISKS</th><th>TECHNICAL</th></tr>
<tr><td colspan="2">1. Funding mechanism
2. Maintenance
3. Attribution</td><td rowspan="4">1. Current high-resolution imagery
   a. OR LiDAR (8PPM minimum)
2. Existing statewide footprints from NCEM
3. Artificial intelligence (AI) deep learning models
4. Proof of concept
5. Statewide Framework Datasets for attribution
   a. AddressNC
   b. Parcels</td></tr>
<tr><th colspan="2">APPROACH</th></tr>
<tr><th>TASKS</th><th>WORKFLOW</th></tr>
<tr><td rowspan="2">1. Data collection
2. Proof of concept for one county
3. Deep Learning/AI feature extraction of geometry
4. Geometry enhancement
5. Geometry Quality Control / Manual clean-up
6. Attribution
7. Maintenance</td><td rowspan="2">1. Identifying new structures
2. Modifying existing structures
3. Removing demolished structures
4. Attribution for new or modified footprints
5. Update attributes for existing footprints</td></tr>
<tr><th>ADMINISTRATIVE</th></tr>
<tr><th colspan="2">CONSIDERATIONS</th><td rowspan="2">1. Temp staffing and/or
2. Contracted vendor
3. Funding
4. Interagency agreements
5. Local government engagement</td></tr>
<tr><td colspan="2">1. Ownership
2. System architecture
3. External applications dependencies
4. End-user permissions and access
5. Centralization
6. Data Migration
7. Data sourcing</td></tr>
</table>

Table 3*: Implementation Requirements*

Table 3 presents the overall implementation requirements with an identified approach as seven workflow categories where Tasks 1 and 2 are required for only initial implementation. Tasks 3 through 7 would be required for each yearly update. Important considerations for approval and successful implementation of this business plan is also defined. The implementing organization should work with the stakeholders to delegate responsibility and tasking for these items. It should also consider the implementation risks and how best to mitigate them.

ORGANIZATIONAL APPROACH

To minimize the risks in Table 3, a clear definition of the roles and responsibilities for the tasks outlined is required when implementing the work of this plan. NCEM is the owner of the current building footprint dataset and will continue to own the data as updates are made since they have the greatest need. In terms of organization for implementation, the plan identifies three approaches for performing the technical work outlined in Figures 1 and 2.

The first approach is to leverage federal workflows and resources to extract the building footprints from the orthoimagery products. Using a similar approach to the one outlined in Figure 1 of this plan, the Department of Homeland Security (DHS), Federal Insurance and Mitigation Administration (FIMA), FEMA's Response Geospatial Office, the USGS, and Oak Ridge National Laboratory collaborate to extract building footprints from satellite imagery for the entire nation. To avoid duplicating effort, the state could collaborate with this federal group to benefit both parties. The federal building footprint effort currently relies on satellite imagery sources to extract the geometry and the imagery from the North Carolina Ortho Program would improve this process due to the higher resolution and tighter ground control. The state, in turn, would avoid the costs of extracting the building footprints. Once geometry updates are received, the state would be responsible for using the new footprint data to update the existing NCEM building footprint dataset.

If collaboration with the FEMA building footprint work is not feasible, then the second approach to implementation would rely entirely on state resources and servers to perform the feature extraction processes required. The resulting features extracted from the Ortho Program imagery would then need to be intersected with the existing dataset to identify change and update as needed. This alternative has a steeper learning curve to set up state resources and models to perform the complicated feature extraction processes. However, with the migration of state server resources to AWS cloud environments, these resources can be scaled to meet the technical requirements for performing the feature extraction processes at a regional scale.

The third approach relies on the private sector and contracting vehicles to perform the technical work with a state stakeholder serving as project manager and directing quality control. The private sector may have innovative approaches and solutions that could benefit the feature extraction and data update processes. Prior to bids solicitation, it is recommended the state release a Request for Information (RFI) to gather information about capabilities and specifications that could then be built into a formal Request for Proposal (RFP) to contract for the data updates required.

Figure 3 presents the three proposed approaches, further defined by five major divisions of roles and responsibilities as (1) ownership and hosting, (2) project management, (3) technical workflows, (4) attribution, (5) and quality control. Project management includes tasking, scheduling, securing of funding, and procurement and contracting. Ownership considers the necessary inputs for centralization and system architecture and external applications dependencies. Hosting considers the means to provide access to stakeholders, end-users, and the public. Technical workflows consider development and tasking identification technical detail behind the processes identified in Figures 1 and 2 workflow diagram. This business plan has separated the essential core attributes from the complete inventory of other attributes necessary for external applications such as FRIS. Therefore, it follows end-user agencies with needs beyond the core set attributes would take ownership of attributing a complete set. Quality control is an important part of the process that validates the results of the technical workflows to ensure that they are meeting the needs of the stakeholders.

Roles & Responsibilities Approaches

TASK GROUP	FEDERAL	STATE	PRIVATE
OWNERSHIP & HOSTING		ALL APPROACHES	
PROJECT MANAGEMENT		ALL APPROACHES	
TECHNICAL WORKFLOWS – FEATURE EXTRACTION	APPROACH 1	APPROACH 2	APPROACH 3
TECHNICAL WORKFLOWS – DATA UPDATES		APPROACHES 1 & 2	APPROACH 3
ATTRIBUTION	APPROACH 1	ALL APPROACHES	
QUALITY CONTROL		ALL APPROACHES	

Figure 3: Organization Approach Matrix

PROGRAM COSTS

This plan has recognized funding as the highest risk and limiting factor for an Initial statewide update and for a sustainable source for maintenance. NCEM developed the initial statewide building footprint dataset from the statewide lidar collection at an approximate cost of $700,000. Based on the number of footprints per county, this demonstrates a cost range of about $1,000 to $45,000 per county to develop this initial data. Since this effort is only updating the existing building footprint dataset and taking advantage of the efficiencies gained using AI, it is anticipated the costs associated with the updates outlined in this plan would be a fraction of the original investment. However, that does not mean costs will be consistent from region to region.

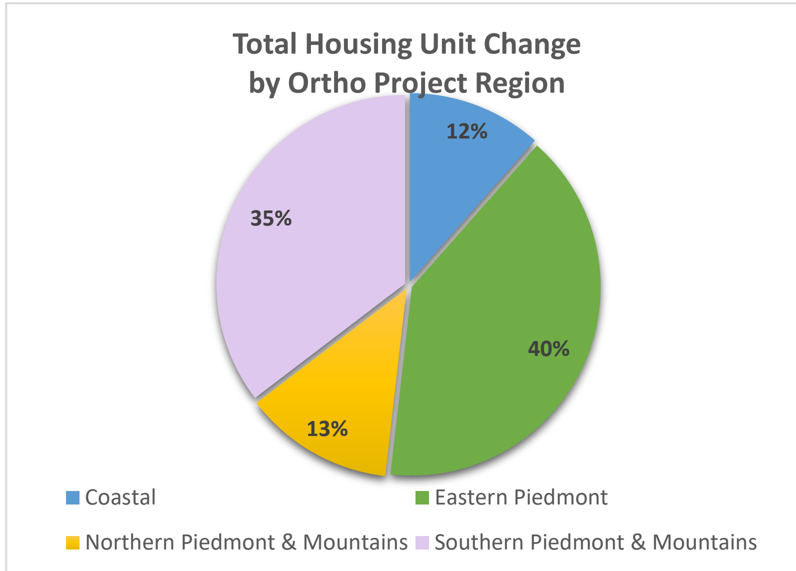

Figure 4: Percent of Total Statewide Housing Unit Change per Ortho Project Area based the 2010 and 2020 U.S. Census Figures.

To estimate the level of effort, 2020 U.S. Census data was analyzed to identify what parts of the state saw the most change. Figure 4 demonstrates the Eastern Piedmont and the Southern Piedmont and Mountains, including the Raleigh-Durham and Charlotte metropolitan areas respectively, experienced a much larger change between 2010 and 2020 accounting for 75% of the new housing units in that span. It is important to understand costs directly related to the magnitude of change taking place.

The Working Group has identified two options on how to begin implementation of the work outlined in this plan. Option 1 as shown in Table 4 is to initially update building footprints in the Coastal and Eastern Piedmont regions and then follow the orthoimagery program cycle thereafter. For this option, the initial budgetary requirements would be minimized since the focus would be to update half of the state before then entering the yearly maintenance after each subsequent orthoimagery project. This option would also allow for the initial focus to be placed on updates in the regions with the most urgent need for updated footprints due to hurricane season. Option 2, outlined in Table 5, is to update the entire state based on the latest orthoimagery products available and then follow the orthoimagery program cycle for subsequent phases. The initial budgetary requirements for this single statewide update will be higher than in option 1. However, the results of option 2 would be consistent across the state and produce a reliable data product for all regions to begin the maintenance of the data following the orthoimagery projects.

Regardless of the options, Figure 4 is still an important consideration for costing. Based on this information, a conservative range of cost for an initial statewide update is estimated at $400K - $600K that would include approximately 10% project management. A phased approach (Option 1) is derived from a statewide approach but is aligned to the most accurate information available from Figure 4 and is weighted per a summary of existing distribution of buildings per county. Annual maintenance, following the Ortho Program project cycle after the initial update, is estimated at approximately $100K and would assume a one quarter level of effort reduced to account for efficiencies gained, lessons, learned, usable code, and other factors. Consideration of these two inputs provides a reasonable and justified approach rather than a straight-line estimate.

Phase	Name	Description
1a	Data Collection	Collect existing statewide building footprint data and orthoimagery necessary for proof of concept.
1b	Proof of Concept	Perform a proof-of-concept project to update existing building footprints and outline clear specifications for scope of work items to use in future updates.
1c	Coastal and Eastern Piedmont Feature Extraction	Use orthoimagery products from 2020 and 2021 orthoimagery projects to extract building footprints using Deep Learning & AI models.
1d	Coastal and Eastern Piedmont Geometry QC	Intersect new extracted footprints with the existing feature in the statewide building footprints dataset to update geometry.
1e	Coastal and Eastern Piedmont Attribution	Populate primary attributes for new and updated features.
2a	2022 Northern Piedmont & Mountains Initiation	Collect existing statewide building footprint data and new orthoimagery products from the 2022 orthoimagery project.
2b	2022 Northern Piedmont & Mountains Feature Extraction	Use orthoimagery products from 2022 orthoimagery project to extract building footprints using Deep Learning & AI models.
2c	2022 Northern Piedmont & Mountains Geometry QC & Attribution	Intersect new extracted footprints with the existing feature in the statewide building footprints dataset to update geometry.
2d	2022 Northern Piedmont & Mountains Attribution	Populate primary attributes for new and updated features.
3a	2023 Southern Piedmont & Mountains Initiation	Collect existing statewide building footprint data and new orthoimagery products from the 2023 orthoimagery project.
3b	2023 Southern Piedmont & Mountains Feature Extraction	Use orthoimagery products from 2023 orthoimagery project to extract building footprints using Deep Learning & AI models.
3c	2023 Southern Piedmont & Mountains Geometry QC & Attribution	Intersect new extracted footprints with the existing feature in the statewide building footprints dataset to update geometry.
3d	2023 Southern Piedmont & Mountains Geometry QC & Attribution	Populate primary attributes for new and updated features.
4	**Continue Yearly Data Maintenance**	**Apply approach from first 3 phases to subsequent orthoimagery projects to continue a 4-year refresh cycle of the statewide building footprints.**

Table 4: Implementation Option 1 phased approach to next steps

Phase	Name	Description
1a	Data Collection	Collect existing statewide building footprint data and orthoimagery necessary for proof of concept and remainder of phase 1 updates.
1b	Proof of Concept	Perform a proof-of-concept project in one or two coastal counties to update existing building footprints and outline clear specifications for scope of work items to use in future updates.
2a	Statewide Update Initiation	Collect existing statewide building footprint data and latest orthoimagery products from the 2019 through 2022 orthoimagery projects.
2b	Statewide Feature Extraction	Use orthoimagery products from 2019 through 2022 orthoimagery projects to extract building footprints using Deep Learning & AI models.
2c	Statewide Geometry QC & Attribution	Intersect new extracted footprints with the existing feature in the statewide building footprints dataset to update geometry.
2d	Statewide Attribution	Populate primary attributes for new and updated features.
3	**Continue Yearly Data Maintenance**	**Apply approach from first 3 phases to subsequent orthoimagery projects to continue a 4-year refresh cycle of the statewide building footprints.**

Table 5: Implementation Option 2 phased approach to next steps

CONCLUSIONS AND RECOMMENDATIONS

The WGBF has substantiated the fact building footprints are critical to supporting a variety of public and private business needs throughout the state including public safety, election confidence and voter information, risk and resiliency, and others. However, the current building footprints data set is not regularly maintained and is not structured to support the overall stakeholder community. Therefore, the WGBF recommends the following:

1. Updating the statewide building footprints should correspond with the newly available orthoimagery produced each year. The Ortho Program has a well-established procedure of collecting orthoimagery for a quarter of the state each year to maintain a four-year refresh cycle. The current orthoimagery cycle map is shown in Figure 5 of Appendix A. (NOTE: It is understood that there may be a need to initially update the coastal and eastern piedmont regions due to the critical nature of having updated building footprints for upcoming hurricane seasons).

2. Advancements in AI and deep learning technologies offer the opportunity to more efficiently complete regular maintenance tasks and should be implemented as part of the workflow used to update and maintain the building footprints data.

3. In summary the plan recommends three approaches to roles and responsibilities for completing the work and two options for initial implementation:

    a. The three approaches to roles and responsibilities are combinations of federal, state, and private contractor. It is necessary to determine the most efficient breakdown of the organizations performing the work for each of the five major divisions of tasks. If collaboration with federal partners for development and processing of the imagery from the Ortho Program can result in cost savings and mutual benefits, approach 1 (federal collaboration for geometry extraction) is preferred to running the required AI models.

    b. Option 1 for initial implementation is to complete updates for the Coastal and Eastern Piedmont regions first, with the rest of the state following the Ortho Program cycle. Option 2 would complete a statewide update of the existing building footprint dataset and then begin annual maintenance following the Ortho Program cycle. The determining factor between the two options is the budgetary constraints for implementation.

4. Stakeholders agree on a common set of attributes (see Table 2) to complete most business tasks. These attributes should be included in the building footprints data set as a common set of information but also ensure that business-specific data can be added.

5. Alternative workflows and ownership must be developed to service subsequent business needs and attributes that go beyond the core set identified in Table 2.

6. Attributes derived from other data may not be standardized across all counties, causing issues when attributing new or existing structures. Outreach and education to the local and county creators of this data through other GICC committees and working groups, such as the Working Group for Seamless Parcels, are necessary to improve the attribution of these other datasets that directly impact the quality of the building footprint attributes.

7. Implement a phased approach to next steps after adoption of this business plan. Annual maintenance that follows the initial data update should follow the Ortho Program cycle of collection for a quarter of the state per year to keep the data current and meeting the needs of the stakeholders.

APPENDIX A – SUPPLEMENTARY DOCUMENTATION

NAME/AGENCY/PROJECT	NEED/BENEFIT
1. GICC – Statewide Mapping Advisory Committee	Identified as a framework dataset where the goal is to build seamless, statewide datasets for critical data layers using the most accurate, precise, and highest resolution data from agencies with program responsibility for managing these data.
2. Department of Public Safety (N.C. Floodplain Mapping Program)	The Statewide Building Footprints are used in a number of NCEM public facing applications, such as FIMAN and FRIS; river mitigation studies, such as the Lumber, Tar, Neuse; and operationally with rapid damage estimates to support joint preliminary damage assessments with FEMA and disaster declarations. They are also utilized in recovery, mitigation, and resiliency studies. Attributes required for flood damage estimation in the FEMA Hazus Methodology include Building Replacement Value to determine reconstruction costs, First Floor Elevation to determine depth of flooding in building, and Heated Square Footage to estimate inventory losses to commercial and industrial buildings. Structure Type (Residential, Commercial, Public, etc.), Foundation Type (Pile, Slab, Basement, Crawl Space, etc.), Number of Stories, and Flood Zone (Coastal A, V or Inland) are required to determine USACE depth-damage functions. Wind functions require Roof cover type, Roof quality, Roof-deck attachment, Roof-deck age, Roof Shape, Roof Frame type, Garage doors and Shutters as attributes.
3. CGIA; AddressNC	The AddressNC Program will utilize building footprints to evaluate completeness. In coordination with parcel attributes such as use type and improved values, footprints will assess the probability of real addresses that should exist but currently do not. This will aid end-user providers with exact locations for updating their authoritative records that in turn will improve NextGen 911. Ultimately, the vision will be to establish relationships between footprints and addresses. This would serve any number of practical applications including for use by NCEM.
4. NC Broadband Infrastructure Office	Current broadband mapping is done through use of the FCC Form 477 data that reports service at a census block level bi-annually. However, the FCC is adopting new mapping requirements that will report service at a household level. Building footprints can be combined with statewide addresses and parcels to create what is termed the "serviceable location fabric" that will represent the homes and businesses that are able to be served by broadband. Having accurate building footprints with attribution on basic categories of land use will allow the creation of the fabric and will better enable policies to be directed at the exact locations that need this critical infrastructure. The federal government has provided a tremendous amount of broadband funding to the State through the American Rescue Plan Act and the Infrastructure Investment and Jobs Act. Having accurate data on the locations and buildings that currently lack adequate broadband service will

	allow those funds to be spent efficiently and in the specific locations needed.
5. NC 911 Board; NG911	NextGen 911. Through AddressNC, addresses are more comprehensive and precise in location that are tied to buildings.
6. NC State Board of Elections	Election confidence and voter information
7. Local government Managers and Coordinators	Tax assessment, planning, and floodplain management
8. Dept. of Insurance State Fire and Rescue Commission	Conducts flood analysis for the Property Fire Insurance, and School Insurance Funds. NCDOI keeps inventory or all structures on each property, this includes everything under 800 sq feet. Building footprints can also be useful for the North Carolina Office of State Fire Marshal (OSFM) fire department ratings inspectors. During a fire department rating, fire ratings inspectors choose certain businesses, residences, or community buildings to test out the hydrant system. Attributes such as, building material, number of floors, and total square footage are beneficial for these inspections.
9. Dept. of Administration	A core part of the State Property Office's Real Estate Portfolio database. The building footprint is used in identifying, inventorying, analyzing, and managing real property assets, owned, and leased.
10. NC Forest Service	Used by the Neighbor 2 Neighbor application for wildfire risk visualization. This enables a community to visualize the scope and scale required for engagement of partners to reduce collective wildfire risk. From a Risk Mitigation focus, building footprints would be utilized for individual building wildfire risk ratings (assessments) dependent on a multitude of attribute requirements. From a Wildfire Response focus, knowing tax values, could utilize building footprints for calculating wildfire estimates. We currently collect estimated values for threatened homes and structures, lost homes, and structures, protected homes, and structures.
11. NC Office of Recovery and Resiliency	Recovery assistance and resiliency planning. critical for accurate risk assessment, disaster recovery and resiliency planning. They are used directly to estimate the impact of storms and to get federal disaster declarations expedited to assist in relief efforts
12. FEMA (within US Department of Homeland Security (DHS)	Used jointly with the NC Department of Public Safety for preliminary damage assessments and disaster declarations. Owner of the USA Structures data that could possibly be leveraged for geometry updates.
13. OSBM Demographic and Economic Analysis	Used to update US Census Bureau Master Address File to ensure complete count of population during decennial census. Potential future use as a data source for annual certified municipal and smaller area population estimates if residential housing units are identified. Housing units and change in housing units are important inputs to population estimates models. The once a decade census counts and annual state and federal

	population estimates help inform population projections and the distribution of resources (including annually more than $43.8 billion in federal funds and $1.8 billion in state funds) to regions and communities.
14. Private Sector	It is assumed private businesses utilize this statewide data for public sector clients as well as other outside uses. Individual uses may vary and input from this sector has not been received as part of this working group effort.
15. NC 911 Primary Safety Answering Points (PSAPs)	Brunswick County PSAP utilizes building footprints as a reference layer to indicate on a base map the general size and existence of a structure. Actively working towards transforming the layer into an attribute layer that will help to determine initial unit response plans by showing what type of structure is involved which ties into critical fire response incidents such as structure fires and collapses. i.e., mobile home vs. industrial warehouse. Potential work with utilizing a building footprint as a container for indoor mapping of floorplans to better map exact caller locations inside facilities such as schools. During weather events the footprints are vital for helping to distinguish impacted structures for evacuations, flooding and search and rescues.
16. NCDOT	GeoAI Training Data Study area potential impacts and minimizing impacts, occupying floodplains, indication of traffic patterns and trip generation Facility Maintenance and linking to NCDOT database of NCDOT owned structures Early Right of Way Relocation/Acquisition cost feasibility Generating visualizations during the planning process prior to surveys being completed Required attributes: Structure condition, Fuel Canopy, Number of stories, Address, Lowest Floor Elevation, Lowest adjacent grade, building materials, square footage, Age, Condition, Construction type, Use type
17. DCR - Historic Preservation Historical Resources	The existing building footprint dataset enables the State Historic Preservation Office to hone the spatial extent of field surveys; locate properties of interest not visible from the public right-of-way or which are shrouded with vegetation; identify historic buildings at flood and sea-level rise risk; and make damage assessments to those buildings in the wake of hurricanes and other disasters. Additionally, an enhanced dataset could streamline the process of finding and assessing comparable historic properties, as federally required by Section 106 of the National Historic Preservation Act of 1966. "Year built" and "ghost building" geometry are critical elements for the office; the date the building was last occupied or altered, its condemned status, and/or demolition schedule are also valuable.

Table 6: Stakeholder Matrix

Table 7: Optional attributes identified by business uses

Field	Potential Derived Source	Data Type	Description
PHOTOFILE	Statewide Parcels	Text	File name of digital picture taken of structure from where attributes were assessed / gathered. Naming convention should mirror BLDG_ID.
YRBUILTSRC	Statewide Parcels	Text	Year Built Attribute Source.
BLDG_VALUE	Statewide Parcels	Numeric	Building Value.
BLDVAL_SRC	Statewide Parcels	Text	Building Value Source.
HTDSQFTSRC	Statewide Parcels	Text	Heated Square Footage Source.
FOUND_TYPE	Statewide Parcels	Text	Structure Foundation Type.
BASMENT_TY	Statewide Parcels	Text	Basement Type.
NUM_UNITS	Statewide Parcels	Text	Number of Units.
MATERIALS	Statewide Parcels	Text	Structure Material
BLOCK_ID	Spatial Overlay	Text	Census Block Identification Number.
FLD_ZONE	Spatial Overlay	Text	Flood Zone.
STATIC_BFE	Spatial Overlay	Text	Is the building within a flood zone with elevations determined with Static BFE?
ISCOASTAL	Spatial Overlay	Integer	In Coastal Zone? 0 = No, 1 = Yes.
NRHD	Spatial Overlay	Integer	Is the building located within and subject to a National Register Historic District? 0=No, 1=Yes
LHD	Spatial Overlay	Integer	Is the building located within and subject to a Local Historic District? 0=No, 1=Yes
HU_MBLD_TY	HAZUS	Text	HAZUS Hurricane Model Building Types.
HU_SCHEME	HAZUS	Text	HAZUS Hurricane Region Scheme.
EQ_SCHEME	HAZUS	Text	HAZUS Earthquake Region Scheme.
EQ_MBLD_TY	HAZUS	Text	HAZUS Earthquake Model Building Types.

EQ_DES_LVL	HAZUS	Text	HAZUS Earthquake Design Level.
EQ_ZONE	HAZUS	Text	HAZUS Earthquake Zone.
FL_SCHEME	HAZUS	Text	HAZUS Flood Scheme.
ISGHOST	GENERATED	Integer	Is this building a ghost structure? 0 = No, 1 = Yes.
WIND_ZONE	N	Text	Wind Zone for Manufactured Homes Only (OCCUP_TYP = RES2) and BUILD_TYPE = MANUFHOUSING.
BLDGADJFAC	N	Numeric	Adjustment Factor for Replacement Value.
BLDGREPVAL	N	Numeric	Building Replacement Value.
CONTREPVAL	N	Numeric	Contents replacement value.
INVREPVAL	N	Numeric	Inventory replacement value.
FFE	N	Numeric	First Floor Elevation.
FFE_TYP	N	Text	Type of Survey used to obtain this FFE.
LIDAR_LAG	N	Numeric	Lowest Adjacent Grade Derived from LiDAR.
LIDAR_HAG	N	Numeric	Highest Adjacent Grade Derived from LiDAR.
RISE	N	Text	Rise of Structure i.e., high, mid, low...
ROOF_SHAPE	N	Text	Shape of the roof.
ROOF_SLOPE	N	Text	Slope of the roof.
ROOF_CV_TY	N	Text	Roof Cover Type.
ROOF_CV_QL	N	Text	Roof Cover Quality.
S2_WTR_RES	N	Text	Secondary Water Resistance?
RF_DECK_AT	N	Text	Roof Deck Attachment.
RF_DECK_AG	N	Text	Roof Deck Age.
RF_WAL_CON	N	Text	Roof Wall Connection.
RF_FRAM_TY	N	Text	Roof Frame Type.

M_RFDCK_AT	N	Text	Metal Roof Deck Attachment.
SHUTTERS	N	Text	Hurricane Shutters?
TIE_DOWNS	N	Text	Hurricane Tie Downs?
WINDOW_AR	N	Text	Window Area.
GARAGEDOOR	N	Text	Measure of Garage Door strength for houses with or without hurricane shutters.
MAS_REINFR	N	Text	Masonry Reinforcing?
JOIST_SPAC	N	Text	Roof Joist Spacing.
WINDDEBRIS	N	Text	Wind Debris.
DEFN_SPACE	N	Text	Has defensible space been created around the property in regard to protection against Wildfire?
HZFUELREDC	N	Text	Have hazardous fuels reduction measures been put into place in regard to protection against Wildfire?
IGNRESMATL	N	Text	Were ignition-resistant materials used during construction or upkeep in regard to protection against Wildfire?
EXCLUDE	N	Integer	Conflation Process, exclude feature function. 0 = No, 1 = Yes.
PIDSTATUS	N	Text	Used during the conflation process exclusively.
LPARCLSTAT	N	Text	Used during the conflation process exclusively.
ISLIMWA	N	Integer	In Limit of Moderate Wave Action (LIMWA) Zone? 0 = No, 1 = Yes.
CONDITION	N	Text	Structure Condition
FUEL_CANOPY	N	Text	Fuel Canopy
ROOF_MATERIAL	N	Text	Roof Material (fire-resistant/non-combustible)
CHIMNEY	N	Text	Chimney (present, spark arrestor, or non-existent)
ATTIC_VENTS	N	Text	Attic Vents (ridge, gable, 1/8-inch metal mesh screening)
EAVES	N	Text	Eaves (boxed, unboxed, sealed, not sealed)
GUTTERS	N	Text	Gutters (existent, no existent, clean, or filled with debris)
SIDING_COMP	N	Text	Siding Composition (fire resistant, vinyl, wood)
WINDOWS	N	Text	Windows (double pane tempered glass or single pane)

ATTACHMENTS	N	Text	Attachments (porches, decks, steps, and landings screened with 1/8-inch metal mesh or underpinned
VERT_ATTACH	N	Text	Vertical Attachments (fences, trellises, and retaining walls)
LANDSCAPING	N	Text	Landscaping (fire resistance)
OVERHANG_LIMBS	N	Text	Overhanging Limbs (trimmed more than 10 feet)
S2S_IGNITION	N	Text	Structure to Structure Ignition Potential (within 30 feet of adjacent structure
DEFENSE_SPACE	N	Text	Perimeter (clear defensible space distance out to 100 feet)
COMBUST_HAZ	N	Text	LP Gas and other combustibles surrounding structure
DRIVEWAY_WIDTH	N	Text	Driveway Width with vertical clearance for emergency vehicle access
VISIBLE_911	N	Text	911 Address visible from both directions with 4-inch reflective numbers
HISTORIC	N	Text	Does the building have a historic designation (National Register, State Study List, Determination of Eligibility)
LOCAL_LANDMARK	N	Integer	Does the building have local landmark status? 0=No, 1=Yes
ARCH_STYLE	N	Text	What is the primary architectural style of the building
HISTORIC_USE	N	Text	What was the building's historic use, if different from OCCUP_TYPE
ARCHITECT	N	Text	Name of the building's architect or builder
LOC_INTEGRITY	N	Text	Is this the original site of the building, a moved site, or unknown
OUTBLDG_TYPE	N	Text	If the building is secondary on the parcel, what type is it
EASEMENT	N	Integer	Does the building have an easement or covenant attached to it? 0=No, 1=Easement, 2=Covenant, 3=Both
DEMO_DATE	N	Date	Date the building was removed from the site (typically demolished, but could be moved)
HOUSE_FORM	N	Text	If the building is a house, what is its general form

Committee Member	Organization	Committee Member	Organization
Ben Shelton	Co-Chair, CGIA	Michael Gore	FEMA
Darrin Smith	Co-Chair, CGIA	Mike Cline	State Demographer's Office
Brett Spivey	CGIA	Nick Short	NCDOT Photogrammetry
Colleen Kiley	CGIA	Marc Swartz	NCDOT Photogrammetry
Brian Ross	Brunswick County Sheriff's Office	Hannah Thompson-Welch	NC Forest Service
Cesar Castro	NC Office of Recovery and Resiliency	Chris Miller	City of Boone
John Cox	NC Dept of Administration	Richard Fogleman	AECOM
Dan Madding	NC Emergency Management	Stan Duncan	Henderson County (*Retired*)
John Lay	NC Emergency Management	Joseph Sloop	Forsyth County
Adam Blythe	NC Dept of Insurance	Andrew Edmonds	NC Historic Preservation Office

Table 8: Working Group for Building Footprints Committtee

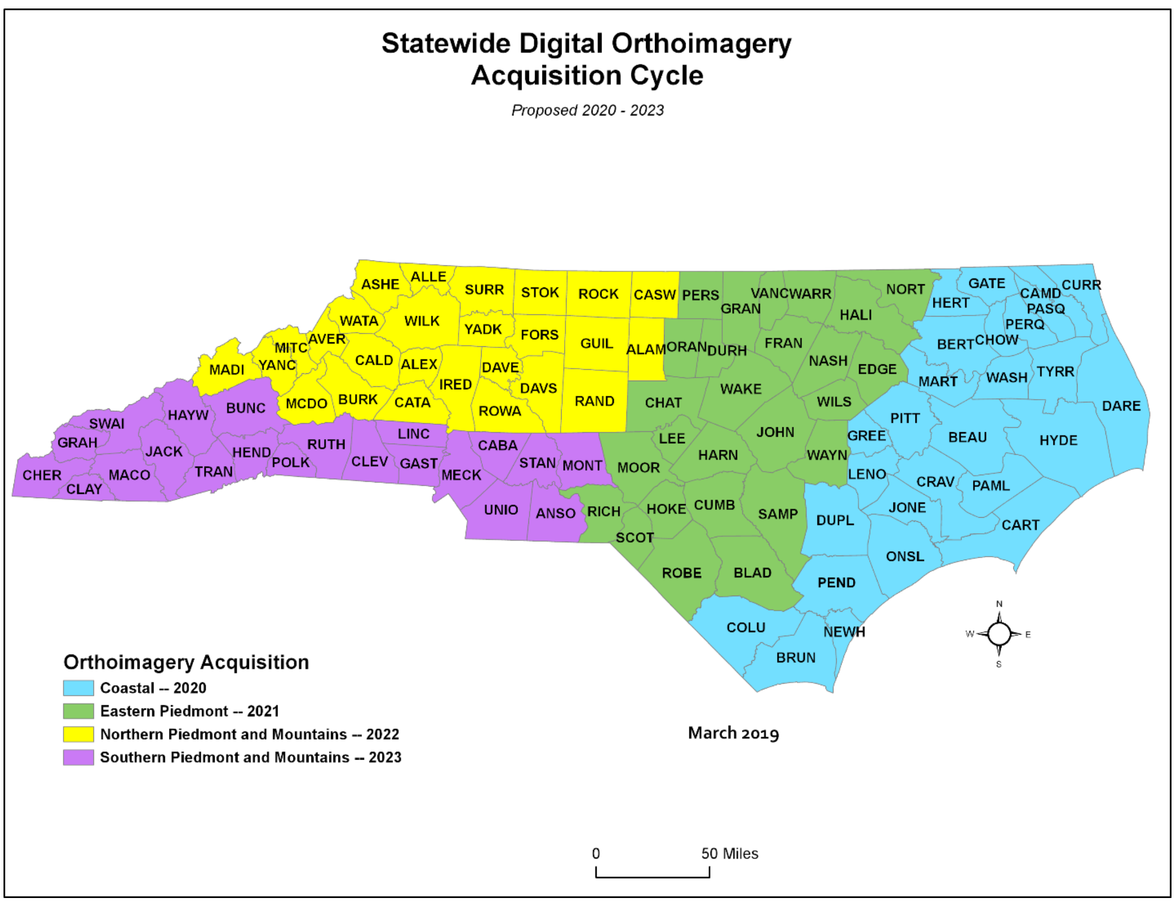

Figure 5: Current Statewide Orthoimagery Cycle