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3D Digital Documentation of Historic Launch Complex Structures at CCAFS: A Workflow Methodology for Cultural Resource Documentation - LC19 and LC34 Areas of Interest

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3D Digital Documentation of Historic Launch Complex Structures at CCAFS: A Workflow Methodology for Cultural Resource Documentation

LC19 and LC34 Areas of Interest

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Prepared for: 45th Space Wing, Cape Canaveral Air Force Station

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Project Overview

Working in collaboration with the 45th Space Wing of the United States Air Force, Cape Canaveral Air Force Station (CCAFS), this digital survey and documentation was undertaken to provide continuing baseline terrestrial laser scanning (TLS) survey, monitoring, and spatial recordation for selected historic launch complexes. Targeted structures were chosen for ongoing assessment and 3D laser scan survey, and these data were brought together with aerial Light Detection and Ranging (LiDAR) and Geographic Information Systems (GIS) applications in a digital platform for landscape and structure consideration. The project was performed in combination with Global Positioning Systems (GPS), videography, and imaging documentation, with the 3D terrestrial laser scanning providing the referent data for the derived 3D Computer Assisted Drawing (CAD) products and archival as-is conditional reference. Previously, six historic launch complexes, two building complexes, and associated structures and features were documented using the survey methods presented here (Figure 1). In this present survey, two additional launch complexes and all associated buildings and features were similarly recorded from the initial survey project (see Collins and Doering 2015), and our analyses using both previously collected data as well as newly acquired data continued and has been further developed (Figure 2).

All work was conducted in accordance with the National Historic Preservation Act of 1966 (PL 89-665) as amended and the Archaeological and Historic Preservation Act of 1974 (PL 93-291) and was performed and directed by a Register of Professional Archaeologists (RPA) qualified archaeologist. In addition, all work meets the guidelines as set forth in the Historic Preservation Compliance Review Program of the Florida Department of State, Division of Historical Resources.

As with the previous survey (Collins and Doering 2015, Collins and Doering 2016), this project utilized a combination of spatial documentation tools including terrestrial laser scanning (TLS) and photogrammetric and imaging techniques, to record as-is and as-built conditions of several structures within historic launch complexes and additional feature (building) locales. The present survey utilized best available documentation survey techniques in an effort to digitally archive and preserve the sites and terrains, and to provide an accurate record for visualization, replication, management, and archival needs. At the landscape level, aerial LiDAR models were combined with areas of terrestrial laser scanning survey, and can allow for the examination of issues and to provide precise means of assessing loss and developing mitigation and stabilization strategies (Abby 2014). Aerial and Terrestrial Laser Scanning (LiDAR) data collection and interpretation has been described as one of the most significant innovations for the field of archaeology and for landscape analysis (Opitz 2013).

Global Positioning Systems (GPS) and Geographic Information Science (GIScience) was utilized to record locations and features of interest in the immediate surrounding environ. Data collected in the 3D survey were used to produce accurate sectional details, models, and drawings of selected structures and complexes, and were used to depict and record terrain conditions associated with the resource. Using data collected on site (TLS, GPS, photographs and notes, in combination with aerial LiDAR and aerial imagery), relevant 3D CAD models, profiles, and perspectives depicting existing conditions were also prepared. These CAD perspectives and drawings, as well as GIS cartographic and 3D products included location maps, terrain and elevation models, and profile and sectional analyses for each site. Sectional details were compared to available as designed drawings. Historic American Building Survey (HABS) and Historic American Engineering Records (HAER) level CAD measured drawings and products were available on some of these complexes and structures, and when possible, comparisons were made to the actual site configurations and
Figure 1. Historic launch complexes, buildings and features documented as part of the initial survey.
Figure 2. Documented historic structures and facilities for the Cape Canaveral TLS Survey completed in second phase. All of LC 19 and 34 were added to the previous documentation, and data development and analyses continued on several target areas for monitoring and condition assessment.
layouts as well as to structural analyses and details. The TLS data collected by this survey stands as a lasting
digital archive of these structures in their current condition, and provide valuable information concerning
monitoring and condition assessment, relationship with natural systems and landscape documentation, and
other management and historic preservation documentation needs.

Aerial LiDAR data was acquired and processed to provide detailed terrain maps for all landscape areas,
yielding a topographical understanding of the historic and modern setting. Additionally, GPS survey and
GPS photography were used to field truth and verify areas of interest and to provide overall site plan map
details and conditional assessment and attribute information.

A GIS geodatabase and derived GIS products (FGDC compliant metadata and data quality standards used),
provide spatial understanding for resources that are presently located within the project area. A GPS photo
report was also produced as a PDF document, showing conditions and features with coordinate and
viewshed information and is provided as an added value product. The TLS data, used to produce sectional
information, are also provided in a 3D PDF format, allowing for manipulation and visualization of the 3D
structural and terrain features. All 3D data collected are kept by the University of South Florida and also are
provided in archival formats using the ASTM E57 standard for 3D imaging data exchange, which is a vendor
neutral data format. All 3D models provided are in ubiquitous .obj formats that are viewable and sharable in
numerous free and neutral software. See our Cape Canaveral collection at:

This report overviews the 3D documentation project and provides representative product examples and
materials developed. An external hard drive is provided in addendum to this report, containing all GPS, GIS,
Geodatabase, imagery and TLS survey data and models produced. A variety of data formats are provided
and will be discussed in later sections. These formats allow for freely available software applications and
viewing of collected information, and serve as a management, visualization, and archival record foundation
for the complexes and facilities documented.

Survey Methods
The Cape Canaveral 3D Digital Documentation Project (Phase 2), utilized a new approach to bringing
multiple types of data together, including 3D, 2D, GIS, and imaging formats, providing an important tool for
archival documentation, management and decision-making. The survey began with a bringing together of
remotely sensed (aerial LiDAR and aerial imagery) data with ground-based survey data such as TLS and GPS
survey data and collected photographic attribute information using standard, panoramic, scanner spherical,
and GPS imagery types. Special effort at 3D archival level documentation and full 3D modeling were
performed for selected facilities and structures at two launch complexes and selected locales. Each area,
along with methods used and results will be overviewed in this report, along with section discussions on each
of the methods used.

Terrestrial Laser Scanning Survey
A 3D laser scanning survey was performed, including full spherical photographic and standard (external from
the scanner) photographic documentation, as well as utilization of aerial LiDAR survey data. Three
dimensional laser scanning surveys can offer a method of rapidly and accurately producing highly
representative and precise 3D details of complex terrains and architectural structures. Accurate portrayal
and understanding of spatial locations of resources is important from both a management perspective and
from a research and public interpretive perspective. The resultant survey was used to create 3D plan view,
profile and sectional analyses, which were provided for detailed CAD and 3D renderings, orthographic
projections, and 3D models. 3D data collected in the survey were used to create a digital archive of current “as-is” conditions, as well as to provide information for the “as-built” understanding of the site for 3D CAD architectural plans. The TLS data were also exported for use in GIS applications.

Accurate spatial mapping can be used to develop slope and erosional representations, and coastal change assessments, and allow delineation for regions of concern for management, having the added value of providing important information for both natural and cultural resource management. These models can also help to provide a precise means of assessing loss and to develop mitigation and stabilization strategies for natural and cultural features (Abby 2014). Models were produced using a combination of aerial laser scanning (ALS) or LiDAR, terrestrial laser scanning (TLS), and ground truth verification with GPS. The Principal Investigators are integrating ALS with TLS and other techniques to examine large scale landscape areas, with rapid and highly accurate assessments of elevation and surface details possible. The GIS exports entailed bringing the TLS data together with the ALS data to provide a more comprehensive overview of the complexes and facilities. ALS data alone would not have provided sufficient detail features on specific structures, but does provide context and landscape terrain details that were brought together with specific TLS target areas. In this way, areas of documentation interest and target can be captured with the highest level of detail and brought together in modeling and GIS platforms with associated structures and features to provide landscape settings and conditions across a large area. Correct assessments of not only locations, but capturing details allowing for a change detection analysis at these sites can insure preservation into the future. Our work to develop accurate digital elevation models (DEMs) derived from ALS, GPS, and TLS applications, should be utilized as a means of assessing condition more accurately and monitoring changes and stabilization needs at the locations where work was performed.

These types of surveys have proven successful for the analysis and conservation of historic objects, structures, and environments (Murphy et al. 2013). Polygonal mesh 3D models were produced, allowing for digital sharing, archiving, and for new techniques such as 3D printing to be performed. These data can be used to create interpretive and tangible items, including full landscape and structure scaled models or even the potential for full-sized architectural detail and object replicas (Leronesa 2010). Complete 3D models were derived from the 3D laser scanning survey data. These data are useful for engineering records and to establish an architectural archive for the feature. Digital terrain models can be shared in fully viewable 3D formats and provide data for future computer interactive apps and interpretative development.

The TLS survey utilized two phase-based FARO Focus 3D laser scanners (x130 and x330 models), chosen for reasons of portability and size as well as robustness and accuracy in spatial metrology and representative documentation needs for the project. Additionally, the x330 model combined distance (up to 330 meters) with low data noise and high accuracy at +/- 2mm. Spherical 360 degree images were acquired concurrent with the TLS survey. Software registration utilized survey targeting schema designed for this project. Options for limited visibility of targets were initiated because in some instances, visibility was a factor due to the complexity and geometry of buildings and spaces being captured in the survey. Intricate or sometimes overly symmetrical geometric positioning, required that pre-planning strategies be developed to examine the distribution of targets that would be used for data registration. For example, targeting for scan point cloud registration can prove difficult in straight line confined and largely symmetric locations, which are challenging for constrained matching and registration of point clouds and surfaces in the post-processing of data (Bellekens et al. 2014). Shafts, tunnel features, and circular shaped structures all pose these types of challenges for TLS survey methods. Subsidence and deformation studies utilizing these data for monitoring and analytic potentials are planned for, and data were collected to be representative as well as serve as a foundational archive for planned return targeted scanning documentation in the future. Sectional analysis and research into the stability and conditional aspects are also possible with a high degree
of accuracy and representativeness using the TLS data (Gu and Xie 2013). The TLS data also enable accurate calculation of volumetric and metrology details, with findings important from a structural assessment perspective as well as from an interpretive perspective in regards to the construction methods and historical engineering.

**GPS, GIS and Cartography**

The 3D documentation survey is inclusive not only of the TLS survey data collected, but is brought together with other forms of spatial and legacy data in a GIS geodatabase platform. The project geodatabase includes all of the collected GPS (sub-decimeter data) and GPS photographs, as well as the LiDAR 3D products. Cartographic products made in the GIS include a site level DEM, digital surface models (DSM), contour maps and terrain models, and 3D GIS and web GIS models. Feature locations, attribute information and the condition details were recorded using GPS across the site, and these data are contained as part of the project geodatabase files.

GPS field data collection for this project provided spatial control for survey precision and accuracy, location and attribute information for database development and for use with interpretive and interactive tools, and provided data for use in georeferencing legacy and previous survey maps that were utilized to view, understand and portray the historic landscape. USF hosts a project page for the Cape Canaveral 3D Documentation Project, and is building a new digital collection site that is part of ongoing funded work. These collections contain most of the GIS cartographic products utilizing the GPS data collected, as well as an online version of the interactive map (Figure 3).

Additionally, a story mapping project was completed for several of the launch complex features and the documentation project, as part of a student project initiative for the USF Museum Visualization course. In this project, graduate students worked with undergrads to develop online interpretative concepts for Cape Canaveral, using data from our survey. Curriculum and course design involved content about Cape Canaveral, using the project as a means of learning about digital heritage preservation and heritage tourism concepts (Figure 4). Efforts are continuing to build more in terms of web and collection platforms and interactive teaching tools, and will be part of the next phase of work that is continuing in 2017-2018.

**Sectional and CAD Analyses**

Sections and orthographic image details from the scan data allowed for CAD, GIS products (especially when combined with LiDAR data and GPS information), and sectional elevation analyses. 3D imaging can be evaluated by sections, and can be compared against as-designed and historic or legacy information (Figure 5). Using the GIS structure, several cartographic products have been created, including site plans and sectional analyses. Data slices and orthoimage point cloud renderings also provide architectural and engineering details and analysis information that can be measured precisely and visualized in a number of ways. Both slices and orthoimages are scaled and contain spatial information that allows for the import into CAD based software, affording highly accurate drawings to be made that portray profiles, elevations, site plans, and other important architectural details (Figure 6). From these slices and data sections, we have provided information for architectural analyses and the production of as-built archival 3D CAD models and detail records. Scan data exports such as tomographic slicing, orthophoto scaled images, and direct CAD import methods are allowing historic documentation records to reflect more accurately, precisely, and representatively the as-built and conditional aspects of landscape and structural features, as compared to more subjective and laborious traditional methods of measurement.
Figure 3. The interactive map web portal (above) allows users to view 3D, CAD, photos, and terrain information for all areas surveyed. This “living document” can be expanded and added to as more data or survey information is collected.
Figure 4. The Story Mapping of Cape Canaveral involved students learning and using web-based GIS tools along with data and information relating to digital preservation, museum interpretative and heritage tourism concepts. The project overviews the course assignment and efforts, and showcases information in a GIS interactive web site about several of the launch complexes that were surveyed. The site includes present day conditions, historical images and maps, and 3D models and interpretative designs.
Figure 5. TLS survey data from BR2268 (Theodolite Building 1 at LC 19 Complex), is here compared against legacy as-design drawings. In this manor, 3D software tools are used to evaluate current conditions against previous or historic conditions, or as in this case, design evaluation against reality.
Figure 6. TLS survey data for the Flame Deflectors (BR2293) at LC34. The point cloud data is shown in elevation perspective, plan view and orthographic slice showing sectional analysis of interior construction and footprint.
Survey Locations
Launch Complex 19 (BR2260)

Launch Complex 19 is one of a number of significant historic launch complexes at the Cape Canaveral Air Force Station (CCAFS). It was listed as National Historic Landmark (NHL) based on its role in the Gemini Manned Space Missions of the United States Man in Space Program, and is also listed in the National Register of Historic Places. According to the Historic American Engineering Record (McCarthy et al. 1994:ii), “Complex 19, [is] rapidly deteriorating, [and] is a safety hazard due to time and the salty environment.”

Construction of four identical and same design launch complexes that were built for the Titan ballistic missile testing program, began in 1959. Launch Complex 19 was one of four identical complexes created, along with Launch Complexes 15, 16, and 20 (Figure 7), to be used for the Titan I missile launches from late 1959 into the early 1960s. Initially activated in June of 1959 to test the Titan I and II Intercontinental Ballistic Missiles (ICBM) (Figure 8), LC19 was converted from weaponry testing into the U.S. Space Program’s only manned Titan II/Gemini launch complex. Two unmanned and ten manned Gemini missions lifted off from LC19 between April 1964 and November 1966 (Figure 9). In 1984, Launch Complex 19, as part of the CCASF Historic District that included Launch Complexes 5, 6, 13, 14, 26, 34, and the Original Mission Control Center, were collectively listed to the National Register of Historic Places (National Park Service and United States Air Force 1983). Later, in 1994, Launch Complex 19 was individually designated a National Historic Landmark (McCarthy et al. 1994:38-39).

Launch Complex 19 initially consisted of a number of structures and features that were constructed by the Corps of Engineers and the Martin Company to accommodate the Titan Missile testing program. A number of modifications and additions were made when the complex was converted to the launch site for the Gemini Program. A total of 29 launches were made from the complex with the last flight in November 1966, and a number of significant astronauts and individuals were associated with the facility (Figure 10). Following the deactivation of the complex in April 1967, for safety reasons, portions of the launch tower and other rusted servicing structures were removed (Lipman 1977:3), and the remainder of the metal erector was demolished in 2012-2013. The White Room, a small area first used in Project Gemini, allowed NASA astronauts to access the spacecraft, was moved to the CCAFS Space and Missile Museum in September 2003 (http://afspacemuseum.org/).

The following information regarding the structures at LC19 were derived from the McCarthy et al. Historic American Engineering Records of Complex 19, Cape Canaveral Air Station, Cape Canaveral Florida, Final Report (1994); R. W. Powell’s Activation Plan for Launch Complex 19 and the Launch Vehicle Support Area (1962); the National Park Service and United States Air Force Cape Canaveral Air Force Station National Register of Historic Places Inventory Nomination Form (1983); and the 2008, Florida Master Site File Forms (FMSF) submitted by Thomas Penders, the CCAFS 45 SW Cultural Resources Manager. The Resource Group was collectively assigned the FMSF number 8BR2260 and contains 11 of the remaining LC19 structural elements at the site. Each of the historic structures within LC 19 were also individually recorded.
Figure 7. As-built drawing plans showing the identical LC15, 16, 19, and 20 locations (Radar and Associates 1960).

Figure 8. Image from Titan launch on December 15, 1959 from pad 19.
Figure 9. Historic American Engineering Record (HAER) report drawings of the Launch Complex 19 area showing site plan above (McCarthy et al. 1994:67), and as built design of complex below (Radar and Associates 1956).
The original launch complex consisted of the blockhouse, launch ramp and test stand, propellant farms, water flume and deluge basin, an umbilical tower, erector service tower, ready room, and an astronaut recovery area. The latter four structures no longer exist due to deterioration, demolition, or removal. Construction of LC 19 began in October 1956 and was completed in June 1959. In 1962, the complex was modified by Aerospace Corporation, the Martin Company, and the Corps of Engineers from missile weapons testing to the Gemini Space Program. A series of constructions, adaptations, and alterations were made to accommodate the new requirements of the Space Program (McCarthy et al. 1994:53). For example, there was installation of new equipment in the Blockhouse, an enlargement of the test stand and west erector, along with the addition of oxidizer and fuel farms, an air-conditioning outbuilding, and a decontamination building.

TLS survey was conducted at Launch Complex 19 (Figures 11 and 12), and included GPS survey, GPS photography, photogrammetric images of built structures, and laser scanning with a mid-range terrestrial LiDAR instrument. This area, inclusive of all exteriors of structures (interiors where access was feasible or allowed and where necessary) and surrounding landscape features, were documented using the previously described survey methods (Figure 13). The TLS and spatial surveys included documentation of the following structures:

1) BR2261 – Launch Complex 19 Blockhouse
2) BR2262 – Launch Complex 19 Cableway
3) BR2263 – LC19 Decontamination Bldg.
4) BR2264 – Launch Complex 19 Launch Stand, Ramp
5) BR2265 – Launch Complex 19 Erector
6) BR2266 – LC 19 LOX (aka Instrument Building)
7) BR2267 – LC 19 Oxidizer Holding Area
8) BR2268 – LC 19 Theodolite Building
9) BR2269 – LC 19 Fuel Holding Area
10) BR2270 – LC 19 Flume and Catchment Basin
11) BR2271 – LC 19 Theodolite Building #2
Figure 11. General location map for Launch Complex 19 at Cape Canaveral Air Force Station, Florida.
Figure 12. Site location map for the digital documentation survey.
Figure 13. LC 19 TLS survey locations included all the associated structures and features for the complex that are still extant. This site plan map was created from aerial and terrestrial LiDAR data collected in combination with GPS data for ground verification and reference.
LiDAR data processing included the blending of terrestrial laser scanning data sets with aerial LiDAR to allow for complete and detailed focus across the launch complex. These LiDAR and survey data were brought together to create landscape assessments in the form of digital elevation models (DEM) and surface models (DEM) for the complex (Figures 14 and 15). The DSM for the LC19 is useful in examining accuracy, change, and location information presented in georeferenced legacy data, such as the McCarthy et al. (1994) Historic American Buildings Survey (HABS) and Historic American Engineering Record (HAER) survey map of the site (Figure 16). Georeferenced legacy maps are provided in the developed geodatabase for the complex location, and allow for an archival and comparative spatial analytic platform going forward into the future.

BR2261 – Launch Control Center, Launch Complex 19 Blockhouse
The Blockhouse at LC19 was the command center that controlled the launch vehicle (Figure 17). The construction design of the blockhouse at LC19 (8BR2261) was a single-pad, with a single blockhouse for the launch complex. The control center was a circular, two-story structure that measured 156 feet in diameter and 50 feet in height. Personnel directing the launches from inside the structure were protected by its 20 foot thick concrete and steel reinforced, sand and concrete mortar exterior walls. Personnel who controlled and monitored launch proceedings at the launch area were only 600 feet away from where the launch took place. To further protect the structure and its contents, an eight inch thick, reinforced concrete retaining wall was constructed around the perimeter of the blockhouse. Observation of the launch stand and pad was possible from within the launch control room, which had four periscopes that extended through the roof of the blockhouse. The entrance was on the west side of the structure, which also contained utility and equipment rooms. The first floor contained the Ready-Room, the Operations Room and the Instrumentation Repair Room, two escape pit areas, and a general area, while the second floor largely contained console and equipment racks and monitoring capabilities, as well as a VIP viewing room.

According to the 1994 McCarthy et al. report (1994:42), the blockhouse appeared to be in relatively good condition and looked “very much the same as it did in the 1960s with instrumentation racks and consoles in place and an operational periscope.” The conversion to the Gemini program in 1962 required relatively minor changes to the blockhouse (e.g., numerous instrumentation, communications, safety, and power systems were replaced or upgraded; improvements were made to the air-conditioned ventilating systems)(Figures 18 and 19). After the decommissioning of the complex in 1967, the blockhouse has been used as a storage facility for documents and records relating to NASA’s Space Shuttle Program (McCarthy et al. 1994: 42).

Methods of Documentation
The BR2261 (LC19 Blockhouse) was documented as part of the overall complex survey using a series of digital and spatial tools. Methods of digitization and documentation included the use of standard and spherical photography, gigapixel and specialized high resolution imaging, aerial LiDAR, terrestrial laser scanning, and GPS survey. Additionally, field condition assessments were made and data collection was targeted in such a way that comparative and repeat measurements and studies can be made into the future.

TLS survey included the exterior of the structure, and consisted of a total of 32 scan positions, of which 18 were ground based and the remaining were elevated positions (Figure 20). These positions allowed for a wide coverage of both building footprint and surrounding terrain information (Figure 21). From these data collected, inclusive of several imaging and GPS tools (Figure 22), 3D models and CAD perspectives, elevations and drawings of the structure have been developed (Figures 23 and 24). Aerial LiDAR, used in conjunction with the TLS survey provides complete coverage of the entire complex as well as detail on specific areas, like the BR2261 location (Figure25).
Figure 14. Digital Elevation Model (DEM) is a 3D representation of the terrain, derived from aerial and terrestrial LiDAR data at LC19 (BR2260). Note that the DEM is processed to reveal building footprints which show here as bare areas.
Figure 15. Digital Surface Model (DSM) of the LC19 area derived from aerial and terrestrial LiDAR. Note that the DSM shows elevation data across both natural and built surfaces, showing for example tree heights and building elevations for the entirety of the complex.
Georeferencing legacy information and historic maps assists in analyzing the site, can help in locating extant structures and features, and provides a timeline for alterations and change that has occurred at the site.
Figure 17. BR2261 – Launch Complex 19 Blockhouse; view facing east.

Figure 18. Line drawing of Blockhouse for LC19 (McCarthy et al. 1994:68).
Figure 19. CAD drawings showing interior of first and second floors of Blockhouse at LC19 (McCarthy et al. 1994:69-70)
Figure 20. Webshare data for LC19 Blockhouse (BR2261) showing locations and data from the TLS survey.

Figure 21. Webshare view of the Blockhouse at LC19, with tools for calculating area and measuring distances available for viewing analysis. Scanning in this area captured the associated cableway, roads and surrounding terrain. The cone shown provides the viewer with the direction of the selected scan location.
Figure 22. Gigapixel image (above) created from high resolution photographs made at defined intervals (middle) from atop the LC19 Blockhouse, allow for digital exploring and perspective analysis using online and sharable platforms (see: http://gigapan.com/gigapans/177977 ). These images allow for panoramic and detail viewing online. The figure shown below is a zoomed in view from the same panoramic gigapixel image.
Figure 23. 3D model created from the TLS data of the Blockhouse at LC19 (BR2261).
Figure 24. CAD model showing roof perspective and side elevations for the BR2261 site (LC19 Blockhouse). The 3D modeling and CAD were derived from the TLS survey data.
Figure 25. LiDAR derived digital surface model (DSM) of the LC19 Blockhouse and surrounding area, including the cableway and adjacent structures. LiDAR data (terrestrial and aerial combined) coverage for the entirety of the site area is processed to provide accurate assessment of ground and structure details.
Our 2016 survey noted several condition assessment issues including the following:

- Vegetation surrounding and beginning to encroach onto and into structure
- Rust starting on upper observation deck and on all doorframes
- Vinyl seams at vertical joints around structure’s perimeter are deteriorating and concrete beginning to breakdown creating surface defoliation and erosion
- Vegetation/invasive exotics are penetrating the dome surface and causing surface cracking

These noted areas and conditional details can be used to revisit, assess, and monitor at select locales as part of future project efforts (Figures 26-31). Additional assessments for the site include analysis of change through time as noted from both historic photographs made available and from examining historic aerials of the overall launch complex as well as the blockhouse and pad features (Figure 32).

*Figure 26. Metal corrosion on the periscopes (left) and the mounting area attaching upper deck platform to the LC19 Blockhouse dome is noted. A large amount of floor grating is also showing corrosive loss across the deck area and stair areas.*
Figure 27. Using Webshare applications with the spherical imagery and scan data, assessment of conditions such as invasive exotics and vegetation intrusion can be examined.

Figure 28. Corrosion across the deck platform is noted as an area of poor condition.
Figure 29. Using the spherical images and scan Webshare files, intrusive vegetation and areas of surface loss, rust, and corrosion can be observed.
Figure 30. Areas of rust, vegetation concerns, structural and surface areas of note are located for further assessment and analysis.

Figure 31. Areas of structural assessment and condition are located spatially using the TLS and GPS data, and corresponding images and field data collected will assist with further review.
Figure 32. Historic aerial analysis for the LC 19 Complex. The collection, archiving, and comparison of digital information can assist with examining change with vegetation and structural aspects.
**BR2262- Launch Complex 19 Cableway**

The cableway is a tunnel-like, reinforced concrete structure that extends 650 feet from the blockhouse to the BR2264 launch stand and ramp area (Figure 33). The cableway is located above the ground surface and is approximately eight feet in height and seven feet wide. The structure protected the thousands of feet of cabling needed to connect the control facility to the launch facility, keeping out weather and protecting against launch blasts. Having the cabling housed in such a structure also made its maintenance relatively straightforward. Steel doors on either end of the cableway allowed entrance and exit (McCarthy et al. 1994). Today, the cableway shows some indication of deterioration, with noted problems including:

- Loss and breakage of metal, surface wall, and roof materials
- Brazilian Pepper (BP) has been removed, but has negatively impacted structure in terms of foundation and surface cracking
- Return of invasive exotics and intrusive vegetation along this area is in need of continuing maintenance and indication of new growth is observed even after relatively recent treatment (see Figure 34 showing BP extents prior to 2009 removal start date).

**Methods of Documentation**

Aerial LiDAR and TLS data were gathered for the entirety of the site location, with basic dimension measurements and review possible. Additional methods of survey included standard and spherical imagery, hand measurement, assessment and field notations, and GPS survey. The GIS geodatabase for the site includes DSM and mapping to show the size, relation, and location of BR2262 (Figure 35).
Figure 34. GPS collected data (shown in red) delineates structures— including the cableway as noted in aerial LiDAR (above)— which was more than 50 percent covered in Brazilian Pepper (BP) prior to the 2009 initiation of removal and management of BP at the site. Current conditions as seen in the 2015 aerial (below), show the clearing of vegetation. BP is currently re-emerging at the site.
Figure 35. BR2262 (LC19 Cableway) is shown in relation to the Blockhouse (BR2261) and the Launch Stand (BR2264). Tree and vegetation cover is derived from laser scanning and showing conditions at the time of documentation.

BR2263 – LC19 Decontamination Building
The construction of the Decontamination Building was conducted in 1962 as a requirement for the conversion of the LC19 1959 construction use to adaptations needed for the Gemini Program. The building is a 2,600 square foot structure located 545 feet southwest of the test stand (Figure 36). The building was needed because of the new propellant being used by the Gemini-Titan II rocket engines, that required propulsion personnel to wear hazardous protection equipment and that a separate building needed to be constructed for decontamination, maintenance, and storage. The building consisted of concrete block walls with a concrete slab foundation and built-up roof, personnel doors and a roll up garage style entry door. The interior of the rectangular-shaped structure, was partitioned into five rooms (McCarthy et al. 1994, Penders 2008). This unique building is a contributing element to the LC19 site, and is associated with famous Gemini, Mercury, and Apollo astronauts as part of the manned space program (Penders 2008). Assessment of the structure shows it to be in fair condition, although roof and gutter deterioration and corrosion of metal elements were noted (Figures 37 and 38).

Methods of Documentation
TLS survey was conducted consisting of nine ground based scan positions and spherical imagery was collected concurrently for the entire structure area. These scans were incorporated into the geodatabase terrain layer and also were used to create 3D and CAD renders of the structure (Figures 39 and 40). Standard photography was used to document the locale and GPS spatial location data were also collected.
Figure 36. BR2263- LC19 Decontamination Building showing the view to the west (above), and facing the north perspective (below).
Figure 37. Areas noted in the field condition assessment
Figure 38. Webshare site survey map (above) showing scanner position setups (red) and data collection for the BR2263 site. The Webshare spherical imagery is useful for examining elevation and perspective views of the site as it was captured. The image below showing the view facing north.
Figure 39. 3D Model derived from the TLS Survey showing the elevations of the Decontamination Building (BR2263) structure.
BR2264 Launch Complex 19 Launch Stand and Ramp Area

Located to the east of the blockhouse at LC19, is the launch stand and ramp area, which is connected to the blockhouse via the previously described cableway (Figure 41). The launch pad was the core of the complex, and was located on an artificially elevated platform, and was composed of a number of primary facilities including the approach ramp, Launch Support Building (LSB), test stand, two erector/service towers, and two umbilical towers. Secondary support or test facilities were also located in and around the pad, and paved roads encircled the perimeter to allow transporters to carry in the missile and payload sections (McCarthy et al. 1994). The ramp and stand form a roof over six bays or rooms that comprise the facility (Penders 2008, Figure 42).

The Launch Support Building (LSB) and Approach Ramp are vital elements of the launch pad. The LSB was a multi-purpose facility containing support and test equipment and systems for the launch vehicle (e.g., power, instrumentation, communication, and propellant lines; and hydraulic and pneumatic pressure controls). A 300 foot-long, paved approach ramp extends off the south side of the LSB, and to the north is the test stand, flume and deluge basin. The launch deck, which supported the erector and service towers was situated on top of the LSB. The LSB was a two-story, steel frame and reinforced concrete structure that was sixty-seven feet wide and 450 feet long. The reinforced surface permitted launch vehicle transporters to deliver the Titan I missile stages to the launch areas, and provided a stable horizontal surface for the erectors towers to reside when disengaged from the missile (McCarthy et al. 1994, Penders 2008).

The Test Stand was a sixty-seven foot square, twenty-eight foot high steel frame construction that extended off the north side of the LSB. Its primary purpose was to test rocket engines. The test stand contained two staging areas with two erector/service towers, two launch mounts, two thrust mounts, two flame buckets, and two umbilical towers. Modifications and additions, including a thirteen foot by nineteen foot ramp extension that was level with the existing stand, and placement of transfer crane at the end of the new
Figure 41. Diagram showing location of BR2264, launch stand and ramp area at Launch Complex 19.

Figure 42. 3D model perspective of the BR2264 site along with elevation image below (facing east).
extension, were made for the Gemini Program, but both have been removed from the complex. The complex was abandoned in place in 1967. The BR2264 site is part of a previously designated National Historic Landmark and the LC19 Complex has been documented by the HAER program (HAER FL-8-4) (Penders 2008). The LC19 site is eligible for listing on the National Register of Historic Places (NRHP), and the BR2264 site is a contributing element to that listing. Condition assessment concerns of note for the BR2264 site include:

- All remaining metal seriously rusted and unstable
- Concrete defoliating and exposing rebar
- Vegetation encroaching and creating problems with the structure

The noted conditions were documented using standard, spherical and GPS photography, as well as with terrestrial laser scanning, with examples of these conditions shown in Figures 43-48.

Methods of Documentation

TLS survey was conducted consisting of 27 ground-based and elevated scan positions (Figure 49). Spherical imagery was collected concurrently for the entire structure area. These scans (Figure 50) were incorporated into the geodatabase terrain layer and also were used to create 3D and CAD renders of the structure. Standard photography was used to document the locale and GPS spatial location data were also collected (Figure 51). Historic CAD data (Figure 52) can be used as a comparative form of documentation, with the 3D CAD models of the BR2264 site created from the laser scanning data (Figures 53 and 54) showing existing conditions. Areas for longer range monitoring and condition assessment were selected and demarcated with GPS for return documentation, and further analysis of current conditions and historic review continues under additional phases of this project.

BR2265 Launch Complex 19 Erector Area

Two steel-frame, multi-level towers were used to raise and position the first and second stages of the Titan I missiles into an upright position (see Figure 55). When the towers were in their vertical position, they also functioned as service towers for launch personnel. The flame buckets had curved steel plates that diverted the launch blast and fluids into the flume and skimming basin area (Figure 56). Because of the larger Titan II rocket and the spacecraft used in the Gemini Program, the erector/service towers required extensive modifications, including the addition of the "white room" and an associated crane and elevator. A depression was created in the launch deck to hold the "white room" when the erector tower was lowered to a horizontal position. Due to the deterioration and safety concerns noted at this structure (Figure 57), the erector/service towers were removed, while the Gemini white room from the top of the booster erector where astronauts made their final preparations and accessed the spacecraft, has been partially restored and is currently on display at the Air Force Space & Missile Museum located at Complex 26 (Figure 58).

Methods of Documentation

All extant features, including areas where structural remains were noted in the LC19 concrete launch pad area where captured both with the TLS survey and were marked in as features with GPS. GPS and standard images were also taken of any extant remains, as well as indicators of feature locations. Historic and legacy data were used to examine the site and for reference in the GPS survey (Figure 59). The TLS survey also captured areas such as the depression feature and roof mount locations associated with the erector and white room, and features associated with the locations of the flame buckets.
Figure 43. BR2264- Launch Complex 19 Launch Stand and Ramp area showing areas of metal deterioration.

Figure 44. Spherical scan image looking into interior of bay, with heavy rust and metal loss deterioration, including of the I-beam construction with both flange (horizontal) and web (vertical) beams in poor condition.
Figure 45. Roof grating looking out from BR2264 to north across the skimming basin area. Heavy metal corrosion and defoliation of metal is noted, as well as problems with the construction beams.

Figure 46. Concrete surface loss in areas has exposed metal rebar reinforced areas, which are corroding where exposed. Shown here is an area along the roof of the structure.
Figure 47. Shot taken looking northwesterly across the BR2264 roof (above), showing horizontal flange I beam with noted deterioration as well as area of exposed rebar and metal grate construction. Below image shows smaller opening on this section facing north, with significant metal corrosion and loss.
Figure 48. Invasive vegetation is noted across the LC19 complex, with areas along the cement construction and seams of particular concern. Roots penetrate and promote defoliation of surface, and the mechanical removal of the vegetation also proving to cause problems once these areas are established.
Figure 49. Point cloud of laser scan captured data for the BR2264 site location (above) and with the 27 scan positions shown (below).
Figure 50. Point cloud (above) showing colorized TLS survey data. Perspective image (below) of the registered 3D data shows interior and below ground surface area detail of the actuator pit.
Figure 51. DSM created from aerial LiDAR and TLS data, showing 3D model of BR2264 (insets).
Figure 52. As designed drawings from the BR2264 site as built (c. 1960).
Figure 53. General views of BR2264 showing as-is condition elements.
Figure 54. Orthographic CAD drawings created from the 3D TLS survey at BR2264.

Figure 55. Schematic drawing of the launch structure at LC19 (McCarthy et al. 1994), showing the now demolished erector, umbilical tower and related features.
Figure 56. BR2265- Launch Complex 19 erector and flame bucket shown in historic image from 2008 and prior to demolition. The cement structure and bay rooms are all that is extant today.
Figure 57. Documentation of the site by Penders (2008) show numerous structural concerns involving all exposed metal areas.
Figure 58. Now preserved and on display at the LC26 Museum site, the white room from the LC19 Launch Stand Erector location (Br2265) shows where astronauts made final preparations for manned launch endeavors during the Gemini manned space program efforts.
The twelve and one-half foot by seventy-five foot long Liquid Oxygen Explosive, or LOX, tank farm and an eighteen foot by thirty-six foot pump room were positioned on the east side of the LC19 launch stand and ramp location (Figure 60). This facility was enclosed by eighteen-foot high concrete retaining walls on the north and south sides, and a twenty-foot high blast wall on the west side. A concrete-block wall was used to partially enclose the east side. Adjacent to the east of tank was an eighteen foot by thirty-six foot pump room structure constructed on a continuous reinforced concrete platform and a poured reinforced concrete frame that was infilled with concrete block and a flat built-up roof. The simple structure was abandoned in place in 1966. Approximately 300 feet to the northeast of the launch stand, a forty-five foot by forty-five foot poured concrete retention pond was constructed to receive contaminated LOX pumped from the missile. The pond was demolished in 1962 during the conversion to the Gemini Program, and the concrete pond was broken into pieces, backfilled, mulched, and seeded (McCarthy et al. 1994, Penders 2008). The site is a potential contributor to the district and is NRHP eligible, with noted unique building construction, engineering, and architecture. Additionally, the site possess information for future research and is unique in character (Penders 2008). Condition assessment during our TLS survey showed:

- Rust on all metal, doorway frame rust allowing concrete to break-up.
- Up-lift problem of note in the floor of structure
- Africanized bees were noted inhabiting along rear of structure
- Historical images show this to be an area with reoccurring and emergent Brazilian Pepper (Figure 61)

Methods of Documentation

Standard and spherical images were collected at the site, as well as GPS photography. GPS consisted of point and line data collected to represent the shape and extent of the area and to use as ground verification for the aerial LiDAR analysis, and for use in the overall site map representation for the LC19 Complex. The TLS survey area is combined with the BR2264/65 scan project area, due to the close proximity of the structure. A total of 12 ground-based and elevated scan locations captured the inside and outside of this structure (Figures 62 - 64). Two interior scans captured the relatively simple rectangular cement block structure (Figures 65 and 66).
Figure 60. BR2266- LC 19 Instrument Building location (above) and showing the doors on the east face of the building (below). The building is located adjacent to the east of the BR 2264 LC19 launch stand and ramp location.
Figure 61. Penders (2008) photo taken during a site visit that shows the structure’s southeast perspective, with Brazilian Pepper and invasive exotic vegetation growth.
Figure 62. The BR2266 Instrument Building for LC19 is in close proximity to the BR2264/65 area, and was linked into the overall scan project for the site. Here, the 12 scans that relate to the capture of the structure are depicted, with the yellow position taken from a slightly elevated position.

Figure 63. Raw data in point cloud format captured near the BR2266 structure and showing wall feature that occurs between the BR2264 and BR2266 locales.
Figure 64. Colorized point cloud showing the TLS survey data collected in the BR2266 area.
Figure 65. Interior of BR2266 building, showing relatively simple and open aspects of the structure.

Figure 66. Spherical images and scan data (shown here using Webshare), can be used to virtually visit the site and conduct measurements and other analyses (wall measurement showing width of 5.239 meters is shown).
BR2267 LC 19 Oxidizer Holding Area

Constructed in 1959 as part of the LC 19 Complex facilities. Located to the southeast of BR2266 near the perimeter road (Figures 67 and 68), and approximately 300 feet south of the test stand, this site was designed to contain the nitrogen tetroxide, an oxidizer used in rocket propellants. The farm’s original single tank was expanded to hold two tanks. The tanks were located in a concrete trough to contain any potential liquid spills, and were further protected by concrete retaining walls and an earthen berm (McCarthy et al. 1994). Except for the earthen berm, concrete walls, and storage tanks, none of the equipment or piping remain at the oxidizer farm (Figure 69). The site was abandoned in place c.1966, and is a potential contributor to district and NRHP eligible (Penders 2008). A condition assessment of the site shows that invasive exotics and vegetation remain problematic, and the site also has noted areas of concrete loss and defoliation. Florida Master Site File forms for this site were found to have a discrepancy in the description, and should be amended.

Figure 67. Location of BR2267 – LC19 Oxidizer Holding Area
Figure 68. BR2267- LC 19 Oxidizer Holding Area, with view to the northwest.
Methods of Documentation
Both standard and spherical imagery were taken at the site, with the 360 spherical imagery acquired concurrent with the TLS survey. The spherical images allow for virtual inspection of the site, using the Webshare platform provided along with this report. GPS survey consisted of mapping and delineating all features on the ground and using the GPS data to examine and verify the site footprint in comparison with aerial LiDAR and imagery in a developed GIS. Conditional aspects, elevation and perspective views of the site were also documented using GPS photography. TLS survey consisted of seven ground-based scan positions (Figure 70). The area was captured in its entirety (Figure 71 and 72).

BR2268 LC19 Theodolite Building 1
Complex 19 contained two theodolite buildings. Theodolite Buildings 1 (BR2268) and Theodolite Building 2 (BR2271), were structures that contained alignment and tracking equipment to monitor the missile’s positional alignment prior to lift-off, and to track its course during flight. Theodolite Building 1, located 250 feet east of the launch stand (Figures 73 and 74), is the larger of the two structures and was built in 1959. It was constructed of reinforced concrete walls, a solidly reinforced concrete foundation, one entry door, and a fortified shed roof (McCarthy et al. 1994).

To maintain stability from missile launch vibration, a two and a half foot thick foundation was erected over a seven foot deep subfloor that rested on five fourteen inch square reinforced concrete pilings that extended
Figure 70. Webshare view of the TLS survey, showing the seven scan positions and documentation of BR2267.

Figure 71. Colorized point cloud view of BR2267, showing circular scanner positions, structural elements and vegetation surrounding the site.
Figure 72. TLS survey data showing elevations of the BR2267 site (north, south, east and west).
Figure 73. Location of Theodolite Building 1 (BR2268) in the upper right portion of the map, is located to west of the launch ramp and stand area.

Figure 74. Theodolite Building 1 (BR2268) shown in relation to the BR2264 structure and shoreline to east of site.
to a depth of twenty feet below the surface grade. Inside the building was a three foot by three-foot by seventeen foot reinforced concrete pedestal. The first and second floors were of poured concrete, but were designed to not connect to the pedestal (Figure 75). These extensive concrete structural and foundational features created an exceptionally stable platform on which to attachment the sensitive tracking equipment. New, updated equipment was added for the Gemini Program, but this equipment has been removed from the structure, which was abandoned in place in 1967 (McCarthy et al. 1994, Penders 2008).

As part of our survey, the site name and location information was corrected with the Florida Master Site File, as an error was discovered when the site form was transcribed into the statewide database (site form correct and FMSF mislabeled). The site was also previously incorrectly plotted in the GIS statewide location data set, and updated plots for this and other sites that use the GPS position information, are provided along with this report for submission to the FMSF. The site is a potential contributor to the district and is NRHP eligible.

Conditional notes concerning the assessment of the site include:

- Metal deteriorating, especially around windows, doors, frames (Figures 76 and 77)
- Interior concrete defoliating (Figure 78)
- Wasp nests cover the inside, but are of no structural concern (Figure 79)

Methods of Documentation

GPS survey was conducted that included documentation of site shape and extent and any related features (prepared slab and floor, terrain). Imagery included standard and spherical imagery. The 360 spherical photos were taken concurrent with the TLS survey. Additionally, high resolution images were acquired around and throughout the interior of the structure, and were used in photogrammetric modeling as well as for documentation of conditions at the site. TLS survey consisted of 11 ground-based and two elevated scanning positions for a total of 13 scans (Figure 80). The TLS data were also made into a 3D model of the site (Figure 81), with measured 3D drawings (Figures 82-85), and a number of visual images and video products produced from the TLS information (Figures 86 and 87). These models include easily viewable and sharable files such as 3D models for education and research [https://skfb.ly/QpRX](https://skfb.ly/QpRX) and video animations such as [https://vimeo.com/173124996](https://vimeo.com/173124996).
Figure 75. BR2268- LC 19 Theodolite Building 1, perspective view to the northeast.

Figure 76. Measured construction drawings of the BR2268 Theodolite Building 1 (Radar and Associates 1960), showing floorplans and through sections for the site.
Figure 77. Metal deterioration is pronounced around the entrance door frame and openings on the structure, and also interior rebar where exposed from concrete loss.
Figure 78. Areas of metal deterioration (above) and cement breakage and metal exposure (below) are found on the second floor portion of BR2268, measureable and viewable in the Webshare spherical imagery.
Figure 79. Concrete cracking and defoliation and structural cracking were noted on the pedestal and interior surfaces, along with metal corrosion and deterioration, and are captured in both imagery and 3D laser scan data.

Figure 80. Wasp nests are found covering portions of the interior of the structure, and noted in imagery and laser scan modeling.
Figure 81. Webshare platform showing the TLS scan data acquired in the survey and allowing virtual presentation of the scans and spherical imagery information.
Figure 82. 3D model showing various perspective elevations views of the BR2268- Theodolite Building 1 site.
Figure 83. CAD Elevations and Planview of the BR2268- Theodolite Building 1 site, derived from the TLS survey.

Figure 84. Orthographic planview sections through the BR2268 site.
Figure 85. Elevations with interior sections from the TLS survey of the BR2268 – Theodolite Building 1.
Figure 86. 3D models created from the TLS survey are sharable online and for virtual presentation and understanding of the site.
Figure 87. Animation video of the BR2268 shows exterior and interior structural elements of the site.

BR2269 LC19 Fuel Holding Area
The fuel holding facility (fuel tanks, transfer/control room, and truck access area) was constructed for the Gemini Program in 1962, approximately 400 feet northeast of the launch stand (Figure 88). The fuel tank area is an eighteen and one-half foot wide by fifty-five foot long concrete “trough” that was sealed off by thirteen foot high concrete walls (McCarthy et al. 1994:59-60). The trough enclosed the fuel tank to protect the surrounding terrain from potential fuel spills. On the south and west sides of the tank area, earthen berms were erected against the concrete walls to add protection from engine blasts (Figures 89-92). The transfer/control room was constructed with three walls of reinforced concrete with the south wall made up of three and one-half inch diameter pipe columns that allowed launch personnel to access the fuel handling equipment. The roof was constructed of eight inch pre-stressed concrete roof panels. Stainless steel pipe...
Figure 88. Map showing location of BR2269 – Fuel holding Area for LC19.

Figure 89. The south (pictured) and west sides of the BR2269 structure have earthen berms.
Figure 90. View of BR2269 to the east showing west side earthen berm and proximity to shoreline (above), and back toward the launch pad facility to the west (below).
Figure 91. BR2269- LC 19 Fuel Holding Area, with earthen berm area shown in aerial from 2014 above, now highly vegetated.
sleeves passed through the concrete wall separating the transfer/control room and tank area. An open concrete drive allowed for fuel transfer from truck to the tank. None of the equipment or piping remains. The site is a potential contributor to district and NRHP eligible (Penders 2008). Field condition assessment noted a high level of impact from vegetation to all parts of the building (Figure 93).

Methods of Documentation
GPS of the BR2269 site captured the shape and extent of the structure, as well as surrounding features including roads, cement slabs and related features, and brick and cement pads possibly for blast-proof cameras that were mounted on towers at LC19 to document launches. Towers were removed when the site was deactivated, but the cement pads were left in place (McCarthy et al. 1994). The documented brick pad feature is located approximately 65 feet to the northwest of the site (Figure 94). Photos included standard and GPS images taken from various perspectives and capturing the environment and contextual setting, as well as spherical images taken concurrently with the TLS survey. A total of 12 scans, five of which were from elevated positions, were taken at the site (Figure 95). These scan positions provide detailed coverage of the site, as well as capturing a wide area of the complex back toward the launch pad, stand and ramp area (Figure 96). TLS data were incorporated into the GIS, and along with aerial LiDAR, GPS, and imagery, provide a high degree of site configuration and layout understanding (Figure 97). GPS locations along with the LiDAR data will also provide areas for monitoring and assessment, particularly relating to vegetation control.
Figure 93. 2009 aerial image with the surveyed GPS data for the BR2269 location (above) and the site after invasive exotics and vegetation removal shown in 2012 (below). The site was again completely covered by 8/2015.
Figure 94. Brick pad area, possibly for a camera mount and tower location that historically were scattered across the LC19 area, is found adjacent to BR2269, approximately 65 feet to the northwest of site.
Figure 95. Webshare scan position map at BR2269 site (above) and scan view with spherical image select location shown (below).
Figure 96. Point cloud image from the TLS survey, showing the BR2269 site in foreground and the Theodolite Building 1 at center and the Launch Pad and Stand in the background.

Figure 97. Aerial LiDAR data is processed using height above ground algorithm to examine areas canopy and vegetation density and potential impact to structural assets.
BR2270 LC19 Flume and Catchment Basin
The skimming basin is located near the base of the launch stand, and worked as part of a system called the flume and catchment basin areas (Figure 98). The BR2270 and the BR area could hold more than half a million gallons of water, captured from the 23,500 gallons of water per minute that passed through the flame bucket area of LC19. The flume and catchment basin area functioned as a cooling system or fire safety mechanism during launches. The water would flow through the 550-foot long concrete flume-way to the concrete deluge basin located at the northern end of LC19. During the conversion to the Gemini Program, the upper portion of the flume was expanded to 29,800 cubic foot in order to handle the increased amount of water used to suppress the launch blast. The site is a potential contributor to district and is NRHP eligible. (McCarthy et al. 1994, Penders 2008). The perimeter road bisects the basin areas, with drains running under to allow overflow from one section to the next (Figure 99).

Condition assessment concerns at the site primarily relate to invasive exotics and vegetation growth. Root penetration into seam areas and along the perimeter of the feature is causing breaking and uplifting of concrete, and is impacting the integrity of the feature (Figures 100-102).

Methods of Documentation
Survey of this site included the processing of aerial LiDAR data for the extent of the site to create a 3D model. The site was also documented using standard and GPS imaging, as well as surveyed as to extent and location with GPS (Figure 103). Aerial LiDAR for the site is combined with other viewable tools such as aerial imagery from current and historic years, to provide a detail record of condition of the site and viewable features. Because the flume and catchment basin are open ground, the aerial LiDAR provides good coverage of the site, and aerial imagery provides some of the best ways to visualize and understand the site and its connectedness with other features.

Online tools allow for comparison and change detection analysis across the site, and in this area there have been noted impacts from invasive exotics. Additionally, aerial imagery allows the visualization of the continued earthen spillway, where the overflow separator allowed water to spill out, and can be seen curving toward the Atlantic (Figure 104). These data are useful not only for monitoring and assessing concerns such as invasive exotic plant management, but for examining shoreline erosion (see the online comparison tool at: http://goo.gl/fZEzXx ). Various years can be examined and compared, with early aerials allowing for more robust observations and comparisons (Figure 105). (see LC34 2009 comparison at: https://goo.gl/xmj6Xp , and LC19 2009 comparison at: https://goo.gl/LUhy4T, and a LC 19 side-by-side 1969, 1999, 2009, 2015 at: https://goo.gl/eYCL0y ).

BR2271 LC19 Theodolite Building 2
The smaller of the two theodolite structures at LC19, the Theodolite Building 2 (BR2271) structure is located in the northeast portion of the complex (Figure 106). The site is comprised of a 178 square foot building that was constructed in 1961 of concrete-block with a poured reinforced concrete slab foundation and roof. Similar stabilization methods as previously described in the Theodolite Building 1 description were used again here to isolate and stabilize the concrete pad that supported the tracking equipment (McCarthy et al. 1994). This structure was abandoned in place in 1970, and has become engulfed by dense vegetation that makes the building largely inaccessible today. The site is a potential contributor to the district and is NRHP eligible (Penders 2008). Condition assessments could not be made as the site is currently impenetrable from invasive Brazilian Pepper growth, and site images from 2008 show that it was being overgrown at the time of last recorded visit (Penders 2008, Figure 107).
Figure 98. Map (above) showing location of BR2270 – the Flume and Catchment Basin, located beyond the BR2264 locale running north (bottom shown in yellow). Site is shown using 2015 aerial imagery base map in the survey GIS, with red lines indicating GPS field data collection (below).
Figure 99. View from atop LC19 launch stand and ramp area, looking out over the skimming area of BR2270 - flume and catchment basin (top) and view looking back toward the launch pad from the perimeter road (bottom).
Figure 100. Vegetation and invasive exotic issues remain a problem for the BR2270 site, with areas showing encroachment seen in the aerial LiDAR (above). Additionally, vegetation is occurring within the basin areas (northern most basin shown in below image), particularly along seams in the cement and can lead to cracking and uplift.
Figure 101. Invasive exotic vegetation growth occurring along cement seams and covering drain area can lead to obscuring and impacts to the surface structures. Above, the view is to the south from the basin at the northern end of BR2270. The below view is to the north and shows the Brazilian Pepper stand and invasive grasses and weeds encroaching and penetrating the site.
Figure 102. BR2270 - LC 19 Flume and Catchment Basin concrete overflow and separator area, captured with GPS imagery and showing the view to the north.
Figure 103. False color imagery from 1999 for the BR2270 site area (above) is shown in comparison to true color imagery from 2015 of the same area (below).
Figure 104. Online tool for observing change and alterations to the complex through time. This tool features aerial imagery from 1969 compared to 2015 base imagery. Shoreline erosion and invasive exotic changes can be examined through these types of legacy data comparisons. (see: \url{http://goo.gl/ZiRu5F}).

Figure 105. Map showing location of BR2271, Theodolite Building 2, as per the FMSF GIS data. The site is overgrown with Brazilian Pepper and could not be relocated or assessed.
Figure 106. Drawing after the site sketch map from McCarthy et al. (1994) showing the theodolite buildings circled in red (BR2271 is center bottom and the larger BR2268 location is closer to the launch pad area.

Figure 107. BR2271 - LC 19 Theodolite Building 2. This image was taken in 2008 during the last field documentation visit, with the view to the southeast showing the site very overgrown.
Structures and Features No Longer Existing at LC 19

The following structures are no longer in existence, and were removed previous to our survey at CCAFS:

1) Launch Mounts, Thrust Mounts, Flame Buckets
2) Camera Pads and Towers
3) Umbilical Towers
4) Sentry House
5) Air Conditioning Shelter
6) Erector/Service Towers (Erectors)
7) Fuel Farm - Today, the only evidence of the fuel farm is the paved fuel tanker transfer drive. Note that this facility is not to be confused with the Fuel Holding Facility (BR2269).
8) Ready Room

Any extant remnants of these features (plates, cement pads, etc.), were relocated with GPS to the extent possible, and documented with GPS photography and standard imaging. Legacy data, including georeferenced maps and CAD drawings and historic aerials were also brought together in the GIS in efforts to provide any documentation for these now destroyed features and locations.

Launch Complex 34 (BR2279)

The Florida Master Site File (FMSF) designation for the Launch Complex 34 Resource Group is BR2279, with the 21 associated buildings assigned BR2280 through BR2300. Launch Complex 34 is a 45 acre missile launch site that was constructed by the U.S. Army Corps of Engineers between June 1959 and February 1961, and is located to the north of the LC 19 facility (Figures 108 and 109). The facility was used for Saturn 1 and Saturn 1B missile test flights and is best known for the Apollo program launches, occurring between 1961 and 1971. The site is also the location of the Apollo 1 tragic accident that occurred here on January 27, 1967, when three astronauts: Virgil Grissom, Edward White, and Roger Chaffee lost their lives in a cockpit oxygen fire during a practice simulation flight on the LC 34 launch pad. The site today is a memorial to that event (Figure 110). Launch Complex 34 was deactivated in November 1971, and abandoned in place in October 1973.

In April 1984, Launch Complex 34 was listed as part of the National Historic Landmark District at Cape Canaveral (Butowsky 1983). The complex was initially registered with the Florida Master Site File (FMSF) by Kimberly Hinder (Hinder 2003a). In 2008, Thomas Penders, CCAFS 45 SW Cultural Resources Manager, supplemented the FMSF by recording the LC 34 Complex as a Resource Group (8BR2279), and listed 21 individual historic structures as contributing elements to this group (8BR2280 to 8BR2300, Figures 111).

The information in the following descriptions were taken from the FMSF surveys and reports, along with accounts by Ward (2015), Hinder (2003a), and Butowsky (1983). Further information was acquired by field observations made during the data collection portion of this project and analysis of that data by the Principal Investigators. This facility is unique in its construction, architecture, and engineering. The original complex consisted of a blockhouse, concrete launch pad and pedestal, an operations support building and several ancillary structures and features (Figures 112 and 113). Over the years (1963 and 1965), many of these structures were modified. Additional alterations were also made to the complex following its abandonment in the early 1973 (Hinder 2003:19-29). The original Launch Complex 34 built in 1960, consisted of a concrete Launch Pad and Pedestal, a Blockhouse, and an Operations Support Building, which was later known as Engineering Support Building. In addition to these structures, the LC 34 FMSF Resource Group consists of a number of ancillary and support facilities and features. Many of these buildings remain in their original positions, but some have been dismantled or demolished and all equipment has been removed.
Figure 108. Location map for the LC 34 Complex (BR2279).

Figure 109. Saturn SA3 from LC 34 in November 1962 (photo courtesy of NASA).
Figure 110. The Apollo 1 crew - Grissom, White and Chaffee (shown above - photo courtesy of NASA) and the commemorative plaque that appears on the launch stand today where the tragedy occurred in 1967.
Figure 111. Map of buildings at LC 34. The aerial imagery used is from 2015, and shows the removal of Brazilian Pepper across 3/4 of the site extent.
Figure 112. Masterplan for LC 34 (Benson and Faherty 1978).

Figure 113. Civil Engineering Construction As-Built plans for LC 34 (Patrick AFB Drawing #AW 60-084178, 1961).
Buildings documented in this survey include:
1) BR2280- Launch Complex 34 Blockhouse
2) BR2281 LC 34 High Pressure Gas Storage Facility
3) BR2282 LC 34 Oxidizer Storage Facility
4) BR2283 LC 34 Liquid Oxygen (LOX) Storage Area – Oxygen Farm and Blast Wall
5) BR2284 LC 34 Theodolite Building
6) BR2285 LC 34 Toxic Vapor Disposal Pad (burn off and blast area)
7) BR2286 LC 34 RP-1 Area Storage Facility
8) BR2287 LC 34 RP-1 Electrical Equipment Building
9) BR2288 LC 34 RP-1 Equipment Bldg. (Special Liquid Storage)
10) BR2289 LC 34 Cableway and Amplifier Facility
11) BR2290 LC 34 Launch Pad
12) BR2291 LC 34 Mobile Service Tower Parking Area
13) BR2292 LC 34 Launch Pedestal (Stand)
14) BR2293 LC 34 Flame Deflectors and Deflector Park Area
15) BR2294 LC 34 Launch Pad Environmental Control Bldg.
16) BR2295 LC 34 Flume and Skimming (Catchment) Basin
17) BR2296 LC 34 LH2 Electrical Equipment
18) BR2297 LC 34 High Pressure Hydrogen Storage
19) BR2298 LC 34 Automatic Ground Control Station
20) BR2299 LC 34 Liquid Hydrogen Storage (and pipeline)
21) BR2300 LC 34 High Pressure Gas Battery

**BR2280- Launch Complex 34 Blockhouse**
The 120 foot diameter, 12-sided dome blockhouse was located about 1,000 feet southwest of the launch pad, and functioned as the launch control center and contained the communications, instrumentation, and computer control consoles (Figure 114). In 1959, a large area was excavated, and lined with sand to reinforce the poured concrete foundation. The dome, which enclosed 20,396 square feet of floor space on two floors, consisted of three different layers (Figure 115). The inner dome was made of reinforced concrete that was poured to be five feet thick, and covered by sand varying in thickness from seven feet at the apex of the dome to 30 feet at the base (Hinder 2003). In case there was a missile explosion on the close-by launch pad, a special blast door that was 23 tons was put in place to insulate the structure (Figure 116). The innermost vault was constructed with five feet of reinforced concrete that was then covered with varying amounts of sand. The exterior of the structure was sprayed with four inch layer of shotcrete to consolidate the dome and secure the materials (Figure 117). Attached by a covered breezeway to the west side of the circular blockhouse, was a rectangular support building that held climate control equipment. A wooden observation deck and access stairway was added to the exterior. The Blockhouse was transferred to NASA from the U.S. Air Force in 1963. It was ‘abandoned in place’ in 1971, and NASA returned the Blockhouse to the Air Force in 1986 (Hinder 2003). Currently, the Blockhouse remains vacant.

In examining conditions in the field and with the collected data, primary issues at the LC 34 Blockhouse site include:
- Invasive exotic vegetation, primarily Brazilian Pepper growing at upper and lower observation decks, expanding in surface cracks (Figure 118)
- Portions of wood stairways, observation decks, and metal supports deteriorating (Figures 119 and 120)
- Building coating defoliation and cracking (Figure 121)
Figure 114. Map of facility at LC 34 showing location of the BR2280 Blockhouse site.

Figure 115. Blockhouse structure at LC 34 looking north in November of 1960, with the service structure shown in rear (Benson and Faherty 1978).
Figure 116. A 23 ton blast door at BR2280 from the exterior entrance area.

Figure 117. BR2280- Launch Complex 34 Blockhouse and connecting cableway in 2015, with view to the southeast.
Figure 118. Brazilian Pepper is shown growing on the top portion of the dome and is displacing the wooden deck in sections as well as causing surface defoliation and cracking.

Figure 119. Any areas with exposed metal are showing deterioration and corrosion as noted here on the deck platform of BR2280.
Figure 120. The blast door mechanisms and other metal surfaces continue to deteriorate, delaminate, and corrode.

Figure 121. Surface cracking and defoliation is occurring across the dome surface and in particular at areas where side faces meet, as noted here where the deck surface and dome connect.
Methods of Documentation
The TLS survey at BR2280 consisted of 50 exterior scan positions, with 25 taken from various elevated positions so that the entirety of the structure and surrounding environs were documented (Figures 122 and 123). Photography consisted of standard and GPS photographs to record elevations, perspectives, conditional aspects, and location specific information (Figure 124). Gigapixel interactive photographs were also taken from the deck area of the Blockhouse site to record in high resolution the surrounding landscape and structures. These images are made available for online and sharable viewing and provide a method of high resolution visual inspection and immersion (Figure 125, see: http://gigapan.com/gigapans/177982 ). Spherical images were also taken concurrent with the TLS survey (Figure 126).

Other forms of documentation included GPS used to delineate location positions, scale and extent, and to ground truth verify features of note from aerial LiDAR data (Figure 127). Aerial LiDAR and other forms of spatial and 3D data were brought together in the GIS geodatabase for the LC 34 Complex, and cartographic products include those showing location, relationship with the overall site complex, and allowing for detailed examination of terrain (Figures 128-130). The aerial LiDAR applications at LC 34 and important for the condition documentation of the BR2280 site location is that it can be useful for examining vegetation growth and occurrence aspects and be used comparatively to look at vegetation change when compared across different years and used in conjunction with aerial imagery and ground verification with GPS. TLS data with the aerial LiDAR provide a detailed understanding of the 3D built environment in relation to the larger scale landscape and are processed in viewable and accessible ways. 3D models for BR2280 were created using the registered point cloud TLS data collected (Figure 131). These data were then used to create models and CAD renderings of the site (Figures 132-133), and to relate condition aspects to locations on the ground for management and monitoring (Figures 134-X).

BR2281 LC 34 High Pressure Gas Storage Facility
This was the original High Pressure Gas Facility that was constructed in 1960 to the east of the Blockhouse (Figure 135). It was used to store and transfer the gaseous nitrogen that was used to fill the launch vehicle’s storage units for in-flight consumption, and to operate some of the ground service equipment. The concrete vault-type structure as-builts show it to be 53 feet wide, 31 feet deep, and 18’ feet high. The interior of the 2,332 square foot structure was used to store cylinders of high pressure helium and nitrogen gases. The large concrete pad along the front and east side of the structure were used for mobile storage and vaporizer vehicles (Figures 136-138). In 1963, alterations were made to the structure to handle the requirements for the new Saturn 1B rocket engines. To improve and expand the capabilities of the high pressure nitrogen and helium batteries, a new High Pressure Gas Battery (BR2300) was constructed closer to the Launch Pad in order to provide additional storage of that were required for the new space vehicle. The facility was abandoned in place in 1973 (Hinders 2003, Penders 2008).

Conditional assessment of the site during our field TLS survey showed that it is in fair condition and was being used as a NASA storage facility. Some invasive exotic presence was noted.

Methods of Documentation
TLS survey at the site consisted of 12 laser scan data positions (Figure 139). Registered point cloud data for the site was used to create 3D models and renders and CAD measured drawing models (Figures 140-144). Photographic data was recorded with 360 spherical imagery concurrent with the TLS survey, and standard and GPS photography were also acquired. GPS field validation and data collection were using in the GIS and in relation to the aerial LiDAR data (Figure 145), and incorporated into the complex geodatabase.
Figure 122. Webshare immersive point cloud view of the BR2280 TLS data, showing locations of scanner positions for the survey.

Figure 123. Colorized point cloud showing the TLS survey data collected at the BR2280 location.
Figure 124. GPS photography showing direction of the photograph (above) and the photograph with position information (below).
Figure 125. Gigapixel interactive panoramic images, like this one from the upper deck of BR2280, can be shred
and provide virtual immersive experiences (see: http://gigapan.com/gigapans/177982).

Figure 126. Webshare image of the BR2280 Blockhouse and cableway. The Webshare allows virtual viewing
with measurements, HD imagery, and panoramic immersion possible.
Figure 127. Aerial LiDAR data for the LC34 area, showing GPS line work (red) and the processed Digital Surface Model (DSM) data for 2016 (above). These data provide an important record of the landscape variables including buildings and vegetation. Note the heavy Brazilian Pepper area shown across LC 34 in the 2007 LiDAR (below) in comparison to the 2016 data. Areas left untreated continue to spread and re-emergence is occurring in areas treated.
Figure 128. Cartographic map for LC 34 showing the BR2280 Blockhouse in relation to the other structures and features. The map shows all areas documented in the TLS and GPS survey.
Figure 129. Digital Elevation Model derived from aerial LiDAR. LiDAR is flown at different intervals, and can provide an important means of terrain and vegetation documentation, especially when used with ground verification GPS survey and when compared to legacy maps and information that can be georeferenced in a GIS.
Figure 130. TLS LiDAR data shown as point clouds with and without intensity reflection values for the BR2280 site.
Figure 131. Colorized point cloud representations of the TLS survey data for the BR2280 site.
Figure 132. Slices (above) can be made through any portion of the 3D point cloud and exported to CAD, allowing for measured drawings based on the TLS survey to be created.
Figure 133. 3D model created from the TLS survey for the BR2280 site.
Figure 134. Condition assessment using photographic documentation in relation to the spatial 3D model.
Figure 135. Location of the BR2281-High Pressure Gas Storage Facility and wall feature in relation to the LC 34 Blockhouse (BR2280) site.

Figure 136. BR2281 showing the front (looking northeast) elevation with pad access area and entry bays.
Figure 137. Blast wall and earthen berm to the east and north of the building.

Figure 138. View to the east showing elevation of BR2281 structure.
Figure 139. Webshare immersive point cloud view of the BR2280 TLS data, showing 12 locations of scanner positions for the survey.

Figure 140. Webshare view of the north side of BR2280, showing measurement capability in the software.
Figure 141. Colorized point cloud from TLS LiDAR data showing the BR2281 survey information and landscape.
Figure 142. 3D CAD model and photographic general views of BR2281.
Figure 143. General views of 3D CAD and images showing BR2281 with wall and pad features.
Figure 144. Orthographic views of the BR2281 site, showing measurements.
Figure 145. Map showing location of BR2281 within the LC 34 Complex at Cape Canaveral.
BR2282 LC 34 Oxidizer Storage Facility

This site is listed with the FMSF as the Oxidizer Storage Facility (Penders 2008), but is discussed by Hinder (2003) as the blast wall (building number 21900C) for the Liquid Hydrogen Facility (Facility number 21900R) in the HAER report for LC 34. Described as a reinforced concrete wall and revetment, this facility was constructed in 1963 and 1964 for the Saturn IB configuration, and was located some 830 feet northeast of the launch pad (Hinder 2003, Figure 146). The steel reinforced concrete blast wall and a protective earthen berm revetment separated the combustible fueling facility from the launch pad.

Condition assessment at the time of documentation showed the site to be heavily overgrown on west side and impacting supports of the transfer system. Also noted was metal rust and concrete degradation.

Methods of Documentation

This area was targeted with GPS based on the photo and the FMSF GIS data, however, neither match with the physical description provided by Hinder (2003), and the FMSF name and facility number vary from the number given in Hinder as well. Follow-up survey and documentation will be conducted in the next phase, in order to better ascertain the location and clarify all for the FMSF recorded detail.
BR2283 LC 34 Liquid Oxygen (LOX) Storage Area – Oxygen Farm and Blast Wall
The Liquid Oxygen (LOX) storage area was constructed about 650' south of the Launch Pad (Figure 147). The facility consists of reinforced concrete blast wall anchored to a concrete slab foundation. The fuel was actually stored in a large, 41 foot diameter, spherical container (Figure 148). An earthen berm was formed on the north side of the wall to separate the fuel from the Launch Pad (Hinders 2003, Penders 2008). Penetrating both the wall and berm were two parallel tunnels that allow access from the container to the pedestal pipeline that carried the fuel to the launch vehicle (Figure 149).

Figure 147. HAER Map georeferenced over aerial LiDAR showing the location of the Liquid Oxygen Facility (BR2283) and the blast wall.

Figure 148. Photograph of Liquid oxygen container at the (LOX) Storage Area. Note concrete blast wall and two doorways/tunnel areas behind the container (HAER No. FL-8-6-29).
Figure 149. BR2283 at LC 34 (LOX Storage Area), showing a view to the northwest with Brazilian Pepper growth. The unique storage container for the liquid oxygen is removed.

Methods of Documentation
This structure was mapped with GPS, and GPS photography was taken along with standard images at the site. This ground verification was used along with aerial LiDAR was used to delineate the size, elevations, and relationship of the building within the LC 34 landscape (Figure 150). Legacy information from HAER, including the HAER reference map was confirmed in the GPS survey. TLS survey was not conducted due to the obscuration of the locale by Brazilian Pepper on all but one side and other partial sections.

Figure 150. GPS Map location shown with aerial LiDAR for the BR2283 structure and cement pad. The arrow indicates the location of the doorway areas and previous position of the LOX storage container. Note the heavy and turning into linear growth of Brazilian Pepper along a feature area to the north of the structure heading back to the pad.
BR2284 LC 34 Theodolite Building
The Theodolite Building was constructed just south of the Launch Pad by NASA in 1965, in preparation for the Saturn III rockets. Also known as the Alignment Building, the 287 square foot structure held a theodolite and associated equipment that assisted in maintaining the missile’s azimuth alignment (Figure 151). The building was entirely made of concrete and concrete block: foundation, walls, and roof. NASA transferred the complex back to the Air Force in 1973, and, in 1975, the building was abandoned in place (Hinders 2003, Penders 2008).

Condition of the site today is heavily overgrown on all sides by Brazilian Pepper and also encroaching into interior of the building (Figure 152). Metal rust and concrete degradation was also noted.

Methods of Documentation
Because of the heavy obscuration of the site, GPS, standard photography and GPS photos were taken for field verification using aerial LiDAR. The position, footprint and scale can be determined in the LiDAR and these data are brought together in the GIS geodatabase for the complex.

Figure 151. Map showing portion of the LC 34 Complex with the position of the Theodolite building shown in relation to the launch pad and stand.
Figure 152. Theodolite building with Brazilian Pepper obscuring nearly entire structure. View is looking north toward launch stand.

**BR2285 LC 34 Toxic Vapor Disposal Pad (burn off and blast area)**

This relatively small structure is composed of a concrete foundation and blast wall and an earthen berm on the northwest side to protect its contents during launches and engine tests. The structure is inaccessible and barely visible through the heavy Brazilian Pepper that have engulfed it. A photo taken during the field visit in 2008 shows a portion of the site that was visible at the time, and is used here to represent the structure (Figure 153).

Figure 153. Photo taken by Penders (2008) of the BR2284 location, showing a portion of the visible blast wall facing to the north.
Methods of Documentation
The BR2284 site was not readily discernable on the ground, and was inaccessible for photography and TLS survey. GPS data was collected on the wall location in the site area. The site was able to then be delineated as to location and size using the GPS and aerial LiDAR in the GIS (Figure 154 and 155).

Figure 154. Location of the Toxic Vapor Pad (BR2284) site, located to the south of the pad and east of the cableway.

Figure 155. The BR2284 blast wall was relocated using GPS, and a point location was collected on a portion of the visible wall feature and related to the aerial LiDAR data (see arrow).
**BR2286 LC 34 RP-1 Area Storage Facility**

This storage facility was constructed in 1960 as part of the original launch complex, and was used to store and transfer the kerosene-based fuel that powered the first stage of the Saturn I launch vehicle. Located about 950 feet southeast of the Launch Pad, the facility's storage and transfer equipment rested on concrete slabs and the fuel was carried along a pipeline supported by a series of pedestals that run northwest to the launch pad (Figure 156). These facilities and features are best visualized using a variety of remotely sensed data combined with field ground verification with GPS. For example, in Figure 156, different aspects are seen better using a combination of LiDAR and aerial imagery, as well as symbolized digital surface models from LiDAR that assist with interpretation of terrain features.

The storage facility was protected from the launch area by a reinforced concrete blast wall and protective earthen revetment, which no longer exists. The facility had two associated support buildings: the Electric Equipment Building (BR2287) and the Special Liquid Storage Building (BR2288). This structure is currently known as the Industrial Waste Storage Facility (Hinder 2003, Penders 2008).

Condition assessment concerns observed at the site included:

- Vegetation encroachment beginning and surface degradation (Figure 157)
- All metal severely rusted to the point of disintegration (Figure 158)
- Erosion of adjacent roadway and concrete pad due to beach intrusion
- Apparently, a seawall was constructed at later date, but it is eroding and being displaced by heavy beach loss in this area (Figure 159)

**Methods of Documentation**

GPS and aerial LiDAR were processed and acquired for the site area, as were standard and GPS photography. Spectroscopy measurements, examining light reflectance, were taken on the beach face in this area to help delineate and refine sand and vegetation patterns with satellite imaging sensors for further work in this area (Figure 160). GPS positions were taken in conjunction with the spectroscopy and will be the subject of a future report.
Figure 156. Aerial LiDAR and 2018 aerial imagery showing structures BR2286, 87 and 88 at LC 34. A Digital Surface Model from LiDAR (below) shows these structures as well as vegetation intrusion around the basal areas. These data also show the continuing erosion of the beach face occurring on the ocean-front side of the structure areas.
Figure 157. View to the west at BR2296 showing surface degradation and vegetation intrusion.

Figure 158. Metal surface are delaminating and corroding on all exposed areas at BR2286.
Figure 159. Image taken from beach looking back west at the BR2286 site. Shoreline erosion has uplifted and washed away part of the site pad foundation.

Figure 160. Spectroscopy measurements, examining the dispersion of an object’s light into its component colors, was measured in several areas of the LC 34 Complex. This is being done in an effort to better delineate vegetation types and exposed surface types from remotely sensed data.
BR2287 LC 34 RP-1 Electrical Equipment Building

The RP-1 Fueling Facility (see BR2286 description above) was powered by motors within the Electric Equipment Building. It is a small 216 square foot structure that was built on a concrete foundation with a built-up roof (Figure 161). The condition assessment notes for the site show that it has heavy vegetation intrusion and the metal surfaces are showing rust and there is concrete degradation.

Methods of Documentation

The BR2287 site was documented at the same time and with the same methods as described in the BR2286 description above. Aerial LiDAR, GPS, and standard and GPS photography were utilized at the site and the data are brought into the GIS geodatabase.

Figure 161. The BR2287 site is in close proximity to the BR2296 location.

BR2288 LC 34 RP-1 Equipment Bldg. (Special Liquid Storage)

The Special Liquid Storage Building was another RP-1 Storage/Fuel Facility support structure (Figure 162). This small, 252 square foot structure was a concrete building with a concrete foundation and built-up roof. The U.S. Air Force used the structure from 1960 to 1963, when it turned it over to NASA who occupied it from 1963 to 1999. The Air Force continues to hold ownership, but it was abandoned in place in 1971 (Hinder 2003, Penders 2008). Condition assessment notations from field observations indicate problems with vegetation intrusion, metal corrosion and structural sagging at the point where the ladder connects on the side of the building roof.

Methods of Documentation

As with the BR2287 and BR2286 sites which are in close proximity, this site was documented using GPS and standard and GPS photography. Data were brought together with aerial LiDAR in the GIS geodatabase for the LC 34 Complex.
BR2289 LC 34 Cableway and Amplifier Facility

The Amplifier Facility and Cableway, an above-ground access tunnel, connected the Blockhouse to the Launch Pad, and enclosed all of the power, computer, and communications lines that ran between the blockhouse, Automatic Ground Control Station, and launch vehicle (Figures 163-165). The attached structures were erected on a concrete foundation and had a built-up roof. One end of the long concrete block structure was located on the southern perimeter of the launch pad and ran southwest to the blockhouse (Hinder 2003).

Condition observations at the site indicate concerns with damage from previous and emergent vegetation growth, metal rust and concrete degradation, and noted bee infestation at various points along the cableway.
Figure 163. DSM derived from aerial LiDAR showing the cableway connecting the Blockhouse to the circular launch pad at LC 34.

Figure 164. The amplifier room along the cableway, close to the pad, is a concrete block connecting structure with rusted metal equipment and corroded fixtures.
Figure 165. BR2289 – the Cableway and Amplifier Facility at LC 34. Looking toward the pad area (above) and back toward the Blockhouse (below). Pepper and palmetto have intruded into the structure and damage from previous vegetation and removal has occurred.
The circular Launch Pad was the core area of the complex (Figure 166). Other facilities that were located on or around the Launch Pad included the Launch Pedestal, Flame Deflector, Automatic Ground Control Station, Umbilical Tower and other launch testing and support features (Figure 167). The circular 430 foot diameter pad that was located about 1,000 feet to the northeast of the Blockhouse was constructed of reinforced concrete (Figure 168). The pad’s height of 16 feet above sea level remains a concern with the Atlantic Ocean less than 750 feet away and continuing to encroach on the site.

The pad contains the following features: The Umbilical Tower Area, was added to the LC 34 Complex for the Saturn 3 Mission (SA 3). At 240 feet in height, this tower provided access of equipment and systems (e.g., power, air conditioning, hydraulic, pneumatic, fuel, measuring, and command) to all level of the vertically positioned rocket and space vehicle. Besides its functions as an access and delivery mechanism, the tower was also a way for astronauts to enter and depart the vehicle. In the case that an emergency exit from the missile was required, an elevator that travel 450 feet per minute could rapidly evacuate personnel. Due to excessive rust and deterioration caused by constant exposure to salt air from the Atlantic Ocean, the Umbilical Tower was dismantled in 1972 (Hinder 2003, Penders 2008).

The Deluge System, which began at the Launch Pad and Pedestal, operated as a water shield between the Saturn vehicle’s engines and any propellant residues that might have ignited prior to launch. The dousing system with oversized tubing and nozzles was installed around the Pedestal to extinguish accidental fires in the launch vehicle or engine compartment. The water used during the dousing procedure flowed into the flume and skimming basin. Fireproof brick was used to line the surface of the portion of the launch pad around the deflector. The refractory or fire brick protected the pad from the intense heat of the rocket exhaust. Clipper-DP, a dry pressed fire brick that is rated for applications of over 3000°F (1650ºC) were selected for LC 34 (Hinder 2003).

Apollo 1 Memorial Benches were installed on the southern perimeter of the launch area as a memorial to the three astronauts who died on the pad in the 1967 accident. The three marble benches are inscribed with the names: Grissom, White, and Chaffee. In 1987, to further honor and acknowledge the astronauts lost in Apollo I and the goals achieved at the complex, a Historical Site Kiosk was erected at the entrance to the Launch Pad (Hinder 2003b:21). Figure 169 shows many of the pad features.

Condition assessment observations at the pad site indicate fair condition. The fire-proof brick area is degrading due to weathering and from vehicle traffic. The roof of an unidentified subterranean room, located under the pad to the west of the Pedestal (approximately halfway between Pedestal and Flame Deflectors), is collapsing due to vehicle traffic.

Methods of Documentation
The pad area was documented in several ways, including targeted TLS across much of the surface area and at the central launch stand site (Figure 170). GPS survey was performed to ground truth verify all features and map location and condition. Photography included spherical imagery from TLS, GPS photos, and standard photography. All data were brought together for use in the GIS for the complex.
Figure 166. The above image is a Digital Surface Model from aerial LiDAR that has been symbolized with a color ramp that is helping to visualize the circular launch pad at LC 34. Central is the launch stand memorial with the two flame deflectors seen to the top left. Brazilian Pepper is emergent along the edges of the pad and is heavier to the right (east of the pad). The image below is a hillshade of the DSM model overlain on aerial imagery to assist in seeing different reflective values, such as noted with cement and built structural features.
Figure 167. GPS and laser scanning were used across the pad area to develop a site plan map of features and structures.
Figure 168. Image above is an aerial photo from 1999 showing full circular pad and associated structures (Joe Marino/Aerospace Reports Photographic Services), and below is a view to the northwest across the pad from the stand area looking at the deflectors.
Figure 169. Launch Pad (BR2290) features discussed.
Figure 170. TLS point cloud data from the LC 34 Launch Pad, with emphasis on the stand memorial.

**BR2291 LC 34 Mobile Service Tower Parking Area**

At 312 feet high, the Mobile Service Structure was the tallest structure at the complex. The steel edifice was an integral part of the launch pad complex that provided work platforms for the assembly, testing, and servicing of the launch vehicle (Figure 171). The initial version of the Tower is shown in Figure 172, later modification were made to adapt to the new Saturn IB configuration. When ready for launch, the tower was moved 600 feet to the west, from its position straddling the rocket, to its “parked” position on a large reinforced concrete pad (i.e., the Mobile Service Structure Parking Area) (Figure 173). This gigantic structure was transported to and from the launch pad via a dual-track railway system. The service towers were dismantled in April 1972, due to excessive rust, corrosion, and deterioration due to constant exposure to the salt air from the nearby Atlantic Ocean (Hinder 2003).

**Methods of Documentation**

See the previous discussion for the BR2290 launch pad and associated features. A combination of methods including TLS, aerial LiDAR, GPS, GIS and imaging strategies were employed. All datasets were brought together in the geodatabase GIS for the complex.

**BR2292 LC 34 Launch Pedestal (Stand)**

The Launch Pedestal is located at the center of the Launch Pad, and supported the launch vehicle during testing and launch. The tremendous weight of the pedestal, missile, and supplementary equipment, plus the impact of the engine thrust required substantial foundational support. The 42 foot square by 27’ high structure was constructed of heavily reinforced concrete, and the surfaces of the columns and platform that were exposed to the highly heated engine exhaust were covered with steel plates. To support this mass, approximately 13 million pounds of reinforced concrete were used in the foundation that measured 106 feet by 160 feet. The central area contained an eight foot thick layer, and the outer perimeter four feet.

The pedestal was designed with a 25 foot diameter opening at the top of the platform (Figure 174) that allowed access to the lower section of the missile and, during testing or launch, the engine exhaust could pass directly to the flame deflectors positioned between the pedestal’s columns.
Figure 171. Servicing of the first Saturn (SA-1) on the LC 34 launch pad. The Mobile Service Tower is shown straddling the missile, which has a protective covering over it to protect it from the elements (after Ward 2015:12).

Figure 172. This 1963 NASA photo shows the Saturn 1 SA-4 Launch Vehicle sitting on LC 34 just prior to launch. The Mobile Service Towers are in their parked position on their pad, away from the missile. Note the parallel sets of railroad track on which the towers could be moved to a position directly over the vehicle for preparation and testing. The umbilical tower stands just beyond the rocket, and the proximity to the Atlantic Ocean is evident.
Figure 173. The area of BR2291 on the circular pad structure at LC 34.

Figure 174. BR2292 – the Launch Stand Memorial with its central open area.
Various retractable mechanisms were attached to the upper portions of the pedestal to hold the missile in its vertical position until lift off. In 1973, the complex transferred from NASA back to the Air Force and it was abandoned in place. Today, however, the pedestal stands as a somber monument to the three astronauts of Apollo I that lost their lives here during a practice simulation flight in 1967 (Figures 175 and 176). In April 1984, the Complex was included as part of a National Historic Landmark District designation for multiple Launch Complex facilities located on the CCAFS (National Park Service and United States Air Force 1983).

To date, the most comprehensive and complete description and assessment of Launch Complex 34 stems from a Historic American Engineering Record (HAER) survey in 2003 by Archaeological Consultants, Inc. (ACI) (Hinder 2003). The HAER survey report provides a complete physical description of the Complex's structural elements and is largely based on a review of multiple historic materials including the As-Built Drawings of the Complex completed in 1959 and 1968 (Hinder 2003:2). Additionally, the HAER report provides important descriptions of the alterations to the Complex that occurred following its abandonment in the early 1970s (Hinder 2003:19-29).

Conditions noted at the stand include rusting and metal surface loss. Concrete surface weathering is also occurring on the pad and stand area (Figure 177). Corrosion of metal is great along the ring at the center, where rust and surface loss are occurring to high degrees.

Methods of Documentation
The launch stand memorial site has been documented using a variety of tools. TLS survey was conducted with 5 ground based scan positions around the stand area. These data were used in the creation of 3D models and animations (Figures 178 and 179), and CAD renders (Figure 180). Additionally, the aerial LiDAR and GPS along with the ground based TLS data have allowed feature mapping in GIS (Figure 181), and allow for a detailed understanding and presentation of the site and surrounding terrain and associated features. Photography, including spherical imagery concurrent with the laser scanning, GPS photography, and standard photography were utilized to provide contextual setting and conditional understanding (Figure 182).

BR2293 LC 34 Flame Deflectors and Deflector Park Area
There were two flame deflectors made of steel frame covered in 1" steel plates and with a 4" layer of heat resistant ceramic, that were available for Launch Complex 34 (Figure 183). One deflector was for use with the launch and the other was kept for in case of any failure or need during the launch. These deflectors weigh in at over 150 tons and measure 43 feet in length, 32 feet wide and 21 feet in height. They were moved to the pad or stored away from the pad via a rail system, and these deflectors were used to protect the vehicle and launch pedestal by diverting engine flames in controlled directions (Figure 184). Their inverted "V" shape and their welded and bolted steel design is of a unique construction and engineering (Hinder 2003). Launch Complex 34 is where the tragic Apollo 1 incident occurred, and today these deflectors are a backdrop on the pad that stands as a memorial to that event.

The Flame Deflectors were designed to redirect the 5000° Fahrenheit engine rocket engine flame blast during testing and launch. The deflector was positioned in the center of the Launch Pedestal columns, under the rocket engines. By controlling the direction of the blast away from the center of the pad, the lower section of the launch vehicle and pedestal were, to a certain extent, protected from the intense heat.

The 150-ton deflector was constructed from a series of welded and bolted steel I-beam trusses that formed an inverted V-shape that sloped downward at an 80 degree angle. The flame deflecting surfaces were
Figure 175. Dedicatory plaque on the south column of the LC 34 Launch Pedestal.

Figure 176. Ad Astra per Aspera memorial plaque on the east column of the LC 34 Launch Pedestal.
Figure 177. Surface loss and weathering as well as metal degradation is occurring at BR2292.
Figure 178. 3D rendered model from the TLS survey showing the elevations and planview as well as textural details of the BR2292 site.

Figure 179. 3D model render from the TLS survey data, including textures developed from high resolution photography.
Figure 180. Measured drawings from the TLS survey and 3D modeling have been created for the BR2292 site.
Figure 181. Map created from use of TLS, aerial LiDAR, and ground verification with GPS. This feature map shows the BR2292 Launch Stand as well as related features and the nearby BR2294 site. The refractory brick areas have been mapped to show relation and extent.
Figure 182. Area of refractory fire bricks in proximity to the BR2292 site.
Figure 183. BR2293 Flame Deflectors located on the LC 34 launch pad for use with the launch stand. Photo shows laser scanner during survey.

Figure 184. Diagram showing how the flame deflector was moved into place via the rail for use with the launch stand at BR2292 (Benson and Faherty 1978).
overlaid with 1 inch steel plates that were covered with a 4 inch layer of specially designed heat resistant ceramic tiles. Hinged side shields, which ran along the exterior edges were 41 inches high, guarded against an overflow or backwash of the flames over the sides of the apparatus. The deflector was assembled on-site in a parking area located on the northwest perimeter of the Launch Pad, where it was kept when not in use. The 43 foot long by 32 foot wide, and 21 foot high structure was transported from the perimeter parking area to the center of the Launch Pedestal by a rail system just prior to launch. A second Flame Deflector was assembled and available on the spur track of the rail system in case of emergencies or damage to the original deflector (Hinder 2003). Both deflectors remain in the original parked position, but the insulating ceramic tiles have been removed and the exposed metal is extremely rusted.

Methods of Documentation
A combination of methods were utilized to capture the context, detail, and spatial positioning of the flame deflectors in relation to the LC 34 launch pad. TLS survey involved data capture across the pad area and also focusing on the deflectors themselves (Figure 185). The TLS was combined with aerial LiDAR and GPS for a holistic understanding of the site and its environs (Figure 186). Point cloud information from the laser scanning survey was next processed to create solid 3D rendered models of the deflectors (Figure 187). The TLS data and models were then used to create measured drawings (Figure 188). All data were also made a part of the GIS geodatabase for the complex. Analysis of laser scanner reflectivity data in comparison to photographic documentation was made to critically measure and visualize areas of rust and corrosion (Costantino et al. 2013)(Figure 189).
Figure 186. Aerial LiDAR data for the Launch Pad area of LC 34, showing the central BR2292 Stand and the BR2293 Flame Deflectors.

Figure 187. 3D model created from the TLS data showing the rail and flame deflectors.
Figure 188. Measured drawings made from the TLS data for BR2293.
Figure 189. Areas of heavy rust on the flame deflectors (above) can be examined using the TLS reflectivity data, which allows better visualization, delineation, study, and measurement of corrosion areas.
BR2294 LC 34 Launch Pad Environmental Building
The remnants of the Environmental Control Building are found immediately to the north of the Launch Pedestal. In 2007, an additional HAER report was completed by ACI for the Complex’s Engineering Support Building and it was assigned the BR2294 FMSF number due to NASA plans to demolish the structure (Slovinac 2007). The remaining foundation of this reinforced concrete structure, and one standing vertical wall and a curb wall or lip on three sides remains (Figure 190). The purpose was to provide the environmental control system for the astronauts while on the launch pad (Penders 2008). Metal rust and concrete degradation is noted at the site.

Methods of Documentation
This site locale was captured as part of the TLS survey in and around structures on the launch pad area. The site is in close proximity to the launch stand area, and so was part of the larger scan area. The scan project was broken out into a separate viewing area for webshare and point cloud analysis and 3D modeling. A total of 14 scan positions were acquired for this area (Figure 191). From the laser scanning data, 3D models were rendered and viewed in 3D and in comparison with photographic data collected (Figure 192). TLS data was also used in conjunction with the GPS field verification data and aerial LiDAR to produce a detailed feature map for the locale (Figure 193). The TLS data also proved useful for creating measured drawings and CAD models (Figure 194).

BR2295 LC 34 Flume and Skimming (Catchment) Basin
The Flume and Skimming Basin were constructed in 1961 to act as receptacles for the Deluge System discussed previously, as well as to drain excess rainwater or liquids that may have accumulated on the launch pad or surrounding areas (Figure 195). The flume was a concrete-lined channel or trench that ran northeast 300 feet from under the launch pad to the skimming or catchment basin (Figure 196). A graded, perimeter trench encircled the launch pad and was connected to the flume to drain surface water. Any leaked or spilled rocket fuel could be flushed into the flume to prevent ground contamination. The skimming basin was a concrete-lined tank, approximately 104 foot wide by 180 foot long and sides that tapered inward to a depth of about five feet. Any fuel that was captured in the basin would float on the top of the water and could be burnt off (Hinder 2003). Condition assessment observations include:

- BP intrusion prevents visibly of portions of flume
- Vegetation impacting concrete structure
- Breaking and uplifting of concrete base

Methods of Documentation
The BR2295 site was documented using GPS field verification survey in conjunction with aerial LiDAR (Figure 197). The LiDAR allows for delineation of the site, as well as vertical and horizontal understanding of features when combined with the GPS survey data (Figure 198). Photographic information including GPS photos also provide both spatial and contextual information, and all is provided in the GIS geodatabase for the complex.
Figure 190. The BR2294 site with its standing wall, curb feature and internal pads and pedestals.

Figure 191. Webshare map showing locations of TLS scanning positions at the BR2294 site.
Figure 192. 3D renders from the TLS data shown in relation to the photographic image for BR2294.
Figure 193. Map of feature and site details as derived from the TLS and GPS survey data.
Figure 194. Measured drawing of the BR2294 site derived from the TLS survey.

Figure 195. The BR2295 Skimming and Flume Basin area of LC 34 Complex.
Figure 196. Culvert or flume trench going under perimeter road toward the skimming basin.

Figure 197. Aerial LiDAR is used to create a DSM that allows complete visualization and dimensional understanding of the BR2295 site.
Figure 198. The culvert flume or channel that runs to the skimming basin is showing impacts and blockage from invasive vegetation as noted in the LiDAR data.
BR2296 LC 34 LH2 Electrical Equipment

Outside of the LC 34 perimeter road, an Electrical Equipment Building, located approximately 750 feet northeast of the launch pad, provided power to the Liquid Hydrogen (LH2) Facility that stored the highly flammable fuel (Figure 199). The facility was constructed to accommodate the Saturn IB configuration in 1963 and 1964. The 240 square foot reinforced concrete electrical equipment building sat on a concrete foundation and had a built-up roof. The building was set away from the LH2 storage area to lessen the chance of fire or explosion. The electric starters and distributors within the building were placed into nitrogen-purged panels that restricted the oxygen content surrounding the electrical devices to prevent potential explosive reactions. A circular metal vent was placed on the roof and another was placed in the east wall to diminish any build-up of vapors or fumes (Hinder 2003). Today, the structure remains but all equipment has been removed. The building lies within a 150 feet of the Atlantic Ocean, and is difficult to access due to aggressive, unrestricted vegetation growth (Figure 200). Condition observations include:

- Severe vegetation makes structure virtually inaccessible
- Metal rust and concrete degradation
- Within meters of beach, facing erosion processes

Methods of Documentation

Due to the inaccessibility of the location due to vegetation obscuration, field documentation consisted of GPS survey and aerial LiDAR modeling.

Figure 199. The BR2296 location with aggressive invasive exotic growth.
Figure 200. DSM from aerial LiDAR showing the location of BR2296 in close proximity to the shoreline. Heavy vegetation and invasive exotics have overrun the site, which is plotted incorrectly with the FMSF by more than 66 meters.

BR2297 LC 34 High Pressure Hydrogen Storage
This facility, constructed in 1965, was located directly to the southwest of the LH2 Facility, and was also outside the perimeter road (Figure 201). The three-sided structure held high pressure gaseous hydrogen (GH2) required for the second stage of the Saturn IB launch vehicle. Reinforced concrete walls sat on a concrete foundation platform of this roofless structure (Hinder 2003). Condition observations at the site show a fair condition with some metal rust and slight concrete degradation (Figure 202).

Methods of Documentation
Aerial LiDAR data is used to delineate and create surface models of the entire site, and GPS survey was used to verify location and extent. GPS photos and standard images were acquired at the site. All was brought together in the geodatabase for the complex.

BR2298 LC 34 Automatic Ground Control Station
This reinforced concrete structure contained an electronic equipment room, battery room, generator room, and distributor pit. Importantly, it housed a slave computer that was directly linked to the master computer in the LC 34 blockhouse, together they constituted the brains for the Saturn checkout system (Ward 2015). The structure was built on the western perimeter of the launch pad (Figure 203), and it is unique at LC 34. The station was built below ground level, with the majority of it extending under of the launch pad. Entry to the substantial 8,170 square foot space was by a flight of stairs that were located immediately adjacent to the flame deflector parking area. The sub-surface structure is inaccessible today due to overgrowth of vegetation, specifically Brazilian Pepper (Figure 204). There also are numerous Africanized bees at the site.
Figure 201. DSM derived from aerial LiDAR showing the three-sided structure and pad for the BR2297 site.

Figure 202. The BR2297 site location, showing all three sides of the structure and a fairly clear pad area.
Figure 203. Map showing launch pad features including the BR2298 – High Pressure Hydrogen Storage site – located adjacent to the LC 34 Flame Deflectors on the pad.

Figure 204. BR2298 site on the perimeter of the LC 34 pad. Brazilian Pepper and Africanized bees are prevalent at the site. View looking east.
Methods of Documentation
TLS data was used in the area and captured some of the terrain aspects of the site, ancillary to the areas targeted for survey (Flame Deflectors, Pad, and Stand). Aerial LiDAR provides a high level of detail (Figure 205), and allows for a non-contact means of documentation. This structure was inaccessible due to Africanized bees as well as heavy vegetation. GPS photo positions for condition and assessment were taken (Figure 206).

Figure 205. LiDAR data was used to create a Digital Surface Model for the site area, and provides details on the position, size, extent, and contextual relationship for the site. The site is adjacent to the Flame Deflectors and consists of three compartments that are below ground surface.

Figure 206. GPS photography was taken to assist with condition documentation and location information.
BR2299 LC 34 Liquid Hydrogen Storage (and pipeline)
The success of the tests of the Saturn launch vehicle required NASA to make modifications to LC 34, one of which was the construction of a Liquid Hydrogen Storage Facility beginning in 1963. The highly flammable liquid hydrogen (LH2) used to fuel the upper stages of the Saturn IB. Because of its potentially hazardous combustible nature, the facility was located outside of the complex’s perimeter road, around 850 feet from the launch pad. A large steel reinforced, concrete blast wall and an earthen revetment protected the facility’s gas tanks along their southern side (Figure 207). A series of concrete pedestals held the pipeline that carried the hydrogen to the launch pad, extended south from the blast wall (Hinder 2003). The site is located adjacent to the Atlantic Ocean and in proximity to structure BR2297 (Figure 208).

Condition observations include surface corrosion of metal areas noted, concrete surface loss, and vegetation overgrowth (sisal and other growth makes the site largely impenetrable). Transfer supports (i.e., reinforced concrete posts) are deteriorating due to weathering and vegetation concerns. The site is within meters of the beach face area and experiences wash-out and erosion. There is an associated concrete foundation to the north of the blast wall that is being impacted by beach erosion.

Methods of Documentation
Aerial LiDAR provides a high level of detail, and allows for a non-contact means of documentation. This structure was inaccessible due to high degree of vegetation over most of the site.
BR2300 LC 34 High Pressure Gas Battery
In 1963, this structure replaced the original High Pressure Gas Facility (BR2281) in order to provide expanded storage space for the additional number of high pressure nitrogen and helium storage batteries that were necessary for the new Saturn IB rocket engine. The new location was to the east of and closer to the launch pad (Figure 209). The structure had three steel reinforced concrete walls that enclosed a series of concrete pads. The fourth side that faced away from the launch pad was left open. A gable roof covered the structure, but it has been removed. A blast wall with an earthen embankment protected the west wall (Hinder 2003).

This site is plotted incorrectly with the FMSF and is more than 106 meters from its correct position. Condition factors of note at the site include heavy invasive exotics (Brazilian Pepper), especially noted on the blast wall side (Figure 210).

Methods of Documentation
GPS survey around existing elements was conducted at the site and aerial LiDAR features were verified. These data were compared to physical description of the site to determine that the FMSF locale was in error and was associated with this location. GPS photographs and standard photography were taken and all spatial data was brought together in a GIS geodatabase.
Figure 209. DSM derived from aerial LiDAR data clearly shows the BR2300 site adjacent to the launch pad area. The series of concrete pads and three walls with one side left open and the west wall earthen embankment are all apparent.

Figure 210. The open-sided wall structure portion (view is from the northwest of BR2300).
Unidentified Blast Wall, Raised platform, and Earthen Revetment

Approximately 1,000 feet to the north of the perimeter of the LC 34 launch pad is a reinforced concrete blast wall and earthen revetment (Figure 211). A pedestrian survey of the area noted a raised, broken asphalt and gravel, vehicle track with concrete pads (Figure 212), a wall of hardened bags of concrete (similar to those in the revetment at LC 22) and vertical concrete columns (Figure 213). These and other unidentified features are present and are located to the south of the blast wall (Figure 214).

Figure 211. View to the southeast showing the blast wall and portions of the earthen revetment

Figure 212. View to the south showing stacked hardened concrete bags and vertical concrete columns.
Figure 213. View to the west showing the raised gravel track with concrete pad. Base of earthen revetment is to the right and the wall of concrete bags and columns are to the left center.

Although this structure is a considerable distance from the LC 34 launch pad, its orientation is aligned with the pad complex (Figure X). The structures are within 25 feet of the eastern unpaved extension of the road that separates the borders of Launch Complex 34 from those of Launch Complex 37. There are no other launch facilities that currently align or appear to be related to the features. It may be possible that these are remnants of previous launch or test facilities that no longer exist. A further investigation of the site seems warranted, and is planned for the follow-up phase of survey and analysis.

Figure 214. Unknown revetment and blast wall (polygon area) is located approximately 300 meters to the north of the pad.
Conclusions

Overall, the 3D models, cartographic products, 3D tomographic slices, and CAD renderings derived from the TLS survey proved useful in the analysis of ‘as built’ archival documentation for the areas of historic launch complexes at the CCAFS. These data are useful for the digital preservation, replication, CAD and sectional analysis, and for future interpretative development options, such as web based heritage tourism, Augmented Reality and mobile device applications, and on site museum, kiosk and wayside interpretative development.

Cartographic products, including digital geodatabases, provide an accurate assessment of the features, structures, and surrounding terrains. Accurate portrayal and understanding of spatial locations of resources is important from both a management perspective and from a compliance and public interpretive perspective. Having a true understanding for locations and associations of features on the landscape help to lessen the potential for conflicts, and allows for the greater protection and preservation of properties (Entwistle et al. 2009).

At the landscape level, aerial LiDAR models were combined with areas of terrestrial laser scanning survey, and can allow for the examination of issues and to provide precise means of assessing loss and developing mitigation and stabilization strategies (Abby 2014). The Digital Elevation Models (DEM) and Digital Surface Models (DSM) were produced using a combination of aerial laser scanning (ALS) or LiDAR, terrestrial laser scanning (TLS), and ground truth verification with GPS. ALS data collection and interpretation has been described as one of the most significant innovations for the field of archaeology and for landscape analysis (Opitz 2013). The AIST at the University of South Florida are integrating ALS with TLS and other techniques to examine large scale landscape areas, with rapid and highly accurate assessments of elevation and surface details possible. At the historic launch complexes and related structures at the CCAFS, these data provide a way to visualize and to digitally document these NRHP, NHL, and eligible sites, using efficient, exact, and highly representative approaches. These data will serve as a foundational step in the longer range planning, management, archive development, and monitoring programs at the CCAFS, and offer a model for how base historic structure management can be conducted.
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