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Leveraging Extensible 3D to Integrate and Empower Disparate Datasets:

Improving Planning Design, Construction, and Resilience

Background on Extensible 3D

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- X3D is an ISO-ratified, file format and run-time architecture to represent and communicate 3D scenes and objects.
- **X3D fully represents 3-dimensional data.**
- X3D has evolved from its beginnings as the Virtual Reality Modeling Language (VRML) to the considerably more mature and refined ISO X3D standard.
- **X3D provides a system for the storage, retrieval and playback of real time 3D scenes in multiple applications, all within an open architecture to support a wide array of domains and user scenarios.**
- **X3D has a rich set of componentized features that can be tailored for use in engineering and scientific visualization, CAD and architecture, Geospatial**, Human animation, 3D printing and **3D Scanning,** AR/MR/VR. Today X3D has several applications in medical visualization, training and simulation, multimedia, entertainment, education, and more.
- **As an open standard X3D can run on many platforms, but importantly can render 3D models in most web browsers without the requirement for additional or proprietary applications.** Further, once models are developed utilizing X3D, these easily port to alternative platforms like holographic, head-mounted or other display devices.

Integrating & Leveraging Existing Data

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- Data is increasingly recognized as another asset to our clients, one that historically has often gone underutilized. The ability to review and interpret data – from changing conditions or changing demand on an installation's energy infrastructure – strengthens our client's ability to pivot to ensure mission readiness, increase resilience, and/or anticipate costs. Adopting X3D can unlock the value of existing data.

- Ideally a good X3D scene will create a Observe, Orient, Decide, & Act feedback loop as it will:

  - ✔ **Understand the past**: It tracks historical context and performance data.
  - ✔ **See present conditions**: Can be regularly updated to detect anomalies and improve model accuracy.
  - ✔ **Predict the future:** It synthesizes and contextualizes that historical and real-time data to give insights into potential future states

X3D Alignment with DOD Guidance

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- Strategic defense priorities requiring accelerated delivery of lethal capacity, increased agility and affordability to compete and win
- DOD Digital Engineering and Data Strategy calls for **conducting digital engineering in more integrated virtual environments**
- The Naval Enterprise must adopt cross-SYSCOM systems engineering **practices and culture that creates, shares and repurposes digitized data** to the greatest extent possible
- **Aligns to recent resilient guidance and strategies** (i.e., energy, water, cyber, climate adaptation)
- Supports Distributed Maritime Operations / Expeditionary Advanced Base Operations within the Joint Engineering Community by driving to common operating picture (i.e., improved site characterization.
- NAVFAC Strategic Design 2.0 likely to apply Command focus to enabling warfighter lethality and maximizing Naval Shore Readiness

Extensible 3D Benefits

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- **Improved efficiency and accelerated risk assessment**
  Engineers can design and evaluate concepts, disrupt the system to synthesize unexpected scenarios, examine the system's reaction, and identify corresponding mitigation strategies. This new capability improves risk assessment.
- **Optimized and predictive maintenance/repair**
  Enterprises can visualize and analyze their data to proactively identify any problems within the system.
- **Quality management**
  Models can be accessed anywhere, enabling users to assess and visualize data establishing a common operating picture.
- **Better collaboration and communication**
  Models allows work force to focus more on inter-team collaboration, which leads to improved productivity and operational efficiency.
- **Better financial decision-making**
  The availability of a large amount of real-time data and advanced analytics enables businesses to make better and faster decisions about whether financial adjustments.

Capital Project Delivery

- ✔ 30%-70% reduction in engineering cost and time
- ✔ Reduced material costs
- ✔ Labor man hours reduced by 30%-80% across multiple key processes

Operations & Maintenance

- ✔ 5%-15% higher production and prevention of unplanned events and failures
- ✔ 20%-40% reduced maintenance costs

Pilot Study 1

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3D Virtual Environment Planning Support for Marine Corps Base Guam (Camp Blaz)

N62472-17-D-0005 TO#N6274219F0354

Pilot Study Background

- MARFORPAC DPRI is to construct and operate a cantonment area, family housing, and an LFTRC on Guam to support the Marine Corps relocation. To meet the purpose of and need for the proposed action the Marine Corps requires facilities that can fully support the missions of the relocated units
- These requirements include a Main Cantonment Area of sufficient size and functional organization to accommodate the number of Marines relocating to Guam, and an LFTRC that allows for simultaneous use of firing ranges to support training and operations of the relocated Marines
  - ✔ The proposed cantonment and family housing would provide essential base operations and support facilities and functions, including, but not limited to: Headquarters and administrative support; Supply, service, maintenance, and storage facilities (including uncovered, paved open storage areas);.
  - ✔ **This Pilot Project will focus on developing 3D Visual Environments to support the planning of this Main Cantonment Area at Camp Blaz.**

Camp Blaz Pilot Study: Goals

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- Enhance accessibility of contextualized real property data in a Digital Twin (an interactive geometrically and geospatially accurate 3D platform)
- Perform real-time, model-based conceptual installation and training activities
- 3D contextualization of existing, disparate geographical, engineering, scientific, and environmental digital data sets, including Facilities, Assets, and Components
- Produce 3D outputs including, training aids, customizable to relevant locations
- Optimize operational & logistics events & allow for advanced iterative modeling, risk assessment & rehearsal of safety-critical operations

Camp Blaz Pilot Study: Key Attributes & Benefits

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- **3D rendered scene was developed using non-proprietary, open-source software and will eventually reside on NAVFAC's SPIDERS3D platform (.mil).**
- Derived from **authoritative models and data sources** (i.e., CAD, Revit, GIS, imagery).
- **Geometrically and geospatially accurate** and can be adapted to convey model metadata for both above ground and below ground assets.
- **Optimized model file sizes for constrained enterprise network bandwidth** so that it could be available to anyone that has access to the NAVFAC portal.
- Digital file size reduction from terabytes/gigabytes to megabytes/kilobytes.
- Web-based, open standards enable sustainable **cross-SYSCOM digital engineering processes across full platform/program lifecycles**.
- Shareable publication and real-time, web-based collaboration of diverse 3D models **enables effective system engineering activities, regardless of original data source.**
- Enables comprehensive long-term approach for 3D sharing, collaboration, visualization, printing, scanning, publication and correlation across all pillars of the Digital Engineering Strategy.

Camp Blaz Pilot Study: Integration of Disparate Data

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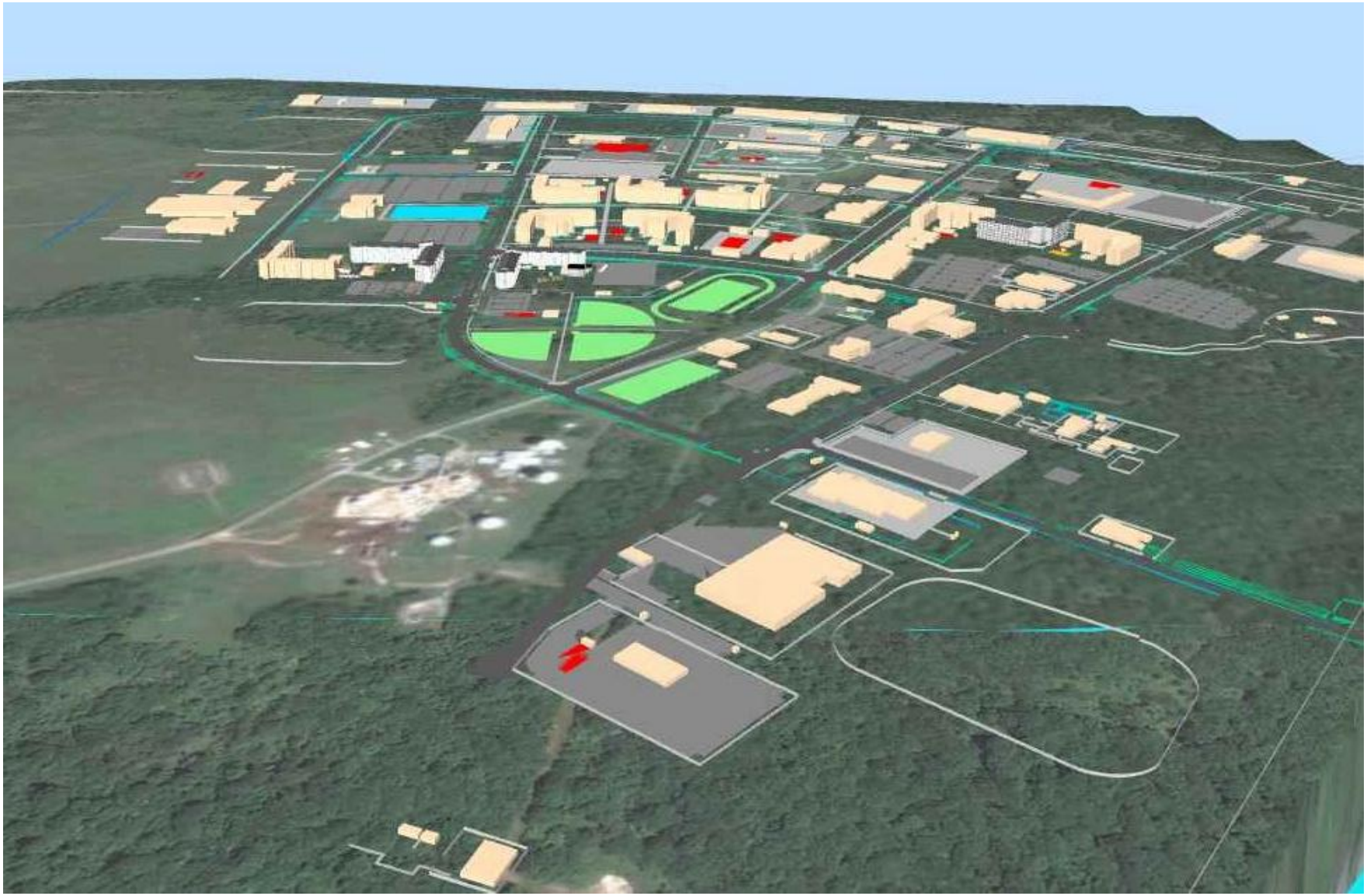

Camp Blaz Pilot Study: Capture of Revit Data

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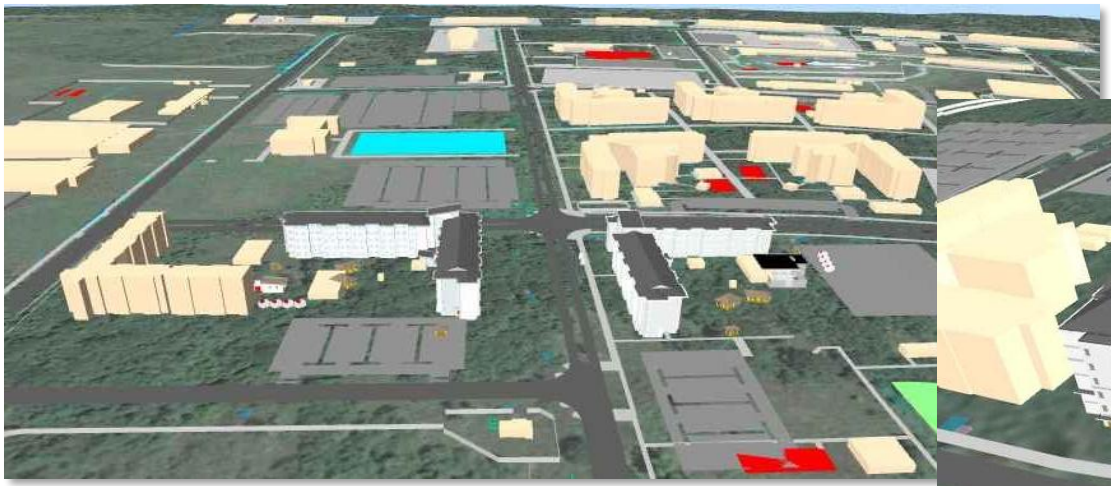

Camp Blaz Pilot Study: Rendering CAD Utility Data

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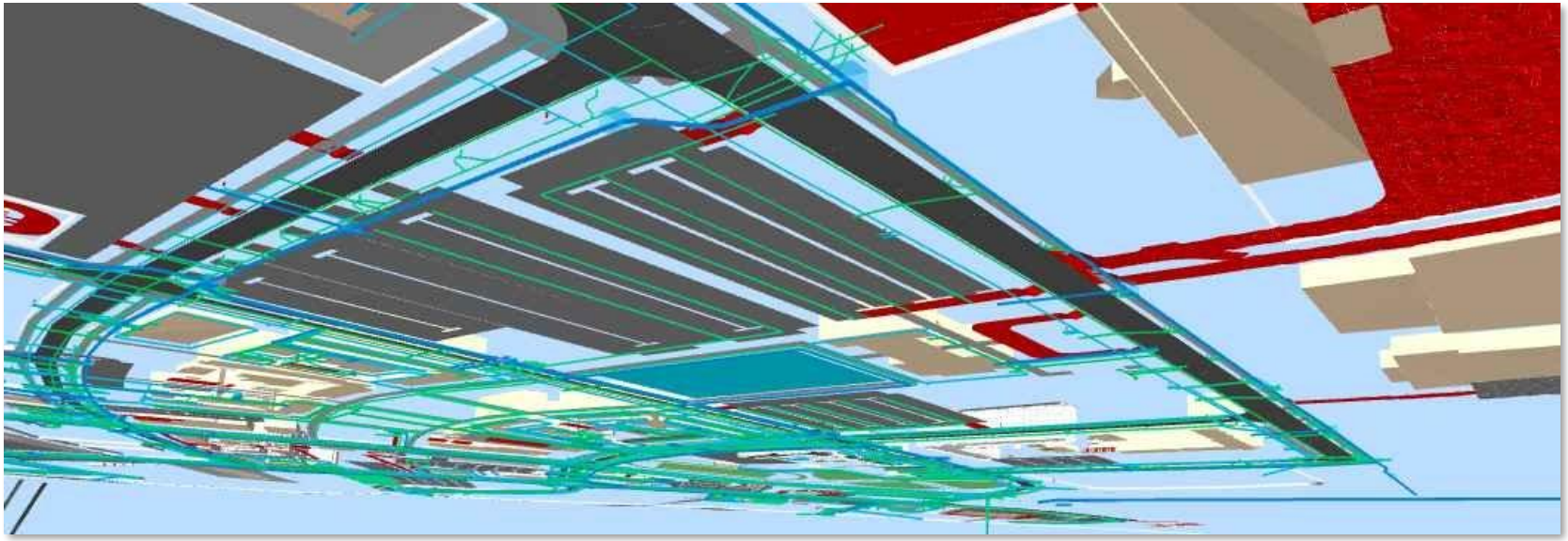

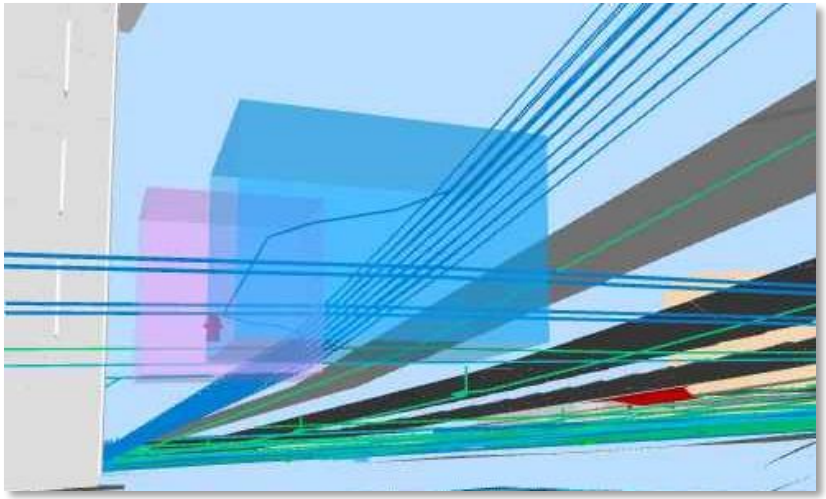

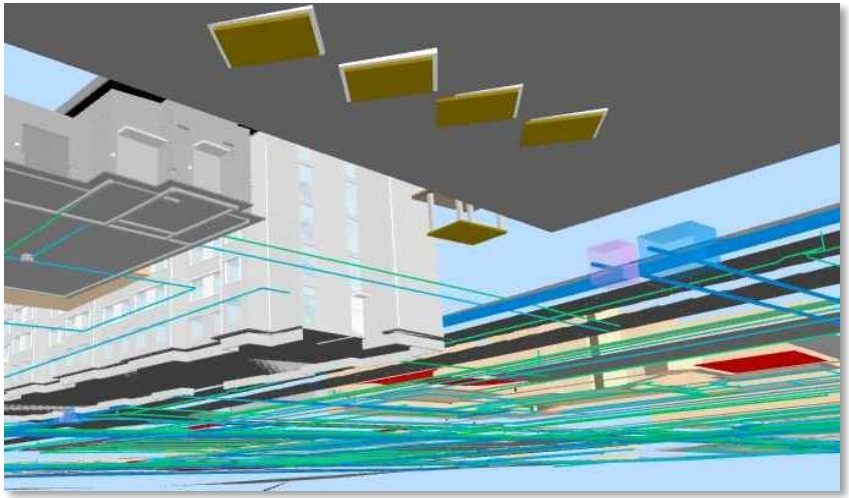

Camp Blaz Pilot Study: P-314

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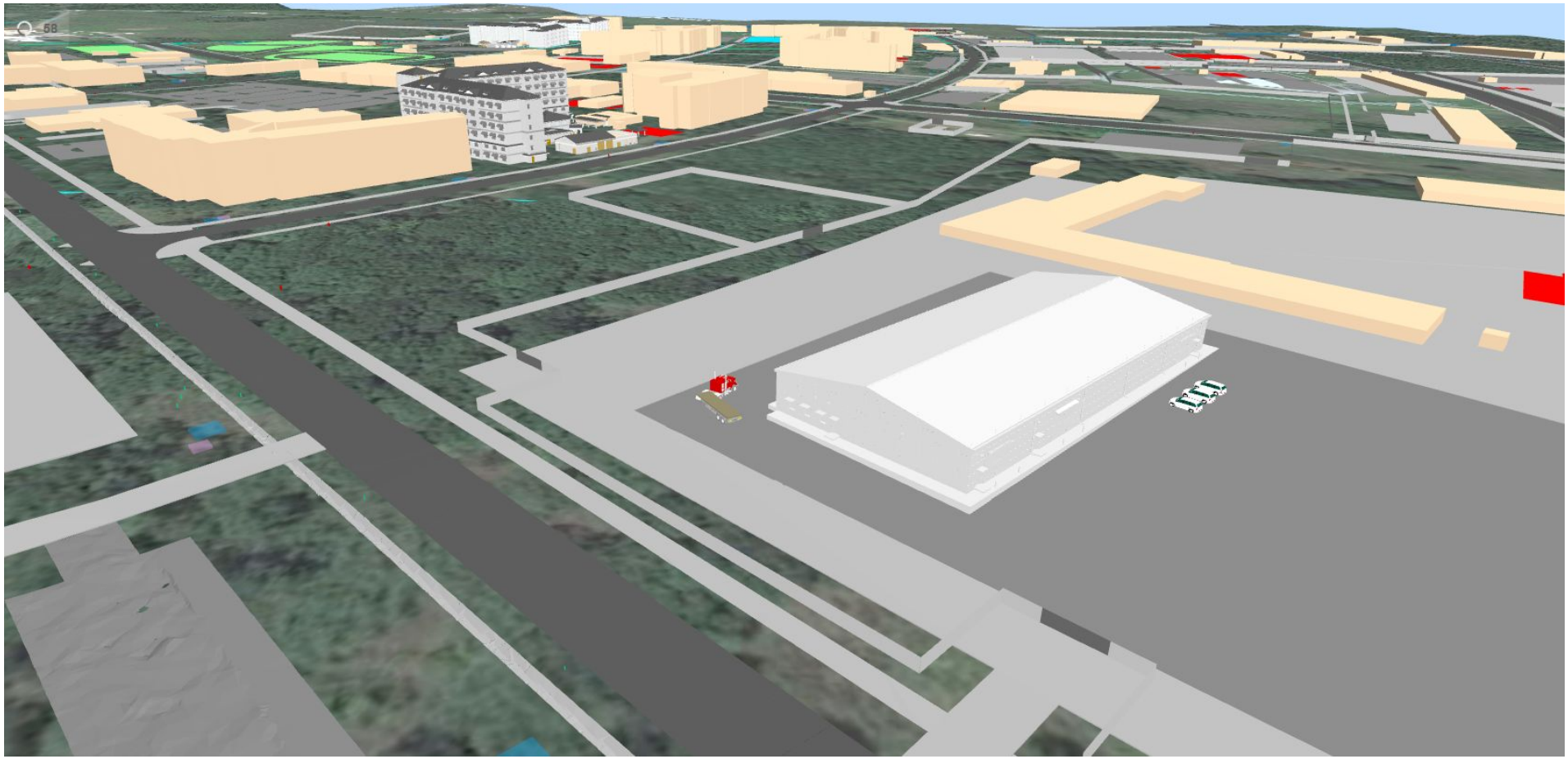

- Revit model of P-314 was converted into an .X3D file and rendered in existing Camp Blaz scene to assess orientation with existing transportation to existing transportation infrastructure and proximity to proposed location of BEQs.

Camp Blaz Pilot Study: P-314

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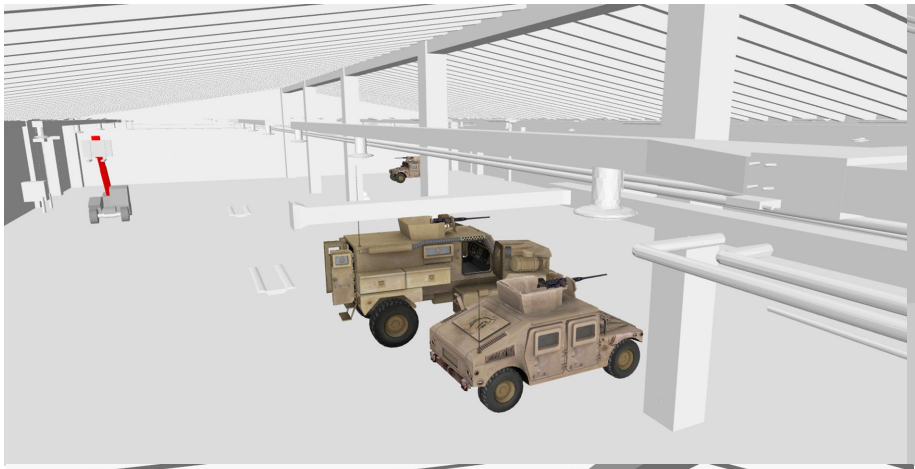

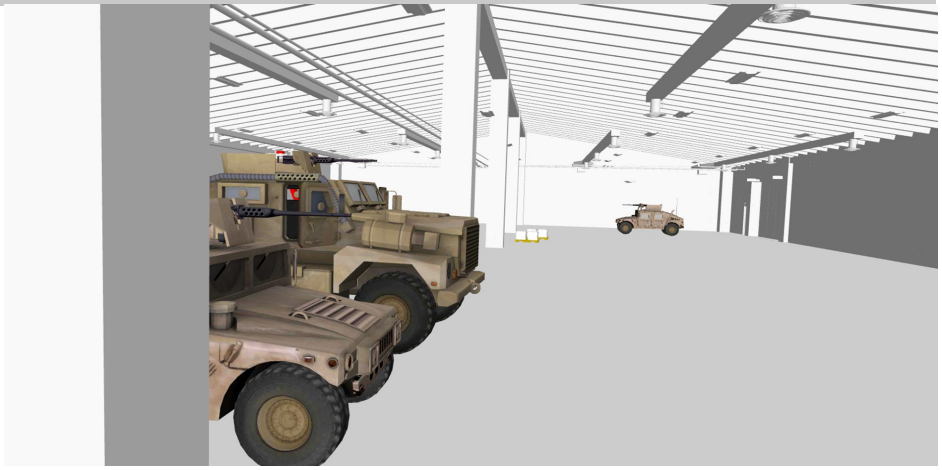

- Weapons systems and maintenance equipment were then placed in P-314 to assess space utilization and operations. This common operating picture will reduce cycle time and improve quality from requirement conception to delivery.

Pilot Study 2

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Pilot Study Background

- Climate change, sea level rise, changing weather patterns and continued subsidence will continue to contribute to an increase in the number and magnitude of coastal flooding events in the near- and long-term future of NSA Annapolis. These conditions will continue to impact land & infrastructure and pose significant challenges to the successful execution of the Naval Academy mission. Protective measures will be necessary to reduce damage from these events and facilitate effective mission execution.
- Awarded in September of 2020, this task order under the NAVFAC Atlantic Mission Sustainment & Coastal Resilience IDIQ is to:
  - ✔ Develop comprehensive plan, project portfolio and year-by-year execution strategy to cohesively address and mitigate the combined effects of land subsidence, sea level rise, coastal flooding/storm surge and inadequate stormwater management on the installation.
  - ✔ **This project includes a pilot venture for using three dimensional virtual environments (3DVE) to better understand and communicate sea level rise impacts and solutions.**

NSAA/USNA Pilot Test: Goals

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- Provide NSA Annapolis, USNA, NAVFAC and CNIC with the 3DVE technologies, tools, data and visualization platform to better understand and communicate projected impacts of climate change on the installation.
- The USNA 3DVE created under this Task Order will also serve as a useful medium for capturing, publishing and visualizing future 3D data content developed or procured by NSAA/USNA stakeholders.
- NAVFAC will leverage NSA Annapolis 3DVE testing and validation of digital survey processing and analytics to assess applicability and value to inform typical NAVFAC products and services (e.g., coastal resilience and climate adaptation, basic facility requirements, master planning, historic preservation and joint land use studies).

3DVE Scene of NSAA/USNA

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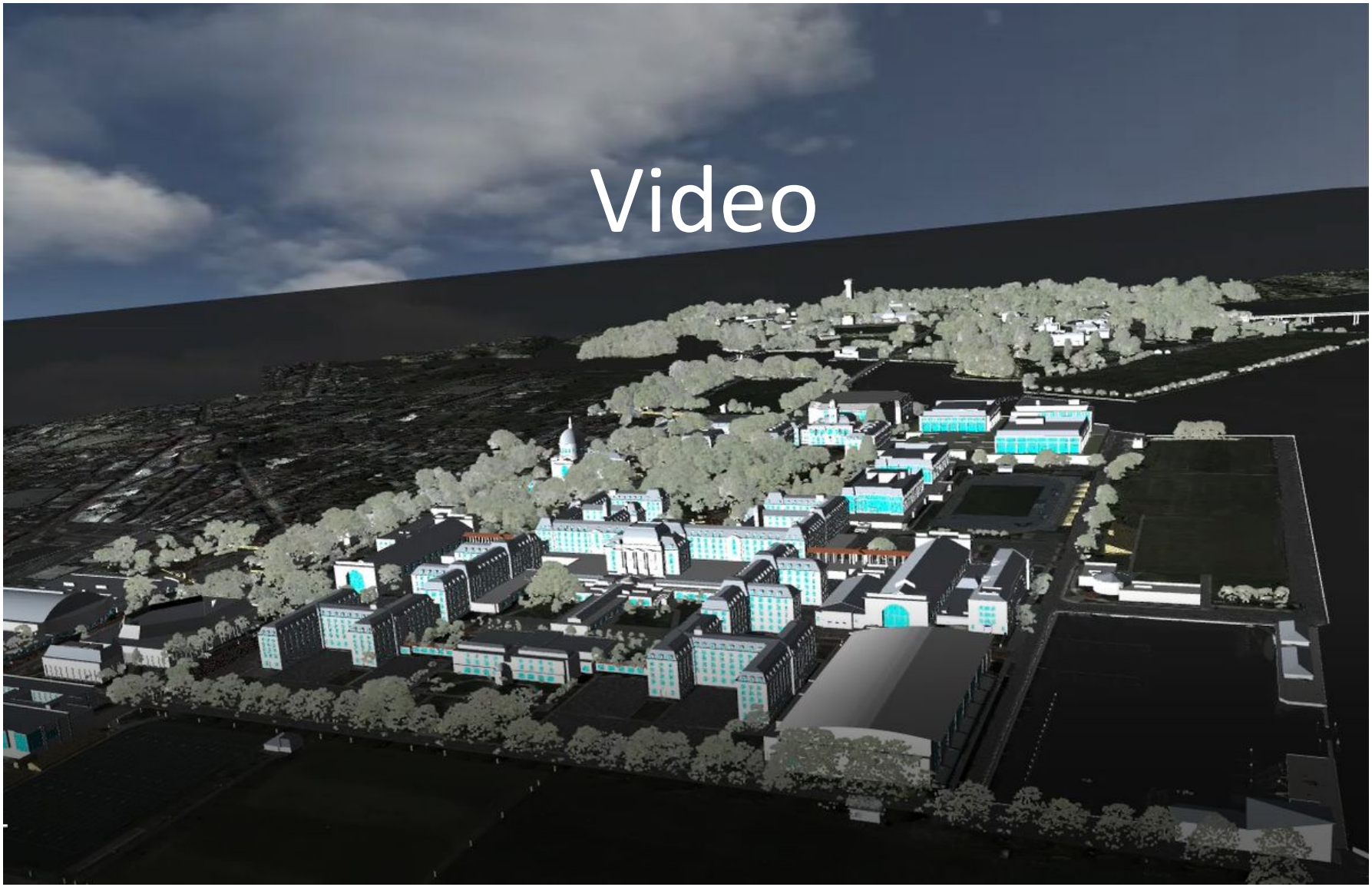

NSAA/USNA Pilot Study: Key Attributes & Benefits

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NSAA/USNA Pilot Test: USACE AGC Data Collection

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- NSA Annapolis encompasses a total of 825 acres, with a population of more than 7,400 personnel.

- 286 acres of land designated as a National Historic Landmark District. Within this boundary,139 facilities comprised of buildings and monuments, are contributing elements of the National Historic Landmark District.

- USACE AGC deployed and collected data from a variety of platforms over 2 days in July 2020.

  - ✔ Buckeye Ground LiDAR System
  - ✔ Buckeye Fixed-winged Aerial LiDAR
  - ✔ Mark 3 Backpack LiDAR
  - ✔ Drone based photogrammetry
  - ✔ Side Scan and Multibeam Sonar

NSAA/USNA Pilot Study: Timeline & Integration of Data

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Project timeline:

- Collection of remote sensing data 4 days (Feb, July 2020)
- Arrival of first dataset render 202 days (23 Sep - 2 Apr 2021)
- **Initiation 3D rendering to completion 88 days (4 Jan to 2 Apr 2021)**

Integration of disparate datasets (examples):

- GIS Shapefiles from NAVFAC GeoReadiness Center 215 MB
- Revit models (.dwg) of buildings from NSA Annapolis 614 MB
- CAD files of Waterfront Infrastructure 550 MB
- eBee Photogrammetry Data 46 GB
- Aerial Fixed Wing Buckeye LiDAR 21.9 GB
- Vehicle Mounted Buckeye LiDAR 455 GB
- Mark 3 Backpack LiDAR (cemetery and other features) 700 MB
- Sonar data (single beam and multibeam) 2.62 GB
- Imagery 1.6 GB
- Digital Elevation Model 2.18 GB

Total >2 TB

NSAA/USNA Pilot Study: Datasets Leveraged in 3DVE Scene

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Datasets used to develop the 3DVE:

- Photogrammetry: eBee
- Aerial Fixed Wing Lidar: Buckeye
- Bathymetry: NOAA's NCEI
- Topography: NOAA's NCEI
- Multibeam Sonar
- SID Imagery
- Geodatabase buildings

3DVE scene file size:

- Beginning point cloud **73 GB**
- Current mesh:
  Buildings, Waterfront, & Civil 535.2 MB Imagery 1.6 GB
  Digital Elevation Model 294 MB Trees 73.2 MB
- Continuing to optimize and test scene
  - **Reduction in Triangles 100s of Trillions to 11 Millions**
  - **3DVE runs on NMCI machines under constricted bandwidth**

NSAA/USNA Pilot Study: 3D Models & Spatial Accuracy

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Example of 3D Models Depicted:

- Number of Acres Rendered: **3,400** (terrestrial and bathymetry)
- Elevations (High and Low): +32 m to -17 m
- Number of Buildings: **253 (2,029,038 sq. ft.)**
  138 Level of Detail 100
  115 Level of Detail 200
- Waterfront Infrastructure: **16,590 lf (13 individual models)**
- Bridges: 3 roads, 1 utility, 1 pedestrian
- Memorials: 1,354 (including cemetery)

Spatial Accuracy Vertical & Horizontal

- Ebee: **Mean <10 cm, Mean (x,y): 8 cm, Mean (z): 15 cm**
  Max (x,y): 18 cm, Max (z): 22 cm
- Buckeye Aerial: **Mean <0.5 m, Lidar (x,y): 0.7 m, (z): 0.4 m**
- Sid Imagery: **Mean 5 cm**
- Sonar Data: Mean (x,y): 1 m, Mean: 1 m (z)

NSAA/USNA Pilot Study: Resources

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Personnel Assigned to Project Study:

- USACE Army Geospatial Center Data Collection 9

- Firms and Number of Staff Supporting 3DVE Scene Rendering
  - Cedarville Engineering Group 2
  - Aerial Genomics 2
  - Synergy Software Design 1
  - VirtuWorlds (Virginia Tech) 2
  - Swift River Versar JV 4

NSAA/USNA Pilot Study: Preliminary Findings

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- Established one of first geometric and extensible Digital Twins of Navy installation.
- Successfully generated a geometrically, geospatial accurate Digital Twin of NSAA/USNA by integrating disparate datasets and leveraging non-proprietary, open-source software.
- Tested and evaluated USACE AGC and NAVFAC EXWC innovation efforts to increase joint service planning interoperability by evaluating platforms and processes that enable Joint Engineering.
- This Digital Twin will allow NSAA/USNA to establish a common understanding NSA Annapolis resilience challenges and adaptation action alternatives they intend to implement to meet their planning vision of 2100.
- This Digital Twin will provide a foundation for future pilot studies and RDT&E efforts (e.g., Smart Basing/Smart Shore Strategy, 5G Experimentation & Testing, etc.).

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Thank You

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