CERTAIN SMART CENTER

Langley Research Center

CERTAIN
UAS OPERATIONS OFFICE

CITY ENVIRONMENT RANGE TESTING FOR AUTONOMOUS INTEGRATED NAVIGATION

National Aeronautics and Space Administration

NASA

www.nasa.gov

CERTAIN Smart Center Project – Purpose and Scope

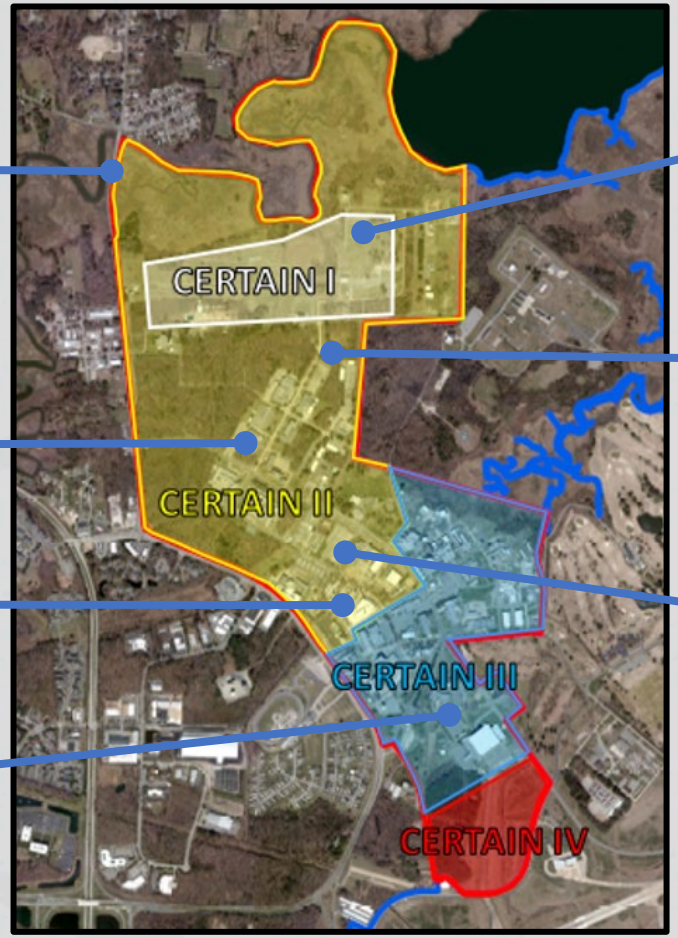
High value use cases with multi-fleet operations across the Center

Perimeter Surveillance Operations

Infrastructure Inspections

Emergency Response

Small Package Delivery



High Density Vertiplex Flight Test Activities

System-Wide Safety Flight Test Activities

RDT&E Activities with Live and Simulated Aircraft

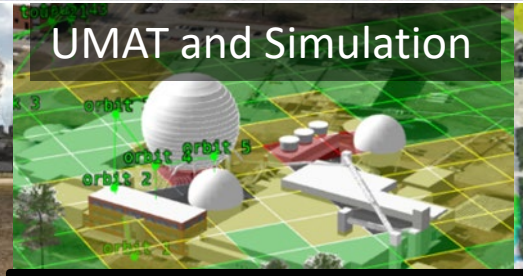
CERTAIN Capabilities

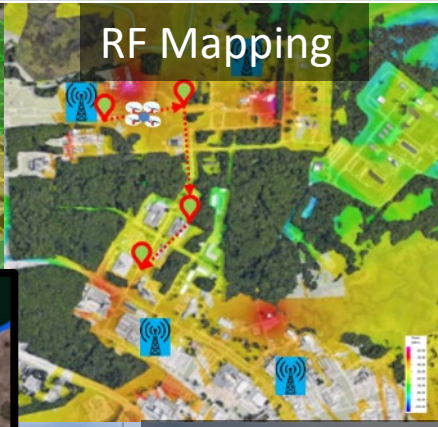
Airspace
- 800 Acres of **Urban** and **Rural** Airspace
- FAA COA and LAFB Letter of Procedure
- 400’ altitude, 125 lbs vehicle weight
- Class D airspace, reverting to Class G

Technology
- NextNav Local Positioning System
- Safeguard Range Containment System
- ClearCom voice communication system
- Radar and RF detection systems installed
- GPS Predictive Quality Services
- UAS Mission Assessment Tool (UMAT)

Data Collection
- Telemetry
- Local Weather Stations
- Data networking

Infrastructure
- Spectrum Management Office
- Rooftop Access and Operations
- Indoor flight/testing capability
- Improved surface for fixed wing operations
- UAV test vehicles
- Safety Process and Procedures
- Simulation capabilities
- Mobile Operations Trailer





CERTAIN Smart Center

MOSAIC is a component of CERTAIN Smart Center

- The goal is to conduct routine UAS missions without field personnel
- Currently at least three field personnel are required for VLOS/EVLOS ops

CERTAIN Smart Center is more than just UAS

- Part of the Digital Transformation Effort
  - Sensors, Cameras, Automation, Data Fusion (Surveillance Data)

Goal: leverage emerging technologies to enhance research AND operational tasks with emphasis on improving efficiency and safety

- Weather sensing, wildlife inventory, road/taxiway deterioration, infrastructure inspections (structural and energy monitoring), spill response, weather event assessment, security

CERTAIN Smart Center – MOSAIC Overview

The Mission Operations & Autonomous Integration Center (MOSAIC) provides a centralized location from which to manage multi-fleet UAS flight operations conducted on City Environment Range Testing for Autonomous Integrated Navigation (CERTAIN) in support of center operations, safety, and research.

MOSAIC is a highly adaptable operations center by design; MOSAIC is currently comprised of the following:

- Six configurable Windows 11 ground control stations (GCS) connected to LARCNET
  - Software and web-interface access enable the GCS to perform the following:
    - Real-time mission planning
      - Ex: QGroundControl
    - Remote command and control (C2) of the sUAS in the field
      - Ex: Botlink (LTE), Skyline (ISM, C2, LTE), MAVLink with Botlink for payload control
    - Remote airspace monitoring tools
      - Ex: UAS Mission Analysis Tool (UMAT), CERTAIN cameras
- Three wall-mounted 85” monitors, controllable/configurable from one ground control station, with an integrated overhead speaker system
- Clear-Com voice over internet protocol (VoIP) communication system coupled with one VHF airband radio and one VHF digital radio
  - This system enables secure communications between remote operators in MOSAIC, field operators at the CERTAIN range, and airspace owners at LAFB tower while providing an additional layer of airspace awareness
- One local cellular network booster
  - Provides a robust LTE and 5G environment within the MOSAIC

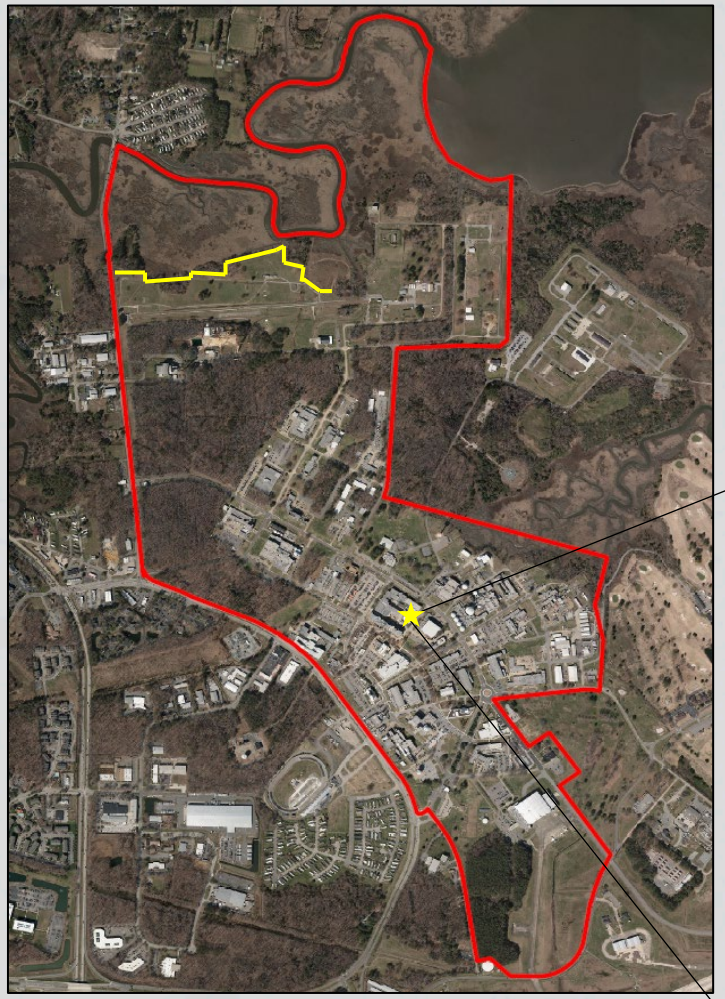
Rendering of MOSAIC, courtesy of Fountainhead Control Room Solutions

Challenges

- **IT Security**
  - Cloud services
  - UAS classified as IT device
- **Scalability of Operations**
  - Increasing ground/sUAS infrastructure is time and resource intensive; moreover, at present the sUAS still requires a crew for setup, battery swap, and storage
- **BVLOS Path Forward**
  - Flight authorizations, approvals with LAFB with respect to RSO placement
  - Streamed video quality
- **Stovepiped Data**
  - How is data placed in an accessible location and how do others know how to find it?
  - IOT Platform/APPDAT, LTI for CERTAIN Database
- **Development of efficient processes tailored to the mission**

LaRC's Perimeter Surveillance Use Case – December 2021 Proof-of-Concept Demo

- Established and successfully demonstrated the **capability to surveil** a portion of **LaRC's perimeter** using a small UAS (sUAS) vehicle
- First step = **WVLOS** flight + use of LTE network
  - CY22 Goal: BVLOS flight enabled by LTE network
- **Live video** of perimeter fence line relayed from vehicle's onboard EO/IR 4K camera to the Mission Operations & Autonomous Integration Center (MOSAIC) located in B1268A/R2119E
  - Camera controlled remotely from MOSAIC (camera pointing, zoom, and mode control)
- Simulated fence line **vulnerability visually identified** by an Office of Protective Services (OPS) observer located in the MOSAIC
- Upon notification by voice comm, a **patrol officer** mobilized and **physically inspected** the fence line anomaly



NASA LaRC Boundary (in red), with Portion of Fence Line Surveilled by sUAS highlighted (in yellow)

Source: https://freeflysystems.com/alta-8/agile

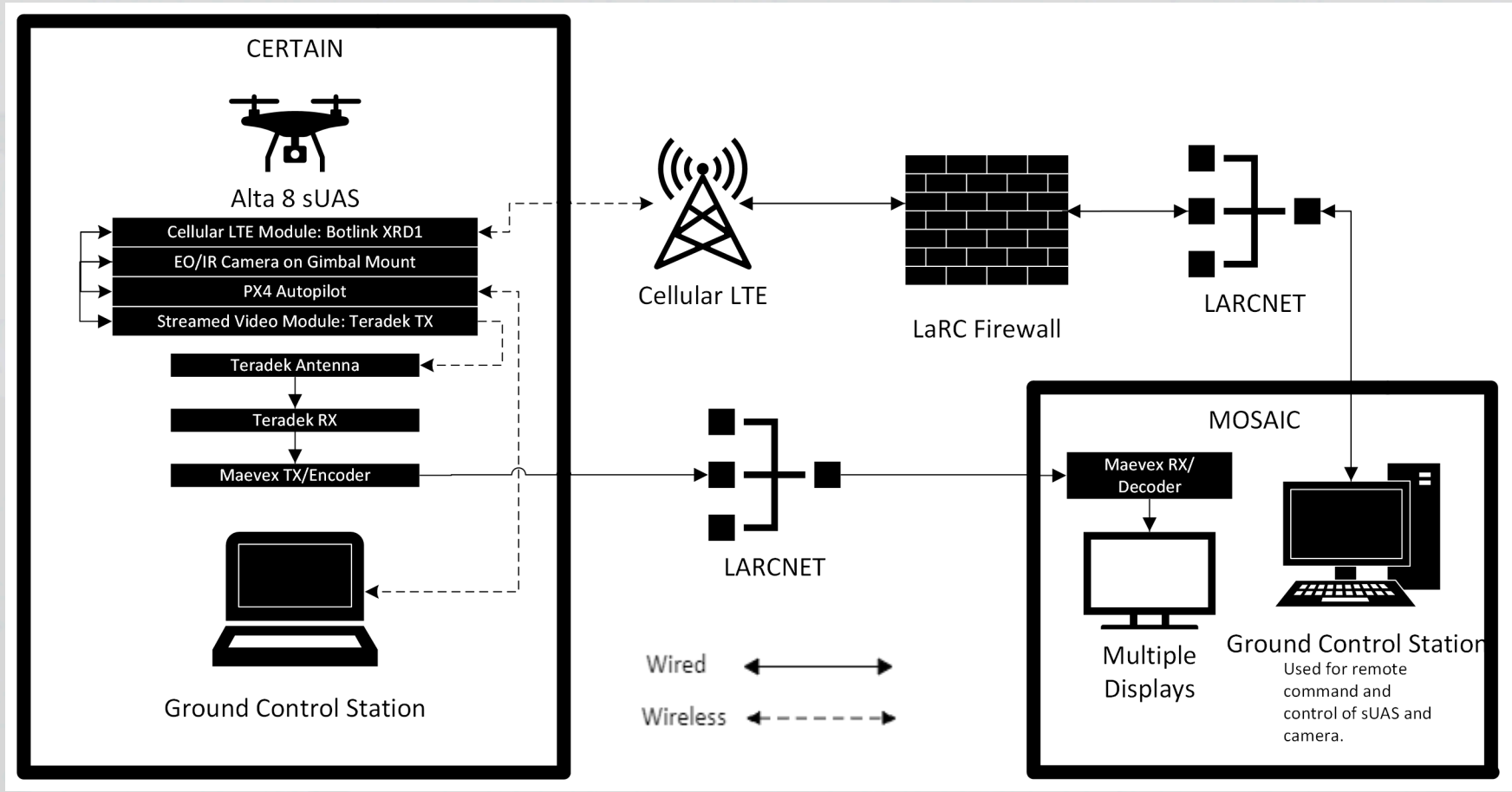
MOSAIC

Located in LaRC B1268A/R2119E

CERTAIN Smart Center – MOSAIC Flight Operations: Data Flows: Alta 8 EVLOS

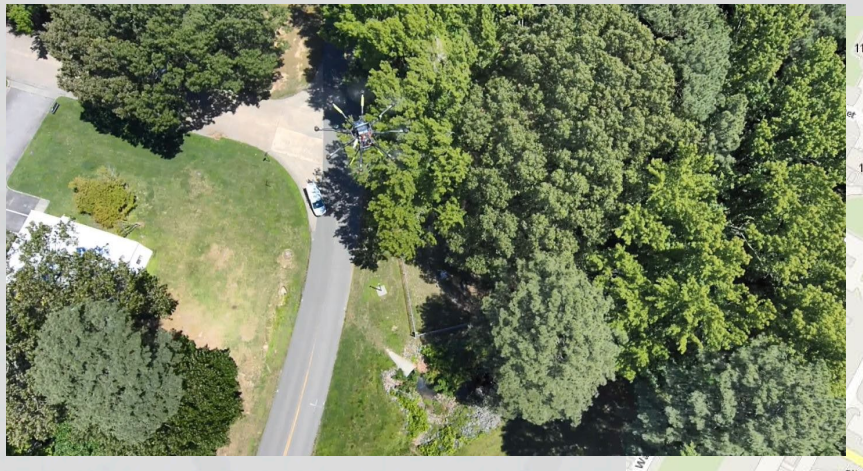
Remote command and control (C2) of the sUAS and camera is achieved through the use of the on-board Botlink XRD1 (superseded by XRD2) module connected to the PX4 autopilot and camera; this link utilizes cellular LTE to facilitate communication between MOSAIC and CERTAIN.

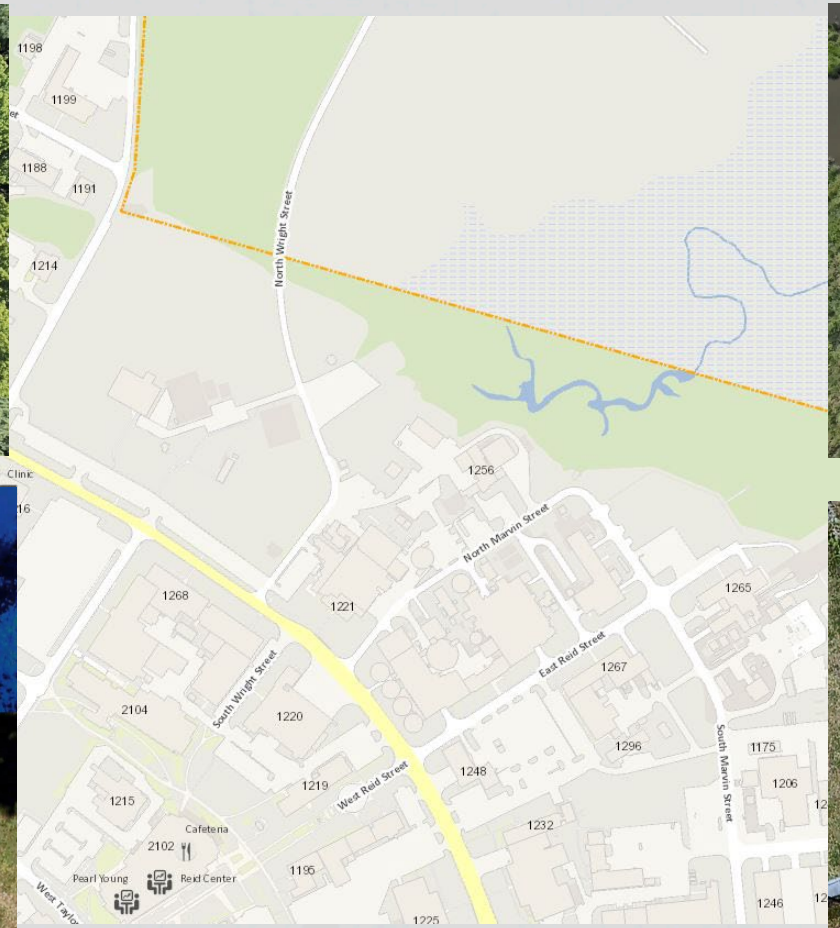
Streamed video is sent from the sUAS on-board camera from CERTAIN to MOSAIC via the Teradek Bolt 4K MAX antenna array, TX/RX units, and a Maevex TX/RX encoder/decoder pair, where it can then be displayed on multiple GCS and the main 85" displays.



The above diagram illustrates data flows between MOSAIC and CERTAIN for the operations center and vehicle configuration used during the perimeter surveillance and stormwater outfall inspection proof-of-concept flights. This setup was successfully used for MOSAICs initial operating capability (IOC).

CERTAIN Smart Center
Stormwater Outfall Inspections using the Alta -8

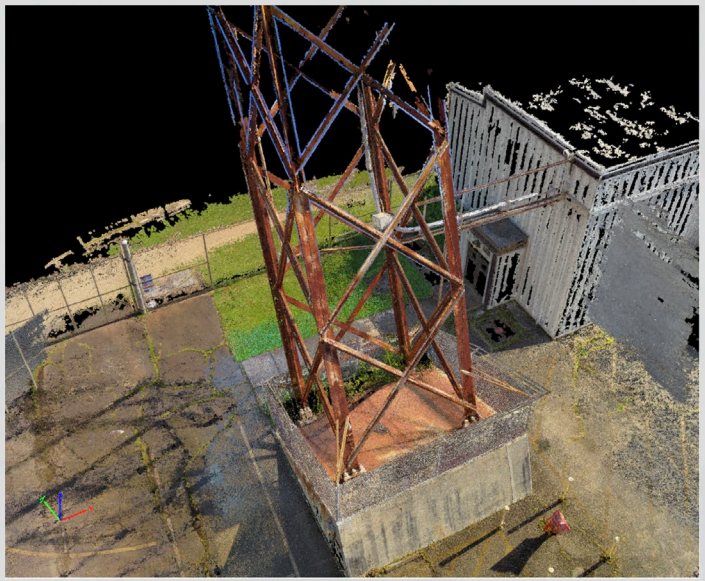




Doolittle Storm Drain Outfall Inspection with IR

North Marvin Storm Drain Outfall Inspection with IR

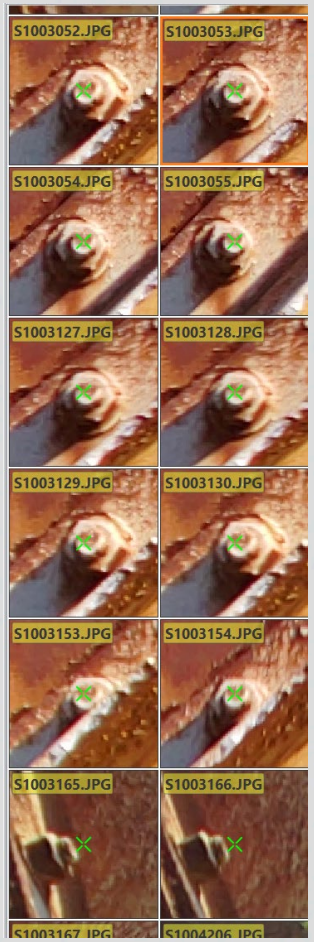
CERTAIN Smart Center – Gantry Inspections



Rendering of the 3D model

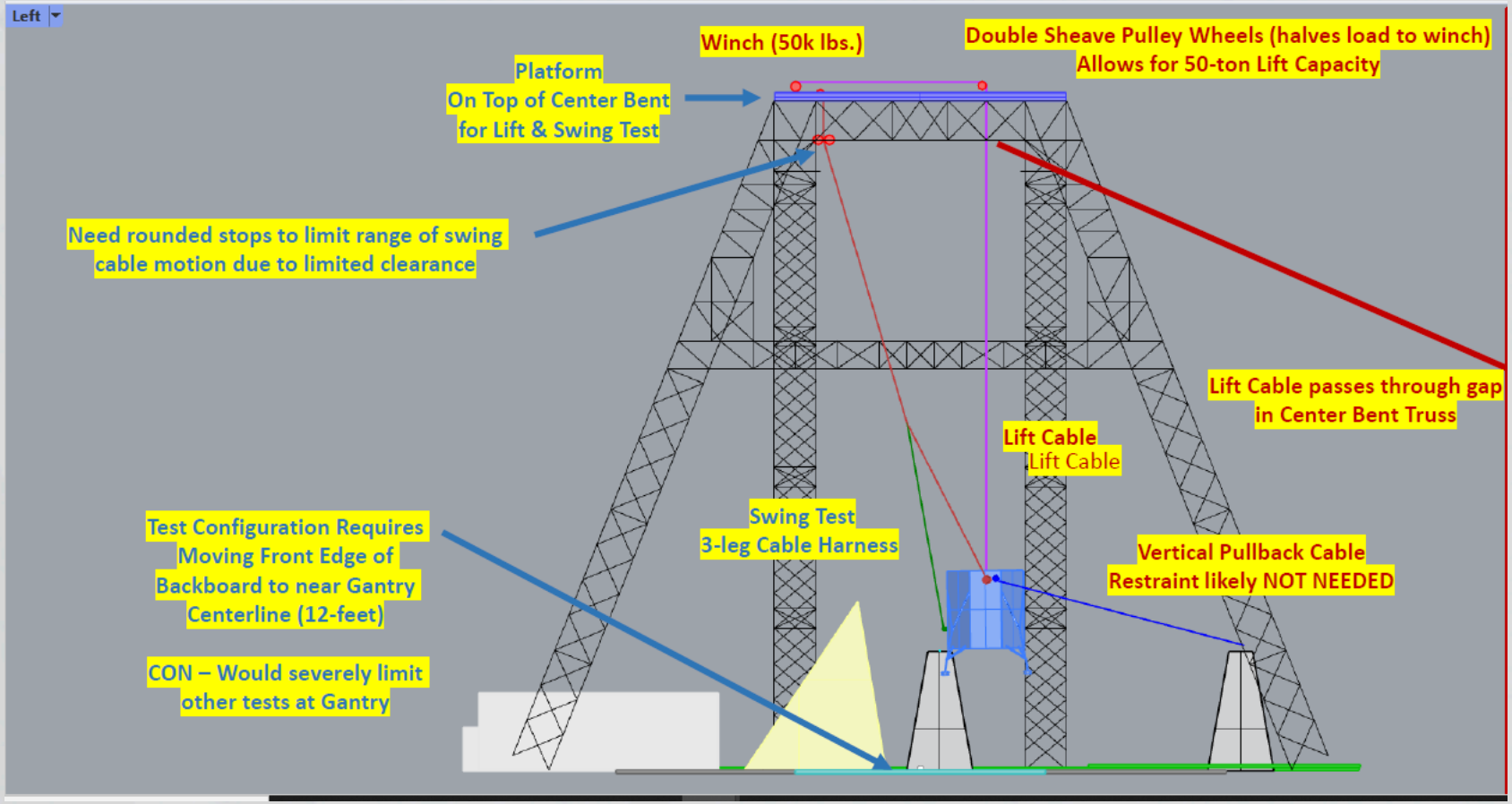
- Semi-autonomous Flight - Pilot Over the Loop
- 3D model of SW leg of the Gantry
- 1,647 photos taken, 11.2 GB
- 1 hour 12 minutes total flight time
- 2 scan sessions needed - recharge batteries
- Vehicle automatically picked up where it left off

Detailed image pulled from the Point Cloud



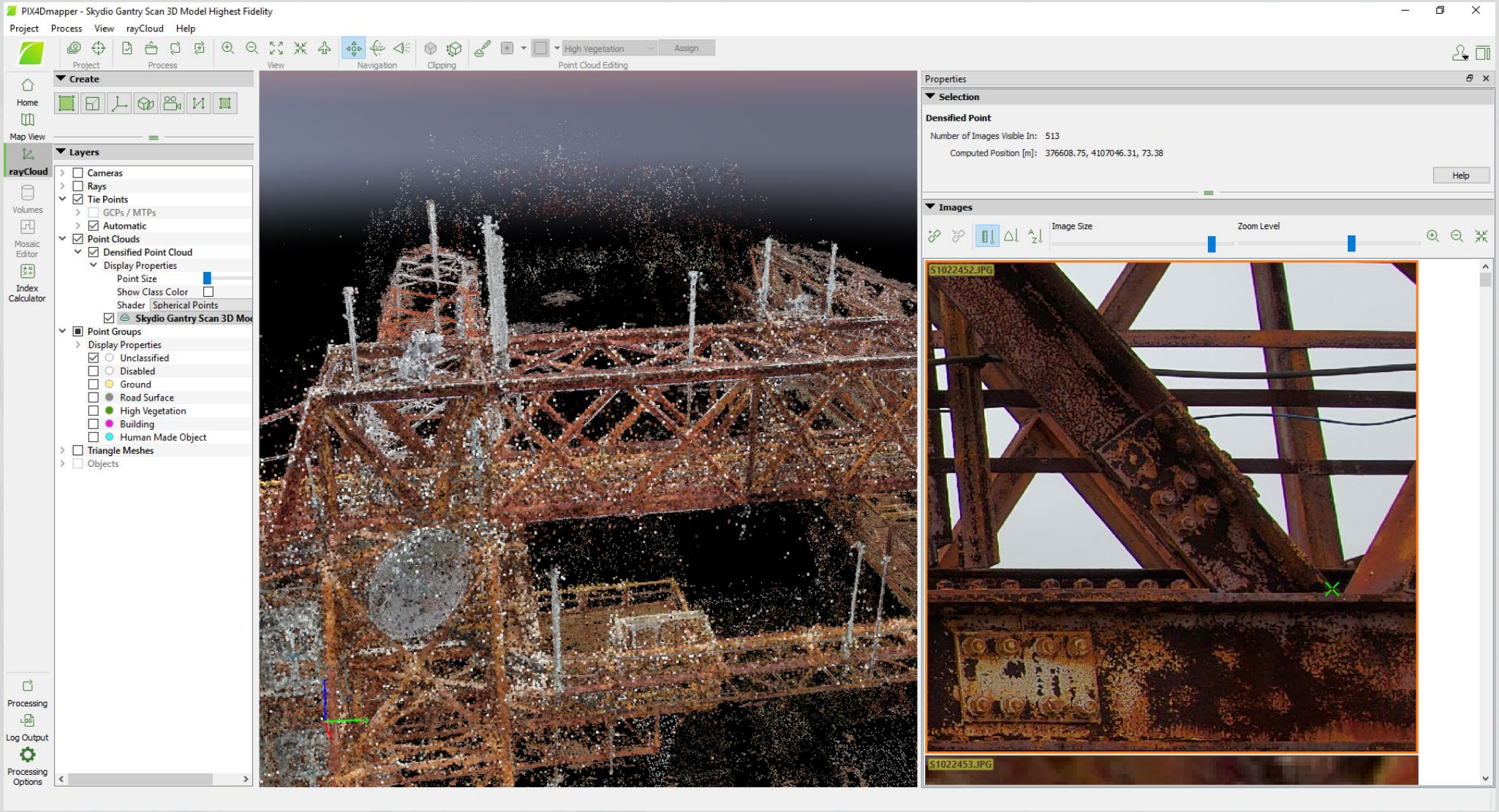
Example of resolution of scan and dimensioning capabilities

CERTAIN Smart Center – Gantry Inspections

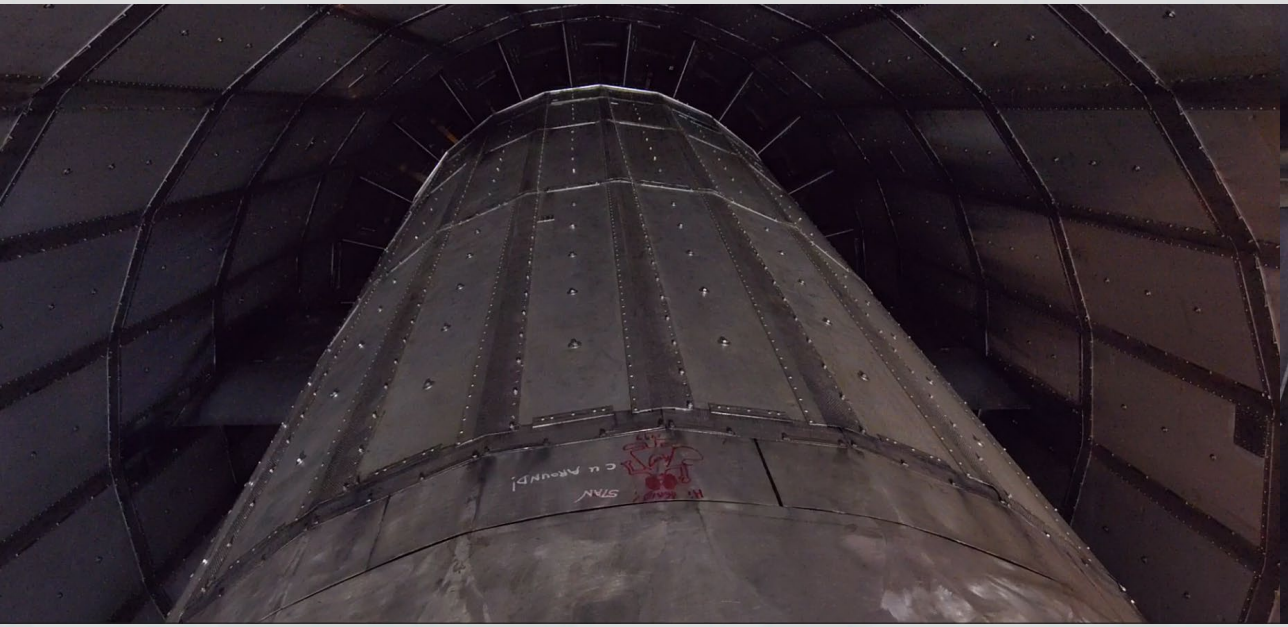


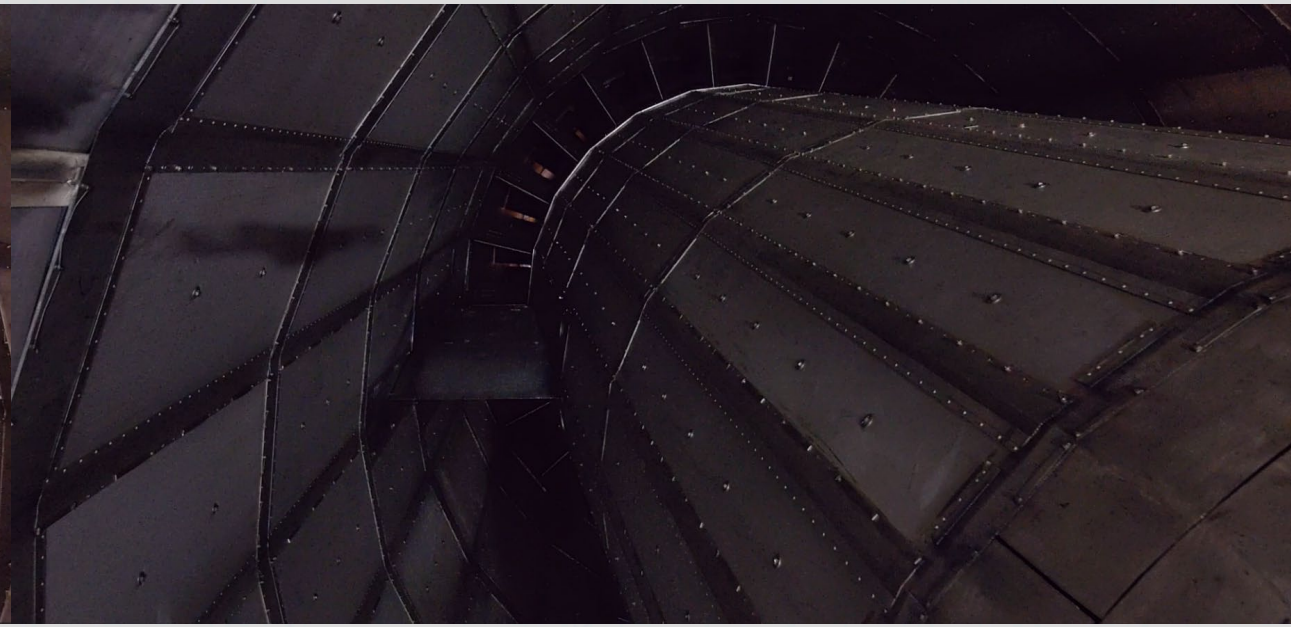
Human Landing System Moon Landing Test Hoist System

CERTAIN Smart Center – Pix4D Point Cloud Model



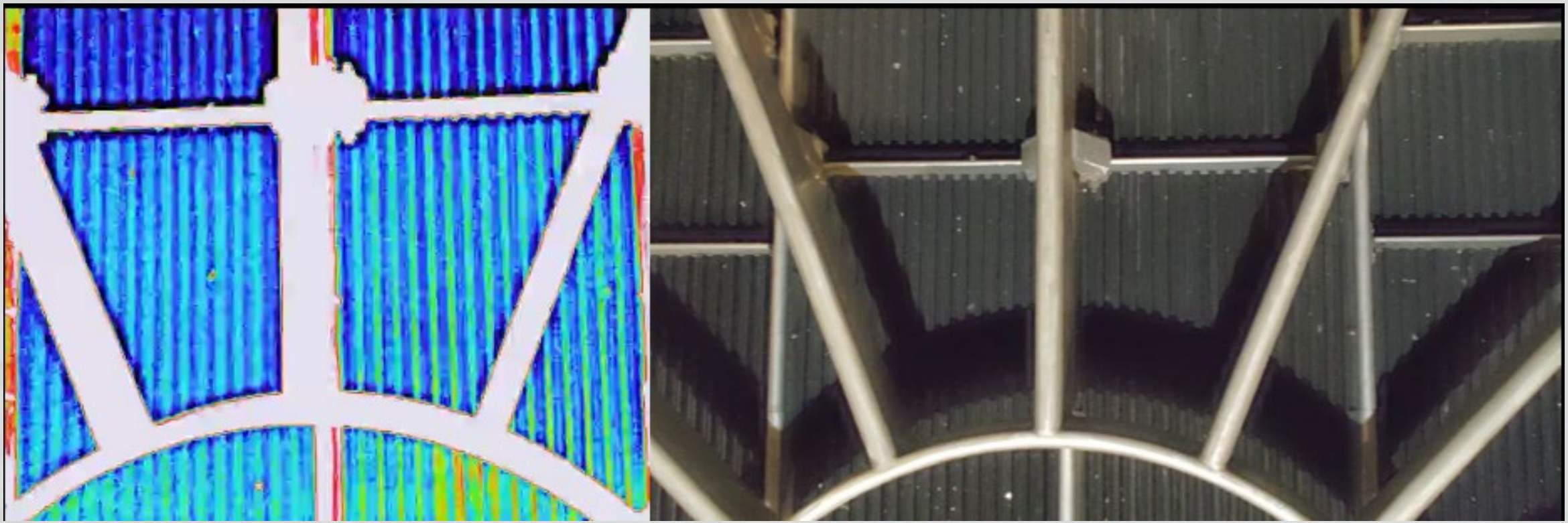
CERTAIN Smart Center - NTF Internal Inspection





- Working with NTF to determine ways to use sUAS to inspect confined, unsafe, and hard to access areas
- Looking for FOD, structural damage, and loose panels
- Used Skydio sUAS with semi-autonomous controls to inspect over and around the NTF nacelle
- Experimenting with on board LED and space lighting to find the right balance for proper navigation
- Investigating the use of AI /ML to process the videos and scans to determine anomalies

CERTAIN Smart Center - NTF Cooling Coils



Side-by-side EO and IR image of the NTF wind tunnel's cooling coils

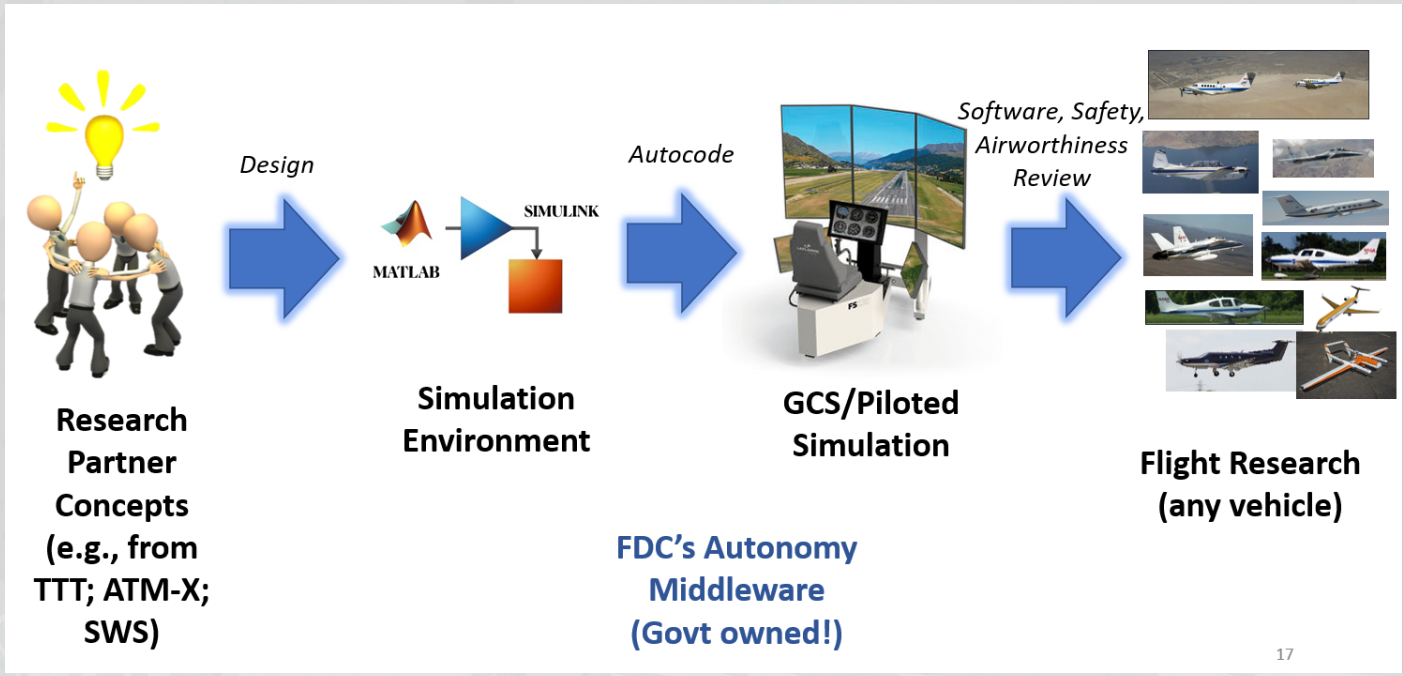
Agency Smart Center Initiative
LN2 Plant IR Inspection

- Proof of concept to correlate sUAS IR scan video with live weather and streaming plant instrumentation data
- This can be used to spot anomalies and assess the health of the system
- Collaboration with ARD, COD, AETC, RSD, and OCIO.
- Showed the benefit of sUAS capabilities integrated with IOT and CBM

https://grafana.labs.appdat.jsc.nasa.gov/d/xur1t5M4k/larc-ln2-sc-demo?orgId=1

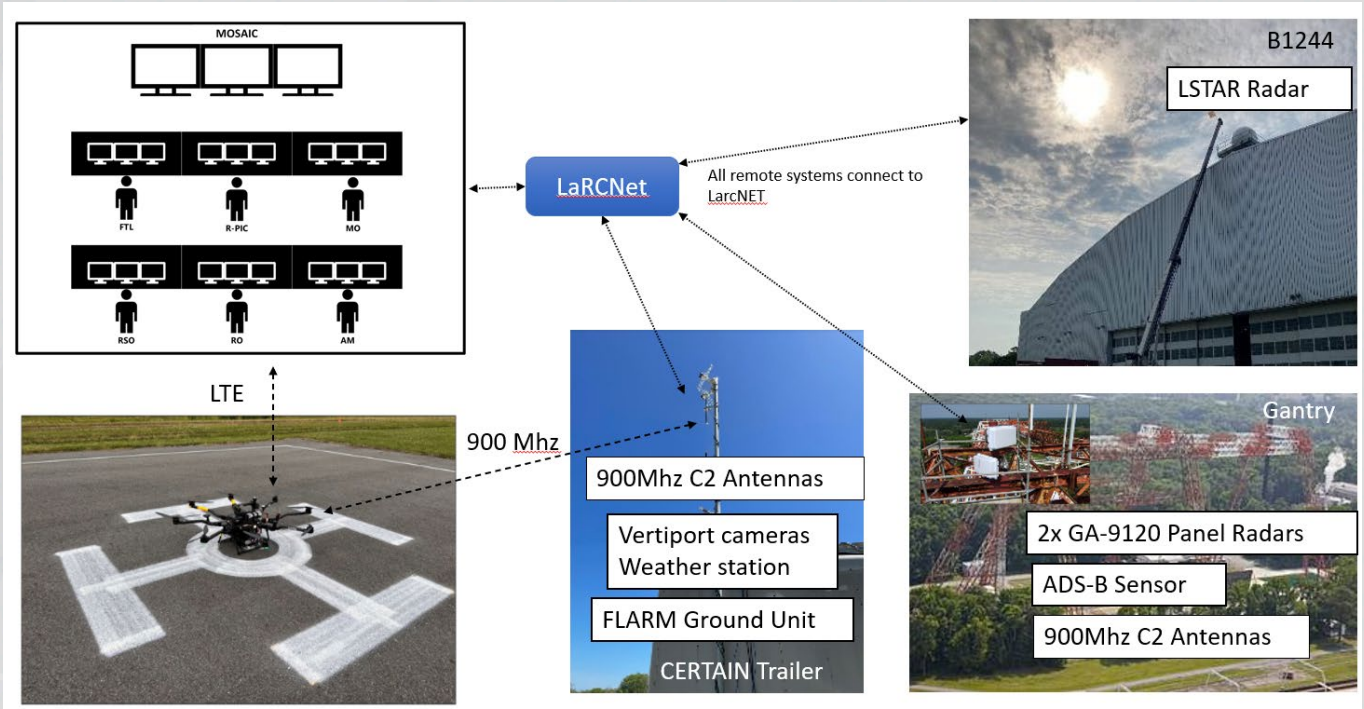
Planned CY24

- Reconstitute Cirrus SR22X “UAS Surrogate” to demonstrate autonomous flight capabilities with general aviation aircraft at LaRC.
- Pull in downlinked data from SR22X to MOSAIC (heading, altitude, airspeed, etc.) & utilize CERTAIN assets (UMAT, FAA AADS, GA-9120 and L-STAR radar displays) to monitor aircraft state and airspace during flight operations. Remotely pilot SR22x from MOSAIC GCS.



Planned CY24

- Initial BVLOS flight with Alta 8 in HDV Config 5.1 – April 2024
- Simultaneous multi-vehicle BVLOS flight operations from MOSAIC & ROAM – Summer 2024
  - MOSAIC & ROAM will carry out independent operational & research tasks in LaRC's airspace



Planned CY24

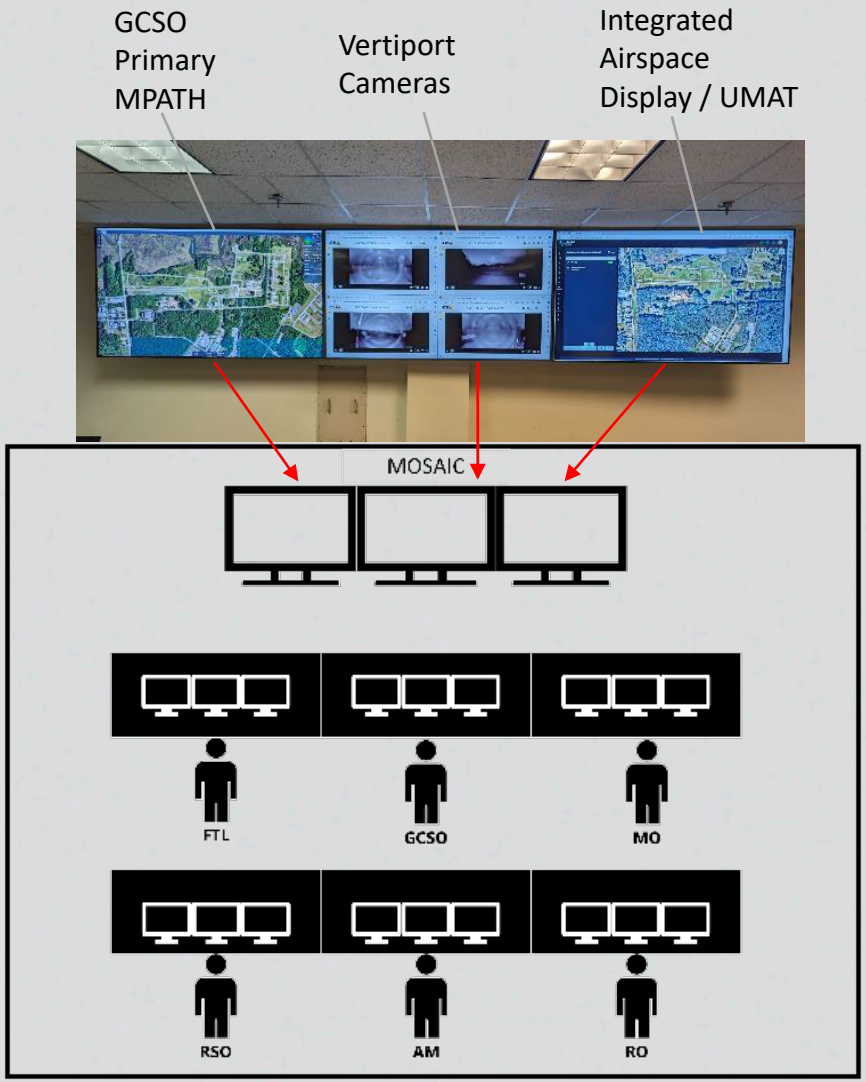
Range Safety Officer (RSO)
- FAA AADS
- Integrated Airspace Display - TAURAS
- Vertiport cameras

Airspace Monitor (AM)
- Integrated Airspace Display - TAURAS
- LSTAR Radar or ADS-B display to cross compare IAD

Radar Operator (RO)
- LSTAR Radar Interface
- GA-9120 Radar Interface

Flight Test Lead (FTL)
- Checklist tracking, UAS Mission Analysis Tool (UMAT), weather, etc.

Ground Control Station Operator (GCSO)
- Primary MPATH (desktop)
- Secondary MPATH (tablet with cellular backup connection)
- Botlink Video



CERTAIN Smart Center – Skydio Drone in a Box BVLOS Operations

Planned CY24

Phase1: Full Remote Vehicle Flight Ops
•Conduct remote C2 flights that require no preflight/postflight human interaction with vehicle
•Autonomous dock charging, cameras for vehicle inspection, etc.

Phase 2: Limited Use Case Operational Routine BVLOS Flight Ops
•Acquire a generic BVLOS COA that allows the use of multiple types of UAS (including skydio) for BVLOS flights
•Conduct limited use case operations (such as a regularly scheduled inspection of a segment of the perimeter) where all operations personnel are within MOSAIC with a limited crew (RSO and GCSO)

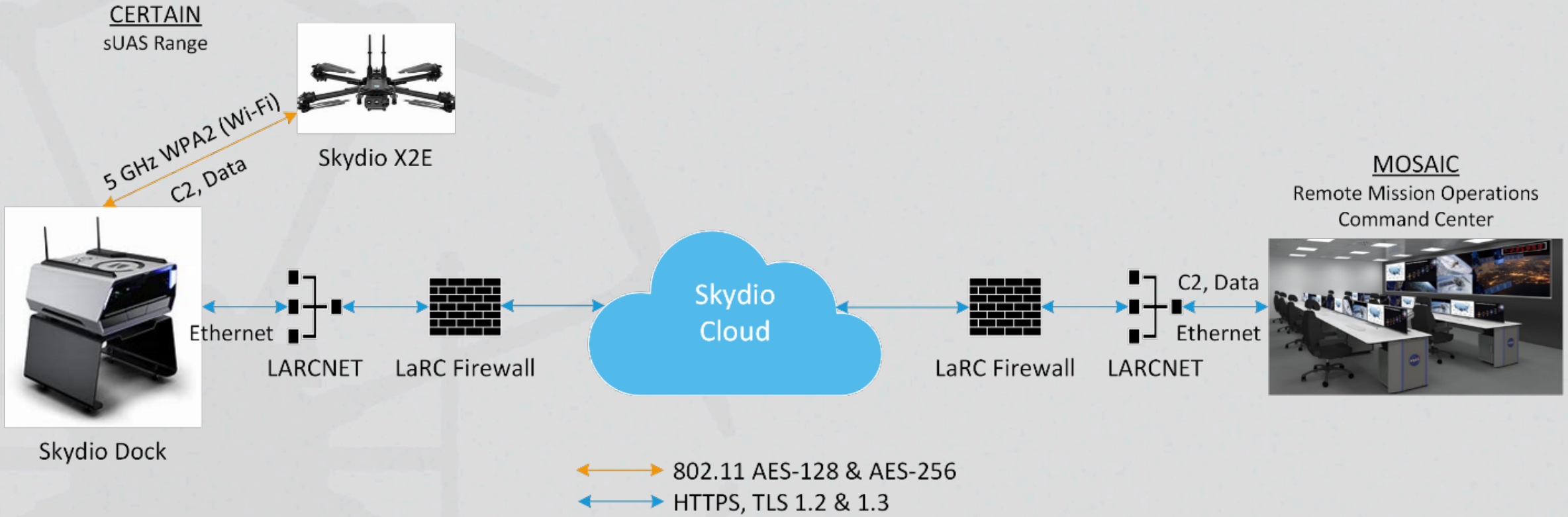
Phase 3: Routine CERTAIN-wide BVLOS Ops
•Regular routine flights around the center
•Requires defining overflight of people rules and procedures.

- Support Skydio "Drone-In-A-Box" development for autonomous, scheduled BVLOS surveillance and inspection flights
  - OPS perimeter surveillance, AETC facilities structural inspection, Post-spill incident inspection, etc.

Skydio Dock, courtesy of Skydio

CERTAIN Smart Center – Skydio Drone in a Box BVLOS Operations

Planned CY24



Planned CY24

- Determine best path forward for routine BVLOS flights from MOSAIC
  - Conduct market survey to determine best path forward for high-quality remote streamed video
- Develop process at LaRC to enable Authority to Operate for cloud-based SaaS (Remote C2, Video)
- Devise a strategy with OCIO for data storage/access (LTI)
- Develop and optimize project/mission-specific capabilities and processes through further collaboration across LaRC

- Building scanning with LIDAR (GeoSlam/Synergy 360)
- Harmful Algae Bloom Research with ODU/NOAA – Multispectral imagery
- Operationalize structural damage inspection using machine learning
- Develop emergency response procedures that allow for rapid deployment without the requirement for an RSO