

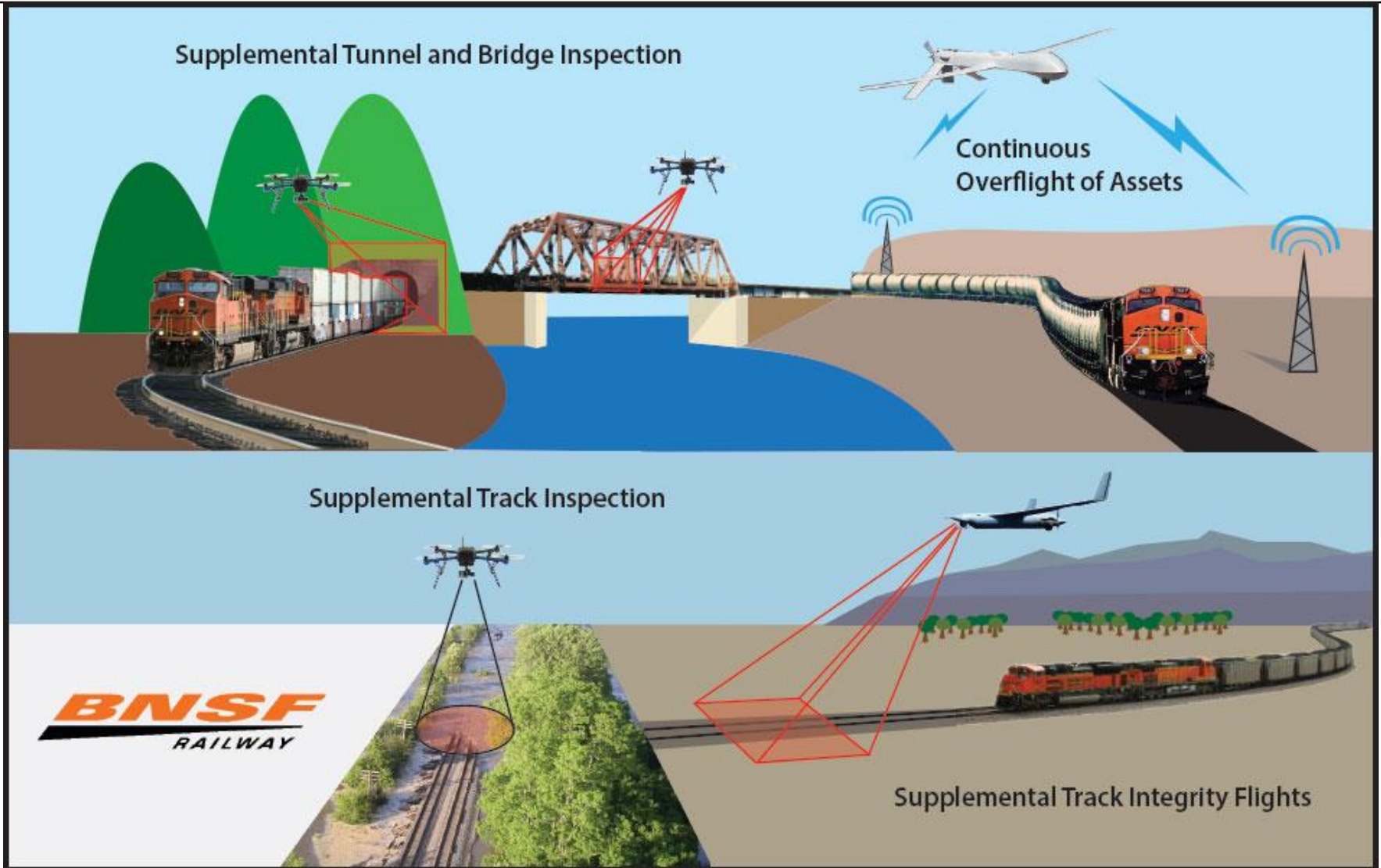


UAS PROGRAM

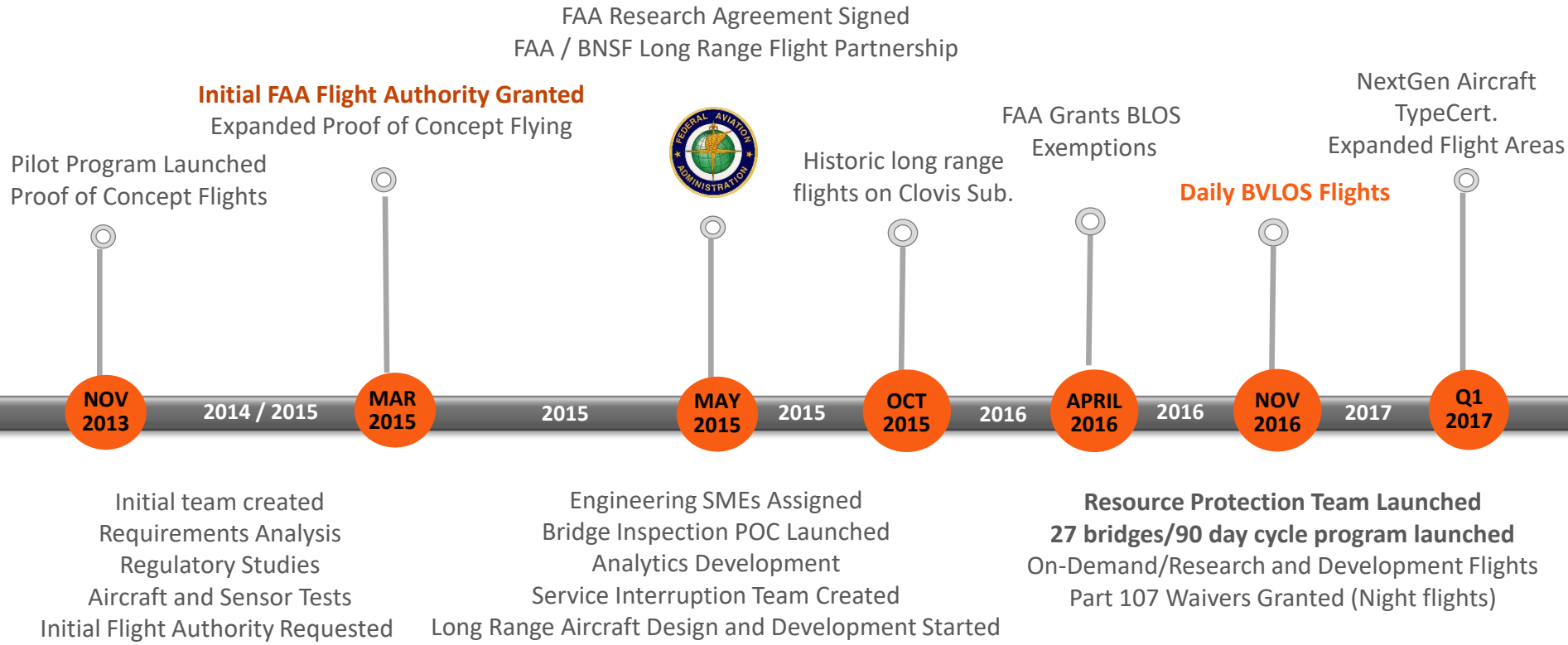


Proprietary Information – Patent Pending

Concept of Operations



BNSF UAS Program Timeline



Example Of Line of Sight Aircraft



- **15-35 minutes of flight time**
 - Line of sight, operations from mobile platforms
 - HD video, high resolution photo, thermal
 - Automated and manual missions

Engineering Supplemental Structure Assessments

■ Business Challenges

- Inspecting bridges without occupancy
- Inspecting areas of bridge structures not easily accessible by traditional methods

■ UAV Solution

- Capability developed to visually inspect large structures
- Easy access to all areas of bridge structure
- Wide range of product outputs including video, still images, 3D models, and change detection
- Developed automated change detection for elevation and alignment



Engineering Supplemental Structure Assessments



BNSF UAS Supplemental Bridge Inspections

STRATSFIT
1.978.371.2299



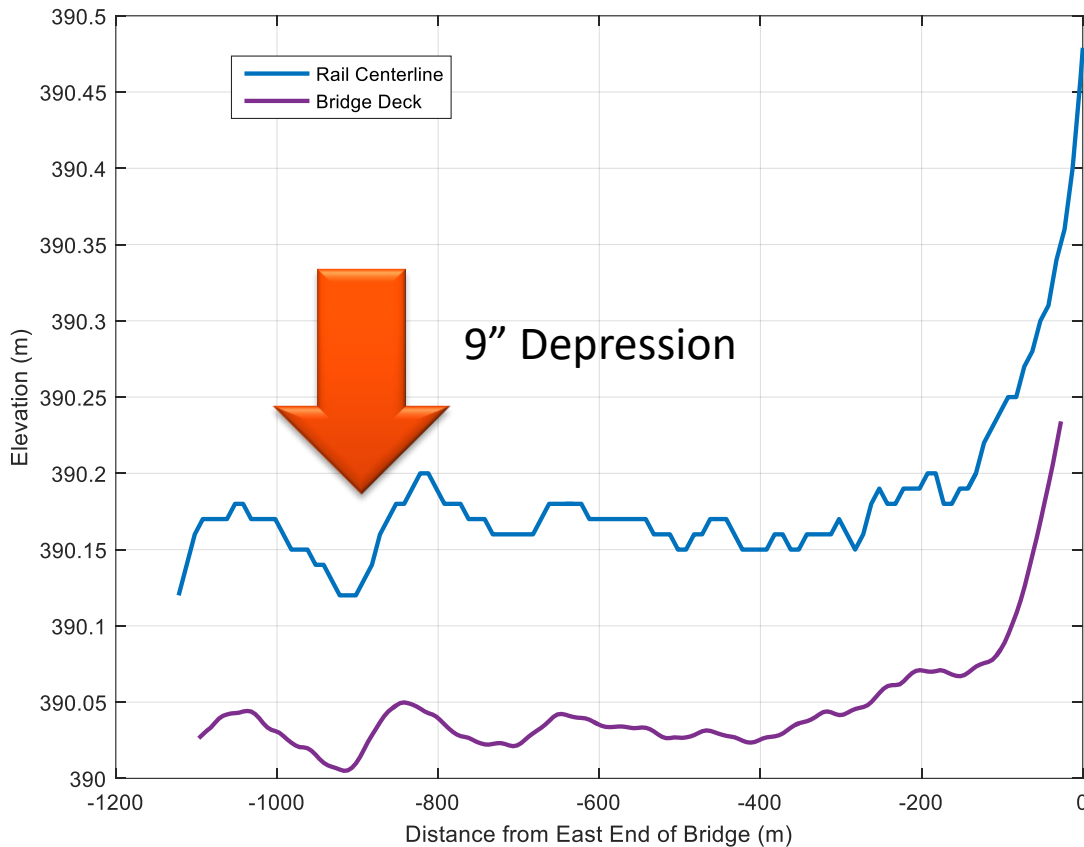
Lidar Bridge Deck Elevation Profile

A simple way to evaluate the profile of the bridge deck through color notation



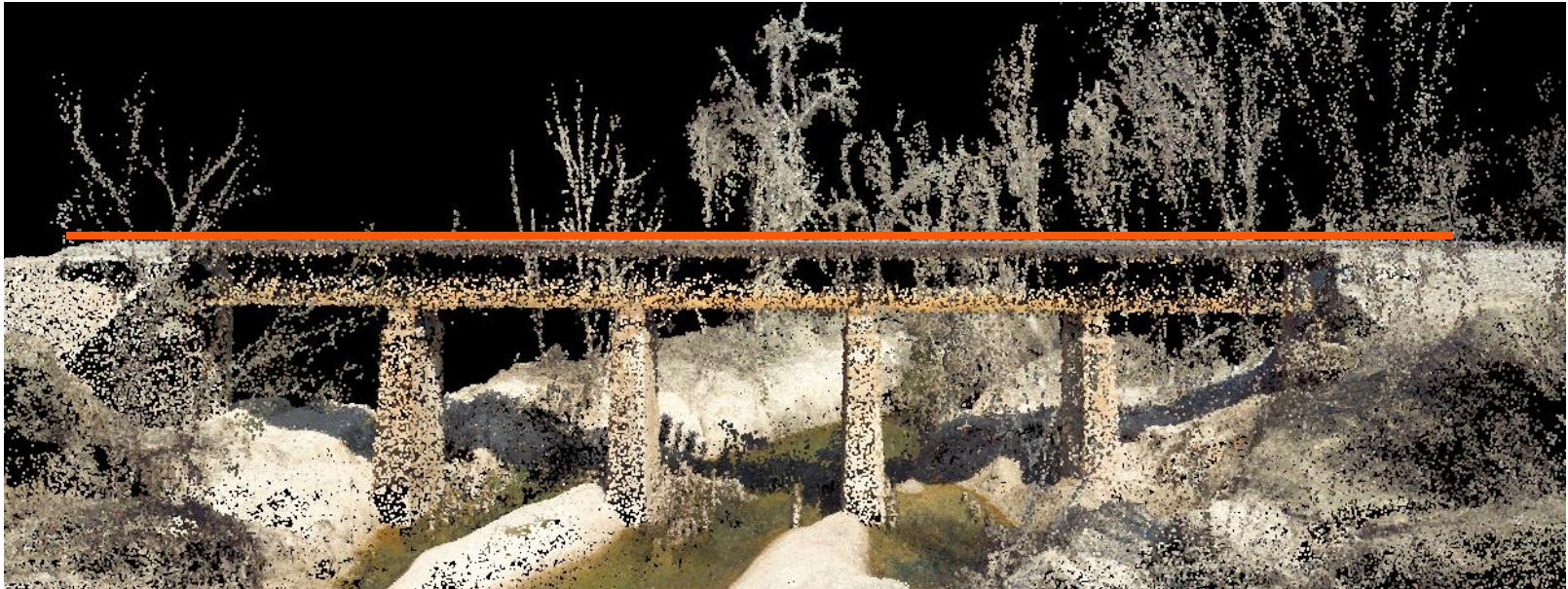
Lidar Bridge Deck Elevation Profile

- Simple one page graph showing the condition of bridge profile
- Results that allows simple change detection
- Same type of results can be produced for bridge alignment



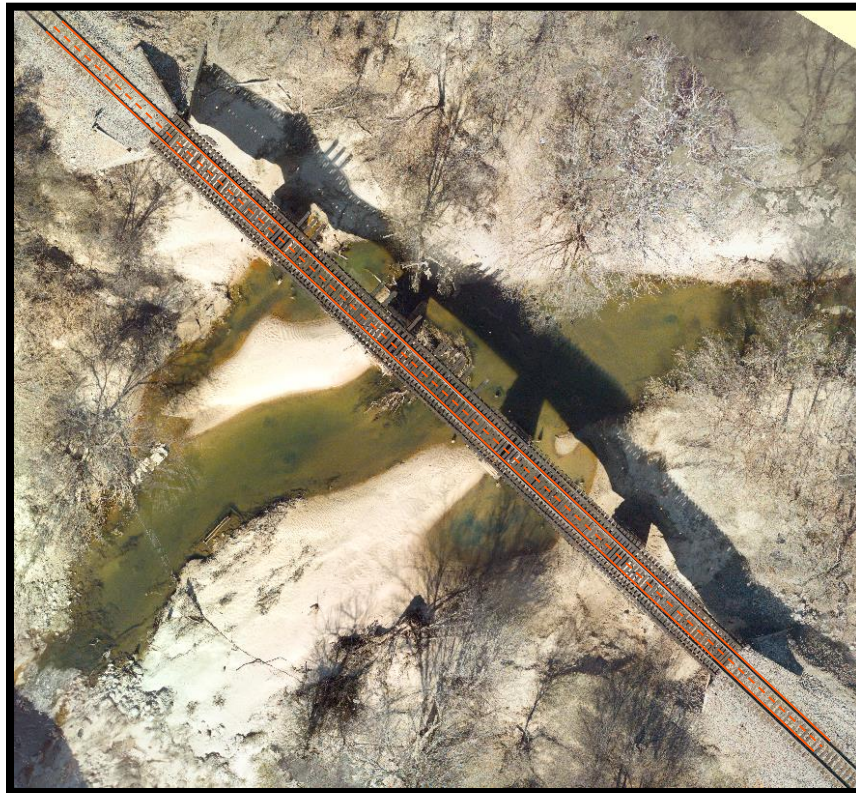
Bridge Elevation Profile

Determine the elevation profile through the track centerline calculated from lines created on the top of each rail utilizing the point cloud image.



Bridge Alignment Profile

Determine the alignment profile of the track centerline determined from lines created on the top of each rail utilizing the orthomosaic image.



ROW Change Detections

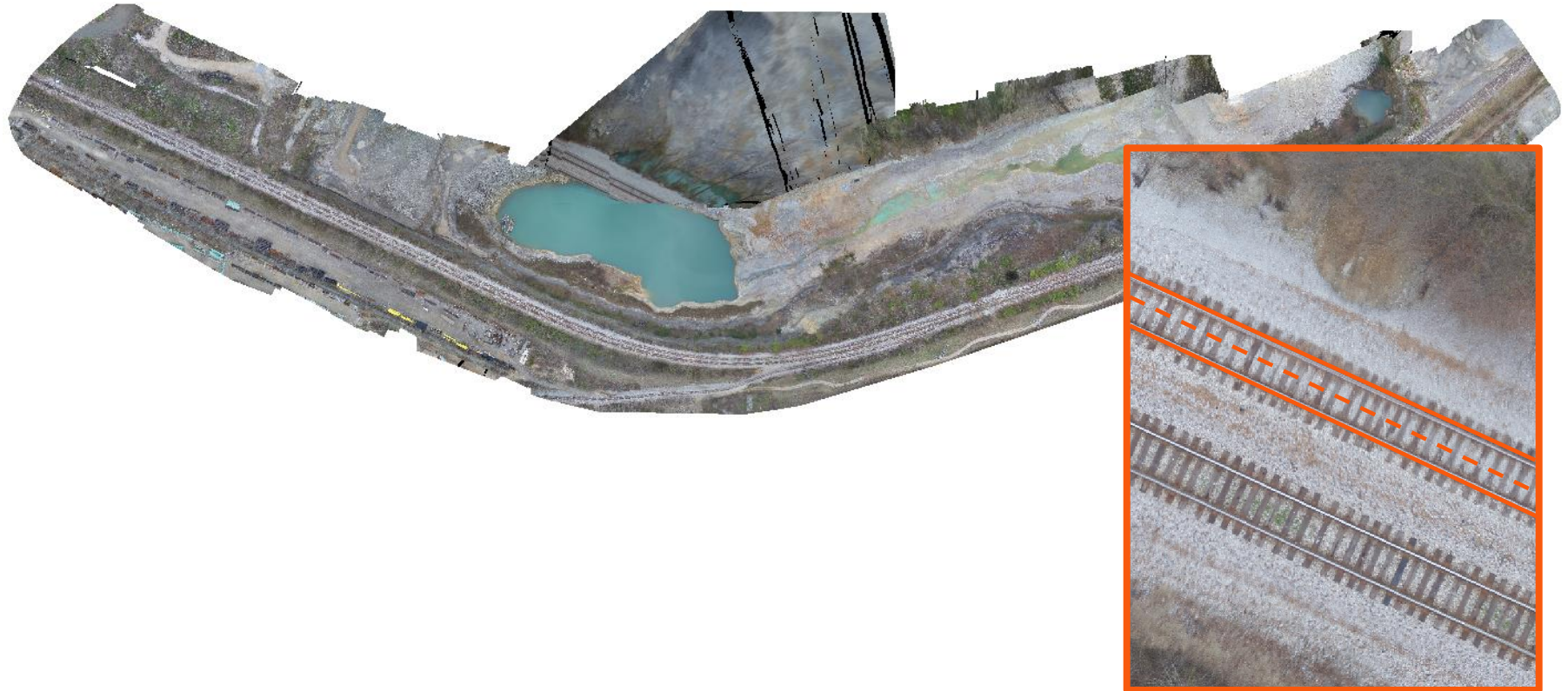
Stitching of UAS imagery to provide a complete view



The stitching technique can be applied to areas of concern to expand detail of several images over single images

Alignment Profile Change Detection

Method creates line graphs of track section for monitoring through the highly detailed top-down stitched image (Orthomosaic). Lines are created for each rail then track centerline is computed. The rail and centerline can be easily be compared though simple line graphs.



Yard Measurements



Yard Asset Identification / Measurement



Service Interruptions

- **24/7/365 – 45 Minute Notice from Call to Readiness**
 - First responder and remediation support + data services
 - New file sharing capability (faster data delivery, easier to use)
 - Lighter/smaller aircraft for limited scope, non-BNSF jet deployments – Option to train field personnel and/or normal responders to operate



Aberdeen Subdivision / Yankton Service Interruption



Glasgow Subdivision / Culbertson Service Interruption

The FAA/BNSF Partnership...

- **A focus on community and employee safety**
 - Supplemental safety assessments of track and structures
 - Reduced track occupancy
 - Opportunity to diminish derailment risk
 - Foundational for multi-modal transportation assessments
- **Safe integration of UAS into The NAS**
 - Full BNSF and FAA executive commitment
 - BNSF and The FAA are focused on risk elimination
 - BNSF flights utilize known, well-managed flight corridors
 - *Existing infrastructure supports aircraft control, ATC communications, SUA de-confliction and sense/avoid capabilities*



Engineering

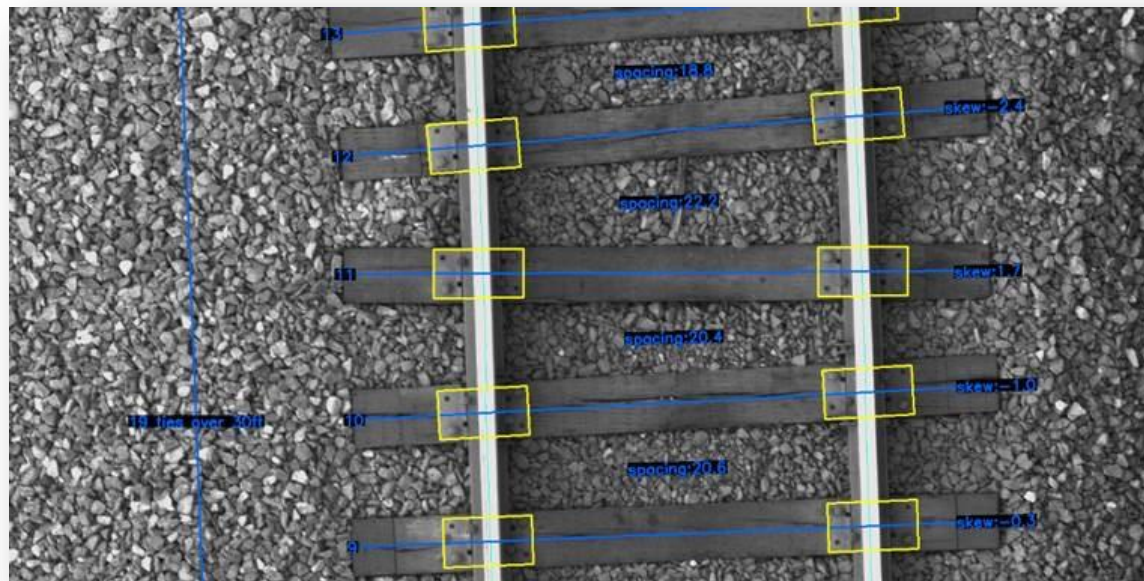
Supplemental Track Integrity

▪ Business Challenge

- Current inspection process requires extensive track occupancy

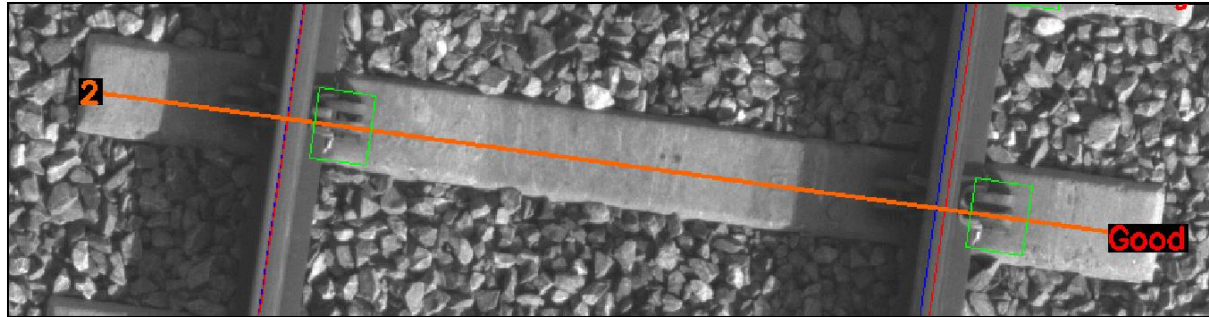
▪ UAV Solution

- Analytics developed for FRA visual track criteria
 - Track occupancy can be focused on fixing rather than detecting
- Additional products include heat patrols, concentrated load defect detection, tie counts, etc.



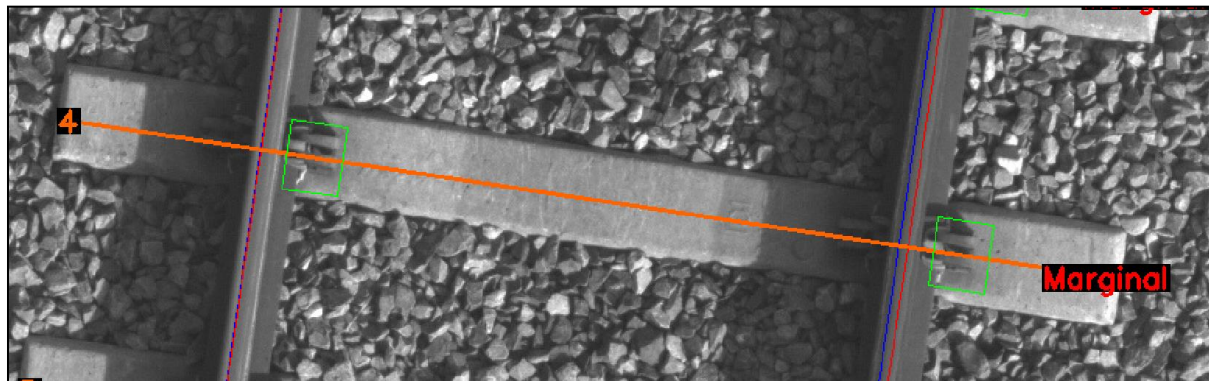
Concrete Tie Condition Evaluation

- **Good (1)**



- **Marginal (2)**

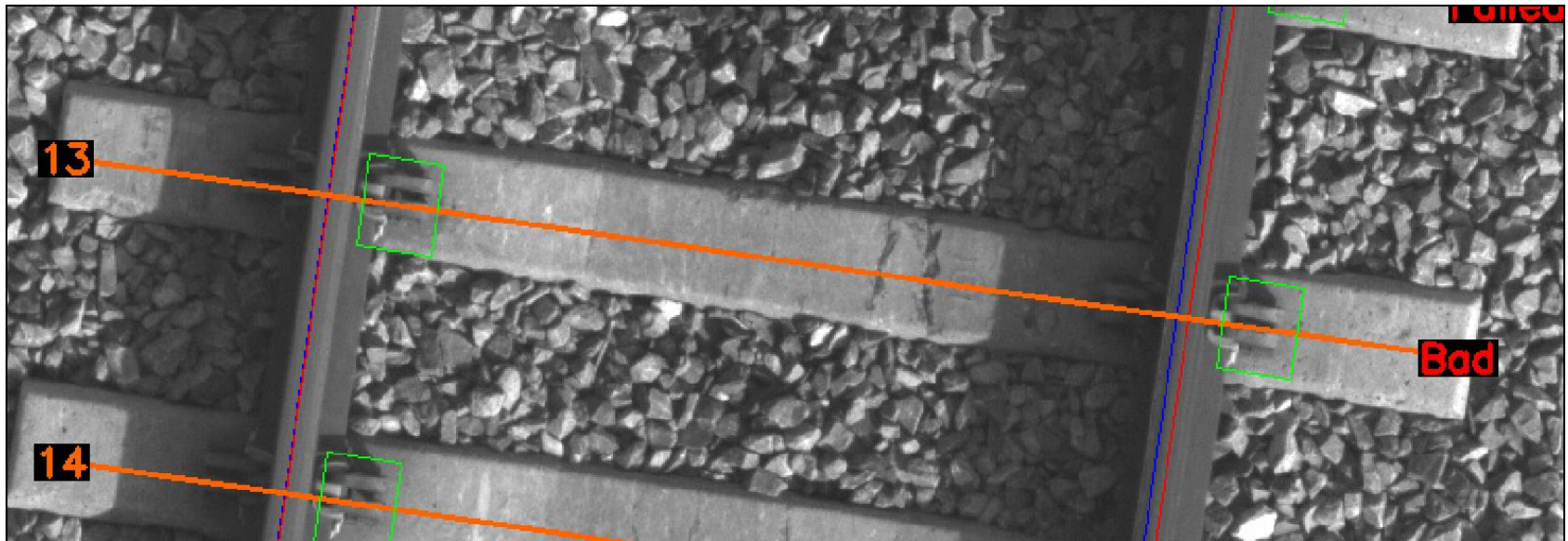
- Minor Damage, potential reduction of tie life.
- Cracks $< 1/16$ " "Hair-line cracks". Anywhere laterally across the tie within gage, not on or near the rail seat.
- Single crack $> 1/16$



Concrete Tie Condition Evaluation

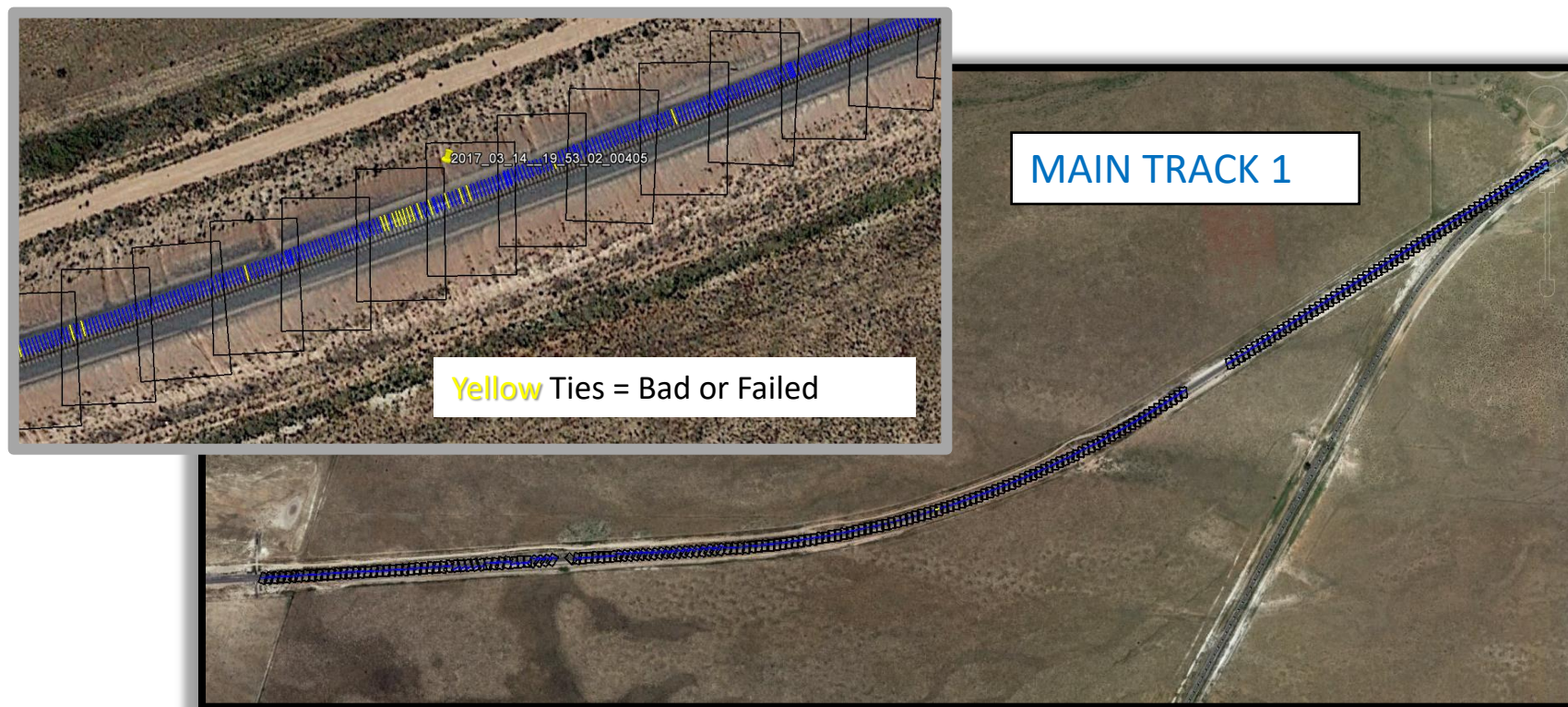
- **Bad (3)**

- Major Damage, Carrying capacity still intact.
- Two or more cracks $> 1/16''$, A crack with two distinct lines.
- Longitudinal crack of significant length extending from shoulder to shoulder.
- Crack under or near the rail seat



Concrete Tie Evaluation

- Tools for visualizing the data collection
 - Color indication of tie quality



Concrete Tie Evaluation

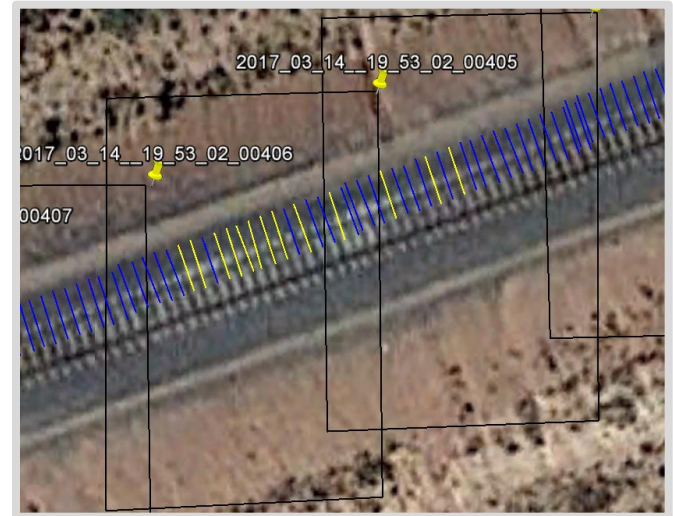
- PDF and HTML Reports
 - For SME verification and for output to internal customers

UAS RailVision (Build 498M) Track Evaluation

Event Summary	
Aircraft/Payload Number	N403BN-HD50-00111
Date	03/14/2017 19:53 CST
Event	Concrete Tie Condition
Division	SOUTHWEST/CLOVIS
Latitude	34.434056
Longitude	-104.744247
Position	LS7100 MP751+3990
Severity	Red Tag - Failed
Number Of Ties	6
Image	2017_03_14__19_53_02/4/00405.jpg

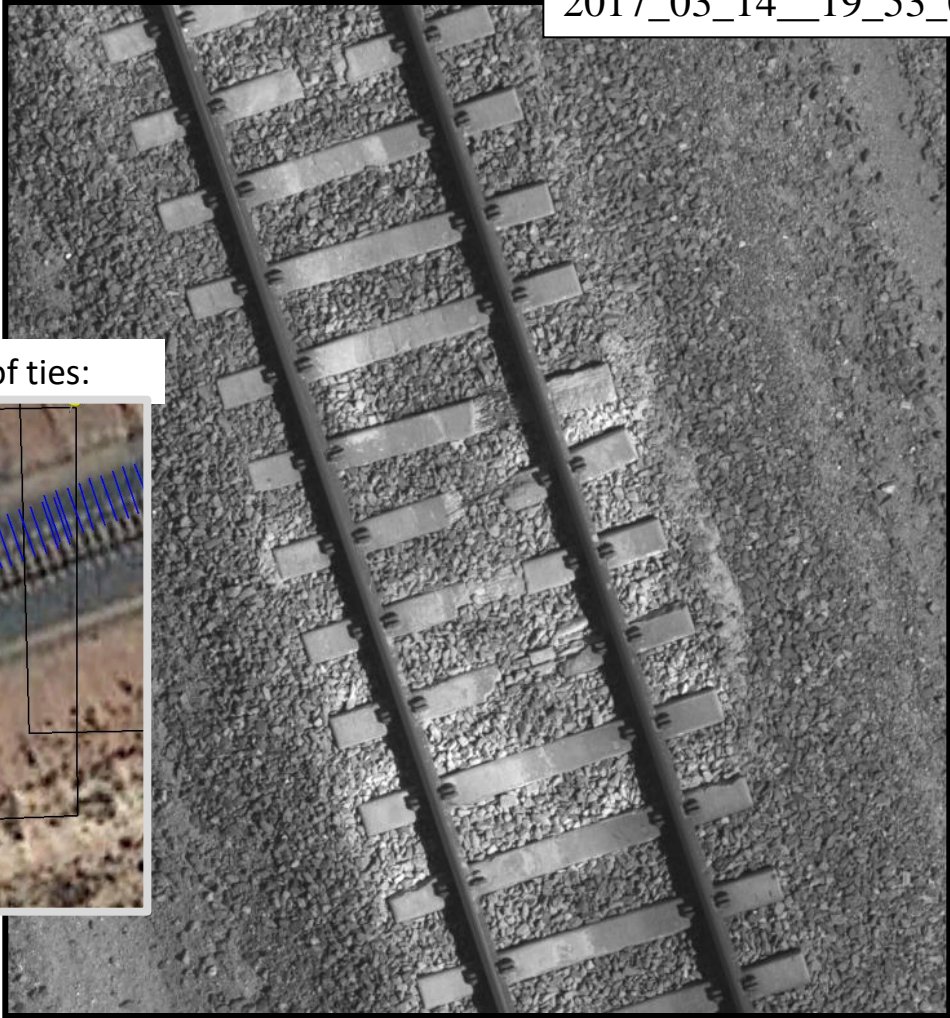
2017_03_14__19_53_02/4/00405.jpg

Report corresponds to grouping of ties:



Concrete Tie Evaluation

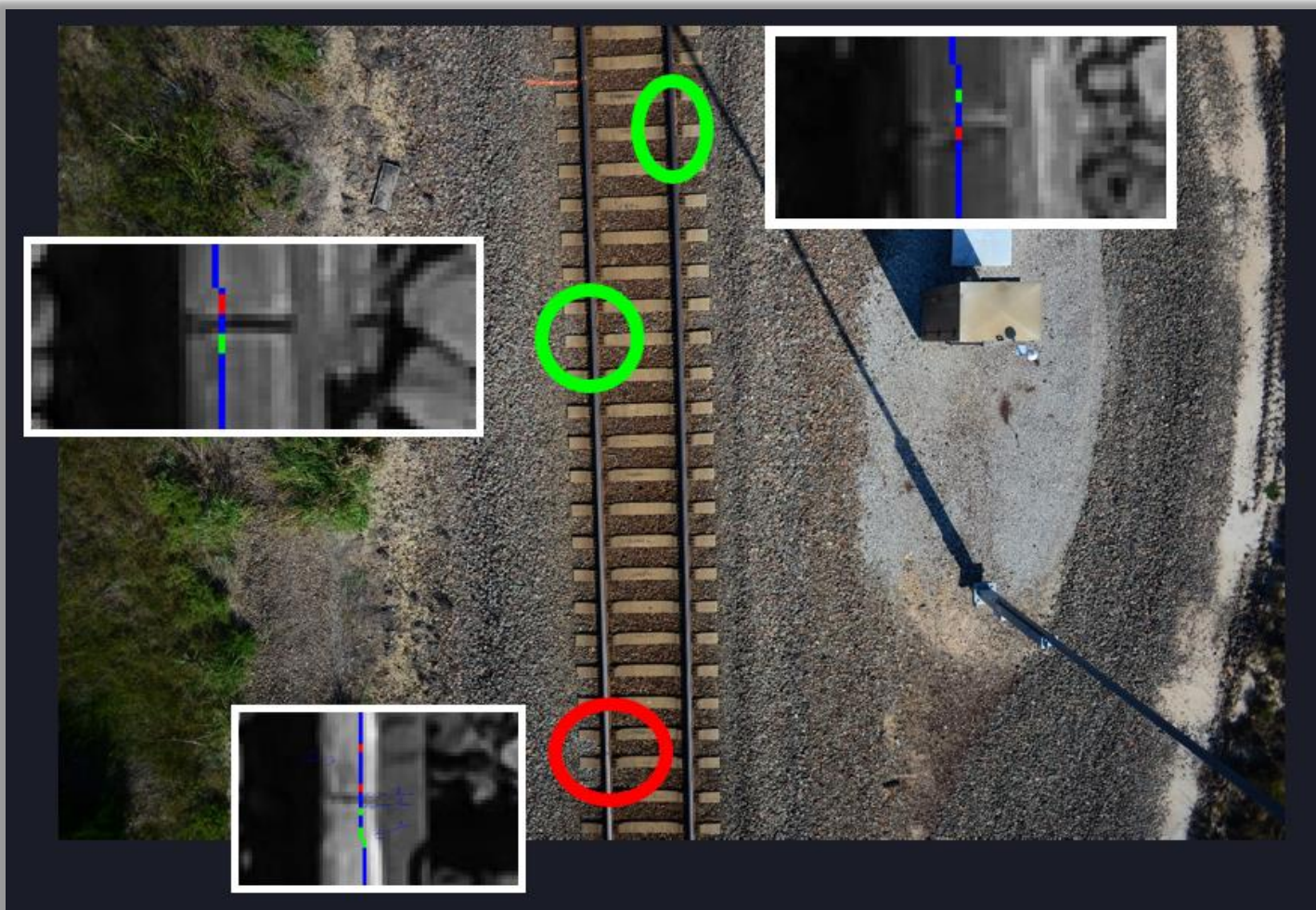
2017_03_14__19_53_02/4/00405.jpg



Report corresponds to grouping of ties:



Rail Gap/break Detection Examples



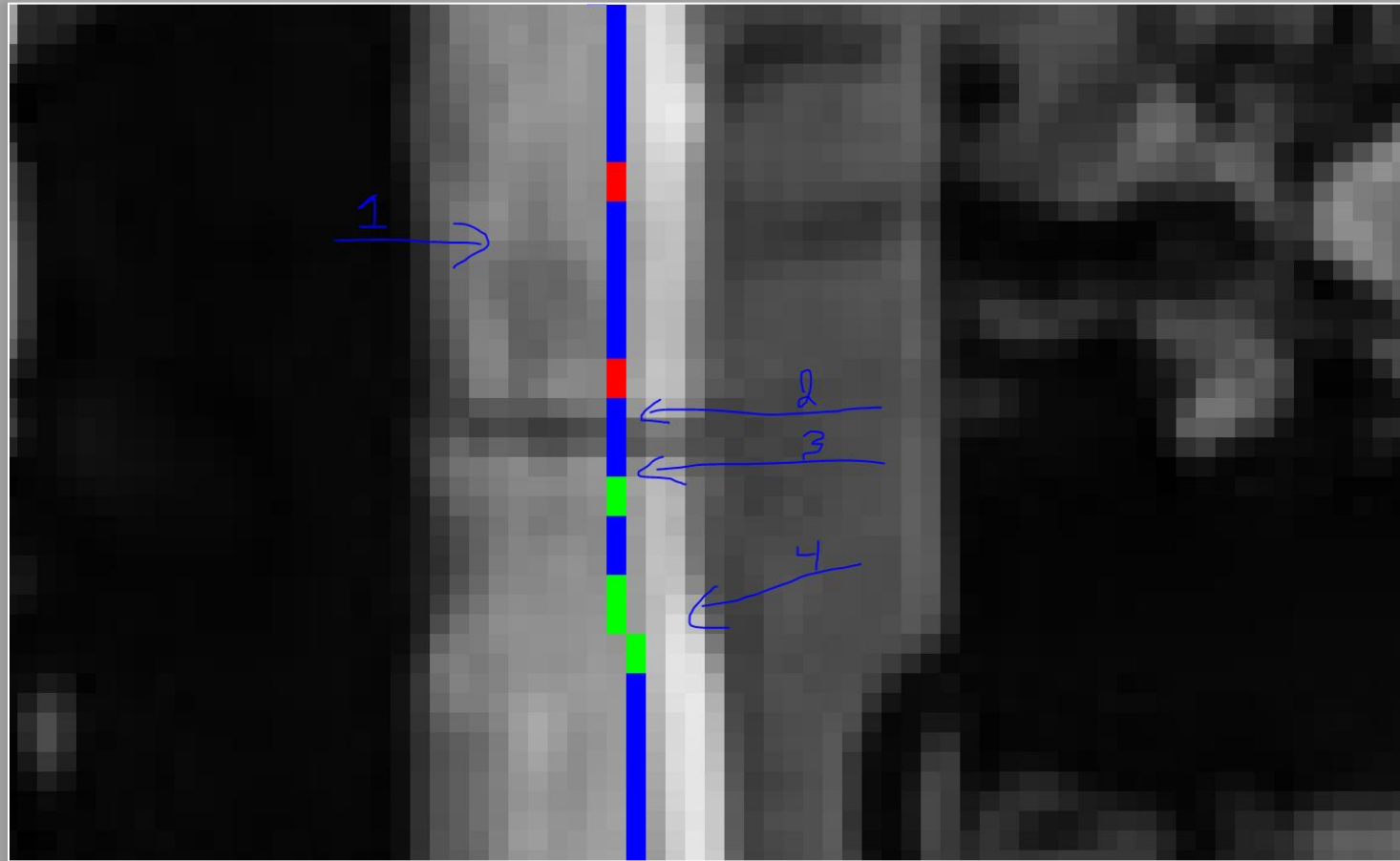
Actual break - Decatur

Rail Gap/break Detection Examples



Actual break - Decatur

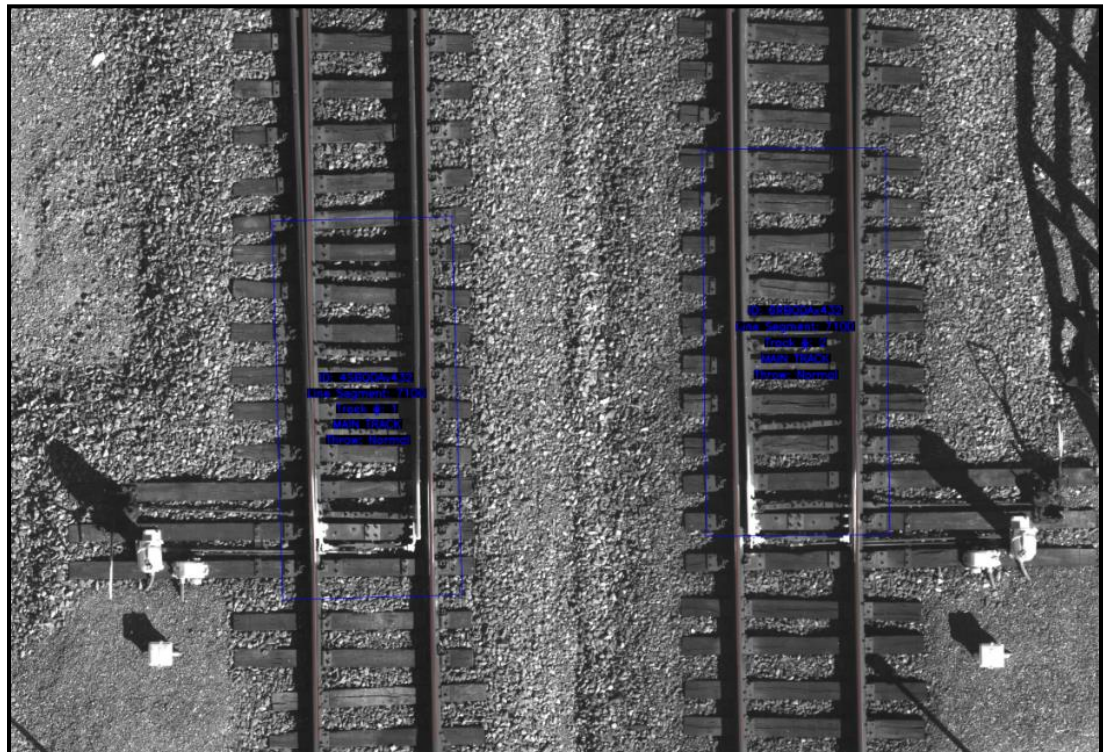
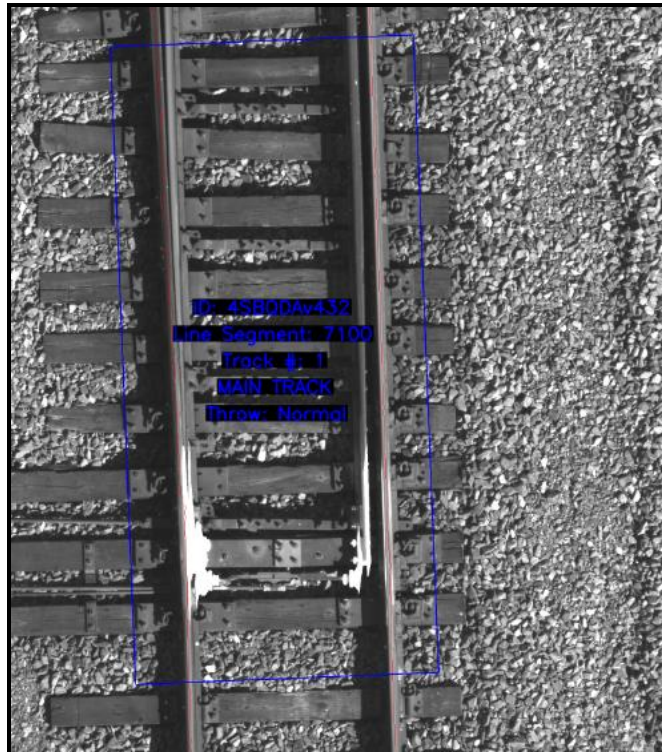
Rail Gap/break Detection Examples



Actual break - Decatur

Switch Position Defection and Reporting

- Detection and evaluation methods implemented
- Turnout ID, Track Association, Normal or Reverse Throw



Example of BNSF's long-range aircraft (HQ40-B)



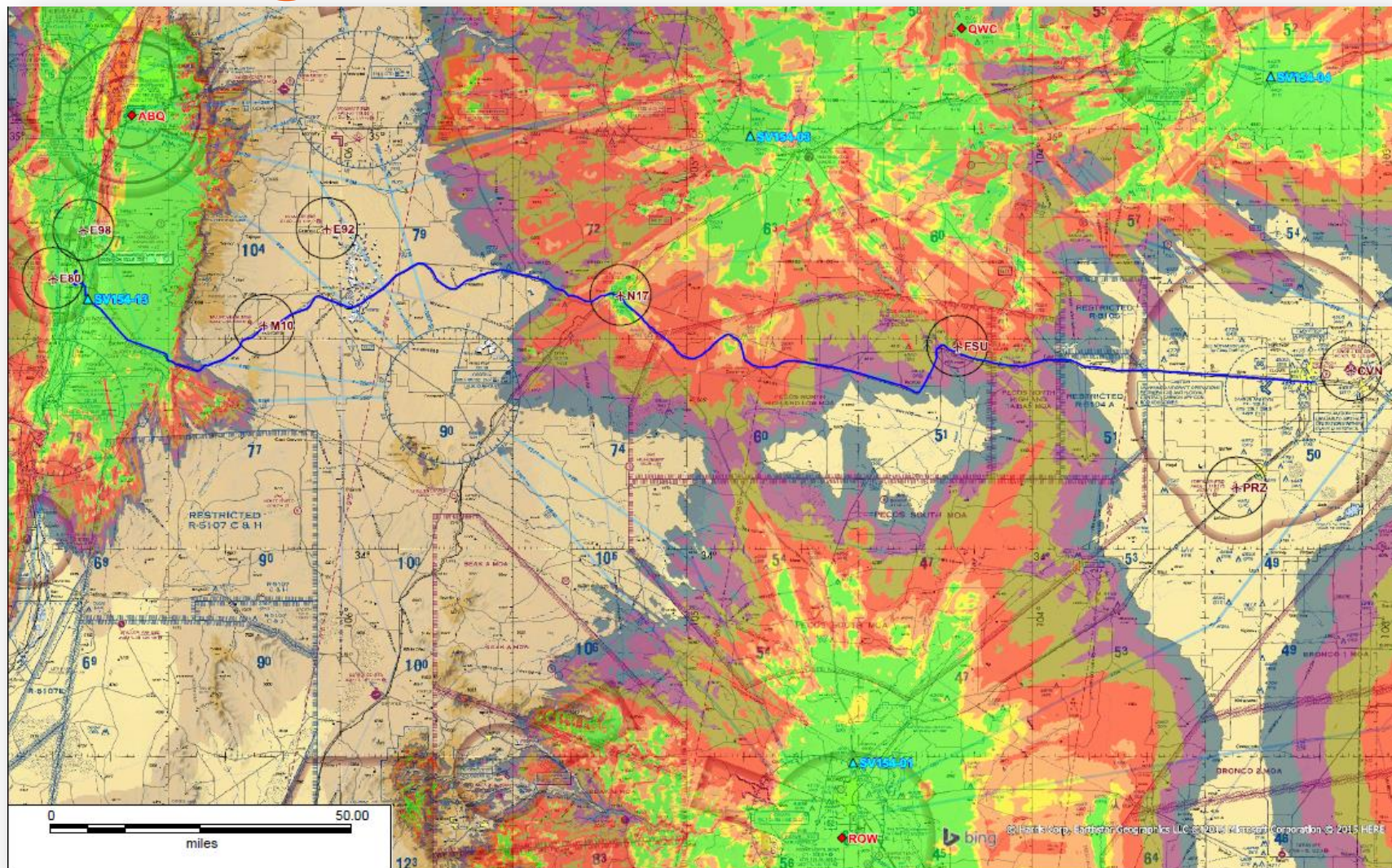
Proprietary Information – Patent Pending



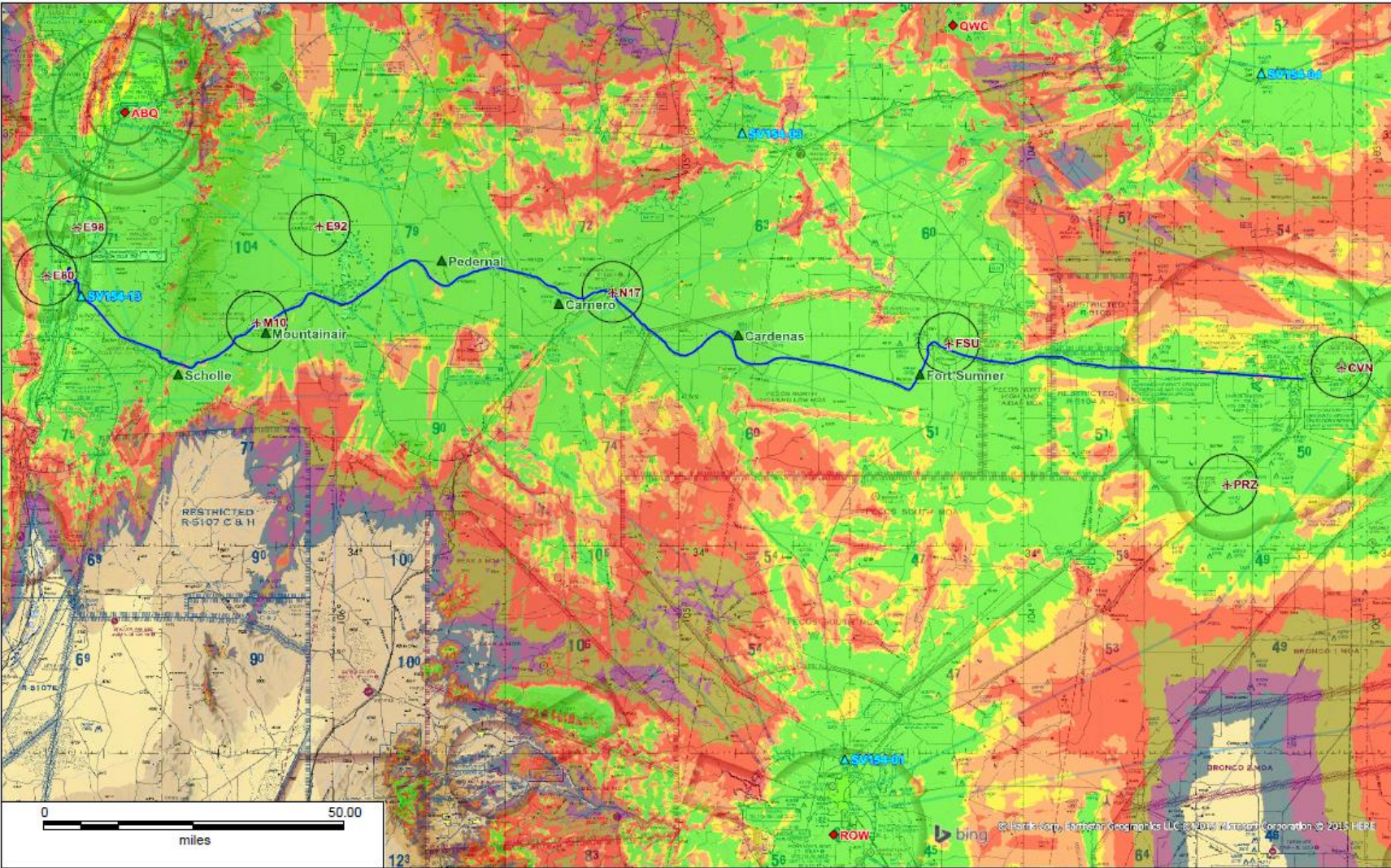
BNSF's new long range aircraft (HQ60-B)



Current FAA Radar and ADSB Coverage



Combined FAA + BNSF ADSB Augment



BNSF's Clovis Subdivision Cockpit



BNSF's Clovis Subdivision Cockpit (2)



Proprietary Information – Patent Pending

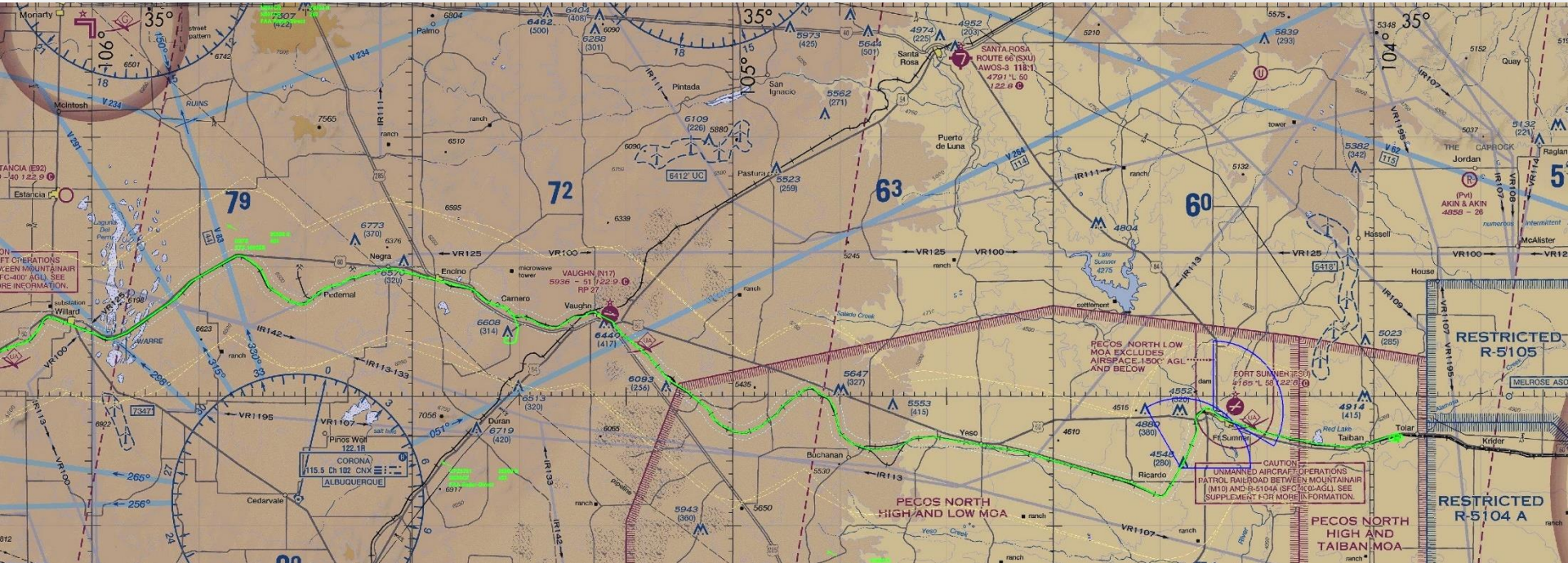


BNSF's Clovis Subdivision Cockpit (3)



A big win for team FAA/BNSF!

November 10th, 2016 – 214 miles



.....entire range of COA flown (N402BN)

Some success (and learning)...

- **Flight hours**

- 1200+ LOS hours
- 100+ ER-VLOS hours to date
- 150+ BVLOS hours to date

- **Data collections**

- 2015 – 23GB of “useable” data
- 2016 – 6+TB of data
- 2017 – 15TB of data to date

- **Safety Record**

- 879 days of no injuries to pilots, customers, observers

- **Customers**

- Daily customer requests
- Regular product delivery

Program Video

