Concept of Operations

Supplemental Tunnel and Bridge Inspection

Continuous Overflight of Assets

Supplemental Track Inspection

Supplemental Track Integrity Flights
BNSF UAS Program Timeline

- **NOV 2013**: Pilot Program Launched Proof of Concept Flights
- **MAR 2015**: Initial FAA Flight Authority Granted
- **MAY 2015**: Expanded Proof of Concept Flying
- **OCT 2015**: Historic long range flights on Clovis Sub.
- **APRIL 2016**: FAA Grants BLOS Exemptions
- **NOV 2016**: Daily BVLOS Flights
- **Q1 2017**: NextGen Aircraft TypeCert. Expanded Flight Areas

**Key Events**

- **2014 / 2015**: Initial team created
  - Requirements Analysis
  - Regulatory Studies
  - Aircraft and Sensor Tests
  - Initial Flight Authority Requested

- **2015**: Engineering SMEs Assigned
  - Bridge Inspection POC Launched
  - Analytics Development
  - Service Interruption Team Created
  - Long Range Aircraft Design and Development Started

- **2016**: Resource Protection Team Launched
  - 27 bridges/90 day cycle program launched
  - On-Demand/Research and Development Flights
  - Part 107 Waivers Granted (Night flights)

- **2017**: FAA Research Agreement Signed
  - FAA / BNSF Long Range Flight Partnership

- **2016**: FAA Grants BLOS Exemptions
- **2017**: NextGen Aircraft TypeCert. Expanded Flight Areas
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
A simple way to evaluate the profile of the bridge deck through color notation

Depression

**Legend**

Elevation (Meters)

Value

- High: 390.234
- Low: 390.005
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

![Graph showing Lidar Bridge Deck Elevation Profile with a 9” Depression]
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.
Determine the alignment profile of the track centerline determined from lines created on the top of each rail utilizing the orthomosaic image.
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
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
    o 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

Yellow Ties = Bad or Failed

MAIN TRACK 1
Concrete Tie Evaluation

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

### UAS RailVision (Build 498M) Track Evaluation

<table>
<thead>
<tr>
<th>Event Summary</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft/Payload Number</td>
<td>N403BN-HD50-00111</td>
</tr>
<tr>
<td>Date</td>
<td>03/14/2017 19:53 CST</td>
</tr>
<tr>
<td>Event</td>
<td>Concrete Tie Condition</td>
</tr>
<tr>
<td>Division</td>
<td>SOUTHWEST/CLOVIS</td>
</tr>
<tr>
<td>Latitude</td>
<td>34.434056</td>
</tr>
<tr>
<td>Longitude</td>
<td>-104.744247</td>
</tr>
<tr>
<td>Position</td>
<td>LS7100 MP751+3990</td>
</tr>
<tr>
<td>Severity</td>
<td>Red Tag - Failed</td>
</tr>
<tr>
<td>Number Of Ties</td>
<td>6</td>
</tr>
<tr>
<td>Image</td>
<td>2017_03_14__19_53_02/4.00405.jpg</td>
</tr>
</tbody>
</table>

2017_03_14__19_53_02/4.00405.jpg

Report corresponds to grouping of ties:
Concrete Tie Evaluation

Report corresponds to grouping of ties:

2017_03_14__19_53_02/4/00405.jpg
Rail Gap/break Detection Examples

Actual break - Decatur

Proprietary Information – Patent Pending
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)
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)
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