Research Section
555 13th Street NE
Salem, OR 97301

ph: (503) 986-2700
fax: (503) 986-2844

OREGON DEPARTMENT OF TRANSPORTATION

SPR Quarterly Progress Report

September 30, 2016 through December 31, 2016

Date December 21, 2016

TO: Technical Advisory Committee Members:
Erick Cain, ODOT Bridge Inventory Coordinator
Michael Goff, ODOT Region 2 Bridge Inspector
Xiugang (Joe) Li, ODOT Research Section, Research Coordinator
Tim Rogers, FHWA Oregon Division
Joseph Thomas, ODOT Geometronics Manager / Deputy Chief of Surveys
Mitch Swecker, Oregon Department of Aviation

1. Project

Title: Eyes In The Sky: Bridge Inspections With Unmanned Aerial Vehicles
SPR 787

2. Project Investigator

Name: Daniel Gillins and Christopher Parrish
Title: Assistant Professor and Associate Professor
Agency: Oregon State University
Address: 311 Kearney Hall, Corvallis, OR 97331
Phone: 541-737-4865
Email: dan.gillins@oregonstate.edu; christopher.parrish@oregonstate.edu

3. Project Coordinator

Name: Xiugang (Joe) Li
Phone: 503-986-4115
E-mail: xiugang.li@odot.state.or.us

4. Key Dates

Project start date: September 2, 2015
Project completion date: January 30, 2018

5. Project Status (Completed by project investigator)

Task 1: TAC Meeting #1; Project kick off meeting
Percent completed reported in last quarterly report: 100%
Percent completed after this quarter:

Key Progress-To-Date

- First TAC meeting was held on June 5, 2015 at the ODOT Technical Leadership Center in Salem, OR.
    - Attendees:
        - Joe Li, ODOT Research Section, Research Coordinator
        - Dan Gillins, OSU
        - Chris Parrish, OSU
        - Tim Rogers, FHWA Oregon Division
        - Erick Cain, ODOT Bridge Inventory Coordinator
        - Mitch Swecker, Oregon Dept. of Aviation
        - Ron Singh, ODOT Geometronics
        - Michael Goff, ODOT Region 2 Bridge Inspector
- The project team gave a presentation on the project background and also presented the work plan.
- The project team collected input on the work plan from ODOT and made the applicable, minor revisions

Specific Progress This Quarter

- TAC Meeting #1 is complete.

Problems

- No problems were encountered; the TAC meeting was successful, and input received from ODOT has been used to plan subsequent project steps.

Work Planned for Next Quarter

- N/A – no further work on this Task is required, as the first TAC meeting has been conducted.

Task 2: Draft Literature Review

Percent completed reported in last quarterly report: 100%
Percent completed after this quarter:

Key Progress-To-Date

- The Task 2 Literature Review Report was submitted to ODOT on December 22, 2015.
    - A detailed literature review was completed and submitted with the following sections:
        - Overview of Unmanned Aircraft Systems
        - Published Literature
        - Bridge Inspection Manuals
        - Conclusions
        - References

Specific Progress This Quarter

- Detailed literature review completed and report submitted.

Problems

- No problems were encountered in this task.

Work Planned for Next Quarter

- N/A – Task 2 is now complete.

Task 3: Preliminary Test Flights

Percent completed reported in last quarterly report: 100%
Percent completed after this quarter:

Key Progress-To-Date

- In December 2015, the team took delivery of a new UAS, the senseFly albris to be used for future bridge and tower inspections
- In February 2016, senseFly provided hands-on training with the albris. The team was trained on how to operate the albris, plan flights, capture both RGB and thermal imagery, and fly closely to structures for inspection. Several field tests were completed since the training.
- The team has flown the albris, along nearby structures in order to identify cracks, missing bolts, etc. The standoff distance from the structure was varied in order to find the appropriate distance for capturing structural defects. The team has downloaded and processed the resulting imagery.
- A safety plan/procedure has been established for all test flights performed by the project team.
- Based on the preliminary test flights, draft flight missions and procedures have been created inspecting wireless communication towers and bridges. These procedures were completed and submitted to TAC in June, 2016.

Specific Progress This Quarter

- N/A-Task 3 is completed

Problems

- No further problems or difficulties were encountered

Work Planned for Next Quarter

- N/A-Task 3 is completed

Task 4: TAC Meeting #2

Percent completed reported in last quarterly report: 100%
Percent completed after this quarter:

Key Progress-To-Date

- TAC Meeting #2 was held on June 10, 2016. The main objectives were to discuss Task #3, as well as the planned July tests of towers and bridges: Crooked River Bridge, Grizzly Mountain Tower, and Mill Creek Bridge.
  - Attendees:
    - Joe Li, ODOT Research Section, Research Coordinator
    - Dan Gillins, OSU
    - Chris Parrish, OSU
    - Matt Gillins, OSU
    - Ron Singh, Engineering Automation Manager/Chief of Surveys, ODOT

- Joseph Thomas, ODOT Geometronics Manager / Deputy Chief of Surveys
- Erick Cain, ODOT Bridge Inventory Coordinator
- Jeff Swanstrom, ODOT Senior Bridge Inspector
- Michael Goff, ODOT Region 2 Bridge Inspector
- Paul Panzica, ODOT Wireless Network Infrastructure Manager

Specific Progress This Quarter
- N/A-Task 4 is completed

Problems
- None encountered or anticipated at this time.

Work Planned for Next Quarter
- N/A-Task 4 is completed

Task 5: Test Inspections of Wireless Communication Towers

Percent completed reported in last quarterly report: 50%
Percent completed after this quarter: 80%

Key Progress-To-Date
- Two flights of Communication Towers were complete on April 25, 2016 following the procedures prepared from Task 3. Both of the towers were inspected using the senseFly albris.
- High resolution photos were able to be captured for inspection purposes. ODOT Wireless Communication Inspection program was present for commenting on the procedures and to supervise the inspection.
  Along with the high resolution photos, images were collected such that Structure from Motion (SfM) algorithms could be applied for 3D reconstruction of the towers to create a full-scale point cloud.

Specific Progress This Quarter
- Inspections of two towers, Grizzly Mountain, Chehalem Mountain were attempted but signal interference was a problem at one site, and weather has delayed the inspections.
- After all flights, a final memo documenting where and what data was collected has been prepared for TAC meeting #3 (Task 7)

Problems
- Radio signal interference can be a major issue working around wireless internet provider towers. Unfortunately, the interference was so great at Grizzly Mtn, that we were unable to do any test UAS flights.

Work Planned for Next Quarter
- One additional tower inspection to test final work for final combination of flight collection method.
- All data is to be delivered to ODOT.

Task 6: Test Inspections of Bridges

Percent completed reported in last quarterly report: 40%
Percent completed after this quarter: 60%

Key Progress-To-Date

- The team identified 3 bridges for inspection in summer, 2016.
- Crooked River Bridge and Mill Creek Bridge were flown in the week of July 11, acquiring hundreds of photos to demonstrate and evaluate the technology. The St. Johns Bridge flights were initially delayed, but completed in September 2016.
- Overall, three bridges (Crooked River, Mill Creek, and St Johns) have been flown and the data analyzed.

Specific Progress This Quarter

- Finding from the three bridges flown to date were presented at TAC meeting #3 (Task 7)

Problems

- Weather initially delayed the flights at the third bridge (St. Johns bridge), but the flights were completed in September 2016.

Work Planned for Next Quarter

- An in-depth analysis of St. Johns bridge is planned, as well as the coordination of UAS flights with an actual bridge inspection by ODOT.

Task 7: TAC Meeting #3

Percent completed reported in last quarterly report: 5%
Percent completed after this quarter: 100%

Key Progress-To-Date

- TAC Meeting #3 was held on Friday, 10/14/2016, 9:30-11:00 am at the ODOT Technical Leadership Center (4040 Fairview Industrial Dr. SE, Salem)

Specific Progress This Quarter

- A productive TAC Meeting (3rd TAC Meeting) was held on Friday, 10/14/2016
  - Attendees:
    - ODOT
      - Ron Singh, Engineering Automation Manager/Chief of Surveys, ODOT
      - Joe Li, ODOT Research Section, Research Coordinator
      - Joseph Thomas, ODOT Geometronics Manager / Deputy Chief of Surveys
      - Jeff Swanstrom, ODOT Senior Bridge Inspector
      - Erick Cain, ODOT Bridge Inventory Coordinator
    - OSU
      - Dan Gillins, Project PI
      - Chris Parrish, Co-PI
      - Matt Gillins, Graduate Research Assistant
  - Agenda items included:
    - Discussion of methodology for UAS flights
    - Presentation on results of test inspections with UAS of 3 wireless communication tower sites and 3 bridges

- Discussion of challenges and successes experienced to date
- Path forward and project transition plan, with focus on next year of project

Problems
- No problems were encountered in the completion of this task.

Work Planned for Next Quarter
- N/A - TAC Meeting #3 is complete.

Task 8: Data Analysis

Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 65%

Key Progress-To-Date
- The results of the Mill Creek, Crooked River, and St. Johns Bridge flights have been used to determine optimal flight planning and data acquisition parameters. A summary was presented in TAC Meeting #3, and additional documentation is contained in Matt Gillins' MS thesis (Gillins, 2016).
- A preliminary ROI analysis has been initiated using 33 bridge inspection budget spreadsheets provided by Erick Cain to develop baseline costs for bridge inspections completed without the aid of UAS.

Specific Progress This Quarter
- Flight planning and data acquisition parameters developed and reported
- ROI analysis initiated

Problems
- None encountered or anticipated at this time.

Work Planned for Next Quarter
- Further develop cost-benefit analysis.

Task 9: Draft Final Report

Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date
- N/A—Task 9 is planned for April – June, 2017.

Specific Progress This Quarter
- N/A—Task 9 is planned for April – June, 2017.

Problems
- None encountered or anticipated at this time.

Work Planned for Next Quarter

- N/A—Task 9 is planned for April – June, 2017.

Task 10: Draft ODOT Research Note

Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date

- N/A—Task 10 is planned for June, 2017.

Specific Progress This Quarter

- N/A—Task 10 is planned for June, 2017.

Problems

- None encountered or anticipated at this time.

Work Planned for Next Quarter

- N/A—Task 10 is planned for June, 2017.

Task 11: TAC Meeting #4

Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date

- N/A—TAC Meeting #4 is planned for July, 2017.

Specific Progress This Quarter

- N/A—TAC Meeting #4 is planned for July, 2017.

Problems

- None encountered or anticipated at this time.

Work Planned for Next Quarter

- N/A—TAC Meeting #4 is planned for July, 2017.

Task 12: Final Report

Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date

- N/A—Task 12 is planned for July to September, 2017.

Specific Progress This Quarter

- N/A—Task 12 is planned for July to September, 2017.

Problems

- None encountered or anticipated at this time.

Work Planned for Next Quarter

- N/A—Task 12 is planned for July to September, 2017.

Task 13: Final Research Note

Percent completed reported in last quarterly report: 0%
Percent completed after this quarter: 0%

Key Progress-To-Date

- N/A—Task 13 is planned for September, 2017.

Specific Progress This Quarter

- N/A—Task 13 is planned for September, 2017.

Problems

- None encountered or anticipated at this time.

Work Planned for Next Quarter

- N/A—Task 13 is planned for September, 2017.

6. <u>Project Coordinator's Comments</u> (Completed by ODOT)

No comments

7. <u>Finances</u> (Completed by ODOT)

SPR Project Summary

VENDOR	FY'16	FY'17	FY'18	FY'19	TOTALS
ORIGINAL BUDGET					$ -
WORK PLAN BUDGET	$ 40,000	$ 134,000	$ 6,000		$ 180,000
REVISED BUDGET	$ 30,000	$ 124,000	$ 26,000		$ 180,000
EXPENDITURES - VENDOR	$ 27,272	$ -	$ -	$ -	$ 27,272
BALANCE	$ 2,728	$ 124,000	$ 26,000	$ -	$ 152,728
ODOT	FY'16	FY'17	FY'18	FY'19	TOTALS
ORIGINAL BUDGET	$ 88,000	$ 110,000	$ 22,000		$ 220,000
REVISED BUDGET	**$ 15,000**	**$ 15,000**	**$ 10,000**		**$ 40,000**
EXPENDITURES - ODOT	$ 15,261	$ 383	$ -	$ -	$ 15,644
BALANCE	$ (261)	$ 14,617	$ 10,000	$ -	$ 24,356
PROJECT	FY'16	FY'17	FY'18	FY'19	TOTALS
ORIGINAL BUDGET	$ 88,000	$ 110,000	$ 22,000	$ -	$ 220,000
REVISED BUDGET	**$ 45,000**	**$ 139,000**	**$ 36,000**	**$ -**	**$ 220,000**
EXPENDITURES - PROJECT	$ 42,533	$ 383	$ -	$ -	$ 42,916
BALANCE	$ 2,467	$ 138,617	$ 36,000	$ -	$ 177,084