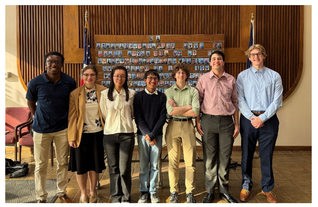
UNITED STATES POSTAL SERVICE

GALLOGLY COLLEGE OF ENGINEERING
AEROSPACE AND MECHANICAL ENGINEERING
The UNIVERSITY *of* OKLAHOMA

GALLOGLY COLLEGE OF ENGINEERING
SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING
The UNIVERSITY *of* OKLAHOMA

Sorter Monorail and Carrier Wheel Condition Monitoring and Reporting on the APPS



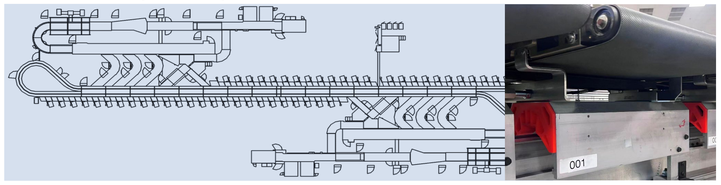
Team Members:

Jacob Osifeso
Isabella Jensen
Sophia Ye
Douglas Nguyen
Patrick Gallagher
Teddy Winter
Kyle Engel

Faculty Advisor:
Dr. Christopher Dalton, Dr. Clifford Fitzmorris

Background

The Automated Package Processing System (APPS) sorts packages, flat-bundles and letter-bundles for the USPS. The system comprises approximately 300 carrier cells. The interdisciplinary team monitors the health of these components to ensure optimal performance.

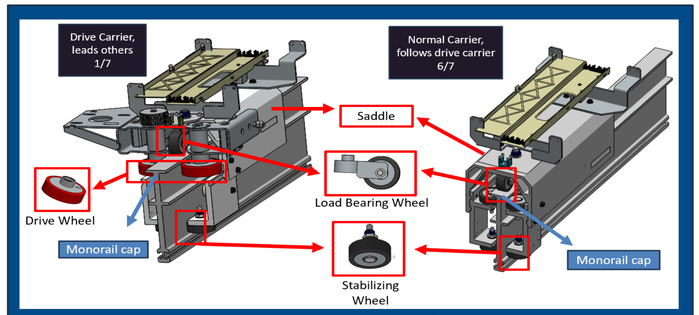


APPS Dual-Sided Closed Loop Blueprint

Carrier Cell

Objectives

1. Monitor the condition of stainless-steel caps riveted to the monorail.
2. Design and implement a wheel health monitoring system for a group of 7 carriers.
3. Detect and report component anomalies and their locations to a centralized data system in HMI configuration.
4. Deliver production-ready design documentation.



Schematic of a Carrier Cell

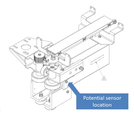
Constraints

- Must meet USPS safety standards
- Be able to operate in jog mode(1500 mm/s)
- Must not interfere with regular operations
- No permanent installation
- Be operator friendly

Design Process

Mechanical Alternatives & Iterations

- Refined the scope of the monitoring system
- **Vibration Sensor Mount**: considered an alternative mounting location, adopted a non-magnetic base for material capability, PLA→ PETG
- **Camera Mount**: adjusted the placement of the gooseneck
- Included isolation measures



Electrical Alternatives & Iterations

- **Sensor Selections**: Keyence, Banner, SICK, Turck, PULS
- **Wheel Monitor**: Encoder → Camera for easy mechanical integration
- **Camera Selection:** Industrial used cameras → PICO2CAM, Quantity of 2 → 1 to reduce cost
- **System Architecture:** Rest API/MQTT/SSH tunnel → Ethernet
- **Software Integration:** RMS, FFT analysis, and Python full-stack maintenance system

Design Details

Load Bearing Wheel & Monorail Cap

Hardware



Banner 3-axis Vibration Sensor



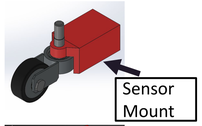
Banner IIOT Receiver

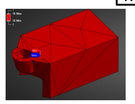
Sensor Properties: 900 MHz, ≈ 12-month battery life, range:0-66.5 mm/sec, 37.3ms sampling rate

Software

The sensor and receiver provide time-sampled data and RMS variables, which enable FFT analysis and peak isolation. Detected anomalies trigger maintenance alerts through the HMI.

Mounting





Safety Factor

Temporary Mount: a box attached to carrier cell and load-bearing wheel
Location: wheel spacer as an anchor point
Method: 3M VHB for secure attachment
Material: PETG

Data Collection & Handling

Data Acquisition: Separate ethernet inputs for vibration sensor and I/O Link Master
Processing: real-time frequency vs. ideal, camera data stored, python-based system
System: HMI for maintenance alert

Drive Wheel

Hardware



PICO2CAM



I/O Link Master

Camera Properties: 3.15 MP, 0.032ms exposure time



Photo Eye Sensor



LED Lighting

Flag System: a photoelectric system triggering a timed photo as a carrier cell passes through the beam.

Software

Software: SICK Proprietary vision software
Configuration: I/O Link interface
Processing: C++ (SICK Vision Suite) + Python (Open CV)
Function: reference image comparison

Mounting

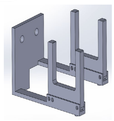
Temporary Mount (top): a gooseneck with a magnetic base
Material: PLA
Location: near maintenance hub (aluminum)



Permanent Mount (below): A tripod swivel mount and a telescoping stand with a spring lock
Material: A36 steel

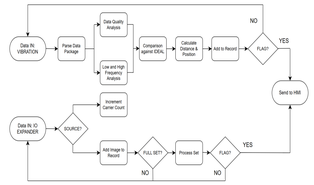


Photo Eye Mount: an L-shaped bracket attached to the APPS and the photo eye sensor.
Material: PETG

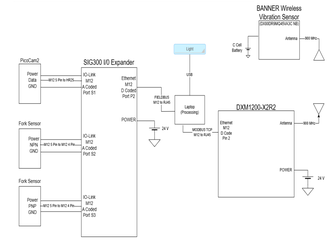


Block Diagrams

Software Architecture

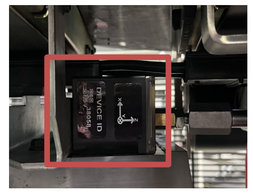


Hardware Architecture



Prototype Installation

Sensor



- Placed on top of a carrier cell saddle for easy installation.
- Remains secure during APPS rotation.
- Data is polled constantly during operation.

Camera



- Magnetically mounted to the APPS handle support.
- Positioned approximately two inches from the drive wheel for monitoring.
- Image is processed through CV

Conclusions

The APPS condition monitoring system is designed to be cost-effective and compliable with the existing USPS architecture. A 3-axis vibration sensor is used to monitor load bearing wheel and cap conditions, with one sensor installed for every 7 carriers. A single camera is utilized for initial imaging of the drive wheel. Potential defects such as wear and bearing issues are reported in the HMI display. The system is designed to be easily accessible and simple to use from a software standpoint. Testing and optimization are still in progress.

Future

- Investigate wired solutions for a more cost-effective option.
- Select a cost-effective, suitable sensor based on the test data.
- Integrate more cameras to provide full visibility of all wheels
- Enhance signal processing and classification algorithms.
- Integrate tool-less mounting approaches.

Standards

Fastener: ISO-898-1
Material: ATSM A36
Plastic Tensile Strength: ISO 527
Ethernet Standard: IEEE 802.3
Software Documentation: IEEE J-STD-016-1995
Accessibility: Section 508 (36 C.F.R. Part 1194)