Leveraging Telematics and Weather Data to Study the Productivity of Roadside Mowers

Jijo Mathew and Matt Kraushar

William Morgan, Howell Li, William Downing, Timothy Wells, James Krogmeier and Darcy Bullock

105th Purdue Road School
Introduction

Data Collection

Data Retrieval

Analysis/Results

Summary
Introduction

• INDOT maintains ~11,000 centerline miles of roads

• Major activities during mowing operations include crew commute, equipment transport between locations, and maintenance

• Current reporting structure lacks the ability to track these activities

• This research proposes various performance metrics to track the daily activity of mowers

• Evaluate the efficiency of mowing operations

• Provide guidance on resource allocation, scheduling
# 7 Mowers

<table>
<thead>
<tr>
<th>Mower #</th>
<th>Make</th>
<th>Model</th>
<th>Year</th>
<th>Description</th>
<th>Unit Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bushwhacker</td>
<td>ST-150</td>
<td>2006</td>
<td>15' Flex-Wing Rotary Cutter</td>
<td>Center of 69</td>
</tr>
<tr>
<td>2</td>
<td>Woods</td>
<td>BW1800X</td>
<td>2017</td>
<td>15' Flex-Wing Rotary Cutter</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Woods</td>
<td>BW1800X</td>
<td>2017</td>
<td>15' Flex-Wing Rotary Cutter</td>
<td>Unit 261</td>
</tr>
<tr>
<td>4</td>
<td>Alamo</td>
<td>EAGLE 15</td>
<td>2005</td>
<td>15' Flex-Wing Rotary Cutter</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Bushwhacker</td>
<td>7210</td>
<td>2008</td>
<td>6' 3-Point Rotary Cutter</td>
<td>Unit 3</td>
</tr>
<tr>
<td>6</td>
<td>Schulte</td>
<td>S-150</td>
<td>2003</td>
<td>15' Flex-Wing Rotary Cutter</td>
<td>Unit 4</td>
</tr>
<tr>
<td>7</td>
<td>Bushwhacker</td>
<td>ST-180</td>
<td>2006</td>
<td>15' Flex-Wing Rotary Cutter</td>
<td></td>
</tr>
</tbody>
</table>
Outline

- Introduction
- Data Collection
- Data Retrieval
- Analysis/Results
- Summary
GPS Trackers

Super small Footprint!!

Magnetic weatherproof case with extended battery pack that lasts for ~1-2 months
Installation

Behind driver seat

Secured with padlocks
7 Mowers in Bluffton, Fort Wayne, IN

1 MONTH DATA COLLECTION

<table>
<thead>
<tr>
<th>May/June 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>S  M  T  W  R  F  S</td>
</tr>
<tr>
<td>27 28 29 30 31  1  2</td>
</tr>
<tr>
<td>3  4  5  6  7  8  9</td>
</tr>
<tr>
<td>10 11 12 13 14 15 16</td>
</tr>
<tr>
<td>17 18 19 20 21 22 23</td>
</tr>
<tr>
<td>24 25 26 27 28 29 30</td>
</tr>
</tbody>
</table>
Data

Driver: PurdueTLab GPS2
Lat,Long: 40.963912,-85.290154
Date,Time: 06/05/2018, 08:55 AM
Heading: South West
Fuel Level: 0
Mileage: 164.76576
Speed: 2.05029
Battery: 87
Current State:
IN-2, Roanoke, IN 46783, USA
Outline

- Introduction
- Data Collection
- Data Retrieval
- Analysis/Results
- Summary
Data Retrieval
## Data Retrieval

### TRAVEL LOG REPORT from 06/11/2018 to 06/15/2018 for PurdueLab GPS1

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Date</th>
<th>Time Type</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Location</th>
<th>Battery</th>
<th>Speed</th>
<th>Mileage</th>
<th>Fuel</th>
<th>Direction</th>
<th>Map IT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Off</td>
<td>06/11/2018</td>
<td>10:41 AM</td>
<td>41.128010</td>
<td>-85.175807</td>
<td>I-69, Fort Wayne, IN 46818</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>NE</td>
<td>Map IT</td>
</tr>
<tr>
<td>Engine Off</td>
<td>06/11/2018</td>
<td>10:41 AM</td>
<td>41.128010</td>
<td>-85.175807</td>
<td>I-69, Fort Wayne, IN 46818</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>NE</td>
<td>Map IT</td>
</tr>
<tr>
<td>Engine Off</td>
<td>06/11/2018</td>
<td>10:41 AM</td>
<td>41.128010</td>
<td>-85.175807</td>
<td>I-69, Fort Wayne, IN 46818</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>NE</td>
<td>Map IT</td>
</tr>
<tr>
<td>Engine Off</td>
<td>06/11/2018</td>
<td>10:41 AM</td>
<td>41.128010</td>
<td>-85.175807</td>
<td>I-69, Fort Wayne, IN 46818</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>NE</td>
<td>Map IT</td>
</tr>
<tr>
<td>Engine Off</td>
<td>06/11/2018</td>
<td>10:41 AM</td>
<td>41.128010</td>
<td>-85.175807</td>
<td>I-69, Fort Wayne, IN 46818</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>NE</td>
<td>Map IT</td>
</tr>
<tr>
<td>Engine Off</td>
<td>06/11/2018</td>
<td>10:41 AM</td>
<td>41.128010</td>
<td>-85.175807</td>
<td>I-69, Fort Wayne, IN 46818</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>NE</td>
<td>Map IT</td>
</tr>
<tr>
<td>Engine Off</td>
<td>06/11/2018</td>
<td>10:41 AM</td>
<td>41.128010</td>
<td>-85.175807</td>
<td>I-69, Fort Wayne, IN 46818</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>NE</td>
<td>Map IT</td>
</tr>
<tr>
<td>Engine Off</td>
<td>06/11/2018</td>
<td>10:41 AM</td>
<td>41.128010</td>
<td>-85.175807</td>
<td>I-69, Fort Wayne, IN 46818</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>NE</td>
<td>Map IT</td>
</tr>
<tr>
<td>Engine Off</td>
<td>06/11/2018</td>
<td>10:41 AM</td>
<td>41.128010</td>
<td>-85.175807</td>
<td>I-69, Fort Wayne, IN 46818</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>NE</td>
<td>Map IT</td>
</tr>
<tr>
<td>Engine Off</td>
<td>06/11/2018</td>
<td>10:41 AM</td>
<td>41.128010</td>
<td>-85.175807</td>
<td>I-69, Fort Wayne, IN 46818</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>NE</td>
<td>Map IT</td>
</tr>
<tr>
<td>Engine Off</td>
<td>06/11/2018</td>
<td>10:41 AM</td>
<td>41.128010</td>
<td>-85.175807</td>
<td>I-69, Fort Wayne, IN 46818</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>NE</td>
<td>Map IT</td>
</tr>
</tbody>
</table>

Showing 1 to 19 of 12,404 entries
Data stored in SQL Database

<table>
<thead>
<tr>
<th>Data Collection</th>
<th>Data Retrieval</th>
<th>Analysis/Results</th>
<th>Summary/Findings</th>
</tr>
</thead>
</table>

**Introduction**

**Data Collection**

**Data Retrieval**

**Analysis/Results**

**Summary/Findings**

---

![SQL Database interface](image-url)

- **SQL Query**
  - SELECT * FROM `moving_data`
  - Result: Various data fields such as `id`, `date`, `time`, `latitude`, `longitude`, `message`, etc.
  - Query executed successfully.
Outline

- Introduction
- Data Collection
- Data Retrieval
- Analysis/Results
- Summary
Gas City Unit

Daily commute to and from unit

GPS traces of mowing activity

Fort Wayne District

Typical day of mowing
Major Activities

- Mowing

- Transport (Equipment)

- Commute

- Maintenance
  - Greasing
  - Changing blades
  - Flat tires
  - PTO shaft
Histogram of Speed

- Mowing: < 6mph
- Transport: >= 6mph
Mileage

- On average, total daily distance covered = **21 mi**
  - 13 mi mowing
  - 8 mi transport

- During one month period
  - Total distance covered by all mowers ~2000 mi
    - Mowing ~1200 mi
    - Transport ~800 mi
Area covered

\[
\text{Area (in acres)} = \frac{\text{Mower Width} (ft) \times 0.90 \times \text{Distance Mowed} (mi) \times \frac{5280 \text{ ft}}{\text{mi}}}{43,560 \text{ sq. ft/acre}}
\]

\[\approx 1800 \text{ acres mowed}\]

Cumulative total area covered by all units
Periods of Activity
Periods of Activity

- Commute
- Maintenance
- Idle
- Work hours

Diagram showing periods of activity over the week of 05/27 to 05/30, with specific time slots highlighted for commute, maintenance, and idle times.
Periods of Activity

Lunch Breaks

Work hours
Weather Grid Overlay

• North American Land Data Assimilation System (NLDAS) from NOAA
  • Temporal Resolution – 1 hour
  • Spatial Resolution – 1/8th-degree grid. (about 14 km)

• Variety of variables:
  – Precipitation by type
  – Temperature
  – Solar flux
  – Wind speed
  – Visibility
  – Blowing snow
  – Severity index

• Road segment weather data is based on a weighted average
Weather Data

Rain intensity by hour of day
Impact of weather on activity periods

Intensity of Rainfall (in/hr)

Inactivity due to weather
Characterization of work hours
Allocation of work hours

- Mowing: 47.39%
- Maintenance: 25.96%
- Commute: 7.08%
- Transport: 6.67%
- Weather: 3.01%
- Idle: 9.9%

- ~1 hr
- ~2.2 hrs
Outline

- Introduction
- Data Collection
- Data Retrieval
- Analysis/Results
- Summary
Summary/Findings

• ~1170 miles mowed
• ~1800 acres of area covered
• Avg. daily distance = 21 miles
• (13 mi mowing + 8 mi transport)
• ~50% time actively spent mowing on an average 9.5 hour work day
• Operational strategies to reduce the maintenance and transport
• Detailed maintenance reporting systems could also provide better insights on the downtime
INDOT – What did we learn?

Our data was similar to the limited reporting of other groups for this type of activity.

Current reporting system doesn’t capture the “other” categories

• “Other” = everything but active process of mowing.
  • Is reporting the “other” important?
    • The “other” IS part of the mowing process.
      • Example- transporting past 1-2 miles of mowed farm field or city is still something that has to occur.
      • Maintenance still has to occur.
      • The crews still need to get to and from the site and they need periodic breaks.
  • What does understanding the “other” help you with?

• Scheduling!

• Areas of improvement?
  • Route modification?
    • Where to start to minimize transporting/dead heading
    • Where to send what crew/machines?
  • Do we have the right equipment?
INDOT – What did we learn?

- Opportunity exists to utilize the GPS technologies to investigate other constantly moving operations
  - Plowing, painting, sweeping, herbicide applications, etc.

- Need for a simple system
  - Hard wired charging rather than batteries- the less intervention the better
  - Want for a universal system that can be used in tractors, trucks, sweepers, other equipment
  - Passive is best- reducing the need for input makes this data more accurate.

- Staff were more than receptive of using GPS- no fears of “big brother”
  - We clearly communicated what we were doing and why.

- Just because a tractor and/or mower is new doesn’t mean it won’t break down!
  - Some down time was due to some fresh off the lot equipment being set up incorrectly.
INDOT – Final Thoughts

- Simply putting some additional effort into the planning process over the status quo can help improve efficiencies.
  - Example - past practice was to use 30 tractors but through careful planning and thoughtful resource allocation the manager determined that the same work could be accomplished with 10 (or less!) tractors.
    - Use of 15’ flexwing mowers rather than 6’ mowers whenever possible.
- Having a plan in place for mechanic crew can reduce down time.
- Do you have a backup? (Operator, Tractor, Mower, Tires, etc?)
- Communication and teamwork make everything much easier - this went very smoothly even though we were in three geographically separate places.
- The data helped us:
  - better understand staffing and equipment needs for the activity
  - bolster internal modeling data
- Allowed finalization of cost benefit analysis.
Jijo Mathew  
Research Engineer  
Joint Transportation Research Program  
kjijo@purdue.edu

Matt Kraushar  
Roadside Maintenance Specialist  
INDOT  
MKraushar@indot.IN.gov