Development of a Moving Automatic Flagger Assistance Device (AFAD) for Moving Work Zone Operations

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Flagging operations are a critical part of construction and maintenance activities on our highways. Flagging personnel are trained to effectively and safely communicate the location of construction or maintenance activities to the traveling public. Due to the nature of the work, flagging personnel are located on the roadway near the work zone, which can result in dangerous vehicle and flagger interactions. With the increasing levels of distracted drivers, safety of flaggers and workers in work zones is an increasing concern. Unfortunately, flagging personnel deaths and near misses continue to occur on our highways during each construction season.

Flagging operations can occur during both stationary and moving operations on two-lane, high-speed roadways. Stationary operations occur at a single location for a specific amount of time. The use and benefits of AFADs at stationary locations is documented in the report Implementation of Automatic Flagger Assistance Devices (AFADs) for Minnesota Department of Transportation (MnDOT) Flagger Operations.

Moving operations involve work zones that are continuously moving, such as pavement crack sealing operations. The use of traditional AFADs in a moving operation is difficult due to the towing requirements of the devices. In order to capture the benefits of AFADs in a moving work zone, the stationary AFAD needed to be modified to allow for self-propelled motion to follow the moving operation.
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FINAL REPORT

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EXECUTIVE SUMMARY

Flagging operations are a critical part of construction and maintenance activities on our highways. Flagging personnel are trained to effectively and safely communicate the location of construction or maintenance activities to the traveling public. Due to the nature of the work, flagging personnel are located on the roadway near the work zone, which can result in dangerous vehicle and flagger interactions. With the increasing levels of distracted drivers, safety of flaggers and workers in work zones is an increasing concern. Unfortunately, flagging personnel deaths and near misses continue to occur on our highways during each construction season.

Flagging operations can occur during both stationary and moving operations on two-lane, high-speed roadways. Stationary operations occur at a single location for a specific amount of time. The use and benefits of AFADs at stationary locations is documented in the report *Implementation of Automatic Flagger Assistance Devices (AFADs) for Minnesota Department of Transportation (MnDOT) Flagger Operations*.

Moving operations involve work zones that are continuously moving, such as pavement crack sealing operations. The use of traditional AFADs in a moving operation is difficult due to the towing requirements of the devices. In order to capture the benefits of AFADs in a moving work zone, the stationary AFAD needed to be modified to allow for self-propelled motion to follow the moving operation.

A review of existing devices already on the market was completed to determine if a similar device was available. The review found no devices that would meet all the required operational needs. Discussions were initiated with DJ Products, Inc. to determine if a moving AFAD device could be manufactured. The initial discussions led to the development of a device prototype, which was ultimately developed into the final moving AFAD device.

Based on the information described in this report, the following conclusions were made:

- A moving AFAD device was developed from conception to completion through this project.

- Operational features of the moving AFAD include:
  - Operated with wireless remote, wired remote, or handle controls
  - Uses the original remote control from the AF-76 for the flagging components
  - On-board batteries and battery charger
  - Moves in forward and reverse directions at speeds up to 5 feet per second
  - Towed to the work site using standard towing hitch
  - Will operate for a minimum of 6 hours on initial charge
• The moving AFAD is operated by one person located off the roadway and out of traffic flow locations.

• Setup and take down require more effort than traditional flagging but are still considered reasonable.

Based on the information contained in this report, the following recommendations are made:

• Continue field testing to determine the appropriate roadway projects for the device

• Document operational issues to assist in development of future devices

• Determine the length of time the device will operate on feasible maintenance projects
CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Flagging operations are a critical part of construction and maintenance activities on our highways. Flagging personnel are trained to effectively and safely communicate the location of construction or maintenance activities to the traveling public. Due to the nature of the work, flagging personnel are located on the roadway near the work zone, which can result in dangerous vehicle and flagger interactions. With the increasing levels of distracted drivers, safety of flaggers and workers in work zones is an increasing concern. Unfortunately, flagging personnel deaths and near misses continue to occur on our highways during each construction season.

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Moving operations involve work zones that are continuously moving, such as pavement crack sealing operations. The use of traditional AFADs in a moving operation is difficult due to the towing requirements of the devices. In order to capture the benefits of AFADs in a moving work zone, the stationary AFAD needed to be modified to allow for self-propelled motion to follow the moving operation.

1.2 PROJECT DESCRIPTION

The objective of this research project was to develop a self-propelled moving AFAD for use in moving work zone operations.

1.3 PROJECT OVERVIEW

This project included the following tasks:

a) Review the needs for the device
b) Review similar devices already on the market, if any
c) Design of the proposed device
d) Fabrication of the device
e) Documentation of device operations
Each of these items is described in detail in the following report chapters.
CHAPTER 2: MOVING DEVICE DEVELOPMENT

2.1 INITIAL DISCUSSIONS

Initial discussions with MnDOT determined the need to investigate a self-propelled moving AFAD for use in moving work zone operations. A draft work zone layout was developed for the use of a moving AFAD. The draft layout is shown in Figure 2.1.

Figure 2-1 Draft Layout for Moving Work Spaces with Moving AFADs
A meeting was held in September, 2014 with MnDOT and Safety Technologies, Inc. to discuss the possibility of developing a moving AFAD device. Discussion at the meeting included developing requirements for the device, including moving speed, device controls, and range of motion. It was concluded that a review of existing devices already on the market would be conducted to determine if any devices were worth pursuing further.

Existing devices already on the market were reviewed to determine how they might work in a moving operation. Most of these devices were designed for moving recreational vehicles and trailers without the use of a towing vehicle. The devices reviewed are shown in Table 2.1.
### Table 2-1 Review of Existing Trailer Moving Devices

<table>
<thead>
<tr>
<th>Name/Location</th>
<th>Type</th>
<th>Cost</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optitec Australia</td>
<td>Remote control jockey wheel</td>
<td>$1,500</td>
<td>single wheel, bolts onto hitch, remote control with steering, speed = 25 feet/minute, supports 660 lbs., powered by the trailer battery</td>
</tr>
<tr>
<td>Camper Trolley Australia</td>
<td>Remote control tracked mover</td>
<td>$2,000</td>
<td>dual tracks, attached to bracket bolted to hitch, internal battery that operates for 30 minutes single charge, speed = 25 feet/minute, supports 660 lbs., shuts off after 3 minutes continuous use</td>
</tr>
<tr>
<td>Easi-Move United Kingdom, Atlanta, GA</td>
<td>Remote control motors that attach to the chassis and move the wheels</td>
<td>$2,000</td>
<td>motors attached to chassis that move each wheel, remote control steering, 5000 lbs. capacity, speed = 25 feet/minute</td>
</tr>
<tr>
<td>Purple Line California</td>
<td>Remote control motors that attach to the chassis and move the wheels</td>
<td>$1,500</td>
<td>motors attached to chassis that move each wheel, remote control steering, 5000 lbs. capacity, speed = 20 feet/minute, shuts off after 3 minutes continuous use</td>
</tr>
<tr>
<td>Parkit360 Canada</td>
<td>Remote control power dolly</td>
<td>$4,000</td>
<td>power dolly attaches to trailer hitch, powered by trailer battery, remote controlled</td>
</tr>
<tr>
<td>DJ Products Little Falls, MN</td>
<td>Multiple cart mover products</td>
<td>unknown, will need to call for quote</td>
<td>Multiple cart mover products including remote control steering, can make custom movers</td>
</tr>
</tbody>
</table>

After review of each device, it was decided to contact DJ Products, Inc. to inquire about their line of cart mover products. DJ Products, Inc. is located in Little Falls, MN, making contact convenient and quick.
2.2 DISCUSSIONS WITH DJ PRODUCTS, INC.

A meeting was held with Jeff Berg and Joe Berg of DJ Products, Inc. in February, 2015. The meeting was held at DJ Products, Inc. headquarters in Little Falls, MN, which also houses the manufacturing operations. A variety of existing devices were reviewed, including devices developed to move multiple shopping carts at retail stores and another device used at airports.

Discussion at the meeting lead to the agreement to develop a prototype vehicle that could ultimately be used for the moving AFAD device.

2.3 PROTOTYPE DEVELOPMENT

Over the next six months, DJ Products, Inc. developed a prototype vehicle that could be outfitted with the AFAD equipment. Initial design drawings were developed as a guide for the device. The initial drawing is shown in Figure 2.2

![Initial Prototype Design](image)
The design was modified to incorporate all the necessary components and requirements for the AFAD equipment. The prototype was completed in August, 2015, and a meeting was held at DJ Products, Inc. to review the device.

At the meeting, Jeff Berg and Joe Berg demonstrated the current version of the mobile unit they developed. The unit could be controlled remotely or with the drive handle. It was large enough to accommodate the AutoFlagger components and could be towed behind a vehicle.

Potential improvements to the device were discussed to better suit MnDOT’s needs. The device was brought back into the shop to implement the improvements.

Photos from the initial review of the device are shown below.

Figure 2-3 Prototype Vehicle Operated with Wired Remote Control
2.4 FINAL PRODUCT

The moving AFAD was completed in April, 2016 and a meeting was held at DJ Products, Inc. to review the device. All components from an AutoFlagger AF-76 were transferred from the trailer to the new device. Operational features of the moving AFAD include:

- Operated with wireless remote, wired remote, or handle controls
- Uses the original remote control from the AF-76 for the flagging components
- On board batteries and battery charger
- Moves in forward and reverse directions at speeds up to 5 feet per second
- Towed to the work site using standard towing hitch
• Will operate for a minimum of 6 hours on initial charge

Photos of the final product are shown below.
Figure 2-5 Final Product Operated with Handle Control

Figure 2-6 Final Product Being Deployed
Figure 2-7 Final Product Fully Deployed

Figure 2-8 Device Components
CHAPTER 3: DEVICE TESTING

3.1 PLANS FOR TESTING

After final delivery of the device to MnDOT in May, 2016, plans were made to test the device in the field. However, due to scheduling and operational issues that occurred, initial field testing was not completed in 2016.

3.2 OPERATIONAL ISSUES

Operational issues were experienced that delayed the initial field testing. In June, 2016 the on-board batteries failed and were replaced. The battery failure was possibly due to the amount of time that had lapsed since the device had last been charged and used. Storing the device in a location where the batteries can be continuously charged and maintained would eliminate this issue.

In addition, other replacement parts were needed, including a new control board. While waiting for the parts, the control box filled with water during a rain event, resulting in additional damage. The device was returned to DJ Products, Inc. in October, 2016 for repairs. To avoid future water damage, the seals for the control cover were improved and drain holes were installed in the control box to allow water to escape.

The repaired device was returned to MnDOT in January, 2017. Due to winter road conditions, field testing was not possible until February 13th, 2017.

3.3 INITIAL FIELD TESTING

On February 13, 2017, the device was used for flagging on a roadway crack sealing project on TH 71 south of Sauk Centre, MN. The device operated as expected and was used for about an hour on the project. Due to the type of crack sealing being performed, the crew was required to move at a faster rate than the device could accommodate. The required speed resulted in some drivability issues with oversteer while moving against traffic. After one hour of use, the device was removed from the project.

Discussions with operations staff indicated the device may be better suited for slower moving operations to avoid the oversteer issues. Additional testing on a variety of roadway types is being considered to determine the best use for the device.

Photos from the initial field testing are shown below.
Figure 3-1 Device Operated on Shoulder

Figure 3-2 Device Operated with Handle Controls
CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

Based on the information described in this report, the following conclusions were made:

- A moving AFAD device was developed from conception to completion through this project.

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REFERENCES


Safety Technologies, Inc. (Internet), AF-76 model, (cited February 2017),
http://www.autoflagger.com/AF-76.html