Optimizing Tow Plow and Wing Plow Deployment

Best Practices Guide

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OPTIMIZING TOW PLOW AND WING PLOW DEPLOYMENT

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INTRODUCTION

This Best Practices Guide is designed to aid state DOTs in determining how and where to deploy various plows and configurations to optimize cost-effectiveness and other efficiencies. This guide was developed as part of Clear Roads project 19-03, “Measuring the Efficiencies of Tow Plows and Wing Plows,” which also developed a **Decision Support Tool (DST).** This Decision Support Tool is referenced throughout this Best Practices Guide and is discussed in detail in a separate report.[1]

The Decision Support Tool is a spreadsheet-based tool that calculates both **plowing efficiencies** (based on real-world plowing data) and **life cycle costs** of plow configurations. The Decision Support Tool and the accompanying User’s Guide are available at https://clearroads.org/project/19-03/.

BACKGROUND INFORMATION ON THE USE OF TOW PLOWS AND WING PLOWS

Tow plows and wing plows can be characterized as accessories that are attached to conventional plow trucks as a means of increasing the plow truck’s single-pass snow clearing width capability. These accessories are maintained in a retracted position within highway legal vehicle width requirements for transportation to and from work zones. While plowing, these accessory plow(s) can be hydraulically extended to widen the plow clearing width. The plow operator controls the width of plowing up to the maximum combined width of the plow configuration to account for factors such as snow water content and tire traction, and to avoid roadside obstructions. The plow accessories can be attached to the base plow truck in three different locations. The head plow on the front of the plow truck can be extended laterally (telescope, front wings), an accessory plow can be mounted to the side of the plow truck and swung out (side wing), or trailered and steered out laterally (tow plow). These plow accessories usually clear snow in a single direction. Some are bi-directional, enabling the plow operator to select the clearing direction. In some less common plowing operations, some plow accessories can even be configured to clear snow in both directions simultaneously.

Given the wide array of plow accessories readily available to DOTs, choosing how best to configure and deploy plow equipment requires a careful examination of many variables. These variables tend to fall into one of the following three main categories: plow equipment considerations, plow operational considerations, or roadway plowing considerations. Since all wing plow, tow plow, and any other plow accessories share a conventional plow truck, the truck forms the baseline of equipment configuration and performance characteristics. As such, in the following discussion of plow accessories, all equipment configuration and/or performance differences begin from a common basis of a conventional plow truck. Also, it should be noted that the choice of selecting and deploying plow equipment is heavily influenced by the capability of applying winter materials such as sand, salt, and deicers. This Best Practices Guide and the companion Decision Support Tool focus solely on plow clearing efficiencies as the first consideration in the plow configuration and deployment metric, since clearing the roadway is the

[1] Duane Bennett and Ty Lasky, “Measuring the Efficiencies of Tow Plows and Wing Plows - Task 7: Decision Support Tool,” plow efficiency simulation report for Tasks 5-7, Clear Roads project 19-03, April 1, 2021.

primary job to enable traffic to pass. The application of abrasives and deicer treatments are secondary considerations and are not discussed in this guide.

Plow Accessory Equipment Considerations

A common consideration when attaching a wing and/or tow plow accessory to a plow truck is accounting for the additional forces generated by pushing the additional snow. The increased forces act to slow the plow truck. In the specific case of asymmetric wing plows clearing snow generates a moment force that acts to spin the plow truck. The plow weight benefit/reduction relationship is complex, but on flat roadways the weight factor is significantly more influenced by abrasives application than plow weight alone. The plow truck standard requirements must be increased to account for installation and operation of any type of plow accessory. Common plow truck upgrades include increased engine power, increased engine cooling capacity, additional hydraulic power and circuits, visibility aids, frame stiffening, additional electrical wiring, additional lighting, and additional controls and data collection. The required plow truck upgrades add significant cost to the plow truck procurement. This additional cost, along with the benefit of the additional snow clearing width capability, is incorporated in the DST plow data libraries. The DST analysis uses this data on a per-plow-route basis, and the data can be used to estimate the time necessary to justify the additional expense of the plow truck upgrades.

Plow Accessory Operational Considerations

Life cycle costs of plow accessories by plow type can be quantified with the DST based on DOT-specific plow operating costs. The use of plow accessories to increase plow width clearing capabilities generates additional common plowing operational issues. Operator training and experience are much more essential when operating plow accessories. The plow driver must possess a higher level of skill to account for the additional plowing force, constantly monitor for obstructions including where the trailing type accessory plows are extended and headed. As the snow load on the plow surfaces increases, the plow operator retracts the accessory plow to maintain speed. The plow driver has an increased number of variables to control simultaneously, which requires a much higher skill level than operating a standard plow truck.

The additional plow accessories obviously contribute to an increase in seasonal and operational maintenance, consumables, and storage costs. However, viewed from the perspective of the required equivalent plow capacity of additional plow trucks and/or plow runs, the cost difference would be minimized. The harsh environment of highway snow plowing with cold temperatures, high salinity, and extreme wear shorten the service life of a standard plow truck. Plow accessories operate in this same environment, so the service life of plow accessories would typically be equivalent to that of a standard plow truck.

Plow Accessory Roadway Considerations

Deploying plows with accessories is an efficient means of providing the additional clearing capacity necessary to clear a route at its widest points and reducing the need for additional plow trucks.

Examples of roadway widening points include intersections, lane increases, wide shoulders, and ramps. Plow accessories can also provide reserve clearing capacity to more cost-efficiently clear roadway geometries that involve departure lanes, such as ramps and merges. Since a roadway split requires a group of plows to separate to clear separate roadway sections, deploying reserve plow capacity with plow accessories is a more cost-efficient strategy than using additional standard plow trucks that are redundant over the remainder of the plow route. The primary objective of deploying plow trucks with plow accessories is to maximize clearing width of a plow truck, but another advantage is the support for variable clearing width. When clearing variable-width roadways with geometric features, the ability to retract large plow surfaces is a great benefit when navigating restricted road segments. As opposed to multiple standard plow trucks that need to queue-up to pass choke points, retractable plow accessories can fold up, and the plow trucks can pass through without adding to traffic congestion. Common choke points include roundabouts, lane reductions, and structures.

SPECIFIC PLOW TYPE CONSIDERATIONS

The Decision Support Tool allows users to compare seven plow types: a conventional-width front/underbody plow (base case for comparison) plus six configurations of plows with accessories. These are:

- Front plow with a right- or left-side wing plow.
- Double wing plow.
- Single-direction tow plow.
- Bi-directional tow plow.
- Single-direction tow plow combined with a wing plow.
- Telescopic head plow.

These plow types can be logically grouped into four plow accessory configurations with similar attributes. Each of the four configurations has advantages and disadvantages related to cost, application, route specifics, and operational requirements. The following are generalized best practices that can be considered when making plow type comparisons.

Wing Plow-Specific Considerations

Wing plows are moldboard attachments attached to a host plow truck via a swing mounting. Wing plows are mounted either to the side or front of the host plow truck.

- Wing plows can be used on single and multi-lane highways.
- Wing plows are the most basic and least expensive plow accessory type.
- Wing plows are less useful in heavy snow due to the inherent snow force moment that acts to spin the plow truck.

- For side-mounted wing plows, the plow operator has limited visibility of the wing plow moldboard, especially in white-out conditions.

Telescopic Head Plow-Specific Considerations

Telescopic plows are head plows that consist of several nested plow moldboard segments that can be hydraulically extended laterally to form an exceptionally wide telescopic moldboard. Telescopic head plows are a relatively new and innovative plow type with limited DOT field deployment experience.

- The telescopic plow can be purchased from the manufacturer for a variety of clearing widths. The widest model can clear two full lane widths in a single pass.
- The telescopic plow is mounted in front of the plow truck providing a direct line of sight for the plow operator.

Tow Plow-Specific Considerations

Tow plows are typically used on relativity flat multi-lane roadways. The following describes the best features and limitations of tow plows.

- Tow plows can be configured with wider head plows to clear up to two full lanes in a single pass.
- Tow plows are adept at plowing heavy snow loads. Due to the rotational joint (hitch) connection to the plow truck and steep rake angle of the tow plow, heavy snow loading does not fully transfer to the conventional host plow truck.
- Tow plows are well adapted for snow clearing applications that require large amounts of granular or brine spreading.
- Tow plows are highly configurable by the manufacturer.
- Tow plow trailer models can be purchased with left, right, or bi-directional clearing capabilities.
- A tow plow can be purchased configured for granular spreading with one or two hoppers of various sizes. The brine version tow plow can be purchased with one or two brine tanks of various sizes or with a combination of granular hopper and brine tank for pre-wet applications.
- The tow plow trailer is a fleet item that has limited potential for non-winter use.
- Tow plows, when connected to the host plow truck, are much longer than any other plow configuration which often requires special equipment storage facilities to be parked inside during snowstorms.
- Tow plows performance diminishes when plowing up steep grades due to their relatively large weight-to-plow surface ratio.
- The plow operator has limited visibility of the tow plow moldboard, especially in white-out conditions.

Multi-plow-Specific Considerations

A multi-plow can plow in multiple directions at once. The DST includes two multiple-direction plow configurations: (1) a right-clearing tow plow with a left-clearing wing plow mounted to the host plow truck and (2) a head plow with double wings. The double wing plow is unique in that it can be configured with a bi-directional or multi-directional head plow.

- The double wing plow trucks can be configured to clear two full lane widths in a single pass while clearing in two directions.
- The tow plow with wing configuration can clear up to two and a half lanes in a single pass while clearing in two directions.
- Multi-direction plows can only plow their full width on separated roadways with large shoulders on both sides of the roadway.
- Plow operators cannot monitor both wing plows at the same time. The driver will need to continuously shift focus between left, right, and center while plowing.
- Multi-plows have limited visibility of the wing plow moldboards, which increases impact risk in congested metropolitan areas.

USING THE DECISION SUPPORT TOOL TO COMPARE PLOW CONFIGURATIONS

As the state highway duty plow truck equipment market continues to expand with manufacturers commercializing new and innovative plow designs and features, the DOT job of deciding which plows to purchase, configure, and deploy becomes more complex. DOT best practices are a good starting point for simplifying these complex decisions and provide some consistency. Best practices are usually a record of how methods succeeded or failed. With the continuous introduction of innovative new plow equipment functionality and capabilities, relying on historical experiences alone as a guide can delay the adoption of new methods that could provide near-term increases in efficiency and level of service. Therefore, this Best Practices Guide and the DST seek to assist DOTs in their examination of new plow types and assist with the analysis of increasing the efficiency of existing plowing operations.

The DST enables DOTs to quantitatively compare cost and efficiency analyses based on their actual cost and performance data. The DST standardizes data sets to reduce variables and provide accurate quantitative comparisons. These comparisons establish best practices for plow type procurement and assist with plow equipment deployment decisions. The DST can be used in different ways depending on the user's known data, key variables, and most importantly, a firm understanding of the ultimate goal. Two primary analyses are plow efficiency comparison and plow life cycle cost comparison. As previously discussed, the DST focuses on comparative analysis as opposed to specific cost and performance calculations, which are too dissimilar to be accurately compared across different plow types. Comparative analysis allows DOTs to visualize cost and performance trends across a wide spectrum of plow types and configurations at specific geometric locations. The comparative analysis is directly compatible with purchase justification for purchasing additional plow equipment, unique plow equipment, and plow equipment distribution.

Best Practices – Plow Efficiency

The DST's plow efficiency comparison analysis can be used in various ways depending on the outcome the user is seeking. The plow efficiency calculation algorithm uses plow equipment cost, performance, and plow route data to quantify plow efficiencies. To use the DST as a best practices predictor for plow type configuration, the user creates a specific plow route as a fixed basis to conduct plow type efficiency comparisons. The best practice is the most cost-efficient plow type configuration or combination of plows, giving an indication of the best choice for deployment. Other factors such as surface treatments are involved in the actual selection process. To account for these ancillary DOT factors, the DST calculates all combinations of the plow configurations that provide the needed plow width and ranks the combinations by ascending cost. The user can use the cost ranking to move down the list and select a plow or plow group that may be slightly less cost-efficient but better meets additional DOT-specific deployment or procedure criteria.

To use the DST as a best practices tool to predict where best to deploy a specific plow type, the user allocates a fixed specific plow type configuration or group of plows, and then runs multiple calculations with different plow routes to determine which roadway geometrics result with the allocated plow(s) being calculated as the most cost-efficient selection(s). Once again, the user can consult the full cost ranking list to consider DOT-specific ancillary deployment or procedure factors when conducting this analysis to qualify selections. Other best practice factors, such as route time, labor allocation, clearing direction, and various maintenance costs, can similarly be quantified for comparison analysis. The DST provides an additional best practices resource for DOTs to consult when faced with complex decisions regarding which plows to purchase, configure, and deploy. The DST has many uses to help DOTs visualize complex decisions by creating quantitative comparisons to help simplify complex choices.

Best Practices – Plow Life Cycle

A plow life cycle estimate on its own has little significance. Plow life cycle estimates only become meaningful when compared to the life cycle estimates of other plows. Therefore, a fundamental best practice for plow life cycle cost analysis must calculate life cycle cost estimates on a common basis. Different plow types and configurations of plow types have varying service lives and use profiles, so plow cost data cannot be directly compared accurately. Instead, a common frame of reference must be established, and the plow type configuration data must be averaged by plow types. Only then can the plow types cost data be normalized to the life cycle frame of reference. This allows meaningful comparison between calculated plow type life cycle estimates. In the DST, the life cycle analysis is based solely on equipment costs, plow operating costs, plow usage, and plow service life. Unlike the efficiency analysis, the life cycle cost analysis is not directly related to plow route or plow performance. A more detailed explanation of the life cycle cost analysis in the DST is presented in the project's final report.[2]

[2] Duane Bennett and Ty Lasky, "Measuring the Efficiencies of Tow Plows and Wing Plows - Task 9: Final Report," Clear Roads project 19-03, December 2021.

The common best practice method for justifying plow procurement is to select a plow type and configuration that meets the needs of the required plowing application. If multiple plows can perform the same described task, then cost typically becomes the leading deciding factor. Low bid procurement favors the plow with the lower initial procurement price, but the cost of the plow over its service life is a better true cost. The DST life cycle cost program can estimate the life cycle costs for all seven of the designated plow types and allows for DOT-customized cost and performance data to generate valid estimates. To run a life cycle analysis, the user need only enter a common plow deployment duration. The DST program then calculates life cycle estimates for the plow types defined in the plow data libraries. The DST life cycle comparison values are also useful for evaluating a return on investment for plow types and identifying efficiencies a DOT can expect from the related investment.

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