# SPR RESEARCH PROGRAM
# SECOND-STAGE PROBLEM STATEMENT
# FY 2017

ODOT Research Unit
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**I. PROBLEM NUMBER AND TITLE**

17-003_MO Guidelines for using sacrificial coatings to protect ODOT equipment assets from deicer corrosion

**II. RESEARCH PROBLEM STATEMENT**

ODOT has used magnesium chloride ($MgCl_2$) products extensively to help maintain safe mobility on winter highways. Relative to solid salt and salt brine, $MgCl_2$ products tend to migrate more into hidden areas and are more difficult to be cleaned from the equipment and vehicles. The exposure to these products poses a significant cost to hundreds of ODOT maintenance equipment and vehicles. The ODOT's estimated Fleet Equipment replacement cost is $400 million, in which deicer exposure contributes a significant portion. In a recent study (Shi et al., 2013), for roadway agencies that report deicer corrosion to equipment as a significant issue, the total cost of current corrosion management and deicer corrosion was estimated to average $1 million and $14 million per year, respectively.

Preliminary field trials by ODOT Fleet Services section have demonstrated the benefits of using sacrificial anodes to mitigate the corrosion of deicer tanks, even though the mitigation was isolated to a small area. In bridge protection and other applications, sacrificial coatings have been proven to work by the same principles as sacrificial anodes, i.e., protecting the metals of interest via supply of electrons. Applying a sacrificial coating to specific high-deicer-exposure areas on vehicles may be more cost-effective than the normal practice of frequent washing. In this context, there is an urgent need to identify various sacrificial coating options and evaluate their performance and cost benefits as a function of typical equipment and exposure scenarios of interest to ODOT.

**III. RESEARCH OBJECTIVES**

The goal is to develop guidelines for ODOT to adopt the cost-effective sacrificial coating treatments to reduce the corrosion effects of deicers to ODOT equipment assets and extend their service life.

**IV. WORK TASKS, COST ESTIMATE AND DURATION**

**Task 1. Assessing current ODOT practices** (~$20,000, months 1-4). The research team will work with the ODOT Fleet Services section to assess the current deicer corrosion ***cost impact*** to ODOT fleet assets, and also identify typical equipment (e.g., plow trucks, slip-in deicer tanks, liquid deicer applicators, hoppers, and front end loaders), corrosion-prone parts, and assembly and exposure scenarios. The parts of interest may include electrical wiring/connections, plated and un-plated lines and fittings on hydraulic and brake systems; fasteners and components; plates and brackets bolted to the truck frame or top of the truck deck; and tank saddle and spray apparatus. We will also document metal types, current protection measures (e.g., Rhino-Shield), deicer loading & exposure time, climatic conditions (humidity & temperature), washing frequencies, and other factors (e.g., abrasives and debris) that affect the corrosion rates of ODOT fleet. We will use a digital, handheld refractometer to measure the deicer concentration on the selected exposed parts, which will be used to create "splatter" diagrams showing most exposed areas of typical ODOT equipment/vehicles to $MgCl_2$ deicer. It is known that deicer exposure exacerbates the risk of crevice corrosion and poultice corrosion "between adjacent pieces of metal, under gaskets and at fasteners, or on the surface of motor vehicle components" (NCHRP, 2007).

**Task 2. Identifying promising sacrificial coatings** (~$10,000; months 3–5). Past and ongoing research will be reviewed and a national survey of fleet managers/engineers will be conducted to identify the various sacrificial coatings that may hold promise for protecting various metallic substrata from deicer

corrosion. These may include long-lasting Zn-, Mg- or Al-based coatings that can form a stable, adherent oxide layer on the metallic substratum, or Zn-rich primer with a top coat.

**Task 3. Accelerated laboratory testing** (~$190,000; months 5–17). In light of findings from Tasks 1 and 2, the research team will conduct a statistical design of experiments to assess the anti-corrosion performance of the identified coatings through accelerated laboratory testing. The metallic substrata will be tested both in bare and coated conditions. The tests will consider the common types of corrosion seen in DOT fleet, such as crevice corrosion, pitting corrosion, galvanic corrosion, and cosmetic corrosion. The simulation of service conditions (e.g., annual rainfall and temperature cycles in various ODOT districts) will be incorporated into the testing program. Other variables to simulate will include: the type and condition of metal to be protected (aluminum alloys, low-carbon formable steels, high-strength steels, etc.), the assembly (e.g., jointed bolts/nuts/washers of dissimilar metals) and mechanical stress (e.g., vibration in HALT/HASS), the level and frequency of $MgCl_2$ exposure (with salt as control), climatic conditions (time of wetness, temperature, etc. via a modified SAE J2334 test), washing frequencies, and exposure to abrasives. The anti-corrosion performance of select coatings will be compared against a coating currently used by ODOT, such as a rubberized coating. A *service life model* of various vehicle parts will be developed to link the results of accelerated laboratory tests to predict field performance of selected coating treatments. Subsequently, the model will be used to establish *acceptance tests* for selected sacrificial coatings and to predict the beneficial life of selected coatings and their life cycle cost. For various selected scenarios, the most cost-effective coating treatment will be identified, considering the costs to apply/maintain the coating and the corrosion cost avoidance.

**Task 4. Field validation** (~$90,000; months 18–30). With the assistance of ODOT Fleet Services section, the key findings from the lab will be validated on selected maintenance trucks in the field over 12 months. A key task is the development and deployment of vehicle-based sensors that on-line assess the condition of key metallic components and their applied coatings, using surface resistivity and electrochemical measurements. Field investigation will confirm the most suitable areas to apply the coatings and validate the effectiveness of existing washing practices. All the project findings will be leveraged to develop guidelines for protecting new/old ODOT equipment and vehicles from deicers.

**Task 5. Final report and presentati**on (~$10,000; months 29–32). The final report will provide final assessment of the identified coatings and develop guidelines for ODOT implementation.

Project cost: $320,000 (+ ODOT support/management $25,000 = Total: $345,000)
*Funds sought from ODOT: $270,000* (84%); cost-sharing by CESTiCC: $50,000 (16%) over 32 months

## V. IMPLEMENTATION

This research will modify ODOT's approach to equipment preservation and enable ODOT to make better decisions on preserving the quality and life of equipment assets. The findings will help ODOT revise the requirements for coatings products in the QPL and in the Equipment Management Manual.

## VI. POTENTIAL BENEFITS

This research will reduce ODOT inspection, maintenance and repair costs, while minimizing the risk of premature equipment failure and maximizing equipment service life, readiness and performance.

## VII. SUBMITTED BY

| ***Stage 1 Submitter*** | ***Stage 2 Submitter*** | ***ODOT champions*** |
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