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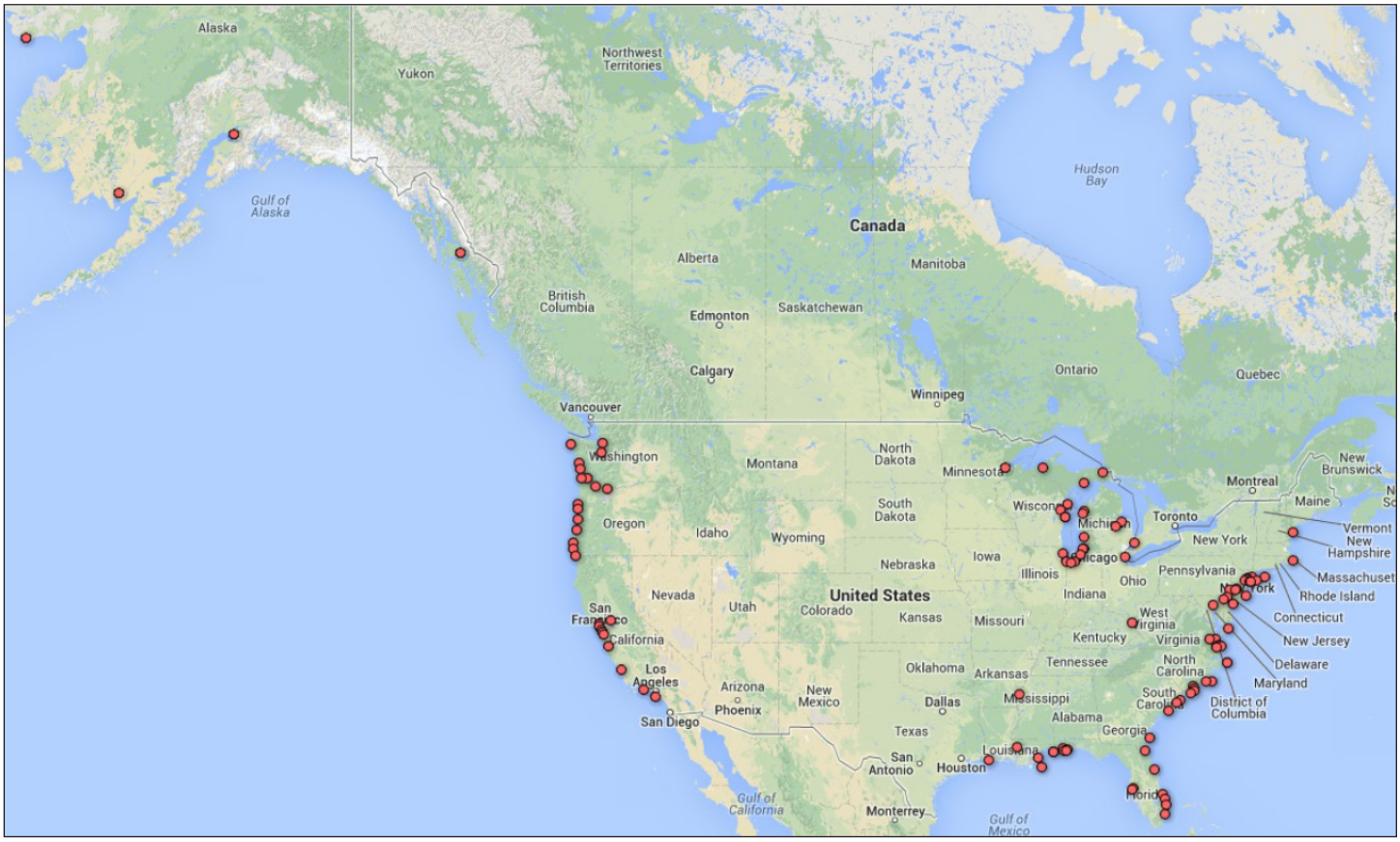
Optimal Dredge Fleet Scheduling within Environmental Work Windows

The U.S. Army Corps of Engineers (USACE) annually dredges hundreds of navigation projects through its fleet of government dredges and individual contracts with private industry. The Maritime Transportation Research and Education Center (MarTREC) built a tool that suggested solutions for USACE's decision of allocating dredge resources to projects system-wide under necessary constraints that included several factors: 1) environmental restrictions concerning when dredging can take place due to migration patterns of turtles, birds, fish, and other wildlife; 2) dredge equipment resource availability; and 3) varying equipment productivity rates that affect project completion times.

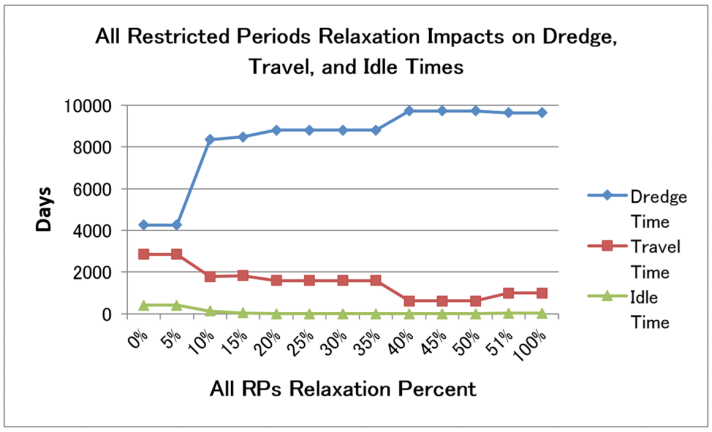
Building on previous research with the USACE, MarTREC developed and implemented a scheduling optimization decision support tool that provides comprehensive sensitivity analysis regarding the impact of travel distance, idle time, varying dredge job sizes, available dredge equipment, and the size of environmental windows. Further, MarTREC has expanded the decision tool to allow for multiple dredge resources to work on a single job and/or in non-consecutive intervals, and for environmental windows to be enforced in a dredge-specific fashion.

The optimization work is part of USACE's ongoing initiative to take a systems operation research approach to aid in their maritime transportation decision processes.



Graphical Depiction of 116 Dredge Jobs Locations

This work has offered a highly generalized dredge scheduling optimization framework for use by dredge planners. The work has already been transferred to USACE computing systems, and various versions of the developed model have been utilized in support of planning efforts on the West and East coast. The results of the project show that partial dredging, dredge maintenance, modified mob/demob (mobilization and demobilization), costs/budgets, multiple dredges per job and multiple visits to jobs can all be allowed for in a constraint programming platform. Using this platform, feasible solutions can be obtained to this complex model in a matter of minutes or hours. Evaluating the potential benefit on cubic yards dredged by considering each model enhancement suggests that these new flexibilities are significant for guiding practitioners to solutions (adding the discussed flexibilities to the models make a significant difference in the solutions obtained).



With a more flexible model and the potential for an increase in cubic yards dredged, comes a new set of computational challenges. In addition to revealing how to model additional problem features, this project has revealed a number of new methodological challenges that need to be explored - increased solution space and more complex decision variable structure.

Photo courtesy of USACE

Environmental restrictions, equipment availability, and productivity rates are factored into project completion schedules.

The acknowledgement of this fact leads the investigators to believe that opportunities to implement the existing constraint programming approach in a parallel computing system could yield immediate solution improvements. Moreover, the complexities of the new problem suggest that it is now appropriate to formally study the parameters utilized in the constraint programming search. While these values were not of significance in the base model, the newly identified computational challenges mean that implementation details are now far more significant. This work will continue in a phase two project that began in August 2016.

This project has been published in the Transportation Research Record and European Journal of Operational Research. Dr. Heather Nachtmann was invited to present at the 4th Biennial Transportation Research Board - Committee on Marine Transportation Systems Conference; 92nd U.S. Army Corps of Engineers Coastal Engineering Research Board Meeting; and the 8th UTC Spotlight Conference on The Role of Freight Transportation in Economic Competitiveness.

About This Project

The *Optimal Dredge Fleet Scheduling within Environmental Work Windows* project was led by Chase Rainwater, Ph.D. and Heather Nachtmann, Ph.D. of the Department of Industrial Engineering at the University of Arkansas (lead site for MarTREC). The final report is available at martrec.uark.edu. For additional information about this or other MarTREC projects, please contact us at martrec@uark.edu or 479-575-6021.