Review of Service Research Within Industrial Engineering

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Abstract

One of Mercer University's five mission statements is "Service to Humankind". Mercer faculty and students pursue this mission by integrating volunteerism and curricula through programs such as: Mercer On Mission. From an industrial engineering perspective, this goal of service to humankind includes better conditions of transportation, communication, heating, lighting, and water supply, all of which produce better health and longer life in the community. This paper reviews examples of industrial engineering projects in the areas of community service, health, and logistics, and provides examples of organizations dedicated to industrial engineering based service research. This paper also shoes how this research has led to several potential service research projects for Industrial Engineers at Mercer. While the focus of the paper is Mercer University, these research examples can provide inspiration to any Industrial Engineering faculty or student interested in reaching out through service.

Keywords

Service Research, Humanitarian, Community Service, Engineering Projects

Introduction and Background

The Southern Association of Colleges and Schools (SACS) is the accreditation organization for schools located in the southern United States. SACS requires each accredited University to provide a Quality Enhancement Plan (QEP). Quoting from SACS's "The Principles of Accreditation: Foundations for Quality Enhancement,"

> At the heart of the Commission's philosophy of accreditation, the concept of quality enhancement presumes each member institution to be engaged in an ongoing program of improvement and be able to demonstrate how well it fulfills its stated mission.

Mercer University has selected "Research that Reaches Out" as their QEP topic. This topic is derived from one of Mercer's five mission components, Service to Humankind:

Service to humankind is ingrained in the Mercer culture. It is found in its academic units – a medical school dedicated entirely to preparing primary care physicians for rural and other medically underserved areas of Georgia and a law school widely recognized for its contributions in the arena of public service – to signature programs like Mercer On Mission that deploy students and faculty across the world to alleviate human suffering.

The idea of service research has resonated with the authors, whose chosen field of interest is Industrial Engineering. This idea has motivated the authors to seek out examples of service research in Industrial Engineering. In this paper the authors present various examples of service

research within the discipline of Industrial Engineering. This investigation is approached by reviewing journal articles that contain examples of service research and by reviewing projects described on websites of organizations doing service research.

This paper begins with examples of service research found in literature. These examples are organized into three areas: community service, the healthcare industry, and logistics. Next, examples are provided of organizations focused on industrial engineering related service research. The final section provides examples of how this research has led to potential service research projects for Industrial Engineering at Mercer University.

In summary, engineering projects with a service aspect or humanitarian relief initiative have positively impacted the world and they continually provide the utmost potential in improving the quality and productivity of mankind.

Community Service Examples

This section contains examples of projects in the area of community service. These examples include improving processes for maintaining recreational facility, assisting the disabled, and improving waste collection.

Park Facilities GIS Database

The College of Engineering at Texas A&M University is doing research on a project called "Park Facilities GIS Database." In the community, the City of College Station Parks Department is responsible for more than 50 parks. Each park maintains a unique set of facilities and items. When one of these items needs attention, identifying and locating it can be a very large and confusing task. The goal of this project is to design and populate a database that contains all necessary data elements for identification and location of selected Parks Department elements. It will also present this data in a format that is compatible with the interface of the City's work order system[1].

ICM: Interactive Campus Maps

At Purdue University, Engineering Projects in Community Service is researching Interactive Campus Maps. The goal of this research initiative is to assist students with physical disabilities in locating the best accessible path from one campus building location to another. The impact includes improved accesses to the Purdue campus for students with disabilities[2].

Optimizing Solid Waste and Recyclable Material Collection

An industrial engineering project at Montana University is seeking to optimize solid waste and recyclable material collection. This initiative helps companies to reduce time taken to handle logistics. Information is vital in modern days and every company needs to make sure that information is flowing within their organization freely[3].

Healthcare Industry Examples

This section contains examples of healthcare related service research. These examples include improved access to fresh food and water sources, access to family doctors and specialized medical services in remote communities, optimal deployment of scare healthcare resources, improved allocation of limited vaccine funds and improved inventory policies for non-profit healthcare agencies.

Food and Water Sustainability

Food and water sustainability is a research project by the Industrial and Systems Engineering Department at the University of Washington. This project focuses on developing agent-based models for food security. Agent-based models include underlying Forest Steward Council system structures as well as local, regional, and/or global food policies, all of which exist within an environment of environmental, economic, and social characteristics, such as climate shifts and unplanned supply disruptions. Research is ongoing to determine if these models can be used to evaluate and improve the degree of food security[4].

Wood-Burning Rocket Stoves

The Thayer School of Engineering at Dartmouth has a Humanitarian Engineering Initiative for wood-burning rocket stoves. Traditional wood-burning stoves are inefficient and smoky, leading to high rates of deforestation and severe respiratory infections. Alternatively, research shows that rocket stoves use about 50 percent less fuel and burns a lot cleaner, helping with both health and energy issues[5].

Telerehabilitation

The Industrial and Systems Engineering Department at Wayne State University has a research project in Telerehabilitation (TR). TR is a rehabilitation environment in which the use of telecommunications technology provides rehabilitation and long-term support to people with disabilities in geographically remote regions. Current wheelchair selection and evaluation processes are based on in-person assessment and is often not available to patients in underserved or rural areas. This is due to lack of expertise by clinicians in wheeled mobility and seating interventions. To improve current rehabilitation processes, technologists and clinicians investigated the use of advanced telecommunications and information technologies. The hope is that it will serve as a way of bridging the geographic distance between individuals with specialized medical needs living in remote areas and the source of specialty care[6].

Improving Malaria Interventions in Africa

The World Health Organization (WHO) is the authority for health within the United Nations (UN), and is responsible for providing leadership to all UN member nations on global health matters. Though the disease is preventable, malaria is a significant problem in Africa, with over one million deaths yearly. Although other countries and non-governmental organizations conduct prevention interventions, there are few guidelines about best methods to deploy scarce resources such as facilities, labor, insecticide, and bed nets. In this study, researchers built optimization

models to maximize the reduction in risk under a limited budget, through a better location of distribution facilities and an optimal deployment plan, with Swaziland used as a pilot country. The estimated benefit of the systems approach is 20–70% over simple decision-making models, with the potential for saving hundreds of thousands of lives across Africa[7].

Improving Vaccine Supply Chain

Pan American Health Organization (PAHO) is the regional office of the WHO for the Americas. It procures vaccines for 37 countries in Latin America and the Caribbean. Each year, based on forecasted demand, PAHO requests bids from vaccines suppliers. The allocations to each supplier are determined manually by considering vaccines costs, estimating transportation costs, supplier's performance, and specializing country requests. To improve this bidding and allocation process, recommendations for demand forecasting and transportation costs estimation were done. Also, the researchers developed a model for bid award allocation to explore bundle bidding that allows suppliers to submit bids for groups of vaccines rather than only individual vaccines. The results of the project provided valuable understanding into supply chain improvements for PAHO's vaccine procurement process[7].

Forecasting Demand for Partners in Health (PIH)

The Massachusetts Institute of Technology Humanitarian Response Lab has a project used to develop a model using historical consumption data of Partners in Health's (PIH) medical supplies to forecast future demand. PIH's current annual order policy is compared with ordering frequently reviewed policies, and the lab discovered that more frequent orders will drastically reduce warehouse space requirements for PIH[8].

Logistic Services Examples

This final section contains examples of service projects in the area of logistics. This research includes allocation of medical supplies; resource allocation, warehouse location and supply chain risk analysis for the World Food Programme; and examples of companies providing logistics support during natural disasters.

Improving Transportation Procurement

MedShare International is seeking to improve their transportation procurement. The goal of MedShare is to improve healthcare through the efficient recovery and redistribution of surplus medical supplies and equipment from U.S. hospitals, manufacturers, and distributors. MedShare shipments are carefully tailored to the needs of recipient organizations worldwide. Transportation services are procured when needed from the cheapest carrier at the moment, resulting in high costs and low service quality. This project consists of developing a long-term strategy for procuring transportation services that will enable the organization to maximize its resources, taking into account its current locations and future growth strategy[7].

Cost Allocation Model for the World Food Programme

The World Food Programme (WFP) is the United Nation's food assistance arm. It provides the logistics support to get food to the right people, at the right time, and in the right place. Currently, WFP's Information and Communication Technology support model is a structure

where each single Country Office maintains a technical support team, resulting in a limited scope, an uneven distribution of resources and support quality, and an inefficient global rollout of applications. WFP plans to implement a new centralized model that would exploit the benefit of global teamwork through Service and Competency Centres (SCC). To operate the global SCCs, a model for allocating the SCCs costs must be developed. This model addresses issues such as appraising the provided services, allocating the costs to the relevant Country Offices, and locating the SCCs optimally[7].

Optimizing a WFP Warehouse

This study uses an analytical hierarchy process to help the WFP choose the location of an Ethiopian warehouse. WFP needed to locate new warehouses in the Somali region of Ethiopia to facilitate efficient flows from ports to final distribution points. Given the challenges of gathering the extensive data required for traditional network design techniques, as well as WFP's desire to incorporate qualitative criteria, this study used the analytic hierarchy process to structure the decision making[8].

Humanitarian Aid in Less Secure Regions

Massachusetts Institute of Technology (MIT) is seeking ways to increase commodities in a project called Humanitarian Aid in Less Secure Regions. An analysis of WFP operations in the Somali region of Ethiopia was conducted. Security concerns and poor infrastructure in the Somali region of Ethiopia endangered and delayed the flow of commodities through WFP's supply chain. This research analyzes the impact on transportation rates and transit time, assesses methods to mitigate risks, and proposes some new approaches to improve the overall security of commodity flows[8].

Human Modeling Approaches to Transportation Planning

MIT plans to help optimize the UN fleet of trucks and helicopters to deliver aid. This project focuses on transportation planning for emergency response, from both a behavioral and a model perspective. One key element missing from our understanding of humanitarian supply chains is the role of people, whose ability to improvise and to learn from experience may provide some advantages in the humanitarian context. On the other hand, mathematical models can better handle complex information and search large decision spaces. This project seeks to develop better decision-making approaches by understanding and building upon the strengths of people and models, focusing in the problem of planning aid deliveries after an emergency. The Logistics Cluster must decide how to use its fleet of trucks and helicopters to deliver aid cargo to affected communities, considering efficiency and prioritizing needed cargo. In order to determine how humans and models can interact to create better delivery plans, a variety of methods are employed: ethnographic observations, a stated preference survey, and modeling approaches[8].

The Home Depot

Home Depot is the world's largest home improvement retailer with a strong home repair retail presence nationwide through its 2,100 retail stores. Home Depot is committed to being a strong first responder serving demand before, during, and after disasters, especially hurricanes. To achieve this, they effectively coordinate their different functional areas such as protecting assets,

merchandising, logistics, and regional management. Establishing hurricane distribution centers, forecasting inventory for a hurricane season, prepositioning canned loads, sending in repair teams, and opening stores right after the storm, are a few example activities that Home Depot does to enable a faster response after a hurricane[8].

Waffle House

Waffle House is a 24-hour diner with more than 1,500 stores in 25 states. Few people know about Waffle House's role in hurricane response along the Gulf Coast. From cooks and servers to senior management, everyone is trained and prepared for fast, efficient response. The day after Hurricane Katrina hit the Gulf Coast, Waffle House's "first response" team, including senior management and CEO Rogers, arrived in Gulfport, Mississippi with generators and supplies. If a restaurant has a generator, ice, and water, and is not in any structural danger, it is reopened. The restaurants that have been flooded or damaged still serve a purpose; they may have food, equipment, and employees that serve as valuable resources. If possible, employees of "closed" Waffle Houses are told to report to a nearby "open" restaurant to help with relief efforts. An important aspect of an adequate response is how the best decisions can be made when resources are limited. For example within 24 hours of a hurricane, Waffle House started serving water and ice to hurricane victims, emergency personnel, and relief workers. Once a restaurant is up and running, they operate from their "Hurricane Menu." This menu balances food safety, timing of food preparation, and space needed for food storage and preparation. It allows Waffle House to provide a much needed service (fresh food and water) in an efficient manner to customers who are stressed and anxious after a storm. Its disaster response activities include pre-season purchasing or leasing agreements for recovery necessities (like generators, portable toilets, etc.), ordering required food items for the transition period, and prioritizing stores for re-opening[9].

Organizations and Enters Dedicated to Service Related Industrial Engineering Research

This section provides three examples of organizations whose mission is Industrial Engineering based service research.

Center for Health & Humanitarian Systems, Georgia Institute of Technology

The mission of the Georgia Tech Center for Health & Humanitarian Systems (HHS) is improving systems and logistics operations in disaster response, long-term development, and global public health to ultimately improve the human condition through education, outreach, projects, and research.

The mission of the center is achieved by focusing on the areas of education, outreach, projects and research. In education, the center strives to increase human resource capacity by training humanitarian logisticians for positions in non-governmental organizations (NGOs), private industry, and the government. In the area of outreach the center fosters multi-organizational collaboration to improve effectiveness of humanitarian logistics operations and prevention and to be the primary source for information on humanitarian logistics. The center uses research and applications to improve humanitarian logistics planning and response in the long-term, while

working closely with NGOs, government, and the private industry to improve their supply chain and logistics operations in the short-term[7].

The leadership of the center includes three co-directors and a host of collaborators. Dr. Ozlem Ergun was the Coca-Cola Associate Professor in the Stewart School of Industrial & Systems Engineering at Georgia Tech where she co-founded the Center for HHS. She continues to serve as a co-director of the Center for HHS. Dr. Ergun received a Bachelor of Science degree in Operations Research and Industrial Engineering from Cornell University in 1996 and a Ph.D. in Operations Research from the Massachusetts Institute of Technology in 2001. Dr. Ergun's research focuses on the design and management of large-scale networks. Specifically, she studies logistics and communications networks that are dynamic, partially decentralized, and are used and operated by coordinating, but selfish, entities. Her main research contributions are the development of a set of new algorithmic and analytical tools and their applications to important real world problems[7].

Pinar Keskinocak serves as the associate director of research for the Health Systems Institute and a co-director of the Center for HHS at Georgia Tech. Dr. Keskinocak's research focuses on the applications of operations research and management science with societal impact, particularly health and humanitarian applications, supply chain management, and logistics/transportation. Previously she served as INFORMS Vice President of Membership and Professional Recognition, is the co-founder and past-president of INFORMS Section on Public Programs, Service and Needs, and the president of the INFORMS Health Applications Society[7].

Dr. Julie Swann serves as an associate professor in the H. Milton Stewart School of Industrial and Systems Engineering at Georgia Tech and a co-director of the Center for Health & Humanitarian Systems (HHS). She received a Bachelor of Science degree in Industrial Engineering from Georgia Tech in 1996. She received both a Master of Science degree and a Ph.D. in Industrial Engineering and Management Sciences from Northwestern University in 1998 and 2001, respectively. In addition to her university experience, Dr. Swann participated in several research projects at General Motors and IBM, focusing on pricing in different industries. At General Motors, Dr. Swann developed a tool integrating pricing, producing and distributing vehicles while meeting Corporate Average Fuel Economy (CAFE) requirements. At IBM, she explored pricing models for efficient bandwidth allocation. Dr. Swann is currently focused on the modeling and analysis of problems and algorithms in logistics, transportation and supply chain management. She has particular interests in developing and analyzing tools to manage demand, such as price, revenue management, or lead-time quotation, to increase the flexibility in the system and is currently doing work in humanitarian supply chains[7].

Each year, representatives from the humanitarian sector, government, nonprofits, and academia address questions relating to the role logistics play in reducing the impact of communicable diseases or how to better prepare a disaster response at the Health and Humanitarian Logistics Conference. Dr. Keskinocak says, “The conference plays an important role in highlighting the key issues and challenges in the health and humanitarian sectors and helps build bridges, enable the exchange of ideas and establish collaborations across different players.” The conference is open to the public.

The Center also offers a professional certificate program designed for practitioners in NGOs, government, industry, and military who are active participants in humanitarian operations including disaster response, long term development, and public health operations**.** The courses are developed for practitioners seeking to build skills and to improve decision making in preparedness, response operations planning, and system design[7].

Humanitarian Response Lab, Massachusetts Institute of Technology
The mission of the MIT Humanitarian Response Lab is to help meet human needs by understanding and improving the crisis response systems behind public services and private markets. Based within the MIT Center for Transportation & Logistics, the Response Lab combines MIT expertise in engineering, management, technology, economics, urban studies and planning, and other disciplines to drive practical innovation for humanitarian response[8].

Dr. Jarrod Goentzel, founder and director of the MIT Humanitarian Response Lab and Erica Gralla, Ph.D. candidate in the Engineering Systems Division, leads the response lab. Dr. Goentzel's research focuses on supply chain design and management, transportation procurement and planning, humanitarian needs assessments, information management, and the use of technology to facilitate decision-making. Previously, Dr. Goentzel was the Executive Director of the MIT Supply Chain Management Program, where he was responsible for design and management of the nine-month professional master's degree program. He joined MIT in 2003 to establish the MIT-Zaragoza International Logistics Program, which developed novel education, research, and outreach programs with the Zaragoza Logistics Center in Spain. Dr. Goentzel received a Ph.D. from the School of Industrial and Systems Engineering at Georgia Tech, a Master of Science degree in Applied Mathematics from Colorado State University, and a Bachelor of Science degree in Mathematics from Tabor College with studies at the Technical University of Budapest, Hungary[8].

Erica Gralla studies humanitarian logistics as part of MIT's Center for Transportation and Logistics. In her doctoral research, Erica studies how humanitarian logisticians design supply chains rapidly, with little information. She seeks to combine the strengths of experts' intuitive approaches with models and techniques from operations research. She hopes this will lead us to better ways to design supply chains in urgent, uncertain environments like emergency response. Erica has a Bachelor of Science in Engineering degree in Mechanical & Aerospace Engineering from Princeton University, where she also earned a certificate in American Studies and spent a semester at the University of Cape Town in South Africa. She has a Master of Science degree in Aeronautics and Astronautics from MIT. Her master's work on the logistics of space exploration, combined with her experience at Princeton studying the humanities and Africa, have inspired her to focus on humanitarian logistics in her Ph.D[8].

Based in the MIT Center for Transportation and Logistics, Dr. Goentzel has developed graduate-level courses in supply chain finance, international operations and humanitarian logistics. He also possesses extensive experience using simulation games to develop intuition and leadership

skills. The Humanitarian Studies Initiative is a two-week seminar for graduate students in essential crisis management skills. The MIT Humanitarian Response Lab provides the logistics curriculum for the course, leading an in-class exercise on procurement and facilitating Logistics Cluster meetings during an immersive, week-long simulation. Students in MIT's Supply Chain Management graduate program may focus their research on supply chain issues in the humanitarian sector. For example, students wrote theses on the optimal warehouse design for aid organizations, how to measure the effectiveness of disaster relief efforts, and how to implement supply chain management software within the humanitarian sector. An event held by the response lab includes the MIT Humanitarian Speaker Series. The Humanitarian Speaker Series, supported by the Center for International Studies and Center for Transportation & Logistics, provides a forum in which students and faculty interact with leaders in the critical field of humanitarian and disaster relief. The goal is to foster interdisciplinary, practical solutions to the problems facing the world's most vulnerable populations[8].

Humanitarian Research Group, INSEAD Social Innovation Centre
Since 2001, INSEAD Humanitarian Research Group (HRG) has been working to develop the science of humanitarian logistics. HRG is housed under the Social Innovation Centre, in the INSEAD graduate business school. The group strives to increase the capacity of humanitarian actors to respond effectively to major disasters by finding solutions to management challenges affecting humanitarian organizations. Facilitating cross-learning between those currently engaged in humanitarian action, HRG works to identify and transfer best practices from the humanitarian sector to private sector companies operating in a volatile world. The HRG concentrates on the following five key areas: logistics of disaster preparedness and disaster response, multi-sector partnerships, fleet management in the humanitarian sector, global healthcare supply chains, and environmental impact of humanitarian operations[10].

The director of The HRG is Professor Van Wassenhove, The Henry Ford Chaired Professor of Manufacturing. Professor Van Wassenhove's research is concerned with operational excellence, supply chain management, quality, continual improvement, and learning. His recent research focuses on closed-loop supply chains, humanitarian logistics and disaster management. Professor Van Wassenhove is published extensively in various academic journals and is the author of many teaching case studies. He also regularly consults for major international organizations. In 2005, Professor Van Wassenhove became a Fellow of the Production and Operations Management Society. In 2006, he received the EURO Gold Medal for outstanding academic achievement. In 2009 he became a Distinguished Fellow of the Manufacturing and Services Operations Management Society. In 2013 he became Honorary Fellow of the European Operations Management Association (EUROMA). He is a member of the Royal Flemish Academy of Sciences. He created the INSEAD Social Innovation Centre and acted as academic director until September 2010[10].

HRG has worked in close collaboration with private sector companies, humanitarian organizations, and private-public partnerships. These include: TNT, The Red Cross Movement, The United Nations and Medicines for Malaria Venture. The group has carried out in-depth

research at headquarters and programme level from Geneva, Switzerland to Guru, Mozambique, to produce rigorous and relevant research. To date, INSEAD HRG's research and academic contribution includes: an MBA elective course, over 15 research papers, and more than 25 case studies. HRG is becoming one of the leading research groups on the subject of humanitarian logistics. HRG partners with Georgia Tech's Center for Health & Humanitarian Systems to organize the annual Health and Humanitarian Logistics Conference[10].

Future MUSE Industrial Engineering Service Research Projects

The purpose of this paper was to expose Industrial Engineering faculty to service research projects in their area of expertise. This led to several potential IE service research projects at Mercer University. In particular, a deconstruction project within the Macon community, and projects associated with humanitarian relief logistics for the United Nations.

Macon Community Deconstruction Project

One of the leading community issues facing the city of Macon-Bibb is blight. Blight is described as uninhabited buildings that are boarded up and decayed. When one or two structures on a block become blighted, the tendency is for neighboring structures to also become blighted. The city of Macon-Bibb has committed to tearing down 100 or more blighted structures each year. Yet, with over 4,000 blighted structures, and more coming on line faster than the tear down rate, the problem is getting worse. In addition, the city struggles to meet the 100-unit demolition goal for various reasons.

Recently, several local churches proposed forming a relationship with the Macon Area Habitat for Humanity to address this issue. They propose to employ transitional housing personnel to deconstruct, as oppose to demolish, blighted properties. Salvageable material will be reclaimed and repurposed. If possible, some salvaged materials could be resold through Habitat's Restore.

Since the deconstruction of blighted properties is a repeated process, Industrial Engineering students and faculty can provide value by observing and analyzing the process. They can work with Habitat to collect deconstruction process data, monitor the process, develop standard operating procedures, develop cost models, and suggest process improvements. These findings can be used to improve the rate of deconstruction and can be shared with other Habitat chapters facing similar challenges.

United Nations Humanitarian Relief Depot Logistics

Another potential avenue for IE service projects is working with the United Nations and the World Food Program. While in its infancy, Dr. Mike MacCarthy is negotiating an affiliation between the Mercer University School of Engineering and the United Nations Humanitarian Relief Depot (UNHRD) lab in Brindisi, Italy. This affiliation may include student internships at the lab, student senior design or honors projects, and faculty research projects.

The UNHRD network consists of 6 depots/warehouses strategically located around the world. These depots contain non-perishable food items such as tents, blankets, MREs, medicines, etc.

that can be rapidly transported to disaster areas via a fleet of aircraft and other transportation vehicles. Within the UNHRD network, there appears to be a number of potential logistics research projects. Examples of these research projects include the optimization of depot locations based on disaster models, real-time simulations of disaster response times, and fleet allocation models.

Summary

The service projects and organizations mentioned in this paper seek to provide basic amenities to needy peoples. These service research projects are based on industrial engineering principles and techniques. Uncovering these examples helped the authors identify and pursue two service research projects; assisting Macon's Habitat for Humanity with a deconstruction project, and pursuing potential logistics projects with the United Nations Humanitarian Relief Depots. Other future projects may include process improvements opportunities at local food banks or other community service organizations, additional projects with Habitat for Humanity, or assisting with logistical challenges for Mercer on Missions projects.

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support. His primary research and teaching interests are in scheduling, heuristics and process modeling.

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