**Title of Project**
Design of a Hub-based Intermodal Logistics System for Multi-regional Commodity Flow

**Intermodal Orientation**
Modes of transportation affected are: highways and railways

**Total Budget and Timeframe**
- Federal and Matching Funds: N/A
- NCIT Funds Requested: $62,685
- Total: $62,685
- 1st FY: $62,685

**Proposed Duration in months**
12

**Inclusive Dates**
1/1/2011 – 12/31/2011

**Matching Funds**
- University: N/A
- Other: N/A

**Principal Investigator(s)**
- Name: Burak Eksioglu
- Title: Associate Professor
- Institution: Mississippi State University
- Department: Industrial and Systems Eng.
- Address: PO Box 9542
- Phone: (662) 325 7625
- Email: beksioglu@ise.msstate.edu

**Co-PIs**

**Administrative Contact** (All correspondence will be sent to Administrative Contact, if different from project PI):
- Name: __________________________
- Title: ____________________________
- Institution: _______________________
- Department: ______________________
- Address: _________________________
- Phone/Fax: ________________________
- Email: ___________________________
2. Project Information

(a) Project Title:
Design of a Hub-based Intermodal Logistics System for Multi-regional Commodity Flow

(b) Principal Investigator:
Burak Eksioglu, Department of Industrial and Systems Engineering, Mississippi State University, (662) 325-7625, beksioglu@ise.msstate.edu

(c) Project Objectives:
Delivering products and services to consumers has been one of the most serious issues not only for commercial organizations but also for government agencies in the last decade or so. The difficulty arises because of geographically dispersed supply and demand points, and the distance between various supply chain entities is continuously increasing due to globalization. The growth of intermodal logistics, which offers viable solution to such highly dispersed supply and demand locations, initially resulted from the globalization of the marketplace (Ishfaq and Sox, 2010). Hence, the use of intermodal shipments, nowadays, has also been on the rise in the US domestic freight market (Ishfaq and Sox, 2010). The main objective of this study is to develop a model for designing an efficient intermodal logistics (IL) system for organizations/companies which provide multiple products and operate in many different regions. More specifically, the problem addresses a hub-based IL network in which locations of hubs, transportation modes, and flow quantities are determined.

(e) Project Abstract, and (f) Intermodal Orientation of the Project
Intermodal logistics networks offer a viable solution to geographically dispersed supply and demand points (Arnold et al. 2004, Gooley 1997). IL incorporates different transportation modes in order to deliver a more competitive service than traditional logistics systems. Nevertheless, the design and the management of such a logistics network are restricted by the existing transportation infrastructure, location of modal transfer points and logistics cost structure (Warsing et al. 2001). A hub-based logistics system, essentially, provides cost savings by creating economies of scale which is driven by consolidation of shipments. Since intermodal networks are combinations of their respective modal networks, it is natural that the hub network has emerged as the most suitable network structure for intermodal logistics (Bookbinder and Fox, 1998). Briefly, a hub network has a small number of hubs where smaller sized shipments are consolidated and shipped using intermodal containers (Ishfaq and Sox, 2010).

There are a number of multi-regional companies which endeavor to build their own IL systems. For example large telecommunication companies, such as Alcatel-Lucent, provide different products and services in many different regions. Especially, service part management, which requires an efficient transportation logistics network, is one of the most serious problems for such companies. In service part management, the company, such as Alcatel-Lucent, has agreements with customers which guarantee that the company either delivers the service part in a certain amount of time or pay a significant amount of penalty cost. Evidently, an efficient transportation and logistics system is a crucial requirement for such companies in order to decrease cost and increase customer satisfaction. Unfortunately, designing such an IL system involves a number of short term and long term decisions which complicates the problem such as hub location decisions. Actually, design and management of hub based logistics networks are the primary issues for IL system. More specifically, the number of
hubs and correspondingly their locations, and the assignments of shipments that are served by each hub need to be identified (Ishfaq and Sox 2010). Furthermore, consolidation of flows and the transportation mode between hubs, demand points and supply points have to be determined. In modern supply chains, the performance of the logistics networks is evaluated based not only on the logistics costs but also on service times (Ishfaq and Sox 2010). Therefore, there are time limitations for delivery of products so that penalty costs are incurred in the case of late product delivery, as it is the case in Alcatel-Lucent example.

The figure above illustrates a sample hub based IL system in which products are delivered between cities, represented by circles, via hubs, represented by triangles. Notice that transportation modes between hubs may change depending on the cost function. For example, the transportation mode between hub 1 and 2 is railroad whereas it is airway between hubs 3 and 4. Transportation modes between cities and hubs are assumed to be trucks. Furthermore, also notice that shipments are consolidated in hubs 1 and 3 for the sake of achieving a lower unit transportation cost, namely economies of scale.

Research Scope: Such a multi-product and multi-mode logistics network design problem requires sophisticated modeling techniques and intelligent solution algorithms that high computational complexity is inherited. We will develop a mixed integer programming (MIP) model for building such IL systems. The model will determine the locations of hubs, assign shipments for each hub, identify the transportation mode for each assignment of shipments, and finally determine the consolidation of shipments. In order to solve that MIP model, we will also develop a heuristic solution algorithm.

Research Impact: This research will positively impact not only the design of intermodal logistics networks but also the operational decisions on that network for multi-regional companies and intermodal logistics suppliers. Moreover, the models and algorithms developed can also be used to analyze, evaluate, and even improve the transportation infrastructure of a particular geographical region or a whole state.

Intermodal Orientation of the Project:
- Modes of transportation: Railway, Highway, Airway
- Major concern: Freight Transportation
- Intermodal transportation system design and operation
Project Deliverables:
1) MIP model that considers design decisions within the logistics network and operational
decisions to coordinate activities.
2) Heuristic algorithm that provides near optimal solutions in a reasonable time for the hub
location, mode selection, and shipment assignment problem described above.
3) Final report that summarizes the findings of the study.

(g) Task Description:
Task 1: Model development:
Mathematical models such as MIP models are well accepted and widely used tools in supply chain
design/planning and logistics management. Although these models, theoretically, provide optimal
solutions for large mathematical planning and design problems, computational effort and solution time
needed to solve those models arise as their main drawbacks. This drawback raises the need for
intelligent heuristic solution algorithms which may sacrifice optimality in exchange of timely response.

First, a detailed literature review that focuses on the design of hub-based intermodal logistics network
will be done. The development of the mathematical model and heuristic algorithm will be done
primarily by the PI. The student will be responsible for developing the model using CPLEX and C++
programming languages.

Task 2: Model validation and verification:
Once the algorithm is developed it will be validated and verified. Validation will be performed by the
graduate student to ensure that the code is free of bugs. The verification step will be performed
primarily by the PI to ensure that the algorithm is doing what is intended to do.

Task 3: Analysis of the results and preparation of the final report.
The description of the algorithm and the results will be summarized in a final report. The report will
also provide future research directions.

(h) Milestones:

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<th>Responsibility</th>
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<th>Feb</th>
<th>Mar</th>
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(i) Yearly Total Budget: $62,865. Most of the budget will be used to fund the graduate research
assistant. The student and the PI will present their work at a national conference which is also
included in the budget.

(j) Student Involvement:
We anticipate that a fourth year PhD student in the Department of Industrial and Systems Engineering
will be involved in the project. The conceptual model for the problem will be developed by the PI. The
student will mainly be responsible for implementing the conceptual model in CPLEX and C++
programming languages. The PI will work closely with the student and guide him/her through each
step of this research project.
(k) Relationship To Other Research or Projects:
Hub-based intermodal logistics network design has been a topic of interest especially in the last decade. This project will contribute to the existing body of knowledge by integrating hub location, assignment of shipments, transportation mode selection, and consolidation of shipments decisions altogether into one complex model. The PI’s recent project titled “Analysis of Mississippi’s intermodal transportation infrastructure relative to prospective sites of automotive assembly plant sites – inbound logistics analysis” funded by MDOT will also provide valuable experience for this project.

(l) Technology Transfer:
The PI plans to disseminate the findings of this research in the form of publications in academic journals and presentations in national and international conferences.

(m) Benefits of the Project:
This study will provide a model that can be used primarily by multi-regional companies and intermodal logistics suppliers. However, the model can be modified to analyze a state’s intermodal facilities as well. The model will assist decision makers to design and operate an IL network. Existing models do not incorporate all of the decision variables considered in this study. However, to be able to design and operate an efficient IL network in practice, the aforementioned decision variables should be considered.

(n) TRB Keywords:
Emergency management, transportation network resilience, community structure, clustering, graph theory.
3. Qualifications of the Research Team

**Dr. Burak Eksioglu**, is an Associate Professor in the Department of Industrial and Systems Engineering, at Mississippi State University. His research efforts are focused on operations research, supply chain optimization, disaster management, heuristics optimization, and logistics and transportation. His research has been funded by the United States Department of Homeland Security (through American Trucking Associations), Mississippi Department of Transportation, United States Department of Agriculture, K&S Custom Warehousing Inc., and the Office of Research at Mississippi State University. Dr. B. Eksioglu will serve as the PI for this project. He regularly teaches Logistics Engineering (IE 4543) and Operations Research I (IE 4713). His expertise in logistics and optimization will be utilized in developing the heuristic algorithms. Dr. B. Eksioglu will be involved in all the major task of this project. Details about his responsibilities in each task are given in section (h).
REFERENCES:


## APPENDIX
### Budget Details
1/1/11 - 12/31/11

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