Center for Excellence in Logistics and Distribution (CELDi)

A National Science Foundation sponsored Industry/University Cooperative Research Center (I/UCRC)
CELDi is an applied research and education consortium consisting of:
  • Nine major research universities;
  • More than 30 member organizations from commercial, military and government sectors of the economy;
  • The National Science Foundation (NSF I/UCRC)

CELDi has the mission of enabling member organizations to achieve logistics and distribution excellence by delivering meaningful, innovative and implementable solutions that provide a return on investment.

CELDi partnerships achieve logistics and distribution excellence by:
  1. Solving real problems that achieve bottom-line impact;
  2. Graduating students with real-world project experience;
  3. Producing generalized, cutting-edge research that is published in leading journals;
  4. Sharing research results amongst member organizations to leverage intellectual and monetary capital.

CELDi is a university-based enterprise providing innovative solutions for logistics and distribution excellence with our partner organizations.
CELDi Academic Partners

University of Oklahoma

University of Arkansas

University of Missouri

Texas Tech

Lehigh

OSU Oklahoma State

Clemson University

Virginia Tech

Arizona State University
CELDi Member Organizations

ABF Freight System, Inc.
Aerospace Inc
Air Force Research Lab
Air Liquide
Arizona Department of Transportation
Arkansas Electric Cooperative
BWXT/Pantex
Cook Technologies
Crane Div., Naval Surface Warfare Center
Emcien
Factory Physics, Inc.
F.L. Smith, Inc.
Federal Aviation Admin. Logistics Center
Fragrance Manufacturing Inc.
GE Energy
Halliburton Energy Services
Innovative Scheduling
Invistics Corporation
Lockheed Martin Logistics Services
Medline Industries
Michelin North America, Inc.
Northrop Grumman
Oklahoma City Air Logistics Center
Oklahoma Department of Transportation
Port of Guaymas / State of Sonora
Queensland Dept of Mines and Energy
Red River Army Depot
Sam’s Club
Science Applications International Corp.
SPAWAR
U. S. Army Defense Ammunition Center
United Parcel Service
Wal-Mart Stores, Inc.
MU Member – Leggett & Platt
MU Member – AmerenUE
MU Member – Hallmark Cards
MU Member – Boeing
MU Member – Freight Pipeline Company
Companies pay a membership fee to join and receive an applied research project, plus share in the work products of the CELDi I/UCRC.

The promise of an I/UCRC is based on synergy and leveraging.
• Company specific project that exceeds $50K for one year buys a 1 year membership in CELDi
  – Involves a faculty member and at least 1 graduate & 1 undergraduate student
  – Single project or sequence of projects in phases

• NSF Role
  – Provides $50K per year for center administration
  – NSF requires each university to cost share => no overhead

• Members agree to share the fundamental research component of the projects with the other members
  – Confidential remains confidential
  – Companies review all documents before they are released and the university works to develop a version that is acceptable to both the company and CELDi
CELDi Membership Benefits

• Member company specified project with specific deliverables

• Shared fundamental research results provides tremendous leveraging of each industrial members research dollars
  – Each member has a nonexclusive, royalty free license to use all project results (access to over $5M in research!)
  – Dissemination
    • Two CELDi Research Conferences per year where results are presented
    • Written reports are accessible from CELDi web page to all members

• Receive CELDi Center Designated Project products
  – Software
  – White papers and Seminars
  – Industry benchmarking

• Membership in the CELDi Industrial Advisory Board (IAB)
  – access to logistics trained students
  – provide direction to CELDi Center Designated Project products
... Leveraging

IAB allocates pooled funds to develop software tools, seminars, white papers, etc. that are then available for all Center members
Center Designated Projects

Improve Inventory Accuracy through Optimal Cycle Counting

An Intermittent Demand Forecasting Tool

Data-Driven Adaptive Forecasting and Inventory Control
Center Designated Projects

Automated Asset Locating System

Logistics Network Design for Less-than-Truckload Consolidation

Helping Green Belts Use What They Know
The MU team:

- 9 industrial engineering faculty
- 5 transportation systems engineering faculty
- 2 management logistics faculty
- 1 health management faculty
- 2 agricultural economics faculty

Research Focus:

“An integrated approach to both facility and large scale logistics system challenges through modeling, analysis, and intelligent systems technologies.”
CELDi Focus Areas

Logistics Systems Analysis and Design

Supply Chain Modeling

Material Flow Design & Improvement

Intelligent Systems
Logistics Systems Analysis and Design

Logistics Strategy
Logistics Network Design
Vehicle Routing
Facility Location
An Inventory Replenishment Strategy
Using International Shipment Consolidation
Research Team: Wooseung Jang (PI), James Noble, Na Deng

Sponsor: Legget and Platt, Inc.

Problem in context: Each branch of Legget & Platt places orders to China independently. They have low order frequencies and high inventory. Coordinated inventory replenishment strategy will reduce inventory a lot. The project is to minimize the total cost by consolidating small international shipments when the coordinated inventory policy is taken.

Technical Approach
- Analyze purchase order history data of each branch
- Improve current logistics network
- Formulate a mathematical model
- Solution algorithms
- Test various scenarios
- Develop feasible implementation practices

Important/Expected Results
- Coordinated inventory replenishment and shipment policy for international logistics network
  - Shipment assignment
  - Inland transportation mode selection
  - Reduced inventory levels
  - Reduced cycle time
  - Increased flexibility
Research Objectives:

Develop an integrated systems, optimization based approach to winter road maintenance planning decisions

Approach:

1) Develop a protocol for determining the desired level of service and the required constraints.
2) Develop an integrated model and efficient algorithms for large scale applications.
3) Validate the model/algorithms and apply results to the state of Missouri.

Broader Impact:

An integrated model that can be applied to a wide range of DOT operations (e.g. snow removal, pavement striping, herbicide application).

Significant Results:

Able to maintain current high level of service with fewer resources (20-30% savings)
### Research Objectives:

Investigate the cost savings associated with changing strategic and tactical transportation and distribution strategies

### Approach:

- Model outbound tire distribution for DC
- Partition orders by demand type
- Design dedicated routes and pool points
- Use a greedy random search followed by local search to find consolidated routes

### Broader Impact:

- Problem has interesting generic features: minimum cost transportation strategies with constraints like hours of service, delivery time windows and conflicting objectives between truckload carriers and vendors
- Heuristic is efficient and runs on Excel

### Significant Results:

- Consolidation of loads (even non-optimally) provides significant savings in distribution.
- Quality solutions are generated in less than 1 minute on consumer level hardware under all real life distribution constraints

![Diagram of tire distribution network]

This …

or this …
Supply Chain Configuration

Supply Chain Management

Inventory Analysis

Demand Forecasting
Supply Chain Design for Energy Conservation
Research Team: James Noble (PI), Wooseung Jang, Kara Staub-Bono, Kelsey Kotur, Adam Rubemeyer

Sponsor: The Boeing Company

Problem in context: Overall supply chain performance is impacted by energy cost which has significantly increased in the past 10 years. Supply chain decisions such as supplier and mode selection, routing, inventory profile and load consolidation, can all be impacted by energy cost. This study aims to lay the groundwork for addressing this crucial issue.

Important/Expected Results
• Identification of key supply chain trade-offs with respect to energy issues
• Development of supply chain reconfiguration approaches as energy cost changes
• Reduce overall supply chain cost
• Design of more robust supply chains from an energy consumption perspective

Technical Approach
• Supply chain and transportation data collection
• Supply chain evaluation model development
• Formulation of energy based supply chain optimization models
• Solution algorithm development
• Model sensitivity analysis
• Supply chain reconfiguration strategies

Supply Chain Modeling
University of Missouri
**Demand Forecasting Models for Dynamic Material Requirements**

**Research Team:** Wooseung Jang (PI), James Noble, Matt Roman, Na Deng

**Sponsor:** Ameren UE

**Thrust Area:** Inventory

**Problem in context:** Thousands of transformers across several different storerooms are used by Ameren every year. These transformers consist of hundreds of different types with widely varying individual demands.

**Important/Expected Results**

- Production of accurate forward looking forecast results
- Creation of a forecast that can be easily applied when scheduling production slots from vendors
- Increase in customer satisfaction by limiting monthly stock outs over a 1 year planning horizon

**Technical Approach**

- Examine existing problem
- Gather relevant data
- Analysis of historic usage data
- Aggregate similar groups of transformers and choose individuals to forecast
- Review different forecasting techniques used on similar demand
- Create forecasting algorithm
- Evaluate forecast accuracy

**Total Usage Seasonality**

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<th>Month</th>
<th>Quantity</th>
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<td>2003</td>
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<td>2006</td>
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<td>2007</td>
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## Improving Inventory Record Accuracy in Retail Operations

**Sponsor:** Walmart  
M. D. Rossetti (PI), N. Buyurgan (co-PI), J. English (co-PI)

### Research Objectives:

To quantify the costs of inventory record inaccuracy and misplaced SKU’s at the store and system level  
To develop process improvement recommendations for the store and distribution centers to improve in-store inventory record accuracy

### Significant Results:

- Set of departments and items that impact the inventory accuracy was found.
- Correcting the problematic SKUs via PIRS provides approximately 10% accuracy, 30% discrepancy improvements.
- Utilizing PIRS generates approximately $500,000 in savings (carrying excess inventory, additional transportation and labor cost, inappropriate replenishment decisions, stock-out).

### Approach

- Gathering data to perform a statistical analysis to identify problem SKUs.
- Applying cycle counting in order to correct these items.
- Models/methods to quantify the costs and benefits related to these issues are developed.

### Broader Impact:

Data mining sampling techniques for large-scale inventory systems

Statistical process control techniques developed to maintain inventory record accuracy
Material Flow Design & Improvement

Material Handling System Design
Warehouse / Storage Systems
Facility Layout
Material Scheduling and Control
Warehouse Floor Layout Optimization
Research Team: Jim Noble (PI), Alec Chang, Almas Ospanov, Sam Trevino, Sarah Harper, Nichole Hillstrom

**Sponsor:** Hallmark Cards.

**Thrust Area:** Distribution

**Problem in context:** Hallmark Cards operates a very large distribution center (> 80k SKU and 220M items/year). The project objective is to develop a user-friendly warehouse floor layout tool that addresses the trade-offs between picking, stocking, shipping and retail stocking costs in order to reduce overall operating cost.

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**Important/Expected Results**

- Effective and efficient methodology for optimal filling floor layout.
- Significant cost savings through explicit analysis of cost trade-offs between picking/stocking/shipping.
- Effective implementation strategy for filling floor relayout timing.

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**Technical Approach**

- Analyze current Hallmark warehouse picking and stocking practices and supporting data.
- Analyze current filling floor layout practices and develop performance metrics.
- Formulate and analyze an integrated warehouse layout model.
- Develop a user-friendly warehouse floor layout tools and provide database integration support.
**Staging Needs in a Cross-docking Environment**

**Research Team:** J. Noble and D. Taylor

<table>
<thead>
<tr>
<th>Research Objectives:</th>
<th>Significant Results:</th>
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<tbody>
<tr>
<td>Develop new staging strategies to minimize space requirements while maximizing crossdock throughput and trailer cube utilization</td>
<td>A Zoned Strategy with simultaneous loading results in a 20% decrease compared with current staging practices</td>
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<tr>
<th>Approach:</th>
<th>Graphic:</th>
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| Development of an integrated analytic and simulation model  
• Analyze a range of environments where staging space = f(material flow pattern, flow pattern stochasticity, dock door availability, dock door assignment policy)  
• Evaluate performance with respect to: staging requirements, flow time, cost of operations | |

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<thead>
<tr>
<th>Broader Impact:</th>
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<td>This research addresses a key distribution issue as less-than-truckload (LTL) carriers seek to improve their operating efficiency.</td>
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Project: Development of a Resource Planning Algorithm  
Sponsor: BWXT/Pantex  
Research Team: Timothy I. Matis, Ph.D.

Research Objectives:

The primary objective for this project is to develop a resource planning algorithm that will improve the existing production and inventory control models used by BWXT/Pantex.

Approach:

The approach that will be used to achieve these objectives includes:

1) Evaluate the current production scheduling and work assignment methods.

2) Develop appropriate production scheduling models for BWXT/Pantex.

3) Develop capacity planning models to more accurately measure throughput capacities.

Broader Impact:

This research effort will have immediate beneficial impact to the Pantex facility. Other member companies have the potential to benefit from the deliverables of this project by modifying and adapting the model to fit their constraints.

Significant Results:

An algorithm used for production planning that is sensitive to multiple variables that affect daily production rates (used for resource planning (personnel, equipment, facilities) to make real-time adjustments to perturbations in production operations).

Adaptation of program Bottle, originally developed by W. Applegate and D. Cook.
RFID

2-D Bar-Code

UID

Database and Information Systems
Multi-Item Load Building Tool for Containers
Research Team: C. Altan (PI), B. M. Pulat, Z. Siddique

Sponsor: TSM/US Army DAC
Thrust Area: Intelligent Systems

Problem in context:
Develop a web-based tool to help DOD ammunition transporters transport various load configurations with minimum number of containers.

Technical Approach
• Review existing process
• Research and capture all requirements
• Develop packing algorithms
• Develop web-based interactive tool
• Test and implement

Important/Expected Results
• Web tool that can be used from remote locations
• Heuristic that can handle a given load with minimum containers
• Ability to change loads and see the impact

What can other members use?
• Capability developed can be used by others for similar transport needs
• Other needs can be addressed with modifications
Technological and Economic Evaluation of Competitive RFID and other Auto-ID Technologies for Asset Tracking

Sponsor: Oklahoma City Air Logistics Center
Principal Investigator: Dr. Satish Bukkapatnam

Research Objectives:
• To investigate technical, data management and economic issues of implementing Automatic Identification (Auto-ID) Technologies (including RFID, Wi-Fi, 2-D barcodes) in depot and ramp operations, and assess their impact on business processes of Tinker AFB

Approach:
• Survey of alternative Auto-ID (AITs) and Automatic Monitoring Technologies (AMTs)
• Economic analysis of the insertion of certain candidate AMTs for various asset management applications in Tinker ramp operations including the operations within and beyond the supply chain using value stream mapping tools

Significant Results:
• New model to predict the read-rate probabilities of backscatter RFID systems
• New POMDP approach to use RFID to search and locate misplaced items
• Framework for economic analysis of AIT systems in warehouse/depot operations by the use of advanced value stream mapping (VSM) tools
• Survey and documentation of industry best practices to address various technological and economic issues

Broader Impact:
• The presented research approach seems to be of interest to a few manufacturing and small businesses located in Oklahoma

Intelligent Systems  Oklahoma State University
Next Steps

First,
• Develop project proposal – objective, tasks, schedule, and deliverables
• Sign CELDi Membership Participation Agreement

Second,
• Commence company research project
• Attend the biannual CELDi Research Conference and IAB meeting
• Participate in Center-designated project selection

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