EmTech

The Library Service Center

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*This document has been created in the framework of a student design project and the Georgia Institute of Technology does not officially sanction its content.
PROJECT OVERVIEW

Problem
- Relocating 1.5 million books
- Ingesting 2.5 million books

Methodology
- Problem Definition
- Data Collection and Validation
- Interpretation

Deliverables
- Library Relocation Portfolio
- Cost Function Model

Overview | Client | Problem | Methodology | Deliverable | Value | Next Steps
EmTech: “serves as a single, off-site collection for both Georgia Tech & Emory University.”

Georgia Tech Library
- 2.75+ million print & electronic books
- 70,000+ research items & electronic journals

Location
- Georgia Tech Library
- Georgia Tech Warehouse

Emory Library
- 4+ million print & electronic books
- 83,000+ electronic journals collections

Location
- Clifton
- High Museum of Art
Design a plan to relocate 1.5 million books from Georgia Tech, and ingest a 2.5 million combined collection.

Five month total timeline

Twenty-four hour cycle time

$2 per book estimation
METHODOLOGY OVERVIEW

Problem Definition

Research

LSC Site Visits

Build Process Map

Understand Problem

Data Collection and Validation

Determine Process Steps and Data Needed

Collect Data

Verify Data

Interpretation

Analyze, Compare, Recommend

Simulation Model

Cost Function Model

Overview  Client  Problem  Methodology  Deliverable  Value  Next Steps
We visited University of Georgia, Duke University, and University of South Carolina to learn more about their LSCs.

**Key Takeaways**

- Many LSCs use the same type of equipment:
  - Raymond pickers
  - Gryphon book trucks
  - Zebra barcode printers
- Standardized barcode placement is important
- Book trucks and plastic totes were used for book transportation
- Processing layouts varied
We have created a process map for the scope of our project, separated by book origin.

GT books from library and warehouse will be moved using our plan.

Processing for all books:
- Vacuuming
- Sizing
- Placing in tray

Emory books from library and High Museum will be moved by a third party.
DATA COLLECTION

Time Studies

• Broken down by task
• Ensure statistical significance

Research

• Industry standards
• Equipment costs
BOOK SIZING EXAMPLE

Time Study

- 30 trials sizing 10 books each trial
- Different sets of books for each trial
- Multiple people switching roles

Overview

Client

Problem

Methodology

Deliverable

Value

Next Steps

Processing at GT

Unload cart to waiting area or first station

Vacuum books

Size books

Tray books

Book sizing template
**BOOK SIZING EXAMPLE**

**ExpertFit outputs for book sizing data:**

Density-Histogram Plot overlaying distributions on sizing books

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Anderson-Darling goodness-of-fit test of sizing data for the Beta distribution

<table>
<thead>
<tr>
<th>Sample Size</th>
<th>Critical Values for Level of Significance (alpha)</th>
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<tbody>
<tr>
<td>30</td>
<td>0.250</td>
</tr>
<tr>
<td></td>
<td>1.248</td>
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<tr>
<td>Reject?</td>
<td>No</td>
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</tbody>
</table>

Simio representation using the best fit distribution for sizing books

Simio Representation of Model 1 - Beta

Use:

$$2.202221 + 4.382335 \times \text{Random Beta}(8.198928, 9.587848, \text{<stream>})$$

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*Overview* | *Client* | *Problem* | *Methodology* | *Deliverable* | *Value* | *Next Steps*
Sizing Example:
• Use ExpertFit to determine appropriate distribution
• Enter given distribution into Simio
• Run model and observe system effects
• Adjust number of stations in order to meet demand

**ExpertFit Output**

- **Use:**
  
  \[ 2.202221 + 4.382335 \times \text{Random.Beta}(8.196928, 9.587848, <\text{stream}>), 2.202221 + 4.382335 \times \text{Random.Beta}(8.196928, 9.587848, <\text{stream}>) \]

**Simio Input**

- **Process Logic**
  - **Capacity Type:** Fixed
  - **Initial Capacity:** 3
  - **Ranking Rule:** First In First Out
  - **Processing Time:** 2.202221 + 4.382335 * Random.Beta(8.196928, 9.587848, <stream>)
    - **Units:** Minutes

**Processing and Shelving portion of Simio**
COST FUNCTION MODEL

**Labor Costs**
- Expected time per sub process
- Overall time per process
- Labor hours associated with each

**Equipment Costs**
- Total equipment cost based on recommendations and client inputs

**Total Cost Function**
- Total cost of relocating and ingesting units

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### Table

<table>
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<th>FLOOR 6</th>
<th>FLOOR 5</th>
<th>FLOOR 4</th>
<th>FLOOR 3</th>
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<td>take empty cart to elevator (seconds)</td>
<td>take empty cart to elevator (seconds)</td>
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<tr>
<td>10</td>
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<td>10</td>
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<td>ride elevator to floor (seconds)</td>
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<td>ride elevator to floor (seconds)</td>
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<tr>
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<tr>
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<td>push cart to shelf (seconds)</td>
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<tr>
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<tr>
<td>ride elevator to Ground (seconds)</td>
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<td>ride elevator to Ground (seconds)</td>
<td>ride elevator to Ground (seconds)</td>
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<tr>
<td>45</td>
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<td>30</td>
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</tr>
<tr>
<td>push cart to loader (seconds)</td>
<td>push cart to loader (seconds)</td>
<td>push cart to loader (seconds)</td>
<td>push cart to loader (seconds)</td>
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<tr>
<td>30</td>
<td>30</td>
<td>30</td>
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</tr>
<tr>
<td>Total time of one trip (seconds)</td>
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<td>Total time of one trip (seconds)</td>
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<table>
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<tr>
<th>CLIENT</th>
<th>VANS</th>
<th>BOXLJUCKS</th>
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<tbody>
<tr>
<td>Cost of Fetching</td>
<td>$5,918.82</td>
<td>$5,918.82</td>
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<tr>
<td>Cost of Loading</td>
<td>$2,407.07</td>
<td>$2,647.78</td>
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<tr>
<td>Cost of Driving</td>
<td>$21,442.10</td>
<td>$15,637.22</td>
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<tr>
<td>Cost of Unloading</td>
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<td>$4,896.30</td>
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<td>Cost of Vacuuming</td>
<td>$44,101.74</td>
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<td>Cost of Barcoding</td>
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<td>Cost of Sizing</td>
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<td>Cost of Scanning</td>
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<tr>
<td>Cost of Shipping</td>
<td>$6,469.81</td>
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<tr>
<td>LABOR TOTALS</td>
<td>$193,041.79</td>
<td>$187,718.33</td>
</tr>
</tbody>
</table>

TOTALS
- 10503.59 trips
- 717,439 hours
- $5,918.82 fetching cost

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MODELS

Models give us the flexibility to observe the effects that labor, equipment, and processing have on cycle time, total time, and total cost.

Simulation Model

• Models total relocation time start to finish per unit
• Identifies bottlenecks
• Ability to model variability in processing times

Cost Function Model

• Cost estimation tool based on expected labor hours per process
• Includes fixed costs of purchasing equipment
• Evaluates the costs for client based on user input
Example where all processing is done at LSC.

- Daily employee
- Supervisor
- Tray
- Sizing chart
- Laptop w/ software
- Vacuum
- Gryphon cart

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**DELIVERABLES**

### Book Relocation Portfolio
- Equipment and Labor Recommendations
- Processing layout/configuration
- Estimated timelines

### Cost Function Model
- Breakdown of costs by process
- Outline of fixed and variable costs
- Estimated labor hours per process
Minimize Cost to be under $2/unit

Streamline Process

Estimate Verification

Knowledge Sharing
NEXT STEPS

Data Collection
- Finalize data collection and replications
- Fit data sets to appropriate distributions using ExpertFit

Simulation Modeling
- Finalize Simio
- Input distributions into model and observe effects
- Identify bottlenecks and evaluate alternatives

Cost Modeling
- Research expected labor and equipment costs
- Update cost estimates depending on Simio output
THANK YOU