Automated Shipping Container Transport System Development
We are doing a third I-Pro on the same subject because

- Intermodal (rail-highway) is a defining industry in the region: 87,000 jobs (ref Chicago Metropolis 2020 freight plan)
- Future projections (volume growth) indicate serious issues (capacity; actual handling processes). Freight is doubling in 7 years.
- Potential for a win-win-win-win-win situation in the form of: Congestion relief; Air quality benefit; Livability improvement; Conservation.
- Big project
This semester’s project consists of:

- Two parts— which can be separate or complementary
- Part A: *Intra*yard handling

Part B: *Between*-yard movement (configured as a truckway expandable to serve the *Intra*yard shuttle)
Spring ‘04 ACCOMPLISHMENTS

Grid-Rail (GRAIL) Over Head Lattice Concept

Inter-Yard Structure Concept
Fall ’04 ACCOMPLISHMENTS

Shortest Distance Network

Central Area Avoidance

Central Area Avoidance Flow as Percent of Total
- 0% - 0.30%
- 0.35% - 1.64%
- 1.64% - 2.70%
- 2.70% - 8.25%
- 8.25% - 12.5%
- 12.5% - 28.19%

2000 Lifts
- 15701 - 50953
- 50654 - 134646
- 134647 - 305226
- 305227 - 480000
- 480001 - 697303

Interstates
Chicago Rail Network
# Second semester in an I-Pro

* Second semester with I-Pro 307
What is a Linear Induction Motor?
LIM/I-Beam Connection

Iron backing plate

Aluminum Reaction plate

.05 inch air gap

Motor stand

3 phase AC coil assembly
LIM Design Specifications

– **Maximum System**
  - 45 motors tied in series
  - 22.5 inch width for the reaction plate
  - Total area of the motors is 36.1 square feet (1.875 ft x 19.25 ft)
  - Acceleration of 0.0166 g’s
  - Time to reach operating speed is 1 minute and 50 seconds
  - Power is 175.95 kW or 235.9 horsepower
  - Total cost of motors $ 67,498.92
  - Total cost to operate 12.32 $ per hour

– **Minimum System**
  - 21 motors tied in series
  - 22.5 inch width for the reaction plate
  - Total area of the motors is 16.8 square feet (1.875 ft x 9 ft)
  - Acceleration of 0.0077 g’s
  - Time to reach operating speed is 3 minute and 55 seconds
  - Power is 82.11 kW or 110 horsepower
  - Total cost of motors $ 31,499.50
  - Total cost to operate 5.75 $ per hour
Between-Yard Structure Semester 1 & 2

28ft clearance for doublestack train

2nd level with a 2nd type of LIM shuttle
Between-Yard Structure

2lane truckway (tollroad)

28ft clearance for doublestack train and additional clearance (22ft) for intrayard shuttle expansion

2nd level accommodates underhung Intrayard shuttle and 2lane truckway

Per frame (25feet):

- 60tons structural steel
- 90cy concrete
- 6200linear ft reinforcing steel
- 40cy concrete deck
- 8cy asphalt
Corwith to 47th Corridor

Approx total length = 5 miles
(1000 frames @ 25 ft each)

East end is rehabbed railroad and residential.

West end is active railroad, CTA and industrial.
Overall Material Qty:

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Units</th>
<th>Corwith</th>
<th>Between</th>
<th>47th St</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel structural</td>
<td>tons x1000</td>
<td>56</td>
<td>60</td>
<td>38.5</td>
<td>154.5</td>
</tr>
<tr>
<td>Concrete</td>
<td>cubic yd x1000</td>
<td>94</td>
<td>90</td>
<td>64</td>
<td>248.0</td>
</tr>
<tr>
<td>Steel reinforcing</td>
<td>linear ft x1000k</td>
<td>7</td>
<td>6.2</td>
<td>5</td>
<td>18.2</td>
</tr>
<tr>
<td>Concrete deck</td>
<td>cy x1000</td>
<td>0</td>
<td>40</td>
<td>0</td>
<td>40.0</td>
</tr>
<tr>
<td>Asphalt</td>
<td>cy x1000</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>8.0</td>
</tr>
</tbody>
</table>
ZONING
Why a $5.00 Toll?

- $4.00 = Truck Plaza Rate on all Tollways
- $6.00 = Truck Skyway Rate
- $7.50 = Waukegan Exit on the Tri-State
- $5.00 = Truck Toll on Golf Road, Willow Road, Lake Cook Road, and Touhy Avenue Ramp Exits on the Tri-State

***An average toll of $5.00 a truck was found on all plazas, the skyway, and major street exit ramps so we find a $5.00 toll sufficient for the truck tolls on our ramps.
### Number of Trucks and Revenue Produced from Both Ramps at $5.00 Toll Per Truck

<table>
<thead>
<tr>
<th>Percent of Trucks Using 55E → 90/94S Ramp</th>
<th>Number of Trucks</th>
<th>Amount of Money Produced Daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>200</td>
<td>$1,000.00</td>
</tr>
<tr>
<td>25%</td>
<td>500</td>
<td>$2,500.00</td>
</tr>
<tr>
<td>50%</td>
<td>1,000</td>
<td>$5,000.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent of Trucks Using 90/94N → 55W Ramp</th>
<th>Number of Trucks</th>
<th>Amount of Money Produced Daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>180</td>
<td>$900.00</td>
</tr>
<tr>
<td>25%</td>
<td>450</td>
<td>$2,250.00</td>
</tr>
<tr>
<td>50%</td>
<td>900</td>
<td>$4,500.00</td>
</tr>
</tbody>
</table>

Equal Percentage of Trucks On Each Toll  
Total Combined Trucks at % From Both Ramps  
Total Revenue Produced Daily From Combined Ramps

<table>
<thead>
<tr>
<th>10%</th>
<th>380</th>
<th>$1,900.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>950</td>
<td>$4,750.00</td>
</tr>
<tr>
<td>50%</td>
<td>1,900</td>
<td>$9,500.00</td>
</tr>
</tbody>
</table>
Conclusions

• Despite its potential advantages, our research has failed to identify the Linear Induction Motor as the best option for propelling the shuttle.

• Much improvement was made this semester in regards to the structural analysis and design of columns, girders, beams, monorails, and foundations.

• Use of a toll collecting truckway opportunely allows for spreading construction costs and advantages over a wider set of stakeholders.
Next steps

• Assess “Time and Motion” of current method (spotting) to set a performance bar (i.e. time/cost/cycle time to beat with alternative system)

• Consider other means of propulsion such as synchronous or rotary motors.

• Explore route alignments for interconnecting additional container handling facilities.

• Evaluate alternative methods that consolidate operations.