Intermodal Transit Center

NCEES Engineering Award Program

Project Description Report

01/01/2009

Abstract
"City X" is rapidly emerging; it is home to many manufacturing and service industries and has been labeled as the fastest growing major city in "State X." Along with this prosperity, however, there comes more traffic, increased emissions, and less parking. How can these challenges be overcome?

A team of eight senior-level engineering students sought to find a solution to the problem. Their answer: an Intermodal Transit Center (ITC), a facility whose function is to connect various modes of transportation in an efficient manner. A successful ITC can reduce transportation costs for the user, ease traffic congestion, supply parking, and provide environmental benefits, including reduced emission. The objective of Phase I of the ITC project was to propose a preliminary design for an ITC in City X, home to the students' university. Phase I was completed during the fall 2008 semester and fulfilled the requirements for part one of the capstone design class under which it was supervised. Phase II of the project, to be completed in the spring 2009 semester (in part two of the capstone design class) will involve the detailed structural design of the ITC, traffic flow study, and cost analysis.

Phase I of ITC project involved collaborative efforts between government officials, engineers, urban planners, transportation specialists, local businesses, city personnel, transportation providers, environmental specialists, and financial contributors. Students were able to apply classroom knowledge to a real world scenario using skills from a variety of disciplines. In the civil engineering field, structural analysis and transportation planning (including applicable legislative procedures) were used. Environmental engineering knowledge was used in determining building materials, site location, and facility layout. Good engineering management skills ensured practical schedules and productive meetings. The student design team also used the principles of safety engineering to design an ITC that would assure public welfare.

Students also made use of available technology to enhance the project. Computer programs such as AutoCAD, Microsoft Project, Microsoft Word, Microsoft Excel, and Microsoft PowerPoint were utilized. In addition, students established a web page (to be made available to the public upon completion of Phase II) through the university website which showcases the project and informs readers about how an ITC would impact City X. Furthermore, the team used an online file exchange system to maintain strong communication and document progress.

By combining engineering skills, professional guidance, and technology, the student team successfully proposed a preliminary design for an ITC in City X. The design is tailored for the needs of City X and includes the following features: parking, public transit connections, shuttle services, smart car rentals, restaurants, retail space, free Wi-Fi, bicycle rentals, bicycle repair shop, bicycle parking (long-term and short-term), access to bicycle routes, lockers & showers, PHEV (plug-in hybrid electric vehicle) refueling stations, and accommodations for future rail connection.

Taking advantage of the opportunity to engage in a project that addresses actual concerns of the local community was truly a worthwhile endeavor. Students have taken great pleasure and satisfaction in knowing they have made a significant contribution towards a venture that has a strong possibility of being realized. Establishing an ITC in City X would certainly bring substantial benefits to the local area. After all, that is what the engineering profession is really about – having a share in strengthening the community!

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Background & Problem Description

An Intermodal Transit Center (ITC) is a versatile facility designed to provide travelers with access to a variety of transportation modes. Thus, it is easier for travelers to choose efficient and eco-friendly travel alternatives. By taking advantage of an ITC and public transit, a community can work together to make the best use of available resources.

The ITC project objective of Phase I was to propose a preliminary design for an ITC in City X in attempt to address the city's problems of traffic congestion, increased parking demand, and substandard air quality.

To accomplish this task, the transportation planning process was applied. The process entails defining the transportation needs of City X, determining what the local businesses and residents would like to see, and using engineering knowledge and principles to determine an optimal location and appropriate features. Applicable codes, standards, and regulations as well as the social and environmental impacts were researched and considered as part of the design process.

Site Selection

Seven potential locations within City X were identified for the ITC. To assess each of these locations, the Level I matrix (Table 1 on next page) was created. Eight major criteria were established, with each rated on a scale of 1-5, with 1 being "not very important" and 5 being "essential." Next, each of the potential locations were rated on a scale of 1-3 on how well they met the criteria, with 1 being "not very well" and 3 being "very well." Finally, weighted totals for each location were calculated and the top three locations (University Campus, Southside, and Downtown #2) were chosen for further analysis.

To compare the top three alternatives, a Level II matrix (Table 2 on next page) was developed. This matrix evaluates more critical criteria: the traffic impact, optimal utilization of current infrastructure, and conformity with City X's long term transportation plan. The rating scale for the criteria is from 1-3 with 1 being "somewhat important," 2 being "important," and 3 being "vital." The potential locations were then rated similarly to the Level I matrix in how well they met the criteria.

The ratings in both the Level I and Level II matrices were based on input from the faculty and local professionals as well as engineering judgment from the student design team. Take for example the second criteria in the Level I matrix, rail access. This criteria was very difficult to rate because it involves future projections. Although City X does not currently use rail for passenger transit, there is much potential and space for it to be incorporated. There is also serious consideration of having a high speed rail or MAGLEV (magnetic levitation) train pass through City X. In speaking with faculty and professionals, the team found that some view the prospect as realistic while others consider it unlikely. The team then faced a major dilemma: should rail access be a priority in the design of an ITC? After doing more research on the subject, the team used engineering judgment to conclude that although rail access would add another mode of transportation to the ITC, the feasibility of passenger rail transit in City X is uncertain at this time and it would not be wise to base the success of the ITC upon something which is so tentative. Therefore, a rating of 2 was assigned to rail access.

Table 1. Level I Matrix

	Weighting Factor	University Campus	Southside	Airport	Downtown #1	Downtown #2	Mall #1	Mall #2
Mass Transit Access	4	3	3	1	3	3	3	3
Rail Access	2	2	2	3	2	2	2	1
Electric Shuttle Access	3	2	3	1	3	3	1	1
Brownfield	4	3	3	2	3	3	3	2
Bicycle Route Access	2	3	3	1	3	3	1	1
Access to Arterial	5	2	3	3	2	2	3	3
Space for H_2 Fueling Station	1	1	1	3	1	2	1	2
Land Availability	5	3	3	2	2	2	3	2
	Weighted Total	**66**	**74**	**51**	**64**	**65**	**64**	**54**

Table 2. Level II Matrix

	Weighting Factor	Southside	University Campus	Downtown #2
Positive Traffic Impact	2	3	2	3
Use of Current Infrastructure	3	3	2	2
In harmony with Long Range Transportation Plan	1	3	2	2
	Weighted Total	**18**	**12**	**14**

Preliminary Design

Based on the matrix analysis, the Southside location was selected as the optimal site for an ITC in City X. In designing the layout of the ITC, the team had to determine which features would best meet the needs of City X. The Outdoor Activities/Bicycle Coordinator in City X, Senior Planner/Director of Regional Transportation, and Transportation Research Program Director were particularly helpful in this regard as they could provide advice on which features would attract users. For example, based on experience in other cities, the Outdoor Activities/Bicycle Coordinator emphasized that long-term and short-term bicycle parking, bicycle rentals, a bicycle repair shop, and lockers and showers would not only encourage bicycling, but when conveniently located (such as at an ITC), can also boost mass transit ridership. Bicyclists would also be able to take advantage of the bicycle racks recently installed on buses in City X. In addition, the Senior Planner/Director of Regional Transportation suggested including free Wi-Fi and obtaining LEED (Leadership in Energy and Environmental Design) certification. Also, the Transportation Research Program Director recommended including smart car rentals (small fuel efficient and low emitting vehicles which users can rent and return at various locations) and refueling stations for PHEVs (plug-in hybrid electric vehicles) in the ITC design.

After considering all the suggestions, the team was able to come up with a preliminary design. Figure 1 below shows the layout of the ground floor. As can be seen from the drawing, the ITC design includes public transit & shuttle connections, smart car rentals, restaurants, retail space, bicycle rentals, a bicycle repair shop, bicycle parking (long-term and short-term), lockers & showers, and accommodations for future rail connection. Not shown on the drawing, but included in the design, are free Wi-Fi, parking (on the 2nd and 3rd floors), and PHEV (plug-in hybrid electric vehicle) refueling stations (on the 2nd and 3rd floors).

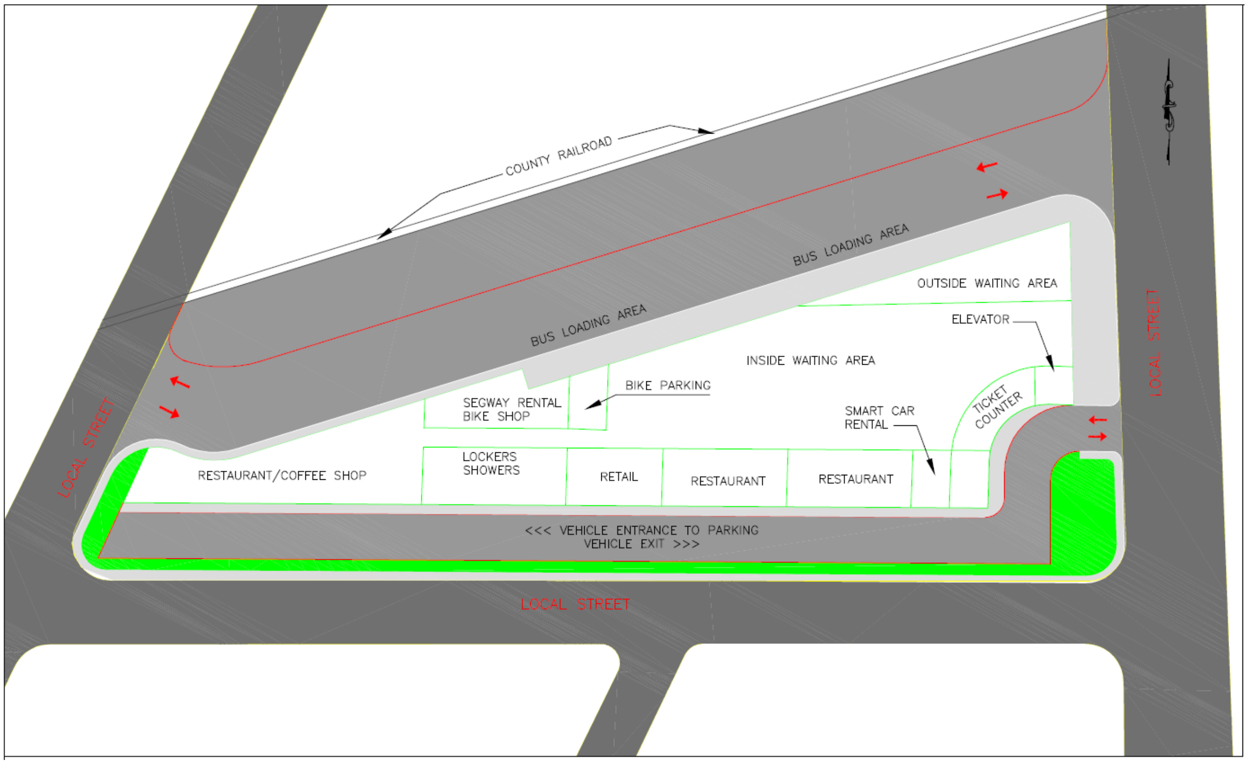

Figure 1. ITC Preliminary Design Ground Floor

Collaboration between Students, Faculty, and Professionals

Listed below is a brief description of the interaction between the student design team, faculty, and local professionals:

- *Classroom Professors:* Initiated the project, provided background information, and helped establish influential contacts (e.g. Mayor of City X). Imparted knowledge regarding project management, business conduct, public speaking, and ethics.
- *Civil Engineering Professors:* Provided guidance in understanding and applying the transportation planning process. Also aided in developing preliminary site drawings.
- *Mechanical Engineering Professor:* Assisted in determining energy consumption and associated costs for an ITC.
- *Senior Planner/Director of Transportation (Regional):* Supplied information about City X's long term transportation plan, which proved to be helpful in determining the feasibility of the ITC concept for City X. Also gave suggestions about unique ITC features for City X such as free internet connection and LEED certification.
- *LEED Accredited Professionals:* Gave detailed tour of the only LEED certified building in City X and offered ideas on how to make an ITC LEED certified. Also supplied information about local grant opportunities applicable to the ITC if LEED certification was obtained.
- *Assistant Vice President of a Top Consulting Firm in the U.S.:* Provided the student design team with a "reality check" on how transportation planning is done within industry. Gave practical advice on how to approach difficulties (such as how to determine the needed amount of parking spaces) encountered by the student design team.

- *Transportation Research Program Director:* Aided in helping students understand the function of an ITC. Provided several examples of ITCs across the nation. Also assisted in setting up the matrix evaluation and recommended including smart car rentals and refueling stations for PHEVs.
- *Mayor of City X:* Student design team made a presentation to the Mayor about the prospect of an ITC in City X and the benefits it could bring. Mr. Mayor provided feedback and gave approval to students to continue research and propose a plan (to be presented at the end of Phase II – May 2009).
- *President of Major Mass Transit Provider in City X:* Gave input on site preferences and discussed with students how an ITC would affect local transit.
- *Outdoor Activities/Bicycle Coordinator in City X:* Supplied the team with data on bicycling activity in City X. Made suggestions about features which would attract bicyclists to the ITC and gave information about various bicycle-related amenities currently available in the market.
- *University Vice Chancellor:* Discussed options for an ITC on the university campus. Supplied information about parking demand, funding, and available space.
- *City Engineers & Director of Development for State X's Railroad Museum:* Assisted in gathering information about potential site locations. Also aided in understanding the permitting process and applicable codes.

Environmental Considerations

Environmental considerations were a major factor in designing the ITC. The team used LEED certification criteria for new construction as an aid in determining ways in which to build a green ITC. LEED criteria are divided into six major categories: sustainable sites, water efficiency, energy & atmosphere, materials & resources, indoor environmental quality, and innovation & design process.

Under the sustainable sites category, the ITC design has the potential to obtain 12/14 points because it offers alternative transportation in the form of public transportation access, bicycle storage, changing rooms, low emitting & fuel efficient vehicles, and parking capacity. Credit is also obtained for being developed on a brownfield site, engineering an efficient stormwater design, taking measures to reduce the heat island effect (by using shading, reflective materials, and vegetation), and reducing light pollution.

To improve water efficiency, landscaping options which require little water are used. Also, water efficient fixtures (e.g. dual-flush toilets) are incorporated throughout the ITC design. Reusing wastewater is another way to conserve water. For example, in a restroom, the plumbing can be arranged so that water disposed of in the sink is reused to flush the toilet.

Energy & atmosphere is another important category for LEED certification. Integrating renewable on-site energy sources through solar, wind, and geothermal strategies significantly contribute to energy optimization. Also, measuring energy consumption using appropriate meters is an excellent way to verify savings and ensure accountability. The ITC design has the potential to include green power by placing solar panels on the roof. This would not only help in energy conservation, but would also aid in reducing the heat island effect.

Although most of the ITC would be constructed from concrete, points can still be scored in the materials & resources category by using recycled (e.g. recycled tires for flooring) and rapidly renewable materials in the restaurants, retail area, bicycle shop, locker rooms, and waiting areas of the ITC.

Indoor environmental quality is achieved by using low-emitting materials (including adhesives, sealants, paints, coatings, carpet systems, composite wood, and agrifiber products) throughout the ITC. Also, controlled lighting is utilized and large windows encompassing most of the ground floor add to improved daylight views and natural lighting.

LEED certification criteria also includes a "bonus" category: innovation & design process. In this division, points are scored for unique design ideas and applications which go above and beyond LEED performance requirements. A point can also be scored if at least one primary participant in the project becomes a LEED AP (Accredited Professional). The design team plans on scoring points in this category by coming up with innovative designs idea during Phase II (spring 2009 semester) of the project. Also, the project manager of the student design team plans on becoming a LEED AP, thus adding another point to the score.

Basic LEED certification requires at least 26 out of a possible 69 points. Based on a conservative estimate, it is projected that the ITC design could attain at least 30 points and thereby acquire LEED certification. Also, thanks the guidance provided by the LEED APs in City X, the team find out that the proposed ITC would qualify for a local grant worth $40,000-$100,000. Such a substantial contribution would greatly enhance the likelihood of the ITC becoming a reality.

Professional Leadership

The ITC project enabled students to strengthen professional leadership skills. For example, prior to meeting with the Mayor of City X, faculty educated students about proper business conduct when speaking with government officials and professional practitioners. In addition to advice on proper dress and speech, students were presented with a seven step process to use when conducting meetings:

1) Engage in "happy talk" – casual conversation which serves to put all participants at ease
2) Ask for permission to proceed – review the agenda and confirm allotted time
3) Establish credibility – show that you are qualified
4) Earn the right to speak – demonstrate that you have done your homework and are knowledgeable in the subject matter
5) Get customer talking – ask them what are their requirements and priorities
6) Playback – repeat your understanding of what the customer said
7) Close – review action items and convey thanks

Additionally, students applied the code of ethics for engineers when carrying out project tasks. The safety, health, and welfare of the public were held paramount. Safety was insured by complying with federal and local regulations which detail requirements for safe design and construction of buildings. The team also went the extra mile in providing public health benefits by incorporating design features such as low-emitting paints and sealants. Added health benefits are provided by the function of the ITC. Since the location of the proposed ITC is conveniently located at the south side of downtown, near major businesses in City X, and is connected to bicycle routes, walking and/or bicycling are very viable and highly encouraged. This increase in physical activity (in comparison to driving a private vehicle) for traveling also results in health benefits. Numerous scientific studies have shown that even moderate physical activity, such as walking or bicycling, can result in decreased risk of heart disease, diabetes, high blood pressure, depression, anxiety, and obesity to name just a few. Also, since the ITC facilitates the use of public transit, smart cars (low- emitting and fuel efficient vehicles), and PHEVs, this results in decreased CO_2 emissions within the city. This results in improved air quality, which also provides public health benefits. These factors not only raise social consciousness and improve public welfare, but also offer a better infrastructure and standard of living for the residents of City X.

In addition to upholding public safety, health, and welfare, students also showed ethical behavior in recognizing their limited knowledge and expertise in the area of intermodal design and consequently relied on qualified professionals to provide engineering judgment. Moreover, the team showed honesty and impartiality by carefully selecting a site location and ITC features which would put public interests first (versus that of any one individual or business). As demonstrated by the Level I and II matrices, all potential site locations were evaluated based on engineering criteria, not mere opinion of what is best.

Knowledge Gained & Use of Viable Technology

The ITC project has provided students on the design team with many opportunities to expand their knowledge and skills. First of all, students learned how to manage a complex project. The team used Microsoft (MS) Project to keep track of individual and group assignments as well as deadlines. Learning how to use the critical path method in MS Project was helpful in determining dependencies between tasks. If the team missed a deadline, it was easy to see how the entire project was affected.

Students also used other Microsoft programs to enhance the project. MS Word was used to develop reports, MS PowerPoint helped give attractive presentations, and MS Excel was utilized in creating the Level I and II matrices shown earlier in this report. Macros within MS Excel, in combination with Google maps, were also used to create a visual presentation of traffic flow at certain intersections.

In creating professional drawings of a preliminary site design, AutoCAD was used. Since only one member of the student design team had prior exposure to AutoCAD, learning the software was a major challenge. However, students realized that learning how to use AutoCAD is a good skill to have and it would be a major advantage for their professional careers. Therefore, many members of the team spent several weeks becoming proficient in the program.

To help provide more exposure about the ITC project, students established a web page (to be made available to the public upon completion of Phase II) through the university website. The web page informs readers about how an ITC would impact City X and highlights the community involvement that went behind the project. It also raises social consciousness by emphasizing green building (including information about LEED) and environmentally friendly travel options.

Students maintained strong communication outside of team meetings and documented progress by making use of emailing and an online file exchange system. Faculty also had access to the file exchange system and were able to use it to provide constructive feedback throughout the span of the project. Emailing proved to be an efficient way to communicate with professional practitioners as it allowed for documented communication, flexibility, and quick response.

Students have also had the opportunity to apply classroom knowledge in a real world setting. Skills from a variety of fields were utilized, including: civil engineering, transportation planning, structural analysis, safety engineering, environmental engineering, and project management. However, being able to translate textbook knowledge into reality was quite another challenge. This is where collaboration with professionals became vital, for without their practical guidance, completing the project would not have been feasible. Professional leadership, as described in the section above, aided in an effective partnership.

Another important skill that students developed was working effectively within a team. Although differences in opinion and personality conflicts arose, the team was able to overcome those issues by focusing on the main goal of designing a successful ITC. Team members learned how to provide feedback in a constructive and positive way and how to communicate their thoughts effectively.

During Phase II of the project, the team plans on utilizing more technology to complete the project. A traffic analysis software known and Synchro will be used to model traffic flow in City X after the addition of an ITC. Such a model would show exactly how much impact the ITC would have on congestion and parking. The team may also use BIM (Building Information Modeling) to ensure optimal performance.

Conclusions

Phase I of the project has lead the team to conclude that an ITC in City X is indeed a good solution to the city's concerns of congestion on roads, increased parking demand, and desire for improved air quality. The team successfully collaborated with faculty and professionals to develop a unique preliminary design for City X. Students also expanded their knowledge by learning new technology, managing a complex project, and working as a team.

The team aims to continue with the project in Phase II of the design (to be completed by May 2009) where structural design, traffic flow study, and cost analysis will be performed. Students will continue collaborating with faculty and professionals, using modern technology, and practicing professional leadership abilities to ensure that City X receives the best designed ITC possible.

Not only has involvement in this project enhanced scholastic abilities, but it also provided students with a great sense of accomplishment and personal fulfillment. Taking part in a venture which has such a positive impact on the local community was a particularly rewarding aspect of the project.

The ITC project has certainly afforded students with excellent experience in tackling realistic engineering problems and has better prepared them for successful engineering careers!