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IPRO 317
[Final Report]

Design & Build Chicago Scale Model For Dynamic Disaster Simulation

May 2, 2007

IPRO 317 It takes a team INTERPROFESSIONAL PROJECTS PROGRAM

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Introduction

The IPRO 317 team took on a project involving the planning, designing, and constructing of a 3-dimensional and dynamic scale model of Chicago City downtown. This model will be used at an interactive model of the city in which to portray disaster scenarios and simulation animations of possible city emergency strategies. The IPRO team had many things to consider. Different teams were formed to tackle the tasks of building the model, defining the disaster scenarios, programming software for a visual display of the scenarios, and determining the appropriate equipment and electronics for this project. Pulling together students from all areas and disciplines, IPRO 317 was a collaborative effort in producing a scale city model with an interactive display that could prove useful and beneficial for use in disaster relief in the City of Chicago.

Background

The idea for IPRO 317 actually started as a proposal for a model developed by students in another class in a previous semester. The students presented a project in the course of CAE 331 – Building Science. These were the original objectives and primary goals discussed in the proposal for the creation of a Chicago City scale model for the purpose of displaying dynamic disaster simulations.

- To Map in Three Dimensions the Highest Density City Areas
- Primarily for Fire Department Use
  - Familiarizing Fire Department Personnel with Target Area
  - Identifying Problematic Scenarios
  - Illustrating a Vast Array of Potential Disasters
  - Simulating Disaster Response in Real-Time
- Other Uses
  - Wind Load Testing
  - Environmental Impact Testing

In their proposal, the students addressed an initial model overview.

- Translucent Acrylic Construction
- Includes All Major Structures
- Special Treatment of Unusual Site Features (2-Story Streets, etc.)
- Digital Projector Technology
- Demountable and Portable
- Expandable

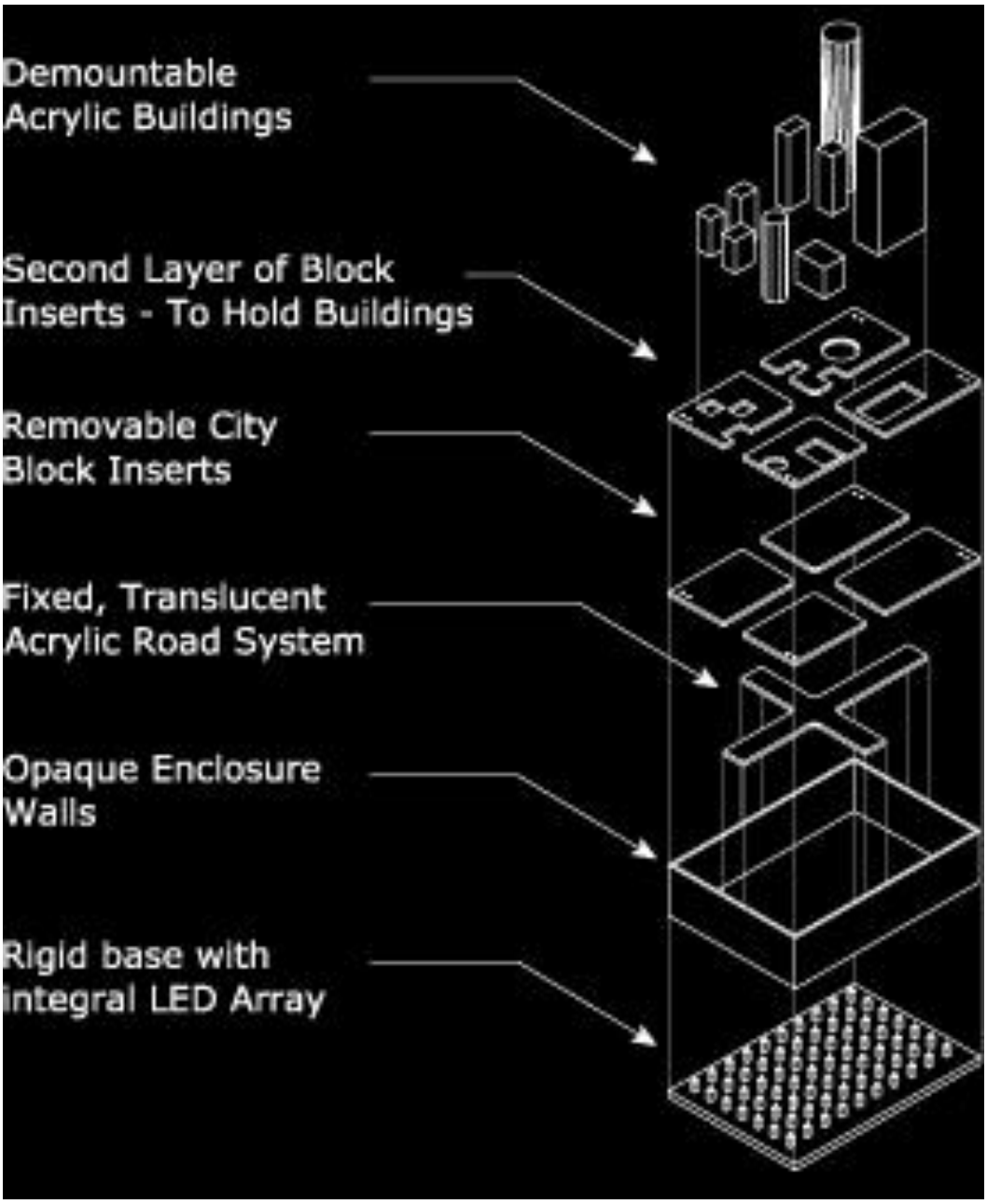
In the initial proposal, the students also had a grasp on the project teams and the skills they needed to complete this task.

- Architecture Students (7 students)
  - Responsible for the physical creation of structures
  - Determine building selection and representation
  - Creation of standards for physical construction
- Animations (2 students)
  - Determine software for displaying scenarios
  - Code scenarios
- Scenarios (3 students)
  - Meet with CPD to develop realistic disaster scenarios
- Electrical Engineers (2 students)
  - Determining an effective means of lighting the model
- Computer Science (2 students)
  - Coordinate methods of display and representation
  - Working closely with architecture studies to turn informative symbols digital

There were initial model construction concepts and the materials needed for this construction. Here is an overview of the model.

- Modular Construction
- Rigidity with Portability
- Fixed Street System
- Removable Blocks and Structures
- Computer-controlled, projector Array resides in base of model

Initially, the model was proposed to be built in different layers.



The proposal included ideas for possible scenario development and considerations for the City of Chicago as the stage for disasters.

- Fire Simulation
  - Localized and un-localized
  - Of various Causes and levels of Intensity
- Bombing
  - Various targets such as those with high tourism draw or iconic level
  - Of various strengths
- Evacuation Modeling
  - Building Evacuation
  - Street Evacuation
  - Wide Scale City Evacuation
- Analysis and Specifics Pertaining to Individual Structures
  - Age: Based on age of fire prevention systems or based on fire code compliance
  - Bridges
  - Daily Population
  - Financial Institutions
  - Fire protection systems in place
  - Height
  - Mass Transit Stations
  - Subterranean Structures
  - Terrorist Targets
  - Tourist Locations

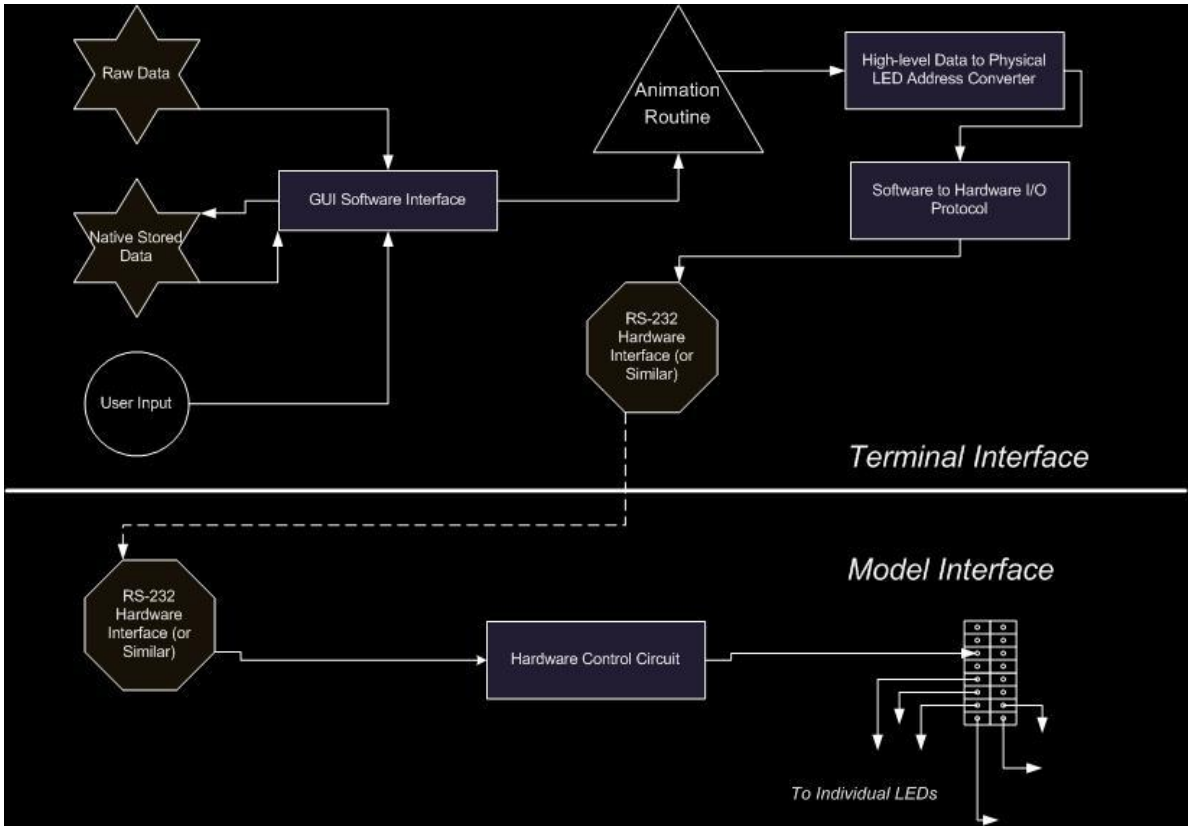
Included in their proposal, the concepts and method of displaying the scenario simulation was decided as an under-light display. The buildings would be illuminated from a projector below allowing people to see visually the colors and graphics integrated into the model.

- LED arrays
  - IPRO built
  - High probability of component failure
  - High power consumption
  - Unavailable and cumbersome controller technology
- TFT
  - Readily available technology and computer interface
  - Low illumination ability
  - Non-discreet edge conditions
  - Awkward methods of controlling
- Digital Projector
  - Readily available computer interface
  - Low power consumption
  - Best option for wide and even light distribution
  - Uniformity in illumination

- Lends best to portability
- Fewest amount of parts - greatest reliability
- Packaging allows ease with serviceability
- Requires the greatest depth

The students considered the need for a software-hardware interface. Programming would be necessary in order to translate the scenario strategy information into a computer language that could be displayed through the lighting display. Ideas for the interface development were also addressed.

- Hardware/ Software interface
  - The consideration of many different software types for creating the best means of model interaction
- Symbol Intermediary
  - Working closely with the architecture students on the goal of effectively bringing in symbols and characters to adequately showcase the preprogrammed scenarios
- Scenario Coding
  - Storing a series of pre-selected and orchestrated scenarios for use as a teaching aid to the CPD
  - Built in flexibility to edit or add more scenarios as the city deems appropriate



Purpose

The purpose of IPRO 317 is to design and construct a 3-D, reduced scale model for a portion of downtown Chicago. The model will be primarily used to test and simulate the likely performance of fire defence strategies in case of fire or other catastrophes related to public health. The problem includes design and building of the Chicago City scale model. The basic concept for the model is a modular, acrylic structure sitting atop a rigid base with opaque sides. The components of the model will be base, streets, city blocks, and buildings. The highlight of the model will be lighted by a projector with the use of mirrors and lenses built into the base structure, which will illuminate the various acrylic features of the model based on input from a computer interface.

This IPRO 317 team is in conjunction with the Chicago Fire Department to develop this Chicago City scale model for dynamic disaster simulation. The city will be able to use this model as a reference and a guide for them to approach disasters. Being dynamic and interactive, the fire fighters and emergency responders can see different scenarios and determine a plan of action in advance to an actual disaster striking Downtown Chicago. The ultimate goal of the Chicago Fire Department is to have a fool-proof, highly sophisticated city scale model with amazing graphics and visuals backed by researched data and proposed strategies for disaster relief.

The team had an idea of many factors that would affect that progress of this project and understood what actions should be taken. Various concepts were explored during the semester of IPRO 317.

- Concepts to be explored and addressed in the IPRO
  - Identification of the scale, materials, technologies, and strategies of construction
  - Physical mapping and computer modelling of the downtown built environment
  - Design of the physical model and computer/electronic components
  - Construction of reduced-area mock-up for final approval by the City of Chicago
  - Familiarizing Fire Department Personnel with Target Area
  - Identifying Problematic Scenarios
  - Illustrating a Vast Array of Potential Disasters
  - Simulating Disaster Response in Real-Time
- Objectives to accomplish throughout course of the IPRO semester
  - Plan, build and construct 3D model of downtown Chicago
  - Choose appropriate section of downtown Chicago for modeling
  - Develop scale for optimal viewing of model
  - Determine appropriate materials for construction
  - Create CAD drawings of buildings
  - Cut and construct scale section of Chicago
  - Simulation of disaster strategies through Flash animations

Research Methodology

At the beginning of the IPRO semester, the objectives were made clear and the tasks that needed to be accomplished were understood. Different teams were created based on certain tasks. In order for each team to accomplish their tasks, research on various topics needed to be conducted. From the research, the appropriate knowledge and skills were applied to the project of IPRO 317. The idea was that each group would be responsible for their own work, and all results would be collaborated for the final deliverables near the end of the IPRO semester.

The team breakdown is listed below and the research conducted in the respective fields.

- Project Finance and Orchestration
  - Investigate the costs of the project
  - Determine budget based on figures from other groups
  - Organize daily tasks and develop schedule for the entire team
  - Evaluate progress of the IPRO and adjust schedule appropriately
- Information – Architecture
  - Find resources necessary to aid in the construction process of models
  - Determine any building heights and scaling necessary for the city model
  - Determine placement and configuration of actual buildings downtown
  - Understand the scope of downtown Chicago and flow of the city structure
  - Determine the appropriate method to display the simulation with the model
  - Develop a design to incorporate the city model with a selected projector
- Symbols and Representation
  - Figure out the necessary items to be displayed in the city model
  - Determine important landmarks and note any key names/terms
  - Select important city features and develop methods to symbolize those items
- Material Collection
  - Determine the necessary materials for the city model construction
  - Select the sizes, material type, and methods to use those materials
  - Find where to purchase these items and how to order those items
  - Calculate the amount of materials necessary
  - Develop a list of necessary items and the costs for the items
  - Ensure a place of storage and a location that can be used for constructing model
- Information – Programming
  - Determine what software is appropriate for this project
  - Learn and understand the programming language for the software
  - Develop programming sequences appropriate for simulation and animations
  - Configure the software to allow for user input and interaction

- Scenarios
  - Meet with Chicago Fire Department officials to obtain important information
  - Look into city emergency data as a consideration for strategies
  - Understand the operations of city emergency services
  - Investigate important locations within the downtown area of Chicago
  - Consult professional opinion and guidance
  - Research disaster relief stories from other circumstances
- Material Testing
  - Investigate possible problems in the construction process
  - Determine the suitable solutions to address those problems
  - Find machines and methods that could be used in construction of the model
  - Run tests on selected materials to determine usability and effectiveness
  - Inquire with individuals on methods necessary for using materials
- IPRO Deliverables
  - Become familiar with IPRO websites and resources
  - Understand requirements of the IPRO office
  - Determine the appropriate way to produce IPRO deliverables
  - Create a schedule of important IPRO dates and deadlines

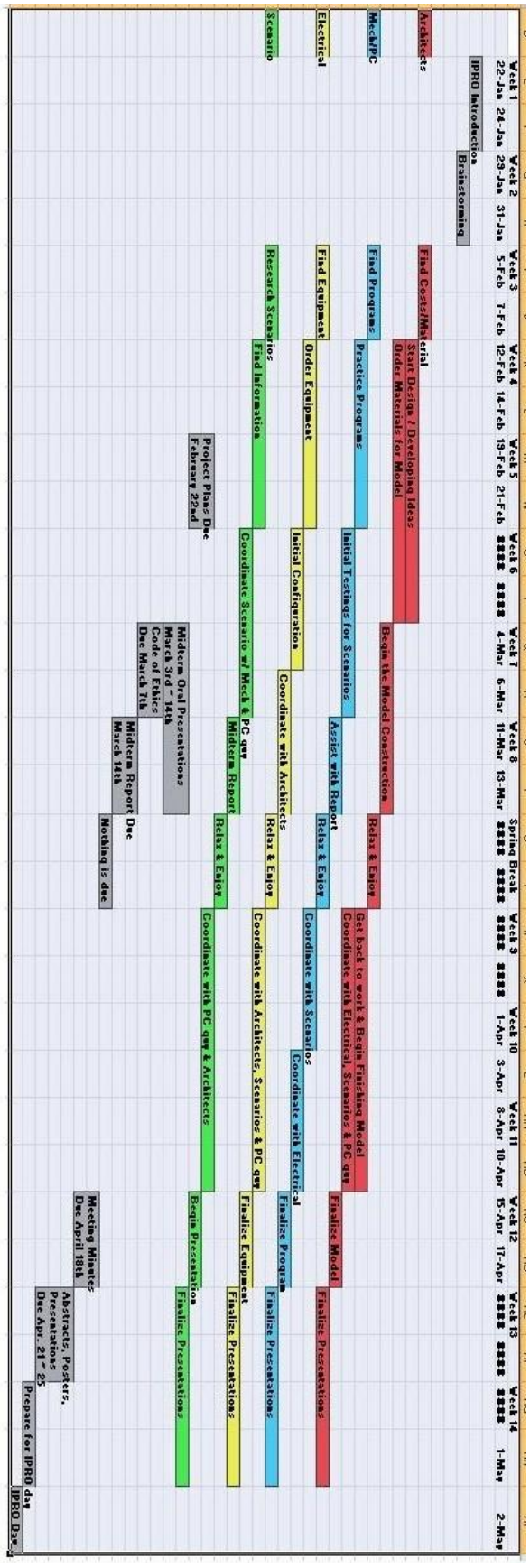
Throughout the course of the IPRO semester, the team followed this process and was able to complete the necessary research for the project. The research methodology was successful in addressing the project goals. From the research that was performed and with the knowledge obtained, the different teams were able to apply the necessary skills to their specific tasks in order to complete the objectives of the IPRO.

Assignments

The IPRO 317 team required many tasks that needed to be completed. The different tasks were divided among the team members. For each area of work, different teams were created. The teams were divided as such. In this IPRO, the work of other teams was integral with one another. Some groups could only operate if the necessary information was provided from another team. This will be explained after the team breakdown and organizational structure is explained.

- Project Finance and Orchestration
  - Mary Cyriac
  - Daniel Sochor
- Information – Architecture
  - Dung Luu
  - LaLuce Mitchell
  - David Parry
- Symbols and Representation
  - Oscar Martinez
  - Homero Rios
- Material Collection
  - Daniel O'Brien
  - Marco Trusewych
- Information – Programming
  - Sonya Martin
  - Donald Myers
- Scenarios
  - Jodi Balido
  - Hana Fakhouri
  - Brandon Macklin
- Material Testing
  - Grahm Balkany
  - Mike Brassil
  - Daniel O'Brien
- IPRO Deliverables
  - Jodi Balido
  - Hana Fakhouri
  - Brandon Macklin

A prescribed schedule was developed for the IPRO team to follow throughout the semester. Changes to this schedule were made accordingly based on evaluations throughout the IPRO semester. That schedule can be seen on the next page. It was produced using the Microsoft Excel program.


Week 1
22-Jan
Week 2
24-Jan
Week 3
23-Jan
Week 4
31-Jan
Week 5
5-Feb
Week 6
7-Feb
Week 7
12-Feb
Week 8
14-Feb
Week 9
19-Feb
Week 10
21-Feb
Week 11
$$$$
Week 12
4-Mar
Week 13
6-Mar
Week 14
11-Mar
1-May
13-Mar
Spring Break
$$$$
$$$$
1-Apr
3-Apr
8-Apr
10-Apr
15-Apr
17-Apr
$$$$
$$$$
$$$$
2-May
IPRO Introduction
Brainstorming
Architects
Find Cost/Material
Start Design / Developing Ideas
Order Materials for Model
Begin the Model Construction
Relax & Enjoy
Mech/PC
Find Programs
Practice Programs
Initial Testings for Scenarios
Assist with Report
Relax & Enjoy
Get back to work & Begin Finishing Model
Coordinate with Electrical, Scenarios & PC guy
Finalize Model
Finalize Presentations
Electrical
Find Equipment
Order Equipment
Initial Configuration
Coordinate with Architects
Relax & Enjoy
Coordinate with Scenarios
Coordinate with Electrical
Finalize Program
Finalize Presentations
Scenario
Research Scenarios
Find Information
Coordinate Scenario w/ Mech & PC guy
Midterm Report
Relax & Enjoy
Coordinate with Architects, Scenarios & PC guy
Finalize Equipment
Finalize Presentations
Project Plans Due
February 22nd
Midterm Oral Presentations
March 3rd - 14th
Code of Ethics
Due March 7th
Midterm Report Due
March 14th
Nothing is due
Coordinate with PC guy & Architects
Begin Presentation
Finalize Presentations
Meeting Minutes
Due April 18th
Abstracts, Posters,
Presentations
Due Apr. 21 - 25
Prepare for IPRO day
IPRO Day

Obstacles

- In preparation for the building blocks:
  - The sheer amount of buildings needing to be cut and organized made this task daunting
  - Cutting 2" acrylic is dangerous and cumbersome in large sheets due to the fact that she sheets are very heavy
  - For bonding and hardware research it was hard to contact informative professionals
- Creating the CAD drawings for the model base:
  - The model base design was far more complicated than anyone had originally estimated
  - Costs will be fairly high
  - Fabrication must be done with exacting precision
  - Time will be required to produce base (additional assistance was required)
- Correspondence with Dr. Muehleisen and the physics department in attempt to secure diffraction gratings
  - Options are limited and none are guaranteed
  - Attempts were unsuccessful
  - Received broken promises from physics department
  - It became too late in the project and decided to not to pursue this anymore
- Projector and projector tests
  - There was a critical flaw in the projector concept that needs to be rectified
  - The team did not catch this problem until testing with the projector
  - Weight of acrylic
  - Proper alignment of the projector is difficult
- Scenario research process
  - Limited availability scenarios team to get information from the Chicago Fire Department
  - Limited availability of contact informative professionals due to busy schedules

Obstacles that were resolved were the cutting out of the acrylic buildings. Some difficulty was exhibited in doing this but this was accomplished by 6 different individuals cutting on the table saw, and this took several hours.

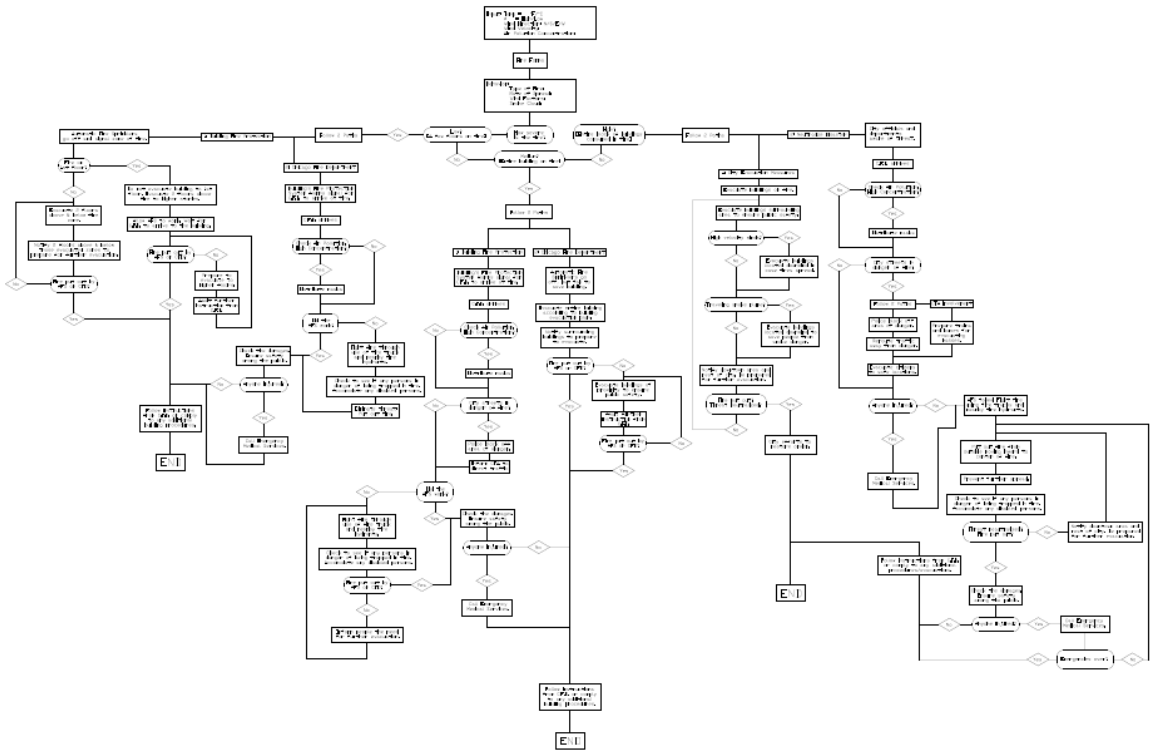
The cost of materials proved to be a challenge but this was overcome by assistance from the faculty advisor. The sole provider of the cost of materials, GIS info, etc, was the Chicago Fire Department. In essence, miscommunication occurred and the teams were not accommodated in this regard.

In the future, teams should recognize the extent of the tasks that need to be completed for a huge area such as downtown Chicago. Teams must understand the area that will be depicted. Teams should expect the same obstacles as stated above, but hopefully there should be more funding in preparation of this project.

Results

Research findings were somewhat successful. Though plenty of research was conducted for this project, such as research for the projector, scenarios, computer programming, etc. the professionals that were sought out to assist understandably have much work of their own to accomplish. So the efforts portrayed in this project were mainly through secondary research tools. Primary research/interviews were conducted, but were not as effective because those types of resources were not always readily available.

Located below the flow chart that was created for the disaster scenario in case of a fire in downtown Chicago.



Recommendations

In creating scenarios, creating a program to accent those scenarios, and creating a model depicting and incorporating all the information needed to comprise this subject, there must be good communication amongst all members of the team. Also there must be proper communication amongst outside sponsors and the team so that issues should not arise quickly. Work and preparation must be started early to reach obstacles in the beginning, so that the obstacles can quickly be dissolved and then the team can move on from there. Future teams must also acknowledge the issue of money early on so that it will not be an issue later when the prospected project is due.

References

Dr. Ahmed Megri

Chicago Fire Department and informative officials

Research via internet and inquiring with shop supervisors in Crown Hall

Acknowledgements

A big thank you is extended to the faculty advisor and the individual team members of IPRO 317 for all their hard work. This IPRO would not be anything if it wasn't for the collective effort of all members in accomplishing their respective tasks.

Faculty Advisor:

- Dr. Ahmed Megri - *Assistant Professor, Co-Director, Architectural Engineering Program, CAEE Department*

Students: (listed by degree program)

- Aerospace Engineering (1 student)
  - Sonya Martin
- Architecture (8 students)
  - Grahm Balkany
  - Michael Brassil
  - Dung Luu
  - LaLuce Mitchell
  - Daniel O'Brien
  - Homero Rios
  - Daniel Sochor
  - Marco Trusewych
- Architectural Engineering (2 students)
  - Jodi Balido
  - Brandon Macklin
- Chemical Engineering (1 student)
  - Hana Fakhouri
- Computer Science (1 student)
  - Donald Myers
- Electrical Engineering (2 students)
  - Mary Cyriac
  - David Parry