Project **SPARTAN SUPERWAY**

International Institute of Sustainable Transportation

San Jose CA, Summer 2015 **Caleb K. KABEYA**

As an apprentice engineer, I had to stay abroad for a period of eight weeks minimum, to complete all requirements to validate my diploma. For its great diversity and culture, I chose California and plus I got a great opportunity to work on the Spartan Superway project in San José.

I want to thank Ron SWENSON, the president of INIST, for giving me this opportunity to work on the project and meet some personnalities.

I thank Professor Furman B. for all advice and mentoring in my tasks.

I thank also Francis De Winter the mentor for his help to cut metal, to give me advice, to help me discover some places in San Fransisco, San José, Santa Cruz, etc.

I want to thank all people whose helped me and participated in the tasks I had to do, including alumni, American students 2015 and mostly the cabin team : Rebecca AVAREZ, Mark ACOBA, Lucas PETERSEN who kept on the work and some tasks after I left.

SUMMARY

I. INTERNATIONAL INSTITUTE OF SUSTAINABLE TRANSPORTATION

Today's new urban populations expect a high quality of life at the heart of their urban experience. Improving the quality of live for city inhabitants is, however, challenging. Finding suitable land for infrastructure projects developing community support, obtaining stakeholder consensus, securing financial resources, and overcoming restrictive protocols—these are the challenges which professionals face. In the process, citizens want to be empowered to participate in designing their surroundings. Recognizing these challenges, an international team of professionals has formed the International Institute of Sustainable Transportation, INIST. INIST will initiate, finance and define Urban change projects on a non-profit basis, assisting in the transition from life based on fossil fuels to a sustainable future based on renewable energy and automated transportation for all.

1. INIST Organization and resources

INIST staff and partners have comprehensive skills and experience in the core disciplines needed to build projects that dramatically improve quality of life – project management, general design, energy analysis, innovative transportation solutions, public outreach and more. INIST does **NOT** compete with traditional consultancy studies. INIST provides conceptual designs in collaboration with students professionals and advisors.

INIST establishes partnerships with top key professional organizations for best performance available on all levels of a project – architects, developers, transit specialists, solar consultants and virtual model providers.

2. INIST Methodology

A vital tool for INIST's work is a communication platform designed to facilitate collaboration by all parties interested in the development of the urban landscape. The platform is based on visualization, simulation and social networking to create a self-generated knowledge database that is easy to understand and share. Participants arriving later in the project can easily pick up and understand process that preceded them. This approach also substantially simplifies the development process, as developers, consultants, and specialists have a common operating platform for all to share.

3. INIST Collaboration

INIST does not require a city to provide any financial support for its participation in identified projects. When offered a quality of life project, the city will be asked to endorse the project and give authority to INIST to negotiate with one or more local stakeholders to finance the development work on a non-profit basis.

4. INIST Advisors and partners

INIST is organizing a group of advisors and a network of partners, all driven by the goal of creating an environmentally sound economy based on rapid innovation and proliferation of best practices for sustainable living.

II. SPARTAN SUPERWAY

A Solar Powered Automated Transportation System

Sustainable Mobility System for Silicon Valley (SMSSV) is an interdisciplinary project from San Jose State University to design a PRT (Personal Rapid Transport) system using renewable resources.

1. Project Overview

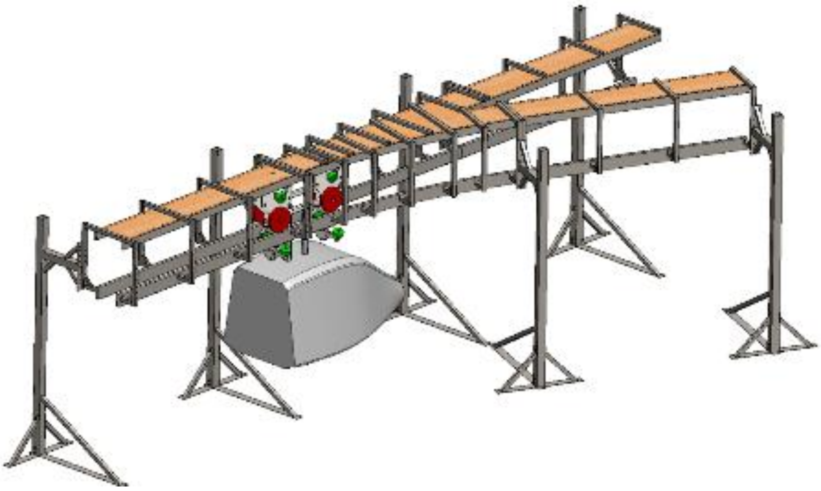
Present mobility options, especially in dense urban areas are becoming more and more unsustainable. Major issues that plague current options are:

- Traffic congestion
- Loss of productivity from time spent in commuting and/or parking
- Continued use of and dependence on hydrocarbon fuels
- Increased possibility of accidents that injure people and damage property
- Decrease in quality of life for residents (wasted time, increased stress, noise, smog, safety)
- High cost of ownership for private vehicles, especially new 'green' vehicles, such as EVs and HEVs
- Excessive consumption of raw materials in the production of automobiles
- Environmental degradation from greenhouse gas emissions and by products from wear out of parts
- Inadequate mass transportation options (slow, limited service area, and relatively high cost)

Fundamentally different approaches to personal mobility are needed to address the problems listed above and achieve sustainability. An automated transportation network (ATN) system utilizing a podcar™ is one such approach (see for example: Irving, et. al. (1978), Rydell (2000), and Shawber (2012)). We propose to develop and bring to market the elements of a solar powered ATN system that will be scalable, replicable, and that can be located within existing rights of way in urban locales.

The Spartan Superway project is a multi-year and interdisciplinary project that is currently in its third year in an academic environment. The Spartan Superway project is an effort to develop and demonstrate the technology of an Automated Transit Network (ATN) that is powered by solar energy. Starting off as 25 students, the students organized themselves into Management, Manufacturing, and Design teams. The management team oversaw and ensured the teams' success by enforcing weekly meeting, meeting agendas, and encouraging team communication. In addition, the management team and team treasurer were responsible for handing the project's expenses. Lastly, the management team was responsible for team outreach. During the 2014-2015 year, Spartan Superway was able to present to Norman Mineta, former U.S. Secretary of Transportation, at the Stanford Precourt Energy Conference, and to Jeff Zhou, CEO of MiaSolé, at Maker Faire. The Manufacturing Team oversaw the Spartan Superway Machine Shop and workspaces, provided consultation concerning manufacturing of models, and assured the safety of their fellow teammates. For 2014-2015, there were four distinct design teams: Full Scale, Scale Model, Cabin, and Solar teams. This year more teams are added as a bogie team, suspension team etc. The following sections will summarize the accomplishments of each design team.

2. Full Scale model



The main purpose of the Full Scale Team was to create and manufacture a modular full scale prototype that can adequately represent the benefits and feasibility of an ATN system to both the public and to any potential sponsors of Spartan Superway. The full scale prototype should closely resemble an actual full scale implementation to the extent that it serves as an adequate proof of concept. This results in the significant dimensions and size of the prototype to be full scale, but the overall strength and load capacity reduced to allow for ease of transport and to reduce cost. The team 2014-2015 focused specifically on making improvements to the guideway, implementing vehicle propulsion, adding a Y-shaped switch track section, and adding a switching mechanism to the bogie, so that it could demonstrate the ability to switch from one guideway to another.In order for the 2015 Full Scale Team to meet its design goals, the previous year's
challenges and issues had to be identified, in order to build off previous work. The Full Scale Team was divided into three sub-teams each of which focused on a different aspect of the project including guideway, propulsion, and bogie switching. Each of these teams focused on their specific tasks and encountered their own issues. Ultimately, each sub-team had common challenges of designing to minimize cost, ease of fabrication, incorporating systems with existing hardware, and designing to sufficient strength to avoid failure while still fulfilling the purpose of the project.

3. Cabin

The purpose of the cabin team is to design the cabin for the ATN and build a mock-up version of a cabin for Maker Faire. The design of the cabin should be structurally sound, aesthetically pleasing, and have a low drag coefficient. The cabin design is intended to be the basis for what could be used in service. From previous years, the cabins were large and difficult to transport. The mock up cabin this year will be made for people to be able to experience what it would be like to ride in a real ATN vehicle. The mock-up will be stationary and not go on the Guideway. It will also be easy to assemble, disassemble, and transport. Since the cabin team is creating a new design, we could not use the work done by previous teams. The design from last year could be improved and there was no mock up cabin preserved to show for Maker Faire. The Cabin team planned on designing a new interior, exterior, and frame. The support of the cabin was designed to be a rib-liked shape; consequently taking on the shape of the exterior. The cabin team built the structure and exterior to be integrated together and added curvature to the cabin. Bondo was used to cover the curved sections and transition it to the flat sides. The interior for the mock up cabin was intended to have different accessories that could be in the real cabin such as a touch screen, and lights but was not implemented. The Cabin team designed a structural frame with a mass of 341 kg but was unable to complete the analysis of supporting 1370.7 kg. The drag coefficient of the exterior shell was 0.03. The HVAC system requires 1.8KW to maintain at 23 ^{o}C. Future work would be to use a master drawing on SolidWorks to keep the designs of the frame, exterior, and interior together. Designing a full cabin with doors is the biggest goal so people could sit and walk around the cabin. Applying an analysis on the cabin not just the frame would be another goal. Having material such as metal and plastic outsourced would make it look professional and closer to the real pod.

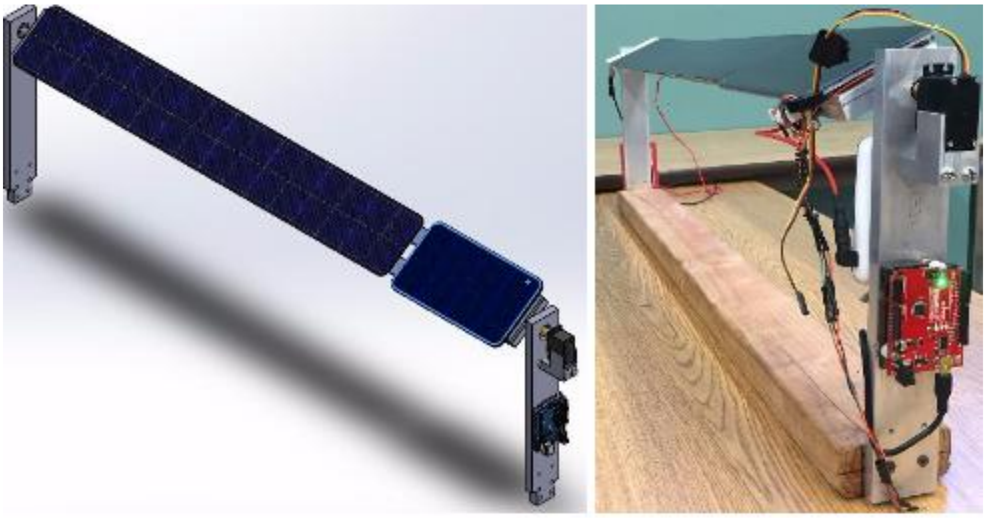
4. Scale Model

The 2014-2015 Scale Model Team focused on several important aspects of the Superway project. The team learned from the previous year's design and throughout the academic year. The main task of the scale team was to redesign the track and bogie while considering a few stipulations. The new track design also allowed the team to simplify the assembly of the track. This design was seen as a solution to the reliability concerns since the bogie would not be getting stuck in the track gaps. The track is composed of simple aluminum bar that is made into modular sections of guideway. These modular sections will look similar to the Full Scale model and ultimately close the gap between Full Scale and Scale model. The final piece of the improvements has to do with supplying power to the bogies. Batteries are being replaced by wayside pickup using multiple power supplies powering electrical rails around the track. The bogie will use this available power without the need to store it on board. The new design emphasized ease of use and reliability. The controls team designed the main hub for the system, and wrote the pod control and communication control codes from scratch. The system was completely functional by the end of the semester but due to mechanical failures, the team was not able to test the controls with the pods on the track. Future work would include redesigning the bogie in order to make it go smoothly around the track. The switching mechanism can be polished a bit more to make it more reliable and simple. The controls portion of the project could use optimization through the use of API mode. The python script can also use a little work to make it more efficient. Cyclic Redundancy Checks (CRC) could be implemented instead of the complicated handshakes included in the current system. It would be nice to designate one person for all the hardware hookups so that every detail is accounted for. If the current schematic is satisfactory, future teams should consider getting a Printed Circuit Board (PCB) made for a cleaner look on the cabin. The track can also be modified to include higher tolerances for smoother travel; current design requires extreme precision, or else nothing will function correctly.

5. Solar Team

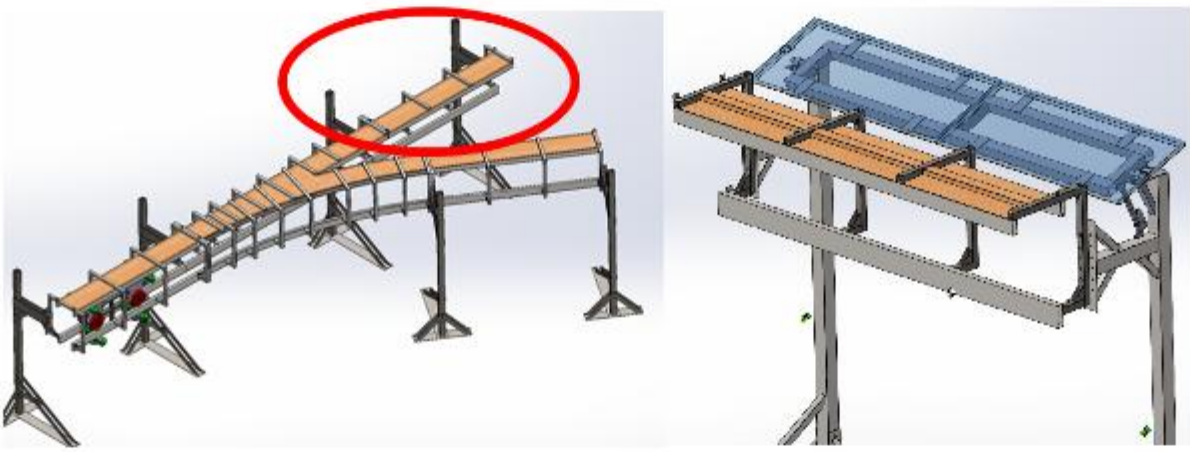
The solar panel implementation is a major contributor to the overall effectiveness of such a system. The 2014-2015 Solar Team's goal is to design and fabricate of a lightweight functional solar tracking system and stationary design which showcases thin film flexible panel donated by Miasolé. In addition, the solar team designed the models for ease of assembly and maintenance and minimal power usage. In order to accomplish this goal, three models were built: Tracker for the Scale Model, Tracking Capable Frame Model for Full Scale, and Miasolé Model for Full Scale. Just like the previous year, the solar panel frame assembly design was split up into two separate models to be demonstrated at Maker Faire Bay Area: a Scale model and a Full Scale model. Thus, the objective for this year's solar team includes the following: (1) design a lightweight single-axis solar tracking frame assembly, (2) successfully rotate the solar panel Spartan Superway 2014-2015 8 assembly, (3) minimize the power required to track the sun, and finally, (4) come up with a design that is both easy to assemble and maintain. However, only objectives (2) and (4) will be demonstrated in the Full Scale Model, because with all successful designs, it is important to design

and build at a small scale before moving onto the actual implementation in a revenue producing ATN full-fledged model. The Tracker for the Scale Model, depicted in Figure 5e-1, uses the inputs from two photo resistors in order to determine the optimum position to collect solar power. An Arduino controller board is used to take the inputs from the photo resistors and drive the servo in the appropriate direction. The servo is attached to a coupler and the drive shaft. As the servo rotates, the drive shaft, solar panel frame, and solar panels rotate with it. This model demonstrates real-time tracking and is automatically positioning. The Arduino is powered by the Voltaic Systems portable solar panel and charging system. In order to collect data, a voltmeter connected to the custom Miasolé thin film flexible solar panel so that panel voltage data can be collected while the tracker
model is active.



: Tracker Model for the Scale Model holds a custom Miasolé Thin film Flexible Panel anc powered with a Voltaic Portable Solar Panel+ Charging System.

The Tracking Capable Frame model (TCF) for the Full Scale Guideway rotates and showcases Stion Modules on a newly retrofitted frame made from recycled aluminum tubing (see Figure 1-6:6). The TCF rotates 70 degrees to 115 degrees and is driven with a 180 lbf. ServoCity linear actuator. Two mounted sleeve bearings are used to assist in the rotation and assure the frame is supported by the full-scale column supports. As a result, this more robust design enables optimum solar power efficiency throughout the day compared to the stationary (i.e. static) solar panel frame that was designed by last year’s team.



III. PERSONAL MISSION ON THE PROJECT

1. Presentation of the mission

My personal mission on the Spartan Superway project was to design and build a lifting gantry. A system which is able to lift the cabin and move it on for any reason. I designed the system thanks to SolidWorks, with a steel as material. Some parts of the system are screwed, and some others parts are welded. The final assembly will be made by technicians from San Jose State University.

I helped also to complete the cabin mockup by sculpting and sanding the exterior.

During my stay on the project, I got some privilege to be trained and improve my knowledge in SolidWorks from a mentor on SolidWorks Paul Albulet. I also attended many meetings about the project. For example a transportation Swedish delegation, and Bill James (Jpods)

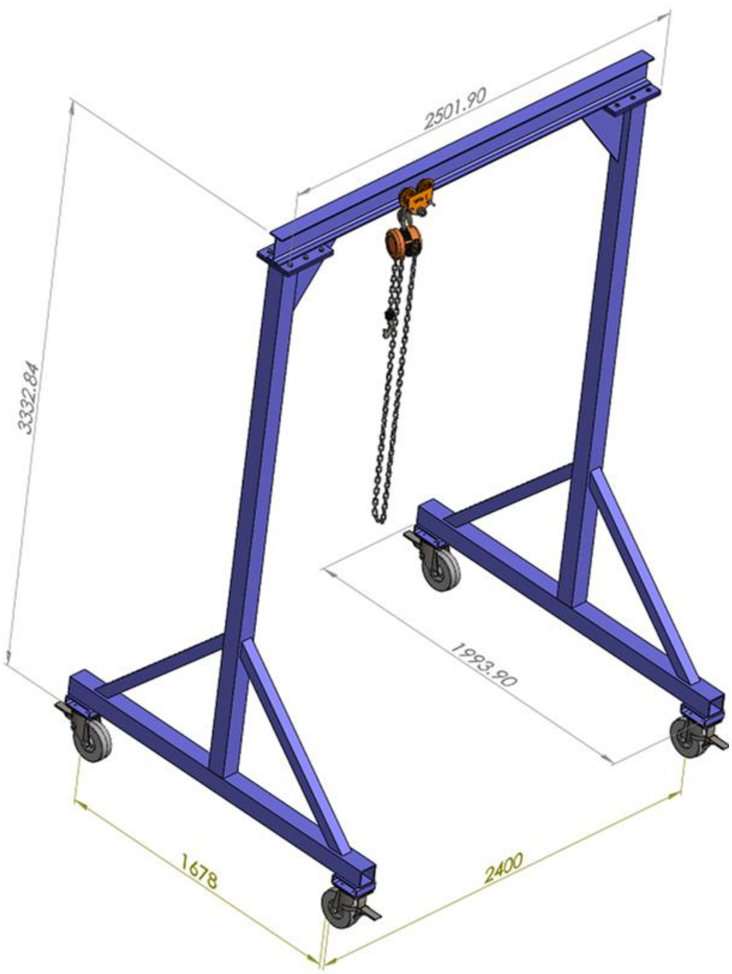
I participated in some public activities, for example a prize-winning exhibit at the annual Silicon Valley Electric Vehicle rally in september.

Caleb Anne Michael Åsa Becca Erik Rod

Below are the range of manufacturing and all details of the design of the lifting gantry

2. List of needs

All dimensions are in millimeters

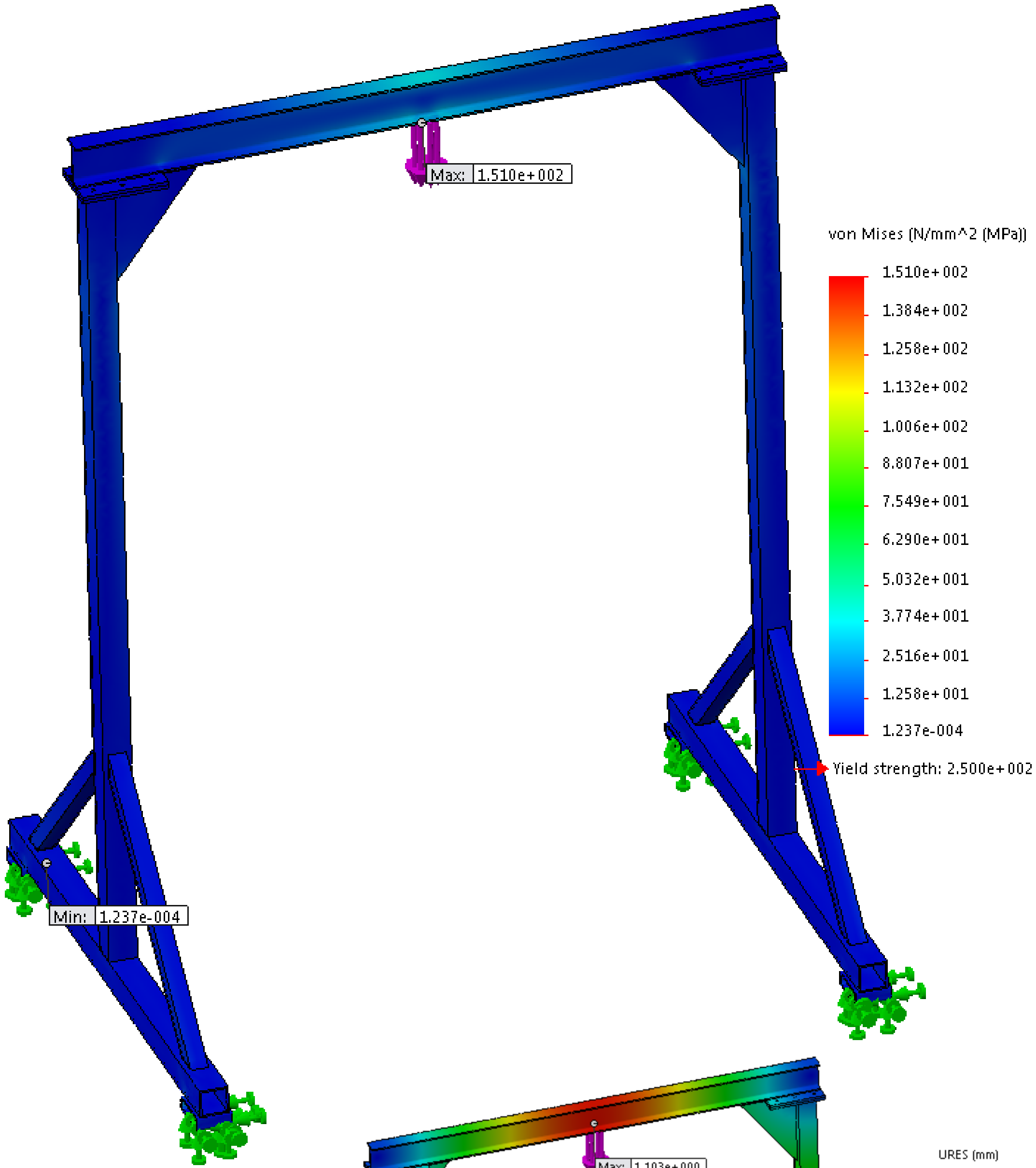


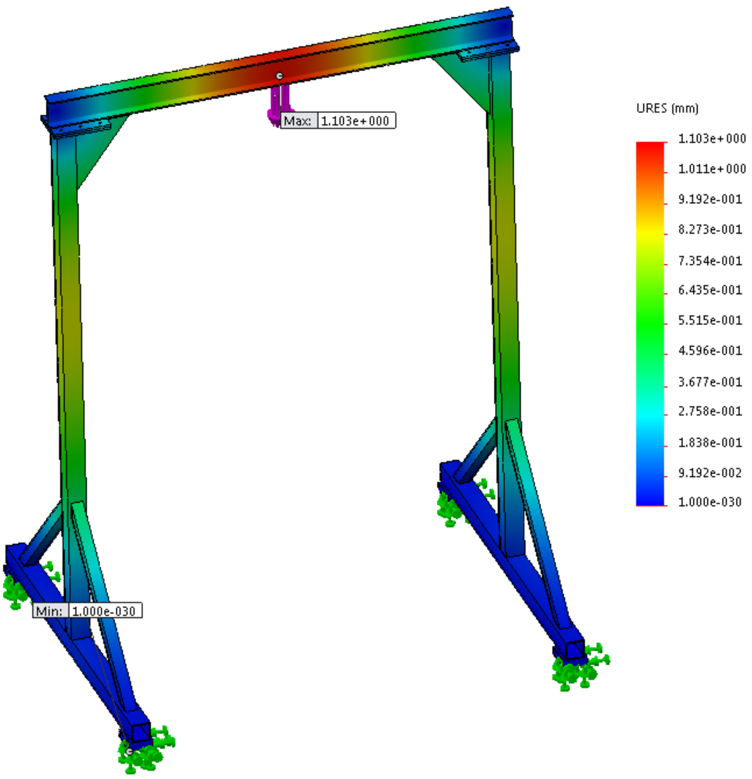
Item	**Dimensions inch**	**Length mm**	**Quantity**	**Comments**
Square tubing	4x4x0.188"	3000	2	
Square tubing	4x4x0.188"	1993.90	2	
Square tubing	2 ½ x2 ½ x0.188"	1130	4	
Rectangular tubing	6x2x0.250"	127	4	
IPE 200	IPE 200	2501.90	1	
Flat bar	12x1/2"	212	4	
Flat bar	12x1/2"	400	2	
Screws	M10	TBD	12	
Screws	M8	TBD	16	
Whashers	M10		24	
Whashers	M8		32	
Nuts	M10		12	
Nuts	M8		16	
Casters	8 inches		4	
Electric Hoist			1	2000 lb

The material used for this design is a steel ASTM A36 grade B

3. Simulation of static deformation

Force of 2000 kg was applied on the top of the lifting gantry. Bellow are the results.





<u>Conclusion :</u>

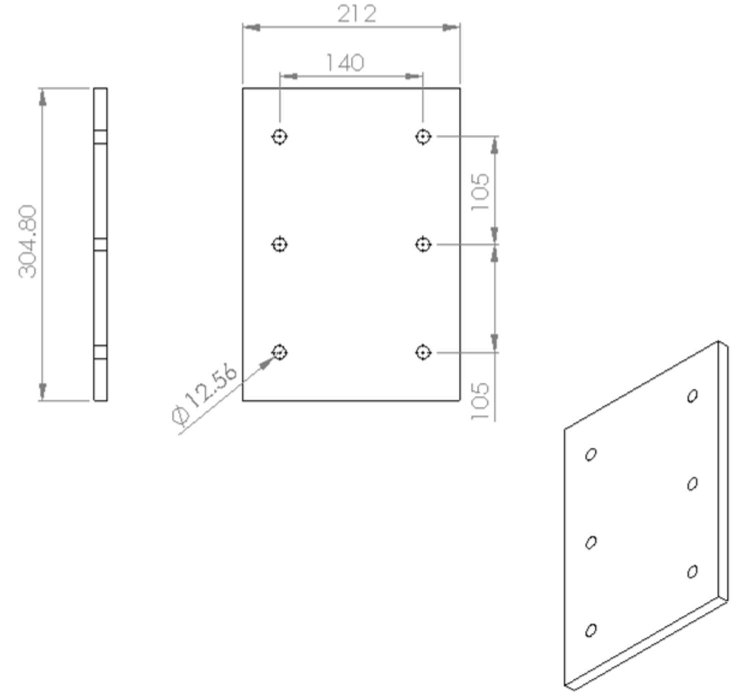
The yield strength of material is 2.500 e002 , and when 2000 lb are applied on the I-beam as shown in this picture the maximum of yield strength is 1.510 e002.
That means we are under the yield strength and the lifting gantry can support 2000 lb.

4. Range of manufacturing

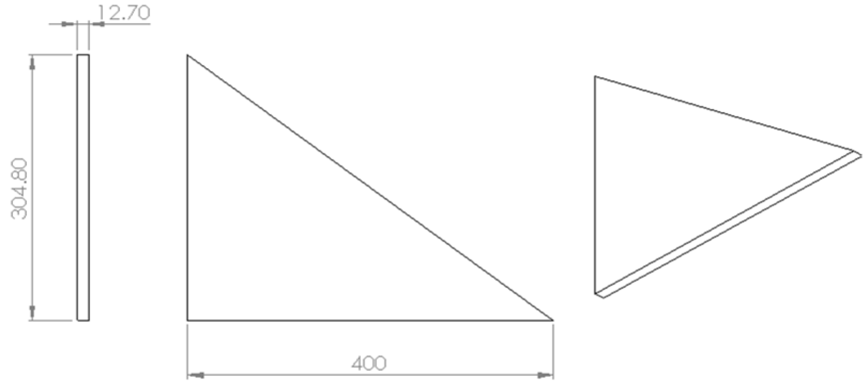
First step

Prepare components by cutting, drilling and deburring frames

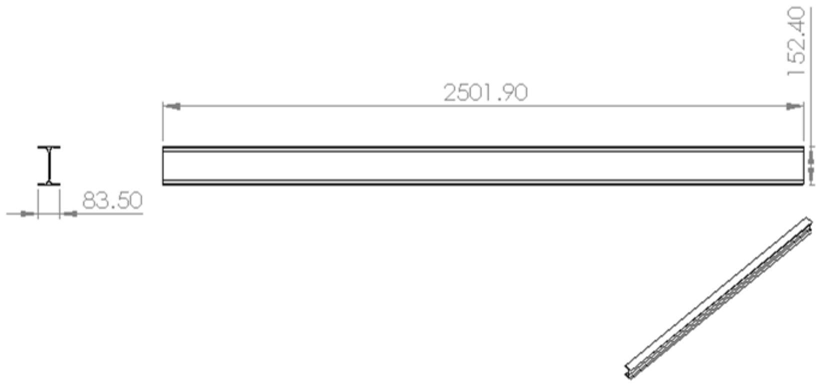
Flat bar 12x1/2"



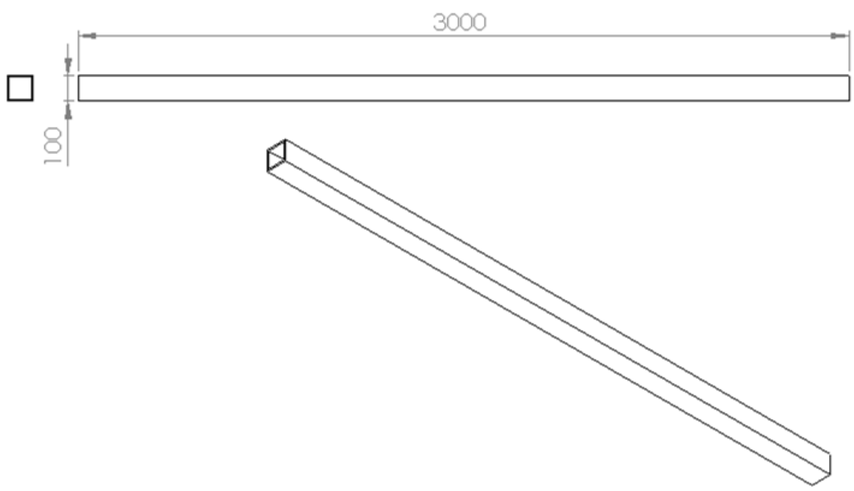
Flat bar 12x1/2"



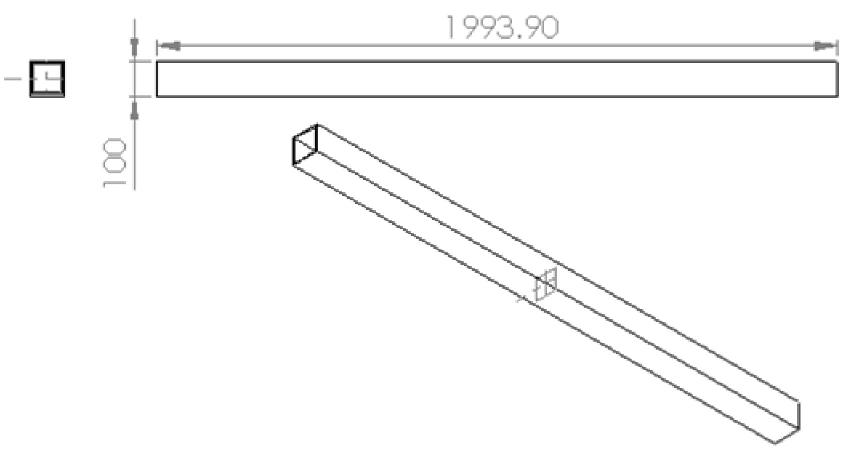
I-beam



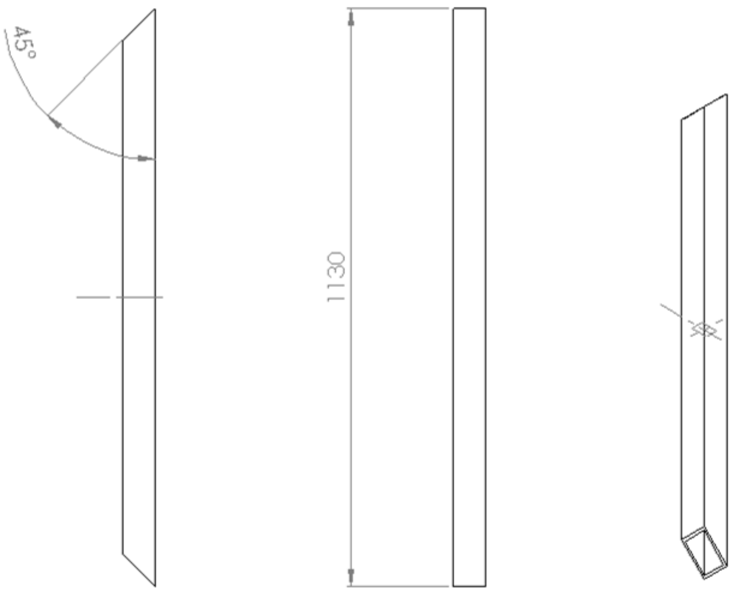
Vertical square tubing



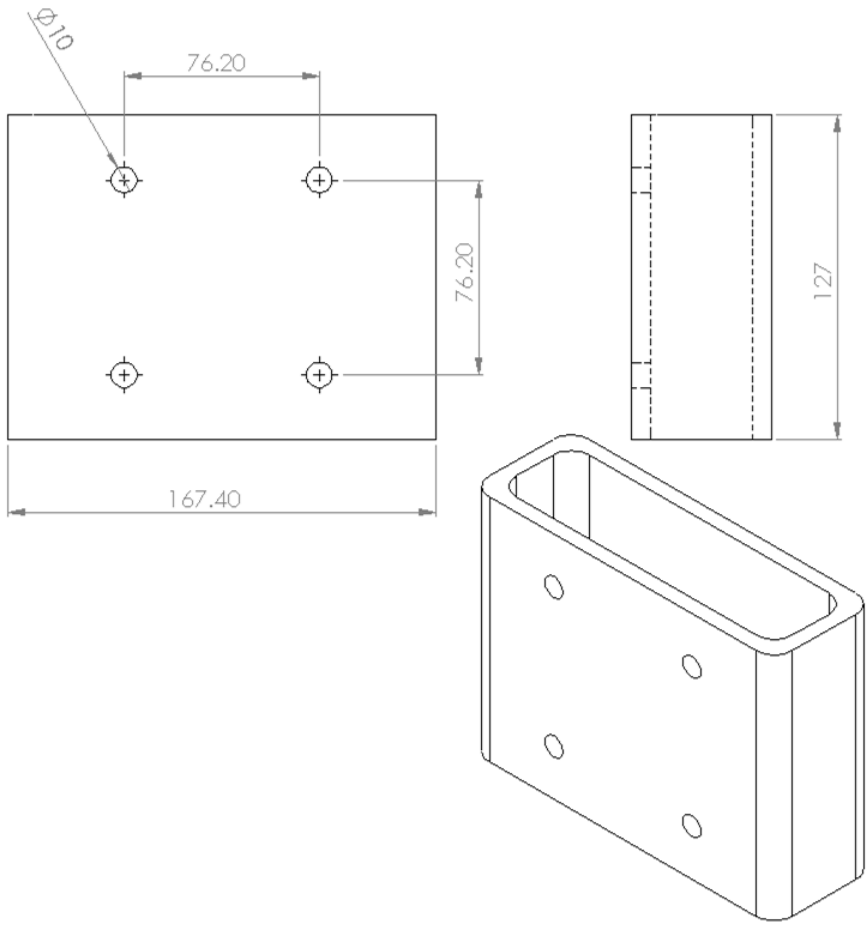
Horizontal square tubing



Mechanical rib square tubing



Support for casters

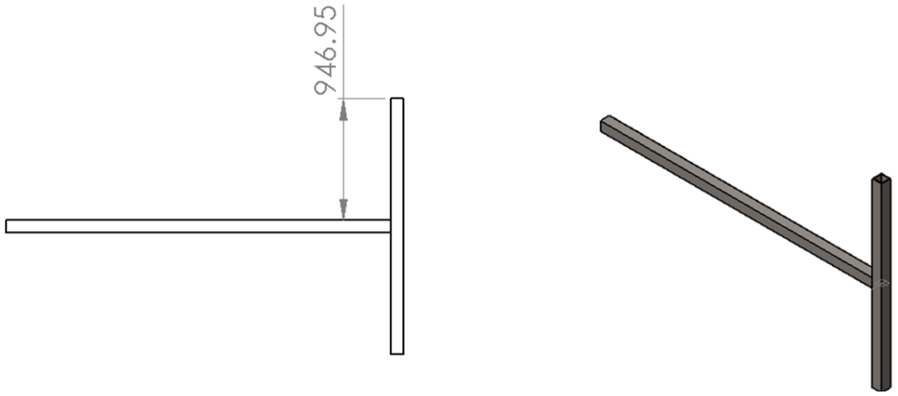


Second step

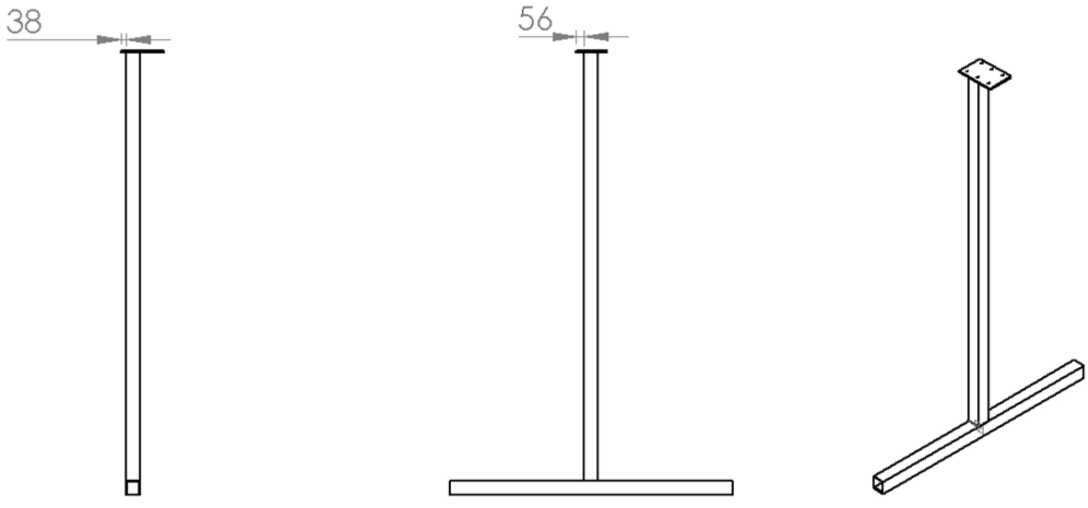
Making assembly step by step : by screwing and welding

Check the squareness before welding

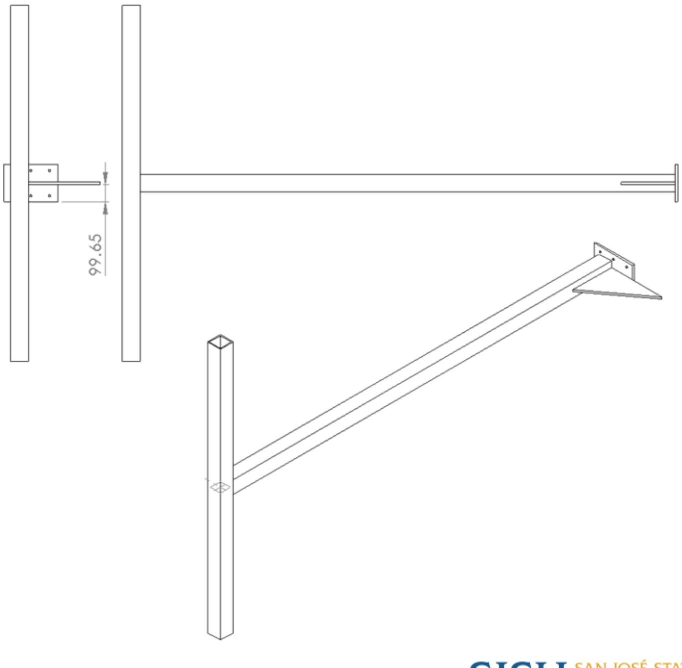
Vertical square tubing with horizontal square tubing



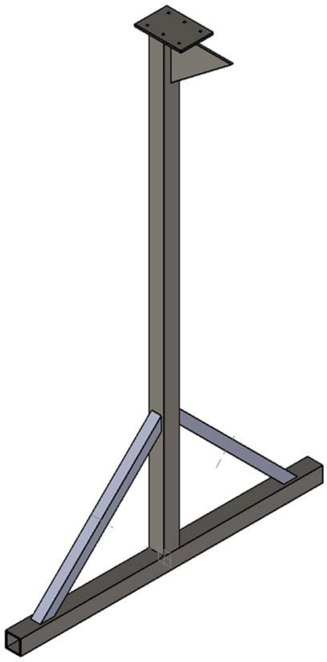
Vertical and horizontal square tubing with flat bar



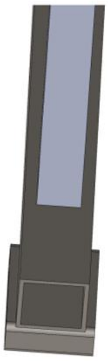
Add triangle



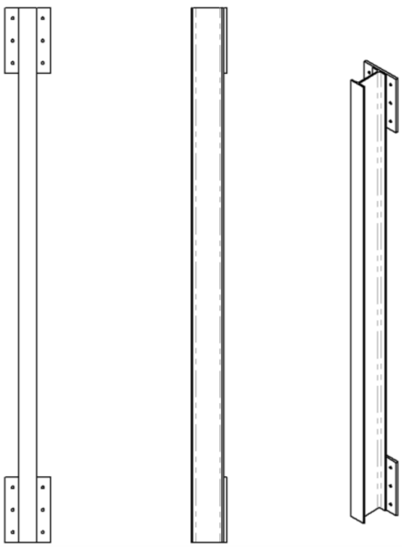
Add mechanical ribs



Add supports of casters



I-beam with flat bar



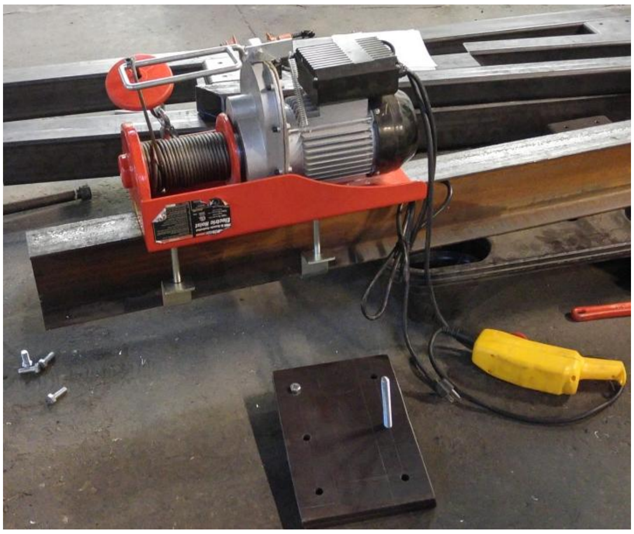
Add Casters before fixing the I-beam

Assembly I-beam with two parts

Use 12 screws M10

5. **Details of casters, electric hoist**

- **Casters :** Load rating 1200 lb, 8 inches with total lock
- **The electric hoist :** Capacity of 2000 lb



IV. THE CULTURE IN CALIFORNIA

1. People

People in California are very cool, pleasant. They are very friendly. By the way there is too much miscegenation, certainly from the story of the State of California, its origins. There many Asian people, from China, Japan, Korea Vietnam etc. Indian people, Black people and Mexican people of course. California was occupied by the Amerindian, then colonized by the Spanish. Afterwards it was taken by the Mexicans before it achieved its independence early as 1948.
Many people can speak Spanish, about 25 % of the people**.**

As there is diversity of people, there are also many types of foods. Mexican food, Chinese food, Indian food etc. There are also the local fast foods.

2. Geography

California is the third largest State in USA afterwards Alaska and Texas, it was the most populous State of the USA in 2010. It should be noted that California is the richest State in the USA.

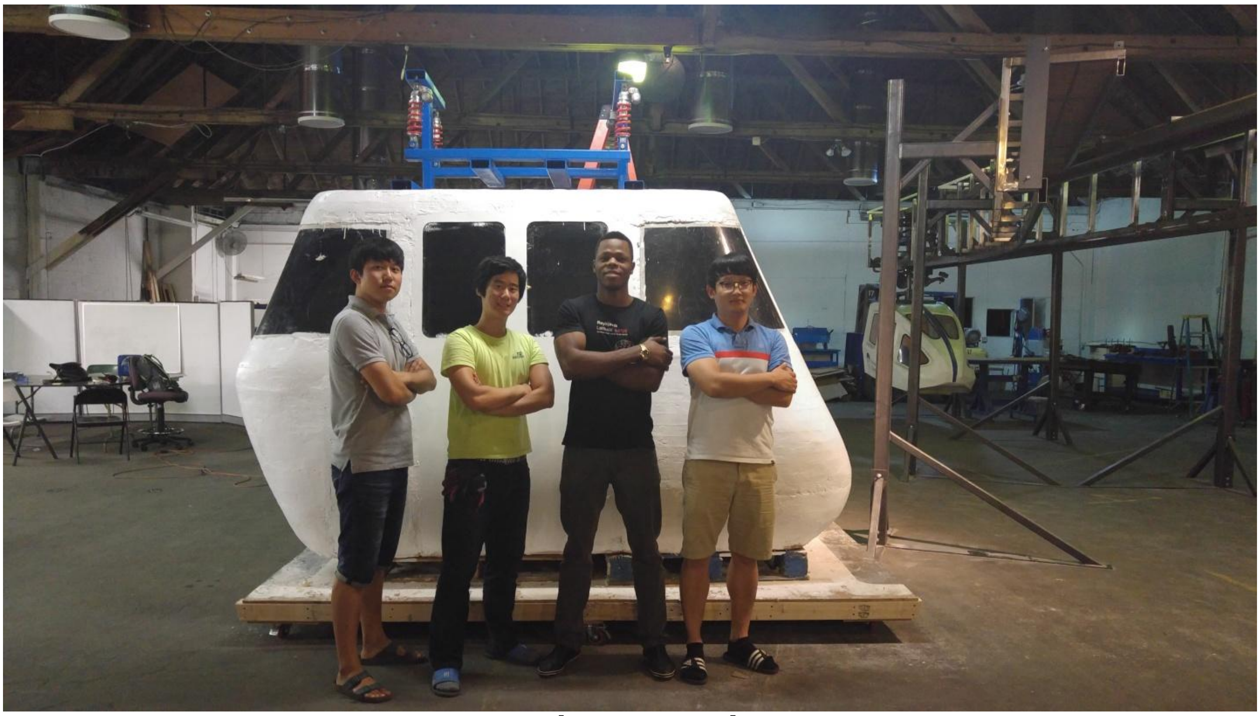
There are many mountains systems and the State is exposed to the seismic forces from the San Andreas fault.
The climate is mediterranean, but the California current, the relief and the latitude determine the weather. More you move away from the sea, the higher the temperature is. And some cities even have difficulty to see the rain, and some others are subject to flooding.

3. Tourism

Approximately 19,4 million tourists visit California each year. The main places of tourism are Disneyland, the marine theme park SeaWorld in San Diego, and the Universal Studio Hollywood.
There are several other good places to visit as the Golden Gate in San Fransisco, some nice parks etc.

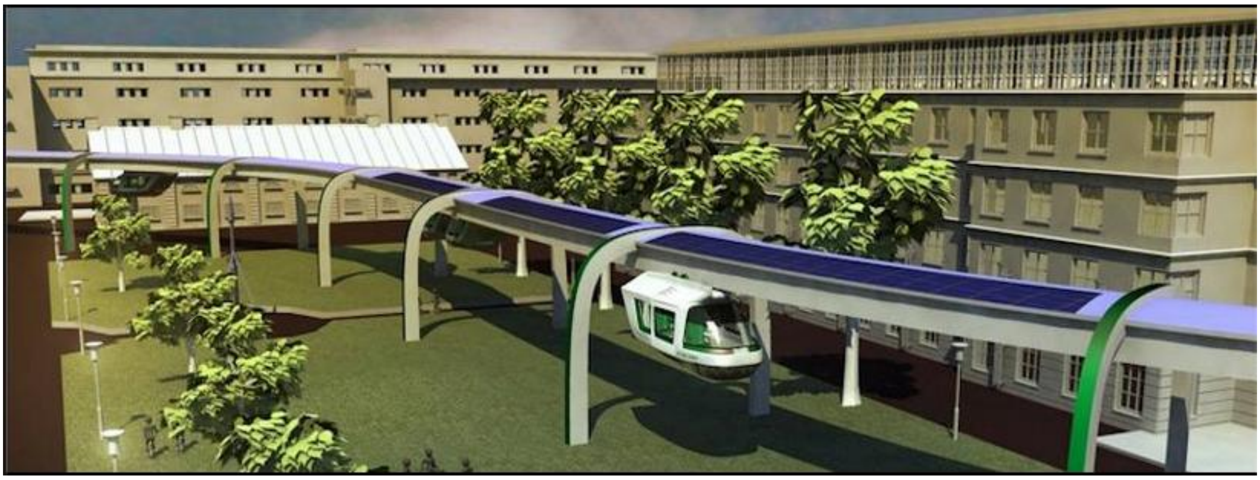
V. SOME PICTURES

Full scale model of th project



With Korean students

With Ron SWENSON at the prize-winning exhibit at the annual Silicon Valley Electric Vehicle rally



Design of an ATN

Visit to the Golden Gate

Visit to Hollywood