

## **Innovating Automated Transit Technology With Students**

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### Summary

Students have played a vital role in the development of automated transit since the early 1950s and continue to do so. At San José State University, we have been driving innovation in solar-powered automated transit network (ATN) development with students since 2012 and continue to the present day through the Spartan Superway Project.

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### Introduction

Since 2012, we have been working with students, primarily at San José State University, but increasingly from countries around the world, to develop solar powered ATN. While most visitors to our operation are impressed with what we have accomplished over the last four years, we sometimes run into a subtle (or not so subtle) 'attitude' of dismissal of the value of what students can actually accomplish when it comes to getting ATN into more widespread use<sup>1</sup>. Quite to the contrary, we think that students have a vital and unique role to play in realizing the promise of solar powered ATN. In the remainder of this article, we will describe our progress and discuss some of the peculiarities of working with students.

### 2012-2013 - The Beginning: Solar Skyways

Our work on solar-powered ATN came as something of an epiphany when I was juggling two efforts, one of which was to develop a new curriculum stem in sustainable mobility within my department, and the other to drum up industry projects for a newly conceived interdisciplinary senior project program in the College of Engineering. Ron Swenson figures prominently in the beginning of (and throughout) the Superway project in that I had invited him to be a member of the steering committee of the sustainable mobility effort, which at the time had been focused on conventional electric and hybrid vehicles. Apart from the steering committee work, Ron was rather persistent in seeking my help to find mechanical

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<sup>1</sup> Significant contributions to the development of ATN technology by students has historical precedence. Donn Fichter was a transportation *graduate student* in 1953 when he made his first sketches of the Veyar system, an early conceptualization of ATN. (Donn Fichter, 1974. "Veyar: Small Cars as the Key to Urban PRT," In *Progress, Problems, and Potential of a Promising New Form of Public Transportation*. 1973 International Conference on Personal Rapid Transit, Denver, Colorado, May 2-4, 1973. pp. 527-534.) J. Edward Anderson got his start with ATN through a development program at the University of Minnesota in 1981 with senior mechanical engineering *students*. (Anderson, James Edward. 2009. "Evolution of PRT." October 21. <http://faculty.washington.edu/jbs/itrans/Evolution%20of%20PRT1.pdf>)

engineering students who could help him with podcar design and help him put together an international student competition relating to develop solar-powered ATN. Toward the middle of the summer of 2012, for various reasons, the plans for the curriculum stem in sustainable mobility were not gelling, and I was not finding any industry-sponsored interdisciplinary projects for the new senior project program. It finally dawned on me that a senior project to develop a solar-powered ATN might be the way forward to deliver on both accounts, since a solar-powered ATN system would be the epitome of sustainable mobility, and would involve many disciplines. So, starting at the end of August, 2012, Ron and I launched our first interdisciplinary team of students to develop solar-powered ATN technology. The team consisted of 11 mechanical engineers, four computer engineers, three business students, one master in Urban Planning student. The project began as the Sustainable Mobility System for Silicon Valley (SMSSV), but soon the students came up with the catchier, 'Spartan Superway' moniker which acknowledged the mascot of San José State University, the 'Spartans,' and the superior, elevated nature of the ATN system.

It was gratifying to see how much the team accomplished by the end of May, 2013 considering that the students started from scratch and had zero knowledge of ATN at the outset of the project. Of particular note was a functioning 1/12<sup>th</sup> scale model of a suspended ATN system with three offline 'stations', a rudimentary control system, and designs for the key elements of the system. The report documenting these accomplishments is available at: <http://tinyurl.com/pvx9pnk>. A video of the scale model is available at: <https://youtu.be/4UeYCxl5yc>. At the same time that our project started, a group of students at Uppsala University in Sweden conducted an analysis of the feasibility of powering an ATN system in Uppsala using solar energy. Their work was documented in a report, which is available at: <http://tinyurl.com/zlkfsbk>. Both the SJSU and Uppsala teams were motivated by the Solar Skyways Challenge, a competition sponsored by the International Institute of Sustainable Transportation (INIST, <https://www.inist.org/> and <http://www.inist.org/Projects/SolarSkywaysChallenge>) to design and build a solar powered ATN.



**Figure 1.** Accomplishments from year 1 (2012-2013) of the Spartan Superway Project. At the left, a rendering of the guideway with solar panels and suspended vehicle. At center, a 1/12<sup>th</sup> scale bogie and vehicle traversing a guideway network, the plan view of which is shown to the right.

## 2013-2014 - Maker Faire and Models

The following academic year, the project continued with a new crop of senior students, 15 mechanical engineers, three electrical engineers, two civil engineers, two master of Urban Planning students, and some 25+ Industrial Design (InD) students through class projects in two Industrial Design classes, DSID 125 and DSID 131. The InD students in DSID 125 envisioned what an ATN vehicle might be and produced full-scale mockups in foam core of their concepts. The students in DSID 131 investigated how potential users might interact with an ATN system, and they produced graphic user interface models for devices such as smartphones.

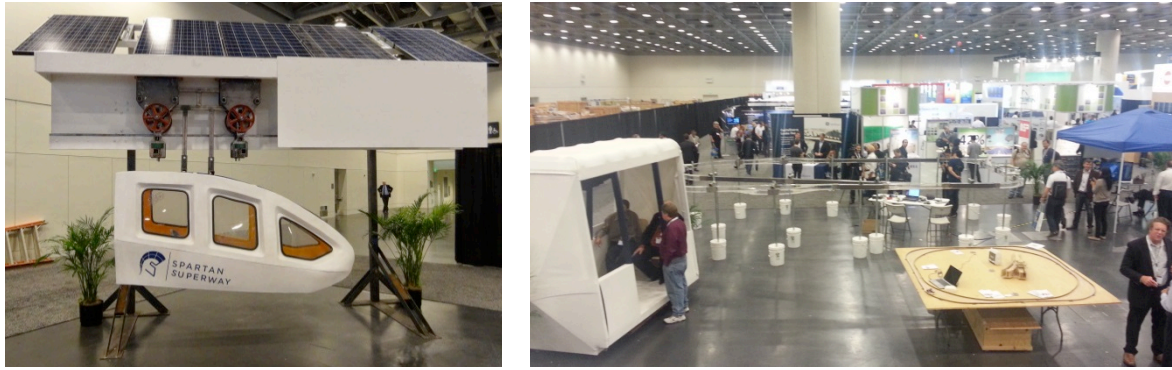
The motivating goal for the teams that year was to display their work at Maker Faire 2014, a popular venue that celebrates the Maker movement (<http://makerfaire.com/makerfairehistory/>). In addition to improving the operation of the scale model, the major accomplishment by the engineers was a full-scale straight section of guideway with movable bogie. In addition to the undergraduate students, MSME student Adam Krueger developed a simplified test track for ATN development, which is described in his thesis, available at: [http://scholarworks.sjsu.edu/etd\\_theses/4426/](http://scholarworks.sjsu.edu/etd_theses/4426/). Pictures and videos from Maker Faire 2014 can be accessed from: <http://www.inist.org/Projects/SpartanSuperway>. The report by the undergraduates is available at: <http://tinyurl.com/hcvi893>.



**Figure 2.** Accomplishments from year 2 (2013-2014) of the Spartan Superway Project. At the left, a full-scale section of guideway with movable bogie and mock-up vehicle cabin. At center, student Man Ho works on the vehicle for an improved 1/12<sup>th</sup> scale model. At the right, graduate student Adam Krueger demonstrates his simplified ATN development platform to youngsters at Maker Faire Bay Area 2014.

## July, 2014 - Superway at Intersolar 2014

Superway made its international debut at the Intersolar 2014 conference in San Francisco (<http://www.intersolar.us/en/home.html>). The section of full-scale guideway with solar panels, the scale models, and a mockup of a full scale vehicle cabin were featured in a large space at the Moscone Center.



**Figure 3.** Spartan Superway Project at Intersolar 2014. At the left, the full-scale guideway (partially enclosed) with solar panels attached. To the right, the exhibition space in Moscone center. The lower left corner of the photograph shows a mock-up of a full-scale vehicle cabin.

#### 2014-2015 - Maker Faire Reprise and Improved Models

The results from the 2013-2014 academic year were substantial and had been well received at Maker Faire and Intersolar 2014. With the start of the 2014 academic year, the team size grew to 26 mechanical engineers, two computer engineers, and one civil engineer. The goals of that year were to motorize the full-scale bogie and demonstrate the working of a switch as well as revise the scale model to be more representative of the design at full-scale. Maker Faire 2015 again served as the motivator and deadline for the students to produce working hardware. The full scale model was fabricated in steel and demonstrated autonomous operation of the motorized bogie and switching mechanism. The report for the project is available at: <http://tinyurl.com/gnfsqts>. Videos of the full-scale and small scale models can be accessed at: <https://www.youtube.com/playlist?list=PLFtP7O7OrwnJX5UELlvfAz2eMaWaOgd9R>. Our exhibition received an Editor's Choice blue ribbon.



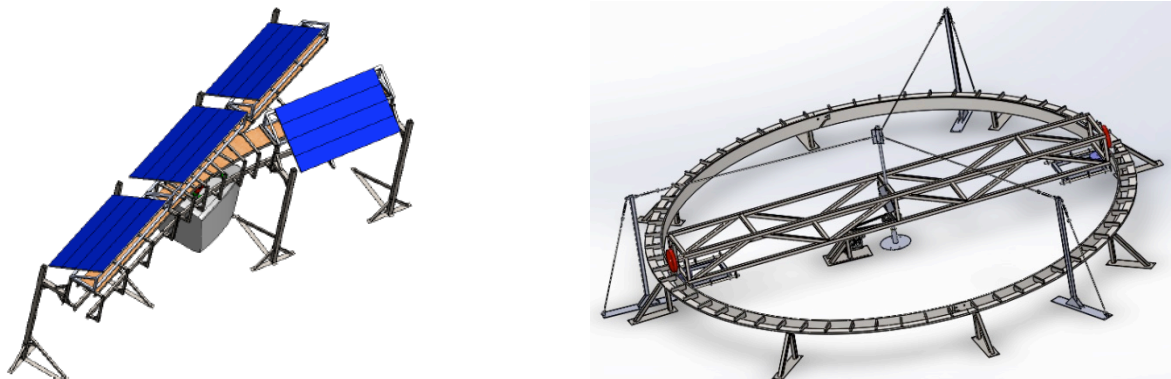
**Figure 4.** Spartan Superway Project at Maker Faire 2015. On the left, the full scale implementation of a 'Y' section of guideway, which supports a motorized bogie to which a mock-up vehicle cabin is suspended. On the right, the approximate 1/12<sup>th</sup> scale model of an ATN network with autonomous vehicle in operation.

#### Summer 2015 – International Summer Research Program

During the summer of 2015, we hosted a large contingent of students who were eager for research experience. We had seven students from Brazil, four from Linköping University in Sweden, six from



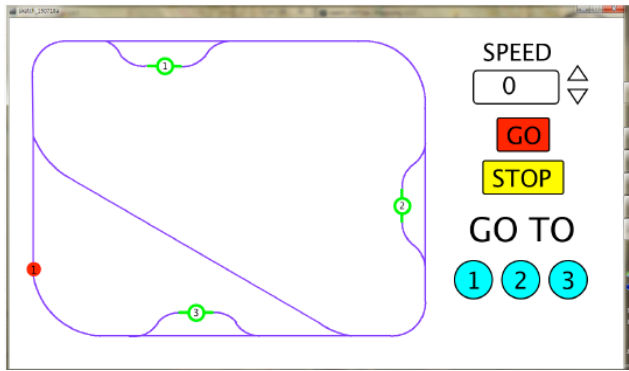
Pusan National University in South Korea, two from France, and a handful from the U.S. The students from Brazil worked on refining various aspects of the solar power subsystem and designing a system for life-testing the switching wheels; the students from Sweden designed and fabricated a full-scale exterior model of an ATN vehicle; the students from Korea improved the control system for the scale model and designed a suspension for the cabin model built by the Swedes; the French students worked on multiple projects including designing a lifting gantry for the cabin model; the U.S. students improved the mechanical design of the scale model vehicles, upgraded the full scale control system, and designed a test specimen for torsion testing of the guideway.



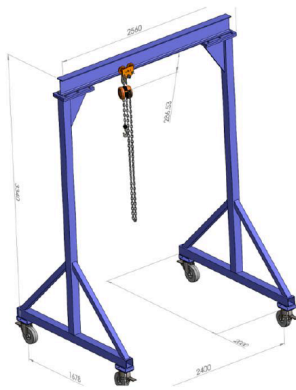
**Figure 5.** Accomplishments by Brazilian interns in summer 2015. On the left, ‘solarization’ of the full-scale model. On the right, a rendering of an apparatus for testing the wheels used in the bogie at full speed and full load.



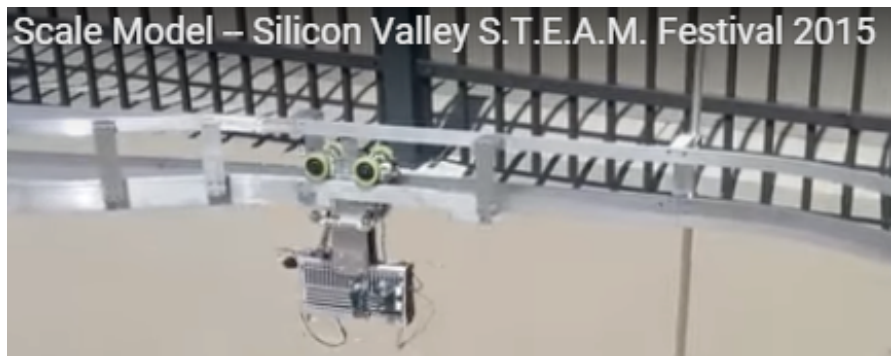
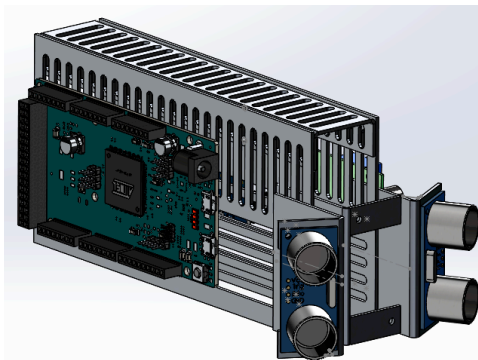
**Figure 6.** Accomplishments by Swedish interns in summer 2015. On the left, the full-sized exterior model prior to finishing. On the right, the finished model painted by the 2015-2016 cabin design team.



**Figure 7.** Accomplishments by Korean interns in summer 2015. On the left, a screenshot of the central control computer and its graphical interface. On the right, a passive suspension above the cabin model.



**Figure 8.** Accomplishments by French interns in summer 2015. On the left, the solid model of a lifting gantry. On the right, the fabricated gantry supporting the exterior cabin model.



**Figure 9.** Accomplishments by U.S. interns in summer 2015. On the left, the solid model rendering of an improved 'vehicle' for the 1/12<sup>th</sup> scale model. On the right, the new vehicle in operation at the Silicon Valley S.T.E.A.M. Festival 2015.

#### 2015-2016 – Current Team

In the current academic year there are 42 mechanical engineers and three electrical engineers, plus two MS software engineers and two MS mechanical engineers working in 12 sub-projects.



**Figure 10.** The Spartan Superway team for 2015-2016.

The various sub-projects address:

- ¼ scale model, which will feature a guideway that will demonstrate that vehicles can traverse 30° inclines
- Fail safe bogie design
- Expanded 1/12<sup>th</sup> scale model that will enable demonstration of network operation
- Smart phone user interface that will simulate (and actually control) how a user would interact with the system
- Active vehicle suspension
- Expanded solar power for all models
- Wayside power pickup for model operation

The motivating goal again is to exhibit at Maker Faire Bay Area 2016 in May, 2016.

### Observations and Lessons Learned

Some observations and lessons we've learned in the process of designing an ATN with students:

1. They bring creativity and enthusiasm into the work

Students are particularly effective in attacking problems with fresh perspective. They have unique freedom to explore what can be done with limited constraint. This is especially important considering where we are in the evolution of ATN technology, which we liken to being somewhere between the walkie-talkie and the smart phone (i.e., not quite there yet).

2. They can accomplish much with limited resources

On the one hand, having very modest resources is limiting in terms of what can be designed, purchased, and fabricated. However, on the other hand, it provides opportunity to develop resourceful and creative thinking to “do more with less” as Buckminster Fuller admonished. Having limited resources also



provides students the opportunity to learn how to go about finding the resources they need, which is a valuable skill in itself.

3. The whole enterprise is simultaneously advancing the technology and educating the next generation of workers and entrepreneurs who will be ready to step into the new transit paradigm when it gains widespread acceptance

We often say that the work that the students are doing is 'raising the bar', meaning that if a group of students with limited time and resources can demonstrate that something can be done or is feasible, then certainly a well-funded entity with experienced professionals will need to do at least as well. Also, the widespread implementation of ATN will require a workforce with understanding and experience that relatively few possess now. As more and more students gain experience with ATN, there will be an enlarging pool of talent to draw upon as ATN becomes an accepted transit option.

4. It's hard to maintain continuity from year to year with 100% turnover

One of the most difficult aspects of working with students is that we only have them for a limited time. Every academic year we start with a new group that has only limited, informal connection to the group who came before. Much time is spent at the outset of the year getting the new students 'up to speed' and helping them set up organizational and managerial structures under which to carry out their work.

5. Knowledge capture, transfer, and organization is a challenge

It is also challenging to capture and transfer knowledge from and between teams, both with current students and from year to year. We've had some success using Google Docs and having each sub-team team and individual student maintain blogs.

### Conclusion

Students can play a vital role in the development of ATN. We have been successful in advancing the state-of-the-art with groups of students from San José State University and around the world since 2012.

### Links to Additional Information on the Project

<http://www.cctv-america.com/2015/11/24/california-technologists-are-developing-the-podcar>

<http://abc7news.com/traffic/engineers-flock-to-mountain-view-to-discuss-future-of-podcars-/1070840/>

<http://blogs.sjsu.edu/today/2015/spartan-superway-may-be-the-ride-of-the-future/>

Swenson, R. (2014). Solar Skyways. *Energy Procedia*, 57, 109-116. Available at:

<http://tinyurl.com/hzoqo3l>