Solar Roadways

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Executive Summary

In 2014, Solar Roadways Inc. announced their flagship product that would take the general public by storm. This product was called Solar Roadway, and was a roadway that was designed to generate solar energy over time. This radical innovation was designed to replace standard concrete roads by transforming modern roadway infrastructure into a source of sustainable and renewable energy. This would have produced an entirely new category of infrastructure, one that combined transportation, energy generation, and smart technology into a single platform. However, some contexts of the company showed that there were some serious issues that the company needed to address. With their R&D capabilities limited by their small team, their pursuing of an aggressive development strategy, and how solar panel popularity was growing in regards to both general public interest and from new ventures, the situation was lining up such that Solar Roadways Inc. was going to experience a massive failure.

In September of 2016, Solar Roadways Inc. conducted a public trial of their flagship product. This trial was the largest innovation challenge that the company had faced, and produced significant negative momentum for the company. With the symptoms of critical manufacturing errors, the low energy generation for its installation cost, and the significantly reduced publicity, the problems began to rise to the surface. Solar Roadways Inc. experienced the problems of a high manufacturing cost, the fact that their limited manpower and expertise didn't match their goals, the technical limitations of solar panels, and an excess of public excitement. These problems all stem from two root problems, being their pursuit of a premature commercialization, and their vision and technical misalignment.

To solve these problems, two potential solutions identified themselves. One was to delay their entry into the market and focus more on R&D, ignoring publicity efforts for now, and conducting more closed door R&D. The other potential solution was to engage in collaborative efforts with an external company, specifically with Siemens in a joint venture. The recommended solution for Solar Roadways was to conduct a joint venture with Siemens and take advantage of their R&D resources, their connections, and their economies of scale.

The following are some of the learning objectives we set out to achieve through this paper:

- Analyze how radical innovations from small companies can successfully create new markets and establish opportunities for scalable growth
- Discover how to mitigate some of the inherent negative effects created by first mover disadvantages in the solar roadway market.
- Understand how company collaboration models and strategies could be used to implement innovations more effectively.

The keywords important for this project include radical innovation, scalable growth, first mover disadvantage, R&D capacity, and joint venture.

Company Background and Introduction

This research project is focused on the Solar Road Panel product from Solar Roadways Inc, a high technological product that looks for generating clean energy in the roads. Its added value is that with this energy produced, the panel powers heating elements and LED's on it, that not only illuminate the road lines, but also show road signs. Related to what Tushman mentions on radical innovation, this product challenges existing infrastructure norms. So it involves escaping from dominant designs and changing core technological assumptions (Tushman & Anderson, 1986).

The innovation that has faced the most difficulty was the initial trials, in which they did not accumulate a sufficient amount of energy to satisfy both the project's goals and public expectations. This hindered them, as they had a very good relationship with the public and had many eyes on them. The unsuccessful first trial really hurt their momentum. They have now created four different prototypes and are working on their fifth version, in which each variation shows positive development in energy accumulation which is one of the innovations that concerned the public the most. So, developing this innovation, along with others that will improve road safety, will definitely help regain the public's trust.

On September 30, 2016, Solar Roadways Inc. experienced a major failure with their Solar Roadways product. In public, over half of their panels cracked, and the surviving ones underperformed in energy generation. The visibility of these product issues dulled the company's momentum. As Tushman and Anderson (1986) note, radical innovation usually begins with poor product performance. Solar Roadways Inc.'s public trial created expectations more suitable for a mature product, verifying Tushman and O'Reilly's (1996) argument that immature innovations must be shielded from short-term pressures. This public failure severely damaged trust.

Scott and Julie Brusaw are the engineering and business directors, respectively, of Solar Roadways Inc. Both are the founders of the company, as well as leaders in their own fields. Scott is the head of engineering for the solar panel development and installation. Scott and Julie would be the best people to consult, as they are both the developers and the financial and decision-making heads of the company. They are the individuals who know what their project needs and what is best for the company to move the product forward.

The project is important to us, as our group cares deeply about creating sustainable products. We are all interested in the process of developing innovative products that are also eco-friendly. We are particularly interested in studying how a small startup company that created a sustainable product faced drastic challenges. This company stood out to us because it introduced a radical innovation and faced first-mover disadvantages as a result. Learning how to prevent or mitigate these disadvantages is important for future innovation endeavors.

Context

Because of the small size of the company, the R&D and manufacturing processes of the company have been limited, generating barriers to reach large-scale partners or institutional banking. Therefore, the scalability of the product is more complicated. Additionally, they started

with an aggressive strategy rather than implementing it in incremental steps. So this approach made it difficult for user adoption in early stages.

Traditional solar solutions were advancing rapidly and becoming increasingly cost-competitive. Moreover, competitive trends like rooftop solar projects or solar farms have developed a better advancement, creating a high benchmark to achieve for Solar Roadways. On the other hand, their potential customers like governments or city planners tend to be risk-averse when talking about infrastructure. In the same way, having public enthusiasm doesn't mean purchasing power or institutional adoption. Besides, the renewable energy industry is highly competitive, with other companies focusing more on cost and product efficiency rather than exploring new markets.

Research Methods:

Some of the research methods to obtain both primary and secondary data was through many different sources. We first looked for a direct source towards the company in which we found their website. In this source we found multiple different sources of information that led us to secondary data that was used in the case study. Many different sources like a blog in which we studied the current developments made and updated by the companies media team and at times updated by the owners. Other information that was shared throughout the website like the different prototypes that were designed. They share the new implementation they made to each model and the output each model ended up doing like the energy it was able to generate as well as the features like stronger material for the panels. All of this was tested in many different locations throughout the years and was all explained in their websites on what occurred during these testing and the school and teams they partnered with to run these tests. We also conducted some secondary research using sources from around the time of the unsuccessful trial to understand how the company was perceived from an external point of view. These sources included news articles and media coverage of the trial results and of the public opinion regarding Solar Roadways Inc. As well as other sources like Tushman, M. L., & Anderson, P. (1986) to understand the occurrence of the initial issues and how the mistake was done in the initial trial has shown to be a trend of unsuccess to other companies as well . Our Primary research was obtained from a group member that had an acquaintance that was Renne Guerrero, ODOT Public Transportation employee. An interview was conducted with Renne Guerrero on May 24th, 2025 in which Anthony has made a series of questions related to the process a company has to go through with ODOT and thoughts on the idea of solar panels being implemented on the road. We also tried to obtain more primary data by contacting Solar Roadways Inc. but unfortunately had no luck as they never responded to our emails or social media attempts of contact (see appendix, figures 1 and 2 for screenshots).

Symptoms

There were many visible symptoms of the problems that Solar Roadways Inc. had leading up to their 2016 publicized trial. Firstly, their initial products had many critical flaws in its manufacturing. Of the 30 initially provided Solar Roadway panels, 18 did not work on arrival (Thunderf00t, 2016). Additionally, their product had low durability against vehicles and against the elements. After one week of exposure to the elements, four and half more were dead as a

result of weather damage (Thunderf00t, 2016). These issues indicate serious design flaws with the product at the 2016 juncture.

Additionally, Solar Roadways Inc. had the symptom of their product having low energy generation compared to its installation cost and compared to traditional solar panels. According to Dylan Ryan with The Conversation, based on the installation cost and the potential energy that could be generated in the 2016 trial, the Solar Roadway panels had a cost per installed kW (how much it costs to set up each unit of power the system can produce) of $31,817.46, more than 20 times higher than the Cestas solar power plant which had a cost per installed kW of $1,386.83 USD (Ryan, 2018). This means that Solar Roadways panels are much more expensive than an average solar plant per unit of energy generation. He then goes on to describe that the Solar Roadway panels are 20 times less efficient than the Cestas solar power plant (Ryan, 2018). This means that through the 6 months of power generation after initial installation in the trial, the Solar Roadway panels produced a far smaller proportion of their theoretical maximum energy output than the Cestas plant. These issues in energy generation highlights the inferiority of the Solar Roadways compared to the average alternative options for solar panels.

Another symptom of their issues is the dramatically negative public sentiment and general skepticism that was developed in the wake of the test installation. Solar Roadways Inc. had been very public about their development process with early adopters, as they had generated over $2.1 million dollars in crowdfunding money prior to their 2016 trial (Hurst, 2014). This successful crowdfunding effort showcased how much momentum and optimism the public had for Solar Roadways Inc. After the 2016 trial, the public perception shifted significantly from that of optimism to being skeptical toward the viability of the Solar Roadways concept. Most new articles released relating to Solar Roadways Inc. around that time were ones with skepticism and criticism, a stark contrast to articles and discussion before the 2016 trial.

Problems

The symptoms of Solar Roadways Inc. illuminate both internal and external problems affecting the company. Internally Solar roadways Inc. experienced a problem of high manufacturing costs. This was evident through the symptom of the high installation costs that drove up the cost per installed kW. This high manufacturing cost created barriers to adoption that made widespread acceptance of the technology difficult.

Another internal problem was that their limited manpower and engineering expertise didn't match their company goals. The company's goal was to scale up a Solar Roadway product to be capable of transforming thousands of miles of pavement into energy generating technology (CBS News, 2016). As Solar Roadways Inc. was a small company developed as a passion project by Scott and Julie Brusaw, they lacked the adequate financial resources for R&D and product development to achieve their goal in a timely manner. This was apparent through the symptoms of there being critical flaws in manufacturing, and also through the symptom of the Solar Roadway panels having low energy generation for their installation costs. Despite these shortcomings, they pushed the product to market prematurely and were ultimately unable to scale or improve the design effectively once public interest surged.

For external problems affecting Solar Roadways Inc, one major problem is the technological limitations of Solar Panels. This problem manifested itself in the symptom of the panels having low energy generation for their installation costs. Since the Solar Roadway panels were a radical innovation and lacked any standard convention or learning effects from a first mover or early followers to follow, they needed to conduct most of the R&D related to implementing existing solar panel technology into durable roadways. This R&D included the technological inefficiencies of having solar panels be driven on described by Dylan Ryan with the Conversation, such as having a permanently flat tilt angle, being consistently dirt/dust covered, and needing to use much thicker glass as vehicles would be driving on it, all of which contribute to reduced solar energy generation compared to traditionally built solar panels (Ryan, 2018).

Additionally, one more external problem was that Solar Roadways Inc. had generated an excess of public excitement leading up to the 2016 trial. This was evident through the symptom of the negative public sentiment developed after the September 2016 trial. As a result of their incredibly successful crowdfunding efforts in 2014 (Hurst, 2014), Solar Roadways Inc. had generated a large general following. The excess publicity from their crowdfunding campaign tied the company's public image and perceived value in the public's eyes to the deliverance of successful products. The overabundance of publicity meant that any company errors would result in skepticism and disinterest from early stakeholders.

Root Problems

The problems of Solar Roadways Inc. are results of the unaddressed root problems that the company faced heading into the September 2016 test. The first root problem was trying to prematurely commercialize a product in an underdeveloped market niche. This problem is aligned with an issue identified by Tushman and Anderson (1986), in that radical innovations often begin with poor performance and require an environment that can absorb early-stage instability. This was something Solar Roadways Inc. lacked, so their development process was negatively affected, never allowing Solar Roadways Inc. to reach its full potential. Solar Roadways Inc. tried to implement a highly radical innovation before the infrastructure, standards, and market demand were mature enough to support it. This directly led to Solar Roadways Inc. experiencing the internal problem of having a high manufacturing cost and the external problem of being technologically limited.

The other root problem faced by Solar Roadways Inc. was the misalignment between their vision and the technical feasibility. As the company entered into a market with an overly idealistic concept that significantly outpaced actual engineering capabilities and resources, they spent excessive amounts of time and money trying to build up enough competency to produce their product. This gave way to Solar Roadways Inc. experiencing the internal problem of having misaligned engineering capability and company goals and the external problem of having an excess of public excitement for their product. The full diagram showcasing the symptom-problem-root problem structure can be found in the appendix, figure 3.

Solutions

All of the technology is beginning to present itself to the point that Solar Roadways Inc. can get to a Phase 2B but there are some questions to ask such as:

Is this too destructive of an innovation for people to want to jump in with both feet?

Are the roadway panels still not where they need to be in order for them to be safe for use?

If I enter, will there become better competitors?

What will get this through the Department of Transportation's policy?

What other risks will I face joining the market?

All of these questions are very important in reference to when to enter the market and it breaks down to two options. The first one is to **delay entry into the market**, delaying entry into the market will eventually open us up to the ability to achieve the technology cluster we are waiting for. The best questions for this is, can Solar Roadways Inc. afford the wait? Yes, after conducting a SWOT analysis, the threats are minimal and the opportunities are developing as they come. Solar Roadways Inc has already developed partnerships with state and federal level transportation regulatory agencies. Furthermore Solar Roadways Inc. is developing partnerships with the Department of Defense (DOD) in an attempt for the military to have the most productive bases. Delaying entry doesn't just mean stopping all together, it means taking it slower and developing the technology needed to make this the best product and otherwise just staying as a safe company. Internal threats of this are relatively limited with partnerships but typically waiting for the market to be ready can break a business, the need to make income can really press a lot of pressure but due to the developing relationships, Solar Roadways Inc. can afford the wait. The strength to this is having the time to master the craft of making these roads and finding the best way to sell the product.

The other plan is to become the first mover in the industry and engage in a **joint venture with Siemens**. This choice gives you the engineering prowess needed and the deep pockets. In 2015, Siemens were expanding their product portfolio to integrate more smart infrastructure into their mix. Siemens had been focusing on urban infrastructure but had branched out to some driving based infrastructure, such as electric vehicle charging and intelligent traffic systems. Partnering with Solar Roadways Inc. would offer Siemens an early entry into a promising niche at relatively low risk to Siemens. Upon another SWOT analysis we answer some of the questions above. The strength of this partnership with a company like Siemens is that Solar Roadways Inc. would gain access to their R&D and their innovations. Another strength is that this is risk pooling, risk pooling with a company that has deeper pockets means they can easily move the money creating a collective research organization. Another strength is the ability to potentially start this at a smaller scale allowing you to learn from your mistakes in a place making it scalable at all. The weaknesses to this are that you would be giving up part of your innovation to another company meaning that might create barriers to partnerships down the line while giving up say of your own company. Opportunities with Siemens is that they already have their foot in the door with the tech industry with specialties in smart grids, sustainability, mobility, and additive manufacturing. Their focus on technology could add a lot of good resources and work that make

up quite the opportunity. Threats of this are again that we lose some say in the company. This might have some good relationships for Solar Roadways Inc. in the future but would wrap up the company potentially with their bureaucratic process, meaning it could slow down the further development of Solar Roadways Inc. potentially harming the company.

Ultimately, while both delaying market entry and forming a joint venture offer strategic benefits, we recommend pursuing the **joint venture with Siemens** as the superior option. Although delaying would allow Solar Roadways Inc. more time to refine its technology and prepare the market, it also poses the significant risks of running out of funding, losing momentum, and falling behind other potential first movers or early followers. A joint venture with Siemens brings immediate access to world-class engineering talent, financial resources, and an established reputation in smart infrastructure. This partnership would allow Solar Roadways to scale its product gradually, test in controlled environments, and reduce risk through shared responsibility. While there are the downsides of reduced autonomy and potential bureaucracy, the long-term benefits of accelerated development, credibility with regulators, and a clearer path to commercialization outweigh the costs. A joint venture not only mitigates first-mover disadvantages but also positions the company to lead the market once the technology cluster fully forms.

Implementation Plan

The first step that Solar Roadways Inc. would take to implement their Joint Venture plan is to formalize their agreement with Siemens so that responsibilities, financial structure, and resource sharing can be clearly laid out. After this, the joint venture would examine the department of transportation requirements and try to acquire early project contracts. In this process, the utilization of Siemens' reputation and connections will make it easier than to attempt it without Siemens.

After the partnership is fully established and the joint venture has begun to acquire contracts, the team will delay any product implementation by at least 1 year to allow for adequate progress to be made on the R&D front. This will allow for the joint venture to start utilizing Siemens' R&D capability and stores of knowledge to enhance the Solar Roadways product. Next, the joint venture will begin employing closed, non-public pilot tests to determine the level of the product without the risk of destroying public confidence. Once all of these steps have been completed, the product will be launched in small scale projects to begin acquiring learning effects which will be applied to further, iterative development as the product begins to scale and the market begins to expand.

Reflection

The first important lesson we learned from conducting this project was that radical innovation development in a small business should generally be done in a quiet and experimental fashion. Following what Tushman and O'Reilly said regarding how immature innovations needed to be shielded from short term pressures (1996), small companies that are experimenting with radical innovations should do so without major publicity to avoid momentum loss and decreased stakeholder confidence.

The second important lesson we learned was that it's important to ensure that the goals of a company also match their means. If the company has too lofty of goals, such that their means are unable to meet those goals, then the company needs to reevaluate those goals given their means, or pursue a collaboration strategy to acquire the necessary resources, depending on what the company wants out of commercialization.

We also learned the important lesson of how a small company can avoid first mover disadvantages. A small company trying to develop a radical innovation and create a new market may experience either first mover advantages or disadvantages, depending on their capabilities and strategy. For small companies developing radical innovations and where R&D is still the primary business activity, it is important to avoid becoming stuck in an R&D loop for an extended period of time where resources and stakeholder patience are limited. If the company's R&D capacity is not high enough to bring the product to market in a reasonable time, it becomes necessary to pursue a collaborative strategy to get enough resources and time for R&D.

Reflecting on this project, we did an excellent job with compiling a list of symptoms and inherent problems, ensuring that the symptoms were items directly caused by the problems, and that the root problems could be traced back to all of the other problems and symptoms. We also did a good job of acquiring decision making insights from our ODOT employee interview. If we could do something differently when pursuing this project again, we would like to acquire more data regarding the inherent workings of the company as we feel our argument could be made more sound and comprehensive with a deeper internal analysis. We would also like to reach out to a Siemens representative to get their thoughts about a partnership with a company like Solar Roadways, and to get an idea of their decision making process when evaluating the viability of partnerships.

To improve the team project in the future for a better learning experience, we would recommend providing a list of companies to choose from whose innovation challenges align directly with course concepts, and then providing a list of resources about that company's challenges so that the students can focus more on applying the course concepts to the project instead of needing to spend time trying to go out and gather the company information from external sources. We believe that this would increase the engagement of students with the course concepts and material, and that this would increase the students' ability to recognize course concepts in real-world companies.

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Appendix

Feedback Adjustments

There were some important modifications we did based on feedback from the instructor. We were recommended by our instructor to elaborate on how a joint venture with Siemens was feasible and possible for Solar Roadways Inc. We included in the solutions section more detail about Siemens and their business activities to help justify their motivation to pursue a joint venture with Solar Roadways Inc. We were also recommended by the instructor to reference Tushman and Anderson in our root problem section to provide more credibility to our analysis regarding radical innovation. We implemented this recommendation by changing our root problem section to reference this source.

Primary Research

(Renee Guerrero, ODOT Public Transportation, May 24, 2025)

Q1. Why do you like the idea of solar roads in reference to your job in public transportation?

Advantages like longevity in reference to our asphalt, lighting makes it safer for lane divisions. The most common thing is reflectant but it isn't really enough. Rejuvenation of power is a large appeal.

Q2. How did you evaluate the trade-offs between innovation and risk in transportation projects? How would these nice new solar roadways interact with public transportation?

The things that go through my mind with mass transportation is anything that develops safety and timeliness is great. Pull up for stops can be implemented.

Q3. What role do long-term performance metrics (e.g., durability, energy generation) play in project approval or continued support for ODOT?

Solar roadways performance metrics such as safety and work would be better.

Q4. How much do public perception or political factors influence funding decisions for experimental infrastructure projects from ODOT?

Funding typically plays major roles in funding but typically that gets handled at the highest points of the food chain. Changes in transportation DO NOT happen overnight it takes a ton of planning. Mass transportation is not developed, it develops around the community instead.

Q5. How does ODOT typically implement new technologies from outside firms? What did that look like at your level?

It looked like training, mapping, and little things that would work with many individuals. It meant thinking about your stops. You have to consider access and regulation. Lift implementation needs consideration so in terms of new roadways you need to think about all of the surrounding world around it. Measuring every piece takes time in conjunction with training of employees of any minor change. Solar Roadways are going to make changes that need training.

Q6. Are there specific requirements or expectations you have for programs (such as startups like Solar Roadways) in terms of technical readiness or scalability before partnering with them?

You would have to really consider every application that goes on the road. Tires would be different as well. All of these things would have to become partnerships. It would be a top down look at the industry.

Q7. How does ODOT approach projects that aim to radically transform existing infrastructure norms (like replacing traditional roads)? In short, when ODOT makes a big change, how does that flow through?

ODOT stays out of it and lets agencies and contractors have a say in how they work the norms. Again it points across multiple industries but odds are they ODOT would require hours of training for any given complexity.

Q8. How does ODOT assess whether a new infrastructure technology is mature enough for implementation? Does it seem smart or thought out or does it seem to frequently come short?

They would require much more training but the maturity would spread across multiple agencies potentially. This would require many grants at several levels.

Q9. When working with ODOT, what seemed to be the focus of their desired changes?

Their focus is on safety but again that is higher on the chain with more individuals.

Q10. What requirements would ODOT need in terms of public safety to want to implement solar roadways?

First they would have to have some kind of campaign for safety. It's hard to say but it would require a lot of things working across many social platforms. They would use every resource possible to get across new content with the idea that “Americans do not like to read.”

Couldn’t contact company after multiple efforts

Renee Guerrero
Takeaways:

I found during this interview that most of this all things considered is going to come down to safety and application. It made me think that maybe they are just looking at this as roadways when they aren’t considering policy, tires, vehicle safety changes, application of softer tires and how that might impact braking. It reminded me of something though, in the book "The *Devil in the White City”* which many say is way too much about the white city and not enough about the devil. The book goes over how after the Chicago fire there was a lot of change that needed to happen. Typically city planning is hard, it requires one minor change at a time as you slowly shift your buildings, priorities, and it takes years of planning, when the fire occurred they were allowed a major overhaul. This overhaul allowed for public transportation, a change in infrastructure, and it provided a proverbial “clean slate” ideal. It gave me a lot of thought to the fact that Solar Roadways are radical innovation and would require a complete shift in how we run every public sector. It would require a lot more work than I had earlier perceived which makes me wonder how many technology clusters would be required to get this moving.

Figures

Alcaraz, Oscar A
To: Press@SolarRoadways.com
Sun 5/11/2025 10:25 PM

Dear [Solar Roadways Team / To Whom It May Concern],

My name is Oscar Alexis Alcaraz, and I am a junior at Oregon State University studying Construction Management Engineering.

As part of a class project, my team and I are conducting a case study on Solar Roadways. We are very interested in learning more about your technology and its practical applications. We would greatly appreciate the opportunity to speak with a team member who could help us clarify a few points and provide insights to support our study.

Please let us know if someone would be available for a short interview at your convenience. I'm happy to provide more information about the project if needed. You can reach me by email at alcaraos@oregonstate.edu or by phone at 971-261-9838.

Thank you very much for your time and consideration.

Best regards,
Oscar Alexis Alcaraz
Junior, Construction Management Engineering
Class: Innovation Management

Oregon State University

Figure 1: Email to Solar Roadways Inc.

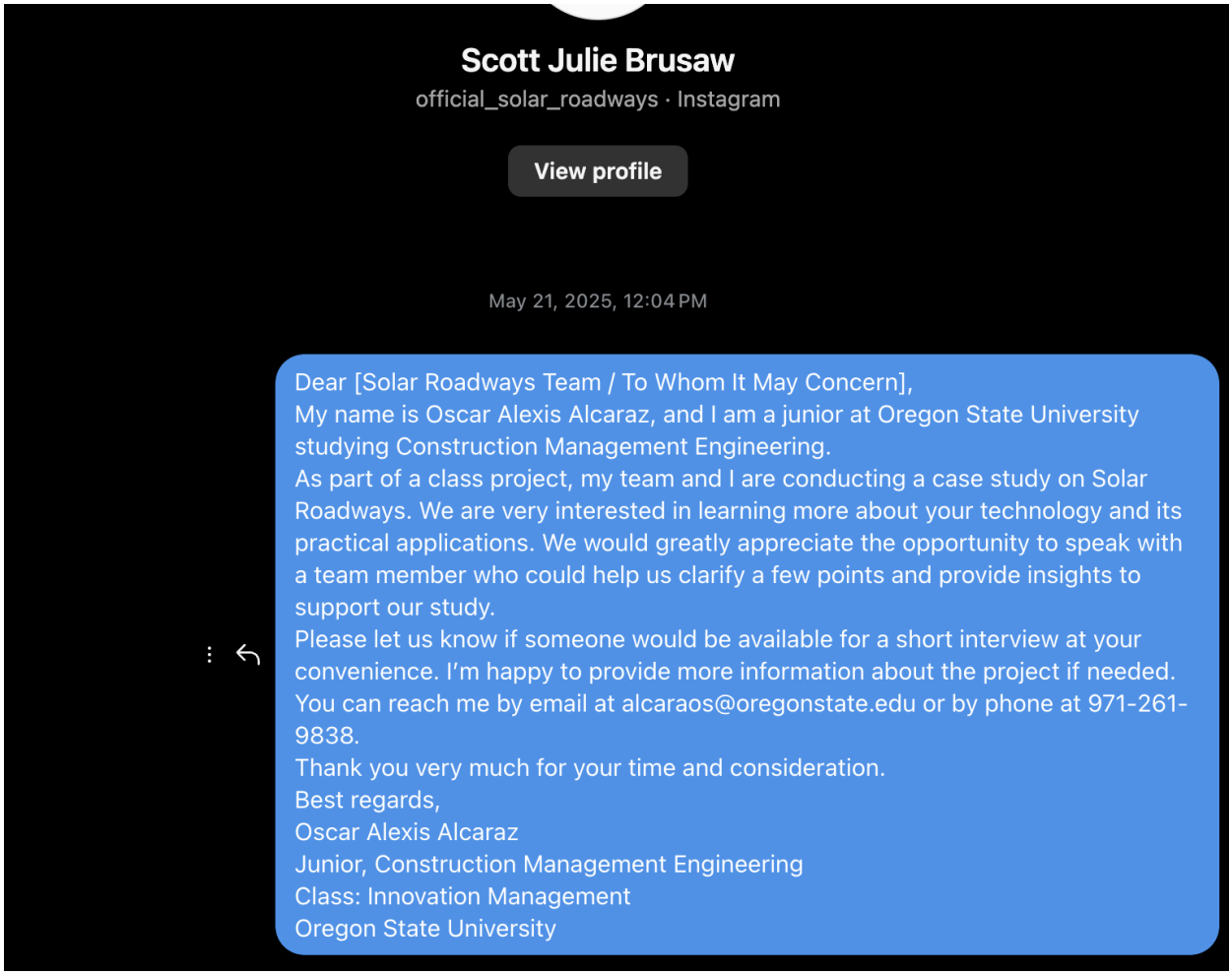

Figure 2: Message to Scott and Julie Brusaw via instagram

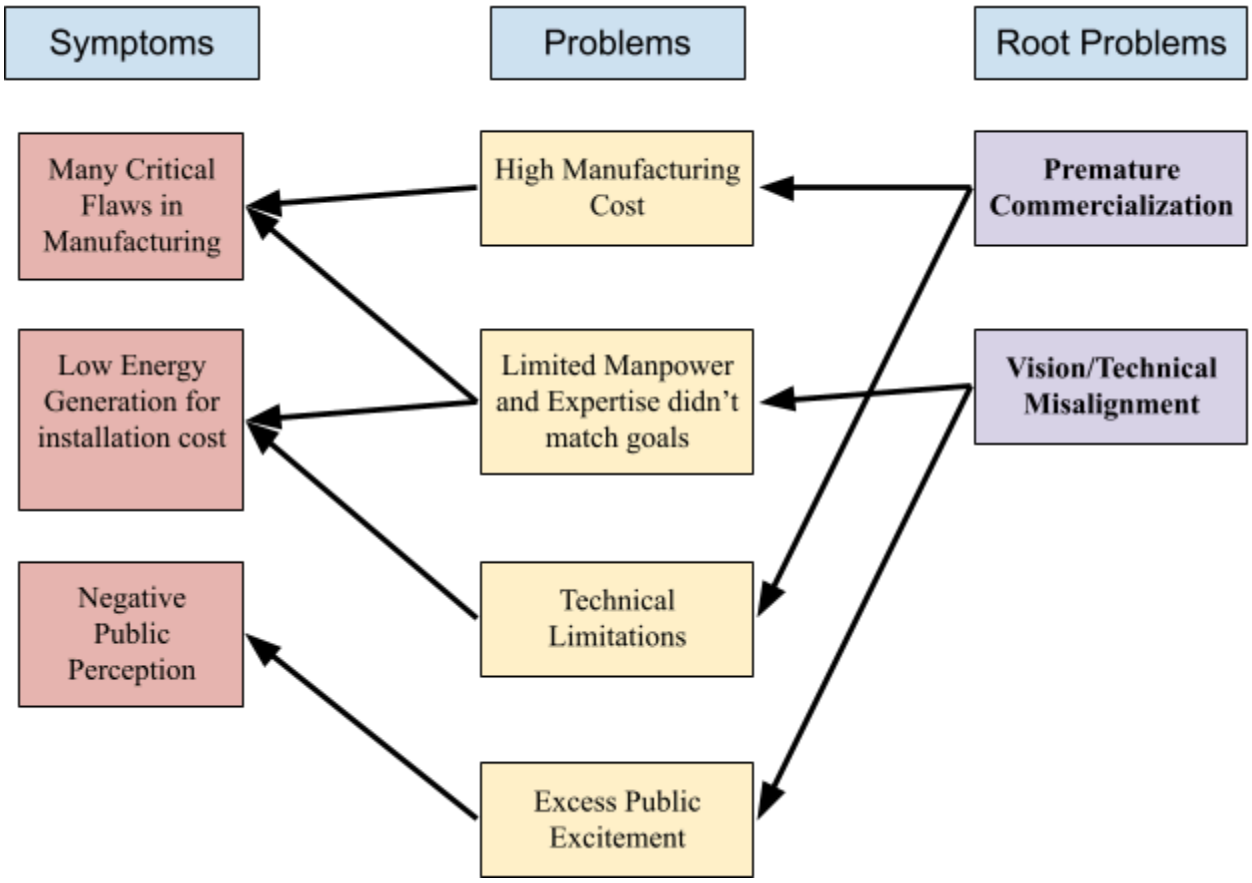

Figure 3: Symptoms-problem-root problem diagram. Arrows indicate that the source caused what the arrow is pointing to.