ECE 44X Tachyon II Space VNX Card (Hardware)

Project Closeout

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1.0 Design Impact Statement

1.1 Public Health, Safety, and Welfare Impacts

The Tachyon II is an experimental project still in progress. Because of this, a lot of questions about how it will affect public health, safety, and welfare remain unanswered. One of the most important properties of a PCB is its heat dissipation [1]. Unfortunately, we had to discard a cooling component out of the system because our space was so limited. This also means we had to fit the components onto a small space, meaning the board's heat will be more concentrated. These two facts about the board mean that the board may overheat easily. If it does, the board could simply fail or it could explode. This would lead to a total failure of the board's application, which could include rockets and automated cars.

Fortunately, these applications could include systems built to improve the public health and safety of people around the world. For example, an automated vehicle could deliver medicine to places that are difficult or even dangerous to reach. While this isn't a direct impact in these areas, the Tachyon could still make significant contributions.

1.2 Cultural and Social Impacts

The Tachyon II uses the innovation of the PolarFire SoC FPGA, the first SoC FPGA to use RISC-V processing technology. RISC-V runs faster than Intel's recent Xeon processor and uses much less power [2]. This will make the Tachyon II a much-sought-after device, driving the industry forward.

The applications of the Tachyon II are what comes to mind with the word “futuristic”. As automated cars and space travel become more commonplace, they become massive parts of society and culture. They could fundamentally change how we work, play, and live. For example, in autonomous cars, “interior cabins will likely be significantly reconfigured, providing greater flexibility for work, leisure and related social activities [3].” The Tachyon II will help these applications reach their full potential. Unfortunately, it may also mean leaving beloved parts of modern culture behind, such as getting behind the wheel both for the thrill and for meditation.

1.3 Environmental Impacts

At its core, the Tachyon II is a PCB. Therefore, any environmental impacts of PCB creation must be considered. The PCB is made from copper, epoxy resin, glass fiber, and water in a high-emission process in factories that produce air pollution [4]. The copper alone must be mined, meaning that the world's copper resources are finite. These mines can also cause disruptions to their surrounding ecosystems. When copper is mined, waste rock that doesn't contain any ore is moved into large piles. Much of this waste rock contains sulfide minerals which leak into the surrounding area. When a common one of these minerals, pyrite, is oxidized, it produces an acid that stunts plant growth [5].

To reduce our carbon footprint, we are making the board as small as possible to use less material. We also researched more environmentally friendly ways to print PCBs such as inkjet and laser printing and even creating a fully biodegradable board [4].

1.4 Economic Factors

Due to the COVID-19 pandemic, there has been a global shortage of semiconductors disrupting the supply chain [6]. This made many components either very expensive due to limited supply or completely unavailable. For the time being, this drives up the price of the Tachyon II, which could deter potential customers.

The good news is that we already have major customers interested in the Tachyon II, including NASA, and with the size of our board being so small, our customers will be saving money on resources and time on production. As Market Watch points out about the PCB market, "the technology is getting shrunk into small sizes in order to increase efficiency… [7]." In addition, the Tachyon II will improve the local economy and, in the long run, the global economy. Praesum is a local company who is selling our product to larger companies. As this technology becomes more available to more companies around the world, the global economy will also be helped. Of course, this assumes the Tachyon II is successful. The Tachyon II is still in the experimentation and simulation stages. We will not know for sure how the Tachyon II will perform in reality until it is printed out and extensively tested. This leaves a lot of questions for our customers to have about our work at the current moment and the ramifications could be disastrous if the Tachyon II fails. This highlights the importance of extensive and extreme tests.

2.0 Project Timeline

Overview of Project Phases

Phase 1 - Initial Project Development (09/23/21 - 12/04/21)

Phase 2 - Advanced Building and Research Phase (01/04/21 - 03/12/21)

Phase 3 - Testing Phase (03/29/21 - 05/13/21)

Phase 4 - Presentation Phase (05/13/21 - 06/04/21)

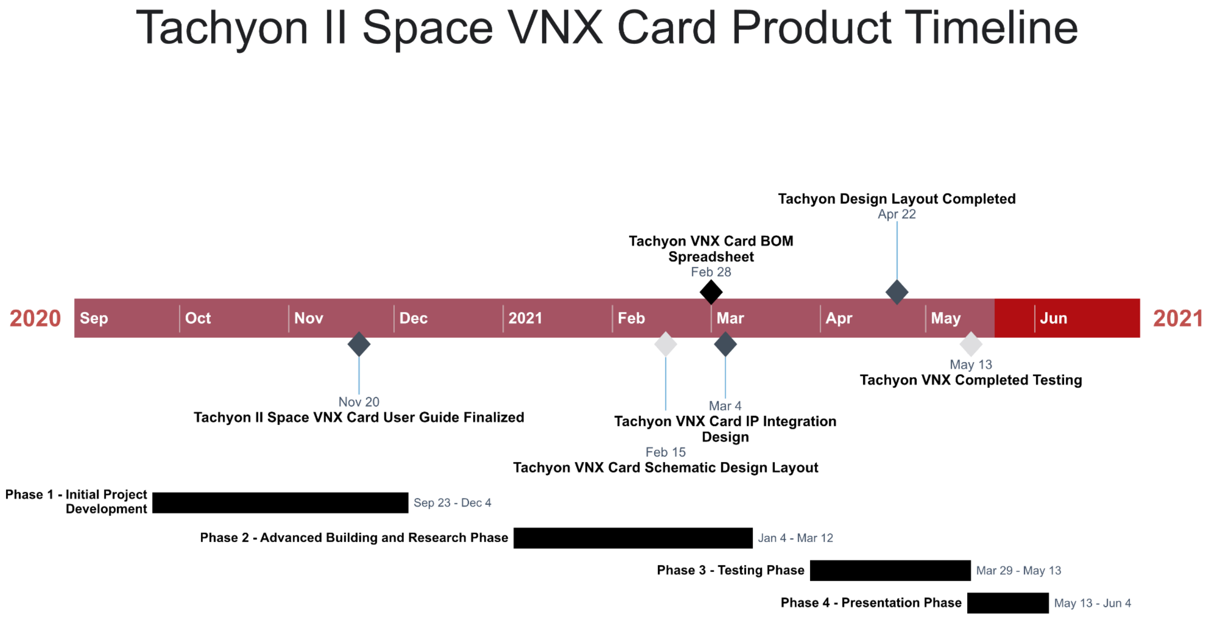

Figure 1: Product Development Timeline

Milestone	Task Description	Involved Members	Deadline
Tachyon II Space VNX Card User Guide Finalized	A user guide/specs that details the components for the Tachyon II Space VNX card so that other users can understand how to implement the board into their own personal designs. We went through multiple rounds of revision with our project partner.	Entire Hardware Team Praesum Communications (Blake Rayburn)	11/20/20
Tachyon VNX Card Schematic Design	Design a schematic layout of the Tachyon II on OrCAD and	Hardware Team (Raymond and Brad)	2/15/21

Layout	ensure that it passes the DRC check. Multiple rounds of revision were done with the project partner.	Praesum Communications (Blake Rayburn)	
Tachyon VNX Card BOM Spreadsheet	Fill out the Bill of the Materials for the Tachyon II.	Hardware Team (Raymond and Brad)	2/28/21
Tachyon VNX Card IP Integration Design	Develop and integrate the RapidIO integration provided by Praesum with the MSS.	Hardware Team (Hassan) Software Team (Matthew Laidlaw and Patrick Shuler)	3/4/21
Tachyon Design Layout Completed	Work with our PCB design contractor to organize and layout the PCB components on OrCAD and agree on layout.	Hardware Team (Raymond and Brad) Praesum Communications PCB contractor (Joe Tasker)	4/22/21
Tachyon VNX Completed Testing	Test the Tachyon II system and show that our defined engineering requirements pass and are verifiable.	Entire Hardware Team	5/13/21

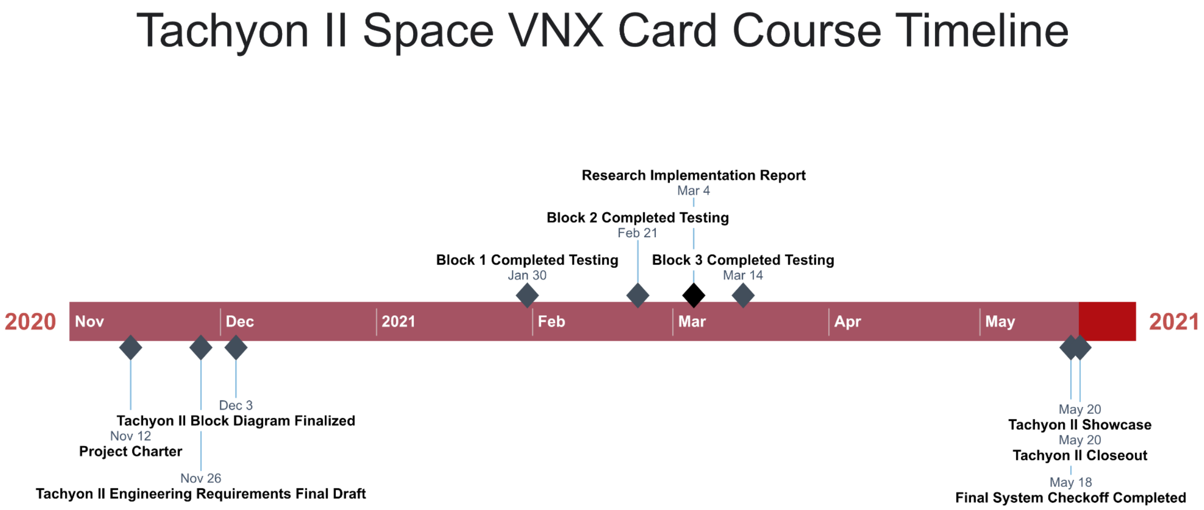

Figure 2: ECE 44X Course Assignment Timeline

Milestone	**Task Description**	**Involved Members**	**Deadline**
Project Charter	Design a document that contains the executive project summary, risk register, team protocol standards, project timeline, and scope of engineering requirements.	Entire Hardware Team	11/12/20
Tachyon II Engineering Requirements Final Draft	Complete a final draft of the project engineering requirements and get it approved by the project partner.	Entire Hardware Team Praesum Communications (Blake Rayburn)	11/26/20
Tachyon II Block Diagram Finalized	Complete a final draft of the project's block diagram and the blocks' respective interface definitions.	Entire Hardware Team	12/3/20
Block 1 Completed Testing	First round of block check offs for the Tachyon system	Entire Hardware Team	1/30/21
Block 2 Completed Testing	Second round of block check offs for the Tachyon system	Entire Hardware Team	2/21/2021
Research Implementation Report	Research components of the project that may prove a challenge and gather insight to help the team overall.	Entire Hardware Team	3/4/21
Block 3 Completed Testing	Third round of block check offs for the Tachyon system	Entire Hardware Team	3/14/21
Final System Checkoff Completed	Record, test our system, and show that it meets the eight engineering requirements defined in Section 3.0	Entire Hardware Team	5/18/21
Tachyon II Closeout	Completed document that details the design impact of the system, project development timeline, engineering requirements, risk register, and future recommendations.	Entire Hardware Team	5/20/21
Tachyon II Showcase	Project overview on the system consisting of a summary, elevator speech, artifacts, and the system's operations	Entire Hardware Team	5/20/21

3.0 Scope and Engineering Requirements Summary

The scope of this project is to create a next gen space VNX development platform. Our main contribution to this project is documenting a detailed user guide on the Tachyon II for future users, designing a schematic layout of the Tachyon, and working on the IP integration into the device. The fully assembled system will be successfully implemented into numerous Praesum Communications projects.

Name	Engineering Requirement
1. Design Place and Route	Within Libero, the project-partner approved design passes place and route without any errors (errors-waived by project partner are acceptable).
2. Design Size	The system will fit within a PCB layout design of a 56 mm by 78 mm area, and approved by the project partner.
3. Device Compatibility	The system will read CSR data from Praesum RapidIO Endpoint IP.
4. Documentation	The system will have a complete user guide that will explain the board’s purpose and specialty in a way that 9 out of 10 OSU students would score >80% in a follow-up questionnaire.
5. LINUX	The system will run on LINUX and will have its project-partner approved hardware design where the FPGA subsystem will be running LINUX and outputting it through a UART serial interface.
6. Schematic Design	The project will produce one schematic that has no errors (errors-waived by project partner are acceptable) in DRC and will include the required subsystems listed

	in the user guide.
7. Tachyon User Guide	The project will produce a document describing the board functionality that is at least 30 pages and is approved by the project partner after undergoing peer review.
8. Temperature	The system will maintain a maximum temperature of 130°C +/- 10 percent during operation for 30 minutes.

4.0 Risk Register

Risk ID	Risk Description	Risk Category	Risk Probability	Risk Impact	Performance Indicator	Responsible Party	Action Plan
R1	The board is damaged in a way that interferes with its functionality.	Technical	15%	H	Physical damages to the board (burns, cracks, warper shape) or internal damages discovered through testing	Hassan alabduha@oregonstate.edu	Reduce - be careful with how we're testing/operating and storing the board
R2	There is an Increase in electronic prices.	External, Cost	15%	L	An increase in electronic prices	Brad steinb@oregonstate.edu	Transfer - contact project partner to discuss if there will be financial changes
R3	Lack of communication between teams could cause a delay on	Program management, communication, planning	10%	M	The software or hardware team is not keeping up with the other team progression	Raymond jungr@oregonstate.edu	Reduce, Communicate, Adjust timeline if needed

	project progression.						
R4	There are incorrect measurements when designing the Tachyon II PCB.	Technical	40%	M	The numbers on the board design are not matching up.	Brad steinb@oregonstate.edu	Reduce - the schematics and board design can be scaled on a software to see if the physical replication will have the correct dimensions
R5	Receiving a defective electronic part could delay the assembly stage	External, Suppliers	2%	M	Electronic parts are not working as intended or at all	Hassan alabduha@oregonstate.edu	Retain, Order new parts
R6	Breach of NDA contract	Legal	5%	L-M	3rd parties that inquire about the	Raymond jungr@o	Avoid - avoid talking

					project details	regonstate.edu	excessively about the project when with non-involved parties

Throughout this project, we have faced many obstacles and setbacks. Many of them happened on our project partner's end, but that doesn't mean it wasn't stressful for us. One of the biggest lessons that we learned this year was that when multiple different teams are working on the same project, and when these teams depend on each other to have something done before moving on the next part, everyone needs to be flexible. Although, with that flexibility, the responsible team still must own up to their mistakes. Early, clear, and honest communication will prevent additional stress on everyone's part. However, we learn that it's important that when problems arise, it's the team vs. the problem and not with each other.

One risk that we did not anticipate was connecting remotely to a computer owned by our project partner. The slow connection caused a lot of lag and only one person could use it at a time, making using it a very time consuming activity. It was a low risk. To deal with this risk, we communicated when we were planning on using the computer and when we were done. We also gave ourselves plenty of time to use this computer rather than procrastinating.

5.0 Future Recommendations

Recommendation	Reasoning	Starting Point
1. Be on the lookout for alternative, smaller parts that can be integrated in the Tachyon PCB.	The Tachyon is a small VNX form factor that is about 20% of the PolarFire SoC Icicle Kit's size. It already requires necessary components such as RAM, FPGA, LEDs, connectors, and memory. Since it requires a good number of parts already, it's a good idea to find any way to maximize the space that one is working with on the board.	Look into part alternatives for the existing design layout of the Tachyon VNX card. If approved by the project partner, it would help prevent the board from overheating. In addition, it can be a good selling point for Praesum to their consumers, a small functioning board that is well-spaced. Parts can be found on DigiKey or Mouser.
2. Client revisions added to PCB	The 2020-21 senior design team finished the second draft of the schematic for the Tachyon Space VNX card. As another team picks up the project and another year of technological progression goes by, there may be changes made to the Tachyon.	Meet with the client(s) to discuss and determine if there will be changes made to the schematic for the Tachyon. In general, while it is good to plan, don't stick to it too tightly. Plans can change depending on the type of revisions so be aware.
3. Update the Tachyon User Guide to reflect the current state	The Tachyon is currently an experimental project, shown by the fact that there is no physical board. It is a work in progress and not finalized. Therefore, the user guide will need to be updated once assembly is	As our assembly process was stopped due to COVID and the resulting part shortages. There shouldn't be drastic changes to the overall structure to the board. However, working with Praesum, as you go through upgrades and

	finished. As the schematic capture process changes throughout, the pin numbers, part numbers, and the specs of the subsystem might change. This would need to be updated on the guide.	improvements, make the necessary changes immediately so you don't forget. It is also good to be in close contact with the client so they can confirm the changes.
4. Update cost analysis	With the Tachyon II having room to change, that means its parts may change as well. This needs to be taken into account. Our BOM did not plan for the shortages that COVID would impact. Now that there is more time, there might be more opportunity to improve the board. Some examples could be finding better ways to keep heat dissipation high and developing the Tachyon PCB with a higher quality material.	Our recommendation is similar to the user guide. stay on top of it and make the necessary updates every time a change is made to the Tachyon, both before and after printing the board. If possible, contact Praesum for the 2021 BOM to have a good starting point on what the template should look like.
5. Be familiar with the OrCAD software.	OrCAD will be the software that will be used to design the schematic and layout the components of the Tachyon PCB. It will be heavily used in the design process so it would be advantageous to know the software.	There is a link written by students to help one get familiar with OrCAD.
6. Be in frequent contact with your	Deadlines can come up unexpectedly. In addition, the	Set up periodic meeting times, weekly or bi-weekly. It also helps to

project partner and other teams throughout the process.	project partner and/or other teams may not be fully aware of the different courses' assignment deadlines. Don't assume they know certain things or wait until it's too late to make things known to them.	respond to emails promptly but also be aware of each other's schedule. For example, sending an email in the morning can garner a response back relatively quickly compared to sending it at night and expecting them to answer on the same day.
7. Be familiar with the Libero software.	Libero will be the software that will be used to design the Tachyon's hardware component and simulate testing results of the board. This is important as the board is being further developed as it is expensive (time and money) to assemble the board and have poor test results.	The Libero user guide link is provided. However, the project partner is there to help. If something is confusing about the softwares one is using, don't hesitate to reach out and ask.
8. Testing the Tachyon Space VNX card	Once the Tachyon is assembled and produced into a physical PCB, it will need to be tested to see if it can boot up properly and interact with Praesum's communication device, the Everest Kit. This was the final stage of our project that couldn't be reached due to part shortages and the inability to assemble a board in time.	Load a LINUX distribution onto the board and confirm that the onboard power supplies are operating at the correct voltages. The system uses both a 3.3V and 5V feed. Test that the board is able to understand, receive and send video streaming data with Praesum's devices. The communication interface used is of the AXI4.
9. Keep an organized space of all the project artifacts and	This lets other team members or other teams understand and follow your work. They will have	Set up a Google folder where each person documents their progress. This can include progress videos,

documentation.	a better understanding of how to document their work and pick up the next advancement	project artifacts such as the Tachyon schematic designs, and meeting minutes outlined on a spreadsheet.

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