VARISS VR APPLICATIONS MEMORANDUM:

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1.0 FOREWORD

In the University of Michigan Aerosp x88 Course Series, our Virtual and Augmented Reality in Space Systems (VARISS) team, is working to design a CO_2 Microbial Scrubber for a closed lunar habitat, functional for a 4-man crew. This endeavor represents the subject and focal point for the VR investigation we have been tasked with by Collins Aerospace. Our team is committed to exploring the potential applications of VR technology, and to reach our objectives, we have designed a set of analyses and investigations to establish the efficacy of VR applications in Computer-Aided Design. After intensive practice with the VR facilities, we have analyzed the benefits and hindrances of using NX Siemens VR capabilities collaboratively. This memo serves the purpose of defining, clarifying, and simplifying the analyses we underwent, and determining the value that VR can add to the collaborative efficiency of NX Siemens Computer-Aided Design. Our team has gained practical insights and proficiency in utilizing Siemens NX VR capabilities for collaborative engineering in CAD, and this memo will provide a comprehensive overview of the benefits and challenges associated with incorporating VR technology into the collaborative design workflow.

Our analyses have not only delved into the technical aspects of VR integration but have also addressed the broader spectrum of collaborative efficiency in the design process. We have undertaken a thorough examination of the application of VR in rendering a 3D model of our CO_2 Microbial Scrubber, assessing its potential impact on spatial understanding, component visualization, and overall design comprehension. The experiences gained during these investigations have allowed us to identify key areas where VR technology can enhance the efficiency and efficacy of our collaborative design endeavors. Through a specific focus on Siemens NX VR capabilities, our team has explored the feasibility, functionality, and adaptability of this technology within this framework of design. By elucidating the value that VR adds to the collaborative efficiency of NX Siemens Computer-Aided Design, we aim to contribute valuable insights to the ongoing discourse surrounding the integration of VR technology in engineering.

2.0 SUMMARY

We have conducted an in-depth exploration of the utilization of Virtual Reality (VR) technology in the Model-Based Systems Engineering design cycle, modeling the development of a CO_2 microbial scrubber as a test case. This investigation, initiated by Collins Aerospace, sought to determine the effectiveness of VR in enhancing the traditional practices of engineering design, notably in the realms of computer-aided design. Through a series of meticulously designed tests - namely the CAD Experience Test - we have compared VR-enhanced methodologies with conventional MBSE approaches. The findings from these tests, derived mainly from these feedback questionnaires, have illuminated several critical aspects of VR in the context of engineering design. The investigation revealed a notable enhancement in spatial understanding and intuitive interaction with design models when VR was employed. Participants reported a significant improvement in visualizing and comprehending complex design components, in turn allowing us to catch design errors, improve model efficiency, and understand the developments in a 3D setting.

However, it is important to note that the study also highlighted the limitations of current VR technology. Notably, the absence of robust editing tools within the VR environment emerged as a significant impediment, demonstrating a continued reliance on traditional CAD methods for initial design phases. This limitation underscores VR's integration in the nascent stages of MBSE, indicating a substantial scope for the development of specialized VR software tailored to the engineering design process. Overall, our investigation reaffirms the potential of VR in enhancing certain facets of the MBSE design cycle, especially in visualization and collaborative review. Yet, the realization of its full potential hinges on future advancements in VR software, which would allow for far more comprehensive and seamless integration into all stages of the engineering design process. The insights gained from this study are pivotal for both Collins Aerospace and the engineering sector at large, offering a directional compass for future VR integrations and innovations.

3.0 INTRODUCTION

This memorandum presents the findings and analyses from a comprehensive investigation into the integration of Virtual Reality technology within the Model-Based Systems Engineering design cycle. Commissioned by Collins Aerospace, this investigation aimed to evaluate the effectiveness and applicability of VR in enhancing various stages of the engineering design process. Utilizing the development of a CO_2 microvial scrubber as a case study, this investigation focused particularly on the computer-aided design stage, exploring how VR can influence traditional methods. In an era where technological advancements continually reshape industrial practices, understanding the potential and limitations of emerging technologies like VR is crucial. This memorandum, therefore, seeks to provide a detailed account of our testing methodologies, the observations and feedback gathered, and an analysis of VR's current capabilities and future potential in the field of engineering design. By dissecting the experiences of test engineers during the CAD process, we aim to offer a nuanced perspective on the role VR can play in revolutionizing design processes, acknowledging both its strengths and areas requiring further development. Our findings are intended to guide strategic decisions regarding the integration of VR technology in complex engineering projects, thereby informing future innovation and efficiency improvements in the aerospace industry and beyond.

3.1 PURPOSE

Our aim in this memo is to outline the objectives and rationale of our investigation in the effectiveness and applicability of Virtual Reality technology across various industrial design processes, using the development of a CO_2 scrubber for a lunar base as a case study. This investigation is part of an initiative to gain deeper insights into the potential role and benefits of VR in industry, particularly within the realms of Model-Based Systems Engineering (MBSE).

Specifically, we are aiming to critically assess how VR can be integrated into different stages of the MBSE design cycle, evaluating its utility, efficiency, and impact on project outcomes. This choice provides a complex, multi-faceted engineering challenge that is ideal for examining the nuances and implications of VR application in a real-world scenario.We specifically focus on identifying where VR technology can most effectively contribute to the design and development process.

Furthermore, the purpose extends to establishing a foundation of knowledge that can be applied to a broad spectrum of industrial applications. The findings from this investigation are intended to guide future decisions regarding the integration of VR technology in various engineering and design projects, setting a precedent for the adoption of immersive technologies in industrial settings.

3.2 SCOPE

This investigation is focused on assessing the utility and feasibility of VR in various stages of the MBSE design cycle, with a particular emphasis on the stages where VR integration is most beneficial. Initially, our team explored the potential use of VR in the requirement writing and schematic development stages. However, it was determined that VR technology did not significantly enhance these initial stages of the design process. The nature of these tasks, which primarily involve text-based documentation and 2D graphical representations, coupled with the current lack of VR software to support these activities, led to our decision to exclude VR from these primary stages of the design cycle.

Moreover, the integration of VR into the Concept of Operations (ConOps) and Development Operations (DevOps) was also considered. While VR could offer innovative ways to visualize operational concepts and development workflows, the substantial resources required for coding and creating VR animations were deemed prohibitive. The time and effort necessary to develop these applications would extend beyond the scope of our current timeline and resources. Consequently, the application of VR in ConOps and DevOps has also been determined to be out of the scope for this investigation.

The primary focus of our VR application, and this memorandum, lies in CAD modeling and the CAD model reviewing stages. In these phases, VR is utilized to enhance spatial understanding and to facilitate more effective communication and collaboration during the design review process. The immersive nature of VR provides a unique and intuitive perspective of the CO_2 scrubber's design, potentially revealing design considerations and issues that may not be as apparent with a traditional 2D interface. Our investigation aims to yield valuable insights into the practicality and added value of VR in these specific areas of the MBSE design cycle.

3.3 BACKGROUND

This memo is drafted in the context of a project contracted by Collins Aerospace, aimed at evaluating the effectiveness of Virtual Reality (VR) technology implementation in industrial-based applications. Collins Aerospace, a leader in aerospace and defense solutions, has recognized the potential of VR to revolutionize design processes, collaborative efforts, and operational efficiencies within their business scope. In pursuit of this, our team was commissioned to conduct an in-depth investigation into the practical applications and benefits of VR technology, particularly in the context of complex engineering projects.

The choice of a CO_2 scrubber for a lunar base as the subject of this investigation was strategic. This project, employing the development of a microalgae-based life support system, presents a series of engineering challenges typical of the aerospace industry - challenges that are both intricate and representative of the broader applications Collins Aerospace envisions for VR technology. The project's nature requires a comprehensive design approach, making it an ideal candidate for exploring the utility of VR in enhancing design and development processes.
Our investigation aligns with Collins Aerospace’s objective to stay at the forefront of technological innovation in the aerospace sector. By understanding the capabilities and limitations of VR in a real-world application, Collins Aerospace aims to gather actionable insights that could shape the future integration of this technology across their various divisions.

4.0 TEST DESCRIPTION

Our focus centers on the application of VR in a computer-aided design (CAD) model for a CO_2 scrubber. These tests are devised to assess the effectiveness of VR in enhancing traditional MBSE methods and to identify potential areas for innovation.

Our defining objective in this test is to answer the question: “In what ways could the use of VR in the computer-aided design and review process affect the traditional MBSE method?” It will be split into two distinct approaches - one involving the use of VR technology and the other following traditional CAD methods without VR integration. In the VR-integrated approach, participants will use CAD software with the option to intermittently switch to VR mode to evaluate their work, verify dimensions, visualize designs, etc. In contrast, the other approach involves the use of CAD software without any VR integration, designing models traditionally. After completing their respective tasks, participants in both approaches are required to fill out a CAD experience form, which aims to capture their experiences with specific VR-mode applications, perceived challenges, and efficiencies or inefficiencies of each method.

4.1 PROCEDURE

Procedure for CAD Experience Test:

Preparation:

- Set up the computer-aided design (CAD) software on designated computers (in this case NX Siemens 2015).
- Ensure the VR equipment is calibrated and integrated with the CAD software for the VR-enhanced portion of the test.
- Prepare CAD experience forms for participants to record their observations and feedback.

Execution - VR Integrated CAD:

- Participants start designing the CO_2 scrubber model or subcomponents using traditional CAD software on a computer.
- At various stages of CAD design, participants switch to the VR environment to evaluate their work, check dimensions, and gain a different perspective on the design.
- Throughout the process, participants take notes on their experience, focusing on aspects like ease of use, perception of accuracy, and overall efficiency.
- Take note of any changes made due to experiences in VR. What tools were helpful? What tools should be added? Answers like this allow for a thorough investigation.

Execution - Traditional CAD:

- Participants design the CO_2 scrubber model or subcomponents using only the CAD software on a computer, without any VR integration.
- Similar to the VR group, these participants document their experience, emphasizing their perception of the design process's efficiency, effectiveness, and any challenges faced.

Post-Design Documentation:

- After completing the design process, all participants fill out the CAD experience form, providing detailed feedback on their experience with or without VR.

Analysis:

- Collect and analyze the CAD experience forms to assess the impact of VR on the CAD design process.
- Conclusions can be drawn from differences in responses by participants in both subject groups. Ideally, the differences will provide categories of VR solutions that prove applicable and/or useful in the technical side of the engineering design process, and other categories that are not yet available, but would be useful.

4.2 OBJECTIVES

The objective of the conducted test is to evaluate the impact of integrating Virtual Reality (VR) technology into a particular portion of the design cycle, specifically in the realm of computer-aided design (CAD). This test aims to ascertain whether the incorporation of VR can enhance the traditional methods of CAD modeling by assessing the applicability of various digital engineering and design tools, including measurement, perspective, editing tools, etc. The primary focus is to compare the efficiency, accuracy, and overall effectiveness of CAD creation with and without the application of VR technology. By conducting these tests, we seek to understand how VR can influence and possibly improve the dynamics of design conceptualization and spatial visualization. This comparison is crucial in determining the practicality and value of adopting VR technology in complex engineering projects, ultimately informing strategic decisions about technology integration in industrial design and development.

A significant aspect of this investigation involves assessing the functionalities of VR tools such as measurement, perspective adjustment, editing capabilities, and collaborative features. By identifying the strengths and limitations of these tools, the objective is to make known the potential for refinement and optimization, thereby enhancing the utility of VR technology in engineering design workflows. Beyond the technical functionalities, we hope to explore how VR influences the dynamics of design conceptualization and spatial visualization. By immersing participants in virtual environments that provide a three-dimensional perspective of the design, the objective is to understand how VR facilitates intuitive interaction with complex engineering models. This exploration aims to uncover insights into how VR can augment creativity, problem-solving, and decision-making processes during design iterations.

Building on the insights garnered from the evaluation, another crucial objective is to identify opportunities for future integration of VR technology. This involves not only recognizing areas where VR proves particularly beneficial but also envisioning potential enhancements and innovations that could further optimize VR integration. By proactively identifying integration opportunities, the goal is to pave the way for continuous improvement and innovation in engineering design methodologies. Ultimately, we want to provide strategic decision support for stakeholders involved in technology adoption and innovation within the aerospace and engineering sectors. By presenting a nuanced understanding of VR's capabilities, limitations, and potential, we can empower decision-makers with the knowledge needed to make informed choices regarding the integration of immersive technologies into industrial design workflows. This strategic decision support aims to drive innovation, efficiency improvements, and competitive advantage within the industry landscape.

5.0 RESULTS

The results from the conducted test, based on feedback obtained through questionnaires from four test subjects - two with VR and two without (Appendix 1, 2, 3, 4) - highlights significant insights into the application of Virtual Reality (VR) in the computer-aided design (CAD) process. These results provide a comprehensive understanding of the benefits and limitations of VR in enhancing traditional Model-Based Systems Engineering (MBSE) methods.

Spatial Understanding and Perspective:

- Both subjects accessing CAD designs via VR reported a heightened spatial understanding of their respective parts - the CO2 inlet interface and the Algae Containment Unit (ACU) flowerpot - when viewed through the VR portal. The VR experience provided a realistic sense of scale and dimension, enhancing their perception of the part's actual size.
- The ability to manipulate and view the model in three dimensions (x, y, z axes) in VR was highlighted as particularly beneficial, offering a more intuitive understanding of the part's geometry compared to traditional 2D CAD methods (Appendix A).
- Participants that did not use CAD reported spatial understanding of individual components to be far more difficult, and can only gain a better understanding after multiple components can be added for reference.
- Subjects who did not use VR also acknowledged the importance of spatial understanding but did not have the opportunity to experience it through VR.

Intuitive Design Tools:

- The subjects found specific VR tools, such as the drawing tool, to be intuitive and effective for sketching and visualizing connections between different components. These features could be used in collaborative design reviews to communicate to reviewers specific component features and processes.
- However, there were limitations in editing capabilities within VR, with one subject noting the absence of VR-based editing options - extrusion, cutting, filling (Appendix B).
- The participants that did not use VR reported that they rely on their experience with traditional CAD software, suggesting that intuitive design tools are essential regardless of the platform. Their feedback underscores the universal importance of user-friendly design tools in CAD software.
- In NX Siemens, one candidate reported that the tools are difficult to locate and learn to use, which cuts into crucial design time (Appendix D).

Measuring and Visualization:

- The VR interface presented some challenges in precise measurement, although simplified measuring tools were still available in VR. The benefits of VR in measuring were noted in terms of providing a visual aid for understanding dimensions and displaying measurements to others, which might be more useful in later-stage collaborative design reviews.
- One candidate that did not use VR reported that the measuring tool in NX Siemens is not convenient and does not always provide the correct value - a potential benefit of measurement tools in VR (Appendix D).
- Those who did not use VR did not comment on VR-specific measuring tools but discussed the process of measuring parts in traditional CAD software. They emphasized the importance of precise measurement for ensuring compatibility with other components and for 3D printing purposes (Appendix C).
- Overall, there was a recognition of the benefits of visualization in both VR and traditional CAD environments for understanding dimensions and spatial relationships.

Additional Observations:

- One subject who used VR expressed the rewarding experience of visualizing and 'holding' a part they designed in VR, highlighting the immersive nature of VR and its potential for enhancing the design experience (Appendix A).
- Limitations in the VR drawing tool were noted by one subject, particularly in the inability to easily undo actions - drawings in particular. This suggests that while VR tools may offer benefits, there are still areas for improvement to optimize the user experience.
- Subjects who did not use VR did not provide additional observations specific to VR but shared their experiences and challenges with traditional CAD software, indicating a need for continued refinement and enhancement in both VR and traditional CAD tools.

The tests underscore VR's potential to significantly enhance spatial understanding, intuitive design, and collaborative review in CAD processes. While there are areas for improvement, particularly in VR editing capabilities and certain tool functionalities, the overall feedback suggests that VR offers a substantial improvement over traditional 2D CAD methods in terms of visualization and collaboration in description of designed components. These findings indicate a promising avenue for incorporating VR technology into the MBSE design cycle, potentially leading to more efficient and accurate design processes.

6.0 DISCUSSION

The test results provide a valuable insight into the current state and potential of integrating Virtual Reality (VR) technology into the Model-Based Systems Engineering (MBSE) design process. Analysis of the feedback from the test subjects highlight both the strengths and limitations of VR in its current form. While it offers enhanced spatial understanding and an intuitive, immersive experience in design visualization, VR's full integration into the CAD process is hampered by the absence of comprehensive editing tools within the VR environment. This limitation underscores the necessity for the development of new, more advanced VR software tailored specifically for engineering design applications.

The feedback points to the idea that VR technology, in the context of MBSE, could still be in its nascency. Existing VR tools show promise in transforming how designers and engineers interact with their models – offering a more tangible understanding of complex designs. However, the technology's potential has not yet fully realized due to this lack of certain functionalities, such as efficient editing and undoing actions within the VR space, which are crucial for a seamless design process in this day and age. This gap highlights an opportunity for software development, aiming to integrate these essential features into the VR design workflow. Moreover, the results suggest that while VR significantly improves the visualization aspect of design, the current technology is likely more conducive to the review and feedback stages of the MBSE cycle rather than the initial design creation phases. A lack of robust VR-based editing tools necessitates a reliance on traditional CAD methods for detailed design work, followed by VR for review and visualization; it is this divergence of the design process which indicates that VR technology, as it stands, is an adjunct tool rather than a standalone solution in the engineering design process.

7.0 CONCLUSION

The investigation into the integration of VR technology into the Model-Based Systems Engineering design cycle has yielded valuable insights into its benefits and limitations, as well as potential for growth. Through a series of feedback questionnaires, our team has gained a nuanced understanding of how VR influences the computer-aided design process, particularly in the context of complex engineering projects like the development of a CO_2 scrubber. The results underscore VR's ability to significantly enhance spatial understanding, intuitive design, and collaborative review in CAD processes. Test subjects reported a heightened sense of scale and dimension when viewing models through VR, facilitating a more human interaction with the design. This enhanced spatial understanding has the potential to improve design comprehension, catch errors, and enhance overall model efficiency.

Additionally, specific VR tools, such as drawing tools, were found to be effective for sketching and visualizing connections between different components. However, limitations in editing capabilities within the VR environment, such as the inability to easily undo actions, indicate areas for improvement. While VR technology offers a significant improvement in visualization, its full integration into the CAD process is hampered by the absence of comprehensive editing tools within the VR environment. The ideal VR applications in CAD might include shape construction, extruding, and even basic manufacturing tools. This limitation underscores the necessity for the development of new, more advanced VR software tailored specifically for engineering design applications.

Furthermore, while the VR interface presented some challenges in precise measurement, simplified measuring tools were still available. The benefits of VR in providing a visual aid for understanding dimensions and displaying measurements were recognized. However, participants that did not experience the VR noted the importance of precise measurement for ensuring compatibility with other components and for 3D printing purposes. Overall, while VR technology shows promise in revolutionizing the CAD process and enhancing collaborative efficiency in engineering, its full potential has yet to be realized. Further advancements in VR software development are necessary to address current limitations and optimize the integration of VR into the MBSE design cycle. By leveraging the insights gained from this investigation, stakeholders in the aerospace, and other engineering sectors can make informed decisions about the strategic adoption and integration of VR technology, driving innovation and efficiency in industrial design workflows.

Moving forward, it is recommended that Collins Aerospace closely monitor the advancements in VR technology. Investing in the development of VR software tailored for engineering applications could be a strategic move, potentially revolutionizing design processes in aerospace and beyond. The knowledge gained from this investigation not only serves as a foundation for Collins Aerospace in their decision-making regarding VR integration, but also contributes to the broader application of emerging technologies in industrial design. This memorandum serves as a guide, pointing towards a future where VR might play a transformative role in engineering, provided that its development continues to align with the specific needs of the MBSE design cycle. The journey of integrating VR into engineering practices is just beginning, and the potential for its impact is vast and promising.

APPENDIX

1. (WITH XR) Questionnaire Response A

Name: Jack Mikhail

Date: **02/03/24**

1. Please describe the component or assembly you are working on in CAD

I was working on the CO_2 inlet interface. This part is a CAD design that is responsible for transferring the airflow from our fan into silicon tubing that connects to stone bubbler rods. The design of this interface is a cone shape in order to best change diameters and flow rates.

2. What CAD software are you using?

I am using Siemens NX to CAD this Object.

3. Describe your spatial understanding of the part you are working on? What size does it feel like when through the VR portal? What size is it really?

The size feels correct, the part itself has a max diameter of 4 inches and holding it in my hand felt very similar to its real dimensions.

4. How is perspective tackled with your CAD software's VR portal? Is this perspective altered or alterable, and are these helpful or harmful?

The perspective was interesting to use, the fact that I could move it in x,y, and z directions made it feel real to hold and see. Moving it further, then closer to me and seeing the size change was the most important part of the perspective aspect.

5. Are editing tools that necessitate visualization of the part intuitive (ie. surface fill, extrusion, hole cutting)? Is editing possible in VR? Please explain.

Yes, the drawing tool especially. I used the drawing tool to sketch the fan and the silicone tubing that attaches to this interface. From then, it was very easy to see what I was looking at and how exactly it connected.

6. What is the process for measuring parts in this software? What are the benefits of measuring in the VR portal? Are there any drawbacks?

There is a measure tool in NX itself, which shows almost every parameter you could want. The VR experience made it a bit more difficult to know exact dimensions of everything, but there is still a simplified measuring tool in VR.

7. Are you working with any other team members on the same part or have a reviewer? If so, please describe the experience.

N/A

8. List any additional observations or comments here:

VR was a very interesting tool to visualize my part in. It felt rewarding to hold something I had just designed in my hand

2. (WITH XR) Questionnaire Response B

Emmanuel Hernandez
Name:

1/25/24
Date:

1. Please describe the component or assembly you are working on in CAD

In our project we are Making a C02 scrubber which in the end will take C02 from the air and make Oxygen. In this scrubber there is the Algae containment Unit that houses the Algae and other pieces of technology to help it survive and produce Oxygen. At the bottom of the ACU there is a Flat surface that we will use to harvest the Algae. For this to work the ACU has to be elevated and the CAD that I am working on is a specific flowerpot that will give the Harvester space to be under the ACU.

2. What CAD software are you using?

I am using Siemens NX to CAD this Object.

3. Describe your spatial understanding of the part you are working on? What size does it feel like when through the VR portal? What size is it really?

When on the interface creating the part, it doesn't feel like I know how big it is until I remind myself of the precise measurements and compare it to other objects of similar size. When seeing it through the VR portal I can see exactly what size it is, and it would be especially

useful when in an Assembly to see the size comparison and if it will fit. The part in reality is big, it has to be 12 inches in diameter plus some margin for the ACU to slip inside of it.

4. How is perspective tackled with your CAD software's VR portal? Is this perspective altered or alterable, and are these helpful or harmful?

In VR I can see all around the CAD model and move around it 360 degrees easily while the NX option is clicking the middle mouse button and hoping it doesn't move in a weird direction. You can change perspectives and I think this is very helpful.

5. Are editing tools that necessitate visualization of the part intuitive (ie. surface fill, extrusion, hole cutting)? Is editing possible in VR? Please explain.

I think that each person that works on the same part has their own way of getting the same result, whether it be a different way to extrude or starting to make the object in a completely different spot. So, each person has their own intuitive thought/visualization of the object. Editing is not possible in VR, though I think it should be available.

6. What is the process for measuring parts in this software? What are the benefits of measuring in the VR portal? Are there any drawbacks?

When measuring parts in the software you click on the measure tool and click on the surface you want to know the measurements for. I think the benefits for measuring in VR is just to display it for other people who are watching and to remind yourself when you are looking at the object. I don't think there are any drawbacks from doing either method as opposed to the other.

7. Are you working with any other team members on the same part or have a reviewer? If so, please describe the experience.

I am not working with a reviewer, but I did have a chance to clear up some of the confusion we had about the harvester location on the ACU. At the time we had a stone circular bubbler at the bottom of the ACU so it blocked the access to where the harvester is supposed to be. When we cleared that up I talked to the sub team lead about where he can access the ACU to harvest so that I can base my design around that decision. By using the Drawing option in VR I was able to show him my plans and we agreed upon a design in under 5 minutes.

8. List any additional observations or comments here:

When drawing, you can't easily undo what you drew. You have to select each stroke separately and click on the delete option which is not practical at all.

It works well for presenting to a big audience when it comes to the assembly, you can cut the thing in half and show anything that may be inside the Model.

3. (NO XR) Questionnaire Response A

Name: Rachel Justus

Date: February 5, 2024

1. Please describe the component or assembly you are working on in CAD

The component that I am working on in cad is a paddle for our fluid distribution system. This component includes a separate mixer and spoke, assembling them together in the software to visualize the final product.

2. What CAD software are you using?

I am using Siemens NX computer aided design software.

3. Describe your spatial understanding of the part you are working on? What size does it feel like when viewed on the screen? What size is it really?

The spatial understanding of the part can be hard to visualize unless you combine it with the component of which it is going in. Although, you are able to accurately visualize that the spoke is significantly longer than the dimensions of the paddle. This is nice as you can see how the two pieces will interface with one another and how the final product will be proportioned.

4. How is perspective tackled with your CAD software? Are there any simplifications to perspective, and are these helpful or harmful?

You are able to choose the plane at which you are putting your sketch or component on which can allow you to easily adjust to that plane. As well, to visualize your component you have an easy ability to put it in an isometric view allowing for consistent viewing of multiple parts of the project.

5. Are editing tools that necessitate visualization of the part intuitive (ie. surface fill, extrusion, hole cutting)? Please explain.

The editing tools to make the part more than just a sketch are in fact pretty intuitive. As well if you hover over the tool it will explain what it does and also offers a tutorial so you can have confidence in the tool that you choose. As well there is a good search tool that will give what you are looking for and a few suggested related options.

6. What is the process for measuring parts in this software? What are the benefits of measuring in CAD software? Are there any drawbacks?

If you want to measure parts there is a simple tool that is actually called measure, you just look up measure and click on the part you want to measure and then it gives the relative dimensions. You are able to find out the proportions in real size and also you are able to make sure it can interface with the other parts, as well if you are 3D printing, which I am, you are able to know how big it will be when you actually print it.

7. Are you working with any other team members on the same part or have a reviewer? If so, please describe the experience.

I am working alone, but am getting reviewed by both Henry and Tobi - our team leads. They are able to help as I am not the most experienced with cad.

8. List any additional observations or comments here:

n/a

4. (NO XR) Questionnaire Response B

Makenzie Womack

Name:

2/6/2024

Date:

1. Please describe the component or assembly you are working on in CAD

Working on assembling the algae containment unit including all of the components that are housed inside and outside as well as necessary components that need to be attached to the ACU.

2. What CAD software are you using?

Siemens NX

3. Describe your spatial understanding of the part you are working on? What size does it feel like when viewed on the screen? What size is it really?

It is about 32L 1.5 ft tall and 1 ft in diameter. I guess I haven't really thought about what size it looks in reality so much as how the scale of things work together which makes sense to me.

4. How is perspective tackled with your CAD software? Are there any simplifications to perspective, and are these helpful or harmful?

There are different views that you can put on your part and different levels of shading. Personally I like having shading on my part because it gives a little more perspective and allows me to see a 2D screen in 3D a bit easier.

5. Are editing tools that necessitate visualization of the part intuitive (ie. surface fill, extrusion, hole cutting)? Please explain.

Overall I think that CAD softwares has very similar tools, but the location and ease of access to these tools in NX is a little difficult to work with. Lots of things are hidden and need searching for which cuts into design time.

6. What is the process for measuring parts in this software? What are the benefits of measuring in CAD software? Are there any drawbacks?

There is dimensioning and then measuring. Personally, I am not a fan of the measuring tool because I am usually looking for a dimension along a single axis and it gives the smallest distance between which is not always helpful. I know that there is a way to get the components of a dimension, but I have yet to figure out how to do this.

7. Are you working with any other team members on the same part or have a reviewer? If so, please describe the experience.

I have been working with other members to get stock CAD which then needs to be put into the overall system. It has been an alright experience, but it could be better. In order to upload an assembly all of the components need to be in the same folder which makes it difficult to share assemblies with people.

8. List any additional observations or comments here:

Overall NX is not my favorite, but I think that I can learn to like it with more practice.