Project Definition Document

Virtual Reality Application for a Gamified Simulation of Manned Space Debris Retrieval

By Gabi Prefit – Msci Computer Science with Games Technology Year 4

## Cover sheet

**Course:** Msci Computer Science with Games Technology

**Module:** INM450 Individual Project

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**Proposed** **by**: Gabi Prefit

**Proprietary** **interest**: This project will use a personal Unity license for the purpose of its development. The project may incorporate third-party assets and resources, and all such materials will be appropriately credited in accordance with their respective licenses and referenced as needed. The project and all iterations shall remain Intellectual Property of Gabi Prefit.

**Other** **promises**: None.

**Word** **count**: 2479

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# Proposal

## Problem to be solved

This project aims to explore the use of Virtual Reality (VR) in an interactive game and simulation of manned space debris removal and Extravehicular Activity (EVA), acting as an accessible, realistic and immersive edutainment game. Unlike existing VR astronaut training programs such as NASA’s (North American Space Agency) JSC VR Lab (NASA, 2023), which is inaccessible to non-astronauts, the project will simulate zero-gravity, accurate physics, and an interactable environment, while remaining accessible to those with a VR headset.

### Motivation

Space sustainability

Space agencies and private companies of the space industry around the globe have identified a critical issue stifling further development of their technology and safety of those who use it: space debris. Space sustainability has become a key consideration in future plans for missions in outer space and specifically Low Earth Orbit (LEO), with leading agencies adopting sustainable frameworks and practices, such as the NASA Space Sustainability Strategy (NASA, 2024) and ESA (European Space Agency) Zero Debris Charter (ESA, 2022) and Space Debris Mitigation Requirements (ESA Space Debris Mitigation Working Group, 2023).

The world has grown dependant on the use of satellites, especially those in LEO, however until recently these satellites have been sent to space with no plan for what happens when they reach end of service. As such, figures from the ESA suggest that by September 2024, over 100 million space debris objects of size varying from 1mm to 10 cm were floating in earth orbit, and not all of these objects were being tracked (ESA, 2024).These objects, despite their relatively small size, can collide with existing satellites and/or manned missions at extremely fast speeds, causing damage and further potential debris. The exponential inflation of debris objects through collisions reaching an unmanageable state is referred to as the Kessler Syndrome. (Kessler and Cour-Palais, 1978)

To mitigate the arrival of the Kessler Syndrome and to work towards a sustainable space infrastructure, the removal of passivated (end of service) satellites that are not on an orbit towards re-entry and that might collide with other objects is required. While current technologies work towards remote options (ESA, no date available), this project will suggest there are benefits towards training astronauts for Extravehicular Activities (EVA) in hypothetical scenarios such as manned debris removal. These include but are not limited to rendezvousing with objects on an orbit using limited propulsion, In-Orbit Servicing (IOS), and system rescue missions. (ESA, no date available)

VR capabilities and market research

Similar games and experiences exist on the market. One example, Mission: ISS (Oculus, 2019), sees players with a VR headset “experience life on board the International Space Station” – being able to interact with modules of the ISS and even “spacewalk”, all the while hearing commentary from NASA astronauts (Oculus, 2019). This game has been well received, boasting a 4 star rating, gathered from 1.7 thousand individual reviews on the Meta Store. Users praise the exploration aspect of the game, as well as its dedication to realism, however some mention getting motion sickness from the zero gravity simulation (Meta forums, 2017). The game also features full body rotation through the use of grabbing onto unmovable objects with both hands and twisting (Meta forums, 2017).

Lone Echo 1 (Oculus Studios, 2017). is praised for its story and use of zero-gravity and a VR environment for enhancing gameplay (Meta Forums, 2017). Lone Echo is a sci-fi puzzle game, and does not focus as much on imitating real life. In reviews of the game, there are less complaints about motion sickness. We can attribute this to the fact that Lone Echo does not feature full body rotation in zero gravity without the aide of button presses, which some complain that it is immersion breaking. (Meta Forums, 2017)

Other successful VR projects to be considered such as Boneworks(Stress Level Zero, 2019) feature extensive care put into physics and immersion, going as far as to simulate the entire player’s body using inverse kinematics (Jagneaux, 2023) to procedurally animate the player’s arms and rest of their body movements. The combination of inverse kinematics with the zero gravity aspect of simulating an outer space environment can go hand in hand, allowing for dynamic adjustment of legs and arms based on body and head rotation in the project.

Moving away from VR, the mix of entertainment with education about space has been very successfully performed by the game Kerbal Space Program (Private Division, 2015), which has received critical acclaim not only from gamers, but also from space agencies such as the ESA, praising its realism and collaborating with the game to offer players the ability to launch Ariane 5 heavy launch rockets into space (ESA, 2020). Kerbal Space Program is a space flight simulation game which lets players build their own custom vehicles to launch and go through custom scenarios with, such as challenging players to build a multiple stage vehicle that can leave Earth’s atmosphere, reach the Moon, then return (Whitehead, 2014).

Conclusion

This project will feature a unique take on the space exploration simulation genre, making use of VR at its full potential to simulate potential real life astronaut operations in a gamified manner, providing entertainment and education on the topic of space sustainability at the same time.

## Project Objectives

As mentioned previously, this project will deliver an immersive edutainment VR game that puts the player in a manned space debris removal scenario.

Tools to be used

* Unity 6000.0.36f1 (Unity Technologies, 2005) – game engine. Newest and recommended official release by Unity Technologies.
* Blender (Blender Foundation, 1994) – 3D asset creation.
* Paint.Net (dotPDN LLC, 2004) – 2D asset creation.
* Visual Studio 2022 (Microsoft, 2025) – coding IDE. Coding language: C#
* Other assets such as (but not limited to) other 3D models, audio files to be sourced online where appropriate if royalty-free and to be referenced appropriately.
* GitHub (Microsoft, 2018) – Project management and version control.
* VR Set including game controller – for VR testing. May require access to multiple VR sets to ensure suitability for multiple platforms.

Development

The objective of the project can be measured and tested using the following milestones, further broken up into smaller objectives:

1. Create a VR player controller that features zero-gravity movement.
   1. Can the player move and look around in a first person view using a VR headset?
   2. Can the player use their hands in VR to push themselves away from objects, floating in zero gravity?
   3. Can the player and their body collide with walls, objects, and so on?
   4. Is the player able to grab onto objects, carrying smaller objects, and anchoring themselves to larger objects?
   5. Is the player able to rotate themselves in zero-gravity by grabbing onto surfaces and twisting their hands?
2. Create an interactable environment which represents the desired scenario.
   1. Is the player able to push buttons, pull levers, and twist knobs in the game?
   2. Is the environment visually representative of outer space and/or a spaceship?
   3. Does the player interacting with their environment have an impact on the environment? (e.g. changing the course of a satellite, activating a door)
   4. Does the player have a clear goal to work towards? (e.g. must collect x debris)
3. Refine the user experience to enhance immersion and create a cohesive story
   1. Does the player character feature inverse kinematics for the arms?
   2. Is there an effective User Interface that is displayed in the game (armband, astronaut helmet)?
   3. Does the project feature a cohesive scenario and story that the player can go through?

## Project Beneficiaries

These features will come together to support scenarios of varying complexity that aim to entertain and immerse the player, while making them aware of space sustainability efforts and the technologies that support them. While players of the game are the main beneficiaries, use of this project can be further explored as training for astronauts and as a template for other scenarios to be developed using the physics created for the game.

## Project Plan

Agile iterations

In order to develop this project, I will iterate through four different sprints:

1. Sprint one:
   1. Core VR player character movement
      1. Moving head
      2. Moving hands
      3. Rotating
      4. Basic movement
   2. Basic player collision
      1. Hands don’t phase through objects
      2. Body doesn’t phase through objects
   3. Zero gravity
      1. Full physics implementation not needed yet
   4. Test environment
      1. Primitives both anchored and unanchored, of various sizes, to test collision and zero gravity
2. Sprint two
   1. Create basic 3D models and textures
      1. For buttons, levers, hands, body, level
   2. Implement physics for “interactables” – buttons, levers etc.
   3. Implement physics for player character – push, grab, throw, etc
3. Sprint three
   1. Refine zero gravity interaction with player character
      1. Full body rotation
      2. Refine collision boxes
   2. Implement logic for scenario timeline
      1. Follow a simple routine: Start – introduction to controls, mid-game: goal introduced, end-game: goal reached in time or failed
   3. Implement goal for player
      1. Ensure appropriate time restriction in place
   4. Implement basic User Interface (UI)
      1. Goal clearly stated through text on screen
4. Final sprint
   1. Inverse kinematics
      1. Arm joints
      2. Max distance for hands
      3. Procedural animation
   2. Refine 3D models and textures
      1. Follow cohesive art style
   3. Introduce soundtrack and sound effects
   4. Refine UI
      1. Implement UI as part of the game environment
      2. Part of the helmet/arm (digital in-game screen)
   5. Refine scenario timeline
      1. Polish up timeline of events and goal

Testing

The development plan will be checked at the end of each sprint against the actual progress of the current build at the time. User testing may be required after the final sprint, to ensure game achieves criteria set out by the proposal according to user reviews.

Work plan

The following Gantt chart outlines the work plan for the proposed project.

A screenshot of a graph

Description automatically generated

## Risks Affecting the Project

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Risk | Likelihood | Severity | Score | Mitigation |
| Motion sickness associated with VR, acerbated by game mechanics | 2 | 4 | 8 | It is hard to predict how users will be affected by VR, but I have used VR before and have not been affected by motion sickness. If I am, or if users are affected by this, I will introduce motion sickness mitigation options for the project. |
| Software incompatibility with different VR headsets | 1 | 4 | 4 | Try to find help online for VR development on varied platforms and attempt to fix the errors. |
| Overly complex scope of the project making me overrun deadlines | 3 | 5 | 15 | While I am confident I can achieve this project in the given time, it is possible to have a scope too big, in which case I can try to cut features that aren’t as useful as others, such as original 3D modelling. |
| Striving for realism can get in the way of accessibility, creating an unpleasant experience | 2 | 3 | 6 | Identify the issue that is dampening accessibility and attempt to fix it. |
| Testing and iteration taking too long | 2 | 4 | 8 | While I am confident I can achieve this project in the given time, it is possible to have a scope too big, in which case I can try to cut features that aren’t as useful as others, such as original 3D modelling. |
| Physical safety for user testers being at risk due to unfamiliarity with VR | 2 | 5 | 10 | I will mitigate this risk by conducting tests in a controlled environment, with others present at all times to deter accidents from happening, and with safety measures being explained to users at the start of every test. This includes, but is not limited to:   * Providing clear safety guidelines * Include warnings about potential dangers such as exertion and dizziness * Encourage breaks to be taken during gameplay * Checking setup of the VR headset for each tester * Clearing “play area” of any obstructions or objects that might otherwise harm the user * All the tests shall be performed at City   If utmost safety cannot be assured, I will perform tests by myself. |
| Not getting enough testers | 2 | 4 | 8 | Perform tests by myself and switch to unit testing against proposal document. |
| Spending too much time iterating on the project and not doing enough for the written parts of the project | 2 | 4 | 8 | Ensure to allocate enough time for the written report, as well as the weekly reports and all other non-software development necessities. |
| Other coursework getting in the way of deliverables of this module | 3 | 3 | 9 | Manage my time wisely to ensure I can meet all of my coursework deadlines without needing to overlap work |
| UI incompatibility with different resolutions | 2 | 4 | 8 | Ensure to follow tutorials on how to create UI that is independent of resolution or specific hardware. |
| Issues with VR development or Unity halting progress | 3 | 3 | 9 | Use the internet to find forums, tutorials, and guides on VR development to help me understand what is going wrong in my project. |
| 3D modelling too complex of a task to do by myself | 4 | 2 | 8 | In the case that I run out of time and cannot model my own 3D models or textures, I can attempt to find suitable replacements online, or create more primitive-based models and Unity prefabs. |

## Legal, Social, Ethical and Professional Considerations

Legal

Key legal considerations that I will be monitoring are to do with the use of third-party assets and licensing of these assets. If I am to incorporate third party assets, such as 3D models, audio files, textures, etc., I must source them from public and/or royalty-free repositories. I will verify that the licence of each asset allows for the usage I intend, and maintain a clear reference list of what assets have been used, and who to credit them to.

Furthermore, referencing NASA, ESA, or other space agencies’ logos or mission data could infringe on certain trademarks or intellectual property. I will mitigate this risk by only using publicly available data, and avoid direct use of protected logos without permission, while maintaining a clear stance that the project is not affiliated with these agencies.

Social

The main social issue presented by this project is that if presented inaccurately, the issue of space preservation and space debris collection could be misrepresented to users, giving the wrong idea about the subject, or create false narratives. I will use educational content from credible sources to base all of my research and work for the game.

Ethical and professional

Mislabelling the project as an “astronaut training” simulation might lead users to believe that it qualifies them for real-life EVA (extravehicular activity) or repair. I will include disclaimers that state the presence of this project as a educational tool only and not a fully realistic astronaut training. Furthermore, it might lead to reputational risk or confusion if people associate the project with real organisations or agencies. I will ensure that there is a clear distinction between the fictional world of the video game and the real space industry, which has not endorsed this project.

## References

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Unity Technologies (8 June 2005) Unity, Available at: <https://unity.com/> (Accessed: 02 February 2025).

## Appendix A: Research Ethics Checklist

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| --- |
| **Research Ethics Review Form for BSc and MSci Projects**  **Computer Science Research Ethics Committee (CSREC)**  <http://www.city.ac.uk/department-computer-science/research-ethics> |

Undergraduate students undertaking their final project in the Department of Computer Science must consider the ethics of their project work and ensure that it complies with research ethics guidelines and the law for data protection. In some cases, a project will need approval from an ethics committee before it can proceed. Usually, but not always, this will be because the student is involving other people (“participants”) in the project.

To ensure that they give appropriate consideration to ethical issues, all students must complete this form and attach it to their project definition document (PDD). There are two parts:

***PART A: Ethics Checklist***. All students must complete this part. The checklist identifies whether the project requires ethical approval and, if so, where to apply for approval.

***PART B: Ethics Proportionate Review Form****.* Students who have answered “no” to all questions in A1, A2 and A3 and “yes” to question 4 in A4 in the ethics checklist must complete part B as well. The project supervisor or consultant has delegated authority to provide approval in such cases that are considered to involve MINIMAL risk. The approval may be ***provisional*** *– identifying the planned work with human end user participants as*likely to involve MINIMAL RISK. In such cases you must additionally seek ***full approval*** from the supervisor or consultant as the project progresses and details are established. You must obtain ***full approval*** in writing, before recruiting and engaging with human end users participants for your project.

**Part A: Ethics Checklist**

|  |  |  |
| --- | --- | --- |
| **A.1 If you answer YES to any of the questions in this block, your consultant/supervisor must have obtained approval for the project from an appropriate external ethics committee, and you need to have received written confirmation of this from him/her. Students cannot themselves apply for ethics approval in this case as the project is considered high risk". This type of research is not covered by City’s process, and external approval from an appropriate institution is required.** | | *Delete as appropriate* |
| 1.1 | Does your research require approval from the National Research Ethics Service (NRES)? | **NO** |
| 1.2 | Will you recruit participants who are covered by the Mental Capacity Act 2005? | **NO** |
| 1.3 | Will you recruit any participants who are covered by the Criminal Justice System, for example, people on remand, prisoners and those on probation? | **NO** |
| **A.2 If you answer YES to any of the questions in this block your consultant/supervisor must have obtained appropriate ethics committee approval** | | *Delete as appropriate* |
| 2.1 | Does your research involve participants who are unable to give informed consent?  For example, people who may have a degree of learning disability or mental health problem, that means they are unable to make an informed decision on their own behalf. | **NO** |
| 2.2 | Is there a risk that your research might lead to disclosures from participants concerning their involvement in illegal activities? | **NO** |
| 2.3 | Is there a risk that obscene and or illegal material may need to be accessed for your research study (including online content and other material)? | **NO** |
| 2.4 | Does your project involve participants disclosing information about protected characteristics (as identified by the Equality Act 2010)?  *For example: racial or ethnic origin; political opinions; religious beliefs; trade union membership; physical or mental health; sexual life; criminal offences and proceedings* | **NO** |
| 2.5 | Does your research involve you travelling to another country outside of the UK, where the Foreign & Commonwealth Office has issued a travel warning that affects the area in which you will study?  *Please check the latest guidance from the FCO - <http://www.fco.gov.uk/en/>* | **NO** |
| 2.6 | Does your research involve invasive or intrusive procedures?  These may include, but are not limited to, electrical stimulation, heat, cold or bruising. | **NO** |
| 2.7 | Does your research involve animals? | **NO** |
| 2.8 | Does your research involve the administration of drugs, placebos or other substances to study participants? | **NO** |
| **A.3 If you answer YES to any of the questions in this block, then unless you are applying to an external ethics committee or the Senate Research Ethics Committee (SREC), you must apply for approval from the Computer Science Research Ethics Committee (CSREC) through Research Ethics Online -** [**https://researchmanager.city.ac.uk/**](https://researchmanager.city.ac.uk/)**. Depending on the level of risk associated with your application, it may be referred to the Senate Research Ethics Committee (SREC).** | | *Delete as appropriate* |
| 3.1 | Does your research involve participants who are under the age of 18? | **NO** |
| 3.2 | Does your research involve adults who are vulnerable because of their social, psychological or medical circumstances (vulnerable adults)?  This includes adults with cognitive and / or learning disabilities, adults with physical disabilities and older people. | **NO** |
| 3.3 | Are participants recruited because they are staff or students of City, University of London?  For example, students studying on a particular course or module.  If yes, then approval is also required from the Head of Department or Programme Director. | **NO** |
| 3.4 | Does your research involve intentional deception of participants? | **NO** |
| 3.5 | Does your research involve participants taking part without their informed consent? | **NO** |
| 3.5 | Is the risk posed to participants greater than that in normal working life? | **NO** |
| 3.7 | Is the risk posed to you, the researcher(s), greater than that in normal working life? | **NO** |
| **A.4 If you answer YES to the following question and your answers to all other questions in sections A1, A2 and A3 are NO, then your project is deemed to be of MINIMAL RISK.**  **If this is the case, then you can apply for approval through your supervisor under PROPORTIONATE REVIEW. You do so by completing PART B of this form.**  **If you have answered NO to all questions on this form, then your project does not require ethical approval. You should submit and retain this form as evidence of this.** | | *Delete as appropriate* |
| 4 | Does your project involve human participants or their identifiable personal data?  *For example, as interviewees, respondents to a survey or participants in testing.* | **YES** |

**PART B: Ethics Proportionate Review Form**

If you answered YES to question 4 and NO to all other questions in sections A1, A2 and A3 in PART A of this form, then you may use PART B of this form to submit an application for a proportionate ethics review of your project. Your project supervisor has delegated authority to review and approve this application under proportionate review. You must receive final approval from your supervisor in writing before beginning the planned research.

However, if you cannot provide all the required attachments (see B.3) with your project proposal (e.g. because you have not yet written the consent forms, interview schedules etc), the approval from your supervisor will be ***provisional***. You **must** submit the missing items to your supervisor for approval prior to commencing these parts of your project. Once again, you must receive written confirmation from your supervisor that any provisional approval has been superseded by with ***full approval*** of the planned activity as detailed in the full documents. **Failure to follow this procedure and demonstrate that final approval has been achieved may result in you failing the project module and/or result in an academic misconduct investigation.**

Your supervisor may ask you to submit a full ethics application through Research Ethics Online, for instance if they are unable to approve your application, if the level of risks associated with your project change, or if you need an approval letter from the CSREC for an external organisation.

|  |  |  |
| --- | --- | --- |
| **B.1 The following questions must be answered fully.**  **All grey instructions must be removed.** | | *Delete as appropriate* |
| 1.1. | Will you ensure that participants taking part in your project are fully informed about the purpose of the research? | **YES** |
| 1.2 | Will you ensure that participants taking part in your project are fully informed about the procedures affecting them or affecting any information collected about them, including information about how the data will be used, to whom it will be disclosed, and how long it will be kept? | **YES** |
| 1.3 | When people agree to participate in your project, will it be made clear to them that they may withdraw (i.e. not participate) at any time without any penalty? | **YES** |
| 1.4 | Will consent be obtained from the participants in your project?  Consent from participants **MUST** be obtained if you plan to involve them in your project or if you plan to use identifiable personal data from existing records. “Identifiable personal data” means data relating to a living person who might be identifiable if the record includes their name, username, student id, DNA, fingerprint, address, etc.  *If YES, you must attach drafts of the participant information sheet(s) and consent form(s) that you will use in section B.3 or, in the case of an existing dataset, provide details of how consent has been obtained.*  *You must also retain the completed forms for subsequent inspection. Failure to provide the completed consent request forms will result in withdrawal of any earlier ethical approval of your project.* | **YES** |
| 1.5 | Have you made arrangements to ensure that material and/or private information obtained from or about the participating individuals will remain confidential? | **YES** |

|  |  |  |
| --- | --- | --- |
| **B.2 If the answer to the following question (B2) is YES, you must provide details** | | *Delete as appropriate* |
| 2 | Will the research be conducted in the participant’s home or other non-University location?  *If* ***YES****, you must provide details of how your safety will be ensured.* | **NO** |

|  |  |  |  |
| --- | --- | --- | --- |
| **B.3 Attachments**  **ALL of the following documents MUST be provided to supervisors if applicable.**  **All must be considered prior to final approval by supervisors.**  **A written record of final approval must be provided and retained.** | ***YES*** | ***NO*** | ***Not Applicable*** |
| Details on how safety will be assured in any non-University location, including risk assessment if required (see B2) |  |  | **N/A** |
| Details of arrangements to ensure that material and/or private information obtained from or about the participating individuals will remain confidential (see B1.5)  *Any personal data must be acquired, stored and made accessible*  *in ways that are GDPR compliant.* |  |  | **N/A** |
| Full protocol for any workshops or interviews\*\* |  |  | **Not Yet Available** |
| Participant information sheet(s)\*\* |  |  | **Not Yet Available** |
| Consent form(s)\*\* |  |  | **Not Yet Available** |
| Questionnaire(s)\*\*  *sharing a Qualtrics survey with your supervisor is recommended.* |  |  | **Not Yet Available** |
| Topic guide(s) for interviews and focus groups\*\* |  |  | **N/A** |
| Permission from external organisations or Head of Department\*\*  *e.g. for recruitment of participants* |  |  | **N/A** |

*\*\*If these items are not available at the time of submitting your project proposal, then* ***provisional approval*** *can still be given, under the condition that you must submit the final versions of all items to your supervisor for approval at a later date.* ***All*** *such items* ***must*** *be seen and approved by your supervisor before the activity for which they are needed begins. Written evidence of* ***final approval*** *of your planned activity must be acquired from your supervisor before you commence.*

**Changes**

If your plans change and any aspects of your research that are documented in the approval process change as a consequence, then any approval acquired is invalid. If issues addressed in Part A (the checklist) are affected, then you must complete the approval process again and establish the kind of approval that is required. If issues addressed in Part B are affected, then you must forward updated documentation to your supervisor and have received written confirmation of approval of the revised activity before proceeding.

**Templates for Consent and Information**

You must use the templates provided by the University as the basis for your participant information sheets and consent forms. You **must** adapt them according to the needs of your project before you submit them for consideration.

Participant Information Sheets, Consent Forms and Protocols must be consistent. Please ensure that this is the case prior to seeking approval. Failure to do so will slow down the approval process.

We strongly recommend using Qualtrics to produce digital information sheets and consent forms.

**Further Information**

<https://www.city.ac.uk/about/governance/committees/cs-research-ethics>

<https://www.city.ac.uk/research/ethics/how-to-apply/participant-recruitment>

[https://www.city.ac.uk/research/ethics](https://www.city.ac.uk/research/ethics%20)