

Final Report
3D Video Game: Star And Salvation

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1. Introduction

While the written word can gain a form of dynamism through ambiguity, applying that to an interactive and visual medium becomes challenging to do concretely. Instead, gameplay elements, such as simulation and customisation, can be used to engender a narrative in the player, giving them the space to fill in the gaps in their own minds. When done well even non impactful decisions can be imbued with a sense of weight, this feeling that everything contributes. On the other end when done poorly, all decisions can become meaningless whether they are impactful or not. What matters is the player believing they're having an impact.

This form of narrative interaction is seen commonly in the large-scale real-time strategy genre (e.g. Stellaris [11], Crusader Kings [12], etc.) where interlocking systems tell the stories of large factions. The objective of this project is to first create a beta version of a game in this genre, then perform a round of user testing. Insights gained from that process will then be used to complete a vertical slice. Given the constraints inherently imposed by solo development across such a limited time scale, it is unlikely a fully finalized version of the game will be completed.

To allow the player to make immediate, impactful decisions at the beginning of any given run, unlike most games in the genre, the player's power (i.e. their ability to affect the simulated environment) will be organized differently to the other factions. Instead of playing as a larger force the player will be a single powerful entity (i.e. a single ship, a single character, etc.) with a large amount of upfront ability to effect change. Alongside this, the player will be immediately presented with customization options for their faction typical to the genre (e.g. faction symbol, faction origin, etc.), leading them into a roleplaying headspace.

To ensure that the player's actions result in dynamic outcomes, the faction simulation will also need to be suitably complex. As such, this project takes a code-agnostic, data driven approach. This involves keeping faction data separate from any given simulation element, as opposed to a typical object-oriented approach, which would intertwine them. This allows simulation modules to be designed and implemented in a flexible manner, as well as allowing extra simulation elements to be added easily as an extension goal.

This report consists of several sections, the first of which is "Professional Considerations", where the BCS Code of Conduct is broken down by section. An ethical review is also included, discussing this project's plan for user testing and acquiring consent for personal data collection in detail. Next is "Requirements Analysis", which outlines the objectives of the project in distinct steps alongside expanding on the explanation of the problem space and my solutions. This includes background research on games in the genre and proposed solutions to game design issues found within, alongside a brief section on "Art Design". That subsection details some techniques used to render the large solar system as an example of some of the work done on the visual side of the game. Next is the "Project Plan", consisting of a breakdown of the work required to complete the project into distinct phases, illustrated using a Gantt chart alongside written explanations. Then there is an "Interim Log" detailing the steps of the Project Plan completed as of the submission of this Interim Report and meetings with this project's supervisor. Finally, there are the references and appendices.

2. Professional Considerations

2.1 BCS Code of Conduct

The BCS Code of Conduct [10] is composed of four key principles, the relevant sections from each have been discussed below.

Principle 1: You make IT for everyone

1.1 Have due regard for public health, privacy, security and wellbeing of others and the environment

Given the sci-fi nature of the project, visuals are likely to be flashy and potentially dangerous for people with epilepsy. An appropriate warning should be displayed when the game is booted. If leaderboards are added, in line with Extension Requirement E2, some player data will be stored, this will simply include game statistics and no non-public personal information. The game's potential age rating (in line with industry standards used by parents to assess what games their children should play (e.g. PEGI)) is discussed in 2.4 below.

1.2 Have due regard for the legitimate rights of third parties

This project uses some third party code, namely MonitorBreak's Additions library for Unity. This is licensed under a modified MIT license[6] and all obligations outlined have been met. It should also be noted that I wrote this code but it simply belongs to a separate entity. If any additional third party libraries or assets are used in the future they will also be properly attributed.

1.3 Conduct your professional activities without discrimination on the grounds of sex, sexual orientation, marital status, nationality, colour, race, ethnic origin, religion, age or disability, or of any other condition or requirement

Populations in the game are abstracted, represented as a series of numbers, user testing however, is relevant to this section. The project will not discriminate when deciding which users to use as a sample instead trying to get an accurate representation of the intended users.

1.4 Promote equal access to the benefits of IT and seek to promote the inclusion of all sectors in society wherever opportunities arise

This game is intended to be released for free and the simulation design will be made fully open source some time after submission. These are both done to hopefully promote more games like this being created.

Principle 2: Show what you know, learn what you don't

2.4 Ensure that you have the knowledge and understanding of legislation and that you comply with such legislation, in carrying out your professional responsibilities

The most relevant pieces of legislation center around the game's suitability for given age brackets. This project does not intend for a physical release (even upon completion of all Extension Requirements) so upon the game's completion only the IARC (International Age Rating Coalition) questionnaire will need to be completed. The questionnaire will give an age rating inline with all participating rating boards. This rating is expected to be in the 7-12 range, given the lack of direct visible violence but the presence of war in an abstract format.

2.5 Respect and value alternative viewpoints and seek, accept and offer honest criticisms of work

All feedback gained from user testing will be treated with equal respect and this project will seek to make no omission when presenting it in the final report. To gain more feedback, additional rounds of user testing are considered a high priority extension objective.

2.6 Avoid injuring others, their property, reputation, or employment by false or malicious or negligent action or inaction

As mentioned in the response to 1.1, steps will be taken to prevent causing issues for people with epilepsy. Additionally care will also be taken during the creation of systems that save to disk (game save system, screenshot system, etc.). This is to prevent potential loss of personal data due to an erroneous disk write operation.

2.7 Reject and will not make any offer of bribery or unethical inducement

During user testing feedback will be gathered anonymously, with no incentive for a better or worse response.

For this project, Principle 3 and Principle 4 contain no relevant sections.

2.2 Ethical Review

This project requires user testing, the nature of the testing is discussed in detail in Requirements Analysis section 3.2. Due to the use of human participants, an ethical review utilizing Sussex's standard Ethical Compliance Form needs to be performed.

A signed copy of this form is included as an appendix.

1. Participants were not exposed to any risks greater than those encountered in their normal working life.

The game includes no visuals, audio or content that pose a significant risk to participants. Their involvement will include only playing the game and answering questions.

2. The study materials were paper-based, or comprised software running on standard hardware.

The game will run on a standard Windows machine, Google Forms will be used to receive anonymous answers and will be accessed using the same machine.

3. All participants explicitly stated that they agreed to take part, and that their data could be used in the project.

It will be made clear to all participants the nature of the project, all participants will be required to sign a standard consent form for data usage. It will be made clear that they can leave at any time should they no longer feel they want to take part.

4. No incentives were offered to the participants.

No participants will be offered any incentive for participating, they will all be volunteers attending the university. No incentive will be given to give a particular type (positive or negative) of feedback.

5. No information about the evaluation or materials was intentionally withheld from the participants

Participants will be told upfront the full scope and nature of the project.

6. No participant was under the age of 18

All participants will have their ages verified prior to their participation.

7. No participant had a disability or impairment that may limit their understanding or communication.

All participants will be able-bodied university students, that they are in an appropriate state of health will be verified prior to user testing.

8. Neither I nor my supervisor is in a position of authority or influence over any of the participants.

All participants will be my university peers and none will share my supervisor if they are also doing their final year project. Their feedback will also be kept separate from their identity to ensure they cannot be linked to particular criticism.

9. All participants were informed that they could withdraw at any time.

It will be made clear to all participants, both at the beginning and at various stages throughout the process, they are allowed to withdraw (for any reason) at any time.

10. All participants have been informed of my contact details, and the contact details of my supervisor.

This information will be provided on a separate piece of paper, alongside a basic written breakdown

of the project.

11. The evaluation was discussed with all of the participants at the end of the session, and all participants had the opportunity to ask questions.

Participants will be allowed to ask questions at any point during the process. Appropriate time will be allocated at the end of the user testing session to allow for additional questions and a discussion on the evaluation.

12. All the data collected from the participants is stored securely, and in an anonymous form.

All responses will be secured behind access to my password and 2FA protected google account before being moved to my password protected PC. Any identifiable information will be redacted.

3. Requirements Analysis

This project aims to produce a player-story driven RTS (Real Time Strategy). in the form of a vertical slice (a version of a game that lacks some features but still showcases what the final product will look like). The game's world will need to be deeply simulated, comprising a large amount of the technical challenge of the project.

3.1 Framework Choice

This project uses Unity [7] instead of a custom engine, the primary reason for this choice is my familiarity with it's workflow. I've previously created a full game using Unity (including shipping it to Steam [14]) and I greatly enjoy its flexibility. Unity makes it easy to extend the editor through creating additional context menu items and entirely new editor tools. The C# (which is Unity's primary coding language) ecosystem is also very broad, with a colossal number of resources to pull from.

I additionally chose not to use this project as an opportunity to learn a new engine as no other contemporary engines seemed fit to purpose. Unreal [8] includes many systems that are superfluous for this project (e.g. Blueprints, Nanite, etc.) and I'm also unfamiliar with C++ to an extent where large practical issues could arise (such as poor design planning, language specific pitfalls, etc.). Godot [9] was initially a contender for my engine of choice (I also have some minor previous experience with it), however, I quickly found tension between myself, and it's scripting language of choice GDScript. The primary issue that arose during testing is that I wanted engines to work similarly to Unity when they had clear differing approaches to design (e.g., Godot's node based workflow).

3.2 User Testing

To assist with the development process, at least one round of in-person user testing should occur. This would involve allowing a number of potential users (ideally 5+) to play the game for a period of time before asking them a sequence of questions.

The sample of players should be made up of both people familiar with the RTS genre and those that are not, ideally spread evenly across that range. Ideally two primary testing rounds should occur, one once an initial beta version of the game is produced and one afterward, utilizing the vertical slice. The beta version can differ from the vertical slice dramatically in terms of completeness but should still be functional. The vertical slice testing (and any additional testing) is helpful but should be considered an extension objective given the time constraints.

3.3 Background Research, Design Problems and Solutions

3.3.1 Game 1: Stellaris

Stellaris (2016) [11] is a large scale space-based strategy game, taking place across a substantially sized galaxy. It involves managing an interstellar faction, taking them from their first ships to combating a galaxy wide threat.

The game puts a heavy emphasis on role-play right from the beginning of a run. Immediately upon selecting "New Game" you are presented with the screen pictured in Figure 3.1.



Figure 3.1: Stellaris Faction Creation Screen

The left side of the screen showcases a list of premade factions (highlighted in yellow) that the player can pick from then customize, these can act as a jumping off point for player ideas. There is additionally an option to create an entirely unique faction at the very top. Positioned directly in the center of the screen is the information on the currently selected faction, including; their governmental practices (highlighted in red), their species traits (highlighted in green), their species origin (highlighted in blue) and their faction's flag (highlighted in orange). All these elements (alongside others) create a distinct feeling for this particular faction and, more importantly, they have gameplay ramifications. Within a minute of starting the game proper the faction shown in Figure 3.1. (an Imperial Divine Empire) was notified it had received a new heir, a special type of unit that acted (in this case) as a scientific advisor.

This focus on role-play is reflected in the reviews for the game, many are simply retellings of their own faction's story. An example of this is pictured in Figure 3.2.

956 people found this review helpful

178 people found this review funny

Recommended

0.0 hrs last two weeks / 1,086.1 hrs on record (425.9 hrs at review time)

Posted: 23 Aug, 2017 @ 2:15pm

I started off as a bird species on the far edge of the galaxy. Their average lifespan was around 60 years, but they made every year count. They were obsessed with technology, already building their first robots before they had even left their world. Unfortunately, they were immediately boxed in by empires that had emerged into FTL travel far before they had.

Their dreams of expanding into distant worlds was immediately and brutally crushed, after their first colony was bombarded into oblivion during in an ill-fated first-contact. Instead of expanding into planets, my people instead built habitats around dead worlds, watching with envious eyes as their hyper-religious neighbours claimed lush, verdant planets.

They waited, watching their old sicken and die, wracked by disease and genetic weakness, while the incredibly long-lived religious neighbours often made it to ages such as 110. Their neighbours scoffed, those Emperors of the Divine. They knew those foolishly materialistic birds could not possibly understand their true purpose in the universe. God was on the side of those

Figure 3.2: A retelling of a Stellaris game, (full review is 650+ words long)

Other systems also assist this storytelling, in particular the Galactic Crises. These are large, late game events that typically have ramifications for the whole galaxy and act as a definitive final boss for a play through. Interestingly, there are also specific cases where a player or AI can become the crisis, another avenue for potential role-play. The player's relationship to other factions can be vitally important during these scenarios, meaning earlier (possible role-play based) decisions can have a major impact.

Space combat is another important part of Stellaris but is more used as a tool to express role-play decisions than a system that encourages role-play itself. The functional act of combat instead enhances the grand strategy side of the game, engagements are often won by decisions made before the battle starts. For example, the ships used by an endgame crisis, "Extradimensional Invaders", largely rely on shields as a defensive measure for their ships. This means that kinetic weapons are particularly effective [2], outfitting ships with these weapons is a decision made when they are created. When actually fighting, fleets of ships will "auto-battle" each other, with no input required by the player. While this project does focus more on a singular powerful entity, it will take a similar pre-planning approach to combat. This is in part due to the time constraints, as time spent making combat rewarding to execute takes time away from the simulation side (and main goal) of the project.

While Stellaris succeeds in many areas and is arguably (with its balance of strategy and role-play) the

closest real example of this project’s goal, it has a few outstanding flaws. The game has a large amount of upfront complexity, the main Stellaris wiki’s Beginner Guide [1] is roughly 17000 words long, split into 20+ sections and subsections. Figure 3. showcases the first screen players will see outside of the faction creation menu. It hosts a suite of information, shown to the player all at once. This includes (but is not limited too); eight types of basic resources, several more advanced resources (including fleet and starbase capacity), a list of all controlled entities (planets, fleets, construction and science ships and shipyards), the current date, many links to other UI windows (including Government Control, a larger galaxy map, Species Control, Technology and Research Management) and buttons for switching map mode (it should be made clear those buttons do nothing on this screen but are still present).



Figure 3.3: Stellaris Solar System View Screen

However, this complexity is an important, and arguably defining, part of the genre [3]. The principal issue here is how it is introduced to the player. Given this project’s intention to, in part, target a wider audience, this issue is quite important. The intended solution is to introduce player elements gradually, in the context of the larger narrative brace of the game this can be expressed as the player’s controlled entity turning back on after many years inactive. To enhance replayability players could be allowed to start already in a fully active state rather than repeating the tutorial each time.

Stellaris also suffers from performance issues, particularly in the late game [4] [5]. Given the relative scales of this project and Stellaris this is a less relevant issue, performance goals are discussed further in a later subsection “Performance and Stability”.

One major difference between this project’s game and Stellaris is that unlike a typical RTS, there will be a larger focus on the world reacting directly to the player as a singular powerful entity and less

on long term historical strategy. While the game will be in part targeted at long time RTS players, this change in power balance (alongside a shift into more role-play focused elements) is designed to allow a wider audience to engage with a typically complex genre.

3.3.2 Game 2: Disco Elysium

This project's role-play centric aims require it to take additional inspiration from outside the RTS genre. Disco Elysium (2019) [13] is a detective RPG, famous for its engaging writing. It has many systems that incentivize role-play such as its "Thought Cabinet" system, pictured below.

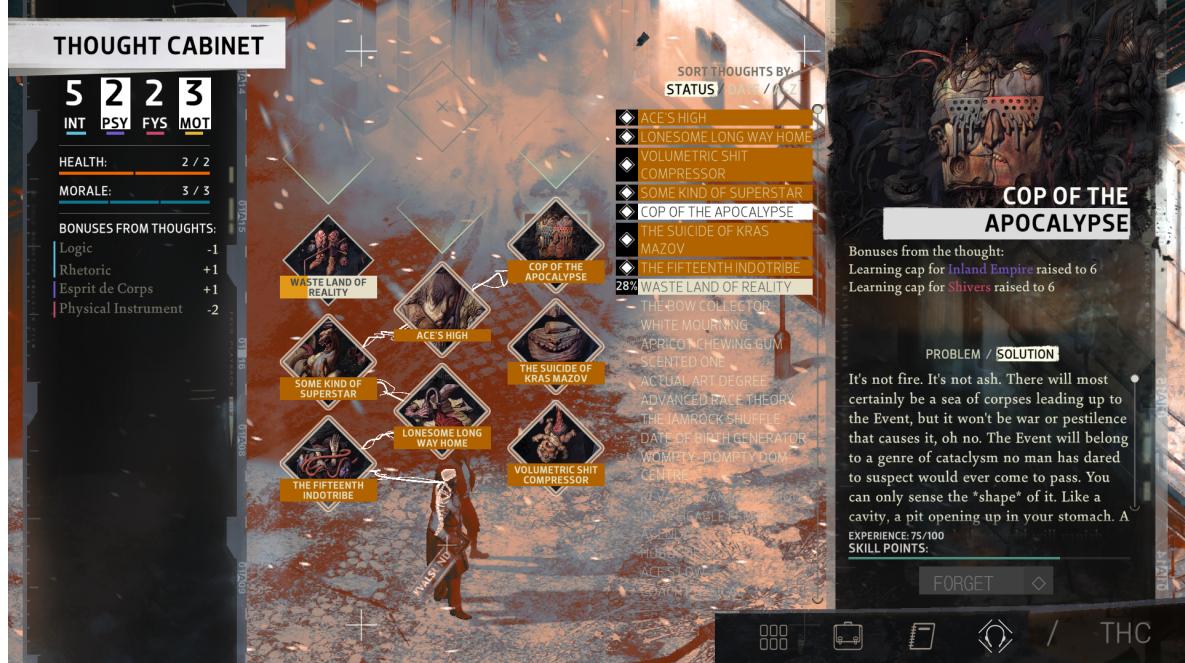


Figure 3.4: Disco Elysium Thoughts Screen

"Thoughts" are discovered naturally on your adventure throughout Elysium's world, after being found they can then be slotted into an open position in the cabinet before taking some time to be "internalized". This system mirrors Stellaris's governmental polices, providing an avenue for role-play but grounding it in a more understandable mechanical benefit/cost. In the case of Disco Elysium, you use a skill point (that could be used on the game's more traditional statistics based leveling system) to unlock more slots in your cabinet. This allows players to make the active choice to engage more with role-play, potentially trading off a traditional power increase.

Disco Elysium's approach to role-play has some pain points, in particular the various bottleneck checks. The primary example is an "Authority" check during a pivotal conversation with Titus Hardie. This check (involving summing the result of two dice and your Authority value to try and meet a threshold) is necessary to move the story forward, with a low enough investment in Authority (a seemingly optional statistic up until this point), the chance to pass it can be as low as 3%. In the

context of a game trying to tell a specific story, with a character that values authority as much as Titus, this (despite the potential player frustration) works quite well, however, in this project, centered on player driven narrative, it would not. This project should seek to ensure these bottlenecks only appear in a foreseeable manner. For example, it makes sense that a faction's military will be tested if it goes to war, hence, a declaration of war should follow logically from previous choices so a player can prepare appropriately.

3.4 Art Design

Visuals are an important part of game development but they are not the focus of this report. This section will focus on the system used for large scale rendering (used for celestial bodies) as an example of some of the work done on that side of the game.

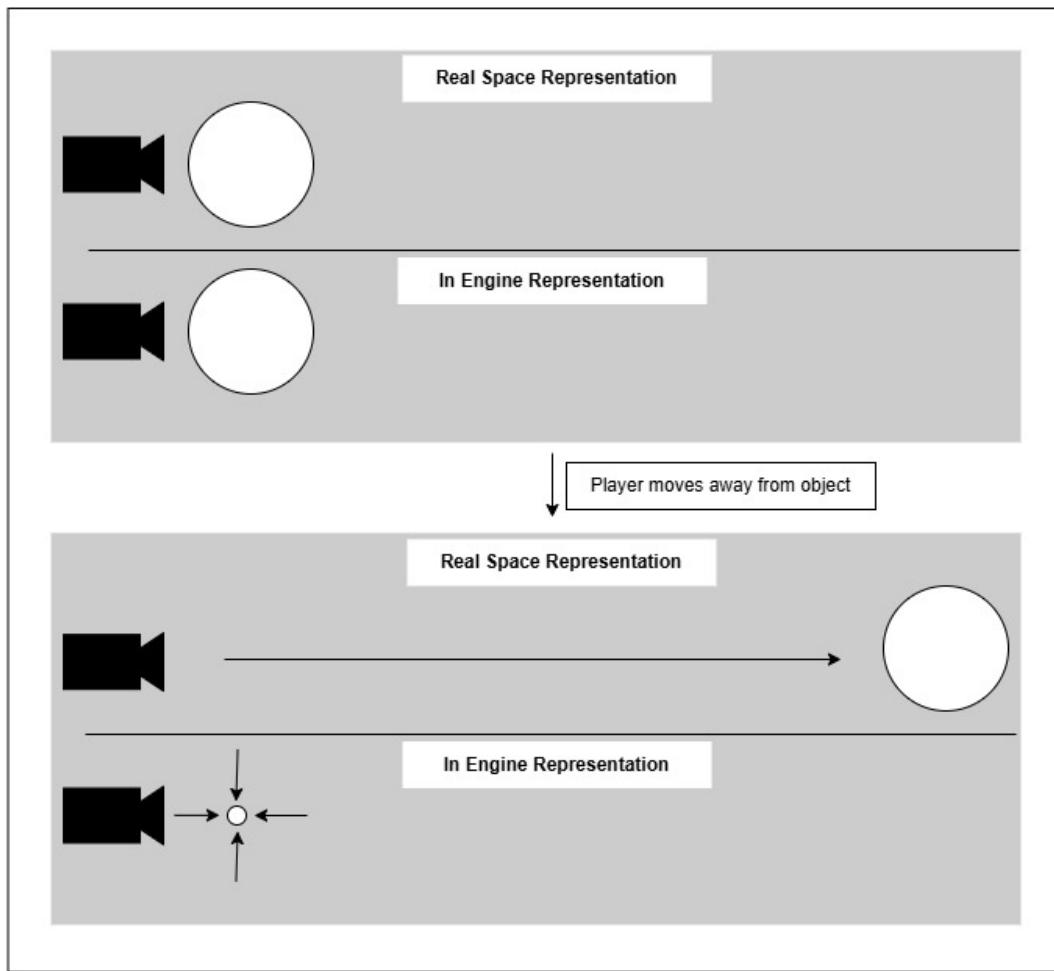


Figure 3.5: 1D Diagram showcasing how the celestial bodies rendering system functions.

The principal issue is Unity's use of Floats to represent positions, an effort to increase performance for the vast majority of games at the cost of precision. Given the large scale of this project's world, extra precision is key for accurate representation.

This system takes advantage of the fact that something moving further away and something shrinking (with no point of reference) are indistinguishable. We calculate how large something should look from the player's perspective, utilizing the higher precision Double type to accurately represent the object's "real" position, before applying the reciprocal result to the object's in engine scale. This means that only the object's scale changes when the player moves and its in engine position stays close to the camera. This is showcased in the diagram above in one dimension. The principal problem is solved here because a general modifier can be applied to the final output scale, shrinking it into a range that floats can accurately represent.

To complete the illusion all celestial objects are rendered using a separate camera and applied between the skybox and the rest of the rendered objects. This means celestial objects always appear behind (and consequently larger) than everything else.

3.5 Performance and Stability

Crashes and bugs should be kept to an ideal minimum. While the time constraints imposed don't allow the thoroughness typical of a standard project, ample time can still be allocated to unit testing and the like. The aforementioned rounds of user testing can also assist with this issue.

Alongside functioning as intended, the final version of the project should also run at a consistent and reasonable frame rate (60 frames per second) on low to medium range hardware. Given the relatively low intended visual complexity of the game, this objective is still important but easier to reach than others. Various different pieces of hardware are available for testing, with varying hardware capabilities in each.

4. Formalized Requirements

Below are the requirements discussed in the above sections formalized into a list;

R1: *Existing games in the genre should be researched, their gameplay focus points, style and design problems should be identified.*

R2: *User testing should be conducted with 5+ potential players, post-game interview questions should be shaped based on insights gained from completion of R1.*

R3: *At least two versions of the game should be created. An initial beta version for user testing and a final vertical slice.*

R4: *The game should run at at least 60 FPS on low to medium range hardware.*

R5: *The game world should be suitably simulated, recognizable as realistic relationships between factions.*

R6: *The player should be able to make early impactful roleplay decisions.*

R7: *The game should have sound effects that fit the theming.*

R8: *The player should be able to move about the game's world.*

R9: *The game should be functionally stable, crashes should occur very infrequently.*

R10: *The game should have UI that accurately describes statistics about the player's faction.*

R11: *The game should have UI that accurately describes known statistics about NPC factions.*

R12: *The player should be able to grow and modify their faction over time, this includes increasing military strength, increasing population and adding unique features to their faction.*

R13: *The player's faction's power should be concentrated to a singular entity (e.g, one building, one ship, etc.)*

R14: *The player should be able to engage in relationships, both diplomatic and hostile, with other factions.*

R15: *The player's actions should be able to have a long term effect on the state of the simulation (e.g, removal of other factions, removal of settlements, etc.).*

R16: *The player's singular entity should be able to engage in combat with other entities.*

R17: *The player should be able to win the game in some manner but the choice to take the win should be optional. The player should be able to keep playing if they wish.*

4.1 Extension Requirements

If time allows, there are some additional requirements that would ideally be met;

E1: *Additional simulation elements. For example, if the current version of the simulation models a planet's resources as a static value, a new simulation routine could decrease that value over time based on population and industrial activity.*

E2: *Online functionality. This would likely take the form of online leaderboards, showcasing statistics such as "Time Survived", "Enemies Killed", "Highest Bounty", etc.*

E3: *More advanced combat functionality, taking the form of additional actions on top of the existing auto battle system.*

E4: *Music. While many royalty-free options exist, unique music would help set the mood properly for players.*

E5: *Releasing the game on Steam. Generally speaking this is a capstone objective and would signal the end of the code side of the project.*

5. Design

6. Implementation

6.1 Routines

A **Routine** is simply code that is run on a Simulation tick. All Routines have a priority value that decides in what order the Routines run, however, certain types of Routines will always run before or after other types. There are four types of Routines:

1. Constant Routines

Routines run every single tick, the default type of Routine.

2. Init Routines

Routines run when data was added last tick and needs to be initialized. Includes a validation check to see if they should act on the new data and always run before any other Routines.

3. Absent Routines

Routines that are only run when specifically invoked. Used typically to test a Routine or temporarily exclude it during testing of other Routines.

4. Debug Routine

Primary testing Routines. Debug Routines won't be run outside of the Unity Editor or while the Simulation is running history. They are excluded from history ticks as they will typically output some data which will slow down the Simulation considerably. Always run after every other type of Routine.

There are 35 Constant and Init Routines, listed below based on priority.

Init	Constant	
PoliticalInit	PlayerSimValuesUpdateRoutine	BattleResolutionRoutine
TerritoryInit	MilitaryPerTickReset	PoliticalChangeRoutine
TargetableLocationInit	StrategyRoutine	NationDeadRoutine
RefineryInit	DesirabilityAttractionRoutine	VoidSwarmDeadRoutine
EconomyInit	PopulationSettlementGrowthRoutine	PeriodChangeRoutine
EmblemInit	SettlementRoutine	CalamityInitiateRoutine
NameInit	SettlementManagementRoutine	TimerProcessRoutine
FeelingsInit	RefineryRoutine	MetaRoutine
MilitaryInit	EconomicPowerReductionRoutine	WarEvaluationRoutine
	PopulationNaturalChangeRoutine	RandomEventTickRoutine
	PopulationBasedTerritoryExpansion	
	PoliticalEffectsOnFeelingRoutine	
	MilitaryCapacityFromPopulationRoutine	
	MilitaryTroopManagementRoutine	
	WarEffectRoutine	
	FeelingsMatchingRoutine	

Most Routines will act directly on **DataModules** (discussed in 6.3) which allows the Simulation to stay flexible, allowing new Entities with varying behaviours to be added very easily. For example, giving an Entity owned territory in the Game World is as simple as giving it a TerritoryData module and a PopulationData module (with some initial starting population value).

Certain Routines will act directly on **SimulationEntities**, for example **NationDeadRoutine** and **VoidSwarmDeadRoutine**. These are always used as a way to add bespoke behaviour per Entity and in reality all Routines of this type could be refactored to instead act on DataModules. The initial iteration of the Simulation's design acted on Entities by type (at that time only Factions such as Nation and PirateCrew) instead of data. This lead to code patterns involving costly and rigid filtering in each Routine typically to create a list of DataModules to iterate over anyway. These Routines are leftovers from that refactor and have persisted through several other minor design iterations. Ultimately, it is hard to justify spending the time to remove them when the benefits could only be seen when a new Entity is added that would want to share that bespoke behaviour.

6.2 SimObject

Fundamentally all actors in the Simulation are **SimObjects**, a generic parent class that contains a large amount of virtual methods, following the "Define as Needed" style outlined in Design. All SimObjects are additionally **DataModules**, allowing them to be stored by **SimulationEntities** and acted upon by **Routines** if needed.

The majority of the code in SimObject is used to interface with non-simulation side systems in a reliable and consistent way, typically with minimal to no extra work per SimObject type. There are five groups of methods, outlined below.

1. Draw

Used to define how to visually display any given SimObject, includes methods for initial drawing, cleanup, per-frame updates and post-tick updates.

2. Battle

Used to define this SimObjects, current health, weapons, on kill reward and on hit reward. Additionally includes a method called when a SimObject is defeated in battle.

3. Interactions

Helper methods that allow Interactions to check if a SimObject has a Shop or offers Quests. Additionally includes similar methods for the disabled Fuel system.

4. Reputation

Methods used to adjust the Player's Reputation with an Entity. Reputation as a system should always act on **FeelingsData** (a **DataModule**), and hence does not allow a per SimObject implementation.

5. IDisplay

A standard implementation of the IDisplay interface, used by UI elements to read (and then display) objects in a consistent way. IDisplay is discussed in detail in a below section.

6.2.1 Accessing SimObjects

While SimObject has many methods that define how it should interact with other systems, those systems need to be able to have some way to access those methods. Primarily this is done through an instance of **SimObjectBehaviour**, a Unity MonoBehaviour that can interact with Unity's runtime. SimObjects will link themselves to a given behaviour script, typically during their initial draw. The Draw system thus inherently needs to be outside of the scope of SimObjectBehaviour and is handled by **PlayerLocationManagement** instead.

The only other time SimObjects are handled by neither the Simulation or a SimObjectBehaviour is on the map screen, where **PlayerMapInteraction** uses the displayed **TerritoryData** to access the SimObject directly.

6.3 SimulationEntity

Any major participant in the Simulation inherits from the class **SimulationEntity** (a child of **SimObject**). There are currently eight Entities, listed below.

1. Player

The Player's Entity, stores any player centric data (e.g., inventory, current stats, current quests, etc.). Most player data was initially stored within an Entity so the current game state could be fully represented using Entities. A few exceptions were taken (e.g., current health, location in world, etc.) for simplicity's sake when it became clear the game state would not need to be saved and loaded in the current iteration.

2. Nation

The primary Faction the Player interacts with, creates Settlements that give Quests and allow for Trade. Spawns Mineral Deposits and Pirate Crews.

3. Mineral Deposit

Represents a location in the game's world that has a large resource node.

4. Pirate Crew

Represents a Pirate Faction, which will raid locations within the game world.

5. Void Swarm

An example of a Calamity, an Entity that has a large effect on the game world, increasing divergence in generation. Has a chance to spawn at random every ten years.

6. AntiVoid Knights

An example of a purely reactive Faction. Spawns by Void Swarms a little after their creation and will only target them.

7. Game World

An implementation of global storage, utilized in performance critical code where constant data parity assurance is necessary but unwieldy to implement.

8. Warp

Meant to represent the space during travel. Used primarily to store a Shop that can be accessed by the Player upon buying a particular item.

SimulationEntity includes two primary systems that are used to define the makeup of an entity. These are **Entity Tags** and **DataModules**.

Tags are simply Enums, typically used as keys for lookup tables. Entity Tags are general descriptors of an Entity or it's state. They are solely an Enum entry and contain no additional data. Most types of Entity have a specific type tag to allow for filtering (for example in the execution of the NationDeadRoutine we want to filter for Nations). An example of an Entity State Tag is the "Dead" Tag, which signals to **Routines** that this Entity needs to be removed or shouldn't be processed.

DataModules are more specific descriptors of Entities, each DataModule is a class, so they can contain arbitrary amounts of data. They are always associated with a Tag (typically an entry in the DataTag Enum) so Routines can filter for them properly. Importantly, DataModules can have multiple layers of inheritance allowing for greater levels of complexity on a per Entity basis.

DataModules vary in their modularity, certain DataModules can function in complete isolation (e.g., EmblemData, NameData, etc.) while others require additional modules to have an sort of functionality (e.g., BattleData, StrategyData, etc.). Consequently DataModule's most important method is **TryGetLinkedData**, which will attempt to retrieve data (tied to a passed Tag) from the same Entity the target DataModule is from. This allows Routines to functionally work on only DataModules (keeping the Simulation flexible and data-orientated) while having the larger context of the Entity the DataModule is describing.

Certain systems require Entities to communicate but having DataModules tied to a given Entity can make this difficult. Two primary approaches have been taken, splitting data into one sided relationships (that require an Entity and DataModule lookup to get the full picture) and using a form of global storage (**GameWorld**).

6.3.1 Individual DataModules Descriptions

Below are lists of every DataModule (sorted based on system) and a brief explanation of its use. This should help demonstrate the current scale and complexity of the Simulation.

Battle System DataModules

1. GlobalBattleData - Global storage for all Battles, used exclusively by **GameWorld**. An essential part of the **BattleResolutionRoutine**. All Battles are also **SimObjects** so they can be drawn.
2. BattleData - Contains references to the Entity's ongoing Battles. Used primarily to decide where to transfer troops to in the **MilitaryTroopManagementRoutine**.
3. MilitaryData - Stores the location of all troops, including ones that don't have a location and are considered in reserve. Additionally dictates what counts as **Fleet** for this Entity. Used by any Routine relating to **Battles** or **TroopManagement**.
4. RefineryData - Stores data on a **Ship** building refinery. Used in the **RefineryRoutine** to produce more troops.

5. DesirabilityData - Used by **DesirabilityAttractionRoutine** to pick randomly fights with other Entities at a Location based on a desirability value. Used by **MineralDeposits**, **PirateCrews** and **VoidSwarms** to have other Entities attack them.
6. StrategyData - Has several virtual functions that are overriden to model various types of strategy. By default **Ships** are added to **MilitaryData**'s retreat buffer after a battle ends.
7. RetreatToReservesStrategy - A type of StrategyData that automatically moves all troops back to reserves after a Battle. Used primarily by the **Player**.
8. GenocidalStrategy - A type of StrategyData that targets all Entities with Territory. Used by **VoidSwarms**.
9. TargetEntityTypeStrategy - A type of StrategyData that targets a specific Entity Type. An entity of that type is chosen and this Entity will continue to attack it until it is destroyed. A new Entity will be then be chosen of the same type (if one exists).
10. WarStrategyData - A type of StrategyData that stores a list of Entities and then targets them with attacks every tick. This is used by **Nations** to model campaigns.
11. ImmediateTargetSpawnSourceData - Forces any **TargetEntityTypeStrategy** attached to this Entity to target the Entity that spawned it.

Relationship System DataModules

1. FeelingsData - Stores the feelings of one Entity about all other Entities it knows about. Used in many parts of the Simulation to guide action, including choosing to go to war.
2. ContactPolicyData - Decides whether other Entities inherently know about this Entity and whether this Entity is openly hostile to everyone (e.g., VoidSwarm).
3. Political Data - Stores the current political climate of an Entity as a value along an Economic and Authority Axis. Affects Entities **FeelingsData**, a difference in PoliticalData is the most common cause for war between Entities.

Player Specific DataModules

These DataModules are used to represent player data. Unlike most other DataModules they are intended to only be used for one Entity.

1. PlayerInteractions - Stores all the **Interactions** the Player currently has access too.
2. PlayerInventory - Stores the currently owned **Items** and the current amount of currency.
3. PlayerQuests - Stores the current **Quests** the Player is on and the max allowed amount of Quests they are allowed to be on.
4. PlayerStats - Stores the Player's current base stats alongside any extra contributors to those stats (typically provided by Items).

Other DataModules

1. TerritoryData - Stores all the territories owned by this Entity alongside their border. The border is used in **PopulationBasedTerritoryExpansion** to add more Territories based on a calcualted upper claim limit. This data is also retrieved to display the map.
2. SpawnSourceData - Stores information on the Entity this Entity was spawned by. Used by the **RandomEventTickRoutine** when it spawns a new Entity.
3. HistoryData - Stores all areas of the world that used to be occupied alongside information about all the time periods the world has gone through. This is used primarily when the Simulation runs history.
4. CalamityData - Stores the last tick a Calamity Entity was spawned and the average time between each Calamity. Used solely by the **CalamityInitiateRoutine**.
5. EconomyData - Includes a **Shop** and an estimate of purchasing power. This purchasing power is set based on **SettlementData** in the **SettlementManagementRoutine**.
6. EmblemData - Stores three colours, a main, highlight and shadow alongside a main icon and a backing icon. Used to represent the colours and flag of an Entity. The Player creates an Emblem before running history.
7. EntitySpawnData - Stores a list of Entity Spawners. Used in the **RandomEventTickRoutine** to make the world more responsive to particular types of Entities.
8. NameData - Stores a name for a given Entity. Typically implemented in a bespoke manner for any Entity that needs a name. Used by **Nations** and **AntiVoidKnights**.
9. PoliciesData - Stores all the Policies of a given Entity. This is an incomplete feature but is intended to allow the Player to make long term strategic decisions about their build that they cannot go back on.
10. PopulationData - Stores a current population count, population cap and natural birth and death rates. Used to help dictate the claim limit in **TerritoryData** and Settlement cap in **SettlementsData**.
11. QuestGiverData - Stores currently pending Quests for the Player to accept. The method used to generate a new quest can be overriden to provide different types based on location.
12. Settlement - Stores information about a Settlement, this includes storing **QuestGiverData** and **RefineryData**. The latter is manually processed in the **SettlementManagementRoutine** (alongside other Settlement processing) as data lookups only include DataModules that directly belong to **SimulationEntities**. Like **Battles**, Settlements are **SimObjects** so they can be drawn.
13. SettlementsData - Stores many Settlements and the max Settlement capacity for this Entity.
14. TargetableLocationData - Represents a visitable location on the map. Used by many **Entities** to represent a significant location the Player could travel too.

15. TargetableLocationDesirabilityData - A child class of DesirabilityData that automatically works for any **TargetableLocationData**.
16. TimerData - Stores the tick that this Entity should be destroyed on. Used by **VoidSwarms** to ensure they don't stay too long and wipe out every Entity continuously.

6.4 SimulationManagement

SimulationManagement is the fundamental backbone of the simulation. It has two primary roles, handling **DataModule** lookups and running **Routines** every tick.

SimulationManagement stores several lookup tables that contain references, using an Enum or ID as a key. There are three primary tables, "idToEntity", "tagToEntities" and "tagToData" and one additional table "tagToNewData" (which is cleared after every tick). When an Entity's **Simulate** method is ran it will first add an entry to "idToEntity" before running the two methods **InitEntityTags** and **InitData**. For every new type of Entity those two methods are implemented to define what that Entity is like. A **SimulationEntity**'s **AddData** and **AddTag** methods will automatically register entries in each lookup table (alongside adding to a local lookup table in each entity) as needed.

6.4.1 Tick Timing and Multithreading

Simulation ticks are run in two primary modes. First "history" mode, where a number of ticks are batched together onto a separate thread. This is done on session start to fill the world with established Entities before the player arrives, typical history length is 250 years (108,000 ticks). Second is "single tick" mode, where a tick is initiated at the end of our execution of a frame and runs until the start of our execution on the next frame. This means the tick runs while Unity does everything else (e.g., rendering). It is forcefully ended, meaning all execution will stop to let it end if it hasn't already. In "single tick" mode, ticks are started automatically on an interval. Typically this is every three seconds but during travel the interval is shortened to every third of a second. Additionally ticks can always optionally be made to be instant, meaning they are not executed on another thread. This feature was primarily used for testing and has no use case in the final version of this project.

Running history raises many performance concerns which would otherwise be non-issues, mainly related to the **BattleProcessRoutine**. Inherently, during time periods where several Nations go to war, many battles take place which results in a large amount of extra processing. Consequently, Battles have been weighted to finish faster. This has to be balanced against the players ability to be involved with Battles as time speeding up during travel can result in Battles ending before the player arrives. The speed up can also not be removed as it causes the rest of the Simulation (during actual gameplay) to slow down considerably, making the world feel static.

6.5 Displaying the Simulation Visually

Locations are a type of SimObject, they act as a wrapper for a **RealSpacePosition** (Mentioned briefly in the Art Design section above). An RPS works at a higher precision than standard Unity positions, using **doubles** instead of **floats**. This is used to combat floating point inaccuracy at the large scales the Simulation works at. **VisitableLocations** are a child class of Location and act as points of interest for the player.

6.5.1 PlayerLocationManagement

Every frame, **PlayerLocationManagement** retrieves certain types of DataModules (from SimulationManagement) and uses various lookup tables within them to search for nearby **VisitableLocations**. The world is divided up into cells with cell centers used as keys for any "spatial" lookup tables. This allows PLM to simply check cells within the players draw distance rather than iterating over every stored VisitableLocations and doing a manual distance check. Any VisitableLocations found are added to a buffer, and additionally if they are in the buffer left over from the last frame they are removed from it. If they weren't in last frame's buffer than **InitDraw** is invoked as they have begun being drawn this frame. At the end of this process any VisitableLocations still in last frame's buffer should no longer be drawn. The **Cleanup** method is invoked on all these objects before last frame's buffer is cleared and replaced with the buffer created this frame.

All remaining VisitableLocations will have two update methods called on them **DrawUpdate** (every frame) and **DrawUpdatePostTick** (after every Simulation tick).

A typical initial drawing process involves retrieving a model from an object pool (a form of runtime **GameObject** storage) and placing it in the scene relative to an anchor provided by PLM. The VisitableLocation will link itself to this model's attached SimObjectBehaviour where some additional drawing (based on the data and type of the SOB) might occur. For example, a **Settlement**'s target SOB (of type **SettlementSimObjectBehaviour**) will generate some instancing buffers to draw all of the neccesary buildings.

Some drawing processes are more complex and require multiple levels of nested drawers, the primary example is **Battles**. Battles draw process involves creating a sequence of **ShipCollectionDrawers** which then create **ShipDrawers**. Each ShipDrawer then gets a model and sets its own position, with some guidance from their parent ShipCollectionDrawer. ShipCollectionDrawers are then drawn or undrawn based on the Simulation state of the Battle rather than distance from the player.

Currently the data retrieved by PLM has to be specifically outlined, however the generalized **TargetableLocationData** (Used by **MineralDeposits**, **PirateCrews**, etc.) allows for any flexibility needed. The method used to operate on this data, **PerformOperationOnNearbyLocations** is reused by **PlayerMapInteraction**.

6.5.2 PlayerMapInteraction

PlayerMapInteraction draws on top of the normal map UI, using PLM's functionality to find VisitableLocations within the Player's travel range. Each of these locations is given a marker that can be interacted with by the player. Locations can specify the colour of their marker and whether to include a flashing visual effect via overriding SimObject methods. If any of the Player's Quests include a destination then that is also drawn on the map, in the form of a large beacon.

PMI also handles the drawing of the Interaction Cursor on the map for map enabled **Interactions**. These include a border highlight mode, a cell selection mode and a line indicator. Interactions are an essential part of the general gameplay loop and are discussed below.

6.6 Player Gameplay And Interactions

6.7 IDisplay and UI

7. Testing And User Evaluation

8. Conclusion

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Appendices

A. Project Proposal

Space Based Simulation and Tactics Game

Candidate Number: 267533

Supervisor Name: Dr Paul Newbury

Aims

Many games try to create a branching narrative. When done well this can imbue even non impactful decisions with a sense of weight, this feeling that everything contributes. On the other end, when done poorly, all decisions can become meaningless, whether they are impactful or not. What matters is the player thinking they're having an impact.

In this project I intend to (with the constraints inherently imposed by solo indie development in mind) create a video game that creates an emergent narrative through gameplay rather than text, maximising the feeling of impact for the player. This form of narrative is seen commonly in the large-scale real-time strategy genre (e.g. Stellaris, Crusader Kings, etc.) where interlocking systems tell the stories of large factions. There will be some simplification to allow users that would normally be turned off by the upfront complexity of these games to also engage with the final product.

Objectives

Primary Objectives

1. Research existing games in the genre, identifying their gameplay focus points & style.
2. Examine what games in the genre do well and what they do poorly.
3. Conduct interviews with 5+ potential players, utilizing insights gained in Primary Objectives 1 and 2 to shape the questions asked
4. Examine what games in the genre do well and what they do poorly.
5. Use information from all Previous completed Objectives to design a game that tells player driven stories.
6. Create a beta version of the completed game that can be tested and critically evaluated, both by me and potential players.
7. Use insights gained from Primary Objective 5 to iterate and improve on the beta version.
8. Ultimately finish a vertical slice that would lack some features but showcase accurately what the final product could look like.

Extension Objectives

1. Perform Primary Objectives 5 and 6 continuously to further improve the final product.
2. Conduct critical evaluation using the vertical slice, in the same manner as Primary Objective 5.
3. Utilize the insights gained in Extension Objective 2 to further improve upon the vertical slice, expanding it into a fully completed game.
4. Implement additional simulated features into the game, refining the model.

5. Implement online leaderboard functionality for various statistics.
6. Release the fully completed game on platforms such as Steam and Itch.io.

Relevance

This project reflects my intended career path, as someone that has already been working with Unity and C# for the last five years. During my gap year (2021 - 2022) I went through the full development process, releasing a 2D game on Steam in early July. Since then, I've been working on both my development and 3D skills and hope to release another game I've been working on a couple months post university.

By doing this project I hope to further both my coding and artistic skills, combining them to create a hopefully great video game. This project tests both of those disciplines alongside my ability to gather effective feedback and implement proper HCI principles.

Resources Required

I will require use of study rooms/seminars to conduct in person user testing. Testing will also be conducted online but that should require minimal resources. No funding will be required as I expect to purchase games used for market research myself. I also expect to pay for the Steam direct fee if Extension Objective 6 is completed.

Some use of lab computers is required (primarily on Mondays) though I intend to use my home PC on a day-to-day basis. This is due to several factors; my extensive backlog of previous projects I can pull reusable systems/assets from, the comfortability of the workspace and the ease of access, alongside various others.

Time Management

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
9:00							
10:00	Lecture		Lecture				
11:00	Project					Project	Project
12:00	Project		Project	<i>Seminar</i>	Project	Project	Project
13:00	Lab	Lecture	Project		Project	Project	Project
14:00							
15:00	Lecture			Lab	Lecture		
16:00	Lecture			Lab	Lecture		

Project time per week is equal to 12 hours. This acts as a minimum goal and (due to my general passion for the subject matter) I will likely do more depending on the week. Any blank slots will be used for other modules, whether coursework or study. The minimum time spent each week will increase depending on unseen factors such as unintended scope creep or hidden complexity.

I intend to have the initial early beta version of the finished shortly after the interim report (Week 8 to 9 of Term 1), utilizing feedback gained over the Christmas break. I then expect to finish the final vertical slice a couple weeks before the final report is due. Any additional time gained, by being ahead of schedule, will be used to complete extension objectives, primarily Extension Objectives 1 and 2.

This proposal has been adapted from Word to L^AT_EX, so exact formatting differs from the original proposal document. Structure and content remains the same.

B. Signed Ethical Compliance Form

Ethical Compliance Form for UG and PGT Projects*

School of Engineering and Informatics University of Sussex

This form is applicable to projects that involve other people ('participants') in the research and/or conduct of a project, for example, getting comments about a system or design, getting information about how a system could be used, or testing and evaluating a working system. If no other people have been involved in the collection of information, then you do not need to complete this form.

If your evaluation complies with **all** of the points below, please complete and sign this form (and have your supervisor sign it) and submit a signed copy with your final project report/dissertation.

If your evaluation **does not** comply with **all** of the points below, then you will need to apply for ethical approval from either the School Research Ethics Officer (for low risk projects) or the Sciences and Technology Cross Schools Research Ethics Committee (for high risk projects). Information about the application procedure and further guidance, including templates for the consent form and information sheet, can be found here:

<http://www.sussex.ac.uk/staff/research/spg/researchgovernance/apply>

1. Participants were not exposed to any risks greater than those encountered in their normal working life.
Investigators have a responsibility to protect participants from physical, mental and emotional harm during the investigation. The risk of harm must be no greater than in ordinary life. Areas of potential risk that require ethical approval include, but are not limited to, investigations that occur outside usual laboratory areas, or that require participant mobility (e.g. walking, running, use of public transport), unusual or repetitive activity or movement, that use sensory deprivation (e.g. ear plugs or blindfolds), sensitive topics (e.g. sexual activity, drug use, political behaviour, ethnicity) or those which might induce discomfort, stress or anxiety (e.g. violent video games), bright or flashing lights, loud or disorienting noises, smell, taste, vibration, or force feedback.
2. The study materials were paper-based, or comprised software running on standard hardware.

*

This checklist was originally developed by Professor Steven Brewster at the University of Glasgow, and modified by Dr Judith Good for use at the University of Sussex with his permission.

Participants should not be exposed to any risks associated with the use of nonstandard equipment: anything other than pen-and-paper, standard PCs, mobile phones, and PDAs is considered non-standard.

3. All participants explicitly stated that they agreed to take part, and that their data could be used in the project.

Participants cannot take part in the study without their knowledge or consent (i.e. no covert observation).

If the results of the evaluation are likely to be used beyond the term of the project (for example, the software is to be deployed, or the data is to be published), then signed consent is necessary. A separate consent form should be signed by each participant.

Otherwise, verbal consent is sufficient, and should be explicitly requested in the introductory script (see Appendix 1).

4. No incentives were offered to the participants.

The payment of participants must not be used to induce them to risk harm beyond that which they risk without payment in their normal lifestyle.

5. No information about the evaluation or materials was intentionally withheld from the participants.

Withholding information from participants or misleading them is unacceptable without justifiable reasons for doing so. Any projects requiring deception (for example, only telling participants of the true purpose of the study afterwards so as not to influence their behaviour) are deemed high risk and require approval from the relevant C-REC.

6. No participant was under the age of 18.

Any studies involving children or young people are deemed to be high risk and require ethical approval through the relevant C-REC.

7. No participant had a disability or impairment that may limit their understanding or communication.

Projects involving participants with disabilities are deemed to be high risk and require ethical approval from the relevant C-REC.

8. Neither I nor my supervisor is in a position of authority or influence over any of the participants.

A position of authority or influence over any participant must not be allowed to pressurise participants to take part in, or remain in, any study.

9. All participants were informed that they could withdraw at any time.

All participants have the right to withdraw at any time during the investigation. They should be told this in the introductory script (see Appendix 1).

10. All participants have been informed of my contact details, and the contact details of my supervisor.

All participants must be able to contact the investigator and/or the supervisor after the investigation. They should be given contact details for both student and supervisor as part of the debriefing.

11. The evaluation was discussed with all of the participants at the end of the session, and all participants had the opportunity to ask questions.

Participants must be provided with sufficient information in the debriefing to enable them to understand the nature of the investigation.

12. All the data collected from the participants is stored securely, and in an anonymous form.

All participant data (hard-copy and soft-copy) should be stored securely (i.e. locked filing cabinets for hard copy, password protected computer for electronic data), and in anonymous form.

Project title: 3D Video Game: Hope and Control

Student's Name: Alexander John Noles

Student's Registration Number: 22206049

Student's Signature: Alex N

Supervisor's Name: Paul Newbury

Supervisor's Signature:



Date: 04/11/2024

Ethical Compliance Form for UG and PGT Projects[□]

Appendix 1: Introduction and Debriefing Scripts

If you intend to obtain verbal consent from your participants, you need to create an introduction script, to read out at the start of the study, and a debriefing script, to read out at the end of the study. You should get your supervisor's approval for your introduction and debriefing scripts before commencing your study. **NB: When submitting the signed Ethical Compliance form, you do not need to include this Appendix.**

Introduction Script

The introduction script must:

- state the general aim of the study
- explain why you need the involvement of other people
- describe what will happen in the study
- describe what data will be collected
- reassure the participant that any data collected will be stored securely, and in an anonymous format
- explain what interaction the participant may have with you during the study
- reassure the participant that this is not a test of ability
- state that the participant may withdraw at any time
- seek explicit consent
- allow the participant to ask questions

An example introductory script (italics indicate required information, some of which will be specific to your project):

**Web Interface Investigation
Final Year Project, 2014-15
Jane Student**

The aim of this study is to investigate the suitability of a new website [*state the general aim of the experiment*]. We cannot tell how good this website is unless we ask those people who are likely to be using it, which is why we need to run studies like these [*explain why you need the involvement of other people*]. I will give you some time to browse the website, before asking you to answer some questions [*describe what will happen in the study*].

I will be observing you while you perform the tasks [*describe what data will be collected*]. If you have any questions, please ask me, and please let me know when you are finished [*explain what interaction the participant may have with you during the study*].

I will ask you some questions at the end of the study [*describe what will happen in the study*]. Please remember that it is the system, not you, that is being evaluated [*reassure the participant that this is not a test of ability*].

You are welcome to withdraw from the study at any time [*state that the participant may withdraw at any time*]. Please be assured that any data collected will be stored securely and in an anonymous form [*describe how the data will be anonymised and stored*].

Do you agree to take part in this evaluation? [*seek explicit consent*]. Do you have any questions before we start? [*allow the participant to ask questions*].

Debriefing Script

The debriefing script that is used at the end of the study must:

- restate the main aim of the experiment
- if applicable, explain any other, related aims of the experiment, and any particular data collected
- allow the participant to make comments or ask questions
- give contact details for the student and supervisor
- thank the participant

An example debriefing script (italics indicate required information, some of which will be specific to your project):

**Web Interface Investigation
Final Year Project, 2014-15
Jane Student**

The main aim of the experiment was to investigate the suitability of this website [*restate the main aim of the experiment*]. In particular, I was looking to see whether you made use of the site map, and whether any of the links on the website seemed to be confusing. I wanted to know how easy the pages are to navigate [*if applicable, explain any other, related aims of the experiment, and any particular data collected*].

Do you have any comments or questions about the experiment? [*allow the participant to make comments or ask questions*]. Here are my contact details, and those of my supervisor, and please let us know if you have any further questions about this study [*give contact details of student and supervisor to participant*]. Thank you for your help [*thank the participant*].