Micro Space Debris Detection Cubesat System
(Technical Report)

Video Game Monetization Model: Balancing Player Experience and Developer Profit
(STS Report)

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By
William Del Giudice
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Technical Team Members:
Ryan Bartlett, Drew Mouritzen, Frances Bailey, Owen Martin, Justin Yankow, Swar Shah, Alex Bellissimo, Kenji McCartney

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-related Assignments.

Advisors
Prof. Pedro Augusto P. Francisco, Department of Engineering and Society
Prof. Haibo Dong Department of Mechanical and Aerospace Engineering
Prof. Tomonari Furukawa Department of Mechanical and Aerospace Engineering

Intro

The technical problem my capstone team is trying to solve is how to track space debris smaller than ten centimeters in low earth orbit. We want to learn and integrate cubesat technology with search radar instrumentation, as well as data communication and debris resolvement algorithms. Our goal is to increase the awareness of space debris for other satellites and space vehicles. According to The Aerospace Corporation in 2024, all objects in space less than or equal to one centimeter in diameter can't be tracked by current technology, of which they estimated there are millions of. These debris have the equivalent kinetic energy of a falling anvil, capable of ripping potentially fatal holes through the ISS, which can only withstand up to 3mm debris. There is a clear gap between the size of debris we can withstand collisions from (3mm) and the size at which we can consistently track and avoid (5cm) which could lead to devastating collisions. This would not only jeopardize the millions of dollars spent launching these space vehicles, but on manned vehicles like the ISS, could claim lives. By tracking and reporting space debris in the ranges of .5cm - 10cm, we can close the gap in the data and ensure that our space missions and astronauts are safe. Ultimately, space technology is striving to expand the human domain and further human curiosity. All is lost, however, if we don't put the Astronauts first and allow them to go into risky situations where their fate is left up to chance. Just like the Astronauts and their safety should be the main priority of their space missions, the player and their experience should be the main priority of the video game industry. That is why I am studying phenomena of Video Game Monetization models for my sociotechnical topic. More specifically, I am trying to explore the ethics, market, publisher motives, and player perception behind different monetization models, since there are contentions around this area of the video game industry. My goal is to find a model, or at least understand the criteria which will balance ethics and stakeholder value to satisfy both the players and the game development companies. This problem is of critical importance because the game industry is growing more and more each year, reaching approximately 2.58 billion people worldwide (Statista 2024). Without a stable industry that supports and upholds its users, video games will negatively affect the population's entertainment,

financial situation, and mental health. Alternatively, if the monetization models do not provide revenue for their companies, the market will stop being competitive, halting development of newer and better games. I want to explore solutions that seek to balance this scale and attempt to unite the incentives of developers with player interest which would bring stability and prosperity to the industry.

Technical Topic

My technical aerospace engineering capstone project is on tracking space debris. According to inmarsat (Cacioni 2022) there are currently about 36,500 pieces of debris in space larger than ten centimeters being tracked by NASA. It is estimated, however, that there are about 130 million pieces of untracked space debris between 1 mm and 1 cm. Despite the large number of debris in this range the ISS is only rated to handle impacts of up to 3mm diameter debris. Our goal is to track and report data on objects between 1mm and 10 cm to fill the gap in data that NASA would need to better model the debris in space and overall decrease the likelihood of crashes with satellites, rockets, and other space vehicles.

We will target low earth orbit (LEO) debris since this region has the highest amount of debris as well as the largest concentration of satellites. We have also chosen to track the debris from space, via a satellite, as opposed to a high powered ground station. Since this is a student project, we will be using the cubesat satellite design, which has a simple and modular form factor making it accessible and intuitive for relatively low cost, educational projects. To sense the debris, we have opted for detection of reflected electromagnetic waves, as there is no atmosphere, and hence no sound in space. Due to the properties of electromagnetic reflection, we are going to design a roughly 50 GHz transceiver which will emit pulses of radiation and then listen for their “echo” off of space debris. By using the time difference between the pulse transmission and reception, as well as the known speed of light, we can calculate the distance to the debris. Algorithmically profiling the data over several measurements, we can extract the position and the velocity, given the known position of the cubesat via gps. We will attempt to estimate size via the power received from the reflection, as return power density is proportional to RCS, which depends on size,

however, this will likely be a rather poor estimate. In addition to the sensing aspects of the cubesat, there are several additional challenges regarding designing a cubesat. We need to account for thermal regulation, keeping the satellite warm when it is eclipsed by the earth, and cool when it is directly exposed to the sun. We also need to stabilize the rotation of the cubesat, utilizing the earth's naturally generated magnetic field via magnetorquers to achieve fuelless motion. A robust electronic power system must be established to deliver electricity to all components of the satellite, likely entailing solar panels and batteries. Due to the limitations of the cubesat platform, the power system could not come close to generating the high voltages and currents required for the transmission of powerful radio waves. This means we will also need an efficient power upscaling system including power amplifiers, capacitors, and frequency converters. We will need an onboard computer that can process the incoming data and translate it into position, velocity, and size information with temporal coherence at a high degree of certainty. Lastly, this data must be sent via a different antenna to other satellites, which can then send the data back to earth, to bring actionable information to NASA and other space stakeholders which can then increase the safety, confidence, and effectiveness of their own missions.

STS Topic

The video game entertainment industry has grown enormously in recent years far surpassing film and music to a whopping 450 billion dollars in revenue in 2024 and projections show that this will only increase. Just five years ago the industry was worth about half of that, and this rapid proliferation has led to a gold rush pursuit of companies trying to break into the market and capture its riches (Clement 2024). With these advances have come wildly new games such as Fortnite or Star Citizen, new ways to play games, such as the Nintendo Switch or VR, and new monetization models like Free to Play (F2P) or blockchain. While users have greatly enjoyed the new games and modes of playing these games, not all have enjoyed the new ways these games are monetized. This is an inherently sticky problem because game development companies, especially the big giants like EA, Microsoft, Ubisoft, and Activision, which are publicly traded, are constantly in a vicious cycle of trying to please investors, which usually

requires attempts to maximize revenue or create long term recurring revenue streams. This places a burden on the players. As I have experienced personally, gamers love the games they play but can feel commoditized once the developers focus more on profit than gameplay. Making better games aligns incentives strongly with the developers and players. On the contrary it seems that choosing the right monetization model inherently causes a conflict of interest between devs and players. Paying money in Free to Play games is shown to have strong correlation to Internet Gaming Disorder (Costes 2022). Additionally, public media sources such as youtube and reddit are filled with countless hate letters to free to play games arguing that they have ruined the industry (Berzurker 2021). Despite the suggestions of social media, these might just be the vocal minority, whereas the silent majority does enjoy free to play games. A survey conducted on thousands of gamers about different monetization models revealed that 47% of gamers like free to play while 53% do not (Lee 2023). I would like to investigate each of the different models and determine their strengths, weaknesses, and overall viability for the industry.

In modern gaming, there are a variety of monetization models. Pay to Play (P2P) is the most basic model where the user pays a one time fee to purchase the product and subsequently owns a copy of the game forever. Free to Play (F2P) is the main alternative to P2P in which the game is free to download, however, the game has optional content which can be purchased in-game, known on PC as microtransactions (MTX) or on mobile as In-App Purchases (IAP). In addition to the main choice of being P2P or F2P, games can have various monetization features: DLC, Cosmetics, Mechanics (P2W), subscription, Lootboxes, Battlepass, or in-game ads (Davidovici-Nora 2013). A game can sell optional Downloadable Content (DLC) which will give an extension to the ways to play the game, such as more levels, environments, characters, etc. A game can offer cosmetic MTX where players can buy character outfits, weapon skins, and other stylistic modifications which do not alter the gameplay itself whatsoever. Alternatively a game can offer mechanics through MTX such as abilities, heroes, power ups, etc which will alter the gameplay, often giving the owning player an advantage over others, referred to as Pay to Win (P2W) (Ivanov 2021). A game can offer a subscription service where players who purchase the

subscription will get access to recurring rewards which can be cosmetic and/or mechanical. When a subscription service is paired with the F2P model, this is referred to as the Freemium model. Lootboxes or Gacha are a specific type of MTX where the player can purchase the ability to open a lootbox, granting them a random chance of winning highly rated cosmetics or mechanics. The battlepass is a specific type of subscription service where the player must play the game and earn points towards unlockable cosmetics, but can only redeem the cosmetics they earned by owning the subscription service (Joseph 2021). Lastly, in-game advertisements are shown to the player to promote products and services outside of the game, thus allowing the developer to receive money without taking it from the consumer. Often there is an option for the user to remove all ads by paying a one time fee.

There are many factors that contribute to a monetization model being good or bad. I would like to define three categories which I will use to evaluate the viability of a model: ethics, profit, and sustainability. A model must be ethical in that it does not take advantage of its players but benefits them and rewards them fairly. A model must obviously generate profit for its developers since this is the primary objective of the business. Lastly, a model must be sustainable, not in the environmental sense of the word, but in the sense that it should be viable in the long-term and not rely on novelty, hype, or a highly specific style of game, that would otherwise make it irrelevant.

My methods for analyzing this issue will be split into two main types: literature review and case studies. I will use research papers on Internet Gaming Disorder and the psychology of monetization tactics. I will pull from the plethora of journals and online articles regarding popular opinion of different models and statistics of player engagement and preference. Lastly I will use a miscellaneous bag of papers, articles, journals, etc to form a knowledgebase of background information pertaining to all the types of models and the theory and motivations behind eac. I will use case studies for real world examples, application of literature theory, and validation of analysis conclusions. Balancing between the two will allow me to critically assess monetization models with state of the art literature analysis techniques, while staying

within the confines of reality and gut-checking the literature with the study of real games, their models, and how players perceive them. While research literature has been around for many years, video games have not and many monetization models aren't even a decade old. A large challenge will be making conclusions without long term historical trends and, in the case of some monetization models, with only a handful of real-world examples.

Conclusion

I am studying the sociotechnical problem of Video Game Monetization models to assess the ethics, profit, and sustainability of different models, in an attempt to align player and developer incentives, bringing balance to the video game industry. Monetization models are a strong point of contention in modern gaming culture and developers and gamers seem at odds regarding how a game should best be monetized. I would like to understand whether the tension is a natural tendency for consumers to want cheaper, better products, or if there is a fundamental flaw in the system. I would also like to look into alternative models that might try to align the incentives of companies and consumers. My paper will result in a definitive ranking of models and possibly a new model proposal. On the other hand, my capstone project is on space debris tracking. In this project I will work with a team of eight other Aerospace Engineering students to fully design and partially build a cubesat satellite with radar technology capable of detecting space debris smaller than 10 cm in size. The satellite will then report this data to other parties such as NASA, allowing them to make informed decisions about rocket launches, satellite maneuvers, etc, making space safer for all.

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