Thesis Project Portfolio

Motion of the Spheres: Constructing a Compact Mechatronic Orrery

(Technical Report)

Analysis of the Joint Strike Fighter Program: Astronomical Time and Cost

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring, 2023

Department of Mechanical Engineering

Table of Contents

Sociotechnical Synthesis

Motion of the Spheres: Constructing a Compact Mechatronic Orrery

Analysis of the Joint Strike Fighter Program: Astronomical Time and Cost.

Prospectus

Sociotechnical Synthesis

Mechatronics is a field characterized by the combination of mechanical engineering, electrical engineering, and computer science to create smart, efficient systems. Mechatronics, like many other technologies, has a wide variety of applications. It could be used for fun, for example kinetic art, or it could be used for large defense projects, for example control surface actuation on fighter jets. My capstone project, the mechatronic orrery as we call it, is an example of a fun, creative application of mechatronics designed to be educational. The mechatronic orrery has allowed me to combine my interest for space and passion for mechatronics into one project. My STS research project pertains to the Joint Strike Fighter (JSF) program to develop of the F-35 Lightning II strike fighter. Living in Virginia Beach near the Oceana Master Jet Base and having a father who was an F-14 and F-18 radio intercept officer instilled in me an interest in fighter jets from an early age. Additionally, I will begin a career in the defense industry this summer, so defense acquisition is also something I enjoy learning about. The F-35 is an example of a large, politically motivated defense project and makes use of many mechatronic systems. My STS research does not focus on the application of mechatronics within the F-35; instead, it focuses on the motivation of the JSF program and analysis of its outcomes. Despite this, it is interesting for me to think about how core concepts used in my capstone project are also used in advanced weapon systems like the F-35.

An orrery is a mechanical model of the solar system, representing the motion of the planets and their respective moons. A traditional mechanical orrery, uses a hand crank to drive complex gear trains that control the motion of the planets and their moons. The gear trains allow for orbital speeds of each planet and moon to be seen relative to each other. Controlling this process through mechatronics allowed our group to expand upon the utility of orreries by including a

database of orbital positions based on dates from 1523 to 2523. Using this database, the user can enter a date within that range, and our system will move to the approximate orbital positions that the bodies would be in on that date. Because of budgetary and time constraints, our group designed this system to just include the Sun, Earth, and Moon. The tilt of the Earth and the multiple degrees of freedom within the assembly made the design process challenging, but we were ultimately able to create a functioning design and fully fabricate the system. Many aspects of the system had to be simplified. For example, the orbit was simplified from elliptical to circular and the sizes of the bodies and distances between the bodies are not to scale. Not all of the aspects we desired were able to be implemented, for example the tilt of the moon and identification of eclipses added another level of complexity that was not feasible within our time and budgetary constraints. However, we produced a mechatronic orrery with basic functions that can be improved upon in the future.

As I stated before, my STS project pertains to the Joint Strike Fighter (JSF) program to develop of the F-35 Lightning II strike fighter. In particular, it focuses on the motivation of the JSF program and analysis of its outcomes. A strike fighter is intended to operate as both an air superiority (air-to-air) aircraft and an attack (air-to-ground) aircraft. The F-35 is a joint program, with three variants being made for the Air Force, Marines, and Navy. The JSF program was a controversial program due to the many challenges it met. These challenges resulted in an extremely drawn out and overbudget program. In my paper, I identify the need for the fifth-generation fighters and suggest changes to the way in which aircraft acquisition is approached in the future. It is only a matter of time before more aircraft acquisition programs are developed, and the United States can’t afford to repeat the same mistakes made by the JSF program.

Working simultaneously on two projects pertaining to two very different applications of many of the same fundamental engineering principles has opened my eyes to the duality of technological innovation. Before this year, I didn't necessarily think about the implications of research and how the same information can be used in very different ways. Whether applications of new research and innovation are good or bad must be determined through a dialogue between the people that this technology effects. Working to develop a physical application of mechatronics while also diving into the world of defense acquisition allowed me to connect with the importance of responsible innovation.