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Economic, Environmental, and Social Impact: Global Positioning System

Technology has been progressing and evolving every day. With the improvement of technology, we forget to recognize the economic, environmental, and social impact of these matters. The question we wonder is whether these new technological innovations are worth the impacts they produce. Are the products engineers are producing worth the effort, money, time, and the possible positive/negative effect on our world? For my capstone, my group and I are focusing on the unmanned ariel vehicle drone and our group has discussed the economic, environmental, and social impact/usage of the drone. I have been focusing on the global positioning system (GPS) portion of the project and have found several impacts that GPS has made in our world today.

In terms of health concerns, GPS does not have any positive/negative effects but can be useful in providing health support. After reading several websites, there was one talking about possible health concerns from GPS signals; however, I am not reliably convinced about the accuracy of this information. If talking about cars utilizing GPS and finding the shorter routes to a final destination, the National Institute of Standards and Technology talks “This reduction in miles means fewer fossil fuels are burned and fewer emissions are created, which, in turn, helps avoid health problems associated with air pollution” (National Institute of Standards and Technology). Indirectly, GPS can play a role in health and possibly prevent future health problems if used accordingly. In terms of privacy and confidentiality, GPS can be both helpful and harmful at the same time: “The primary concern about the use of GPS is the amount of information that can be deduced from the person’s movements and how that information may be used” (Journal of Global Health).

In a summary, GPS was founded and used in the 1960s and 1970s for satellite navigation with many uses for the military and our everyday technology. As time progressed, especially a decade after the founding of GPS, there were more eyes focused on this new technology being able to utilize satellites. Capturing data, images, and location became the new technological advancement that was then implemented into our phones, laptops, smart cars, and more. GPS

was created by the United States Department of Defense based on twenty-four satellites in space, being used as a reference point for the receivers down on Earth for military and civilian technology.

The engineering solution and impact of GPS are substantial locally and globally on several occasions. By looking at a military perspective, GPS is used for navigation, rescue missions, tracking objectives, and maps. The Coast Guard utilizes all of the following which is crucial to our mission for search and rescue cases, maritime response, readiness, law enforcement, prevention, cyber, aids to navigation, drug and migrant interdiction, and coastal security (Baijal and Arora). On cutters, whether that requires drug and migrant interdiction or search and rescue, the main source of our location information comes from our GPS. We have several GPS modules on board giving the most accurate and precise data coming from the satellites above. Map and navigation updates are crucial in our service considering as we travel across the ocean and through ports, we need to ensure the safety of the crew by not running hazards, shoal water, or other dangers. As we operate in search and rescue missions, our cutters and small boats must know their course and speed, calculated by GPS, as well as our MH-65s in the sky. The reason we utilize GPS for our UAV drone is crucial for navigation and transportation. We are told to travel through several waypoints, according to the RoboBoat Competition, as well as deliver a payload to a certain location. For us to do that, we need GPS and currently, I am working on GPS-RTK (Real-Time Kinematic) allowing millimeter accuracy and precision for our drone to cooperate with the autonomous surface vessel group.

I'd like to argue that society as a whole is impacted by GPS. Before the 1960s, modes of transportation and navigation were solely based on paper charts, maps, and memorization/familiarization of certain areas. Look at vehicles now today where we have created "smart cars" where cars can navigate themselves where "GPS receivers can give drivers exact driving directions and instructions" (McArthur). Mobile cellphones, that According to the Pew Research Center, 97% of the world population owns a cellphone, and increasing as the years progress and cellphones, especially smartphones, have GPS receivers. The importance of GPS receivers is important and seeing that most of the world's population uses GPS emphasizes the importance of GPS, especially in our UAV drone. It's phenomenal that college students are working on GPS and creating autonomous UAV drones and surface vessels to this day, meaning technology is being innovated every year. Continuing this topic of social impacts, some countries

have their own “GPS” since GPS is U.S.-based. China utilizes BeiDou, Europe uses Galileo and Russia uses GLONASS. The idea is that the concept of satellite navigation systems is used socially by countries around the world. For our capstone project, we have utilized satellite data from BeiDou, Galileo, and GLONASS along with our GPS information using GPS-RTK.

There are several economic impacts regarding GPS that should be discussed. According to the National Institute of Standards and Technology from the U.S. Department of Commerce, there have been a “1.4 trillion that U.S. private sector has gained regarding economic benefits since the 1980s” when GPS was being finely-tuned (McTigue). “RTI’s (Research Triangle Institutes) Director of Innovation Economics, Alan O’Connor, noted that GPS enabled innovators to develop a host of applications, services, and products. These advances have led to substantial gains in productivity, efficiency, and personal enjoyment” (McTigue). O’Connor goes on to say that according to his research along with 200 other experts, “if there was a loss of GPS service, it would average a $1 billion per-day impact to the nation.” All this to say that GPS has heavily impacted the U.S. and this information was for 2017. 5 years later, there have been improvements and more usage of GPS that there could be a loss of money if not used. To reiterate what the National Institute of Standards and Technology said, the fact that the U.S. alone has gained $1.4 trillion in the past 40 years shows the economic benefit of GPS in our country. According to a GPS survey application with model data and graphs, “it is shown that GPS is a cost-effective method to collect data” (Stopher). This article describes how cost-effect GPS can be, supporting our claim that economically GPS plays a positive role.

Along with social and economic impacts, several environmental impacts go along with GPS. According to the official U.S. government information about GPS and related topics, “Aerial studies of some of the world's most impenetrable wilderness are conducted with the aid of GPS technology to evaluate an area’s wildlife, terrain, and human infrastructure. By tagging imagery with GPS coordinates, it is possible to evaluate conservation efforts and assist in strategic planning” (GPS.gov). When talking about the Coast Guard missions, one of them is living marine resources. For the safety and security of wildlife in the U.S., we have the capabilities to watch over them through technology utilizing GPS such as cameras and sensors. When talking about sensors, our UAV drone utilizes LiDAR, “LiDAR sensors are equipped to provide point cloud information for the UAV to accurately sense the surrounding environment” (Tang). LiDAR and GPS work together especially with our drone when landing and recognizing

a sensor marker on the ground. With the drone we are currently working on, GPS-RTK is involved in providing millimeter accuracy, compared to standard GPS providing meters of accuracy. This in turn would help the possibility of targeting these wildlife animals in a way to make sure these animals are safe and prevent further harm to them. Another aspect of the environment GPS provides is accurate forecast and changes in the environment. According to resources, the atmosphere's water can be measured to determine and improve the accuracy of weather forecasts. One fact I learned is that GPS receivers can be put on buoys to track the spread of oil spills which is neat information since we want to prevent the spread of water contamination, especially in the Coast Guard.

As seen from several articles and websites, GPS is used predominantly around the world. The Coast Guard, other military services, and civilians use technology that has GPS implemented into it. Primarily, GPS can determine location with positional accuracy with the help of satellites which remains one of the most useful tools in the world. If we take a look at smart cars, smartphones, laptops, smart houses, and watches they utilize GPS. With this equipment, we can even share our location with positional accuracy whether that information is from Snapchat or the Apple IOS. I believe implementing GPS in the drone is crucial for the drone to meet the requirements of arriving at each waypoint and offloading a payload. Without GPS, our UAV drone would not be able to function and travel to the correct location. Bringing it a step forward, our group decided to utilize GPS-RTK, which was briefly discussed, which brought our several-meter accuracy to millimeter accuracy. The importance of RTK allows the drone to land on the back of the autonomous surface vessel reliably and controlled. The smaller the accuracy value, the better the accuracy. Out starting point to use GPS has been the best choice and taking it one step forward by using RTK has been accommodating to our requirement needs. The impact GPS has economically, socially, and environmentally has been positive and overall a tool that is useful in the Coast Guard, military, transportation, navigation, and especially our capstone project.

References

[1]K. McTigue, "Economic Benefits of the Global Positioning System to the U.S. Private Sector Study", *NIST*, 2022. [Online]. Available: https://www.nist.gov/news-events/news/2019/10/economic-benefits-global-positioning-system-us-private-sector-study. [Accessed: 15- Apr- 2022].

[2]"GPS.gov: Environmental Applications", *Gps.gov*, 2006. [Online]. Available: https://www.gps.gov/applications/environment/. [Accessed: 15- Apr- 2022].

[3]M. McCreless and B. Trelstad, "A GPS for Social Impact", *Stanford Social Innovation Review*, 2012. [Online]. Available: https://rootcapital.org/wp-content/uploads/2018/01/Fall_2012_A_GPS_for_Social_Impact.pdf. [Accessed: 15- Apr- 2022].

[4]J. McArthur, "Engadget is part of the Yahoo family of brands", *Engadget.com*, 2016. [Online]. Available: https://www.engadget.com/2016-07-14-how-gps-has-changed-technology-culture-and-our-minds.html. [Accessed: 15- Apr- 2022].

[5]A. O'Connor et al., "Economic Benefits of the Global Positioning System (GPS)", *Rti.org*, 2019. [Online]. Available: https://www.rti.org/sites/default/files/gps_finalreport.pdf. [Accessed: 15- Apr- 2022].

This scholarly article provided information regarding health and how, indirectly, GPS can be used for the benefit of future health issues and preventing the emission of possible burned fossil fuels.

[6]"Mobile Fact Sheet", *Pew Research Center: Internet, Science & Tech*, 2021. [Online]. Available: https://www.pewresearch.org/internet/fact-sheet/mobile/. [Accessed: 15- Apr- 2022].

[7]R. Baijal and M. Arora, "GPS: A military perspective", *Geospatial World*, 2009. [Online]. Available: https://www.geospatialworld.net/article/gps-a-military-perspective/. [Accessed: 15- Apr- 2022].

For this scholarly source, I was able to receive information regarding GPS importance in a military persepctive and several specifics of how they apply such as navigation, rescue missions, tracking, map updation, and more.

[8]A. Apte et al., "Ethical considerations in the use of GPS-based movement tracking in health research – lessons from a care-seeking study in rural west India", *Journal of Global Health*, vol. 9, no. 1, 2019. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6596313/. [Accessed 15 April 2022].

This scholarly article was used for information regarding privacy and confidentiality. There was analysis involved with this article and described some of the ways GPS can be harmful when being used by knowing your location and the possible lack of privacy.

[9]Y. Tang, "Vision-Aided Multi-UAV Autonomous Flocking in GPS-Denied Environment", *Ieeexplore.ieee.org*, 2019. [Online]. Available: https://ieeexplore.ieee.org/document/8333748. [Accessed: 15- Apr- 2022].

This scholarly article talked about LiDAR. Although the paper focuses its' attention on GPS, LiDAR plays an important role along with GPS in terms of landing the UAV drone on the back of the autonomous surface vessel.

[10]L. Shen and P. Stopher, "Review of GPS Travel Survey and GPS Data-Processing Methods", *Transport Reviews*, vol. 34, no. 3, pp. 316-334, 2014. Available: 10.1080/01441647.2014.903530.

This scholarly article talks about the economic impact with GPS regarding GPS being a cost-effective method. There is a lot of information that also shows the important implications and necessities GPS has, which goes along with how much money GPS was able to benefit regarding the U.S. alone.