# Next Steps

This document lists several recommendations for moving forward with the project. These recommendations are meant to address the technical and documentation deficiencies of the project in its current suggestion, elaborate on the importance of each component, and provide general guidelines for the future development of each section.

## 1. Integration of ROS into Website

**Significance:** Robot Operating System, or ROS, is an operating system commonly used in Robots. As robotics is one of the most straightforward applications of GPU technology, the summary on the website should deal with ROS extensively and provide support for the integration of GPU tools into RO.

**Status:** The original plan was to include ROS tutorials on the website. Over the course of the project, it became apparent that it was futile to compete with existing ROS documentation within the time constraints.

**Recommendation:** Reorganize the website with the assumption that the users know and intend to continue using ROS.

## 2. Integration of FFmpeg into Website

**Significance:** FFmpeg is a library of software that focuses on converting, compressing and playing various forms of multimedia files. Due to its availability, FFmpeg software is commonly used when dealing with Multimedia files.

**Status:** Discussion of using FFmpeg began at the end of Winter term, and research began during the Spring. However, we did not have the time or resources to experiment with FFmpeg on our own device, rendering us unable to create reliable resources for the website.

**Recommendation:** Have one member of your team take Multimedia Systems. That background knowledge will make this integration much easier. Have that member prepare an introduction to FFmpeg, as well as various well-used pieces of software from the library, with the assumption of basic background in Multimedia Systems.

## 3. Possible Security Systems-Based Projects

**Significance:** Security systems are a common use of FFmpeg integration, and is one that could be relatively simple as a project for a college student. Preparing examples and concepts for Security-based projects would allow for more teams to take this project further in the future.

**Status:** Some research was done during Spring term, but more focus into FFmpeg would be required before really stepping into that pool.

**Recommendation:** After the FFmpeg section is complete, look into different project ideas that apply FFmpeg and GPU concepts onto the field of Security. Create example code to show future students how to get started and pitch these projects to the Senior Capstone team.

## 4. File Compression Integration on Website

**Significance:** File compression can take a lot of processing power, and seems perfectly aligned with the capabilities of a GPU. As such, including this as a possible project in the video is an easy leap to make.

**Status:** While ideas of looking into File Compression were voiced, that idea was put on the back burner in favor of other topics. It's still worth looking into at a later date, however.

**Recommendation:** Once again prepare with a history of Multimedia Systems in mind. Create a tutorial with the basic File Compression concepts, as well as new research that could be worth expanding on with a project of its own.

## 5. Integration of GPGPU software into a ROS stack

**Significance:** GPGU processing through libraries such as OpenCV, PyTorch, or Numba allows users to more rapidly generate access to the GPU for a variety of applications.

**Status:** Currently, the project has some treatment of these libraries, and existing documentation is enough to get users set up with it. However, to fully incorporate these libraries into a format usable by multidisciplinary engineering groups, it is imperative that these be developed in a way that they can be executed via ROS.

**Recommendation:** The next step in this area will entail a thorough exploration of if and how these libraries can be incorporated into ROS. OpenCV integration already exists through cvbridge, but it will be necessary to explore dependencies and functionality for the specific CV modules such as DNN. Furthermore, research and tests must be conducted to better the degree to which PyTorch and Numba function in ROS.

## 6. Incorporate Videos into the Website

**Significance:** A great deal of the website was introductions and tutorials. However, while these written tutorials work for everyone, they don't serve the best interests of every type of learner. As such, including video resources on the website could serve a wider audience, and provide for more capable forms of demonstration.

**Status:** Unfortunately, due to the scattering of the team during Spring term, many of the applications we hoped to research ended up being much harder to work on. As such, we were unable to work together on video demonstrations as we hoped to. In addition, the text-format of the website is poorly suited for communicating the intricacies or problems generally encountered during the setup. These difficulties could be more easily addressed through visual formats.

**Recommendation:** Experiment using the different tutorials on the website and other notable pieces of software, and determine which of them most require a video to fully grasp the concept of. Create those video demonstrations and upload them to the GitHub site, YouTube, or both as necessary.

## 7. Deepstream-to-ROS Integration

**Significance:** Deepstream is an Nvidia SDK of image-recognition and object tracking libraries, designed for deployment in smart-city settings. It provides powerful on-board functionality for computer vision.

**Status:** Currently, Deepstream setup on the Jetson Nano is functional in the standalone version, but packages have not been created to incorporate into a ROS stack.

**Recommendation:** Devise a method to launch/access deepstream functionality from another program, either by calling it from outside the program or developing an API to access functions inherent to the program. A good start to this process would be to explore existing applications by companies or other third-parties to understand the types of integrations that Deepstream permits, and then work to ensure that it runs within the systems specified for the project.

## 8. Further Detailing of SDK Info onto Website

**Significance:** Collection of different software development tools in a package. Lots of different options to use a Software Development Kit, including creating applications, debugging and using SDK as a framework for different projects.

**Status:** Multiple different Development Kits were linked on the website for students to access. However, we did not have time to go into as much detail as we would have liked on them, and the entries they currently have could be expanded upon more.

**Recommendation:** Create longer, more detailed entries for the kits already mentioned on the website. Once those are updated to a more useful state, find more Development Kits that could prove useful to the various disciplines that would be making use of the website, and create the more detailed entries initially rather than later on. In addition, include video-evidence and more complete documentation for the demonstration of these SDKs.

## 9. Digital Meeting-Collaboration Platform

**Significance:** Taking into the ongoing COVID-19 pandemic, the current lack of a vaccine, and the likelihood of future events, it is imperative to develop a work environment that can be sustained digitally or in a responsibly socially-distanced manner.

**Status:** This wasn't something we realized would be important until it was already too late to prepare. As such, our team had no plans on what to do in case this project needed to go fully digital. This is not a mistake that future teams should have to deal with.

**Recommendation:** Alongside the initial project plan and timeline, also create a set of documents discussing what the team would do with the team materials and how a disaster could offset the plans you had for project development. Some general suggestions would be to explore Docker, TeamViewer, and Zoom, (or a combination of the three) to ensure that remote collaboration is possible.

## 10. Further Documentation of Setup Errors

**Significance:** The environment setup is a difficult and important phase that precedes any software implementations. One of the initial motivations of the project was to generate support and documentation for common setup issues.

**Status:** While the physical steps have been completed, the issues relating to software version, hardware-release discrepancies, and run-time issues remain not fully documented.

**Recommendation:** Some basic information has been left behind in the documentation for tracking these errors, but they have yet to be made into the website. The next step will be to more rigorously track the different releases of the Jetson Nano board and to have more thorough steps related to getting the physical hardware of the Jetson up-and-running.

## 11. Expand Scope Beyond that of a Jetson Nano

**Significance:** Testing with more than one GPU gives you a familiarity with the system, allowing you to gain experience and knowing what to do when a problem arrives.

**Status:** The current layout of the website only discusses setup and implementation on the Jetson Nano.

**Recommendation:** Test with different GPU and looking at covering multiple companies. This will increase the overall knowledge of how a GPU is supposed to function regardless of the company that makes it.

## 12. Formal Project Proposals

**Significance:** As the purpose of the current documentation is to set up future users, it is wholly appropriate that a few formal recommendations be made to set up future users with a project deemed to be applicable to the materials.

**Status:** Some project proposals have been discussed but in the meantime, no formal recommendations have been made. These proposals were limited by time constraints, but furthermore, fell outside of the timeline and scope of the school year.

**Recommendation:** Draft two or three proposals, including a preliminary engineering requirements document and system requirements for future teams.