ECE 453 Project Proposal (Fall 2018)

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1 Introduction

We are interested in building a *quadcopter* plus *ground station* and *web-based user interface*. We have chosen to call this project the **fault-tolerant quadcopter**. This name reveals one of our design goals that will be covered in a future section.

This document serves as the formal proposal to be vetted by the course instructor, Joe Krachey. We have additional documentation in work online that we plan to keep in sync with our project's scope and current progress. At the time of writing it is not yet in a stable state.

This project is designed for three major bodies of work that were mentioned above but are better captured by **Figure 1**:

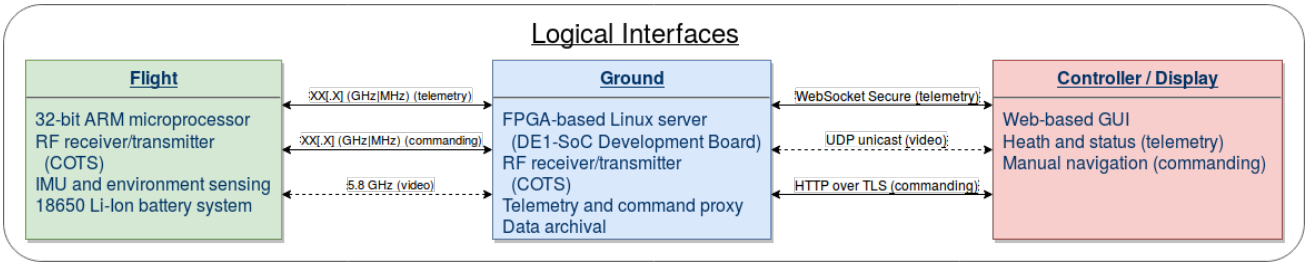

Figure 1: High-level overview of the major components and their interfaces.

This high-level architecture is inspired by existing aerospace avionics and software systems that we have done research on and have some first-hand experience with. Our current, collective experience with such systems (and the technical challenges we anticipate being associated with them) is minimal, though. For this reason **we seek feedback on our lower-level goals and approach**, provided that this high-level idea suffices as a project worth pursuing.

2 Technical Features

A vehicle that is *single-fault tolerant* is capable of continuing nominal operation after experiencing any arbitrary failure in a well-defined *fault space*. We aim to implement single-fault tolerance by:

1. Limiting the initial fault space to a "loss of ground station heartbeat" event
2. Executing a "landing maneuver" upon fault detection
3. Iteratively hardening our design to a broader fault space, time permitting

We recognize some intermediate milestones that will need to be reached before an *automatic flight-termination system* described above can be expected to function:

- Establish wireless communication between the vehicle and ground station
- Establish percentage-based throttle control over each motor
- Establish manual-commanding capability to the vehicle from a web-based user interface
- View live telemetry from a web-based user interface
- Sense angular velocity via gyroscope and force experienced via inertial measurement unit

- Develop a control algorithm to fly in a stable hover or holding pattern
- Extend control algorithm to control for velocity in three axes to achieve controlled motion
- Sense relative altitude
- Extend control algorithm to control for a specific *delta-y* (perpendicular to ground plane)

Our limited understanding of control theory and lack of experience in general with avionics systems may limit what we can achieve in the end, but we recognize this and have focused on primarily *system-level* goals and requirements versus specific technical requirements (battery life, thrust and payload capability, etc.).

2.1 Quadcopter

For the flight vehicle, we intend to pursue an implmentation depicted in **Figure 2**:

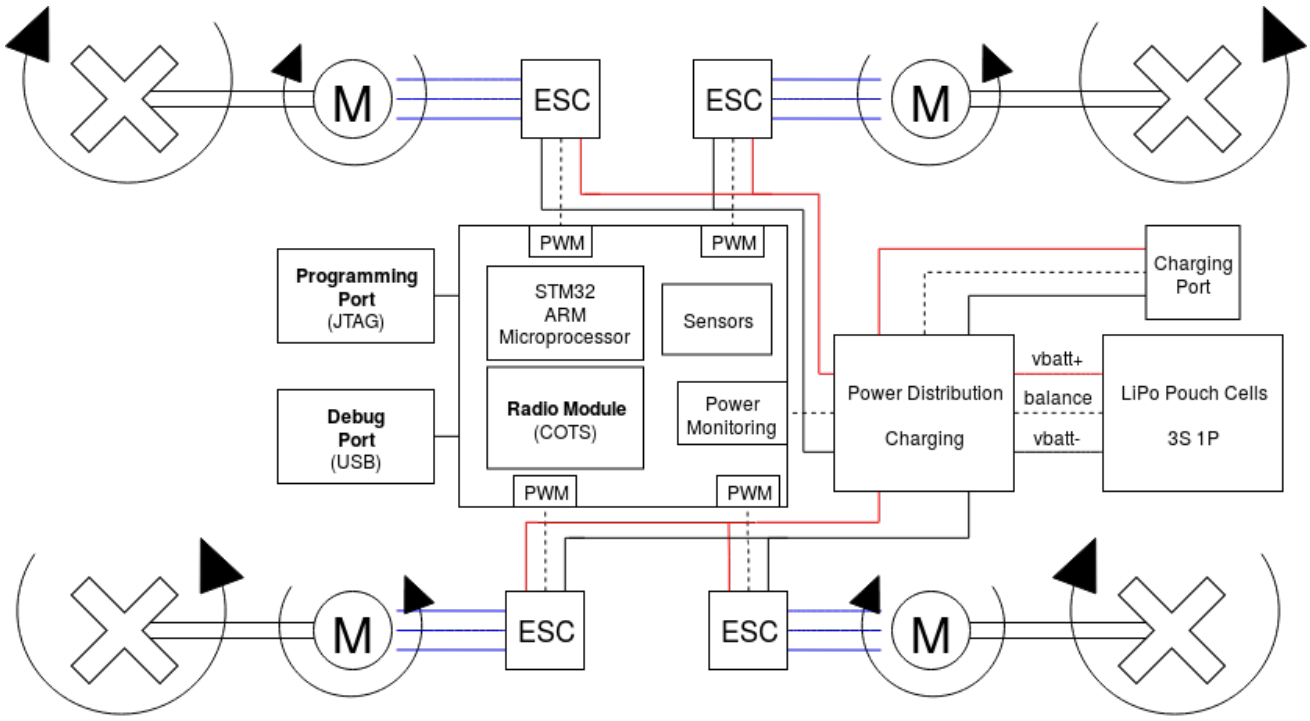

Figure 2: Block diagram view of the quadcopter.

Responsible Engineer: **Vaughn**

2.2 Ground Station

For the ground station, we intend to pursue an implmentation depicted in **Figure 3**:

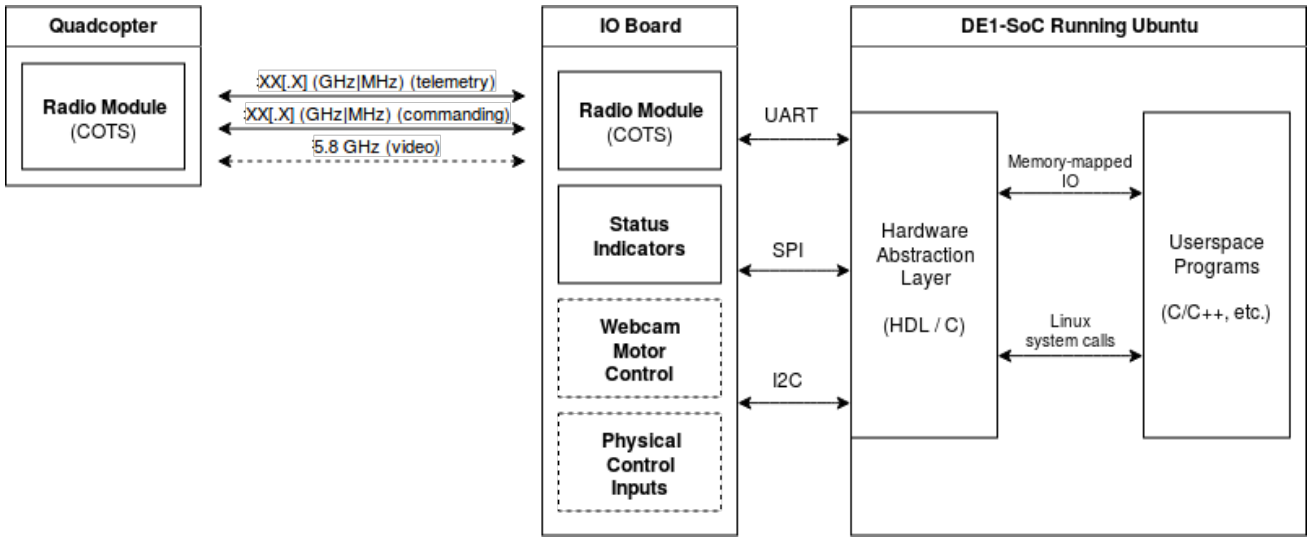

Figure 3: Block diagram view of the ground station.

Responsible Engineer: **Cooper**

2.3 Display and Controller

For the display and control interface, we intend to pursue an implmentation depicted in **Figure 4**:

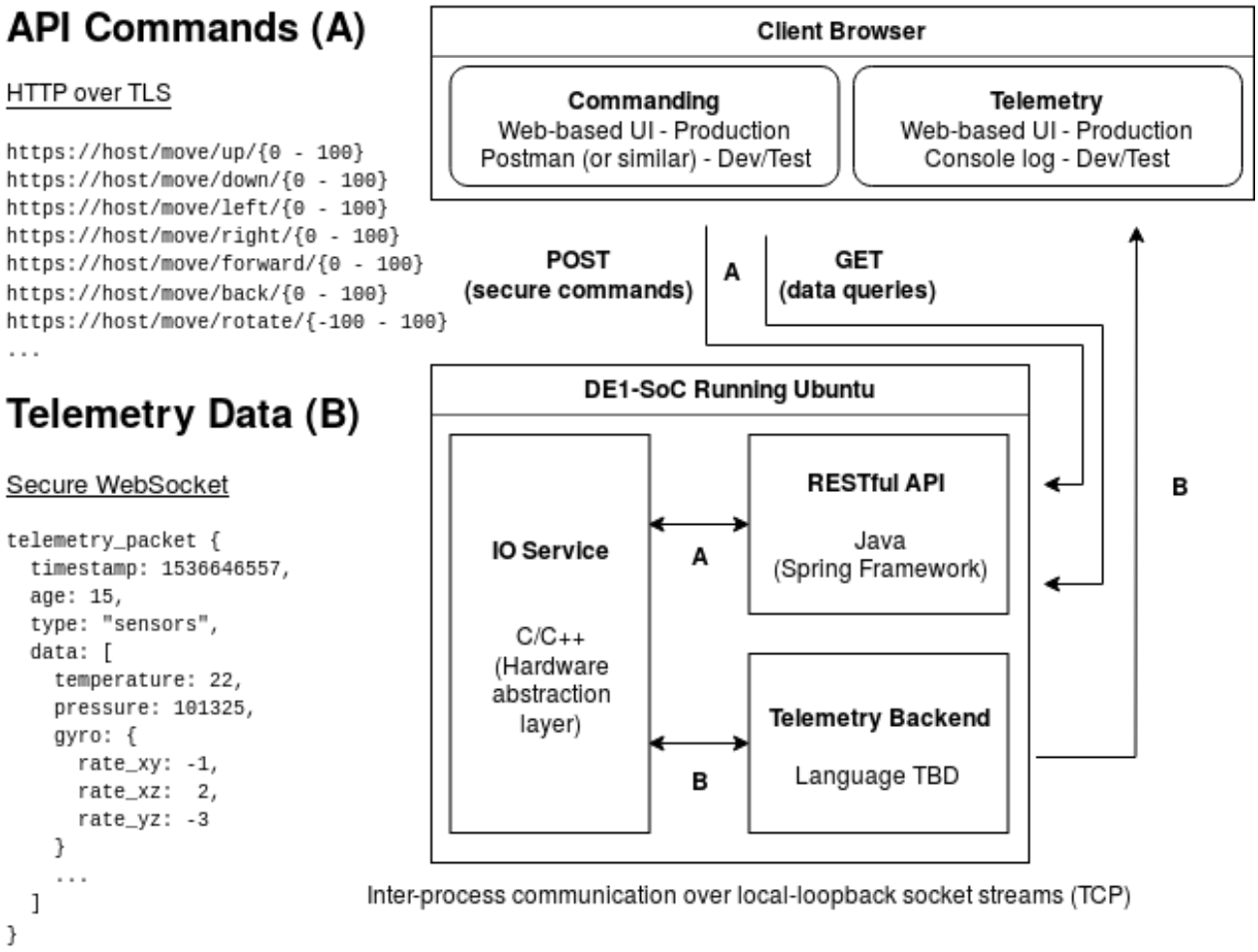

Figure 4: Block diagram view of the display and control user interface.

Responsible Engineer: **Mayank**

3 Roles and Responsibilities

"A problem well stated is a problem half solved." - Charles Kettering

Distribution of work and responsibilities has been discussed and the following summaries represent a consensus reached on initial roles and task delegation.

3.1 Vaughn Kottler

Flight Hardware Final design and assembly of the quadcopter. Validation of component selection to ensure flight is feasible.

Flight Software The firmware image flashed to the flight computer. Includes necessary control algorithms and runtime configurability.

Project Oversight Track project progress and maintain documentation.

3.2 Mayank Katwal

Telemetry Display A web-based dashboard that summarizes the health and status of the quadcopter during flight.

Vehicle Control Interface A web-based user interface that allows manual control of the quadcopter during flight.

Data and Command APIs User programs that expose flight data and command capability to client browsers via HTTP over TLS requests.

3.3 Cooper Green

Ground Station Hardware asbstraction layer source code and mezzanine board implementation. A coherent and well-defined interface to the hardware from user programs.

Radio Frequency Communication Choice of frequency bands and protocols used to send and receive data with radio modules.

Telemetry Storage A data archival system for post-flight analysis.

4 Project Management

> *"If I had an hour to solve a problem I'd spend 55 minutes thinking about the problem and 5 minutes thinking about solutions." - Albert Einstein*

The value of detailed (but *precise*!) planning for a project of this scope and timeline cannot be overstated. Prototyping and experimenting is inevitable but must be guided to avoid allocating disproportionate effort towards minor goals that put higher-level goals at risk. **Figure 5** introduces our approach and **Figure 6** establishes a proposed process for handling integration and final stages in project realization.

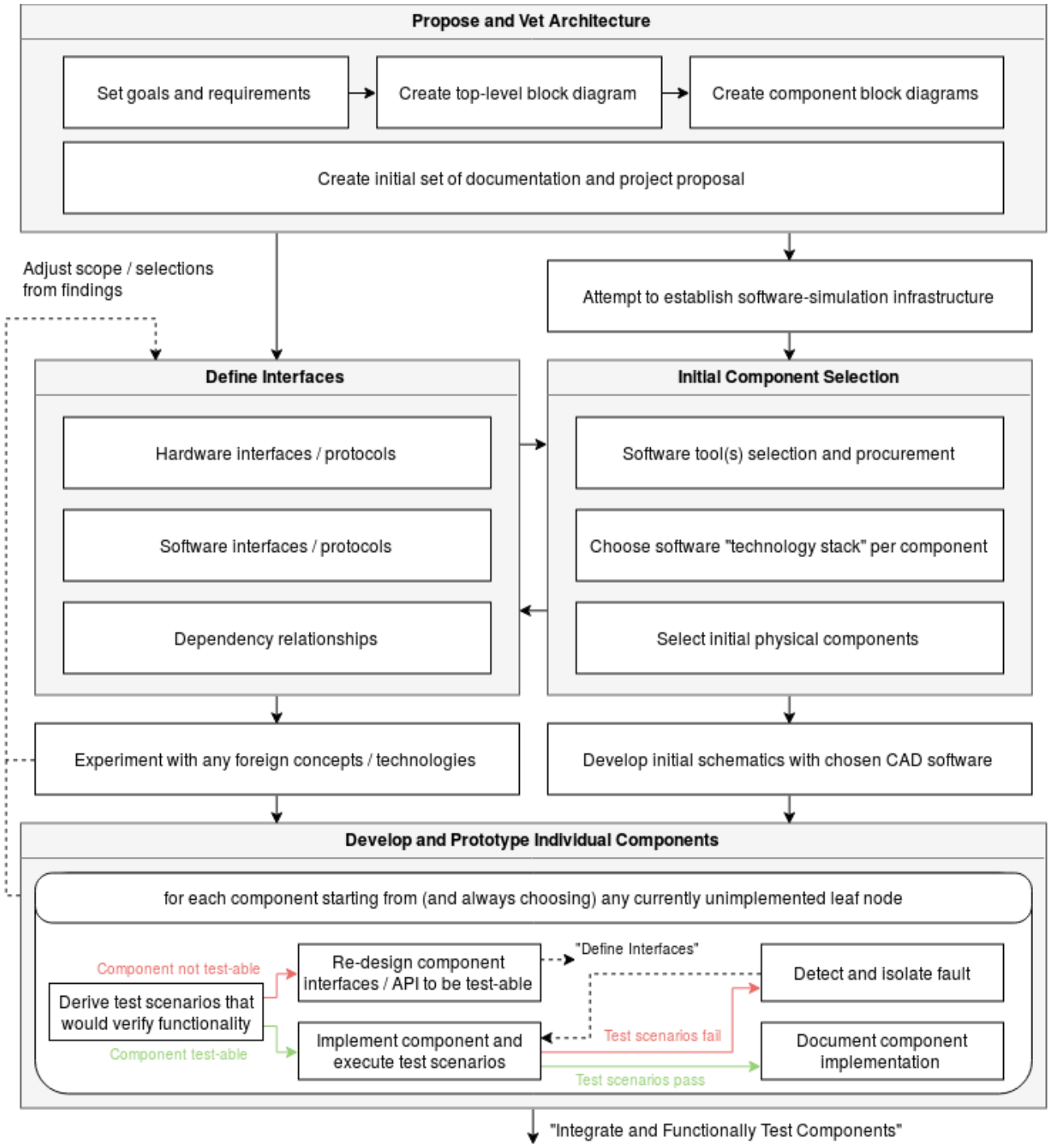

Figure 5: A flexible workflow diagram that attempts to capture our ideal process for initial prototype and development work.

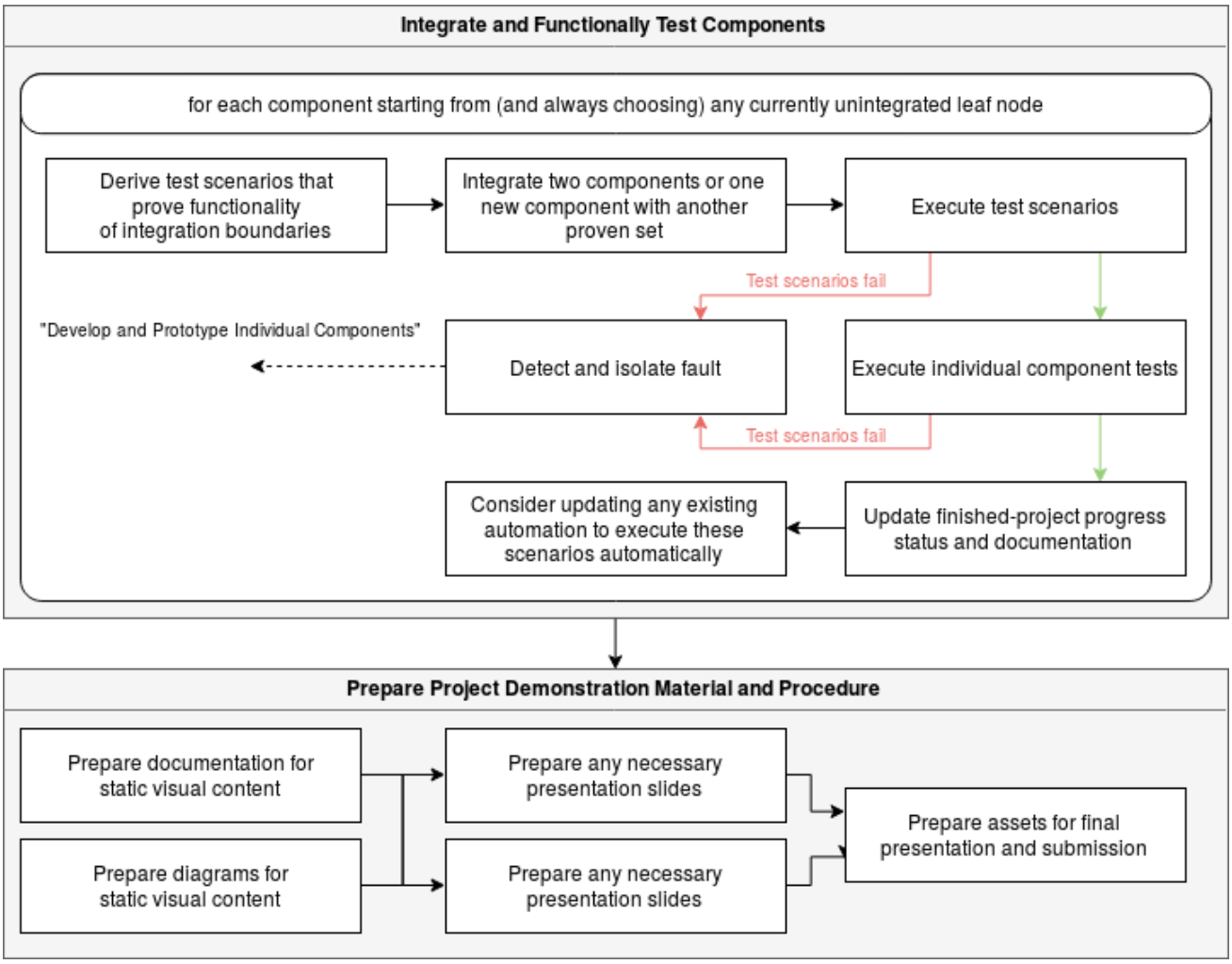

Figure 6: The remaining stages of the workflow diagram that captures our intended process for bringing the project to completion.