Software Requirement Specification
Modern Helicopter Flight Control System

University of Connecticut
Department of Electrical and Computer Engineering
Group 2101: Elizabeta Sofroni, Siddarth Suresh, Alexander Jatsiv
Introduction:
Modern flight control system design philosophies desire to gain greater control over the aircraft motion, while simultaneously reducing pilot workload. To that end, flight modes have become the norm for many years. These selectable modes for pilots allow them to vary the amount of software-assisted flight control as desirable for the mission at hand.

Product in context:
The objective for this product is to create an ACVH (attitude command velocity hold) utilizing the open-source flight control software PX4 to add the additional “assisted” flight mode. This mode will be implemented utilizing model-based design engineering practices within the Simulink software package. This new flight mode will need to be thoroughly validated at multiple levels of test coverage. Utilizing open-source software, the design can be fully verified software-in-the-loop on desktop drone simulation software. Once a build is qualified for light, the team will utilize a commercial of the shelf drone employing a PixHawk 4, to fly the new build of their software on real hardware.

The flight control software utilized in this project is the open-source PX4 software. This software is compatible with the PixHawk 4 flight controller. As such, the drone used to test the flight mode developed in this project must be compatible with the software and controller. The design must be verified software-in-the-loop through desktop drone simulation software. The flight mode must satisfy certain altitude and operational envelope requirements of the aircraft, as well as mission-capability requirements.

Parameters:
Specific Requirements to include for SRS
- Maximum pitch (Parameter: FW_MAN_P_MAX)
- Maximum roll (Parameter: FW_MAN_R_MAX)
- Maximum upward velocity (Parameter: MPC_Z_MAX_UP)
- Maximum downward velocity (Parameter: MPC_Z_VEL_MAX_DN)
- Deadzone of stick (Parameter: MPC_HOLD_DZ)
- Min airspeed/throttle (Parameter: FW_AIRSPD_MIN)
- Max airspeed/throttle (Parameter: FW_AIRSPD_MAX)
- Cruise speed. Default (Parameter: FW_AIRSPD_TRIM)
- Position Hold (Parameter: MPC_HOLD_DZ)
- Position Control in horizontal direction (Parameter: MPC_ACC_HOR_MAX)
- Acceleration max (Parameter: MPC_ACC_HOR)
- Acceleration min (Parameter: MPC_DEC_HOR_SLOW)

Description of the system properties:

Control Loop
**System Specifications:**

- The Attitude-Command Velocity Hold (ACVH) flight mode shall be an additional assisted flight mode in the PX4 autopilot.
- ACVH shall allow the drone to fly at a constant velocity while maintaining stability with no additional effort from the pilot.
- ACVH shall allow the drone to maintain a reference velocity by commanding attitude.

**How is (ACVH) engaged?**

- There shall be a three-position switch known as the Mode Switch that specifies flight modes using a dedicated transmitter channel known as the Mode Channel.
- The Mode Channel shall distinguish between modes using PWM.
- When the Mode Switch is in the center position, the Stabilized flight mode shall be engaged. This position shall be called the Stabilized Position of the Mode Switch.
- When the Mode Switch is in the upward position, the Attitude-Command Velocity Hold (ACVH) flight mode shall be engaged. This position shall be called the ACVH Position of the Mode Switch.
- Attitude-command velocity hold (ACVH) shall be engaged when the Mode Switch is in the ACVH Position.
- ACVH shall be set at the velocity of the drone at the time the Mode Switch is set to the ACVH Position.
- The flight mode should maintain set velocity in presence of air resistance.
- The flight mode should maintain set velocity in presence of storms.

**When ACVH is engaged what direction should the drone go?**

- When ACVH is engaged, if the drone is moving in only the lateral or longitudinal direction, then the drone shall maintain its velocity in that direction.
- When ACVH is engaged, if the velocity vector of the drone has a component in both the longitudinal and lateral direction, then this means the drone is turning, and the drone shall continue turning and maintain its tangential velocity.

**How do you know (ACVH) is engaged?**

- The drone should send telemetry data indicating ACVH is engaged.
- The drone should send telemetry data indicating the velocity and heading of the drone.
- The drone should send telemetry data indicating the altitude of the drone.

**Does the reference change when ACVH is engaged?**

- In the event that ACVH is engaged, the control loop shall close on reference velocity.

**Under what conditions can (ACVH) be engaged/disengaged?**

- ACVH shall not be engaged during takeoff and landing.
- ACVH shall not be engaged if the drone is below a certain altitude.
- When ACVH is engaged this means that the Mode Switch is in the ACVH Position and the drone will maintain its velocity with no input from the pilot.

**How is (ACVH) disengaged?**

- ACVH shall be disengaged when the Mode Switch is switched out of the ACVH Position.

**Under what conditions can (ACVH) be disengaged?**

- ACVH shall be disengaged in the event that sensor data exceeds certain thresholds and shall default to 1 notch below (ACVH) flight mode.

**Does the reference change when ACVH is disengaged?**

- In the event that ACVH is disengaged, the drone shall default to 1 notch below (ACVH) flight mode and eventually in Position mode, which uses GPS position as its reference. (NULL)

**How do we measure the reference?**
ACVH should close on barometric altitude sensors to maintain reference altitude.
- ACVH should close on GPS and accelerometers to maintain reference velocity

**Should reference be limited?**
- ACVH reference velocity shall not exceed a maximum velocity.
- In ACVH the drone shall not exceed certain acceleration thresholds.

**How will feedback be received when ACVH is activated?**
- The drone should send telemetry feedback to the remote controller.

**How are we using acceleration?**
- When ACVH is engaged, reference acceleration shall be set to 0. (NOT SURE)

**Other Questions to worry about later:**
- Overshoot
- Settling time
- Steady-state error
- Ramp response

**Constraints placed during the development process:**
- **Limitation**
  - Drone - the kind of drone that will be purchased, knowing the features that it comes with already.
  - Pilot - What task will the pilot have to do in order to use the velocity control command/ is the velocity hold command suited for the pilots needs and comfort

**Low-level requirements:**
- Communication Protocol:

**References:**
- [https://docs.px4.io/v1.9.0/en/config_mc/advanced_mc_position_tuning.html](https://docs.px4.io/v1.9.0/en/config_mc/advanced_mc_position_tuning.html)

- Accel/Gyro: ICM-20689
- Accel/Gyro: BMI055
- Magnetometer: IST8310
- Barometer: MS5611
- GPS: ublox Neo-M8N GPS/GLONASS receiver; integrated magnetometer IST8310

**IGNORE:**

- ACVH shall be disengaged in the event the pilot moves control sticks past the dead zone.
- ACVH shall default to 1 notch below (ACVH) flight modeWhen ACVH is disengaged, the dro