Autonomous Optical Guidance System

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Project Goals and Objectives

- The desire to create a system which will autonomously guide a model airplane on a collision course with a specific target using image recognition.
- To experience using microcontrollers to control plane navigation.
- To experience designing schematics to interface with various components.
- To experience synchronizing multiple microcontrollers to control airplane flight.
- To implement image manipulation while minimizing processing time.

Project Specification and Requirements

1. Track and collide with target using image processing without user input.
2. Capture frame from camera, store into SRAM, conduct image processing, and send target offset to flight microcontroller.
3. Use target offset coordinates and flight hardware to correct the plane's flight course.
4. Design a dual microcontroller circuit which will interface flight sensors with optical hardware.

Design Approach and Implementation

- Minimization of abstraction layers
  - Appropriate data formats
  - Direct interfacing
- Robust physical and electrical construction
  - Shock resistance
  - Operating margins prevent restarts
    - Cannot afford to restart flight microcontroller in flight

Design Decisions

Dual Microcontrollers

- Flight controller maintains final decisions regarding flight

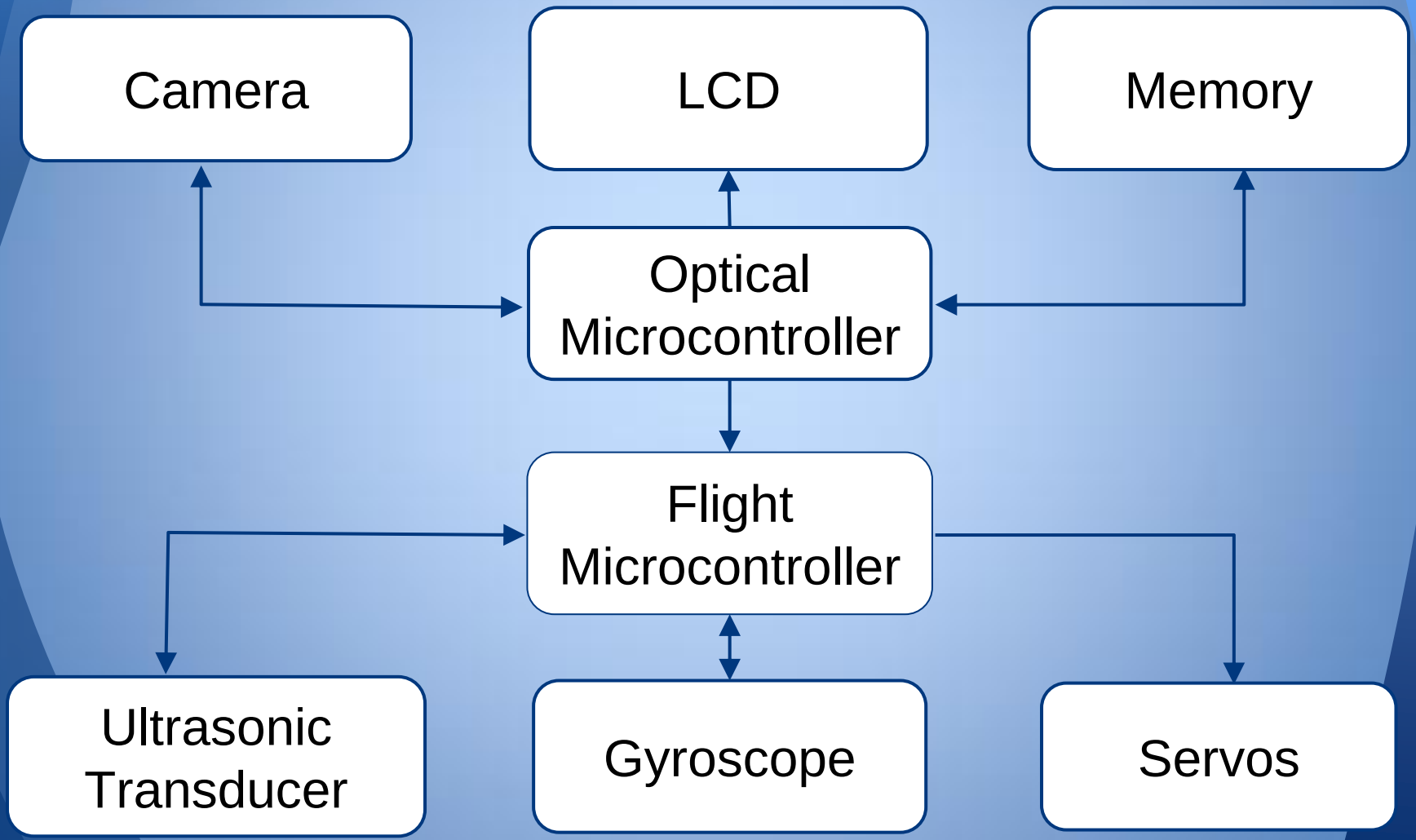
Camera solutions

- Complete cameras vs. sensors

Displays

- Controlled vs controllerless

Overall Block Diagram



Component Decisions

Microcontroller:

Microcontroller	**Development Environment**	**Speed**	**Availability**	**Cost**	**Pin I/O**
STM32F4	Atollic	168Mhz	Digikey	$15.25	114
AT32UC3A4256S-C1UR	Atollic	66MHz	Digikey	$14.30	88

Component Decisions

Camera:

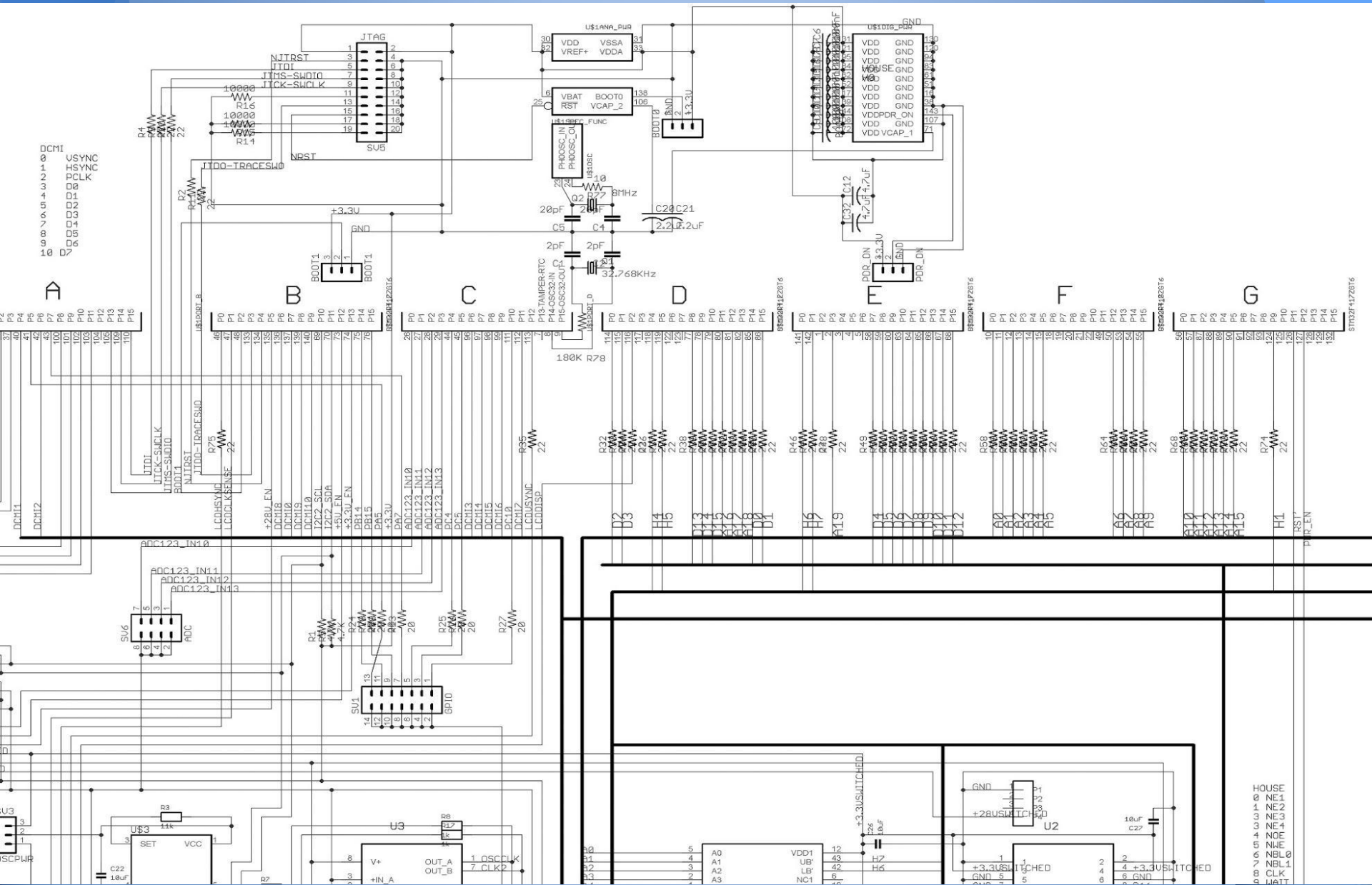
Camera	Resolution	Speed	Availability	Cost	Pin I/O
GoPro	1280 x 1024	30fps	Manufacturer website	$149.99	component/ composite video (analog)
OV7670	640 x 480	>30fps	Various	$20.00	parallel data (digital)
OV9655	1280 x 1024	30fps @ VGA 15fps @ full	Various	$50.00	parallel data (digital)

Component Decisions

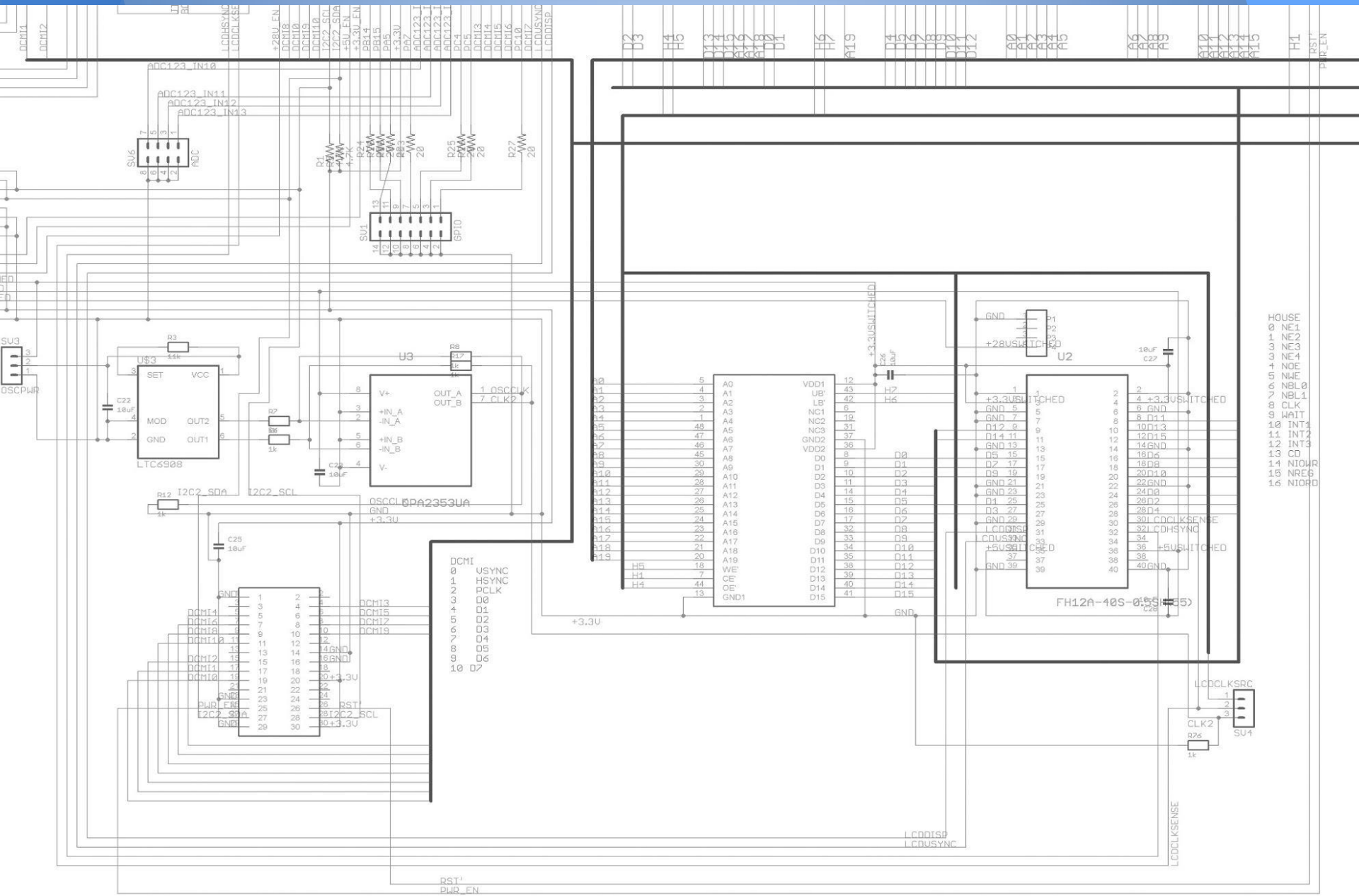
Memory:

Memory	**Access time**	**Availability**	**Cost**	**Pin I/O**
SRAM	10ns	digikey	$149.00	parallel
SDHC	1.2ms	various	$9.00	serial

Hardware Schematic



Hardware Schematics cont.

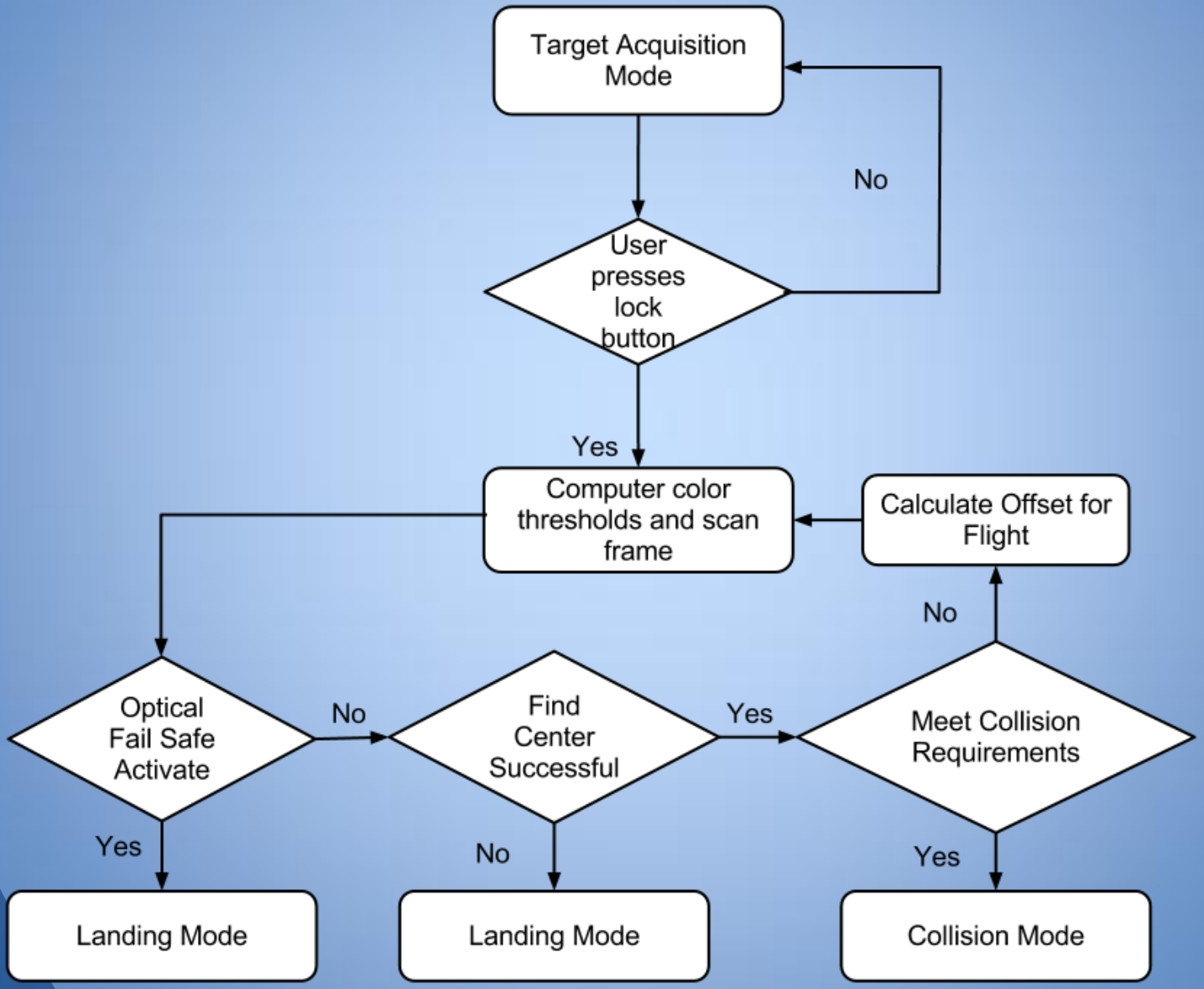


Design Decisions

Image processing algorithms:

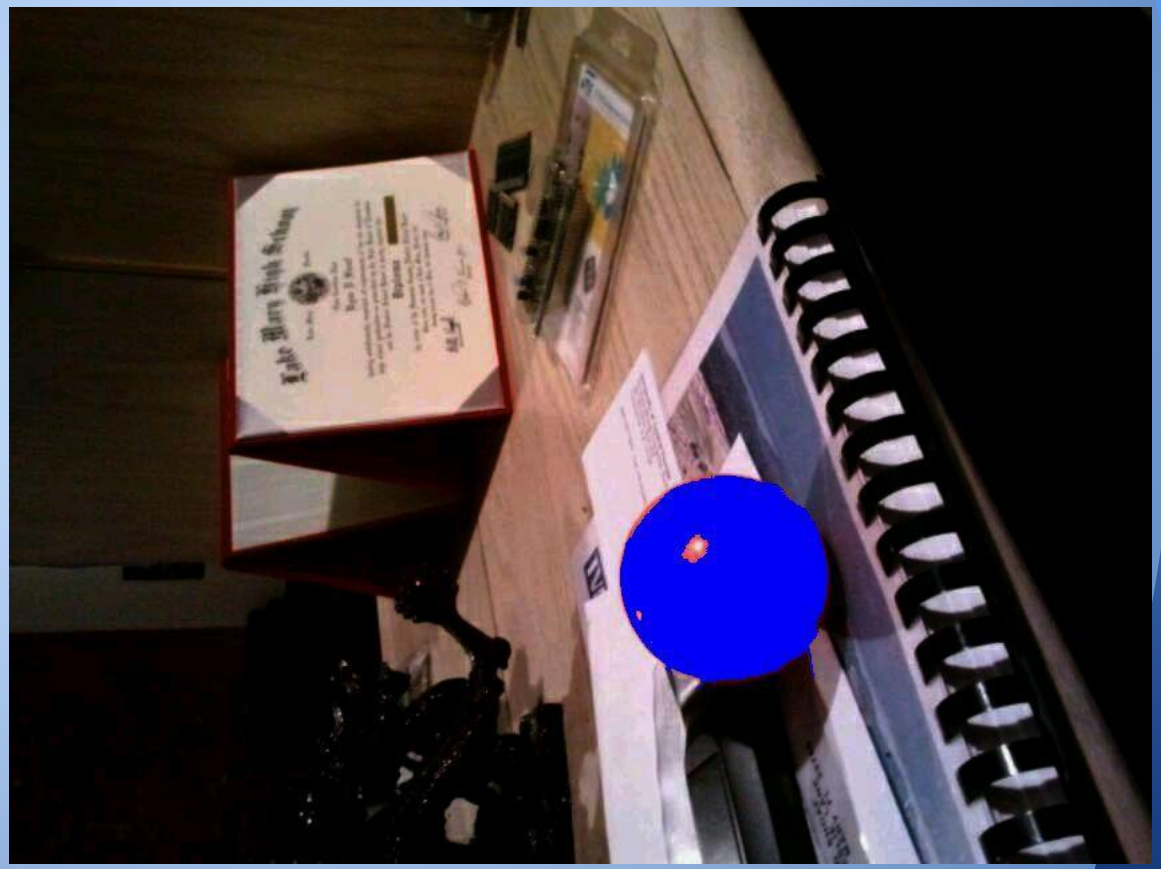
Algorithm	**Implementation Difficultly**	**Execution Speed**	**Execution Results**	**Scalibility**
KLT Tracker	High	High	High	High
SIFT	High	High	High	High
Color Histograms	Moderate	Moderate	Moderate	Moderate
Scanning	Low	Low	Moderate	Low

Image Processing Overview



Color Threshold

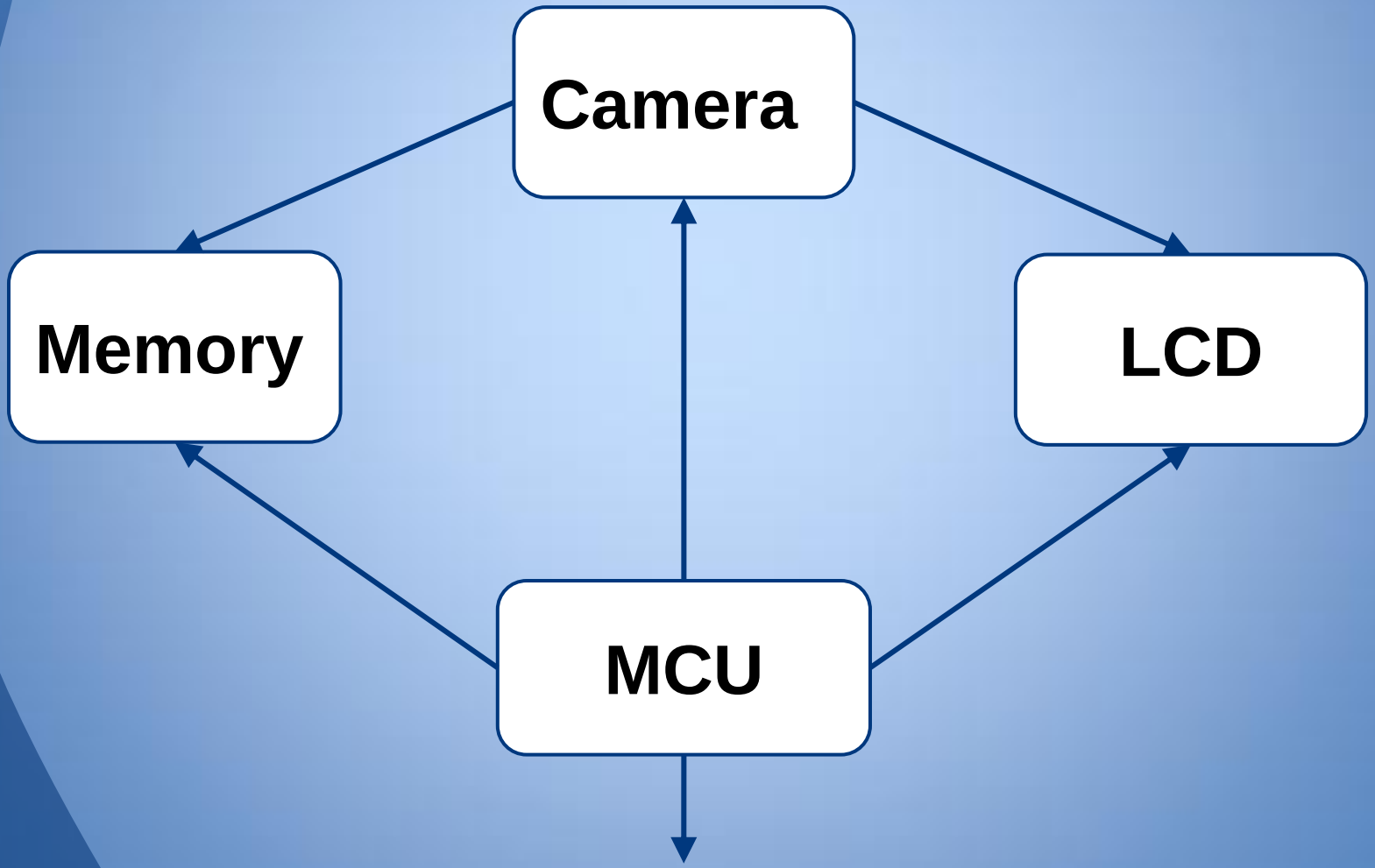
The image processing uses a double threshold to admit only colors close to the target color. The first threshold is set very low to only accept colors very close to target. Since this will omit a large portion of the target, a second threshold is set high and will allow only colors that are next to a low threshold.



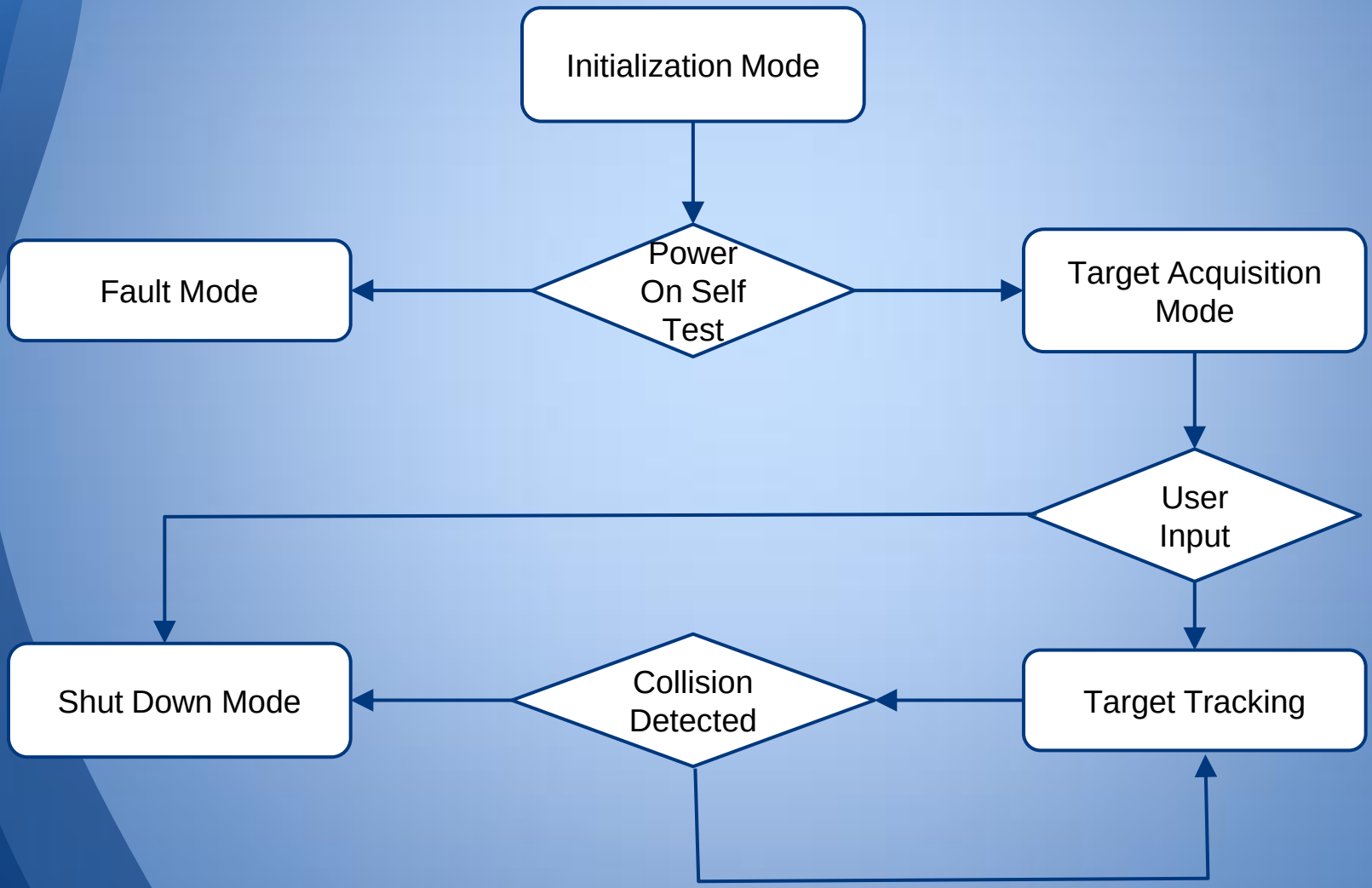
Target Center and Offset Calculation

The target center is conducted after the first color threshold pixel is found. From the first pixel, the algorithm will determine the height by going down until the last color threshold. The width is calculated by going half the height and going left and right. The offset is calculated by pixels from the center of the image to the target center.

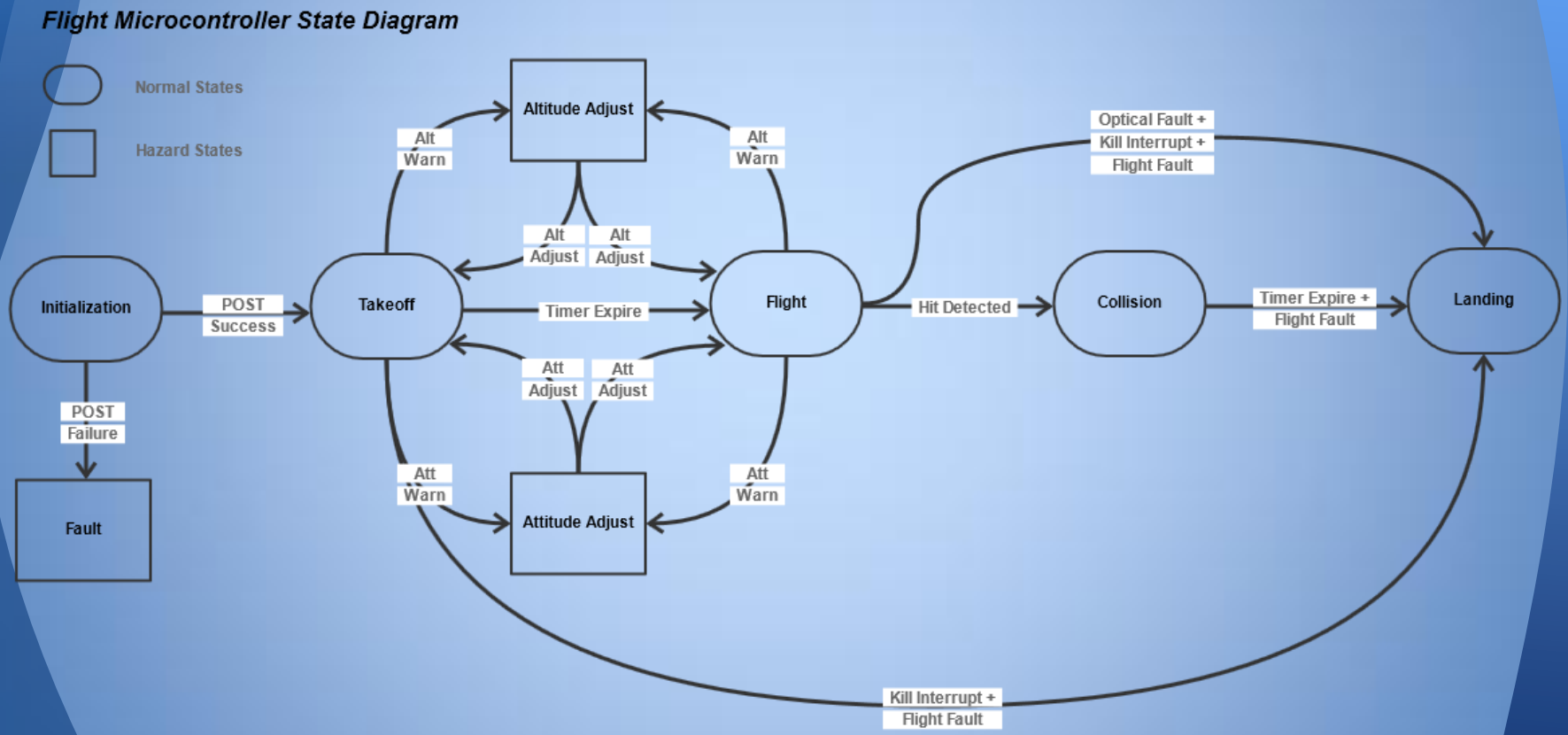
Optical Microcontroller



Optical Controller Process Overview



Flight Controller Process Overview



Project Difficulties

Flight processing difficulties:

- Gyroscope signal processing
- Barometric sensor produces inconsistent data

Optical processing difficulties:

- Communicating with subcomponents using I^2C
- Communicating to LCD
- Storing camera data into memory

Image processing possible difficulties:

- Calculating correct color tolerance
- Optimizing target detection and offset calculation

Hardware difficulties:

- LCD connection

Administrative Content

Budget and Financing:

- $2000 for three systems, airplanes, radios, and construction materials.
- Self financed