

Eclipse Imaging System

for the
Eclipse Rocket Payload

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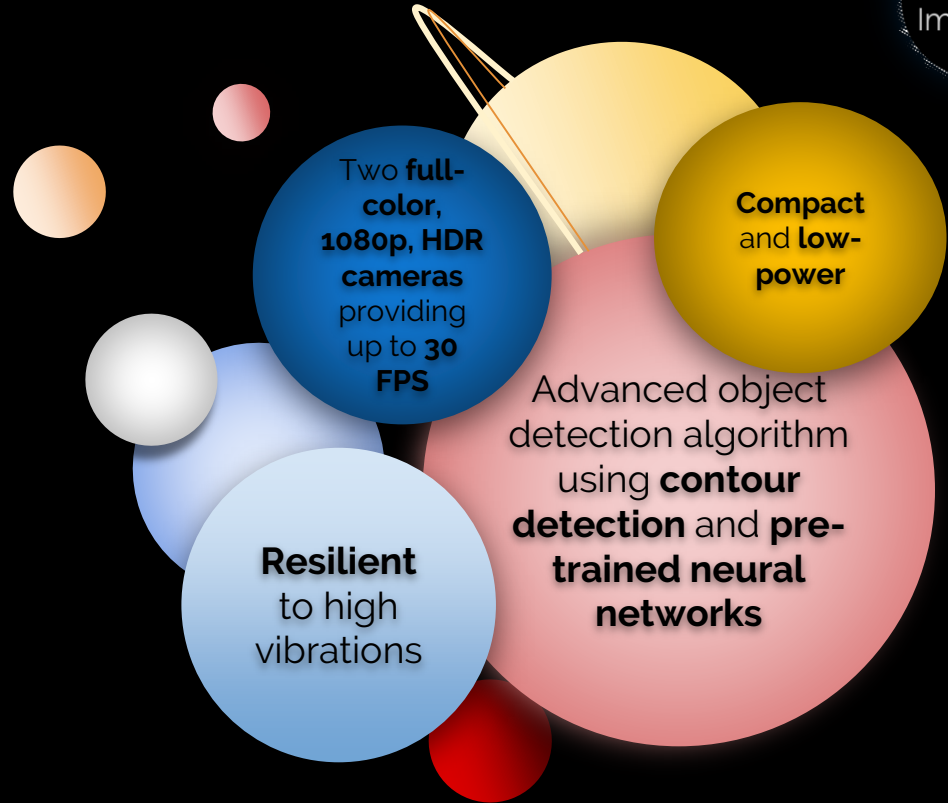
The
Eclipse Imaging
System
is a
target detection
imaging solution
for
rockets, drones,
and many other
aerospace applications.

Two **full-color, 1080p, HDR cameras** providing up to **30 FPS**

Compact and low-power

Advanced object detection algorithm using **contour detection** and **pre-trained neural networks**

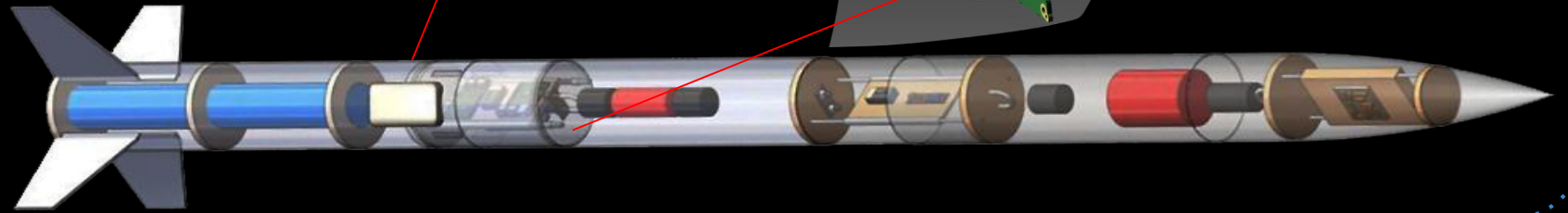
Resilient to high vibrations



Hardware

Powerful imaging system enclosed in a resilient structure

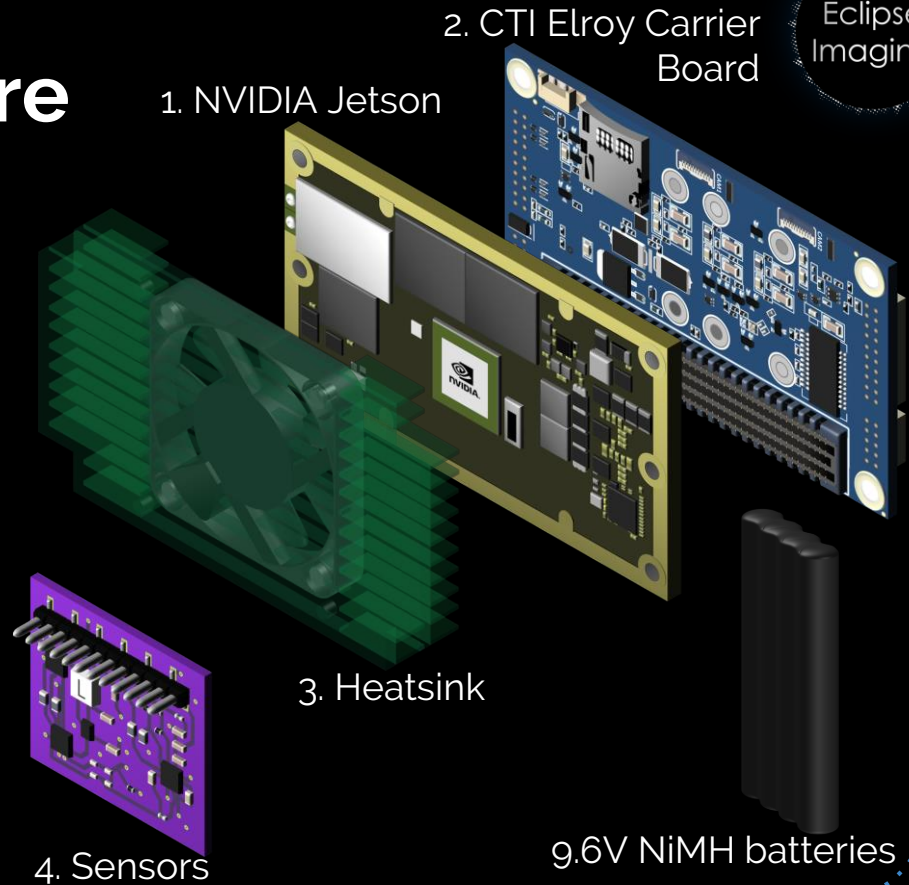
Payload Enclosure Model



Processing Hardware

1. Powerful, compact computing with the NVIDIA Jetson TX1
2. Communication enabled to the system through the CTI Elroy Carrier Board
3. Active heatsink fan
4. Sensors for automation

Maximum tradeoff: Price versus Space/Weight



Imaging Hardware

Eclipse Imaging

Protocol	USB 3.0		USB 2.0	
Resolution	FPS (Standard)	FPS (HDR)	FPS (Standard)	FPS (HDR)
640 x 480	60, 45	60, 45	60, 45	60, 45
960 x 540	58, 30	55, 30	30, 15	30, 15
1280 x 720	45, 30	42, 30	16, 8	16, 8
1280 x 960	34, 22.5	32, 22.5	12, 6	12, 6
1920 x 1080	30, 15	28, 15	8, 4	8, 4



960 x 540 *

650 x 480 **

1920 x 1080

1280 x 960

1280 x 720

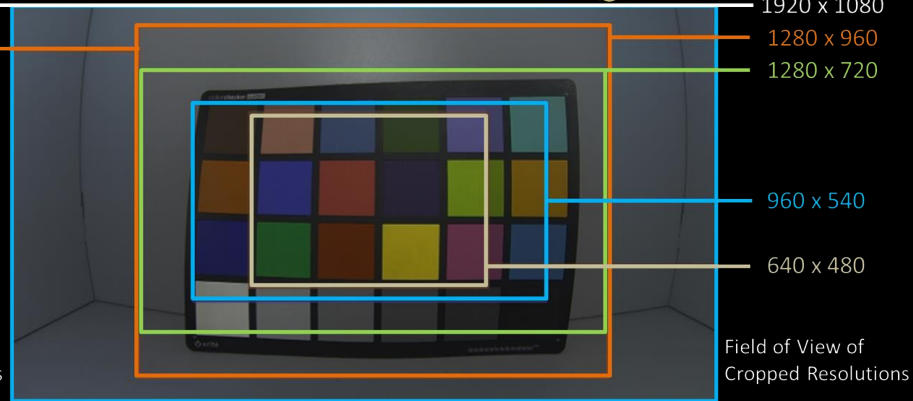
960 x 540

640 x 480

~ 5 FPS while running software

Field of View of
Binning Resolutions

Field of View of
Cropped Resolutions



Power Analysis

	IDLE	ON
Elroy Carrier Board	~6W	~12W
NVIDIA Jetson TX1	~1-2W	~15W
USB Cameras (x2)	~0.5W (x2 = ~1W)	~2W (x2 = 4W)
Fan	~1-2W	
TOTAL:	~8W	~15W

For a single 9.6V NiMH battery pack...

IDLE Mode: 833mA @ 9.6V;
lasts 2.4 hours

ON Mode: 1.666mA @ 9.6V;
lasts 1.2 hours

Sensors for automation are
considered within the power budget
of the telemetry team

Software

Object identification and tracking with the target detection algorithm

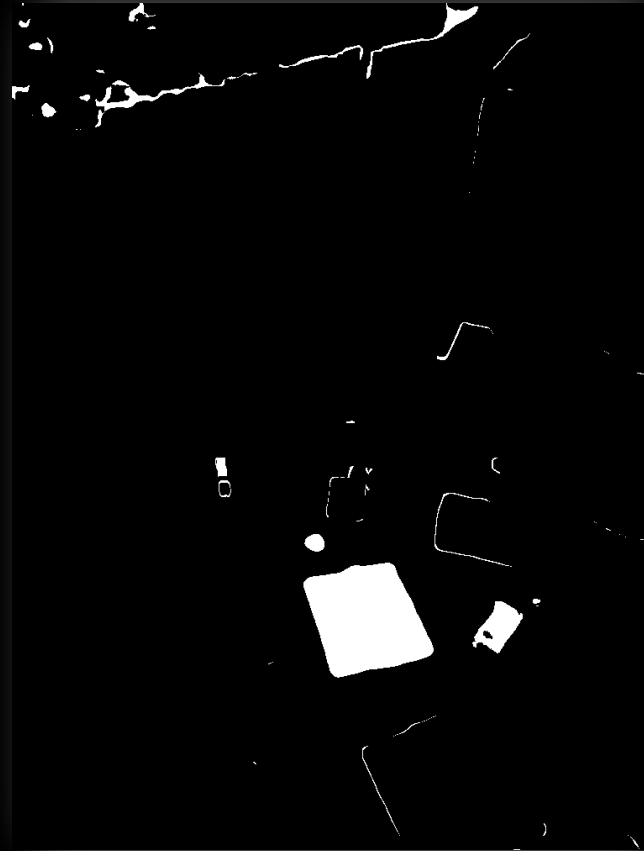
Capture an image from the camera

- Analyze images from both rocket cameras.
- Images taken from high altitude.
- May have many confusing objects.



Find regions of desired color

- Get target colors from calibration data provided before flight.
- Convert the image to HSV to separate colors from lighting.
- Find regions containing target color.



Identify contours

- Targets appear as large, square-shaped contours.
- The wider the range of colors, the more contours there are.
- Trade-off between having a narrow color range and potentially missing the target.



Finding the right shape

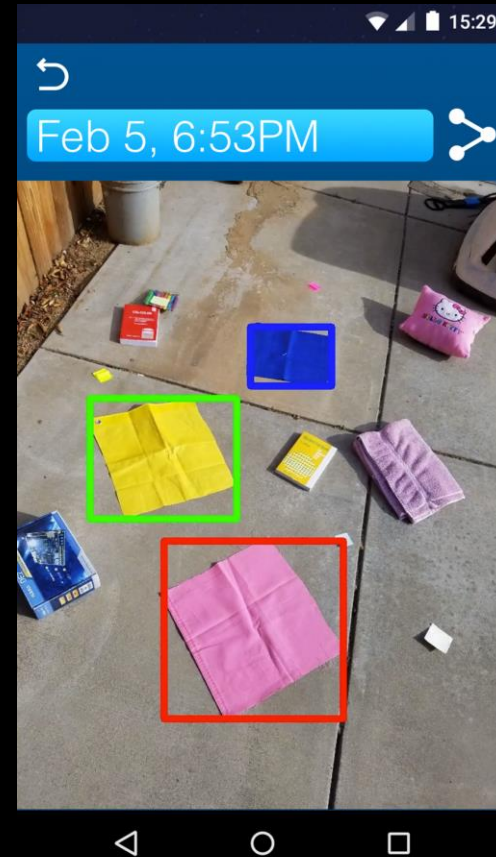
- Tarps are large, uniformly-colored squares of a very specific color.
- If any contours meet all selection criteria, the contour with the largest area is chosen.



Mobile Application

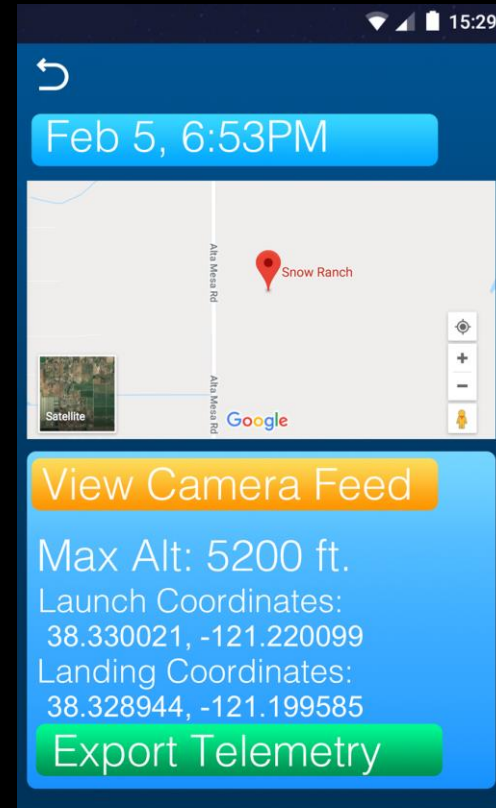
- Upload images via Dropbox
- Set preflight parameters such as exposure and target colors.
- View system health status.
- Display processed images after landing.

Acknowledgements: Itai Ofir



Mobile Application

- Use telemetry data to find images from a specific point in the vehicle's flight path.



Acknowledgements: Itai Ofir

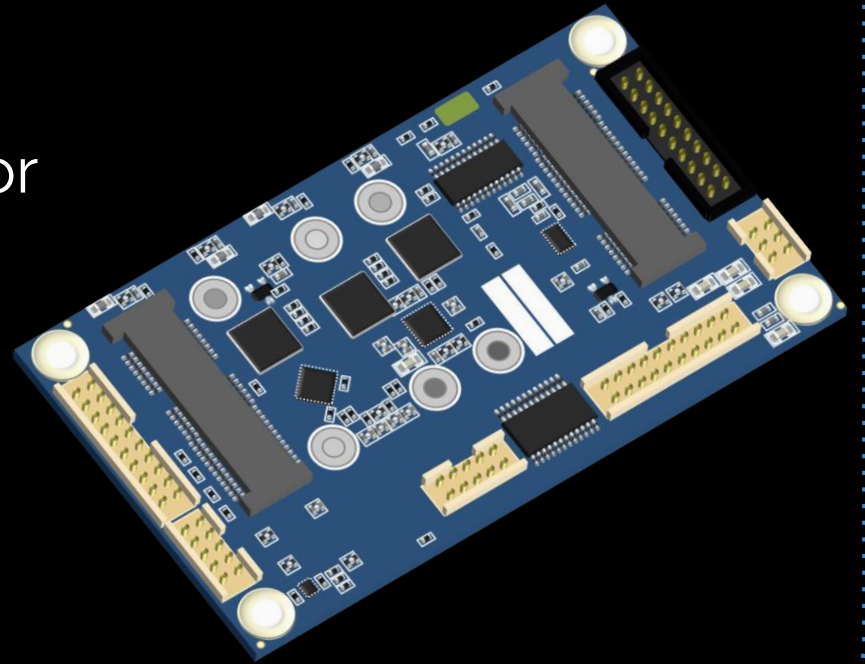


Firmware

An autonomous design suitable for aerospace applications

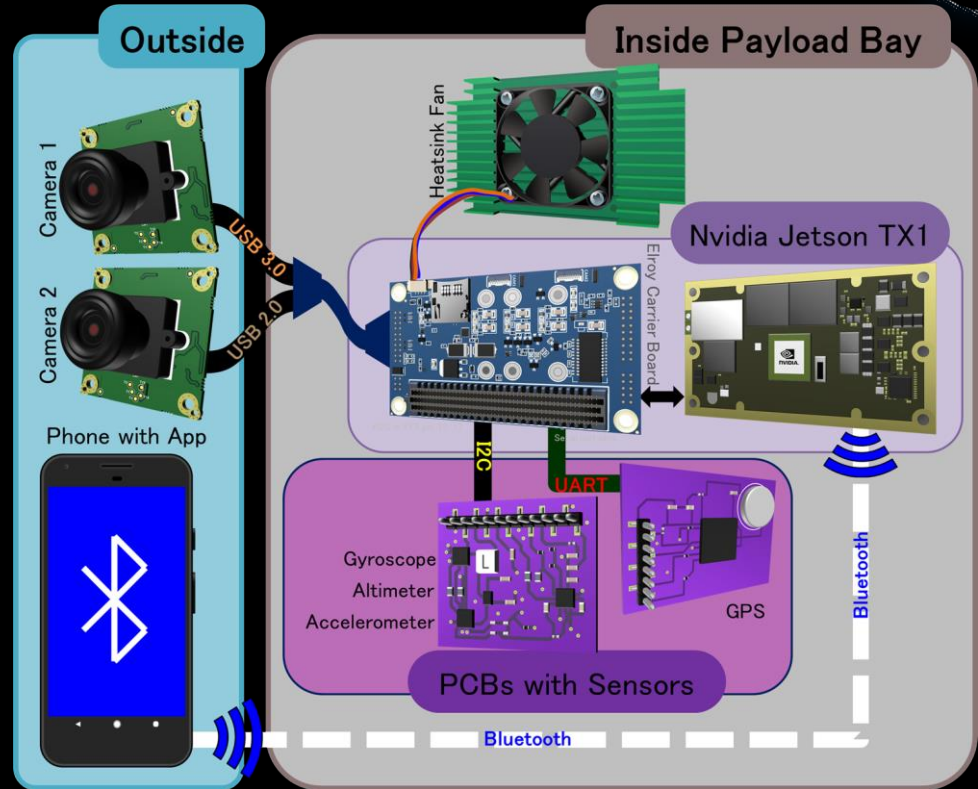
Firmware Overview

- Scripts written in Bash for the Elroy carrier board
 - Automation
 - Power management

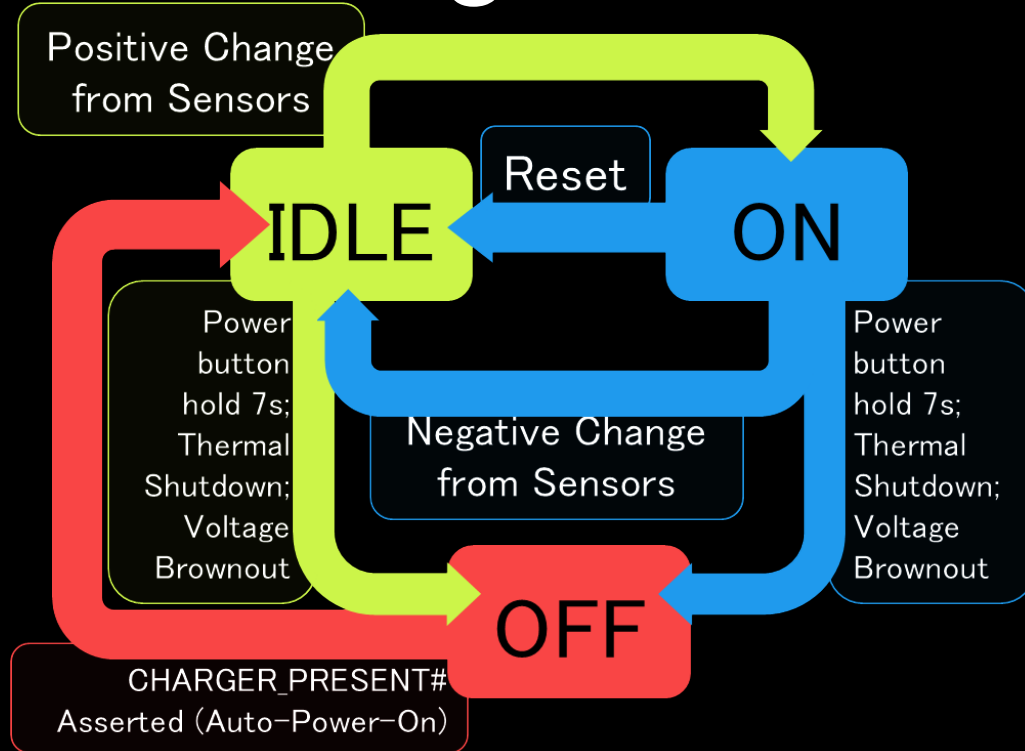


Communications Diagram

- **Cameras:** USB2.0 & USB3.0
- **Sensors:** I2C
- **GPS:** UART
- **Phone App:** Bluetooth



State Diagram



IDLE

The default state when the system is powered. This is a *low-power* mode which keeps attached peripherals on, but disables data collection (i.e., image capture).

ON

Cameras capture images, which are then saved for post-processing.

OFF

The default state when the system is not powered.

Development Plans

Project costs and timeline

Bill of Materials*

Category	Description	Quantity	Single Price	Bulk Price (1000)
Camera System	NVIDIA Jetson TX1	1	\$344.00	\$299.00
	CTI Elroy Carrier Board	1	\$496.00	\$481.00
	CTI Heatsink/Fan	1	\$62.00	\$62.00
	2MP USB 3.1 Camera	2	\$358.00	\$358.00
	64 GB MicroSD Card	1	\$38.37	\$38.37
	HDMI Adapter	1	\$57.00	\$57.00
	USB 3.0 Dual-Port Adapter	1	\$8.99	\$8.99

* Items in blue indicate new additions since Alpha. Prices highlighted in green indicate bulk cost savings.

Bill of Materials

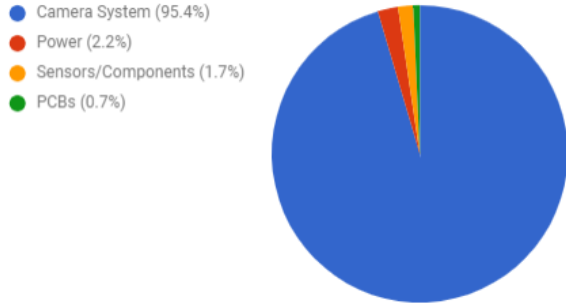
<i>Category</i>	<i>Description</i>	<i>Quantity</i>	<i>Single Price</i>	<i>Bulk Price (1000)</i>
Power	9,6V NiMH Battery	1	\$14.99	\$13.79
	Battery Plug Adapters	3	\$0.74	\$0.74
	Heat Shrinks	1	\$7.83	\$7.83
	6-Pin Converter Plug	2	\$7.99	\$7.99
	Molex Cables	6	\$0.18	\$0.08
PCBs	Accelerometer Breakout	1	\$7.50	\$1.50
	Altimeter Breakout	1	\$2.55	\$0.52

Bill of Materials

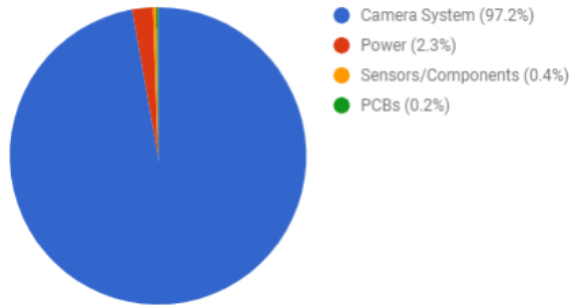
<i>Category</i>	<i>Description</i>	<i>Quantity</i>	<i>Single Price</i>	<i>Bulk Price (1000)</i>
Sensors/Components	Accelerometer	1	\$1.97	\$0.73
	Altimeter	1	\$3.66	\$2.69
	Capacitors - 0.1 uF	12	\$0.60	\$0.01
	Capacitors - 1 uF	10	\$0.84	\$0.02
	Capacitors - 10 uF	2	\$1.00	\$0.14
	Capacitors - 4.7 uF	1	\$0.20	\$0.05
	Resistors - 4.7K ohms	2	\$1.38	\$0.07
	Resistors - 10K ohms	10	\$0.42	\$0.01
	Inductors - 470 uH	2	\$2.78	\$0.67
	LEDs - Red	2	\$0.88	\$0.08
	Headers	10	\$9.98	\$0.63

Project Costs

Cost per Unit



Bulk Cost per Unit (1000 Units)



SUBTOTALS

Category	Single	Bulk	Bulk Savings
Camera System	\$1364.36 (95.4%)	\$1304.36 (97.2%)	\$60.00
Power	\$31.73 (2.2%)	\$30.43 (2.3%)	\$1.30
Sensors/Components	\$23.71 (1.7%)	\$5.10 (0.4%)	\$18.61
PCBs	\$10.05 (0.7%)	\$2.02 (0.2%)	\$8.03

NRE Costs	Project manager	\$50/hr	Total Cost (15 week schedule):
	Software & firmware engineer	\$55/hr	
	Hardware engineer	\$45/hr	
			\$92,250

Project Costs Summary

Single Unit Total:

\$1,429.85

-\$87.94



Bulk Unit Total:

\$1,341.91

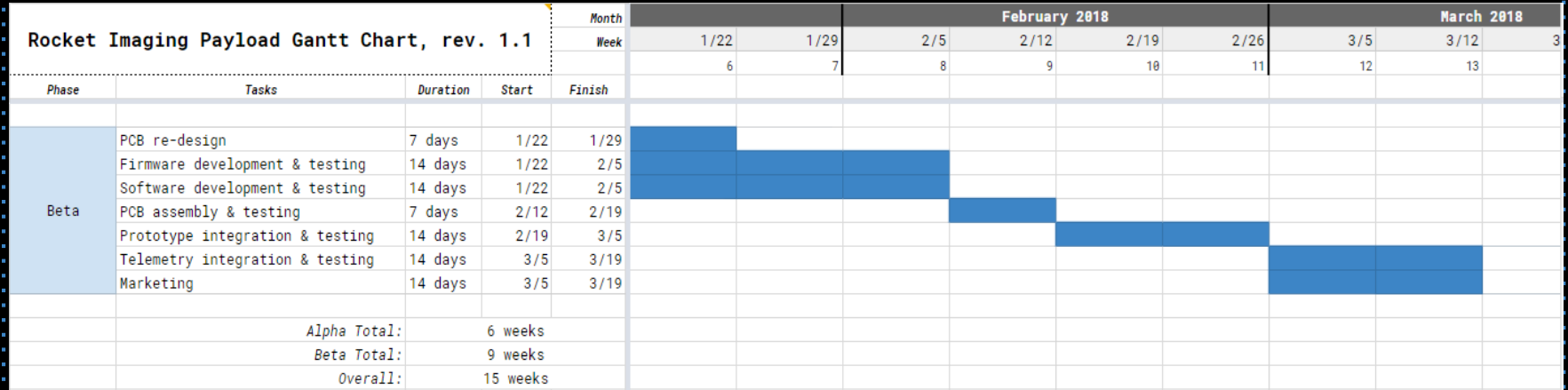
Overall Project Cost to Production:

\$93,679.85

Gantt Chart - Alpha

Rocket Imaging Payload Gantt Chart, rev. 1.1					Month	December 2017		January 2018				
					Week	12/18	12/25	1/1	1/8	1/15	1/22	1/29
					1	2	3	4	5	6	7	
Phase	Tasks	Duration	Start	Finish								
Alpha	Research	14 days	12/18	1/1								
	PCB design	9 days	12/18	12/27								
	Hardware verification tests	11 days	12/27	1/8								
	Firmware development & testing	19 days	12/27	1/15								
	Software development & testing	19 days	12/27	1/15								
	PCB assembly & testing	7 days	1/8	1/15								
	Prototype integration & testing	14 days	1/15	1/29								

Gantt Chart - Beta





Eclipse
Imaging