Ground to Space in 8 Weeks

Adam Reif & Ashton Meginnis - Pumpkin, Inc.

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Slide 1

Creative Launch Configuration

- A unique 3U launch opportunity

- Greater return from double 1.5U than a single 3U

- 2x 1.5U (vs. e.g. 1U + 2U) meant that both spacecraft could be identical, hardware-wise

- Only software configurations of each 1.5U differed (albeit only slightly)

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Slide 2

Development Schedule

	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
Contract signed	■							
System Design	■	■						
Mechanical Design		■						
Software Development		■	■	■	■			
Integration				■				
Testing					■	■		
Delivery							■	
Launch								■

- Total time from ink on paper to launch <8 weeks
- Rush charges applied

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Slide 3

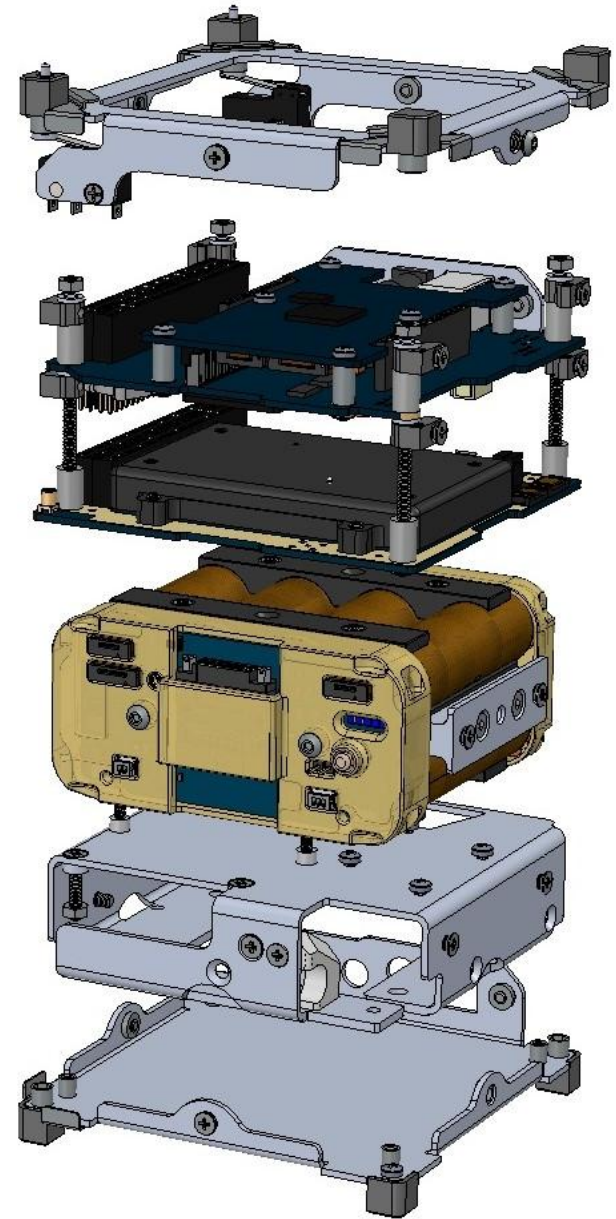# Defining Mission Requirements

- Unique challenges in a rapid turn around mission
  - Short schedule for manufacturing and testing
  - Limited scope due to small budget

- Identify the major objectives of the mission
  - Transmit beacon over geographic area

- Reduce the scope of CONOPS to be achievable with limited on-board resources
  - Constrain operating modes and peripheral features
  - Spacecraft enters sleep mode when payload ops not required

- De-risk wherever possible

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Parallelizing Build Efforts

- Standard interface of Pumpkin SupMCU modules

- Divide and conquer
  - Pumpkin handled systems, mechanical, software advice and integration
  - Pumpkin developed new software for battery module BM 2 (first flight on this mission)
  - Customer provided flight software and payload

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The Power of COTS

- All COTS parts in stock, with moderate modifications
  - CSK 1.5U Solid Chassis
  - CSK Baseplate
  - CSK 4-switch Large Aperture Coverplate
  - CSK RBF (Remove Before Flight) Bracket
  - Pumpkin MB + PPM E3
  - Pumpkin GPSM
  - Pumpkin BM 2

- Leverage on-hand COTS to reduce risks and development time, versus developing new hardware

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Impact of Limited Funds

- Components were selected based upon cost and lead time considerations to meet the program's budget

- Reuse spare hardware from previous spacecraft to reduce manufacturing costs

CubeSat Kit 1.5U solid chassis machined with features to fit mission parameters

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Code Repurposed

- Both 1.5U spacecraft flew a prototype Pumpkin PPM E3 with the PIC24FK512GB610 16-bit MCU, plugged into Pumpkin Motherboard (MB 1)

- Reused codebase from a university project
  - Salvo RTOS as foundation
  - Included various typical C&DH tasks, plus CCSDS code, etc.
  - Only new code is payload flight software
 - Both Pumpkin and customer were familiar with the code & methods employed

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Embedded Orbit Propagator

- Payload operations needed to happen above specific geographic locations

- On-board Vinti7 orbit propagator (OP) allowed the system to identify the time when the spacecraft would be in the right location

- Vinti7 OP is included as part of Pumpkin GPSRM 1 GNSS receiver. Vinti7 takes BESTXYZ data from GPS receiver as (initial) input; no need for TLEs from the ground (SGP4)

- The system would sleep until a few minutes before the ground pass

- Payload operations would occur and the system would compute the time until the next pass

- The system goes to sleep until the next pass

- Allows for minimum energy loss -> maximum mission life

Smart Batteries as EPS

- Low power mission profile enabled Pumpkin BM 2 battery to act as the (sole) EPS

- Implemented SLEEP function
  - BM 2 programmed to sleep at 0.01% of total system draw
  - BM 2 wakes up at a predetermined time
  - Payload operates
  - BM 2 goes back to sleep
  - Repeat
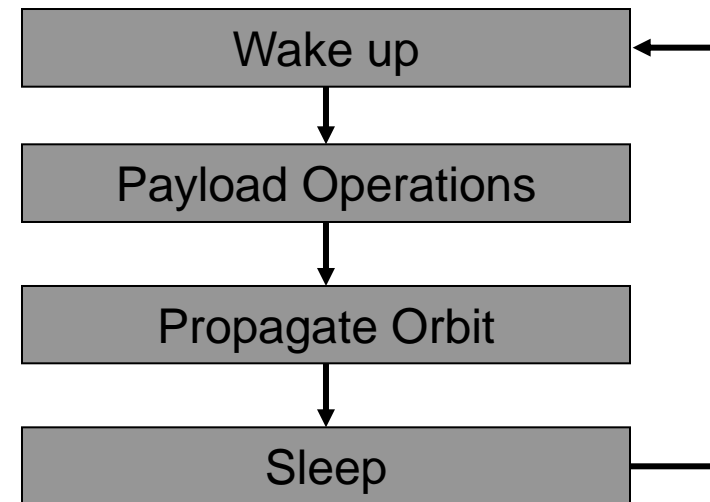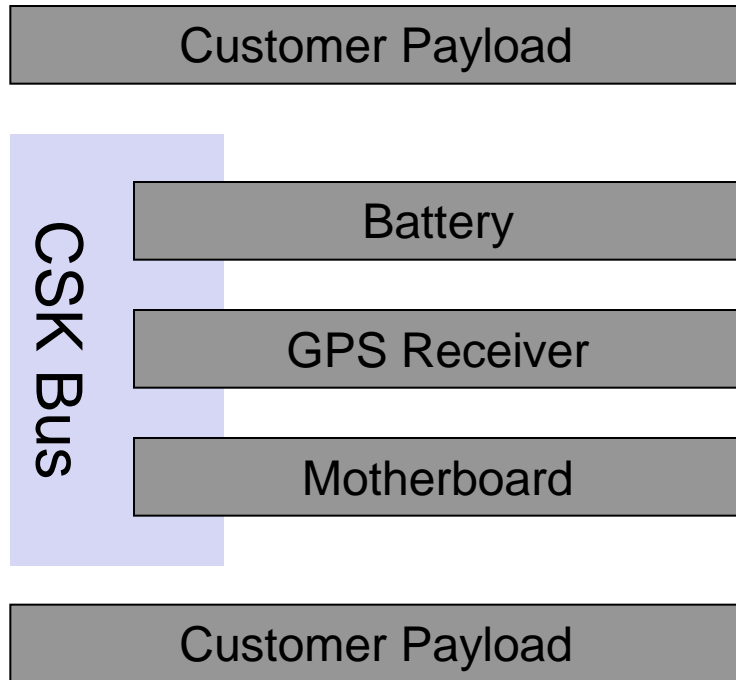

```
Wake up
   ↓
Payload Operations
   ↓
Propagate Orbit
   ↓
Sleep ──→ (back to Wake up)
```

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System Block Diagram…

Customer Payload

CSK Bus

Battery

GPS Receiver

Motherboard

Customer Payload

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Lessons Learned

- Measure twice, cut once

- Computer Aided Design and simulation

- Fabricate mechanical parts using best precision process you can afford

- Design to your strengths

- Design for ease of assembly

- Clearly define the roles & responsibilities between team members

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Q&A Session

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Slide 13

Appendix

- **SUPERNOVA, MISC 3 & CubeSat Kit information**
  - More information on Pumpkin's SUPERNOVA can be found at http://www.pumpkinspace.com/. Patented and Patents pending.

- **Copyright**

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Slide 14