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Recent Advances in the CubeSat Kit™ Family

Andrew E. Kalman, Ph.D.

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CubeSat Workshop
SmallSat Conference 2007



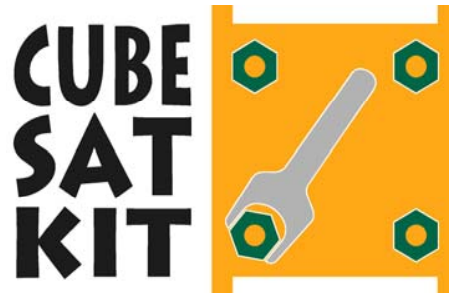
Introduction

- Andrew E. Kalman
 - President and CTO, Pumpkin, Inc.

- Author of



- Creator of the



- 20+ years of embedded systems design and programming experience
- Contact: aek@pumpkininc.com



Outline

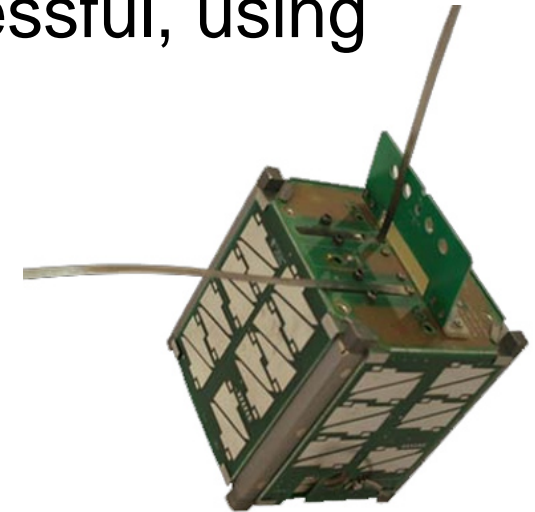
- Part I: State of the CubeSat Kit
- Part II: Structural Components
- Part III: Customer Payloads
- Part IV: IMI-100 ADACS
- Part V: Software
- Part VI: The Future

State of the CubeSat Kit

- Delivered to over 40 customers since Dec 2003, with
 - 1U (solid-wall & skeletonized)
 - 3U (solid-wall & skeletonized)
- 4th-generation (Rev D) structural components
- 3rd-generation (Rev C) electronics
- Salvo 4 RTOS now in use
- EDFS-THIN FAT File System for CubeSat Kit
- Linear and Clyde Space EPS now available
- Preserved substantial backwards compatibility
- Improved documentation including datasheets

Part I (cont'd)

- First customer (Libertad-1) launch successful, using
 - 2nd-generation CubeSat Kit structure
 - 2nd-generation CubeSat Kit electronics
 - Pumpkin Salvo v3 RTOS
 - StenSat Group VHF/UHF Module
 - User-designed EPS, antennas
 - Batteries only (no working Solar Panels)
- Upcoming CubeSat Kit launches:
 - TU-Delft's Delfi-C3
 - KySat
- SSDL's BioLaunch program proving to be low-cost, responsive testbed for recoverable test flights
 - Flying Lippert Cool LiteRunner 2
PC/104 low-power PC-class SBC



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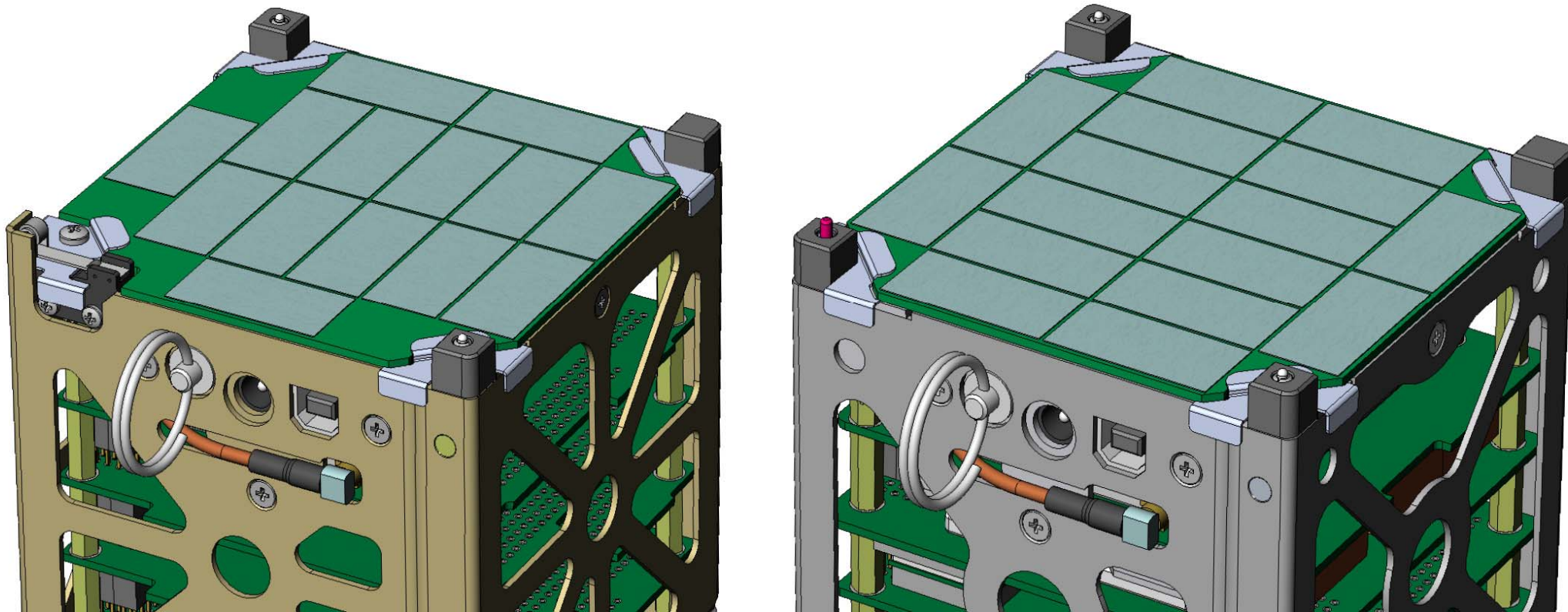
Structural Components

- Newest structures offer several enhancements over prior:

	Rev A, Rev B & Rev C	Rev D
Launch Switch	Partially exposed, direct action	Internal with translating pin
M3x5mm Screws	12	10
Mass	Already best-in-class	-10% on 1U
Wall Cutouts		Greater cutout area
Cross Section	Box with 2 end flanges	Box only (no flanges)
Solar Panel Clips	7 + 1	All 8 identical
Solar Panel PCBs	Top & bottom unique	Top & bottom identical, with more available area
External User Payloads	Complex, must mate in CAD/3D to structure	Simple, via Payload Adapter Plate
Finish / Plating	Non-RoHS (yellow Cad)	RoHS (silver trivalent)

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Part II (cont'd)



3rd-generation/Rev C (left) & 4th-generation/Rev D (right) skeletonized CubeSat Kits showing changes in cutouts, plating, Launch Switch, Launch Switch foot, Solar Panel Clips & available area on Solar Panel PCB.

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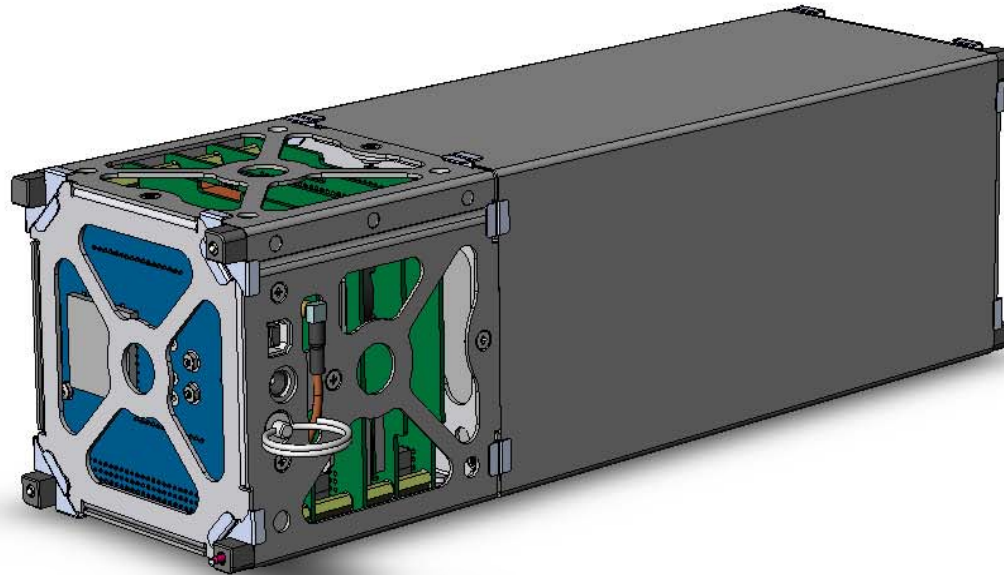
Customer Payloads

- As before, customer can pack *internal* payloads in the 90mm x 96mm x 15mm User Module form factor *inside* complete CubeSat Kit structures.
- Rev D structures can also accommodate *external* customer payloads using the full 100.0mm x 100.0mm cross-section, with:
 - CubeSat Kit Payload Adapter Plate
 - ◆ At interface(s) of Chassis Walls and customer payload
 - CubeSat Kit Payload Cover Plate
 - ◆ At end of customer payload
 - CubeSat Kit Payload Panel Clips & Solar Panel Clips
 - ◆ At Payload Adapter Plate and Payload Cover / Cover Plate Assemblies
- Configurations with *external* payloads:

Length	Payload Size+CSK Size Combinations			
3U	2.5U+0.5U	2U+1U	1.5U+1.5U	1U+2U
2U	1.5U+0.5U	1U+1U	0.5U+1.5U	
1.5U	1U+0.5U	0.5U+1U		
1U	0.5U+0.5U			

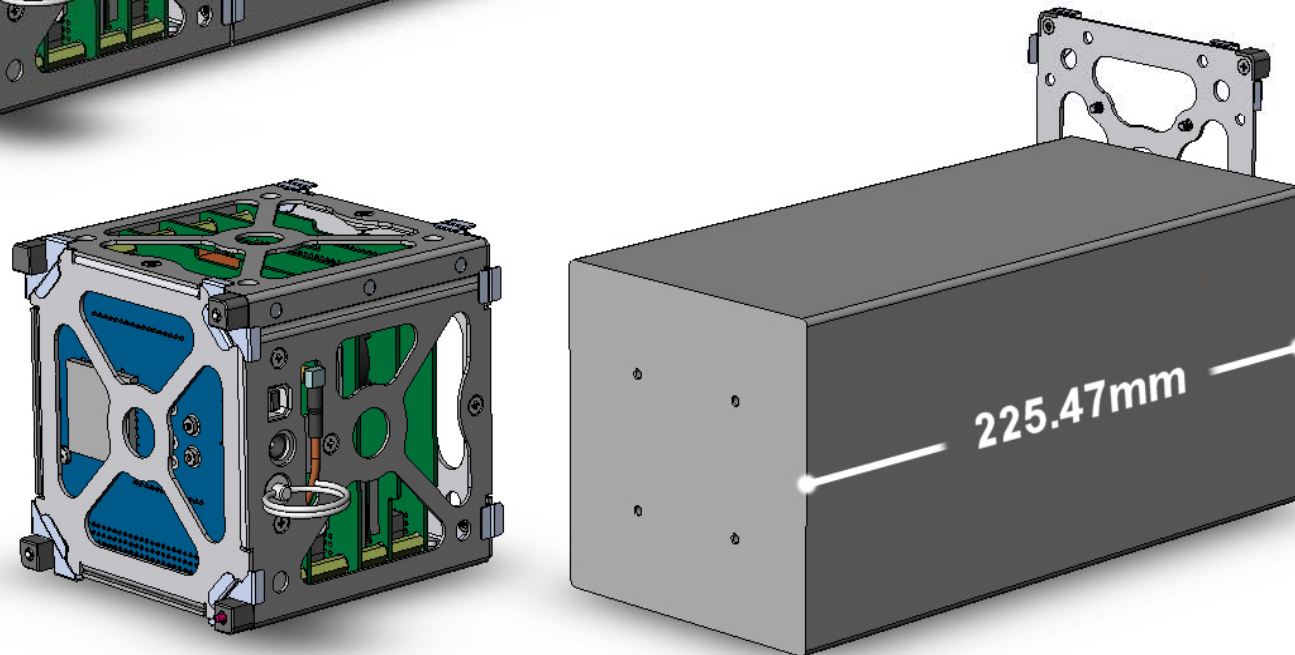
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Part III (cont'd)



3U CubeSat Kit constructed from a single 1U skeletonized CubeSat Kit (w/ C&DH, radio, EPS & internal payloads) and a 2U external payload (100 x 100 x 225 mm).

Total length is 340.50 mm.



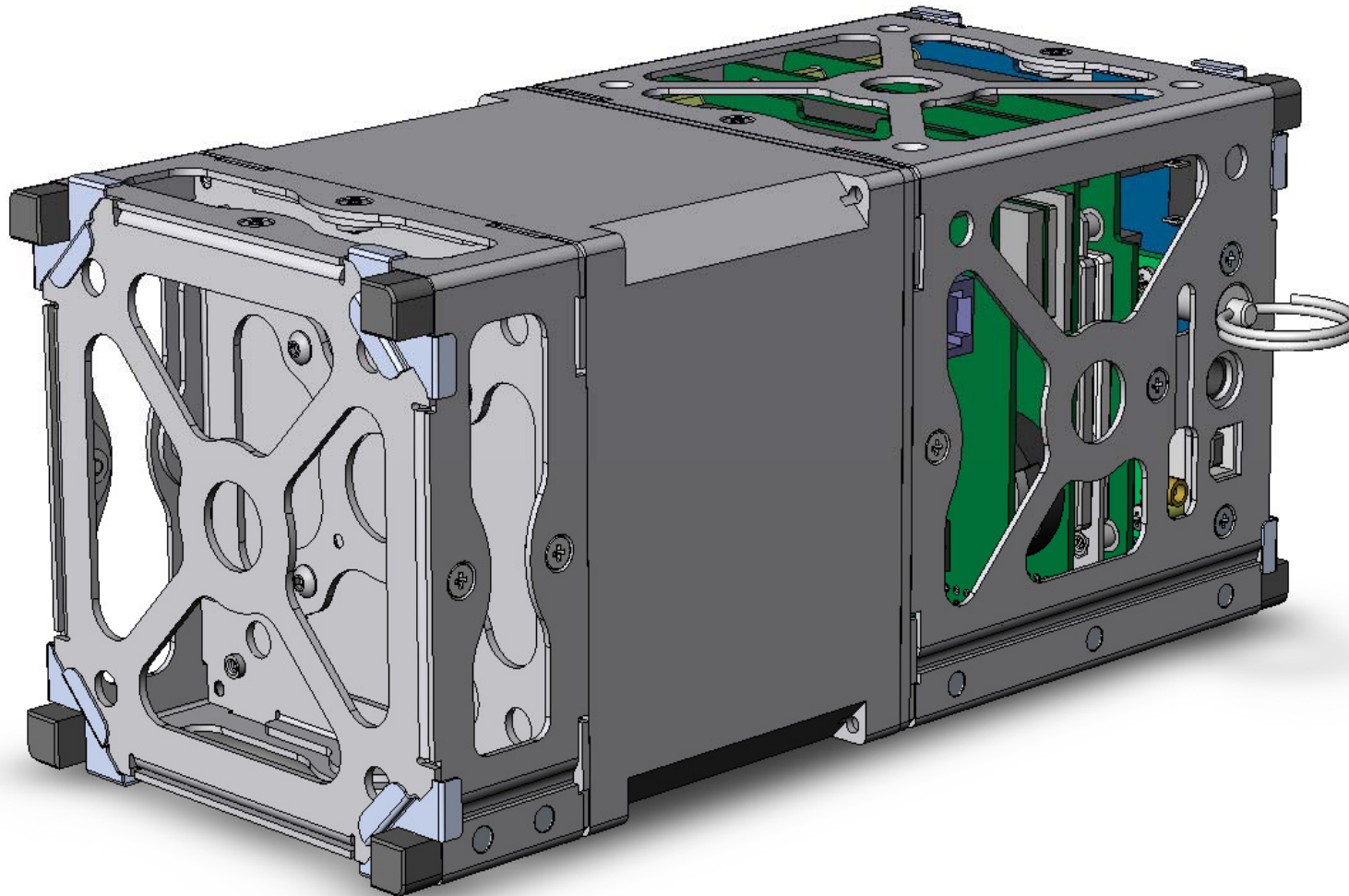
IMI-100 ADACS

- Modular 3-axis Attitude Determination and Control System (ADACS) from IntelliTech Microsystems, Inc. (IMI)
 - 1 degree pointing accuracy w/external magnetometer & sun angle info
 - Integrated stepper motors and torque coils (for damping)
 - < 4.5W peak power consumption
 - < 1kg mass, < 1U size
 - Designed to interface directly to CubeSat Kit structure Rev D and later
- Complete kit includes:
 - IMI-100 with calibrated magnetometer
 - 2 x CubeSat Kit Payload Adapter
 - 1 x CubeSat Kit ADACS Payload Walls
 - 1 x CubeSat Kit ADACS Interface Module
 - 1 x CubeSat Kit Payload Panels Clips Set
 - Integration support from Pumpkin
 - Configuration and orbital support from IMI



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Part IV (cont'd)



L to R: ADACS Payload Walls, IMI-100 ADACS & 1U skeletonized CubeSat Kit with ADACS Interface Module, internal payload(s), EPS, radio and FM430 Flight Module. Slide 11

Software

- CubeSat Kit software growing to provide a library of driver-type routines.
- HCC-embedded EFFS-THIN for CubeSat Kit:
 - Access on-board SD card as a FAT drive
 - Have multiple streams open simultaneously (e.g. read audio data for streaming, write captured data, write to log/error/debug file)
- Salvo 4 RTOS has improvements over Salvo v3 in the areas of:
 - Interrupt latency (now zero)
 - Easier control of interrupts in critical sections (no longer requires source code for configuration)

Future

- Customers and prospective customers are *constantly* asking us for:

- EPS
- Solar Panels
- Radios
- Ground Stations
- Space-capable GPS
- and more ...

- CubeSat Kit System Chart

- Illustrates how everything fits together
- COTS for CubeSats is a reality
- Ready to accommodate future products



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Q&A Session

Thank you for attending this Pumpkin seminar at the CubeSat Workshop at SmallSat 2007!

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www.pumpkininc.com/content/doc/press/Pumpkin_CSWS2007.ppt

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Appendix

• Speaker information

- Dr. Kalman is Pumpkin's president and chief technology architect. He entered the embedded programming world in the mid-1980's. After co-founding Euphonix, Inc – the pioneering Silicon Valley high-tech pro-audio company – he founded Pumpkin to explore the feasibility of applying high-level programming paradigms to severely memory-constrained embedded architectures. He holds two United States patents and is a consulting professor at Stanford University.

• Acknowledgements

- Stanford Professors Bob Twiggs' and Jamie Cutler's continued support for the CubeSat Kit, and their inputs on enhancements and suggestions for future CubeSat Kit products, are greatly appreciated.
- Pumpkin's Salvo and CubeSat Kit customers, whose real-world experience with our products helps us improve and innovate.

• Salvo, CubeSat Kit and CubeSat information

- More information on Pumpkin's Salvo RTOS and Pumpkin's CubeSat Kit can be found at <http://www.pumpkininc.com/> and <http://www.cubesatkit.com/>, respectively.

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First presented at the CubeSat Workshop at the 21st Annual Conference on Small Satellites in Logan, Utah on August 12, 2007.