ARCHITECTURE OF HIGH POWER NANOSATELLITES **SSC22-P3-05**

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Current CubeSat architecture has been developed "ad hoc" throughout multiple years with main goals of creating mechanically stable, sufficiently lightweight and low-cost structure. From their conception up to the current times, thermal issues in CubeSats have been of little concern due to relatively low power consumption. Typically, to accommodate a considerable number of different components in a CubeSat, the components are mounted on brackets. The brackets are connected to external panels which radiate waste heat into space. This heat path, from a component to a radiator, typically has a high thermal resistance which worsens the thermal performance of the satellite. This becomes a significant problem at high heat flow rates. However, in the case of low heat flow rate (as in majority current CubeSats), this phenomenon is not problematic and thermal implications of CubeSat architecture (like, component location) have been unimportant.

Current trends in CubeSat industry clearly indicate a demand for increased component power. This significantly increases waste heat generation and the flow rate of waste heat from a component to a radiator. Under current CubeSat architectures, it leads to a significant reduction of thermal performance of CubeSats. Our paper discusses a proposed architecture which provides a successful solution to this problem. It suggests a CubeSat architecture in which components placement increases a thermal efficiency of waste heat rejection. For example, high heat generating components should be mounted directly to a radiator and connected to it by a low thermal resistance interface. Components with low heat generation could be mounted on brackets and be connected to the radiator by high resistance thermal paths. The paper shows that the proposed CubeSat architecture will make CubeSat thermal performance more efficient while having the same component density. The major benefactors of the new architecture are high power nanosatellites. Demonstrated simulation results and test data confirm improvement of thermal efficiency of a CubeSat with the proposed architecture.

1. Introduction

Current CubeSat architecture has been developed "ad hoc" throughout multiple years with main goals of creating mechanically stable, sufficiently lightweight and low-cost structure. From their conception up to the current times, thermal issues in CubeSats have been of little concern due to relatively low power consumption. Typically, to accommodate a considerable

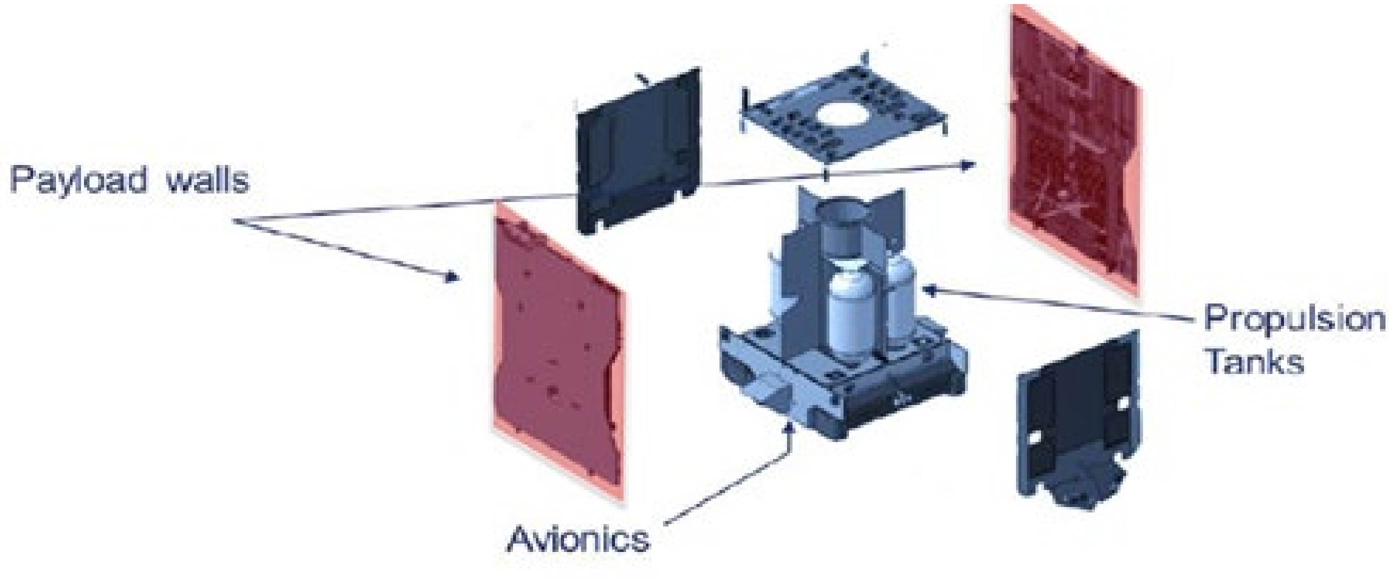


Figure 2 Typical cubesat architecture [Ref.4].

number of different components in a CubeSat, the components are mounted on brackets. The brackets are connected to external panels which radiate waste heat into space. This heat path, from a component to a radiator, typically has a high thermal resistance which worsens the thermal performance of the satellite. This becomes a significant problem at high heat flow rates. However, in the case of low heat flow rate (as in majority current CubeSats), this phenomenon is not problematic and thermal implications of CubeSat architecture (like, component location) have been unimportant.

- Current trends is to increase functionality and to demand for more power (ref. to my paper)
- Energy density – energy density in unit satellite space shown in Table 1

Table 1 Energy Density Cubesat vs. Comsat

satellite	Volume [m3]	Used Energy [W]	Energy density [W/m^3]
12U	0.012	100	8333
Satcom[JSAT-2]	41.8	10,000	239

- Cubesats are acquiring more and more functions which leads to an exponential increase of energy consumption and, correspondingly, an exponential increase of waste heat generation in cubesats.
- Current and, in general, future cubesats are more energy intensive than large, Communication satellites, which makes thermal control system for cubesats is obligatory.
- In Fig. 1 shelfs/brackets with heat generated components are painted red

Figure 3 Typical cubesat architecture [Ref.4].

Comparison of cubesat and comsat architectures reveals striking facts that

#1 Energy density in a cubesat significantly exceeds energy density in communication satellites. More energy concentration more difficult to control it.

#2 cubesat architecture does not help to remove heat from efficiently.

Let's consider two cases of electronics placements per:

a) traditional cubesat architecture

b) ComSat architecture

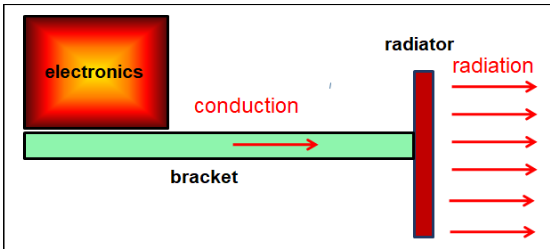


Figure 5 cubesat architecture

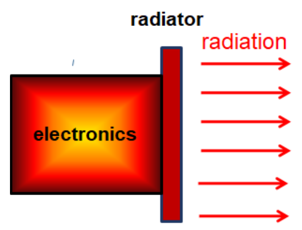
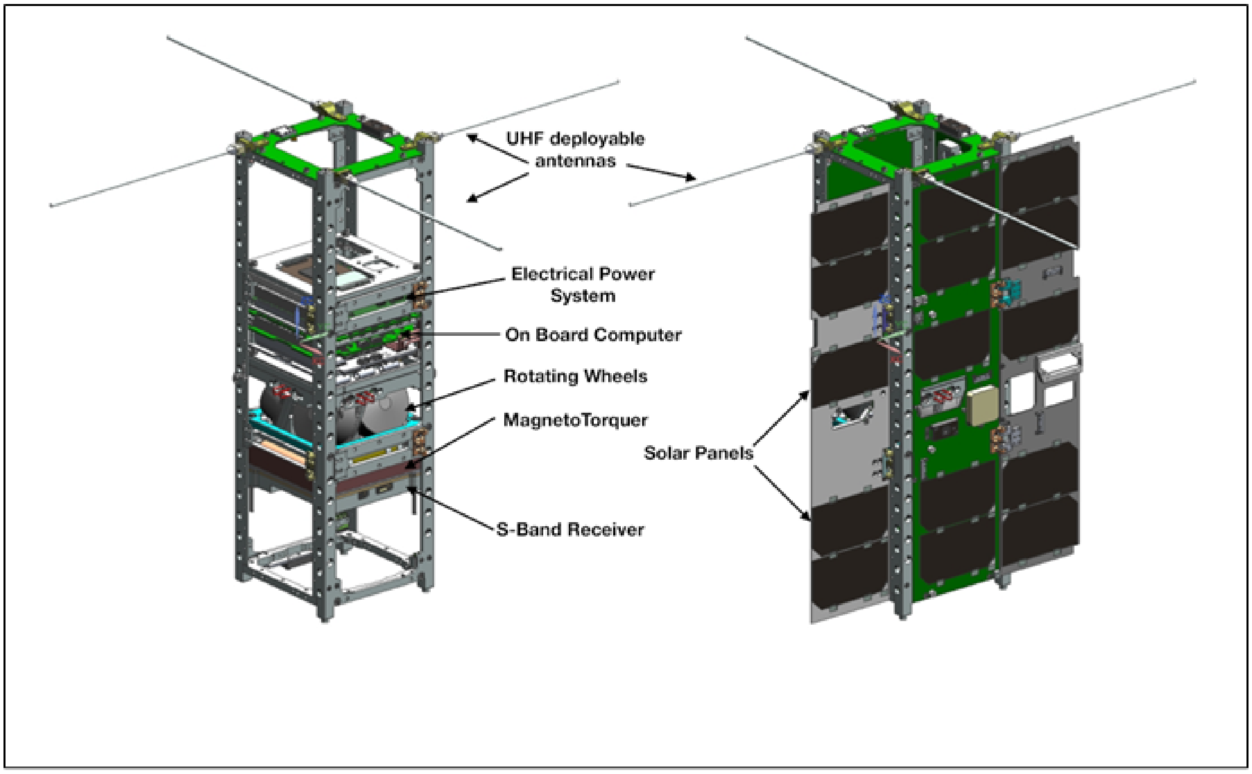


Figure 4 comsat architecture

Assumptions:

- 12 U cubesat w solar arrays
- 90 watts
- Max. electronics temp – 50 C
- 3 Major heat generation components – 25 watts each(examples from Ref.2: UHF Beacon – 21.5 W; IRIS SSPA – 27 W)
- 2 minor heat generation components – 7 watts each (examples from ref. 2: Solar panel gimbal – 5.5 W; C&DH – 13 W)
- Traditional design – shelfs/brackets (Fig.1)
- Thermal gasket between electronic box and mounting place

- Energy efficient design – shelfs/brackets- 2mm alum. panels and wall mounting
- Four External surfaces – radiators 0.24 m2
- Determine electronics temperature



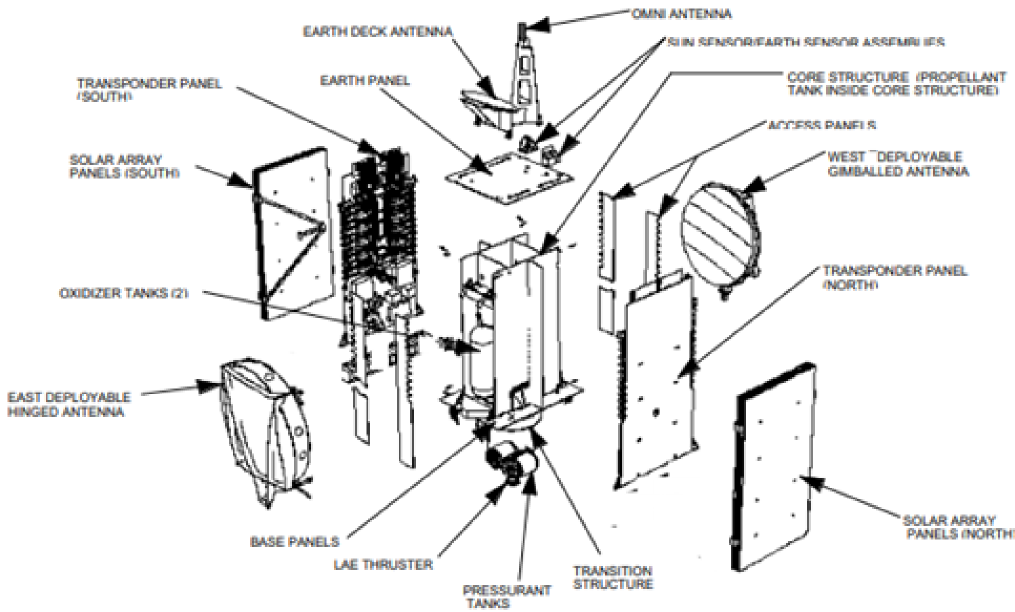
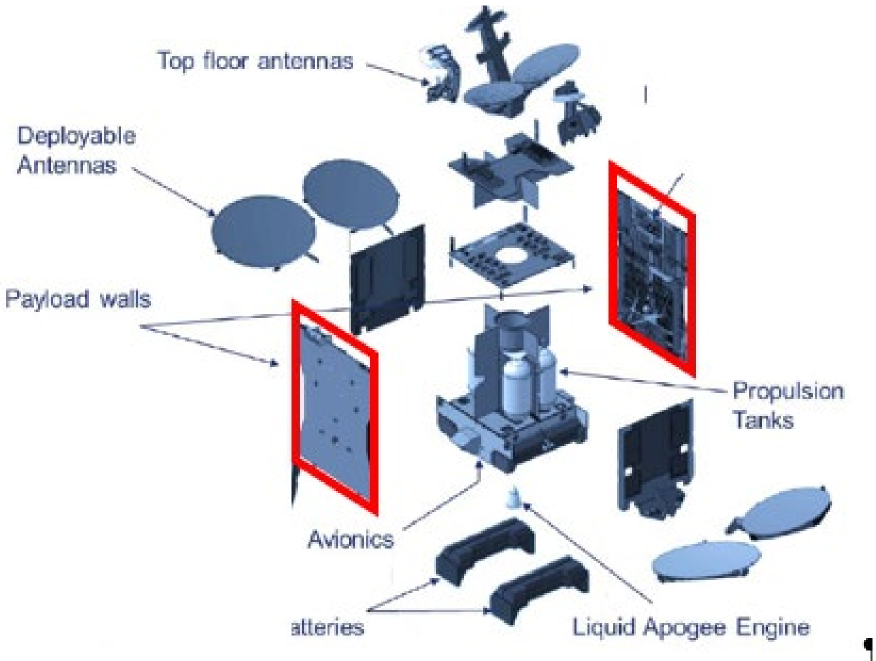


Figure 1 LM A2100 satellite [ref.6]



Table

	traditional cubesat design	thermally efficient design
25 w unit	77.8	41.3
7 w unit	42.1	31.9

Conclusion

- For low heat generating units, say below 10 w, a traditional cubesat design mounting unit on a shelf/bracket is sufficient enough to maintain unit temperature in reasonable range
- For high heat generating units, 20 W and higher, a thermally efficient cubesat design provides a significant reduction in unit temperature.

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