Topics

• “Traditional” and Small Satellite Domains
• SmallSats as a Laboratory
• Migration Between Domains
• Future Trends & Symbiosis
• Conclusion
“Traditional” and Small Satellite Domains

- The satellite industry can be divided into two domains – each with a set of manufacturers, customers, component vendors, support services
- Each domain has unique role and capabilities they bring to industry

**Traditional Satellite Domain**
- Larger, more complex vehicles and systems
- System costs are much greater and can be secondary driver for requirements and design
- Risk averse customers and stakeholders
- Decades of heritage in technology, operations, and processes
- Change is slow paced and evolutionary

**Small Satellite (SmallSat) Domain**
- Smaller and simpler vehicles and systems
- Far more cost conscious and price is always a primary driver in requirements and design
- Much higher risk tolerance
- Willing to invent or import new technology, operations, and processes wholesale
- Change is rapid and can be non-linear
“Traditional” and Small Satellite Domains

• SmallSat domain is a “Disruptive Innovation” for the satellite industry
  – The SmallSat domain will not replace the Traditional Satellite Domain
  – The mission requirements & complexity rule that out
• SmallSats started with Sputnik\(^{(2)}\), but now reaching a critical mass
• Migration between the two domains is accelerating
• Kratos can offer insights on the symbiosis between the domains

**Disruptive Innovation**
- Products that redefine “trajectory”
- Not as good as currently available
- Simpler, more convenient, less expensive
- Appeal to new or less demanding customers

Ref: Christensen, see Note 1

**Kratos and the Two Domains**
- Long history of working with all the major companies and organizations within the Traditional Domain
- Strong background in SmallSat domain with numerous customers
- SmallSat focused, cross discipline team inside Kratos for new products & customers
- Has developed line of SmallSat oriented products for command and control, modems, front end processors
SmallSats as a Laboratory

• As a Disruptive Innovation, the SmallSat domain is a “laboratory”
• One analogy is the Bullets and Cannonball case from Good to Great (3)
  – Bullets are smaller attempts to zero in on a target – Lower risk; verify aim
  – Cannonballs are large attempts – Use all resources to hit and “sink” the target
  – The mantra they advise → Bullets then Cannonballs
• A Cannonball for a SmallSat company is a Bullet on the SmallSat Domain or Satellite Industry scale

Do the SmallSat Domain Efforts Qualify as “Bullets” for the Satellite Industry?

• A Bullet is Low Cost: Compared to the cost of a typical traditional satellite, the cost is far lower for a SmallSat domain innovation
• A Bullet is Low Risk: There are little to no consequences to the Traditional Satellite Domain from failures in the SmallSat domain
• A Bullet is Low Distraction: SmallSat efforts have not stopped missions or technology for the Traditional Satellite domain from continuing

Ref: Collins and Hansen, see Note 3
SmallSats as a Laboratory

• Many examples of technical innovation from the SmallSat domain, but four *trends* are noteworthy
  – Use of COTS products & standards from outside the space industry
    • Not just at piece part level, but component / element level
    • PhoneSat,\(^4\) ArduSat,\(^5\) Cameras, Batteries, Processors, ……..
  – Software – More open source, more commercial tools, more APIs
    • CAN Bus (for road vehicles) used by SSTL\(^6\) - Others now using
  – “Data center” ops is the model desired for C2 operations
    • Highly automated, VMs, Cloud Infrastructure, HTML5 User Interface
  – Modularity – “designing in” modularity and planning to use modular parts and standards
    • CubeSat and P-POD standards
    • Standards helped grow vendor “ecosystem”
SmallSats as a Laboratory

• The “laboratory” is also producing business trends
  – Focus more on consumer vs space technology efforts
    • OneWeb and SpaceX broadband constellations
    • Planet Labs’ data “transparency” objective
    • On-line shops for credit card users to purchase spacecraft kits
  – New efforts not predicated on winning corporate IRAD
    • Kickstarter used to finance projects – ArduSat
    • Company to company funding → Millennium Space Systems' Bootstrap program as an investor and developer
    • Venture Capital funding for new companies

(Partial Portfolio as an example)
SmallSats as a Laboratory

• As a corollary to the Bullets and Cannonballs suggested by Collins and Hansen in *Good to Great*:
  – *In a given time, more Bullets can be “fired” than Cannonballs*
  • “How quick can they be reloaded?”
• A “laboratory” or petri dish environment has rapid generations of prototyping and evolution
• On a company level, the Planet Labs approach to rapid spacecraft evolution embodies this
  – “Release Early, Release Often” – Like commercial software
• From a domain perspective, the use of 3D printing highlights this pace
  – Initially some Cubesats (KySat-2, PrintSat, RAMPART)
  – Now a 27U bus from Millennium Space Systems (ALTAIR)
Migration Between Domains

• Technical Trends
  – 3D Printing (Additive Manufacturing)
    • 3D printing of aerospace parts has increased in recent years
    • 3D printing in SmallSat Domain has reduced risk
    • Modernization of Lockheed Martin A2100 features significant use of 3D Printing for cost and efficiency reasons\(^{(18)}\)
  – Modularity
    • Reuse of flight proven systems is not necessarily modular, each reuse may require significant rework to fit new application
    • Designing in modularity from the start increases initial costs and long term flexibility; Decreasing costs of later systems
    • Boeing 502 Phoenix Satellite product line highlights flexibility due to modularity\(^{(19)}\)
Migration Between Domains

• Technical Trend Migration (con’t.)
  – Commercial Data Center like CONOPS for Command and Control (C2) is just starting to be considered in Traditional satellite domain
    • Data Center CONOPS: Combined use of Virtual Machines, Cloud Infrastructure, Web Based User Interface, and Lights Out automation
    • Sunk costs for existing systems may be preventing broader adoption
    • Already a high level of automation (albeit not lights out), so additional cost for last portion may not be worth ROI
    • Potential adopters will closely monitor SmallSat efforts for a Data Center CONOPS, especially for large fleets, for risk reduction
Migration Between Domains

• A technical and business trend is the development of SmallSat expertise in house within Traditional Satellite domain companies
  – Change to structure and approach highlights how seriously the Traditional domain considers the changes from SmallSats
    • Seen as an opportunity to build expertise and then crossflow new technology and processes to mainline programs
    • Seen as a business need to participate in SmallSat domain
  – Some centers are being built through acquisition, as with EADS Airbus and their purchase of SSTL in 2009
  – Others are using “skunkworks” type approaches, such as Boeing did when it developed the Phantom Phoenix line of SmallSats
  – Another option is partnering outside the company, such as Northrop did with Sierra Nevada for a line of SmallSats
Migration Between Domains

- Business deal structure is another trend where SmallSats have influenced the Traditional Satellite domain
- The Traditional satellite domain has seen more Joint Ventures (JV), where the satellite manufacturer shares initial risk and long term profit
  - Different than the usual “cash and carry” contract
  - ViViSat, which is selling on orbit stationkeeping services not spacecraft, is a JV between US Space LLC and Orbital-ATK
  - The companies competing to form a JV with OneWeb for their satellite production highlights the impact
    - The potential partners – Lockheed Martin, Space Systems/Loral, OHB, Airbus, Thales Alenia – are all in the traditional space domain
- Other new partnership approaches are being used
  - As part of the contract to build the next 13 Skybox satellites, Space Systems/Loral gained licensed use of the Skybox design
Future Trends

- A larger focus on the data and less on the space segment
  - New systems will be seen – even by the spacecraft developers – as “data systems that use space” versus “space systems that generate data”

- Emphasis on use of COTS and standards along with modular design approaches
  - Standards and COTS will propagate directly from the SmallSat domain as they are proven in orbit
  - Increase will make modular design easier and more prevalent

- Commodity computing with cloud based systems and data center like operations
  - Efforts underway now (Small and Traditional) will drive this
Future Trends

• Blurred line between “large” SmallSats and small Traditional satellites
  – Technology and processes developed newly built up in house expertise will shape next generations of satellites

• Partnerships between Traditional domain companies and SmallSat companies will turn into acquisitions
  – As the SmallSat company’s IP becomes more critical for market viability and profitability, they will become attractive to purchase

• Personnel crossflow between the domains will become a torrent, with significant benefits to each domain
  – Rapid size increase of SmallSat domain increases talent pool size
  – More opportunities for students to be hands-on prior to starting career also increases level of skills for the talent pool
  – SmallSat growth offers opportunities for Traditional domain talent
Conclusion

• The SmallSat domain is a “Disruptive Innovation” for the satellite industry
  – Laboratory for new ideas and ideas and processes that serve as “bullets” for overall industry progression
• The “Traditional” satellite domain will not be replaced by the SmallSat domain, but it will be influenced by it
  – The migration of ideas – technical and business – has begun
• The trends seen to date are indicators of future change for the Traditional satellite domain
  – Not a crystal ball, but valuable to examine
• The symbiosis between the two domains is still in an early stage, but the benefits will be good for both
References


• Note 18: “A2100 Modernization”, Accessed March 21, 2015. [http://www.lockheedmartin.com/content/dam/lockheed/data/space/photo/a2100/Modernized%20A2100%20Flysheet.jpg](http://www.lockheedmartin.com/content/dam/lockheed/data/space/photo/a2100/Modernized%20A2100%20Flysheet.jpg)


