



**Jet Propulsion Laboratory**  
California Institute of Technology

## QAWG - SmallSat Discussion

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*Office of Safety and Mission Success*

Jet Propulsion Laboratory, California Institute of Technology

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# Overview

- SmallSat Overview
- The Evolving SmallSat Market
- SmallSat Supplier Surveys
- Data mining Examples
- Conclusions

# Highlights of SmallSat in 2017

## 2017 Highlights

- The global launch vehicle market demonstrated its ability to meet the growing demands of the nano/microsatellite segment **without the presence of dedicated small satellite launch vehicles**
- **PSLV C37 launched a record 104 satellites** in a single launch in February, the vast majority of which were nano/microsatellites
- 2017 was also a record setting year for Planet, who **acquired Terra Bella, launched 146 satellites**, and finally **achieved their goal of daily revisit coverage**
- The **QB50 academic constellation officially launched**, marking a major milestone for international cooperation in the nano/microsatellite arena; in all **36 QB50 satellites** were deployed



PSLV-C37 launches a record-breaking 104 satellites



QB50 satellites after deployment from the ISS

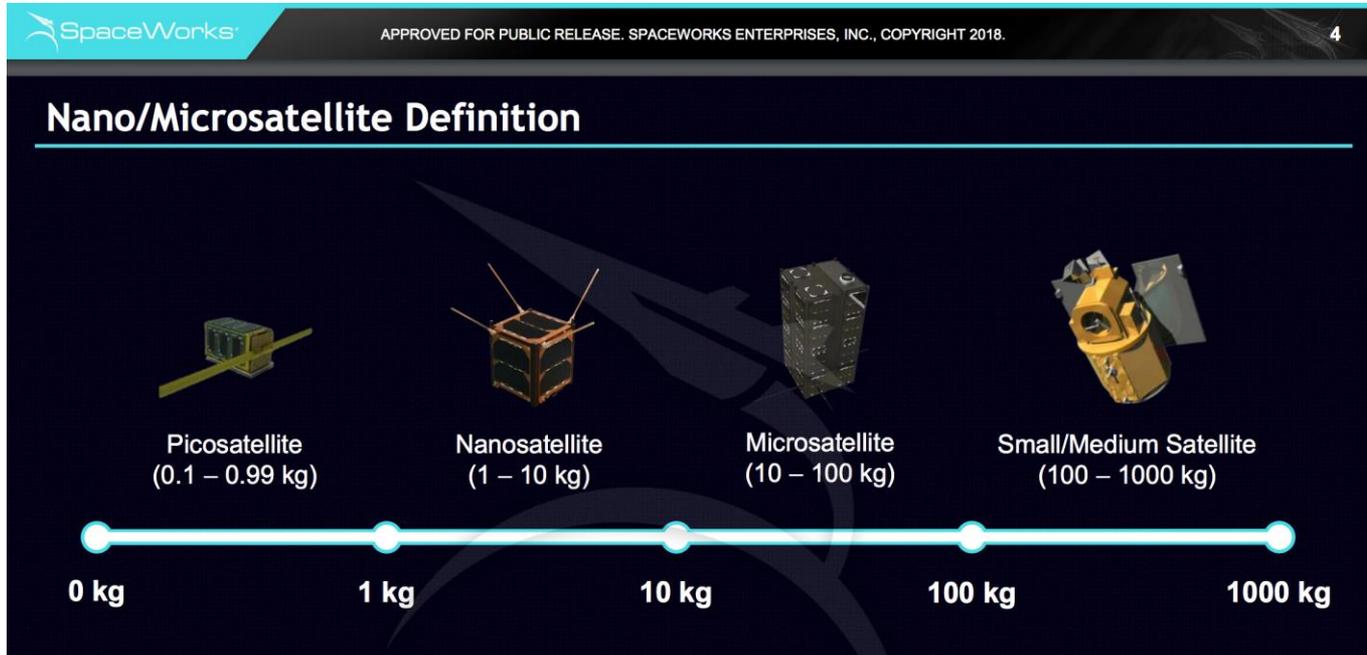
Image Credits: ISRO, NASA



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# Basic Definitions of SmallSats



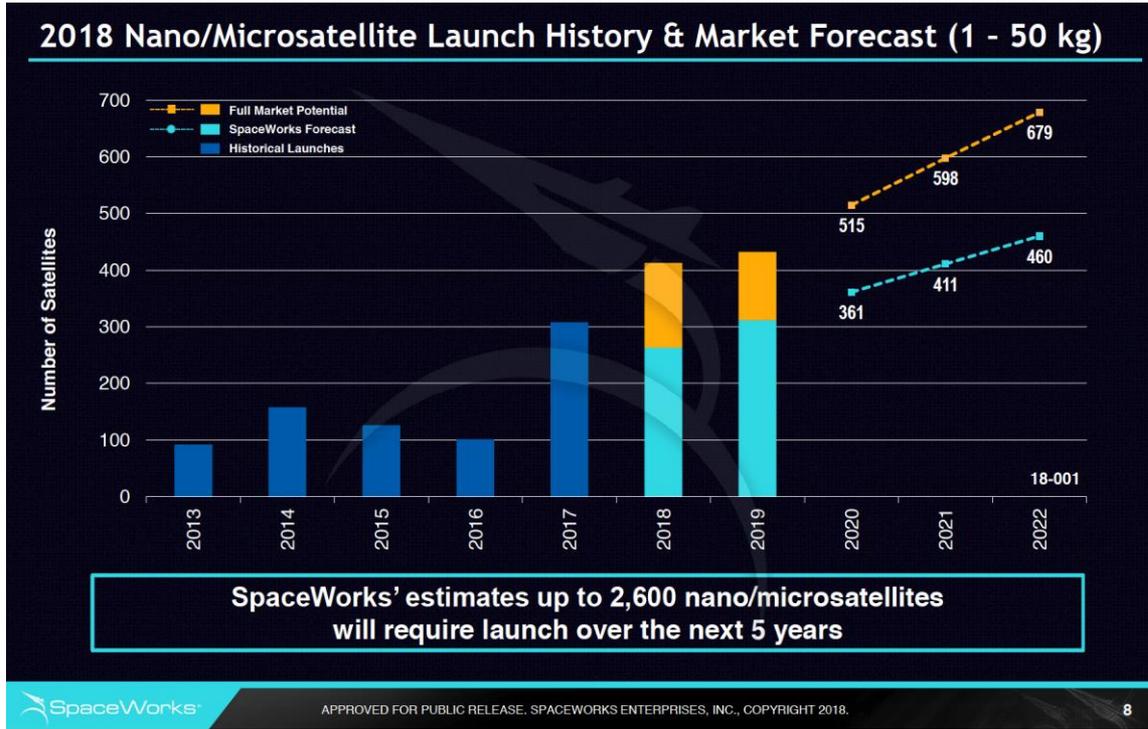
- Mass difference have significant impact on systems architectures, parts and materials selection

# SmallSat Supplier Base



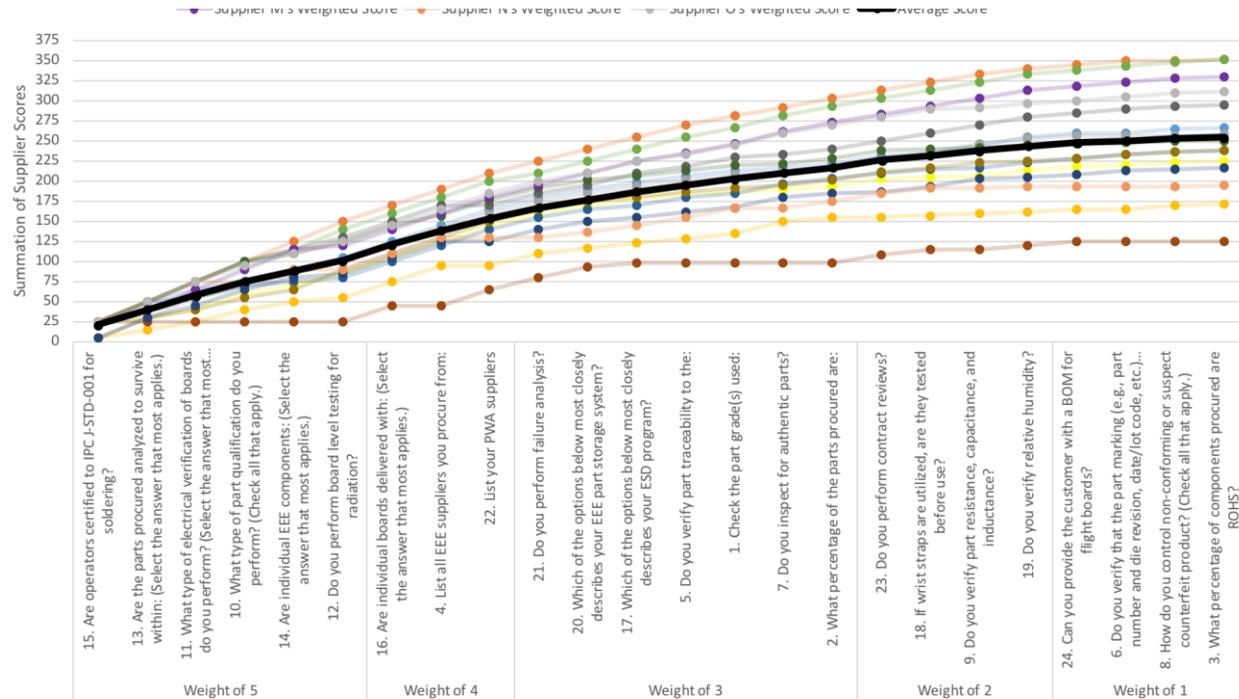
- Suppliers are beginning to organize product lines by spacecraft mass
- Audits need to adapt to this this changing environment

# Thousands of SmallSats expected to be launched in 5 years



- The supplier base will have to grow in capability and capacity to meet this demand
- Supplier Quality will have a significant impact on this forecast being realized

# SmallSat Supplier Evaluation/Questionnaire - NEPP



- Significant variation (3X) across supplier base
- Wide range of responses indicative of wide range in quality

# QA Visual Inspection of SmallSat PCB/Subassemblies

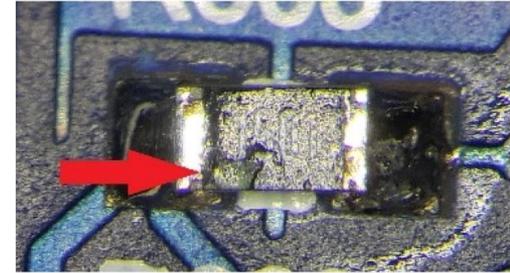
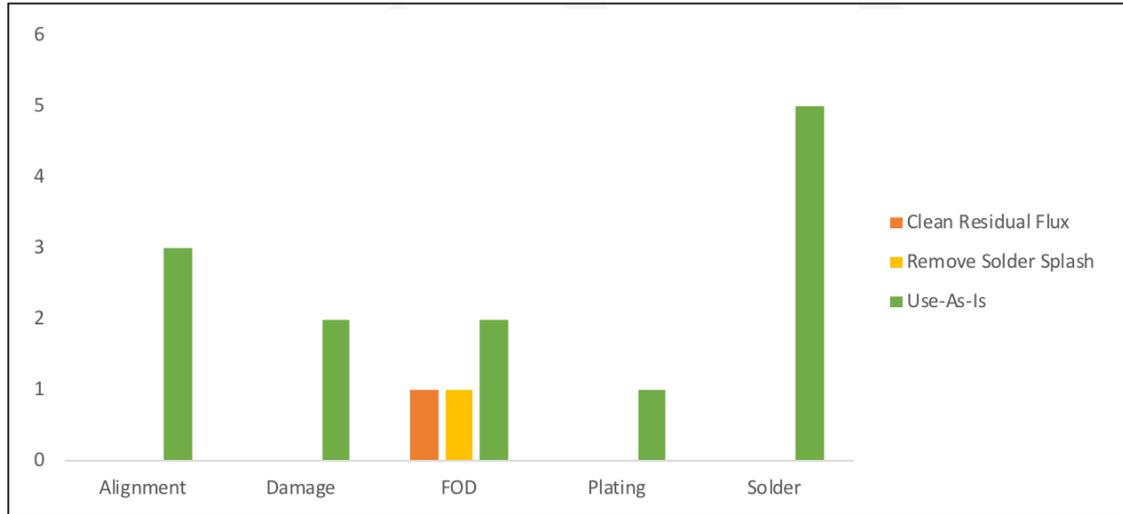


Figure 7 – Damage to Resistor Passivation Layer

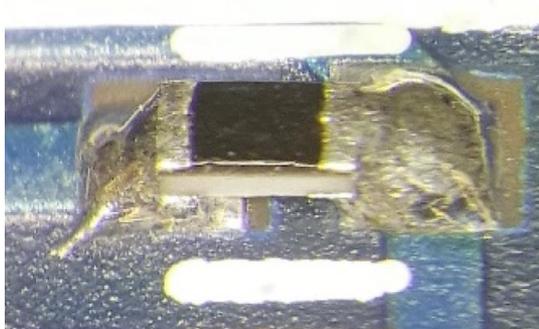


Figure 9 – Resistor Alignment Issue

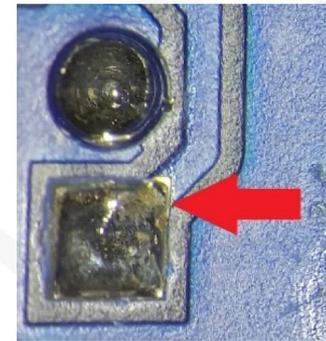
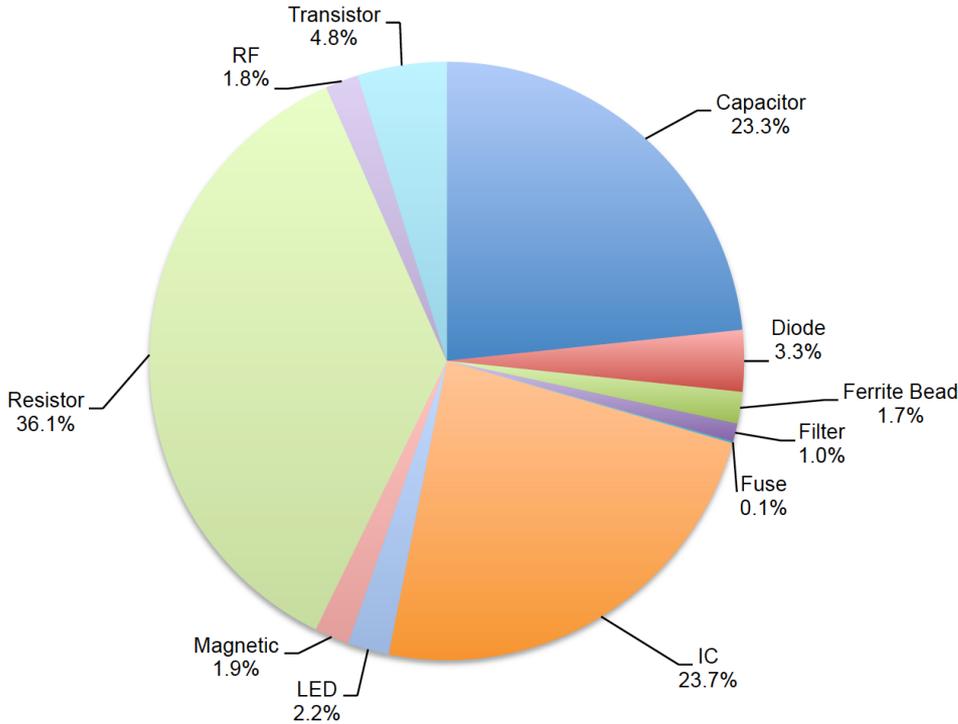
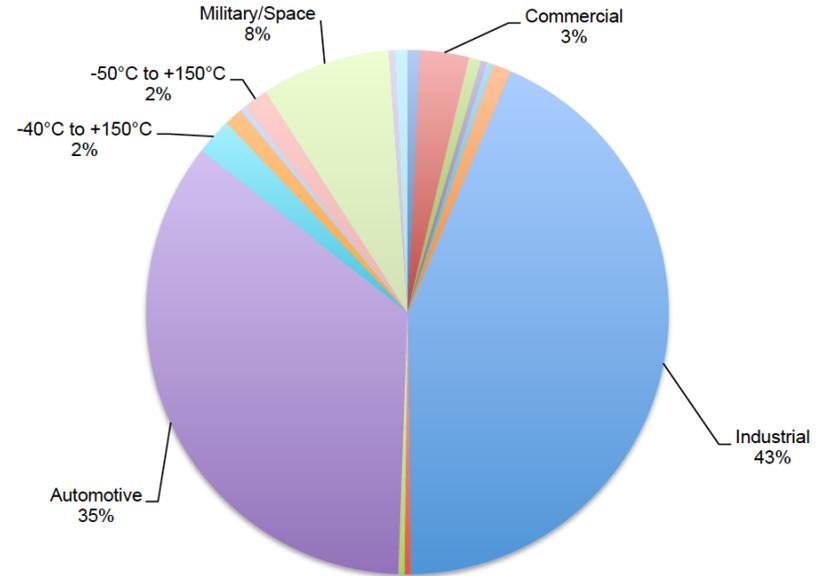


Figure 8 – Residual Solder Flux

# NASA NEPP CubeSat Parts Data Base

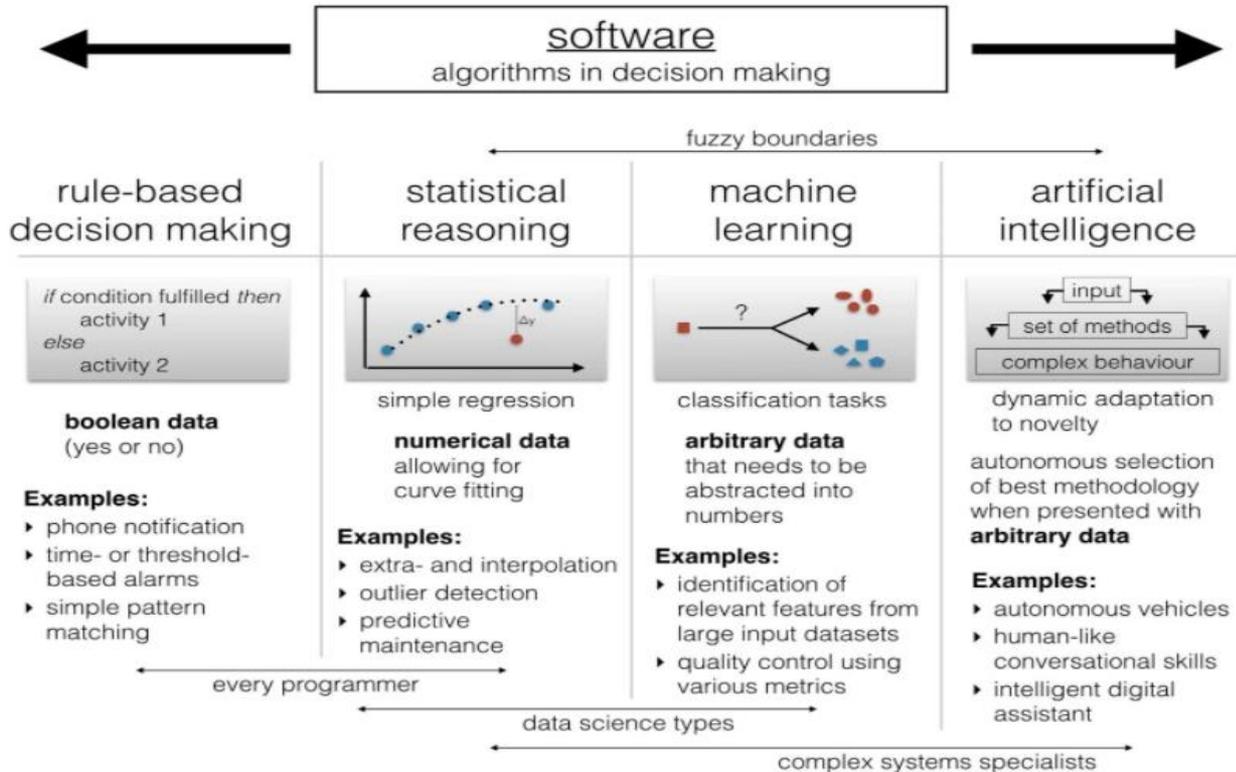


Total Parts in database



Part Type/Classification

# Overview of decision making tools and concepts



# Future enhancements to databases – Data mining techniques

## Apply Cosine Similarity to EEE Parts Data

### Raw Data

Part Number	Height	Length	Width	Operating Temp Min	Operating Temp Max	Output Voltage Min	Output Voltage Max	Input Voltage Min	Input Voltage Max
LT1965EDD-3.3#PBF	0.8 mm	3.0 mm	3.0 mm	-40.0 Cel	125.0 Cel	3.201 V	3.399 V	4.3 V	20.0 V
LT3090HDD#PBF-ND	0.8 mm	3.0 mm	3.0 mm	-40.0 Cel	150.0 Cel	0.0 V	32.0 V	1.5 V	36.0 V



### Vectorized Data

Part Number	Height 0.8 mm	Length 3.0 mm	Width 3.0 mm	Operating Temp Min -40.0 Cel	Operating Temp Max 125.0 Cel	Operating Temp Max 150.0 Cel	Output Voltage Min 3.201 V	Output Voltage Min 0.0 V	Output Voltage Max 3.399 V	Output Voltage Max 32.0 V	Input Voltage Min 4.3 V	Input Voltage Min 1.5 V	Input Voltage Max 20.0 V	Input Voltage Max 36.0 V
LT1965EDD-3.3#PBF	1	1	1	1	1	0	1	0	1	0	1	0	1	0
LT3090HDD#PBF-ND	1	1	1	1	0	1	0	1	0	1	0	1	0	1



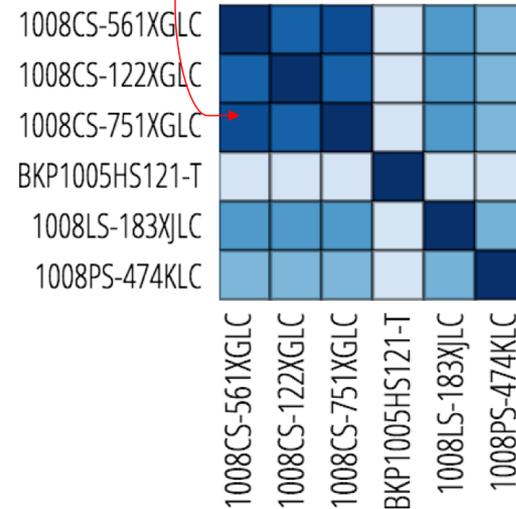
Cosine Similarity = 0.44

- Data from IEEE datasheets360.com via web scrapper
- *Not hand entered*
- Using Python API (including BeautifulSoup and pandas)

# Cosine Similarity – Parts List Revision

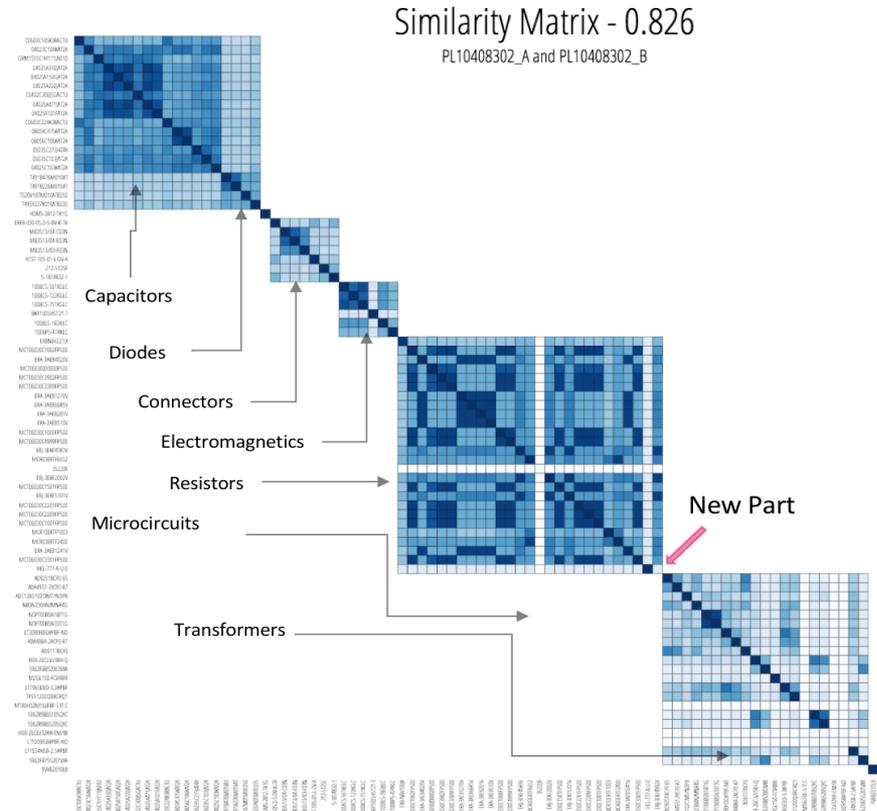
- **Similarity matrix for L type parts (electromagnetics)**
  - Similarity calculated between parts of the same type
- **Coloring indicates strength of similarity:**
  - 0 – white (no similarity)
  - 1 – dark blue (identical)
- **Diagonal of 1's is an artifact of comparing different revisions of the same part list**

Part Type	L
Part Number	1008CS-561XGLC
Part Number	1008CS-751XGLC
Similarity	0.892

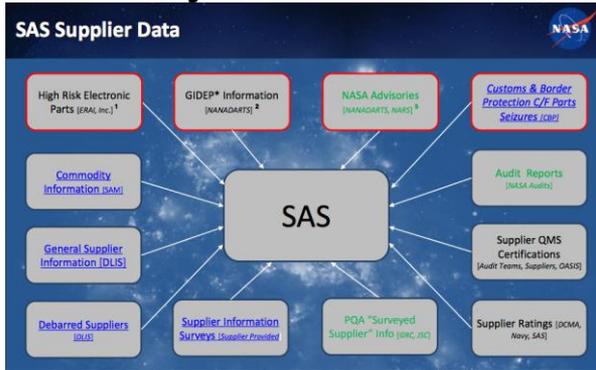


# Cosine Similarity – Parts List Revision

- **Similarity matrix for two part lists**
- **Coloring indicates strength of similarity:**
  - 0 – white (no similarity)
  - 1 – dark blue (identical)
- **Diagonal of 1's is an artifact of comparing different revisions of the same part list**
  - One-off in diagonal indicates addition of a new part
- **Distinct regions correspond to part types**
  - Part comparisons are not made between different part types
- **Manage subtle changes in part type, provide an precise definition of “Heritage” as way to reduce risk**



# Many different databases – Opportunity to mine for data



## Approved Suppliers List

Search My Favorites Reports Contacts Links About Metrics Suggestions Logout

Basic Search Tyvak Nano-Satellite Systems LLC Quick Approved Supplier Search Clear Advanced Search

Records Found = 1 Compare Suppliers Export to Excel

Compare	Supplier	Approval Scope	View
<input type="checkbox"/>	<b>Tyvak Nano-Satellite Systems LLC - Irvine, CA (6JBJ8)</b> ASL Status: Approved by Supplier Visit Expiration Date: 07/31/18 Rate this supplier	Intrepid and Endeavour Product Lines. More Information...	
	Quality Rating:		
	Inspector Rating:		
	Customer Satisfaction:		
	Workmanship Stds: 0		
	Auditor Rating:		

**Planet**  
Planet builds small satellites and delivers information about the changing planet.  
San Francisco, California, United States

Categories: Aerospace, Analytics, Geospatial  
Founded Date: Dec 24, 2010  
Founders: Chris Boshuizen, Robbie Schinger, Will Marshall  
Operating Status: Active  
Funding Status: Late Stage Venture  
Last Funding Type: Secondary Market  
Number of Employees: 251-500  
Also Known As: Cosmogia

Company Type: For Profit

Website: [www.planet.com/](http://www.planet.com/) US  
Facebook: [View on Facebook US](#)  
LinkedIn: [View on LinkedIn US](#)  
Twitter: [View on Twitter US](#)  
Contact Email: [press@planet.com](mailto:press@planet.com)  
Phone Number: 415-655-9083

Planet is a startup based in San Francisco and founded by former NASA employees that collects information about our changing planet with a fleet of compact, highly capable Earth-imaging satellites. Planet's mission is to image the entire Earth every day, and make global change visible, accessible and actionable. The broad coverage and high...

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SMALL SATELLITE CONFERENCE

## Gunter's Space Page

Space News

06.05.2018 (1 day, 14 hrs ago) With a launch mass of 6000 kg, the 2nd, final Intrepid 2018 to the second heaviest (TD) payload launched on Falcon 9 for and the heaviest on a generally recoverable booster.

06.03.2018 (1 day, 14 hrs ago) A SpaceX Falcon 9 rocket has successfully launched the Intrepid 2018 nominal from a secondary reusable orbit. Stage 1 was intentionally not recovered due to bad weather conditions off shore.

01.03.2018 (3 days, 22 hrs ago) An Atlas-5011 rocket lifted off from Cape Canaveral to put the geostationary weather satellite GOES-R into orbit.

Most recent and planned orbital launches: → 2018

ID	Date	Payload(s)	Vehicle	Site	Remark
2018-025	06.03.2018	Intrepid 2018-6	Falcon-9 v1.2	CC BLD-40	Shuttlefield 18B sat
2018-020	01.03.2018	GOES-R (2)	Atlas-5011	CC BLD-43	Orbital Reflector sat set
2018-021	17.03.2018	ISS-Orbit-6	IN-2A-2002	IN-2A-2002	To TLP-1
2018-022	22.03.2018	Prog-1 / MicroSat 2b, 2c (Twin A, B)	Falcon-9 v1.2(eng)	IN BLD-46	IN BLD-46
2018-019	13.02.2018	Progress-MG 08	Dragon 2 (v)	IN BLD-31(18)	

## Siftery

ACTIVE PRODUCTS PRODUCTS TIMELINE

Total Products Active Total Product Changes

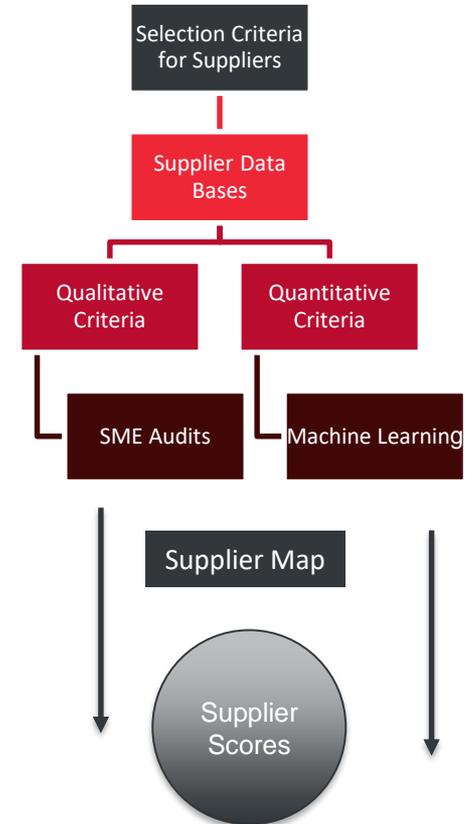
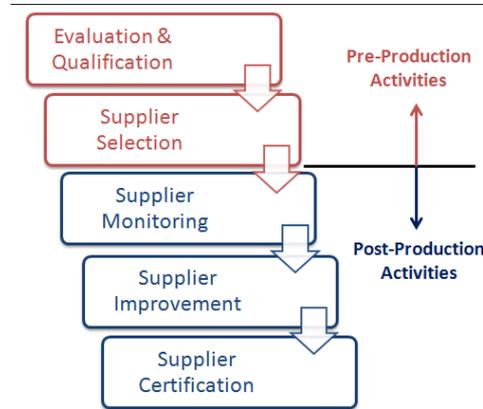
UNLOCK MORE DATA

## Funding Rounds

Number of Funding Rounds: 6 Total Funding Amount: \$183.1M

Announced Date	Transaction Name	Number of Investors	Money Raised	Lead Investors
Jun 1, 2017	Secondary Market -	-	-	-
Apr 14, 2015	Series C - Planet	5	\$23M	IPC Venture Capital Group
Jan 20, 2015	Series C - Planet	16	\$70M	Data Collective
Jan 20, 2015	Debt Financing - Plan..	1	\$25M	-
Dec 18, 2013	Series B - Planet	12	\$52M	-
Jun 25, 2013	Series A - Planet	7	\$18.1M	-

# Evolution of Supplier Management – Ranking Using Analytics and Continuous Feedback to Improve



# Conclusion

- SmallSat market will continue to grow at a rapid and accelerating pace for at least the next 5 years
- The quality of vendors that serve this market is a key critical path item to both the short term and long term success
- Databases of various information are foundational to supporting NASA SmallSat missions
- The evolution of modern data science tools can begin to have an important contribution to understanding and communicating the capabilities of SmallSat vendors to mission designers, assurance professionals, and decision makers



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