ASCoT R2:
A Web-based version of the NASA Analogy Software Costing Tool
Goodbye Excel

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August 23-25, 2016

2016 NASA Cost Symposium
Glenn Research Center

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TOOL Demo and mini-tutorial is

8:30 Thursday in room 105/106

Introduction & Background - 1

- ASCoT an Analogy Cost Model using data mining algorithms
  - Methodology handles
    - small sample sizes
    - noisy and sparse data
  - The purpose of ASCoT is to
    - Supplement current estimation capabilities
    - Be effective in the very early lifecycle when our knowledge is fuzzy
      - uses high level systems information (Symbolic Data)
    - Be usable by Cost Estimators, Software Engineers and Systems Engineers
  - ASCot R1 was released through the NASA ONCE Portal in Dec. 2015
  - Previous talks and papers described the research approach and activities
    - ICEAA 2014, 2015
    - NASA Cost Symposium 2014, 2015
    - IEEE Aerospace 2016

What's New - Goodbye Excel!!

Rev 1

- Excel front end with algorithms in Python
- Only ran on PC
- Data in excel workbook
- Tool juggled multiple workbooks
- Required loading miniconda and had configuration issues
- Tool difficult to modify

Rev 2

- Web-based tool runs on both Mac and PC
- On-Line Help and data value popups
- Data in a real database
- Greatly expanded data visualization
- Tool is easily extendable
- More data

Data Sources

- Where the data came from
  - CADRe
  - NASA 93 - Historical NASA data originally collected for ISS (1985-1990) and extended for NASA IV&V (2004-2007)
  - Contributed Center level data
  - NASA software inventory
  - Project websites and other sources for system level information if not available in CADRe

Data Items Overview

Data Item	# of Records
Total development effort in work months	36
Logical Lines of code (LOC)	
Delievered LOC	49
Equivalent LOC	43
Systems Parameters	
Mission Type (Deep Space, Earth/Lunar, Rover-Lander, Observatory)	49
Multiple element (probe, etc…)	49
Number of Instruments	49
Number of Deployables	49
Flight Computer Redundancy (Dual Warm, Dual Cold, Single String)	49
Software Reuse (Low, Medium, High)	41
Software Size (Small, Medium, Large, Very Large)	49

- Updates from 2015:
  - Glory, GPM Core, Insight, IRIS, NuStar, OCO3, OSIRIS-Rex

Data Items: Missions with some Data

Earth/Lunar Orbiter (23)	Observatory (6)	Deep Space (15)	Insitu (5)
LRO	HST	GLL	MPF
OCO	GRO	DS1	MER
SDO	Kepler	Stardust	MSL
Grail	WISE	Mars Odyssey	Phoenix
SMAP	Stereo	Genesis	Insight
GPM Core	Contour	Deep_Impact	
OCO3		MRO	
NuStar		JUNO	
GEMS		Maven	
GLORY		New Horizons	
GOES R		Messenger	
NEAR		Cassini	
GEOTAIL		OSIRIS REX	
EO1		Dawn	
Aqua		Van Allen Probe (RBSP)	
GLAST			
NOAA-N-Prime			
NPP			
LDCM			
RHESSI			
LCROSS			
TIMED			
IRIS			

Data Summary – Key Metrics

Effort, Lines of Code and Productivity by Mission Type

Mission Type	# of Records	Effort (Months)		Logical Delievered LOC		Logical Equivalent LOC		Productivity (Logical Del/month)		Productivity (Equiv/month)	
		Median	S.D.	Median	S.D.	Median	S.D.	Median	S.D.	Median	S.D.
Earth/Lunar Orbiter	23	544	380	95,000	43,691	62,000	43,037	203	216	91	212
Observatory	6	492	631	87,300	36,384	64,000	23,178	126	174	63	122
Deep Space	15	643	343	121,500	61,444	115,000	49,803	183	147	148	113
Insitu	5	1,080	555	204,762	145,335	154,000	198,745	249	81	185	84

Number of Deployables and Instruments by Mission Type

Mission Type	Instrument		Deployables	
	Median	Range	Median	Range
Earth/Lunar Orbiter	3	1-7	2	0-7
Observatory	4	1-6	2	0-6
Deep Space	5	2-12	2	0-8
Insitu	5	3-10	6	2-10

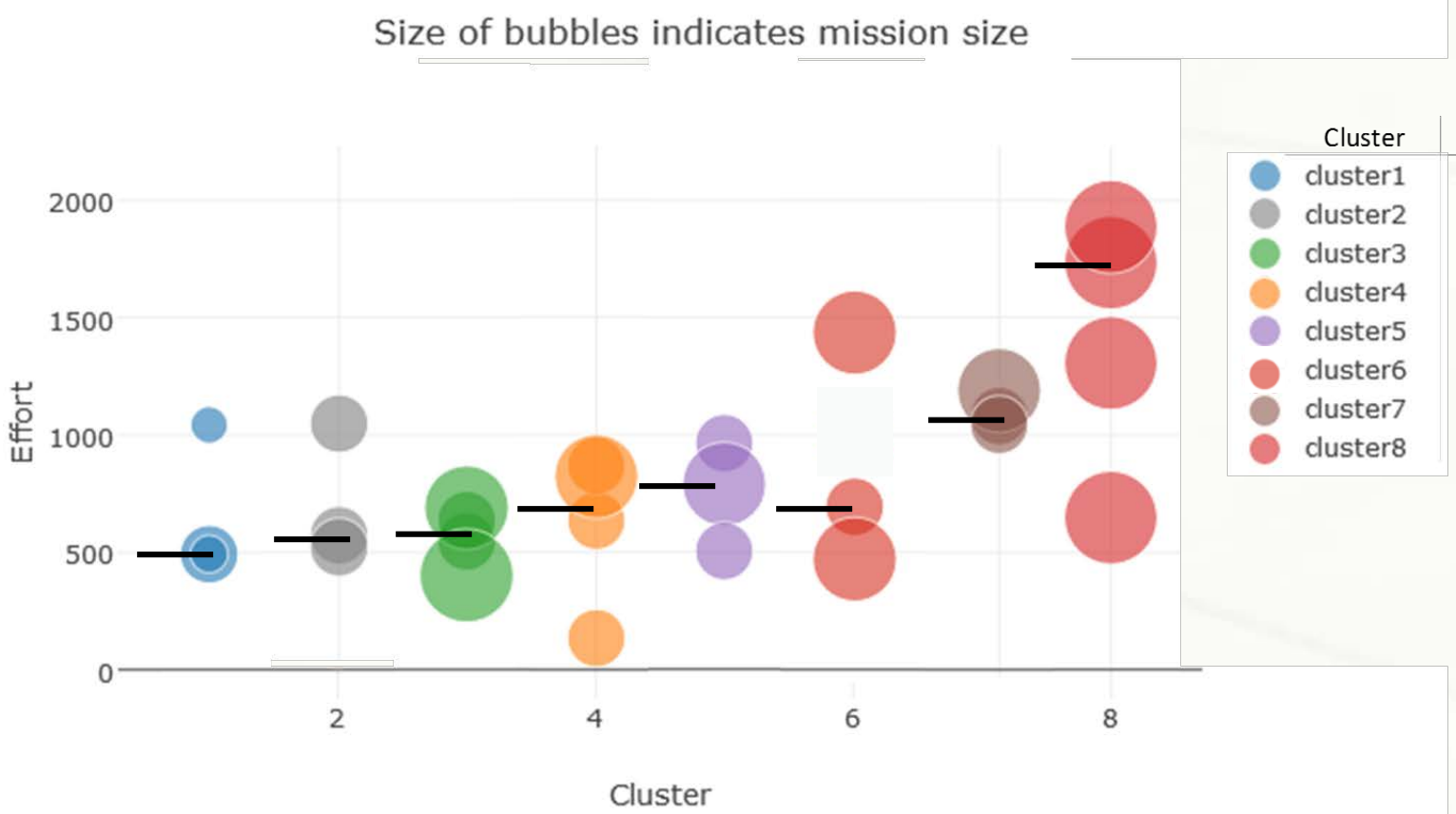
System Descriptor Details (Example)

Mission Type		
Values	**Description**	**Example**
Earth/Lunar Orbiter	Robotic spacecraft that orbit the earth or moon conducting science measurements. These spacecraft are very similar if not identical to the many commercial satellites used for communication as well as many military satellites. They often can have high heritage and even use production line buses from industry.	Aqua
Observatory	Observatories are space based telescopes that support space based astronomy across a wide set of frequencies. They can be earth orbiters or earth trailing at the various LaGrange points created by the gravity fields of the earth, sun and moon.	Hubble
Deep Space	Any robotic spacecraft that goes beyond the moons orbit. So this category includes any mission whose destination is a planet, planetoids, any planetary satellite, comet, asteroid or the sun. These mission can be orbiters or flybys or a mixture of both.	Deep Impact
Static Lander	A robotic spacecraft that does its science in-situ or from the surface of a solar system body. It does not move from its original location.	Phoenix
Rover	A robotic spacecraft that does its science in-situ or from the surface of a solar system body and has the ability to move on the surface. To date all rovers have wheels but in the future they may crawl, walk or hop.	Mars Exploration Rover (MER)

Reminder - What We Learned from Methodology

- There are a variety of models whose performance are hard to distinguish (given currently available data) but some models are better than others
- If one has sufficient data to run COCOMO or a comparable parametric model then the best model is the parametric model
- When insufficient information exists then a model using only system parameters can be used to estimate software costs with relatively small reduction in accuracy. The main weakness is the possibility of occasional very large estimation errors which the parametric model does not exhibit.
- A major strength of the nearest neighbor and spectral clustering methods is the ability to work with a combination of symbolic and numerical data
- While a nearest neighbor model performs as well or better as spectral clustering based on MMRE, spectral clustering handles outliers better and provides a structured model with more capability

Effort Variation by Cluster

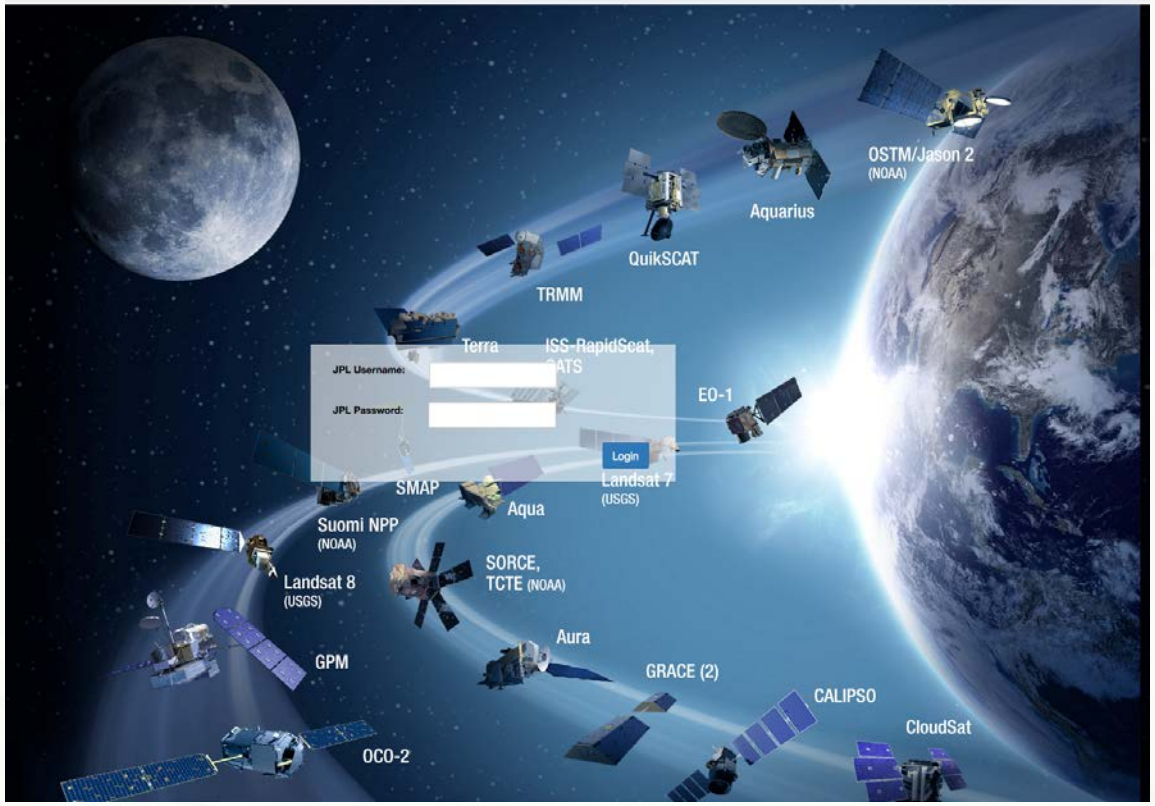


Cluster	Median
cluster1	493
cluster2	572
cluster3	592
cluster4	728
cluster5	789
cluster6	694
cluster7	1080
cluster8	1521

Mission Membership by Cluster

Cluster	Project	Effort	Software Size	Inheritance2	Mission Size	Mission Type	Secondary Element	Num Instruments	Redundancy	Num Deployables
1	DS1	1043	large	medium	small	deep space	none	6	single string	1
1	OCO	492	large	high	medium	earth/lunar orbiter	none	1	single string	1
1	NuStar	493	medium	very high	small	earth/lunar orbiter	none	1	single string	1
2	Deep Impact	1048	large	low	medium	deep space	impactor/ probe	3	dual string - cold backup	3
2	Stereo	572	very large	high	medium	observatory	multiple spacecraft	4	dual string - cold backup	6
2	Messenger	521	large	low	medium	deep space	none	8	dual string - cold backup	2
3	Stardust	546	medium	medium	medium	deep space	sample return	2	dual string - cold backup	3
3	Genesis	637	medium	high	medium	deep space	sample return	3	dual string - cold backup	5
3	MRO	691	very large	very high	large	deep space	none	7	dual string - cold backup	2
3	OSIRIS-Rex	401	large	very high	very large	deep space	sample return	5	dual string - cold backup	2
4	Phoenix	634	large	high	medium	static lander	edl	4	dual string - warm backup	3
4	Grail	868	large	very high	medium	earth/lunar orbiter	multiple spacecraft	4	single string	1
4	InSight	822	large	very high	large	static lander	edl	5	dual string - warm backup	2
4	GLORY	133	medium	very high	medium	earth/lunar orbiter	none	3	single string	1
5	LRO	964	medium	very low to none	medium	earth/lunar orbiter	none	7	single string	3
5	SMAP	789	large	medium	large	earth/lunar orbiter	none	2	single string	3
5	TIMED	504	large	very low to none	medium	earth/lunar orbiter	none	4	single string	0
6	JUNO	1436	medium	high	large	deep space	none	9	dual string - cold backup	1
6	Maven	694	large	very high	medium	deep space	none	8	dual string - cold backup	1
6	New Horizons	470	medium	low	large	deep space	none	7	dual string - cold backup	0
7	MPF	1080	medium	very low to none	medium	rover	edl	4	single string	10
7	SDO	1190	medium	high	large	earth/lunar orbiter	none	3	single string	5
7	GPM Core	1043	medium	high	medium	earth/lunar orbiter	none	2	single string	4
8	GLL	648	small	very low to none	very large	deep space	impactor/ probe	11	dual string - warm backup	8
8	MER	1735	very large	low	very large	rover	edl	8	dual string - warm backup	7
8	MSL	1888	very large	very low to none	very large	rover	edl	12	dual string - warm backup	6
8	Cassini	1307	large	very low to none	very large	deep space	impactor/ probe	12	dual string - warm backup	4

ASCoT Overview



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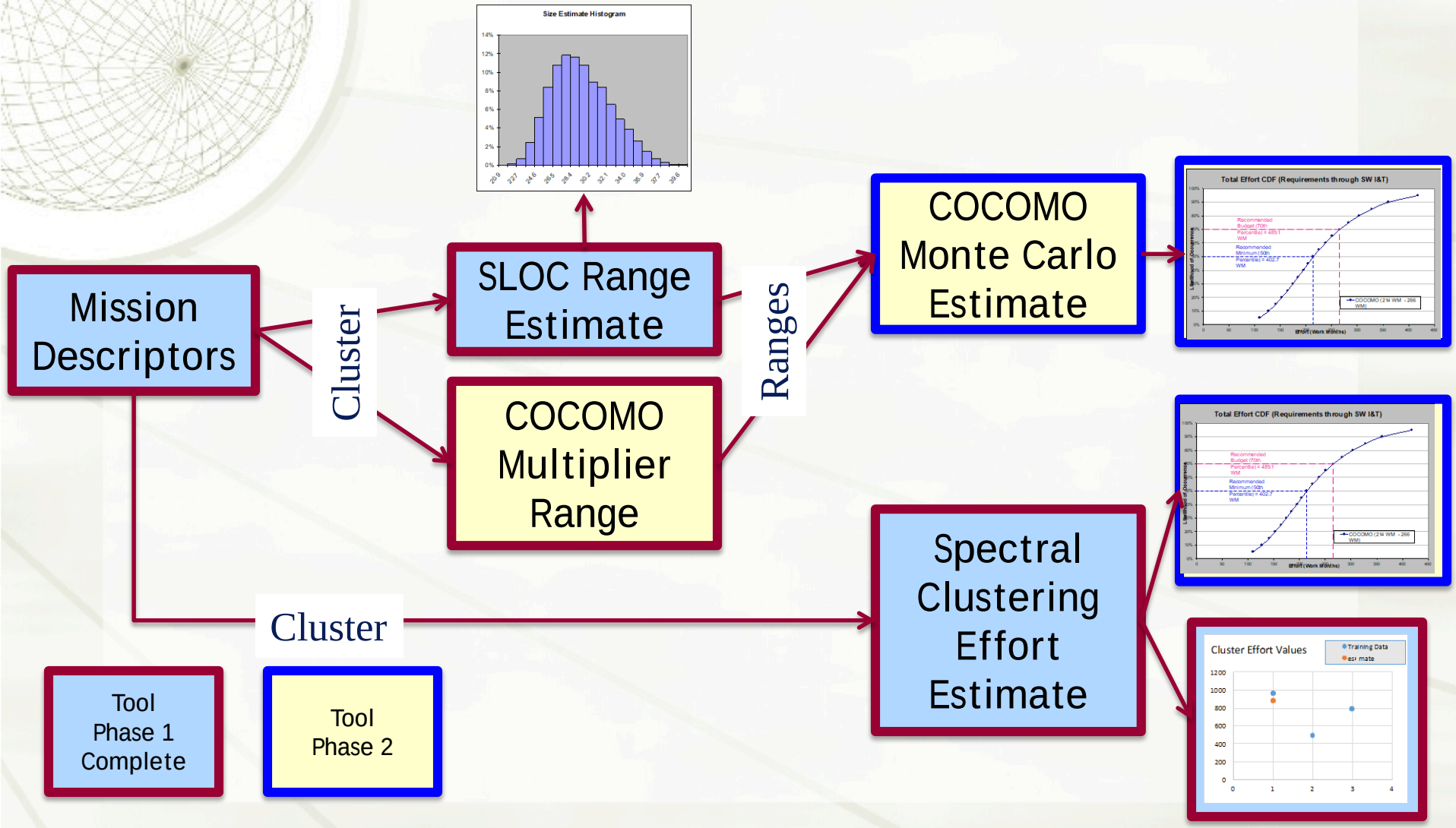
ASCoT Model Architecture



ASCoT Components

- Web-based tool run form a server
  - Has access control
- Written Python
  - Uses a number of Python Packages
- MySQL database
- Framework
  - Django Web and Rest
- Centos ??

On-Line help windows

ASCoT

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ASCoT Clustering

- User Estimates
- Cluster Parameter Variation
- Cluster Effort Variation
- 3D Visualization
- Cluster Detail Tables

ASCoT Clustering

Create New Estimate

Project Name: Medium Earth Orbiter Ex. 1	Software Size: Medium
Inheritance: High	Mission Size: Medium
Mission Type: Earth/Lunar Orbiter	Secondary Element: None
Redundancy: Single String	Num Instruments: 1
Num Deployables: 1	Config: Release_2

Create Estimate

User Estimates

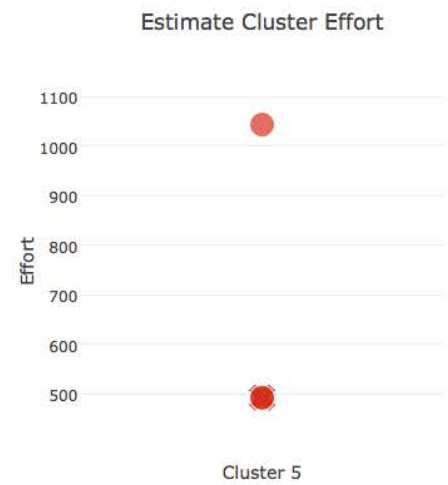
Medium Earth Orbiter Ex. 1 Choose Estimate

Current Estimate

Estimated Effort: 493 Effort Range: 492 - 1043

Cluster Results Summary

Cluster Members	Effort
Medium Earth Orbiter Ex. 1	493
DS1	1043
OCO	492
NuStar	493

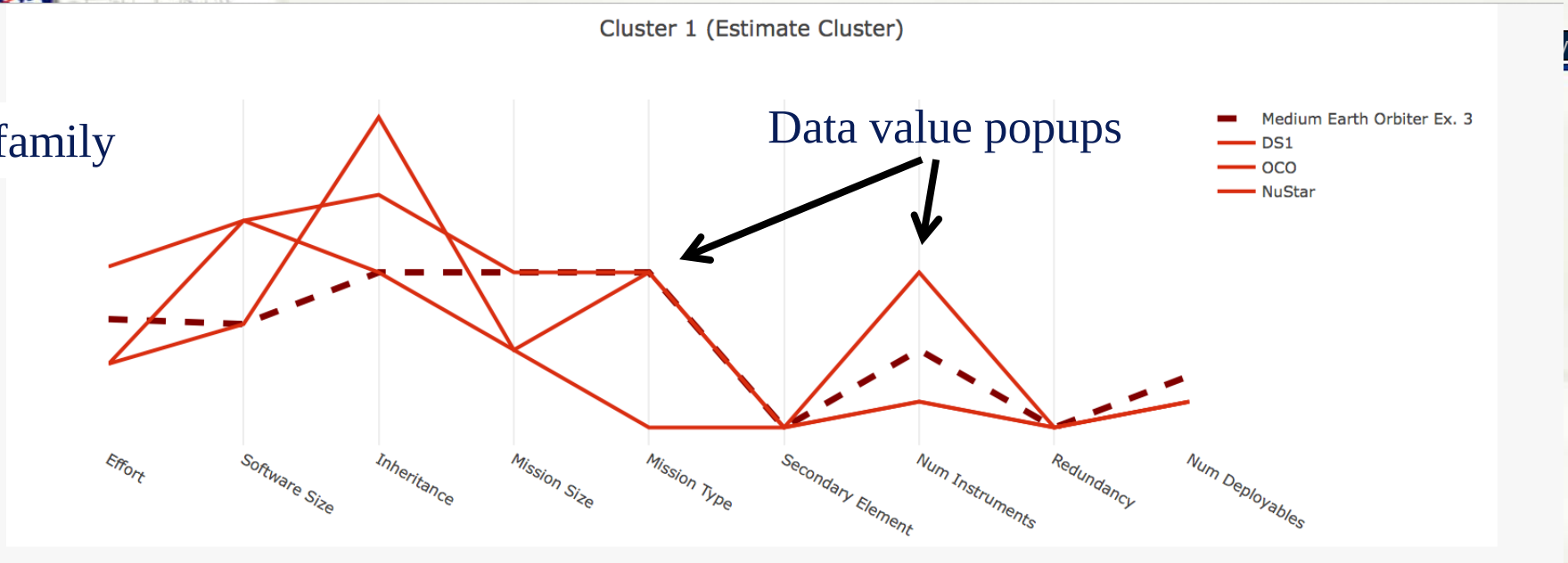


Inputs

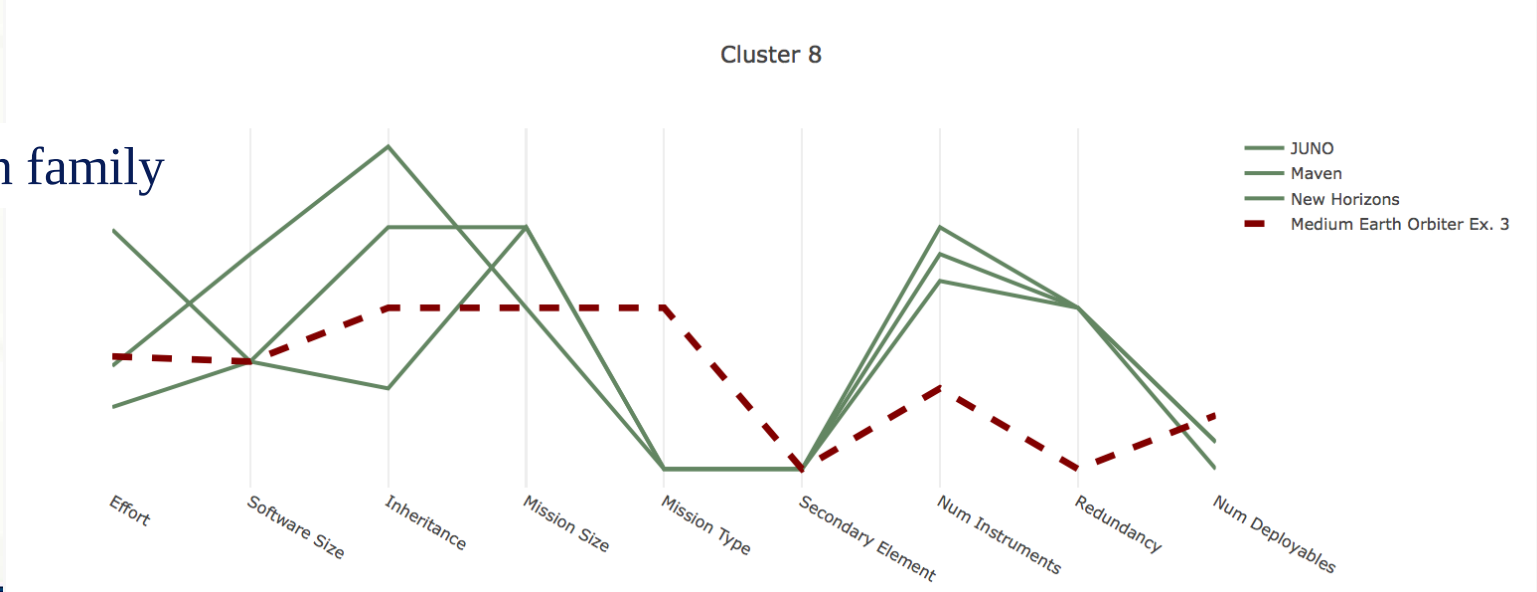
Estimate

ASCoT – 2- Cluster Parameter Variation

In family



Not in family



ASCOT -3 – Cluster Effort Variation

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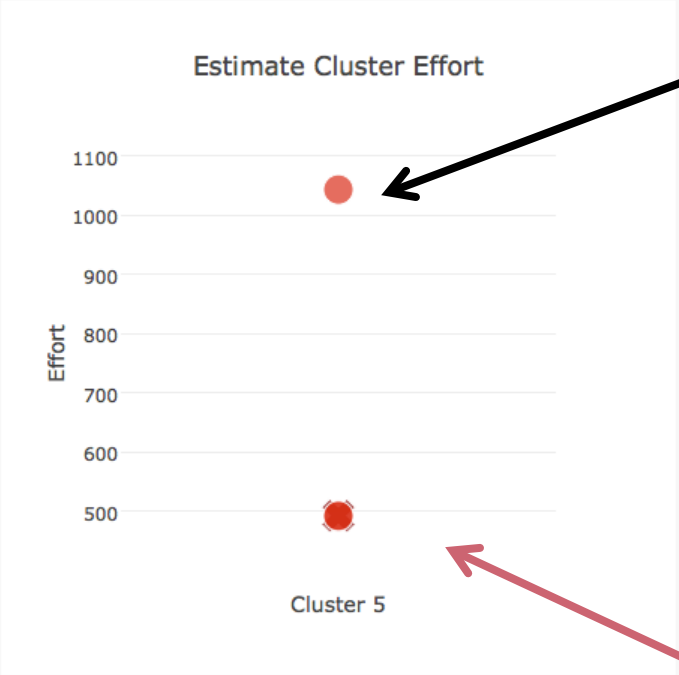
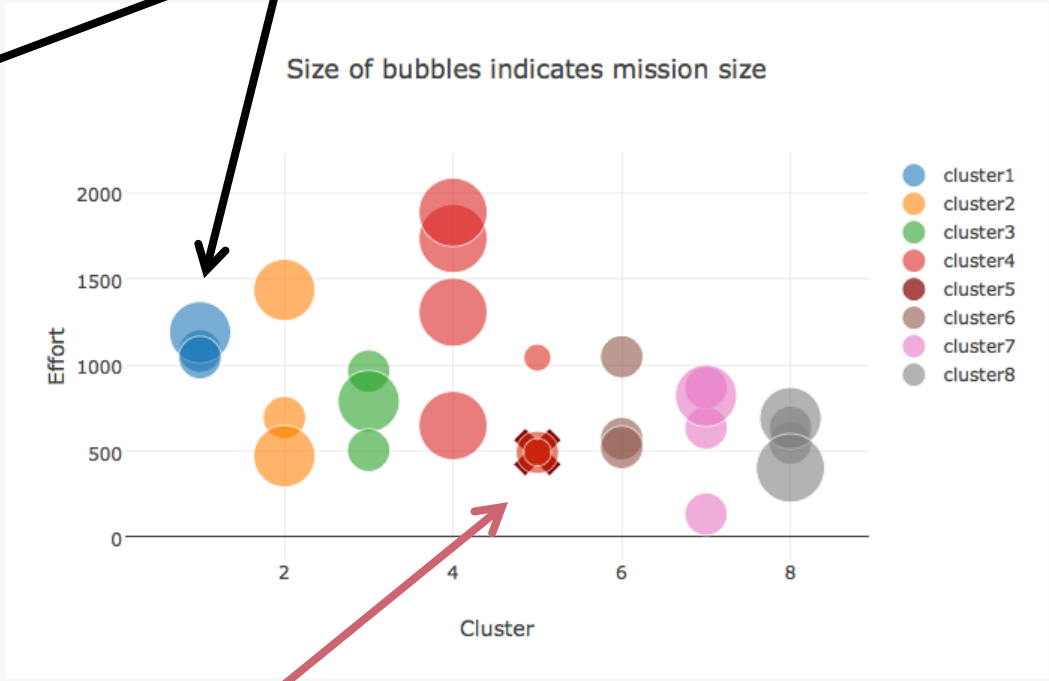
Data value popups

Effort Variation for Medium Earth Orbiter Ex. 1

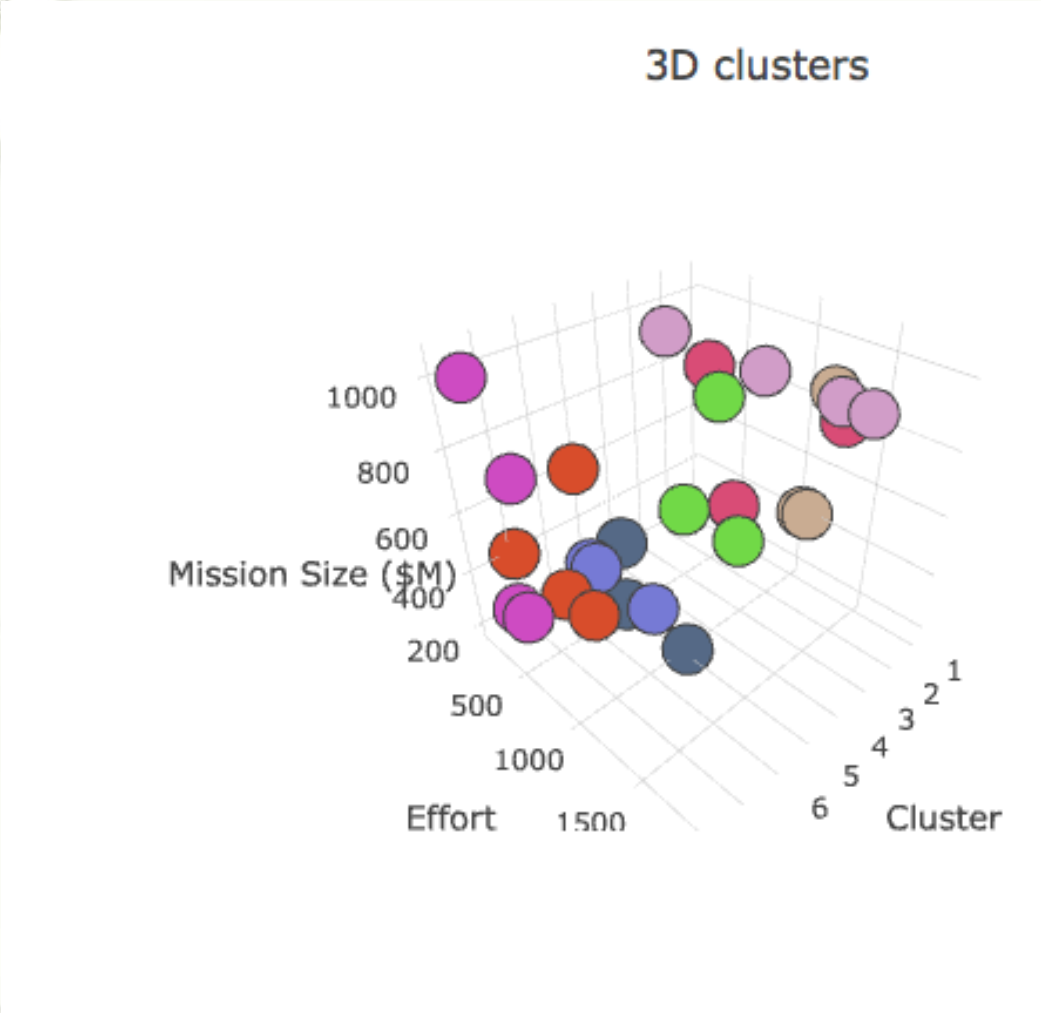
Effort: 493





Where estimate falls

ASCOT – 4 – Work In Progress



Next Steps

- Plan is to deliver ASCoT Rev 2 in early December
  - Add Simple regression, COCOMO II, Nearest Neighbor
  - Improved clustering algorithm
  - Add LOC estimates and statistics
  - Add MRE performance statistics
  - Add data export feature
- COMPACT, the CubeSat cost model, will be delivered in the same web-based environment
- Paper forthcoming for IEEE Aerospace

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Back Up

Development Team

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Jet Propulsion Laboratory, California Institute of Technology

- Requirements, Tool Development, Data Specification and Collection, Domain Expertise

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- Methodology

James Johnson

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- Requirements, Review, Oversight, Domain Expertise