Development of the Small Satellite Cost Model 2014 (SSCM14)

Eric Mahr, Anh Tu, Anil Gupta
The Aerospace Corporation

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Outline

- Introduction
- History
- Modeling Framework
- CER Development
- Cost Risk
- Funding Profile
- Implementation
- Advantages & Limitations
- Current Plan
- Future Work
- Wrap-up

Motivation

- Paradigm shift in early 1990's saw a move from traditional large satellites to small satellites
  - *NASA Faster, Better, Cheaper (FBC)*
  - *Commercial communications*
  - *Universities*
  - *Technology demonstrations*

- Parametric weight-based cost models based on traditional large satellites do not accurately predict the costs of small satellites[G1,G2,G3]
  - *Overlook strategies that are an integral part of the small satellite design process*
    - Highly focused missions
    - Streamlined development process and reduced programmatic oversight
    - Shorter design lifetimes and lower reliabilities

- Need existed for a model that could credibly estimate costs of small satellites

Description

- Parametric cost model
- Estimates development and production cost of a spacecraft bus for small (<1000 kg total wet mass) Earth-orbiting or near-Earth planetary missions
- Subsystem-level Cost Estimating Relationships (CERs) derived from technical and cost database of historical small spacecraft
- CERs include cost drivers that are not strictly weight-based
  - *Performance*
  - *Configuration*
  - *Technology*
  - *Programmatics*
- Applies to civil, commercial and military missions

SSCM Small Satellite Cost Model

Current Users

- NASA
  - *JPL*
  - *NASA Headquarters*
  - *NASA Langley Research Center*
  - *NASA Goddard Space Flight Center*
- DoD
- Others
  - *Commercial contractors*
  - *Universities*
  - *Foreign organizations*

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History – External Funding

- Early 1990's: Funding from various DoD organizations
  - *Estimated system-level costs based on very limited database*
  - *Eventually implemented in DOS-based PC program known as the Small Satellite Cost Model (SSCM)*
  - *Used mass and other spacecraft technical parameters (e.g., power, pointing accuracy) to generate estimate*

- Mid-1990's: Continued refinement of both CER development methodology and modeling level of detail
  - *Introduction of General Error Regression Model (GERM) to develop CERs*
  - *Work begun on development of subsystem CERs*

- 1995: NASA's Lewis Research Center and HQ Code BC funded the first phase of an activity to gather information on small satellite capabilities and costs and develop subsystem CERs
  - *Effort involved an examination of technical and economic issues related to designing, manufacturing and operating small satellites*
  - *Data that was collected consisted not only of mass, power, technical parameters and cost for satellites, but also impacts on cost such as schedule difficulties, funding interruptions, requirements changes and cost-sharing among multiple contractors*
  - *Provided recurring and non-recurring costs of subsystems*

History – Internal Funding

- 1998: Funding for SSCM development and upgrades began to come from Aerospace internal funding
  - *First version to incorporate interplanetary spacecraft and Technology Readiness Levels (TRLs) to generate risk-based estimates*
  - *Model migrated from DOS-based to Excel-based tool*
  - *Two versions: Intro (system-level CERs, for public release) and Pro (subsystem-level CERs, for internal, government and data providers)*

- SSCM has been updated at various intervals over the last 15 years
  - *Releases in 2000, 2002, 2005, 2007 and 2010*
  - *Major updates*
    - SSCM02: User interface; cost risk algorithm; funding profile spread
    - SSCM05: Two sets of CERs derived – Small satellites ~100 kg to 1000 kg total wet mass) and Micro satellites (~100 kg and below total wet mass)
  - *Recent updates incorporated new data*

Small Satellite Cost Model 2014 (SSCM14)

- Technical and cost database was expanded to include missions that had recently been launched
- Review of cost drivers used in CERs

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Small Satellite Cost Model

Small Satellite Characteristics

Characteristic	Cost Related Observation
Physical	
Light (Mass)	Reduced spacecraft cost
Small (Volume)	Simplified systems engineering
Functional	
Specialized design	Reduce interface requirements, complexity
Dedicated mission	Fewer users, shorter lifetimes
Procedural	
Short project schedule	Focused design effort, minimize optimization
Streamlined organization	Less management structure
Developmental	
Existing components/facilities	No development of new parts or technologies
Software advances	Extensive software reuse
Risk Acceptance	
Low to moderate mission value	Rely on existing technology
Higher tolerance for mission risk	Reduced redundancy, complexity
Launch	
Small vehicle or piggyback	Avoid launch date slips, stand-downs
Ground Terminals	
Simplified/autonomous	Need fewer personnel

SSCM Small Satellite Cost Model

Elements Estimated

- Satellite Program
  - Program Management (PM)/Systems Engineering (SE)/Mission Assurance
  - Flight Segment
    - **Spacecraft Bus**
      - **Attitude Determination and Control Subsystem (ADCS)**
      - **Propulsion**
      - **Power**
      - **Telemetry, Tracking and Command (TT&C)**
      - **Command and Data Handling (C&DH) [includes Flight Software]**
      - **Structure**
      - **Thermal**
    - Payload
    - **Integration, Assembly and Test (IA&T) [includes Ground Support Equipment (GSE)]**
    - **Program Management (PM)/Systems Engineering (SE)/Mission Assurance (MA)**
    - **Launch and Orbital Operations Support (LOOS)**
  - Ground Segment
  - Mission Operations
  - Launch Segment

Elements estimated highlighted in **bold**

SSCM Small Satellite Cost Model

Subsystem Definitions

Subsystem	Components
ADCS	Control electronics, attitude sensors (earth, sun, star, magnetometers, gyroscopes), actuators (torque coils, reaction/momentum wheels) and gravity gradient booms
Propulsion	Tanks, thrusters, servo electronics and propellant feed plumbing
Power	Batteries, power control electronics, power converters, wire harness and solar arrays
TT&C/C&DH	Antennas, transponders, baseband units, receivers, transmitters, telemetry encoders/decoders, command processors, power amplifiers, signal and data processing equipment and magnetic or solid state data recorders
Structure	Support structure for spacecraft and payload, launch adapter or deployment mechanism, other deployment mechanisms and miscellaneous minor parts
Thermal	Thermostats, heaters, insulation (tape, blankets), special conductors and heat pipes. Does not include payload-specific cooling equipment.
IA&T	Research/requirements specification, design and scheduling of IA&T procedures, ground support equipment, spacecraft bus and payload-to-bus integration, systems test and evaluation and test data analyses. Typical tests include thermal vacuum and cycle, electrical and mechanical functional, acoustic, vibration, electromagnetic compatibility/interference and pyroshock.
PM/SE/MA	Systems engineering (quality assurance, reliability, requirements activities), program management, data/report generation, and special studies not covered by or associated with specific satellite subsystems
LOOS	Prelaunch planning, trajectory analysis, launch site support, launch-vehicle integration (spacecraft portion) and initial on-orbit operations before ownership is turned over to the operational user (typically 30 days)

Assumption & Ground Rules

- Estimates are the cost of developing and producing one spacecraft bus
  - *No concept development or operations*
    - From post-Preliminary Design Review (PDR) to Launch+30 days
    - Phase C/D for NASA and Phase B & part of Phase C for DoD
  - *No payload or launch vehicles/upper stages*
  - *Non-recurring and recurring costs can be estimated separately, using provided factors*
    - Non-recurring costs cover all efforts associated with design, drafting, engineering unit IA&T and ground support equipment
      - *Includes all costs associated with design verification and interface requirements (e.g., drawings, schematics, mockups, boilerplates, breadboards and brassboards)*
    - Recurring costs cover all efforts associated with flight hardware manufacture & IA&T

- Estimates yield costs that represent an “average” amount of heritage, an “average” level of technology complexity and an “average” amount of schedule delays and engineering changes
  - *Make use of cost risk to account for possible heritage savings or development difficulties*

Assumptions & Ground Rules (cont.)

- Estimates are actual contractor costs at completion
  - *Burdened costs including direct labor, material, overhead and general and administrative costs*
  - *No award fees/incentives or government costs*
  - *Attempt to include civil service costs where a NASA center acted as the contractor*
  - *Contractor estimate at complete (EAC) used for satellites not complete at time data was provided*

- CERs are statistical fits to data derived from actual costs of recent small satellite programs
  - *Assumption: Historical trends used to generate CERs will accurately reflect future costs*
  - *CERs developed using constant year dollars*
    - Underlying cost data inflated using most recent NASA inflation indices
    - FY14$ for SSCM14

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CER Development

- Identification of cost drivers in each subsystem
  - *Technical database contains 100+ technical parameters*
  - *Narrowed field of potential cost drivers using statistics, sound engineering judgment and common sense*

- Several forms of CER were considered for each set of inputs
  - *One-variable linear and non-linear*
  - *Multi-variable, using non-correlated cost drivers*

- Data from a particular subsystem was segregated if it made engineering sense
  - *e.g., Spin-stabilized vs. 3-axis stabilized attitude control subsystems*

General Error Regression Model (GERM)

- Significant work has been done at Aerospace in developing regression techniques for application to cost analysis

- Errors can either be additive (a) or multiplicative (m)

Linear:

$$y = a + bx + \varepsilon \quad \text{(a)}$$

$$y = (a + bx) * \varepsilon \quad \text{(m)}$$

Nonlinear:

$$y = ax^b + \varepsilon \quad \text{(a)}$$

$$y = ax^b \varepsilon \quad \text{(m)}$$

– *Additive errors are independent of the driving cost parameters*
  - This can be a problem in cases such as when costs change by an order of magnitude or more as a function of the parameters

– *Multiplicative error makes the error proportional to the magnitude of the estimate, effectively making it a function of the parameters*
  - This is the formulation used in the development of SSCM

General Error Regression Model (GERM) (cont.)

- The goal then is to develop CERs with coefficients that minimize the sum of squared relative deviations (errors) from the predictions
  - *In other words, minimize the sum of squared percentage errors*

$$\text{minimize } \sum(\varepsilon_i - 1)^2 = \sum\left[\frac{y_i}{f(x_i)} - 1\right]^2 = \sum\left[\frac{y_i - f(x_i)}{f(x_i)}\right]^2$$

- The above equation is arrived at through the use of "General Error Regression" and solved through the use of the "General Error Regression Model (GERM)"[CR1]
  - *Implementation of Least Squares that provides ability to solve linear and non-linear equations with both additive and multiplicative error*
  - *Also aids in finding the global minimum for any equation form*

CER Quality Assessment

- There are a number of ways to assess the quality of a derived CER
  – *Standard Error of Estimate (SEE): root-mean-square (RMS) of all percentage errors made in estimating points of the data*
  – *Average Percentage Bias: algebraic sum (positives and negatives included) of all percentage errors made in estimating points of the data averaged over the number of points*
  – *Pearson's Correlation Squared (R2): measures the amount of correlation between estimates and corresponding database actuals*

- Two schools of thought within the GERM framework as to which types of CERs to derive: Minimum Percentage Error (MPE) or Minimum Percentage Error under Zero Percentage Bias constraint (MPE-ZPB)
  – *Currently SSCM is developed using MPE-ZPB*

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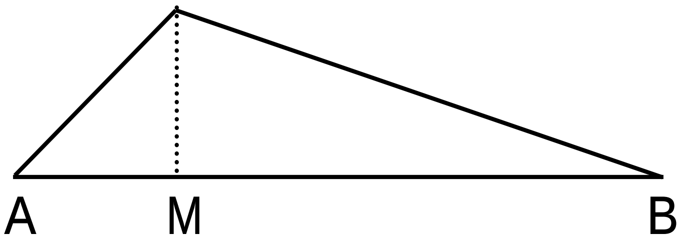
Cost Risk Modeling

- Point estimate generated by any cost model does not reflect uncertainty or risk

- Two sources of error: general cost estimating uncertainty and technical risk
  - *General cost estimating uncertainty is an attribute of the model*
    - In SSCM, it is quantified by the SEE
  - *Technical risk is an attribute of the mission under development*
    - Cost growth due to unforeseen technical difficulties has greater potential to cause costing uncertainty than any other single influence*
      - *Cost growth can be mitigated by avoiding undeveloped technologies and using high heritage components and designs*

- SSCM treats technical risk as a triangular cost probability distribution
  - *Point estimate is most likely value (M)*
  - *Lower and upper limits (A, B) are user-defined based on their understanding of the heritage and technology maturity of the subsystem*



Example Triangular Distribution

*GAO Report NSIAD 93-97, 1993

Cost Risk Calculation

- Need to combine the two sources of error into one cost probability distribution

$$Mean = \frac{1}{3}(A + B + M) \qquad Var = SEE^2 + \frac{1}{18}(A^2 + B^2 + M^2 - AB - AM - BM)$$

- Total variance is also affected by correlation of the errors in the individual subsystems[CR2,CR3,CR5]
  - *Correlation coefficients calculated using Pearson's product-moment correlation*[CR4]

$$Var_T = \sum_{i=1}^{n} Var_i + 2\sum_{k=2}^{n}\sum_{j=1}^{k-1} \rho_{jk}\sigma_j\sigma_k$$

- The outcome is a total spacecraft cost-probability distribution
  - *Performed using FRISK which uses a lognormal approximation to calculate confidence percentiles without Monte Carlo simulation*[CR6]

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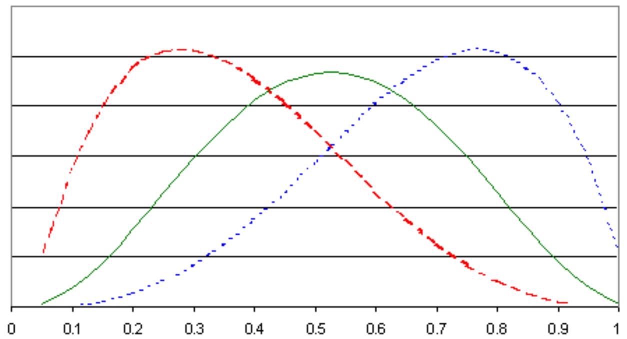
Spreading Costs Over Project Duration

- SSCM generates curves of expected expenditures over the development phase of a mission
  - *Illustrates required funding by fiscal year and cumulative funding*
- Cost estimate is allocated by fiscal year depending on user input of launch date and length of development schedule
  - *Spreads costs over Phases B/C/D*
    - Phase B estimated by addition of 10% to Phases C/D estimate produced by model[FP2]
  - *Plot can be generated using a choice of values from cost risk analysis*
  - *Values can be in constant year or real year dollars*
- Funding by fiscal year uses beta curve formula[FP1]
  - *Shape based on the fraction of funding spent by the midpoint of the schedule*



Example Funding Profile Curves

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SSCM14 User Interface

Technical Parameter	Units	Value	Notes
Programmatic			
Fiscal Year for Estimate	YYYY	2014	
Inflation Methodology	---	NASA	
Development Time	months	48.0	
Calendar Year for Phase B Start	YYYY	2015	
Design Life	months	60.0	
System			
Destination	---	Planetary	
Satellite Wet Mass	kg	750.0	
Spacecraft Bus Dry Mass	kg	300.0	
Number of Instruments	#		
Power			
Solar Array Mounting Type	---	Deployed – Fixed	
Solar Cell Type	---	Gallium Arsenide	
Battery Type	---		
Power Subsystem Mass	kg	80.0	
BOL Power	W	500	
Solar Array Area	m^2	10.00	
Structure			
Primary Structure Material	---	Aluminum	
Structure Subsystem Mass	kg	100.0	
ADCS			
Star Tracker?	---	Yes	
ADCS Subsystem Mass	kg	40.0	
Pointing Control	deg	0.003	
Propulsion			
Monopropellant or Bipropellant?	---	Monopropellant	
Propulsion Subsystem Dry Mass	kg	50.0	
TT&C/C&DH			
Communications Band	---		
TT&C/C&DH Subsystem Mass	kg	40.0	
Transmit Power	W	60	
Data Storage Capacity	MB	100	
Thermal			
Thermal Subsystem Mass	kg	25.0	

Input Data

Technical Parameter	Range				
	Low	Minimum	Value	Maximum	High
Development Time (ATLO)					
Development Time (PM/SE)		12.0	48.0	92.2	
Design Life		0.2	60	96.0	
Spacecraft Bus Dry Mass (ATLO)		52.0	300.0	778.0	
Spacecraft Bus Dry Mass (PM/SE)		52.0	300.0	699.4	
Number of Instruments					
Power Subsystem Mass		22.3	80.0	160.8	
BOL Power (Power)					
BOL Power (Structure)					
BOL Power (Thermal)		141	500	10500	
Solar Array Area		1.15	10.00	36.42	
Structure Subsystem Mass		16.8	100.0	298.0	
ADCS Subsystem Mass		0.6	40.0	59.2	
Pointing Control	32.4%	0.004	0.003	3.000	
Propulsion Subsystem Dry Mass		7.1	50.0	118.2	
TT&C/C&DH Subsystem Mass		4.7	40.0	106.7	
ansmit Power		1	60	100	
orage Capacity		.3	100	96000	
ystem Mass		.0	25.0	53.0	

Comparison to CER Data

1

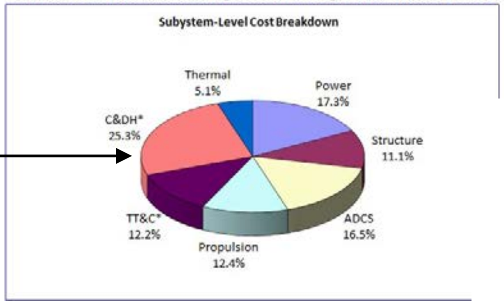
Subsystem Cost Estimates

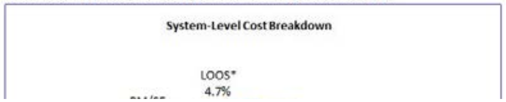
	Estimate (FY14$K)				% of	% of	Range
	Non-rec	Rec	Total	Std Error	Sub-level	Sys-level	Range
Spacecraft Bus Subsystems							
Power	3,647	5,814	9,460	4,569	17.3%		
Structure	3,147	2,900	6,047	2,165	11.1%		
ADCS	4,197	4,783	8,980	3,349	16.5%		Pointing Control is 32.4% low.
Propulsion	2,311	4,474	6,[illegible]84	3,250	12.4%		
TT&C*	3,309	3,362	6,671	10,396	12.2%		
C&DH*	6,841	6,952	13,793		25.3%		
Thermal	1,445	1,347	2,793	1,167	5.1%		
Spacecraft Bus	24,897	29,631	54,528	12,521	100%	67.2%	
IA&T*	4,512	5,062	9,574	5,855		11.8%	
PM/SE	6,079	7,182	13,260	7,227		16.3%	
LOOS*	0	3,795	3,795			4.7%	
S/C Development & First Unit	35,488	45,669	81,157	15,598		100%	

2

*TT&C/C&DH and IA&T/LOOS costs are generated from single CERs and standard error is presented as such. Per subsystem cost presented is based on database data.

Cost Breakdown





SSCM14 User Interface (cont.)

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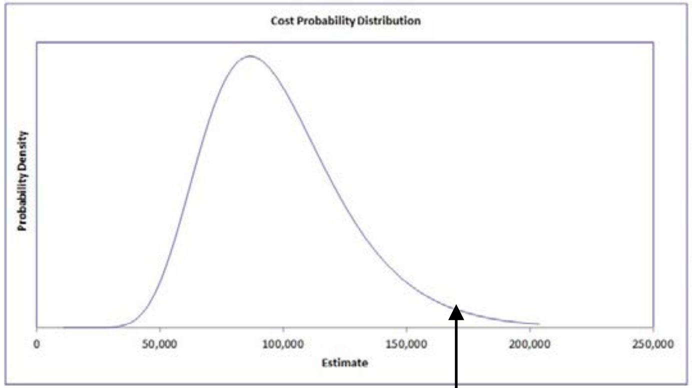
Cost Risk Assumptions

3

Risk-Adjusted Estimates

	Percentages		Distribution Points			Estimate (FY14$K)	
	Low	High	Low	Most Likely	High	Mean	Std Dev
Spacecraft Bus Subsystems							
Power	20%	[illegible]	7,568	9,460	14,191	10,406	5,216
Structure	5%	35%	5,744	6,047	8,163	6,651	2,441
ADCS	10%	40%	8,082	8,980	12,571	9,878	3,810
Propulsion	10%	10%	6,106	6,784	7,463	6,784	[illegible]
TT&C/C&DH	0%	150%	20,464	20,464	51,161	30,696	17,190
Thermal	5%	45%	2,653	2,793	4,049	3,165	1,360
Spacecraft Bus			50,618	54,528	97,598	67,581	23,664
ATLO	0%	60%	13,368	13,368	21,389	16,042	7,276
PM/SE	0%	30%	13,260	13,260	17,239	14,586	8,005
S/C Development & First Unit			77,246	81,157	136,226	98,210	29,106



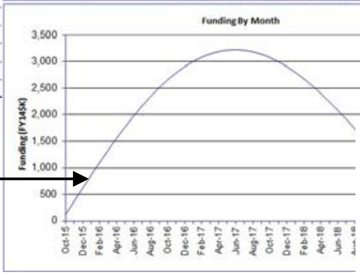
Percentiles of Cost (FY14$K)	
Percentile	Cost
10%	64,921
15%	69,706
20%	73,760
25%	77,425
30%	80,871
35%	84,201
40%	87,488
45%	90,790
50%	94,161
55%	97,658
60%	101,344
65%	105,300
70%	109,636
75%	114,516
80%	120,206
85%	127,196
90%	136,572
95%	151,754

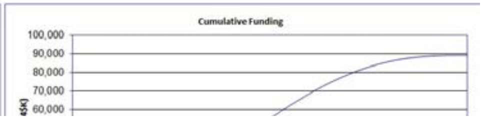
4

Launch Date (MM/DD/YYYY)		Sep-19
Estimate Choice		Base Estimate
Funding Spent at Schedule Midpoint (%)		60
Basis for Funding Profile	Constant Year	Real Year

Milestone	Date
Development Start	Oct-15
Development End	Sep-19

Funding Profile (FY14$K)	FY16	FY17	FY18	FY19
Yearly Funding	16,773	36,790	28,979	6,730
Cumulative Funding	16,773	53,563	82,542	89,272





Cost-Probability Distribution

Funding Profile

SSCM14 User Interface (cont.)

- Navigation Toolbar
- User-defined Inflation Factors
- Glossary
- Drivers
- CERs
- Graphs
- Inputs Sheet

Navigation Toolbar

Year	NASA	OSD	Custom
2004	4.19%	2.00%	
2005	3.80%	2.80%	
2006	4.20%	3.10%	
2007	3.59%	2.70%	
2008	2.87%	2.40%	
2009	1.32%	1.50%	
2010	2.32%	0.80%	
2011	2.04%	2.00%	
2012	0.99%	1.80%	
2013	1.85%	1.50%	
2014	2.21%	1.50%	
2015	2.38%	1.70%	
2016	2.57%	1.90%	
2017	2.80%	2.00%	
2018	2.75%	2.00%	
2019	2.61%	2.00%	
2020	2.58%	2.00%	
2021	2.57%	2.00%	
2022	2.56%	2.00%	
2023	2.57%	2.00%	
2024	2.65%	2.00%	
2025	2.60%	2.00%	
2026	2.60%	2.00%	
2027	2.60%	2.00%	
2028	2.60%	2.00%	
2029	2.60%	2.00%	
2030	2.60%	2.00%	
2031	2.60%	2.00%	
2032	2.60%	2.00%	
2033	2.60%	2.00%	
2034	2.60%	2.00%	

User-defined Inflation Factors

Example – Inputs

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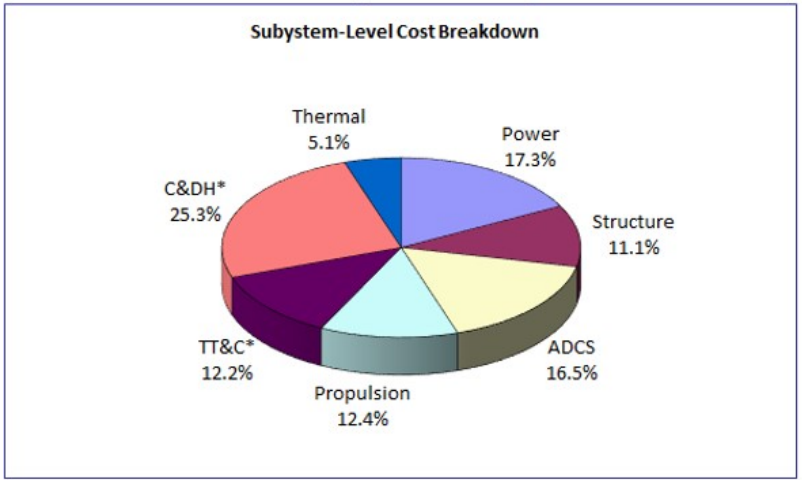
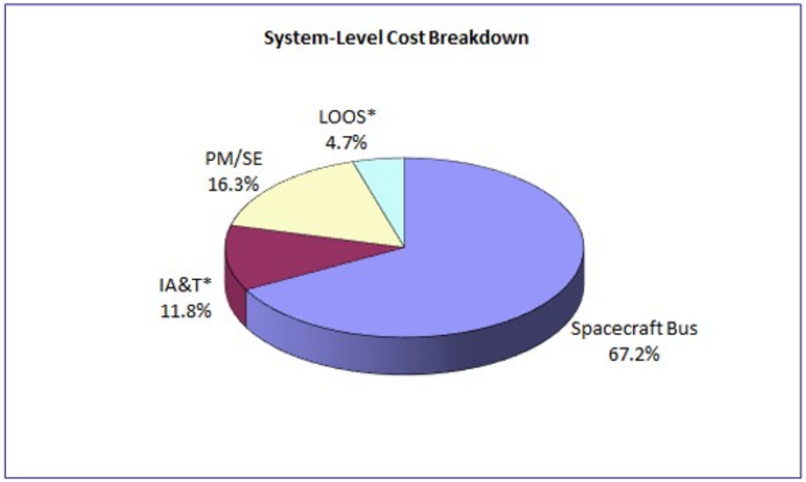
Spacecraft Bus Subsystems							
Power	3,647	5,814	**9,460**	4,569	17.3%		
Structure	3,147	2,900	**6,047**	2,165	11.1%		
ADCS	4,197	4,783	**8,980**	3,349	16.5%		Pointing Control is 32.4% low.
Propulsion	2,311	4,474	**6,784**	3,250	12.4%		
TT&C*	3,309	3,362	**6,671**	10,396	12.2%		
C&DH*	6,841	6,952	**13,793**		25.3%		
Thermal	1,445	1,347	**2,793**	1,167	5.1%		
Spacecraft Bus	**24,897**	**29,631**	**54,528**	**12,521**	**100%**	67.2%	
IA&T*	4,512	5,062	**9,574**	5,855		11.8%	
PM/SE	6,079	7,182	**13,260**	7,227		16.3%	
LOOS*	0	3,795	**3,795**			4.7%	
S/C Development & First Unit	**35,488**	**45,669**	**81,157**	**15,598**		**100%**	

*TT&C/C&DH and IA&T/LOOS costs are generated from single CERs and standard error is presented as such. Per subsystem cost presented is based on database data.

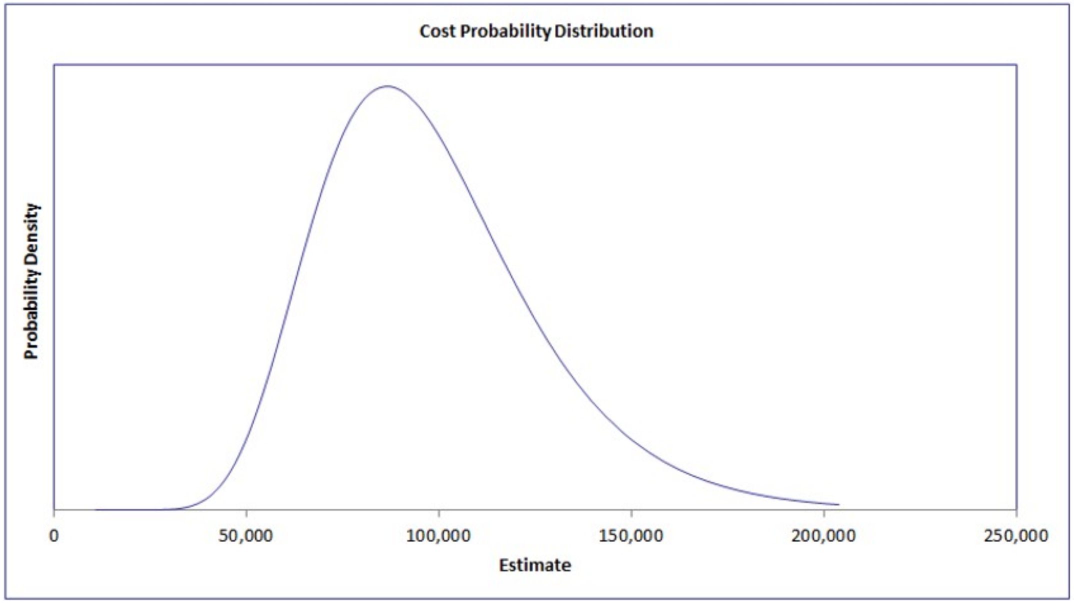




SSCM Small Satellite Cost Model

Example – Cost Risk

	Percentages		Distribution Points			Estimate (FY14$K)	
	Low	High	Low	Most Likely	High	Mean	Std Dev
Spacecraft Bus Subsystems							
Power	20%	50%	7,568	9,460	14,191	10,406	5,216
Structure	5%	35%	5,744	6,047	8,163	6,651	2,441
ADCS	10%	40%	8,082	8,980	12,571	9,878	3,810
Propulsion	10%	10%	6,106	6,784	7,463	6,784	3,262
TT&C/C&DH	0%	150%	20,464	20,464	51,161	30,696	17,190
Thermal	5%	45%	2,653	2,793	4,049	3,165	1,360
Spacecraft Bus			50,618	54,528	97,598	67,581	23,664
ATLO	0%	60%	13,368	13,368	21,389	16,042	7,276
PM/SE	0%	30%	13,260	13,260	17,239	14,586	8,005
S/C Development & First Unit			77,246	81,157	136,226	98,210	29,106



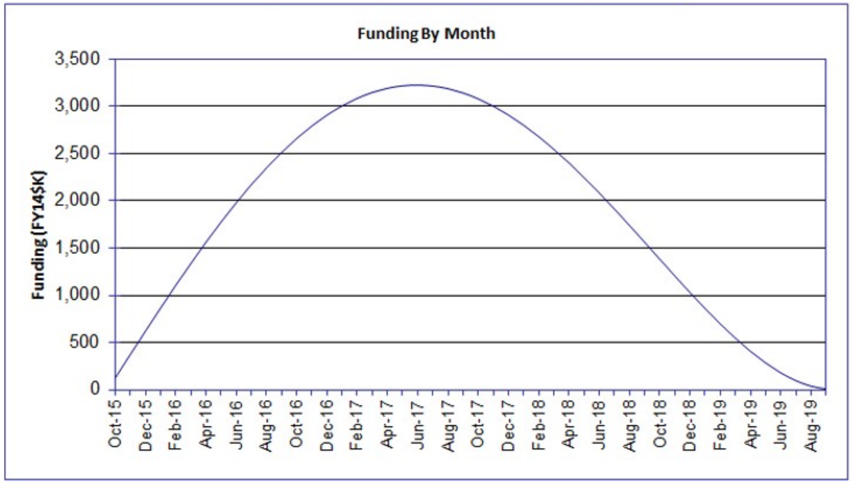
Percentiles of Cost (FY14$K)	
Percentile	Cost
10%	64,921
15%	69,706
20%	73,760
25%	77,425
30%	80,871
35%	84,201
40%	87,488
45%	90,790
50%	94,161
55%	97,658
60%	101,344
65%	105,300
70%	109,636
75%	114,516
80%	120,206
85%	127,196
90%	136,572
95%	151,754

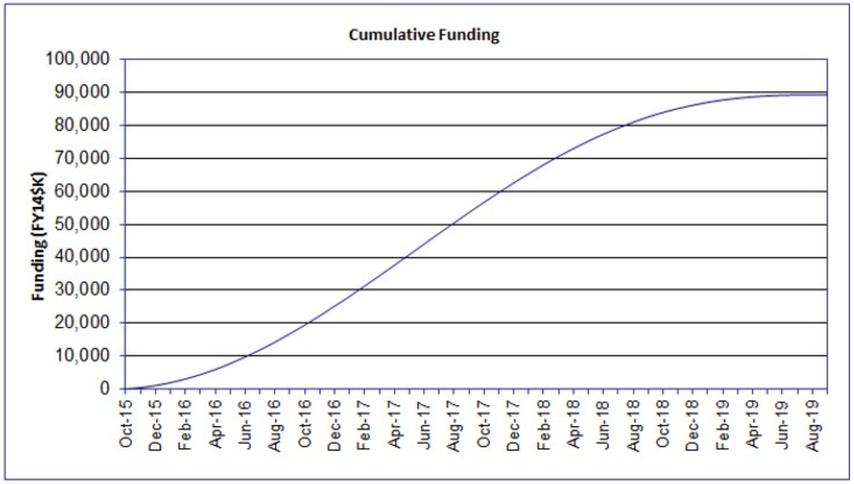
Example – Funding Profile

Launch Date (MM/DD/YYYY)	Sep-19
Estimate Choice	Base Estimate
Funding Spent at Schedule Midpoint (%)	60
Basis for Funding Profile	◉ Constant Year ○ Real Year

Milestone	Date
Development Start	Oct-15
Development End	Sep-19

Funding Profile (FY14$K)	FY16	FY17	FY18	FY19
Yearly Funding	16,773	36,790	28,979	6,730
Cumulative Funding	16,773	53,563	82,542	89,272





Outline

- Introduction
- History
- Modeling Framework
- CER Development
- Cost Risk
- Funding Profile
- Implementation
- Advantages & Limitations
- Current Plan
- Future Work
- Wrap-up

Advantages & Limitations

- SSCM is very useful for cost estimation in the project development phase
  - *Provides top-down cost estimate*
  - *Limited number of inputs required*
  - *Most inputs are high-level system parameters*
  - *Detailed design not required to generate cost estimate*
  - *Cost risk analysis can be used to allocate adequate reserves*
- SSCM is less useful when detailed estimates are required
  - *Need for a bottoms-up estimate*
  - *Designs that trade mass versus complexity*
  - *Trade studies looking at specific hardware component performance and levels of redundancy*

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Plans for Next Release

- General cycle is every two to three years
  - *Targeting 2017*
- Collect more data
  - *Add missions launched since last release*
  - *Gather more complete data for missions with partial data*
- Generate new CERs
  - *Revisit assumptions about cost drivers*
  - *Incorporate newest data*

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Tasks for the Future

- Nothing specific identified
  - *Always looking to improve tool functionality*

SSCM
Small Satellite Cost Model

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Summary

- SSCM is
  - *Used to estimate the development and production costs of small satellite buses*
  - *A parametric, subsystem-level cost model*
  - *Most applicable to proposal and concept study level designs*
  - *Updated periodically to reflect trends in recent small satellite missions*
  - *A tool to perform cost risk analysis on a given point estimate*
  - *A tool to create preliminary budgeting profiles*

Contacts

- Presenter:
  - *Eric Mahr*
    - Email – eric.m.mahr@aero.org, Phone – 310-336-5329

- Website:

  http://www.aerospace.org/expertise/technical-resources/small-satellite-cost-model/

  - *Provides general description and instructions for obtaining the model*

- Email: sscm@aero.org
  - *Contact for more information or to obtain a data survey form*

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