Standardizing Space Systems O&M Cost Estimating [Cost Estimating Research Overview]

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Agenda

- Project Objectives
- O&M Cost Estimating Context
- Proposed Cost Element Structure
- Issues and Uncertainties
- Summary

Project Objectives

- **Far Term**

Develop and implement an integrated cost estimating tool which accommodates cost models for all phases of a Space System's Life Cycle

- **Near Term**

Develop and document an O&M Cost Element Structure (CES)

  - Create a hierarchal cost structure consistent with a program work breakdown structure
  - Create a representation of the CES which relates the structure temporally to a Space System's Life Cycle Phases
  - Conduct data analysis of current program O&M cost data to determine the most appropriate Cost Estimating Relationships (CERs)

Operations and Maintenance (O&M) Context

- **Space O&M Definitions**
  - Operations consists of those actions required to use a system for its intended purpose
  - Maintenance consists of corrective or preventative actions taken to ensure equipment or material is in an operational condition
- **Estimate Of Current Space O&M Cost Modeling Situation**
  - Some aspects of maintenance are addressed in the operations models but not all aspects
  - There is a void in maintenance models
  - Space Community has a set of uncoordinated O&M cost models
  - Space Community lacks a comprehensive CES for O&M

Survey of O&S Cost Models (Active)

	Cost Methodology			Use In NASA Phase							
Model Name	**Parametric**	**Analogy**	**Build Up**	**Pre-A**	**A**	**B**	**C/D**	**E**	**CES**	**Strengths**	**Weaknesses**
Active Models Operations Cost Model (OCM)		X		X	X				X	1. Generation of ROM cost 2. Good off-line documentation 3. Includes a rate curve to account for annual per flight learning 4. Can be calibrated to historical data 5. Launch categories help provide mission context 6. CERs for non-recurring facilities 7. Includes flight rate	1. Not designed for broad dissemination (not "goof-proofed") 2. Single year cost - not Life-Cycle 3. WBS is somewhat confusing blurring direct and indirect costs 4. Large complex EXCEL spreadsheet
Model for Estimating Space Station Operations Cost (MESSOC)	X			X	X	X			X		1. No relational structure to CES
Space Operations Cost Model (SOCM)	X			X	X	X			X	1.CES can be organized into activities 2. Scable model -- ROM to Detailed Cost 3. Strong staffing focus 4. Good to Fair User Manual - no algorithmic docs	1. Not designed for broad dissemination (not "goof-proofed") 2. Single year cost - not Life-Cycle 3. WBS / CES does not handle direct and indirect costs separately 4. WBS structure is different than NASA CEH standard 5. Large complex EXCEL based spreadsheet which seems to be a little buggy. Never got it to start properly 6. Other non-labor costs hard to track
TRANSCOST - Space Ttansportation Systems Cost Estimation	X			X	X	X			X	1. Uses Man Year as cost in order to get cost data which is valid internationally and without respect to annual changes of inflation or other factors 2. Expilcitly handles direct and indirect costs 3. Good documentation 4. Weight and Size parametrics	1. Facilities are accounted for but rolled into other factors - should be more visable 2. Not readily available on line
Space Shuttle Program Retirement	X			X	X	X					
Shuttle Operations Simulation (ShuttOps Sim)[1]	X			X	X	X	X			1. A discrete event simulation of the Space Shuttle ground processing operation 2. Yields flight rate for the fleet and facility utilization	1. Limited scope 2. EXCEL based limited documentation
Launch and Landing Effects Ground Operations Model (LLEGO)[1]			X			X	X	X			1. Limited scope - ground processing only 2. EXCEL based with limited documentation
Generic Environment for Modeling Future Launch Operations (GEM-FLO)			X			X	X	X		1. Flights per year, facility utilization, half-widths, min's and max's	1. Limited scope - ground processing only 2. EXCEL based with limited documentation
E20 Supply Chain Sim[2]			X			X	X	X			

Notes:
1 - Very limited open source data
2 - No open source data

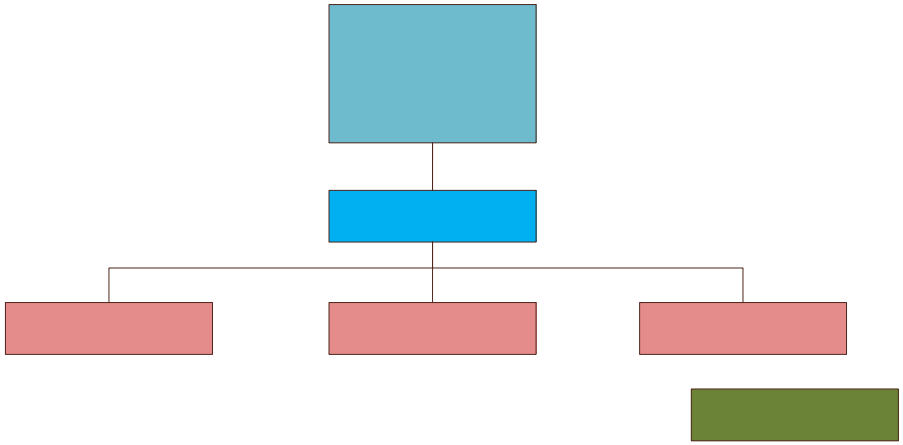
Survey of O&S Cost Models (Inactive)

Model Name	Cost Methodology			Use In NASA Phase					CES	Strengths	Weaknesses
	Parametric	Analogy	Build Up	Pre-A	A	B	C/D	E			
Inactive Models											
Reliability Maintainability Assessment Tool (RMAT) - matched to Logistics Cost Model (LCM)	X			[X]	[X]					1. Estimates reliability and maintainabillity requirements 2. R&M generated at subsystem level and can provide input to LCM to determine cost 3. Flight rate specific manpower, fleet size, maintenance burden, and turn-around time	
Architecture Assessment Tool-Enhanced (AATe)	X			[X]	[X]				X	1. Ops cost is an interaction of vehicles with ground infrastructure	
Mission Operations Cost Model (MOCM)	X			[X]	[X]					1. Very very quick top level estimate	1. Black box 2. Lacks documentation 3. Single rolled up value
Activity Generator / Estimator (SAGE)			X			[X]	[X]	[X]		1. For cost need to represent a vehicle by those characteristics that have been recognized by operations experts as having an effect on the ground processes and that are decided at the conceptual and early phases of the detailed level. 2. Integrated Vehcile and Flight Elements	

Notes:
1 - Very limited open source data
2 - No open source data

Comparison of O&M Cost Estimating Structure By O&M Model

Operational Cost Model (OCM)



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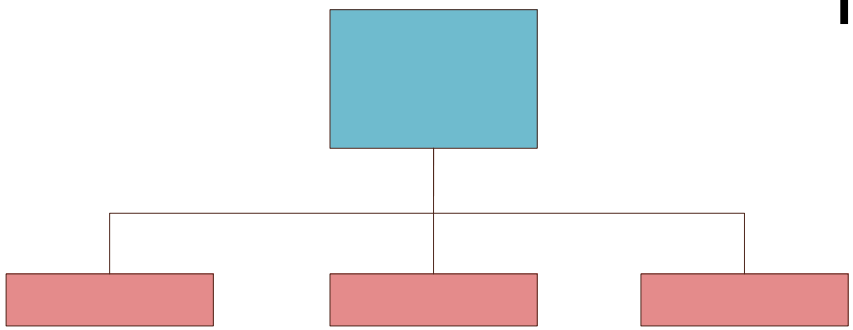


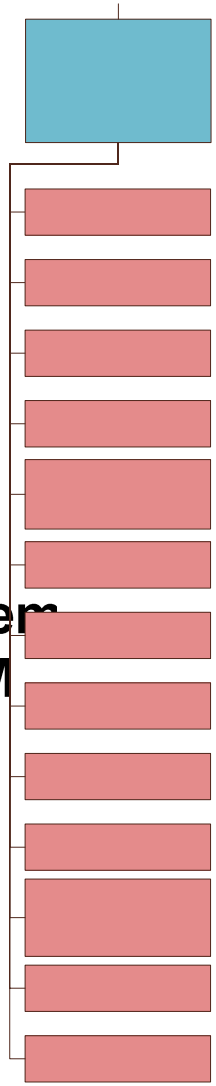
1.0 Program Segment

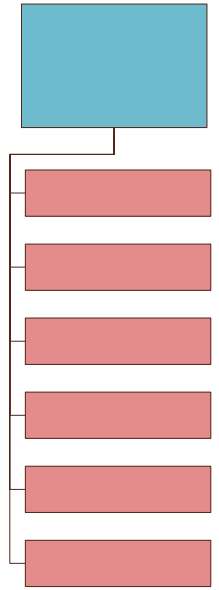
2.0 Vehicle Segment

3.0 Launch Operations Segment

4.0 Segment

Space Operational Cost Model (SOCM)[1]





Space System Total O&M Costs

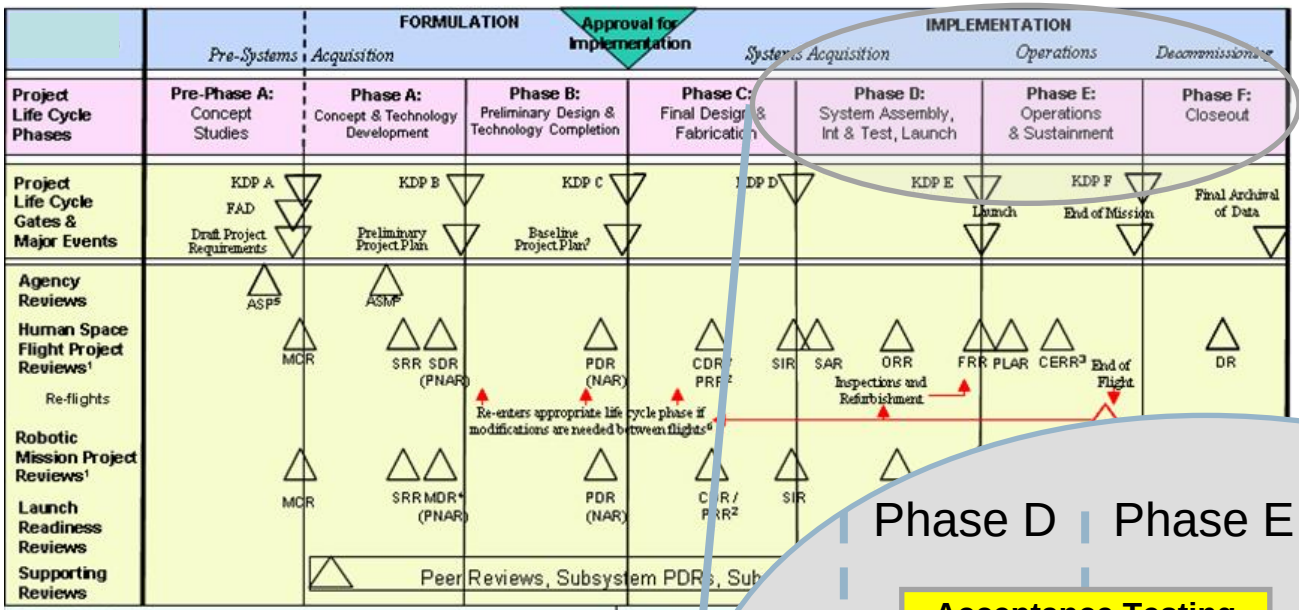
Notes
1 - SOCM has 2 different views or versions
2 – Architecture Assessment Tool Enhanced (AATe) 12 elements similar to SOCM traditional WBS output

Characterization of Space Vehicle O&M

- **Includes Direct System and Non-System Support Elements**
  - System includes booster, core, upper stage, engine, payload
  - Non-system includes launch pad facilities, mission control facilities, test facilities, and so forth
- **O&M Includes Both Fixed (level of effort) and Launch Rate (variable) Costs**
  - Fixed costs include launch pad and mission facility maintenance, base support (security, medical / safety, etc.)
  - Variable includes propellants, hardware refurbishment

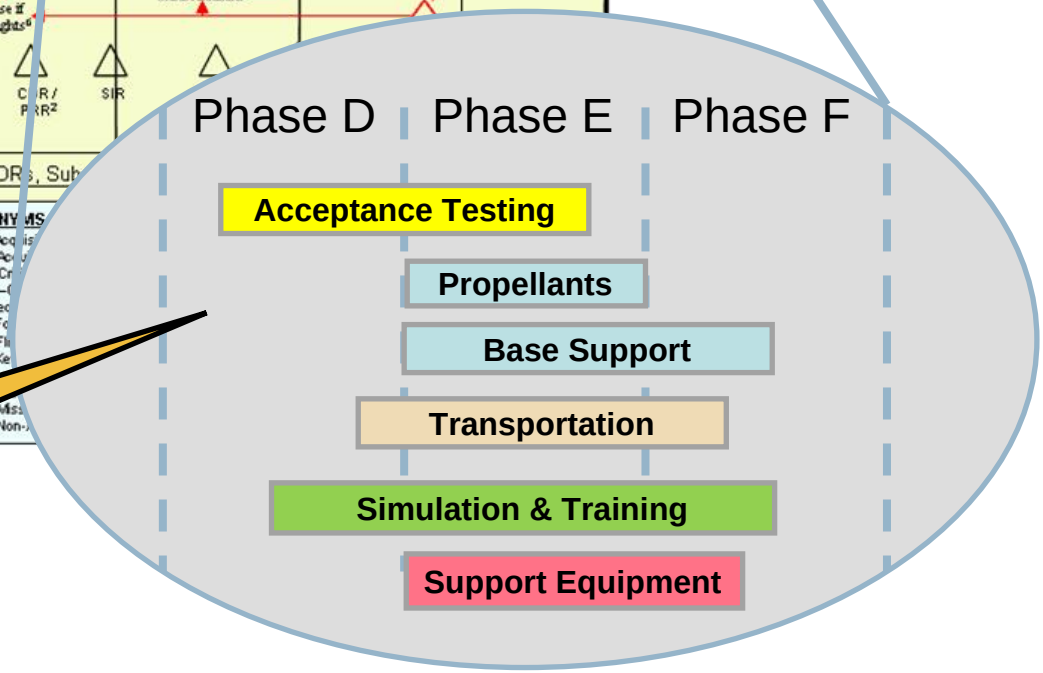
	Manned	Unmanned
Reusable	Shuttle	“Venturestar”
Expendable	Saturn / Apollo	EELV

O&M Cost Estimating Context



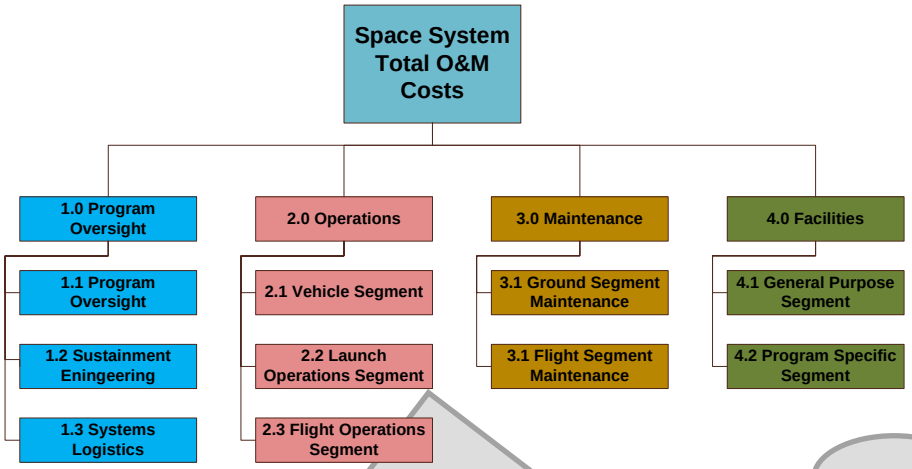
Key Cost Estimating Structure

- Vehicle Segment
- Launch Operations
- Flight Operations
- Ground Segment
- Flight Segment



Cost Estimating Structure should support temporal views of cost data

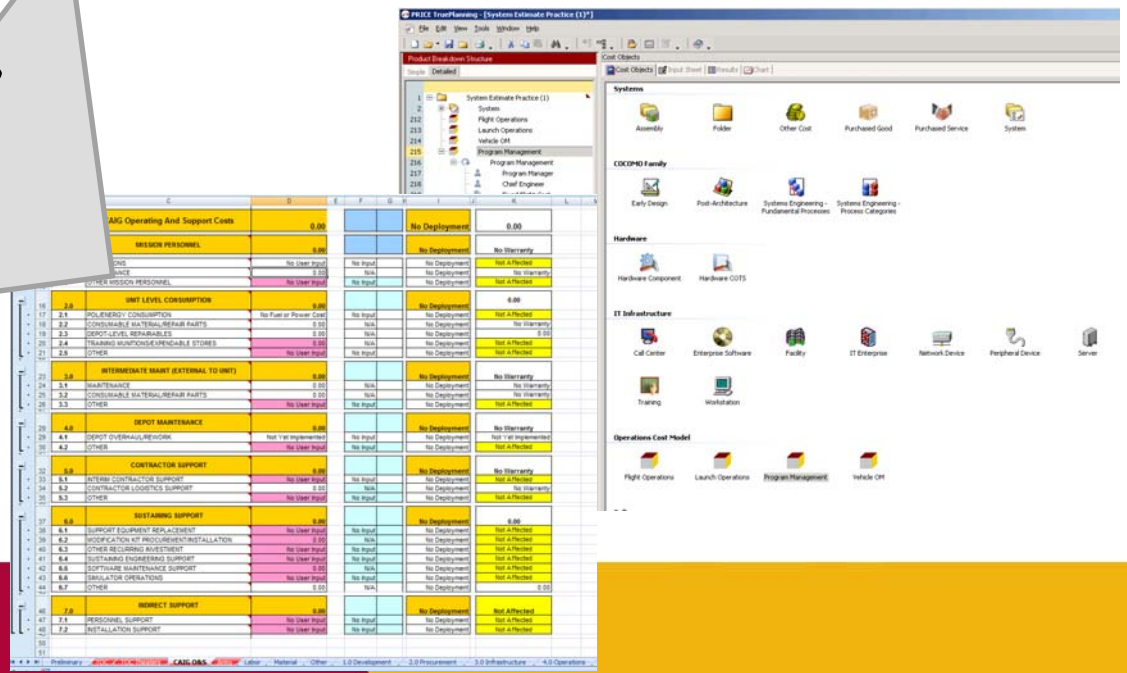
Space Systems O&M Costing Approach Discussion



Which Cost Estimating Approaches

Direct	Headcount (Fixed Cost + Variable Per Flight)
Ratios	TFU * Ratios Per WBS Cost Element
Parametric	Vehicle Segment – Expendable HW
	Vehicle Type Lookup
	1- Reusable * Total Spares Cost
	Total Spares Cost = TFU^(1-% reusable)

Work From End State to Cost Model CER to PRICE Software Setup and / or Changes



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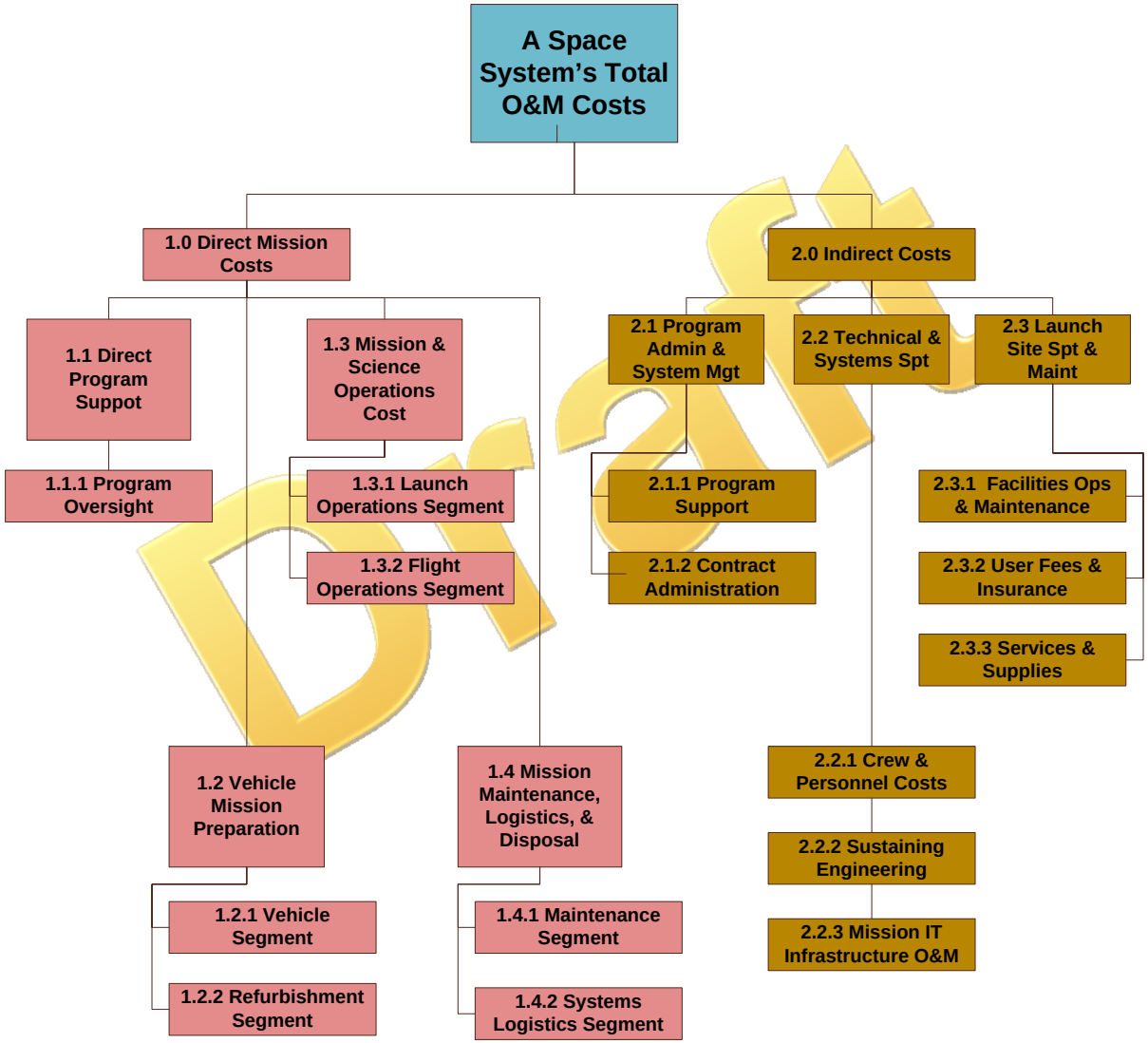
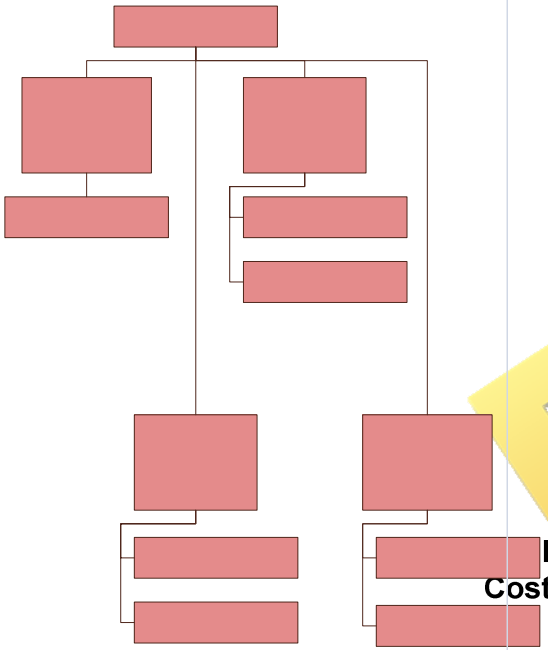
Proposed Cost Estimating Structures



Proposed Cost Estimating Structures Expansion
Direct Mission Costs

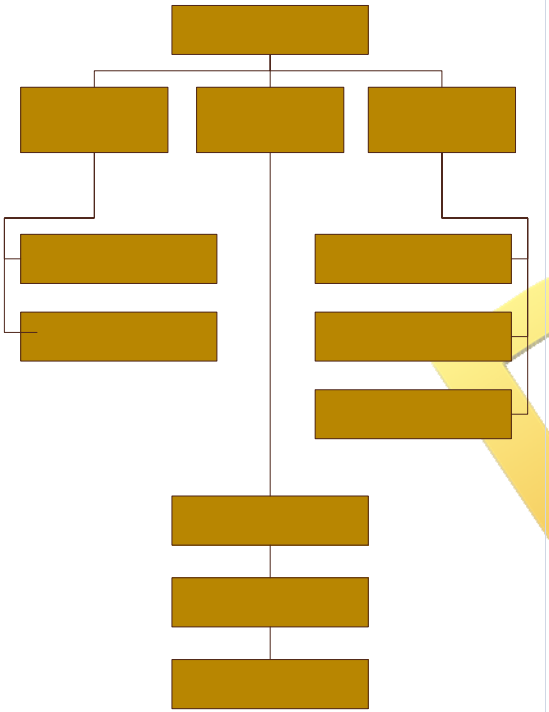


A Space Systems Total O&M Cost			
Tier 1	**Tier 2**	**Tier 3**	**Elements**
1.0 Direct Mission Costs	**1.1 Direct Program Management**	**1.1.1 Program Oversight**	1.1.1.1 Program Management 1.1.1.2 Sustaining Systems Engineering 1.1.1.3 Safety Reliability, Maintainability, and Quality Assurance
	1.2 Vehicle Mission Preparation	**1.2.1 Vehicle Segment**	1.2.1.1 Expendable Hardware Manufacturing 1.2.1.2 Assembly Integration 1.2.1.3 Acceptance Testing 1.2.1.4 Direct Contractor Labor
		1.2.2 Refurbishment Segment	1.2.2.1 Reusable Hardware Refurbishment 1.2.2.2 Vehicle Overhauls 1.2.2.3 Payload Overhauls 1.2.2.4 Launch Facilities Refurbishment 1.2.2.5 Direct Contractor Labor
	1.3 Mission & Science Operations Cost	**1.3.1 Launch Operations Segment**	1.3.1.1 Pre-launch Ground Operations 1.3.1.2 Processing Engineering 1.3.1.3 Payload Processing 1.3.1.4 Launch Site Transport 1.3.1.5 Propellants, Gases and Consumables 1.3.1.6 Ground Software O&M 1.3.1.7 Direct Contractor Labor
		1.3.2 Flight Operations Segment	1.3.2.1 Flight and Mission Planning 1.3.2.2 Mission Software O&M 1.3.2.3 Mission Control Operations 1.3.2.4 Mission Simulation & Training 1.3.2.5 Science Data Processing & Analysis 1.3.2.6 Direct Contractor Labor
	1.4 Mission Maintenance, Logistics, & Disposal	**1.4.1 Maintenance Segment**	1.4.1.1 Mission Control Maintenance 1.4.1.3 Vehicle Maintenance 1.4.1.3 Payload Maintenance 1.4.1.4 Training & Simulation Maintenance 1.4.1.5 Direct Contractor Labor
		1.4.2 Systems Logistics Segment	1.4.2.1 Ground Support Equipment Spares 1.4.2.2 Vehicle Spares 1.4.2.3 Payload Spares 1.4.2.4 Transport and Recovery 1.4.2.5 Storage Operations 1.4.2.6 Direct Contractor Labor 1.4.2.7 Disposal

1.1.1 Program Oversight

1.3.1 Launch Operations Segment

Proposed Cost Estimating Structures Expansion Indirect Mission Costs



2.1 Program Admin & System Mgt

2.2 Technical & Systems Spt

2.3 Launch Site Spt & Maint

2.0 Indirect Costs

A Space Systems Total O&M Cost			
Tier 1	**Tier 2**	**Tier 3**	**Elements**
2.0 Indirect Missions Cost	**2.1 Program Admin and System Management**	**2.1.1 Program Support**	2.1.1.1 Program Administration 2.1.1.2 Safety & Mission Assurance 2.1.1.3 Financial Management 2.1.1.4 Marketing
		2.1.2 Contract Administration	2.1.2.1 Contract Oversight 2.1.2.2 Contract Accounts
	2.2 Technical & Systems Support	**2.2.1 Crew and Personnel Costs**	2.2.1.1 Training & Education 2.2.1.2 Crew Support
		2.2.2 Sustaining Engineering	2.2.2.1 Engineering Labor
		2.2.3 Mission IT Infrastructure O&M	2.2.3.1 Network & Computer Operations 2.2.3.2 Command/Uplink Management 2.2.3.3 Data Capture & Accountability 2.2.3.4 Long Term Data Archive Support 2.2.3.5 IT Security
	2.3 Launch Site Support & Maintenance	**2.3.1 Facililties O&M**	2.3.1.1 Launch Facilities 2.3.1.2 Mission Control Facilities 2.3.1.3 Vehicle Assembly & Integration Facilities 2.3.1.4 Payload Processing Facilities 2.3.1.5 Testing Facilities 2.3.1.6 Landing & Recovery Facilities 2.3.1.7 Adminstrative & Engineering Facilities 2.3.1.8 Roads and Grounds 2.3.1.9 Non-Recurring Facilities Cost
		2.3.2 User Fees & Insurance	2.3.2.1 Launch Site and Mission Support User Fees 2.3.2.2 Public Damage Insurance 2.3.2.3 Vehicle Loss Charge 2.3.2.4 Mission Abort Charge
		2.3.3 Services & Supplies	2.3.3.1 Base Support 2.3.3.2 Range and Safety Operations

Element Definitions

2.1.1 Program Support	2.1.1.1 Program Administration 2.1.1.2 Safety & Mission Assurance 2.1.1.3 Financial Management 2.1.1.4 Marketing
2.1.2 Contract Administration	2.1.2.1 Contract Oversight 2.1.2.2 Contract Accounts
2.2.1 Crew and Personnel Costs	2.2.1.1 Training & Education 2.2.1.2 Crew Support
2.2.2 Sustaining Engineering	2.2.2.1 Engineering Labor
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Rkoury:

2.1.1.1 Program Administration (SOCM+OCM+BK New)
Program administration; business development, business operations, interface coordination to non-project support; project scientist; program control

2.1.1.2 Safety & Mission Assurance (TRASNCOST + BK - new)
Safety and Mission Assurance is the technical and management efforts of directing and controlling the safety and mission assurance elements of the project. This element includes design, development, review, and verification of practices and procedures and mission success criteria intended to assure that the delivered spacecraft, ground systems, mission operations, and payload(s) meet performance requirements and function for their intended lifetimes. This element excludes mission and product assurance efforts directed at partners and subcontractors other than a review/oversight function, and the direct costs of environmental testing.
source NASA procedural requirements 7120.5D
http://nodis3.gsfc.nasa.gov/npg_img/N_PR_7120_005D_/N_PR_7120_005D_.pdf

2.1.1.3 Financial Management (TRASNCOST + BK - new)
Finance and budget oversight, accounting, earned value management, budget tracking and review

2.1.1.4 Marketing (TRASNCOST + BK - new)
Direct and support labor associated with public relations, marketing, and customer relations. Includes marketing services and supplies.

Issues and Uncertainties

- **Issues**
  - Project Scope
    - Level of Cost Estimating Relationships to be developed
  - Validated data and data availability
- **Uncertainties**
  - Single standard approach from clean sheet of paper or legacy
  - Generic approach which can accommodate all research centers
  - Implementation in PRICE H only
  - What level of implementation - integration