Solar Imager Radio Array (SIRA)

Price - H Cost Modeling

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Why Do a Parametric Cost Model?

- **Validate "grass-roots" cost estimate**
  - PRICE H approaches cost estimate by describing hardware to be built, development environment, and operational environment
  - PRICE H model is built from engineering data (e.g., mass properties spreadsheet) readily available in the IMDC
  - PRICE H cost estimate is an independent cost assessment derived from the engineering data used to develop grass-roots cost estimates
- **Consistent with Technical, Management, and Cost (TMCO) approach**
  - NASA-wide site license for PRICE H (and SEER) managed by Langley Research Center
  - RAO at GSFC is official point-of-contact for PRICE H licenses for GSFC
  - According to Dr. David Gilman, NASA Langley Research Center (Jan. 2002), parametric models used during TMCO reviews to validate cost proposals
  - Criteria for validation: proposal cost estimate and parametric model estimate within 10%
- **Improved understanding of:**
  - Cost drivers
  - Impact of design trades
  - Impact of schedule constraints/slips

PRICE H Cost Model

- **PRICE H: Commercial Parametric Hardware Cost Modeling Tool**
- **Tool Heritage: DOD**
- **Global Parameters:**
  - Labor Costs: 2003 GSFC Bid Rates (labor and overhead)
  - Inflation (NASA Escalation Table)
  - Engineering Environment
    - NASA environment defined by PRICE Systems, Inc. calibration study
    - Baseline environment emphasizes System Engineering, Project Management, and automated design capabilities
- **Key Component Parameters:**
  - Complexity Factors (Table driven from industry experience)
  - Modification Level/Remaining Design Factor (Heritage)
  - Quantity and Design Repeat (Learning Curve)
  - Composition (Structure, Electronic, Purchased, Cost Pass-through)
  - Mass
  - Operating Platform (Unmanned Space – High Reliability)

IMDC PRICE H Cost Modeling

- **SIRA study began with IMDC PRICE H cost model template**
  - S/C Bus cost model template developed over 2.5 years
  - Multiple proposal efforts and prior IMDC studies have contributed to template development
  - New knowledge and experience gained from prior studies incorporated in cost model template
  - SIRA cost model inherits knowledge and experience gained from over 2.5 years of cost modeling

- **IMDC study output products:**
  - Power-point presentation
  - PRICE H model exported to Summary Excel Spreadsheet
  - PRICE H model exported to Detailed Excel Spreadsheet
  - PRICE model file (requires PRICE H software)
  - Upon request: Text reports containing input/outputs for each cost element

Top-Level Cost Model

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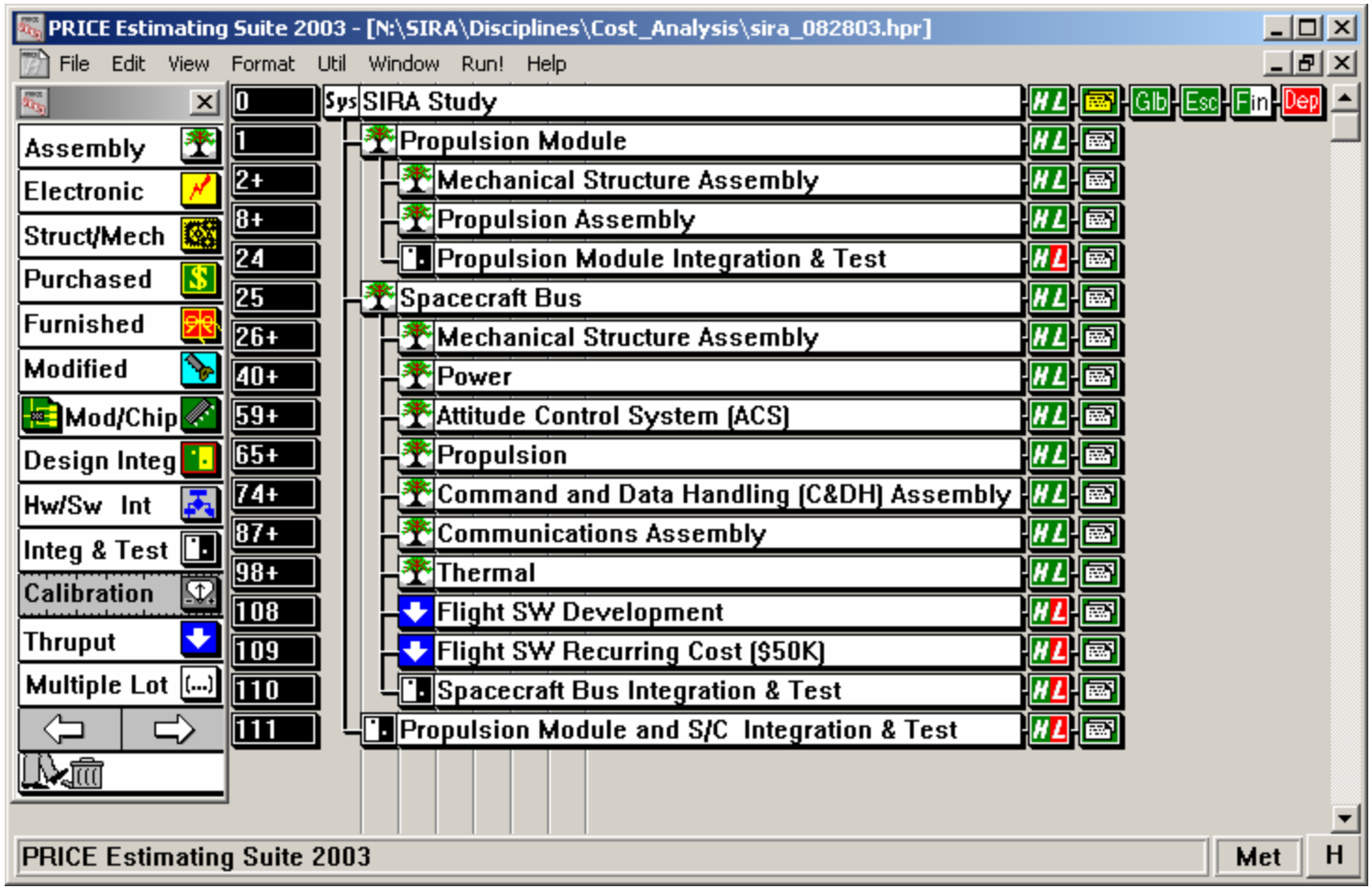

Expanded Model

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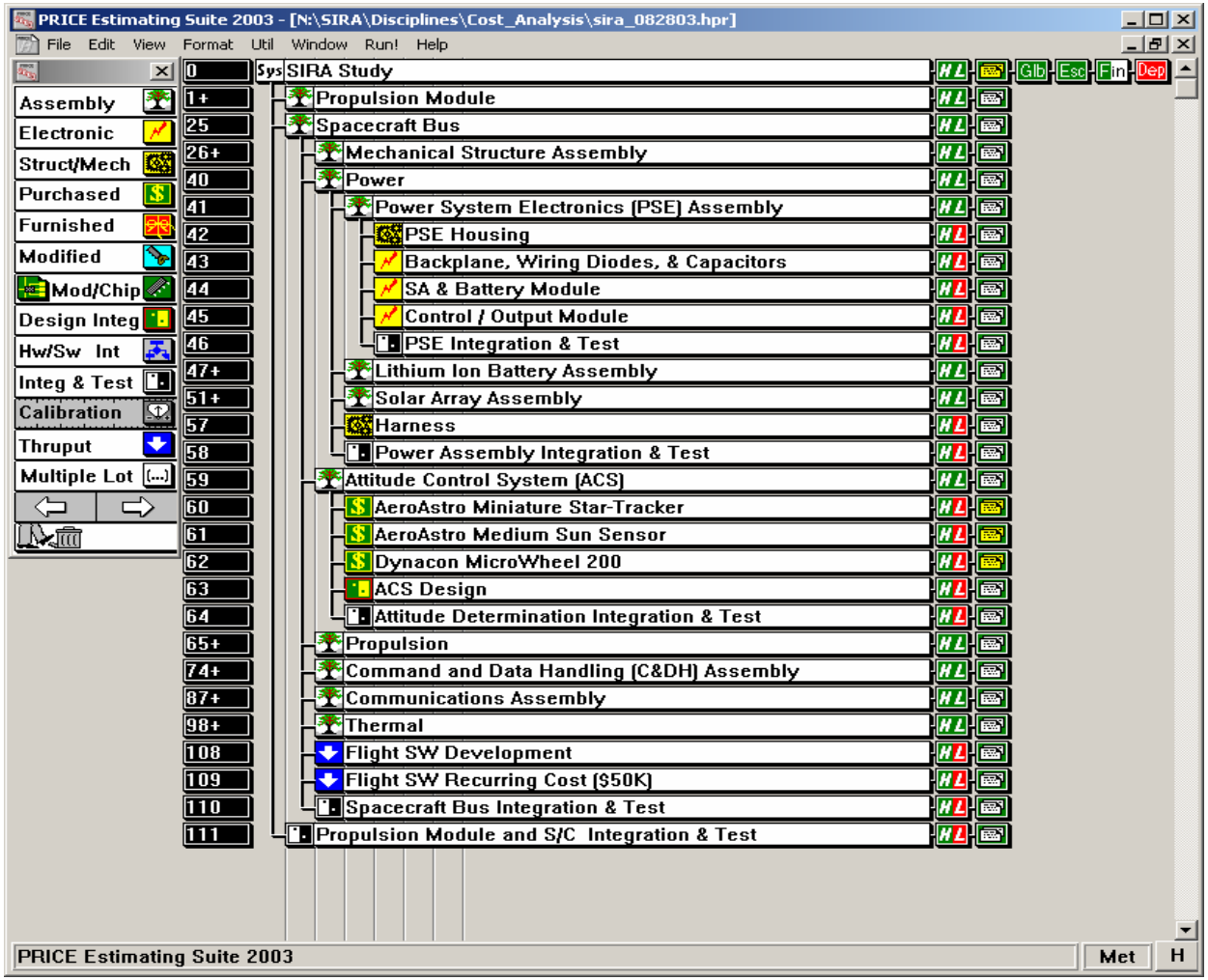

PRICE H Summary Report
(SIRA: Propulsion Module & 1 S/C)

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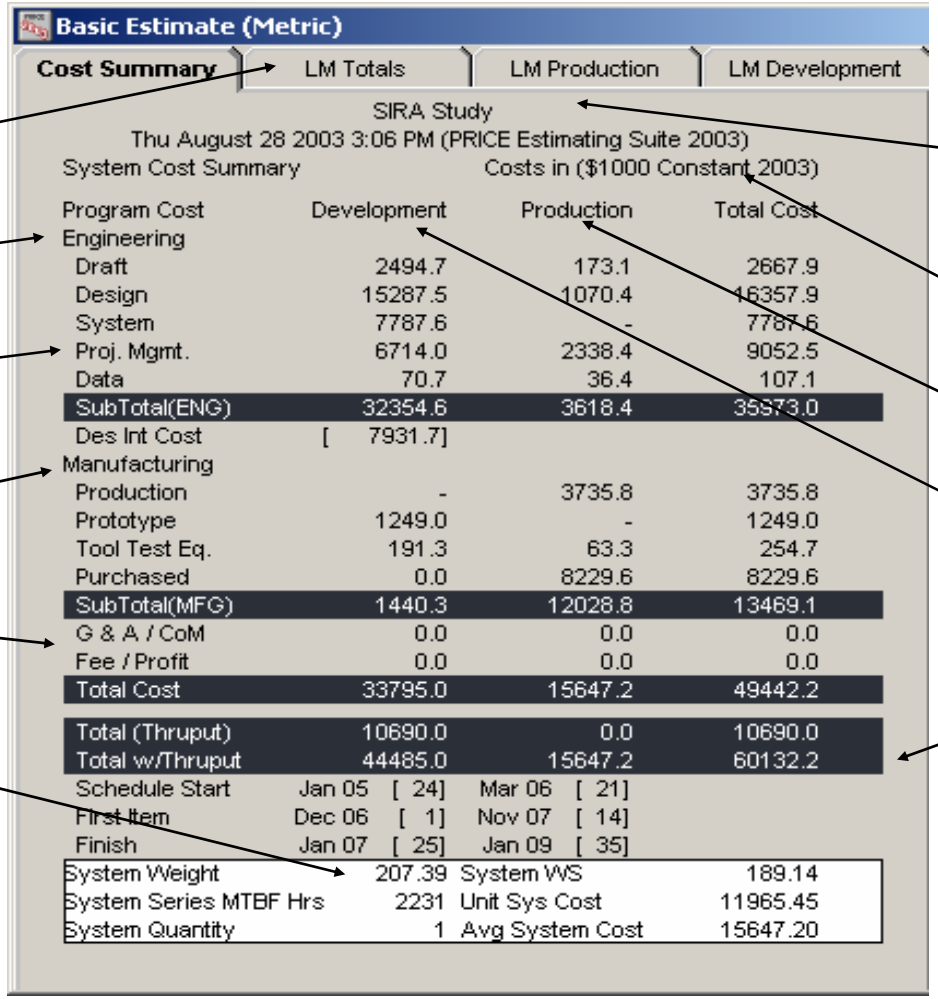

Basic Estimate (Metric)

Cost Summary | LM Totals | LM Production | LM Development

SIRA Study
Thu August 28 2003 3:06 PM (PRICE Estimating Suite 2003)
System Cost Summary — Costs in ($1000 Constant 2003)

Program Cost	Development	Production	Total Cost
Engineering			
Draft	2494.7	173.1	2667.9
Design	15287.5	1070.4	16357.9
System	7787.6	-	7787.6
Proj. Mgmt.	6714.0	2338.4	9052.5
Data	70.7	36.4	107.1
SubTotal(ENG)	32354.6	3618.4	35973.0
Des Int Cost	[7931.7]		
Manufacturing			
Production	-	3735.8	3735.8
Prototype	1249.0	-	1249.0
Tool Test Eq.	191.3	63.3	254.7
Purchased	0.0	8229.6	8229.6
SubTotal(MFG)	1440.3	12028.8	13469.1
G & A / CoM	0.0	0.0	0.0
Fee / Profit	0.0	0.0	0.0
Total Cost	33795.0	15647.2	49442.2
Total (Thruput)	10690.0	0.0	10690.0
Total w/Thruput	44485.0	15647.2	60132.2
Schedule Start	Jan 05 [24]	Mar 06 [21]	
First Item	Dec 06 [1]	Nov 07 [14]	
Finish	Jan 07 [25]	Jan 09 [35]	

System Weight	207.39	System WS	189.14
System Series MTBF Hrs	2231	Unit Sys Cost	11965.45
System Quantity	1	Avg System Cost	15647.20

Labor/Material

Engineering

Project Management

Manufacturing

G&A, Fee

Mass

Cost Element (Summary Report Available for each cost element)

Real Year Dollars

Production

Development

Propulsion Module & S/C (Qty. 1) Cost Estimate $60.13M

Learning Curve Basics

- **PRICE H Users Manual:**
  - Basis for improvement is the “human learning process”
  - Learning curves in PRICE H apply to production run (not development)
  - The more one produces, the more efficient one becomes

- **NASA Cost Estimating Handbook (April 2002)**
  - The learning curve concept is used primarily for ***uninterrupted manufacturing and assembly tasks***
  - The major premise of learning curves is that each time the product quantity doubles the resources (labor hours) required to produce the product will reduce by a determined percentage.

Multiple Production Unit Studies (PRICE H Learning Curve)

- **PRICE H:**
  - Calculates Theoretical First Piece (T1) production unit (most costly to produce)
  - Incorporates industry standard Boeing Unit Learning Curve (ULC)
  - Applies a correction factor to improve accuracy (for lower quantity studies)
  - Includes Stanford-b formula to transfer prototype learning to manufacturing
  - Calculates Production Average Unit Cost (UPC)

$$\text{Production Cost} = T1\,\frac{(QTY + QCF + Stan\_b)^{A} - (QCF + Stan\_b)^{A}}{A} - ULCF$$

Where:

$$ULCF = \frac{(A - 1)(A - 2)}{24}$$

ULCF is PRICE H correction factor

$$A = 1 + \frac{\ln(UNITLC)}{\ln(2)}$$

Part of Boeing Equation

$$QCF = 0.5151 - 0.001116 \ln(QTY)$$

Quantity dependent correction factor

$$Stan\_b = (\text{input \%})(Protos)$$

Percent of Prototypes to include

SIRA Learning Curves for Microsats

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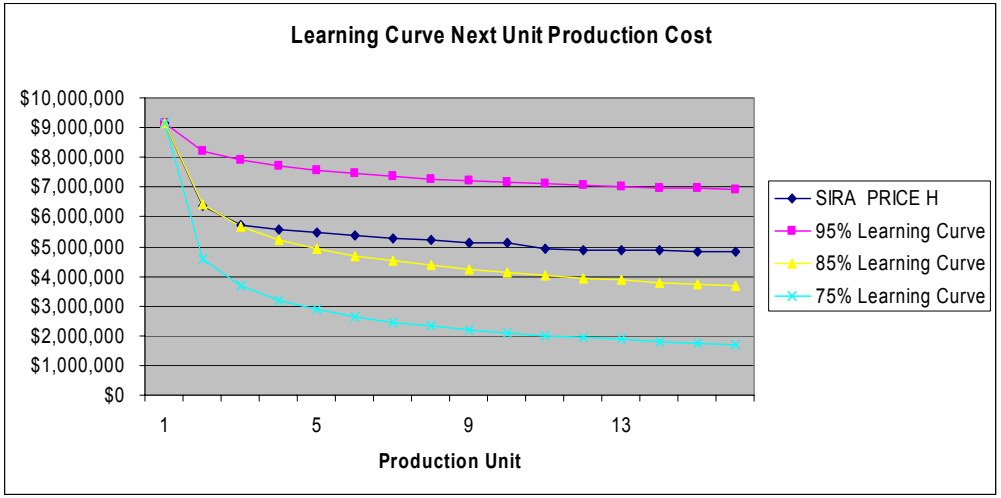
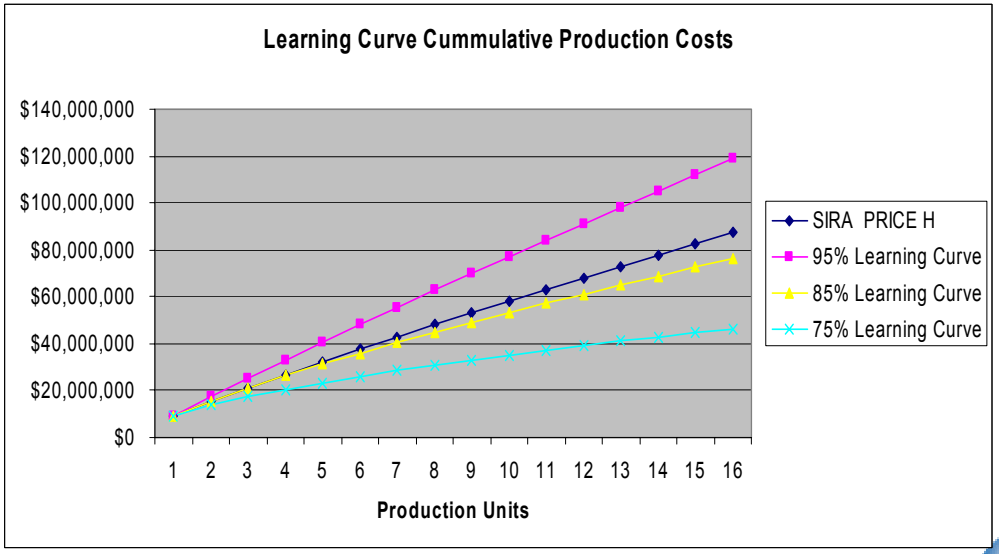
NASA Cost Estimating Handbook (April 2002) Section 7.6 Learning Curves Rules of Thumb	
Aerospace	85%
Complex machine tools	75-85%
Electronics manufacturing	90-95%
Machining or punch press	90-95%
Repetitive electrical operations	75-85%
Repetitive welding operations	90%
Raw materials	93-96%
Purchased parts	85-88%





PRICE H Summary Report
(SIRA: Propulsion Module & 12 S/C)

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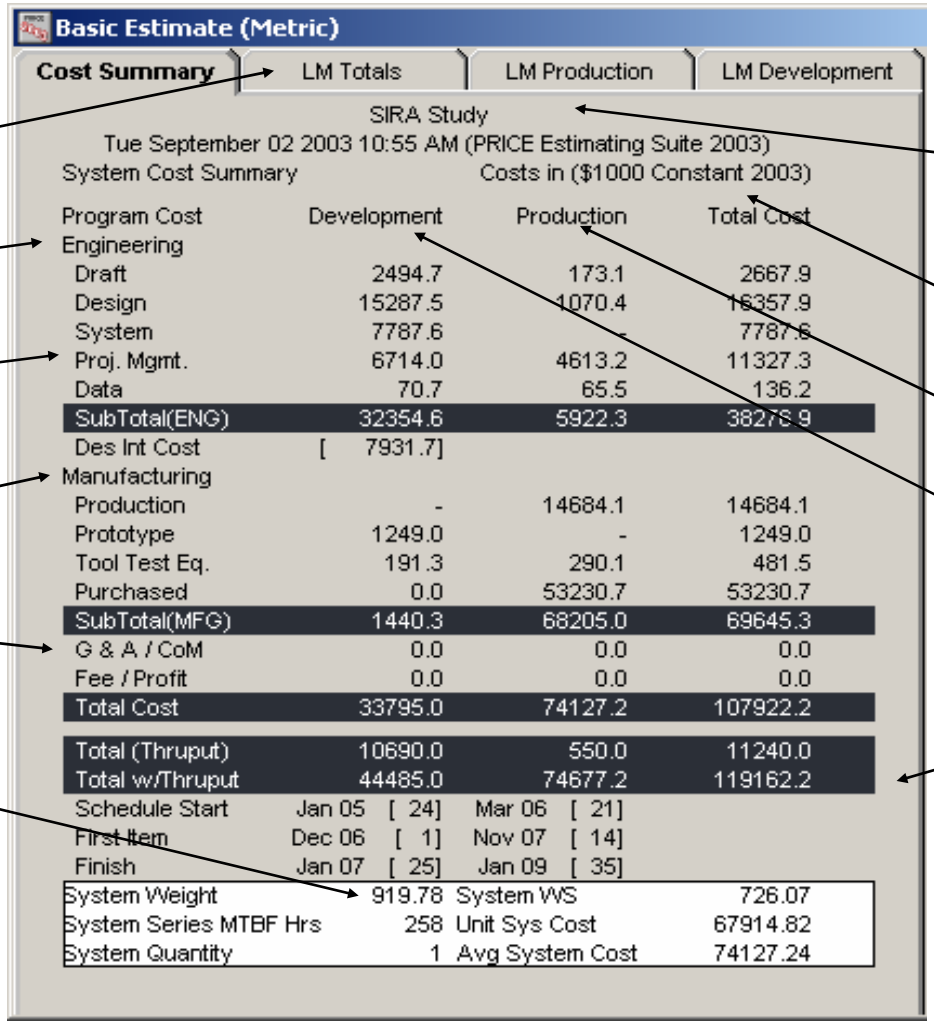

Basic Estimate (Metric)

Cost Summary | LM Totals | LM Production | LM Development

SIRA Study
Tue September 02 2003 10:55 AM (PRICE Estimating Suite 2003)
System Cost Summary — Costs in ($1000 Constant 2003)

Program Cost	Development	Production	Total Cost
Engineering			
Draft	2494.7	173.1	2667.9
Design	15287.5	1070.4	16357.9
System	7787.6	-	7787.6
Proj. Mgmt.	6714.0	4613.2	11327.3
Data	70.7	65.5	136.2
SubTotal(ENG)	32354.6	5922.3	38276.9
Des Int Cost	[7931.7]		
Manufacturing			
Production	-	14684.1	14684.1
Prototype	1249.0	-	1249.0
Tool Test Eq.	191.3	290.1	481.5
Purchased	0.0	53230.7	53230.7
SubTotal(MFG)	1440.3	68205.0	69645.3
G & A / CoM	0.0	0.0	0.0
Fee / Profit	0.0	0.0	0.0
Total Cost	33795.0	74127.2	107922.2
Total (Thruput)	10690.0	550.0	11240.0
Total w/Thruput	44485.0	74677.2	119162.2
Schedule Start	Jan 05 [24]	Mar 06 [21]	
First Item	Dec 06 [1]	Nov 07 [14]	
Finish	Jan 07 [25]	Jan 09 [35]	

System Weight	919.78	System WS	726.07
System Series MTBF Hrs	258	Unit Sys Cost	67914.82
System Quantity	1	Avg System Cost	74127.24

Labor/Material

Engineering

Project Management

Manufacturing

G&A, Fee

Mass

Cost Element (Summary Report Available for each cost element)

Real Year Dollars

Production

Development

Propulsion Module & S/C (Qty. 12) Cost Estimate $119.16M

PRICE H Summary Report
(SIRA: Propulsion Module & 16 S/C)

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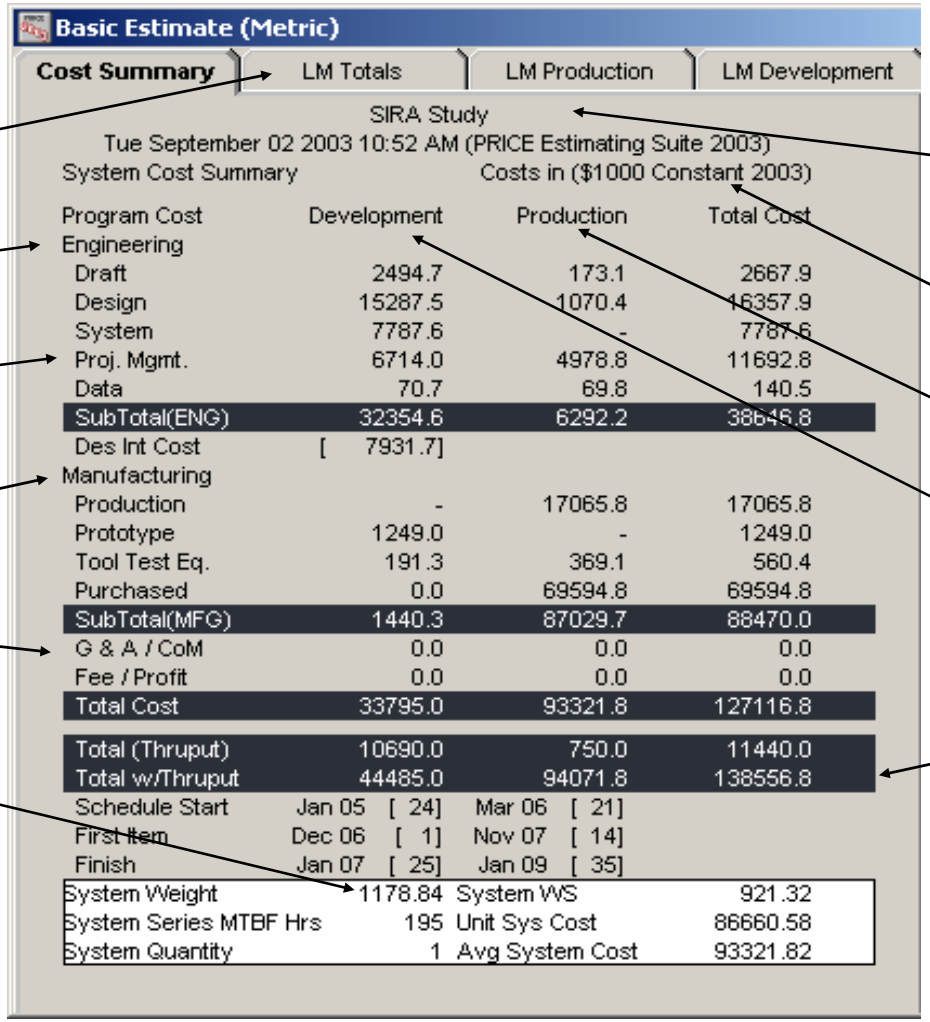

Basic Estimate (Metric)

Cost Summary | LM Totals | LM Production | LM Development

SIRA Study

Tue September 02 2003 10:52 AM (PRICE Estimating Suite 2003)

System Cost Summary — Costs in ($1000 Constant 2003)

Program Cost	Development	Production	Total Cost
Engineering			
Draft	2494.7	173.1	2667.9
Design	15287.5	1070.4	16357.9
System	7787.6	-	7787.6
Proj. Mgmt.	6714.0	4978.8	11692.8
Data	70.7	69.8	140.5
SubTotal(ENG)	32354.6	6292.2	38646.8
Des Int Cost	[7931.7]		
Manufacturing			
Production	-	17065.8	17065.8
Prototype	1249.0	-	1249.0
Tool Test Eq.	191.3	369.1	560.4
Purchased	0.0	69594.8	69594.8
SubTotal(MFG)	1440.3	87029.7	88470.0
G & A / CoM	0.0	0.0	0.0
Fee / Profit	0.0	0.0	0.0
Total Cost	33795.0	93321.8	127116.8
Total (Thruput)	10690.0	750.0	11440.0
Total w/Thruput	44485.0	94071.8	138556.8
Schedule Start	Jan 05 [24]	Mar 06 [21]	
First Item	Dec 06 [1]	Nov 07 [14]	
Finish	Jan 07 [25]	Jan 09 [35]	

System Weight	1178.84	System WS	921.32
System Series MTBF Hrs	195	Unit Sys Cost	86660.58
System Quantity	1	Avg System Cost	93321.82

Labor/Material

Engineering

Project Management

Manufacturing

G&A, Fee

Mass

Cost Element (Summary Report Available for each cost element)

Real Year Dollars

Production

Development

Propulsion Module & S/C (Qty. 16) Cost Estimate $138.55M

SIRA_PRICEcost.xls
Summary Cost Estimate

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IMDC PRICE H Cost Model Summary (Development and Production Costs)	Flight Units = 1 Engineering Units = 1 Cost Estimate ($03)		Flight Units = 12 Engineering Units = 1 Cost Estimate ($03)		Flight Units = 16 Engineering Units = 1 Cost Estimate ($03)	
SIRA Spacecraft						
Propulsion Module + Spacecraft Bus	**$60,132,158**		**$119,162,204**		**$138,556,777**	
Propulsion Module						
Mechanical Structure Assembly		$10,785,345		$10,785,345		$10,785,345
Propulsion Assembly		$7,708,896		$7,708,896		$7,708,896
Propulsion Module Integration & Test		$531,021		$531,021		$531,021
Spacecraft Bus						
Mechanical Structure Assembly		$603,665		$1,570,007		$1,766,782
Power		$4,188,452		$7,480,552		$8,186,431
Attitude Control System (ACS)		$2,099,488		$5,046,264		$6,085,941
Propulsion		$2,579,035		$9,725,511		$12,220,493
Command and Data Handling (C&DH) Assembly		$9,488,267		$14,207,644		$15,168,935
Communications Assembly		$8,525,876		$45,572,786		$58,743,909
Thermal		$706,010		$1,485,560		$1,758,531
Flight SW Development		$10,690,000		$10,690,000		$10,690,000
Flight SW Recurring Cost ($50K)		$0		$550,000		$750,000
Spacecraft Bus Integration & Test		$1,294,523		$2,877,036		$3,228,913
Propulsion Module and S/C Integration & Test		$931,581		$931,581		$931,581
Ground Support Equipment (GSE) (~5% of SIRA Cost Estimate)	**$3,006,608**		**$5,958,110**		**$6,927,839**	
Environmental Testing (~5% of SIRA Cost Estimate)	**$3,006,608**		**$5,958,110**		**$6,927,839**	
Launch Vehicle Integration & Test (~5% of Deployment S/C Cost Estimate)	**$3,006,608**		**$5,958,110**		**$6,927,839**	
	$69,151,981		**$137,036,534**		**$159,340,294**	

NOTE: GSE, Environmental Testing, & LV I&T are ***NOT PRICE H*** estimates, but are derived from PRICE H Spacecraft Bus estimated cost.
These are ***ROM*** estimates included as reminders -- Grass-roots may have better estimates of these costs

SIRA_PRICEcost.xls

Propulsion Module & 16 S/C Detailed Cost Estimate

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IMDC PRICE H Cost Model Summary
Magcon Spacecraft

Indenture	Title	QTY	Mass	Total Mass		Estimated Cost	Mode
0	SIRA Study	1				$138,556,777	System
1	Propulsion Module	1				$19,025,262	Assembly
2	Mechanical Structure Assembly	1				$10,785,345	Assembly
3	Propulsion Structure	1	25.00	25.00		$2,987,386	STRUCTURAL / MECHANICAL
3	Thrust Tube	1	40.00	40.00		$4,160,055	STRUCTURAL / MECHANICAL
3	Propulsion Deck	1	15.00	15.00		$2,097,935	STRUCTURAL / MECHANICAL
3	Radials	1	7.00	7.00	87.00	$1,236,979	STRUCTURAL / MECHANICAL
3	Mechanical Structure Integration & Test	1				$302,990	INTEG & TEST
2	Propulsion Assembly	1				$7,708,896	Assembly
3	Fuel Storage Tank	4	6.00	24.00		$1,801,628	PURCHASED/DETAILED COST
3	Presssure Tank	1	10.00	10.00		$257,375	PURCHASED/DETAILED COST
3	22N Bi-prop Thrusters	4	1.50	6.00		$1,029,502	PURCHASED/DETAILED COST
3	445N Thrusters	1	4.00	4.00		$643,439	PURCHASED/DETAILED COST
3	2N Thrusters	4	0.07	0.29		$102,950	PURCHASED/DETAILED COST
3	Flow Components	1				$1,432,532	Assembly
4	Tank Filters	5	0.50	2.50		$51,475	PURCHASED/DETAILED COST
4	Pressure Transducer	3	0.08	0.24		$46,328	PURCHASED/DETAILED COST
4	Pressure Regulator	1	1.00	1.00		$38,606	PURCHASED/DETAILED COST
4	Fill/Drain Valve	6	0.10	0.60		$38,606	PURCHASED/DETAILED COST
4	Latch Valve	4	0.50	2.00		$128,688	PURCHASED/DETAILED COST
4	Tubing	1	5.00	5.00	55.63	$854,602	STRUCTURAL / MECHANICAL
4	Flow Component Integration & Test	1				$274,227	INTEG & TEST
3	Propulsion Design Engineering	1				$1,807,796	DESIGN INTEG
3	Propulsion Integration & Test	1				$633,673	INTEG & TEST
2	Propulsion Module Integration & Test	1				$531,021	INTEG & TEST
1	Spacecraft Bus	16				$118,599,934	Assembly
2	Mechanical Structure Assembly	16				$1,766,782	Assembly
3	Upper Deck	16	1.25	20.00		$238,038	STRUCTURAL / MECHANICAL
3	Lower Deck	16	1.25	20.00		$238,038	STRUCTURAL / MECHANICAL
3	Corner Posts	48	1.75	84.00		$508,507	STRUCTURAL / MECHANICAL
3	Close-Out Panels	32	0.50	16.00		$139,820	STRUCTURAL / MECHANICAL
3	Misc Hdwr.	16	0.18	2.88		$58,390	STRUCTURAL / MECHANICAL
3	Clips, Brackets, Fasteners, etc.	16	0.18	2.88		$57,393	STRUCTURAL / MECHANICAL
3	Comm Antenna Caging	16	0.50	8.00		$120,302	STRUCTURAL / MECHANICAL
3	Solar Array Deployment Mechanism	16				$271,031	Assembly
4	Dampers	32	0.25	8.00		$97,929	STRUCTURAL / MECHANICAL
4	Deployment Springs	32	0.06	1.76		$30,783	STRUCTURAL / MECHANICAL
4	Solar Array Caging	16	0.47	7.52	171.04	$114,826	STRUCTURAL / MECHANICAL
4	Deployment Mechanism Integration & Test	16				$27,493	INTEG & TEST
3	Mechanical Structure Integration & Test	16				$135,262	INTEG & TEST