MDA BOOSTER COST ANALYSIS

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MDA Boosters – Cost Analysis Seminar

- ***MDA Booster Missions & Requirements***
  - *Interceptors*
  - *Target Systems*
- ***Common Booster Elements & Components***
  - *SRMs & TVC Nozzles*
  - *Interstage Structures*
  - *Electrical Power*
  - *Guidance & Control Electronics*
  - *G&C Software*
  - *Safety Systems*
  - *Payload Systems*
- ***Basing, Support Systems & Below-the-Line Costs***
- ***Launch Ops and Range Operation Costs***
- ***Conclusions***

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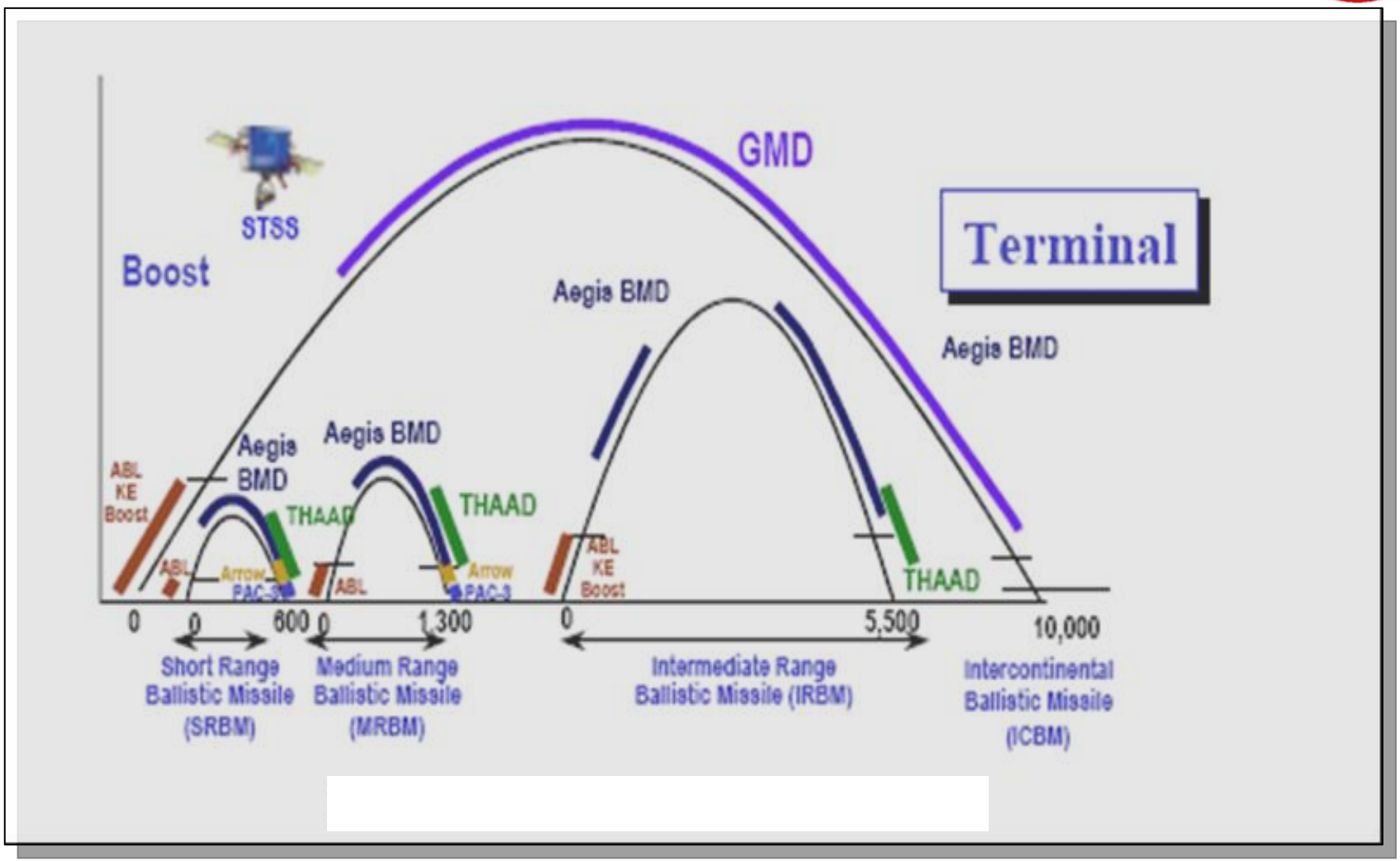
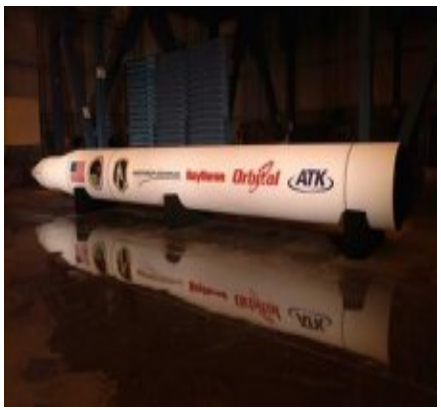
Missile Defense Agency Interceptor Systems



Missile Defense Agency Interceptor Systems

MDA Boosters - Interceptors



Kinetic Energy Interceptor

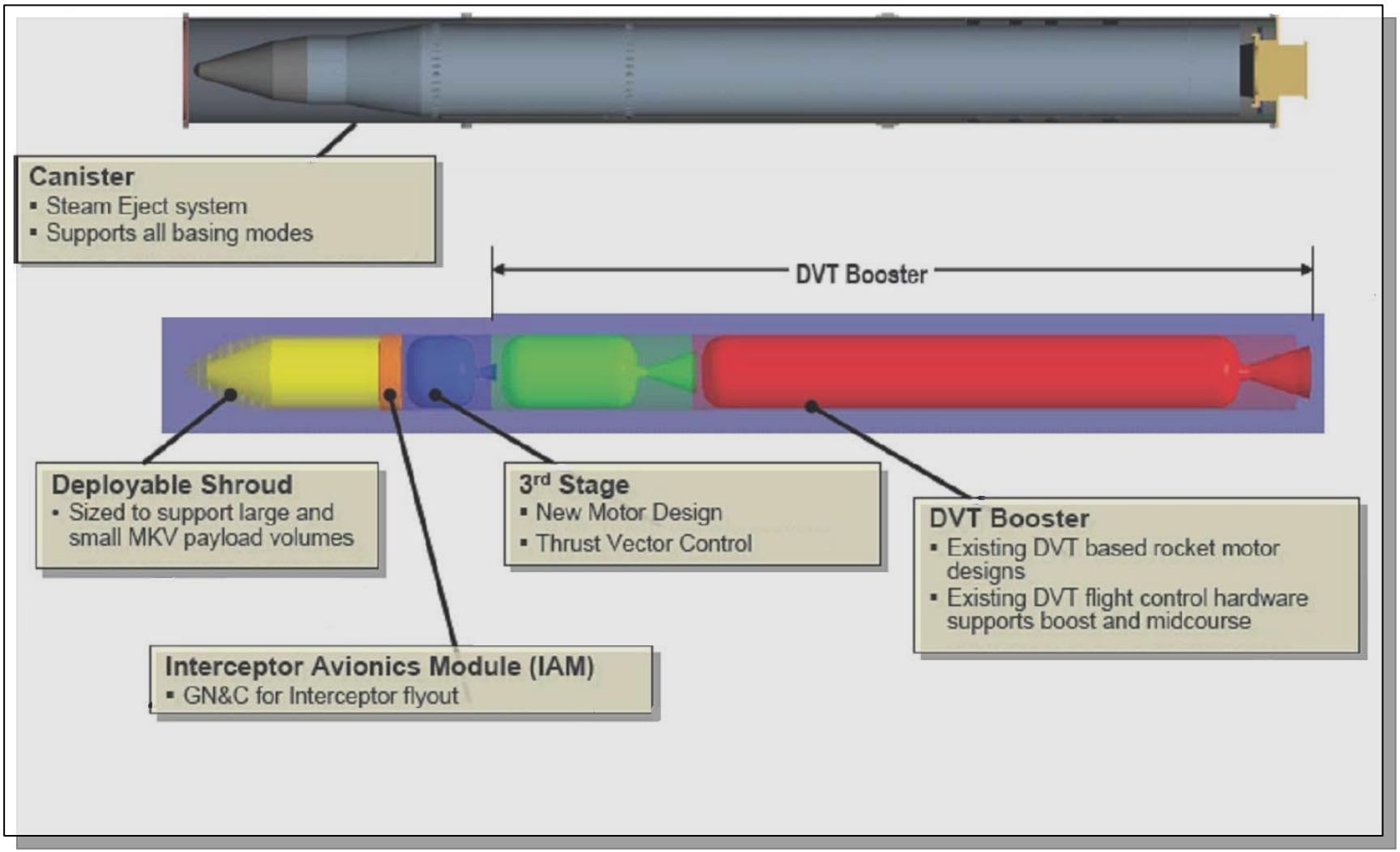
Standard Missile-3

Ground-Based Interceptor Midcourse Defense

Terminal High Altitude Area Defense (THAAD)

Patriot Advanced Capability-3 (PAC3)

Missile Defense Agency
Interceptor Systems - KEI



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Missile Defense Agency
Interceptor Systems - KEI

INTERCEPTOR:	KINETIC ENERGY INTERCEPTOR
STATUS:	UNDER DEVELOPMENT
PRIME CONTRACTOR	NORTHROP GRUMMAN
SEEKER	MULTIPLE INFRARED KILL VEHICLES
PROPULSION TYPE	SRM
GROSS LIFT OFF WGT (LBS)	26500+
STAGES	3 STAGES + KILL VEHICLES
LENGTH (FT)	38.8
MAX SPAN - WINGS/FINS (FT)	3.33
BODY DIAMETER (FT)	3.33
FORCE SIZE	TBD
IOC	POST 2013
MISSION	BOOST PHASE ANTIMISSILE
EFFECTIVE RANGE (NM)	750+

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Missile Defense Agency
Interceptor Systems – SM3

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Missile Defense Agency
Interceptor Systems – SM3

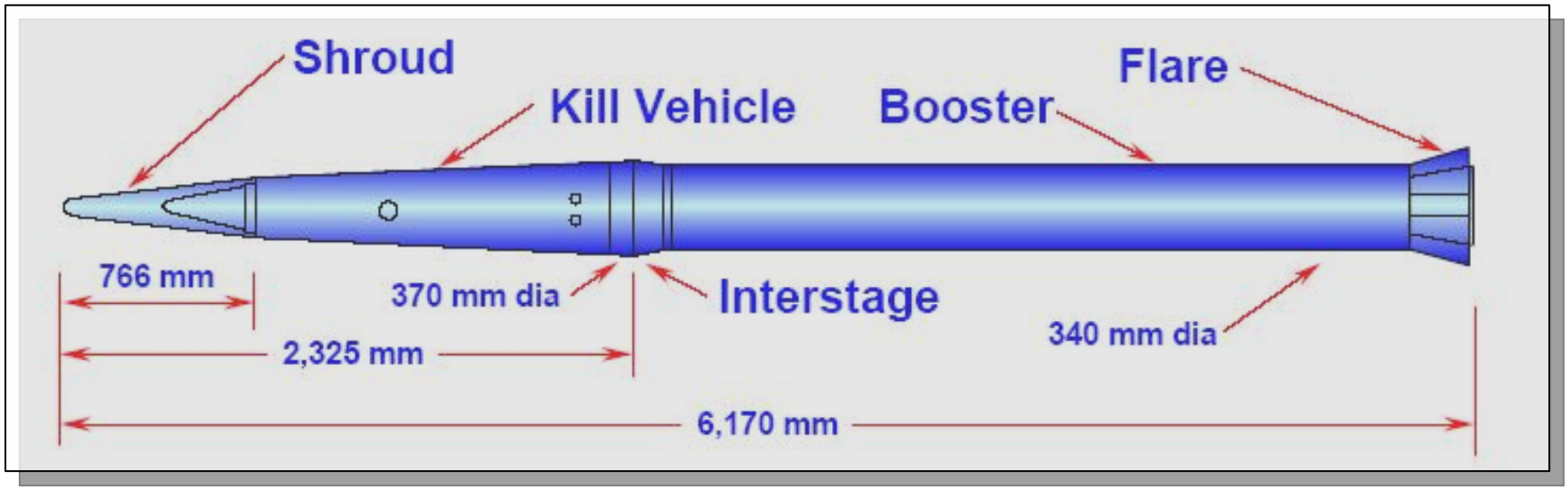
INTERCEPTOR:	**STANDARD MISSILE 3 (RIM-161A)**
STATUS:	**OPERATIONAL**
PRIME CONTRACTOR	**RAYTHEON**
SEEKER	**INFRARED KILL VEHICLE**
PROPULSION TYPE	**SRM**
GROSS LIFT OFF WGT (LBS)	**3310**
STAGES	**3 STGS, 1 KILL VEHICLE**
LENGTH (FT)	**21.6**
MAX SPAN - WINGS/FINS (FT)	**3.5**
BODY DIAMETER (FT)	**1.1**
FORCE SIZE	**1200**
IOC	**2002**
MISSION	**AREA DEFENSE - ANTIMISSILE**
EFFECTIVE RANGE (NM)	**270+**

Missile Defense Agency
Interceptor Systems - GBI

Missile Defense Agency
Interceptor Systems - GBI

INTERCEPTOR:	**GROUND BASED INTERCEPTOR**
STATUS:	**OPERATIONAL**
PRIME CONTRACTOR	**BOEING**
SEEKER	**INFRARED KILL VEHICLE**
PROPULSION TYPE	**SRM**
GROSS LIFT OFF WGT (LBS)	**28000+**
STAGES	**3 STAGES + KILL VEHICLE**
LENGTH (FT)	**55**
MAX SPAN - WINGS/FINS (FT)	**4.17**
BODY DIAMETER (FT)	**4.17**
FORCE SIZE	**50+**
IOC	**2003**
MISSION	**MIDCOURSE ANTIMISSILE**
EFFECTIVE RANGE (NM)	**3300+**

Missile Defense Agency
Interceptor Systems - THAAD



Missile Defense Agency
Interceptor Systems - THAAD

INTERCEPTOR:	**THAAD**
STATUS:	**UNDER DEVELOPMENT**
PRIME CONTRACTOR	**LOCKHEED MARTIN**
SEEKER	**ACTIVE/SEMI-ACTIVE RADAR**
PROPULSION TYPE	**SRM**
GROSS LIFT OFF WGT (LBS)	**2000**
STAGES	**1 BOOSTER, 1 HTK DACS**
LENGTH (FT)	**20.4**
MAX SPAN - WINGS/FINS (FT)	**------**
BODY DIAMETER (FT)	**1.1**
FORCE SIZE	**48**
IOC	**2009**
MISSION	**TERMINAL ANTIMISSILE**
EFFECTIVE RANGE (NM)	**125+**

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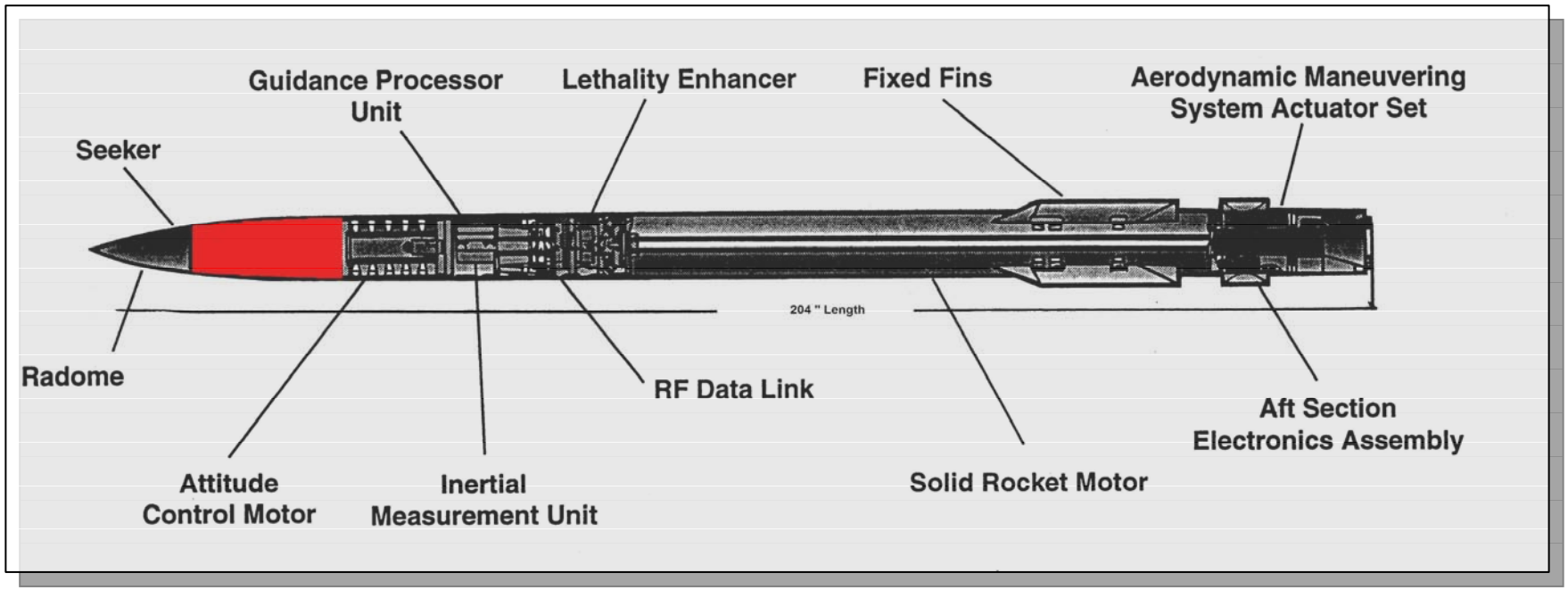
Interceptor Systems – PAC3



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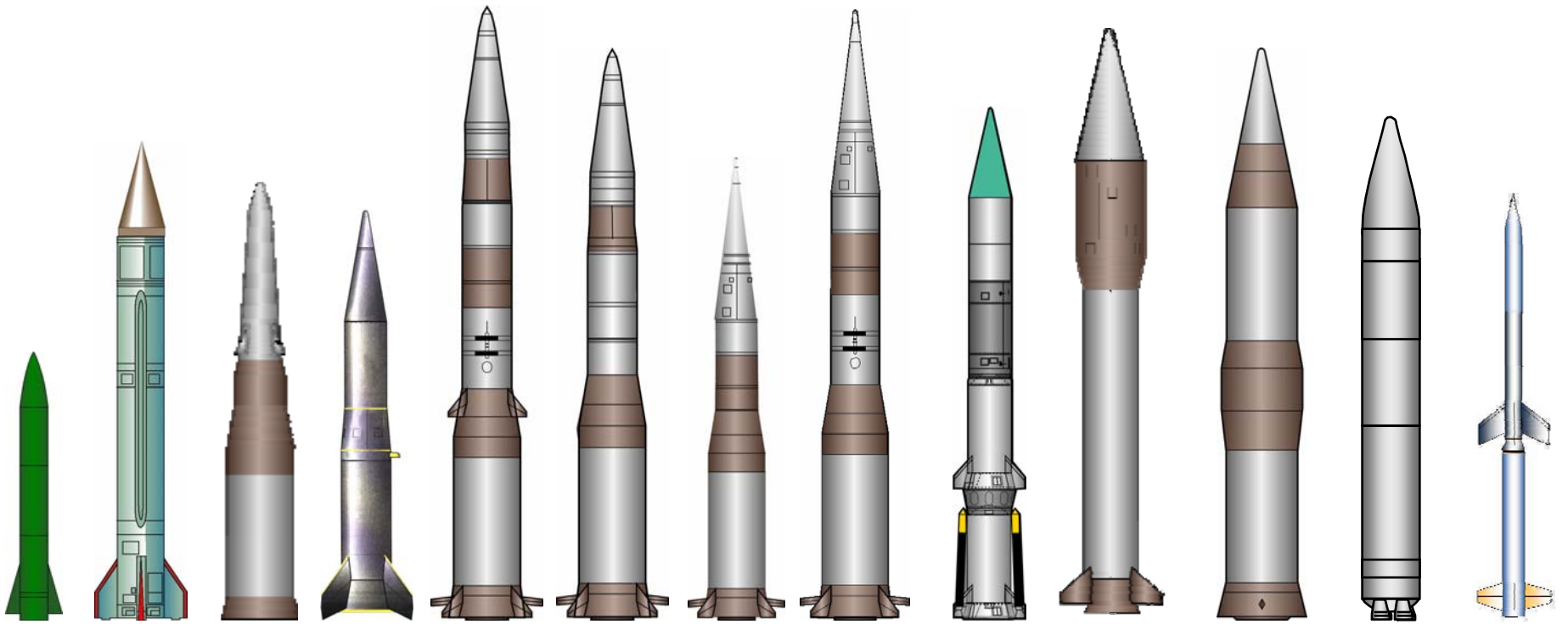
Missile Defense Agency
Interceptor Systems – PAC3

INTERCEPTOR:	**PAC-3**
STATUS:	**OPERATIONAL**
PRIME CONTRACTOR	**LOCKHEED MARTIN**
SEEKER	**ACTIVE/SEMI-ACTIVE RADAR**
PROPULSION TYPE	**SRM**
GROSS LIFT OFF WGT (LBS)	**700**
STAGES	**1 BOOSTER + MANEUVER KILL VEHICLE**
LENGTH (FT)	**17**
MAX SPAN - WINGS/FINS (FT)	**1.67**
BODY DIAMETER (FT)	**1**
FORCE SIZE	**1200+**
IOC	**1995**
MISSION	**TERMINAL ANTIMISSILE**
EFFECTIVE RANGE (NM)	**25+**

Missile Defense Agency Target Systems

Family of Legacy Targets (52 Inch Diameter and Smaller)



Lance (130 km)	FMA Scud (300 km)	MTTV Storm II SR19 (350 km)	TTV Aries M56 (500 km)	MBRV-3 Hera SR19/M57 (500 km)	MBRV-3 SRALT SR19 (500 km)	MBRV-1 SRALT SR19 (600 km)	MBRV-1 Hera SR19/M57 (900 km)	MBRV-2 OT-2a SR19/SR19 (1100 km)	MBRV-2 MRT Castor IVB (1100 km)	MBRV-4 LRALT SR19/SR19 (2400 km)	STARS (3700 km)	Terrier/ Lynx (600 km)

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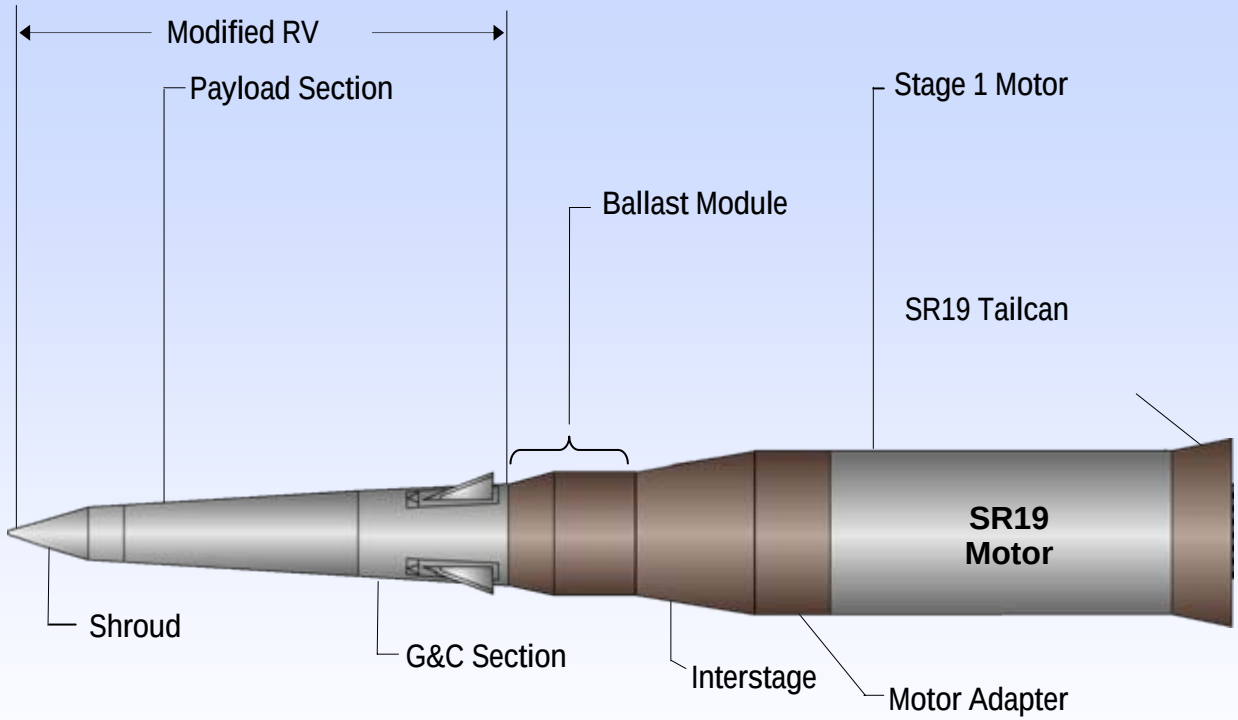
Missile Defense Agency Target Systems



TYPICAL LEGACY TARGET SYSTEM

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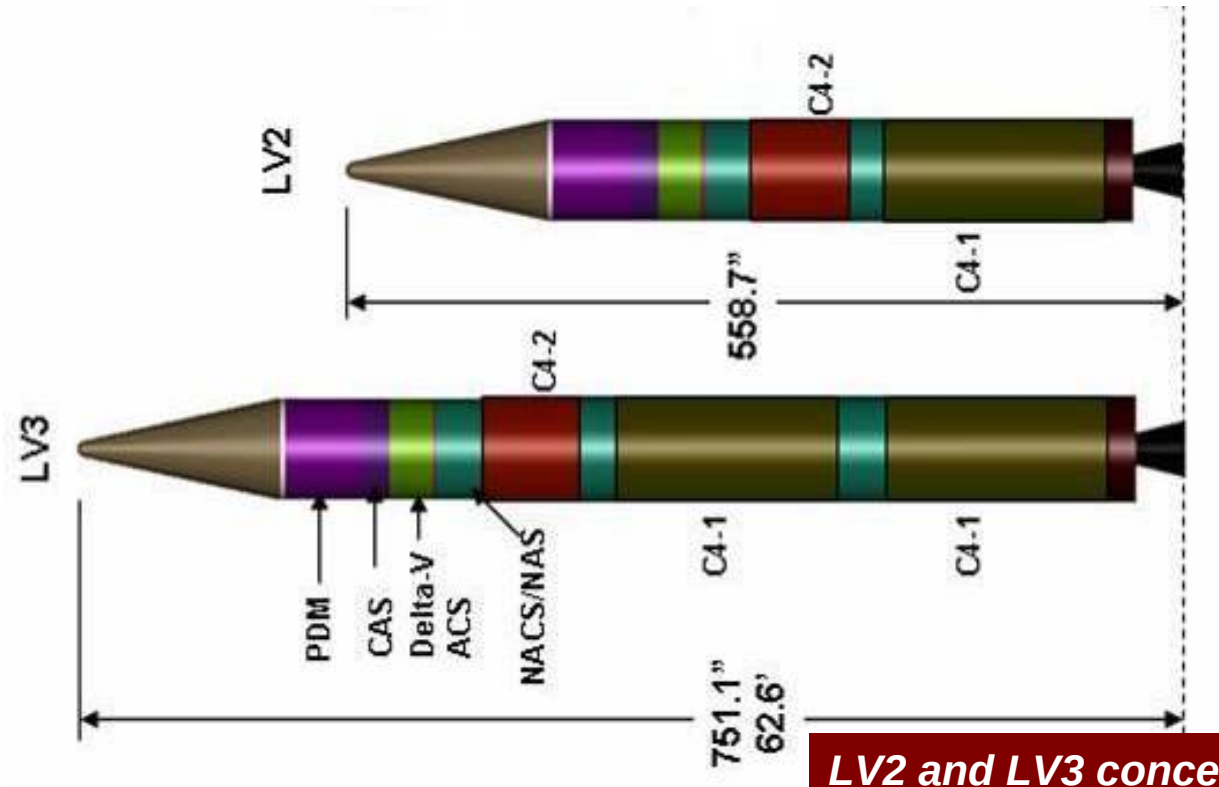
Missile Defense Agency Target Systems

Family of 72" Targets (Under Development):



LV2 and LV3 concepts use retired C4 SRMS and modular interstages, payload instruments, and countermeasure packages.

Missile Parametric Cost Model

- ***DEVELOPED BY GREG BELL FOR USE ON SPECIAL MISSILE, MUNITION, AND MDA CONCEPT STUDIES & PROGRAMS.***

- ***THE MODEL HAS UNDERGONE CONTINUOUS REFINEMENT SINCE 1998, AND HAS GROWN INTO A FAMILY OF VERSIONS COVERING VARIOUS TACTICAL, STRATEGIC, AND MDA MISSIONS AND TECHNOLOGIES.***

- ***THE MODEL IS A <u>PARAMETRIC</u> MODEL WITH CERS, FACTORS, AND DEFAULT VALUES THAT ARE USED TO ESTIMATE ALL LCC ELEMENTS, INCLUDING DEVELOPMENT, PRODUCTION, SUPPORT, AND O&S COSTS.***

- ***<u>PARAMETRIC METHODS (Examples):</u>***

COST1 = f(WEIGHT)
COST2 = f(KSLOC)
COST3 = f(EVENTS or OBJECTS)
COST4 = f(OTHER COST)

COST5 = f(THRUST/Fn)
COST6 = f(SHP)
COST7 = f(POWER*APERTURE)
and Many Others

Cost Model Description

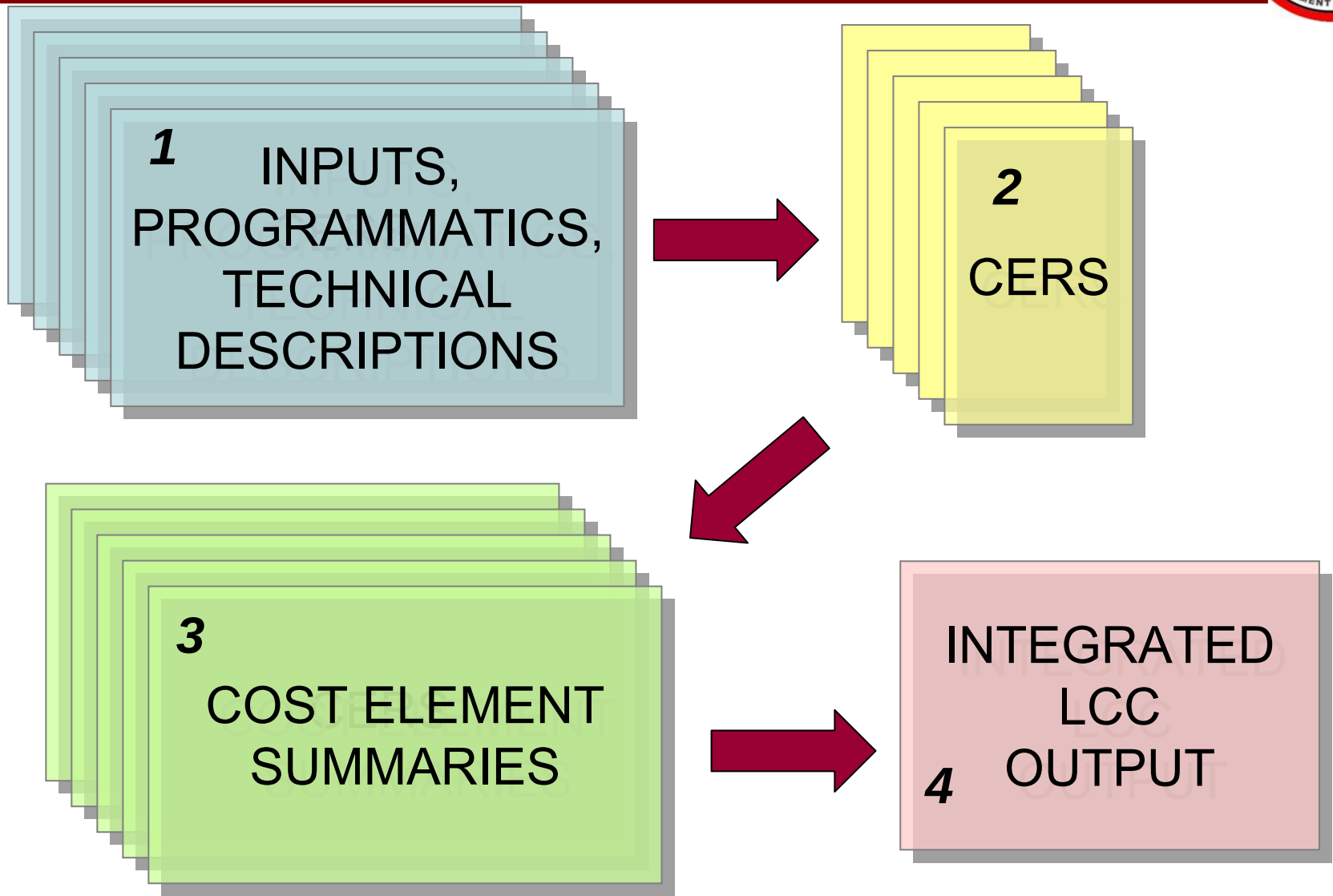
- ***Populated with historical data from U.S. industry programs***
- ***CERs forecast labor hours and material dollars, based on weight, K-SLOC, test events, Engine power output, and other independent drivers.***
- ***Global Inputs: wrap rates, fly-to-buy ratios, equipment and raw material costs/lb, and adjustment factors for composites and specialty metals (aluminum is a 1.0).***
- ***Direct inputs: Weights, Test Agenda and Hours of Test Flight, software KSLOC, engine characteristics, programmatic planning and special factors for complexity.***
- ***Model generates hours for design, test, tooling, factory, SEPM, QA, ILS, other support efforts, material and supplier costs and integrates them into a parametric cost estimate.***
- ***Over 400 CERs are available in MPCM.***

Some Model Sources

- *"Cost Models and Support Data for Solid Propellant Rocket Motors (U)," Tecolote Research, Inc., TM-127, 1980.*
- *"Electro-optical, Missile, Radar, and Avionics Systems Cost Research, Volume 3, Missile Production Cost Model," MCR, Inc., 1988.*
- *"Missile Cost Handbook," Nicholas, T., et. al., Data Search Associates, Fountain Valley, 1976-1998.*
- *"Naval Weapons Center (NWC) Missile Cost Model," A. Vokolek, NWC 1983.*
- *."Naval Weapons Center (NWC) Modular Missile Cost Model," Tecolote Research Inc., CR-0172, 1987.*
- *"R&D Cost Model for Tactical Missile Solid Propulsion Systems," Tecolote Research, Inc., TM-158, 1982.*
- *"Solid Rocket Motor Cost/Reliability Predicting Methodology," Booz Allen, NWC TP 5634, NWC 1974.*
- *"Tactical Missile Development Cost," SAIC, 1987.*
- *"Tactical Missile RDT&E Cost Model," Tecolote Research, TM119, 1979.*

And Others …

Parametric Cost Estimation Process



CER Libraries For Each Cost Element

MSL ENGINEERING CERS 12-Jul-03	"A" COEFF	"B" EXP	CER FORM	OBSER-VATIONS	R^2	SEE	RANGE OF INDE-PENDENT VARIABLE	SOURCE
DESIGN ENGINEERING (HDW)								
STRUCTURES DESIGN								
Wing Grp	344.0	1.00	DES MHRS = A*(WGT^B)	7	BASED ON MHRS/LB		1 LBS - 1000 LBS	INDUSTRY DATA BASE
Tail Grp	498.0	1.00	DES MHRS = A*(WGT^B)	7	BASED ON MHRS/LB		1 LBS - 1000 LBS	INDUSTRY DATA BASE
Fuselage Grp	612.3	1.00	DES MHRS = A*(WGT^B)	7	BASED ON MHRS/LB		1 LBS - 1000 LBS	INDUSTRY DATA BASE
Inlet Grp	78.5	0.85	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LBS - 100 LBS	
Intertank Structure	14.1	1.00	DES MHRS = A*(WGT^B)	3	BASED ON MHRS/LB		410 LBS - 13800 LBS	INDUSTRY DATA BASE
Fuel/Oxidizer Tank	12.9	1.00	DES MHRS = A*(WGT^B)	4	BASED ON MHRS/LB		700 LBS - 36000 LBS	INDUSTRY DATA BASE
Dome Grp (RF)	406.5	1.00	DES MHRS = A*(WGT^B)	5	BASED ON MHRS/LB		1 LB - 100 LBS	INDUSTRY DATA BASE
Dome Grp (EO)	3359.0	1.00	DES MHRS = A*(WGT^B)	4	BASED ON MHRS/LB		1 LBS - 100 LBS	INDUSTRY DATA BASE
RAM/RAS Structures	24.8	1.08	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LBS - 100 LBS	
Other Structures	0.0	1.00	DES MHRS = A*(WGT^B)					
PROPULSION GROUP DESIGN								
Liquid Rocket Engine	44.4	0.85	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 1000 LBS	
Solid Rocket Motor	44.4	1.00	DES MHRS = A*(WGT^B)	8	BASED ON MHRS/LB		10 LBS - 2000 LBS	INDUSTRY DATA BASE
Exhaust/Nozzle Grp	78.4	0.85	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 100 LBS	
Turbojet Engine	44.4	0.85	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 1000 LBS	
Turbofan Engine	44.4	0.85	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 1000 LBS	
Ramjet (External)	182.8	1.00	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 1000 LBS	
Ramjet (Internal)	182.8	1.00	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 1000 LBS	
Engine Start/Cntl	176.0	0.85	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 100 LBS	
Engine Accessories	176.0	0.85	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 100 LBS	
Fuel/Lubrication Grp	197.6	0.85	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 100 LBS	
Pressure Tank/Lines	74.5	1.00	DES MHRS = A*(WGT^B)	2	BASED ON MHRS/LB		650 LBS - 9500 LBS	INDUSTRY DATA BASE
Other Propulsion	0.0	1.00	DES MHRS = A*(WGT^B)					
FIXED EQUIP DESIGN								
Surface Cntls	1367.0	1.00	DES MHRS = A*(WGT^B)	7	BASED ON MHRS/LB		1 LB - 100 LBS	INDUSTRY DATA BASE
Aux Power Grp (SSG)	182.2	0.85	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 100 LBS	
Hyd & Pneu Grp	345.2	0.85	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 100 LBS	
Electrical Grp	1403.0	1.00	DES MHRS = A*(WGT^B)	8	BASED ON MHRS/LB		1 LB - 100 LBS	INDUSTRY DATA BASE
Environ Cntl Grp	262.2	1.00	DES MHRS = A*(WGT^B)		POSTULATED TREND		1 LB - 100 LBS	
Other Fxd Eq Grp	0.0	1.00	DES MHRS = A*(WGT^B)					

Example

WBS for Booster Cost Estimating

	Development Cost	Production Cost
Prime Mission Product		
SRMs & TVC Nozzles		
Interstage Structures		
Electrical Power		
Guidance & Cntl Electronics		
G&C Software		
Safety Systems		
Payload Systems		
Below The Line Costs		
Ground Support Equip (Pad)		
Ground Support Equip (Transport)		
Data		
Training		
Pad Spares		
Site Activation		

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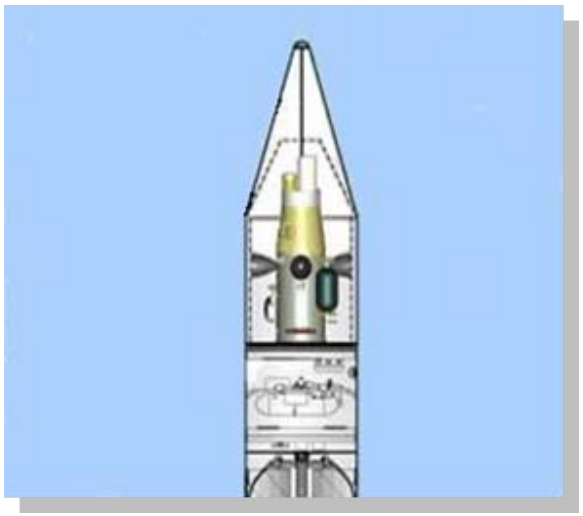
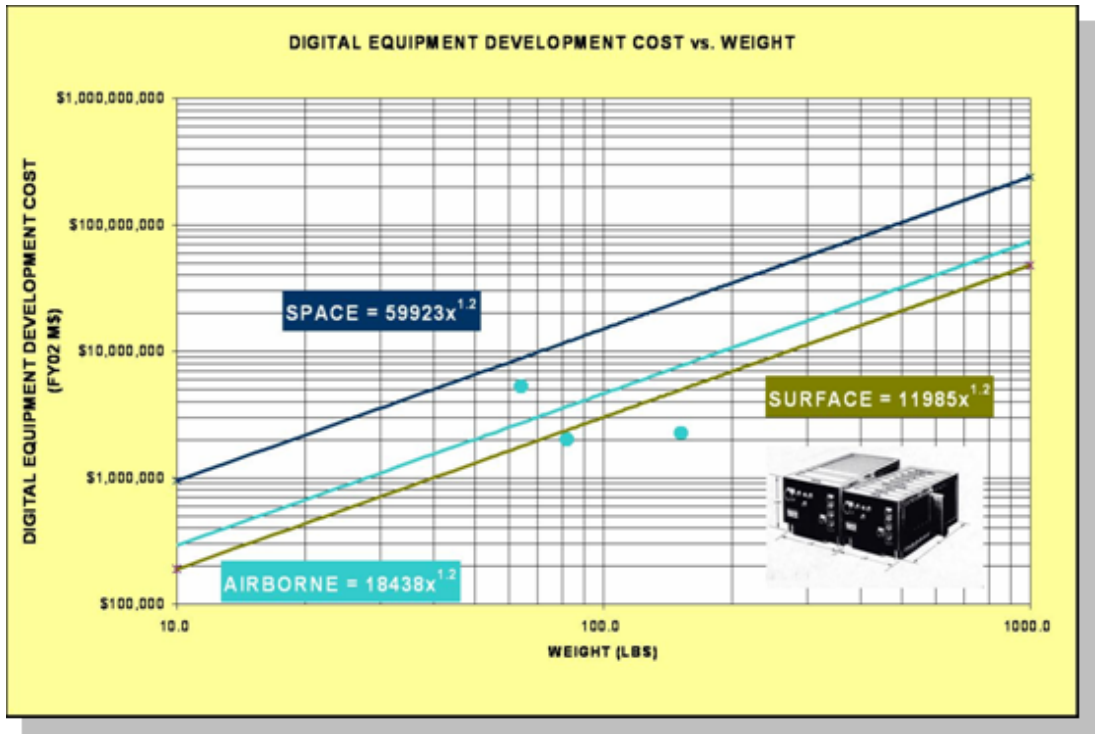
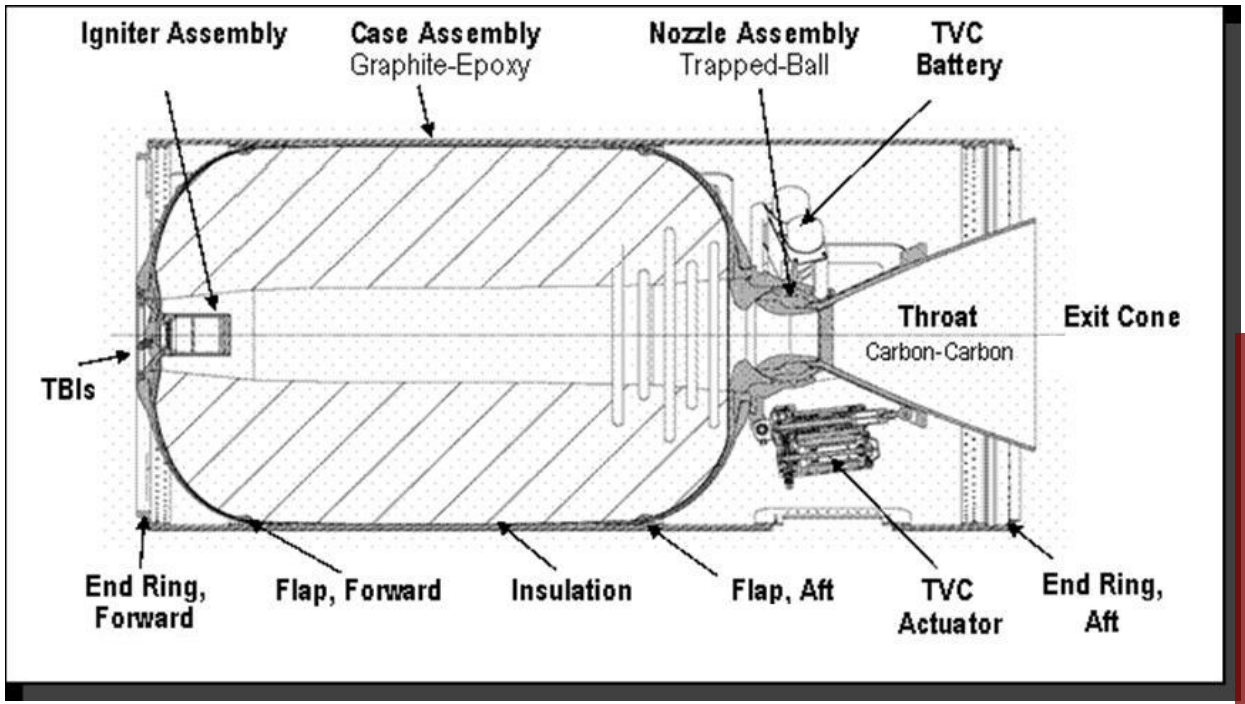
Missile Technology & Cost Estimating Methods

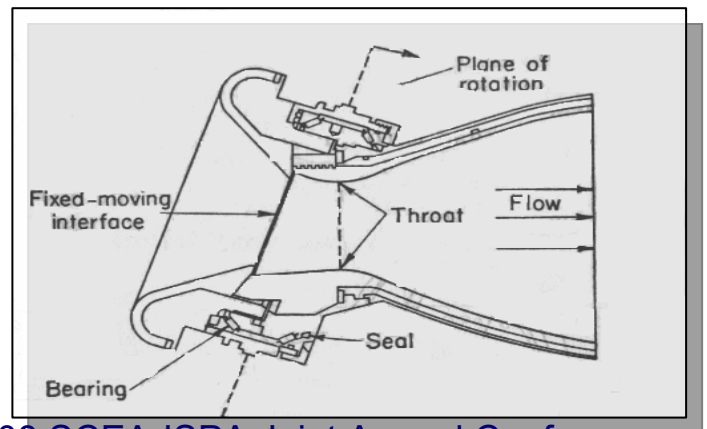




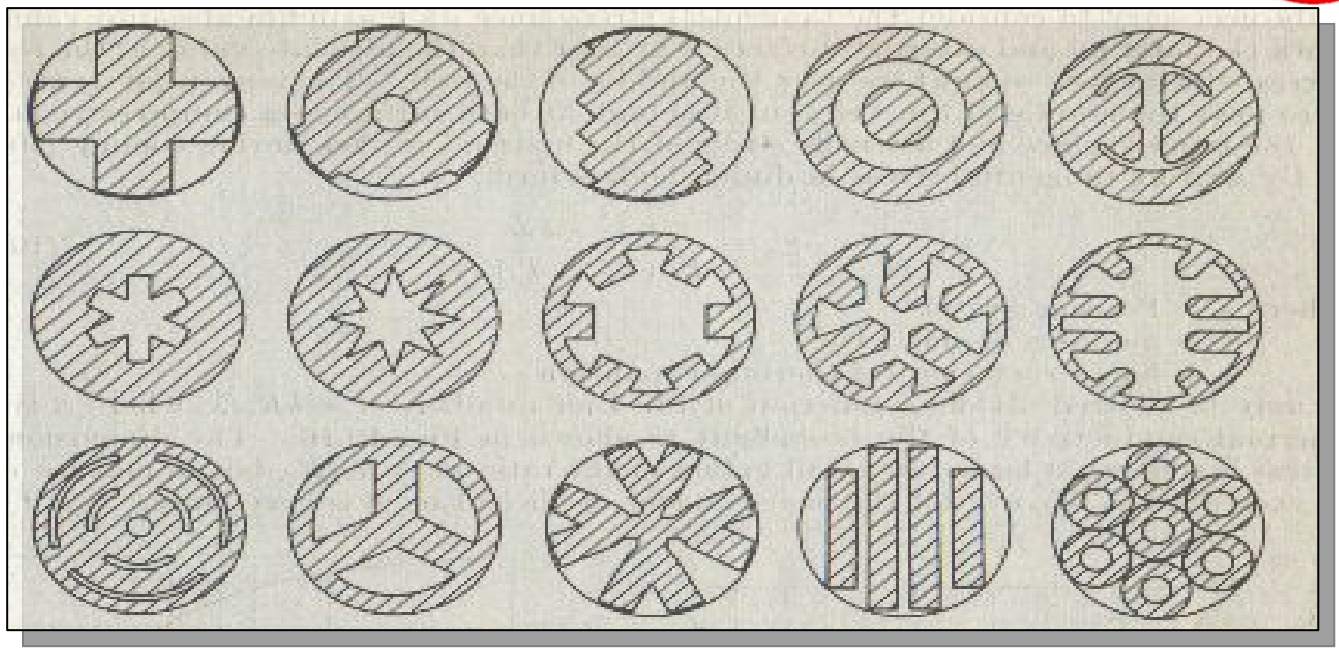
SRMs and TVC Nozzles

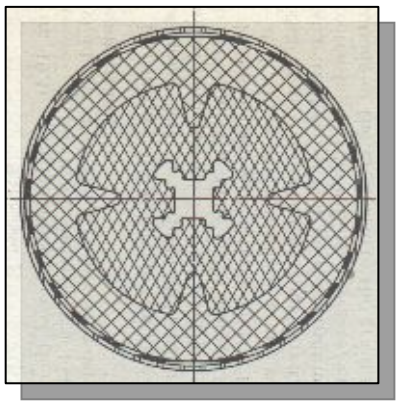


Solid Rocket Motors consist of a case, insulation, poured propellant (called a grain), igniter, and a Nozzle system. The exposed surface area of the Grain determines the burn rate and specific thrust.



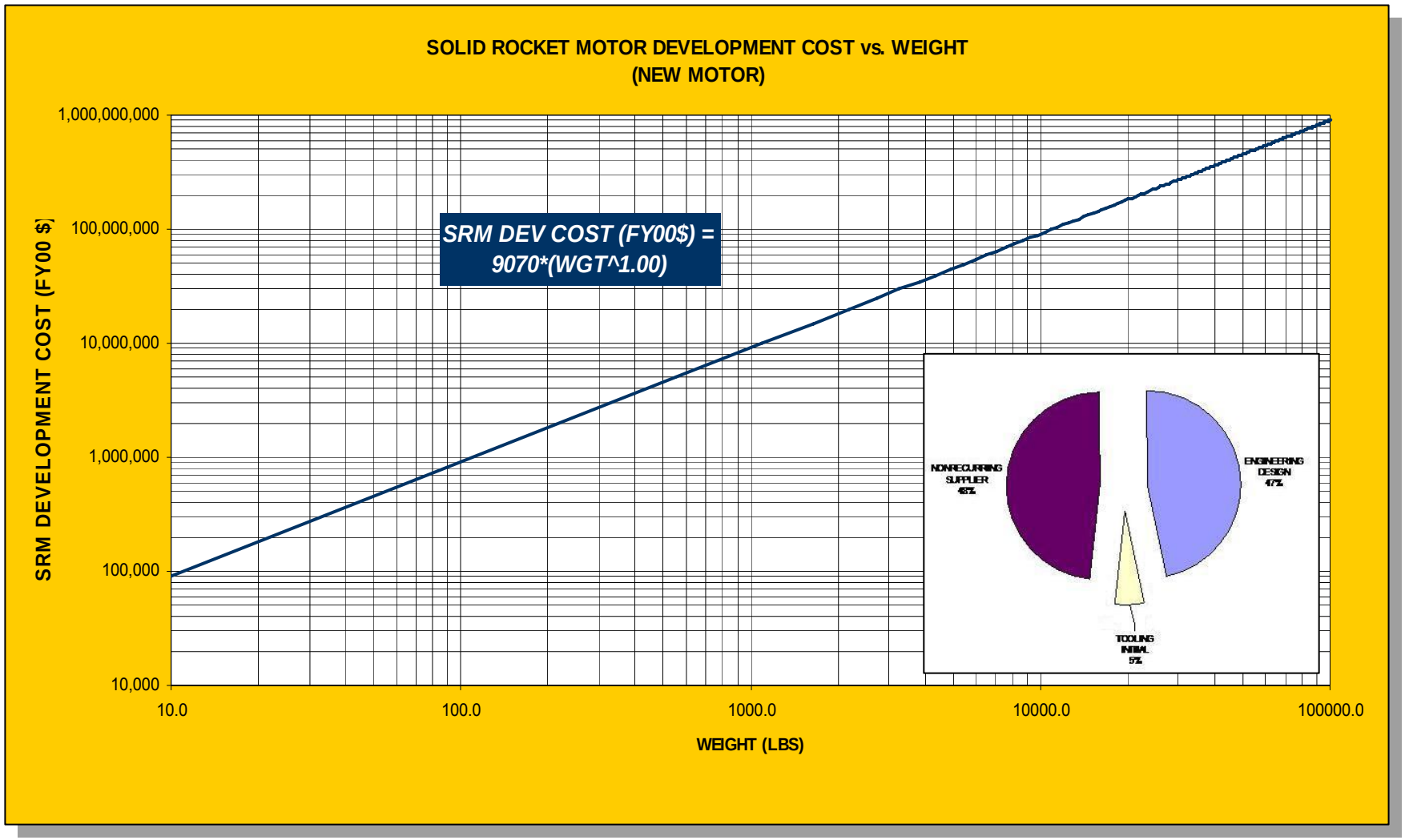
SRMs and TVC Nozzles – Propellant Grain



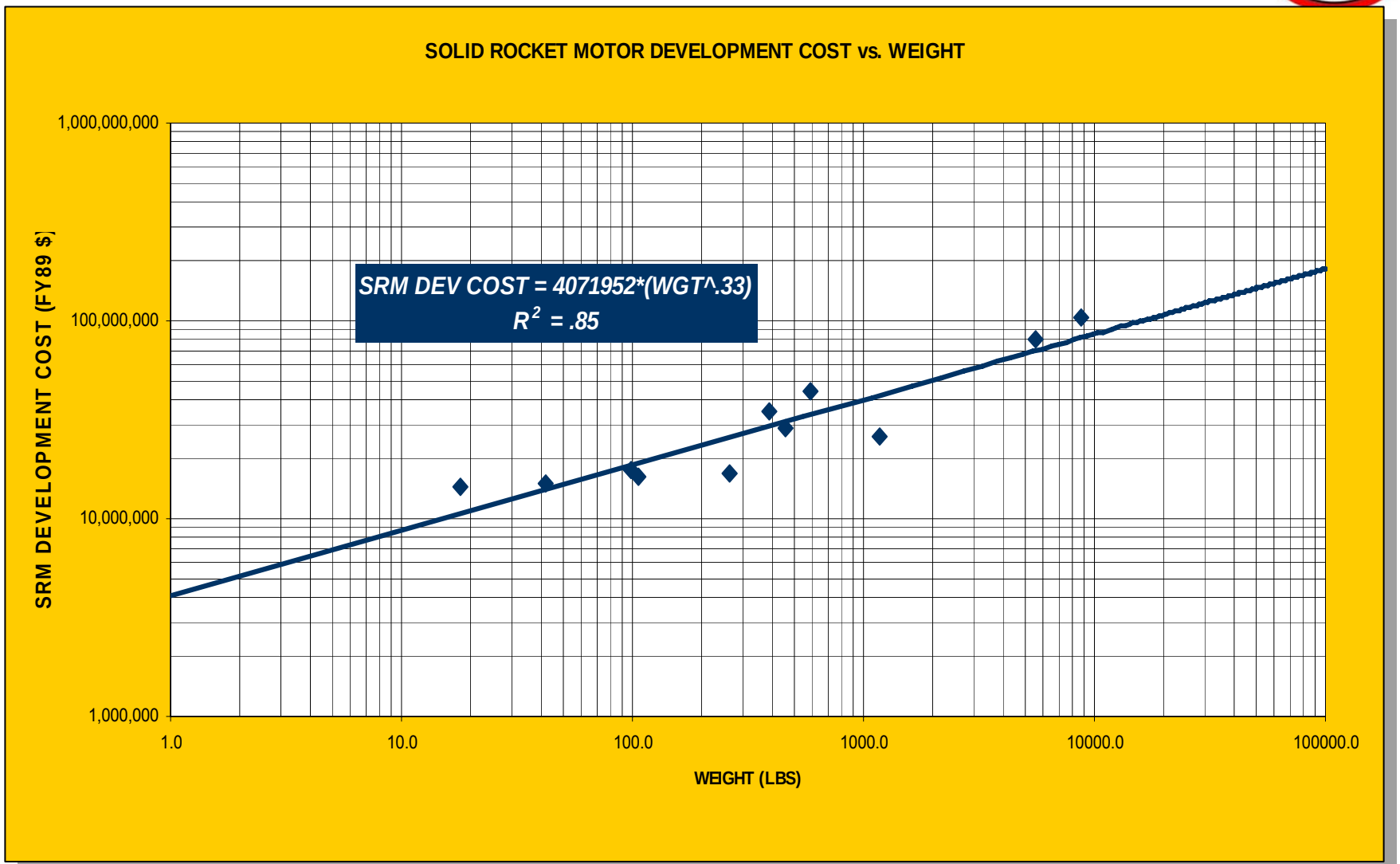


Propellant cross-section determines the burn rate and specific thrust. These figures illustrate some historical cross-sections and how a dual grain can be used to provide high boost thrust followed by low sustainer thrust.

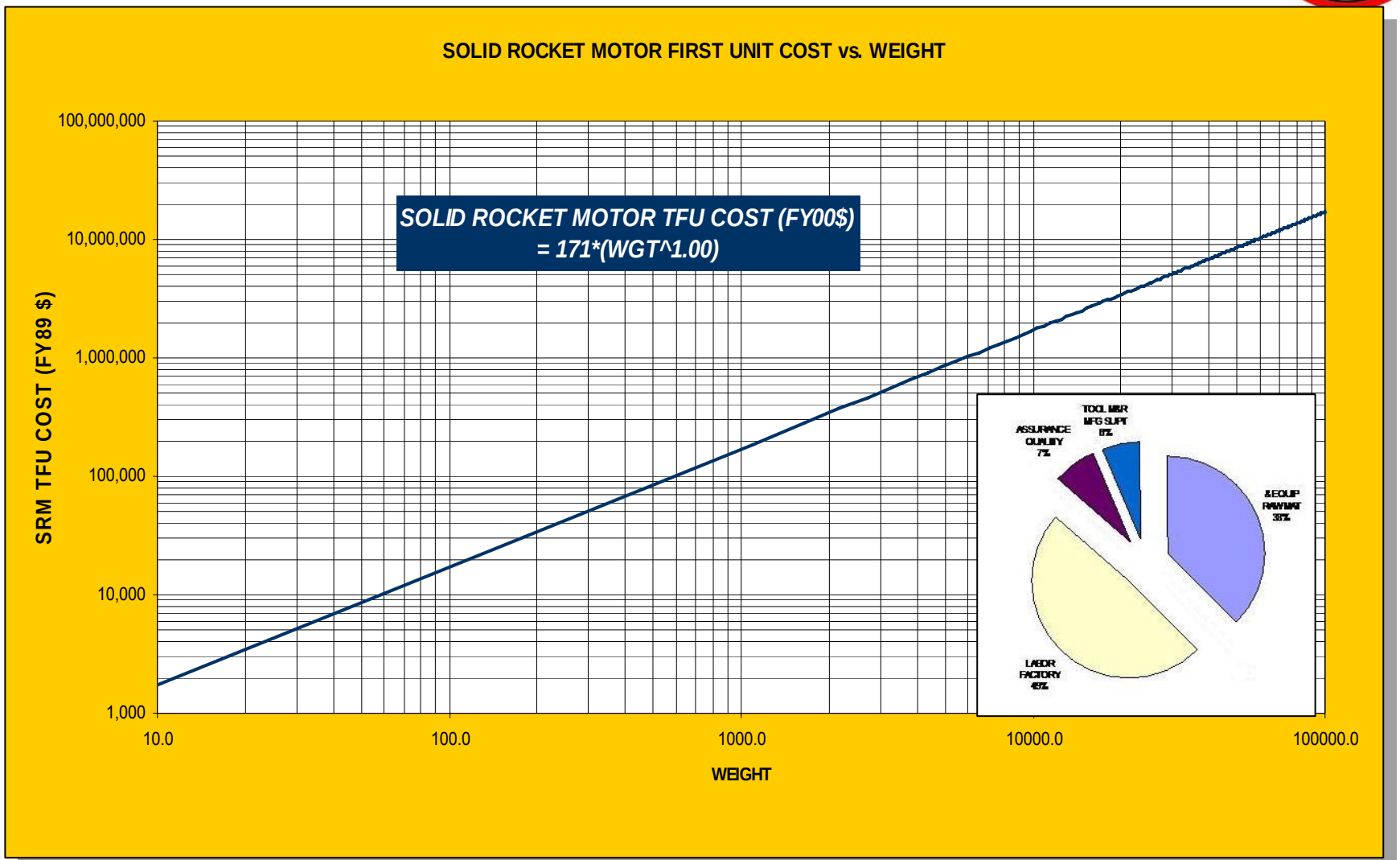
SRMs and TVC Nozzles – Development Cost (New Motors)



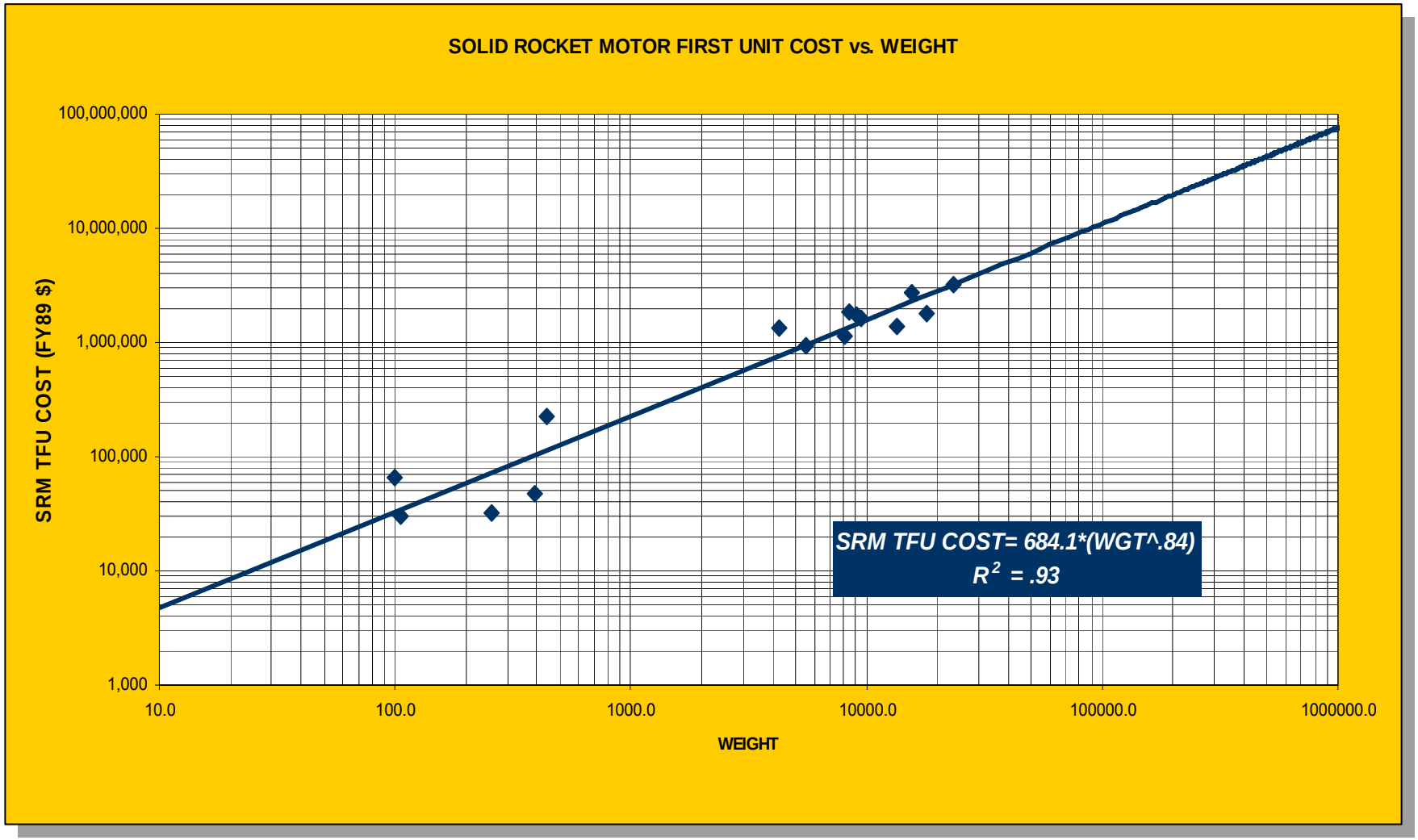
SRMs and TVC Nozzles – Development Cost (Basis of Estimate)



SRMs and TVC Nozzles (New Motors)
TFU Production Cost

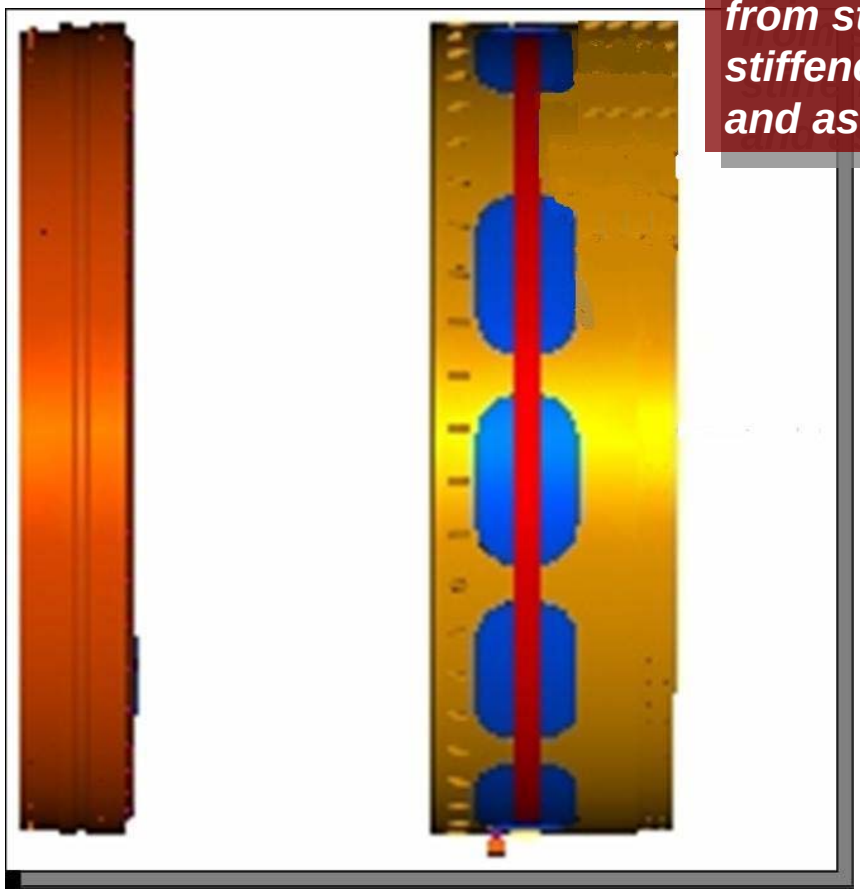


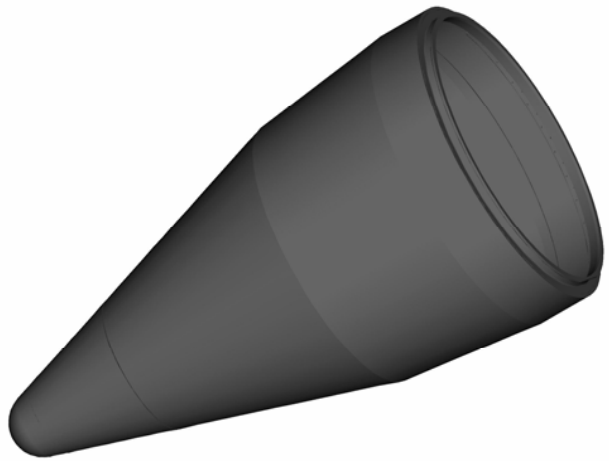
SRMs and TVC Nozzles (New Motors)
TFU Production Cost (Basis of Estimate)



Interstage and Shroud Structures

Typical interstage structures are fabricated from steel. They include skins, frames, stiffeners and doors to allow installation and assembly of stages and components.





Shrouds are fabricated from titanium, high temp steel, and may have ablative coatings.

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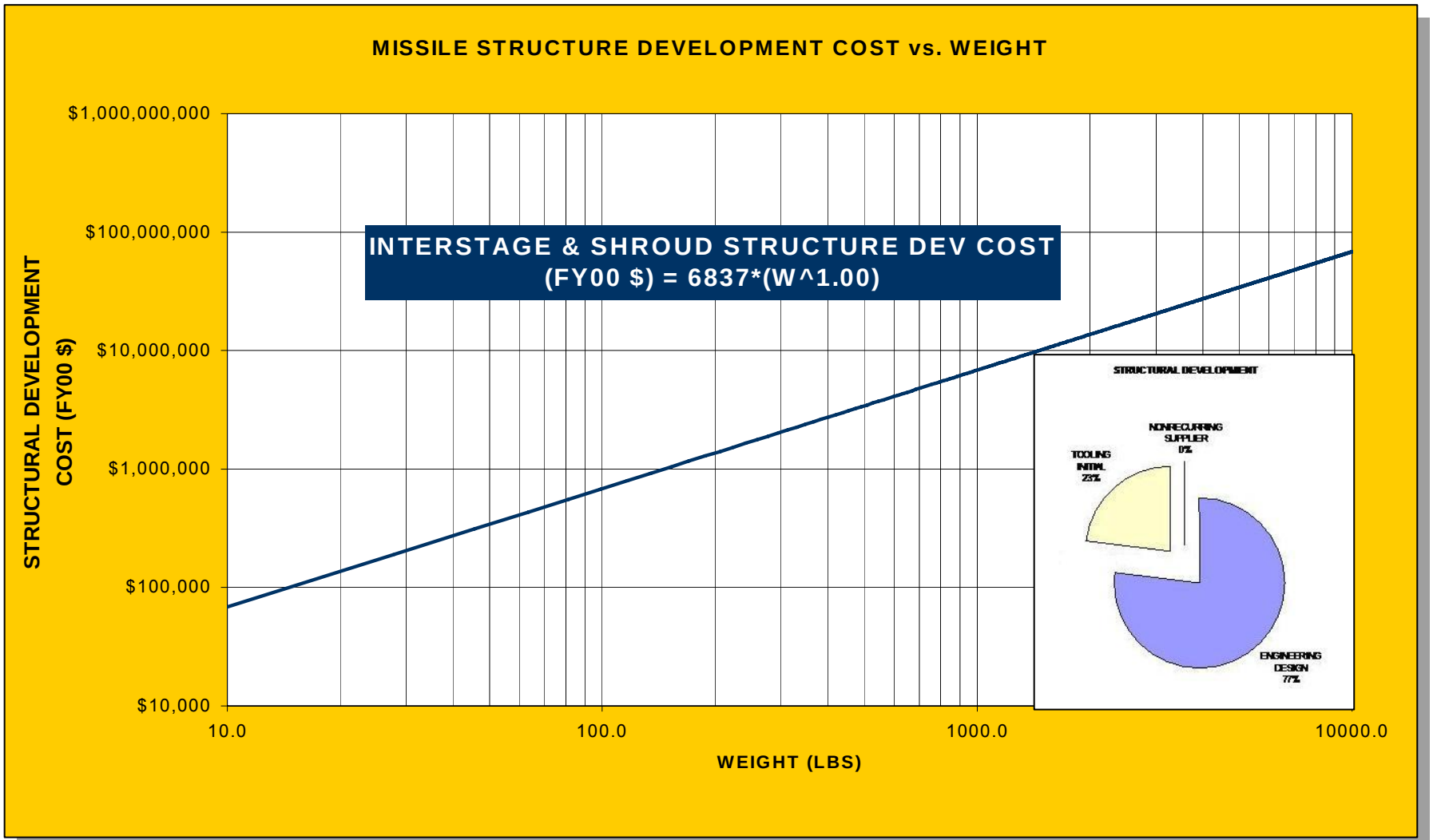
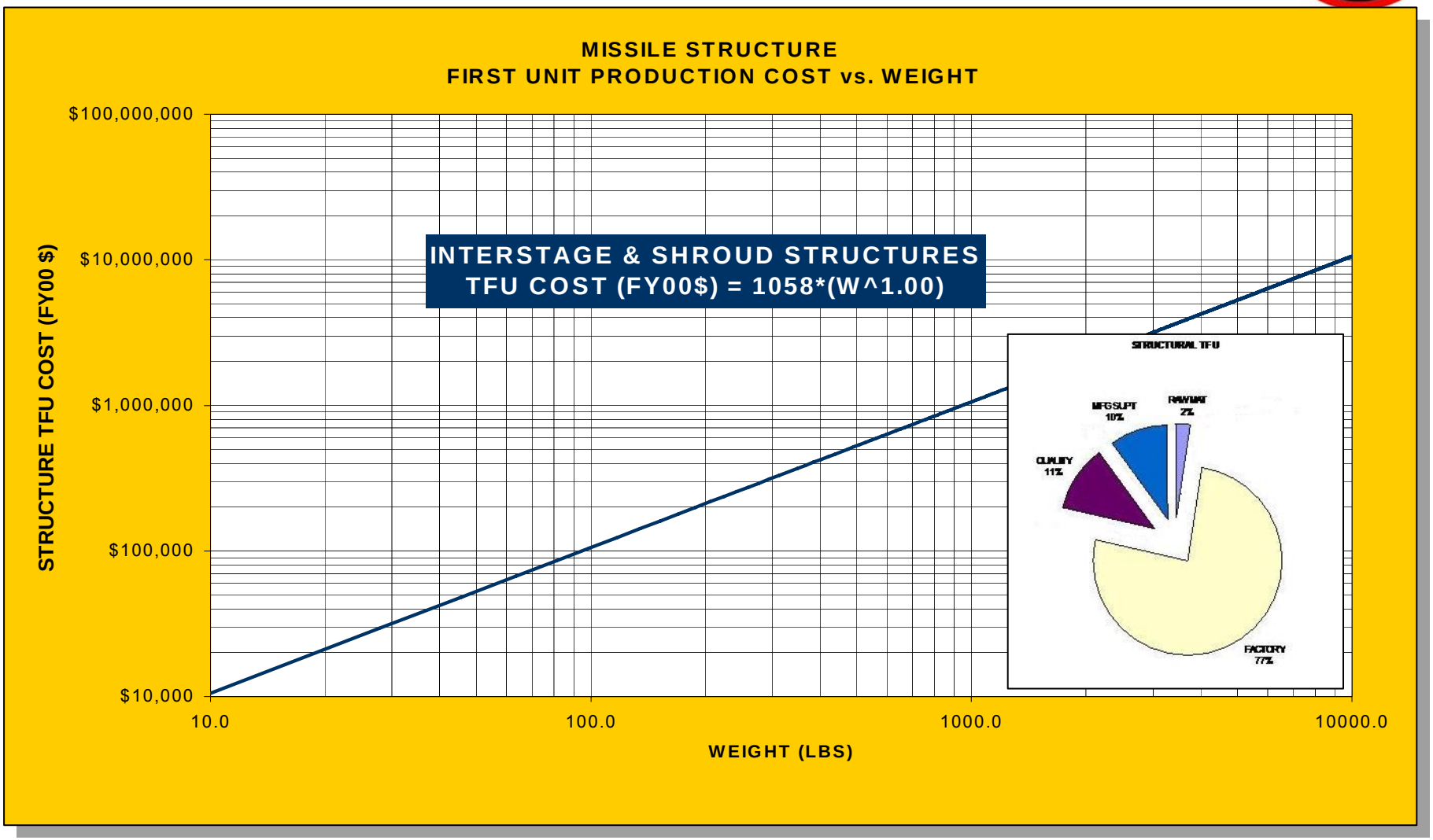
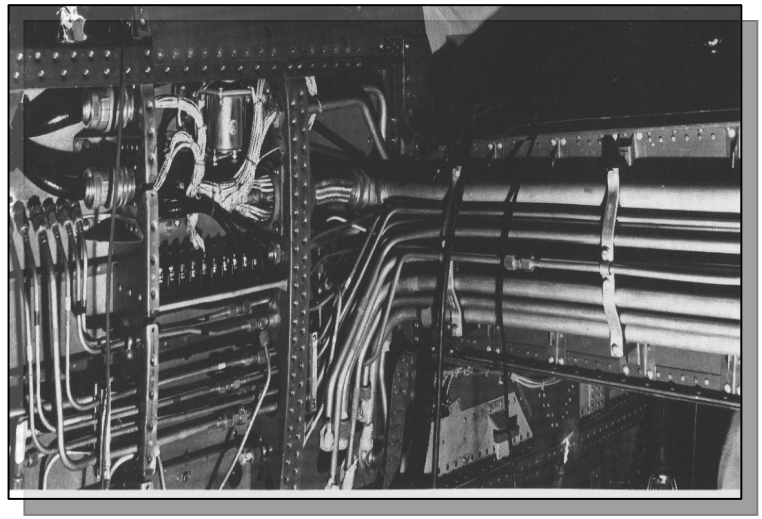
Structures – Development Cost



Structures – TFU Production Cost



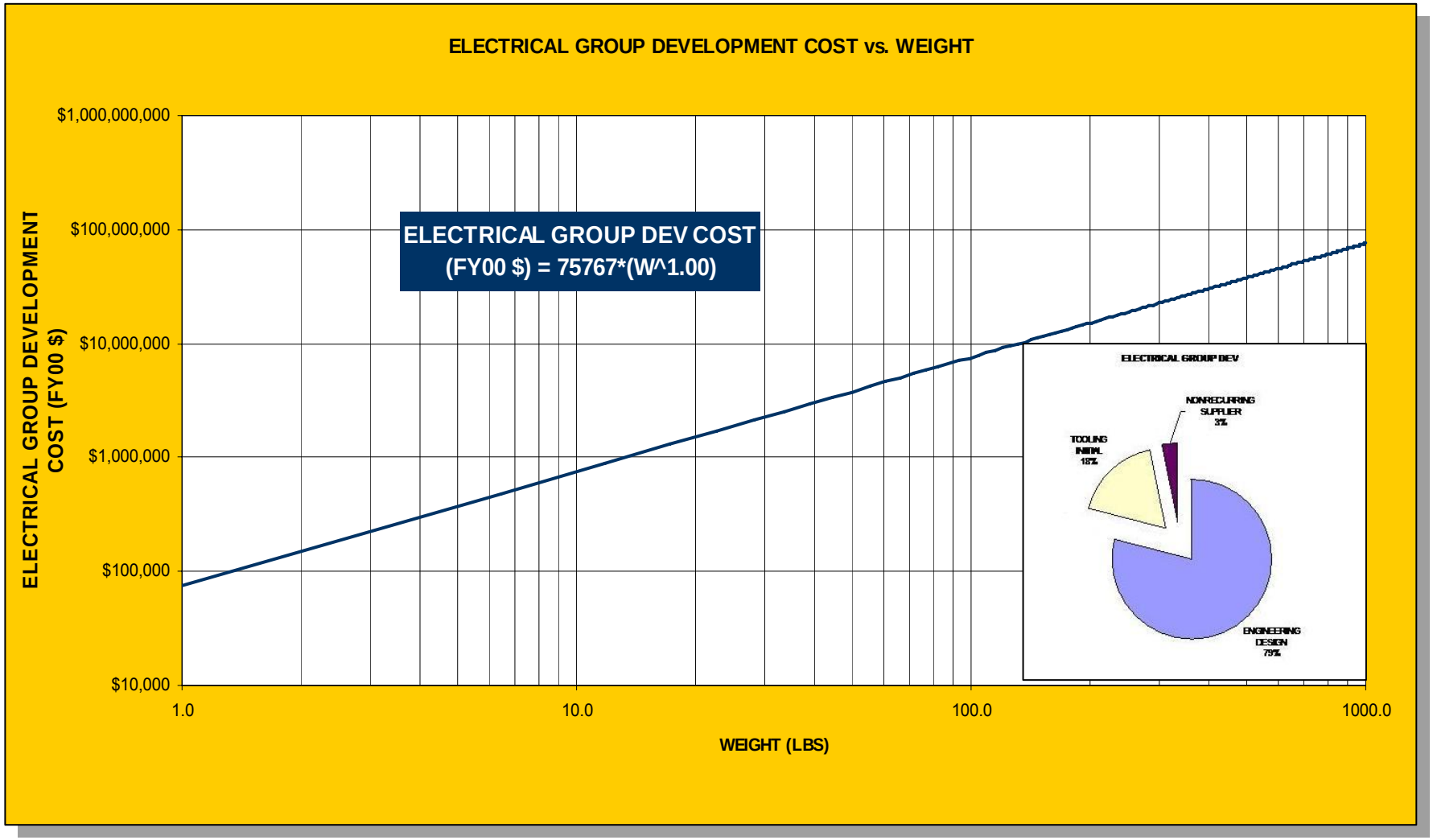
Electrical Power – Batteries and PC&D



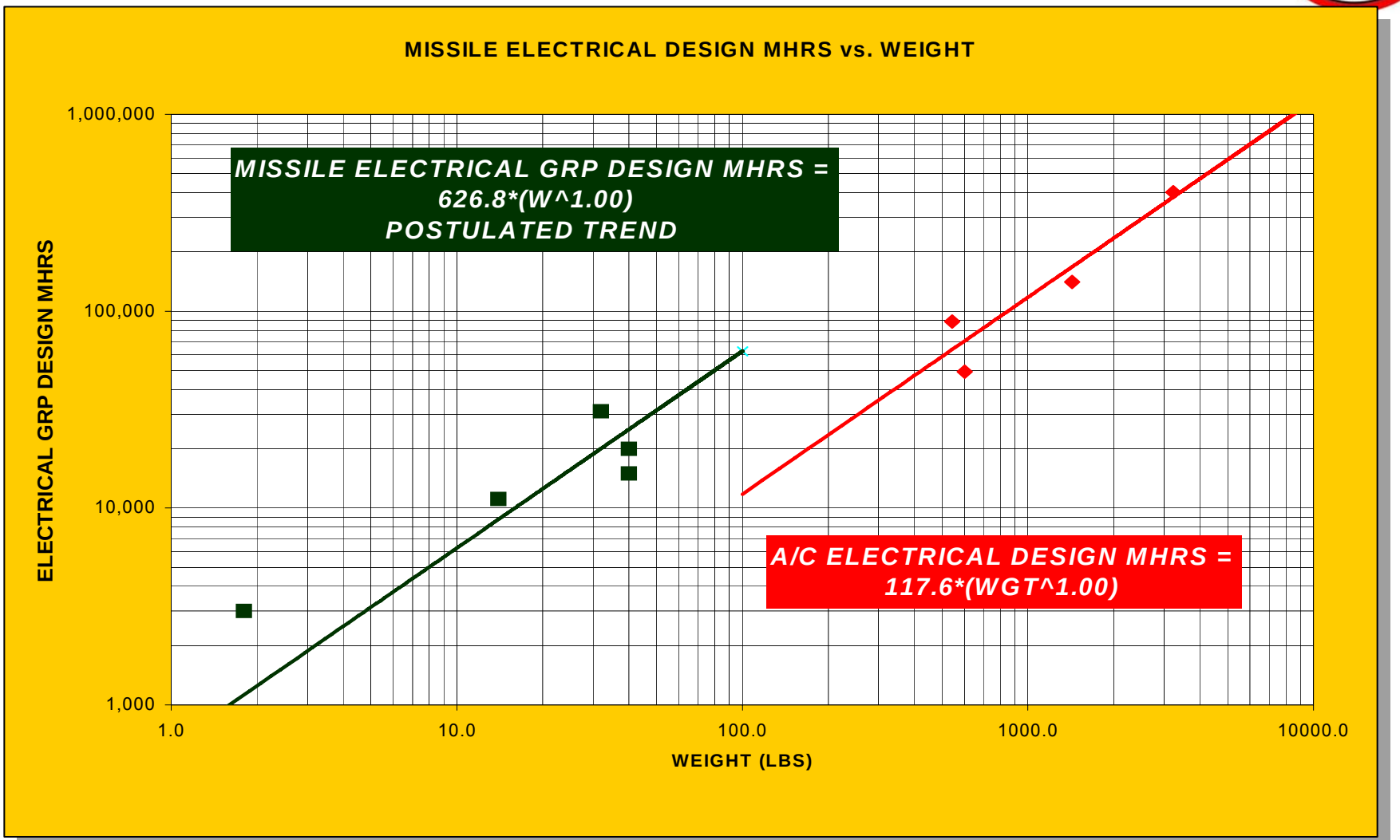
Electrical power for missiles generally comes from banks of thermal batteries. For the largest ICBMs and ELVs, chemically powered turbo generators are also employed.

In addition to the batteries, power must be conditioned and distributed. Some cables are mounted external to the SRMS in structural raceways or tunnels.

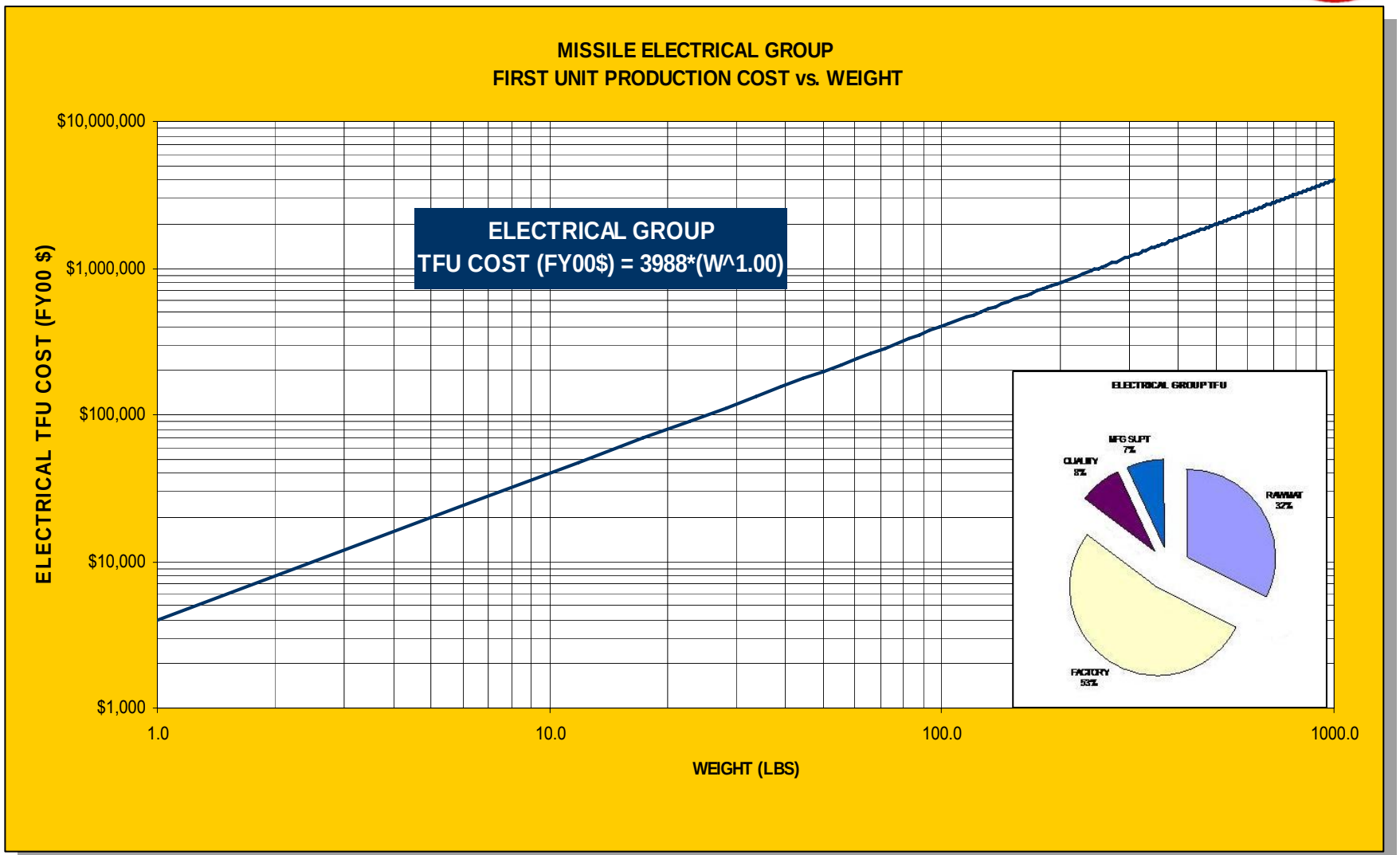
Electrical – Development Cost



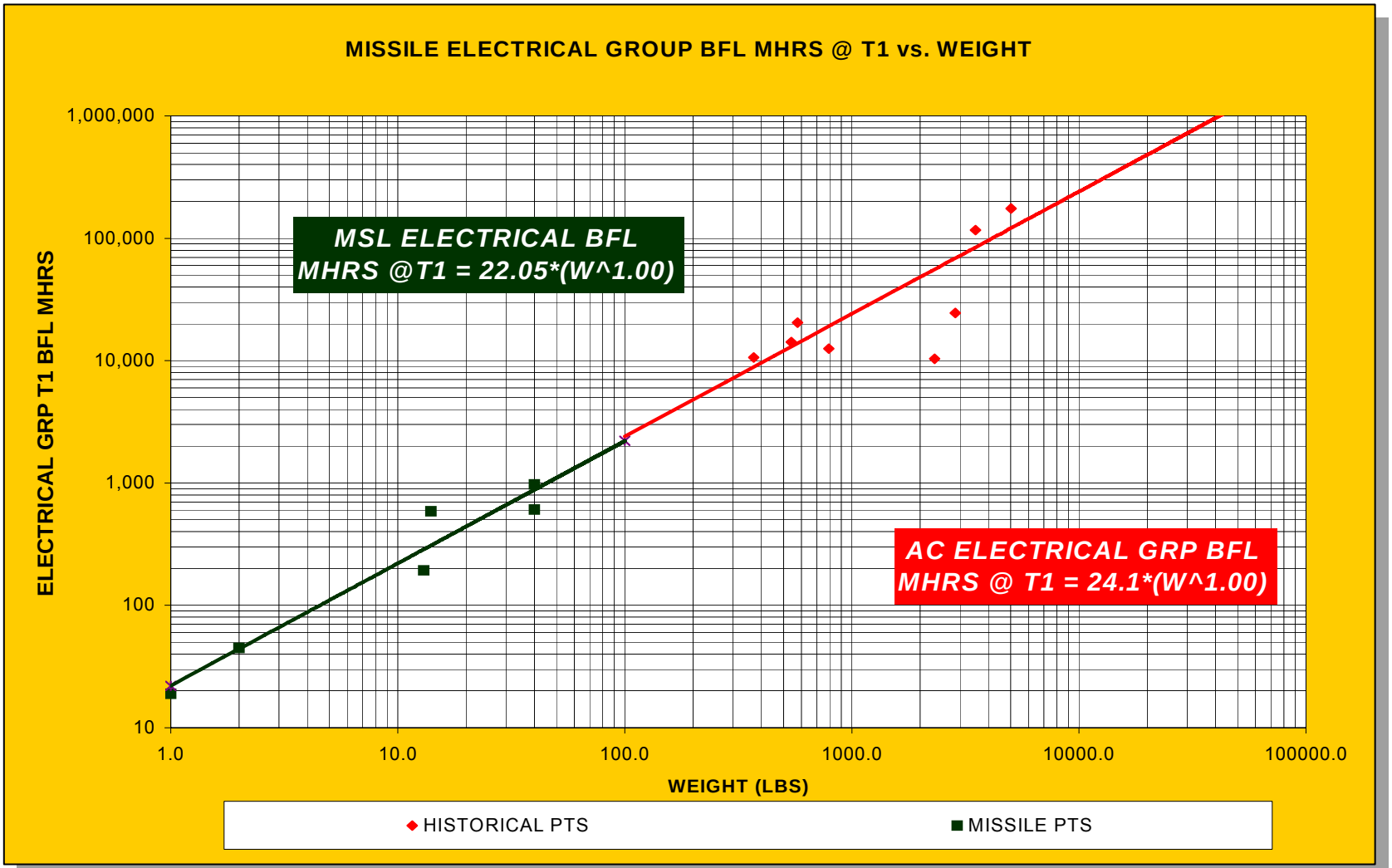
Electrical – Development Cost



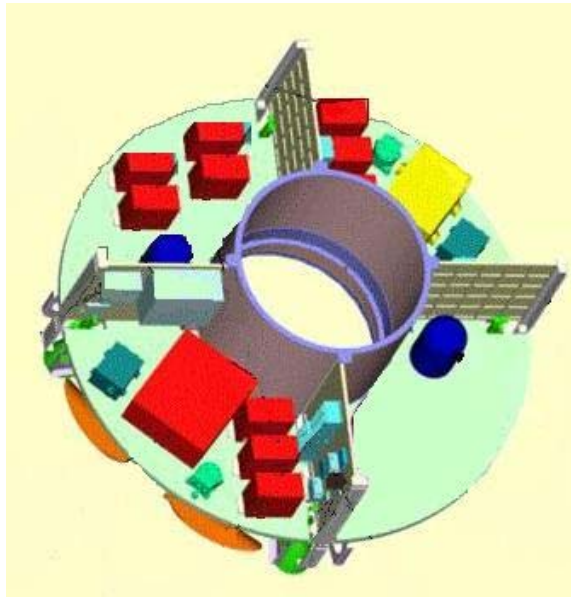
Electrical – TFU Production Cost



Electrical – TFU Production Cost



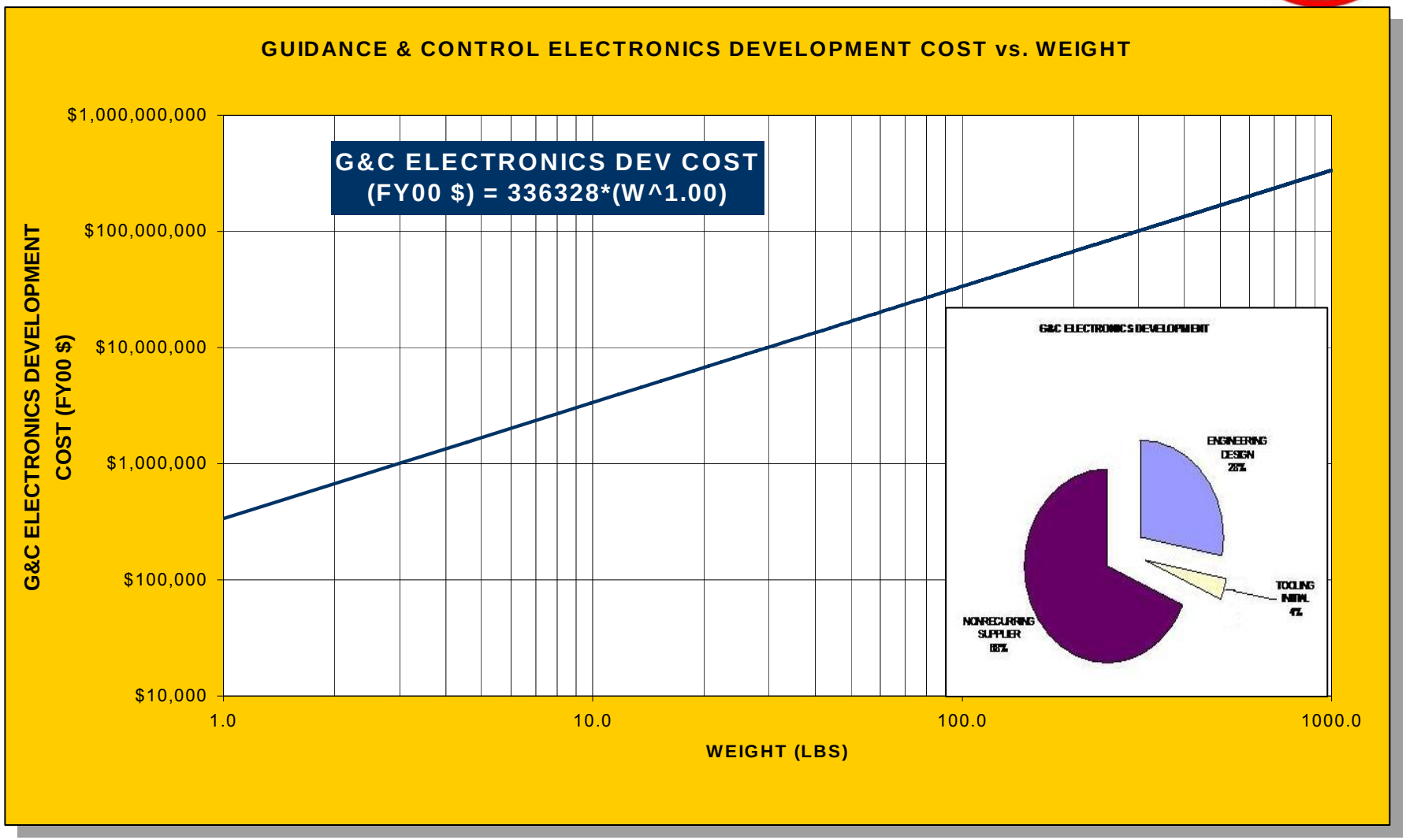
Guidance & Control Electronics



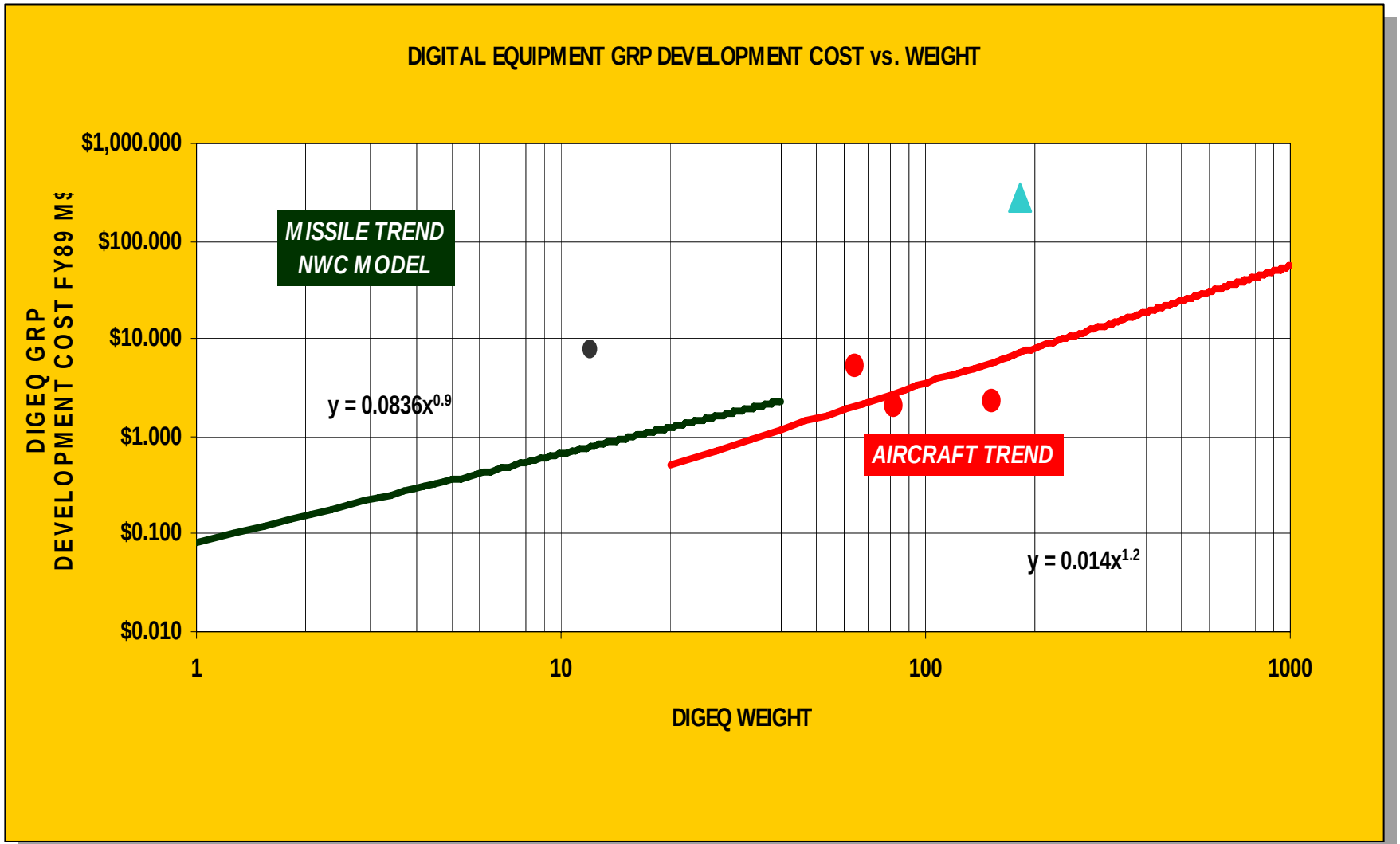
The Guidance and Control section includes Navigation systems (typically inertial and GPS, Autopilot/mission computer that steers the booster and may also include Sensors or communications links.

In addition to the electronic LRUs, provisions are required. These includes interconnect cables, mounts, and shielding as required.

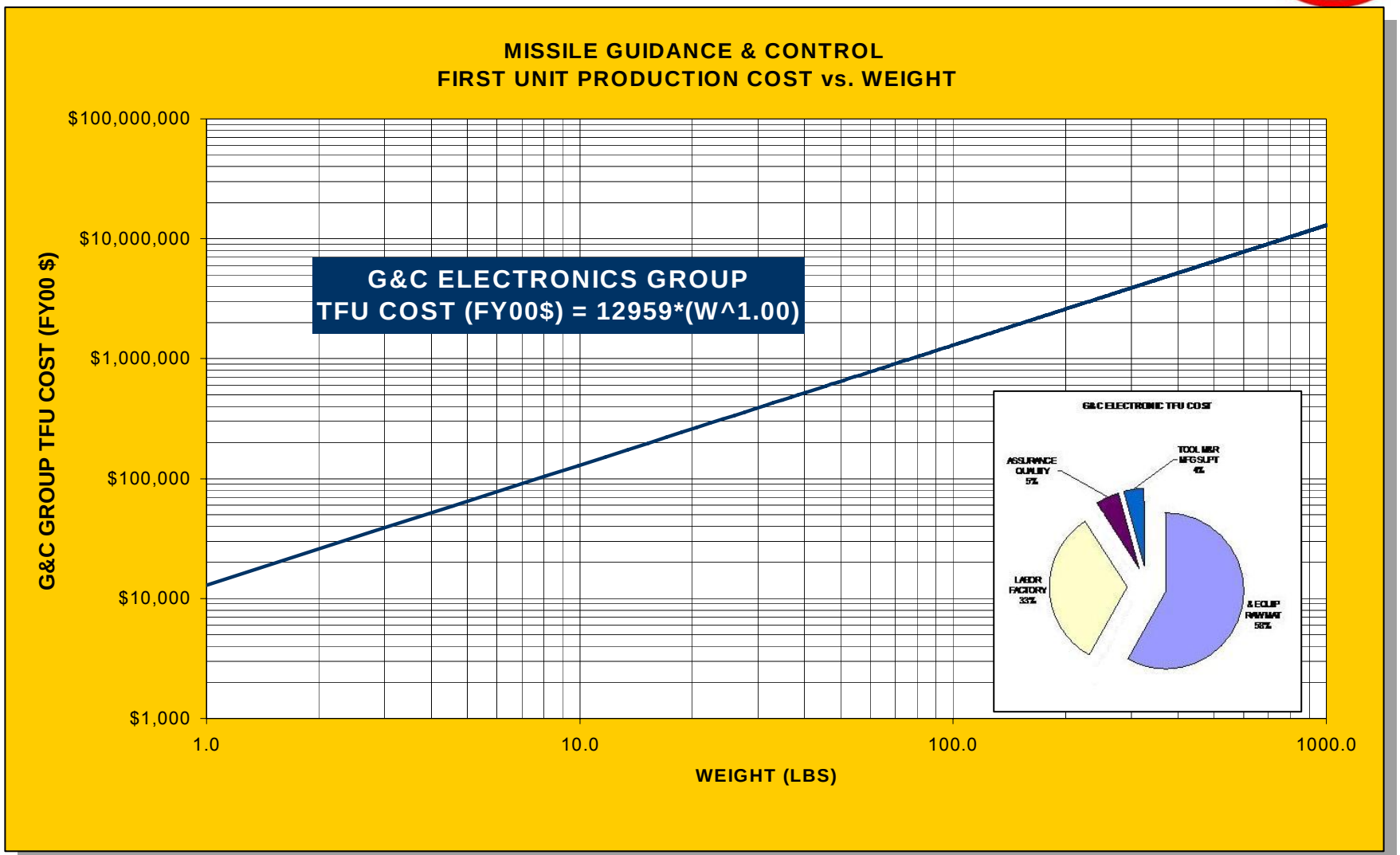
G&C Electronics – Development Cost



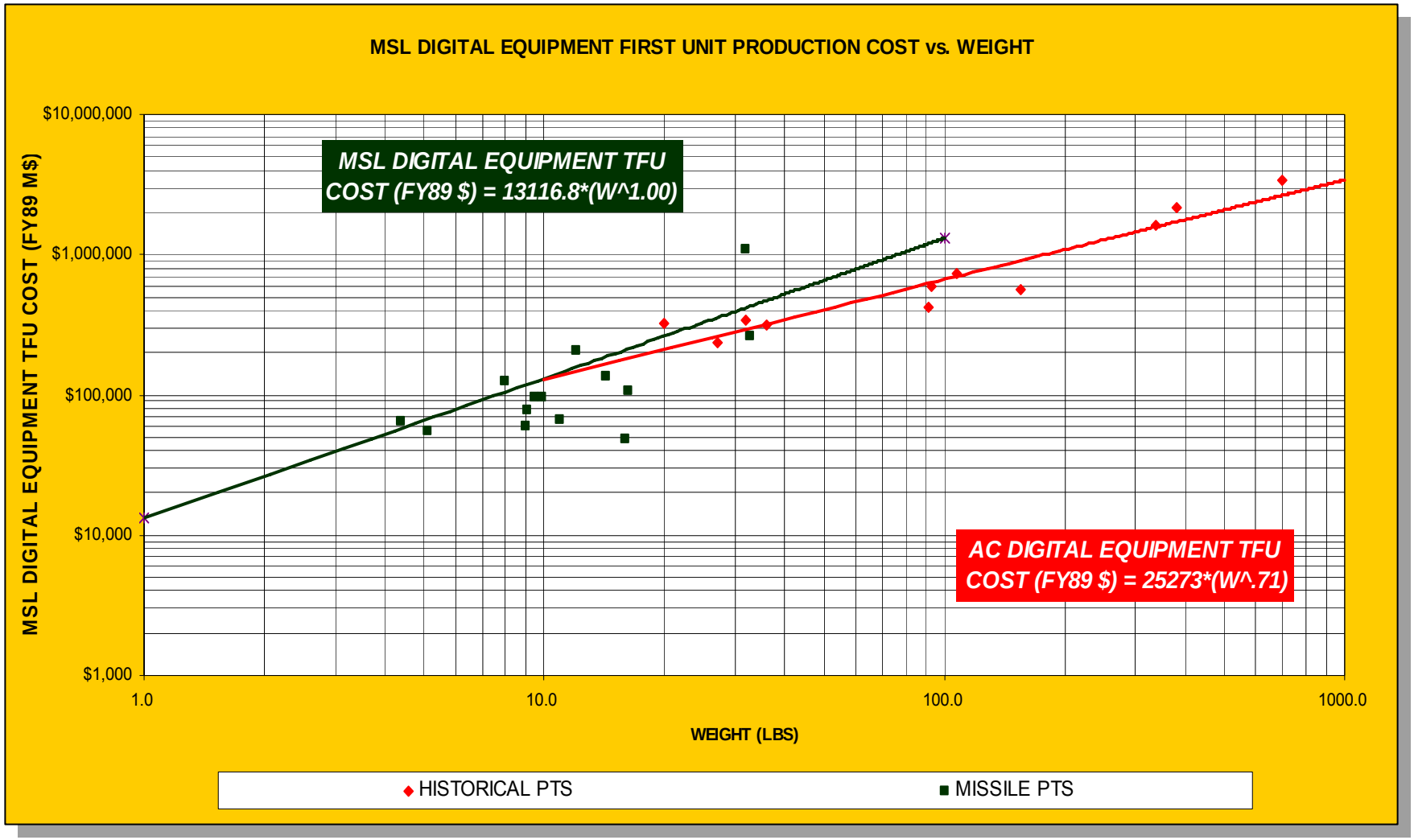
G&C Electronics – Development Cost



G&C Electronics – TFU Production Cost



G&C Electronics – TFU Production Cost



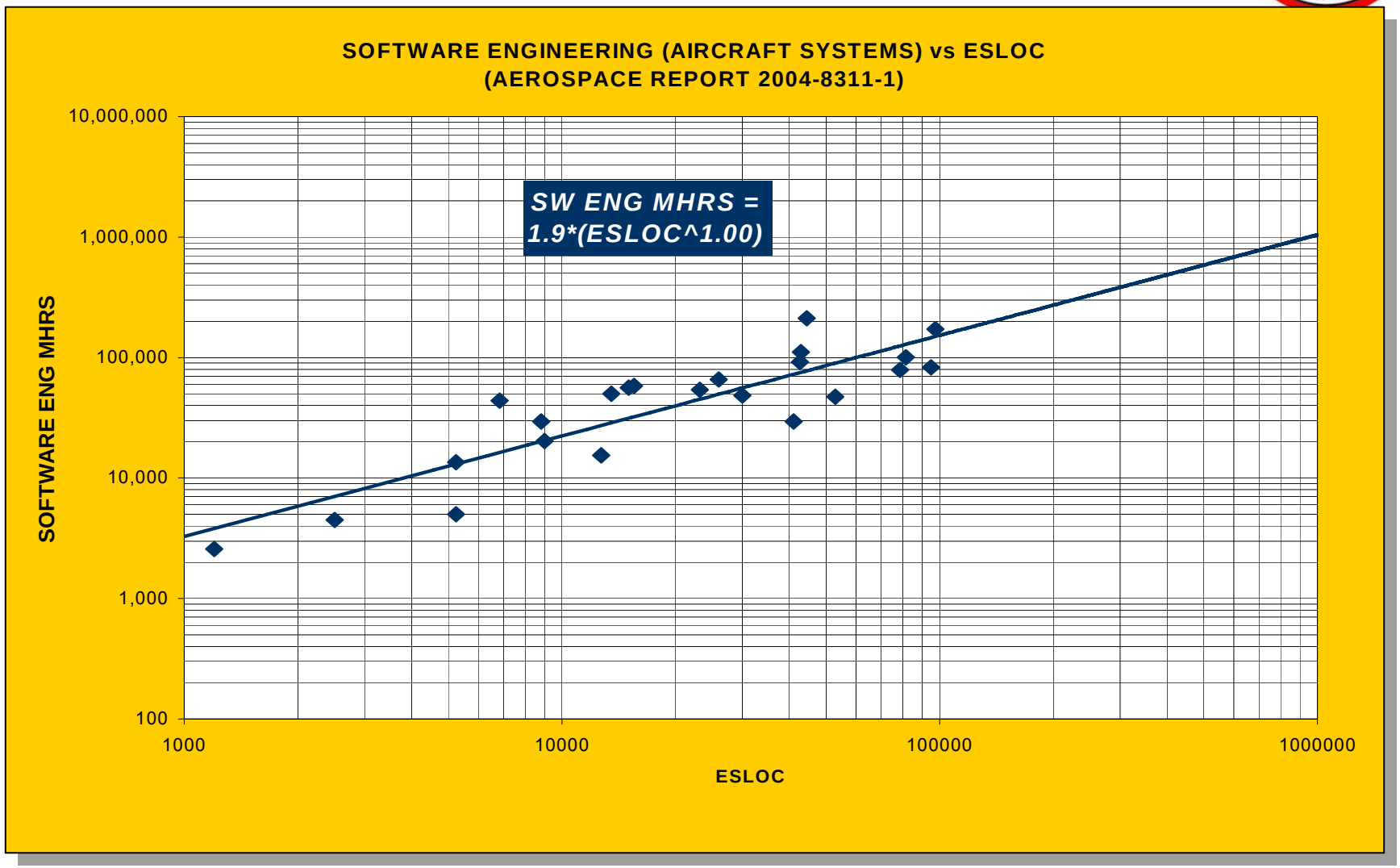
Guidance & Control Software Cost

MISSILE OPERATING ENVIRONMENT

	HIGH	LOW	AVERAGE	MEDIAN	SAMPLE SIZE
	27,500	530	8,334	5,985	18
COMMAND/CONTROL	16,000	11,500	13,750		2
Guidance and Control	16,000	11,500	13,750		2
GN&C	8,000	8,000	8,000		1
Attitude Determination	8,000	8,000	8,000		1
OS/EXECUTIVES	1,471	1,471	1,471		1
Executive Functions	1,471	1,471	1,471		1
SIGNAL PROCESSING	27,500	530	6,354	5,400	14
Attitude Determination	1,125	1,125	1,125		1
Control	645	645	645		1
Executive Functions	5,200	5,200	5,200		1
Mathematical	530	530	530		1
Pointing	19,720	19,720	19,720		1
Security	1,100	1,100	1,100		1
Track/Target	27,500	5,600	14,561	10,583	3
Utilities	2,550	1,200	1,875		2
Weapons Delivery	18,648	6,370	12,432	12,278	3

Software Size Estimation – Analogies from Missile Systems

Guidance & Control Software Cost

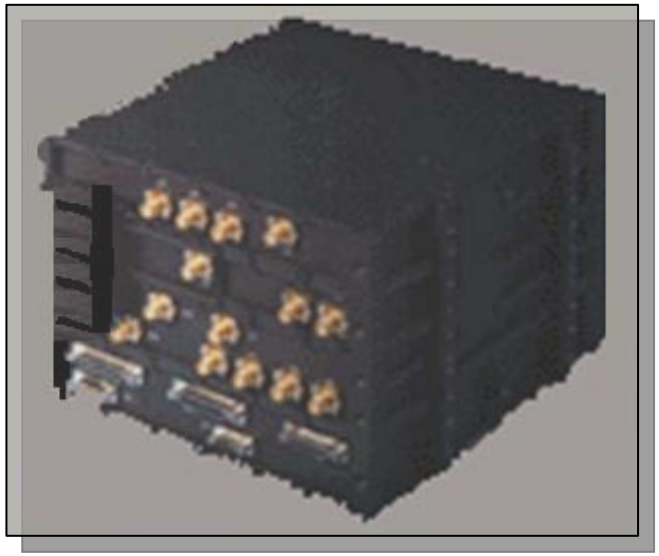


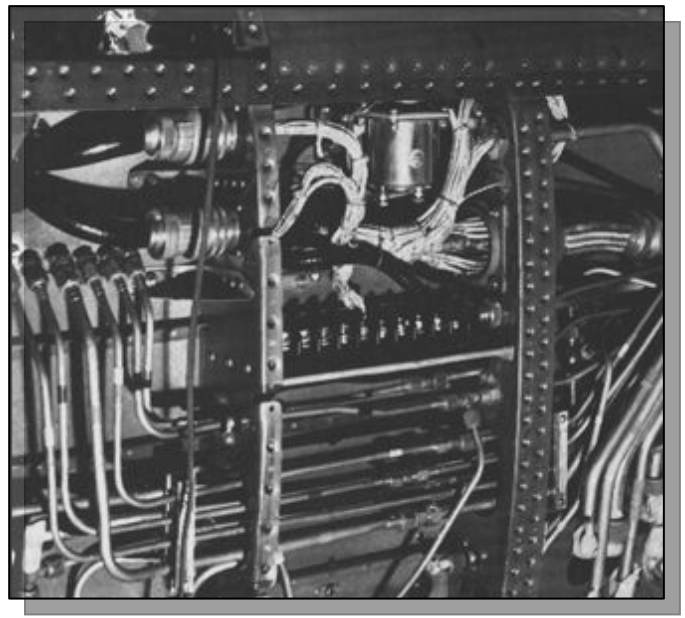
Cost Per SLOC (FY07$)

SOFTWARE PLATFORM	COST PER ENGINEERING MHR FY2007	MHRS PER SLOC (DES/CODE/UNIT TEST)	TOTAL SYSTEM ENGINEERING MHRS	TOTAL ENGINEERING MHRS PER SLOC	FY07 COST PER SLOC (W/O FEE)	MEAN FY07 COST PER SLOC (W/O FEE)
GROUND (LOW)	$150	1.1	1.30	2.40	$360	$480
GROUND (HIGH)	$250	1.1	1.30	2.40	$600	
GROUND MOBILE (LOW)	$150	1.5	1.77	3.27	$491	$654
GROUND MOBILE (HIGH)	$250	1.5	1.77	3.27	$818	
AIRBORNE (LOW)	$150	1.9	2.24	4.14	$621	$828
AIRBORNE (HIGH)	$250	1.9	2.24	4.14	$1,036	
UNMANNED SPACE (LOW)	$150	3.1	3.66	6.76	$1,014	$1,352
UNMANNED SPACE (HIGH)	$250	3.1	3.66	6.76	$1,690	

The cost of a line of code varies with contractors and by software platform or type.

Flight Termination Group





The Flight Safety group includes a communications link, an encoder, an event controller (computer and timer) and carefully positioned explosive charges.

In addition to the electronic LRUs, provisions are required. These includes interconnect cables, mounts, and shielding as required.

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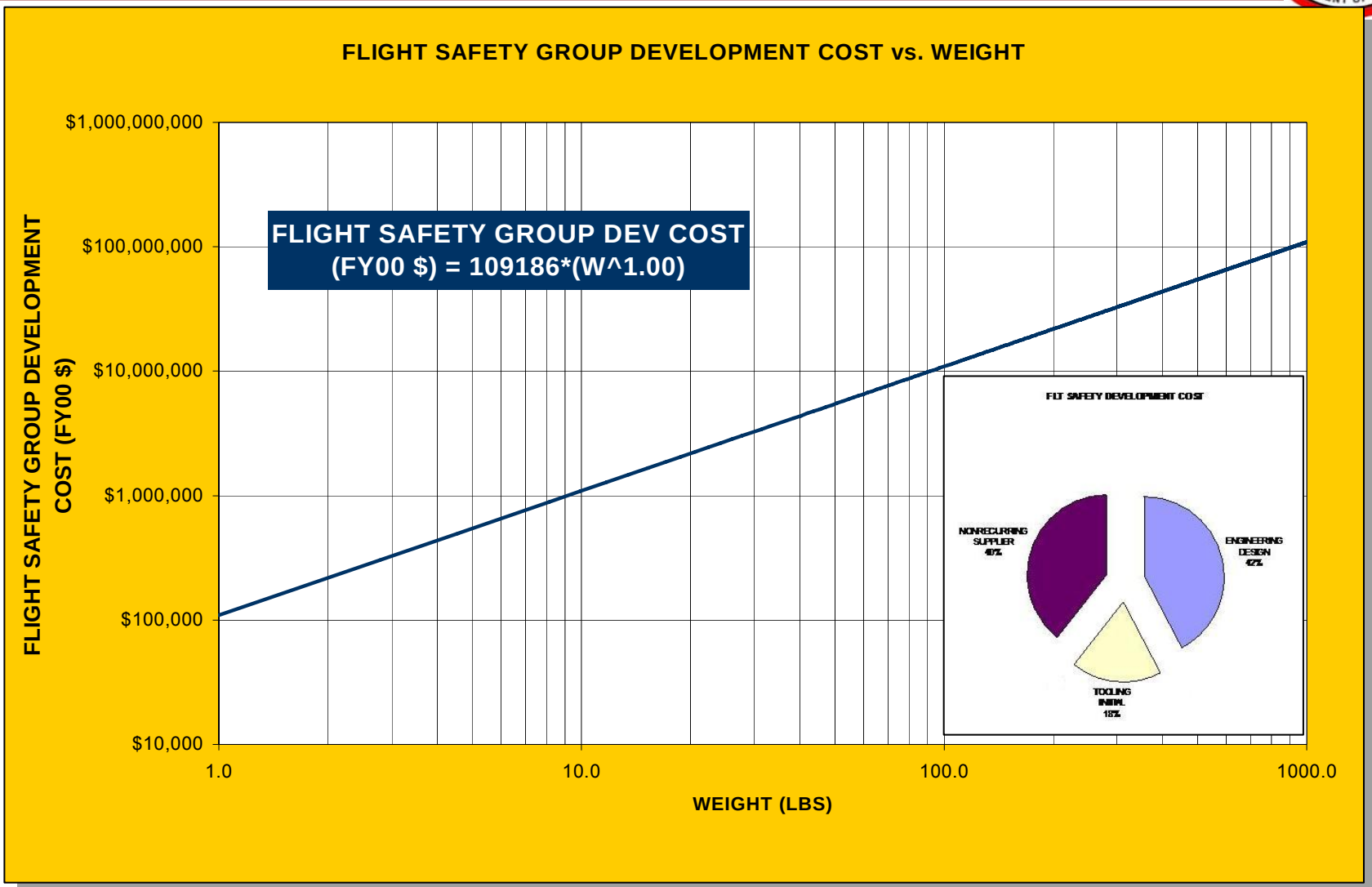
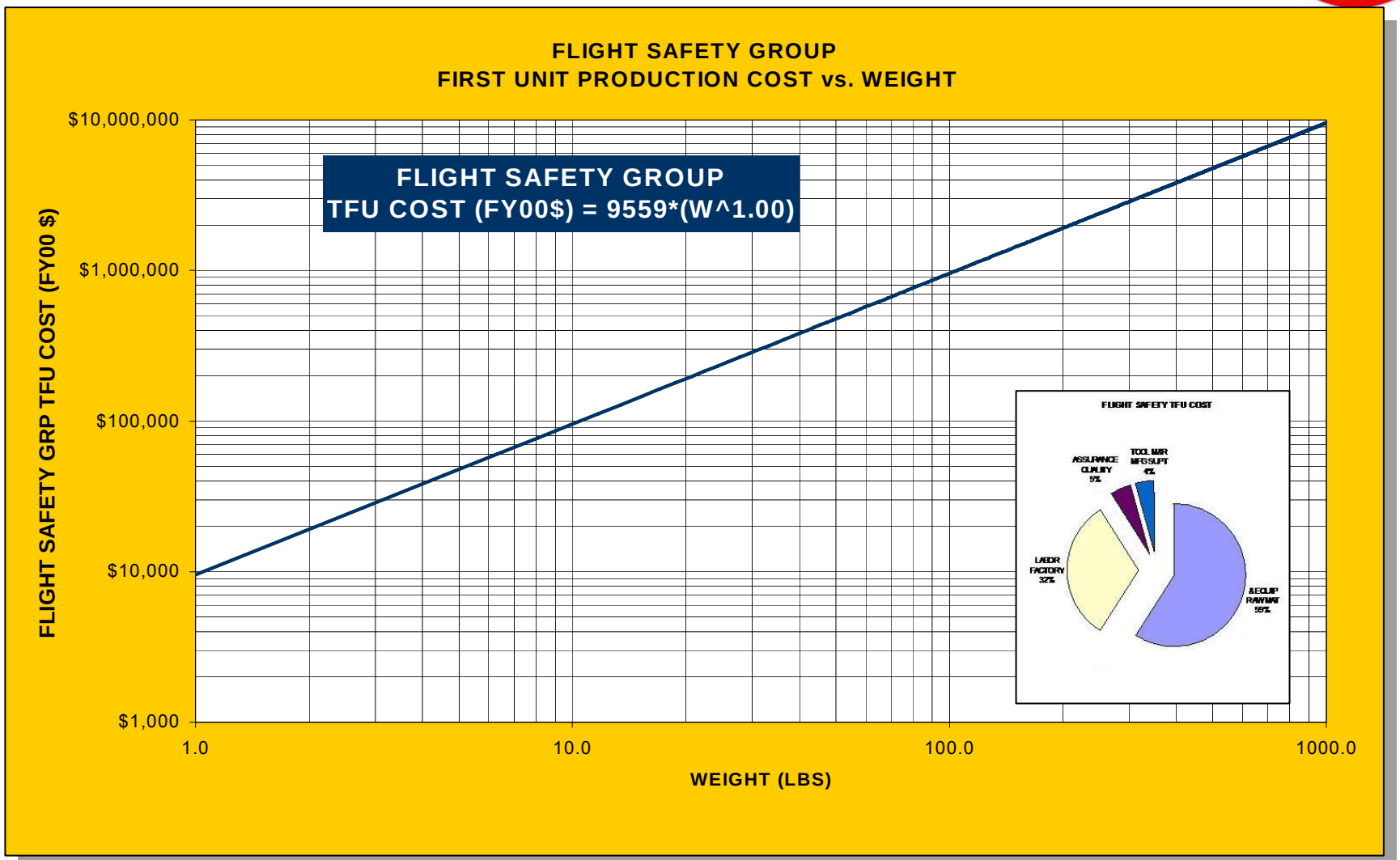
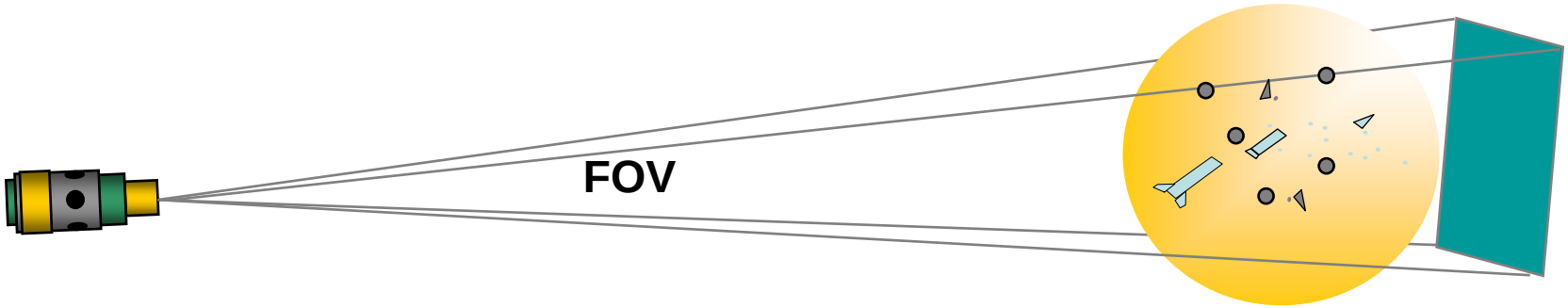
Flight Termination Group – Development Cost

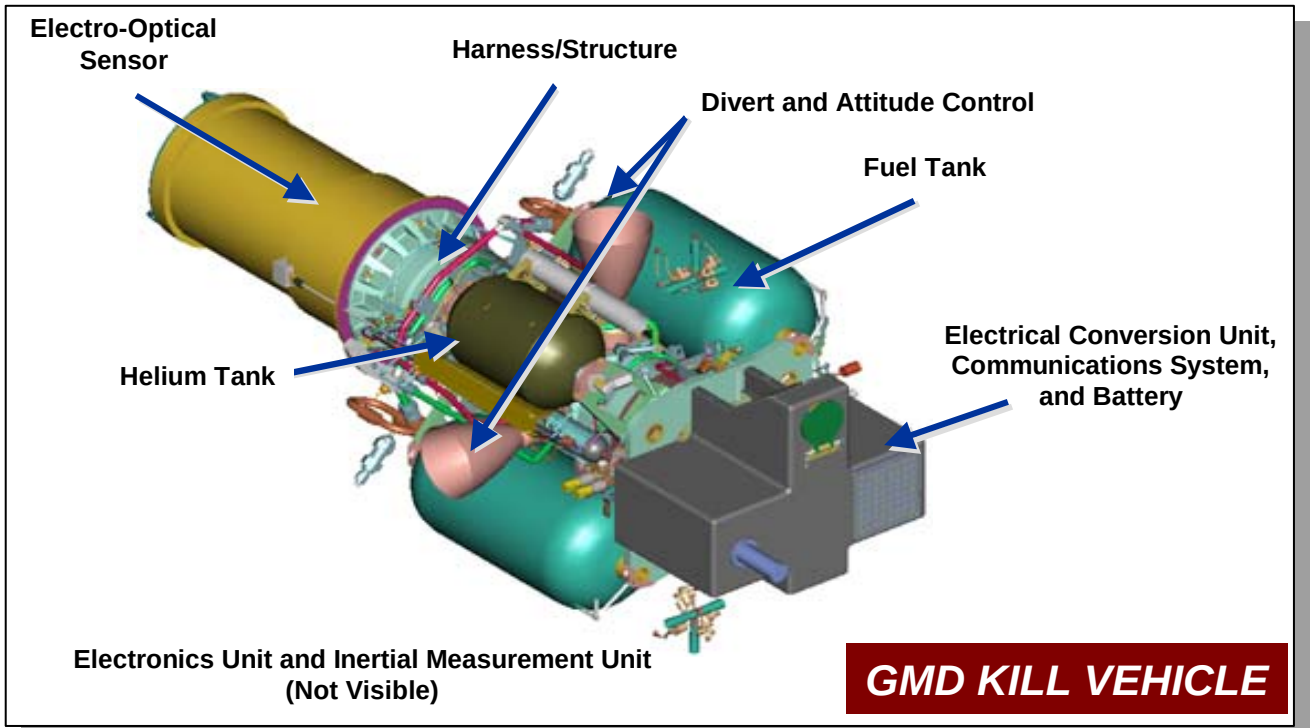


Flight Termination Group – TFU Production Cost

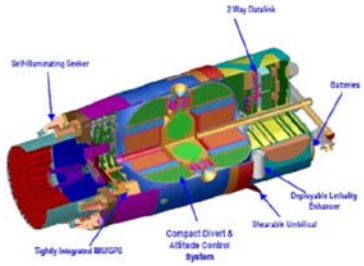


EKV System
Technical Characteristics



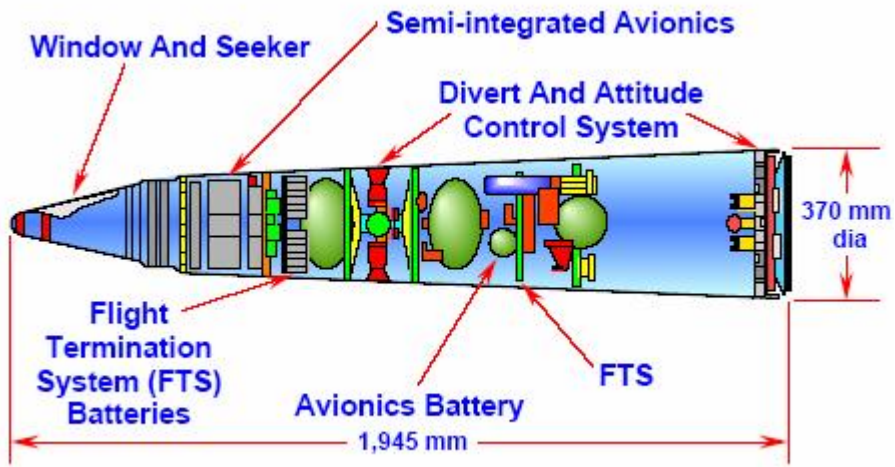


Other MDA KV Systems



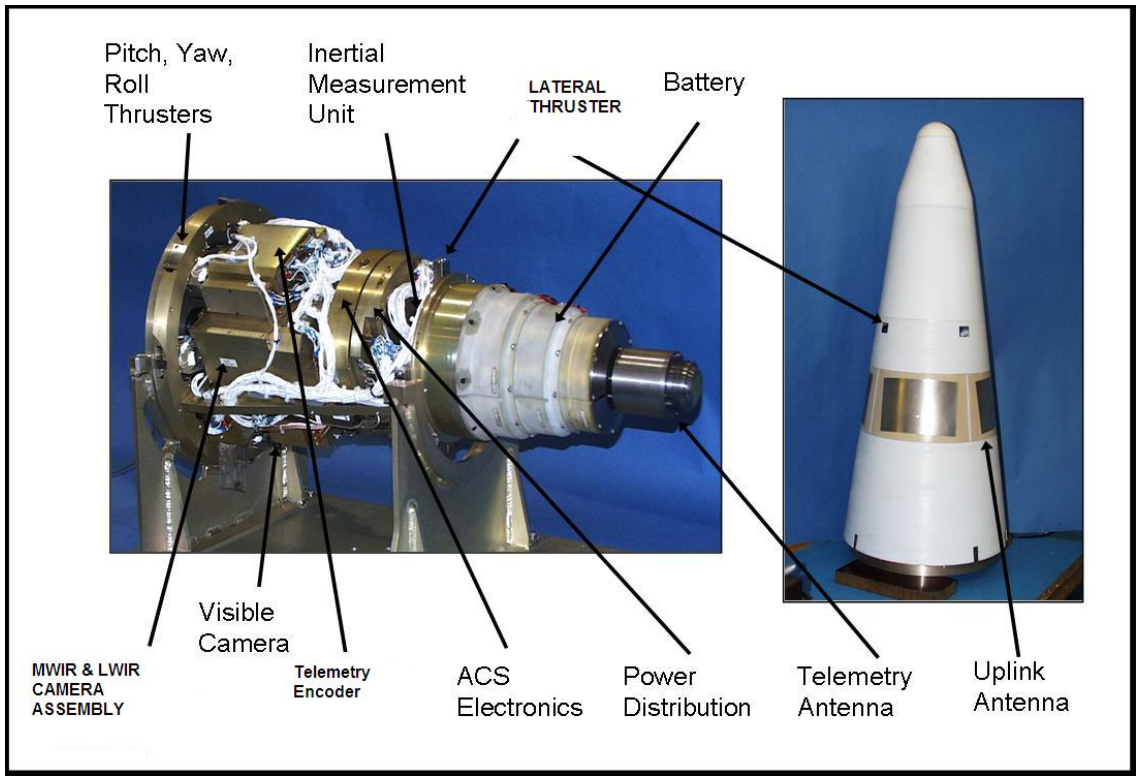
MULTIPLE KILL VEHICLE

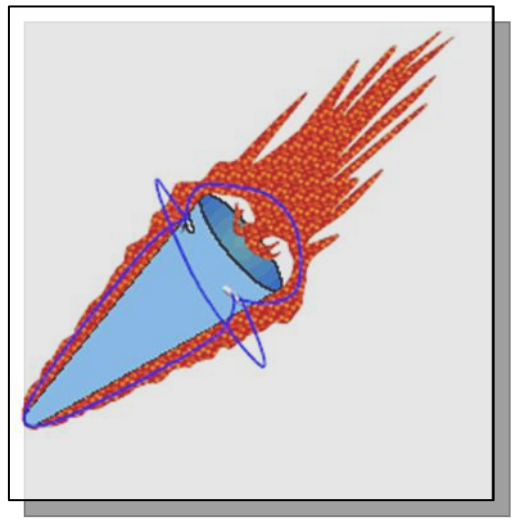
SM3 SEEKER/KV



THAAD SEEKER/KV

Target System Payloads





INSTRUMENTED RE-ENTRY VEHICLE

FLY ALONG SENSOR PACKAGE

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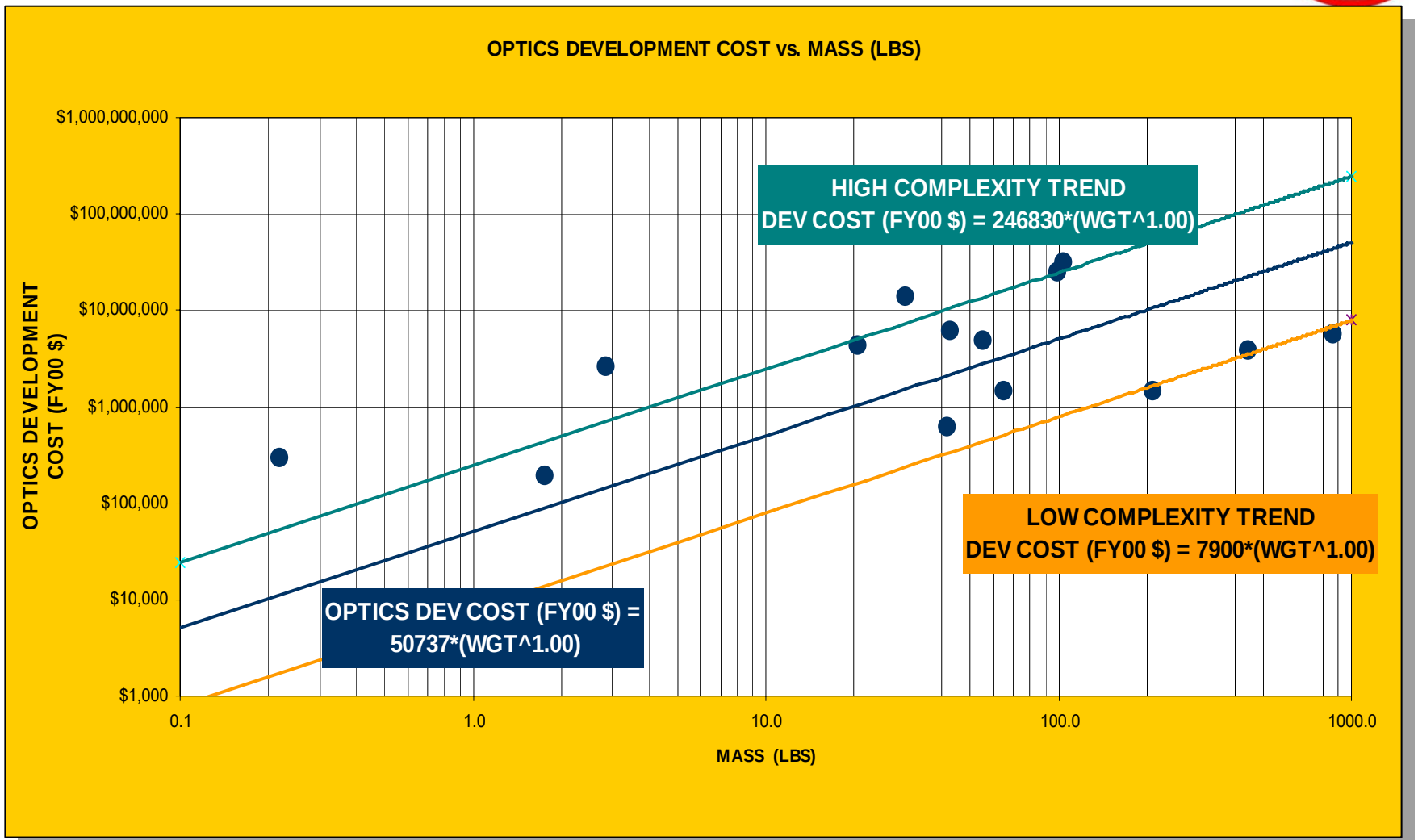
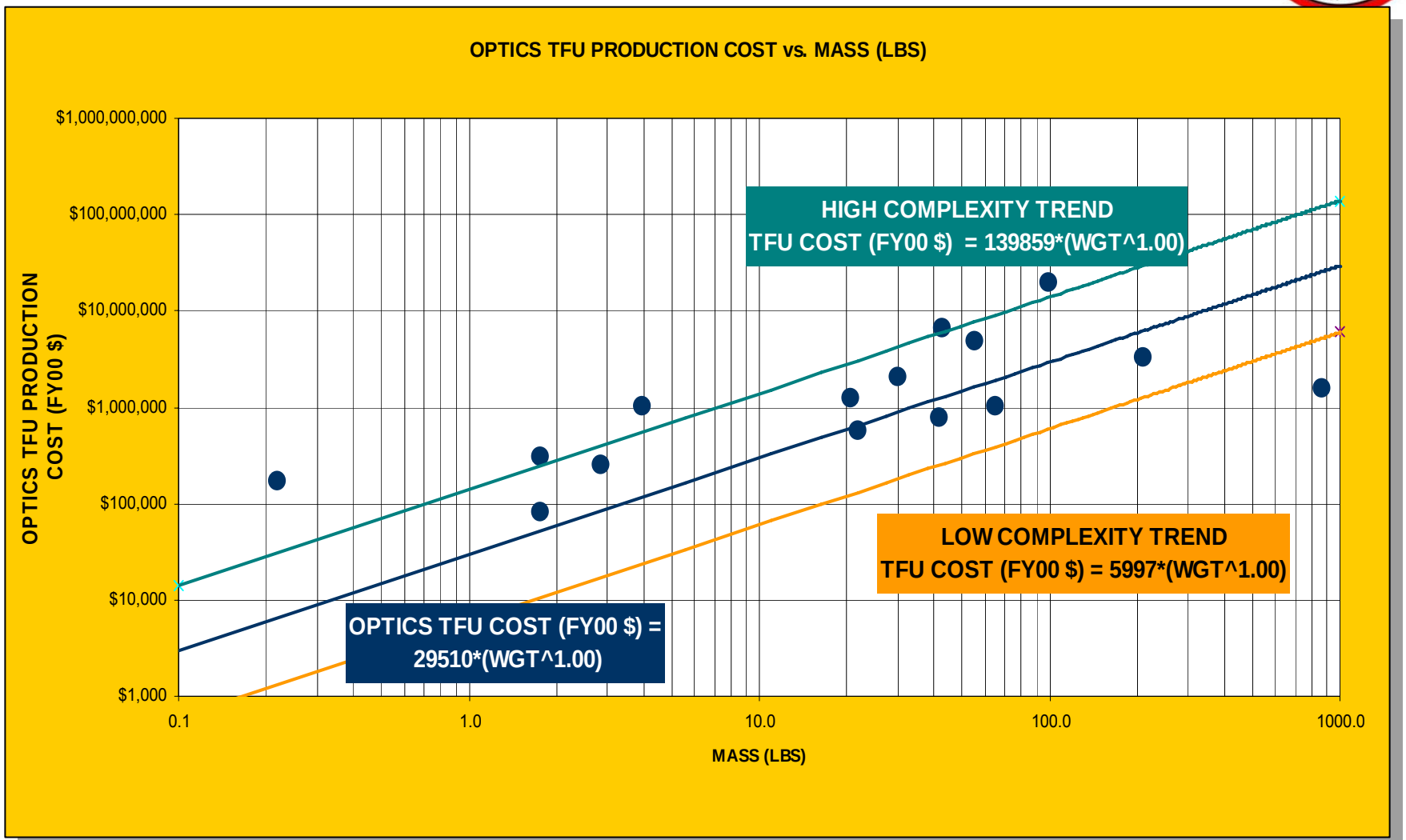
Payload CERs from Spacecraft Cost Models



Payload CERs from Spacecraft Cost Models



Booster Cost Estimating WBS Architecture

	Development Cost	Production Cost
Prime Mission Product		
SRMs & TVC Nozzles		
Interstage Structures		
Electrical Power		
Guidance & Cntl Electronics		
G&C Software		
Safety Systems		
Payload Systems		
Below The Line Costs		
Ground Support Equip (Pad)		
Ground Support Equip (Transport)		
Data		
Training		
Pad Spares		
Site Activation		

Below The Line Factors – Strategic Missiles

STRATEGIC MISSILES SYSTEM LEVEL WRAP FACTORS SLW COST = f(PME COST)	DEVELOPMENT	PRODUCTION
IACO	0.279	0.222
TEST & EVAL	0.123	0.040
SE/PM	0.349	0.250
GSE	0.032	0.137
DATA	0.020	0.020
TRAINING	0.011	0.014
SPARES	0.065	0.080
SITE ACTIVATION/ICS	0.008	0.095
OTHER LOGISTIC COMMODITIES	0.050	0.050
FACTOR TOTAL	0.937	0.908
SOURCE	SAMSO	SAMSO

Below The Line Factors – Tactical Missiles

TACTICAL MISSILES SYSTEM LEVEL WRAP FACTORS SLW COST = f(PME COST)	DEVELOPMENT	PRODUCTION
IACO	0.095	0.057
TEST & EVAL	0.345	0.050
SE/PM	0.590	0.150
GSE	0.040	0.048
DATA	0.079	0.026
TRAINING	0.036	0.020
SPARES	0.065	0.056
SITE ACTIVATION/ICS	0.021	0.005
OTHER LOGISTIC COMMODITIES	0.005	0.005
FACTOR TOTAL	1.276	0.417
SOURCE	NWS	BELL

Below The Line Factors – Target Missiles

TARGET MISSILES SYSTEM LEVEL WRAP FACTORS SLW COST = f(PME COST)	DEVELOPMENT	PRODUCTION
IACO	0.050	0.050
TEST & EVAL	0.070	0.000
SE/PM	0.200	0.100
GSE	0.167	0.000
DATA	0.080	0.010
TRAINING	0.050	0.000
SPARES	0.000	0.020
SITE ACTIVATION/ICS	0.000	0.050
OTHER LOGISTIC COMMODITIES	0.000	0.000
FACTOR TOTAL	0.617	0.230
SOURCE	BELL	BELL

Transporter-Erector-Launcher (TEL) Systems

KEI TEL SYSTEM

PAC3 TEL SYSTEM

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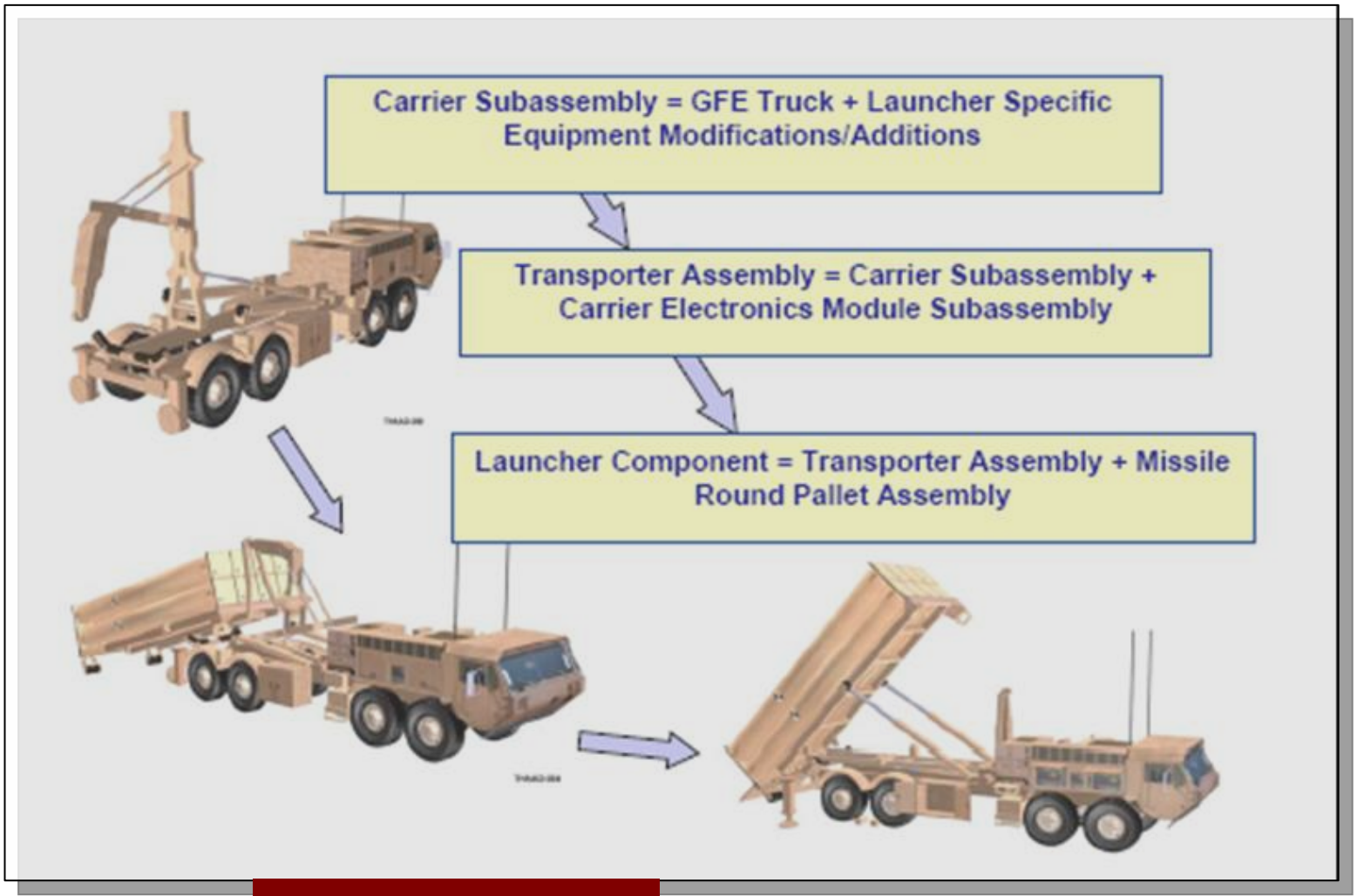
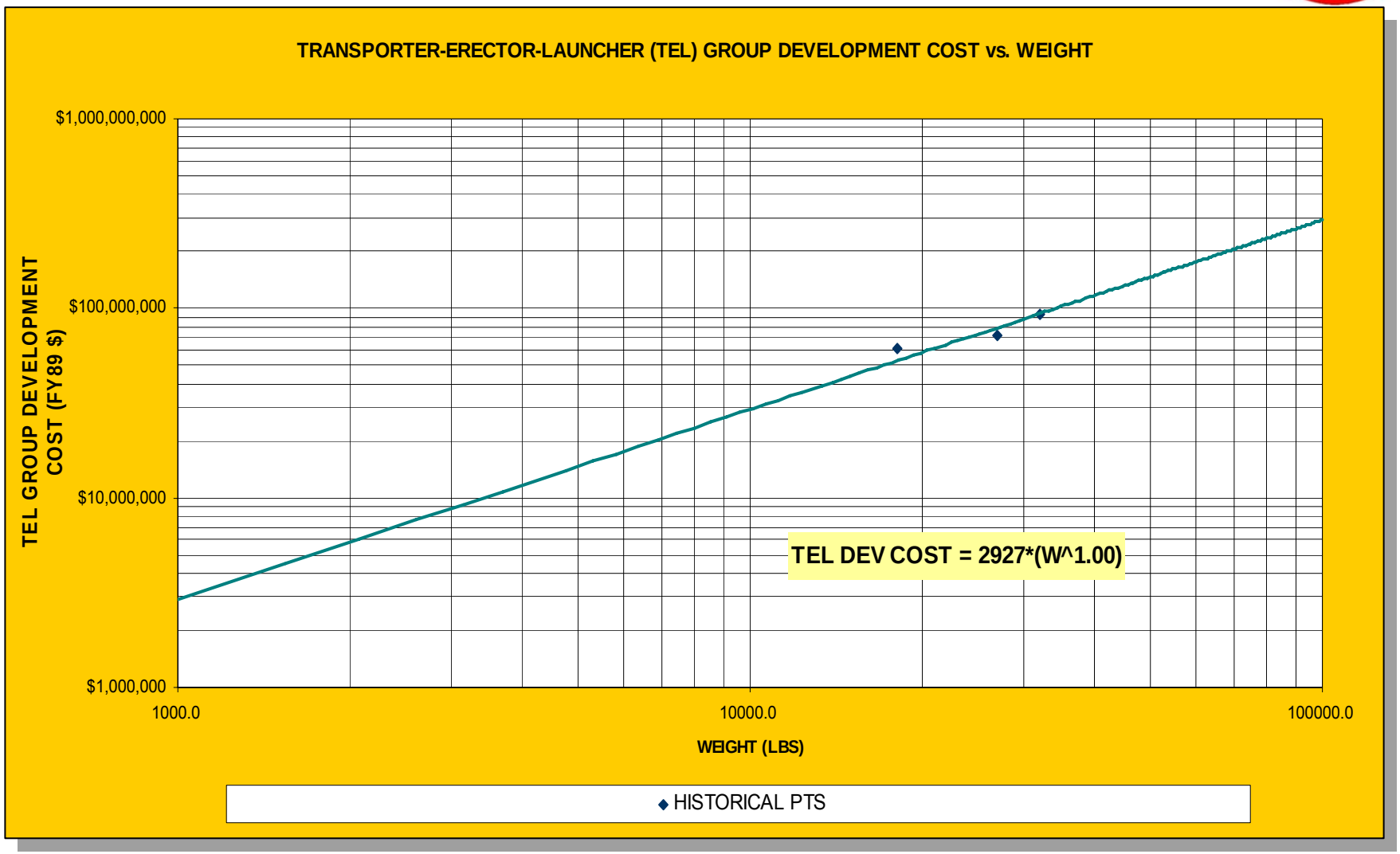
Transporter-Erector-Launcher (TEL) Systems

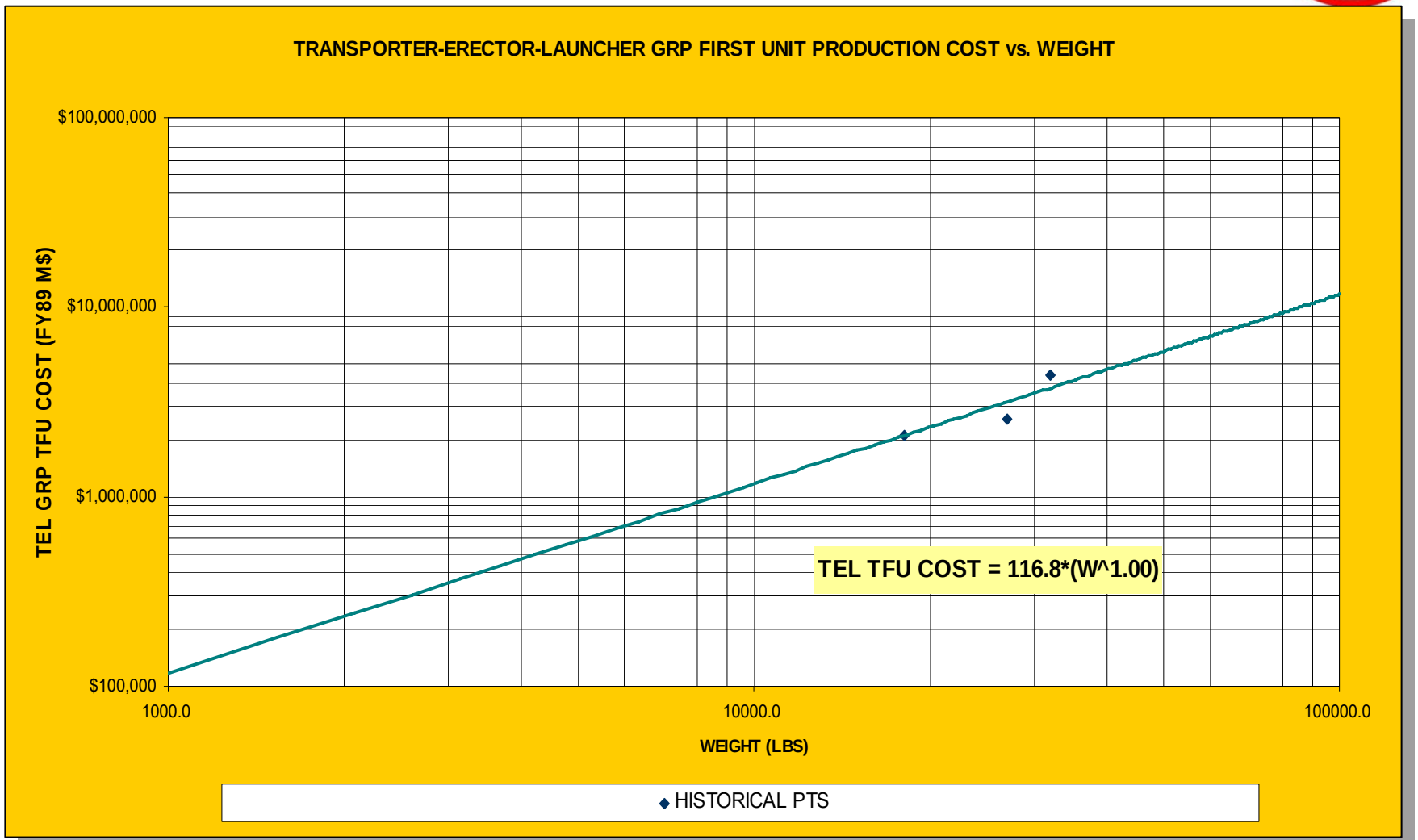


THAAD TEL SYSTEM

TEL Development CER



TEL TFU Production CER



SILO System for Ground-Based Interceptor

Typical SILO arrangement for Ground-Based Interceptor Missile Field.

MK41 Vertical Launch System for Sea-Based Interceptors

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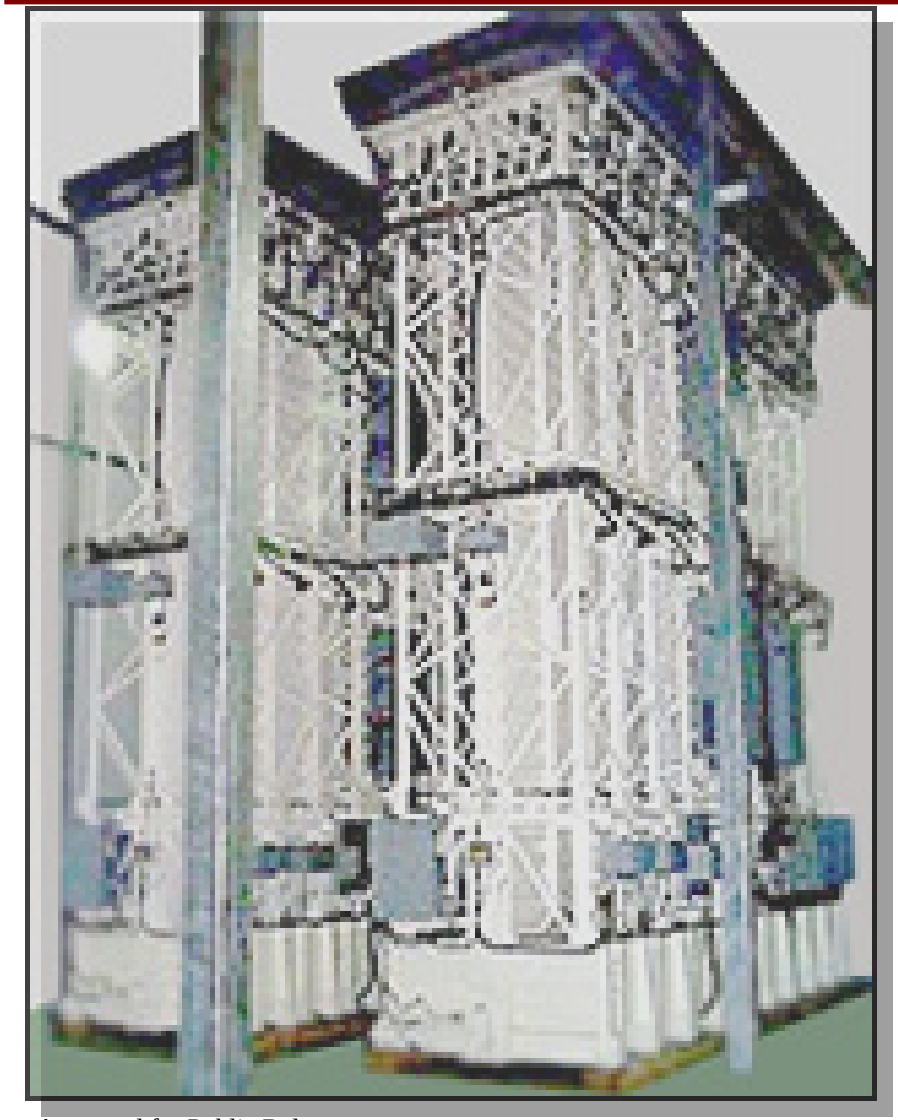
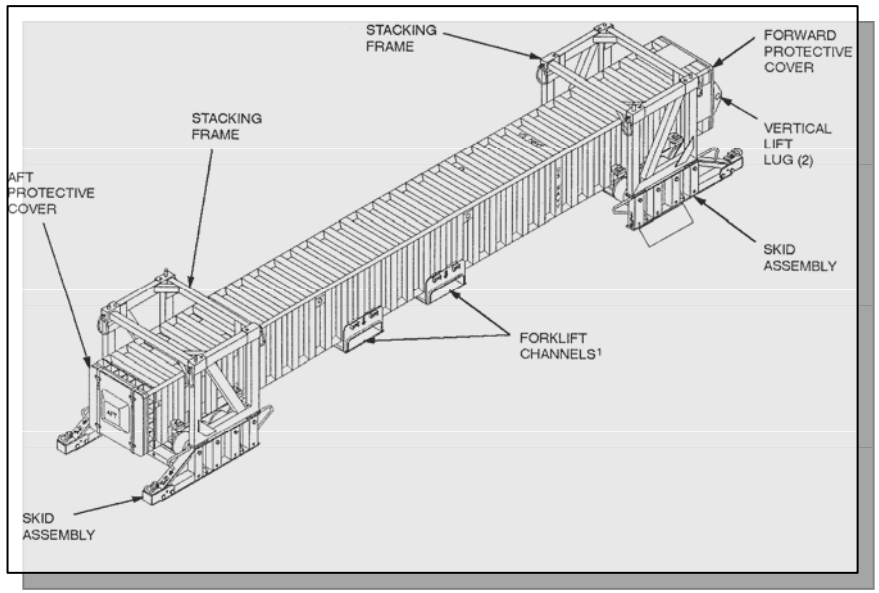
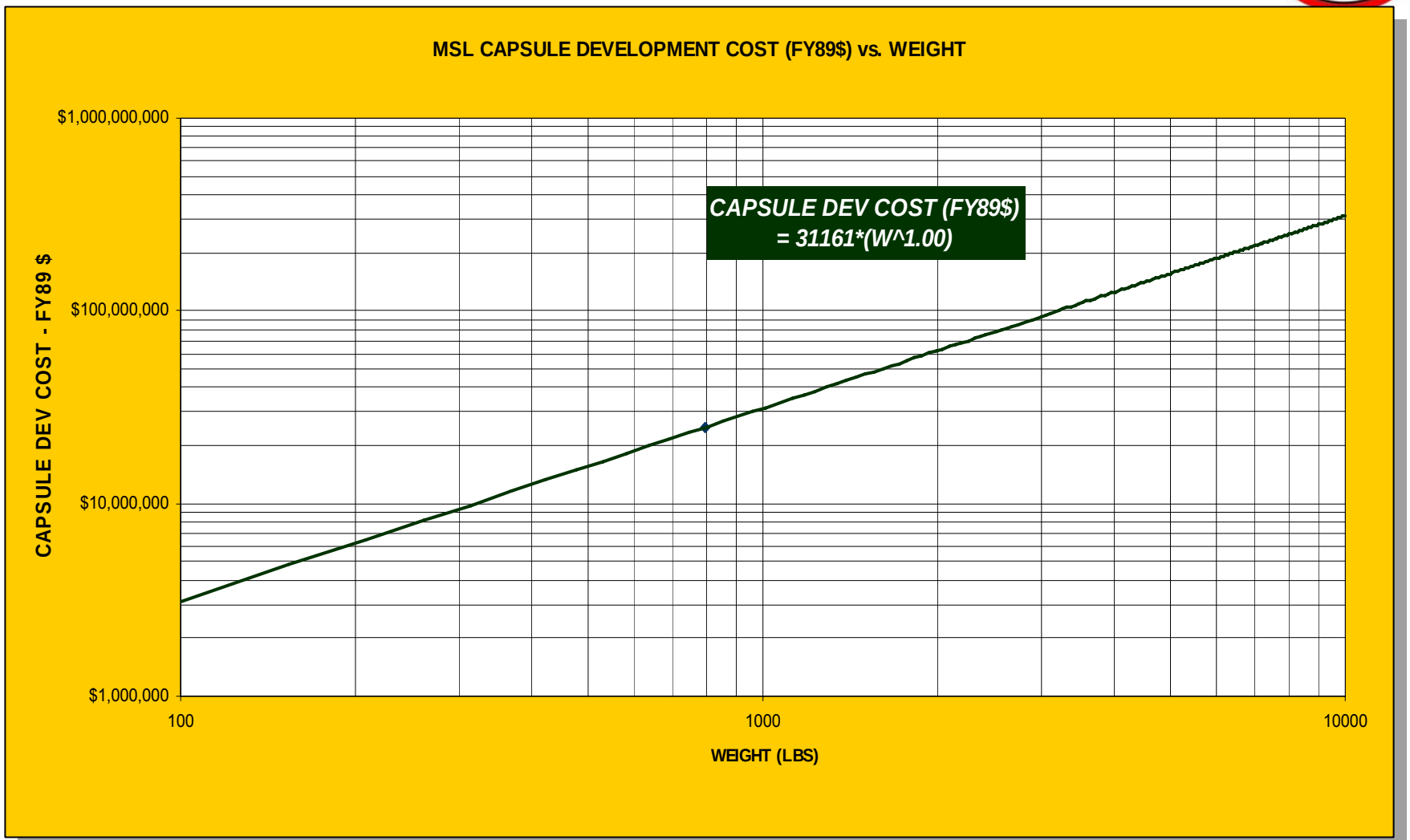
MK41 Vertical Launch System for Sea-Based Interceptors

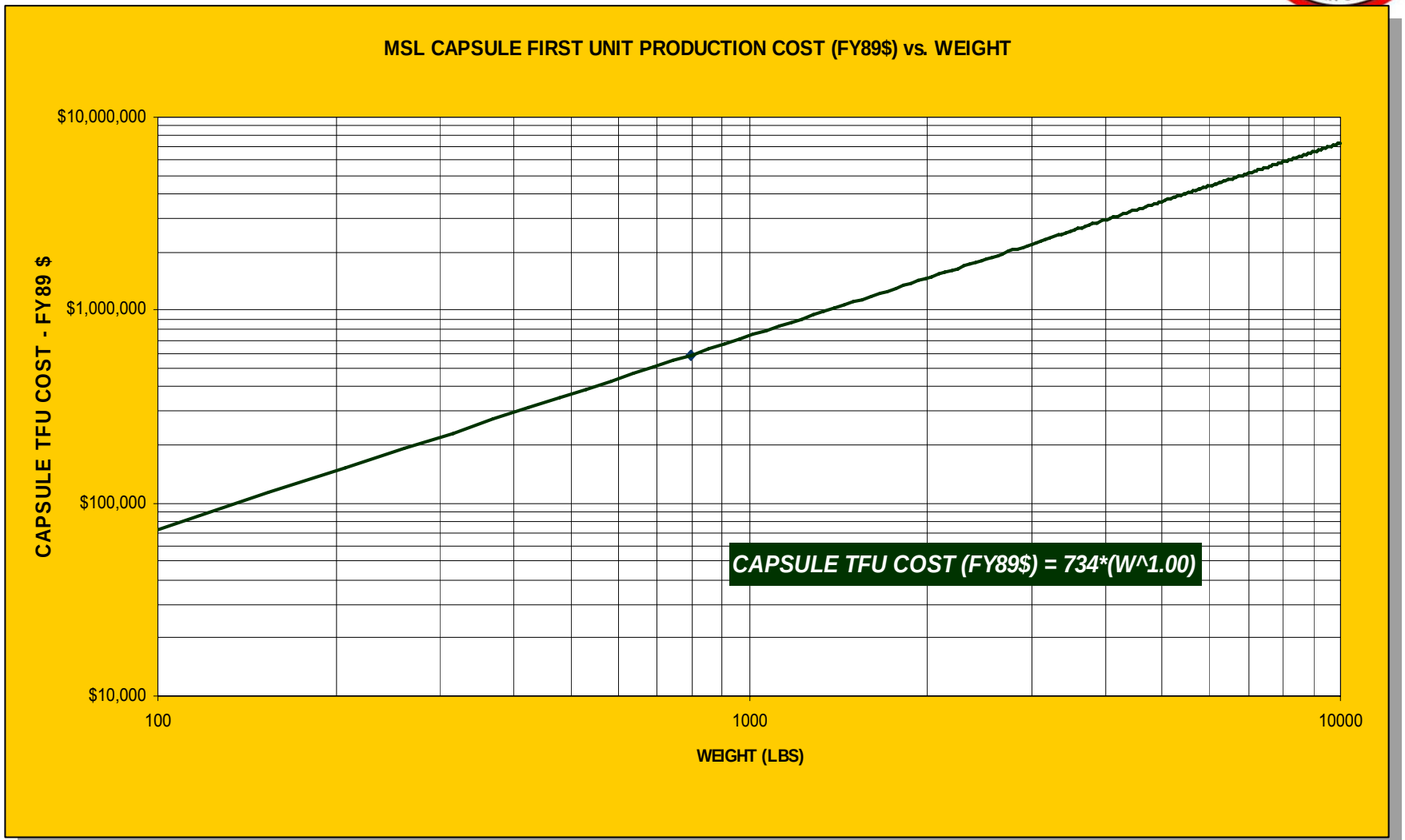




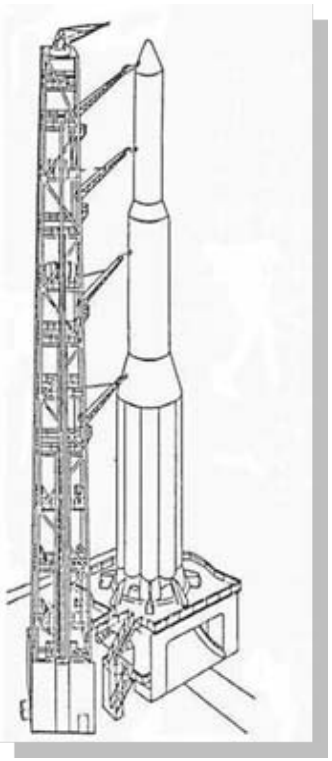
Capsule Development CER

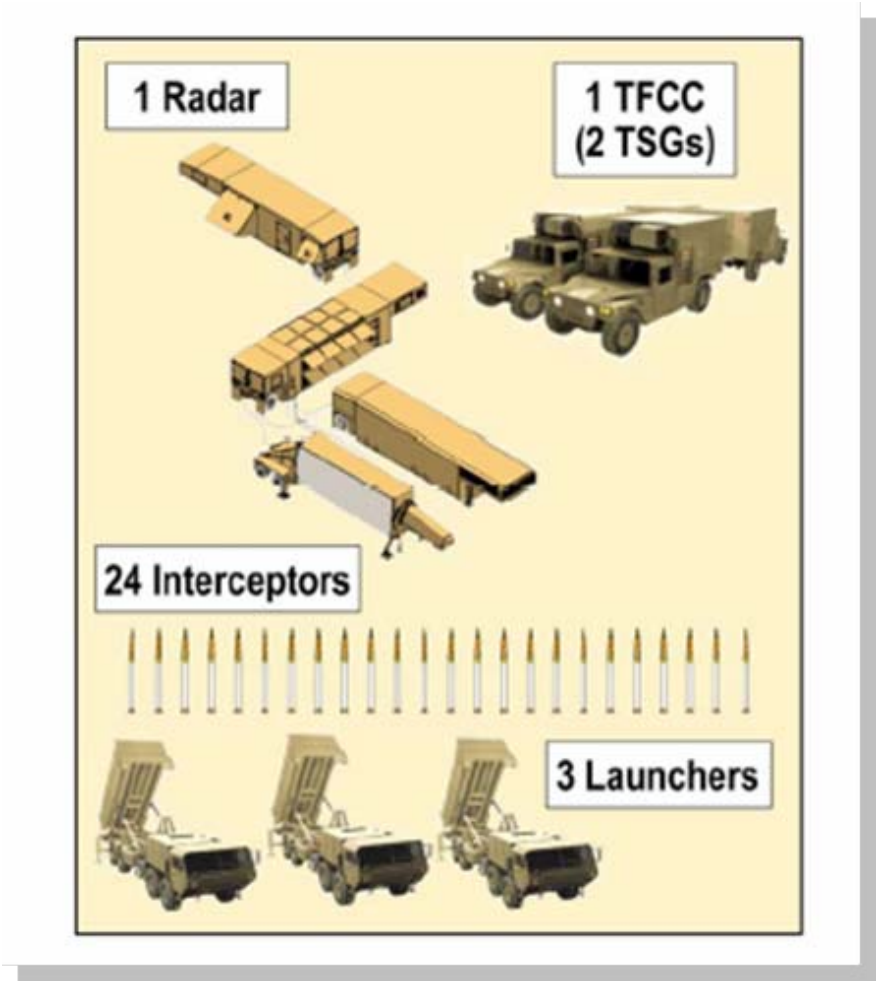


Capsule TFU Production CER



Missile System O&S Cost & Launch Operations For MDA Target Systems





TARGET LAUNCH FOR TEST

FIRING UNIT OR BATTERY

ANNUAL FORCE O&S COSTS (FY06 M$) NOTIONAL BALLISTIC MISSILE		FOUO			S9 20-Sep-06	
SYSTEM LIFE	20 YRS	(BATTERY) (4) UNITS ANNUAL	(SUPPT CO) (1) UNITS ANNUAL	(HQ UNIT) (1) UNITS ANNUAL	TOTAL ANNUAL	TOTAL LIFE CYCLE
O&S ELEMENT		O&S $	O&S $	O&S $	O&S COST (FY06 M$)	O&S COST (FY06 M$)
UNIT MISSION PERSONNEL						
OFFICER ANNUAL COST		$1.088	$0.543	$0.543	$2.174	$43.480
ENLISTED ANNUAL COST		$6.176	$4.429	$1.950	$12.555	$251.100
CIVILIAN ANNUAL COST		$0.000	$0.000	$0.000	$0.000	$0.000
TOTAL UNIT PERSONNEL COST		$7.264	$4.972	$2.493	$14.729	$294.580
UNIT LEVEL CONSUMPTION						
GROUND VEHICLE POL COST		$0.024	$0.004	$0.003	$0.031	$0.620
MISSILE PROPELLANT COST		$0.000	$0.000	$0.000	$0.000	$0.000
MAINT SUPPLIES (VEHICLES)		$0.024	$0.005	$0.007	$0.036	$0.720
MAINT SUPPLIES		$0.468	$1.320	$0.117	$1.905	$38.100
OTHER UNIT OPERATING MATERIALS		$0.000	$0.000	$0.000	$0.000	$0.000
TOTAL UNIT LEVEL CONSUMPTION COST		$0.516	$1.329	$0.127	$1.972	$39.440
DEPOT LEVEL MAINTENANCE						
D-LVL MAINTENANCE					$4.387	$87.746
TOTAL DLM COST					$4.387	$87.746
SUSTAINING INVESTMENT						
REPLENISHMENT SPARES					$8.155	$163.100
REPLACEMENT GSE					$0.425	$8.500
CL IV MODS/SW MAINT/TECH SUPPT					$0.497	$9.932
ANNUAL TEST FIRINGS					$34.908	$698.160
SUSTAINING TECH SUPPORT					$4.188	$83.767
TOTAL SI COST					$48.173	$963.459
INSTALLATION SUPPORT PERSONNEL						
OFFICER ANNUAL ISP COST		$0.000	$0.000	$0.181	$0.181	$3.620
ENLISTED ANNUAL ISP COST		$0.000	$0.000	$1.097	$1.097	$21.940
CIVILIAN ANNUAL ISP COST		$0.000	$0.000	$0.000	$0.000	$0.000
TOTAL ISP COST		$0.000	$0.000	$1.278	$1.278	$25.560
INDIDRECT PERSONNEL SUPPORT						
NONPAY INSTALLATION SUPT COST		$1.232	$0.864	$0.623	$2.719	$54.380
NONPAY MEDICAL O&M COST		$0.096	$0.066	$0.048	$0.210	$4.200
PCS PERSONNEL COST		$0.752	$0.519	$0.388	$1.659	$33.180
TOTAL IPS COST		$2.080	$1.449	$1.059	$4.588	$91.760
PERSONNEL ACQUISITION & TRAINING						
PERSONNEL ACQUISITION COST		$0.284	$0.181	$0.157	$0.622	$12.440
LAUNCH CREW TRAINING		$0.065	$0.000	$0.000	$0.065	$1.302
NON LAUNCH CREW TRAINING		$0.192	$0.177	$0.131	$0.500	$10.000
TOTAL PAT COST		$0.541	$0.358	$0.288	$1.187	$23.742
UNIT OPERATING COST (FY06 M$)		$10.401	$8.108	$5.245	$76.314	$1,526.287
ANNUAL OP COST PER UNIT		$2.600	$8.108	$5.245		

FOUO

O&S Cost for Missile Fields or Firing Units

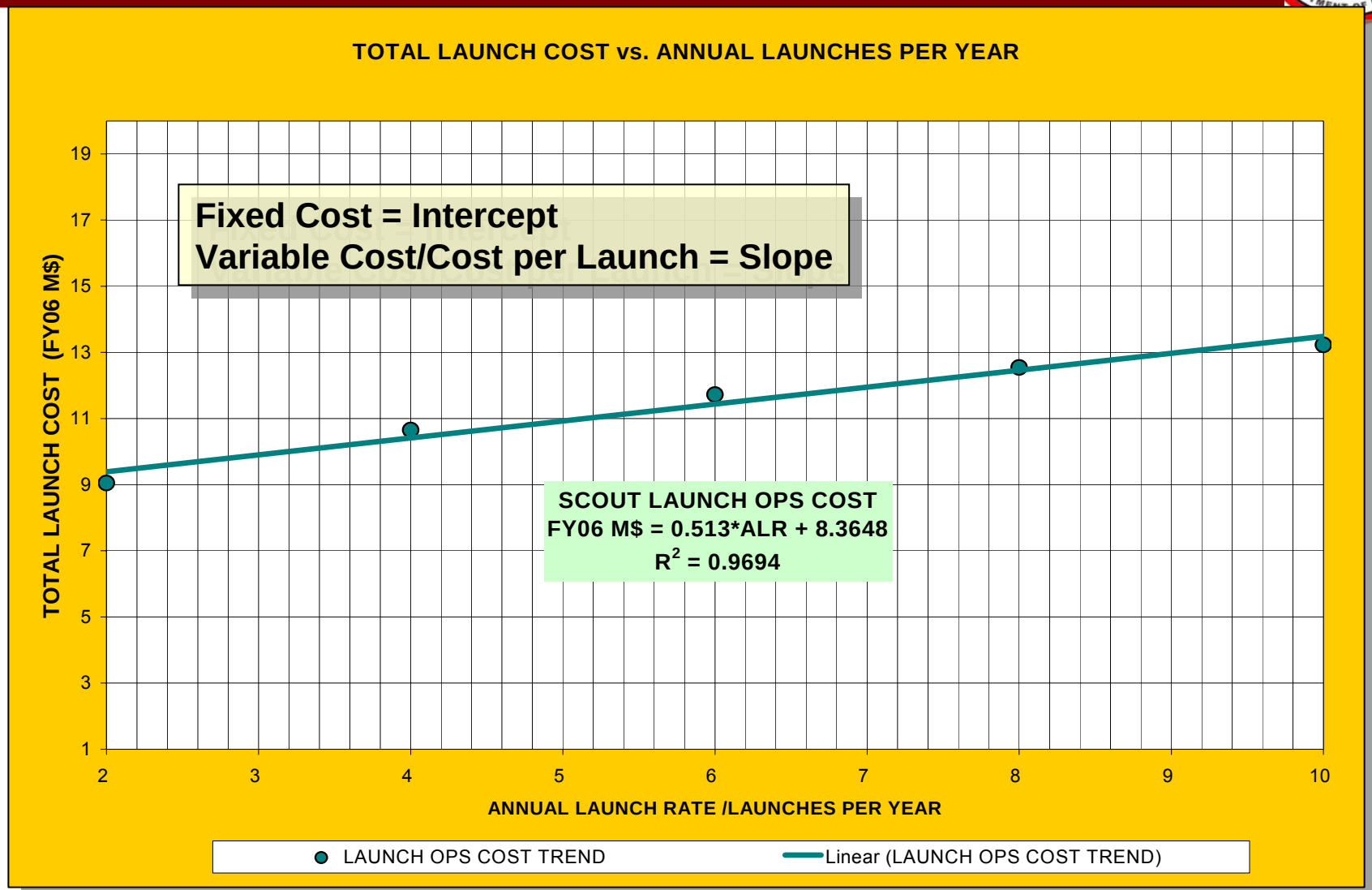
Inputs for O&S Cost - Missile Fields or Firing Units

	BATTERY	SUPPT CO	HQ UNIT
GROUND VEHICLES (LT)	3	4	15
VEH UTE (MILES/YR)	1250	1250	1250
LT VEH MILES/YR	3750	5000	18750
LT VEH MILES/GAL POL	12	12	12
VEHICLE POL GAL/YR (LT)	313	417	1563
GROUND VEHICLES (HVY)	10	6	0
VEH UTE (MILES/YR)	1250	1250	1250
HVY VEH MILES/YR	12500	7500	0
HVY VEH MILES/GAL POL	5	5	5
VEHICLE POL GAL/YR (HVY)	2500	1500	0
POL $/GAL	$2.00	$2.00	$2.00
PROPELLANT $/MISSILE YR	$0		
VEH MAINT $/MILE	$0.36	$0.36	$0.36
MAINTENANCE MAT/MMH	$10.19	$10.19	$10.19
MAINTENANCE MH/MY	1440	1440	1440
TOTAL MAINTENANCE MAT $	$117,367	$1,320,376	$117,367
RESERVED OTHER MAINT $/YR	$0		
RESERVED OTHER MAINT $/YR	$0		
RESERVED OTHER MAINT $/YR	$0		
OTHER MAINT $/YR	$0	$0	$0

Inputs for O&S Cost - Missile Fields or Firing Units

DEPOT MAINTENANCE	
DEPOT MANAGEMENT	15%
DEPOT $/MHR	$69.86
MSL FLT SW-SLOC	75000
CMD/LAUNCH SW-SLOC	1500000
MISSILE UNIT FLYAWAY COST	$16.500
LAUNCH SYSTEM COST/UNIT	$8.000
FIRE UNIT ELECTRONICS COST/	$7.500
CMD UNIT ELECTRONICS COST/	$23.000
SYSTEM PGSE COST (M$)	$8.500
SYSTEM INITIAL SPARES (M$)	$12.000
CONDEMNATION RATE/YR	0.050
GSE REPLACEMENT RATE/YR	0.050
REPLN SPARES/MSL YR (M$)	0.025

Target Operations: Fixed & Variable Costs



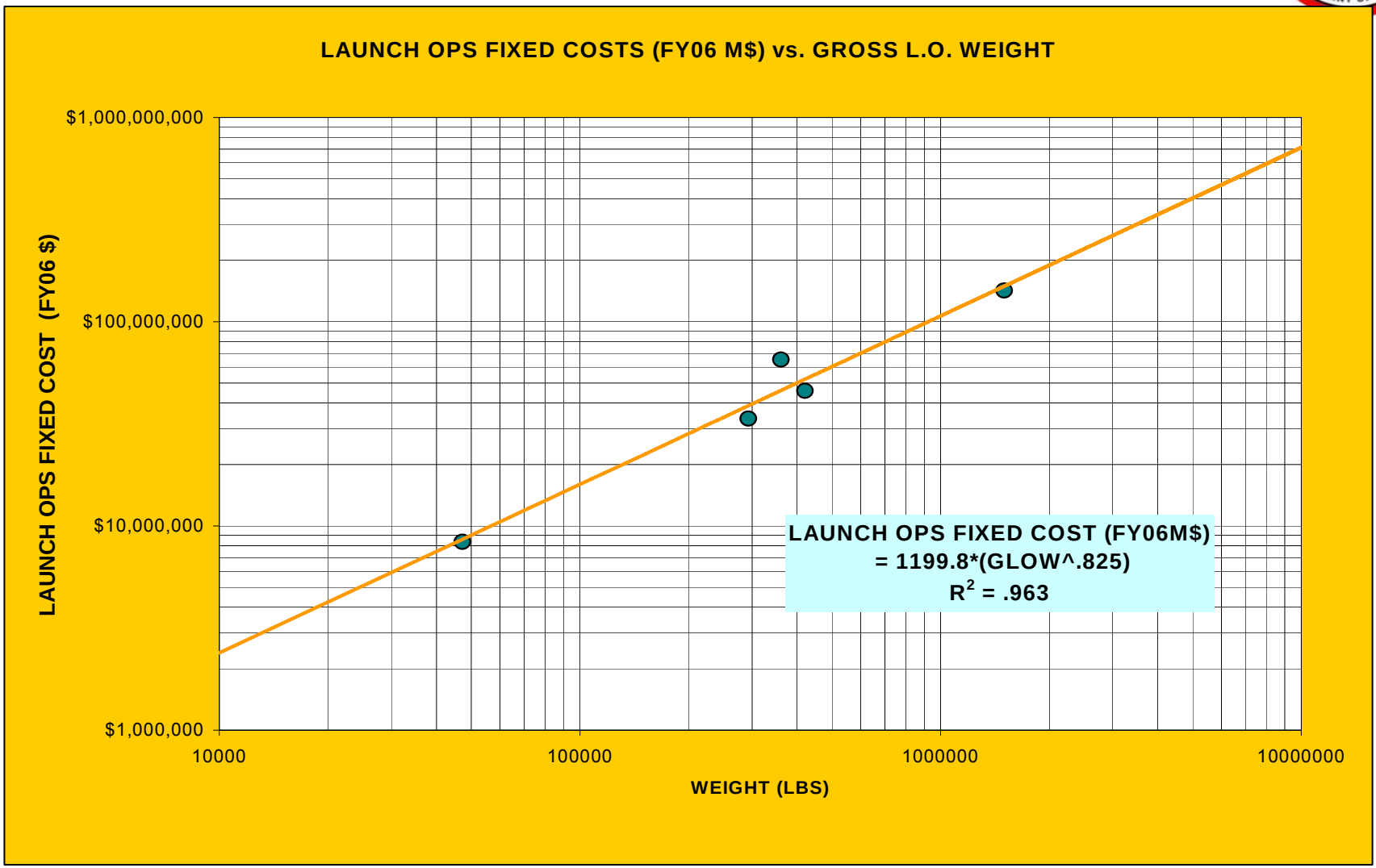
NASA Launch Ops Cost

(FY88 Cost $ Shown)

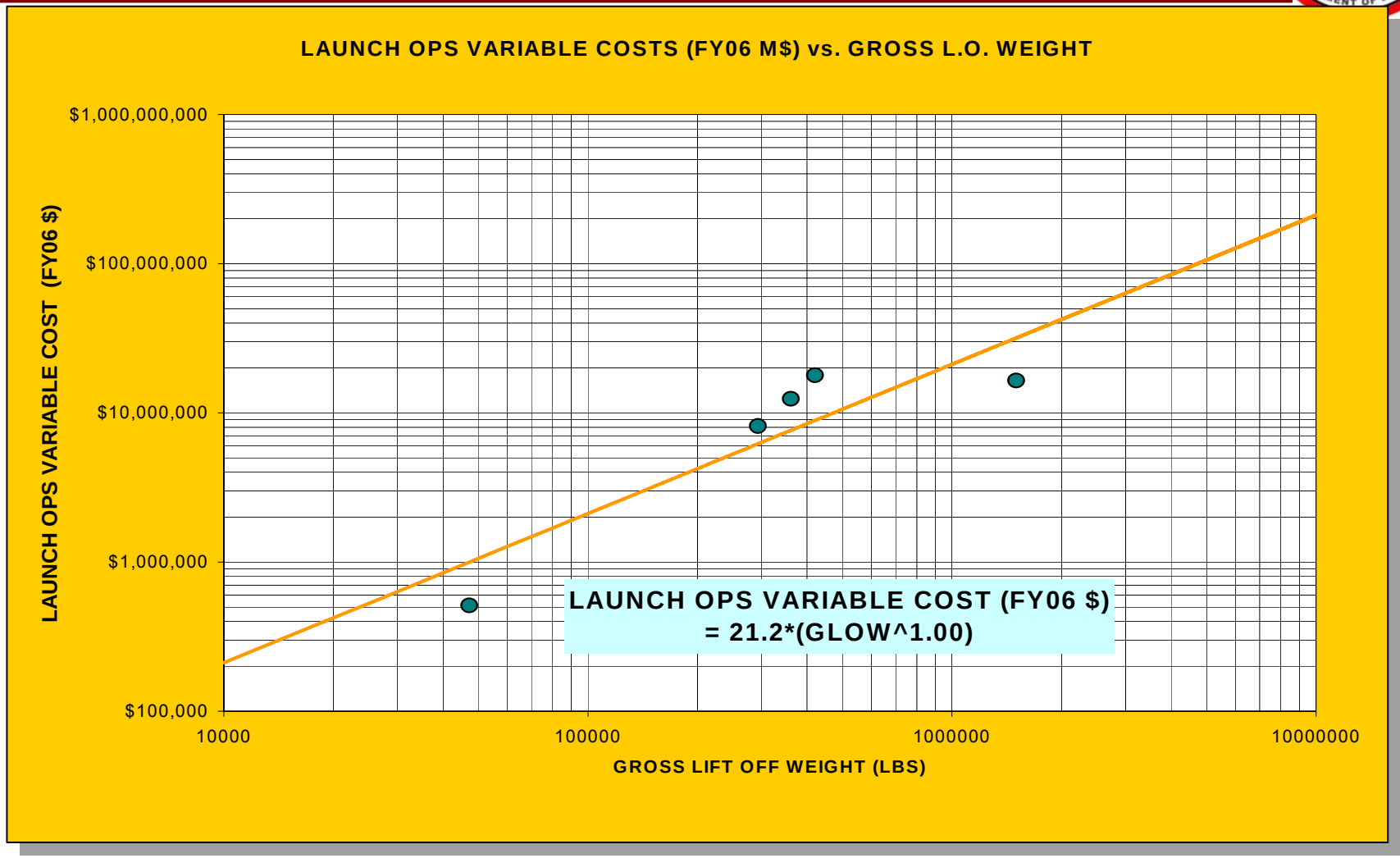
	GLOW	RATE/YR	COST TOTAL	COST/LAUNCH	FIXED COST	VARIABLE COST
TITAN 34D	1500000	2	$73.472	$36.736	$63.206	$5.133
		4	$83.738	$20.935		
		6	$94.004	$15.667		
		8	$104.270	$13.034		
		10	$114.536	$11.454		
		12	$124.803	$10.400		
SCOUT	47200	2	$5.701	$2.850	$4.888	$0.406
		4	$6.513	$1.628		
		6	$7.326	$1.221		
		8	$8.138	$1.017		
		10	$8.951	$0.895		
		12	$9.763	$0.814		
DELTA II	420500	2	$28.702	$14.351	$24.662	$2.020
		4	$32.742	$8.186		
		6	$36.782	$6.130		
		8	$40.822	$5.103		
		10	$44.862	$4.486		
		12	$48.902	$4.075		
ATLAS H	293000	2	$21.977	$10.988	$18.877	$1.550
		4	$25.076	$6.269		
		6	$28.176	$4.696		
		8	$31.275	$3.909		
		10	$34.375	$3.437		
		12	$37.474	$3.123		
ATLAS CENTAUR	360600	2	$25.621	$12.810	$22.011	$1.805
		4	$29.230	$7.307		
		6	$32.839	$5.473		
		8	$36.449	$4.556		
		10	$40.058	$4.006		
		12	$43.667	$3.639		

Fixed Cost = Intercept
Variable Cost/Cost per Launch = Slope

Fixed Launch Ops Cost = f(GLOW)



Variable Launch Ops Cost = f(GLOW)



Target Launch Ops Cost Model

TARGET SYSTEM:	FTF LV2
TARGET GLOW (LBS):	66000
ANNUAL LAUNCH RATE	10
FIXED LOPS COST (FY06 $)	$11,356,189
VARIABLE LOPS COST/LAUNCH (FY06 $)	$1,399,200
TOTAL TARGET SYSTEM LOPS COST	$25,348,189
COST PER LAUNCH IN YR OF INTEREST	$2,534,819

LAUNCH & RANGE OPS COST MODEL
BY06 OUTLAYS AS FUNCTION OF GLOW, LAUNCHES PER YEAR
BASED UPON NASA LAUNCH EXPERIENCE (SSCAG HNDBK)

LAUNCH COST WBS APPORTIONMENT

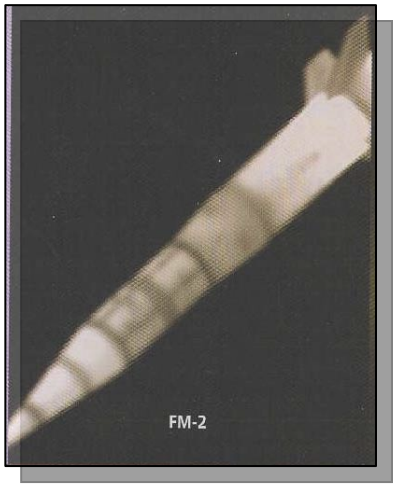
		FIXED FRACTION	VARIABLE FRACTION	FIXED COST ALLOCATION	VAIABLE COST ALLOCATION	ALLOCATED COST PER LAUNCH
LAUNCH SITE/RANGE COSTS						
LCC SEPM & SUPPORT	FIXED	14.85%		$1,686,915		$168,692
RANGE SAFETY	FIXED	34.16%		$3,879,540		$387,954
RANGE SECURITY OPS	FIXED	2.97%		$337,748		$33,775
RANGE OPS	VARIABLE		87.44%		$12,234,421	$1,223,442
LCC MODS	FIXED	1.45%		$164,310		$16,431
LAUNCH STAND MODS	FIXED	1.82%		$207,213		$20,721
RANGE MODS	FIXED	0.40%		$45,642		$4,564
TARGET VEH MODS	VARIABLE		1.11%		$155,249	$15,525
OTHER MODS	VARIABLE		0.00%		$0	$0
RANGE HEADQUARTERS SITE COSTS						$0
RANGE SEPM & SUPPORT	FIXED	44.34%		$5,034,821		$503,482
DATA REDUCTION	VARIABLE		5.30%		$742,170	$74,217
TARGET OFFLOAD & TRANSPORT	VARIABLE		0.28%		$39,807	$3,981
TARGET BUILDUP	VARIABLE		3.08%		$431,194	$43,119
TARGET HORIZONTAL C/O	VARIABLE		0.88%		$122,925	$12,293
TARGET VERTICAL C/O	VARIABLE		1.90%		$266,232	$26,623
TOTAL ALLOCATIONS - FY06 $ OUTLAYS		100.00%	100.00%	$11,356,189	$13,992,000	$2,534,819

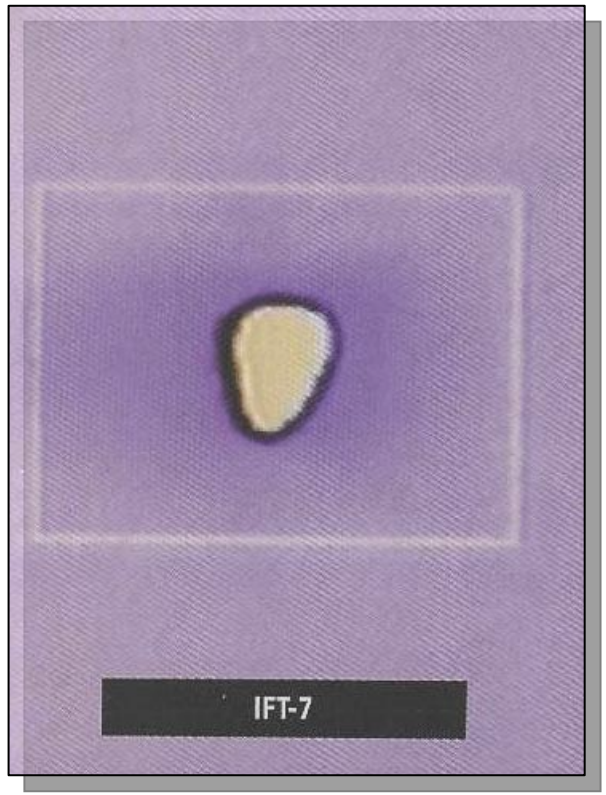
The NASA method results in a Launch Ops Cost Model that forecasts fixed and variable launch costs for vehicles of a certain size. The total fixed and variable costs are then allocated downward to lower WBS levels for budgeting and control purposes.

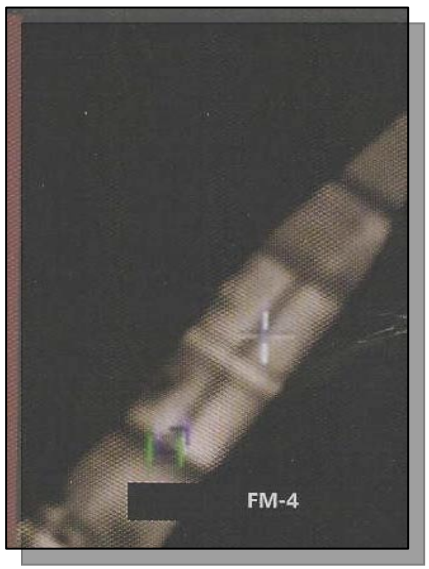
Missile Cost Modeling – Process Steps

- ***For analogy or bottoms-up, assemble cost data, assemble SMEs.***
- ***For parametric approach, obtain mass properties, SW SLOC, and other drivers for the missiles under study.***
  - ***Define new and inherited content, changes to missile flight software, and test and evaluation program.***
  - ***Revise/tailor CERs and cost models as required.***
- ***Perform and Document Cost excursions :***
  - ***Determine excursions (quantity scenarios, capability excursions, etc.)***
  - ***Document, Present, Defend outputs. Provide recommendations to Program Management.***

Accomplish MDA's Technical and Operational Goals Within Budget







MDA Booster Cost Modeling Conclusions

- *MDA – Adaptive Organization.. Adaptive Products.*
  - *Booster products and operational concepts are always changing and are constantly being modified for new applications.*
  - *Cost models must be revised and updated, as required.*
  - *MDA policy supports the development of Government/Industry Common Cost Models. (Consensus vs. Confrontation).*
- *MDA DOBE mission: create and document credible/defendable cost estimates.*