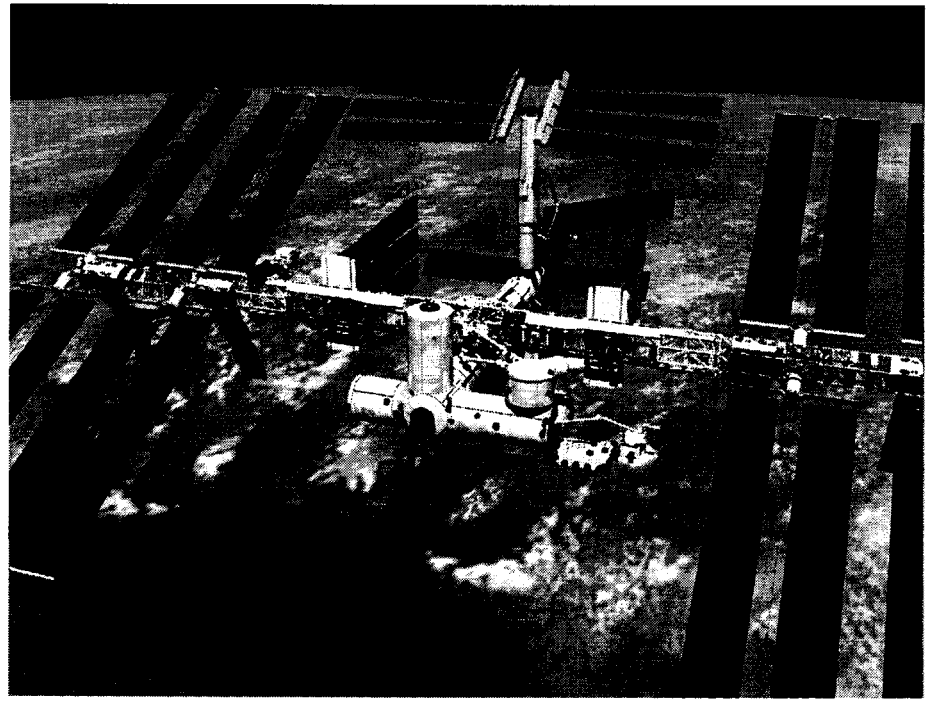
Model for Estimating Space Station Operations Costs (MESSOC)



What is MESSOC?

- A Model for Estimating Space Station Operations Costs in the mature operations phase
- An operations cost and performance estimating tool using station and ground system characteristics
- A way of capturing the flow of operations activities and estimating the resultant cost through causal relationships
- A high-level model to compare alternative scenarios to inform program decisions
- Only one piece, but an important one, of the life-cycle cost estimate

How MESSOC Can Be Used

- Long-term strategic-level resource envelope for users (e.g., crew time, upmass, power, robotic availability)
- International operations cost sharing analyses
- Operations costs/performance inputs to studies and plans (e.g., P3I and station growth studies)
- Comparison of budget submits against top-down estimates

MESSOC Concept

- Tie operations cost estimate to Station performance metrics within a consistent framework
- Develop capability for both total cost and marginal cost
- Develop capability to estimate logistics "cross-consumptions"
- Enable (unpredictable) "what if" questions at multiple levels of detail
- Provide "storage" of cost-related key data for future HEDS programs
- Provide high-level insight into operations costs with inputs/parameters completely traceable to fundamental data

MESSOC Development Strategy

- Recognize that operations involves many different functional areas
- Build on existing NASA/DoD models
  - Logistics
  - Training
  - Orbital mechanics
  - Launch vehicle performance
- Emphasize causal relationships in algorithms and equations
- Capture interactions among represented functional areas
- Recognize dynamic year-to-year relationships to accommodate changes in station configuration and operations activities
- Document algorithms/equations thoroughly and consistently for cost analyst training and software maintenance/improvement

MESSOC Background

- MESSOC has a long history
  - Initially supported by JSC (FY85-86), then by Level I and Level II (Reston, Code MSU, FY87-90)
  - Extensive validation activities, both independent and within SSF
  - Supported by IPAO (FY98-FY02) and SSPO (FY99)

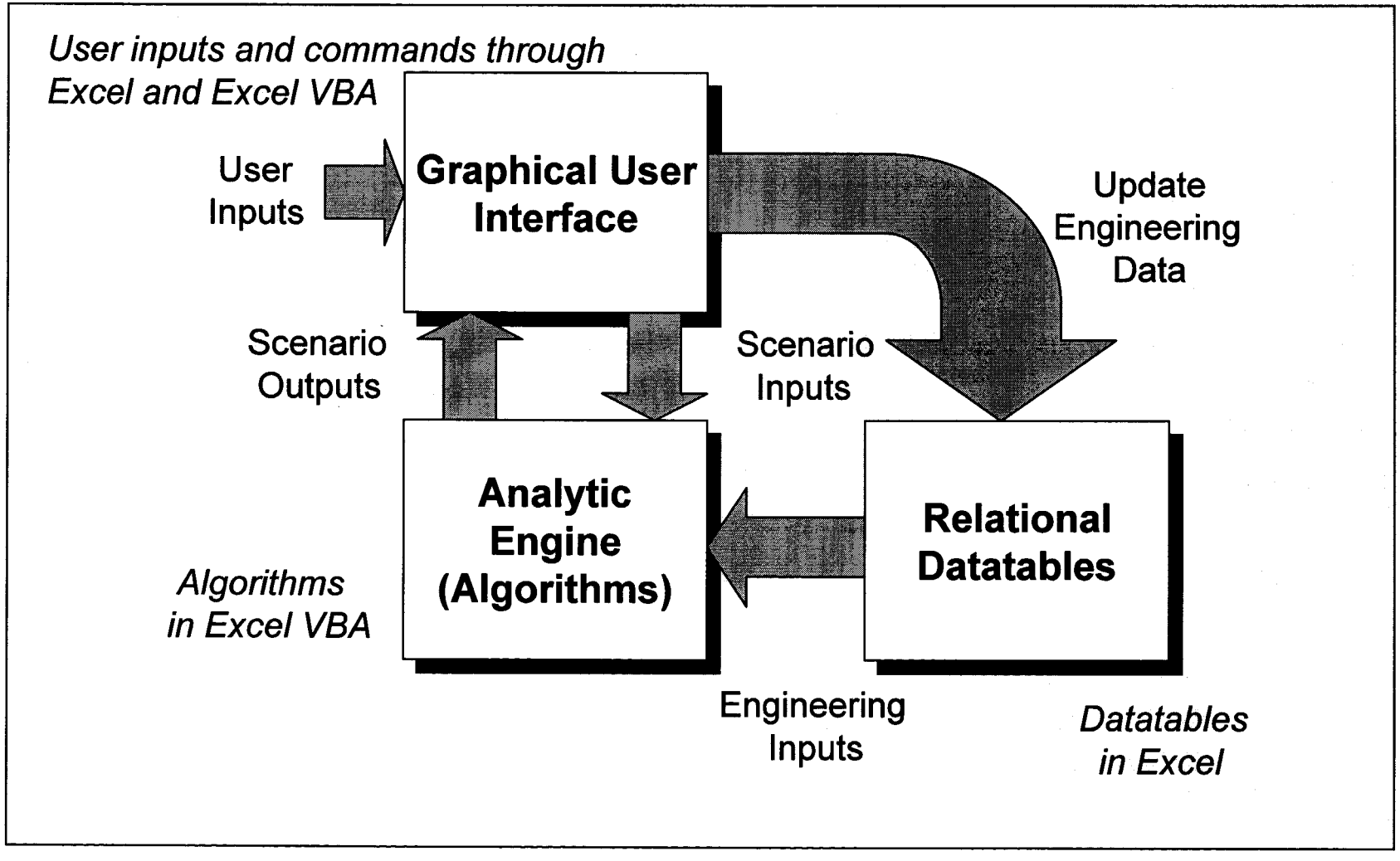
- MESSOC has adapted to space station program changes
  - Oct 1986 (Ver 1.2) First demonstrated at JSC
  - Apr 1987 (Ver 1.3) Incorporated CETF
  - Dec 1987 (Ver 1.4) Incorporated SSOTF
  - Oct 1988 (Ver 2.0) Validation version
  - Dec 1989 (Ver 2.1) First controlled version
  - Dec 1990 (Ver 2.2) Second controlled version
  - Dec 2000 (Ver 3.0) First version for ISS
  - Oct 2001 (Ver 3.1) IMCE/CAST version
  - Aug 2002 (Ver 3.16) ICE version

MESSOC 3.X Design Requirements

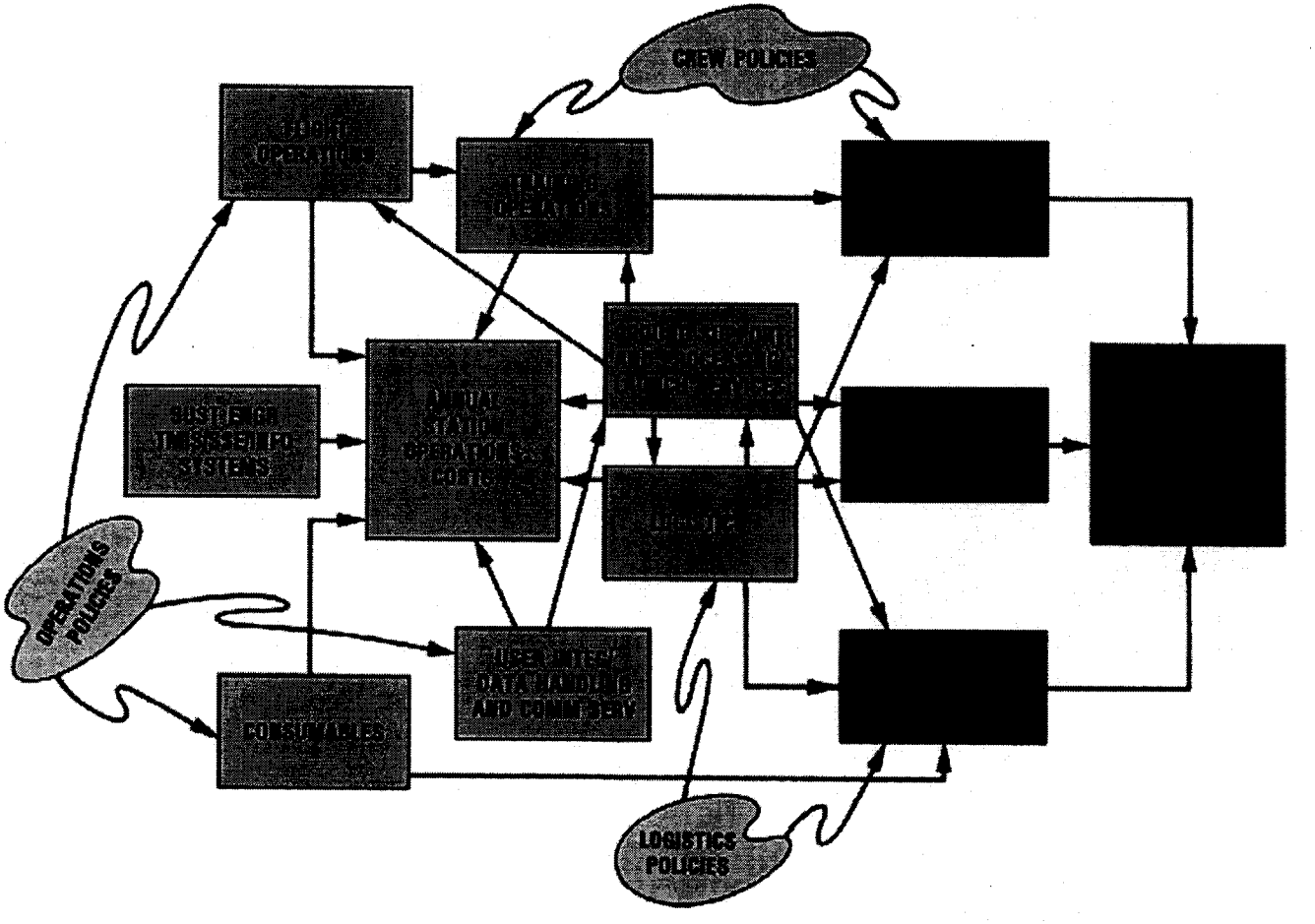
- **Functionality of MESSOC 2.2 with minor simplifications**
- **Programmed using Excel '97 and Excel '97 VBA**
- **Use a fully relational database structure in third normalized form; all datatables in Excel spreadsheets fully integrated with MESSOC**
- **Permit specific algorithms to be run separately**
- **Update all datatables and baseline scenario inputs for ISS**
- **Use "modern" GUIs for user inputs, options, and help files**

Note: Originally, MESSOC was developed under DOS 3.0, programmed in TurboPascal with databases separately maintained in dBase III+.

MESSOC 3.X Architecture



Conceptual View of MESSOC Algorithms



MESSOC Algorithms: Annual Cost by Function

- **Flight Operations**
  - **SSCC/ESC maintenance and support**
  - **Flight design**
  - **Flight planning**
  - **Flight implementation**
  - **Training operations**
- **Logistics and Maintenance**
  - **Intermediate/depot-level repairs**
  - **Flight equipment spares**
  - **Station consumables**
  - **Maintenance documentation, databases, procedures, and analysis**

MESSOC Algorithms: Annual Cost by Function

- **Sustaining engineering**
  - **Flight HW sustaining engineering**
  - **Flight SW sustaining engineering**
- **Launch Site Operations**
  - **Element processing and reprocessing**
  - **GSE maintenance and support**
  - **Launch site ILS**
  - **User physical integration**
- **Communications and SW Support Systems**
  - **SW facilities maintenance and support**
  - **NISN services**

MESSOC Algorithms: Annual Cost by Function

- **User integration**
  - **User operations integration**
  - **Data handling operations**
- **Integration management and institutional support**
  - **R&PM**
  - **Other direct costs**
  - **Flight crew P&A and support**
  - **Program taxes**
- **Program reserves**
- **NSTS/ELV launch services**
- **Space communication (TDRSS/SOMO) services**

MESSOC Algorithms: Operations Performance

- Station
  - Station mass
  - Pressurized modules
  - User racks
  - Rendezvous altitude
  - Reboost altitude
  - Reboost and total impulse
  - Growth mass
  - Upmass available for users (utilization)
  - Downmass (non-destructive) available for users (utilization)
- Logistics
  - Recoverables pressurized mass
  - Recoverables unpressurized mass
  - Recoverables pressurized volume
  - Recoverables unpressurized volume
  - Recoverables mass sigma
  - Required fuel deliveries
  - Consumables mass
  - Robotics utilization (SSRMS and SDPM)

MESSOC Algorithms: Operations Performance

- Crew
  - Crewhours available
  - Housekeeping crewhours
  - Crew medical ops crewhours
  - On-orbit CAP crewhours
  - On-board training crewhours
  - Visiting vehicle ops crewhours
  - IVA maintenance crewhours
  - EVA maintenance crewhours
  - EVA preparation crewhours
  - EVA observer crewhours
  - EVA crewhours available
  - Training loads

CARD–Generated Changes to MESSOC Inputs

- New higher wage rates: most significant changes in launch site (17%), SW engineer (17%), and flight controller (26%) wage rates
- MCC-Houston SLOC much higher than estimated in FY98
- MCC-Houston ISS allocation reduced from 100% to 54%
- ISIL enhancements included
- NISN costs allocated between ISS and SOMO
- New ORU price estimates

ORU Prices: Original versus CAIG Update

Original Equation (based on FY98 data):

$$\ln C = 11.789 + 0.762 \ln M - 1.141 X - 1.317 Y - 0.664 Z$$

C = Cost (FY98$)
M = Mass (kg)
X = Structure/Thermal Control Dummy
Y = Mechanical Dummy
Z = EPS Dummy

ORU Prices: Original versus CAIG Update

CAIG/IDA Equation (based on FY02 data):

$$\ln C = 9.32 + 0.893 \ln M + 1.898 E + 0.749 ECLSS - 0.04321 Life + 0.277 Crit$$

C = Cost (FY98$)

M = Mass (kg)

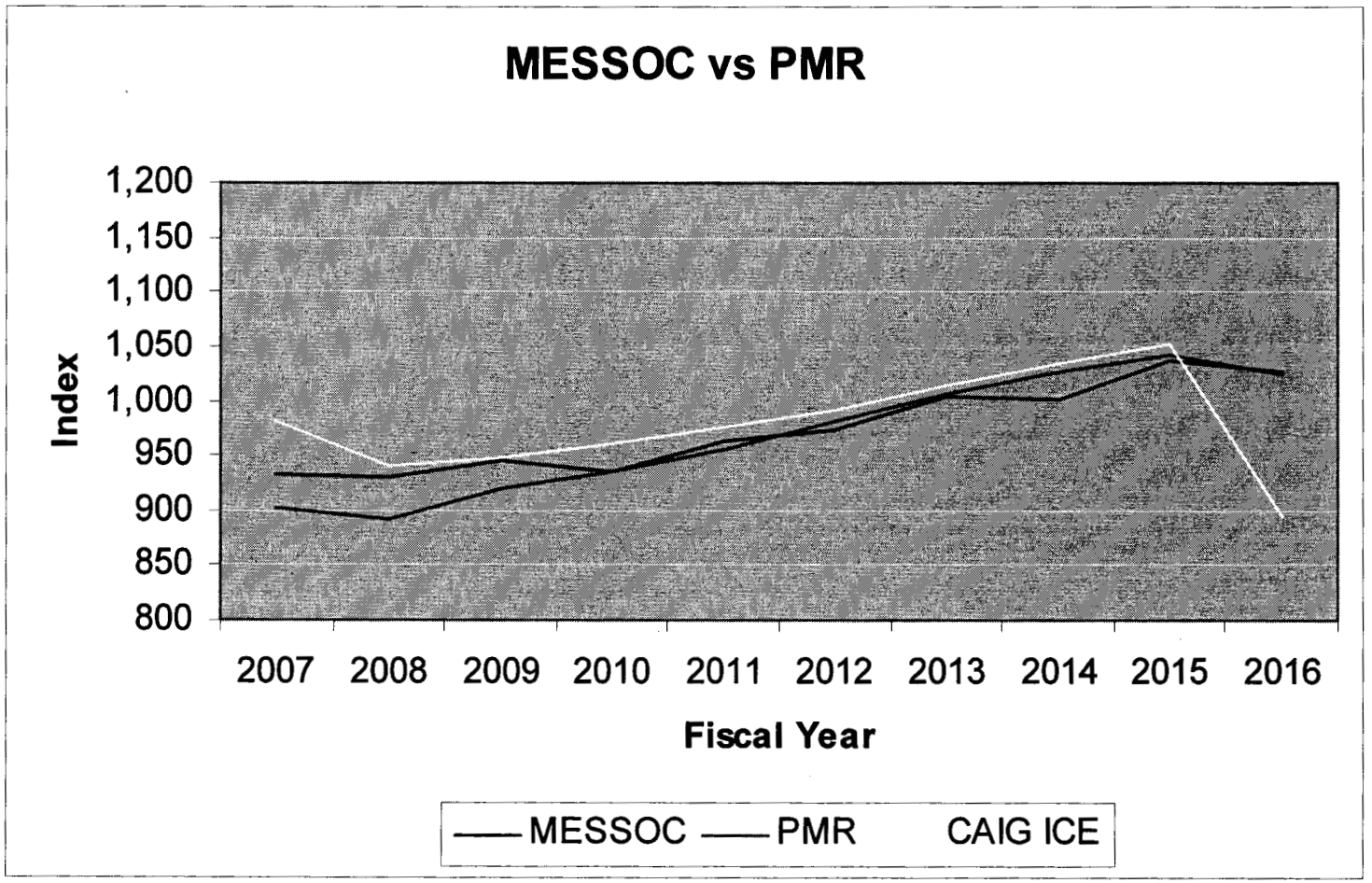
E = Electronics (C&T, GN&C, C&DH) Dummy

ECLSS = ECLSS Dummy

Life = Life Limit (yrs)

Crit = Criticality Dummy

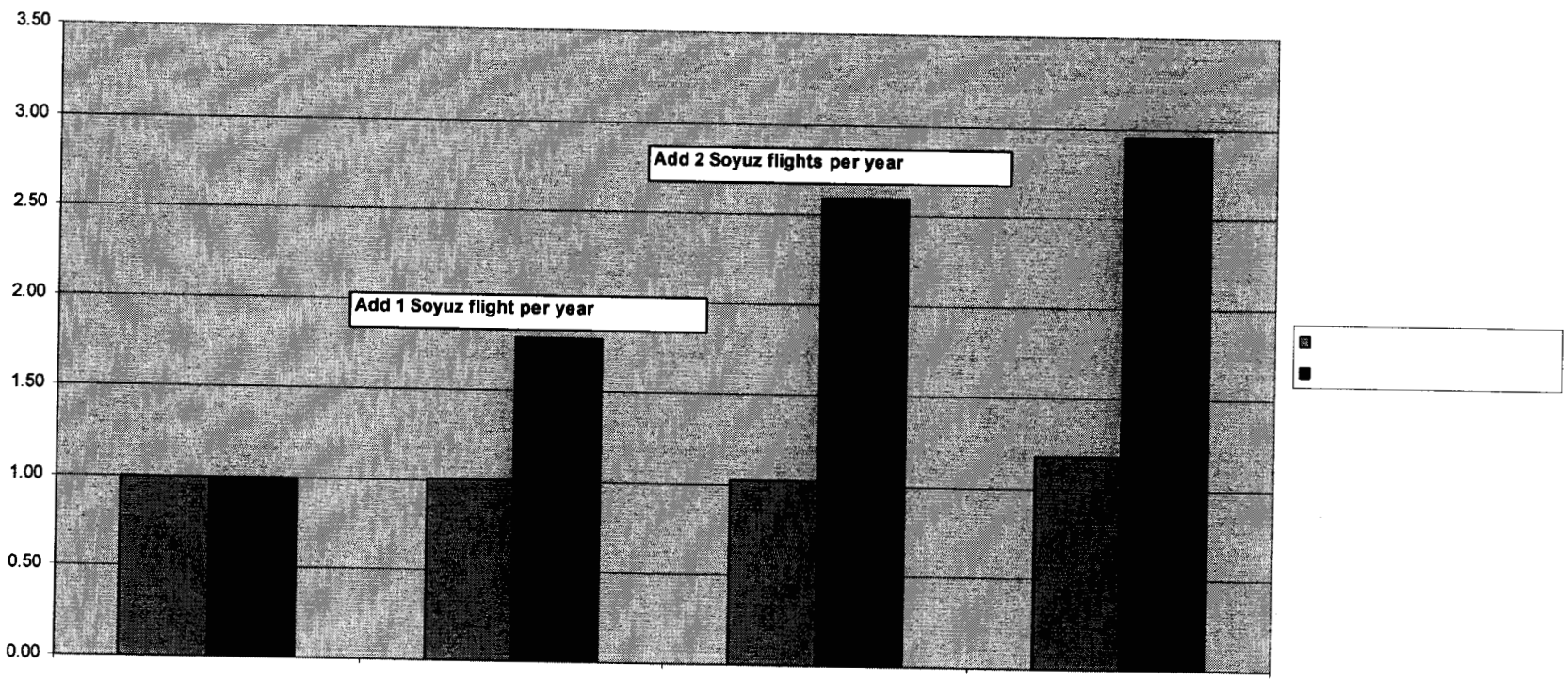
U.S. Annual Cost Comparison



U.S. Annual Cost Comparison By Function Group

Functional Group	PMR	MESSOC
Flight Operations	18%	18%
Logistics and Maintenance	14%	13%
Sustaining Engineering	25%	24%
Launch Site Operations	10%	8%
Comm and SW Support Sys	3%	7%
User Integration	6%	7%
Int Mgmt and Inst Support	25%	23%
	100%	100%

Model Excursions



CARD Observations

- CARD revealed full program content
  - Identified areas not presently estimated in MESSOC
- CARD updated/revised some very important data
  - Critical, and sometimes sensitive, data not in CARD
  - Need to improve consistency in data sources
- CARD's organization did not lend itself easily to cost estimation
  - Hard to identify a clear set of costable activities/functions
  - Large amount of overlap
  - Need to write CARD with costing methodologies in mind in order to ensure that all relevant data are included
  - Need to provide a real CBS and relate each element to associated data sources
  - CARD far bigger and more technically detailed than needed
  - No single CARD template will work for all programs