NASA/Air Force Cost Model

NAFCOM

Science Applications International Corporation

Propulsion for Space Transportation of the 21st Century
May 15, 2002

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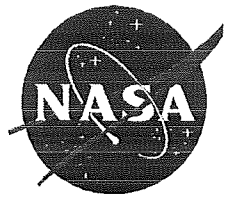

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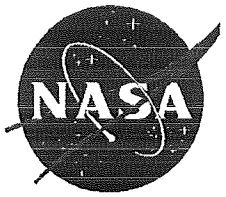

NAFCOM Description

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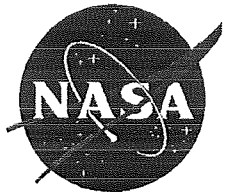
The NASA/Air Force Cost Model (NAFCOM) is a parametric estimating tool for space hardware. It is based on historical NASA and Air Force space projects and is primarily used in the very early phases of a development project. NAFCOM can be used at the subsystem or component levels.



NAFCOM Database

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- NAFCOM is based on spacecraft data from the Resource Data Storage and Retrieval Library (REDSTAR)
- REDSTAR is NASA's major repository of cost, technical, and programmatic information including over 25,000 documents
  - 540 companies, government agencies, universities, and aerospace societies represented
  - Total program to subcomponent cost data
  - Information on spacecraft bus, attached payloads, engines, launch vehicles, upper stages, scientific instruments, aircraft, DoD, cost models and cost estimating, schedules, ground and launch operations, mission operations, Lessons Learned
- The normalized database includes 122 missions with:
  - 76 unmanned earth orbiting, 24 unmanned planetary, 11 launch vehicles, 8 manned, 3 engines

NAFCOM Evolution

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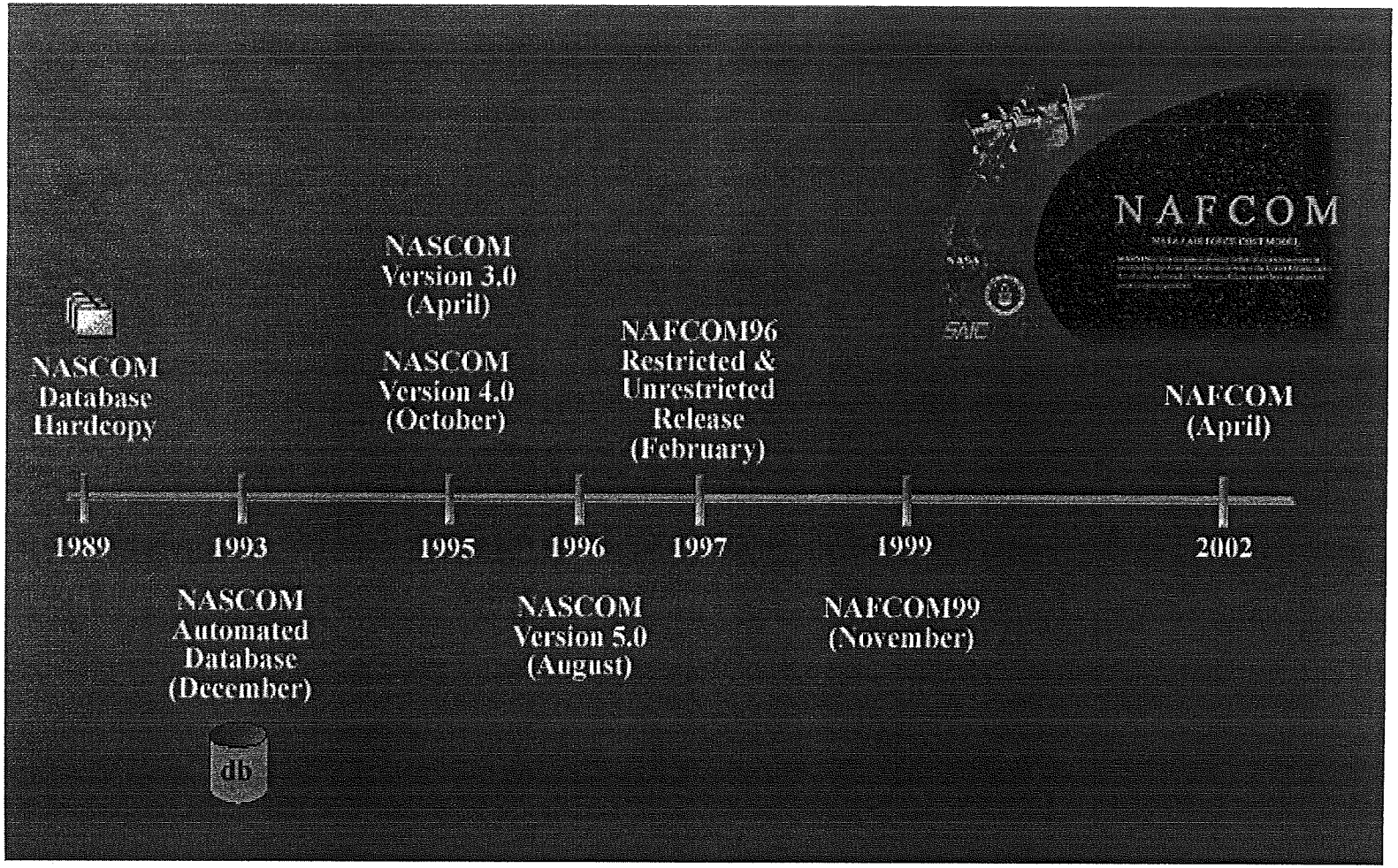

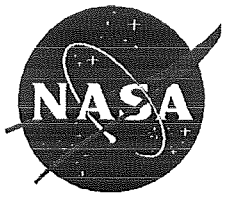

NAFCOM Features

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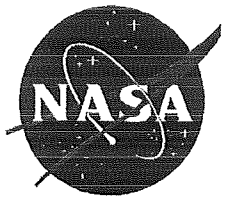
- Subsystem-level Complexity Generators
- Process-based Schedule Estimating
- Time Phasing of Cost
- Cost Trades
- Enhanced Engine Estimating
- Integration into CEC
- Quick estimate startup with use of template wizard
- Expert knowledge of database embedded in template selection process



NAFCOM Features

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- Subsystem Level Complexity Generators
  - Application of multiple cost drivers
    - The equations follow the form:

      Cost = C * Weight ^ W * Inheritance ^ X * Technology ^ Y * Management ^ Z
  - Data driven, statistically based
  - Documents estimating assumptions
  - Minimizes the use of subjective inputs
  - Repeatable and verifiable
  - Nine new complexity generators have been developed including SRM, propulsion (less engines), OMS, TVC, recovery, landing, thermal control, crew accommodations, and ECLS.

NAFCOM Features

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- Process-based Schedule Estimating
  - SAIC identified the processes for currently defined common subsystems and system integration elements and tied these processes to schedule estimating algorithms
  - The methodology considers cost and technical parameters in the calculation of the schedule baselines
  - Three levels of schedules are generated:
    - System level by Stage
    - Stage level by Subsystem
    - Subsystem level by Process

NAFCOM Features

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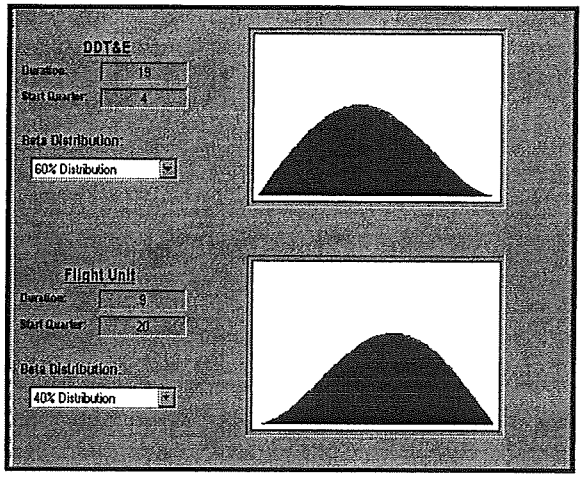
- Time Phasing of Cost
  - Developed using schedules generated in process-based module
  - Cost is spread at the subsystem level
  - DDT&E and flight unit cost are shown separately
  - User may select either fiscal or calendar years
  - Beta distributions can be changed for DDT&E and flight unit



NAFCOM Features

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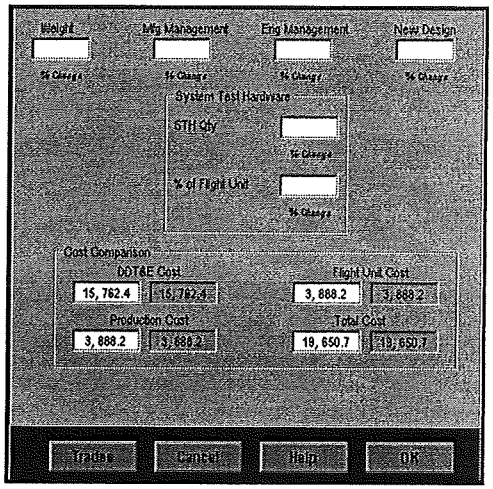
- Cost Trades
  - Allows the user to perform "what if" scenarios based on global changes to technical factors:
    - Weight
    - Manufacturing management
    - Engineering management
    - New design
    - System Test Hardware



  - One, all, or a combination of the factors can be increased or decreased by a percentage to determine the effect these changes have on total cost

NAFCOM Features

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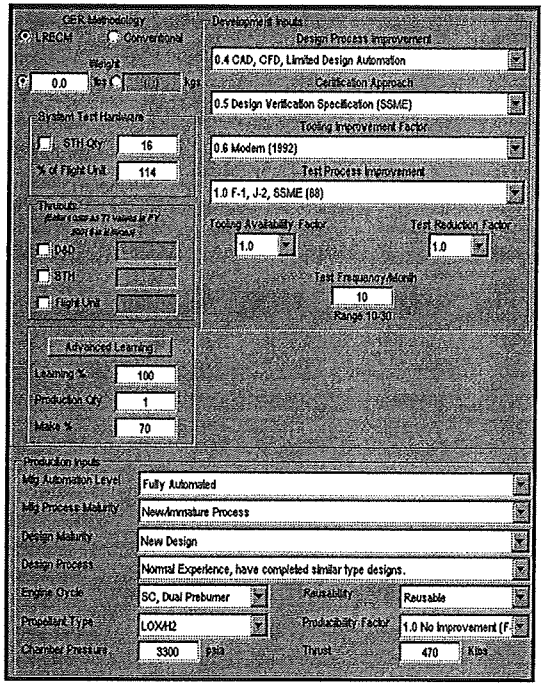
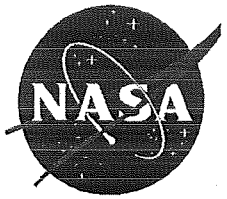
- Enhanced Engine Estimating
  - Fully integrated versions of a liquid rocket engine model and a combined cycle propulsion model
  - Algorithms from the U.S. Air Force jet engine cost model





NAFCOM Features

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- Integration into collaborative environments
  - NAFCOM estimates are saved as Excel spreadsheets allowing easy manipulation of inputs external to the application

Elements	Weight	STHQty	FUPer	ManfMgmt	EngMgmt	NewDesign
Single Stage to Orbit Vehicle	346600					
Stage	346600					
SSTO Subsystems	346600					
Structures & Mechanisms	188000	1	130	50	70	100
Vehicle Structures & Mechanisms	123000	1	130	50	70	100
Tank Structures & Mechanisms	65000	1	130	60	50	100
Thermal Control	49000	1	130	50	70	100
Environment/Active Thermal Control	5500	1	130	50	50	100
Induced Thermal Protection	41000	1	130	50	70	100
Tank Thermal Control	2500	1	130	60	50	100
Reaction Control Subsystem	7000	1	130	50	70	100
Orbital Maneuvering System	4500	1	130	50	70	100
Main Propulsion System (less engines)	41000	1	130	50	70	100
Electrical Power and Distribution	32000	1	130	50	70	100
Command, Control & Data Handling	3500	1	130	50	70	100
Guidance, Navigation and Control	500	1	130	50	70	100
Environmental Control and Life Support	6000	1	130	50	70	100
Crew Accommodations	1100	1	130	50	70	100
Landing System	14000	1	130	50	70	100

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NAFCOM Sample Screens

Introduction Screen

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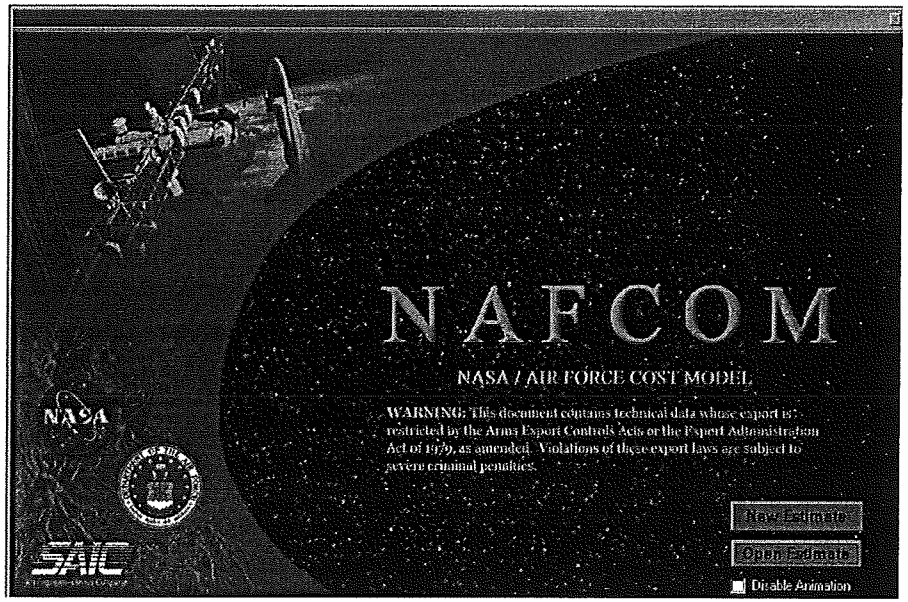

Wizard

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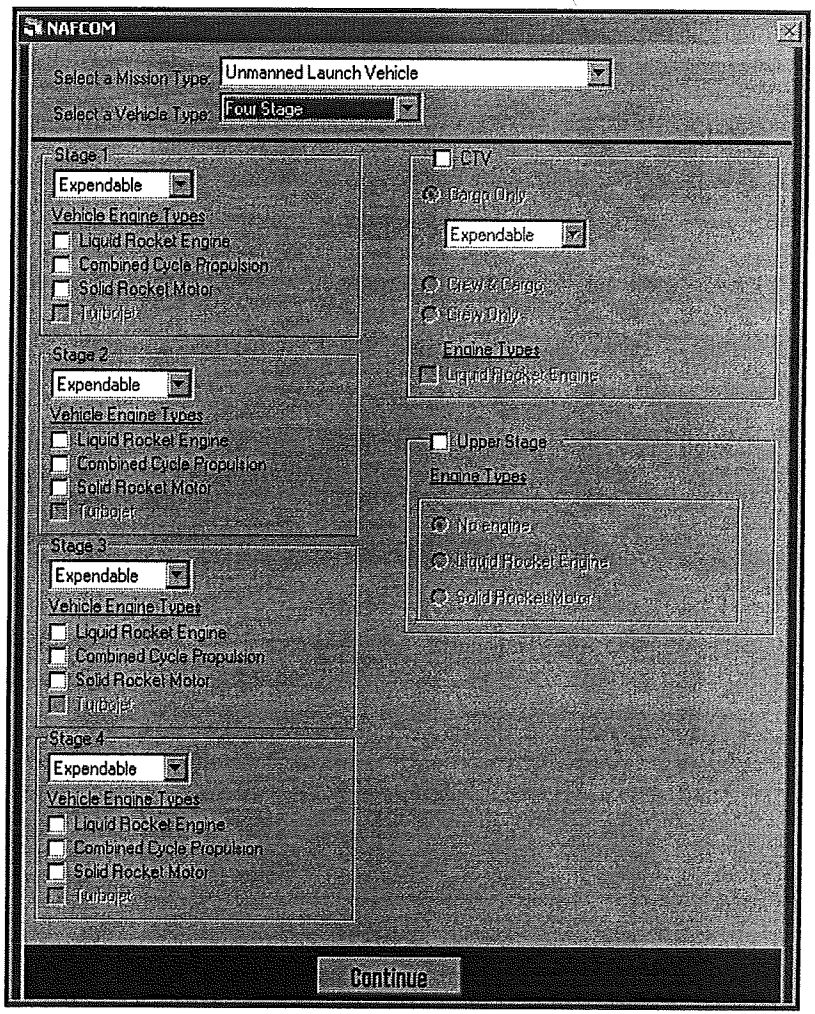
- A SINGLE screen dynamically changes based on Mission and Vehicle Type providing the capability to estimate hundreds of possible vehicle configurations
- Vehicle Types
  - Single-stage to Orbit
  - Two-stage to Orbit
  - Two-stage Bimese
  - Three-stage to Orbit
  - Four-stage to Orbit
  - Shuttle-derived



New Interface

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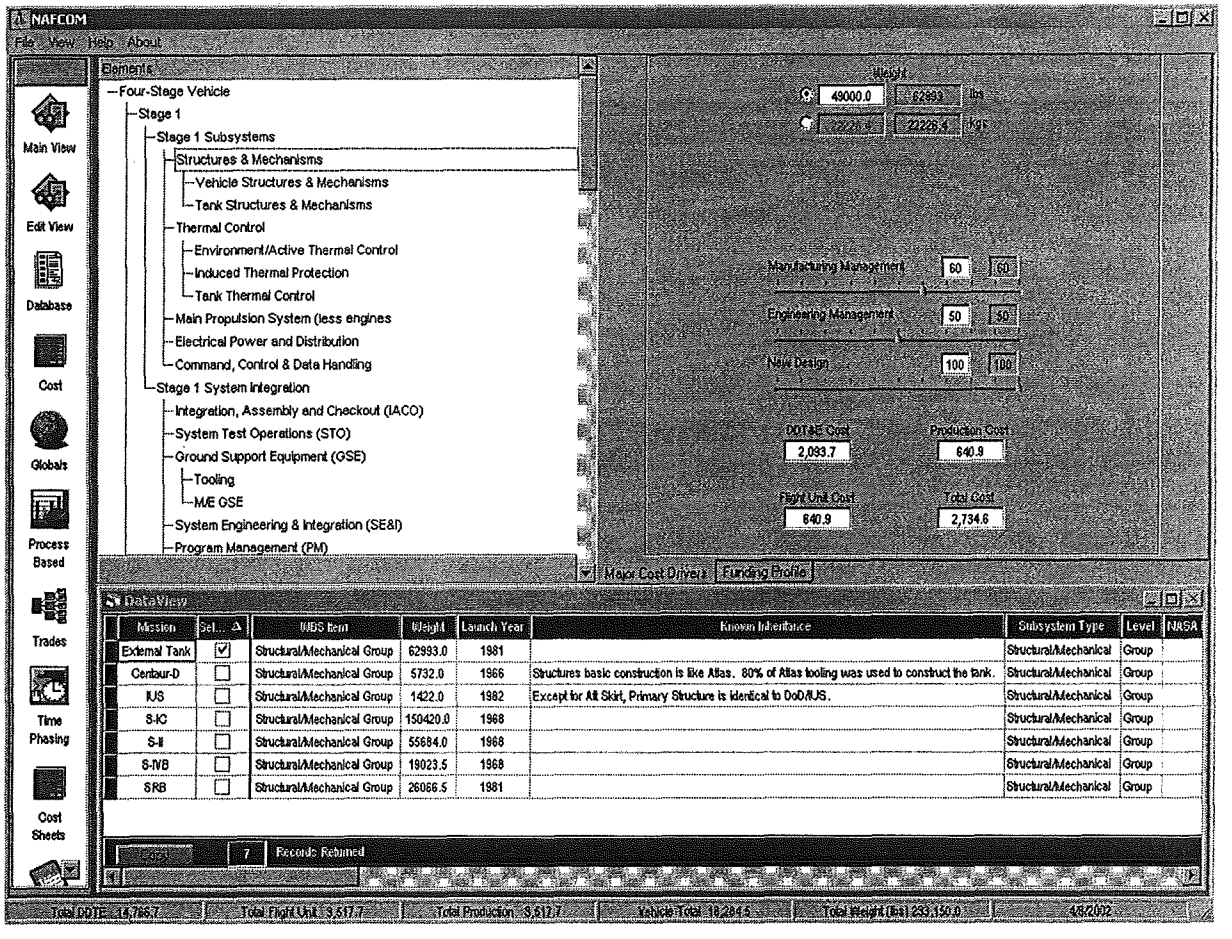
- Toolbar provides easy access
- WBS is generated based on wizard but allows addition of lower level elements
- Data and reports on screen change based on WBS element selected
- Various on-screen reports are provided
- Major cost drivers allow quick changes to template defaults on simple screens
- Funding profiles can be selected at the subsystem level
- Status bar provides dynamic view of cost estimate



Detailed Input Screen

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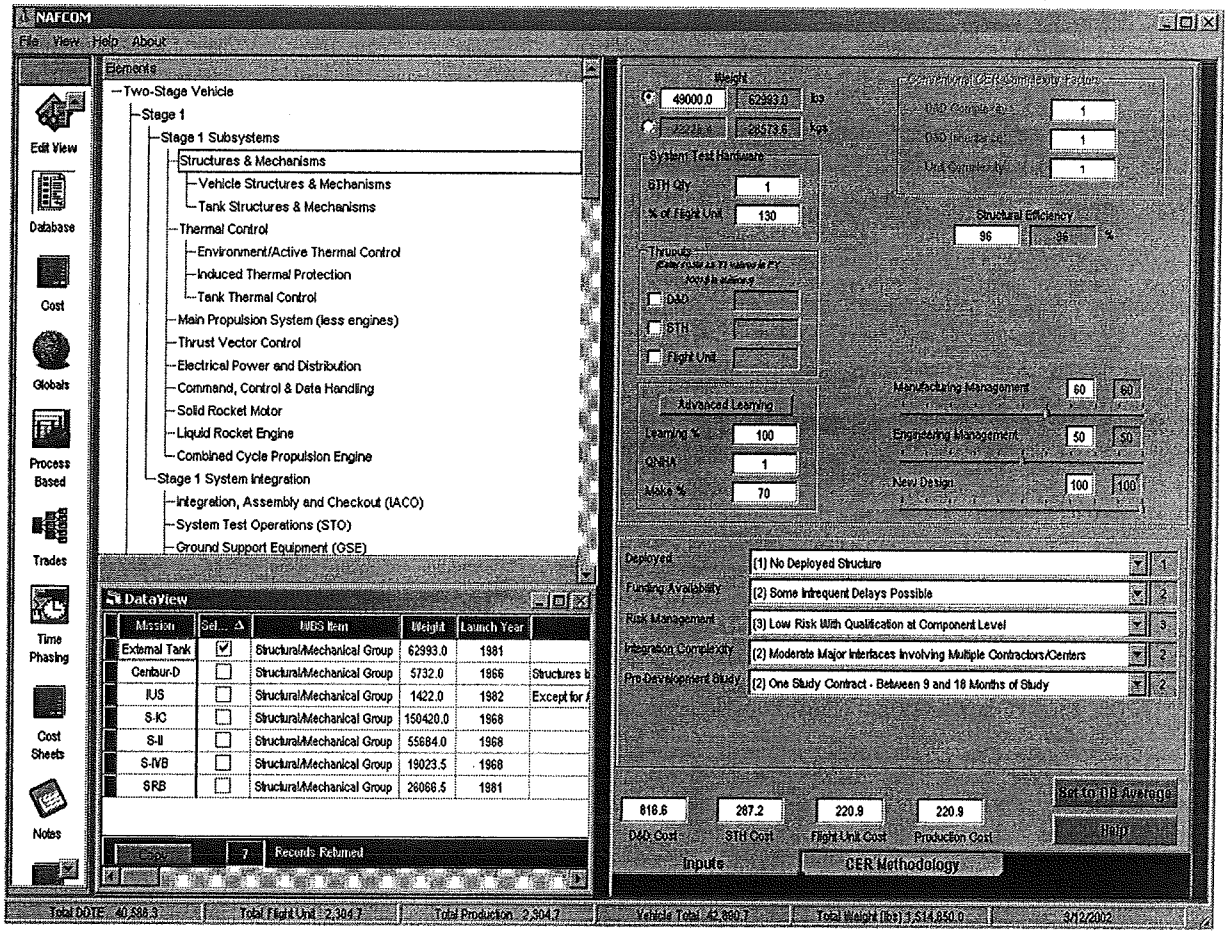
- Detailed Inputs will include all non-global inputs available for a WBS element on one screen.
- The analogous missions can be changed below.



Detailed Input Screen

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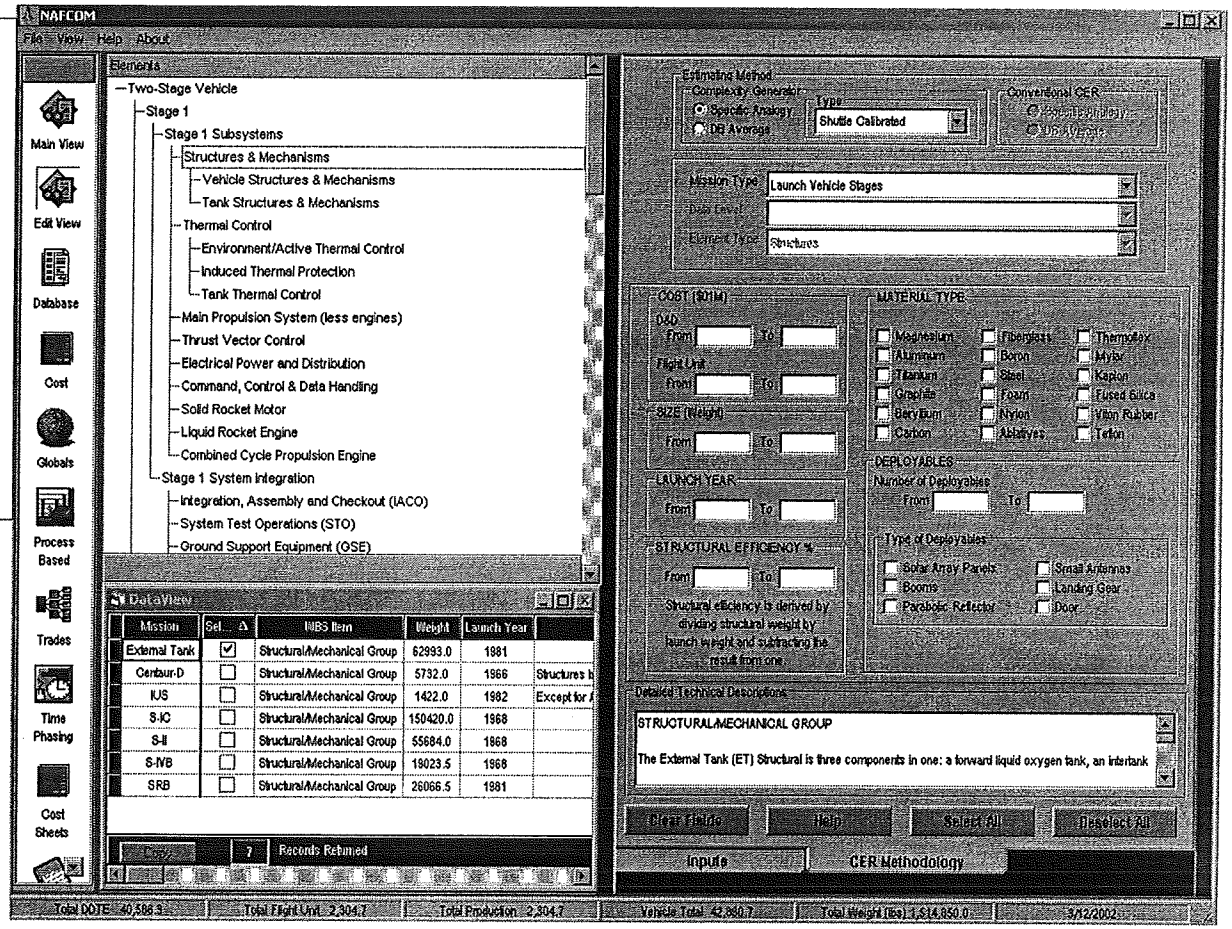
- Estimating Method will determine whether Complexity Generators or Conventional CERs are used.
- Mission Type, Data Level, and Element Type will determine what part of the database is available.
- Database Filters will change based on the Mission, Level, and Element selected. The database screen will change as filters are entered.
- Detailed Technical Descriptions will be provided for the selected item in the database.



Sample On-screen Outputs

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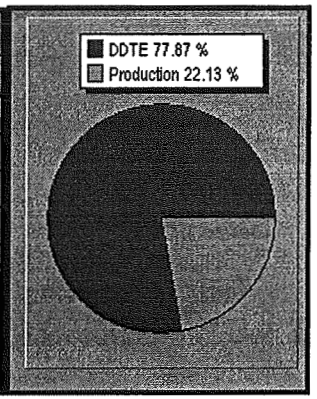
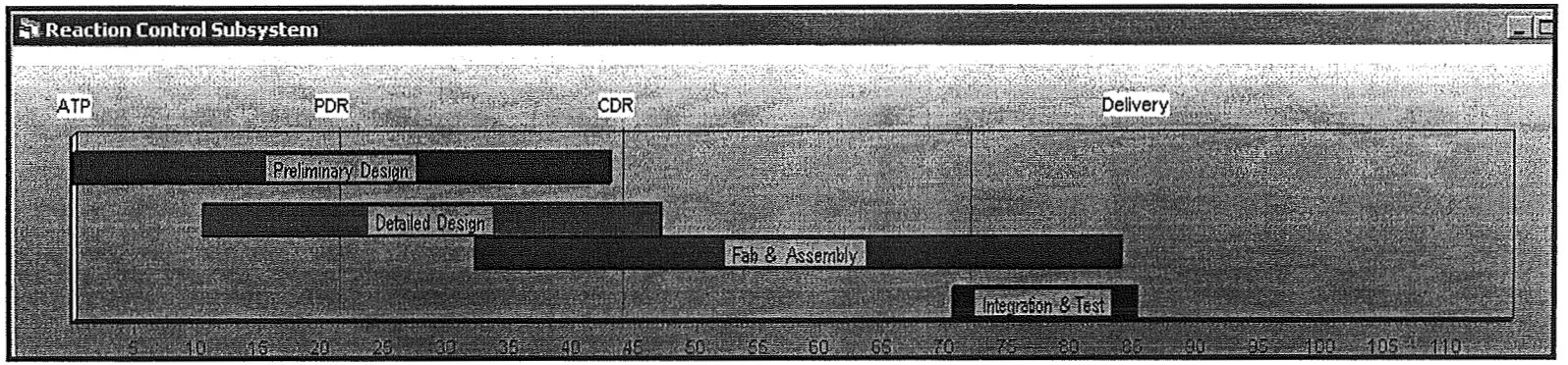
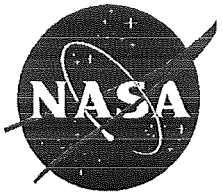
Cost Report

Elements	D&D	STH	DDT&E	Flight Unit	Production	Total
SSTO Subsystems	6,568.1	3,848.7	10,416.4	2,960.4	2,960.4	13,376.8
Structures & Mechanisms	2,535.5	1,898.2	4,433.7	1,460.1	1,460.1	5,893.8
Thermal Control	913.2	309.3	1,222.4	237.9	237.9	1,460.3
Reaction Control Subsystem	144.4	134.8	279.2	103.7	103.7	382.9
Orbital Maneuvering System	335.2	116.2	451.4	89.4	89.4	540.7
Main Propulsion System (less engines)	720.3	646.0	1,366.3	496.9	496.9	1,863.2
Electrical Power and Distribution	762.7	461.0	1,223.7	354.6	354.6	1,578.2
Command, Control & Data Handling	794.9	197.3	992.2	151.8	151.8	1,144.0







Planned Release and Training

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- Public release of NAFCOM is not planned
- Requests for NAFCOM will be controlled through NASA software usage agreement
- Launch Vehicle version was released in April 2002
- Unmanned Spacecraft version is planned for release this June
- Training will be completely revamped
  - Class time will be reduced to one day
  - Emphasis will be on model usage not estimating theory
  - Training will be scheduled beginning in early Summer
  - Training will be conducted using the unmanned spacecraft version of NAFCOM