Parametric Cost Modeling of Unmanned Deep Space Missions in the New DNP Environment

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February 5, 1998

Parametric Cost Modeling of Unmanned Deep Space Missions in the New DNP Environment

- Outline
  - Background - The Times Have Changed
  - Situation in Today's World
  - JPL's Advanced Project Design Team (Team X)
  - What is DNP?
  - Team X Cost Estimation
  - Current Cost-Model Related Work
  - Model Structure - WBS, Inputs, Outputs
  - Conclusions

Parametric Cost Modeling of Unmanned Deep Space Missions in the New DNP Environment

- The times have changed
  - Mid 1960's - early 1990's* (*Cassini is part of this group)
    - Noncompetitive missions, no real cost caps (cost growth was typical)
    - 11 planetary missions from 1964 - 1992
    - Early missions had 2 spacecraft
    - Average design & development cost ≈ $550M, operations cost ≈ $200M
    - Average design & development time ≈ 6.2 years, operations time ≈ 6.8 years
    - Single function instruments
    - Galileo cost $2B without launch vehicle

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- Today
  - Competitive proposals (Discovery, Midex, etc), cost caps
  - 1 - 1.5 missions per year
  - Maybe 1 small spacecraft, maybe no mission
  - Average design & development cost ≈ $160M, operations cost ≈ $20M
  - Average design & development time ≈ 3.1 years, operations time ≈ 3.6 years
  - Multi-function instruments
  - Recent study: Galileo today ≈ $450 - $650 with launch vehicle

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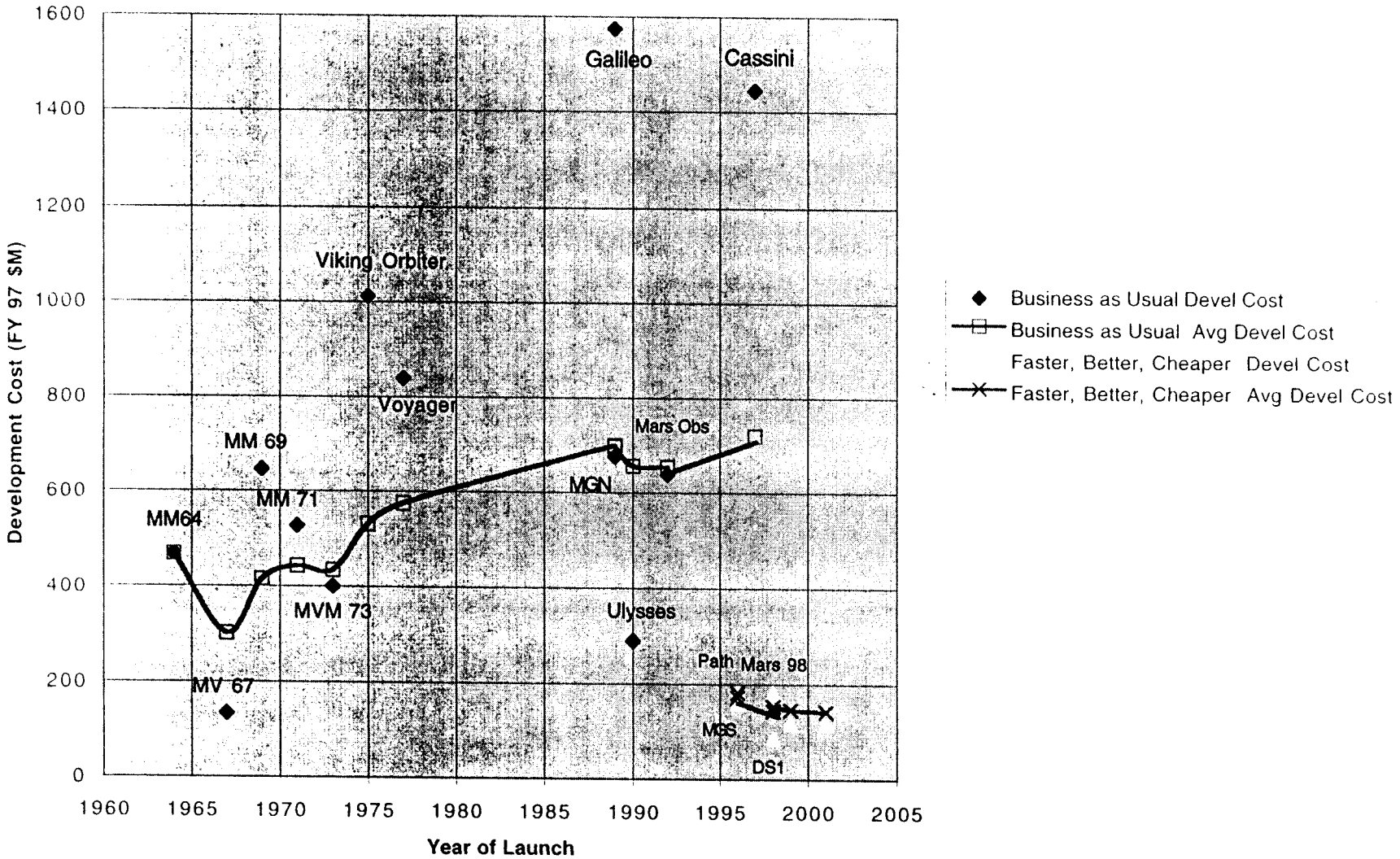
- Today (continued)
  - Cost & schedule caps
  - Electronic development vs hand crafted
  - More inheritance from previous missions; off-the-shelf equipment
  - Less redundancy, less testing
  - More functions/instrument; less instr competition on S/C
  - Fewer instrument & science teams/mission
  - Computer data system carries real operating system
  - Solid state storage instead of tape recorder

JPL Mission Development Cost vs Launch Year



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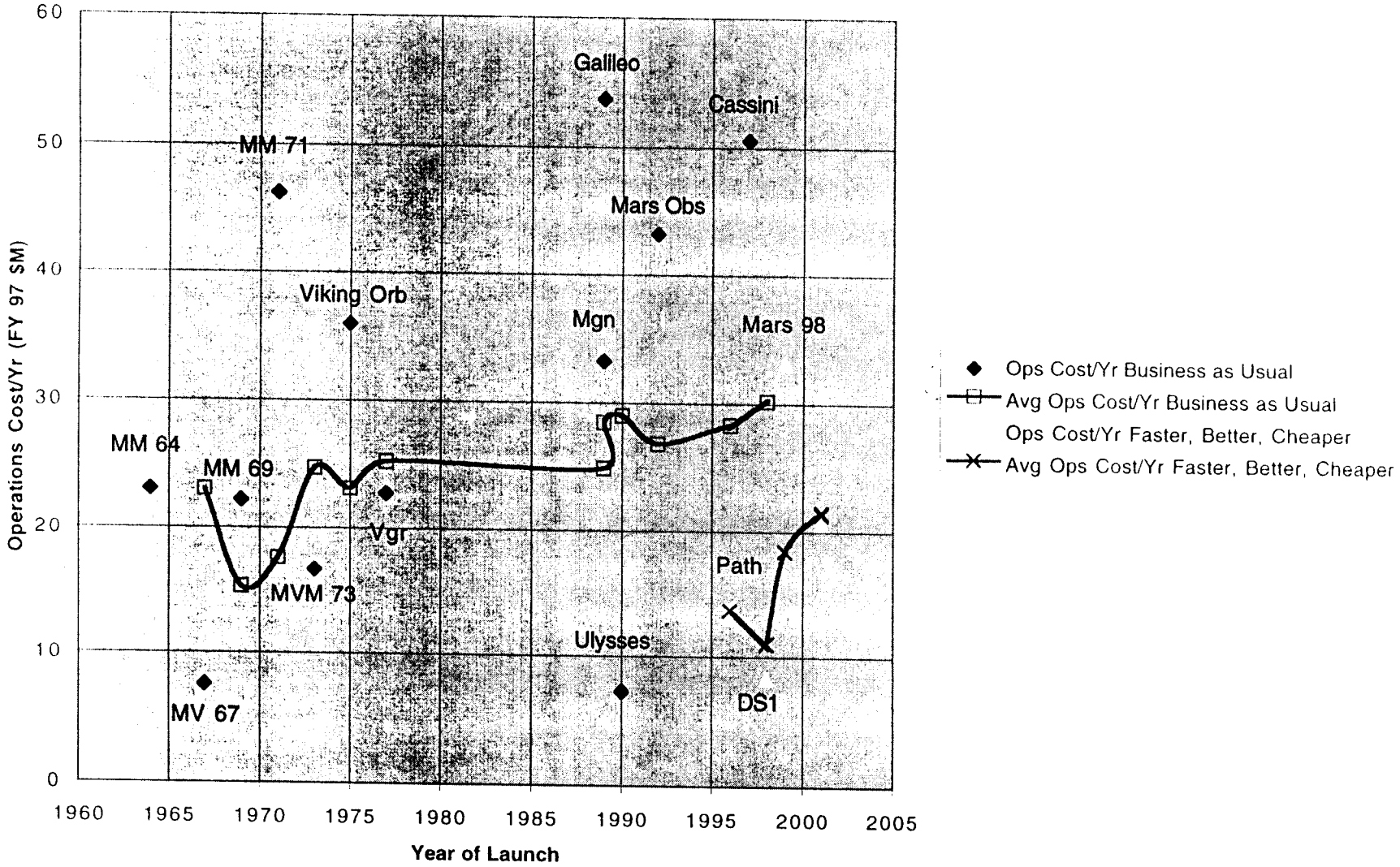
JPL Operations Cost/Yr vs Launch Year



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What on earth is DNP?

Parametric Cost Modeling in the New DNP Environment

- Future goals beyond Faster, Better, Cheaper
  - Cut the time to design & build a spacecraft by 1/2
  - Cut the cost to design & build a spacecraft by 1/3
  - Essentially, perform complex deep space missions at today's costs
- To achieve this the following principles will be followed in a new project called Develop New Products (DNP)
  - Concurrent engineering
  - Model driven design process
  - Continuous integration & testing
  - Automated fabrication from models
  - Strategic stockpile for long lead items

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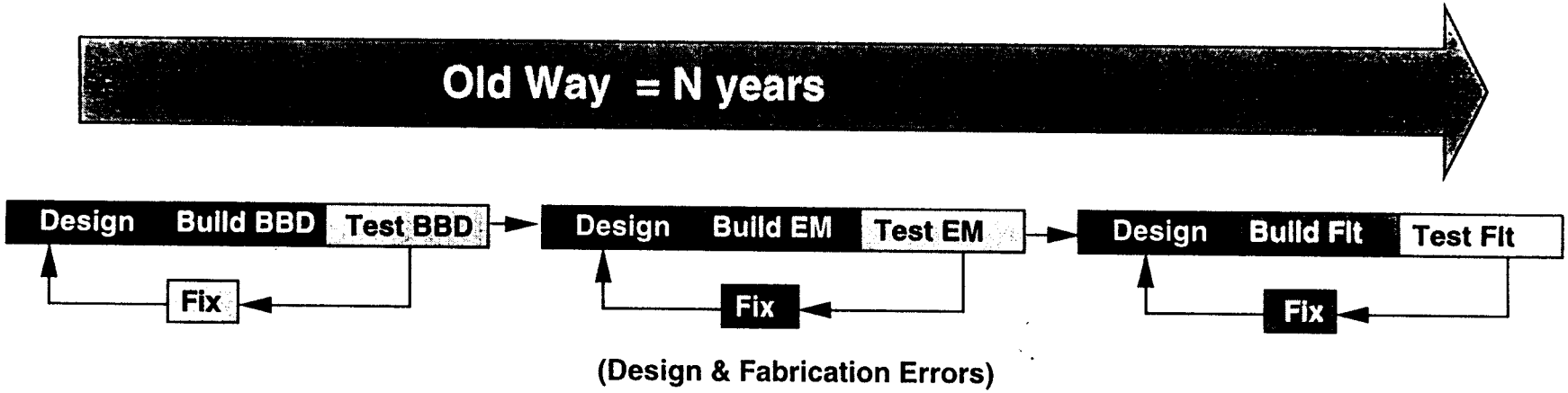
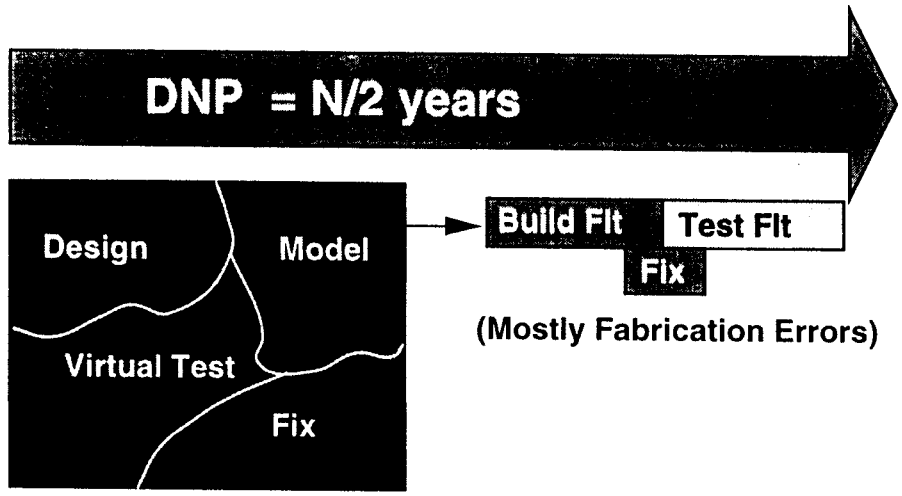
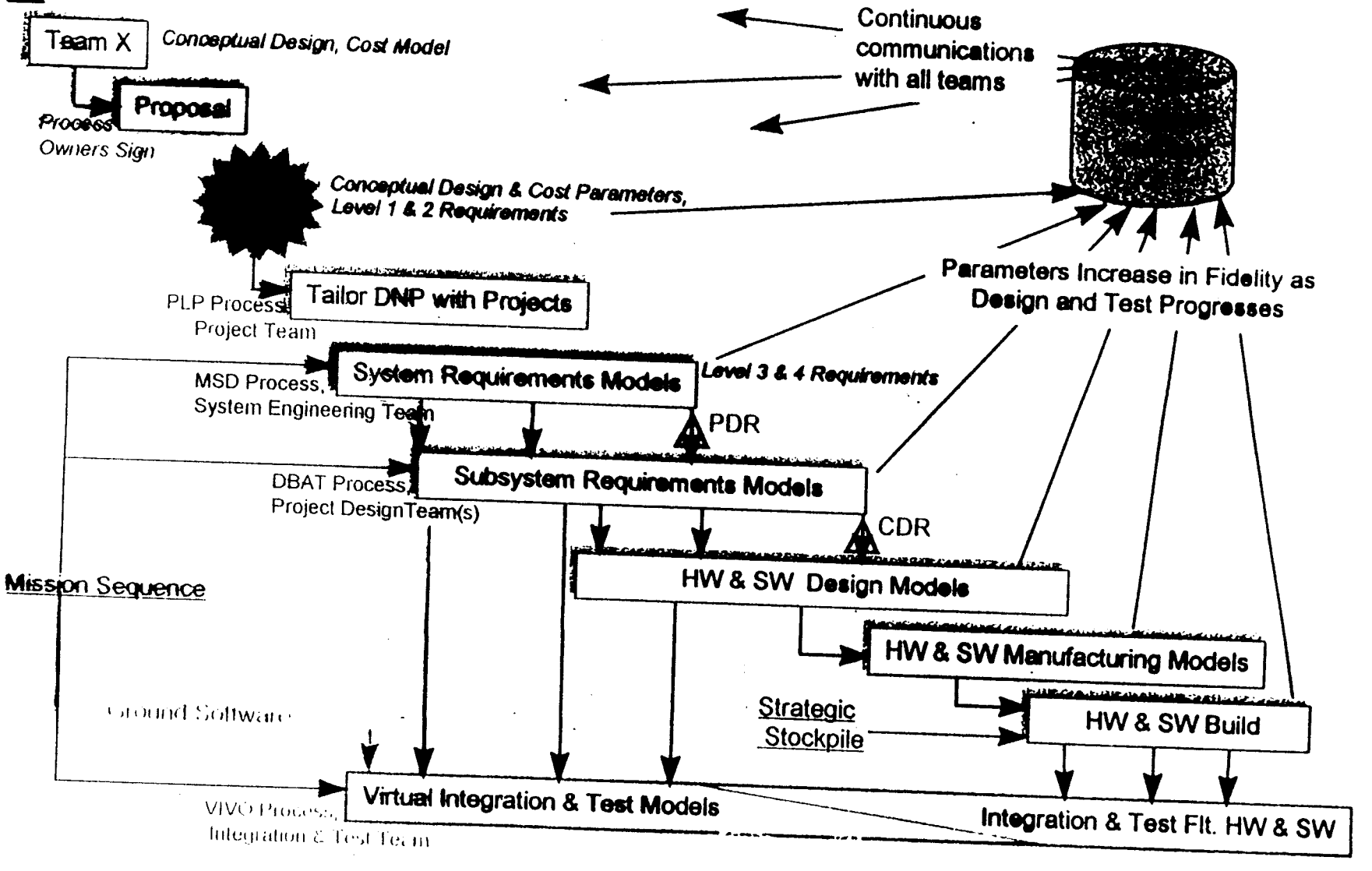
Development Phase Comparison



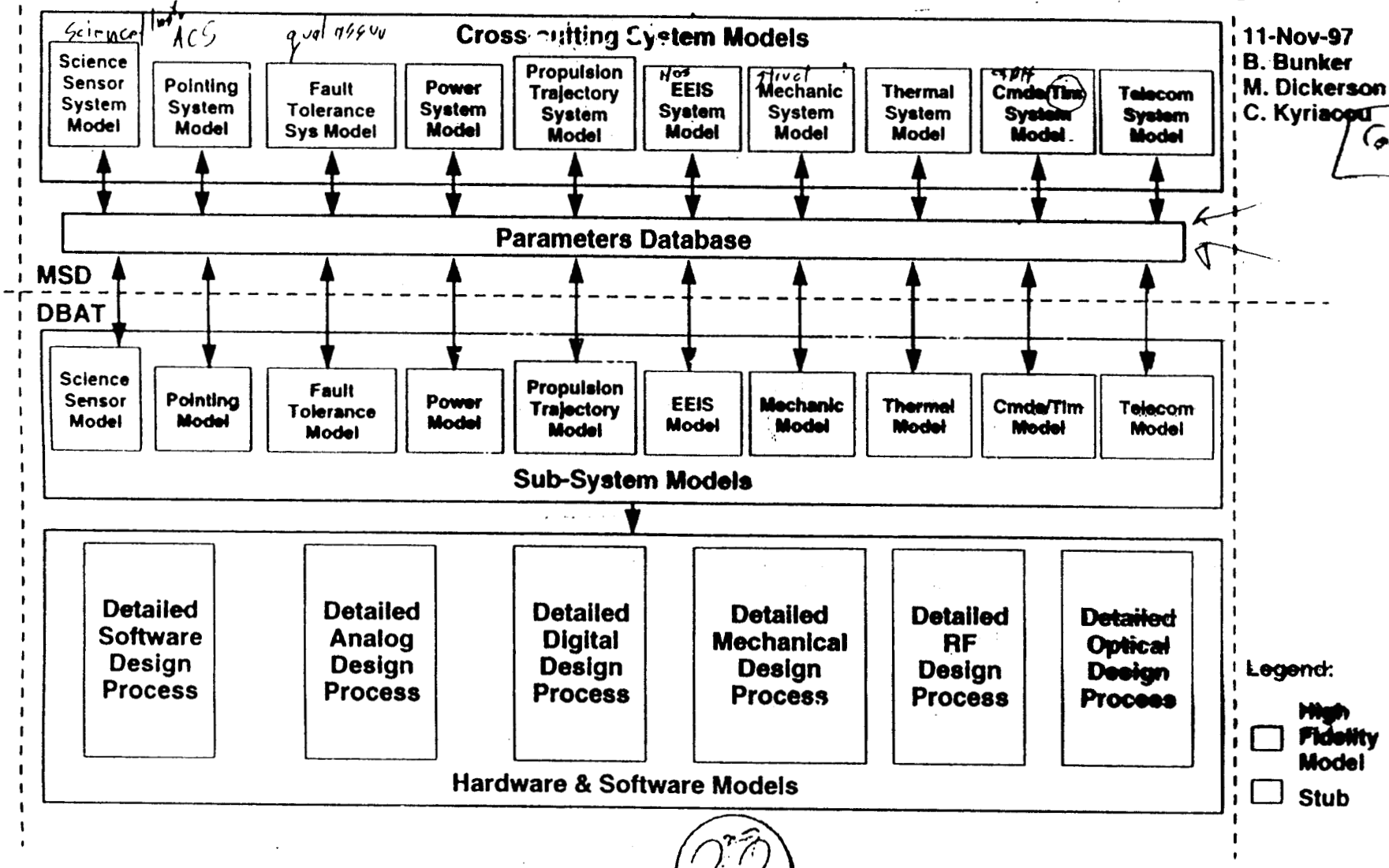


JPL *Develop New Products Project*

Level 1 DNP Process Flow



DNP TRANSITION STATE ASSUMPTIONS



11-Nov-97
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- JPL formed an Advanced Projects Design Team (Team X) in March 1995
- Charter:
  - To improve the quality of JPL's new mission studies using the concept of concurrent engineering
  - Develop generalists from promising engineers
  - Create a reusable study process, circumventing re-invention of custom teams
- In nearly 3 years:
  - Standardized process (incl. tools)
  - ≈85 studies/yr (previously ≈5 studies/yr)
  - Several awards (TQM, Group Achievement)

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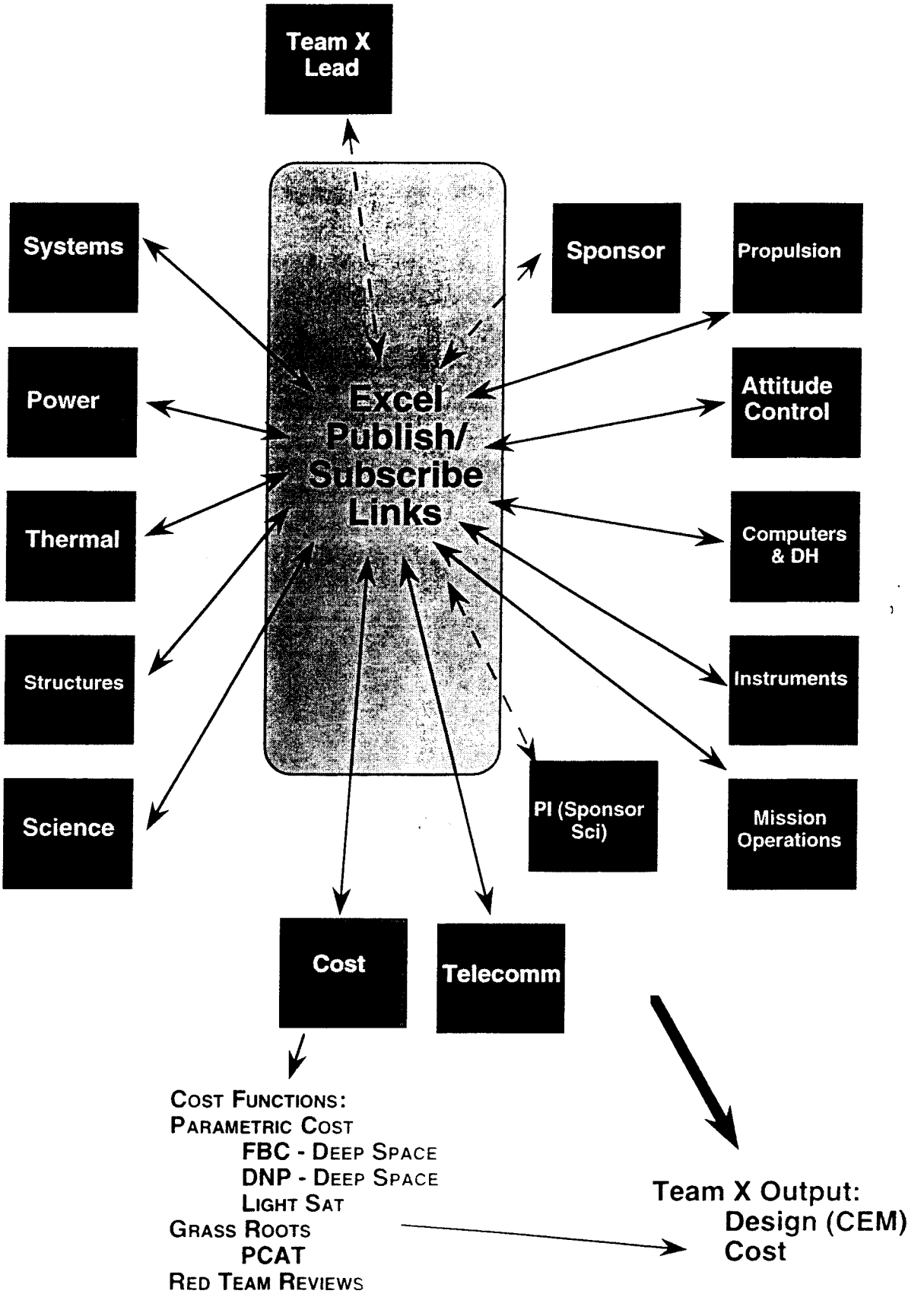
- Team X cost estimation:
  - Old missions not that applicable to the new way of doing business
  - New, updated modeling techniques are needed
    - Faster, better, cheaper - today
    - DNP - tomorrow
    - Concurrent engineering
    - New technology assumptions (inflatables, small transponder, solar electric propulsion, etc.)
    - Behavioral & cross-cutting automated models

Team X Process



Parametric Cost Modeling in the New DNP Environment

Current Model-Related Work

- Parametric deep space cost model of individual subsystems (≈75% complete, $R^2 \approx 88\%$)
- Uses (≈40 - 50) objective technical parameters (mass, pntg acc, power, data rate, etc)
- Model is based on 15 Team X DNP studies (however, none have flown)
- Model uses Monte Carlo techniques (prototype working)
  - Inputs: probability distributions, means, variances
  - Outputs: Cost by WBS, histograms, reserves, checking of inputs
- Validation activity has started:
  - Pathfinder, MGS, Stardust, Genesis, DS1, Grace, Galex
- Easily converted to current FBC methods
- Documentation - ongoing
- Complete automation is the goal **(including user friendliness)**
- I/F to Excel links make it easy to integrate into MSD database

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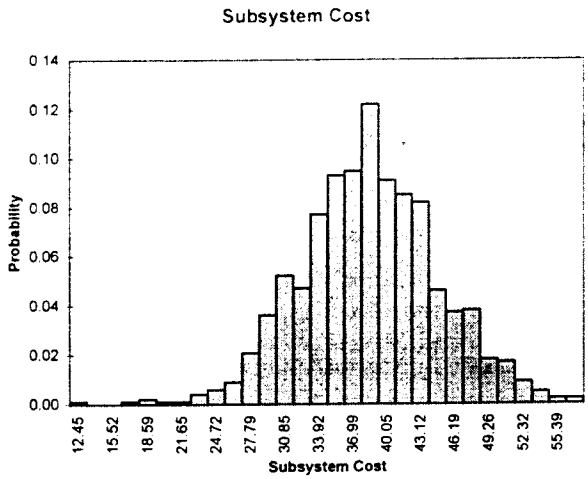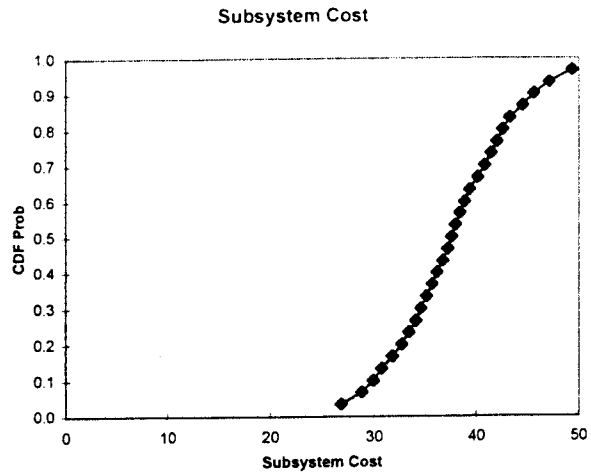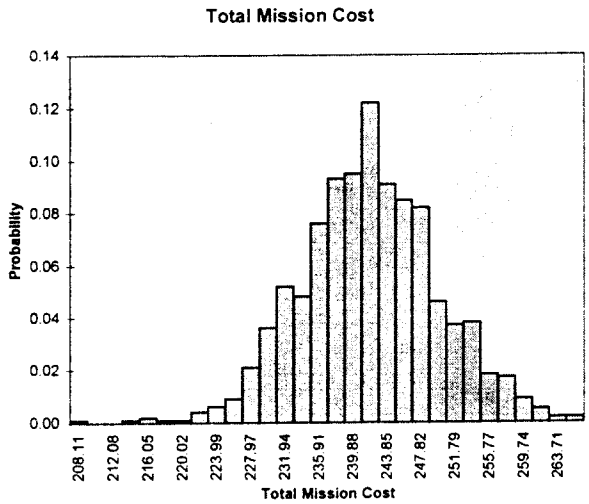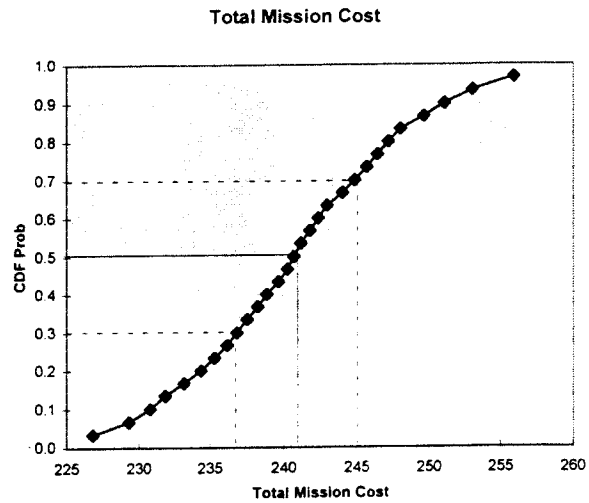
DNP Deep Space Parametric Cost Model Output