- **Mark Steiner**

Systematic Technology Planning - GSFC Perspective

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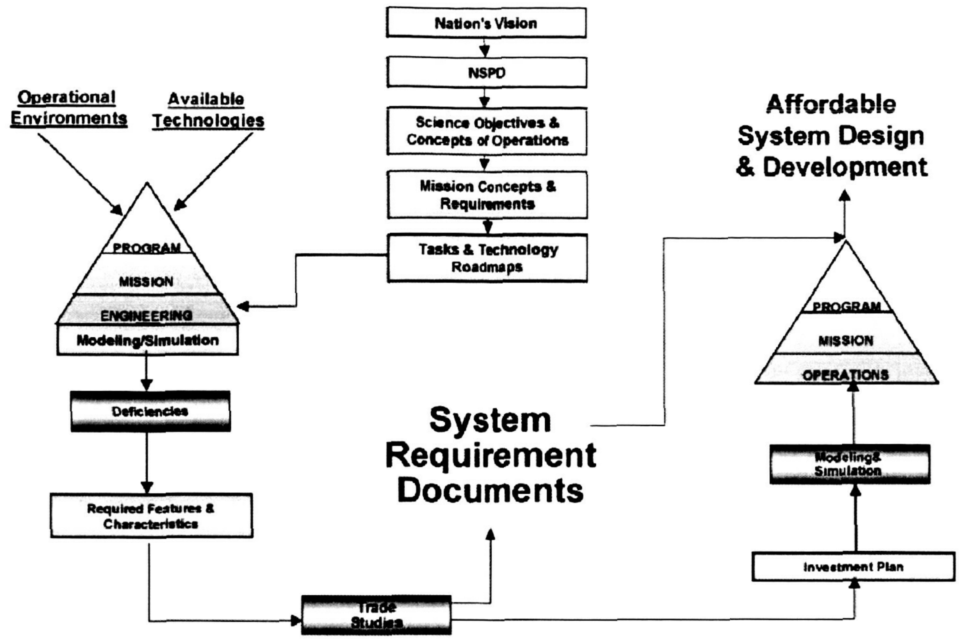
Introduction

How do we integrate systematic technology investment planning into the process of architecting NASA's new space missions?

- GSFC perspective based on:
  - Exploration Initiative and current mission planning environment
  - FY 2003 Lidar Technology Pilot Study w/ LaRC
  - FY 2004 TAA study w/ JPL
- Goddard's vision as to what needs to be done next

Strategy-to-Task-to-Technology Process



Engineering and Technology Support Across Life Cycle

Strategic technology investment analysis enhances ...

Pre-formulation/Formulation

- Roadmap generation and review
- Advanced concept development and review
- Refinement of roadmaps, advanced concepts, technologies, etc.
- Proposal development and review
- Technology development and review
- Tracking and execution of roadmaps, advanced concepts, technologies, etc.
- Requirements and Systems Analysis

Cross Life Cycle Activities

- Risk management
- Project/Program cross-coordination and cross-coupling
- Independent technical/management review
- Lessons Learned Identification & Feedback

Implementation & Decommissioning

- Requirements management
- Design and development of missions, instruments, systems, technologies, etc.
- Product and service delivery
- Integration & test
- Launch, early-orbit check-out
- Operations & sustaining engineering
- Technology Commercialization

Approval

- Technology planning
- Approval review engineering and product support
- Program/Project plan support

... sound decisions across mission and program life cycles.

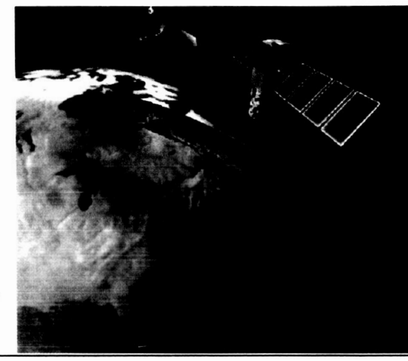
Lidar Pilot Study: Charter from Code R

Code R tasked GSFC and LaRC to perform a technology assessment study of Lidar missions with the following objectives:

1. Develop a process for assessing the system-level benefits of new technology investments to guide program investment decisions.
2. Establish performance goals for evaluating the progress of technology development & risk relative to the state of the art.
3. Identify high-payoff crosscutting technologies that are enabling for sets of future mission concepts with similar scientific objectives.

GSFC and LaRC performed this Technology Assessment Analysis (TAA) pilot study 2003

- Used system engineering approach to determine expected return on technology investments that could ultimately be used at the mission, enterprise, or agency level
- Allowed specific technologies to be evaluated for their impact on life cycle cost



Study Flow - 1

Science inputs

Captured science goals for aerosol Lidar -

- Examined ESTIPS database to establish science objectives for next generation Lidar and found that more detailed information was needed.
- Performed survey of aerosol-climate community and Lidar experts to fully populate domain of science measurement goals (e.g., detect aerosols and clouds and obtain their optical characteristics).

Derived science measurement needs that drove the integrated instrument performance requirements (such as SNR for atmospheric area of interest).

Study Flow - 2

Science inputs

↓

Technology inputs

Captured technology options that would improve Lidar performance

Surveyed technologists and grouped results into generic Lidar system component options.

Study Flow - 3

Science inputs

↓

Technology inputs

↓

Modeling

Developed model of aerosol and cloud Lidar instruments: maps technical performance into instrument performance in area of atmosphere to be measured.

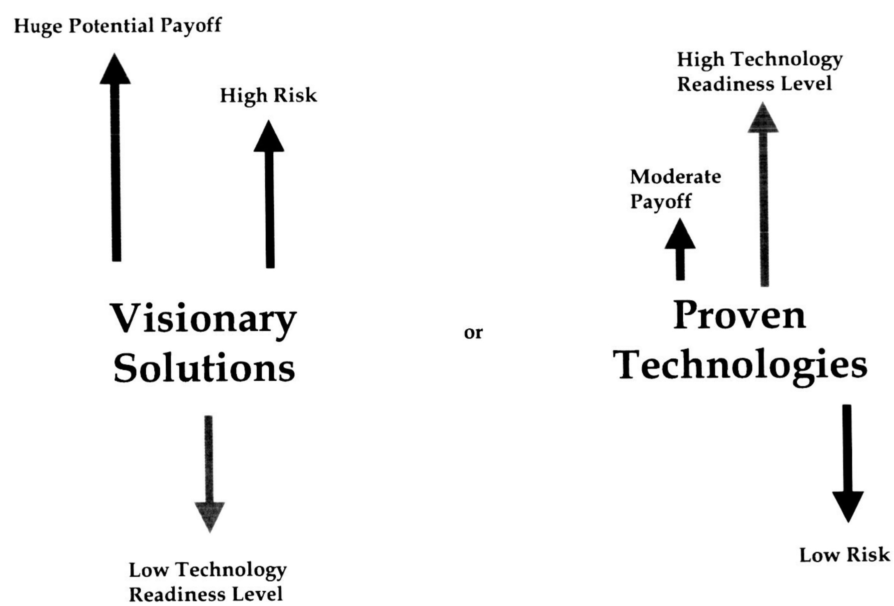
Developed technology development model (from starting TRL to TRL 6): maps development risk and investment plan to technology performance over time.

Study Flow - 4

Science inputs
↓
Technology inputs
↓
Modeling
↓
Results

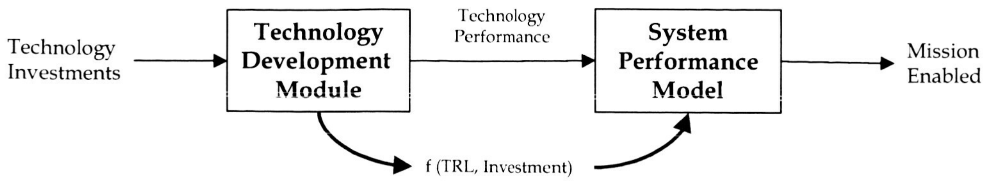
Linked models and used them to trade off cost, development risk, and instrument performance to optimize technology investment plan.

Technology Development Risk



Always a Trade-Off in Technology Investments

Technology Development Modeling

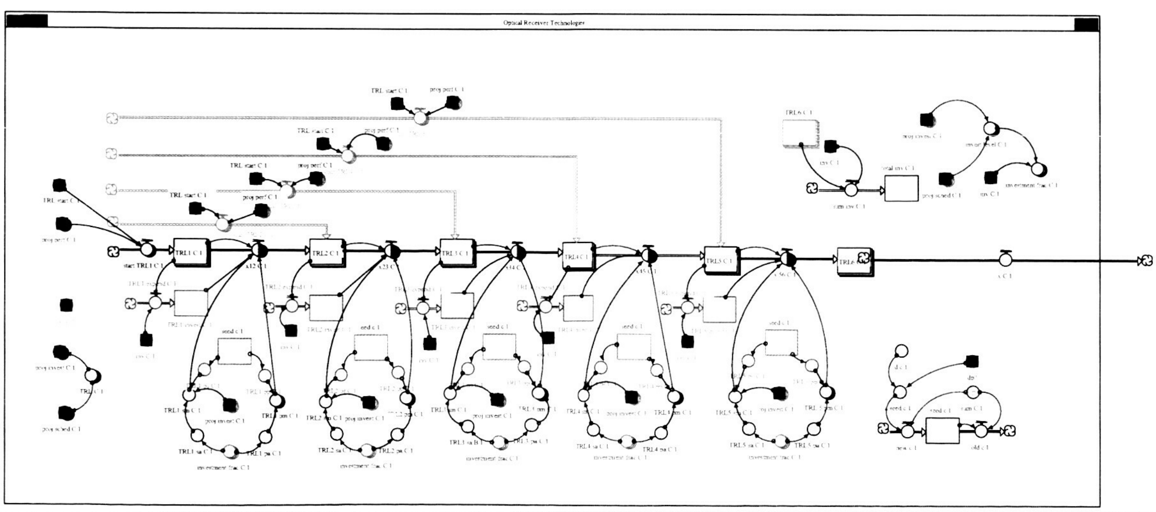


Technology Development Model (from starting TRL to TRL 6) maps development risk and investment plan (estimated schedule and budget) to technology performance over time.

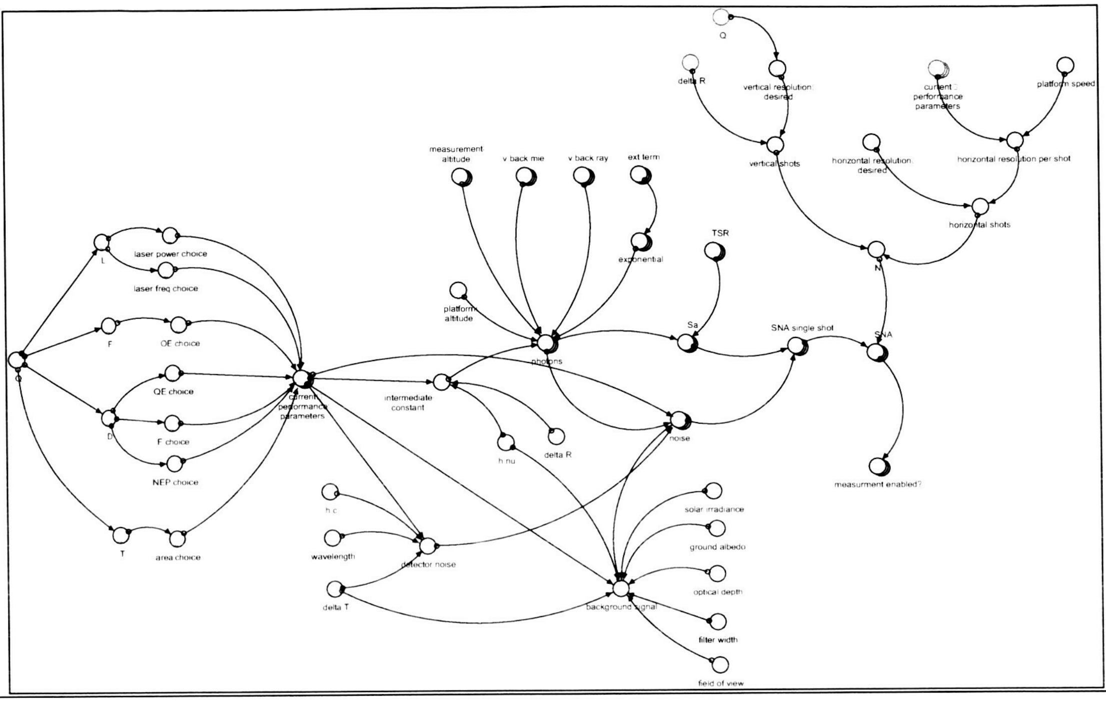
System Performance Model maps technology performance into system performance

Link models and use them to trade off cost, development risk, and system performance to optimize technology investment plan.

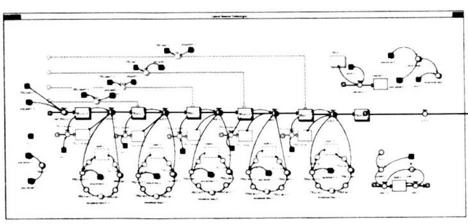
Systems Dynamic Modeling – Technology Development



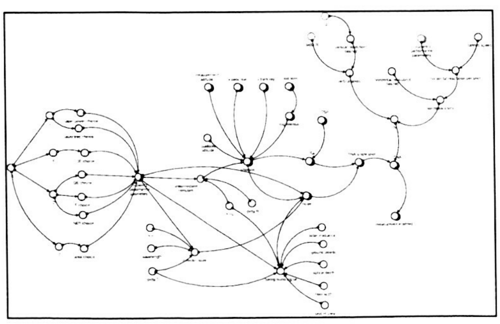
Systems Dynamic Modeling – Lidar Performance



The Study Methodology Enables

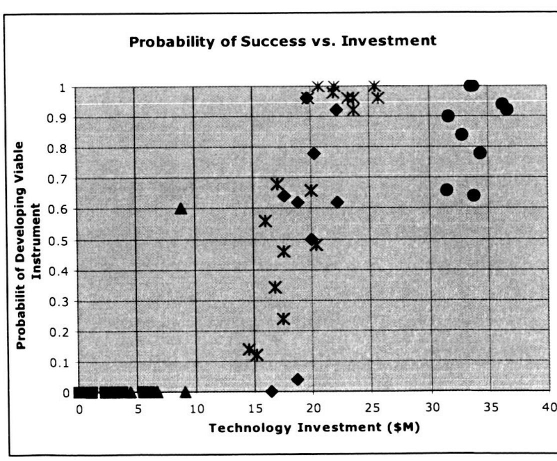


Combining lidar technology development modeling . . .



. . . and lidar performance modeling . . .

. . . to determine return on investment . . .



and provide best estimate as to which group of technologies would enable the mission, reduce cost, and be most likely to enhance overall value.

FY04 TAA Study

Lidar Pilot Study FY03:

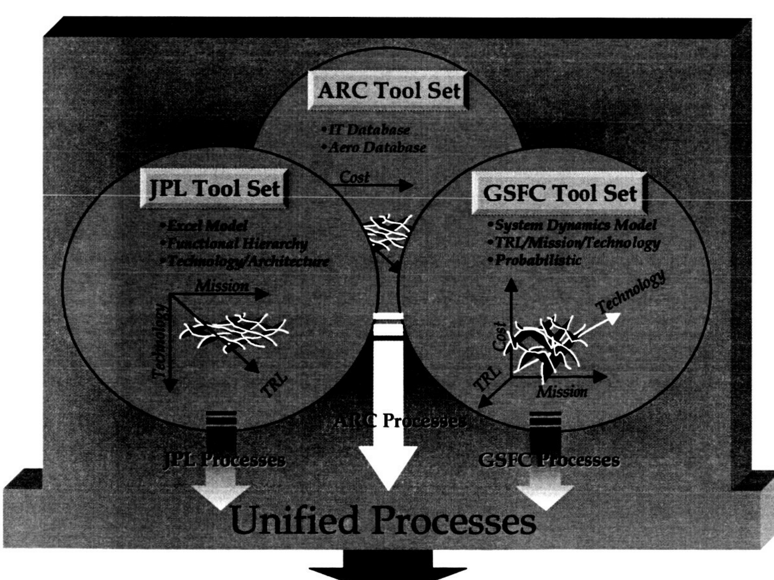
- Develop an approach to maximize the value of NASA's technology investment.
- Understand process of gathering information, developing models, and presenting results:
- Develop a general approach for optimizing technology investments and apply to LIDAR measurements

Expansion in FY04:

- Partner with JPL to extend process to space architect's Design Reference Missions
- Work with other centers (LaRC, ARC) to broaden technology databases, share processes, share results
- Extend performance modeling to include instrument accommodations (spacecraft and ground system)

Unified Agency-Wide Technology Assessment Framework

Unified Technology Assessment Framework



Features

- ***Toolbox approach***
- ***Each tool is unique***
- ***Different views based on same data***
- ***Each tool optimizes over a specific dimension, depending on question being asked***
- ***Convergence results in Unified Process and helps V&V tools***

Quantifiable and Risk Based Technology Investment Strategy

Reference Missions & Grand Challenges

Reference Missions (not listed in order of priority)	Grand Challenges
Orbital Aggregation and Space Infrastructure Systems (OASIS)	Modular, Distributed Structures, Human Protection, Robotic Assembly
Mars Surface Missions (e.g. Mars Science Laboratory; Astrobiology Field Lab; etc.)	Long-Range Mobility on Ice; Deep Drilling; Automated Return Launch; Risk Mitigation (Pre-Phase A)
Lunar Survey Study Mission	Sensor Webs & Data Fusion: Lidar/Radar Instrument Systems; Multi-Spectral Scanner; Model-Driven Multi-Measurement-Validated Data Reduction
Earth Biomass (surface, mid-canopy, and canopy heights.	Lidar/Radar Instrument Systems; Multi-Spectral Scanner
Sensor Webs & Data Fusion	Model-Driven, Multi-Measurement- Validated, Data Reduction
RASC - L2 Earth Observing Telescope	Large deployable mirrors, membrane type shape control, formation flying
Venus Surface Missions	Extreme Environments (460C temp; 90 bar pressure; sulfuric acid clouds at 50 km)
Generic Critical Design Review requirements derived from Pathfinder, Space Station or other recent mission	Quantify mission-level impact of ECS technologies, such risk management and human organization, whose primary contribution is to the design process, and that are not necessarily embodied within a hardware or software flight system

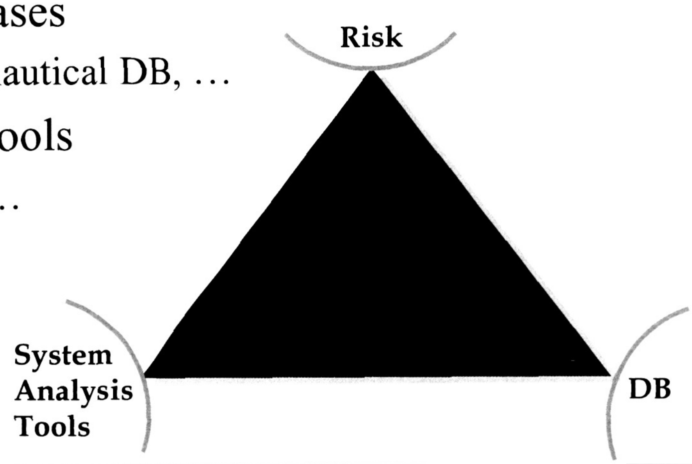
NOTE: GSFC and JPL will share performance data on all reference missions.

Study Data Gathering

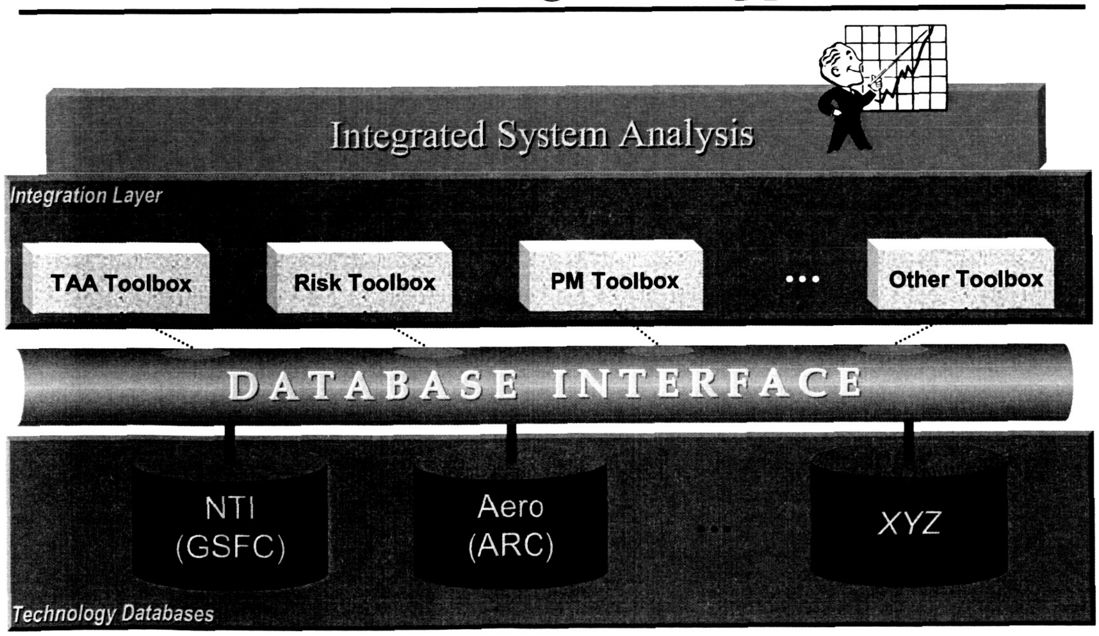
- **Have developed a technology list in cooperation with JPL**
  - **Shows who will gather technology information in which areas**
- **Have common technology data gathering template, based heavily on Space Architect work**
- **Common technology data template and sharing of this and the reference mission performance information will allow JPL and GSFC to run common data through both sets of tools and provide results for comparison**
- **Analyze differences between tools, since view problem from different but complementary angles:**
  - **JPL – good for matrixing many technologies across many mission sets**
  - **GSFC – good for in-depth analysis of technology development within particular mission (performance parameter) set**

Integration of Risk into Technology Planning

- Risk
  - Tools and methodology
- Technology Databases
  - NTI, ESTO, Aeronautical DB, …
- System Analysis Tools
  - TAPS, JPL Tool, …



Ideas for an Integrated Approach



Guesswork/Gut Feel Replaced with Integrated System Analysis

Considerations for NASA

Currently -

- We conduct deterministic and probabilistic assessment of existing systems based on mission requirements
  - Probabilistic sensitivity analysis for point solutions (Shuttle, Station, ...)
    - *system decision trees are often complex and may not capture everything*

Future -

- Assessment of entire architecture trade space to include technology development risk, programmatic risk, operational risk (vehicle, etc.) and cost
  - Effect of technology on system design/development/cost/schedule
- Models to develop probability distribution of expected outcome
  - Probability based Genome Model will integrate TRL to provide a powerful view into future mission strategies and architectures.

Next Steps for NASA

- Get all technology players to play together
- Integrate processes and tools as makes sense to answer questions at the appropriate level
- NASA Technology Assessment Technical Committee??

Unified Agency-Wide Technology Assessment Framework