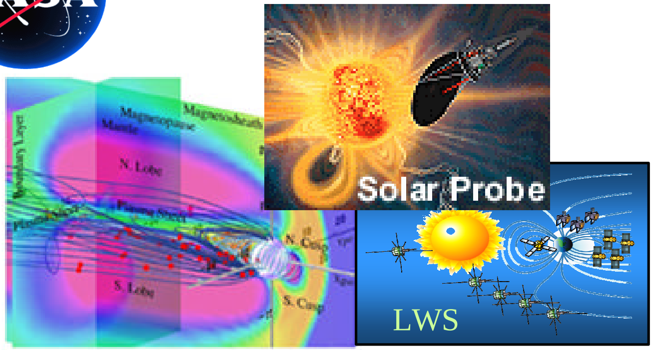
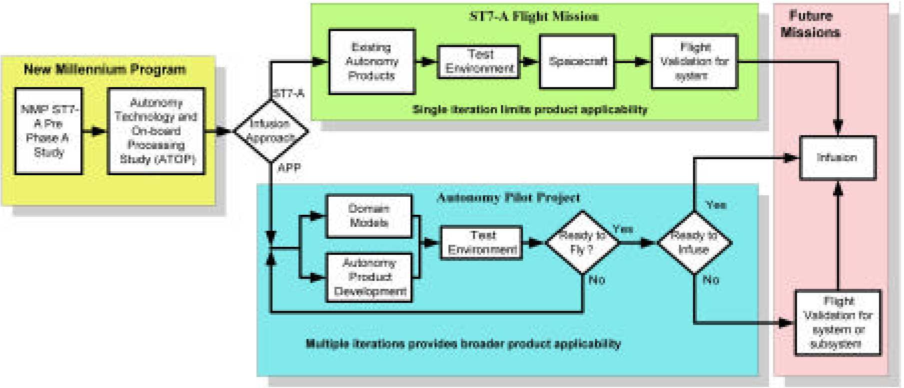
Autonomy Technology and Onboard Processing





Fundamental question:

➢How to cost effectively build and operate fully-autonomous Space Science missions.

Why this question is important:

➢ Full autonomy cannot be cost-effective with current, ad-hoc software reuse practices,

➢ Operations cost savings are likely to be modest for single-spacecraft missions.

➢ Full autonomy can be economically advantageous with domain-based "black box" reuse.

➢ Multi-spacecraft missions are too expensive with current ad-hoc reuse and intensive human in the loop operations.

Objectives:

➢ Introduce cost effective reuse and infusion for flight software

➢ Infuse fully integrated advanced autonomy as productized applications

➢ Integrate flight and ground autonomous systems.

➢ Introduce distributed compute environment to provide sufficient computational power to support the autonomy technologies.

➢ Use model-based approach to save significant development and test time

Technology description:

➢ Onboard mission operations autonomy,

➢ Onboard reactive planning

➢ Distributed compute environment

➢ Productization of flight software

Infusion strategies:

➢ Enable mission community to understand autonomy technologies for direct infusion.

➢ Integrate autonomy technologies in an end-to-end simulation with realistic flight environment simulators.

➢ Integrate autonomy software with mainstream mission software.

➢ Productize autonomy packages for direct infusion by flight missions.

The technology requirements:

➢ Creating broadly reusable, modular autonomy software that operates in a plug-in architecture.

Autonomy Software
Cost Effectiveness is Strongly Affected by Reusability.

N M P

High-Level Commands

Enhances most science missions:

- Direct interaction with scientist
- Lower mission operations cost

Onboard Science Campaigns

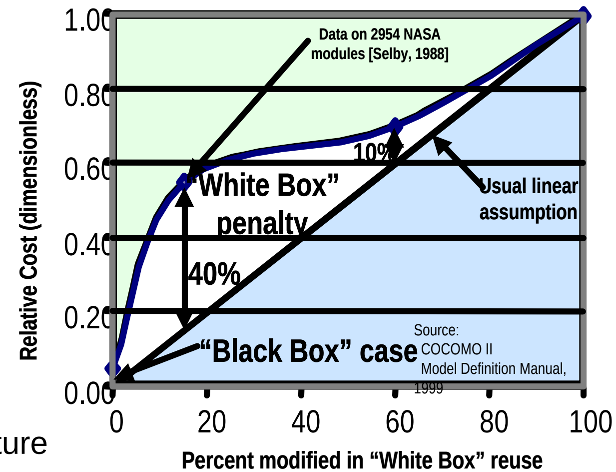
Enhances all science missions:

- Increased daily science return
- Lower mission operations cost
- Special value for survey (e.g., full sky) science efforts

Complex Observations

Enhances most science missions:

- Improved instrument efficiency
- Lower mission operations cost
- Special value for the Origins and Structure & Evolution of the Universe Programs



Downlink Priorities

Enhances most science missions:

- Increased science return average value
- Special value for distant (e.g., Mars)
- Missions with high bandwidth requirements

Fault Tolerance

Enhances all science missions:

- Lower mission operations cost
- Increased average daily science return

Robust Attitude Control

Enhances all science missions

- Lower mission operation costs
- Enables critical real-time operations of landers, distant rovers, critical distant maneuvers
- Special value for SSE, SEC landings, insertions, encounters, coordinated maneuvers

	Percent Reuse	Additional Work Required	Cost for Mission	Break Even Time	Savings for Single 3 Year Prime Mission	Savings for Single 10 Year Mission	Savings for 35 Spacecraft Constellation 10 Year Mission
			M$	Years	M$	M$	M$
ST7-A case	0	1	8	12.3	-6.05	-1.5	5
Normal case	85	0.55	4.4	6.8	-2.45	2.1	8.6
Black Box Reuse Case	100	0.05	0.4	0.6	1.55	6.1	12.6

Operations: $650K/year (~5 FTE/year) -- Constellation: $1,300K/year