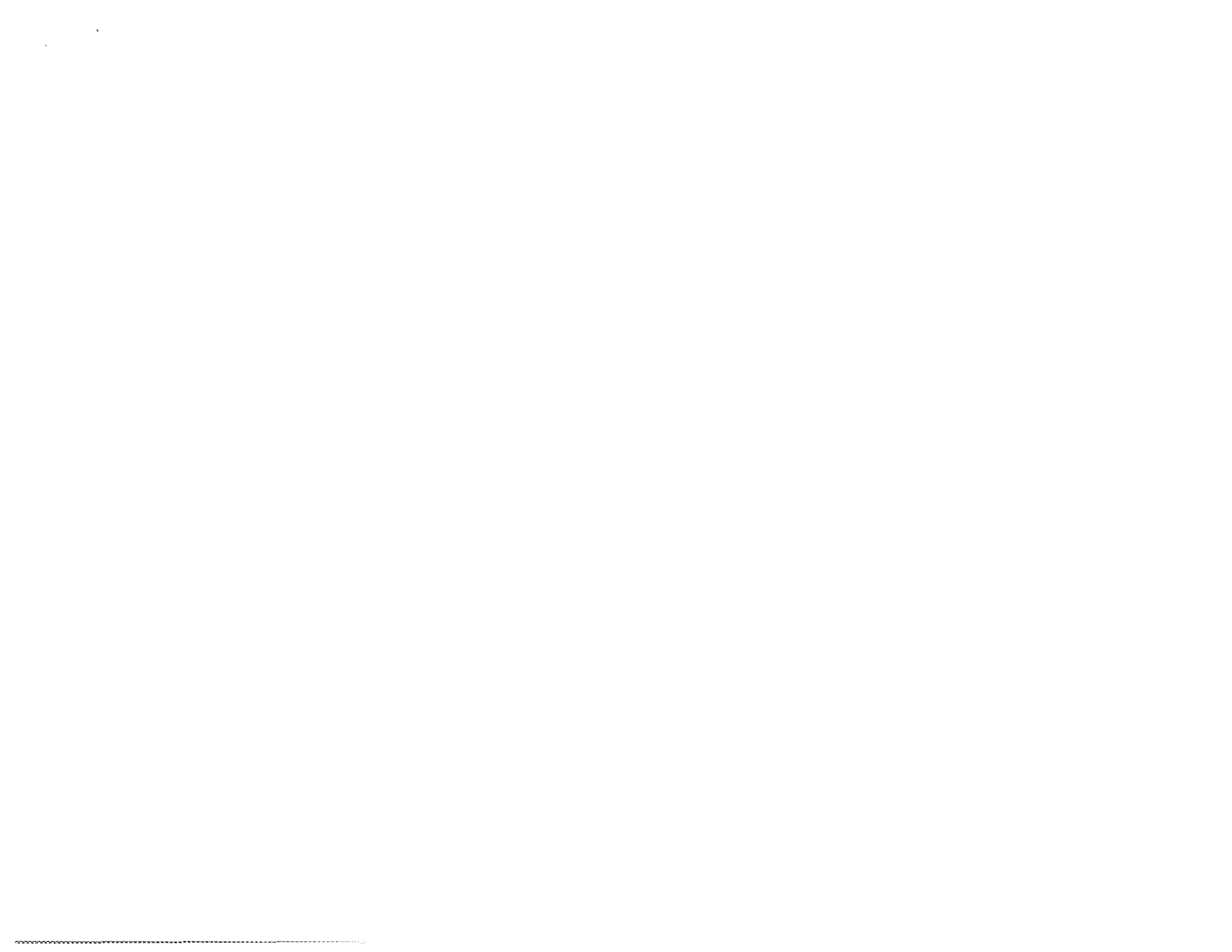


Explanation of Change Cost & Schedule Growth Study Interim Status Briefing

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Bob Bitten, Debra Emmons, The Aerospace Corporation

April 1, 2010





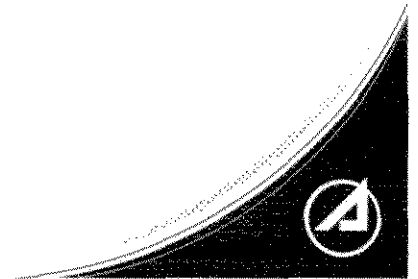
Introduction

- Study Overview
 - *Understand the primary reasons for cost and schedule growth*
 - *Determine percentage of growth outside of the project's control*
- Approach
 - *Examined project documentation, including CADRe, milestone presentations, monthly project reports, etc., to develop a case history of each project*
 - *Conduct interviews with key project personnel to provide the insight required to understand all reasons for growth*
 - *Allocated growth events to "Explanation of Change" EoC "tree" to quantify reasons for growth*
- Timeline
 - *First set of 10 NASA historical missions reviewed November/December 2009*
 - *Results of second set of 10 missions & 20 mission total reviewed in this briefing*
 - *Remaining set of missions, analysis & recommendations completed by October*



Phase II Executive Summary

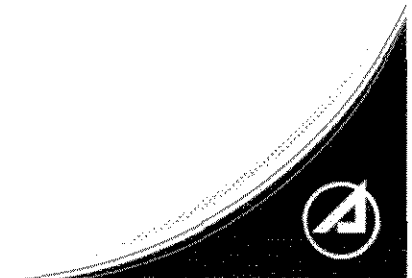
- Mission data collected for twenty NASA science missions
- Binning process used to identify cause of cost growth
- Results of Mission Explanation of Change (EoC) categorization
 - *5% External to NASA*
 - *22% External to the Project*
 - *34% Relative to Project Planning*
 - *39% Relative to Project Execution*
- Following Aggregate Cost Increase, Not Including Reserves, Observed
 - *19% additional cost increase due to HQ and external factors*
 - *24% cost increase from Phase B start until realistic programmatic baseline established typically after confirmation*
 - *27% cost increase after realistic programmatic baseline established*



Interview Preparations

- Case histories developed
 - *NASA science mission cases developed including references*
- Assess initial EoC Categorization
 - *Initial allocations developed while waiting for interviews*
 - Standard template developed to “standardize” EoC categorization
- For each mission, preparation of case summary provided to interviewees
 - *Key event timeline*
 - *Mission Cost growth bar chart*
 - *WBS element cost growth pie chart*
 - *Schedule summary chart*
 - *Reasons for cost growth*
 - *Additional questions*

Interviews provided input to modify initial EoC Categorization



Interview Approach

- Speak to broad range of project personnel if available
 - *Project Manager*
 - *Spacecraft Manager*
 - *Payload Manager*
 - *Project Systems Engineer*
 - *Resource Manager*
- Review organization charts from milestone documents to determine most appropriate personnel
 - *Tried to identify personnel who were in place when primary cost growth occurred (typically CDR)*
 - *Recommended to Center POCs specific personnel to interview*
 - *Center POCs checked for availability of personnel*
 - *Typically, a subset of project personnel were available for interview*

Interviews were required to assess undocumented development issues



Common Themes Discovered Only By Interview Process

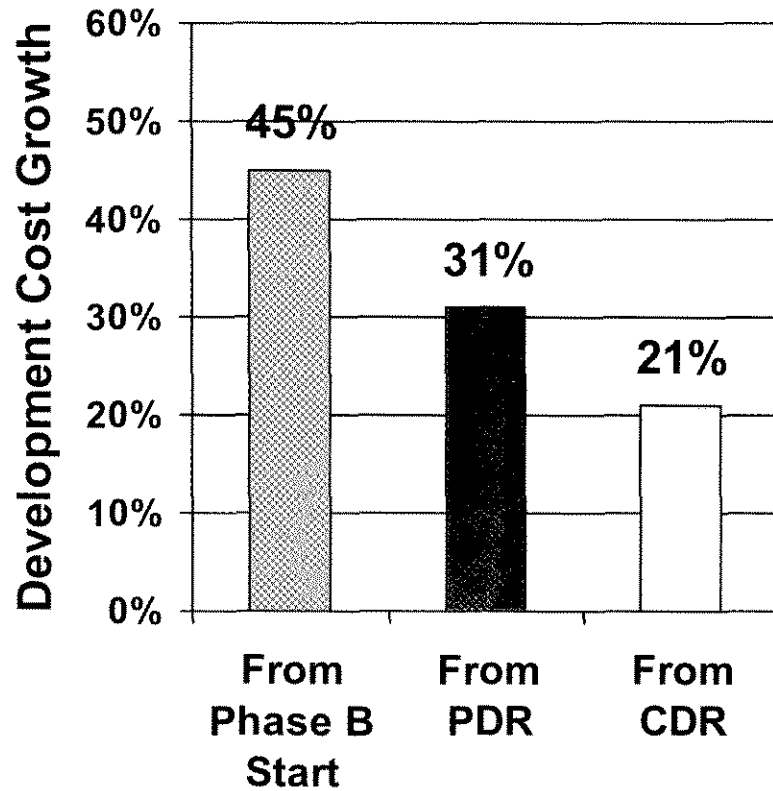
- Optimism in Initial Proposed Design & Scope
 - *Underscoping of effort*
 - *Expectations of subcontractor*
 - *Pressure from HQ or Center to reduce cost for Directed missions*
- Overselection of Competed Instruments on Directed Missions
 - *Competitive Instrument AO process led to instruments being selected that:*
 - Were outside the technical constraints, or
 - Had very little chance of meeting technical constraints, or
 - Had greater number of instruments than originally planned
- Organizational Issues
 - *Initial roles and responsibilities were not clearly defined and therefore expectations were different leading to discontent and mistrust among different organizations*

Interviews were invaluable in providing insight into undocumented issues in development

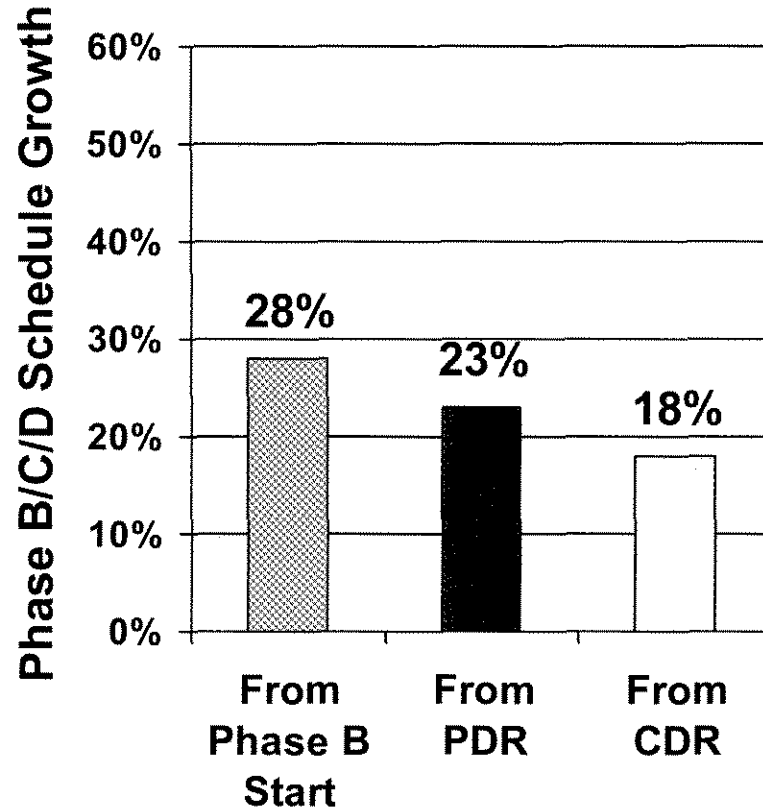


Cost Growth Summary – Combined 20 Mission Average

Development Cost Growth*



Schedule Growth

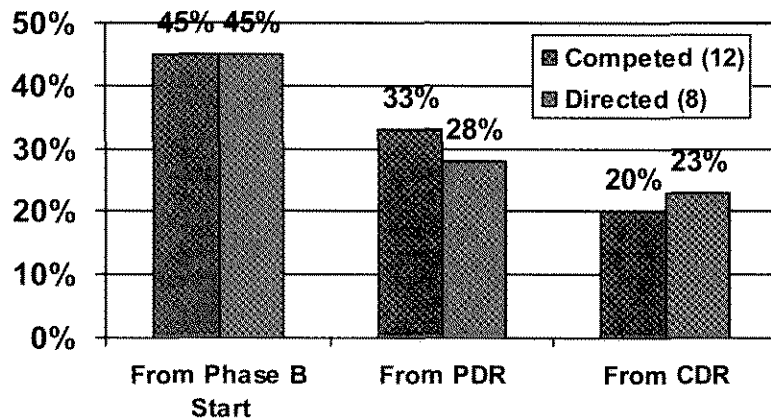


* Note: Development cost represents Phase B/C/D cost including reserves but not including launch vehicle cost

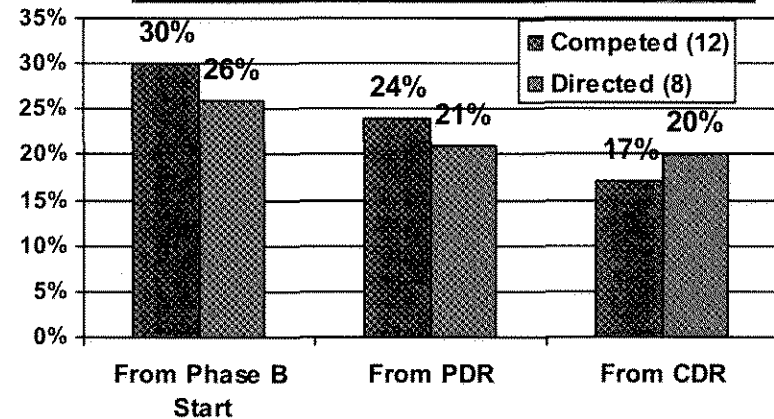


Comparison of Competed vs. Directed Missions

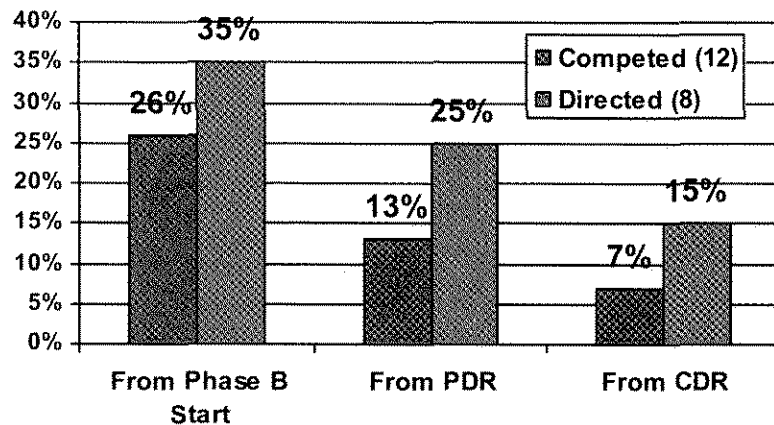
Development Cost Growth



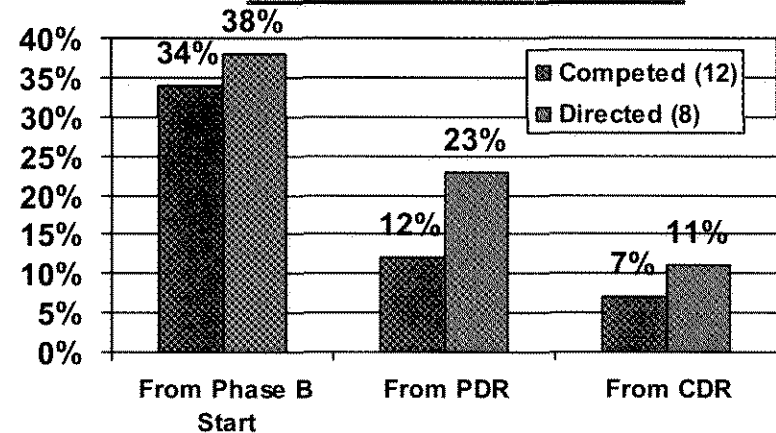
Development Schedule Growth



Spacecraft Dry Mass Growth



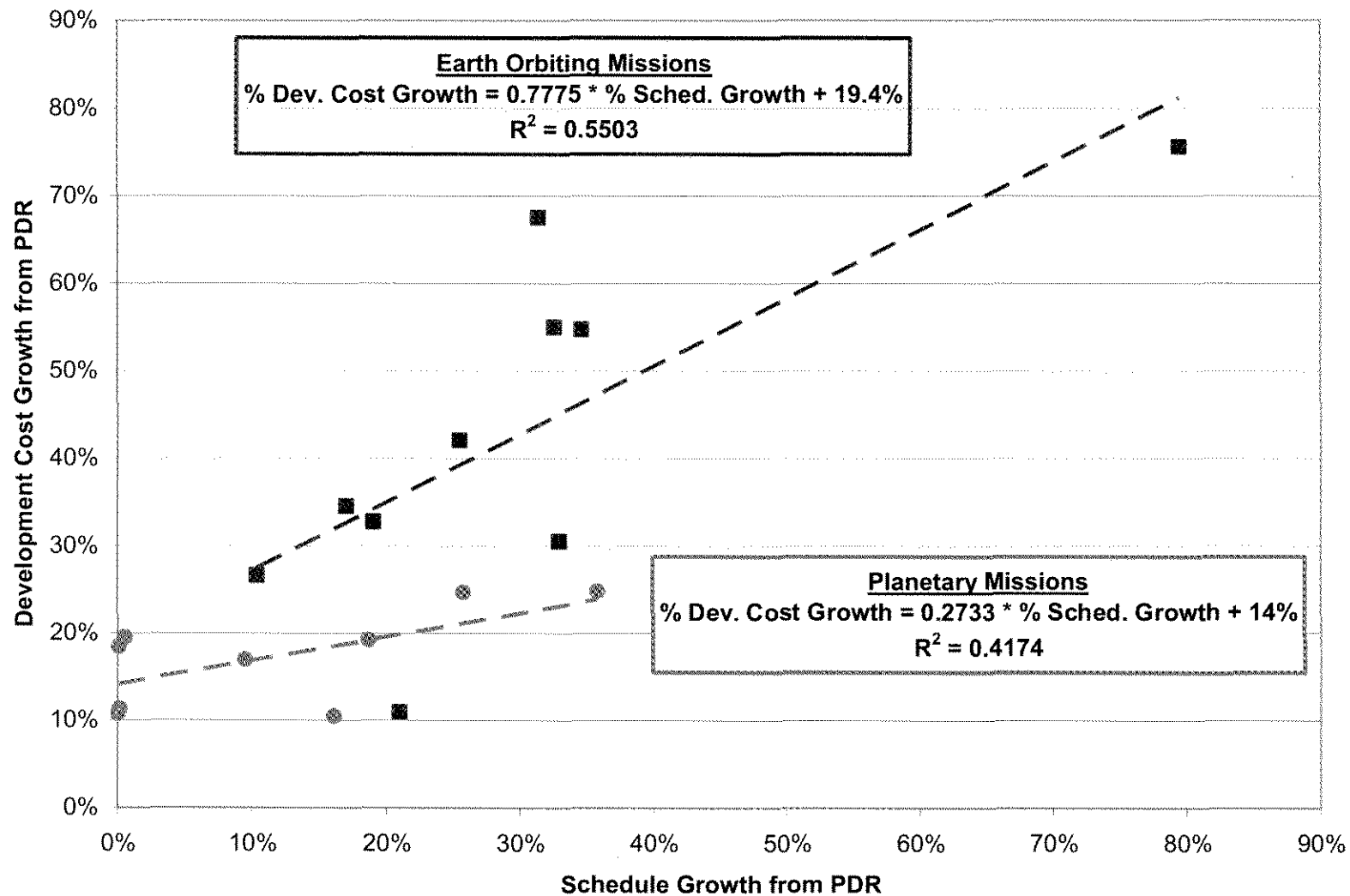
Payload Mass Growth



For Missions in study, Competed Missions have similar cost & schedule growth



Interrelationship of Cost & Schedule Growth

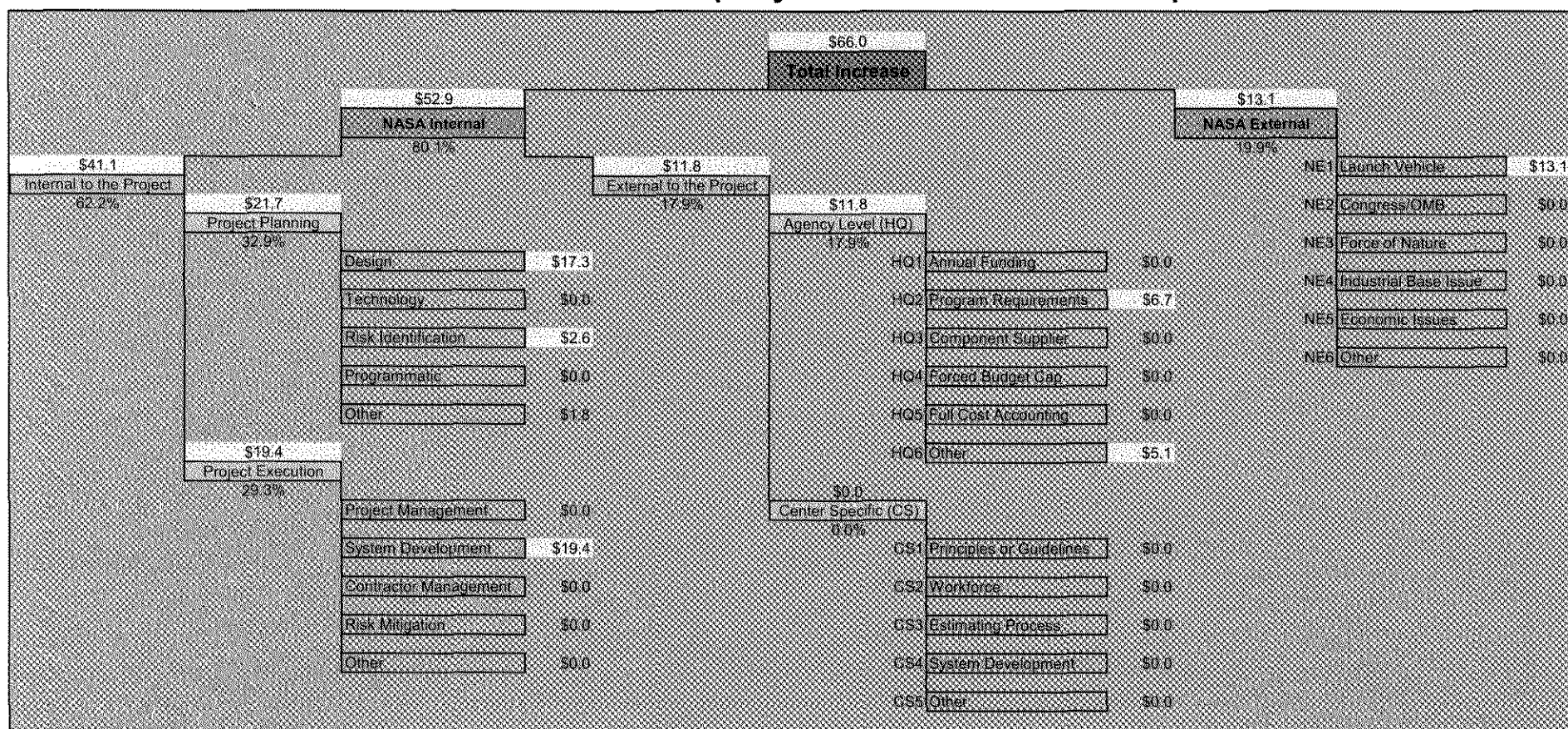


Cost will typically grows as Schedule grows



Explanation of Change (EoC) Categorization “Tree” Example

- Standard worksheet allows display/calculation of roll-up results



* Note: Increase above represents Phase B/C/D cost increase not including reserves



EoC Event List Example

- Events, quantification and rationale are documented in worksheet
- Events are allocated to different elements in EoC tree

Explanation of Change Categorization	Code	Value (\$)	Rationale
	Total	\$ 66.0	Should match total growth for Project
PP2-Project Planning-Design-Instrument	PP2	\$ 7.8	PABSI descope but cost increase because CPR and HVPS designs were underscoped - The CPR stru
PP1-Project Planning-Design-Spacecraft	PP1	\$ 7.4	SC bus design change - Changes include shortening of the bus to fit in DPAF envelop and change to acc
PP5-Project Planning-Programmatic	PP5	\$ 2.6	Underscoping of mission assurance and SE effort
PP7-Project Planning-Other	PP7	\$ 1.8	Mission design change to formation fly with EOS-Aqua requiring additional reviews and change in MSRD
HQ2-External to the Project-Agency Level (HQ)-Program Requirements	HQ6	\$ 5.1	March 2003 to April 2004 launch delay due to adding Calipso co-manifest - estimated as proposed cost
PE4-Project Execution-System Development-Instrument	PE4	\$ 9.2	CPR delivery delay slowing down the SC team and leading to bath tub periods - I&T problems such as th
PE3-Project Execution-System Development-Spacecraft	PE3	\$ 5.7	Typical development issues associated with spacecraft development
PE6-Project Execution-System Development-Ground Systems	PE6	\$ 3.2	Typical development growth
PE4-Project Execution-System Development-Instrument	PE4	\$ 1.2	PM/SE/MA Growth allocated to difficulties with instrument development
PP2-Project Planning-Design-Instrument	PP2	\$ 2.1	CPR transmitter being picked up by JPL since CSA could not make it with their proposed budget
HQ2-External to the Project-Agency Level (HQ)-Program Requirements	HQ2	\$ 4.0	Additional requirements imposed to project (ex..., 7120.x and 7119.x), additional reviews, ITAR
HQ2-External to the Project-Agency Level (HQ)-Program Requirements	HQ2	\$ 2.7	Launch slip from April 2005 to June 2005 due to readiness of CALIPSO and also NOAA's N launch delay
None			
NE1-NASA External-Launch Vehicle	NE1	\$ 1.4	Instrument cost due to 11 month LV delay
NE1-NASA External-Launch Vehicle	NE1	\$ 5.2	Spacecraft cost due to 11 month LV delay
NE1-NASA External-Launch Vehicle	NE1	\$ 2.8	PM/SE/MA cost due to 11 month LV delay
NE1-NASA External-Launch Vehicle	NE1	\$ 3.8	GDS/MOS/Science cost due to 11 month LV delay

* Note: Increase above represents Phase B/C/D cost not including reserves



Summary of Findings: Allocated Cost Increase for New Missions

- Growth Internal to the Project due to Execution (39%)
 - *Both spacecraft and instrument issues occurred*
 - *Difficulty in objectively assigning instrument vs. spacecraft may not show true impact*
- Growth Internal to the Project due to Planning (34%)
 - *Initial optimism seems to have played a large part*
 - *Typically allocated prior to establishing “realistic” programmatic baseline*
- Growth External to the Project (22%)
 - *Primary issues were additional HQ or program requirements like NIAT*
- Growth External to NASA (5%)
 - *Primarily Industrial base issues like LV delays*



Initial Data Set Can Be Used to Develop Reserve Level Sanity Check

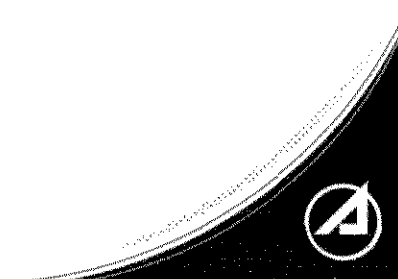
- Based on cost increases from each broad category, a “required reserve” percentage can be calculated to determine the additional cost required to cover increase experienced
- These initial observations, however, are based on this small set of 20 NASA Science missions and may change significantly if Human Flight or larger scale missions are added
- These observations can also provide a focus area for either reducing perceived cost growth or reducing the cost of missions as a whole
 - *Current approach suggests adding appropriate buffer to cover natural design evolution and typical challenges to reduce perceived cost growth*
 - *Greater emphasis on more robust initial estimates (i.e. JCL) may reduce the “collateral damage” cost by fitting more clearly within initial budget caps*



Agenda

- Study Overview
 - *Task Overview*
- Progress
 - *Case Studies*
 - *Interviews*
- Pre-Interview Results Summary
 - *Cost & Schedule Growth*
 - *EoC Categorization Example/Summary*

➔ • Next Steps



Potential Science Mission Selections for Phase III

Mission List

<u>Number</u>	<u>Round</u>	<u>Missions</u>	<u>Center</u>	<u>Theme</u>
21	3	Cassini	JPL	Planetary
22	3	Chandra	Other	Astro
23	3	GALEX	JPL	Astro
24	3	RHESSI	GSFC	Astro
25	3	EO-1	GSFC	Earth
26	3	Landsat-7	GSFC	Earth
27	3	TRMM	GSFC	Earth
28	3	WISE	JPL	Astro
29	3	SDO	GSFC	Helio
30	3	TIMED	APL	Helio
31	3	NEAR	APL	Planetary
32	3	THEMIS	Other	Helio
33	3	Stardust	JPL	Planetary

Distribution

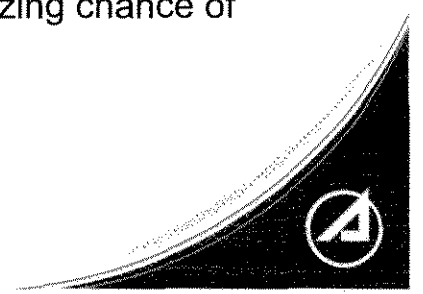
<u>Center</u>	<u>Count</u>	<u>Distribution</u>
JPL	14	42%
GSFC	12	36%
APL	4	12%
Other	3	9%
Total	33	

<u>Theme</u>	<u>Count</u>	<u>Distribution</u>
Earth	7	21%
Planetary	12	36%
Astro	8	24%
Helio	6	18%
Total	33	



Example of Recommendations – Potential Changes to AO Selection Process

- To remove potential optimism in initial proposal submittal, behavior must be changed
 - *Incentive to maximize science irrespective of cost risk must be removed*
- Example of Acquisition Policy Change
 - *Current: Choose maximum science at similar perceived cost*
 - Assuming all proposed cost are at cap and not unachievable (i.e. not high cost risk), pick the proposal that has the greatest science value
 - Example: Kepler & Dawn selection
 - Requires more robust estimating to anticipate growth to minimize threat of breach
 - *Potential Change: Choose lowest cost risk for equal science*
 - Once Step 1 downselect occurs, all science deemed Category 1 and considered equal, allowing the proposal with the lowest cost risk to be selected
 - Example: GRAIL selection premise
 - Requires “advertising” in AO solicitation combined with repeated demonstration by selections providing message to community that change is permanent and real
 - Should increase chance of mission staying within cost cap thereby minimizing chance of collateral damage



Summary

- Mission data collected for twenty NASA missions
 - *Detailed data collected and referenced*
 - *Data summarized and assessed*
- Interviews conducted and were found to be extremely valuable
- Results of 20 Mission Explanation of Change (EoC) categorization
 - *5% External to NASA*
 - *22% External to the Project*
 - *34% Relative to Project Planning*
 - *39% Relative to Project Execution*
- Next steps
 - *Additional NASA science missions plus pursuing ISS elements*
 - *Formulating recommendations based on interviews and supporting data*
 - *Final mission results & recommendations presented October 2010*

