



# **A Status Report on NASA Cost Analysis Including Improvements Under Development**

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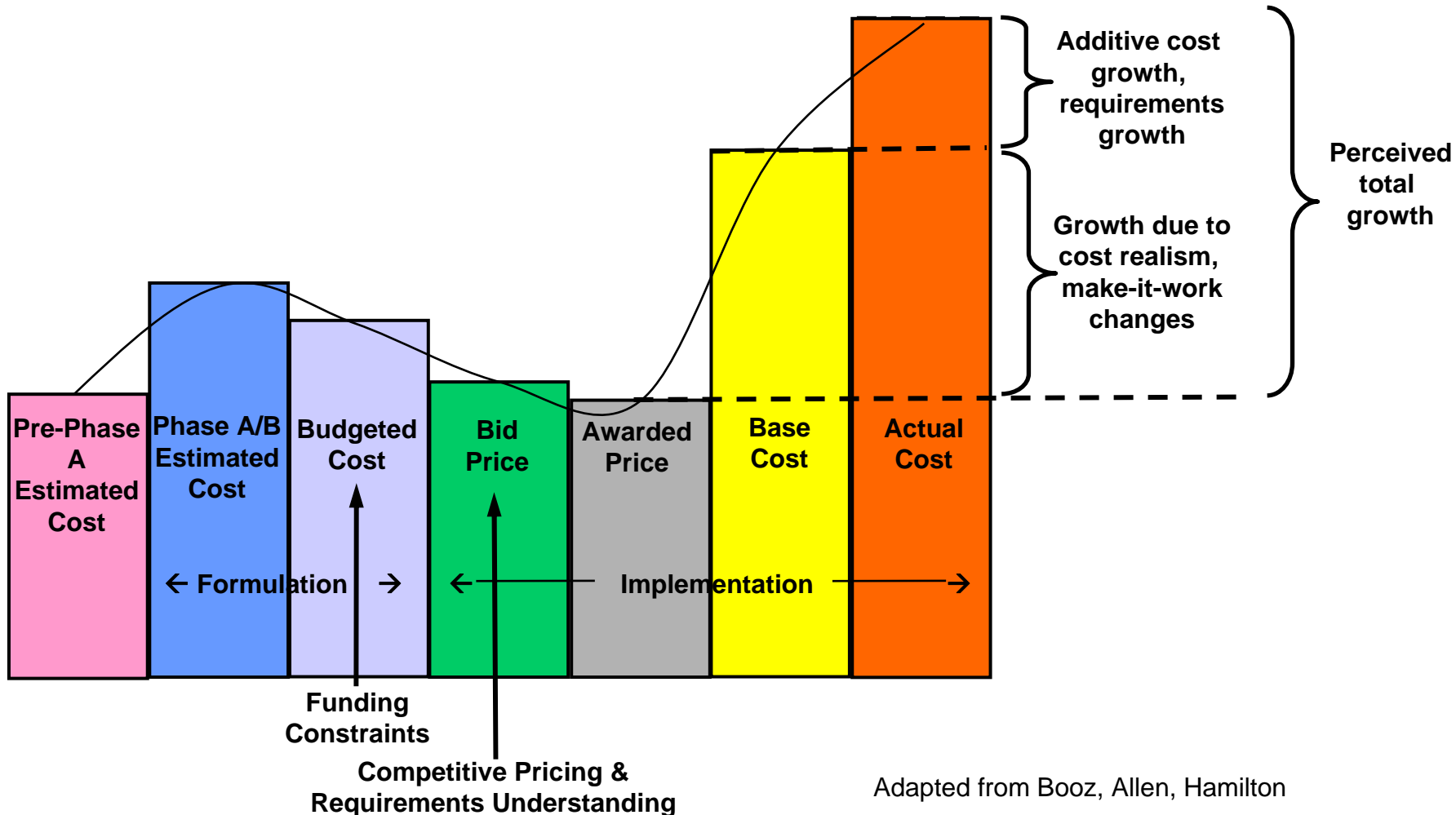
# Outline of Briefing

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- Introduction/Background
- Status of NASA Cost Analysis
- Cost Analysis Improvements In Work

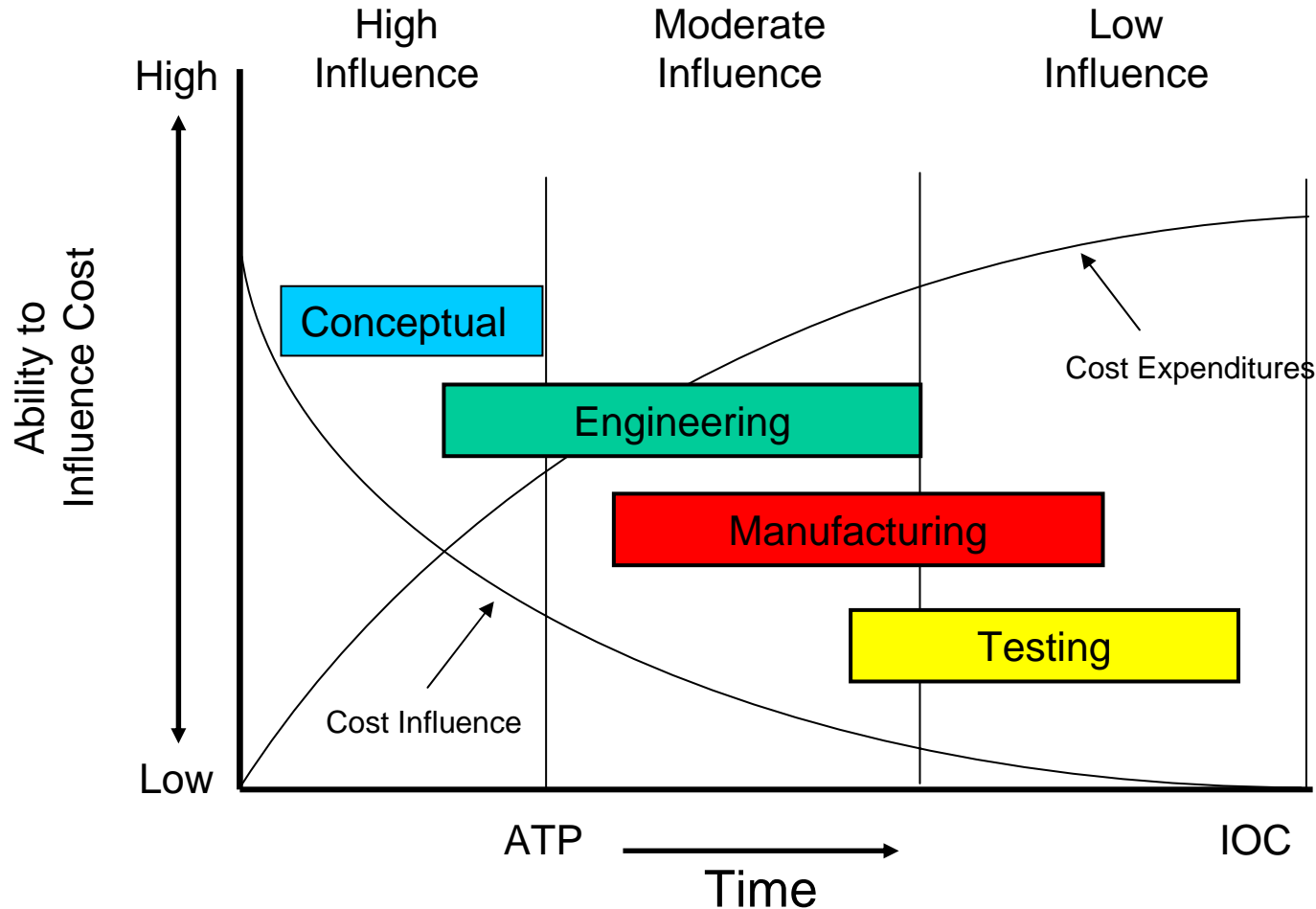


# Typical Project Cost Trajectory Over Time





# Cost Analysis Leverage Over the Project Life Cycle



**Most cost leverage exists prior to ATP**



# Cost Issues Over the Life Cycle

## Pre-Formulation

- Variable and poorly defined requirements
- Project content not fully captured and reflected in cost estimate (e.g. ground systems, software, etc)
- Optimism in TRL projections
- Over optimism in hardware/software reuse
- Going external with cost too early

## Formulation

- Inadequate reserves; lack of cost/schedule risk knowledge
- Untenable schedules
- Overconfidence in team capabilities
- Oversubscription to management reforms
- Tendency to accept contractor buy-in
- Lack of independent validation of costs/schedules

## Implementation

- Basic requirements changes
- Make-it-work changes
- Inadequate risk mitigation
- Integration and test difficulties
- Reluctance to reduce headcounts after peak
- Inadequate insight/oversight
- Poor use of EVM and schedule analysis as early warning
- Funding instability and stretch outs
- De-scoping science and/or operability features to reduce nonrecurring cost



***Cost growth is a consequence of decisions across the life cycle.***



# Status of NASA Cost Analysis



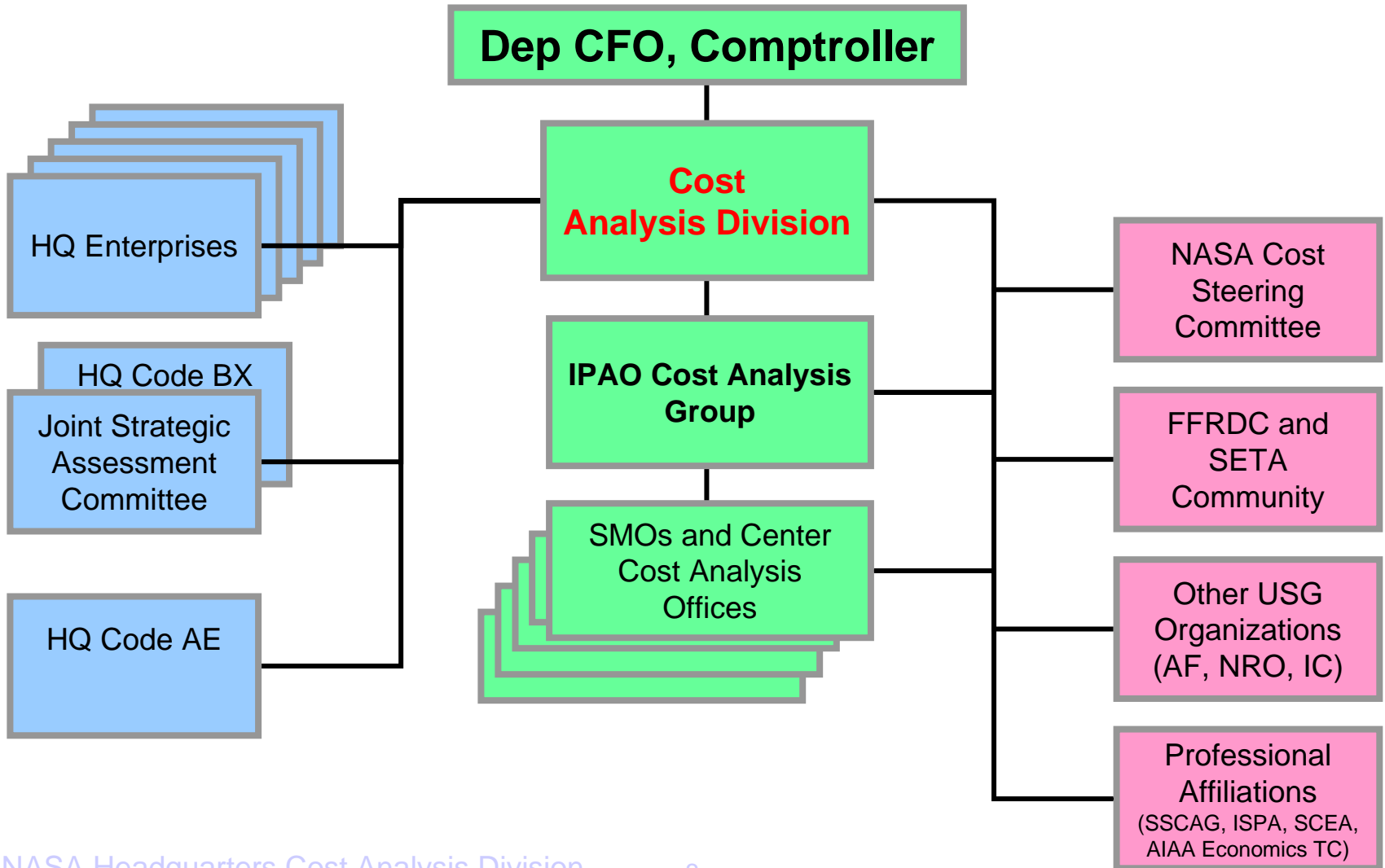
# Cost Credibility

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- **NASA history replete with cost and schedule growth problems**
- **Problems continue**
  - Project cancellations due to cost and performance issues
  - Programs re-planned due to cost and schedule growth
  - Project with significant “sticker price” increases during formulation
- **Basic requirements for improvements**
  - Receptive management culture
  - Independent cross checks
    - System Management Offices (SMOs), Independent Program Assessment Office (IPAO), HQ Cost Analysis Division (Code BC), HQ Independent Program Assessment (Code AE DIPA)
  - Known and certain consequences for overruns
  - Improvements in people, tools and processes



# NASA Cost Analysis Organizations and Interfaces





# Agency Cost Estimator Headcounts\*

Center	Civil Service	Support Contractor	Total Count
ARC	3	1	4
DFRC	1	0	1
GRC	7	1	8
GSFC	10	8	18
JPL	11	3	14
JSC	18	3	21
KSC	5	0	5
LaRC	4	2	6
MSFC	8	8	16
SSC	1	0	1
IPAO	3	0	3
HQ BC	3	0	3
HQ ENTERPRISES	2	0	2
<b>Total</b>	<b>76</b>	<b>26</b>	<b>102</b>

**Significant increase in cost analysis headcount in last year**

- Increase of 22 heads
- 28% increase
- 3/4 civil service, 1/4 contractor
- Recruitment continues

## **Development**

- Career Development Plan in draft
- Training programs being utilized
- Certification being encouraged
- Mentoring being encouraged
- Cost Estimating Handbook Version 2 in draft

\* Current as of April 2003



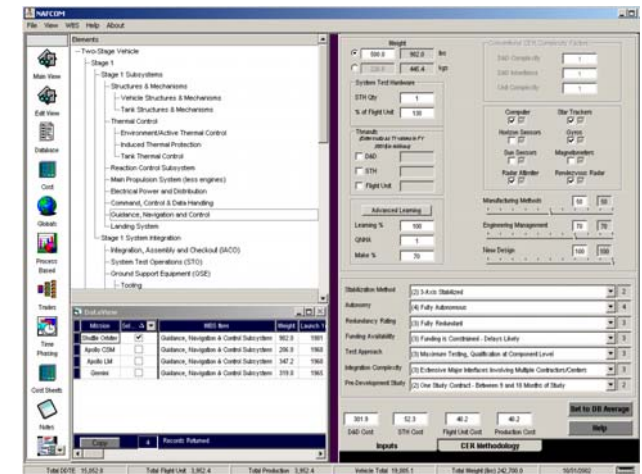
# Cost Analysis Tools Are Continuing to Improve

NASA Developed

REDSTAR Data Base

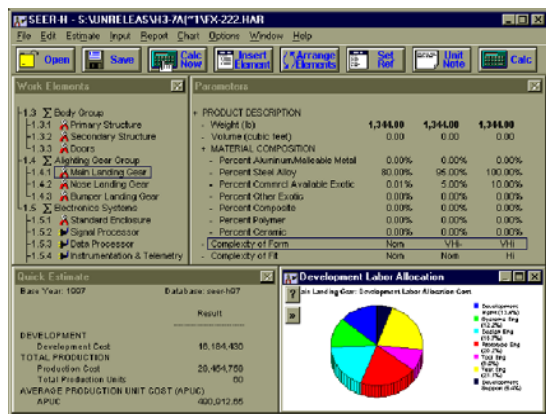


NAFCOM Cost Model

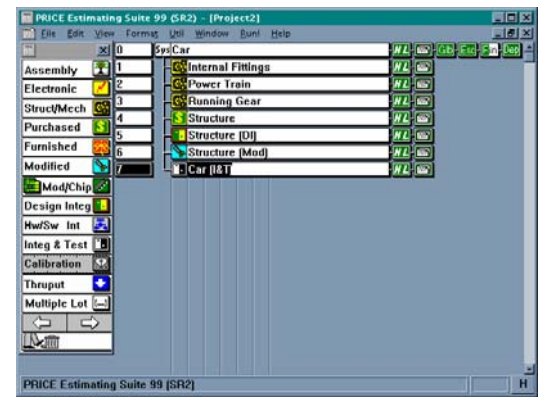


COTS Cost Tools

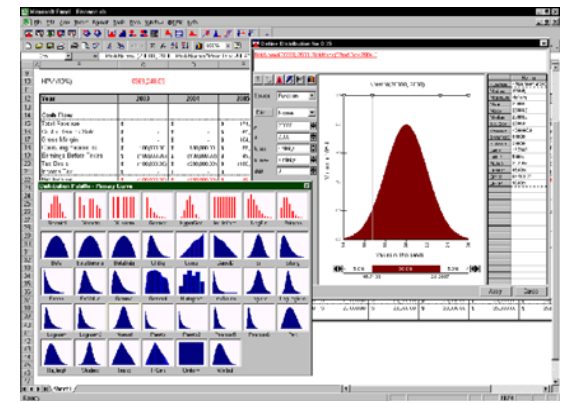
SEER Model



PRICE Model



@Risk





# Summary of Status of Agency Cost Analysis

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- **We largely understand, from numerous past studies, why we have cost, schedule and performance problems**
- **We know the basic requirements necessary for improvement**
- **Agency cost estimating personnel, while allowed to atrophy in the 1990s, are being revitalized**
  - Organizational elements are in place at Centers, IPAO and HQ
- **Agency cost estimating tools, while continuously being improved, are generally up to the job**
  - Models and methods are continually re-calibrated to latest completed projects
  - Published first NASA Cost Estimating Handbook last year
    - Rev B in work
- **Cost estimating process, in tandem with overall revision of Agency independent evaluation process, can be adjusted for improved results**

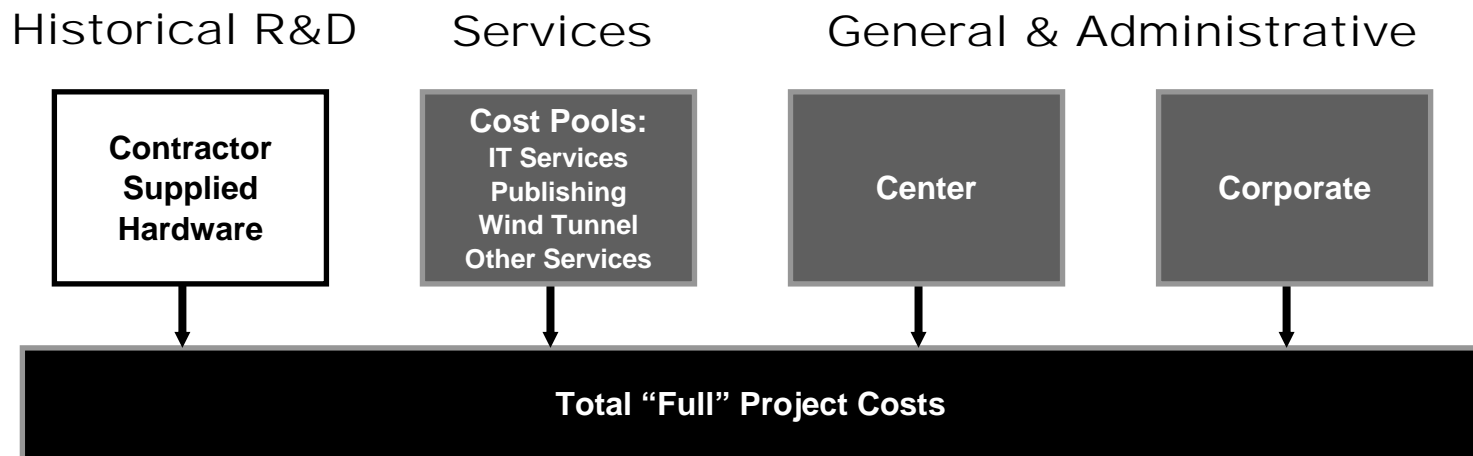


# Cost Analysis Improvements



# Full Cost Budgeting and Management

- Historically, NASA cost analysts have focused on presenting “R&D cost”
  - Including only “taxes” on civil service labor
  - Generally excluding civil service labor and overhead
  - Often excluding full cost of other Agency goods and services
- While total NASA budget neutral, “full cost” will increase the “sticker price” of programs/projects
- Cost estimating models and data bases are being updated to estimate the total “full” project costs





# Cost Analysis Requirements Document (CARD)

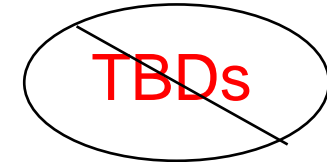
## *System:*

- Mission
- System Description
- Technical Description
- Work Breakdown Structure
- Hardware Description
- Software Description
- Interfaces
- Test and Integration
- TRLs and heritage

- Pre-CARD late Phase A
- Tailor after streamlined NRO “CARD” process
  - Use data sheet templates
  - Estimators attend TIMs + use interviews to draft sheets
- “CARD” jointly reviewed by project and cost analysts—signed by PM

## *Management:*

- Management Plan
- Acquisition Plan
- Schedule
- Safety
- Risk
- Staff
- Contract Type
- Security
- “-illities”



- **No TBDs allowed**
- **Ranges OK (treated as random variables in cost risk analysis)**

## *Operations:*

- Facilities
- Activity Rate
- Level of Effort
- Training
- Maintenance
- GFE



# Cost Risk Analysis

## Risk Areas

**Safety**

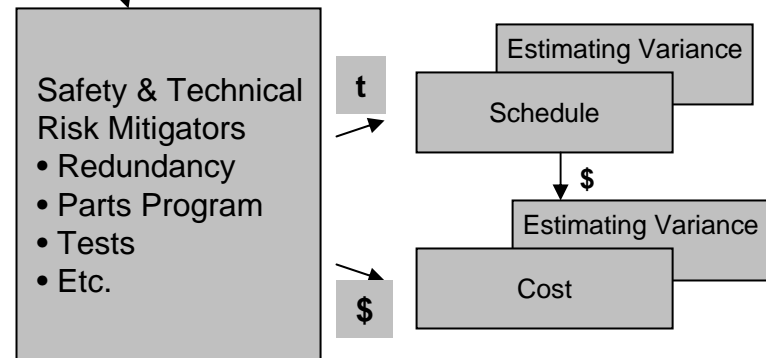
**Technical/Performance/  
Engineering**

**Schedule**

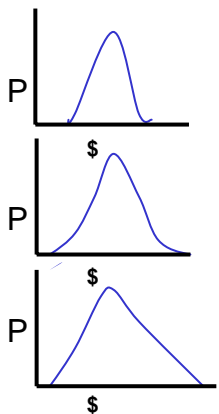
**Cost**

PRA

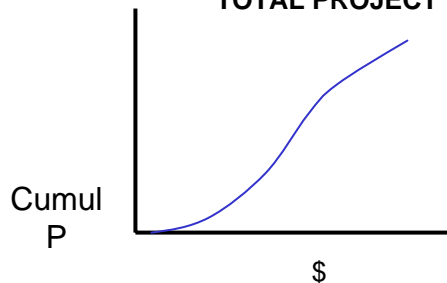
## “Dollarizing” Risks



## WBS Elements



## TOTAL PROJECT



Lows via modeling optimistic assumptions  
 Highs via modeling pessimistic assumptions

- **All cost estimates are really probability distributions**
  - Variance narrows as project life cycle proceeds
- **Sources of uncertainty**
  - Uncertainties in project definition (“known unknowns”)
  - Cost model statistical variance
- **Cost risk analysis quantifies budget reserves necessary for acceptable level of confidence**



# Cost Risk Analysis

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- **Specify use of probabilistic cost risk analysis to quantify uncertainties in cost estimates**
  - Address uncertainties in technical design (especially in Phase A/B)
  - Address uncertainties in cost estimating methods (e.g. statistical variance in CERs)
  - Provide decision makers range of cost outcomes as a function of confidence levels
    - Use for reserve determinations
- **Analysis process forces the consideration of cost risks**
  - Enhances underestimating complexity of system development
  - Attaches valuation to risk reduction activities/risk mitigation plans
  - Integrates cost analysis and Probabilistic Risk Analysis
- **Generally Code BC will recommend budgeting at 70% to 85% confidence levels**
  - Depending upon project scope, importance, sense of completeness of risk analysis
- **Risk dollars phased where likely be needed**
  - Problems manifest between PDR and CDR and then again during I&T
  - High leverage risk mitigation is prior to PDR



# Cost As An Independent Variable

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- **Specify use of CAIV where appropriate in systems engineering process to define the trade space for missions in Phase A/B**
- **CAIV seeks to make cost an active part of the design process as opposed to a result of the design process**
  - Can design to some set of acquisition cost goals
  - Can design to some set of operational cost goals
  - Can design to some set of life-cycle cost goals
- **Integrate CAIV into concurrent engineering environments as a principal cost engineering/systems engineering function**
- **More extensive NASA CAIV process instruction in development by IPAQ (leveraging off DoD successes)**



# Cost Reporting External to Agency

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- **All costs routinely reported in full cost, real year dollars**
- **All WBS items routinely costed (no TBDs)**
- **One reconciled set of numbers go out of Agency**
  - Project, Enterprise and Code BC reconciliation generally occurs prior to PMC briefings
  - Costs include reserves consistent with cost risk analysis
  - “Cost Readiness Level” scale under development
- **Congressional requirement for LCC at end of Phase A for projects >\$250M LCC\* threshold**
  - Communicated as range estimate
- **OMB budget lead time is typically ~ 2 years prior to PDR/NAR commitment estimate**
  - At end of Phase A provide OMB with firm first year of Phase C/D
  - Out years remain ranges until PDR/NAR commitment estimate

\*Proposed to Congress; currently \$150M threshold





# Summary of Recommended Cost Analysis Improvements

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- **Phase A**

- All cost estimates done in full cost
- Preliminary CARD in late Phase A
  - All WBS items costed (no TBDs)
- Preliminary Code BC/IPAO ICE at end of Phase A for projects with expected LCC > \$250M
  - Required Congressional LCC clearly communicated as preliminary, subject to change
  - OMB provided first year of implementation funding; out years as ranges
  - Label estimates with “Cost Readiness Levels”
  - Probabilistic cost/schedule risk range across multiple configurations/design solutions

- **Phase B**

- Full CARD in late Phase B (modeled after IC CAIG streamlined ICBD)
  - Initial version by Pre-NAR, matured at major milestones (NAR, PDR)
  - Cost organizations assist in developing CARD but owned and signed by PM
- Code BC/IPAO ICE based on increasing detail (eventually major assembly, component level)
- Probabilistic cost/schedule risk analysis (tied to PRA identified risks) plus programmatic and management risks
- Use of CAIV in systems engineering process
- Field Center, Enterprise and Code BC reconcile to one probabilistic estimate for PMC

- **Phase C/D**

- Estimates of major engineering changes (in cooperation with EVM community)
- Estimates if project re-baselines
- Improved processes for capturing cost analysis knowledge for future cost models
  - Via EVM and IFM
  - Possible new data collection instrument using DOD CCDR system



# Next Steps

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- **Continue cost staffing ramp up at HQ and Centers**
- **Continue revision of cost models for full cost**
  - Training in full cost
- **Continue development of cost risk analysis capabilities**
  - Training in cost risk analysis
- **Continue development CARD template/process**
  - Training in CARDS
- **Apply CAIV where appropriate (OSP)**
- **Jump start implementation of improvements on high profile projects (OSP, JWST, Prometheus, etc.)**
  - Full cost, cost risk analysis, CARDS, CAIV in work for these projects
- **Continue development of 7120.5C to codify improvements**
- **Continue development Rev B of NASA Cost Estimating Handbook**



# Inflation Indices

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- **NASA cost estimating community has historically used the “NASA New Start Index” for**
  - Adjusting historical cost to “today’s dollars” for data base purposes
  - Including inflation in future estimates to reflect “real year dollars”
    - Incidentally, economists use the terms
      - “Real” to mean without inflation (“real interest rate” is a rate net of inflation)
      - “Current” to mean with inflation (“current” to the year in which the dollars are phased)
  - The NASA New Start Index is based on a weighted average of DRI indexes
    - Currently maintained by IPAIO (and SAIC)
- **NASA budget community has (sometimes) used the OMB index to include inflation in future estimates**
  - The OMB index is OMB’s projection of future inflation (P.E.)
- **Recent agreement between Code B and OMB calls for**
  - NASA will use DRI index for adjusting historical actuals
  - NASA will use OMB index for “out year” adjustments of estimates/budgets for “real year dollars”
- **Action to IPAIO to construct index reflecting above agreement**
- **Steve Isakowitz to sign memo reflecting above understanding**