Why Can't We All Just Get Along?

Lessons In Reconciling Cost Estimates

Neal D. Hulkower, Ph.D.
Vice President, Operations
nhulkower@mcri.com
(703) 584 7001

Lawrence Wolfarth
lwolfarth@mcri.com
(571) 216 2224

Affidavit of Prejudice

The authors are veterans of many Independent Cost Estimates (ICEs) and Very Few Program Office Estimates (POEs) by Choice!

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Outline

- "Reconcile"
- A Brief History of Cost Reconciliation
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"Reconcile"

Main Entry: **rec·on·cile**
Pronunciation: 're-k&n-"sI(-&)l
Function: *verb*
Inflected Form(s): **-ciled; -cil·ing**
Etymology: Middle English, from Anglo-French or Latin; Anglo-French *reconciler,* from Latin *reconciliare,* from *re-* + *conciliare* to conciliate
transitive verb
1 a : to restore to friendship or harmony <*reconciled* the factions> **b : SETTLE, RESOLVE** <*reconcile* differences>
2 : to make consistent or congruous <*reconcile* an ideal with reality>
3 : to cause to submit to or accept something unpleasant <was *reconciled* to hardship>
4 a : to check (a financial account) against another for accuracy
b : to account for
intransitive verb **: to become** reconciled

Source: Merriam-Webster's Online Dictionary, 10th Edition

A Brief History of Cost Reconciliation: In The Beginning…

- ..... there was only one estimate…
  - Generated by managing engineers, sometimes with the help of those who would do the work
  - Examples: John Roebling & Brooklyn Bridge, Steve Bechtel & Hoover Dam
- The results were generally good:
  - Quick
  - Responsive
  - Generated by the those who would have to live with the costs
  - Provided a basis for financing…and assigning blame if costs rose
- But they were not perfect:
  - Only as good as the estimators' experience…and sometimes made bad by their personal biases
  - Inconsistent across projects
  - Frequently incomplete
  - Reflective of the risk aversion of entrepreneurs in search of funds

A Brief History of Cost Reconciliation: Later On…

- **Seeing this, the bill payers said,**

Let the project office create a "formal" estimate.

- **"Formal" = "procedural", more inclusive, involving more departments and more experts…**
- **And the results were better:**
  - **More documentation for the financers & oversight groups**
  - **Easier to identify biases, missing costs**
- **But still not perfect:**
  - **Still success driven (still biased)**
  - **Always precisely wrong at the end…and sometimes way wrong early on**

A Brief History of Cost Reconciliation: Still Later…

- **So the bill payers said,**

Let there be a second, independent estimate.

- **"Independent" = "unbiased"***
- **And the results were more → twice as many estimates**
- **But not always better: What happens when the two estimates disagree?**

*** In fact, a different set of biases**

A Brief History of Cost Reconciliation: Today

- **So, finally, the bill payers said,**

Let the two estimates be reconciled.

- **And the results were better still:**
  - **Arithmetic errors were identified and fixed**
  - **Sometimes the totals of the two estimates equal each other (within some error bounds)**
- **Except for two small problems:**
  - **The estimates typically never agree completely below the top line**
  - **Neither estimate is ever exactly right**

Why Do We Reconcile Cost Estimates?

- **Reconciliation is necessary when there are:**
  - **Other estimates of the program**
  - **Changes in the technical and programmatic inputs during the course of the estimating process**
- **For Independent Cost Estimates (ICEs), reconciliation with the Program Office Estimate (POE) is typically needed**
- **Reconciliation is not "target practice"**
  - **Goal is not replication**
  - **May need to agree to disagree about risks, ground rules, assumptions**

Why We Should Expect Problems (Philosophical)

- **Cost estimation deals with forecasting, not foretelling; hence any cost estimate is always exactly wrong**
- **A cost estimate is not "real;" you cannot observe an estimated cost in the real world**
- **The cost estimator/analyst must build an estimate from the engineers' model of a yet unrealized program**
- **In other words, every cost estimate is a (*model*, estimate, *incomplete characterization*, copy) of a (model, *estimate*, incomplete characterization, *copy*) which is reminiscent of....**

Why We Should Expect Problems (Theoretical)

“‘Four’ is cloned from ‘Two’, and has the mentality of an overly-curious child. Unfortunately since he is a clone-of-a-clone, his IQ is considerably lower than that of his predecessors, since the personality defects are more pronounced when a clone is cloned (The analogy from the movie refers to how a copy of a copy may not be as 'sharp' as the original).”
http://en.wikipedia.org/wiki/Multiplicity_(film)

Why We Should Expect Problems (Practical)

- **Actors have different perceptions**
- **Motives of one's client vary sometimes even over the course of the reconciliation effort**
  - **Political pressure builds**
  - **Expected outcome replaced by feared one**
- **Stakeholders have conflicting and changing expectations about the process and outcome:**
  - **No collusion!**
  - **How can we use the best of the information to come up with a single number to budget to?**

What Are the Problems?

Here Are A Few

- **Different Motives**
- **Different Methodologies**
- **Time Lag**
- **Lingering Vagueness**
- **Different Ground Rules and Assumptions**

Different Motives

- **The POE generally reflects a success-oriented outlook and a plan the way the program office wants it to be. It may**
  - **Be in a buy-in mode**
  - **Uncritically accept contractor claims**
  - **Ignore history**

"Who are you going to believe, me or your own eyes?"...Chico Marx

- **The ICE generally**
  - **Tries to account for the worst that can happen**
  - **Comes from a nonadvocate, honest broker perspective and reflects lessons of multiple historical programs**
  - **May be required to ensure adequate funding to cover risks**
  - **May be perceived or actually intended to kill a program.**

Different Methodologies

- **POE**
  - **Parametric models calibrated to a particular environment**
  - **Engineering judgment**
  - **Contractor data and estimates**
  - **Vendor quotes**
  - **Bottom up**
  - **Extrapolation from Actuals**
- **ICE**
  - **Parametric models that produce estimates based on industry averages**
  - **Historical data**
  - **Industry trends**

Time Lag

- **ICE relies on compiled information representing a snapshot of the program at a given time**
  - **Technical Description (CARDs, Technical Specifications) documentation updated infrequently**
  - **Access to functional specialists limited**
- **POE benefits from close and continuous contact with engineers and program management and thus may lead the ICE by several months**
- **Each may be estimating a different program**

Lingering Vagueness

- **Requirements still volatile**
  - **Designs immature**
  - **Quantities undecided**
  - **Manufacturing readiness uncertain**
  - **Payloads in flux**
- **Potential players not all identified (both sponsors and contractors)**
- **Schedule**
  - **Actual need date**
  - **Availability of essential technology**
- **Program office and ICE Team may simply end up with different views**

Different Ground Rules and Assumptions

- **Perceptions of Uncertainty and Risk**
  - **Weight growth**
  - **Code growth**
  - **GFE**
  - **COTS**
  - **Heritage of hardware**
  - **Reliance on other programs**
- **Headcounts**
- **Inflation rates**

What Can We Do About It?

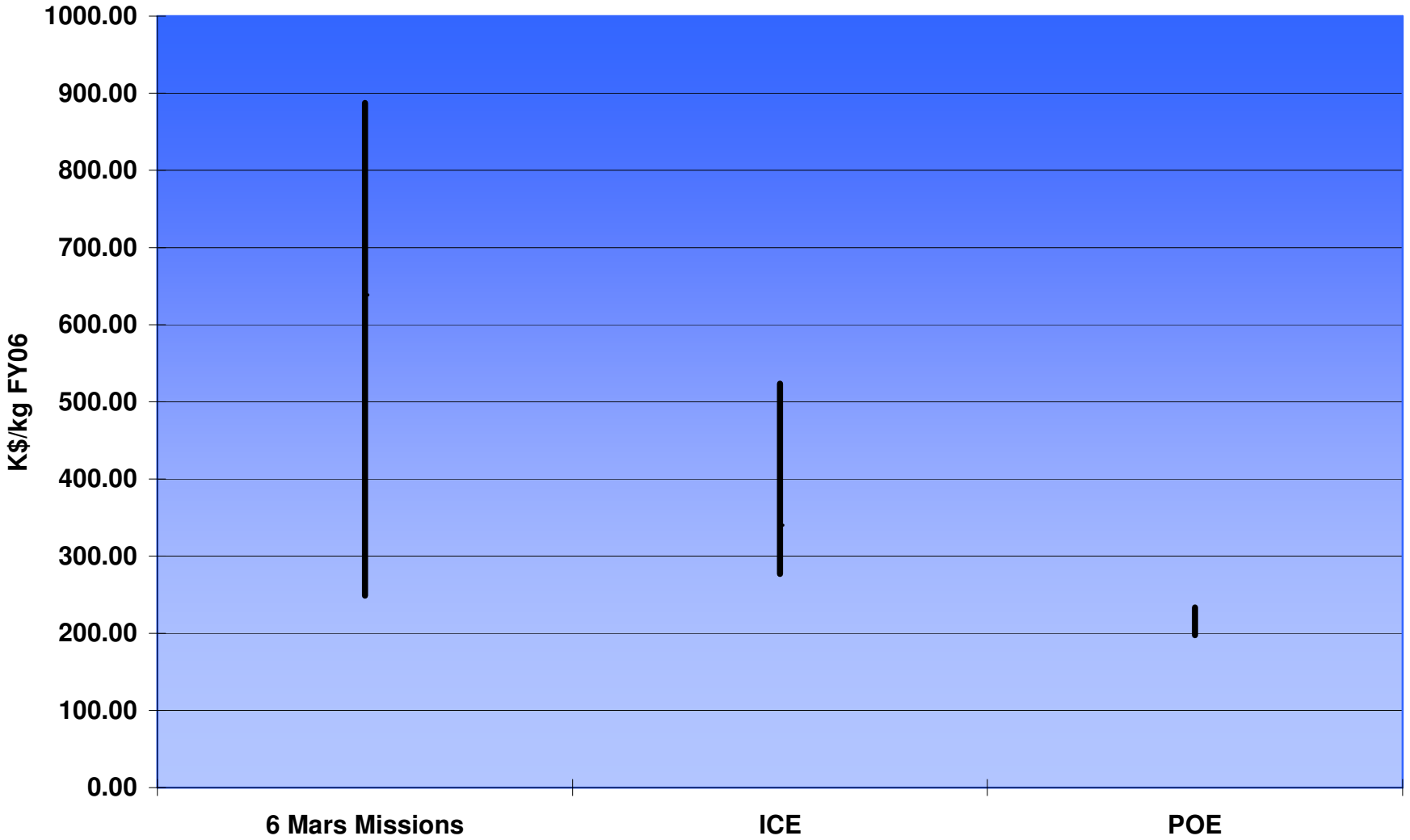
Sanity Checks

- Let history into the discussion
- Better, faster, cheaper: you can't get all three and are lucky to get just one
- The contractor community is not Lake Wobegon: they are not all above average
  - Neither are most program offices
- New ways of doing business generally aren't

"In an insane world, a sane man looks insane"
.....Ray Covert

Space Vehicle Comparisons: Cost per kilogram (FY06$)

DDT&E and First Unit for Space Vehicle Including Payload



Agree to Disagree

- **Since the only certainty is that neither the POE nor the ICE will be correct, humility on both sides is appropriate**
- **Choice of methodology is usually a matter of opinion**
  - **Can expect different results**
  - **Each will have a different error associated with the estimate**
- **Future trends of inflation, cost, technology, etc. are open to differing viewpoints**
- **Should NOT agree to disagree to avoid doing diligence, for example.....**

When Not to Agree to Disagree

- **Handling of program level item (system engineering, program management, integration and test)**
- **Objectively verifiable information**
  - **Mass and mass growth potential**
  - **Software size**
  - **Code reuse and growth potential**
  - **Demonstrated performance**
  - **Technology Readiness Level (TRL)**
- **Computational and algorithmic errors**
  - **"You are entitled to your own opinion but not to your own mathematics".....NDH**

"Your insistence does not relieve our requirement for due diligence"....Ray Covert

Tips for Presenting the Outcome of a Reconciliation

Highlight Differences in Ground Rules and Assumptions

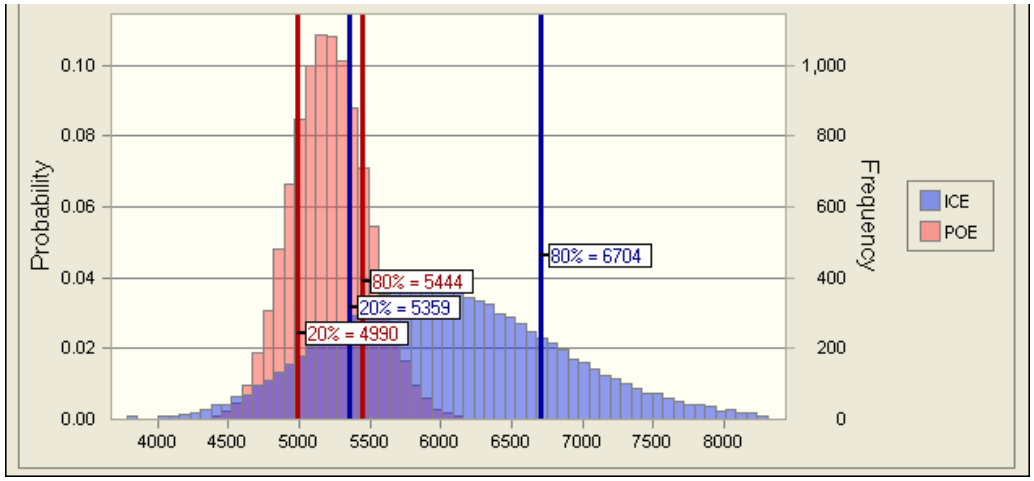
- **ICE**
  - Uncertainty is applied to all WBS elements
  - Estimates are presented in FY06$ through G&A but without fee
  - DoD Inflation factors are used to escalate cost
  - O&S estimated through 2030
  - Pessimistic assessment of potential code growth is a factor of 2.5
  - Most likely estimate of software assumes 20% code reuse
  - Most likely schedule estimate includes 6 month delay in delivery of Hemiflexer from The Twinkler program
  - COTS hardware and software will be upgraded every 3 years
- **POE**
  - Uncertainty is applied to all WBS elements except the payloads
  - Estimates are presented in FY03$ with fee
  - NASA inflation factors are used to escalate cost
  - O&S estimated through 2025
  - Pessimistic assessment of potential code growth is a factor of 1.5
  - Most likely estimate of software assumes 90% code reuse
  - Hemiflexer will be delivered from The Twinkler program 3 months before launch
  - COTS hardware and software will be updated every 5 years

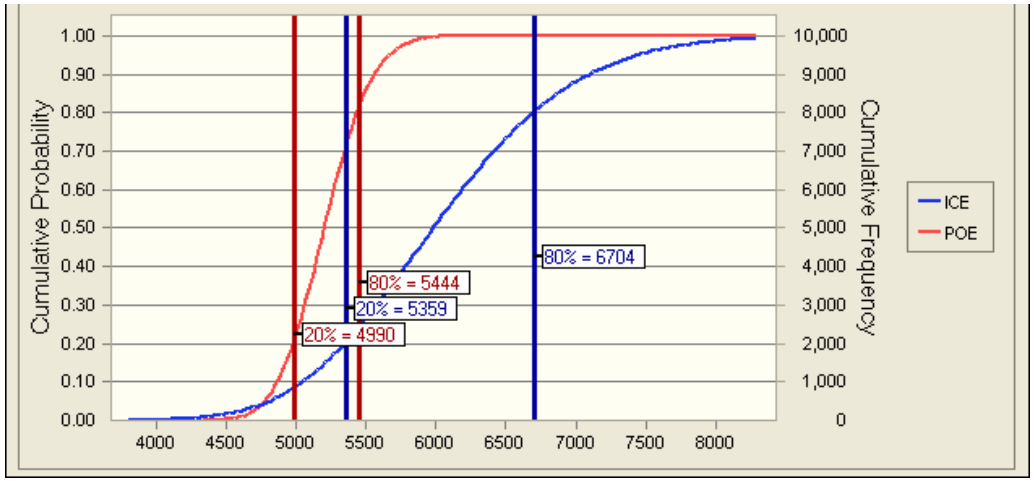
Compare Methodologies By WBS Elements at a Suitable Level

Level 2 Elements	ICE	POE
1.0 Program Management	Factor	Staffing by analogy
2.0 Systems Engineering	Factor	Staffing by analogy
3.0 Safety and Mission Assurance	Factor	Staffing by analogy
4.0 Science/Technology	Space Operations Cost Model (SOCM)	Staffing by analogy
5.0 Payload	NASA Instrument Cost Model	Extrapolation from Actuals
6.0 Spacecraft	Hardware: Top-level models such as AMCM and QuickCost; Analogy; Dollars per kg comparison; Software: Lines of code per staff month comparisons, Aerospace CERs	Hardware: NAFCOM or other subsystem level parametric models; Software: COCOMO II Early Design version
7.0 Mission Operations	SOCM; Software: COCOMO II Early Design version	Staffing by analogy
8.0 Launch Vehicle/Services	Look up tables, historical data adjusted as necessary	NASA Pricing Quotations
9.0 Ground Systems Development	Hardware: Ground Station Rules of Thumb; Software: COCOMO II Early Design version, Aerospace CERs	Hardware: Vendor Quotes; Software: Lines of code per staff month comparisons
10.0 System Integration Assembly & Test	Factor	Staffing by analogy
11.0 Education & Public Outreach	Factor	Analogy

"Creating Customer-Focused Success"

Compare Estimates

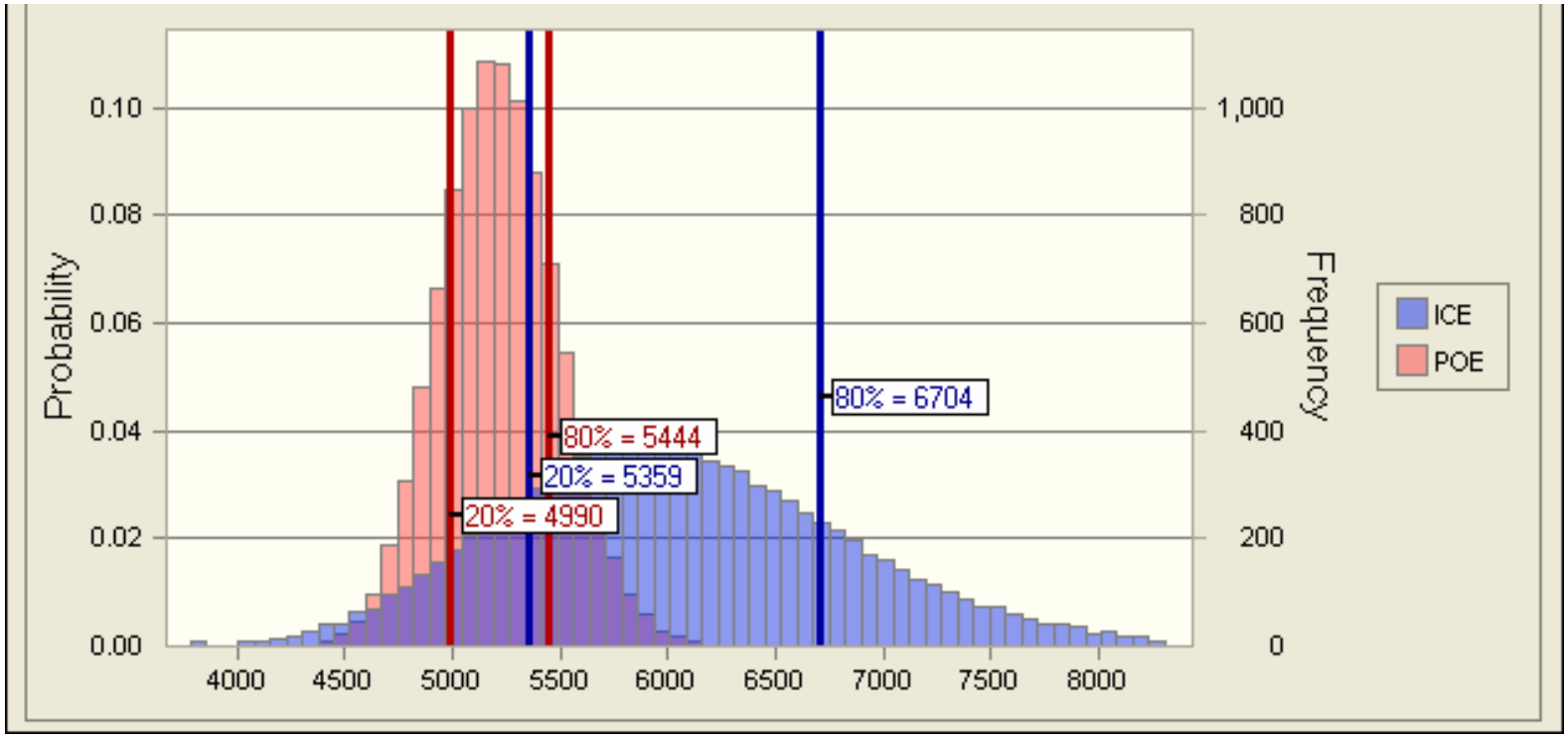




Statistic	ICE	POE
Trials	10,000	10,000
Mean	6052	5219
Median	5984	5212
Standard Deviation	806	270
Variance	649915	72884
Skewness	0.5213	0.1518
Kurtosis	3.42	3
Coeff. of Variability	0.1332	0.0517
Minimum	3934	4329
Maximum	10509	6285

Percentile	ICE	POE
10%	5,073	4,878
20%	5,359	4,990
30%	5,583	5,072
40%	5,780	5,144
50%	5,984	5,212
60%	6,187	5,281
70%	6,429	5,355
80%	6,705	5,444
90%	7,129	5,569

Compare Distributions



- **ICE entirely overlaps POE**
  - **POE mean (5,211) falls below the ICE 20th percentile**
  - **All scenarios in POE are in ICE**
  - **POE significantly understates the risk of total program cost overruns**

Compare Estimates at an Appropriate WBS Level

		POE				ICE				Delta (ICE-POE)	% Difference (ICE-POE)/ ICE
WBS	WBS	Mean	50th	80th	80/50	Mean	50th	80th	80/50	Means	Means
	Total	2,606	2,606	2,722	4%	3,030	2,989	3,377	12%	424	14%
1.1	System Level Segment	214	n/a	n/a		460	446	531	16%	247	54%
1.2	Space Segment	781	n/a	n/a		933	904	1,099	18%	151	16%
1.2.1	Space Segment SE/PM	140		155		67	58	91	36%	(73)	-109%
1.2.2	Space Segment AI&T	60	-	66		50	44	68	36%	(10)	-20%
1.2.3	Payload 1	172	168	198	15%	244	225	302	25%	73	30%
1.2.4	Payload 2	32	32	32	0%	32	32	32	0%	(0)	0%
1.2.5	Payload 3	36	36	40	9%	103	93	134	31%	67	65%
1.2.6	Payload 4	100	98	114	14%	129	120	163	26%	28	22%
1.2.7	Payload 5	31	31	35	11%	31	29	39	27%	0	0%
1.2.8	Spacecraft/Bus (including AGE and LOOS)	209	207	243	14%	278	268	329	19%	68	25%
1.3	Ground Segment	150	149	163	9%	244	239	272	12%	94	39%
1.3.1	Ground Segment SE/PM	23	23	25	9%	49	45	63	29%	26	52%
1.3.2	Ground Segment AI&T	4	3	4	9%	33	30	42	29%	29	89%
1.3.3	Ground Sites	114	113	125	10%	137	135	149	9%	22	16%
1.3.4	Terrestrial Communication	0	0	0	14%	5	5	6	15%	5	94%
1.3.5	Training, Simulators and Spares	8	8	10	16%	21	20	25	20%	12	60%
1.4	Off Contract Effort	86	85	95	10%	131	128	153	16%	46	35%
1.5	Software Segment	303	299	360	17%	335	295	496	41%	32	10%
1.6	Launch Segment	201	198	228	13%	225	221	259	14%	25	11%
1.7	Operations & Support Segment	322	321	346	7%	372	367	417	12%	51	14%
1.8	Government Costs	500	497	538	8%	329	324	371	13%	(171)	-52%
Combined 1.1 and 1.8		714				790				76	10%

Need to be prepared to explain each major discrepancy!

List Unresolved Issues

Issue	WBS Element(s) Affected
Reliable TRLs for high-cost items unavailable in time for the ICE	1.2.3, 1.2.4, 1.2.5, 1.2.6, 1.2.7
Math error in POE suspected	1.2.8
Code count used in ICE lower than the one used for the POE	1.5
About 40% of the POE comes from contractors with unproven track records	1.2
ICE disregards significant heritage of platform	1.2.8

Summary

- Any cost estimate is a prediction and predictions are always precisely wrong!
- There are any number of reasons why cost estimates differ
- Recognize that reconciliation means identifying the valid reasons for the differences, not unnaturally forcing two estimates closer to each other
- Use relevant history as a source of sanity checks
- The POE represents more of a policy as to how much management is willing to pay and what the head count will be
- The ICE is more likely to represent how much the program actually could cost

Why Can't We All Just Get Along?

Because we're really not supposed to!

Acronyms

AI&T	Assembly, Integration and Test
AMCM	Advanced Mission Cost Model
B	billion
CARD	Cost Analysis Requirement Description
CER	Cost Estimating Relationship
COCOMO	Constructive Cost Model
COTS	Commercial Off the Shelf
Dem/Val	Demonstration/Validation
DDT&E	Design, Development, Test and Evaluation
DoD	Department of Defense
ESLOC	Executable Source Lines of Code
FY	Fiscal Year
GFE	Government Furnished Equipment
ICE	Independent Cost Estimate
K	thousand
kg	kilogram
M	million
NASA	National Aeronautics and Space Administration
NDH	Neal David Hulkower
NICM	NASA Instrument Cost Model
NRE	Nonrecurring Engineering
O&S	Operations and Support
POE	Program Office Estimate
ROM	Rough Order of Magnitude
SEE	Standard Error of Estimate
SM	Staff months
SOCM	Space Operation Cost Model
TRL	Technology Readiness Level
WBS	Work Breakdown Structure