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Building a Cost Analysis Improvement Group – Best Practices and Lessons Learned

Society of Cost Estimating And Analysis
Annual Conference
June 7-11, 2011

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Discussion Items

- CAIG History — Keith Robertson
- It's All About the Data and Relationships — Linda Williams
- Key Process, Methods and Tools — Erik Burgess

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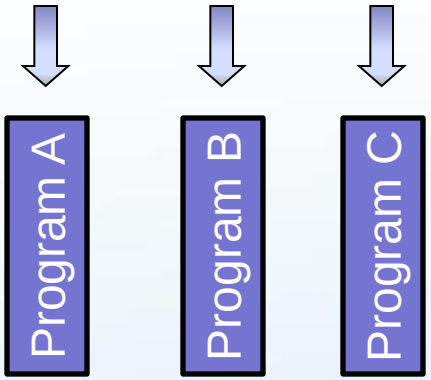
Evolution of NRO Cost Estimating

Early years Cost Estimating within Independent entities



- Cost estimating, data collection, modeling efforts developed:
- Primary support to SIGINT Programs

1990s: NRO stood up a Corporate Financial Reporting Structure

- Corporate Acquisition Process Established
- FIA prompted development of formal data collection requirements
- Budget builds started to reflect NCG ICEs
- Database model evolution initiated

Early Years → **1990's**

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Evolution of NRO Cost Estimating

2000: NCG processes and tools significantly mature

NRO Cost Group Continuing to Evolve Corporate Level Cost Estimating

SIGINT | IMINT | COMM | AS&T

- CIPT
- NSCM
- NCAT → SCATTR
- CER Development
- Track Record Established
- Schedule and Phasing Models
- ECP Study

Today: NRO transforms and NCG transforms with it

NRO Cost Analysis and Improvement Group

SIGINT | IMINT | COMM | AS&T | GED | SO

- NRO updates corporate processes
- Corporate EVM Support integrated with Cost Estimating
- Budget to ICE – 2004
- Government Estimate At Complete
- Continued tool development - ACME

2000 → **Today**

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(U) NRO Organization

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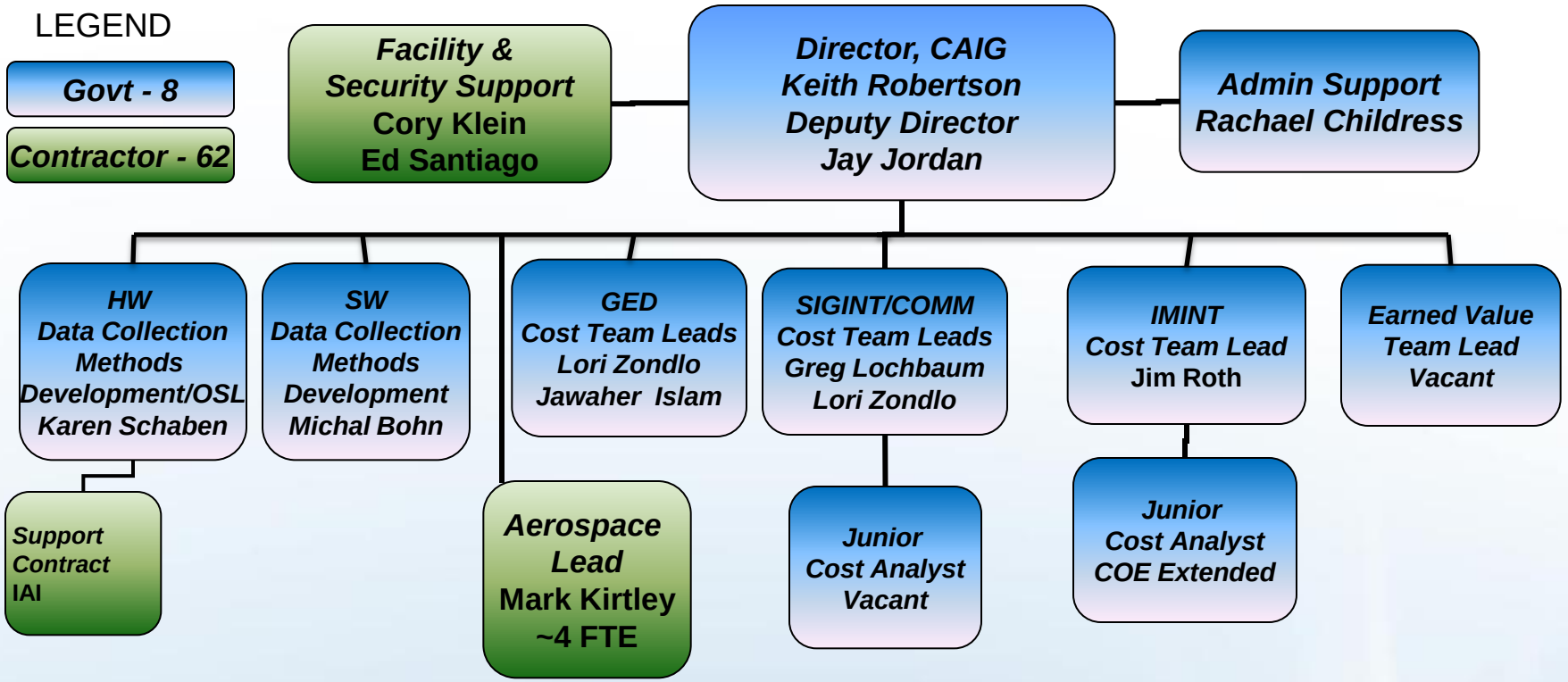
The Infrastructure: NRO CAIG Organization



Cost and Earned Value Support Contractors

Booz Allen Hamilton
PM – Ken Odom

Wyle
PM – Linda Williams

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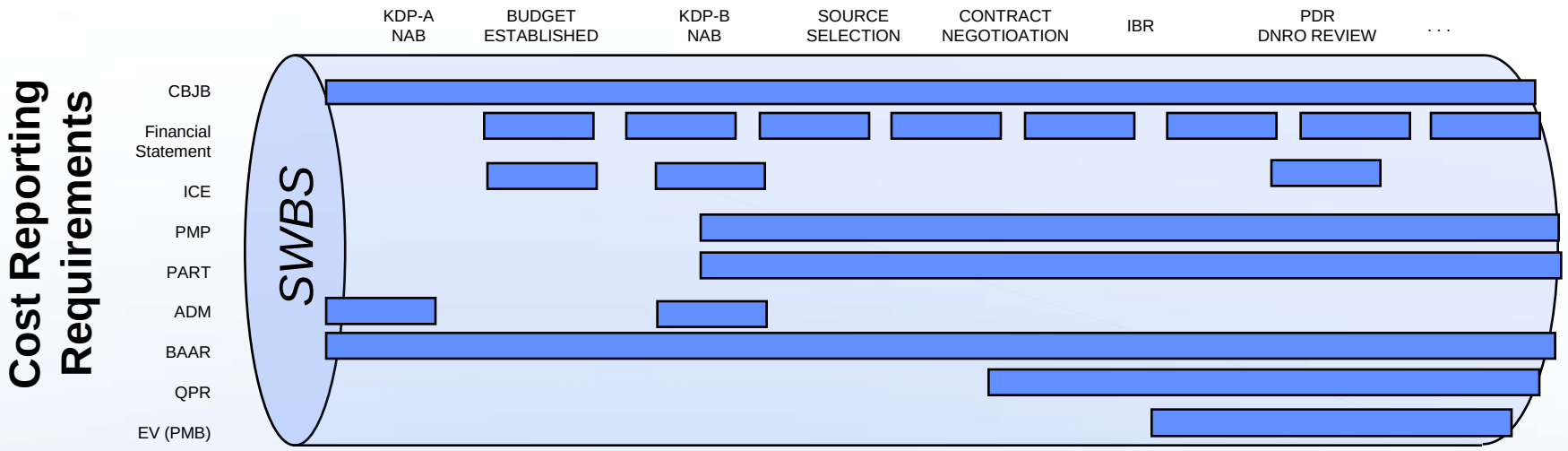
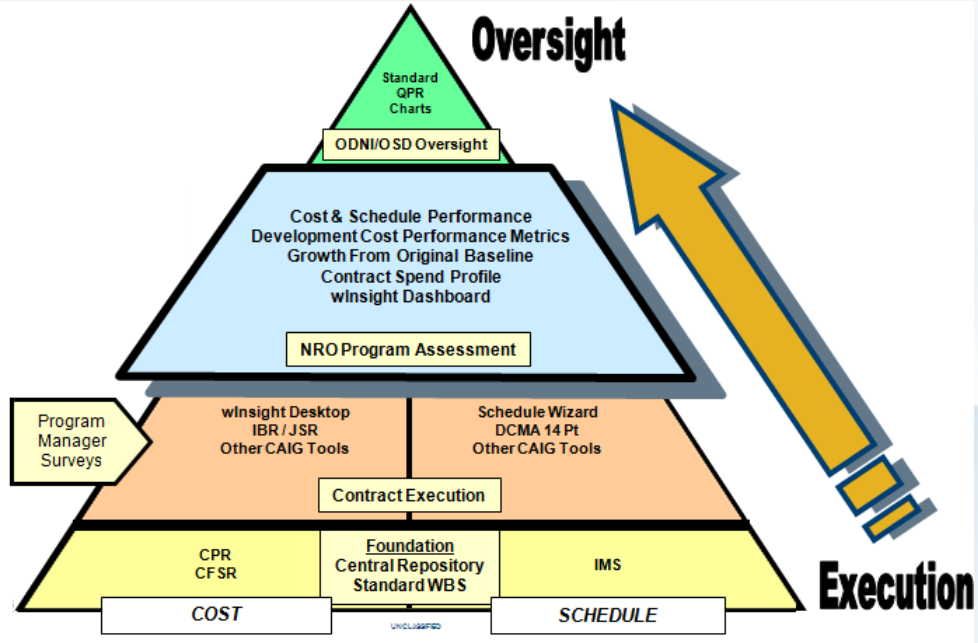
Linking Consistent WBS through Program Life Cycle

Program Planning and Execution Events



THE CORPORATE LOOK

Common Standard, Expectations, and Processes



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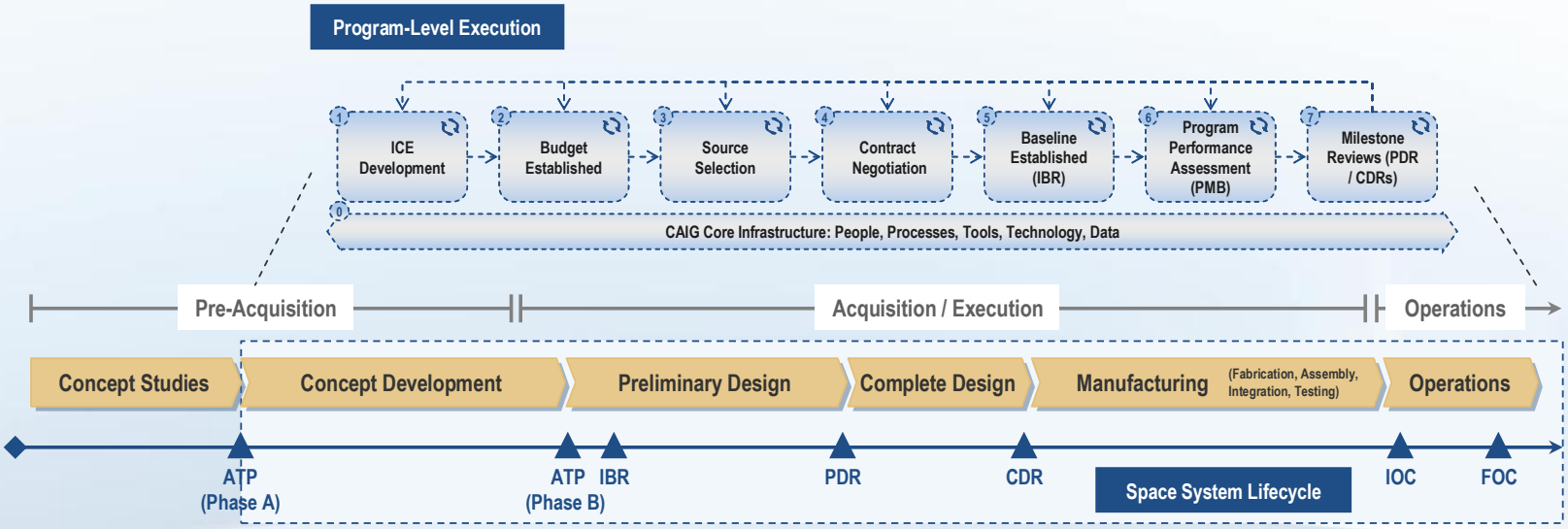
Supporting All Phases of NRO Programs

- At the program level, the CAIG provides **objective, independent pre-investment decision analysis and in-process program management decision support capabilities**
- These capabilities are delivered through the CAIG's *Cost Estimating and Analysis* and *Earned Value Management* collective skill set and evolving knowledge base
- Cost Estimating and Analysis and Earned Value are:
  - Foundational building blocks of proper Program Management
  - Utilized throughout program execution providing benefits to multiple stakeholders



NRO CAIG provides Program Offices with decision analytics throughout Programs' lifecycles through empirical datasets and unparalleled knowledge of corporate history

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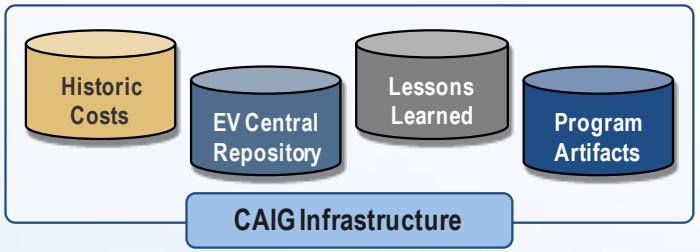
CAIG Cross-Program Perspective

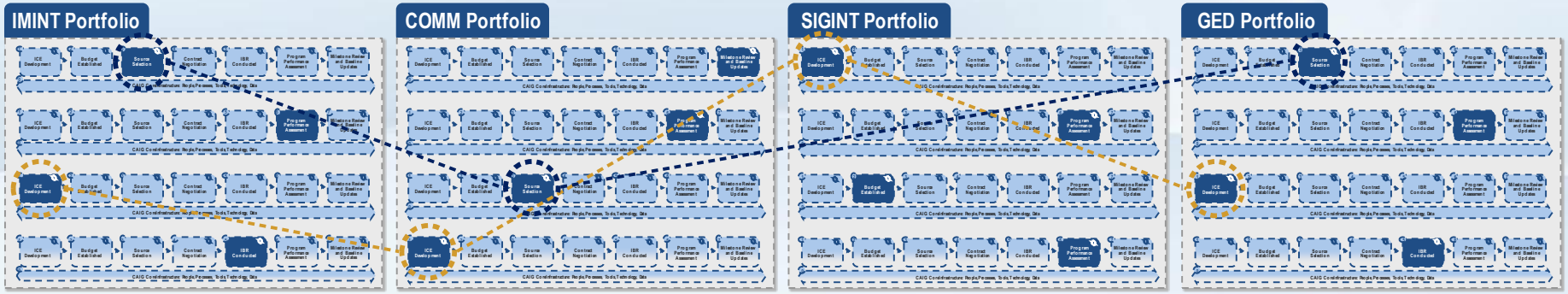
- In addition to individual program support, **the NRO CAIG is uniquely positioned to provide cross-program insight and analysis**:
  - Supports operating as a single integrated entity optimized for Enterprise not individual-level performance
  - Places renewed emphasis on Enterprise-Level planning and cross-INT integration

CAIG Perspective & Value Proposition

- Extensive Knowledge of NRO Corporate History
- Unparalleled breadth of Enterprise decisions and consequences across programs over time
- Deep Quantitative Skill Set and Knowledge Base



- Constantly evolving centralized repositories for all Cost, Schedule, and Program Artifacts
- Maturing cross-program understanding of lessons learned



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Track Record

TY$M

Description	NRO CAIG Track Record: ICE vs. Act	NRO CAIG Track Record: Adj ICE vs Act	Contractor Proposal Metrics: Proposal vs Act	Contractor Proposal Metrics: Adj Proposal vs Act
Program 1	-1%	-1%	Unknown	N/A
Program 2	-31%	-31%	-30%	5%
Program 3	-111%	-111%	-152%	
Program 4	-37%	-45%	-13%	-16%
Program 5	-9%	-9%	-236%	-101%
Program 6	-18%	-18%	-37%	N/A
Program 7	-101%	-11%	-175%	N/A
Program 8	-76%	-76%	-302%	-302%
Program 9	-3%	-3%	-36%	-13%
Program 10	-51%	-34%	-56%	0%
Program 11	-12%	0%	-6%	2%
Program 12	-9%	-5%	-20%	0%
Program 13	-27%	-24%	-32%	-27%
Program 14	30%	30%	-79%	-79%
Program 15	0%	0%	-26%	-16%
Program 16	15%	15%	5%	6%
Program 17	22%	-7%	24%	N/A
Program 18	-151%	-151%	-377%	-69%
Program 19	-15%	-12%	-64%	-46%
Program 20	4%	4%	-31%	-31%
Program 21	-2%	-1%	-5%	
Program 22	-9%	-9%	-64%	-36%
Program 23	-32%	-32%	-57%	11%
Program 24	-63%	-52%	-110%	-27%
Average Difference	-29%	-24%	INFO Only No Metrics	
Average Difference w/ out Program 18	-23%	-19%		

Mandated under WSARA Promotes Continuous Improvement

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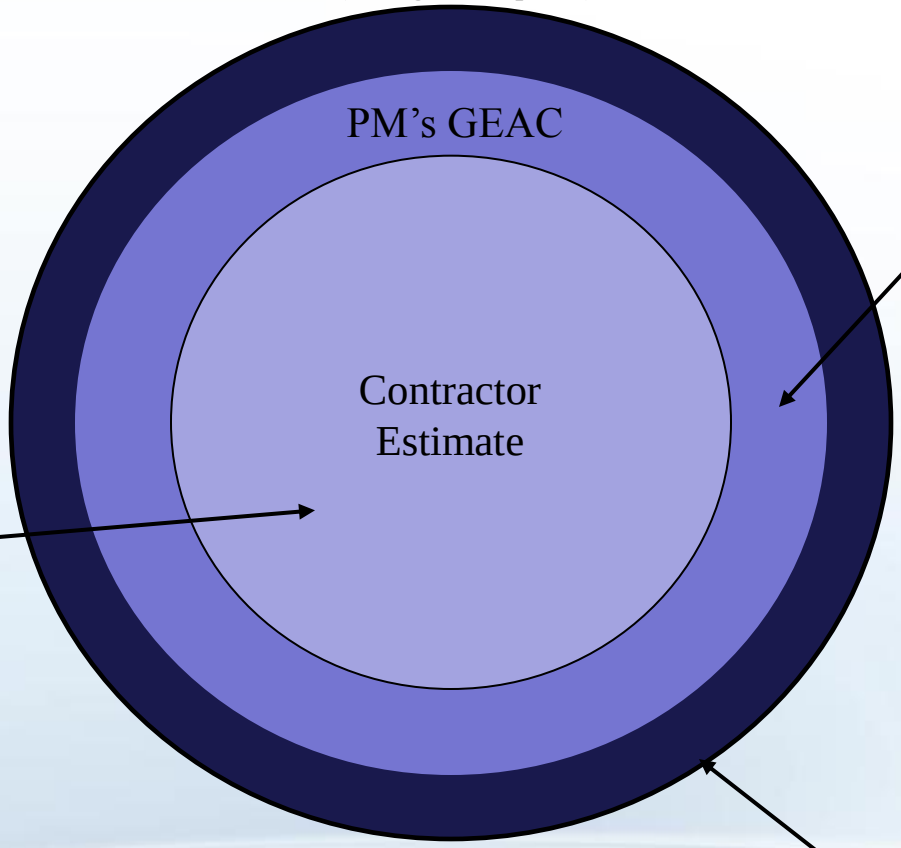
What Are The Differences?



Contractor Estimate

- Based on current technical/program assumptions
- Could be based on competitive position
- Designed to meet program cost & schedule goals
- Could include technical risks (Low-High Inputs) and cost uncertainty (Best-ML-Worst Case EACs)

Govt Program Office Estimate

- Covers all contract liabilities
- Includes costs for known but not yet definitized scope changes
- Margin to handle "nominal" program contingencies
- Includes other Government Costs (OGCs)

Govt ICE

- Intended to capture final costs of program, except for "major scope" adds – added payloads, change in qty, etc.
- Includes margin to address technical baseline uncertainties, schedule delays, launch vehicle delays, budget constraints, inflation changes, …

Relationship with Industry fosters better understanding of Estimate content

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It's All About the Data and Relationships

- Up front investment in the data and relationships with Government and Industry will enable organization to develop models and tools
- Key steps to Data and Relationship investment
  - Gain support from upper level management that data collection is a critical effort
  - Dedicate resources to the task – both people and dollars
  - Put together data collection plan and data protection policy
  - Market plan and prospective capabilities to all stakeholders to gain continued support
  - Set a schedule – stick to deadlines
  - Start small, and use data as soon as it is available
  - Document, document, document
  - Develop repository to make data available to as many people as possible
  - Maintain metrics/track record to determine added value of data collection effort/continuous improvement
  - Establish regular meetings with Government/Industry to share information and lessons learned
  - Continue to improve process

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Data Collection Process

- Data collection
  - This process outlines the method for data collection
  - NRO CAIG has developed a standard CDRL that is implemented on all Major System Acquisitions
  - CDRL outlines data that is required to be delivered to support CAIG efforts
- CDRL details
  - NRO Policy established in 1997 mandates CDRL will be placed on contract and PM will allocate budget to execute
  - Specific delivery milestones – 60 days prior to PDR, 60 days prior to CDR, 120 days after IOC, 3 additional deliveries at customer request
  - Program cost data summarized to standard WBS (box level) broken out by NR and Rec
  - Program technical information – PDR, CDR packages, Mass properties reports, subsystem block diagrams
  - Program Schedule
- Data protection policy
  - Rigorous policy outlined to assure contractors that their proprietary data will be protected
  - Training of all personnel handling data
  - Data distribution guidelines – only Government personnel can distribute data to other organizations

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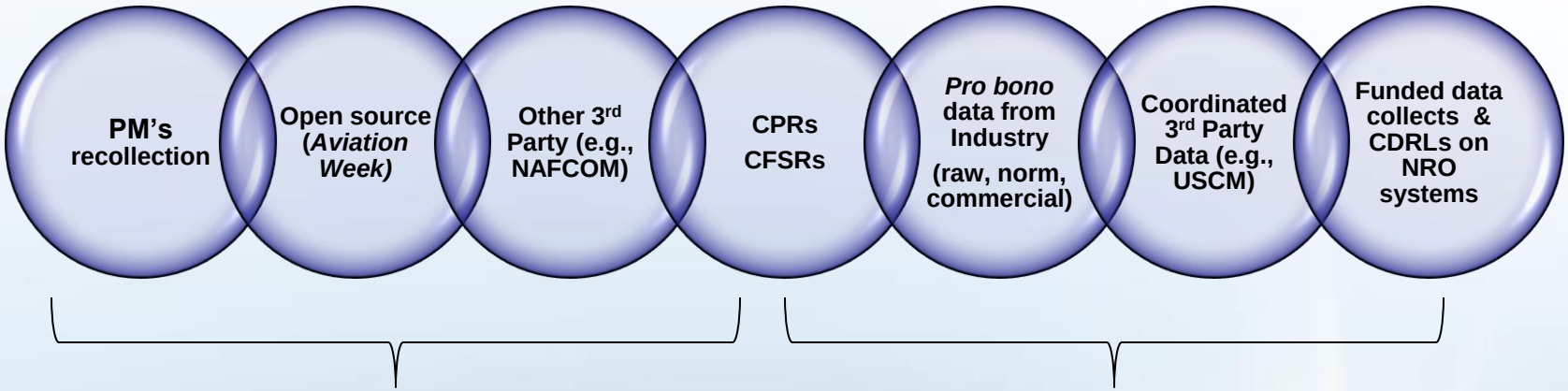
NRO CAIG Data

- Actual costs and technical descriptions of TBD space-system contracts
  - Satellites, individual payloads, ground systems, software
  - NRO, Commercial, NASA, DoD
- Fidelity varies but all data is useful



Used for special studies, sanity checks

Used to develop detailed CERs
Currently 2000+ end items

Managing All of These Data is a Challenge

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NRO CAIG Data Normalization Process

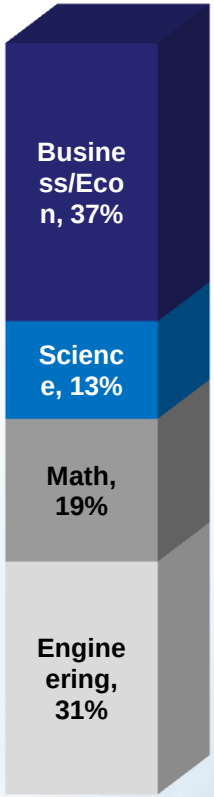
- Raw data from contractor or other government source

- Cost Data
  - Lowest level of WBS
  - Total and Phased
  - Hours
  - Labor $
  - Material $
  - Subcontract $
  - ODC $
  - G&A
- Technical Data
  - Data sheets
  - Mass Properties
  - PDR/CDR
  - CDRLs

Review Each Step With Contractor

Analyze Raw Data → Develop mapping to Standard WBS → Develop Allocation Scheme → Convert data to BY$ → Develop Final Normalized Cost → Develop Metrics (T1, NR/T1, T1/Wt, $/KSLOC → Technical/Quality Review, Develop Data Quality Indicators → Upload into Searchable Database, Release to PM/Contractors, Develop Website

CAIG Skill Mix



Key Take-Aways

- Raw data is used as is, no adjustments to actuals
- All data is usable data
- Dialog with Contractor is paramount to understanding data
- Assess quality of data after normalization

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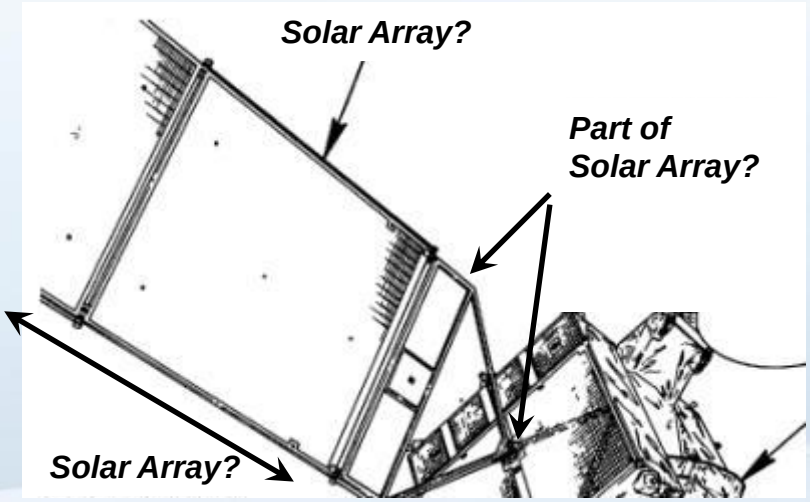
Typical Problems With Normalized Cost Data

- Contractor used a different WBS
- Provenance of data sometimes unknown
- Data collected before end of contract – EAC typically grows at end
- Number of end-items produced is not known (spares, engineering units, refurbishments)
- Costs not accumulated by "tail number"
- Technical scope and cost scope are misaligned. For example…



Solar array technical documentation and mass properties may include all panels, cells, substrates, hinges, and drive positioner.

Cost data often includes only panels, only cells, etc. Other items booked to structures or mechanisms.

Every program and contractor may be different.

Data Normalization & Correction is Ongoing, Often Lasts Years

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Two Data Management Approaches

Approach	Pros	Cons
#1: Revolution • All normalizations, databases, WBS, and models revamped in one coordinated effort • Develop suite of models based on new dataset	• End-to-end integrated models and database • Easier configuration control • Consistent scope, data and WBS	• May be 5-10 years before next increment/update • Requires dedicated model-development team (not estimators) • Data will change after freeze
#2: Evolution • Data base, WBS, and normalizations continuously updated, improved • Always have mix of high/low quality items • CER developers and estimating teams never wait for data -- use best available at that time	• Best available data used right away • CER update frequency can vary with staff workload • No dedicated model development team -- work spread across all estimators	• Configuration control is harder • Scope and WBS inconsistencies may arise

NRO CAIG Uses Evolutionary Model

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Current In-House Models & Tools

MODELS: Mathematical representations based on data

- Hardware CERS
  - Box
  - Subsystem
  - Demo-satellites
- Acquisition complexity
- Technical complexity
- Schedule estimating
- Time phasing
- Inflation
- SEIT/PM models

TOOLS: Promote consistency, efficiency

- EVM Central Repository
- SCATTR (database)
- Software database
- Data normalization mapper
- Phasing tool
- Sanity checking tool
- NRO Space System Cost Model (NSCM)
- Advanced Cost Modeling Environment (ACME)

Customized Models and Tools

Transparency maintained from raw data to final estimating product

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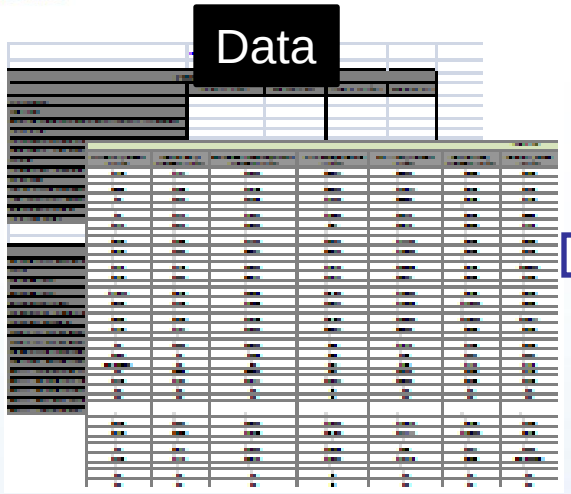
Tools Are Nice to Have …



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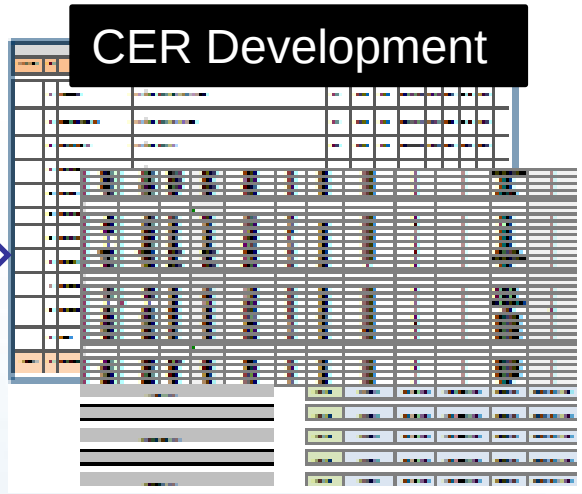

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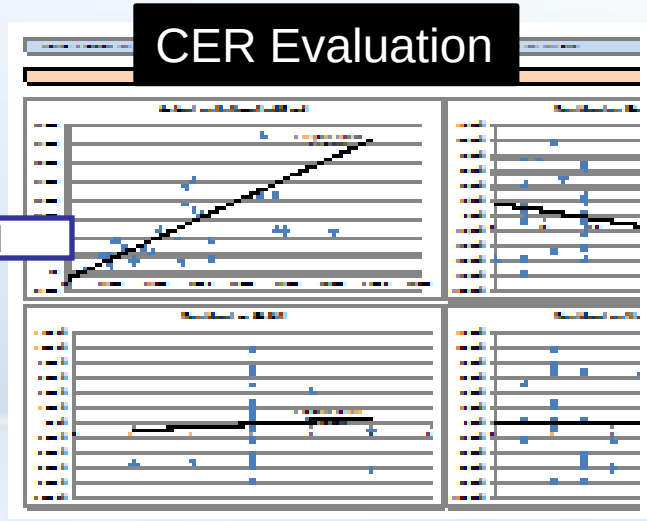

… But Underlying Models and Data Are Essential

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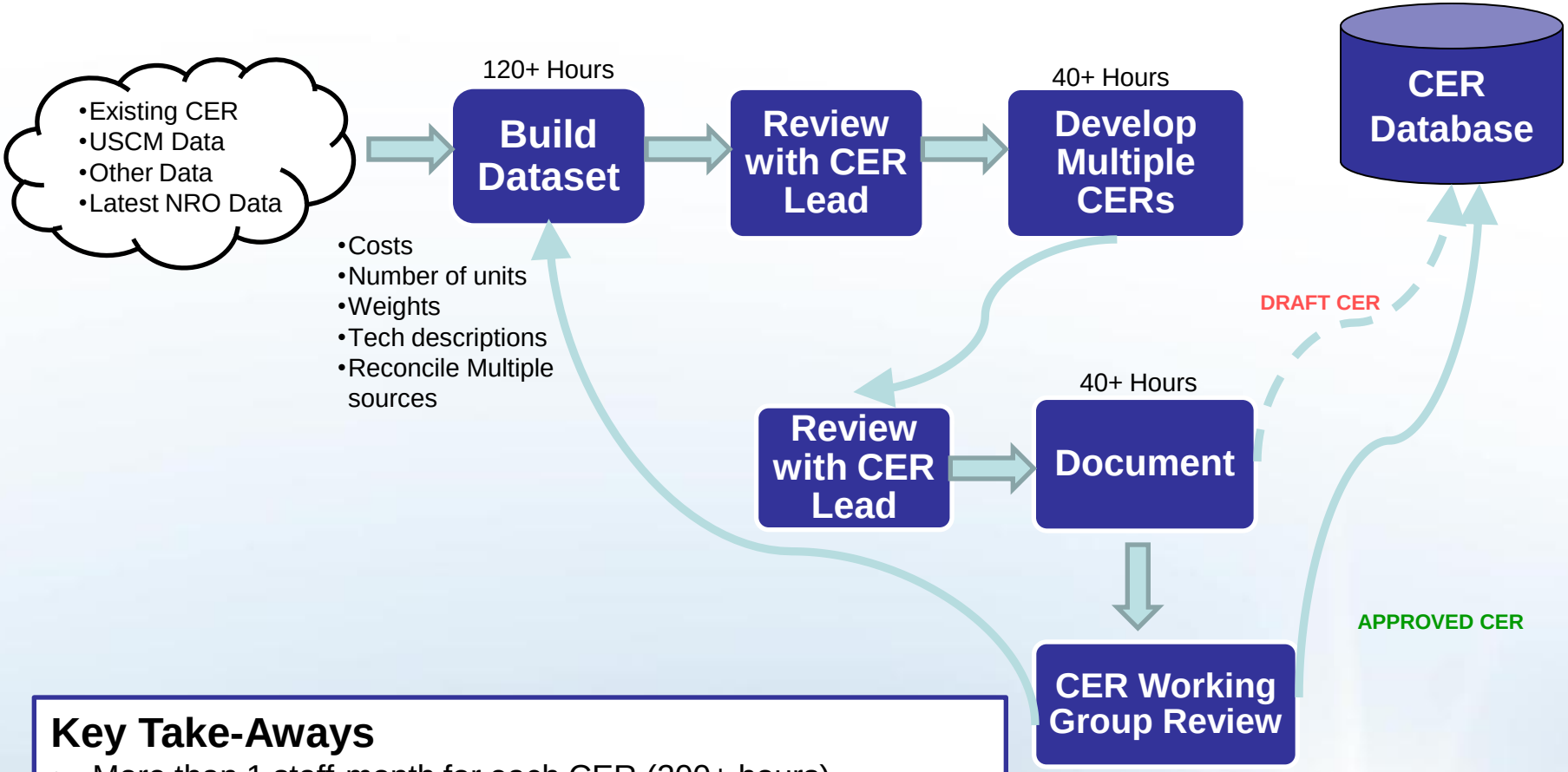
NRO CAIG CER Management Process



Key Take-Aways

- More than 1 staff-month for each CER (200+ hours)
- Continuous
- Data Focused
- Iterative Peer Review Process

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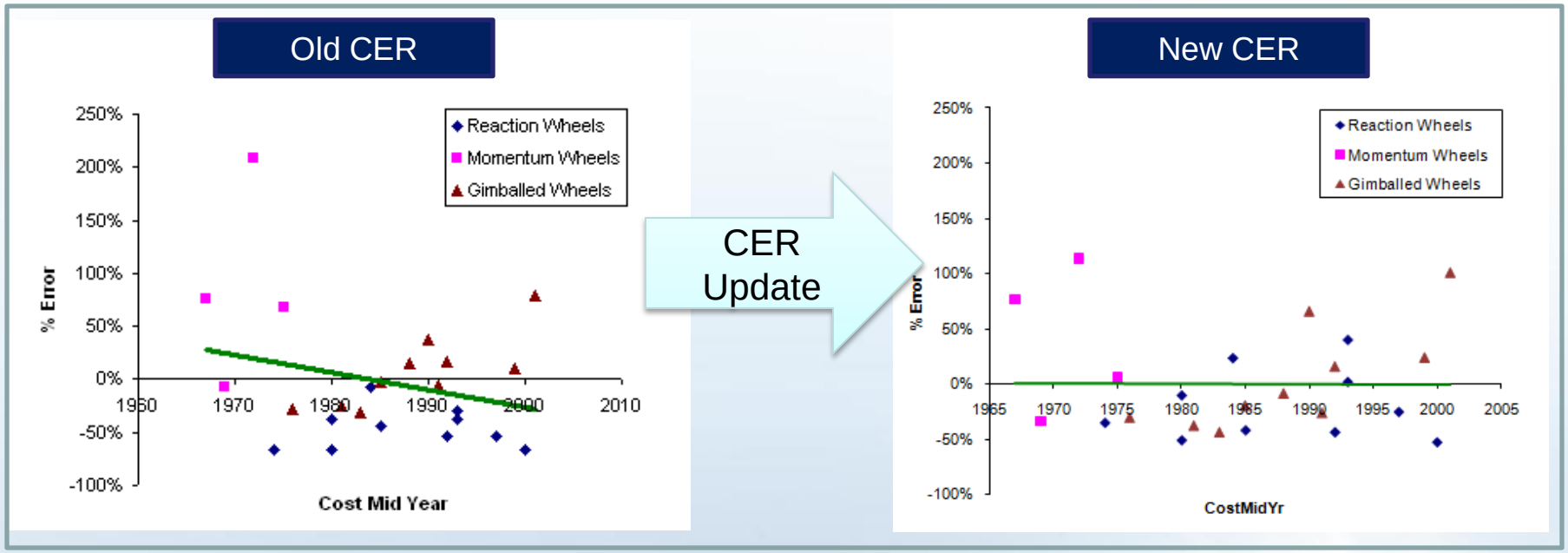
Motivation for Continuous Improvement

- CERs reflect latest technologies
- Best available CERs available to all estimators
- Models accurate over decades



If average error (sample bias) is consistent over 30 years, we are confident the model is reasonable for our estimates now.

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Ensuring Improvement

CER Summary Table:
Ensures updates are, in fact, better than the original.

Evaluate existing CER

Add new data

Try to improve it

CER Type	CER Form	Coefficients a	b	c	d	DOF	SPE	R^2	Bias	Comments
LOLS	$a*WT^bVPC^cd^{lowcost}$	91	-0.31	-0.23	0.20	11	79.4%	0.400	1.2%	This was the starting point: the original LOLS CER that was based on an old data set
LOLS	$a*WT^bVPC^cd^{lowcost}$	91	-0.31	-0.23	0.20	21	65.2%	0.785	-2.2%	The same CER was updated with new data from NCAT and other sources in order to determine how the current CER performs against today's best available "truths." From this point forward, variations to the CER form were performed to determine whether a better CER existed.
LOLS	$a*WT^bVPC^c$	57	-0.19	-0.23		22	71.0%	0.779	1.5%	The only low cost data point was not included in the Sanitized Data set, so the Low Cost variable was dropped from the equation. Solver was run on the original CER with the additional data to obtain a new CER equation. This did not change the numbers siginificantly, so other CER variations were tried.
LOLS	$a*WT^bBPC^c$	96	-0.23	-0.36		21	52.6%	0.699	0.4%	BPC was substituted for VPC. This resulted in a steeper learning curve but a lower SPE. Other variations were tried next to see if something better existed.
LOLS	$a*DL^bVPC^c$	82	-0.26	-0.23		22	70.9%	0.706	1.7%	Exponent on design life is negative--doesn't make sense.
LOLS	$a*WT^bDL^cVPC^d$	112	-0.16	-0.20	-0.23	21	65.0%	0.729	0.9%	Exponent on design life is negative--doesn't make sense.
LOLS	$a*WT^bDL^cBPC^d$	65	-0.31	0.21	-0.48	20	51.8%	0.720	0.4%	By not constraining the CIC, the exponent on design life becomes positive, CER has a better SPE, and R^2
ZMPE	$a*WT^bVPC^c$	235	-0.50	-0.66		21	58.0%	0.722	0.0%	Switching to the ZMPE form resulted in a lower CIC curve, SPE, AUC and Bias. The CIC was only 64%, so Solver was rerun constraining c (this CER was named ZMPE_Updated.)
ZMPE	$a*WT^bVPC^c$	169	-0.48	-0.23		22	63.8%	0.791	0.0%	Constraining c elevated the SPE, as well as the R^2. Other variations were tried to see if something better existed.
ZMPE	$a*WT^bDL^cVPC^d$	251	-0.30	-0.48	-0.23	21	57.1%	0.697	0.0%	Adding design life as a cost driver caused the SPE and the R^2 to decrease. Also, Design Life has a negative exponent, so this is unrealistc.
ZMPE	$a*WT^bBPC^c$	110	-0.24	-0.40	0.00	21	51.8%	0.683	0.0%	BPC was substituted for VPC. This resulted in a steeper learning curve but a lower SPE. Other variations were tried to see if something better existed.
ZMPE	$a*WT^bDL^cBPC^d$	72	-0.31	0.21	-0.51	20	51.3%	0.706	0.0%	Design Life was added to see the effect of a (SPE and R^2 improved slightly. Comparable

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Spin-off Projects

- CER Working Group sponsors innovative research
- Studies and models evolve out of questions asked during CER development, review, and application

Commercial Acquisitions Programs Study (CAPS) ◊
- Model to Estimate the Cost of a Government Program that is "Commercial Like"

Box vs. Subsystem CER Study ◊
- Studied the applicability of developing CER's at the sub-system level for use in estimating when box level detail is unavailable

Incidental Nonrecurring (INR) Model
- Estimated the NR Cost Associated with Space Hardware that is 0% New Design
- This is due to things such as minor obsolescence, new set-ups, etc.

Satellite Sizing and Weight Growth Models % New Design
- Parametric Models to evaluate reasonableness of Program Office/Contractor Baselines. In addition to Independent Technical Assessments.

NR vs. Production Quantity Study
- Investigating the finding that NR cost is correlated with Production Quantity

Demo-Satellite Cost Model ◊
- Subsystem-level model for one-of-a-kind demos

Production-cost Variance Study ◊
- Assess inherent cost variation in build-to-print items

Bootstrapping ◊
- Prototype bootstrapping method for assessing CER prediction intervals

◊ Published/ Public

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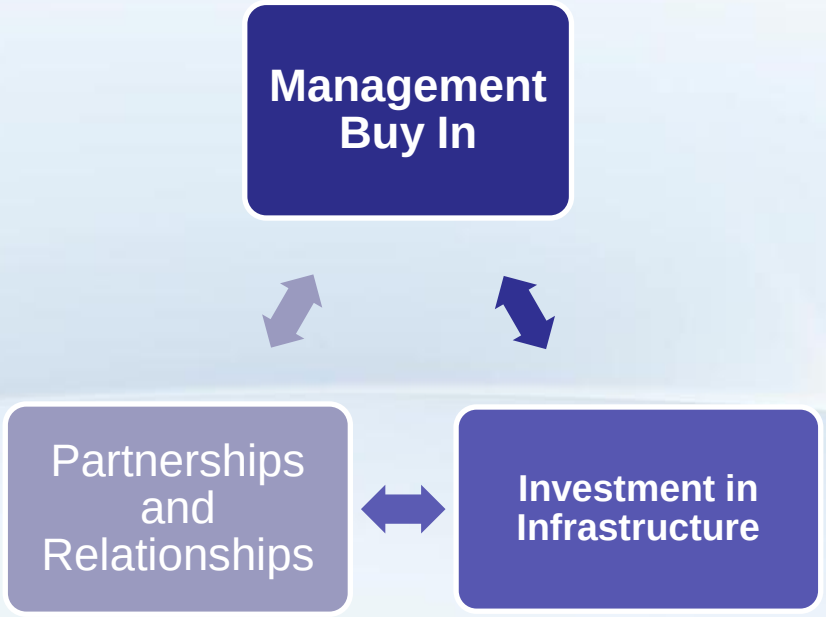
Summary

- Keys to Success
  - Obtain Management Buy-in
  - Plan, Start Small, Document
  - Symbiotic Partnerships/relationships
- A continuous cycle of improvement is necessary
- As data is collected, models and tools are generated
- Additional data needs are identified and refined models and tools are developed



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