



May 24, 2019

TO: Members of the Program Management Council

FROM: Associate Administrator

SUBJECT: Joint Cost and Schedule Confidence Level (JCL) Requirements Updates

The purpose of this memorandum is to update the requirements for developing a JCL at specific milestone reviews and key decision points (KDPs). Although NPR 7120.5E specifies requirements for process and products needed as programs and projects pass through decision gates at key milestones, the Agency is updating programmatic expectations for all projects, including Single-Project Programs, with a Life-Cycle Cost (LCC) of \$1 billion or more. Lastly, this document does not substitute existing KDP C JCL policy as specified in NPR 7120.5E.

1. **Projects and Single-Project Programs, with a LCC of \$1 billion or more, shall develop and provide the following¹:** Please note, the below requirement updates do not apply to two-step Announcement of Opportunity missions due to acquisition down-selection serving as KDP B (NPR 7120.5E, Section 2.2.7.1).

At Key Decision Point (KDP) - B:

- a) A JCL informed by probabilistic analysis of development cost and schedule duration. Methodology for JCL analysis is not limited to a Probabilistic Cost-Loaded Schedule (as specified for KDP C JCL): other parametric and bivariate methodologies can also be applied.
- b) The JCL will include the development cost estimates through the hand over to operations, i.e., end of the on-orbit checkout, consistent with KDP C policy.
- c) A high and low value for cost and schedule with the corresponding JCL value (e.g. 50%, 70%).
- d) Mission Directorates plan and budget programs and projects based on a 70 percent JCL or as approved by the Decision Authority.
- e) The justification for budgeting programs and projects below the 70 percent confidence level shall be included in the KDP-B Decision Memorandum.

¹ New KDP-B JCL requirements will be in lieu of existing cost and schedule range estimate requirement specified in NPR 7120.5E, Section 2.4.3.1.

At Critical Design Review:

- a) Projects and Single-Project Programs with a LCC of \$1 billion or more shall update their KDP C JCL.
- b) Projects and Single-Project Programs shall communicate updated JCL values for the Agency Baseline Commitment (ABC) and Management Agreement (MA) to the Agency Program Management Council (APMC) for informational purposes.

At KDP D:

- a) Projects and Single-Project Programs with a LCC of \$1 billion or more shall update their JCL if current development costs have exceeded their development ABC cost or 5%.
- b) Updated JCL values for the ABC and MA shall be documented in the KDP D Decision Memorandum.

2. Tightly coupled programs, single-project programs, or projects with an estimated life-cycle cost greater than \$250M

At Rebaselines:

- a) When a tightly coupled program, single-project program, or project with an estimated life-cycle cost greater than \$250M is rebaselined, the JCL shall be recalculated and approved as a part of the rebaselining approval process.

The requirements set forth in this memorandum are effective immediately.

/S/

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Original KDP-B Policy Rationale

- KDP-B range estimate was established partially because of the realization that JCL analysis at KDP-C was too late to protect projects from misalignment of programmatic constraints and technical requirements
- In the formulation stage, specifically for KDP-B, policy is for programs and projects to provide probabilistic analysis on both their cost and schedule estimates, resulting in documented range estimates for both cost and schedule
- Projects typically do not have detailed plans available to support an *in-depth* JCL analysis, so by design, the requirement at KDP-B was intended to support KDP-C expectations

KDP-B Range Estimate Policy was developed to support successful KDP-CJCL Policy.



Defining JCL

- 7120.5E and NASA PM Handbook Definition (*highlights added*)
 - Joint Cost and Schedule Confidence Level. (1) *The probability that cost will be equal to or less than the targeted cost and schedule will be equal to or less than the targeted schedule date.* (2) A process and product that *helps inform management of the likelihood of a project's programmatic success.* (3) A process that combines a project's cost, schedule, and risk into a complete picture. JCL is not a specific methodology (e.g., resource-loaded schedule) or a product from a specific tool. The JCL calculation includes consideration of the risk associated with all elements, regardless of whether or not they are funded from appropriations or managed outside of the project. JCL calculations include the period from KDP C through the hand over to operations, i.e., end of the on-orbit checkout.
- NASA Cost Estimating Handbook, JCL Appendix (*highlights added*)
 - Joint Cost and Schedule Confidence Level (JCL) analysis is a process that combines a project's cost, schedule, and risk into a complete picture. JCL is not necessarily a specific methodology (e.g., resource loaded schedule) or a product from a specific tool. The JCL calculation includes consideration of the risk associated with all elements, regardless of whether or not they are funded from NASA's appropriations or managed outside of the project (e.g. a partner contribution).
 - *A JCL identifies the probability that a given project or program cost will be equal to or less than the targeted cost AND that the schedule will be equal to or less than the targeted schedule date. There are two fundamental ways that one could generate a JCL*
 - 1) bivariate distributions and
 - 2) probabilistically cost loading a probabilistic schedule (Probabilistic Cost-Loaded Schedule [PCLS]).
 - *Both methodologies will fundamentally produce a JCL; however, to fulfill the intent of the NASA JCL policy requirement [at KDP-C], it is intended that a project or program perform the latter (probabilistic cost loading of a probabilistic schedule)...The rationale for the Agency focusing in on the PCLS methodology stems from the fact that the method forces the project and the review entity to focus on the project's plan.*

JCL has always been communicated as a product and not a specific methodology



JCL Process at KDP-C and KDP-B

Current KDP-C JCL Process

1. Build a JCL schedule/logic network
 - Logic network
 - Minimize use of constraints
 - Link to major milestones
 - Schedule health check for viability for analysis
2. Cost load the schedule
 - Map cost to schedule
 - Load as resources if using schedule system
 - Determine phased fixed/variable costs and assign to schedule/logic network
3. Implement risk list
 - Quantify likelihood and cost/schedule impacts
 - Link to schedule/network activities
 - Load risks
4. Conduct uncertainty analysis
 - Schedule uncertainty
 - Cost uncertainty
5. View results & plot

Proposed KDP-B JCL Process

1. Conduct a Schedule Risk Analysis
 - Parametric utilizing Schedule Estimating Relationships, or
 - Traditional SRA, or
 - Combination of both
2. Conduct a Cost Risk Analysis
 - Parametric, or
 - QRA based on baseline, or
 - Combination of both
3. Implement Risk List
 1. Identify and add specific risk items to both SRA and CRA
 2. Incorporate SER/CER statistical uncertainty to analysis
4. Convolve SRA and CRA distribution together*

At a minimum, the only addition would be to apply a correlation between the cost and schedule distributions.

Already Conducted as part of KDP-B
Range Estimates

*Please note, process shown here is purposely generic. There are methods for producing a JCL with KDP-B cost/schedule range estimates that don't simply "convolve" final cost and schedule distributions.

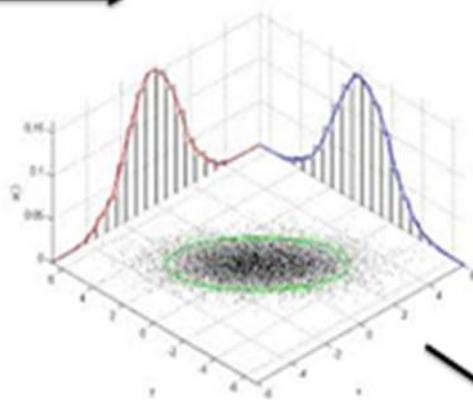
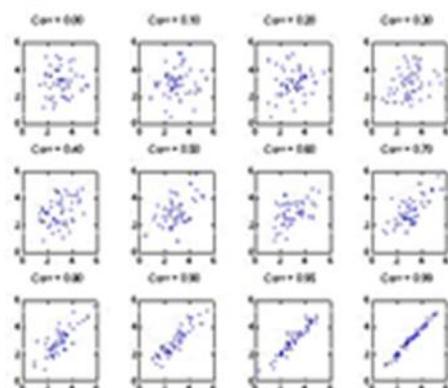
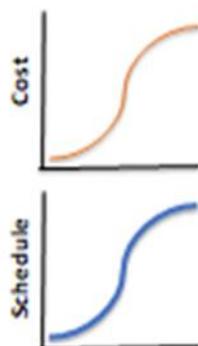


KDP-B JCL Process, Simplified Bivariate – Convolution Distributions

Conduct CRA and SRA

Determine Correlation between Distributions

Convolve Distributions



Analytical Techniques Published:

- Garvy, P. 2000. *Probability Methods for Cost Uncertainty Analysis*. New York: Marcel Dekker
- Coveat, R. 2014. *Cost and Schedule Risk Analysis*. Cowens
- Simulation Techniques known within JCL Community

Determine JCL*

Knowing what combination of cost and schedule confidence levels that are truly setting up a successful chance for reasonable JCL values are not transparent in current policy.

	Cost Confidence Level															
Schedule Confidence Level	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	98%	99%	99.5%	99.8%	99.9%	100%
10%	7%	8%	10%	12%	15%	17%	20%	24%	28%	32%	36%	40%	44%	48%	52%	56%
20%	8%	11%	14%	17%	20%	24%	28%	32%	36%	40%	44%	48%	52%	56%	60%	64%
30%	10%	13%	17%	21%	25%	29%	34%	38%	42%	46%	50%	54%	58%	62%	66%	70%
40%	12%	16%	20%	24%	28%	32%	36%	40%	44%	48%	52%	56%	60%	64%	68%	72%
50%	15%	19%	23%	27%	31%	35%	39%	43%	47%	51%	55%	59%	63%	67%	71%	75%
60%	18%	22%	26%	30%	34%	38%	42%	46%	50%	54%	58%	62%	66%	70%	74%	78%
70%	21%	25%	29%	33%	37%	41%	45%	49%	53%	57%	61%	65%	69%	73%	77%	81%
80%	24%	28%	32%	36%	40%	44%	48%	52%	56%	60%	64%	68%	72%	76%	80%	84%
90%	28%	32%	36%	40%	44%	48%	52%	56%	60%	64%	68%	72%	76%	80%	84%	88%
95%	32%	36%	40%	44%	48%	52%	56%	60%	64%	68%	72%	76%	80%	84%	88%	92%
98%	36%	40%	44%	48%	52%	56%	60%	64%	68%	72%	76%	80%	84%	88%	92%	96%
99%	40%	44%	48%	52%	56%	60%	64%	68%	72%	76%	80%	84%	88%	92%	96%	100%
99.5%	44%	48%	52%	56%	60%	64%	68%	72%	76%	80%	84%	88%	92%	96%	100%	100%
99.8%	48%	52%	56%	60%	64%	68%	72%	76%	80%	84%	88%	92%	96%	100%	100%	100%
99.9%	52%	56%	60%	64%	68%	72%	76%	80%	84%	88%	92%	96%	100%	100%	100%	100%



KDP-B / KDP-C Attributes

- JCL Policy at KDP-B and KDP-C will produce same measurements utilizing techniques consistent with KDP maturity.
- However KDP-C JCL implementation provides several positive externalities

To a stranger, the probability that I shall send a letter to the post unstamped may be derived from the statistics of the Post Office; for me those figures would have but the slightest bearing on the question – John Maynard Keynes, A Treatise on Probability

JCL Attributes	KDP-C	Proposed KDP-B
Communication	JCL, by way of its probabilistic nature, helps the Agency communicate the risk posture (and rationale) to stakeholders and, in theory, helps Agency protect reserve (UFE) positions allocate those resources efficiently	KDP-B JCL will more effectively align KDP-B policy to KDP-C JCL policy
Basis of Estimate	Project Plan: JCL has demonstrated utility by addressing and bringing forward specific project plan issues (schedule, risk identification, etc)	Consistent with KDP-B maturity, KDP-B JCL will rely less on plan on more on cost/schedule technical drivers
PP&C Best Practices	JCL requirement has been a forcing function to help the PPC community integrate stove-piped work products (IMS, resource management, risk management)	Techniques for producing KDP-B JCL is consistent to NASA and GAO cost/schedule guidance
Quantitative	JCL provides an assessable "measurement" of project programmatic health	KDP-B JCL does not lose any quantitative rigour already produced in support of Range Estimate Policy

KDP-B JCL maintains intent of Agency Programmatic Policy while preserving the positive attributes of current policies.



Resources to Conduct Analysis at KDP-B Range Estimate vs. JCL (Bivariate Solution)

KDP-B JCL would be utilizing the same input data, Personnel, and Tools as current KDP-B Range Estimates

Attribute	Probabilistic Cost-Loaded Schedule (KDP-C JCL)	Bivariate Independent Cost and Schedule Distributions (Proposed KDP-B JCL)	Additional Analysis Compared to current KDP-B Range Policy
Description	JCL developed by directly linking cost and schedule logic based on project's specific schedule and cost plans	JCL developed by independently producing a probabilistic cost and schedule distributions. The distributions are combined using classical bivariate joint probability methods (analytical and simulation).	Joining current range estimate distributions
Detail Level	Typically, more detailed.	Typically, less detailed.	BOE detail level would be equivalent.
Cost/Schedule Methodologies	Typically detailed costs built from SME, grassroots, or proposed data.	Typically parametric but can be done analogy, SME based, or grassroots methodologies.	Same general methodologies can be used till distributions are convolved for JCL.
Risk/Uncertainty Methods	Risks are informed by risk management system and uncertainty is typically SME based.	Risk an uncertainty inherent in parametric and analogy based data. If done by SME or grassroots methods, the risks and uncertainty would be informed by SMEs.	None
Data Sources	Detailed project plans, historical and SME input for risk/uncertainty.	Typically historical data.	None
Tools	Management tools (Microsoft Project, MS Excel) and simulation software (e.g., ACEIT, OPRA, JACS, Polaris, etc.)	Parametric tools (eg. PCEC, NICM, ASCOT, SMART, SEER, PRICE, etc), management tools (Microsoft Project, MS Excel), and simulation software (e.g., ACEIT, OPRA, JACS, Polaris, etc.)	Integration of distributions can be conducted with current tool set.
Recommended Uses	Rigorous analysis in support of KDP-C and beyond.	Cross check for PCLS analysis. Early assessment during formulation.	N/A

Source: Adapted from Valid Cost Estimating Handbook

Note: Additional support on how to convolve cost and schedule would need to be provided to project/community. SID can provide this till techniques are properly documented.