

NASA

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Office of Inspector General

Office of Audits

AUDIT OF NASA'S JOINT COST AND SCHEDULE CONFIDENCE LEVEL PROCESS

September 29, 2015

Report No. IG-15-024





Office of Inspector General

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RESULTS IN BRIEF

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IG-15-024 (A-14-019-00)

WHY WE PERFORMED THIS AUDIT

Throughout its history, NASA has struggled with accurately predicting the amount of time and money required to complete its space flight projects. The resulting cost and schedule overruns have in turn led to challenges in the project development process, diversion of funding from other projects, and an overall reduction in the number and scope of projects the Agency can undertake. Over the years, studies have identified several root causes for NASA's challenges in producing accurate cost and schedule estimates. While some of the causes are outside the Agency's control, NASA has developed tools that can improve the fidelity of its cost and schedule estimates. To this end, since 2006 NASA has incorporated progressively more sophisticated probabilistic estimating techniques into Agency policy, culminating in 2009 with formal adoption of a Joint Cost and Schedule Confidence Level (JCL) requirement.

A JCL analysis generates a representation of the likelihood a project will achieve its objectives within budget and on time. The process uses software tools and models that combine cost, schedule, risk, and uncertainty to evaluate how expected threats and unexpected events affect a project's cost and schedule. To generate this data, project managers develop comprehensive project plans, inputs, and priorities that integrate costs, schedules, risks, and uncertainties. NASA officials contend that gathering this data encourages better communication among project personnel; improves cost, schedule, risk, and uncertainty analyses; and fosters an understanding of how project elements impact one another. Accordingly, a JCL analysis not only establishes the basis for proposing project and program budgets, but may improve project planning and provide stakeholders the rigor and documentation to better justify funding requests. Since 2009, NASA has completed a JCL analysis for 22 projects with a combined price tag of more than \$49 billion.

We initiated this audit to determine whether NASA had implemented appropriate controls and procedures to establish a JCL process capable of improving cost and schedule estimates and therefore providing more reliable information to decision makers.

WHAT WE FOUND

Based on our review of these 22 projects, it appears the JCL policy is having a positive impact on NASA's historical challenges with cost and schedule fidelity. That said, the process is relatively new, still evolving, and not a one-stop solution to solving all root causes of cost overruns and schedule delays. Specifically, the process has inherent limitations in that, like any estimating practice, it does not fully address the issue of predicting "unknown/unknowns" or address some of the root causes of NASA's project management challenges such as funding instability and underestimation of technical complexity.

We identified varied expectations and understandings among Agency stakeholders about the JCL process, ranging from those who see JCL as a multifunctional tool that can significantly improve cost and schedule management to others who view it as just another task projects must complete before moving into the development phase. We also identified issues with the quality of some JCL cost, schedule, and risk data inputs for several of the projects we reviewed. In-depth assessments of 9 of the 22 projects revealed 5 projects that had significant weaknesses in project scheduling, risk assessment, and cost estimating. Remedying these weaknesses would improve the overall accuracy of JCL analyses.

Moreover, the effectiveness and consistency of the process NASA uses to review projects' JCL analyses could be improved. For example, the extent and type of review varied widely from project to project. We attributed this inconsistency to a lack of formal guidance, inadequate training for review board members, and inconsistent expectations among the review board chairs regarding how projects should consider and incorporate the results of board reviews. We also found training for project personnel could be improved.

Finally, the confidence levels stipulated in the JCL policy may not be suitable for single-project programs, which cannot leverage funding from other projects in the same portfolio that finish under budget. Accordingly, holding those programs to the levels stipulated in the policy may not be appropriate.

WHAT WE RECOMMENDED

To improve the Agency's JCL process, we made eight recommendations to NASA: (1) clarify that project managers and Decision Authorities are to use JCL results as the basis for proposing and establishing project budgets rather than as a validation tool; (2) assess the effectiveness of the scheduling function at NASA and develop a plan to ensure all NASA Centers have access to trained and qualified schedulers with experience commensurate with the complexity of assigned projects; (3) require use of historical data in JCL analyses; (4) establish formal guidance and clarify expectations for the review process; (5) establish a formal, JCL-specific training program for involved personnel; (6) work with JCL software providers to add a function that tracks and creates a report reflecting modifications to input data and require review boards to consider this information; (7) assess the appropriateness of the current confidence level requirement for single-project programs and consider clarifying or supplementing that requirement; and (8) require projects to include all identified, relevant, and discrete development risks with potential cost and/or schedule impacts in their JCL models.

In response to a draft of our report, the Acting Director of the Office of Evaluation concurred with seven of our recommendations and described corrective actions the Agency has or will take. The Acting Director did not concur with our recommendation to add a function to JCL software that would track and create a report reflecting modifications to input data. However, the Agency's proposal to work with JCL software vendors to implement other features and functions that can aid with input data organization and verification is potentially responsive to our recommendation. Accordingly, although we continue to encourage NASA to further assess the economic and operational feasibility of adding a data input tracking and reporting function to the JCL software, we consider all recommendations resolved.

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Acronyms

CAD	Cost Analysis Division
EVM	Earned Value Management
GAO	Government Accountability Office
IMS	Integrated Master Schedule
IPAO	Independent Program Assessment Office
KDP	Key Decision Point
JACS	Joint Analysis Cost/Schedule
JCL	Joint Cost and Schedule Confidence Level
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
OIG	Office of Inspector General
PERT	Program Evaluation and Review Technique
SRB	Standing Review Board

INTRODUCTION

Throughout its history, NASA has struggled with accurately predicting the amount of time and money required to complete its space flight projects. The resulting cost and schedule overruns have in turn led to challenges in the project development process, diversion of funding from other projects, and an overall reduction in the number and scope of projects the Agency can undertake. Moreover, requesting additional funding from Congress for projects that have failed to meet announced cost and schedule goals has led stakeholders to question the integrity of Agency estimates as well as its ability to efficiently accomplish its mission.

Studies and assessments by NASA, the Office of Inspector General (OIG), and the Government Accountability Office (GAO) have identified several root causes for NASA's challenges in producing accurate cost and schedule estimates. Although some of the causes – for example, funding instability – are primarily outside the Agency's control, NASA has developed tools that can improve the fidelity of cost and schedule estimates. To this end, since 2006, NASA has required progressively more sophisticated probabilistic estimating techniques, culminating in 2009 with formal adoption of a Joint Cost and Schedule Confidence Level (JCL) requirement.¹

We initiated this audit to determine whether NASA had implemented appropriate controls and procedures to establish a JCL process capable of improving cost and schedule estimates and therefore providing more reliable information to decision makers. We reviewed the 22 NASA projects with a combined price tag of more than \$49 billion that have undergone a JCL analysis, conducted in-depth case studies, interviewed project managers and project personnel, and gathered information from Agency officials responsible for implementing and overseeing the JCL process. See Appendix A for details of the audit's scope and methodology.

Background

A JCL analysis generates a representation of the likelihood a project will achieve its objectives within budget and on time. The process uses software tools and models that combine cost, schedule, risk, and uncertainty to evaluate and illustrate how expected threats and unexpected events affect a project's cost and schedule. To generate this data, project managers develop comprehensive project plans, inputs, and priorities that integrate costs, schedules, risks, and uncertainties. NASA officials contend that gathering this data encourages better communication among project personnel; improves cost, schedule, risk, and uncertainty analyses; and fosters an understanding of how project elements impact one another. Accordingly, a JCL analysis not only establishes the basis for proposing program and project budgets, but may improve project planning and provide stakeholders the rigor and documentation required to justify funding requests. Table 1 identifies the 22 projects for which NASA has completed a JCL analysis since 2009.

¹ NASA Policy Directive (NPD) 1000.5, "Policy for NASA Acquisition," January 15, 2009. Probabilistic estimating adds prospective ranges to cost and schedule elements to generate project outcomes and determine the likelihood a project will meet a particular cost and schedule.

Table 1: NASA Projects with a Completed JCL Analysis

Project ^a	Mission Directorate	Baseline Date ^b	Life-Cycle Cost (millions of dollars)	Actual or Expected Launch Date
NuStar	Science	September 2009	161	June 2012
MMS	Science	June 2009	1,083	March 2015
LDCM	Science	December 2010	942	February 2013
MSL ^c	Science	June 2009	2,331	November 2011
LADEE	Science	August 2010	263	September 2013
OCO-2 ^c	Science	January 2013	468	July 2014
SOFIA ^c	Science	October 2010	3,016	February 2014
MAVEN	Science	October 2010	671	November 2013
JWST ^c	Science	September 2011	8,835	October 2018
GPM ^c	Science	October 2011	961	February 2014
SMAP	Science	September 2012	917	January 2015
ICESat-2 ^c	Science	May 2014	1,064	June 2018
SGSS ^d	Human Exploration and Operations	April 2013	863	June 2017
OSIRIS-REx	Science	May 2013	1,121	October 2016
GRACE-FO	Science	February 2014	432	February 2018
SPP	Science	March 2014	1,553	August 2018
InSight	Science	March 2014	675	March 2016
TESS	Science	October 2014	378	June 2018
SLS ^e	Human Exploration and Operations	August 2014	9,695	November 2018
GSDO ^e	Human Exploration and Operations	September 2014	2,813	November 2018
ICON	Science	October 2014	253	October 2017
Orion ^e	Human Exploration and Operations	September 2015	11,284	April 2023

Source: NASA OIG analysis.

^a See Appendix B for a list of the projects and their acronyms.

^b A project's baseline consists of requirements, costs (both development and life-cycle, that is, through the end of planned operations), schedule, and technical information that forms the foundation for project execution and performance assessment.

^c Information depicted is for projects' updated or "rebaselined" cost and schedule estimates.

^d Project is in the process of being rebaselined; therefore, figures depict original cost and schedule estimates.

^e Information depicted is the project's baseline commitment to a Launch Readiness Date.

Evolution of NASA's Estimating Practices

The building blocks for NASA's JCL process are projects' cost (point) estimates, Integrated Master Schedules, and continuous risk management databases.² Unlike estimates derived from the JCL process, point estimates do not include a probabilistic analysis. NASA primarily uses three techniques to develop point estimates.

- Analogy cost estimating that adapts actual costs from similar projects.
- Parametric cost estimating that applies historical, statistical trends to available data from the current project.
- Engineering build-up or grass roots estimating that estimates and totals the cost of each activity in the project schedule.

Integrated Cost and Schedule Estimation

As early as the 1960s, NASA integrated the costs and schedules of its projects using the Program Evaluation and Review Technique (PERT). PERT considers the probability of project success by factoring an optimistic, pessimistic, and most likely cost estimate into each element in the schedule. NASA phased out PERT in 1967 after concluding its impact on estimate accuracy did not justify its costs.

Probabilistic Cost Estimation

In 2002, the Agency recommended projects provide estimates of the likelihood of success when requesting funds so that budgets could be developed with sufficient reserves to manage the unpredictable challenges inherent in developing space missions. In 2004, following a recommendation from GAO that NASA incorporate risk and uncertainty into its cost estimation models, the Agency began recommending cost model probability distributions and implemented a 70 percent cost confidence level requirement.³ This policy was more widely adopted following the then-Administrator's insistence on confidence level budgeting for the Constellation Program.⁴

Establishment of the JCL Requirement

In its 2004 report, GAO recommended NASA adopt many of the key features of the JCL process, including the Monte Carlo simulation, risk and uncertainty analyses, and independent reviews.⁵ NASA first formalized the use of probabilistic and confidence based models in 2005 with a brief mention of risk-adjusted costs and a requirement that projects "determine a level of confidence in successfully

² An Integrated Master Schedule is a logic driven schedule that identifies and assigns timelines to all tasks required to complete a project. The continuous risk management database is a repository for documenting and tracking identified risks.

³ GAO, "NASA: Lack of Disciplined Cost-Estimating Processes Hinders Effective Program Management" (GAO-04-642, June 22, 2004). A 70 percent confidence level indicates the project's likelihood of being completed within the established cost estimate.

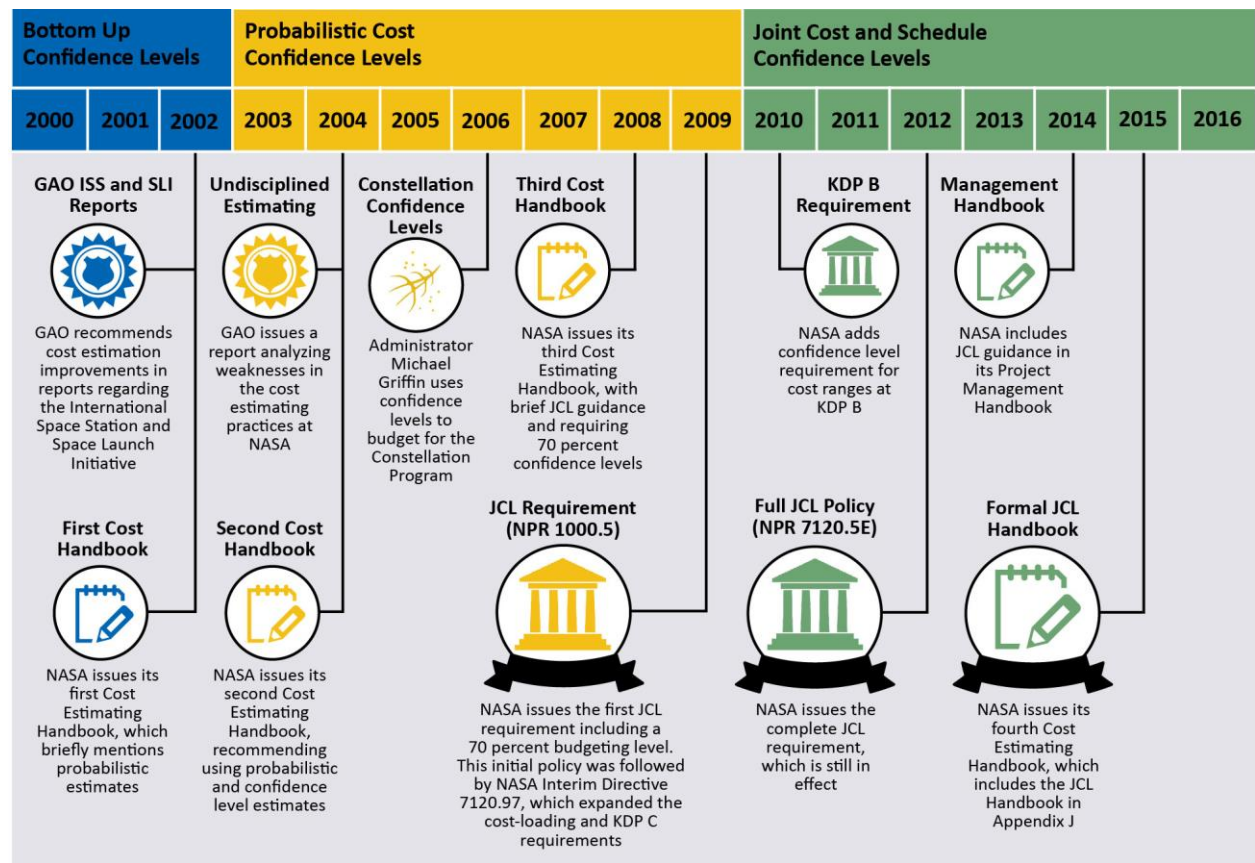
⁴ The Constellation Program was a NASA human space flight program with goals to travel to the Moon and eventually Mars. The Program encountered significant cost and schedule delays and was cancelled in 2010.

⁵ GAO-04-642. The Monte Carlo process randomly generates numbers and simulates events to estimate solutions to complex problems. As part of the JCL analysis, Monte Carlo is one of the methodologies used to randomly generate cost, schedule, and risk values within the parameters provided.

completing the system(s) within the estimated cost” in NASA Procedural Requirements (NPR) 7120.5C.⁶ In 2009, NASA implemented NASA Policy Directive (NPD) 1000.5 requiring use of joint cost and schedule estimates in Agency acquisitions. These estimates fully integrate cost, schedule, and risk with uncertainty to produce probabilistic estimates that reflect the impact of risk and uncertainty on planned cost and schedule. The NPD also required programs be baselined and budgeted at the 70 percent joint cost and schedule confidence level and funded at a minimum of 50 percent of that level. From that point forward, NASA has required joint cost and schedule confidence levels for the life-cycle cost and schedule estimates established at project baseline, about mid-way through the development cycle.

In 2012, the requirement to perform a JCL analysis was moved to NPR 7120.5E and the Cost Analysis Division (CAD) of NASA’s Office of Evaluation was assigned responsibility for maintaining and implementing the requirement.⁷ This policy and many of the current processes for conducting probabilistic risk analyses are contained in NASA’s Cost Estimating Handbook, originally published in 2002 and most recently updated in 2015.⁸ The timeline for implementation of the JCL requirement at NASA is shown in Figure 1.

Figure 1: NASA’s Cost Policy Timeline



Source: NASA OIG analysis.

⁶ NPR 7120.5C, “NASA Program and Project Management Processes and Requirements,” March 22, 2005.

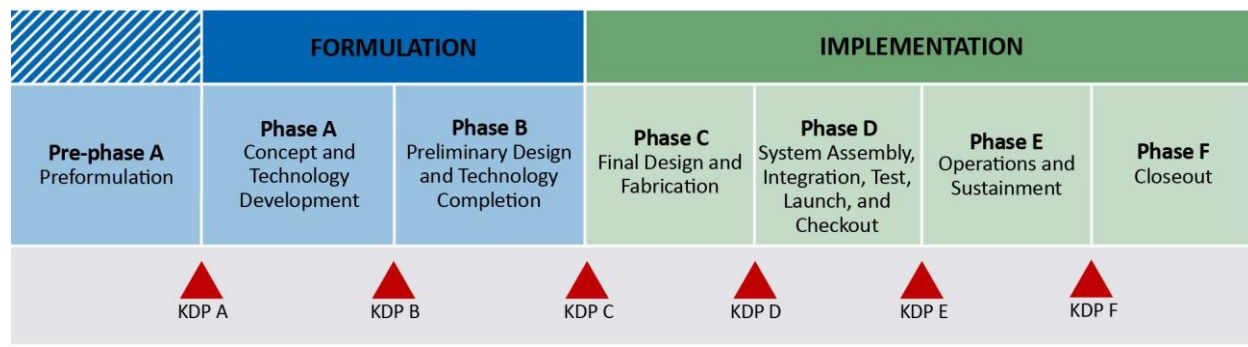
⁷ NPR 7120.5E, “NASA Space Flight Program and Project Management Requirements,” August 14, 2012.

⁸ NASA Cost Estimating Handbook, Version 4.0, February 2015.

NASA Project Life Cycle

As shown in Figure 2, NASA divides the life cycle of its space flight projects into two major phases – Formulation and Implementation – which are further divided into phases A through F. Phases A and B consist of Formulation and C through F Implementation. This structure allows managers to assess the progress of their projects at key decision points (KDP) in the process.⁹ Before proceeding to Implementation, projects must pass through KDP C, at which time decision makers assess the preliminary design to determine whether the project is sufficiently mature to proceed and establish cost and schedule baselines against which the project will thereafter be measured. NPR 7120.5E requires projects to conduct a JCL analysis at KDP C for: (1) each single-project space flight program, (2) each program of interdependent space flight projects (tightly coupled program), and (3) any space flight project for which the estimated life-cycle cost is more than \$250 million. This analysis must cover all remaining costs through Phase D of the project (i.e., all costs required to get the project into operation).¹⁰

Figure 2: Project Life Cycle



Source: NPR 7120.5E.

Based on this analysis, projects are funded at a minimum of the 50 percent confidence level (the Management Agreement) and budgeted at the 70 percent confidence level (the Agency Baseline Commitment or external commitment), although the Decision Authority for a project – namely the Mission Directorate Associate Administrator or NASA Associate Administrator who chairs the respective Directorate Program Management Council and Agency Program Management Council – may approve exceptions to these levels.¹¹ A JCL is also required when a project is rebaselined or upon the Decision Authority’s request.¹²

⁹ A KDP is defined as the point in time when the Decision Authority – the responsible official who provides approval – makes a decision on the readiness of the project to progress to the next life-cycle phase. KDPs serve as checkpoints or gates through which projects must pass.

¹⁰ Projects that do not clearly define development phases may be required to provide a JCL analysis up to a point agreed upon between the Decision Authority and the project, such as achievement of full operational capability.

¹¹ The Management Agreement is regarded as a contract between the Agency and the program/project manager and provides the parameters and authorities over which the program/project manager is accountable. The Agency Baseline Commitment contains the cost and schedule parameters NASA submits to the Office of Management and Budget and Congress.

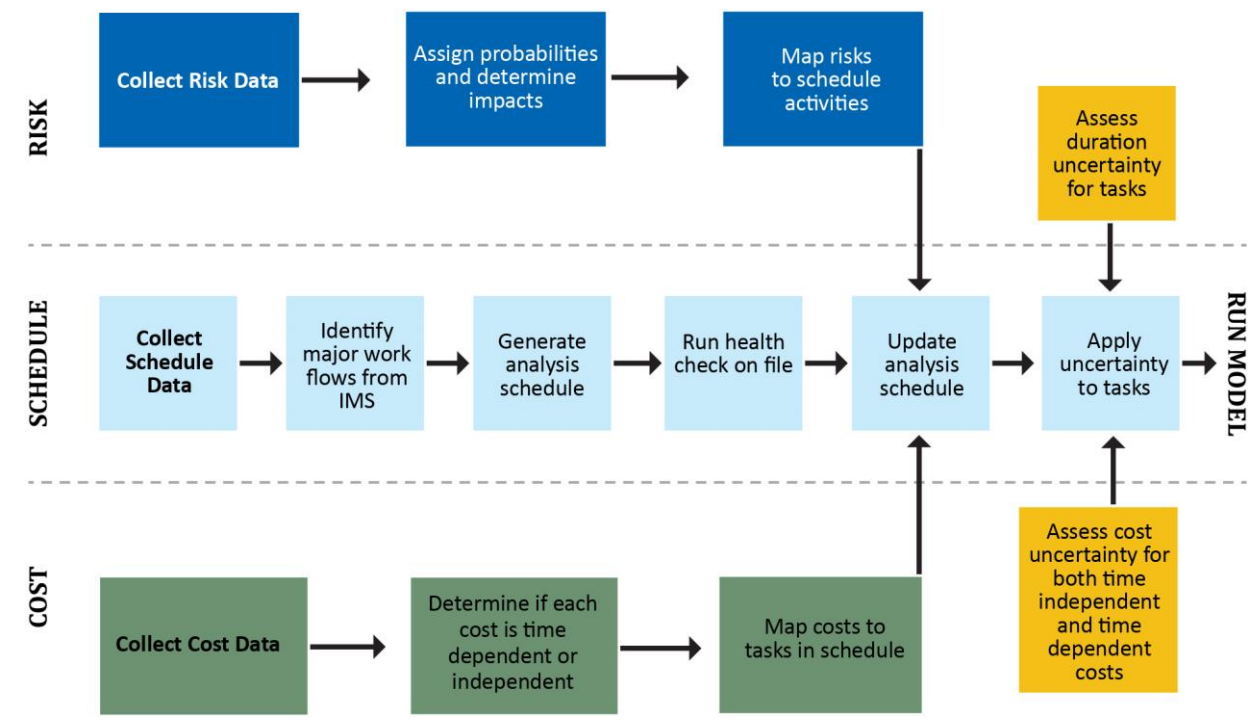
¹² NASA may rebaseline a project when significant changes are required or under the terms of Pub. L. No. 109-155 Section 16613 (b)(f)(4), which requires Congressional authorization to continue any project that will exceed the development cost estimate provided in the baseline report by 30 percent or more, or if launch is delayed by 6 months or more.

The 50 percent confidence level was adopted to give projects a “50/50 chance” of successfully meeting their cost and schedule commitments. Funds associated with the difference between the 50 and 70 percent confidence levels are held outside of the project at the Mission Directorate level as unallocated future expenses and can be transferred between projects within a program’s portfolio, if for example, a project does not need all of the resources originally allocated to it. When projects are grouped into a diversified portfolio, using a 70 percent confidence level may yield a higher cumulative probability of success by balancing individual project success, diversification of risk, the availability of operational capital, and reducing the impact of cost overruns (portfolio effect).

Building a JCL Model

To perform a JCL analysis, project teams assemble an analysis schedule or use the project’s Integrated Master Schedule (IMS) that includes all remaining tasks through Phase D.¹³ The team incorporates time independent costs (costs incurred regardless of project duration, such as for materials) and time dependent costs (costs that change proportionately with schedule changes, such as for labor) into the schedule. To account for foreseeable but potentially unrealized risks and historical variations in cost and schedule, the team loads discrete cost and schedule risks into the model along with the events those risks are expected to impact. Risk values include both the timing and value of a risk’s expected impact, as well as the likelihood it will occur.¹⁴ See Figure 3 for a visualization of the JCL analysis process.

Figure 3: JCL Process – Integration of Cost, Schedule, and Risk



Source: NASA OIG analysis.

¹³ An analysis schedule is typically a truncated version of a project’s IMS. NPR 7120.5E requires projects to develop an IMS and the NASA Schedule Management Handbook, March 2011, recommends building an IMS as a best practice.

¹⁴ Projects must also include correlation values, which are measures of the tendency for two attributes to vary together.

To account for unforeseeable events, the project team includes uncertainty values in its analysis. According to NASA's Cost Estimating Handbook, uncertainty is indefiniteness about a project's baseline plan and represents the fundamental inability to perfectly predict the outcome of a future event. Uncertainty values include an optimistic, pessimistic, and most likely point estimate for cost, schedule, and risk inputs.¹⁵

All of these variables are analyzed using a simulation analysis tool that can perform Monte Carlo or Latin Hypercube functions.¹⁶ This process requires risk and uncertainty values because the tools select stratified random values within the ranges provided to simulate variations in cost and schedule. A single cost and risk loaded schedule can produce thousands of potential results. For example, if two tasks both take between 5 and 10 days, the tool will analyze random durations of each task such as 7 and 5 days, 8 and 9 days, and 7 and 10 days to show variations in duration between a total of 10 and 20 days.

NASA has several software tools to run these simulations: Oracle's Primavera Risk Analysis, Tecolote Research, Inc.'s Joint Analysis Cost/Schedule (JACS), and Booz Allen Hamilton Inc.'s Polaris (Polaris). Each of the software packages has scheduling, cost loading, and risk modelling capabilities and each produces a variety of analysis tools, including sensitivity reports, criticality indices, annual reports, and risk impact charts. JACS and Polaris were sponsored and partially funded by NASA, tailored with features and inputs geared toward serving the Agency and its unique projects, have been provided at a reduced cost, and are recommended in the 2015 NASA Cost Estimating Handbook.

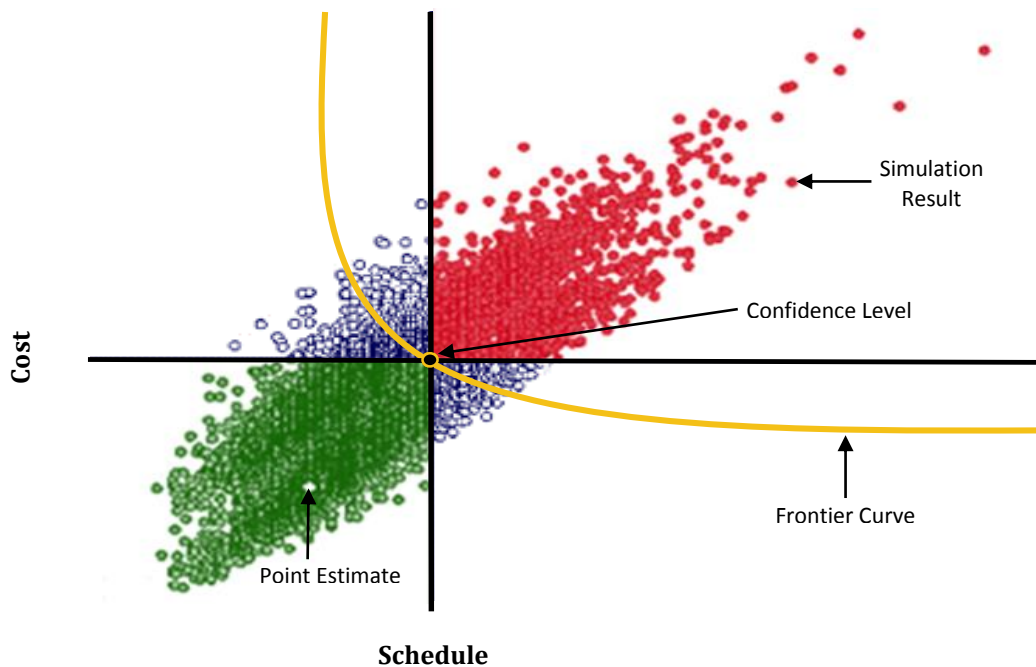
JCL results are typically represented in a scatter plot in which each point is a result of the simulation calculation representing one cost and schedule pair. The scatter plot translates into the final confidence level by indicating the point at which 70 percent of the modelled scenarios lie below the selected cost and schedule estimate.¹⁷ As shown in Figure 4, three points are typically reflected in the scatter plot: the point estimate (the cost and schedule without any uncertainty analysis), the 50 percent confidence level (the amount of funding the project receives), and the 70 percent confidence level (the external commitment and the minimum project budget including reserve). Additionally, projects model different scenarios by using combinations of risks and can view the potential consequences of each scenario. Project management uses the results of the analysis to develop the project plans and budgets that will be presented to key stakeholders during the life-cycle review process.

¹⁵ Projects also use distribution curves to describe the likelihood of each estimate. Normal, lognormal, Weibull, Rayleigh, PERT, or uniform distributions are commonly used probability distributions.

¹⁶ Latin Hypercube sampling is a technique that allows the user to study the effects of assumptions on selected input variables.

¹⁷ Numerous points will fall along the "Frontier Curve" (below which 70 percent of the modelled scenarios lie). The scatter plot represents a snapshot in time and is only valid for the time it is run. For example, if costs or schedule changes are realized later in the project development, management must run a new model to obtain a valid JCL.

Figure 4: JCL Scatter Plot Results



Source: NASA.

Note: The plot demonstrates the result of a Monte Carlo analysis of a probabilistic cost loaded schedule. The schedule portion is represented on the horizontal axis while the cost component is represented on the vertical axis. Each point represents a simulation result. The red points represent simulation results that overrun the required joint confidence level, while the green points represent the simulation results that satisfy the required joint confidence level. The blue points are simulation results that meet either the cost or schedule at that confidence level. The crosshairs divide the graph into points that meet the schedule confidence level and the cost confidence level. The Frontier Curve represents all of the points that would satisfy both the cost and the schedule confidence level requirement. The point that represents the project's cost and schedule without any risks or uncertainty applied is called the point estimate.

Key Stakeholders in the JCL Process

Project managers are responsible for creating the JCL models for their projects while the CAD, a division of NASA's Office of Evaluation, is responsible for implementing the JCL process and providing projects with guidance on how to execute a JCL analysis. Independent assessments of the results of the JCL analysis are performed by programmatic analysts from the Independent Program Assessment Office (IPAO) that are part of the Standing Review Board (SRB) and analyze projects' JCL model results.¹⁸ SRBs are normally provided access to a project's JCL model 60 days before the life-cycle review. Ongoing dialogue between SRB and project personnel to clarify the project's analysis and revisions based on that dialogue typically occur through the conclusion of the project's life-cycle review. The results of the project and the independent reviews are presented to the relevant Directorate Program Management Council or the Agency Program Management Council and the Decision Authority who makes the final budget and schedule determination to establish the Management Agreement and the Agency Baseline Commitment, both of which are documented in the KDP C Decision Memorandum.

¹⁸ An SRB is composed of independent experts who provide assessments of the project's technical and programmatic approach, risk posture, and progress against the project baseline and offer recommendations to improve performance or reduce risk. A new SRB is selected for each project. The technical evaluators of the SRB are funded by the Directorate under which the project falls. The programmatic members from the IPAO are funded by the Agency.

NASA'S JCL PROCESS IS HELPFUL BUT CAN BE IMPROVED TO PROVIDE MORE ACCURATE DATA AND BETTER INFORM DECISION MAKERS

Based on a review of 22 projects, it appears the JCL policy is having a positive impact on NASA's historical challenges with cost and schedule fidelity. That said, the process is relatively new, still evolving, and not a one-stop solution to avoiding cost overruns and schedule delays. Specifically, the process has inherent limitations in that, like any estimating practice, it does not fully address the issue of predicting "unknown/unknowns" or address some of the root causes of NASA's project management challenges such as funding instability and underestimation of technical complexity.¹⁹

NASA could improve its JCL process to ensure it contributes to formulation of more consistent, accurate, and reliable cost and schedule estimates. Specifically, we found (1) varied expectations and understandings among stakeholders about the process, (2) issues with the quality of some cost, schedule, and risk data inputs, (3) a lack of formal SRB review procedures and robust controls to prevent overly optimistic results, and (4) inadequate training for involved personnel. Additionally, the confidence levels stipulated in the JCL policy may not be appropriate for single-project programs.

NASA Cost Estimates Improving Under JCL

As of August 2015, 10 of the 22 projects for which NASA performed a JCL analysis have launched. As shown in Table 2, four of those projects came in under budget, one met its budget, and five exceeded their budgets. However, only two of the overruns exceeded 10 percent.²⁰ Of the 12 projects currently in development, the Ice, Cloud, and land Elevation Satellite 2 (ICESat-2) was rebaselined with a revised development budget 37 percent higher than its baseline and the Space Network Ground Segment Sustainment (SGSS) Project is being rebaselined due to cost overruns and schedule delays. The other 10 projects appear to be executing within cost and schedule estimates; however, because 8 of them were baselined less than a year after our fieldwork began, it is too early in development to draw conclusions about the effect of the JCL process on cost and schedule estimates for these projects.

¹⁹ "Unknown/unknowns" are future situations that are impossible to predict.

²⁰ The JCL analyses for the Mars Science Laboratory (MSL), Stratospheric Observatory for Infrared Astronomy (SOFIA), and Global Precipitation Measurement (GPM) were performed in connection with rebaselines rather than initial estimates.

Table 2: Projects with JCLs Completed That Have Launched

Project ^a	Baseline Development Cost (millions of dollars)	Actual Development Cost (millions of dollars)	Percent Change
MSL ^b	1,720	1,769	3
SOFIA ^c	1,118	1,120	0
MMS	857	877	2
LDCM	588	503	(14)
MAVEN	567	472	(17)
GPM ^d	519	484	(7)
SMAP	486	479	(1)
OCO-2 ^e	249	329	32
LADEE	168	188	12
NuStar	110	116	6

Source: NASA OIG analysis.

^a See Appendix B for a list of the projects and their acronyms.

^b MSL development cost reflects project rebaseline after October 2009 launch date was missed. In 2006, NASA baselined development costs at \$969 million.

^c SOFIA development cost reflects the project's second rebaseline value. Historical development cost estimates are difficult for comparative purposes due to changing programmatic milestones. However, in 1997 NASA estimated costs for the project to reach its Operational Readiness Review of \$265 million.

^d GPM development cost reflects the project's rebaseline value. NASA descoped the project and set the initial baseline at \$555 million with a launch date of July 2013. The Project was further descoped and rebaselined to launch in February 2014.

^e OCO-2 baseline development cost reflects initial Agency Baseline Commitment, which for comparison purposes is analogous to the other projects listed in the table. OCO-2 was rebaselined in January 2013 as discussed on page 17.

These figures are a marked improvement from the Agency's record prior to implementation of the JCL process. For example, in the decade preceding implementation, 85 percent of NASA projects exceeded their budgets by an average of 53 percent (see Table 3).

Table 3: Development Cost Growth by Decade for Pre-JCL Projects Greater than \$250 Million

Decade	Number of Projects	Number of Projects Over Budget	Percent of Projects Over Budget	Average Cost Growth (percent)
1960 – 1969	2	2	100	179
1970 – 1979	5	4	80	240
1980 – 1989	22	21	95	87
1990 – 1999	15	12	80	95
2000 – 2009	20	17	85	53

Source: NASA OIG analysis of various sources.

Moreover, project managers told us the JCL process provides other benefits in addition to improved cost and schedule estimates. Specifically, by requiring that the fundamental elements of project management – cost, schedule, and risk – be integrated into a single framework, JCL can improve

communication between cost estimators, schedulers, and risk managers and enhance other aspects of project management such as modeling alternative scenarios and identifying key cost and schedule risk drivers.

In addition, by modeling different scenarios project managers and senior decision makers may gain a better understanding of the ways in which individual project risks affect cost and schedule. For example, with a JCL analysis managers interested in determining if a specific risk is worth mitigating can run the model with that risk “turned on” and “turned off” to determine how it might impact cost and schedule. Additionally, several of the software models have the capability to rank risks by their impact on cost and schedule.

Although we are encouraged by these indications of success, our enthusiasm is tempered by several factors. First, the population of projects with a completed JCL analysis is still relatively small, the process is still evolving, and more experience with the process is needed before definitive conclusions about its impact can be drawn. Second, as CAD officials noted, compared to the group of projects currently in development, the majority of the first 10 projects that underwent a JCL analysis and launched were generally smaller and less complex, while the 2 largest and more complex projects generally met rebaselined estimates. Therefore, it is not clear how JCL analyses will affect the fidelity of cost and schedule estimates for larger and more complicated projects. Finally, recent project successes may be attributable to factors other than the JCL process. For example, managers of the Mars Atmosphere and Volatile Evolution Mission (MAVEN) Project, who underran their baseline cost estimate by 17 percent, credit their success to sound project management practices such as gaining an early understanding of project risks, attaining a high technology readiness level, and establishing stable project leadership rather than the JCL process.

Stakeholders’ Expectations and Understanding of JCL Vary

We found varied expectations and understandings among stakeholders about the JCL process. We interviewed project teams that completed JCL analyses, Office of Evaluation personnel, NASA Center and program executives, and Center support personnel and reviewed external reports and other public documents to obtain an understanding of stakeholder expectations of JCL. We found expectations for the process ranged from those who see JCL as a multifunctional tool that can significantly improve cost and schedule management to others who view it as just another task projects must complete before moving into the development phase. The former creates expectations the JCL process cannot currently meet, while the latter would constitute a waste of resources that discounts the benefits JCL can provide.

Additionally, NASA needs to ensure it does not oversell the benefits of the JCL process. For example, in a hearing before the Subcommittee on Space Aeronautics in May 2007, the Associate Administrator for the Science Mission Directorate described NASA’s then new policy requiring a 70 percent confidence level as a process that “will greatly reduce mission costs.”²¹ Similarly, in its fiscal year 2014 budget request NASA linked cost and schedule performance to estimation and asserted that JCL had improved the cost performance of such projects as the National Polar-orbiting Operational Environmental Satellite System Preparatory Project (NPP), Mars Science Laboratory (MSL), MAVEN, and Landsat Data Continuity

²¹ U.S. House of Representatives, Committee on Science and Technology, House Report 110-935 - Summary of Activities (U.S. Government Printing Office, 2009).

Mission (LDCM).²² However, several of these projects, including NPP and MSL, had previously overrun established cost and schedule estimates and been rebaselined, and NASA did not conduct a JCL analysis for them until relatively late in the development process, after many cost growth and schedule delay issues had already been identified and quantified.²³ In our judgment, NASA must take more care to ensure stakeholders understand what JCL can and cannot do so that the process is not perceived as solely responsible when cost and schedule overruns or underruns occur.

The JCL Process is Not a One-Stop Solution for Addressing All Root Causes of Project Cost Growth and Schedule Delay

While there is a general consensus among project teams, Center support personnel, and senior Mission Directorate executives that the JCL process can improve cost and schedule estimating, the process does not address some of the root causes undergirding cost overruns and schedule delays in NASA projects. In Table 4, we summarize JCL’s ability to address 14 root causes commonly associated with NASA’s project management challenges.²⁴

Table 4: JCL’s Ability to Address Root Causes of Cost Overruns and Schedule Delays

Root Cause	Positive Impact by JCL		
	None	Some	Significant
Inadequate Definitions Prior to Agency Budget Decision and to External Commitments		✓	
Optimistic Cost Estimates/Estimating Errors		✓	
Inability to Execute Initial Schedule Baseline			✓
Inadequate Risk Assessments			✓
Higher Technical Complexity of Projects than Anticipated	✓		
Changes in Scope (Design/Content)		✓	
Inadequate Assessment of Impacts of Schedule Changes on Cost		✓	
Annual Funding Instability	✓		
Eroding In-House Technical Expertise	✓		
Poor Tracking of Contractor Requirements Against Plans	✓		
Launch Vehicle Problems		✓	
Inadequate Reserves		✓	
Lack of Probabilistic Estimating			✓
“Go As You Can Afford” Approach	✓		

Source: NASA OIG analysis and assessment of comments from subject matter experts interviewed.

²² The Management and Performance section of NASA’s Congressional Justification, Addressing Management Challenges and Improving Performance (see http://www.nasa.gov/pdf/754125main_12-NASA_FY14_M&P508-pt3.pdf, accessed August 3, 2015).

²³ See NASA OIG, “NASA’s Management of the NPOESS Preparatory Project” (IG-11-018, June 2, 2011) and “NASA’s Management of the Mars Science Laboratory Project” (IG-11-019, June 8, 2011).

²⁴ In a September 2012 audit, we examined NASA’s challenges to achieving cost, schedule, and performance goals. NASA OIG, “NASA’s Challenges to Meeting Cost, Schedule, and Performance Goals” (IG-12-021, September 27, 2012).

Consistent with the opinion of many subject matter experts from NASA’s estimating community, we found that the JCL process has “significant” impact on only 3 and “some” impact on 6 of the 14 causes. However, NASA management stated the JCL requirement has had some impact on annual funding instability and the “go as you can afford” approach, in that policy makers have been less willing to revise budgets for projects that have gone through the JCL analysis and established Agency Baseline Commitments. Nevertheless, JCL is not a one-stop solution for solving all the root causes of cost growth and schedule delays and other management tools must be used to address these project management challenges.

Inherent Limitation of the JCL Process

While NASA’s JCL process is structured to consider all known risks at the time the analysis is performed – generally at the end of the formulation phase – some studies have indicated that a significant number of risks to project success are typically not identified until later in the project cycle. Consequently, the potential impact of these “unknown risks” is not fully quantified as part of the JCL process. One way NASA attempts to mitigate this issue is by funding projects at the 50 percent confidence level but budgeting at the 70 percent level – with the difference held as unallocated future expenses by the Mission Directorate. In addition, most projects we reviewed tried to predict and include in the JCL analysis as many risks as possible, including potential “unknown risks.” To assist in this process some project managers suggested developing an Agency-wide database to capture potential risks projects should consider.²⁵ In addition, CAD is working on methods to collect and quantify the impact of unknown risks on projects for incorporation into JCL analyses.

The JCL Model is Not Intended to Be Used as a Validation Tool for Day-to-Day Project Management

Several projects we reviewed inappropriately viewed the JCL analysis as a tool to validate the project’s point estimate. As a result, confidence levels were set to correlate with the point estimate, rather than to analyze and determine the budget and schedule required to attain a 70 percent confidence level. The JCL process is part of NASA’s estimating process that brings a probabilistic component to a project’s point estimate, not an independent cost estimate intended to validate that estimate.

Additionally, in their February 2015 High-Risk Series report to Congress, GAO stated that regular updates to projects’ JCLs is critical to improving NASA acquisition outcomes.²⁶ CAD and some Center-based JCL support personnel also envision the JCL process and the associated software as a project management tool that can be used throughout the development phase of a project. However, some projects told us that performing the JCL analysis was a labor intensive process requiring several months to complete. Considering the time it takes to develop and run the model and the other project management tools available and required of managers, such as Earned Value Management (EVM), we believe the JCL

²⁵ At the Center-level, Goddard Space Flight Center personnel told us of efforts to collaborate and share risks between projects at their Center.

²⁶ GAO, “High-Risk Series: An Update” (GAO-15-290, February, 2015).

process in its current state is most valuable to the Agency for providing the needed information to establish the project’s baseline cost and schedule at KDP C.²⁷ In the future, as the process is improved and the software evolves, NASA can consider expanding the role JCL plays in project management and performance monitoring.

Questionable Quality of Some Inputs to the JCL Model

As previously noted, the building blocks for NASA’s JCL process are the projects’ cost and schedule point estimates, IMS, and continuous risk management databases. Accordingly, the quality of these inputs affects the accuracy of the JCL output. Given their importance, we conducted in-depth assessments of 9 of the 22 projects that have completed a JCL analysis and found significant weaknesses in the areas of project scheduling, risk assessment, and cost estimating in 5 of the projects. Remedying these weaknesses would improve the overall accuracy of JCL analyses.

Project Schedules

We identified issues with the schedules of two of the projects reviewed – SGSS and the James Webb Space Telescope (JWST) – that may have affected their JCL analyses. Additionally, two program analysts, two project managers, and several JCL consultants we interviewed identified the scheduling function as an area for improvement, particularly as it relates to the availability of experienced schedulers.

Projects have the option of using an IMS or a derived analysis schedule for the JCL analysis.²⁸ The majority of the 22 projects used a derived analysis schedule; however, some projects such as the Lunar Atmosphere and Dust Environment Explorer (LADEE), Stratospheric Observatory for Infrared Astronomy (SOFIA), and Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) used their IMS.

Regardless of which type of schedule a project uses, it is essential that schedule logic be accurate and representative of the actual work to be completed between and within each activity to ensure accurate dates and critical paths are generated when activity durations in simulations change based on assigned probability distributions and ranges.²⁹ If an analysis schedule is used to conduct a JCL analysis, it must be updated as work is completed and discrete risk data kept current. This ensures simulations will run in accordance with the probability of occurrence and impact assigned to each discrete risk and the uncertainty distributions and ranges assigned to the schedule activities.

²⁷ EVM is a methodology for integrating scope, schedule, and resources to objectively measure and assess project performance and progress during the execution of a project. Earned value data provides the value of work performed expressed in terms of the approved budget assigned to that work for an activity or work breakdown structure component.

²⁸ An analysis schedule is a high-level overview of an entire program/project where a subset of task durations is captured in a single task.

²⁹ A critical path is the sequential path of tasks in a network schedule that represents the longest overall duration from “time now” through project completion. Any slippage of tasks in the critical path will increase the project duration.

We found that significant professional scheduler experience is required to derive an analysis schedule from the IMS with sufficient detail to attach discrete risks, accurately represent total project float, and not be ambiguous or require assumptions regarding the time required to complete tasks – assumptions that can be highly inaccurate.³⁰ We identified two projects for which creating a representative analysis schedule proved challenging.

Space Network Ground Segment Sustainment

A lack of experienced schedulers proved problematic for SGSS. First, few schedulers had experience with software projects in which multiple development and integration activities were occurring simultaneously (parallelism). Second, the schedulers lacked experience handling large contracts for projects not developed “in-house” by NASA personnel and did not participate significantly in the JCL process. Consequently, the schedulers struggled to create an analysis schedule that was sufficiently detailed to properly apply discrete risks to the activities projected to be impacted. Moreover, the project’s IMS was complicated and poorly constructed and therefore did not provide adequate guidance to the JCL team. Ultimately, the project breached the 30 percent cost growth threshold, requiring a rebaseline and approval from Congress to continue development. According to the project manager, projects that are not NASA-developed would benefit from having experienced schedulers assigned.

James Webb Space Telescope

Issues with JWST’s IMS and project management’s approach to development of the JCL analysis schedule may have impacted the quality of the analysis. First, after the project exceeded its baseline cost estimate by more than 30 percent and schedule by more than 6 months, NASA halted development work, re-planned the schedule in 2011, and, because the IMS was not available, based the project’s JCL model on the contractor’s intermediate schedule.³¹ Second, GAO identified issues with JWST’s analysis schedule stemming from activity durations that were too long and overly summarized.³² Specifically, during their review GAO noted that 46 activities had durations ranging from 500 to more than 1,000 days and because the critical path was made up of six level of effort activities all with the same duration of 2,238 days, it was not adequate.³³ In their supporting documentation, GAO further explained the impact of using such a compressed analysis schedule:

Since the purpose of the critical path is to show the work necessary to finish the project, [level of effort] activities should never be on the critical path because they cannot drive any milestone finish date . . . With the prevalence of so many very long summary activities in the longest path and in the risk analysis it is a concern that this schedule is too summary to give a reliable picture of the JWST plan and puts into question the risk analysis presented by the program. So much of the work is summarized at a high level that we do not know what is included in some very long activities, where to put the risks, and how to account for the areas of total float.

³⁰ Total project float is the amount of time a task or milestone can slip before affecting the project end date.

³¹ In October 2010, NASA notified Congress pursuant to Public Law 109-155 that JWST would exceed its baseline cost estimate by more than 15 percent and its schedule by longer than 6 months. In August 2011, NASA notified Congress that JWST would exceed its baseline cost estimate by more than 30 percent and by longer than 6 months.

³² GAO, “James Webb Space Telescope: Actions Needed to Improve Cost Estimate and Oversight of Test and Integration” (GAO-13-4, December 3, 2012).

³³ Level of effort activities require effort of a general or supportive nature that does not produce definite end products.

Project Risk Assessment Needs To Improve

A credible JCL analysis requires inclusion of all known discrete technical and programmatic risks with potential cost and/or schedule impacts and an accurate analysis of the probability of their occurrence. We found that several projects – ICESat-2, SGSS, LADEE, and Orbiting Carbon Observatory-2 (OCO-2) – did not identify all relevant development risks at KDP C and/or did not accurately quantify the full impact of the risks included in their JCL models.

Ice, Cloud and land Elevation Satellite-2

The ICESat-2 mission appropriately identified 49 project-level discrete development risks at KDP C but underestimated by approximately \$120 million the impact of schedule uncertainty; specifically, those risks associated with development of the Advanced Topographic Laser Altimeter System instrument. This significantly contributed to an increase in the Agency Baseline Commitment from approximately \$860 million to \$1.1 billion.

Lunar Atmosphere and Dust Environment Explorer

The LADEE mission did not model risks outside the project’s control and used a conservative range of likelihood of occurrence for each identified risk. LADEE project managers told us they had difficulty obtaining a comprehensive list of risks at KDP C because team members overestimated the likelihood of success for their parts of the project and therefore underreported the number of risks. The Aerospace Corporation subsequently provided an independent cost estimate for the project’s development showing higher cost and schedule estimates based on modeling additional risks from its experience with previous projects.³⁴ This estimate added \$27 million and 8 months to the project’s projected Agency Baseline Commitment.

We concluded that projects that do not include all development-related discrete risks – accurately modeled with respect to probability of occurrence and potential cost or schedule impacts – must include those potential impacts as uncertainties in their project’s baseline and categorize them as “unknown/unknowns.” However, in doing so project managers assume an inherent risk of excluding, underestimating, or overestimating those impacts on a project’s JCL cost and schedule estimates because the consequence of uncertainty cannot be accurately modeled.³⁵

Artist Depiction of ICESat-2



Source: NASA.

³⁴ The Aerospace Corporation (Aerospace) is a non-profit organization that provides independent advice based on proprietary risk data to increase the likelihood of space mission development success. Aerospace conducted the SRB function instead of the IPAO due to the small size of the LADEE Project.

³⁵ Uncertainties are influences on a project’s cost or schedule originating from an event or condition which will definitely occur but with an unknown or uncertain effect(s).

Space Network Ground Segment Sustainment

Although SGSS properly considered and generally included all known risks in the JCL model, we found project managers significantly underestimated the magnitude of some of these risks, which contributed to a \$345.7 million cost overrun and 27 month schedule delay. We found managers properly utilized the monthly risk management process, identified all appropriate discrete development risks at KDP C, and included all significant risks listed in the risk register in the JCL model. However, project managers acknowledged significantly underestimating the magnitude of some of the identified risks, including the parallelism issue discussed previously.

Orbiting Carbon Observatory-2

NASA's JCL process requires management include all significant risks to a project's proposed cost and schedule regardless of whether they concern specific tasks in the project development path or relate to outside factors such as launch vehicles or international partner contributions. We found OCO-2's initial JCL analysis did not include launch vehicle risks. OCO-2 is a replacement mission for OCO, which failed to reach orbit in February 2009 when its Taurus XL launch vehicle experienced a payload-faring separation failure. In September 2010, NASA baselined OCO-2 with a Taurus XL launch scheduled for February 2013 – about 2 years after

another mission, Glory, was scheduled to launch on a Taurus XL. However, the Taurus XL used to launch the Glory mission failed in March 2011. After this failure, OCO-2 was forced to rebaseline and switch to the Delta II launch vehicle, increasing the project's life-cycle costs from \$349.9 million to \$467.7 million and delaying launch from February 2013 to February 2015. In light of the OCO failure and an overall relatively poor launch success rate for the Taurus XL, we believe it would have been advisable for OCO-2 managers to have included the risk of a launch failure during the Glory mission in their JCL analysis.³⁶

Artist Depiction of OCO-2



Source: NASA.

Underestimated Cost Related Inputs

The accuracy of every JCL model output depends significantly on the accuracy of the cost and activity duration inputs and the quality of the discrete risk data incorporated into the model. We found that cost and schedule baselines for SGSS and ICESat-2 were affected by inaccurate cost and schedule inputs.

Space Network Ground Segment Sustainment

The development plan for SGSS was overly optimistic, which resulted in an inaccurate point estimate of approximately \$300 million for the project. The low point estimate, combined with miscalculation of the impact of known risks at KDP C, resulted in inaccurate uncertainties being added to the project's baseline plan. These factors, coupled with SGSS project management's perception that the

³⁶ In September 2001, NASA's Quick Total Ozone Mapping Spectrometer was lost in a Taurus XL launch failure. Consequently, prior to the Glory launch the Taurus XL launch vehicle had demonstrated a 75 percent success rate, having flown six successful military missions and two failed NASA missions. The two failures occurred during the rocket's most recent three launches.

Management Agreement should not deviate significantly from the point estimate, resulted in a re-plan and a \$550 million contract cost that increased to \$850 million. The SGSS project team attributed its struggles with schedule analysis to the unique nature of the project and lack of comparable development activities; a lack of data and feedback from the contractor; uncertainty regarding the appropriate inputs to insert into the model; and difficulties appropriately applying programmatic, technical, and abstract risks into their analysis schedule. Many of these difficulties were a result of the relative newness of the JCL process and a corresponding lack of analogous models to reference.

The SGSS team also experienced difficulties applying cost and duration uncertainties to the JCL model. The uncertainty values the team applied were based on EVM data from Phase B that turned out to be nonpredictive because the contractor's productivity decreased as result of a combination of server, coding, and software parallelism development challenges that occurred after KDP C. Furthermore, the project acknowledged that generally NASA projects use historical data rather than EVM data as the basis for uncertainty inputs into their respective models.

Ice, Cloud, and land Elevation Satellite-2

We found the ICESat-2 mission underestimated the technical complexity of building the Advanced Topographic Laser Altimeter System instrument. Specifically, the engineering directorate did not understand how complex and challenging the instrument build would be and therefore significantly understated the cost and duration estimates. The project's JCL team used the Work Breakdown Structure to establish costs and appropriately identify all tasks.³⁷ However, the project's cost and schedule uncertainty values were determined through interviews with project team members, few of whom understood the concept of uncertainty in the context of a JCL analysis. Also, while the project appropriately identified discrete risks, the impact of those risks were masked by flawed cost estimates. In addition, the JCL team had difficulty extrapolating costs for technologies based on estimates for prior instrument builds and did not include launch vehicle costs. Moreover, the project chose not to rely on historical cost overrun data from analogous projects the SRB provided during the KDP C milestone review.

Improvements Needed to the Standing Review Board Process

JCL results assist Decision Authorities in determining whether a project should proceed into development and in setting budgets and schedules for a project's development phase. We identified weaknesses in the controls NASA has in place to help ensure the JCL process provides these Decision Authorities with reliable information. Specifically, we found that the effectiveness and consistency of the SRB review process could be improved.

NASA's SRB review process is intended to provide the Agency, Decision Authority, and key external stakeholders with an independent assessment of emerging project designs by comparing them to project plans, processes, and requirements. SRBs are tasked with conducting assessments free of bias through a membership balanced in terms of knowledge and experience, and are typically composed of

³⁷ Work Breakdown Structure is a product-oriented hierarchical division of the hardware, software, services, and data required to produce the program's or project's end product(s), structured according to the way the work will be performed and reflecting the way in which program/project costs and schedule, technical, and risk data are to be accumulated, summarized, and reported.

individuals from academia, industry, government, and nonprofit organizations. The group's reviews include an assessment of a project's JCL model, led by SRB members with technical expertise who focus on risk related activities in the model and SRB members from the IPAO who focus on its programmatic aspects (i.e., cost and schedule).

According to several senior NASA officials, it is important to the SRB process that members with technical expertise understand JCL analyses. Because the Decision Authority does not perform any assessments or tests of a JCL analysis when making key budgeting and schedule decisions, the SRB is the Agency's primary means to assess and ensure that each JCL model is comprehensive, accurate, and reliable.

We found that the extent and type of review the SRBs performed of JCL models and corresponding inputs varied widely from project to project. Specifically, we found (1) a lack of formal guidance related to establishing requirements for SRB review of the JCL process, (2) little or no JCL process training provided to or required for technical SRB members, (3) varying amounts of review of the JCL by SRB technical members, and (4) inconsistent expectations among the SRB chairs regarding how projects should consider and incorporate the results of the SRBs' review of the JCL analysis. In addition, NASA should provide the SRBs with more information about projects' model development process.

Guidance

NASA has not provided formal guidance to assist technical SRB members reviewing the results of JCL analysis. For example, project personnel from one project told us that they trained SRB members regarding the JCL process and corresponding software because there was no guidance for the members. In addition, one SRB chair told us he would like to have a better understanding of NASA's expectations of the SRB's JCL review process. Although technical SRB members have access to the guidance that IPAO uses when reviewing JCL models, we believe they would benefit from guidance specifically focused on their role in the process.

Training

Although technical SRB members have the option of attending an SRB "boot camp" that has a small JCL analysis component, NASA provides no formal JCL training for SRB members. Several senior NASA officials and several project team members expressed the view that SRB members need a better understanding of the JCL process. Additionally, personnel from three of the projects we surveyed commented that SRB members would benefit from additional training regarding the JCL process.

Model Review Effort and SRB Expectations

The time SRBs spent reviewing a project's JCL model varied significantly. For example, one SRB chair told us that technical members spent a "couple of hours" reviewing a particular JCL model, while another SRB chair indicated the technical members on his SRB spent several days reviewing a JCL model. The SRB chairs also differed regarding their expectations about how a project should use the results of the SRB's review of the project's JCL model. The majority of the chairs surveyed stated they expected projects to incorporate review results into their JCL models, while several others stated they do not expect projects to do anything in particular with the review results. Other SRB chairs stated that while they did not necessarily expect projects to incorporate their input, they did expect project personnel to understand the review results and the implications of not incorporating them.

NASA relies on the SRB to ensure each JCL analysis is comprehensive and accurate. Accordingly, we believe the Agency should also consider issuing formal guidance developing and requiring standardized training for SRB technical members related to the JCL review process.

Access to Additional Information Regarding Projects' JCL Development Process

As noted in our September 2012 report, a culture of optimism permeates every aspect of NASA. While essential to producing the types of unique space flight projects the Agency undertakes, this optimistic culture may also lead managers to overestimate their ability to overcome the risks inherent in delivering such projects within available funding constraints, which in turn can lead to the development of unrealistic cost and schedule estimates.³⁸ When properly administered, a JCL analysis is capable of illuminating instances where cost and schedule point estimates are unreasonable due to unrestrained optimism and performance expectations. Providing the SRB an opportunity to review how JCL inputs are established would help them assess the reasonableness of project-developed estimates. However, NASA's current JCL process does not provide SRBs with a complete record of projects' inputs or any modifications of JCL data.

At KDP C, SRBs receive confidence levels and corresponding cost and schedule estimates produced by project teams using one of several JCL software packages. However, the software does not track any changes the teams have made to inputs such as risk impacts, probabilities, and uncertainties, which could alter cost and schedule figures produced by the JCL analysis to make estimates fit perceived parameters of reasonableness. A software function that tracks such changes would provide the SRB with additional transparency into projects' model development processes and therefore additional opportunities for SRB members to question projects' underlying assumptions, inputs, and modifications. Agency officials told us that such a tracking function could be incorporated into the JCL software applications NASA uses.

NASA Has Not Provided Adequate Training for the Primary Users of JCL Analyses

NASA has not provided adequate training to project and oversight personnel concerning development and use of JCL analysis. The JCL process is the most recent cost and schedule estimating methodology adopted by NASA and has been a requirement at the Agency only since 2009. Accordingly, most projects required to perform a JCL analysis are doing so for the first time and many SRB technical members have limited experience with the process. Without adequate training, NASA cannot ensure that the JCL process will contribute to more reliable cost and schedule estimates.

The majority of program and project personnel we contacted stated they received no formal JCL process training. Rather, most indicated they became familiar with the process by "learning as they went" or by speaking with other project team members who had some experience building and executing a JCL analysis. Several project team members told us that at the request of their project they received limited

³⁸ IG-12-021.

training on the JCL process from CAD. They also cited several areas where formal training would have been helpful, including an overview of the JCL process and the stakeholders involved, the application of uncertainty, and training on risk-related inputs.

Until NASA released the new Cost Estimating Handbook in February 2015, the Agency had no formal JCL process guidance in place.³⁹ We reviewed several JCL models and found they varied in cost and schedule detail as well as in the level of effort exerted by the project in developing the JCL model. For example, the number of tasks in projects' schedules ranged from about 300 to 2,000. Some project personnel took the JCL process very seriously and were dedicated to building an accurate and comprehensive model while others seemed to do the minimum amount of work needed to satisfy NASA's requirement. In addition, one NASA official we spoke with stated that there needs to be more consistency in applying the JCL process between Centers. For example, JCL models for projects run out of the Jet Propulsion Laboratory are developed and executed by a dedicated Cost Estimation and Pricing Office and the Goddard Space Flight Center developed its own JCL handbook and hired a JCL liaison to oversee the JCL analyses. In contrast, projects managed at other Centers develop and execute the JCL themselves.

JCL Requirements May Not be Appropriate for Single-Project Programs

Requiring programs and projects be budgeted using the JCL process at a 70 percent confidence level and funded to at least the 50 percent confidence level appears to be a reasonable approach for a portfolio of loosely coupled projects such as the Mars Science Laboratory and MAVEN. However, it may be less appropriate for single-project programs such as the Space Launch System, Orion, or JWST. Single-project programs cannot leverage funding from other projects in the portfolio that finish under budget – a concept referred to as “portfolio theory.”⁴⁰ Additionally, they tend to be NASA's flagship missions and generally very expensive when compared to other projects and missions. Furthermore, large single-project programs that culminate in a long-term operational capability without an “end-of-mission” date have unique challenges in defining the life cycle to which the JCL is applied. These complexities are exacerbated by concurrent development of capability upgrades during the operational timeline.

Artist Depiction of MAVEN



Source: NASA.

³⁹ Limited guidance was first provided in the NASA Space Flight Program and Project Management Handbook (NASA/SP-2014-3705, September 2014).

⁴⁰ These types of projects do not benefit from the portfolio effect because these funds are less transferrable to other projects. Specifically, for these projects up to 5 percent of any specific appropriation may be transferred to another appropriation. However, such a transfer cannot increase the receiving appropriation by more than 10 percent.

When the JCL policy was first implemented in 2009, there was little rationale for budgeting projects at the 70 percent confidence level other than prior practice. In 2012, CAD undertook studies to determine whether the 70 percent confidence level maximized the use of the portfolio theory. The results showed that it was a sound strategy, but that deviations from the 70 percent level may be warranted for single-project programs that cannot take advantage of the portfolio effect.

While the current policy allows for justified deviations from the 70 percent requirement, the Agency may benefit from clarifying which programs and projects may be good candidates for such deviations. The lack of clear guidance or policy places the Agency at risk from a financial efficiency perspective and may lead to external stakeholders misinterpreting the intent of NASA's JCL process. For example, the explanatory report accompanying the 2012 Commerce, Justice, Science, and Related Agencies appropriations bill noted:⁴¹

The adoption of a joint cost and schedule confidence level (JCL) approach and a requirement for budgets to be formulated at a 70 percent JCL are positive steps for improving cost estimates, but the integrity of these policies is undermined by NASA's willingness to make exceptions and allow projects to move forward at lower confidence levels. The Committee urges NASA to discontinue the exception policy and strictly hold all projects to the 70 percent standard...

In our judgment, holding single-project programs to the 70 percent "standard" may not be an effective means of implementing the JCL process for these efforts.

⁴¹ House Report 112-169, Commerce, Justice, Science, and Related Agencies Appropriations Bill, 2012, July 20, 2011.

CONCLUSION

Historically, NASA has struggled to complete projects within cost and schedule estimates. In an effort to improve the fidelity of its estimates, the Agency began using the JCL process in 2009 and although it appears to be having a positive effect, the process is still evolving and it is too early to draw definitive conclusions about its value. Moreover, we found varied expectations and understandings among stakeholders about the process, issues with the quality of some of the information that goes into the model and regarding the effectiveness and consistency of the review process, and inadequate training for personnel involved throughout the process. Additionally, the confidence levels stipulated in the JCL policy may not be appropriate for single-project programs. Addressing these issues will improve the process to ensure it provides more consistent, accurate, and reliable cost and schedule estimates.

RECOMMENDATIONS, MANAGEMENT'S RESPONSE, AND OUR EVALUATION

To improve the Agency's JCL process, we recommended the Acting Director of the Office of Evaluation:

1. Clarify that project managers and Decision Authorities are to use JCL results as the basis for proposing and establishing project budgets rather than as a validation tool.
2. Assess the effectiveness of the scheduling function at NASA. Develop a plan to ensure all NASA Centers have access to trained and qualified schedulers with experience commensurate with the complexity of assigned projects.
3. Require all NASA projects to use historical data as JCL analysis inputs for cost and schedule uncertainties in addition to EVM data or subject matter expert opinion.
4. Establish formal guidance and clarify expectations governing the SRB review of JCL analyses.
5. Establish a formal, JCL-specific training program for project managers and technical SRB members.
6. Work with JCL software providers to add a function that tracks and creates a report reflecting modifications to input data and require SRBs to review the report to assess the appropriateness of any modifications.
7. Assess the appropriateness of the 70 percent confidence level requirement for single-project programs and consider clarifying or supplementing current requirement language.
8. Require all NASA projects include all identified relevant discrete development risks, to include strategic risks, with potential cost and/or schedule impacts in their JCL models.

We provided a draft of this report to NASA management, who concurred with seven of our recommendations and described actions the Agency has taken or will take to address them. We will close these recommendations upon completion and verification of the proposed corrective actions.

The Acting Director of the Office of Evaluation did not concur with our recommendation to add a function to JCL software that tracks and creates a report reflecting modifications to input data and require SRBs to review the report to assess the appropriateness of any modifications. However, the Agency's proposal to work with JCL software vendors to implement other features and functions that can aid with input data organization and verification is potentially responsive to our recommendation. The Acting Director also stated that a priority of the SRB is to understand the quality and basis of JCL estimates for projects' final input data. Although we continue to believe that adding a function that tracks data input and modification could aid in this endeavor and encourage NASA to re-evaluate the economic and operational feasibility of adding this functionality, we will resolve and close this recommendation upon reviewing the additional features and functions NASA implements.

In addition, with respect to our recommendation to require all NASA projects to include all identified relevant discrete development risks in their JCL models, the Acting Director asserted that NPR 7120.5E already requires projects to include all identified relevant risks in their analysis. However, as discussed in the report we found instances in which projects had not done so, which in turn resulted in inaccurate JCL analyses and project baselines. Accordingly, we encourage management to consider additional controls, share lessons learned, and devise a methodology to ensure adherence to the requirement that all risks to projects' cost and schedule are included in JCL models.

Lastly, the Acting Director stated that our report does not adequately credit the positive contributions made by the JCL policy relative to the 14 root causes of NASA's cost overruns and schedule delays. We disagree. As stated in the report, our assessment was not solely based on our research and analysis but was also informed by the opinion of subject matter experts we interviewed. We also note the input from the Office of Evaluation when determining the root causes of cost growth and schedule delays.

Management's full response to our report is reproduced in Appendix C. Additional technical comments provided by management have also been incorporated, as appropriate.

Major contributors to this report include Raymond Tolomeo, Science and Aeronautics Research Director; Stephen Siu, Project Manager; Gerardo Saucedo, Team Lead; and Scott Collins, Michael Day, and Alyssa Sieffert, Analysts. Additional support was provided by Monique Brewer, Patricia Reid, and Benjamin Patterson.

If you have questions about this report or wish to comment on the quality or usefulness of this report, contact Laurence Hawkins, Audit Operations and Quality Assurance Director, at 202-358-1543 or laurence.b.hawkins@nasa.gov.

A handwritten signature in black ink, appearing to read 'PKMJA', written in a cursive, stylized font.

Paul K. Martin
Inspector General

APPENDIX A: SCOPE AND METHODOLOGY

We performed this audit from September 2014 through September 2015 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

This review evaluated the effectiveness of NASA's JCL process. We sought to determine whether NASA had implemented appropriate controls and procedures, resulting in a JCL process that could improve cost and schedule estimates and provide more reliable information for decision makers. Specifically we evaluated the: (1) Agency's overall implementation of the JCL process, (2) the SRB's JCL review process, (3) internal controls related to the process, and (4) the incorporation of risk in the projects' JCL models. Our review of NASA's JCL process was conducted at Goddard Space Flight Center, NASA Headquarters, the Jet Propulsion Laboratory, Kennedy Space Center, and Langley Research Center.

To accomplish this review, we spoke with project and program managers and staff from Ground Systems Development and Operations, ICESat-2, JWST, LADEE, MAVEN, Orion, SGSS, SLS, and Soil Moisture Active Passive. Additionally, we reviewed most of their JCL models. Moreover, we administered an online survey to projects that were not included in our case studies but were still required to develop a JCL model. We also administered an online survey to the SRB chairs responsible for leading a review of a program or project that was required to develop and execute a JCL model. Additionally, we took a training course through a JCL software vendor. Throughout the course of our audit we also interviewed relevant NASA officials from NASA Headquarters, IPAO, and CAD regarding the Agency's JCL process.

We obtained and examined internal and external applicable documents related to JCL as well as NASA policy. The documents we examined included the following:

- NPR 7120.5E
- Cost Analysis Division's Cost Estimating Handbook – JCL Appendix
- Independent Program Assessment Office's Standard Operating Procedures
- NASA's Goddard Space Flight Center Flight Projects Directorate JCL Handbook
- NASA's Standing Review Board Handbook

Use of Computer-Processed Data

We used limited computer-processed data to perform this audit. Specifically, as a part of our case study reviews, we reviewed project JCL models which included Microsoft Project files as well as JACS data. Generally, we concluded the data was valid and reliable for the purposes of the review.

Review of Internal Controls

We reviewed and evaluated internal controls related to NASA's JCL process. We considered the primary internal control, the SRB review, as adequate but needing improvement, along with other aspects of the JCL process. Implementing our recommendations should improve the internal controls and process.

Prior Coverage

During the last 5 years, the NASA OIG and GAO have issued 9 reports of significant relevance to the subject of this report. Unrestricted reports can be accessed at <https://oig.nasa.gov/audits/reports/FY15> and <http://www.gao.gov>, respectively.

NASA Office of Inspector General

NASA's Top Management and Performance Challenges (November 14, 2014)

NASA's Challenges to Meeting Cost, Schedule, and Performance Goals (IG-12-021, September 27, 2012)

Government Accountability Office

NASA: Assessments of Selected Large-Scale Projects (GAO-15-320SP, March 24, 2015)

James Webb Space Telescope: Project Facing Increased Schedule Risk with Significant Work Remaining (GAO-15-483T, March 24, 2015)

NASA: Human Space Exploration Programs Face Challenges (GAO-15-248T, December 10, 2014)

NASA: Assessments of Selected Large-Scale Projects (GAO-14-338SP, April 15, 2014)

NASA: Assessments of Selected Large-Scale Projects (GAO-13-276SP, April 17, 2013)

NASA: Assessments of Selected Large-Scale Projects (GAO-12-207SP, March 1, 2012)

NASA: Assessments of Selected Large-Scale Projects (GAO-11-239SP, March 3, 2011)

APPENDIX B: JCL PROJECT LIST

The list below details NASA projects that have completed a JCL analysis and have launched or are in development. This list was updated June 2015.

Table 5: Projects with Completed JCL Analysis

Project	Status
Global Precipitation Measurement (GPM)	Launched
Lunar Atmosphere and Dust Environment Explorer (LADEE)	
Landsat Data Continuity Mission (LDCM)	
Mars Atmosphere and Volatile Evolution (MAVEN)	
Magnetospheric Multiscale Mission (MMS)	
Mars Science Laboratory (MSL)	
Nuclear Spectroscopic Telescope Array (NuStar)	
Orbiting Carbon Observatory-2 (OCO-2)	
Soil Moisture Active Passive (SMAP)	
Stratospheric Observatory for Infrared Astronomy (SOFIA)	
Gravity Recovery and Climate Experiment Follow-On (GRACE-FO)	In Development
Ground Systems Development and Operations (GSDO)	
Ice, Cloud, and land Elevation Satellite-2 (ICESat-2)	
Ionospheric Connection Explorer (ICON)	
Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight)	
James Webb Space Telescope (JWST)	
Orion Multi-Purpose Crew Vehicle (Orion)	
Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-REx)	
Space Network Ground Segment Sustainment (SGSS)	
Space Launch System (SLS)	
Solar Probe Plus (SPP)	
Transiting Exoplanet Survey Satellite (TESS)	

Source: NASA OIG analysis.

APPENDIX C: MANAGEMENT'S RESPONSE

National Aeronautics and Space Administration
 Headquarters
 Washington, DC 20546-0001



SEP 25 2015

Reply to Attn of: Office of Evaluation

TO: Assistant Inspector General for Audits
 FROM: Acting Director, Office of Evaluation
 SUBJECT: Response to OIG Draft Audit Report, "Audit of NASA's Joint Cost and Schedule Confidence Level Process" (A-14-019-00)

NASA appreciates the opportunity to review the Office of Inspector General (OIG) draft report entitled, "Audit of NASA's Joint Cost and Schedule Confidence Level Process" (A-14-019-00) dated September 1, 2015.

In the draft report, the OIG makes eight recommendations addressed to the Acting Director of the Office of Evaluation and the Chief Engineer, with the intent to improve the Agency's Joint Confidence Level (JCL) process. Management's response to the OIG's recommendations, including planned corrective actions, follows:

To improve the Agency's JCL process, the OIG recommends the Acting Director of the Office of Evaluation:

Recommendation 1: Clarify that project managers and Decision Authorities are to use JCL results as the basis for proposing and establishing project budgets rather than as a validation tool.

Management's Response: Concur. NASA Procedural Requirements (NPR) 7120.5E, "NASA Space Flight Program and Project Management Requirements" for conducting JCL analysis states that the JCL is used to inform Decision Authorities regarding setting the Agency Baseline Commitment for cost and schedule. NASA's Project Management Handbook, and the new Appendix J (JCL Analysis) of the recently updated NASA Cost Estimating Handbook (CEH), as well as the earlier Goddard Space Flight Center (GSFC) JCL Handbook, also describe how JCL results are to be used. NASA will further clarify this through an explanation of the functions and purpose of JCL policy, as well as uses of the analysis results, in the training identified in NASA's response to Recommendation 5.

Estimated Completion Date: NASA's current JCL documentation describes how JCL results are to be used. NASA will further clarify this through additional training courses (Recommendation 5) that will be completed by the end of 2016.

Recommendation 2: Assess the effectiveness of the scheduling function at NASA. Develop a plan to ensure all NASA Centers have access to trained and qualified schedulers with experience commensurate with the complexity of assigned projects.

Management's Response: Concur. NASA initiated a Scheduling Initiative (SI) in May 2014, led by the Office of Evaluation, to strengthen scheduling capabilities across the Agency and improve performance results. One of the first steps in the initiative was an assessment of scheduling capabilities across NASA and a needs assessment to identify areas for improvement. Based on this assessment, a plan was developed that encompasses key functional capability areas, including professional development and training. Some Centers have already made good progress toward improved scheduling. The Office of Evaluation (OoE) is leveraging work done by the Centers (e.g., GSFC best practices and software for schedule quality assessment) to develop training, tools, and best practices as part of this initiative. OoE is working with all the Centers to help ensure that they can use these resources to develop and train their schedulers with the needed skills. However, it will be up to individual Centers to ensure that they have the appropriately trained and experienced personnel assigned to projects.

Estimated Completion Date: The Scheduling Initiative is an ongoing activity aimed at continuous improvement of NASA's scheduling capabilities. The assessment has been completed, and a plan has been developed and is now being implemented in coordination with the Centers through the Agency-wide Scheduling Community of Practice (SCoPe).

Recommendation 3: Require all NASA projects to use historical data as JCL analysis inputs for cost and schedule uncertainties in addition to Earned Value Management (EVM) data or subject matter expert opinion.

Management's Response: Concur. NASA's NPR 7120.5E establishes the requirement to conduct JCL analysis, but it is not the appropriate document for providing guidance and best practices for how the requirement is to be implemented. This guidance is contained in the new Appendix J (JCL Analysis) of the recently updated NASA Cost Estimating Handbook, and is consistent with this recommendation. In addition, when Standing Review Boards (SRBs) review project JCL analysis, they assess the quality of inputs as described in the recommendation, consistent with guidance in the SRB Handbook. NASA will also include explanations of the recommendation in training materials being developed as defined in NASA's response to Recommendation 5.

Estimated Completion Date: NASA's current guidance for JCL development by projects, as well the guidance for SRB assessments of project JCL analysis, are consistent with this recommendation. Additional training that is being developed (Recommendation 5) will further address this recommendation and will be completed by the end of 2016.

Recommendation 4: Establish formal guidance and clarify expectations governing the SRB review of JCL analyses.

Management's Response: Concur. As stated in the body of this report, this recommendation is directed to enhance guidance for the technical members of the SRB to assist in their role performing independent assessments of the JCL prepared by the project. The SRB Handbook published by the Independent Program Assessment Office (IPAO) provides formal guidance to all members of any SRB. This document provides a definition of the JCL, as well as information relating the JCL to the Agency Baseline Commitment, and describes how the technical and programmatic analysts work together to perform the programmatic assessment that includes the assessment of the JCL.

IPAO is continuously revisiting how cost, schedule, risk, and uncertainty inputs/assessments are captured from the technical SRB members to increase the effectiveness and efficiency of the JCL assessment process with improvements having been recently prototyped and being incorporated into our guidance. As part of these improvements, special attention has been placed on clarifying expectations for the involvement of the technical members of the SRB. These expectations will also be incorporated into the SRB team training, as described in NASA's response to Recommendation 5.

Estimated Completion Date: NASA currently has formal guidance documented in the SRB Handbook and will strengthen clarification of expectations through training (Recommendation 5) that will be completed by the end of 2016.

Recommendation 5: Establish a formal, JCL-specific training program for project managers and technical SRB members.

Management's Response: Concur. IPAO has been actively working on strengthening the training of SRB technical members to include JCL. For example, over the last year IPAO has baselined an initial training session for all new SRB chairs that includes familiarization with programmatic analyses, including JCL assessment. Technical SRB members are briefed on their role in assessing JCL input during the SRB kickoff meeting for the PDR life-cycle review, and projects typically receive an introductory JCL briefing as they begin preparations for Preliminary Design Review (PDR). In addition, IPAO has recently released (in August 2015) a new feature on the NASA Engineering Network (NEN) Web site, <https://nen.nasa.gov/web/ipao>, which includes self-paced training and other reference material to enhance training for all SRB members, including JCL assessment.

A JCL-specific training session for the Virtual Project Management Challenge was completed in 2013 and is available online at <http://www.nasa.gov/content/2013-virtual-pm-challenge-includes-jcl-policy>. In addition, GSFC established a one-hour

course in SATERN for introductory JCL training in 2013, and that course will be made broadly available across the Agency. The Cost Analysis Division will continue to promote training of all types, including JCL, and is developing a detailed training course for cost estimators, which includes a significant JCL training component. This course, in addition to the SRB training, will provide content for training project managers.

Estimated Completion Date: NASA will complete the detailed estimating training course and a new JCL-specific training course for project managers by the end of 2016. The GSFC introductory JCL course in SATERN will be available Agency wide by the end of 2015. All other training materials mentioned are completed and available, and will be updated as needed, to clarify and strengthen the points made in Recommendations 1, 3, 4, and 7 by the end of 2016.

Recommendation 6: Work with JCL software providers to add a function that tracks and creates a report reflecting modifications to input data and require SRBs to review the report to assess the appropriateness of any modifications.

Management's Response: Non-concur. NASA believes that projects would benefit more if NASA works with the software vendors on implementing other features and functions to the JCL software that can aid with input data organization and verification. A specific function that tracks and creates a report reflecting modifications to all JCL input data would be cumbersome and costly, negating the benefit of JCL models to quickly recalculate various alternative inputs (or scenarios). Furthermore, requiring SRBs to review how projects have modified input data as models are being developed would divert time and resources from higher priority assessments, such as understanding the quality and basis of estimate for the project's final input data. Additionally, not all tool vendors may implement the function, and the software development costs would have to be paid for by NASA. With limited resources available for enhancements to software tools, tracking modifications to input data is not a high priority.

Estimated Completion Date: Not applicable.

Recommendation 7: Assess the appropriateness of the 70 percent confidence level requirement for single-project programs and consider clarifying or supplementing current requirement language.

Management's Response: Concur. NASA has conducted an assessment of the 70 percent confidence level included in NPR 7120.5E and concluded that while it is appropriate for projects that are part of a portfolio, it may also be appropriate to use lower confidence levels for single-project programs. The JCL policy allows flexibility for the Decision Authority to set the appropriate confidence level, and an example of this for a single-project program is the James Webb Space Telescope (JWST), which has an Agency Baseline Commitment (ABC) at a Joint Confidence Level of 66 percent. Because this flexibility exists with the current policy, changes to the requirement are not needed. However, to help clarify this flexibility, NASA

will incorporate supplementary descriptions of this flexibility in the training courses being developed in response to Recommendation 5.

Estimated Completion Date: NASA has completed the assessment and will include clarifying language in the training, as appropriate, by the end of 2016.

Recommendation 8: Require all NASA projects include all identified relevant discrete development risks, to include strategic risks, with potential cost and/or schedule impacts in their JCL models.

Management's Response: Concur. NPR 7120.5E requires that projects include all identified relevant risks in their JCL analysis. This includes cost, schedule, technical, and other types of risks associated with all elements, including those managed outside of the project. Further guidance on how risks should be included in a project's JCL analysis is provided in both the Project Management Handbook and the recently updated Cost Estimating Handbook. To ensure that projects are meeting this requirement, NASA utilizes an SRB and life-cycle review process to perform an assessment of a Project JCL analysis. The SRB provides an independent assessment of the projects risks to ensure the appropriate risks are identified and being modeled in the JCL analysis.

Estimated Completion Date: NASA is currently implementing practices consistent with this Recommendation.

In addition to providing responses to the Recommendations, NASA believes it is important to identify some disagreements with the information presented in Table 4. NASA offers the following arguments that the OIG assessment does not adequately recognize the positive contributions made by NASA's JCL policy towards several specific items in Table 4:

- NASA believes that the OIG position that JCL has no impact on the "Pay as You Go" or "Annual Funding Instability" root cause is incorrect. JCL models are based on the project plan and provide a method for the project to conduct an integrated analysis of the project's cost, schedule, and risk, including when the project may be constrained to flat funding in a 'Pay as You Go' environment. The JCL policy has required establishing a commitment for cost and schedule, leading to increased stability in budgetary environments by creating a direct causal link between changes to funding profiles and a resulting impact to confidence levels.
- "Higher technical complexity of Projects than Anticipated" can be addressed through a discrete risk in the model if the project has identified that risk. It may also be addressed in JCL modeling by the incorporation of generic historical uncertainty, which captures past performance of projects that may have also had higher technical complexity than anticipated.

- Regarding Changes in Scope/Design Content, the JCL model can be a useful tool to assess outputs based upon varying inputs. Accordingly, project teams have used JCL analysis this way, to run multiple scenarios to assess the impact of descoping an instrument or an extension of the Integration & Test period, as examples. NASA strongly feels that an operational JCL model is well suited to studying the impacts of various scenarios prior to making commitments and has provided a significant positive impact.

We have reviewed the draft report for information that we believe should not be publicly released. We have not communicated any concerns regarding the public release of information contained in your report.

Again, thank you for the opportunity to review and comment on the subject draft report. If you have any questions or require additional information regarding this response, please contact Doug Comstock, Director, Cost Analysis Division on (202) 358-0760.



Helen Grant

cc:
Office of the Chief Engineer/Mr. Roe

APPENDIX D: REPORT DISTRIBUTION

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