Response to OIG Recommendation #4 from Report No. IG-20-015, "Management of the Low Boom Flight Demonstrator Project", May 6, 2020.

4. Document and provide the JCL analysis approach used by LBFD to the NASA Chief Knowledge Officer to serve as a reference for future large-scale X-plane development projects.

Driving Events:

The Low Boom Flight Demonstrator (LBFD) project is developing an all new, full scale manned X-plane, the X-59 Quiet SuperSonic Technology (QueSST) aircraft. The LBFD Project is the first all new manned X-plane development project in a generation for NASA Aeronautics. As stated in NASA Procedural Requirements document for NASA Space Flight Program and Project Management Requirements (NPR 7120.5), the LBFD project was required to conduct a Joint Confidence Level (JCL), which is "a product of a probabilistic analysis of the coupled cost and schedule to measure the likelihood of completing all remaining work at or below the budgeted levels and on or before the planned completion of Phase D." NASA requires a JCL analysis be completed and submitted at Key Decision Point (KDP)-C to assist in the establishment of the project's baseline. Typically, a JCL is anchored in historical data from similar projects. However, given the duration since the last NASA X-plane as well as the fact that X-planes are unique aircrafts developed by a variety of federal agencies and contractors, the historical documentation on X-plane project plans, cost and schedule performance and lessons learned was not relevant and/or available for application to the LBFD project's JCL.

Lessons Learned:

The LBFD Project started the JCL process in the fall of 2017 – over a year prior to the project's KDP-C. JCL analysis was new to many of the team members so it took time to educate the team on what the analysis is, what it is used for and what inputs are required. This time to educate the team was well spent, since it also helped to get their buy-in into what would be a long process. Since this was also new to the stakeholders, project management also communicated the process and how to interpret the results to program and mission directorate stakeholders. The project hired an experienced JCL analyst to conduct the analysis and ensure the project was following standard processes. The goal of the project with respect to the JCL analysis was to ensure the processes and inputs were sound so that the results would be meaningful.

Due to starting the JCL process early, it was important that the process included built-in timeframes for updates to the inputs supporting analysis iterations. For example, the schedule from the fall of 2017 was not the same as the schedule from the fall of 2018 due to project/contractor performance and risks that were realized. Therefore, the cost, schedule, risk and uncertainty inputs to the JCL were updated periodically throughout the process to ensure the results were relevant given what the project knew and experienced to date.

One of the first steps in the JCL process was to conduct extensive workshops across the entire team to capture risks and assess uncertainties associated with the schedule. The outputs from these workshops formed the basis for the initial JCL inputs. In addition, the exercise helped to focus the team and identify areas for risk mitigation and schedule planning. The LBFD Project required a formal contract data deliverable from its prime contractor to provide their evaluation of uncertainty and risk inputs for use in the JCL analysis as well. The LBFD project evaluated these inputs, yet did not use the contractor uncertainty values in the final runs of the JCL because they seemed overly optimistic.

The next significant step in the process was to find a dataset of other similar projects to anchor the model to. Due to the unique nature of each X-plane and the variety of federal agencies involved, there was not one complete set of X-plane project performance data that was usable for the model. Therefore, after much searching, an Air Force Institute of Technology (AFIT) thesis on "Predicting Cost Growth Using Program Reviews and Milestones for DoD Aircraft" by Scott Kozlak (March, 2016) was utilized as the anchor for the JCL model. The results of the thesis were focused to ensure more alignment to the X-59 aircraft by excluding unrelated modification programs and different airframes like Electronic Warfare (EW), Command, Control, Communications and Computers (C4) and surveillance aircrafts. In addition, the results that were utilized focused on the project duration up to the end of Design, Test and Evaluation (DTE), which is comparable to the scope of the LBFD project. One draw back of utilizing this dataset was that the dataset was primarily from projects that were intended to go into production and build multiple copies of the same aircraft; however, the LBFD project is building only one aircraft. Also, the X-59 aircraft is utilizing a variety of Government Furnished Equipment (GFE), which is unlike the other DoD projects that are purchasing mostly commercial off the shelf or custom parts. Although not perfect, this dataset was the most relevant data found and was judged useful for anchoring the LBFD JCL.

Utilizing this dataset of 13 new aircraft development projects as the anchoring point, the dataset indicated that the average cost growth of a similar project with similar scope was 21% as shown in Figure 1 below. This cost growth included the cost of any schedule slips that occurred on these similar DoD projects. Through knowledge of the DoD projects used in the sample and also experience with NASA projects, schedule slips were judged to be a much bigger cost driver than rates increasing or discrete parts rising in cost. Therefore, the 21% cost growth was split 70% schedule and 30% cost, see Figure 2 below for details.

Devlopment Cost Growth Factor Relative to PDR Estimate

Aircraft	CDR	First Flight	End of DDT&E	IOC (first production unit fielded)	Last SAR (typically mid-life or end-life)
A10	1.09	1.19	1.18	1.19	1.27
B1-B	1.05	1.05	1.17	1.16	1.31
C17	1.22	1.36	1.41	1.54	1.81
F14	1.32	1.32	1.47	1.48	1.83
F15	0.98	0.98	1.09	1.09	1.37
F15E	1.07	1.07	1.09	1.09	1.48
F16	1.00	1.25	1.28	1.31	2.51
F/A18 A/B	1.08	1.11	1.15	1.15	1.36
F/A18 E/F	0.99	0.95	0.98	0.98	0.98
F22	1.12	1.19	1.50	1.47	1.64
F35 (CTOL)	1.25	1.24		1.53	
T6	1.02	1.02	0.84	0.86	0.90
T45	1.07	1.09	1.31	1.31	1.53
AV-8B	1.00	1.01	1.21	1.20	1.30
B1-A	0.96	1.15			1.10
Average	**1.08**	**1.13**	**1.21**	**1.24**	**1.46**
Standard Deviation	0.11	0.12	0.19	0.21	0.41

Kozlak, Capt. Scott J., PREDICTING COST GROWTH USING PROGRAM REVIEWS AND MILESTONES FOR DOD AIRCRAFT, AIR FORCE INSTITUTE OF TECHNOLOGY, March 2016

Based on Selected Acquisition Reports (SAR)

Eliminated modification programs and EW, C4, and surveillance aircraft

Average 21% Cost Growth During Development Phase

Figure 1 – Dataset from AFIT Thesis Utilized as the Anchor for the JCL Model

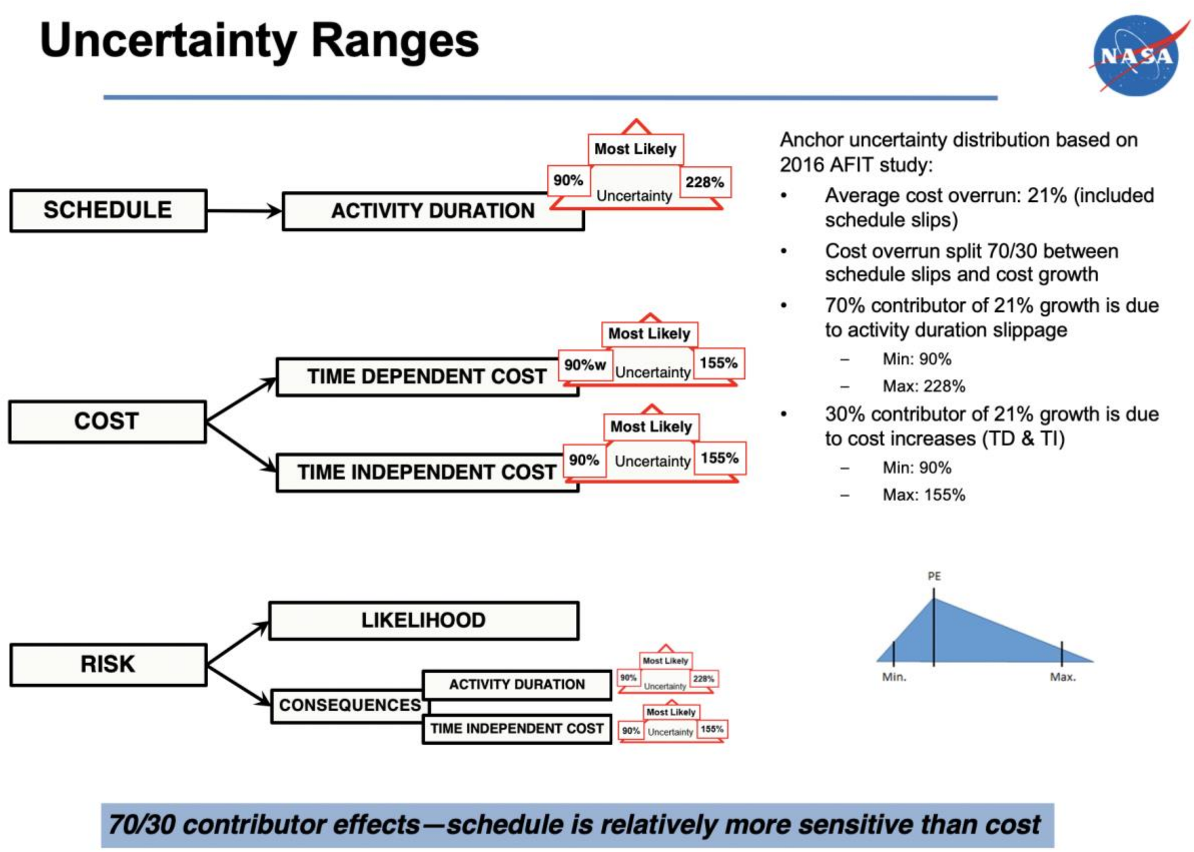

Figure 2 – LBFD JCL Input Uncertainty Ranges

The JCL model takes many iterations to ensure the model is behaving in a consistent manner and that sensitivities can be understood. The LBFD project conducted 7 full runs of the analysis as well as many other sensitivity and driver analyses to ensure the model was sound. The JCL schedule results were evaluated after each iteration by the project team and modeling adjustments were made to improve the quality and accuracy of the model. The final results were reasonable and justifiable.

In addition, the Independent Review Board (IRB) also assessed the project's JCL processes, model and results without any significant findings or issues. The IRB ran the same model with additional risks and some different risk levels for Project identified risks based on of the IRB's assessment from the Delta Preliminary Design Review (DPDR).

Per NPR 7120.5, mission directorates are to base a project's overall plan and budget on a 70 percent joint cost and schedule confidence level with the project-held funding consistent with the 50 percent confidence level. The LBFD project recommended the schedule baseline for the Agency Baseline Commitment (ABC) be based on the JCL 70% probability results and the internal Management Agreement (MA) on the 50% probability results. The 2 month difference between these two dates, with the associated budget, would be held at the program level as Undefined Future Expenditures (UFE). Schedule reserves were split between First Flight and System Acceptance Review (SAR) proportionally aligned with the risk and uncertainties in the project schedule. Prior to First Flight, the majority of the cost and schedule risk exists due to the first time build of an aircraft, integration of numerous GFE and new parts, and testing of the systems for the first time. After First Flight, the project is conducting flight operations; this portion of the project schedule already has built in efficiency levels based on historical flight efficiencies from Armstrong Flight Research Center (AFRC). These flight efficiencies consider down time for maintenance, weather and troubleshooting. Since the schedule already assumed some uncertainties and risks in the existing plan, it was reasonable for less schedule reserves to be needed at SAR than at First Flight.

The JCL model results showed the schedule being a significant driver in the model. There was little spread in the cost and there was a clear trend in cost increases with schedule as shown in the JCL results shown in Figure 3. The cost results appeared to be understated and seemed to not account for unknown unkowns that are generally experienced by projects. The assumption of the 70/30 split in cost growth could have been a factor in causing this behavior in the model; this was a fundamental assumption hardwired in and was not able to be easily removed. As a result, the LBFD project utilized a detailed accounting of threats, liens, and encumbrances (TLE) to estimate the required cost reserves. The TLE provided detailed known cost risks to the project that provided much more fidelity and comprehensive evaluation of fiscal year impacts. After incorporating the TLE impacts, the project had $9M left of cost reserves, which equated to 2.5% of unthreatened cost reserves on the costs to go. Utilizing a common NASA guideline of projects holding 20-30% reserves on costs to go, the project recommended additional cost reserves to cover current threats, liens and encumbrances plus 10% reserves on costs to go, which totaled roughly 20% cost reserves on cost to go.

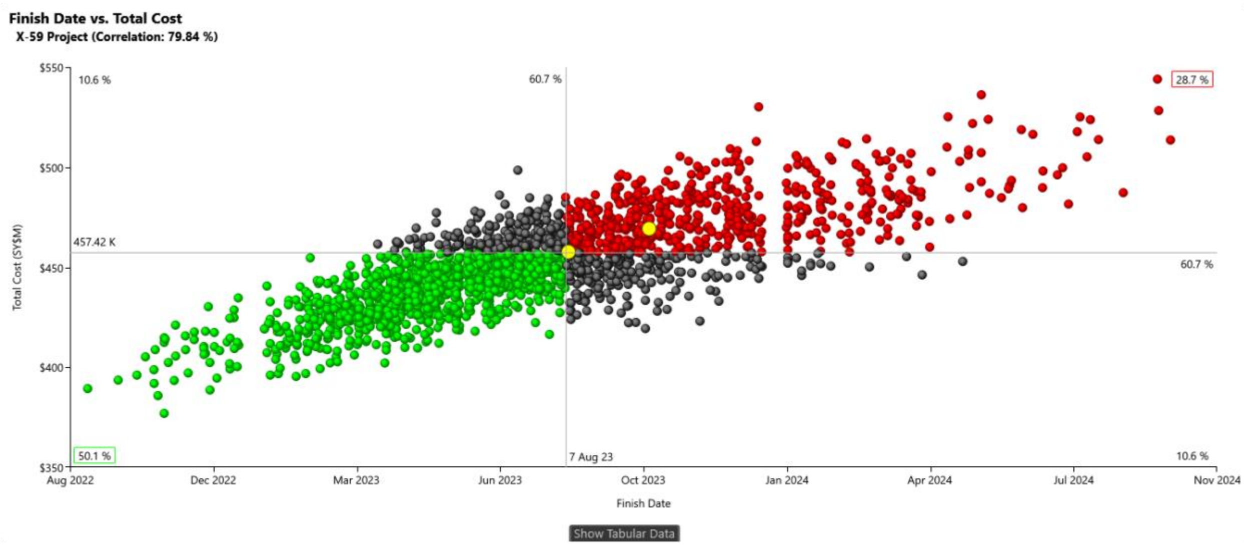

Figure 3 – LBFD JCL Scatter Plot for Project Completion

Since LBFD was a pathfinder in the Aeronautics Research Mission Directorate for conducting a JCL, the LBFD project was asked to benchmark its JCL processes and results as compared to projects in other NASA mission directorates. The JCL analyst evaluated 5 other NASA projects mostly from the Science Mission Directorate. The analyst found that the LBFD inputs, model and outputs are consistent with the other projects with the only major difference being the lack of historical data in the NASA CADRe/ONCE database that contains historical NASA space flight project performance. It was noted that some of the other projects did have to consider their unique mission circumstances in conducting or evaluating the JCL results, similar to the LBFD project having to consider its unique historical comparison. Furthermore, the analyst commented that the use and impact of JCL results tends to vary with each mission directorate’s risk tolerance (i.e. evaluation of the scatter, corresponding data points, significance, and implications to project cost and schedule baselines). For this reason, several of the projects were baselined with reserves above the 70 percent joint cost and schedule confidence level.

Recommendation:

The JCL was a valuable tool in developing the LBFD project’s baseline recommendation to the mission directorate. It helped to integrate many project tools and forced the development of a high quality anlaysis of the schedule and risk database to create a single probabilistic assessment. Starting early (a full year prior to KDP-C) was what enabled the LBFD project to conduct multiple iterations of the analysis and ensure buy-in from the project team and stakeholders. Like with any analysis, the JCL processes have to be adapted to fit the situation and the results have to be assessed for realism. Anchoring the JCL utilizing relevant data from analagous projects is required to produce credible results. In hindsight, the unknown unkowns (i.e. the longest government furlough and a world-wide pandemic) had significant impacts on the project. The JCL would not have been able to predict such significant events but it is a lesson to not underestimate the unknown unknowns. Recommend incorporating an additonal level of cost reserves beyond the JCL estimate to account for these unknown unknowns.