January 4, 2019

MEMORANDUM FOR THE ADMINISTRATOR

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SUBJECT: Independent Cost Estimate (ICE) for the W80-4 Life Extension Program (LEP)

This memorandum summarizes the ICE developed by the Office of Cost Estimating and Program Evaluation (CEPE) in support of the W80-4 LEP Phase 6.3 authorization. The W80-4 LEP will refurbish the W80-1 thermonuclear warhead to be carried in the payload section of the Air Force's Long Range Stand-Off (LRSO) missile. The ICE is based on detailed technical descriptions and requirements contained in the draft Military Characteristics for the W80-4 Nuclear Warhead, dated August 21, 2017, the draft Stockpile to Target Sequence for the W80-4 Warhead, dated August 31, 2017, the Nuclear Weapons Production and Planning Directive (P&PD) 2018-0, dated December 2017 and additional supporting documentation. This ICE assesses the total estimated direct cost to the W80-4 LEP and does not assess costs for scope outside of the LEP otherwise known as Other Program Money (OPM). All dollar figures are in Then Year (TY) dollars unless otherwise specified.

Program Description/Background. The W80-4 LEP is a joint NNSA and Air Force program to arm the Air Force's LRSO cruise missile, the replacement for the aging Air Launched Cruise Missile with a life-extended W80 warhead. The LRSO cruise missile is currently in the Technology Maturation and Risk Reduction phase of development.

The W80-4 LEP design is a nuclear and non-nuclear modification of the W80-1 warhead, extending its useful life to 30 years, refreshing the primary's main charge, providing detonator safing, modernizing the electronics and incorporating safety and security features. The LEP also includes a partial refurbishment of the secondary. The W80-4 will be the first NNSA LEP to simultaneously refurbish the warhead as the delivery platform undergoes its own development and production program.

The W80-4 entered Phase 6.2 *(Feasibility Study)* on July 23, 2015 following a year long Phase 6.1 *(Conceptual Design Study)*. Phase 6.2A *(Design Definition and Cost Study)* began in November 2017. The program plans to enter Phase 6.3 *(Development Engineering)* in January 2019.

ICE Summary. The ICE is based on historical data from three on-going modernization efforts: the B61-12 LEP, W88 Alt 370 and the W76-1 LEP. Historical cost and schedule data combined with associated programmatic and technical data were used to perform a schedule analysis and develop cost estimates for the Development Engineering, Production Engineering, and Production Stage Phases.

The W80-4 was the first LEP to undergo a full reconciliation process. The goal of the reconciliation process was to 1) verify that CEPE and the W80-4 program are estimating the same scope; 2) outline and understand the significant discrepancies between the two estimates in terms of assumptions and methodology; and 3) identify and articulate differences in support of senior leadership decisions. Arriving at a common CEPE / Program Office number was not a goal of reconciliation.

CEPE's initial to-go (FY19-FY32) costs were $1.7B lower than the initial Weapon Design and Cost Report (WDCR) estimate. The differences between the estimates were due to differing assumptions for escalation, NNSA taxes, labor rates, production efficiencies, as well as relatively minor differences in scope. Both the CEPE ICE and the WDCR were independently adjusted based on these reconciliation findings. After adjustments, to-go costs differ by $53M (Figure 1).

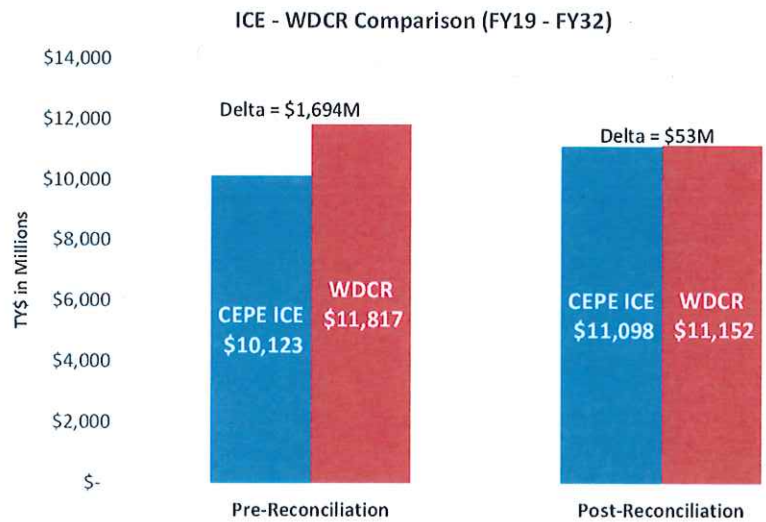

Figure 1. Estimated To-Go (FY19-FY32) cost pre and post reconciliation

Including sunk costs, the CEPE ICE totals $11.9B as compared to $12.0B for the WDCR (Table 1), a delta of less than 0.5%. These figures do not include OPM costs of $283M, of which more than 81% were already sunk prior to FY2020.

	Sunk FY15-FY18	Current FY19	FYNSP FY20-FY24	To Complete FY25-FY32	Total Program FY15-FY32
W80-4 CEPE ICE	$825	$655	$5,137	$5,307	**$11,924**
W80-4 WDCR	$825	$655	$5,253	$5,246	**$11,979**

Table 1. Total Program Cost Comparison

ICE Methodology. Program/site schedules, monthly Earned Value Management (EVM) reports, and detailed charge code data produced by the development and production agencies were used in the analysis. Cost estimating models were developed by 6.X Phase and by site. The data basis for the models varies by phase and site due to data recency and availability (Table 2). For example, the Development and Production Engineering (Phases 6.3 and 6.4) models for the Development Agencies (DAs) and Production Agencies (PAs) were based on historical charge code data from the B61-12 and W88 Alt370 programs because those programs are current, nearing completion of the development and production engineering phases, and the data is reliable. The production stage models (Phases 6.5 and 6.6) for the PAs were based on historical charge code data from the W76-1 program (supplemented with Integrated Contractor Order (ICO) data from the B61-12 program). The W76-1 program is currently the only LEP with actual production history.

	Phase 6.3 Development Engineering	Phase 6.4 Production Engineering	Production Stage	
			Phase 6.5 FPU	Phase 6.6 Full-Scale Production
Development Agencies	B61-12 Historical Charge Code Data W88 Alt370 Historical Charge Code Data		W76-1 Historical Charge Code Data B61-12 Historical ICO Data	
Production Agencies				

Table 2. ICE Basis of Estimate

Charge code data was categorized into recurring and non-recurring type elements which were then tested for correlations between groupings. This data was mapped to key technical and programmatic variables which were used to generate regression models, non-linear optimizations or other statistically derived predictive models which combine to generate deterministic point estimates. Given the statistical uncertainty inherent in the resulting equations, a stochastic process was applied to account for estimating uncertainty, resulting in confidence levels. The CEPE ICE is set at the 50th percentile.

The modeling effort allowed for site by site comparison, as well as component cost estimates for major W80-4 components identified in the program work breakdown structure. These results were shared in the reconciliation meetings between CEPE and the FPO. Adjustments to the model were made in the post-reconciliation process to generate the final ICE.

Development Cost Estimate. The development cost estimates relied heavily on B61-12 and W88 Alt 370 data to develop cost estimating relationships (CERs) based on actual labor and non-labor charges applied to specific activities associated with component development at the respective sites. This methodology improved upon the general staffing level-of-effort (LOE) methodology used for the W80-4 Independent Cost Report (ICR), allowing for higher fidelity in scope definition, extensive use of detailed historical data, and the ability to quantify estimating uncertainty using stochastic processes.

Procurement Cost Estimate. The W80-4 procurement cost estimate was generated based on parametric analysis of historical W76-1 actual cost data as it is similar in scope and uses the same production agencies. This is the same methodology as in the W80-4 LEP Phase 6.2A ICR, with additional detail where appropriate to align with the more refined definition of scope.

Scope adjustments were made to remove work associated with the W76-1 that is not required on the W80-4 and to add work associated with the W80-4 that is not part of the W76-1. Cost estimates for other components were based off of B61-12 historical cost data for same or similar components produced during the B61-12 development and production engineering phases. Additional production agency effort required to support the design agencies and to develop manufacturing processes, production test equipment, and tooling associated with the individual components was also adjusted as a function of the estimated war reserve production effort.

ICE Comparison to WDCR. The resulting cost estimates were compared to the WDCR by site. While the total ICE is comparable to the total WDCR, offsetting differences exist at the site level (Figure 2). Overall, the ICE is higher for the Development Agencies (Sandia and Lawrence Livermore National Laboratories) whereas the WDCR is higher for the Production Agencies (Kansas City National Security Campus, Y-12, and Pantex). The difference for the development agency estimates is driven by the schedule to FPU, and the difference for the production agency estimates is driven by learning curve rates.

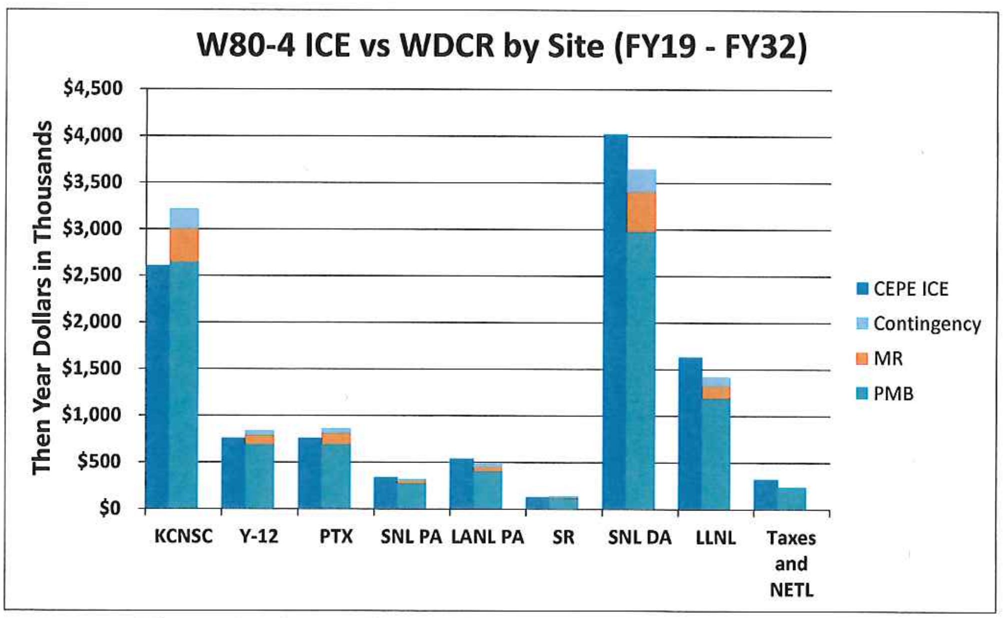

Figure 2. Comparison of CEPE ICE and WDCR By Site

Confidence Levels. The ICE methodology of conducting statistical analysis of historical data generated results that contain statistical uncertainty. This uncertainty was quantified using standard statistical approaches and modeled through Monte Carlo simulation, which produced the confidence levels associated with total program cost (Figure 3). The total ICE is $11.9B at the 50% confidence level. Total program cost ranges from $10.5B at the 20% confidence level to $14.3B at the 80% confidence level.

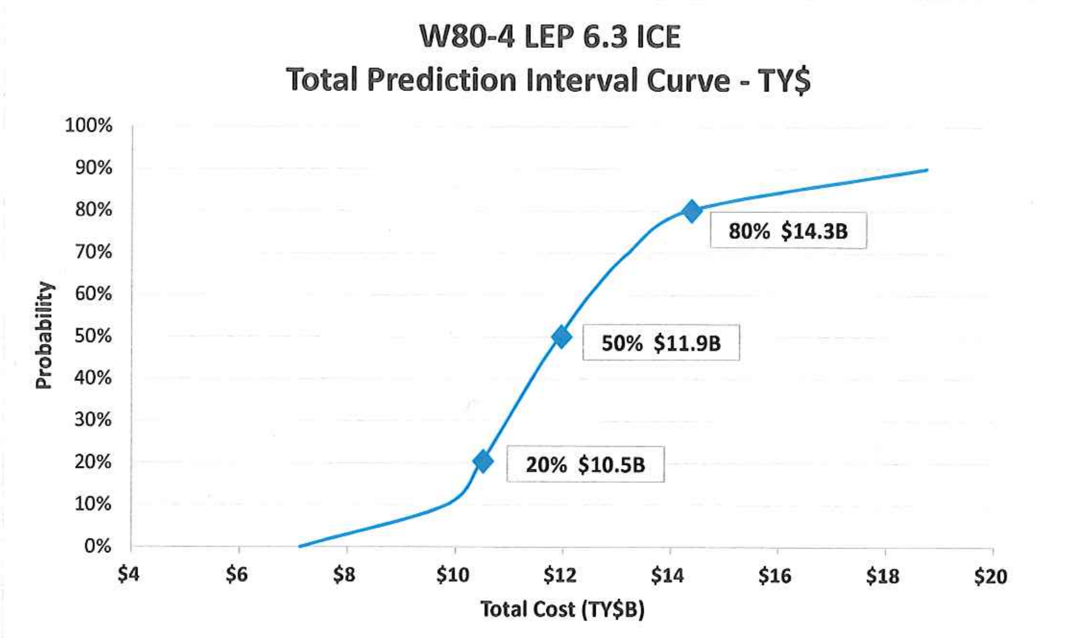

Figure 3: Total Program Cost Probability Curve

The total cost cumulative distribution curve is also commonly referred to as the risk and uncertainty curve. However, this is not to be confused with or compared to the risk and uncertainty curves typically generated by program offices, as those curves were used to estimate Management Reserve (MR) and contingency requirements. Because CEPE relied on analysis of historical data which inherently captures realized risks, MR and contingency were captured within the total cost.

Schedule Assessment. The W80-4 program schedule was built with the objective of achieving a First Production Unit (FPU) date of FY 2025. CEPE assessed the schedule objective by applying three separate approaches. The first approach benchmarked the W80-4 duration from the start of phase 6.3 to FPU against historical programs. This approach was completed in support of the W80-4 phase 6.2A Independent Cost Review (ICR) (Figure 4).

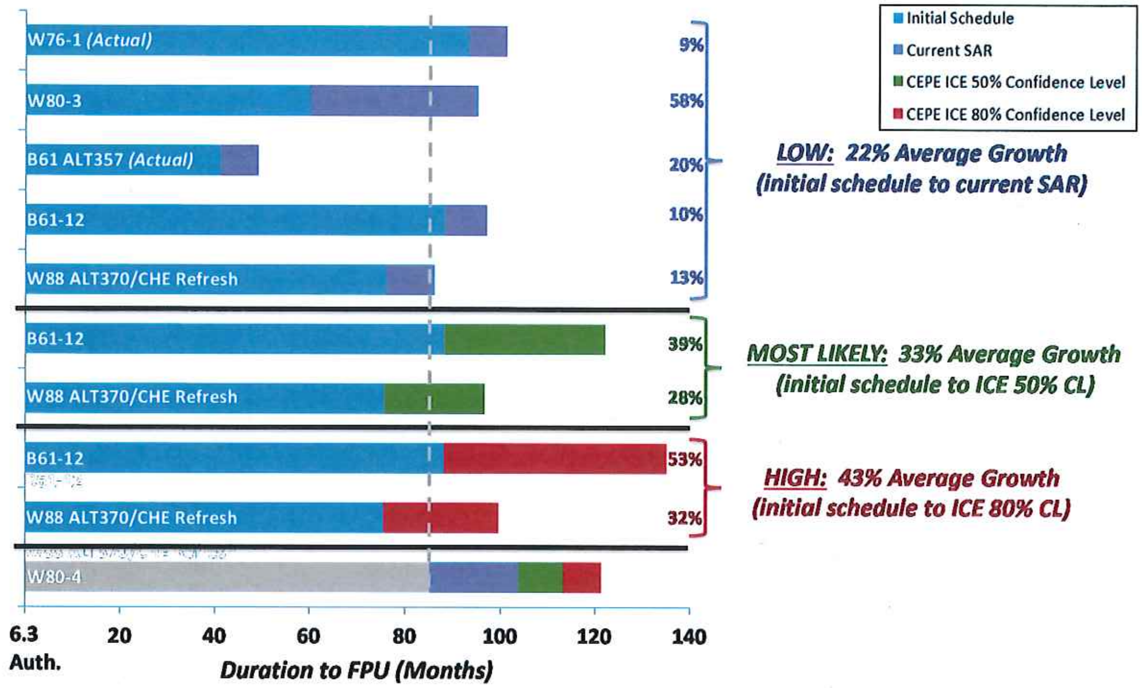

Figure 4: Phase 6.3 Authorization to FPU Benchmarking

The top portion of Figure 4 displays the duration growth realized to date on five current and historical modernization programs. None of the programs were able to achieve the FPU dates forecasted in the initial schedules. On average, programs have exceeded the initial duration estimates for Phase 6.3 to FPU by 22%.

The second approach evaluated the extent of schedule compression inherent in the W80-4 detailed sites schedules relative to actual B61-12 program experience (Figure 5).

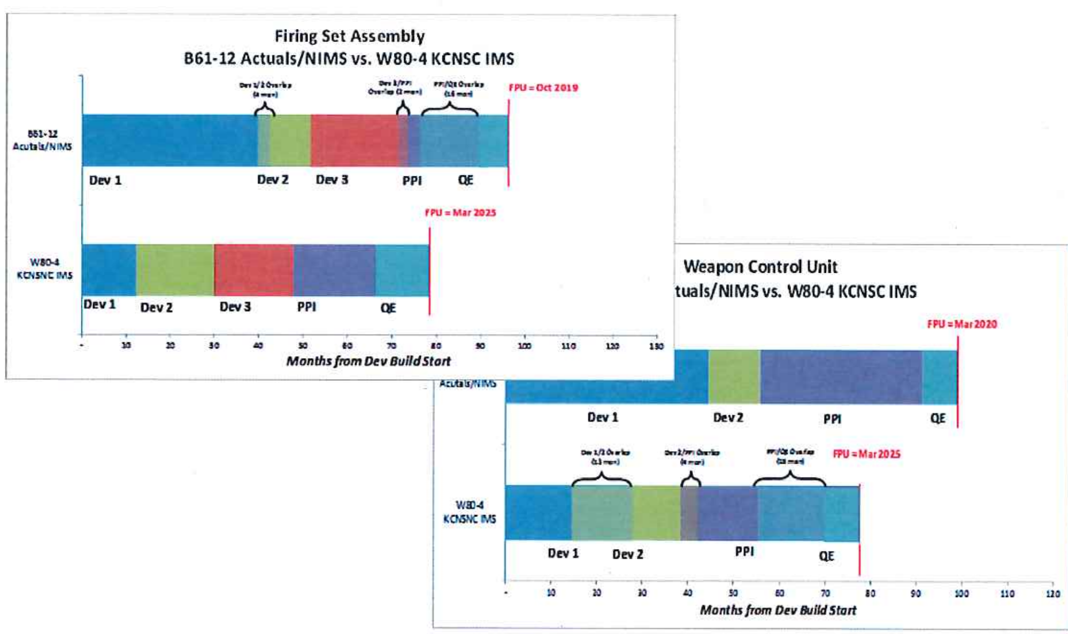

Figure 5: Component Schedule Compression

The two examples shown in the charts (representative of many W80-4 components) illustrate the extent of schedule compression planned for the W80-4 Firing Set Assembly and Warhead Controller Unit (WCU) as compared to the same or similar components on the B61-12. The development schedule for the W80-4 Firing Set Assembly is compressed two years in comparison to the realized development duration for B61-12, whereas the Process Prove-In (PPI) and Qualification Evaluation (QE) phases have similar durations due to extensive overlap (more than one year) between those phases on the B61-12. Similarly, the development schedule for the W80-4 WCU is compressed approximately one year in comparison to the realized development duration for B61-12, whereas the PPI and QE phases have shorter durations due to extensive overlap (more than one year) between those phases on the W80-4.

The third approach assessed the extent that development and production engineering activities would extend beyond the planned FPU date of FY2025, based on stochastic modeling of historical data (Figure 6). The analysis shows that 17% of development and production activities would continue beyond a FY25 FPU, as compared to 8% of development and production activities continuing beyond a FY26 FPU.

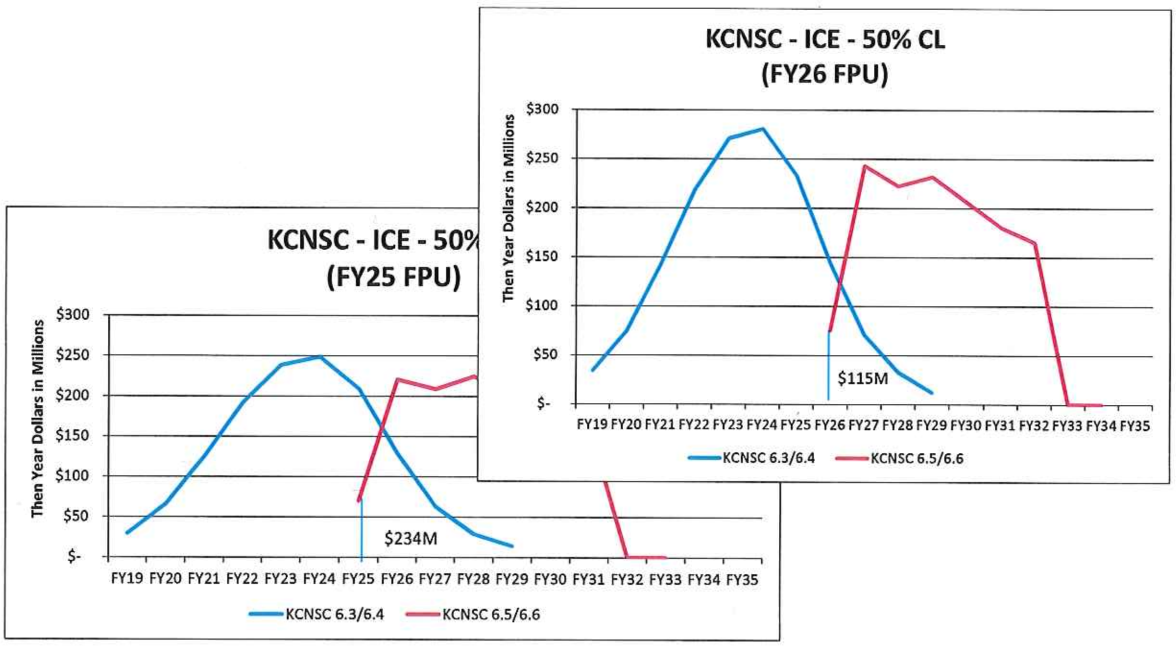

Figure 6: Engineering and Production Overlap

The conclusion from each of these three separate approaches is consistent: for the W80-4 program to achieve FPU in FY2025 requires a rate of program execution that has not historically been demonstrated by the complex and is therefore highly unlikely.

A one year shift in FPU to FY2026 increases schedule duration by 14%. This is consistent with the duration growth seen in the W88 Alt 370 (13%) and the B61-12 (10%) following their respective WDCRs. To be consistent with analysis performed to date, CEPE based this ICE on an FY 2026 FPU.

A one year shift in FPU to FY2026 aligns FPU with the cruise missile Milestone C, relieving a significant amount of warhead schedule compression while preserving the ability to meet DoD's Initial Operating Capability (IOC) in FY30 as planned.

Resource Requirements. Table 3 details the funding resource requirements of the ICE and the WDCR against the funding requested in the Fiscal Year (FY) 2019 President's Budget extended through FY2024. The ICE funding profile highlights funding shortfalls in the Future Years Nuclear Security Program (FYNSP). CEPE's analysis of schedule supports FPU in FY 2026, allowing for greater budgeting flexibility. The CEPE budget profile is phased to reflect historic execution rates whereas the WDCR phasing will likely lead to large carryover amounts early in the FY20-24 FYNSP.

		FYNSP						Out-years					
TY$M	FY19	FY20	FY21	FY22	FY23	FY24	*FYNSP Total*	FY25	FY26	FY27	FY28	To Complete FY29-FY32	TOTAL FY19-FY32
PB19 + FY24	$655	$714	$770	$804	$803	$823	***$3,915***						
CEPE ICE	$655	$790	$897	$952	$1,111	$1,387	***$5,137***	$1,312	$1,049 (FPU)	$815	$666	$1,465	$11,099
DELTA from PB19 + FY24	***$0***	***($76)***	***($127)***	***($148)***	***($308)***	***($563)***	***($1,222)***						
WDCR	$655	$899	$1,021	$1,088	$1,144	$1,101	***$5,253***	$1,048 (FPU)	$937	$806	$722	$1,733	$11,154
DELTA from PB19 + FY24	***$0***	***($185)***	***($251)***	***($284)***	***($341)***	***($278)***	***($1,338)***						

Table 3. Funding Resource Requirements (TY$M)

Summary. While CEPE and the FPO largely agree on total program cost ($11.9B ICE, $12.0B WDCR) and to-go costs ($11.1B ICE and WDCR), they differ on the FPU date and the near term phasing of funds across the FYNSP.

CEPE concludes that the ability for theW80-4 to meet an FY2025 FPU is highly unlikely, and that a FY2026 FPU is more realistic given historical schedule execution. While FPU is a significant achievement for the NNSA, the first major mission accomplishment is Initial Operational Capability (IOC). A FY25 FPU is possible, but will likely require scope reduction, reducing requirements, and major changes in the development process.