Advanced Photon Source Upgrade

Advanced Photon Source Upgrade Project

Preliminary Design Report

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Chapter 2: Project Overview

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Acronyms and Abbreviations

APS	Advanced Photon Source
APS-U	Advanced Photon Source Upgrade
Argonne	Argonne National Laboratory
ASO	Argonne Site Office
BCE	Baseline Cost Estimate
BES	Office of Basic Energy Sciences
CD-n	Critical Decision (n = 0, 1, 2, 3, 4)
DOE	U.S. Department of Energy
ESAC	Experimental System Advisory Committee
FPD	APS-U Project Federal Project Director
IPS	Integrated Project Schedule
IPT	Integrated Project Team
LIC	Line Item Construction
M&S	Materials and Services
MAC	Machine Advisory Committee
MBA	Multi-Bend Achromat
MIE	Major Item of Equipment
PARS	Project Assessment and Reporting System
PMAC	Project Management Advisory Committee
R&D	Research and Development
SC	Office of Science
TPC	Total Project Cost
UChicago	UChicago Argonne LLC
WBS	Work Breakdown Structure

2 Project Overview

2-1 Introduction

When the Advanced Photon Source (APS) at Argonne National Laboratory (Argonne) was first proposed three decades ago, it was envisioned as a third-generation synchrotron radiation source that would offer revolutionary gains in photon beam brightness, expanding the horizons of experimentation across a wide range of scientific disciplines. Today, the APS has more than fulfilled that initial promise: the APS is now the largest and most productive of the five complementary light sources operated by the U.S. Department of Energy (DOE), playing a critical role in our nation's R&D infrastructure. The APS is the nation's highest-energy, highest-brightness storage ring source of hard x-rays (i.e., photon energies above 20 keV), and now draws more than 5,000 researchers each year. APS users have published over 20,000 journal articles and won two Nobel Prizes in Chemistry, in 2009 and 2012, for research conducted on our beamlines.

The scientific impact of the APS is greatly magnified by its location at Argonne. The APS is unique in the world as the only premier high-energy x-ray facility located within a major multidisciplinary laboratory. APS users work alongside Argonne's distinguished researchers and have convenient access to the laboratory's suite of other top-tier user facilities, which include the adjacent Center for Nanoscale Materials and Mira, a 10 petaflop supercomputer. The proximity of these vital resources puts the APS at the center of a powerful research ecosystem for the development and use of x-ray science

As we consider the APS' record of successful operation, it is clear that a great opportunity now exists for the Department of Energy to bring about another revolutionary advance in x-ray science through the APS Upgrade. The development of a new storage ring magnet lattice design—the multi-bend achromat (MBA)—makes it possible to transform the APS into a next-generation storage ring source that approaches the diffraction limit, with orders-of-magnitude increases in brightness and coherence. The exceptional capabilities of an upgraded APS will offer researchers access to a new frontier of x-ray science—one that will give us unprecedented access to the inner workings of matter, and one that will transform our ability to understand the manipulation of matter at the nanoscale.

The Upgrade will put the APS on the path to continued world leadership in hard x-ray science, creating an unparalleled x-ray microscope with the capability to access the full array of powerful x-ray contrast modes, from fluorescence and spectroscopy to diffraction and resonant inelastic scattering. The potential impacts of these new capabilities will include the ability to observe and characterize individual structures as small as single atoms inside materials, making it possible to solve important problems in chemical catalysis, cell biology, environmental science, structural materials, and functional materials. The unprecedented coherent flux at high energies enabled by the MBA lattice will facilitate exciting new research techniques, such as coherent diffraction imaging with resolution approaching the x-ray wavelength and photon correlation spectroscopy to access dynamical behavior in previously inaccessible regimes. This new technology also will provide researchers with the highest possible spatial resolution over a broad temporal range, and with x-ray sensitivity to atomic structure and strain, elemental composition and chemical states, and electronic and magnetic structure.

The APS and its users recently commemorated the 30th anniversary of the Eisenberger-Knotek report, created by an ad hoc committee sponsored by the DOE Office of Basic Energy Sciences (BES) and chartered to "solicit and evaluate ideas from synchrotron-radiation providers and users as to the future opportunities and technical needs for synchrotron radiation-based research." Ultimately, that committee—co-chaired by Peter Eisenberger and Michael L. Knotek—proposed a new generation of synchrotron-radiation sources based on insertion devices. Their report predicted that these new facilities would have revolutionary impacts on science and technology, a prediction that has been proven true again and again. Today, we face an equally historic opportunity with the APS Upgrade, which will unite the visions of Roentgen and von Laue and close the gap between imaging and diffraction in x-ray science. With the APS Upgrade, we will—for the first time—connect real space and Fourier space images, bridging the nano and micro scales. The APS-U will create a transformative research tool that will be invaluable to academia, to industrial innovation, and to U.S. scientific competitiveness in this century.

2-2 Work Breakdown Structure

All required scope for completion of the APS-U project is included in the Work Breakdown Structure (WBS), shown to level 4 in Figure 2.1, beginning with the first year of funding in FY 2010 and continuing through project completion in FY 2026 (CD-4). The early years of funding, FY 2010 to FY 2013, was allocated to pre-MBA scope, labeled U1. Funding for the MBA scope began in FY 2014 and is incorporated in U2. Development of the WBS and WBS dictionary is consistent with the requirements set forth in DOE Order 413.3B [1], *Program and Project Management for the Acquisition of Capital Assets and ANSI/748c, Earned Value Management Systems.*

The organization of the WBS reflects a logical breakdown of the work by major component and system. Each component or system contains progressively lower levels to further define the sub-elements down to the lowest WBS element. Each element of the WBS captures all costs, resources, and activities necessary to complete that particular scope of work with an associated schedule, and the WBS dictionary describes the detailed activities and elements required to design, fabricate, construct, and install the APS-U. All changes to the WBS must be approved prior to implementation, following the process defined in the APS-U Project Controls Guidelines [2] document.

The second- and third-level WBS elements are defined as:

- U.U1 - Includes all actual costs incurred to design, procure, fabricate, install and test aspects of the APS-Upgrade Project through FY 2013, prior to inclusion of the MBA storage ring.
- U.U2 - Includes all phases of design, procurement, fabrication, installation and testing of the MBA storage ring, associated front ends and insertion devices, and new, upgraded and improved beamlines.
- U.U2.01 - Project Management, Planning and Administration: Project Office administrative and management activities that cross the entire project, such as management, regulatory compliance, quality assurance, safety, project controls, etc.
- U.U2.02 - Conceptual Design and Development: Conceptual Design and R&D activities necessary to support delivery of project objectives.
- U.U2.03 - Accelerator: Includes management specific to accelerator scope, and all phases of design, procurement, installation, and testing of the accelerator upgrades.
- U.U2.04 - Experimental Facilities: Includes management specific to experimental facilities scope, and all phases of design, procurement, installation, and testing of new beamlines and upgrades to beamlines.
- U.U2.05 - Front Ends and Insertion Devices: Includes management specific to front end and insertion devices scope, and all phases of design, procurement, installation, and testing of front ends and insertion devices for beamlines.

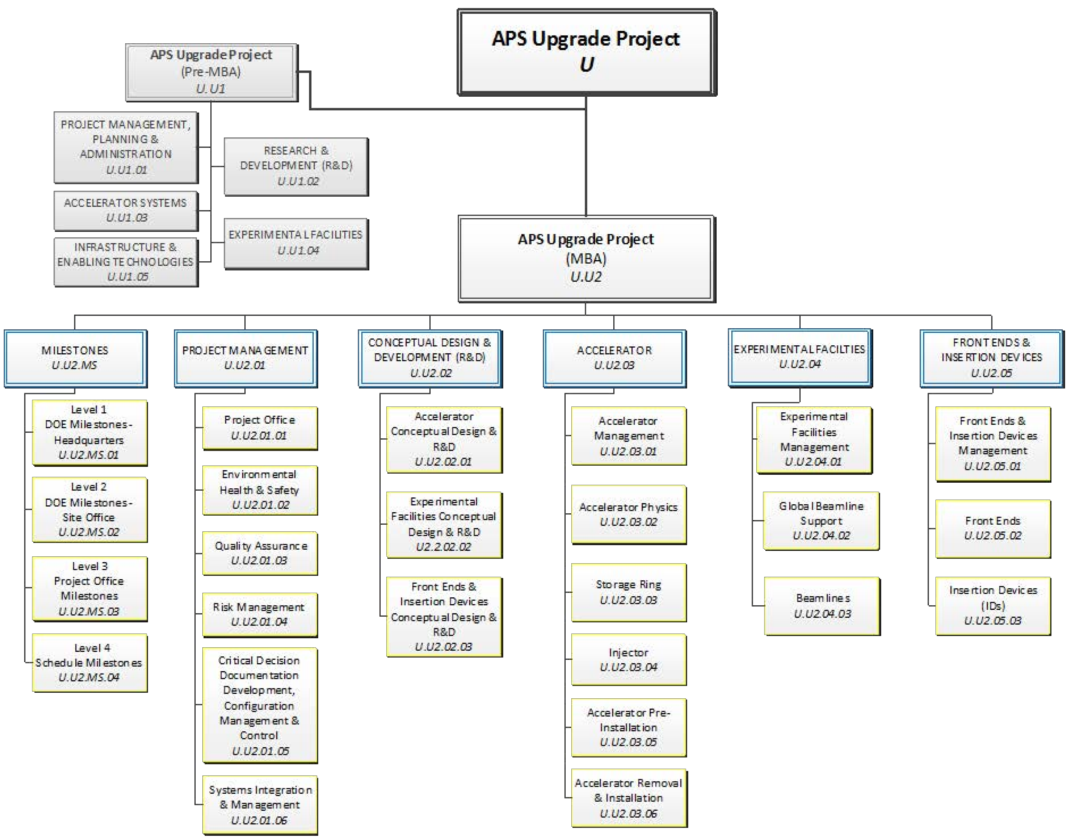

Figure 2.1. APS Upgrade Project work breakdown structure to level 4

2-3 Cost and Schedule

2-3.1 Cost

The preliminary cost range of the APS Upgrade Project is $700M to $1,000M, with a current Total Project Cost (TPC) point estimate of $770M. This includes $44M of actuals for pre-MBA scope and $173M of contingency, as shown in Table 2.1. The cost and schedule estimate was developed using a bottom-up approach. The cost estimate is based upon expert analysis and opinion from engineers, accelerator physicists, scientists and technicians who have recently constructed and/or fabricated systems similar to those systems and components at the APS. They have used discussions with suppliers, their own experience, the experience of other colleagues, historical information from similar deliverables, scaled estimates from projects of similar scope, and vendor estimates for major items, such as the magnet power supplies. All cost estimates are based on the component and system layouts described in the Preliminary Design Report.

Table 2.1. APS Upgrade Project total cost estimate to level 3 of the WBS

WBS node	Description	Baseline cost estimate ($M)
U	APS-Upgrade Project	597
U.U1	APS-Upgrade Project —Pre MBA	44
U.U2	APS-Upgrade Project —MBA	553
U.U2.01	Project Management, Planning and Administration	50
U.U2.02	Conceptual Design & Development (R&D)	43
U.U2.03	Accelerator Systems	244
U.U2.04	Experimental Facilities	153
U.U2.05	Front Ends and Insertion Devices	64
	Contingency (based on estimate to complete)	173
	Total Project Cost	770

The cost estimate shown in Table 2.1 represents a theoretical baseline cost estimate (BCE) at level 3 of the WBS, which includes direct costs, escalation, indirects, and contingency. The BCE is generated from the integrated project schedule (IPS). Based on a preliminary target of $770M as the total project cost estimate, Table 2.2 shows the initial project timeline and a notional funding profile (not yet approved) that is being used for planning purposes only. The quantity for each type of funding listed in Table 2.2 is also under review for future years to ensure consistency with current definitions, but the TPC will remain unchanged. This profile will be updated and the project plan updated as the funding for FY 2018 and beyond is clarified. The total actuals for work completed prior to FY 2014 are shown in the “Prior Years” column.

At this time, the APS-U project has about 35% contingency on the estimate for work remaining. This is consistent with a qualitative assessment of risks associated with the project and with uncertainty in the current cost estimate. As the design continues to mature, and as more information becomes available, constant contingency analysis will be done to identify risks and determine appropriate levels of contingency; the percentage level will be adjusted accordingly. A full quantitative analysis will be complete before the Critical Decision 2 (CD-2) DOE milestone, currently projected in FY 2019.

Contingency is managed centrally and is not pre-allocated or pre-assigned to any item. Scope

Table 2.2. Estimated initial funding profile in millions

	Prior Years	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	Total
OPC	8.5								5	27.5	10	51.0
TEC Design	34.2	17	20	20	30	29	3.5	3.3				157.0
TEC Construction	5.8	3.0			12.5	38	78.3	149.1	160	82.5	32.8	562.0
Total	48.5	20	20	20	42.5	67	81.8	152.4	165	110	42.8	770.0

contingency is planned, both to offset unexpected costs and to enable priority based expansion of scope as feasible. Contingency funds will be allocated for these purposes only if there is sufficient confidence in overall project cost estimates, and if the remaining contingency is sufficient to mitigate all known significant risks going forward.

All materials and services (M&S) and labor costs are subject to escalation over the lifetime of the project. Labor cost escalation rates were based on published FY 2015 Argonne labor escalation rates [3]. The escalation rate for M&S and labor is assumed to be constant throughout the life of the Project. A further study of escalation will be conducted prior to CD-2. Table 2.3 shows the escalation used for the initial cost estimate.

Table 2.3. Escalation rates used in the initial cost estimate

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Labor	Incremental	0.0%	0.0%	0.0%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%
	Compounded	1.00	1.00	1.00	1.033	1.067	1.102	1.139	1.176	1.215	1.255
Material	Incremental	0.0%	0.0%	0.0%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%
	Compounded	1.00	1.00	1.00	1.032	1.065	1.099	1.134	1.171	1.208	1.247

2-3.2 Schedule

An initial APS-U summary schedule including expected timeline and milestones is shown in Figure 2.2. The schedule for the MBA scope, assumes an FY 2014 start and an early completion in FY 2023. The APS Upgrade will be planned and executed with minimal impact on APS Operations until the one-year removal and installation period, scheduled to begin no earlier than FY 2022. Initial subsystem and component testing, major system integration testing, and testing with beam will occur during this 'dark' period. The Integrated Project Schedule (IPS) is technically driven, with 33 months of schedule contingency before a CD-4 date in the 1st quarter of FY 2026. The detailed IPS was developed from the WBS scope packages and forms the basis for the initial schedule baseline. The details of the schedule will continue to mature until approval of the performance baseline at CD-2.

The schedule contingency reflects the large uncertainty for the APS Upgrade in the budget process, between the current FY 2018 Presidential Budget Request and the ongoing negotiations in Congress.

In the meantime, the Project is attempting to hold internal schedules consistent with the technically driven early completion date, and will adjust after the FY 2018 budget becomes firm. Depending on the budget profile, the Project may propose a standard split CD-2 and CD-3 as shown in Figure 2.2. Proposed Level 1 (L1) milestones representing the project's critical decision strategy are provided in Table 2.4.

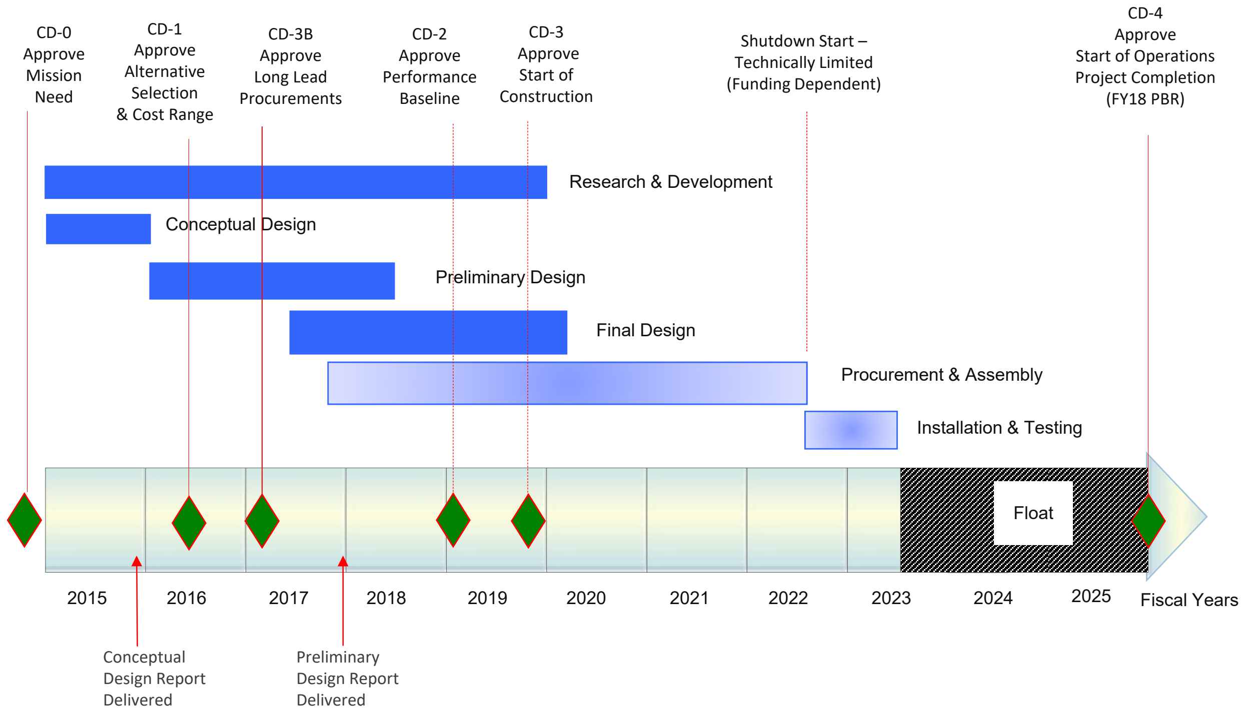

Figure 2.2. APS Upgrade proposed timeline and milestones

Table 2.4. APS Upgrade proposed critical decision milestones

Major Milestone Events	**Preliminary Schedule**
CD-0 (Approve Mission Need)	4/27/2010 (Actual)
CD-1 (Approve Alternative Selection and Cost Range)	2/04/2016 (Actual)
CD-3b (Approve Long-Lead Procurement)	10/06/2016 (Actual)
CD-2 (Approve Performance Baseline)	1st Qtr, FY 2019
CD-3 (Approve Start of Construction)	4th Qtr, FY 2019
CD-4 (Approve Start of Operations)	1st Qtr, FY 2026

2-4 Project Management

The APS-U's success rests on three major institutional participants: (1) DOE Headquarters, Office of Basic Energy Sciences (BES); (2) Argonne Site Office (ASO); and (3) UChicago Argonne, LLC (UChicago). Figure 2.3 shows DOE's organization of the APS-U project.

The Argonne Site Office (ASO) is the Office of Science's (SC) federal line manager for DOE conducted operations at Argonne. Such operations are executed by Argonne under a Prime Contract between DOE and UChicago. In this capacity, ASO's Manager is responsible for oversight of the Laboratory, as well as for facilitating mission accomplishment. Accordingly, and in support of this project, the ASO is responsible and accountable for providing/securing all necessary federal resources to support the project, including but not limited to the Federal Project Director (FPD), construction safety engineers, contracting officers, etc.

The APS-U Project FPD serves on the behalf of the ASO and is responsible for the requirements assigned in DOE Order 413.3B [1], Program and Project Management for the Acquisition of Capital Assets. The FPD will (1) submit key project documents and critical decisions to the appropriate Acquisition Executive for approval; (2) report project progress; (3) provide environment, safety, and health oversight; (4) coordinate approval of NEPA documentation; and (5) assess contractor performance on project execution.

The Integrated Project Team (IPT) will support these responsibilities. The APS Upgrade IPT is headed by the FPD and includes as its core members the DOE/BES Program Manager, the DOE APS Upgrade Deputy Federal Project Director, the APS Upgrade Project Director, and the APS Upgrade Project Manager. The IPT also may include any specialized support personnel at DOE or Argonne as required on an ad hoc basis. The FPD, Deputy FPD, APS Upgrade Project Director, and the APS Upgrade Project Manager meet weekly to communicate, coordinate, and expedite Project progress; the core members of the IPT hold monthly phone conferences.

Although the APS-U project is a Major Item of Equipment (MIE), the intent is to implement DOE Order 413.3B [1] via a tailored approach that optimizes control, progress, and performance of the APS-U Project. It is proposed that the APS-U will become a Line Item Construction (LIC), as early as FY 2018, in which case DOE Order 413.3B [1] will be applied consistent with the practices of projects within the DOE Office of Science.

UChicago manages and operates Argonne for DOE under the terms and conditions of Contract No. DE-AC02-06CH11357. UChicago has provided the Laboratory Director with overall responsibility for all projects, programs, operations, and facilities at Argonne. Argonne commits to manage the APS-U project within cost and on schedule, and to deliver the promised technical scope and performance. The Laboratory is committed to maintaining the APS now and after the APS-U as a premier scientific user facility. Argonne's management organization is shown in Figure 2.4; Argonne's organization for the APS-U project is shown in Figure 2.5.

Within Argonne, the Laboratory Director has currently designated a Project Director and a Technical Director. The APS-U Project Director is responsible for the management and execution of the APS-U. The Project Director will ensure that the Project is successfully completed within budget and on time, meeting the planned scope. In addition, the Laboratory Director uses the Argonne Project Oversight Council to hear at least monthly on any issues with respect to the Project, and receive guidance and recommendations on the best management practices to use with regards to any issues occurring on the project. Argonne will establish a written Memorandum of Agreement between the APS-U and all laboratory organizations to explicitly define roles, responsibilities, relationships, authorities, resources, and deliverables.

Argonne has a certified Earned Value Management System in place [4]. For the APS-U Project, the DOE APS-U FPD will provide quarterly reports to DOE Headquarters and monthly updates to the Project Assessment and Reporting System (PARS) starting at CD-2. In addition, with CD-3B approval in October 2016, any Long Lead Procurements which receive concurrence of the program for execution will be approved, tracked and reported in accordance with the tailoring procedure specified in the APS Upgrade Preliminary Project Execution Plan [5], including reporting of those items into PARS. A monthly progress report on the APS-U Project, including technical and cost performance reports as appropriate, will be issued by the APS-U Project Director and distributed to appropriate DOE offices and other organizations outside the Project.

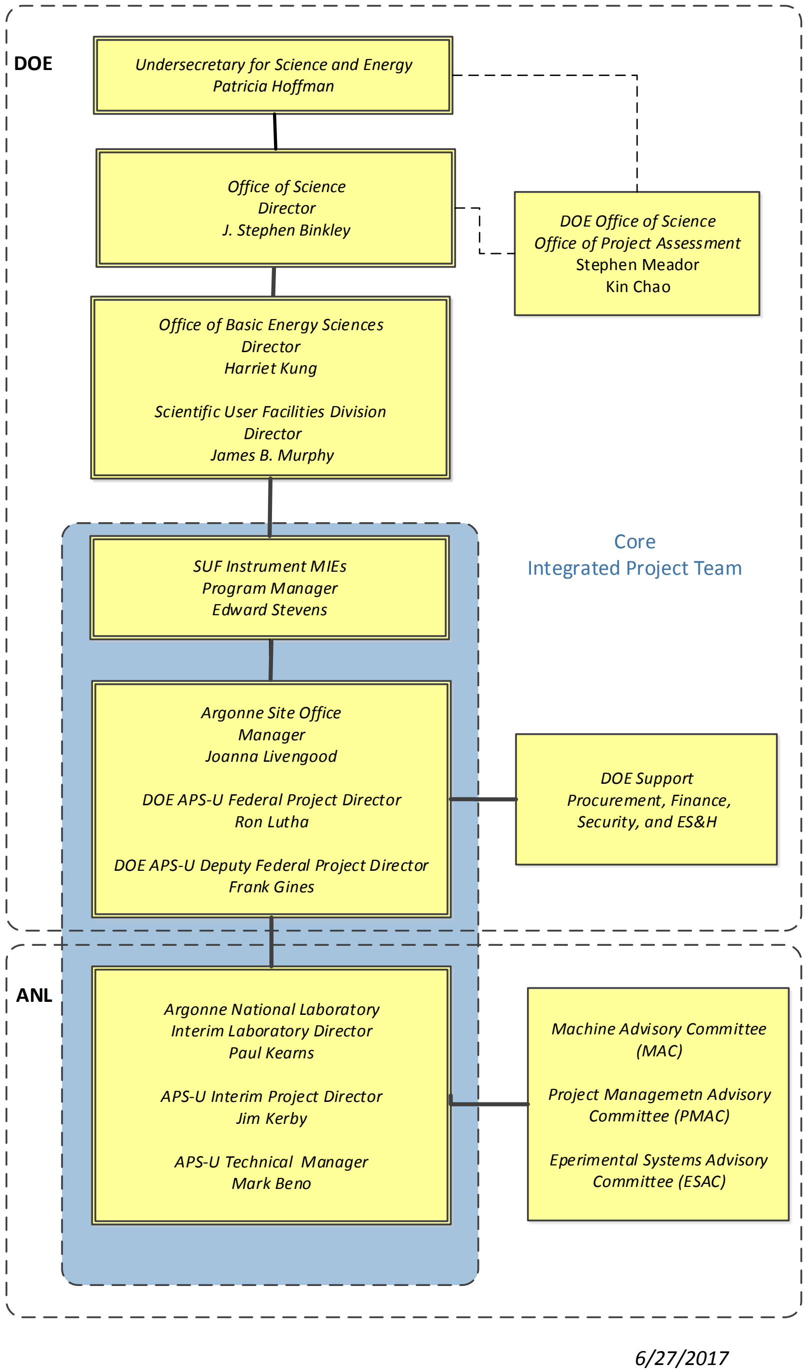

Figure 2.3. DOE APS-U Project organization showing IPT

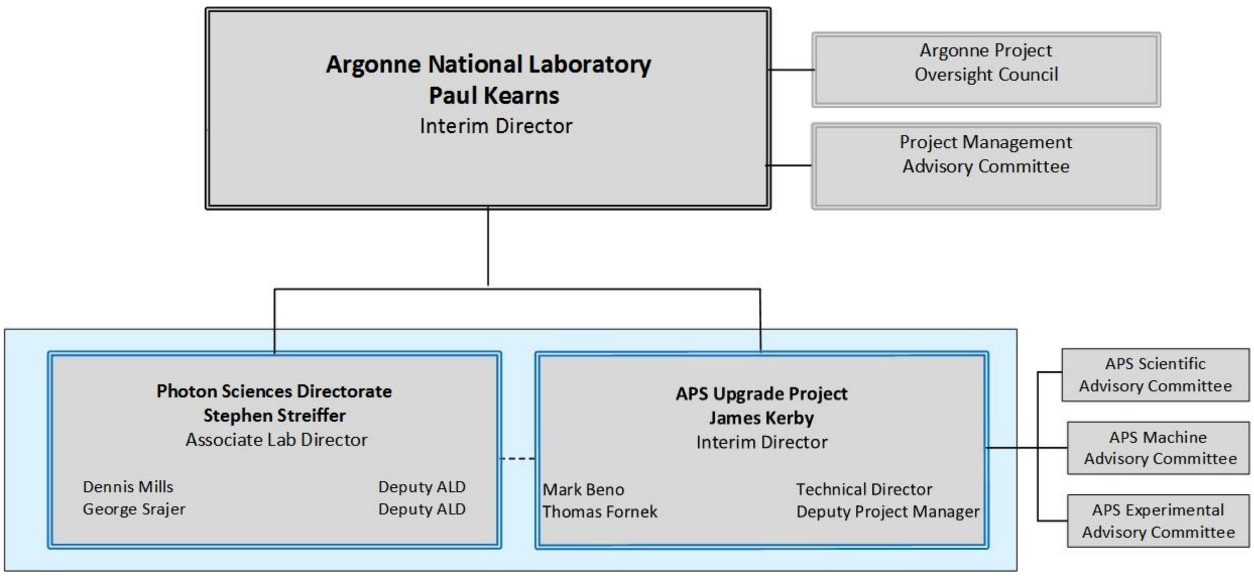

Figure 2.4. Argonne management organization

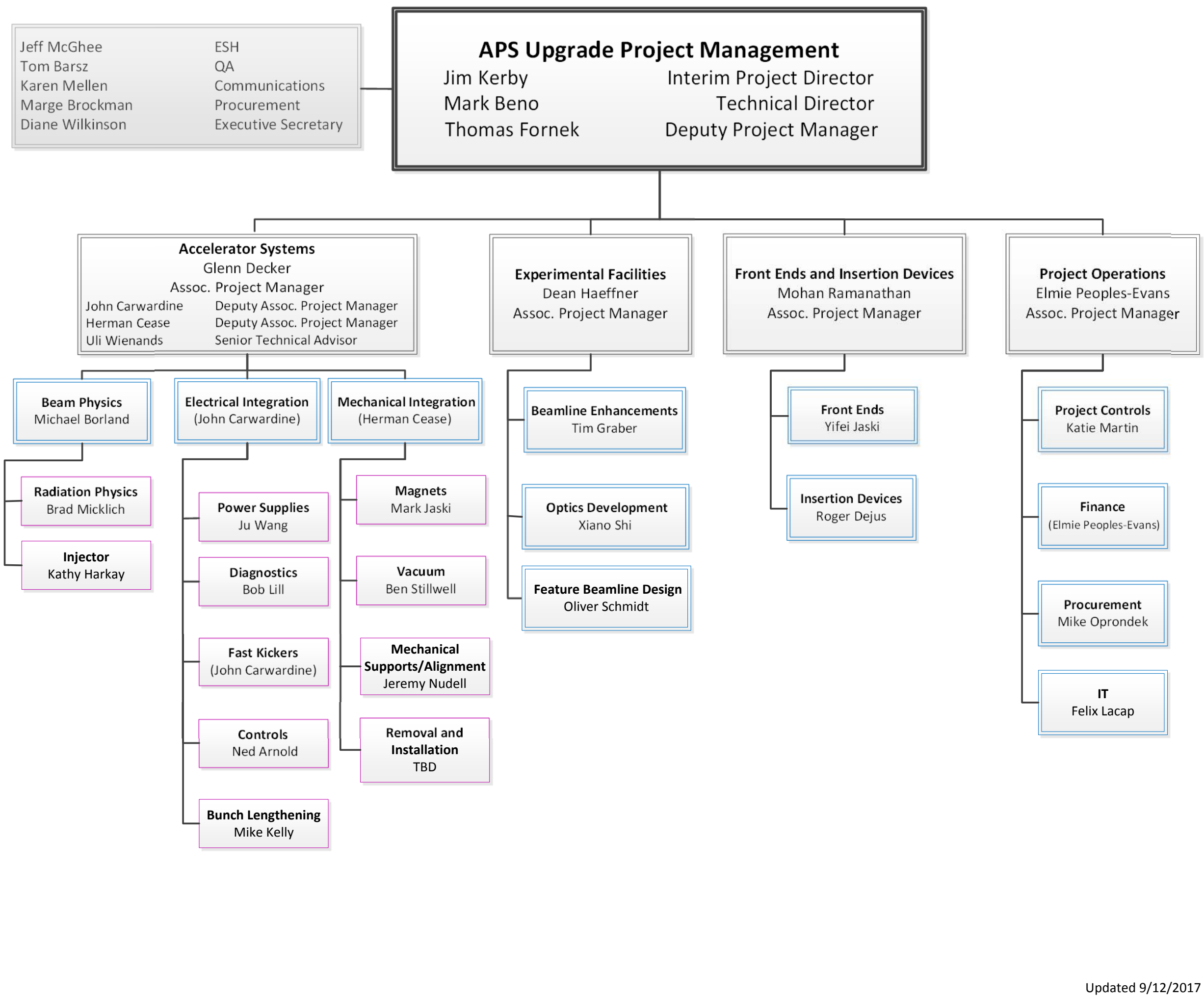

Figure 2.5. Argonne APS-U project organization

References

[1] U.S. Department of Energy. *DOE O 413.3B, Chg. 3.* Washington, DC, 2016.

[2] Argonne National Laboratory. APS-U Project Controls Guidelines.

[3] Argonne National Laboratory. Escalation percentages.

[4] Argonne National Laboratory. Earned Value Management System Description, JSTD-120-W-T001, Rev. 2, 2010.

[5] Argonne National Laboratory. Preliminary Project Execution Plan for the Advanced Photon Source Upgrade (APS-U),APSU-1-PLN-001-00 (latest revision), 2016.