Appendix A: Cost Analysis Data Requirement (CADRe) and One NASA Cost Engineering (ONCE) Portal Overview

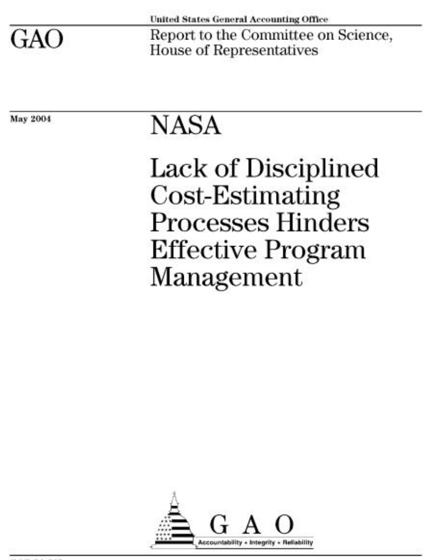
A.1. CADRe

A.1.1. Introduction

The Cost Analysis Data Requirement (CADRe) is a formal project document that describes the programmatic, technical, and life-cycle cost and cost/schedule risk information of a project. It is a three-part document that describes a NASA project at major life-cycle milestones and provides a historical record of cost, a schedule, and technical project attributes so that estimators can better estimate future analogous projects. A 2005 initiative, the CADRe is NASA's unique response to the need to improve cost and schedule estimates during the formulation process, providing a common description of a project at multiple given points in time as the project matures through its life-cycle.

A.1.1.1. History of CADRe

In 2004, the Government Accountability Office (GAO) released a critical report on NASA titled "Lack of Disciplined Cost-Estimating Processes Hinders Effective Program Management" (see Figure A-1). The GAO made a number of recommendations to NASA, including urging the Agency to develop a document to fully describe a project and include the actual costs of the project so that estimators could use that data to better estimate similar future projects. Agency Project Managers (PMs) have historically estimated the cost of their projects using a bottom-up method—otherwise known as "grassroots estimating," which is highly optimistic and tends not to include all potential risks. To combat this tendency, GAO recommended using actual historical costs and building a repository of cost and technical data for use in preparing cost estimates.


United States General Accounting Office

GAO

Report to the Committee on Science, House of Representatives

May 2004

NASA

Lack of Disciplined Cost-Estimating Processes Hinders Effective Program Management

GAO

Accountability • Integrity • Reliability

GAO-04-642

Figure A-1. 2004 GAO Report—The Beginnings of CADRe

In response, the Agency agreed (in line with the GAO recommendations) that all major space projects would develop what is now known as a CADRe. The CADRe would serve as a formal means to capture and archive cost, technical, and programmatic data for use in estimating future NASA projects. Unique templates for each part of the CADRe (A, B, and C) were developed to standardize the development of the document across all of NASA's flight projects. The CADRe document was formally established in 7120.5C, which was a new policy and directive to implement CADRes across all of NASA. The CADRe requirement was further documented in 7120.5D and 7120.5E. With the requirements framework in place, the Cost Analysis Division (CAD) began implementing CADRe on current missions as well as preparing CADRes for many historical missions.

A.1.1.2. CADRe Purpose

The CADRe effort satisfies a foundational cost estimating need, capturing data across all major flight projects at NASA, including major instruments that fly on foreign partner spacecraft to provide historical cost data, which is vital to performing estimates for future missions. The CADRe provides information to support an Independent Cost Estimate (ICE) as well as actual cost and technical information so that estimators can do a better job of projecting the cost and schedule of future analogous projects. The CADRe tracks and explains changes that occurred from one milestone to the next, and it helps the PM capture, in one document, all the events that occurred during the project both internal and external.

A.1.1.3. CADRe Ownership

The CADRe is a project-owned document and is signed by the PM; therefore, it does not include any independent assessments or evaluations or opinions about the project. It simply records the known configuration at the specific milestone. CAD at NASA Headquarters provides the necessary funding and support to prepare the document on behalf of the project by using existing project documentation prepared during the milestone review process. In the few cases where a CADRe is prepared for a previously launched mission, CAD will determine if there is enough data, and, if so, will prepare a single Launch or End of Mission (EOM) CADRe.

A.1.2. CADRe Structure and Content

Composed of three parts, the CADRe captures detailed programmatic, technical, and cost data in a standardized format. The document is prepared six times during the life cycle of a project at major milestones (i.e., System Requirements Review [SRR], Preliminary Design Review [PDR], Critical Design Review [CDR], Systems Integration Review (SIR), Launch, and End-of-Mission [EOM]). (See Figure A-2.)

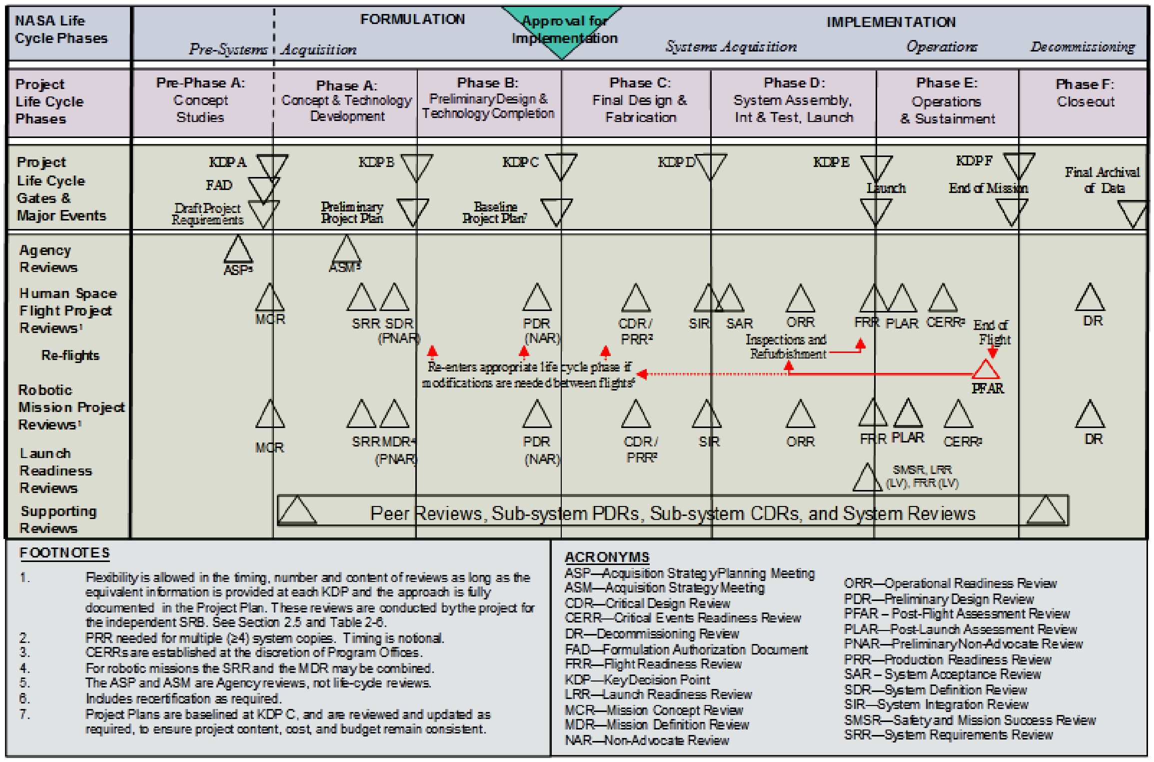


Figure A-2. When CADRes Are Required

The three parts of a CADRe are as follows:

- Part A: Describes the project at each milestone (i.e., SRR, PDR, CDR, SIR, Launch, and EOM) and describes significant changes that have occurred. Part A includes essential subsystem descriptions, block diagrams, and heritage assumptions that are needed for cost-analysis purposes (see Figure A-3). The templates for robotic or human space flight missions can be found at *http://www.nasa.gov/offices/ooe/CAD.html*.

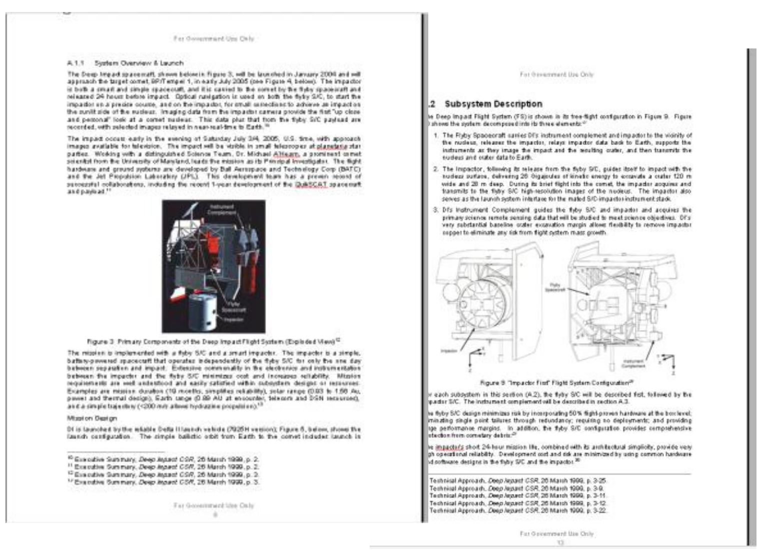


Figure A-3. CADRe Part A Example

- Part B: Contains standardized templates to capture key technical parameters that are considered to drive cost, such as mass, power, data rates, and software metrics in a Microsoft Excel Workbook (see Figure A-4). This template uses standard NASA terminology, such as Current Best Estimates (CBEs) and CBE Plus Contingency. (Visit *http://www.nasa.gov/offices/ooe/CAD.html* for more information.)

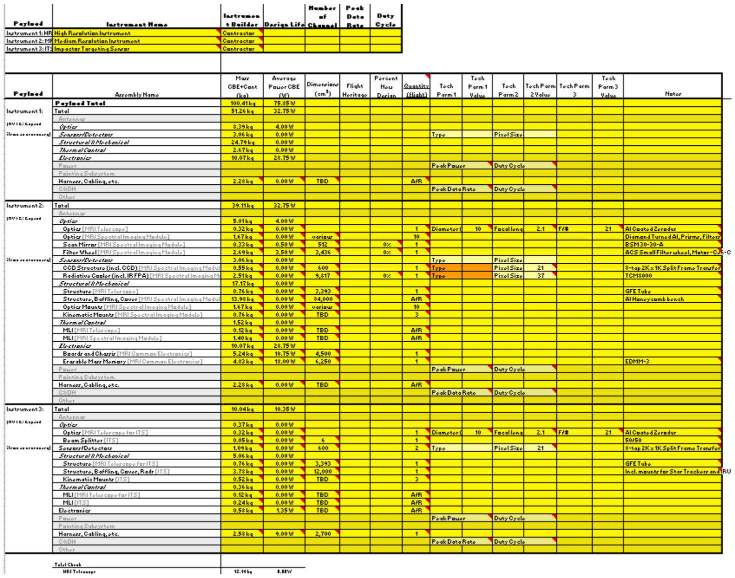


Figure A-4. CADRe Part B Example

- Part C: Captures the cost estimate and actual life-cycle costs within the project's Work Breakdown Structure (WBS) in a Microsoft Excel Workbook. This section also captures the project schedule, risks, and ground rules and assumptions (GR&A). (See Figure A-5 and *http://www.nasa.gov/offices/ooe/CAD.html* for more information.)

#	Project WBS Elements	vel	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	Total
1.0	Project Management / Mission Analysis / System Eng	1	2,041	1,855	2,204	2,268	659	-	-	9,027
2.0	Science Team	1	766	530	688	758	338	-	-	3,080
3.0	Flight System	1	18,174	42,573	37,344	14,786	1,604	-	-	114,481
3.1	Program Management	2	1,247	1,086	1,483	1,449	468	-	-	5,733
3.2	System Engineering	2	892	645	315	11	-	-	-	1,863
3.3	Instruments	2	3,450	13,677	7,635	1,644	255	-	-	26,661
3.3.1	Instrument Management	3	599	1,070	1,525	528	64	-	-	3,787
3.3.2	Instrument Systems Engineering	3	547	763	1,009	799	157	-	-	3,275
3.3.3	Instrument Product Assurance	3	104	287	478	194	12	-	-	1,075
3.3.4	Telescopes	3	135	859	148	-	-	-	-	1,142
3.3.5	Spectral Camera	3	347	4,476	683	-	-	-	-	5,505
3.3.6	Electronics Module	3	699	3,664	885	-	-	-	-	5,247
3.3.7	Instrument Software	3	857	771	388	95	22	-	-	2,133
3.3.8	HRI	3	50	267	609	-	-	-	-	927
3.3.9	MRII	3	63	271	536	-	-	-	-	870
3.3.A	Impactor Target Sensor	3	49	331	763	27	-	-	-	1,171
3.3.B	Ground Support Equipment	3	-	918	610	-	-	-	-	1,529
3.4	Flyby Spacecraft	2	9,680	19,920	20,526	7,032	717	-	-	57,874
3.4.1	Program Management	3	2,179	1,848	2,834	2,323	391	-	-	9,574
3.4.2	System Engineering	3	830	781	852	458	118	-	-	3,039
3.4.3	Product Assurance	3	425	542	703	513	-	-	-	2,183
3.4.4	Propulsion	3	403	1,454	1,096	186	197	-	-	3,336
3.4.5	Telecommunications	3	723	2,678	1,826	424	5	-	-	5,658
3.4.6	Electrical Power	3	644	3,192	2,049	304	5	-	-	6,193
3.4.7	Structure	3	764	2,720	3,411	239	-	-	-	7,134
3.4.8	C&DH	3	608	3,688	2,527	750	-	-	-	7,573
3.4.9	ADCS	3	439	977	2,071	489	-	-	-	3,977
3.4.A	Thermal	3	269	445	766	193	-	-	-	1,672
3.4.C	Software	3	2,037	704	679	-	-	-	-	3,420
3.4.D	Integration & Test	3	75	212	1,035	897	-	-	-	2,218
3.4.E	Ground Support Equipment	3	285	678	677	256	-	-	-	1,896
3.5	Impactor	2	2,905	7,245	7,385	2,909	29	-	-	20,474
3.6	Deep Impact Integration & Test	2	-	-	-	1,741	136	-	-	1,877
3.6.1	System Integration & Test Management	3	-	-	-	284	21	-	-	305
3.6.2	Flyby S/C and Impactor Integration & Test	3	-	-	-	1,035	114	-	-	1,149
3.6.3	System MGSE	3	-	-	-	172	-	-	-	172
3.6.4	System EGSE	3	-	-	-	250	-	-	-	250
4.0	Launch Site & Orbital Operations	1	86	140	243	422	783	-	-	1,673
4.1	Pre Launch Planning	2	86	140	243	237	67	-	-	773
4.2	Launch Site Support	2	-	-	-	185	606	-	-	791
4.4	Flight Operations	2	-	-	-	-	109	-	-	109
5.0	Pre-Launch GDS/MOS Development	1	398	391	1,187	2,959	978	-	-	5,913
6.0	Mission Operations and Data Analysis	1	-	-	-	-	3,471	5,426	1,265	10,161
6.1	Mission Operations	2	-	-	-	-	1,572	2,315	159	4,046
6.1.3	Phase E Mission Operations	3	-	-	-	-	1,572	2,315	159	4,046
6.2	Science Team	2	-	-	-	-	1,899	3,111	1,105	6,115
7.0	Deep Space Network (DSN) or Other Tracking Servic	1	-	-	-	-	-	-	-	-
8.0	Education and Public Outreach	1	636	419	606	779	993	743	232	4,409
10.0	Launch Services	1	-	-	-	-	-	-	-	-
	Subtotal		22,101	45,909	42,272	21,972	8,826	6,169	1,497	148,746

Figure A-5. CADRe Part C Example

The CADRe is produced using existing project documents. The CAD does not require any unique documentation to produce the CADRe. This is one of the key aspects of a CADRe that makes it a one-stop source of data. Part A includes documents such as the project plan and milestone briefing charts; Part B uses the project mass and power reports; and Part C uses the project's cost estimates, schedules, and cost reports. See Figure A-6 for many of the key documents used.

Part A. Descriptive Information
-Project Plan
-Architecture Description Document
-Acquisition Plan
-Project Implementation Plan
-System Engineering Plan
-Risk Mitigation Plan
-Integrated Design Definition Documents (Constellation)
-Milestone Review Briefing Packages (SDR, PDR, CDR etc)
-Concept Study Report/Proposal (if applicable)
-Concept of Operations
-Integrated Master Schedule
-Integrated Test Plan
-Monthly Status Reports
-Any Instrument specific MDR, CDR, PDR packages
-ATLO Plan (used later in the project)
-Mission Readiness Review (used later in the project)
-Pre Environmental Readiness Review (used later in the project)
-Launch Readiness Review (used later in the project)

Part B. Technical Data
-Master Equipment Lists
-Project Schedules
-Mass Property Reports
-Power Budget Summary Report
-Software Design Reports
-Milestone Briefing Packages/Documentation

Part C. Life Cycle Cost Estimate
-Project Cost Estimate by WBS
-WBS Dictionary
-POP costing details
-533 reports (used later in the project)
-EVM reports (used later in the project)

Figure A-6. Key Documents Needed for a CADRe

CADRe templates may be a significant aid to developing a CADRe submission and should be reviewed early in the project development to ensure awareness of the data reporting requirements as the project matures through its life cycle. Templates can be found in the ONCE Portal at *http://www.nasa.gov/offices/ooe/CADRe_ONCE.html*.[1]

A.1.3. The CADRe Development Process

The process of preparing a CADRe is as follows: after a kickoff meeting with the PM approximately 60 to 90 days before the milestone, CAD will collect all relevant existing documentation during the life-cycle review process. The CADRe is prepared using existing project documentation that provides descriptive information, mass statements, power statements, schedules, risk list, and life-cycle cost estimates as well as any other technical parameters that tend to drive costs. CAD will deliver the document for the PM's review and signature shortly after a capstone Key Decision Point (KDP) briefing such as the Agency Program Management Counsel (APMC) or the Directorate Program Management Counsel (DPMC)—when the cost and schedule positions are finalized—is held.

[1] Project and Program Managers may contact the Cost Analysis Division directly for templates and guidance at *hq-cad@email.nasa.gov*.

Completed CADRes are available from the ONCE portal to facilitate fast searches and retrieval to support cost and schedule estimating.[2]

A.1.4. Application of CADRe Data

The application of CADRe data helps NASA PMs and cost analysts analyze important attributes of projects to help deliver projects within cost, schedule, and technical margins. With a large, historical archive of project data, it is possible to determine trends that may be useful to PMs. Here are some examples:

1) Cost engineers use CADRe to estimate the cost of future systems based on known technical parameters such as mass and power. The CADRe data are also used to help evaluate proposals from contractors on new missions.
2) System engineers use CADRe information to perform mass architecture trades earlier in concept design by using time-tagged mass data on all major NASA projects.
3) Analysis of CADRe data has shown that schedule growth on payload instruments is a significant factor that increases the total cost. On average, instrument development schedule growth was 33 percent or approximately 10 months above the trend line as can be seen in Figure A-7.

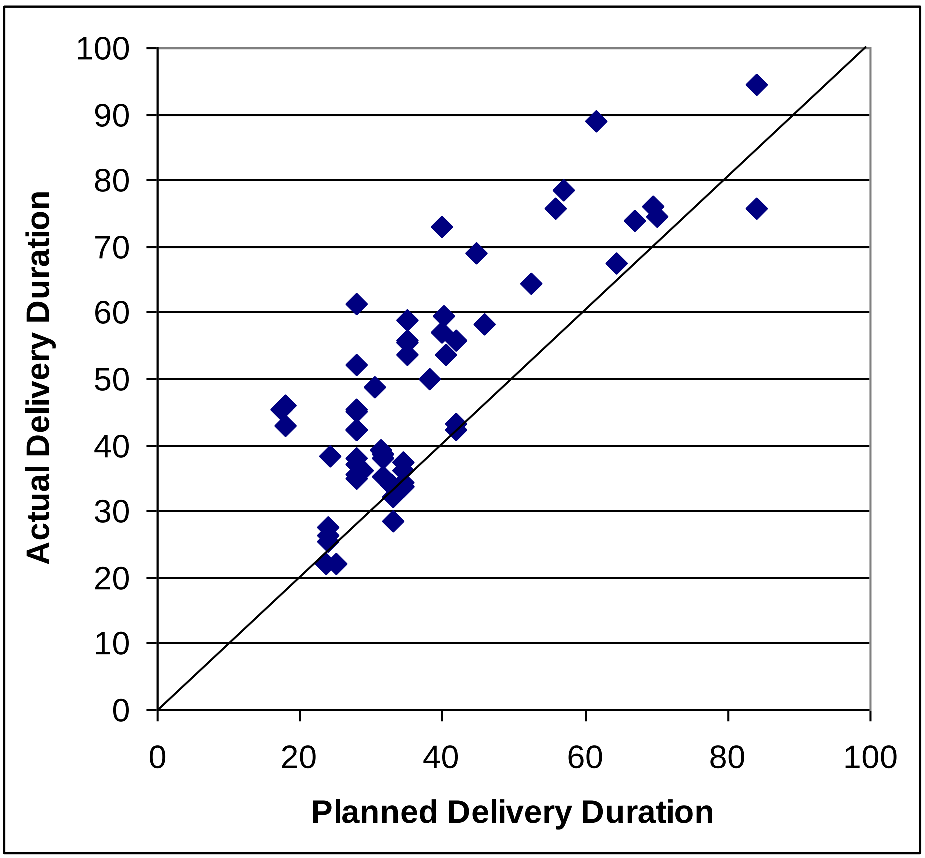


Figure A-7. Planned Versus Actual Delivery Durations for Payload Instruments

In another example, research of the mass data in CADRe is showing that actual instrument mass often exceeds the planned mass contingencies that are routinely used. An analysis of over 30 NASA instruments showed that the baseline mass contingency was not enough to protect against mass growth.

[2] Information for accessing ONCE can be found at *http://www.nasa.gov/offices/ooe/CADRe_ONCE.html*.

With this information, PMs of future projects will be able to program more appropriate levels of mass contingency tailored to the type of instrument being developed.

A substantial database of completed CADRes, looking back approximately 15 years, is now available on the ONCE portal, where membership has grown to over 200 users. Furthermore, these data have been used in many cost estimates to develop analog costs. Projects can now determine if they are in a family with other similar projects across cost, schedule, and various technical parameters. As CAD completes more CADRes, CAD expects the use of these data will improve the quality of estimates and lower the cost growth of projects over time and therefore improve NASA's credibility with external stakeholders, including Congress. As the number of CADRes continues to grow, more robust analysis can be accomplished, resulting in more advanced costing practices and tools.

A.1.5. Lessons Learned and the Challenge of Implementing CADRe

In the early years of implementing a CADRe, there was resistance from the PM community. Many PMs attempted to write "waivers" so they would not have to support the preparation of a CADRe. The CAD worked diligently to build consensus within the PM community by alleviating concerns and misunderstandings about how a CADRe works and by communicating the value and future benefit of having a CADRe document to improve estimating of future project costs. The CAD negotiated exactly what data and project documentation was needed to prepare the CADRe documents, and once the CADRe was prepared, explained how the PM needed to review and sign the document.

A different challenge occurred when CAD undertook the effort to prepare CADRes for historical missions going back 10 to 15 years. A determination was made that anything older than 20 years would not yield functional CADRes simply because the detailed data were not readily available. Still, gathering data on historical missions necessitated customized templates; the creation of something called a CADRe Plus, which is a single CADRe that combines all available data from each milestone as the data become available; and persistence in data collection and in finding the PM to review and sign off on those CADRes.

A.2. One NASA Cost Engineering (ONCE) Portal

The ONCE portal is a secure Web-based application containing all completed CADRes in the ONCE portal for easy retrieval and faster data analysis, as well as tools available to the NASA cost and schedule analysis community. This portal is fully cloud compliant, and the server is located behind the Marshall Space Flight Center (MSFC) firewall. The portal provides advanced search routines to quickly access CADRe data across multiple projects and milestone events. Since CADRes represent snapshots of a project at successive key milestones, the ONCE portal captures all project changes and their associated cost and schedule impacts. The result provides enhanced insight and management of historical cost and technical data, which is helping to advance costing practices and analysis across the Agency. Anyone who needs access to the ONCE portal can go to the ONCE Web site at *http://www.oncedata.com* and click on the "request access" link on that page.[3] The portal is pictured in figure A-8.

[3] The key requirement for access is a NASA Identity in NASA's IDMAX system.

Figure A-8. ONCE Portal