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IDC Reengineering Phase 2 & 3 US Industry Standard Cost Estimate Summary

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Abstract

Sandia National Laboratories has prepared a ROM cost estimate for budgetary planning for the IDC Reengineering Phase 2 & 3 effort, using a commercial software cost estimation tool calibrated to US industry performance parameters. This is not a cost estimate for Sandia to perform the project. This report provides the ROM cost estimate and describes the methodology, assumptions, and cost model details used to create the ROM cost estimate.

ROM Cost Estimate Disclaimer

Contained herein is a Rough Order of Magnitude (ROM) cost estimate that has been provided to enable initial planning for this proposed project. This ROM cost estimate is submitted to facilitate informal discussions in relation to this project and is NOT intended to commit Sandia National Laboratories (Sandia) or its resources.

Furthermore, as a Federally Funded Research and Development Center (FFRDC), Sandia must be compliant with the Anti-Deficiency Act and operate on a full-cost recovery basis. Therefore, while Sandia, in conjunction with the Sponsor, will use best judgment to execute work and to address the highest risks and most important issues in order to effectively manage within cost constraints, this ROM estimate and any subsequent approved cost estimates are on a 'full-cost recovery' basis. Thus, work can neither commence nor continue unless adequate funding has been accepted and certified by DOE.

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REVISIONS

Version	Date	Author/Team	Revision Description	Authorized by
1.0	1/9/2015	SNL IDC Reengineering Team	Release for I2	Bob Huelskamp

1 PROJECT BACKGROUND

The CTBTO's International Data Centre (IDC) has recognized the need to reengineer their waveform data processing software system. In the 16 years since the delivery of the first version of IDC software, major components of the system have been replaced in response to advances in monitoring technologies leading to new functional requirements and infrastructure changes. In the absence of an up-to-date, overarching architecture, the result of these development activities is an increasingly fragmented software landscape with little software reuse, code duplication, and outdated technologies. Such a system is increasingly difficult to maintain and enhance as new technologies become available.

In response, the Provisional Technical Secretariat (PTS) has established a three-phase reengineering effort. Phase 1 focused on enhancements to individual components of the system and is near completion. Moving forward, Reengineering Phase 2 (RP2) & 3 (RP3) will address development of a modern, model-based component architecture as the foundation for a cost-effective, maintainable and extensible system that will allow the CTBTO to meet its treaty monitoring requirements for the next 20+ years.

2 COST ESTIMATE OVERVIEW

To support budgetary planning for an IDC Reengineering effort, Sandia has developed an initial ROM cost estimate for RP2 & RP3 based on costs for a typical US software development company to execute the project. This estimate assumes that RP2 & RP3 will be executed using an incremental, iterative software development approach using best practices based on the Rational Unified Process (RUP) framework (http://en.wikipedia.org/wiki/RUP).

This estimate is provided at the 80% confidence level based on Monte Carlo analysis of cost uncertainty (see *Section 3.2* for more information on cost-risk analysis methodology). Table 1 summarizes cost information for RP2 & RP3 in then-year dollars. At 80% confidence, the total estimated cost for RP2 & RP3 is $124M.

Cost sources in the estimate include labor as well as purchases & travel. Purchase estimates account for hardware and software acquisition and recurring licensing costs required for the project development environment. Delivered system hardware & software purchases are assumed to be funded by other elements of the PTS, and are excluded from this estimate.

IDC Reengineering Phase 2 & 3	*80% Confidence*
RP2 - Inception	$1,431 K
RP2 - Elaboration	$10,381 K
RP3 - Development & Transition	$112,240 K
Total Cost	**$124,052 K**

Table 1. IDC RP2 & RP3 Cost Summary

Figure 1 shows the cost profile for RP2 & RP3 as generated by SEER.

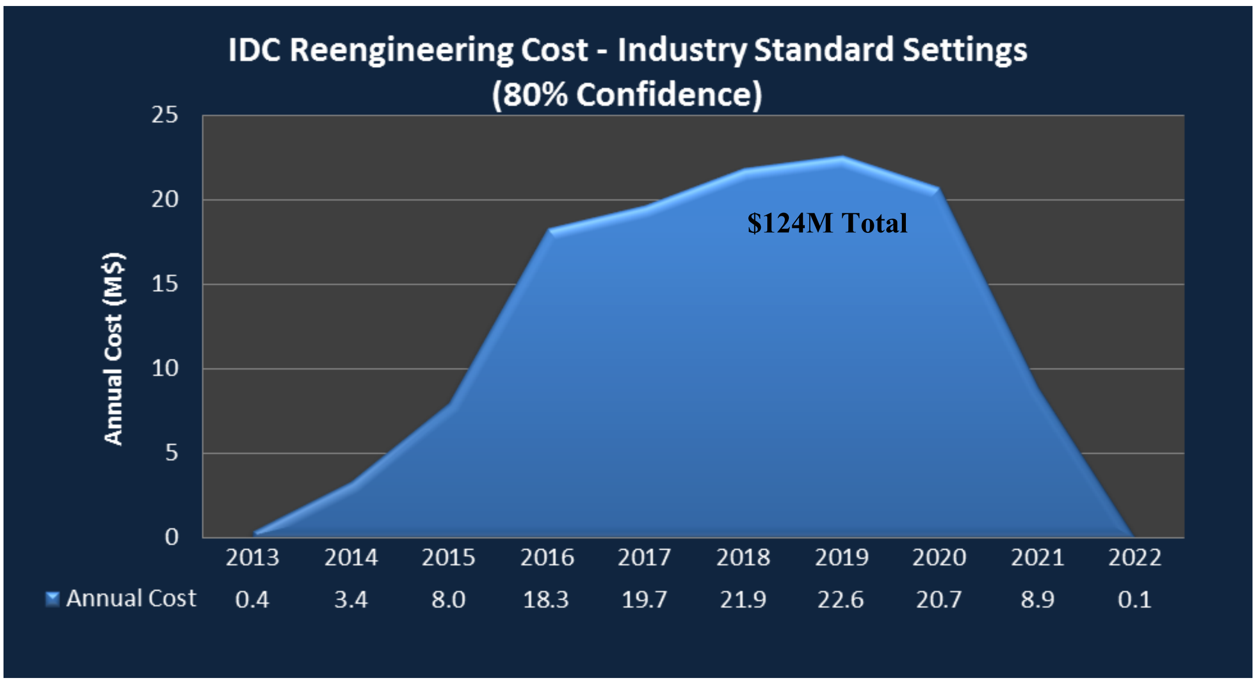

Figure 1. IDC Reengineering Project Cost Profile.

3 METHODOLOGY

The cost estimate presented here was developed using a combination of parametric models and engineering judgment, informed by experience with similar projects at Sandia.

Software engineering costs were estimated using parametric cost models based on project assumptions regarding scope, staffing, development processes and schedule. The Sandia project team used the *SEER for Software*[1] (SEER) cost estimation product to develop these parametric models. SEER is an industry standard cost estimation tool that includes industry-calibrated parameter knowledge bases for a large number of types of projects and development methodologies.

The Sandia project team set up a SEER project using the parameter knowledge bases recorded in Appendix B. A work breakdown structure based on the major components of the system was set up, setting parameters for the type of component, size, and schedule (schedule is discussed in section 4.3). Project-specific parameters were set based on the assumptions of the project, including percentage of redesign and reimplementation, potential multiple site development, and component integration factors. Sandia used the industry-standard personnel capabilities parameters included in SEER, as well as the SEER industry standard labor rate of $22,800/person-month for mission critical systems. Using these settings, SEER calculated statistical estimates of effort and cost for a range of confidence levels. Sandia used the 80% confidence level estimate, as is typically accepted to account for risk margin. Sandia applied the SEER standard 2.23% cost escalation factor for each year. Purchases and travel costs were estimated using engineering judgment based on actual costs from similar projects ($4M total).

3.1 Software Sizing

As is common practice at Sandia and in US industry, Logical Source Lines of Code (SLOC) were used as the initial measure of system size for this cost estimate; function points were used to a limited degree to model Commercial Off-The-Shelf (COTS) components, following the default SEER modeling approach. SLOC estimates for the reengineered IDC system were derived from code counts provided for the current system. Existing SLOC were scaled to account for anticipated reductions in code size resulting from the elimination of duplicative and dormant code.

3.2 Cost Risk Analysis

The SEER parametric modeling tool supports Monte Carlo analysis of total cost, accounting for uncertainty model parameters. Inputs to the tool, including SLOC and project assumptions, were modeled as three-point distributions representing least, likely and greatest values. The distributions were sampled within the SEER model to produce a cumulative frequency distribution representing software engineering effort as a function of confidence. For projects such as IDC Reengineering, Sandia uses an 80% confidence estimate of the software engineering effort. This estimate translates into an 80% chance that the total cost of the system will be at or

[1] www.galorath.com

under the estimated cost. This confidence level is typically used as an industry standard for fixed-price contract budgets, and accounts for the margin needed to mitigate cost risk.

4 KEY ASSUMPTIONS

The assumptions detailed in the following sections were used to develop the initial IDC Reengineering project ROM cost estimate for RP2 and RP3.

4.1 Scope Assumptions

The cost estimate includes RP2 & RP3. Together, these two phases account for all four of the RUP phases (see *Section 4.3* for more on RUP). The Reengineering project will address all IDC deployments and subsystems, including:

- Operational (OPS) & alternate (ALT) processing deployments
- Standalone system
- Testing and Training subsystems

An all-new modular, service-based software architecture will be developed for the reengineered system, accommodating expanded sensor networks and facilitating the integration of new computational modeling techniques, computer network technologies, and geophysical data analysis processes. It is assumed that:

1) Most of the legacy software will not be compatible with the modernized system architecture and design. Exceptions to the software replacement rule include the data acquisition software and common libraries.
2) Most of the existing IDC system software (~80%) is expected to be replaced.
3) Most of the data acquisition software is expected to be reused with moderate changes. This area of the system is considered to be more robust and maintainable than others and has not been identified as a priority for the modernization effort.
4) The common libraries are not expected to be heavily impacted by the changes in system architecture.
5) The overall size of the reengineered system software is expected to decrease by 20-30% percent as a result of duplicate/dormant code elimination and reorganization of the code in the new architecture.

4.2 Development Process Assumptions

This estimate assumes that RP2 & RP3 will be executed using an incremental, iterative software development approach based on the RUP framework (http://en.wikipedia.org/wiki/RUP).

In keeping with the Rational Unified Process, the project will be organized into four high-level phases: *Inception*, *Elaboration*, *Development* and *Transition*.

1) RP2 will execute the Inception & Elaboration phases; RP3 will execute the Development and Transition phases.
2) The underlying project schedule accounting for these phases will be divided *iterations*, each of which will encompass a complete development cycle, including requirements analysis, architecture analysis & design, implementation, integration, and test as applicable based on the project phase.

3) During RP3, each iteration will produce a functional version of the system.

4.3 Schedule Assumptions

The RP2 & RP3 project schedule is assumed to span the 8-year period CY2014 – CY2021. Figure 2 shows the relation between the IDC Reengineering Phases 2 & 3 and the RUP project phases.

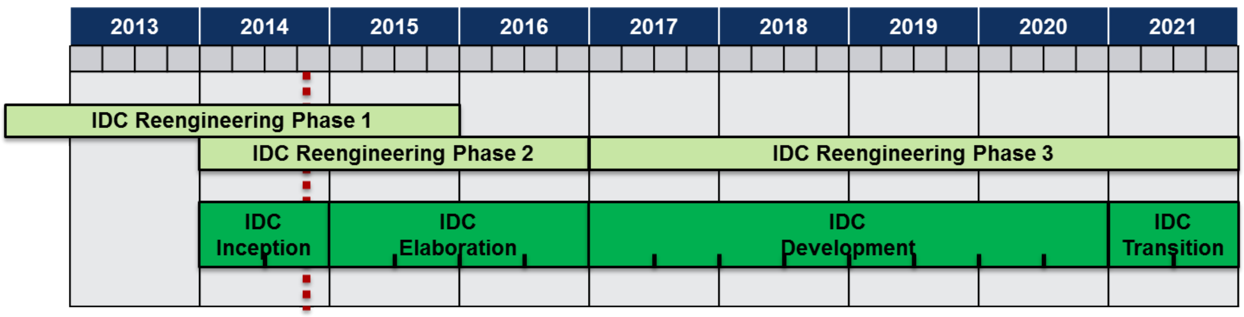

Figure 2. Schedule of RUP phases.

To represent a reasonable, executable development schedule in SEER, the elements of the work breakdown structure (loosely equivalent to software components) were manually scheduled to distribute the effort over time. Figure 3 shows the element development structure used in SEER.

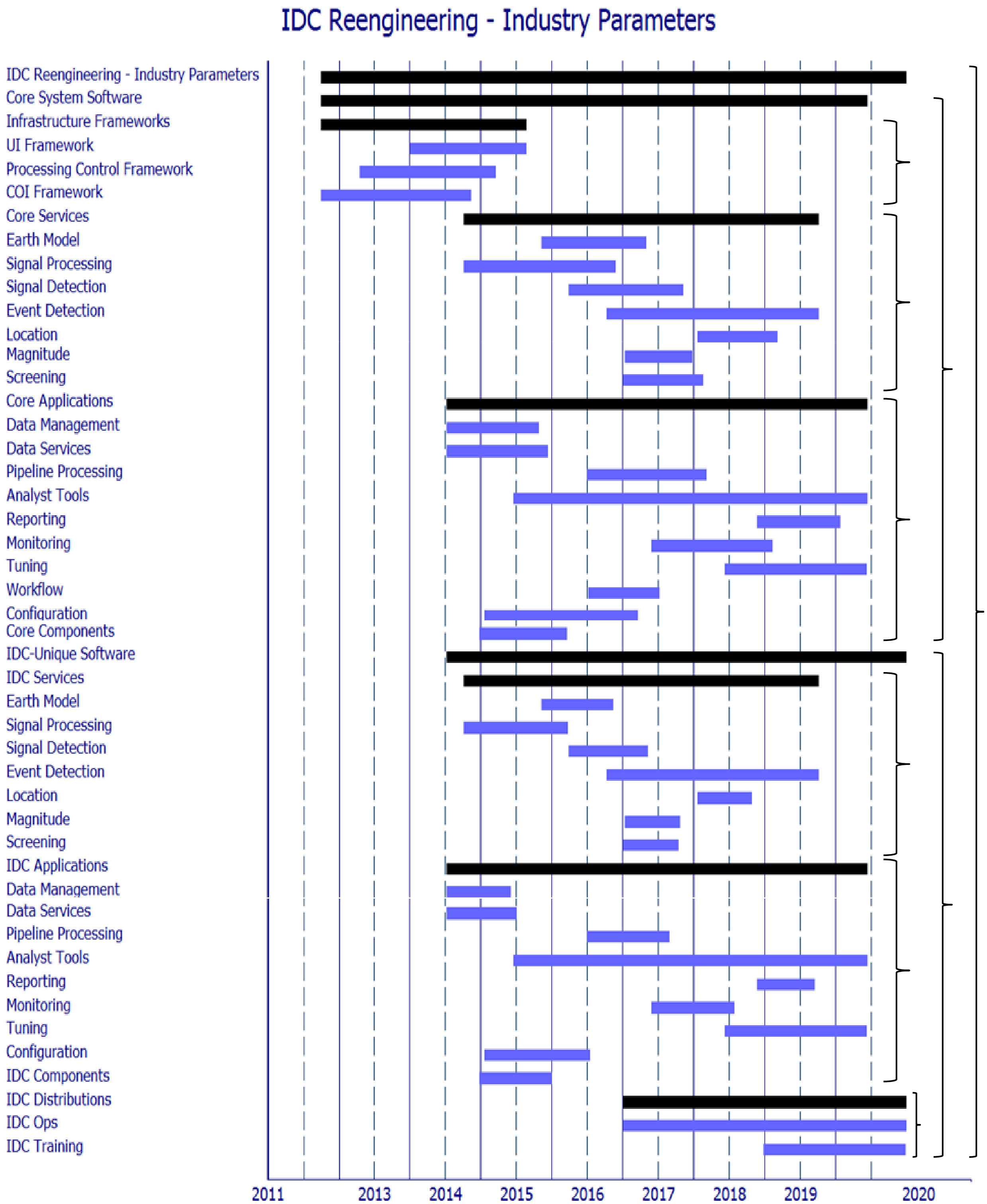

Figure 3. Work breakdown structure and development schedule used in SEER.

4.4 Deployment Assumptions

Mission operations must be maintained during the transition to the reengineered system. To meet this requirement:

1) Mission capabilities will be transferred incrementally from legacy to new system components as they are integrated, verified and validated.
2) This incremental capability transfer will occur during RP3.
3) Operations and Maintenance (O&M) of the reengineered system following the end of RP3 are expected to be managed separately within the PTS, and have not been included in the estimate.

4.5 Staffing Assumptions

This ROM cost estimate is based on the assumption that the IDC RP2 and RP3 project will be executed as a contract with a US software development company (or equivalent) as modeled in the standard SEER parameters. All effort estimated for this project is assumed to be provided by the contractor. The PTS is assumed to provide system requirements, system descriptions, system software, guidance, and integration support to the contractor.

APPENDIX A. ESTIMATED LINES OF CODE (LOC) BY WORK BREAKDOWN STRUCTURE (WBS) MODEL ELEMENT

WBS Element Description	Counts from System		Used in Cost Model	
	Effective Lines of Code	Total Lines of Code	New Lines of Code	Existing Lines of Code
IDC Reengineering Phase 2-3	**509708**	**823646**	**85000**	**717500**
Core System Software	**377679**	**642146**	**60000**	**573750**
Infrastructure Frameworks	**60833**	**60833**	**60000**	**0**
UI Framework	15000	15000	15000	0
Processing Control Framework	15000	15000	15000	0
COI Framework	30833	30833	30000	0
Core Services	**73207**	**100396**	**0**	**98750**
Earth Model	11120	15250	0	15000
Signal Processing	22240	30500	0	30000
Signal Detection	11120	15250	0	15000
Event Detection	13900	19063	0	18750
Location	5560	7625	0	7500
Magnitude	3707	5083	0	5000
Screening	5560	7625	0	7500
Core Applications	**222593**	**340583**	**0**	**335000**
Data Management	9026	15250	0	15000
Data Services	11524	76250	0	75000
Pipeline Processing	12370	15250	0	15000
Analyst Tools	123700	152500	0	150000
Reporting	6185	7625	0	7500
Monitoring	18555	22875	0	22500
Tuning	6185	7625	0	7500
Workflow	4123	5083	0	5000
Configuration	30925	38125	0	37500
Core Components	**21046**	**140333**	**0**	**140000**
Common Libraries	21046	140333	0	140000
IDC-Unique Software	**132030**	**181500**	**25000**	**143750**
IDC Services	**26505**	**36000**	**0**	**33750**
Earth Model	3927	5333	0	5000
Signal Processing	7853	10667	0	10000
Signal Detection	3927	5333	0	5000

Event Detection	4908	6667	0	6250
Location	1963	2667	0	2500
Magnitude	1963	2667	0	2500
Screening	1963	2667	0	2500
IDC Applications	**77358**	**117333**	**0**	**110000**
Data Management	3253	5333	0	5000
Data Services	4131	26667	0	25000
Pipeline Processing	4373	5333	0	5000
Analyst Tools	43733	53333	0	50000
Reporting	2187	2667	0	2500
Monitoring	6560	8000	0	7500
Tuning	2187	2667	0	2500
Configuration	10933	13333	0	12500
IDC Components	**11500**	**11500**	**10000**	**0**
Common Libraries	11500	11500	10000	0
IDC Distributions	**16667**	**16667**	**15000**	**0**
IDC Ops	10833	10833	10000	0
IDC Training	5833	5833	5000	0

APPENDIX B. SEER MODEL KNOWLEDGE BASES APPLIED

A SEER knowledge base is a set of parameter values applied to the project WBS in the cost model. SEER provides knowledge bases based on research of actual industry projects, categorized so they may be applied as initial values for similar projects. SEER includes a set of knowledge bases organized into six standard categories, plus a category to capture custom project overrides:

- Platform knowledge bases describe the primary mission or environment of the software.
- Application knowledge bases describe the primary function of the software.
- Acquisition Method knowledge bases describe the scope and type of project being developed or maintained.
- Development Method knowledge bases describe the methods or paradigm used to develop software.
- Development Standard knowledge bases describe the standards to be followed during development. They generally include values for the specification, test, and quality assurance level parameters.
- Test Rigor knowledge bases are parameters for COTS elements that are only tested. A Test Rigor knowledge base is not used here.
- The Class knowledge base category contains custom settings.

SEER Knowledge Base Type	Knowledge Base Applied
Platform	*Ground-Based Mission Critical*
Application	Set for each model WBS element, including: • *Signal Processing* • *Mathematical and Complex Algorithm* • *Graphical User Interface* • *Process Control* • *Data Warehousing* • *System & Device Utilities*
Acquisition Method	Custom, based on *Re-engineering, Major*: Increased *Redesign*, *Reimplementation* and *Retest* factors above the knowledge base to account for modernized architecture and significant software replacement
Development Method	*RUP Full*
Development Standard	*IEEE-EIA 12207*
Class (Custom)	None

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