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Robust Decision Making

INCOSE 2010

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Robust Decision Making

For INCOSE 2010

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Abstract

The Idaho National Laboratory (INL) is funded through the Department of Energy (DOE) Office of Nuclear Energy and other customers who have direct contracts with the Laboratory. The people, equipment, facilities and other infrastructure at the laboratory require continual investment to maintain and improve the laboratory's capabilities. With ever tightening federal and customer budgets, the ability to direct investments into the people, equipment, facilities and other infrastructure which are most closely aligned with the laboratory's mission and customers' goals grows increasingly more important. The ability to justify those investment decisions based on objective criteria that can withstand political, managerial and technical criticism also becomes increasingly more important. The Systems Engineering tools of decision analysis, risk management and roadmapping, when properly applied to such problems, can provide defensible decisions.

Introduction

The Project Managers responsible for some of the INL investment decisions turned to INL's Systems Engineering Department (SED) for suport in evaluating a broad range of disparate investment requests in the hope that better investment decisions could be derived using the Systems Engineering tools. SED developed objective criteria against which the investment requests could be measured, organized a team of stakeholders to evaluate the requests, managed the process of scoring and prioritizing requests, and collected feedback to improve the process in subsequent years. Because SED strives for continuous improvement and integrated decsions, this process has evolved significantly over the past three years and continues to improve.

Objective Criteria. The first generation of objective criteria was based on those things that appeared to be important to the success of the INL and its customers. Before the second generation of criteria were developed, the INL published an updated Strategic plan which formally documented those things that are important to the success of the INL and its customers. So the second generation of criteria were based on these documened strategic objectives, but added criteria to cover issues critical to the INL which were not discussed in the strategic objectives. As the Strategic Plan evolves, so will the criteria.

Team of Stakeholders. The first generation team of stakeholders involved people from the organizations affected by the investment decisions. The second generation team of stakeholders added people from affected organizations that were not initially recognized as affected organizations. Future teams of stakeholders will continue to adjust based on the lessons learned and improve how organizations and people are involved.

Process. The first generation process used an early MS Excel tool based on utility theory to score and evaluate the proposed investments. The second generation process adapted a more refined version of the tool that accepted more inputs and added several new output options that inspired discussion and collaboration between the stakeholders. It was able to present the affect of the team's decisions in real time during the coordination meetings further enhancing the value of those meetings. Another improvement initiated during this second generation of the process was the gathering and documenting of the reationale for any changes in priorities that were made anywhere in the process, whether during the stakeholder meetings, executive management review, or project management implementation. The next generation process will expand to accept inputs from more investment plans and synchonize those plans to get more consistency across the INL. Future generations of the process will continue to expand the scope of investments considered by including investment opportunities that could be funded through sources that are not currently included in the process. Future generations of the process will also incorporate new tools that can link investments to each other and to the INL's capabilities that they support. These future tools are being prototyped and will be able to model how the investments in people, equipment, facilities and other infrastructure affect each other and the INL's capabilities. They will also provide status indicators that will clearly show how individual investments affect the state of each INL capability.

Feedback. One sure way to sink a process such as this is to imagine you have all the answers and ignore the cumulative intelligence brought to bear on the problem. Many of the meetings that supported this decision making process were facilitated by SED personnel other than the SED personnel directly involved in managing the process. These independent sets of eyes and ears provided useful feedback in assessing the strengths and weaknesses of the process and the personalities involved in it. In addition, as phases of the process were completed, the facilitators formally requested and received feedback from the participants and affected organizations that was used in subsequent generations of the process.

This paper will focus on the second generation of the process, but provide ties to what was learned from the first generation and how the lessons learned to date are influencing future plans.

Scope

This process was initiated on behalf of the project management organization responsible for the laboratory infrastructure. Their budget includes:

- Reactor and Nonreactor Nuclear Research Reactor Operations and Maintenance
- Engineering and Support Facility Operations and Maintenance
- National Scientific User Facility
- Radiological and Environmental Sciences Laboratory
- Research Reactor Infrastructure
- Idaho Facilities and Infrastructure Revitalization Program (IFIRP) including General Purpose Capital Equipment (GPCE)
- Line Item Capital Projects

The focus of this decision support process was just the last 2 bullets, which have an annual budget ranging from an approximate low of $16M to an approximate high of just over $26M in the next several years. As discussed in the introduction, as the process matures, it will encompass larger portions of the investment decisions and other funding sources currently outside this scope.

Prioritization and Decision Criteria

Problem Statement and Analysis Approach. INL must periodically assess its needs for various facilities and infrastructure investments to maintain existing capabilities and meet future needs of the laboratory. Through this assessment, near-term needs are relatively well defined; however, less rigor is expended on needs further into the future because various conditions can significantly alter the future direction of the laboratory. Even the near-term needs are in a state of flux as customer funding ebbs and flows, costs change, the scope of a repair or modification changes, or another priority enters the mix. A standard systems engineering analysis of alternatives approach is used for these evaluations (as shown in Figure 1).

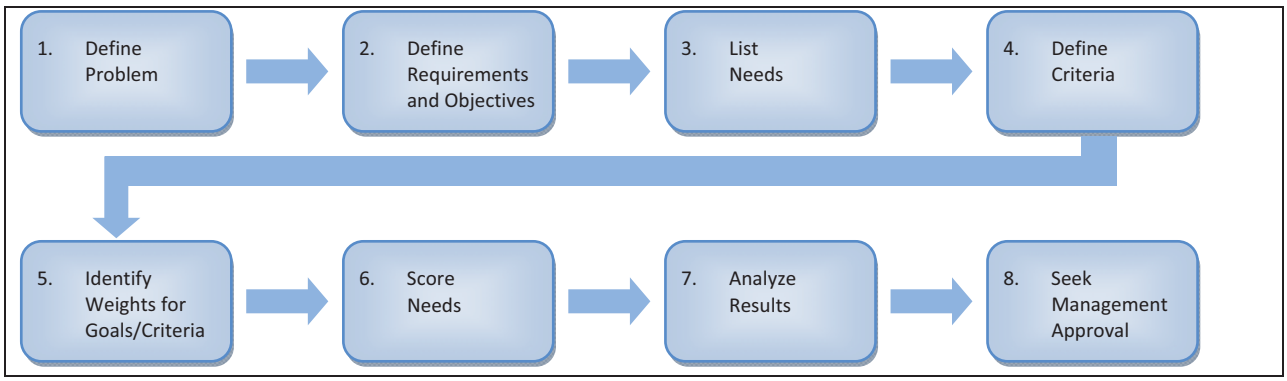


Figure 1. System engineering standard analysis of alternatives process.

Define Requirements and Objectives. The overall purpose of this investment prioritization process is to support the vision of INL being the preeminent nuclear laboratory. The

comprehensive objectives of this facilities and equipment prioritization process are to provide proper facilities and equipment for INL's programs (assuming sufficient funding), optimize cost effectiveness, manage risks, and use a valid decision support process to guide investments. The defined process provides for a balance of site maintenance, nuclear programs, National and Homeland Security programs, and clean energy programs. INL's strategic objectives, as documented in the INL Strategic Plan, were used as the guiding requirements and objectives.

Define Alternatives. Each of the organizations requesting investments assigned a Point Of Contact (POC) who acted as their representative through the remainder of the process. INL Management was briefed on the process. The POCs were trained on the process and given the previous, as yet unfulfilled, facility and equipment investment requests from their organizations. The POCs updated those requests, cancelled the requests that were no longer required, and initiated new requests for needs not previously submitted. Funding determinations and estimates were initiated or updated.

Criteria Definition. To support the vision and objectives, SED developed a set of decision criteria derived from the strategic objectives and risks associated with the business. The criteria were established to minimize the chance that any proposed investments could garner extra consideration or undue advantage by taking credit for the same benefits to the laboratory under multiple criteria. The criteria were developed, vetted by various management teams, and used by the analysis team to evaluate investment needs. Despite the diligence taken in developing the criteria, interpretations by the members of the analysis team varied and a couple of the criteria were identified as not being reasonable discriminators. The ambiguities were corrected and the nondiscriminating criteria eliminated. The following table explains the criteria used to evaluate the needs for this fiscal year.

Strategic Goal Title	Strategic Goal	Criteria	Description
1. Nuclear Reactors and Fuels	Lead advanced nuclear reactor and fuel cycle research, development, and demonstration (RD&D)	1-1: Applicability to advancing the nuclear energy mission	Define how this investment advances nuclear reactor and fuel cycle programs/ projects
2. Nuclear Energy Partnerships	Develop, demonstrate, and promote nuclear energy technology through public-private partnerships	2: Nuclear energy partnerships	Included in Criterion 7
3. National and Homeland Security	National and Homeland Security – build leading roles in nuclear nonproliferation and critical infrastructure protection	3-1: Applicability to advancing the national security missions	Define how this investment advances national security programs/projects
4. Clean Energy	Energy and Environment – become a leading clean energy	4-1: Applicability to advancing the clean energy RD&D	Define how this investment advances clean energy RD&D

	laboratory valued as a regional resource	missions	
5. Existing Assets	Build and equip facilities that advance our nuclear energy and other programmatic missions using innovative approaches and maximizing existing assets	5: Existing assets	Included in Criteria 1, 3, and 4
6. Multiproject Research	Focus investments in distinctive areas to advance nuclear and multi-program research	6: Multiproject research	Included in Criteria 1, 3, and 4
7. Strategic Partnerships	Build strategic partnerships and leverage their influence and market knowledge	7-1: Growth in improving our strategic partnerships and leveraging our technologies into the market	Define how this investment advances strategic partnerships, improves communications with those partners, and enables technology transfer and commercialization
8. Strategic Hires and Retention	Build an organization that attracts and retains key nuclear and other scientific researchers/engineers, enabling INL to reach high levels of laboratory performance	8-1: Employee working conditions and services	Metric to define effect of investment on increasing employee morale
9. Business Efficiency	Implement business and operational practices that reduce bureaucracy and promote safe, efficient, and secure mission accomplishment	9-1: Return on investment	Each score includes three parts. If your situation is reflected in multiple scores, choose the highest score you can justify. In this context, payback period is estimated annual revenue gain divided by total cost.
10. Public Trust	Develop public trust and confidence in INL and nuclear energy	10-1: Growth in improving effective communications with the public and	Metric to define the level of support investment has toward improving our ability to

		INL employees	effectively communicate with the public and our employees
Risks:		11-1: Program/ project critical facility operational impact	Define the level of risk if the investment is not funded this year
		11-2: Safety impacts	The amount of safety risk mitigated by the investment
		11-3: Compliance impacts	The amount of compliance risk mitigated by the investment
		11-4: Security impacts	The amount of security risk mitigated by the investment
		11-5: Environmental impacts	The amount of environmental risk mitigated by the investment
		11-6: Annual business impact	Metric to define the total annual dollar value of the program(s)/project(s) impacted by this investment (this is not saving)

Identify Weights for Goals/Criteria. Representatives from INL's management, operations and science and technology counsels were surveyed to gather the relative importance of the criteria. The representative from each counsel had a slightly different interpretation of the relative importance of the criteria, but each set of weights was entered into the analysis tool, along with the criteria. Several other weighting schemes were also entered into the tool to assess what combinations of criteria weights might pose contrasting priorities. In the end, the weighting schemes proposed by each of the counsel representatives and the risk weighting scheme were shown side by side for comparison.

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Critieria Name	Management Council		Operational Council		S&T Council		Risk Focus	
1-1: Applicability to advancing the nuclear energy mission	10	1	12	1	10	1	1	1
3-1: Applicability to advancing the national security missions	9	1	9	1	7	1	1	1

4-1: Applicability to advancing the clean energy RD&D missions	8	1	4	1	6	1	1	1
7-1: Growth in improving our strategic partnerships and leveraging our technologies into the market	8.5	1	6	1	8	1	1	1
8-1: Employee Working Conditions and Services	5	1	5	1	7	1	1	1
9-1A: Payback period for investment (expressed in years)	7	10	8	6	7	10	1	1
9-1B: Annual Cost Savings		8		5		7		1
9-1C: Life Cycle Cost Avoidance		9		7		5		1
10-1: Growth in improving effective communications with the public and INL employees	5	1	3	1	5	1	1	1
11-1: Program / Project Critical Facility Operational Impact	8	9	10	5	7	10	1000	1
11-2: Safety Impacts		8		10		5		1
11-3: Compliance Impacts		8		10		5		1
11-4: Security Impacts		10		10		5		1
11-5: Environmental Impacts		8		10		5		1
11-6: Annual Business Impact		9		8		7		1

Scoring Alternatives. While management representatives were providing their input on criteria weighting, the organizational POCs worked with teams from their organization, scored each of their requests against the established criteria on a scale of 1 through 5, justified any scores greater than 1, and submitted their scores and justifications. To minimize confusion, ambiguities, and variation among the multiple scoring POCs, clear scoring definitions were written and vetted before being presented to the POCs in a pre-scoring training session. One of the criteria is presented in the following table along with its scoring explanation to demonstrate this point.

Criteria	Description	Scoring Explanation
1-1: Applicability to advancing the nuclear energy mission	Define how this investment advances nuclear reactor and fuel cycle programs/ projects	Investment provides: 1. No direct or indirect maintenance of or advancement in nuclear reactor or fuel cycle facilities, equipment, or capabilities 2. Indirect advancement in nuclear reactor or fuel cycle facilities, equipment, or capabilities or maintenance to avoid loss of capability 4+ years away 3. Enablers needed prior to advancement in nuclear reactor or fuel cycle facilities, equipment, or capabilities (e.g., user facility usefulness) or maintenance to avoid loss of capability 1 to 3 years away 4. Maintenance of or a direct advancement in nuclear reactor or fuel cycle facilities, equipment, or capabilities 5. Maintenance of or a direct advancement in both nuclear reactor and fuel cycle facilities, equipment, or capabilities.

Normalizing Alternatives. The submitted scores and justifications were compared to the documented investment requests to assure consistency and to the criteria to assure they were correctly interpreted. Any improperly justified or inconsistent scores were returned to the POCs with comments for resolution. Once all the scores and justifications were evaluated individually, POCs were assembled in a facilitated working group and allowed the opportunity to review their scores and justifications with the scores and justifications of their peers. This team normalization portion of the process assured the scores and justifications were consistent among the POCs and helped the POCs to buy into the results. The tools used during this stage of the process allowed automatic sorting by score under each criterion. This feature allowed group review of like scored investment requests, adjustments to the scores, and real time resorting to view the results.

- Criteria 1,
  - Score 5, Project H, justification …
  - Score 4, Project F, justification …
  - Score 4, Project B, justification …
  - Score 4, Project C, justification …
  - Score 3, Project D, justification …
  - Score 3, Project A, justification …
  - Score 3, Project G, justification …
  - Score 2, Project J, justification …
  - Score 2, Project I, justification …
  - Score 1, Project E, justification …

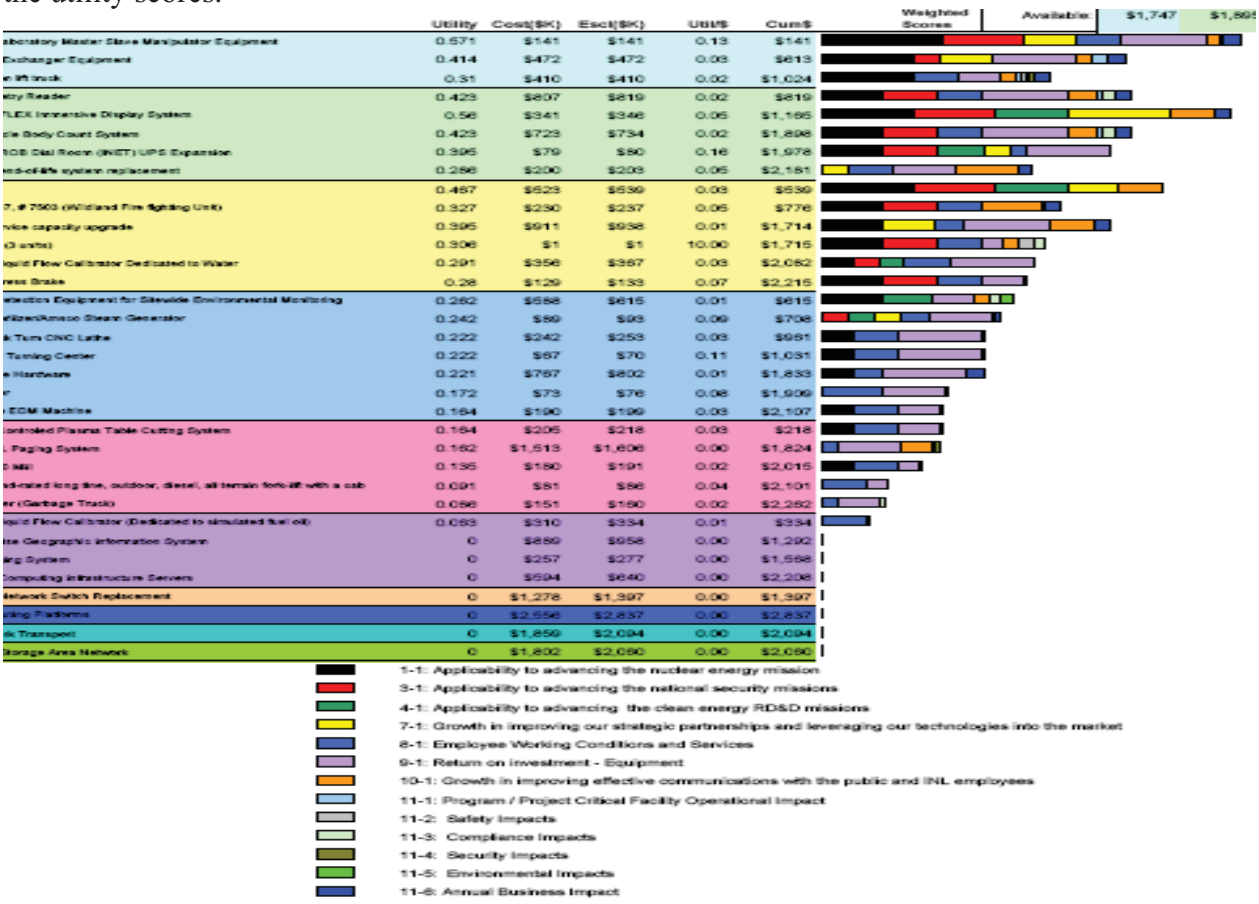
Analyze Results – Prioritization. Calculations were run using the criteria scores and weighting scenarios to generate priority-ordered lists of the facilities and equipment requests. With these ordered lists, the POCs again were assembled in a facilitated working group and allowed the opportunity to reconcile the lists and to recommend and justify changes to the prioritized lists. The POCs provided a critical review of requests by their peers to reprioritize the lists. They only accepted a few well-justified changes, such as moving up a lower priority item that was a prerequisite for a higher priority item. The rationale for the accepted changes was documented. The result was a vetted priority list that was presented to management.

Fiscal year budgets were overlaid on the prioritized lists presented to management for their concurrence or realignment. Because of fiscal year constraints, a few priorities were readjusted, the rationale for the changes documented, and the prioritized lists approved by the Infrastructure Steering Committee.

The following chart shows the fiscal year banding overlayed on the prioritized lists where several weighting scenarios are displayed side-by-side for easy comparison and contrast. The far left column displays a color code based on the anticipated funding year versus the critical need date. Green indicates on-time funding. Yellow is early funding. Red is late funding. The far right shows the rational for changes made between the tool recommendations and the prioritizations resulting from the team meetings.

Date	Funding	Critical Da	Org	Project	Cost($K	Escl($K)	Cum($K)	Sort Scenario1	Council Scenario2	Scenario3	Council Scenario4	Scenario5	Notes
0	2010	2010	MFC	Analytical Laboratory Master Slave Manipulator Equipment	141	141	141	1	1	1	1	7	
0	2010	2010	RTC	HDW Heat Exchanger Equipment	472	472	613	2	6	6	5	4	Moved up because of risk
0	2010	2010	MFC	Taylor 25 ton lift truck	410	410	1,024	3	10	10	9	3	Moved up because of risk. Parts only avail thru salvage. New lease must not exceed 90% of purchase.
-2	2011	2009	CFA	TLD Dosimetry Reader	807	819	819	4	5	4	4	2	Needed for Accreditation
-1	2011	2010	CAES BLDG	Mechdyne FLEX Immersive Display System	341	346	1,165	5	2	2	2	10	Moved down, less supportive of hard science
-2	2011	2009	CFA	In Vivo Whole Body Count System	723	734	1,898	6	4	3	3	1	Can follow TLD & still meet process accredn needs
0	2011	2011	CFA	CFA and EROB Dial Room (INET) UPS Expansion	79	80	1,978	7	7	8	7	25	
2	2011	2013	ALL	Voice Mail end-of-life system replacement	200	203	2,181	8	13	11	15	12	Voice Mail & Network service capacity switched in
-1	2012	2011	CAES BLDG	Powerwall	523	539	539	9	3	5	6	26	Moved down, less supportive of hard science.Related to immersive Display
1	2012	2013	CFA	Wildland 667, # 7503 (Wildland Fire fighting Unit)	230	237	776	10	9	9	11	8	
1	2012	2013	ALL	Network service capacity upgrade	911	938	1,714	11	8	7	8	9	Voice Mail & Network service capacity switched in
1	2012	2013	CFA	Ambulance (3 units)	0	0	1,714	12	11	12	10	5	DELETED - Emergency Mgt & Fire Dept to Lease
1	2012	2013	CFA	400 GPM Liquid Flow Calibrator Dedicated to Water	356	367	2,081	13	12	13	13	23	Moved down because of lower risk
1	2012	2013	MFC	Hydraulic Press Brake	129	133	2,214	14	14	14	12	17	
-2	2013	2011	MFC	Radiation Detection Equipment for Sitewide Environmental Monitoring	588	615	615	15	15	18	14	6	
-1	2013	2012	IRC	Century Sterilizer/Amsco Steam Generator	89	93	708	16	16	17	19	14	
0	2013	2013	TRA 653	Mazak Quick Turn CNC Lathe	242	253	961	17	17	15	17	16	
0	2013	2013	NHL	HAAS CNC Turning Center	67	70	1,031	18	18	16	18	18	
0	2013	2013	EROB	Disk Storage Hardware	767	802	1,833	19	19	19	16	11	
1	2013	2014	NHL	Laser Etcher	73	76	1,909	20	20	20	20	19	
1	2013	2014	NHL	Sodick Wire EDM Machine	190	199	2,107	21	21	21	21	21	
0	2014	2014	MFC	Computer Controled Plasma Table Cutting System	205	218	218	22	22	22	22	22	
-1	2014	2013	INL	Replace INL Paging System	1,513	1,606	1,824	23	23	23	23	13	
1	2014	2015	MFC	HAAS VS/50 Mill	180	191	2,015	24	24	24	24	20	
-1	2014	2013	CFA	15,500 pound-rated long tine, outdoor, diesel, all terrain fork-lift with a cab	81	86	2,101	25	25	25	26	27	
-4	2014	2010	CFA	Dump Master (Garbage Truck)	151	160	2,262	26	26	26	25	15	
-2	2015	2013	CFA	150 GPM Liquid Flow Calibrator (Dedicated to simulated fuel oil)	310	334	334	27	27	27	27	24	
-6	2015	2009	IRC,EROB	INL Enterprise Geographic Information System	889	958	1,292	28	28	28	28	28	
-4	2015	2011	MFC	X-Ray Imaging System	257	277	1,568	29	29	29	29	29	
-2	2015	2013	IORC	Enterprise Computing Infrastructure Servers	594	640	2,208	30	30	30	30	30	

The following chart shows the fiscal year banding overlayed on the prioritized lists, but in place of the weighting scenarios, the display shows the overall utility score for each investment request and a horizontal stack bar chart showing how each of the criteria scores contributed to each of the utility scores.



These prioritized lists were then sanctioned by the INL Executive Council, recorded in a configuration controlled document and submitted to DOE for their approval.

Cost Estimates and Critical Dates

Reliable cost estimates are independent of this process until fiscal year bands are added. Critical dates are more closely tied and some estimate of the need date is required to accurately socre any time based criteria, such as, “what happens if this investment is not made in the year planned?” In a highly technical organization such as a National Laboratory, many of the technical people who are best at explaining how an investment are severally challenged when confronted with defensible cost and schedule estimates. When needed, engage in laying out a Systems Engineering Management Plan that helps the technical experts define their needs along with their cost, schedules, and risk management strategies. Know when to get help from Project Management and Finance personnel. At INL, SED, Project Management and Finance have worked together to establish a minimum fidelity required for investment requests, but to avoid

unneccessary expenditures estimating and re-estimating investment requests, we only hold near term requests to the estimating requirements.

Biography

Chris Dieckmann has been a Senior Systems Engineer at the Idaho National Laboratory since the Fall of 2007. Before joining the INL, Chris was a Quality Manager, Systems Engineer, Flight Test Management Engineer, Product Engineer, and Product Assurance Engineer for Honeywell, Analex, the US Army and the US Air Force. He has supported a wide variety of projects including energy systems, ground vehicles, air vehicles and related equipment. His career has taken to several cities and a bunch of remote locations across the country, but he grew up in Chicago and now calls Idaho Falls home.

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- LWP-1201, “Document Management”