Oil & Natural Gas Technology

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Quarterly Progress Report (10/01/07 – 12/31/07)

Gas Storage Technology Consortium

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ABSTRACT

Gas storage is a critical element in the natural gas industry. Producers, transmission and distribution companies, marketers, and end users all benefit directly from the load balancing function of storage. The unbundling process has fundamentally changed the way storage is used and valued. As an unbundled service, the value of storage is being recovered at rates that reflect its value. Moreover, the marketplace has differentiated between various types of storage services and has increasingly rewarded flexibility, safety, and reliability. The size of the natural gas market has increased and is projected to continue to increase towards 30 trillion cubic feet over the next 10 to 15 years. Much of this increase is projected to come from electric generation, particularly peaking units. Gas storage, particularly the flexible services that are most suited to electric loads, is crucial in meeting the needs of these new markets.

To address the gas storage needs of the natural gas industry, an industry-driven consortium was created – the Gas Storage Technology Consortium (GSTC). The objective of the GSTC is to provide a means to accomplish industry-driven research and development designed to enhance the operational flexibility and deliverability of the nation's gas storage system, and provide a cost-effective, safe, and reliable supply of natural gas to meet domestic demand.

This report addresses the activities for the quarterly period of October 1, 2007 through December 31, 2007. Key activities during this time period included:

- Scheduling and hosting the 2007 GSTC Fall Meeting, Portland, OR on November 6-7, 2007;
- Scheduling and hosting a software training workshop in Morgantown, WV on November 19, 2007;
- Identifying projects for co-funding;
- Scheduling and participating in two (2) project mentoring conference calls;
- Soliciting nominations for five (5) Executive Council seats;
- Recruiting and invoicing membership for FY 2008;
- Preliminary planning for the 2008 GSTC Spring Meeting, Chicago, IL, on April 17-18, 2008; and
- Releasing the *GSTC Insider* e-newsletter.

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INTRODUCTION

Gas storage is a critical element in the natural gas industry. Producers, transmission and distribution companies, marketers, and end users all benefit directly from the load balancing function of storage. The unbundling process has fundamentally changed the way storage is used and valued. As an unbundled service, the value of storage is being recovered at rates that reflect its value. Moreover, the marketplace has differentiated between various types of storage services and has increasingly rewarded flexibility, safety, and reliability. The size of the natural gas market has increased and is projected to continue to increase toward 30 trillion cubic feet over the next 10 to 15 years. Much of this increase is projected to come from electric generation, particularly peaking units. Gas storage, particularly the flexible services that are most suited to electric loads, is crucial in meeting the needs of these new markets.

To address the gas storage needs of the natural gas industry, an industry-driven consortium was created – the Gas Storage Technology Consortium. The objective of the GSTC is to provide a means to accomplish industry-driven research and development designed to enhance the operational flexibility and deliverability of the nation's gas storage system, and provide a cost-effective, safe, and reliable supply of natural gas to meet domestic demand. Consortium technology development is conducted in the general areas of well-bore and reservoirs, operations, mechanical, and salt caverns. Consortium members elect an executive council that is charged with reviewing projects for consortium co-funding. Projects are submitted by GSTC members and are funded on an annual basis. Proposals must address improving the production performance of gas storage and provide significant cost sharing. The process of having industry members develop, review, and select projects for funding ensures that the GSTC conducts research that is relevant and timely to the industry.

The scope of Penn State's activities includes managing the process of attracting and maintaining consortium members, soliciting proposals, awarding and monitoring subcontracts to members to accomplish the selected technical works and disseminating the results of the technical work via meetings and final reports.

EXECUTIVE SUMMARY

This report summarizes the important accomplishments during the period of October 1, 2007 through December 31, 2007. The GSTC was established under contract to The Pennsylvania State University from the U.S. Department of Energy (DOE), National Energy Technology Laboratory (NETL), in June 2004. The agreement provides the Pennsylvania State University with the overarching management responsibilities for the GSTC. Key activities for this reporting period included the following:

2007 GSTC Fall Meeting

The GSTC conducted the 2007 Fall Meeting in Portland, OR on November 6-7, 2007. The meeting offered technology updates from seven 2005, 2006 and 2007 projects, as well as presentations from five proposals requesting co-funding.

GSTC Software Training

The GSTC hosted and conducted a software training session for two of the 2005 awarded projects on November 19, 2007 in Morgantown, WV.

2008 Projects Selected

The GSTC Executive Council met immediately following the close of the 2007 Fall Meeting to consider the five projects that requested over $542,000 in co-funding. The Council recommended two proposals to be funded. The projects are targeted to begin on February 1, 2008. The projects selected for funding were:

- Predicting and Mitigating Salt Precipitation - Phase II: Correlations Company
- Gas Storage Facility Design Under Uncertainty: University of Texas at Austin

Project Mentoring Conference Calls

Continuing the mentoring team procedure that was established last year, two conference calls were scheduled and conducted in this quarter, as follows:

- RGD X-ray Technology Well Bore Inspection and Assessment- A Feasibility Study (GTI), December 17, 2007; and
- Penetration Power of Ultrasonic Guided Waves for Piping and Well Casing Integrity Analysis (The Pennsylvania State University), December 17, 2007.

Executive Council Candidates

The GSTC solicited nominations for candidates to serve on the Executive Council for 2008-2009. During the next quarter the Technical Advisory Committee will vote to elect five (5) representatives to replace the outgoing representatives.

Membership Invoicing for 2008

Invoices for 2008 memberships were sent to current and potential members in November 2007. The membership for 2007 included 42 members from 16 states, Washington D.C. and 2 from Canada.

GSTC Insider E-newsletter

The *GSTC Insider* e-newsletter was released in December 2007. This is the third newsletter in 2007 and offers an additional mechanism for keeping the industry informed.

EXPERIMENTAL

A description of experimental methods is required by the DOE for all quarterly technical progress reports. In this program, Penn State is responsible for establishing and managing an industry-driven underground gas storage consortium. Technology development research awards are made on a competitive basis. Technical reports from the individual researchers are required to contain experimental discussion sections and are submitted to consortium members and the DOE for review. Therefore, this section is not applicable to the Penn State contracted activities.

RESULTS & DISCUSSION

This report addresses the activities for the reporting period from October 1, 2007 through December 31, 2007. Key activities during this time period included:

- Hosting and conducting the 2007 Fall Meeting;
- Hosting and conducting a software training workshop;
- 2008 projects identified;
- Conducting two mentoring team conference calls for 2007 projects;
- Identifying candidates to serve on the Executive Council for 2008-2009;
- Issuing invoices to current and potential members for 2008;
- *GSTC Insider* e-newsletter released; and
- Preliminary planning and identify the meeting site for the 2008 Spring Meeting.

Technology Transfer/Outreach

There are several avenues for accelerating the commercialization and deployment of technology into industry. The GSTC strategy includes meetings to hear technology updates from co-funded projects, software training, and disseminating the final research results in a timely manner.

2007 GSTC Fall Meeting

The GSTC planned and hosted the 2007 GSTC Fall Meeting on November 6-7, 2007 at the Hotel Vintage Plaza, Portland, OR. Forty people attended this two-day meeting. The meeting was an opportunity to hear technology updates from 2005, 2006, and 2007 projects. In addition, all proposals received in response to the request for proposals gave a PowerPoint presentation, followed by a question and answer session. The Executive Council met immediately following the close of the general session to decide which projects to go forward. The agenda for the meeting is attached as Appendix A.

GSTC Software Training

Twenty-five people attended the software training for the New Comprehensive Inventory Analysis Tool, (Schlumberger) and Gas Storage Field Deliverability Enhancement and Maintenance: an Intelligent Portfolio Management Approach (West Virginia University) on November 19, 2007 at the Waterfront Place Hotel, Morgantown, WV. Both projects were part of the 2005 project portfolio.

The New Comprehensive Inventory Analysis Tool software will (1) Allow easy importation of typical storage inventory data, (2) Automatically generate pertinent raw data plots and diagnostic plots for the analyst's review and processing of inventory data, (3) Provide on-line help that gives an overview of the inventory analysis process and explains the assumptions, applications, limitations, and processes used to analyze specific diagnostic plots, and (4) Provide a "toolbox" application that will perform calculations useful in the process of inventory analysis.

This new tool significantly improves operators' ability to effectively monitor inventory and resolves gas loss issues by making inventory analysis processes much more automated and much more comprehensive. It also enhances the analysis process by guiding the engineer to the appropriate analysis techniques and away from the inappropriate analysis techniques via the on-line help tools. The software operates on Windows 98, NT, XP, and MS Excel. The Executive Summary for this project is attached as Appendix B.

The objective of Gas Storage Field Deliverability Enhancement and Maintenance software is to apply the state-of-the-art in optimum portfolio management to the gas storage field in order to optimize the return on investment associated with well remedial operations. In order to make the best use of capabilities of the software package, it is recommended that the storage filed have a minimum of 75 wells (wells with data that can be used for analysis). The software will run on Windows Operating Systems, ME, 98, NT, and XP. The Executive Summary for this project is attached as Appendix C.

GSTC Administration

The scope of the GSTC administration activities includes managing the process of attracting and maintaining consortium members, soliciting proposals, developing strategies for action on recommendations from the technical committee and executive council, keeping the industry informed on issues and events, and awarding and monitoring subcontracts to members to accomplish the selected technical works.

2008 Projects Selected

The GSTC Executive Council met immediately following the close of the 2007 Fall Meeting to consider the five projects that requested over $542,000 in co-funding. The Council recommended two proposals to be funded. Contract negotiations will take place during next quarter and the projects are targeted to begin on February 1, 2008. The executive summaries are attached as Appendix D and E. The projects are:

- Predicting and Mitigating Salt Precipitation - Phase II: Correlations Company
- Gas Storage Facility Design Under Uncertainty: University of Texas at Austin

Project Mentoring Conference Calls

Two project-mentoring conference calls were conducted. The mentoring team was established in 2006 to better communicate between meetings, hence assuring the projects are on track. The notes from the conference calls are posted in the member's only section of the GSTC website: http://www.energy.psu.edu/gstc/

The calls were:

- RGD X-ray Technology Well Bore Inspection and Assessment- A Feasibility Study (GTI), December 17, 2007; and
- Penetration Power of Ultrasonic Guided Waves for Piping and Well Casing Integrity Analysis (The Pennsylvania State University), December 17, 2007.

The objective of the Penetration Power of Ultrasonic Guided Waves for Piping and Well Casing Integrity Analysis project is to dramatically improve the penetration power of guided waves in piping for the long range detection of defects like cracks and wall thinning from corrosion. This project is concentrating on the penetration power of guided waves, i.e., the length of piping that can be inspected from one location.

The RGD X-ray Technology Well Bore Inspection and Assessment- A Feasibility Study project proposes to study, develop, and demonstrate a real-time RGD tool for *in situ* compositional identification and quantification of scale in gas storage wells and pipelines. The RGD tool will also assess and quantify material defects, pitting, and penetrations in casings and associated piping. This innovative technology can provide real time data and analysis on both scale formation inside the well bore as well as assess the well bore casing integrity.

Executive Council

During this quarter, the GSTC solicited members who are interested in serving on the Executive Council. The GSTC will elect five members to serve on the Executive Council for a two-year term (2008-2009) during the next quarter. The Council's responsibilities include attending a two-day proposal meeting to review and select proposals for GSTC funding, to participate, either in person or via teleconference, in other Council meetings at various locations throughout the year and are encouraged to serve on Ad hoc committees to steer the GSTC research projects. The Executive Council members who served in 2006-2007 are:

- Allen Bues, Ameren Corp.
- Douglas Elenbaas, TransCanada
- Timothy Habovick, Equitrans
- David Burnett, Texas A&M
- Richard Stocke, Texas Gas Transmission

The Executive Council members who will continue to serve until the end of 2008 are:

- Greg Theirl, Dominion Delivery
- Todd Thomas, NW Natural
- Jim Mansdorfer, Southern California Gas
- George Hodges, Southern Union

Membership Invoicing for 2008

Invoices for 2008 memberships were sent to current and potential members in November 2007. The 2007 membership included 42 members from 16 U.S. states and 2 members from Canada. The GSTC will continue to recruit throughout 2008.

***GSTC Insider* E-newsletter**

The *GSTC Insider* electronic newsletter was released in December 2007. This was the third electronic newsletter for 2007. The newsletter is another method of keeping representatives informed on issues relevant to the industry. The newsletter was distributed to the GSTC list serve as well as being posted to the GSTC website.

Planned Activities for the Next Reporting Period

During the next quarter the GSTC will:

- Negotiate the subcontracts for the projects identified at the 2007 Fall Meeting;
- Release a Request for Proposals;
- Conduct elections for five Executive Council seats;
- Continue the mentoring team conference calls for 2007 and 2008 projects; and
- Release an online newsletter; and
- Continue planning for the 2008 GSTC Spring Meeting in Chicago, IL on April 17-18, 2008.

CONCLUSIONS

During this reporting period, the GSTC hosted a 2007 Fall Meeting, where technology updates from 2005, 2006, and 2007 projects were heard, as well as presentations from all projects that were submitted in response to the request for proposals. The GSTC hosted a one-day software training session for two projects. Two mentoring conference calls were held. The administration opened nominations for five Executive Council seats. The annual invoices were sent to current and perspective members. The GSTC administration secured a meeting site and began preliminary planning for the 2008 Spring Meeting. Through these efforts, the GSTC continues to improve and better serve the gas storage industry.

REFERENCES

A listing of referenced materials is required by the DOE for each quarterly technical progress report. However, this technical progress report for the GSTC did not utilize any reference materials during this reporting period.

APPENDICES

Appendix A – 2007 Fall Meeting Agenda, Portland, OR

Appendix B – New Comprehensive Inventory Analysis Tool Executive Summary

Appendix C – Gas Storage Field Deliverability Enhancement and Maintenance: An Intelligent Portfolio Management Approach Executive Summary

Appendix D – Predicting and Mitigating Salt Precipitation - Phase II Executive Summary

Appendix E – Gas Storage Facility Design Under Uncertainty Executive Summary

Appendix A
2007 Fall Meeting Agenda
Portland, OR

GSTC FALL MEETING

Hotel Vintage Plaza
422 SW Broadway • Portland, OR 97205

November 6, 2007	
7:15 am	Continental Breakfast and Registration
8:00	Opening Remarks and Introductions
8:15	Effects of Tensile Loading on the Remaining Strength of Corroded Casing *Presenter: Kiefner and Associates*
8:45	Proposal: Real-Time Monitoring of Near-Wellbore Damage for Multiple Gas Storage Wells *Presenter: West Virginia University*
9:15	Proposal and Technology Transfer: Predicting and Mitigating Salt Precipitation-Phase II *Presenter Correlations Company*
10:00	Break
10:30	Technical Feasibility Evaluation of Non-Intrusive Optical Detection, Monitoring and Preliminary Characterization of Casing Cement Leaks for Gas Wells *Presenter: URS Group, Inc*
11:30	Proposal: Gas Storage Facility Design Under Uncertainty *Presenter: University of Texas at Austin*
12:00	**Lunch**
1:00	Evaluation of Magnetic Pulse Welding (MPW) for Improved Casing Repair *Presenter: Edison Welding Institute*
1:30	Proposal: Improved Well Test Analysis Method to Enhance Economics of Gas Storage Operations *Presenter: West Virginia University*
2:00	Penetration Power of Ultrasonic Guided Waves for Piping and Well Casing Integrity Analysis *Presenter: The Pennsylvania State University*
2:30	Brine String Integrity-Case History Survey and Model Evaluation *Presenter: PB Energy Storage Services, Inc.*
3:00	**Break**
3:30	Wellbore Cement Bond Integrity *Presenter: University of Texas at Austin*
4:00	Smart Gas: Using Chemicals to Improve Gas Deliverability – Phase II *Presenter: Correlations Company*
4:30	Proposal: Ultrasonic Guided Waves for Corrosion and Erosion Defect Sizing in Piping *Presenter: The Pennsylvania State University*
5:00	RGD X-ray Technology Well Bore Inspection and Assessment – A Feasibility Study *Presenter: Gas Technology Institute*
5:30	**Day 1 Wrap-up**
6:30	Reception

November 7, 2007	
8:00 am	Continental Breakfast
9:00	Strategic Planning
10:00	**Meeting Wrap-up**
10:15	Executive Council Session Begins*:*

Appendix B
New Comprehensive Inventory Analysis Tool Executive Summary

Abstract - New Comprehensive Inventory Analysis Tool

Inventory analysis is critical to proper management of gas storage facilities. Often, basic inventory analysis plots (e.g., P/Z vs Inventory) are updated and reviewed once or twice a year, with additional scrutiny being applied if several cycles' worth of data suggest possible inventory problems.

There are over a dozen useful diagnostic plots and techniques available for monitoring inventory and identifying potential causes of lost gas in storage reservoirs. However, many operators have given more and more responsibilities to fewer and fewer personnel in recent years, making truly comprehensive inventory analyses more difficult to accomplish in a reasonable timeframe. In addition, as new storage engineers enter the market to replace the graying retirees, unfamiliarity with the underlying assumptions and limitation inherent in the less known analysis techniques may cause undue hesitation to implement these techniques.

We are proposing development of a user-friendly software package developed using off-the-shelf software that would: 1) readily accept all inventory data available for a given field, 2) automatically generate and interactively interpret all diagnostic plots possible with existing data, 3) have available on-line help screens summarizing the technical assumptions of each analysis technique, the applicability of the techniques to various types of storage reservoir (dry gas, aquifer, etc), the inherent dangers of each technique, and example plots of each technique would prove to be an invaluable tool to the practicing storage engineer. We are proposing development of this tool for the storage industry to improve the quality of inventory monitoring and verification as well as aid the resolution of gas loss issues when they occur.

The proposed work is in line with GSTC's mission to "…assist in the development, demonstration, and commercialization of technologies to improve the integrity, flexibility, deliverability, and cost-effectiveness of the nations UGS facilities…" Specifically, the proposed work addresses several items delineated in the Research Focus Area section of the RFP, including investigations that address reservoir characterization and develop new approaches to inventory verification.

The objectives of this work include 1) development and field test a software tool that readily accepts all inventory data available for a given field and automatically generates and interactively interpret all diagnostic plots possible with existing data, 2) Development of on-line help tools within the software that summarizes the technical reference(s) on which the analysis technique is based, the technical assumptions inherent in each analysis technique, the applicability of each techniques to various types of storage reservoir (dry gas, aquifer, etc), the inherent dangers of each technique, and provides example "type curve" plots for each technique showing the characteristic shapes indicative of gas losses, growing bubble size, etc.

This tool will significantly improve operators' ability to effectively monitor inventory and resolve gas loss issues by making inventory analysis processes much more automated and much more comprehensive. It will also enhance the analysis process by guiding the engineer to the appropriate analysis techniques and away from the inappropriate analysis techniques via the on-line help tools.

Appendix C
Gas Storage Field Deliverability Enhancement and Maintenance: An Intelligent Portfolio Management Approach Executive Summary

PROJECT TITEL:

Gas Storage Field Deliverability Enhancement and Maintenance: An Intelligent Portfolio Management Approach – Phase II **(Continuation - Second year)**

EXECUTIVE SUMMARY

This is a proposal for continuation and completion of a two year project. The first phase of the project (first year) is successfully completed prior to the start of the second and final phase of the project.

Portfolio management, a common practice in the financial market, is essentially an optimization problem that attempts to increase return on investment. The objective this project is to apply the state-of-the-art in intelligent, optimum portfolio management to the gas storage field in order to optimize the return on investment associated with well remedial operations.

Each year gas storage operators spend hundreds of thousands of dollars on workovers, re-completions, and re-stimulations of storage wells in order to battle the decline in deliverability due to well damage with time. A typical storage field has tens if not hundreds of production wells. Each well will respond to a remedial operation in its own unique way that is a function of a set of uncontrollable parameters such as porosity and permeability and a set of controllable parameters such as completion and stimulation practices.

The objective of this project is to identify the best candidate wells for the remedial operations that will result in the most successful program each year, and consequently provides the highest return on investment. The deliverable for the second phase of the project is a Windows-based software application that would perform the analysis and recommends a list of wells and their corresponding remedial operation for each year base on the budget constraints identified by the user (operating company).

The state-of-the-art in hybrid intelligent systems that is currently being used extensively in the Wall Street is the methodology to achieve the objectives of this proposed project. This methodology includes a hybrid form of artificial neural networks, genetic algorithms and fuzzy logic. The principal investigator of this project is a pioneer in application of intelligent systems in the oil and gas industry and has a successful track record in developing intelligent applications for our industry.

Columbia Gas Transmission Corporation has been the industry partner of this project and has provided valuable data and field expertise to the research and development team for the successful completion of the first phase of the project. Columbia Gas Transmission Corporation will continue its cooperation for the second phase and completion of this project.

Appendix D
Predicting and Mitigating Salt Precipitation - Phase II Executive Summary

Public Executive Summary

Brine solutions are often produced during gas storage operations, and when these solutions encounter changing temperature or pressure, salt can precipitate. This salt can impair productivity and may even result in abandonment of wells. Dilution with fresh water is one method of mitigating the salt buildup. However, this can be expensive depending on the method of application, and as fresh water becomes scarcer, a wasteful use of water.

The purpose of the proposed "applied research into the development/evaluation of low cost salt inhibitors" study is to explore the combination of inhibitors and fresh water in mitigating salt blockage. Both laboratory and engineering analyses will be applied to meet the objectives that will be addressed in the following manner:

- By evaluating various chemicals, combinations of chemicals, and chemicals combined with fresh water for their ability to prevent salt deposition in NaCl brines, which also contain calcium and/or magnesium such as $CaCl_2$ work over fluids.
- By developing an empirical model to predict amounts of chemicals or chemicals in conjunction with fresh water that would be necessary to prevent salt build up in gas production and storage operations.
- By field testing the model using automated conductivity/total dissolved solids (TDS) measuring equipment.

A number of chemicals have been reported to reduce or prevent salt deposition. Among them are ferrocyanide, and some organic molecules such as nitrilotriacetic acid and nitrilotriacetamide. Their effectiveness, however, varies with their concentration and the composition and concentration of the brines. For example, ferrocyanide is a very effective salt inhibitor; however, at low pH or in the presence of small amounts of iron it decomposes, thus rendering it ineffective. Nitrilotriacetamide, while not as effective as ferrocyanide in preventing salt deposition, is not affected by low pH or small amounts of iron. The action of both chemicals is reduced as the reservoir water increases in calcium and/or magnesium, and they eventually become ineffective. But even when precipitate is formed, both inhibitors affect the properties of the precipitate so that there is no caking and no tendency to form large crystals that could prevent salt blockage. Dilution of the produced brine with small amounts of fresh water in combination with the addition of a salt inhibitor is also a possibility for reducing salt buildup.

Expected benefits include:

- A model to predict amounts of fresh water and/or chemicals or combination of chemicals necessary to prevent salt build up in gas operations.
- Comparison of the retention properties of salt inhibitors and a scale inhibitor squeeze chemical.
- Exploration of the possibilities of an on-line automated system to detect when fresh water or chemicals should be added.
- Lower costs and more efficient production.

Appendix E
Gas Storage Facility Design Under Uncertainty Executive Summa

Gas Storage Facility Design Under Uncertainty

Public Executive Summary

During the concept comparison phase of gas storage projects, many estimates are required to value the development scenarios under consideration. These estimates determine which concept proceeds into front end engineering and design. Estimates are required for reservoir attributes, surface facility costs, construction schedule, facility performance attributes, and market demand and price. The importance of these estimates cannot be overstated, they determine which concept is selected for development, the configuration and sizing of facilities, project timing, maximum injection and delivery rates, and ultimately, the value derived from the project.

This research project examines the sensitivity of gas storage facility design decisions to uncertainty in the estimates used during concept comparison and selection. There are two research objectives. (1) To investigate how uncertainty in estimates influences optimal facility sizing and other design decisions. (2) To assess the relative value of reducing uncertainty in these same estimates.

The first objective is accomplished using a stochastic simulation approach (Monte Carlo). The second objective employs the same approach but integrates it within a value-of-information framework. That is, reducing uncertainty increases project value—the question to be asked is "by how much?" The researchers will specify a dynamic optimization model of a greenfield and/or brownfield gas storage project assuming a risk-neutral, profit-maximizing decision-maker. Real options to expand will be fully accounted for in the model.

The project will yield practical and valuable deliverables that provide insight into which estimates "matter most" to project value:

1. A quantitative and qualitative assessment of the sensitivity of gas storage design decisions to uncertainties in estimates used during concept comparison;

2. A detailed value-of-information analysis that provides information on the relative value of reducing the uncertainty of estimates;

3. A workflow that incorporates the learning from the above assessment and analysis, including (a) a toolbox of specific planning aids for engineering teams to use in facility design given a particular project's attributes and uncertainties, and (b) guidelines for decisions to collect, or not to collect, additional information to reduce uncertainty.

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