

NGDS User Centered Design Meeting the Needs of the Geothermal Community

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ABSTRACT

In order to ensure the widest and greatest utility of IT and software projects designed for geothermal reservoir engineering the full consideration of end users' task and workflow needs must be evaluated. This paper describes the user-centered design (UCD) approach taken in the development of a user interface (UI) solution for the National Geothermal Data System (NGDS). This development process has been research based, highly collaborative, and incorporates state-of-the-art practices to ensure a quality user experience. Work is continuing on the interface, including future usability tests to further refine the interfaces as the overall system is developed.

Background and Objectives

The National Geothermal Data System (NGDS) is a distributed, interoperable network of data repositories and state geological service providers from across all fifty states and the nation's leading academic geothermal centers. This project is sponsored by the United States Department of Energy's Geothermal Technologies Program under Award # DE-EE0001120-#004.

The ultimate goal of the NGDS is to support the discovery and generation of geothermal sources of energy. NGDS will provide critical geothermal-related data that can be easily accessed to:

- Help companies be more (cost and time) effective in exploration, development and usage of geothermal energy
- Support a knowledge repository and archive for geothermal data, lessons learned, reports.
- Advance earth sciences by identifying gaps in our knowledge and informing new knowledge
- Increase public awareness in geothermal energy

These goals can only be accomplished if NGDS provides a quality user experience, and is widely adopted by users in the geothermal community.

There are three targeted user communities for NGDS, and each user group has different goals, needs, and tasks when interacting with NGDS.

- **Data providers** who will expose information to NGDS through standardized, internet-accessible interfaces and interface formats.
- **End users or data consumers** who will utilize NGDS to access data to support their work in geothermal energy exploration and development.
- **Application developers** who will build applications that utilize the data in NGDS, and make it easier for end-users to interact with the system.

This paper focuses on the end users / data consumers.

Design Approach

User-Centered Design

To ensure NGDS is usable and meets users' needs, we followed a systematic and data-driven design philosophy called user-centered design (UCD) (also called the human-centered design process – ISO 9241-210:2010). UCD is based on three underlying principles (Gould and Lewis 1985):

- **Early focus on users and tasks.** Understanding the users of a system, the tasks they perform, and the environment in which they work. Best practices advocate for direct contact between users and the design team throughout the development life cycle.
- **Empirical measurement of product usage.** Emphasis is placed on behavioral measurements such as ease of use early in the design process, through the development and testing of prototypes with actual users.
- **Iterative design.** A product is designed, modified, and tested repeatedly. True iterative design allows the team to

shape the product through a process of design, test, redesign and retest.

The UCD approach ensures usable systems resulting in positive customer experiences, reduced development time, minimized risk for expensive changes to the system post-launch, increased user adoption and an enhanced reputation for the organization responsible for the system (Bias and Mayhew, 2005).

Multi-Disciplinary Team

Complex systems such as NGDS are best designed and developed by multi-disciplinary teams (Mayhew, 2008). For this project, the Department of Energy brought together experts in geothermal development and production, software development, user-centered design and project management, and outlined a plan that leverages respective skill sets and areas of expertise.

Designing NGDS

We outlined various methods to inform the design of NGDS. Specifically, the team organized:

- A domain committee to gather data requirements and standardize interchange formats for commonly produced data;
- Interviews with expert users that uncovered end-user goals, needs and design requirements;
- Design concept and wireframes to visualize the user experience early on and test the system with end users;
- Usability testing sessions at the Geothermal Resources Council (GRC) annual conference in Reno, NV to further iterate the design concept.
- Use case development to specify how NGDS will support users' key tasks.

The remainder of the project will incorporate additional usability testing throughout the development cycle to continually improve the user experience of NGDS.

Defining the End Users

Team members worked together to define the end-user groups. Specifically, project partners documented NGDS end users' key characteristics, including their domain knowledge, typical organizations they work for, anticipated frequency of use, motivations, goals and tasks for using NGDS. This initial exercise generated well over 26 different user groups.

A classic user experience mistake is to design for every possible user type. Such designs often suffer from busy and overwhelming interfaces that have too many features that too few users care about. To avoid such an experience, the UCD team further analyzed the 26 user groups and clustered commonalities in behaviors, attitudes and motivations.

Based on this analysis, seven key user groups emerged, each with distinct goals for the NGDS. These include:

- **Industry representatives** who focus on the geothermal exploration and development process
- **Researchers** who want to generate scientific knowledge or study a specific area of interest
- **Federal and state agencies** who make land and resource management assessments

- **Legislators** who make policy decisions that impact geothermal exploration and development
- **Interested public** who want to understand implications of local geothermal energy sources
- **Educators and students** who teach, learn or explore the education pipeline for careers in the geothermal energy industry.
- **Financial investors** who determine whether or not invest in a potential geothermal site.

Figure 1 outlines the user profiles for NGDS.

User Personas

Based on user research results, we developed user personas for NGDS. User personas are archetypal representations of users based on data (Cooper, 1999). They are compelling communication tools because they put a personal face on otherwise abstract data about users, and help the development team focus on the real end user, rather than making design decisions based on assumptions. Figure 2 illustrates one of the personas with goals, needs, and desires explicitly spelled out.

Expert Interviews

Goals

We conducted interviews with nine geothermal experts representing the key user groups. The goals of the interviews were to:

- Gather information about the people who use the system; validate/refine the user personas.
- Understand users' current processes and workflow for gathering data when prospecting potential geothermal sites.
- Identify the types of data end users look for and which data is most important for their specific goals.
- Find out where users currently go to locate data.
- Understand users' processes for verifying and analyzing the data.

The interviews were conducted by phone and utilized screen sharing technology. This allowed participants to show the facilitator their computer systems, applications and software used for their work, and file structures used to organize data sets.

Interview Findings and Implications for NGDS Design

The expert interviews provided key insights into current work practices and pain points in the data gathering process. We learned that:

- Geothermal exploration and development is a highly data-driven process. Gathering quality data is the most cost-effective and efficient way to reduce risk and predict favorability of a specific geothermal site.
- Users value all types of data. While there are key data types that are higher priority, users emphasized that all data, ranging the spectrum of geophysical, geochemistry, well data and more are valuable.
- The search for data is typically geographically oriented. For industry representatives who focus on geothermal

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INDUSTRY	RESEARCHERS	AGENCIES	LEGISLATORS	INTERESTED PUBLIC	EDUCATORS & STUDENTS	FINANCIAL & INVESTOR COMMUNITIES
Industry representatives or consultants who focus on the exploration and development process • Geologist / geophysicist • Engineer • EIS writer or scientist • GIS specialist • Archeologists • Environmental consultants (working on behalf of industry)	Applied researchers and academic researchers • Professor • Research assistant • Geoscientists • Engineers • May work with or for industry	Federal, state, local government organizations • Permit issuer • Land use planner • Policy maker	• Public policy analyst • Lobbyist	People who care about geothermal energy and the environment in a specific area of interest • Homeowner • Technical writer • Environmental interest groups • People who care about the planet	• Elementary school teacher • High school teacher • Undergraduate educator • Graduate students • Students • Job seekers	• Investor • Consultant working on behalf of investor • Companies that do the financial analysis for investors • Investment counselors
MOTIVATION						
Determine geothermal potential for a specific site.	Generate scientific knowledge. Scientifically characterize a specific geologic area to contribute to the field's body of knowledge.	Guide exploration and development by establishing, evaluating and modifying policies, rules and regulation that impact land and natural resource use.	Make informed and data-driven policy decisions that impact geothermal exploration, development, land use etc. (examples: endangered species, land withdrawals - wilderness, historical value etc.)	Understand how geothermal activities affect me, my community and the environment.	Find data to inform course work or research (thesis). Understand who the players in the industry are and find job opportunities.	Determine whether or not to invest in geothermal exploration or development. Get an independent / neutral assessment.
DATA USAGE & CONTRIBUTION						
Read and potentially contribute data (depends on funding source)	Highest	Read and contribute data (authoritative source for land related information)	Read	Read	Read	Read
EXAMPLES						
Ormat, US Geothermal Inc	Universities, National Labs	Federal Bureau of Land Management, National Science Foundation, local agencies that issues permits, Department(s) of Natural Resources, Division of Minerals, State Geological Surveys		Resident of a town that has geothermal power plants.	Graduate student in geological sciences. High school science teacher	Land/mineral development organizations interested in geothermal energy investments. Geothermex
DOMAIN KNOWLEDGE						
High	Highest	Medium to low	Medium to low	Low	Medium to low	Medium to low
VISIT FREQUENCY						
Frequently (Bi-weekly / Monthly)	Frequently	Periodically	Rarely	Rarely	Periodically	Periodically to rarely
PRIORITY TO NGDS						
High	High	Moderate	Moderate	Moderate to low	Moderate to low	Moderate to low

NGDS AD HOC USER PROFILES 5 | 2012

Figure 1. User profiles for NGDS.



THE END USER/DATA CONSUMER

Matthew Parker

"My intent when conducting research is to understand the geothermal potential in a specific area for future investments."

Age 48
Profession VP of Resource Management
Location Salt Lake City, Utah

Goals:

Efficiently locate and synthesize quality data to enable my team to produce reports which will provide geothermal information for specific geographical locations.
Easily share data securely with clients, agencies, and repositories.

Methodology:

- Utilize resources to understand potential of sited locations.
- Gather data such as a well location/size, geyser temperatures, permeable/impermeable rocks, property logistics, mineral makeup, etc to determine economic value of a site.
- Verify quality of data.

Resources:

- State Bureau of Mines
- Agency Websites
- Universities
- Purchased Proprietary Data

Tools:

- Coordinate Systems
- Numerical Predictive Simulator
- Maps

Frustrations:

- Finding data is time consuming and lacks a sense of direction.
- Property data should not be so difficult or expensive to obtain from sources.
- Georeferencing is poorly supported by a lack of proper land zoning.

Desires:

- A map system that holistically provides organized quality data of potential geothermal sites.
- NGDS provides an incentive for data providers to contribute data for a lower premium price.

Meet Matthew!

Figure 2. End User Persona for NGDS.

• Users utilize various approaches to validate the data such as getting expert or peer opinions, reading published research, getting direct measurements, and triangulating data with other sources.

• Users rely on proprietary or third party software to do the analysis. Industry representatives, researchers and financial investors said that they use GEOSOFT, ARC GIS, and other proprietary software to manipulate and analyze data.

Implications for Design

The user research findings informed several design requirements and helped the team prioritize features for NGDS. A strong unifying message was the desire to have a "one-stop system." At this point in the program it is not certain how many of the features will be incorporated due to resource constraints. Other key implications for design included:

1. Focusing the core functionality of NGDS on data discovery and validation, and deprioritizing features that focus on data analysis and manipulation. Users indicated that they currently use a variety of proprietary software to analyze, manipulate and visualize data and that much time and frustration goes into discovering the data. NGDS can provide the most value by supporting data discovery and validation. In addition, the system must allow users to export data in a variety of formats that allow for streamlined usage in their own analysis tools.
2. Making geographic search and discovery the most prominent feature of the system. This underscores the importance

of continuing to geocode data that will be exposed in NGDS.

3. Supporting multiple ways for users to find and narrow down data set results. This includes providing the ability to do:

- Simple text searches

exploration it is pertinent that they can visually explore what data exists in a specific geographic area.

- The data gathering process happens over a long period of time, is inefficient, collaborative, and dependent on using many distributed systems.

- Geographic searches
 - Narrowing results by different criteria such as topic, user rating, data format and more
 - Sorting data set results by specific criteria
4. Providing the ability to let users rate and comment on data sets to and exposing ratings to all users to support finding and validating data based on peer ratings.
 5. Helping users save searches and “favorite” specific data sets so they can retrieve them easily across multiple sessions.
 6. Allowing users to share data sets with colleagues to support the collaborative nature of the data collection process.
 7. Ensuring multiple formats for each data set so users can export data and utilize it in their analysis tools.
 8. Providing key metadata for each data set that helps users determine the validity of the data. These include information about source, author, dates, instruments, related data, and peer rating of the data set.
 9. Relying on common web-based standards for the user interface. Users are already familiar with other types of web based systems such as Google, Bing, common e-commerce or library web sites. NGDS can leverage standardized interactions to minimize users’ learning curve with the system.
 10. Giving users an option to “follow” certain datasets and signing up for email alerts when new data that meets their criteria have been uploaded or changed in the system.

NGDS Design Concept

To visualize these design requirements and get feedback from prospective users, we prototyped the system. The prototype laid out key sections of the system, including:

- **The NGDS homepage** (Figure 3) which provides easy access to top users’ tasks.
- **The map** (Figure 4) where users can easily find geocoded datasets by searching geographically or zooming into an area on the map. Map layers let users visualize thematic data such as geological features, environmental data, land use, ownership and more.
- **The library** where users can access all datasets (geocoded or not) by browsing, searching or both.
- **A resources section** which provides links to tools, applications and web sites that help users analyze their data. In addition, users can suggest additional information .

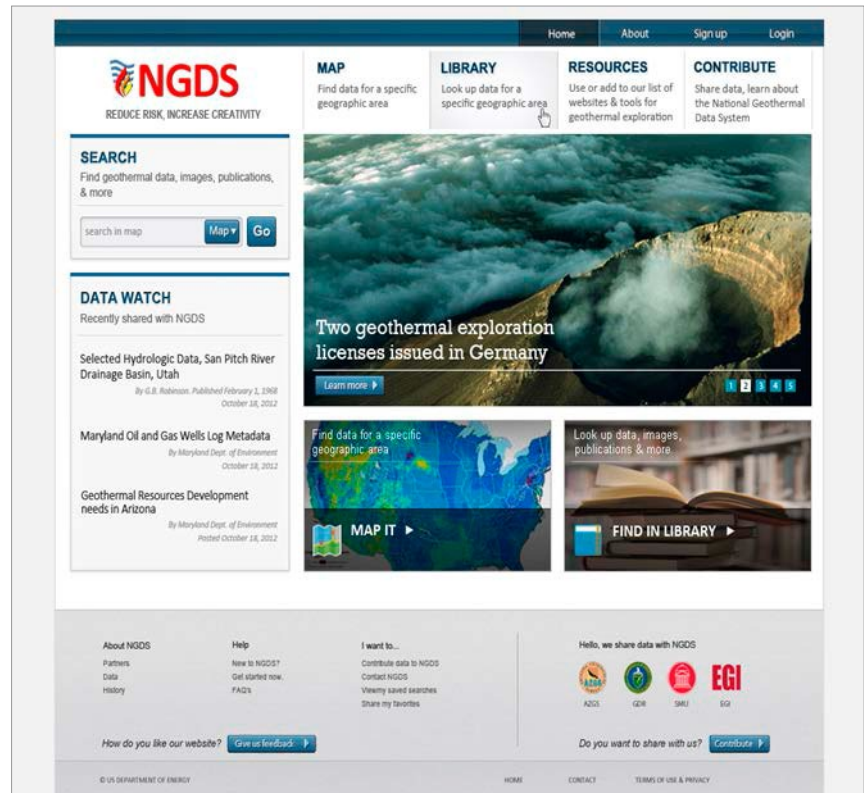


Figure 3. NGDS Homepage.

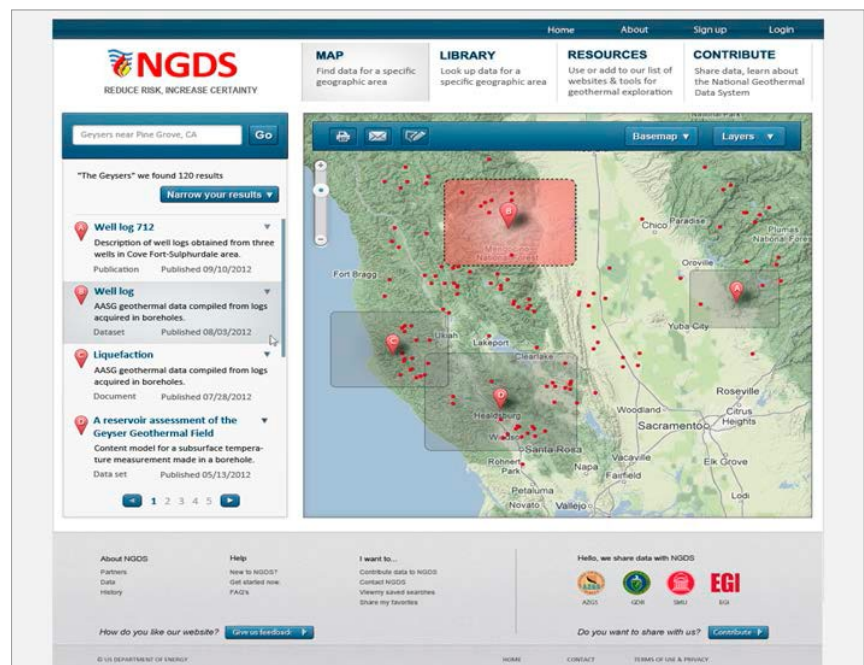


Figure 4. NGDS Map.

- **The contribute section** where users can contribute data to NGDS.

Moreover, the prototype reflected key features in the system such as interactions that detail how a user can rate a data source, save a search or add a data set to their favorites.

Usability Testing the NGDS Design at GRC and Stanford Geothermal Workshop

To evaluate the prototype with target audiences, we prepared for usability studies at the Geothermal Resources Council Annual Meeting and Geothermal Energy Association Annual Expo in Reno, NV. Our goal was to collect behavior and perceptual data in a short amount of time, and refine our design concept before finalizing the design requirements and starting system development.

A total of 18 users representing key user groups took part in the study. At the outset of each study, we conducted a basic user interview to further understand participants' role, characteristics, and goals for geothermal exploration. This information was used to further validate the user profiles.

After the pre-study interview, we asked each participant about a recent project they worked on, and what types of data they sought to support the project. We then asked them to use the NDGS system to explore this recent scenario. Following this open-ended scenario we provided users with key predeveloped scenarios and observed as they used the NGDS prototyped system. We captured a variety of notes including their think aloud protocol, pathways in the system, errors and task completion.

In this study we learned that:

- Participants worked with the prototype easily. In particular they easily navigated to the correct sections and used a combination of searching, browsing, and sorting to work with results lists. In addition, key features such as sharing datasets with others, selecting favorite data sets and downloading a data set were easy to use.
- Participants were primarily drawn to use the map to find respective data sets and examine potential for a specific geographic area. In most cases, participants zoomed to a geographic area of their interest and expected related datasets to display in the results list.
- Participants have high expectations for the ease of use of the system. They stated that NGDS must save time and money in comparison to the data collection process they are currently practicing.

In addition, the study findings suggested that there were several areas for improvement in the user experience including:

- More controls to manipulate the map such as the ability to draw a precise shape (polygon) on the map and refine results within that area.
- Ability to track how many people had downloaded a specific dataset.
- More file formats for exporting datasets so they can work with them easily in their proprietary systems.
- Making search more discoverable.
- Auto-suggest or complete search terms.

The design team iterated the design concept to address found usability problems and meet users expectations.

NGDS Use Cases

To ensure the NGDS design concept and user requirements are fully understood by the software development team, we developed

use cases. Use case modeling is a common methodology used in software development to identify, clarify, and organize system requirements. A typical use case is a list of steps that defines interactions between a user and a system, to achieve a specific goal (Constantine & Lockwood, 1999; Jacobson et al, 1992). For instance, end- user/data consumers are using NGDS to gather data, validate data, and analyze the data after exporting it. Data submitters are as important as data consumers. The two major use cases for data submitter are batch import of dataset files, and create metadata record through a form. We developed more than 50 use cases for NGDS. Each use case captures the important user requirements and steps for different users interacting with the NGDS and provides a foundation for the NGDS system requirement specification document.

Initial Website

We constructed a beta website and search engine to provide users with a basic mechanism for finding data while the UCD process is in process. The site is available at www.geothermaldata.org and includes resources for data users (i.e. the area that will transition to the map and library described above), data submitters (i.e. the contribute section), and application developers (i.e. the resources section). The site currently includes a beta search-engine style, map-based search application for data discovery. The search application includes much of the functionality end users identified, including the ability to search by area (bounding box) or by key word, and to access the data in a variety of formats, including Excel, ArcGIS shape files, and Open Geospatial Consortium (OGC) Web Map Services (WMS) or Web Feature Services (WFS). The site and search functionality will be refined as the UCD process concludes and the software is developed.

Next steps

The team is refining the NGDS design concept and continuing to test extended functionality.. In parallel we are prioritizing features and preparing for the agile development process. The UCD and completed NGDS system is scheduled to launch in-full during the Fall of 2013.

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