

## Section 5. Task 1B Options for Developing Models for Providing Web-based Access to Ceramic Property Data

### 5.1 Introduction

The last twenty years has seen a rapid maturing of the World Wide Web as the primary mechanism for providing access to all types of information, including the properties of ceramics materials. While in the early years of the web, the emphasis was on free access, but the potential for commercial web uses has emerged, and today an incredibly rich diversity of commercial services complement the no-fee services. In this section, we discuss various options for developing models for web-based access to ceramic property data.

### 5.2 Basic Data Access Process Model

Our model for this discussion is illustrated in Figure 2. We have divided the entire data access process into three components: users, data resource builders, and the data access providers that link the two together. Feedback loops between the components are critical to ensuring that needed services and products are provided.

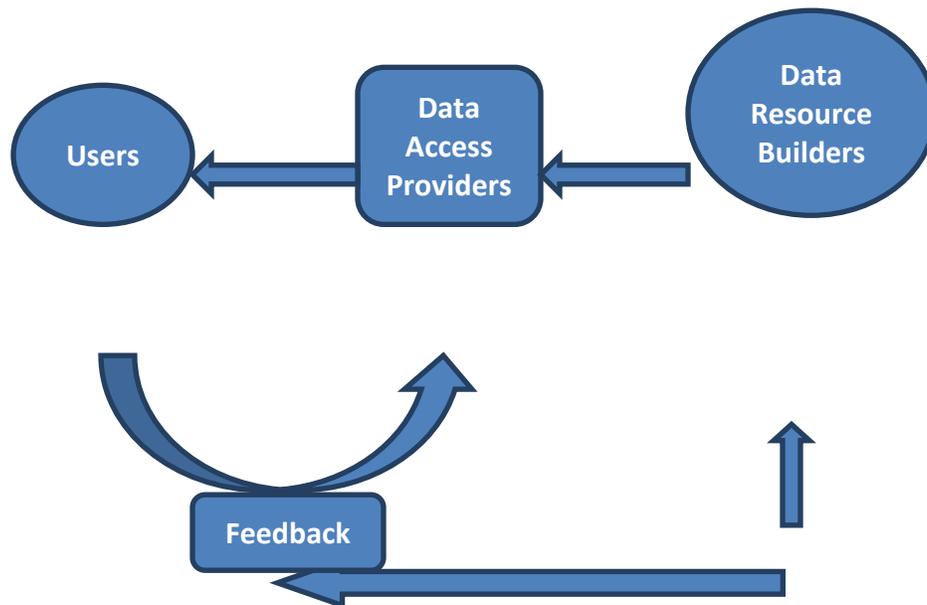


Figure 1. The basic data access process model.

It is instructive to begin from the user perspective, to ask, *what does a user of ceramic property data need, want, and expect?* The answers to these questions can be summarized as follows.

1. **What is needed?** Access to property data for newest materials, as well as fundamental properties of all materials
2. **What is wanted?** Quick and easy access, with the minimum fuss, through the smallest number of access points possible
3. **What is expected?** Lowest possible costs, systems that always provide answers as advertised, with 100% availability and highest quality or provenance indicators

From the perspective of those who build data resources, the questions are as follows:

1. **How do we preserve generated data (from experiments, calculations, compilation) easily and accurately?** Through use of modern, easy-to-use database tools
2. **How can these data be made available to those who need them?** Through use of the World Wide Web
3. **How can the data collection and preservation effort be supported?** Through government or private sector subsidies or fee-based services

These two communities are linked by the data access providers. These are organizations, non-profit and commercial, that provide access to data as a free service, for profit, or both. Types of data access providers found in the world of materials data in general, and ceramics data in particular, and their characteristics, are listed in Table 5-1 below.

| <b>Table 5-1 Types of Data Access Providers</b> |  |   |                         |
|---|--|---|-------------------------|
| <i>Organization Type</i>                        | <i>Characteristics</i>   | <i>Example(s)</i>                           | <i>Types of Charges</i> |
| Professional Societies                          | Organized around a discipline or special interest; membership usually limited to specialists in a field; provides data as a service to its members | American Ceramic Society, International ASM | Fee-based services      |
| Commercial Data Services (Multi-disciplinary)   | Companies that provide data in a variety of fields, sometimes not even related to science and technology; often former publishers                  | Springer-Verlag, CRC Press                  | Fee-based services      |
| Commercial Data Services (Specialized)          | Companies that provide data in a few disciplines (usually related); often provide tools to exploit the data  | Granta                                      | Fee-based services      |
| Web Search Services                             | General web search engines that can find all types of information  | Google, Yahoo, Bing                         | Free                    |

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| <i>Organization Type</i>                        | <i>Characteristics</i>  | <i>Example(s)</i>   | <i>Types of Charges</i>                                    |
| Materials Producers                             | Companies that make materials and provide data about their materials products   | Kyocera   | Free   |
| Government Agencies                             | Government agencies that maintain data programs either in many disciplines or to support specific missions  | NIST (General S&T data), DoD (many types of materials data; DOE (mission specific data) | Mostly Free, but NIST has authority for fee-based services |
| Universities                                    | Academic organizations that make available data produced by their research groups either under a single grant or from a series of related projects            |   | Free and fee-based services                                |
| Research Institutes                             | Non-profit research organizations that make available data produced by their research groups either under a single grant or from a series of related projects |   | Free and fee-based services                                |
| Non-profit Data Organizations                   | Organizations established to collect and provide access to special types of data, usually spun off from other organizations                                   | International Centre for Diffraction Data   | Free and fee-based services                                |
| Materials Advocacy Organizations                | Groups that promote the use of specific materials   | Aluminum Association; American Iron and Steel Institute                                 | Generally free   |

The question now becomes, do these data providers have the motivation to provide access in a manner that meets user needs, as listed above, or in a manner that meets the needs of those building data resources? For ceramic property data, based on the analysis we have given in Section 2 describing present-day available ceramics data resources, the answer is *no*. In fact, most data providers do not seem to want to provide access to any data resources besides their own. They do not want to make access to multiple data resources easy, quick, or through a single

point of entry. The exception might be commercial data providers, but to date, none has provided access to many ceramic data resources through a single data portal. Given the numerous data resources and the difficulty a single user would have in knowing about and using multiple resources, it seems that individual providers of ceramic data resources want to keep the present system.

There are a number of reasons why these data resource builders and data access providers do not serve the ceramics data user community adequately today in terms of providing access to multiple data resources, including the following:

- Small number of potential users
- High cost of building and maintaining a comprehensive system
- Poor understanding of benefits and revenue streams
- Labor-intensive nature of building and maintaining scientific and technical data collections
- Variability of ceramics properties due to small changes of composition, processing, or manufacturing
- Expense of data evaluation and curation
- Lack of standardization of ceramic materials
- Rapid innovation leading to new materials

At E-Ceramics 2012, the ceramics informatics workshop held in June 2012 as part of this study (see Section 5), the difficulty in learning about ceramics data resources and gaining access to them was highlighted as a major concern of the user community. *In particular, participants were generally unaware of the multitude of ceramics data resources presently available, and even if they knew about a resource, contractual and fee arrangements posed significant barriers to use.*

The preponderance of challenges to those who build and provide access to ceramics data resources combine with the challenges faced by the ceramics data user community to make the present-day situation unsatisfactory. The goal is to identify and understand these challenges so that access to needed ceramic property data will improve significantly over the next decade.

### ***5.3 Options for Developing Models for Providing Web-Based Access to Ceramic Property Data***

Based on the opinions expressed by attendees at the E-Ceramics workshop 2012 (Section 3), user needs for access to ceramic property data are not being met. How best can interested parties— industrial product designers, component manufacturers, and government agencies—plan to meet those needs? First we must recognize that ceramic property data are important enough to industrial and government designers and engineers so that they have historically been willing to pay for data handbooks, individual databases, and research programs to gain access to needed data. The economic value of ceramic property data is well established, and fee-based services are accepted.

At the same time, ceramic property data are usually just one input into the complicated, non-linear process that results in commercial products or materials. Property data are often critical in the *early* stages of product conceptualization and design, so that the time separation between data usage and release of a product is usually several years. The conundrum is that the value of property data is recognized, but its importance in the economics of a final product is underestimated.

In addition to these considerations is the fact that properties of engineering materials, especially ceramics, are highly variable in terms of small compositional, processing, and manufacturing changes. Many ceramics are individually tailored by a single company to specific product needs. A specific ceramic is unlikely to be reproduced by other companies. As a result, ceramic property data are important for determining general materials selection, but they often involve significant fine tuning before a final selection is needed.

Consequently, responsibility for meeting the needs of a general user of ceramic property data is not clear cut. Professional societies, which collectively are a major provider of materials property data in the United States, do not feel the pressure to provide a one-stop service for ceramic data. Government agencies, especially in the areas of defense, energy, and security, have limited mandates. Large commercial data providers see limited market potential. While small commercial data providers claim to provide comprehensive coverage, in fact, their data products are outdated, incomplete, or both. Ceramics manufacturers are interested in advancing only their materials.

How can the ceramics data user community coalesce and provide a coherent argument for meeting their needs? Based on activities in other scientific and technical disciplines, several potential approaches have been identified that are discussed below.

- ***Informal action of the user community through workshops and articles in materials and informatics press***

In many areas, such as astronomy, grass-roots efforts have succeeded, primarily because individual scientists recognized the value of having coordinated data activities, and they also recognized that the limited *economic* value of their data precluded fee-based services. As a result, once grass-roots efforts reached a certain level of activity, researcher funders came on board and provided the needed subsidies.

Ceramics property data are important to ceramic producers who use data to differentiate and sell their products. They are also important to product manufacturers who use data to produce better engines, electronics, etc. This high economic value complicates and inhibits grass root efforts to provide better access. Ceramics producers want to control their proprietary data; manufacturers who use ceramics data do not want to share data in order to maintain market share.

- ***Professional societies or industrial organizations should be approached to establish new ceramics data activities.***

For over a century in the United States, professional societies and industry associations have been primary mechanisms for industrial firms to cooperate in sharing technology, information, and data. Many of these organizations routinely provided quality data products and services in the form of publications, handbooks, and data tables, usually but not always on a fee basis. In fact, for many groups, the income from these products helps support other activities.

Over the last three decades, professional societies in particular have had to confront moving into the information age, and with the World Wide Web and internet, they have struggled to develop data services that were revenue neutral, at a minimum. The size of the perceived initial investments, as well as the lack of a fee structure that would be accepted, is still a challenge today, resulting in far fewer online data services than might be expected. It has been easier to maintain the status quo rather than to take big risks, especially for many societies for which membership has been declining through the recent financial crisis.

One goal of this work is to alert professional societies interested in ceramic property data to see that significant opportunities exist for providing new and important services to their members and others by providing better access to those data.

- ***The Federal Government should fund an independent review of access to ceramics data to identify the problem and propose solutions.***

Beginning in the late 1970s, a large number of studies and reviews of the opportunities associated with computerized materials data have been undertaken, some of which led to the establishment of the fairly short-lived National Materials Property Data Network. The issues faced by the data community today have been well recognized and studied. Further review is unlikely to lead to immediate action. The challenges to U.S. leadership in terms of its materials capabilities, however, are another matter. As other countries, especially China, continue to invest heavily in an informatics future, U.S. industrial, economic, and security competitiveness must be scrutinized. Advanced materials play a critical role in our competitiveness, and periodic assessments of the issues are needed to ensure that we maintain our world leadership. It must be recognized, however, that such studies and reviews are more important for government actions rather than private sector investments. As a result, improvements in access to ceramic property data by the private sector (industry, professional societies, and information industries) are less likely to result.

#### ***5.4 Potential Business Models for Web-based Access to Ceramic Property Data***

To review briefly what users want:

- They want web access to as much ceramic property data as possible.
- They want access to be as easy and quick as possible.
- They want to know the quality of what they are accessing.

In terms of having a single point of access, the two business model *extremes* are as follows:

1. A single, monolithic ceramics data system is established with data from as many sources as possible in the system in a uniform format and a single interface. A single license is needed.
2. A federated ceramics data system is established with a single point of entry, with the user having to contract with each data resource available in the system and with multiple interfaces.

Neither approach is likely to be viable. The cost of building a monolithic data system is significant, even with all the advances made in information technology and web technology over the last twenty years. No standards exist for describing ceramic materials or ceramic property data. The effort to integrate data from the more than 50 ceramics data resources identified in this report is daunting and not economically feasible. Many of the data resources are proprietary and are designed to make money for their builders or providers. These have little economic incentive to cooperate with a monolithic system.

A federated system with a single point of entry, but with multiple user interfaces and requiring users to contract individually with each resource, is essentially the system in place today, with Google, Yahoo, or other search engines acting as the single entry point, and with linkage to each identified data resource the responsibility of each individual user. Today's system is unsatisfactory from many points of view, not the least of which is the lack of selectivity among search results. Further, such a system does not provide detailed information about the contents of each data resource, and the utility and coverage of a resource often cannot be determined without considerable effort. In some cases, the contents cannot be understood until contracts are in place.

A more workable business model lies between the two extremes defined above. A robust ceramics data system that inherently meets user needs is a hybrid federated system. In this model, there are multiple points of entry via multiple systems, depending on the market place. Each system would be similar in many respects and would likely include the following characteristics:

1. A single access point, commonly referred to as a data portal, would be available and operated by a *system provider*.
2. Users would have one contract with the system provider.
3. The system provider would have contracts with as many data resources as possible, such that a user wanting to use a resource would need only to invoke the user-system provider contract.
4. Over time, the system provider would create detailed directories of the content of all data resources to make it easy for users to locate needed data.
5. The system provider would initially provide a simple, easy-to-execute link to individual data resources.
6. Over time, the system provider would develop standard displays, tools, and cross data resource searching capability.
7. Access to data resources through a quality system provider would provide some level of data quality that would increase over time as users return to the system.

The success of such a business model depends on the willingness of a system provider to (1) include the greatest possible number of data resources in its system and (2) to negotiate contracts that provide adequate revenue to each data resource and to the system provider. Given the existing recognition by the user community of the economic value of ceramics materials data, the willingness to pay is not lacking. Instead, the major hurdles are (1) knowing that a data resource exists, (2) knowing the actual contents of each data resource, and (3) the difficulty of negotiating contracts with multiple data access providers.

While some private sector organizations have attempted to develop a comprehensive materials data system, none have tried to do this for ceramic property data alone. From the perspective of today's users, as described throughout this report, many data resources are unknown, and access can be difficult. The need for one or more single points of entry (data portals) to multiple existing data resources is clear, and the opportunity to use current tools to create such a system is there. With more than 50 data resources available today, coverage in terms of materials and properties is *likely* sufficient to attract a sufficient number of users to generate the revenue necessary for a sustaining system. Before investing in such a system, any organization seriously embarking on this path would need to conduct a detailed user survey and would also need to negotiate with data resources.

The role of the government in designing, building, operating, or even advocating such a system is limited. The government's does build individual data resources needed for its missions, but the government also can and should work with interested parties to help them overcome barriers in making government-funded data widely available on such a system.

