Examining the Influence of Key Choices on Context, Structure, and Scientific Processes in a Large DOE User Facility:

A Study of the Oak Ridge Center for Nanophase Materials Sciences

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Our goal is to gain insights into the role of R&D institutional context in influencing the societal implications of emerging technologies

How do key choices by various players at the Oak Ridge Center for Nanophase Materials Sciences (CNMS) affect the flow of the Center's outputs, and the ability of use-inspired science to achieve its societal objectives?

- Examples of Choices
  - What is the specific research agenda?
  - Who will carry out the research?
  - What are the research endpoints?
- Examples of Context
  - Center goals
  - Management structure
  - Formal practices
- Examples of Processes
  - Method of choosing the users
  - Ensuring Center resources are used efficiently
  - Transferring/translating science to downstream users (often other scientists)

CNMS is one of 5 DOE Office of Science Nanoscale Science Research Centers (NSRCs)—collaborative, multidisciplinary, *user* research facility.

Center for Nanophase Materials Sciences

U.S. DOE Nanoscale Science Research Center

An Office of Science User Facility

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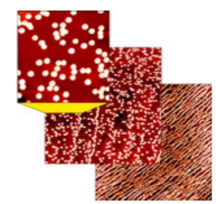
SCIENCE AT THE CNMS

The Center for Nanophase Materials Sciences (CNMS) at Oak Ridge National Laboratory (ORNL) is a Department of Energy / Office of Science Nanoscale Science Research Center (NSRC) operating as a highly collaborative and multidisciplinary user research facility. The CNMS is one of five DOE NSRCs that form an integrated national user network. Each NSRC is associated with other major national research facilities at one of DOE's National Laboratories, enabling their application to nanoscale science and technology. The central organizing concept of CNMS is to provide unique opportunities to understand nanoscale materials, assemblies, and phenomena, by creating a set of scientific synergies that will accelerate the process of discovery.

To accomplish this, the CNMS integrates nanoscale science with three highly synergistic national needs:

- **Neutron Science**, using the Spallation Neutron Source, SNS, and the recently upgraded High Flux Isotope Reactor, HFIR.
- **Synthesis Science**, or what we call "science-driven synthesis," facilitated by extensive and novel synthesis capabilities in the first three CNMS Research Capabilities areas listed at the bottom of this page and by a new Nanofabrication Research Laboratory.
- **Theory, Modeling and Simulation**, through establishing a new Nanomaterials Theory Institute, with close connections to the staff expertise and computational capabilities of ORNL's Center for Computational Sciences and the new national Leadership Scientific Computing Facility.



AFM images of Fe nanodots and nanowires on flat and stepped NaCl surfaces (edge length 750nm)

The CNMS's research capabilities provide a broad community of scientists, engineers, and students from throughout the nation, but particularly the southeastern United States, with ready access to the full range of tools and collaborative capabilities needed for nanoscale research, in a single location.

Scientific Themes

CNMS research focuses on understanding, designing, and controlling the dynamics, spatial chemistry, and energetics underlying functionality and properties of nanoscale materials, systems, and architectures.

Source: http://www.cnms.ornl.gov/about_cnms/about_cnms.shtm

Our research takes place through three stages

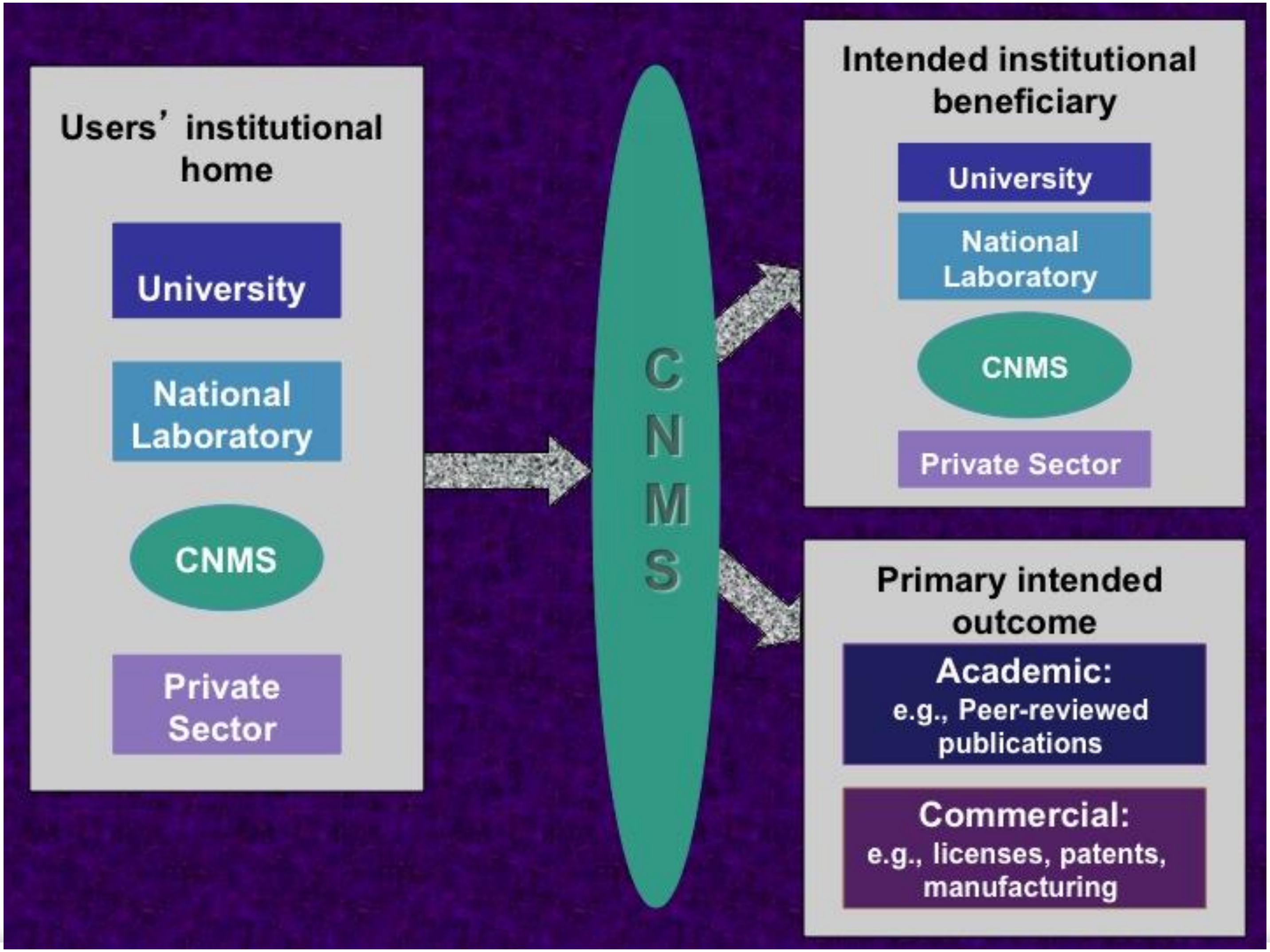
- Data collection–principally a set of interviews
- Data organization–by the relationships among the various players
- Data interpretation–identifying societal implications

*We define **implications** as the consequences of alternative choices, for example, a choice to focus on one aspect of science or of the R&D continuum rather than others.*

Our interviews seek to understand how managers and researchers perceive the context, processes, and key choices for the CNMS

- Semi-structured interview format
- Protocol employs leads and prompts to focus interviews on topics of interest
- Interview sessions last about one hour, with two interviewers and one interviewee
- Initial interviewees selected by management roles, with subsequent interviews selected by snowball process
- 24 total interviews
- Strict human subject controls

Schematics were useful points of departure in eliciting information from interviewees



We organize our interview results by decision points that shape the flow of information through the CNMS—*"information handoffs"*

- **Parallel handoffs** describe relationships between sponsors and the CNMS
  - DOE provides a general research agenda to the CNMS that the CNMS implements
  - Other sponsors may include other public or private groups
- **Upstream handoffs** describe relationships between the CNMS and potential CNMS users
- **Downstream handoffs** describe relationships between the CNMS research products and the scientists and engineers who will employ CNMS outputs

Handoffs may be formal processes that are visible to all or may be invisible because they take place informally among individuals.

Examples of our results

- Perceptions about DOE's goals for CNMS
- CNMS process for choosing Center users
- Formal and informal transfer of new science to "downstream scientists and engineers"

Interviewees uniformly agreed that the Center's mission was to produce important, new basic knowledge, evidenced by a flow of high quality publications

- Strong basic science organization (with example comments from interviews)
  - "Single objective: to generate knowledge and publications"
  - The DOE Office of Science (SC) …"is interested in basic science, not applications"
  - SC "…supports the idea of use-inspired science." but uses this and other related phrases to describe fundamental work that will ultimately fill technical gaps
  - (purely applied work) "…would get no credit …" (at SC)
- Still, some CNMS research sparks application-oriented interest
  - …"a new scanning probe microscope based on research by 'scanning probe guys' led to private sector license and a commercial license"
- There seems to be a wide acceptance of successful science, which can have broad interpretations
- The Center managers and the scientists generally have the same incentives to encourage publication
- This might be described as a transparent handoff from SC to the CNMS

The CNMS also contributes to DOE's traditional goals

- Interact with industry–with limitations on proprietary findings
- Support other agencies of government–such as military applications
- Support more applied programs–such as the DOE Office of Energy Efficiency and Renewable Energy
- Train students–in this case in the use of the unique resources of the CNMS and ORNL in general

The CNMS process for choosing outside users integrates outside visitors and ORNL staff

- Calls for proposals from outside users
  - Generally university faculty and students (about 400 each year)
  - Could involve private sector (bias against proprietary research)
  - Often outside proposers interact extensively with Center prior to submission
  - Unique equipment often requires ORNL staff to execute analyses
- Proposals externally peer reviewed to determine quality and relevancy
- Proposals also reviewed internally to match demand and supply for Center resources
- A number of users indicated that the CNMS call for proposals was sufficiently flexible to accommodate their research interests
- This results from a series of transparent upstream/downstream information flows between the CNMS and the users

When queried about their role in seeing their research findings handed off to downstream users, often other researchers, responses were varied

- Some respondents simply didn't worry about downstream transfer
  - For example, one said "It's not my job"
- Others said that the traditional process of publishing results worked fine
  - "I write papers and they read them"
- The existence of formal technology transfer programs was noted
  - Some respondent thought they didn't transfer much of the basic science produced by CNMS researchers
- Some said that they tried to see their work made available to downstream users
  - Took personal pleasure in seeing their work used
  - Encouraged to transfer technology in grad school
- One reported that a defense-related sponsor had no interest in technology transfer

Analysis of the interviews has identified a flow of information downward that is diverse and nearly invisible. Relative to the finding of uniform understanding of DOE's goals for the CNMS and the CNMS process for choosing users, we find the downward handoff of basic knowledge to be varied and often informal. We find at least three ways for moving research findings toward use:

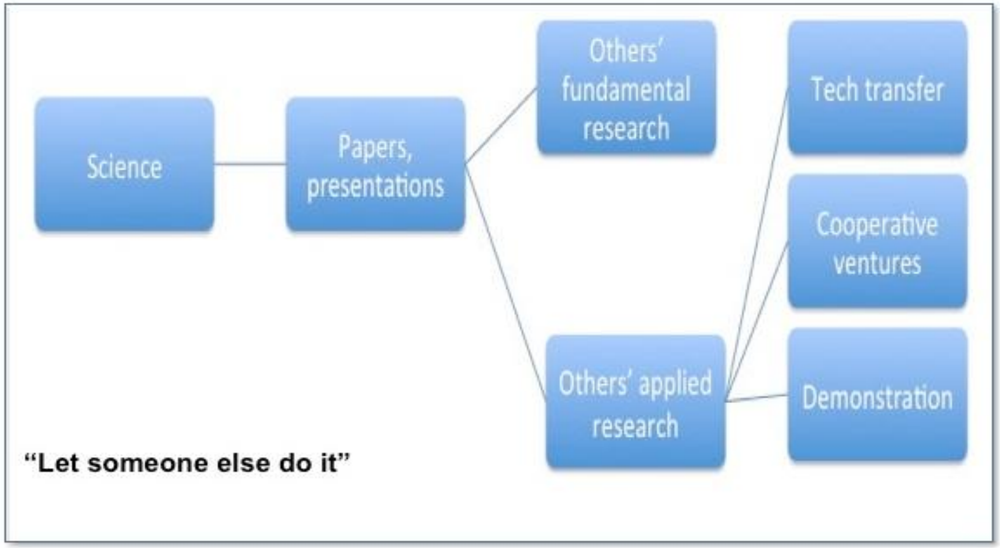
"Let someone else do it"

"Reaching in"

"Trickle down"

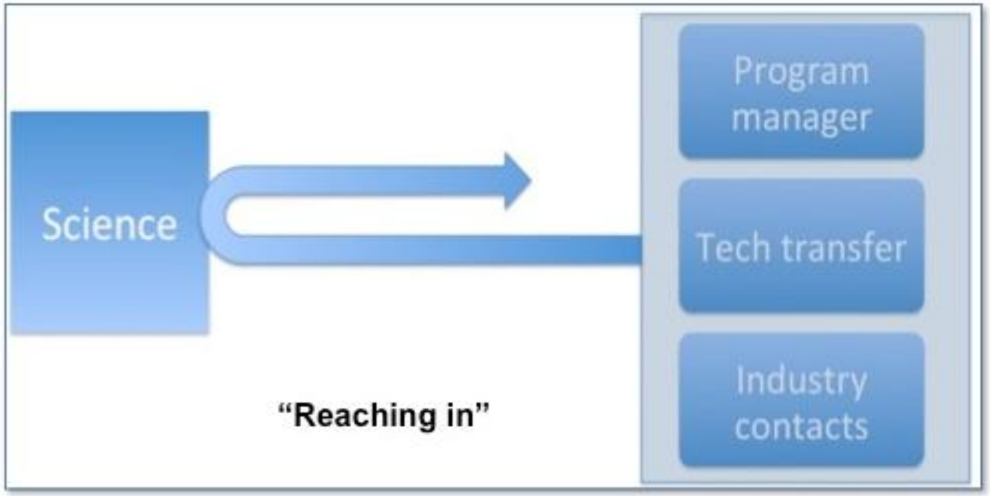
We refer to these means of information transfer as the "invisible handoff."

Most interviewees subscribed to the "Let someone else do it" approach to science and technology transfer



- In this case, upstream scientists publish their work and move on
- All respondents noted that CNMS emphasized high-impact journal publications
- Most respondents indicated that this emphasis matched their personal priorities and those of their home institutions

Many interviewees recognized the "Reaching-in" model

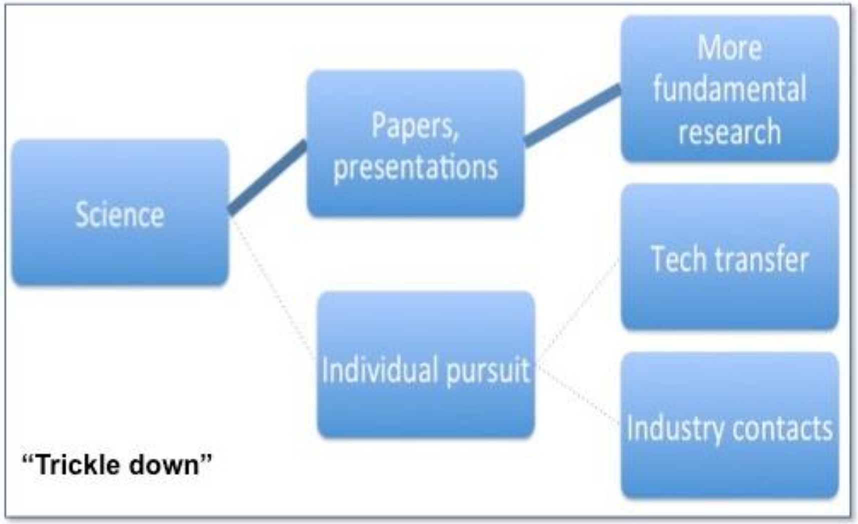


1. Occurs when downstream users take the initiative to seek upstream information
2. Numerous respondents described it as a possible strategy for advancing research toward use

   2a One respondent reported having used this approach successfully

   2b Two respondents reported instances where this approach was tried, but failed

Several interviewees have pursued the "Trickle down" approach



- Occurs when upstream scientists promote the downstream use of their research
- Private-sector CNMS users seem especially likely to adopt this approach of actively pushing their promising findings toward use
- Several other respondents recognized this approach as a possibility, but had not pursued it

To revisit our questions

- What research products are produced?
  - DOE SC produces a research agenda that the Center implements through a call for proposals. Most users find that this call is sufficiently flexible to accommodate their research, given that their research proposals anticipate producing new, basic research that can be published in strong journals.
- Who will carry out the research?
  - The Center has a small dedicated staff and also supports research by other ORNL staff. Outside users number about 400 annually and are typically post docs, students and university faculty. DOE's nanoscale science research centers differ from past user centers, which one interviewee described as "commodity centers" that produce "beams" and other non-unique outputs. In contrast, the CNMS requires a specialized technical staff who often serve as co-investigators with outside users.
- What are the research endpoints?
  - Publications are the metric, and most researchers view publication as their endpoint. Applied work is generally not rewarded and may be discouraged.

Questions, cont.

- In addition to the research community, who will ultimately use the research?
  - Many interviewees did not know and assumed that interested parties would find their work. Some who were familiar with downstream transfer of knowledge and took personal responsibility to help their research find use. In other cases, knowledgeable downstream players sought out results important to their work.

Implications of findings

- In creating the CNMS and its other NSRCs, DOE SC has chosen to create a different type of user center. This type of center possesses resources that are costly, unique and essential to creating the science of the future, but they are also possessed of a level of sophistication that places new demands on the host institution. In particular, CNMS staff often help users to carry out research using equipment and techniques that would be impractical for an outside user to master and in doing so become partners in research. ***This working arrangement may further buttress the many relationships that have already developed between DOE's national laboratories and the academic community and offers new opportunities to both types of organization. It may also better train students who do not choose traditional academic careers.***

Implications cont.

- The initial assignment for the NSRC program was to advance the state of knowledge in basic physical science. DOE SC sometimes describes this assignment as fundamental research that is “use-inspired” or “mission-driven.” Some interviewees discussed use-inspired as a recognition of the power of pure science to find ultimate use in unanticipated downstream applications. Others stated that the NSRC program might undertake more focused mission-driven enquiry in the future. When the National Nanotechnology Initiative was first undertaken, significant emphasis on engineering and application activities was included and continues***. However, throughout the National Nanotechnology Initiative the DOE NSRC program has maintained a focus on basic science. This focus contrasts with a second DOE program, the Bioenergy Research Center (BRC) program, which was directed at both science, technology and application from its outset, to support the development of a lignocellulosic ethanol program. The lessons from the BRC program may prove useful for the NSRC program if, in the future, it adopts an application orientation.***

Implications, cont.

- The choice to create a mission endpoint that relies on journal publications as a means of measuring productivity falls well within the fundamental science tradition and, based on our interviews, is consistent with the goals of most Center users. Nevertheless, it is only one means of *communicating* the science produced by the CNMS. Other means of indirect communication include interactions at professional meetings, the participation of professors, students and post docs at the Center, and the extensive communication network associated with the internet and related vehicles. Direct means include trickle down, reaching in, and letting someone else do it. We characterize these means of communication as invisible, because they take place through a variety of decentralized mechanisms that are difficult to observe and are equally to measure. Based on our interviews and our related research, we believe that distinctions between basic and applied research will continue to diminish for many areas of nanoscience, much as with the scanning probe microscope, a process sometimes described as converging sciences. We believe the research partnerships that we described will support this convergence. ***Creating institutions that can take into account the reaches of fundamental research and the communication of knowledge not fully captured by publications may both promote science communication and provide a better means to measure scientific progress in its diverse forms.***

The gang

- Maria
- Amy
- Barry
- Dave