

NSF's MRSEC Program *Looking Back, Moving Forward*

*Final Report of the National Academies
MRSEC Impact Assessment Committee*

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Genesis

- In late 2004, NSF approached the National Academies about conducting a “10-year assessment” of the Materials Research Science and Engineering Centers (MRSEC) program
 - Consultation among Physics, Materials, and Chemistry boards yielded a successful proposal for an “impact assessment”
 - First meeting was in November 2005
- **The committee was tasked as follows**
 - Assess the performance and impact of the National Science Foundation's Materials Research Science and Engineering Centers (MRSEC) program;
 - On the basis of current trends and needs in materials and condensed matter research, recommend future directions and roles for the program.

Committee membership

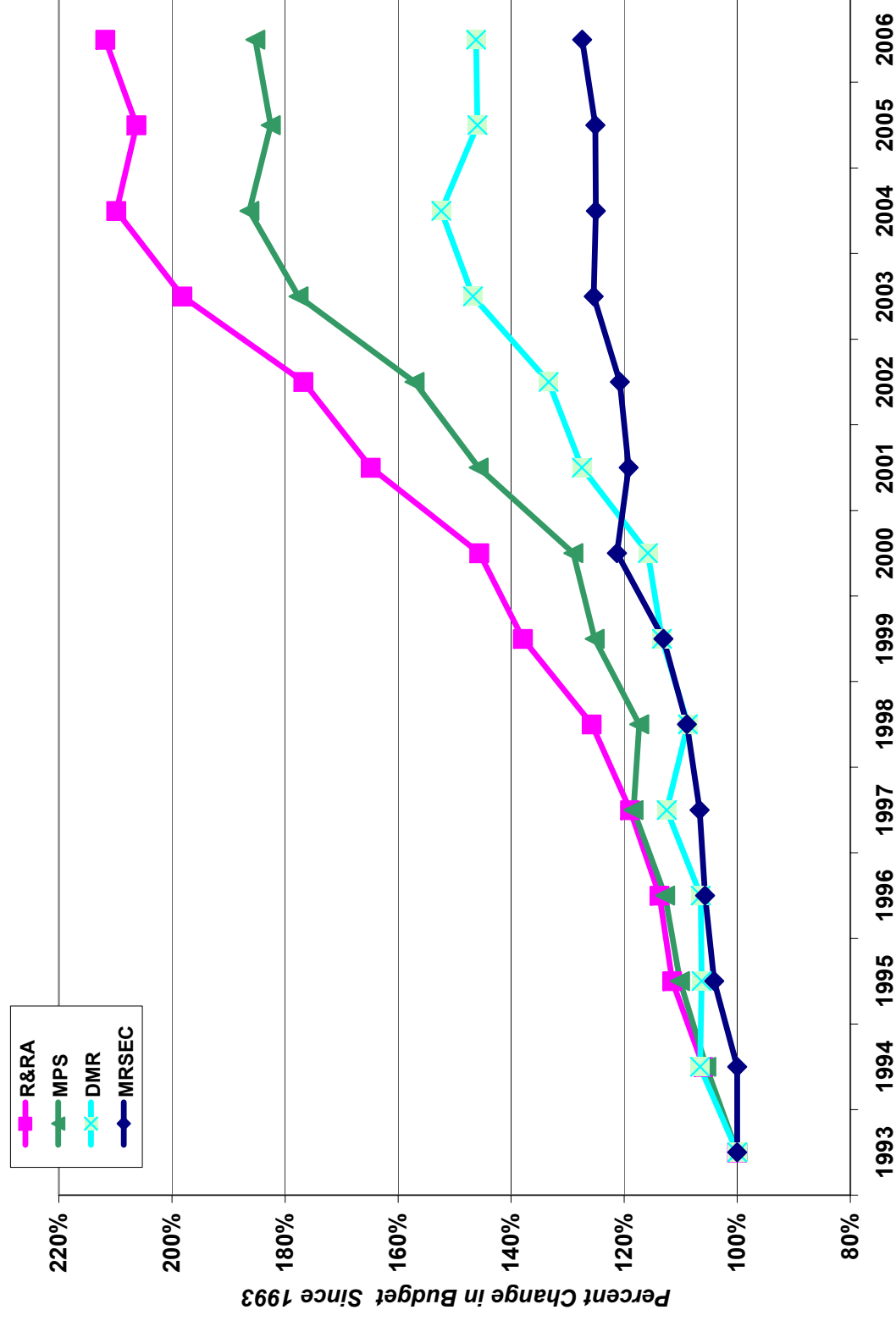
- A committee with broad membership was sought in order to critically examine the scientific stakes
 - Experts from materials science, engineering, physics, chemistry, and biology, were sought
 - Several experts familiar with other areas of centers-based research were included as well
 - The committee was also balanced with respect to “MRSEC experience” and also included experts from “big” and “small” industry

<i>Matthew Tirrell, UC Santa Barbara</i>	Bruce Margon, Space Telescope Science Inst (now UCSC)
Kristi Anseth, Colorado	Andrew Millis, Columbia
Meigan Aronson, Michigan (now BNL)	Venky Narayanamurti, Harvard
David Ceperley, Illinois	Ralph Nuzzo, Illinois
Paul Chaikin, New York	Doug Osheroff, Stanford
Ron Davidson, Princeton	Stuart Parkin, IBM
Duane Dimos, Sandia	Neil Paton, LiquidMetal Technologies
Frank DiSalvo, Cornell	Diandra Leslie-Pelecky, Nebraska
Edith Flanigen, UOP (retired)	Julia Phillips, Sandia
Lyle Schwartz, AFOSR (retired)	Eli Yablonovitch, UCLA (now UCB)
Tom Kuech, Wisconsin	

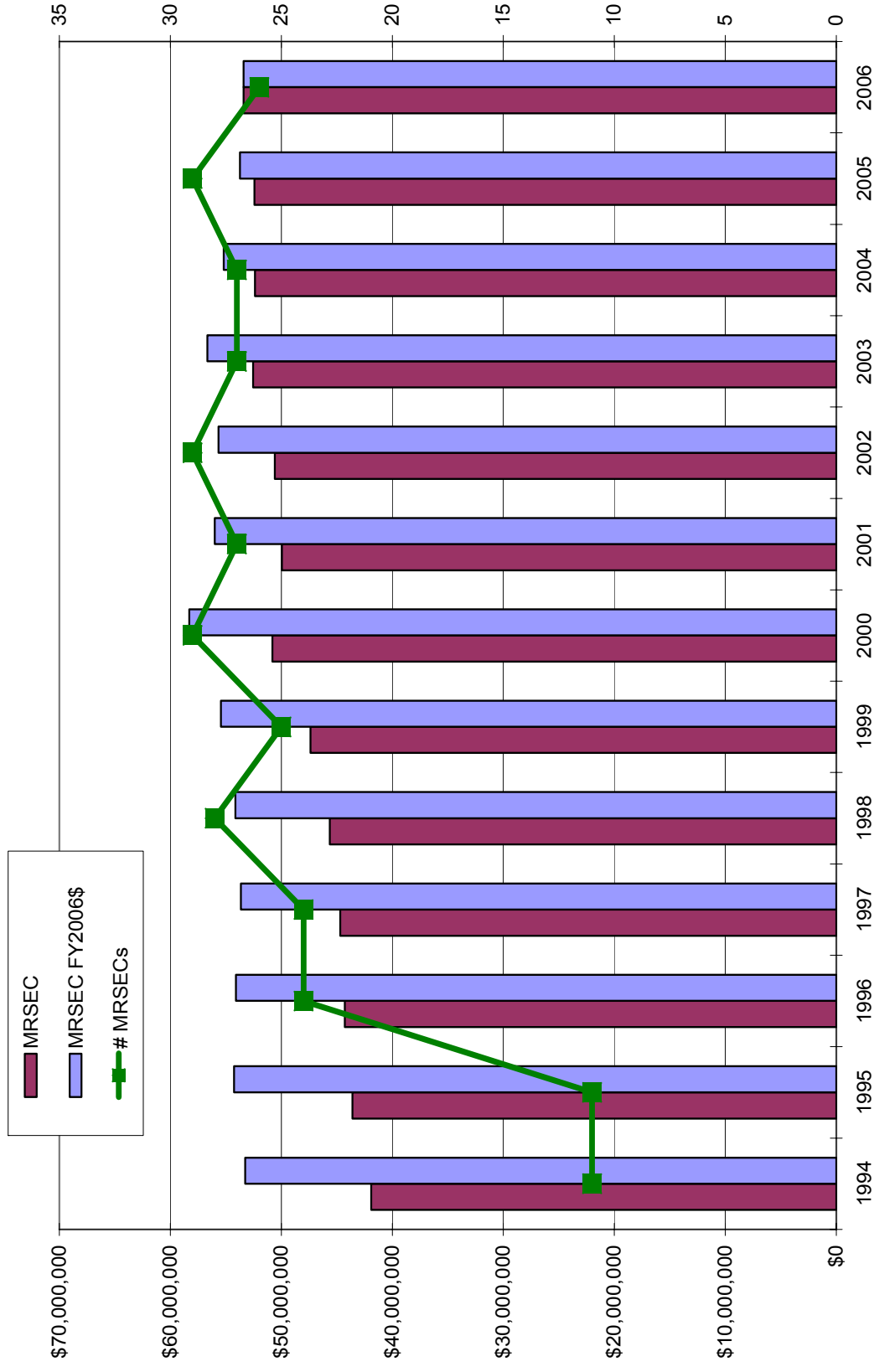
Historical context

- MRSECs are the latest step in a long evolutionary line
- Interdisciplinary Laboratories were created in 1960 by the Advanced Research Projects Agency
- These laboratories became the Materials Research Laboratories (MRLs) under NSF's DMR in 1971 as part of the Mansfield amendment
- MRLs were supplemented by Materials Research Groups in the 1980s
- In 1994, the program was re-organized into the present Materials Research Science and Engineering Centers program
- From an initial dozen or so centers, the program now supports 27 centers with 6-year awards renewable through open competition

Budget context (1)



Budget context (2)



Impact Assessment

Methodology (1)

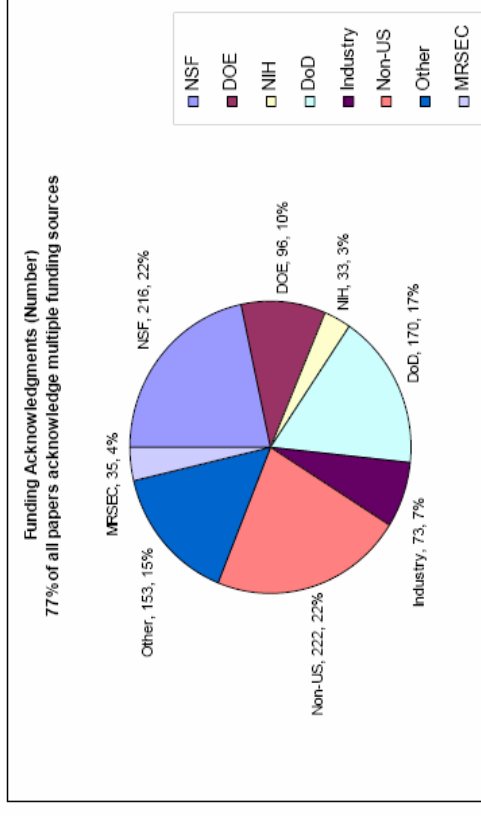
- The committee sought for a quantitative, objective assessment of the relative impact of MRSEC-supported activities in comparison to other mechanisms for support
- Several key impact areas were identified
 - Research and shared facilities
 - Education and outreach
 - Industrial collaborations and interactions

Methodology (2)

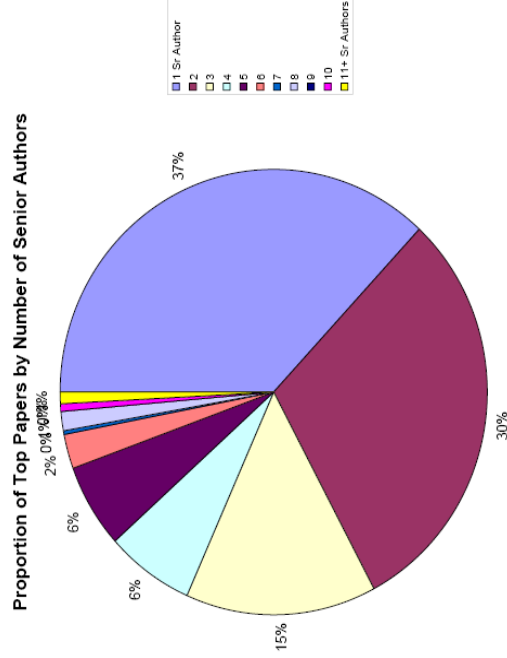
- Principal challenge was in constructing an algorithm for distinguishing the MRSEC-enabled results from any others
 - MRSEC participants are supported by many funding sources
 - MRSEC participants engage in multiple activities with multiple collaborators
- The committee explored several options, cognizant of a previous 1978 Mitre Corp report on the MRLs
- The committee also recognized that
 - Average performance often does not capture the full impact of a portfolio of efforts
 - MRSECs are intended to enhance the conditions for *conceiving* of research and education activities and yet most impact measures examine the results from the *execution* of these activities
- In the committee's judgment, the competitive selection process for MRSEC awards unavoidably emphasizes the pre-existing strength of the institutional research effort. While a MRSEC may enhance an institution's materials research programs, it cannot bring them into being.

Research (1)

- Consistent with previous analyses, the committee found no simple, quantitative, objective measure to clearly differentiate the MRSEC research product from that of other mechanisms supporting materials science and engineering research.



- Sponsors of research are increasingly unable to claim “sole ownership” of research results; MRSECs are no exception.
- Most highly-cited publications contain one or two senior authors, indicating that the size of research collaboration is usually small.



Research (2)

- Overall, the MRSEC program produces excellent, frontier science of the same high standard as that supported by NSF through other mechanisms. The quality of MRSEC research is at least on a par with other multi-PI programs and with individual grants in the United States and internationally, and is an important element of the overall mix for support of materials research, including big centers and single-investigator grants.

- The outstanding discoveries, leading research groups and most significant publications worldwide are associated with universities at which there are MRSECs.
- MRSECs are involved in the most active areas of materials research as established by their publication records compared with those of the entire field.
- The MRSEC program has the same level of research collaboration as found in comparable national and international groups.

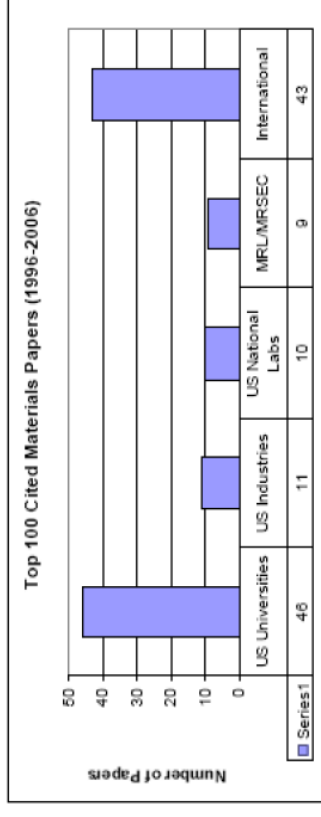
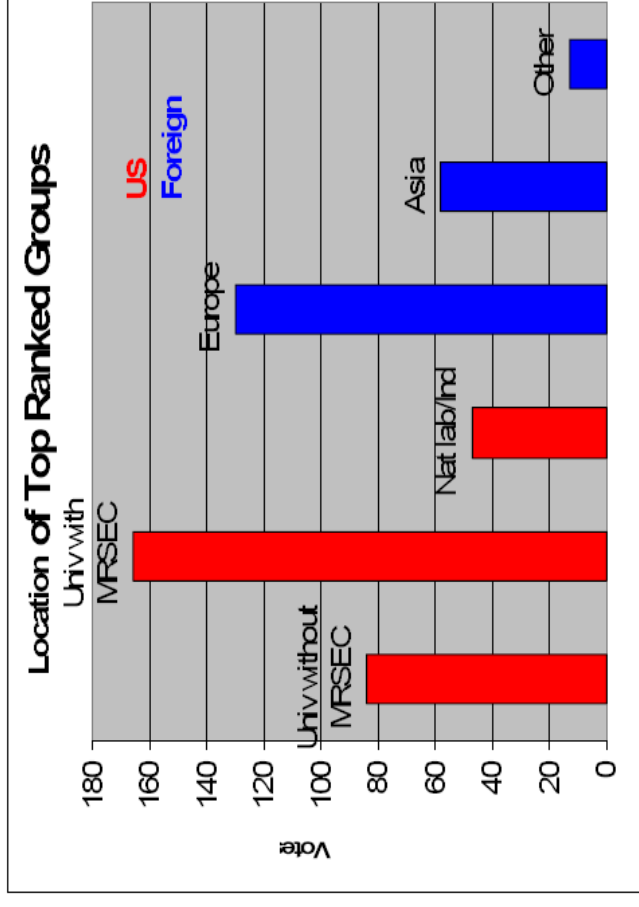
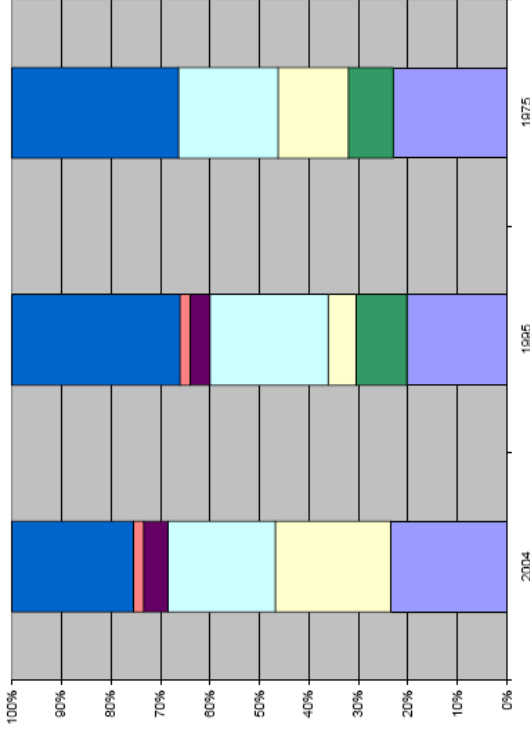


Figure 3.5. Analysis of the affiliations reported for the overall top 100 most highly cited papers in materials research since 1996.



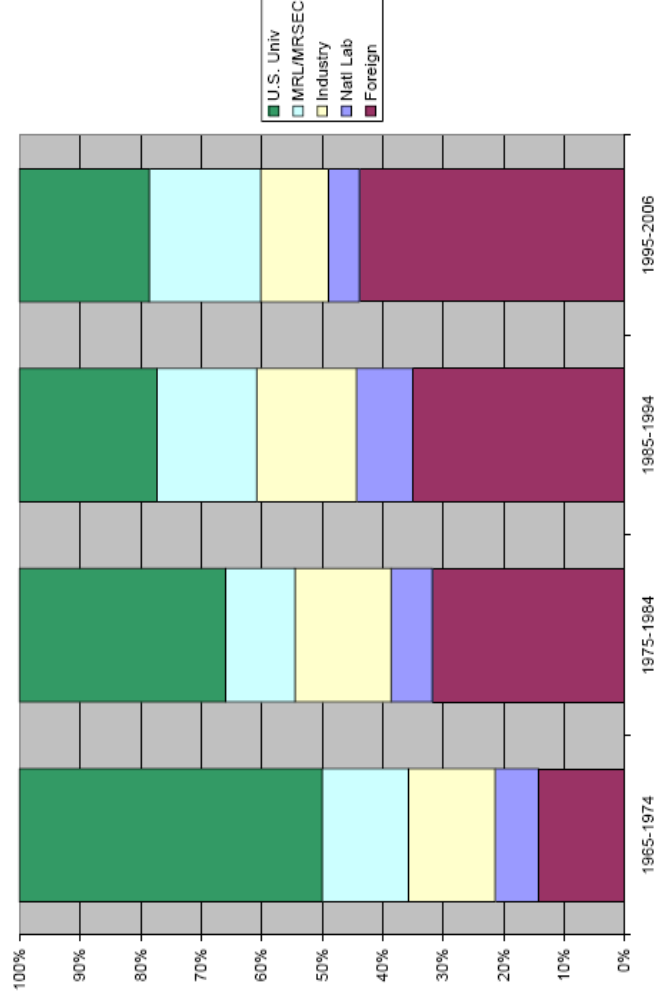


Research (3)

- Trends in national & institutional affiliations of top 100 materials papers over time shows that MRL/MRSEC holding strong while U.S. univs lose ground to foreign competition

- Trends in departmental affiliations of MRL/MRSEC participants show steady contributions with more “other” and more biology

Affiliations of Lead Authors of Top 100 Materials Research Cites by Decade



Education and Outreach (EO)

- The MRSEC EO program has impacts on the NSF mission to educate and prepare the nation's future workforce.
 - The most significant and well-documented contribution of MRSEC EO programs is the preparation of future researchers at all levels.
- Although the impression of the committee is that most MRSECs are doing good-to-excellent jobs with their EO programs, and that many of these programs have significant impact on their audiences, the lack of data to support these assertions poses a serious problem for NSF as it seeks to make the most efficient use of its resources.
- The future impact of MRSEC EO activities is threatened. The continued lack of specificity in EO expectations at the agency level has led to an emphasis on quantity over quality and innovation over impact.
- Most MRSECs feel compelled to participate in many different activities. This approach often does not make optimal use of the MRSEC's strengths, dilutes their potential impact and, in fact, the likelihood of determining what that impact is.

Industrial collaborations

- The program goals for MRSEC industrial collaborations are appropriate. A flexible approach to meeting those goals is essential to address the needs and capabilities of the individual MRSECs.
- The MRSEC program requirement for industrial collaboration leads to important activities that likely would not occur otherwise (e.g., workshops, short courses, external advisory boards with industrial advisors).
- MRSECs have developed industrially relevant programs while maintaining a commitment to solving long-term research problems.
- MRSEC industrial collaboration efforts are generally supported by multiple sources, in addition to MRSEC funds, such as funds from industrial partners themselves.
- The importance given industrial collaboration and technology transfer in the review process is seen as not being commensurate with the importance of this program goal.

Going forward

Perceived and measured impact

- MRSEC center awards continue to be in great demand. The intense competition within the community for them indicates a strong perceived value. These motivations include:
 - The ability to pursue interdisciplinary, collaborative research;
 - The resources to provide an interdisciplinary training experience for the future scientific and technical workforce from undergraduate to postdoctoral researchers;
 - Block funding at levels that enables more rapid response to new ideas, and supports higher risk projects, than is possible from single investigator grants;
 - The leverage and motivation MRSECs provide in producing increased institutional, local and/or state support for materials research;
 - The perceived distinction that the presence of a MRSEC gives to the materials research enterprise of an institution, thus attracting more quality students and junior faculty;
 - The infrastructure MRSECs can provide to organize and manage facilities and educational and industrial outreach.
- The committee examined the performance and impact of the past decade of MRSEC activities in the areas of research, facilities, education and outreach, and industrial collaboration and technology transfer. The MRSEC program has had important impacts of the same high standard of quality as those of other multi-investigator or individual-investigator programs. Although the committee was largely unable to attribute observed impacts uniquely to the MRSEC program, MRSECs generally mobilize efforts that would not have occurred otherwise.

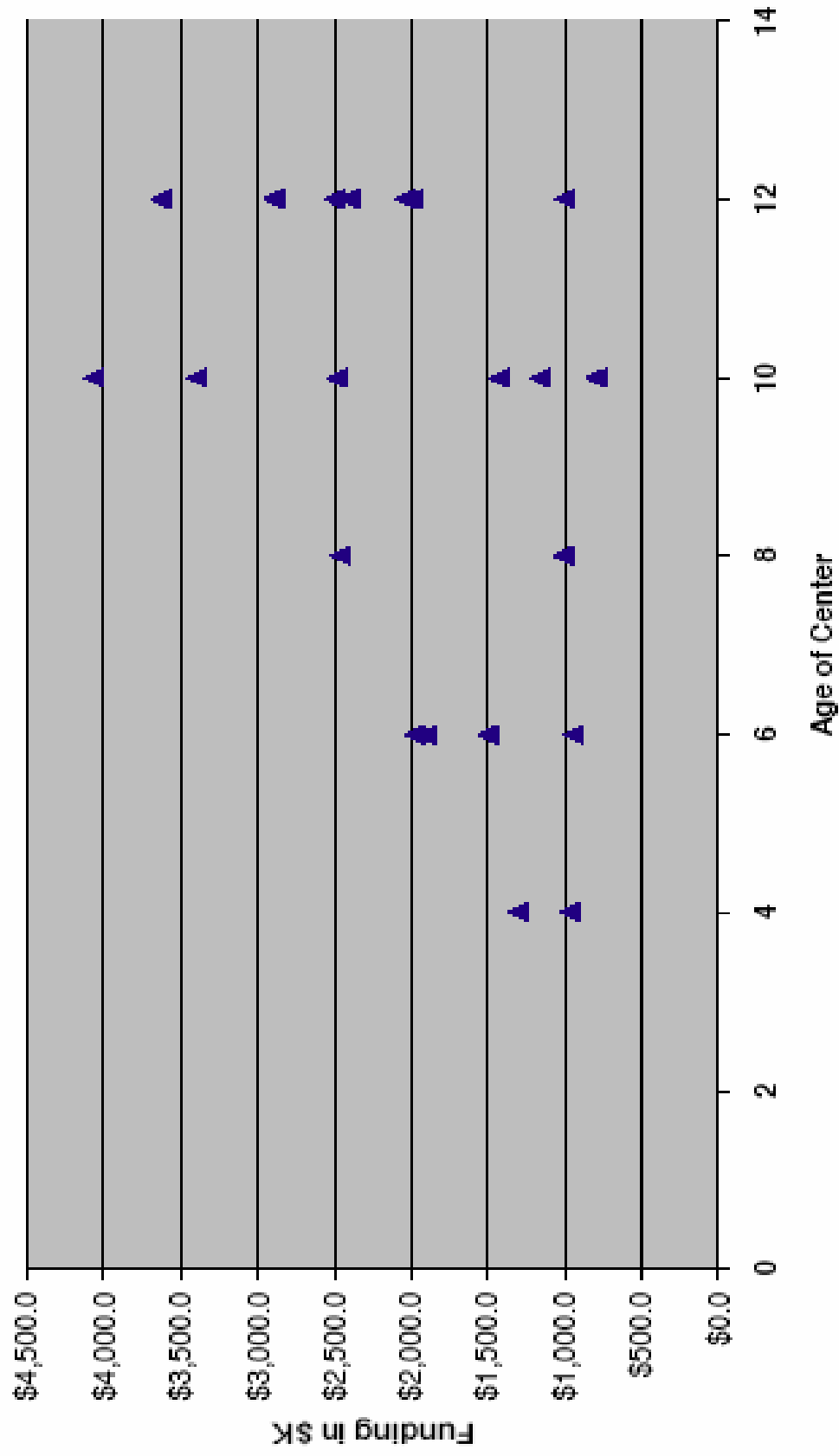
A new look (1)

- MRSECs arose from the combination of MRLs and MRGs in the 1990s
 - Perceived need to encourage collaborative, multidisciplinary research in a friendly environment with access to shared resources
- Circumstances, research, and community have evolved
 - MRSECs are torn between serving as community and campus service centers and serving as small teams of highly skilled, agile researchers
- The MRSEC program must evolve in order to successfully meet its objectives in the coming decade. To do so, the National Science Foundation must restructure the program to reduce requirements, reduce the number of MRSEC awards, and/or increase the total funding of the MRSEC program while preserving its positive elements.

A new look (2)

- To respond to changes in the budgetary landscape and changes in the nature of materials research in the coming decade, NSF should restructure the MRSEC program to allow more efficient use and leveraging of resources. The new program should fully invest in centers of excellence as well as in stand-alone teams of researchers.
 - MCE Centers would focus on the infrastructure tasks of pooling resources, instrumentation, and educational opportunities
 - MRG Groups would compete directly with each other to tackle the most compelling research problems
 - 5-6 year awards and the group-to-group formal competition are important distinctions compared to the current focused research group (FRG) program
- The committee offers one vision for restructuring that starts from a revenue-neutral transition but allows room for growth.

Total Funding vs. Age of Center



A new look (3)

	Existing MRSEC	New “MCE”	New “MRG”
Budget	\$0.7-\$5M	\$3M-\$5M/yr	\$0.5M-\$1.0M
Equipment	\$0-\$1M	\$1M + yearly operating costs	\$0.1M-\$0.2M equipment
Review Cycle	5 year+ 1 year	5 year+1 year	4 year + 1 year
Number of awards	28 total	10-12 total	45-50 total
#Awards/cycle	12 renew/2 (last cycle)		15/competition
Proposal Evaluation	Preliminary Proposal and RSV	Preliminary Proposal and RSV	Panel selection – no reverse site visits (RSV)
Theme	Unifying theme sort of	Unifying theme or facilities	Single theme
Multi-institutional	Mostly single campus	Maybe multi campus	Many would be multi campus to take advantage of expertise
Educational outreach (EO), industrial outreach (IO)	EO/IO required	REU required. IO required. Can compete for independent EO and/or IO supplements of up to \$1M. See Chapters 4 and 5.	None required
Management	Director	Director	PI

Bottom line

- MRSECs are productive, crucial elements of our materials research portfolio.
- The unique funding mechanism supporting their work brings diversity and robustness to the materials research enterprise.
- Attributing impacts uniquely to the MRSEC program is difficult in the modern era of multiple funding sources and multiple projects per PI.
- Budget constraints and the changing landscape of the research drive the committee to propose a reorganization of the program that capitalizes on the stability of consolidated centers and the nimbleness of small teams.