Research Priorities of the Supporting Industries Program

Linking Industrial R&D Needs

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SUMMARY

The U.S. Department of Energy Industrial Technologies (DOE/IT) program (formerly the Office of Industrial Technologies [OIT]) supports technology partnerships with energy-intensive industries interested in developing and adopting new technologies with the goal of improving industrial energy efficiency. To achieve this goal, DOE/IT has undertaken the Industries of the Future (IOF) initiative, through which industry-government teams develop vision statements and technical roadmaps that identify performance targets and research needs to achieve industry goals.[1] Nine industries—agriculture, aluminum, chemicals, forest products, glass, metal casting, mining, petroleum, and steel—are included in the IOF initiative.

In a previous study conducted for the DOE/IT Industrial Materials for the Future (IMF) program (Silberglitt and Mitchell, 2001), RAND reviewed every IOF technical roadmap and constructed matrices that link research projects funded by the DOE to the performance targets and research needs described in the roadmaps.[2] The RAND Corporation then used those matrices to identify the IOF industries' high-priority materials research needs and the IMF program's research and development (R&D) priorities that are aimed at meeting those needs.

This documented briefing describes the results of a subsequent RAND study, conducted for the DOE/IT Supporting Industries (SI) program.[3] This study supplements the earlier IMF study data on performance targets, research needs, and research projects for five Supporting Industries—advanced ceramics, forging, heat treating, powder metallurgy and particulate materials (PM^2), and welding and joining. This study was done to identify materials and materials processing research priorities for the SI program and to identify links between the SI program and other DOE/IT programs (the various types of links are defined later in this summary). These links serve to illustrate the research needs and

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[1]Through these "vision statements" and "roadmaps," IOF participants set goals for the future, determine technology priorities, and assess the progress of research and development in their industries. The statements and roadmaps are available at http://www.oit.doe.gov/industries.shtml (click on any of the nine industries listed under "Industries of the Future," and then click on "Vision and Roadmaps" on the industry page).

[2]Readers may wish to review Silberglitt and Mitchell (2001) for background on the multiple-industry research priorities approach.

[3]Supporting industries are those that provide enabling materials or processes for the IOF industries (e.g., ceramic materials, powder metals, or particulate materials used in IOF process equipment, heat treating, forging, or welding and joining). The SI industries play a key role in helping the IOF industries to reduce their energy use and increase their efficient use of energy.

challenges that the DOE/IT programs have in common. They also define those areas in which DOE/IT programs can leverage their funds by working together and the overarching research needs and basic research areas that are critical to achieving the goals of more than one industry.

DATABASE ON MULTIPLE-INDUSTRY RESEARCH NEEDS, CATEGORIES, PROJECTS, AND RESEARCH AREAS

To define the links between the SI program and other DOE/IT programs, RAND integrated information on performance targets, research needs, and research projects from the matrices in Silberglitt and Mitchell (2001) into a database, which in turn facilitated the creation of four entities discussed in this briefing:

- Multiple-Industry Research Needs (MIR*N*s): R&D needs that appear in more than one industry roadmap.

- MIR*N* Categories: Groups of related R&D needs that appear in different industry roadmaps. They are useful because they enable the examination of a whole set of needs for all industries in closely related areas of research.

- Multiple-Industry Research Projects (MIR*P*s): Projects that fulfill R&D needs in more than one industry roadmap.

- Multiple-Industry Research Areas (MIR*A*s): Underpinning[4] research areas that include MIRNs across multiple MIRN Categories.

This database contains all of the R&D needs and performance targets from the nine IOF industry roadmaps discussed in Silberglitt and Mitchell (2001)—i.e., all of the needs identified by the roadmap teams as being high priority (except in the case of the steel industry, for which the team did not identify priorities). As such, all of the steel materials-related needs are included in the database.

For this study, we added all of the R&D needs and performance targets from the five SI roadmaps to the database, resulting in 887 R&D needs and 133 performance targets.

The database also contains all of the DOE-funded projects (the matrix elements in Silberglitt and Mitchell [2001])[5] from sources referenced in that study[6] that address at

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[4]We describe MIRAs as "underpinnings" in this briefing because advances in those areas address basic needs that are common to multiple industries.

[5]For the Silberglitt and Mitchell study, a matrix with rows and columns consisting of performance targets and high-priority materials R&D needs, and matrix elements consisting of DOE research projects that address those targets and needs, was built for each of the nine IOFs. The matrices were used to identify multiple-industry research needs, projects that address those needs, and needs not currently addressed by projects.

least one of those R&D needs or performance targets. In addition, we included a group of priority projects recently proposed by the PM^2 industry roadmap team (*PM^2 Roadmap Collaboration Workshop,* 2003), leading to a total of 309 research projects.

Finally, we grouped similar R&D needs into categories and found that all the needs could be assigned to one or more of 25 MIRN Categories and that the following 14 MIRN Categories include research needs found in more than half of the 14 industry roadmaps:

- Databases and Properties (13 industry roadmaps)
- Standards Product Quality and Testing (13 industry roadmaps)
- Corrosion-, Erosion-, and Wear-Resistant Materials (12 industry roadmaps)
- Modeling and Simulation (12 industry roadmaps)
- Process Design and Improvement (12 industry roadmaps)
- Waste and Byproduct Treatment, Recycling, and Use (12 industry roadmaps)
- High-Temperature Materials and Refractories (11 industry roadmaps)
- Sensors and Sensor Materials (11 industry roadmaps)
- Design Tools (10 industry roadmaps)
- Process Monitoring and Control (9 industry roadmaps)
- Raw Materials (9 industry roadmaps)
- Coatings (8 industry roadmaps)
- Joining and Welding (8 industry roadmaps)
- Surfaces and Interfaces (8 industry roadmaps).

These MIRN Categories provide a good starting point to identify common research needs across industries that can be addressed through joint workshops, solicitations (i.e., requests for proposals for research projects), partnerships, and other coordinated activities between the DOE/IT programs and the industries they represent.

DATABASE ANALYSIS

Our analysis showed that the MIRN Categories, with one exception, include R&D needs from more than half of the five SI industries (i.e., at least three industries) *and* from more than half of the nine IOF industries (i.e., at least five industries). This illustrates the strong connection between the SI and IOF industries via the SI industries' role of providing materials and materials processing to create products and product components that reduce energy use and environmental impact and increase the productivity of the IOF industries. Moreover, within several multiple-industry research areas, two or more MIRN

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[6]Those sources included Energy Materials Coordinating Committee (fiscal year 1999), Materials Sciences Program (1998), and project descriptions listed on the OIT Web site.

Categories have a significant number of R&D needs in common. These links between MIRN Categories provide another indication of common research needs and can be used to identify the multiple-industry research areas.

Our analysis also showed that research projects funded or proposed by the SI program, in addition to those funded by the IMF program, typically address multiple research needs that are common to more than one industry roadmap and that fall into multiple MIRN Categories. By contrast, the projects funded by the IOF industry teams typically address a single research need that falls into a single MIRN Category. In fact, most of the SI and IMF projects are multiple-industry research projects that address multiple-industry research needs. A project that addresses the needs of multiple industries and that crosses the boundaries of multiple research areas is usually found within one of the underpinning MIRAs.

PROJECT LINKS AMONG SUPPORTING INDUSTRIES

Figure S.1[7] illustrates an example of how SI projects, industries with specific needs, and the MIRN Categories addressed by those projects are linked. The industries shown in the
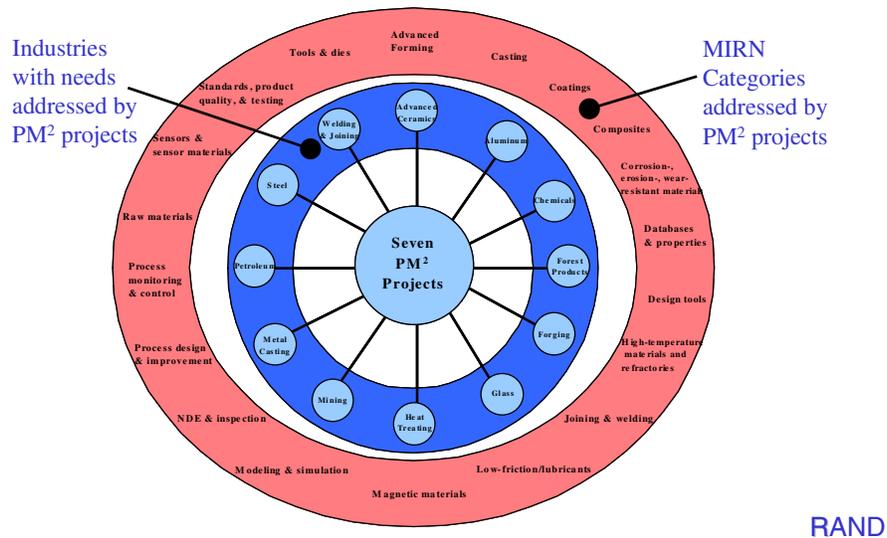

Figure S.1—How SI Projects Serve to Link Multiple Industries and MIRN Categories

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[7]Readers wishing to see the figures in this briefing in greater detail may view them in the DB420slides.pdf file on the accompanying CD. The zoom tool may be used to increase the view size of the figures.

inner ring in the figure all have R&D needs addressed by one or more of seven priority projects proposed by the PM^2 industry roadmap team to meet PM^2 roadmap needs. The MIRN Categories shown in the outer ring are addressed by one or more of these same projects.

THE DATABASE NAVIGATOR

RAND developed a Microsoft PowerPoint presentation as a navigational tool to facilitate browsing through the database. This tool, which we call the "Database Navigator," or simply the "navigator," can be found on this document's accompanying CD. The database, which is in Microsoft Access format, is also included on the CD. The navigator, which is in HTML, is organized by MIRN Category pages, such as the example page for the MIRN Category "Adhesives" shown in Figure S.2.

The boxes on the right side of Figure S.2 list the three industries that have R&D needs within this MIRN Category. Each box links to a page that shows the R&D needs for that industry that fall within this MIRN Category.

The arrows on the left side of the figure illustrate the links to information on *other* MIRN Categories that apply to each industry. The width of the arrows denotes the number of industries the link encompasses. In this example, there are links for this MIRN Category to the Joining and Welding and to the Corrosion-, Erosion-, and Wear-Resistant Materials
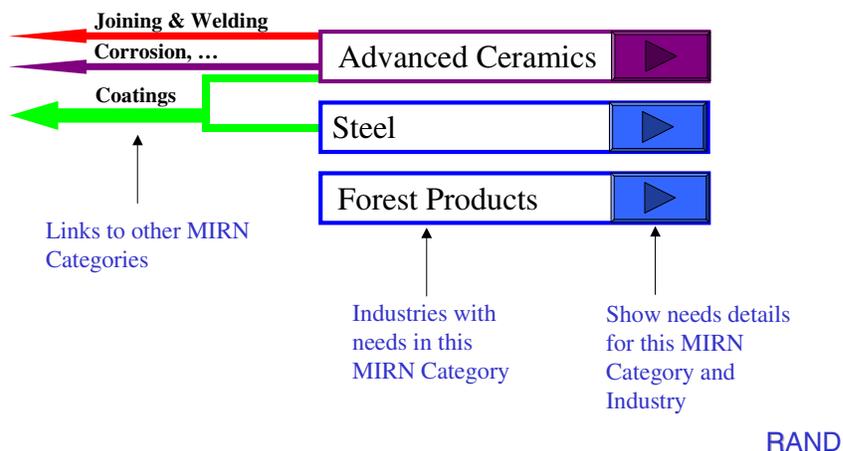

Figure S.2—Example Database Navigator Page for the MIRN Category "Adhesives"

MIRN Categories via R&D needs from the Advanced Ceramics industry roadmap. There are also links to the Coatings MIRN Category via R&D needs from the Advanced Ceramics and Steel roadmaps. The fact that no arrows emanate from the Forest Products box shows that although there are Adhesives R&D needs in the Forest Products roadmap, none of them fall into any other MIRN Category.

The pages with the needs details that are linked to this MIRN Category page by the arrows on the right side of the figure also link to additional pages that show all of the project information for all projects that address R&D needs in this MIRN Category for all industry roadmaps. Thus, the navigator can be used to browse through all industries and all MIRN Categories to identify research needs and research projects common to multiple industries.

IDENTIFYING MULTIPLE-INDUSTRY RESEARCH AREAS THROUGH LINKS ACROSS MULTIPLE-INDUSTRY RESEARCH NEEDS CATEGORIES

RAND used the navigator to analyze MIRN Category links across the 25 MIRN Categories, the five Supporting Industries, and the nine Industries of the Future. Browsing by MIRN Category showed consistent links among the Coatings; Corrosion-, Erosion-, and Wear-Resistant Materials; High-Temperature Materials and Refractories; and Tools and Dies MIRN Categories through the Advanced Ceramics, Forging, PM^2, Chemicals, Glass, Metal Casting, Petroleum, and Steel industries. We then concluded that the three SIs and five IOFs have strong overlapping research needs in coatings for resistance to severe environments.

Browsing by MIRN Category also identified links involving all five SIs and all IOFs, except Agriculture, between the Databases and Properties and Modeling and Simulation MIRN Categories. These MIRN Categories were further linked to Design Tools, Process Design and Improvement, Standards, Product Quality, and Testing, as well as to the Coatings-based MIRN Categories.

Finally, the navigator showed that Joining and Welding (which is both a MIRN Category and a Supporting Industry) is linked to 20 of the 24 other MIRN Categories through the Advanced Ceramics, PM^2, Aluminum, Chemicals, Forest Products, Metal Casting, and Steel industries. These common research needs represent opportunities for joint efforts between industries to maximize the impact of their R&D funds.

The MIRN Category links analysis also pointed the way toward the MIRAs that serve to underpin these common research areas. For example, the development and application of improved coatings for severe environments depend upon progress in the understanding and control of surface and interface properties of materials that have the ability to withstand these environments, e.g., materials such as ceramics for new refractories or metal alloys tailored for high-temperature oxidation or corrosion resistance. In addition, the design of materials for industrial process environments requires materials-property

databases and models that represent those environments with sufficient precision and reproducibility. Progress in solving the joining and welding problems identified in both SI and IOF roadmaps depends upon both of these MIRAs, i.e., understanding and controlling surfaces and interfaces, as well as accurate materials property databases and models.

CONCLUSIONS AND RECOMMENDATIONS

Our analysis of the SI and IOF roadmaps, and the DOE projects that address the R&D needs and performance targets described in these roadmaps, produced the following conclusions and recommendations.

Conclusions

- The R&D needs of the SI and IOF roadmaps are strongly linked through multiple common MIRN Categories.
- Most SI research projects address research needs in multiple industries, and are therefore MIRPs.
- The same MIRAs serve to underpin the achievement of both SI and IOF R&D needs.

Recommendations

- The DOE/Industrial Technologies programs should sponsor and participate in workshops that include multiple-industry teams and that cross the boundaries of multiple research areas. These "cross-cutting" workshops would differ in both participation and content from the roadmap workshops that these programs normally sponsor. Participants should include members of all industry teams with relevant R&D needs, plus guest speakers who are knowledgeable about ongoing and prospective research projects that could address those needs. The format should allow for industry presentations on their R&D needs, detailed technical presentations at the project level, and discussions between researchers and end users of the research, leading to the identification of priority research projects. The first of these workshops could address the common research areas: coatings for resistance to severe environments, databases and models for process design and quality control/standards, and joining and welding. The participating industries should at least be those that have roadmapped needs within the linked MIRN Categories that relate to these research areas, but invitations could also be extended to participants from other industries. Subsequent workshops would address other MIRAs, and the relevant industrial and research personnel for those areas and industries would be invited.

- The DOE/IT programs should coordinate their solicitations (i.e., requests for proposals) to allow for joint research projects, where appropriate, that would address common R&D needs. The workshops discussed in the previous paragraph could identify such opportunities. The multiple-industry research areas that serve to underpin the common research areas, and in which the needs of multiple industries cross the boundaries of multiple research areas, are another source of joint solicitation and joint research project opportunities.

- The DOE/IT staff should use the database RAND developed for this study to facilitate further discussion of links between DOE/IT programs. This dialogue could be initiated through discussions of MIRN and MIRN Category links and the relevant MIRPs by the program staff responsible for the industries that have the roadmapped needs being addressed and/or that are conducting projects addressing those needs. These discussions should be aimed at identifying common research needs and identifying underlying research problems that, if solved, would allow industries to meet those needs. Joint projects could then be funded to address those problems, after which each team would then separately fund projects aimed at their industry-specific needs. Through regular updating of the roadmaps and database, this process will continue to provide the means to identify and address research needs that industries have in common and opportunities for joint projects within common research areas.