HIGH PERFORMANCE ALLOY TECHNOLOGY TO MARKET SUPPORT

MICHAEL VERTI, CORINNE CHARLTON, LAUREL COOPER, AILEEN RICHARDSON

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Michael Verti\textsuperscript{1,2}: Conceptualization; Corinne Charlton\textsuperscript{1,2}: Writing – Original Draft; Laurel Cooper\textsuperscript{1,2}: Investigation; Aileen Richardson\textsuperscript{1,2}: Data Curation Erik Shuster\textsuperscript{2*}: Supervision

\textsuperscript{1} National Energy Technology Laboratory (NETL) support contractor
\textsuperscript{2} NETL
*Corresponding contact: Erik.Shuster@netl.doe.gov, 412.386.4104

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## Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>DOE</td>
<td>Department of Energy</td>
</tr>
<tr>
<td>GTM</td>
<td>Go-to-Market</td>
</tr>
<tr>
<td>HPM</td>
<td>High Performance Materials</td>
</tr>
<tr>
<td>MATI</td>
<td>Market Applicability Technology Integration</td>
</tr>
<tr>
<td>NETL</td>
<td>National Energy Technology Laboratory</td>
</tr>
<tr>
<td>OEM</td>
<td>Original equipment manufacturer</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and development</td>
</tr>
<tr>
<td>RIC</td>
<td>Research and Innovation Center</td>
</tr>
<tr>
<td>T2M</td>
<td>Technology-to-Market</td>
</tr>
<tr>
<td>TRL</td>
<td>Technology Readiness Level</td>
</tr>
<tr>
<td>U.S.</td>
<td>United States</td>
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EXECUTIVE SUMMARY

The goal of the Technology to Market Assessment for Advanced Alloys is to identify non-technical support needs of research teams that could accelerate a path toward commercialization. The successful adoption of new technology into the market has positive impacts on direct stakeholders, taxpayers, and is important to showcase the strength of the United States (U.S.) Department of Energy (DOE) National Energy Technology Laboratory (NETL) Crosscutting High Performance Materials program. This assessment leverages a series of proven frameworks developed by NETL innovation specialists to determine which projects within NETL’s Crosscutting Advanced Alloys portfolio are in the best position for commercialization. The projects were then assessed for specific non-technical support needs.

The projects that were deemed high priority through this process were Tasks 5, 7, 8 (assessed as a single project), Task 11 & 12 (assessed as a single project) and Task 16 as seen in the table below.

<table>
<thead>
<tr>
<th>Main Project</th>
<th>Supporting Tasks (Task # and Task Title)</th>
</tr>
</thead>
</table>
| Design and Manufacture Large-Scale Ingots | Task 5 - Simulate and Manufacture Large-Scale Ingots  
Task 7 - 800 C HEA Ni-superalloy Development  
Task 8 - Grain Boundary Engineering & Design Techniques |
| Evaluating Materials for high Temperature High Pressure Applications | Task 11 - Low-Cost Steel for Low-Temperature Recuperators in Direct sCO2 Power Cycles  
Task 12 - Effect of sCO2 Cycle Environment on Mechanical Behavior |
| Design Tool for Creep-Resistant Materials and Low-Cycle Fatigue Modeling | Task 16 - Design Tool for Creep-Resistant Materials and Low Cycle Fatigue Modeling |

Though these projects differ significantly in technology maturity, development goals, and program needs, they invariably would benefit from improved external communications. Improved communications skills can lead to stronger collaborations, new partnerships, and increased investments.

To help the research teams strengthen their communications skills, the NETL Technology-to-Market (T2M) team developed one-page communication documents, with standardized elements highlighted for each project. These documents provide clear and concise details about the research that are relatable to potential partners. They are highly tailorable, and can be altered depending on the specific audience. It is the recommendation of the T2M team that these communication documents be developed for all research teams within the portfolio, because early collaboration with potential customers and partners can greatly influence the success and adoption of technology development.
1 INTRODUCTION

The goals of the United States (U.S.) Department of Energy (DOE) National Energy Technology Laboratory (NETL) Crosscutting High Performance Materials (hereafter, “Crosscutting”) program include maturing novel technologies for commercialization that can enhance new and existing fossil power plants. [1] For this research to impact U.S. taxpayers and other stakeholders, it must be successfully transferred from laboratory-research-scale projects into commercially-viable technology solutions that are adopted by industry.

Much of the research that NETL funds is early-stage developmental research. NETL’s Crosscutting Advanced Alloys portfolio addresses a wide range of technical challenges, and includes projects from early discovery research as well as higher maturity technologies. The portfolio of funded research does not include technologies that are fully ready for commercial deployment, but there is a programmatic value in aiding connections with industry that will eventually result in commercial adoption.

Projects that have the highest potential for commercialization may have non-technical challenges that could benefit from external support. The Technology-to-Market (T2M) team is experienced in identifying challenge areas, gaining industry perspective, and providing tailored support to research groups.

In this analysis, the T2M team focused on identifying high potential projects through a series of three evaluation frameworks, determining alignment with NETL’s mission, the external market potential of the technology, and any barriers to adoption that the technology may experience. Assumptions made during this process were validated through conversations with industry representatives from AmericaMakes, “the nation’s leading and collaborative partner in the additive manufacturing and 3D printing.” [2] From this analysis, three high-ranking research projects were chosen to dive deeper into specific challenges. The portfolio analysis was followed by a Needs Assessment, wherein the selected project teams were evaluated for gaps in non-technical support (Exhibit 1-1).
2 Tools and Frameworks

2.1 Frameworks for Prioritization

This analysis utilized three different frameworks to analyze NETL’s Research and Innovation Center (RIC) Advanced Alloys portfolio, identifying projects that have a high potential for commercialization. The Ambition Matrix is a Deloitte Consulting framework featured in the Harvard Business Review [3] that maps the innovativeness of an organization’s research portfolio by looking at proximity to core capabilities and market areas. The Ambition Matrix sorts projects that are core to the organization’s mission to those that are transformational. This helps to make sure that the riskier transformational projects have the potential for a large impact to compensate for the development risks. The Balanced Breakthrough Model assesses individual projects’ desirability in the marketplace, technical feasibility, and commercial viability. Lastly, the Market Applicability Technology Integration (MATI) matrix evaluates projects based on their implementation needs, and their readiness for industry adoption. These frameworks all work together to highlight priority projects within the portfolio, and to reveal high potential projects. Each framework is integral to identifying good candidates for the specific goals of this project.

The frameworks are applied according to type of assessment. The Ambition Matrix is purely descriptive, providing context for the goals of each project, while the MATI matrix is categorized as prescriptive, and where a project lands within the MATI matrix will determine project needs and next steps. The Balanced Breakthrough Model provides a happy medium between the two matrices. It captures the current state of a project across three different dimensions, while revealing weaknesses or project needs.

2.2 Ambition Matrix

The Ambition Matrix plots individual research projects as a function of potential market and novelty of the solution. As a result, projects end up in one of three zones: Core, Adjacent, or Transformational (Exhibit 2-1). Projects that are core to an organization’s mission or technology space are often incremental improvements over existing technology. They have narrow market opportunity, and most of the potential users would be within the organization’s mission space. Adjacent projects are those which build upon foundational portfolio technologies, but push solutions into new markets. Transformational projects have novel solutions that may be outside of an organization’s primary technology portfolio. These projects may attract new customers or partners, and expand the organization into new markets. The projects become increasingly more uncertain as they move from core to adjacent and transformational. It’s important from a portfolio management perspective to balance the development risks with the potential impact on the market. This analysis used this risk-versus-reward assessment to assist with the down selection. Transformational projects have the greatest risks, but should also have the greatest potential for impact.
2.3 Balanced Breakthrough Model

2.3.1 Method

The Balanced Breakthrough Model is a method of assessing projects’ potential for impact by measuring their desirability in the marketplace, their technological feasibility, and their commercial viability (Exhibit 2-2). Each of these considerations are given equal weight, and ideally, a project should reflect all three. To score a project, a series of questions in each category was discussed with individual researchers, as well as with representatives from industry. The projects were ranked according to these questions, indicating where each project’s strengths and weaknesses lie.
Each category had three questions, and projects were given a score of 1–5 for each question, for a total possible score of 45 points. The T2M team posed questions to the researchers, then used current literature and industry knowledge to provide a score. Justifications for each score were captured, and shared with research teams for validation.

2.3.2 Questions for Assessment

Assessing a project’s desirability relates to whether it is solving a market need. Projects with high desirability are addressing challenges that impede other technology innovation, and that there are already potential customers for. Viability of a research project determines whether the market demand for a product or technology can support the cost of investment required for development. A research project may be technically successful, but if the cost is too high, or implementation is too difficult, it may not succeed. Feasibility relates primarily to technical challenges that researchers may be anticipating, and what timeline they expect to achieve certain project milestones. The questions posed to the research teams to determine scores in each category are outlined in Exhibit 2-3.

<table>
<thead>
<tr>
<th>Desirability</th>
<th>Viability</th>
<th>Feasibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will end-users find your solution useful; will it fulfill their needs?</td>
<td>Can the business offer the technology at an acceptable price point?</td>
<td>Has the research team or NETL accomplished something similar in the past? Near core capabilities?</td>
</tr>
<tr>
<td>Does the solution align to identified market trends in the industry? Beyond the industry?</td>
<td>Is the solution scalable to the target market?</td>
<td>What TRL does the tech currently sit at? What is the expected timeline to meet technical goals and milestones?</td>
</tr>
<tr>
<td>What is the global market forecast range? (How big is the market size?)</td>
<td>Can the solution be easily adopted and create a sustainable position in the market?</td>
<td>Is it possible to accomplish the technical objective of the study?</td>
</tr>
</tbody>
</table>
The answers to these questions, along with additional context from each interview helped to determine the project’s implementation potential.

### 2.4 MATI Matrix

The MATI Matrix is the most prescriptive framework that was used in this analysis. It is a proprietary framework that evaluates a technology’s commercialization difficulty by considering two diagnostic questions: 1) How broad is the market impact? and 2) How integrated is the solution into an existing system? Projects are plotted according to these two dimensions and placed according to their overall scope and range of applications, as well as their ease of implementation or adoption with an industry setting (Exhibit 2-4). Where they sit within the matrix determines the next steps that will improve their probability of commercialization.

![Exhibit 2-4. MATI Matrix](image)

Placement within this matrix was determined by the T2M team, based largely on interviews with the research project teams. The Market Applicability spectrum ranges from narrow to broad. This describes the potential users of the product or technology; widely applicable technologies are not necessarily better than those with niche markets, but they will have different paths to commercialization. The Technology Integration spectrum evaluates the project’s ability to be integrated into the current marketplace. If integration will require significant changes to manufacturing systems, training, or software upgrades, the project is considered to have high integration. If the technology will work with current systems and requires little training or other upgrades, it is considered to have low integration. Projects with low integration have lower barriers to entry, and often are more readily adopted into the marketplace. Projects with higher technology integration may have additional steps to take before they can be successfully commercialized.
2.4.1 Drop + Go

Technologies in the Drop + Go area of the MATI Matrix have a demonstrable market entry point, and require little-to-no integration for market adoption. Whether they have broad market applicability or are focused in niche markets, these products and technologies are best served by defining their value proposition and conducting a market analysis for the most strategic market introduction. As long as the technology can easily be integrated into the existing system, the market applicability is less critical to the technology’s path toward commercialization. It is acknowledged that technologies with narrow versus broad market applicability have different business development activities; it is thus the belief that both narrow and broad market application technologies should be managed with a single pathway. The pre-commercial steps and milestones are not significantly different enough to justify an additional process.

2.4.2 Focus + Build

Technologies in the Focus + Build area of the MATI Matrix similarly have a high integration score, but also have a narrow market focus. This suggests that the technology developer has a focused path to commercialization; it is imperative to find partners within the existing value chain early on in the technology’s development cycle, enabling integration within the technology’s limited market scope. Long-duration energy storage is an example of a domain-specific technology that requires integration, as it is fit-to-purpose to enable renewables to replace fossil-based technologies (i.e., coal and gas) on the energy grid. Since long-duration energy storage solutions target the grid, it is important for research and development (R&D) teams developing solutions to engage utilities and power generation asset owners during the early stages of R&D. These connections both create strong development collaborations and provide stakeholders in the industry enough time to build confidence in the solution and plan the investment requirements.

2.4.3 Expand + Connect

In addition to being integrated, technologies in the Expand + Connect area of the MATI Matrix have multiple market applications. Broad market applicability has the benefit of providing research teams different options to test and de-risk the technology during the development cycle, and potentially create an additional scale that will help the economics of the technology solution. However, managing those different market channels requires a deliberate approach, particularly in the government-funded research sector that links awards and investment to specific goals related to the mission of that organization. An example of an Expand + Connect technology would be the development of a novel high-performance metal alloy. Superalloy materials can be used to improve efficiencies of land-based turbines used in power generation applications, but also in aerospace turbine engines. Before a turbine component made from a new alloy can be field-ready for deployment, it needs to be tested, validated, and designed into an original equipment manufacturer (OEM) system, which could have a decades-long roadmap for a next-generation turbine. Therefore, it is crucial to facilitate engagement between external researchers and the OEMs in the early stages of development.

Early-stage R&D is often subsidized by public funding. Government funding for new alloy research for turbines can come from DOE or the Department of Defense. Researchers managing
alloy development programs need to build development partnerships and technology maturation plans that carefully adhere to the strategic intent of those funding organizations. The MATI Matrix approach helps organizations with their program planning and prepare to manage those funding hurdles.

The MATI Matrix was an important tool for this analysis because it allowed the T2M team to analyze the portfolio of projects on their commercialization difficulty. One of the goals of this project was to identify opportunities for a “quick win” and identify the projects that are categorized as Drop + Go, which would be those facing the least number of market adoption hurdles.
3 PRIORITY TASKS

3.1 PROJECT SELECTION

Based on analysis done using the three frameworks discussed in this report, three priority projects emerged that demonstrate high commercialization potential. These projects not only demonstrated high potential in the Balanced Breakthrough Model, but also span a diverse range of implementation readiness. The three projects chosen and the supporting tasks from the portfolio analysis are listed in Exhibit 3-1. Project / Task Relationship Exhibit 3-2. Project Description provides a description of each of the three projects.

### Exhibit 3-1. Project / Task Relationship

<table>
<thead>
<tr>
<th>Main Project</th>
<th>Supporting Tasks (Task # and Task Title)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and Manufacture Large-Scale Ingots</td>
<td>Task 5 - Simulate and Manufacture Large-Scale Ingots</td>
</tr>
<tr>
<td></td>
<td>Task 7 - 800 C HEA Ni-superalloy Development</td>
</tr>
<tr>
<td></td>
<td>Task 8 - Grain Boundary Engineering &amp; Design Techniques</td>
</tr>
<tr>
<td>Evaluating Materials for high Temperature High Pressure Applications</td>
<td>Task 11 - Low-Cost Steel for Low-Temperature Recuperators in Direct sCO2 Power Cycles</td>
</tr>
<tr>
<td></td>
<td>Task 12 - Effect of sCO2 Cycle Environment on Mechanical Behavior</td>
</tr>
<tr>
<td>Design Tool for Creep-Resistant Materials and Low-Cycle Fatigue Modeling</td>
<td>Task 16 - Design Tool for Creep-Resistant Materials and Low Cycle Fatigue Modeling</td>
</tr>
</tbody>
</table>
### Exhibit 3-2. Project Description

<table>
<thead>
<tr>
<th>Main Project</th>
<th>Projects Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and Manufacture Large-Scale Ingots</td>
<td>Model &amp; design alloys using computational tools to develop processing methods that reduce a lack of chemical uniformity</td>
</tr>
<tr>
<td></td>
<td>Formulate, melt, and cast heats for each composition</td>
</tr>
<tr>
<td></td>
<td>Fabricate alloys into plate using hot forging and rolling operations and assess creep and tensile properties</td>
</tr>
<tr>
<td>Evaluating Materials for high Temperature High Pressure Applications</td>
<td>Examine and compare nickel alloys, steel, and experimental alloys’ performance under various operating conditions</td>
</tr>
<tr>
<td></td>
<td>Evaluate performance results and overlay material cost information</td>
</tr>
<tr>
<td>Design Tool for Creep-Resistant Materials and Low-Cycle Fatigue Modeling</td>
<td>Develop a first-of-its-kind creep and fatigue model that incorporates essential physics and microstructural effects</td>
</tr>
</tbody>
</table>

### 3.2 Ambition Matrix

The Ambition Matrix was used to align the projects in the portfolio to the larger goals of the Crosscutting program. Assessing each project along the two levers provided structure to the portfolio, to determine which are core to the mission, which are adjacent, and which are transformative (Exhibit 3-3).
The Core projects, Tasks 5, 7, 8 were identified as such because they focus on material systems and technologies with which NETL has a lot of experience and, therefore, have low technology risk. Transformational projects, such as Task 15 and Task 16 are computational modeling projects that require significantly more technical development, but that have high potential for impact when they are complete.

### 3.3 Balanced Breakthrough Model Results

The projects selected as demonstrating high potential for commercialization had relatively high and evenly distributed Balanced Breakthrough Model scores.

*Design and Manufacture of Large Scale Ingots* received a score of 11 for Desirability, 13 for Viability, and 11 for Feasibility, resulting in a total score of 35. The project demonstrates high
viability, as it has a price point that is competitive with current market standard materials, and has broad applicability with potential customers. The technical feasibility was influenced by a small number of technical challenges that will need to be resolved, as well the project is at a relatively low Technology Readiness Level (TRL), although the TRL is consistent with many NETL Crosscutting projects. The desirability score reflects the project’s wide range of applicable markets and consistent need for high performance materials (HPM) at relatively low costs.

*Evaluating Materials for High Temperature, High Pressure Applications* received a score of 13 for feasibility, 11 for viability, but a relatively low score of 5 for desirability. In this case, the low desirability represents a niche market, but one in which the technology would be highly desirable, and straightforward to implement. This makes the project promising for commercialization, even though it may be a smaller opportunity.

*Design Tool for Creep-Resistant Materials and Low-Cycle Fatigue Modeling* demonstrates an exceptionally high desirability in the marketplace, with a score of 15, but a relatively low feasibility score of 7, and a 9 for viability. The low feasibility comes from a long lead time until projected milestones are reached. Moderate viability comes from a scalable product and pricing model, but a comparatively difficult market entry and implementation strategy into industry practice.

### 3.4 Value Proposition

The process of determining the Balanced Breakthrough Model scores for each project also enabled the T2M team to draft value proposition statements. These statements help to contextualize the goal of the project, the intended customer, and the potential for impact. They summarize these concepts into a standardized format that is relatable to stakeholders, who may be less familiar with the work. Exhibit 3-4 shows the format of the value proposition statements, and the specific content for each project.
Exhibit 3-4. Value proposition statements

<table>
<thead>
<tr>
<th>Design and Manufacture of Large Scale Ingots</th>
<th>Evaluating Materials for High Temperature, High Pressure Applications</th>
<th>Design Tool for Creep-Resistant Materials and Low-Cycle Fatigue Modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FOR</strong></td>
<td>the high-performance alloy market, including hydrogen and decarbonized economy applications</td>
<td>FOR sCO₂ power plants, concentrated solar and nuclear power, onboard ship propulsion applications</td>
</tr>
<tr>
<td><strong>WHO</strong></td>
<td>aim to improve efficiency and reduce cost</td>
<td>WHO need performance data for materials in new applications</td>
</tr>
<tr>
<td><strong>OUR</strong></td>
<td>cost-effective high-performance alloy development</td>
<td>OUR alloy performance and evaluation</td>
</tr>
<tr>
<td><strong>IS</strong></td>
<td>catalytic for robust materials supply chain</td>
<td>IS reducing technology development costs</td>
</tr>
<tr>
<td><strong>THAT</strong></td>
<td>improves performance</td>
<td>THAT enables engineers to use materials in new applications</td>
</tr>
<tr>
<td><strong>UNQLY</strong></td>
<td>by using industrially scalable equipment and techniques at a competitive cost</td>
<td>UNQLY tackling complicated data collection process in extreme environments</td>
</tr>
</tbody>
</table>

Having clear, concise value proposition statements enables researchers to communicate to a wider range of potential partners and collaborators. The ultimate goal of initiating these conversations is increased engagement that could lead to additional funding or successful technology transfer.

3.5 MATI Results

The three projects that were down selected from the Balanced Breakthrough Model results were then assessed using the MATI Matrix. This process enabled the T2M team to determine the best course of action for each project.
Task 16 and Task 11 & 12 were evaluated as Drop + Go. These projects have very different potential market sizes, but have little technology integration required for adoption by industry. Task 5, 7, 8 is in the Focus + Build category. These projects have considerable potential market size, but may require significant investment to be integrated into existing technology systems.
4 Needs Assessment

4.1 Non-technical Support Offerings

Successful commercialization requires de-risking projects along three categories of uncertainty: technology, business, and market. Typically, research teams focus on addressing technology risk through a series of experiments and testing. However, the non-technical risk elements (i.e., business and market) are often overlooked yet are just as critical for successful market adoption. To determine the types of non-technical support needed for each project, the T2M team provided each research team with a high-level overview of examples of non-technical support such as market studies, economic modelling, and business plan development. A general observation when conducting the Needs Assessments was that research teams were enthusiastic about receiving external services, because their primary focus is achieving technical milestones. The teams understood why these activities are necessary and saw the value in engaging experts from the T2M team to execute.

The research teams articulated their non-technical needs, which were then grouped according to discrete services from which they could benefit. While each team had different needs, there was some alignment with challenges that were present across all projects (Exhibit 4-1).

Exhibit 4-1. Results from research team interviews

Developing a clear communications and outreach strategy for each team emerged as an important first step. This could also help to initiate progress in some of the other challenge areas as well. For each project team, the most impactful communications strategy varies, depending on their immediate needs.
4.2 Design and Manufacture of Large Scale Ingots

The team leading Design and Manufacture of Large-Scale Ingots focused their conversation around scaling their technology and challenges with adoption of their technology in industry. A major concern expressed by the team was the ability to have technical conversations with industry representatives, without compromising intellectual property. This is an important challenge to address, as demonstrating plant-scale manufacturing capabilities and performance is critical to gaining market entry.

The T2M team determined that providing the research team with a thoughtfully articulated way of talking about their project would enable them to communicate the technology’s value without disclosing technical details. Translating technical milestones and features into relatable impacts that are important to their target customers helps to build opportunities for collaboration and partnerships.

4.3 Evaluating Materials for High Temperature, High Pressure Applications

The team leading Evaluating Materials for High Temperature, High Pressure Applications quickly identified their primary challenge as a need to secure an industrial-scale demonstration of their technology. The team has met many of its lab-scale technical milestones and is ready to transition to the next stage. However, identifying potential partners, coordinating schedules and production timelines, and drafting contracts all take time and resources that the team does not have.

An effective outreach strategy for this team is to highlight application spaces outside of their core market. The technology developed in this research project was developed for a relatively narrow field, but may provide high-performing, low-cost solutions for other industry needs as well. Communicating the value of the solution to industry representatives, rather than technical details, will help this research team to connect with potential partners.

4.4 Design Tool for Creep-Resistant Materials and Low-Cycle Fatigue Modeling

The Design Tool for Creep-Resistant Materials and Low-Cycle Fatigue Modeling is a tool with widespread industry appeal and broad potential applications. However, it is an ambitious project that requires several years of development, and contribution from a highly-skilled cross-functional development team. Identifying smaller scale products that could serve as market entry points could be valuable in helping this team obtain the internal support and resources it needs to grow.

The aim of the communication strategy for this project is to create focus. Bringing clarity to complex technical subject matter requires an understanding of multiple perspectives and what is valuable to each.
5 Conclusions

5.1 Key Messages

Successful commercialization requires a balanced consideration of technological feasibility, commercial viability, and end-user desirability. Research teams at national laboratories and academic institutions need to be supported with non-technical expertise and resources to ensure commercial readiness alongside technology readiness.

The value of early communications with industry cannot be overstated. Technology that is developed in direct collaboration with its potential customer has a better chance of meeting those customer needs. This analysis determined that research teams would benefit from a revised communications strategy, beginning with standardized one-page communication documents highlighting project specifics.

The key elements to include in these documents were determined to be the challenge and approach to the research project, the impact to a potential customer or partner, and a specific call to action. These documents use clear, succinct language, and articulate project details such that they can be understood by broad audiences. By establishing consistent focus areas, but keeping the documents in an editable form, research teams can tailor their messaging according to different audiences, or update them as their projects grow. The work products were delivered as living documents to the project teams; images of the documents are captured in the Appendix: One-Page Communication Documents.

In addition to support for improving strategic communications for the research teams, the analysis revealed that business planning and go-to-market support is also a key need for the teams to better position them for successful market transfer.

5.2 Final Recommendations

The goal of this analysis was to identify research groups that demonstrate the highest potential for commercialization, and to understand their non-technical support needs. By evaluating each research project through three different frameworks, the T2M team selected three projects with high potential. The final-stage Needs Assessment provided a method to rapidly discuss the types of non-technical support from which these project groups could benefit from. Improving understanding of project value, and creating a robust communications strategy tailored to each research team will be catalytic in achieving commercialization of these technologies.

It is the recommendation of the T2M team that the Needs Assessment continue with each of the remaining research teams. These conversations help to not only understand the unique challenges of each project, but also to educate the research teams on what types of services could be available to them. Building a tailored communications strategy for each team will empower them to drive conversations with potential partners, regardless of the current stage of their project. In addition, for each of the high-priority projects selected, the T2M team recommends further building out a strategic communication approach and tactical go-to-market plan.
6 REFERENCES


APPENDIX: ONE-PAGE COMMUNICATION DOCUMENTS

Exhibit A-0-1 through Exhibit A-0-3 show one-page communication documents created for the three chosen projects to facilitate partnerships and collaborations between research teams and industry.

Exhibit A-0-1. Communication document: Design & Manufacture Large-Scale Ingots

Design & Manufacture Large-Scale Ingots

Developing alloys and manufacturing processes to increase service life of low-cost alloys in extreme environments

THE CHALLENGE
• Large scale alloy melting results in inconsistent products that leads to poor mechanical properties
• Advanced alloys in particular require complex manufacturing methods to ensure quality
• A lack of uniform microstructure in expensive metal alloys can lead to reduced performance life and premature failure which is a direct impact on end-user operations and profitability.

OUR DRIVING QUESTION
• Can we apply a data science-based approach to better understand the relationship between chemistry, processing, microstructure, mechanical behavior and performance life?

OUR APPROACH
• Model & design alloys using computational tools to develop processing methods that reduce a lack of chemical uniformity
• Formulate, melt, and cast heats for each composition
• Fabricate alloys into plate using hot forging and rolling operations and assess creep and tensile properties

THE IMPACT
• Microstructural control improves component performance by enhancing the quality of large-scale ingot manufacturing
• The application of computational methods to ingot design will accelerate development of new products and technologies
• Improving the microstructure expands materials options for extreme environments providing greater flexibility to component designers

CALL TO ACTION
NETL is looking for collaborators to support scaling up experimental results and perform demonstration testing

CONTACT US
• Omer Dogan, Materials Scientist, Omer.Dogan@net.ltc.gov
• Martin Detrio, Research Scientist, Martin.Detrio@net.ltc.gov
• Paul Jablonski, Metallurgist, Paul.Jablonski@net.ltc.gov
Evaluating Materials for High Temperature, High Pressure Applications

Reduce deployment costs and accelerate market adoption through analysis of commercially available steels for harsh environment applications.

THE CHALLENGE

- The drive towards greater efficiency in power generation systems puts increased requirements on materials.
- Materials requirements for these applications include high-temperature strength, environmental resistance and good fabrication characteristics.
- The materials typically used for these applications are nickel-based superalloys that are expensive, limiting the adoption and proliferation of the higher-efficiency systems.

THE IMPACT

- Demonstrating that lower-cost, commercially available alloys can meet the stringent requirements in high-temperature, high-pressure applications will reduce the overall cost of the improved efficiency systems leading to greater adoption of these new technologies.
- These materials can be used in multiple applications including industrial plants and power generation (waste heat, fossil, concentrated solar, nuclear power).
- Reduces technology development costs.

OUR DRIVING QUESTION

- Can lower-cost, commercially available alloys meet performance demands in these harsh environments?

OUR APPROACH

- Examine and compare nickel alloys, steels, and experimental alloys performance under various operating conditions.
- Evaluate performance results and overlay material cost information.

CALL TO ACTION

NETL is looking for collaborators to conduct system-level demonstration trials for these lower-cost alloys.

CONTACT US

Richard Oleksak, Research Scientist, Richard.Oleksak@netl.doe.gov
Omer Dogan, Materials Scientist, Omer.Dogan@netl.doe.gov

Design Tool for Creep-Resistant Materials and Low-Cycle Fatigue Modeling

Validated computational tool predicts the performance of structural alloys at high temperatures

THE CHALLENGE

- The penetration of renewables in the energy system requires greater operating flexibility and cycling in existing power generation units
- These new operating conditions require new tools and methods for predicting performance life of materials
- In order to operate at higher efficiencies, operators need to understand the microstructural effects of both creep and fatigue to enable flexible mission profiles.
- Existing models do not incorporate a physics-based approach to couple creep, fatigue and environmental effects on materials performance

OUR DRIVING QUESTION

- Can we develop a better approach for predicting material behavior and performance life in these emerging power generation applications that require increased operating flexibility?

OUR APPROACH

- Develop a first-of-its-kind creep and fatigue model that incorporates essential physics and microstructural effects

THE IMPACT

- Enabling better prediction of performance life will allow for improved systems designs and operations planning
- Accelerates the process of alloy development for energy applications and lowers overall cost of alloy manufacturing
- Enables engineers to use materials in new applications
- Ultimately, improving the component design and end-user operations will lead to improved efficiencies and more reliable energy system

CALL TO ACTION

NETL is seeking additional resources and collaborators to accelerate the development and improve the effectiveness of the model

CONTACT US

Youhui Wen, Engineer, youhui.wen@netl.doe.gov