EMSL

EMSL Strategic Plan to Maximize Scientific Impact of the Quiet Wing

PEMP Notable Outcomes Goal 2.3

AA Campbell

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1.0 Introduction

The Quiet Wing at the Environmental Molecular Sciences Laboratory (EMSL) was constructed in 2011 to house the newest generation of ultra-high resolution (chemical) imaging instruments. Of its seven major instruments, two (the liquid helium cryoTEM and the Dynamic Transmission Electron Microscope) have been added in the last year. This expanded capability is one of three capital assets recently funded by the Office of Biological and Environmental Research (BER) to foster high-impact science for the benefit of BER's science missions, those of other offices of the U.S. Department of Energy (DOE), and the greater scientific community. In order to jumpstart interest within the scientific community (particularly in the BER community), accelerate the impact of this capability, and maximize the scientific benefit of that investment, the Performance Evaluation Management Plan (PEMP) for fiscal year 2014 for DOE-Battelle Prime Contract for the Management and Operations of Pacific Northwest National Laboratory (DE-AC05-76RL01830) includes a Notable Outcome to develop and execute a strategy for high-impact science using this capability. This strategic plan, developed in the broader context of the overall EMSL Strategic Plan, serves as the deliverable for that PEMP Notable Outcome.

1.1 Goals

The goals by which the success of the capability will be measured are:

- **Maximize Scientific Impact** by ensuring that EMSL's new assets are effectively used for high- quality science that positions EMSL to be distinctive and by leading the science agenda in its Science Themes and Leadership Areas,
- **Ensure Strategic Alignment** with BER/DOE science mission areas,
- **Maximize Utilization** of the assets at a facility/capability level to maximize the benefit of the investment, and
- **Target Outreach** to cultivate new users and ultimately demonstrate leadership by using these capabilities to perform distinctive, high-impact science.

1.2 Document Organization

Section 2 of this strategic plan describes the science vision for the Quiet Wing in the context of the Science Themes and Leadership Areas in the overarching EMSL Strategic Plan. Section 3 outlines a specific, actionable 2-3-year plan for achieving the goals in Section 1.1. Section 4 sets metrics for measuring performance against the goals. Section 5 establishes the vision for sustainment of this capability.

2.0 Science Vision for the Quiet Wing

The EMSL Quiet Wing is the best, if not the only, place to image biological, biogeochemical, aerosol, and other samples with high time and high spatial resolution because of the quiet and controlled environment, the unique capabilities of the dynamic transmission electron microscope, and this tool's proximity to complementary instruments.

Science programs at DOE's BER support research focused on understanding and providing sustainable solutions to global challenges resulting from the increased demand for energy worldwide. This demand affects environment and climate, and strengthens the need for clean alternative energy sources. BER has a long history of determining the biological and environmental impact of energy production and use on the environment, and understanding the interplay of climate and energy. Over the next 10 years, scientific research at EMSL will likewise focus on advancing the predictive understanding of key components of environmental, biological, and energy systems. Emphasis will be on gaining a mechanistic understanding of key molecular-scale components of a system to improve the accuracy of larger-scale models that simulate mesoscale behavior. Breakthrough advances in BER science areas, which include aerosol formation and aging, structural biology, biochemistry for biodesign, elemental cycling, and contaminant fate and transport, depend upon the ability to visualize dynamic processes and probe physical and chemical properties at atomic and molecular scales in realistic environments. The overall EMSL Strategic Plan more completely describes the EMSL Science Themes and Leadership Areas, and the contributions EMSL will make in these areas. Consistent with that plan, this document describes how EMSL's Quiet Wing can provide a number of needed technical capabilities to enable these advances and open new areas of research that have significant potential to produce high-impact science for multiple BER programs. Such capability is needed in other DOE science areas as well, including the design and performance optimization of catalysts for biofuel production and energy storage materials.

2.1 Contributions to Atmospheric Aerosol Systems Science Theme / Biogenic Organic Aerosols Leadership Area

One of the greatest uncertainties in climate model simulations is the effect of aerosols on radiative forcing directly through their light-scattering or light-absorbing properties, or indirectly through particle-cloud interactions. Fundamental questions remain regarding how aerosols grow and change with time and environment, and how those changes affect cloud properties and radiative forcing. Consequently, aerosols cannot be adequately included in regional- or global-scale climate models. Advancing predictive models requires understanding how the molecular-level processes that lead to the formation and growth of inorganic and biogenic organic aerosols, and their radiative and ice nucleation properties as a function of time and environment, affect cloud properties. This work also establishes a fundamental basis for parameterizing these processes for incorporation into climate process models.

Fundamental questions in aerosol science include how aerosols nucleate and grow and the heterogeneity among and within particles. The unique *in situ* capabilities in the Quiet Wing provide the high-resolution tools needed to begin answering questions regarding aerosols such as:

- What is the three-dimensional structure and chemical make-up of aerosol particles and how do these affect light absorbing/scattering and ice nucleation properties?
- How do the structure, composition, and resulting physicochemical properties of these aerosols evolve as a result of atmospheric aging?

The environmental, analytical (S/TEM), and dynamic transmission electron microscopes open new options for characterizing aerosol composition and morphology at high-resolution—examining aerosol nucleation and growth with high-temporal resolution, and studying the aging effects upon exposure of the aerosols to controlled environmental conditions. Unique projects that will utilize the new capabilities in the Quiet Wing will focus on chemically induced changes in aged/transformed aerosols in environmental cells and, once specialized specimen holders are in place, ice nucleation and growth. The low temperature scanning probe microscope provides a platform to study ice nucleation processes on oxide minerals surfaces as a function of composition.

2.2 Contributions to Biosystem Dynamics and Design Science Theme / Biological Compartmentalization Leadership Area

Decadal scale challenges in this BER priority area include gaining a detailed understanding of how biological systems respond to and modify their environment, so that scientists can improve strategies for modifying and manipulating plants, fungi, and microbes to advance systems biology for biofuels and renewable chemicals. Research in EMSL will focus on understanding sub-cellular compartments and the transport of metabolites within and between cells that are key to controlling cellular and intracellular functions.

Specific questions that this capability can address include:

- How do dynamics of membrane protein structures translate into biological function?
- What is the spatial organization of regulatory protein complexes and how does this relate to the transport of molecules within and between cells?

Significant advances in understanding protein complex assembly dynamics are expected with the use of the dynamic transmission electron microscope (DTEM). When fully operational, the DTEM will enable the visualization of *live* biological samples in liquid solutions at a resolution for identification of sub-molecular details. This emerging capability will establish a new paradigm for biological imaging and provide novel, important insights to efficient energy transduction mechanisms, including the assembly and molecular actions of supramolecular protein machines in biology. Targeted research topics include analysis of the protein structure dynamics related to enzymatic turnover and the detailed processes in membrane-bound transporter proteins. The DTEM will allow the study of dynamic events at unprecedented resolution in cellular and molecular research enabling milestone advancements in our understanding of inter- and intracellular biological processes. The liquid helium cryoTEM provides a high-resolution imaging platform for biological samples and complements the protein dynamics provided by the DTEM.

2.3 Contributions to Terrestrial and Subsurface Ecosystems Science Theme / Hydrobiogeochemical Elemental Cycling Leadership Area

There is a fundamental gap between molecular and nanoscale research of biogeochemical interactions between soil carbon, minerals, and microbial ecosystems and field-scale measurements. By providing a mechanistic understanding of biogeochemical and microbial processes in soils and the subsurface, and linking those processes via pore-scale hydrological models, strategies for sustainable solutions to contaminant attenuation, remediation, and carbon storage can be improved. In biogeochemistry, the ability to follow the dynamic biological and geochemical processes that occur in complex subsurface environments at the molecular scale will increase our ability to understand the biogeochemical cycles that support life, control local and regional chemical fluxes that govern soil and water quality, and link the carbon and hydrologic cycles that occur below ground to the atmosphere.

Specific questions that this capability can address include:

- How does pore-scale water distribution drive biogeochemical transformation of carbon and other nutrients?
- What fraction of soil carbon is protected from degradation through chemical or physical mechanisms?

High-resolution research of biogeochemical systems has been a major component of EMSL. *In situ* TEM and DTEM capabilities housed in the Quiet Wing will significantly advance this area of science by making it possible to follow the dynamic biological and geochemical processes that occur in these complex environments with high spatial resolution at timescales not previously attainable. Research at the EMSL Quiet Wing will include high-resolution imaging, chemical compositional analysis of minerals undergoing redox cycling, persistence of carbon in soils, and low-level contaminant fate and transport.

2.4 Contributions to Energy Materials and Processes Science Theme/Solvent-mediated Interfacial Chemistry Leadership Area

The efficiency and durability of energy conversion and storage systems are often dominated by dynamic transformations and chemical properties of critical interfaces. Structure, composition, and dynamics of the solvent-solid boundary are distinct from those for bulk or solid-solid boundary systems, manifesting local order and emergent properties that cannot be predicted. Advanced and developing capabilities in the Quiet Wing can provide molecular-level information about the processes occurring at this critical interface and, along with predictive modeling, provide information and understanding needed for the design and development of practical, efficient, environmentally benign and economically viable energy storage and energy conversion systems.

Specific questions that this capability can address include:

- What are the impacts of correlation effects on local order and emergent properties at solvent/solid interfaces?
- How do buried interfaces change with time and applied potential, and how do these changes affect the critical charge and mass transport and chemical reactivity behaviors of the interface?

Electrochemical processes using environmental cells can now be studied *in situ* in a TEM, and high- resolution imaging of battery materials and their phase transformations can be investigated under *operando* conditions with the use of micromanipulators, liquid cells, and stages. Environmental cells and the environmental transmission electron microscope (ETEM) permit the examination of catalytic processes for upgrading bioproducts and energy conversion under realistic conditions. The DTEM will dovetail with the scanning transmission electron microscope (S/TEM) and ETEM experiments to obtain information on dynamic material transformation, interface composition, and transport processes that occur in electrochemical and catalytic systems.

2.5 Quiet Wing Unique Capabilities

Capabilities in the Quiet Wing are uniquely suited to conduct high-impact science that has significant potential to make breakthrough advances in BER science areas. The ability to extract more detailed information on dynamic systems in realistic environments (i.e., *in situ* and *operando*) is possible with the high-spatial and high-temporal resolution of instruments housed in the EMSL Quiet Wing.

***In situ* and *operando* dynamics.** Electron-based characterization methods are required for a wide range of biological, environmental, and energy-relevant grand challenges. Such capabilities allow researchers to probe structures in their native environments to study biomolecular processes[1-2], redox processes, microbe-mineral interactions, and catalysts and energy materials.[3] The ability to observe processes under conditions that replicate real-world and real-time conditions with minimal loss of image or spectral resolution is a top priority in meeting these scientific challenges.

Combined high-spatial and high-temporal resolution. When *in situ* capabilities are combined with high-spatial and high-temporal resolution, they enable investigations of biological and chemical processes in real time. Present state-of-the-art *in situ* TEM instrumentation allows time resolution of seconds or milliseconds at best, which are far removed from the natural time scale on which biological and inorganic processes occur. Significant scientific progress can be expected with the DTEM capability being developed at EMSL for time-resolved, *in situ* measurements capable of nanosecond-scale image acquisition. High-temporal and high-spatial resolution under *in situ* conditions is needed for BER-specific scientific topics relevant to biology, biogeochemistry, catalysis, carbon capture, and general DOE related topics such as energy storage, solid-state lighting, compact light sources, and electron scattering.

[1] Grand Challenges for Biological and Environmental Research: A Long-Term Vision (2010) Biological and Environmental Research Advisory Committee
[2] Biosystems Design: Report from the July 2011 Workshop, U.S. Department of Energy Office of Science
[3] Future Science Needs and Opportunities for Electron Scattering: Next Generation Instrumentation and Beyond (2007) Department of Energy Workshop on Electron Scattering for Materials Characterization

3.0 Strategic Approach

EMSL is implementing a multi-pronged approach to achieve the goals and science vision discussed in Section 2, and thereby generate *high-impact science*, increase *alignment* with BER/DOE science mission areas, maintain high rates of facility *utilization*, and establish *leadership* within the scientific community through distinctive science and scientific capability. Several of the actions within the approach are tactical and short-term to immediately increase the external visibility of the capability and its utilization by projects aligned to the vision. Other efforts are longer-term, guided by our overall scientific vision for EMSL, to lead and drive scientific progress within specific technical communities. Both types of actions are described in this section, and many immediate actions are complete or under way.

3.1 Immediate Actions

3.1.1 External Validation Through Advisory Committee Input

The Quiet Wing has an advisory committee consisting of BER Principal Investigators (PI) who will be consulted "virtually" (e.g., through email exchanges on topics) for the following:

- Vet and enrich the Quiet Wing science vision,
- Identify near-term scientific opportunities to produce high-impact science, and
- Review proposals for quality and alignment with the vision.

In addition, we will ask the advisory committee to help promote the capability within research communities they represent, targeting and cultivating high-impact users, and facilitating outreach opportunities such as themed workshops or symposia.

Quiet Wing Advisory Committee

Advisory Member	Institution	Focus
Colleen Hansel	Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution	Biogeochemistry, environmental microbiology, and marine chemistry
Michael Hochella	Department of Geosciences, Virginia Tech	Geochemistry, biogeochemistry, and environmental microbiology
Cheryl Kerfeld	Michigan State-DOE Plant Research Laboratory and Lawrence Berkeley National Laboratory Physical Biosciences	Structural biology and genomics of photosynthetic systems, bioengineering
Daniel Knopf	School of Marine and Atmospheric Sciences, State University of New York at Stony Brook	Atmospheric aerosol microphysics, chemistry, and kinetics
Ryan Moffet	Department of Chemistry, University of the Pacific	Analytical, physical, atmospheric, and environmental chemistry
Stephen Long	University of Illinois	Environmental physiology, C4 photosynthesis improvement, biomass energy crops

Quiet Wing Advisory Committee (continued)

Eoin Brodie	Lawrence Berkeley National Laboratory	Microbial communities in the context of environmental and human health, and sustainable energy
James Liao	University of California, Los Angeles	Metabolic engineering, synthetic biology, and systems biology for carbon assimilation and biofuel/chemical production
Jennifer Pett-Ridge	Lawrence Berkeley National Laboratory and JBEI	Ecology of microbial communities; biogeochemistry; diversity and functional relationships in soil microbial communities

3.1.2 Review of Existing EMSL Projects for Acceleration and Additional Access

Existing user projects and proposals submitted through the 2014 Call for Proposals have been reviewed. Projects and proposals with clear BER alignment and potential for high-impact science are being considered for additional attention, staff time, funding, and priority access to key instrumentation to accelerate their progress and heighten probability of success. Candidate projects are organized by Science Theme[1] in the "Candidates from Existing User Projects" table.

Candidates from Existing User Projects

Science Theme	Researcher	Institution	BER Role	Focus
AAS	Alex Laskin	EMSL	Former BER PI	Chemical changes that affect optical radiative properties, mechanisms of coagulation and water uptake, and propensity to serve as cloud condensation nuclei with aging.
	Gourihar Kulkarni	PNNL		Anthropogenic effects on particle aging and ice nucleation properties of mineral aerosols.
BDD	Gary Stacey	University of Missouri	Former BER PI BER Advisory Committee (BERAC) Chair	Biological and abiological factors responsible for sequestering and protecting organic matter and carbon-bearing phases in soils.
	Nathan Gianneschi	University of California San Diego		Complex cellular stimuli responsive to nanoscale transformations relevant to applications in CO_2 fixation, bio-inspired energy capture and storage, and *in vivo* diagnostics and therapeutics.
	Lance Seefeldt	Utah State		Supramolecular protein complexes that facilitate electron transport to extracellular metal oxides, catalyze hydrogen production/carbon fixation, and reduce dinitrogen in air to ammonia.

[1] The Science Themes at EMSL are Atmospheric Aerosol Systems (AAS), Biosystem Dynamics and Design (BDD), Terrestrial and Subsurface Ecosystems (TSE), and Energy Materials and Processes (EMP).

Candidates from Existing User Projects (continued)				
TSE	Kevin Rosso	PNNL	BER PI	New mechanistic framework that treats the mineral and water interface in terms of the global composition, structure, and morphological characteristics of whole crystals.
EMP	Libor Kovarik	EMSL		Phase stability, reactivity, and oxidation mechanisms of catalytic nanoparticles in response to differences in their environment (elevated temperatures and reactive oxidizing environments), size, structural characteristics of low-index surfaces, and presence of support material.
	Chongmin Wang	EMSL		Structure-property relationships and correlation to charge and ion transport, lattice stability, chemical and structural evolution, and stability of the solid electrolyte interphase layer and capacity fading mechanisms of new battery materials.

3.1.3 Special Call for Proposals

A Special Science Call (http://www.emsl.pnl.gov/access/calls/science_call/) opened in April 2014 for research proposals in selected topics that would be enabled by utilization of all three new capabilities (the Radiochemistry Annex, the Quiet Wing, and the High Resolution and Mass Accuracy Spectrometry Capability). Proposals are being reviewed as received to accelerate scientific advancement and impact. To increase a project's alignment to high-impact, BER-relevant science, principal investigators are being contacted, cultivated, and encouraged to respond to the Special Call. Candidate projects are in the "High-impact, BER-aligned Target Users" table.

High-impact, BER-aligned Target Users

Science Theme	Researcher	Institution	BER Role	Prior EMSL User?
AAS	Vicki Grassian	Iowa State University	BER PI	Yes
	Mary Gilles	Lawrence Berkeley National Laboratory (LBNL)	BER PI	Yes
	Jian Wang	Brookhaven National Laboratory (BNL)	BER Atmospheric System Research SFA	No
	Daniel Knopf	State University of New York at Stony Brook	BER PI	Yes
	Konrad Thurmer	Sandia National Laboratories	BER PI	No
BDD	Brian Davison	Oak Ridge National Laboratory (ORNL)	DOE BioEnergyScience Center	No
	Mike Doktcyz	ORNL	DOE Plant-Microbe Interface SFA	No
	Jay Keasling	Joint Bioenergy Institute	DOE Bioenergy Research Center	No
	Cheryl Kerfeld	Michigan State University/LBNL/University of California, Berkeley	BER PI and Joint Genome Institute (JGI)	No

High-impact, BER-aligned Target Users (continued)				
BDD (continued)	Judy Wall	University of Missouri	DOE Enigma SFA	Yes
	Todd Yeates	University of California, Los Angeles	BER PI	No
TSE	Jill Banfield	University of California, Berkeley	BER PI	Yes
	Scott Fendorf	Stanford	BER PI	Yes
	Margaret Torn	LBNL	BER PI	Yes
	Donald Sparks	University of Delaware	BER PI	Yes
	Jim Fredrickson	PNNL	BER Genomic Science Program Genomic Science Program PI	Yes
	Vanessa Bailey	PNNL	BER TES PI	Yes
	Ljiljana Paša-Tolić	EMSL	EMSL Research Campaign	Yes
	Susannah Tringe	JGI	Metagenome Program Lead	Yes
	Gary Stacey	University of Missouri	Former BER PI, BERAC	Yes
	Richard Ferrieri	Brookhaven National Laboratory	Former BER PI	Yes

3.2 Outreach and Longer-Term Action Plan

The broader scientific community will also be engaged through technical meetings and conferences, symposia, and workshops to raise visibility of the Quiet Wing capabilities. Both oral presentations of science results and poster presentations highlighting capabilities at EMSL have been successful mechanisms for reaching new users and strengthening scientific collaborations in the past. In the near term, EMSL will promote the Quiet Wing at several scientific meetings (shown in the “Upcoming Scientific Meetings” table) that are well aligned to the science vision and user base.

Upcoming Scientific Meetings

Fiscal Years 2014-2015 BER PI Meetings and Workshops	Dates
DOE-Terrestrial Ecosystem Science/Subsurface Biogeochemical Research Joint PI Meeting	May 6-7, 2014
DOE Genomic Science Program Contractor Meeting	February 2015
Fiscal Year 2014 Workshops and Regional Meetings	
PNNL Chemical Imaging Initiative Workshop on C Sequestration	April 7, 2014
EMSL Integration 2014 User Meeting "Atmospheric Organics"	May 6-7, 2014
Advances in Structural and Chemical Imaging (PREMIER Network Meeting)	May 28-29, 2014
Microscopy and Microanalysis (M&M) (Microscopy Society of America)	August 3-7, 2014
Pacific Northwest Microscopy Society/Pacific Northwest AVS/PREMIER Network Workshop	September 16-19, 2014
Fiscal Years 2015-2016 Society Meetings	
American Association for the Advancement of Science (AAAS); proposing special session on “Imaging Molecules in the Environment” in 2015	February 12-16, 2015
American Geophysical Union (AGU)	December 15-19, 2014 December 14-18, 2015
Geological Society Meeting (GSA)	October 19-22, 2014 November 1-4, 2015
Goldschmidt Conference	June 8-13, 2014 August 16-21, 2015 (with permission) June 26-July 1, 2016 (with permission)
American Society of Plant Biologists (ASPB)	July 26-30, 2015 July 7-13, 2016
Microscopy Society of America (M&M); have proposed special session on microscopy/imaging in the rhizosphere for 2015	August 2-6, 2015 July 24-28, 2016
American Society for Microbiology (ASM)	May 30-June 2 2015 May 2016
DOE-Terrestrial Ecosystem Science/Subsurface Biogeochemical Research Joint PI Meeting	2015
International Society for Microbial Ecology (ISME)	August 2016

Additional outreach activities include scientists at EMSL contacting BER PIs and Science Leads, and engaging EMSL's User Executive Committee, Science Advisory Committee, and Science Theme Advisory Panels to reach out to peers in their respective fields for advocacy on EMSL's behalf.

Over the longer term, as lead time for planning permits and both the user base and the EMSL scientific base expand, EMSL will host on-site workshops and conduct specialized sessions at national society meetings to bring together researchers interested in science enabled by the capability. Ultimately, we foresee these workshops as opportunities to achieve not only visibility but recognition of EMSL's unique abilities and contributions to the areas described in the science vision and to create excitement within the user community to collaborate with EMSL.

We have already begun promoting the Quiet Wing capabilities at two on-site workshops including a PNNL Chemical Imaging Workshop on carbon dynamics and elemental cycling in subsoils and a microscopy workshop focusing on atmospheric aerosols at the May 2014 EMSL user meeting. Continued promotion of Quiet Wing capabilities will be conducted at future EMSL user meetings and on-site workshops. EMSL scientists will also promote capabilities and present science at targeted society meetings listed in Table 3.4. Additionally, we are beginning to work with program chairs to lead special sessions on microscopy and imaging at these international symposia including a proposed session on "Imaging Molecules in the Environment" at the 2015 AAAS annual meeting and proposed session on "Microscopy and Imaging in the Rhizosphere" at the 2015 Microscopy and Microanalysis annual meeting in Portland, Oregon.

4.0 Target Metrics

The long-term goals and outcomes of this effort are for these capabilities to truly distinguish EMSL and its science to BER and the broader scientific community: EMSL will be seen as the go-to place, or BER hub, for sophisticated high spatiotemporal chemical imaging and for the study of difficult scientific questions. A leading indicator of success will be that this Quiet Wing capability soon joins other EMSL capabilities such as mass spectrometry, nuclear magnetic resonance, and computation that are routinely over-subscribed. Additional indicators will be recognition of these capabilities in major invited talks (by both EMSL staff and users), review papers that highlight EMSL's pre-eminent capability, leadership in forward-looking capability/science workshops, and inclusion in National Academy or other reports and projections on science and technology direction. EMSL will strive to reach this level of accomplishment within the next 3 years and sustain this level for the next decade and beyond.

We propose a set of specific metrics aligned to the four goals listed in Section 1.1. There are four primary metrics well aligned to the goals; however, some of these (in particular, publications and special sessions at symposia) tend to be lagging indicators. In these cases, secondary metrics that are more leading or real-time indicators are also proposed to help manage performance against the primary metrics.

- Science impact:
  - Primary: High-impact publications featuring the capability in the Quiet Wing
  - Secondary: Number of BER-focused pre-publication science accomplishments submitted
  - Secondary: Number of distinguished participants on user projects
- Utilization: General utilization of major equipment in the Quiet Wing at the capability level
- Alignment: Utilization by projects aligned to BER missions and interests
- Outreach and leadership:
  - Primary: Number of workshops, special sessions, tutorials held
  - Secondary: Number of proposals submitted by potential users.

These metrics are benchmarked against fiscal year 2013 performance in the "Metrics and Targets for the Quiet Wing" table. Note: primary metrics are in bold. These metrics are well-aligned, but some tend to be lagging indicators. Secondary metrics are in italics; these are not the direct focus, but are more leading indicators.

Metrics and Targets for the Quiet Wing

Goal	Metric	FY13	FY14 Target	FY15 Target	FY16 Target
Science Impact	**High-impact publications**[1]	48	50	56	65
	Number of BER-focused pre-publication science accomplishments submitted	1	3	6	9
	Number of distinguished participants in user projects[2]	43	50	60	70
Utilization	**General utilization**[3]	29%	45%	55%	65%
Alignment	**BER-aligned utilization**[4]	2%	6%	15%	35%
Outreach and Leadership	**Number of workshops, special sessions, tutorials held**		4	5	6
	Number of proposals submitted by potential users	55	50	60	80

[1] Defined as number in top 10% journals
[2] Numbers include distinguished participants and PIs.
[3] Defined at the capability level across all major instruments based on available operating hours (hours used / hours available as a percent)
[4] Defined as percent utilization by projects aligned to BER science interests (a value of 4+ on alignment during proposal review); may be funded by other agencies

5.0 Sustainment

This strategic plan focuses on accelerated utilization and impact of the Quiet Wing over the next 2-3 years. This capability will require continued stewardship as it matures (i.e., 4-8 years and beyond). The EMSL Strategic Plan will include stewardship needs, further outreach, and other leadership actions for this capability. Annual measures will be added to EMSL's manual dashboard. Furthermore, EMSL commits to implementing similar approaches for accelerating new capabilities in the future.