EMSL Strategic Plan to Maximize Scientific Impact of HRMAC

PEMP Notable Outcomes Goal 3.2

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1.0 Introduction

Achieving a holistic, molecular-level understanding of cellular machinery and communication, microbial community dynamics, and other interactions between organisms and their environments remains a formidable scientific challenge. Realizing this goal would enable more rapid and cost-effective resolution of environmental problems, improved approaches for carbon capture and sequestration, efficient and large-scale biomass conversion processes, and improved energy storage and development methodologies. To this end, new analytical techniques that can provide universal molecular information to inform and guide our understanding of molecular dynamics in complex systems are needed. In response, a concept for a new mass spectrometry system that will offer unparalleled levels of molecular composition and structural detail at the Environmental Molecular Sciences Laboratory (EMSL) has been developed. This system, a High Resolution Mass Accuracy Capability (HRMAC), will provide unmatched ability to identify molecular and biomolecular species in complex systems.

HRMAC is being built and is one of three newly acquired capital assets funded by the Office of Biological and Environmental Research (BER). HRMAC will 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 jump start interest in the scientific community (especially in the BER community), accelerate the impact of this capability, and maximize the scientific benefit of that investment, the Performance Evaluation and 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 HRMAC 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 HRMAC

> HRMAC will offer unprecedented mass resolution and accuracy, more than any mass analyzer with co-located capabilities in high-throughput omics, imaging, and microfluidics. HRMAC will be the best, if not the only, capability in the world to characterize molecular species in complex systems including microbial communities, atmospheric aerosols, and the soil and rhizosphere ecosystem.

While Fourier transform ion cyclotron resonance (FTICR) offers the highest mass resolution and mass accuracy of any mass analyzer, our vision is to use HRMAC's even-higher resolution and accuracy to capture the full range of information for increasingly complex natural mixtures (e.g., atmospheric aerosols, soil [or dissolved] organic matter) and analytical problems (e.g., proteomics, metabolomics), particularly to advance science identified within the EMSL Science Themes and Leadership Areas. Because all key measures of FTICR mass spectrometry performance improve linearly (e.g., resolution, scan speed) or quadratically (e.g., mass accuracy, dynamic range) with increased magnetic field strength, a high-field (i.e., 21T) FTICR spectrometer will greatly enhance performance over any existing or contemplated mass spectrometry technique.[1] HRMAC will enable efficient characterization of proteins two to four times larger than presently attainable and enable characterization of the functional proteome. The unequivocal and distinctive ability of HRMAC to discern and characterize molecular species in complex systems will enable researchers to tackle current analytical grand challenges in omics and systems biology, intact proteins and protein assemblies, microbial communities, fossil fuels, atmospheric aerosols and other natural organic matter to address DOE mission needs[2]. The ultra-high resolving power offered by HRMAC will enable the determination of the isotopic fine structure for a wider range of biomolecules (peptides, proteins, and larger metabolites), thus providing new chemical and structural information. Similarly, it will facilitate measurements of isotopic patterns in (*in situ*) stable-isotope profiling experiments, including protein turnover and metabolic flux measurements.

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 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 basis for parameterizing these processes for incorporation into climate process models.

Fundamental questions in the chemistry and dynamics of atmospheric aerosols include the influence of mixed biogenic/anthropogenic emissions on the formation and aging of aerosols. The ultra-high resolving power and mass measurement accuracy produced by HRMAC will provide unambiguous speciation of aerosols. HRMAC will also deliver unique insights into the chemistry underlying atmospheric processing of biogenic secondary organic aerosols in the

[1] The second 21T FTICR mass spectrometer is at the National High Magnetic Field Laboratory in Tallahassee, Florida. It is stewarded by the National Science Foundation. Research is focused on petrolomics (e.g., analysis of crude oil) and human biology.
[2] Charges and reports on the Biological and Environmental Research Advisory Committee Web site at http://science.energy.gov/ber/berac/reports

presence of anthropogenic emissions, characterization of unique markers of this chemistry, and ultimately lead to improved representation of aerosol-cloud interactions in global climate models.

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 energy and molecules that are key to controlling cellular and intracellular functions.

EMSL and Pacific Northwest National Laboratory (PNNL) have a long history (more than 15 years) and scientific record of accomplishment in the proteomics and metabolomics arena. A well-established user base also will benefit from the state-of-the-art mass spectrometry that HRMAC will feature. Many proteomics users who rely on peptide-level proteomics want to extend their studies to intact proteins, recognizing this is still the only way to reliably understand protein regulation and ultimately biology. A broader scientific community views this as a natural progression in the field of proteomics, and EMSL is counting on HRMAC to stay on the leading edge of this field. Similarly, metabolomics will substantially benefit from HRMAC's ability to precisely and confidently determine elemental composition of a wide variety of organic molecules within complex mixtures (e.g., via resolved fine isotopic structure) and in a spatially resolved manner. EMSL will accordingly feature first science applications in the following areas to capture this community's interest and involvement:

Top-down proteomics. HRMAC will enable studies aimed at functional characterization of intact proteins (including combinatorial post-translational modifications, proteolytic processing, and site mutations) and protein machines within the natural or engineered plant, fungal, and microbial systems. For instance, HRMAC will facilitate in-depth characterization of complex and heterogeneous glycoforms in fungal secretomes and provide important information for functional studies of glycosylation and biotechnological applications. HRMAC will enable efficient characterization of proteins two to four times larger than presently attainable and enable characterization of functional proteomes.

Mass spectrometry-based imaging for decoding the chemical language of bacteria, fungi, and plants. HRMAC will facilitate studies to spatiotemporally characterize intact molecules (metabolites, peptides, and proteins) in complex samples originating from natural or engineered plant, fungal, and microbial systems. The new high magnetic field FTICR platform will dramatically increase spectral acquisition rate and attainable sensitivity, thus enabling high-throughput measurements at higher spatial resolution than ever before. For instance, this capability can be used to characterize intact molecular structures in soil while addressing spatial relationships and heterogeneity. In combination with fluorescence *in situ* hybridization (FISH) and nanoSIMS (secondary ion mass spectrometry), these experiments will enable linking biota with processes at the submicron scale.

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 on 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 the 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.

HRMAC can make significant contributions to understanding the chemistry and dynamics of the below-ground carbon cycle by identifying and precisely quantifying intact molecular structures derived from higher plants, the soil microbial community, and mycorrhizal fungi within their native three-dimensional (3D) inorganic soil matrix. The overall aim is to advance molecular-scale mechanistic understanding of the role of physical, geochemical, and biological processes in the persistence of soil carbon below ground by addressing spatial relationships and heterogeneity to a level of detail not previously attainable.

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 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. Others 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 Spectrometer Design Advisory Committee (Jonathan Amster, University of Georgia; Evan Williams, University of California, Berkeley) has provided advice and will be retained or appropriately reconstituted ("Candidates for the HRMAC Advisory Committee" table) for the following:

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

Candidates for the HRMAC Advisory Committee

Advisory Member	Institution	Focus
Colleen Hansel	Woods Hole Oceanographic Institution	Marine chemistry and geochemistry
Janet Jansson	PNNL	Microbial ecology
Sergey Nizkorodov	University of California, Irvine	Aerosol photochemistry
Barbara Finlayson Pitts	University of California, Irvine	Atmospheric chemistry
Jennifer Pett-Ridge	Lawrence Berkeley National Laboratory and JBEI	Microbial ecology and biogeochemistry
Blake Simmons	Joint BioEnergy Institute and Sandia National Laboratories	Biomass science and conversion technology
Gary Stacey	University of Missouri	Host-microbe interactions
James Tiedje	Michigan State University	Microbial ecology
Susannah Green Tringe	Joint Genome Institute (JGI)	Microbial ecology
Judy Wall	University of Missouri	Biochemistry

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

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 approached 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.

[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

Science Theme	Researcher	Institution	BER Role	Focus
AAS	Scot T Martin	Harvard University	GO Amazon Campaign (Atmospheric System Research [ASR]); BER principal investigator (PI)	Formation and Life Cycle of Atmospheric Organic Aerosol: Molecular-Level View
BDD	Jon K Magnuson	PNNL (and Joint Bioenergy Institute [JBEI])	BER-funded through JBEI	Heterogeneity of heterologous glycoside hydrolases
	Bradley Tebo	Oregon Health Sciences University	National Science Foundation	Studies Mn oxide mineral formation by an expressed bacterial Mn(II,III)-oxidizing multicopper oxidase. Top-down and native mass spectrometry (MS) to study the secretome
BDD and TSE	Colleen Hansel	Woods Hole Oceanographic Institution	JGI-EMSL proposal; BER PI	Investigations of the role of secreted proteins and reactive metabolites in carbon degradation by ascomycete fungal communities
TSE	Vanessa Bailey	PNNL	BER PI	Focuses on the structure, function, and manipulation of microbial communities in terrestrial ecosystems to understand and enhance carbon sequestering systems in soils.
	John Bargar	SLAC National Accelerator Laboratory	SLAC Science Focus Area research manager and co-PI	Coupling of subsurface natural organic matter (NOM) to biogeochemical cycling of Fe, S, and U in the subsurface at the DOE-BER-CESD-funded Rifle, Colorado Integrated Field-Research Challenge (IFRC) field research site. A unique combination of HRMAC, nanoSIMS, near edge X-ray absorption fine structure (NEXAFS) and Fourier transform infrared (FTIR) spectroscopy to characterize chemical composition and transformations within NOM-rich sediments.
	Paul Dijkstra	Northern Arizona University	EMSL Science Theme proposal in collaboration with TES project at the University of Central Florida (Ross Hinkle PI)	Analyzing the soil microbial central C metabolic network under contrasting conditions of carbon availability and oxygen concentration in a Florida landscape

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 the use of all three new capabilities (the Radiochemistry Annex, the Quiet Wing, and HRMAC). While HRMAC is not yet available, EMSL envisions fast tracking toward first science by conducting experiments on lower field FTICR instrumentation at EMSL to provide comparative data and better inform, guide, and optimize experiments that will be performed when HRMAC is online. 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 listed in the "High-impact, BER-aligned Target Users" table.

High-impact, BER-aligned Target Users

Science Theme	Researcher	Institution	BER Role	Focus	Prior EMSL User?
AAS	Rainer Volkamer	University of Colorado	ASR funding, BER PI	Secondary organic aerosols formation mechanisms at the molecular level	Yes
	Qi Zhang	University of California, Davis	ASR funding, BER PI	HRMAC will be used for characterizing the molecular composition of phenol-derived, high-molecular mass organic species	Yes
	Jian Wang	BNL	ASR-funded SFA	The evolution of aerosol chemical composition as the aerosol is transported downwind of major sources	
BDD	Scott Baker	EMSL	BER PI	Top-down proteomic analysis of Yarrowia lipolytica during the transition to lipid accumulation. Top-down proteomics will enable quantitative characterization the spectrum of post-translational modifications affecting metabolic enzymes of the triglyceride biosynthetic pathway prior to and after nitrogen starvation	Yes
	Richard Ferrieri	Brookhaven National Laboratory	Former BER PI	Study Setaria viridis as a model grass system for exploring mechanisms underpinning bacterial association by plant growth promoting rhizobacteria	Yes
	Jim Fredrickson	PNNL	Foundational Scientific Focus Area (FSFA), BER PI	Understand, at the species level, the dynamics of microbial populations and their gene regulatory networks in response to environmental perturbations	Yes
	Cheryl Kuske	Los Alamos National Laboratory	SFA, BER PI	Test the hypothesis that secretomes from soil fungi in temperate forests and arid grasslands are responsive to altered C and N deposition using top-down and imaging capabilities	

High-impact, BER-aligned Target Users (continued)

BDD (continued)	Bill Morgan	PNNL	Low Dose Radiation Research Program Scientific Focus Area Lead, BER PI	Top-down proteomics enabled by HRMAC will be employed to study the “true” proteome (i.e., post-translational regulation in the context of low-dose radiation exposure); focus on epigentetics	
	Blake A Simmons	JBEI	BioEnergy Center	Understanding lignin depolymerization in ionic liquid and lignin decomposition (i.e., lignomics)	Yes
	Anne Summers and Judy Wall	University of Georgia and University of Missouri	BER PIs	Ultrahigh resolving power will enable characterization of Hg modifications on intact proteins to shed light on biological Hg transformations and their relationship to Hg intoxication	Yes
BDD and TSE	Mary K. Firestone		JGI-EMSL joint proposal; BER PI	Mapping soil carbon from cradle to grave using comparative transcriptomics, proteomics and metabolite analysis to identify the microbial blueprint for root-enhanced decomposition of organic matter	Yes
	Kirsten S. Hofmockel	Iowa State University	BER PI; JGI-EMSL joint proposal	Linking genomic function to C metabolism and warming; and developing novel approaches to target microbial drivers of C cycling in soil aggregates.	Yes
TSE	Baohua Gu	Oak Ridge National Laboratory	Member of the Next-Generation Ecosystem Experiments (NGEE) Arctic Biogeochemistry team	Characterization of dissolved organic matter and soil organic matter from BER's NGEE Arctic campaign and Hg-solid organic matter complexes in samples from the Arctic campaign.	Yes
	Jennifer Pett-Ridge	Lawrence Livermore National Laboratory (LLNL)	BER PI	Characterization of tropical soil carbon and soil microbial communities in both dissolved and mineral-associated pools to test the effects of soil warming.	Yes
	Margaret Torn	LBNL	BER PI	Characterization of mineral-organic matter associations in the subsurface	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 HRMAC. 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 HRMAC at several upcoming scientific meetings (Table 3.3) that are well aligned to the science vision and user base. These meetings include:

- EMSL User Meeting and EMSL Science Theme meetings (STAP);
- BER PI meetings (Genomic Science Program [GSP], Subsurface Biogeochemical Research [SBR], Bioenergy Research Center [BRC], Atmospheric Radiation Measurement [ARM]); SFSA/SFA meetings;
- National society meetings; and
- Selected BES User Facility Meetings (user facility cross-fertilization).

A list of PI and national meetings is presented in the "Targeted Meetings to Promote HRMAC" table.

Targeted Meetings to Promote HRMAC

Fiscal Year 2014 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	
American Chemical Society (national and regional meetings)	Various
European FTMS Workshop 2014	April 22-25, 2014
EMSL Integration 2014 User Meeting "Atmospheric Organics"	May 6-7, 2014
Fiscal Years 2014-2016 Society Meetings	
American Association for the Advancement of Science (AAAS)	February 12-16, 2015
American Society for Mass Spectrometry (ASMS)	June 15-19, 2014 May 31-June 4, 2015 June 5-9, 2016
American Society for Microbiology (ASM)	May 17-20, 2014 May 30-June 2, 2015
American Society of Plant Biologists (ASPB)	July 26-30, 2015
Goldschmidt Conference	June 8-13, 2014 August 16-21, 2015 (with permission) June 26-July 1, 2016 (with permission)
International Society for Microbial Ecology (ISME)	ISME 15 August 2014 ISME 16 August 2016 (with permission) ISME 17 August 2018 (with permission)
Pacifichem 2015 Pursuing HRMAC-specific session	December 15-20, 2015

Over the longer term, as lead time for planning permits and both the user base and the EMSL scientific base expand, EMSL will host workshops on-site to attract new users and inform the existing user base about its advanced capabilities, including HRMAC. The goal of these workshops will be to develop scientific interest and expertise, and foster collaborations for increasing the value of HRMAC to BER science. EMSL scientists will also conduct special sessions at national society meetings, for example, to bring together researchers interested in science that is enabled by HRMAC alone or in combination with other state-of-the art instrumentation at EMSL. The PIs at EMSL are also involved at several levels in other publications and national societies, and are able to use information gained here to plan early and get involved in national and international activities related to conference and workshop organization. As an example, several EMSL scientists participated in the recent Stanford Synchrotron Radiation Lightsource (SSRL) and the Linac Coherent Lightsource (LCLS) Annual Users' Meeting and Workshop (October 2013), which brought together scientists investigating the biotic and abiotic forces affecting the carbon cycle using synchrotron radiation and other complementary techniques. As a result, several existing Science Theme proposals now feature mass spectrometry (including HRMAC) as a means of studying natural organic matter in soils and subsurface sediments. While the initial experiments will be accomplished using lower magnetic field (12T and 15T) FTICR spectrometers currently available at EMSL, HRMAC will boost attainable chemical specificity and allow elemental composition (molecular formula) of a broader range of species to be read directly from the mass spectrum. These initial, lower-field experiments will provide valuable experience and background with samples and other matters that can facilitate expedited use of HRMAC once available, as well as provide excellent comparative capability examples. Ultimately, these workshops are opportunities to achieve visibility and recognition for unique abilities and contributions.

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—for EMSL to be seen as the go-to place, or BER hub, for sophisticated complex organic composition/structure characterization and answering the most challenging scientific questions. A leading indicator of success will be that this capability soon joins other capabilities at EMSL. 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 to sustain such pre-eminence 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 are proposed that are more leading or real-time indicators to help manage performance against the primary metrics.

- Science impact:
  - Primary: High-impact publications featuring HRMAC
  - Secondary: Number of BER-focused pre-publication science accomplishments submitted
  - Secondary: Number of distinguished participants in user projects
- Utilization: General utilization of HRMAC
- 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

Metrics and Targets[1]

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

Goal	Metric	FY15 Target	FY16 Target
Science Impact	**High-impact publications**[2]	6	12
	Number of BER-focused pre-publication science accomplishments submitted	4	8
	Number of distinguished participants in user projects	6	12
Utilization	**General utilization**[3]	60%	80%
Alignment	**BER-aligned utilization**[4]	50%	70%
Outreach and Leadership	**Number of workshops, special sessions, tutorials held**	2	3
	Number of proposals submitted by potential users	20	40

[1] While the system will become available to the wider user community in late 2015, we are seeking researchers interested in conducting preliminary studies on mass spectrometry instrumentation currently available at EMSL to provide staging experiments, provide surrogate samples and generate comparative data to better inform, guide and optimize future experiments on the new, high-magnetic field FTICR platform.

[2] Defined as number in top 10% journals

[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 HRMAC 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.