<u>In-Progress Working Draft</u>

Preliminary Briefing Report on Wayne State University Research Competencies and Strategic Opportunities

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I. Introduction

This preliminary report sets out an independent and detailed assessment of Wayne State University's research capacities and possible opportunities for enhancing research at the University, with an emphasis on multi-disciplinary research opportunities aligned with broader needs of the Detroit region as well as broader societal challenges.   This assessment is intended to inform and complement the ongoing strategic planning effort for the University that President Wilson announced in early 2014.

As a foundational analysis for understanding the position of Wayne State University's research enterprise, this assessment seeks to identify existing research competencies at the University as the building blocks for advancing future research opportunities. As defined by Hamel and Prahalad in *Competing for the Future,*[1] a "competence" is a bundle of skills and technologies representing the sum of learning across individual skill sets and organizational units.

A key premise of this effort is that rather than a "field of dreams" approach of simply picking "hot" areas of multi-disciplinary research, it makes more sense to consider the base of existing capabilities and excellence at Wayne State University for identifying opportunity areas.   The ultimate aim of this focus on research enhancement is to identify in consultation with University leaders, faculty and other key stakeholders three to five strategic R&D focus areas at Wayne State University to pursue as well as offer bold but realistic strategic investment approaches for Wayne State University in these targeted opportunity areas.

In this preliminary briefing report, a number of the key project objectives are addressed, including:

- What are the existing and emerging research competencies of Wayne State University?

- How can Wayne State University best align these research competencies into strategic opportunity areas advancing multidisciplinary research as well as addressing broader industry and community needs in the Detroit region?

To provide the independent and expert analysis to inform this assessment, Wayne State University retained the services of the Battelle Technology Partnership Practice (TPP). Battelle TPP is the technology-based economic development consulting arm of Battelle, the nation's largest nonprofit research and development organization, with more than 22,000 scientists, technologists, and specialists at more than 130 locations globally. Battelle TPP has experience working with leading research institutions — such as Carnegie Mellon University, Washington University, University of Arizona, and University of Southern California — but also has partnered with universities and university consortiums that have a commitment to their region and local community, such as the University of Massachusetts Boston, Georgia Research Alliance, Arkansas Research Alliance, and the University of Connecticut.

- [1] Hamel and Prahalad, Competing for the Future, Harvard Business Press, 1994, pg 90 and 217.

A. Key Findings

Battelle's review of Wayne State's research enterprise suggests a current trajectory of decline despite a substantial base to build upon (with not only a high overall research volume but specific areas of research focus and scholarly activity). There is a critical need , and opportunity, for Wayne State University to transform its research enterprise in line with the emerging 21st century research paradigm of integrating use-inspired and translational research involving multi-disciplinary approaches grounded in addressing research challenges posed by Detroit's needs and broader societal challenges.

Using both quantitative and qualitative methods, Battelle applied a rigorous approach that identified 29 specific research competencies at Wayne State University**. These research competencies can be grouped into two major categories: 19 are in life sciences and biomedical fields and another 10 are found across engineering, physical sciences and social sciences.

The assessment of research competencies at Wayne State University is the first step to advancing a more forward looking and transformative research enhancement strategy aligned to the demands for research in the 21st century. Today, each of the research competencies makes significant contributions to the status and stature of Wayne State University in terms of research funding and scholarship output. Looking forward, these research competencies can serve as the building blocks – offering a critical mass of faculty expertise and research assets – for leading-edge multi-disciplinary research platforms at Wayne State University.

Ideally the multi-disciplinary research platforms to be advanced at Wayne State University would comprise:

- Leveraging of multiple major core competencies, especially those comprising world-class areas of strength at the University
- A line-of-sight to impacting Detroit Metro Area/Urban industry and community challenges and opportunities.
- A line-of-sight to impacting global challenges and opportunities.

The line of sight to both local and global challenges and opportunities that leverage Wayne State University's existing research competencies fall into two broad categories:

- **Societal Challenge Opportunities** focusing on research directed towards societal and community needs involving basic inquiry and encouraging multi-disciplinary translational research directed toward advancing solutions to those identified needs. In today's world many of the most pressing societal challenges involve public health, climate change, education, growing disparities, food security, water resources and economic sustainability.

- **Technological Challenge Opportunities** that deploy and leverage research to advance the development of transformative technologies that have the potential to re-envision existing products, create new markets, and possibly even foster new industries. Wayne State offers a number of more technologically-based research competencies that have the potential to link

basic biological and physical research with engineering to create products and services for the future. Often these technological challenge opportunities are termed "disruptive innovation" in recognition of how they can offer new possibilities in how we live, communicate and work.

B. Societal Challenges Informing Multi-Disciplinary Research Platform Opportunities

Significant efforts and building blocks are in place to focus WSU broadly as a leading university focused on use-inspired and translational research challenges addressing "urban transformations." This represents a broad theme and can be further delineated into specific platform areas. It would involve university-wide efforts to address urban public health systems (environmental urban health issues, health disparities, re-engineering of hospitals and health systems), pressing medical problems (reproductive health, cardiovascular, traumatic brain injury, and cancer), urban behavioral health (child development, lifespan, workplace/societal violence), urban infrastructures (water, transportation) and urban educational systems.

Being more specific, five areas of focus for multi-disciplinary research platforms might include:

Urban Child and Lifespan Development – Examining the challenges, characteristics and needs pertaining to children and adolescents in urban communities. This could encompass a diverse research universe, ranging from fundamental studies of gene expression and physiology through to studies of the social, family and environmental conditions impacting children, youth, and aging adults, and learning strategies. It may also include taking a holistic approach to the study of human health, environmental factors and changing physiology across the lifespan, seeking to elucidate childhood and adolescent antecedents to adult disease and changes in health and well-being from the fetus through old age..

Health Disparities – Working to identify and characterize causes and typologies of health disparities and to develop solutions for limiting or eliminating major health disparities, especially in urban populations.

Behavior and Behavioral Interventions – Researching the causes and effects of risk behaviors and developing and testing interventions. At Wayne State, this can span a spectrum from fundamental studies in behavioral neuroscience to the development of specific interventions in areas of strength for the University such as: maternal lifestyles; drug abuse; STDs and infectious disease; violence; and obesity. Translational research can occur not just in the development of effective interventions, but also in the development of novel tools and technologies to facilitate interventions.

Environmental Health, Prevention and Livable Communities – Working to identify and characterize elements of the environment that impact health, and to elucidate the relationships, and mechanisms of action, between environmental factors, disease morbidity, and health outcomes. This is becoming a reinvigorated area at Wayne State University with the recent CURES grant award. Looking forward, it offers opportunity for even more broad engagement with the university's strengths including establishing the gene-environment linkage drawing on the university's strengths in genetics and genomics including new diagnostics; prevention leveraging broader behavioral science applications for individuals; and broader community systems to monitor, educate and generate solutions to deep-rooted environmental health challenges.

Urban Revitalization and Development – Applying studies of the built environment, social forces, education, economics and other social-science oriented factors that support or hamper economic revitalization, economic health and sustainability of large urban areas.

It is evident that even among the five themes above there are trans-thematic linkages. For example:

- Disparities in socio-economic status, living environment, etc. have an impact on behavior
- Disparities in socio-economic status, living environment, etc. have an impact on child and lifespan development
- Environmental health factors impact child development, behavior and health across the lifespan
- Urban revitalization and development impacts the environment, socio-economic conditions and other factors impacting upon the health-oriented themes.
- Behavior and behavioral interventions will impact incidence of risk behavior impacting child development and health across the lifespan.

C.   Technology Innovation Opportunities

As noted previously, the review of core competencies at Wayne State University also identified a series of University strengths pertaining to specific technologies – including the development and application of technologies. In particular, Battelle's review suggests that there are opportunities to leverage Wayne State's technological capabilities to build robust technology-development platforms focused on:

- **Imaging and Diagnostics for Precision Medicine –** Wayne State University has a strong focus on medical imaging to build upon and a more emerging focus on diagnostics from the device to the development of clinical genetics/molecular diagnostics tests. Key resources to be tapped include the MR Center, the PET Center, the Applied Genomics Technology Center, the Center for Molecular Medicine and Genetics, and specific research programs that are growing in advanced nano-microfluidic devices that offer high content analysis to detect and analyze disease and in vivo molecular-genetic imaging. These imaging and diagnostics technologies are the backbone for the future of medicine as more specific patient-oriented assessment and treatment plans are advanced. Wayne State University can help lead the way in disease diagnosis and treatment targeting from imaging to genomics

- **Immunotherapies** – Addressing the immune system to fight off infections is a well-developed approach for medical treatment, involving preventative vaccines, anti-viral drugs and antibiotics. Advances in modern biosciences – increasing understanding of disease pathways and how the human immune system functions – are leading to a broader range of "immunotherapies" to induce, enhance or suppress the immune system for a wide range of diseases from infectious diseases, such as HIV/AIDS, to cancers, autoimmune and other chronic diseases. Wayne State University has active efforts involved in the development of cell-based cancer vaccines to improved approaches for antibiotic treatment of medically acquired infections, as well as a long standing focus on HIV disease management.

- **Data to Decision Systems** – This platform focuses on sensors and sensor systems for real-time data gathering, analysis and decision-making connected to industrial systems applications, logistics and supply chain, and health care patient monitoring. This multi-disciplinary platform brings together growing activities in large database informatics, wireless networking, systems modeling and simulation and sensor development taking place at Wayne State University.

- **Materials for Life Sciences Applications** – Utilizing core competencies in chemistry, physics, materials science and biological sciences to develop biocompatible materials, films, coatings, degradable polymers, microparticles and other materials for in vivo biomedical applications. Linking Wayne State University's activities in nanotechnology and biomaterials with clinical applications is of critical value.

- **Systems approach to manufacturability** – A key challenge for advanced manufacturing is reducing the time for product development through enhanced design; reducing costs in manufacturing processing through less expensive materials, reduced number of parts and alternative fabrication using forming and joining techniques; and reducing component testing and qualification. This involves a wide range of engineering disciplines including use of computer modeling and simulation, instrumentation for real-time data gathering and performance prediction and non-destructive testing. Of particular importance for the Detroit region is applying these systems approaches for manufacturability to the next-generation of automotive systems in specialized areas such as electric vehicle power and propulsion and vehicle safety systems.

II. Current Status of Wayne State University

A. The Importance of Research for WSU

Research is an integral part of the character and operations of Wayne State University. Classified by the Carnegie Foundation as a RU/VH institution (Research University/Very High Research Activity), the highest category of research institution, Wayne State is placed within a prestige group of 108 U.S. institutions (the same peer category as the University of Michigan, John's Hopkins University, Cornell University, UCLA, and Penn State, to name a few).

Being highly active in research carries intrinsic benefits for Wayne State University and its key stakeholders:

- Significant research discoveries enhance the reputation of faculty and the University, serving to enhance the attractiveness of the institution to top quality domestic and international students.

- The performance of research serves as a practical training ground for undergraduate and graduate student skills development.

- Engagement in research keeps faculty on the leading-edge of their discipline and enhances their teaching.

- Interdisciplinary research crosses traditional departmental boundaries and provides stimulus for the development of innovative trans-disciplinary education programs.

- Externally sponsored research provides funding to support faculty salaries and graduate student studies, and provides indirect cost support for university infrastructure and services.

- Research innovations may result in high value intellectual property.

- Research advancements can improve clinical practice within the academic medical center and bring leading-edge treatments to the clinic.

- The performance of research can be an important component in the attraction of donor support and philanthropic gifts for the University.

As Paul Johnson notes:

> *Some research benefits are obvious - for example, benefits of an economic kind (a new product, technology or service), a social kind (increased knowledge of relevance to policy makers), of an environmental kind (improved techniques to ensure sustainable food production), of a cultural kind (increased understanding of cultural values or social approaches) or of a health kind (a better understanding of the causes of medical conditions or better means of delivering health services).* [2]

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[2] The University of Western Australia - Paul Johnson, Vice Chancellor. Accessed online at:
http://www.news.uwa.edu.au/201203194542/vice-chancellor/importance-academic-research

The framework of U.S. research in the 21st century is undergoing significant change. Through much of the 20th century, a typical university research approach, encouraged by federal funding, focused on supporting either basic or applied research activities, which had very distinct goals in mind. The objective of basic research was intended to advance fundamental knowledge and the scientific theories in areas such as matter, physical processes, biological function, and human nature without regard to its practical applications. In contrast, applied research sought to apply well-understood basic research insights in making something work or in solving a practical problem. This lead to the notion of the "ivory-tower" where universities pursue a linear, sequential flow of discovery-based research followed by more applied development activities, often divorced from those involved in basic science and undertaken in concert with key industry, healthcare and government stakeholders. Often this "ivory tower" focused on advancing research within specific academic disciplines and created a world of university research dominated by clear delineations of departments. As James L. Applegate explains, "It is sometimes said that society has problems, while universities have departments."[3]

This dichotomy between basic and applied research is today very much in question with the recognition of "use-inspired" research. A powerful insight advanced by the late Donald Stokes, a faculty member at Princeton University, is that the linear continuum between basic and applied research is too simplistic and misses the more complex rise of "use-inspired" research in how basic science and technology advances interact. Stokes cited the model case of fundamental, basic research undertaken by Louis Pasteur as an example of "use-inspired" research with the intention of addressing a significant societal need that laid the foundation of microbiology nearly a century ago.

What "use-inspired" research recognizes is that the relationship between basic science and technological change has been fundamentally altered in today's advanced knowledge-based age. Technology today is increasingly science-based, while science has been increasingly technology-based--with the choice of problems and the conduct of research often inspired by societal needs. An example is the work of the quantum-effects physicists who are probing the phenomena revealed by the miniaturization of semiconductors from the time of the transistor's discovery after World War II. [4] Instead of a split between basic and applied research, university research activities now function in a more complex interweaving of basic, applied and use-inspired research.[5]

Where does that technology come from?
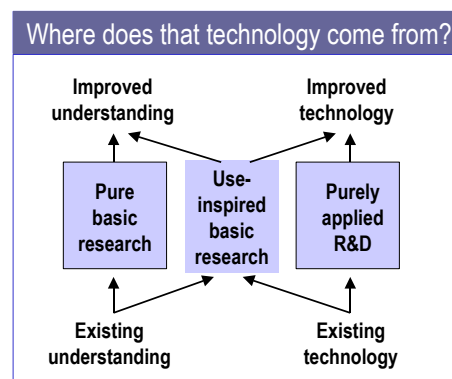
Source: Stokes, *Pasteur's Quadrant*

Perhaps no field of science is embracing this focus on use-inspired research and forcing the barriers between basic research and their applications to breakdown within universities than in biomedical research. The fast pace of basic research advances in biotechnology is reshaping all aspects of

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[3] James L. Applegate, "Engaged Graduate Education Seeing with New Eyes, Association of American Colleges and Universities, 2004, page 6.

[4] See http://www.brookings.edu/research/books/1997/pasteur to learn more about Donald Stokes' assessment set out in its widely acclaimed book, Pasteur's Quadrant.

[5] James Applegate, op. cit., page 5.

biomedical development—including the way we study medicine, discover and develop therapeutics, and diagnose and treat diseases and medical conditions for both humans and animals. At the same time, biomedical sciences development has a unique translational research requirement that calls for especially close connections between academic medical centers and industry**.** The connection between biomedical product advancement and clinical care is not simply one of advancing a supplier and buyer relationship. Instead, there is a close and necessary interface of "bench and bedside" for biomedical innovation to move forward. The U.S. National Institutes of Health (NIH) explains that "information flow at this interface is bi-directional, requiring close interaction between clinical and bench scientists."[6] For instance, physician observations often provide insights into unmet medical needs or protocol refinements. Those involved in research and product development often find insights for applications from epidemiological studies and conversations with clinical practice professionals. Furthermore, advances in life sciences to treat human health require extensive clinical trials to ensure the safety and efficacy of new medical products, which in turn call for close collaborations between industry and clinicians.

Along with the recognition of the importance of use-inspired research as a paradigm for 21st century university research, there is a growing recognition that traditional basic sciences are converging and deep strengths in single disciplines are insufficient to address basic research questions. As the Chronicle of Higher Education notes, "[interdisciplinary] partnerships are proliferating in academe—and slowly changing the face of science—because they offer the best hope for answering some of the thorniest research subjects including climate change, biodiversity and cancer."[7] World class university research now depends upon advancing multi-disciplinary basic science teams that recognize this convergence of sciences as necessary for addressing key research problems and applications development.

Again biomedical development may be leading the way as it stands out as a convergence point for academic basic research in engineering, information technology, nanosciences, and communications/media. However, this convergence is occurring across an array of scientific disciplines resulting in significant advancements, including, for example: nanotechnology improving how drugs can be delivered; while information technology unlocking a multitude of "hidden" insights, from analyzing the human genome to advances in digital technology, which are improving how we diagnose diseases and monitor patients. Because of this convergence, the biomedical sciences offer enormous potential for linking basic research innovations across a wide range of other disciplines. As a result, there is a strong need for bigger teams of scientists undertaking discovery and development.

The implications of this changing 21st century research paradigm for Wayne State University are transformational – business as usual will result in the decline of the university's research enterprise. Traditional academic schools and departments must become more agile in advancing collaboration or they risk holding back the quality and impact of Wayne State University's research enterprise. Key needs in Detroit, and broader societal challenges, are not simply focus areas for "community

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[6] National Institutes of Health, Request for Applications for Regional Translational Research Center Planning Grants, page 4, October 2004.

[7] Jeffrey Brainard, "U.S. Agencies Look to Interdisciplinary Science," *Chronicle of Higher Education,* June 14, 2002.

engagement and service" but need to be understood as defining challenging research questions to be studied. Wayne State University – in its multiple roles as a leading public research university, significant academic medical center and urban-serving university – must identify strategies for combining use-inspired research and translational research in transforming how it advances and enhances multi-disciplinary research strengths that bring together basic and applied research to have greater societal impact.

A way to describe this 21st century research focus might be best stated as a "concurrent strategy for research." Stephen Cross, Senior Vice President for Research at Georgia Tech explains their approach to research in the 21st century:

> While most universities pursue a linear, sequential flow of discovery-based research followed by occasional declaration of intellectual property and subsequent licensing or company formation/spin-out; Georgia Tech pursues a concurrent strategy centered on the core research areas … selected because they are appropriate aggregations of core competencies represented in over 300 research centers and laboratories at Georgia Tech, their interdisciplinary and trans-disciplinary nature, the alignment with strategic markets within the region, and the existence of industry partners interested in working with the Institute.[8]

It is this transformational view of 21st century university research that is guiding the analysis and identification of opportunity areas for Wayne State University.

B.   WSU in the Rankings

While research is, and should be, regarded as a key element of the mission and operations of Wayne State University, it is also an important contributor to the stature of the University and its ranking among academic peers – globally, nationally and regionally. Rankings help to place the University within a peer context, but it should also be noted that they also play a significant role in influencing key decision of undergraduate and graduate students (in terms of where to enroll), faculty (in terms of where to pursue their career), employers (in terms of where they recruit), and certain funders (in terms of where they approach for sponsoring research).

1. Global Rankings

At the present time, there is considerable room for improvement in Wayne State University's global rankings. Within the two most frequently cited academic ranking schemata for universities (the "Academic Ranking of World Universities" produced by Shanghai Jiao Tong University and "THE World University Rankings" produced by Times Higher Education), Wayne State ranks quite far down the lists:

- In the Academic Ranking of World Universities, Wayne State has been placed in the 301-400 ranking category since 2010 (having dropped in the rankings from the 201-302 category in 2009 and previous years).

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[8] Stephen E. Cross, "Strategic Considerations in Leading an Innovation Ecosystem," GSTF Journal on Business Review, 2013, vol. 2, no. 3, 104-109,

- In the Times ranking of world universities, Wayne State places in the 301-350 ranking category.

The Shanghai Jiao Tong University format provides a broad range of rankings across various metrics and these serve to further illustrate Wayne State's comparative position among global universities. Some key points for Wayne State include:

- Certain broad subject fields stand-out for having a higher ranking than that for the University overall. Most notably, for 2013 these are: "Natural Sciences and Mathematics" ranked in the 151-200 category; "Clinical Medicine and Pharmacy" ranked at 151-200, and "Social Sciences" similarly with a 151-200 ranking).

- Among subject fields, "Chemistry" was ranked in the 76-100 category until 2012, but dropped into the 101-150 category for 2013. Mathematics and Physics each rank in the 151-200 category for 2013.

Using "Institutional Income" (where Wayne State ranks 172nd among 780 ranked institutions, a percentile of 22) as a baseline metric for comparing the University across other Shanghai rankings serves to illustrate some strengths and weaknesses of the Wayne State research position:

Table 1: Wayne State University Rankings and Percentiles in Metrics Reported within the Academic Ranking of World Universities

Ranked Above Baseline of Institutional Income (percentile 22)	Ranked Below Baseline of Institutional Income (percentile 22)
Number of Doctoral Degree Awarded Ranked 53 among 805 institutions. (6.6 percentile)	Institutional Income per Student Ranked 300 among 775 institutions. (38.7 percentile)
Number of Academic Staff (Research Only) Ranked 86 among 575 institutions.(15 percentile)	Total Amount of Research Income Ranked 203 among 744 institutions. (27.3 percentile)
Number of Academic Staff (Teaching Related) Ranked 140 among 869 institutions. (16.1 percentile)	Research Income per Academic Staff Ranked 312 among 554 institutions. (56.3 percentile)
Total Number of Academic Staff Ranked 99 among 621 institutions. (15.9 percentile)	Research Income from Industry Ranked 391 among 711 institutions. (55 percentile)
Research Income from Public Sectors Ranked 162 among 753 institutions. (21.5 percentile)	Number of Highly Cited Researchers Ranked 362 in the world.
	Number of SCIE and SSCI Papers Ranked 212 in the world.

These data suggest that Wayne State compares favorably in terms of its overall size among global universities, and in attracting public sector funds for research. However, in terms of key research metrics such as overall research income, research income per student and per academic staff member, and research income from industry, Wayne State ranks in a lower percentile than in the baseline of overall institutional income. It is also important to note that Wayne State, in the Shanghai rankings, places at just 362nd in the category of "highly cited researchers".

2. Domestic Rankings

The National Science Foundation provides the most thorough comparison of research expenditures for universities. Table 2 sets out Wayne State University's ranking for total research expenditures from all sources (federal, industry, state, philanthropy, etc.). It is important to consider, these rankings across all research universities and the smaller subset of public research universities, especially given the difficult fiscal condition of states in recent years.

Among all research universities, both private and public, Wayne State University's ranking in 2012 stood at 84th. This represents a significant drop in Wayne State University's ranking among all universities since 2007, when the university was 73rd. When compared to just public research universities, Wayne State has slipped just four places in its national ranking from 2007 to 2012, from 50th to 54th.   This reflects the fact that public research universities across the nation have faced a difficult budget environment with the severe cutbacks due to the recent recession.

Table 2: Wayne State University Rankings in Federally Funded R&D and Total University Research Expenditures. Source=National Science Foundation[9]

Data Year	Wayne State University's Ranking Among all Research Universities in Total Research Expenditures (all sources)	Wayne State University's Ranking Among Public Research Universities in Total Research Expenditures (all sources)
2012	84	54
2011	81	52
2010	78	51
2009	75	52
2008	73	52
2007	73	50

B.   Research Funding Levels and Trends

The National Science Foundation also tracks R&D expenditures at universities by R&D field. The NSF reported data for Wayne State are shown in Table3. Overall R&D expenditures at Wayne State University have grown slightly over the past six years (2007-2012), ranging from a high of $259.9 million in 2011 to a low of $238.7 million in 2007.   A closer examination suggests the general variability of year-to-year growth in research expenditures at Wayne State with this growing from 2007 to 2009, declining from 2009 to 2010, growing from 2010 to 2011 and then declining from 2011 to 2012. Nationally, university research expenditures have continued to rise each year since 2007, though the growth in the most recent year, 2011 to 2012, was less than 1%.

Still, as predicted by the Vice President for Research and others such as the Dean of the School of Medicine back in 2008, the growth in research at Wayne State University has been weak[10]. Over the

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[9] Accessed online at: https://ncsesdata.nsf.gov/profiles/site?method=view&fice=2329

period 2007-2012, Wayne State's total research expenditures rose a mere 3% compared to 27.5% nationally. So over this period, Wayne State University's share of the U.S. in university research expenditures fell from 0.46% to 0.37%.

Table 3:   Wayne State University Total R&D Expenditures by Field 2008-2012.
Source=National Science Foundation[11]

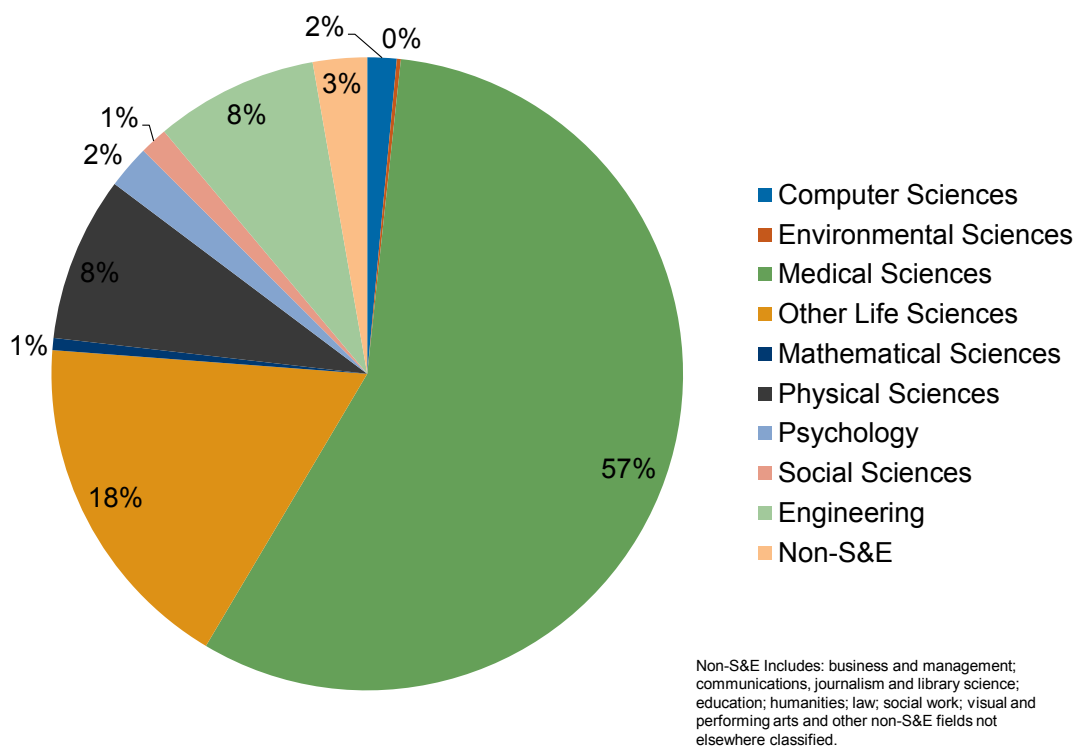| Field	2012	2011	2010	2009	2008	2007
All R&D fields	245,888	259,895	254,492	257,207	253,604	238,738
Science	218,912	230,852	227,830	232,869	231,386	218,566
Computer sciences	3,628	2,517	2,145	2,638	2,879	2,259
Environmental sciences	502	456	259	224	90	149
Atmospheric sciences	0	0	0	0	0	0
Earth sciences	499	456	259	224	90	149
Oceanography	3	0	0	0	0	0
Environmental sciences, nec	0	0	0	0	0	0
Life sciences	180,718	191,134	187,547	197,995	197,045	187,060
Agricultural sciences	0	0	0	0	0	0
Biological sciences	32,687	33,703	35,137	37,634	39,954	42,918
Medical sciences	137,872	146,124	142,055	147,404	144,187	132,442
Life sciences, nec	10,159	11,307	10,355	12,957	12,904	11,700
Mathematical sciences	1,491	861	728	790	534	618
Physical sciences	20,453	21,757	25,711	17,797	18,837	15,975
Astronomy	0	0	0	0	0	0
Chemistry	10,880	10,419	11,098	9,184	10,902	9,490
Physics	5,194	6,816	7,899	5,834	5,231	3,938
Physical sciences, nec	4,379	4,522	6,714	2,779	2,704	2,547
Psychology	5,370	4,993	3,687	5,508	5,239	4,880
Social sciences	3,460	4,228	4,814	4,955	5,199	5,584
Economics	108	225	215	160	174	37
Political sciences	36	36	8	27	15	25
Sociology	275	582	331	287	383	413
Social sciences, nec	3,041	3,385	4,260	4,481	4,627	5,109
Sciences, nec	3,290	4,906	2,939	2,962	1,563	2,041
Engineering	20,254	21,768	20,923	18,985	17,824	16,620
Aeronautical/astronautical engineering	0	0	0	0	0	0
Bioengineering/biomedical engineering	4,887	6,536	5,078	5,371	4,861	4,482
Chemical engineering	2,255	2,263	2,376	2,810	2,825	2,141
Civil engineering	3,148	2,283	2,205	1,680	1,284	930
Electrical engineering	3,358	4,163	5,106	3,612	3,079	4,218
Mechanical engineering	5,697	5,628	5,155	4,709	4,867	4,320

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[10] It should be noted that Wayne State University incoming Presidents (in 2008, 2010 and 2013), and the Board of Governors, received memoranda and reports anticipating declining research volumes from the VP-Research office and the Dean of the School of Medicine.

[11] Accessed online at: https://ncsesdata.nsf.gov/profiles/site?method=report&fice=2329&id=h1

Field	2012	2011	2010	2009	2008	2007
Metallurgical/materials engineering	0	0	0	0	0	0
Engineering, nec	909	895	1,003	803	908	529
Non-S&E	6,722	7,275	5,739	5,353	4,394	3,552
Business and management	780	1,009	930	775	680	423
Comm'ns, journalism, and library science	219	193	58	18	52	64
Education	1,414	2,026	1,786	1,529	1,044	1,038
Humanities	376	563	411	657	676	433
Law	279	234	177	66	5	46
Social work	1,157	1,459	778	752	633	537
Visual and performing arts	405	401	440	342	257	137
Non-S&E, nec	2,092	1,390	1,159	1,214	1,047	874

In terms of broad R&D fields it is evident (Figure 1 and Table 3) that Medical Sciences and Other Life Sciences (including Biological Sciences and other life sciences not elsewhere classified) comprise three-quarters of total 2012 research expenditures at Wayne State (75 percent).

Figure 1: Wayne State University Percent of R&D Expenditures by Field 2012. Data=NSF.

Non-S&E Includes: business and management; communications, journalism and library science; education; humanities; law; social work; visual and performing arts and other non-S&E fields not elsewhere classified.

The other key R&D fields, in terms of R&D expenditures, include Physical Sciences and Engineering. In combination, the four categories of Medical Sciences, Other Life Sciences, Physical Sciences, and Engineering account for fully 90 percent of all R&D expenditures at Wayne State University.

In terms of NSF reported research expenditures for Wayne State, the top 10 specific R&D fields are:

1. Medical Sciences ($137.9 million, 57% of research funding)
2. Biological Sciences ($32.7 million, 13.3%)
3. Chemistry ($10.9 million, 4.4%)
4. Life Sciences not elsewhere classified ($10.2 million, 4.1%)
5. Mechanical Engineering ($5.7 million, 2.3%)
6. Psychology ($5.4 million, 2.2%)
7. Physics ($5.2 million, 2.1%)
8. Bioengineering/Biomedical Engineering ($4.9 million, 2%)
9. Physical Sciences not elsewhere classified ($4.4 million, 1.8%)
10. Computer Sciences ($3.6 million, 1.5%)

Taken together, these 10 R&D fields constitute $220.8 million (89.8 percent) of the total $245.9 million in 2012 research expenditures at Wayne State University.

Several R&D fields have seen significant research expenditure gains over the 2008-2012 reported time period. Among those increasing their research expenditures by more than $500,000 over the five-years are: Civil Engineering (+$1.8 million); Mechanical Engineering (+$830,000); Computer Science (+$749,000), and Social Work (+$524,000).

Battelle analysts also examined the Wayne State's 2012 research expenditure data for the R&D fields shown on Table 3 in comparison to overall national funding in those fields, and calculated a percent of total national research expenditures in the field comprised by Wayne State. Overall, Wayne State University captures 0.37 percent of total academic research expenditures across all fields combined. In certain fields, however, Wayne State is capturing a significantly higher percentage, with these key fields including:

- Medical Sciences (0.68%)
- Chemistry (0.62%)
- Social Work (0.58%)
- Bioengineering/Biomedical engineering (0.56%)
- Visual and Performing Arts (0.48%)
- Psychology (0.45%).

C. Academic Publications

Publications activity is another key measure of scholarly activity. While publications are a common means by which researchers report findings from their grant-funded activities, it is also true that publications, when based on more theoretical work or pilot studies, can be critical in demonstrating a body of work to win research grants. Thomson Reuters tracks publications and associated citations in peer-reviewed journals for universities in 114 fields involving basic, applied, and clinical research.

On an annual basis, since 2007, Wayne State University peer-reviewed publications rose from 1,611 to 1,824 in 2013, representing an increase of 13.2%. This growth in peer-reviewed publications was slightly behind the U.S. average of 14.3% from 2007 to 2013, resulting in a relatively flat share of U.S. publications for Wayne State University from 0.59% of all U.S. publications in 2007 to 0.58% in 2013.

It is interesting to note that Wayne State's competitive position relative to the U.S. in peer-reviewed publications is better than in research expenditures. In research expenditures Wayne State have been growing over the 2007 to 2012 period, but has been well off national growth trends resulting in declining share and lower institutional rankings. The same is not true in peer-reviewed publications activity where Wayne State is growing comparable to the U.S. and maintaining its share of total US publications.   This suggests that the weaknesses in research activity can be addressed with focused actions since the base of scholarly activity is still in place.

To examine publications activity across individual fields, it is important to review over a several-year period to avoid year-to-year variability. Between 2009 and 2014 (through March) the Thomson Reuters Current Contents Connect system lists 11,955 publications with a Wayne State or KCI author. This total represents 0.6 percent of all U.S. academic publications for that time period. Wayne State has 33 publishing areas in which its hare of U.S. publications considerably exceeds its overall average, and seven publishing areas in which its publishing captures more than double the Wayne State average: Neurology (1.21%); Oncology (1.37%); Chemistry Physics Pure Applied (1.44%); Oncogenesis Cancer Research (1.49%); Pediatrics (1.53%); Physics (1.59%), and Reproductive Medicine (3.24%).

Table 4:   Wayne State University[12] -- Publication as a Share of U.S. Publications by Discipline. 2009 to March 2014. Wayne State University Overall = 0.6% of U.S. Publications.

Discipline/Publications Category in Which Wayne State University has a Share of U.S Publications >=0.6%	Records	Share of U.S.
Reproductive Medicine	457	3.24%
Physics	824	1.59%
Pediatrics	302	1.53%
Oncogenesis Cancer Research	371	1.49%
Chemistry Physics Pure Applies	552	1.44%
Oncology	416	1.37%
Neurology	339	1.21%
Medical Research Organs Systems	428	1.00%
Neurosciences Behavior	715	1.00%
Social Work Social Policy	86	0.99%
Otolaryngology	74	0.95%
Clinical Psychology Psychiatry	119	0.94%
Radiology Nuclear Medicine Imaging	184	0.92%
Anesthesia Intensive Care	109	0.90%

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[12] Includes Karmanos Cancer Institute

Discipline/Publications Category in Which Wayne State University has a Share of U.S Publications >=0.6%	Records	Share of U.S.
Medical Research General Topics	254	0.87%
Clinical Immunology Infectious Disease	146	0.86%
Pharmacology Toxicology	311	0.85%
Public Health/Health Care Sciences	417	0.85%
Inorganic Nuclear Chemistry	59	0.84%
Psychiatry	124	0.82%
Research Laboratory Medicine Medical Technology	136	0.77%
Hematology	85	0.76%
General Internal Medicine	155	0.76%
Cardiovascular Respiratory Systems	273	0.75%
Physiology	50	0.74%
Cardiovascular Hematology Research	211	0.71%
Environmental Medicine Public Health	121	0.71%
Biochemistry Biophysics	321	0.70%
Language Linguistics	12	0.68%
Psychology	394	0.66%
AI Robotics Automatic Control	75	0.66%
Spectroscopy Instrumentation Analytical Sciences	125	0.64%
Mathematics	201	0.62%
Computer Science Engineering	82	0.60%
Cell Developmental Biology	152	0.60%

Insight as to Wayne State academic research core competencies can also be gained for examining the academic journals in which Wayne State authors have a substantial base of publications. Looking across more than 2,400 academic journals/publications, Wayne State authors have a substantial presence across several key disciplines and thematic areas (Table 5). Notable evident strengths include:

- Perinatology, Reproductive Medicine and Obstetrics and Gynecology
- Cancer
- Physics
- Neurology and Neuroscience
- Infectious Diseases
- Mathematics
- Psychology and Psychiatry
- Imaging and Instrumentation
- Therapeutics and Pharmacology
- Pediatrics, Child Development and Welfare.

Table 5: Wayne State University[13] -- Academic Publications in Which Wayne State University Authors Represent a High Share of U.S. Authors. 2009 to March 2014.

Journal/Publication Title	Disciplinary Theme	Number of Publications	Percent of Journal's Publications Comprising a WSU Author
Journal of Perinatal Medicine	Perinatology	32	23.2%
Neurological Research	Neurosurgery, Neurology and Neuroscience	47	20.3%
Systems Biology in Reproductive Medicine	Reproductive Medicine	12	17.9%
Journal of Maternal Fetal Neonatal Medicine	Perinatology	77	15.3%
Biochimica et Biophysica Acta Reviews on Cancer	Cancer	11	13.3%
Ultrasound in Obstetrics Gynecology	OB/GYN and Imaging	18	12.2%
European Physical Journal C	Physics (Theoretical and Experimental)	42	10.3%
Journal of Neurological Sciences	Neurology and Neuroscience	40	9.4%
Physics Letters B	Physics (Nuclear and Particle)	107	8.8%
Child Maltreatment	Child Abuse and Neglect	10	8.7%
Neurotoxicology and Teratology	Neurology and Neuroscience	18	7.7%
American Journal of Reproductive Immunology	Reproductive Medicine	18	7.4%
Clinics in Laboratory Medicine	Clinical Pathology	15	7.2%
SIAM Journal on Optimization	Mathematics	10	7.1%
Journal of Hematology Oncology	Cancer	12	7.1%
Journal of Instrumentation	Physics and Instrumentation	33	6.9%
BJOG an International Journal of Obstetrics and Gynaecology	OB/GYN	10	6.0%
Nutrition and Cancer an International Journal	Cancer	17	5.7%
Clinical Neuropsychologist	Psychology and Neuroscience	16	5.5%
International Journal of Antimicrobial Agents	Infectious Disease	12	5.4%
Congenital Heart Disease	Cardiovascular	12	5.0%
Placenta	Perinatology	12	5.0%
Nonlinear Analysis Theory Methods Applications	Mathematics	21	5.0%
Obstetrics and Gynecology	OB/GYN	51	4.9%
Criminal Justice and Behavior	Criminology	12	4.8%

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[13] Includes Karmanos Cancer Institute

Journal/Publication Title	Disciplinary Theme	Number of Publications	Percent of Journal's Publications Comprising a WSU Author
American Journal of Obstetrics and Gynecology	OB/GYN	65	4.6%
Journal of Parallel and Distributed Computing	Computer Science	12	4.5%
AIDS Patient Care and STDs	Infectious Disease	16	4.3%
Physical Review D	Physics (Particles, Fields, Gravitation, Cosmology)	235	4.2%
AIDS Care Psychological and Socio Medical Aspects of AIDS HIV	Infectious Disease	26	4.0%
Investigational New Drugs	Drug Discovery and Development	12	4.0%
Journal of Child Neurology	Neurology and Neuroscience	21	3.9%
Academic Psychiatry	Psychiatry	10	3.9%
Journal of High Energy Physics	Physics	101	3.9%
Psychiatry Research Neuroimaging	Psychiatry and Imaging	13	3.9%
Neurotoxicity	Neurology and Neuroscience	13	3.9%
American Journal of Perinatology	Perinatology	16	3.8%
Clinical Neurophysiology	Neurology and Neuroscience	12	3.8%
Pediatric Neurology	Neurology and Neuroscience + Pediatrics	12	3.7%
Journal of Neurointerventional Surgery	Neurosurgery	14	3.6%
Pharmacotherapy	Pharmacology	19	3.4%
Cancer Chemotherapy and Pharmacology	Cancer and Pharmacology	19	3.2%
Fertility and Sterility	Reproductive Medicine	37	3.1%
American Journal of Health System Pharmacy	Clinical Pharmacy	21	3.0%

CONCLUSIONS:

These data indicate that, on a global stage, Wayne State is a dichotomous institution. It stands among the top 20 percent of universities in terms of size (as measured by number of academic staff), but is lower ranked in terms of its overall research funding and research output per staff member. The University excels in the number of doctoral degrees awarded, but is fairly low ranked in terms of "highly cited researchers", one measure of quality.

Within the U.S. academic environment Wayne State is classified by the Carnegie Foundation as a RU/VH institution (Research University/Very High Research Activity), and this is reflected in the fact that, with

over $245 million in NSF-report research expenditures in 2012, the University ranks among the top 100 university research institutions. Still, Wayne State is not keeping pace with the growth of U.S. university research and has shown variability in growth from year-to-year recently.   It should be noted that Wayne State University incoming Presidents (in 2008, 2010 and 2013), and the Board of Governors, received memoranda and reports anticipating declining research volumes from the VP-Research office and the Dean of the School of Medicine.

In contrast, peer-reviewed publications data suggests that scholarly activity remains active at Wayne State University and is growing at nearly the national rate.   This suggests that Wayne State University still has a solid underpinning of faculty expertise to grow research in the years ahead, but requires strategic intervention to convert that faculty potential into more robust research growth.

Within specific fields of research, the research enterprise at Wayne State University is heavily oriented towards scientific and engineering disciplines – as is the case at most research-oriented universities that have a College of Engineering and a Medical School. Life Sciences, especially Medical Sciences, are especially important to the University's overall position in national rankings, comprising almost three-quarters (73.5 percent) of research expenditures. In addition to engineering, other key contributors of research expenditures are found in the Physical Sciences (especially within Chemistry and Physics), in Psychology and in Computer Sciences. The same holds true in academic publishing, where the key areas of concentration for Wayne State (as measured by percent of U.S. overall publications volume in the discipline) are dominated by life science and physical science (physics) disciplines, with a small number of other significant areas including "social work and social policy", "language and linguistics", "mathematics", "AI robotics and automatic control" and "computer science engineering".

III.   Core Competency Assessment

The critical need for strategic attention to Wayne State University's research enterprise is clear. The current trajectory is one of decline. Still it appears that there is a substantial base to build upon with not only a high overall research volume but specific areas of research focus.

Advancing a more refined and rigorous assessment of Wayne State University's research competencies is a key underpinning to identifying how the university can transform its research enterprise in line with the emerging 21st century research paradigm of integrating use-inspired and translational research involving multi-disciplinary approaches grounded in research challenges posed by Detroit's needs and broader societal needs.

Research core competencies at a university represent those fields with a critical mass of ongoing activity along with some measure of excellence. No one single source of information is sufficient to identify research core competencies. Rather, a variety of integrated and complementary analyses are required to help identify an institution's current position and strategic focus areas across a state's research base.

Using both quantitative and qualitative methods, Battelle applied a rigorous approach for assessing the research competencies of Wayne State (Figure 2). The key factors used by Battelle to identify research competencies at Wayne State University included:

- **Cluster Analysis of Publications Activity:** One key dimension of core competency analysis is to understand the focus and extent of activities through documented activities in peer-reviewed publications activity, a key measure of scholarly activity by faculty across the university. Through the use of a data mining software tool, OmniViz, it is possible to examine "clusters" of research areas through textual analysis of the abstracts from publications of faculty at Wayne State University. A key strength of this clustering approach is that there are no pre-determined categories, and instead the clustering of publications reflects the actual focus of research. By its nature, this type of analysis is more quantitative and enables the identification of leading research themes across the entire University research enterprise.

Figure 2: Project Methodology

- **Extent of Institutional Focus based on Field Interviews:** It is also important to understand, probe and analyze the research programs on-the-ground, and to further inform the identification of areas of focus and emphasis through institutional based interviews with academic leaders and research faculty. This more qualitative field interview process can help reveal where the research
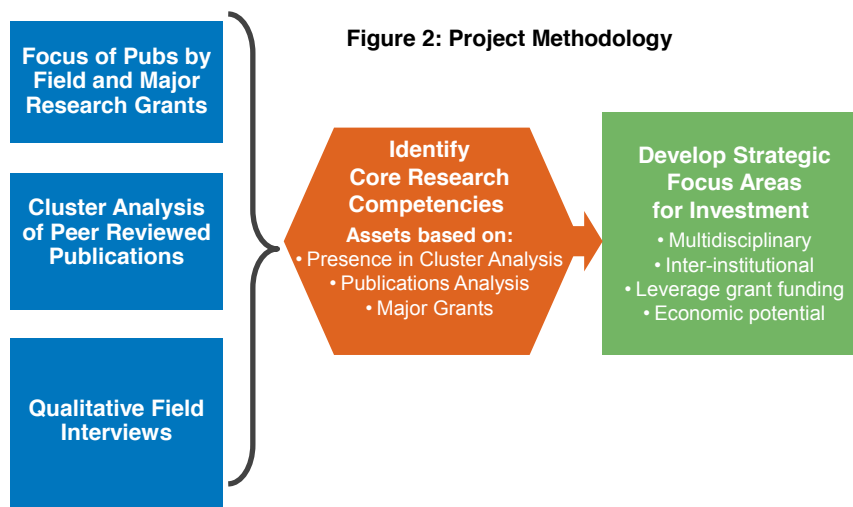
enterprise at Wayne State University is going and not just where it has been as suggested by the cluster analysis of publications. Altogether over 50 university leaders and faculty and were interviewed by the Battelle project team.

- **Presence of Major Grant Awards:** Major research grants are an important indicator of research strength and often enable groups of faculty to collaborate. Battelle identified and coded major research grant awards of over $500,000 awarded to Wayne State University faculty from 2009 to 2013 relating to each research core competency area. These major grants came from a variety of sources from federal agencies, state government, foundations, industry and other collaborating universities and non-profits.

- **Publication Fields with a High Share of Total U.S. Publications**: Beyond the cluster analysis of peer-reviewed publication abstracts, it is also useful to consider how well Wayne State University performs in identified fields of research based on the types of publications. Thomson Reuters Web of Knowledge has developed a set of 116 research fields that it tracks based on groupings of related journals that define a field of study. The share of the U.S. total provides an indication of having critical mass within a research field.

Battelle identified 29 specific research competencies at Wayne State University based on this assessment approach. These research competencies can be grouped into two major categories: 19 are in life sciences and biomedical fields and another 10 are found across engineering, physical sciences and social sciences. Table 6 lists these 31 core competencies.

Table 6: Research Competencies Identified by Assessment of Publication Clusters, Major Grants and Field Interviews

Biomedical and Life Science-Related	Engineering, Physical Sciences, and Social Science-Related
- Reproductive Medicine (OB/GYN – Perinatology/ Maternal-Fetal Medicine) - Cancer - Cardiovascular - Basic and Behavioral Neuroscience - Psychiatric/Neurological Disorders - Child and Adolescent Health/Pediatrics - Child and Family Development - Environmental Health Sciences - Health Care Services and Delivery/Health Care Systems (Incorporates Public health) - Infections and Infectious Disease Management - Metabolism, Endocrinology, Obesity and Diabetes - Protein Sciences and Biochemistry - Drug Abuse - Genetics, Genomics and Molecular Biology - Vision Research and Ophthalmology - Biomedical Imaging - Pharmacology and Pharmaceutical Science - Bioengineering - Gerontology	- Physics - Mathematics - Big Data, Networking and Sensing Systems - Industrial & Systems Engineering - Social Work and Social Policy - Materials Science and Nano-based Materials - Automotive Research/ Next Generation Auto - Economic, Urban and Labor Studies - Education - Environmental Engineering

The breadth of these research competencies do vary substantially at Wayne State University. To provide a more refined assessment of each of the research competencies, Battelle has developed a rating system across the factors to help identify which of these research competencies stand out within and across the specific factors as following:

Presence in Cluster Analysis of Grant Awards and Publications:

◆◆◆◆ Top Tier: Related meta-clusters contain 400 or more records
◆◆◆   Middle Tier: Related meta-clusters contain 200 -400records
◆◆   Lower Tier: Related meta-clusters contain 100-199 records
◆   Bottom Tier: <100 records
–   No Presence: No related meta-clusters
CC   Cross-Cutting: Presence across more than several meta-clusters

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Publications Level (2009-2014 TD)

◆◆◆◆ Top Tier: >1% Share of Total US Publications
◆◆◆   Middle Tier: 0.7% to 1% Share of Total US Publications
◆◆   Lower Tier: 0.3% to 0.6% Share of Total US Publications and 50 or More Publications
◆   Bottom Tier: Less than 0.3% Share of Total US Publications
–   Not Available: No field listed

Presence of Major Funded Grants: Reviews active major grant awards for programs or centers in excess of $500,000.

◆◆◆◆ Top Tier: Ten or more funded grants above $500,000
◆◆◆   Middle Tier: Five to nine funded grants above $500,000
◆◆   Lower Tier: One to four funded grants above $500,000
◆   Bottom Tier: No funded grants above $500,000

Institutional Focus:

◆◆◆◆ Top Tier: Major centers or institutes at Wayne State, with major cluster of faculty researchers funded in the area
◆◆◆   Middle Tier: Well-established strength with a cluster of faculty researchers funded in the area
◆◆   Lower Tier: Growing strength with an existing presence and key plans to advance
◆   Bottom Tier: Emerging strength still at a nascent level.
–   No Presence

The results from this rating of research competency factors do suggest a number of research competencies that stand out (see Tables 7 and 8 for the detailed ratings). Considering from the perspective of a "balanced scorecard" there are a few research competencies that a truly stand-outs earning top ratings across all factors, followed closely by a number of upper-tier research competencies and then a broader pack of research competencies that either earn top ratings in a number of the factors or do well across nearly all of the factors (but fall short of top ratings):

- **Only two research competencies are top rated across all factors:**

    o *Reproductive Medicine*

    o *Cancer Research*

- **Four research competencies are top-rated in 3 out of the 4 research competencies and so stand out as upper-tier research competencies:**

    o *Cardiovascular Research*

    o *Basic and Behavioral Neurosciences*

    o *Psychiatric and Neurological Disorders*

    o *Child and Adolescent Health*

- **Another ten of the research competencies fall into the "middle tier" research competencies with either top ratings in two out of the 4 factors or a middle rating in 3 out of the 4 factors:**

    o *Infections and Infectious Disease Management*

    o *Metabolism, Endocrinology, Obesity and Diabetes*

    o *Genetics, Genomics and Molecular Biology*

    o *Vision Research*

    o *Biomedical Imaging*

    o *Pharmacology and Pharmaceutical Science*

    o *Physics*

    o *Education Policy and Development*

    o *Environmental Health*

    o *Health Care Sciences and Delivery*

The remaining 13 research competencies all have aspects that stand out but are more uneven across all of the factors considered. Some of these areas are more emerging, while others are longer-standing areas of research focus, but have not risen to prominence.

Together this portfolio of research competencies at Wayne State University offers a rich and diverse set of building blocks for strategies to enhance research, with an emphasis towards biomedical research, behavioral sciences and engineering for the life sciences.

Table 7: Life Science and Biomedical Fields

Core Competency Field	Cluster Analysis	Publications Share of U.S.	Major Grants (Over $500,000)	Institutional Focus	Interview Identified Strengths
Reproductive Medicine (OB/GYN – Perinatology/ Maternal-Fetal Medicine)	◆◆◆◆ 692 records. Multiple clusters in: preterm births; fetal health, fetal alcohol syndrome, obstetrics, and reproductive medicine.	◆◆◆◆ 3.24% share (457 publications) in Reproductive Medicine/ Obstetrics and Gynecology	◆◆◆◆ >10 over $500K	◆◆◆◆ NIH/NICHD Perinatology Research Branch. CS Mott Center for Human Growth and Development Multidisciplinary with major engagement from OB/GYN and Pediatrics	• Recognized signature program for University. • Multiple highly published authors/PI's • Environmental factors and fetal exposure • Maternal lifestyles • Preterm births • Fetal imaging • Reproductive immunology • Strong genomics core. • Placental tissue repository. • Michigan neonatal biobank.
Cancer	◆◆◆◆ 1,386 records Multiple clusters across wide range of cancers including breast, lung, leukemia, prostate, ovarian, renal. Plus focus on chemo- and radiation therapy.	◆◆◆◆ 1.37% share (416 publications) in Oncology	◆◆◆◆ >10 over $500K	◆◆◆◆ Barbara Ann Karmanos Cancer Institute. Dedicated cancer hospital. NCI designated Comprehensive Cancer Center	• Basic science: population science/epidemiology; molecular therapeutics, tumor biology/microenvironment; molecular imaging. • Phase I trials • Specific cancers: breast, lung, prostate, ovarian/uterine/renal, leukemia. • Major bone marrow and stem cell transplantation • Emerging in cancer immunotherapy (vaccines and cell therapy). • Radiation oncology.
Cardiovascular Physiology	◆◆◆◆ 755 records Multiple clusters involving hypertension, coronary artery disease, ischemia and heart function	◆◆◆ 0.7% share (373 publications) in cardiovascular system and cardiology	◆◆◆◆ >10 over $500K	◆◆◆◆ Cardiovascular Research Institute. Major focus of Physiology funding.	• Hypertension • Ischemia/stroke and reperfusion/cardiac protection • Coronary artery disease • Heart function • Major focus within Physiology Department (large animal physiology models).

Core Competency Field	Cluster Analysis	Publications Share of U.S.	Major Grants (Over $500,000)	Institutional Focus	Interview Identified Strengths
					• Fetal cardiology.
Basic and Behavioral Neuroscience	◆◆◆◆ 533 records. Multiple clusters. Brain Research (292), Neural Cell Function (49), Cognition (139), and Memory (53)	◆◆◆◆ 715 publications in Behavioral Neurosciences (1.0%).	◆◆◆◆ >=10 over $500K Divided among school of medicine and Arts & Sciences.	◆◆◆ Multidisciplinary, with multiple engaged groups.	• Research emphasis on cognitive and developmental psychology using brain imaging and longitudinal studies. Impact of physical health and disorders on psychological health. • Cognitive behavioral therapies (emphasis on fibromyalgia patients)
Psychiatric/Neuro logical Disorders	◆◆◆ 367 records. Schizophrenia (79), Depression (96), and Epilepsy (72).	◆◆◆◆ 124 publications in Psychiatry (0.82%). 339 publications in Neurology (1.21%). 119 publications in Clinical Psychology Psychiatry (0.9%)	◆◆◆◆ >10 over $500K	◆◆◆ Multidisciplinary, with multiple engaged groups in: Psychiatry; Neurology; Pharmaceutical Science; Pharmacology, Pediatrics, Molecular medicine and Genetics and Gerontology.	• Autism • Traumatic Brain Injury • Epilepsy/seizures • ADHD • Psychiatric Disorders (Schizophrenia, Depression, Anxiety) • PTSD (VA Med Center). • Neuroprotection. • Stroke treatment • Pharmacology • Links to other clusters in child mental health.
Child and Adolescent Health/Pediatrics	Cross-Cutting	◆◆◆◆ 1.53% share (302 publications) in Pediatrics	◆◆◆◆ >10 over $500K	◆◆◆◆ Children's Research Center of Michigan. Pediatric Prevention Research Center. CS Mott Center for Human Growth and Development.	• Risk behaviors and prevention • Obesity and weight loss • Pediatric PET imaging and development of tracers. • Epilepsy surgery • Pediatric neurology • Psychology
Child and Family Development	◆◆ 140 records in youth and adolescent	– Likely publications across a range of journals in multiple	◆◆ **3-4 over $500K**	◆◆◆◆ Merrill Palmer Skillman Institute for Child and Family Development.	• Internationally recognized programs within MPSI (children and parents) • Mental health and functional brain imaging and RNA/gene expression.

Core Competency Field	Cluster Analysis	Publications Share of U.S.	Major Grants (Over $500,000)	Institutional Focus	Interview Identified Strengths
	behavior	disciplines (Sociology, Social Work, Psychology, pediatrics, Family Medicine, Family and Consumer Sciences, etc.)		Developmental Disabilities Institute.	• Link to perinatology on impact of maternal alcohol and drug use. • Major outreach efforts • School of Social Work engagement in child welfare, interpersonal violence and behavioral health. • Developmental disabilities • Adolescents, behavior and risk. • Training program in Child Mental Health (MPSI) • Child maltreatment research.
Environmental Health Sciences	Cross-Cutting	♦♦♦ 0.7% share (121 publications) in Environmental Medicine/ Public Health	♦♦♦ 5-9 over $500K (including just announced CURES grant)	♦♦♦♦ Institute for Environmental Health Sciences. Multidisciplinary research focus.	• Focus on urban responses to environmental stressors • Major recently funded CURES program • Environmental impact on: modulation of the immune system; metabolism and metabolic diseases; mental health, and cancer. • Genetics and biomarker identification. • Community outreach (TRANSIT team) • Two core facilities
Health Care Services and Delivery/Health Care Systems (Incorporates Public health)	Cross-Cutting	♦♦♦♦ 0.85% share (417 publications) in public health/health care science and 0.51% share (62 publications) in health care sciences/ services	♦♦♦ 5 to 9 over $500K	♦♦♦ Center for School health in Education. Center for Urban Studies (Partnership with henry Ford Hospital). Pediatric Prevention Research Center.	• Population sciences/epidemiology/ biostatistics and disparities • Operations research and systems engineering of hospitals (through Industrial & Systems Engineering Department) • Symptom Sciences (Nursing)
Infections and Infectious Disease	♦♦♦♦ 473 records.	♦♦♦ 0.86% share (146	♦♦♦♦ >10 over	♦♦♦ Multidisciplinary, including	• Major emphasis in hospital/medically acquired infections.

Core Competency Field	Cluster Analysis	Publications Share of U.S.	Major Grants (Over $500,000)	Institutional Focus	Interview Identified Strengths
Management	Primarily focused on medically acquired infections	publications) in Clinical Immunology/ Infectious Disease and 0.5% share (136 publications) in Immunology.	$500K	leadership in Internal Medicine, plus Chemistry, Immunology and Microbiology, Pharmaceutical Science, Pharmacy Practice and Pediatrics.	• Antimicrobial resistance and clinical research in antimicrobials • HIV prevention and interventions • Perinatal infectious diseases (HIV) • Infections in immune suppressed patients • Mycology • Basic research in immunology and molecular pathogenesis
Metabolism, Endocrinology, Obesity and Diabetes	♦♦♦ 367 records. Multiple clusters found in lipid research, obesity and diabetes	♦♦ 0.47% (83 publications) in Endocrinology/ Metabolism/ Nutrition	♦♦♦♦ >10 over $500K	♦♦♦ Multidisciplinary (but not coordinated) engagement across: Physiology, Molecular medicine, Psychiatry, Biochemistry, Internal Medicine, Ophthalmology, Computer Science and Pharmaceutical Sciences.	• Research foci in: lipids; obesity; diabetes. • Prevention focused research with urban youth and other sub-populations. • Metabolism group within the Pediatric Prevention Center (will be in MBRB). • Tend to focus on chronic disease management rather than acute care research. • African American and Arab American populations with high incidence.
Protein Sciences and Biochemistry	♦ 96 records with Phosphorylation theme.	♦♦♦♦ 0.7% share (321 publications) in Biochemistry/ Biophysics and 0.4% share (83 publications) in Organic Chemistry	♦♦♦ 5 to 9 over $500K	♦♦♦ Multidisciplinary. Hub in Department of Biochemistry and Molecular Biology in the School of Medicine. Additional focus within the Department of Chemistry. Collaborations with School of Pharmacy.	• Strength in protein crystallography. Cardiovascular methylases and retroviral crystallography. • Structural biology using e-ray crystallography and NMR spectroscopy) • Cellular metal homeostasis and drug resistance • Molecular and cellular bioenergetics (mitochondrial biochemistry) • Enzymology • Molecular biology and cancer.

Core Competency Field	Cluster Analysis	Publications Share of U.S.	Major Grants (Over $500,000)	Institutional Focus	Interview Identified Strengths
Drug Abuse	♦ 36 records Focus on risks and treatment of alcohol and cocaine	Not Available	♦♦♦♦ >10 over $500K	♦♦♦ Multidisciplinary engagement across Psychiatry, pediatrics, Pharmacology and Pharmaceutical Science.	• Drug use and HIV • Link to perinatology on impact of maternal alcohol and drug use and the Merrill Palmer Skillman Institute
Genetics, Genomics and Molecular Biology	♦♦ 181 records Focus on RNA/DNA and Mitochondrion	♦♦ 0.45% share (108 publications) in Molecular Biology Genetics	♦♦♦♦ >10 over $500K	♦♦♦♦ Center for Molecular Medicine and Genetics. Multidisciplinary with engagement across multiple departments (Medicine, Chemistry, Biological Sciences)	• Multidisciplinary center (Center for Molecular Medicine and Genetics), with own PhD program. • Applied genomics core in Perinatology Research Branch • Cancer Center genomics core • Medical genetics residency program.
Vision Research and Ophthalmology	♦ 50 records Retinal and eye research	♦ 0.36% share (32 publications) in ophthalmology	♦♦♦♦ >10 over $500K	♦♦♦♦ Ligon Research Center of Vision – Kresge Eye Institute. Multidisciplinary with Ophthalmology and Anatomy.	• Evident visual neuro-anatomy and neuroscience focus. • Infectious diseases of the eye • Retinal diseases (including diabetic retinopathy). • Translational research in glaucoma • Developing in optical genetics. • 1 of 40 national Centers of Vision Excellence.
Biomedical Imaging	♦♦ 123 records. (MR imaging and brain imaging). Also very crosscutting among other cluster areas.	♦♦♦ 0.92% share (184 publications) in Radiology Nuclear medicine Imaging	♦♦♦ 5-9 over $500K	♦♦♦ Multidisciplinary, with multiple engaged groups in: School of Medicine, KCI, Chemistry, Physics and Engineering.	• History of expertise in PET, especially pediatric PET imaging. • Bioengineering research team with strengths in biomolecular imaging • MR research center in Radiology, with MR and MR spectroscopy • Susceptibility weighted imaging. • Applied research strengths in brain and cancer imaging. • Imaging chemical agents.
Pharmacology	Cross-cutting	♦♦♦	♦♦♦♦	♦♦♦	• Strong focus on therapeutics

Core Competency Field	Cluster Analysis	Publications Share of U.S.	Major Grants (Over $500,000)	Institutional Focus	Interview Identified Strengths
and Pharmaceutical Science		0.9% share (311 publications) in Pharmacology Toxicology .	>10 over $500K – overlapping with cancer	Multidisciplinary, with multiple engaged groups within the Medical School, KCI, College of Pharmacy and Health Sciences, and Chemistry.	development and trials in cancer. Cancer molecular therapeutics. • Significant toxicology expertise • Joint work with engineering in pathomimetic models using microfluidic technology.
Bioengineering	Cross-cutting	Not available	♦♦ 3-4 over $500K	♦♦ Bioengineering Center	• Impact of trauma • Biomechanics
Gerontology	Cross-cutting	♦ 19 publications identified in major journals of gerontology.		♦♦♦ Institute of Gerontology (but no department).	• Cognitive aging research and functional imaging. • Potentially links to a more holistic "life span" theme across the University • Longitudinal studies • Social and behavioral research, including transitional to/from care. • Active engagement by medical anthropologists in gerontology. • Center for Molecular Medicine and Genetics research in peroxisome research and aging.

Table 8: Physical Sciences, Social Sciences, Engineering and All Other Fields (Non-Life Science)

Core Competency Field	Cluster Analysis	Publications Share of U.S.	Major Grants (Over $500,000)	Institutional Focus	Interview Identified Strength
Physics	◆◆ 114 records. Focus on elemental particle identification and measurement	◆◆◆◆ 1.4% share (824 publications) in Physics. Also 1.4% share (552 publications) in category of "Chemistry Physics Pure Applied"	◆◆◆ 5 to 9 over $500K	◆◆◆ Physics Department	• Fundamental nuclear and particle physics • High energy physics • Cosmology • Applied engagement in imaging. • Building capabilities in biophysics.
Mathematics	–	◆◆ 0.6% share (201 publications) in Mathematics.		◆◆ Center for Excellence and Equity in Mathematics	• Relatively diverse research foci in pure and applied mathematics (algebra, geometry and topology, and probability and statistics. • Pre-college prep in STEM. • Middle and high-school teacher training in mathematics education. (primarily centered within College of Education)
Big Data, Networking and Sensing Systems		◆◆ 0.6% share (82 publications) in Computer Science and Engineering; 0.3% share (31 publications) in IT Communications Systems; 0.15% share (32 publications) Electrical and Electronics Engineering	◆◆◆ 5 to 9 over $500K	◆◆ Focused in the College of Engineering.	• Bioinformatics data systems • Link to family medicine and population health in big data analytics. Real-time sensing and control networks • Sensors for medical applications.
Industrial & Systems Engineering	–	◆◆ 0.66% share (75 publications) in Artificial Intelligence,	◆ <3 over $500K	◆◆ Part of NSF Funded IUCRC Center for Logistics and	• Logistics and supply chain • Engineering management for new product development

Core Competency Field	Cluster Analysis	Publications Share of U.S.	Major Grants (Over $500,000)	Institutional Focus	Interview Identified Strength
		Robotics, Automatic Control and 0.52% share (46 publications) in Engineering Management		Distribution with University of Arkansas + involved in new federally funded Center for Reconfigurable Manufacturing with University of Michigan	• Systems engineering of health care delivery • Product reliability and machine tool research, and sogftware technology for manufacturing engineering (in Mechanical Engineering department).
Social Work and Social Policy		♦ 86 publications in Social Work/ Social Policy (1.0%)		♦♦♦ Center for Social Work Research	• Violence against women • Child welfare, child maltreatment and neglect. • Center for Social Work Research well-connected to regional agencies and governments.
Materials Science and Nano-based Materials	♦♦ 165 records. Two clusters: Nanoparticles/Materials with 88 records, and thin films with 77 records.	♦ 0.23% share (75 publications) in material science and engineering and 0.19% share (156 publications) for applied physics/ condensed matter materials sciences and 0.64% share (125 publications) for Spectroscopy/Analytical sciences and 0.16% share (30 publications) for Semiconductor and Solid State Materials	♦♦ 3-4 over $500K	♦♦ Nano Incubator Program advancing multi-disciplinary research	• Identified strength in lightweight composite materials and lightweight metals. • Polymer nanoparticles for drug delivery (Chemical Engineering). • Materials for regenerative medicine. • Chemical Engineering research in material properties, fatigue and fracturing (especially in ductile metals).
Automotive Research/ Next Generation Auto		♦♦ 0.52% share (46 publications) in	♦♦ 3-4 over $500k	♦♦♦ Center for Automotive Research	• Automotive engineering management • Supply chain management • Modeling and simulation of ground

Core Competency Field	Cluster Analysis	Publications Share of U.S.	Major Grants (Over $500,000)	Institutional Focus	Interview Identified Strength
		Engineering Management And 0.34% share (63 publications) in mechanical engineering			vehicles • Testing of automotive materials • Good labs facilities, with 8 test cells, at Automotive Research Center. Powertrain orientation. • Engine dynamics, tribology and combustion dynamics research. • Electric vehicle and energy storage research.
Economic, Urban and Labor Studies	♦ 96 records	♦ 0.24% (76 publications) in Economics; 0.2% (27 publications) in Geography; 10 publications in Employee Relations Human Resources		♦♦♦ Labor Studies Center. Center for Workplace Issues Center for Urban Studies	• Health economics • Labor analysis and labor/management and union relations.
Education		♦♦ 0.5% share (57 publications) in Education Research		♦♦♦♦ Institute for Learning & Performance Improvement	• STEM education instruction (see math category above). • Teacher training • Education performance tracking • Educational psychology (child and adolescent behavior, risk and resilience).
Environmental Engineering	–	♦ 0.2% (32 publications) in Civil Engineering; 0.1% share (96 publications) in Environmental Sciences	♦ 1-2 grants over $500k	♦ Key research focus of Civil and Environmental Engineering Department	• Urban watershed research. • Ground water and surface water interactions • Water transmission and distribution • Link to Environmental Health Sciences category

IV.   From Research Competencies to Strategic Impactful Multi-Disciplinary Research Opportunities

The assessment of research competencies at Wayne State University is the first step to advancing a more forward looking and transformative research enhancement strategy aligned to the demands for research in the 21st century. Today, each of the research competencies makes significant contributions to the status and stature of Wayne State University in terms of research funding and scholarship output. Looking forward, these research competencies can serve as the building blocks – offering a critical mass of faculty expertise and research assets – for leading-edge multi-disciplinary research platforms at Wayne State University.
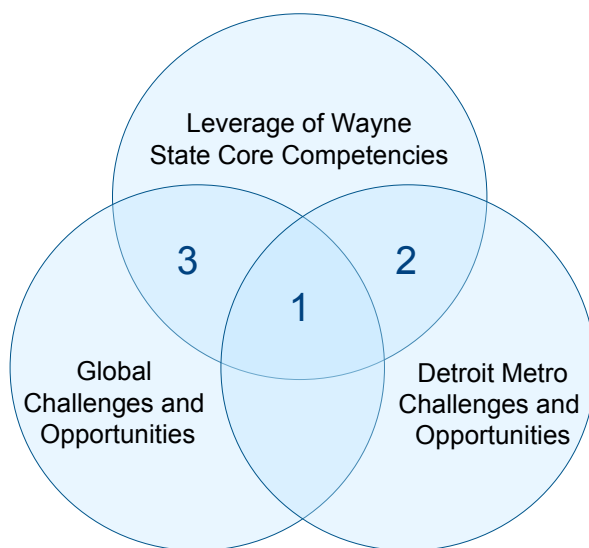
A. Approach to Identifying Multi-Disciplinary Research Platforms

Ideally the multi-disciplinary research platforms to be advanced at Wayne State University would comprise:

- Leveraging of multiple major core competencies, especially those comprising world-class areas of strength at the University
- A line-of-sight to impacting Detroit Metro Area/Urban industry and community challenges and opportunities.
- A line-of-sight to impacting global challenges and opportunities.

As Figure 3 illustrates, an ideal multi-disciplinary research initiative would lie at the intersection of these three elements – leveraging multiple Wayne State University research competencies to make significant progress with global and regional challenges and opportunities.

Figure 3: Elements of Ideal Multidisciplinary Research Platforms at Wayne State University

The line of sight to both local and global challenges and opportunities that leverage Wayne State University's existing research competencies fall into two broad categories:

- **Societal Challenge Opportunities** focusing on research directed towards societal and community needs involving basic inquiry and encouraging multi-disciplinary translational research directed toward advancing solutions to those identified needs. In today's world many of the most pressing societal challenges involve public health, climate change, education, growing disparities, food security, water resources and economic sustainability.

- **Technological Challenge Opportunities** that deploy and leverage research to advance the development of transformative technologies that have the potential to re-envision existing products, create new markets, and possibly even foster new industries. Wayne State offers a number of more technologically-based research competencies that have the potential to link basic biological and physical research with engineering to create products and services for the future. Often these technological challenge opportunities are termed "disruptive innovation" in recognition of how they can offer new possibilities in how we live, communicate and work.

From the detailed examination of the research competencies identified at Wayne State by the Battelle research team together with initial discussions and analysis of the Detroit region needs, a set of five societal challenge opportunities and five technological opportunities are proposed for discussion to identify the 3 to 5 multi-disciplinary research initiatives to examine for more detailed implementation planning.

Societal Challenges Informing Multi-Disciplinary Research Platform Opportunities

Significant efforts and building blocks in place to focus WSU broadly as a leading university focused on the use-inspired and translational research challenges focused on "urban transformations." This represents a broad theme and can be further delineated into specific platform areas. It would involve university-wide efforts to address urban public health systems (environmental urban health issues, health disparities, re-engineering of hospitals and health systems), pressing medical problems (reproductive health, cardiovascular, traumatic brain injury, and cancer), urban behavioral health (child development, lifespan, workplace/societal violence), urban infrastructures (water, transportation) and urban educational systems.

Five more specific areas of focus for multi-disciplinary research platforms might include:

Urban Child and Lifespan Development – Examining the challenges, characteristics and needs pertaining to children and adolescents in urban communities. This could encompass a diverse research universe, ranging from fundamental studies of gene expression and physiology through to studies of the social, family and environmental conditions impacting children, youth, and aging adults, and learning strategies.. May also include taking a holistic approach to the study of human health, environmental factors and changing physiology across the lifespan, seeking to elucidate childhood and adolescent antecedents to adult disease and changes in health and well-being from the fetus through old age..

Health Disparities – Working to identify and characterize causes and typologies of health disparities and to develop solutions for limiting or eliminating major health disparities, especially in urban populations.

Behavior and Behavioral Interventions – Researching the causes and effects of risk behaviors and developing and testing interventions. At Wayne State, this can span a spectrum from fundamental studies in behavioral neuroscience to the development of specific interventions in areas of strength for the University such as: maternal lifestyles; drug abuse; STDs and infectious disease; violence; and obesity.   Translational research can occur not just in the development of effective interventions, but also in the development of novel tools and technologies to facilitate interventions.

Environmental Health, Prevention and Livable Communities – Working to identify and characterize elements of the environment that impact health, and to elucidate the relationships, and mechanisms of action, between environmental factors, disease morbidity, and health outcomes. This is becoming a reinvigorated area at Wayne State University with the recent CURES grant award. Looking forward, it offers opportunity for even more broad engagement with the university's strengths including establishing the gene-environment linkage drawing on the university's strengths in genetics and genomics including new diagnostics; prevention leveraging broader behavioral science applications for individuals; and broader community systems to monitor, educate and generate solutions to deep-rooted environmental health challenges.
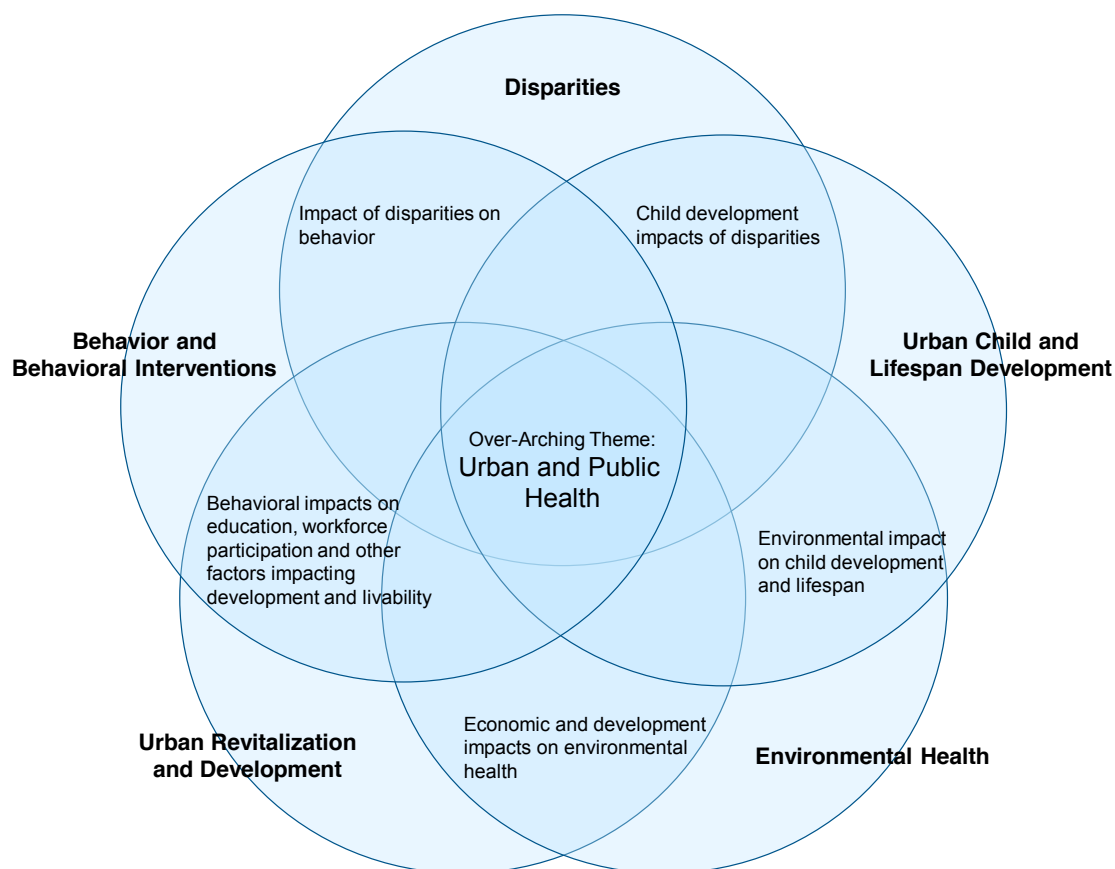
Urban Revitalization and Development – Applying studies of the built environment, social forces, education, economics and other social-science oriented factors that support or hamper economic revitalization, economic health and sustainability of large urban areas.

It is evident that even among the five themes above there are trans-thematic linkages. For example:

- Disparities in socio-economic status, living environment, etc. have an impact on behavior
- Disparities in socio-economic status, living environment, etc. have an impact on child and lifespan development
- Environmental health factors impact child development, behavior and health across the lifespan
- Urban revitalization and development impacts the environment, socio-economic conditions and other factors impacting upon the health-oriented themes.
- Behavior and behavioral interventions will impact incidence of risk behavior impacting child development and health across the lifespan.

Figure 4 provides a diagrammatic representation of the interconnectivity between and across platforms. It also suggests that there is an overarching theme of "Urban and Public Health" that unifies the platforms emerging from many of Wayne State University's core competencies.

Figure 4: Illustrative Interconnectivities within Societal Challenge Themes

Technology Innovation Opportunities

As noted previously, the review of core competencies at Wayne State University also identified a series of University strengths pertaining to specific technologies – including the development and application of technologies. In particular, Battelle's review suggests that there are opportunities to leverage Wayne State's technological capabilities to build robust technology-development platforms focused on:

Imaging and Diagnostics for Precision Medicine – Wayne State University has a strong focus on medical imaging to build upon and a more emerging focus on diagnostics from the device to the development of clinical genetics/molecular diagnostics tests. Key resources to be tapped include the MR Center, the PET Center, the Applied Genomics Technology Center, the Center for Molecular Medicine and Genetics, and specific research programs that are growing in advanced nano-microfluidic devices that offer high content analysis to detect and analyze disease and in vivo molecular-genetic imaging. These imaging and diagnostics technologies are the backbone for the future of medicine as more specific patient-oriented assessment and treatment plans are advanced. Wayne State University can help lead the way in disease diagnosis and treatment targeting from imaging to genomics

- **Immunotherapies** – Addressing the immune system to fight off infections is a well-developed approach for medical treatment, involving preventative vaccines, anti-viral drugs and antibiotics. Advances in modern biosciences – increasing understanding of disease pathways and how the human immune system functions – are leading to a broader range of "immunotherapies" to induce, enhance or suppress the immune system for a wide range of diseases from infectious diseases, such as HIV/AIDS, to cancers, autoimmune and other chronic diseases. Wayne State University has active efforts involved in the development of cell-based cancer vaccines to improved approaches for antibiotic treatment of medically acquired infections, as well as a long standing focus on HIV disease management.

- **Data to Decision Systems** – This platform focuses on sensors and sensor systems for real-time data gathering, analysis and decision-making connected to industrial systems applications, logistics and supply chain, and health care patient monitoring. This multi-disciplinary platform brings together growing activities in large database informatics, wireless networking, systems modeling and simulation and sensor development taking place at Wayne State University.

- **Materials for Life Sciences Applications** – Utilizing core competencies in chemistry, physics, materials science and biological sciences to develop biocompatible materials, films, coatings, degradable polymers, microparticles and other materials for in vivo biomedical applications. Linking Wayne State University's activities in nanotechnology and biomaterials with clinical applications is of critical value.

- **Systems approach to manufacturability** – A key challenge for advanced manufacturing is reducing the time for product development through enhanced design; reducing costs in manufacturing processing through less expensive materials, reduced number of parts and alternative fabrication using forming and joining techniques; and reducing component testing and qualification. This involves a wide range of engineering disciplines including use of computer modeling and simulation, instrumentation for real-time data gathering and performance prediction and non-destructive testing. Of particular importance for the Detroit region is applying these systems approaches for manufacturability to the next-generation of automotive systems in specialized areas such as electric vehicle power and propulsion and vehicle safety systems.

B. Platform Details

Urban Child and Lifespan Development

General Description:

This platform encompasses research that examines the challenges, characteristics and needs pertaining to children and adolescents in urban communities. This encompasses a diverse research universe, ranging from fundamental studies of gene expression and physiology through to studies of the social, family and environmental conditions impacting children and youth. Given the connectivity between childhood disease morbidity and childhood exposure to environmental factors to later stage adult-onset conditions, research in this area has implications for health sciences across the lifespan. As such, this platform also includes taking a holistic approach to the study of human health, environmental factors and changing physiology across the lifespan, seeking to elucidate childhood and adolescent antecedents to adult disease, and changes in health and well-being from fetus through old age.

Potential Goals and Outcomes:

- Understanding of physiological and neuro-psychological development of the child under varying environmental, sociological and psychological stressors and conditions.
- Understanding of risk factors and behaviors negatively impacting healthy development of children and adolescents.
- Researching periods of substantial change in the lifespan process (e.g. birth, infancy, adolescence, early adulthood, middle age, menopause, old age, etc.)
- Translation of research into policy and practice to positively impact child development and lifespan health.

Regional Relevance

The Detroit Metro region constitutes a rich research environment for studying the impact of a range of factors on child and lifespan development. Factors such as the impact of: race; socio-economic status; family structure; exposure to environmental stressors, etc. are diversely present in the Detroit Metro, and the development of solutions to pressing related challenges will have significant positive impacts on regional livability.

The 2010 Right Start Michigan Report ranked Detroit as "high risk" due to the city's rank on indicators signaling a higher probability of developmental delays and health problems in the first 5 years of life.

Major Existing Programs/Core Competency Areas:

The Merrill Palmer Skillman Institute is a core center at Wayne State focused on this platform, coordinating multi-disciplinary research across a wide-range of factors affecting development, with a lifespan perspective (in collaboration with the Institute of Gerontology).. Focus areas in biological and environmental risk, developmental changes, interventions research, and cognitive and functional neuroscience.

The Perinatology Research Division also is directly relevant, with a research focus on understanding environmental and maternal health and associated behavior impacts on child health and development.

Additional areas of strength identified through interviews and the core competency analysis include:

- Fundamental, behavioral and cognitive neuroscience and neuro-imaging
- Child and family development
- Social work
- Basic and clinical psychology
- Genetics and genomics
- Population health
- Gerontology
- Nursing research in symptom management and pain management across the lifespan.

Disparities

General Description:

This platform focuses on research to identify and characterize causes and typologies of disparities having a negative impact on health and socio-economic status. It also works on developing solutions for limiting or eliminating major disparities, particularly those heavily impacting urban populations.

Many inequities represent significant social justice issues for American society. Racial and ethnic health disparities, for example, are evident in areas such as infant mortality, cancer incidence and prevalence, diabetes, incidence of encountering violence-related trauma, etc. Similarly, disparities are evident in educational attainment, pay, standard of living, and a range of metrics across race, ethnicity, gender and spatial dimensions.

Concern about disparities is a thread running across multiple departments and research programs at Wayne State University. The immediate needs and challenges of the Detroit region serve as a local environment that facilitates inquiry in disparities, while the depth of regional challenges mean that solutions proven in Detroit will have far reaching implications for positive outcomes in other geographies.

Potential Goals and Outcomes:

- Identification and characterization of disparities – their prevalence, demography and spatial characteristics.
- Understanding of the etiology of characterized disparities.
- Research to understand linkages between disparities and the emergence of increased disease morbidity in focused areas such as cancer, obesity, diabetes, hypertension, immunological diseases, and infectious disease transmission.

- Research to understand linkages between disparities and societal challenges including: criminal behavior; workforce participation; educational attainment, migration, etc.

Regional Relevance

The economic and sociological challenges of the Detroit Metro region manifest themselves in a broad range of negative statistics indicative of disparities as a root cause or contributing factor. Just some indications of the regional relevance of the study of disparities include:

- The poverty rate in Wayne County is 20.5%, and is even higher in the City of Detroit (44%).
- African American's are demonstrating significantly higher rates of specific diseases, and experiencing higher mortality rates.
- In Detroit, the majority of families with children are headed by a single female – and, children living in female-headed families experience far higher rates of poverty than children in families headed by married couples or by single males.
- The death rate for Detroit children 1 to 14 years of age was nearly 6.5 times the state rate. For the 15 to 24 age cohort, Detroit's death rate was 2.2 times the state rate.

Major Existing Programs/Core Competency Areas

Research relating to health disparities, either as a public health issue or pertaining to individual diseases, is a key thrust of research in multiple departments and programs across the College of Medicine. Population sciences research, prevention research, genetic and genomic analysis, health systems research, pediatric and perinatal research, infectious diseases research, and multiple other medical arenas, have distinct bearing on health disparities and their effects. Work ranges from basic science inquiry as to physiological and genomic factors influencing disease risk among various subpopulations, through to detailed epidemiological studies and longitudinal studies of population groups.

Key strengths identified at Wayne State include:

- Pediatric Prevention Center with 10 faculty focused in health disparities and intervention development. Active programs with community organizations and regional health workers and professionals.
- Cancer disparities research and associated population sciences.
- Population science and epidemiology (and it should be noted that this is also said to be a strength at the Henry Ford Health System)
- Active research in Humanities and Social Sciences relating to relevant areas in: population change and demography; sources of disparities; criminal justice disparities; language and communications disparities; technological access, and education. Ranges across multiple departments including: Sociology; Political Science; Economics; Linguistics; English; Anthropology; Criminal Justice, and urban planning.
- Impact on disparities of healthcare delivery systems and health systems engineering.

Environmental Health

General Description:

Environmental health focuses on the understanding the impact of the natural and built environment on human health. At Wayne State there is distinctive sand multidisciplinary work occurring to identify and characterize elements of the environment (especially the urban environment) that impact health, and to elucidate the relationships, and mechanisms of action, between environmental factors, disease morbidity, and health outcomes.

Potential Goals and Outcomes:

- Research illuminating mechanisms of exposure to health-impacting stressors in the urban environment.
- Research leading to enhanced understanding of the negative impacts on health associated with complex urban industrial environment exposures.
- Development and testing of interventions and solutions to environmental health challenges.
- Applied testing and predictive tools using biomarker identification and bio-repository data. Provision of information on risk.

Regional Relevance:

The urban and industrial environment of Detroit is "encumbered with an overabundance of industrial and post-industrial environmental toxicants, socioeconomic strains, violence and housing decay."[14] The Detroit environment represents a high-need environment for research into urban environmental health, and solutions derived from Detroit regional research will have likely implications for many North American and global industrial and post-industrial cities.

Major Existing Programs/Core Competency Areas

- Institute of Environmental Health Sciences (IEHS) and the associated Center for Urban Responses to Environmental Stressors (CURES) are key components of Wayne States core competency in environmental health. Here research is focused on the goal of examining how chemical and non-chemical stressors in Detroit's urban environment affect the health of Detroit's vulnerable populations. Key interest groups formed within the CURES Center and its 55 affiliated researchers include: environmental modulators of the immune system; environmental modulators of metabolism and metabolic disorders; gene-environment and cancer, and environmental stressors and mental health.
- Research at the Merrill Palmer Skillman Institute examines exposures to toxins, drugs, community violence, etc. that affect child development and life-long health and wellbeing.
- Urban watershed research.

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[14] Wayne State University. Proposal for the President's Inaugural Symposium. "Title: The Center for Urban Responses to Environmental Stressors (Cures)". PI: Melissa Runge-Morris, M.D., Director, Institute of Environmental Health Sciences.

- Neuroendocrinology and neurotoxicity.
- Karmanos Cancer Institute

Behavior and Behavioral Interventions

General Description:

This platform encompasses multidisciplinary research into the causes and effects of human risk behaviors and in the development and testing of interventions. At Wayne State, this can span a spectrum from fundamental studies in behavioral neuroscience to the development of specific interventions in areas of strength for the University such as: maternal lifestyles; drug abuse; STDs and infectious disease; violence; and obesity. Translational research can occur not just in the development of effective interventions, but also in the development of novel tools and technologies to facilitate interventions.

Potential Goals and Outcomes:

- Enhanced fundamental insight into risk behaviors, information processing, decision making and pathways to effective behavioral interventions.
- The development and testing of potential behavioral interventions.
- Translation of effective interventions for risk behaviors into practice across the lifespan.
- Development of communications and educational technologies and informational materials for effecting behavioral change.

Regional Relevance:

The Detroit Metro region faces severe challenges related to the negative impacts of human behavior. High incidence rates in terms of interpersonal violence, drug abuse, obesity, contraction of STD's, pre-term birth, educational drop-out, lack of workforce participation, etc. in Detroit are indicative of the need for, and relevance of, effective behavioral interventions.

Major Existing Programs/Core Competency Areas:

Behavioral and interventional science researchers are found across a range of departments and programs at Wayne State University.

- Behavioral neuroscience and cognitive behavioral therapy
- Psychology and Psychiatry
- Pediatrics, OB/GYN and Perinatology with an emphasis on maternal risk behaviors (including alcohol and drug abuse)
- Pediatric Prevention Research Center, conducting behavioral, epidemiologic, biomedical, translational research in the areas of HIV/STD, substance use and misuse, and mental health in both

domestic and international settings. Applied programs using motivational interviewing, computer avatars, and intensive in-home interventions.

- Criminology
- Social Work and Sociology
- Family Medicine
- Medical Genetics
- Psychology
- Education and the Center for School Health in Education
- Merrill Palmer Skillman Institute, focused on child and family behaviors and associated impacts.

Urban Revitalization and Development

General Description:

There are multiple individual faculty and research teams at Wayne State University focused on applying studies of the built environment, social forces, education, economics and other social-science oriented factors that support or hamper urban revitalization and development of large urban areas. It should be noted, however, that Battelle notes that there is a lack of a comprehensive and coordinated focus at Wayne State on urban development, revitalization and sustainability – and that this platform represents a need against which some strengths may be applied – rather than a well-established present cluster to build upon. The fact that Wayne State lacks a focus in regional economics, economic geography and other related disciplines hampers the regional relevance of the institution in terms of regional science and research-based solutions to urban sustainability issues in the Detroit Metro.

Potential Goals and Outcomes:

- Strategies and actions to improve educational attainment
- Strategies and actions to enhance population workforce readiness, skills and labor force participation
- Urban and neighborhood planning and adaptive re-use strategies
- Entrepreneurial development and research commercialization for new business cluster formation and cluster enhancement.

Regional Relevance:

The need for innovative, research-based solutions to urban development challenges is acute in the Detroit Metro area. Recent reporting by ABC News, for example, notes that the City of Detroit (now in bankruptcy) has $18 billion in unfunded liabilities and contains 80,000 abandoned buildings.[15] The region has significant problems in educational attainment (only 7% of City of Detroit eight graders are proficient in reading), in labor force participation and employment, and has the highest violent crime

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[15] ABC News. July 19, 2013. "10 Biggest Dilemmas Detroit has to Face."

rate of any major U.S. city. Outmigration from the City has resulted in a far less dynamic urban environment, with the City now containing just 700,000 people compared to its peak population of 1.86 million in the 1950s.

Major Existing Programs/Core Competency Areas

- Center for Urban Studies. This Center provides survey research, data collection, analysis and evaluation services to inform public policy and development decisions within the region.
- Urban Studies and Planning
- Labor Studies Center and the Center for Workplace Issues. These primarily focus on organized labor and labor issues.
- Economics.

C. Technology Platform Details

Imaging and Diagnostics for Precision Medicine

General Description:

The advancement of imaging and molecular diagnostics technologies are ushering in a new era of precision medicine to establish more specific patient-oriented assessment and treatment approaches. According to the National Research Council, precision medicine "does not literally mean the creation of drugs or medical devices that are unique to a patient, but rather the ability to classify individuals into subpopulations that differ in their susceptibility to a particular disease, in the biology and/or prognosis of those diseases they may develop, or in their response to a specific treatment. Preventive or therapeutic interventions can then be concentrated on those who will benefit, sparing expense and side effects for those who will not."

Potential Goals and Outcomes:

- Research to improve or develop advanced MR. PET and CT imaging technologies – and their combination – as well as the interpretation and analysis systems of these images.

- Advancing nano-based microfluidics-technology that offers high content information on specific diseases and its progression.

- Utilizing in vivo molecular-genetic imaging of reporter genes to provide spatial and temporal information on cellular changes that occur during disease processes. Key advances are needed in the development of new probes and imaging agents, along with emerging new imaging technologies.

- Advancing new molecular diagnostic tests, leveraging availability of biobanks (including the Michigan neonatal biobank) and core genomic facilities at Wayne State University.

- Developing the combined approaches in disease identification across population groups by combining phenotype imaging with genomics.

- Establishing the bioinformatics capabilities to analyze and to interpret the large and complex data sets from across imaging and molecular diagnostics.

Regional Relevance:

The biomedical industry in the Tri-County Detroit Region (Wayne, Oakland and Macomb counties) is one of the region's growing technology industry sectors and now employs over 5,000 workers across nearly 300 business establishments. While still an emerging industry for the Tri-County Detroit Region, it has outpaced U.S. growth over the economic recovery period of 2009 to 2012. In examining the presence of innovative emerging and established companies (as identified through patents, SBIR awards, venture

capital funding and MEDC awards), there are eight that seem to fall into a focus on imaging and diagnostics in the Tri-County Detroit Region – so not a very strong base of activity.

As in other emerging bioscience industry clusters with major academic medical centers, much of the growth of innovation needs to be driven in concert with Wayne State University.

Major Existing Programs/Core Competency Areas:

This multi-disciplinary research platform builds upon several research competencies found at Wayne State University, including:

- Medical Imaging
- Genetics, Genomics and Molecular Biology
- Big Data, Networking and Sensor Systems
- Nano-based Materials

Key research centers to be tapped include the MR Center, the PET Center, the Applied Genomics Technology Center, and the Center for Molecular Medicine and Genetics.

Among specific research programs ongoing including Bioengineering faculty involved in in-vivo molecular-genetic imaging, Chemistry and Pharmacy faculty involved in new imaging agents and Electrical and Computer Engineering faculty advancing nano-microfluidic devices that offer high content analysis to detect and analyze disease and Computer Science faculty involved in bioinformatics.

Immunotherapies

General Description:

Addressing the immune system to fight off infections is a well-developed approach of medical treatment, involving preventative vaccines, anti-viral drugs and antibiotics. Advances in modern biosciences are increasing understanding of disease pathways and how the human immune system functions is giving way to a broader range of "immunotherapies" to induce, enhance or suppress the immune system for a wide range of diseases from infectious diseases, such as HIV/AIDS and medically acquired infections, to cancers and chronic diseases.

Potential Goals and Outcomes:

- Maintain a national leadership role in clinical research focused on cancer immunotherapies and antibiotic combination treatments – Wayne State has already garnered major grant funding for these clinical research efforts.

- Strengthen more applied and basic immunology research at Wayne State University involving the development of more effective monoclonal antibodies and vaccine technologies, as well as

advancing technologies to probe immune function, modulation and reconstitution. Create a stronger focus on animal model studies

- Establish stronger industry collaborations as immunotherapies are becoming an increasingly key focus of industry development for a wide range of diseases from cancers, influenza, hepatitis, and chronic diseases.

- Pursue emerging areas of science that can help leapfrog advances in immunotherapies, such as glycomics in which some major grants to Wayne State have already been awarded. A 2012 National Research Council Report on "Transforming Glycoscience: A Roadmap for the Future," notes that glycans are particularly important in immunity as antibodies are glycosylated proteins and glycans can also be targets for antibody binding and generating immune responses. The National Research Council further notes that while glycans are important in regulating immunity, they are also key actors in the constant battle between our cells and invading pathogens, including viruses, bacteria and parasites. Indeed glycans are the dominant molecules at this interface. Moreover, the great majority of biotherapeutics are produced as glycoproteins, and glycosylation – the process that attaches glycans to proteins –has significant impacts on efficacy and other features of biotherapeutics.

Regional Relevance:

Detroit's large underserved population has many untreated diseases and so the focus on clinical research is an important public health benefit. Detroit has a high level of incidence of infectious diseases among its residents, including HIV, Hepatitis and even community-based staph infections. Cancer rates are also quite high in Detroit.

Major Existing Programs/Core Competency Areas:

This multi-disciplinary research platform builds upon several research competencies found at Wayne State University, including:

- Infections and Infectious Disease Management
- Cancer Research

Key research center to be tapped is the Kormanos Cancer Center. The Karmanos' Immunotherapy Team is a national leader specializing in cancer immunotherapy treatment that combines cell- and antibody-based therapy, or bispecific antibody-targeted T cell immunotherapy in combination with initial chemotherapy to remove any remaining cancerous cells. Currently being used for Breast, Colon, Myeloma, Non-Hodgkin's Lymphoma and Pancreatic cancers. A key complement and collaborator on the Immunotherapy Team is the Bone Marrow & Stem Cell Transplant Program.

Among other specific research programs relevant to immunotherapies at Wayne State are the efforts of: the Immunology Department in molecular pathogenesis involving HIV and Herpes, with strong linkages to cancer immunotherapies; the Department of Infectious Disease in advancing antibiotic treatments for resistant staph infections found in hospitals as well as treatment approaches for HIV; and the

Department of Pharmacy Practice work on in-vitro modeling and simulation for combination antibiotics as well as the epidemiology of staph and other highly resistant infections.

Data to Decisions

General Description:

Data to Decisions is a particular niche area of a significant transformation taking place today in how information technology impacts society, businesses and our daily lives, commonly referred to as the new era of Big Data. The driver of Big Data is an unprecedented amount of digital information being generated from digitizing of records, on-line transactions, social networking and Internet searches. These massive data sets are too large and complex for humans to effectively extract useful information without the aid of computational tools.[16] It is this continuous use of data to inform real-time decisions that stand out as perhaps the most transformative aspect of Big Data in our daily lives. Often referred to as Data to Decisions (D2D), it will require much more complex, emerging technologies in sensor and sensor systems to gather and process data. This continuous use of data to inform real-time decisions poses significant systems engineering challenges, along with the need for improved data storage, processing and predictive analytic tools to interpret this complex unstructured data.

Potential Goals and Outcomes:

- Digital medical innovations – Advance the reshaping of health care delivery through the development and use of portable and wireless-enabled patient monitoring systems connected with advancements in biotechnology. Eric Topol, formerly head of Cleveland Clinic's Lerner Research Institute and now Chair of Innovative Medicine and Director of Scripps Translational Science Institute, provides examples of how the transformation of medicine through digital innovation taking place today builds upon increased understanding of how individual variations in genomics relates to diseases:

   "Imagine a genomic panel that indicated a high risk of diabetes mellitus in an individual who therefore now uses a sensor that adheres to the skin that continuously tracks blood glucose levels, promoting lifestyle changes or facilitating tailored pharmacologic approaches. Or imagine a woman with an increased risk of breast cancer who can monitor herself for breast cancer using a smart phone with the capability of acquiring and transmitting ultrasound images. Even today, remote wireless monitoring can be used to detect previously undiagnosed yet important heart rhythm disorders in individuals who carry DNA markers associated with increased risk for atrial fibrillation or ventricular tachyarrhythmia."[17]

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[16] Rick Robinson, "Taming Big Data," Research Horizons, Georgia Institute of Technology, Fall '12–Winter '13, pg 6

[17] Eric J. Topol, Transforming Medicine via Digital Innovation, Translational Medicine, January 27, 2010, Vol 2 Issue 16, pages 2–3

- Industrial Systems and Facilities -- With the increased use of robotics in manufacturing it is critical to create the control and monitoring systems that better sense how equipment is operating and provide prognostics on when components are failing and when product quality is slipping through real-time monitoring through remote communications to a service center.

- Financial industry applications of Data to Decisions will include addressing the complexity of securing financial transactions as the use of mobile payment through smart phone applications grow. At the same time, financial services firms are increasingly competing on their ability to make real-time decisions on providing credit to individuals, companies, and other financial institutions, and managing large investment portfolios, which call for use of predictive analytics in making real-time business decisions.

- Transportation and Distribution – Advance logistics and supply chain management through the use of sensors to track and monitor cargo. Of particular importance is ensuring temperature, pressure, humidity and other environmental controls for perishable cargo.

Regional Relevance:

Data to Decisions will have broad range of uses to industries located in the Tri-County Detroit Region. One of the largest growing industry sectors in the Tri-County Region is hospitals and medical centers, with an employment base of over 96,000 workers and a growth rate of 5% since 2009. Finding new ways to deliver care more cost effectively utilizing digital innovations will be important competitive differentiator in the years ahead.

Industrial automation also stands out as both a potential user and innovator in the Tri-County Detroit Region. With the large presence of automotive-related manufacturing operations remaining in the Tri-County Detroit region it is not surprising that there is also a healthy industrial automation sector in the region, employing 5,591 workers and growing by 14.8% from 2009 to 2012, as the auto industry rebounded. Sixteen industrial automation companies in the region were identified as active in innovation activities as measured by patents, SBIR funding, venture funding and local sources.

Major Existing Programs/Core Competency Areas:

This multi-disciplinary research platform builds upon several research competencies found at Wayne State University, including:

- Big Data, Networking and Sensor Systems
- Health Care Services and Delivery
- Industrial and Systems Engineering
- Next Generation Auto

This multi-disciplinary platform brings together growing activities in large database informatics (Computer Science), wireless networking (Computer Sciences), systems modeling and simulation (Industrial and Systems Engineering), sensor development (Electrical and Computer Engineering) and data visualization (Arts) taking place at Wayne State University.

Materials for Life Sciences Applications

General Description:

Biomaterials are naturally-derived (e.g., blood vessel or a protein such as collagen) or synthetic (e.g., polymer, metal, ceramic or composite) materials that are used in a wide range of medical devices, implants, transplants, surgical procedures, wound healing, skin treatments, drug delivery, dental replacements and other medical applications. What differentiates a biomaterial from other materials is its ability not to trigger adverse reactions while being able to withstand corrosion from being in contact with bodily fluids and tissues.

Potential Goals and Outcomes:

- Advancing new targeted drug delivery approaches using polymer-based nanoparticles.
- Advancing implantable biomaterials for tissue engineering and wound healing
- Advancing new diagnostic and analytical devices using stem cell platforms

Regional Relevance:

Within the emerging and growing biomedical industry in the Tri-County Detroit Region, there number of innovative therapeutic and medical device companies that may be able to benefit from advancements in biomaterials. Still there are only a handful of such companies in the Tri-County Detroit Region that are identified based on innovation activities as measured by patent, SBIR funding, VC funding and local Michigan sources.

As in other emerging bioscience industry clusters with major academic medical centers, much of the growth of innovation needs to be driven in concert with Wayne State University.

Major Existing Programs/Core Competency Areas:

This multi-disciplinary research platform builds upon several research competencies found at Wayne State University, including:

- Nano-based materials
- Cancer
- Pharmacology and Pharmaceutical Sciences
- Cancer Research and possibly Other Disease Research Areas

Wayne State University does not have a dedicated materials research center for life sciences applications.

Systems Approach to Manufacturability

General Background:

A key challenge for advanced manufacturing is reducing the time for product development through enhanced design; reducing costs in manufacturing processing through less expensive materials, reduced number of parts and alternative fabrication using forming and joining techniques; reducing component testing and qualification. This involves a wide range of engineering disciplines including use of computer modeling and simulation, instrumentation for real-time data gathering and performance prediction and non-destructive testing.

Potential Goals and Outcomes:

- **Advancing industrial robotics and reaching next level of manufacturing automation**. Wide uses of robotics in manufacturing sought – both for continuous assembly manufacturing as well as specialized high value, low quantity components. Plus, interest in robotics for tooling and inspections.

- **Improved human-machine systems operation and interfaces**, such as augmented reality to help operator with tasks and advancing embedded systems.

- **Digital manufacturing design innovation** to go to market quicker with new products, aid in design and testing of products

- **Offer more shared use test beds for automobile supply chain,** such as an integrated manufacturing design innovation facility linked with 3D prototyping capacity

Regional Relevance:

Engineering and technical services involved in all aspects of product development and design for the auto industry is a critical driver of Michigan's high tech manufacturing base, employing 36,221 workers in the Tri-County Detroit Region in 2012 and generating outstanding growth of 30% from 2009 to 2012.

This strong focus on engineering and technical services in the region points to the importance of advanced systems approaches for manufacturability to the next-generation of automotive systems for the region.

Major Existing Programs/Core Competency Areas:

This multi-disciplinary research platform builds upon several research competencies found at Wayne State University, including:

- Next Generation Automotive Research
- Industrial and Systems Engineering
- Big Data, Wireless and Sensing Systems

The presence of the Automotive Research Center at Wayne State brings a specialized focus in areas such as electric vehicle power and propulsion and vehicle safety systems. In addition, the collaborative effort with Ford in offering an Engineering Management Masters provides a critical resource for identifying specific needs for systems approaches to improve manufacturability from the OEMs perspective as a well as an important connections for advancing partnerships in the future. An important development is the potential to expand this effort to Tier 1 suppliers of Ford. Finally, the participation of Wayne State University in the new Center for Reconfigurable Manufacturing, led by University of Michigan, is an important step towards further expanding Wayne State's manufacturing design expertise.

D. Summary Mapping of Research Competencies to Proposed Multi-Disciplinary Research Platforms

Tables 9 and 10 illustrate the connectivity of the identified Wayne State University research core competencies to the recommended thematic and technology platforms. Each core competency is identified as one of three types of contributor to the platform:

- **Critical Contributors** – comprising core competencies that have substantial existing programs focused within the theme and which are performing current research directly focused on central questions and issues in this thematic area. Core competencies in this category would have a significant cluster of faculty already working in research subject matter directly related to the theme.
- **Major Contributors** – comprising core competencies that may have direct connectivity to key elements relating to the theme, and which have one or more key faculty engaged in research directed towards directly relevant issues.
- **Minor Contributors** -- comprising core competencies which may be able to contribute to research activity in the theme in niche areas or provide specialized expertise on an as-needed basis (e.g. analytical support, specialized subject matter expertise, or access to instrumentation or specific resources).

Table 9: Multidisciplinary Thematic Platforms

♦♦♦	= Critical Contributor
♦♦	= Major Contributor
♦	= Minor Contributor

Meta-Themes (Challenge or Opportunity Oriented)

Core Competency Field — Life Science and Biomedical Fields	Urban Child and Lifespan Development	Disparities	Environmental Health	Behavior and Behavioral Interventions	Urban Revitalization and Development
OB/GYN – Perinatology/ Maternal-Fetal Medicine	♦♦♦	♦♦♦	♦♦	♦♦♦	
Cancer	♦	♦♦♦	♦♦	♦♦♦	
Cardiovascular	♦	♦♦♦	♦♦	♦♦♦	
Basic and Behavioral Neuroscience	♦♦♦	♦	♦♦	♦♦♦	
Neuro/Psychiatric Disorders	♦♦	♦♦♦	♦♦	♦♦♦	
Psychology	♦♦♦	♦		♦♦♦	♦
Child and Adolescent Health/Pediatrics	♦♦♦	♦♦♦	♦♦	♦♦♦	
Child and Family Development	♦♦♦	♦♦♦		♦♦♦	♦
Environmental Health Sciences	♦♦	♦	♦♦♦	♦♦♦	
Health Care Services, Systems and Public Health	♦♦♦	♦♦♦	♦♦♦	♦♦	♦♦
Infectious Diseases	♦♦	♦♦♦	♦	♦♦♦	
Metabolism, Endocrinology, Obesity and Diabetes	♦♦♦	♦♦♦	♦♦	♦♦♦	
Protein Sciences and Biochemistry	♦♦				
Drug Abuse	♦♦	♦♦♦		♦♦♦	
Genetics, Genomics and Molecular Biology	♦♦♦	♦	♦♦♦	♦♦	
Vision Research and Ophthalmology		♦♦♦	♦♦		
Transplantation and Stem Cells					
Biomedical Imaging	♦♦♦			♦♦♦	
Pharmacology and Pharmaceutical Science	♦			♦	
Environmental Science and Ecology	♦		♦♦	♦	♦♦
Bioengineering	♦			♦♦	
Gerontology	♦♦♦	♦♦♦	♦♦	♦♦♦	

Core Competency Field Physical Sciences, Social Sciences, Engineering and All Other Fields (Non-Life Science)	Urban Child and Lifespan Development	Disparities	Environmental Health	Behavior and Behavioral Interventions	Urban Revitalization and Development
Physics			♦		
Chemistry			♦♦		
Mathematics	♦				
Big Data, Networking and Sensing Systems	♦♦	♦♦♦	♦♦	♦	♦
Industrial Engineering /AI- Robotics and Automation Control					♦
Social Work and Social Policy	♦♦♦	♦♦♦		♦♦♦	♦♦
Materials Science and Nano-based Materials					
Automotive Research/ Next Generation Auto					♦
Economics	♦♦	♦♦	♦		♦♦♦
Education	♦♦♦	♦♦♦	♦		♦♦♦
Labor Studies					♦♦♦
Urban Studies	♦♦♦	♦♦	♦		♦♦♦

Additional programs and disciplines with potential direct relevance

Other Departments, Programs or Disciplines at Wayne State University	Urban Child and Lifespan Development	Disparities	Environmental Health	Behavior and Behavioral Interventions	Urban Revitalization and Development
Civil & Environmental Eng.			♦♦		♦
Electrical & Computer Eng.			♦		
Industrial & Systems Eng.					
Mechanical Engineering					
Computer Science		♦	♦	♦	
Electric Drive Vehicle Program					
Nursing	♦♦	♦♦	♦	♦♦	
Fine, Performing and Communication Arts	♦	♦		♦♦	♦♦
Law	♦	♦	♦		
Business Administration					♦♦
Sociology	♦♦	♦		♦♦	

Anthropology	♦			♦♦	
Criminal Justice	♦♦	♦		♦♦♦	
Urban Planning	♦	♦	♦	♦	♦♦
Nutrition and Food Science	♦	♦		♦♦	
Dietetics	♦	♦		♦♦	
Political Science	♦	♦	♦	♦	♦♦
Public Policy	♦	♦	♦	♦	♦♦
Library & Information Science	♦	♦		♦♦	

Table 10: Technological Innovation and Development Platforms

♦♦♦	= Critical Contributor
♦♦	= Major Contributor
♦	= Minor Contributor

Core Competency Field	Imaging and Diagnostics for Precision Medicine	Immunotherapeutics	Data to Decisions	Materials for Life Science Applications	Systems Approach to Manufacturability
OB/GYN – Perinatology/ Maternal-Fetal Medicine	♦♦	♦♦	♦		
Cancer	♦♦	♦♦♦	♦		
Cardiovascular	♦♦	♦	♦		
Basic and Behavioral Neuroscience	♦♦	♦	♦		
Neuro/Psychiatric Disorders	♦♦	♦♦	♦		
Psychology	♦♦		♦		
Child and Adolescent Health/Pediatrics	♦♦	♦	♦		
Child and Family Development	♦♦		♦		
Environmental Health Sciences			♦	♦♦	
Health Care Services, Systems and Public Health			♦		
Infectious Diseases		♦♦♦	♦		
Metabolism, Endocrinology, Obesity and Diabetes		♦♦	♦	♦♦	
Protein Sciences and Biochemistry	♦	♦♦♦		♦	
Drug Abuse					
Genetics, Genomics and Molecular Biology	♦♦	♦♦♦	♦♦	♦	
Vision Research and Ophthalmology	♦	♦♦	♦	♦	
Transplantation and Stem Cells		♦♦		♦♦	
Biomedical Imaging	♦♦♦	♦	♦♦	♦	
Pharmacology and Pharmaceutical Science	♦	♦♦♦	♦	♦♦	♦
Environmental Science and Ecology			♦		

Core Competency Field	Imaging and Diagnostics for Precision Medicine	Immunotherapeutics	Data to Decisions	Materials for Life Science Applications	Systems Approach to Manufacturability
Bioengineering	♦♦♦	♦	♦♦	♦♦♦	♦
Gerontology	♦♦		♦		
Physics	♦♦♦			♦♦	
Chemistry	♦♦	♦♦♦		♦♦♦	♦
Mathematics	♦♦		♦♦		♦
Big Data, Networking and Sensing Systems	♦♦		♦♦♦		♦♦♦
Industrial Engineering /AI- Robotics and Automation Control		♦	♦		♦♦♦
Social Work and Social Policy			♦		
Materials Science and Nano-based Materials	♦♦♦	♦♦		♦♦♦	♦♦♦
Automotive Research/ Next Generation Auto					♦♦♦
Economics			♦		♦
Education					
Labor Studies					
Urban Studies					

Additional programs and disciplines with potential direct relevance include:

Other Departments, Programs or Disciplines at Wayne State	Imaging and Diagnostics for Precision Medicine	Immunotherapeutics	Data to Decisions	Materials for Life Science Applications	Systems Approach to Manufacturability
Civil & Environmental Eng.					
Electrical & Computer Eng.	♦♦♦		♦♦♦	♦	♦♦
Industrial & Systems Eng.				♦	♦♦♦
Mechanical Engineering	♦			♦	♦♦
Computer Science	♦♦		♦♦♦	♦	♦♦
Electric Drive Vehicle Program					♦
Nursing		♦			
Fine, Performing and Communication Arts			♦		
Law			♦		
Business Administration					♦

Sociology					
Anthropology					
Criminal Justice					
Urban Planning					
Nutrition and Food Science					
Dietetics					
Political Science					♦
Public Policy					♦
Library & Information Science			♦♦		