THE UNIVERSITY OF WISCONSIN-MILWAUKEE
College of Engineering and Applied Science

F A C U L T Y   M E E T I N G

Friday, September 28, 2017   10:30 A.M.   EMS E180

A G E N D A

I. DEAN UPDATE

II. INTRODUCTIONS

A. Faculty

1. Xiaoli Ma, Assistant Professor, Materials Science and Engineering
2. Timothy Patrick, Associate Professor, Industrial and Manufacturing Engineering
3. Nathaniel Stern, Associate Professor, Mechanical Engineering

B. Staff

1. Mike Andrew, Director of Corporate Relations

III. ANNOUNCEMENTS

A. Development Update – Jean Opitz

B. New TER System – Paul Klajbor

C. Update on Methods of Student Academic Misconduct – Ethan Munson

D. Center of Excellence in Advanced Materials and Manufacturing – Nidal Abu-Zahra

IV. INFORMAL REPORTS – See Attachment 1

A. Opportunity for questions regarding Informal Reports

V. DETERMINATION OF THE PRESENCE OF A QUORUM FOR FACULTY MEETING

VI. AUTOMATIC CONSENT BUSINESS

A. Course Changes – See Attachment 2

B. Computer Science Program Change – See Attachment 3

VII. SPECIAL ORDER OF BUSINESS -- Nominations

A. Awards and Recognition Committee

Only members of Biomedical Engineering, Civil and Environmental Engineering and Mechanical Engineering may be nominated. Two members are to be elected.

Continuing Member:

Prof. Naira Campbell-Kyureghyan – Industrial and Manufacturing Engineering

VIII. NEW BUSINESS

A. Curriculum Committee Charter – See Attachment 4

B. BME Concentration in Ph.D. – See Attachment 5

C. Proposal to Create the Connected Systems Institute – See Attachment 6

IX. GENERAL DISCUSSION

X. ADJOURNMENT

John R. Reisel, Secretary
CEAS Faculty

JRR
Attachments

ATTACHMENT 1

INFORMAL REPORTS

Office of Student Services – Todd Johnson
No Report

Career Services – Juli Pickering
No Report

Curriculum Committee – Prof. Church
No Report

Graduate Program Subcommittee – Prof. Liao
No Report

Academic Planning Committee – Prof. Misra
No Report

Faculty Senate – Prof. Reisel

Following the Chancellor's Plenary Address, the Senate actions most relevant to CEAS involved converting Graduate Faculty Council policies to Graduate Faculty Committee policies and modifying the charters of the graduate committee subcommittees. These actions were necessary as the campus continues to work on incorporating the graduate program governance into university governance.

ATTACHMENT 2

COURSE CHANGES

APC 340 LEGAL AND ETHICAL RESPONSIBILITIES OF THE IT PROFESSIONAL, 3 cr., U
Legal, regulatory, ethical and compliance issues associated with developing software and using information systems in an organization.
Prereq: admis to BS-APC prog; APC 320 (C)

had been

APC 340 LEGAL AND ETHICAL RESPONSIBILITIES OF THE IT PROFESSIONAL, 3 cr., U
Legal, regulatory, ethical and compliance issues associated with developing software and using information systems in an organization.
Prereq: admis to BS-APC prog; APC 320 (P)

COMPSCI 595 CAPSTONE PROJECT, 4 cr., U
Students will integrate their knowledge of the undergraduate computer science curriculum by implementing a significant computer science team project.
Prereq: sr st, CompSci 351 (P), CompSci 361 (P), and credit in at least 6 credits of 400 or higher CompSci or ElecEng courses.

had been

COMPSCI 595 CAPSTONE PROJECT, 4 cr., U
Students will integrate their knowledge of the undergraduate computer science curriculum by implementing a significant computer science team project.
Prereq: sr st, CompSci 351 (P), CompSci 361 (P), and credit in at least 6 credits of 400 or higher CompSci courses.

MATLENG 411 MATERIALS LABORATORY, 3 cr., U
Experiments demonstrating the basic laws governing the processing, structure, and properties of materials.
Prereq: Jr st; MatlEng 201(P).

had been

MATLENG 411 MATERIALS LABORATORY, 3 cr., U
Experiments demonstrating the basic laws governing the structure, properties, and processing of materials.
Prereq: sr st; MatlEng 201(P).

MATLENG 316 (442) THERMODYNAMICS OF MATERIALS, 3 cr., U

Chemical thermodynamics and application of thermodynamics to single and multi-component materials systems. Topics including heat and mass balance, enthalpy, entropy, free energy, reaction equilibria, behavior of solutions; phase diagrams.

Prereq: Math 233(P), Physics 209(P) or Physics 219(P), Matleng 201(P) and Chem 105 (P) or Chem 104 (P).

had been

MATLENG 442 THERMODYNAMICS OF MATERIALS, 3 cr., U/G

Third law of thermodynamics; application of thermodynamics to materials processes and systems; behavior of solutions; reaction equilibria.

Prereq: jr st, admis to MatlEng major, MatlEng 201(P); or grad st; or cons instr.

ATTACHMENT 3

Action **CHANGE**
Major **Computer Science**

UW-MILWAUKEE ONLINE PROGRAM CHANGE FORM

I. Current

Applied Mathematics Electives (Select 6 credits from the following list.)
[details omitted]
May include only one of Math 240, Math 234, ElecEng 234.
May include only one of Math 320, Math 234, ElecEng 234.

II. Proposed Change Summary

Change requirements to include Linear Algebra.

III. Effects

Additional Faculty Required

Four-Year Faculty Needs

Library Resources

Required Additional Facilities and Equipment

Program Costs

Resource Reallocation

IV. Justification

Basic linear algebra is an important mathematical topic that all computer science students should know.

V. New Copy

Applied Mathematics Electives (Select 6 credits from the following list.)
[details omitted]
Must include exactly one of Math 240, Math 234, ElecEng 234.
May include only one of Math 320, Math 234, ElecEng 234.

VI. Proposed Effective Date **Spring 2019**

VII. Comment

VIII. Approval

Vice Chancellor's Signature ________________________________
Date ____

ATTACHMENT 4

CURRICULUM COMMITEE CHARTER REVISION

Note: Edits have been highlighted in yellow. The strikethrough font was used to indicate text to be removed.

3.3 CURRICULUM COMMITTEE

3.3.1 Membership:

The Curriculum Committee shall consist of six (6) voting members and the CEAS deans as ex-officio, non-voting members. The Electrical Engineering and Computer Science Department shall establish a division of faculty into electrical engineering or computer science faculty for the purpose of electing a representative for each group. The other departments shall each have one representative. Changes to the membership structure, such as adding a representative for a new program or department, shall require the approval of the CEAS faculty.

3.3.2 Responsibilities:

a. The Curriculum Committee shall be responsible for:
   1. Policies concerning the core courses. ~~(individual courses are administered by departments)~~, The Committee shall periodically review the core courses of the College and recommend changes and additions as needed to the CEAS faculty through the CEAS Coordinating Committee.
   2. Supervision of undergraduate students admitted to CEAS who have not chosen a major.
b. The Curriculum Committee shall review and monitor all undergraduate programs and courses in the College. To carry out this responsibility it shall:
   1. Periodically review the undergraduate programs of the College using ABET accreditation and University reviews.
   2. Review all new undergraduate courses or changes to existing courses submitted and recommend on their approval to the CEAS Faculty through the CEAS Coordinating Committee, and transmit approved courses for which graduate credit is requested to the Graduate Program Subcommittee.
   3. Review all proposals for new programs or for changes in existing programs and, if approved, submit to the CEAS Faculty through the CEAS Coordinating Committee

3.3.3 Membership Election Procedures for Curriculum Committee:

a. Faculty Eligibility: All levels of faculty (Assistant Professors, Associate Professors, and Professors) with 50% or more of their academic appointments in CEAS are eligible to vote in committee membership elections and hold membership on the Curriculum Committee. Visiting Professors are not eligible.
b. Election of Department Representatives:

    1. The election of Department representative is by majority vote of eligible members of each department. Electrical Engineering and Computer Science faculty are to be divided into two groups, each of which elects a representative. No faculty member shall vote for more than one representative.
    2. Elections shall occur each spring in time to be announced at, or before, the April College Faculty Meeting.
c. Election of Curriculum Committee Chairperson:
    1. The membership of the curriculum committee shall meet annually prior to the May faculty meeting to elect a chairperson for the next academic year, from among its members. (Note: The Chairperson shall be eligible to vote on all matters coming before the committee).
d. Terms of Office:
    1. The terms of office of each member shall be for two years and shall begin September 1, or at the start of the academic year, whichever comes first. Elections shall be held according to the following schedule:

Representative	Year of Election
Biomedical Engineering	Odd
Civil Engineering	Even
Computer Science	Odd
Electrical Engineering	Even
Materials Science and Engineering	Odd
Mechanical Engineering	Even
Industrial & Manufacturing Engineering	Odd

    2. Three consecutive unexcused absences by a member from regularly scheduled committee meetings automatically vacates the position.
e. Filling Vacancies for Unexpired Terms:
    1. Policies and procedures for filling of vacancies shall follow CEAS Fac. Doc. 251.
    2. Should a vacancy occur from among the departmental representatives, the Committee shall immediately notify the chairperson of the Department concerned. A new member shall be elected within one month of notification to complete the term of the vacated position.
    3. A new member elected to fill an unexpired term shall take office immediately upon election. The new member shall complete the term of the original committee member.
    4. If the Chairperson's position becomes vacant, the vacancy shall be filled according to the preceding rules after which the committee shall elect a new chairperson to complete the unexpired term of the original chairperson.

COLLEGE OF ENGINEERING & APPLIED SCIENCE
Establishment of the Biomedical Engineering Concentration
In
Doctor of Philosophy in Engineering

Formal Name of Concentration

Biomedical Engineering

Degree Program

Doctor of Philosophy in Engineering

Reasons for Establishing the BME Concentration

Biomedical engineering is a multidisciplinary program that applies engineering techniques to healthcare area. Therefore, this program attracts a broad spectrum of students and researchers including women and underrepresented in the STEM. There are plenty of job opportunities, potential to start a successful business, and secure large and sustained research funding from various sources in this field.

Our undergraduate program has attracted nearly 100 students within three semesters since it started in fall 2016. Since restructuring last year to align with the market demand, the biomedical engineering concentration in Master's degree in engineering program has started growing and some of these students are looking for a doctoral degree in biomedical concentration. Further, we have been getting frequent inquiries from prospective students across the globe for a doctoral degree program in biomedical engineering. Therefore, the proposed concentration is expected to expand our doctoral program in engineering and the research activities significantly. Further, it will help retain our current faculty, and recruit competitively new faculty members to grow existing B.S. degree in BME and BME concentration in Master's degree programs.

Compelling Reason for Posting the Concentration on the Transcript

Most biomedical engineering doctoral degrees awarded in the US and abroad indicate the major area. Since our doctoral degree is not program-specific, it puts us in a disadvantage when recruiting students. Inclusion of the biomedical engineering as a concentration on the transcript will make us more competitive. Further, this will describe the student's background better and enhance their employment opportunities.

General Requirements

A minimum of 15 credits of graduate courses from the following list and any new graduate courses that Biomedical Engineering Program introduces in the future with BME coding. Only 1-cr of BME 999 (Advanced Independent Study) will be counted towards this requirement. Also, the student is required to take at least 18 credits of doctoral thesis under BME 998. Since most of the courses are offered regularly, students will have no problem in satisfying the requirements.

Qualifying Courses

BME 705 Rehabilitation Robotics (new course)
BME 720 Machine Perception
BME 733 Sensors and Systems
BME 890 Special Topics
BME 999 Advanced Independent Study
COMPSCI/ELECENG 710 Artificial Intelligence
ELECENG/MECHENG 701 Advanced Linear System Analysis
COMPSCI/ELECENG 711 Pattern Recognition - Statistical, neural, and fuzzy Approaches
COMPSCI/ELECENG 712 Image Processing
ELECENG/MECHENG 718 Nonlinear Control Systems
ELECENG 737 Fundamentals of Neuroimaging
ELECENG 765 Intro to Fourier Optics and Optical Signal Processing
ELECENG 810 Advanced Digital Signal Processing
MECHENG 715 Numerical Methods in Engineering

Compliance with GFC Doc.878

This concentration meets the requirements of GFC Doc. 878. Students who wish to receive this concentration within the Ph.D. degree in Engineering must complete 15 credits from the approved list of courses. Further, the student’s doctoral thesis must be completed under BME 998.

ATTACHMENT 6

PROPOSAL TO CREATE THE CONNECTED SYSTEMS INSTITUTE

The proposal to create the connected systems institute can be found on the following pages.

PROPOSAL TO FORM A UWM INSTITUTE

(SEPTEMBER 18, 2018)

A. PROPOSED NAME: CONNECTED SYSTEMS INSTITUTE (CSI)

B. EXECUTIVE SUMMARY

The concept of Internet of Things (IoT) is the network of physical systems including processes, actuators, sensors and data network, and cyberphysical systems including software, data analytics platform, and data storage. There is bi-directional data transfer between cyberphysical and physical system to improve overall system efficiency and cost reduction. In a connected system, the concept of IoT is integrated with business enterprise functions including Manufacturing Execution system (MES), Enterprise Resource Planning (ERP), supply chain management, Human Resources (HR), and customer relations to create a single system from suppliers to customers. This connected system provides opportunities for real time connection from hardware to data and business layers enabling total system optimization.

The vision here is to establish an internationally recognized, multidisciplinary Institute, centered at UWM in collaboration with industry leaders including Rockwell Automation, Microsoft, Johnson Controls and other companies, with an initial focus on industrial Internet of Things (IoT). The Institute will be a cutting-edge test bed to conduct research, provide education, and offer programs to develop talent, expertise, and solutions to lead companies to greater productivity through IoT technologies and applications. UWM is uniquely positioned to establish the Institute, because of its strengths and experiences in IoT-related disciplines, its location in the center of a key industrial and manufacturing hub for the nation, and its strong ties with many companies. The CSI will benefit the participating members in many ways, including conducting advanced research in the areas of industrial IoT, training talent with expertise in IoT suites and products, and connecting member companies to large, medium and small businesses in need of support in the IoT area. The ultimate goal is to reduce the cost and risk for the member companies to adopt the new technologies and transition to a connected system.

UWM teams have visited domestic and global companies and educational institutions, including Microsoft's IoT Innovation Center in Taiwan and lab in Munich, the Fraunhofer Institute in Berlin, IBM's IoT Center in Munich, industrial IoT events, and several Rockwell Automation Connected Enterprise test beds, to identify areas of collaboration, refine the CSI's focus areas, and develop a unique portfolio of research and education initiatives.

UWM teams continue to meet with industrial and manufacturing firms to assess their interest and to seek their advice with respect to CSI focus areas and structure. Interest is very strong. UWM is asking for financial support from member companies in the form of a one-time investment and/or multi-year membership commitment.

C. Background, Brief Description, Purpose, and Justification

During years 2016 and 2017, representatives from UWM have met separately with executives from Microsoft and Rockwell Automation to discuss partnership ideas related to the Internet of Things (IoT). The ideas presented in those discussions, and formulated based on UWM's strengths and industrial relationships, have been merged into the concept for the Connected Systems Institute (CSI).

Following internal discussions with faculty and administrative leaders, it is proposed to establish an internationally recognized, multidisciplinary IoT Institute, a collaboration among UWM, Rockwell Automation, Microsoft, Johnson Controls, and other industry leaders. The Institute will be a test bed to provide education, conduct research, and offer programs to develop talent, expertise, and solutions to lead companies to greater productivity through IoT technologies and applications. Founding partners will be drawn from the technology and manufacturing industries, and the beginning focus of the Institute will be in the realm of industrial IoT, aligned with UWM's strengths and needs of the industry. As the Institute expands, future points of focus could include smart cities, transportation, water technologies, energy, healthcare, financial services, agriculture, and education.

To remain competitive, a company, or any major organization, must connect smart devices, machines, and processes across production/operations to management and business enterprise. This business philosophy of connectivity across an enterprise requires both sophisticated research leading to innovation and a workforce interested in continuous improvement. The philosophy leads to improved manufacturing and industrial processes. It also enables productivity and security enhancements through real-time data gathering, analytics, and sharing mechanisms. To help companies and organizations achieve this competitive advantage, the CSI will focus on both research and educational activities. It will sponsor programs, lectures, webinars, and conferences that share strategies and tactics for implementing connectivity in alignment with a company's mission and goals. It will serve as a resource for enterprises that are developing, selecting, and testing IoT solutions.

CSI's research mission is a vital component, as research findings that promote greater efficiency, responsiveness, reliability, security, and agility will advance innovation in IoT technologies and application. Research will also help shape the curriculum, so that students are current with technological developments.

CSI will prepare the future workforce to provide the talent that industry requires to benefit fully from connectivity resulting from widespread use of IoT. Management and professional development programs will help organizations' current employees to learn new technologies to foster productivity and innovation.

The Institute will build on the solid and widely recognized work of faculty from the CEAS, LSB, and other academic units at UWM and other leading universities. Based on this overview, the remainder of this proposal will describe the central components in the CSI, including UWM strengths and partnerships, research, talent and workforce development, and facilities. We believe that these components, when fully developed and established, will result in one of the country's leading industrial IoT entities for research, education, and corporate engagement.

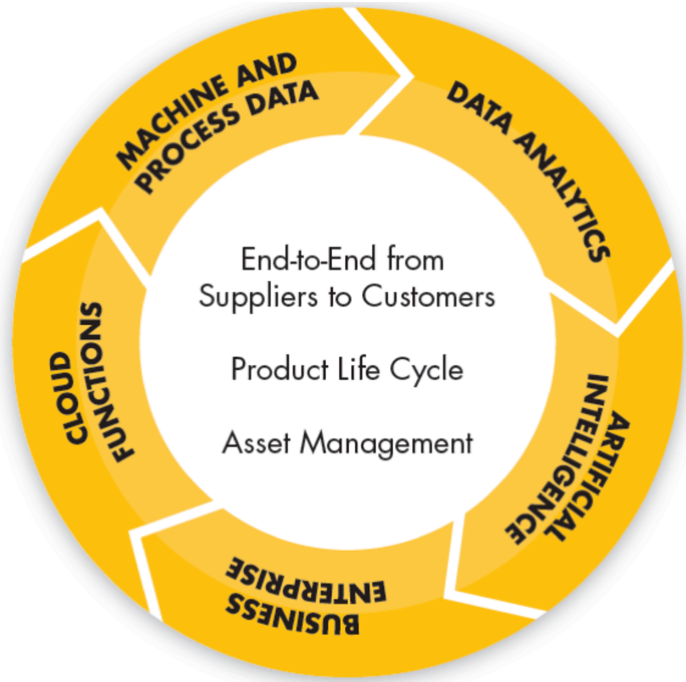

Figure 1. The concept and focus of the CSI.

D. Organizational Structure, Including the Method of Appointment and Term of Office for the Director

The governance structure of the CSI is based on three primary management groups: (1) Steering Committee; (2) Industrial Advisory Board; and (3) Academic Advisory Board. The labs and their associated faculty, engineers, and support personnel will report to the two advisory boards depending on their home organization, while the two advisory board chairs will coordinate both the working schedule and decisions between the University and company research teams.

Figure 2 illustrates how the functions will be distributed to achieve optimum definition, coordination, and execution of CSI deliverables.

Roles of CSI Team Members

- *Steering Committee:*
  The steering committee is responsible for overseeing the overall direction, status, and progress of CSI development when measured against its stated objectives and promised deliverables. The members of this committee are drawn from industry, community, and academia. The steering committee will work closely with the executive director as well as the industry and academic advisory boards. The steering committee meets twice a year with both the industry and academic advisory committees to understand the status of the Institute.
- *Academic Advisory Board (AAB):*
  The academic advisory team is responsible for overseeing the process for curricula development and professional MS, Certificate, and Executive Education programs within

CSI. AAB is also responsible for defining research needs and topics, based on inputs from industry members, and establishing a process to fund research projects. It is composed of directors of centers and institutes related to CSI as described in section V below as well as representatives from other participating academia.

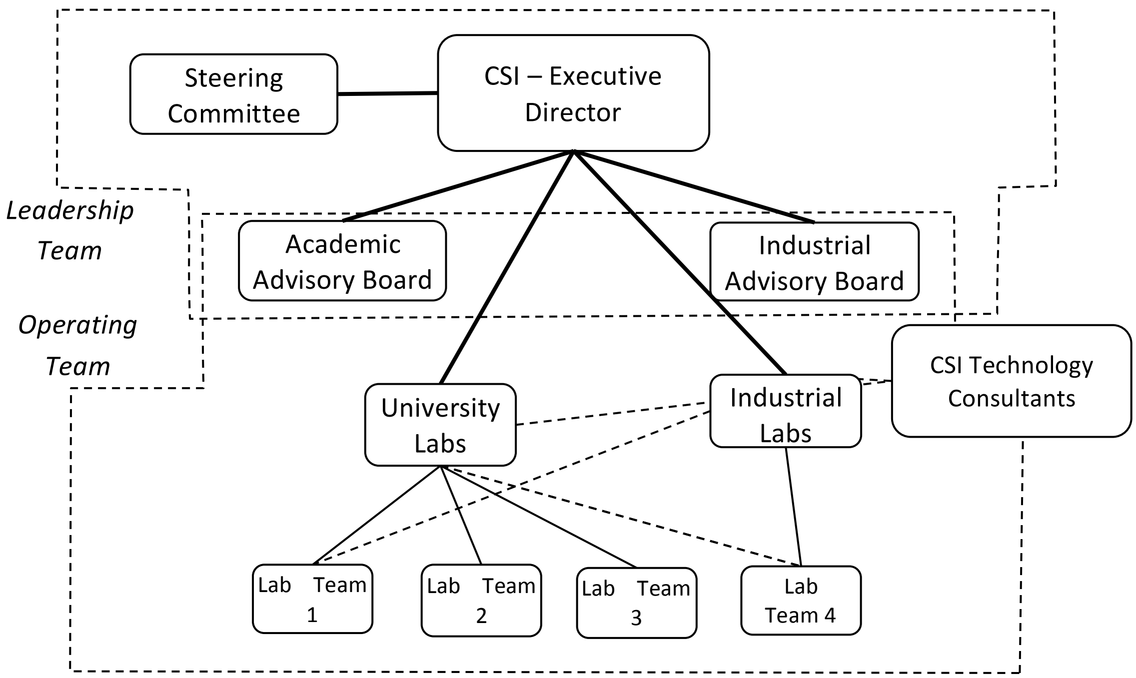

Figure 2. Structure and governance of CSI.

- *Industry Advisory Board (IAB)*
  The IAB will select successful research projects for funding from a pool of projects proposed by the researchers. The IAB will also require at least two updates per year from the project leaders as reports, posters, or presentations. The IAB will also work closely with the researchers to make them aware of the needs at the participating companies. IAB is composed of representatives from a selected number of CSI member companies.
- *Lab Managers:*
  Each of the four CSI labs will have a lab manager. The managers' core responsibility will be to prepare, review, and manage all objectives and milestones while providing day-to-day guidance and mentorship for researchers and students in a combined Research-Education operating team. The lab managers will take the lead in managing the communications in all forms, through regular transmittal to all of the project team and external stakeholders, and through the Executive Director when needed.
- *Research Team:*
  The Research Team includes researchers from UWM and other participating academic institutions, including professors, postdoctoral fellows, research assistants, and students, as well as researchers from participating industry partners. The research team will meet periodically with the industry members to learn about their needs. The research team will

develop research proposals and submit them to the IAB twice a year for funding consideration through a competitive process. Successful projects must provide updates twice a year and also via CSI webinars. The research team coordinates with the lab managers for use of the labs.

- *CSI Technology Consultants:*
  The consultants work with the primary investigators and with a role of bringing to the operating team deep insights into the broader system interactions that affect the CSI application. Their chief roles will be to comment, critique, suggest, and guide the aspects of the research, development, and emulation.

- *Executive Director:*
  The Executive Director is expected to provide leadership, vision, policy direction, and management oversight for the CSI. S/He will be deeply involved in the establishment of the CSI and its on-going operations, including facilitating participation by faculty with expertise in related disciplines and leading efforts to design and construct CSI facilities in conjunction with UWM's Office of Campus Planning and Management. The executive director will also be expected to collaborate and engage with executive and technical leadership of member companies as well as with academic partners. The executive director will also work closely with the Office of Sponsored Research and the Office of Development to secure external funding to advance the CSI's mission.
  The executive director will be appointed through a national search and will report directly to the Provost and Chancellor with dotted lines to deans of College of Engineering & Applied Sciences (CEAS) and Lubar School of Business (LSB). The term of appointment for the CSI Executive Director will be for five years.

Dr. Adel Nasiri has been appointed as CSI Interim Executive Director starting Nov 2017 for a 12-month term through an internal search within UWM led by the Provost. Prof. Nasiri is an internationally recognized energy systems leader and over the last 13 years at UWM, he has continuously received major research funds to address various issues in electrical energy systems. Dr. Nasiri served as associate dean for research in CEAS from 2015-2018. He is currently director for the Sustainable Electrical Energy Systems center, and site director for the NSF Industry/University Collaborative Research Center on Grid-connected Advanced Power Electronics. Dr. Nasiri has graduated 14 PhD students, 20 MS students, and currently supervises nine PhD students and three MS student. He is currently the PI on an Air Force grant totaling $1.9M to establish a connected energy and water system at an Air Force base.

E. Key Areas of Research Focus

The Institute will be a place where teams of researchers from UWM and industry partners address major issues associated with connectivity and integrated decision-making. UWM boasts world-class faculty who will be major contributors to the Institute’s research goals and initiatives. Figure 3 highlights the research tasks to be conducted at the Institute.

The CSI labs will be operated and organized based on five key principles that will differentiate them from all other institutes while providing key non-duplicative partnering opportunities as follows:

- Top-to-bottom system configurations that enable the study and research of IIoT functionalities and key application processes as whole solutions.

- Development of evolution mapping of the major industrial process technologies and their combinations to provide superior insight and foresight by relating them to well identified and emergent classes of IIoT technology challenges. This mapping will link them directly to key industries and application areas.

- Focus on the conversion of big data to smart data to knowledge-based systems. The CSI labs will assume that at any level of sensing and control there are information-to-knowledge, visualization, and machine learning opportunities. The labs will design in capabilities in modeling and experimental validation to reflect the new world industry and academic institutions live in.

- Solutions to the key challenge of "system scale up". Many key university/industry partnerships have identified understanding the engineering science of system scale up as a significant knowledge gap in choosing an approach to IIoT productization.

- Dynamic Techno-Economics analysis. IIoT systems challenge the research and education teams to bring together the science, engineering, and business models in ways that have traditionally been done for only utility scale systems. Intrinsic Techno-economic modeling is designed into the simulation and emulation approaches at all levels of the labs. Real time dynamic activity based cash flows will be embedded in the model schemas and visualization platforms.

A major unique feature of the CSI will be the end-to-end concept from devices and processes to data network and analytics, and to business layer. All use cases developed under CSI will apply the end-to-end concept.

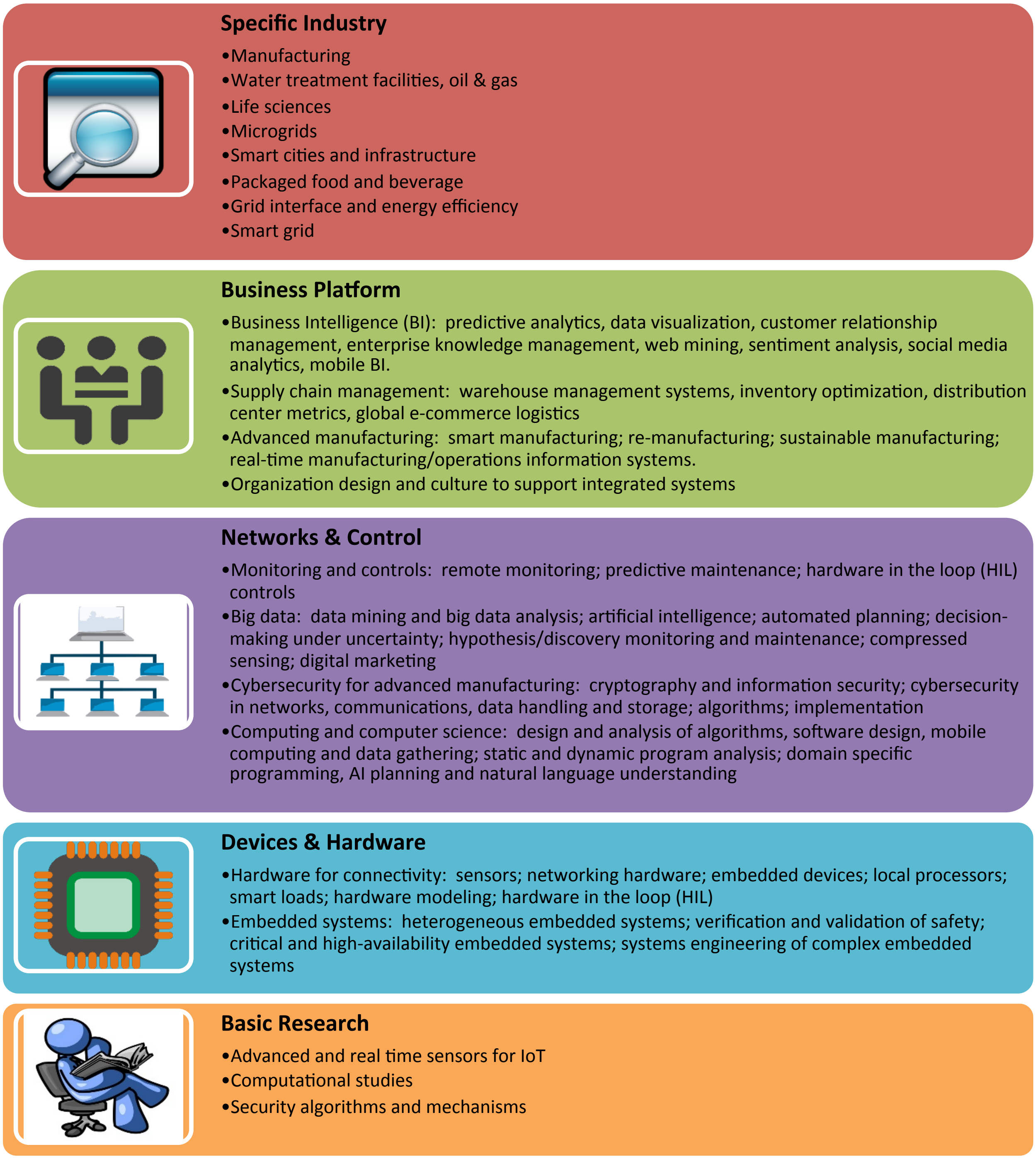

Figure 3. Research topics for the proposed Institute from basic to system level.

Three major areas of research focus at CSI will be on:

- **IIoT within factories and plants**

The focus of this research will be to implement an end-to-end connected system from supplier to customers at a factory level to improve overall system efficiency, productivity, and reliability. An example of this research focus is depicted in Figure 4 showing details of an example for an electronic assembly line. The system includes the assembly process, automation, controls, networks, data analytics, MES system, edge computing, visualization, cloud computing and storage, and ERP system. Artificial intelligence can be applied at several levels including edge and cloud.

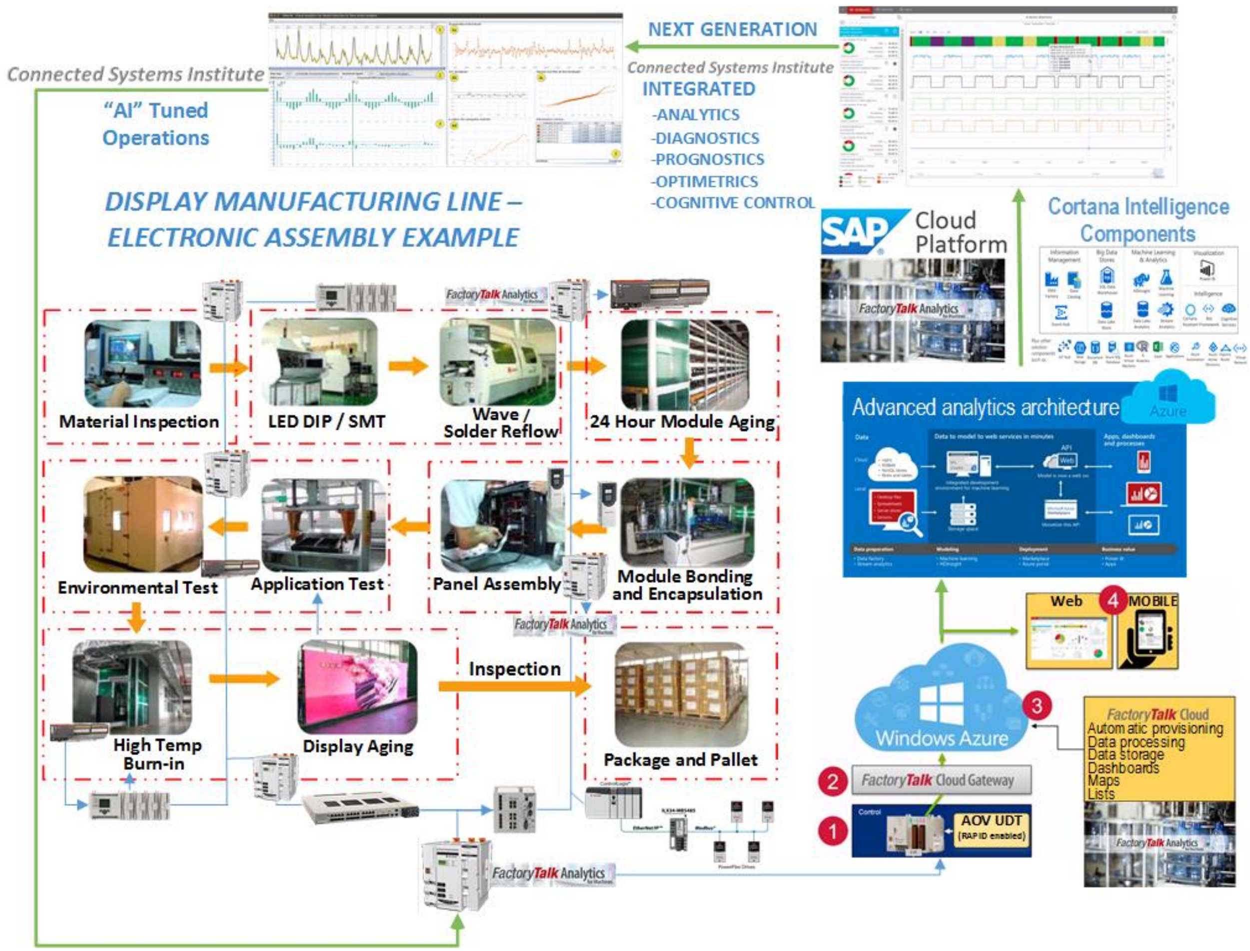

Figure 4. Example setup for the IIoT concept within a factory for an electronic assembly line.

- **Asset management**

Asset management is revolutionized in the concept of connected systems by applying sensors, data network, data analytics, visualization, and artificial intelligence. The faculty and researcher domain knowledge of electromechanical systems, materials, and processes will enable effective implementation of this concept. Figure 5 shows the concept for building asset management. Smart sensors are deployed across the system with ability to perform limited computation and establish communication with next level controller. Second level of computation and data analytics is performed at the system edge level. Processes are applied to perform predictive maintenance and remote monitoring. Several optimization techniques can be applied at the device level, edge level, or cloud level.

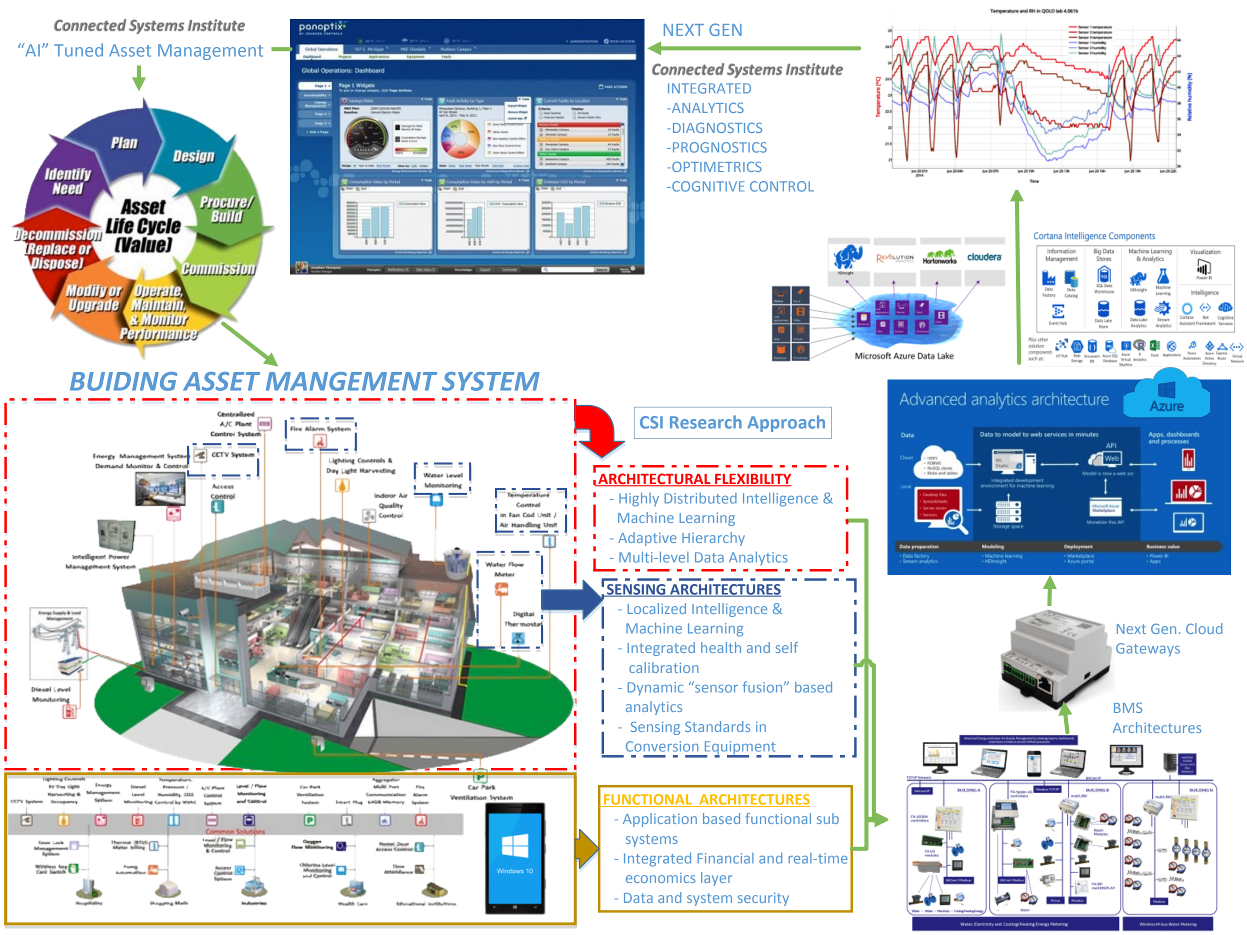

Figure 5. Example concept for the connected asset management for building assets.

- **Connectivity for product life cycle**

Another major concept in connected systems is to manage product life cycle from production to retirement/recycling. This is task is performed using collected real time data, product characteristics, usage, and data analytics. The process can provide valuable information while product is in use including state of function, remaining life, need for maintenance, etc. An example of this concept is depicted in Figure 6 for a battery pack used in various automotive applications. The on-board system collects data from the battery and with the cloud enabled historical data and scientific information on vehicle energy management system can determine the battery state of health, state of charge, and other functions. A data gateway is required to transfer the data between vehicle and other vehicle or a stationary system.

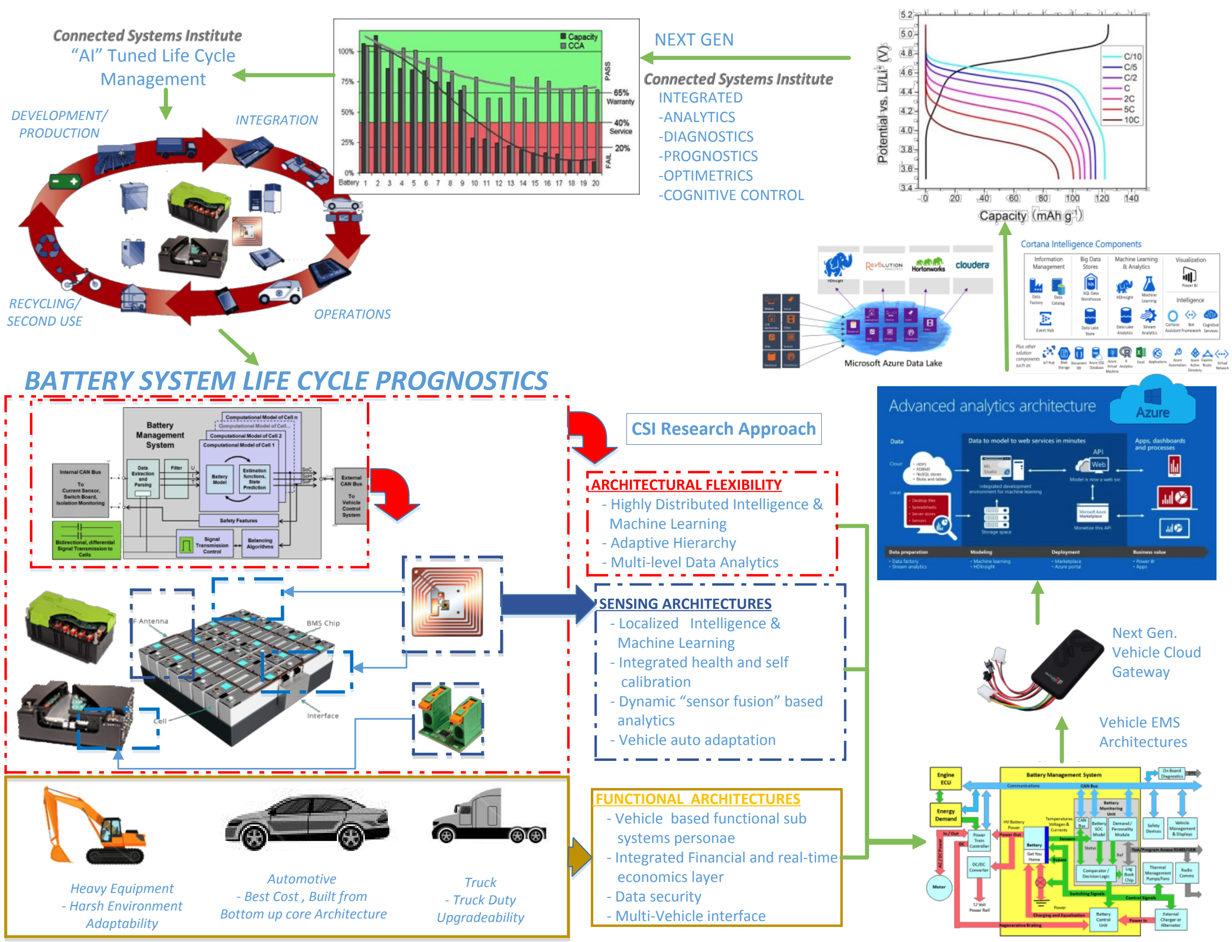

Figure 6. Example concept for the connected life cycle management for a battery.

F. Educational Components

Industry and higher education recognize the need for interdisciplinary integration of knowledge and skills at academic institutions and for mutually beneficial collaborations between academia and business. Traditionally, electrical and industrial engineering, computer science, management information systems, information technology, supply chain management, data analytics, and business intelligence have been taught in discrete courses or programs – the "silo" approach. CSI reflects a new approach, however, integrating these courses to better prepare the future workforce – but still ensuring that students have a solid grounding in traditional content and application. The curricula development will be from introductory concepts in connected systems to devices and controls, networking and business objectives, software and data, and to advanced topics. Faculty will include university professors and Professors of Practice from industry. Elements of CSI educational portfolio will include:

- Undergraduate and Graduate Students: Courses and labs will be designed for students in various disciplines in the form of elective courses to prepare students for the variety of challenges in IoT. Students will learn to use the latest software platforms from industry partners. We plan to develop a full complement of courses across CEAS, LSB, and SOIS (School of Information Studies), covering all aspects of connected systems. The course list includes basic courses in engineering and business on Connected Enterprise, a course on automation and safety, business courses on business intelligence and e-commerce, courses on big data and data analytics, data and sensor networks, quality and validation, and advanced courses in adaptive controls, supply chain, and cybersecurity. UWM has already started the course sequence by offering two Connected Enterprise courses, one with an engineering focus and another with a business focus. Table 1 lists the 13 courses across UWM colleges and schools under CSI. UWM now offers several courses, especially on networking, business intelligence, and cybersecurity, that closely match the courses listed in Table 1. These courses can be modified from an existing syllabus to fit CSI's mission.

Table 1. Initial list of potential CSI courses.

Connected Systems Institute Courses					
• Introduction To Connected Systems (CEAS) • Connected Systems for Business (LSB)	• Automation for Industrial Systems (CEAS)	• Business Intelligence for Connected Systems; Organizational Design (LSB) • E-Commerce and Advanced BI customer Relationships (LSB)	• Big Data and Data Analytics (CEAS) • Data Analytics, Visualization and Managment (LSB) • Artificial Intelligence and machinge Learning (CEAS)	• Cyber security for Connected Systems (CEAS) • Adaptive controls in Connected Systems (CEAS) • Data and Sensor Networks in Connected Systems (CEAS)	• Standards, Quality, and Validation (CEAS) • Advanced Supply Chain Optimization (LSB)

- Joint Professional Master's Degree: CEAS and LSB will develop a joint MS program on connected systems, which will include some courses already existing at CEAS, LSB, and SOIS as well as new courses listed in Table 1. There will be three groups of courses for this program: (1) required; (2) group A electives; and (3) group B electives. Students will be required to take a minimum number of courses from group A.

- Management and Executive Education: In addition to described courses, a separate program will be designed for executives within CSI to educate them on connected systems, including its benefits and challenges. This program will be particularly valuable for executives from companies considering how to use and exploit connectivity for strategic advantage in their businesses. The initial offering will be a four-day course covering essentials and implementation of connected systems with sessions on basics, functions, data science, supply chain, and linkage to MES and ERP systems.

- Professional Development: In addition to the professional MS program, various short courses for working professionals will be designed based on Table 1's course offerings. These courses will use CSI facilities for training.

- Certificates: A subset of CSI courses will be selected for a certificate program in connected systems. (The certificate is typically a 15-credit program with three core required courses and two elective courses.)

All the course programming must be approved through UWM's approval process.

G. FACILITIES

The concept of the CSI lab organizations is vertical rather than horizontal cutting across the IIoT space. Figure 7 contrasts the concept of CSI labs with the majority of the other IoT centers. Several existing IIoT facilities do not include the technological processes level and mostly emulate the hardware components. In addition, the existing labs are divided horizontally across layers. In contrast with existing setups, the CSI labs will be aligned as vertically integrated "end to end system" composites and will include the process level. The Labs are differentiated by capabilities as follows:

(i) Lab 1 – System Simulation Capability: utilizes coordinated simulation engines that are partitioned across the full range of IIOT functions starting from the very bottom of the stack representing machine functions, individual devices and the lowest level controllers.

(ii) Lab 2- System Simulation and Emulation: utilizes reference models from Lab 1 and adds emulation capabilities with additional HIL emulators and embedded system emulators covering the fuller angle of processor types.

(iii) Lab 3- Test Beds: utilizes the reference simulation-emulation designs and adds factory like real hardware combinations as scaled process lines and industrial network pilot configurations.

(iv) Lab 4 – Test Plants: Takes fully calibrated reference models as supra models and operates them in parallel combination with actual instrumented plants and enterprise facilities. This lab provides the ability to do actual complete calibrated shadow simulations utilizing real data from operating plants and predicting and validating key principles of new functions and structure architecture against real time non-linearities and events.

Four CSI labs will be connected together as described in Figure 7. The simulation (Lab 1) and simulation/emulation (Lab 2) labs will have capability to model both test bed setups as well as the test plants. The simulation lab provides reference models to the simulation/emulation lab. In turn, Lab 2 provides reference configurations to the test bed setups. Lab 4 will have two components, a real factory live data stream and a real time shadow stream. The output of the shadow model will be analyzed and displayed simultaneously with the real factory data. The labs will have a unique approach to test-beds. Test beds will be aligned across many scales but always with the key capability to evaluate end to end system configurations, multi-tiered data and control applications utilizing real hardware and hardware combinations (sub-systems), fully functional software at all levels, and advanced visualization. All test-beds would have complete simulation/emulation models developed and tested against highly dynamic use cases to assure that every hardware/software test cell operates in a "virtual plant" digital ecosystem.

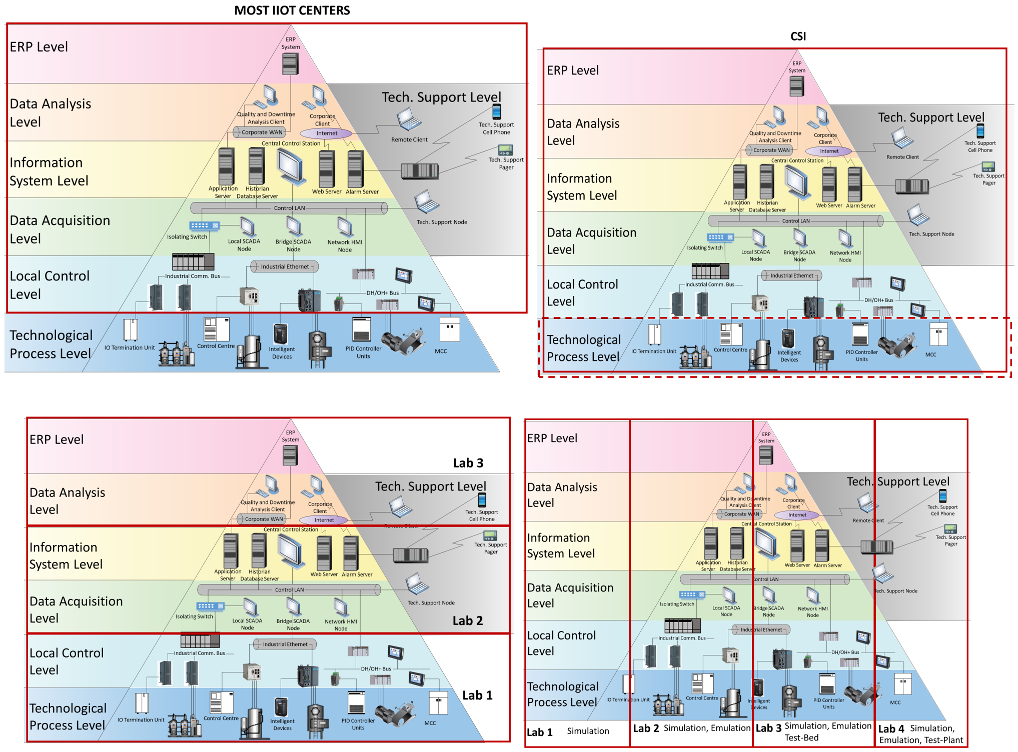

Figure 7. CSI lab concept contrasted with existing IIoT centers.

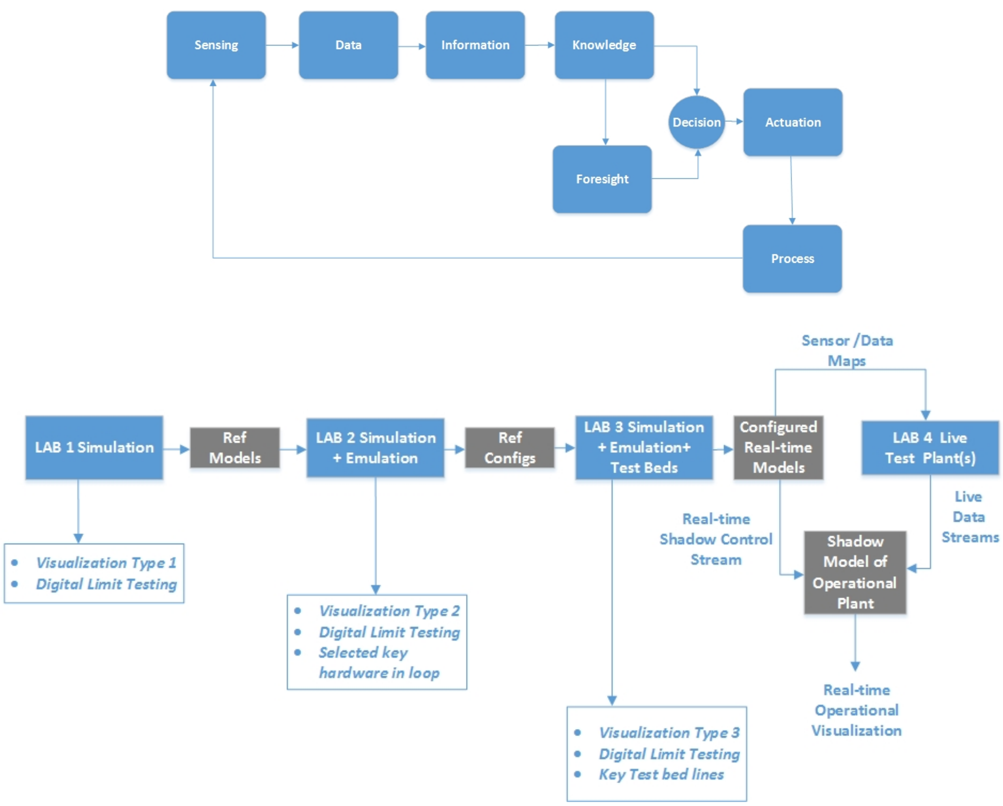

Figure 8. Components for all CSI labs (top) and flow of models among four CSI labs (bottom).

CSI Lab Test Bed Example:

The Phase I set of test-bed reference configurations for Lab 3 are envisioned to be: (i) Advanced Manufacturing Flexible Cell, (ii) Distributed Water Processing System, and (iii) Energy Optimizing Distributed Industrial Power Network.

Advanced Manufacturing Flexible Cell. The Advanced Manufacturing Flexible Cell test-bed is a scalable plug and play configuration that would have rack-level sub-process stations that would connect to a modular conveyor system. The typical sub-process stations would have rack systems that would allow complex sensing-control-data hardware running various levels of embedded, encapsulated, and distributed software to perform stochastically realistic operations accomplishing rigorous process objectives. The test cells are envisioned in a modular and scalable architecture between small and medium size systems. The actuation and conversion processes at the stations could range from simple pick and place to multi-level sortations and assemble robotics, to small modular machine tools, to additive manufacturing stations. The medium size cell is envisioned to be a modified fully integrated modular machine cell containing integrated machining, joining, forming sub-cells and those higher difficulty sensing-control-data process capabilities.

Distributed Water Processing Cell. The Distributed Water Processing Cell test-bed is a scalable plug and play configuration that would have rack-level sub-process stations that would connected by a modular piping and fluid control sub-systems. The typical sub-process stations would have rack systems that would allow complex sensing-control-data hardware running various levels of embedded, encapsulated, and distributed software to perform stochastically realistic operations accomplishing rigorous process objectives. The test cells are similarly envisioned in a modular architecture between small and medium size systems. The actuation and conversion processes at the stations could range from simple pump flow-pressure balance control to highly non-linear filtration, and coagulation. The medium size cell is envisioned to be a modified fully integrated modular process pallet containing high dynamic range filtration, field activated water processes, and chemical analytical sub-cells and those higher difficulty sensing-control-data process capabilities.

Energy Optimizing Distributed Industrial Power Network. This test-bed can be built upon the previous two test-beds by the addition of specific sensors, software functions, and higher-level model reference controllers and data engines. The key challenges to be explored by this test bed are the optimization of energy functions for the key process functions such as advanced manufacturing and water processing.

CSI Test Plant Example- Cement Process Top to Bottom Systems View

The advantage of the four-lab organization envisioned for the CSI can be demonstrated by the following example. In Figure 9, we can see a modern cement processing facility where the raw materials necessary for different grades of cement are converted. The figure illustrates the advanced functionalities of our facility approach that enable combinations of present product architectures to be extended by use of advanced modeling and analytic toolsets supplied by our

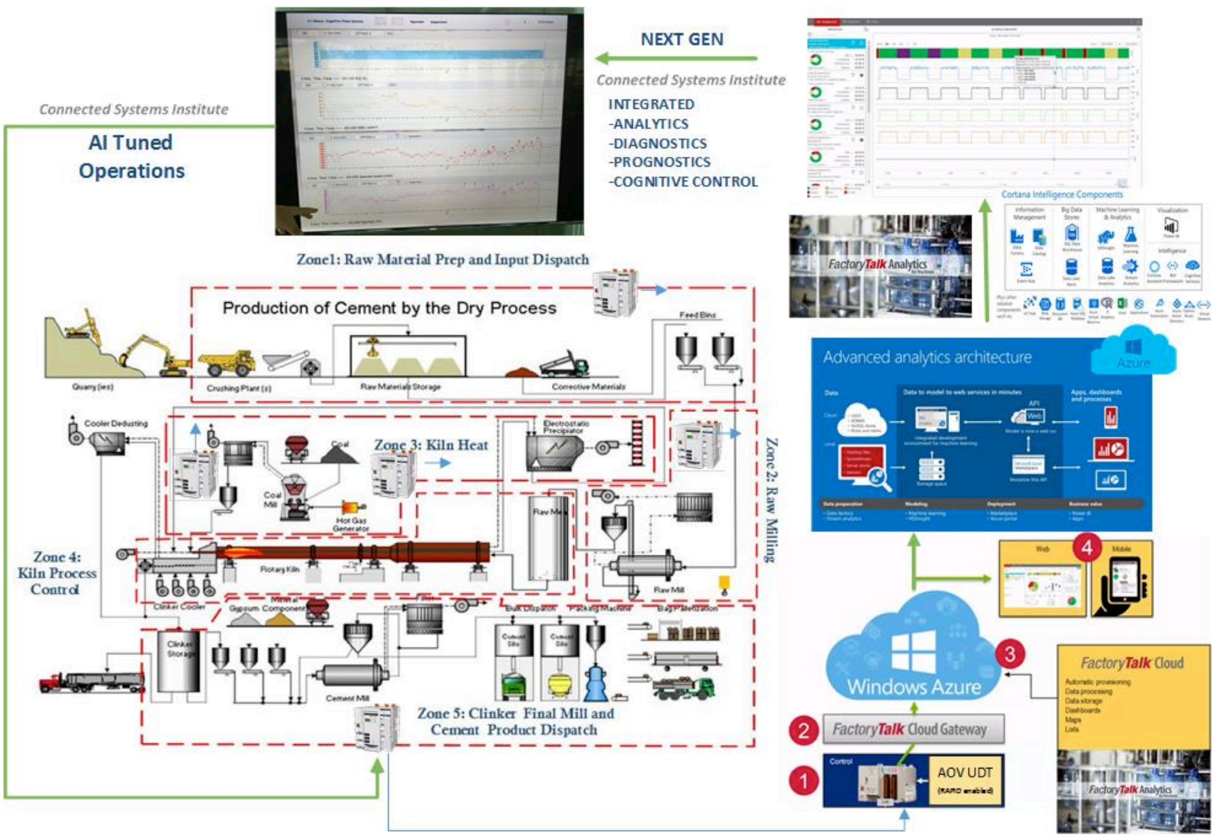

Figure 9. Example test plant setup for a cement factory integrated with advance IIoT tools.

core partners. In this real-world process system example, smart process zone controllers like the CompactLogix 5480 (capable of running both Logix Platform OS as well as Windows10) operate the hardware in the loop emulation environment of the cement plant. The emulation operates multiple smart process cell controllers that talk up the cloud hierarchy through FactoryTalk cloud gateway to a fully configured Factory Talk Analytics platform running on the Azure cloud utilizing a library of analytics services from the Cortana cognitive processing suite. Next generation data-decision processing streams are then fed back into key parameters of the cell controllers. This example was configured to explore various adaptive plant tuning approaches while maintaining stability and optimality of the process and strict "control safe" integrity. This facilities and capabilities approach is unique among all the IIoT research centers that have been benchmarked.

The CSI will be located on the first floor of the East Wing of UWM Golda Meir library. UWM space committee has allocated 7,700 sq-ft of space to CSI and it can be expanded to 12,000 sq-ft. Renovation for this space to house CSI has already begun. An architectural firm is hired to perform the design of the space. Another company will be hired to renovate the space after completion of the design.

H. BUDGET

The main components of the CSI budget include the cost for facilities, personnel, and research staff. Preliminary and draft budget numbers for CSI are provided below in Table 2.

Table 2. Overall annual cost profile for the CSI and details for 2018-2019.

Annual Operating Cost

Personnel				
	Program Manager	$56,160.00		50%, Includes 44% fringe
	Executive Director	$306,000.00		12-month, includes 35% fringe
	Marketing	$16,000.00		
	Facilities Manager	$152,640.00		Includes 44% fringe
	Admin assistant	$25,000.00		Includes 44% fringe
Miscellaneous		$50,000.00		
SAP Facilities support		$53,150.00		
Faculty research pool		$350,000.00		
Facilities		$200,000.00		
UITS support		$50,000.00		
Course Offering		$215,000.00		
New CEAS Faculty		$140,000.00		9-month, includes 35% fringe
New LSB Faculty		$180,000.00		9-month, includes 35% fringe

Total	**$1,793,950.00**

One-time cost beyond Summer 2019

Executive director startup	$300,000.00
Faculty startup	$600,000.00
Brewery testbed	$850,000.00
Facility completion	$350,000.00
Metal forming testbed	$750,000.00

Total	**$2,850,000.00**

2018-2019 Expenses			
Faculty research pool		$175,000.00	
Course development		$195,000.00	13 courses X $15,000; faculty summer buyout
Personnel			
	Project Manager	$45,000.00	Includes 44% fringe
	Executive Director	$53,562.00	Includes 35% fringe
	Marketing Assistant	$16,000.00	
	Facilities Manager	$32,000.00	Remindar of FY 19 hire
	Administrative assistant	$25,000.00	Remindar of FY 19 hire
Miscellaneous		$30,000.00	Travel, marketing, workshops
Digital twin for testbed		$21,500.00	Course buy out
Facilities build		$1,400,000.00	
First testbed		$1,300,000.00	Donation
UITS Support		53,510.20	
SAP Facilities Support		50,000.00	
Simulation Lab		$110,000.00	
Emulation Lab		$165,000.00	
AV		$436,000.00	Donation
Furniture			
TOTAL		**$4,107,572.20**	

The membership structure of CSI has several levels as described below.

- Naming partner: $5M over five years.
- Founding member: $2.5M over five years.
- Sustaining member: $1M over five years
- Associate member: $250K over five year
- Academic member: $200K to enter and $20K annually
- Fee-based user agreement for Small and Medium Enterprises (SME)

Till date, Rockwell Automation has committed $1.3M for development of facilities, provided $400K of cash. Another $750K of cash commitment is under consideration by Rockwell Automation. Wisconsin Economic Development Corporation (WEDC) has committed a total of $900K to the CSI over three years. A proposal is being prepared for submission to Microsoft for support. ANSYS has committed all the engineering software needs for the CSI, valued at $4.6M per year. A proposal for cash commitment will also be submitted to ANSYS soon. We are the progressing stage of developing partnership with Johnson Controls. Eaton Corporation and AO Smith are at the final stages of commitment for associate membership.

I. CSI OFFERINGS

CSI will offer numerous membership benefits as listed in Table 3. CSI members will be eligible for tiers of benefits based on membership levels.

Table 3. CSI member benefits.

ADVANTAGES	FOUNDING MEMBER $500,000 ANNUALLY $2.5 M over 5 yrs	SUSTAINING MEMBER* $200,000 ANNUALLY $1M over 5 yrs	ASSOCIATE MEMBER $50,000 ANNUALLY $250,000 over 5 yrs
Upstream and downstream industry networking	✔	✔	✔
CSI Roundtable: pre-competitive research/results	✔	✔	✔
Non-exclusive intellectual property on pre-competitive research †	✔	✔	✔
Enhanced voting rights on CSI Roundtable Projects	5 votes	3 votes	1 vote
Membership credit for new or existing members in CSI affiliated organizations † ‡	50% credit on 2 memberships for 5 years	50% credit on 1 membership for 5 years	33% credit on 1 membership for 5 years
Participation in Industry Advisory Board	✔	✔	✔
Participation in CSI Catalyst Grant Program	✔	✔	
I-Corps Site Training (4 weeks) †	✔	50% discount for 2 organizations	
Exclusive one-day member session to discuss specific connectivity needs	✔	✔	
Membership on CSI Steering Committee	✔	✔	
Participation in CSI conferences and webinars †	✔	✔	Fee Based
Participation in CSI Industry Executive Day	✔	✔	
Scheduled use of facilities and equipment † §	✔	✔	
Virtual factory setup: mutually proprietary simulation and emulation on specific product †	✔		
Named CSI Catalyst Grant Program	✔		
UWM CSI Executive Education (4-day program) †	✔	Fee Based	Fee Based
UWM Career Fair with Prime placement †	✔	Fee Based	Fee Based
On-site CSI Executive Education	Fee Based	Fee Based	Fee Based
CSI Sponsored Research Contracts	Fee Based	Fee Based	Fee Based
Professional MS program on Connected Systems	Fee Based	Fee Based	Fee Based
UG Certificate on Connected Systems	Fee Based	Fee Based	Fee Based

J. List of CSI Faculty Advisory Board

Faculty members from departments across UWM schools and colleges have been invited to join CSI AAB. The following 23 faculty agreed to join the board. The first AAB meeting was held in March 2018 more are scheduled. The research and teaching interests of many faculty in CEAS, LSB, and SOIS applies to CSI. The interested faculty can be members of a larger affiliated list of faculty participating in more focused activities including research, course teaching, seminars, short courses, and events.

LSB:
Sarah J Freeman
Purushottam Papatla
Huimin Zhao
Edward F Levitas
Atish Sinha
Ehsan Soofi
Ross Hightower

CEAS:
Amol Mali
Nidal H Abu-Zahra
Mohammad H Rahman
Jun Zhang
Hossein Hosseini
Ilya Avdeev
Lingfeng Wang
Zeyun Yu
Al Ghorbanpoor
Ryo Amano
Jin Li
Matt Petering
Hamid Seifoddini

SOIS:
Michael Zimmer
Jacques du Plessis
Matt Friedel

Also after the UWM approval, faculty from other local and regional academic institutions will be invited to join the Institute and collaborate as appropriate.