2017 ILO Summit Presentations

July 26th - 28th, 2017

North Carolina State University

Raleigh, NC
Sustainability Planning
For Post Graduation

Presented by:
Lisa Beard
Industry Outreach Director
And Liaison Officer

July 27, 2017
Purpose
• Transition strategy for CURENT to move from a NSF/DOE jointly funded ERC to a self-sufficient organization
• Secure additional support/funding for continuation beyond year 2020
• Four-year business plan/roadmap to outline necessary steps for implementation
• Engage stakeholders in planning process

What is needed to transition to self-sustained institute
• Leadership of the management team
• Broad engagement of faculty, staff, industry partners, and university administration, which allows for both ownership in the plan and commitment from all stakeholders
• High degree of University commitment
• High education program value to faculty, students and industry
• Commitment of core group of faculty
• Active industrial support, contribution of membership fees and guidance
• Effective implementation of a transition plan that builds on Center’s strengths
Sustainability Planning Process

• Initiated discussions with potential partners and funding sources
  • Reviewed other successfully graduated center’s sustainability plans
  • Conducted one-on-one meetings with principal and key members
  • Ask for input during IAB workshops and retreats
  • Held Internal discussions with Leadership across Universities to gain institutional support
  • Developed action plan to procure resources including State Funding, Endowments
    e.g. NYSERDA, UT Center of Excellence, Gov. Chair
    e.g. Gates Foundation
• Formed the CURENT Industry Sustainability Working Group (CISP)
• Met with NSF ILO Consultants at UTK in April 2017 to discuss Center Sustainability Planning and Tech Transfer
• Presented and discussed CISP progress with IAB/SAB during July 2017 summer retreat
• Establish cooperative efforts with multi-disciplinary partners at CURENT Universities
• Working with two, small, start-up companies for technology transfer (option to license)
• Launch Core projects during Years 9 and 10
• Seek support to continue beyond Year 10
• Develop Plan for Education and Outreach Continuation
CURENT Industry Sustainability Planning Group (CISP)

• **Team Purpose**
  o determine methods to retain and grow relationships with current members and explore other opportunities to help sustain the center.
  o help center build a sustainable model by providing guidance for financial support and facilitation of its programs.

• **Mission and Objectives**
  o increase the likelihood of a successful transition so Center is able to sustain itself (both its mission and budget) and continue to operate after graduation.
  o anticipated that several key changes can be expected for the Center. The goals of the plan is to positively manage those major changes and develop creative approaches to augment the core programs of the Center in other ways.
# CURENT Sustainability Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
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<tr>
<td><strong>Industry</strong></td>
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<tr>
<td>Tom King (chair)</td>
<td>UT/ORNL</td>
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<tr>
<td>Hongming Zhang</td>
<td>Peak Reliability</td>
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<tr>
<td>Dejim Lowe</td>
<td>Tennessee Valley Authority</td>
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<tr>
<td>Xiaoming Feng</td>
<td>ABB/IAB Co-chair</td>
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<td>Dave Bertagnolli</td>
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<tr>
<td>Matthew Gardner</td>
<td>Dominion/IAB Chair</td>
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<tr>
<td>Phil Overholt</td>
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<tr>
<td>Ali Abur</td>
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<tr>
<td>Joe Chow</td>
<td>RPI Campus Director</td>
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<tr>
<td>Fran Li</td>
<td>UTK Campus Director</td>
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<tr>
<td>Greg Murphy</td>
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<td>Bill Dunne</td>
<td>College of Engineering,</td>
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<td></td>
<td>Associate Dean &amp; Professor</td>
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<td><strong>Staff</strong></td>
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<tr>
<td>Lisa Beard</td>
<td>Industry Outreach Director</td>
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Sustainability Plan
Four Key Components

1. **Programmatic**
   - Define Post-Graduation Mission & Goals

2. **Financial**
   - Secure University Support
     - Institutional Support (financial)- written commitments from 4 Deans
     - Interdisciplinary research grants obtained from Federal and State agencies
     - Innovation Partnerships – education grants and start-up companies
   - Continue to Increase Industry Engagement
     - 14 on-site visits to industry sites in 2016 and 8 in YTD in 2017
     - 35 members 5/30/2017 – goal is 40 or less
     - Consider modifying cost structure
   - Capitalize on Technology transfer

3. **Cultural**
   - Develop future workforce by educating students who are prepared to work as teams, to become entrepreneurs, and are cross-trained in power electronics and power systems;
   - Build a cross-section with public-private partnerships and leverage both public and private funding;
   - Seek technology innovation through research, development and application;

4. **External**
   - Marketing/Action plan
   - Conduct Outreach/Workshops
CURENT’s mission is to be a critical catalyst for the technical evolution of the power industry. Several key changes expected for the Center:

- Goal of the sustainability plan is to positively manage those major changes and develop creative approaches to augment the core programs of the Center in other ways. The plan will address the following areas: 1) financial, 2) programmatic, 3) cultural and 4) external.
- Metrics of success include the ability to maintain the core Center characteristics of system driven approaches and the core elements of industry engagement, research and education.

*Key Challenge will be balancing scope and availability of resources*
Activities Across Different Time Dimensions

Innovation (Long-Term, 10-20 yr)
- Identify and research top technology trends (ten to twenty year timeframe) with emphasis on enabling scalable, power-industry positive impacts
- Develop and publish a series of high-priority technology white papers for Members
- Develop attractive proposals and experiments in an effort to support long-term industry innovation and assure future investment
- Build a strategic technology portfolio (patents, licenses, etc.) to provide incremental independent funding while also providing value to Members

Research and Development (Mid-Term 3-5yr)
- Grow core competence in technology areas such as Ultra-Wide-Area Management, Monitoring and Measurement, Cyber Security, Large Scale Modeling, Analytics and Visualization
- Working closely with top tier Members Power

Technology Transfer (Short Term 12-24 months)
- Technology Testing/User Group(s)
- Software tool development and prototype design
- Annual Industry Conference
- Communications
Post-Graduation Business Plan

Draft Funding Plan (notional)

- Inst. Cost Share
- Industry
- Sponsored Research
- Block Grant
- NSF

[Graph showing funding plan from 1/1/11 to 1/1/25]
Our Sustainability Plan will focus on Principal and Full Memberships

- Increase principal/full membership participation
- May consider modifying membership fees
- May consider developing focused membership groups/projects

**Principal**
- Access to ERC non-proprietary info
- Seminars, Workshops
- Access to Students, Faculty
- Advisory Board
- IPPF member
- **Focused Research**
- $50K or more

**Full**
- Access to ERC non-proprietary info
- Seminars, Workshops
- Access to Students, Faculty
- Advisory Board
- IPPF member
- $10K/$15K (IPPF)

**Associate**
- Access to ERC non-proprietary info
- Seminars, Workshops
- Access to Students, Faculty
- Advisory Board
- IPPF member
- $10K in-kind

**Small Business**
- Companies with employees 50 or less
- Will need to establish IP policy with the IAB
- $2K cash/$10K in-kind

Number of Members
- Principal: 12
- Full: 11
- Associate: 10
- Small Business: 2
Sustainability Plan
Innovative Stakeholder Partnership – States, Federal opportunities

- Continue to pursue State and Federal funding opportunities
  - NYSERDA
  - Massachusetts
  - Alabama
  - Tennessee

- Innovative Stakeholder Partnership: e.g. Cherokee Farm Innovation Campus is a collaborative effort of The University of Tennessee and Oak Ridge National Laboratory.

- Aggressively pursue opportunities with DOD, DHS, DOE
Commercialization paths

- Continue strong partnerships and collaboration with industry
- Increased financial assistance from each of the partner Universities and industry,
- Transfer of technologies to industry, business and marketing plans being implemented utilizing research expertise of the center’s faculty, testbeds and research facilities.

Technology commercialization roadmap

- Basic Research
  - Early Stage Research
  - Development
- Prototype Design or discovery
- Demonstration
  - Pilot
  - Large Scale
- Deployment
  - Pre-commercial
  - Commercial

Commercialization paths

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>EXAMPLES</th>
<th>COMMERCIALIZATION PATHWAYS</th>
<th>TECHNOLOGY APPROACH</th>
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<tbody>
<tr>
<td>Component &amp; Devices</td>
<td>Next Generation Monitoring</td>
<td>Generate Intellectual Property &amp; Collaborate with Innovation Partners</td>
<td>Device development</td>
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<td>Hardware test-bed demo</td>
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<td>Software</td>
<td>Control Algorithms</td>
<td>Member Co. License</td>
<td>Field trial</td>
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<td>MOVARTI – Volt/Var</td>
<td>Small Business License</td>
<td>Full deployment</td>
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<td>Situational Awareness</td>
<td>Start-up Company</td>
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<td>User Facility</td>
<td>Hardware Test-bed</td>
<td>ERC Consulting</td>
<td>Algorithm development</td>
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<tr>
<td></td>
<td></td>
<td>Start-up company</td>
<td>Modeling system impacts</td>
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</table>

- Define problem with client
- Develop scenarios for HTB
- Results communicated to client
I-CORP Program – Develop Business Model Canvas

Participated in UAB Regional ICORP Process – June 2017
4 weeks, 19 interviews, no additional funding

The Business Model Canvas

- **Key Partners**
  - Eaton – CYME
  - ABB, GE, Hitachi, and other Inverter Manufacturers, related labs

- **Key Activities**
  - Scale evaluation platform into mobile app
  - Hardware testing
  - ID and develop functional requirements document
  - Develop User Cases
  - Determine cost and resources needed for testing

- **Value Propositions**
  - VP 1 – Inverter documentation costs lost revenue to utility
  - VP 2 – It is testing of very low-cost and more variety than testing in field
  - VP 3 – Obs testing allows for a greater number of rapid field testing conditions

- **Customer Relationships**
  - Look for partners like Eaton, ABB, etc. that are responsible for analysis of renewable and vendors that have proprietary models.

- **Customer Segments**
  - Senior Engineers, Transmission Engineers, Consulting Engineers, Vice Presidents of Strategic Research Senior Product Manager Interconnection Planners, Transmission and Distribution Planners Inverter manufacturer engineers

- **Channels**
  - How do our customers want to be reached?

- **Cost Structure**
  - User Space, Lab Director

- **Revenue Streams**
  - What is our revenue model? What are our pricing tactics? For what value are our customers willing to pay? - ask at NHREL and other non-profit customer model
Action Plan

• CURENT Industry Sustainability Plan Working Group/Plan
• Continue CURENT Research Outside of NSF/DOE ERC
• Extend CURENT Roadmap for Post Graduation
• Develop Business Plan (operating expenses/projected revenue)
• Work with three “technovators” for technology transfer
• Measures of Success
  o Secured financial assistance
  o Interdisciplinary research grants obtained from Federal and State agencies
  o Adopted technology developed business and marketing plans
  o Re-defined scope of the research portfolio
  o Fee structure established and being used for outside use of testbeds and research facilities transfer models
  o Continue Education Outreach Efforts
Discussion

Question everything
Acknowledgements

This work was supported primarily by the ERC Program of the National Science Foundation and DOE under NSF Award Number EEC-1041877 and the CURENT Industry Partnership Program.

Other US government and industrial sponsors of CURENT research are also gratefully acknowledged.
Recruiting and Retaining New Members at NSF ERCs

R. Casey Boutwell, Ph.D., MBA
Director of Industry Engagement
2017 NSF ILO Summit
July 27, 2017 – Raleigh, NC
Outline

- Needs/Value Analysis
- Benchmarking /Landscaping
- Contact
- Resonance

Figure 1 - Center Development Cycle
ASSIST Industry Members in 2017

**Full Members**
- REX
- UNC HEALTH CARE
- MERCK
- STRIV

**Associate Members**
- ANALOG DEVICES
- PVH
- HANES Brands Inc
- JSR Corporation

**Affiliate Members**
- muRata
- EASTMAN
- RTI INTERNATIONAL
- SABIC
- MAS

[Logos of all members]
Industry Membership

- Growth in health sector
  - Pharmaceuticals
  - Medical Devices
  - Systems
- Evaluation
- Engagement
- Advocates for ASSIST

Number of ASSIST Members in Health Industry

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Members</th>
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<tr>
<td>3</td>
<td>2</td>
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<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
</tr>
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</table>

8/21/2017
Active Membership Recruitment

• Seeking companies to help support growth
• ASSIST’s needs change as our technologies develop
• Flexible electronics, IoMT, and medication adherence
• Target members:
Needs/Value Analysis

- High level needs analysis of ERC
  - Next level of growth for ERC (research or development-wise) (CEO)
  - Site Visit Team key questions (CSO)
  - Input of new stakeholders, rounding out technology offerings (CCO)
  - Testbed development and broader deployment (COO)

- Skill/values analysis of faculty/leadership
  - Development capabilities and interests
  - Laboratory tools, throughput volume, student skills/development
Benchmarking/Landscaping

- Characterization of the ERC value chain (where do research products go?)
  - What innovation or materials lead the Center’s use?
  - Who is the next natural owner of the Center’s research product outputs?
  - Who else captures value in the supply chain as Center outputs progress towards the end user?

- Landscape analysis of main industry sector(s)
  - What firms are leading in your sectors? What firms have a growth mentality?
  - Big cash rich companies (sponsored research)
  - Mid-size companies with high press coverage and rapid growth (research and development)
  - Small companies with VC backing and experienced teams (co-development on specific projects)

- Identifying the right member firm
Contact

- Identifying the right contact
  - ILO needs bizdev/exec/director contact
  - PI needs engineering contact

- Expanding the contacts (finding engineering and business leads who know each other)
  - ILO pitches to bizdev team
  - ILO hosts call with engineering lead and key PIs
  - Host Center visit for both technical and business contacts
Keeping the relationship growing, stakeholder weigh-in/buy-in

Incorporation on larger projects/responsibilities ASAP (more in IAB Role)

Building metrics for success:
- In-person visits
- Joint calls
- Papers/presentations emailed
- IP disclosed in field
- Press coverage
- Students/faculty hired
- Connections to other members/customers
- Private presentations/visits by students/faculty

Circle back frequently for check-up, happy with engagement, new needs/opportunities?
Examples

- **Noven Pharmaceuticals**: ILO identified lead, pitched business teams, built support top-down

- **Profusa Inc**: PIs identified lead, pitched co-development projects, awarded shared grants, built support bottom-up

- **Bluedoor**: Partnership/community identified, active in shared goals, supporting Center growth

- **VitalFlo Inc**: Commercialization identified, supporting specific individual growth/license
Group Dialogue

- How many members do you each have?
- How many members gained/left last year?
  - Do you see this trend continuing?
- Who is your greatest internal advocate?
- Who is your greatest external advocate?
The Role of the Industrial Advisory Board at NSF ERCs

R. Casey Boutwell, Ph.D., MBA
Director of Industry Engagement
2017 NSF ILO Summit
July 27, 2017 – Raleigh, NC
Outline

- **Step 0: ASSIST’s IAB in Bylaws**
- **Motivation of the IAB** (Philosophy)
  - Diversity, Advisement, Engagement
- **Objectives for the IAB** (Strategy)
  - Capabilities, Contributions, Advocacy
- **Examples of Strategies** (Execution)
Step 0: How is ASSIST’s IAB structured?

- Full and Associate Members (3 vs 1 vote each)
- Advise
  - Commercialization strategy, core/non-core mix
- Review
  - Reports, budgets, proposals, IP
- Votes
  - Membership-pool-funded projects, IP decisions

ASSIST has 17 IAB Members, 5 Full and 12 Associate 5
ASSIST Industry Members in 2017

Full Members

Associate Members

Affiliate Members
IAB Philosophy

- Diverse boards build a broad bench with deep expertise
  - 5 large, 10 medium, 1 small company
  - European, Asian, American headquarters
  - Textiles, Electronics, Pharmaceuticals, Materials, Data Analytics
  - General research vs specific projects
IAB Philosophy

► Advisement
  ▶ Reviewing and providing context for project selection
  ▶ Answering strategic questions (Proj. X or Y? What after Proj. X? etc.)
  ▶ Clarifying ASSIST’s place in the value chain for our field (who do we support, who supports us?)

► Engagement
  ▶ Finding new engineering contacts to support key PIs and key projects
  ▶ Supporting projects inside firm (for bizdev attention, partnerships, or intern selection)
  ▶ Challenging PIs and students (for relevance of work, for further funding, etc.)
Strategies for the IAB

- Identifying capabilities of individual board members or firms (and recruiting missing needs, previous talk)
- Translating capabilities to contributions
- Mechanisms for inclusion:
  - Sub-chairs based on ERC needs
  - Taskforces for high priority projects
  - Technical calls with high performing PIs
  - Engagement with non-team players
  - Strategy calls with key IAB members
  - Advocacy for membership drive events
Expanding IAB Leadership

- 3 sub-chairs: Data, Health, Self-sufficiency
- Go-to connection for strategic questions
  - IAB Chair:
    - Anna Kravets
    - Director of Business Consulting
    - Merck & Co. - Pharmaceuticals
  - Health Adviser:
    - Anita Watkins
    - Director Rex Strategic Innovations
    - UNC Rex Healthcare – Healthcare Provider Network
  - Data Adviser:
    - Dr. Deva Kumar
    - Distinguished Systems Architect
    - SAS Institute – Data Analytics and Intelligence
  - Self-sufficiency Adviser
    - Currently open
Examples: IAB Engagement at ASSIST

- **External Advocacy**
  - New membership: target members respect existing member opinions, existing members invite target members to events
  - To the NSF: explain realistic commercialization and IP objectives, describe useable outputs of research projects

- **Internal Advocacy:**
  - Helps direct attention to areas ILOs feel of greatest need (great asset)
  - Connect member engineering teams with holistic needs of Center, not just on their projects (benefits of systems center)
  - General examples: commercialization, IP, partnerships, testbed development
  - Specific examples: MDs, insurance companies, investors
Examples: IAB Engagement at ASSIST

- Testbed level taskforces
  - Provides domain expertise, market intelligence, and engineering engagement
  - Grows multiple relations between members and PIs (stronger mesh)
  - Increases membership value for members and engagement value for PIs

- Hosting showcase and membership drive:
  - Profusa hosted ASSIST in SF, invited 40 companies to PI pitch rounds and demo review (gained two new members)
  - Analog Devices hosting similar event in September in Boston
The role of the IAB at ASSIST

- The role of the IAB is to advise the Center Leadership.
- Advice and engagement is for research objectives supporting commercially relevant goals.
Group Dialogue

- How many members are in your IABs?
- How is your IAB structured?
- What would you like to get out of your current IAB?
- What is the best-performing IAB we could create?
- What external stakeholders can we tap to help create this structure?
Advocates for the Center, to the NSF, faculty, students

Advising director and d.dir

Task forces on center needs (data, health, sustainability, testbeds)

Ask targeting questions:

- “how do we leverage results of proj. x to be more effective and attractive to particular sectors or companies”
- “should we focus more on data infrastructure in our research or can we leave that to industry as a solved problem (to just plug and play in the future)?”
Help find technical contacts for scientific advisory board, closely ties member to center.

Providing material for incorporation in testbeds and research prototypes (benefits member and team)

Supports ILO in membership searches externally for connecting to internships

Supports ILO mission internally to advocate for industry focus and specific IP strategy,
### Different Stages

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Years</th>
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<tr>
<td>Formation &amp; Foundation</td>
<td>Build the core team and start planning</td>
<td>2 thru 0</td>
</tr>
<tr>
<td>Define &amp; Develop</td>
<td>Define the product and process</td>
<td>1 thru 3</td>
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<tr>
<td>Refine &amp; Optimize</td>
<td>Refine the product and process</td>
<td>4 thru 6</td>
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<tr>
<td>Redefine &amp; Mature</td>
<td>Redefine and mature the product</td>
<td>7 thru 10</td>
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<tr>
<td>Sustain &amp; Rejuvenate</td>
<td>Sustain and rejuvenate the product</td>
<td>10+</td>
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#### SRC Stages & Key Concepts

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<tr>
<th>SRC Stages</th>
<th>Key Concepts</th>
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<td>10+</td>
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<tr>
<td>Year</td>
<td>Companies Joined</td>
<td>Companies Exited</td>
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Some Retained from Inception - 25 Exited - Mostly a changing business emphasis (Average Longevity ~4yrs)
Mega Trends

LUX: Amid low oil prices, investors have shifted focus in 2016 to commercializing biobased products that offer improved performance, not just “greener” replacements for petro-based compounds.

Impact of US Crude Oil Inventories on Crude Oil Prices
US crude oil inventories and crude oil prices are usually inversely related.

- US crude oil inventories hit an all-time high of 525.5 MMbbls in the week ending March 31, 2017.
- US crude oil prices hit a 20-month high.
- US crude oil prices hit a 13-year low as inventories test record highs.

Global shale gas basins, top reserve holders
Source: EIA, NYMEX

Timeline
Biofuels Biofuels Biofuels Biofuels Biofuels
Biofuels Bioprodcts Specialty Cosmetics
Biofuels Bioprodcts Specialty Cosmetics
Biofuels Bioprodcts Materials Composites
Biofuels Bioprodcts Specialty Cosmetics Materials Composites Nutraceuticals Food

Center for Biorenewable Chemicals
One Year Away from Zero Members

- Members stayed between 1 year and 8 years
- Recruit, Reward, Retain.
- Stagger start/renewal date when sign agreement.
- Tiered membership offers valuable flexibility.

<table>
<thead>
<tr>
<th>Members</th>
<th>Strategic No IP Options</th>
<th>Full Includes options to negotiate IP Rights</th>
<th>Sponsoring</th>
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<tbody>
<tr>
<td>Large</td>
<td>$25,000</td>
<td>$50,000</td>
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<tr>
<td>Medium</td>
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<td>$25,000</td>
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<tr>
<td>Small</td>
<td>$2,500</td>
<td>$5,000</td>
<td>*</td>
</tr>
<tr>
<td>Startup</td>
<td>$500</td>
<td>$1,000</td>
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Attract & Retain

ERC’s need an active IAB with sufficient diversity to add value to the center.

• Find
• Hire
• Train
• Engage
• Retain

ENGAGE
• Using creative compensation structures as a motivator
• Succession planning at all levels
• New feedback mechanisms and approaches to performance management
• Flattening the hierarchy

FIND
• Where do you find talent today?
• How do you make sure the fit is right?
• How do you not miss the hidden talent?

RETAIIN
• Using creative compensation structures as a motivator
• Succession planning at all levels
• New feedback mechanisms and approaches to performance management
• Flattening the hierarchy

HIRE
• Selling the company to potential employees
• Competing for talent

TRAIN
• Fostering innovation
• Reskilling in the wake of automation
• Sharpening skills for changing demands
• Making business development part of everyone’s belief
Find - Core Needs

Understand why companies are members. They are not all the same.

- Clear Understanding of Industry Membership Benefits & Costs, and your Membership Agreements
- Solid Knowledge of your ERC’s Science & Technology
- Classy Brochure with your ERC Story
- Convincing PowerPoint Presentation with Great Slides
- Consistent Credibility with your ERC Management Team and University Admin
- Build Links to the Broad Industry of your ERC
- Dialogue & Good Relations with your Industry Member Folk
- Patience, Perseverance, Persuasion, Passion & Vision
Track - Membership Database

Build a database of company names, connections, contact info and notes.

- Spreadsheet is a good start.
- Need to track member changes and evolving contact lists.
- Next level is a database. Best if database and invoices are integrated.
- ILO’s that exit leave a challenge behind.
Hire, Recruit

Recruit key decision makers. Industry folk move jobs. Track with LinkedIn.

- Cold calls do not work.
- CDA is sometimes a problem.
- Use your IAB and Faculty.
- Business Summits

- Emails, connections, business meetings, lectures, brochures.
- Imperative to reach the “right person” as senior as you can get. Build many connections.
- Follow-up with conference call and campus visit.
- Invite select guests to Annual Meeting (Fee & CDA).
Train

- Explain, describe and summarize.
- Often get new people to member meetings.
- Legal side and patents and internet access and strategy and SWOT.
- Build a good rapport with your IAB.
Engage

Respond effectively to emails, phone calls, meetings, discussions, comments.

• Annual meetings are very important.
• Newsletters and webinars are very effective.
• Impossible to provide all information about an ERC to the membership.

Listen, Evolve, Professional
Retain

• Improve your program over time so that there is always a next level.
• Build multiple relationships with members.
• IAB Seed projects from membership fees.
• Sponsored research, internships, mentoring all build a deeper root in the ERC.
• Find creative ways to not lose members.

Members that leave do not come back.

<table>
<thead>
<tr>
<th>Strategic No IP Option</th>
<th>Full includes options to commercialize IP rights</th>
<th>Sponsoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>$25,000</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>$12,500</td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>$2,500</td>
<td></td>
</tr>
<tr>
<td>Startup</td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$1,000</td>
<td></td>
</tr>
</tbody>
</table>
Thank you!!

How will you innovate for a better world?
Build Intermediates to make Branches

- Bio-engineering to build ideal branches.
- Chemical engineering to build leaves.
- Leverages investment in bio and power of chemistry.
- Economics of commodity chemicals creates a challenging market entry.
Computational Biocatalysis

Ideal Intermediate Molecules

Platform Array of Molecules

Biocatalysis

Chemical Catalysis

Polymers
Resins
Personal Care
Surfactants
Lubricants
Composites
Materials
Ecosystem Accelerator

- Students gain real insight into project and startup concept planning.
- At least one startup from each Entrepreneurship Course.
- Startups need mentoring and require funding.
- CBiRC’s startups have accessed over $6m of funding since 2011.
<table>
<thead>
<tr>
<th>ERC STAGES &amp; YEARS CONCEPT</th>
<th>Stage 1. ERC Years -2 thru 0 Formation and Foundation</th>
<th>Stage 2. ERC Years 1 thru 3 Define and Develop</th>
<th>Stage 3. ERC Years 4 thru 6 Refine and Optimize</th>
<th>Stage 4. ERC Years 7 thru 10 Redefine and Mature</th>
<th>Stage 5. ERC Years 10+ Graduate to Sustainable Center</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ideation and Formation</strong></td>
<td>Work closely with ERC Founders and University advisors to develop ideas within context of NSF ERC Guidelines. Help define ERC opportunity.</td>
<td>Define and develop ERC concept working closely with ERC Management Team.</td>
<td>Refine ERC concept working closely with ERC Management Team.</td>
<td>Redefine Center concept based around a vision of future sustainability.</td>
<td>Review and define new sustainability strategy.</td>
</tr>
<tr>
<td><strong>Member Recruitment</strong></td>
<td>Secure letters of intent from future industry members. Identify key individuals to work with.</td>
<td>Develop active outreach process through business connections, technical summits, outreach presentations, fliers and brochures. Tiered membership structure based on company size, varying benefits. What is a realistic MB size.</td>
<td>Refine recruitment efforts with a greater emphasis on maximizing ability to retain key members.</td>
<td>Redefine recruitment and retention around a future sustainability strategy.</td>
<td>Develop connections to forge the best path into Sustainability.</td>
</tr>
<tr>
<td><strong>Commercialization of IP</strong></td>
<td>Begin to define strategy to retain members through engagement in center activities including newsletters, websites and other informational tools.</td>
<td>Develop ideas around joint projects, testbeds, and other ERC opportunities.</td>
<td>Maximize ERC / company interaction and benefits. Cultivate interest in joint projects, involvement in testbeds, and other ERC opportunities. Value and mechanisms of establishing multiple points of contact in firms.</td>
<td>Redefine commercialization strategy around a future sustainability strategy.</td>
<td>Develop retained connections to forge the best path into Sustainability.</td>
</tr>
<tr>
<td><strong>Intellectual Property</strong></td>
<td>Begin to define testbeds and cross project integration alongside a strategy for commercialization.</td>
<td>Develop industry R&amp;D needs alongside ERC needs in testbeds. Integrate industrial input from project inception, using project management tools (timelines, go/no-go points, cross project integration, etc.). Strategies for increasing sponsored research projects with industry.</td>
<td>Meet Industry R&amp;D needs alongside ERC needs in testbeds. Integrate industrial input from project inception, using project management tools (timelines, go/no-go points, cross project integration, etc.). Strategies for increasing sponsored research projects with industry.</td>
<td>Redefine intellectual property strategy around a future sustainability strategy.</td>
<td>Redefine IP strategy in light of sustainability path.</td>
</tr>
<tr>
<td><strong>Innovation Strategy</strong></td>
<td>Begin to identify key local innovation partners and infrastructure.</td>
<td>Develop paths to entrepreneurship activities in the ERC and University, connecting to local, state, and regional economic development and incentive programs and role of investment groups such as Angels, VCs.</td>
<td>Cultivate entrepreneurship activities in the ERC and University, connecting to local, state, and regional economic development and incentive programs and role of investment groups such as Angels, VCs.</td>
<td>Redefine innovation strategy around a future sustainability strategy.</td>
<td>Redefine innovation strategy in light of sustainability path.</td>
</tr>
<tr>
<td><strong>Education Programs</strong></td>
<td>Begin to identify strategy to develop valuable education programs.</td>
<td>Start student mentoring programs, short courses and workshops for industry. Certificate programs and distance learning models, Faculty and student exchange. Active promotion of industrial recruitment of graduates.</td>
<td>Refine student mentoring programs, short courses and workshops for industry. Certificate programs and distance learning models, Faculty and student exchange. Active promotion of industrial recruitment of graduates.</td>
<td>Redefine education strategy around a future sustainability strategy.</td>
<td>Redefine education strategy in light of sustainability path.</td>
</tr>
</tbody>
</table>
## Strategy: Define and Refine

<table>
<thead>
<tr>
<th>Goals</th>
<th>Define, Develop, Refine and Optimize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy and Ideation</td>
<td>Define, Develop, Refine and Optimize CBiRC, Work Closely with Leadership Team</td>
</tr>
<tr>
<td>Innovation</td>
<td>Cultivate Innovative Culture, Entrepreneurship Course, Translational Research, Startup Companies, Innovation Partners, Angels and VCs</td>
</tr>
<tr>
<td>Education</td>
<td>Student Spotlights, Industry Internships, Distance Learning, Exchange, Student Mentoring, Recruitment</td>
</tr>
<tr>
<td>Member Recruitment</td>
<td>Industry Outreach, Summits, Conferences, LinkedIn, Connections, Site Visits</td>
</tr>
<tr>
<td>Member Retention</td>
<td>Newsletters, Networking, Poster Competition, Student Seminars, Technology Fair, Technology Transfer, Two-Way Confidentiality, Sponsored Research, Internships</td>
</tr>
<tr>
<td>Commercialization of IP</td>
<td>Integrate Industry Input, Invention Disclosures, NSF Translation Research Grants, Startup Companies</td>
</tr>
<tr>
<td>Intellectual Property</td>
<td>Invention Disclosure Process, Align with Offices of IPTT,</td>
</tr>
</tbody>
</table>
Research Need for POETS

- Electrification is a mega-trend for mobile systems
  - All mobility sectors affected by electrification
    - Land, sea, air
    - Mobility → power density
  - Increased number of vehicles
  - Increased power system per vehicle
  - Increased density of power systems
Research Need for POETS

• Safety and performance concerns

Hoverboards
Research Need for POETS

- Current electrical systems are thermally limited in power density
- Far easier to put thermal energy into a confined volume than it is to take it out
  - Each field approaches the problem from their own perspective and misses the whole
  - Lack of a systems-level approach to power management
- POETS brings the systems approach
POETS Vision

• Vision:

The POETS vision is to be the pre-eminent research and education organization driving the integrated, optimized, concurrent movement of thermal and electrical power in tightly constrained mobile environments.

• We will be able to route thermal power in confined spaces as easily as electrical power

10X to 100X increase in power density over 2014 state of the art
Tight integration of Thrusts is critical

Thrust 1
- How to off-line optimize the system for operational effectiveness?
- How to manage power flow on-line?
- System operation

Thrust 2
- Off-line multi-physics design with constraints
- Integration of thermal and electrical module requirements
- Subsystem integration

Thrust 3
- What materials can be used?
- What fabrication techniques are feasible?
- Component fabrication

Thrust 1: How to operate?
Thrust 2: How to package and integrate?
Thrust 3: How to fabricate?
POETS Testbeds

- Reflect industry market segments

Testbed 3
Off-highway equipment
100-1000 kW

Testbed 4
Aircraft
1MW and above

Testbed 2
On-highway vehicles
10-100 kW
Industry & Government Partners

... and growing
Summary

• Right problem
  – Complex, multi-disciplinary, systems-level problem is appropriate for an ERC

• Right time
  – Clear need driven by global trends that will not reverse

• Right team
  – Right blend of expertise
  – Right team of institutions and industries
Help address the Terawatt Challenge

Richard Smalley – 1996 Nobel Prize Winner

“Find enough clean energy to raise the living standards of people around the globe”

1.5 Billion people in the dark (21%)
Consortium of 8 universities
Consortium of 8 universities and industrial partners

- Arizona State University
  - Lead University
  - Silicon
  - Nanostructures
  - Power conditioning

- Georgia Tech
  - Nitride growth
  - Indium gallium nitride

- The University of Arizona
  - Optics

- University of Houston
  - III-V

- University of New Mexico

- California Institute of Technology
  - Nanowires photonics

- University of Delaware
  - Thin film CIGS

- Massachusetts Institute of Technology
  - Material defects
QESST 1.0

Margins

Increase efficiency
Reduce costs
Generate electricity (only)

Focused research in low margin business environment requires government funding

2017
QESST 2.0

research

education

alliances

infrastructure
QESST 2.0

alliances
QESST Strengths – Leveraging Alliances

Leading team of researchers in photovoltaics

Unmatched facilities for hands-on training

Leading educators in photovoltaics

Worldwide network

NNCI Southwest
QESST 2.0

infrastructure
QESST Strengths – Infrastructure

The University of Arizona
College of Optical Sciences

Caltech

NNCI Southwest

Delaware
QESST 2.0

education
Higher Education – 5% of US exports

Source: BEA.gov; GDP deflator/Dick Startz
QESST 2.0 Example - Education

Margins

Over million visits per year
English, Korean, Spanish

2020

Differentiation
By 2020 IoT will impact close to 6% of the global economy

$3.5T Revenue Redistributed

Revenues realized within the world economy that will potentially move from one player to another with no net increase in total economy

$100T Global Economy in 2020

$177B Value to End Customer

Direct reduction in costs driven by IoT and realized by end customers

$344B Additional IoT Revenues

Revenues directly attributable to sale of IoT hardware, software, and services

$1.9T Productivity Improvement

Direct increase in output per unit of cost, enabled by IoT and reinvested in productive assets and activities

IoT will be materially disruptive – there will be winners and losers

Source: A.T. Kearney
QESST 2.0

By 2020
212 billion IoT devices
> 25 per person
All needing power

source: IDC
Who cares?
Who cares? Advertisers

Personalized advertising
1984
Value proposition: Unwired
No: data, text, camera, GPS, apps
Forecast: 300,000 devices
Background

1984
Value proposition: Unwired
No: data, text, camera, GPS, apps

Forecast: 300,000 devices

2017
7,000,000,000
QESST 2.0

212 billion devices in need of power
Wireless wins
Energy harvesting wins
QESST 2.0 Example - PVoT

Custom form factors
Sensor networks
Building integrated
2020 Military applications

Margins
Differentiation
QESST 2.0 Example – DoD

ARMY VISION FOR NET ZERO
NET ZERO IS A FORCE MULTIPLIER

Net zero by 2020
DoD pays $400 per gallon of gasoline
Next Generation Modules

High Margin Market: Light weight, Aesthetics → BIPV

Frameless
SolarWorld
Canadian Solar
Trina

Clear Panels
Prism Solar
DSM Advanced Surfaces
Topray Solar
Sunshine Solar

Tiles
Solar City

Solar Skin
Sistine Solar
QESST 2.0 Solution

PVoT, DoD, BIPV

Continue existing research

2020

PV EDUCATION.ORG
Fundamental limits of PV: Defects, New Physics

Re-envisioning Modules: Ubiquitous PV

Pathways to Sustainable Energy Transitions

Workforce for the Energy Transition

Industry Partnership
Thank You
The Role of the IAB

Nasser Hamdan
Role of the IAB

Primarily concerned with providing direction for Center research and education programs.

- Provide perspective into the **critical needs** of industry and practitioners.

Provide input on-

- Research priorities
- Technology demonstrations
- Technology-to-market business planning.
Role of the IAB

Responsibilities include:

Annual and midyear review of current projects (tech., pract.)

Guidance regarding these projects (crit. needs?)
  - Informs our internal reviews

Review & input on new, annual projects
  - which ones should be awarded?

Annual SWOT
Role of the IAB . . . Getting into the weeds

Role of the IAB is fairly clear, but not so simple in practice.

To understand this, check the composition of the IAB (17 Industry Partners) and highly diverse nature of the Center:

- Geotech and contractors → ground improvement
- Geoenvironmental → soil and water remediation
- Consultants → ground improvement, remediation, exotic/complex projects
- Owners/operators → landfill, mining, oil & gas, slag/metals, utilities
- Agencies → State DOT, State Environmental
Industry Partners

- WSP
- Freeport McMoRan Copper & Gold
- Salt River Landfill
- Republic Services
- Geosyntec Consultants
- ARCADIS
- BioCement Technologies
- Nicholson
- Hayward Baker
- Schnabel Baker
- ADEQ
- Chevron
- ADOT
- Matrix Neworld

CBBG Center for Bio-mediated & Bio-inspired Geotechnics
Industry partners have very different types/ranges of expertise

Industry-specific concerns favor certain research areas/projects

Diverse nature of CBBG covers wide range of projects and research

**25 projects covering 6 research areas!**

1. Lifecycle analysis
2. Bio-cementation/solidification
3. Fluid flow/Transport
4. Microbial processes
5. Environmental/Landfills
6. Infrastructure

- Enzyme induced carbonate precipitation
- Liquefaction mitigation via microbial denitr.
- Electro-kinetics
- Annelid Inspired Geo-probe
- Microbial processes in extreme env.
- Tree/plant root inspired foundations

Breadth of technical content is outside capabilities of any single
Role of the IAB . . . A practical approach

Only 4 projects per industry partner → they choose projects

- Typically follow their “favorites” anyway
- Provide deeper technical and value input

“Orphan” and low-count projects are politely “assigned”

- Relevant expertise is a limiting factor
- Encouraged to comment on potential value to (other?) industry(s)
Role of the IAB . . . A practical approach

Projects closest to field testing/application receive value input

- Not necessarily same as the “technical” favorites
- Input typically involves costs and lifecycle considerations
  - follow-ups!
- A great tool to solicit direct industry support!

Ultimately, you must know your industry partners . . .

**strengths, interests** and **capabilities** (time, staff, etc.)
Role of the IAB . . . the Annual SWOT

A similar logic applies to gather details for SWOT

But, SWOT requires **holistic approach**

- Individual, sub-group technical interests become secondary
- Intra-industry competition and secrecy is not a concern
- Cross-industry perspective in the context of the Center mission
  - Develop innovative technologies to serve civil engineering industry
  - Educate & train future engineers in the field of Biogeotechnics

This is where IAB group work happens over partner interests
Role of the IAB . . . Education

This is where IAB group work is seen again

Open, positive discussions about multidisciplinary education program and student activities

Plenty willing to speak with students
  - Individually, sub-groups/specialty areas and via webinar

General perception that students are well-prepared and ready to hire
  - Several hires and internships by industry partners
Thank You

Questions?