Imaging Strategic Planning Workshop Aug 17-18, 2015 Biosphere 2

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Attendees names in green, other invitees in red

Imaging Strategic Planning Workshop Flipchart Notes – Aug. 18

Physical Infrastructure:

- Visualization center for image analysis
- Bio5-style center
- Access to human PET scanner for research
- Cyclotron
- Ultra-fast network to enable Big Data capabilities

Virtual / Collaboration / Other Issues:

- Platform for collaboration
- Virtual vs physical center ?
- Need for adequate operational personnel for *any* new facility
- Criteria for promotion and tenure
- Communicating our expertise
- Building a culture of teamwork and shared software
- Separation of research strategy from cluster hiring process

Strategic Planning Workshop

Imaging

August 17-18, 2015

Frank Lederman

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Goals for Day Two

- Breakout sessions for each program theme (2 x 60 min)
- Report-backs to entire group
  - What are the most exciting ideas?
  - Summarize key results & issues
  - What items need further work?
- Group discussion
  - Review strategic issues and common resource needs
  - Develop action plan

Breakout Sessions - Key Topics

- What makes (or could make) us unique?
- What grand challenges are addressed?
- What new strategic capabilities?
  - What new competitive advantage?
  - What can we demonstrate in the short-term?
  - How can capabilities be extended to other parts of the university?
- Specific opportunities for external funding
- Resources required
  - Program-specific
  - Infrastructure
- What partnerships can help us?
- Other program risks
- Strategic issues

We Need a Strategy to:

- Support the vision and/or strategy of parent organization
- Guide allocation of resources
  - What will grow and what will shrink?
- Show focus
- Inspire objectives that are *required* to achieve the vision
- Help unify the organization around a common set of goals

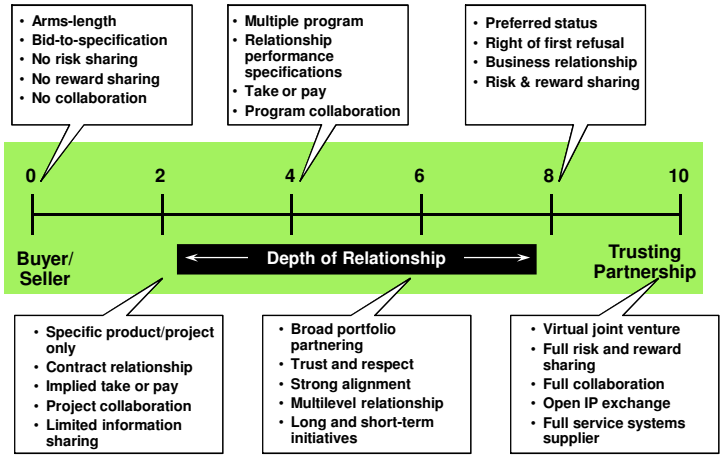
Strengths and Weaknesses

- Internal focus – emphasis on competitive capabilities
- What are our core competencies?
  - Transcend several departments or groups
  - Provide true competitive advantage / differentiation
  - Produce a barrier for others to enter
- Examples
  - Unique facilities difficult and/or expensive to duplicate
  - Unique skills, such as a critical mass of talent in one area that took years to establish
  - Local climate / ecology
  - Key partnerships / relationships
  - Weaknesses: resource limitations in required areas

What can we do?

Sources and Partners

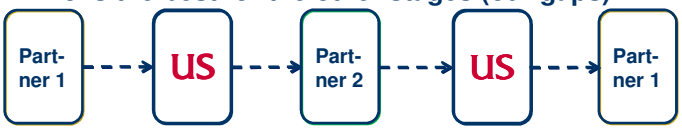
Classifying the nature / depth of a relationship



How deep of a relationship do you need?

Strategic Relationships

- **Analyze the "supply chain" of your technology**
  - For what capabilities / stages are we truly the best?
  - We can afford to be the best for only one or two stages
  - Who is the best for the other stages (our gaps)?



- **Analyze the strategy for possible partners**
  - What is *their* strategy for their gaps (why they need us)?
  - If they won't tell us, put ourselves in their shoes & guess

A mutually-strategic relationship is a competitive advantage

Opportunities and Threats

- External focus
- What are the external forces affecting your organization?
  - What changes have you seen and do you envision?
- Examples
  - Evolving model for competing for federal funding
  - New budget constraints
  - Changing demographics for students, legislature, philanthropy, …
  - Changes in partners and / or their strategies
- What are the strategic options to respond?
  - What strategic capabilities are required?
  - Which programs should grow? Which should shrink?

What should we do?

Breakout Sessions – Key Topics

- What makes (or could make) us unique?
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- Resources required
  - Program-specific
  - Infrastructure
- What partnerships can help us?
- Other program risks
- Strategic issues

Breakout Session Locations

A. Computational Imaging
Machine Industrial Imaging
— Vis. Ctr. Conf. Rm. 1 Ali Bilgin, Mike Lesser

B. New Contrast Mechanisms
— Visitor Center Conf. Rm. 2 Robert Norwood

C. Multi-dimensional Imaging
— Casita 1900 Leilei Peng

D. Extracting Quantitative Information
Quantifying Information Extraction
— Sahara Room Barrett, Zarnescu

Breakout Session A

Computational Imaging

Ali Bilgin and Michael Lesser

- What makes us unique
    - Optical Sciences Center
    - Astronomical Imaging (visible, UV, IR sensor, LSST and future LSST Data Center)
    - iPlant
    - Center for Gamma Ray Imaging (CGRI)
    - Existing imaging collaborations across campus
    - System level approach to imaging

- What grand challenges are being addressed?
    - Brain Initiative
    - Big Data
    - Bridging the gap between cellular and human imaging (resolution)
    - Smart adaptive sensing with optimized analysis (hardware and software)
        - Portable imaging
        - Mobile imaging
        - Autonomous vehicles
    - Monitoring healthcare delivery systems to ensure quality of care.
        - Reducing costs while improving outcomes
- Potential benefit from Banner merger on the medical imaging side.
  What are the specific opportunities for external funding?
    - Brain initiative
    - Many opportunities (NSF, NIH, DOD, NASA), hard to list specific ones.
    - CMS- Medicare/Medicaid grants in tens of millions dollars
    - Weather related imaging programs?
- What resources are required (program-specific and/or infrastructure)?
    - Imaging “Program”, “Center”, “Cores”, “Colloquia”
    - Continued TRIF Imaging Fellowships
    - Pilot funding > $50K (targeted for collaborations). Should not only be focused on junior faculty
    - Leveraging our strengths in optics to develop a campus-wide fast network may give us a competitive advantage in Big Data problems.
    - A “system level” approach to computation imaging could lead to a “Center”.
- Strategic Issues
    - Promotion and tenure considerations in large grant collaborations (already being addressed?)
    - Investigator incentive awards. Part of IDC flowing back to the investigator (College/Department level? Already exists in some colleges?)
    - Retention especially for “Cores”

Breakout Session B

New Contrast Mechanisms - - Breakout Session

R. A. Norwood
College of Optical Sciences
University of Arizona

College of Optical Sciences
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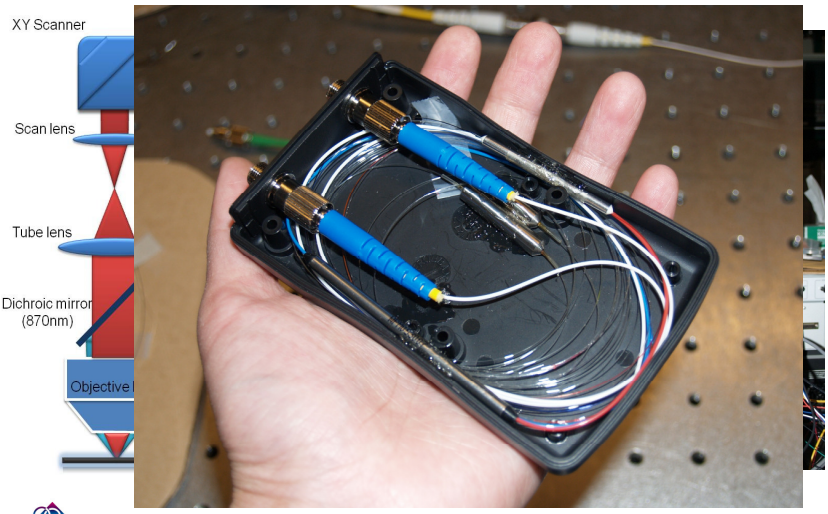
Multiphoton imaging (MPI)system



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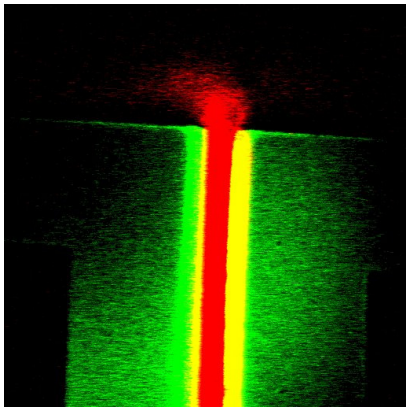
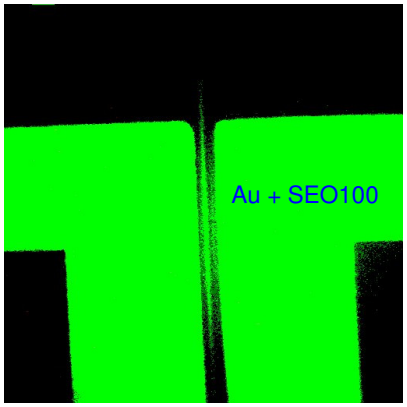
K. Kieu, et. al, *Biomedical Optics Express* **4**, 2187 (2013)

SHG imaging to assess material properties



Nonlinear image of a poled EO modulator using SEO100, SHG (red), THG (green)



Nonlinear image of a unpoled EOmodulator using SEO100, SHG (red), THG (green)

R. Himmelhuber, et. al, *Applied Physics Letters* **104**, 161109 (2014)

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The University of Arizona

New Contrast Mechanisms

- "material" agents, such as new molecules and biochromophores
- "photonic" agents such as new nonlinear microscopy modalities such as fiber-laser enabled second harmonic generation, third harmonic generation, two-photon fluorescence, three-photon fluorescence
- "structural" agents that take advantage of unique nanostructures (metamaterials, etc.), that are enabled by nanofabrication techniques such as electron beam and focused ion beam lithography, for which state-of-the-art systems have recently been installed at the University
- other new agents that don't fall into these categories

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What makes us unique?

- Intelligent instrumentation - - equip an instrument with the task that it needs to do - - smart equipment - - make the equipment adapt to the patient - great interdisciplinary teams
- Significant expertise in the development of FDA approved contrast agents
- We have a very strong group a synthetic chemists who can support contrast agent development - V. Rhuby, M. Pagel, D. McGrath, C. Aspinwall, T. Matsunaga, E. Unger, J. Wagner, J. Pyun – this is a capability that other new imaging mechanisms can take advantage of

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What makes us unique?

- Advanced fiber laser technology enables compact multimodality multiphoton microscopy – discussion developed around the use of this for endoscopy and for collagen identification in the liver, for example
- Confluence of advanced nanofabrication techniques such as focused ion beam and electron beam lithography and strong foundation in image science
- Strong capability in two-dimensional graphene analogs
- Advanced materials imaging capability
- Partnership with Banner provides a potential vehicle for acquiring capital intensive new facilities

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What grand challenges are being addressed?

- Do imaging with less damage to tissue
- Achieve 10,000 to 1 depth to resolution ratio
- Determine what is happening in an advanced electronic devices in situ and materials with Angstrom resolution
- Turn-key, portable multimodality multiphoton microscopy (SHG, THG, TPEF, 2PEF, 3PEF, CARS)
- Using SHG to image collagen in the liver
- Microwave/acoustic imaging and treatment agents
- Characterizing lymph nodes and pancreas fiber optically with 2-3 cm depth resolution

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What new capabilities will be developed?

- Robust three-photon (THG, 3PEF) microscopy system – all materials have a THG and 3PEF signature (as opposed to SHG and 2PEF)
- Shared Good Manufacturing Practice (GMP) facility for contrast agent development - - need to have the ability to get human data
- Establish a Molecular Theranostics Institute (with Banner)
- Nanofabrication enabled imaging vehicles (plasmonic lenses, nanolenses, etc.)

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What longer-term competitive advantage will be created?

- Build on initial position in compact modelocked fiber lasers and extend capability to a number of other wavelengths
- Marry state-of-the-art multiphoton microscopy capability with unique TEM and SEM modalities becoming available
- We discussed who our peer group is - - the following list was generated: U Colorado, UC Irvine, UC Davis, U Michigan, U Wisconsin, UCLA...

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What could be an early demo of the new capabilities?

- A number of demonstrations of the multiphoton microscope have already taken place including the study of neural tissue
- A potentially near term demo that was discussed was multiphoton enabled endoscopy
- An exciting sensor demo would be to perform multiphoton imaging on a plasmonic nanostructure that also included adsorbed molecules

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How can these capabilities be extended to other parts of the UA?

- Work is already underway with the Medical School and exploratory work has been pursued with faculty in Chemistry and Materials Science
- A proposal has been approved by the VPR's office to create a 3-photon microscope - - this will be a user friendly facility open to the campus which will be portable and will be also taken to NAU and ASU for demos

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What partners would help us?

- Chemical and pharmaceutical companies with experience in conventional contrast agents and perspective on how the new techniques could benefit the field
- Collaborators with deep experience in conventional photonic microscope techniques, principally Raman
- We need collaborators who are experts in proteomics to further some of the contrast agent development underway
- Develop off-shore partners who can facilitate the development of human contrast agent data
- Partner with vendors - - look to creatively engage vendors to reduce capital equipment costs

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Strategic issues

- Determining how best to use new contrast modalities to complement and extend existing approaches
- Securing intellectual property rights for the use of new fiber lasers and light sources in imaging systems
- Where should we invest in new capabilities and where should we partner?

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Breakout Session C

Multi-dimensional Imaging

4D Imaging
Multi-modal imaging

Aug. 18, 2015

1. What makes us unique?

- Strength in Technology
  - Optics
  - Bioengineering
  - Medical Imaging
- Existing collaboration within the campus

2. What grand challenges are being addressed?

- Data visualization, analysis.
- Integrated multi-modality imaging analysis.
- Imaging Informatics
- Identify the need?
- Sustainable and expandable collaboration

3.What new capabilities will be developed?

- **Visualization center, imaging informatics**
- **Platform for connecting technology and users**
    - Involvement of potential users during development
    - Generating multidisciplinary solution for specific problem

3.1 What longer-term competitive advantage will be created?

- Remove barrier between developing, facility and imaging analysis/informatics
- Incubate inter-disciplinary collaborations

3.2 What could be an early demonstration of the new capabilities?

- Survey of existing technique/facilities and potential users
- Mailing list, and workshops to promote communication to find common ground between all aspects.

3.3 How can these capabilities be extended to other parts of the university?

- Integrating biomedical and non-biomedical imaging
    - More involvement in disciplinary other than bio

4. What are specific opportunities for external funding?

- Biomedical application
    - Imaging diagnostic
    - New frontier in basic science: functional genomics
- Broaden applications areas

5. What resources are required (program-specific and/or infrastructure)?

- New Recruit
- A Bio5 style center
  - Core facility that housing both mature techniques and developing techniques
  - Virtual connection between technique, imaging science/informatics and applications

6. What partnerships would help us?

- HHMI (Bio)
- Industry

7. Other program risks

- Investment vs Return vs Risk
  - Virtual vs Physical Center
  - Piggy backing existing program (TRIF?)
  - Leverage current available source

8. Strategic issues

Breakout Session D

Extracting quantitative information; quantifying information extraction

Daniela Zarnescu
(Molecular and Cellular Biology, Neuroscience)
Harry Barrett
(Optical Sciences and Medical Imaging)

1. What makes us unique?

A strong image-science curriculum at the College of Optical Sciences and numerous related grants that implement the task-based approach to assessment and optimization of image quality. The task can be either classification of the object that led to an image or estimation of numerical parameters characteristic of the object; the latter is the focus of this group

Long-standing image-science collaborations among Optical Sciences, Medical Imaging, Biomedical Engineering, Applied Mathematics and the UA Cancer Center

The Center for Gamma-Ray Imaging (Medical Imaging and Optical Sciences) has a 16-year history of applying optimal methods of information extraction to molecular imaging with radioactive tracers; the time is ripe for a much broader application of these principles.

Also have strengths in structural biology, gene expression regulation, aging, cardiovascular and neuroscience research, but there are emerging unmet need for quantitation. Examples include integration of data from multiple modalities in brain imaging science (functional/structural image fusion), molecular and cellular systems.

Identified unmet needs: address sample heterogeneity (molecular mixtures, cell to cell variation in gene expression and response) and dynamics of biological systems. Modeling was also identified as a need across specialties. Additional identified needs include infrastructure in the areas of statistics, data management and computational infrastructure.

2. What grand challenges are being addressed?

A key challenge is to bring rigorous, statistically optimal methods of image quantitation to interested groups across campus and across the whole imaging community.

The methods will require careful system calibration and comprehensive characterization of the image statistics, and the estimation algorithms will take full cognizance of null functions and nuisance parameters.

The same mathematical and statistical methods used to construct the estimator will also be used to quantify its performance, defined ultimately by the outcomes of scientific or medical tasks. Moreover, the resulting task performance will be used to optimize the design of the system used to obtain the image data in the first place.

From a biological perspective, the challenge is to identify applications where better quantitation will lead to new understanding of biological processes molecular structure and function. These newly developed applications have translational implications.

3. What new capabilities will be developed?

Methods for calibrating imaging systems and characterizing the image noise covariance.

Algorithms and software for incorporating system-specific information into optimal parameter estimation, signal detection and detection of changes between images. These methods will solve the identified biological/biomedical needs on campus.

What longer-term competitive advantage will be created?

Exportable methods and software for estimating object parameters in a system-independent manner, permitting multi-center trials and broad collaborations.

What could be an early demonstration of the new capabilities?

Choose a modality and a collaborator, work through the details of data management, system calibration and parameter estimation.

How can these capabilities be extended to other parts of the university?

Set up facility and staffing for repeating the early demo in multiple departments.

4. **What are specific opportunities for external funding?**

   One could imagine a Center for Image Quantitation

   or

   Center for biological complexity

   or

   Center for molecular dynamics

5. **What resources are required (program-specific and/or infrastructure)?**

   Faculty and staff, instrumentation for calibration, computer infrastructure

6. **What partnerships would help us?**

   FDA Center for Devices and Radiological Health (Virtual clinical trials)

   HHMI,

   Betty and Gordon Moore Foundation

   Manufacturers of imaging systems.

7. **Other program risks**

   Manufacturers may restrict access to raw data.

8. **Strategic issues**

   Identify low hanging fruit, prioritize…