3.2 Best Practices for Strategic Planning

3.2.1 Strategic Planning is Important

Each ERC develops a top-level strategic plan for all of its operations using the ERC Programâ€™s 3-level strategic planning chart that depicts how engineered systems goals guide and motivate the centerâ€™s fundamental research, enabling and systems technology research, and testbeds. The core of the plan contains the major elements involving researchâ€”a research strategy that reflects and supports the ERC vision plus a comprehensive plan that:

- Covers the three levels of ERC research (i.e., fundamental knowledge, enabling technologies, and engineered systems)
- Identifies clear barriers in the way of achieving the systems goals
- Identifies clear research goals derived from those barriers, by thrust and overall, as well as milestones for their achievement
- Contains adequate human and dollar resources
- Articulates metrics for measuring progress toward final completion of individual projects.

Amplifying these general guidelines, five strategic-planning best practices for research thrust leaders are described below.

3.2.2 Clearly Define Roles and Responsibilities

The strategic plan must define fully the roles and responsibilities of the thrust leader, each member of the team, and their relationship to the rest of the leadership teamâ€”from the top to the bottom. Full definition encompasses three elements:
1) the reporting structure within the ERC;
2) how decisions are made on funding or discontinuing a project; and
3) an appropriate balance of industry interests against long-term research goals.

Aspects of the following best practices contain elaborations of these three elements.
However, definition of roles and responsibilities has to include the added mandate that research thrust leaders must be delegated *authority* commensurate with their responsibilities. In other words, the thrust leaders cannot be held *responsible* for leading if they do not have sufficient authority to do so. This problem is generally avoided if thrust leaders are able to participate in early strategic research planning, are included in the ERCâ€™s leadership team, and can negotiate their role as members of that team to fulfill the thrustâ€™s/ERCâ€™s goals.

Management references often contain discussion of authority accompanying responsibility. For example, *â€œTypically, an employee is assigned authority commensurate with the task. â€¦ When an employee has responsibility for the task outcome but little authority, accomplishing the job is possible but difficult. The subordinate without authority must rely on persuasion and luck to meet performance expectations.â€•* (Endnote 4.)

3.2.3 Capture the Components of a Good Plan

A good strategic plan has many components. Inclusion of the following components is very important:

- An ERC has to establish a team culture versus the more traditional, individual-research culture, both intra- and inter-university;
- Ensure that the overall ERC vision and mission are articulated in the plan and shared by those in the research thrust leaderâ€™s area of responsibility;
- Define resource and budget needs, given the goals;
- Lay the groundwork to take advantage of the best communication technology (e.g., to facilitate â€œbrainstorming sessionsâ€• and other necessary interactions).
- Define succinct deliverables and outcomes on reasonable timelines.

3.2.4 Define a Structure for Adjusting the Plan

Research thrust leaders should never assume that, once a plan is completed, it will not need to be changed. In fact, change is

more likely the norm. Therefore, at the outset a structure must be defined in which adjustments or corrections relating to the research plan can be made. Among other things, this type of structure would ensure that financial resources can be distributed or redistributed, both within and among universities.
To help measure progress and determine adjustments, metrics should be defined for successful research within an ERC. Proper metrics should not be just numbers of papers published or students graduated. Rather, they should:

- Measure each projectâ€™s contribution to the thrust, such as advancing the testbed
- Exhibit an incentive to improve the thrust
- Consider additional funding from other non-ERC Program sources, attracted by the ERCâ€™s research
- Take account of industry funding obtained for the thrust.

3.2.5 Ensure the Research Tasks Can be Accomplished with the Resources Allocated

Despite the fact that budget reallocations will probably be needed at times, the initial plan should contain budget estimates that adequately cover the research tasks as well as the necessary administrative and management support. Donâ€™t volunteer to do too much for too little. Since budgets are likely allocated in the beginning from top levels of the ERC downward, be sure the plan contains commitments to do only what the budgeted resources will allow, and no more.

3.2.6 Create a Transparent Organizational Structure

A transparent organizational structure, preferably one that is â€œflat,â€• should be created and set forth in the plan. This type of structure would succinctly identify the various interactions and dependencies that exist, both within individual thrusts and between thrusts.

3.2.7 Examples

The following excerpts are from the strategic research plans of three ERCs [1-Synthetic Biology Engineering Research Center (SynBERC, with overall objective: enabling technologies); 2-Mid-InfraRed Technologies for Health and the Environment (MIRTHE, with overall objective: enabling technologies); and 3-Collaborative Adaptive Sensing of the Atmosphere (CASA, with overall objective: specific system product). The excerpts furnish examples of the general strategic planning guidelines and best practices described in this Section 3.2.
Note that the objective statement for each ERC signifies the type of overall goal for the center. There is a difference in strategy when the goal is a very specific system versus breakthroughs in process or understanding that would make possible a variety of different system developments.
Referral to the planning details for the individual research thrusts contained in these and other ERC plans should further expose research thrust leaders to a range of strategic planning approaches. *Nevertheless, each thrust leader faced with developing strategic plans should try to ensure that the best practices outlined in Section 3.2 above are accommodated, regardless of past or current practices at any particular ERC.*

3.2.7.1 Addressing the Three Levels

ERC strategic plans normally display the standard â€œthree-plane diagramâ€• showing effort devoted to fundamental knowledge (bottom plane), enabling technologies (middle plane), and engineered systems (top plane). Although involved most heavily in the lower planes, research thrust leaders must recognize the great importance of their work to achieving success in the top plane.
To portray a variety of concepts, several three-plane diagrams appear below (see Exhibit 3.2.7.1(a-c)). The last (c) has text associated with it as an aid to understanding the diagram in subsection 3.2.7.2.

EXHIBIT 3.2.7.1 (a)

SynBERC Year Four Annual Report

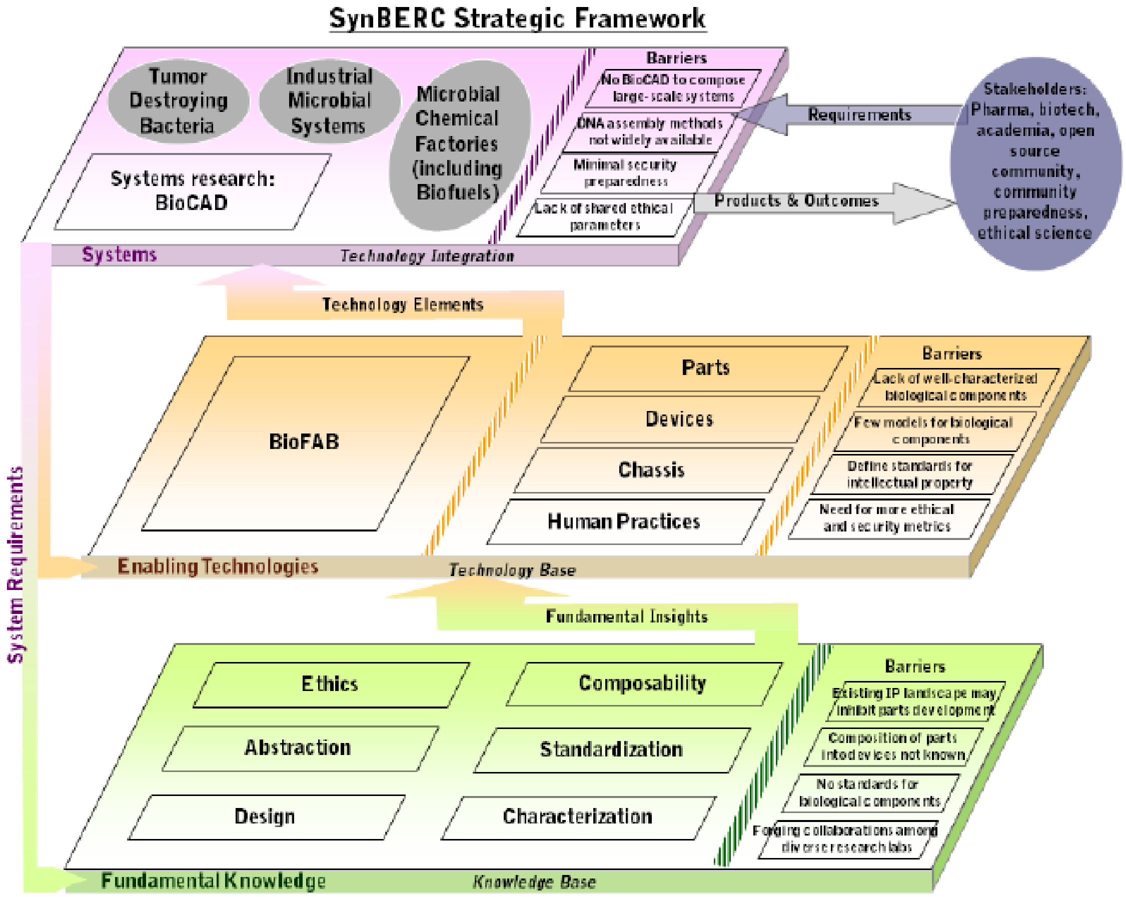
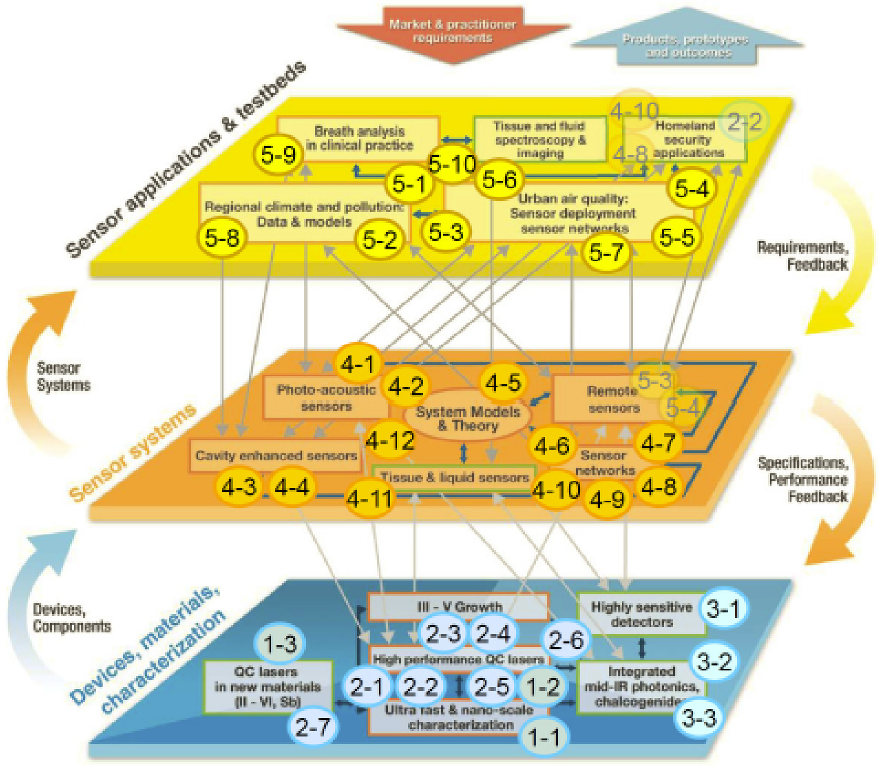


Figure 5.1-1. SynBERC three-plane strategic diagram. Last updated January 4, 2010.

EXHIBIT 3.2.7.1 (b)



Project assignment to MIRTHE's 3-level ERC strategic framework

Thrust –index	Project name ...
5–1	Coupled Water, Carbon, and Nitrogen Cycles in Urban Environments
5–2	Coupled Water, Carbon, and Nitrogen Cycles in Urban Environments
5–3	Monitoring Trace Gas and Aerosol Properties in the Urban Environment
5–4	Monitoring Trace Gas and Aerosol Properties in the Urban Environment
5–5	Nitrous Oxide Instrument Development Using a Single Mode, Continuous Wave,...
5–6	Ultra Sensitive Ammonia Sensor for Urban Air Quality
5–7	Monitoring of Ammonia Mixing Ratios in Houston Using MIRTHE Technology
5–8	Gas Sensing Using Mid-Infrared Technology in Fish-Smoking Areas In ...
5–9	Breath Ammonia in Humans, a Pilot Study
5–10	Development of Mid-Infrared Based Instrumentation for In Vitro Toxicity Testing

Thrust –index	Project name ...
4–1	Development of Quartz Enhanced Photo-Acoustic Spectroscopy Based ...
4–2	Development, Verification, and Validation of Three-Dimensional Models for ...
4–3	Development of Trace Gas Sensor Platforms for Applications in Health , ...
4–4	Development of External Cavity Quantum Cascade Lasers with High Speed, ...
4–5	Develop Statistical and Deterministic Signal Processing Algorithms for ...
4–6	Development of Ultra-Low Power, All-Digital-Signal-Processing Laser-Based ...
4–7	Gas Sensing Wireless Networks
4–8	Optical Transmission and Signal Cancellation Techniques in Sensor ...
4–9	Integrating MIRTHE Sensors into Wireless Meteorological Sensing Networks
4–10	Securing Sensor Networks
4–11	Mid-Infrared Cancer Detection and Monitoring
4–12	Confocal Microscopy Based on Quantum Cascade Laser and Single Hollow Core ...

Thrust –index	Project name ...
3–1	Novel Mid-Infrared Sources and Detectors Based on Resonant ...
3–2	Photomodifiable Chalcogenide Glass Materials for Integrated ...
3–3	Chalcogenide-on-Lithium Waveguides
2–1	High Performance (Threshold, Power, Efficiency) Quantum ...
2–2	Spectrally High-Performance Quantum Cascade Lasers
2–3	3-5 µm Quantum Cascade Laser Gain Materials
2–4	Broadband Quantum Cascade Laser Gain ...
2–5	Modelocking of Quantum Cascade Lasers
2–6	Integrated Tunable Quantum Cascade Lasers
2–7	Solid State Mid-Infrared Lasers Pumped by ...
1–1	Nanoscale Characterization of Metal Organic Molecular Beam ...
1–2	Mid-Infrared Ultrafast Diagnostic Instrumentation for Quantum Cascade ...
1–3	Wide Bandgap II-VI Semiconductors for ...

EXHIBIT 3.2.7.1 (c)

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SECTION 2 - STRATEGIC RESEARCH PLAN AND OVERALL RESEARCH PROGRAM

2.1 STRATEGIC RESEARCH PLAN

The innovation being pursued in the CASA project is to supplement - or replace - the present national network of 150 large weather radars with thousands of small radars that can be deployed on cellular telephone towers, rooftops and other infrastructure. The closer spacing of the new radars will avoid the obstruction caused by Earth curvature and allow forecasters to directly view the lower atmosphere with high-resolution observations. This new dimension to weather observing leads to improved characterization and better forecasting of storms, resulting in improved warning and response to tornadoes and other hazards. In addition to the many engineering challenges associated with the radar network itself, software architectural problems to be solved include managing the system's many resources and data volume and designing an effective user interface. The central challenge is in designing and deploying a system that can sample the atmosphere where and when the user need is greatest to reliably issue alerts that the public trusts and responds to appropriately.

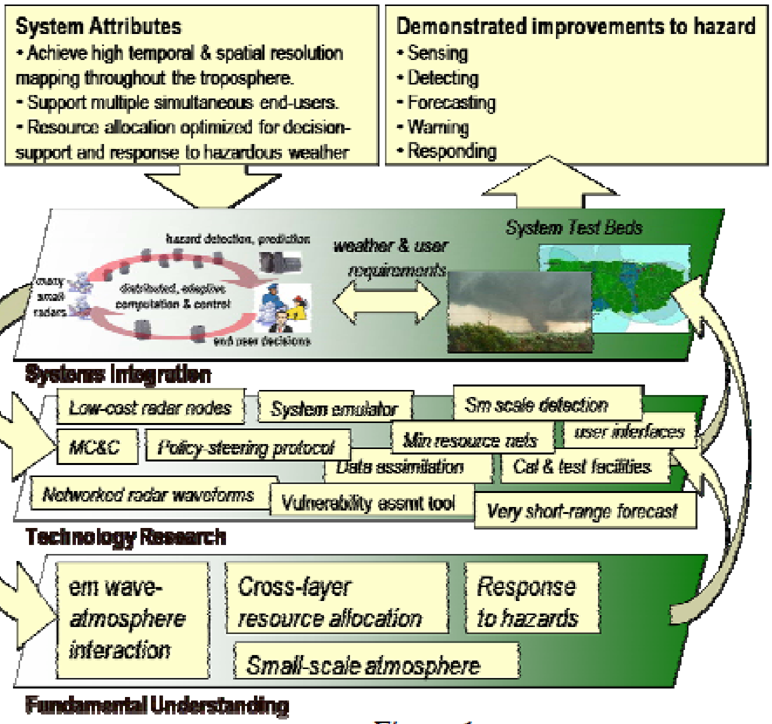


Figure 1.

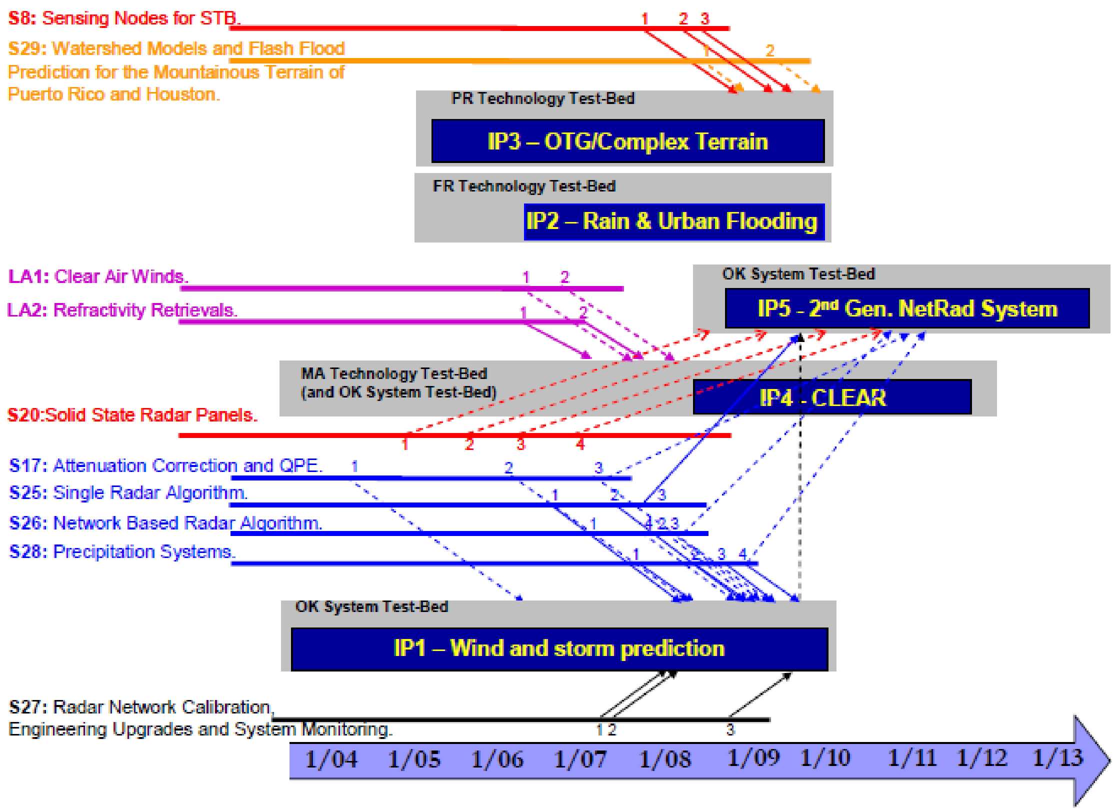
The solutions to the different problems posed by this project are to be found through CASA's working on three planes of engineering research as shown in figure 1. CASA's system focus (upper plane) is a real-time distributed system capable of focusing its resources onto particular sub-volumes of the atmosphere and delivering forecasts and other data that enable forecasters, emergency managers and the public to generate accurate alerts and make effective decisions when weather strikes occur. Realizing an effective and efficient system requires creating a number of new enabling technologies (middle plane) and conducting fundamental research to create new knowledge (bottom plane). Multi-disciplinary research in the lowest plane spans several disciplines, from electrical engineering investigations of how electromagnetic waves interact with the atmosphere, to atmospheric science investigations related to detecting and forecasting storm cells at high resolution, to computer science investigations related to resource optimization, to sociological and decision-theoretic studies about how individuals and organizations respond to severe weather hazards, utilize warnings and ultimately take protective action. Whereas the lowest plane tends to be the "comfort zone" of academic faculties, CASA's strategic concept is an interdisciplinary orchestration of work in all planes, from the definition of the system in the upper left, through targeted technology and fundamental

3.2.7.2 **Identifying Clear Goals and Milestones**

The CASA thrust-level example below (Exhibit 3.2.7.2) amplifies the general guideline of identifying clear goals and milestones by emphasizing the best practice of *defining succinct deliverables and outcomes on reasonable timelines*. This project-level milestone chart extends the CASA three-plane diagram shown in Exhibit 3.2.7.1 (c) above.

EXHIBIT 3.2.7.2

The milestone and deliverable chart for the Sensing thrust are shown in Figure (17). Sensing hardware (S27) and algorithms (S17, S25, S26, S28, and LA2) were extensively tested, evaluated, and improved through the successful operation of IP1 radar network. Other significant completed milestones include development and installation of sensing nodes (S8, S20), system calibration for IP1 operation (S27), system planning of test beds (S8, LA1), and application development (S17, S28, S29, LA2). The sensing system design of DCAS systems progresses through the IP1 test bed and the IP3 test beds, following system engineering approaches and CASA's strategic plan, and then progresses into the design of the IP5 test bed. The exploration of new processing algorithms and network based system models is on going with actual radar observations of the IP1 system level test bed.



S8.1 First OTG radar installation in Puerto Rico	05/09
S8.2 Second OTG radar installation in Puerto Rico	08/09
S8.3 Cross-validation of PR1 radar and OTG radars	12/09
S17.1 Operational attenuation correction algorithm	04/06
S17.2 Development of IP1 rainfall estimation system	07/08
S17.3 Development of IP1 hydrometeor type classification	07/09
S20.1 Antenna and TR module performance review	04/08

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S20.2 Antenna and TR module fabrication	05/09
S20.3 Radar system integration	03/10
S20.4 Field test at MA1 / CSU-CHILL	06/10
S25.1 Dynamic waveform selection and processing	06/08
S25.2 Digital waveform generator	04/09
S25.3 Integration of wideband waveform with solid-state transmitter	12/09
S26.1 Real-time implementation of network reflectivity retrieval	10/08
S26.2 Implementation of networked waveform system	07/09
S26.3 Statistics of rain attenuation in IP1 network	08/09
S26.4 Interface Q-function algorithm with MC&C	06/09
S27.1 Implement networked waveform structure	02/08
S27.2 Implement clear air mode	03/08
S27.3 Transition to IP5	12/09
S28.1 Real-time implementation of DARTS	06/08
S28.2 Including DARTS nowcasting in MC&C	04/09
S28.3 Scale analysis for nowcasting	10/09
S28.4 Evaluation of network resolution enhancement system	12/09
S29.1 Prototype real time flood alarm system	05/09
S29.2 Radar rainfall mapping in STB	03/10
LA1.1 Statistics of insect scattering	02/08
LA1.2 Analysis of scan strategy for insect scatters	06/08
LA2.1 Implement real time refractivity retrieval	10/07
LA2.2 Clear air scan for refractivity measurement	05/08

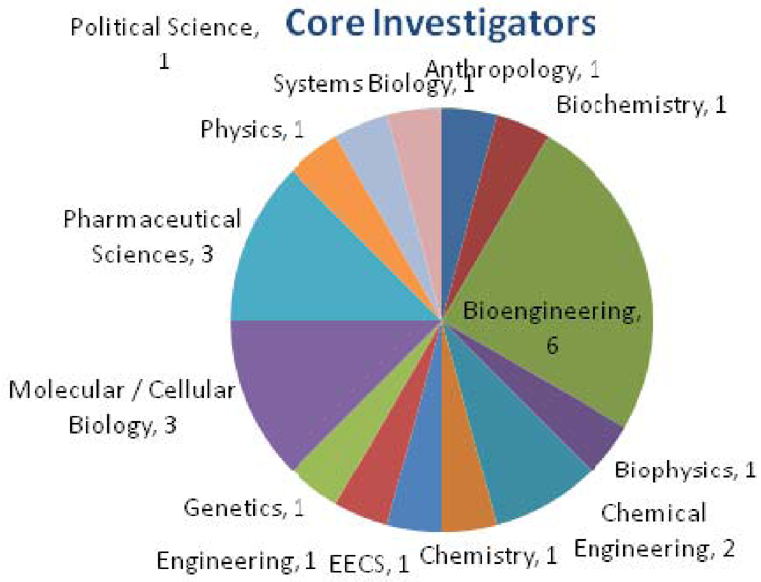
Figure 17. The milestones and roadmap for Sensing thrust research

3.2.7.3 Adequate Human and Dollar Resources

Exhibit 3.2.7.3 (a) shows the range of human resources needed by one ERC for its research program. This diversity of participants underlines the importance of best practices that establish a group culture, share the overall ERC vision and mission, and make use of the best communication technologies.

Rather than providing examples showing dollar resources that are merely accumulations of pages of ERC cost estimates by research project, the second exhibit below (3.2.7.3 (b)) amplifies a part of the best practice of defining a structure for plan adjustments, which could include financial adjustments. The example suggests that the original resource estimates may have been a bit short, which highlights that a priority emphasis for strategic planning should be on ensuring that the research tasks can be accomplished within the originally allocated resourcesâ€” requests for later â€œadjustmentsâ€• in the form of budget increases will not likely be received favorably. Another example of adjusting the original strategic plan appears in subsection 3.3.8.1.

EXHIBIT 3.2.7.3 (a)



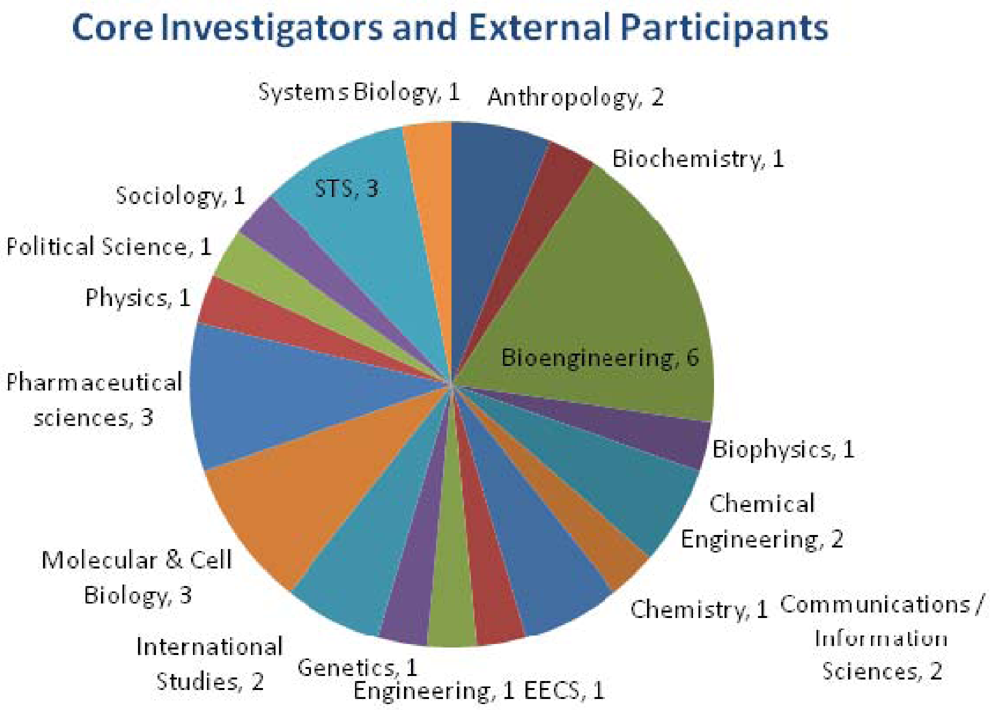


Figure 5.1-5. Research project investigators by discipline

EXHIBIT 3.2.7.3 (b)

2.1.8 Changes in MIRTHE's Budget

MIRTHE is still in the budgetary ramping up phase, and requests an additional $250k of NSF core funds in year 5, after which the budget is expected to be flat. These additional $250k are being used to support MIRTHE's ongoing research program, off-setting inflationary costs, and strengthening or supporting new programs with special attention to:

(i) Supporting MIRTHE's junior faculty;
(ii) Instituting a new mini-grant competition for post-doctoral researchers;
(iii) Supporting the speed up of the wireless sensor network projects;
(iv) Supporting student internships at industry/practitioner sites; and
(v) Providing more opportunities for direct student–industry interaction.

Overall, no major funding shifts are anticipated in the short term.

3.2.7.4

Articulating Metrics

The importance of good metrics cannot be over-emphasized. Several examples of metrics appear below (note the emphasis on â€œuser-definedâ€œ metrics). See Exhibit 3.2.7.4.

EXHIBIT 3.2.7.4

Apart from storm motion and temporal correlation, in collaboration with the predicting thrust we will also produce Very Short-Range Forecast (VSRF), directly serving the end-user groups. This product will be initially built upon the current operational nowcast system in IP1. Currently, the nowcast product is used to predict the storm locations in a short-term. The performance will be quantitatively evaluated by Critical Success Index (CSI), as well as POD and false alarm rates. In IP5, the VSRF product will be also used to impact the "siren blows". The impact on the use by the end user group (emergency managers) will be the primary metric used in the operation process. We will work with the End-user thrust to define additional quantitative metrics to evaluate the performance, where the missed detection needs to be emphasized and the location of interest needs to be subjectively selected. A simple but significant example of the impact of VSRF on the end user group is spotter deployment (Collaborative System Goal). This collaborative system goal spans into three stages of development namely, a) demonstrate real-time detection, analysis, and VSRF products to Emergency Managers, b) demonstrate optimum MC&C protocol to maximize VSRF skill and c) demonstrate optimum MC&C protocol to maximize spotter deployment decision support. The metrics of effective spotter deployment are different from the direct metrics for VSRF such as CSI. For example the spotters may want to be located in a region, close to escape routes (good roads), as well as good vantage points with better visibility as well as the potential to get ahead of the storm. These needs will be mapped, via the MC&C into the scanning strategy to

â€¦

Goal #1 Plans: In years 7 -10, we will begin to implement more objective measures for determining user needs and socioeconomic benefits to allocate system resources.

- *Users Needs* – We will develop user-defined metrics for data quality for response based goals such as emergency manager deployment of spotters. Metrics include FAR, POD, spatial and temporal requirements, and display considerations. This information will be determined as part of the EUI thrust's on-going decision modeling of user groups.

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- *Weights* - Evolve from static trade-off coefficients to dynamic coefficients, based first on optimizing forecast skill and detections based on performance metrics developed by the scientific community, then based on user defined metrics for data quality, and ultimately based on higher level socio-economic goals.
- *Scan quality* – Quality is defined as obtaining the best data for users based on the user defined-metrics, or for the VSRF products. The user will no longer define scanning strategies, rather the spatial, temporal and physical properties of the phenomena of interest and the capabilities of the radar network determine the scanning.

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Infrastructure Goal #2: Deploy 2 escan radars in the IP5 domain by 1/12; Infrastructure Goal #3: Deploy a 2nd generation MC&C by 1/11. In Version 4 of User Rules/MC&C, users state their preference for scanning frequency and coverage. The addition of escan radars creates a hybrid network containing radars with distinctly different scanning capabilities. Escan radars have agile beams that can be repositioned many times more quickly than mechanical radars. In addition, the user community is not familiar with the capabilities of escan radars. Therefore, as part of the deployment of escan radars and a second generation MC&C, the End User group will collaborate with the Distributing and sensing thrust to evolve a new set of user rules, multi-attribute utilities, and trade-off coefficients based on user-defined performance metrics for CASA products and decision goals. (See System Goal #1 for milestones related to user-defined performance metrics) In addition the EUI will collaborate to create the following system features for MC&C:

- Flexible data formats to enable visualization of base moments and new CASA products through existing software packages, such as AWIPS, the operational data platform used by NWS Forecasters, OKFirst, the operational platform used by emergency managers, a mobile platform for Blackberries and Iphone, and 3D multi-radar programs such as GR2 Analyst.
- Interfaces for dynamic user input into the system by weather spotters and by the NWS.

â€¦

5.2.1.5 Challenges to the thrust

A remaining problem is to appropriately and systematically characterize part behavior, including the development of standardized metrics (e.g., promoter output in units of polymerases per second) and ways to assess composability and generalizabiliy in multiple contexts, as well as experimental protocols for their measure. Systematic characterization in many contexts is often beyond the scope of a typical student or post-doc-driven project, although much progress has been made in this respect with the first "datasheet" for an engineered device [33] and work to characterize promoter activity using an *in vivo* reference standard [34]. The development of the BioFAB will drive progress in part characterization, both by providing data on generalizability and interoperability of components, as well as by development of measurement standards that can be used in the individual SynBERC-funded projects.

â€¦

- Standardized experimental protocols and metrics for measuring characteristics including:
  - part specifications;
  - part composability;
  - part compatibility;
  - part interoperability.

â€¦

These features can be standardized with weighted metrics to indicate the usefulness of any chassis that contain all or a subset of such features. Chasses are then compared to one another based on these weighted metrics so as to determine the most appropriate one for a specific application. For example, a chassis with natural competency and high recombinogenicity may be best suited for genomic manipulations while ones with stable genomes and robust growth may be appropriate for metabolite production. Chassis characteristics are quantified and indexed in a database; an optimization search algorithm can be used to determine the most appropriate chassis within the database for use. Currently, chassis features are being characterized and quantified to determine the most effective implementation of such chassis standardization.