Cooperative State Research, Education, and Extension Service

Planning and Accountability

Evaluating Federal Research Programs: New Approaches

NIH P&E
July 11, 2006

Cheryl J. Oros, Director, P&A

Around Town

- **Marburger Task group on Science of Science Policy (with NSF)**
- **WREN (Washington (World) Research Evaluation Network**
- **Federal Evaluation Leaders (dialogue w/ OMB – Tables 1 & 2)**
- **AEA – Research TIG**

VISIT WREN TODAY

www.wren-network.net

WREN serves as a forum for the publicly funded R&D evaluation community to explore new approaches that will improve the management of science and technology organizations.

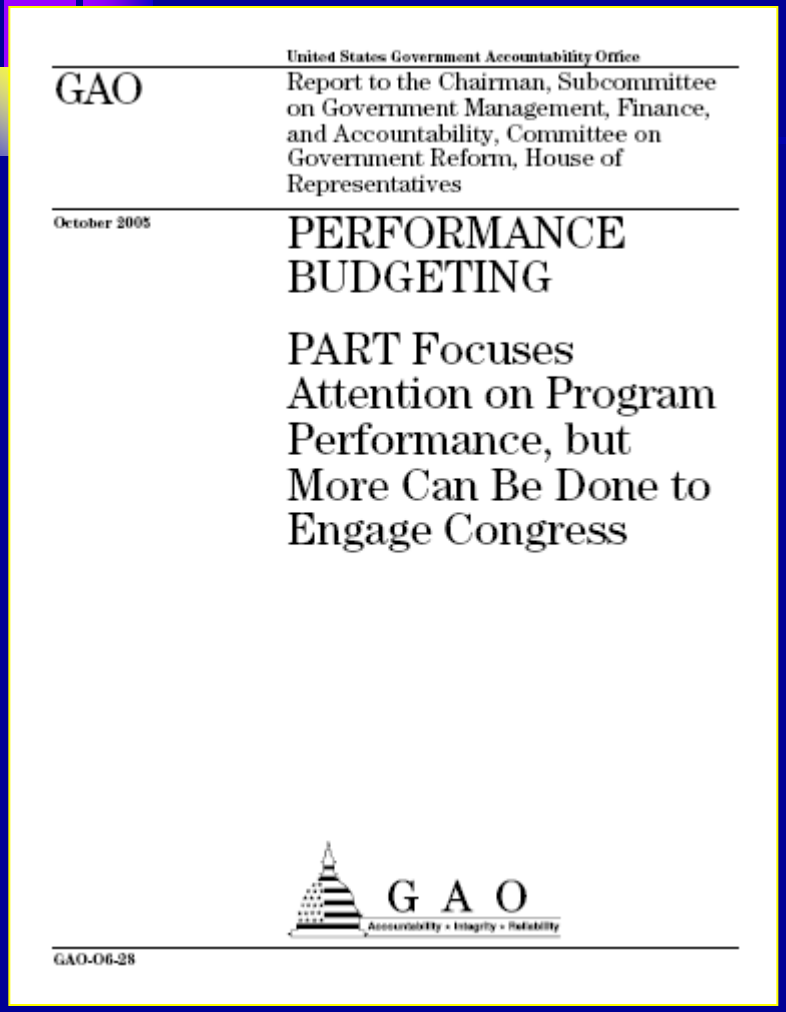
And Congress is Paying Attention…

House Rpt.108-554 - ENERGY AND WATER DEVELOPMENT APPROPRIATIONS BILL, 2005

"*Performance Measures.*--The Committee commends the Office of Science for its efforts to develop quantifiable performance measures for its research activities. Some of the measures (e.g., inverse picobarns) are less comprehensible to Congress than others, but the overall approach to quantitative performance measurement is worthwhile. The Office of Science presented clear data on operating time for user facilities within each Science subaccount, but future budget requests should include a standardized summary presentation for all Office of Science user facilities."

http://thomas.loc.gov/cgi-bin/cpquery/?&db_id=cp108&r_n=hr554.108&sel=TOC_157325&

General Accounting Office



United States Government Accountability Office

GAO

Report to the Chairman, Subcommittee on Government Management, Finance, and Accountability, Committee on Government Reform, House of Representatives

October 2005

PERFORMANCE BUDGETING

PART Focuses Attention on Program Performance, but More Can Be Done to Engage Congress

GAO

Accountability • Integrity • Reliability

GAO-06-28

"PART assessments underscored long-standing gaps in performance and evaluation information throughout the federal government. By reaching agreement on areas in which evaluations are most essential, decision makers can help ensure that limited resources are applied wisely."

PERFORMANCE BUDGETING
February 2005

Evaluation Dialogue

Between OMB Staff and
Federal Evaluation Leaders

Digging a
Bit Deeper into
Evaluation
Science

July 2006

What steps do evaluators use?

1. Conceptualize the program
2. Develop relevant and useful evaluation questions
3. Select appropriate evaluation approaches for each evaluation question
4. Collect data to answer evaluation questions
5. Analyze the data and draw conclusions
6. Communicate results and recommendations

Table 1: Common Evaluation Questions Asked at Different Stages of Program Development

Program Stage	Type of Activity	Common Evaluation Questions
Program design	Needs assessment	▪What are the dimensions of the problem and the resources available to address it?
	Design assessment	▪Is the design of the program well formulated, feasible, and likely to achieve the intended goals?
Early stage of program or new initiative within a program	Process evaluation or implementation assessment	▪Is the program being delivered as intended to the targeted recipients? ▪Is the program well managed? ▪What progress has been made in implementing new provisions?
Mature, stable program with well-defined program model	Evaluability assessment	▪Is the program ready for an outcome or impact evaluation?
	Outcome monitoring or evaluation	▪Are desired program outcomes obtained? ▪Did the program produce unintended side-effects?
	Process evaluation	▪Why is a program no longer obtaining desired outcomes?
	Net impact evaluation	▪Did the program cause the desired impact? ▪Is one approach more effective than another in obtaining the desired outcomes?

Table 2: Common Evaluation Approaches For Assessing Program Effectiveness

Typical designs used to assess program effectiveness	Design features that help control for alternative explanations	Best suited for (typical examples)
Process and outcome monitoring or evaluation	Compares performance to a pre-existing goal or standard. For example: • OMB R&D criteria of relevance, quality, and performance • Productivity, cost effectiveness, and efficiency standards • Customer expectations or industry benchmarks	Research, enforcement, information and statistical programs, business-like enterprises, and mature, ongoing programs where: • Coverage is national, complete • There are few, if any, alternative explanations for observed outcomes
Quasi-experiments – Single Group	Compares outcomes for program participants before and after the intervention. • Outcome data are collected over multiple points in time • Statistical adjustments or modeling control for alternative causal explanations	Regulatory and other programs where: • Clearly defined interventions have distinct starting times • Coverage is national, complete • Random assignment of participants is NOT feasible, practical, or ethical
Quasi-experiments – Comparison Groups	Compares outcomes for program participants with outcomes for a comparison group selected to closely match participants on key characteristics. • Key characteristics are plausible alternative explanations for a difference in outcomes • Outcomes are measured before and after the intervention (pretest, posttest)	Service and other programs where: • Clearly defined interventions can be standardized and controlled • Coverage is limited • Random assignment of participants is NOT feasible, practical, or ethical
Randomized experiments – Control Groups	Compares outcomes for those randomly assigned to participate (“treatment group”) with outcomes for those assigned not to participate (“control” group) • Outcomes are measured before and after the intervention (pretest, posttest)	Service and other programs where: • Clearly defined interventions can be standardized and controlled • Coverage is limited • Random assignment of participants is feasible and ethical

How do we determine the quality of an evaluation?

- Evaluation questions have been answered fully
- Findings support conclusions
- Conclusions portray strong causal arguments
- Study meets professional evaluation standards
  - Utility, Feasibility, Propriety, and Accuracy

Checklist of Questions for Assessing the Quality and Usefulness of a Program Evaluation

- Are the study's objectives stated?
- Were the objectives appropriate with respect to the developmental stage of the program?
- Is the study design clear?
- Was the design appropriate given the study objectives?
- Was the indicated design in fact executed?
- Did the variables measured relate to and adequately translate to the study objectives and are they appropriate to the study objectives and are they appropriate for answering the client's questions?
- Are sampling procedures and the study sample sufficiently described? Were they adequate?
- Are sampling procedures such that policymakers can generalize to other persons, settings, and times of interest to them?
- Is an analysis plan presented and is it appropriate?
- Were data-collector selection and training adequate?
- Were there procedures to ensure reliability across data collectors?
- Were there any inadequacies in data collection procedures?
- Were problems encountered during data collection that affect data quality?
- Are the statistical procedures well specified and appropriate to the task?
- Are the conclusions supported by the data and the analysis?
- Are study limitations identified?
- What possibly confounds the interpretation of the study findings?

Next Steps to Improve

- Network analysis
- Track citations and use of knowledge
- New Marginal Cost analysis (per OMB)
- Improve indicator selection and data availability
- Improve databases and analytic capability
- Engage upper level decision makers in evaluation – what salient questions can we answer

How can evaluators better serve decision makers' needs?

- Evaluators need to explain/train-- & listen
- Raise confidence in evaluation -- Policy makers want trustworthy input for complex, risky allocation of resources
- Tie results of past R&D efforts to forecasting of future payoffs; time lag and pipeline investing issues
- Tie longer-term outcome indicators to processes managers can control

Improvements Needed Around Town

- OMB needs to use bigger picture of increasingly common crosscutting cross-departmental research efforts and overarching indicators
- Traditional budget decision processes need to truly open as evaluations improve – win confidence that results are useful
- BPI required, but not central to budget decisions

USDA Research Agencies

- All 5 agencies with research now using similar approach
- Example of CSREES

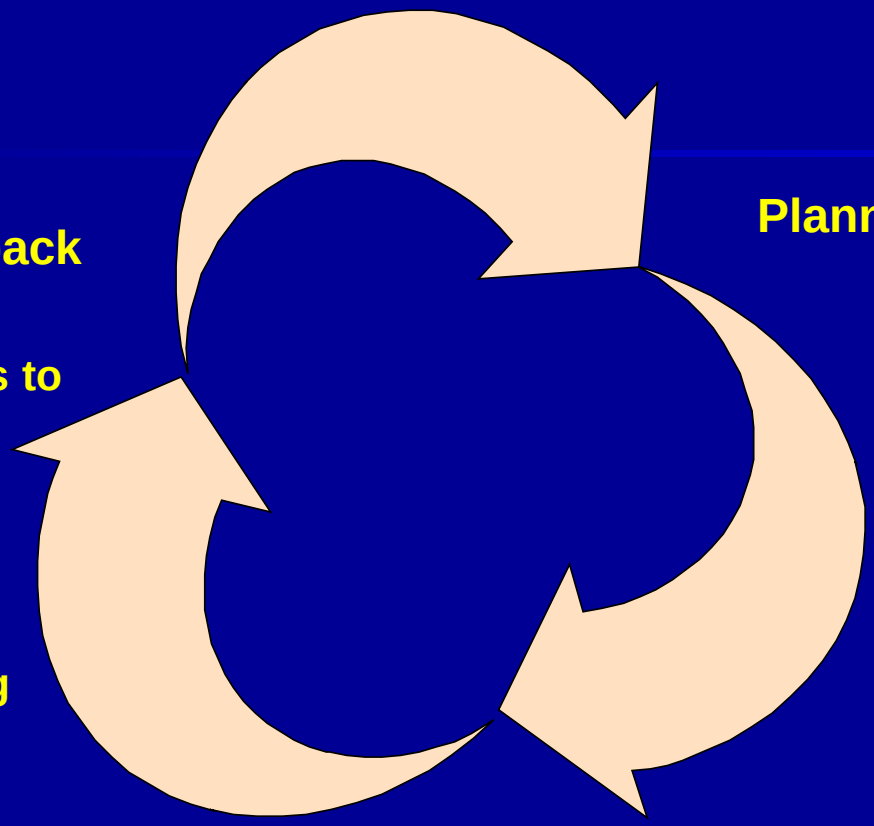
CSREES Mission and Functions

- Knowledge generation and dissemination to solve national problems/ meet needs/ seize opportunities identified in the Strategic Plan
- 57 funding lines; 64 programs; "mini department"
- Agency works through state and university partners via grants
- 4 other USDA agencies conducting research have adopted CSREES approach and share main database

P&A Goal – Aid Leaders

- Applied research in service to decision makers
- Provide performance and evaluation results which will enable managers and decision makers to implement, manage, refine, and show the impact of the highest quality programs.

Evaluation/Management Cycle



Evaluation Feedback

- Feedback of Evaluation Findings to Managers
- Refinement of Program
- Continued Funding

Planning/Decision Making

- Identify needs, problems, solutions, refinements
- Conceptualization of Program
- Formulation of Evaluation Questions and Design

Implementation

- Actualize the Program Plan
- Collection of Evaluation Data
- Analysis of Data

P&A External Requirements

- Government Performance and Results Act of 1993 (GPRA);
- Agricultural, Research, Extension, and Education Reform Act of 1998 (AREERA);
- OMB requirements re performance assessments (PART);
- The President's Management Agenda (BPI & e-gov);
- Budget justifications;
- Other legal and managerial requirements as they arise (including audits by USDA OIG and GAO).

OMB PART

- OMB's Program Assessment Rating Tool
  - Program Purpose & Design
  - Strategic Planning
  - Program Management
  - Program Results
- CSREES Goal 1 Portfolio was reviewed this year; Goals 3 & 5 next year (2005); Goals 2 & 4 in 2006

Federal Budget & Performance Integration

- Budget submissions need alignment with goals & objectives, with funds distributed accordingly, along with quantifiable performance measures
- Congress also requires traditional budget submission

Explanatory Notes/ Budget Justifications

- Introduction: national problem, why important & how CSREES plans to solve problem
- How CSREES plans to spend funds
- What would happen if funding not received

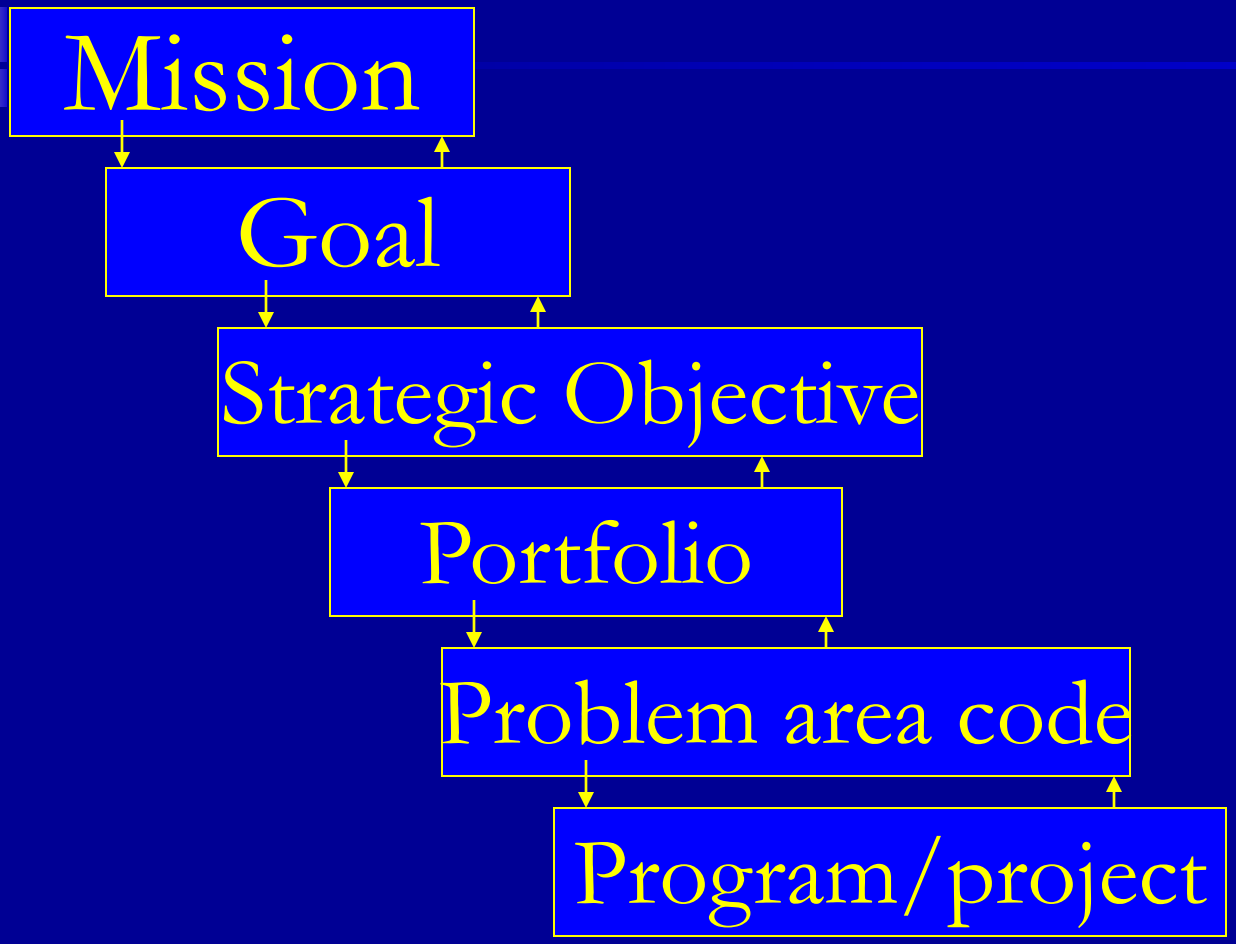
Budget justifications (cont.)

- Draw on past accomplishments
- Identify performance measurements and evaluation plans
- Acknowledge and deal with environmental complexities
- Cover 57 funding lines (64 programs)

Fully aligned USDA-CSREES Strategic Goals:

1. Enhance economic opportunities for agricultural producers
2. Support increased economic opportunities and improved quality of life in rural America
3. Enhance protection and safety of the nation's agriculture and food supply
4. Improve the nation's nutrition and health
5. Protect and enhance the nation's natural resource base and environment

Cascading Alignment



Evaluating Research & Education Efforts: Portfolio Approach

- OMB PART/BPI led to development of new portfolio assessment tool and measures
- Portfolio analysis (meta-analysis) used to assess progress toward goals; guide announcements for grants
- Uses OMB R&D criteria (relevance, quality, performance)

“Portfolio” concept

- Allows numerous complex interrelated programs and funding lines to be described as they address strategic objectives and goals

Portfolio Review Expert Panel (PREP) Process

- Focus on outcomes rather than processes
- Level of analysis is a portfolio identified via Problem/ Knowledge Area codes in databases
- A PREP scores portfolio progress & provides recommendations for Agency

Evaluation Approach

- Alignment of research programs and projects with portfolios, objectives and goals in Strategic Plan
- Use of logic models to develop relevant evaluation questions, indicators, and approaches
- Use of OMB/ NAS Research and Development Criteria by expert review panels

Portfolio Review Expert Panel (PREP) Process

- Focus on outcomes rather than processes
- Level of analysis is a portfolio identified via research topic areas in databases
- Scores portfolio progress for OMB
- Provides recommendations for Agency to alter research investments to better meet Agency mission & goals

Evidentiary materials

- Tracks papers, citations, patents, products, educational efforts, adoption of products/ practices
- Entire evaluation studies and special analyses
- Budget tables to show portfolio priorities and emphases

5 Dimensions of Relevance

- Scope
- Focus on critical needs
- Identification of emerging issues
- Integration of CSREES programs
- Interdisciplinary integration

4 Dimensions of Quality

- Significance of findings & outputs
- Stakeholder assessment
- Alignment of portfolio with current science
- Methodological rigor

5 Dimensions of Performance

- Portfolio productivity
- Portfolio completeness
- Portfolio timeliness
- Agency guidance relevant to portfolio
- Portfolio accountability

Portfolio Review Expert Panel (PREP) Process

1. Selection of high-level panelists with broad experience in topic area, reviewed for absence of conflicts of interest, e.g.:

- University Vice-Presidents
- Deans and Associate Deans
- Industry Experts (Vice Presidents)
- Evaluation Experts

Portfolio Review Expert Panel (PREP) Process (cont.)

2. Self assessment document written by CSREES and sent to panelists prior to meeting:
   - Report sections
     - Executive Summary
     - Portfolio (performance per logic model and future directions)
     - Problem areas that comprise portfolio (performance per logic model and future directions)
     - Adherence to R&D criteria
   - Compilation of evidentiary materials
   - Self assessment scoring prior to panel

Portfolio Review Expert Panel (PREP) Process (cont.)

3. Panelists meet for 2 ½ days:
   - Day 1 - orientation, short briefings along with Q&As
   - Day 2 - review of evidentiary materials, discussion, voting, and development of recommendations
   - Day 3 - complete draft report; panel debrief for Agency staff

Panel Scoring Sheet

- Panel scores each dimension of each of three R & D criteria using customized anchors on a 3-point scale:

  3=Exceeds expectations

  2=Meets expectations

  1=Needs improvement

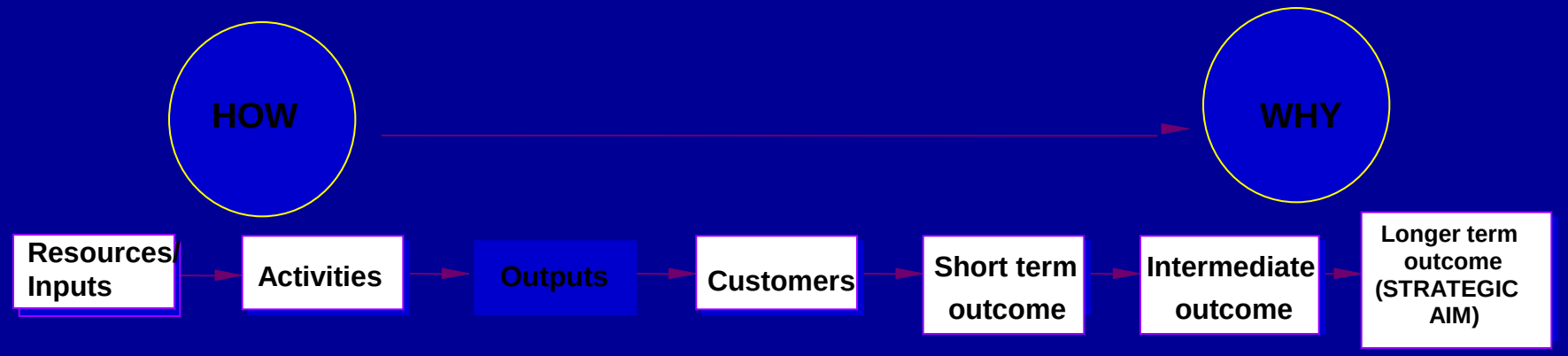
Panel Scoring Sheet Example: Relevance

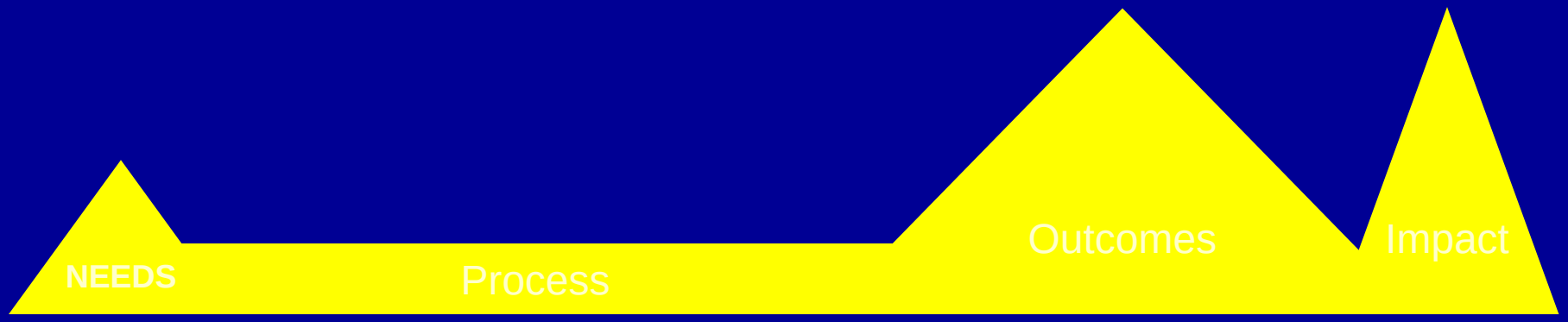
Section 1: Relevance Dimensions	Purpose of Dimension	Rating: 3	Rating: 2	Rating: 1	40% of total	Total relevance score
1.1 Scope – coverage of the work of the full portfolio	Define & summarize needed & existing portfolio topics	Fully demonstrates exceptional depth	Portfolio coverage is static in depth	Portfolio is falling behind	40%	
1.2 Portfolio's ability to remain focused	Clarify & examine if portfolio focus on critical needs	Fully focused	Adequately focused	Needs improvement	20%	
1.3 Identification of emerging issues	Identify important new issues consistent with the portfolio mission	Contemporary & emerging issues identified	Missing some emerging issues	Needs coverage of important issues	20%	
1.4 Integration of agency programs for portfolio	Demonstrate functional integration	REE fully integrated	Partially integrated	Insufficiently integrated	10%	
1.5 Multi-disciplinary balance	Demonstrate disciplinary and scientific balance...	Extensive balance among relevant disciplines	Partial balance	Little balance	10%	

Comparison of Panel Portfolio Scores to Self-scores

Portfolio		Self	Panel
1.1	Markets/Trade	72	75
1.2	International Dev.	72	69
1.4	Farm Structure/Management	70	73
1.3	Food & Non Food	72	80
1.5.A	Plant Production	85	81
1.5.B	Animal Production	79	81
3.1	Food Safety	80	83
3.2.A	Animal Protection	92	95
3.2.B	Plant Protection	79	80
5.1	Forestry	67	77
5.2	Natural Resources	82	81

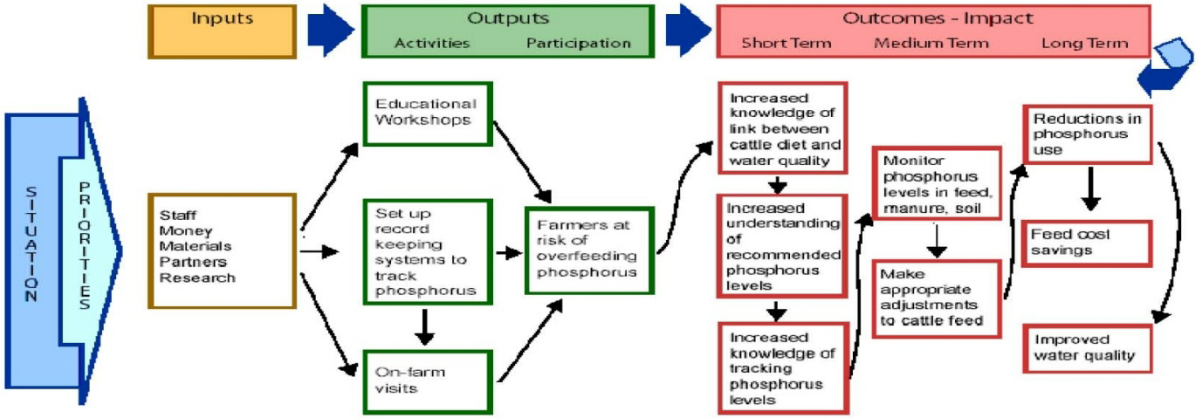
Types of evaluation questions as they fit into the logic model





UW Extension

Water Quality Program: Logic model, evaluation questions, indicators



Evaluation Questions: What do you want to know?					
Were the inputs sufficient, timely? Did they meet the program goals? Were they sufficient given the situation?	Did all activities occur as intended? Quality of intervention: appropriate content; usable record keeping system; well planned visits?	Did the targeted farmers participate? Who did not? What were their reactions? Who else was reached?	Did knowledge increase? Did understanding of P levels increase? What else happened?	Are farmers monitoring P levels? Are they adjusting cattle feed? Anything else?	Is there a reduction in P use? How much $ saved? Other benefits? Negative consequences?

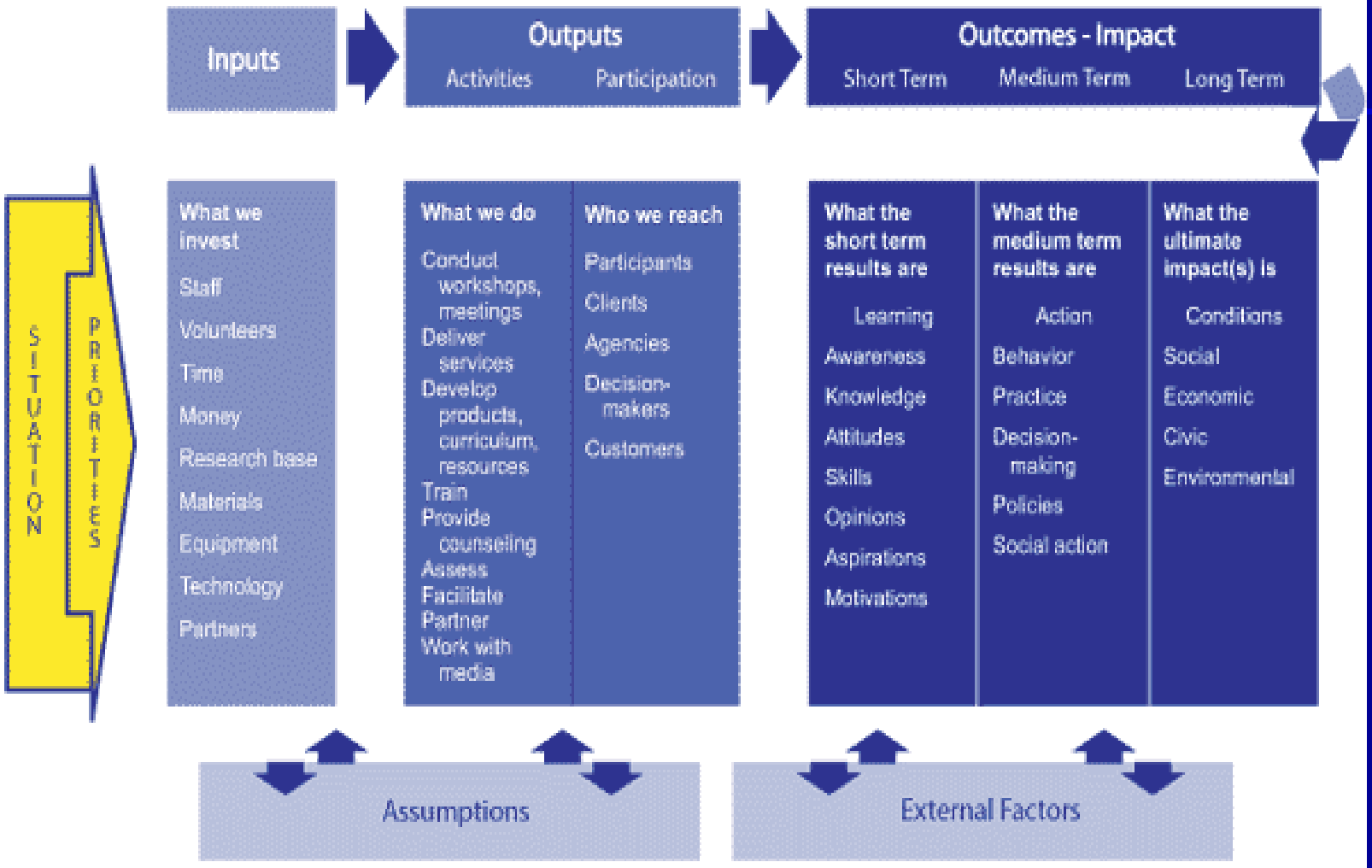
Indicators: How will you know it?					
# staff; $ invested; delivery timetable	# workshops, data systems, on-farm visits. Farmer self-reports of quality	Actual vs. desired attendance. #, % attended per session.	#, % with increased knowledge of …. Additional outcomes: +, -.	#, % monitoring P levels; making adjustments to cattle feed Additional outcomes: +, -.	#, % reducing P use; level of reduction. # Dollars saved/farmer. Additional outcomes: +, -.

Taylor-Powell, Ellen. University of WI-Extension, October 2002

What uses does the Logic Model serve?

- Planning tool
- Communication tool
- Implementation tool
- Evaluation design, data identification and selection tool

Logic Model



Source: University of Wisconsin Extension

Overall Portfolio 1.3 Logic Model: Food and Non-Food Products Development

Situation

New products, new uses, and value added processes must have consumer acceptance to create effective demand.

Bio-based technologies promise opportunities for energy, industrial, pharmacological, and other non-food markets for U.S. producers.

Inputs

$$$

Land grant

Private industries

CSREES

Outputs

Activities

>Develop bacteria for ethanol production
>Develop materials for erosion control

>Develop new cooking methods

>Understand factors that promote lipid oxidation

>Develop non-chemical methods to disinfest fruit and food

>Develop biodegradable containers

Participants

Change in knowledge
Attitude and behavior

>Developed organisms with ability to metabolize Cellulose
>Better understanding of flow of heat transfer
>Elimination of harmful chemicals
>New knowledge of on-farm grease production
>Caster oil acrylated (CAM)-based latex paint developed

Knowledge & Technology Transfer

Outcomes

Short-term

Control measures incorporated into production processes

Latex paint produced and used

Soy-based grease and oil sold

Intermediate

Biobased opportunities realized

Long-term

Reduction on Oil imports

Pollution Prevention

Energy Efficiency

Increased economic opportunities for rural producers

External factors – Variable funding, scientific advancements; changing priorities; producers' and consumers' attitudes; natural disasters; economic conditions; coordination and cooperation with other government entities; public policy

Source: CSREES Planning & Accountability 2004 Portfolio Review Expert Panel (PREP) Package

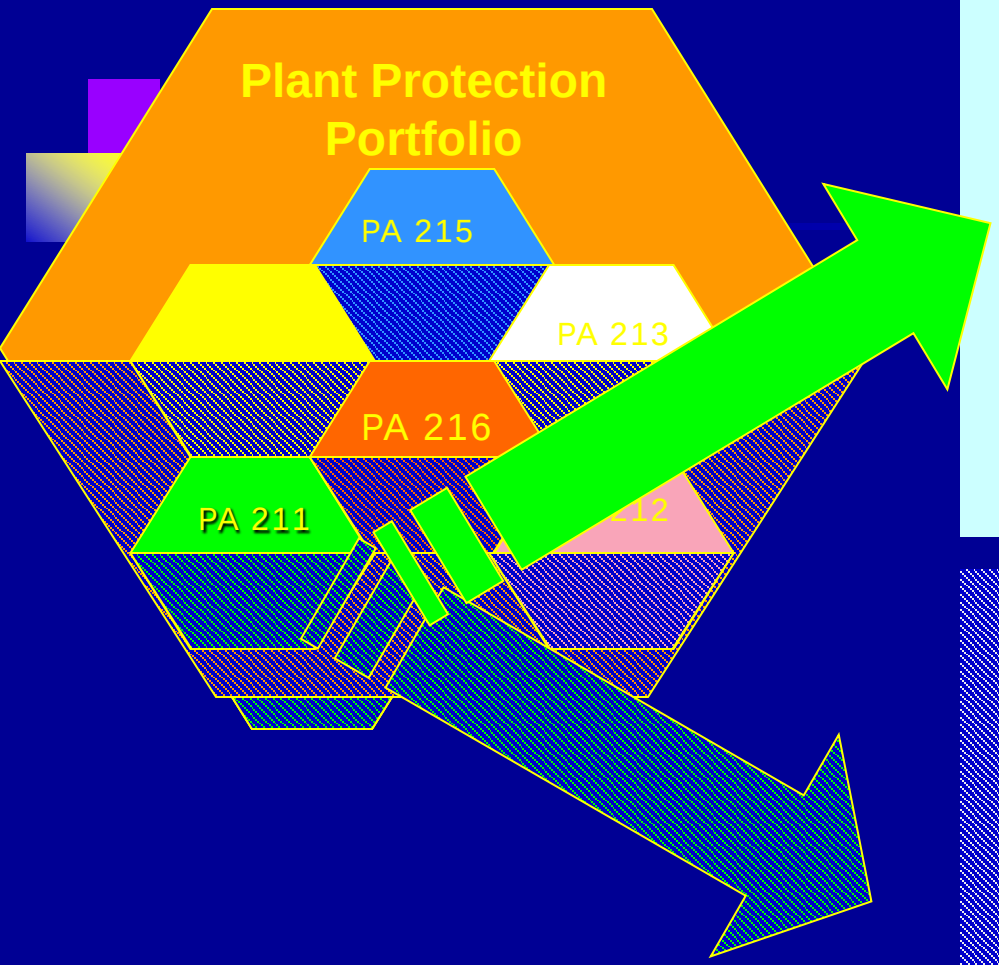
Evaluation Data Matrix

Goal & Objective	Evaluation Question (Hypothesis)	Data Needed	Source of Data	Data Collection Approaches	Research Design/ Methods	Analysis Plans	Expected Results	Audience	Products	Dissemination Plan
Goal 1										
Objective 1										
Objective 2										
Goal 2										
Objective 1										
Objective 2										
Goal 3										
Objective 1										

Use of Honeycomb Graphics

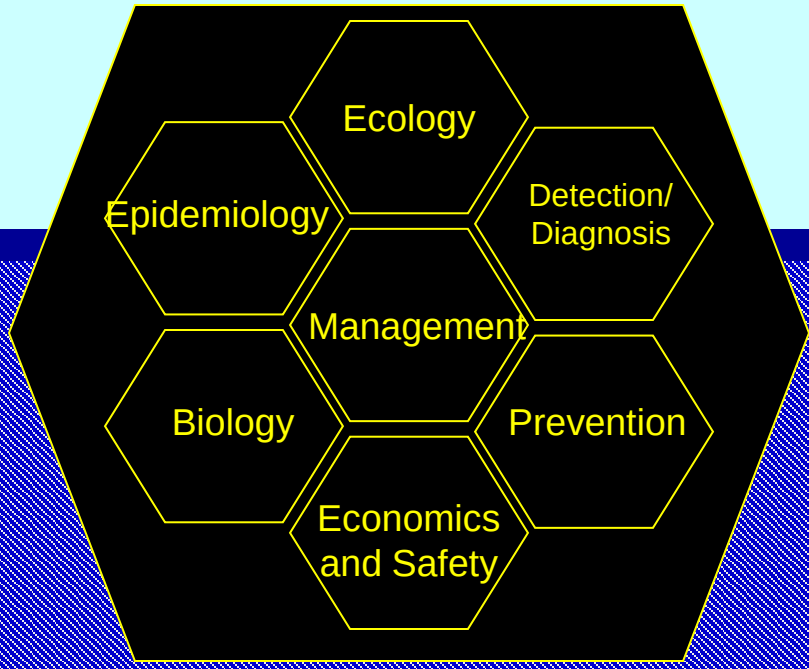
- Key players; roles and coordination
- Address questions of overlap and duplication across agencies/depts.
- Show topic area (Portfolio and PAs) in context of world, U.S. partnersips, federal entities, USDA, and within CSREES

Accomplishments



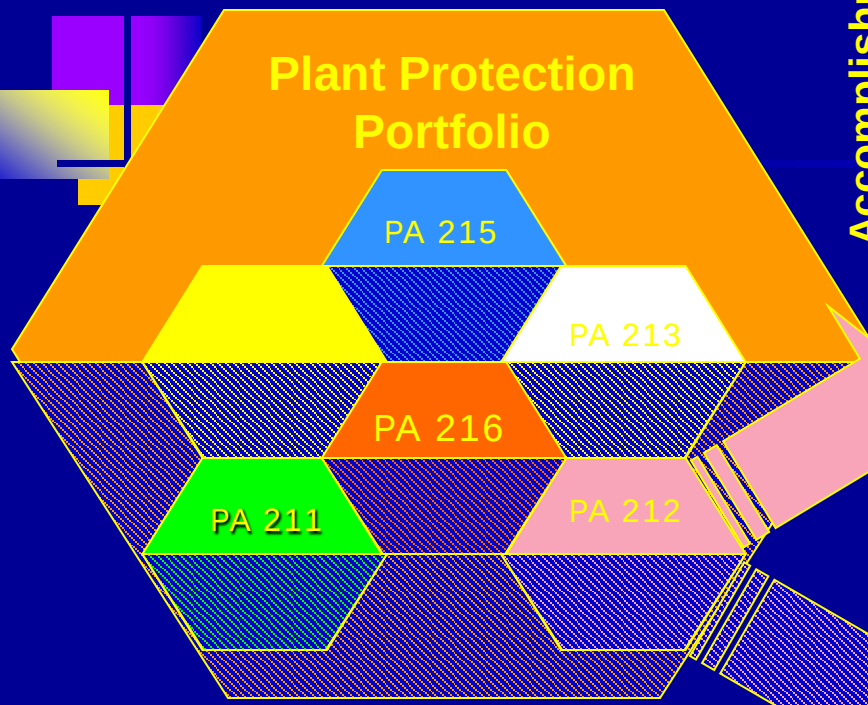
PA 211 Insects, Mites and Other Arthropods Affecting Plants

Areas of Science:



Needs

Based on work by Thomas Kessler



PA 212 Pathogens and Nematodes Affecting Plants

Accomplishments

Prevention
- Disease free seed and stock for some diseases
- Breeding resistant plants
- Novel types of resistance genes
- Marker assisted selection

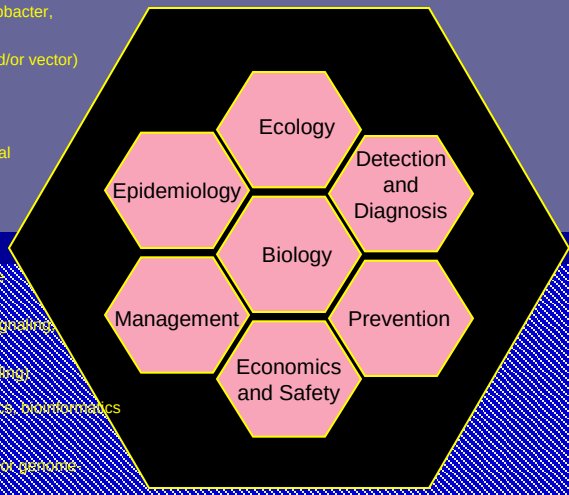
Biology and Ecology
- Ability to identify some unculturable organisms
- Characterizing take-all suppressive soils
- Ecology of vectors
- Genomic sequencing
- Molecular communication between plants and microbes
- Programmed cell death

Detection & Diagnosis
- Pathogen's genetic fingerprint used for rapid diagnosis
- Pathogenicity sequences identified
- Digital diagnosis / NPDN
- Seed propagation certification programs
- Quarantine programs
- Traditional detection methods

Epidemiology
- Understanding dynamics of spread
- Understanding mechanisms of spread
- Forecasting of disease based on knowledge of environmental parameters

Management
- Biological control –e.g., A. radiobacter, Trichoderma, nematodes
- Chemical control (pathogen and/or vector)
- Cultural practices, IPM

Economic Sustainability and Safety
- Disease loss estimates
- Trade embargoes – international and interstate
- Safer pesticides, reduced use through IPM



Needs

Prevention
- Isolate resistance genes, create resistance genes
- Interfere with mechanisms of signaling, pathogen's virulence systems
- Durable resistance (understanding)

Biology and Ecology
- Functional genomics, proteomics, bioinformatics
- Non-host resistance
- Publicly accessible databases for genome-enabled biology

Detection & Diagnosis
- Ability to detect individuals within a microbial population
- Rapid / high-throughput methods of detection (user friendly/economical)
- Genomic reclassification of microbial taxonomy
- Culture collection and characterization, and specific DNA probes for identification
- Other pathogens genetic fingerprint for rapid diagnosis
- Other pathogenicity sequences

Epidemiology
- Influence of global change on pathogen spread and disease establishment
- Accurate determination of disease origin

Management
- BC agents – establishment, mechanisms, compatibility
- Alternatives to methyl bromide
- Post-harvest disease
- Chemical induction of resistance
- Chemical resistance management

Economic Sustainability and Safety
- Better understanding of impacts of diseases
- Development of sustainable production practices
- Development of trace-back

PART Strengths: Revitalization of Evaluation as Leadership Tool

- The PART and BPI have raised consciousness and focused attention on post-award management and use of evaluation results for planning

Summary

- Self-assessment report referenced throughout the deliberation process
- Inclusion of credible support data extremely important
- Use of Logic Models and Portfolio graphics provide clear and concise maps of work

Summary (cont.)

- Meaningful outcome indicators for OMB PART and BPI provided via scores from panel
- Panelists provided useful recommendations
- Managers have used PREP recommendations in planning, writing RFAs, budget, etc.

Summary (Cont.)

- PREP process provided panelists with new insights in planning and accountability to spread around U.S.
- PREP improved panelists' understanding and willingness to integrate their university/organization activities into the overall federal goals identified

Logic model benefits

- 1. Improves management
  - Requires that everyone articulate and agree on achievable outcomes
  - Helps provide roadmap for implementation
  - Allows everyone to recognize specific data needed for performance assessment and proof of accomplishments

Logic model benefits (cont.)

- 2. Facilitates evaluation
  - Facilitates the creation of evaluation designs
  - Facilitates the identification and selection of appropriate data elements
  - Facilitates appropriate data collection
  - Helps in the provision of measurable impacts

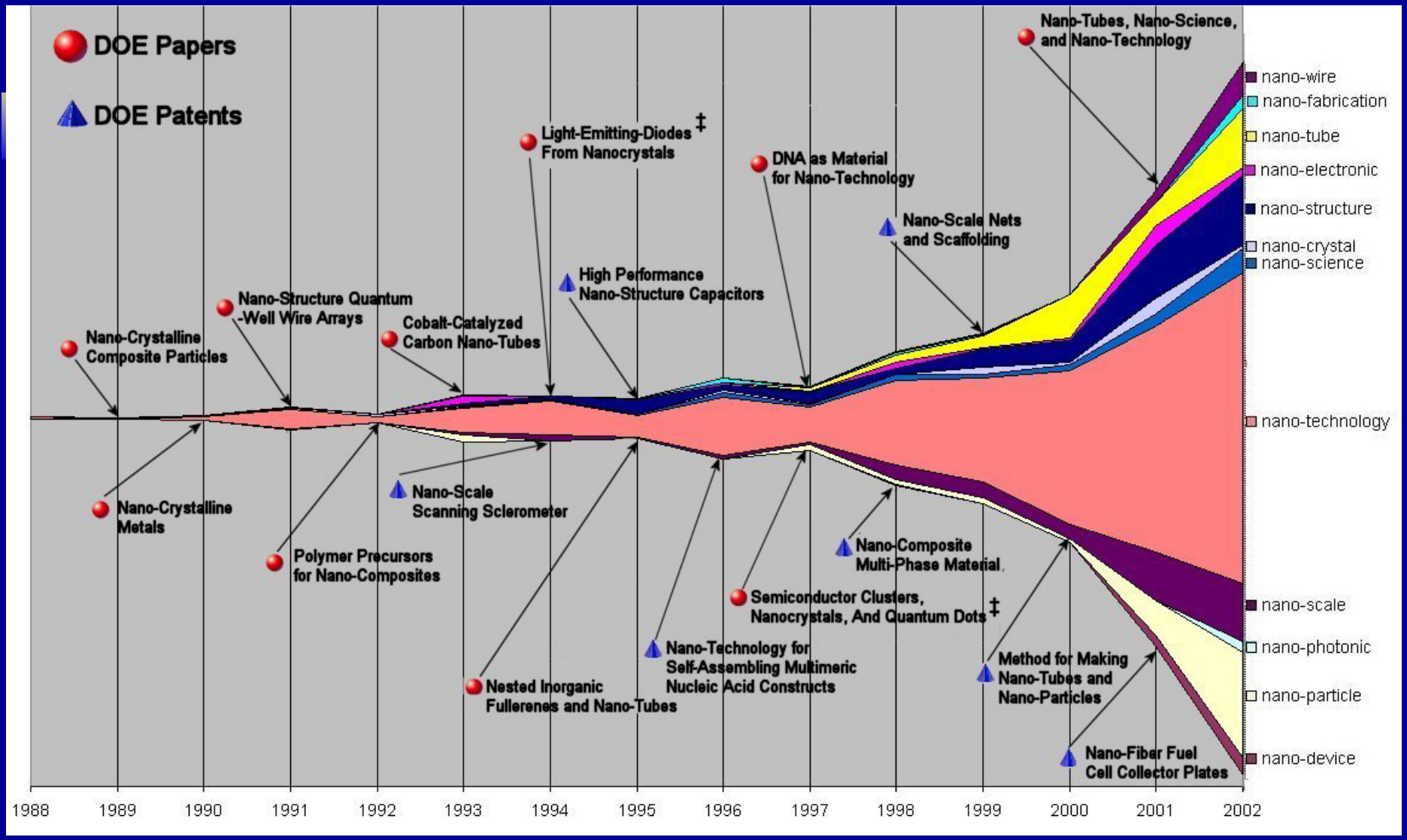
Logic model benefits (cont.)

- 3. Facilitates accountability reporting and funding decisions
  - Establishes links between problems areas and strategic plan
  - Extremely useful in justifying additional funds
  - Takes fuzziness out of the program
  - Helps in demonstrating attributional links in a chain of activities

Sources of Indicators

- Network analysis
- Patent analysis
- Citation analysis

Emergence of the Term "Nano" in the Open Literature*
Showing Representative DOE Papers and Patents



*Terms with at least 10 occurrences in at least one year. Width of color band indicates relative number of occurrences
‡ Papers identified by the Institute for Scientific Information as among the Top 25 Highly Cited Papers in Nanotechnology.

SC Patent Analysis Tool - Data

Abstracts and background data from 12,869 patents originating from work sponsored by DOE

4,390 SC Patents

Abstracts and background data from 50,263 patents that cite DOE patents as prior art representing 82,737 citations

27,699 citations of SC patents

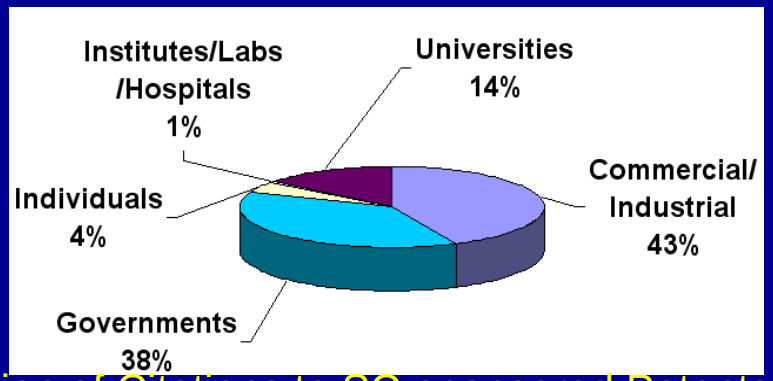
1,231 Distinct organizations have attributed one or more of their patents to work sponsored by DOE

453 organizations attribute to SC

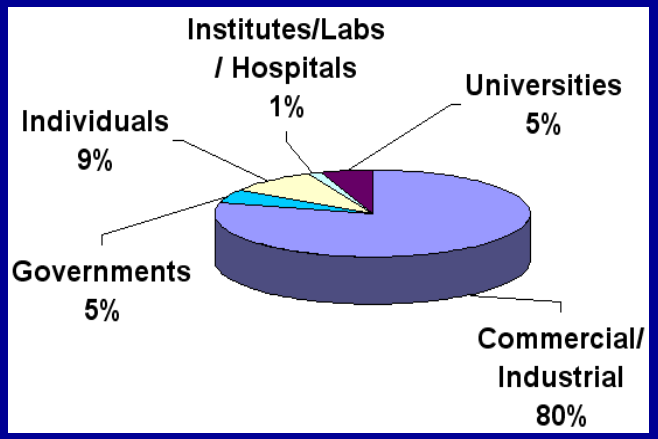
13,345 Distinct organizations have cited one or more of DOE patents as prior art.

4,172 organizations have cited SC

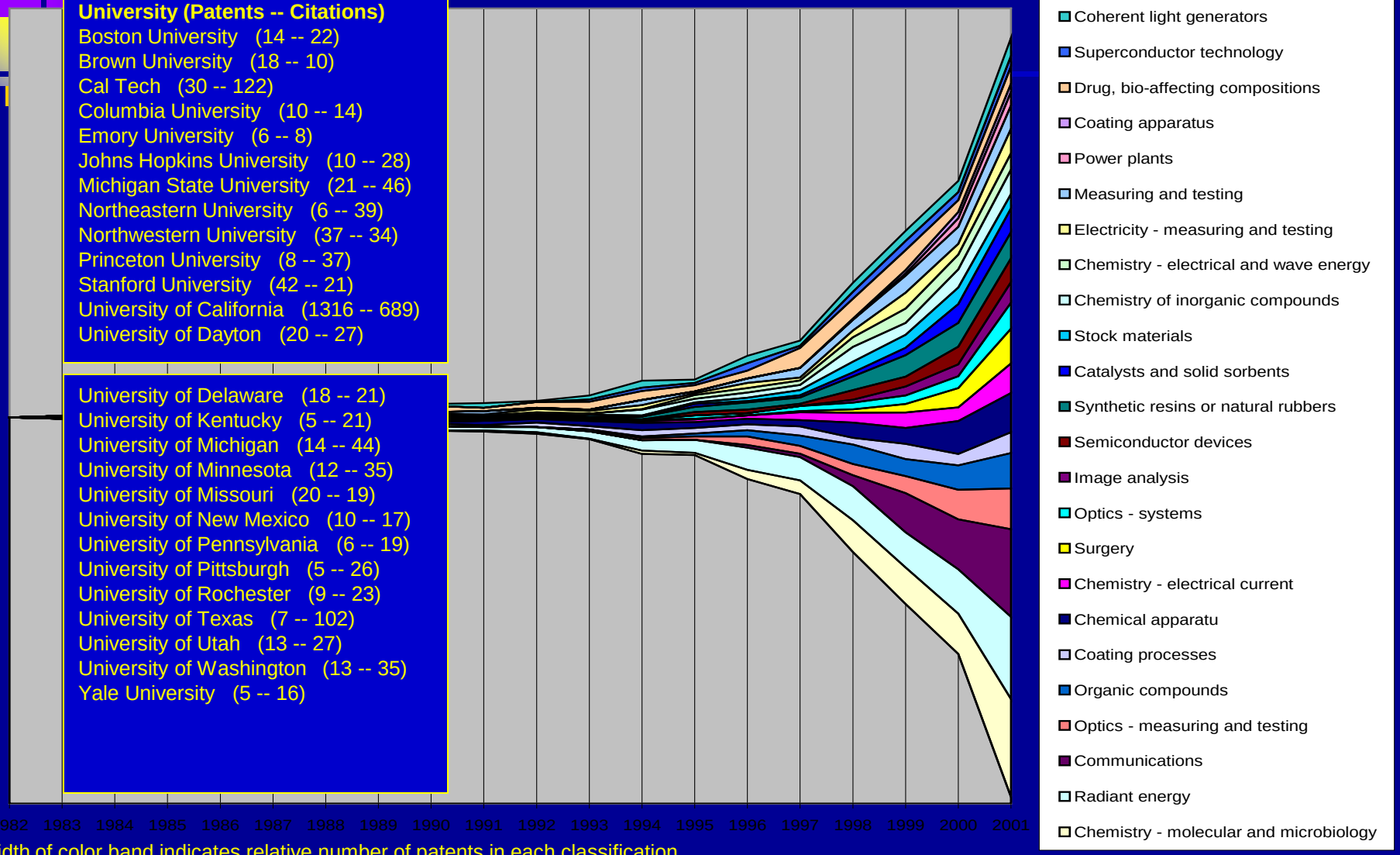
Distribution of SC-sponsored Patents



Distribution of Citations to SC-sponsored Patents



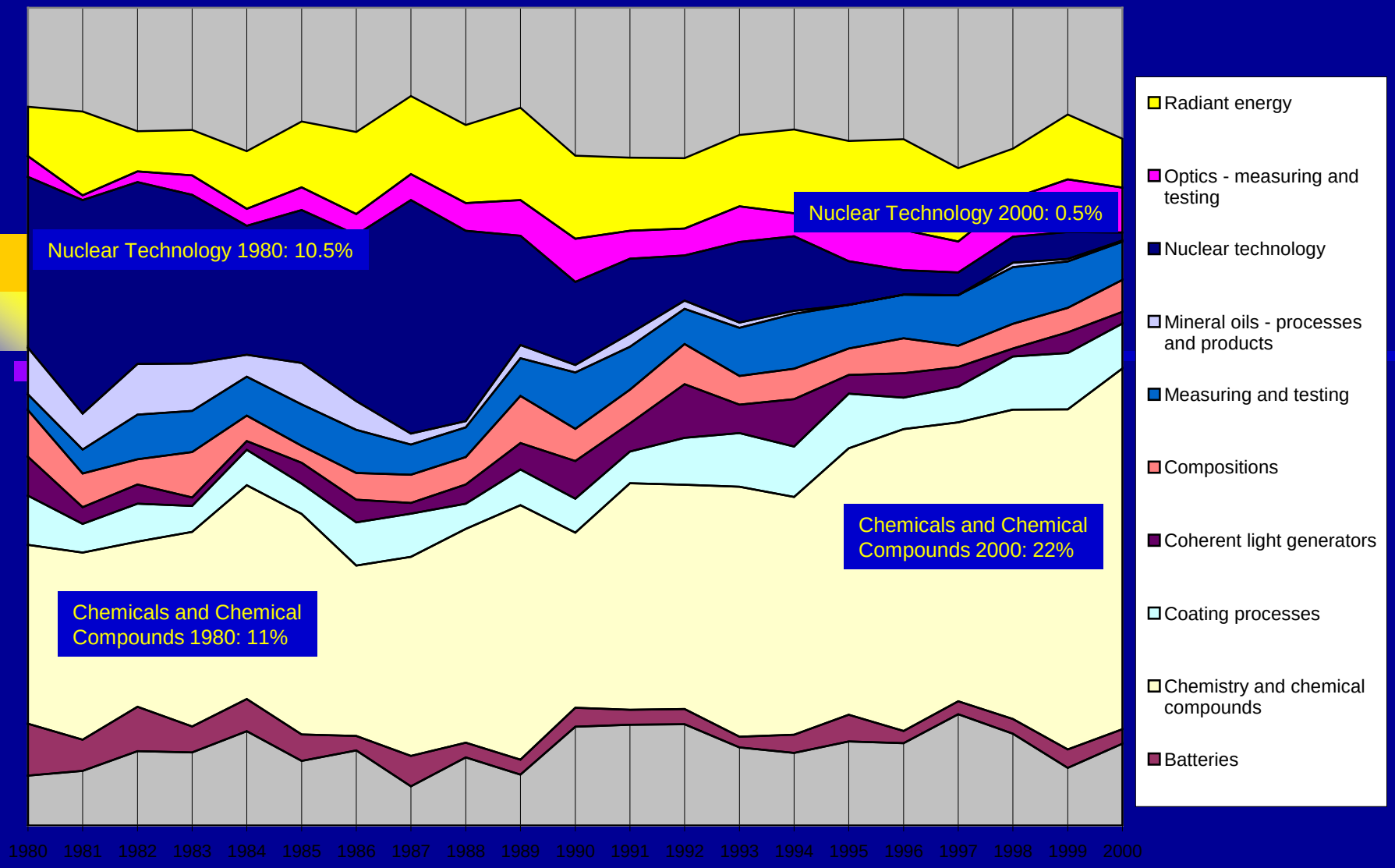
DOE Support at Leading US Research Universities Has Produced Patents and Citations in a Wide Range of Areas*



*Width of color band indicates relative number of patents in each classification.

Evolution of the DOE Patent Portfolio 1980-2000*

Selected DOE Patent Classifications as Percent of Total DOE Patents



*Width of color band indicates relative number of patents in each classification

The Network of Basic Science

Principle Investigators:

Susan A. Mohrman

Jay R. Galbraith

Peter Monge

University of Southern California

Study funded by
Office of Science, Department of Energy
and
Sandia National Laboratories

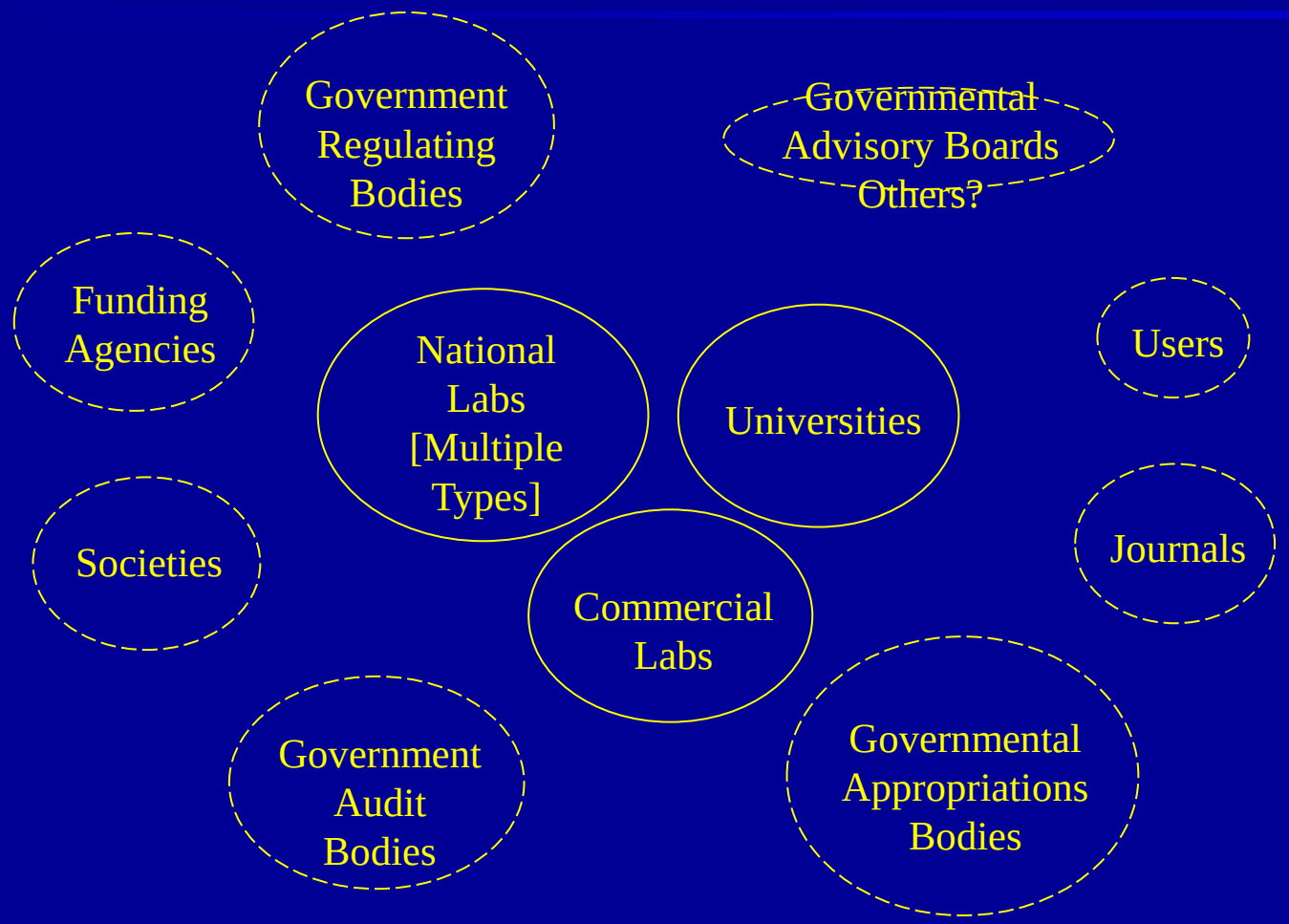
Partial Theoretical Framework Assumptions

- Organization important, although “invisible”
  - Modern Science – requires scale, level of technology & information processing transcending organizations
  - Management of Science – skills required to manage multidisciplinary & large scale science run counter to traditional human capital strategies
- Modern science is extraordinarily nimble
  - Agility – freedom to explore & move out of confines of specific disciplines & stated problems is key
  - Coordination – around problems, not institutional objectives
  - Self-organizing – teams of researchers do not form around one institutional or organizational setting
- Possible to distinguish between knowledge flows of different scientific disciplines <u>and to assign value to those different flows.</u>

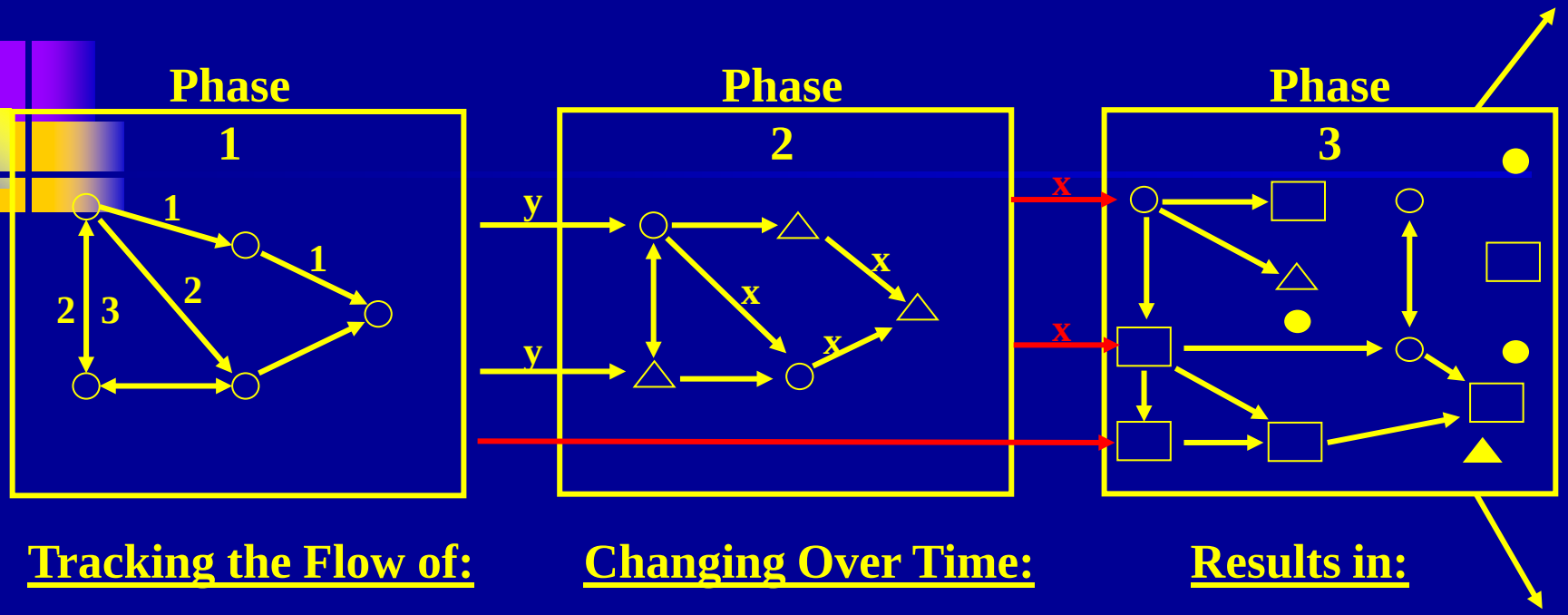
Interesting Networking Questions

- Does knowledge multiply within “ideas market place?”
- Can we identify ways to facilitate flow (leverage) of “value” through the network?
- Do organizations help or hinder this knowledge flow & formation of networks?
- Is it possible to quantify the “flow of knowledge?”
- Who are important players & why do researchers cluster around them?

Network Elements (Organizational)



Tracking Linkages Through Time



Tracking the Flow of:

People

Funding

Discipline

Projects

Application

Changing Over Time:

Linkages Grow

Networks Expand

Disciplines Evolve

Knowledge Grows

Results in:

New Networks

New Ideas

New Products

New Disciplines

Some Initial Conclusions from Science Network Analyses

- Networks of science self-organizing & very fluid.
- Money important, but not how imagined:
  - Multiple funding is sign of “Alpha-PI”
  - Sustained funding most important
- Organizations facilitate network formation, but mostly just get in the way.
- Possible to assign value to flow of knowledge.

Portfolio Evaluation, or…

How do you make choices

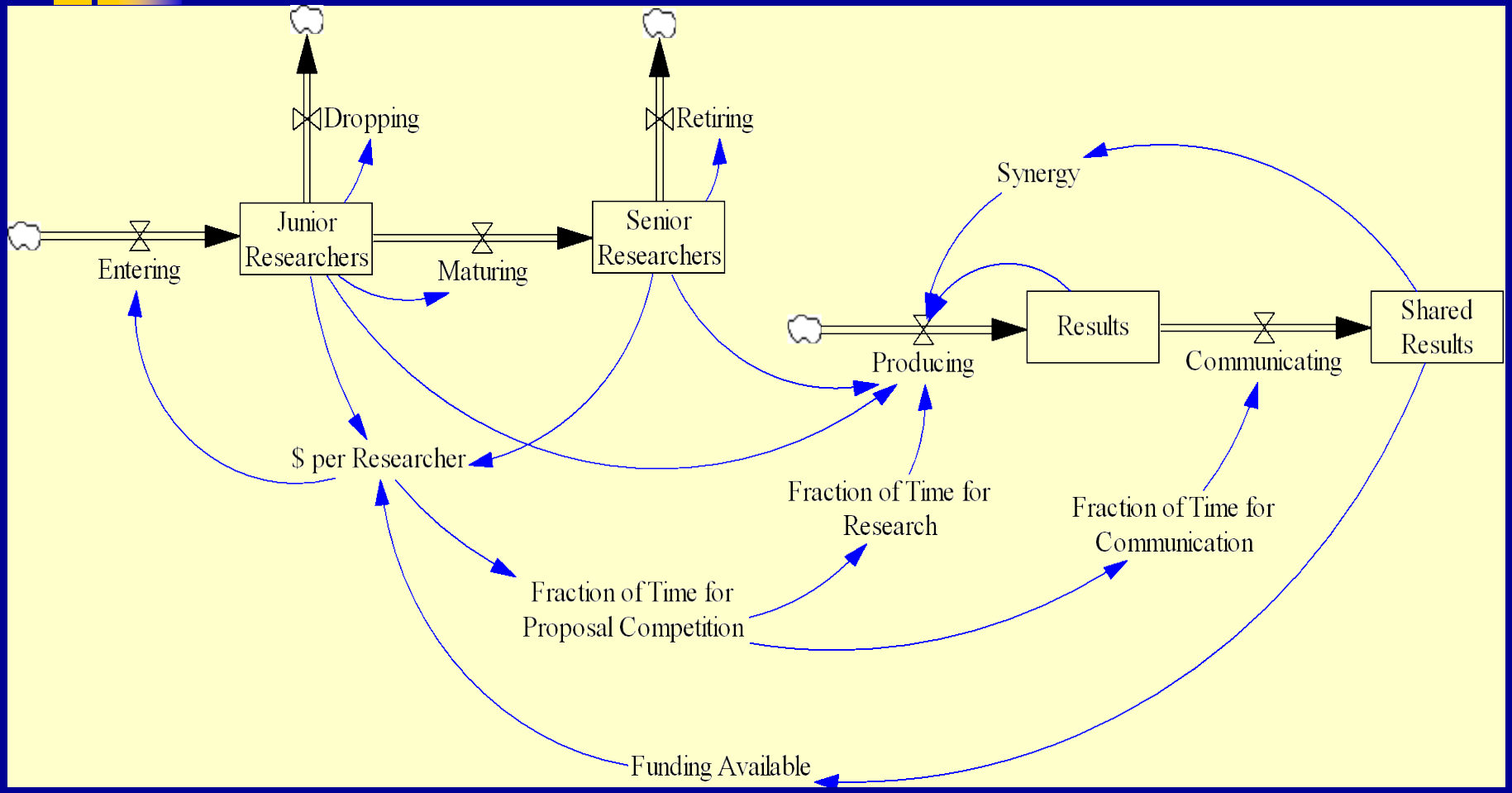
Between:

- *NSF & SC*
- *Physics & biology, or*
- *U.S. & EU?*

Systems Dynamics

Systems Dynamics developed 50 years ago by MIT -- enables organization to make predictive judgments about effects of their management decisions.

- Data underpins all models.
- Algorithms tested in many industrial/ public settings.
- A working SC systems dynamics model is under development.


Dropping
Retiring
Synergy
Junior Researchers
Senior Researchers
Entering
Maturing
Results
Shared Results
Producing
Communicating
$ per Researcher
Fraction of Time for Research
Fraction of Time for Communication
Fraction of Time for Proposal Competition
Funding Available

Adoption of Network Analysis?

- CSREES assessing new evaluation methodologies to improve post-grant R&D program management.
- Exploring additional approaches with Dr. Caroline Wagner, George Washington University (also work by dr. Nicholas Vonortas)

Why use Network Analysis?

- Knowledge is Networked
- Researchers self-organize
- Trends in R&D make monitoring more difficult
  - As collaborative research proliferates, so does complexity of relationships.
- → Conduct & performance of collaborative programs can be more fully understood by examining the network of relationships in which they exist.

Functionally speaking, individuals and institutions use networks to:

- Collect and disseminate knowledge
  - Tackle tasks too large for one entity
  - Share risks in concept development as well as in application and final product development

Knowledge is Networked, therefore:

- Innovation requires combining scientific, design, engineering and operational knowledge from different sources
- Individual or organization rarely has all knowledge needed for the whole process of innovation
- Types of skills/ knowledge of research activity are unknown at start
- Most efficient way to create knowledge is to enable researchers to identify needed work, find each other, link up, & share resources
- Knowledge-creating process facilitated by understanding how networking happens

Researchers self-organize through formal & informal channels/ interactions

- Network development:
  - U.S. ground-up
  - Europe top-down

Strengths of Self-Organizing Knowledge Systems

- Agents join networks to share resources
- Respond to incentives in system
  - Opportunities, equipment, funding, social goods
- Adapt to their “landscape”
  - Local, regional, global
- By definition, organization is optimal
  - Shape & structure of the network reflects dynamics
- Robust, resilient, flexible
- Systems/networks assumed to be efficient

Slippery, Transparent, Dynamic Networks:

- cannot be controlled or managed
  - only *influenced*
- cannot be seen or monitored
  - Indicators of activity can be used to reveal structure and activity
- are not flat -- they have structure
  - Structure influences who is in & who is excluded
- pose challenges to policymakers who seek to encourage innovation
  - Recent network studies can provide insights

What can Network Analysis do?

- Intuitively account for complex formal & informal relationships
- Very effective in providing process indicators:
  - Use input & output indicators, with occasional innovation data
  - Analysis offers view into “black box”
  - Big picture emerges

Networks features:

- Networks captured graphically with links & nodes
- While links in an analysis usually remain the same, the nodes can differ:
  - Research entities, Firms, Govt. Labs, Universities, or RJVs are used for a more macro level analysis
  - Co-authorships, informal relationships, or keywords are used for a more micro level analysis

Indicators of Activity Can Reveal Network Structure

People	→	**Co-authors; Project participants**
Places	→	**Institutions; Country names; Region names**
Dynamics	→	**Cross-sectoral links; Core-periphery links**
Knowledge	→	**Citations; Patents; Journals; Words**

Capturing the innovation process…

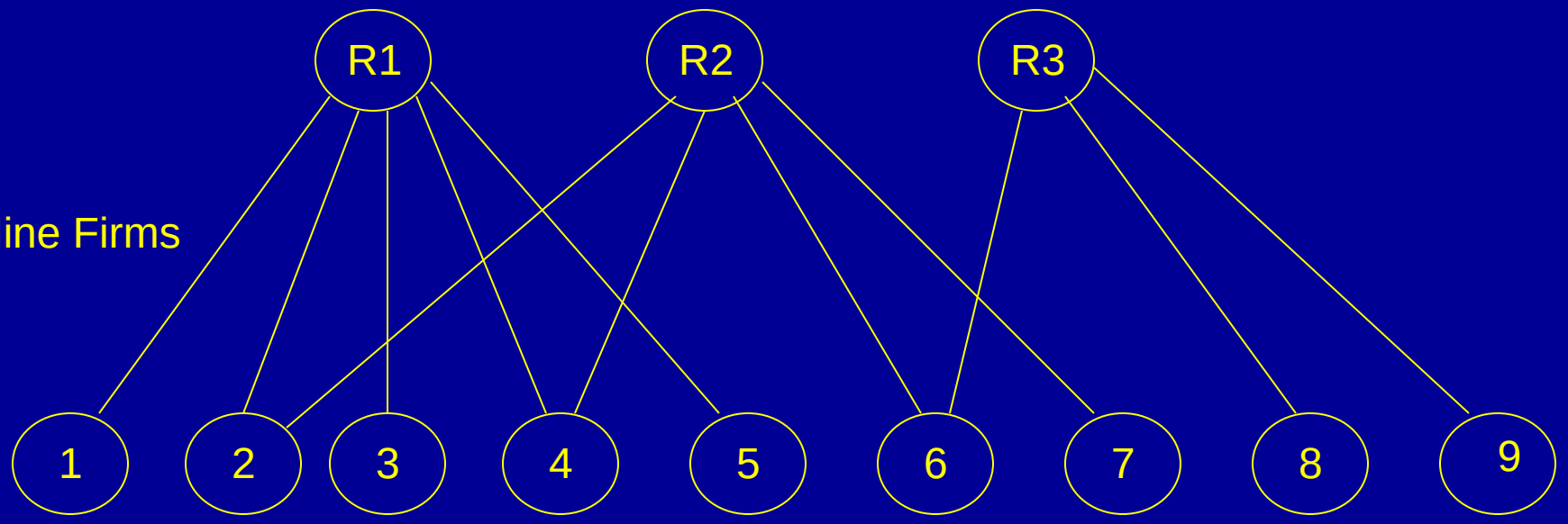
- Traces of communications/ connections between entities give both snapshot & evolutionary insight into relationships

Constructing a Network

Converting a Research Partnership Network to a Standardized Network

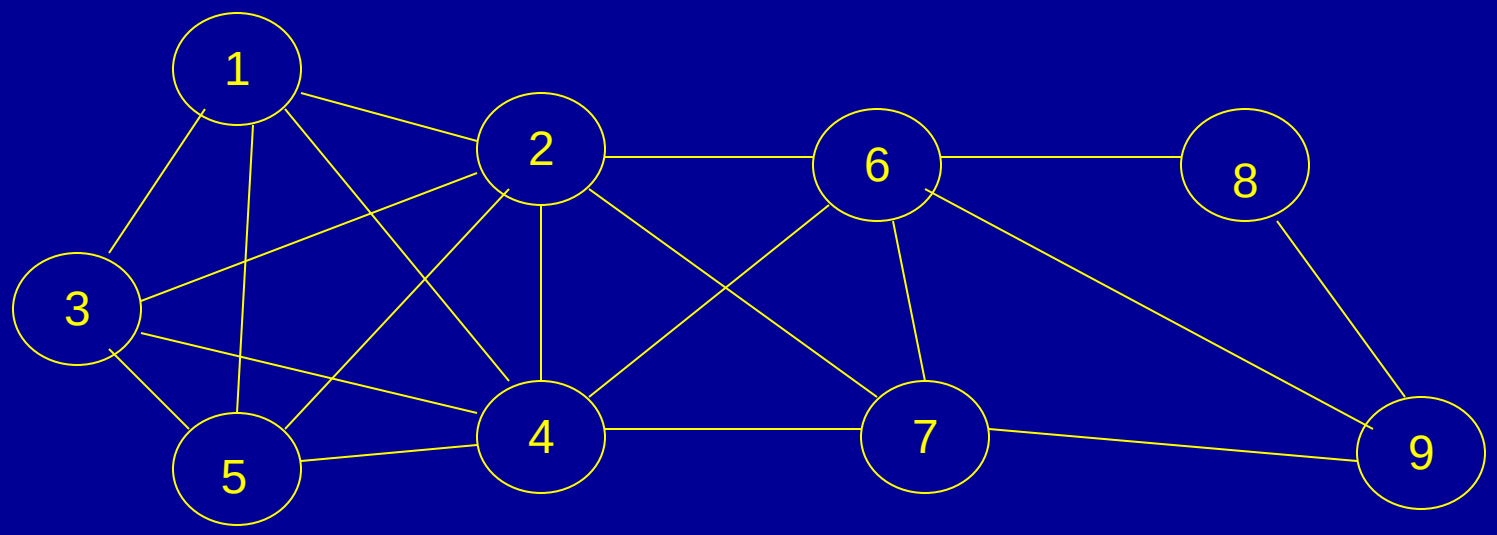
Three Research Partnerships

Nine Firms



From Dr. Nicholas Vonortas' 2005 International R&D Evaluation Symposium

Constructing a Network



From Dr. Nicholas Vonortas' 2005 International R&D Evaluation Symposium

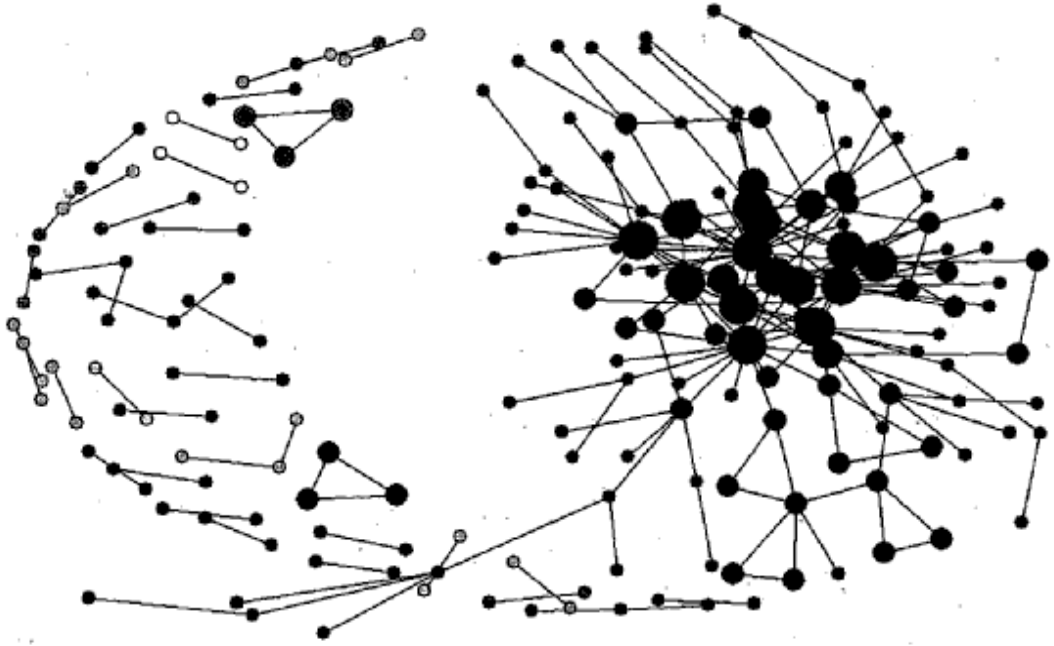
Applying this procedure to larger networks and examining them at two points in time, we see revealed:

Innovation vs. Diffusion Networks

Network Indicators

Visualization of 91-95 (U.S.) Inter-firm Network

(There are 4 levels of k-cores in this network)

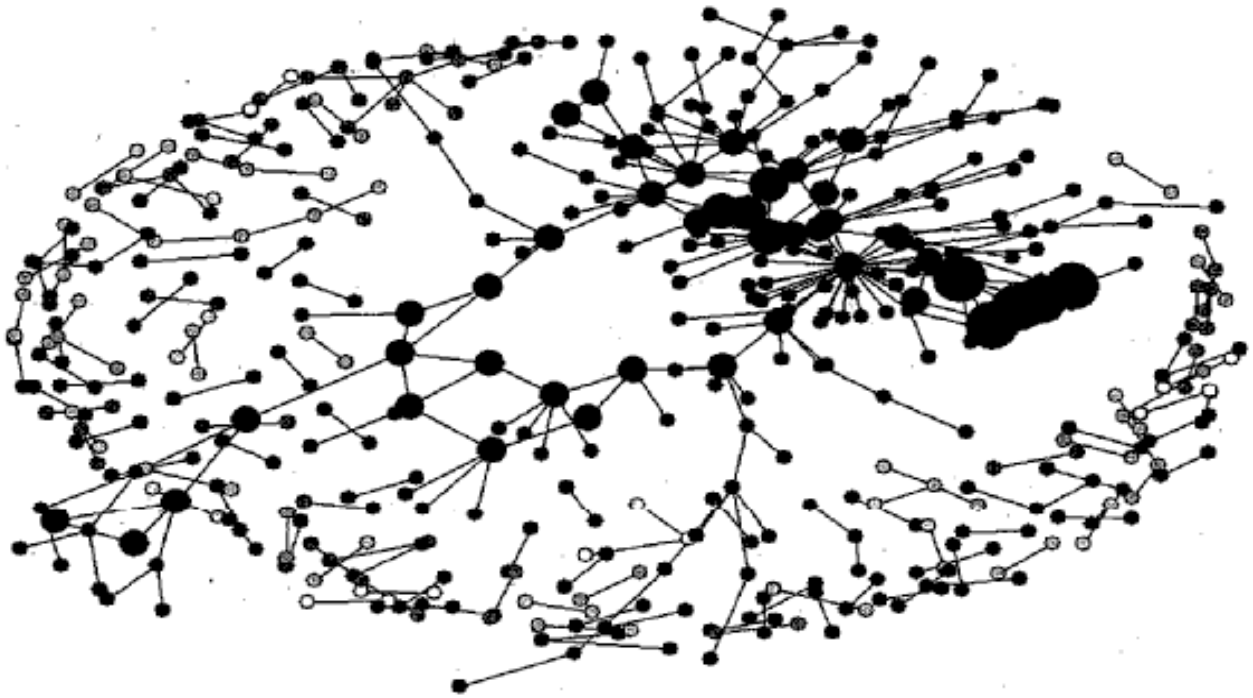


From Dr. Nicholas Vonortas' Presentation of Innovation Networks at the International R&D Evaluation Symposium – Tokyo Japan 2005

Network Indicators

Visualization of 96-00 (U.S.) Inter-firm Network

(There are 4 levels of k-cores in this network)



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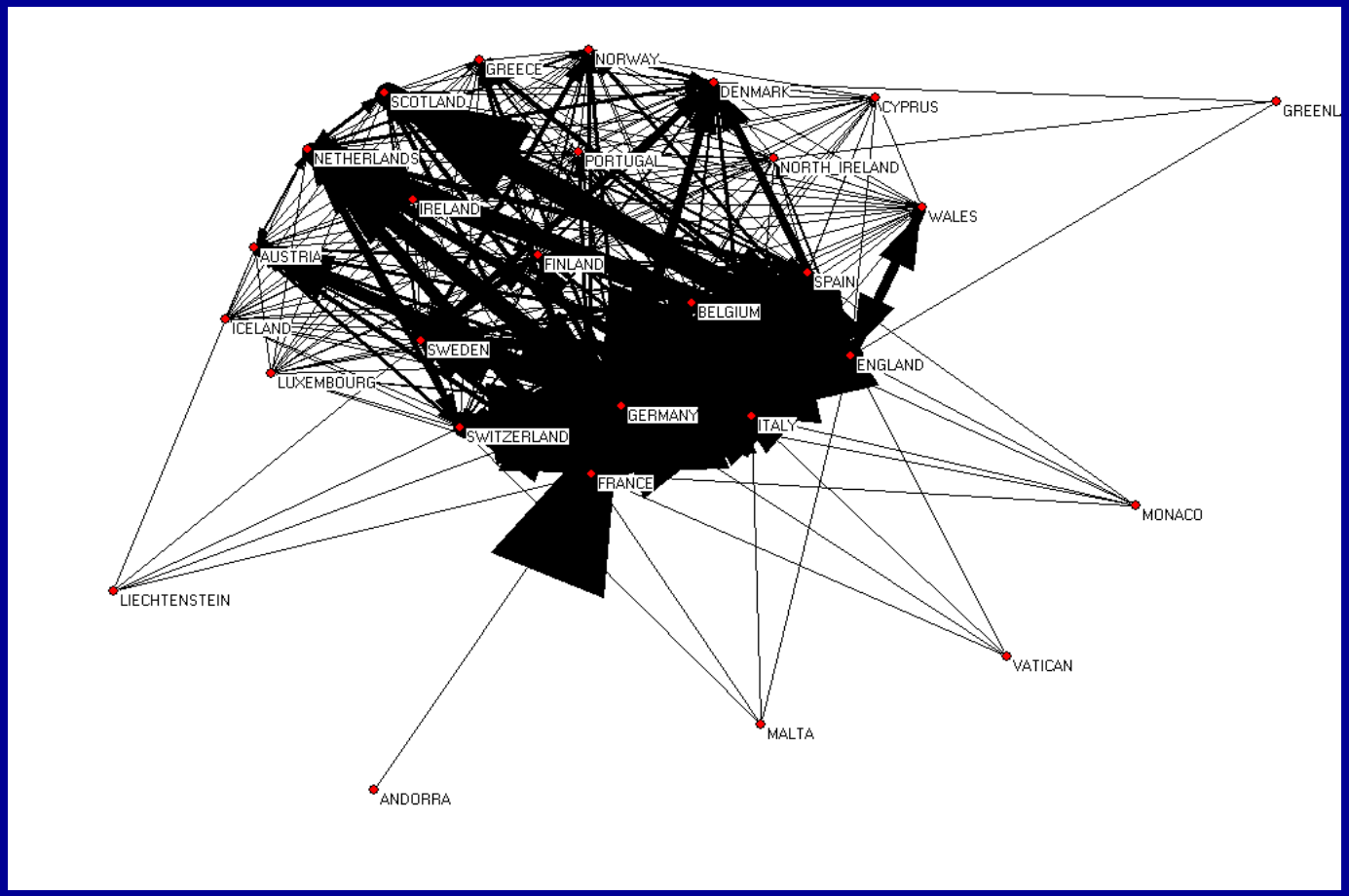
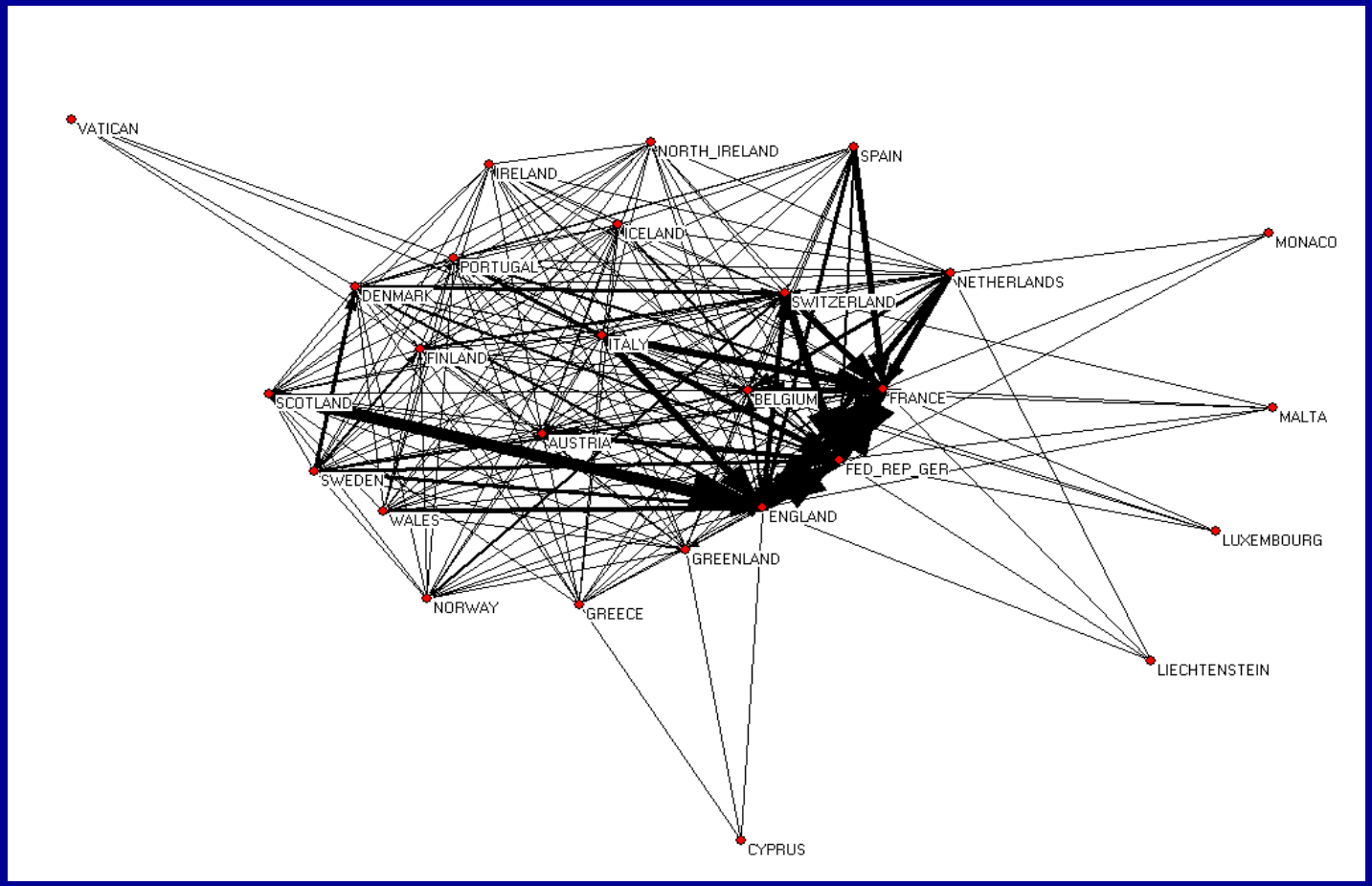
Collaboration in Europe - 2000



Collaboration in Europe - 1990