Evaluation Tools
for Public R&D Investments

ARS Workshop: Assessing the Benefits of ARS R&D within an Economic Framework

Washington, DC
March 10, 2008

Rosalie T. Ruegg
Managing Director, TIA Consulting, Inc
ruegg@ec.rr.com

TIA Consulting, Inc.

An Overview of the Directory of Methods

- Why evaluate?

- Why multiple methods?

- Determining specific evaluation needs & developing an evaluation strategy

- Methods overview

- Questions/discussion

TIA Consulting, Inc.

Why Evaluate?

- ## To guide program management & strategy
  - how is the program performing?
  - are there performance problems?
  - are there problems with operational efficiency?
  - are adjustments needed?

- ## For accountability
  - is the program doing what it was intended to do?
  - is it worth continued support?
  - at the same level; at a reduced level?
  - are fundamental design changes needed?

TIA Consulting, Inc.

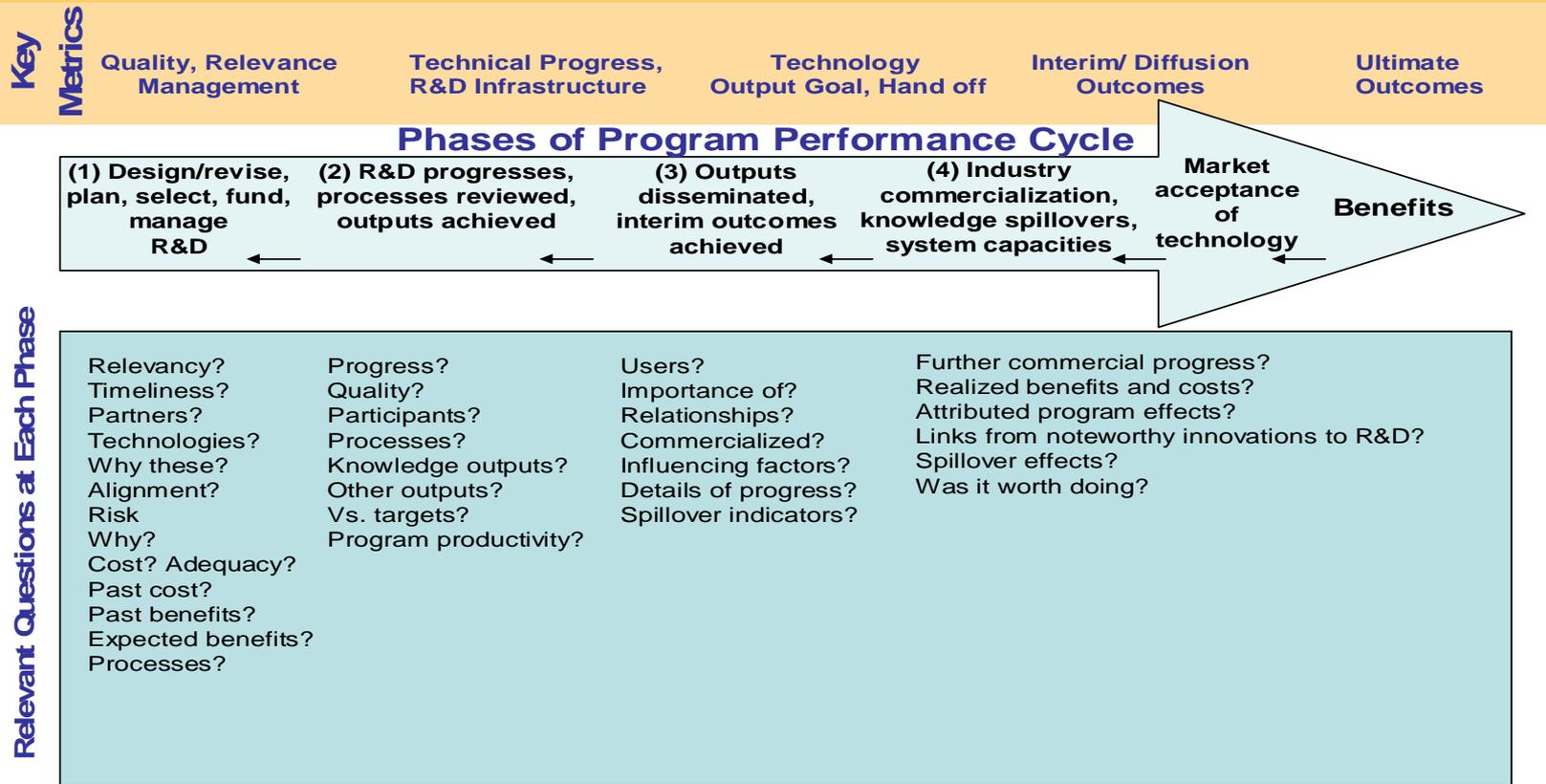# Why Multiple Evaluation Methods?

- to answer different stakeholders questions

- to provide alternative perspectives

- to provide multiple lines of evidence

- to meet both program management & accountability requirements

TIA Consulting, Inc.

Developing an Evaluation Strategy

Determining WHO needs to know WHAT and WHEN

- WHO: e.g., senior managers, program staff, OMB, Congress, other stakeholders

- WHAT: e.g., about inputs, outputs, outcomes, impacts

- WHEN: e.g., in advance, short-term, intermediate term, long term

TIA Consulting, Inc.

Helps to Start with Program Logic Model

Key Metrics				
Quality, Relevance Management	**Technical Progress, R&D Infrastructure**	**Technology Output Goal, Hand off**	**Interim/ Diffusion Outcomes**	**Ultimate Outcomes**

Phases of Program Performance Cycle

(1) Design/revise, plan, select, fund, manage R&D	(2) R&D progresses, processes reviewed, outputs achieved	(3) Outputs disseminated, interim outcomes achieved	(4) Industry commercialization, knowledge spillovers, system capacities	Market acceptance of technology	**Benefits**

Relevant Questions at Each Phase

Relevancy?	Progress?	Users?	Further commercial progress?
Timeliness?	Quality?	Importance of?	Realized benefits and costs?
Partners?	Participants?	Relationships?	Attributed program effects?
Technologies?	Processes?	Commercialized?	Links from noteworthy innovations to R&D?
Why these?	Knowledge outputs?	Influencing factors?	Spillover effects?
Alignment?	Other outputs?	Details of progress?	Was it worth doing?
Risk	Vs. targets?	Spillover indicators?	
Why?	Program productivity?		
Cost? Adequacy?			
Past cost?			
Past benefits?			
Expected benefits?			
Processes?			

[Source: Gretchen Jordan, SNL]   Revised 03/21/2006

TIA Consulting, Inc.

6

Common Types of Evaluation Questions

- **Descriptive questions:** what, who, how, how much, how many

- **Normative questions:** how do actual outcomes compare against a program standard or goal

- **Impact (cause-effect) questions:** what effects has the program caused –

  - causal relationship should make sense;
  - logical time order
  - elimination of rival explanations

TIA Consulting, Inc.

Selected Methods of Evaluation

- Peer review/expert judgment
- Monitoring, data compilation, use of indicators
- Bibliometrics
- Network analysis
- Historical tracing
- Case study method
- Survey method
- Benchmarking method
- Benefit-cost analysis
- Econometric methods

TIA Consulting, Inc.

Peer Review/Expert Judgment

- ## To assess qualitatively

  (often informed by quantitative evidence)

  ## such things as:

  - research quality

  - researcher productivity

  - feasibility of goals

  - program success

TIA Consulting, Inc.

Monitoring/Tracking Activities, Milestones & Outputs

To provide short-term performance answers:

- to indicate need for strategic corrections

- to meet accountability requirements

- to help build databases for quantitative evaluation of outcomes

TIA Consulting, Inc.

Monitoring/Tracking Activities, Milestones & Outputs – example of monitoring

TIA Consulting, Inc.
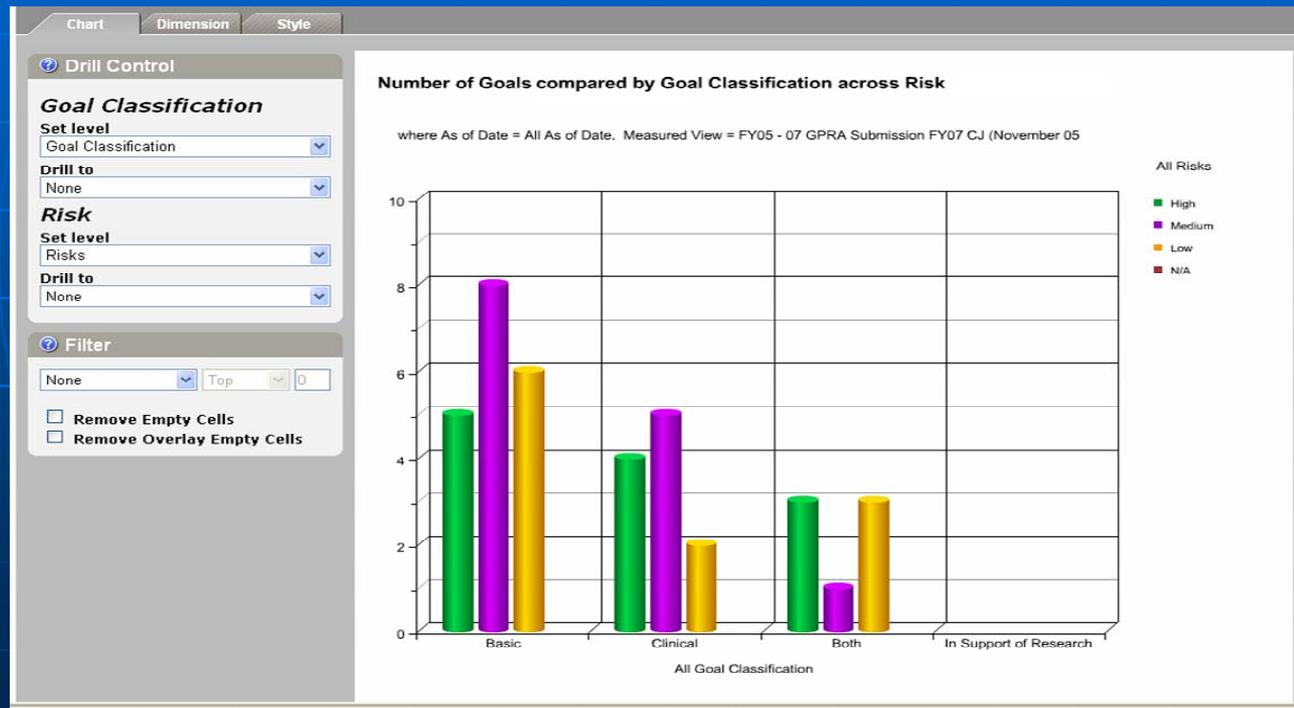
Methods for Demonstrating Knowledge Creation/Dissemination

- **Bibliometrics,** including 3 distinct methods
  - counts & citation analysis of publications & patents
  - "hot" patent analysis
  - text data mining

- **Network analysis**
  - diagramming connections (knowledge-flows) among people & organizations

- **Historical tracing**
  - documenting linkages between R&D and use in downstream innovations

TIA Consulting, Inc.

Bibliometrics, single patent citation example
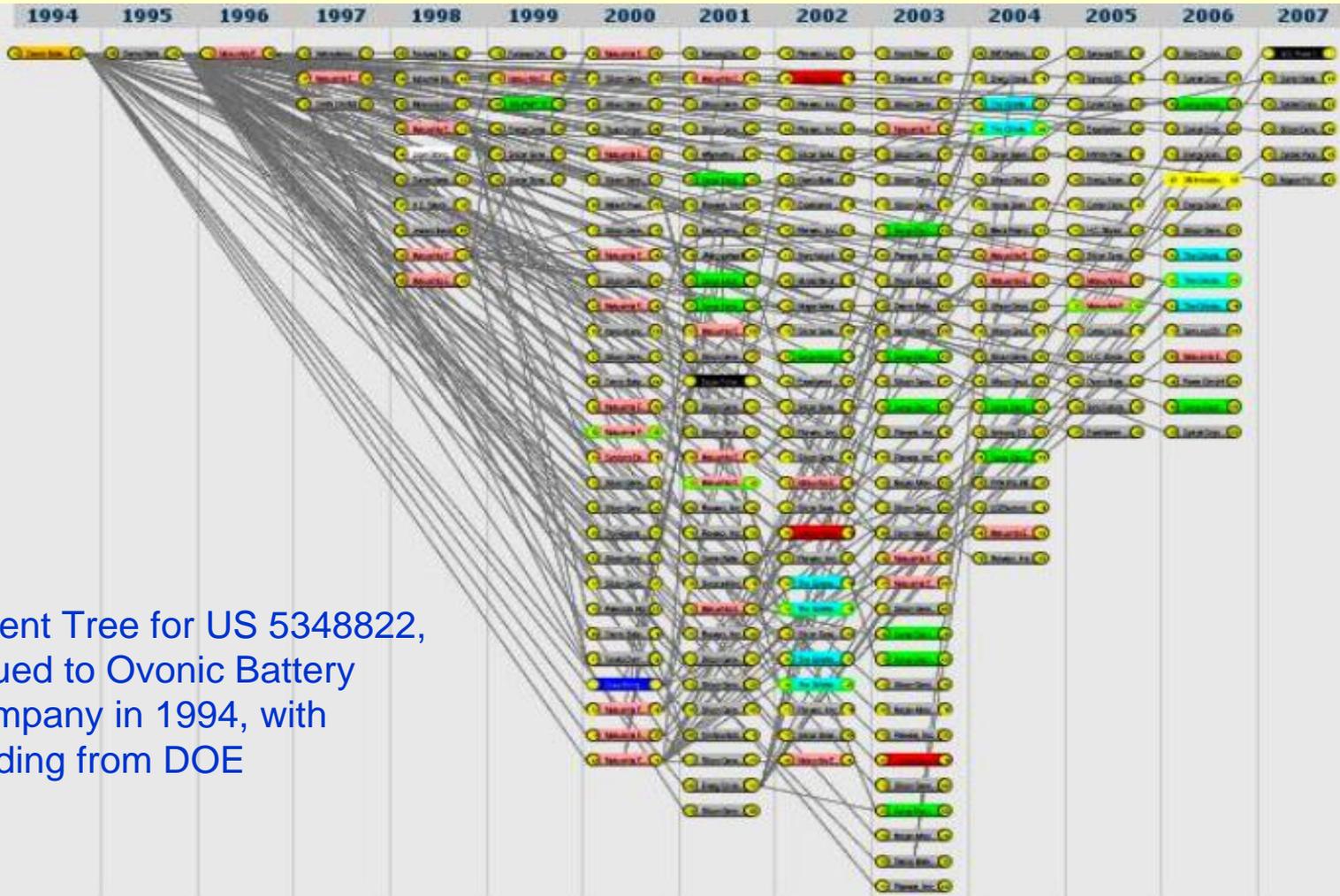
Patent Tree for US 5348822,
Issued to Ovonic Battery
Company in 1994, with
funding from DOE

TIA Consulting, Inc.

Bibliometrics, aggregate citation example

Figure 6-3. Organizations whose patents are cited most frequently by HEV Battery/Ultracapacitor Patents
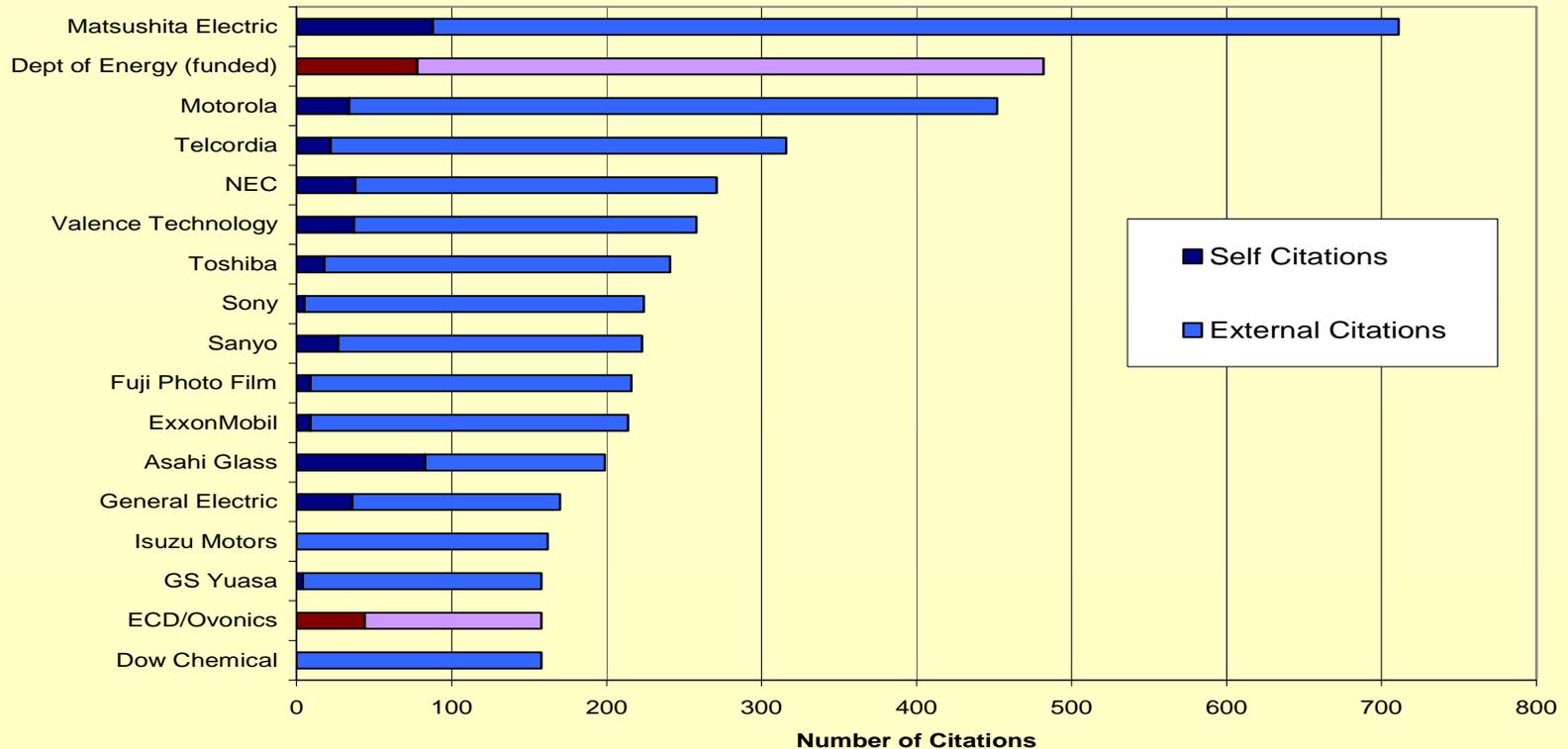
Source: Ruegg & Thomas, DOE's Energy Storage R&D for Vehicles and its Linkages to Batteries and Ultracapacitors for Hybrid and Electric Vehicles, 2008.

TIA Consulting, Inc.

Bibliometrics, "hotspot patent" example

Papers funded by different agencies have strong links to hotspot patents in different technologies

Patent Office Classifications (POC's) with the largest number of hotspot patents citing papers funded by different government agencies (excluding molecular biology)

POC – Description	POC – Description
DOE	**NSF**
438 – Semiconductors	424 – Drugs/Body Treating Compositions
204 – Electrical and Wave Energy	438 – Semiconductors
536 – Organic Compounds	707 – Databases
382 – Image Analysis	709 – Multi-Computer Coordination
NASA	**NIH**
382 – Image Analysis	424 – Drugs/Body Treating Compositions
118 – Coatings	600 – Surgery (diagnostics)
424 – Drugs/Body Treating Compositions	536 – Organic Compounds
370 – Multiplex Communications	606 – Surgery (instruments)

Office of Science

Office of Planning & Analysis   Evaluation   Research   Policy Development

TIA Consulting, Inc.

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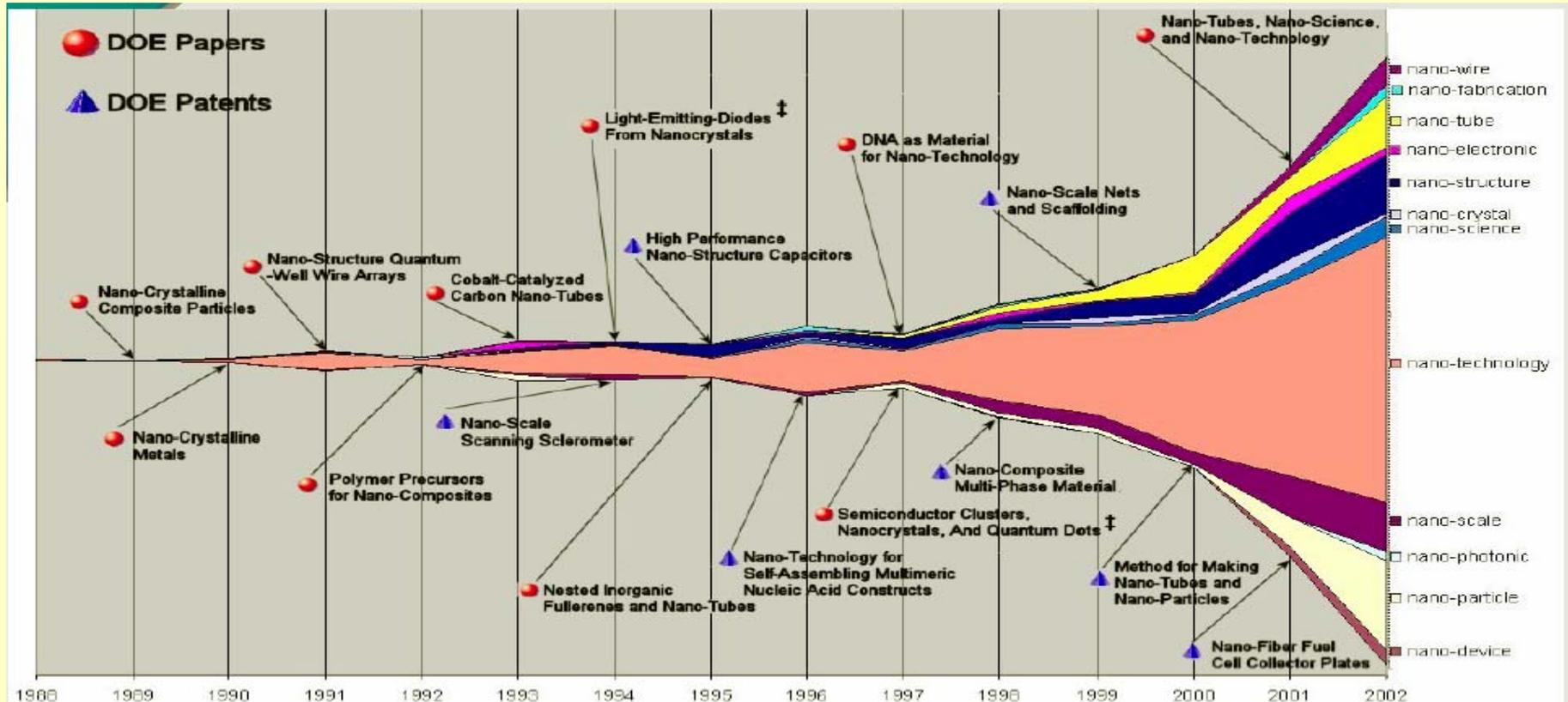
*Terms with at least 10 occurrences in at least one year. Width of color band indicates relative number of occurrences
‡ Papers identified by the Institute for Scientific Information as among the Top 25 Highly Cited Papers in Nanotechnology.

Battelle

Pacific Northwest National Laboratory
U.S. Department of Energy 21

TIA Consulting, Inc.

16

Network Analysis, Example of evolving modeling/simulation network at Sandia National Laboratories

TIA Consulting, Inc.

17
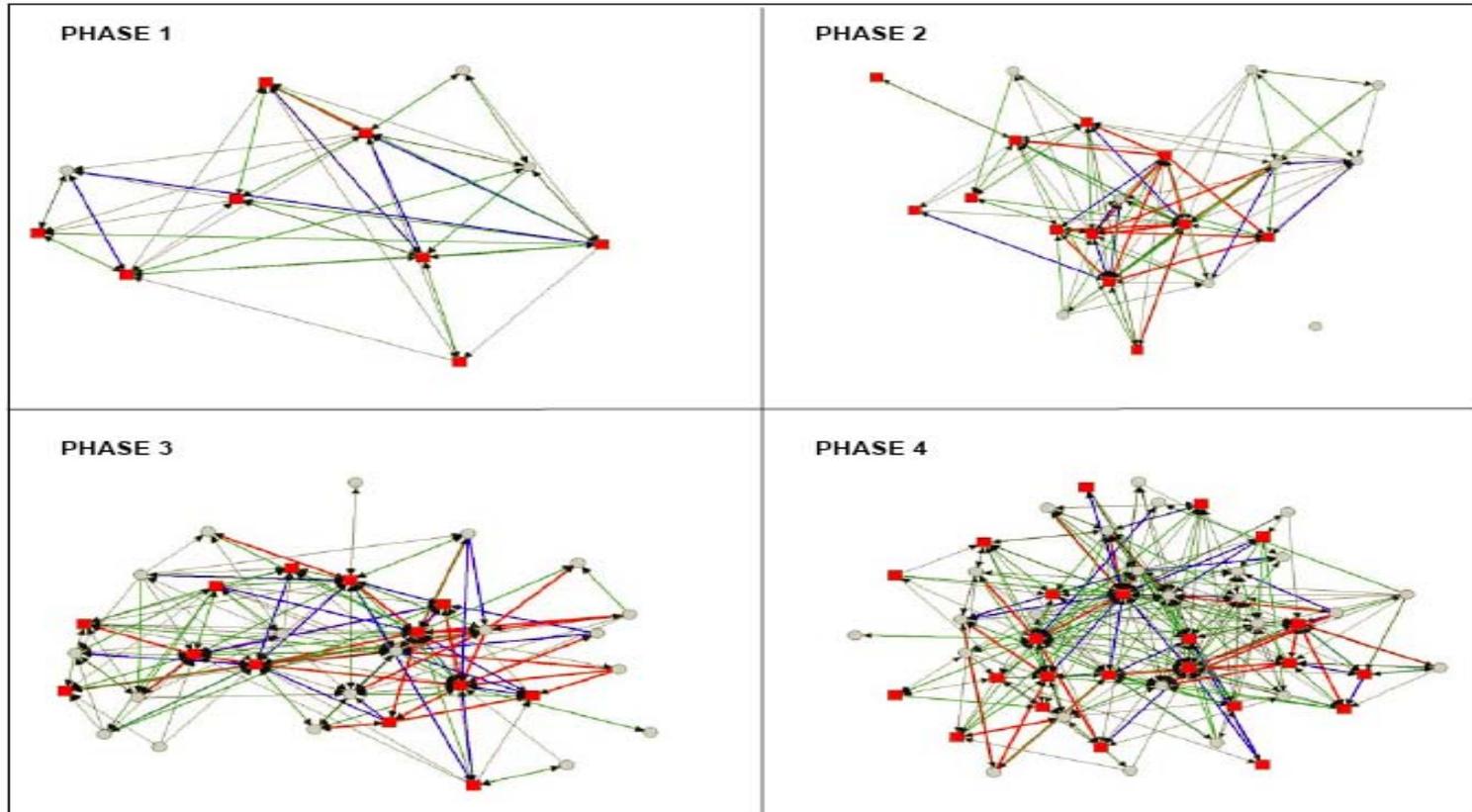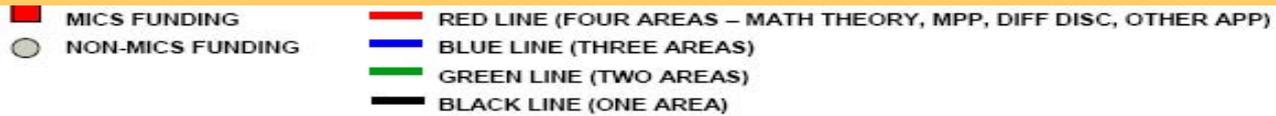
# Historical Tracing

Techniques:

- Interview
- Document review
- Analysis of institutional roles and relationships
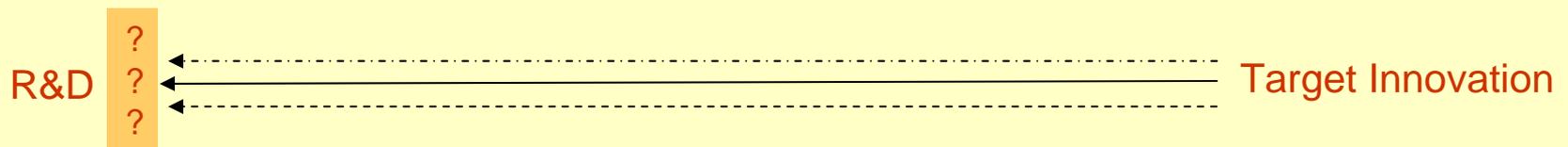- Citation analysis

Uses:

- to document paths linking R&D with downstream products and processes
- to show the evolutionary processes by which R&D leads to innovation
- to compare (qualitatively) a demonstrably valuable innovation against a research program shown to underpin the innovation

TIA Consulting, Inc.

Historical Tracing Method

- Forward tracing from R&D to downstream outcomes

R&D

Innovation 1

Innovation 2

Innovation 3

Innovation 4
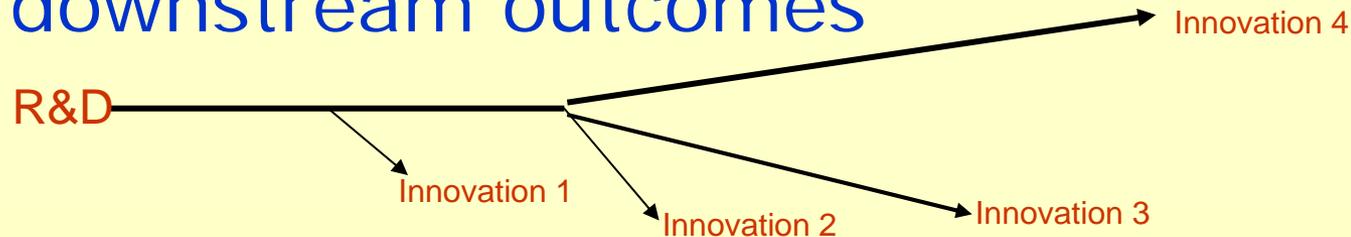
- Backward tracing from a selected outcome to upstream R&D

R&D

?
?
?

Target Innovation

TIA Consulting, Inc.

Methods for Describing, Understanding, Answering Questions, and Comparing

- ## Case study

  - telling the stories of research; explaining the what, why, and how of research; exploring hypotheses for further exploration

- ## Survey

  - asking people questions, coding responses, aggregating and analyzing data; using statistical, tabular, & graphical techniques to report results, show trends, rate customer satisfaction, generate performance measures, etc.

- ## Benchmarking

  - comparing aspects of programs, institutions, regions, countries, or other entities with selected performance measures

TIA Consulting, Inc.

Case Study -- example

ATP's collection of case studies on all completed projects

- avoids charges of "cherry picking"
- provides complete set of project data for analysis
- has enabled portfolio analysis

TIA Consulting, Inc.

Benefit-cost analysis

Relates positive effects to negative effects, expressed in monetary terms to provide measures of
- net benefits
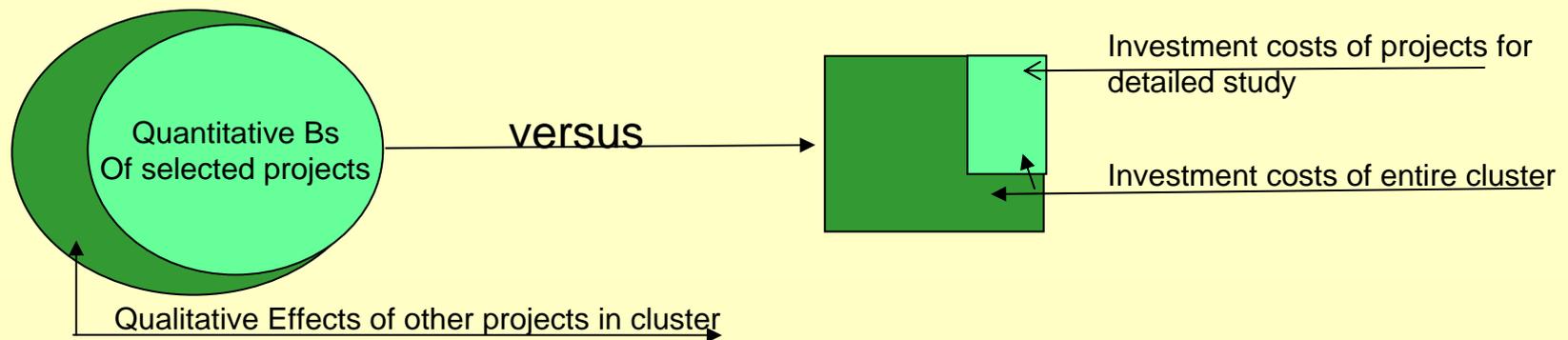- benefit-to-cost ratio
- rate of return on investment

For public programs, B-C analysis focuses on

- social returns (not just private returns)
- including measurable spillover effects
- taking into account public program additionality

TIA Consulting, Inc.

Benefit-Cost Studies, applications

- to a single **applied** research project
- to a cluster of related **applied** research projects
- to a program

Cluster Study: compares benefits of several selected projects in a cluster to the entire cluster costs

Quantitative Bs
Of selected projects

versus

Investment costs of projects for detailed study

Investment costs of entire cluster

Qualitative Effects of other projects in cluster

TIA Consulting, Inc.

Econometric methods

Encompasses multiple mathematical & statistical techniques used to capture relationships between R&D investment and changing economic, technological, and social phenomena

Examples of Uses:

- to measure the impact on firm productivity of participating in government-funded research using a production-function model

- to estimate market spillover benefits using a cost-function model

- to extract more info with greater rigor from survey results

TIA Consulting, Inc.

Questions/Comments/Discussions

TIA Consulting, Inc.