Lessons on Managing Research: From Years of Study of the Research Environment

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Outline

- Motivation, Overview of U.S Department of Energy (DOE) project
- Conceptual framework – Research Profiles
- Overview of research environment survey
- Lessons learned from survey and case studies
- Future research

Motivation for assessing research environment and management

- Desire to define strategies to improve research effectiveness
  - research environment is deteriorating
  - slim study to date of management of science
  - Organize thinking about differences in RTD (Research Technology & Development) organizations, and circumstances
  - Examine multiple levels and linkages (portfolio, projects)
- Respond to public demand for demonstrating accomplishments
  - Legislative and administrative requirements (GPRA, PART)
  - Need for a leading indicator

DOE project overview

- Research by Sandia labs in collaboration with Dr. Jerald Hage and the Center for Innovation, University of Maryland
- Sponsored by U. S. Department of Energy (DOE) Office of Basic Energy Sciences
- Concentration has been on
  - – Understanding and developing theory relating the research environment to broader management of RTD
  - – Tools to assess key factors in the research environment that foster excellence and impact in order to improve these.

Evolution of the project

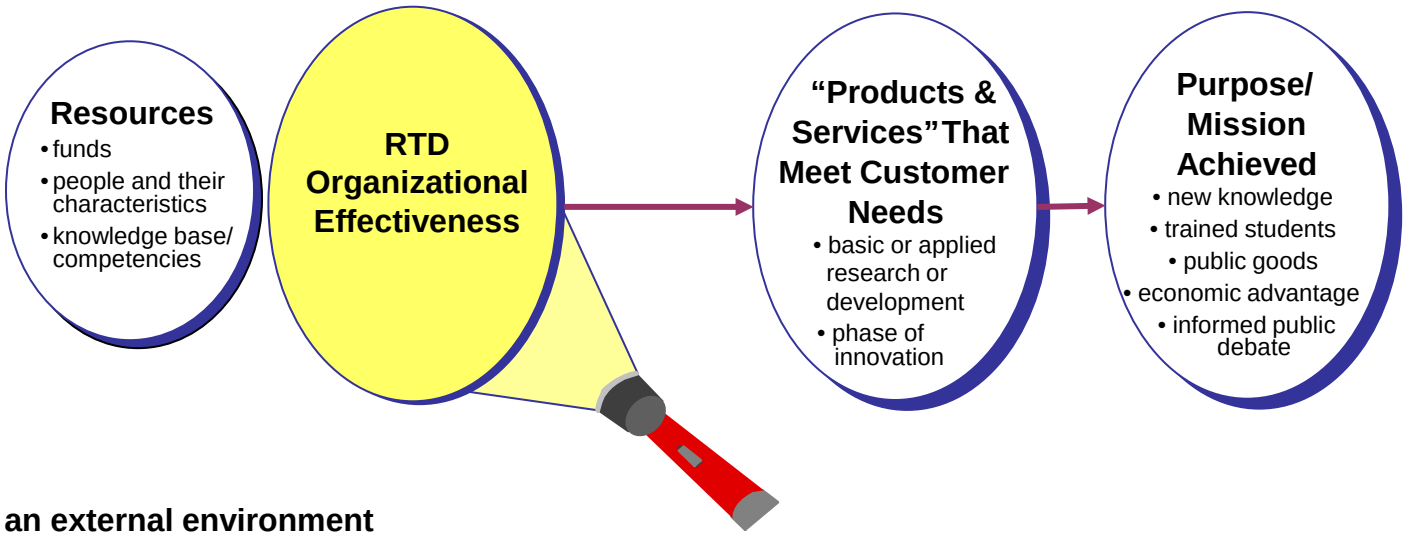
- 19 focus groups (DOE, industrial, university) and extensive literature review
- Defined attributes and organized within the Competing Values Framework (Cameron, Quinn, et al), extending for RTD.
- A survey to capture employee perceptions of their research environment
  - To link to nature of work
  - To analyze and present data to encourage action plans
- Used with case studies to determine impact of specific management interventions

Beginning to

- Link survey findings with data on performance
- Develop management and measurement models

Conceptual Framework

Assessing the research/work environment focuses on an important part of RTD evaluation



Within an external environment

- **economic**
- **technical**
- **political/legal**
- **social/ demographic**

Conceptual framework behind the survey

- Contingency theory of organizational effectiveness (performance is highest when structure matches strategy)
- Not all RTD has the same strategy so there are tensions inherent in management
- Capture with two dimensions of strategy and two related dimensions of structure

Major question 1
Why and how can we be "more innovative/radical"?

Degree of Radicalness (a continuum) of the discovery or innovation, is the significance of an advance, as recognized by peers, citations, other performance measures including

- Amount of change from the current state of the art
- Centrality to the field and/or problem
- Difficulty of the problem

This defines a general dimension for both S & T.

Managing for more radical innovation - the strategic choice

- Aim for more radicalness and if so, how much more?
- Implied trade offs
  - Lower, more certain payoff vs. higher, less certain payoff
  - Timeframe for payoff
  - Lower vs. higher risk
  - Building new and/or exploiting existing

- Trade offs are “contingent” on the internal environment
  - Required structural changes
  - Historical competencies, resources available
- And the current external environment (e.g., how “hot” the technical field is, competition, national funding priorities)

Structural choices and management levers for radical innovation come with inherent tensions

DIMENSIONS OF ORGANIZATIONAL AND TASK STRUCTURE	
Research autonomy vs. control	**Complex teams vs. specialized**
Tensions • Maintain core competencies & investigate new, but who decides? • Encourage creativity but maintain corporate requirements • Criticize and mentor at same time • Provide resources for uncertain payoff but maintain accountability **Management Levers:** Encourage exploration & risk taking Encourage change & critical thinking	**Tensions:** • More diverse knowledge sets are harder to integrate • Challenge researchers without discouraging them • Have enough external contact to stimulate and access resources and leave time to work and not lose too much organizational autonomy **Management Levers:** Integrate ideas internally and externally

Major question 2
Why and how do we manage if broad scope, large?

Scope of Focus or Impact (a continuum) is the scope of the advance, as recognized by peers, citations, and other performance measures, including

- Number of parameters, systems, data collection facilities or schemes involved
- Extent of conditions or number and diversity of fields/markets covered
- Extremeness of conditions

This defines a general dimension for both S & T.

Major question 2
Managing broad scope, large - the strategic choice

- How broad a scope of the S&T shall we focus on?
- Implied trade offs
  - Stay small and access/feed the larger systemic problem or convince stakeholders to back large scale S&T
  - Risk getting false/no answers or not entering market vs. risk of failing to manage so much uncertainty
- These trade offs are contingent on the internal environment
  - Current organizational structure (e.g. expertise in managing large projects)
  - Competencies, resources available
- And depend on current external circumstances (e.g. does the research require broad scope; political mandate for speed, collaboration)

Structural choices and management levers for broad scope innovation come with inherent tensions

DIMENSIONS OF ORGANIZATIONAL AND TASK STRUCTURE	
Allow autonomy and coordinate large	**Manage complex and broad tasks, teams**
Tensions: • Gathering large resources for an uncertain future outcome • Balancing S&T, short & long term • Working toward a project goal & still being creative **Management Levers**: Clearly defined goals & strategies Champions & other strategic relationships	**Tensions:** • Plan & execute given uncertainty • Managing numerous complex and diverse inter-organizational teams • Measure progress (some uncertain) toward goal and maintain creativity **Management Levers:** Good project planning and execution Strategic relationships

A 2 x 2 typology of these general dimensions defines four Research Profiles, “contingencies”

Research Profiles show

- Major differences in strategy and task structure for both S and T
- Inherent tensions along these dimensions
- Ways to manage tensions that are contingent on the dimensions

Horizontal dimensions

STRATEGY: Where to be on continuum from incremental to radical

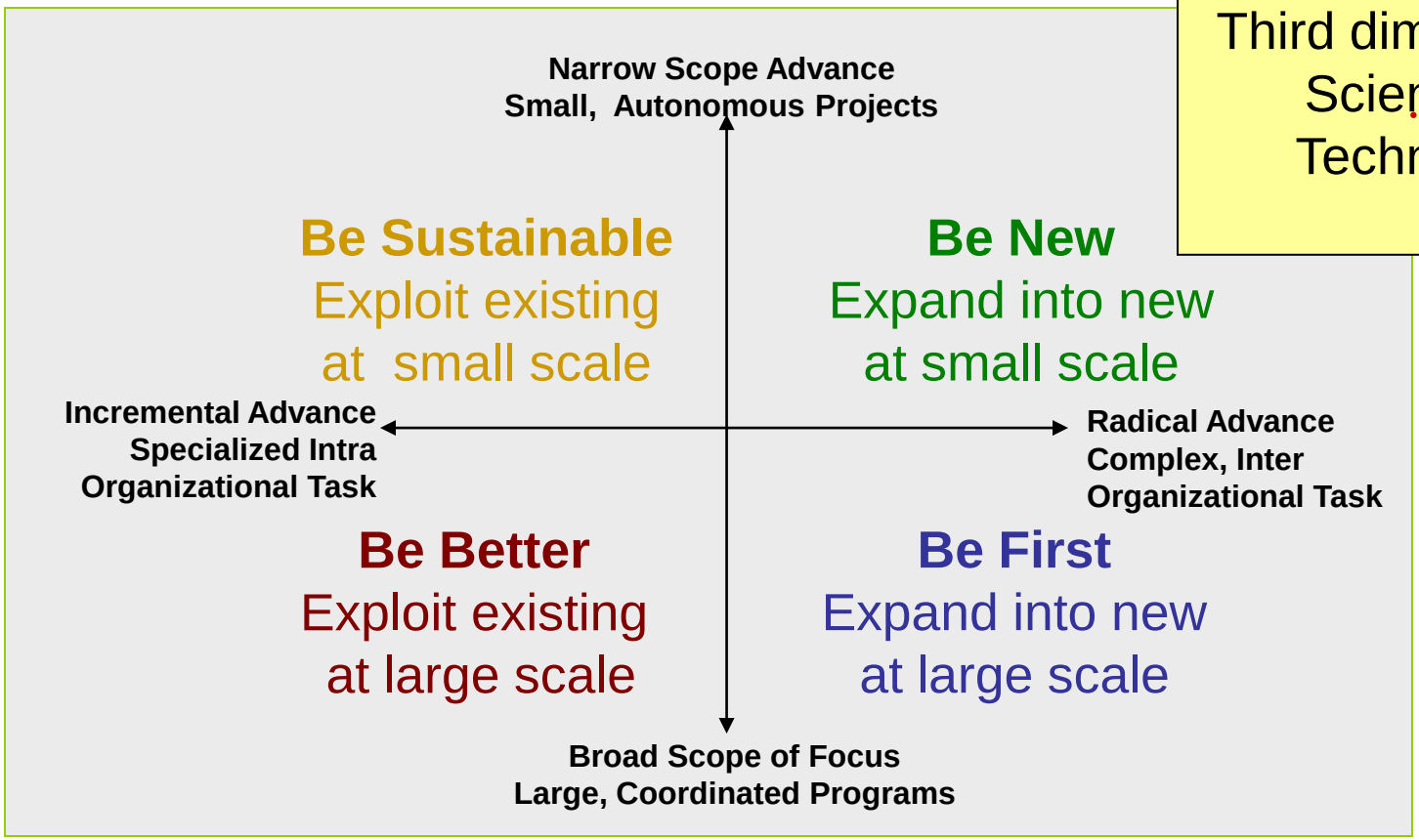
STRUCTURE: Specialized vs. complex teams; Organizational autonomy vs. inter-organizational ties

Vertical dimensions

STRATEGY: Where to be on continuum of narrow to broad scope

STRUCTURE: Small vs. large projects; Research autonomy vs. coordination

Four Research Profiles with different strategic outcomes, each with specific challenges, opportunities



Third dimension is Science or Technology

An organization or program can have a mix of the four profiles and would manage them differently.

For example, dilemmas and tensions for the profile of large radical research

- Research has risk and uncertainty associated with “stretch” goals, centrality, difficulty, and many parameters, conditions, extremes covered
- More radical research needs autonomy but larger, more complex tasks also need coordination
- Broad scale requires sustained commitment of large resources, while remaining open to change
- More radical and broad scope requires complex tasks and teams, including multiple organizations
- Integration is more difficult
  - Many parameters, conditions as well as knowledge sets
  - Integrating teams as well as team members
  - Integrating across organizational boundaries

Tailor management to these tensions.

Overview of the Survey

Key attributes of the research environment were determined through …

- Information from 19 focus groups of scientists and managers at three DOE laboratories, one industry lab, and one university
  - ✓ "What do you need in your research environment to do excellent work?"
  - ✓ "What attracted you to the lab and what keeps you here?"
- Study of current literature
- Developed and tested survey questions
  - √ PNNL EHSD Division in 1999, Ford Research Lab in 2000
  - √ SNL – 3 Centers in 1998, 17 Centers in 2001, 2003, 2008
  - √ SNL and NOAA case studies in 2003-2004, 2005-2007
  - √ NMSU in 2006

Research Environment Survey
- a diagnostic tool looking at 42 attributes

Rewards for Research/Work
Salaries
Benefits
Educational/Professional Development
Technical Career Advancement
Recognition for Merit
Respect for People

Value of Managers of Research
Management Integrity
Technical value added
Overall Value-Added Management

Quantity & Quality of Resources
Equipment for research
Lab/ Physical Work Environment
Stability of funding
Quality of Technical Staff
Staffing for Optimal Mix of Skills

Organizational Support for Research
Staff Services
Laboratory Systems & Process
Competencies –range& depth
Competitiveness/Overhead Rates
Reputation for Excellence

Control Via Managers
Project Planning & Execution
Project-Level Measures of Success
Measures of mission success

Autonomy
Autonomy in Decision-Making
Freedom to Explore New Ideas
Resources for Exploring New Ideas

Internal Collaboration/ Integrate Ideas
Internal Communication about research
Collaboration inside the organization
Internal teams with multiple fields
Provide critical thinking for each other

Exploration
Time to Think Creatively
Able to Take Risks with Ideas
Sense of enthusiasm

Agile, Long term Investment
Investing in new program areas
Investment in basic research
Identify new opportunities
Internal Resource Allocation

External Collaboration/ Integration
Collaboration outside the organization
Exchange ideas within the field
Exchange ideas with different fields
External teams with multiple fields

Focus with Clearly Defined Goals
Research Vision
Research Strategies
An integrated R&D portfolio

Survey components

20-25 minute (often web-based) survey includes

- Rate status of 36 attributes (and preferred for some of these)
- Overall rating the environment and trend
- Questions of specific interest to that organization
- Questions on characteristics of their projects
- Limited demographics (org. unit, source of funds, job classification, career stage, years at lab)
- Two Open-ended questions: major barriers to progress and who can do something about it; Other

Longer survey includes sub parts on some attributes

Shorter survey asks only 18 of the 36 attributes

Researchers can suggest areas for improvement by providing time preferred

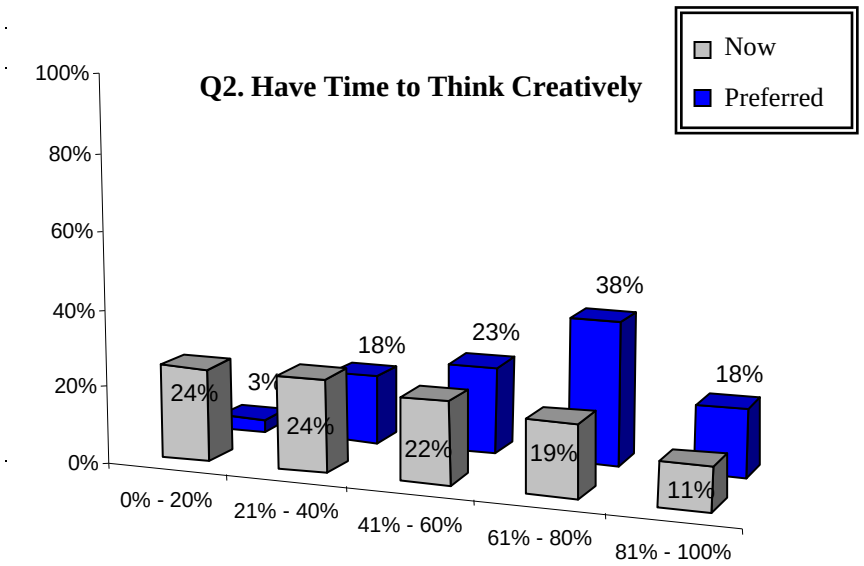
2. People have time to think creatively and explore.

(I have time to do my research, think creatively, and explore new approaches, all in a normal work week. I don't work on too many projects at once and am free from excessive organizational obligations.)

O 0 to 20% O 21 to 40% O 41 to 60% O 61 TO 80% O 81 to 100% O NA

2b. For your profile, for what percent of the time should people have time to think creatively and explore?

O 0 to 20% O 21 to 40% O 41 to 60% O 61 TO 80% O 81 to 100% O NA



Managers can assess the appropriateness of requests for change, knowing the nature of the work and current circumstances

Analysis by demographic groups helps tailor management actions (e.g. by Job Classification)

- One job classification or level may have issues another does not (Level 3 in this case)
- The most unsatisfied do not reveal their job classification
- Managers (Level 1) often rate the lab higher than staff

Significantly Better

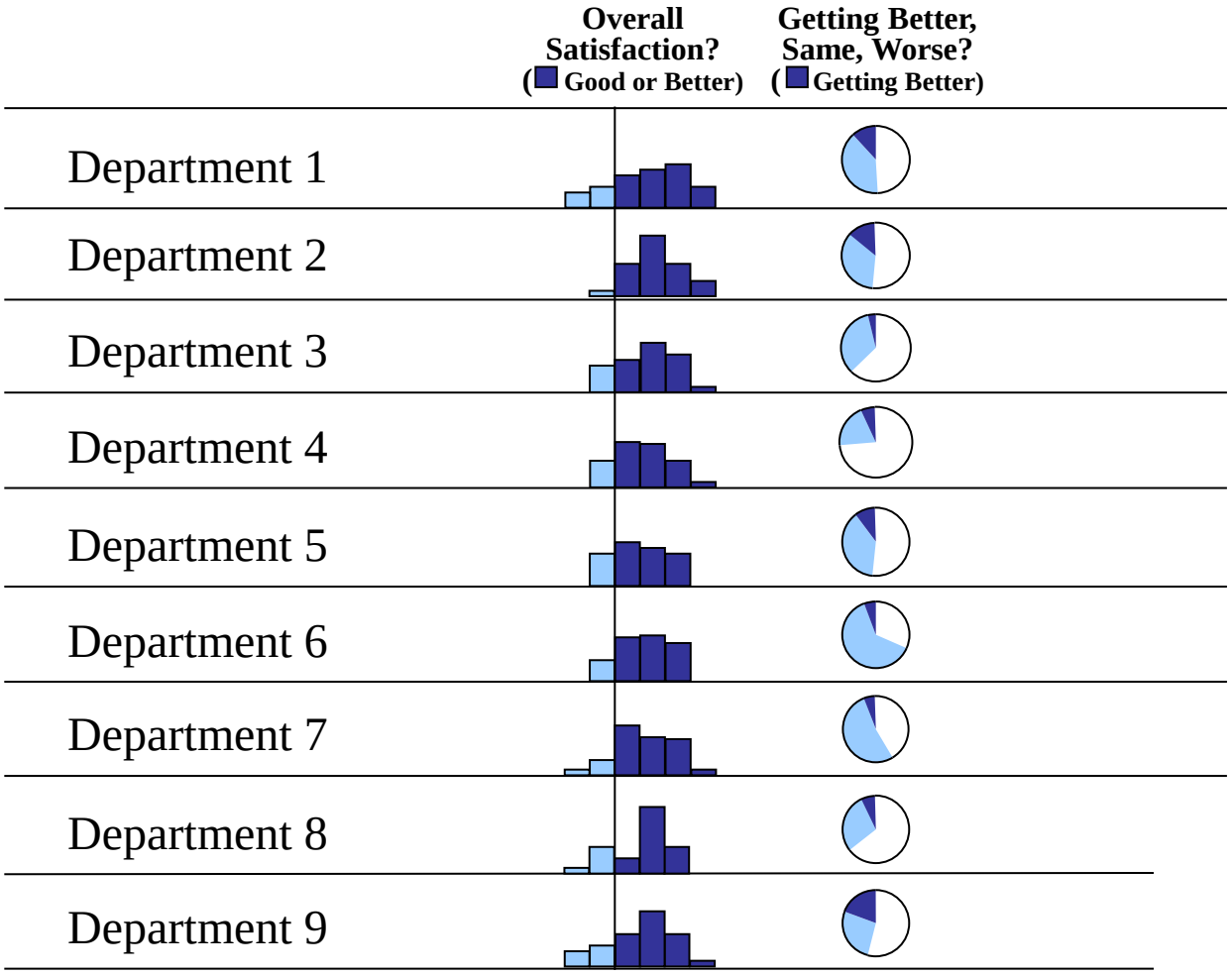
Significantly Worse

*Significant at .05

	Percent Favorable Response (Good to Outstanding)					
Attribute	Total	Level Unknown	Level 1	Level 2	Level 3	Level 4
Sense of Challenge and Enthusiasm	82.3	**63**	88.9	88.3	83.9	82.6
Time to Do Research and Explore	49.8	38.6	50	48.7	45.7	**59.9**
Pursuit of New Ideas	57.8	**39.1**	87.5	59.7	54.9	**64.9**
Commitment to Critical Thinking	81.4	**68.2**	88.9	78.2	82.4	85.1
Teamwork & Cooperation	75.4	65.2	77.8	76.9	72.8	**81.3**
Internal Cross-Fertilization of Technical Ideas	62.5	**47.8**	66.7	**73.1**	59.4	65.8
External Collaborations & Interactions	76.1	65.1	88.9	83.8	74.3	77.2
Equipment and Physical Work Environment	89	**76.1**	100	**94.7**	88.8	89.7
Quality of Colleagues	92	**79.1**	100	94.7	91.8	94
Project Funding	61.5	**48.9**	77.8	62.3	58.3	**68.7**
Project Support	70	**51.1**	88.9	69.7	70	74.7
Salaries & Benefits	85.3	**75.6**	100	**94.7**	83.8	84.9
Opportunities for Career Development	38.4	28.9	**88.9**	44.3	35.4	39.5
Educational/Professional Development	80.6	**60.9**	100	84.8	82.3	80.6
Rewards and Recognition	29.8	20	44.4	**42.3**	27.8	28.3
Respect for People	74.7	**52.2**	100	**82.9**	76.2	73.7
Management Integrity	58.6	**42.2**	88.9	61	58.8	60.1
Autonomy in Project Management	66.9	60	88.9	**79.5**	**61.2**	69.4
Championing R&D	53.9	**37.2**	66.7	52.6	50.7	**63.5**
Decisive, Informed Management	65	**51.1**	88.9	67.9	64.6	66.7
Value-added Management	72.8	**56.5**	100	72.7	73	76.1
Resource Allocation	51.8	**34.1**	**88.9**	54.4	50	55.9
Good Project Planning and Execution	58.7	**42.2**	88.9	63.3	57.4	61.4
Project-Level Measures of Success	44.8	39.5	**77.8**	**57.3**	41.8	42.4
Internal Communication	75.8	71.1	88.9	**87.2**	75.2	71.6
Laboratory Services	83.2	**65.2**	100	85.5	83	86.8
Laboratory Systems and Processes	61.8	56.5	88.9	**71.6**	**57.3**	63.8
Relationship with Sponsor	56.8	57.8	77.8	56.6	**52.5**	61.7
Laboratory-Wide Measures of Success	42	38.1	44.4	42.5	38.9	47.2
Reputation for Excellence	74	65.1	100	78.9	71.6	75.8
Id New Projects and Opportunities	41.1	45.5	50	44.6	**34.8**	46.9
Research Vision	43.9	42.9	**77.8**	40.8	42.1	46.5
Research/Technology Strategies	60.3	59.1	77.8	62.8	56.1	64.4
Research Competencies/Knowledge Base	74.4	64.3	100	75.3	72.2	78.5
Integrated and Relevant R&D Portfolio	66.8	62.8	88.9	66.7	67	66.4
Investing in Future Capabilities	42.6	45.2	**77.8**	37.3	38.8	47.6
OVERALL SATISFACTION BY LEVEL	84.7	71.4	100	87.3	**81**	88.5
OVERALL TREND BY LEVEL (IMPROVING)	9.9	0	0	7.6	8	**14.8**

Data shown here are notional.

Looking at differences across organizations provides benchmarks, stimulates action



Data shown here are notional.

Analyzing differences across time can be useful, especially when tied to management or external changes in that period

ANOVA Table

		200X			200X + 2				
		N	Mean	True Time Mean	N	Mean	True Time Mean	Sig.	
1	Sense of Challenge & Enthusiasm	1279	3.94	68.8	500	4.04	70.9	0.037	*
2	Time to Think & Explore	1278	3.28	55.6	500	2.69	43.7	0.000	***
3	Resources/ Freedom to Pursue New Ideas	1258	3.25	55.1	321	3.16	53.1	0.173	
4	Commitment to Critical Thinking	1263	3.96	69.2	326	3.95	69.1	0.936	
5	Teamwork & Collaboration	1273	3.82	66.4	325	3.86	67.2	0.546	
6	Cross-Fertilization of Ideas	1260	3.39	57.8	785	3.26	55.2	0.010	**
7	Frequent External Collaborations	1234	3.80	66.0	491	2.56	41.2	0.000	***
8	Good Internal Project Communication	1266	3.41	58.2	778	3.44	58.7	0.556	
9	Good Equipment/ Physical Environment	1282	3.74	64.8	498	3.85	67.1	0.059	
10	High Quality Technical Staff	1272	4.22	74.4	328	4.29	75.8	0.169	
11	Sufficient, Stable Project Funding	1242	2.90	47.9	326	3.11	52.2	0.006	**
12	Optimal Mix of Staff	1248	3.41	58.2	499	3.82	66.5	0.000	***
13	Good Salaries & Benefits	1259	3.11	52.2	482	3.72	64.3	0.000	***
14	Good Career Advancement Opportunities	1258	3.16	53.2	314	3.47	59.4	0.000	***

Data shown here are notional.

A Few Lessons Learned and Continuing Research

What is important to RTD workers?

Areas of Agreement Among 40 Research Organizations (2200 staff in three different laboratories)	
Highest Favorable Ratings	**Lowest Favorable Ratings**
• Quality of staff (37) • Respect for people (26) • Equipment & physical environment (25) • Sense of challenge & enthusiasm (23) • Autonomy (18)	• Identifying new projects/opportunities (28) • Rewards & recognition (27) • Internal research funds allocation (26) • Laboratory-wide measures of success (16) • Reducing overhead rate/burden (15)
Drivers of Satisfaction (in top ten)	**Drivers of View on Trend (in top ten)**
• **Research vision & strategies (21)** • **Invests in future capabilities (19)** • Sense of challenge & enthusiasm (19) • **Identification of new opportunities (17)** • Project level measures of success (17)	• **Research vision & strategies (27)** • **Investment in future capabilities (28)** • **Identification of new opportunities (20)** • Decisive, Informed management (19) • Champion long term research (18) • Reward and recognize merit (18)

Note: Does not include data from 2003 forward

Increased product innovation because of the research environment survey…

The Director of the Center for Satellite Applications and Research (STAR) in NOAA reports a five-fold increase in new products and attributes it to our advice.

From Center for Innovation at the University of Maryland/Sandia National Laboratories reports:

- The 2005 survey recommended efforts to facilitate and foster greater communication among the researchers.
- The 2007 survey responses indicate that there have been marked improvements in communication.
- 15 managerial attributes had significant or near significant increases, including evaluation of the research process, strategic vision, and management that is informed and decisive, adds value).
- There were positive increases in the overall assessment of the research environment, particularly the perception that it is improving.
- The amount of change desired on attributes related to innovativeness has largely declined. Staff indicate they want change in a new area where management has recently pressed for change, more external collaborations.

Example: Case study findings (survey and interviews) Measures of creativity and risk-taking

	S&T MD 2004		CO-LO 2004	
Attribute	**Mean**	**Percent Time True**	**Mean**	**Percent Time True**
Authority to Make Decisions	4.8	86	3.9	68
Resources/ Freedom to Pursue New Ideas	4.4	78	3.3	57
Sense of Challenge & Enthusiasm	3.8	66	4.3	76
Time to Think & Explore	3.6	62	3.1	52
Commitment to Critical Thinking	3.6	62	3.9	68

Comparing perceptions of a basic research department in a manufacturing division to survey response of a group co-locating basic and applied researchers and developers to speed radical new product development

- Autonomy and economic resources are higher in S&T MD (manager gave them time to define and develop their own projects)
- Time to think is higher in S&T MD (more do basic research)
- Challenge is lower (due to constrained choice of problem/approach)
- Critical thinking is lower, but in interviews said they had a great deal; (manager was also a mentor)

Second case study (project data) showed significant differences across project characteristics

- Nature of the work: basic science vs. technological tasks
- Complexity of labor: 6+ departments vs. less
- Size: small (< $1M) vs. large projects

For example, as expected we observe

- a steady decline in group means as move from small/less complex to large/complex
- Small/complex rate external collaboration lower than the other groups
- Large/complex rate investment in future capabilities lower

Research agenda to further develop Research Profiles Theory

- Continue to integrate multiple literatures
- Build a base of data linking performance to management aspects
  - Research Environment surveys with diverse organizations, problem areas
  - Compare high and low performers in context
  - Analyze data to link performance with presence of specific attributes
- Study cases of experiments in management interventions, measuring before and after strategy, management, performance
  - Develop real time progress measures; performance management systems
  - Look at interviews and trends in survey compared to performance
- Move theory (then tool) development to systems levels

Summary of Contributions

Research Profiles approach begins to define

- Dilemmas and general dimensions for research strategy and outcomes
- Related tensions around general dimensions of task and organizational structure

For S&T managers and evaluators this provides

- Advice and levers for improving performance – depending on the research profile
- A language and suggested measures for communicating about different research profiles and evaluating different kinds of advances in S&T

For study of S&T/ innovation management this

- Extends the organic model of organizational innovation to include integration (both intra- and inter-organizational)
- Calls attention to science and relationships among types of research done in different organizations, important for the study of inter-organizational networks

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