



Leveraging Collaborative Innovation at NASA Space Life Sciences

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Overview

the need.

future NASA problems will require SLSD to effectively leverage collaboration with external organizations

the approach.

categorization of its problem types will enable SLSD to best match problems with collaboration strategies

the challenge.

hurdles to creating a collaborative environment exist and must be considered as SLSD implements change

the future.

SLSD, with a focused strategy for pursuing external collaboration, can systematically improve performance

the need.

the approach.

the challenge.

the future.



the need.

➔	the need.
	the approach.
	the challenge.
	the future.



The need

Challenging pressures face NASA SLSD:

- increasingly complex, unfamiliar problems
- limitations on talent, time, resources
- disconnection with external innovation sources

Unrealized potential for NASA SLSD:

- other orgs see tremendous results from collaboration
- SLSD is well-positioned to attract collaborators
- current, relevant success stories exist
- external opportunities abundant





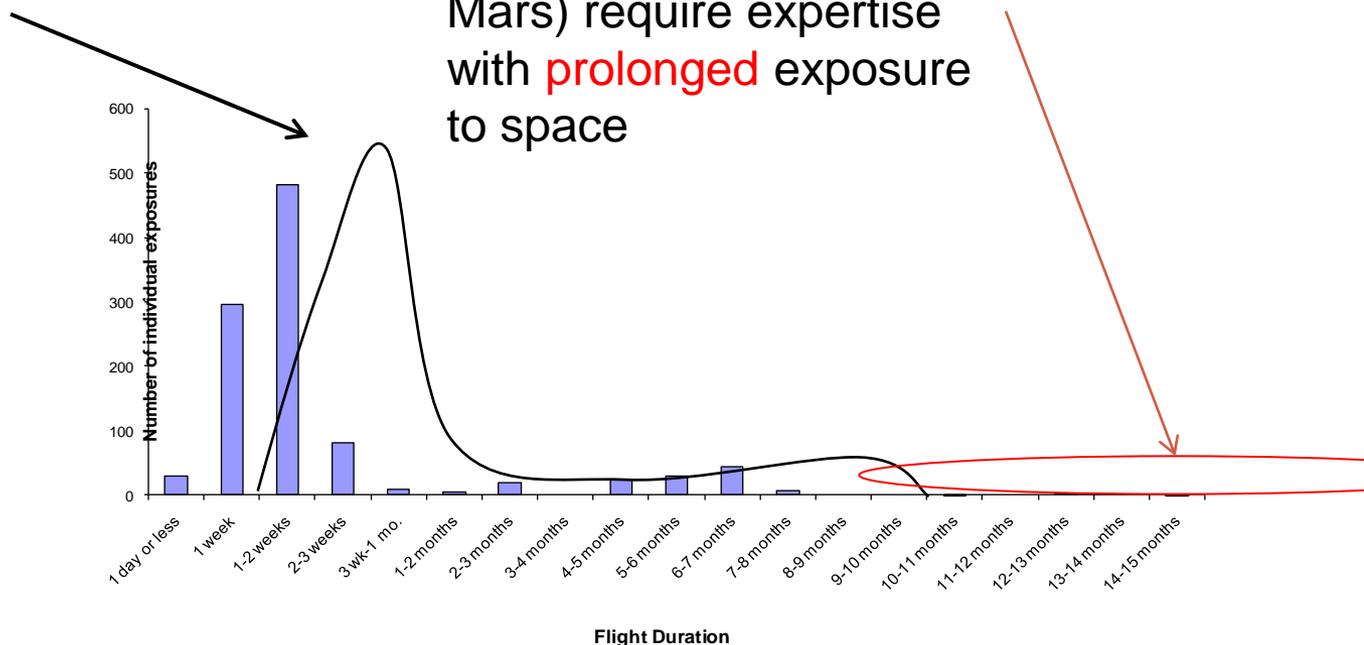
Increasingly complex, unfamiliar problems

Current expertise

Expertise studying human health risks limited to relatively **short** flight duration

Future imperative

Future missions (Moon, Mars) require expertise with **prolonged** exposure to space



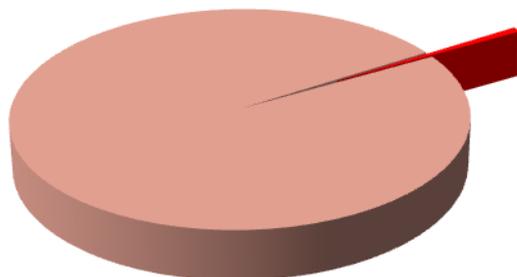
Future challenges entail increasingly complex human health risks from longer flights and habitation in space

- the need.
- the approach.
- the challenge.
- the future.



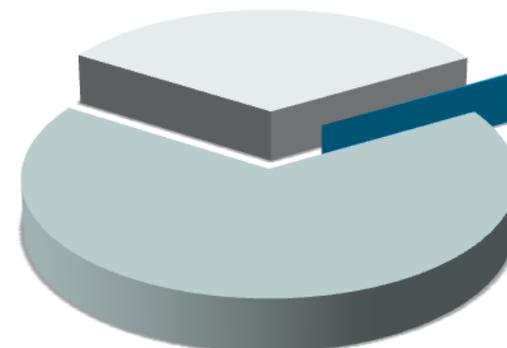
Relatively limited talent, resources

U.S. Life Science Scientists



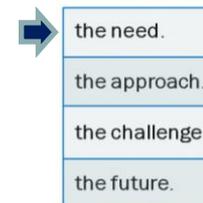
- All Others (130K)
- NASA SLSD (< 1K)

U.S. Life Sciences Expenditure



- Industry (\$58B)
- Academia (\$28B)
- NASA SLSD (\$150M)

**NASA SLSD represents less than 0.8% of life scientists
and less than 0.2% of life science funding in the U.S.**





External opportunities abundant, Joy's Law applies

“No matter who you are, most of the smartest people work for someone else”

Joy's Law: Bill Joy, Founder of Sun Microsystems

Causal factors behind Joy's Law

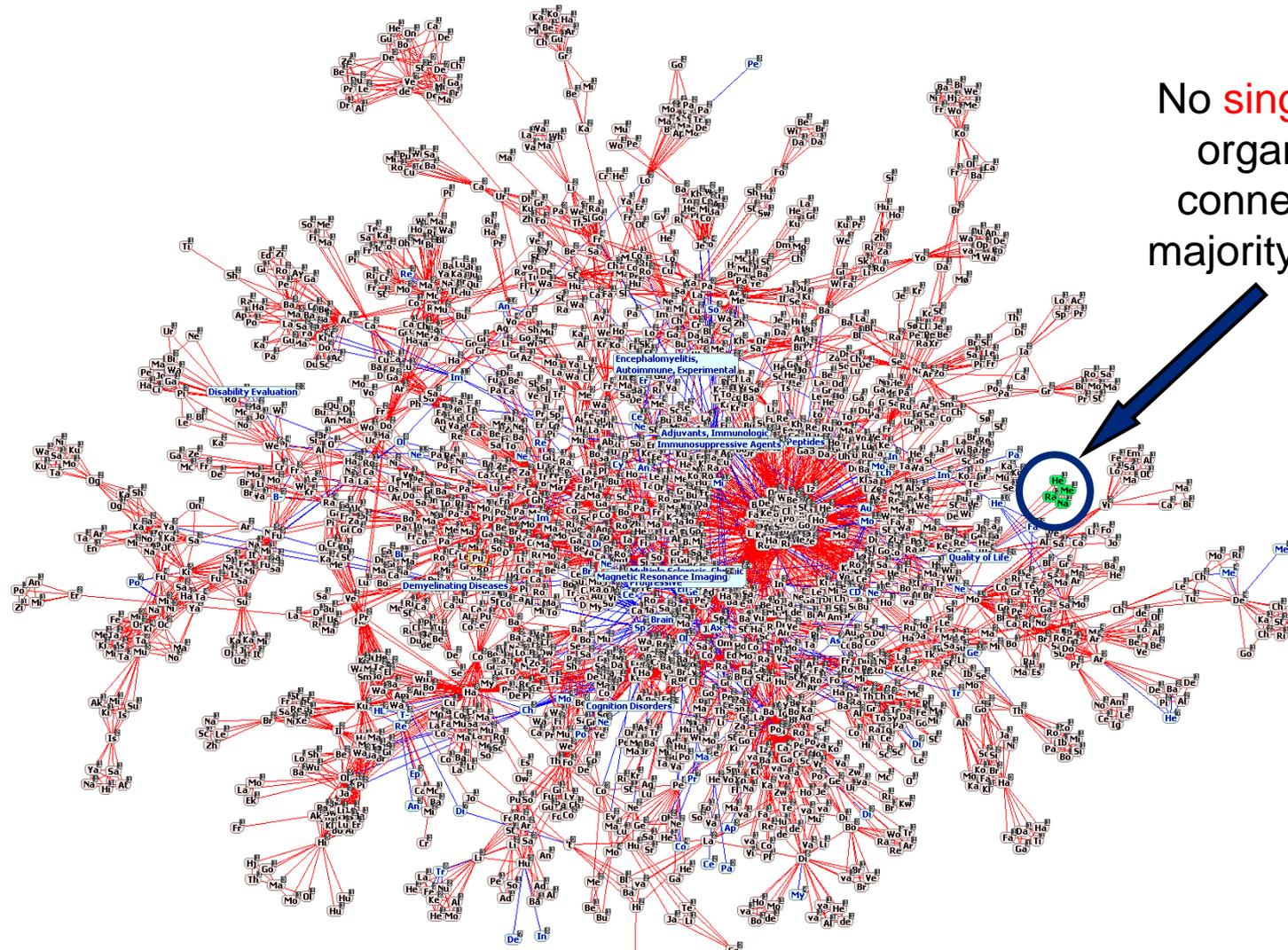
- knowledge is **unevenly distributed** – Hayek (1945)
- knowledge is **sticky** – von Hippel (1994)

Significant opportunity lies beyond any organization's boundaries





External opportunities abundant, Joy's Law in pharma research



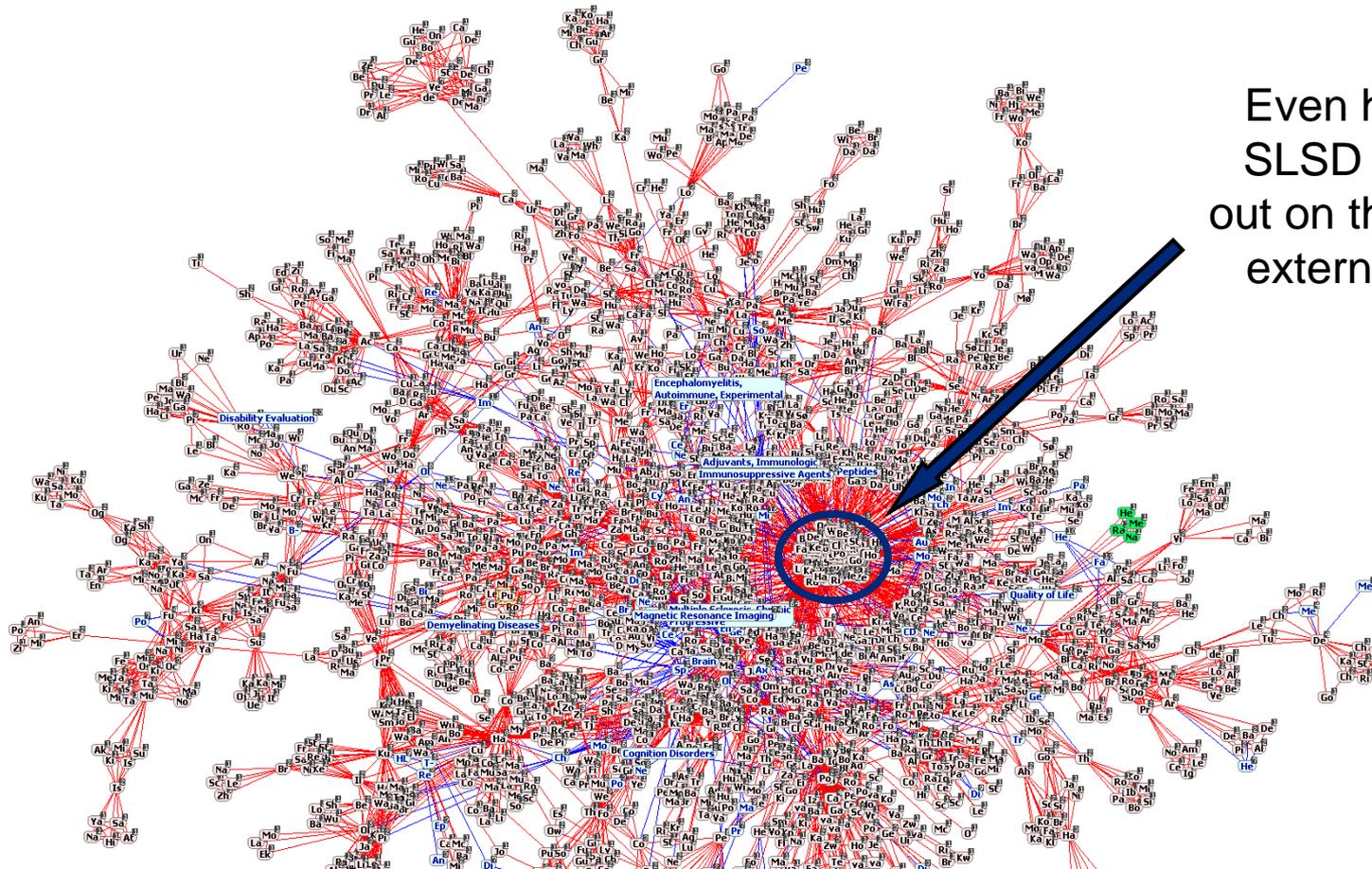
No **single** research organization is connected to the majority of research

- the need.
- the approach.
- the challenge.
- the future.



External opportunities abundant, Joy's Law in pharma research (cont.)

Even here, NASA
SLSD would miss
out on the **majority** of
external research



Significant opportunity lies beyond any organization's boundaries

- the need.
- the approach.
- the challenge.
- the future.



Disconnection with external innovation sources; three examples

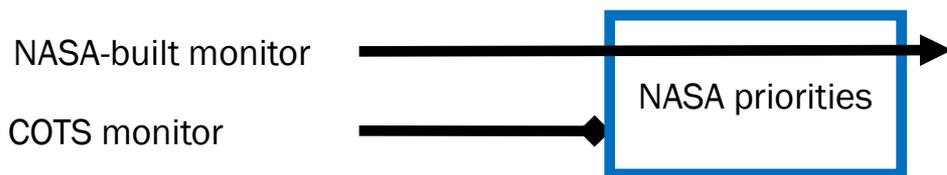
1) External Defibrillator



Background

NASA R&D concurrent with COTS solution R&D, both redundantly spend years and millions of dollars to develop external defibrillator

2) GC Mass Spectrometer



NASA group develops own GC spectrometer for air quality monitoring, individual identifies COTS solution but has difficulty getting green-light to pursue. Several millions would have been saved by identifying a COTS early on

3) Bone Loss Research



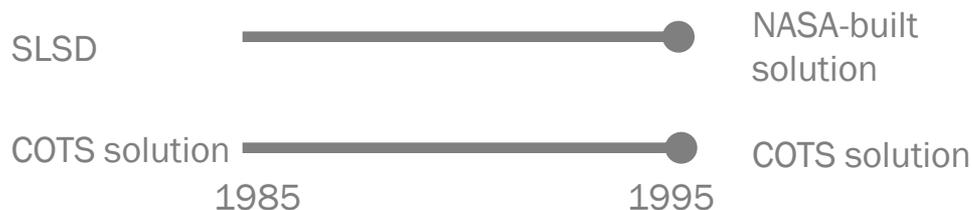
Risk mitigation research into bone loss separated into pieces and parceled out to different functional silos within SLSD. View of problem and insights not shared across silos

- the need.
- the approach.
- the challenge.
- the future.



Barriers to innovation and accessing distributed knowledge

1) External Defibrillator

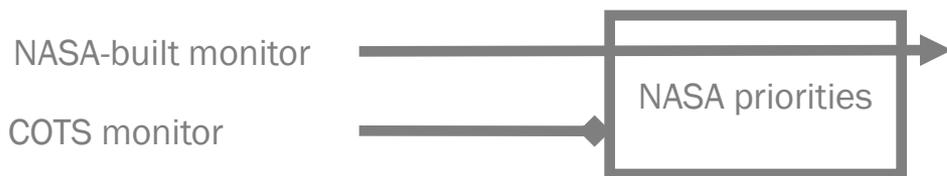


Barriers in **identification**

No effort to pursue external solutions

Opacity of external R&D

2) GC Mass Spectrometer



Barriers in **prioritization**

Internal solutions prioritized over less expensive COTS solution

No systematic review

3) Bone Loss Research



Barriers in **coordination**

Rewards based on individual success

Functional silos

- the need.
- the approach.
- the challenge.
- the future.

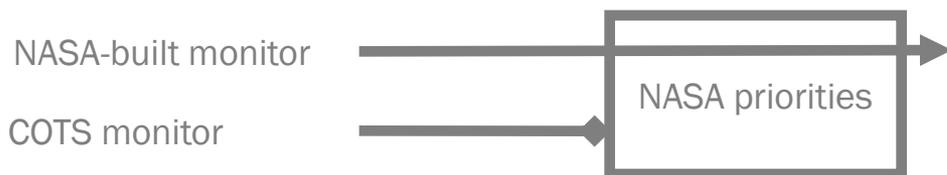


Collaboration potential with external entities is enormous

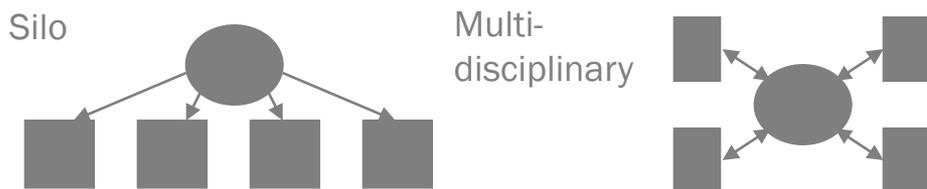
1) External Defibrillator



2) GC Mass Spectrometer



3) Bone Loss Research



Potential impact:

- Time
- Money
- Better science
- Establish relationships

- the need.
- the approach.
- the challenge.
- the future.



Previous external collaboration successes have been realized by NASA

Paint chip gun

Background
SLSD employee internally adapts “paint chip gun” technology to test water biocide levels

Dental carie ultrasound

SLSD scientist knowledgeable about problem knows scientist at small company developing relevant ultrasound technology, introduces him to NASA, solution is in testing

Lightweight trauma module

SLSD/Wyle team joins military consortium developing closed-loop autonomous vital sign monitoring & ventilation equipment for trauma in remote, resource-limited situations

Remote-controlled equipment

NASA develops partnership with heavy-equipment manufacturer, sharing expertise in remote control of equipment for expertise in heavy equipment design

Specialized test tubes

NASA contractor has small manufacturer develop specialized test tubes for space use after large manufacturer says no

When NASA and SLSD collaborate externally, NASA benefits significantly



the need.

the approach.

the challenge.

the future.



Successes overcame barriers that inhibited collaboration failures

	identification	prioritization	coordination
Paint chip gun	existing tech sparked idea	SLSD employee prioritized within his own time	no coordination needed
Dental carie ultrasound	personal relationship	generated internal support via SLSD contact	minimal coordination needed
Lightweight trauma module	knew military had similar interests	Wyle's Advanced Projects group prioritized	attend consortium meetings, personal relationships
Remote-controlled equipment	Heavy-equipment manufacturer approached NASA	Innovative Partnerships Program oversees	Innovative Partnerships Program oversees
Specialized test tubes	known, small manufacturer	easy to prioritize, NASA has no prod facilities	minimal coordination needed

Successes overcame barriers but were achieved in an unsystematic, ad hoc manner

- the need.
- the approach.
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- the future.



Several external models are both successful and systematic (1/3)



Innovation “needs” published online

Needs

Title	Created	Description
Snacks Partners	Nov 12, 2007	P&G is looking for partners to work with who can develop/produce ... more
Bismuth Subsalicylate Alternates	Dec 21, 2007	Alternative to bismuth subsalicylate for indigestion and diarrhea ... more
Methods and Ingredients that Reduce the Caloric Density of Snack Foods without Affecting Taste	Jan 29, 2008	Seeking to reduce the caloric density of snack products without a ... more

Large Innovation Network

- Companies
- Individuals
- Independent entrepreneurs
- Government laboratories
- Contract laboratories
- Research institutes
- Financial Institutions
- Subject-matter experts
- Suppliers
- Academia
- Members of e-R&D networks
 - [InnoCentive.com](#)
 - [NineSigma.com](#)
 - [Yet2.com](#)
 - [yourEncore.com](#)

Internal Scouting & Review

70 senior managers work as “technology entrepreneurs”

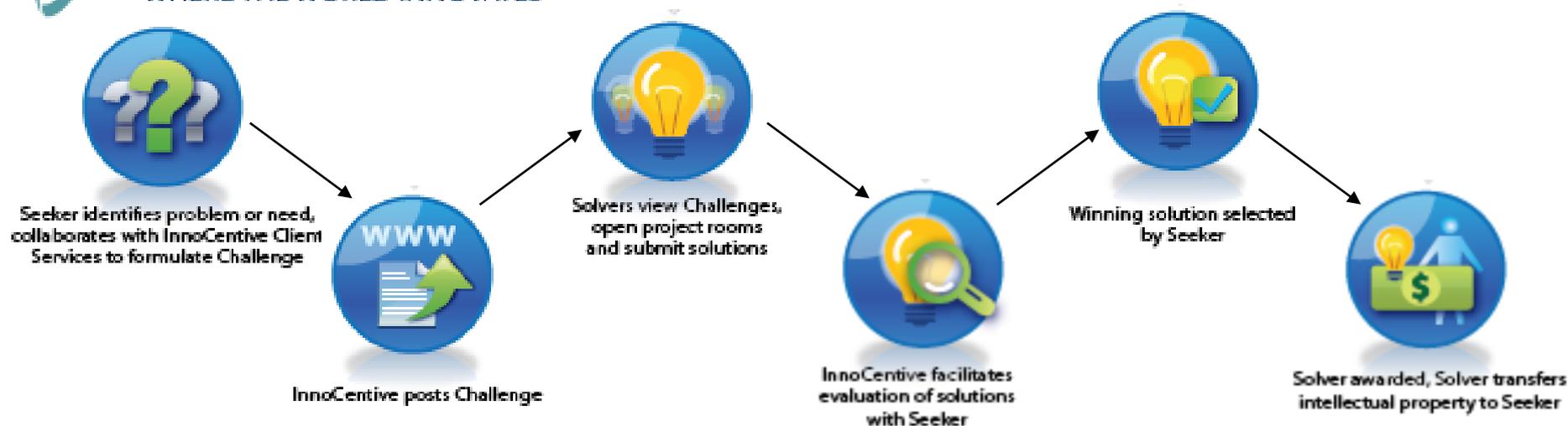
Systematically review ideas & assess for P&G fit

100 new products in two years
35% of new products have external elements & increasing
60% more productive R&D





Several external models are both successful and systematic (2/3)



~240 independent solvers examining each problem
~10 submitted solutions per problem
49 of 166 (29.5%) problems solved over 3 year period
ROI 2,175% for 1 firm with 12 solved problems

- the need.
- the approach.
- the challenge.
- the future.



Several external models are both successful and systematic (3/3)



75,000 Active Contributors
2,673,685 Articles in English
36% of American adults on the internet use accuracy rating same as Encyclopedia Britannica
20x the articles



800 Submissions/Week
35,000 to 60,000 T-shirts Sold/Month
highly profitable business model

- the need.
- the approach.
- the challenge.
- the future.



the approach.

	the need.
➡	the approach.
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The approach

Successful collaborative innovation at SLSD requires an understanding of its unique needs

- four most important attributes of the types of problems that NASA SLSD faces
- framework to use when assessing SLSD problems
- problems most likely to be solved more efficiently through collaborative innovation
- strategies for collaborative innovation that could be implemented successfully by SLSD





Four critical characteristics of NASA SLSD problems

How important are problem and solution disclosure?

- Can we share the need and critical information with external audiences?

How dispersed is the use knowledge?

- What individuals or organizations have the resources & expertise to determine whether a solution meets a need?
- Are they distributed or concentrated?

How dispersed is the solution knowledge?

- What individuals or organizations have the resources & expertise to develop an effective solution?
- Are they distributed or concentrated?

How much coordination is required?

- How complex is the need?
- Can it be broken into smaller pieces (modularized)?

Varying requirements of four attributes can be used to determine SLSD's approach to harvest innovation



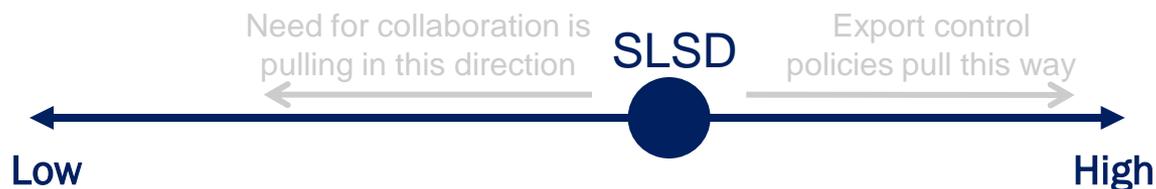


Problems can have high or low requirements for disclosure consideration

Disclosure problem

Need and critical information can be easily shared

Need and critical information are proprietary or sensitive



New T-shirt
New shopping cart

Military technology
Technology with IP protection

In general, most SLSD problems will require a high degree of disclosure consideration

- the need.
- the approach.
- the challenge.
- the future.

Usefulness of solution can be best judged by groups of varying distribution



Use knowledge

Small, concentrated group that can judge usefulness of solution

Large, distributed group that can judge usefulness of solution



Design a more effective nuclear reactor
Create a new system of Braille
In-flight technology (radiation, air/water monitoring)

Design a new car exterior
Design a new cell phone

Generally, the effectiveness of proposed SLSD solutions will be best evaluated by specialists



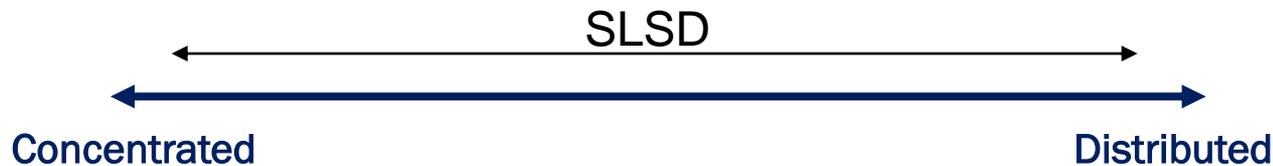
Problems may have concentrated or distributed solution knowledge



Solution Knowledge

Small, concentrated group that can develop effective solution

Large, distributed group that can develop effective solution



Cutting edge integrated circuits
Cutting edge racing yacht
New fashion trends

Scientific problems
New T-shirt

Knowledge required to solve SLSD problems can be widely distributed, or concentrated in a defined group





Problems may require low or high levels of coordination to solve

Coordination Required

Need is simple, easily articulated, or can be broken into parts

Need is complex, development requires close interaction



New T-shirt
New shopping cart

Cutting-edge integrated circuits
Cutting-edge racing yachts
In-flight technology (radiation, air/water monitoring)

SLSD problems require varying levels of coordination to facilitate the innovation of a solution





Determining the criteria used to best evaluate SLSD problems

How important are problem and solution disclosure?

- Can we share the need and critical information with external audiences?

How dispersed is the use knowledge?

- What individuals or organizations have the resources & expertise to determine whether a solution meets a need?
- Are they distributed or concentrated?

How dispersed is the solution knowledge?

- What individuals or organizations have the resources & expertise to develop an effective solution?
- Are they distributed or concentrated?

How much coordination is required?

- How complex is the need?
- Can it be broken into smaller pieces (modularized)?

SLSD problems can be best categorized by their knowledge dispersion and coordination required



Usually important

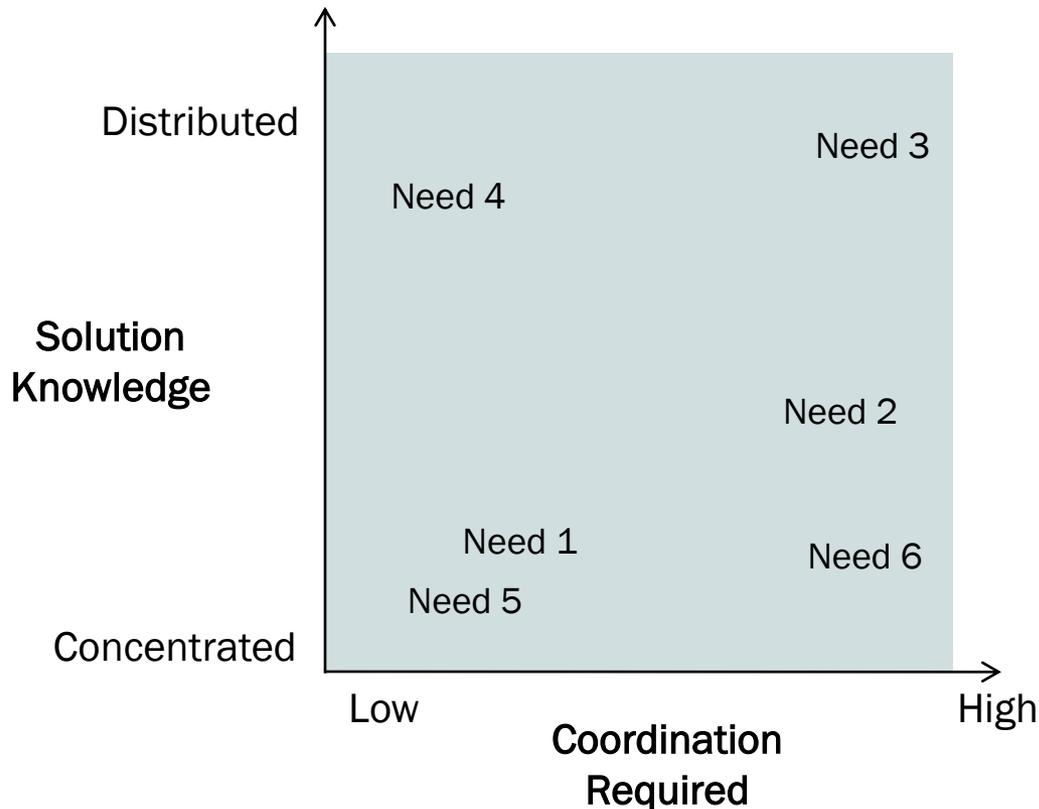
Usually concentrated

Often variable

Often variable



SLSD problems should be mapped by coordination required and solution knowledge

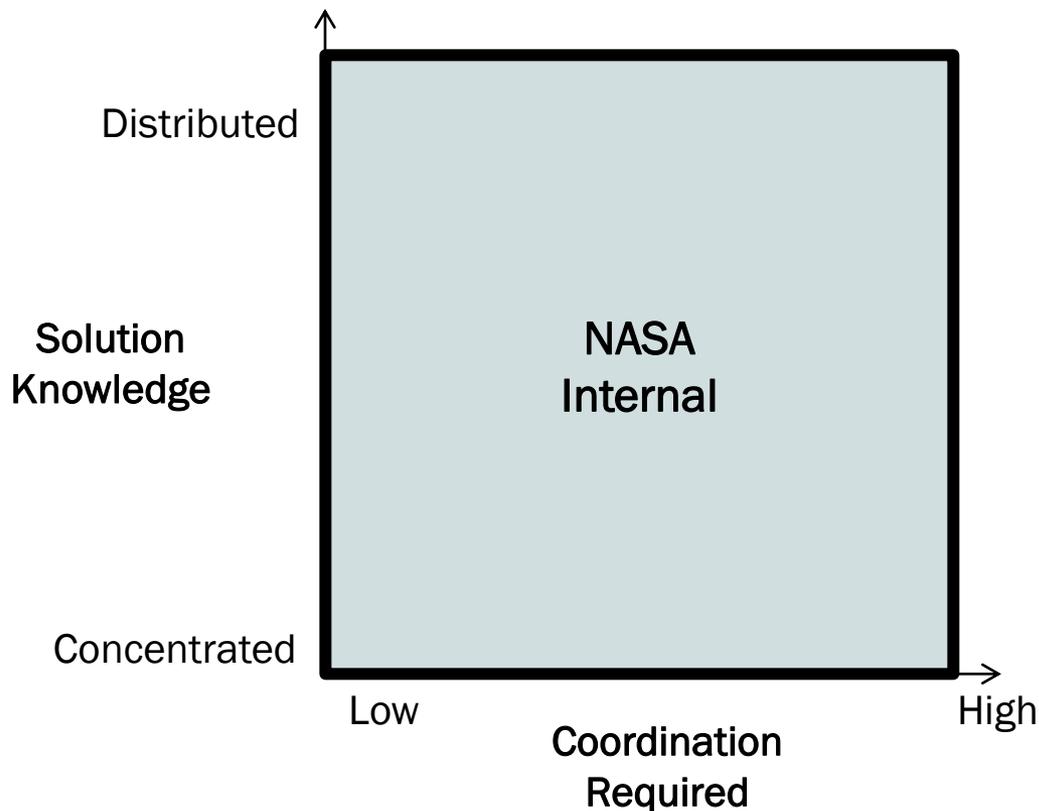


Mapping problems using two criteria will help SLSD match problems to effective collaborative models

- the need.
- the approach.
- the challenge.
- the future.



How NASA previously addressed problems requiring new innovation

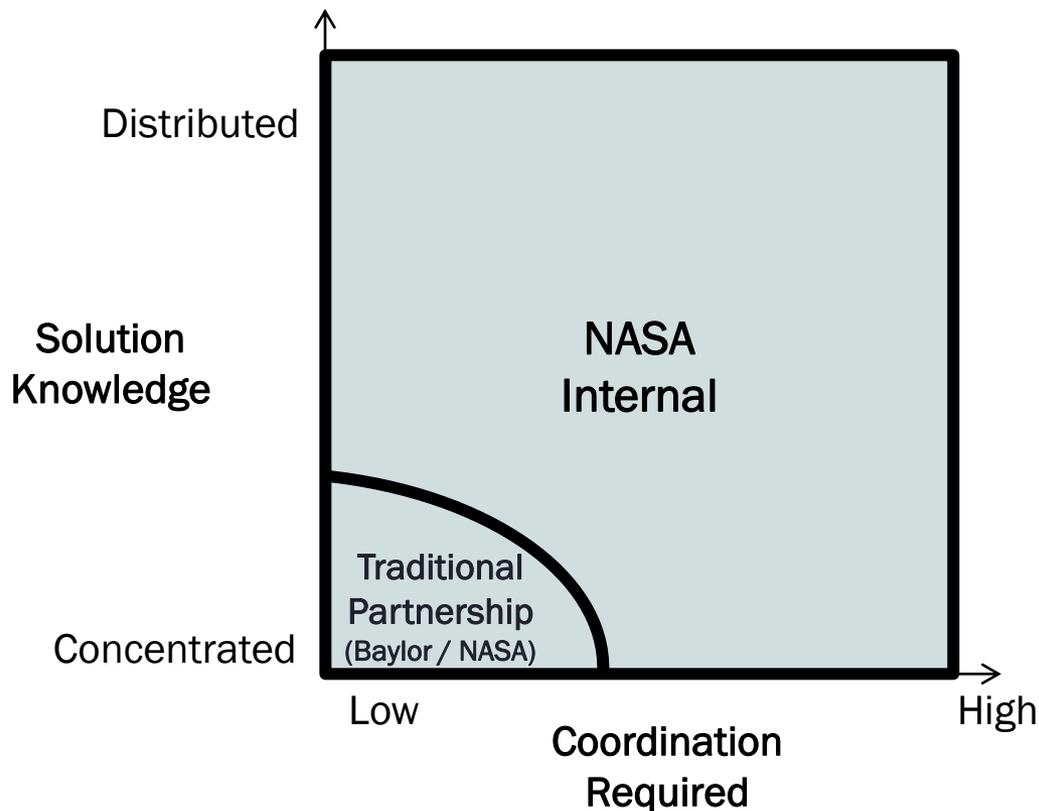


Regardless of characteristics of problem, all innovation was sourced internally to NASA scientists

- the need.
- the approach.
- the challenge.
- the future.



SLSD has recently partnered with small groups on easily-coordinated solutions

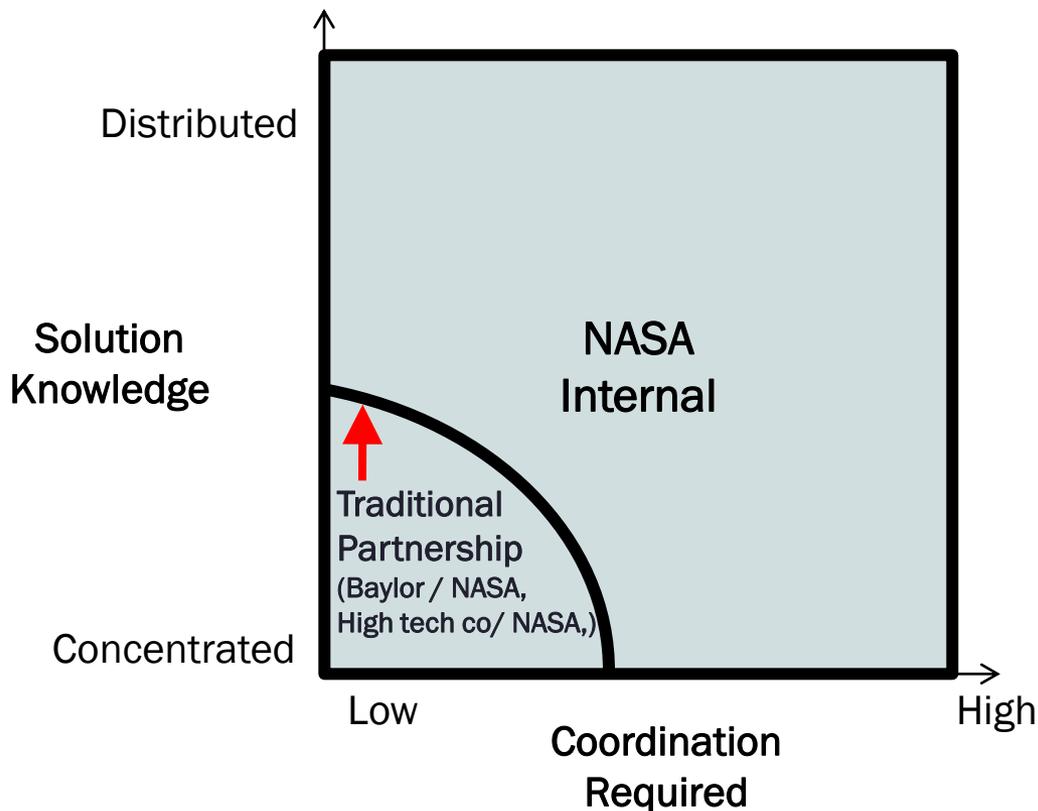


One-off partnerships were utilized when NASA learned about niche groups with specific expertise

- the need.
- the approach.
- the challenge.
- the future.



SLSD is now reaching-out to a larger crowd for easily-coordinated solutions

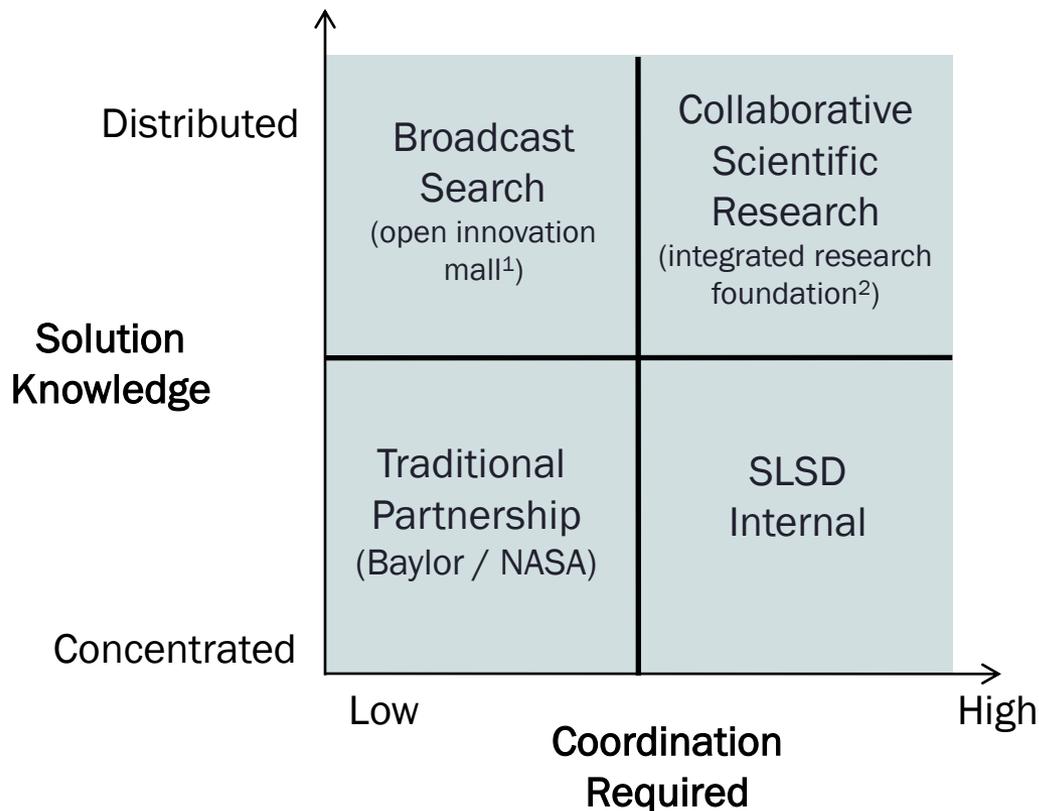


A broader crowd of one-off partnerships have been created leaving an impression of high collaboration

- the need.
- the approach.
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SLSD's collaborative innovation strategy: a way ahead

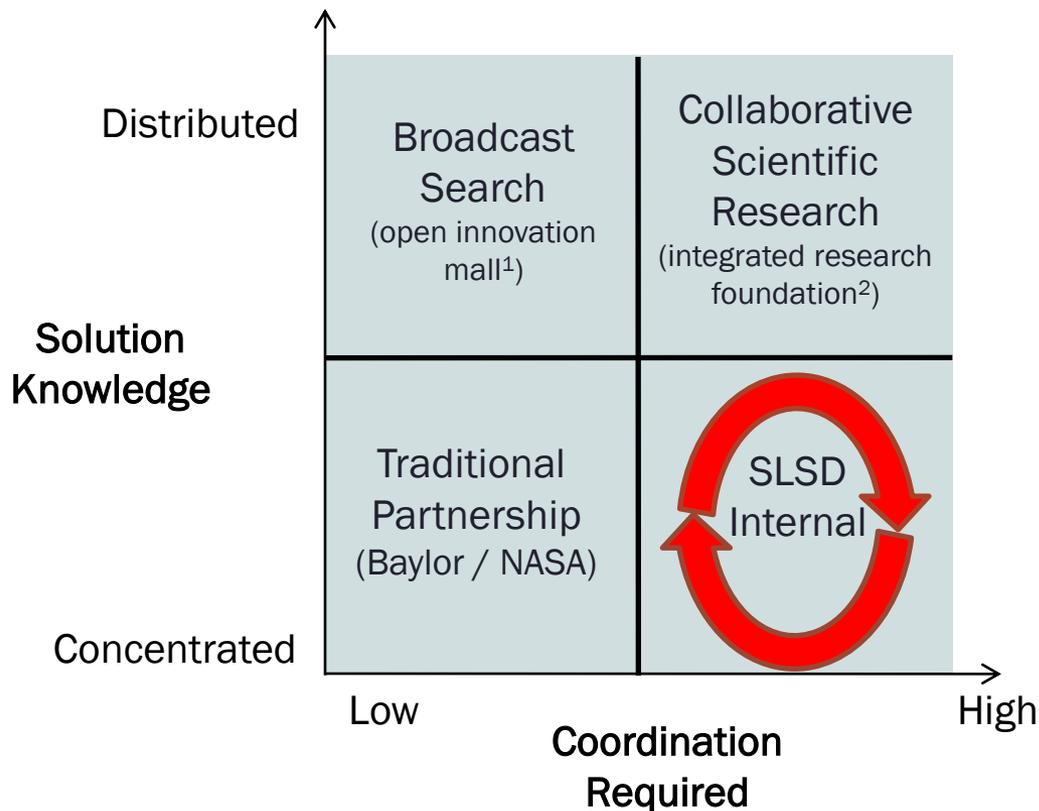


SLSD problems mapped according to solution knowledge and coordination required can be matched with most effective collaborative innovation strategy

- the need.
- the approach.
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Problem reevaluation: a critical step

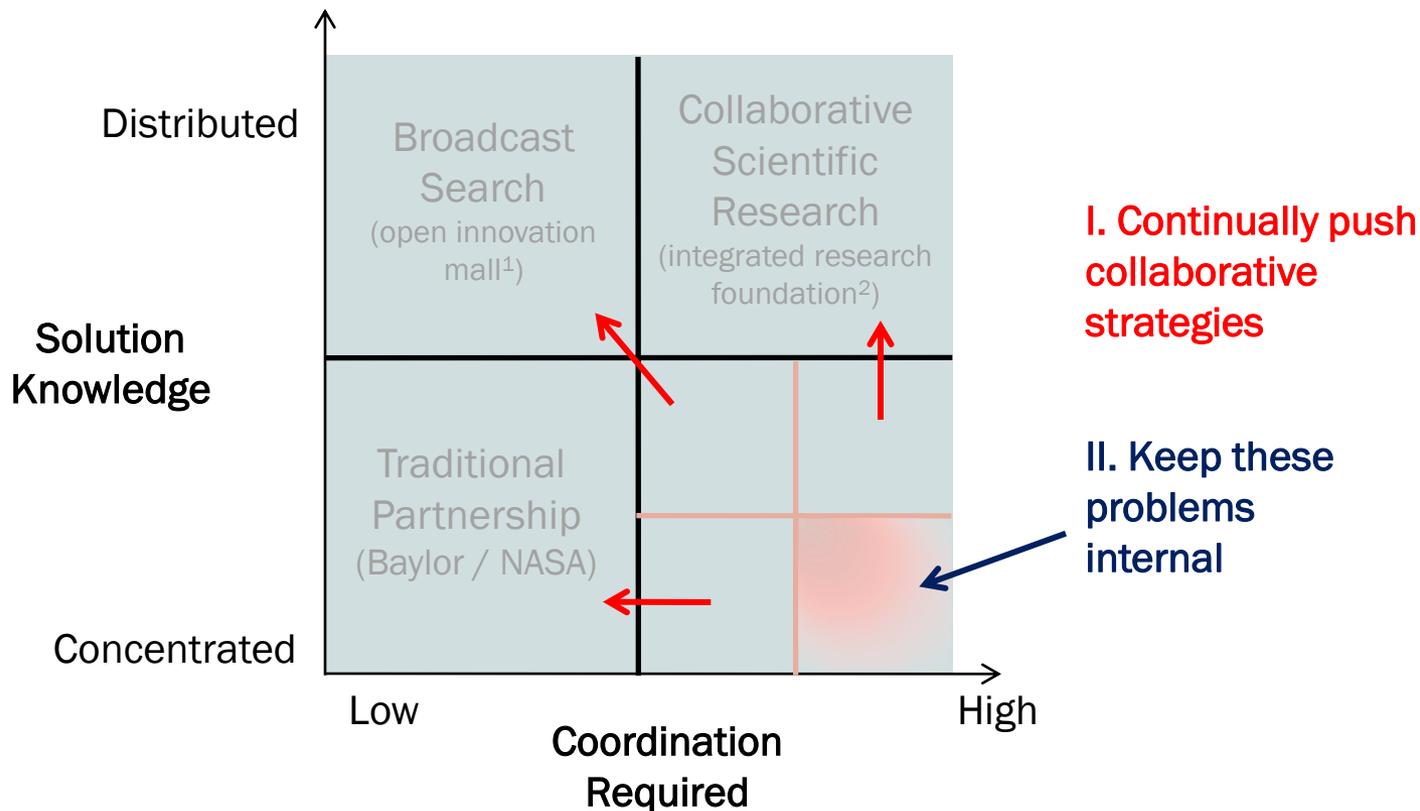


SLSD should constantly reevaluate its portfolio of problems and favor collaboration as much as possible

- the need.
- the approach.
- the challenge.
- the future.



Evolution: continual organizational pressure towards more collaboration



Percentage of internally-solved NASA problems should decrease over time

- the need.
- the approach.
- the challenge.
- the future.



the challenge.

the need.
the approach.
the challenge.
the future.





The challenge

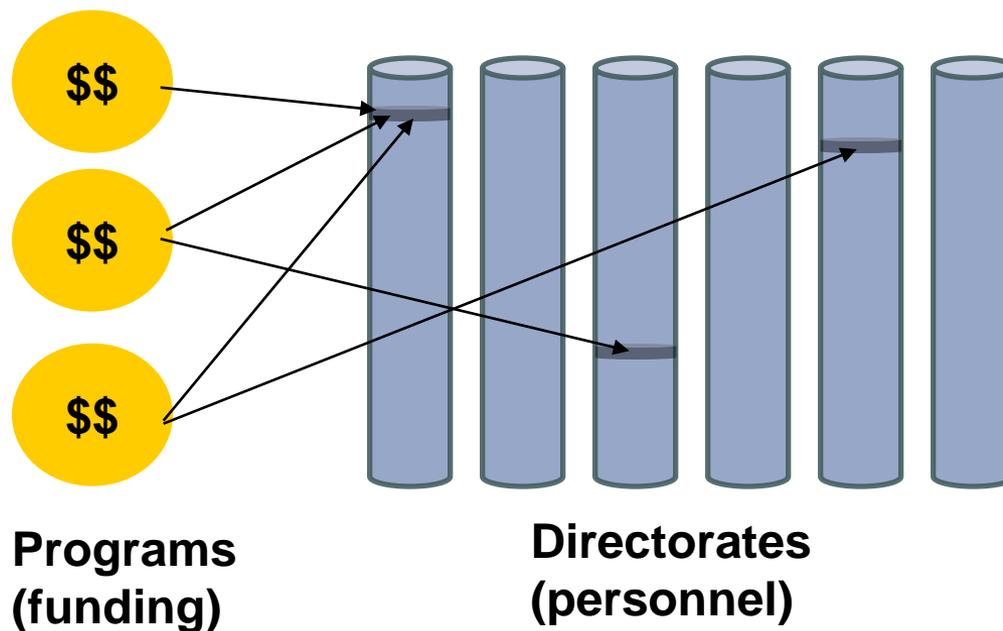
Several factors internal and external to SLSD present significant obstacles to collaboration

- disconnection between resources/problem solvers
- cultural, organizational, functional silos
- conflicts between sourcing internally and externally
- limited external network with external players
- significant NASA barriers to a collaborative culture
- several SLSD-specific hurdles to implementation





Money and people are separated and siloed, although problems are shared

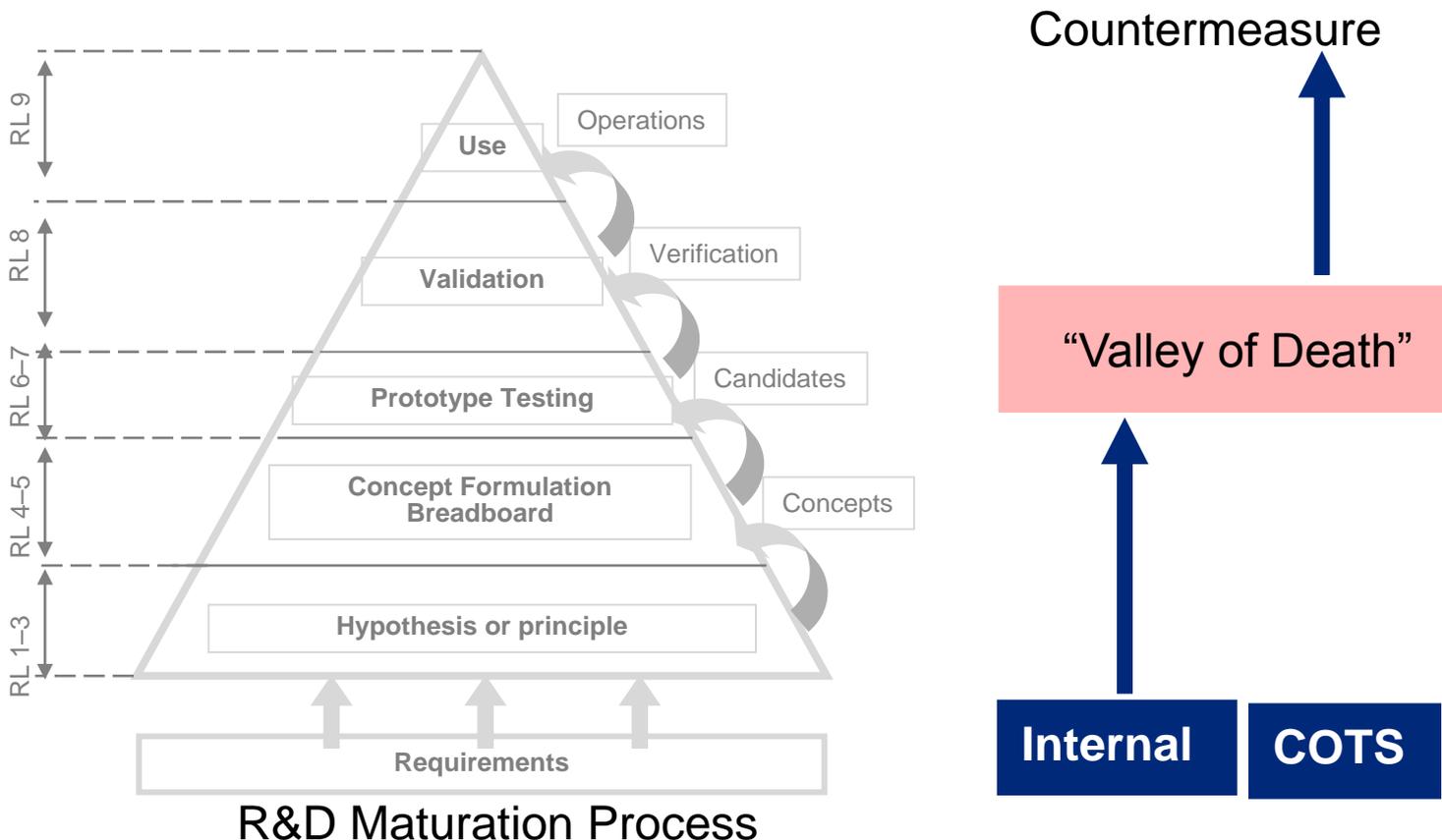


Internal collaboration made difficult by the nature of the organization and how it interacts with itself

- the need.
- the approach.
- the challenge.
- the future.



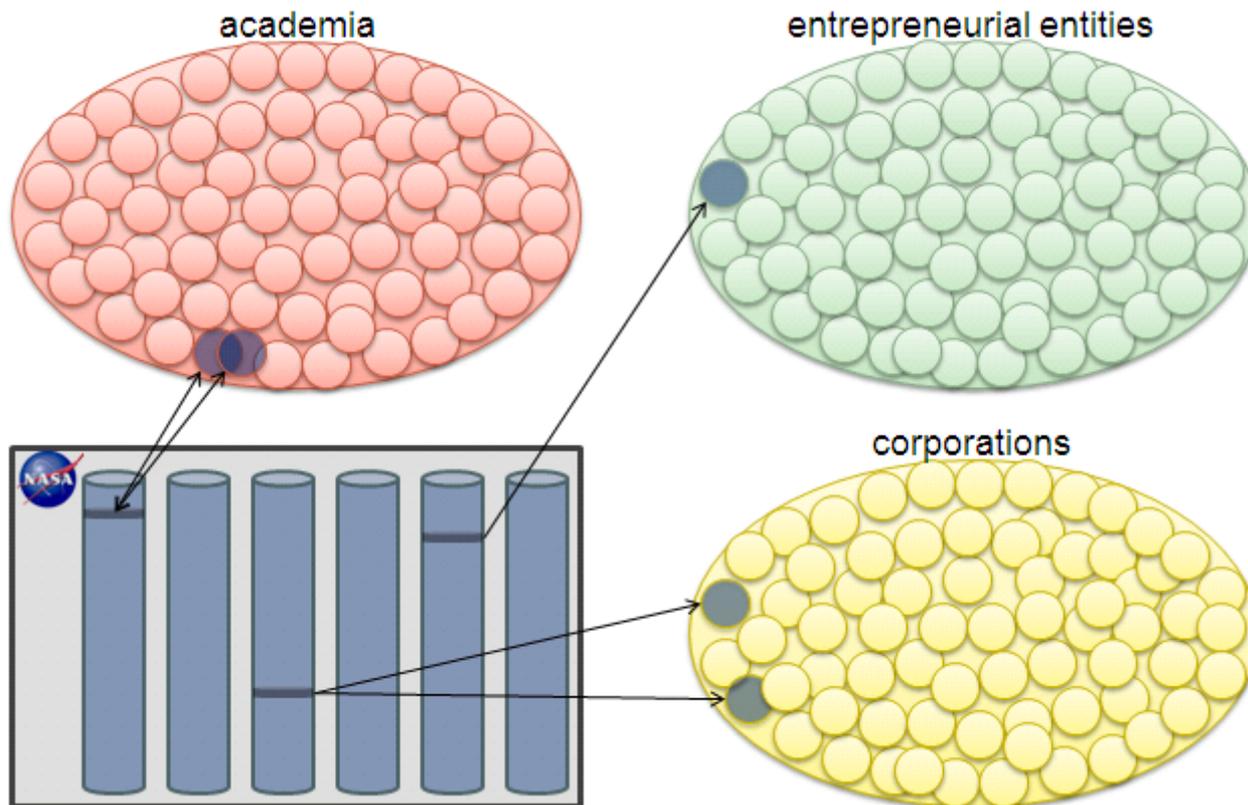
Challenges with both COTS and “NASA Internal” solutions



COTS solutions require extensive validation and modification while internal solutions tend to be abandoned once prototype is developed

- the need.
- the approach.
- the challenge.
- the future.

Current relationships with external entities leaves much to be desired



Internal fragmentation, serendipitous partnerships yield limited external network

- the need.
- the approach.
- the challenge.
- the future.

NASA parent org presents several internal barriers to innovative culture



NASA reality

- “10 Healthy Centers” strategy → Expertise diluted, integration challenges
- “We’re on the cutting edge” → Nobody else worth partnering with
- Indiv. competition for resources → Disincentive to help others within NASA
- Culture: credit for “cool” science → Sharing discouraged; “I did it” culture
- Legal, security, IT firewalls → Cumbersome to share, even internally
- “Innovation compromises safety” → Culture of risk and change aversion
- Aging pop. with high tenure → Formerly agile, status quo now easier

Implication

SLSD recognizes that creating an innovative culture within the NASA umbrella presents unique challenges



SLSD has several hurdles to overcome in the creation of an innovative culture



SLSD reality

Implication

- “Jeff is driving this effort” → Lack of ownership in creating change
- “The best science is done here” → Team unwilling to look externally
- Orgs own \$ or people, not both → External collaboration is “not my job”
- Ops: “research doesn’t get it” → Misalignment on mission contribution
- Research: “ops doesn’t get it” → Misalignment on mission contribution
- “Cool projects” are sought after → NASA priorities not always “cool”

Within SLSD, internal hurdles can be overcome by encouraging external collaboration





Tactical barriers to fostering successful external relationships

Significant external barriers to creating collaborative relationships

- Legal impediments
- Security protocols / export control
- IT firewalls: cumbersome to cooperate
- Bureaucracy slows process: unacceptable externally (e.g.: \$50 exercise bar; 8 mo, \$100K to certify)

Mature partnerships w/ large orgs haven't worked; weak value proposition

- Excessive market risk (Companies unwilling to risk negative publicity of failure in space)
- Insufficient incentives (funding scarce, program timelines long, coordination painful)

Within SLSD, internal hurdles can be overcome by encouraging external collaboration





Successes have been serendipitous

Serendipity (instead of systematic processes) is fostering external networks

- Paint chip gun technology to analyze air → one employee's breakthrough
- Dental carie → researcher's personal relationship with entrepreneurial venture
- Lightweight trauma module → employee aware of concurrent military research efforts

Occasional successes are one-off opportunities, but teach us something

- Large manufacturer of construction equipment (needs overlap, both parties benefit)
- Smaller companies more willing to connect (e.g.: small test tube co. production)
- Those interested in partnering must benefit enough to put up with the NASA hassle

Those most willing to “endure” NASA partnerships are likely to be small, entrepreneurial science orgs





SLSD pursuit of internal collaboration in the face of a challenging environment

SLSD Efforts	Collaborative Element	Goal
Human Risk Forum	Internal communication / Integrated problem-solving	Faster, more efficient solutions
SLSD Newsletter	Internal communication	Better internal coordination
SLSD Strategy Office	Internal organization / communication	Better internal coordination

Within SLSD, internal hurdles can be overcome by encouraging internal collaboration





SLSD pursuit of external collaboration in the face of a challenging environment

SLSD Efforts	Collaborative Element	Goal
TechWatch	Local search	More partners we identify know our problems
Publishing evidence manuals Digital Astronaut	Opening up content knowledge	Modularize knowledge and allow others to contribute
Open Innovation Mall ¹	Broadcast search	Find unknown partners
SBIR/STTR grants VC network via Astrolab Ventures	Find earlier stage R&D	Find unknown partners
Lightweight trauma module Hi-tech company	Partnerships	Develop known partners
Integrated research foundation	Integrated problem-solving	Faster, more efficient solutions

Within SLSD, internal hurdles can be overcome by encouraging external collaboration





the future.

the need.

the approach.

the challenge.

the future.





The future

- Focus of efforts
- Funding
- Communicating value to all is critical
- Culture shift
- Process-based vs. personality-based processes will ensure future success

the need.

the approach.

the challenge.

the future.





NASA SLSD in 1Q 2009: collaboration abundant

- HRP Forum / Board
- Partnerships
- Engaged/aligned leadership (Davis, Grounds)
- Open sharing: Digital Astronaut, Evidence Manuals
- Convergence of people and resources
- Benchmarking studies
- Organizational changes (Strategy office)

SLSD is making significant strides to collaborate, but risks internal reputation of collaboration - should focus energy/message

the need.

the approach.

the challenge.

the future.





Pursue low-hanging fruit

- Initial goals should be loud and visible, but yield measurable success
- Individual contributors should be incentivized to communicate loudly about collaboration successes
- “Innovation Day” should be considered – an opportunity to set the tone for the organization and show-off funding, partnerships, leadership buy-in

SLSD should continue to shift emphasis from discovery-based science to results-based science

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Internal coordination with HRP

- Human Research Program is the key gatekeeper to success of implementation of collaborative strategies
 - HRP owns the money, heavily influences solution strategy
 - HRP buy-in supports SLSD mission
- Give Human Risk Forum official authority
 - Encourage crosstalk between SLSD and HRP
 - Prove success over time, extend further to rest of org.
- Sharing credit (patent rights, knowledge rights, etc.)
 - Standardized processes for collaboration frees up org to collaborate
- One-off strategic alliances not as important as established strategies for assessing challenges

Prove success on a small-scale first; scale-up to distribute through rest of organization

the need.

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Culture shift

Personnel

- consider internships for undergrad and graduate students – objective, fresh perspective
- movement between NASA organizations
- “ambassador programs” – encourage personnel exchange across partner organizations

Communication

- communicate impact – must show and prove success of collaboration
- focus on results vs. science – best solutions make it into space regardless of how they are acquired

Process-based hierarchy of ideas should replace a personality- or position-based hierarchy of ideas

the need.

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Systematically overcome barriers

- Barriers to identification
 - apply framework to identify collaboration opportunities
 - increase transparency in NASA R&D to external entities
- Barriers to prioritization
 - encourage problem-solving “seekers” to look externally
 - prioritize/emphasize external solutions
- Barriers to coordination
 - increase incentives for external partnerships (value solution over process)
 - broadcast efforts internally to allow higher level of transparency / awareness

**Increased transparency and internal focus on results
will yield culture focused on results-based science**



Methodology

Authors:

The preceding slide deck was developed for NASA SLSD for the purpose of internal discussion in conjunction with a Harvard Business School case study

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Timeframe:

Research for this deck was conducted over a six month period from Sep 08 – Feb 09.

Methodology:

Research for this deck was conducted through various means including, but not limited to:

- Individual research through HBS, MIT, external sources regarding collaborative innovation
- 50+ phone interviews with NASA and Wyle employees located around the country
- 3 days in at Johnson Space Center (Houston) interviewing Life Sciences personnel
- Extensive discussions with Professor Karim Lakhani, Harvard Business School Richard Hodgson Fellow

Use:

This deck is not intended to serve as endorsements, sources of primary data, or illustrations of effective or ineffective management practices.



Questions?