Evolution of U.S. Government Innovation Organization: From the *Pipeline Model*, to the *Connected Model*, to the Problem of "*Political Design*"

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GRIPS Innovation, Science and Technology Seminar (GIST),
April 15, 2013

A Close Look at the History of U.S. Innovation Organization…

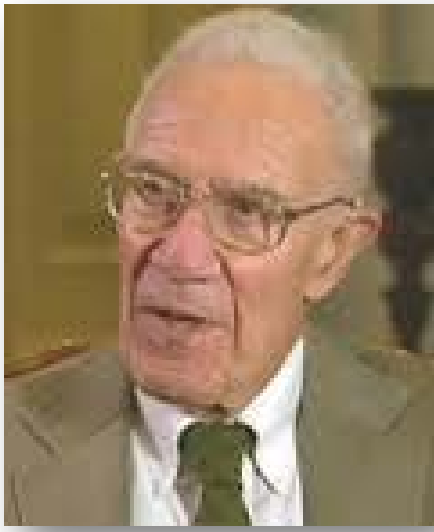
- What has the U.S. government learned about its role in U.S. *innovation organization*?
- Are there organizational lessons?
- And how do we take account of the lessons on "*political design*"?
  - R&D occurs in an intense U.S. body politic
  - We typically design for substance, but:
    - What are the lessons of political design, that buttress the substantive design?

Lessons from the Four Periods of U.S. Innovation Organization…

- ***Background:*** – U.S. Innovation Economics
- Period 1 – U.S. Science Organization in 1945 – from a "connected" model in WW2 to a "disconnected" model in the Postwar
- Period 2 – Sputnik 1957 - Defense returns to the connected model – the DARPA example
- Period 3 – the Competitiveness Period of the 1980s – elements of the Connected Model in Civilian Agencies
- Period 4 - Applying the Connected Model to Energy – the 2000s
- ***Political Design Lessons*** from Each Period

BACKGROUND – Innovation Economics – the Economic Backdrop to the U.S. Innovation Agencies

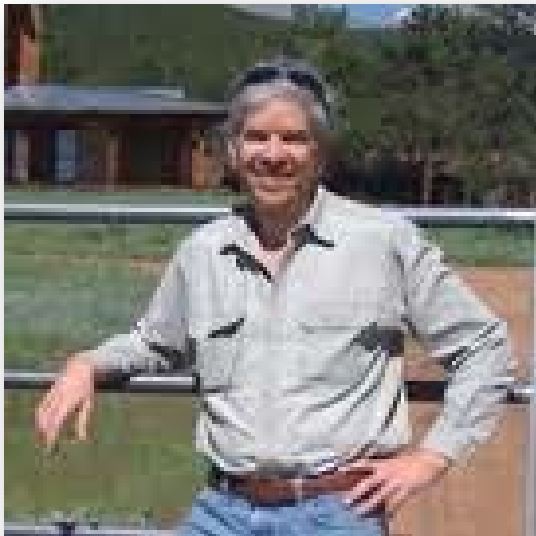
Part I: Background: U.S. "Innovation Economics"



- Robert Solow – key to growth: "technological and related innovation" (shorthand: R&D)
- Paul Romer – behind technology: "human capital engaged in research" – prospector theory (shorthand: Talent)
- 2 Direct Innovation Factors –

  R&D and

  Talent



Innovation Economics Summary, con't

- Richard Nelson:
  - Idea of innovation as a *complex system*
  - Operates at a national scale
  - Can do comparative analysis of national innovation systems
  - System operates at the INSTITUTIONAL LEVEL - look at connections, interaction between innovation actors in public and private sectors
- *IS INNOVATION ORGANIZATION A DIRECT INNOVATION FACTOR?*
- Note - INDIRECT Innovation Factors, too
  - Mix of indirect and direct innovation factors interacting in a complex innovation ecosystem

Three Pictures of the Innovation System:

- The Linear Model of Innovation

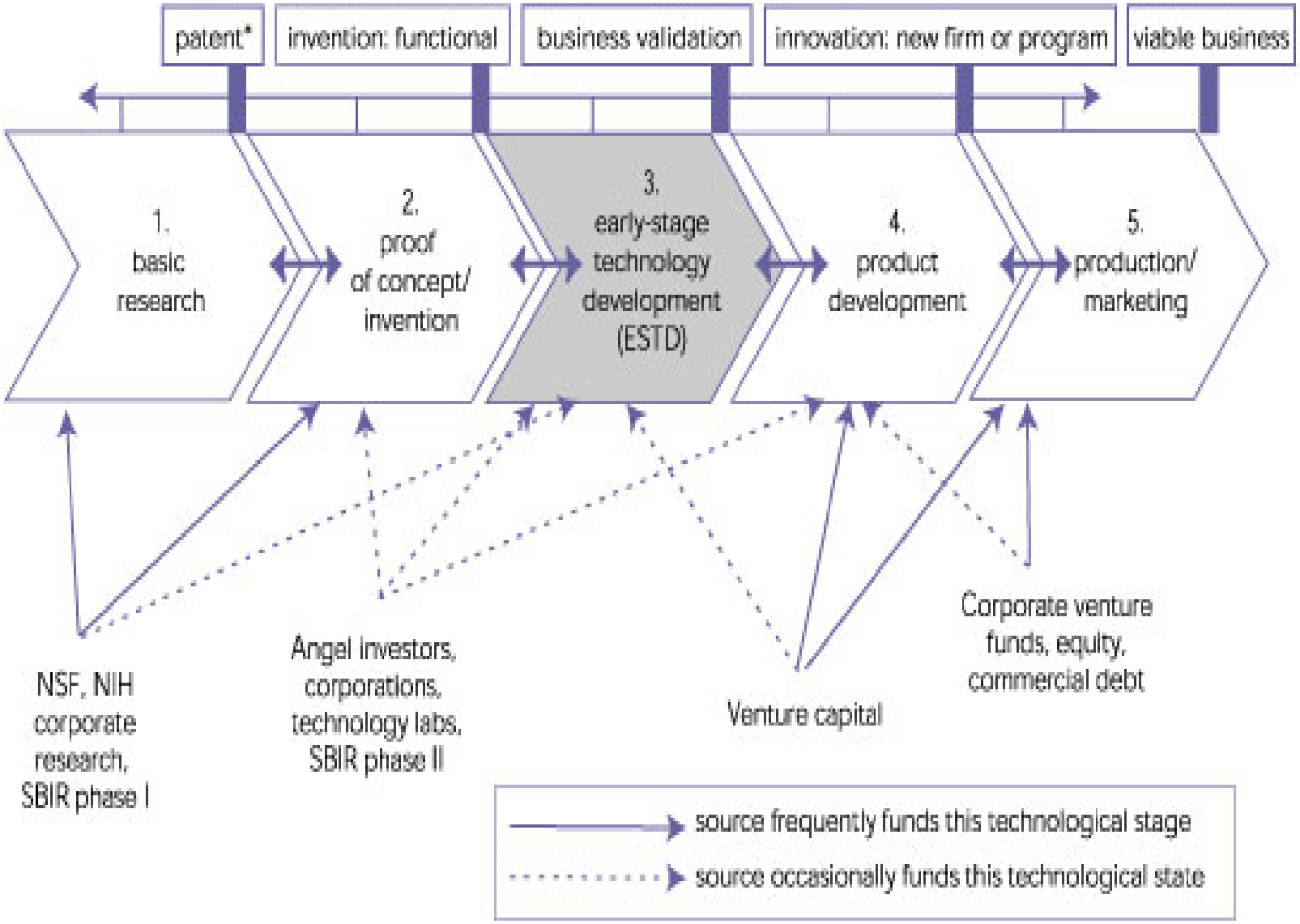
  Verses:

- The Innovation Valley of Death

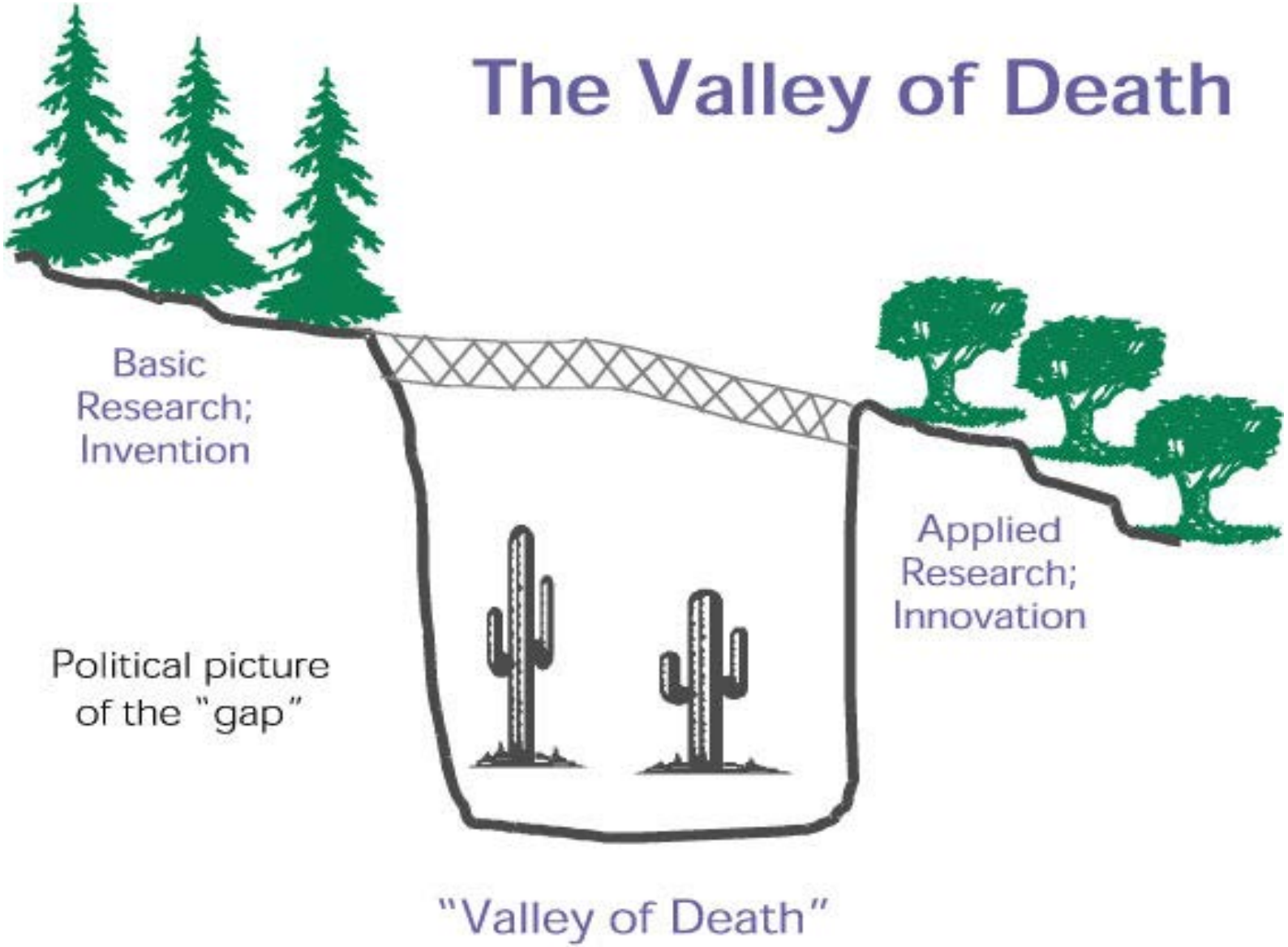
  Verses:

- The Innovation Darwinian Sea

The Pipeline/Linear Model (Branscomb & Auerswald):



The Valley of Death:



The "Darwinian Sea" (Branscomb & Auerswald): Innovation is a Two-Way Street - L to R, R to L

Period 1 – U.S. Science Organization in 1945:

From a “connected” model in WW2 to a “disconnected” model in the Postwar

Period 1: WW2 – the *Connected Model* for R&D and Innovation and the Postwar *Disconnect*

- The "Rad Lab" and Alfred Loomis – connected model

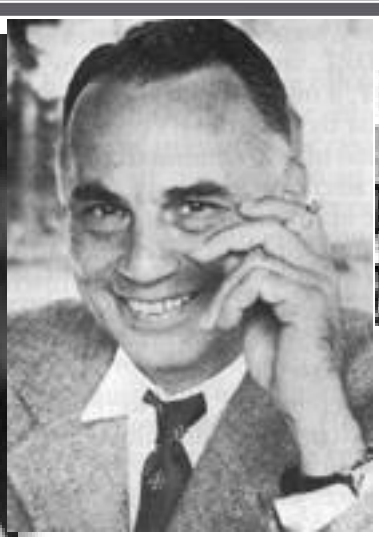
THEN:

- The Postwar – Vannevar Bush, and the Stokes Critique – the disconnect

The WW2 Rad Lab:

E.G. Bowen, Lee DuBridge, I.I. Rabi and the “Cavity Magnetron”

Alfred Loomis – “the last of the great amateurs of science” – Luis Alvarez



Alfred Lee Loomis 1887-1975

Early military radar syst

ALFRED LEE LOOMIS

November 4, 1887–August 11, 1975

BY LUIS W. ALVAREZ

THE BEGINNING of this century marked a profound change in the manner in which science was pursued. Before that time, most scientists were independently wealthy gentlemen who could afford to devote their lives to the search for scientific truth. The following paradigms come to mind: Lord Cavendish, Charles Darwin, Count Rumford, and Lord Rayleigh. But after the turn of the century, university scientists found it possible to earn a living teaching students, while doing research "on the side." So the true amateur has almost disappeared—Alfred Loomis may well be remembered as the last of the great amateurs of science. He had distinguished careers as a lawyer, as an Army officer, and as an investment banker before he turned his full energies to the pursuit of scientific knowledge, first in the field of physics, and later as a biologist. By any measure that can be employed, he was one of the most influential physical scientists of this century. In support of that assessment, one can note: (1) his election to this Academy when he was 53 years old, (2) his honorary degrees from prestigious universities, (3) his crucial wartime role as director of all NDRC-OSRD radar research in World War II, and (4) his exceedingly close personal relationships with many of the leaders of American science and government in the mid-twentieth century.

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Alfred Loomis and the Rad Lab

- Loomis – investment banker for electrical utility sector, but loves science
- Sells interests before the 1929 Crash
- Founds private lab in Tuxedo Park, NY; leading world scientists work there
- Becomes informal science advisor to his cousin Henry Stimson, Sec. of War in 1940
- British give him the “cavity magnetron” – key to microwave radar in 1940
- In weeks, he founds the “Rad Lab” at MIT to develop microwave radar for WW2 – war winning technology

Loomis and the Rad Lab, con't

- The Rad Lab Does Development
  - Loomis moves Rad Lab into the continuum from fundamental science base to applied science
  - By August 1942 Loomis works for collaboration with Army so that technology becomes tied to Army's "doctrine" – (its fundamental approaches to military problems)
  - But keeps Rad Lab out of military
  - Tied to production firms
  - Loomis adds engineering design, design for mfg., and mfg. prototyping to role of Rad Lab
  - INVENTS: integrated, Federally Funded Research and Development Center (FFRDC) science lab – creates the connected R&D model

Loomis and the Rad Lab, con't

- CHARACTERISTICS OF RAD LAB - Model for the Postwar FFRDC:

  GREAT TALENT
  - 10 Nobel prizes go to Rad Lab scientists

  FLEXIBLE FUNDING
  - Loomis himself advances the funds for start-up
  - Contracting with industry is non-bid; Loomis just awards – there's a war on

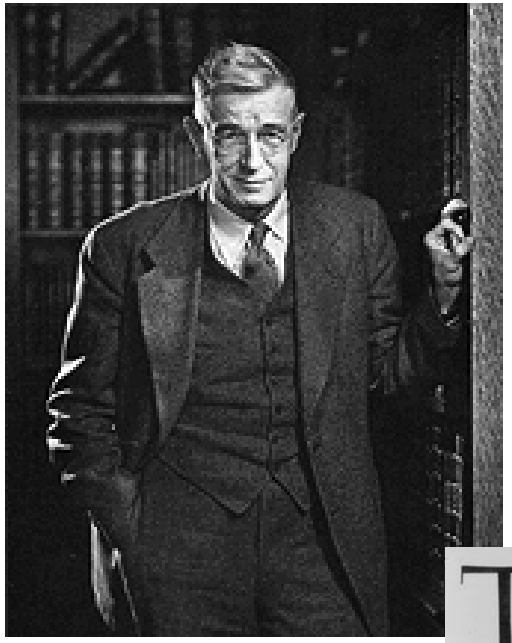
  LOOSE, INFORMAL ORGANIZATIONAL MODEL
  - Non-bureaucratic org., loose, interacting groups teams; Leadership based solely on talent
  - "easy camaraderie"; casual tone; interactive
  - "long hours"
  - Almost all scientists – few in support staff – at first, 36 scientists, 1 secretary

  ABILITY OF LAB HEAD TO GO TOP
  - Loomis heads Rad Lab – reports officially to V. Bush of National Research Defense Committee (NRDC) (which oversaw the development of radar and atomic bomb during WWII)
  - BUT- frequently goes directly to War Sec. Stimson
  - Loomis forces slow military bureaucracy to adopt new technology
  - SO: another key to Rad Lab – access to top decision-makers
  - *[NOTE: These rules become DARPA rules]*

Loomis and the Rad Lab, con't

- **Postwar: Rad Lab's Connected Model *Ends***
  - Loomis shuts down Rad Lab shortly after the end of the war
    - Decides it won't work without war pressure
    - Retains deep faith in private enterprise
  - Vannevar Bush shares his view
    - Bush fights to retain gov't role in basic research

Vannevar Bush, 1890-1974



Vannevar Bush, "Science, The Endless Frontier" (1945) – *Disconnected Science*

- 11/17/44 – Pres. Franklin Roosevelt writes Bush (did Bush draft it for him?) – asks for a postwar plan for the federal role in R&D
- Bush's "new frontiers of the mind"
  - Takes historians' concept of the role of the frontier in American life
  - Proposes new *science* frontier as next American frontier
- V. Bush's paper comes out in July 1945 after FDR's death – it is the <u>most influential policy paper ever written on US science organization</u>

Vannevar Bush, “Science, The Endless Frontier”, con’t

- BACKGROUND:
  - V.Bush is thinking through the postwar model for US science, thinking about the gov’t’s future role
  - The “connected” model dominates WW2
  - V.Bush *dis*-connects science away from this model – Why?
    - Probably convinced politics will dismantle the WW2 model of integrated research and development
    - Wants to salvage basic research for a gov’t role
    - Concerned that applied science dominated WW2 – sees need to restore basic science

Vannevar Bush, “Science, The Endless Frontier”, con’t

- V. Bush’s Report Defines the Future Direction of US Science Progress:
  - Bush announces new popular causes for US Science
  - Science is to be “part of a team” for “health, security, prosperity” –
  - separates science as a separate player from other innovation actors – against “connected” model for science
  - Announces 3 goal areas for science:

1) “War Against Disease” Direction:

- Bush and FDR saw huge medical gains in WW2
- Antibiotics key – reduced disease, cut death from disease in WW2 to .6/1000, from WW1 of 14,1/1000
- Health provides new public purpose for science

Vannevar Bush, “Science, The Endless Frontier”, con’t

2) National Security Direction:

- Pre-Cold War, but argues military research in peacetime vital for US security, can’t rely on allies (lesson of WW2 preparedness)
- But insists on Loomis’ Rad Lab approach – must be civilian control of defense science, with “close liaison” to military
- Because National Science Foundation (NSF) is not formed until after Cold War starts, NSF was never assigned defense R&D

3) “Public Welfare” Direction:

- Goal is “full employment” – big postwar anxiety
- Proposes idea that “basic research is public capital”
- Science role is to add capital, value to innovation system, not to dominate it or be integrated into it

4) Nurture “Talent” Direction:

- Bush envisions gov’t role in educating science talent

Vannevar Bush, “Science, The Endless Frontier”, con’t

- Bush has a “pipeline” theory of innovation:
  - Science with gov’t backing will contribute basic research, not applied
  - Industry will apply it to practical problems
  - Gov’t role is to increase “scientific capital” by supporting academic research
    - This form of research is removed form “pressure for immediate tangible results”
  - Bush’s idea: remove science from the fray – protect it, put it back into the ivory tower
    - Is that a good idea?

Vannevar Bush, “Science, The Endless Frontier”, con’t

- Bush calls for a single “New Agency” to carry out the directions he proposes for US science:
  - Bush argues that US science requires “long range research programs” – basic research - which will be based on “stable funding” – hence agency at arms’ length from gov’t
  - His model agency becomes NSF – but delayed
  - Other R&D agencies stood up in the meantime

The Postwar R&D Agencies Follow the Vannevar Bush Basic Research Model

- The delay in standing up NSF leads to expansion of other R&D agencies
  - U.S. adopts decentralized multi-R&D agency model for historical reasons
- Office of Naval Research (ONR)
- Dept. of Energy Labs
- National Institutes of Health (NIH)
- National Science Foundation (NSF) – not adequately funded until 1958
- Etc.

The Critique of the Vannevar Bush "Disconnect": Prof. Donald Stokes, 1928-1997

- Dean of the Woodrow Wilson School at Princeton
- Died of Leukemia shortly after finishing "Pasteur's Quadrant"

Donald Stokes, Pasteur's Quadrant, con't

- Stokes argues Bush's basic research cannon has two parts:
  - "It is performed without thought of practical ends"
  - "Basic research is the pacemaker of technological improvement"
- Bush belief: understanding and use are conflicting goals, so basic and applied research must be separate
  - "applied research drives out pure"
- Bush: aimed to persuade the policy community that investment in basic science would yield the technology to solve a broad spectrum of national needs.

Donald Stokes, Pasteur's Quadrant, con't

- BUSH'S ORGANIZATIONAL PLAN IS DEFEATED
  - Bush Plan – Put Science under One NSF Tent
  - But the delay in setting up NSF results multi-agency decentralized approach

- BUT: BUSH'S BASIC SCIENCE IDEOLOGY TRIUMPHS IN FIRST GENERATION U.S. SCIENCE AGENCIES

Donald Stokes: Summary

- In WW2 - Vannevar Bush creates a connected model for innovation
- Post-war – he creates research univ., basic research only, disconnected model - institutionalizes the "Valley of Death"
- **Bush's segmented *linear/pipeline model:***

Basic → applied → development → production

- No wonder US has had historic trouble converting its leadership in technology inventions into products – Bush made this a suspect activity
- Assumed advances flowed left-right, research to applied – *but* innovation is a 2-Way Street

Stokes' Pasteur's Quadrant:

Search for fundamental under-standing	Consideration of Use? No	Consideration of Use? Yes
Yes	**Pure basic research –** ***- Ex- Nils Bohr***	***Use inspired basic research*** ***- Ex- Louis Pasteur***
No	**Review of the particulars not the general** ***- early Darwin***	**Pure applied research –** ***- Ex- Thomas Edison***

Political Design Lessons from Period 1:

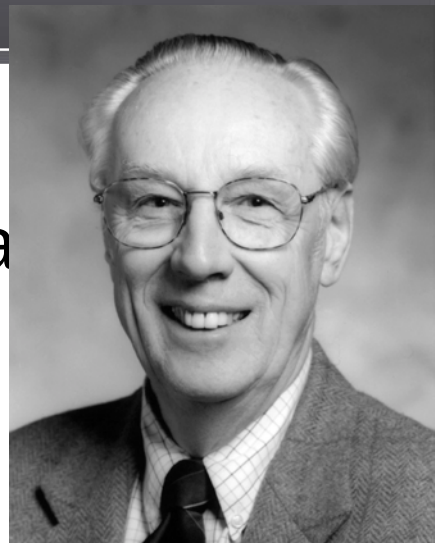
- *Period 1: Post-1945 – creation of numerous new innovation institutions and large labs on a basic research model:*
- *Rule 1*, *Beware of Scale*; when an innovation agency reaches a large scale in a particular locality, this multiplies its political support, this may limit future research and mission flexibility.
- *Rule 2*, *Don't let Narrow Front advance cancel out the Broad Front*; a large-scale research effort at an entity focused on a particular area of advance may crowd out and limit a broader front for science and technology advance.

Period 2 – Sputnik 1957 - U.S. Defense Department Returns to the "Connected Model"

The Sputnik Agencies

- SPUTNIK - 1957:
  - Leads to "Golden Age" of US Science
  - Sputnik transformed NSF from a small agency; tripled funding to $134m in '59 and grew to $500m in '68
- NASA – Sputnik also led to founding of NASA in 1958 – had portfolio of space mission applied science, but also related basic science
  - Continued US trend of specialized science agencies
  - Sputnik also forced Congressional reforms – strong science Committee for space and general science formed in the House
  - Sputnik also forced major science education reforms in K-12 education, and strong federal support for graduate science education
  - NSF also began supporting science facilities and equipment in Universites.
- And DARPA…

Period 2: The Defense Dept.'s Parallel Universe



- So: most of US R&D on basic research/pipeline model -- but there is a parallel universe:
- BUT: Vernon Ruttan - "*Is War Necessary for Economic Growth*"
  - Dept. of Defense (DOD) rebuilt the connected model of WW2 for the Cold War – *could not take a disconnected model*
  - Launched: aviation, nuclear, space, computing, internet – major innovation waves
  - DOD: *Pervasive role at all stages of the pipeline* – from: R -> to D -> to prototype -> to demonstration -> testbed -> to creating initial market

Defense Advanced Research Projects Agency – DARPA – Back to the Connected Model

- DARPA Formed from Sputnik Challenge in 1958
  - Pres. Eisenhower frustrated by separate service space efforts – took it way from them and put DARPA in the Sec. of Defense's office
- Mission: Avoid "technology surprise" like Sputnik
- Spurred fundamental military and commercial breakthroughs – high speed computing, internet, stealth, etc.

Innovation: Both Institutional & Face-to-Face

- Innovation Organization: the third innovation factor (after R&D and Talent):
  - Institutional and face-to-face – innovation is personal, people innovate not institutions
- Bennis/Biederman – great innovation group theory
  - The "Great Groups" Ruleset
  - Ex's of Great Groups: Industrial Revolution, Edison, Rad Lab, Oppenheimer, Transistor group, Xerox Parc – Bob Taylor, Genentech, Venter, DEC
  - Great Groups have a common ruleset
- *DARPA creates "great groups" of innovators – combines institutional/personal elements to foment innovation*

The DARPA Model

- DARPA – innovation at the institutional level – connected science, and it is initiator of great groups – operates at *both* levels of innovation

Well-known Elements in the DARPA Culture:

- Flat; empowered program managers (PMs)
- Talented, entrepreneurial program managers; 3-5 year term – change agents
- Challenge-based, "right-left" – *UPFRONT RESEARCH VISIONING*
- Research is performed outside DARPA by the top performers in the field - "hybrid" model
- Projects are "high-risk / high payoff"
- Short-term funding for seed efforts; then scale to promising concepts
- Terminate non-performing projects
- Connected Science – tied to DOD system
    - Again: R to D to prototype to demo to testbed to initial market creation – can use DOD procurement to spur markets for new tech's
- "One hundred geniuses connected by a travel agent"

DARPA – Return to the Connected Model

- **Key points:**
- DARPA returns to the "connected model" – tied to DOD
- DARPA is a "right/left" Challenge Approach

  Compare: Vannevar Bush: Left/Right Pipeline approach
- DARPA operates at the two levels of innovation –

  - The institutional level, connected to other DOD elements that can further its innovations

  AND

  - The face-to-face, personal level of innovation – it forms innovation "great groups"

Political Design Lessons – Period 2

Period 2: 1957 Sputnik – the connected Defense Model and creation of DARPA:

- *Rule 3: Think Innovation System* – When innovation is looked at as separated institutional elements rather than as a connected system, inefficiencies are built into the system. Overcoming that disconnect, making the links, the 2-Way Street, have been key to DARPA success. *Consider the implementation pathway not just the research, and innovation at both levels: institutional and personal/"great groups."*
- *Rule 4*, *Tie to a Mission* - particularly if a new entity will be involved in late stage development along with research, it may face ideological challenge, so it must be tethered to a strong, politically-recognized mission area to justify its tasks. This has been key to DARPA's success – tied to a mission, national security.

Further Design Lessons from DARPA…

- How do you do multigenerational technology thrusts?
- How do you do strategic technologies efforts that are complementary?
- How do you build a strong advocacy as well as idea-sharing community?
- How do you link to other innovation actors?
- How do you take on technology incumbents?
- How do you stay tied to leadership – agency and industry – that can push your advances?
- What are the ways to encourage initial market creation?
- How do you take advantage of gov't testbed and procurement roles?

Period 3 - the Competitiveness Period of the 1980s – Elements of the "Connected Model" in Civilian Agencies

The 1980s – the Valley of Death Innovation Organizations: Reconnecting

- 1970-80s – Japan Launches the *Quality Manufacturing Revolution*

- U.S. realizes it's slow to transition technology from its basic research emphasis to its disconnected industrial sector
- Adds new connected elements in the 1980s to do this:
  - Bayh Dole Act – to give universities a stake in tech transfer - *Worked*
  - SBIR – to bring small startup companies into the innovation process – *Design flaws*
  - Manufacturing Extension Program (MEP) – bring new manufacturing technologies and processes to U.S. small manufacturers - *Worked*
  - Advanced Technology Program (ATP) – grants for technology advances to small and mid-size firms – *Failed – mission and support constituency problems*

Political Design Lessons: Period 3

- *Period 3: The 1980s Competitiveness Period – pushed the connected model toward civilian R&D agencies – some survived, some failed*
- *Rule 5, Must design R&D programs to have a Supporting Constituency* - will only survive if they are designed to have a strong supporting constituency that will back their funding and mission. (ATP Problem.)
- *Rule 6, The Supporting Constituency Must Want Quality* - when designing constituency support, ensure that the selected constituency base will support a quality program consistent with the substantive program design, not divert it to its own ends. (SBIR problem.)

Period 4 - the 2000s - Applying the Connected Model to Energy

2000s - The Problem of Energy Innovation

- DARPA – tends to innovate in defense-supported sectors, and related frontier technology areas
- But: innovation in established, complex, established sector like energy is a much more complicated proposition

Difficult Because the US is a Covered Wagon Culture

- U.S. is good at completely new things
- Don’t like your neighborhood?
- Take a covered wagon over the mountain to new territory
- This is also true in technology --
  - U.S. good at standing up completely new things - creating new functionality
  - We’re used to standing up technology in open fields - like computing
  - We pack our metaphorical Tech Covered Wagons and Go West, leaving Legacy problems behind

U.S. Innovations Like to Land in Unoccupied Territory. Energy is Occupied Territory

- With energy, parachuting new technology into occupied territory -

  - and will be shot at

- We're not good at going back over the mountains in the other direction - at rediscovering established territory and bringing innovation to it - we don't do West to East
  - We do biotechnology, we don't go back and fix the health care delivery system.
- Yet huge gains not just from the new but fixing the old

A Complex, Established "Legacy" Sector is a "Non-Level Playing Field"

- Existing technologies are heavily subsidized and politically powerful
- New entrants are up against an established *Techno-Economic-Political Paradigm*
- Alternative technologies are evolving
- Must be price competitive immediately upon market introduction against legacy competitors that don't pay for environmental or geopolitical costs

Problem of "New Functionality"

- **IT: new functionality** added to the US economy - major new functions, accompanying productivity gains
- Energy - more complicated
  - Still have cars, electricity still from wall outlets
  - But: over time: new functionality - LED light walls, distributed power - takes time to evolve
  - Throughout: efficiency gains that translate over time into productivity gains in all sectors
  - Productivity gains crucial to innovation waves
- **Consumers will pay a premium for first generation of new functionality** products
- But **first gen of new energy won't offer much new functionality**
- So: ***R&D strategy has to consider R&D that drives down cost to introduce new technologies at scale***

The Missing Backend Role of DOD in Energy

- Dept. of Energy (DOE) organized around Frontend R&D - only innovates up to the prototype stage
- But testbeds and initial markets – the Backend - are needed in energy
- Unlike DOD, DOE does not play an acquisition role – it has no real technology procurement role - DOE does not buy or sell technologies
- Creates a big backend challenge for DOE in energy

Origins of the Advanced Research Projects – Energy – ARPA-E

- "Advanced Research Projects Agency – Energy" –> ARPA-E
  - Proposed in National Academy report "Gathering Storm" in 2006
  - Authorized in "America Competes Act" 2007
  - Initial Appropriations: $300m FY2009/10 from economic stimulus bill
  - Current Appropriations : $275m in FY12
- *Conscious attempt to apply DARPA model to energy – a "connected" model for energy*

Comparing the ARPA-E and DARPA Models

A) ARPA-E has incorporated the DARPA model:

- *Flat, non-hierarchical*
- *"Empowered" Program Managers*
- *Streamlined approvals*
- *Challenge-based "right-left"*
- *Revolutionary breakthroughs*
- *World-class talent*
- *Fast hiring*
- *Project duration: life of the PM*
- "*Other transactions authority*"
- *"Hybrid" model*
- *"Island/bridge" model*

New Elements at ARPA-E

- **Forcing Mechanism: Energy challenge different – so 3 new areas:**

1) *Sharpening Research Visioning, Selection, Support*
2) *Building a Support Community*
3) *Technology Implementation*

New Elements at ARPA-E, con't

Particularly Important – the Connected Model Elements:

Re: Technology Implementation:

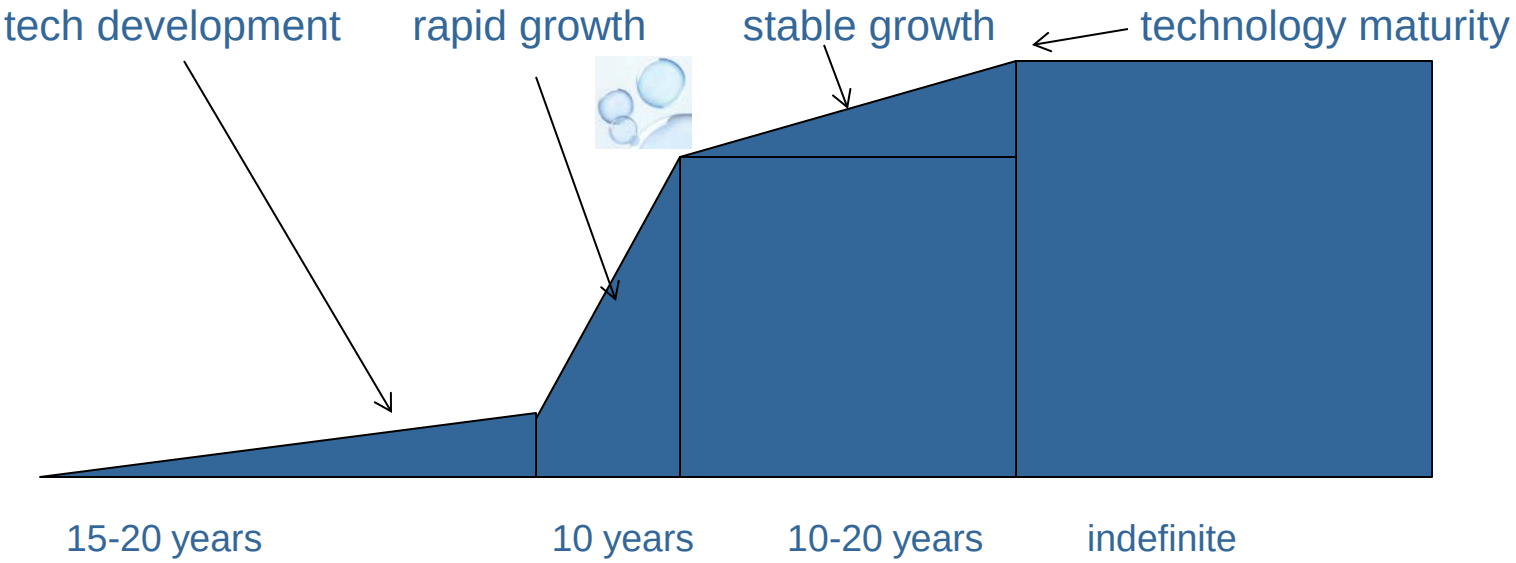
- Designs R&D to drive down cost
- Considers implementation in selecting the R&D project
- Uses "In-reach" within DOE
  - Connects to other DOE agencies, labs
- Tie to DOD for testbeds/initial markets
- "Technology-to-market" Commercialization team
  – Has actual commercialization team that works to connect researchers to industry implementation
- Uses "Halo Effect"

Summary: DOE Needs to Consider DOD Systems Model

- DOD played key role in the IT revolution by playing at every stage of the innovation system
  - From research to development to demonstration to test beds to financing to procurement to creating the initial market
  - But note: it was tied to strong private sector pick up – and IT: private sector lead
- An energy transformation is at least as hard as IT
- Energy requires operating at all the stages of the system, frontend and backend
- *DOE and ARPA-E need to build their "backend" implementation reach – innovation must be seen as a system*
- Q: Will Congress continue to back ARPA-E? allow a

Innovation Wave Theory

- Kondratieff growth wave:



Energy as an Economic Wave?

- Energy - Next technology revolution?
  - **Could it be new tech *innovation wave*, drive efficiency throughout the economy?**
  - **If you can get an energy tech revolution into innovation wave status, it goes on autopilot**

Political Design Lessons – Period 4

- *Rule 7*, *Bring the Grant-Losers into the Community, too*
- *Rule 8*, *Make Agency Rivals into Allies*
- *Rule 9*, *The Agency Start-up is the Moment to Build Political Support*
- And *Rule 10, Analyze the Innovation Gaps and Build Industry Support for Filling the Gaps*

- *Will elaborate on these rules in a minute…*

Closing:
10 Design Lessons from the Four Periods

OVERALL POINTS --

- *Innovation Organization* *is a* *Direct Innovation Factor*
- U.S. increasingly seeing, in its designs for innovation organization, the need to move to a *more connected R&D system*
- What are some of the particular *political design lessons*?

Political Design Lessons – Period 1

- *Period 1: Post-1945 – creation of numerous new innovation institutions and large labs on a basic research model:*
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Political Design Lessons: Period 3

Period 3: The 1980s Competitiveness Period – pushed the connected model toward civilian R&D agencies – some survived, some failed

- *Rule 5, Must design R&D programs to have a Supporting Constituency* - will only survive if they are designed to have a strong supporting constituency that will back their funding and mission.
- *Rule 6*, *The Supporting Constituency Must Want Quality* - when designing constituency support, ensure that the selected constituency base will support a quality program consistent with the substantive program design, not divert it to its own ends.

Political Design Lessons – Period 4

Period 4: Energy Technology – lessons from ARPA-E and new energy agencies:

- *Rule 7*, *Bring the Grant-Losers into the Community, too* - because the number of grant applications will exceed the number of grants awarded, which alienates much of the strongest potential political support community for an agency, those that it could fund. An agency should offer alternative ways to build its support base, offering additional services aside from grants to its applicant pool, such as mentoring, or connections to industry or as a convenor for a research community.
- *Rule 8*, *Make Agency Rivals into Allies* - to avoid inter-agency rivalry where a new program will be seen as a funding competitor, the new program should attempt to integrate rival agency entities into its deliberations and complement their missions, supporting their efforts as well as its own, to coopt the existing programs.

Political Design Lessons – Period 4, con't.

Period 4, con't – Energy Technology, ARPA-E –

- *Rule 9*, *The Early Agency Start-up is the Moment to Build Political Support* - the launch process is key to building political support; the agency creation process should be viewed as an opportunity to build a supporting constituency for the new program in the process of forming for it, and as a chance to create Congressional understanding and buy-in. Congressional and support group launch surprise should be avoided.
- And *Rule 10, Analyze the Innovation Gaps and Build Industry Support for Filling the Gaps* - innovation in Legacy economic sectors, such as energy, health care delivery and manufacturing, requires an analysis of gaps in those innovation systems, particularly of the applied side and back end of the pipeline, from prototype and demonstration to commercialization. Since industry likely dominates the applied side and back end in these established sectors, careful cultivation of industry support will be required for backend organizational interventions.

Domo Arigato!