

# At the Intersection of Science, Technology, Engineering, and Business: Addressing Global Issues

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## Introduction<sup>1</sup>

This short paper puts forward the hypothesis that a source of sustainable competitive advantage for a state (i.e., nation) is its ability to execute the STEB (science, technology, engineering, business) cycle faster than other states (i.e., the competition).

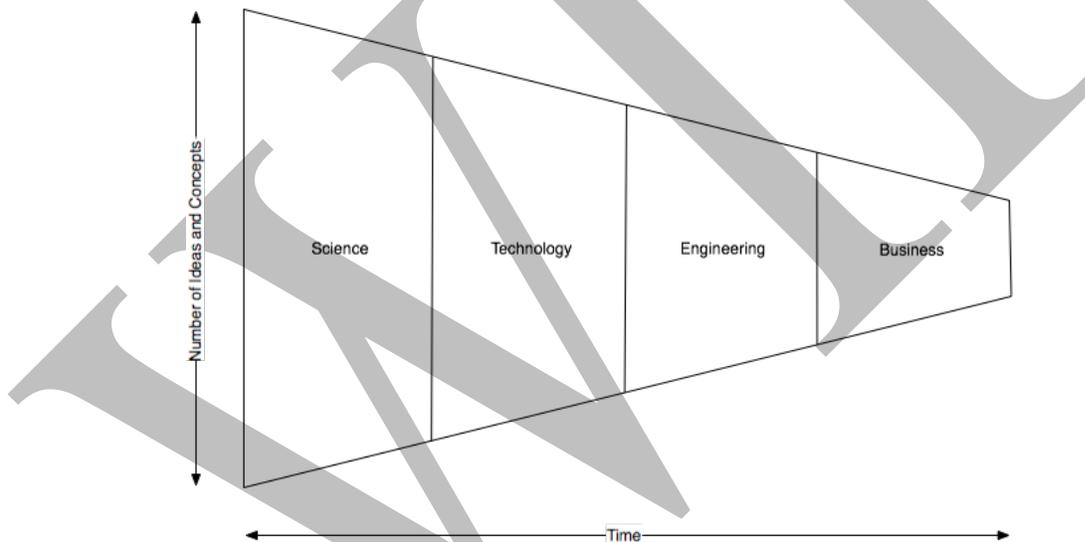


Figure 1 The Basic Model

The fundamental argument is that the STEB components are related as shown in Figure 1. The slope of the line represents ideas rejected from a previous stage. For example, not all of the original ideas in science make it through to technology.

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<sup>1</sup> The idea for this short paper came from a Call for Papers for the International Science, Technology and Engineering Conference ISTECC 2013.

If a state is to become more competitive it needs to “squish” the basic model. That is, the number of ideas and concepts must increase, and the time to move through the four stages must decrease.

Taken up herein are the questions of process and protocol, on the one hand, and on the other hand, the set of knowledge, skills, experiences, and behavior that must be exhibited by the personnel critical to the success of this idea. This, of course, extends to the education required of the human component of the competitive system.

This is not intended to be a coherent theory, but rather an initial, and hopefully useful statement of the issues that draws on a variety of ideas from different sources.

## **Requirements for the Squish (horizontal)**

Two obtain:

1. Shorten the time in process (e.g., engineering).
  - a. Process reengineering (i.e., eliminate all process, tasks, and steps which do not add value; simplify that which remains).
  - b. Improve the speed and quality of the messages that link processes.
2. Improve the protocols. Protocols are the rules for networking processes, tasks, and steps.

These protocols should embody the principles of communication.

- a. The grammar and syntax of the messages being exchanged are understood.
- b. The information communicated in the messages is relevant.
- c. The medium of communication is acceptable.
- d. There is a desire to communicate.
- e. There is confirmation of understanding (Drogan, 2009). A common protocol reduces the transactions costs (i.e., the time to hand a concept or idea off between one meta-process and another).

These precepts deal with shortening the time (i.e., squishing horizontally). This notion of process improvement is well researched and likely needs no further attention here.

However, what about the protocols? What meta-protocols allow the meta-processes to communicate more effectively and efficiently?

And what about expanding vertically? This requires the generation of new ideas. How is this to be accomplished?

## Requirements for the Squish (vertical)

Think of squeezing a balloon. The volume or area remains constant and, as a consequence the vertical dimension increases in a squish.

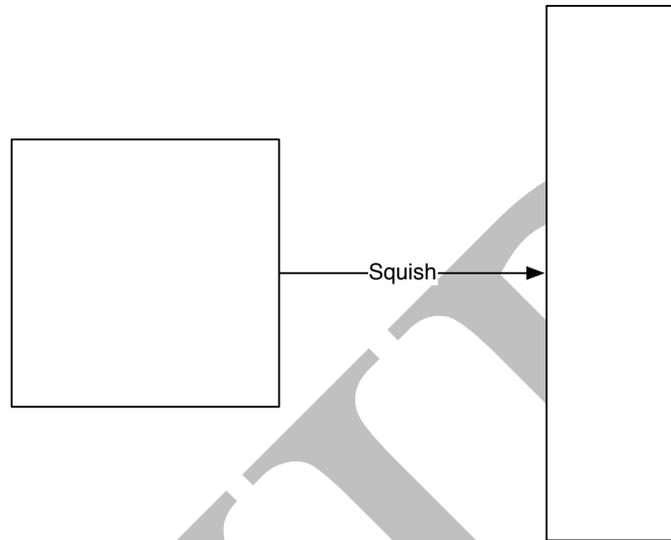


Figure 2 The Squish

The implication with respect to Figure 1 is that the ideas automatically increase in the case of the squish. Of course this is not true. In fact, it seems possible that the squish might actually reduce the number of new ideas.

## Time

The hypothesis is that it is difficult to schedule the insight and imagination that leads to the ideas from which innovation springs.

Before we dive into the nuances of scheduling innovation, we first need to go over some of the basics of scheduling. The first is a simple equation for how long a task will take:

$$\text{Duration} = \text{Effort} / \text{Resources}$$

So, in order to know how long a task will take, you need to know how much effort it takes along with how many resources you can apply. All too often, even seasoned managers, plan a project based on the duration of the tasks and not the effort. It is important to understand the difference and base your project plans on effort. The reason is that figuring out the effort is much easier than the duration. The duration depends on resources and resources that can be highly variable. Resources can be doing multiple things, have never done the task before or be on vacation. All of these variables can be taken into account as long as each task is in terms of effort not duration. A general rule of thumb is that your tasks should be in days of effort not hours or minutes – that is just too granular. (Bolander, 2009).

How does one know how much effort or the nature of the resources required to generate an idea? This seems to me to be an unanswerable question. Consider the following.

After many experiments, first with carbon filaments in the early 1880s and then with platinum and other metals, in the end Edison returned to a carbon filament. The first successful test was on October 22, 1879; it lasted 13.5 hours. Edison continued to improve this design and by November 4, 1879, filed for U.S. patent 223,898 (granted on January 27, 1880) for an electric lamp using "a carbon filament or strip coiled and connected to platina contact wires".

Although the patent described several ways of creating the carbon filament including "cotton and linen thread, wood splints, papers coiled in various ways", it was not until several months after the patent was granted that Edison and his team discovered a carbonized bamboo filament that could last over 1,200 hours. The idea of using this particular raw material originated from Edison's recalling his examination of a few threads from a bamboo fishing pole while relaxing on the shore of Battle Lake in the present-day state of Wyoming, where he and other members of a scientific team had traveled so that they could clearly observe a total eclipse of the sun on July 29, 1878, from the Continental Divide. ("Thomas Edison," 2013).

I very much doubt that Edison scheduled the innovation that resulted in the first commercially practical incandescent light. Note also the origination of the idea.

I speculate that the squish might actually reduce the number of new ideas because what gets squished out is that most important of resources, time.

I began to work on first-of-a-kind projects in the late 1960s. First-of-a-kind projects would not be first-of-a-kind if the ideas were known. First-of-a-kind projects depend on the Aha! moments. These moments are a function of time and the knowledge, skills, experiences, attitudes and behaviors of the members of the project or innovation team.

A critical decision is thus how far to squish in the time dimension. I suspect this is far more an art than a science.

## **The Innovation Team**

The phrase "innovation team" is borrowed from MIT ("Innovation Teams," 2013). "The Innovation Teams (I-Teams) course brings together students from MIT Sloan and the MIT School of Engineering for a semester-long project, assessing the commercial feasibility of novel MIT technologies" ("Innovation Teams," 2013). Note that this notion of commercial feasibility is the endpoint of Figure 1 The Basic Model.

Innovation Management.se provides a set of ideas for building the I-Team (Fudge & Roca, 2013). I've included short clips from the Fudge and Roca item to further elaborate on their ideas.

### **1. Start by building a bigger box rather than trying to think outside it**

The box represents the sum of the experiences, skills, professional networks and academic knowledge that the team possesses collectively. The more diverse the backgrounds of the team are, the bigger the box they will have to draw from (Fudge & Roca, 2013).

For example, suppose the object is to identify innovative ideas directly related to the maritime industry.<sup>2</sup> One might want to have a team comprising all the disciplines deemed necessary for an effective and efficient maritime industry.

## **2. Select your team for *who* they know as well as *what* they know**

The old adage of “it’s not what you know but who you know” is true for innovation teams. Every innovation team needs well-connected team members, who, with one glance at their Rolodexes (or iPhones) can find answers and call in favors, fast. As management guru Jon Katzenbach explains, “In an innovation team, there is no way to divorce the individual innovator from his network.” Access to a strong network provides insight into a broader range of knowledge, but it also provides support. An innovation team that doesn’t take advantage of its networks will be less successful (Fudge & Roca, 2013).

Hard-earned experience suggests a factor for success at least as critical as any other is that *one know what one knows, know what one doesn’t know, and know those who know what one doesn’t know.*

## **3. Pick one leader and provide him or her the autonomy they need to be successful**

First, having just one appointed leader on the team is optimum. While some innovation teams have experimented with leadership duos or trios, they have rarely succeeded. One entrepreneur, Tim Ogilvie who was part of a three-way leadership team at a software startup remarked, “Any innovation team that has more than one leader isn’t set up for success.” He reasoned that the key downsides are inefficient decision-making and lower morale: “Equal voting rights creates gridlock over decisions and grumpy partners!” A solo leader is free to own the vision and make final decisions, which helps him keep the process moving along fast – a vital trait in this kind of work. For the leader of the innovation team, continuing to press forward even with imperfect information is better than stalling progress while waiting for elusive data points (Fudge & Roca, 2013).

## **4. Build a team that can both identify gaps in the market and markets in the gap**

We all know that a good business idea usually fills a gap in the market – the idea addresses some sort of unmet need for which there is no other solution currently available. That is an important start, but it isn’t enough to be considered true innovation. Innovation happens when there is not only a good idea, but also real customers willing to pay for it – that is to say, there is also a market in the gap.

Being able to assess the size of a market is often the part that innovation teams find easier... While there is no doubt of the value that financial analysts bring, this unfortunately doesn’t ensure that the idea is good to start with. It’s impossible to staff a team full of analysts and expect them to come up with anything truly innovative.

To generate creative ideas and identify gaps in the market, nothing can replace the original insights gleaned through a team member trained in ethnography (Fudge & Roca, 2013).

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<sup>2</sup> Think Malcolm McLean and containerization.

Apple is perhaps the best example of finding the gaps in the market. Who besides Jobs knew we needed iPhones.

## **5. Find team members who tell great stories**

In our experience, the ability to communicate the new business idea is almost as important as the quality of the idea itself. Whether you are presenting to your boss, your colleagues or to a panel of Venture Capitalists, it is absolutely vital that they come away with a clear understanding of the concept's value proposition, and a shared enthusiasm to make it successful. A good storyteller can help make this a reality (Fudge & Roca, 2013).

The example that comes to mind is, "First, I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth" (Kennedy, 2007).

## **6. Understand the difference between good and bad conflict**

While we strongly believe that a diverse innovation team will achieve the best results, there is no doubt that bringing together such a wide variety of people who have different roles, thinking preferences and perspectives will lead to some interpersonal friction...

... "The value of the team and its ability lives in the diversity of their perspectives, but we also know that accomplishing things in the face of very diverse perspectives is difficult to do."

In fact, not only is some conflict inevitable, but perhaps it is even desirable. Katzenbach said, "People think you put teams together because they are compatible, well you sure don't want that on an innovation team! You certainly want team members to learn to work together, but you don't want compatibility because you want their ideas to challenge each other."

Managing and profiting from this inevitable, but desirable conflict, is amongst the most difficult of tasks. Emotional intelligence<sup>3</sup> in the members of the team is critical.<sup>4</sup>

## **7. Supplement the innovation core team with an external provocateur**

In some cases teams lacking a spark should consider hiring a wild card member, who in the words of Katzenbach, will come up with "eight crazy ideas and two really good ones." Any interpersonal idiosyncrasies that they might bring are more than mitigated by their potential to come up with a game-changing idea or insight. We like to refer to this role as that of the "Irritant." This is not to say that they must in fact be an irritating person, rather that their personality and experiences are in such contrast to that of the rest of the group that their mere presence can act as a boost of energy (Fudge & Roca, 2013).

Here is where the concept of emotional intelligence can be most sorely tried.

< Insert Cappeto's view of thinking aloud >

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<sup>3</sup> Emotional intelligence is the ability to identify, assess, and control the emotions of oneself, of others, and of groups.

<sup>4</sup> In 2000 an opportunity for a consulting engagement for one of the largest ocean container shipping companies in the world was likely lost because of the lack of emotional intelligence.

## 8. Remember to set goals and measure progress

Some innovation teams neglect to set goals at the start of a project because the range of possible outcomes from the project are so extreme... Even though it might seem to be a difficult exercise, teams that don't have the discipline to set goals upfront are likely making a mistake.

Starting off by...painting an image of the future that the whole team buys into feeds the team's hunger for success while also mitigating conflict. "When team members are confident, they are all striving for the same goal, interpersonal conflict is lessened," because the only things they can disagree on will be how to achieve those goals.

This is perhaps one of the more difficult of the tips from Innovation Management.se to come to grips with for it seems to constrain the creative instincts.

## 9. Think like a startup entrepreneur

After spending time with successful entrepreneurs, we were struck by the stories they told about the high levels of motivation and focus they displayed at their peak. This level of commitment and engagement is hard to mimic in a large corporation, where members of innovation teams often work under less pressure. In fact, we've often been surprised to see members of corporate innovation teams going about their work in a "business as usual manner" in stark contrast to the approach of startup entrepreneurs whose passion often drives them to work long hours and make other personal sacrifices for the good of the business. Much of the innovation taking place in today's world is happening because of entrepreneurs and if big corporations are going to keep up, mindsets and behaviors among innovation teams will need to change (Fudge & Roca, 2013).

## 10. Ensure team members have "both feet in"

According to Carter Griffin from Technology VC firm, Udata Partners, successful innovators have a unique mindset. The mentality is one that they "have to put their entire being behind this initiative, as the ones who try to hedge fail. The ones who don't pour their soul into it typically don't make it" (Fudge & Roca, 2013).

Curiosity and courage seem to be the underpinning of successful I-Teams.

*In How Do You Talk to Big Data?* I ask:

What do

Nobel laureates,

Winners of the John Bates Clark Medal,

Pulitzer recipients,

winners of the Fields Medal,

awardees of the Man Booker Prize, and

Hugo Awards recipients

have in common? They ask, and sometimes answer, hitherto unknown questions.

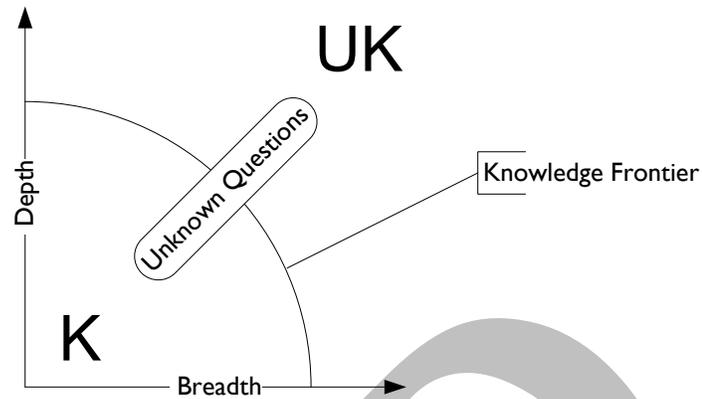


Figure 3 Unknown Questions

The K labels the region of the known in terms of both breadth and depth. The UK represents the unknown (undiscovered knowledge in Figure 5 Knowledge Movement on page 7 [of the referenced document]). The hypothesis here is that one discovers new meaning by asking unusual questions on both sides of the knowledge frontier.

Innovation, arising from the answers, is the progenitor of progress. Thus, to restate from page **Error! Bookmark not defined.**, there is a need for innovative questions, of seeing things through different and multiple lenses, of curiosity, and of being unafraid to ask what might seem to be irrelevant questions (Drogan, 2011) .

If, therefore, we are to squish in a meaningful manner we need to assure that the assembled I-Team has the proper composite of knowledge, skills, experiences, attitudes, and behaviors.

No easy task, this.

## Education

Whence the knowledge, skills, experiences, attitudes, and behaviors (i.e., capabilities)?

These capabilities can be developed, purchased, or rented.

Education is one aspect of development. For example, we might ask which courses support the development of the innovation tips mentioned above.

		Courses				
		C <sub>1</sub>	C <sub>2</sub>	C <sub>...</sub>	C <sub>n-1</sub>	C <sub>n</sub>
Innovation Tips	1. Start by building a bigger box rather than trying to think outside it					
	2. Select your team for who they know as well as what they know					
	3. Pick one leader and provide him or her the autonomy they need to be successful					
	4. Build a team that can both identify gaps in the market and markets in the gap					
	5. Find team members who tell great stories					
	6. Understand the difference between good and bad conflict					
	7. Supplement the innovation core team with an external provocateur					
	8. Remember to set goals and measure progress					
	9. Think like a startup entrepreneur					
	10. Ensure team members have "both feet in"					

These capabilities may not be fully developed by the educational system. And perhaps they should not be.

Consider the following finding from a formal review of the MBA program at London Business School: “The corporate leaders we interviewed indeed produced an extensive

list of qualities they desired in future recruits, but almost none involved functional or technical knowledge. Rather, virtually all their requirements could be summed up as follows: the need for more thoughtful, more aware, more sensitive, more flexible, more adaptive managers, capable of being molded and developed into global executives” (Barker, 2010).

Perhaps it is possible for formal education to over-develop its students.

Academic programs prepare graduates for the external environment. Hence, a view of the effectiveness of the program is the degree to which successful completion has prepared the graduate for their chosen career as measured, say, by their uptake by industry. This is affected by the knowledge, skills, experiences, attitudes, and behavior deemed important by organizations in the industry (adapted from Drogan & Sturges, 2012).

Academic success depends upon the degree to which it aligns with industry (Drogan, 2012).

The purchasing of capabilities refers to the hiring of appropriate people. The rental refers to the use of consultants. No more will be said about these two options in this paper.

## Policy

“Innovation is not available by decree” (Pilling, 2013).

Policy exists at all levels of an organization. Here we are concerned with the policy of the state.

Policy is considered to be the formalization through law of relevant regimes. Robert O. Keohane (2004, p. 495) cites Stephen D. Krasner as defining international regimes as “sets of implicit or explicit principles, norms, rules and decision-making procedures around which actors’ expectations converge in a given area...” Here, we are concerned about the explicit, but appreciate the influence of the implicit.

The state is confronted with a complex agenda that is generally, especially in democracies, a melding of the needs and wants of various groups.<sup>5</sup> For an interesting discussion of regimes in corporations see *Blue Magic* (Chposky & Leonsis, 1988).

The seminal question is whether the policies of the state will allow the emergence of a more efficacious innovation cycle.

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<sup>5</sup> A camel is a horse designed by a committee. An expression critical of committees—or by analogy, group decision-making—by emphasizing the ineffectiveness of incorporating too many conflicting opinions into a single project. In this figure of speech, the distinguishing features of a camel, such as its humps and poor temperament, are taken to be the deformities that resulted from its poor design (“A camel is a horse designed by a committee,” 2013).

## Protocols

Of critical importance are the protocols that link science, technology, engineering, and business.

It seems reasonable that the science principal would be motivated by confirmation that the idea under consideration is likely to find favor with the downstream meta-processes. The converse is also true. The business principal would be motivated by confirmation that the idea under consideration in the science meta-process is likely to fill a need or want recognized by the final customers.

What then, would be the characteristics of a common protocol that would unite science, technology, engineering, and business that would result in an increase in ideas that moved swiftly through the process structure to make a difference in the market?

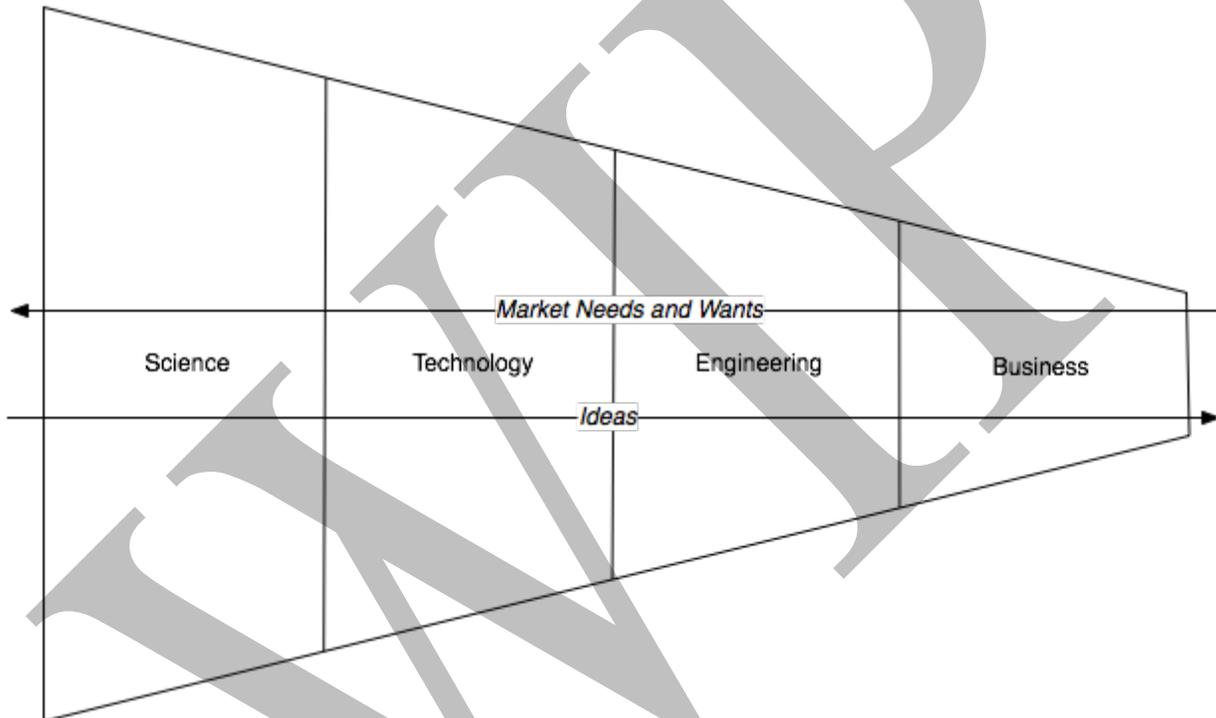


Figure 4 Protocols

At an abstract level the protocols are of two types; 1.) the wants and needs of the market, and 2.) ideas that emerge upstream from the market.

It's difficult to conceive of a single protocol stream that would satisfy all principals, but it does seem possible that a common protocol stream could be interpreted in ways that would be sensible to all principals.<sup>6</sup>

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<sup>6</sup> Much like the biblical miracle of tongues.

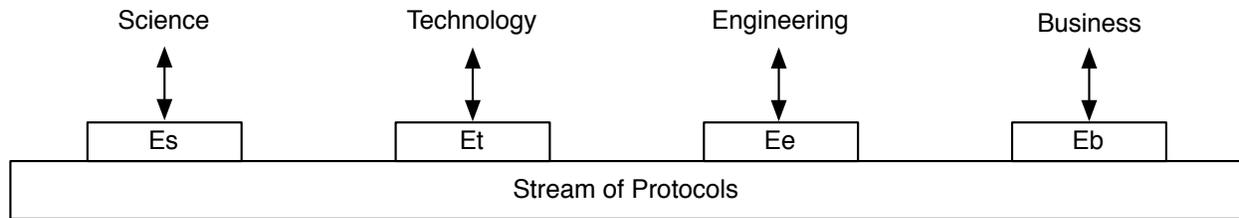


Figure 5 Protocol Streams

The small rectangles above are meant to represent a means whereby the principals can interact with the protocols using a familiar grammar and syntax.<sup>7</sup>

## Incentives

Machiavelli reminds us

There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new (Machiavelli, 1995).

Herein is being discussed “a new order of things.” One ought to appreciate and prepare for the reluctance of individuals to change.

Lou Gerstner, writing in *Who Says Elephants Can't Dance?* (Gerstner, 2002, pp. 148–149), makes the following points:

One of the obvious but puzzling causes of IBM's decline was an inability to bring its scientific discoveries into the marketplace effectively. The relational database, network hardware, network software, UNIX processors, and more – all were invented in IBM's laboratories, but they were exploited far more successfully by companies like Oracle, Sun, Seagate, EMC, and Cisco.

During my first year at IBM I probed frequently and deeply into the question of why this transfer of technology innovation into the marketplace performance had failed so badly. Was it a lack of interest on the part of IBM researchers to deal with customers and commercial products? It did not take long to realize that the answer was no.

The major breakdown was on the product side, where IBM was consistently reluctant to take new discoveries and new technologies and commercialize them. Why? Because during the 1970s and 1980s that meant cannibalizing existing IBM products, especially the mainframe, or working with other industry suppliers to commercialize new technology.

Bill Gates, interviewed by the *Financial Times* (Waters, 2013), provides another interesting perspective on incentive.

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<sup>7</sup> The E is taken from epiphany.

These days, it seems that every West Coast billionaire has a vision for how technology can make the world a better place. A central part of this new consensus is that the internet is an inevitable force for social and economic improvement; that connectivity is a social good in itself. It was a view that recently led Mark Zuckerberg to outline a plan for getting the world's unconnected 5 billion people online, an effort the Facebook boss called "one of the greatest challenges of our generation". But asked whether giving the planet an internet connection is more important than finding a vaccination for malaria, the co-founder of Microsoft and world's second-richest man does not hide his irritation: "As a priority? It's a joke."

Then, slipping back into the sarcasm that often breaks through when he is at his most engaged, he adds: "Take this malaria vaccine, [this] weird thing that I'm thinking of. Hmm, which is more important, connectivity or malaria vaccine? If you think connectivity is the key thing, that's great. I don't."

Experience suggests that the human motivational factors associated with scientists, technologists, engineers, and business people are different.

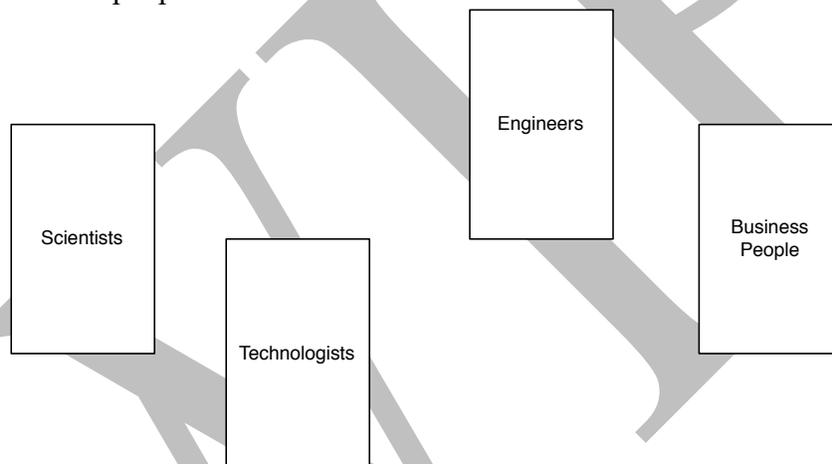


Figure 6 Alignment

What, then, is the incentive structure that causes the human behavior that will enable the desired innovation? As I consider this aspect of the intersection I'm reminded of "Systems aligned with human motivational factors will sometimes work. Systems opposing such vectors will work poorly or not at all" (Gall, 1975).

Perhaps Maslow ("Maslow's Hierarchy of Needs," 2013), especially the concepts of self-actualization and esteem, provides a useful starting point for considering this issue.

## Cross-Cultural Considerations

A big story of the year so far has been the discovery of the Higgs Boson at the Large Hadron Collider of CERN.

The term CERN is also used to refer to the laboratory, which employs just under 2,400 full-time employees, 1,500 part-time employees, and hosts some 10,000 visiting scientists

and engineers, representing 608 universities and research facilities and 113 nationalities (“CERN,” 2013).

While CERN may be an extreme example of the confluence of cultures for the accomplishment of a mission, it is also representative of the world in which we find ourselves; a world of globalization. Those involved in innovation will increasingly find themselves in an intercultural environment that will help shape the approach to achieving a jointly help goal.

**T**here is ample evidence that cultures of the world are getting more and more in contact. The business world is becoming increasingly global. The United States exports around \$850 billion every year, over 70% of American industry are facing stiff foreign competition within the U.S. market, and the U.S. is also the largest recipient of foreign investment in the world.

Although globalization opens many opportunities, it also creates many complex challenges. That is why a survey of Fortune 500 firms showed that having competent global leaders is the most important factor in business success. The same survey showed that 85% of executives do not think they have an adequate number of global leaders.

In this paper we present important findings from the GLOBE project that can enhance global managers’ cultural acumen. GLOBE is a research program consisting of 150 researchers who for the past several years have been collecting data from 18,000 middle managers in 62 countries.

How do people make decisions in this intercultural environment?

The clip to the left (Javidan & House, 2001) is indicative of the nature of this subissue.

On the other hand, the thrust of this document has been on what the state must do. The temptation is, therefore, to restrict involvement in the innovation effort to those most closely aligned with the culture of the state.

We are all citizens on Buckminster Fuller’s Spaceship Earth (“Operating Manual for Spaceship Earth,” 2013) and it’s thus difficult to imagine that a monoculture will triumph at innovation.

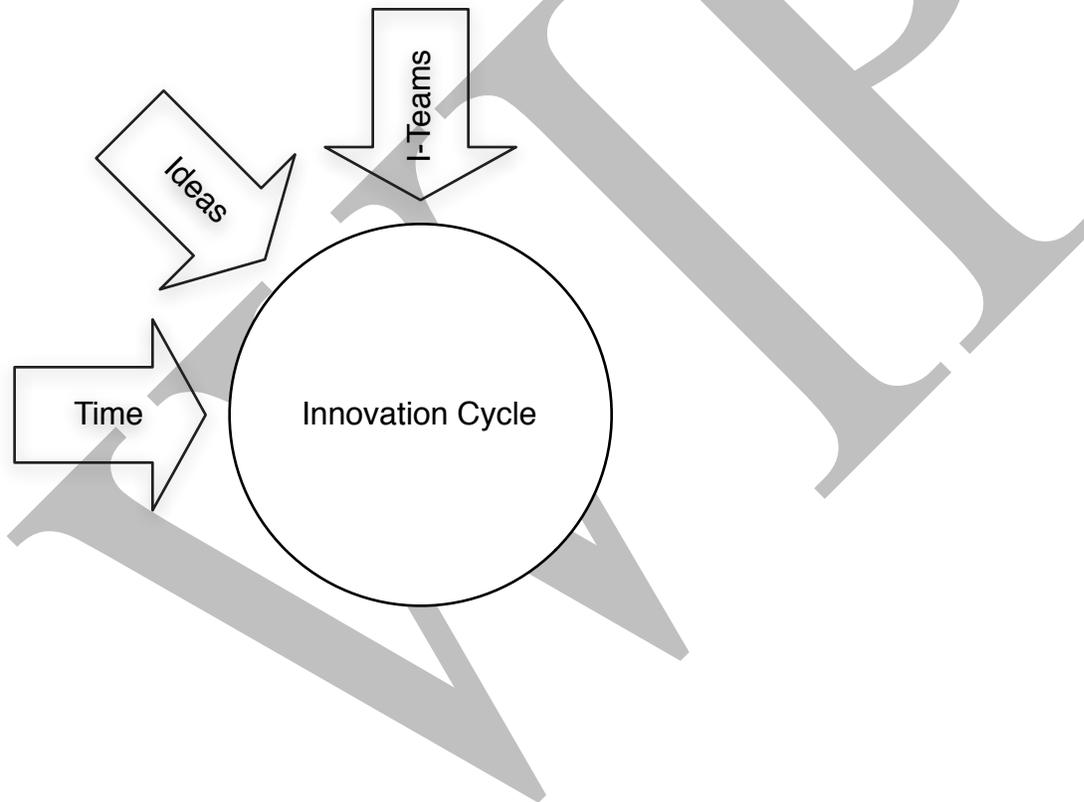
This being the case, how then ought I-Teams be constructed and managed to achieve the desired results. Perhaps more importantly, will state policies allow for this?

## Implications

The world of work, the world for which we are preparing our students, is changing at an increasing pace. Two books, *Average is Over* (Cowen, 2013) and *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies* (Brynjolfsson, 2014), make this abundantly clear. We need to assure, to paraphrase Daniel Pink, that we are preparing our students for their future, and not our past.

## Coda

Put forward herein is the thesis that sustainable competitive advantage is important to a state and that this can be achieved by executing the STEB cycle faster than the competition. The initial suggestion is that consideration of a number of forces is required.



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