

Getting More Bang for Our R&D Bucks

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Abstract- While some may want to argue the point, many believe it is innovation and the resulting technology that provides society with the impetus to advance and to provide the greatest value to the members of that social order. Some would also argue that advanced or advancing technologies provide the fastest way to improve the health, wealth, and well being of the individual. Independent of these arguments, it is clear that innovation, particularly the game-changers, has had an accelerating impact on the development of almost every social order on this planet. It is through the creativeness of the individual, plus the organized efforts of research and development programs that have allowed the fostering of ever-growing numbers of new innovations in every aspect of society: agriculture, medicine, transportation, communication, etc. What may be of particular note is that some of the earlier and most contributive to the innovation race are currently less than effective than they once were, or possibly others are simply out-running them. The United States, plus several others, was one of the earlier contributors to the technology revolution. By most of the standard global measures it is clear the US has not maintained the edge in technology and innovation that was, for many decades, the beacon to a large portion of the rest of the world. While the US is not the only country that has allowed the innovation gap to slip and in some cases to reverse, it may be very representative of the reason the rest have also slowed their progress. More importantly, the reasons may have very little to do with capabilities, resources, education, manpower, etc. It may simply be managed expectations, thus the purpose of this paper.

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1. THE HOME REPAIR ANALOGY

Let's start and later finish an analogy. In this scenario you find yourself in need of getting something fixed around your house: plumbing, electrical, or maybe carpentry. If you are young and/or inexperienced or new to the locale, you might check the phone book, or your computer, for someone suitable for the job or call on a family member for their help. You might even consider the task yourself and then, if the skill-set and learning curves aren't too great and the cost to equip the effort isn't prohibitive, you might decide to perform the work yourself. For a lot of us, this last alternative may later find us calling on outside help once the extent of the project is realized or we have exacerbated the problem beyond all hope of our repair. There is also the more annoying case where you do not know the extent of the problem and the symptoms are, at best, under-defined and sporadic. Patience now becomes the game with the hope that the symptoms will become better defined or the problem will simply go away. Unfortunately, waiting can make the situation worse and add unforeseen future additional problems. Independent of what you eventually choose to do, a few discussions with a neighbor or colleague may provide proper direction, diagnosis, or at least the name of a trusted someone who might help. Whatever the methodology, the choice of random calling for help or advice will most likely become expensive, time consuming, and not guaranteed to fix the original problem. For the veterans among us, you most

likely can look at the problem yourself and decide if it is something you want to tackle or seek expert assistance on. More importantly, with a little experience and time in the saddle, you probably already have a list of those people that you can trust to diagnose the problem and get to the solution as expediently and inexpensively as possible. As you mature and gain more experience, this list of problem-solvers will become larger and better defined. More importantly your ability to distinguish the "I know" from the "I think I know" how to fix the problem becomes more pronounced. You will also learn, often the hard way, that hiring your best friend, the neighbor's relative, the best advertised, or the most prestigious is a clear recipe for disaster. Just because you are great at one thing doesn't necessarily mean you are great in everything else. In fact, by definition, it means you clearly aren't unless, of course, you are lucky enough to have found that one in a million - don't bet on it. Also, accepting somebody else's obligation to use their friend or relative, or someone with an enhanced personal interest in the outcome of your effort will not improve your prospects for an acceptable solution.

2. R&D RETURN ON INVESTMENT

So, what does the process of getting your home projects successfully completed have to do with Return on Investment (ROI) in Research and Development (R&D)? Actually, everything. The story above is similar in too many cases for those companies and organizations that are

looking for that next great idea/product or another way to improve, streamline, or economize current work products. That need to innovate is like the home repair example above. The questions normally boil down to recognizing the problem and then finding the best problem solver. This then becomes a game of who to choose, along with the difficult task of developing the outcome expectations and program measures to use to encourage a successful, cost-effective result. It may seem a stretch to compare the analogy above with the efforts required to innovate through the complexities of the R&D process. There are acknowledged and notable differences between basic and applied research, product development compared to process improvements, and finally evolutionary versus disruptive innovation. The definable characteristics and descriptive inter-relationships of each are well defined in the open literature and as such will not be covered here. Suffice it to say that while each is different in perceived intent and the approaches to their solution, the overarching need to complete the effort is not that unique. The distinctive differences flow from the initially proposed outcome metrics and what is regarded as successful progress, plus each price point. At least this seems to be the way the process should be approached. Without clear process and outcome expectations, what you get is the popular phrase, "just fix it". While this might have a place in a few situations, like replacing a broken part, the reality is that for most problems each of the three words in this statement must be carefully defined or someone, probably you, is going to be disappointed. While we may or may not be aware of the reasonableness of our outcome expectations, we should always have a well-defined process for getting to that solution or, at a minimum, know when to quit when sufficient progress hasn't been made. For instance, some basic research has value only to the furthering of knowledge and to a yet-to-be-identified problem solution. The metrics for these efforts in academia, or even in some national labs, are somewhat intangible and are often measured through numbers of publications, professional training, or students' educated. For industry, this same basic research is often conducted in hopes of a new profit-bearing discovery or to enhance the knowledge base, or more importantly, to stay ahead of the competition. For applied research, particularly applied engineering, it is the solution outcome that counts and, for at least the commercial sector, it is measureable in product development and process improvements, or in other terms, profits and savings. It is the magic that occurs when the right problem finds its way into the hands of the best problem-solver that wins the day - a real connection to the home repair analogy stated above.

3. THE RESEARCH AND DEVELOPMENT DILEMMA

So, what are the best and most efficient ways to do research and development (R&D), and is the US, as a nation, using an effective process to vet the results of this

work to improve our global economic position? For the first part of the question, there is no one best process and, in fact, any responsive and proactive approach must change as the problems change. The least we should have, though, is a definite idea of the identified need, or a well recognized problem to solve, plus what constitutes an appropriate time line and expectations for completion of the effort. The answer to the second part is a clear, no. All an individual needs to do is check our domestic economic and innovation rankings against the rest of the industrialized globe to see the reality. The only acceptable end game for any R&D effort is a well-documented and supportable outcome and a way to get the results into the proper hands to make something of value out of it. Can we, though, identify the fundamentals that would allow us to better take advantage of the skills, resources and intellects that are so abundant in this country and thus move us forward in these economic indicators? For this question there should be a resounding, yes. So why are we lagging behind? What are the rest of the industrial countries doing that we seem to be having problems with? It may all turn out to be as simple as establishing and delivering the proper expectations for outcomes matched to the required resources. In other words, getting what we pay for and on a schedule we can accept. Defining these measurables up front, with appropriate contingencies, will help ensure that we are being fiscally responsible and effective, insuring that the problem solution will evolve and complement the commercial and social environment we are trying to benefit.

4. GLOBAL R&D

So how does the global R&D effort work? How is it integrated into the commercial sector and how can we take the lessons learned to help with the state of our national economy and our ability to compete on a global basis? Clearly, a significant amount of global funds are set aside for knowledge gathering, training and dissemination, in addition to problem-solving, product development, process improvement and, of course, innovative breakthroughs. If this weren't the case, the marketplace would stay the same and there would be a near zero net gain in the global economy. Clearly, a sizeable fraction of the global economic value is being committed to these ever-expanding discovery efforts through commercial and government supported programs. For every problem and for each set of solutions there are a variety of stakeholders and participants, each committing resources to the outcome with an expectation of continued growth and prosperity for their organizations and the economy that supports and defends them.

5. FOLLOWING THE LEADER

It turns out that large enterprises, and in similar ways governments, are very good at following, but most likely not encouraging, technology innovators. It is ironic that while most all organizations have innovators, these same

groups make it harder for their own homegrown few to have an impact. Knowing that the exception is generally the rule doesn't change the fact that the truly innovative ideas and the people attached to them tend to migrate out of these larger organizations, commercial and government alike, in favor of locations where they at least seem to have choices and some control. Interestingly, they tend to get more attention while on the outside than they ever did while part of the original group. As the resulting innovations come to pass, a few of which will hopefully become disruptive, transformative game-changers, the larger companies will take notice and subsequently buy in or compete using their own solutions to stay ahead. The same will occur in government, which follows this cycle, albeit somewhat time-lagged, with their own funding, policies, regulations and laws. Thus, fighting big government or large corporate cultures is not necessary, and most likely ineffectual. Encouraging innovation and pushing technology forward forces the giants to change or eventually cease to exist. If we want to make a change in the way we do business and stop all of the complaining about the current state of our affairs, we will need to encourage innovation at the grass roots level. Getting ahead of the curve where the technology is driving the social and economic order will force the larger organizations to adapt and to stop expecting us to accept the norm they are the most comfortable in providing to us.

6. R&D DRIVING FORCES

Agency and departmental mandates plus mission statements drive government R&D sponsorship. Each program in its own way is supposed to reflect the current needs, not necessarily the future needs, of our country where the funding is expected to bridge some gap in knowledge or technology. Admittedly, some of the funding is a day late and a dollar short due to the time it takes government to get funding into the mainstream but the question is not how much or when, but how the original subject areas were selected and what outcome expectations were built into the programs. Government agencies and departments, unlike industry, get their program ideas a little differently. Most of these agencies have a large legacy of ideas and the language that supports it. Their political leaders and their constituency also influence them. More often than not, they are more reactive than proactive and are influenced by news of other agency or global accomplishments. These account for some of their programs; the rest are a little less clear but nevertheless, still interesting. Some government agencies send out Requests for Proposals (RFPs) with little or no expectation of providing funding. They then use the ideas in these proposals to seek their own internal funding (a larger piece of the pie) or to obtain a larger portion of somebody else's future funding. This is in addition to those politically negotiated grants and contracts that are apportioned to voting constituencies and large contractors. All in all this selection and allocation process still has less

of a consequence than not requiring specific program outcomes, along with the completion of progress milestones, the theme of this paper. It should be pointed out that the practice of idea seeking with little or no expectation for awards, when not disclosed to the participants, is ill conceived and a terrible waste of intellectual capital. Again, this impact is still effectively small when compared to a lack of accountability on both the sponsors' and the recipients' parts and where these scenarios provide few requirements and little expectation for bottom-line value. As a contrast, for-profit businesses identify their R&D funding areas within their corporate capabilities. Even when they want to venture outside of their competency and comfort areas, they tend to purchase what they need to mitigate potential losses and to help insure progress and hopefully success. Again, they will set some timely goals, and if they don't see a promise for success, they will abandon the project and move on to the next idea.

7. GLOBAL COMPETITIVENESS

To identify another problem, most of the industrialized countries in the world provide structure for government and industry to work together, where in a lot of cases universities and national labs are used as indispensable, contributing resources. In the US, industry has little faith in mutual projects. Government and industry have a historical mistrust for each other. The result is that in most cases neither party actively encourages a government/industry collaborative, no matter what the current popular language may include. Effectively, the laws, regulations, and policies within our governing structure are not designed to facilitate these activities or relationships; plus, the administration of the funds without clear commercial outcomes and deliverables is a recipe for fiscal disaster for the corporate portion of the equation. Unlike government, a failed cooperative program, even if substantially funded by the government, could result in the failure of the company. Universities are not without their problems also. Universities can work with government and sometimes with industry, but rarely as a successful three-way cooperative. We, in academia, have been left to our own devices for so long and with, until recently, an adequate source of government funding that we have created our own set of internal metrics and requirements for success that has little to do with program schedules, deliverables, or market and social value. To be successful in an academic environment, which boils down to gaining tenure and the continued pursuit of promotions or administrative rank, requires the graduation of students, the publication of papers in quality journals, the acquisition of outside funding, along with a level of service to the institution and the professional community, the measure of which is nebulous at best. There are no bottom-line measures of value or contributions to society and few penalties for a failure to perform on any grant or contract. It is no wonder industry generally has little use

for institutionalized R&D. With respect to government funding, the problems are multi-fold. The complexity of government funding, especially for academia, requires a prohibitive level of administrative activities where those that survive on both sides must be administratively competent and not necessarily technically adequate. While many have had the pleasure of working with some of the more technically competent, few would argue that they are the exception, and that could be argued for both sides of the equation. When dotting the I's and crossing the T's are the metrics, and not value-based outcomes, then you get what you pay for - mediocrity. In other words, too much of the money is administrative, leaving too little for properly supported R&D.

8. IDENTIFYING THE PROBLEM ISN'T ENOUGH

Government has, again, recognized that there are problems with the current R&D funding system and is trying to find ways to put larger groups together to encourage better cooperation of overlapping talents. They have tried cost-matching with industrial partners, who are getting more difficult to partner with, where the matching is often in-kind or work and product contributions only. They have encouraged the use of multi-discipline and multi-institutional collaborations in hopes of pairing the most talented with the best facilities and infrastructure. It has been said that the larger multi-institutional efforts do tend to find the better talent, which may just mean that we have increased the odds that at least one star will surface and the less productive participants will have minimal impact on the overall outcome. What happened to agreeing to do something and then doing it to the best of your abilities? And yes, this means all of the parties. Time will only tell the outcome, but what seems to be surfacing is a direct correlation between the clear dysfunction between the relationships within the three groups that have the most to say in the national R&D arena - as measured on a global basis - and the need to establish more accountability and delivered outcomes - true social and economic value. What is clear to this author is that each party has a lot to bring to the table in resources and capabilities. As has been recognized around the world, there is a need for government and industry to work with the institutional laboratories available to them to affect the most positive economic and social outcome. Clearly the current system in general is not working but there are demonstrated instances where it can come together nicely. It is these instances where we need to pay close attention to the formula that allowed the program to be successful, which brings us back to the original analogy.

9. FINDING THE PROPER PROBLEM SOLVER

In the original home repair scenario you were faced with learning the hard way or trusting to a name out of a phone book or computer, or one provided from your neighbor or

work mate. In a similar situation if you are a commercial concern or a government agency, you may similarly be tempted to trust the name that is given to you. This would be especially true if the name comes from your boss or, if you are a commercial concern, it comes from the director for research at a major research institution. In these cases, for instance, your boss' hidden choice of his son-in-law, or the research directors' choice of their favorite non-research faculty or the one that needs to gain experience in the topic area, would each have a profound impact on the outcome of your project. Without accountability and a penalty for lack of performance the outcome will most likely always remain the same. Universities often use large funding opportunities, especially those with no outcome expectations, in what amounts to spreading the wealth to maximize the potential influence, or to further institutional goals and personal ambitions, in contrast to the delivering of value. We all need to learn to work together and to develop the requirements and expectations that make our R&D investments meaningful. With a little experience, if you are from the commercial and the government sectors, you will find the individuals and their academic institutions that constantly deliver as promised. You won't work at the higher management levels and you will learn to associate with the individuals that work in the trenches. Your contracts for the work will be reasonable with standard over-rides but ones that will have schedules and deliverables with penalties for failure to perform, and you will honor those contracts and the institutional needs that they come with. Note that in academia it is their intellect you are looking to utilize plus the products of their efforts: the direct products produced, future employees, and the IP that is created, in whatever form it may take. Contracts that involve government and industry must work towards a substantial bottom line. Commercial entities survive by making a profit. Using government funds with no intent to field a profitable product is the same as taking research funds at a university with little or no intent on delivering a finished project. Finally, the government must stop signing contracts with any party where there are no milestones or deliverables. Otherwise, we will continue to waste financial resources and the intellects that we have so expensively developed.

10. THE HOME REPAIR ANALOGY CONCLUSION

All of this leads back to the original story; find the right people and match them to the real problems with an expectation for success on a specified date and at an agreed to price. This is what you do for your home repair projects unless you have no concern for the outcome or what it will cost. So why shouldn't we do it where we work?