Defense Intelligence Reference Document

Acquisition Threat Support

[redacted]

30 March 2010

ICOD: 1 December 2009

DIA-08-1003-017

Maverick Inventor Versus Corporate Inventor: Where Will the Next Major Innovations Arise?

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Prepared by:

(b)(3):10 USC 424

Defense Intelligence Agency

Author:

(b)(6)

Administrative Note

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Introduction

Technological innovation has been advanced by several sectors of human society and via a diverse set of circumstances. In the early 20th century, the solitary maverick inventor was responsible for the bedrock of most of today's industrial and commercial enterprises. As these enterprises grew larger, they could afford their own research and development departments, tasking them with developing products and processes aimed at increasing the market share of the parent company. Generally speaking, as time went on these types of enterprises became less hotbeds of true innovation than places where improvements to the current technologies were tightly managed. Such management became stultifying for many inventors wishing to produce true innovation, and these mavericks shunned the commercial research agencies and went off to carry out their own brand of research.

Another institution where true innovation is fostered is the university. University research as it exists today started in Europe only in the 18th century. The bulk of the discoveries in science leading to technological innovation came from university research laboratories in the 19th and early 20th centuries. Currently there is considerable controversy surrounding the degree to which research at universities is free from external influences, whether from within the university, from the greater scientific community, or from public and/or private agencies that fund the research. As university salaries and expenses go up, there is increasing reliance on external funding sources, the majority of which wish to exert some influence over the type of research they are underwriting.

Human aggression and human needs gave birth to two additional areas of innovation. As governments became embroiled in conflicts, they found the need to fund "think tanks" for the purposes of stimulating scientific developments that could aid war efforts. As well, the needs of their constituents for food, shelter, health care, energy, economic development, space exploration, and so forth demanded the establishment of government-funded agencies to perform research and produce policy. To be effective, military planners needed access to the most innovative technologies in all areas of endeavor, not just armaments, and so established their own research and development departments.

Circumstances determine the temporal requirement for innovation. Modern versions of the Four Horsemen of the Apocalypse (wars, pestilence, lies, famine/death: read conflict, environment, economy, health) pretty well sum up the major stimulants that foster innovation. Fortunately, human society—at least so far—has shown a remarkable propensity for inventing methods of overcoming seemingly insurmountable obstacles.

This paper concentrates on two areas of technological innovation where solutions have been particularly hard to come by—namely energy and

propulsion, in particular aerospace and space propulsion. It is now the case that new and exotic materials and their dimensions are driving the quality and quantity of energy and propulsion innovations and preventing the average inventor from contributing new and useful forms and assemblies. The capital outlay required to probe the limits of current high technology in search of a new breakthrough is also beyond the means of the vast majority of lone inventors. These are the major reasons for the shift in focus from the lone maverick inventor to the "corporate inventor," the latter being a part of a large organization.

This paper compares the roles of the maverick inventor who is less constrained by the strictures of a large organization with those of the corporate inventor and provides some insight into where to expect required future innovations in the areas of energy and propulsion.

Maverick Inventor

Most of the easy combinations of components and materials have been investigated repeatedly since the time of Michael Faraday. However, it is still to this "low-hanging fruit" that the average maverick inventor is drawn for inspiration. For example, in the area of energy innovation, it is still attractive to many inventors to try various combinations of permanent magnets and wire to try to improve the efficiency of modern electrical machinery, or better yet, claim to extract possibly limitless energy from these magnets. The average energy inventor is not bothered by pesky Laws of Energy Conservation or that the devices he is spending endless time on have been investigated hundreds of times before.

There is also the role of the media, most important the Internet, in continuing to stimulate the creativity of the maverick inventor. Movies continue to depict the lone genius saving the planet via some invention, be it a physical weapon or a piece of computer code. This no doubt propels succeeding generations to believe that they may one day single-handedly develop a new free-energy or antigravity device and save the planet. Unfortunately, the Internet has fostered the belief that new inventions, especially in the areas of energy generation and gravity control, are relatively straightforward—one simply needs the correct combination of macroscopic components.

One of the disadvantages of the access to apparent technological innovation that the Internet provides is to foster and maintain intellectual and experimental laziness. This manifests itself in many ways, principally in that the prospective inventor increasingly believes that simply spending a few minutes on the Internet can give him all the background information about who has done what in a particular field of invention. Indeed, the would-be inventor does not even need to leave his chair and physically investigate the situation himself. A corollary concern is the lack of information on prior attempts that is available to maverick inventors. Whereas the corporate inventor has immediate access to a broad range of technical resources, including patents and scientific and technical publications, the cost of these resources and their publicly accessible concentration in university libraries drive the average maverick inventor to rely solely on the Internet. Fortunately there are now positive signs that at least as far as "free energy" and antigravity are concerned, there are Internet sites trying to be repositories for failed inventions in these areas (Reference 1, 2).

Another major problem is the decreasing reliance on a sound technical education, either in the sciences or in engineering. Why bother enduring 4 years of an extremely difficult undergraduate program when all the answers are right there on the computer screen. It is the age of instant, albeit self-proclaimed, geniuses. No need to bother with correct measurement procedures or proper control experiments when you can publish the results of your studies on YouTube without bothersome peer review.

So how might one characterize the maverick inventor? Useful categories of maverick inventors (assumed to be in the context of the late 20th and early 21st centuries) might include the following types:

- Individual with no formal training and little money.
- Individual with no formal training and some money.

- Individual with formal training and little money.
- Individual with formal training and some money.
- Small group (usually two or three) of knowledgeable inventors with money.

"Formal training" is assumed to be in the specific scientific or engineering discipline in which the invention would naturally be situated. Of course, in the last entry in the above list, the maverick inventor begins to look more like the "corporate inventor," but the idea should be clear.

Although this paper does not dwell on the personality of the maverick inventor, it is useful to remind ourselves that the maverick inventor is by definition a loner both in social and scientific/technical areas. In an online article (Reference 3), maverick inventor Dean Kamen[1] writes: "It's not that they're brilliant or well-educated...They work all the time. They don't let failure demoralize or destroy them. They pick themselves up and keep going and eventually, every once in a while, one of your ideas actually breaks through and works, and it makes all that stuff seem worthwhile."

Kamen's article goes on to state: "Stubborn, delusionally optimistic, creative, fearless, flexible and focused are some of the ways psychologists and business people describe the personality of the maverick...'You need to be in denial or in ignorance about the huge challenges you face,' laughs Guy Kawasaki, a former Apple executive and entrepreneur who's starting the self-described "magazine rack" alltop.com. 'You have to believe that it wouldn't be hard for you to succeed.'"

Corporate Inventor

The corporate inventor is a part of and relies on a large organization, conveniently labeled a think tank, to both stimulate and sustain him. There is constant interaction between like-minded innovators that serves both as a stimulus to explore new areas and as a much-needed "dead-end detector." Usually, sufficient cash and equipment are on hand, especially when the desired innovation is being funded externally. These think tanks may be government, military, academic, corporate, or private. The closest model to the freedom associated with the maverick inventor is usually found in a university setting, although a number of privately sponsored institutions exist (for example, Perimeter Institute in Waterloo, Canada). At least until recently, academic institutions prided themselves in the freedom granted to their research scientists and engineers.

Table 1 provides examples of the various types of think tanks.

[1] Dean Kamen is an experienced inventor in the medical field, where his inventions include the AutoSyringe. Among his many other inventions are devices using the Stirling cycle for energy generation and water purification and the Segway Personal Transporter.

Table 1. Types and Examples of Think Tanks

Type	Examples
Universities	Radlab, MIT, Cambridge, MA
Government	Sandia National Laboratories, Albuquerque, NM Lawrence Livermore National Laboratory, Livermore, CA Brookhaven National Laboratory, Upton, NY NASA (for example, Glenn Research Center, Brook Park, OH)
Quasi-Government/Military	DARPA, Arlington, VA
Corporate	GM Research Laboratory, Warren, MI Alcatel/Lucent – Bell Labs, Murray Hill, NJ Skunk Works, Palmdale, CA
Privately Funded	Perimeter Institute for Theoretical Physics, Waterloo, Canada Institute for Advanced Studies, Austin, TX SARA (Scientific Applications & Research Associates), Cypress, CA
Independent, Nonprofit	Battelle, Columbus, OH SRI International, Menlo Park, CA EPRI (Electric Power Research Institute), Palo Alto, CA Austrian Research Centers, Seibersdorf, Austria

These entities typically arose in response to a particular need or crisis. Perhaps the most famous and effective think tank was the vast agency known as the Manhattan District. Less well known to the public was, for example, the RadLab at MIT.

Except in the case of privately funded organizations, they all support many hundreds to thousands of researchers, of which a variable proportion could be termed "inventors." Even the smaller entities support a dozen or so highly motivated scientists and engineers easily classified as inventors.

A benefit of being an inventor in a large organization is access to information. The corporate inventor can quickly determine whether a certain avenue of approach has already been tried, using resources not generally available to the maverick inventor, such as patent searches, scientific and technical documents, or an in-house library.

Another benefit is access to the latest technical apparatus, prototyping, and machining capabilities. In most cases, the inventor does not need to be an expert in the operation of all types of analytical or experimental equipment or machine tools. There are technicians at his disposal able to convert his ideas into reality.

A relatively recent development in the larger organizations is the establishment of a "blue-sky" team of highly creative individuals, sometimes just two or three people, whose job it is to think outside the corporate box and provide directions and policy, usually for the long term. However, in general, their tasks still fall within the general purview of the entity funding them. Sometimes government laboratories will allow such teams to investigate unusual areas and possibly set up experiments leading to eventual inventions assigned to the laboratory. A particular example is that of Tajmar (Reference 4). Other relevant models for this type of activity are found in research and university hospitals, where continuous innovation is the norm.

Corporate inventors also benefit from belonging to an organization that includes people with business acumen. An invention is worthless as a commercial innovation if it cannot be produced or marketed at a competitive price. The business side of the corporation is an essential component of successful innovation. The maverick inventor typically does not have these skills close at hand, and often the enterprise fails not for technical reasons, but because the inventor has not thought out an appropriate business plan.

However, there are drawbacks to the life of the corporate inventor. Fluctuations in the overall economy can put projects on hold, cause them to be canceled, or force layoffs that can stall or kill a project. The maverick inventor will strive to keep his project alive regardless of the external economy, which unfortunately sometimes means loss of savings, house, family, friends, and so forth. A Not Invented Here (NIH) syndrome often can interfere with overall progress in areas where a corporate inventor approach is the most suitable. If an idea did not originate with a particular organization, it may not be pursued, even though it may represent the best approach. Maverick inventors rarely suffer from NIH. Whereas the maverick inventor is generally accustomed to putting 100 percent of his time into the invention, the corporate inventor may suffer from burnout if he is not as personally motivated or has such a personal stock in the invention. After a while, "group think" syndrome can infect large organizations, including their innovators. This happens in organizations that do not recognize or encourage radical thinking, resulting in mediocre innovation performance. This process is exacerbated if the number of projects being attended to by corporate inventors starts to overwhelm them. The maverick inventor is usually single minded in his attention.

Technologies

In order to gain a clearer understanding of the relative roles of the maverick and the corporate inventor, it is instructive to observe how each addresses specific technological areas. This paper concentrates on innovations in the areas of unconventional energy and propulsion systems as examples of ideas pursued by the maverick inventor in particular. The study does not focus on how the personality of the maverick inventor determines his innovative capacity so much as it focuses on what tools and techniques are available to him in addressing a particular potential innovation.

The inventors highlighted in this study investigate technologies encompassing the production or conversion of energy from novel sources, sometimes referred to as "new primary energy sources," including permanent magnets, cold and warm fusion, "zero-point fluctuations," and novel uses of batteries and rotating systems, as well as theoretical and experimental approaches to modulating the local gravity field. Some of these inventors and inventions are described in recent books (see Reference 5, 6).

Historically, what has been the relative contribution to the major innovations in these areas? Taking the specific area of electrical energy production as an example, it was the contributions, inspiration, and determination of maverick inventors such as Tesla that resulted in the design of many of the current power-generating technologies in use today. As far as radically new recent designs of alternators and motors is concerned, there have been very few innovations from maverick inventors, Flynn's dual-path magnetic circuit being a notable exception (Reference 7). Most of the innovations in this area come from corporate inventors in the electric power industry, as the only path left toward increasing efficiency is through novel materials such as high-temperature superconductors. Such research is generally out of reach of the maverick inventor. There has been no lack of attempts by maverick inventors to produce electrical "free energy" and related machines.

In the area of space propulsion and earth-to-orbit methods in particular, again it was the contributions of mavericks such as Tsiolkovsky and Goddard that laid the foundations for modern rocketry. Both inventors took a practical approach to rocketry, as the field was in its embryonic state. Initially denigrated as being "only" a high school math teacher with no formal scientific training, Tsiolkovsky developed the fundamental equation for rocket propulsion. Although Goddard was university trained, like Tsiolkovsky, his fundamental work on rocket dynamics was largely ignored until later in his life. During their early, creative years, neither man worked for large organizations. As far as radically new propulsive means are concerned, there have been innovations only in the efficiency and overall design, and the fundamental mass expulsion model has remained unchanged. The efficiency innovations have sprung from corporate inventors who have the resources to plan and test their increasingly costly designs only in the context of large organizations.

The current innovations in these two fields come from larger organizations such as those highlighted in the previous section. However it should be noted that these innovations, largely increased in efficiency, have been economically as well as technically viable. There are plenty of novel thruster designs that would be excellent candidates for inclusion in the breakthrough category if only they were not so expensive. Antimatter propulsion using positrons and antiprotons is a good example (Reference 8, 9). In the early development of electrical machines, many parts of the system were very expensive—electrical steel laminations, for example—but mass production brought prices down. Fortunately inventions are not completely discarded simply because they are too costly at the time of their conception. Increasingly today, materials costs rather than manufacturing costs drive economic decisions about the development and commercialization of inventions in this category. This is due in part to the replacement of human manpower with its robotic equivalent and the scarcity of certain strategic technologically important raw materials, such as rare earths.

The Type 1 Inventor

One should examine the area of novel energy generation inventions from the standpoint of the maverick inventor who has no formal training. Because the approach and timeline of the typical energy inventor mimic those of the propulsion (read "antigravity") inventor,[2] we will concentrate on the energy inventor. Often the invention involves a device that is purported to produce more energy than it consumes. In some cases the inventor naively thinks his invention is simply creating the extra energy from nothing. More often the inventor believes his device is tapping a new energy source, such as "zero-point energy" or "magnetic energy." He typically begins his quest by literally playing with storage batteries or pulse-driven, simple, permanent-magnet-based motors. Since the typical maverick inventor has negligible funds for research and development, cheap measuring instruments are the norm. A very cursory understanding of electrical wiring and possibly a rudimentary capability in designing solid-state circuitry seem all that are necessary from an educational standpoint. Delving into thermodynamics, proper experiment design, error analysis, or even power factor is usually seen as taking valuable time away from construction of an invention prototype.

Alas, it is most often in the area of measurement that the maverick inventor solidifies his belief that he has discovered the answer to the world's energy problems. His fear of ridicule and belief that the local university or testing agency would (a) steal the invention, (b) not do a proper test because they do not believe in the underlying concept (for example, zero-point energy), or (c) are in league with big oil and will suppress the invention ensure that proper measurements are rarely performed at the important early stages of the invention's development. Fear of suppression also contributes to the typical inventor's lack of proper note taking. The test instruments used usually are not suitable for use in measuring the various electrical parameters in, for example, pulsed-motor designs. Even if more expensive oscilloscopes are purchased, their internal math functions are overrelied upon without giving a second thought to applicability, calibration, or use of proper probes within specification, among a host of bothersome details. The measurement problem is generally compounded when attempting to measure the true power or energy output of a device, especially where the output is a rotating shaft or source of heat.

The modern Type 1 inventor shuns publishing in the peer-reviewed literature for obvious reasons and instead makes a YouTube video or appears on a TV "weird science" program or news clip to further promote this incredible invention.

Up to this point, the invention has been developed using personal or immediate family funds. Once the maverick inventor is convinced he has the ultimate solution, the next step is to raise the necessary funds to produce a larger, higher power prototype. Note the key step of independently verifying the technical validity of the device at low power is to be avoided. "Only a big power output will convince the skeptics" is the slogan at this stage. And a high-power prototype will take much longer to build, thus buying more time for the inventor to invent excuses for why the whole idea was unworkable in the first place. Usually the original prototype is either scrapped or robbed of components to make a new high-power device.

[2] For typical examples of inventors concentrating on gravity and propulsion means, see Reference 10, 11, 12.

Where does the inventor find funding for such a development? The typical inventor (Reference 13) will canvas a wider network of friends, his church, a local venture capitalist or private investor who is not very savvy, or a fund specifically established to invest in exotic energy startups (Reference 14, 15). After convincing them of the incredible return on their investment in the technology by "demonstrating" it (without proper protocols, test equipment, and so forth), manpower, space, and new equipment are purchased. Usually the last thing on the inventor's mind at this stage is wasting investors' money on an independent laboratory test such as might be found at a local university's engineering or physics department or certified testing laboratory to determine whether there is any validity to the technology.

Around this time, the major investors start to sense there might be something amiss in their original assessment of the validity of the technology. This might arise from any number of factors, including continual requests for more funding, continual delays in demonstrating the new high-power unit, more-informed friends asking probing technical questions, and so forth. Investors start to withdraw, accepting the fact of their bad investment, and the inventor eventually recedes into oblivion or skips town to start up again under a different guise somewhere else. This is typical behavior for the con artist (Reference 16, 17, 18), whose exploits will not be further analyzed herein. However, some enterprising individuals parlay their experience into related conventional businesses (Reference 19), and some investors hang on long past the time a reasonable person would quit (Reference 20).

Patent protection generally is not sought by the Type 1 inventor. And if a patent is sought, either it is rejected outright by the patent office or a watered-down version is obtained that is usually worthless from either the physics or technical point of view or as part of the intellectual property to eventually be sold to an investor interested in commercializing the device.

What can be learned from the Type 1 inventor? Given their lack of formal education in the relevant disciplines, there is a negligible chance that Type 1 inventors will contribute anything of significance to major innovations in the energy and propulsion areas. Their undisciplined approach, coupled with their lack of funds and interest in science by media, virtually guarantees failure.

The Type 2 Inventor

The major—and sometimes only—difference between Type 2 and Type 1 inventors is that Type 2 inventors tend to be even more confident in their inventions because they have been able to purchase fancy and costly measuring equipment and have high-quality machining done. However, because of their general lack of education in the relevant areas of instrumentation, they can misuse the instruments or misinterpret the resulting data just as badly as Type 1 inventors (Reference 21). However, Type 2 inventors have the advantage of being able to purchase external expertise in these areas (Reference 22). The degree to which they rely on and believe the external expertise—for example, a university laboratory—is dependent on several factors, most notably the personality of the inventor himself. The more self-assured personality relies less on outside expertise.

Type 2 inventors generally have more to lose in terms of money, as they typically start out big and want to go bigger faster. They tend to investigate less speculative areas of a technology. Also, they are not generally plagued by the insecurities of the Type 1 inventor about subjecting their inventions to outside scrutiny, and some will be bold enough to publish in respected scientific journals (Reference 23). This means they keep better lab notes than Type 1 inventors. It does not mean they are intrinsically better scientists or inventors.

Type 2 inventors generally have a bit more training in physics and sometimes start with a theory of which they request analysis from a local university professor, for example. Usually the theory is either partially formed or is not directly relevant to the proposed invention. The professor dutifully examines the theory presented while not being informed of the overall use to which his work is to be put and makes a pronouncement that the inventor can usually twist one way or another to suit his future fundraising efforts (Reference 24). Often the inventor has access to various theories about energy or gravity that are posted in non-peer-reviewed media and uses these to initiate or justify the proposed invention.

Type 2 inventors have a generally greater success at securing a patent, as they have a better basis on which to make a claim and can afford better patent lawyers. Some of the more advanced Type 2 inventors realize they need to start with a more pure-physics experimental approach rather than going straight for the applied invention, although these are rare (Reference 23).

Once the initial concept has proved infeasible on the bench, these inventors can burn through a large amount of additional money in a scatter-shot approach, trying to save face and what little money is left. Some will continually scan the Internet or underground press for other likely energy candidates to switch allegiance to (Reference 14, 15), or will simply convince other gullible investors to continue to prop up the technology with ever-more contorted descriptions of what is needed to succeed. Eventually the house of cards collapses, and all the players go home, licking their financial and psychological wounds. This occurs when an investor finally starts asking the tough technical and measurement questions that should have been addressed at the outset.

What can be learned from the Type 2 inventor? On the one hand, these inventors can be much more dangerous than Type 1 inventors, as they can use their enhanced financial clout to make it appear as if they have something of value and thereby attract capital that might otherwise be used in more fruitful pursuits. On the other hand, Type 2 inventors can serve a useful purpose in showing others where not to tread. Their ability to instantiate some degree of professional sophistication—for example, university professor—marginally increases the likelihood of a true innovation. However, the personality of the Type 2 inventor will dictate their receptiveness to external advice.

The Type 3 Inventor

As the inventor gains more formal training, the foundation for the innovations tends to be a hypothesis or mathematical model leading to basic experiments, as opposed to starting with a full-blown embodiment of the hoped-for invention. In the best case, this is a staged approach in which the inventor already has sufficient knowledge about the area to know how to design a succession of experiments and interpret the results properly to make increasingly accurate assessments of the likely validity of the invention. Optimally, the hypothesis is based on an extension of known physical laws and calls on known or reasonably postulated primary energy sources. In contrast to Type 1 and 2 inventors, who seem never to realize that a permanent magnet cannot be an energy source in and of itself, for instance, the Type 3 inventor relies on the known conservation laws. Type 3 (and 4) inventors generally realize the enormity of the problems they face, whereas Types 1 and 2 have insulated themselves from this realization.

As a result of his education, the Type 3 (and 4) inventor should know where to access specific technical and scientific literature to aid in the process of researching their ideas. The inventor may be associated with a local university or an emeritus professor and use this expertise on an informal basis to compensate for a lack of funds. Primary funding comes from personal or family finances or from small groups of like-minded aficionados (Reference 25). Generally the Type 3 (and 4) inventors are older than Types 1 and 2. They are also much better at explaining the scientific basis for their proposed invention and thus can attract additional funding from venture capitalists, foundations, or government granting agencies. This is a much more palatable approach in the eyes of prospective investors, as there is the feeling that their investment is based on science rather than on pure speculation and thus has a better chance of a positive return. In some cases, the individual or venture investors' funds can be matched by government grants if the idea is passed by a scientific review board. Most investors in Type 3 and 4 inventions are more sophisticated than those who invest in Types 1 and 2.

Type 3 inventors generally have a record of publications in peer-reviewed literature. However, even with a greater degree of education, it is often the case that the inventor makes mistakes in measurement or interpretations of data (Reference 26, 27), especially when the initial results apparently confirm the inventor's hypothesis or physical model (Reference 28). This is most often what leads to the demise of the innovation. However, in these cases, the investors are not as angry or embarrassed as Type 1 and 2 inventors, and so may continue to support the inventor for some time as he tries to work out the problems in understanding the innovation more fully.

The very fact of their higher education makes the Type 3 inventor more easily able to denigrate competing theories and experiments. This facet can be derived from or evolve into a rather dogmatic belief that the Type 3 inventor's theory is the only correct interpretation and the only one likely to succeed. This aspect must be taken into account when assessing the inventor's potential to accept other explanations or assistance when he eventually encounters difficulty with his theory or experiment.

Typically the scope of the claims is more modest compared with Types 1 and 2. Instead of trumpeting that the invention will literally save the world, these inventors are more realistic, suggesting how the invention might be one part of an overall solution.

What can be learned from the Type 3 inventor? Type 3 inventors' education and familiarity with the scientific method puts them in an entirely different league from Types 1 and 2. Access to their publications provides good insight into their capabilities. They are more realistic in their goals and expectations. It is easier for investors and other scientists to deal with Type 3 inventors, but Type 3 inventors are hungrier for funding than Type 4 inventors, so caution is still required in interpreting their spiel. A Type 3 inventor displaying a rigid and dogmatic approach should be avoided.

The Type 4 Inventor

If a maverick inventor educated in science or engineering already has personal funding, many of the attributes ascribed to the Type 3 inventor also apply. However, the Type 4 inventor is freer to pursue his innovation without as much concern for outside opinion. It is often the case that such inventors have made their money from previous inventions, so they already know the process. They have a much easier time attracting capital, as evidenced by their track records. However, not all have money from previous inventions. Some have family wealth, and some may have made money developing technology in areas somewhat removed from their current interest.

Type 4 inventors generally are less inclined to pursue inventions in the areas of energy generation and propulsion as defined above. In fact, the likelihood of such inventors even being interested in novel primary energy generation or gravity modification is greatly diminished. They still tackle difficult technical challenges, but not generally fundamental issues like gravity and primary energy. It is by avoiding these supremely difficult areas that they have been able to invent in other areas and are thus already better funded!

Type 4 inventors realize the necessity of a step-by-step approach and the pitfalls of developing ideas from scratch. They tend to apply their genius to improvements to status quo in these areas rather than providing complete breakthroughs. For instance, Kamen's Segway (Reference 29) contains no fundamentally new technology. Although Ovshinsky (Reference 30) did manage to develop new materials for solar electricity generation, the general idea of harnessing the Sun's energy to produce electricity was not new. Incidentally, Ovshinsky is included in this category even though he had no formal university education but is a self-taught genius. Notwithstanding their aversion to the fundamental issues relevant to this study, Type 4 inventors are capable of determining at an early stage whether an idea has merit and how it might properly be developed, assuming the basic concept is sound.

It should be noted that Type 1 and 2 inventors usually are true loners, whereas Types 3 and 4 may be part of a small group of up to 3-4 people dedicated to a single objective.

What can be learned from the Type 4 inventor is quite similar to that of the Type 3 inventor. The major difference is the track record of invention and the likely increased business sense of the Type 4 inventor compared with those of the Type 3 inventor.

The Type 5 Inventor

Here one starts to see an overlap in form and function with the corporate inventor. The primary distinction is the number of active inventors constituting the group: in this study, we assume that 5-6 inventors is a typical group size. The small group setting allows the individuals to bounce seemingly crazy ideas back and forth with little concern about ridicule. Depending on the nature of the organization, no topic is taboo. However, the inventor in this situation is usually required to contribute to near-term commercial products rather than exotic innovations. This is because most small groups of inventors are primarily interested in keeping their enterprise afloat. They realize that the effort required to tackle topics such as gravity and primary energy would be enormous, and although the payoff would be exceedingly large, the probability of success is small given that their competitors are in well-funded academic and government laboratories.

These innovators have a high degree of motivation for near-term commercial projects but less motivation for exotic long-term projects and typically have specific educational qualifications in the relevant fields. They generally work on improvements to the technological status quo (Reference 31). These improvements are expected to be commercial products in the near-to-medium term, compared with the energy and propulsion technology discussed here, which have a long time horizon.

What can be learned from the Type 5 inventor? He is significantly less interested than the lone maverick inventor in pursuing exotic inventions. As part of a commercial enterprise, a Type 5 inventor's motivation to investigate long-term possibilities with a low likelihood of success is small. This is not to say that the individual inventor within the group might not be the most suitable candidate for considering exotic inventions if he can operate with considerable freedom and enjoy the support and intellectual milieu of the small group.

Comparisons

Table 2 below compares the essential elements that characterize the types of inventors discussed in the previous sections. The various attributes shown can be used as criteria for determining the inventor type most likely to produce the necessary innovations in the areas of advanced primary energy and exotic propulsion.

Table 2. Essential Elements That Characterize the Types of Inventor

Attribute	Type 1 (& 2)	Type 3 and 4	Type 5	Corporate
Age	Younger	Older	Younger	Various
Motivation	High	High	Medium	Various
Realism	Low	Medium	High	High
Bureaucracy	Low	Low	Medium	High
Capitalization	Low (& Medium)	Low (& Medium)	Medium	High
Education	Low	High	Mixed	High
Business Sense	Low	Various	High	Medium
Measurement	Low	Medium	Medium - High	High
Lab Skills	Low	High	High	High
Externals	Low	High	Medium	High
Flexibility	High	High	Medium	Medium
Media Interest	High	Low	Mixed	Low

For clarity and compactness, Types 1 and 2 and Types 3 and 4 are combined, since in general the only meaningful difference is the capitalization. As discussed above, unfortunately, merely having more funding does not lead to substantially greater capabilities in other areas.

Motivation: degree of commitment to initiating and completing the task and belief that it is possible a priori.

Realism: degree of realization of the difficulties to be faced.

Bureaucracy: amount of general and administrative overhead to be put up with by the inventor.

Capitalization: relative amount of funding available to the inventor for the specific invention.

Education: level of education achieved by the inventor in the relevant fields of science or engineering.

Business Sense: degree of business acumen associated with inventor.

Measurement: capability of the inventor to understand and properly use measuring instruments.

Lab Skills: ability to show orderly development from original concept, keep proper lab notes and communicate ideas to others.

Externals: inventor's interest in and capability of using external assistance—for example, a university, including publishing.

Flexibility: ability to work on different sorts of projects, even when highly exotic.

Media Interest: interest in self-promotion and reliance on various popular (nonscientific) media for guidance; this is more an indicator of the psychology of the inventor than of his technical skills.

In a 2003 NASA tutorial on breakthrough propulsion (Reference 32), Millis describes the division between "masters" and "pioneers" in the context of determining where the next space propulsion breakthrough might arise. At the extreme end of the masters are the "pedantic prudes" who consider that the process is already at the end-point of advancements in the field. This classification is similar to the least motivated corporate inventor. At the opposite end of the pioneers, he places the "pathological pundits" who characterize themselves using phrases such as "My theory is great...I can't be wrong...If you don't agree, you are part of the suppression conspiracy," and can thereby be classified as Type 1 or 2 inventors. Millis also characterizes Type 1 and 2 inventors and "nonrigorous enthusiasts" (Reference 33).

Conclusions

We can draw several conclusions from the comparisons in Table 2.

Maverick inventors of Types 1 and 2 score high in motivation and flexibility with little bureaucracy, but in all other areas, they are lacking. Especially troubling for the present scenario is the lack of education leading to substandard to nonexistent measurement capabilities and laboratory skills, together with overreliance on media.

Types 3 and 4 also exhibit beneficial attributes relating to motivation, flexibility, and bureaucracy, as well as their treatment of media. As far as the present scenario is concerned, in all other attributes, Types 3 and 4 rank higher than their Type 1 and 2 counterparts. Their measurement skills could be improved, particularly in view of the requirements of these new areas of energy and propulsion.

Type 5 inventors are not as motivated as their Type 1 to 4 counterparts in these areas of innovation, possibly owing to their increased sensitivity to the difficulty of the task. Business sense is higher than Types 1 to 4, but the extent to which this impacts their ability to innovate is not clear. They are more constrained insofar as bureaucracy is concerned, which tends to hamper carrying out "blue-sky" innovations.

Finally, the corporate inventor scores high in all areas except motivation, business acumen, and flexibility. As noted previously, the corporate inventor suffers from being employed in an agency that, except for the university, does not generally promote the types of innovations addressed in this paper. In many cases, university innovators are hidebound by dogma that prevents them from even entertaining the possibility.

Therefore, as far as maverick inventors are concerned, Types 3 and 4 appear to be the best choice regarding where to expect the next innovations to arise and should be carefully selected based on criteria similar perhaps to those used above. Millis considers the same scenario (Reference 32) when he states that the innovators he seeks are published, credible risk-takers with vision. They should be monitored and encouraged by means of financial and other incentives to pursue these difficult areas of innovation.

If the corporate inventor, and especially the university-based inventor, could be motivated and granted sufficient flexibility, he would be an excellent candidate to carry out the required innovations in energy and propulsion and rival Types 3 and 4 for innovation capacity.

Type 5 inventors are the next best possibility, with Types 1 and 2 merely being watched casually, as no substantial innovation is expected to arise from these quarters.

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