

TRUST, RISK & AEROSPACE SOFTWARE: BALANCE AND OPTIMIZATION

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The ability to trust is often thought of as a subjective trait – subject to irrational assessments such as familiarity and name recognition. Trust, however is not completely subjective, nor completely bipolar; that is we do not necessarily either trust or distrust. Sometimes, we can trust a little, or trust a lot, or trust individuals or organizations in some aspects but not others. Trust, therefore, can more rationally and objectively be treated as a risk assessment, unique for each case. Software is one of the most important products used in aerospace, yet one of the most difficult to assess. Managers can be prone to trust organizations with whom they have had previous dealings or are familiar without a complete assessment of risk and other products. This paper remarks on some of the pitfalls of this and provides framework for avoiding them.

INTRODUCTION

“Yeah, it used to be that property was sold with a handshake,” said our California realtor with a tone of nostalgia as we finished filling out the twenty-some pages of forms to sell our California home in the year 2000.

Okay, forget real estate. Real estate, for most of us, is the largest single personal purchase or sale we will ever make. One might think that a twenty-some page contract and a lawyer overseeing a closing is reasonable. But what about a small purchase? Try buying something – *anything* – without a receipt. The receipt is proof of purchase of an item (as if possessing the item itself is not proof, but never mind that). It may or may not give the purchaser an opportunity to return the item, and it is, in some small way, a contract. “I bought this, I [either] paid you or agreed to pay to for this item. You guarantee that this item will function as advertised.”

What has happened over the years? Why did we, as a society at one time in history, feel secure selling and buying real estate without paperwork, and more

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importantly, why don't we now? Why were we at one time able to purchase an item without a receipt? Trust and risk are the two inexorably intertwined entities that we balance in our everyday lives as well as in the most complicated technology-producing companies and government agencies. To trust is to accept risk and in doing so, believe that the benefit will outweigh whatever the accepted level of risk. As such, trust, as risk, exists on varying levels, varying magnitudes, and is by no means bipolar, that is, we do not either trust or not trust, as discussed later. Trust can be built as well as broken down. It can be *swift*; gained rapidly, or *thick* and built over time. It is emotional, but also can be calculated against risk. It is complicated, but also can be wonderfully simple.

To analyze how it affects behavior in the contracting world, this paper shall begin by defining trust according to classic and modern theory – both from a micro (personal) and macro (marketplace) vantage. It shall then examine trust and the contractor relationship, and finally the balance between trust and risk.

TRUST IN A NUTSHELL

Trust as Encapsulated Interest

I shall describe here what we generally think of as commonplace trust, or what has been termed *trust as encapsulated interest* (Hardin, 2002). In its simplest form, trust is a dyadic relationship. I trust you because I deem you to be trustworthy; for whatever reason. But this is truly an oversimplification for the pragmatic purposes of trust. It is nearly impossible to trust implicitly – for all entities and all services and all things. Carte blanche trust exists only in theory. Indeed, a practical trust is one that exists in a triadic relationship. For example, A trusts B to perform task X.¹ Next, one might think of the magnitude in which A trusts B to perform task X. I may trust my daughter to clean up her room, but do I trust her enough not to verify it? And when will she complete this task? Will the room stay clean? So: *Mom trusts Daughter to clean up room.* (See **Figure 1**: A trusts B to do X, and A requires that X be done.) But to what extent? Is it to a magnitude where I would not verify that the task has been completed? Not likely for me or any other mom I know.

In almost all cases, though trust may be present, verification is nearly always part of the equation; it is a question of degree of verification. In the example of the real estate market, 20 pages of signatures may not seem so bad on a deal that could be hundreds of thousands of dollars. *Prospect theory* asserts that we do not like to lose but we really do not like to lose big. (Tversky & Kahneman, 1992) They have shown that people are unwilling to take almost any risk when losses loom large. As many aerospace contracts are monetarily large, program managers are likely, also, to be risk-averse. Verification and paperwork are likely to overwhelm the process. As discussed later, though, when the quantity of paperwork is so enormous that it impedes project completion, or increases the cost beyond affordability, then a reexamination of the process is necessary.

¹ For the purposes of this paper, trust shall be represented in a triadic relationship, though theorists have noted that a quaternary relationship is even more specific, if not more accurate. As such: “A trusts B to do X in matters Y” (Hardin, 2002, page 9).

By most, trust is considered a good thing, and much has been written on this. (Kramer, 2002) But a violated trust is what frequently leads to the phenomenon of over-verification, as in the example above. Once trust is violated, verification can escalate to a state of monitoring – a distrusting relationship.

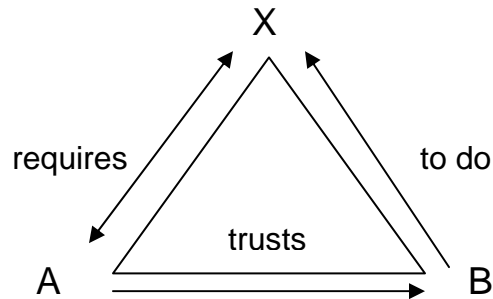


Figure 1: Encapsulated Trust. This shows basic trust in a nutshell. Hardin (2002) refers to this as encapsulated interest trust and emphasizes that this is a simplification of a highly complicated process that could also include context and magnitude.

Formation and Basis of Trust

Trust is grounded. That is, there is usually a basis for either trust or distrust of an individual or organization. It can be based on objective as well as subjective observations, and more often both. Common bases for trust include trusting a friend or family member (Hardin, 2002; Kipnis, 1996), shared interests (Hardin, 2002), past experience or performance (March, Sproull and Tamuz, 1999) rich social cues (Iacono & Weisband, 1997), and examination and objectivity. (Kramer, 2002)

To begin with, there is the most fundamental trust: that between family and friends. Hardin (2002) suggests that something close to unconditional trust exists almost exclusively in a relationship of love. To say *I trust you* without placing parameters (such as to do X in matters Y on a magnitude of Z) is rare in our lives. This is quite nearly a blind trust, for example, where a baby feels safe in his or her mother’s arms, but not those of a stranger. Or that a husband trusts a wife with care of their children is almost beyond reproach. Trust of and between family and friends is one of the rich rewards of being trustworthy and having family and friends.

Having a shared interest, either between individuals or organizations is a rational and dependable area of trust. In the area of contracting, it is typically in the common interest of both firms to produce a product, get to it market and maximize profits. Their interests are thus the same and they can count on an implicit trust. If either entity fails at task, then they will both lose. The selection of the contractor-subcontractor (or supplier) relationship is thus one that is carefully selected and nurtured in competitive markets. Between individuals, the shared-interest-trust relationship is similar. Envision a 4x4 relay race. Four individuals each depend on each other to run fast for the singular goal of

winning. It is clearly in their shared interest to outperform competitors, and thus they are each motivated to do so.

Trusting based on past performance is more complex. Past performance has taken place in a different time, possibly under different circumstances and in a different environment than future performance. Also, discussed later, the difference between organizational and individual behavior in this arena is marked. Often, past performance judgments have few data points; sometimes only one. An organization can be stigmatized or anointed for performance that may never occur again. (March, Sproull & Tamuz, 1999; Sutton & Callaghan, 1987) Individual performance is less complex, as an individual can be deemed trustworthy based on past performance, but one would look carefully at “X” and “Y”; that is, to do what in what context. Perhaps, again, the conditions have changed.

We are constantly trusting from rich social cues. (Iacono & Weisband, 1997) Clothing, language and mannerisms, for example, can provide much information (Elsbach, 2004) Organizational context also changes our perceptions about individuals or groups. For example, as we get on commercial aircraft every day, what do we know about the pilot? Usually nothing – name, gender, training – usually completely unknown to the passenger. Yet, for some reason, we are willing to place our lives, and often the lives of our family in his or her hands. Social cues such as clothing, language, and perhaps most importantly, organizational context. The airline has endorsed the pilot, and we have a common interest with the airline as well as the pilot to travel safely from one destination to another. This common interest as well as all we observe at the gate or ticket counter is fed into our ability to judge and thereby trust (or not trust) this organization or individual with our livelihood.

Finally, our objective knowledge is an important input to our ability to trust or not trust. Kramer suggests that in order to be prudent in our ability to trust that we gather information. (2002) Hardin suggests that we pay close attention to feedback. (2002) Grounded in our own knowledge, this is a rational way to judge.

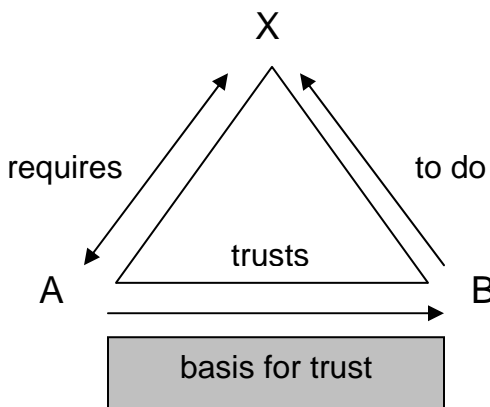


Figure 2: Grounding of Trust This diagram shows that while A trust B to do X, there must be some basis or grounding for the trust. These possible bases can include common interest, past experience, and rich social cues.

Traditional and Swift Trust

Early theories of trust assert that trust is an entity that is built over time and grounded in the notion that multiple observations of behavior can accurately predict future behavior. Sometimes called *thick trust*, (Hardin, 2002), this is what is considered traditional trust. Based in the entities mentioned above, thick trust is typically a result of a long relationship and many data points. More recently, academics have turned their focus toward the phenomenon of *swift trust*. (Hardin, 2002; Meyerson, Weick & Kramer, 1996) Swift trust is common to temporary groups in high time-pressure environments. This has been studied in cockpit crews (Hackman, 1993) and surgical teams (Edmondson, Bohmer & Pisano, 2000) to name only two. In some cases, the individuals have not even met their colleagues before performing their duties so trust must come quickly. Trust is essential for mutual success and this is a good reason for high-trust. Lack of trust, under such circumstances, could lead to certain failure.

ORGANIZATIONAL TRUST

Individual trust is distinctly different from organizational trust. (Kramer, Brewer & Hanna, 1996) The complexity of an organization, varied personalities, organizational structure, budgets and politics can perturb a trust relationship immensely. Individuals in each organization may trust each other, but that does not guarantee inter-organizational trust. While individual trust is easily measured in a succinct series of interactions and performance, organizational behavior is far more complicated. Organizational actors are constantly changing – especially in the high-tech arena or the Department of Defense (DOD). Though there are surely analogies between individuals and organizations, it is impossible to always treat their behaviors similarly. (Hardin, 2002) Keeping that in mind, the inter-organizational contract relationship is discussed next.

TRUST IN THE CONTRACTOR RELATIONSHIP

The contractor relationship has been one of great interest in the government over the past ten years. There has been a well-known emphasis on moving the DOD from a design-and-build environment to the use of COTS (commercial-off-the-shelf) products.²

The design-and-build contracting process evolved when products were unavailable in the commercial sector. For example, computer technology was not available commercially in the 1950s and the DOD was responsible for hiring contractors to build systems, both desktop and internet-type, as such systems did not exist as the

² This move began with the “Perry Memo,” 1994, authored by then Secretary of Defense William J. Perry stating essentially that when a commercial product was available it was to be used instead of the traditional design- and-build process which had proven slower and often less effective. Perry was committed then and remains committed to increasing contracting efficiency in DOD by leveraging best products from the commercial market.

computing was in its infancy. At the time, such a contracting system made sense. (Carter & Perry, 1999) The products did not exist in the marketplace and fledgling companies were unable to assume all risk for building what essentially were feasibility studies. From the 1950s to the 1980s products slowly migrated from the public to the private sector. There was and continues to be a boom in the commercial computing sector as well as aerospace.³ Now, in the twenty-first century, commercial computing products are readily available off-the-shelf, and satellite technology has been absorbed by the commercial market.

The move in the DOD toward greater COTS use has been somewhat lethargic, especially considering the initial mandate was over ten years ago. While the reasons for this have been multi-faceted, this paper shall focus on *trust*. Earlier theories of market transactions can easily be applied to what has occurred in the past ten years. The *fundamental transformation* (Williamson, 1975) describes what happens when a free market transforms from one with many competitors, essential to competition and therefore best product or service at best price. Williamson observes that in some, especially specialized industries, a large number of competitors often exists at the outset competing for a single, large contract. The stakes can be very, very high. When the contract is awarded, the contract winner prospers, while the other firms seek alternate contracts or go out of business. The market then transforms from one where there are many competitors to one where there are few. Thus, the next time a similar contract is put out to bid, there are fewer, if any competitors. There is even a practice in the DOD where program managers can obtain a waiver from competing the contract at all by claiming that it must be “sole sourced;” thus the government selects a contractor without competing the contract. One can easily observe that the DOD has undergone the *fundamental transformation*, arguably many times. Companies have come and gone, and many have merged or been taken-over. Williamson also points out that once the *fundamental transformation* has occurred, *opportunism* can occur, leaving the contracting organization stranded. Taken one step further, while some argue that opportunism is a company trying to maximize its profits and is perfect rational behavior, Granovetter suggests that *malfeasance* is when ties between organizations are embedded in a trusting relationship, and the trust is intentionally violated for the benefit of one party. (1985)

It is easy to think of examples where the remaining defense contractors⁴ have thick, age-old, embedded ties with the DOD program managers, so I will leave that up to the reader. Where one draws the line between *opportunism* and *malfeasance* in that arena is also up to the reader. Consider COTS software company *Alpha*. They make software, but are not privileged to the algorithm required by a certain DOD contract. They know that they can provide better software at a lower price than the current contractor, but since the DOD will not give them the necessary algorithm, they simply cannot compete on any level. In this case, it is unclear who is holding onto the code, or if it has been done

³ Of course, the aerospace industry and computing industry are not just casually intertwined. Without computers, the aerospace industry could not function, and without aerospace, it is not likely that the computing industry would have evolved as rapidly or in the same manner in which it did over the past 50 years.

⁴ Though technically part of the commercial world, defense contractors are to be distinguished from COTS providers in that a truly commercial product is one that is already available prior to a bid.

intentionally to keep smaller, leaner, more competitive companies away, or if it's even a matter of security. (That answer seems to come up more than it should.) But it is difficult for the most eternal optimist to not be cynical in such a case. Once again, the taxpayer has lost.

In the case above, as in many cases, the trust between the government and the defense contractor may exist on a personal, more subjective level than objective and the DOD has in effect excluded a viable competitor. It seems that once trust has been established and program managers become reliant on known quantities, they stay with it for better or worse. A new entity is perceived as risky, though it may be very clear that their product is better. According to the theory of *bounded rationality* (Simon, 1955), managers are rational, but boundedly so. In a high-tech contract, a manager cannot possibly know or understand every line of code or every part of an instrument. Thus, they rely on their advisors, subordinates, staff, and associates to do so. Once again, while making a selection of a contractor for a highly technical contract, the government program manager, rational but bounded, must place a certain amount of trust in his or her contractor. Since it has been established that we are likely to trust those with whom we are familiar, and that when the stakes are high, we do not like to take what may be perceived as risk, the government manager may be biased toward a company that is familiar to the exclusion of ones that may have a better products – perhaps even a commercial product that is already proven.

As a result, there is consensus among both government and industry leaders that the government and especially defense related contracts are somewhat weak in their market searches.⁵ Managers seem to move along embedded lines to well-known contractors or “sole source” suppliers. On the other side, many commercial vendors cannot or do not desire to do work for the government. The reasons for this are multifold. Government work requires – you guessed it – an inordinate amount to paperwork and regulations. Companies moving at high-velocity in high-tech environments are often not in a position to slow themselves down with this. The work often involves clearances taking months, and a bidding process that is costly, inefficient and long. One interviewee told me that in a high level meeting with industry leaders in Silicon Valley, many admitted to not even reading the *Commerce Business Daily* ⁶ to seek government contracts.

Where does this leave new companies? And what about commercial product companies with COTS products well suited to DOD needs? So far, it seems that they are outside the circle of the DOD and defense contractor relationship. Some have survived by getting into the DOD through subcontracting to defense contractors. Take, for example, software company *Beta*.⁷ They had a software product well suited to a DOD need, and bid on the contract. They lost the bid to defense contractor *Gamma*, but they ended up subcontracting to *Gamma*, and the DOD got the *Beta* product anyway at twice the price. A second example, COTS software company *Alpha* bid for a contract with government agency *Rho*, but lost the bid to defense contractor *Lambda*. (*Alpha's* bid was for \$1M;

⁵ From my own research.

⁶ As the name suggests, this is a daily report put out by the government announcing new business and opportunities to participate and bid.

⁷ The cases are real, but all company and agency names are pseudonyms.

Lambda's bid was \$100M.) After five years and a broken baseline of \$113M, *Lambda* had still not produced a functioning system. *Rho* finally returned to COTS software company *Alpha*, who had a system up and running within a year for the original \$1M. \$113M taxpayer dollars wasted, yet no one in the government was held accountable for this enormous error in judgment. It appears, as one COTS company partner told me “*That the lesser known companies need a big brother to get them in the door.*” Though apparently true with the U.S. DOD, so it does not seem to be as true overseas. Other countries are only all too happy to have the superior technology at lower prices. So, in order to stay alive, COTS companies are turning to international business.

Trust has worked against the market because it is only perceived trust based on past performance or other things that may have changed. Once again, James G. March cautions of learning from past experience (1999). And what about companies without a long history? In such cases, to mitigate risk, (discussed next) information gathering is key to a new trust relationship. (Kramer, 2002)

TRUST AND RISK

Escalation

Recently I talked with a program manager. He revealed the changes that had taken place in a specific government office over the past twenty-some years. Whereas the government program office was once highly leveraged against the contractor – that is there were few government managers and many contractors; a ratio, he recalled of about 1:20, he said that it was approaching a 1:1 relationship. “*It is getting just about as expensive to manage the contract as to build the actual product.*”⁸ We discussed the potential cause of this. With the design-and-build contracts – some that began before the emphasis on COTS and others that were able to skirt the newer commercial push in that no such products were available off the shelf – there has been much discrimination. For example contracts that have broken budget baseline or have run late, oversight has become understandably unforgiving. Thus, the level of trust for the government manager has lessened. In order to comprehensively answer to oversight, the government manager responsible is compelled to increase his or her staff to the point where they are matching the contractor nearly one-to-one. This is not only inefficient, but also very, very expensive. As a result, he told me, there are usually more meetings and more required reviews. The responsible manager or staff member or contractor is required, in such a review, to brief his or her superior on the status of the program or their segment therein. This requires hours of preparation and often travel. As such, there seems to be a trickle down effect; if the boss requires a review then the person responsible will require input from all of his or her subordinates. This is time consuming and costly. One military program manager with whom I spoke commented that when he was required to have an inordinate number of reviews, he told his superiors: “*Look, you guys need to get*

⁸ From a 18-year government veteran with extensive contracting experience who preferred not to be identified.

*somebody else because this is doing nothing... and it's wasting time. And if you want to do this, then that's fine, but find somebody who would feel fulfilled doing a lot of paperwork. If you want me to answer the question that you fundamentally asked... then stop having reviews and let's get down to doing work."*⁹ In his case, the commanding officer uncharacteristically backed off from the reviews and did as the manager suggested. But I dare say that the majority of program managers would simply comply with the request for reviews, and go ahead with the paperwork. If there is one review at a high level, then there are several at the lower levels, and so on. This is clearly a result of a lack of trust for subordinates will do their jobs. If one is constantly double-checking, then trust is weak. For some government contracts, the paperwork could fill a room.¹⁰

High trust in the marketplace has been touted because it reduces transactions costs. (Williamson, 1975) In manufacturing, for example, the *JIT* (just-in-time) inventory control methodologies depended on *trust*. The system, first popular in Japan, was an inventory system characterized by low inventory (and thus low inventory cost), but a high dependence on suppliers. Relationships between manufacturers and suppliers were tight, and grounded on common interest. The suppliers wanted to ensure that the manufacturers had their materials so that they would optimize output and require more supplies. The manufacturers also wanted to optimize output so that they could optimize income and required their suppliers to be trustworthy. As such, their suppliers were treated well. Trust was also essential for the *TQM* (total quality management) management philosophy that is based on the concept that responsibility should be pushed to the lowest level, and ensures that the lowest level is competent. Some argue that these two methodologies, both developed in Japan, were in part the reason for Japanese automobile manufacturing competing successfully with the U.S. auto industry. It is easy to see how trust in the marketplace has been considered an asset.

Returning to the fundamentals of trust, it is indeed true that to trust requires a certain amount of risk. (Hardin, 2002) When individuals trust, they are really doing so in belief that the outcome will outweigh any risk that they have taken in forming a trusting relationship. When organizations trust, they are doing the same thing. Indeed Williamson (1975, 1981, 1995) is correct when he states that trust can reduce transaction cost in the marketplace. That trust can be a good characteristic is a well-known axiom of the marketplace. (Kramer, 2002) If these relationships were trusting, then such paperwork, double-checks and reviews that slow the process beyond what is necessary would not exist. But over the years, as the government and defense contractors have been victims of opportunism, in order to answer to the taxpayers and Congress, documentation and contracting has become a huge part of any government work.

Balance

It is not likely in the professional world that unconditional trust exists. As discussed earlier, a holistic trust exists on a higher, even biblical plane. Thus trust in the

⁹ From a 25-year military veteran, now retired, who worked extensively in procurement.

¹⁰ I have seen this firsthand.

professional world must be balanced against risk. Though these entities may be difficult to quantify, the decision sciences have done this with great success. Within that, the science of risk assessment has been a helpful tool in making logical decisions with all the information available to the decision maker at the time of the decision.

Thus, in the professional world there needs to be a balance between trust and risk. In order to trust, especially initially, one must assume some risk. The payoff can be a new relationship with increased payoffs. Risk can be mitigated by a policy of *trust and verify*, or as Ronald Reagan used to say “Doverjai no Proverjai.” Reagan liked to trust people but he was also wary and savvy about political relations. Treaty monitoring was an important part of treaties authored by the former president. Rod Kramer (2002) refers to this as phenomenon, or management philosophy as *prudent paranoia*. A form, he notes of *constructive suspicion*, where people scrutinize and monitor their environment and colleagues. With the emphasis on prudence, Kramer gives the reader guidelines for being able to trust without becoming overly paranoid as he admits that he has been criticized for using the word paranoia. He also admits that being overly paranoid can paralyze organizational actors by disallowing them to take any risk – even a small one.

An organization does not want to experience paralysis in never trusting that which is unknown, nor does it want to be bowled over by untrustworthy behavior. So in the spirit of balance, the most successful organizations are those that can carefully balance trust and risk. Among other things, Kramer suggests that as well as other factors it is important to gather data. Returning to the discussion of the government, the DOD needs to become more acutely aware of the market, learn to trust those with whom they are not familiar, and balance risk, trust and verification.

MOVING FORWARD

As of the writing of this paper, the United States is involved with two very costly wars. In order to keep the deficit at bay, a 10% across-the-board budget cut has been approved for nearly all DOD programs. There is no better time in history for the DOD to seek leaner, sleeker commercial solutions to problems that have traditionally been solved with design-and-build programs. It is also important to note that even the benefits of COTS can be lost when paperwork is out of control, oversight is excessive and trust and risk are not appropriately balanced. Paul C. Light writes about the thickening government, a term he uses to describe a phenomenon of added layer upon layer of bureaucracy to answer to oversight and guard against risk. But at what cost? Clearly this is a case where prudent risk analysis and an informed decision to trust are not part of the equation.

Meanwhile, other countries are purchasing new and cutting edge COTS products that the DOD has turned away from. Where does that leave the DOD? In a position of spending more for less. The problem with software poses some new and interesting questions: How do you trust a product that you can't see built by people you don't know? In the COTS arena, many government program managers have found the answer to this question in using a multitude of approaches. (Baron, 2005) Here I emphasize the fly-before buy approach, the data gathering and trust and verify. Additionally, one should

note that software prices can vary wildly; especially in the COTS and design-and-build arena. It is more important to research what a proven product can do than judge products assuming that if something is less expensive, it can't possibly be good. Finally, companies who are not commercial providers have tried to peddle their wares as COTS when they are not. Some signs of this are high prices and the company background. A true COTS software provider makes about 70% of its revenues from software licenses. Sounds simple enough – almost obvious or intuitive – though it has not been part of mainstream past practices in the aerospace arena.

But all is not lost. There are many people in the DOD who are tenacious about changing this. Though their efforts may be somewhat akin to chiseling away at a glacier, indeed with an organization with the size and inertia of DOD, this is how change will come. In the meantime, it is costing tax money and lives. One of the most disturbing statements made by an Army officer, who I interviewed was this: “... *And here is the sad thing. With all the new hand held-technologies available, and all the inexpensive commercial technology that we could buy, our infantry fighter is still out there with basically a helmet and a rifle – not much different than WWII. Oh sure, there have been some improvements, but not to the degree that they should have occurred.*” The wars are happening now and the U.S. cannot wait any longer to embrace the whole of the commercial market. Our enemies surely have. It is time to move forward.

CONCLUSION

Trust, frequently touted as an asset in the marketplace as it can reduce paperwork and other transaction costs, can also be detrimental. Real trust is based on knowledge, and though knowledge may include past performance, as James March points out, history is not always a good teacher. Perceived trust is dangerous as it is based largely on perception. It is dangerous to trust too much with little verification or a comprehensive market search. On the other hand, inefficient verification – where the verification process costs more in time and money than the product is also not acceptable. As the DOD adds staff and “thickens,” as Paul C. Light (1995) observes, the organization gains inertia and entangles itself to a near halt. To be successful, the DOD needs to strike a balance between risk and trust. “Trust and verify,” as Reagan used to say. Rod Kramer terms it prudent paranoia. That is, to be prudent he notes that one must be on top of the facts, but not to the extent that it impedes progress. The United States is a business place like no other. The free society and abundant resources have allowed a technological commercial market that is second to none. It is time to capture these.

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