

**House Armed Services Committee**  
**The Tactical Air Land Forces Subcommittee**

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Testimony by

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Chairman Weldon, Congressman Abercrombie, members of the Subcommittee, I am honored by your invitation and offer the following testimony into the record:

My name is Alexander D. Stoyen, and I am the Founder and CEO of 21<sup>st</sup> Century Systems, Inc.® 21<sup>st</sup> Century Systems is a pioneer in intelligent agent based decision support software technology. An eight year old DOD contractor, 21<sup>st</sup> Century Systems, Inc. is applying its revolutionary technology to a wide spectrum of mission-critical systems, from dismounted soldier to Navy ships to Command and Control centers.

**Background: 21<sup>st</sup> Century Systems, Inc.’s Technology**

Before I share with you our very positive experience as well as opinions on the way ahead with the Small Business Innovative Research program, let me first explain what our technology is.

Today, it is fairly well understood what humans are good at and what are some of the basic limitations of human cognition and decision making. While humans possess exceptional “big picture” thinking and intuition, they are severely constrained in the volumes of unstructured data they can process. Humans also need patterns to discern what matters and how to then prioritize tasks under time constraints. On the other hand, it is also fairly well understood to what extent computer software can be used to fully automate a decision process. Software is endowed with exceptional computational prowess. Software can look for patterns in seemingly unstructured data, while not needing to find a pattern for comfort (the way humans do). On the other hand, software lacks human intuition and may engage in arbitrarily long “thinking” without realizing it.

Having understood well the strengths and weaknesses of both humans and computer software, 21<sup>st</sup> Century Systems, Inc. believes that humans and computer software working together can do better than either one alone. We accomplish this task by inventing very special software to support human decision makers. This software is based on intelligent agents, which are software components capable of both reactive and proactive intelligent behavior, learning and interaction with humans, other intelligent agents and a wide variety of information and data sources, such as combat system data flows, sensors and other information flows and devices.

Our intelligent agents perform a wide variety of tasks: proxy for human or other entity, data collector, fusion and reconciliation, arbitration and – very importantly – assisting humans in their decision processes. A typical intelligent agent or team of agents will bring in data from a variety of sources, then scale, convert and otherwise fuse the data, and then prioritize it and deliver it as appropriate to the human

partner, with the appropriate recommendations for the subsequent course of action. Agents also engage in extensive background analysis and exploration of alternatives, through an extensive array of heuristic algorithms, Game Theory, Devil's Advocate and What-If?-analysis, and other applied mathematical methods.

While there are a number of products available that essentially collect and deliver the data to a single display or screen, we consider these products to be not only of limited use but downright counter-productive. Human decision makers are already often flooded with too much "raw data". These other products merely present the same "raw data" in a different, more aesthetically pleasing fashion. The mere fact that the data are now "prettier" does not take away from the fact that the human decision maker is still overwhelmed and that the data are still not properly organized. As a result, the human decision maker in a time-critical situation likely will not be able to process mission-critical information – possibly missing crucial pieces of information – with potentially disastrous results. By stark contrast, our agents bring to the human decision maker what is needed, when it is needed and in the form that is needed.

Our intelligent agent based decision support technology has been captured in a commercial product called the AEDGE® or Agent-Enabled Decision Guide Environment. AEDGE components provide the abstractions of agents and all their interactions and other operations. The AEDGE is openly architected and allows easy management of components, including export of our components and import of third party components. This approach makes it very easy for the AEDGE to connect and otherwise interoperate with other systems, including much older legacy "stovepipes" (e.g., combat systems, simulators and trainers, sonar sensor suites). Essentially a decisions support system "toolkit", the AEDGE already incorporates our extensive know-how, making it orders of magnitude easier to build a particular decision support system (DSS) – say, a DSS to support a Tactical Action Officer (TAO) aboard an Aircraft Carrier – using the AEDGE toolkit than to build such a DSS from scratch.

21<sup>st</sup> Century Systems, Inc.'s products have application across the full spectrum of mission areas. Our decision support software can be used when one has too much information, not enough information, uncertainty of information, in real-time situations, post-op, tactical or security, and so on. Some of the representative SBIR Phase III applications of our adaptive technology are as follows. The Consolidated Undersea Situational Awareness System (CUSAS, **Figure 1**) focuses on decision support under uncertainty, for the Submarine Fleet. The Advanced Battlestation with a Decision Support System (ABS/DSS) provides tactical decision support for command and control personnel aboard Aircraft Carriers. A CUSAS variant, Shipboard Automated Reconstruction Capability (SHARC) is going to provide Navy platforms (beginning with the Virginia class submarine) with mission reconstruction and training tools. SituSpace (**Figure 2**) provides a Single Integrated Space Picture for the Army and (under consideration) Joint space operations. HiRSA, or High Resolution Situational Awareness (**Figure 3**) is being fielded in August with the 1 Marine Expeditionary Force in Iraq beginning in August, and provides a high-resolution 3D command and control platform for urban tactical operations. ExLoG21 provides the intelligent decision support capability for autonomic logistics systems, supporting expeditionary logistics operations. SentinelNet creates a fused, intelligent network of sentries, sensors, computers and command and control center personnel, and will provide Anti-Terrorism/Force Protection command and control for Navy ships and shore installations. SASA provides weapon-target pairing and automated ingress/egress routing for tank crews. Webster is an intelligence analysis tool that continuously monitors, interprets and correlates web-based open source information, providing analysts with correlated hypotheses on terrorist activities occurring worldwide. I hope these project snapshots give you an idea of the wide variety of applications and implementations we have been able to achieve with our software as a result of the SBIR process.

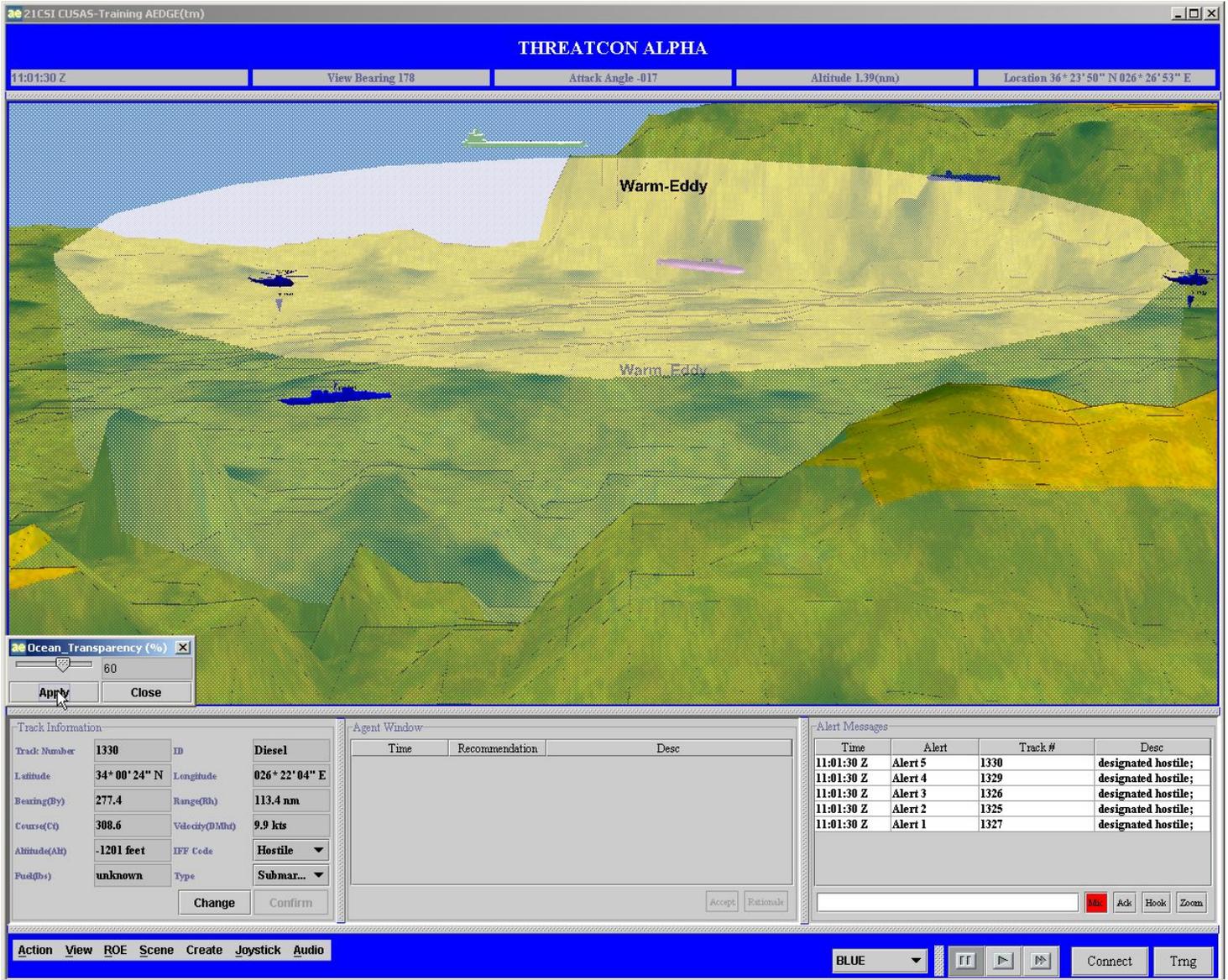


Figure 1. CUSAS

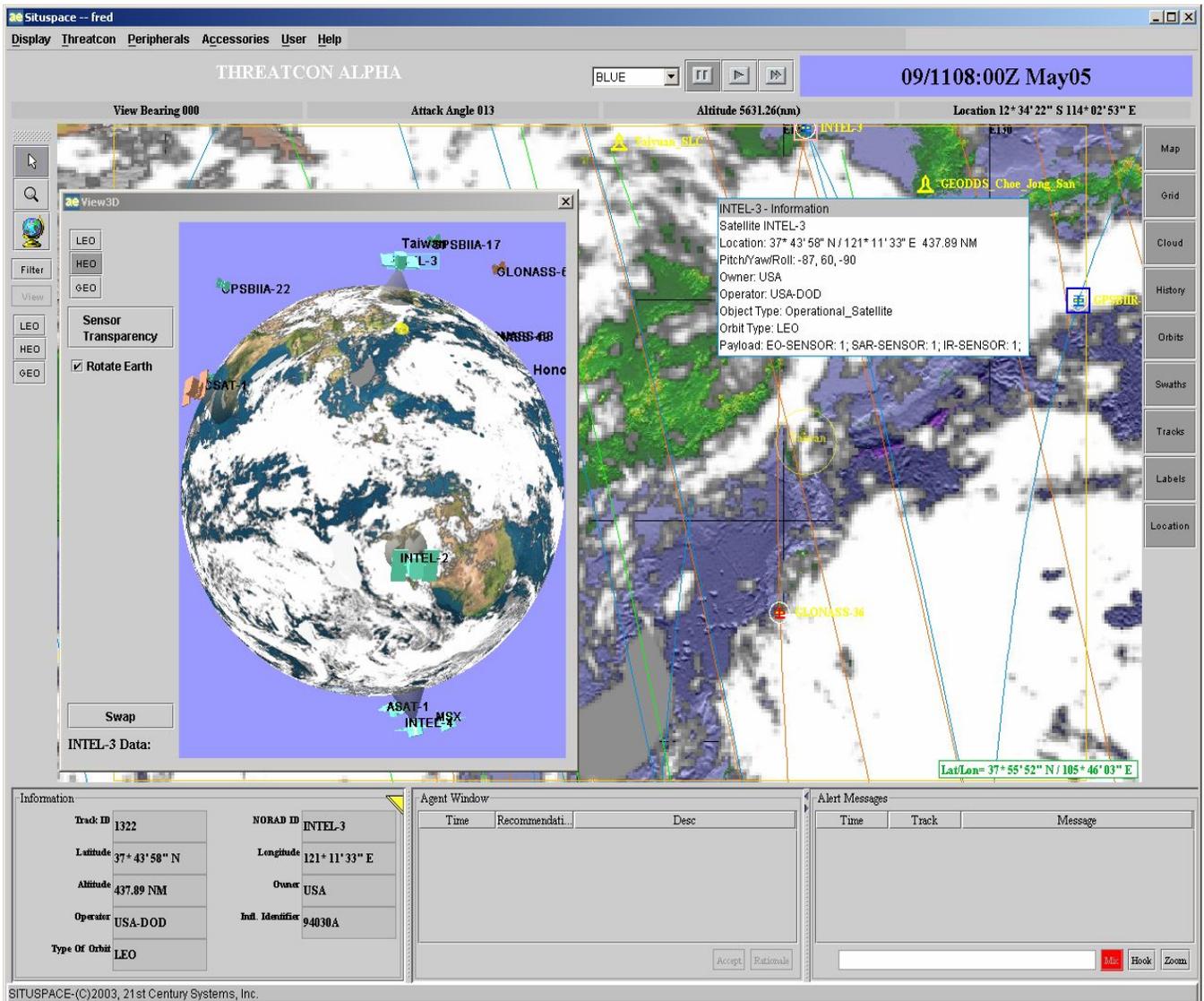


Figure 2. SituSpace



**Figure 3. High Resolution Situational Awareness (HIRSA)**

## **21<sup>st</sup> Century Systems, Inc. and the Federal SBIR Program**

No Federal program can (or should) be sufficient to create and keep on “feeding” a business. Every company worthy of mention starts with an idea that should come from the entrepreneurs who start it, not the Federal Government. 21<sup>st</sup> Century Systems, Inc. is no exception. Computer Science founders have established theoretical limitations on what computers can do alone, but they never ascertained how these limitations can be pushed by humans and computers working together. My idea therefore was to start a company to find out just how much more can be accomplished by humans and computers (or more precisely, intelligent computer software) working together, than by either one alone. This is why 21<sup>st</sup> Century Systems, Inc. was started. Obviously too, one has to be insane to start a high-technology company without any idea of how its technology will in fact be pursued and delivered to eventual customers. Thus, without any help from the SBIR program, I and those who joined 21<sup>st</sup> Century Systems early on already had the fundamental scientific underpinnings of our technology and of the basis of our software (the AEDGE) worked out. And for completeness, let me add that this basic research and the AEDGE ongoing evolutionary design and development have always been an IR&D activity, not a DR&D activity at 21<sup>st</sup> Century Systems, Inc.

However, no company can exist on ideas and technology alone. Customers are needed and the technology must be cast into the form that each customer would benefit from and therefore would consider paying for. 21<sup>st</sup> Century Systems, Inc.’s customer is the Department of Defense. DOD acquisition programs are typically long-lived, highly complex undertakings. It takes a major effort, in time and resources to learn and understand what these programs need. A very real issue for a small business is: How does one meet payroll while learning about the customer and before there are any real sales?

Enter the SBIR program. Today, this three-phase program is the best if not only fair and open way to meet one’s payroll while trying to apply one’s technology to a particular customer need. Learning about the customer has to be part of the undertaking. Obviously, not every company can be taught successfully, nor is every technology necessarily of eventual use to the Federal customer. Moreover, no company should be paid indefinitely to learn, without some reciprocity and delivery of a useful product to the customer. Most small high-technology companies will, in fact, not succeed in the SBIR program. Many will fail promptly and in no uncertain terms. A number may become life-style companies and “hover” at a life-style level of funding for a while, without transitioning, thus ultimately failing. Still, the best will survive, excel and eventually thrive. Based on extensive observation and experience, I can say with near absolute certainty: the companies that do succeed in the SBIR program are the most innovative, agile and competitive in the Nation. And I can also say with near absolute certainty that without the SBIR program these companies likely would have never delivered any of their technology to the Federal customer.

21<sup>st</sup> Century Systems, Inc.’s own experience with the SBIR program, predominantly in the DOD, has been very positive with awards from USAF, USA, USN, OSD, DARPA and SOCOM. We received funding for a Phase I SBIR in our first year of operations. The work never went to Phase II but we had an opportunity to show what we were doing to a number of eventual customers, who next funded us for more Phase Is, eventually Phase IIs. While this funding enabled 21<sup>st</sup> Century Systems, Inc. to maintain very modest operations and even meet payroll, we recognized early on that the DOD end users are not those folks immediately associated with the SBIR work. The end users are our soldiers, sailors, airmen and marines. With the strong blessing and support of our SBIR program managers, we therefore went to the end user – the warfighter – to find out what they thought of our work. The warfighter very much liked our technology and wanted the it fielded as soon as possible. With this message in hand, we went back to the program managers.

We soon found out that while not every program manager in the DOD thinks equally highly of the idea of accepting technology from small businesses, a number of them did approve of this and were willing to give us a chance. That number has grown over the past few years and our work is now transitioning very well – as DOD Phase III SBIRs – into various DOD acquisition programs. The majority of these programs are in the Department of the Navy (including USMC) and a growing number of very significant transitions are now in the Army. We fully expect our first Air Force Phase III possibly in FY04 and certainly no later than FY05.

### **Consolidated Undersea Situational Awareness System: An Example of a Successful SBIR**

To illustrate how 21<sup>st</sup> Century Systems, Inc. pursues SBIR work, I would like to provide an example of one of our very successful SBIR programs, namely Consolidated Undersea Situational Awareness System (CUSAS). CUSAS started as a DARPA Phase I SBIR and transferred to the Navy for Phase II (and now Phase III), to provide the Submarine Force with suitable tactical decision support. Given the nature of sensors (predominantly sonar) aboard submarines, CUSAS has to provide decision support under conditions of both massive data inflow and extreme uncertainty in the data. We have worked closely with the submarine community. Commander Submarine Force Pacific at Pearl Harbor, Hawai'i, has advocated very strongly for CUSAS' development, experimentation and fielding. CUSAS' baseline intelligent agent training is based on submarine doctrine and tactics provided and kept by the Submarine Development Squadron 12 at SUBASE Groton. The Office of Naval Research (ONR) that manages CUSAS has enabled all official provisions and government furnished information, and has worked closely with Naval Sea Systems Command (NAVSEA) to find an official transition home for CUSAS.

In turn, the Navy Program Executive Office Integrated Warfare Systems (PEO IWS) at NAVSEA has accepted CUSAS into its acquisition programs, in the Undersea Warfare Systems area (PEO IWS 5). The CUSAS Phase III is occurring in parallel with the Phase II still active. This technology will be in the hands of the warfighter many years before any other Federal program could have discovered, grown and fielded it. CUSAS is inexpensive. Furthermore, evaluations of our technology have shown that warfighter's function is considerably enhanced and manning requirements reduced by the technology. Once fielded, therefore, CUSAS will result in additional savings due to increased performance and reduced manning requirement as well.

In addition to the obvious benefits to the Navy (and the taxpayer) presented above, CUSAS has a number of other benefits. One of these is the excellent relationship between 21<sup>st</sup> Century Systems, Inc. and the University community that CUSAS funding has facilitated. One outstanding example of this is our discovery of a unique (and largely unfunded by Federal programs) expertise at the University of Hawai'i. Specifically, in the College of Social Studies at the University of Hawai'i there is expertise in modeling how culture affects decision making. Through a subcontract from the CUSAS SBIR to the University of Hawai'i, a very fruitful collaboration was struck. Near future generations of CUSAS will include and field "culture" DSS modules. A US submarine commander will be able to predict much more accurately how a foreign counterpart may react to relevant tactical situations. Cultures play significant role in this process. A foreign CO will not necessarily act the way a US doctrine and tactics would prescribe. Obviously the submarine-relevant modules will be classified. Yet an unclassified subcontract continues to pay for basic research – harvested thus indirectly but very effectively by the DOD – by outstanding university faculty and graduate students.

## **How Can the SBIR Program be Improved Further?**

Today 21<sup>st</sup> Century Systems, Inc. is a Navy and DARPA SBIR Success Story. Our DOD SBIR Commercialization Index (meaning transition through Phase IIIs) is 100%. We believe that, as the DOD realizes the vital importance of applying intelligent decision support systems to the practice of modern warfare, our technology will be eventually fielded into nearly every platform in the DOD, and across all Services in the next four to ten years.

Yet I would be remiss in what I have been invited to talk about today if I did not provide some suggestions as to how the already very strong and well-working SBIR program can be made even stronger. My remarks will continue to be limited primarily to the DOD SBIR Program and to our technology area (which is part of a larger area, namely Information Technology).

**Improve Links Between SBIR-Funded Programs with Acquisition Programs.** One observation is that not all DOD SBIR component programs are of equal strength. The issue is absolutely not for lack of trying, but rather, in the fact that each program is organized differently. From our point of view, the Navy SBIR Program is run extremely well because it makes a significant effort in identifying transition and commercialization opportunities early on in the SBIR lifecycle. The Navy program is run by the Office of Naval Research (ONR), in close collaboration with the Naval System Commands (SYSCOMS: NAVSEA, NAVAIR, SPAWAR and others). Since the ONR and the SYSCOMS are, respectively, the R&D and the acquisition arms of the Navy, such collaboration is a very good way of running the SBIR program. To provide for cross-pollination of technology suppliers and those who demand it, the program runs a unique year long undertaking, the Technology Assistance Program (TAP). Not surprisingly, the first 21<sup>st</sup> Century Systems, Inc. Phase III was awarded by the Navy and Navy Phase IIIs remain in the clear majority of all our Phase IIIs. It would be a mistake, however, to say that the other Services do not pursue their SBIR programs with rigor. We have been awarded funding from most other DOD components. In the Army, we now have a growing number of very significant transitions. These are coming to us directly from Army's own PEOs and acquisition programs. It is significant to note that the CUSAS program discussed earlier originated at DARPA before it was transferred to the Navy. A number of our transitioning (into Phase III) SBIRs are funded in Phases I and II directly by the OSD, Homeland Security and other Service-independent organizations, but are managed by the Navy. We therefore believe that if every Service were to effectively link SBIR management with acquisition program management, their SBIR transitions would increase and the program would be even more successful.

**Educate Acquisition Community on SBIRs.** Another area of improvement and one that would be beneficial across the Services, is educating the acquisition management community about the SBIR program. This subject must be made part of this community's formal education and certification, in the Defense Acquisition University curriculum, at every level, and mandatory for advancement. At their Level 3 certification, these professionals should be experts on not only acquisition in general but SBIR Phase III acquisition. Today this community often has trouble understanding that Phase III is both post-compete and considerably less expensive than alternative sources.

**Educate Acquisition Community on Information Technology (IT) and on Small Businesses As Major Sources of IT Innovation.** In the Information Technology sector, we have an additional educational barrier. The acquisition community does not fully understand that innovative technology in the IT sector has always come from three sources: corporate research divisions of major IT corporations (such as IBM Research, Xerox PARC or AT&T Bell Labs), small businesses and, somewhat modestly (due to their preference for basic research as opposed to applied research and technology) universities. Thus, innovative technology has not come traditionally from system integration divisions or Federal

sector divisions. Yet today the acquisition community purchases innovation predominantly from large IT integrators. In doing so, they are not getting much innovation and are furthermore blurring the boundaries between innovative technology and technical services. One good example of how blurred the boundaries have already become is in the fact that every program or contract officer understands work for pay but many have trouble understanding software licensing (Yet the latter is a core concept in software product sales).

**Rapidly Accelerate Insertion of SBIR-Funded Information Technology.** Another observation of possible benefit to the DOD SBIR program is that Information Technology (IT) evolves far faster than many other technologies. Today, it takes two to four years to start a new program, and then enter into a POM'ed six year FYDP. Such a cycle is probably fine for building hulls and reactors, but not IT. In six to ten years IT undergoes multiple generational changes. Thus, DOD should consider considerably more rapid, "just in time" Information Technology acquisition. 21<sup>st</sup> Century Systems, Inc. found some program managers – such as in the NAVSEA PEO IWS 5 as mentioned earlier – who are willing to try such rapid insertions. Still, this is not an easy task for these program managers to undertake. A program office that would be dedicated to rapid insertions of relevant areas of IT – with strong support from the SBIR program managers (such as in ONR) – would be an even better way for the DOD to acquire this technology. Perhaps a pilot program office of this kind could be tried in PEO IWS 5 or elsewhere.

**Create DOD-Small Business Enterprise Exchanges.** I would create an exchange program between senior DOD technology and acquisition leadership and small innovative business executives (much like the IPA program works today at DARPA, ONR and the NSF, though I would emphasize acquisition commands for the government side of the program).

**Make SBIR Technology Insertion A National Priority.** To level the existing playing field with large integrators, we would strongly welcome a Presidential Executive Order, a Resolution of Congress or better yet both to make SBIR technology insertion into DOD acquisition programs a priority.

**Permit Flexible and Practical Data Rights for SBIR Technology.** DOD should specifically authorize flexible data rights authority and negotiations by DOD officials with SBIR firms, so that data rights can be quickly and efficiently adapted to each weapons program (instead of forcing DOD officials to deal with the "One Size Fits All" prescriptions in today's DOD data rights clauses).

## Conclusions

The SBIR Program is the most effective way to secure first-quality technology meeting government customers' needs while allowing small enterprises like ourselves to remain viable. We have experienced a number of shared positive results from the SBIR process that should be articulated in this important evaluation. First, the SBIR process often fosters a durable relationship of professional trust between the developers of technology and the DOD customers. In the traditional procurement process, this is often a problematic hurdle because of the size and complexity of contracts involving large integrators. The closer professional understanding allows the technology development to occur through a far more collaborative and cost-effective scenario, one that often becomes more flexible and responsive to customer needs.

Second, I submit to you that the SBIR process allows for more accountability of funding for research. Because contracts are more discreet, and customers have flexibility to guide the R&D to meet their priorities, one can honestly conclude that in a variety of ways, government is getting more return on its

investment in technology through SBIR. Further, no scientific study is needed to appreciate that many SBIR companies are highly entrepreneurial, very efficiently run, with a minimum of overhead.

Third, the SBIR (and STTR) paradigm, encourages and embraces the development of relationships with universities and non-commercial research institutions. These relationships in turn facilitate rapid and timely inclusion of cutting edge basic research into innovative, practical technology.

Fourth – and I mean no disrespect to the distinguished legacy of our nation's major research institutions – we have learned first-hand that many of our most talented young technologists and researchers have opted for the small business environment, high-energy, very personal environment over a large bureaucracy. One need only survey the exciting array of SBIR participating companies to see how wonderfully effective we have been in attracting some of America's sharpest young minds who thrive in this kind of workplace.

In brief, the SBIR Program is already a winning formula for the triumvirate of beneficiaries to its long-term success: The taxpayer, small business and the Federal government. Thus, my considered recommendations for improvement of this already stellar technology innovation program are offered for the further benefit of this troika, such that the DOD SBIR Program will thrive even more.

Given the decreasing R&D budgets of large corporations since the late 1980s, and as someone with extensive R&D experience in all of large corporate research, academia and small business, I am of the strongest and well-founded, expert opinion that the most innovative IT now comes from small businesses. I started in large corporate research and then left for academia. I then left a tenured, endowed full professor position to run 21<sup>st</sup> Century Systems, Inc. Luckily for me, 21<sup>st</sup> Century Systems, Inc. has enjoyed exceptional success. With all sincerity I can say that very much of this success is fully attributable to the DOD SBIR program. Thank you for this exceptional program and thank you for inviting me to share our SBIR experience with your Committee.

### **Biographical Summary**

Dr. Alexander D. Stoyen is Founder and CEO of 21st Century Systems, Inc.® (21CSI®). Previously, he was an Endowed Full Professor and Director, Center for Management of Information Technology at the University of Nebraska at Omaha and the Peter Kiewit Institute of Information Science, Technology and Engineering. Dr. Stoyen's prior appointments have included the IBM T. J. Watson Research Center, the IBM Zurich Research Laboratory and the New Jersey Institute of Technology. An accomplished technologist and researcher, he is well known for his work in decision support systems, real-time systems and languages, distributed programming environments and remote procedure calls, and in engineering of complex computer systems. An IEEE Computer Society Golden Core Member, Dr. Stoyen holds a Ph.D. in Computer Science from the University of Toronto. He can be contacted at [Alexander.Stoyen@21csi.com](mailto:Alexander.Stoyen@21csi.com).