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Simulation, Computing, Information, and Future Warfare

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ABSTRACT

To fully exploit the capabilities that will become possible through the integration of all of these advances, a laboratory has to have a strong, fundamental position in each of them. To foresee the new capabilities possible, it is necessary to be able to think quantitatively and creatively all the way from the technologies for precision to the unthinkable to nuclear deterrence in an amorphous world. By a combination of foresight and luck, Los Alamos has such a combination, and is committed to remain on the forefront of the technologies that define the competitive advantage of the U.S. military and the industries that stand behind it.

I. INTRODUCTION

Recent memos on "Computing, Information, and Information in the Future" and "Warfare in the Year 2030" were written quickly and separately, but share certain themes. They are joined here as background material for discussions of the future of the Los Alamos National Laboratory. Certain redundant paragraphs are omitted.

II. THOUGHTS ON SIMULATION, COMPUTING, AND INFORMATION

Los Alamos has some real strengths. Most people think they reside in our large, hungry computers. Computers are a resource, but perhaps its smallest one. Its real resource is the people who are skilled at using them in very large simulations and the contacts we have in the services who would like for us to use them more effectively on simulations of their virtual reality.

As to the latter, the DoD's DARPA and DDR&E have finally brought virtual reality to the threshold of virtual respectability. It is now believed that large simulations can do more good than harm in defining and deciding between new weapons systems and hierarchies. A big problem in the past was service advocacy. Most of the big simulations of the past, including those that led to "Air-Land Battle 2000" and FUFO were tuned up to sell fighters or tanks or both. What is needed is a neutral group of expert simulators who do not have a stake in the hardware implications of the simulations--just in doing the best simulations possible. Los Alamos could be such a group.

A general problem in doing simulations is establishing an interface with the military service users that can translate missions into models with any useful degree of fidelity. Los Alamos now defines that interface for Army simulation and has been asked to do likewise for the Air Force Space Command, STRATCOM, and Combat Command. Los Alamos has excellent contacts with the Navy at all relevant levels. It is in a position to do excellent simulations of future systems and organizations for each of the services and hence for overall combined force operations in the theaters of interest in the future. The Laboratory could simulate integrated operations involving land, air, sea, and space forces and do them with real fidelity and confidence.

A big part of that capability is the large number of people trained here, many in the weapons program, who are not afraid to tackle big models, run very large and expensive calculations, and try to extract very subtle messages from them. That has been their job for years. They could shift to massive simulations of combined-arms virtual reality in a matter of months.

Los Alamos also has good working relations with the external world in component models. Contractors would not be reluctant to bring their component models here, as long as the Laboratory concentrates on the big picture and lets them eat off of their component pieces. People like to come here, and they have found our CCF a nice place to send their toys electronically. The Laboratory has built up a lot of good will that we could count on in our marketing.

Los Alamos has a lot of skill at both conventional and advanced signal processing. The Laboratory can handle big number crunching problems with conventional techniques today. And the work it did in defining data handling distributed remote sensing brought us up to the state of the art in the world in data fusion and advanced signal processing--although our capability in those esoteric arts is not as yet fully appreciated in the general community.

Finally, Los Alamos does have computers. Tackling the design of the military forces of the future is an immense task. We barely have the resources required. No one else does. We also have the skills in graphics, presentation, and interpretation that could keep us from drowning in bits and that are needed to communicate the important results to military users. Los Alamos has another

thing, too: the DoD's respect. It may not like the Laboratory's independence or stumbling attempts at building DoD hardware, but it recognizes the Laboratory's unique ability to tackle large computer problems of this nature as a natural, and has no one else adequate to the challenge just now.

III. THOUGHTS ON WAR FIGHTING IN 2030

2030 is a long way off. It is hard, but useful, to imagine what technology will be like then. The military systems of 2010 are those that are in development today. We would be hard pressed to introduce more advanced technology into them. But those of 2030 are hardly defined, and could be impacted profoundly by advanced and creative research. Thinking about what the world will be like is a bit of a guide. For one thing, 2030 is about when even the most optimistic, environment-free predictions indicate that the competition for resources will become acute. It will be a mean world. The rich are getting richer and the poor are getting poorer--and madder.

A. Trends

The DoD thinks current policy and trends are likely to lead to a world some 15-20 years hence in which there are 20-30 nations who do not like us very much with weapons of mass destruction and several means of delivering them. By 2030 the number could grow to 40-50 nations with access to user-friendly versions of much of the latest military hardware sold to them by our current allies. Some conclude there is "little likelihood that [proliferation] can be stopped soon, much less reversed." This powerful, negative summary of our honest thinking means that there will be threats to U.S. security and that future coalitions will be much harder. Defenses will be a necessity--not a luxury. We will largely be going it on our own to protect access to resources and to maintain the independence of like-minded minor nations without major military facilities to support our long-range operations.

Over the next 3-4 decades, technology is likely to explode at a much higher rate than the present. By 2030 global sensor suites will be able to find and track almost anything in real time, and advanced weapons will be able to target those targets with precision in real time. They will be able to strike globally, partially from space. The war between the hiders and finders will become a desperate scramble in the air, land, sea, and space. There will be no sanctuaries.

B. Role of Technology

The question then becomes what technology can do to enable the U.S. to project power globally in a largely hostile world with at best the previous generation of technology and few inhibitions about using it. My answer is currently unpopular: the main thing the U.S. DoD will have going for it is the capability and dedication of its military people; thus, increasingly the margin of victory will be in using technology to squeeze the maximum of performance from each one.

There will be tremendous advances in electronics, computing, and manufacture, but these advances will be focused into force multipliers for the man behind every plane, tank, ship, or spacecraft. The reason for that conclusion is a simple scaling argument. Information processing capability roughly doubles every 2-3 years, so over approximately the next 40 years, information processing will improve about a factor of $2^{20} \approx 10^6$. That will make machines that are "brilliant-squared" by today's standards, but in absolute terms, they will be about as smart as chickens. Their main role will be to improve the performance of man, who will still be the fastest and most versatile parallel processor in the battle.

Getting the most out of man will require getting the most out of every supporting technology. Electronics will have to be pressed to the nanotechnology region to keep up with him. Biology will be pushed to the limits of sensing to read out his commands, convert them into signals, and feed back the results of actions or analyses. Computers will be pushed to gigaflop and petaflop rates to analyze possibilities and control auxiliary sensors and weapons. Communications will be pushed to the limit to maximize his contribution while minimizing his exposure to hostile environments and giving him access to the best data and technical and political advice.

C. Simulation, Computing, and Information

Such a capability is a logical outgrowth of current trends, taken to their logical extremes. As noted above, DARPA and DDR&E have brought virtual reality to the threshold of virtual respectability. People now believe that large simulations can do more good. The challenge of the next decade will be to make a reality out of decision-assisting systems. The challenge of the next decade will be to convert those virtual realities into mechanisms for controlling those systems and hierarchies. The challenge for 2020-30 will be using the limits of bioengineering and computers to allow man to not only command those systems but to reconfigure them in real time to maximize performance against adversaries almost as capable and flexible as himself.

It is said that "Wellington's drills were bloodless battles, and his battles were bloody drills." It may be necessary to approach that level of correspondence between training and combat again to get maximum performance from the new generations of technology. The path to maximizing growth in that dimension is to develop the simulations of systems and the simulators for training together in an integrated system, package, and facility.

Los Alamos could help in each of these challenges. In the past a big problem in systems simulations was service advocacy. What is needed now is a neutral group of expert simulators who do not have a stake in the hardware implications of simulations, which is almost a definition of Los Alamos' normal functioning. Los Alamos is working with DDR&E to capitalize on its expertise in simulation and excellent working relationships with the military services to provide a capability to do excellent simulations of future systems and organizations for each of the services and hence for overall combined force operations in the theaters of interest in the future.

Because of its capability in both hardware and software, Los Alamos could also add all-important hardware-in-loop simulations needed to rapidly assess the impact of new possibilities. That is critical, given that the goal is not only to put the best options in the hands of the user, but to put the best options there faster than the other side can. Now delinquent, that time-to-market could be the biggest contributor to the margin of victory in an increasingly competitive future. Los Alamos has other real strengths. Most people think they are our large, hungry computers, but we have another: DDR&E's respect. It recognizes our unique ability to tackle big computer problems.

D. Biological Sciences

Computer, software, and simulations skills are dominant through 2000-2010. Thereafter, the principal areas for competition are likely to be biotechnology and bioengineering, in which Los Alamos has very strong positions. In those decades it will not be enough to synthesize new materials and sensors; it will be necessary to grow them through a synergism between materials and biological engineering. The sensors and satellites of 2020 may not have focal planes that are etched lithographically; they may be grown organically to enormous size and complexity. Satellites and aircraft of the future may likewise have skins and energy stores that are grown and partly biological. In designing hybrids to perform such functions, it is essential to have a full-spectrum research capability that can learn from how living organisms themselves evolve to provide new, competitive capabilities.

The limits of the fusion of material science, bioengineering, and information technology are almost limitless, but they surely include smart sensors that can generate their own energy and seek the enemy, satellites the size of basketballs that can fight or flee and adapt their sensors to new challenges, and undersea creatures with enough intelligence and resources to track their prey.

IV. SUMMARY AND CONCLUSIONS

To fully exploit the capabilities that will become possible through the integration of all of these advances, a laboratory has to have a strong, fundamental position in each of them. To foresee the new capabilities possible, it is necessary to have a laboratory that can think quantitatively and creatively all the way from the technologies for precision to the unthinkable to nuclear deterrence in an amorphous world. By a combination of foresight and luck, Los Alamos has such a combination. And it is committed to remain on the forefront of all of these technologies that define the competitive advantage of the U.S. military and the industries that stand behind it.