

Research



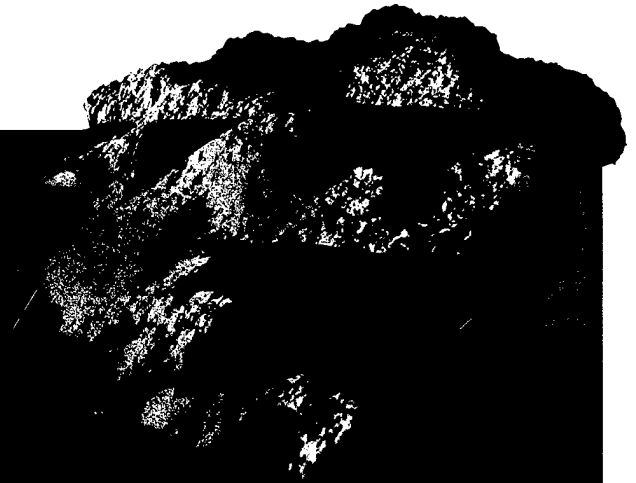
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Space Tracking Technology Focuses on Deep Space

new, state-of-the-art space
tracking technology will
give the Air Force better
situational awareness of the
space environment by
providing better detection
and tracking of objects
in deep space.



Dr. Grant Stokes

This new technology, developed by an AFOSR-supported research team lead by Dr. Grant Stokes at MIT-Lincoln Laboratory, improves the worldwide capability for detection of Near Earth Objects (NEOs) by 300 percent.

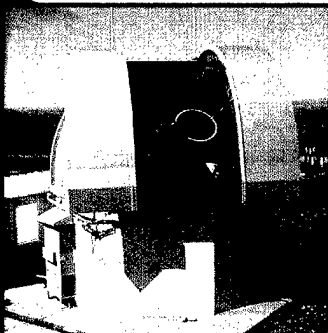
Basic research in detection and tracking of NEOs benefits the Air Force's mission in space by:

- Providing a test-bed to develop enhanced technology for the detection of smaller, fainter, and more slowly moving space objects, and

- Contributing to multi-agency initiatives intended to identify, catalog, and predict the orbits of space objects that may pose a threat to the Earth, or high-value space assets such as the International Space Station, among others.

continued on page 3...

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AFOSR Provides Early Support for Principal Architect of Computer Revolution

Back in the early 1960's, AFOSR Project Supervisor Mrs. Rowena Swanson probably didn't realize the tremendous impact one contract, No. AF49(638-1024) and the resulting report, No. AFOSR 3233 would have on both the military and civilian community.

After all, the researcher's colleagues and prospective employers didn't offer much support for his vision of augmenting human intellect and the potential of computers to assist people in complex decision-making.

For some reason, AFOSR did see the potential and awarded a contract to Dr. Doug Englebart at the Stanford Research Institute.

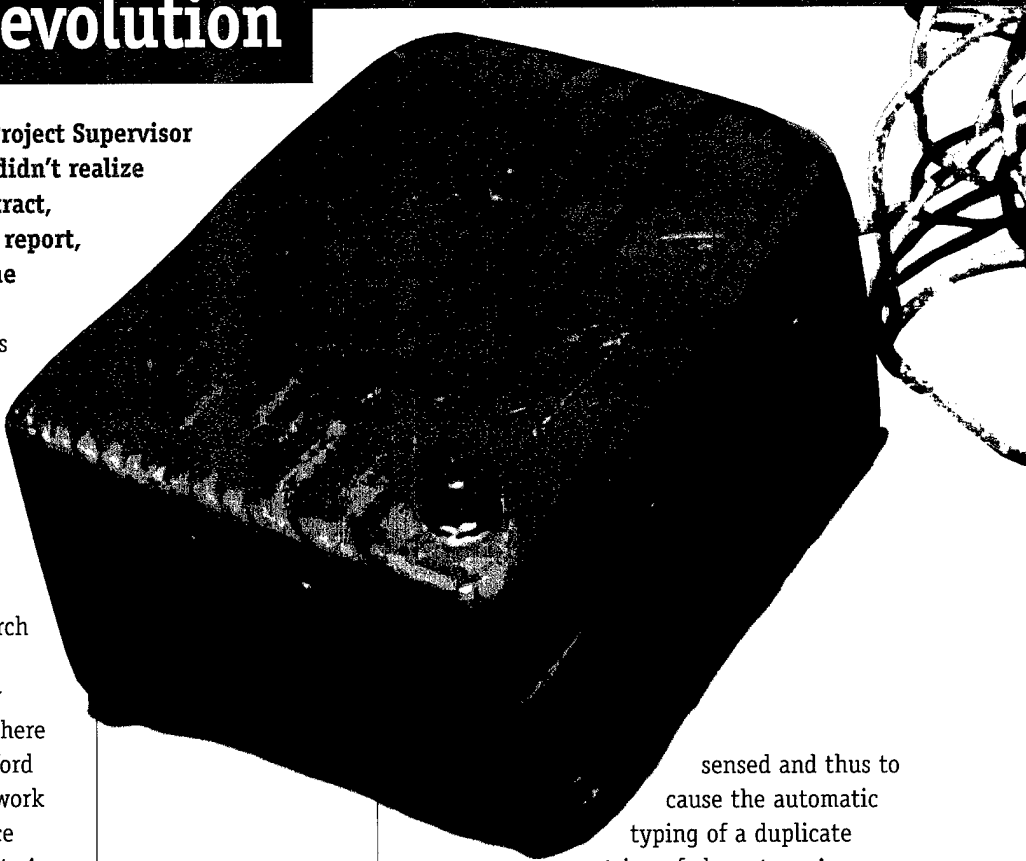
"I got some money from a small Air Force Office for Scientific Research, and there was enough there along with SRI's (Stanford Research Institute) contribution I could work full time for a couple of years and produce what I called *Augmenting Human Intellect: A Conceptual Framework*," said Englebart in a May, 1994 interview.

That resulting work, published in 1962, serves as a sort of roadmap for developing computer technologies. Englebart believed that the complexity of problems facing mankind was growing faster than the ability to solve them.

"We envisioned problem-solvers using computer-aided working stations to augment their efforts. They required the ability to interact with information displays using some sort of device to move (a cursor) around the screen," said Dr. Englebart in published interviews.

In his report, Englebart gives some clues as to where computing would develop.

He suggested the development of an auxiliary device, a gadget "that is held like a pencil and, instead of a point, has a special sensing mechanism that you can pass over a line of the special printing from your writing machine (or one like it). The signals which this reading stylus sends through the flexible connecting wire to the writing machine are used to determine which characters are being



sensed and thus to cause the automatic typing of a duplicate string of characters. An

information-storage mechanism in the writing machine permits you to sweep the reading stylus over the characters much faster than the writer can type; the writer will catch up with you when you stop to think about what word or string of words should be duplicated next, or while you reposition the straightedge guide along which you run the stylus.

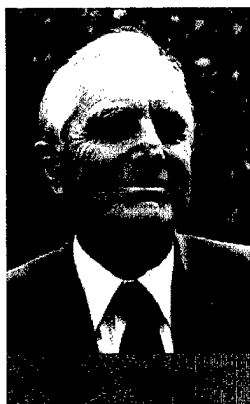
Today, that gadget is known as a mouse.

"A bonus feature," as Englebart describes it, would be a common working structure so that individuals, as part of a team, can work on the same project simultaneously. "The whole team can join forces at a moment's notice to 'pull together' on some stubborn little problem, or to make a group decision."

He called it inter-communication via computer, today it is called networking.

Englebart's report, with AFOSR support, is filled with concepts that have materialized and fueled the Information Age.

More information on Englebart's work, *Augmenting Human Intellect: A Conceptual Framework*, as well as his current initiatives can be accessed at: www.bootstrap.org



As the inventor of the mouse and scores of computer-related innovations, Dr. Englebart has a thirty-year track record in predicting, designing and implementing the future direction of organizational computing.

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ABOVE: The first computer mouse was invented in 1963-64 as part of an experiment to find better ways to "point and click" on a display screen. Due to space restrictions, the first mouse (pictured above) had only one button and was carved out of wood. An improved mouse eventually contained three buttons — an "upgrade" that was limited due to space required for the three micro-switches.

continued from page 1...

The Lincoln Near-Earth Asteroid Research project, or LINEAR, uses a 1-meter aperture telescope located near Socorro, N.M. to detect and track potential NEO candidates. This telescope uses highly sensitive electronic devices called charge-coupled devices (CCDs) to photograph the sky, while computer algorithms process the images and quickly detect any changes from one observation to the next. Asteroid observations are forwarded to astronomers at the Minor Planet Center in Massachusetts, who then calculate the object's orbit and provide discovery acknowledgments.

The LINEAR system incorporates innovative technologies, including:

- Large format, highly sensitive, back illuminated CCDs,
- Fast frame transfer readouts that allows a new image to be collected while the previous image is being read out — thus yielding very high search efficiency,
- New camera systems for improved sensitivity, and
- Customized, high throughput data processing systems.

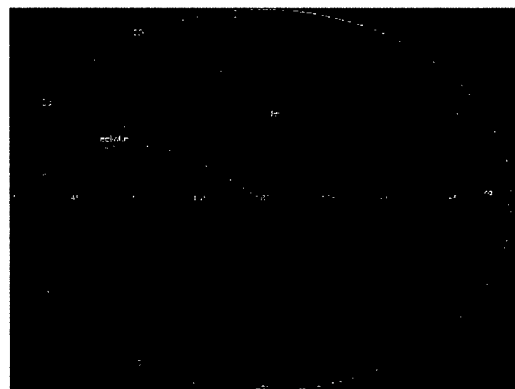
These technologies combine to allow LINEAR to search more than 12,000 square degrees per month, to a limiting magnitude of approximately 19.5 (250,000 times dimmer than the human eye can detect), compared with the typical 1,000 square degrees obtained by "competing systems."

This leads to a very productive searching system for NEOs, comets, and main belt asteroids. Since March 1998, LINEAR has been responsible for the discovery of more than 70 percent of the NEOs detected worldwide.

LINEAR's state-of-the-art technology is an integral part of the Air Force's initiative to modernize the Ground-based Electro-Optic Deep Space Surveillance, or GEODSS, system. The system, which consists of 1-meter telescopes and 1970's television technology, is part of the Space Surveillance Network run by the Air Force Space Command.

Additional information may be found at: www.ll.mit.edu/LINEAR

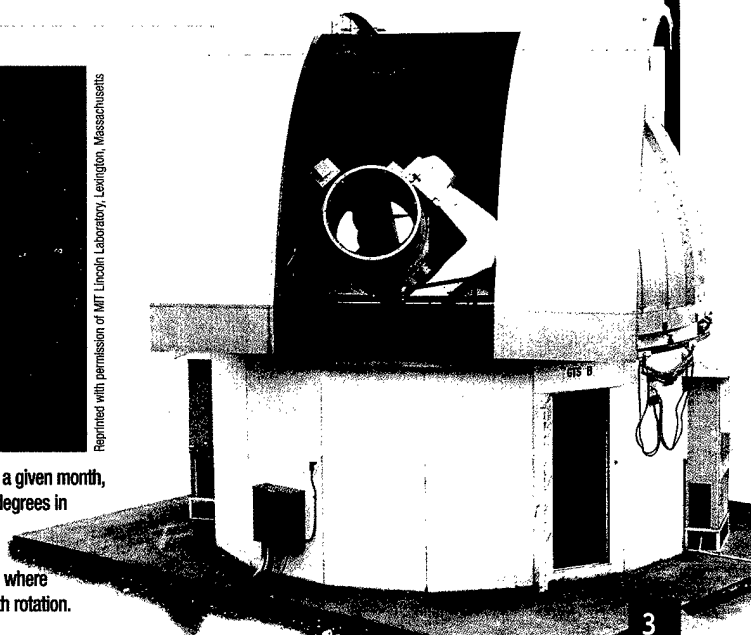
Maj. Paul Bellaire
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ABOVE: The red area shows the coverage of the earth during a given month, LINEAR achieves coverage of 12,000 degrees out of 16,000 degrees in the entire sky. The black area indicates areas that were not covered due to daylight, horizon blockage, weather, or other factors. The Ecliptic line shows the plane of the solar system where most asteroids exist. Undulation caused by 26 degree of earth rotation.

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BELOW: The GTS-2 telescope is a 1-meter folded prime focus Cassegrain design identical to that of the Ground-based Electro-Optical Deep Space Surveillance (GEODSS) telescope used by the Air Force for space surveillance. It is located at the Experimental Test Site (ETS).



Research Investments in Information Security

Just as the Air Force saw value in supporting early computer research, AFOSR continues to support research that contributes to the Air Force's core competency of information superiority:

Information Warfare: Networks are becoming critical to day-to-day operations in both wartime and peacetime. Researchers are working on new methods to detect unforeseen network intrusions, automatically recover corrupted systems, and provide mechanisms for software to formally prove its own safety. Future systems will have to be able to dynamically adjust to a variety of hostile environments, detecting and responding to attacks that have never been seen before.

High Performance Knowledge Bases: The scope of military conflicts and the complexity of weapons systems continue to grow at an alarming rate. This research involves in-depth knowledge that is encoded into a form that allows the computer to perform abstract reasoning and provide expert support for human decision-makers. While current knowledge bases contain around 10,000 axioms, future knowledge bases will contain 10 million axioms. The difference in capabilities is that, while current knowledge bases can, for example, *trouble-shoot* car problems, future knowledge bases will be able to *design* a car. Current knowledge bases can answer complex geo-political questions such as: "What

are Saudi options to respond to Iran's closing of the Straits of Hormuz?"

Intelligent Agents: This research involves creating software entities that act on the behalf of a human. Agents are typically proactive, autonomous, highly personalizable and sometimes mobile, with the capability to independently move across networks to different machines. Agents seek out information and solve problems on their own, with little involvement from the human. Software agents have the potential to completely revolutionize the way we use computers, making the process much more like human to human interaction.

Component-Based Software: Software is often still the most difficult part in any new weapon system development. This research is developing new theoretical foundations to allow "tinker toy" type software development, where proven components can be easily assembled to produce complete software systems in much less time than in the past. These components can easily be re-used across different systems, and customized for the task at hand without requiring any knowledge of the underlying structure of the component.

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Research Highlights

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