

the GTRI connector

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Volume 1 Number 8

June 1985

GTRI Plans Role in Star Wars

by Martha Ann Stegar, RCO

President Reagan's "Star Wars" initiative may be causing a storm of debate, but it's already being implemented—and GTRI is submitting numerous research white papers and proposals.

The Strategic Defense Initiative (SDI), as "Star Wars" is officially called, stems from a speech made by President Reagan on March 23, 1983, calling for a missile defense system that would render nuclear weapons impotent and obsolete.

What Is SDI?

As conceived by defense strategists, it would be a layered defensive system with various components to destroy ICBMs or other enemy missiles at different stages in their trajectory. Some would attack the missile soon after launch, in the so-called "boost" stage; others during the post-boost phase, when the missile releases multiple warheads and decoys; others at mid-course, and still others upon re-entry into the earth's atmosphere, just prior to impact. Obviously, the most effective and efficient time to destroy the enemy offensive weapons is in the boost phase.

Defensive weapons for the first three stages most likely would be space-based, although they could be fired from the ground. The weapons most often sensationalized in the media are lasers and accelerated particle beams. They are the ones best suited to boost-phase use, but they also present the most difficult technical problems. X-ray lasers currently are considered to have the greatest potential for success.

Kinetic-energy weapons are objects such as homing devices, rockets or pellets hurled at a missile or warhead to destroy it by impact. Theoretically, they can be used at any flight stage, but would be most effective during the mid-course phase. This is the best-proven technology to date. Kinetic-impact anti-ballistic missiles already are a reality.

In the terminal or re-entry phase, effective weapons would be ground-based X-ray lasers, ABMs and nuclear weapons (to counter enemy nuclear warheads).



Is SDI Feasible?

The Strategic Defense Initiative Organization (SDIO) was formed within the Office of the Secretary of Defense to determine whether or not a useful defense against nuclear missiles can be developed. It will require huge technological advances, and here the popular "Star Wars" space battle image is misleading. The key will be giant strides in sensor and data processing technology—both hardware and software. Weapons development is only half the battle; they are ineffective without computerized battle management capabilities of the utmost sophistication and speed.

Essential tasks of an advanced missile defense system would be surveillance and threat detection; target acquisition, discrimination and tracking; and target destruction. The following quote from *Time* magazine (March 11, 1985, pp. 22-23) gives some idea of the enormity of the task: "Sensors are crucial to any system: they have to find the target first and aim at them over thousands of miles of space . . . Computers would have to keep track of tens of thousands of objects (warheads, decoys, smart rocks) moving at high speeds, analyze instantly billions of bits of information from sensors and weapons platforms, determine which weapons to fire, when to fire them and at what targets."

The challenge is enormous. As the President said, "It will take years, probably decades of effort on many fronts." And opponents fear that implementation of SDI will have a destabilizing effect on U.S.-Soviet relations. But government officials point out that, whether or not a true space defense is fielded in the future, the related research

will, like the NASA space program, have beneficial fallout through peaceful applications of the technology developed.

How Does GTRI Fit In?

GTRI has a large SDIO Committee which meets biweekly to compare notes and plan strategy. Jim Wiltse (OOD) chairs the group, with Jerry Carey as his alternate. Members are: ECSL - Bruce Warren (Fred Cain, alternate); EML - Charlie Rucker and Bob Hyde (Walter Cox and Dave Schmieder, alternates); EMSL - John Handley and Jim Lefferdo (Bob Cassanova, alternate); RAIL - Josh Nessmith and Gary Lunsford; SEL - Dave Plummer, Sam Blankenship, and Lee Edwards; STL - Larry Corey; OOD - Fred Dyer and Milton Bennett.

GTRI research laboratories have submitted numerous white papers (pre-proposals) and are contributing to several major proposals. Some of the areas covered are described below:

EMSL has proposed a study of the effectiveness of lasers on materials under adverse conditions. Another EMSL white paper suggests a large rotating power station to run space-based weapon systems.

SEL is proposing to develop methods of discriminating between an ICBM warhead and decoys/debris while the objects are still in space. They also have proposed to construct the systems analysis tools to evaluate the workability of different SDI architectures (combinations of weapons).

EML has responded jointly with Texas Instruments and Stanford University to long-range millimeter radar needs involving the ultimate solid-state approach—monolithic integrated circuits. Through prime contractors, they also

have responded to the Air Force on a program to monitor and help advance monolithic integrated circuit technology.

ECSL is joining with industry and other research organizations on a proposal for a radio frequency sensor analysis and evaluation program. They also have submitted three white papers. One proposes an investigation of the feasibility of detecting missile launches during boost phase. Another involves investigating the potential of artificial intelligence techniques for analysis and control of C³I networks in a missile defense scenario. The third outlines a program to develop techniques for enhancing the survivability of strategic defense systems from both friendly and hostile electromagnetic emitters.

EMSL and RAIL have contributed to a large omnibus proposal directed by Professor Cecil Alford of the Electrical Engineering School. RAIL also has proposed several programs involving study and evaluation of both ground-based and space-borne phased array radar systems.

The Pentagon already has announced that a nine-university consortium, including Georgia Tech's School of Electrical Engineering, will engage in a study of high-speed parallel data processing. Dr. Thomas Gaylord, who will participate along with Dr. William Rhodes, says it is aimed at allowing a defense system to keep track of hundreds of enemy missiles at once and distinguish between missiles and decoys.

(Major published sources: George J. Church, "Exploring the High-Tech Frontier," *Time*, March 11, 1985, pp. 20-23. Jim Martin, "SDI: The Technical Alternatives," *Defense Science* 2003, April/May 1985, pp. 49-59.)

In Memoriam

Jerry L. Birchfield
November 1942 - May 1985

Director, Advanced Technology
Development Center, 1982-1985

Director, Technology
Applications Laboratory, EES,
1979-1982

Research Engineer and Senior
Research Engineer, EES,
1967-1979

Graduate Research Assistant,
Georgia Tech, 1965-1967

M.S.E.E., Georgia Tech, 1967

B.E.E., Georgia Tech, 1964

SEL Team Designs Integrated Circuits

by Henry L. Owen, SEL

Under contract with the military, engineers in the Systems Engineering Laboratory (SEL) have designed four semi-custom standard cell integrated circuits for use in a radar warning receiver.

GTRI project personnel completed the design of these very large scale integrated (VLSI) circuits with the assistance of Dr. Jay Schlag from the School of Electrical Engineering. The Georgia Tech Microelectronics Research Center (MRC) provided support through its facilities and equipment. The use of VLSI technology allowed the designers to incorporate a level of complexity and performance that could not be obtained by more traditional implementations.

The military contract required redesign of the processing portion of a radar warning receiver. These receivers are used in aircraft to give indications of radar systems that are active in the aircraft's environment.

If traditional integrated circuits had been chosen to meet the radar warning receiver design specification, more than 700 of them would have been required, and they would have had to be incorporated into a design that had to fit on one 7 by 10 inch printed circuit card. Since cards of this size can accommodate only about 80 traditional integrated circuits, the research team selected the semi-custom microelectronics technology of standard cells as the implementation method.

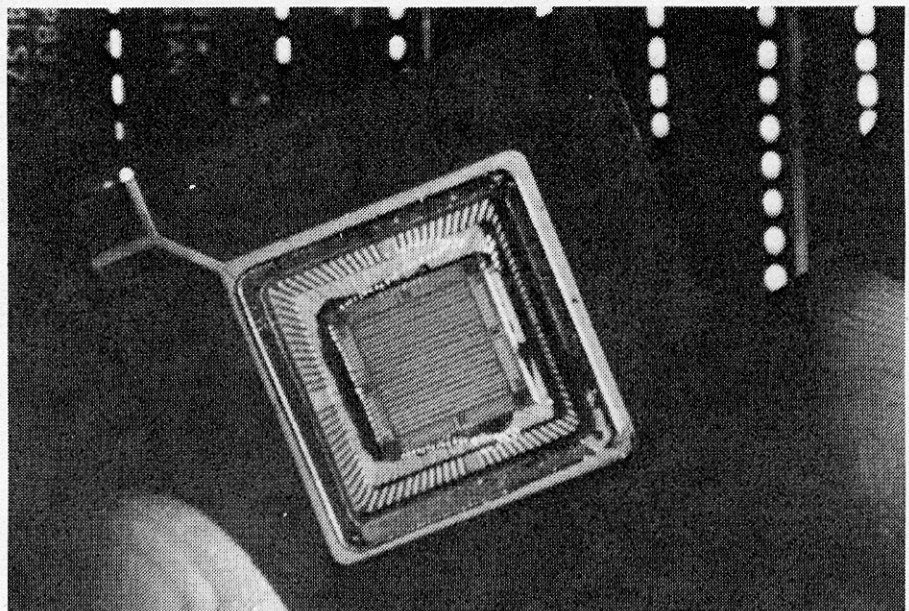
The goal of the standard cell design procedure was the reduction of digital hardware contained in many integrated circuit packages into a single package not much larger than two or three traditional integrated circuit packages.

After completing the radar warning receiver redesign, the team began the task of partitioning the design into standard cells. This phase of the design process required dividing the circuit up so that the maximum amount of circuitry could be placed in the minimum number of standard cell integrated circuits.

Upon completion of partitioning, the designs were entered into a circuit simulator, and the task of determining all possible system inputs and the correct system outputs was initiated. This was the most time-consuming part of the design process, since any errors in this analysis might mean system failures or inconsistencies in the final implementation.

A key aspect of the design process was to determine the physical positioning of various circuit components inside the standard cells. This was accomplished by using a computer program known as a router. The router was made available through another government-sponsored contract, and is maintained by the MRC as part of the design capabilities of the Center.

Data bases which contained the detailed information for the completed designs were sent from the MRC to the outside company that acted as the integrated circuit manufacturer.



Eight of these standard-cell VLSI chips run the processing portion of a radar warning receiver. Designed by an SEL team, each is smaller than a thumbnail. Together they have the computing power of nine 7 by 10 inch circuit cards using traditional integrated circuit designs. (Photo by Charles Haynes)

The data were sent over normal telephone lines using a high-speed modem that connects the Center computer to other selected computers.

The SEL team has completed all four standard cell designs and has received prototypes of the four integrated circuits. GTRI engineers are pleased with the results of their efforts; all four designs work well. Upon the sponsor's acceptance of the designs, the standard cells may be flying in an aircraft as early as 1988.

Editor's Note: Following are comments by Project Director Terry E. Tibbitts on the above project: "This technology area was extremely risky and involved many unknown factors. This is the first program at GTRI to make extensive use of this type of VLSI circuit design,

and we had many difficult problems to solve.

"It is difficult to convey the accuracy and precision required on this program. A single logic gate error out of almost 20,000 gates would have resulted in failure. Every circuit element had to be simulated in software, tested and retested to insure proper operation. Over 30,000 lines of Tegas software code and over 5000 lines of 9445 assembly code had to be written for testing and verification. An error in any of the software could also have resulted in failure."

Tibbitts praised the VLSI design team for this major accomplishment: Henry Owen (associate project director), Mike Kopp, Steve Cole, Charles Cole, David Loftus, David Zurn, Joe Hendricks, Byron Coker, and Cecelia Kilpatrick.

New Antennas Made of Exotic Materials Are Investigated

Dr. Johnson Wang of the Electronics and Computer Systems Laboratory (ECSL) is conducting basic research that opens up a new dimension in antenna technology. His research involves the use of "exotic," or unconventional, materials.

Dr. Wang is a principal research engineer and branch head with ECSL's Electromagnetic Effectiveness Division. The project is sponsored by the Electromagnetic Sciences Division, RADC/ET, at Hanscom Air Force Base.

"For two decades, the antenna, and electromagnetic theory as well, has been viewed as an established field in which no surprises of any significant extent could be expected," Dr. Wang says. "But with the phenomenal progress in com-

puter and microelectronics technologies, antenna technology is sorely lagging behind. In fact, the antenna is now widely viewed as an antiquated burden in modern electronic systems."

There is, according to Wang, a silver lining for the profession in this otherwise dismal scenario—a lot of research needs to be done. "An explosion of research demands is now in progress," he says, "arising not only from peer pressure within the electronic systems research community, but also from drastic changes in the thinking at higher levels in the social, political and military contexts." The demand for better performance from antennas is pressing.

For the past couple of years, Wang has been investigating the use of exotic materials to "create a new dimension in the antenna world." He explains the thrust of his research in this way:

"For example, a conventional antenna can be used either to transmit or to receive electromagnetic waves. The 'exotic antenna' perhaps might use an anisotropic material, having properties that differ according to the direction of wave propagation. With that kind of antenna, a distinction must be made as to whether it is to transmit or receive. In fact, from a practical point of view, only the radiation pattern of an antenna made of linear, isotropic material is reciprocal,

that is, independent of whether it transmits or receives." Dr. Wang has made much progress in his work on this subject, and he is confident that a patent and three journal papers soon will emerge.

Dr. Wang thinks the implications for the future are immense. "We're on the threshold of a brand new ball game," he says. "It's like the textile industry when it expanded from cotton to plastic fibers—a whole new range of properties and applications came into being that were nonexistent in the past. It's too early to assess the full potential of the new materials for antennas, but it is safe to say that they will lead us into a totally new game."

1985 Promotions

Congratulations to the following 31 GTRI employees, who are being promoted on July 1 to:

Principal Research Engineer:

Charles E. Brown RAIL
John C. Handley EMSL
William E. Sears, III SEL
Michael T. Tuley RAIL

Senior Research Engineer:

William C. Darley, Jr. EDL
Ronald E. Forsythe EML
Kathryn V. Logan EMSL
George F. McDougal SEL
David H. Poss, II EDL
Steven M. Sharpe ECSSL
Mark A. Strickland EML
J. Craig Wyvill EDL

Senior Research Scientist:

James P. Coleman ESCL
John J. Owen, III ECSSL
Thomas B. Wells ECSSL

Phillip L. Williams EDL

Research Associate II:

William M. Ewing EDL

Research Engineer II:

Amy S. Dean ECSSL
Steven P. Livesay SEL
Daniel P. Murphy SEL
Carolyn C. Olive SEL
William S. Petty SEL
Nicholas A. Pomponio SEL
Larry J. Schaeffer EML
Vincent B. Sylvester RAIL
William K. Thompson SEL

Research Scientist II:

Paul G. Friederich ECSSL
James R. Galt RAIL
William E. Kenyon, Jr. SEL
Greer E. Valentine, Jr. EDL

Research Technologist II:

Douglas M. Devine STL



The secretaries of Tech's regional office system had their annual meeting in Atlanta May 13-16. They discussed GTRI procedures, took software training, and participated in a time management workshop. Poised on the grand staircase in CRB, they are, left to right: **Back row**—Helen Worrell (Columbus), Rosemary Hall (Dublin), Deborah Reynolds (Macon), Helen Blum (Savannah); **2nd row**—Shirley Brown (Carrollton), Mamie Clark (Albany), Cheryl Cleveland (Douglas); **3rd row**—Sara Marshall (Rome), Melissa Merritt (Gainesville), Delorise Music (Brunswick); **descending stair**—Queen Buford (Atlanta), Pam Daniels (Augusta), Dottie Freeman (Madison). (Photo by Charles Haynes)

PERSONAL NOTES

Marriages

ECSSL: **Mark Fries** was married to Meta Leigh Goetz on June 22 in Warner Robins. Meta is a Georgia Tech student who expects to graduate in 1986. The couple will reside in Stone Mountain.

OOD: **Celeste Cone** has resigned. She was married to Mark Mullins on June 8 and has moved to San Diego, where her husband is stationed in the Navy.

SEL: Edgar and **Deborah Thomas** recently were married.

Births

STL: Laurel and **Barry Sharp** have a daughter, Audrey Elizabeth, born May 7. Keith and **Robin Parks** have a son, Kevin Austin, born May 28. Best wishes!

Deaths

SEL: Our sympathy to **Larry Holland** on the passing of his mother, Mrs. Alma Holland.

Continuing Education News

August 6-8. **Techniques of Radar Reflectivity Measurement.**

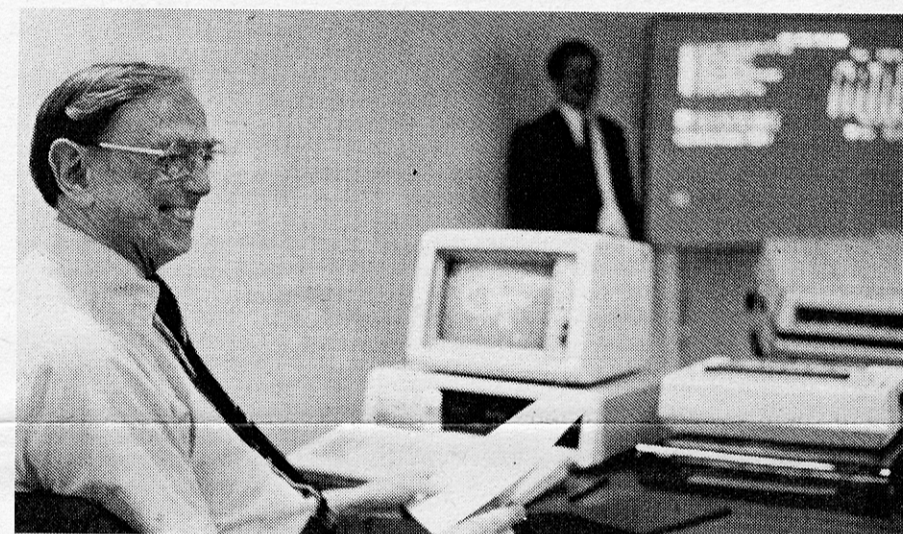
Academic Administrator: Nick Currie (RAIL).

August 12-15. **18th Annual Industrial Training Conference**, Jekyll Island. Sponsored by Industrial

Education Group, EDL. For details, call ext. 3950.

September 17-19. **Radar Cross Section Reduction.** Course Ad-

ministrator: Eugene Knott (RAIL). Attendance restricted to U.S. citizens with a SECRET clearance.



Continuing Ed: President Pettit recently learned some useful electronic mail tricks in the Advanced PROFS class at the Research Software Training Facility. (Photo by Charles Haynes)

PROFESSIONAL ACTIVITIES

ECONOMIC DEVELOPMENT LAB

Johanna Thomas, associate director of the Business Development Division's Management Services Branch, completed her Ph.D. from Georgia State University June 15. The title of her dissertation was "Organizational Control Systems: A Behavior Analysis."

Carol Aton has been appointed to the editorial review board of *U.S. Woman Engineer*.

George Rivers, director of the Brunswick Regional Office, has been elected vice president of the southeast chapter of the Georgia Society of Professional Engineers.

John Nemeth presented a paper on hazardous waste permit preparation at the HAZMAT '85 Conference in Philadelphia.

William Spain and **Bill Ewing** coauthored a research report in the April issue of *Pediatrics*, along with four physicians from the Atlanta-based Centers for Disease Control. The article was entitled "Measles Outbreak in a Pediatric Practice: Airborne Transmission in an Office Setting."

At the National Meeting of the American Industrial Hygiene

Association in Las Vegas in May, **Marilyn Black** presented two papers: "Case History of Indoor Air Pollution" (coauthored by **Charlene Bayer**) and "Environmental Chamber Studies of Formaldehyde" (coauthored by **David Jacobs**). Dr. Black was coauthor with University of Georgia Professor Bruce Haines of a paper—"Potential Sulfur Gas Emissions from a Tropical Rain Forest"—presented to the NATO Advanced Research Workshop in Toronto.

Robert Hawkins and **Daniel Ortiz** presented an "Ergonomics Overview" seminar May 15 at Columbus (Ga.) College.

On June 18 at Gainesville Junior College, the Agricultural Technology Branch cosponsored a workshop on repetitive motion injury designed for first-line supervisors in poultry processing plants.

ELECTROMAGNETICS LAB

At the IEEE Computer Vision and Pattern Recognition meeting in San Francisco June 12-13, **John Gilmore** presented a paper, coauthored by **Antonio Semeco**, on "Route Planning through Non-Uniform Terrain."

ELECTRONICS & COMPUTER SYSTEMS LAB

Tom Wells and **Rick Moore** have been invited to present a paper at a materials conference in Salisbury, England, in July. Dr. Wells will attend the conference and give the paper, entitled "Fabry-Perot Measurements at Millimeter Frequencies."

ENERGY & MATERIALS SCIENCES LAB

At the American Ceramic Society annual meeting in Cincinnati May 5-8, **Kathryn Logan** presented a paper entitled "Effect of Heating Rate on Ignition Behavior in the Thermite System - TiO₂ + B₂ + O₃ + Al."

Dan O'Neil has been elected a Fellow of the American Institute of Chemists in recognition of his "record of significant scientific and technological accomplishments in chemistry and chemical engineering disciplines."



SYSTEMS & TECHNIQUES LAB

Charles Wilson and **Joe Parks** were in London, England, May

22-29, along with U.S. Army personnel, in connection with an ongoing contract with MICOM.

Don Bodnar will present a short course on antennas and radomes to National Security Agency personnel in June.

SYSTEMS ENGINEERING LAB

The Seventh Annual Electronic Warfare Program Review, sponsored by the EW Techniques Analysis Program for the Air Force Wright Aeronautical Laboratories, was held April 30-May 2. **Lloyd Lilly**, manager of the Techniques Analysis Program Office, organized and hosted the three-day meeting, which was attended by 60 representatives of various Department of Defense agencies with interests in electronic warfare.

SEL personnel conducted a short course on "Fundamentals of Electronic Defense" May 21-23. Plans are to conduct a similar course for Warner Robins and Eglin Air Force Bases.

In May, **Richard Ingle** talked to the Computer Science Club of West Georgia College on "Some Real-World Problems in Computer Science" and presented a slide-talk on the Space Shuttle to the Georgia Tech Flying Club.



Twenty-seven industrial park developers from Paris, France, toured ATDC and visited GTRI during a trip to Atlanta June 6-7. Tech alumnus Brian Hogg (left), vice president of Corporex Development Services, and Dr. Donald J. Grace (3rd from left) were co-organizers of the French tour. Shown with them are two of the French visitors. The group also toured several industrial parks and high-tech industries, and met with city, county and state officials. Dr. Grace participated in the Atlanta Chamber of Commerce business mission to Paris April 18-25. (Photo by Charles Haynes)

New Training Association Formed

The International High-Technology Training Association is a new, nonprofit business association offering training services to high-tech industries. It proposes to enhance the skills of technical trainers, create an information net-

work of persons interested in the field, and conduct conferences and other educational programs concerning high-tech training. For further information, contact McCamie Davis, Industrial Education Group, ext. 3950.

PERSONNEL NEWS

ECONOMIC DEVELOPMENT LAB
Keith Nelms has been assigned to the Gainesville Regional Office, effective July 1.

William Whitworth joined the Industrial Extension Division as a senior research associate on June 13, and will work on an hourly basis.

Lamar Griffin of the Industrial Energy Group resigned in May.

Components of the Environmental Health and Safety Division have moved from Area II into O'Keefe. The entire health and safety group, including the Asbestos Technical Information Center, now occupies basement offices. Having outgrown Area II, EHSD is expected to relocate other staff in O'Keefe by late summer or early fall.

ELECTROMAGNETICS LAB

The Electro-Optics Division welcomes **Dr. Raymond C. DuVarney** as a senior research scientist in the Systems Analysis Branch. Dr. DuVarney, who began work on May 15, formerly was the Director of Undergraduate Studies, Department of Physics, Emory University. He has extensive experience in NMR/ESR spectroscopy, experimental physics, digital electronics, microprocessor logical design and display technology.

ELECTRONICS & COMPUTER SYSTEMS LAB

The Command and Control Division welcomes **Jackie Perkins** as a full-time research scientist I, following the award of her B. S. from the Georgia Tech School of Information and Computer Science. She has been a student assistant in CCD.

Elizabeth Lowry recently joined the Communications Systems Division as a research engineer I. She is a graduate of the University of Tennessee (M.S.E.E.) and Maryville

College (B.A.), and has several years teaching experience at U.T.

ENERGY & MATERIALS SCIENCES LAB

Tom Starr, chief of the Materials Sciences Division, has moved his office from Emerson to the first floor of the Baker Building.

Carolyn Hodges has resigned.

OFFICE OF THE DIRECTOR

Kathleen Shewmaker is the new receptionist/senior secretary for OOD, and is located in the front hall of the second floor of CRB. She formerly assisted in marketing GTSTRUDL, Civil Engineering's structural design language. She is working on her bachelor's degree in marketing at Georgia State University.

SERVICE GROUPS

Connie Henson has joined Supply Services as assistant manager.

Rusty Embry is now an assistant department manager for Facilities Management. He will work with telecommunications for GTRI as well as serve as building manager for CRB.

With the name change from Personnel Services to Human Resources, the department is adding the recruiting and training functions to its responsibilities.

SYSTEMS & TECHNIQUES LAB

The Microwave Systems Division welcomes **John Sanford** as a research engineer I. An electrical engineering graduate of Syracuse University, he will be working on phased-array antenna design.

SYSTEMS ENGINEERING LAB

Andy Spiessbach has transferred from EML to SEL's Defense Systems Division. He is a senior research scientist working in the area of artificial intelligence.

Resignations include **Neil Hilsen**, **Michael Lottridge**, and **Darinda Guidry**.



Software Review

by Pat Mathiasmeier

Word processing is used today by more people than ever before and by a wider range of people as well. Word processing is no longer used only by secretaries to type memorandums and letters, but also by engineers and scientists to write reports and articles and by programmers to write computer programs.

To help meet these diverse needs, the Research Software Training Facility (RSTF) offers several courses in word processing. Included in the Basics of Computer Literacy course is an Introduction to Word Processing which covers what a word processor can do for you, how to decide if you really need a word processor, what you should look for in selecting a word processor, and a discussion of the basic features available. RSTF also offers courses on specific word processing packages for different uses: Personal Editor, Volkswriter Deluxe, and Wordstar.

Personal Editor

For programming, the IBM Personal Editor offers a fast, easy way to create ASCII files used in running programs. The Personal Editor course teaches the user to assign personal key definitions for editing

functions and save these definitions in a separate file. Other features covered in the course include block moves, text formatting, PE commands, file functions, and printing files.

Volkswriter Deluxe

For the basics of word processing—speed, reliability and ease of use—Volkswriter Deluxe meets the needs of the office user. The Volkswriter Deluxe course covers typing a letter, editing and formatting, and printing a letter. Other word processing features covered include embedded commands, text merge, and file conversion.

Wordstar

For basic to advanced word processing, Wordstar caters to the user who needs to merge programs, create form letters, and use spelling and indexing capabilities. RSTF offers courses in both Beginning and Advanced Wordstar. The Beginning Wordstar course includes file functions, entering and editing text, formatting for a two-column mode, and using the search and replace mode. The Advanced course covers creating special document formats with dot commands, wildcard characters in search and find commands, personalizing AUTOEXEC. BAT for your Wordstar disk, special print functions, and using the install function to personalize your Wordstar. A course in Wordstar Mailmerge will be offered in the future.

The RSTF schedule is always in *The Connector* and also is available electronically on PROFS. If you are interested in signing up for a class, call ext. 6206.

Software Training Schedule

Computer Literacy (9-4:30): July 9, 26; Aug. 29.

GTIMS (9-4:30): July 18.

Beginning PROFS (10-12): July 5; Aug. 2.

PROFS Scheduling (10-12): July 12; Aug. 9.

PROFS Document Mode (10-12): July 19; Aug. 16.

Advanced PROFS (10-12): July 26; Aug. 23.

Communication (9-12): Aug. 1.

Beginning DOS (9-12): July 10; Aug. 14, 22. (1:30-4:30): July 10, 19; Aug. 16, 23.

Advanced DOS (9-12): July 8, 29; Aug. 12.

Beginning dBASE II (9-4:30): July 1; Aug. 13.

Advanced dBASE II (9-4:30): July 24; Aug. 28.

Beginning Lotus 1-2-3 (9-4:30): July 11, 31; Aug. 8, 15.

Advanced 1-2-3 (9-4:30): July 25.

Symphony (9-4:30): July 22-23; Aug. 26-27.

Advanced Symphony (9-4:30): July 2-3.

LISP (9-4:30): July 15-17; Aug. 19-21.

Volkswriter (9-12): Aug. 30.

Wordstar (1:30-4:30): July 8; Aug. 9.

Advanced Wordstar (1:30-4:30): July 29; Aug. 22.

C Programming (9-4:30): Aug. 5-7.

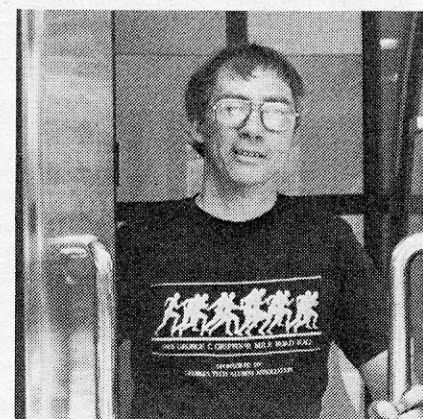
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... is published for Richard Turner, mail clerk who won a T-shirt in the George C. Griffin Pi Mile Road Race ...



and other employees of GTRI.

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