CASI DMT HARDWARE AND SOFTWARE DEVELOPMENT EFFORT

RESEARCH PROGRESS REPORT FIRST QUARTER 1Q

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Research Technical Progress report 01 for

NIST ATP COOPERATIVE AGREEMENT
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Principle Investigator

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1 ABSTRACT

This report covers the first quarter of our project, which formally started Oct 1 2001.

From an organizational perspective, our first quarter progress has been staffing our little organization from a one-person band to a formally constituted professional organization. Our effective launch was from November 1.

Our technical progress has been on three fronts. The first has been in technical recruitment, the second in progress with algorithm development, the third in client computing. These will be detailed in this report.

We have recruited key professional manpower that is working on programming and algorithm development of DMT software and technology. Algorithm development is progressing on two fronts, with two variations in DMT criticality detection algorithms being simultaneously programmed by Drs. Karron and Cox. It is not clear which approach is the most efficient or suitable for large-scale production. Dr. Cox's version is being written in Java, Dr. Karron's version is being written in C. The Java version will be used in our web based demonstration mock-up milestone. Dr. Wolberg is working on graphics display code and on weighting the criticalities once they are detected. Preliminary code has been produced in C and is going to be validated on data from Dr. Cox's criticality tree graph.

Our first milestone progress has been the purchase and configuration of our computer systems, which has slowly begun production in December. A full description of our hardware and systems resources is described herein. In order to obtain the extreme state of the art / bleeding? edge performance from our imaging and computing systems, we are building our own computers and network systems. This work started late, when we received our first cash advance and started issuing purchase orders for the advanced computer systems we are custom building from components. This has been a slow process because custom high-end equipment has to be built to specifications and requires the establishment of trade credit accounts with the vendors in order to use purchase orders. A small company like CASI had a difficult time negotiating large high- end computer purchases until demonstrating proof to some vendors that we had the resources to pay for high end computing equipment, which was facilitated by the ATP grant.

2 EQUIPMENT PURCHASES AND SYSTEMS CONSTRUCTION

CASI started out as a small graphics research shop with two outdated SGI Indigo2 extremes and an Indigo server, both with less compute capacity than a high-end personal computer at present. This was state of the art in computer graphics workstations in 1995. Thanks to our ATP funding, CASI is now a super high-end graphics research facility with two high-end Octane 2 workstation class computers. One machine has been donated by SGI, and the other was purchased at almost half price through the SGI developers' organization. CASI and SGI are joining forces, with SGI making a significant investment of resources in the medical market. SGI is offering significant hardware and programmer support to CASI. CASI's PI is visiting SGI for the SGI Developer Conference in February, and may spend a significant time at SGI headquarters in Mountainview, working as a visiting scientist, learning very high end computing techniques.

CASI Client Computing.

CASI has built, from components, three dual Xenon class CPU workstation class personal computers (PC's). They are overclocked to 1.6 gigahertz, and each has high-end digital video and Open GL graphics cards. They drive Samsung 24 inch HDTV format flat panel displays. These are the highest resolution, largest and brightest flat panel displays that we could order as of November 2001. They were delivered in January, and while they are very good monitors, we have problems in quality of video that has forced us to drop back to using Analog video to drive the displays. We have asked for an engineer from Samsung to visit to help rectify the problems. A full windows and a full Linux development system is available on each computer. CASI has four workstations for full time programmers (two SGI based programmers and two Windows-Intel (Wintel) based programmers. Each Wintel computer has an ATI Radon Open GL accelerator board. Each workstation has two very fast (and hot?) Seagate Cheetah 15,000 RPM (normal disks are 7,200 rpm or higher end disks rotate at 10,000 rpm) disks for 3.2 millisecond random data access latency. All peripheral I/O on the workstations is through on board dual SCSI III LVD 160 Mbytes/sec, and we have disabled the ATA based I/O completely. Each Wintel and SGI computer on the CASI network has two network interfaces, a 10-100 BaseT Network Interface Card (NIC), generally built into the motherboard or host computer. We have purchased an additional 1000BaseT NIC, dual porting each computer so that each computer has two IP addresses on the local CASI network. There are two networks at CASI, a private in- house network, inaccessible from off- site using the unassigned network address pool convention. The ultra fast network access is through this network. There is a second network at CASI, with 16 public addresses, accessible from the outside world. These are the slower NIC's, and the more vulnerable to outside attack. Since CASI is a well-known network resource (we host Dr. Karron's class web site as well as the CASI web site), the public network is regularly probed and viruses and works attack unprotected Wintel machines, freshly installed on the net in hours of connection. Currently, all outside network accessible machines are locked down with full security measures and CASI does not have a problem with viruses or worms.

CASI has three legacy SGI boxes, running MIPS 3000 and MIPS 4000 computers. These have slower SCSI II disks, and are woefully inadequate for modern research computing. However, these machines are extremely reliable, and remain in service without rebooting for 6 months at a time. We have kept the software on the machines current, and use them for low demand but essential network services such as DNS, NIS, DHCP service, with redundant fallback service from the two legacy SGI boxes. While they are old, they are extremely reliable, and between the two computers we have reliable redundant network services.

The main CASI servers are two Xenon dual CPU class raid servers; one running Windows 2000 advanced server and hosting 0.7 Terabytes of raided service. Because of the size of the file system, it consists of two independent Class 5 raids, each with the ability to withstand a single disk failure, and a hot spare disk idling in the system, ready to take over for a failed disk instantly. The larger box consists of 24 15,000 rpm Cheetah 34 gigabyte disks, with their spindles phase synchronized for maximum parallel throughput.

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3 SUBCONTRACTOR REPORT

The originally proposed subcontract with CUNY Institute for Software Design and Development has been delayed owing to the direct engagement of Dr. George Wolberg , Professor of Computer Science. At a future point in CASI's software development, subcontacting with CUNY will be more effective and economic.

The collaboration with NYUMC is now premature, as much more software development is required before alpha version software can be tested with the clinical staff in such a way as to permit the critical software development to proceed without CASI providing a high level of software support for a product that is not ready for an unsophisticated user. We expect to be ready for clinical applications at the earliest by summer/fall 2002, possibly extending to project year 2.

4 STAFFING REPORT

Personnel

–Prof. James L. Cox PhD

•Mathematical Modeling and Programmer, (consultant)

–Prof. George Wolberg PhD, (consultant)

•Graphics Programmer

–Charles DaSalla, BS

•PhD Student: Systems Manager.

•Learns Everything, Does Everything

–Elisha Gurfein,BS, MBA

•Project Manager

Slots to be filled:

Browser Designer/Network/System Analyst (Note: we are actively reviewing candidates.)

5 PROGRESS METRICS

5.1 5.1 STATEMENT OF PROJECT TASKS AND ANTICIPATED ACCOMPLISHMENTS

5.1.1 5.1.1 First year project milestones

For the first project year, we will focus on algorithm development and implementation to efficiently produce and manipulate the images and models by their DMT graph node. Concurrently, the client side interface team will design, mock up, and write browser-based interfaces for our intended medical imaging collaborators and clients. This will demonstrate the DMT principle of producing maps of objects that do not require contrast enhancement to be parsed out of their proximate objects. We will boot up our network services server on the Internet.

STATUS: Mockup for Internet will be started in (Month) 2002
Computer Hardware for research infrastructure 85% done
SGI machines were delivered in January, upgrades on machines due by March.
Wintel/PC's all up and running, Gigabit networking 90% function?
Servers up and running, RAID up and running.

PROGRESS Metrics

5.1.1.1 5.1.1.1 MILESTONE 1: Server live on Internet

We will launch our project with the purchase and configuration of the CASI project web site server.

TASK: install the project management software, and establish protocols for collaborative programming with the team members.

PROGRESS: Our current server, www.casi.net is live on the Internet, but does not have the compute capacity for production applications. We naively thought we could put in high capacity Internet service in our residential apartment. Power and wiring limitations will mean that until we can move into a suitably connected and powered (and adequately air conditioned) facility, we will design our Java software to run on our current general-purpose server.

We have installed Microsoft Project, and have broken down the various software tasks into a detailed roadmap for algorithm implementation.

The detailed roadmap consists of the following tasks:

•Development Roadmap
–Criticality Detection
–Criticality Sorting
–Criticality Flooding
–Graph Construction
–Graph Display / Decrowding
–Graph and Volume Navigation
–Segmentation Surface
–Model Rendering

5.1.1.2 5.1.1.2 MILESTONE 2: Public client mock-up facility life? on Internet

Publish concept mock up our system into which we will insert the real functionality as that milestone is achieved.

TASK: Design various user interfaces for radiological, RT, Neurosurgical, patient and public use classes.

PROGRESS: Java version underway (Cox). Internet software programmer slot to be filled

5.1.1.3 5.1.1.3 MILESTONE 3: Surface tiled models from DMT graphs

Generate a tiled surface model in RGB Color image data from a user selected threshold value and a DMT graph node.

TASK: Program SpiderWeb algorithm and DMT graph decomposition

PROGRESS:

Tiled surface code in progress.(Karron)

5.1.1.4 5.1.1.4 MILESTONE 4: Generate DMT graph from image stacks

Generate DMT gray scale graph from MRI and CT from the VHP. Generate DMT graph of the color (RGB) VHP pixel data. We will use the female ‘Eve’ data set, and do the thorax and abdomen.

TASK: Generate DMT Graph

PROGRESS:

5.1.1.4.1	Java	Implementation	underway	(Cox)

5.2 PROGRESS CHART (GANTT)

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N	Major Project Tasks	First Year Project Time				Major Milestone
		Q1	Q2	Q3	Q4	
1	Server hardware installation and software configuration task	85%				Server live on Internet
2	Public client mock up facility design task	15%				Public client mock-up facility life on Internet
3	Program SpiderWeb surface tile generator task	25%				Surface tiled models from DMT graphs
4	Recognize, sort Crits, connect; graph display code task	25%				Generate DMT graph from image stacks

7 DIFFICULTIES

CASI has built a state of the art imaging computer facility that requires continuous cooling and air circulation. During the winter months, the windows must be kept open else the disk temperature alarms (on all of the 30 disks in the company RAID storage system) start going off. We have installed a state of the art gigabit Ethernet fabric switch that has intense cooling fans that sound like a continuous vacuum cleaner. The working conditions are degraded due to the large number of fans and the street noise from the open windows.

We are concerned that as the temperature increases as we approach the summer, we will have to shut down key components and halt the research because of temperature sensors shutting down equipment as it begins to overheat. Too strong!

Additionally, our ability to recruit key personnel will be degraded because of the uncomfortable working conditions of nose and heat in the CASI workspace.

Currently, CASI is based out of an apartment across the street from NYU Medical Center in Kips Bay Towers, a large residential complex. The building was built in 1961, and is underpowered by modern standards. The building management has declined our request for additional power capacity. The building management has expressed its displeasure and non-cooperation with our request for additional air conditioning capacity.

Staffing Problems

CASI has had problems finding a professional systems analyst who can also design web sites. CASI is a small research company operating at a very high technical level. The PI has been combing out students at CUNY for a candidate.

8 ACCOMPLISHMENTS

CASI now has a state-of-the-art computer graphics research shop with a very high performance network and storage environment. This was done at a significant cost savings, as the PI designed and built the infrastructure from components and parts. SGI is in the process of signing on to the project and will be an important asset both for hardware support and for programming/marketing support. Two new funding opportunities are underway via Mr. Franklin Madison of the New York City ITAC office. Mr. Madison is pursuing cash co-funding for CASI from New York State. Additionally Mr. Gurfein and Mr. Madison are pursuing venture capital funding.

A copy of our ITAC proposal is appended.

9 SIGNIFICANT PUBLICATIONS AND SEMINARS

The PI is being invited to speak at a number of important national meetings. The following are scheduled or have been presented:

Journal Publication in “Graphical Image and Model Processing”: Seminal Digital Morse Paper accepted for publication .

MMVR 2001: Technical Panel and ATP Panel

SGI Developers Meeting: Invited by SGI.

SPIE Medical Imaging: Boston March 2002 (Invited by Prof. Fred Bookstein)

Papers in Press:?

10 APPENDIX

LETTER TO FRANKLIN MADISON OF ITAC

COMPUTER AIDED SURGERY, INC.
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http://www.casi.net

Sunday, February 10, 2002 at 017:55:34 Hours

Industrial Technology Assistance Corporation
253 Broadway
Room 302
NEW YORK, NY 10007

Attention: Franklin Madison Jr., Technology Program Director

Dear Mr. Madison;

Our company is currently working on an ATP grant to develop software for Digital Morse Theory. Digital Morse Theory has the potential for having significant application in many fields. CASI is planning to build on the ATP work and develop software packages for a number of technical applications. As you know, ATP funds may only be applied to scientific research activities as delineated in the grant. The ATP grant is designed to be co-funded for support of commercial development and support services.

In order for CASI to grow into a viable and thriving commercial enterprise in New York, additional co-funding with our ATP grant is vital. The attached proposal is submitted for your consideration and assistance in obtaining the necessary funding for successful commercial implementation.

ITAC has been instrumental in assisting numerous companies toward robust economic growth. We trust that CASI will be fortunate to receive ITAC's assistance and guidance in the proposed activities. We look forward to a mutually rewarding relationship with your organization.

Sincerely,

D. B. Karron, Ph.D.
President

10.1 PROPOSAL TO NYC - ITAC

COMPUTER AIDED SURGERY, INC.

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10.1.1 Proposal

I. Overview: **C**omputer **A**ided **S**urgery, **I**nc. ("CASI"), established in 1995, is a cutting-edge software developer that has emphasized medical research applications. CASI has won a number of past grants from the **D**efense **A**dvanced **R**esearch **P**rojects **A**gency ("DARPA") and the **N**ational **I**nstitutes of **H**ealth ("NIH"). In October of 2001, CASI was awarded an **A**dvanced **T**echnology **P**rogram (ATP) grant from the **N**ational **I**nstitute of **S**tandards and **T**echnology ("NIST"). This grant is aimed at generating software using **D**igital **M**orse Theory ("DMT") for the purpose of enabling accurate and precise segmentation of anatomical organs from difficult medical imagery. Essentially, the goal, as cited in the grant, is for this software to delineate edges between adjacent soft tissue organs. The primary applications are for radiation oncology planning and for surgical planning. The benefit to be derived from this software will relieve the radiation oncologist from the tedious and time-consuming effort of carefully circumscribing the volume to be treated; it will yield a more accurate and repeatable volume. When reduced to practice, this will result in significant cost savings to the payers as well as attractive growth and income for CASI. ATP funds are restricted for direct technical research and development costs only. Additional funds are now needed for the overhead costs of this project and the commercialization of this technology for these medical applications and a wide range of other applications.

10.1.2 II. ATP Grant

II.a. The Goal of the ATP Grant: The goal of the ATP grant is to generate the algorithms and thereby the DMT software necessary for segmenting soft tissue organs from each other, enabling the accurate automated circumscription of anatomical organ volume. The typical modality is CT imagery, using Houndsfield numbers (density). The density between adjacent organs is very similar, making this a non-trivial problem. (Note: There are competing products in the marketplace, but they are not useful in soft tissue adjacent to soft tissue organs, but only in soft tissue adjacent to bone.) In addition to developing the DMT software, CASI will validate the software and will have clinical validation performed at NYU Medical Center.

II.b. Potential DMT Applications: In addition to the medical applications noted above, there are numerous potential timesaving applications where DMT can be applied, yielding superior results. This plan addresses some of the more compelling applications. There are many fields where the raw data imagery is either diffuse, lacks resolution, and contains low contrast, among other shortcomings. DMT may be an effective tool for a

wide range of imagery applications. These include satellite imagery for reconnaissance, mapping, geodesy, surveying, and topography; meteorology; air traffic control; medical education and training; medical animation; entertainment industry animation and fluid mechanics, among many others.

II.c. **The ATP Advantage:** Piggybacking on the technical foundation to be derived from the ATP activity, CASI plans to apply DMT software to the most compelling of the applications cited. While all of the applications will be examined, finally the three most attractive ones will be given a highly comprehensive evaluation. In addition to technical consideration from among the various modalities, *i.e.*, visible spectrum, infrared, color, Houndsfield number, *etc.*, for each application, a market survey will be performed for all. Some of these investigations will be performed in parallel with the ATP work.

III. Benefits of DMT Software:

IIIa. Economic benefits are expected to be very significant. Taking the example of radiation therapy planning for prostate cancer, it takes a radiation oncologist about an hour to carefully circumscribe the volume of the prostate, using a cursor on a computer monitor image. This is done slice-by-slice and is very tedious. Medicare currently pays $770 per radiation plan. DMT software would enable this cost is estimated to be around $250…a saving of over $500 per patient. On a national scale, with 200,000 new prostate cancer cases in 2001, this would amount to a saving of over $100 million per year just for prostate cancer.

III.b. Clinical benefits are numerous. The physician will have more time to spend with patients. The physician will be relieved of a tedious task. The software should provide a more accurate and repeatable volume, thereby avoiding the predisposition of the physician of being either too generous (radiating too much and affecting adjacent organs, e.g., bladder, rectum, with harsh results) or conversely to plan on radiating too little and leaving too many cancer cells untreated. The patient's overall quality of care will be markedly improved and the physician will have more time to attend to patients.

III.c Collaborators As with radiation oncology, CASI will be collaborating with university academic medical scientists. CASI will be engaging collaborators, who are bellwether hands-on state-of-the-art researchers. Specifically, for satellite imaging we will engage specialists involved in reconnaissance and mapping, such as National Reconnaissance Office (NRO), National Imagery and Mapping Agency (NIMA). For meteorology, experts from the National Oceanic and Atmospheric Administration (NOAA) will be recruited as collaborators.

III.d. Generally it is expected that other applications will benefit from both the time saving aspects and the accuracy and repeatability of DMT software.

IV. Need for Public Funds: Restrictions on our current ATP grant necessitate additional co-funding, as the ATP funds may not be used for commercialization, market surveys or any function not directly related to the approved **technical** proposal. The nature of DMT software development, while extremely encouraging, is not sufficiently mature to attract

private equity funds. Therefore, on the expectation that DMT will be of great broad-based economic benefit, CASI is seeking co-funding in the range of $2 million dollars. These funds will be employed as described below.

V. Use of Funds: The primary use of funds will be for:

- **a.** Investment in technology infrastructure support equipment including computers, high speed Internet, high quality photographic imaging printers, data backup and uninterruptible power supplies;
- **b.** Market surveys for each of six (6) potential DMT applications;
- **c.** Adapting the software developed for the ATP activity to the three most promising applications;
- **d.** Examining the feasibility of distributing the software via Internet;
- **e.** Hiring staff
- **f.** Leasing data port-equipped specially air-conditioned computer lab facilities;
- **g.** Building patent position;
- **h.** Presenting papers, attending seminars and publicity;
- **i.** Marketing of products via license and /or Internet ASP.

VI. Rationale and Schedule of Activities and Expenditures:

a. ATP funds may be only applied to the specific research tasks delineated in the grant. This applies to both activities and equipment. Additional infrastructure equipment is needed to expand our commercial horizons.

b. CASI will engage the market research arm of the Industrial Technical Assistance Corporation ("ITAC"), as an independent marketing research consultant, for the purpose of designing a market survey. From over a dozen initial candidates, six potential applications will be selected based on technical, marketing and profitability factors.

c. The aim is for CASI's intellectual property portfolio to be diversified for product balance and future growth. A market research study will be performed in parallel on each of the six provisional (6) applications areas. This research will be done along with the ITAC market research activity. Based on these research results, the three most promising applications will be selected for product development. In addition to adapting the DMT software for each application, CASI will engage professional consultants in order to get a hands-on understanding of the ultimate users needs. As an example, if meteorology is selected, we will engage a meteorology concern to enable CASI to fully understand the needs of a meteorologist in analyzing weather imagery/data.

d. A data communications design feasibility study will be performed to determine suitability of establishing an Application Service Provider for distributing products. This is one of the two primary approaches that will

be pursued to market/distribute the DMT software; the other being licensing to software companies that specialize in the various application technologies.

e. Support staff will be required. CASI will hire a marketing professional to supervise the various marketing studies and then to implement marketing effort. CASI will employ an administrator and a bookkeeper, which will manage fiscal reporting and audit requirements.

f. In contemplation of hiring personnel and obtaining high powered computing equipment CASI will move into suitable commercial / industrial space. Requirements for this space are 10 workstations for scientists, technologists, programmers, management, and support specialists.

g. To preserve and optimize the intellectual property developed by this project we will engage patent counsel services. Developing patentable intellectual property is key to attracting private capital investment and also assures CASI's ability to license its technology.

h. In order to educate, promulgate, and disseminate the knowledge developed from this project, many papers will be presented at national symposia, and international meetings. Hands on demonstrations at conference exhibitions will help accomplish dissemination of this technology.

VII. Key Personnel: (See attached bio sketches)

Dr. D.B.Karron-CEO & Chief Technology Officer has been active in computer science for medical applications for over fifteen years. A former research professor of Surgery at NYUMC and current professor of computer science specializing in BioInformatics at CCNY, he is the Principal Investigator of the current ATP grant. Dr. Karron has broad knowledge of the needs of the medical disciplines. He co-invented DMT with Professor J L Cox. Dr. Karron has been awarded previous grants from DARPA and NIH.

E. Gurfein-Chief Operating Officer has over 25 years of business experience in scientific and technical companies. He has an undergraduate degree in mathematics, with advanced training from Courant Institute. He earned an MBA and managed technical projects at Sperry-Rand, General Precision, Perkin-Elmer Corporation and Engelhard Industries. He has extensive technical marketing and commercialization background. He was director of technical marketing for the Hubble Space Telescope. Mr. Gurfein has technical familiarity with satellite optical systems and imagery, laser technology and applications, inertial guidance systems, ballistic missile operations and catalytic combustion, among others.