EOCAP APPLICATIONS BUSINESS REVIEW
OCTOBER 20, 1997

1.0 BUSINESS IDENTIFICATION

Project Title:

ORTHORECTIFIED HIGH RESOLUTION MULTISPECTRAL IMAGERY FOR APPLICATION TO CHANGE DETECTION AND ANALYSIS

Company Name:

Positive Systems, Inc.

Principal Investigator:

Cody A. Benkelman

Project Start Date:

September 15, 1994

Project End Date:

September 14, 1997

Co-Investigator(s):

San Diego State University

Customer Partner(s):

ImageMaps (Far East distributor, Singapore)
NASA TechLink
Eastman Kodak
Vexcel Corporation
ImageLinks
DATRON/Transco Corporation
TRIFID Corporation

Advisory Panel Member(s):

Pacific Meridian Resources
Spencer B. Gross, Inc. (George Gross)
Aerial Services Inc. (Gary Brown)
Dr. Warren Cohen, USFS

EOCAP APPLICATIONS BUSINESS REVIEW
OCTOBER 20, 1997

2.0 COMMERCIAL OFFERING STATUS - PRODUCT, PROCESS, SERVICE

2.1 Legal Protection	Granted	Applied For	To Be Determined	No Protection
Trade Mark	[ ]	[D]	[A]	[ ]
Service Mark	[ ]	[ ]	[X]	[ ]
Copyright	[ ]	[ ]	[X]	[ ]
Patent	[ ]	[ ]	[X]	[ ]
Other:_____	[ ]	[ ]	[ ]	[ ]

Offering's name(s):

ADAR System 5500, ADAR System 3000, ADAR System 1000, DIME Software

Legend for the check boxes above and in section 2.2:
"X" refers to all products; but where differentiated,
"A" refers to status for all ADAR Systems (models 5500, 3000, and 1000) and "D" refers to status for the DIME Software.

2.2 Development Status

	Project Start	End CY3	1/99
Conceptual	[A]	[D]	[ ]
Feasibility Test/Demonstration	[A]	[D]	[ ]
Pre-production	[A]	[D]	[ ]
Production/Sales	[ ]	[A]	[ ]
Additional Offerings or Refinements	[ ]	[X]	[ ]

2.3 Offering Revenues
(A = Actual or P = Projected)

	1995 (Year 1)	1996 (Y2)	1997 (Y3)	1998 (Y4)	1999 (Y5)
GROSS REVENUES ($k)	$ 333 A	$ 567 A	1,045 A	$ 972 P	$1,216 P
NET REVENUES ($k)	($ 442)A	($ 9.6)A	(158)A	$ 101 P	$ 126 P

NOTE: If above figures represent adjustments of more than 15% from those forecasted at Project Start, list MAJOR ISSUES affecting revenue streams.

Revenue forecast for Year 3 was $778,000, with projected profits of $80,000. Although revenues far exceeded the projected figure, the revenue mix was not as envisioned (with a much higher percentage of revenues from service as compared to system sales) and expenses were clearly higher than anticipated. One key cause for the increased costs was the cash required to field a third ADAR System 5500 for the 1997 flying season. The increased service revenues were positive, but improvements must be realized in sales of systems to enable the company to reach profitability; alternatively, if service revenues continue to generate the bulk of the company's

revenues, the allocation of internal funds for system and market development will need to be restructured to better control costs in a purely service-oriented business.

2.4 Please state the original project business/technical goals and objectives and describe to what degree those were met at the close of CY93.

The following objectives were taken from the Executive Summary of the original proposal for this EOCAP project:

> The project team has outlined several technical objectives which will allow the companies to improve on their current capabilities. These include modifications to the imaging system, enabling it to operate more cost effectively and with greater ease of use, automation of the post-processing software to mosaic and orthorectify the image scenes collected, and the addition of radiometric calibration to greatly aid in the ability to perform accurate change detection.
>
> Business objectives include fine tuning of the market plan plus specification of future product requirements, expansion of sales activities (including identification of necessary additional resources required to meet stated revenue objectives), development of a product distribution plan, and implementation of a worldwide sales effort.

The following section will briefly address the degree of success toward achieving those goals.

2.4.1 Enhancements to the ADAR Systems.

Very few hardware changes were made to the ADAR System 5500 during this project, other than a dramatically improved camera housing and improvements in the manufacturing process (to decrease the cost and lead time for development of additional systems). Many improvements were made in the software, both for in-flight operations as well as post-flight processing.

Regarding other systems, the company expanded its "family" of ADAR Systems, developing and introducing the ADAR System 3000 (a lower cost, single camera system based on the same Sun/Sparc architecture as the System 5500) as well as the ADAR System 1000 (our lowest cost system, retailing for under $50,000, using a single digital camera and a powerful laptop computer running Windows NT).

Although our engineering design team has a long list of improvements to make to these systems, within the framework of EOCAP we consider this task to have been very successful.

2.4.2 Automation of the post-processing software for mosaicking and orthorectification.

As noted elsewhere in this report, the company and its collaborators have made progress toward the stated goal, but it has required some alteration of the goal as originally stated. Generally speaking, Positive Systems does have solutions for projects which require orthorectified imagery, but those solutions (through one of several partner companies) are rather expensive and time consuming.

The company has new software currently in development ("DIME") which will address the requirement for rapid image mosaicking but without requiring the accuracy of fully

orthorectified imagery.

Although this goal was not achieved in full, we feel the progress made has kept the company very competitive in this area which is very challenging for all participants in this industry.

2.4.3 Addition of radiometric calibration.

With the assistance of the Technical Support Group (TSG) at NASA Stennis, the project team completed an extensive Performance Verification Test (PVT) in the sensor test lab. This test addressed system linearity, uniformity, and spectral response. Although it has not answered all questions regarding system calibration, the test data were invaluable in addressing many different needs.

2.4.4 Improved marketing plan and definition of future product requirements.

It will be forever arguable whether or not the company's marketing plan has been "improved," but the revenue growth experienced by the company has been steady and positive, indicating at least some degree of marketing success.

EOCAP has allowed Positive Systems to increase its staff in marketing and sales, and numerous new product requirements have been generated through interaction with the company's "customer advisory panel." Specific products developed through these activities have included the ADAR System 3000, the ADAR System 1000, the "vignette mask" radiometric correction, image mosaicking software, and the DIME architecture (on Windows NT) for simplified interface to a variety of pre-processing tools which will streamline extraction of information from imagery via existing tools such as ERDAS Imagine,
Earth Resource Mapper, PCI, etc.

2.4.5 Expansion of sales activities

As mentioned in the previous section, EOCAP funds allowed the company to expand its sales and marketing staff, generating a direct impact on sales activities and associated results. As shown in section 2.3, revenue growth has been significant over the three years of this EOCAP project.

2.4.7 Development of a product distribution plan, including a worldwide sales effort

The company has pursued numerous avenues for improved product distribution, including development of a training program for prospective system operators. During this past summer, two different ADAR System 5500s were operated by flight service contractors, without Positive Systems personnel being involved in day-to-day operations.

The company continues to explore and develop new avenues for contacting prospective customers, selling projects and systems, and distributing data products to customers.

The company has also maintained its commitment to expanding a market for ADAR products outside the U.S. Salespeople have attended conferences and visited with potential

customers and distributors in the Far East, Australia, and Europe. With the recent sale of an ADAR System 1000 to our distributor in Singapore and the associated demonstration project completed in Vietnam, the company has begun to see success from its efforts to expand sales outside the U.S.

2.5 Describe specific hurdles or difficulties encountered since project inception that affected the original project objectives or changed the direction of your project. What adjustments were made to the project to overcome them?

2.5.1 Limited financial resources

As a small startup company, limited financial resources has been and remains one of the key challenges faced by Positive Systems. Funding from EOCAP was absolutely instrumental in achieving the degree of success the company has attained, but resources are still extremely limited.

In 1996 and early 1997, the company developed a Private Placement memorandum through our new law firm (Stoel-Rives, Seattle, WA) in an attempt to locate one or more investors to allow the company to expand. This investment effort has not succeeded, with the primary problem believed to the difficulty in defining the market for ADAR Systems and imagery. The CRSP at Stennis has provided invaluable assistance on this question of market definition, but it remains a difficult subject to portray to the non-technical investment community. An investor will typically want to understand both the market and also the company's position and ability to provide a return on that investment; both aspects have proven very difficult to define in quantitative, favorable terms.

Lacking the cash investment, the company has had to limit many of its growth plans and fund limited new technology development through its service revenues. This reinvestment of revenues has in turn limited the company's ability to show profitability.

2.5.2 Geocoding image data

As noted above, one of the primary goals for this EOCAP project has been to develop a low cost, streamlined method for orthorectification of image data from the ADAR Systems as well as other sources. Although the processes are technically feasible, reducing the costs and turnaround times has remained an elusive goal. One key adjustment to our plans was to realize that some projects do not require the geometric accuracy of orthorectified imagery, thus we have been pursuing methods for generating geocoded data with nominal accuracy in a manner that is faster and lower in cost than via classic photogrammetric methods.

Partner companies that are capable of generating orthorectified imagery, at a variety of costs and accuracies, include TRIFID Corporation and VEXCEL. For less accurate image mosaics, Positive Systems has worked with Booz•Allen and Hamilton and now ImageLinks. We have also explored the methods, costs, and tradeoffs re: creation of detailed, system-specific camera models with TRIFID, VEXCEL, LEICA/GDE/Helava, as well as the Stennis TSG and numerous individual consultants. Finally, the company is developing the DIME software architecture for ultimate implementation of the lower accuracy mosaic tools (but DIME is not intended to generate orthorectified imagery in competition with other

software in this industry).

2.5.3 Radiometric corrections

Early in this project, the radiometric nonuniformities caused by Rayleigh scattering and bidirectional reflectance became an issue to be resolved. Some of the EOCAP activity conducted by SDSU was focused on attempts to understand and then correct for the effect, generally attributed to solar illumination angle. By mid-1996, it became clear that this problem was too large for the scope of the EOCAP project, so the company signed an agreement with a NASA technology transfer center ("TechLink" at Montana State University) to develop a new project focused specifically on this issue. That shift in emphasis allowed EOCAP funds to be used to address other issues while still making progress on a correction for these variable solar illumination effects.

Because of the complexity of the effects in question, the company does not expect to fully solve the problem of generating a valid solar correction, but we are optimistic that a "first order" correction (to remove the majority of the nonuniformities) will be implemented within the DIME software early in 1998.

2.6 Describe significant gains in company productivity (such as time, labor, materials, cost savings, etc.) as a result of your EOCAP involvement.

It would arguably be more dramatic to be able to point to individual "breakthrough" items which provided a large step forward in productivity, but in the case of Positive Systems this growth has been incremental over the duration of this project. The company has made significant productivity improvements in several areas, all of which were supported by the EOCAP project:

2.6.1 In-flight operations

The company has made numerous improvements in the software used for in-flight data acquisition, which has improved project execution through fewer operator errors. This software development was directly supported by EOCAP.

In addition, during the summer of 1997, three ADAR System 5500's were operational, allowing the company to continue to expand the number of customers and projects being served. Although the development of additional ADAR System 5500s was not directly supported by EOCAP, the revenue growth which provided the internal funding was a result of EOCAP activities.

2.6.2 Post flight data processing

Simultaneous with improving the in-flight software, the company also made improvements in the software used for post-flight data processing. The company also doubled the number of post processing systems in our data processing lab (from one to two Sun workstations dedicated to image data production). This has helped to improve overall throughput of image data from acquisition to customer delivery.

In addition to the hardware and software improvements, the company hired two new employees (1996) to specifically address the post-flight data production tasks.

2.6.3 Improved accounting procedures

On the more "mundane" side, the revision of Positive Systems' accounting methodologies (made necessary by the DCAA audit conducted for this EOCAP project) paid several dividends, including both improved financial records (to allow better future forecasting) as well as an improvement to the company's ability to respond to other federal procurements.

2.7 Please provide the latest versions/examples of products developed during your EOCAP partnership that you are currently marketing (actual products sold to customers).

An example multispectral image, showing a mosaic covering the entire Kennedy Space Center complex, will be attached to this report.

3.0 MARKET INFORMATION

3.1 Describe the Offering's original target market/customers.

At the outset of the project, the key target markets being addressed were generally described as being under a general description of "environmental monitoring and management." One example of end users for this data (although not necessarily our direct customers) would be government, from the city and county level up to state and federal agencies.

More specifically, the four key market categories to be addressed were identified to be:

3.1.1 Municipal and Regional Land Use Development

Examples included infrastructure map updating, land cover classification, and storm water run-off management (based on National Pollutant Discharge Elimination System, or NPDES, regulations).

3.1.2 Toxic Waste Monitoring

This category was to include applications such as monitoring cleanup of toxic spills or sites with long-term contamination issues (e.g., industrial sites, mining operations).

3.1.3 Revegetation

Examples in this category included environmental monitoring applications such as wetlands mapping and monitoring for regulatory compliance.

3.1.4 Vegetation Stress, Mortality, and Devegetation

Most agricultural applications (e.g. crop yield projections, water utilization, fertilizer coverage, crop stress, and freeze damage assessment) would be under this category, as would many natural resource management applications (e.g. forestry).

3.2 Describe the Offering's current (end of CY3) target market/customers.
(Highlight particular Offering attributes providing customer benefit.)

With the exception of item 3.1.2, "Toxic Waste Monitoring," the target markets have not changed substantially from those originally identified. However, this project has greatly improved its definition of specific customers within (or selling to) these markets.

Within the U.S., increased emphasis has been placed on aerial photography companies as the largest customer group for the ADAR family of digital aerial photography systems. The company

has developed seminars specifically geared toward 1) educating aerial photographers regarding this technology as well as 2) assisting with marketing and sales efforts to their large base of existing customers.

Outside the U.S., the company is continuing to find very strong interest in the ADAR systems and associated products. In many developing countries, the direct customer for Positive Systems will be an agency within the government. Toward the goal of selling to these customers, the company has been developing strategic alliances with companies experienced in international business, and has signed an agreement with its first distributor outside the U.S. (ImageMaps in Singapore, with point of contact Mr. Bill Love).

Regarding cleanup and monitoring of contamination sites (item 3.1.2 above), we have encountered a general lack of interest in remote sensing within the mining, petroleum, and chemical industries, as well as engineering and environmental service companies. This poor acceptance seems to be driven at least in part by the lack of policies within the EPA to accept remotely sensed data as evidence in remediation activities[1]. Opening new markets subject to this sort of regulatory influence is an extremely long term and costly effort. As such, the company cannot afford to place a great emphasis on these market opportunities, although Positive Systems is working on efforts to assist with making changes in these regulatory policies.

3.3 Discuss strategies for existing market expansion and additional target market entry in the next two years.

3.3.1 Aerial Photography Market Development

Although some aerial photography companies are focused solely on film processes, the company is finding many new and established companies in this industry which are receptive to increased use of digital imaging. The company remains committed to its efforts to expand this market using a variety of pricing plans (contract service work, leasing, and outright purchase of ADAR Systems) and the training/marketing seminars mentioned above.

3.3.2 International Development

Positive Systems will continue to emphasize development of international markets. The company has signed a distributor agreement with ImageMaps in Singapore, with proven experience in marketing, sales, and distribution of high technology products in the Far East. ImageMaps has already completed demonstration projects in Vietnam using the ADAR System 1000, with more demonstrations planned for Malaysia and Indonesia. The company will be responsible for representing Positive Systems in 8 countries.

Plans for a market exploration trip to South Africa, reported in the Y2 summary report, were canceled primarily due to limited resources at Positive Systems and the unfavorable exchange rate between the U.S. and South African currencies.

Emphasis in international market development is being placed on developing countries, since

[1] "What's Wrong with the Environmental Remote Sensing Market", Dr. Frederick B. Henderson III, GIS World, Sept. 1995.

those with growing economies tend to embrace new technology. In addition, the developing countries generally have a great need for geographic (map) data coupled with difficulties in obtaining film imagery, especially color infrared for vegetation mapping. As a result, these developing countries are still considered to be excellent markets for the ADAR family of digital imaging systems.

3.3.3 New Product Development

Positive Systems will continue its development of new products, with primary emphasis on software for post-flight value added processing. Technical developments of secondary emphasis include advanced components within the airborne imaging systems (such as an attitude sensing subsystem and differential GPS), which will improve the accuracy and speed of the post processes, as well as software for improved in-flight quality assurance.

Regarding software for value-added processing, the company has a major project currently underway for development of software referred to as "DIME" (for Digital Image Management Environment). The primary focus of this software will be to bridge the gap between raw imagery (whether from ADAR Systems, aerial film cameras, or other sources such as the new high resolution satellites) and the existing image analysis software packages. Thus DIME will not be positioned as a competitor to ERDAS, ERMapper, PCI, etc., but rather a valuable tool to rapidly prepare imagery for analysis in these existing packages. The first tool to be included under the DIME architecture will be a rapid mosaicking capability. The company has worked with numerous potential partner companies to develop this product, but in each case we have encountered difficulties in working with those other companies (typically related to corporate goals and market emphasis). As a result, Positive Systems has now determined that the best method to create a tool truly suited to the specific needs of our company and customers is to complete the development in-house (with the assistance of a software consulting company, Software Engineering Solutions, of Louisville, Colorado). The first release of the DIME Software is scheduled for first quarter 1998.

The company intends to continue with its commitment to be a top-quality engineering company, developing innovative products while maintaining a strong emphasis on customer interaction to ensure the engineering efforts are driven by "market pull." As has been true from the beginning of this EOCAP project, high costs remain a key limitation to increased growth in GIS/remote sensing, so Positive Systems is focusing technical efforts on elimination of costly mistakes in the flight planning, data acquisition, and post-flight processes.

3.3.4 Service Projects for Applications Development

Positive Systems also remains committed to its historical emphasis on completion of service projects across a range of vertical markets. The company's service revenues have experienced continued growth and allowed development of solid relationships within many industries as well as "proof of concept" applications.

3.3.5 Resource Leverage

From its very beginning, Positive Systems has always been challenged to provide adequate

funding to enable the level of development required to achieve the company's technical and marketing goals. That challenge remains, but the company is taking a slightly different approach to solve that problem. Beginning in Q3 1997, the company signed an agreement with a software consulting company, Software Engineering Solutions (SES), under which SES will provide technical services related to software development. The compensation package agreed to by SES includes deferred compensation in the form of both stock in Positive Systems as well as royalties on future product and service sales.

Although this will reduce the company's profit margin on later sales, it seemed to strike the best compromise between limited technical and financial resources.

3.3.6 R & D contracting

Beginning in 1996, Positive Systems began a concerted effort to seek additional sources of development funds, with the EOCAP program as one example, and the Small Business Innovation Research (SBIR) program another. This is not meant to distract the company from its original focus: providing aerial imaging systems and services. However, a long term commitment to pursuing the various programs that offer funding for technical research and/or business development can provide an answer to one of the key challenges faced by all businesses - the lack of money to develop new products.

4.0 COMPETITIVE ANALYSIS

4.1 Describe the Offering's competitive advantages in the original and current target market(s).

4.1.1 Market awareness/name recognition

Although the market(s) for high resolution imagery is (are) still difficult to define, Positive Systems has done a very good job of introducing its capabilities to the remote sensing industry. The general feedback received from the marketplace has been that the company and products are relatively well known, with a reputation for emphasis on quality. This favorable market awareness is providing positive results in terms of sales, and with a commitment to quality and customer satisfaction (coupled with appropriate press!) we believe the favorable momentum will be continued.

4.1.2 Full Frame Imagery

In contrast to the companies offering line scanning technology for airborne data acquisition[1], imagery acquired with the full-frame sensor format used in the ADAR Systems is subject to far less geometric distortion. For any GIS-based applications, ground registration of the imagery is a key requirement, and ADAR imagery is easier to ground register than line scanner data. This advantage is further enhanced by the company's relationship with Vexcel Corporation to provide image orthorectification services.

4.2 Large Sensor Footprints

The large footprint of the ADAR System 5500 (1500 x 1000 pixels) provides a significant advantage in comparison to video-based systems such as the DMSV (see below). Further, the ADAR System 3000 and 1000 both provide true color or color infrared imagery with a footprint of 2000 x 3000 pixels. Although many factors are involved in the cost of airborne data acquisition, one of the key costs is based on the amount of time the airplane must remain over the site. The larger sensors maximize ground coverage, thus minimizing flight time. This is especially important if a project site is too large to cover in a single day, since the risk of encountering weather delays can dramatically impact the overall project cost.

4.3 "Trickle Down" from High Resolution Satellites

Regarding entry into the high resolution marketplace by new satellite companies, Positive Systems has a clear advantage in being fully operational while the new satellite companies generate increased market demand for imagery which they are currently unable to deliver. In fact, the company has been working with both Space Imaging and Earthwatch to acquire imagery to be used to generate sample applications. Although the eventual launch of the new high resolution satellites will almost certainly capture some of the current/potential market for ADAR System imagery, the relative sizes of our respective organizations leaves

[1] Daedalus Enterprises, Itres Research, etc.

Positive Systems in an excellent position to benefit greatly even if it retains only a fraction of the total market being forecast by the new satellite companies.

4.2 Describe the Offering's unique characteristics.
(For example, increased performance over existing products in use.)

The products and services offered by Positive Systems are unique in a number of ways.

4.2.1 Emphasis on high volume production

The ADAR System 5500 and 3000 are designed for use on production applications, rather than cutting-edge remote sensing research. Specifically, emphasis has been placed on ease of operation and efficiency of storage and post processing when dealing with high resolution imagery covering geographic areas the size of a typical city or county. Although customers are still requesting that the cost be reduced, services based on the ADAR Systems provide the most cost effective solution in the marketplace today for multispectral imagery within the range of 1/2 to 3 meters per pixel. Following image acquisition, turnaround time to fully processed, customer ready data can be as little as 36 hours per gigabyte of imagery (formatted as separate frames). The slower delivery time for image mosaics (several days to weeks, depending on project size) is a key area of improvement being targeted by the company's DIME software, with a goal of reducing the turnaround time for a mosaic by a factor of at least 2.

4.2.2 Modular design

All of the ADAR systems have been designed using as many standard, off the shelf components as possible in order to allow the simplest possible upgrade when new components become available. Prior to the ADAR System 1000, the company had chosen to build its systems using the Sparc architecture and Sun Microsystems' OpenWindows interface. Although Sparc systems are more expensive than the Intel (Windows) systems, this strategy allowed rapid software development via the very robust set of software development tools available for the Sparc systems.

However, in response to the ongoing cost reductions for Intel (Windows) hardware, as well as the continued growth in ancillary hardware compatible with that platform, Positive Systems has made a commitment to develop software for the Windows NT platform, beginning with the company's new DIME product. This will allow the company to develop valuable experience with the NT platform, increasing the company's options for future products.

4.2.3 Emphasis on customer needs

Although it may sound like a simple business matter to be "market driven" and build products only if potential customers for those products can be identified, it is very easy to follow the alternative path, and "build technology for technology's sake." Positive Systems spends considerable effort in understanding the customer's needs before a service project or system sale, then places a high priority on ensuring the product delivered met those needs. It is easy in a written document to claim to be customer focused; Positive Systems has a

repeat customer rate in excess of 50%, and the feedback from customers (both direct and "via the grapevine") indicates a very high degree of customer satisfaction.

As a result of this customer focus, Positive Systems continually emphasizes cost reduction, an area that still requires improvements in order to dramatically expand the utilization of high resolution imagery in GIS applications.

In addition, all of the company's recent product developments (the ADAR System 1000 and the DIME software) have come directly from customer requests for products or services that are "good enough" for their applications at the lowest possible cost.

4.2.4 Wide range of products

Another aspect of the customer focused approach has been the creation of a range of products, from single cameras through the ADAR Systems 1000 and 3000 to the full ADAR System 5500. With list prices ranging from $15,000 to $245,000, this approach has provided the widest possible range of options for a market consisting of widely varying requirements and users. This approach appears to be generating the desired results: generating revenue from entry level systems sold to the larger market of "tentative" and "future" customers, while offering an upgrade path for those early customers who wish to expand their capabilities to handle larger scale projects.

4.3 Discuss the products that are competitive with your Offering.

In general, the currently available competitive products can be categorized as follows: digital video systems, linescanning systems, film-based systems, and roughly equivalent digital imaging systems. In some cases, these companies are offering systems for sale, while in other cases the offering is for a service only.

4.3.1 Digital Video Systems

The key limitations to video systems are the small size of the video footprint and (for some systems) the timing gap between the two interlaced fields of the video image.

4.3.1.1. SpecTerra (Australia) manufactures and sells the Digital Multispectral Video (DMSV) system. This four-channel system is roughly equivalent to the original ADAR System 5000. SpecTerra has had some limited success in selling these systems in the U.S. (to the Army Corps of Engineers and Terra Systems of Hawaii, for example).

4.3.1.2. Kestrel Corporation (New Mexico) has developed the AirCam for sale, a three- or four- camera noninterlaced video system, basically equivalent to the DMSV.

4.3.1.3. Enso Forest Development (Finland) has developed the EnsoVIDEO system, again roughly equivalent to the DMSV.

4.3.1.4. Utah State University at one time offered multispectral video imaging services. Positive Systems encountered this system as a commercial competitor on at

least one occasion, but the current status of this group is believed to be strictly research, with no plans for commercial operation.

4.3.2 Linescanning Systems

Linescanning systems generally record a large number of spectral channels, making them very well suited to research projects but generally less necessary for "production" oriented projects. In addition, although gyroscopes or other attitude sensors can improve the line-to-line registration of scanner imagery, airborne scanner data is generally more difficult to ground register than full frame imagery such as that recorded by the ADAR Systems or film cameras.

4.3.2.1. ITRES Research (Canada) has been making the compact airborne spectrographic imager (casi) for many years, providing 288 channels within the visible and near IR spectral range, using a CCD imager.

4.3.2.2. Daedalus Enterprises (Michigan) makes a number of image scanning systems: the Airborne Bispectral Scanner (ABS, thermal IR plus visible or NIR), Airborne Multispectral Scanner (AMS, 6 channels, visible, NIR, thermal IR), Airborne Thematic Mapper (ATM, 11 channels, visible, NIR, thermal IR).

4.3.2.3. Geophysical & Environmental Research (GER) Corp. (New York) also makes a number of hyperspectral image scanning systems, providing from 32 up to 211 spectral channels within the visible, NIR, and thermal IR regions of the spectrum.

4.3.2.4. OMNI Solutions International, Ltd. (Virginia) is offering services based on its Direct Digital Panoramic (DDP) camera. The DDP records panchromatic imager, so is only marginally competitive to the ADAR Systems.

4.3.3 Film-based Systems

Classic film aerial photography is not always a competitor to the ADAR System when discussing multispectral imagery, but scanned aerial photos (true color or color infrared) can be used in many of the applications being served by the ADAR Systems. However, in many cases the primary advantage of film is its high resolution and large coverage, providing the ability to generate terrain data. Since terrain mapping is not currently offered by Positive Systems, film systems are not necessarily competition, and in fact film aerial photographers are key customers for the company. However, as the ADAR System technology improves, this competition is expected to increase.

4.3.4 Equivalent Digital Imaging Systems

4.3.4.1. Resource 21 (Mississippi) is offering "Farmview" maps based on multispectral imagery acquired with their digital imaging system which is roughly equivalent to the ADAR System 5500. The long term goal of Resource 21 is to launch a satellite which will replace their airborne system, but it is not known if that will definitely come to pass. Positive Systems has been frustrated in dealing with this company, since they are closely affiliated with the Space Remote Sensing Center at

NASA Stennis and benefit from appearing to fall under the NASA umbrella.

4.3.4.2. Airborne Data Systems, Inc. (Minnesota) offers the Spectra-View system, with 5 to 10 spectral channels. In the visible and NIR, the sensor is a 1024 x 1024 pixel CCD, with a 256 x 256 pixel InSb detector for the thermal IR. This is a relatively new company, and their status is not well known.

4.3.4.3. The USDA Agricultural Research Service (Weslaco, Texas) has built a four-camera digital imaging system equivalent to the ADAR System 5500 under contract to the EPA. Although this particular procurement was clearly in competition with Positive Systems, it is not expected that this represents a trend or policy which will continue. The company has reviewed the status reports regarding design and construction of the A.R.S. system throughout this project.

4.3.4.4. Daedalus Enterprises (Michigan) is also offering a full-frame digital camera system, with resolution of 2000 x 2000 pixels. This is currently a panchromatic system, but Daedalus has announced plans to offer a color (or perhaps multispectral) system in the near future.

4.3.4.5. In the summer of 1997, TASC (Massachusetts) fielded a new digital imaging system (via the EOCAP program) which utilizes the Kodak DCS color infrared camera and precise angular pointing information to acquire imagery for agricultural applications. An additional component of the TASC product is distribution of data via their existing subsidiary, Weather Systems International. The company experienced some competition from the multiple TASC systems in 1997.

4.4 Discuss the Offering's market-entry challenges from the perspective of both competitive challenges and consumer challenges.

(For example: customer acceptance of the offering, weaning customers away from long-standing/traditional solutions, customer retooling hardware and/or software to accept your offering.)

4.4.1 Limited Resources

Perhaps it could be argued that having "limited resources" (money, personnel, equipment) is a universal challenge for every business, and as such is incidental to this discussion. However, Positive Systems must deal with some aspect of this issue on a daily basis, and increased financing would definitely allow the company to improve its results. Given greater resources, many activities could be expanded, such as software development, sales calls to potential customers, and advertising (the company placed its first-ever paid advertisement this year, in the agricultural industry magazine "Modern Agriculture").

Although many individual technical goals for system and process improvement are still identifiable and the market for the company's products is clearly still developing, Positive Systems firmly believes that its current products are of value to a market already large enough to generate greater success than has been achieved to date. A fundamental challenge facing the company is the ability to identify, qualify, and interface with customers and then close sales. On this issue, increased success will be based on a combination of increased resources, intelligent decisions (re: allocation of resources, identification of good

vs. poor sales prospects, etc.), and some degree of good luck.

4.4.2 Product Costs

Although Positive Systems has placed emphasis on reducing the cost of both the ADAR Systems and the company's imaging services, interactions with customers indicate that the cost is still too high for many applications. The company must remain committed to further cost reductions, to be achieved primarily via increased automation (for service work) and the historic trends toward price reductions for computer/electronic hardware (for system sales).

4.4.3 Customer Retooling

Regarding sales of turnkey ADAR Systems, one key sales objection from the perspective of aerial photographers is the cost already invested in film cameras and film processing equipment. Those with significant investments in film-based systems will be amortizing their capital equipment for several more years. In addition to the issue of "retooling" regarding image acquisition (film camera vs. an ADAR System), the potential customer must also consider the equipment required to conduct post-flight image data processing[1].

On this issue, Positive Systems is focusing on the growing companies that are committed to further hardware investments as well as the numerous new businesses that are just entering the aerial photography business. This issue will remain a challenge for several more years.

4.4.4 State of the Market

Although the airborne imaging market has many different facets and use of digital imagery has been growing steadily, the vast majority of the production oriented projects are still completed with film or other manual (non-imagery related) processes. With continued exposure in the trade journals and the advertising efforts of the new high resolution satellite companies, the market is expected to continue to grow, especially in repeat monitoring applications.

---

[1] Note that the ADAR Systems are fully capable of completing post-flight processing, but once again for any high volume production operation, a large company will be more efficient if the airborne system remains dedicated to the task of image acquisition while a different system completes the post flight image processing tasks. Positive Systems is currently developing the DIME software to support the needs of a company using an ADAR System for high volume data acquisition.

5.0 PROJECT DATA

5.1 Total Project Funding:	$ 2,374,406
5.1(a) NASA Funding:	$ 639,319
5.2 Expenditures to Date (9/1/97):	
5.2(a) Partner Cash:	$ 1,647,590
In-kind Labor:	$ 18,535
In-kind Facilities:	$ 68,962
5.2(b) NASA Cash:	$ 639,319
5.3 Marketing Expenditures to Date:	$ 179,142

Note: this represents direct marketing expenditures, not including salaries for personnel performing marketing functions.

5.4 Jobs Created, EOCAP Attributable:

Positive Systems has added one full time sales person, one marketing support person, one production operator, and one manufacturing/ production manager as a result of participation in this EOCAP project.

5.5 Personnel Dedicated to EOCAP (by employment position):

- Engineering: 1.5 people
- Marketing/Sales: 3 people
- Flight Operations: 1 person
- Manufacturing/production: 1.5 people

5.6 Facilities Expansion, EOCAP Attributable:

- In 1994, Positive Systems moved to a new office building (leased), expanding total office space from approximately 1200 square feet to approximately 2200 square feet. Approximate facilities expenditures increased from $3,500 to $12,000 (annual costs).

- Regarding computer equipment, Positive Systems has added two Sun workstations and one Windows NT development system (annual leasing costs approximately $10,000) and fielded two ADAR System 5500s dedicated to service projects.

5.7 Business Arrangements, EOCAP Attributable:

- TRIFID Corporation - system purchaser, offering image orthorectification services.

• DATRON/Transco Corporation - system purchaser, offering image acquisition services.

• VEXCEL Corporation - offering image orthorectification services in conjunction with Positive Systems.

• Eastman Kodak - strategic partner, providing imaging sensors to Positive Systems and conducting joint marketing re: Color Infrared Camera System.

• ImageLinks Inc. - offering image mosaicking services in conjunction with Positive Systems.

• ImageMaps (Mr. Bill Love) - system purchaser and international distributor for the Far East.

• Software Engineering Solutions - software design consultant, working with Positive Systems on the architecture of the DIME software.

5.8 Contributions of Outside Investments, EOCAP Attributable

None to date

5.9 Productivity Enhancements/Cost Avoidance:

5.9.1 In May of 1995, Positive Systems introduced the ability to generate a vector plot of overlapping footprints to indicate coverage provided by the ADAR System 5500 image sensors. This new feature assisted customers with data management, and also has proven instrumental in providing a rapid quality assurance (QA) tool to allow confirmation that the imaging flight successfully covered the target image area.

Availability of the footprint plots has saved the company money in both a) early detection of flight problems and b) reduced technical support (answering customer questions regarding location of images), with annual cost savings from this feature alone estimated at $15,000 to $20,000.

5.9.2 Productivity gain made possible by the addition of two sales people is somewhat subjective, but addition of one salesperson in EOCAP Year 1 generated approximately $40,000 in added revenues (counting productivity as increased gross sales minus the salesperson's salary), and approximately $120,000 for Year 2 (second salesperson added). In Year 3, the added sales volume from the additional salespeople exceeded $250,000.

5.9.3 During the third quarter of Year 2, the company implemented a new graphical user interface (GUI) for post processing of ADAR System imagery. Although quantitative measures of cost savings are estimates at this time, it is expected that this new interface will reduce the manual labor applied to post processing by approximately one-third, primarily in terms of record keeping regarding which post processes are being applied.

5.9.4 In 1997, Positive Systems completed full training for system operators at Bergman Aerial Services (Portland, OR, affiliated with Spencer B. Gross, Inc.) and Aerial Services

Inc. (Cedar Falls, Iowa). Each of these two service providers operated an ADAR System 5500 in the region for the summer of 1997, expanding the capabilities of Positive Systems without an increase in staff.

5.10 Trade Shows Attended/Exhibited:

1994

EOSAT Conference (Seattle, WA, 10/94)
"GIS in the Rockies" Conference (Golden, CO, 9/94)
GIS In the Asia/Pacific (Kuala Lumpur, Malaysia, 10/94)
Environmental Technology Exposition (Atlanta, GA, 12/94)

1995

NARSIA (Dallas, TX, 1/95)
ACSM/ASPRS (Charlotte, NC 2/95)
ERDAS User's Group Meeting (Atlanta, GA, 3/95)
Association of American Geographers (AAG, Chicago, IL, 3/95)
AM/FM Conference (Baltimore, MD, 3/95)
EOSAT Conference (Dallas, TX, 4/95)
Montana GIS User's Conference (Helena, MT, 5/95)
MAPPS conference (Whitefish, MT, 7/95)
EOSAT conference (Denver, CO, 9/95)
ERIM Third Thematic Conference on Remote Sensing for Coastal and Marine Environments (Seattle, WA, 9/95)
GIS in the Pipeline Industry (Houston, TX, 10/95)
International Geoscience and Remote Sensing Symposium (IGARSS) '95 (10/95)
GIS In the Asia/Pacific (Kuala Lumpur, Malaysia, 10/95)

1996

Petroleum Industry Conference (Houston, TX, 1/96)
First ADAR System User's Group Meeting (San Diego, CA, 1/96)
ERDAS User's Group Meeting (Atlanta, GA, 3/96)
US Forest Service Remote Sensing Conference (Denver, CO, 5/96)
Fifth Annual Natural Resources GIS-GPS Conference (Columbia, CA, 5/96)
ESRI-Users Conference (Palm Springs, CA, 5/96)
ERIM 2nd International Airborne Remote Sensing Exhibition (San Francisco, CA, 6/96)
MAPPS meeting (Kennebunkeport, ME 7/96)
GIS in the Pipeline Industry (Houston, TX, 9/96)
GIS In the Asia/Pacific (Kuala Lumpur, Malaysia, 9/96)
3rd International Conference on Precision Agriculture (Minneapolis, MN, 6/96)
Hazardous Waste World (Washington, DC, 10/96)

1997

MAPPS/Airborne GPS (Reston, VA, 2/97)

ASPRS Workshop/color photography and videography for resolution. (Weslaco, TX, 4/97)
ESRI Annual Users Group meeting (San Diego, CA, 7/97)
MAPPS (Lake Tahoe, CA, 7/97)
AM/FM International Conference (Nashville, TN, 3/97)
Urban and Regional Info Systems Association (URISA, Toronto, Ontario, Canada, 7/97)
GIS Asia Pacific (Jakarta, 10/97)
18th Asian Conference on Remote Sensing (Kuala Lumpur, 10/97)

5.11 Participation in Government and Industry Policy Fora:

Positive Systems is a member of the following industry organizations:

- ASPRS
- MAPPS
- The Coalition for Advancement of Commercial Remote Sensing

6.0 EOCAP CRITIQUE

6.1 Please provide suggestions for improving the Program's Administration.

6.1.1 Program Administration

No new issues have arisen which are worth noting. Early in the project, a few changes made by NASA in reporting requirements caused confusion (noted in our Year 2 report). In addition, clarification of allowable marketing expenditures also caused confusion early in the project, but that has not been a problem since Year 1. Overall, we feel the company's relationship with NASA has been very productive, with effective communication channels in place.

6.1.2 Technical Support

No suggestions at this time.

6.1.3 Project Liaison Support

It would be helpful if the project liaison were able to visit each EOCAP company under his/her oversight approximately once per year. Our liaison was not able to visit our office during Year 3. In no way did this present a problem for Positive Systems, but an in-office visit would help ensure optimal communication with the liaison and potentially generate new ideas for collaboration.

6.1.4 Procurement

Positive Systems experienced a "learning curve" at the project outset, but once the company's accounting system had been approved by DCAA, no difficulties have been experienced in this area.

6.2 Please state lessons learned from your EOCAP experience.

6.2.1 As noted in 6.1.4, the audit conducted by the Defense Contract Audit Agency (DCAA) at the beginning of this project was critically helpful in defining proper accounting procedures. The improved accounting system has been helpful in execution of other contracts with government agencies.

6.2.2. Selling new technology into an established marketplace (i.e., selling to aerial photography companies) presents a formidable challenge. However, given an appropriate business case, there are always a small number of progressive companies willing to take chances on new products. In such scenarios, product quality and customer service are critical.

6.2.3. The cornerstone of Positive Systems' business to date has been through service

projects within the U.S., but the company remains committed to expanding the market for systems and software outside the U.S. In particular, the company is emphasizing the Far East, based partially on the strength of the economies in that region (Japan, Thailand, Malaysia, Korea, The Philippines, etc.).

6.2.4. Reduction of aerial image data into image mosaics is a critically important step for most applications. Although the established image processing software available in the marketplace (ERDAS, PCI, ERMapper, etc.) can create mosaics of separate frames, none are extremely efficient for processing a large number of frames in an automated fashion. Softcopy photogrammetry packages from companies such as Vision, International provide excellent quality through classic block triangulation techniques, but do not address the need for rapid turnaround in cases where full orthorectification is not required. Positive Systems' DIME software (under development) will provide a very efficient tool for mosaicking large numbers of digital images.