Large Format Resistive Array (LFRA) InfraRed Scene Projector (IRSP) Performance & Production Status

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ABSTRACT

SBIR has passed the midpoint of delivering ten 1024x1024 IR Scene Projector Systems (IRSPs) to the Government. Six systems have been installed at Redstone Technical Test Center (RTTC), Patuxent River, and Edwards Air Force Base. Four more systems are in production and will be shipped by the end of this year. The commercial name of the LFRA IRSP is Mirage XL. This ground breaking projector technology is being leveraged on the Wide Format Resistive Array (WFRA) program and on the Mirage II product. The WFRA IRSP, also known as Mirage HD, features an even larger 1536x768 emitter array and will be in system integration by the end of the year. Mirage II, which also leverages LFRA, is being readied as the next generation 512x512 projector system.

Additional signal processing capabilities have been installed in the LFRA systems. Each system now has full Translation/Rotation Processing (TRP) capability. Systems also have image convolution and 400Hz 1024x512 windowing capabilities.

Keywords: IR Scene Projection, LFRA, Mirage XL, WFRA, Mirage HD, Mirage II, Translation Rotation Processing, Convolution, Emitters

1. INTRODUCTION

Mirage XL –LFRA- systems are being completed on approximately 2 month centers at SBIR. Six systems have shipped to government customers and #7 will be delivered in May. New capabilities have been installed in the last year including Translation/Rotation Processing, Image convolution, and 400Hz 512x1024 'Windowed' mode. In the last year, Mirage XL has paved the way toward two new IRSP systems; Mirage HD and Mirage II. Both of these systems feature the core Mirage XL technology.

Mirage XL was conceptualized and developed over a four year period in support of Tri-Services EO sensor test & evaluation programs. Government contributors to the program include:

- **STRICOM**
- **Redstone Technical Test Center (RTTC)**
- **US Navy – Pax River**
- **Wright Patterson AFB**
- **Naval Air Warfare Center; China Lake**
- **Edwards AFB**
- **Eglin AFB**

The Mirage XL (LFRA) system includes a 1024x1024 IR emitter array which projects dynamic imagery at a frame rate of 200 Hz. The emitter array is housed in the Digital Emitter Engine (DEE). The Command & Control Electronics (C&CE) provide Non Uniformity Correction (NUC), image Translation & Rotation, Convolution, and UUT frame synchronization. The Thermal Support System (TSS), along with a stand alone chiller provides power and cooling to the DEE. These three major subcomponents, shown in figures 1.1, 1.2, and 1.3 make up the Mirage XL system.

Figure 1.1. A Mirage XL DEE

Figure 1.2. The Mirage XL C&CE

Figure 1.3. A Mirage XL TSS

Figure 1.4 provides a block diagram of the entire Mirage XL system. Note that the two-way arrows indicate communication pathways between the DEE, TSS, and C&CE. The two-way communication serves as a sophisticated network of status checking and data logging.

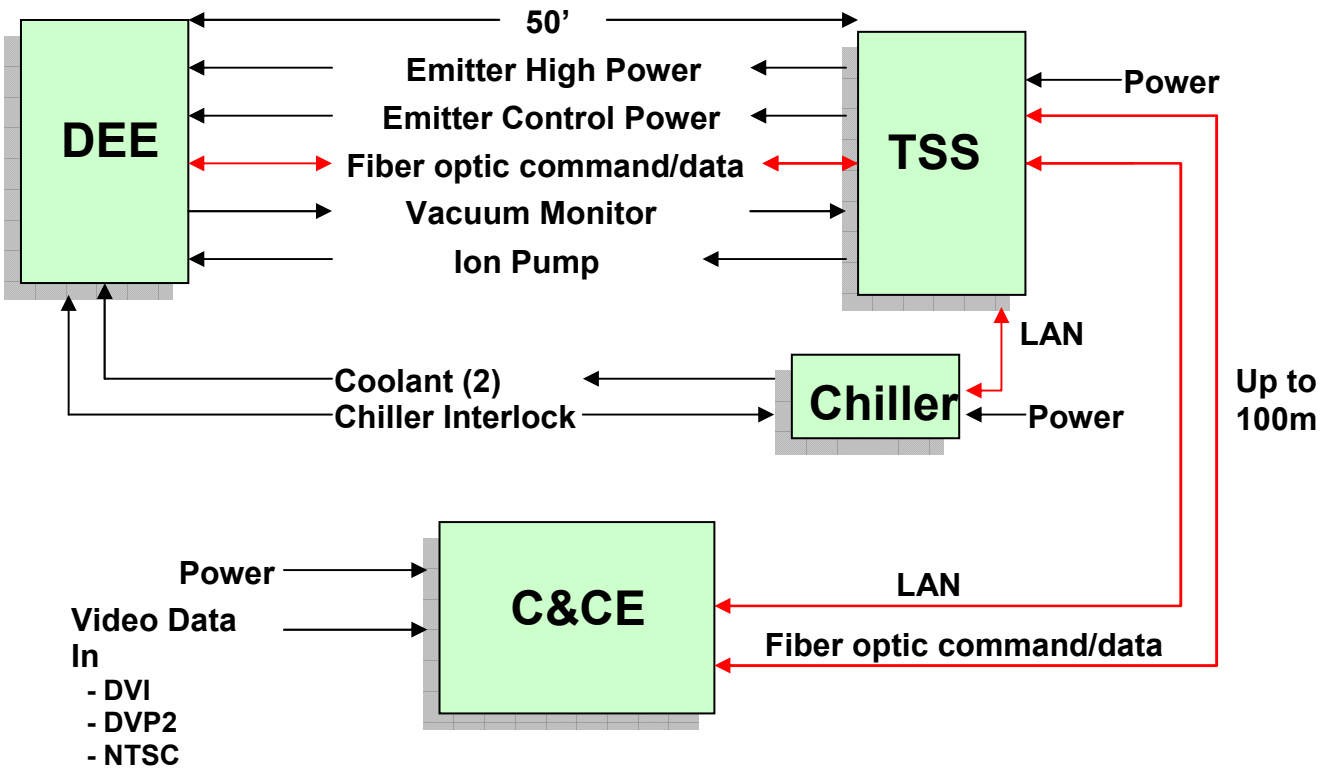


Figure 1.4; Mirage XL Block Diagram showing the communication routes between components.

2. Video Signal Processing

The Mirage XL Command & Control Electronics (C&CE) provide all signal processing and user interface functions. Along with signal processing, the C&CE has capabilities not found in any other IR projection system. First, the C&CE can perform in-process data checks identifying corrupted frames of video. The C&CE can identify spurious frame sync pulses from an external source and ignore them. Each frame of data can be checked as it moves from one C&CE card to the next. This ensures that there is no internal corruption of the data during a simulation. Each Mirage XL C&CE undergoes substantial frame-by-frame video signal processing checks before being accepted.

2.1 Translation/Rotation Processing

The Translation/Rotation Processing (TRP) feature is being installed in all Mirage XL systems. TRP allows the user to manipulate the position and rotational orientation of video data after they have left the image generator. In this way TRP reduces overall system latency. The Mirage XL TRP function interfaces with a user PC that provides rotation and transitional coordinates directly to the C&CE.

To address possible 'dead' or no-signal corner pixels when a square frame of data is rotated, the C&CE accepts oversized input images. An image that is rotated 10 degrees can still fill the frame when an 1128x1128 input is used. The maximum input frame size of the C&CE is 1192 x 1192 which provides extra headroom for the TRP function. The TRP interface is highlighted in figure 2.1. The TRP capabilities of the Mirage System are listed in Table 2 as well.

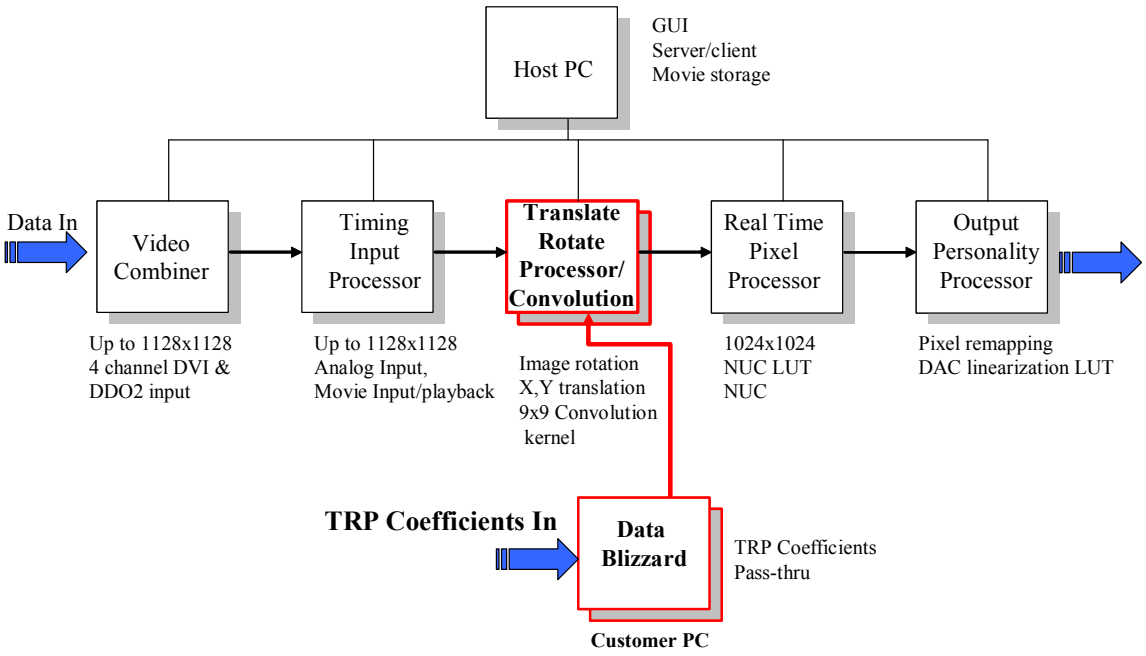


Figure 2.1; Block diagram of the Mirage XL Command & Control Electronics (C&CE) highlighting the TRP interface.

Percent Image Oversize (x, y)	Minimum Input Image Size (pixels)	Display Mode (-)	Lines of Vertical Pixel Displacement	Max. Frame Rate (Hz)
-	1024h x 1024v	Full-Frame	±127	200
5%	1080h x1080v	Full-Frame	±120	180
10%	1128h x 1128v	Full-Frame	±115	164
16%	1192h x 1192v	Full-Frame	±108	150
-	1024h x 512v	Window	±127	400
5%	1080h x 540v	Window	±120	360
10%	1128h x 564v	Window	±115	328

Table 2; TRP processing capabilities

2.2 Convolution

The convolution function provides the user with the ability to blur the video image via a 9x9, 16 bit kernel. Convolution is provided on the came C&CE card as TRP but is an independent function. It can be utilized or bypassed through a dialog box in the user interface. An example of the use of convolution is provided in figure 2.2 a and b.

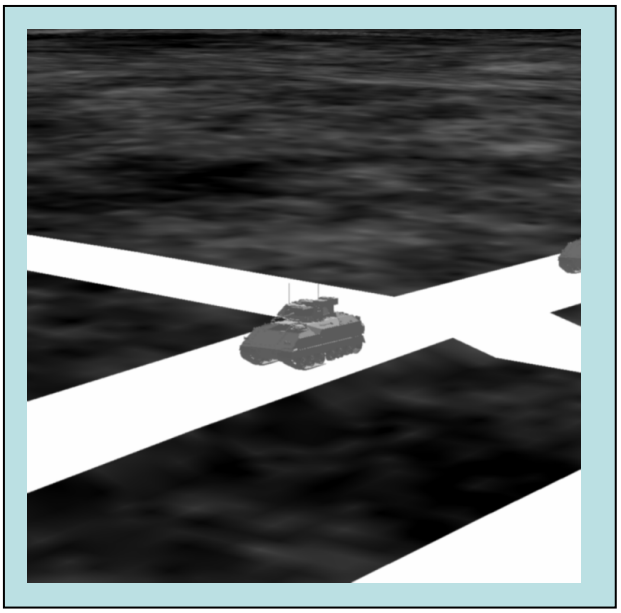


Figure 2.2a
Video frame input from the scene generator

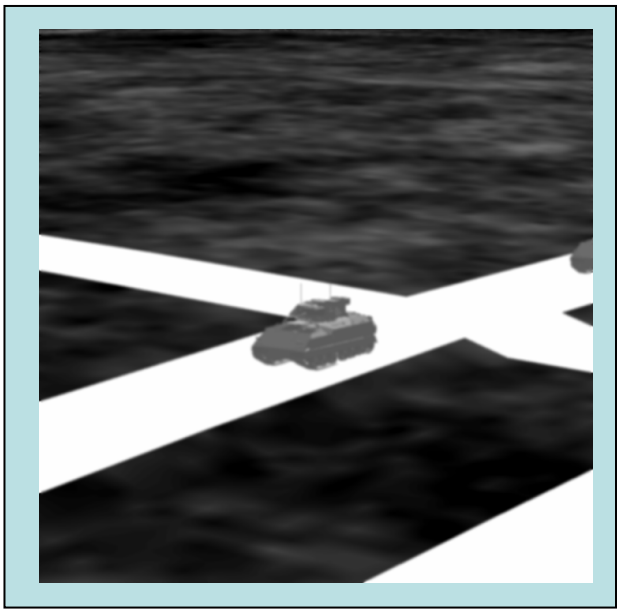


Figure 2.2b
The same frame after a convolution term is added

2.3. Image Projection

The Mirage XL DEE is designed to mount on collimating optics. The three point mounting structure provides x, y, z and theta adjustability. The photo in figure 2.2 shows a Mirage XL DEE integrated with government owned collimating optics and projecting into an IR camera. As indicated in the block diagram of figure 1.4 the DEE/collimator and TSS can be separated by up to 50 feet.

Figure 2.2; Mirage XL DEE mounted on collimating optics

3. Emitter Array Performance

3.1 LFRA Array Production

Arrays of exceptionally high operability are being delivered with the Mirage XL systems. The arrays, similar to the packaged device shown in figure 3.1a, are for SBIR produced at RTI in Raleigh/Durham North Carolina. Typical operability is between 99.6 and 99.9%.

The next emitter lot, with 16 deliverable candidates, is due to complete processing in May. The coming lot features faster rise & fall times than previous devices. The new architecture is provided in figures 3.2 a & b. This full pipeline of emitter and RIIC material ensures a steady capability to ship Mirage XL systems over the long term.

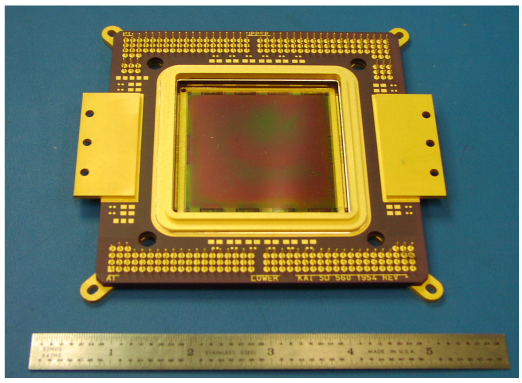


Figure 3.1a, A packaged Mirage XL emitter array

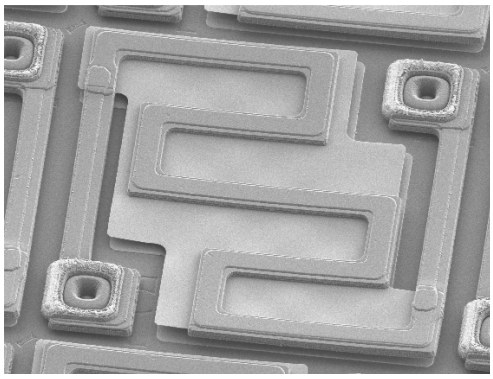
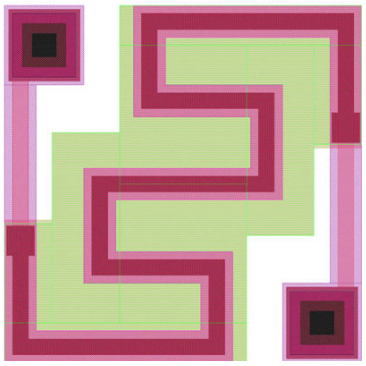


figure 3.1b A SEM of a single emitter pixel

3.2 Emitter Array Performance

Of the key performance parameters; operability, maximum apparent temperature, and rise time, the Mirage XL emitters are performing well. All arrays produced thus far meet the operability and maximum temperature requirements with margin. Rise time, which was slower than required on the first production emitter lot, is addressed on the new release of emitter arrays due to complete this May. The new emitter geometry features a 15 micron leg as shown in figure 3.2. The new leg length will provide sub 5ms rise time along with the required 700K MWIR maximum apparent temperature.



Rise time @ 700K = 4.5mS

Figure 3.2
Updated emitter geometry currently in production will provide sub 5ms rise time at 700K.

Other key parameters are Delta temperature repeatability & stability and Spatial Nonuniformity. Delta temperature repeatability & stability refers to the minimum controllable temperature *step* resolution. It is measured by setting a block of emitter pixels at a low level output and measuring radiance. A second radiance measurement is made at a drive level 256 counts hotter than the first one. The step resolution is the change in radiance divided by the number of steps. The measurement is made twice at an hour interval. The measurements show that the step resolution of a Mirage XL emitter array is typically 0.02 K. The step resolution is also repeatable and constant over time.

Emitter array nonuniformity data are acquired as part of the operability measurement. It is an evaluation of the variation in radiant output at a given drive level across the emitter array. There are several contributors to nonuniformity; transistor drive current, emitter pixel resistance, emissivity variations and measurement system drift. The combined nonuniformity of these sources is at or above the specified value of 10%.

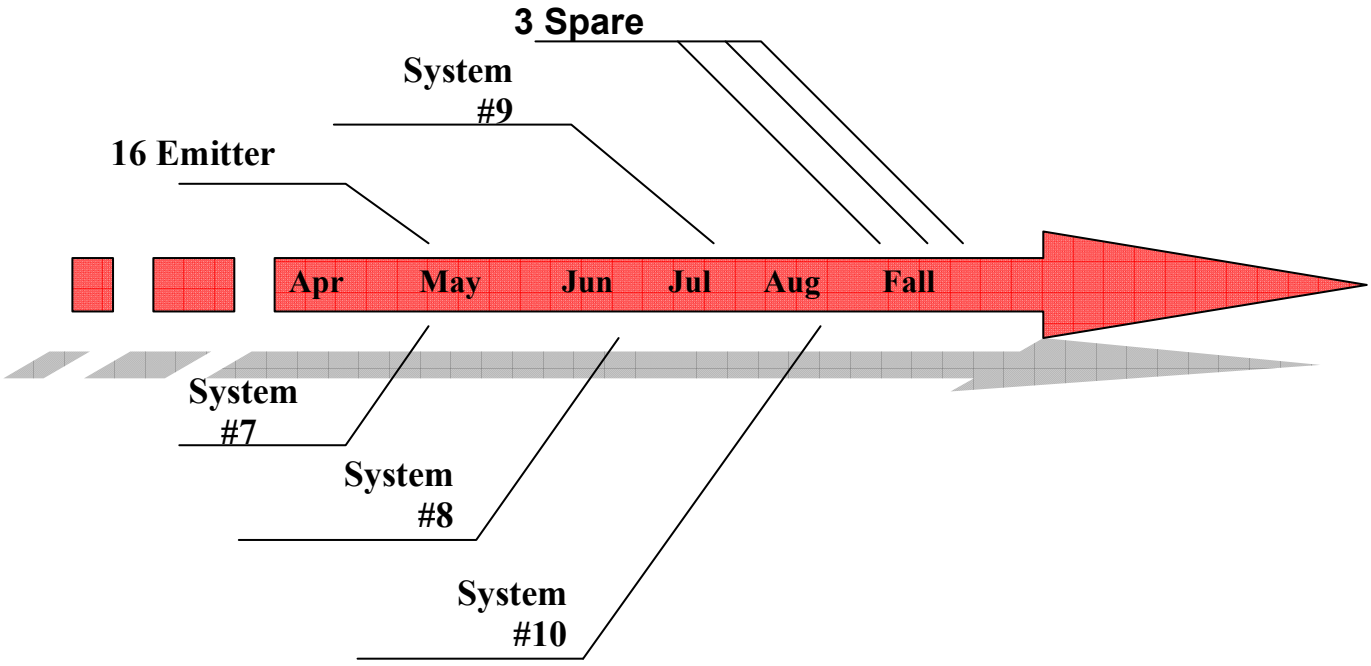
A summary of the performance of the six delivered emitter arrays is provided in table 3.1.

Parameter	Spec	System 1	System 2	System 3	System 4*	System 5	System 6
MWIR Max Temp	700K	704K	747K	762K	746K	707K	706
Operability	>99%	99.8%	99.9%	99.9%	99.8%	99.6%	99.7%
Spatial Nonuniformity	<10%	4.5%	9.9%	15.7	<15%	13.7%	14.9%
Delta temperature repeatability, stability	0.05K	0.02K	0.03K	0.02K**	0.02K	0.02K	0.02K
Rise Time	<5ms	8.1ms	10.8ms	9.4ms	9.0ms	9.3ms	9.5ms

Table 3.1 Performance of emitters shipped as part of MIRAGE XL systems.

4. Mirage XL Summary
Mirage XL is Mid Way Through Production

The LFRA program, which set out to design & develop a large format IRSP, is a success. The Mirage XL systems developed under the LFRA contract are now in production and being delivered to user facilities. SBIR has demonstrated that 1024x1024 IR emitter arrays are fully producible and address the most stringent requirements of the IRSP community. Six Mirage XL systems have been delivered and the seventh is in final integration at SBIR. The remaining three systems and three spare DEEs will be completed during the next eight months.



5. Mirage HD
Wide Format Resistive Array

A high definition version of the Mirage XL system is in development under the Wide Format Resistive Array (WFRA) program. WFRA is funded by the US Navy under the CEITIP effort at Patuxent River, Md. Its key features are a 1536x768 emitter array and 100Hz true raster capability. Three Mirage HD systems are to be integrated, tested & shipped as the WFRA program deliverables. Hardware design on WFRA has been completed and initial parts' procurement is under way. The systems are planned to begin integration late in 2007. They will be tested and delivered in the first half of 2008. The key WFRA system requirements are provided in table 5.

Requirement	Value
Array format	1536x768
Maximum Apparent Temperature (MWIR)	600K
Frame rate	100Hz
Output mode	Raster, snapshot
Radiance rise & fall time	<5ms
Windowed mode	200Hz 1024x768

Table 5. WFRA System Requirements

5.1 WFRA DEE

Great care has been taken to use the lessons learned fabricating & testing Mirage XL DEEs and systems. The DEE designed on WFRA matches the Mirage XL mechanical footprint and uses the same electrical interface. The optical interface is the same except for the different focal plane length and width. An illustration of the DEE designed on WFRA is shown below along with a Mirage XL DEE for comparison.

Figure 5a The Mirage XL DEE

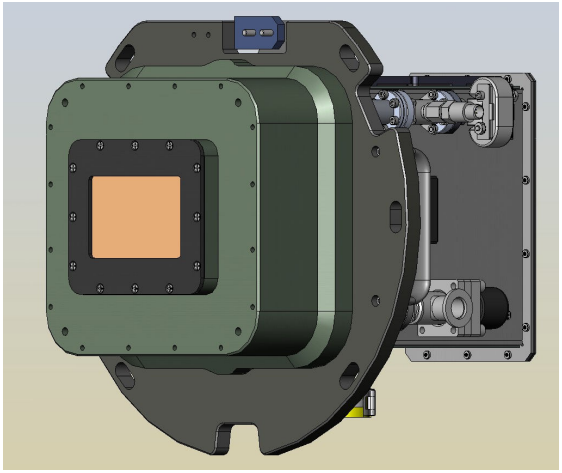


Figure 5b, The WFRA DEE

6. Mirage II
High Performance 512x512 Emitter Array

MIRAGE II utilizes the same system architecture and emitter geometry as MIRAGE XL. Due to the emitter processing improvements put in place for Mirage XL, these arrays are expected to provide superior operability; typically on the order of 99.8-99.9%. The system is configurable per customer specification for the parameters of DEE/TSS separation (up to 50') and optical passband (broadband, MWIR or LWIR).

The MIRAGE II C&CE utilizes the same architecture as the larger systems. It has single DVI and DVP2 inputs to support the required data rates for a 512x512 emitter array. TRP and convolution features can be provided as added features. Table 6 summarizes the MIRAGE II performance parameters.

MIRAGE II Projector System Requirements	
Apparent Temperature (max)	>700K (MWIR >550K (LWIR)
Radiance Rise Time	<5ms
Frame Rate	20-400Hz
Array Configuration	512x512
Pixel size	48x48 microns
Frame Update Modes	Snapshot, Rolling
Video Input	DVP2, DVI, NTSC, PAL

Table 6. MIRAGE II performance

7. Summary

The Mirage XL system build is past the mid way point and six systems are in use at customer sites. Translation/Rotation Processing (TRP) is being installed in all systems along with image convolution. SBIR anticipates completing all ten Mirage XL system deliveries required on the LFRA program in the next six months.

While LFRA wraps up in 2007 with the delivery of the remaining Mirage XL systems, the new wide format Mirage HD will begin production. Mirage HD, featuring the 1536x768 emitter array will be built in 2007 for system deliveries in 2008. Mirage HD is being developed on the WFRA program and utilizes all of the features proven on LFRA.

The MIRAGE II system is being readied as the standard 512x512 product. It will feature all of the Mirage technological advances to provide superior performance and reliability.