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

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ABSTRACT

SBIR has completed development of the Large Format Resistive Array (LFRA) Infrared Scene Projector (IRSP) and shipped the first production system. Nine more systems are in production and will be shipped to several US Government customers on approximately six week centers. The commercial name of the LFRA IRSP is Mirage XL. System performance meets a broad range of program requirements and SBIR has been extremely successful in producing this ground breaking projector.

Tests performed on System #1 reveal broad compliance to the specification and, in particular, outstanding emitter array performance. Key emitter requirements that have been met or exceeded include Operability, Maximum Apparent Temperature, and Array Uniformity. Key System specifications are:

- **Large-format emitter array (1024x1024)**
- **High maximum apparent temperature (>700K)**
- **200 Hz full-frame operation**
- **400 Hz static window mode (1024x512)**
- **Non Uniformity (uncorrected) <10%**

Keywords: Command & Control Electronics, Emitters, IR Scene Projection, LFRA, Mirage XL, Network

1. INTRODUCTION

Production assembly and test of several next-generation resistive emitter-base IRSP systems is in full swing at SBIR. The transition from development to production was completed in 2005 and SBIR is now assembling these systems on a routine basis.

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 wih 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. This will be discussed further in section 2.

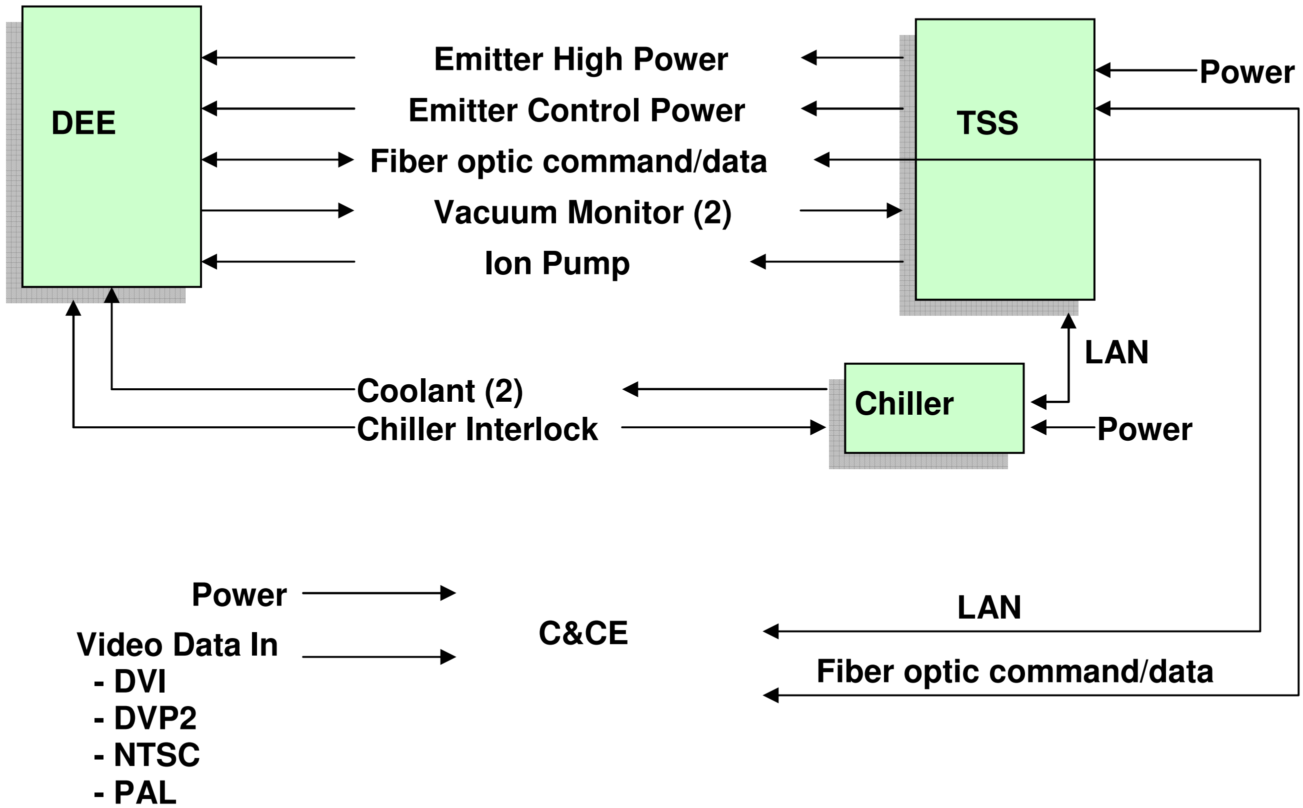


Figure 1.4; Mirage XL Block Diagram showing the communication routes between components.

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 many hours of frame-by-frame video signal processing checks before being accepted.

The second feature is a fully networked server/client user interface. The C&CE acts as a server where all system control is maintained. The user at the C&CE being in close proximity to the scene generator can monitor both projection and scene generation. While the server is in control, any number of remote users can monitor the system's configuration & status via the network.

The user at the C&CE server can relinquish control to any one of the remote users. This feature is greatly useful in applications where the scene generator and IR projector head (DEE) are in separate locations. The client at the DEE/TSS location can set the system up for a set of simulations and run test images and movies to check for proper test configuration. Once the system is configured and checked, the user at the server end can take over and project using the full closed loop capability of the scene generator and Mirage XL.

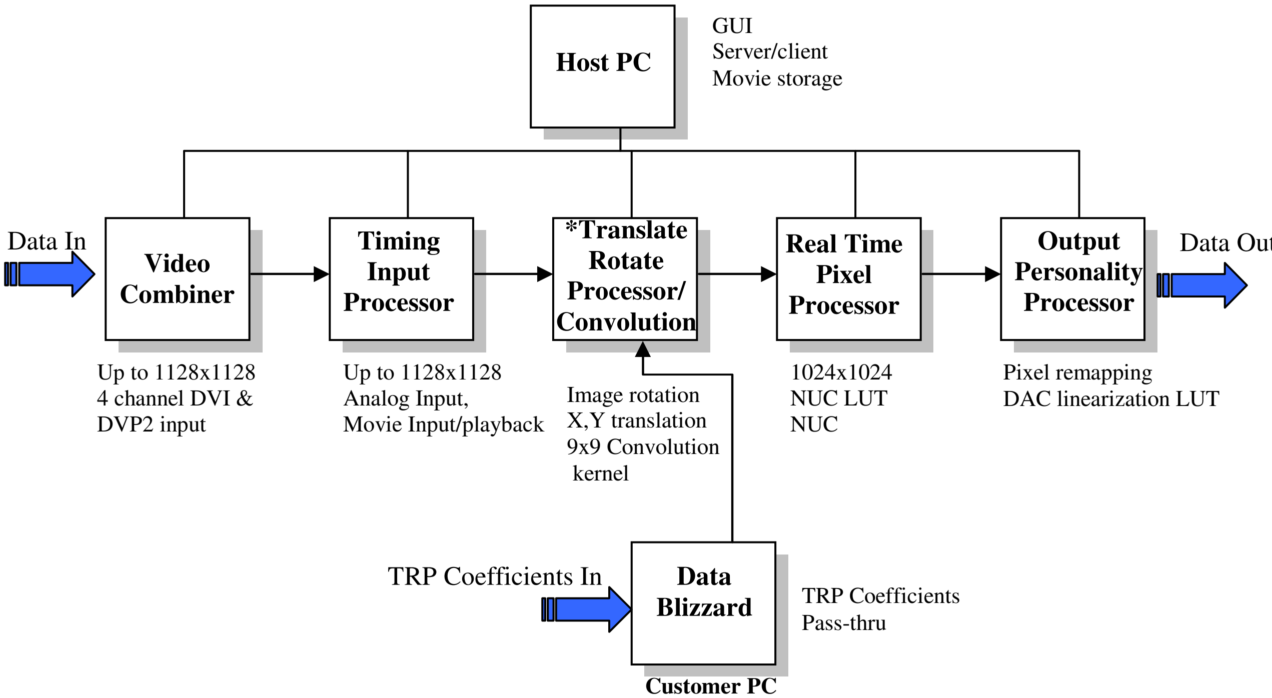


Figure 2; Block diagram of the Mirage XL Command & Control Electronics (C&CE).

2.1 User Interface

Mirage XL is driven via a Graphical User Interface (GUI). All system configuration, status, and process monitoring functions are relayed to the user through the GUI. The server/client architecture of the C&CE allows the system to be networked so that the GUI can be enabled on any remote computer that is networked in to the C&CE.

Figure 2.1; Mirage XL Graphical User Interface

2.2. 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

Exceptionally high operability arrays were yielded from the fist Mirage XL emitter lot. LFRA-010, similar to the packaged array shown in figure 3.1a, was the first deliverable candidate to be packaged and tested. It's operability proved to be >99.9%. Additional arrays from this lot are in integration and test.

The next emitter lot, with 15 deliverable candidates, is due to complete processing in July. A third lot, just starting process, will provide another 15 arrays near the end of the year. Future emitter production is supported by a large inventory of silicon Readin Integrated Circuit (RIIC) wafers. This full pipeline of emitter and RIIC material ensures a steady capability to ship Mirage XL systems over the long term.

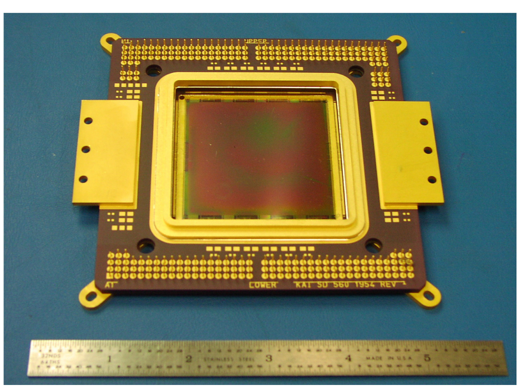


Figure 3.1a, A packaged Mirage XL emitter array

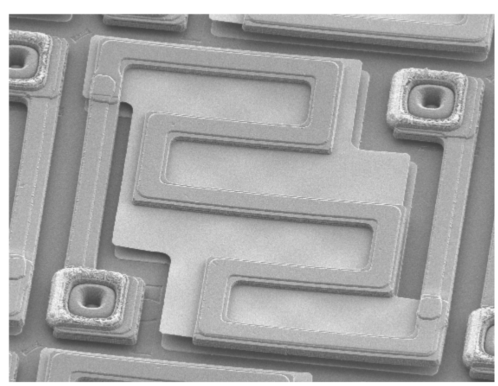


figure 3.1b A SEM of a single emitter pixel

3.2 Emitter Operability

Great emphasis has been placed on operability as the first Mirage XL emitter lot was processed. The large physical size of the array (2"x2") made defects a clear risk. In fact, the first array tested, LFRA-010, showed superb operability as seen in figure 3.2. The specification allows for 10,486 (1%) dead pixels. LFRA-010 has only 770. The photo in figure 3.2 shows that the few inoperable pixels are randomly distributed across the array.

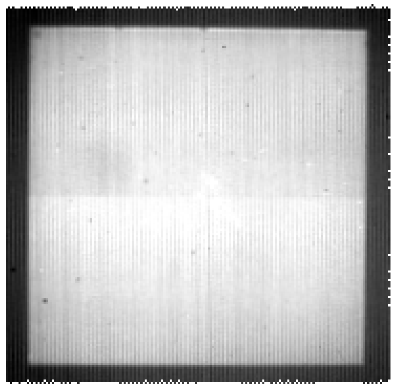


Figure 3.2; LFRA-010 driven to 32,000 counts showing exceptional pixel operability

The other key operability requirements are dead rows & columns and cluster defects. LFRA-010 has no dead rows or columns. The largest clusters are well within specification. The specification requires that no cluster in the center 512x512 of the array be larger than 36 pixels. LFRA-010 has one cluster and, at 20 pixels, is well within the spec.

3.3 Emitter Max Apparent Temperature

Maximum Apparent Temperature was measured on several arrays as part of emitter validation and system acceptance test. The arrays consistently meet the requirement of 700K as shown below.

Array	Measured Temp
• **LFRA-010**	**704K**
• **LFRA-016**	**730K**
• **LFRA-021**	**746K**
• **LFRA-024**	**>710K**

The 746K apparent temperature measured on emitter array LFRA-021 was with the entire array powered at 60,000 counts. At that drive level the array current draw was 135 Amps.

3.4 Emitter Uniformity

LFRA-010 had its steady state radiant output measured for uniformity. The entire array was driven at 32,000 counts (half drive) and the output was measured. The nonuniformity was measured to be 4.5% which is well within the <10% requirement.

3.5 Emitter Spectral Output

The spectral output of LFRA-021 was measured using a Bomem spectral radiometer. The Bomem collected data from the array at near background (300K) and near maximum drive (725K). Calibration data were acquired using an extended source blackbody at the same temperatures as the emitter array. The spectral results, shown in figures 3.5 a and b, indicate that the array acts as a graybody with no features in its spectral profile.

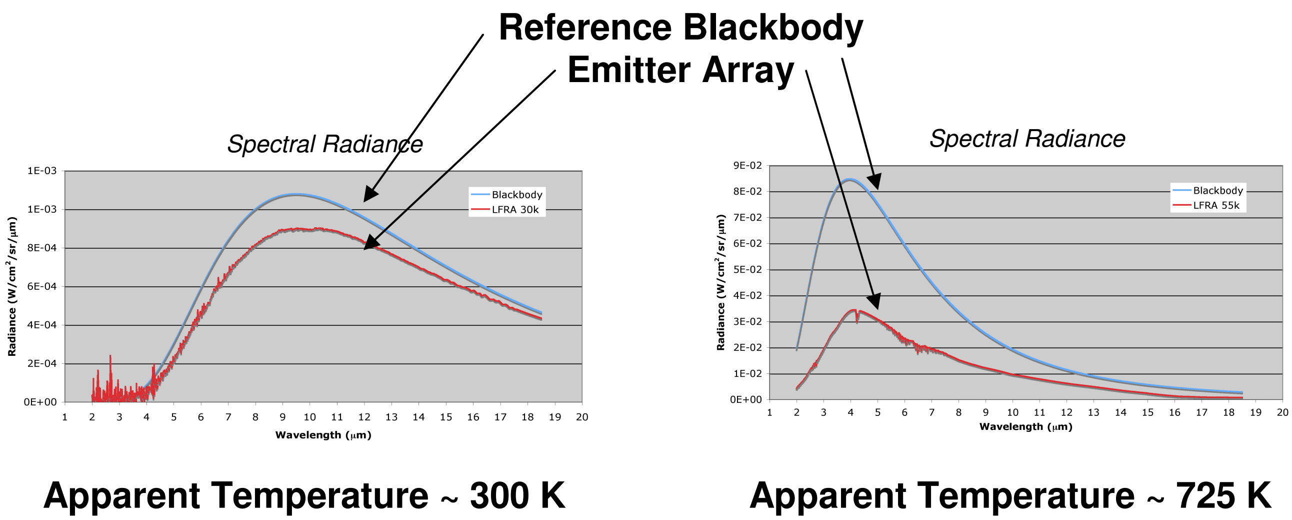


Figure 3.5a Spectral Response at 300K

Figure 3.5b Spectral Response at 725K

3.6 Emitter Rise Time

Rise time between background and 700K for LFRA-010 was measured to be 8.4 ms. Fall time was 5.4 ms. In addition, measurements were made at ¾ and ½ drive as shown in figure 3.6

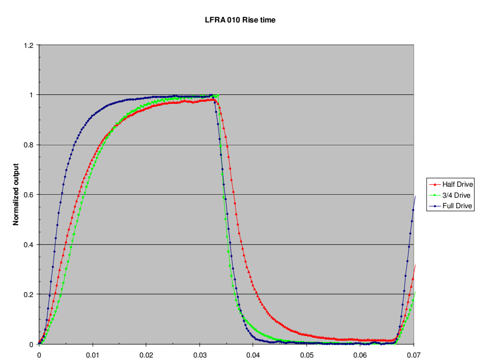
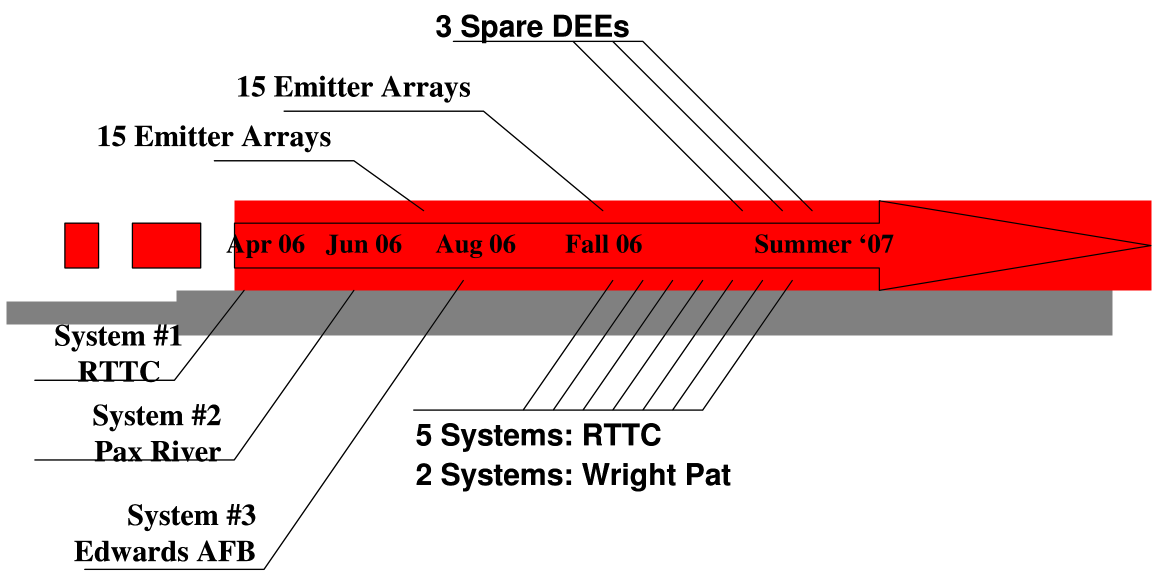


Figure 3.6; Pixel rise & fall times at 100%, 75% and 50% drive

New emitters, with shorter leg length, are being processed at RTI. These arrays will provide 5ms rise time and maintain the 700K maximum apparent temperature.

3. Summary
Mirage XL is in Production

Mirage XL System #1 was shipped in early April and #2 is being readied for a June acceptance test. Components for eight additional Mirage XL systems are in stock at SBIR. SBIR has organized the production build of Mirage XL for a system delivery every six weeks. The current demand for ten systems and three spare DEEs will be satisfied by mid 2007.



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 meet the stringent requirements of the IRSP community.