Title: Small Projector Array Display System

Members: Nicholas Futch, Ryan Gallo, Chris Rowe, Gilbert Duverglas

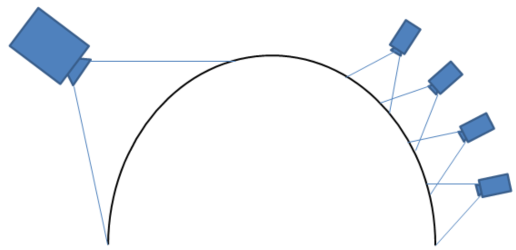
Sponsors: Q4 Services LLC., Martyn Rolls

Project Narrative:

Today's flight simulators have benefited greatly from recent technological advances. High resolution projectors have brought bright, high quality images to military flight simluators. New display technologies such as the collimated and dome display screens have allowed for a depth and realism previously never seen from a video image. However, the combination of these technologies has brought about new issues in the simulator world.

Simulators can come with any number of projector channels, some common configurations being 3, 5, 7, and 10 channel systems. Single input projectors are limited in picture quality, by the ability of the projector to spread these millions of pixels across a screen. Even the high resolution projectors we see today are limited by this lens deficiency. Slight changes in the geometry and light output across the viewing area have proven to cause significant problems for many simulator companies. The collimated and dome display units only stand to intensify this deficiency. Both display systems utilize curved and spherical display systems and therefore warp our original image. This distorts our pixels and greatly decreases the light intensity at the edges of our image. This requires the need for warping hardware, software or a combination of the two. This also requires the man hours needed to warp and align the picture once installed in the system. The warping and distorting of the image will essentially cause a "loss" of pixels, and therefore picture quality.

To combat this degradation in image quality we propose to simply use more projectors. As more projectors are introduced to the system their required coverage of the screen is decreased. Geometry tells us that if we decrease the area of any one spot of a spherical surface to an infinitesimal level, we eventually are left with a planar surface. Therefore if we introduce more projectors we can approach a more planar surface and limit the amount of warping and distorting of pixels.



Advantage of using more projectors

By utilizing the emerging Pico Projector technology we can create an array of small, power efficient, and cost-effective projectors driven from a single computer source to implement this idea.

An array of projectors may sound costly considering most quality projectors can cost thousands of dollars, however the emerging pico projector market offers a suitable alternative to their larger counterparts. Coupling a pico-projector array to the back-projection-screen (BPS) of a WIDE display is highly efficient in terms of physical space and display performance. The individual projectors of the array will shine directly onto the section of BPS in front of them, which means there will be no cross-reflections. This design also allows baffles to be placed between individual projectors to further prevent secondary reflections and stray light from washing out native image contrast. The number of pico-projectors needed to fill up a field-of-view is more than needed using traditional projectors; however the pico-projectors will be far less expensive on a unit basis, at a cost of only a few hundred dollars each. They will also be essentially maintenance-free with excellent color and brightness uniformity over their live cycle, particularly when controlled by an auto-alignment system. These projectors have low power and heat output and will not require any special cooling systems.

Specifications:

Pico Projectors

The classification of pico-projectors is in fact somewhat arbitrary. They are based on physical dimensions, weight and price; however, they are all exceptionally small relative to traditional projectors. Actual size is not particularly critical. It is the unique features of the small projectors that offer the potential for innovation and cost-performance-functionality benefits, i.e., the black/dark level and collimating aspects of laser diodes that provide the promising benefits.

LED and laser diode life is comparable since both types are in the tens of thousands of hours. Laser diodes do draw more power than LED's, but both are very low in power consumption when comparing to traditional projector standards. There may be some decrease in brightness as LED's and laser diodes age, but the color will remain highly stable over time. Laser diode color performance is actually superior to LED, and laser diode projectors will also be even easier to color match when placed in arrays. There is still some remaining concern about laser "speckle" as an unwanted image artifact.

In addition to superior black/dark level and color performance, laser diode light is also fully collimated. This means it does not need to be focused and lends itself far more readily to image forming on irregular (non-flat) projection screens or other surfaces. The etendue ("spread") of laser light is close to zero, which means that lasers can be ganged together to increase the brightness level of a single projector. Conversely, the etendue of LED light is high and it is therefore extremely difficult (optically complicated and cost-prohibitive) to produce a brighter projector by ganging LED light sources.

Pico-projector Specifications:

- 4 to 6 projectors
- Supported input of mini-HDMI, HDMI, or DVI
- LED or Laser LED optical engine prefered
- 100-300 lumen brightness
- Contrast ratio of at least 2000:1
- Power input: AC 120/230 V (50/60 Hz)

Graphics Post Processing

Many of the video processor technologies in today's simulation industry are based around using large projectors and are only capable of integrating a couple of these projectors from a single interface. The problem with this approach is that when these images are projected onto spherical and cylindrical screens, which are how most modern simulators are developed, millions of pixels are either lost or distorted due to the complex methods of image warping that is currently available in today's industry. The simplistic solution to this approach would be to use more, small projectors to create these systems that will decrease the amount of "waste" and reduce the amount image warping included in these systems. However, this leads to another problem of finding post processing technologies that are capable of handling a large number of projectors from a single point of interface. If multiple interfaces are needed to integrate all of the projectors into a single image, it defeats the purpose of lowering the amount of image warping as this becomes equally complex as the current industry methods.

For our project, we will need a video processor that is capable of running as many pico projectors as possible, for our project we will use 6, from a single user interface. We believe that there may be a software or hardware solution that can make this possible from a single interface, and could potentially be applied in the future to integrate even more projectors from a single point. The ability of all components of the simulator system to be controlled from a single point will allow ease of installation, use, and maintenance as conventional methods may allow for certain components that are not maintained from a single point to restore to factory defaults during power failures or other maintenance routines. Also we need a video processor that is capable of taking a single signal from the computer and splitting it multiple times amongst all of the projectors without any loss in signal amplitude, phase, or frequency as all could be detrimental to the performance of the system. A single projector that does not operate at the same quality and capacity as the other projectors in the array will cause a completely distorted image when all of the projectors images are warped together. Overall the collimated array of pico projectors will reduce the amount of pixels lost when the image is displayed, reduce the amount of image warping necessary to implement the system, which overall increases the efficiency and image quality of the simulator.

Graphics Post Processing Specifications:

Support for multiple monitors (minimum of 6 outputs)
Minimal loss of image when splitting (10% or less loss per channel)

Auto Alignment Systems

Auto alignment is the process by which the image from the projector is fitted perfectly onto the screen. For our project we will be using 6 pico projectors in an array to project the image of the flight simulation program on a collimated mirror display. There are three new auto alignment processes that have been identified that will be investigated to determine which one is the optimum solution for the project. The three auto-alignment processes are the "Warpalizer" software by Univisual, the Sol GPU by Mersive, and a new alignment system announced by 3DPerception at ITEC 2012.

Univisual's Warpalizer supports all types of simulators and trainers that include a seamless multi-projector based projection system, projecting onto flat, cylindrical or spherical screens. Being able to align in a multitude of different screen variations, especially spherical, is ideal as we would want to display our image on a collimated mirror display. The Warpalizer also supports any number of channels in 1, 2 or 3 rows configuration, in addition to the polar cap. The Warpalizer is the only product in the market that supports overlap generation and warp and blend of up to 6 channels from 1 single graphic card. Warpalizer should allow the implementation of 6 pico projectors then. Further investigation is needed.

The Warpalizer has already been used in various simulation and video game applications. Some notable applications include the Presagis Vega Prime 5.0, a 360 degree display with treadmill and gun mounted motion detection, and a cylindrical screen projected with 6 FullHD projectors at the Digital Art Center in Sweden. Vega Prime 5.0 is used in many real time 3D simulations. Battlefield 3, one of the most processor-intensive video games available, was used in the 360 degree display to demonstrate the Warpalizer. In the demonstration a single power full PC was connected with six super short throw projectors.

Mersive's Sol GPU software is designed to run on a Windows 7 PC. It provides a fully integrated software-only warp/blend solution in which no other hardware is needed. The Sol GPU supports multi-projector screen which include flat and cylindrical displays. Some of the key features of the Sol GPU software include:

- Ultra high, beyond HD resolution
- Sub-Pixel accuracy
- Compatibility with flat and curved display surfaces
- Projectors can be in front of or behind screen
- No external warp/blend hardware needed
- Continuous warp/blend with no latency

Univisual's Warpalizer and Mersive's Sol GPU will be extensively tested to determine which auto-alignment software is the most compatible to used with the collimated mirror display.

Specifications for Auto Alignment:

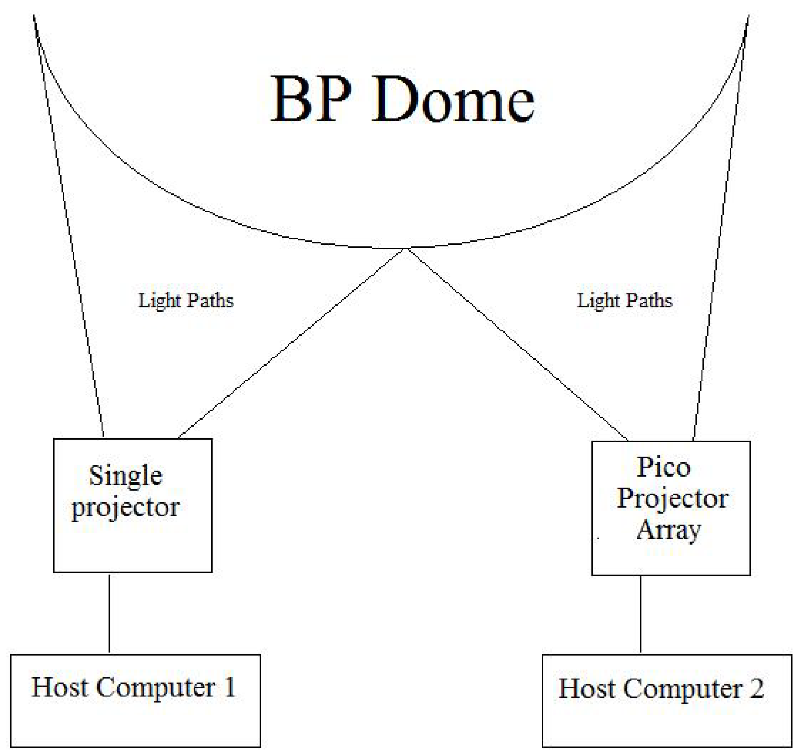
Must be able to configure at minimum a 6 channel system
Ability to configure both row and column formations

Additional Identified Design Considerations

- Frame to hold Pico Projector array
- Power considerations for Pico Projector array
- Power safety features to prevent damage to the Pico Projector array in the event of power failure
- Possible remote control of Projectors (This is dependent upon the projector as not all projectors offer remote control abilities)

Design Block Diagram

Our design we plan to present will show a comparison between the single projector and Pico Projector Array systems. We will use a high resolution projector, similar to those used on actual simulators, to show the single projector system on one half of the BP screen. We will also have our Pico Projector Array system running simultaneously on the other half of the screen.



Financing

This project will be funded by Q4 Services LLC. Q4 specializes in the production of collimated display systems for flight simulators, their control systems, and CRT display system repairs. Our sponsor and contacts there will be Martyn Rolls, Vice President of Business Development, and Tiffany German, Project Manager. All parts will be either purchased or donated by Q4. These materials include but are not limited to:

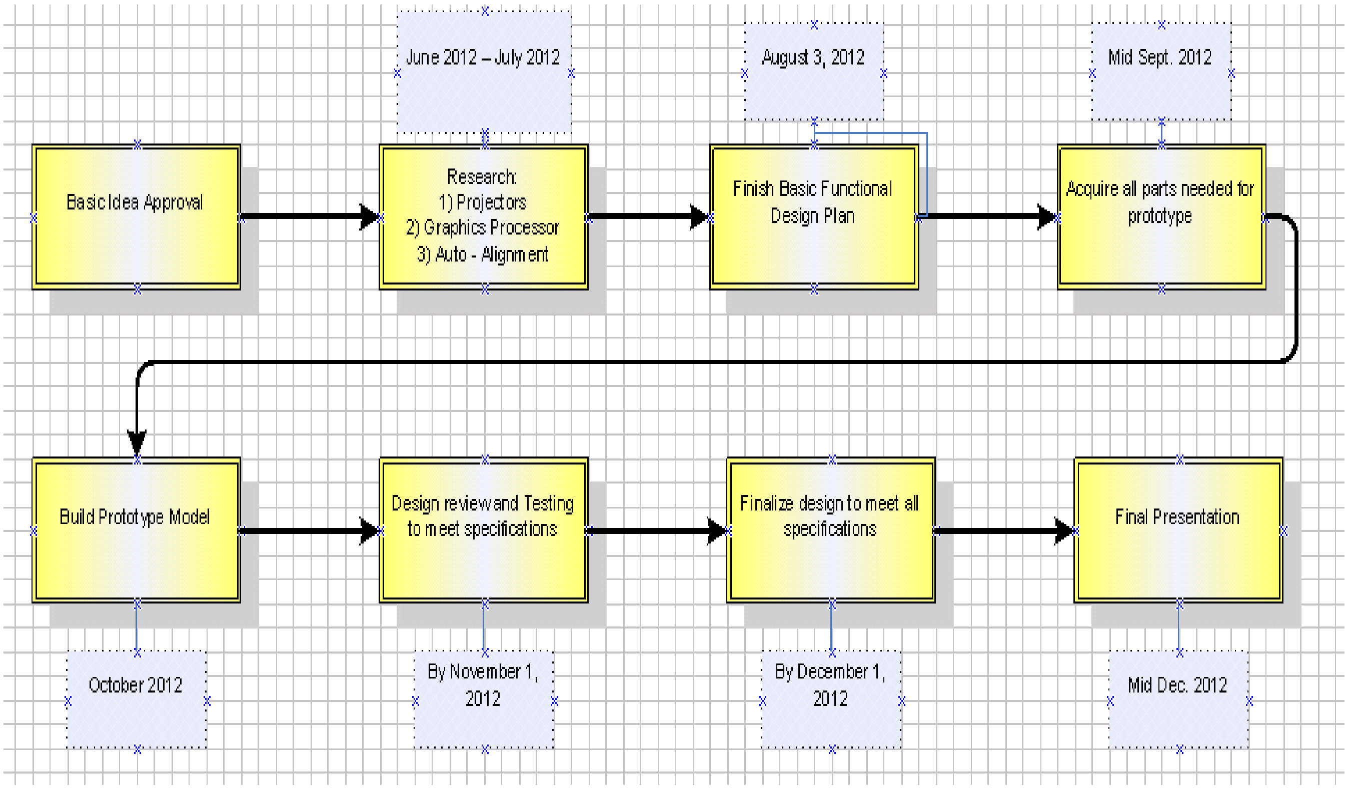
Item	Cost per Unit	Amount	Total Cost
Projectors	$500	4	$1000
Computer Host System	$2500	1	$2500
Auto Alignment	Donated	1	Donated
Array Frame	Donated	1	Donated
BP Dome	Donated	1	Donated
Miscellaneous Parts	N/A	N/A	$600
TOTAL			**$2200-4200**

Group Member Responsibilities

Each member of our group will have a specific element of this project to accomplish. This will include researching, testing, and ultimately (with some group input) make a final decision on each aspect of this project. Since Nicholas Futch is a current employee of Q4 Services and has the greatest knowledge of simulator design and implementation, he will assume to role of project manager and assist in all aspects of the project. While all members will play a crucial role in the research, testing, and final design of this project we have chosen to divide the elements to each member as follows:

Nicholas Futch – Project Manager/Software Development
Ryan Gallo – Graphics Post Processing
Chris Rowe – Pico Projectors
Gilbert Duverglas – Auto Alignment

Project Milestones:



Summer 2012

Decide on pico projector:	June 11, 2012
Decide on video post-processor technology (software/hardware):	July 2, 2012
Decide on auto-alignment software:	July 16, 2012
Begin final documentation:	July 18, 2012
Finish final documentation:	August 3, 2012

Fall 2012

Order all parts needed	August 15, 2012
Begin Prototype build (pending parts arrivals)	August 15, 2012 and later

Acquire all parts (Planning for any lead time)	Mid September 2012
Completed Prototype Build	October 15 2012
Completed Testing	November 15 2012
Sponsor Review	November 20 2012
Presentation:	December 5-11, 2012