

Using the GPU to Create a Seamless Display from Multiple Projectors

Steve Nash, Nvidia

Paul Green, Scalable Displays



Agenda



- **The Problem -- what do we mean by seamless?**
- **The way it's been done up until now**
- **Our solution**
- **Scalable Display's implementation**

The Problem



- Increases in pixel density and total pixels have not kept pace with increases in CPU and GPU power
- Different solutions for adding more pixels
 - LCDs: obtrusive bezels in the way



- Nearly bezel-less

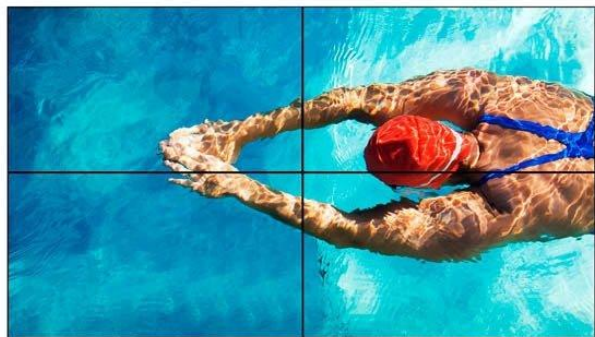
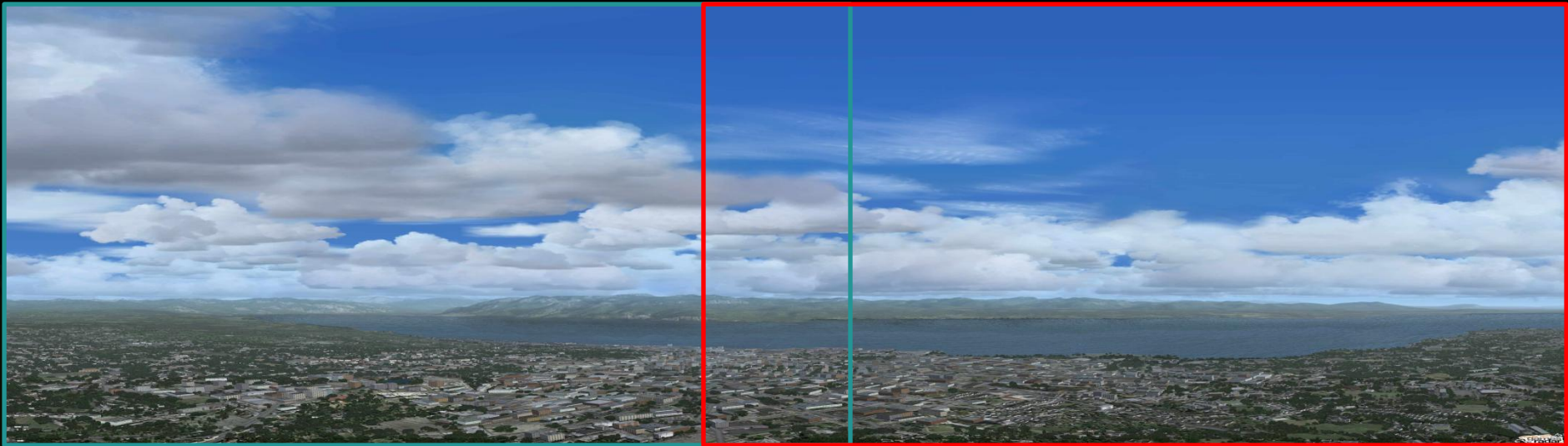


Image: © NEC Display Solutions Europe GmbH, Munich

The Problem (cont'd)



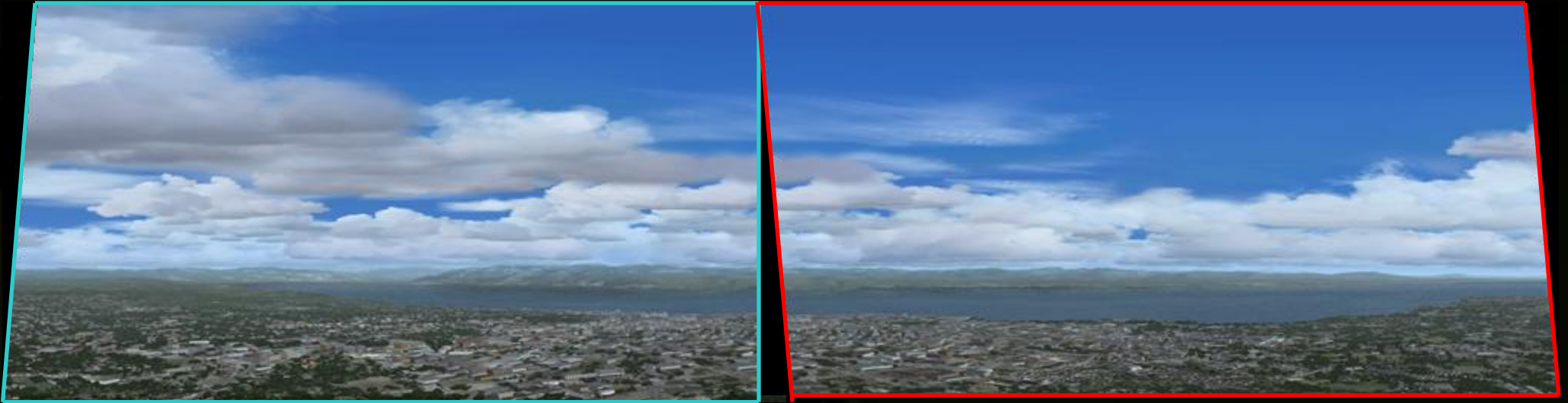
- **Projectors: overlap the edges to hide the seam**



The Problem (cont'd)



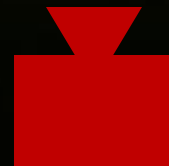
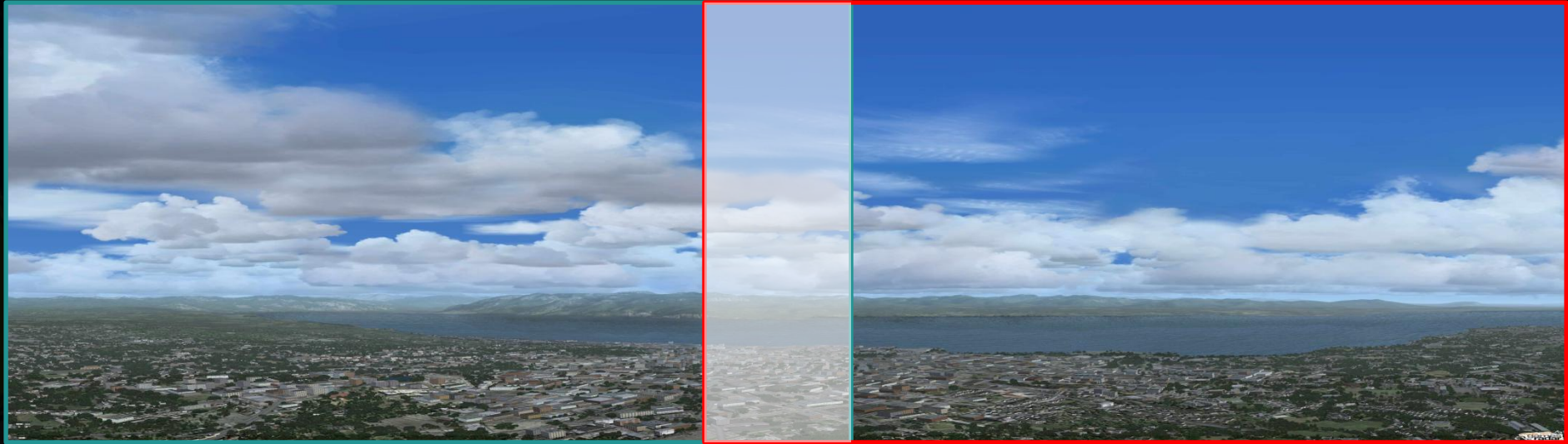
- **Projectors: optics (and screens) are never perfect**



The Problem (cont'd)



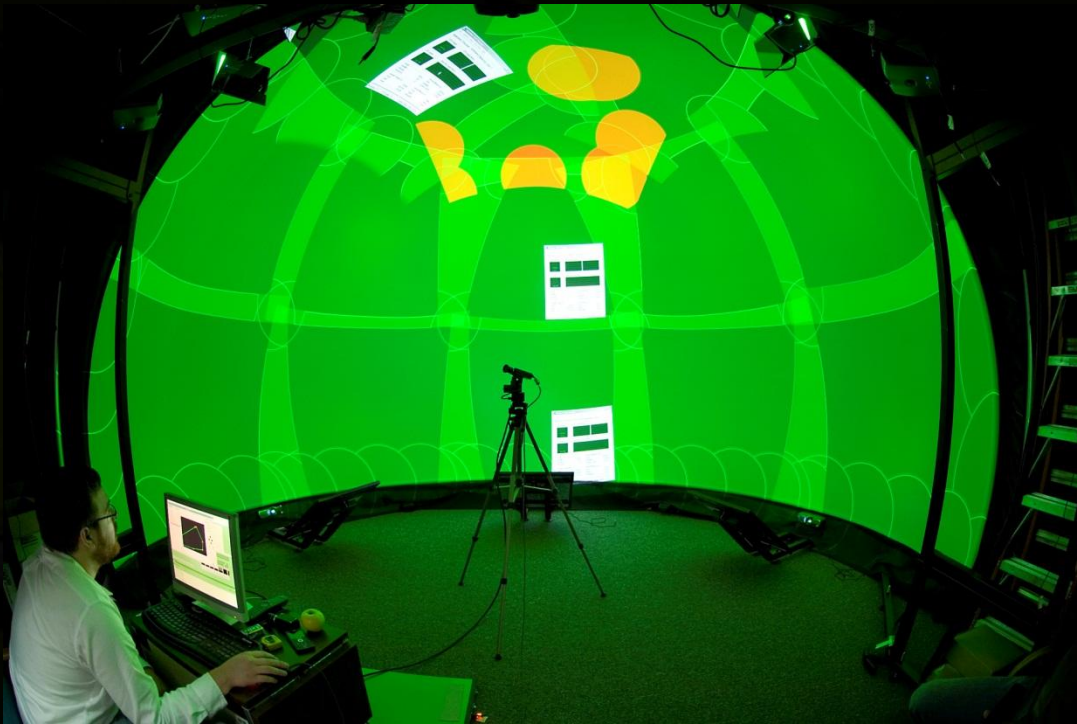
- Just creating the overlap makes a hot spot since the overlap region gets twice the light



The Problem (cont'd)



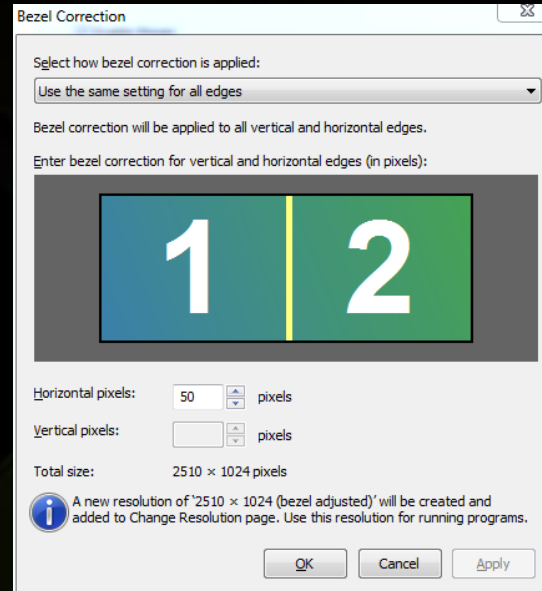
- Projectors: how to project on domes and curved screens?



Working with Multiple Projectors



- Current Nvidia SLI Mosaic product lets you specify overlap



- To be truly seamless, need to account for geometry and brightness differences between projectors

The Solution



- **Warp & Blend**
 - **Warp = Geometry Corrections**
 - **Blend = Intensity adjustments**
- **Can do one or the other, or both**

The way it's been done up until now



- **Hardware appliance for warp and intensity adjustment**
 - Expensive
 - Extra performance delay tax on the display pipeline
 - Additional complexity
- **Software warp and intensity adjustment**
 - Applications need to be written to manage
 - There has not been an easy way to implement this for any application, until now...



NVIDIA's Solution



- **We can do this on the GPU!**
 - **GPUs are fast, and already have the pixel information**
 - **Perform the transformation in the display pipeline before the pixels get scanned out**
 - **By doing this on the GPU, we have more flexibility: high quality filtering, integration with SLI Mosaic, etc.**

NVIDIA's Solution



- Works on Quadro 5000, 6000, and Quadro Plex 7000
- Use it with G-sync to get synchronization between displays



How's it Done: Work Flow



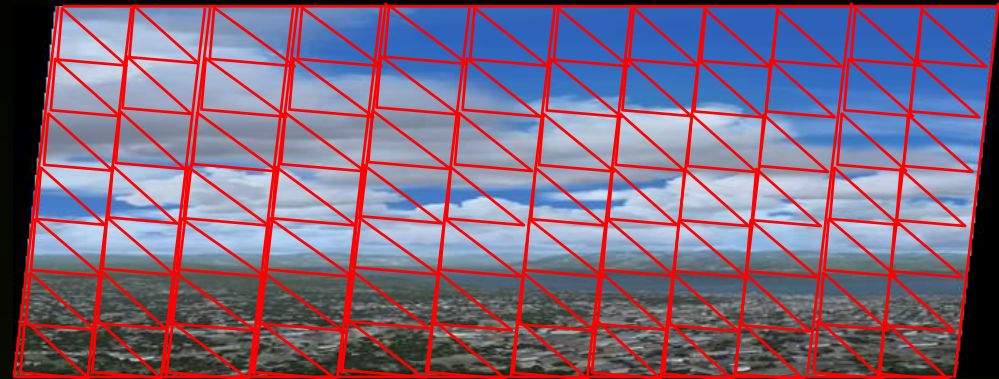
Take picture of
calibration pattern



Create warping mesh
based on picture of
calibration pattern
relative to true image



Typical Warping
Mesh contains 1-10K
vertices



How's it Done: NVAPI



- NVAPI is Nvidia's programmatic interface to configure and control the GPUs. <http://developer.nvidia.com/nvapi>
- New interfaces are added in the 275+ NDA version to allow warping and intensity adjustment before the final scanout
- Currently works with single screen, multiple screen capability coming with R285 driver (mid September)

How's it Done: Warping

1. Initialize NVAPI
 2. Get GPU Handle
 3. Get Display ID
 4. Define Warping Mesh
 1. Use `NvAPI_GPU_GetScanoutConfiguration()` to get current desktop
 2. Each vertex has:
 1. x,y: 2D Vertex coordinates
 2. u,v: 2D Texture coordinates
 3. r,q: perspective correction
- } 6 floats per vertex
5. Call `NvAPI_GPU_SetScanoutWarping(NvU32 displayId, NV_SCANOUT_WARPING_DATA* scanoutWarpingData, int* piMaxNumVertices, int* pbSticky);`

How's it done: Intensity Adjustment



1. Initialize NVAPI
2. Get GPU Handle
3. Get Display ID
4. Define Intensity Map: GL_RGB value for each pixel
5. Call `NvAPI_GPU_SetScanoutIntensity(`
 NvU32 displayId,
 NV_SCANOUT_INTENSITY_DATA* scanoutIntensityData,
 int *pbSticky);

Scalable Display Technologies

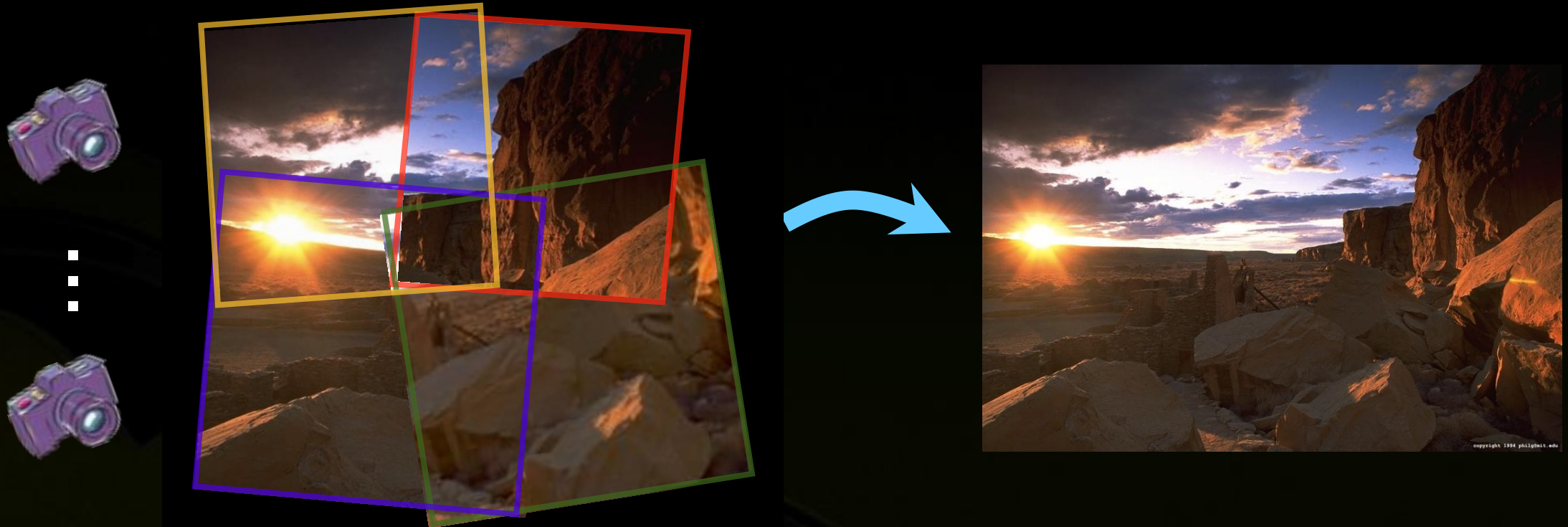


Scalable Display Technologies



- **Leading provider of auto-calibration software for seamless multiple-projectors displays**
- **Founded in 2004, based on Ph.D. work of Rajeev Surati at MIT**
- **Over 100 Customers**
 - **Command and Control**
 - **Business Collaboration**
 - **Visualization**
 - **Simulation and Training**
 - **Pro A/V**
 - **Projector OEMs: 70,000+ licenses**

Core Auto-Calibration Technology (IP)



- Camera feedback to automatically warp and blend many projectors into one seamless display
- Patented by MIT and licensed exclusively to Scalable

Benefits of NVIDIA W&B API



- **Scalable Display Manager** (mil-sim, cmd&ctrl)
 - No longer need SDK integration
 - No need for warping box hardware (\$\$\$)
 - Application Independence
 - Quadro support for Gen-lock



Fewer requirements, barriers and restrictions means **broader market** and **stronger growth**

Benefits of NVIDIA W&B API



- **Scalable Desktop** (warped Win7 Desktop)
 - Full integration with Windows (login screen, ctr+alt+del)
 - Eliminates mouse pointer issues
 - Performance benefit
 - Expands potential outputs up to 24



100% integrated Windows solution

Case Studies



- **100 MPixel Space Command and Control**
- **Navy Combat System Display**
- **20 MPixel Touch Display Wall**
- **48 MPixel F-16 Simulator**
- **Commercial Collaboration Systems**
 - Fortune 100 Collaboration room
 - Oil and Gas viz room
 - Classroom Info wall and whiteboard

AFRL - 100 MPixel Space Command System

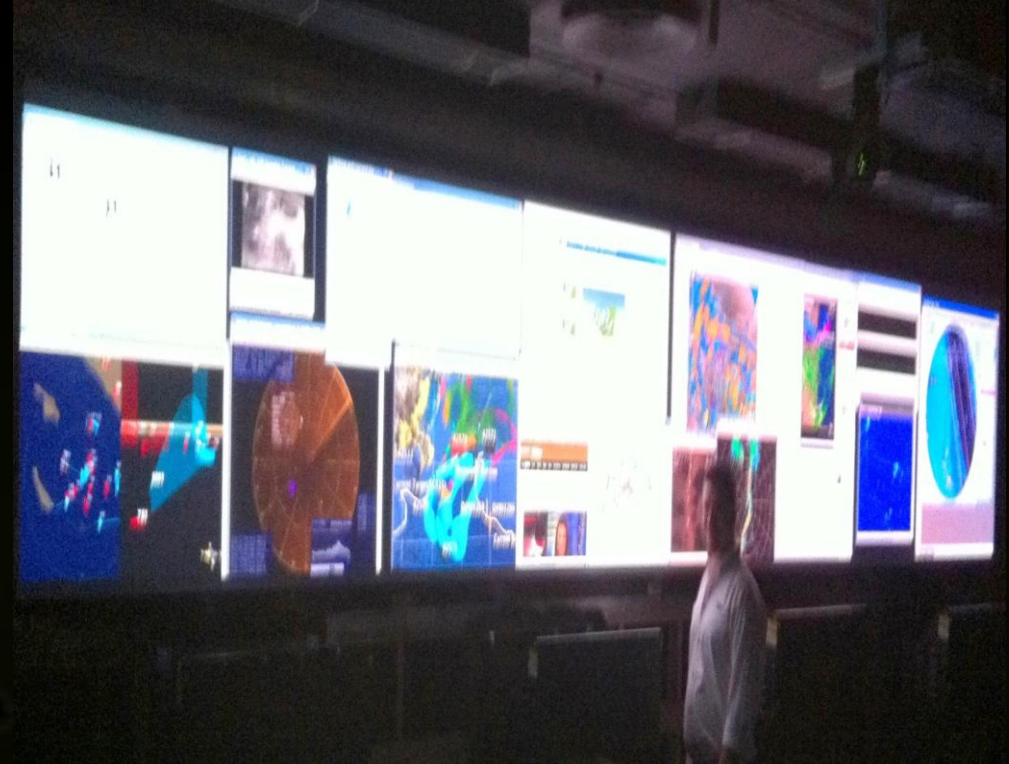


- 25 Computers with Quadro cards running 50 projectors
- Custom SDK integration that can run a single application
- Application independence with NVIDIA W&B API

Navy Combat System Display



- **Aegis Combat System Display**
- **Delivered 22 Cruisers, 62 Destroyers to follow**
- **US, Japan, Spain, Norway, Korea, Australia**
- **Required Gen-Lock and SDK integration**



MIT Lincoln Labs - 20 MPixel touch wall



- 12 Projector system using dual Quadroplexes
- Will be first install to use NVIDIA W&B API
- Prototype Design for Virtual Shopping Aisle System

AFRL - 48 MPixel F-16 Simulator



- **“Low cost” simulator (\$500K)**
 - Immersive Display Solutions (IDSi)
- **Application independence is essential to make “turn key”**
- **No warping box hardware keeps costs down**
- **Multi-Quadroplex system**
 - SLI Mosaic
 - Gen-Lock



Commercial Collaboration Systems – Edge Blending Goes Mainstream



Summary

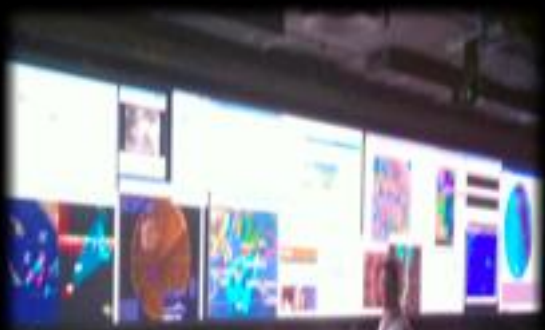


- **SDT is leader in auto-calibration**
- **NVIDIA Warp and Blend API makes our technology application independent**
- **Fewer requirements, barriers and restrictions means broader market**
- **Full windows integration**
- **Loads and loads of examples enabled or enhanced by new NVIDIA W&B API**

Further Information



- QuadroSVS@nvidia.com
- sales@scalabledisplay.com



Present Big Ideas in a Big Way



Thanks!

