Applying Virtual Reality, and Augmented Reality to the Lifecycle Phases of Complex Products

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Lockheed Martin Rotary and Mission Systems (RMS)

- Designs, manufactures, services and supports
  - Military and Civil Helicopters
  - Naval and Radar Systems
  - Provides World-Class Systems Integration Training and Logistics

- Lockheed Martin Moorestown, New Jersey
  - Naval and Radar Systems
  - World-class Systems Integrator
Ship Integration & Test
- 3D Space Arrangements for Naval Ships
- Topside Design for Naval and Ground Based Systems
Surface Navy Innovation Center (SNIC)
A research, development and demonstration lab dedicated to innovating affordable solutions across the maritime domain.

Tenets:

*Put the Warfighter First* – SNIC enables innovative concept exploration, rapid prototyping, and risk reduction activities for current and emerging Naval capabilities.

*Accelerate Capability to the Warfighter* – SNIC accelerates the push to adapt available technology and capabilities for maritime use.

*Offer Flexible, Modular, Adaptable Solutions* – SNIC utilizes an agile methodology and enabling architecture to respond quickly to new requirements and technologies.

*Set the Standard for Collaboration* – SNIC establishes an open community space for government, industry, and academia.

Technical Domain Focus:

- Training
- Cybersecurity/IA
- Big Data Analytics
- Models and Simulation
- Additive Manufacturing
- Mobile/Remote Workforce
- Advanced HMI/GUI Displays
  - Advanced Display Technologies
  - Augmented / Virtual Reality
  - Situational Awareness
  - Lifecycle Engineering
  - Architecture/Design
  - Cloud Computing
  - Mission Planning

Driving Innovation, Affordability, and Capability

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Lifecycle Phases of a Product

- Engineering and Deployment of Complex Products
  - Naval Combat Ship
  - Land Based Facilities

- Lifecycle Phases of Complex Products
  - Conceptual Design
  - Production
  - Deployment
  - Upgrades

- For which phases of the Lifecycle process are Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) applicable?
COMITS Software Suite

- COMITS (OpenGL based)
  - (Computerized Object Manipulation In Three-dimensional Space)

- COMITS-Ray
  - Physics Based Renderer (PBR)
  - Real-time Interaction
  - Photorealistic 360 VR Panorama images
  - High Quality Video Production

- COMITS-Ray Cloud
  - Photorealistic streaming on the company intranet

- COMITS-VR (Virtual Reality)
  - Real-time OpenGL VR App
  - OpenGL 4.5 / DesignWorks® / VRWorks®

- COMITS-AR (Augmented and Mixed Reality)
  - Direct3D®
  - NVIDIA® GPU rendering via Holographic remoting
Bidirectional Data Exchange with CATIA® and AutoCAD®

AutoCAD

DWG Translator

NavisWorks Translator

Ship Constructor

COMITS

Visual Basic Macros

$obj

Rhino

Creo

CATIA

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• Accomplished in 2012 via the NVIDIA Iray® SDK
• GTC 2017 (S7351) Applying GPU Technology to Combat System Integration and Maintenance
COMITS-Ray Cloud Using AI

- Interactive Streaming in a Chrome® Web Browser
  - F35 model
  - A ship model

9.5 million triangles
COMITS-Ray with AI

- AI Denoiser: Enhance Rendering Quality, SIGGRAPH 2017 talk by Martin-Karl Lefrançois
Lifecycle Phases

■ Conceptual Design
  ● Product fully represented is 3D Computer Aided Design (CAD) system
  ● Bring 3D CAD data into a VR system
    □ Can the inhabitants of the complex product operate and maintain it?
      ○ Ergonomics
        – Can personnel comfortably
        – See what they need to?
        – Reach what they need to?
        – Navigate to where they need to?
      ○ Collision resolution (multiple CAD systems)
      ○ Many, many, many more use cases
  ● Measurements
  ● Allow multiple local or remote users to collaborate
  ● Allow for model manipulations with changes send back to CAD system
COMITS-VR

- Running on NVIDIA® P6000 with HTC Vive®
  - 9.6 million triangles
  - 189 – 213 Frames Per Second (FPS) in standalone mode
  - 90 FPS sustained with Vive® attached
  - Plans for further optimizations and visual enhancements
COMITS-VR

- 360 Panoramas generated from COMITS-Ray
- Viewable in Vive®, or Oculus®, or on smart phones
Lifecycle Phases

■ Production
  ● Augmented Reality
    □ Assembly Line Guidance
    □ Extend the information for the shop floor workers
    □ Drawings and diagrams
    □ Videos of assembly sequence

  ● Virtual Reality
    □ Equipment Installation Planning

  ● Mixed Reality
    □ Visual Cues mixed in with the real world
    □ These visual cues help guide the operator through a series of assembly or maintenance steps

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Lifecycle Phases

- **Deployment**
  - Product Familiarization
  - Operations Training
  - Maintenance Training
Virtual Reality

- Product Familiarization
Virtual Reality

- Operations
  - Virtual Sandbox
  - Multi-User VR
Augmented Reality

Maintenance
Product Modernization

- Product Upgrades
  - Need a representation for the “As-Built” model
  - Two choices
    - Go to the ship or facility
      - Mixed Reality
    - Bring the ship or facility back
      - Laser Scans
COMITS-AR

- Microsoft HoloLens®
  - Mixed Reality
  - Holographic display
  - Voice recognition
  - Spatial sound
  - Gesture recognition
  - Spatial mapping
  - Untethered
  - 2-3 hour battery life
Mixed Reality

- Fitting holographic cabinet through real door
Microsoft HoloLens®
- Can display models up to ~80,000 polygons while running on 60 FPS
- Larger models lag in the display

How do we overcome this limitation?

Image generation
- Constant image size per frame
- One image required for left and right eye per frame
- 720p or 1268x720 per eye

Use GPU to generate left and right eye images
- Send these two images to HoloLens® device via Wi-Fi
GPU-AR

- Install the Microsoft® Remoting Player app
- Establishes a connection with the HoloLens and server with one or more GPUs
- The connection is made using standard Wi-Fi
- Receives a data stream with input from a HoloLens
- Renders content in a virtual holographic view
- Streams content frames back to the HoloLens in real-time
- This two-way connection allows the HoloLens to send sensory and control information to the server
  - Gestures
  - Voice commands
  - Spatial mapping
- Server processes this information, updates the state of the application, and sends images and sound back to the HoloLens® in a constant stream
- 64 bit application vs 32 bit
  - More accuracy

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GPU-AR
COMITS (OpenGL Based)

- Real-time Point-Cloud Rendering (utilizing P6000)
- 120 million points with sustained rendering at 60 FPS
COMITS (OpenGL Based)

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- Real-time Point-Cloud Rendering (utilizing P6000)
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COMITS (OpenGL Based)

- Real-time Point-Cloud Rendering (utilizing P6000)
- A billion points rendered
COMITS (OpenGL Based)

- Real-time Point-Cloud Rendering (utilizing P6000)
- GPU memory paging
COMITS (OpenGL Based)

- Future plans to view these point clouds in VR and AR
COMITS (OpenGL Based)

- Future plans to view these point clouds in VR and AR
- Overlay with CAD data
We are truly leveraging NVIDIA® technology to the fullest!

Apply VR and AR To Lifecycle Phases
- Conceptual Design
- Production
- Deployment
- Upgrades

Apply VR and AR To
- Catch problems early in Conceptual Design
- Training
- Operations
- Maintenance
- Readiness

Evolving 3D representation of platform

Reduce Lifecycle cost
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- Brady White, VR content creator

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  - John Chaney
  - Martin-Karl Lefrancois
  - Stefan Radig
  - Robert Menzel
  - And many, many others…

- My mentors
  - Dr. Norm Badler, University of Pennsylvania
  - Dr. John Weaver, West Chester University
Links to references

- **(S7351) Applying GPU Technology to Combat System Integration and Maintenance by Rich Rabbitz**
  - **Slides**
  - **Recording**

- **AI Denoiser: Enhance Rendering Quality by Martin-Karl Lefrançois**
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