Massive Model Visualization (MMV) at Boeing

Christopher J Senesac
Associate Technical Fellow
Visualization and Interactive Techniques
The Boeing Company
• **Chris:**
  - Involved in computer graphics since 1990
  - Boeing Associate Tech Fellow for Visualization and Interactive Techniques
  - Specialty - being able to apply technology to real world problems
  - Passion is to simplify complex problems
Visualization is any technique for creating images, diagrams, or animations to communicate a message.

Visualization has been an effective way to communicate both abstract and concrete ideas since the dawn of man.

Visualization is a great Integration/collaboration tool; provides open communication amongst differing functional groups/organizations/cultures/languages.
Product visualization involves visualization software technology for the viewing and manipulation of 3D models, technical drawing and other related documentation of manufactured components and large assemblies of products.
### CAD/CAM in Aerospace

- **APT – Automated Programmable Tools**
  - Computer Applications Group of the Servomechanisms Laboratory at MIT in 1956
  - 1960’s development moved to IIT; 4-5 axis

- **CAD/CAM – Graphical front-end to APT**
  - Patrick J. Hanratty - “Father of CAD/CAM” – GM
  - Boeing – TIGER/Axxyz
  - McDonald Douglas – UniAPT > Unigraphics (Siemens)
  - Lockheed – CADAM > IBM > Dassault
  - Dassault – CATIA

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’64 Mustang - Ford
Paradigm Shift for Visualization – Massive Model Viewer

Deliverable’s

Paper, Velum

2D Plot

2D Drawings

CAM - APT

60’s
Paradigm Shift for Visualization – Massive Model Viewer

Deliverable’s

Paper, Velum

2D Plot

2D Drawings

CAD model

IGES

CAM - APT

CAD/CAM – 3D Wireframe

Surfacing

70’s

60’s

2D Drawings
Paradigm Shift for Visualization – Massive Model Viewer

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Deliverables

Paper, Velum
2D Plot
2D Drawings

CAM - APT

CAD model

IGES

STEP

20's

60's

70's

80's

CAD/CAM – 3D Wireframe
Hidden Line Removal
Primitive Solids

CAD/CAM – Surfacing

CAD model

STEP
Paradigm Shift for Visualization – Massive Model Viewer

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Deliverable's

- 2D Plot
- Paper, Velum
- CAD/CAM – 3D Wireframe
- Hidden Line Removal
- Primitive Solids
- CAD/CAM – Solids Modeling
- 80-90’s
- CAD/CAM – Shaded Wireframe
- Surfacing
- 80’s
- 70’s
- 60’s
- 2D Drawings
- CAD model
- IGES
- STEP

CAM - APT

- 2D Plot
- Paper, Velum
- CAD/CAM – 3D Wireframe
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- Primitive Solids
- CAD/CAM – Solids Modeling
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- 2D Drawings
- CAD model
- IGES
- STEP
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Deliverable’s

- Paper, Velum
  - 2D Plot
  - 2D Drawings

- CAD model
- IGES
- STEP

- 3D PDF

- CAM - APT

- CAD/CAM –
  - 3D Wireframe
  - Surfacing

- CAD/CAM –
  - Shaded Wireframe
  - Hidden Line Removal
  - Primitive Solids

- CAD/CAM –
  - Solids Modeling

- CAM - APT

- CAD/CAM –
  - Model Based Design (MBD)

- 90-00’s

- 80-90’s

- 80’s

- 70’s

- 60’s

- 50’s

- 2D Drawings
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Deliverables

- Paper, Velum
  - 2D Plot
  - 2D Drawings

- CAD model
  - IGES
  - STEP

- CAD/CAM – Solids Modeling
  - Model Based Design (MBD) – 90-00’s

- CAD/CAM – 3D Wireframe
  - Shaded Wireframe
  - Hidden Line Removal
  - Primitive Solids
  - Solids Modeling – 80-90’s

- CAD/CAM – Surfacing
  - 3D PDF

- CAM - APT

- CAM - 3D Wireframe

- 2D Drawings

- 2D Plot

- Deliverable’s

Deliverables

- 2D Drawings

- 2D Plot

- 3D PDF

- CAD model

- IGES

- STEP

- CAM - APT

- CAD/CAM – 3D Wireframe

- Shaded Wireframe

- Hidden Line Removal

- Primitive Solids

- Solids Modeling

- Model Based Design (MBD)

- 90-00’s

- 80-90’s

- 80’s

- 70’s

- 60’s

- 60’s
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- CAD/CAM – Solids Modeling
- MBD
- Paper, Velum
- CAM - APT
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- Model Based Design

90-00’s
80-90’s
80’s
70’s
60’s
70’s
80’s
90-00’s

Model Size + Visualization

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High-end vs Low-end

Use Cases

- Design Review/Training/Eng. & E&M/Tracing systems
- 3D Scans/Sales & Mktg
- Safety & Survivability
- Quality
- Assy & Maint Instructions
- Part Dim & Tol/Part Context
- Parts Catalog
- Design in Context

Number of Parts (log scale)
Standard Visualization Applications

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Polygon-Equivalents (log scale)

C-17? or new 747

787

777

P-8A

F-18

Satellite

Parts in Context

Typical Part

Adobe Reader
Browsers
UG JT2go

UG VisMockUp
IVT/Standard Edition

< 100,000 parts

< 1,000 parts

IVT/SuperViewer
essentially unlimited

< 1,000 parts

< 100,000 parts

10 Million

100 Million

1 Billion

Polygon-Equivalents (log scale)
Why Massive Model Viewers

- Model complexity continues to increase because of fundamental advances in 3D modeling, simulation, and data capture techniques
- Computer power increases, users take advantage and create more complex data sets
- Exceeding Scale – some constrained resources become overloaded
- Constraints impose limits on what users can expect in performance
- Users will always push the limits

‘Real-Time Massive Model Rendering’ (Yoon, Kasik, Gobbetti, Manocha ) 2008
Massive Model Visualization

Legacy Visualization

Load

Unload
Massive Model Visualization

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FlyThru

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- Implemented in early 1990’s to support design reviews for the 777 (Bob Abarbanel, Eric Brechner, Bill McNeely, et al.)
- Published by Abarbanel at SIGGRAPH’96
- Sucked all possible performance from SGI hardware
- Linked to geometry configuration management systems (EPIC/DIRECT)
- Eventually implemented on IBM RS6000s
- Preferred visualization tool in BCA and some BDS.
• FlyThru transitioned to IVT (Interim -> Integration Visualization Tool) and PCs for the 787 in early 2000’s (Bill McGarry, Nik Prazak, Richard Clark, et al.)
• Linked to geometry configuration management systems (EPIC/DIRECT, Enovia)
• 20,000 registered users across BCA/BDS programs
Massive Model Visualization

• Dr. Kasik started investigating ways to visualize entire aerospace products in 2004 in collaboration with organizations around the world
• Monograph ‘Real-Time Massive Model Rendering’ (Yoon, et al.) 2008
Massive Model Visualization Use Cases

Dozens of use cases, including
- Visualize entire BCA AC – gain insight into complex relationships
- Non-conformances - Quickly identify part meta data and coordinates on AC for reporting of issues
- Visualize installations in context
- Provide Condition of Assembly – right amount of data, right time
- Visualize incoming out-of-sequence work
- Visual analytics for non-geometric data - Heat maps of issues
- Serialized Controlled parts
- As-designed to Current build comparison (Shake)
- Customer comparison of two AC
- ………
Lessons Learnt

- Massive Model Viewing is not for everyone

- New paradigm working with massive amount of data
  - Subtractive visualization
  - Hiding data is faster than loading and reloading data

- Industry will need to develop methods and processes to deal with MMV
  - Current industry state is trying to develop MMV

- Key to success is integration of MMV to other systems

- # 1 …… Present the user with the right amount of data
Demonstration