

Massive Model Visualization (MMV) at



Christopher J Senesac

Associate Technical Fellow
Visualization and Interactive Techniques
The Boeing Company

GLOBAL PRODUCT DATA INTEROPERABILITY **S U M M I T** 2015



ELYSIUM

Parker Aerospace

NORTHROP GRUMMAN

BOEING

ELYSIUM

Parker Aerospace

NORTHROP GRUMMAN

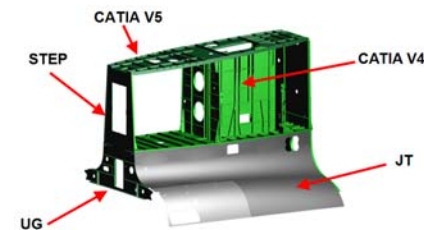
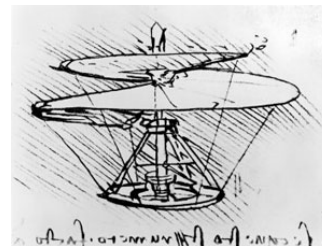
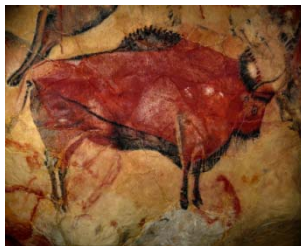
BOEING

- **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 Defined

Global Product Data Interoperability Summit | 2015

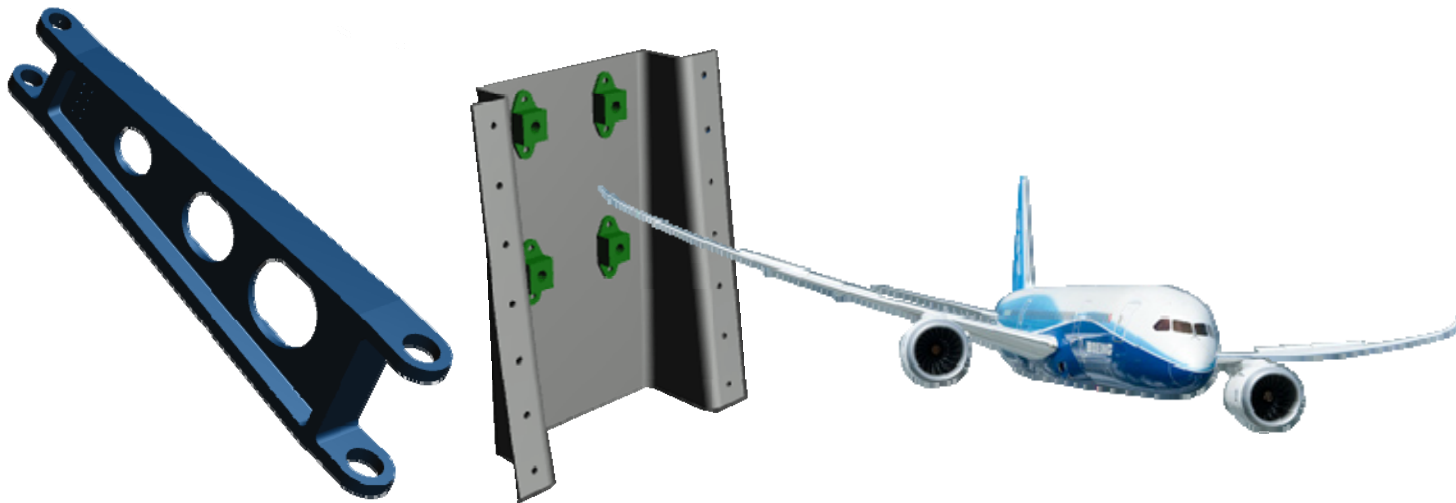
- Visualization is any technique for creating images, diagrams, or animations to communicate a message.
- Visualization has been an effective way to communicate both abstract and concrete ideas since the dawn of man.
- Visualization is a great Integration/collaboration tool; provides open communication amongst differing functional groups/organizations/cultures/languages



Product Visualization

Global Product Data Interoperability Summit | 2015

- **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

Global Product Data Interoperability Summit | 2015

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

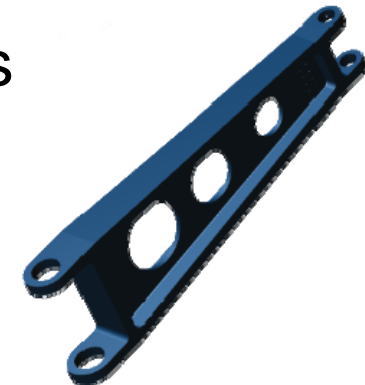


'64 Mustang - Ford

- **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**



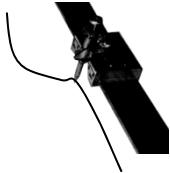
Paradigm Shift for Visualization – Massive Model Viewer

Global Product Data Interoperability Summit | 2015

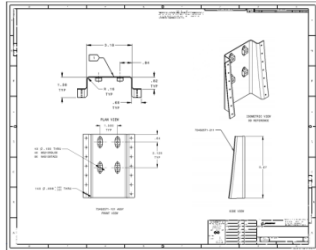
Deliverable's

Paper, Velum

2D Plot

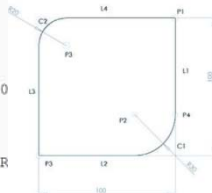


2D Drawings



CAM - APT

```
PARTNO / APT-1  
CLPRNT  
UNITS / MM  
NOPOST  
CUTTER / 10.0  
$SGEOMETRY DEFINITION  
SETPT = POINT / 0.0, 0.0, 0  
STRPT = POINT / 70,70,0  
P1 = POINT / 50, 50, 0  
P2 = POINT / 20, -20, 0  
C1 = CIRCLE / CENTER, P2, R
```



60's

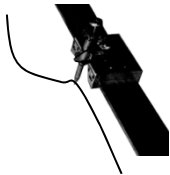
Paradigm Shift for Visualization – Massive Model Viewer

Global Product Data Interoperability Summit | 2015

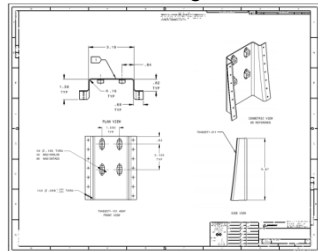
Deliverable's

Paper, Velum

2D Plot



2D Drawings

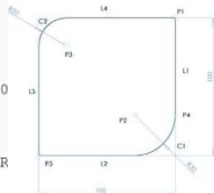


CAD model
IGES

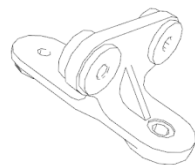


CAM - APT

```
PARTNO / APT-1
CLPRNT
UNITS / MM
NOPOST
CUTTER / 10.0
$SGEOMETRY DEFINITION
SETPT = POINT / 0.0, 0.0, 0
STRPT = POINT / 70,70,0
P1 = POINT / 50, 50, 0
P2 = POINT / 20, -20, 0
C1 = CIRCLE / CENTER, P2, R
```



CAD/CAM – 3D Wireframe
Surfacing



70's
60's

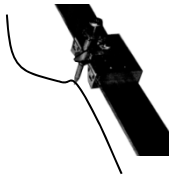
Paradigm Shift for Visualization – Massive Model Viewer

Global Product Data Interoperability Summit | 2015

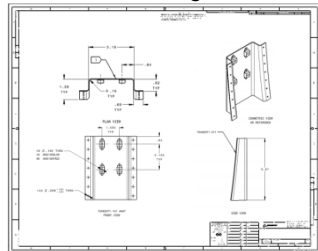
Deliverable's

Paper, Velum

2D Plot



2D Drawings

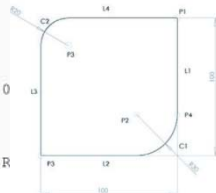


CAD model
IGES
STEP



CAM - APT

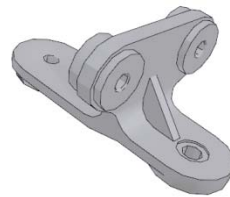
```
PARTNO / APT-1
CLPRNT
UNITS / MM
NOPOST
CUTTER / 10.0
$SGEOMETRY DEFINITION
SETPT = POINT / 0.0, 0.0, 0
STRPT = POINT / 70,70,0
P1 = POINT / 50, 50, 0
P2 = POINT / 20, -20, 0
C1 = CIRCLE / CENTER, P2, R
```



CAD/CAM – 3D Wireframe
Surfacing

60's

70's



CAD/CAM –
Shaded Wireframe
Hidden Line Removal
Primitive Solids

80's

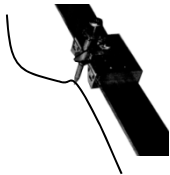
Paradigm Shift for Visualization – Massive Model Viewer

Global Product Data Interoperability Summit | 2015

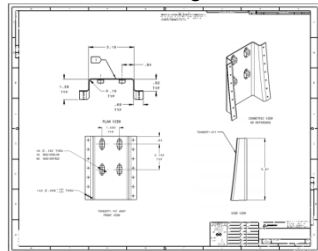
Deliverable's

Paper, Velum

2D Plot



2D Drawings

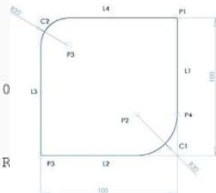


CAD model
IGES
STEP



CAM - APT

```
PARTNO / APT-1
CLPRNT
UNITS / MM
NOPOST
CUTTER / 10.0
$SGEOMETRY DEFINITION
SETPT = POINT / 0.0, 0.0, 0
STRPT = POINT / 70,70,0
P1 = POINT / 50, 50, 0
P2 = POINT / 20, -20, 0
C1 = CIRCLE / CENTER, P2, R
```



CAD/CAM – 3D Wireframe
Surfacing

60's

70's

CAD/CAM –
Shaded Wireframe
Hidden Line Removal
Primitive Solids

80's

CAD/CAM –
Solids Modeling

80-90's



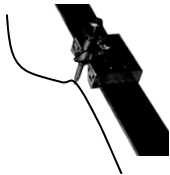
Paradigm Shift for Visualization – Massive Model Viewer

Global Product Data Interoperability Summit | 2015

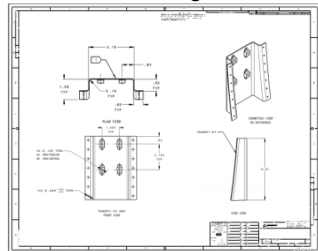
Deliverable's

Paper, Velum

2D Plot

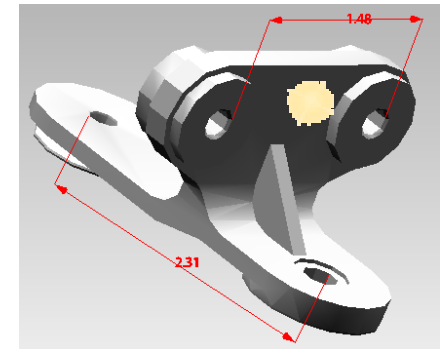


2D Drawings



CAD model
IGES
STEP

3D PDF



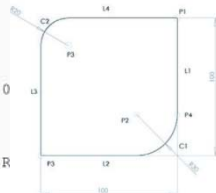
CAD/CAM –
Solids Modeling Model Based Design
(MBD)

90-00's



CAM - APT

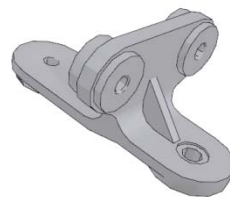
```
PARTNO / APT-1
CLPRNT
UNITS / MM
NOPOST
CUTTER / 10.0
$SGEOMETRY DEFINITION
SETPT = POINT / 0.0, 0.0, 0
STRPT = POINT / 70,70,0
P1 = POINT / 50, 50, 0
P2 = POINT / 20, -20, 0
C1 = CIRCLE / CENTER, P2, R
```



CAD/CAM – 3D Wireframe
Surfacing

70's

60's



CAD/CAM –
Shaded Wireframe
Hidden Line Removal
Primitive Solids

80's



CAD/CAM –
Solids Modeling

80-90's

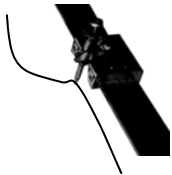
Paradigm Shift for Visualization – Massive Model Viewer

Global Product Data Interoperability Summit | 2015

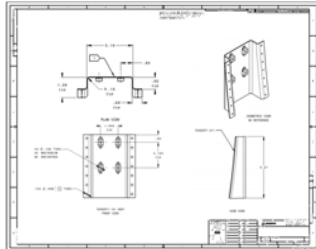
Deliverable's

Paper, Velum

2D Plot

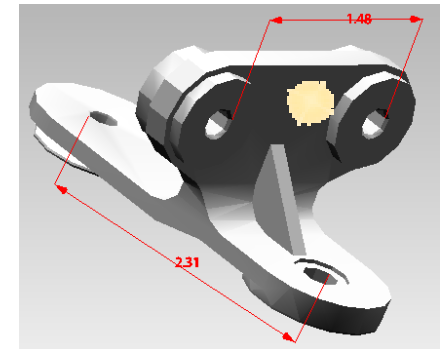


2D Drawings



**CAD model
IGES
STEP**

3D PDF



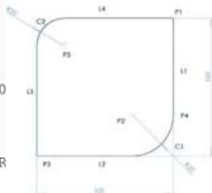
CAD/CAM –
Solids Modeling
Model Based Design (MBD)

90-00's



CAM - APT

```
PARTNO / APT-1
CLPRNT
UNITS / MM
NOPOST
CUTTER / 10.0
SSGEOMETRY DEFINITION
SETPT = POINT / 0.0, 0.0, 0
STRPT = POINT / 70,70,0
P1 = POINT / 50, 50, 0
P2 = POINT / 20, -20, 0
C1 = CIRCLE / CENTER, P2, R
```



CAD/CAM – 3D Wireframe
Surfacing

60's



CAD/CAM –
Shaded Wireframe
Hidden Line Removal
Primitive Solids

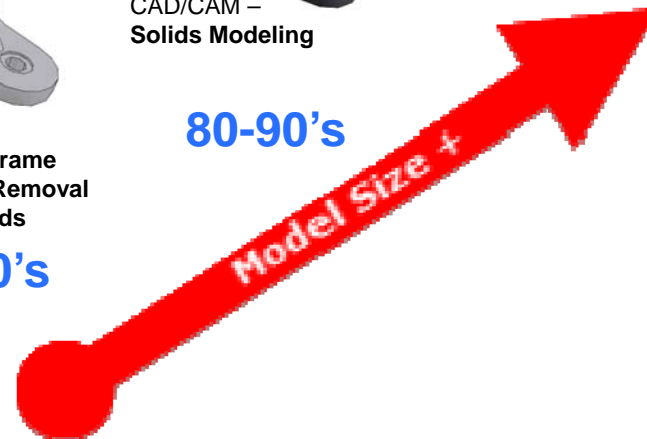
70's

80's



CAD/CAM –
Solids Modeling

80-90's



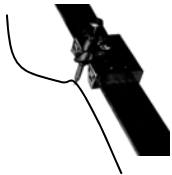
Paradigm Shift for Visualization – Massive Model Viewer

Global Product Data Interoperability Summit | 2015

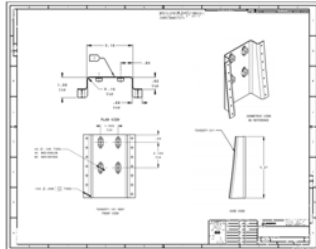
Deliverable's

Paper, Velum

2D Plot

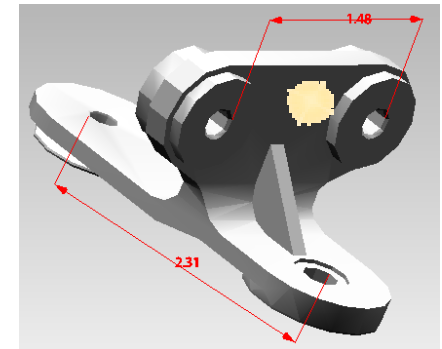


2D Drawings



**CAD model
IGES
STEP**

3D PDF



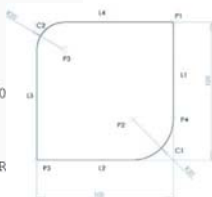
CAD/CAM –
Solids Modeling
Model Based Design (MBD)

90-00's



CAM - APT

```
PARTNO / APT-1
CLPRNT
UNITS / MM
NOPOST
CUTTER / 10.0
SSGEOMETRY DEFINITION
SETPT = POINT / 0.0, 0.0, 0
STRPT = POINT / 70,70,0
P1 = POINT / 50, 50, 0
P2 = POINT / 20, -20, 0
C1 = CIRCLE / CENTER, P2, R
```



CAD/CAM – 3D Wireframe
Surfacing

60's

70's



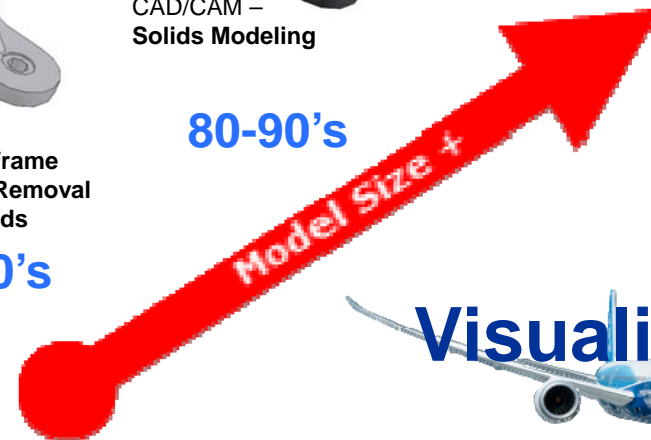
CAD/CAM –
Shaded Wireframe
Hidden Line Removal
Primitive Solids

80's



CAD/CAM –
Solids Modeling

80-90's



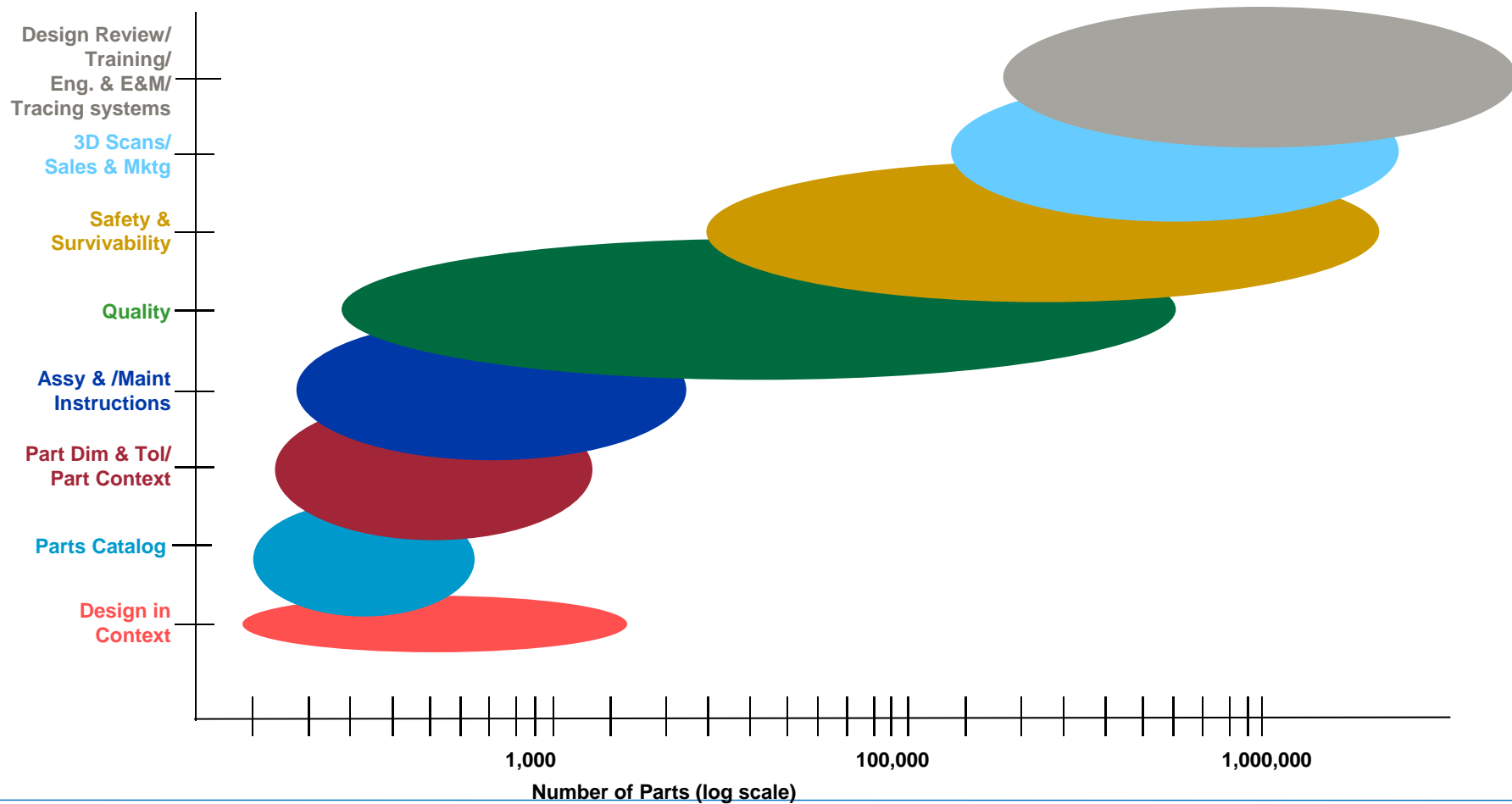
Visualization



High-end vs Low-end

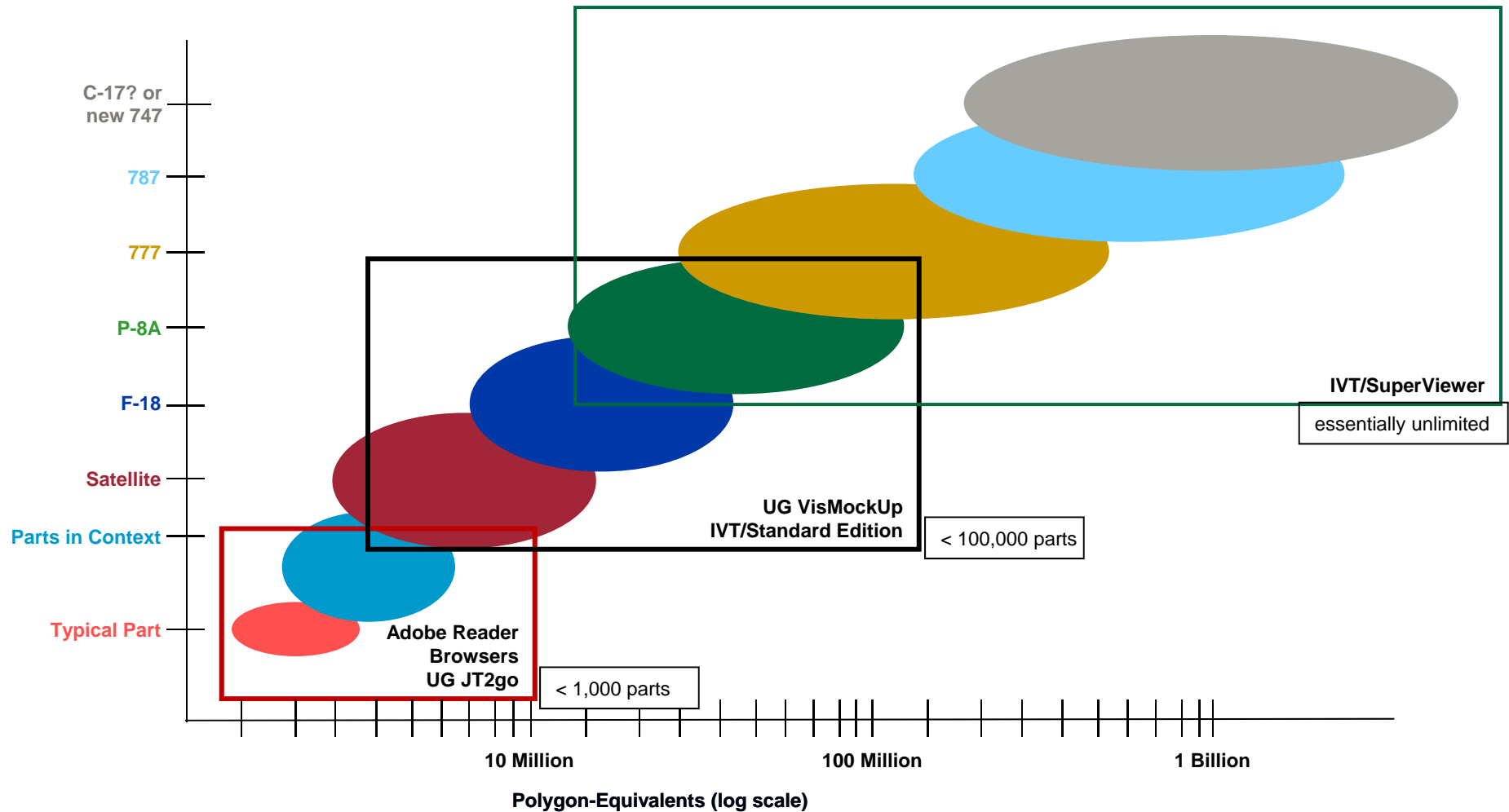
Global Product Data Interoperability Summit | 2015

Use Cases



Standard Visualization Applications

Global Product Data Interoperability Summit | 2015



Why Massive Model Viewers

Global Product Data Interoperability Summit | 2015

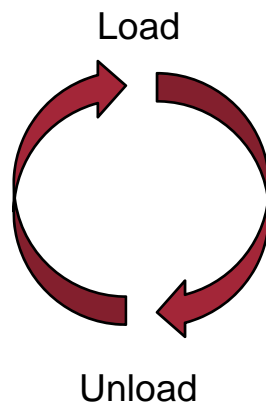
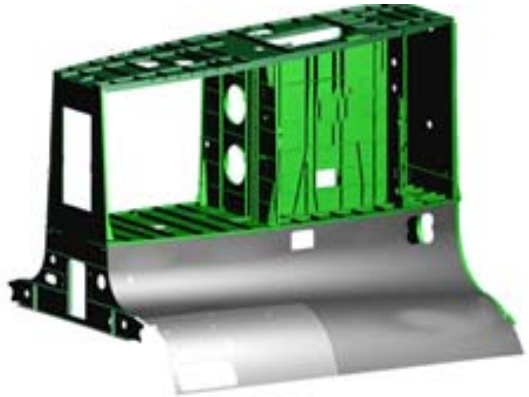
- **Model complexity continues to increase because of fundamental advances in 3D modeling, simulation, and data capture techniques**
- **Computer power increases, users take advantage and create more complex data sets**
- **Exceeding Scale – some constrained resources become overloaded**
- **Constraints 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

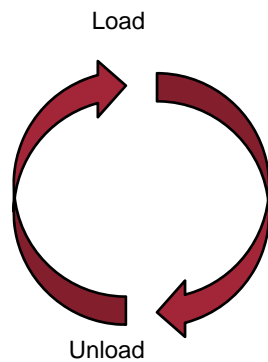
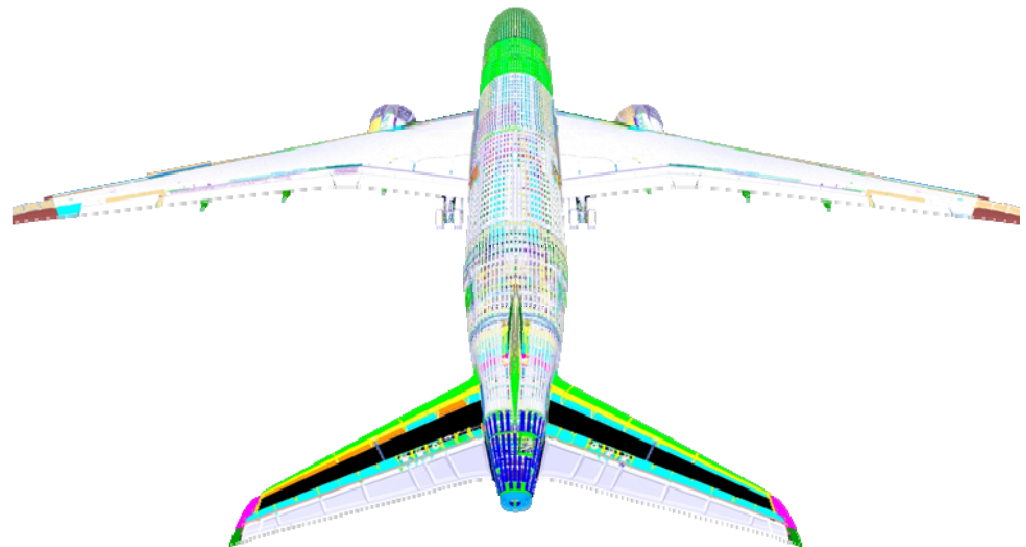
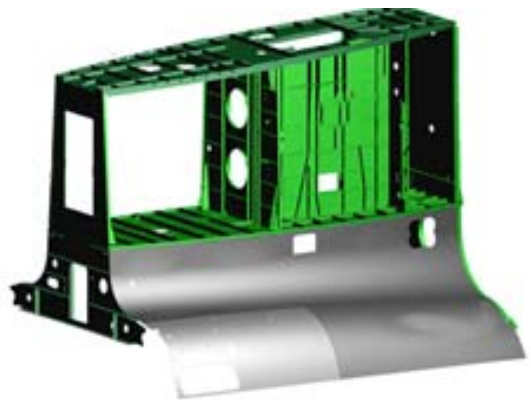
Global Product Data Interoperability Summit | 2015

Legacy Visualization



Massive Model Visualization

Global Product Data Interoperability Summit | 2015

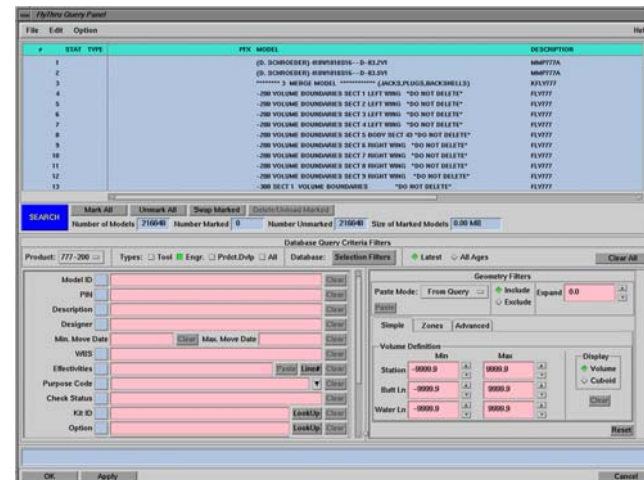
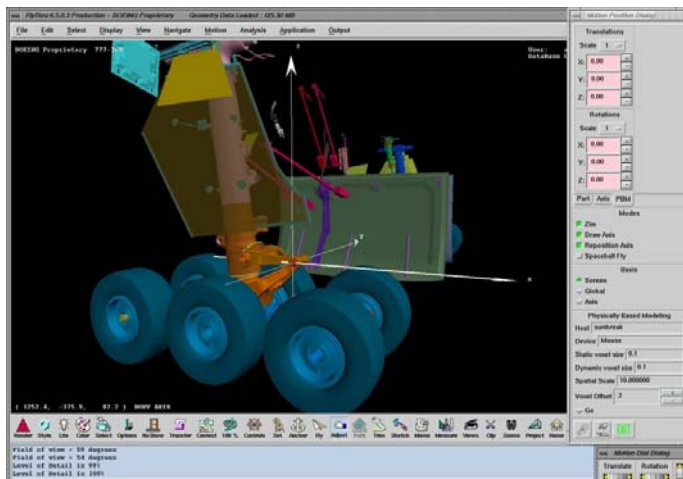


Load Once

FlyThru

Global Product Data Interoperability Summit | 2015

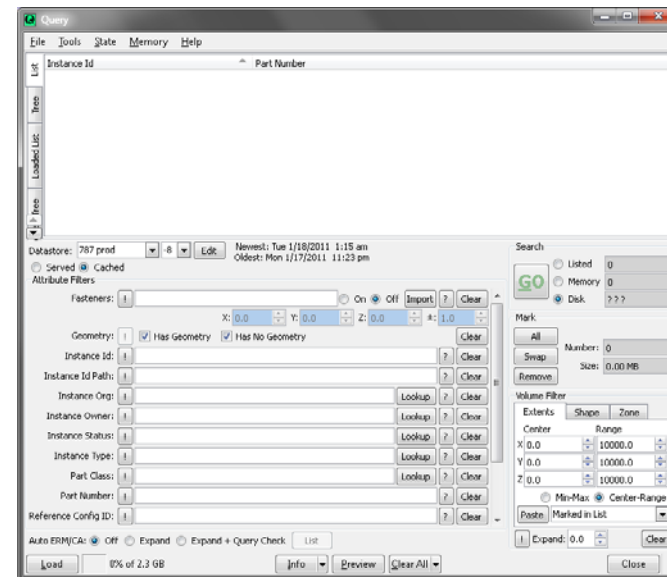
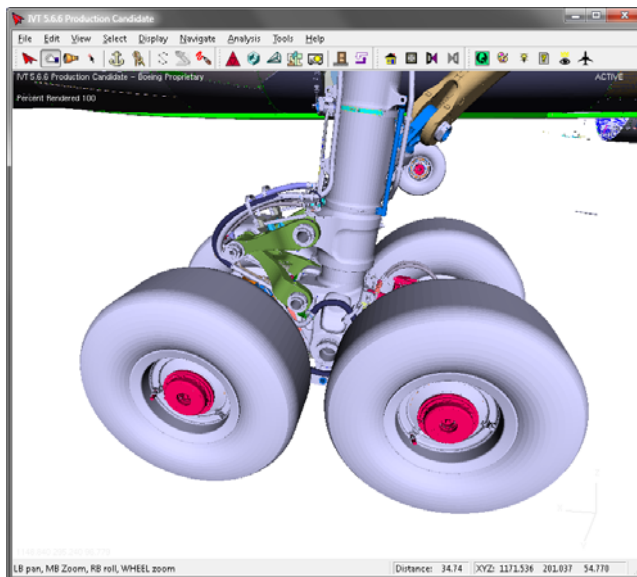
- Implemented in early 1990's to support design reviews for the 777 (Bob Abarbanel, Eric Brechner, Bill McNeely, et al.)
- Published by Abarbanel at SIGGRAPH'96
- Sucked all possible performance from SGI hardware
- Linked to geometry configuration management systems (EPIC/DIRECT)
- Eventually implemented on IBM RS6000s
- Preferred visualization tool in BCA and some BDS.



IVT

Global Product Data Interoperability Summit | 2015

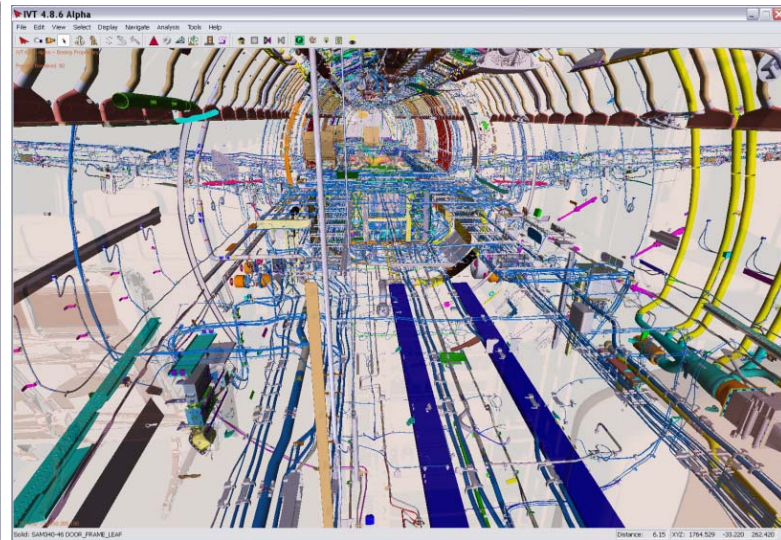
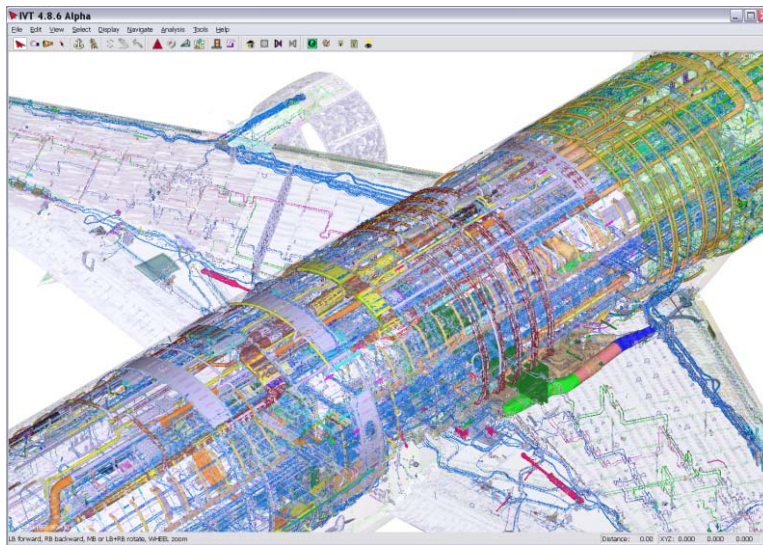
- FlyThru transitioned to IVT (Interim -> Integration Visualization Tool) and PCs for the 787 in early 2000's (Bill McGarry, Nik Prazak, Richard Clark, et al.)
- Linked to geometry configuration management systems (EPIC/DIRECT, Enovia)
- 20,000 registered users across BCA/BDS programs



Massive Model Visualization

Global Product Data Interoperability Summit | 2015

- 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

Global Product Data Interoperability Summit | 2015

- **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

Global Product Data Interoperability Summit | 2015

- **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

Global Product Data Interoperability Summit | 2015





