

# Technical Debt & The Digital Thread On the AH64 Apache Helicopter

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Boeing - Mesa

## GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2023



# Bio: Rick Amann

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## Boeing - Mesa, AZ (IT Product Systems, Associate Technical Fellow)

### **Work History**

33 years supporting Mesa engineering using UG/NX CAD/CAM systems

- 1986 - Pratt & Whitney Aircraft Engines (Columbus, GA) N/C machining & Precision Inspection of forge die tooling for jet engine blades & vanes. Responsible for bringing UniGraphics into Pratt & Whitney in 1988 To replace Computervision CADD3 for design & Anvil 4000 for NC machining (UniGraphics V6 running on Sun SPARCstations)
- 1990 - McDonnell Douglas Helicopters (Mesa, AZ) CAD/CAM Support, NC automation, converted machine shop from PTP to Greco floppy disks/DNC, CMM inspection (Valisys), Reverse engineering (Grip), started Data Exchange workshop (1993)
- 1997 - Boeing (merger with McDonnell Douglas, Mesa, AZ) UniGraphics (NX) CAD/CAM system admin, Unix admin, Design automation via Grip and Unix & Windows Scripts, Mesa Data Exchange workshop merges with Boeing to become GPDIS
- 2005 - Migrated Apache BOM data from in house IBM Mainframe system IEDB (Integrated Engineering Data Base) into Teamcenter Engineering / NX2 via Unix (over 40,000 large UG assemblies, updating all pre-V10 components)
- 2008 - Boeing Associate Technical Fellow (CAD/CAM System Integration & Automation)
- 2014 - Upgraded Mesa site to Teamcenter Unified 8.3/NX8 (Mesa is still using these outdated application versions today, due to several contributing factors. Remaining on legacy application versions adds to our Technical Debt)

### **Education**

- BS Computer-Aided Design, Brigham Young University (1986)
- MS Information Systems, University of Phoenix (2009)

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## *Definitions: Technical Debt & The Digital Thread?*

### **Technical Debt**

- Implied cost of future rework required to update or replace outdated “legacy” applications, systems, and data that accumulate "interest", making it hard to implement change and typically incurs a higher cost to fix

### **Digital Thread**

- Authoritative data generated from across the full product lifecycle, collection, transmission, and sharing of that data between systems and applications enabling real-time decision making, to design, iterate, & produce the product

# Technical Debt & The Digital Thread

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## AH-64 Apache

40 Years Proven  
30 More to Come...

The Most  
"Respected & Feared"  
Gunship



### Technical Debt Challenges

- Legacy data – Mylar & paper drawings
- Duplication of data due to legacy systems
- System security for legacy applications (security updates)
- Data security (US & International customers)
- Reduced IT spend & Common Systems
- LOTAR (Long Term Archival & Retrieval, 40-70 years)



### Digital Thread Opportunities

- Generate CAD/JT data (entire ship)
- Digital work instructions & PMI data to the shop floor via Mobile devices
- Reduced data duplication
- Digital data for field support & data delivery to customers & suppliers

## *AH-64 Apache Helicopter History*

- 1972 U.S. Army request for Advanced Attack Helicopter (AH-64 helicopter design begins on paper)
- 1975 First flight of the Hughes AH-64 Helicopter (September 30, 1975)
- 1983 First production AH-64 Apache (Hughes helicopter facility Mesa, Arizona)
- 1984 McDonnell Douglas purchased Hughes Helicopters (Transition from paper drawings to CADD)
- 1987 McDonnell Douglas Automation UniGraphics (Migrate CADD to UG V5 / Unix workstations)
- 1996 Personal Workstations / Email (CAD rooms to Windows PC, UG V11 / WinXP)
- 1997 Boeing / McDonnell Douglas merger (Drawings & data change to Boeing)
- 2005 PDM moved from in-house IBM Mainframe (Transition to Teamcenter Engineering / NX2)
- 2007 Boeing decision to use common CAD/PDM systems (All Boeing sites to use Catia/Enovia)
- 2014 Last Mesa Upgrade for CAD/PDM (NX8 / Teamcenter Unified 8.3, BDS Standard)
- 2017 Boeing decision to use common CAD/PDM systems (All Boeing sites to use 3DEXPERIENCE)
  
- 2023 Mesa still using NX8/TC8 (Reduced IT, common systems & Technical Debt)

## *Challenges of Technical Debt (40 Years)*

- Converting design data from paper drawings to CAD/CAM systems
- Legacy GD&T migration from paper to CAD & then to PMI
- Migrating CAD & PDM data between multiple systems over decades
- Redesign of automated data processes between systems (Unix, Windows, & Linux)
- Application certification with ongoing Security updates (Windows O/S, Java, Office 64bit)
- NX Help on context & documentation (disabled in NX8 due to new browser security)
- Legacy data outside of Teamcenter (MFG data, Tooling data, Quality data)
- Automated Technical Data Package processes created on legacy systems (Unix)
- Unable to use new technology enhancements due to legacy data limitations
- “If its not broke, don’t fix it” Mentality

# Bio: John Daniel

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Boeing - Mesa, AZ (Tools and Processes, NX SME)

## **Work History**

34 years aerospace engineering using UG/NX CAD/CAM systems

- 1989 – McDonnell Douglas Long Beach C-17 Wing Skins & Stringers
- 1993 - McDonnell Douglas Long Beach MD-12X (Jumbo MD-11)
- 1994 – McDonnell Douglas Huntington Beach International Space Station Electrical Systems
- 1995 – Northrop El Segundo F-18 E/F Fuel Systems
- 1996 – McDonnell Douglas Mesa AH-64 Apache Configuration, RWSTD (JSF MBE)
- 2001 – Boeing Mesa AH64 Apache Process and Tools, NX / Vis Subject Matter Expert

## **Education**

- BS Aeronautical Design, University of Illinois(1988)

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# Technical Timelines

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## AH-64A



## C-17



## 777



## AH64 D



## AH64E (Block III)



Design	1975	1985	1990	1995	2010
Production	1975-1983	1985-1995	1990-1995	1992-1995	2006-2010
Produced	1983+	1995-2015	1995+	1995+	2010+
CAD SYSTEM	2400+	279	1700+	530 A ⇄ D & 500	634 D ⇄ E
LANGAUGE	Drafting Boards	CADD	CATIA 4	UG V11	NX2
OS	-	CADTRAN	IUA	GRIP	GRIP
COMPUTERS	-	IBM	UNIX	UNIX	WINDOWS 7
DISPLAYS	-	MAINFRAME	Workstations	Desktop	Desktops
VIS TOOLS	-	Evans & Sutherland	Monitirs	Monitors	Monitors
PDM	Wood Shop	CADD	IVT	UG V11	NX2
	IEDB	DATABASE	ENOVIA	IEDB	TCE



# Apache MBE Timeline

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In 1975 Apache A Model Program began Drawings Based Pre CAD

In 1995 Apache D Model Program began still Drawing Based but 100% CAD  
UGV11 CAD Models stored in UNIX Directories + IEDB Engineering Bill Of Material

In 2006 Apache D Model Data Migrated from UNIX Directories to Team Center Engineer (TCE).  
Zipped EBOM Data and CAD Models together in TCE.

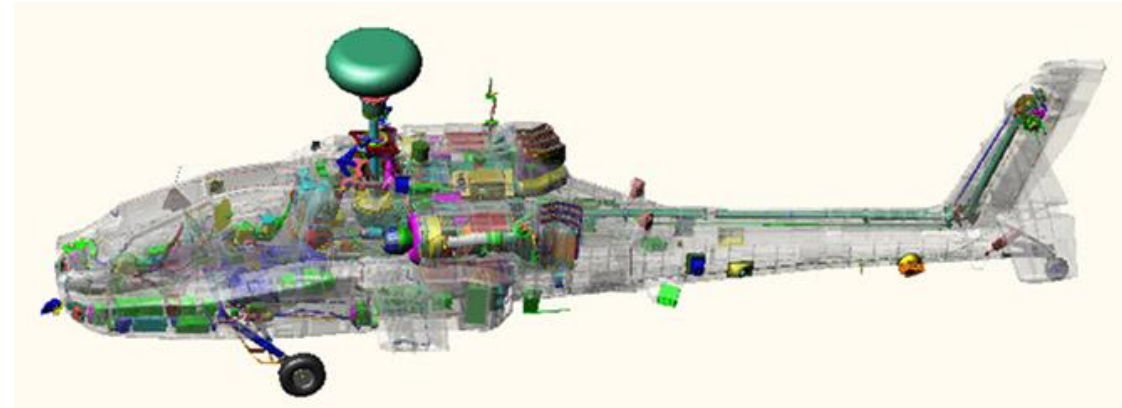
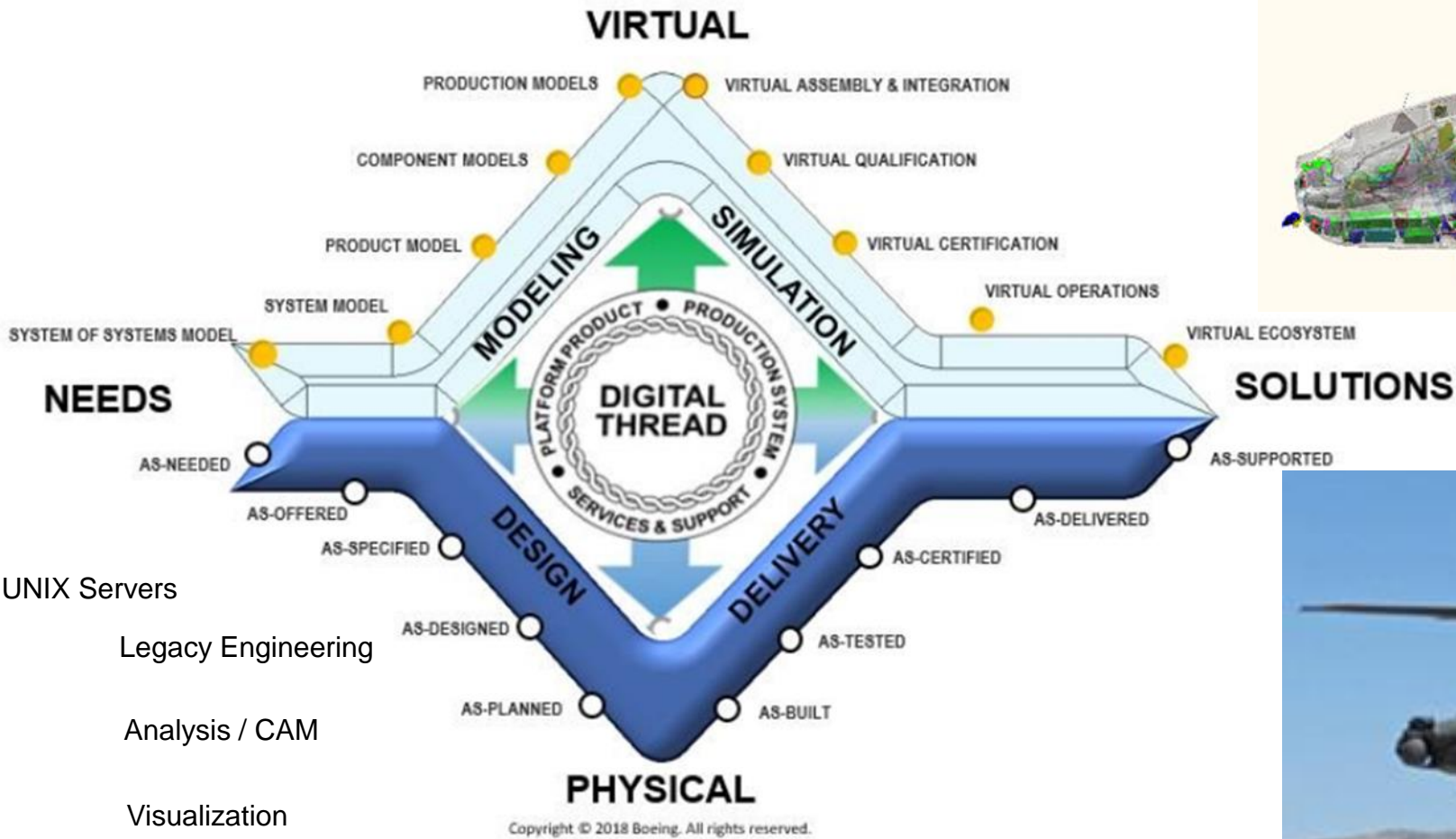
In 2014 Apache (Block III) E Model Upgraded to NX8 and TCE8  
Last Major upgrade to CAD or TCE

In 2025 we will move to IPDM (Integrated Product Data Manager), the Common BDS PDM System  
Supports Model Based Environment  
No longer ties the version of CAD to version of TCE – NX Continuous Improvement  
Higher emphasis on MBD with automated tools, Technical Data Packages  
Look to move Analysis and Manufacturing Data off UNIX Servers in the future

Transitioning from a document-focused mindset to a digital engineering mindset that leverages information flow across the lifecycle

# Apache Digital Thread Digital Twin

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## Principles For MBE

- Master Model
- Detail and Assembly MBD
- Mono Detail
- All Parts Modelled
- No Added Parts for Convenience
- Full Definition (Pilot Holes)
- EBOM = MBOM at Jig Station
- Fully Associated Parametric Models
- Same Modeling method for everyone
- Morphable Parts
- Cut / Paste User Defined Features
- Mapping of TCE Attributes
- Consistent to Standard
- Set up for VR and MBI
- Ability to view VR by Revision Rule
- MBD PMI

## Associated Apache Modeling Issues

- Master Model only on newer models
- Detail and Assembly Drawings
- Multi Detail & Multi Configuration
- Missing Parts (Vellum) / Point Models (Standard Parts)
- Many parts contain extra parts / assemblies
- Not Modelled at Full Definition
- Use of Synthetic Numbers (Op Center 2027?)
- Limited use of Parametric Models
- No Standard Modeling method for everyone
- Parts built at Fixed position
- No User Defined Features, Very little Part Reuse
- No Mapping of TCE Attributes
- Inconsistent Standardization
- Not Set up for MBI
- No Ability to view VR by Revision Rule
- MBD mixed GD&T and PMI

# Apache Moving Towards MBE

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Address current Modelling Issues during IPDM Test Period  
IPDM Test Environment 4<sup>th</sup> Quarter 2023  
Test and Evaluation thru 2025

Continue to provide Apache Design Focused Upgrades:

Pilot / Copilot Canopy Structure

Conversion to MBD

Have to have a need to update: Complex Area / High EO Traffic

Composite Horizontal and Vertical

Aft Center of Gravity Weight issue

Possibility of Future Apache Models

Would be a chance to do a full MBE with possibility of a clean sheet design

# Apache Virtual Reality / Immersive Design Environment

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“Don’t think of that as a screen, think of it as a window through which one looks into a virtual world.”  
Ivan Sutherland, 1965



Immersive Demo 2012



Immersive Design Room 2023

# Apache Virtual Reality / Immersive Design

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VR capabilities added first used in 1998 on the RWSTD Program  
dVise + Flock of Birds @ \$250K Render Speed 30,000 Polygons @ 20 FPS  
Evaluated for RWSTD Program but not funded.

Helmet and Glove VR capabilities added in late 2022  
Vis Mockup + HTC Vive Pro + GPU @ \$5K Render Speed 500,000 Polygons @ 90 FPS  
Took 5 years to finally get funding for this project,

Boeing has recently added Unreal Engine to supported Boeing Software  
Mesa to hold it's first VR Configuration Study later this year.

“Don't think of that as a screen, think of it as a window through which one looks into a virtual world.”  
Ivan Sutherland, 1965

Catch 22 – If you don't have experience using VR it is hard to implement when you have a new program.



## Lessons Learned

- The cost of Technical Debt increases drastically over time, if you don't have time/money to fix the problem now, the cost will be much higher in the future and your options may diminish
- Today's data is tomorrow's "Legacy Data", good vision & planning is needed to realize the true benefits from using the Digital Thread across the whole life cycle of the product
- Data is "King", ease of access and use of authoritative data between all systems & applications is key, standardized use of the digital thread will lead to proficiency & profitability throughout all phases of design & manufacturing

# Technical Debt & The Digital Thread

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*Warning! watch your speed in Arizona...*



Q&A ?