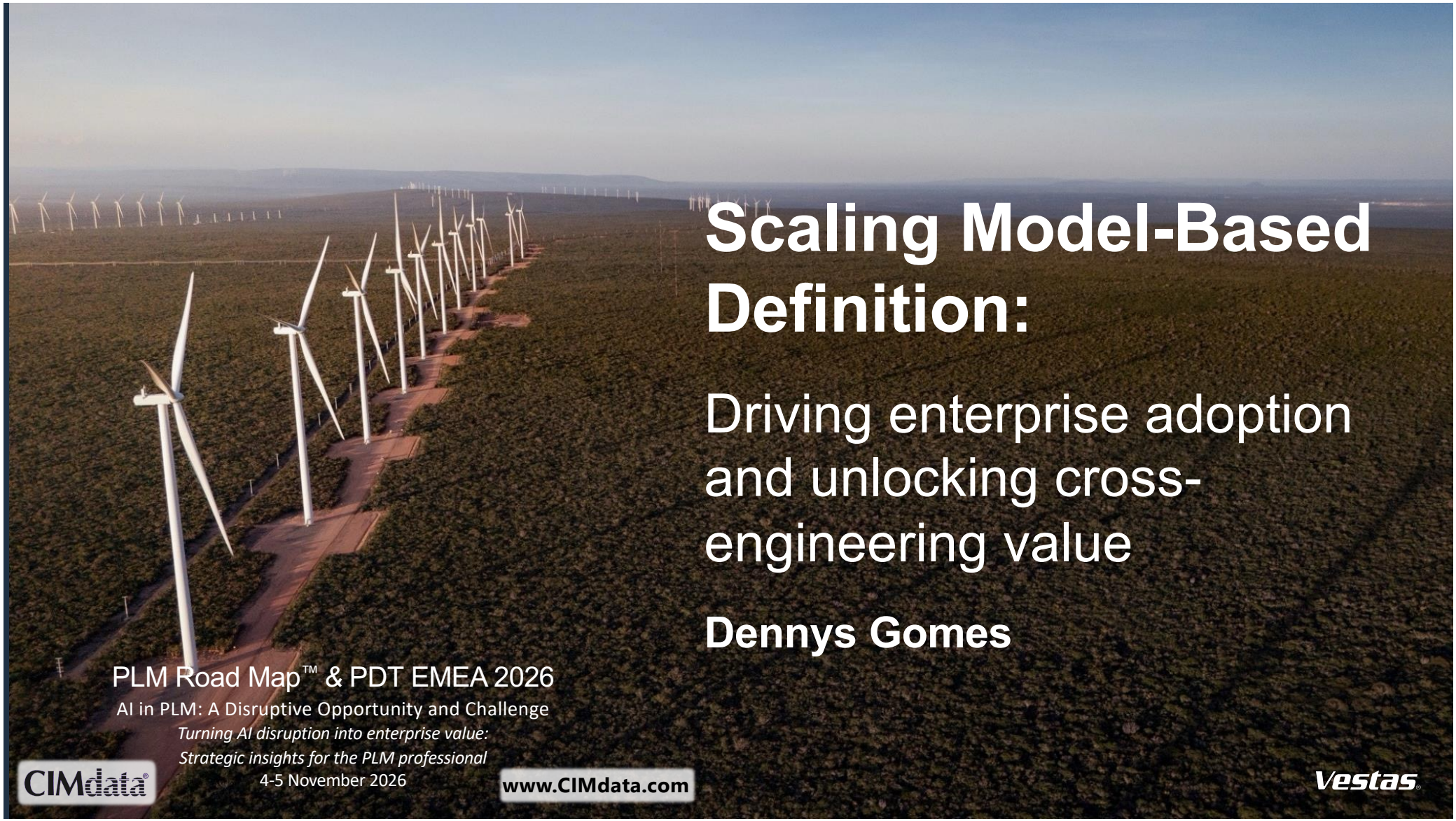


Scaling Model-Based Definition:

Driving enterprise adoption and unlocking cross-engineering value

Dennys Gomes

PLM Road Map™ & PDT EMEA 2026
AI in PLM: A Disruptive Opportunity and Challenge
Turning AI disruption into enterprise value:
Strategic insights for the PLM professional
4-5 November 2026
www.CIMdata.com

The Global Leader in Sustainable Energy Solutions



From a bold vision to the global leader in sustainable energy solutions

1898 — Blacksmith beginnings
Hans Søren Hansen buys a blacksmith shop in the town of Lem in Denmark.

1945 — The Vestas name
Hans' son Peder takes over the company, and founds Vestjysk-Stålteknik A/S, which is later shortened to Vestas. The company produces agricultural machinery and later hydraulic cranes.

1979 — 1st turbine
The first Vestas turbine is sold and installed – with a 10-meter rotor and capacity of 30 kW



1987 — Focus on wind
Vestas Wind Systems A/S, is born and focus is shifted entirely on wind energy, beginning the journey towards becoming a global, high-tech market leader.

1995 — Going offshore
Vestas constructs its first offshore wind turbine farm "Tunoe Knob" in Denmark. One of the first offshore wind farms ever built.

2000s — World leader
New technology, efficiencies and the merge with NEG Micon leads to Vestas becoming the undisputed world-leader in modern wind energy.

2019 — 100 GW of installed capacity
Vestas becomes the first company to install 100 GW of wind turbines, solidifying our position as the world's leading manufacturer of wind power solutions.



2020 — Back in Offshore
Vestas acquires MHI Vestas Offshore Wind, welcoming offshore wind back as a core member of the Vestas family and becoming the undisputed global leader in wind.

2025 — 200 GW of installed capacity
Vestas also becomes the first company to install 200 GW of wind turbines globally. A testament to Vestas' leading position within wind energy solutions and the scale at which renewables is growing in the global energy system.

November 10, 2026

Classification: Public

Vestas

The undisputed global leader in wind energy



+39,000

employees

Every day, our employees help create a better world by designing, manufacturing, installing, developing, and servicing wind energy and hybrid projects all over the world



+56,000

turbines under service

Our service technicians keep the world spinning by servicing a global portfolio of + 165 GW - the largest fleet in the world



+207 GW

installed wind turbine capacity

We have installed more wind turbine capacity than any other company in the world, with installations in 88 countries



250m

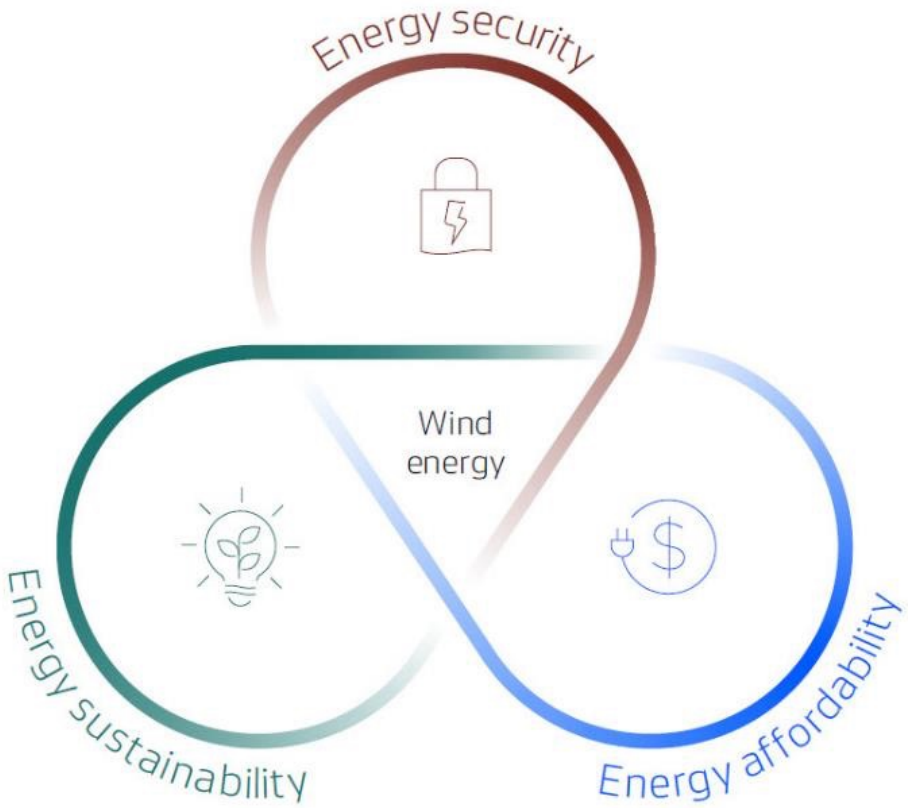
tonnes CO_2e avoided annually

Our total aggregated installed fleet annually help the World avoid emissions of 250 million tonnes CO_2e

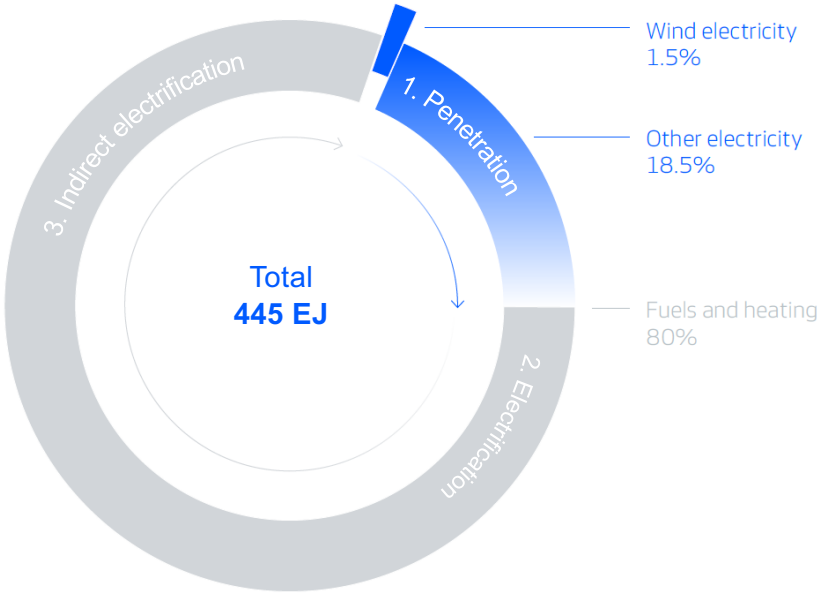
Data as of Q2 2026

Classification: Public

Wind energy key to affordability, security and sustainability



World energy consumption by source 2023
In exajoule (EJ) and percent (%)



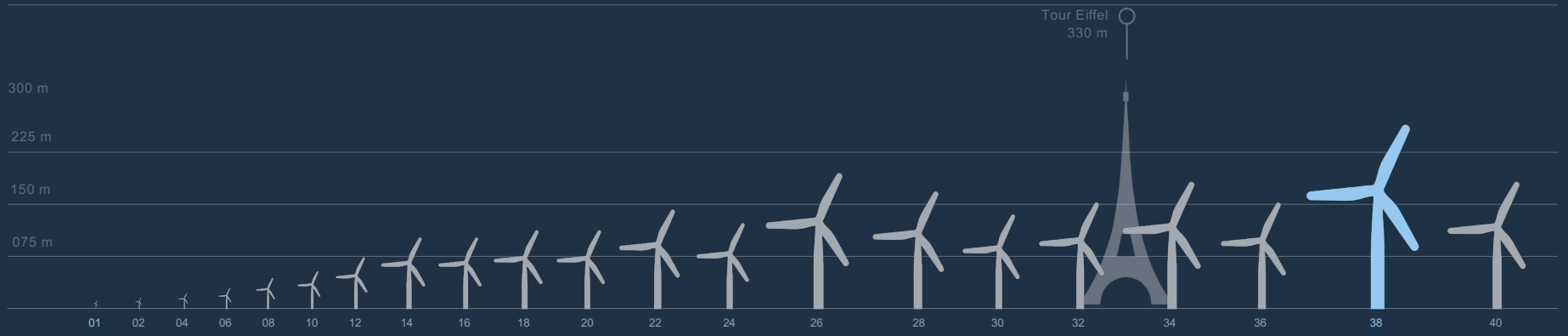
Source: International Energy Agency: IEA World Energy Outlook 2023

November 10, 2026

Classification: Public

Vestas

Technology evolution from 30 KW to 15 MW



Households powered assumes turbine operating at max capacity and powering an average European household
Tower height varies depending on site

01	1979	V10-30 KW	**08**	1991/95	V39-500 KW*	**15**	2003	V82-1.62 MW	**22**	2013	V126-3.3 MW	**29**	2017	V116-2.0 MW	**36**	2022	V136-4.5 MW
02	1981	V15-55 KW	**09**	1995	V44-600 KW	**16**	2004	V90-2.0 MW	**23**	2014	V105-3.3 MW	**30**	2017	V120-2.2 MW	**37**	2022	V150-4.5 MW
03	1984	V17-75 KW	**10**	1997	V47-660 KW	**17**	2009	V100-1.8 MW	**24**	2014	V110-2.0 MW	**31**	2019	V117-4.2 MW	**38**	2022	V236-15.0 MW**
04	1986	V19-90 KW	**11**	2000	V52-850 KW	**18**	2009	V100-2.6 MW	**25**	2014	V164-8.0/9.5/10.0 MW**	**32**	2019	V136-4.2 MW	**39**	2023	V162-7.2 MW
05	1987	V20-100 KW	**12**	1999	V66-1.75 MW	**19**	2010/13	V112-3.0 MW*	**26**	2014	V174-9.5 MW**	**33**	2020	V150-6.0 MW	**40**	2023	V163-4.5 MW
06	1988	V25-200 KW	**13**	2000/02	V80-2.0 MW*	**20**	2013	V100-2.0 MW	**27**	2015	V136-3.45 MW	**34**	2020	V162-6.2 MW	**41**	2024	V172-7.2 MW
07	1989	V27-225 KW	**14**	2002/05	V90-3.0 MW*	**21**	2013	V117-3.3 MW	**28**	2017	V150-4.2 MW	**35**	2021	V155-3.3/3.6 MW			

Year of prototype
* *Onshore/Offshore turbine*
** *Offshore turbine*

Classification: Public

Vestas

Wind turbine platforms for every segment

Onshore



2MW
Platform

Turbines
V110-2.0 MW®
V120-2.2 MW®



4MW
Platform

Turbines
V117-3.45 MW®
V126-3.45 MW®
V117-4.2 MW™
V136-3.45 MW®
V136-4.2 MW™
V150-4.2 MW™
V136-4.5 MW™
V150-4.5 MW™
V163-4.5 MW™



EnVentus™
Platform

Turbines
V150-6.0 MW™
V162-6.2 MW™
V162-7.2 MW™
V172-7.2 MW™
V182-7.2 MW™

Offshore



V236-15.0 MW™

Turbines
V236-15.0 MW™

Classification: Public

Vestas

SCALE
of our solutions:

"Every turn of a V236 rotor generates roughly enough electricity to power an average household for about two days.“

That means that one V236-15.0 MW turbine generates about 80 GWh annually, enough electricity for roughly 20,000 households every year.



Scaling and unlocking the potential of annotations and the structured approach to data



November 10, 2026

Classification: Public

Vestas

The path to Model Based Enterprise



Vision

Classification: Public

USE MBD CAPABILITY MATURITY LEVELS AS BASIS FOR AN MBD ROADMAP AND FRAMEWORK (SCHEMA)

		Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
		Dwg-Centric	**Model Centric**		**Model Based Definition**		**Model Based Enterprise**	
Design Data (CAD)	Geometry	Geo. from dwg., no assoc.	All geometry from model					
	Dimensions & Tolerances	Dim. & tol. from drawing	Most dimensions & tolerances from model		All dimensions & tolerances from model			
	Notes, non-geom data	Notes on drawing			Notes in model		Notes in database	Notes in PLM system database
	BOM	Manual in ERP, no link to CAD	Managed in PLM, linked to CAD					
Technical Data Package (TDP)		Ad-hoc, manual creation & delivery			Structured, manual creation and manual delivery		Automated creation by PLM	Automated delivery by PLM
Change and Configuration Management Data		Drawing-based			Model-based			
External and Internal **Manufacturing Data Exchange**		Drawing-based	Geometry from model, using neutral formats. Annotations from drawing		All information from model, different databases may exist		All managed in PLM, full associativity	
Quality Requirements, Planning, and Inspection Code Generation		Remastered 3D model	Neutral models	Copies of native models		Native models from PLM	Native models from PLM, parallel process	
Enterprise Collaboration and Data Exchange		Drawings-based, sent to supplier	Drawings & models, sent to supplier		Models & deriv., automat. sent	Models & deriv., automat. shared	Models & derivatives, shared through external PLM access	

Vestas in 2020

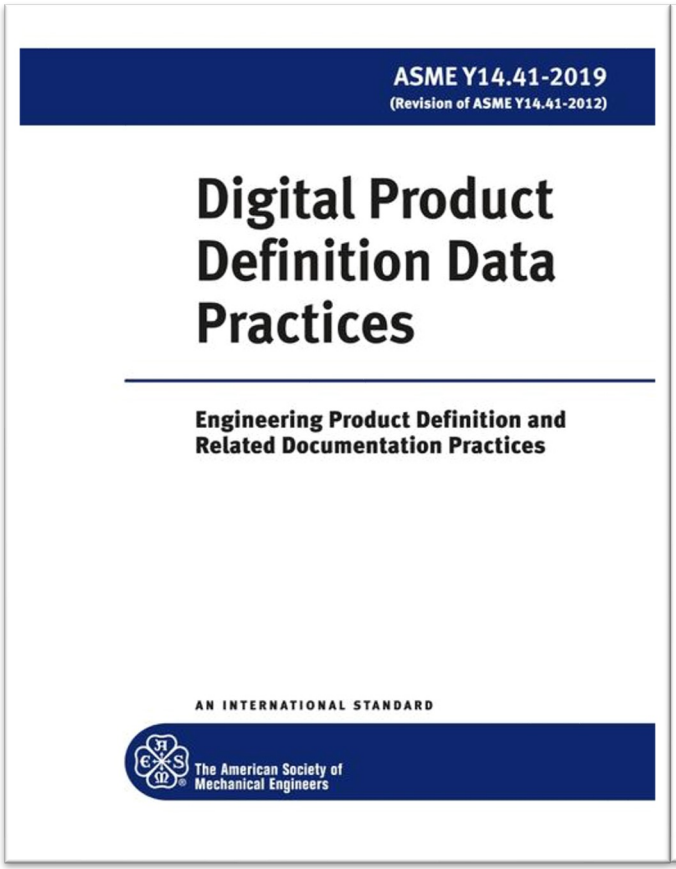
Goal for 2030

Vestas

Source: NSC MBE Maturity Index Issue C

Classification: Public

ASME



ASME Y14.41-2019
(Revision of ASME Y14.41-2012)

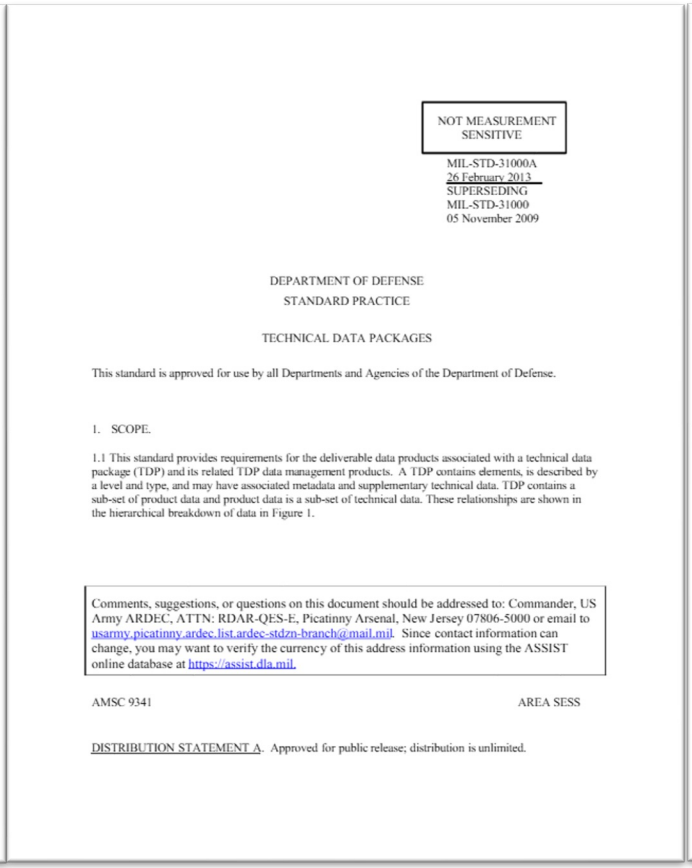
Digital Product Definition Data Practices

Engineering Product Definition and Related Documentation Practices

AN INTERNATIONAL STANDARD

The American Society of Mechanical Engineers

MIL-STD



NOT MEASUREMENT SENSITIVE

MIL-STD-31000A
26 February 2013
SUPERSEDING
MIL-STD-31000
05 November 2009

DEPARTMENT OF DEFENSE
STANDARD PRACTICE

TECHNICAL DATA PACKAGES

This standard is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE.

1.1 This standard provides requirements for the deliverable data products associated with a technical data package (TDP) and its related TDP data management products. A TDP contains elements, is described by a level and type, and may have associated metadata and supplementary technical data. TDP contains a sub-set of product data and product data is a sub-set of technical data. These relationships are shown in the hierarchical breakdown of data in Figure 1.

Comments, suggestions, or questions on this document should be addressed to: Commander, US Army ARDEC, ATTN: RDAR-QES-E, Picatinny Arsenal, New Jersey 07806-5000 or email to usarmy.picatinny.ardec.list.ardec-stdzn-branch@mail.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST online database at https://assist.dla.mil.

AMSC 9341 AREA SESS

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ISO



INTERNATIONAL STANDARD **ISO 16792**

First edition
2006-12-15

Technical product documentation — Digital product definition data practices

Documentation technique de produits — Données de définition d'un produit

Reference number
ISO 16792:2006(E)

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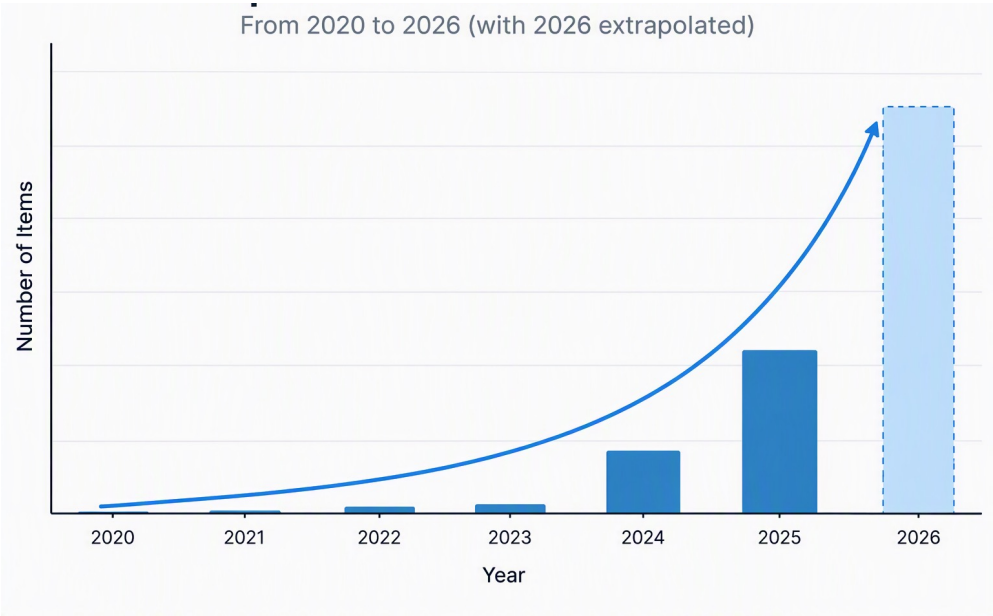
10 November 2026

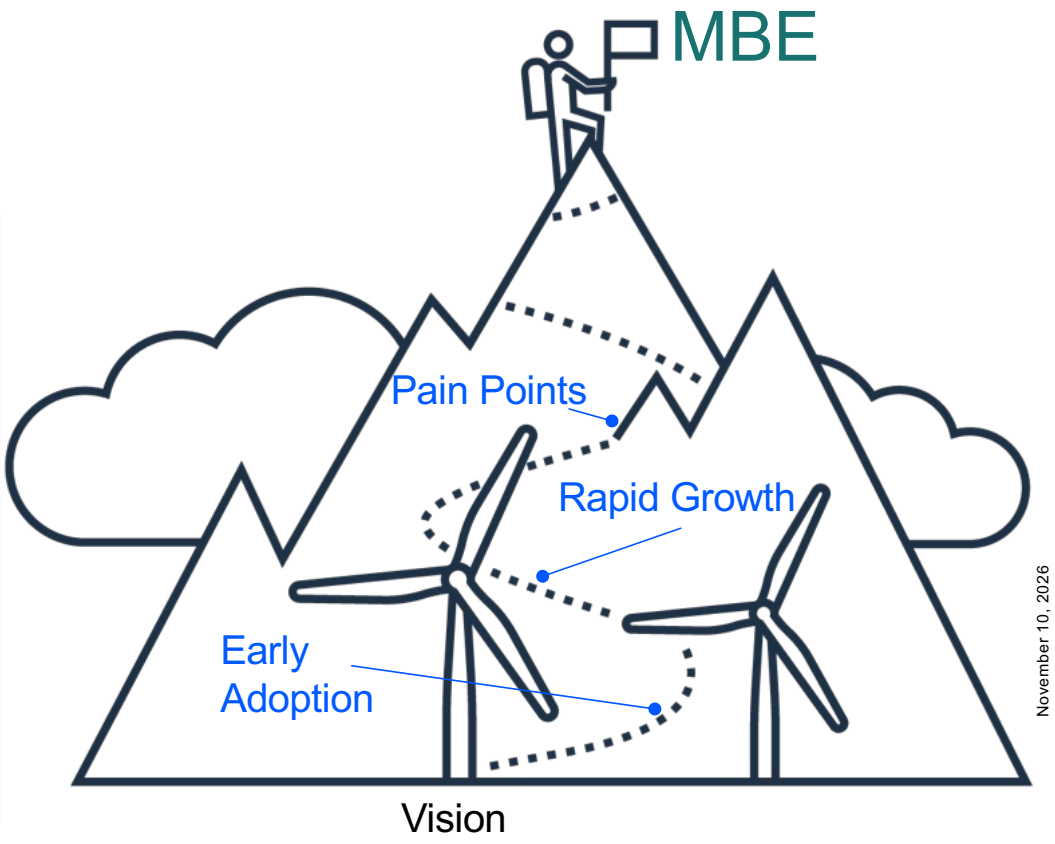
Classification: Public

Vestas

Growth and Scale

The more successful we became at deploying MBD, the more challenges we uncovered.

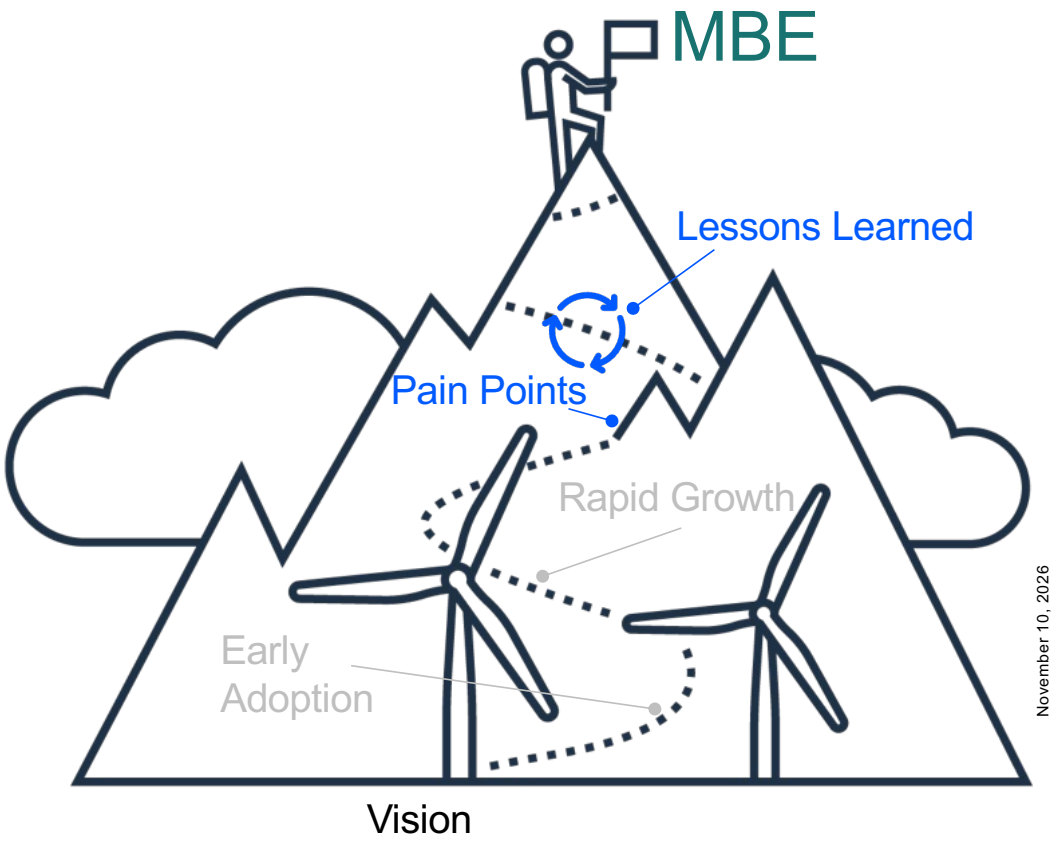




Classification: Public

Lessons learned Close Loop Quality

Solving those challenges forced us to mature our processes and data. Each of them taught us something important.



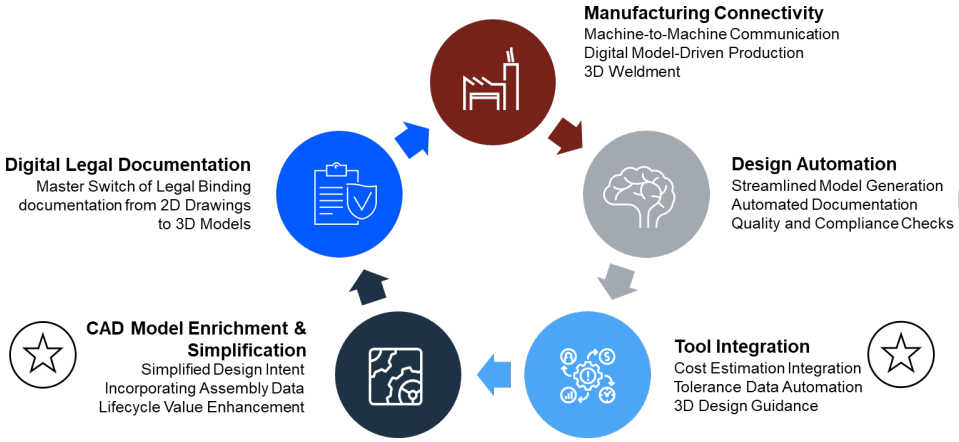
Classification: Public

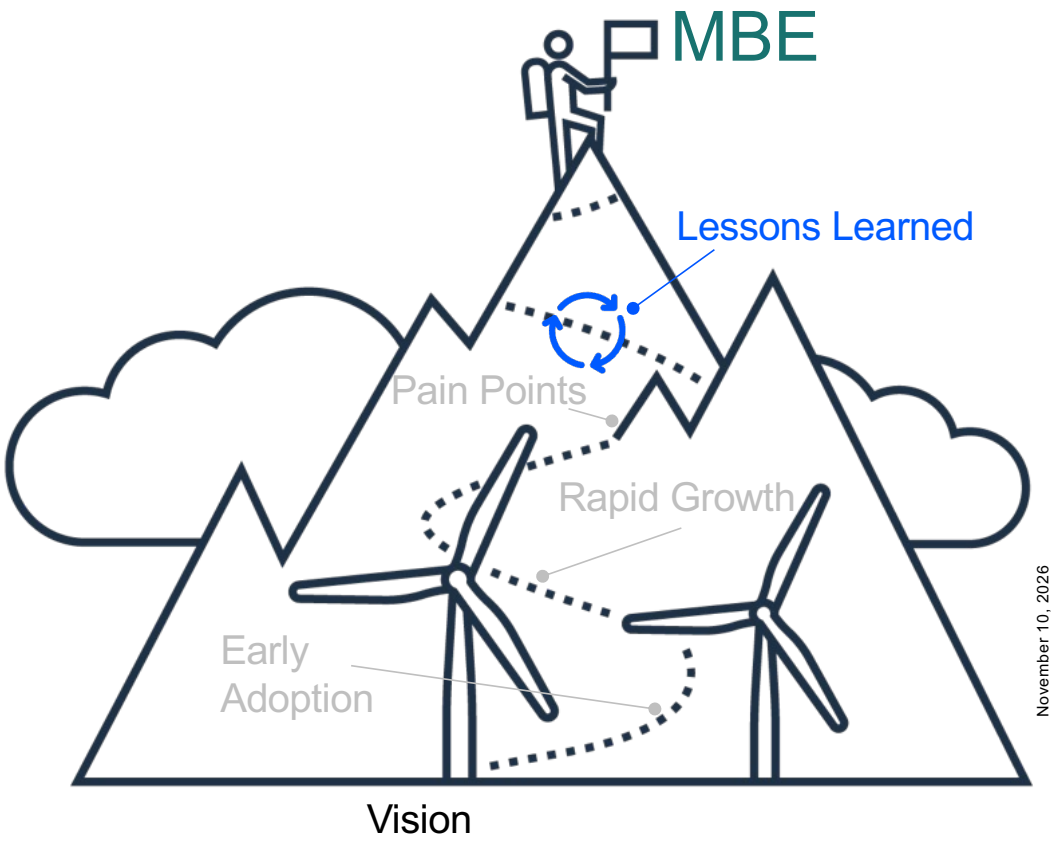
November 10, 2026

Vestas

New Capabilities Identified

Those lessons shaped the next phase of our journey and ultimately enabled capabilities we had not originally envisioned.





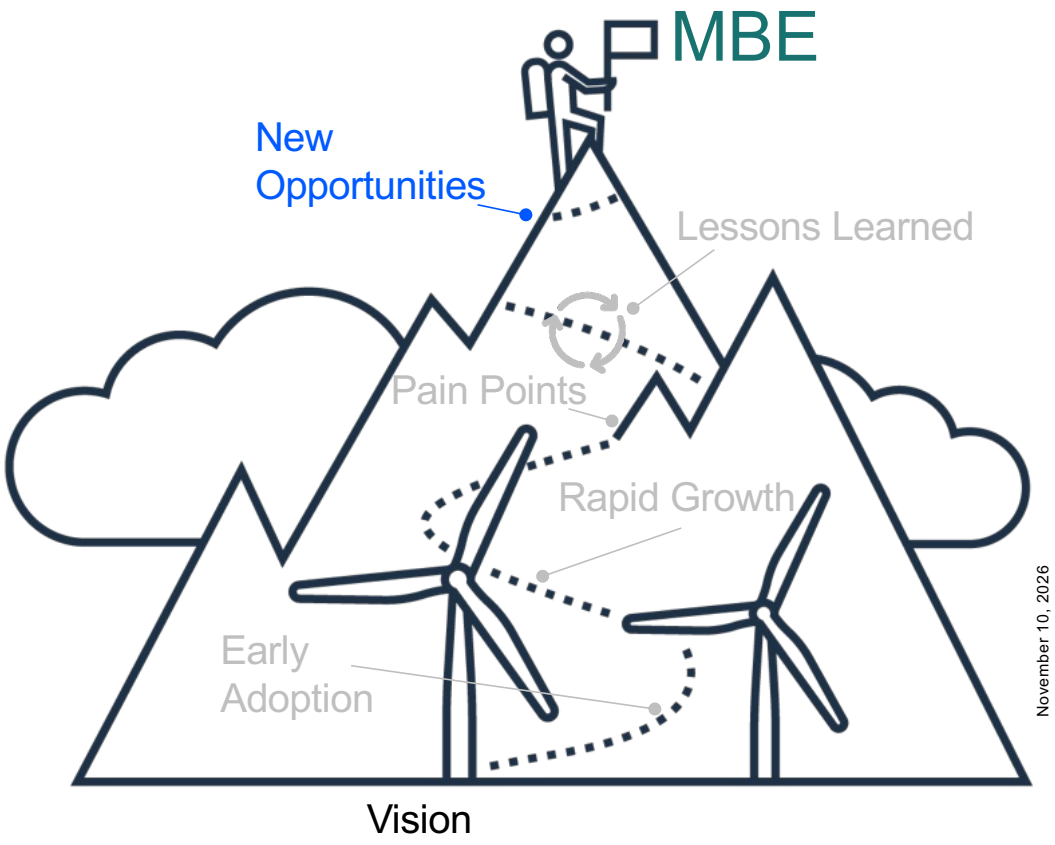
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Classification: Public

Vestas

Scaling and unlocking the potential of annotations and structure approaches to data

The surprising outcome was that the value of MBD extended far beyond documentation.



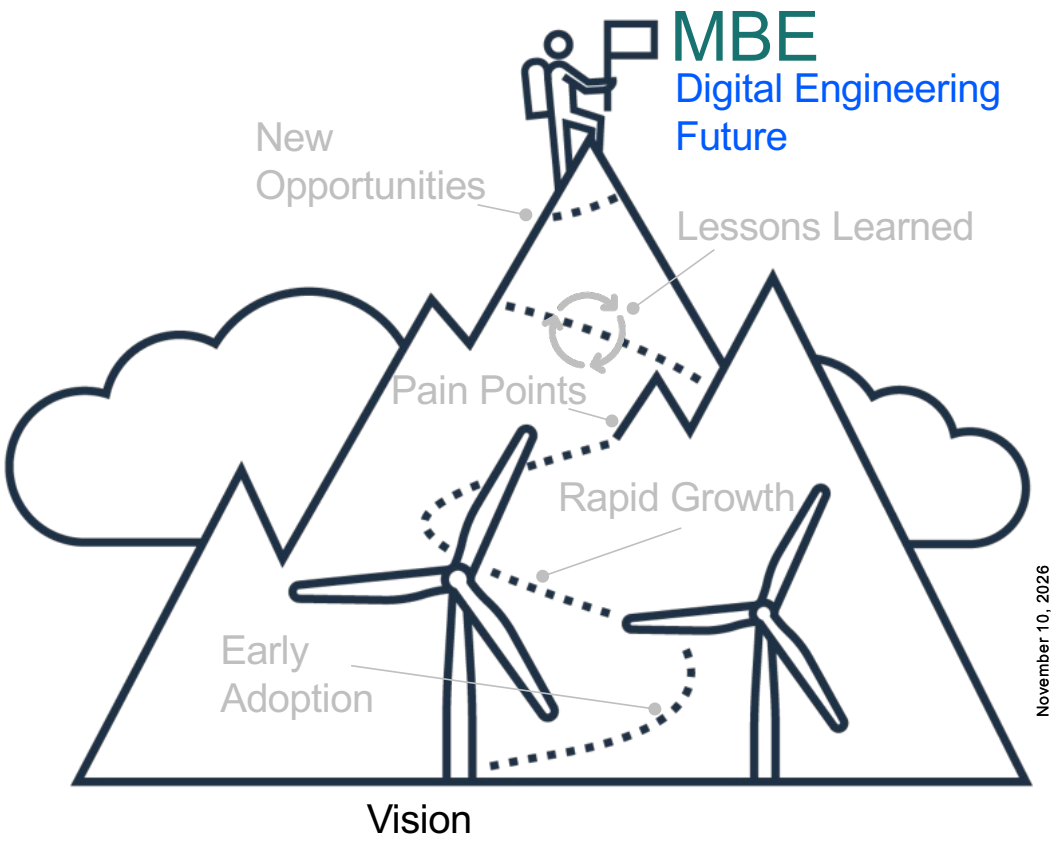
Classification: Public

November 10, 2026

Vestas

Scaling and unlocking the potential of annotations and structure approaches to data

It became not only an enabler for engineering automation but also for digital continuity."



Classification: Public

Growth and Scale



Classification: Public

Scaling

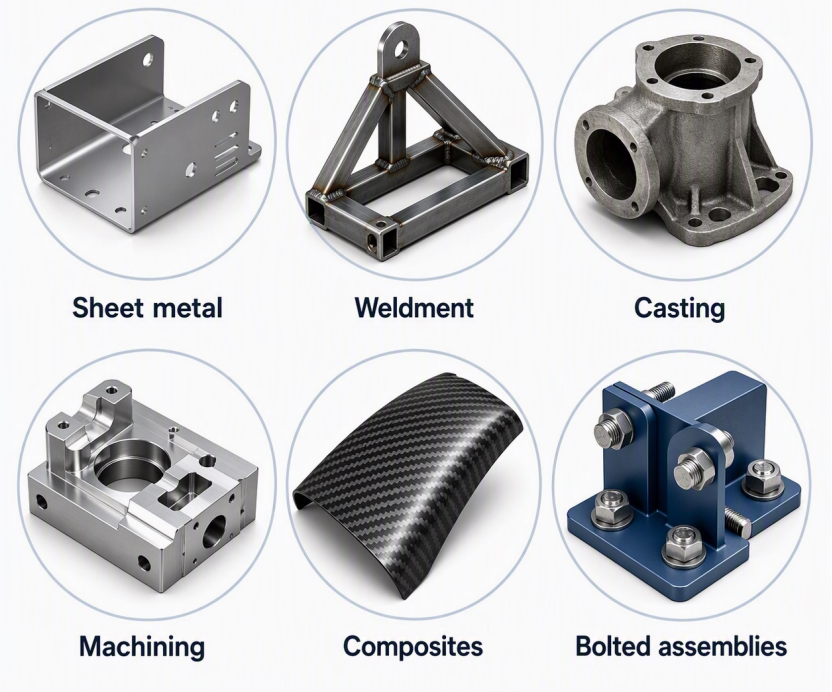
We are now able to apply MBD to many items that we design ourselves, using the following technologies:

Reaching…

77%

of the total amount of components in our wind turbine

(excluding Cables, and Hydraulic Assemblies)



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Classification: Public

Vestas

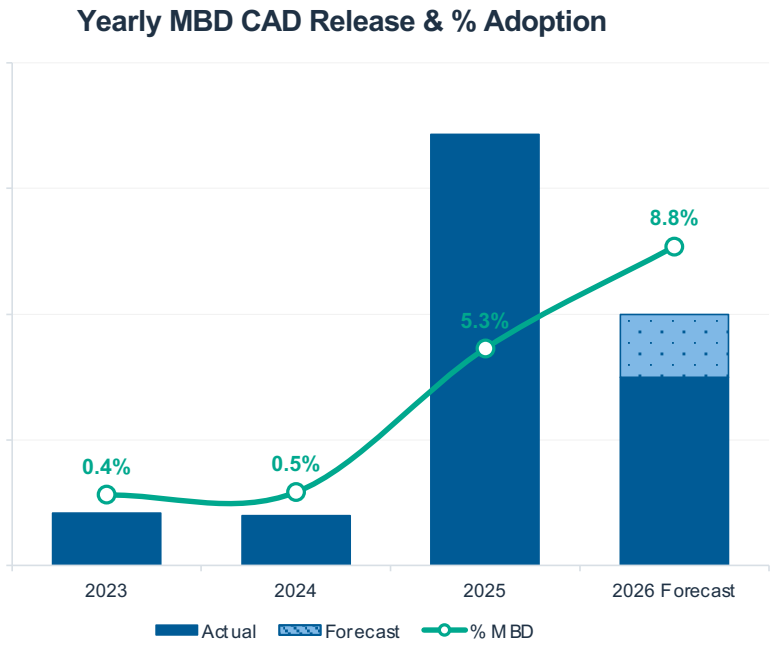
Adoption

We have increased the utilization of the technology and the adoption of MBD quite significantly:

22 times

from where we started

And during the process we have also learned that the implementation of MBD is a continuous improvement activity…



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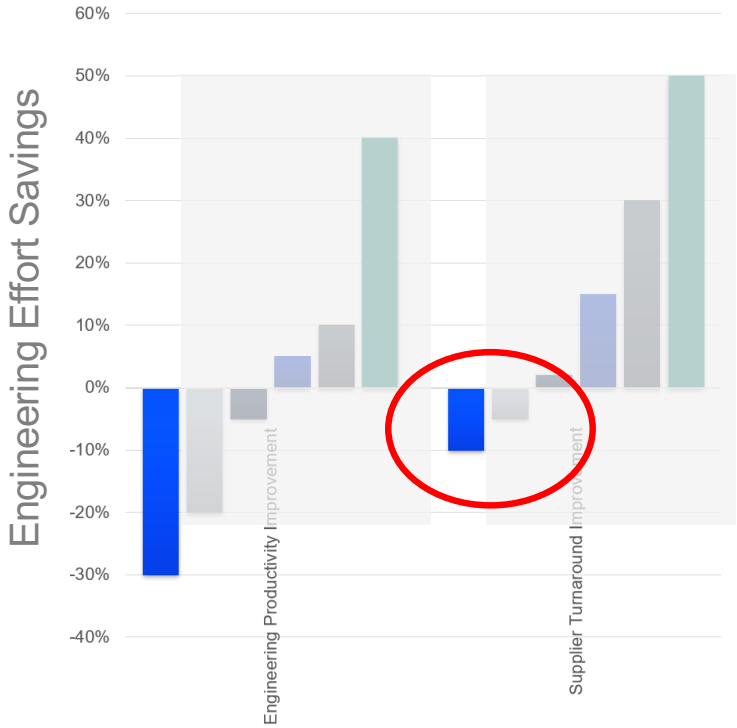
Classification: Public

Vestas

Growth pains

The first time a team converts to MBD, it is not all roses.

There is a steep learning curve and change management plays a significant role into all aspects of the technology deployment and scaling.



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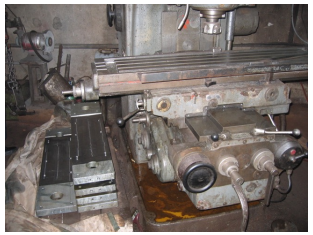
Classification: Public

Vestas

Supplier Maturity





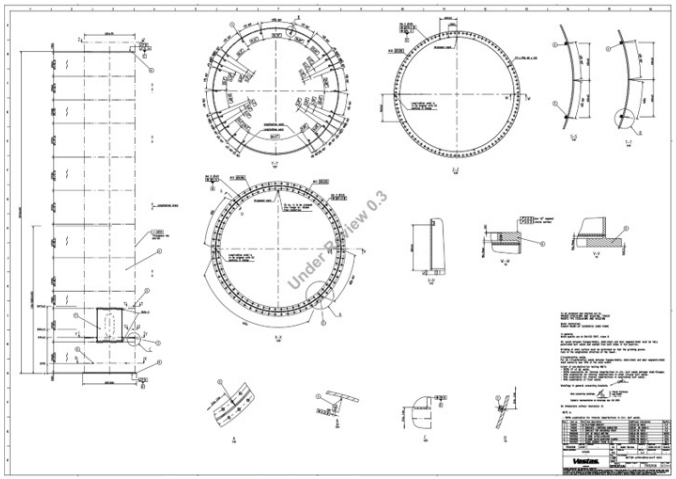


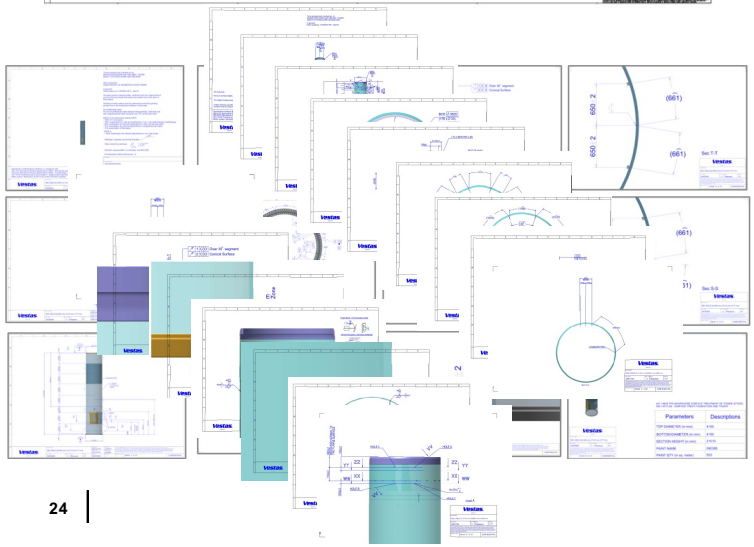


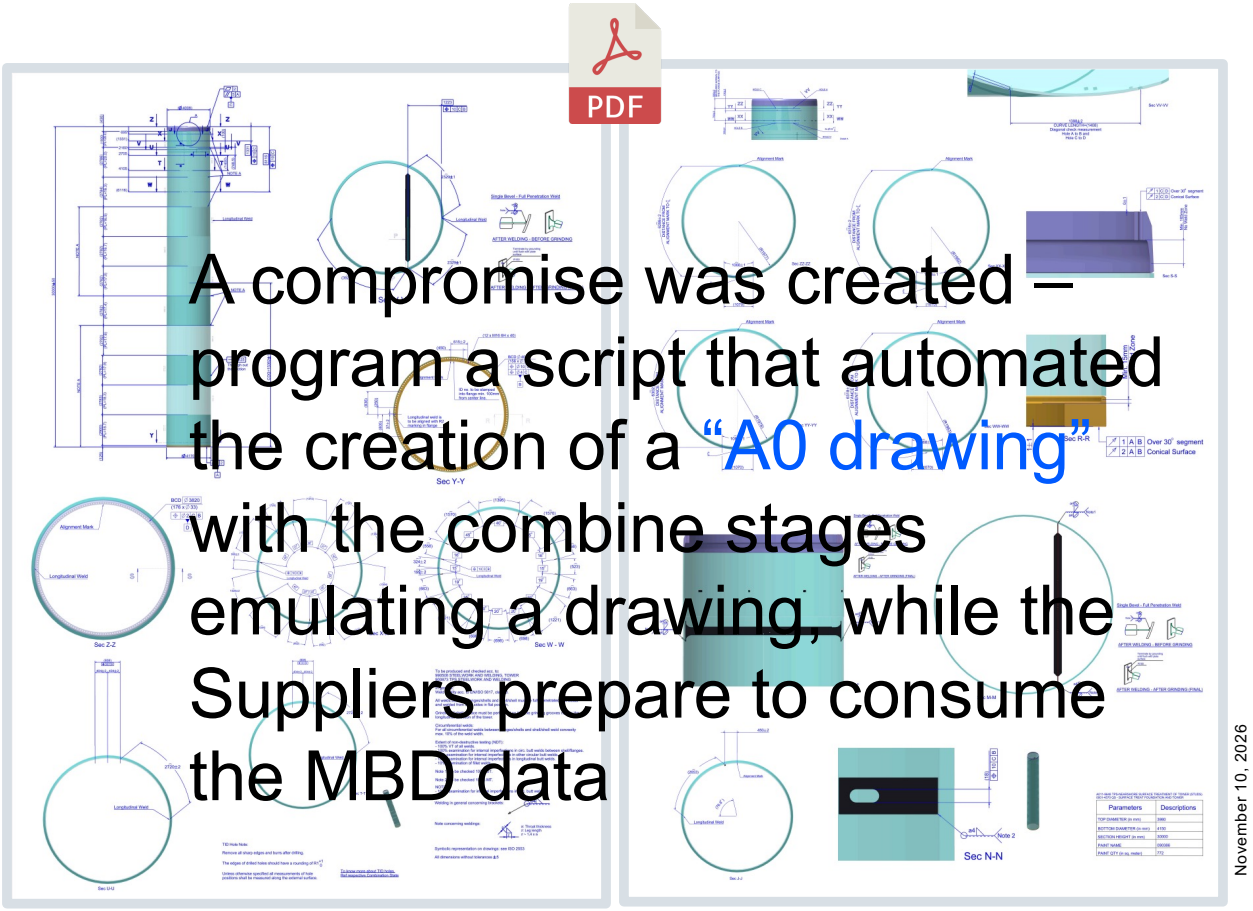

We needed to visit multiple of our suppliers and provide them training and guidance on how to profit from MBD

Classification: Public

Suppliers and 2D Drawings…







A compromise was created – program a script that automated the creation of a “A0 drawing” with the combine stages emulating a drawing, while the Suppliers prepare to consume the MBD data

Classification: Public

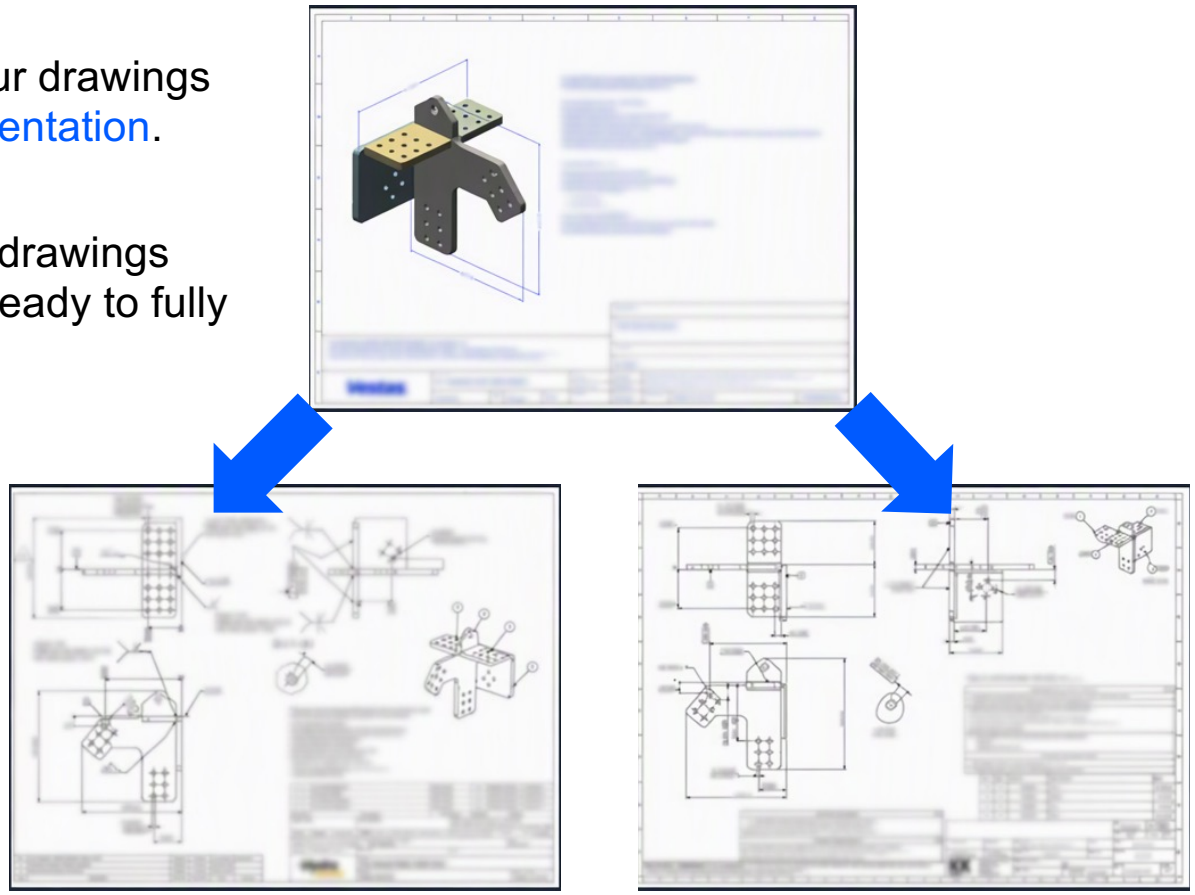
Manufacturing Drawings…

Suppliers have been, historically, using our drawings as proxies for their Manufacturing Documentation.

With MBD, they had to “RECREATE” the drawings using the 3D models until they would be ready to fully adapt to MBD.

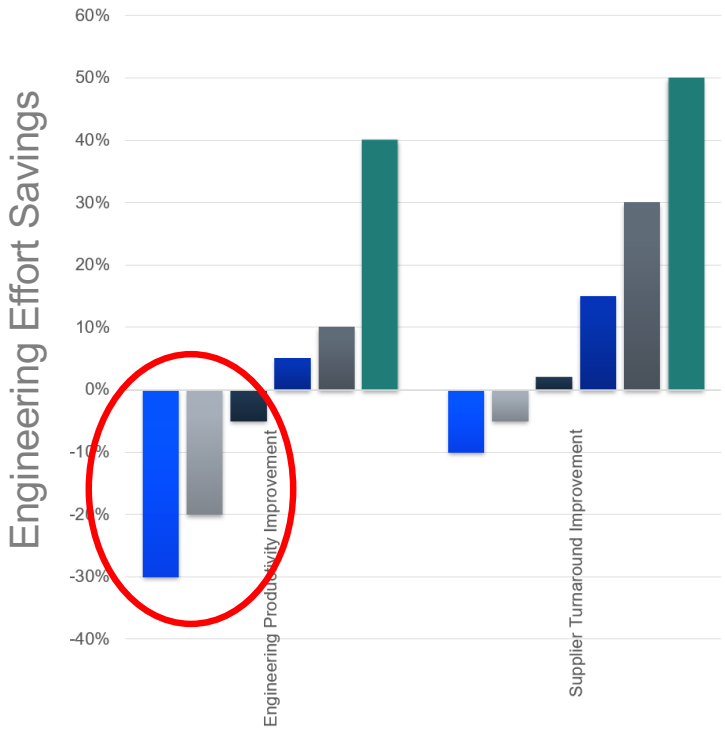
This activity has been used as an excuse to charge us for that work.

Our procurement team had to educate them on the gains of MBD and negotiate new deals and contracts with them.



Growth pains

In engineering we also felt some impact initially.

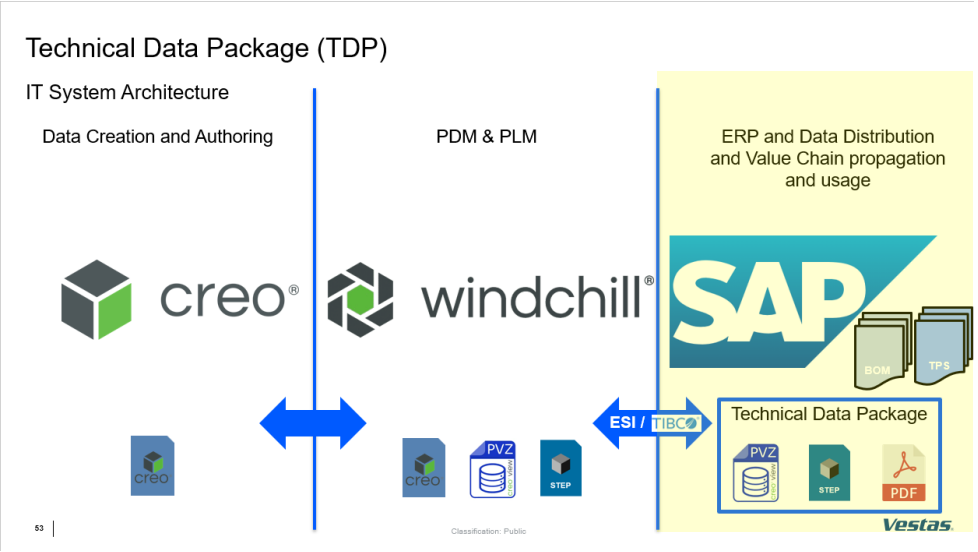


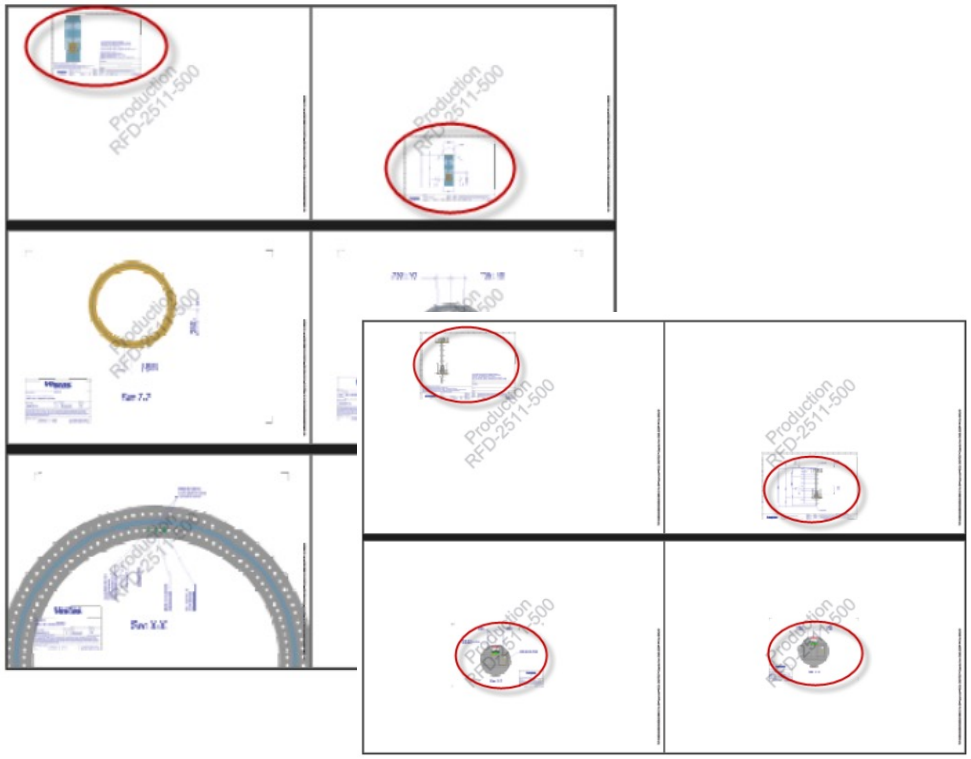
November 10, 2026

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Vestas

Internal struggles with the architecture of the solution





Our IT team not always manages to solve issues that create problems with the PDF's that we have created to help the suppliers to slowly adapt to MBD

Advise – make sure that the architecture allows the designers to review the any derivative as early as possible – possibly on the authoring tool or PLM system

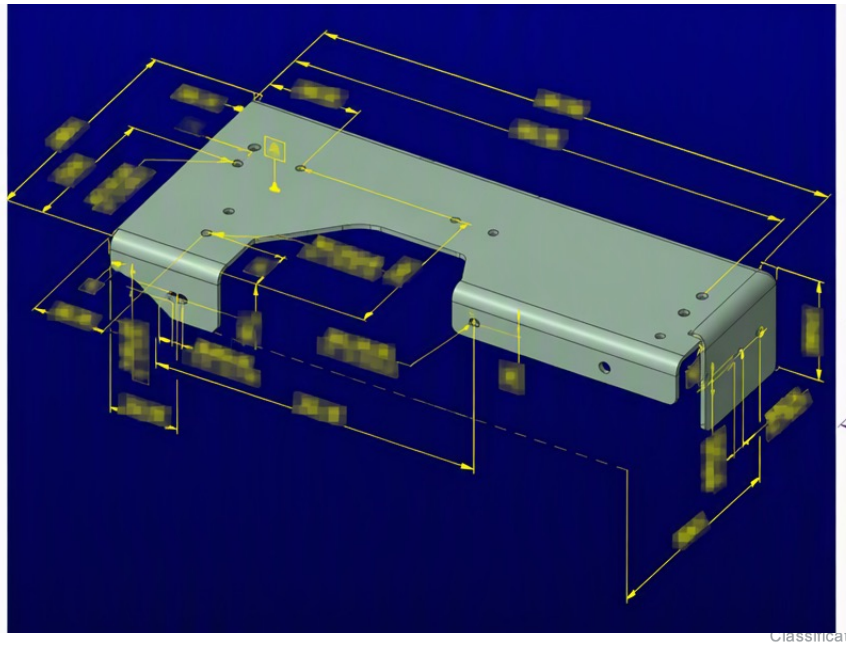
November 10, 2026

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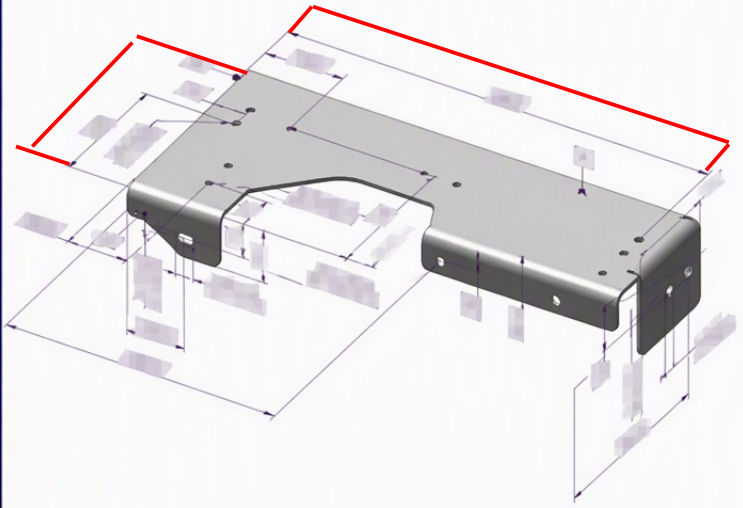
Vestas

Structural Issues with MBD - Internal STEP & Light Format models issues

Validate, Validate, Validate any derivative as early as possible



tate validation takes extra time because the
ew must be checked in both Creo and Creo View
e all dimensions, GD&T, notes, and annotations
d correctly.
what looks correct in Creo may appear
differently or be missing in Creo View, so repeated checking
is required before release.



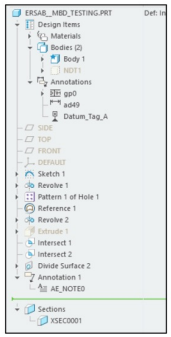
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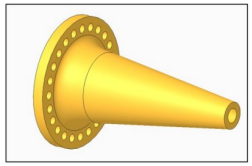
Structural Issues within MBD - Cad compatibility

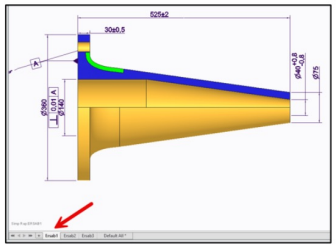
Step ap242 from Creo Parametric

Creo Parametric 12.4.2.0

Test model 1.



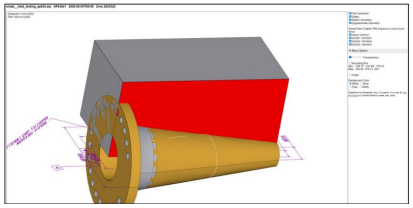




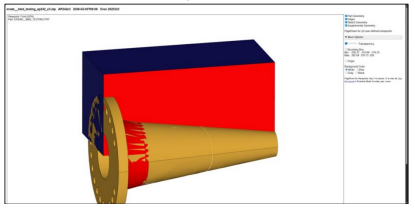
NIST STEP File Analyzer and Viewer 5.41

Note, there is less information in ap242e3 compared with ap242

ap242



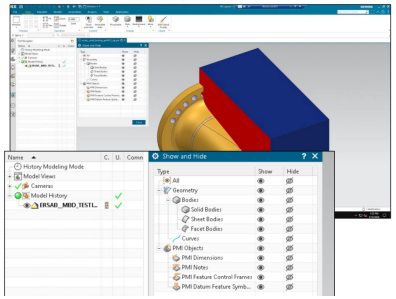
ap242e3



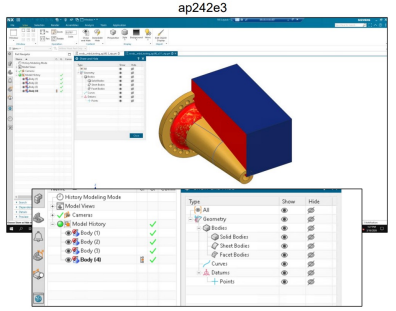
Siemens NX 1953

Note, there is less information in ap242e3 compared with ap242

ap242



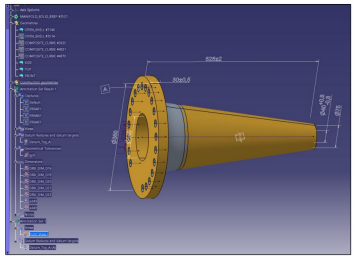
ap242e3



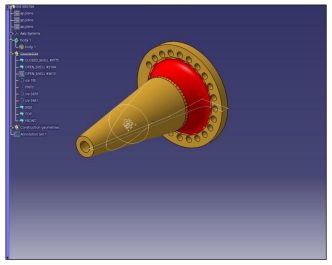
Catia V5 R6 2024

Note, there is less information in ap242e3 compared with ap242

ap242



ap242e3

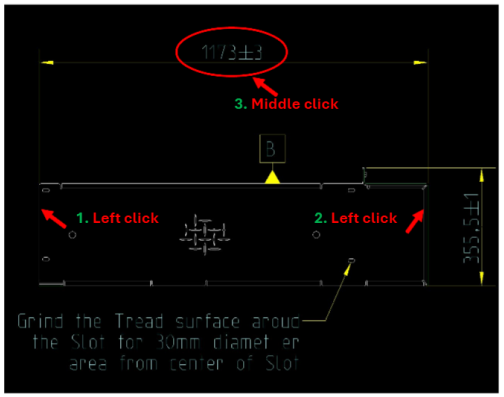


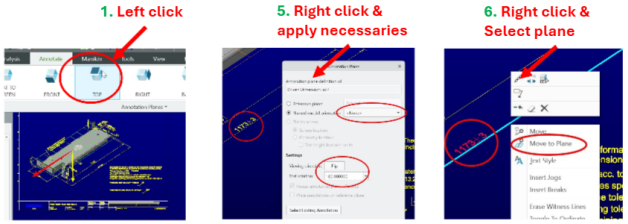
It comes down to the small details…

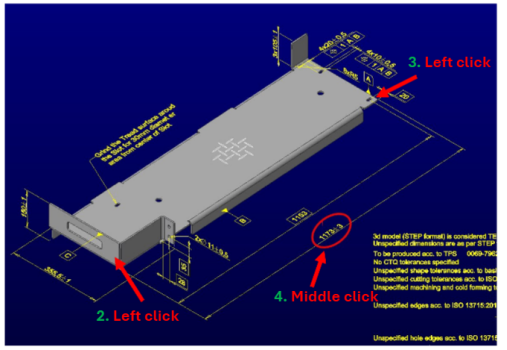
Scaling the solution means that more opinions come to the table and a lot of feedback from the engineering team arrives.

Sometimes down to the number of clicks one needs to do to get a semantic PMI annotation in the model, compared to the 2D drawing

Issues in MBD: Number of click







NOTE:

- 1. 2D takes very less number of clicks to create 1 dimension

For example:

i) Dimension creation with 3 clicks

- 2. MBD takes minimum 6 to 10 clicks to create 1 dimension.

For example:

i) Annotation plane selection,
ii) Dimension creation with 3 clicks,
iii) orientation/flip adjustment,
iv) dimension move to plane

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Classification: Public

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Challenges on training engineers and the value chain in MBD

The biggest obstacle to MBD adoption is has not been the software or the methodology.

It was to overcome centuries of engineering culture that equates more documentation with better communication.

6.000 Year History of Engineering Drawings



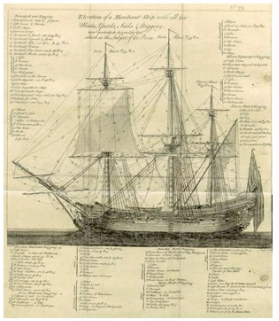
4th millennium BC



Papyrus widely used in Egypt, Greece, Roman Empire

From 3rd millennium BC





Paper arrived in Europe between the 11th and 12th centuries

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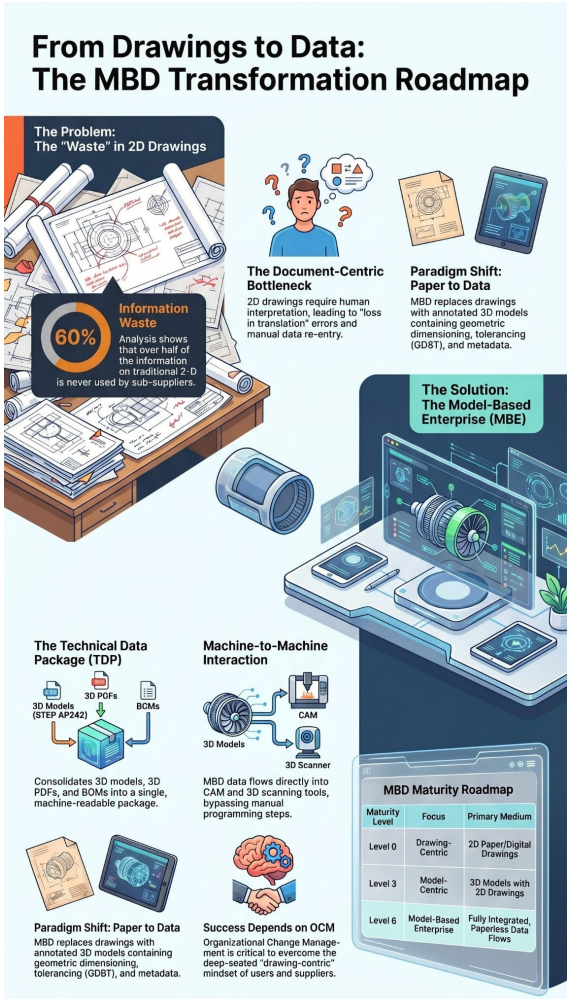
Challenges on training engineers and the value chain in MBD

The challenge is one of trust, habit, and professional identity rather than technology

Mindset: trust the 3D model as the authoritative source of product definition and communicate only the information that cannot be inherently derived from it.

This requires a shift from "adding information" to "curating information".

The engineer's value no longer comes from creating more annotations, but from deciding which annotations are truly necessary



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New opportunities



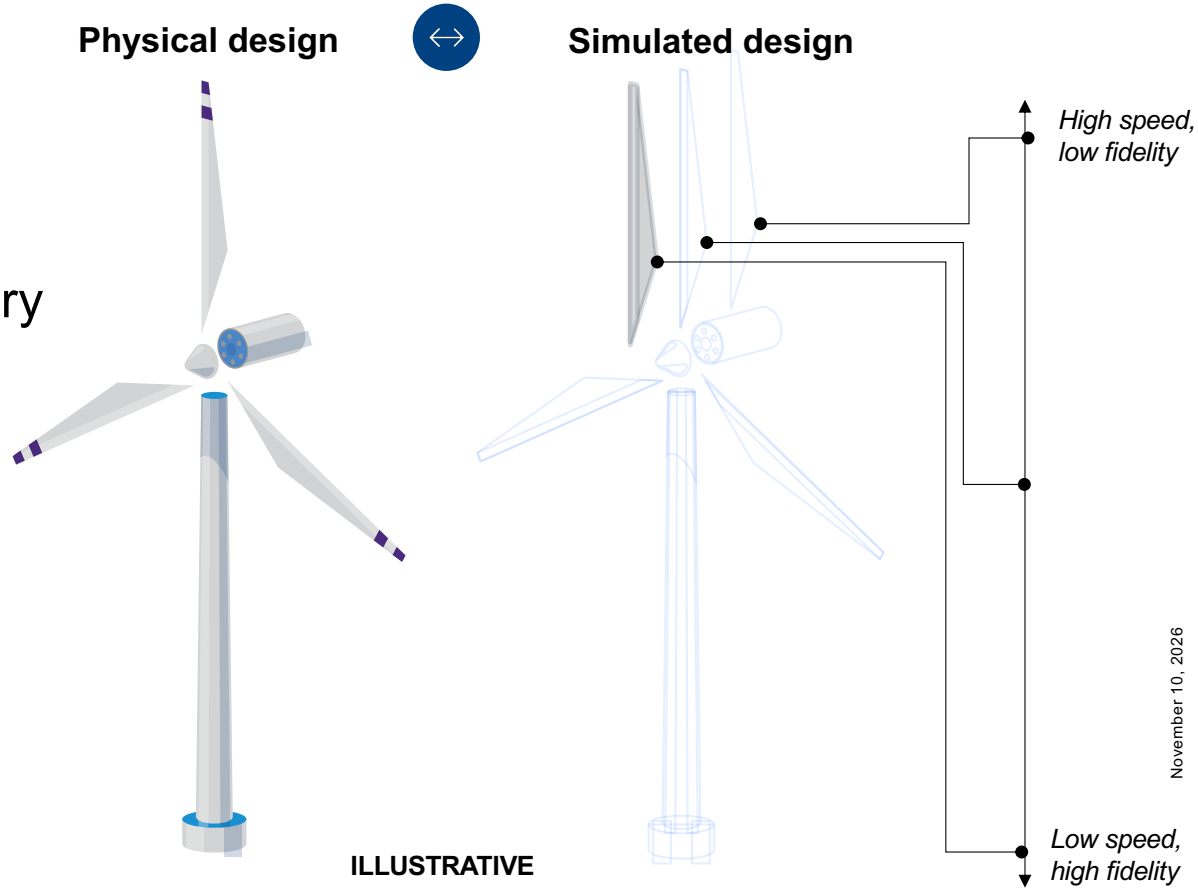
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The new possibilities that MBD enables @ Vestas

Looking inwards

The wind turbine is subject of very extreme loads and needs to sustain performance thought 20 years in very harsh conditions.

That requires us to perform a lot of structure analysis using FEA (Finite element Analysis) Software, fatigue calculations and Computer Fluid Simulation (CFD).



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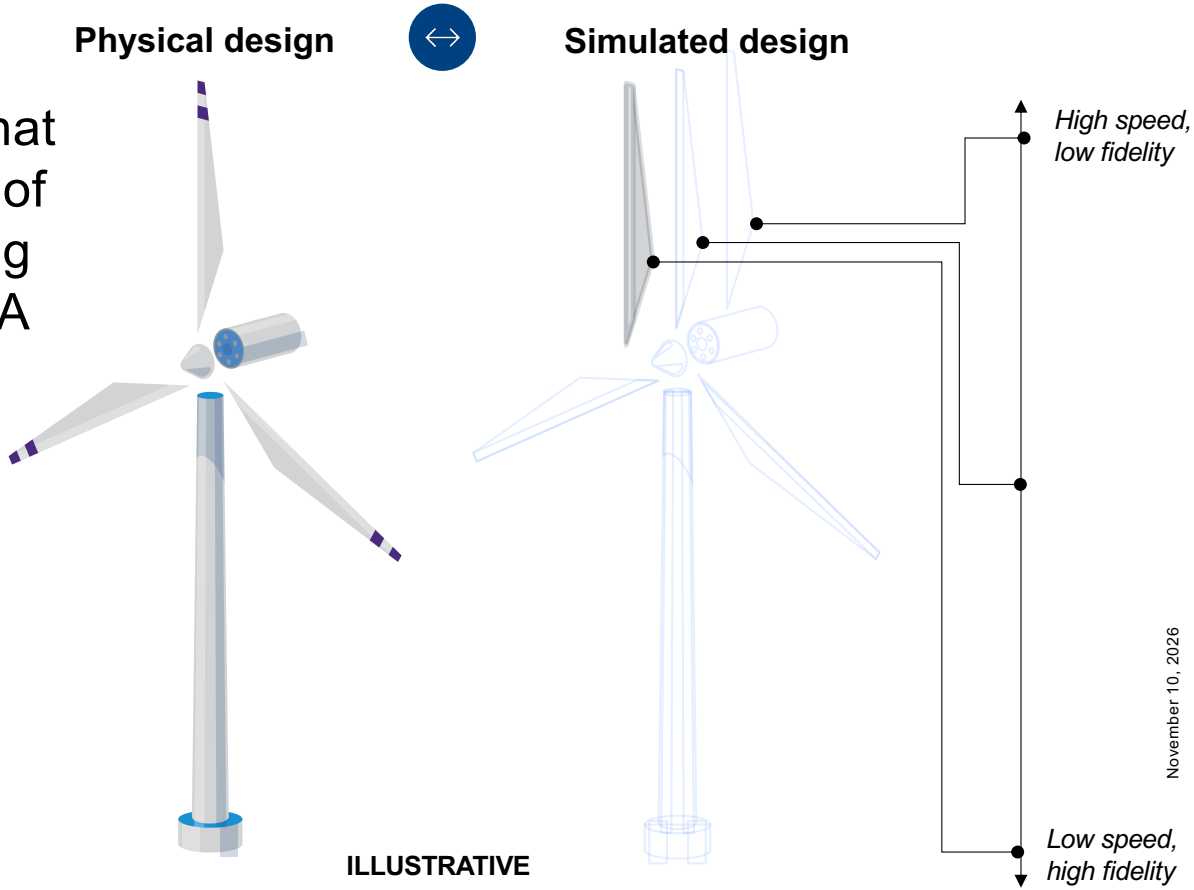
Vestas

The new possibilities that MBD enables @ Vestas

Opportunity

We understood that our designers that were spending a significant amount of time “cleaning” up 3D models, coping information from drawings to the FEA models manually on the simulation pre-processing phase of the activities…

We have heard before….

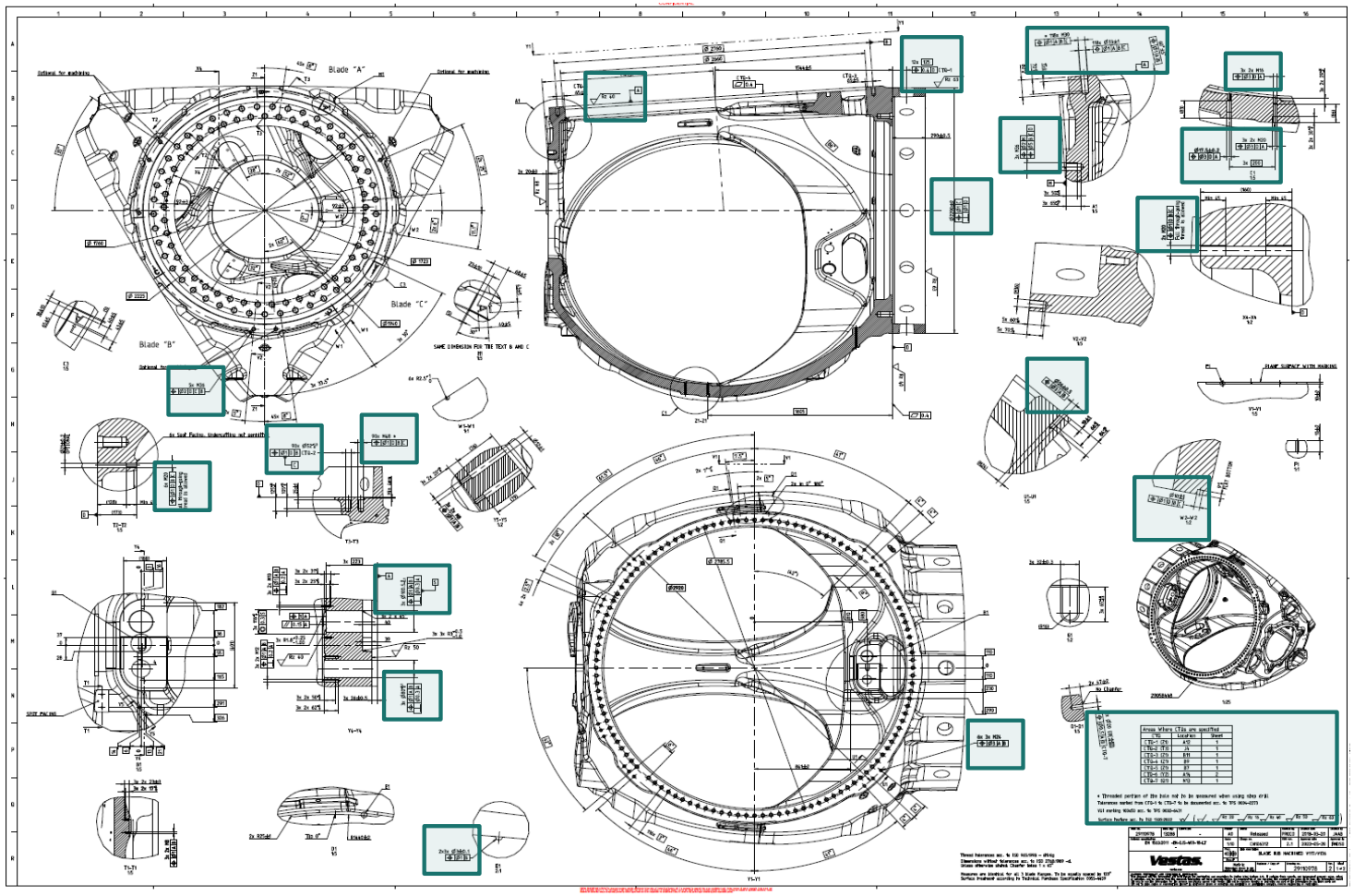


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What is important?



+

STEP

TPS

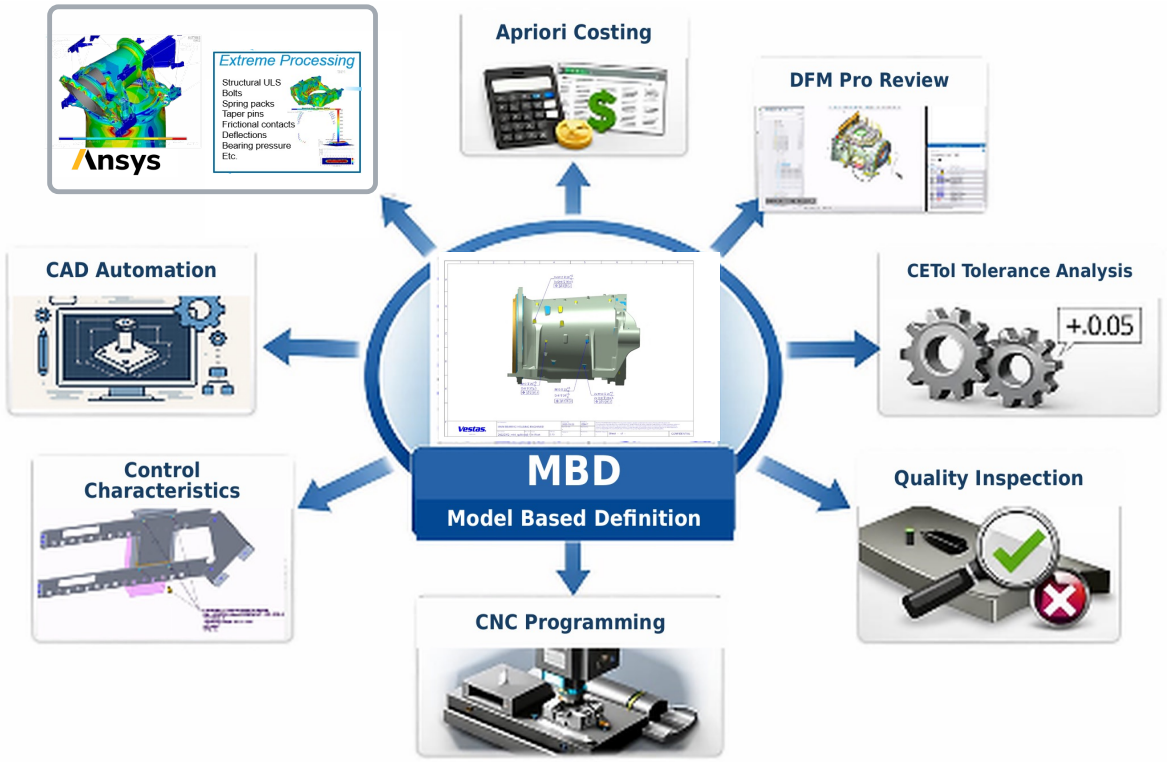
10 November 2026

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MBD Metadata transfer for FEA

We realized that besides all the gain and benefits we already have achieved with MBD, there was still more to do…

A deep integration with our Simulation Tools using the semantic data from our MBD models would unleash the power of machine-to-machine readability into the flow of intense calculation



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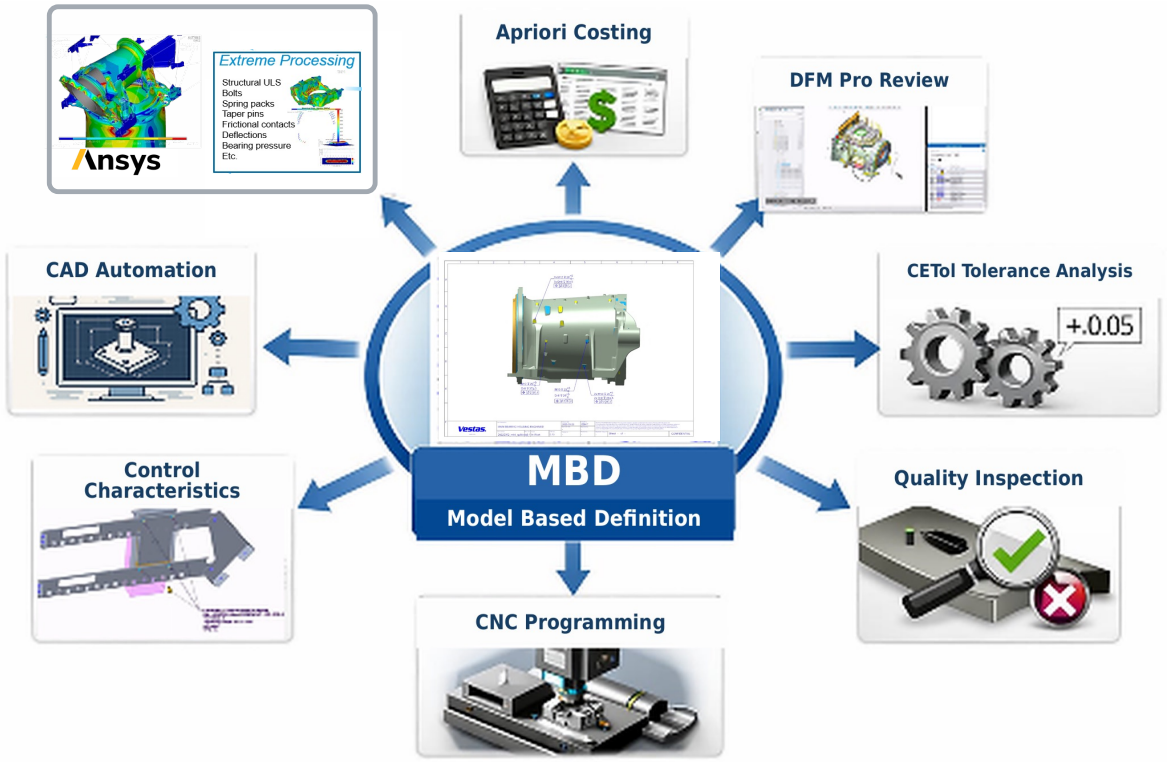
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MBD Metadata transfer for FEA

Usage of semantic annotations and attributes to define

- Machining Properties
- Surface Treatment
- Non-destructive testing (NDT) Zones
- Surface Roughness
- Materials

And adapt the way we create the MBD cad models, tailoring them for internal engineering consumptions, without jeopardizing the existing gains was the way forward



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MBD – FEA Integration Implementation

Aligned with the Simulations roadmap, Supplier-ready Model-Based Definition

TRACK 1

FEA Integration

Meta data transfer from MBD to Vestas Proprietary FEA Integration tool.

Roadmap-driven implementation

- ✓ Identify and distinguish cast surfaces from machined model
- ✓ Transfer surface treatment and surface roughness information
- ✓ Transfer fit tolerances and NDT requirements
- ✓ Transfer bolt details and bolted-interface information
- ✓ Create semantic annotation features for all data required by our FEA integration Tool

ALIGN → PROVE → SCALE

TRACK 2

Onboarding- MBA

Enable suppliers to manufacture parts directly from the MBD Technical data package.

Generic MBD requirements

- ✓ Dimensions & tolerances
- ✓ Surface treatment & roughness
- ✓ NDT Zones and machining requirements
- ✓ Engineering notes
- ✓ Semantic references
- ✓ Supplier training & Onboarding

TRAIN → VALIDATE → ONBOARD

APPROACH | Align, train and onboard suppliers with the existing model; update it once all internal requirements are ready

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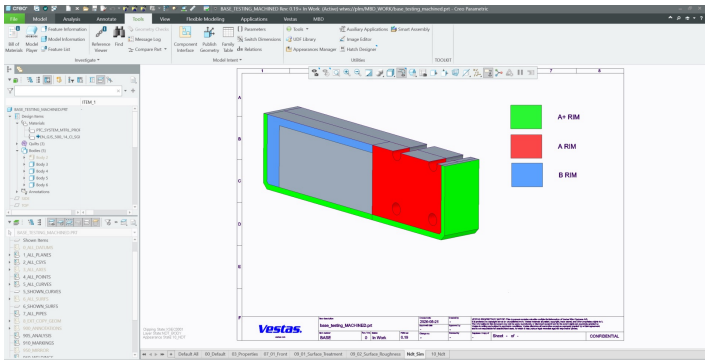
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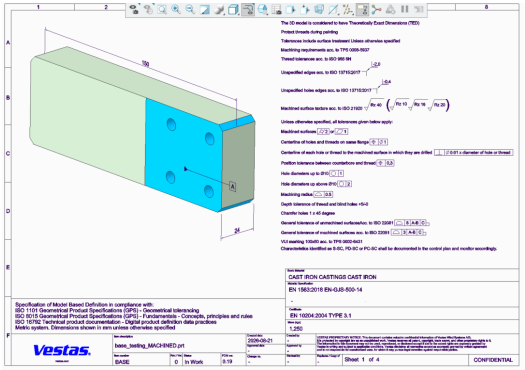
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New 3D CAD Modeling Methodology

Clear and steady methodology on CAD creation to create predictability for automation and data transferring

Tailoring of the methodology of creating CAD models to enhance the internal calculation systems and Increase significantly the robustness and speed of models





Deliver methodology for creating robust CAD models with meta data (MBD) that works for simulations and the entire value stream

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The investment of MBD returns take some time, but is quite **SOLID**



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Cost out of designing and measurement (forecast)

	Internal Cost Out Creation and Review	External Cost Out Measurement
Towers Automation	40%	0%
Casting Machining	40%	20%
Sheet Metal	40%	75%
Welded	75%	20%
Total	50%	50%

Annotated 3d model
Easy understanding and reviewing

Machine readable
Notes, dimensions and tolerances tied to a features or surfaces

Full measurable part geometry
Less dimensions required

One master product definition with all information
Easy to “Check in” in Windchill

Reduce time to market
Simpler compared to 2D

Automation potential
One click tower automation

Possibility to use
color

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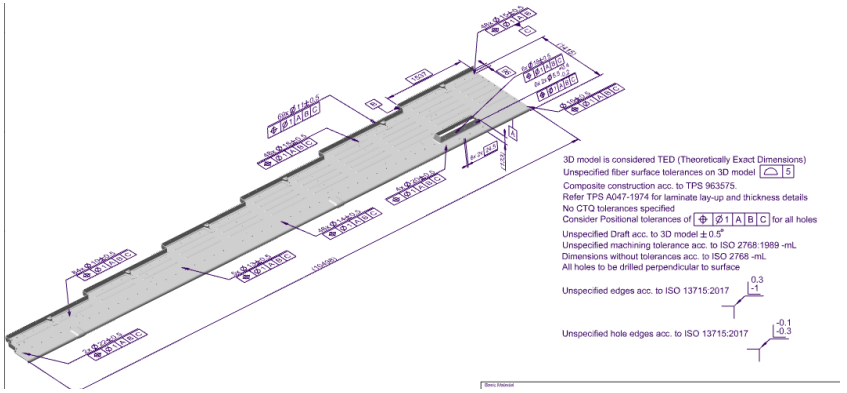
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Comparison calculation examples

Feedback received from Nacelle cover

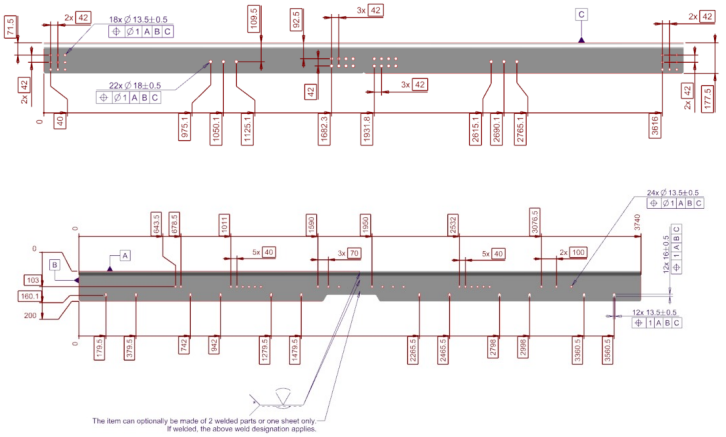
Feeback from - PRAAR

DESCRIPTION		Drawing from scratch (Min)	TIME SPENT FOR MBD (Min)
SHEET,METAL,3636 mm,150 mm,8 mm,STEEL	Updated	90	15
SHEET,METAL,1524 mm,150 mm,8 mm,STEEL	Updated	90	15
SHEET,METAL,177 mm,158 mm,12 mm,CS	Updated	90	15
PLATE,ALLOY STEEL,350 mm,200 mm,5 mm	Updated	90	15
SHEET,METAL,247 mm,127 mm,10 mm,CS	Updated	90	15
SHEET,METAL,3829.5 mm,240 mm,10 mm,CS	Updated	90	15
SHEET,METAL,205 mm,101 mm,12 mm,CS	Updated	90	15
SHEET,METAL,613 mm,205 mm,12 mm,CS	Updated	90	15
SHEET,METAL,205 mm,101 mm,12 mm,CS	Updated	90	15
SHEET,METAL,476.5 mm,205 mm,12 mm,CS	Updated	90	15
PLATE,SS,112 mm,75 mm,5 mm	Updated	90	15
Total saving Percentage		**86%**	



Feedback received from Cooler top

Number of cooler top Components/ Turbine	Traditional 2d drawings	MBD Technology	Total Hours savings/ Turbine
70	70*6 = 420 Hours	~ 50 Hours	370 Hours
Total saving Percentage		**88%**	



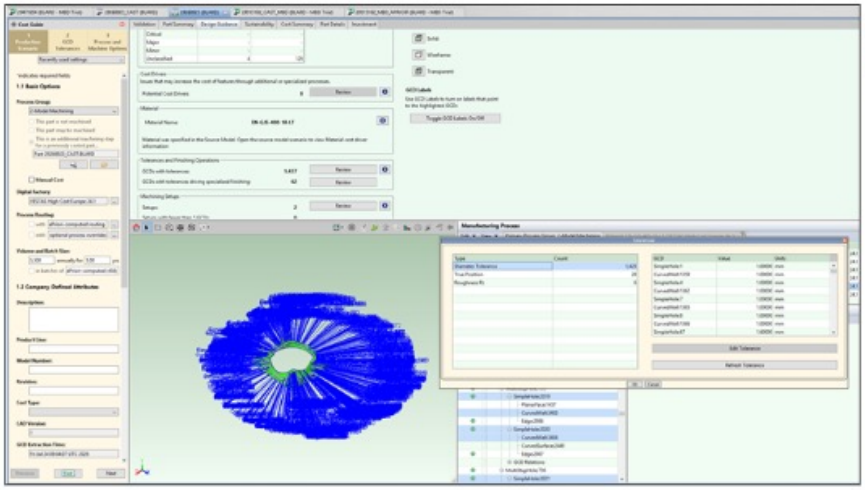
Only Internal CAD Hours savings considered here

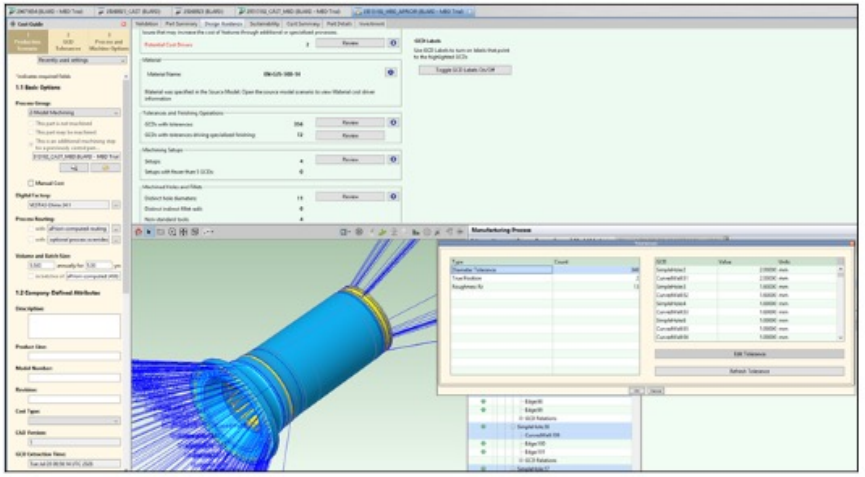
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Cost Calculation using Apriori

Executive Summary

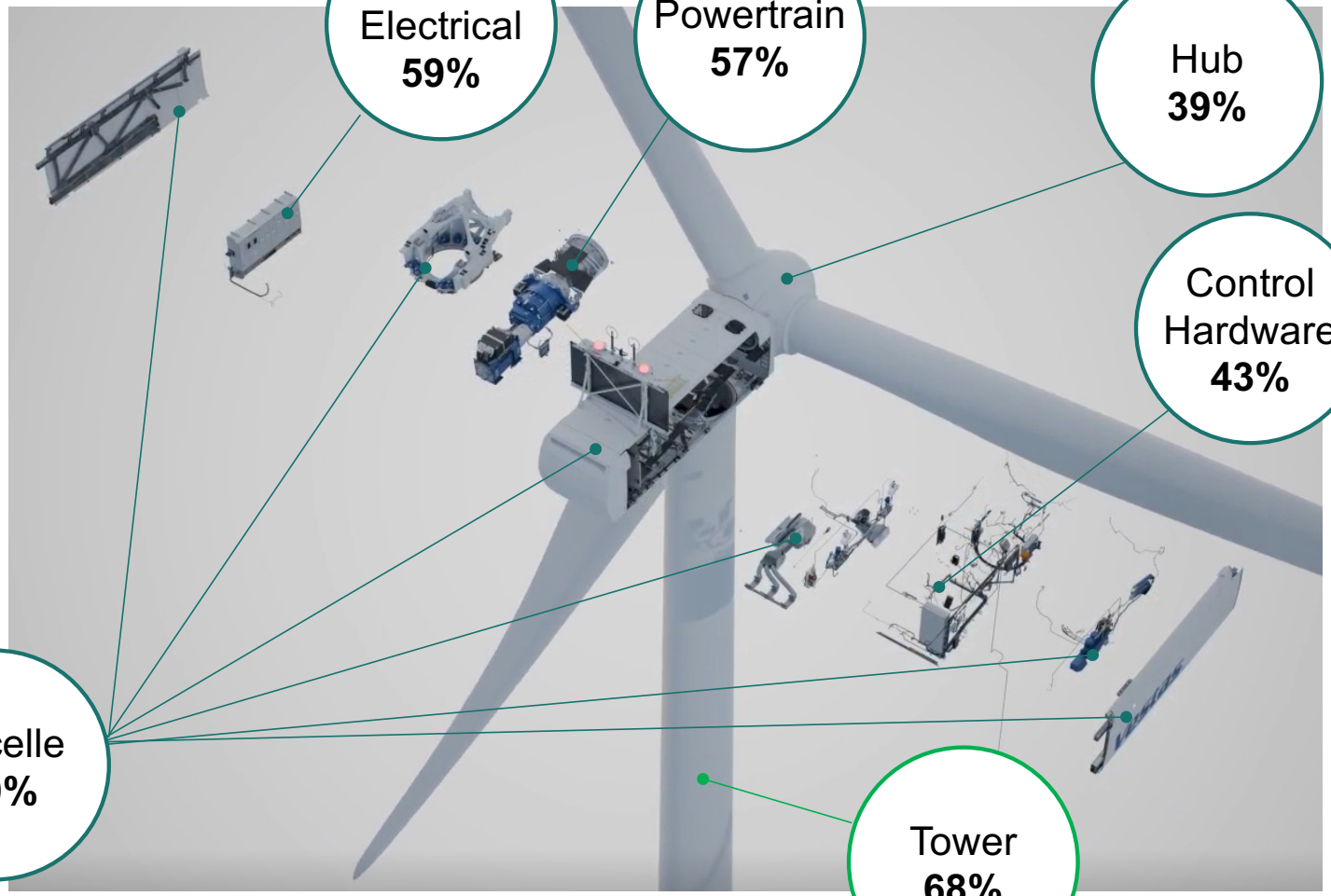
[redacted]	Part Type	GD&T Count	Time Saved per Part
	Simple Sheet Metal	11	10–12 min
	Medium Weldment	27	30–35 min
	Complex Casting [redacted]	356	4–5 hrs.
	Complex Casting	1,437	10–11 hrs.
	Complex Casting	1,351	10–11 hrs.





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R&D hours reduction



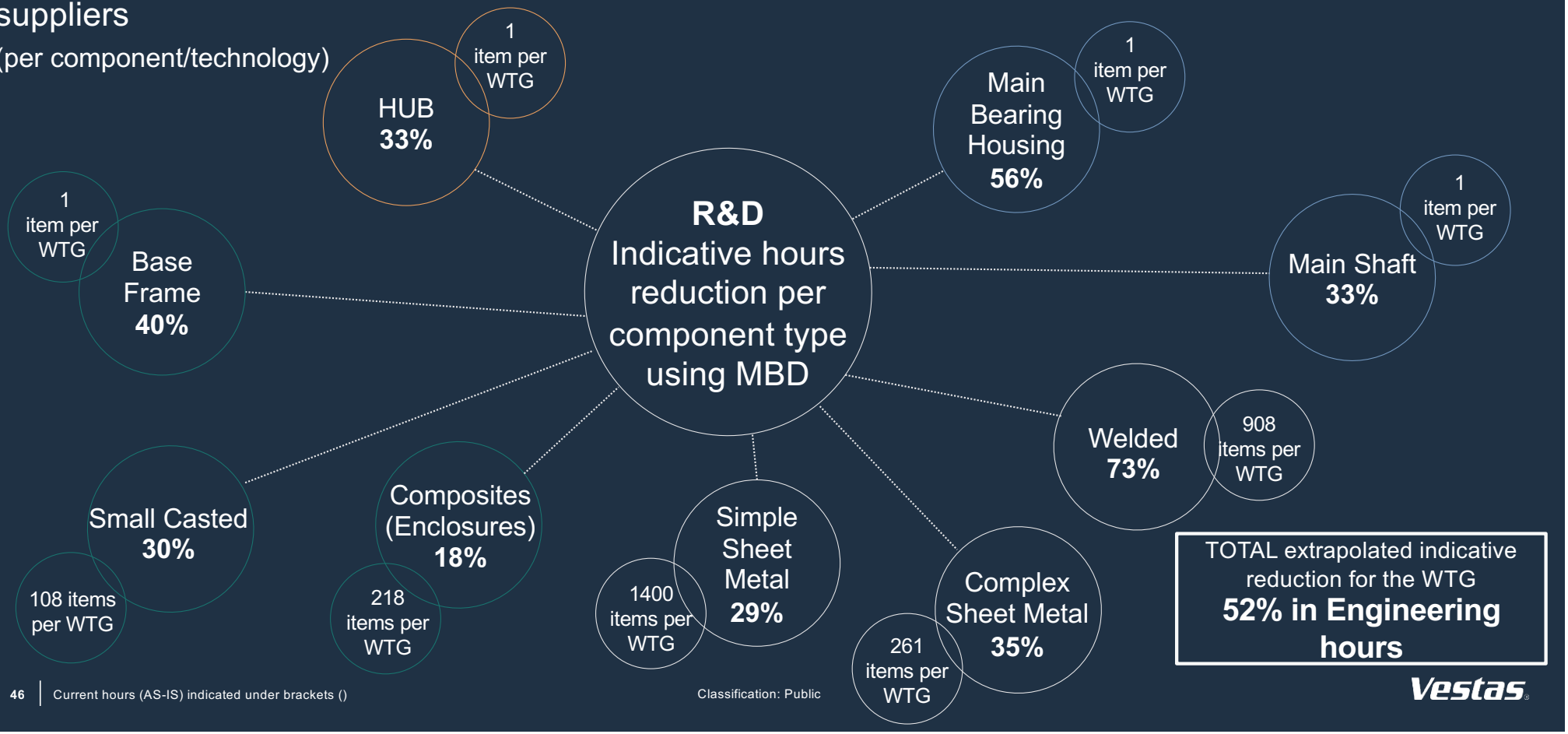
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GAINS FOR ENGINEERING – % OF IMPROVEMENTS

Considering a full new WTG Design

Indicative Reduction of hours on creation (CAD Hours) and **review** of the documentation for our suppliers

(per component/technology)



TOTAL extrapolated indicative reduction for the WTG
52% in Engineering hours

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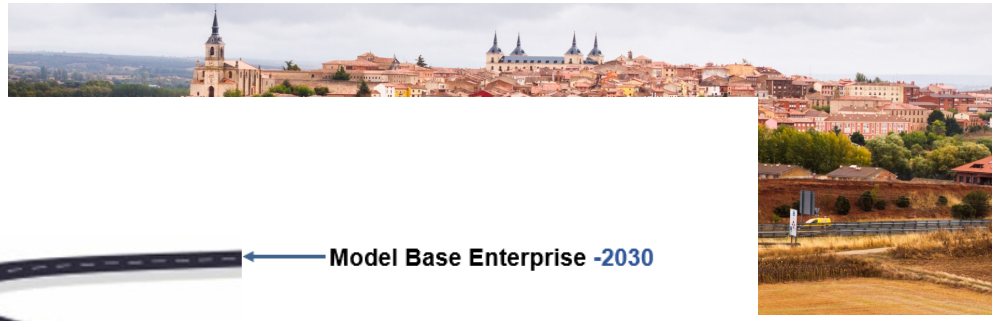
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Next Steps

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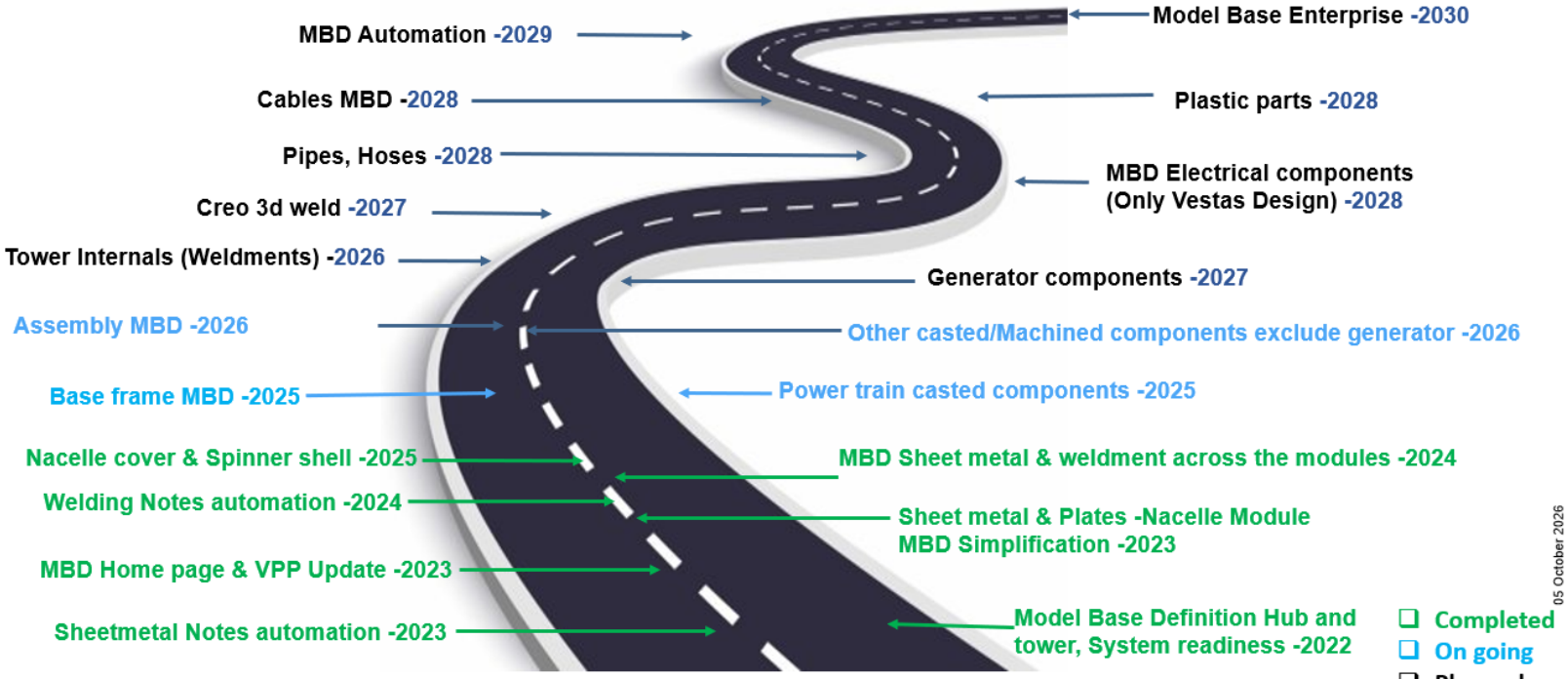
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ROADMAP



05 October 2026

November 10, 2026

Accelerate the roadmap and continue the development of missing areas

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Conclusions

Scaling the technology is possible in a very controlled way

Keep focus on stakeholders is a must do

Capture the lessons learned and apply automation towards the pain points

Continue engaging with management and constantly reminding the bigger picture

Simplify even more workflows and processes



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Wind. It means the world to us.™

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