

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

CIMdata

PLM Road Map™ & PDT North America 2023
The Digital Thread in a Heterogeneous, Extended Enterprise Reality
A call for PLM Professionals to share their knowledge & experience
May 3 & 4

CIMdata **—eurostep—**

**Digital Thread:
Why Should We Care**
PLM Road Map™ &
PDT North America 2023

3 May 2023—Washington D.C. USA

Peter Bilello, President & CEO, p.bilello@CIMdata.com
+1.734.668.9922

www.CIMdata.com
Copyright © 2023

CIMdata Defining What Comes Next in Digital Transformation

Strategic management consulting for competitive advantage in global markets

The leading independent authority on PLM and its digital transformation. We provide research, education, and strategic consulting to clients around the world.

OUR MISSION:
Maximizing clients' ability to design, acquire, deliver, and support innovative products and services.

www.CIMdata.com
Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

CIMdata

CIMdata's Services

 Strategic advice & counsel through a comprehensive & integrated set of services



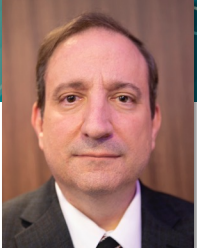
<ul style="list-style-type: none">• Research & analysis• Technology evaluations• Market-specific insights• Industry news & trends	<ul style="list-style-type: none">• Industry conferences• Seminars & webinars• Certificate programs• Best practices	<ul style="list-style-type: none">• Strategic guidance• Aligning solutions with needs• Program management advisement• Market positioning
--	--	---

3 Copyright © 2023

CIMdata

Peter A. Bilello, President & CEO

 Professional background




- More than 35 years of experience in the development of IT solutions for research, engineering, and manufacturing organizations worldwide
- Led numerous projects in PLM analysis, selection, implementation & management, synchronous and lean manufacturing consulting & software engineering, as well as general data management & governance strategy development and support
- Authored many papers & research reports on PLM and related topics, as well as numerous articles, commentaries, and perspectives that have appeared in publications throughout the NA, EMEA & Asia
- Holds a B.S. in Computer Science (minor in Physics) & M.S.E. in Manufacturing Systems Engineering


4 Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023




Key Takeaways


 Digital Thread: Why Should We Care (1 of 2)

- The digital thread is one of CIMdata's Critical Dozen Digital Transformation trends & enablers
- Digital threads sew together disciplines, as well as the end-to-end product lifecycle
- The digital thread is best represented as a network of decisions that connect data & processes—these threads define a digital web/network
- An organization's digital web must have a purpose—it is not linear
- Understanding the human factor in digital web/network enablement is critical, along with data governance

5 Copyright © 2023



Key Takeaways

 Digital Thread: Why Should We Care (2 of 2)

- Digital web/network implementations are never straightforward
- A sound plan to maintain & enhance the organization's digital web/network throughout its useful life must be defined & maintained
- The value of the digital thread lies in the myriad of links to data that feed & validate decision-making from concept through life
- A digital web/network is required to support a digital twin's creation and management
- A digital web/network and its potentially countless digital threads helps us see into every product- or service-related decision

6 Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

CIMdata

Agenda

- What is the Digital Thread
- How to Create the Digital Thread
- The Human Side of the Digital Thread
- Why Should We Care
- Concluding Remarks

7 Copyright © 2023

CIMdata

CIMdata's Critical Dozen

01 End-to-end connectivity

02 Data & process management

03 Configuration management


04 Bills of information

05 Model-based structures

06 Digital thread

CIMdata's Critical Dozen
The Top 12 Trends and Enablers of Digital Transformation


12 familiar, evolving trends & key enablers of digital transformation that you cannot, or should not, live without.




8 Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

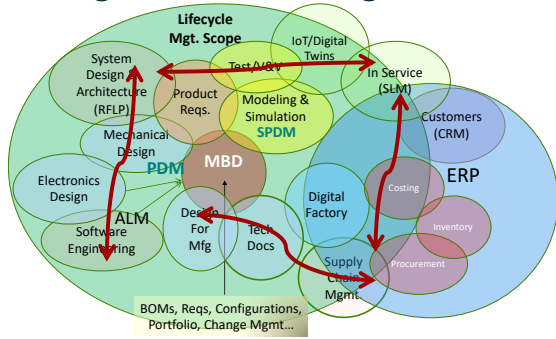


Defining the Digital Thread



CIMdata's preferred definition

- A **communication framework** that allows a connected data flow & integrated view of an asset's data (i.e., its Digital Twin) throughout its lifecycle across traditionally siloed functional perspectives


Digital thread is enabled and supported by a robust end-to-end and connected systems model and MBSE processes



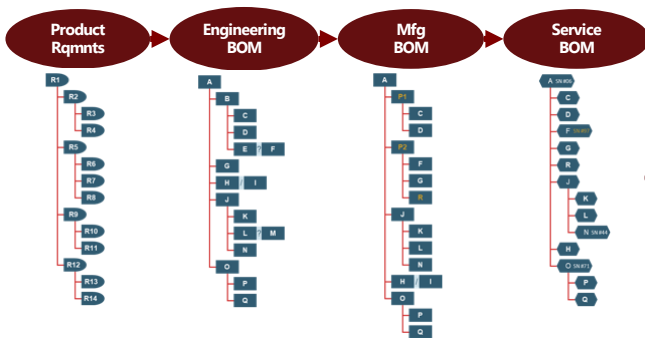
Extracted from: https://www.dodmantech.com/ManTechPrograms/Files/AirForce/Cleared_DT_for_Website.pdf
 Also see: <http://www.manufacturing-operations-management.com/manufacturing/2016/04/what-is-the-digital-thread-and-digital-twin-definition.html>
Copyright © 2023



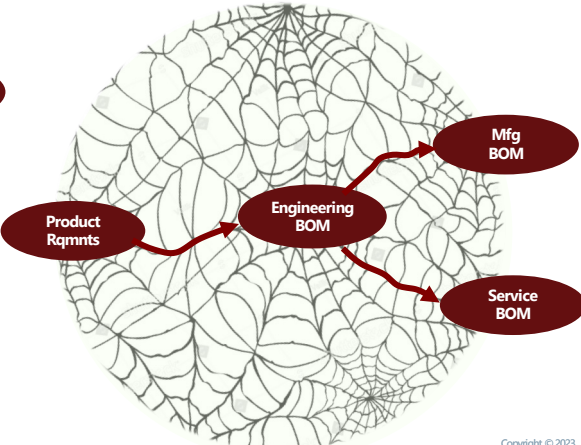
E2E: Lifecycle Product Structures


Connections between the four principal structure configurations – Thread vs. Web

Product Lifecycle Timeline Sequence (Thread)



Derivative Dependencies (Web)



10
Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

Digital Thread: In Summary



In essence, what is a digital thread?

- A digital thread/web is a chart, or network of decisions
- A digital thread must effectively connect data and processes so that digital twins can be created, maintained, and leveraged
- A web or network is a more realistic representation of how data and processes are interconnected in enterprises
- Each of these webs can contain hundreds of informational nodes and data repositories
 - These range from simple flat files to model-based structures, each packed with info critical for making sound process decisions

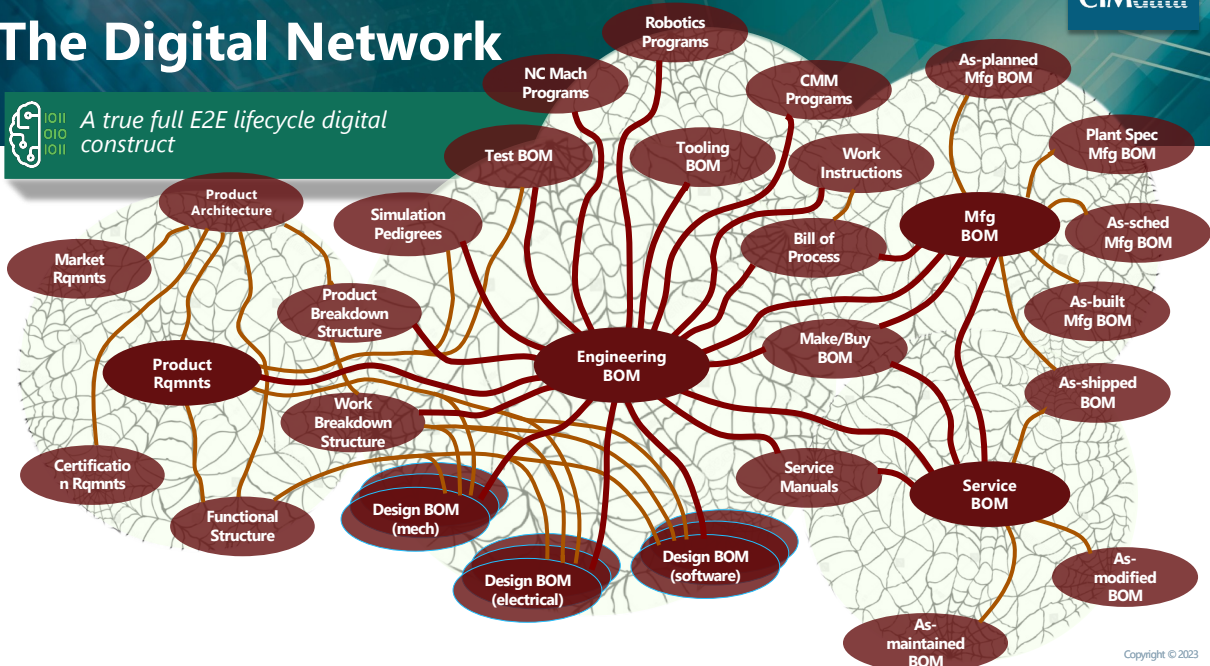
11

Copyright © 2023

The Digital Network



A true full E2E lifecycle digital construct



12

Copyright © 2023

Digital Thread: Why Should We Care


PLM Road Map™ & PDT North America 2023—3 May 2023




Agenda

- What is the Digital Thread
- How to Create the Digital Thread
- The Human Side of the Digital Thread
- Why Should We Care
- Concluding Remarks

13 Copyright © 2023



Creating a Digital Network: A Starting Point

 *This means choosing and connecting to the many data repositories relevant for any given process*

- Unfortunately, no two business units or departments organize their information in the same way, so establishing these connections can be tedious—but they are crucial
- One should start at the beginning of product conceptualization:
 - Marketplace information on what sells and what does not
 - Add to this any related competitive analyses that try to predict which product features and capabilities will be snapped up and which may be ignored
- With marketplace requirements clearly understood, the organization can move on to building out its digital web/network


14 Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

CIMdata

Creating a Digital Network: What's Next


 *A digital network can & should be systematically defined to maximize benefits (1 of 3)*

- Examine regulatory requirements databases—these hold countless must-have requirements
- Examine industry standards, every industrial markets have “do” & “don’t” data that must not be overlooked
- Find repositories that aggregate customer wants & needs
- Connect with systems & tools used by developers & design engineers to do the primary geometric configurations of new products
 - CAD/CAE, EDA/MDA, PDM/PLM, simulation and analysis

15 Copyright © 2023

CIMdata

Creating a Digital Network: What's Next

 *A digital network can & should be systematically defined to maximize benefits (2 of 3)*

- Identify additional configuration refinements that developers and designers use, e.g., CAM, MES/MOM, M&S, and MRP/ERP
- Build connections to the engineering bill of materials (eBOM) and other BOMs in production, and to the systems that generate BOMs for downstream & upstream use, such as sales, marketing & service
- Identify key repositories in the MBSE domain that the business unit or enterprise implemented in its move away from paper & 2D drawings
- Reach deeper into downstream data repositories where modifications are generated in every new product's later development stages


16 Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

CIMdata

Creating a Digital Network: What's Next


 *A digital network can & should be systematically defined to maximize benefits (3 of 3)*

- Don't forget a vital connection—*engineering change process*, a consistent approach to managing & tracking network changes
- Developers & maintainers of digital networks should always be on the lookout for feedback loops
 - Even simple processes may have dozens of loops feeding changes and decisions back “upstream” to the beginnings of processes
 - These loops keep processes up-to-date, playing a major role in the organization's drive for continuous improvement

17 Copyright © 2023

CIMdata

Creating a Digital Network: Closing the Loop


 *The final two connections that must be considered for digital web/network enablement*

- The databases in design engineering that track fast-moving developments in CAD/CAE and EDA, CAM, MES/MOM, and of course PDM/PLM
 - Monitoring these developments helps digital network users keep up with developers' and designers' new techniques
- The databases that monitor the impacts of technology & economics on customer expectations
 - Tracking these impacts can help users of digital networks anticipate decisions that developers and designers are likely to face near-term
- Both can help keep complexity from being overwhelming

18 Copyright © 2023

Digital Thread: Why Should We Care


PLM Road Map™ & PDT North America 2023—3 May 2023




Agenda

- What is the Digital Thread
- How to Create the Digital Thread
- The Human Side of the Digital Thread
- Why Should We Care
- Concluding Remarks

19 Copyright © 2023



Considering the Human Factor



Understanding the human factor in digital network enablement is critical

- In the development, production, and service of any product, there is a very human tendency to underestimate the range of factors impacting each decision
- Also commonly underestimated is:
 - The vast amount of information available
 - The variety of repositories & other sources
 - The likelihood of unexpected change
 - The complexity of other parts of any process when compared to one's own role
- These result in short-sightedness, and all can be averted or overcome with the appropriate digital web/network

20 Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

CIMdata

A Few Additional Considerations



Some of the common challenges

- Digital web/network implementations are never straightforward, and changes to connections to any one repository may affect feedback loops and links to other data stores
- Not all the repositories are to be found in your business unit or even in your enterprise
 - Almost every organization is part of another organization's digital web/network
- A significant amount of coding & testing is inevitable

21

Copyright © 2023

CIMdata

A Few Final Points



Some practical advice (1 of 2)

- Any process can be enabled with a digital web/network in different ways and purposes—thereby defining different digital constructs
 - An organization needs to reach agreements with all users on what its digital threads should achieve—their purpose & expected value, why they are needed and by whom—what its digital web/network must support
- To assure access to the internal technical expertise & outside resources
 - Actively promote the benefits of the digital network & its multiple threads
- Data Governance must be implemented to ensure that all extended enterprise participants have access to clear, concise, and valid data
 - i.e., ensure that all information assets are trustworthy

22


Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

CIMdata

A Few Final Points

 Some practical advice (2 of 2)

- Delve deeply into the tools available in your PLM solution(s), as well as the supported & necessary data standards
 - They are numerous and powerful, but many require significant experience to use effectively
- Enlist help with technical issues, especially connectivity to the variety of repositories and data formats (old & new) that will be encountered
- Develop a sound plan to maintain and enhance the organization's digital web/network throughout its useful life, just as the underlying processes & threads must be maintained

23Copyright © 2023

CIMdata

Agenda

- What is the Digital Thread
- How to Create the Digital Thread
- The Human Side of the Digital Thread
- Why Should We Care
- Concluding Remarks


24Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

CIMdata

Finding the Digital Network's Value

 The value of an organization's digital network lies in what it is designed to represent (1 of 2)

- The value lies in the myriad of links to data & information that feed & validate decision-making from concept through life
- It enables digital twins of its physical assets—an exact, up-to-date digital representation of the enterprise's physical products or services, or even its manufacturing system
- It captures & represents all the decisions made throughout the lifecycle of a product or service, and the impacts of those decisions
- Building the digital web/network is about choosing which informational nodes & repositories to link in any given process & how best to digitize those links

25 Copyright © 2023

CIMdata

Finding the Digital Network's Value

 The value of an organization's digital network lies in what it is designed to represent (2 of 2)

- Once the effort needed to build a digital web/network is understood, it is more than reasonable to ask, *"Why go to all this trouble?"*
- Fundamentally, a digital web/network, and it potentially countless digital threads, helps us see into every product- or service-related decision, and better understand how & why each decision was made
 - If we fail to remember why a decision was made and what we considered in reaching it, we will fail to learn from our past mistakes and risk repeating them
 - Worse, we will be unable to build on our prior successes
- Bear in mind that a digital thread is required to support a digital twin's creation & management

26 Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

CIMdata

CIMdata's Critical Dozen: What's Next

01 End-to-end connectivity

02 Data & process management

03 Configuration management

04 Bills of information

05 Model-based structures

06 Digital thread

07 Digital twin

CIMdata's Critical Dozen
The Top 12 Trends and Enablers of Digital Transformation

12 familiar, evolving trends & key enablers of digital transformation that you cannot, or should not, live without.

The more comprehensive & effective the digital network, the greater the value of its digital twin to its users

27

Copyright © 2023

CIMdata

Digital Twin

A digital representation of products and/or services at any point throughout the lifecycle

- A **virtual representation** (i.e., digital surrogate) of a physical asset or collection of physical assets (i.e., physical twin) that exploits data flow to/from the associated physical asset(s).

Digital Twin of the Product

Digital Twin of Production

Digital Twin of Service

Digital twin is enabled and supported by a robust end-to-end and connected systems model and MBSE processes

28

*Adapted from input from ASSESS (see www.assessinitiative.com)


Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023

CIMdata

Digital Twins


 Key characteristics

- There are multiple Digital Twins for different purposes, each have specific characteristics
 - For example, Data Analytics Digital Twins, MRO Digital Twins, Financial Digital Twins, Engineering Digital Twins, and Engineering Simulation Digital Twins
- Each Digital Twin must have a physical twin (i.e., a physical asset)
 - A virtual representation can and should exist prior to its physical twin
 - The physical asset can be a plant, a ship, infrastructure, a car, etc.
- Each Digital Twin must communication with its Physical Twin
 - It does not have to be real time or electronic

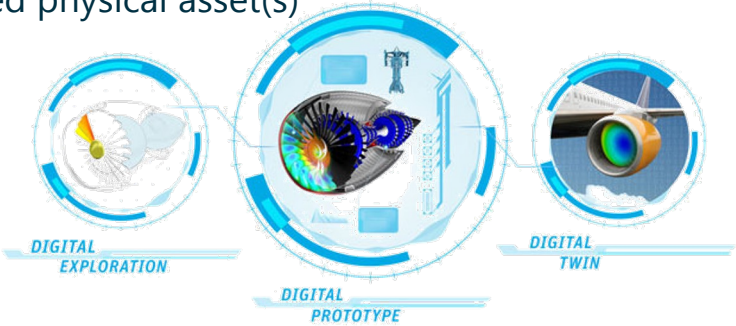
29 Adapted from input from ASSESS (see www.assessinitiative.com) Copyright © 2023

CIMdata

Engineering Simulation Digital Twin

 CIMdata's preferred definition

- A **physics-based virtual representation** of a physical asset or collection of physical assets (physical twin) that allows simulations of the associated physical asset(s)



DIGITAL EXPLORATION DIGITAL PROTOTYPE DIGITAL TWIN

(Courtesy of Ansys) Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023



Creating & Maintaining the Digital Twins


Digital Twin vision cannot be achieved without a full product/process model

Physical Asset



Physics-based analytics

CAD Courtesy of Volvo Cars

<http://www.ansys-blog.com/digital-twin-pump/>

Digital Twin -- From Design to Operation

Virtual Prototype




https://community.plm.automation.siemens.com/15/Tecnomatix-News/Digital-Twin-Blurring-the-lines-between-reality-and-simulation/ba-p/333483



https://blogs.dmg.com/software/2016/04/digital-twins-structural-engineering/

Copyright © 2023

31



CIMdata's Critical Dozen: What's Beyond

01

End-to-end connectivity

02

Data & process management

03


Configuration management

04

Bills of information

05

Model-based structures



12

Digital skills transformation

CIMdata's Critical Dozen

The Top 12 Trends and Enablers of Digital Transformation

12 familiar, evolving trends & key enablers of digital transformation that you cannot, or should not, live without.

11

Data governance

10

Big data & analytics

09

Changing views of "product"

08

IoT & PLM

06

Digital thread


07

Digital twin

32

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023




Agenda


- What is the Digital Thread
- How to Create the Digital Thread
- The Human Side of the Digital Thread
- Why Should We Care
- Concluding Remarks

33

Copyright © 2023



Concluding Remarks



Digital Thread: Why Should We Care (1 of 2)


- Every digital process is precious to its users & vulnerable to a host of detrimental changes
- Incorporating processes into a digital web/network maximizes the value of its information to its users
- It must have a purpose—it is not linear, it can have countless threads
- A digital web/network's potential countless digital threads helps us see into every product- or service-related decision
- Its value lies in its myriad of links to data and information that feed & validate decision-making

34


Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023




Concluding Remarks



Digital Thread: Why Should We Care (2 of 2)

- The digital thread is one of CIMdata’s Critical Dozen Digital Transformation trends & enablers—it sews together disciplines & the end-to-end product lifecycle
- Remember: A digital web/network is required to support a digital twin’s creation & management
- Digital network implementations are never straightforward
- Develop a sound plan to maintain and enhance the organization’s digital network throughout its useful life

35
Copyright © 2023



Implementation Status: Past the Tipping Point?


What is the business process scope of your current generation PLM solution?*

CIMdata comment: Heavily weighted towards the “traditional” PDM aspects of PLM. This is consistent with CIMdata’s experience.

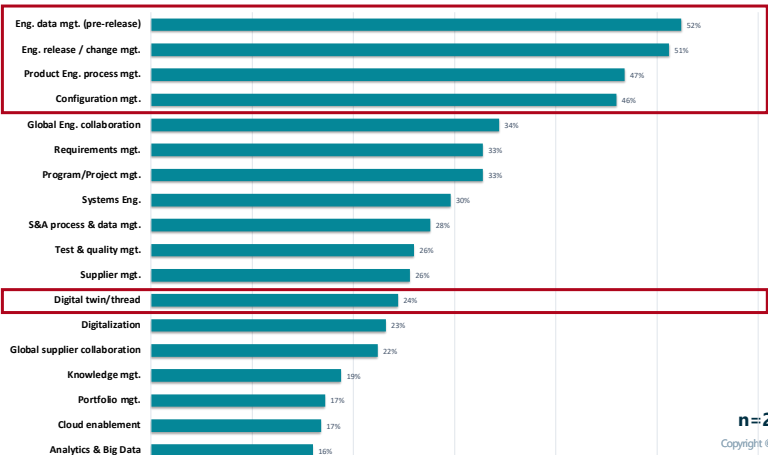
2023 Digital twin/thread 24%

2022 34%

2021 18%

2020 25%

2019 17%



Business Process Scope	Percentage
Eng. data mgt. (pre-release)	52%
Eng. release / change mgt.	51%
Product Eng. process mgt.	47%
Configuration mgt.	46%
Global Eng. collaboration	34%
Requirements mgt.	33%
Program/Project mgt.	33%
Systems Eng.	30%
S&A process & data mgt.	28%
Test & quality mgt.	26%
Supplier mgt.	26%
Digital twin/thread	24%
Digitalization	23%
Global supplier collaboration	22%
Knowledge mgt.	19%
Portfolio mgt.	17%
Cloud enablement	17%
Analytics & Big Data	16%

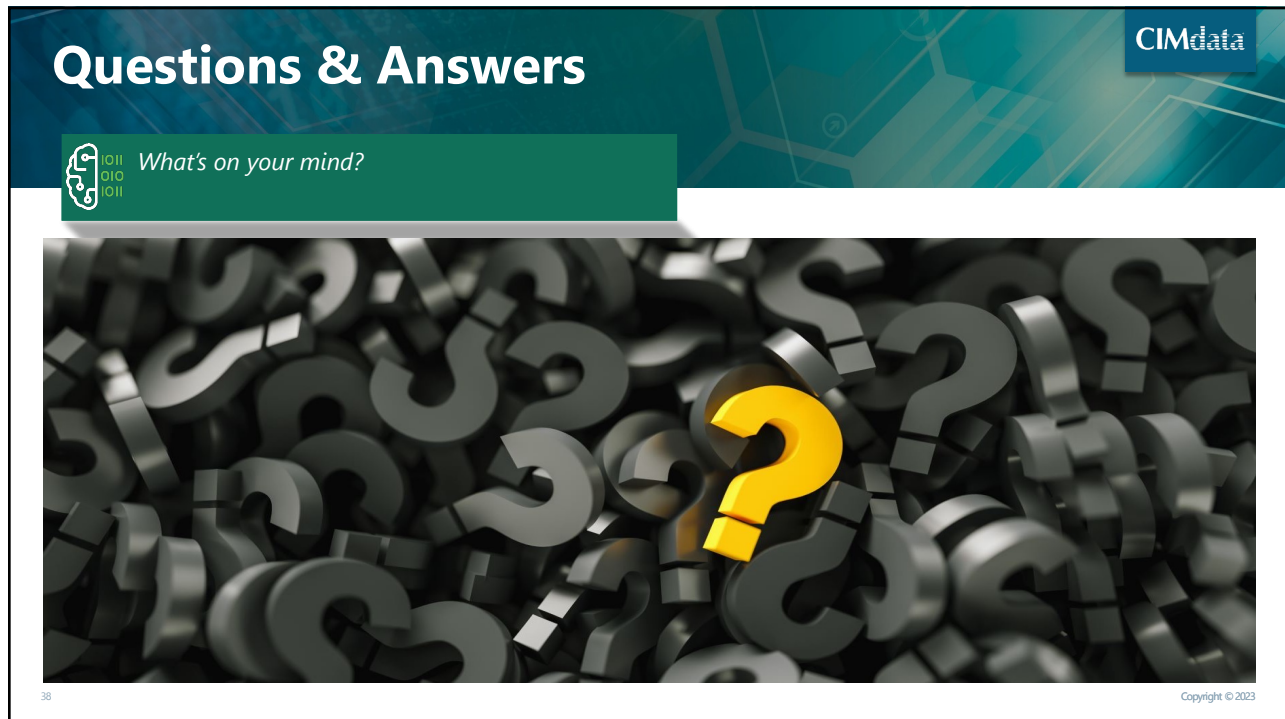
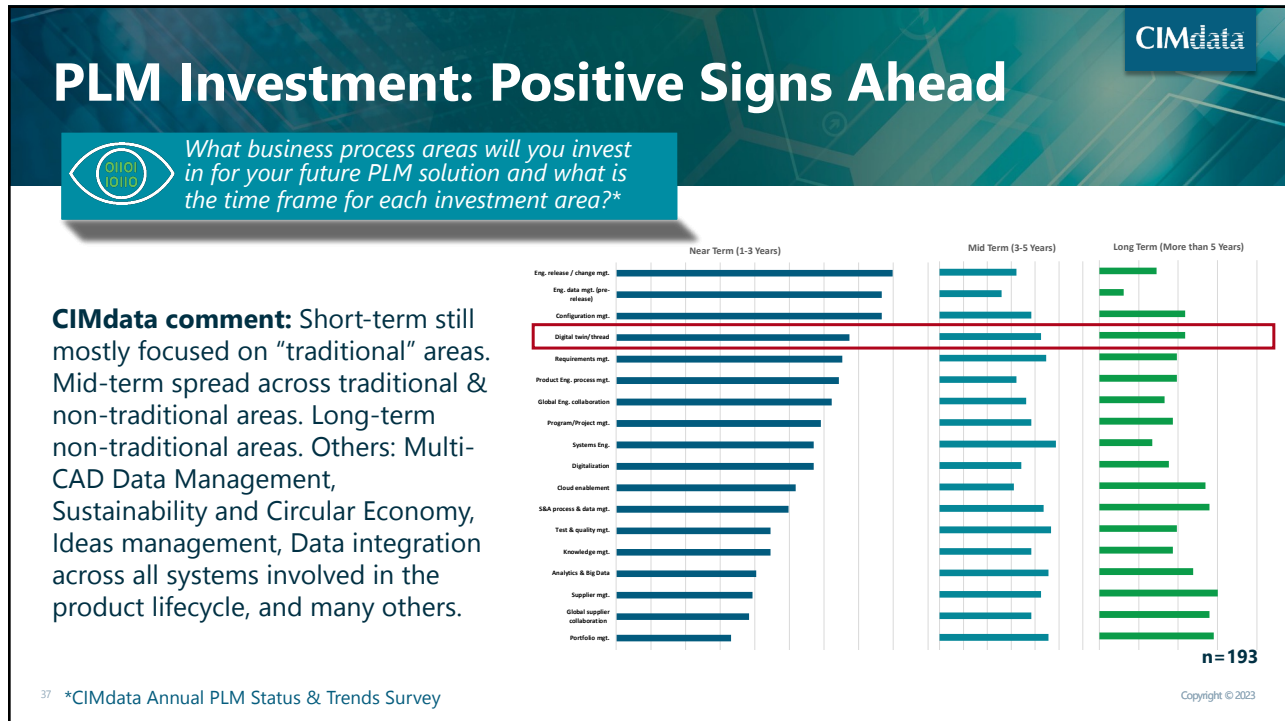
36 *CIMdata Annual PLM Status & Trends Survey

n=252

Copyright © 2023

Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023



Digital Thread: Why Should We Care

PLM Road Map™ & PDT North America 2023—3 May 2023



Serving clients from offices in North America, Europe, and Asia-Pacific

World Headquarters Ann Arbor, Michigan USA Tel: +1.734.668.9922	EMEA Headquarters Weert, NL Tel: +31 (0) 495.533.666	Asia-Pacific Headquarters Tokyo, Japan Tel: +81.47.361.5850
--	---	--

www.CIMdata.com

Copyright © 2023