

State of PLM: Today's Market & Leading Trends

2021 CIMdata PLM Market & Industry Forum

State of PLM: Today's Market & Leading Trends

PLM Market & Industry Forum

A CIMdata PLM Leadership Event

15 April 2021

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Global Leaders in PLM Consulting
www.CIMdata.com

#plm4um

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Our Mission...

Strategic management consulting for competitive advantage in global markets

CIMdata is the leading independent global strategic management consulting and research authority focused exclusively on PLM and the digital transformation it enables.

We are dedicated to maximizing our clients' ability to design, deliver, and support innovative products and services through the application of PLM.

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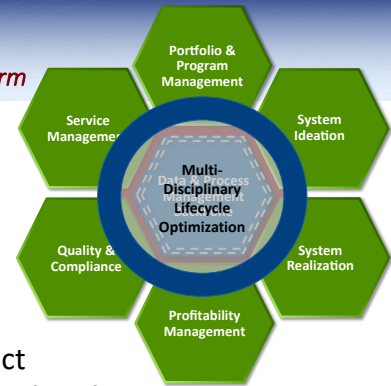
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PLM – CIMdata's Definition

Digital transformation of the lifecycle—enabled by a product innovation platform

- Strategic business approach
 - **NOT** just technologies
 - Consistent set of business solutions
- Collaborative creation, use, management & dissemination of product related *intellectual assets*
 - All product/plant definition information – the virtual product
 - AEC, MCAD, EDA, ALM, SE, requirements, simulations, analytics, portfolio, formulas...
 - All product/plant process definitions – the virtual processes
 - Processes that plan, design, produce, operate, support, decommission, recycle...
- An innovation platform that supports the extended enterprise
- Spans the full lifecycle, from idea/concept through life



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Key Takeaways

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- 2020 was a challenging year, but with challenge comes opportunities
- Unfortunately, most are still spending on traditional areas of PDM, but fortunately, money is still being spent on PLM
- There are several emerging trends & challenges that are impacting PLM today and will in the coming months and years
- New methods & advanced analytics software tools are needed to quickly unlock actionable insight embedded in all the data being generated
- To be successful in today's competitive and very challenging environment, solution providers must stay focused...opportunities abound

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Agenda

- What's New from CIMdata
- 2020: The Year in Review
- 2021: Today's Trends & Challenges
- Looking Towards the Future
- Concluding Remarks

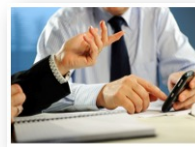
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CIMdata Services...

Creating, disseminating, and applying our intellectual capital in support of your digital transformation



**PLM
Foresight**

**PLM
Leadership**

**PLM
Transformation
PLM Invest
PLM
Success**

Delivering strategic advice and counsel through a comprehensive, integrated set of research, education, and consulting services

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PLM Success

Services for PLM Solution Providers—supporting the drive towards market success in the evolving digital economy

CIMdata's PLM consulting methodology for PLM solution providers

A comprehensive set of services tailored to fit your specific needs...

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Jim Roche, CIMdata
A&D Practice Director

AEROSPACE & DEFENSE PLM ACTION GROUP

Aerospace & Defense PLM Action Group

Founded in February 2014

Administered by:
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Aerospace & Defense PLM Action Group

Mission

An association of aerospace & defense companies within CIMdata's globally recognized PLM Community Program, which functions as a **PLM advocacy group** to:

- Set the direction for the aerospace & defense industry on PLM-related topics that matter to members
- Promote common industry PLM processes and practices
- Define requirements for common interest PLM-related capabilities
- Communicate with a unified voice to PLM solution providers
- Sponsor collaborative PLM research on member-prioritized industry and technology topics

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Project Workstreams Evolution

Members prioritize topics and fund research and team projects annually

Number and scope of projects has increased year over year due to increase of available funds from larger membership

Topic	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Members	4	4 -> 5	5 -> 7	8 -> 10	10 -> 11	11 -> 10	10 -> 8
Global Collaboration	Research Phase 1	Research Phase 2		Team Project Phase 3 --	Team Project -- Phase 3 --	Team Project -- Phase 3	Team Project Phase 3
Obsolescence Management	Research Phase 1	Research Phase 2	Team Project	Project Close Out			
Model-based Definition (MBD) and BOM Definition			Team Project Phase 1	Team Project Phase 2	Team Project Phase 3 --	Team Project -- Phase 3 --	Team Project -- Phase 3
Multiple-view Bill of Material (Multi-view BOM)			Team Project Phase 1	Team Project Phase 2	Team Project Phase 3	Team Project Phase 4 --	Team Project -- Phase 4
Model-based Systems Engineering (MBSE)				Team Project Phase 1	Team Project Phase 2	Team Project Phase 3 --	Team Project -- Phase 3
Standards Working Group						Team Project Phase 1	Team Project Phase 2

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Multi-view BOM Solution Evaluation Benchmarks

Reports

Multiple View Bill of Materials (BOM) Solution Evaluation Benchmarks [Jul 2020]

- Report of Findings and Conclusions

Multiple View Bill of Materials (BOM) [Feb 2019]

- Problem Statement, Desired State, and Requirements
- Appendix A: Glossary
- Appendix B: Concept Definition and Use Cases

Available on the AD PAG website at www.ad-pag.com

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Communication Strategy

Influence the direction of the PLM ecosystem beyond A&D on PLM-related topics

AD PAG website launched Nov 2017, making project artifacts publicly available (at www.ad-pag.com)

Content

- Direction statements (3)
- Research reports (4)
- Position papers (8)
- Benchmark Report (1)
- CIMdata A&D webinars (4)
- CIMdata Road Map A&D conference presentations (20+)

Status

- Over the period from Nov 2017 to Apr 2021
 - 1,236 individuals
 - 1,871 sessions
 - 14,829 documents downloaded

Industry	Downloads (02Apr2021)
A&D	4,447
Academic	507
Automotive	317
Constuction	99
Consulting	774
Consumer Goods	139
Electronics /Hi Tech	448
Fabrication & Assembly	198
Government	345
Mechanical Machinery	186
Medical Device	203
Other	1,477
Other Transportation (non Auto)	122
Process / Petro Chemicals	69
Shipbuilding	169
Solution Provider	5,154
Utilities	175
Total downloads	14,829

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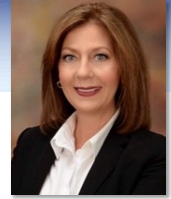
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Data Governance

Practice overview



- Director: Janie Gurley
- Mission:
 - Ensure that high quality data is always available to all extended enterprise participants via the development and execution of a company-wide data governance strategy that results in improved efficiency, increased profitability, and lowered business risk
- Focus:
 - Strategy and guidance provided to industrial clients and solution providers to promote the application of Data Governance best practices
 - Enable better decision-making, reduce operational friction, protect the needs of data stakeholders, train management and staff to adopt common approaches to data issues, build and/or adopt standards, enhance processes, reduce cost, and increase effectiveness through the coordination of efforts while ensuring transparency

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Digital Skills Transformation

Practice overview



- Mission:
 - Assess, define, and enable the workforce of the future in this rapidly evolving age of digital transformation
- Focus:
 - Design of company-specific digital skills transformation strategy by determining need, analyzing audience, and establishing goals
 - Development of company-specific digital skills transformation frameworks by reviewing existing materials, and organizing, developing, and enhancing content
 - Development of company-specific digital skills transformation roadmaps
 - Delivery of company-specific digital skills transformation implementation support
 - Execution of digital skills assessments, including review of goals and objectives, the development and execution of evaluation strategies and associated tools, and the collection and analysis of assessment data for continuous improvement

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CIMdata's PLM Road Map™

Right-sized, regional, industry-focused collaborative events



- PLM Road Map™ & PDT Fall 2020
 - Extremely successful event (1st Virtual PLM Road Map™)
- PLM Road Map™ & PDT Spring 2021
 - Theme “Disruption—the PLM Professionals’ Exploration of Emerging Technologies that Will Reshape the PLM Value Equation”
 - Virtual – 19-20 May 2021
- PLM Road Map™ EMEA 2021 & PDT Europe 2021
 - Tentatively 17-18 November 2021, Sweden

PLM Road Map, in its 28th year, continues to be a premier international PLM industry event in the rapidly transforming digital world

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2021 CIMdata PLM Status & Trends Survey

Some key conclusions

- CIMdata once again executed its comprehensive PLM Status & Trends survey
- Most respondents have more than one PLM solution and have been working on PLM for more than 10 years
- Most implementations still focus on “traditional” PDM aspects of PLM
- For the most part, companies continue to find PLM worth investing in
- There's an emphasis on getting faster, better, cheaper
- Enterprise systems confusion still exists, as well as culture & practice differences, and potential conflicts with other priorities (e.g., digital)
- Management disconnect is believed to be widespread
- PLM appears to have gained momentum in 2020

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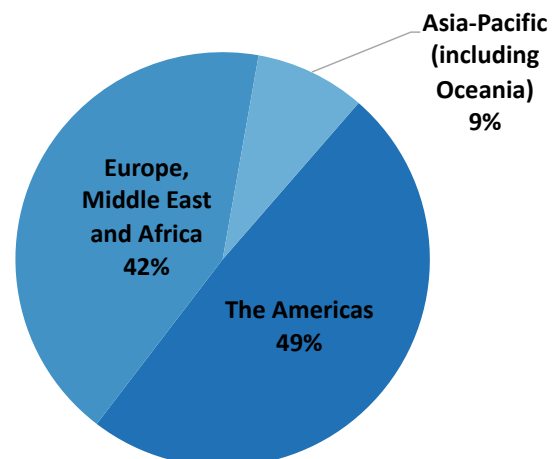
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Response Demographics

(1 of 5)

In which geographic region is your company's headquarters located?

CIMdata comment: Respondents primarily from the Americas and EMEA.



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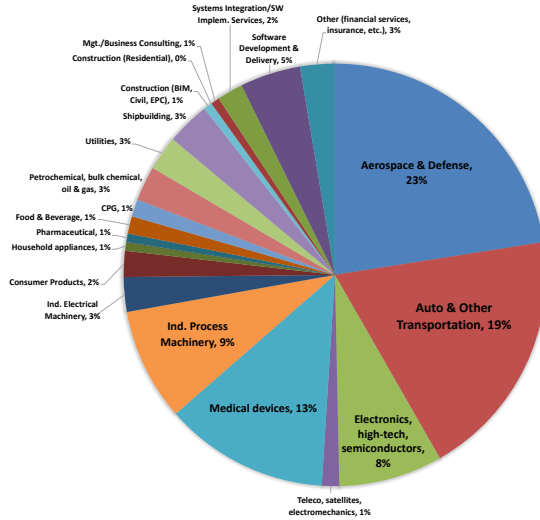
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Response Demographics

(2 of 5)

What industry does your company operate within?

CIMdata comment: This industry spread approximately matches the overall spend on cPDM offerings, traditionally led by automotive, then aerospace and defense, medical device, industrial machinery, and high-tech.



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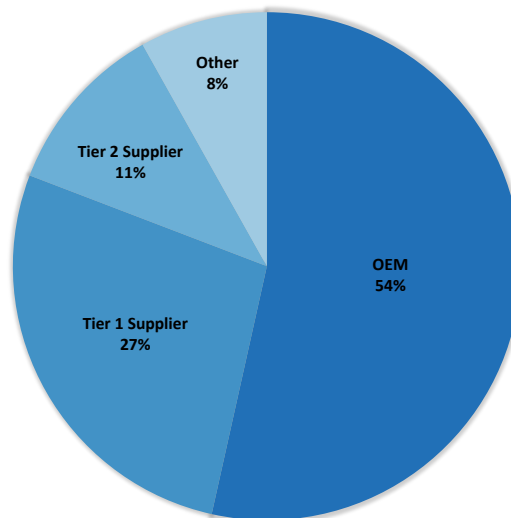
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Response Demographics

(3 of 5)

What is the primary position of your company in the ecosystem?

CIMdata comment: The survey respondents were weighted towards OEMs. Not surprising since historically they represent a large portion of the PLM spend.



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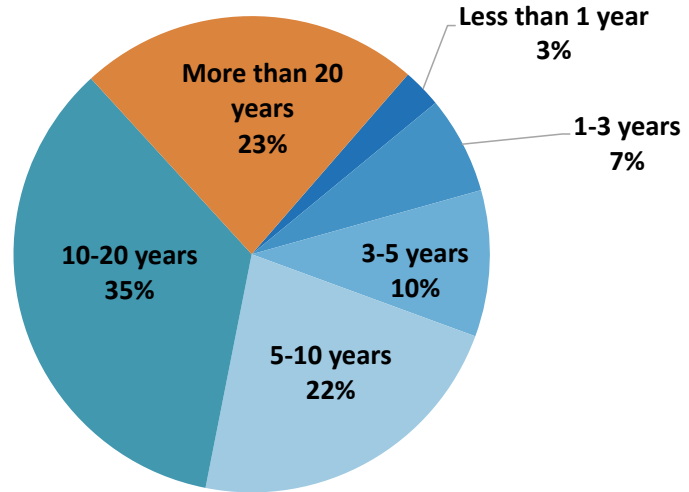
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Response Demographics

(4 of 5)

How long have you been working in PLM?

CIMdata comment: A rather mature set of respondents. Almost 60% have been at this for more than 10 years. This is consistent with other CIMdata research that many cPDM implementations are long-standing.



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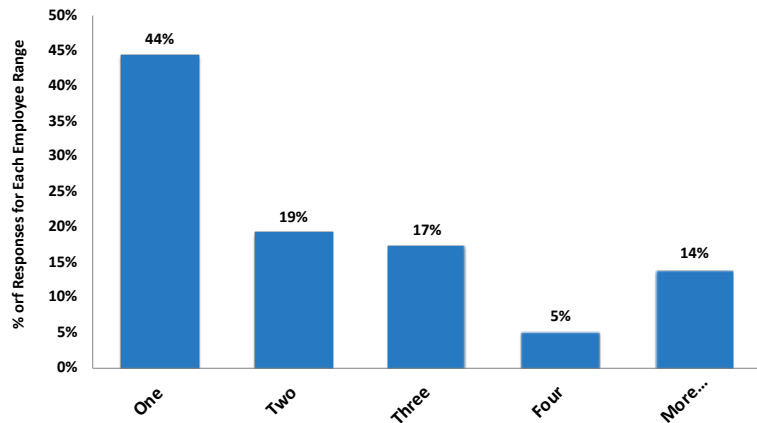
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Response Demographics

(5 of 5)

How many commercially available PLM solutions are currently in operation within your company?

CIMdata comment: Almost 60% of respondents have more than one PLM solution. This is consistent with CIMdata's industrial consulting work, where many large companies built through mergers and acquisitions have many solutions in place.



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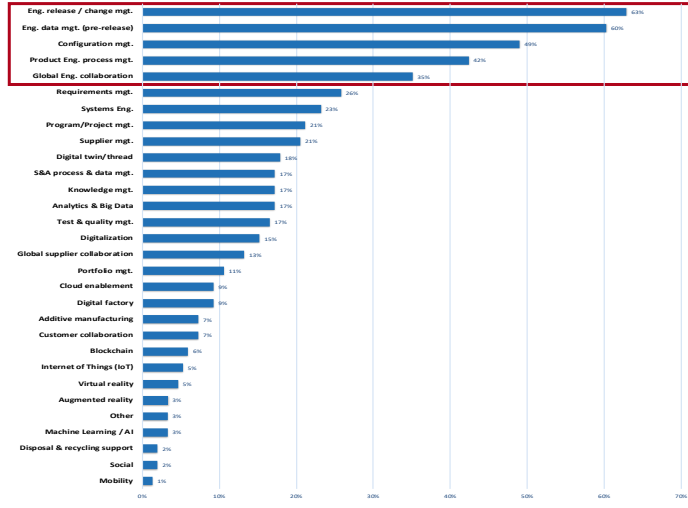
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Implementation Status

(1 of 2)

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 with industrial clients. Others: Doc. Mgt., Product Arch., Prod. config. Integ., Color & Quote Mgmt., and Installed base.



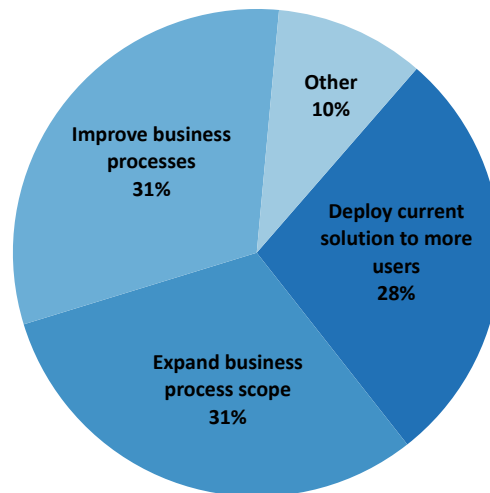
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Implementation Status

(2 of 2)

Please estimate the size, as a percent, of your total investment for each of the categories listed.



CIMdata comment: Investment evenly split among the three main investment areas.



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PLM Financials

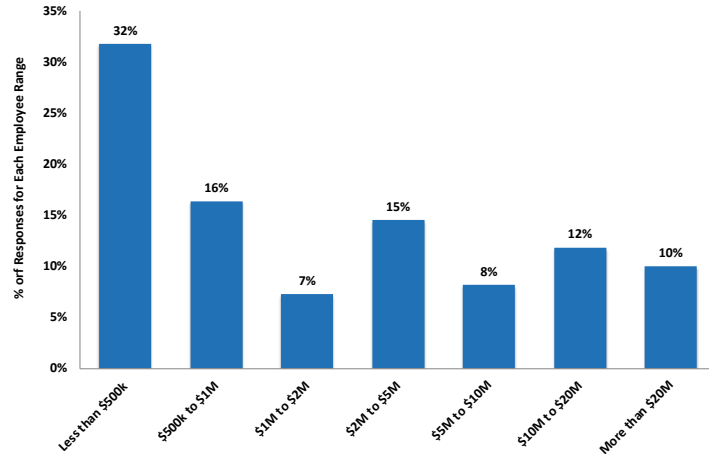
(1 of 3)

What is your current annual PLM budget?

CIMdata comment: A good cross section of implementation sizes, with 52% spending more than US\$1 million each year.

2020: 58%

2019: 43%



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PLM Financials

(2 of 3)

What is your PLM budget trend from the previous two years?

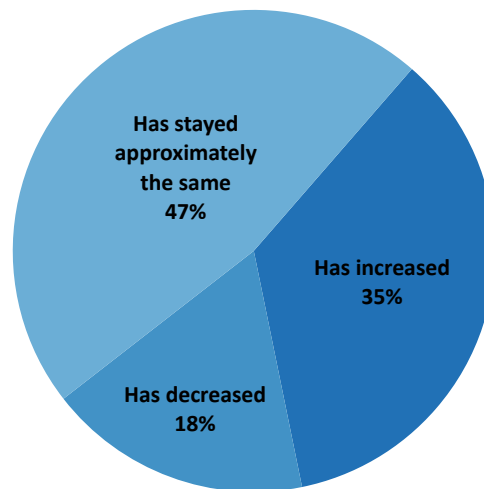
CIMdata comment: Overall, a positive sign that companies find PLM worth spending money on.

2021: 82% increased or stayed the same

2020: 84%

2019: 80%

2018: 76%



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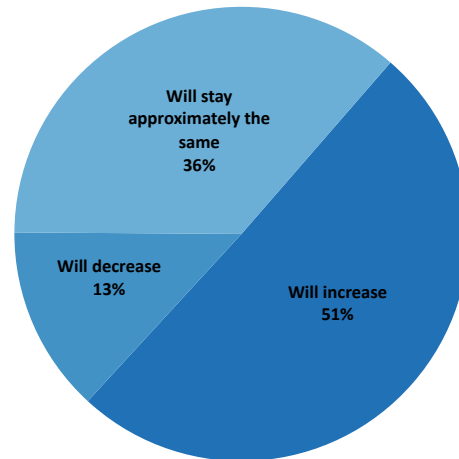
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PLM Financials

(3 of 3)

What is your expected PLM budget trend for the next two years?



CIMdata comment: A positive sign for continued investment.

2021: 51% Will increase
2020: 42%*
2019: 64%
2018: 48%

*Most of the responses received prior to major 2020 European and US COVID-19 outbreak.

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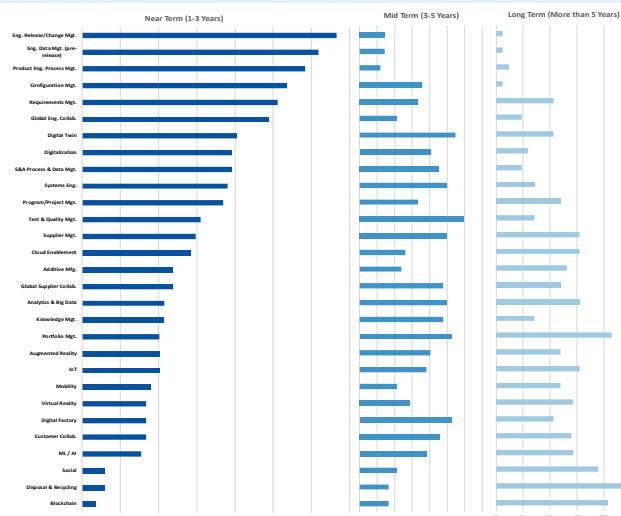
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PLM Investment

(1 of 2)

What business process areas will you invest in for your future PLM solution and what is the time frame for each investment area?



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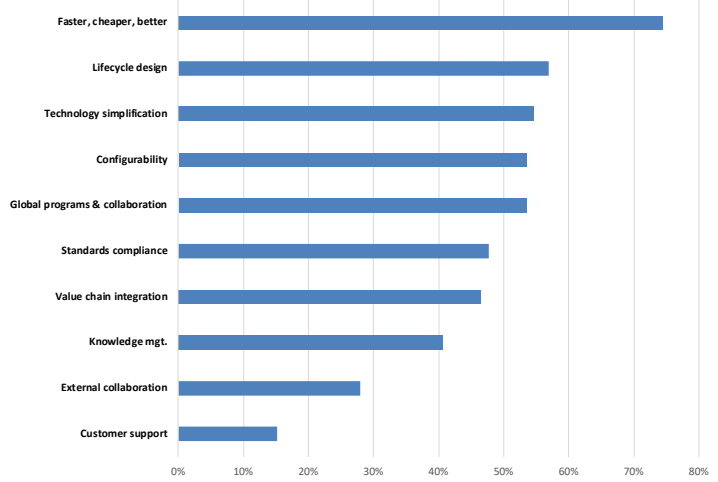
PLM Investment

(2 of 2)

What are the business objectives that have been established for your future PLM solution?

CIMdata comment: Significant future focus getting faster, better, cheaper. Same as in 2019 & 2020.

Lifecycle design moved up two spots. Configurability dropped one spot. Technology simplification moved up two spots.



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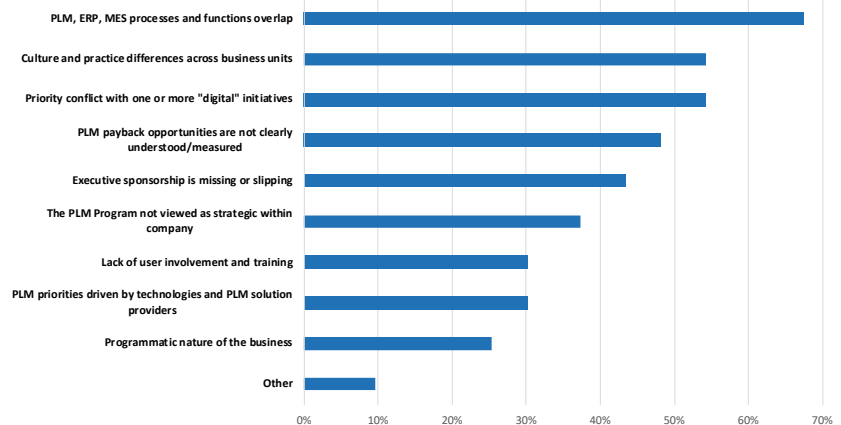
Investment Challenges

(1 of 1)

What are the major challenges to be overcome for the success of your future PLM solution?

CIMdata comment: Enterprise systems confusion still exists, as well as culture and practice differences, conflicts with other priorities (e.g., digital initiatives).

Culture moved up two spots. Payback dropped two spots.



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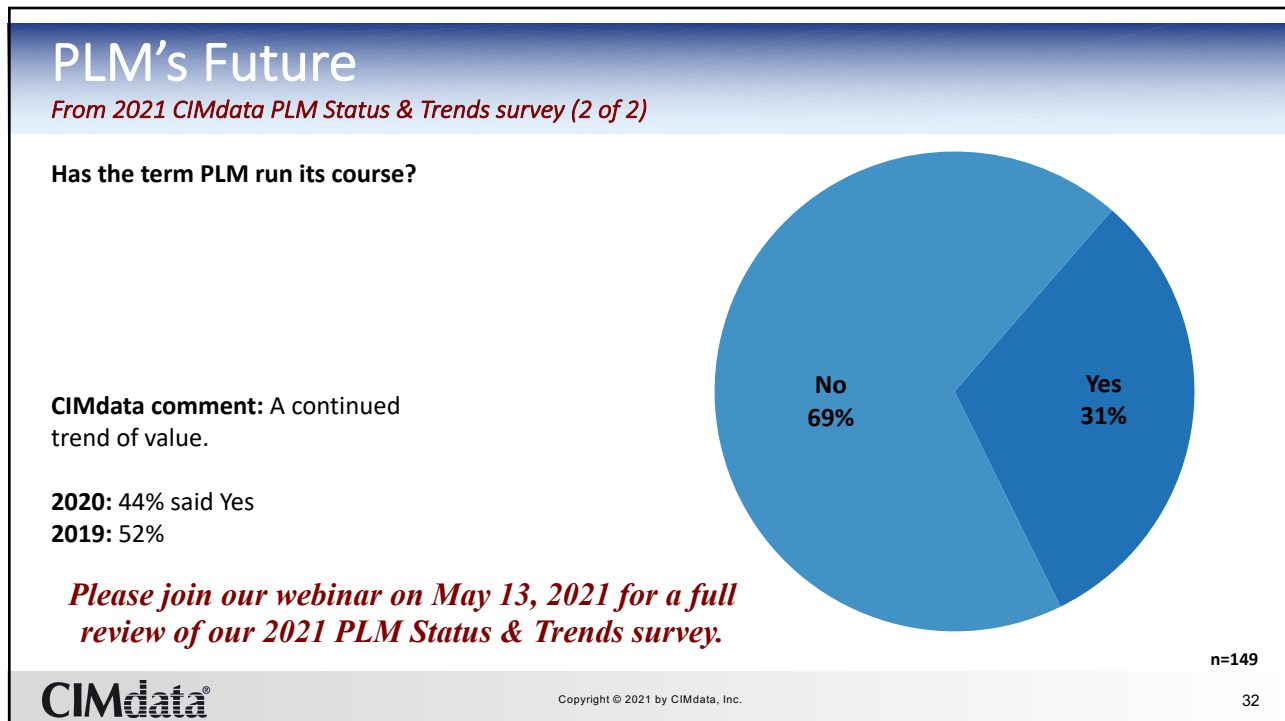
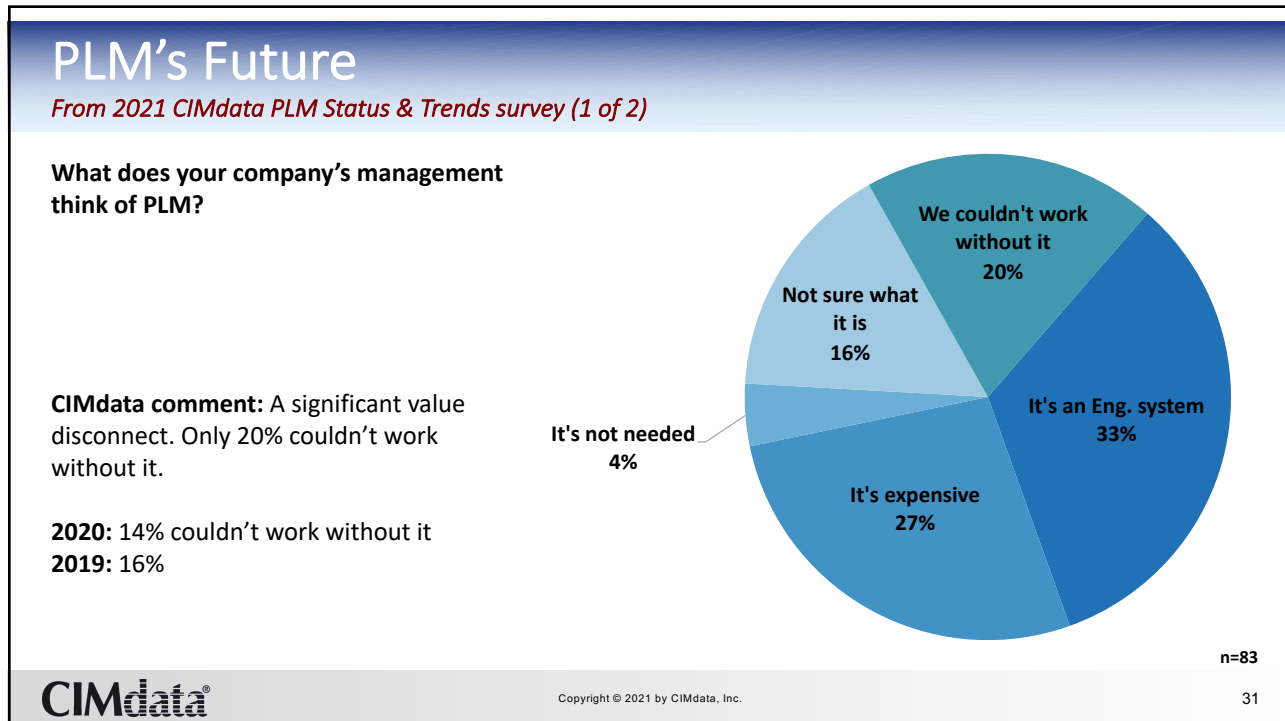


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What CIMdata Has Been Saying

Some examples—have you seen what we have been publishing since the last Forum—more than one release per week

<p>Connecting the Product Lifecycle Across the Enterprise February 25, 2021 Whitepaper highlighting the issues faced by companies through their lifecycle, the emerging technologies that will need to make investments to reap the most benefits.</p>	<p>Responsible Value Chains Help Reach Sustainability Goals (Commentary) Thursday, January 21, 2021 PDF Key takeaways: While digital transformation and Industry 4.0 dominate the business headlines, improving global sustainability is also a major global imperative. Companies need to evolve their value chain strategy from focusing on logistics and costs to "responsible value chains." Accenture believes that to become responsible and transform the business...</p>	<p>Configuration Management: Configuration Integrity is a Business Success (Commentary) Thursday, September 17, 2020 Configuration management is a fundamental capability required for any product produced in series and any complex machine. Poor configuration management guarantees business failure in the long-term and often in the short-term. It supports lifecycle configuration management at scale and manages as-maintained serialized configurations. Advanced Manufacturing...</p>
<p>PMI—Enabling MBD, MBE, and Actualizing the Intent February 18, 2021 With ever increasing product complexity and rapidly shifting pressure to increase productivity and quality as they look to support technology for deploying Model-Based Design and digital thread, companies can accelerate their share. Siemens Digital Industries Software's NX MBD solution.</p>	<p>Connected Engineering Accelerates Innovation (Commentary) Tuesday, January 19, 2021 PDF Key takeaways: Experts collaborate better when contextually connected. Design changes are completed faster when assembly and requirements traceability is easy to access and examine. Reuse of everything, from requirements, to features, to designs, to services, will delight customers with robust products and services. Managing product line variations consistently for...</p>	<p>Design: Capturing and Managing All Data Holistically (Commentary) Product development in the advanced machine industry needs data management to control product data. Modern manufacturing involves a variety of manufactured and purchased parts and are driven by software as well as actuators and motors driven by...</p>
<p>Making Service Lifecycle Management A Profitable Investment January 26, 2021 This eBook defines the need for a modern SLM solution, Siemens' strategy, program, technologies, solutions, and of OEMs, EPCs, O/Os, and product line builders.</p>		
<p>Creating a Flexible, Open, Lifecycle Value Chain December 01, 2020 This eBook describes the broad capabilities available with benefits across all enterprises' facets.</p>		

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Today's Major Trends & Potential Disruptors

A convergence of ideas, technologies, strategies, and associated complexities

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GenDesign, AdvMat & Additive Manufacturing

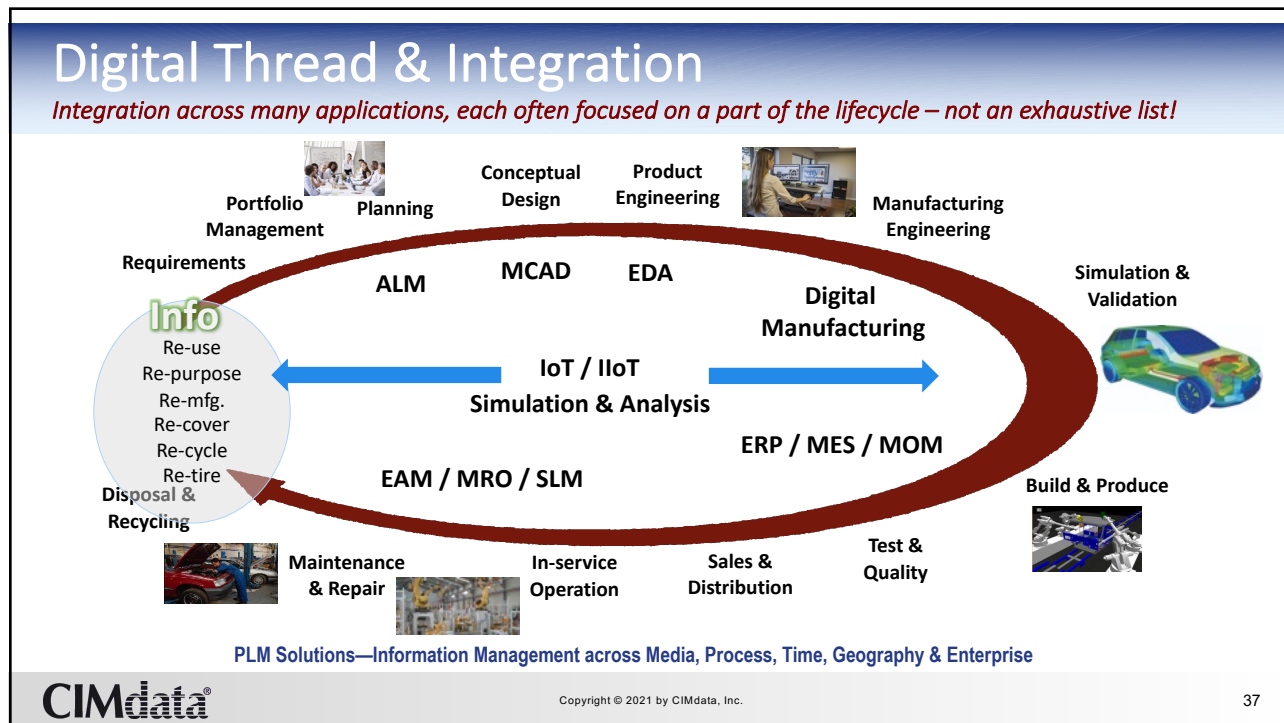
Synergistic capabilities in a sea of enabling technologies

- Generative Design
- Advanced Materials (AdvMat)
- Additive Manufacturing (AM)
- ...alone or together will enable incredible innovation in years to come
- ...aided by other process and IT technologies

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Engrg., Info. & Op. Technology Convergence

Closing the multiple systems of systems loops that exist throughout an enterprise

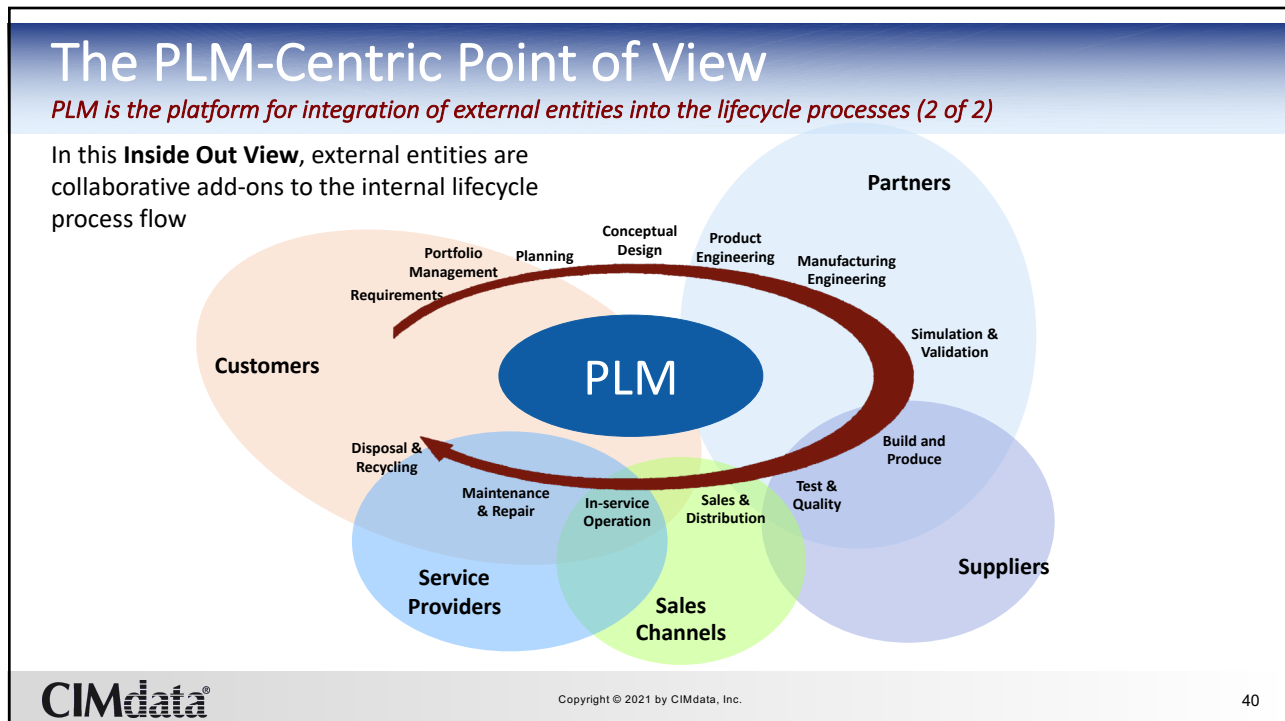
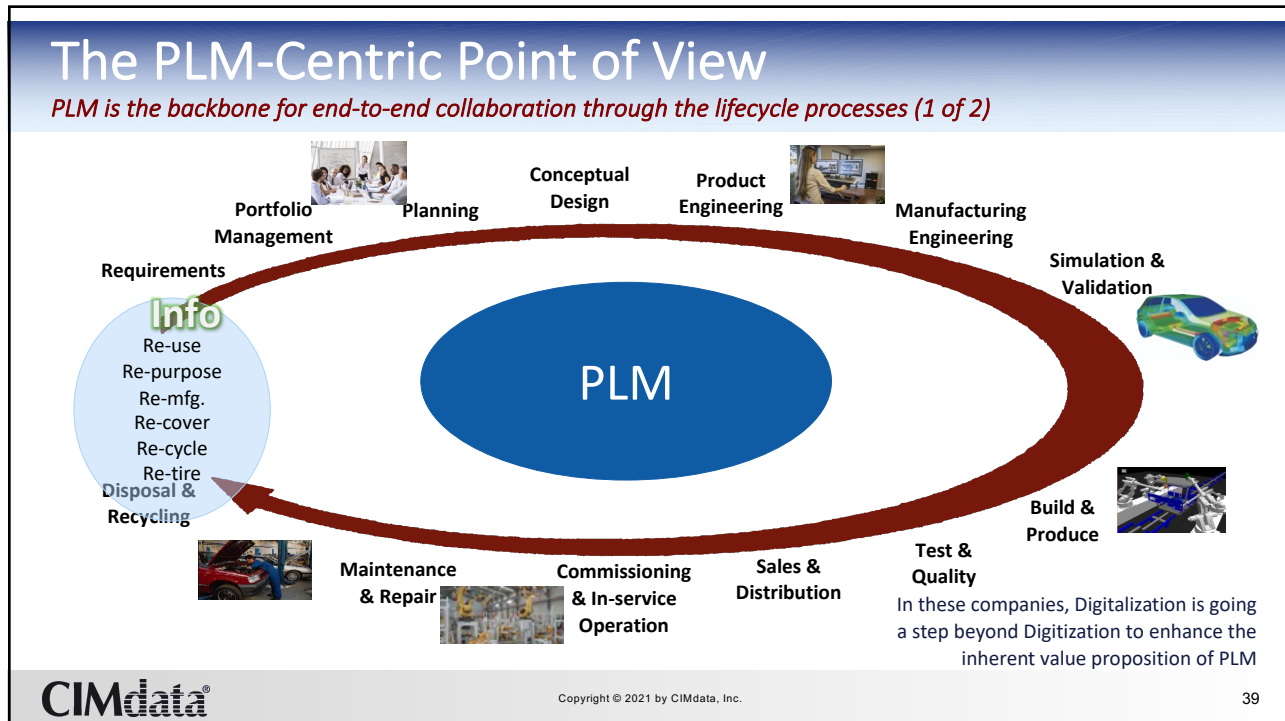
- The integration of ET & IT systems used for data-centric creation & computing with OT systems used to monitor events, processes and devices, and adjust enterprise and industrial operations
 - ET includes those systems and tools that support the development and evaluation of product and process definitions (i.e., an organization's product-related IP)
 - IT includes any use of computers, storage, networking devices and other physical devices, infrastructure and processes to create, process, store, secure, and exchange all forms of electronic data
 - OT, traditionally associated with manufacturing and industrial environments, includes industrial control systems (ICS) such as supervisory control and data acquisition (SCADA)
- Convergence enables more direct control & more complete monitoring, with easier analysis of data from these complex systems

<https://searchitoperations.techtarget.com/definition/IT-OT-convergence>

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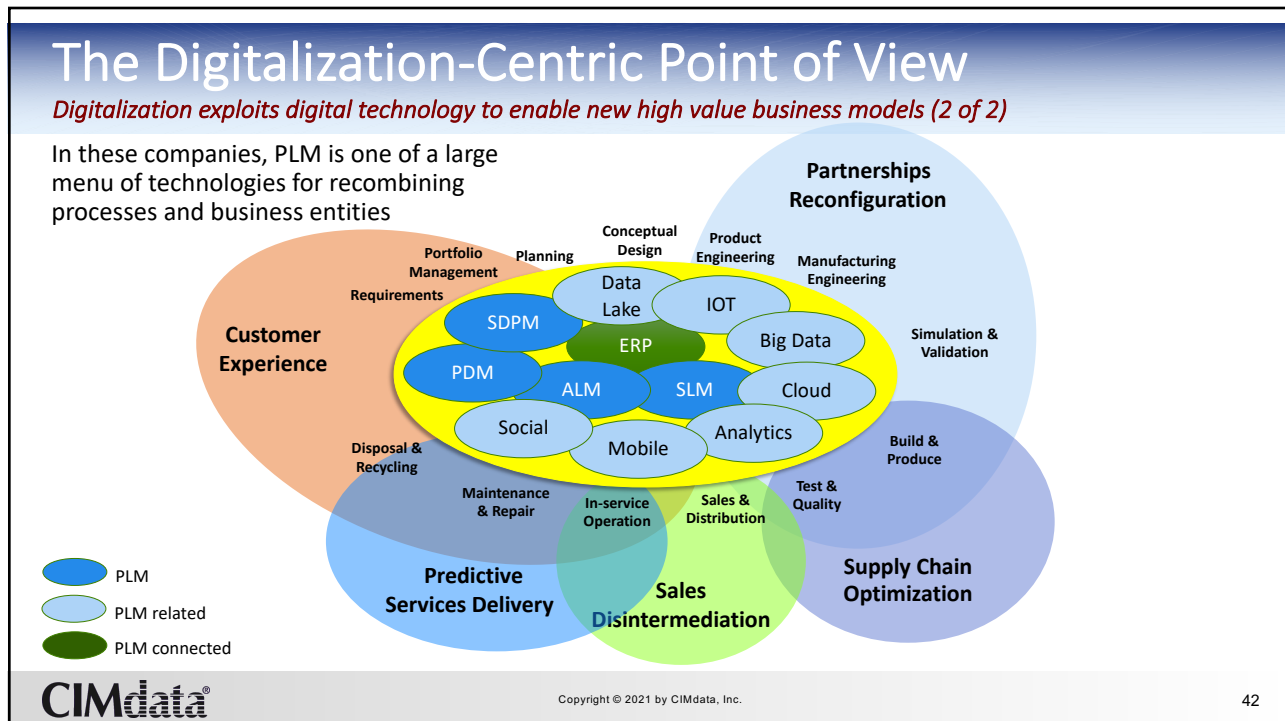
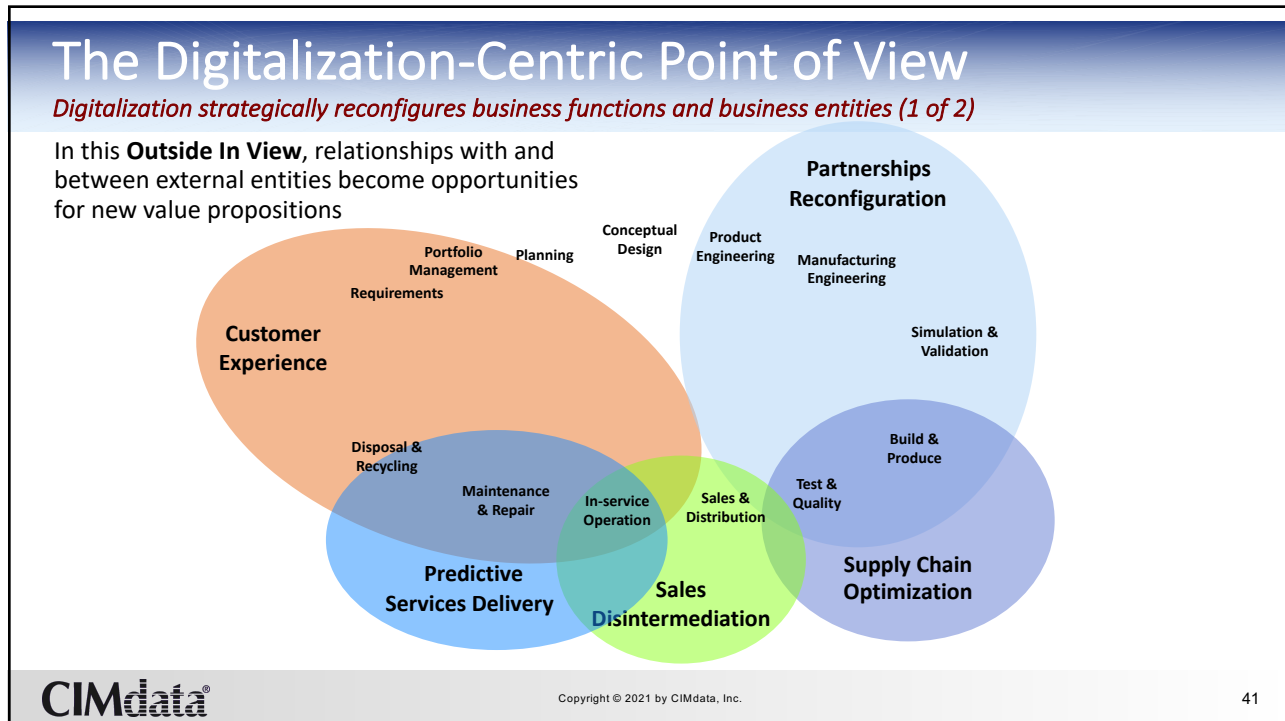
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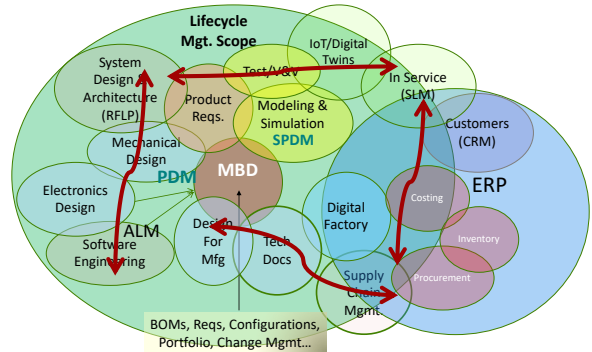
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Digital Thread

CIMdata's preferred definition

- **Digital Thread** refers to the **communication framework** that allows a connected data flow and 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>

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Digital Twin

CIMdata's preferred definition

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

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

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Products, Smartly Connected

CIMdata's 2020 PLM Market & Industry Forum Theme

- In last year's Forum, we explored best practices and identified gaps in the processes and tools for developing smart connected products
- We discussed the fact that the phrase "smart connected products" has been in vogue for the last 5 years, but the idea has been a reality in some industries for many more years
- Additionally, we presented how work to date barely scratches the surface of what is possible
 - Many of the enabling technologies, like the IoT and AI/ML, are early in their adoption lifecycle so there is still a lot of experimentation driving learning
- Without dealing with the explosion of data, not much value will result



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Data Debris: Finding the Gold

Finding insights, trends, and correlations in Big Data Debris

- Big Data provides opportunities—with a huge challenge—how to sift it using the evolving data analytics tools & techniques (e.g., AI/ML)
 - Companies are overwhelmed & drowning in the data lake
- Knowledge and insights are built up from countless data points, we must find the right points
- Industrial companies need to understand...
 - What data are needed to design more competitive products?
 - What are the best ways to retrieve this information?
 - How can measurements—data in the raw—be placed in their proper informational contexts, e.g., trends and correlations?
 - What predictive analyses can be applied in support of closing the loops?



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Traditional Analytics Problem Statement

Traditional analytics are highly dependent on specialists & are saddled with constraints—new methods are needed

People Intensive Limited Set of Hypotheses Data Scientists Data Insight

Slow, iterative process
Incomplete & missing insights
Supports Analysts
Limited to intuition or traditional ML

New methods and advanced analytics software tools are needed to quickly unlock actionable insight

Courtesy of SIAI, a SymphonyAI Group company

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Topology Data Analysis: Overcoming Many Issues

Many of today's analytics tools & methods can't handle the complexity & shear size of the data sets

- New predictive methods are emerging that offer the potential to quickly unlock actionable insight from a sea of structured and unstructured data
- Topology data analysis (TDA) enables users to interact with and represent structured and unstructured data through a topological network
- A TDA-based AI approach accelerates the investigation of operational performance, and inherently probes the sea of data for patterns that reveal predictive insights from unknown-unknowns
- Topology, a branch of pure mathematics, studies the nature of shapes:
 1. The measurement of shape
 2. The representation of shape
 - Both tasks are relevant to interrogation of large, complex, and high dimensional data sets for patterns and relationships

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Topology Data Analysis (TDA)

Topological Network example

The network graph shows a complex web of nodes and edges, with nodes colored in shades of green, yellow, and orange. A sidebar on the left provides statistical data for the 'Debt to Asset Ratio [log]' variable:

Q1	1.43
Q3	3.60
Avg	1.75
Debt to Asset Ratio [log]	1.75
Length of First Mortgage...	88.8
Length of Mortgage	73.0
Total Debt	1.95e+6
Total Debt (3mo avg)	1.95e+6

Courtesy of SIAI, a SymphonyAI Group company

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A Proven TDA Approach

SIAI, a SymphonyAI Group company, focuses on defining & delivering AI-driven solutions that provide high value

The diagram shows a process flow: Data Sources (represented by database icons) feed into Algorithms (represented by a stack of blue boxes). This leads to Topological Summaries (represented by a network graph), which are then analyzed by a Domain Expert (represented by a person icon) to generate Insights (represented by lightbulb icons). The final output is Reporting (represented by a computer monitor). A feedback loop labeled 'Automatically tune the parameters' connects the Reporting stage back to the Algorithms stage.

Extremely Fast and Accurate **Transparent and Documented** **Updated Continuously**

- Fast, data-first approach**
- Comprehensive & deep insights**
- Supports Domain Experts**
- TDA-enabled Explainable Machine Intelligence**

A proven approach that accelerates the investigation of known-unknowns, and inherently probes the sea of data for patterns that reveal predictive insights from unknown-unknowns

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Agenda

- What's New from CIMdata
- 2020: The Year in Review
- 2021: Today's Trends & Challenges
- Looking Towards the Future
- Concluding Remarks

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Top Strategic Tech Trends

Gartner's Top Strategic Technology Trends

2019

1. Autonomous Things
2. Augmented Analytics
3. AI-Driven Development
4. Digital Twin
5. Empowered Edge
6. Immersive Experience
7. Blockchain
8. Smart Spaces
9. Digital Ethics & Privacy
10. Quantum Computing

<https://www.gartner.com/smarterwithgartner/gartner-top-10-strategic-technology-trends-for-2019/>

Direct connection
Indirect/secondary connection

2020

1. Hyperautomation
2. Multiexperience
3. Democratization of Expertise
4. Human Augmentation
5. Transparency & Traceability
6. The Empowered Edge
7. Distributed Cloud
8. Autonomous Things
9. Practical Blockchain
10. AI Security

<https://www.gartner.com/en/newsroom/press-releases/2019-10-21-gartner-identifies-the-top-10-strategic-technology-trends-for-2020/>

2021

1. Internet of Behavior
2. Total Experience
3. Privacy-enhancing Computation
4. Distributed Cloud
5. Anywhere Operations
6. Cybersecurity Mesh
7. Intelligent Composable Business
8. AI Engineering
9. Hyperautomation

<https://www.gartner.com/smarterwithgartner/gartner-top-strategic-technology-trends-for-2021/>

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COVID-19's Impact Will Potentially be Far Reaching

A March 16, 2020 McKinsey article—two possible scenarios identified at that time

Economic impact. Large-scale quarantines, travel restrictions, and social-distancing measures drive a sharp fall in consumer and business spending until the end of Q2, producing a recession. Although the outbreak comes under control in

most parts of the world by late in Q2, the self-reinforcing kick in and prolong the slump until the end of Q3. Companies lose revenue and lay off workers, and unemployment rises. Investment contracts, and corporate bankruptcies slow down the banking and financial system.

Economic impact. Demand suffers as consumers cut spending throughout the year. In the most affected sectors, the number of corporate layoffs and bankruptcies rises throughout 2020, feeding a self-reinforcing downward spiral.

The financial system suffers significant distress, but a full-scale banking crisis is averted because of banks' strong capitalization and the macroprudential supervision now in place. Fiscal and monetary-policy responses prove insufficient to break the downward spiral.

The global economic impact is severe, approaching the global financial crisis of 2008–09. GDP contracts significantly in most major economies in 2020, and recovery begins only in Q2 2021.

Both were wrong...

<https://www.mckinsey.com/business-functions/risk/our-insights/covid-19-implications-for-business>

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Ripped from the Headlines

A lot has been written—are we at a new tipping point and what does this potentially mean for the PLM Economy?

The Washington Post
Democracy Dies in Darkness

The hybrid office is here to stay. The shift could be more disruptive than the move to all-remote work.

Citigroup, Ford, TIAA, Target: A growing number of bellwether companies are outlining their hybrid return-to-work plans

By **Jena McGregor**

March 30, 2021 at 6:00 a.m. EDT

Raytheon to shrink office space in push for 'huge savings'

Salesforce says 'the 9-to-5 workday is dead' and will provide 3 new ways for employees to work — including the possibility of working from home forever

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The Future of Work After COVID-19

The impact on industry varies widely

70%

Time spent in computer-based office work could be spent remotely without losing effectiveness

In the computer-based office work arena, 70 percent of time could be spent working remotely without losing effectiveness, compared to most other arenas, where as little as 5 to ten percent of work could be done remotely.

The future of work after COVID-19, McKinsey Global Institute, February 2021.

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Challenges Bring Opportunity

How will you respond?—more on this later...

Every challenge, every adversity, contains within it the seeds of opportunity and growth.

Roy Bennett - 1957-2018 - Politician

The COVID-19 crisis has created an imperative for companies to reconfigure their operations—and an opportunity to transform them. To the extent that they do so, greater productivity will follow.

The next normal arrives: Trends that will define 2021—and beyond, by Kevin Sneader and Shubham Singhal, McKinsey & Company, January 2021.

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Concluding Remarks

The market continues to expand and evolve—differentiation is key

- 2020 was a challenging year, but opportunities abound
- Most are still spending on traditional areas of PDM but, fortunately, money is still being spent on PLM
- PLM continues to evolve, with more opportunities just around the corner
- Digitalization: Outside In or Inside Out...both play major roles
- TDA and other new methods & advanced analytics software tools are needed to quickly unlock actionable insight embedded in the data being generated
- PLM will continue to evolve, and we will need to be ready for it to do so
- To be successful in today's competitive and very challenging environment, solution providers must stay focused...opportunities abound

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