

Supporting collaboration in systems engineering: state of the art and practices

Emmanue CHEBBI – 2024.12.04

Financé par



The world **keeps accelerating**

and Systems Engineering must face a **growing number of challenges:**



Remain competitive



Address sustainability



Meet stakeholder expectations



Conform to new regulations



Handle uncertainty



In this **changing** world,

systems engineering **must** continue to evolve

– Systems Engineering Vision 2035 ©INCOSE



to evolve... but how?

This presentation is
a state of the art and practices



... conducted by Inria, the French research institute

... providing an overview of collaboration capabilities
in Systems Engineering and trends for the future

... synthesizing trends in both scientific and industrial worlds



to evolve... we need **INNOVATION**

INNOVATION

EXPLORATION *(of a design space)*

reliable DECISION MAKING

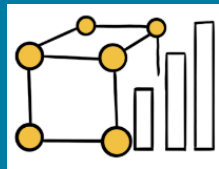


Future of Collaboration in SE

INNOVATION

EXPLORATION (of a design space)

reliable DECISION MAKING



DIGITAL THREAD

- break data silos
- the right information
 - at the right time
 - in the proper context



AUGMENTED ENGINEERING

- enhance engineers
- let them focus on what matters
- context-aware tooling



CONTINUOUS ENGINEERING

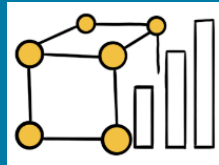
- change-resilient workflows
- shared responsibilities
- unify design and runtime

INNOVATION

EXPLORATION (of a design space)

reliable DECISION MAKING

KNOWLEDGE MANAGEMENT



DIGITAL THREAD

- break data silos
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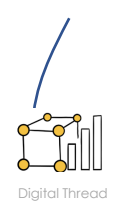
AUGMENTED ENGINEERING

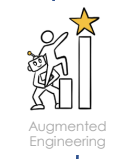
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CONTINUOUS ENGINEERING

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- unify design and runtime







Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management



Future of Collaboration in SE


The Digital Thread

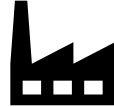
A journey towards data-centricity





A topic of **high interest**...

 in the scientific community

 in the industry



+ 1000 research papers

in 5 years^[1]

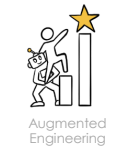
”

We must [...] become a **data-centric** DoD.

– United States Department of Defense (DoD)
DOD Issues New Data Strategy



[1] Zhang, Q., Liu, J., & Chen, X. (2024). *A Literature Review of the Digital Thread: Definition, Key Technologies, and Applications*. *Systems*, 12(3), 70.



The ultimate dream of the digital company is that **everything** relevant is **connected in context**

— Jos Voskuil (PLM Green Alliance co-founder),
in his blog article [“Coordinated or Connected”](#)



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management

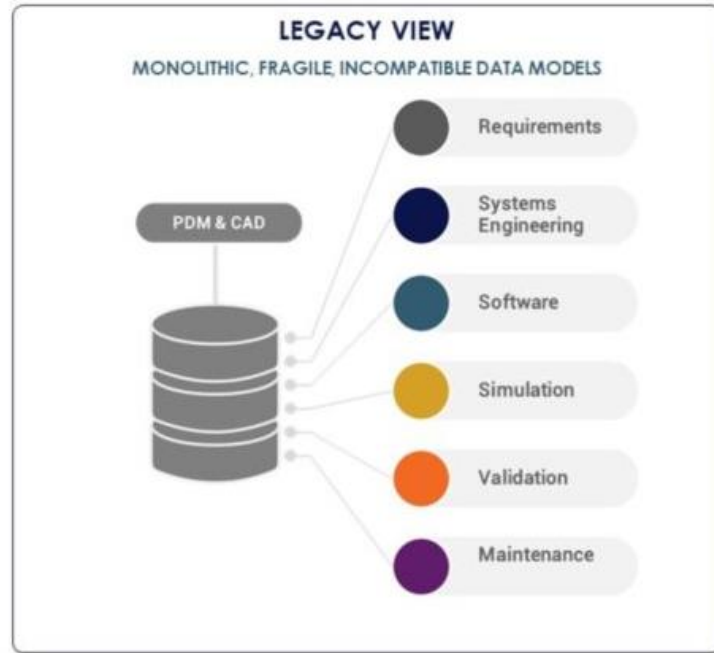


Future of Collaboration in SE

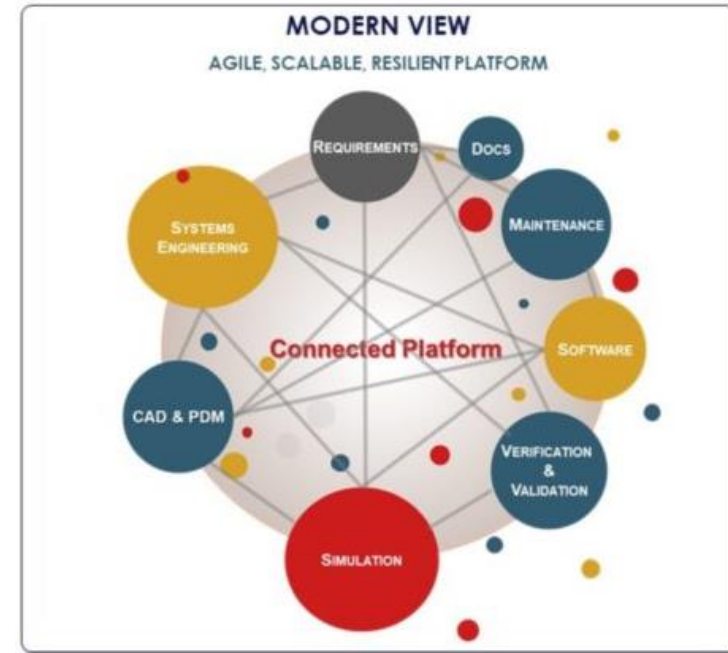
”

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from Data Silos...



*...to a connected, **holistic** platform*



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management

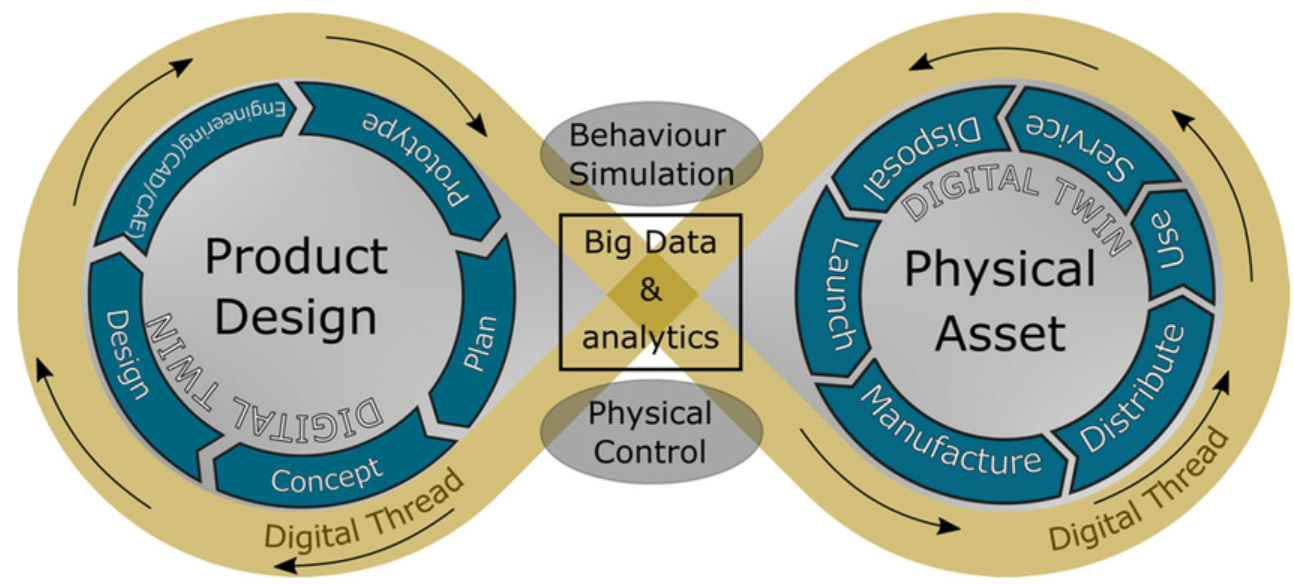


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Digital Thread

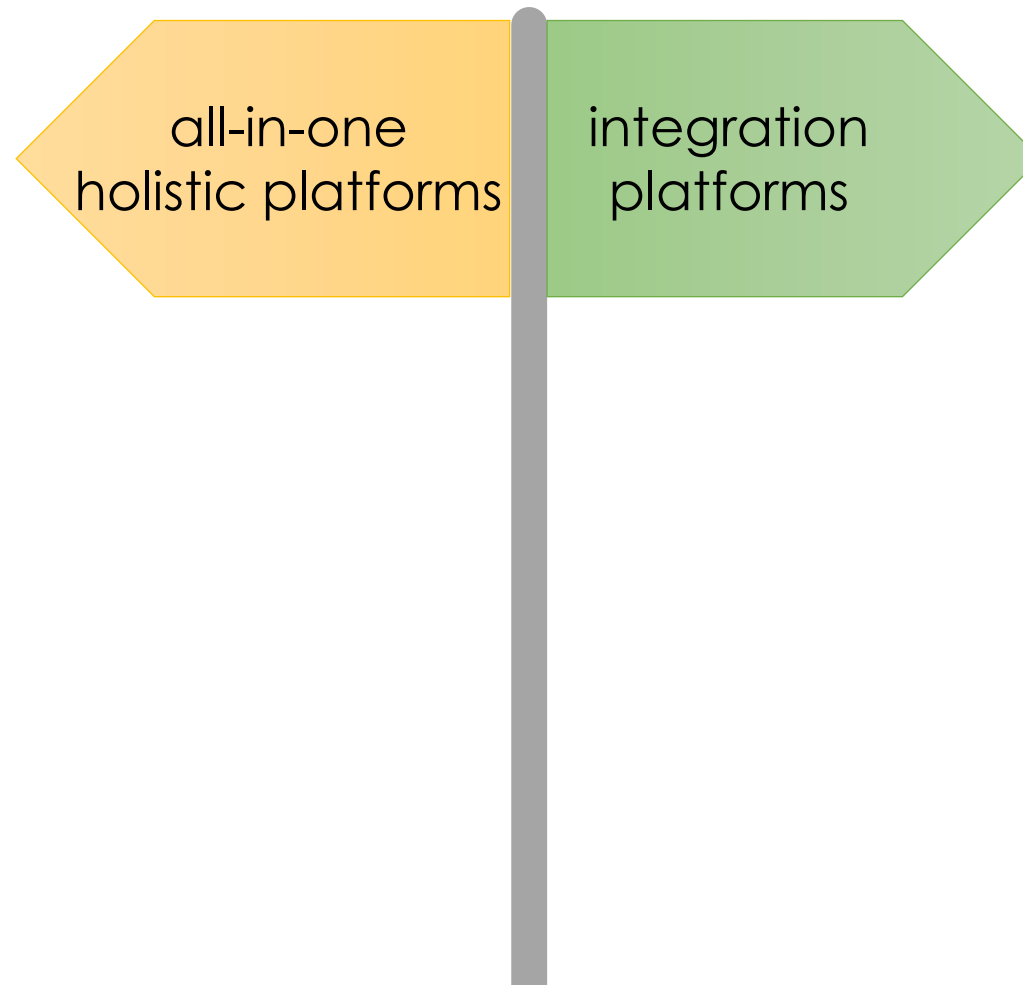
A framework where...

- **heterogeneous data** coming from various domains are **linked and kept consistent**
- throughout the product's **lifecycle**
- in order to **inform decision makers**
- and turn data into **actionable information**. [1,2,3]



[1] The Defense Acquisition University, <https://www.dau.edu/glossary/digital-thread>, 26/03/2024
 [2] Zhang, Q., Liu, J., & Chen, X. (2024). A Literature Review of the Digital Thread: Definition, Key Technologies, and Applications. Systems, 12(3), 70.
 [3] Lehner, C., Padovano, A., Zehetner, C., & Hackenberg, G. (2024). Digital twin and digital thread within the product lifecycle management. Procedia Computer Science, 232, 2875-2886.

2 main directions towards the digital thread





all-in-one
holistic platforms



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management

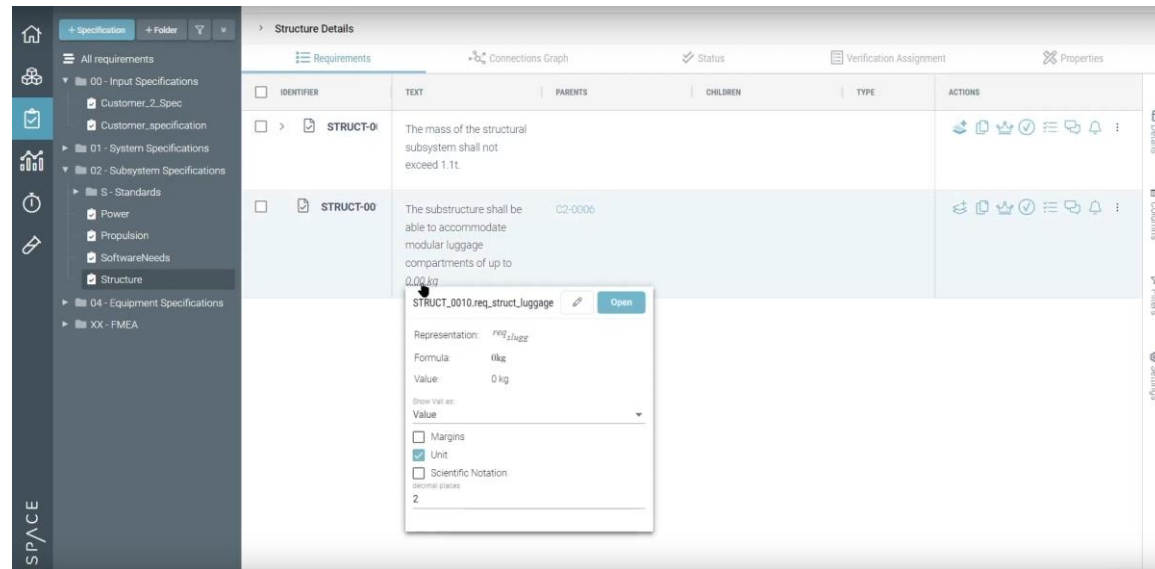


Future of Collaboration in SE

VALISPACE

A **web platform** to streamline engineering processes, from requirements to design and validation

all-in-one holistic platforms



- **Reuse requirement values as variables within simulation models,**
- **Evaluate the immediate impact of design choices**
- **Acquired by Altium,** leading provider of design software for the electronics industry



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management



Future of Collaboration in SE

AVEVA

all-in-one holistic platforms

A data-driven web platform for real-time engineering data

A best In Class User experience

The screenshot displays the AVEVA Engineering software interface for a project named 'Sustainable, MDB - GreenHydroGen'. The interface is divided into several panes:

- Grids Explorer:** A tree view on the left showing the project hierarchy, including Administration, Default Grids, Deliverables, Electrical, General, Instrumentation, Junction Boxes, Line Data, Mechanical, Mechanical Pumps, Unified Engineering, Administration, Engineering Items, Functional Items, Hydrogen Items, H2 ENG Electrical Transformers, H2 ENG Equipment, H2 FJUNC Heat Exchangers, H2 FJUNC Streams, H2 PFD Equipment, Nozzles, Simulation Items, and Valves.
- Properties Panel:** A central panel showing properties for selected equipment, such as 'H2 FJUNC Heat Exchangers'. It includes fields for Overall Length, Nominal Diam, Duty (kW), Required Area, Effective MTD, Connected Mean T, LMTD, UMTD, Heat Transfer Coef, Overall Heat Trans, F Factor (FT), Minimum Oil Disso, Minimum Oil Disso, Orientation, Input, Output, Temperature, Suffix, Number Required, LPA Value, and Shell Side Pw.
- Functional (PFD):** A process flow diagram showing the functional process flow.
- Functional (Grids):** A grid-based functional process flow diagram.
- Detail (P&ID):** A detailed process and instrumentation diagram.
- AVEVA Process Simulation:** A simulation view showing the process flow with simulation results.
- Detail (E3D Design):** A 3D CAD model of the equipment.

Plant	Default Name	Name	Actual type	Description	Manufacturer	Client	Database	Overall Length
H2	E6-AB	H2-E6-AB-FUN	FJUNCHeatExchng	Shell and Tube Ex.				3000
H2	E7-AB	H2-E7-AB-FUN	FJUNCHeatExchng	Shell and Tube Ex.				3000
H2	E7-A	H2-E7-A	HeatExchanger	Shell and Tube.	AVEVA Solution.			3000
H2	E7-B	H2-E7-B	HeatExchanger	Shell and Tube.	AVEVA Solution.			3000

- A holistic and multi-disciplinary environment
- Integrates engineering, design and simulation



Digital Thread

S

integration
platforms



Augmented
Engineering



Continuous
Engineering



Knowledge
Management



Future of
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SE

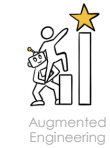


Digital Thread

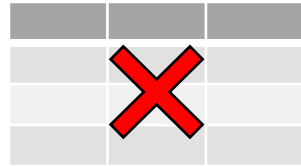
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integration platforms

old concept... but modern platforms tend to rely on **ontologies and knowledge graphs**



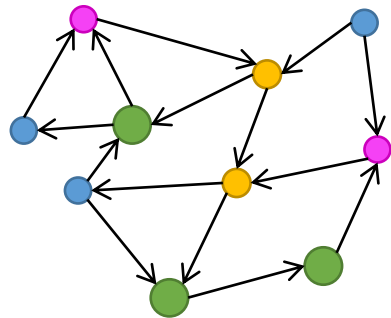
Augmented Engineering



(from relational databases)



(to semantically interconnected data)



Advantages:

- simplify data representation and user interaction [1]
- ease the capture, query and analyze of data [2]
- make a perfect fuel for AI (ML, LLM, etc.) [3]
- support decision making [4]
- enable interoperability and communication [5]



Continuous Engineering



Knowledge Management



Future of Collaboration in SE

[1] Fang, Y., Chen, M., Liang, W., Zhou, Z., & Liu, X. (2023). Knowledge Graph Learning for Vehicle Additive Manufacturing of Recycled Metal Powder. World Electric Vehicle Journal, 14(10), 289.

[2] Tang, X., Chi, G., Cui, L., Ip, A. W., Yung, K. L., & Xie, X. (2023). Exploring research on the construction and application of knowledge graphs for aircraft fault diagnosis. Sensors, 23(11), 5295.

[3] Hagedorn, T., Bone, M., Kruse, B., Grosse, I., & Blackburn, M. (2020). Knowledge representation with ontologies and semantic web technologies to promote augmented and artificial intelligence in systems engineering. Insight, 23(1), 15-20.

[4] Schweitzer, G., Bitzer, M., & Vielhaber, M. (2023). Engineering Graph as an Approach to Support Design Decisions in Product Development. Proceedings of the Design Society, 3, 1625-1634.

[5] Yang, L., Cormican, K., & Yu, M. (2019). Ontology-based systems engineering: A state-of-the-art review. Computers in Industry, 111, 148-171.



Digital Thread

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Augmented Engineering



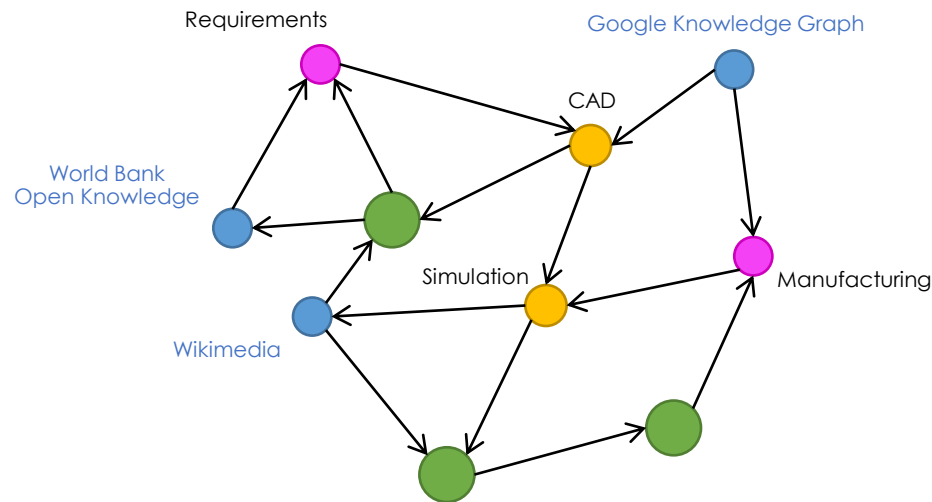
Continuous Engineering



Knowledge Management



Future of Collaboration in SE



"The Engineering Graph" (in scientific literature [1])



"The Digital Web" or "Connected Platform" (in industry [2,3,4])

- a broad, interconnected network of data and services
- may include **publicly available data** (Wikimedia, etc.)

[1] Schweitzer, G. M., Mörsdorf, S., Bitzer, M., & Vielhaber, M. (2022). Detection of cause-effect relationships in Life Cycle Sustainability Assessment based on an Engineering Graph. Proceedings of the Design Society, 2, 1129-1138.
 [2] "The Value of Digital Threads and How to Build Out an Enterprise Digital Web", [a webinar by CIMdata](#), 14 March 2024
 [3] Mentioned by, among others, [Aras](#), [Dassault Systèmes](#), [Oleg Shilovitsky](#) (OpenBOM co-founder), [Jos Voskuil](#) (PLM Green Alliance co-founder)
 [4] web article "[2020 A&D Wrap-up and Looking Ahead](#)" from [aras.com](#), visited on June 2024



Digital Thread

S

integration platforms

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Augmented Engineering



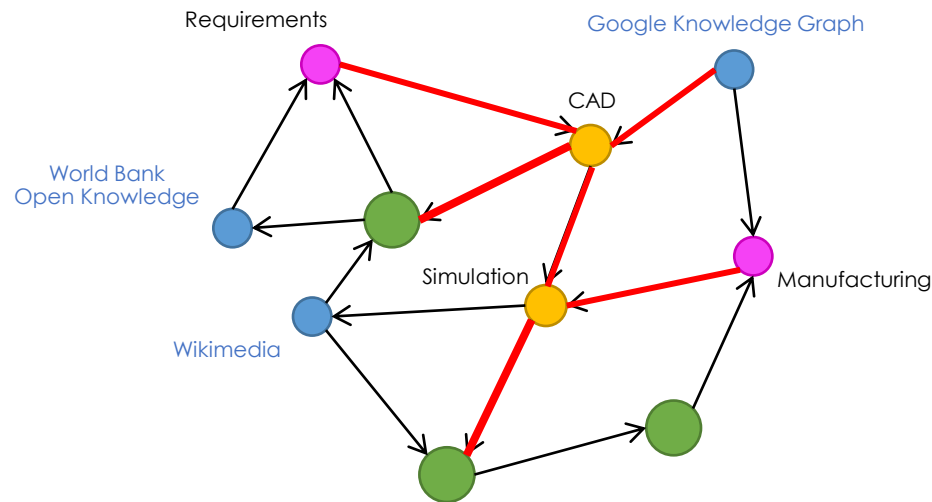
Continuous Engineering



Knowledge Management



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"The Digital Thread"

- product-specific
- continuous stream throughout the whole lifecycle
- integrates data and tools to ensure accurate and real-time information

[1] Schweitzer, G. M., Mörsdorf, S., Bitzer, M., & Vielhaber, M. (2022). Detection of cause-effect relationships in Life Cycle Sustainability Assessment based on an Engineering Graph. Proceedings of the Design Society, 2, 1129-1138.
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Digital Thread


S

integration platforms

old concept... but modern platforms tend to rely on **ontologies and knowledge graphs**



Augmented Engineering

 Industrial, graph-based, PLM solutions



Ganister PLM
Graph-Based Digital Thread

openbom

 **Syndeia**



opentext™

 Academic work on ontology-based integration



Onto4Reuse

OntoCAPE

PRESTO system

CPS-KMoDS

OntoEvent

DOLCE



Continuous Engineering



Knowledge Management



Future of Collaboration in SE



Digital Thread


S

integration platforms

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Augmented Engineering

 Industrial, graph-based, PLM solutions



opentext™

openbom



 Academic work on ontology-based integration

Onto4Reuse

CPS-KMoDS

DOLCE



OntoCAPE

PRESTO system

OntoEvent



Continuous Engineering

Built on open standards for data exchange:



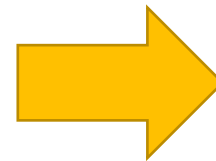
STEP



<xml />



PLCS



to achieve an **open digital thread** [1,2]

- leverages open data [2,3]
- supports open standards
- enables different aspects of collaboration [3]
- emphasizes collaboration with external entities



Knowledge Management

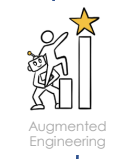


Future of Collaboration in SE

[1] Kulcsár, G., Ráth, I., & Lunk, P. (2023, July). The Quest for an Open Digital Thread: Challenges and Practices. In INCOSE International Symposium (Vol. 33, No. 1, pp. 1586-1599).

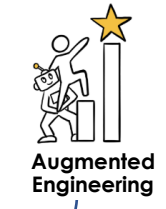
[2] Weiher, N., Mies, R., Senge, N., & Gogineni, S. (2022). Towards an open digital thread for electric mobility. DS 118: Proceedings of NordDesign 2022, Copenhagen, Denmark, 16th-18th August 2022, 1-12.

[3] "Open data and content can be freely used, modified, and shared by anyone for any purpose", <https://opendefinition.org> (visited on October 2024)





Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management

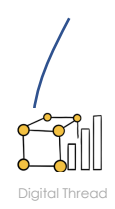


Future of Collaboration in SE

Augmented Engineering

A journey towards enhanced engineers





Supporting engineers through an **integrated and assistive tooling** allowing for **technical and human benefits**

– “Augmented Worker” © [Tulip.co](https://tulip.co)

seamless part of the work environment

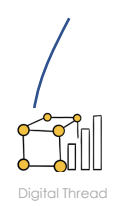
improved efficiency

enable maximal human performance

”

Supporting engineers through an **integrated and assistive tooling** allowing for **technical and human benefits**

– “Augmented Worker” © [Tulip.co](https://tulip.co)



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management

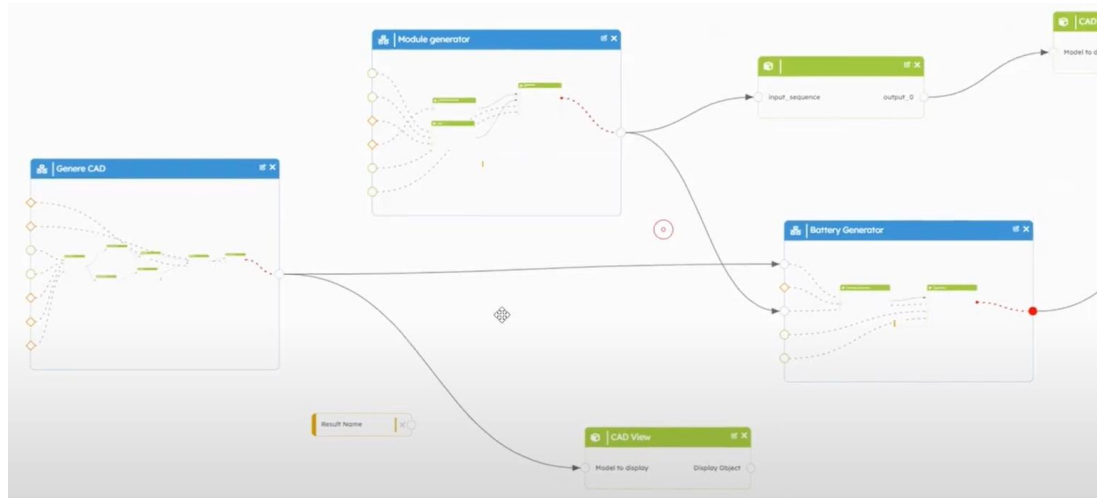


Future of Collaboration in SE

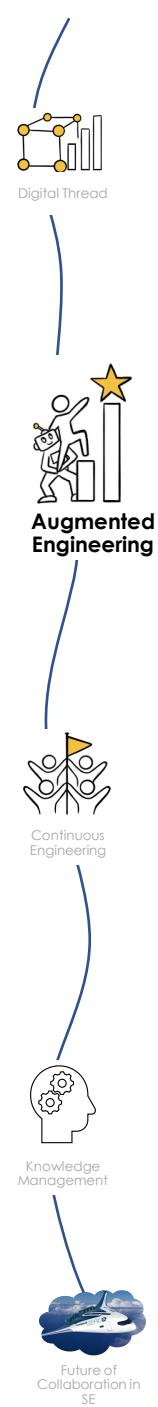
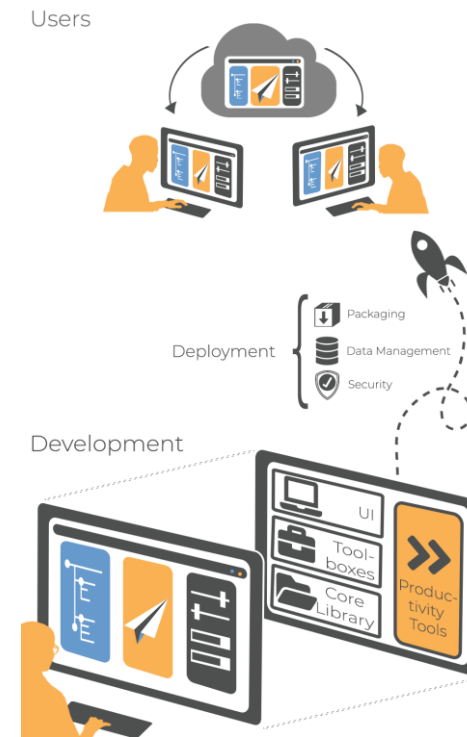
Get rid of repetitive/laborious tasks



A web platform to explore design by leveraging customizables and AI-powered workflows



A web platform to provide engineers with domain-specific environments that automate repetitive tasks





Digital Thread



Augmented Engineering



Continuous Engineering



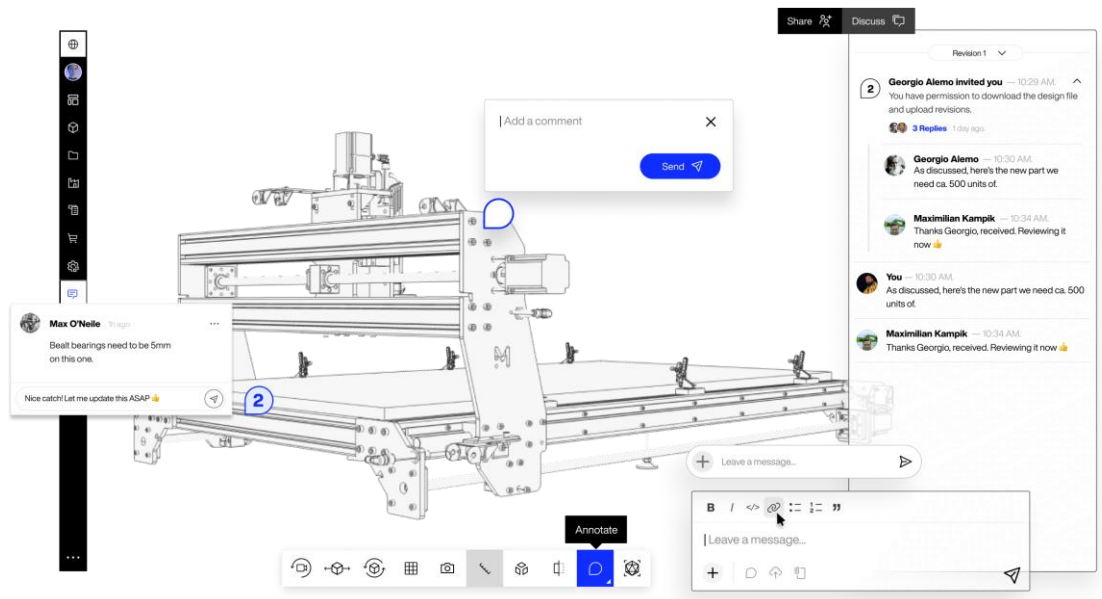
Knowledge Management



Future of Collaboration in SE



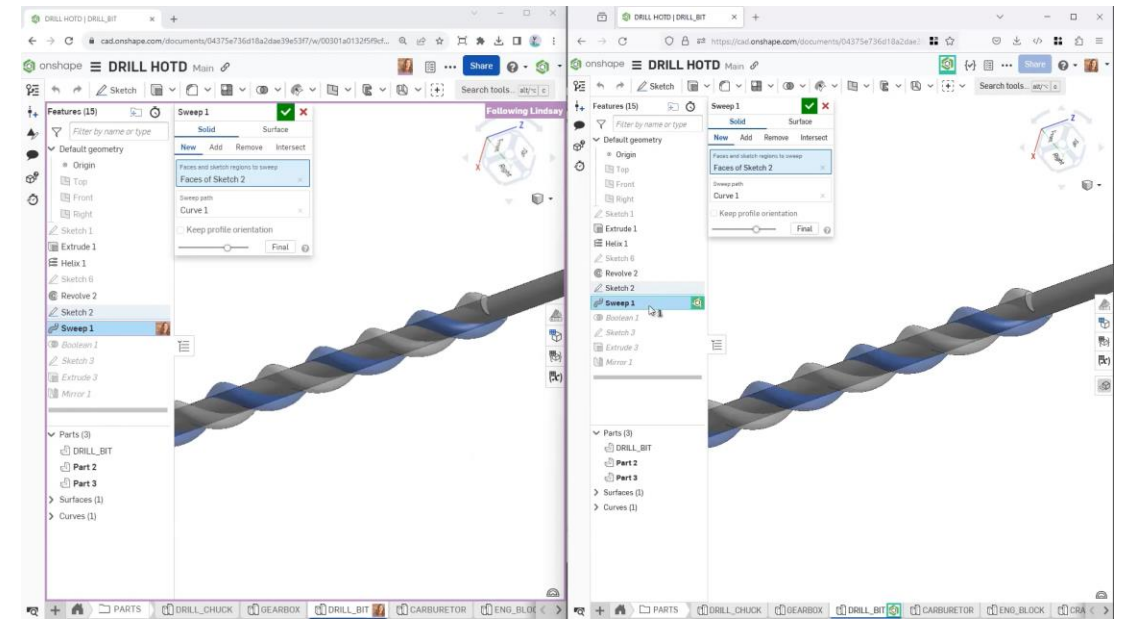
A cloud-based CAD collaboration platform

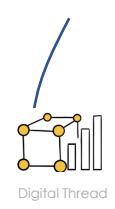


Ease collaboration



A cloud-based collaborative platform for CAD and PDM





Digital Thread



Augmented Engineering



Continuous Engineering



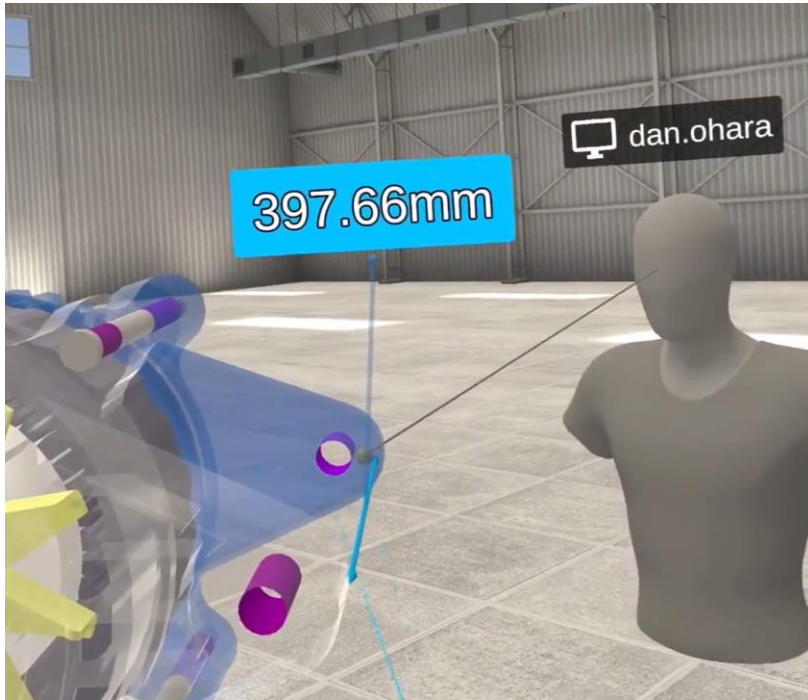
Knowledge Management



Future of Collaboration in SE



An “augmented, mixed and virtual reality for the engineering metaverse”

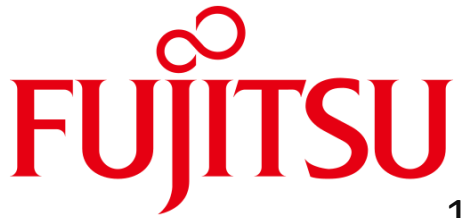


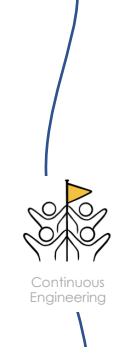
More creative thinking

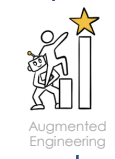


An “XR engineering application for visualizing, interacting and collaborating on 3D CAD data”





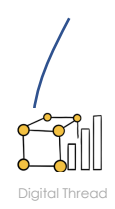




Continuous Engineering

A journey towards change-resilient teams





Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management



Future of Collaboration in SE

Continuous Engineering

An **holistic** approach
that **integrates all the stages** of a product lifecycle
into a **continuous lifecycle**

Agile processes

End-to-end integration

Data-driven decision making

Continuous improvement

Seamless toolchain

Change-resilience

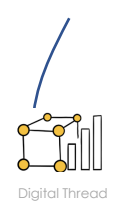
Cross-disciplinary collaboration



Agile
processes

End-to-end
integration







Digital Thread



Augmented
Engineering



**Continuous
Engineering**



Knowledge
Management

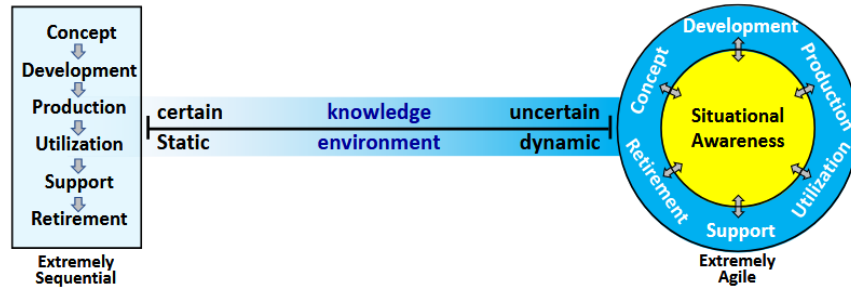


Future of
Collaboration in
SE

ability to embrace change at any time in the product lifecycle [1,2,3,4]

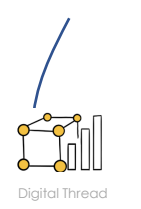
What does it mean to be agile?

” Agility is being prepared to navigate a systems engineering project through dynamic and uncertain operating environments
– paraphrased from [4]



Systems lifecycle spectrum (figure extracted from [4])

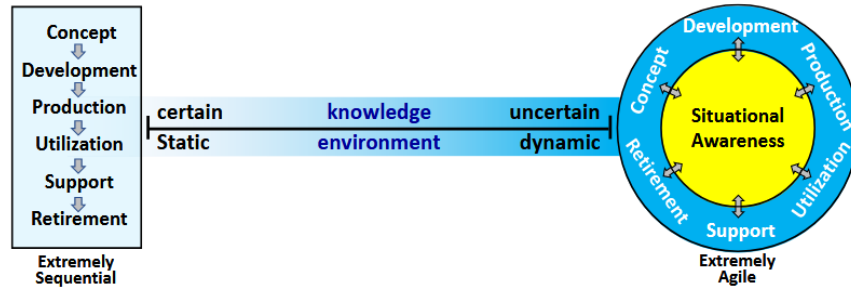
[1] Dove, R., & Schindel, B. (2019, July). Agile systems engineering life cycle model for mixed discipline engineering. In INCOSE International Symposium (Vol. 29, No. 1, pp. 86-104).
 [2] Ainejian, S., Boy, G. A., Charlier, N., Decre, Y., Krob, D., & Le Sauce, L. (2019, December). Agile Systems Engineering: an Iterative and Collaborative Approach for Complex Systems Development. In 10th Complex Systems Design & Management Conference.
 [3] Phyllis Marbach. "Agile Systems Engineering" in SEBoK Editorial Board. 2024. The Guide to the Systems Engineering Body of Knowledge (SEBoK), v. 2.10, N. Hutchison (Editor in Chief). Hoboken, NJ: The Trustees of the Stevens Institute of Technology. Accessed October 2024. www.sebokwiki.org. BKCASE is managed and maintained by the Stevens Institute of Technology Systems Engineering Research Center, the International Council on Systems Engineering, and the Institute of Electrical and Electronics Engineers Systems Council.
 [4] Dove, R., Lunney, K., Orosz, M., & Yokell, M. (2023, July). Agile systems engineering—Eight core aspects. In INCOSE International Symposium (Vol. 33, No. 1, pp. 823-837).



ability to embrace change at any time in the product lifecycle [1,2,3,4]

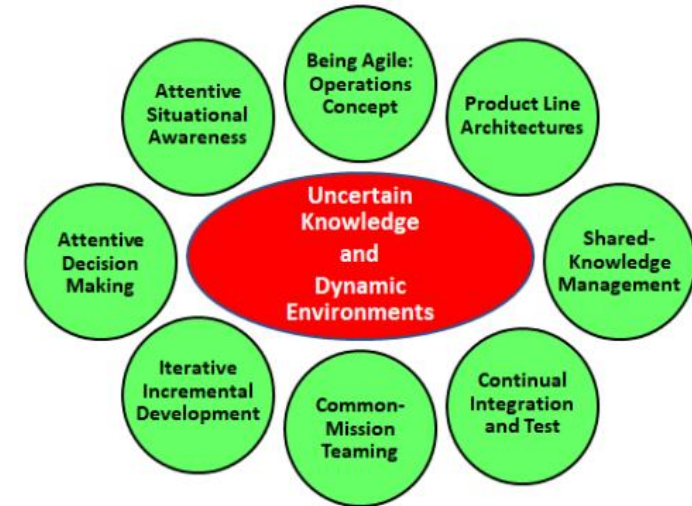
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Systems lifecycle spectrum (figure extracted from [4])

Sounds great! But... how?



Eight core aspects of agile systems engineering (figure extracted from [4])

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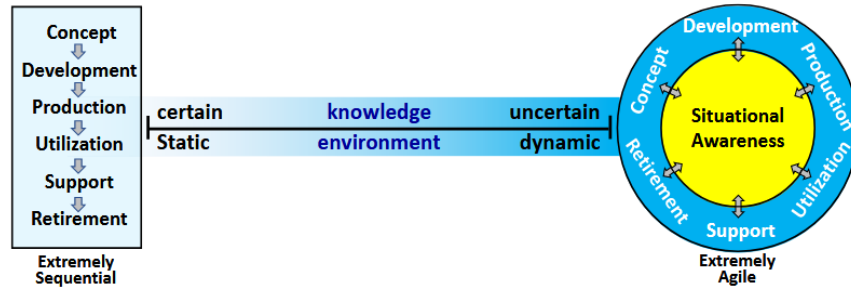
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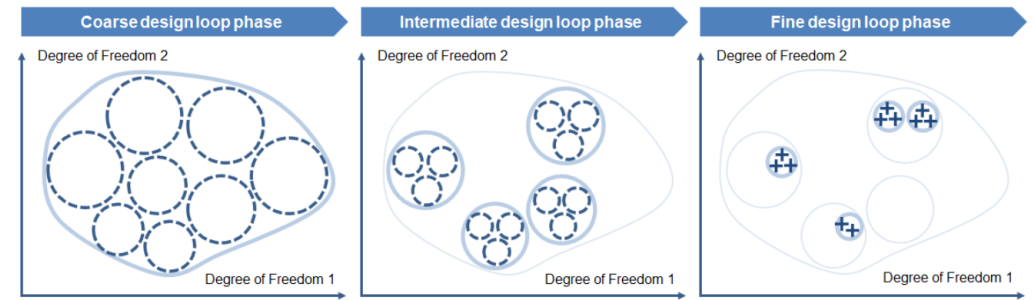
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Systems lifecycle spectrum (figure extracted from [4])

Sounds great! But... how?

“An agile project is a mechanism for iteratively refining a product’s design space – paraphrased from [2]



Principle for exploring the design space in an agile way (figure extracted from [2])

Key Features [2,5]

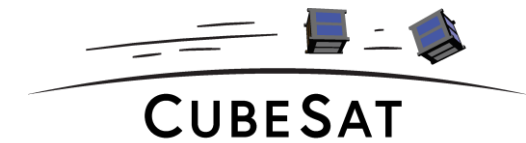
- iterative and incremental development
- autonomous and product-centric teams
- mindset of working towards a common goal
- early system integration and validation

[1] Dove, R., & Schindel, B. (2019, July). Agile systems engineering life cycle model for mixed discipline engineering. In INCOSE International Symposium (Vol. 29, No. 1, pp. 86-104).
 [2] Ainejian, S., Boy, G. A., Charlier, N., Decre, Y., Krob, D., & Le Sauce, L. (2019, December). Agile Systems Engineering: an Iterative and Collaborative Approach for Complex Systems Development. In 10th Complex Systems Design & Management Conference.
 [3] Phyllis Marbach. "Agile Systems Engineering" in SEBoK Editorial Board. 2024. The Guide to the Systems Engineering Body of Knowledge (SEBoK), v. 2.10, N. Hutchison (Editor in Chief). Hoboken, NJ: The Trustees of the Stevens Institute of Technology. Accessed October 2024. www.sebokwiki.org. BKCASE is managed and maintained by the Stevens Institute of Technology Systems Engineering Research Center, the International Council on Systems Engineering, and the Institute of Electrical and Electronics Engineers Systems Council.
 [4] Dove, R., Lunney, K., Orosz, M., & Yokell, M. (2023, July). Agile systems engineering—Eight core aspects. In INCOSE International Symposium (Vol. 33, No. 1, pp. 823-837).
 [5] Denil, J., Salay, R., Paredis, C., & Vangheluwe, H. (2017). Towards agile model-based systems engineering. In CEUR workshop proceedings (pp. 424-429).

ability to **embrace change**
at **any time** in the product lifecycle [1,2,3,4]



Success stories [1,5,6,7,8]



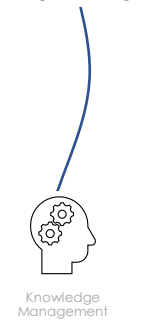
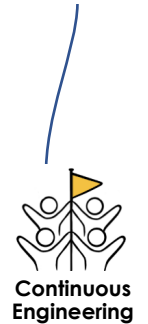
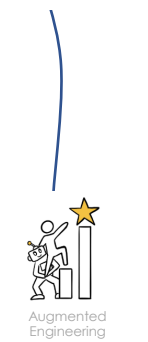
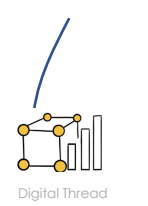
[1] Dove, R., & Schindel, B. (2019, July). Agile systems engineering life cycle model for mixed discipline engineering. In INCOSE International Symposium (Vol. 29, No. 1, pp. 86-104).

[5] Denil, J., Salay, R., Paredis, C., & Vangheluwe, H. (2017). Towards agile model-based systems engineering. In CEUR workshop proceedings (pp. 424-429).

[6] Poth, A., & Wolf, F. (2017). Agile procedures of an automotive OEM—views from different business areas. In Systems, Software and Services Process Improvement: 24th European Conference, EuroSPI 2017, Ostrava, Czech Republic, September 6–8, 2017, Proceedings 24 (pp. 513-522). Springer International Publishing.

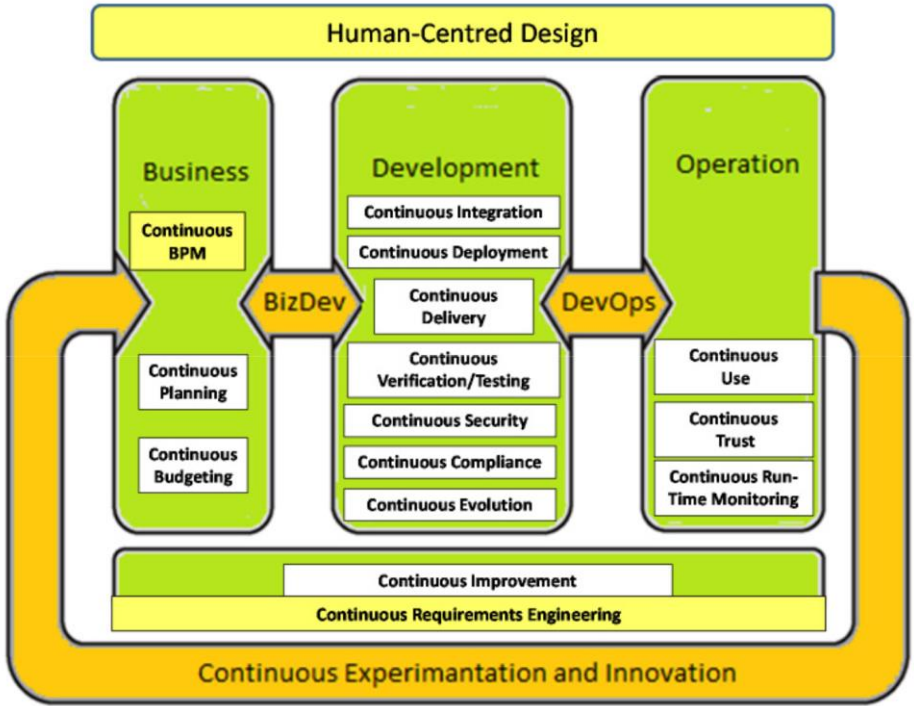
[7] Dove, R., Schindel, W., & Garlington, K. (2018, July). Case study: Agile systems engineering at lockheed martin aeronautics integrated fighter group. In INCOSE International Symposium (Vol. 28, No. 1, pp. 303-320).

[8] Carlson, R., & Turner, R. (2013). Review of agile case studies for applicability to aircraft systems integration. Procedia Computer Science, 16, 469-474.



unify all the "times" of a product lifecycle (design-time, runtime...) [1,2]

...in theory: a holistic lifecycle (yes, still breaking silos)



General overview of continuous engineering activities (figure extracted from [1])



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management



Future of Collaboration in SE

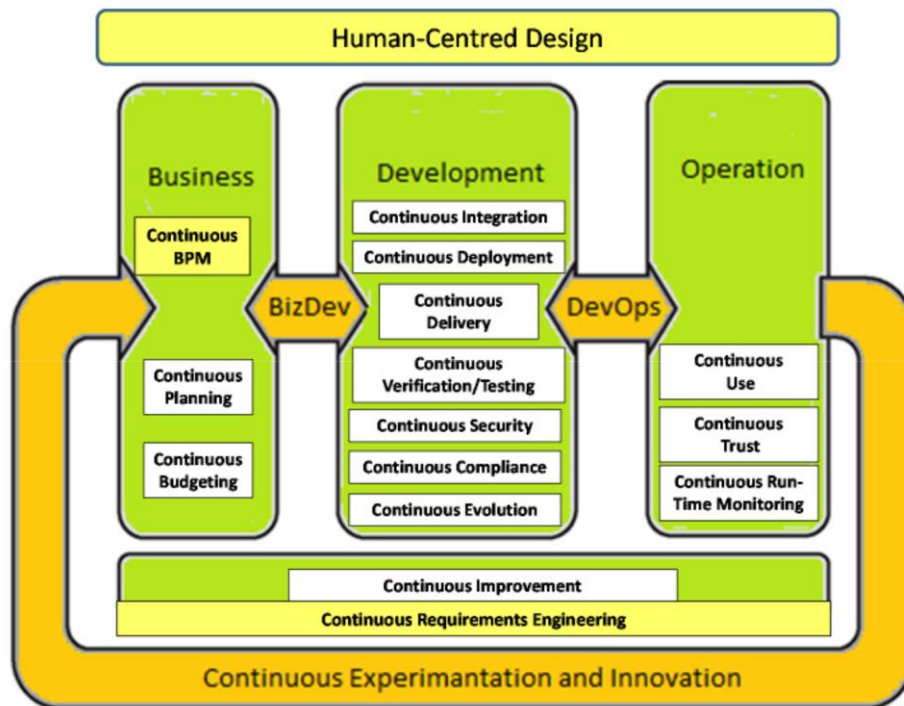
[1] Forbrig, P. (2017). *Does Continuous Requirements Engineering need Continuous Software Engineering?*. In REFSQ Workshops (pp. 1591886083-105399991).

[2] Antonino, P. O., Capilla, R., Kazman, R., Kuhn, T., Schnicke, F., Treichel, T., ... & Salamanca, V. (2022). *Continuous engineering for Industry 4.0 architectures and systems*. Software: Practice and Experience, 52(10), 2241-2262.

unify all the "times" of a product lifecycle (design-time, runtime...) [1,2]

...in theory: a holistic lifecycle
(yes, still breaking silos)

...in practice: leverage Digital Twins [3,4,5,6]



General overview of continuous engineering activities (figure extracted from [1])

A **HUGE** topic: **+2000** research papers
(... between 2020 and 2022)

- Definition {
- a **virtual replica** of a real-world entity
 - **continuously updated** with real-time data
- Benefits {
- monitoring and optimization
 - extracting insights for decision making
 - experimenting with new solutions

[3] Liu, X., Jiang, D., Tao, B., Xiang, F., Jiang, G., Sun, Y., ... & Li, G. (2023). A systematic review of digital twin about physical entities, virtual models, twin data, and applications. *Advanced Engineering Informatics*, 55, 101876.

[4] Eramo, R., Bordeleau, F., Combemale, B., van Den Brand, M., Wimmer, M., & Wortmann, A. (2021). Conceptualizing digital twins. *IEEE Software*, 39(2), 39-46.

[5] Jones, D., Snider, C., Nassehi, A., Yon, J., & Hicks, B. (2020). Characterising the Digital Twin: A systematic literature review. *CIRP journal of manufacturing science and technology*, 29, 36-52.

[6] Alimam, H., Mazzuto, G., Tozzi, N., Ciarapica, F. E., & Bevilacqua, M. (2023). The resurrection of digital triplet: A cognitive pillar of human-machine integration at the dawn of industry 5.0. *Journal of King Saud University-Computer and Information Sciences*, 101846.



unify all the “times” of a product lifecycle
(design-time, runtime...) [1,2]

Cool... but what about Continuous Engineering?



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management



Future of Collaboration in SE

unify all the "times" of a product lifecycle (design-time, runtime...) [1,2]

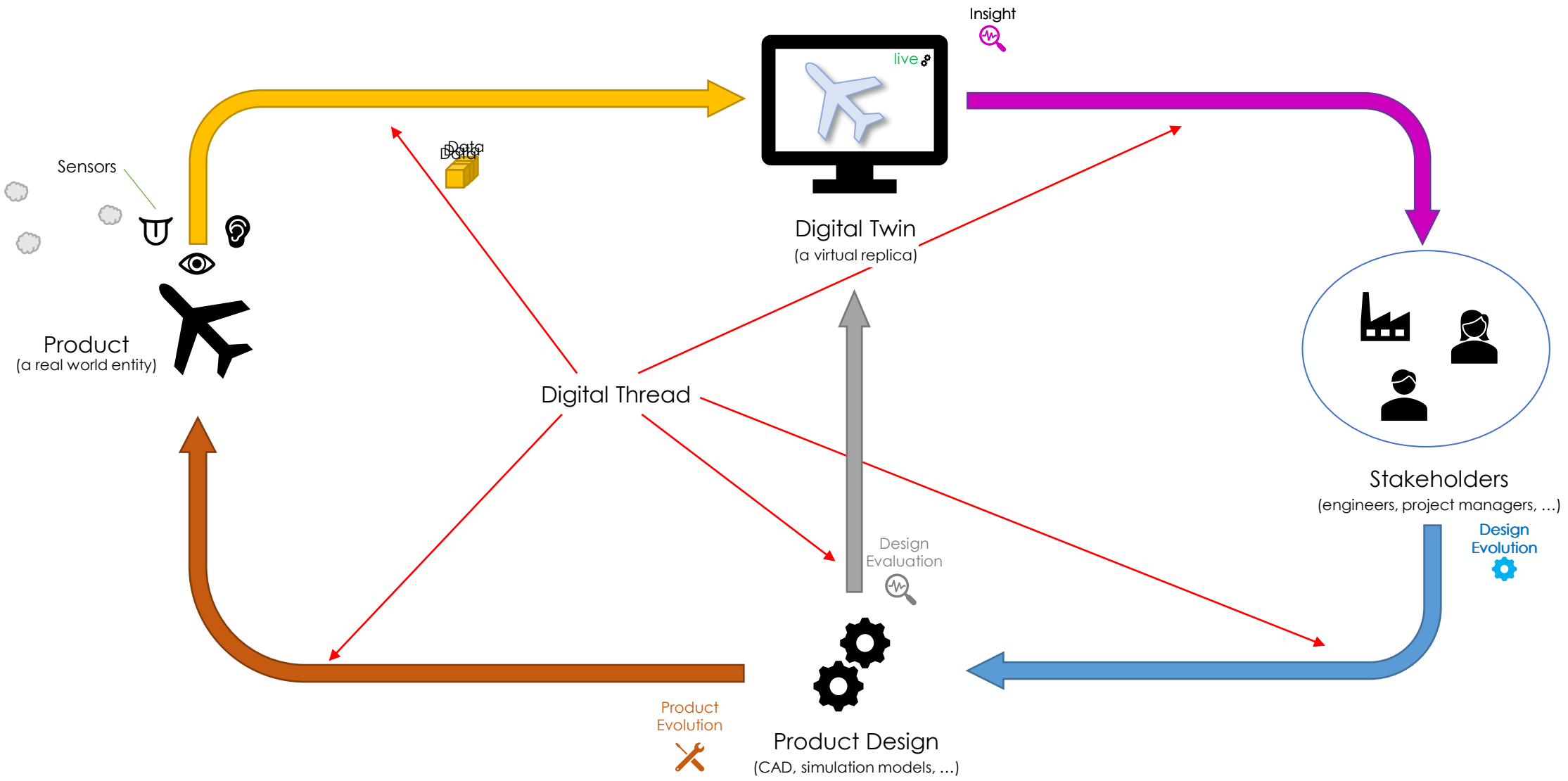
Digital Thread

Augmented Engineering

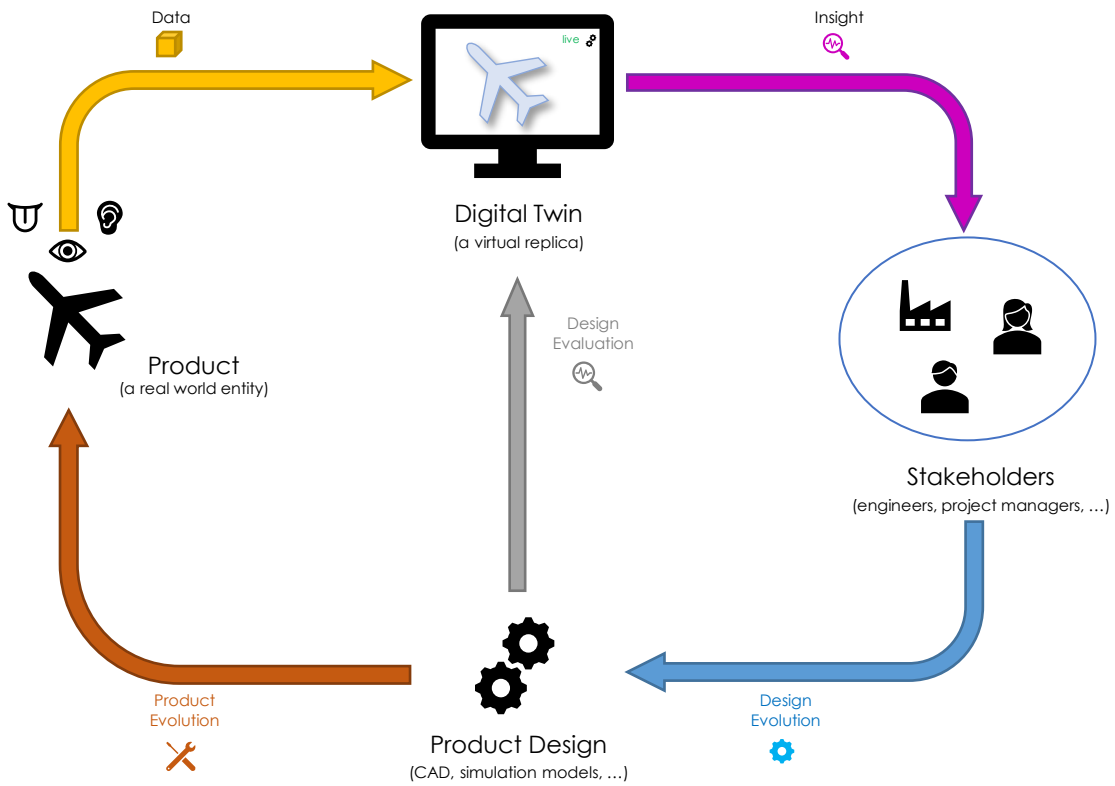
Continuous Engineering

Knowledge Management

Future of Collaboration in SE



unify all the "times" of a product lifecycle (design-time, runtime...) [1,2]



Highlights

- bridges the gap between design-time and runtime
- enables agility throughout the whole lifecycle
- relies on a digital thread



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management



Future of Collaboration in SE

unify all the “times” of a product lifecycle
(design-time, runtime...) [1,2]



Digital Thread



Augmented
Engineering



**Continuous
Engineering**



Knowledge
Management



Future of
Collaboration in
SE



Digital Thread



Augmented Engineering



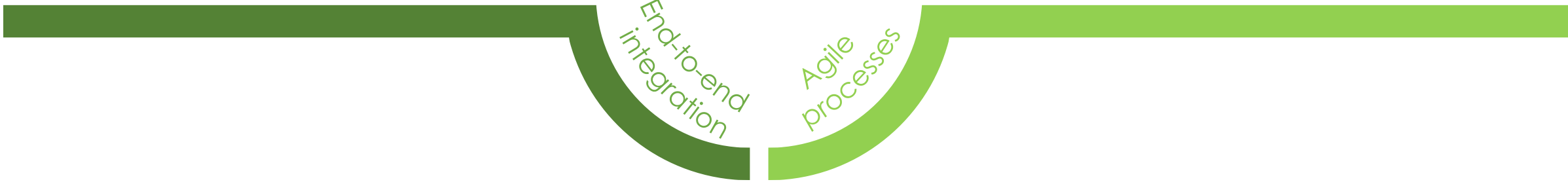
Continuous Engineering



Knowledge Management



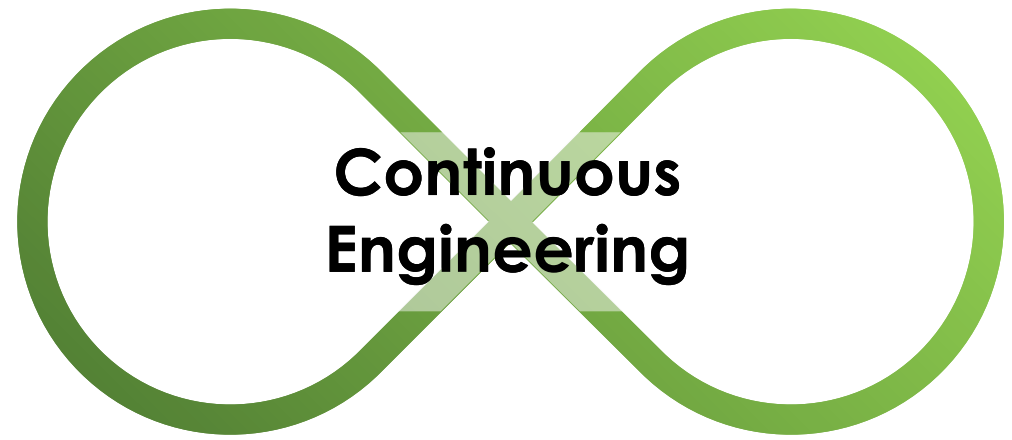
Future of Collaboration in SE



End-to-end integration

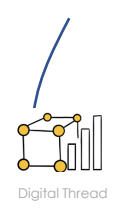
Agile processes

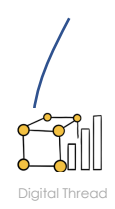
unify all the “times” of a product lifecycle



Continuous Engineering

ability to embrace change at any time in the product lifecycle





Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management

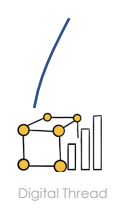


Future of Collaboration in SE

Knowledge Management

A journey towards actionable information





Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management



Future of Collaboration in SE



The collection of methods relating to **creating, sharing, using and managing** the **knowledge and information** of an organization

– Girard, J., Girard, J., & Sagology. (2015), *Defining knowledge management : Toward an applied compendium*. Online Journal of Applied Knowledge Management, 3, 1-20



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management



Future of Collaboration in SE

DATA
Raw

INFORMATION
Processed

KNOWLEDGE
Interpreted

WISDOM
Actionable

```

01011000
10100001
11101011

11111010
00011011
00110011

01011010
00100110
00001100

```





Digital Thread



Augmented Engineering



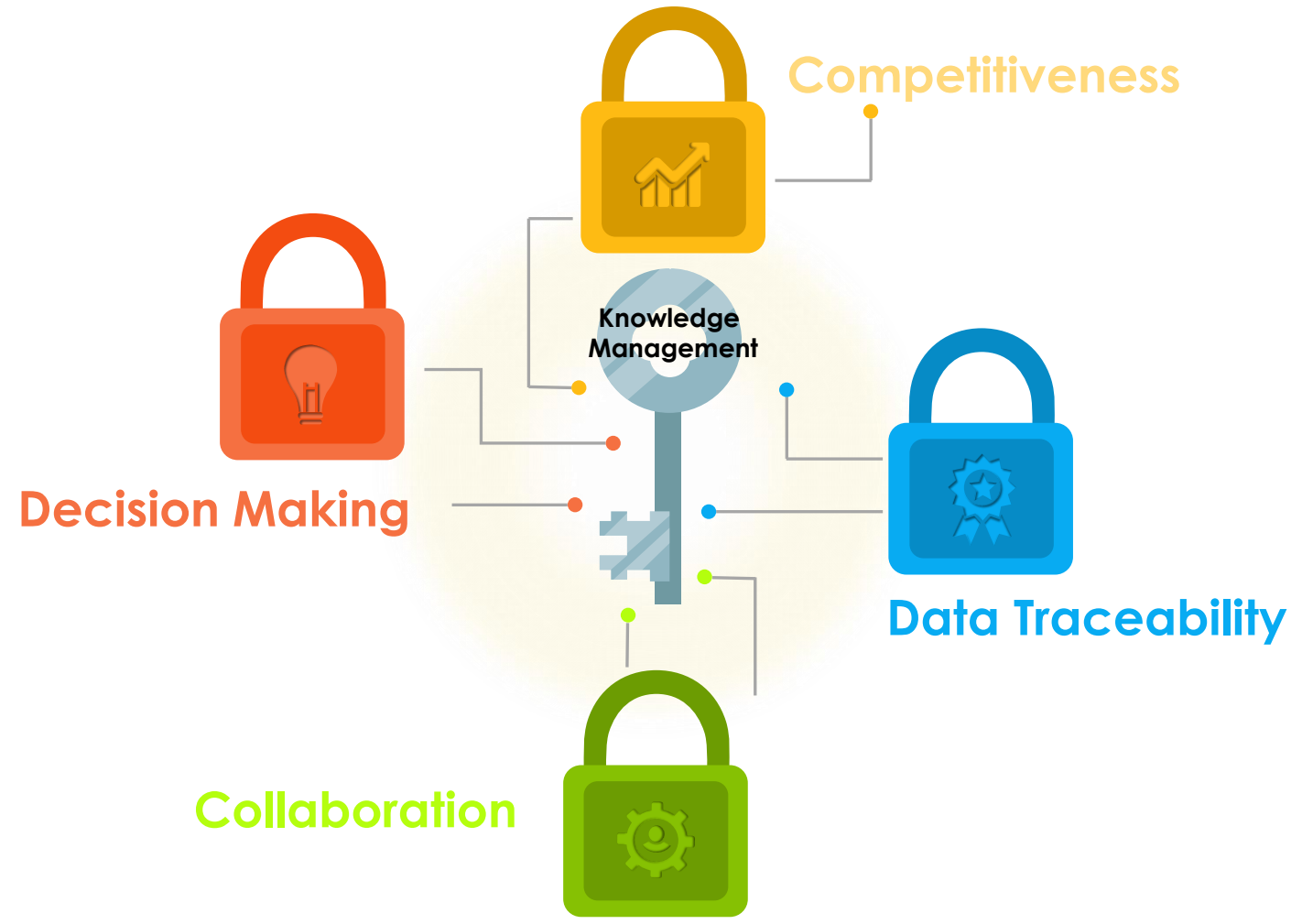
Continuous Engineering



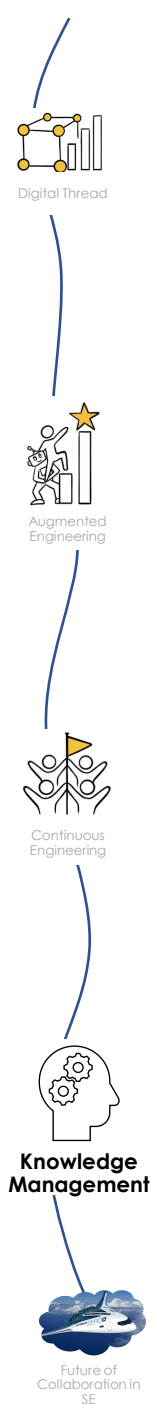
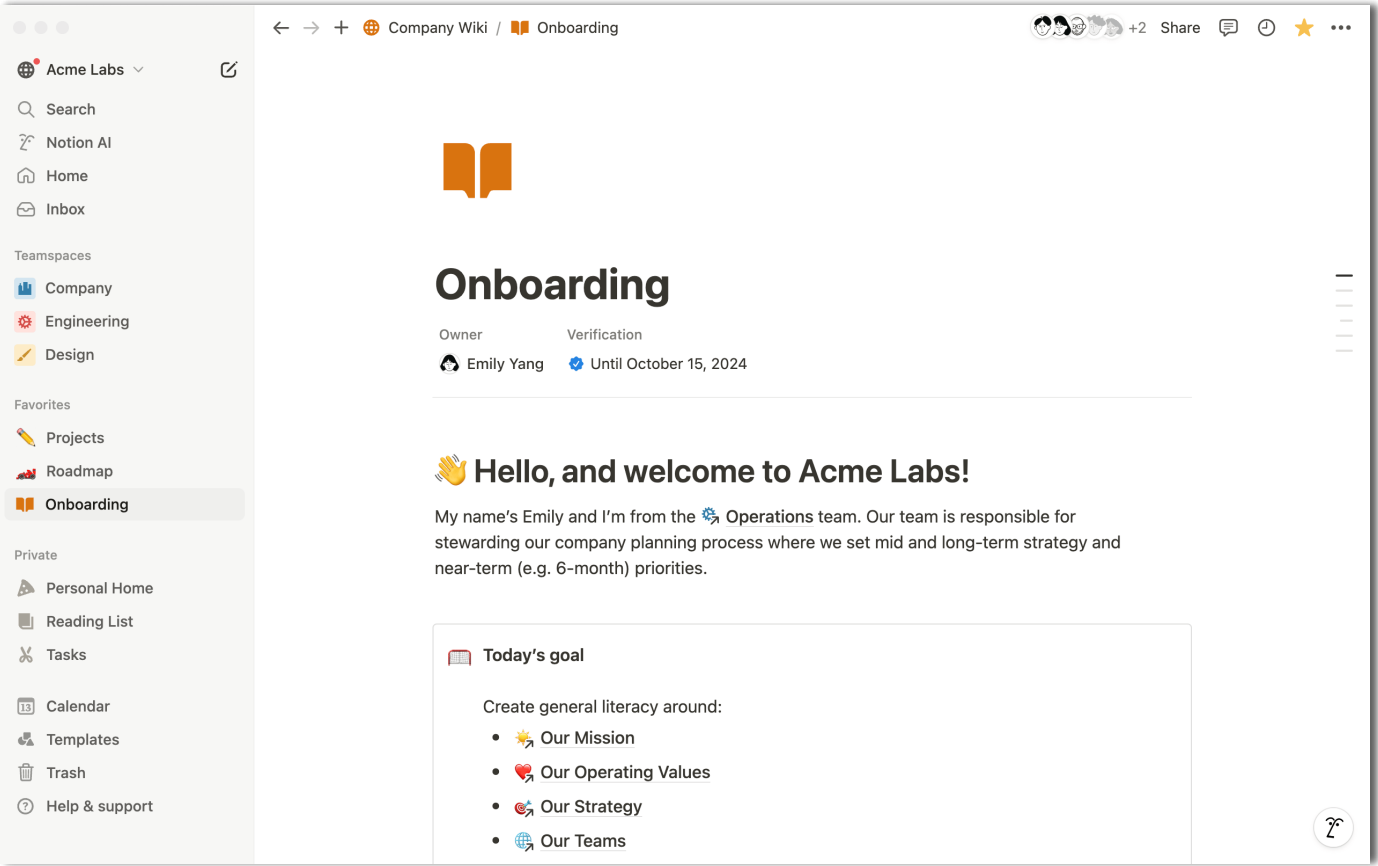
Knowledge Management



Future of Collaboration in SE



Example of a wiki built with Notion





Digital Thread



Augmented Engineering



Continuous Engineering



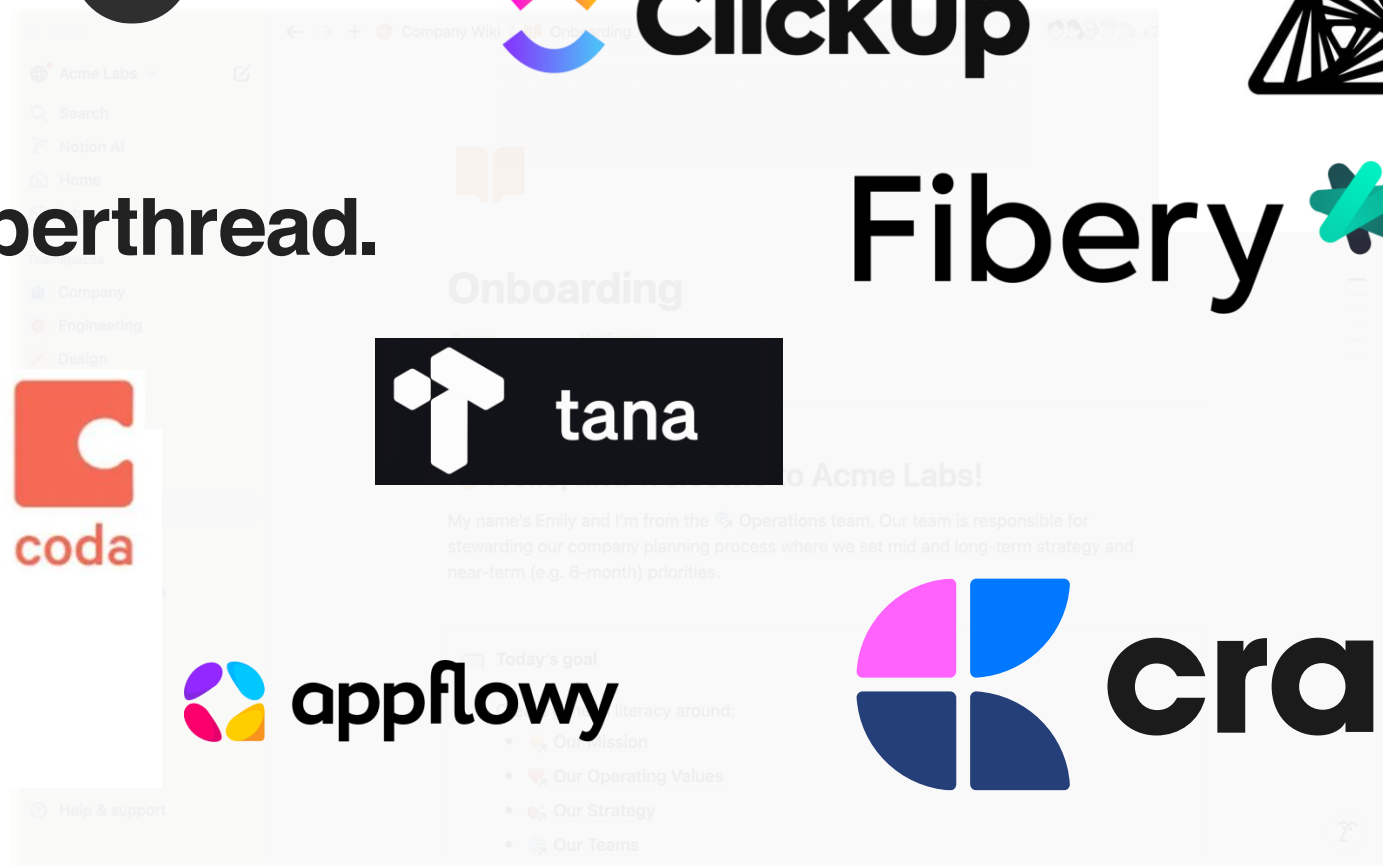
Microsoft Loop



Knowledge Management



Future of Collaboration in SE





”

Documentation sucks because it's hard/impossible to do well.

Every change [...] can trigger cascading changes in documentation and **there's no compiler to tell you which things need to change.**

— RandalBrown (on HackerNews)

Knowledge sharing is challenging



Digital Thread



Augmented Engineering



Continuous Engineering

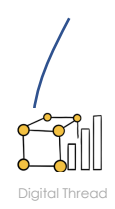


Knowledge Management



Future of Collaboration in SE

[1] Haass, O., & Azizi, N. (2020). Challenges and solutions across project life cycle: A knowledge sharing perspective. International Journal of Project Organisation and Management, 12(4), 346-379.



Digital Thread



Augmented Engineering



Continuous Engineering



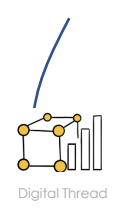
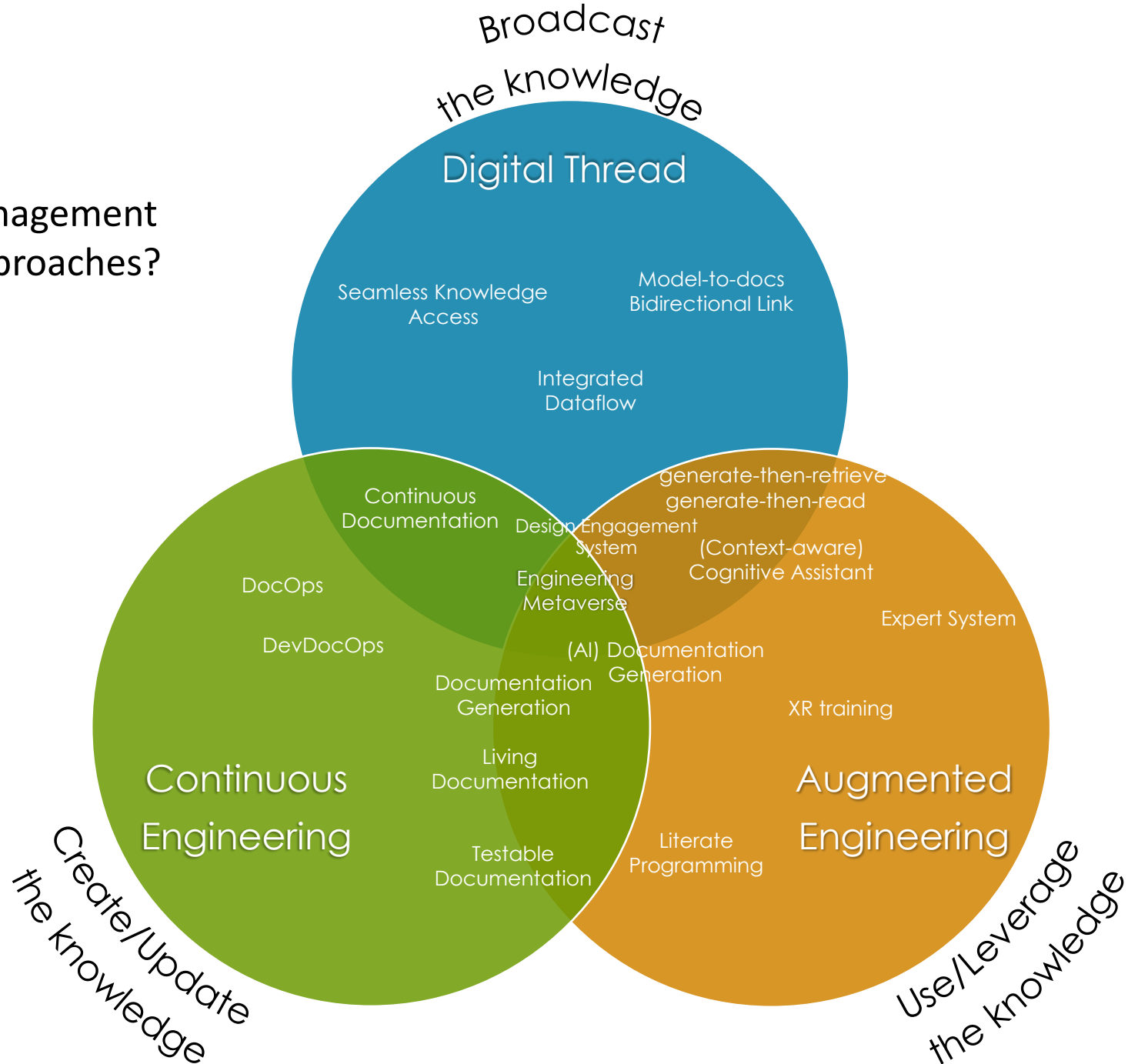
Knowledge Management



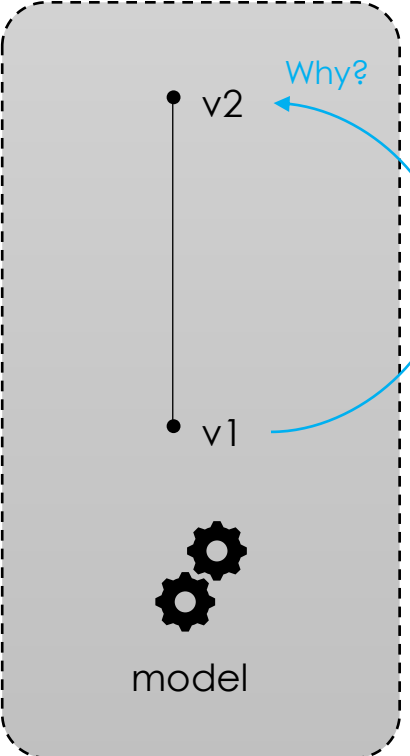
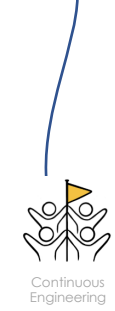
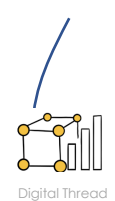
Future of Collaboration in SE

How can knowledge management benefit from modern approaches?

How can knowledge management benefit from modern approaches?

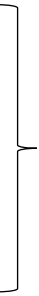


Design System of Engagement (DES) [1]

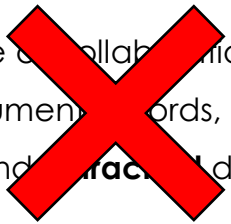


CAD, PLM

- Why was v2 necessary?
- What lead to v2?
- What were the discussions?
- What was taken into consideration?
- Who was involved?



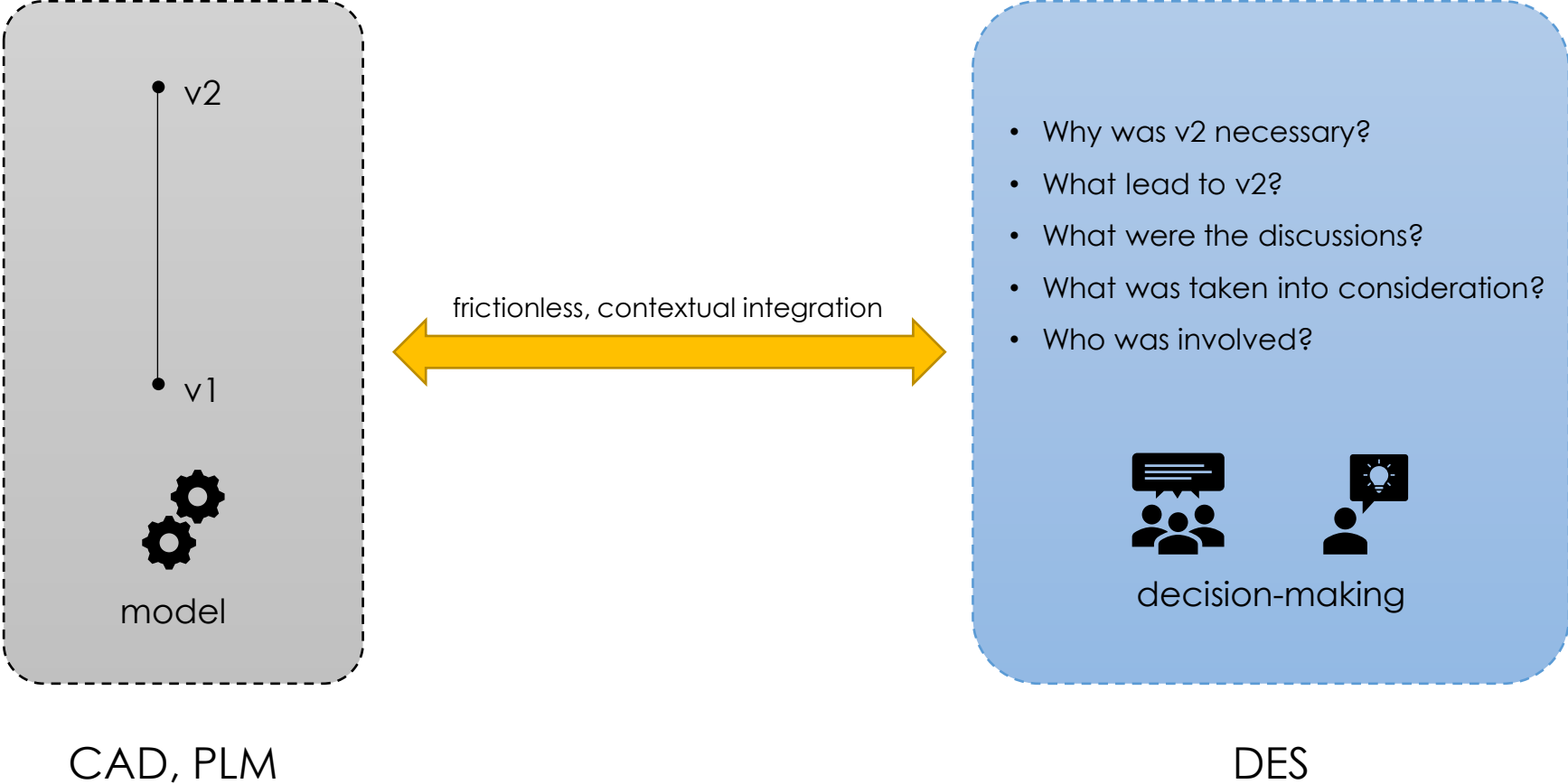
- happens outside of collaboration platforms (oral discussions, emails)
- split across documents (word, Excels, etc.)
- **disconnected** and **fragmented** decision-making process



decision-making

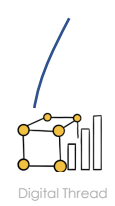
[1] "What is a Design Engagement System?", blog article at colabsoftware.com (visited on October 2024)

Design System of Engagement (DES) [1]



Digital Thread
Augmented Engineering
Continuous Engineering
Knowledge Management
Future of Collaboration in SE

[1] "What is a Design Engagement System?", blog article at colabsoftware.com (visited on October 2024)



Digital Thread



Augmented Engineering



Continuous Engineering

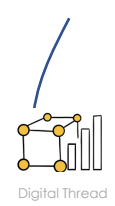
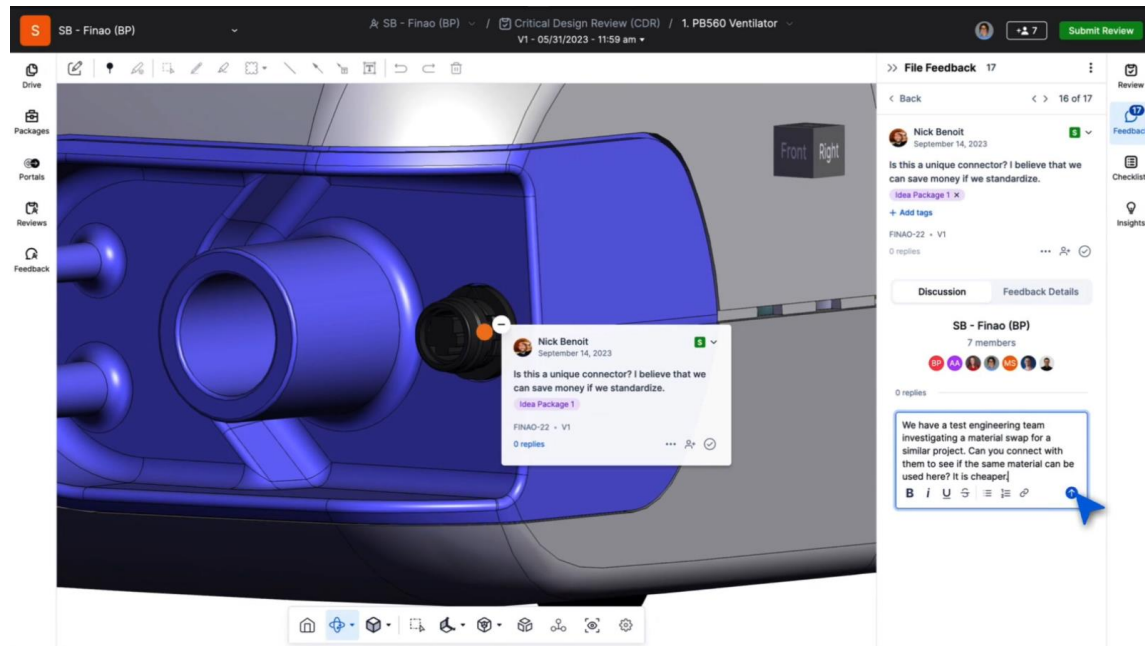


Knowledge Management



Future of Collaboration in SE

The screenshot displays the COLAB software interface. At the top, the header shows the project name "SB - Finao (BP)", the review type "Critical Design Review (CDR)", and the specific item "1. PB560 Ventilator". A "Submit Review" button is visible in the top right. The main workspace features a 3D CAD model of a blue ventilator component. A feedback comment from "Nick Benoit" is overlaid on the model, asking: "Is this a unique connector? I believe that we can save money if we standardize." The comment includes a tag "Idea Package 1" and "0 replies". To the right, a "File Feedback" sidebar shows a list of comments, with the selected one expanded to show the text: "We have a test engineering team investigating a material swap for a similar project. Can you connect with them to see if the same material can be used here? It is cheaper." The sidebar also shows the group name "SB - Finao (BP)" with 7 members and a "Feedback" button with a notification count of 17.



Digital Thread



Augmented Engineering



Continuous Engineering

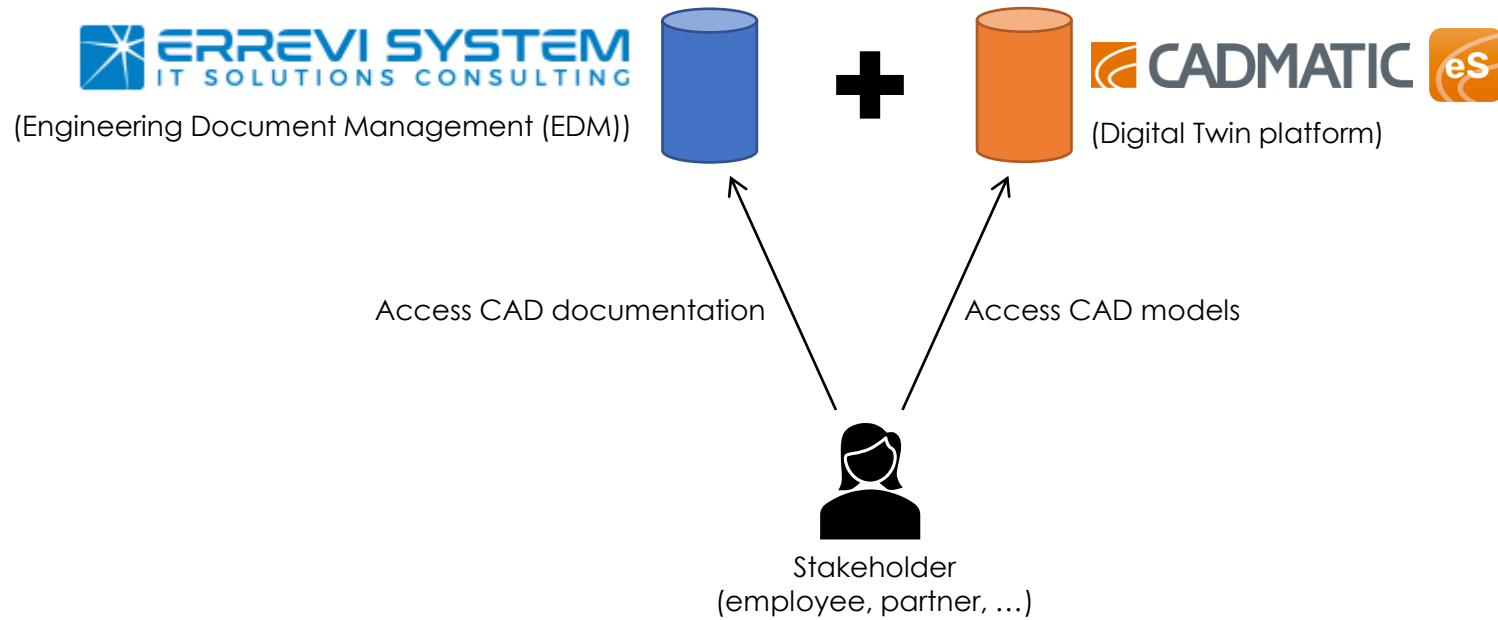


Knowledge Management



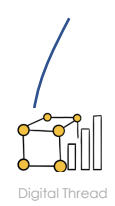
Future of Collaboration in SE

Testimony: the case of Bonatti



OLD, SILOED SYSTEM

- separated silos
- manual synchronization of an external repo
- slow documentation access



Digital Thread



Augmented Engineering



Continuous Engineering

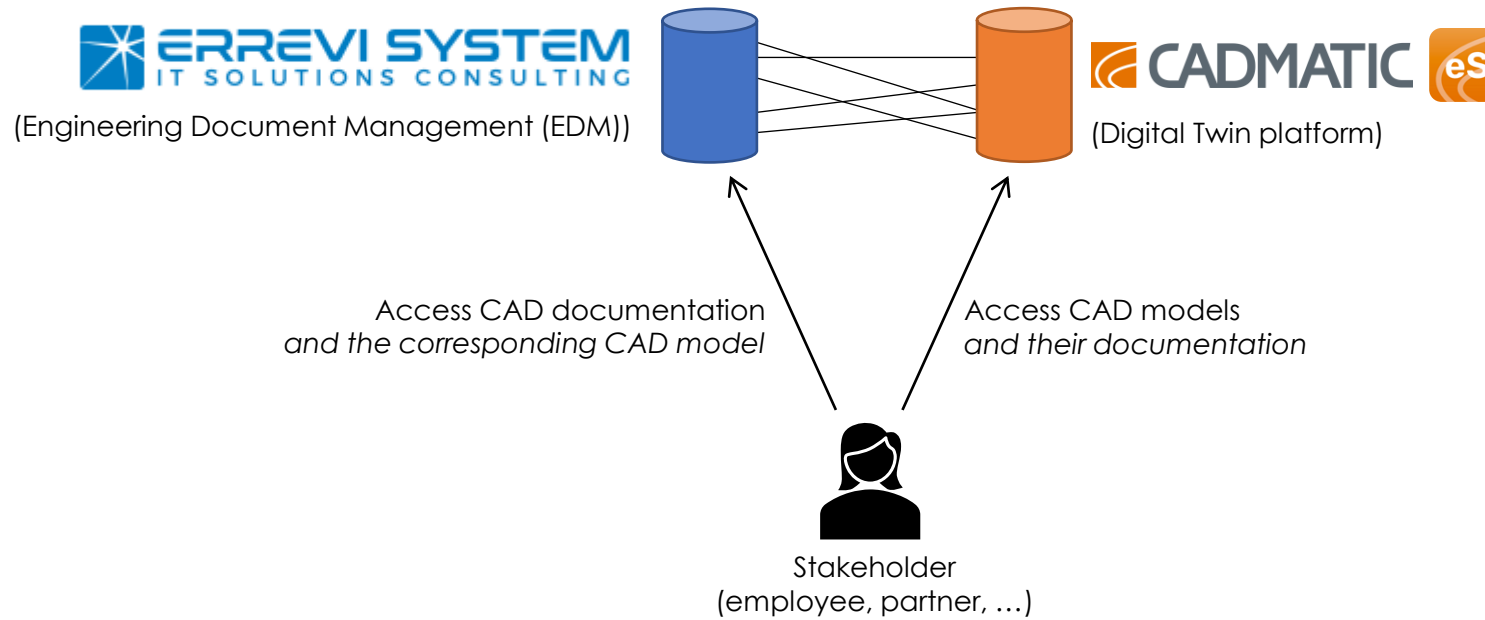


Knowledge Management



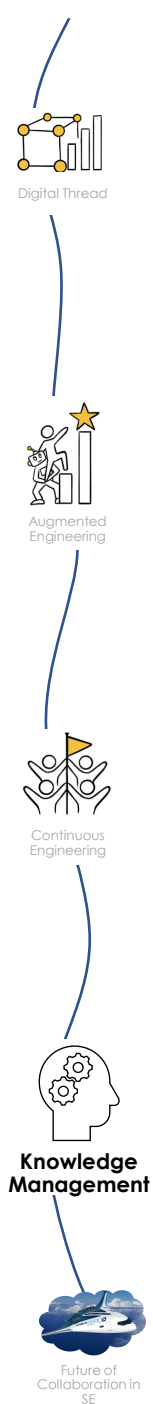
Future of Collaboration in SE

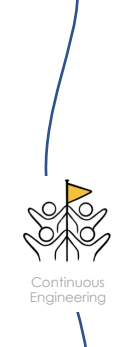
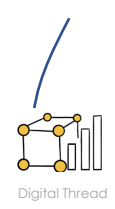
Testimony: the case of Bonatti



NEW, INTEGRATED SYSTEM

- reliable documentation
- always up-to-date
- single source of truth
- fast documentation access







The Engineering Forge



Future of Collaboration in SE

A journey towards the future



The Engineering Forge

Insight

One of the main challenges to tackle is
to **enable social interactions and collaboration**



(individual) mindset changes



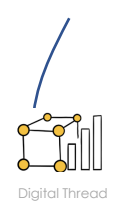
organizational changes



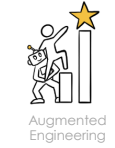
common-mission teaming
("working towards a common goal")



appropriate tooling support



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management

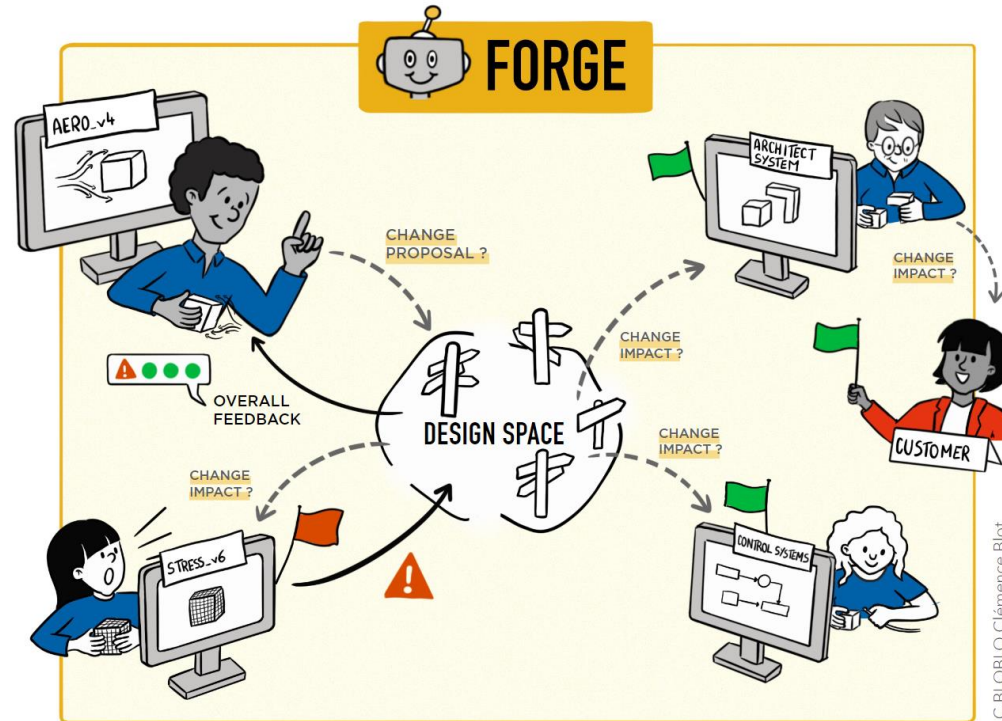


Future of
Collaboration in SE

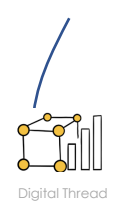
The Engineering Forge

A collaborative platform to support the exploration of a design space by:

- leveraging the Digital Thread,
- connecting Augmented Tools,
- enabling Continuous Engineering.



- C.BLOBLO Clémence Blot



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management



Future of Collaboration in SE

Main takeaways

The world **keeps accelerating**



Competitiveness



Sustainability



Dynamicity



Legislation



Expectations



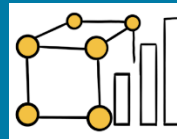
Uncertainty

INNOVATION

EXPLORATION

DECISION MAKING

KNOWLEDGE MANAGEMENT



DIGITAL THREAD

- break data silos
- the right information
 - at the right time
 - in the right context



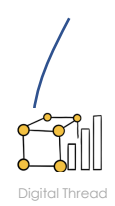
AUGMENTED ENGINEERING

- enhance engineers
- let them focus on what matters
- context-aware tooling

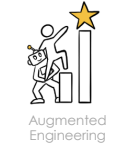


CONTINUOUS ENGINEERING

- change-resilient workflows
- shared responsibilities
- unify design and runtime



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management



Future of Collaboration in SE



Digital Thread

S

integration platforms

old concept... but modern platforms tend to rely on **ontologies and knowledge graphs**



Augmented Engineering



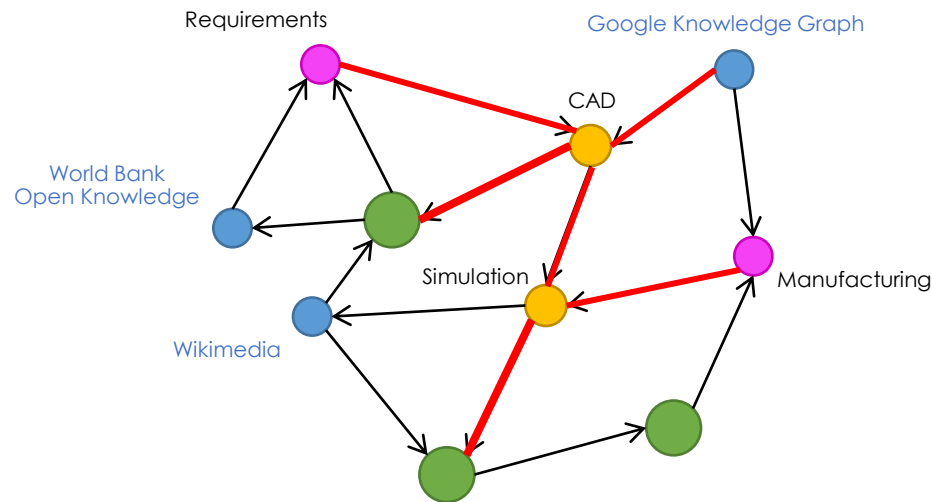
Continuous Engineering



Knowledge Management



Future of Collaboration in SE



"The Engineering Graph" (in scientific literature [1])



"The Digital Web" or "Connected Platform" (in industry [2,3,4])

- a broad, interconnected network of data and services
- may include **publicly available data** (Wikimedia, etc.)



"The Digital Thread"

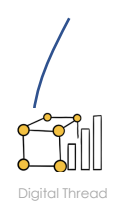
- product-specific
- continuous stream throughout the whole lifecycle
- integrates data and tools to ensure accurate and real-time information

[1] Schweitzer, G. M., Mörsdorf, S., Bitzer, M., & Vielhaber, M. (2022). Detection of cause-effect relationships in Life Cycle Sustainability Assessment based on an Engineering Graph. Proceedings of the Design Society, 2, 1129-1138.
 [2] "The Value of Digital Threads and How to Build Out an Enterprise Digital Web", [a webinar by CIMdata](#), 14 March 2024
 [3] Mentioned among others by [Aras](#), [Dassault Systèmes](#), [Oleg Shilovitsky](#) (OpenBOM co-founder), [Jos Voskuil](#) (PLM Green Alliance co-founder)
 [4] web article "[2020 A&D Wrap-up and Looking Ahead](#)" from [aras.com](#), visited on June 2024

”

Supporting engineers through an **integrated and assistive tooling** allowing for **technical and human benefits**

– “Augmented Worker” ©[Tulip.co](https://tulip.co)



Digital Thread



Augmented Engineering



Continuous Engineering



Knowledge Management



Future of Collaboration in SE

unify all the “times” of a product lifecycle (design-time, runtime...)

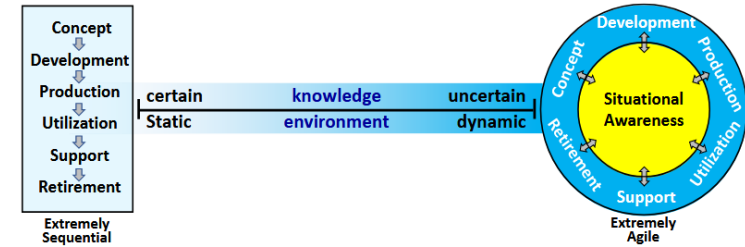
- bridges the gap between design-time and runtime
- enables agility throughout the whole lifecycle
- relies on a digital thread

ability to **embrace change**
at any point in the product lifecycle

End-to-end
integration

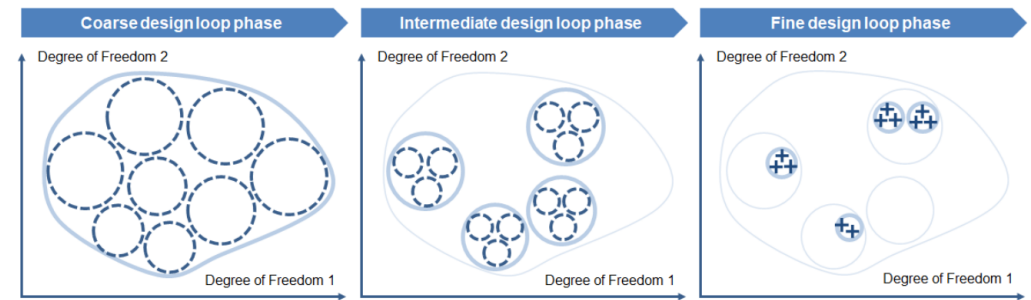
Agile
processes

What does it mean to be agile?



Systems lifecycle spectrum (figure extracted from [4])

Sounds great! But... how?



Principle for exploring the design space in an agile way (figure extracted from [2])

Key Characteristics

- iterative and incremental development
- autonomous and product-centric teams
- mindset of working towards a common goal
- early system integration and validation

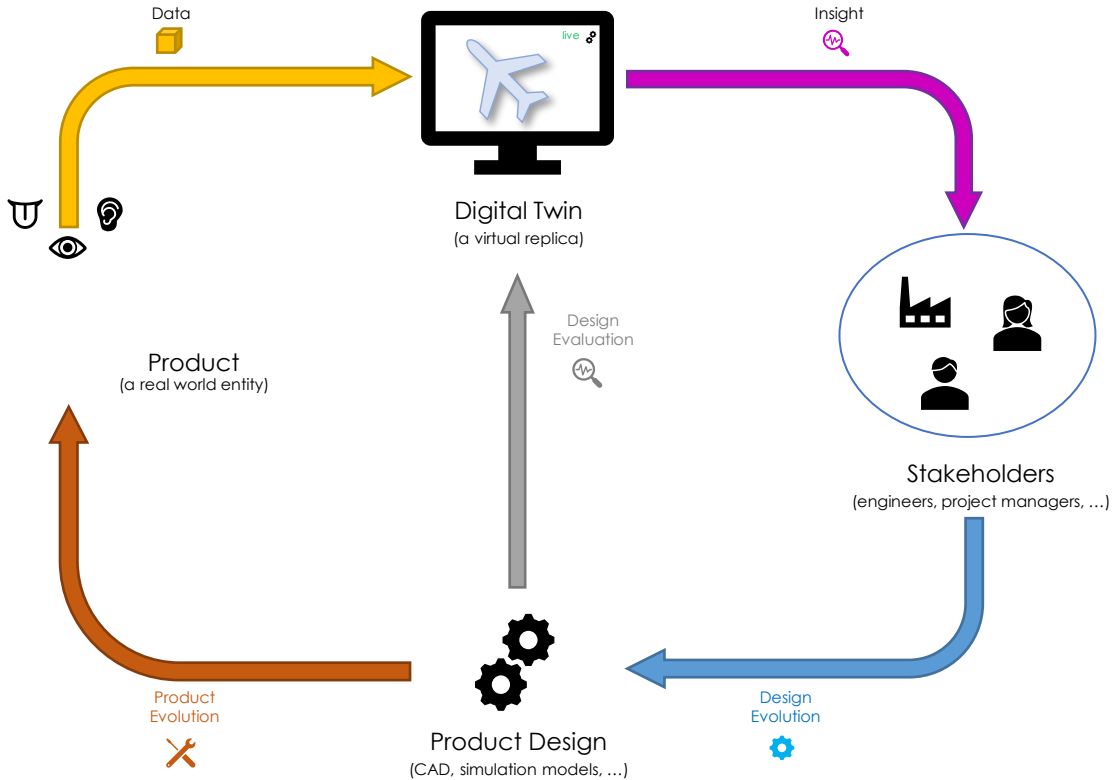
Digital Thread

Augmented Engineering

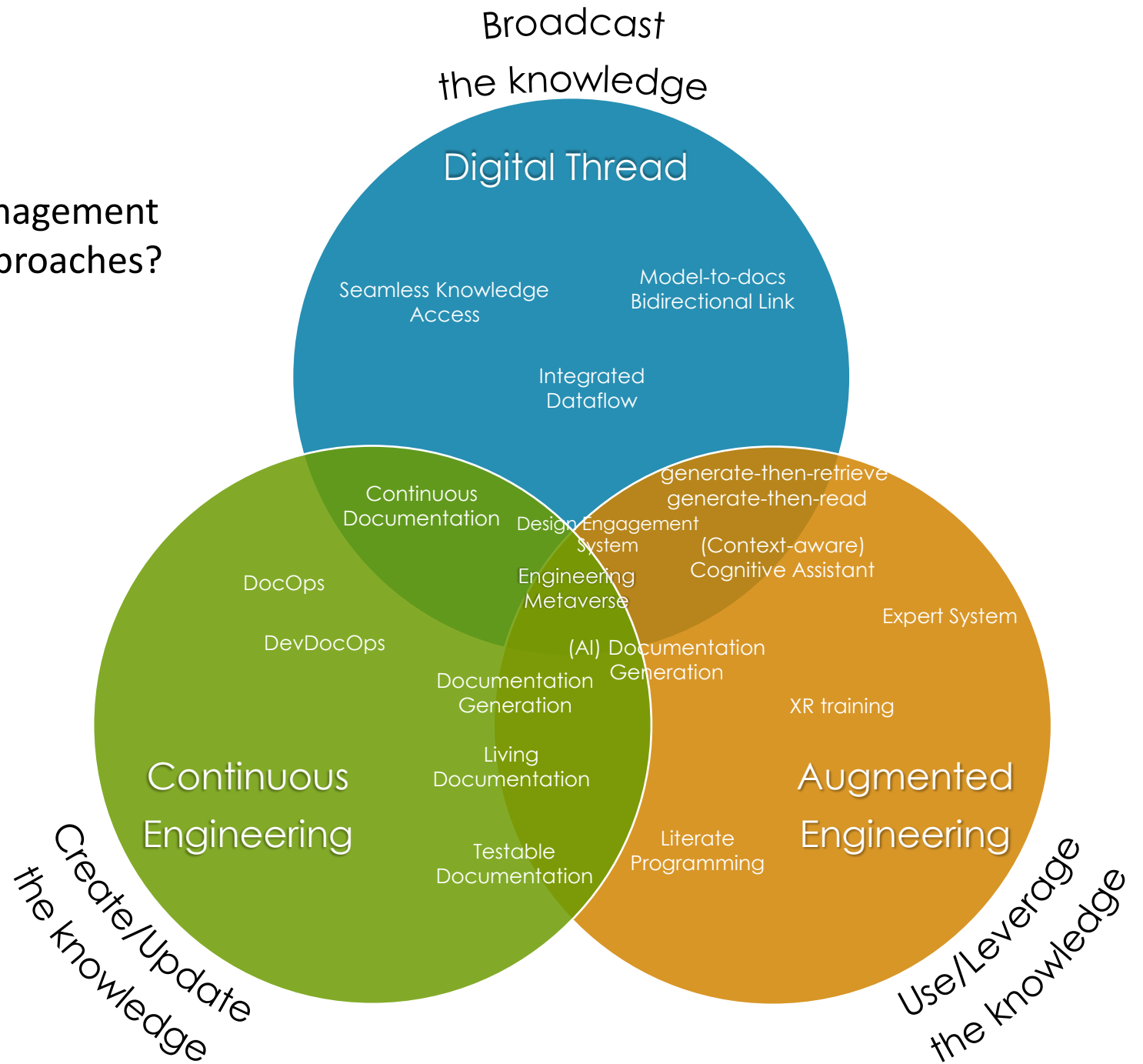
Continuous Engineering

Knowledge Management

Future of Collaboration in SE



How can knowledge management benefit from modern approaches?



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