



Digital twins

A modern time machine improving
operational processes

prof.dr.ir. Wil van der Aalst

www.vdaalst.com | @wvdaalst | www.pads.rwth-aachen.de | www.celonis.com



DIGITAL BULLETIN

Issue 34 | Nov '21

DevOps DEBATE

Industry experts on
how companies can
instill a DevOps culture

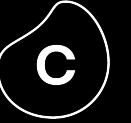
BRIDGING THE GAP

Analysing IBM's
plans to skill 30m
people by 2030

THE GODFATHER

The creator of process mining, Professor Wil van der Aalst, on
joining Celonis as Chief Scientist and why the technology has
only fulfilled a fraction of its potential

About Wil



Professor at RWTH Aachen University

Chief Scientist Celonis

Fraunhofer FIT, TiU, TU/e, QUT, FBK, etc.

CoE Internet of Production (IoP)

RWTH Center for Artificial Intelligence

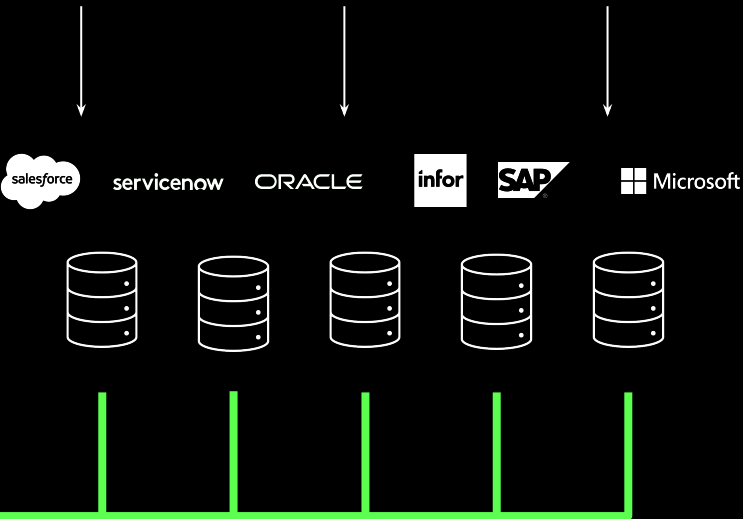
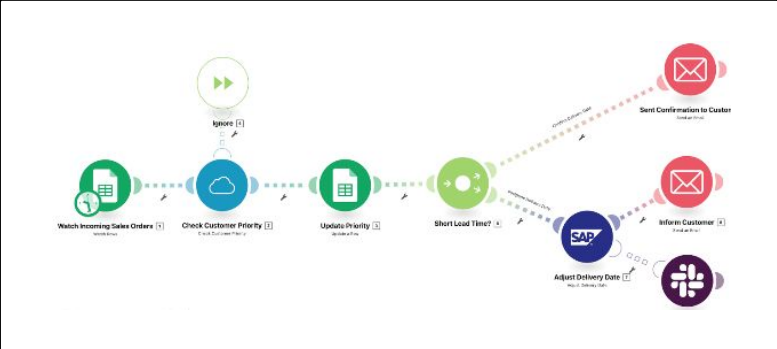
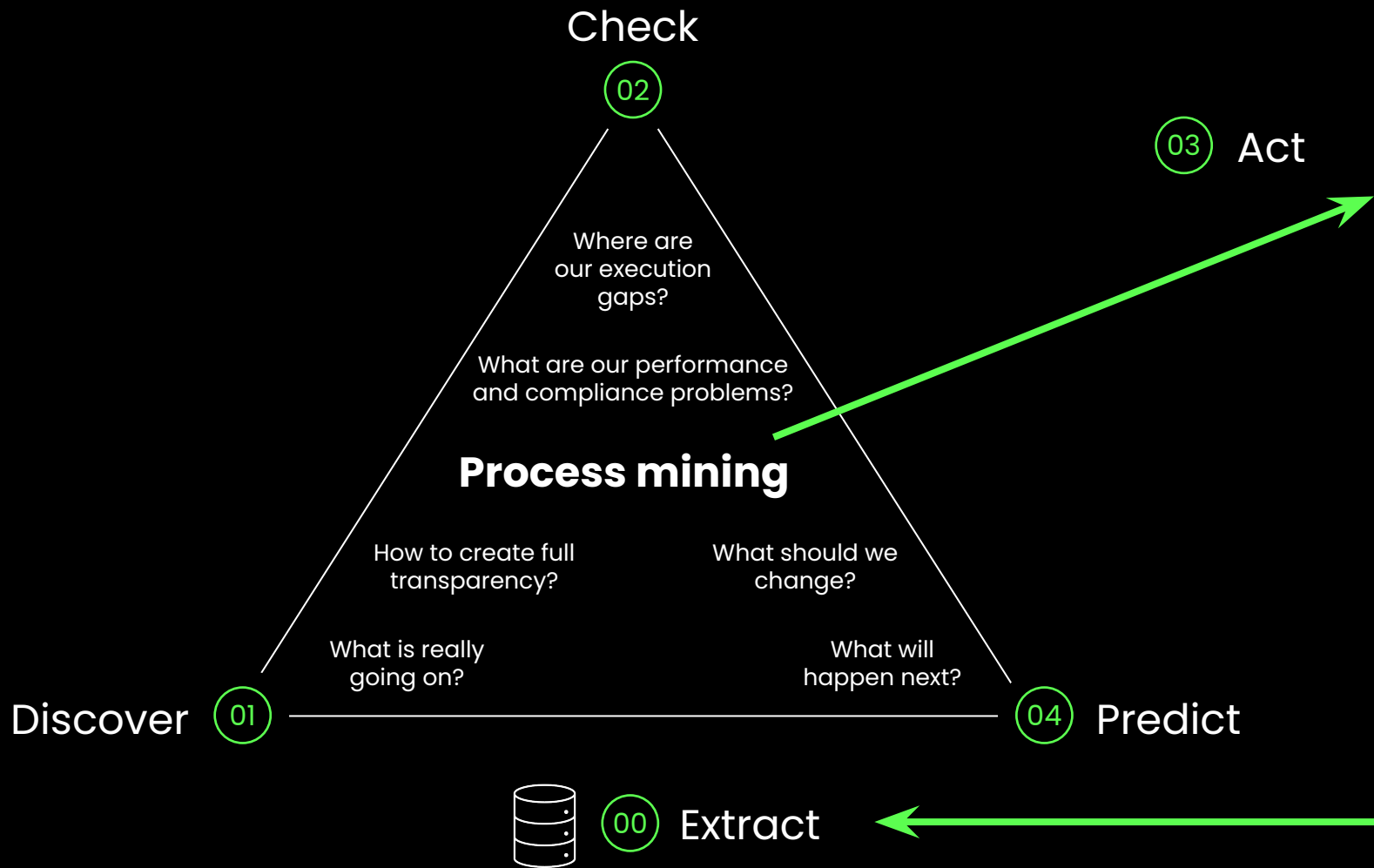
H-index 169, >128,000 citations

IEEE Fellow, ACM Fellow, IFIP Fellow

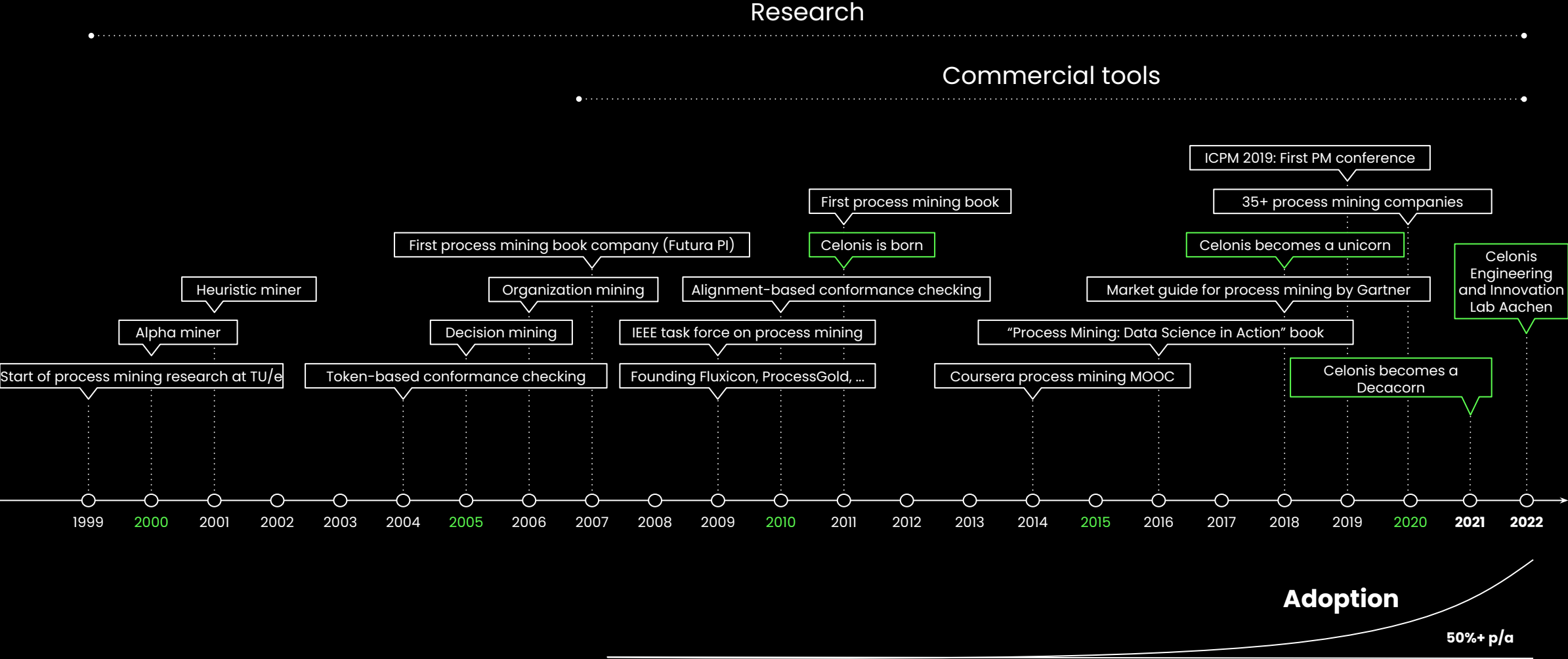
Alexander-von-Humboldt Prof. (€5M)

Several honorary degrees and elected member
of KNAW, KHMW, AE, AWK-NRW

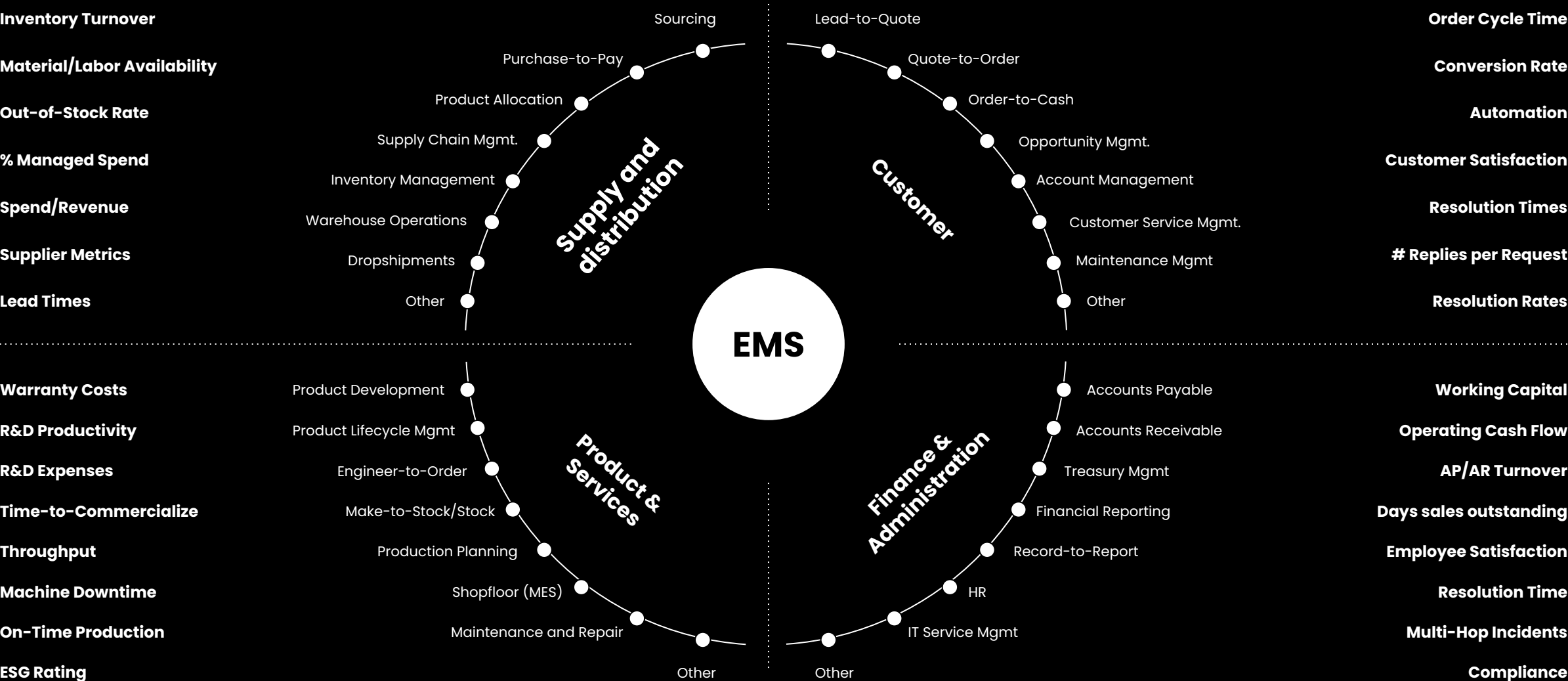
What is Process Mining?



Brief history of Process Mining



Improve performance and compliance of any operational process in your organization – Performance and Compliance



As generic as spreadsheets



C11 (L) TOTAL C1
25

	A	B	C	D
1	ITEM	NO.	UNIT	COST
2	MUCK RAKE	43	12.95	556.85
3	BUZZ CUT	15	6.75	101.25
4	TOE TONER	250	49.95	12487.50
5	EYE SNUFF	2	4.95	9.90
6				
7			SUBTOTAL	13155.50
8			9.75% TAX	1282.66
9				
10			TOTAL	14438.16
11				
12				
13				
14				
15				
16				
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20				
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23				
24				
25				

Screenshot of VisiCalc running on an Apple II computer (1979).

As generic as spreadsheets



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Process Explorer 1

Process Explorer 2

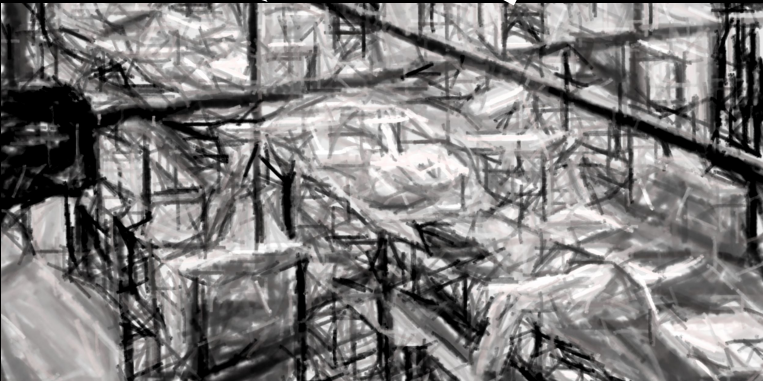
Do anything with ~~numbers~~ events

Digital Model



Manual

Manual



Digital Model

Digital Model, Digital Shadow



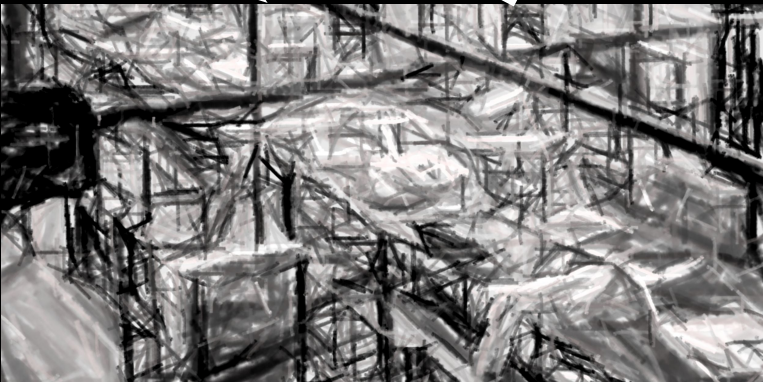
Manual

Manual



Automated

Manual

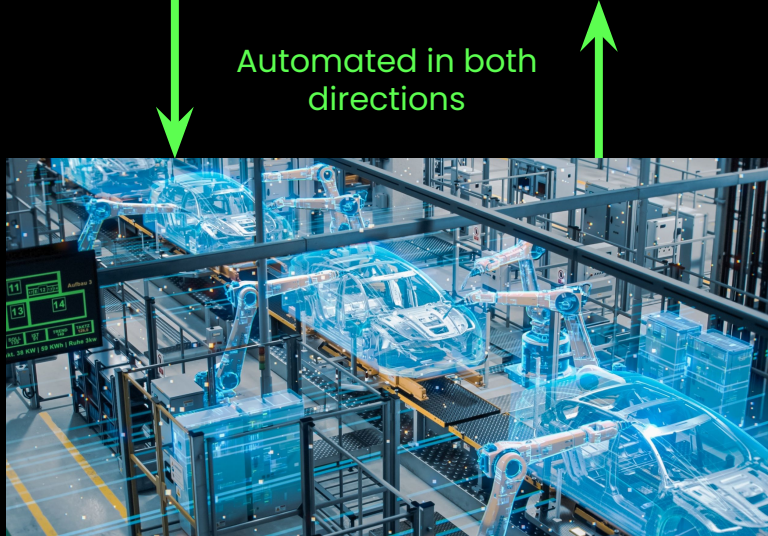
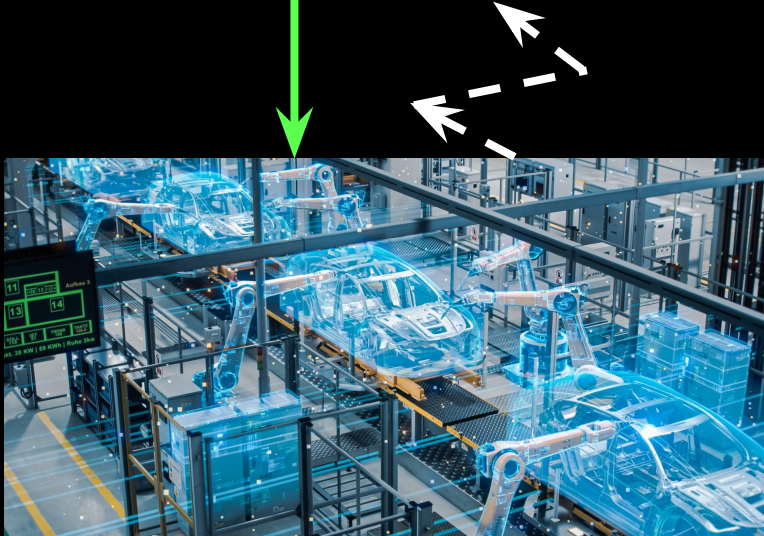
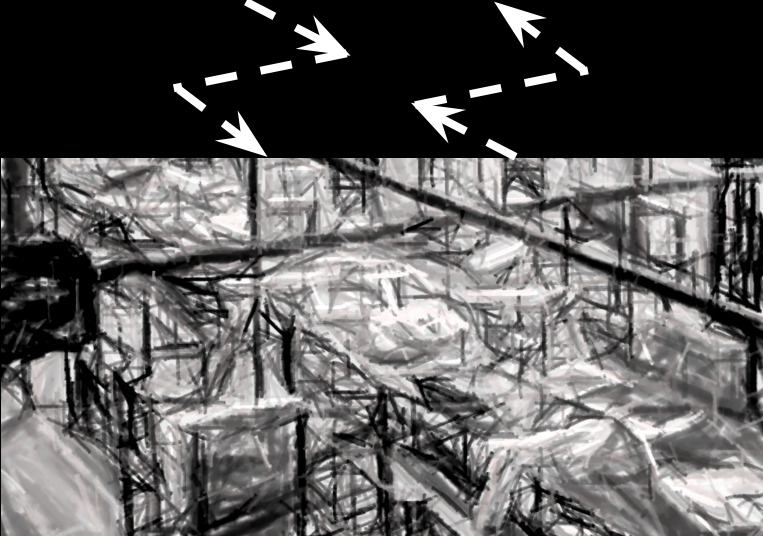


Digital Model



Digital Shadow

Digital Model, Digital Shadow, Digital Twin



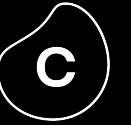
Digital Model

Digital Shadow

Digital Twin

Automated in both directions

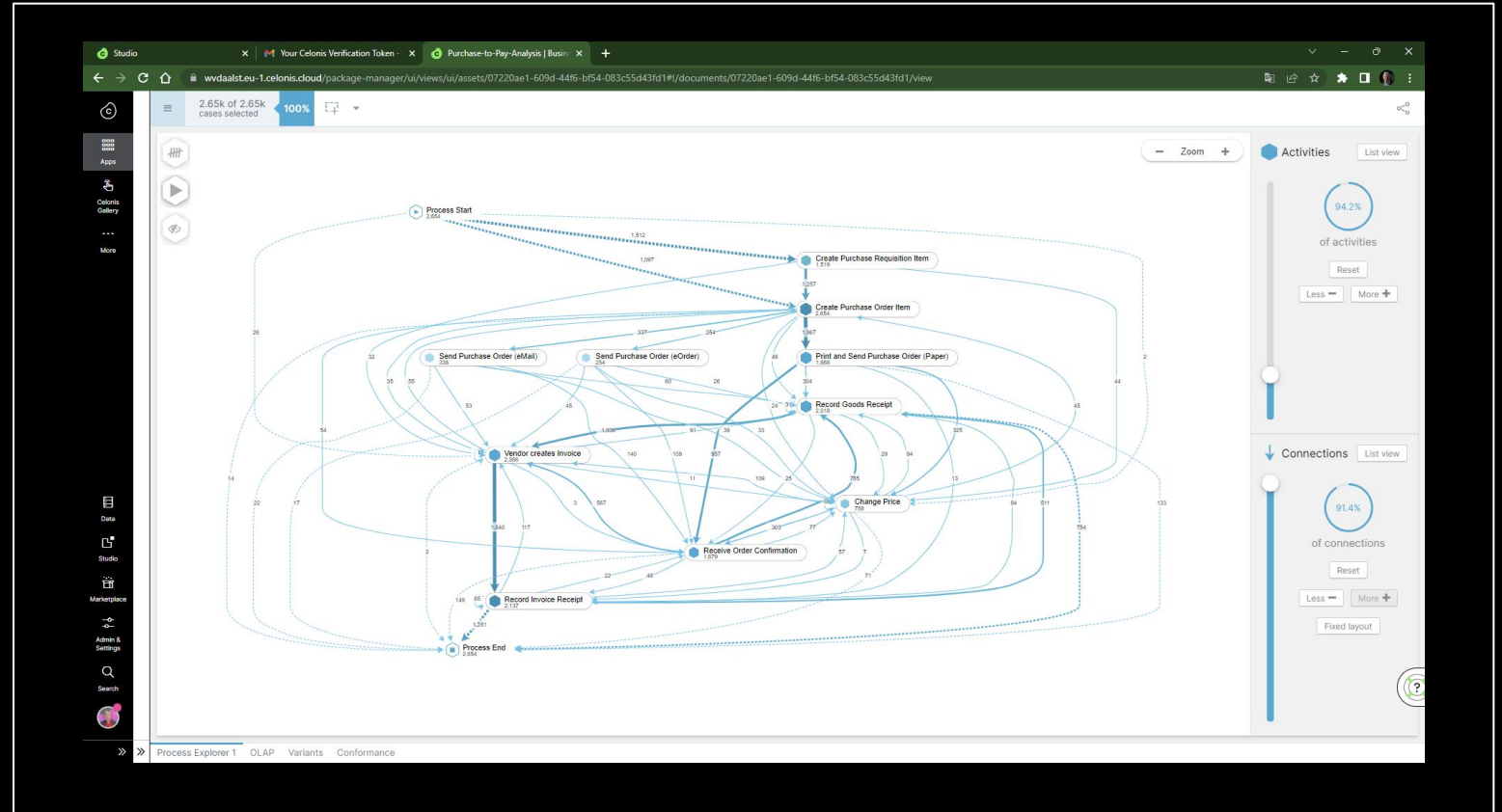
The first digital shadows of operational processes are a reality thanks to process mining



Process Mining

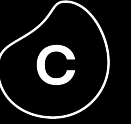


Digital Shadow



Recent developments in **object-centric process mining** will help to create more realistic digital shadows (2D to 3D).

... but Digital Twins require Hybrid Intelligence



Digital Twin

Human Intelligence People and experiences

Flexible
Creative
Emphatic
Instinctive
Commonsensical

Hybrid intelligence

Fast
Efficient
Cheap
Scalable
Consistent

Machine Intelligence Data and algorithms

The Covid pandemic, war in Europe and supply chain disruptions show that fully autonomous digital twins are still a dream rather than a reality.

Compare to autonomous driving



SAE INTERNATIONAL		Level 00	Level 01	Level 02	Level 03	Level 04	Level 05
What does the human in the driver's seat have to do?		You are driving whenever these driver support features are engaged – Even if your feet are off the pedals and you are not steering			You are not driving when these automated driving features are engaged – Even if you are seated in “the driver’s seat”		
		You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
		These are driver support features			These are automated driving features		
What do these features do?		These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the drive	These features provide steering AND brake/acceleration support to the drive	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met	This feature can drive the vehicle under all conditions	
Example features		<ul style="list-style-type: none">• Automatic emergency braking• Blind spot warning• Lane departure warning	<ul style="list-style-type: none">• Lane centering OR• Adaptive cruise control	<ul style="list-style-type: none">• Lane centering AND• Adaptive cruise control at the same time	Traffic jam chauffeur	<ul style="list-style-type: none">• Local driverless taxi• Pedals/steering wheel may or may not be installed	Same as Level 04, but feature can drive everywhere in all conditions

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Levels defined by the Society of Automotive Engineers (SAE)
<https://www.sae.org/>



Mercedes-Benz S-class and EQS: First level 3 internationally certified car on sale since May 2022.

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Process automation and management will show a similar gradual development.

Process Mining: From Theory to Execution

Professor Wil van der Aalst pioneered the field of process mining in the 1990s, describing it as the missing link between data science and real-life processes. Enter an entirely new academic discipline, which has since become the industry standard for better business process execution. Learn about the science behind the technology and its real-life applications, including the way it's being used today by a large number of Fortune 500 companies, during this self-paced, virtual course.

Watch the trailer

Visit www.processmining.org, www.celonis.com, www.vdaalst.com, read the “**process mining bible**”, and take one of the courses “**Process Mining: From Theory to Execution**” and “**Process Mining: Data Science in Action**”.

Process mining

- Generic (anything with events)
- Increasingly adopted
- Excellent tool support
- Used to create digital shadows

Towards digital twins

- Object-oriented process mining plays a key role
- Hybrid Intelligence rather than full autonomy
- Will be a gradual development (like self-driving cars)

Do not wait, start today with the basics!