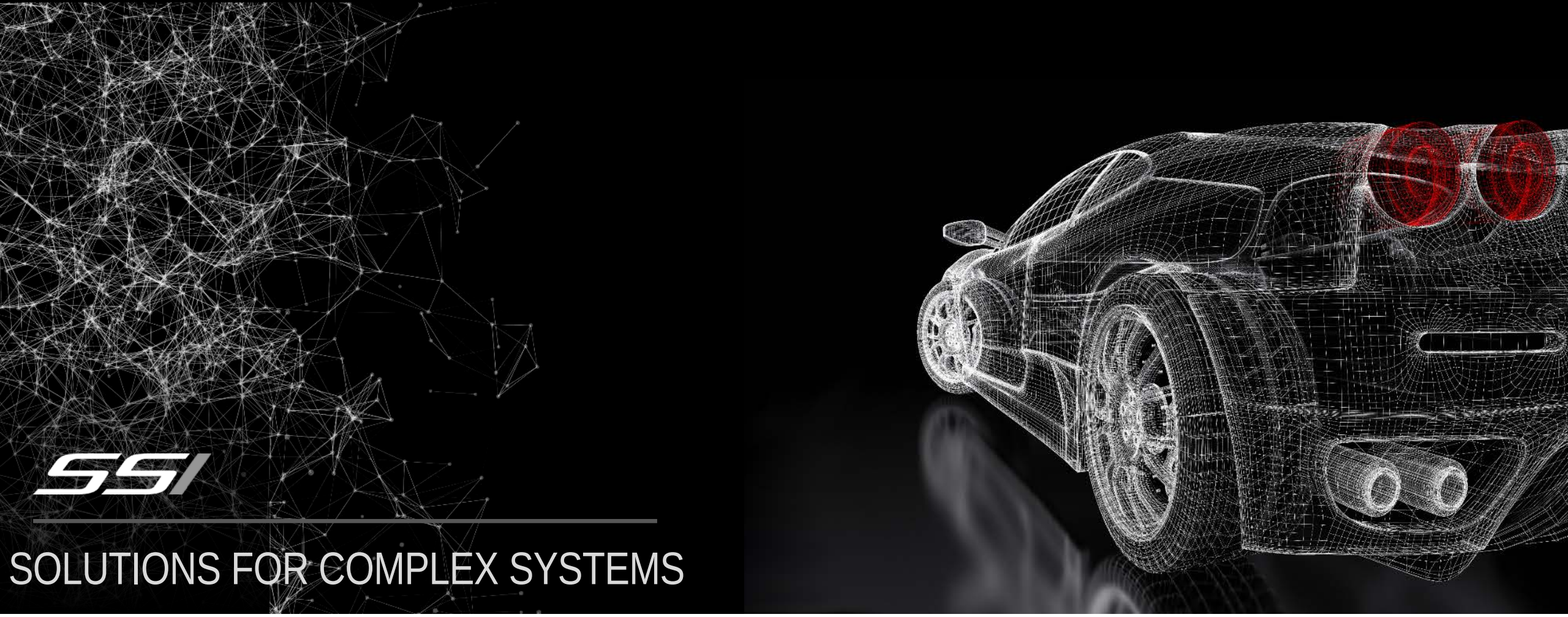

GLRC 2018

Augmented Intelligence: Combining Model Based Systems Engineering with AI & Machine Learning

Mark Petrotta
SYSTEM STRATEGY, INC.
Principal Engineer
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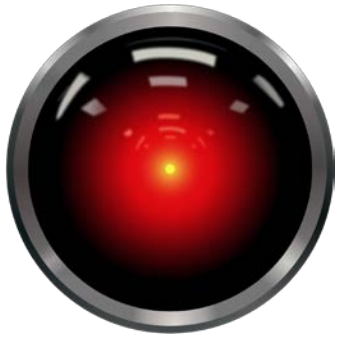
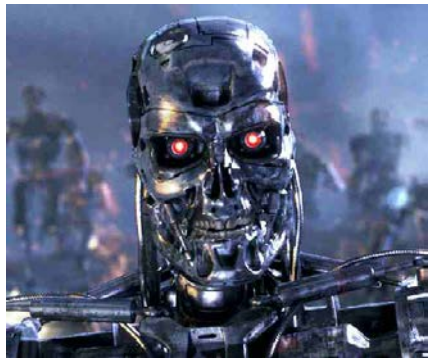
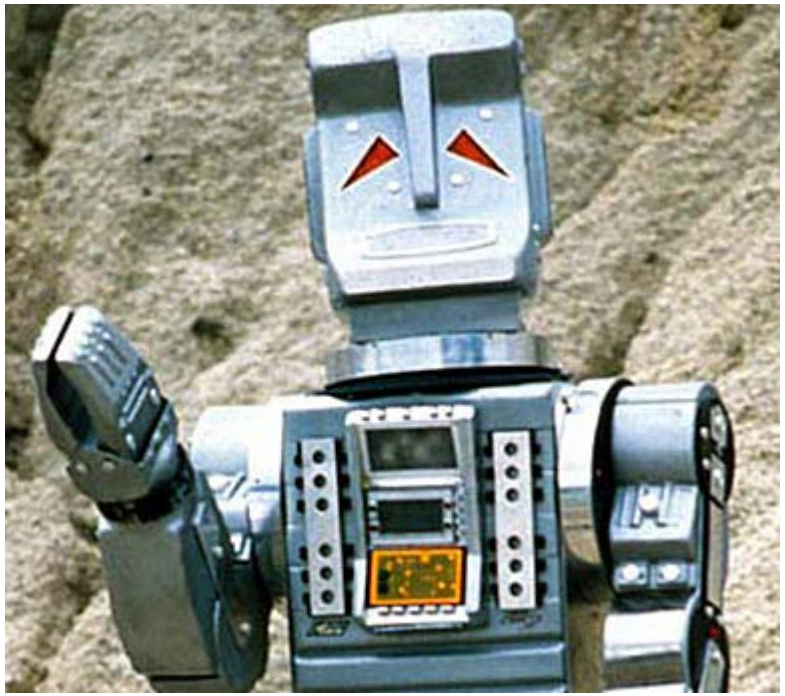
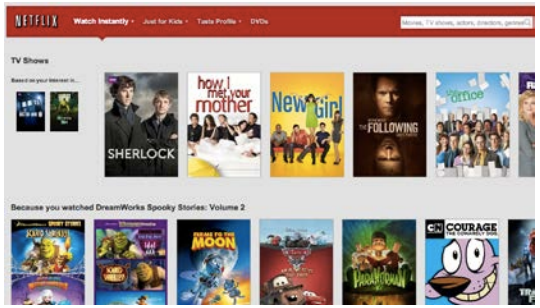
AI We Expected



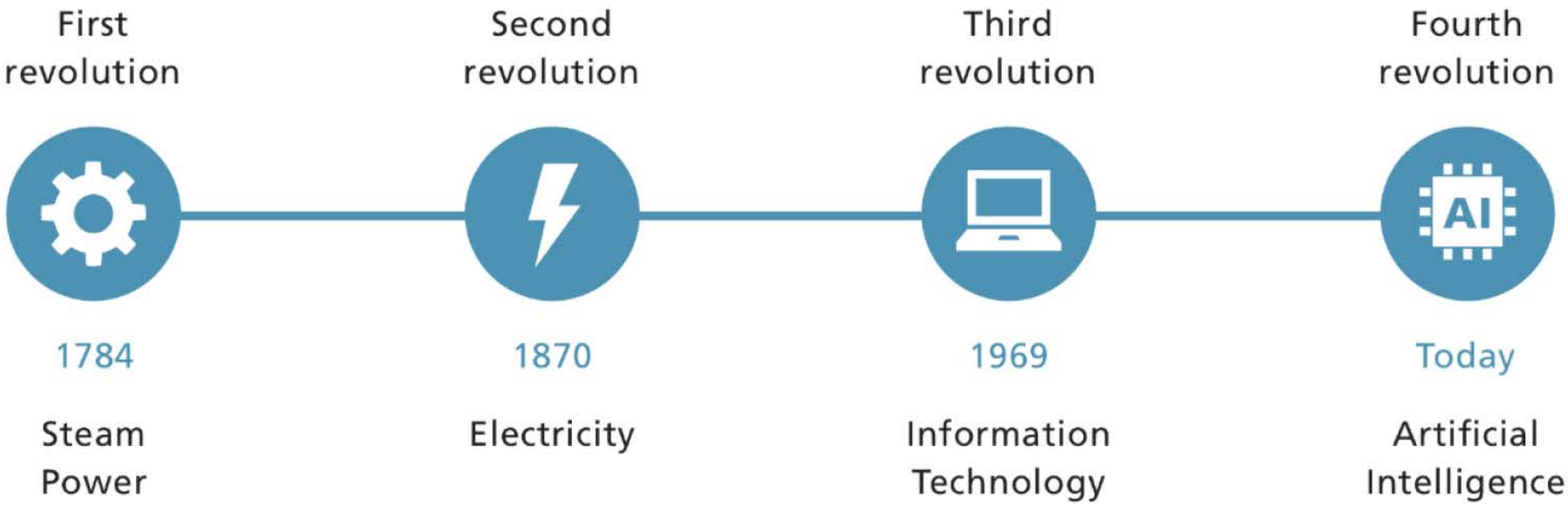




AI We Got



AI and the Fourth Industrial Revolution



+ robotics, nanotechnology, quantum computing, biotechnology, IoT, 3D printing and autonomous vehicles.

But wait…

What is Toronto?

Augmented Intelligence in SE: Beginnings

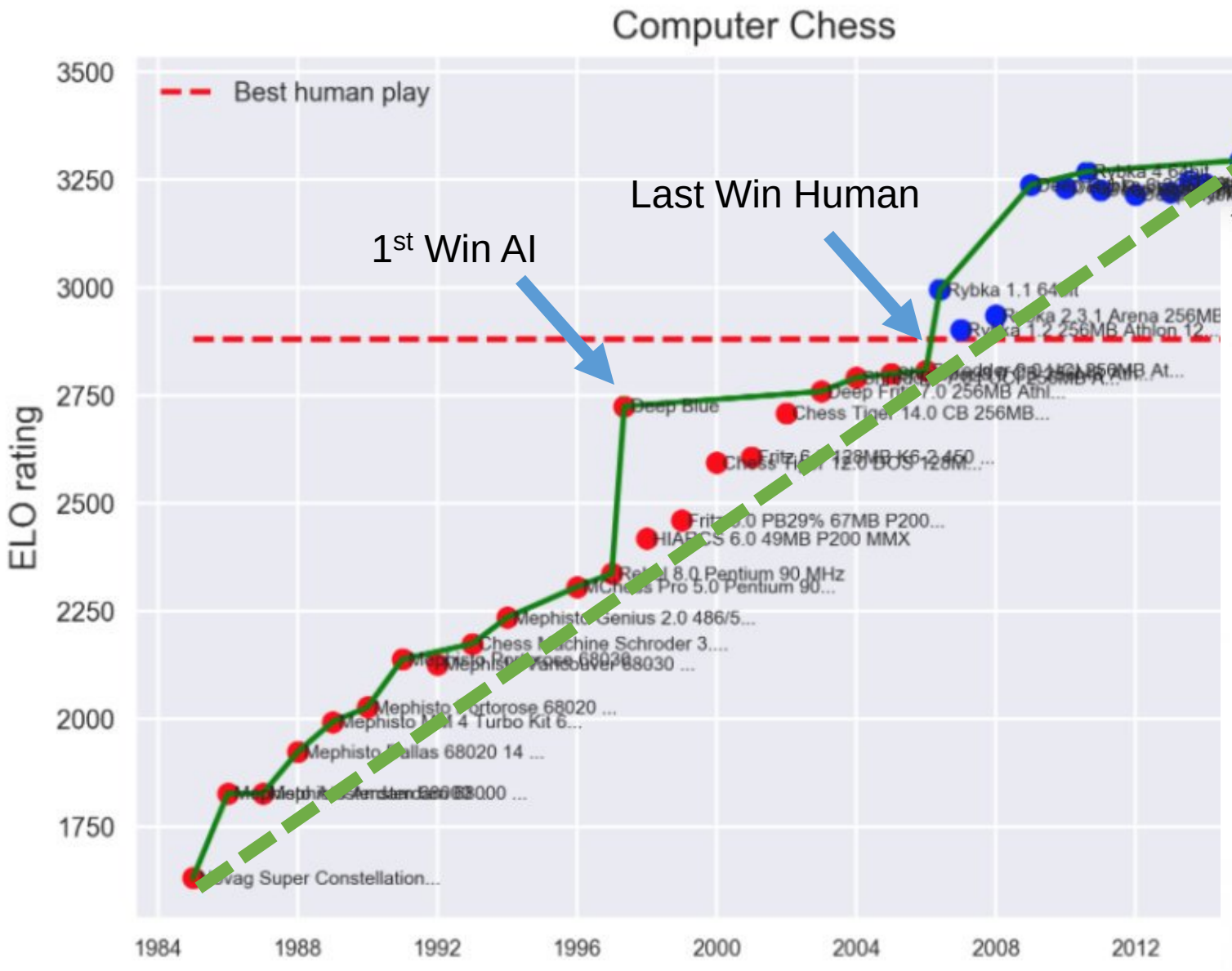
- INCOSE Challenge Team, Augmented Intelligence for Systems Engineering
  - Chartered 2018:

    …further the understanding of how computational approaches, such as artificial intelligence, machine learning, and data science, can collaborate with human systems engineers to measurably improve the system engineering effort. The challenge team will seek out approaches that enhance human capabilities in systems engineering.

    http://www.omgwiki.org/MBSE/doku.php?id=mbse:augmented

- Related
  - Digital Engineering / Digital Twin
  - Agile SE
  - MBSE
  - Software 2.0

Chess: Human vs AI



Kasparov has Deep Blues after losing

Chess champ: I was rooked

By MICHELE McPHEE, K.C. BAKER and CORKY SIEMASZKO
Daily News Staff Writers

The world's greatest human chess player threw a tantrum and cried foul yesterday after being thrashed by a supercomputer.

It took IBM's Deep Blue just 19 moves to defeat world chess champion Garry Kasparov — a stunning finale to an epic week-long battle of man versus machine.

Not mollified by his $400,000 loser's share, Kasparov stormed off like a sore loser after resigning. He later accused IBM of unfairly programing the high-speed computer to beat him specifically.

He suggested that Deep Blue, which was supposed to play on its own, was coached during the match.

He stopped short of saying the computer team cheated.

"I suspect there were things in the match that were well beyond my understanding," Kasparov said. "And when a big corporation with unlimited resources would like to do so, there are many ways to achieve the result, and the result was achieved."

IBM team leader C.J. Tan denied the computer was coached. "Once the clock started, it relied on Deep Blue's system itself," he said.

Kasparov's pal, Michael Khodarkovski, blamed Kasparov's graceless exit on a lack of practice — he said Kasparov had never lost a match.

Kasparov came close to losing to Anatoly Karpov in a 1984-85 championship match that was suspended without a victory on either side.

Kasparov, 34, considered by some chess experts as the greatest player in the history of the game, last year defeated Deep Blue 4-2.

After losing the opening game of the rematch at the Equitable Center in Manhattan, the computer won the second game and fought Kasparov to draws in the next three.

Then yesterday — with a swiftness that stunned the chess world — Deep Blue took advantage of Kasparov's clumsy opening moves and pinned him in a no-win situation after less than an hour of play.

Unable to find a way out, Kasparov — playing the black pieces — tipped his king and resigned. He buried his head in his hands and didn't look at IBM's Tan when they shook hands.

The final score was 3½ points for the computer and 2½ points for Kasparov.

Kasparov said he "cracked under the pressure."

"I am ashamed," said Kasparov, who would have won $700,000 if he had beaten the computer.

Patrick Wolff, author of "The Complete Idiot's Guide to Chess," said the world champ "basically cracked."

Kasparov, playing black, used a standard defense known as the "Caro-Kann," forcing white to sacrifice a piece. But for some reason he botched his seventh move and "he became lost," Wolff said.

"This is not a position he wanted to get into," said Ilya Gurevich, a grand master from Manhattan. "It's a pure calculating position where the computer has a big advantage. The computer's strength is tactics."

The computer Kasparov battled was capable of analyzing 200 million positions per second — twice as many positions per second as the IBM model he defeated in Philadelphia last year.

One expert said he was surprised when Kasparov resigned. "It didn't seem lost," said grand master John Fedorowicz of the Bronx, who helped the IBM team prepare its game plan.

At Chess Forum on Thompson St. in Greenwich Village, die-hard chess fans expressed shock at Kasparov's loss.

"This is a historic event," said Mark Wieder, 46, also a computer programer. "The greatest human player of all time lost to a machine."

Chess Forum owner Imad Khachan, 31, said Kasparov was following in the footsteps of other sore losers by suggesting his foe didn't play fair.

"This is not uncommon in chess," he said. "When Viktor Korchnoi was playing Karpov in the '70s, Korchnoi made the accusation that the KGB was sending him telepathic messages to destroy his concentration."

RESIGNED: Chess champion Garry Kasparov is disappointed yesterday after losing to IBM's Deep Blue supercomputer. IBM's team leader C.J. Tan (left) cerried the computer had been coached, as Kasparov charged after the historic loss in Manhattan. Kasparov will get $400,000 for his efforts.

Artifical intelligence not black and white

FORGET ABOUT THE Garden or the Meadowlands. The real action was outside the Equitable Center on Seventh Ave., where Garry Kasparov, with a name like a hockey player, did battle with Deep Blue, an IBM supercomputer whose name suggests some starlet who did her best work on 42d St. in those halcyon days before Disney.

The scalpers were asking as much as $500 for a $25 seat. "Actually, I'd settle for a couple of hundred," said Ze Ayala. "I have extras."

In the history of New York, there's never been a scalper so hopelessly well mannered as Ze Ayala, Ph.D. Instead of the usual hawker's cry — "Who got tickets?" — Ayala was content to let the business come to him as he burnished his new henna tattoo with a cotton ball doused in lemon juice. "The lemon juice helps the absorption of the dye," he said. The tattoo bore the name of his band, "Flashpot," for whom the tall, long-haired Ayala plays guitar. It should be noted that in lieu of a day job, he works at the Institute of Molecular Evolutionary Genetics at Penn State. His mission wasn't even mercenary; it was professional. He said he wouldn't have sold his own seat for a million bucks.

"My field is artificial intelligence," he said. "And this is the coolest thing to happen in my lifetime."

MARK KRIEGEL

In such a spirit, the 28-year-old scientist had come to witness the inevitable coolness: Man mangled by Machine.

He couldn't help but root for Kasparov. The sentimental part of him was taken with the chutzpa of obsolescence. But he knew better than to bet against technology.

Kasparov is the best chess player in the world; but unlike Deep Blue, he can also be vain, angry, neurotic, panicked, fearful, in all, human. "Chess is fundamentally psychological," Ayala said. "And that's precisely what Kasparov has working against him."

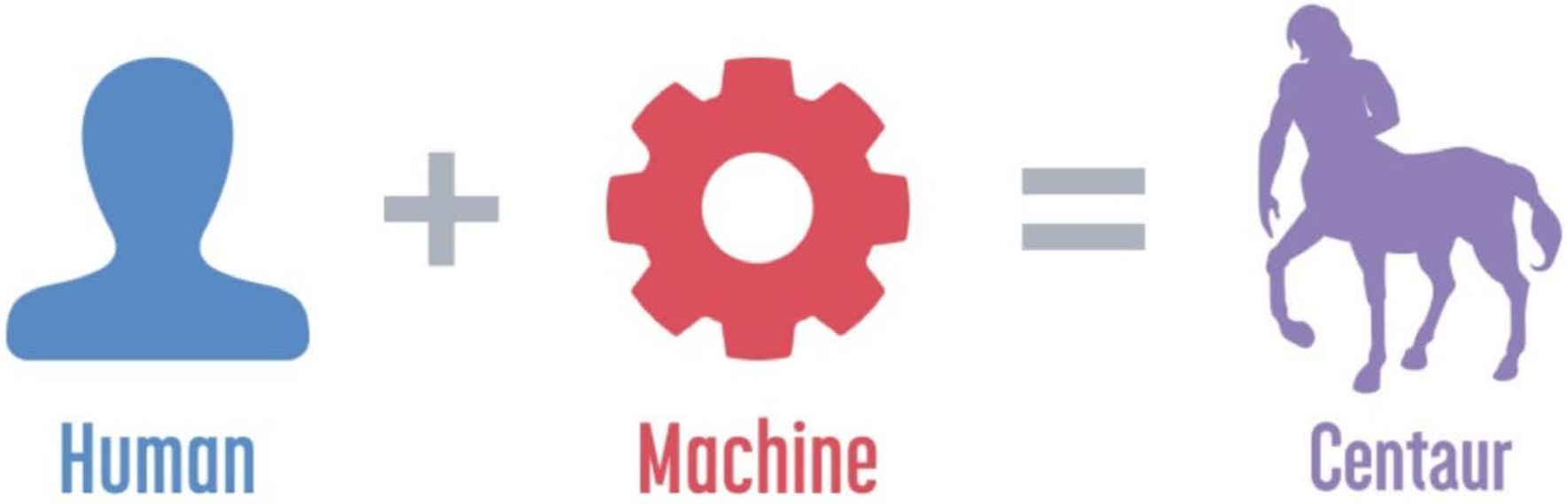
I asked him how long before Deep Blue is playing lead guitar in his band.

That day will come, he said, and it won't be too long. "You know the band Nine Inch Nails?" he said. "That's all computers. But what you're really asking is: Will a computer be able to write

SEE KRIEGEL, PAGE 26

Freestyle / “Centaur” Chess

Rules: {}



0..n

0..n

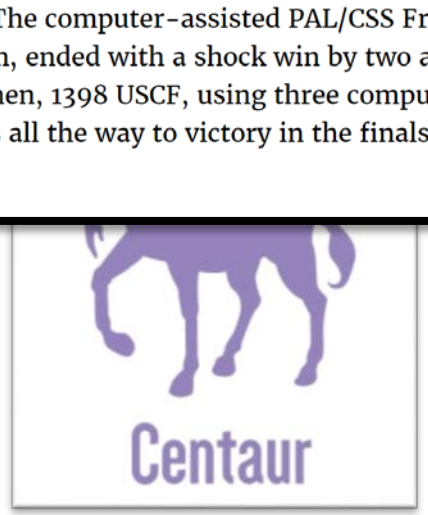
2005 Freestyle Tournament

Dark horse ZackS wins Freestyle Chess Tournament

I like it! | 0 Comments

6/19/2005 – The computer-assisted PAL/CSS Freestyle Chess Tournament, staged on Playchess.com, ended with a shock win by two amateurs: Steven Cramton, 1685 USCF and Zackary Stephen, 1398 USCF, using three computers for analysis, defeated teams of strong grandmasters all the way to victory in the finals. We bring you a first flash report with games and results.

GM + 



GM + 

GM + 

“ZackS”

Q: What makes for a great freestyle operator?

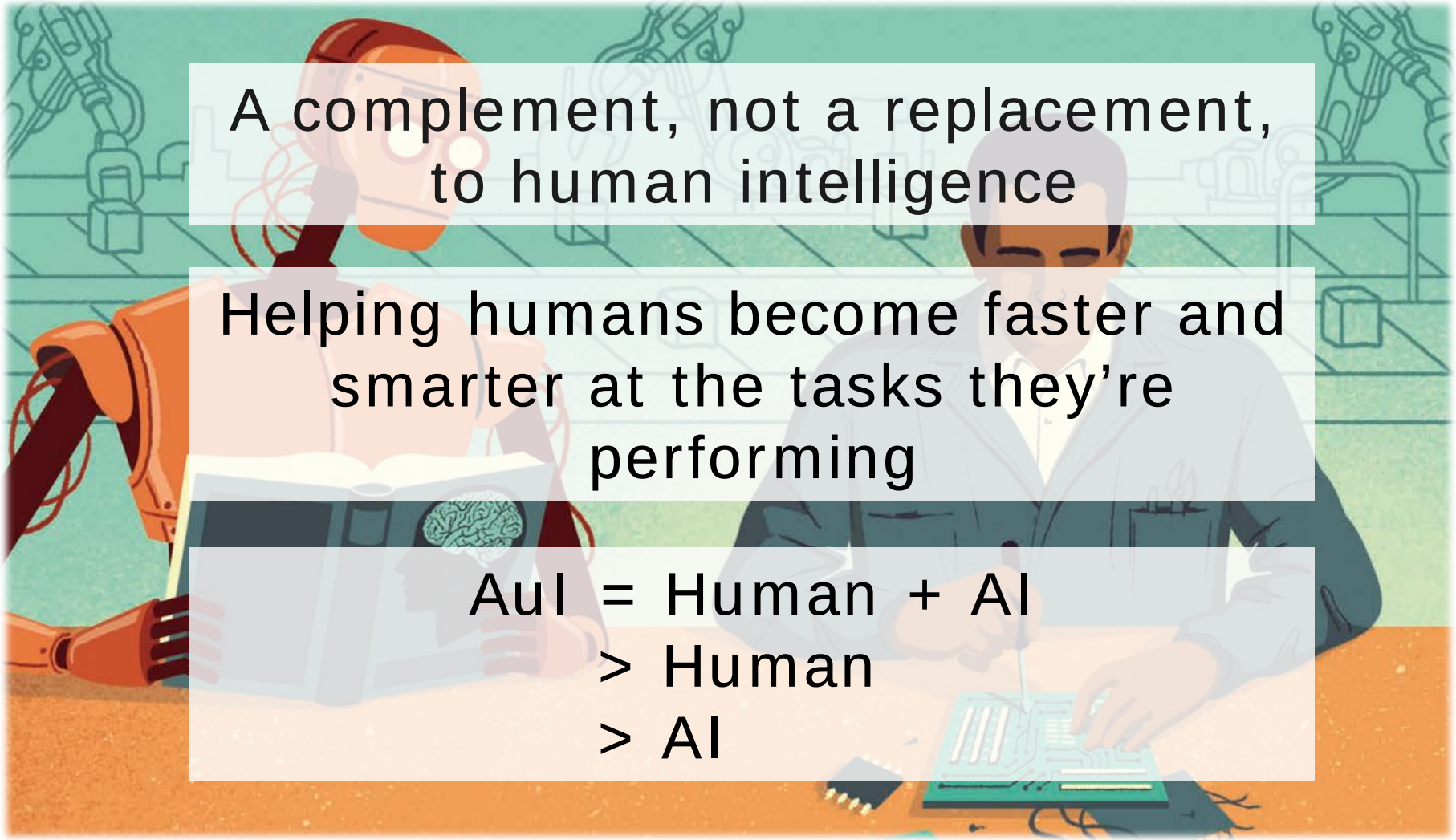
KASPAROV: Someone who can work out the most effective combination, bringing together human and machine skills. I reached the formulation that a weak human player plus machine plus a better process is superior, not only to a very powerful machine, but most remarkably, to a strong human player plus machine plus an inferior process.

Kasperov's Law:

Weak Player + AI + Good Relationship
Outperforms
Strong Player + AI + Inferior Relationship

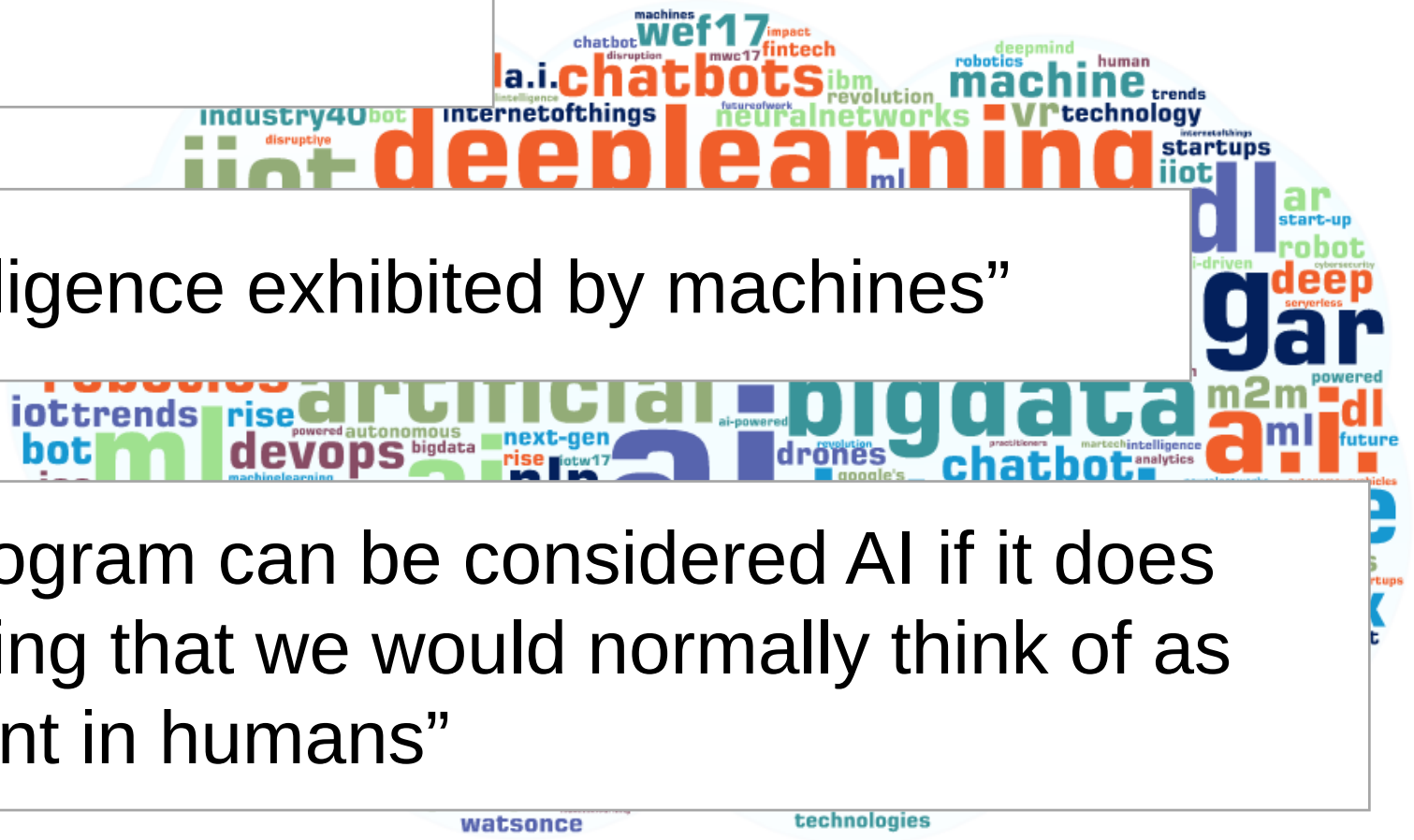
Augmented Intelligence

What is Augmented Intelligence?



What is Artificial Intelligence?

Using computers to solve problems

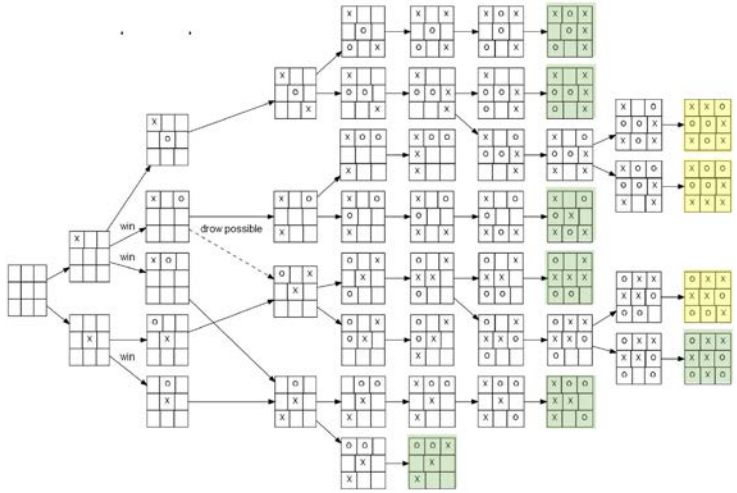


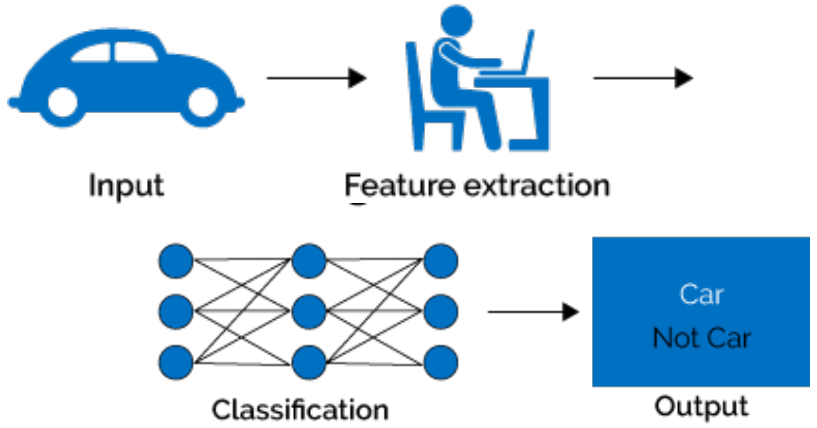
"Human intelligence exhibited by machines"

"Any program can be considered AI if it does something that we would normally think of as intelligent in humans"

Two Categories of AI

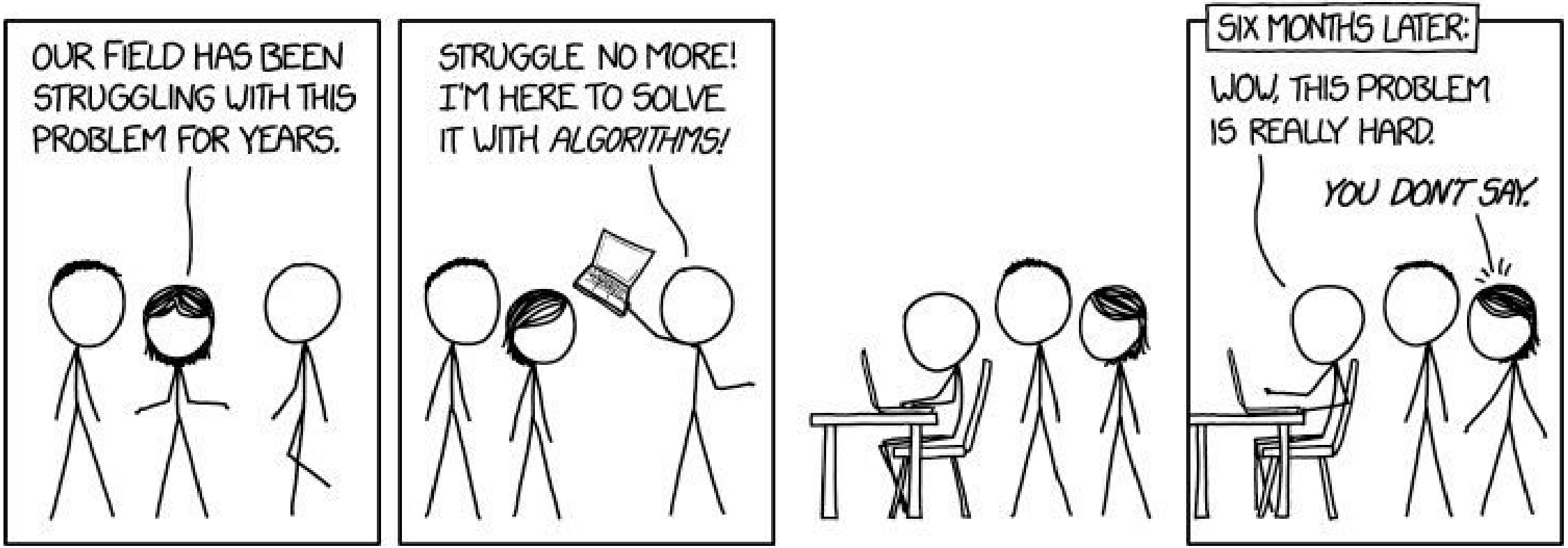
Categories	Techniques
“Rules Based” **Explicit Knowledge**  	• Expert Systems • Bayesian • NLP • Genetic Algorithms • Solvers
“Patterns Based” **Tacit Knowledge**  	• Machine Learning • Neural networks • Deep Learning • Support Vector Machines





Augmented Systems Engineering

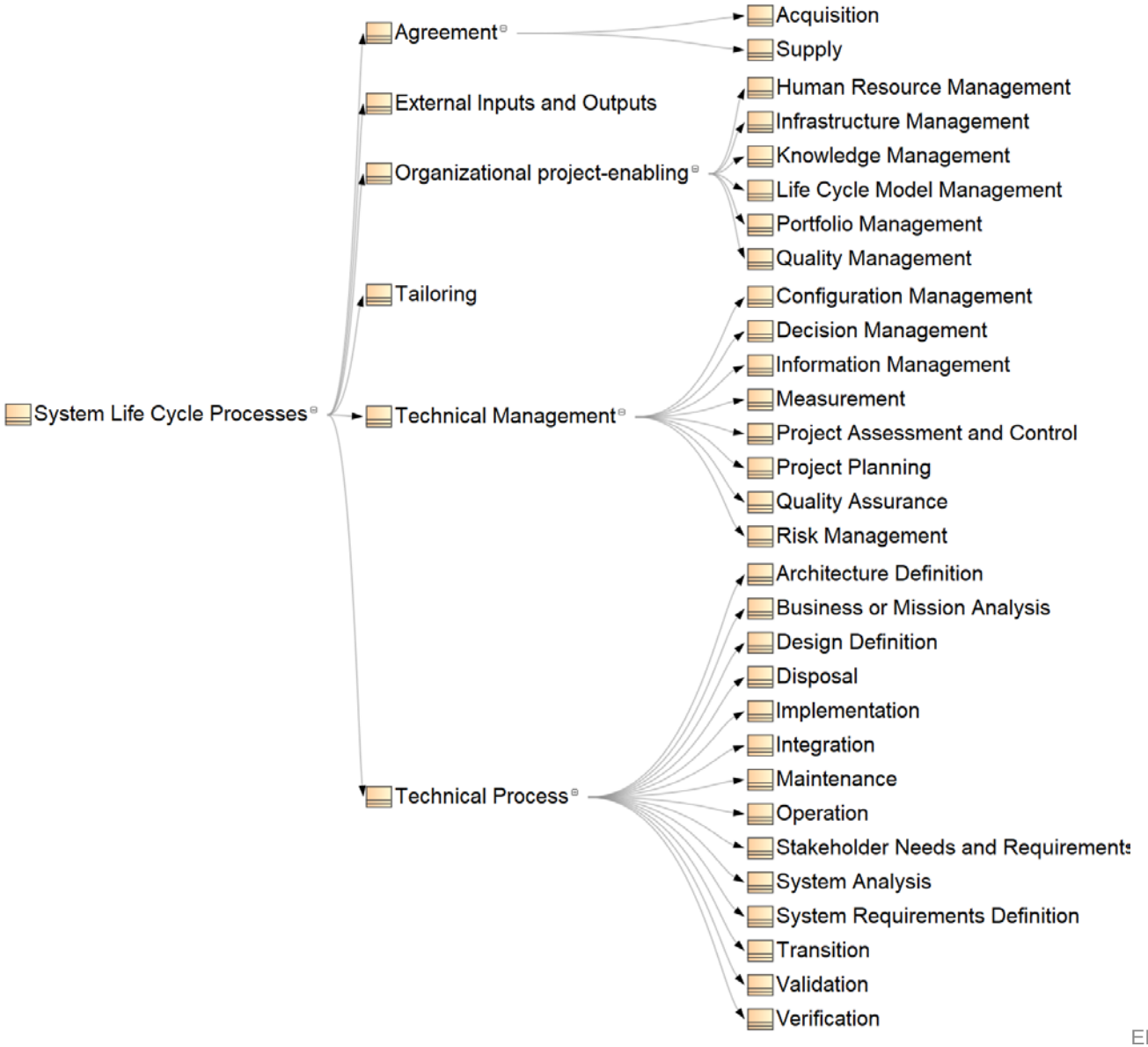
AI in Systems Engineering



XKCD: Here to Help, https://xkcd.com/1831/

ISO 15288 and SE Processes

ISO/IEC/IEEE 15288: "Systems and Software Engineering–System Life Cycle Processes"

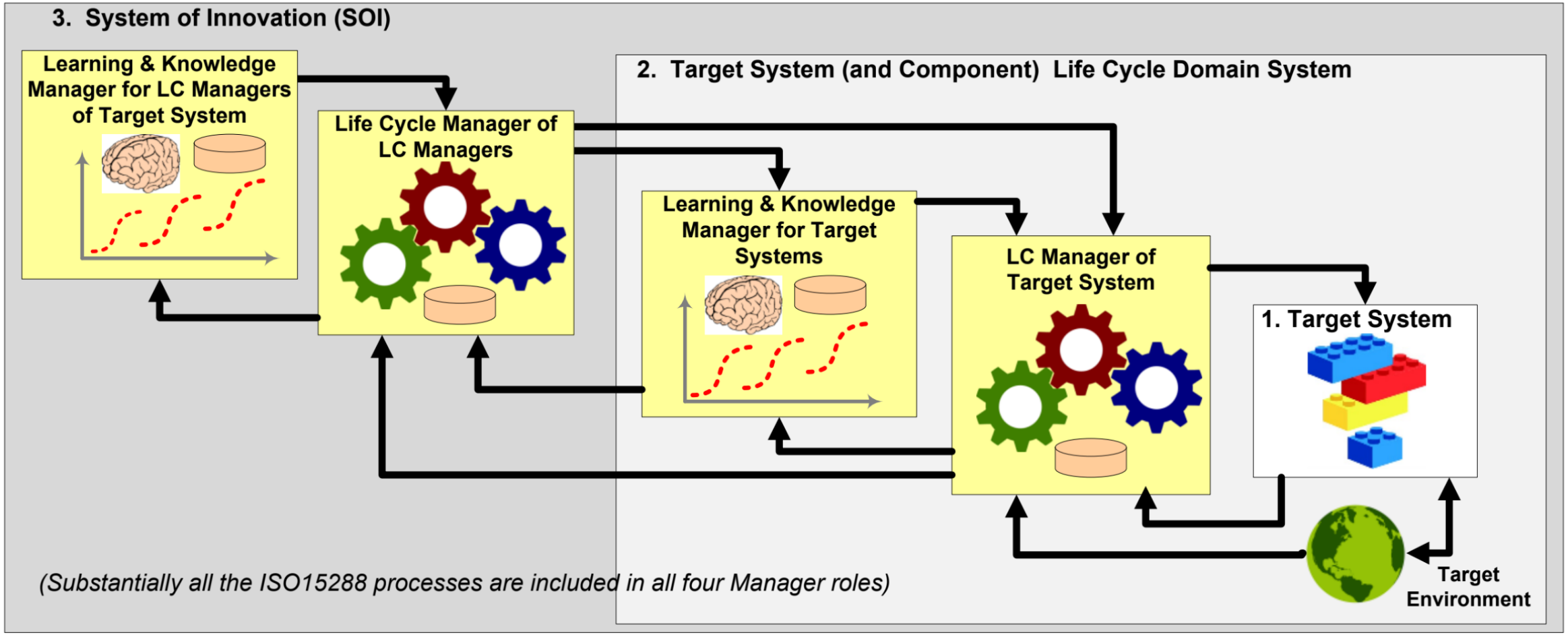


Establishes a common framework for describing the life cycle of a designed system

Defines a set of processes and associated terminology from an engineering viewpoint

Can be applied at any level within a system's hierarchy structure and along any stage of the system's life cycle

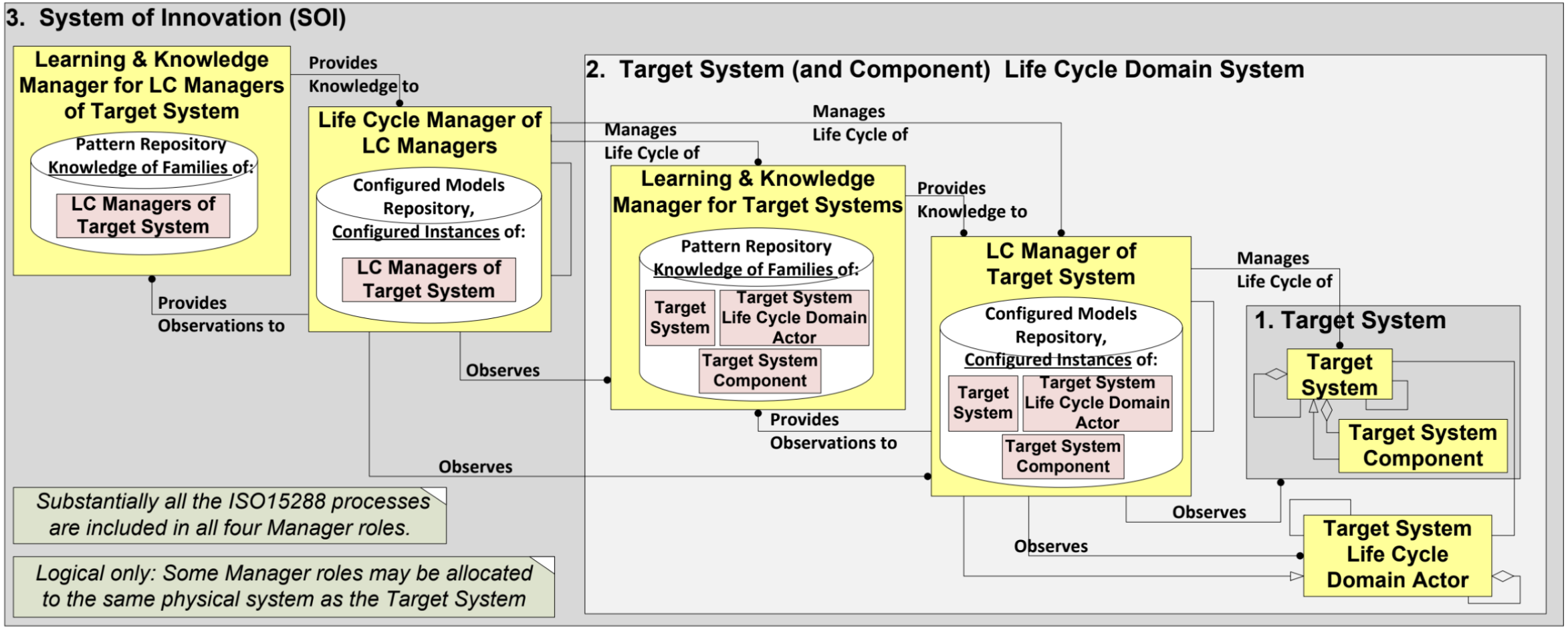
Conceptual Model for Augmented MBSE



Source: INCOSE Agile Working Group

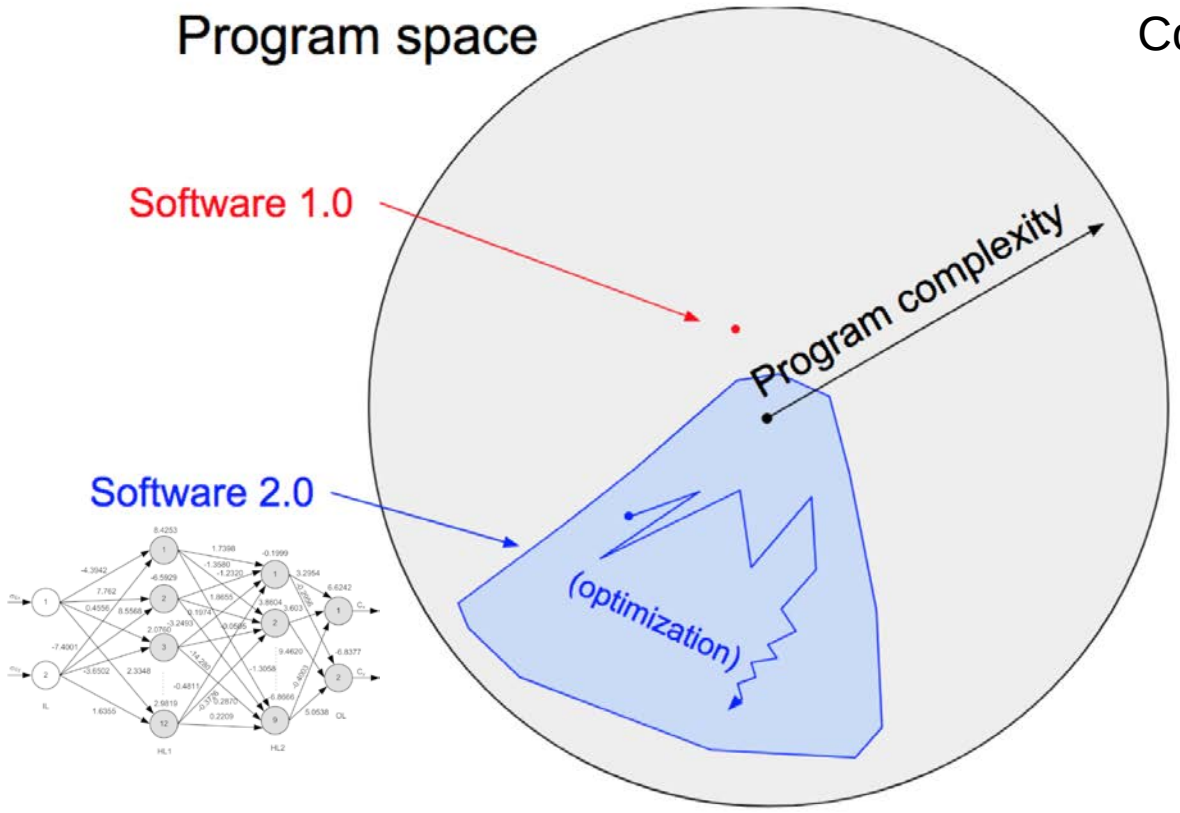
Formal Domain Model

Augmented SE: Build



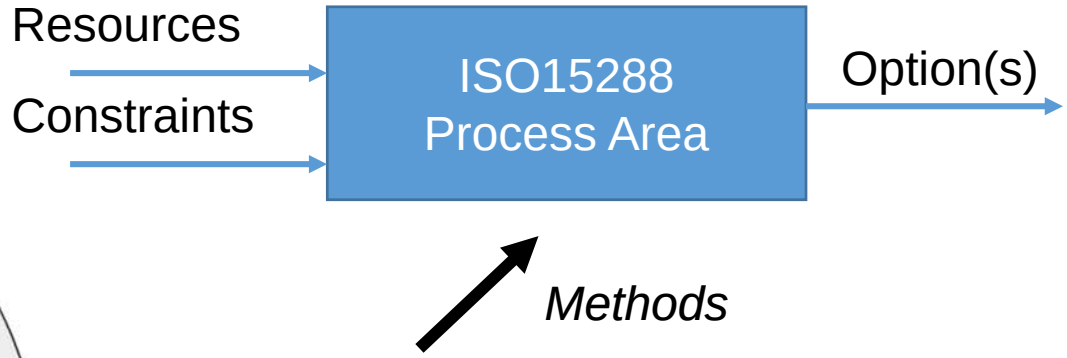
Source: INCOSE Agile Working Group

Augmented Design in Software



Software 2.0, Andrew Karpathy
https://medium.com/@karpathy/software-2-0-a64152b37c35

To specify some goal on the behavior of a desirable program:



Software 1.0: Traditional design, code, compile, test
Software 2.0: Identify subset of program space to search, and use the computational resources at our disposal to search this space for a program that works.

Challenges:

- Transparency
- Explainability
- Biases
- Contextualization
- Trust
- …

Corollary to Kasperov's Law:

Human-centered design - a well-designed decision environment - is a necessary for both the creation and deployment of algorithms intended to improve expert judgment

Human Centered Design: Rules of Algorithm

The Algorithm should have:

Agency

Reflect the information, goals, and constraints that the decision-maker tends to weigh when arriving at a decision

Perspective

Analyze from a position of domain and institutional knowledge, and an understanding of the process that generated it

Relevancy

Anticipate the realities of the environment in which it is to be used

Objectivity

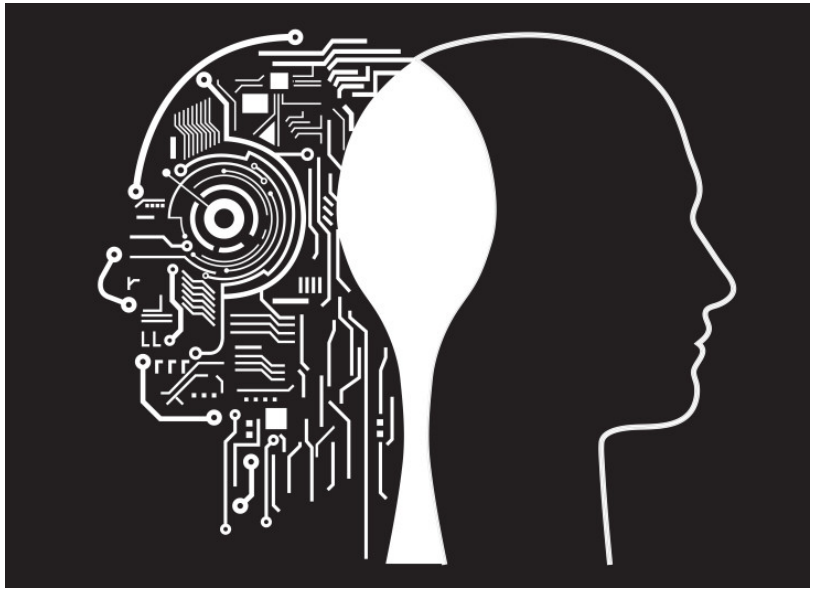
Avoid biased predictors

Transparency

Be transparent, peer-reviewed or audited to ensure that unwanted biases have not inadvertently crept in

Candor

Effectively present measures of confidence and “why” messages (ideally expressed in intuitive language) explaining why a certain algorithmic indication is what it is



Why artificial intelligence needs human-centered design - Deloitte Review, issue 22

Human Centered Design: Rules of User Environment

The User Environment should have:

Clarity

The algorithm's assumptions, limitations, and data features should be clearly communicated through information visualization

Intelligibility

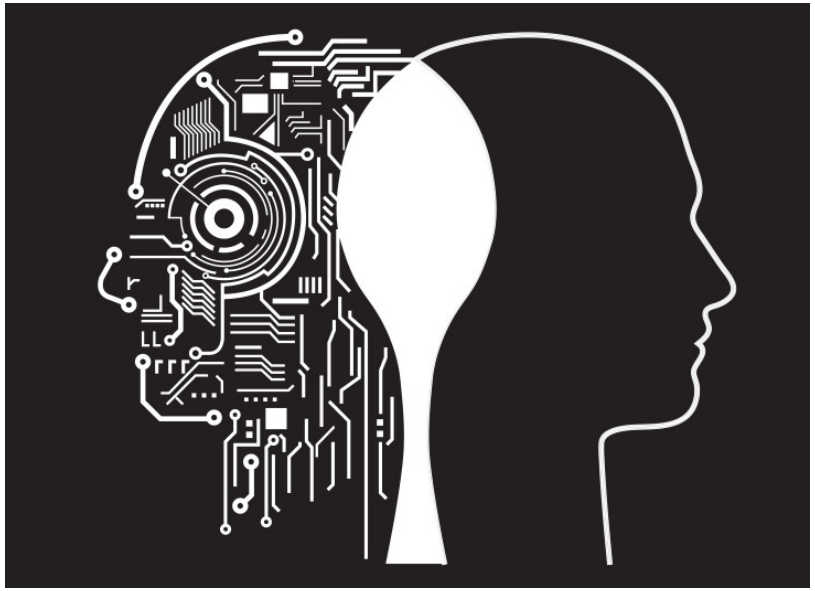
Algorithm end users should have a sufficiently detailed understanding of their tool to use it effectively

Methods

Guidelines and business rules should be established to convert predictions into prescriptions

Responsibility

Suggest when and how the end user might either override the algorithm



Why artificial intelligence needs human-centered design - Deloitte Review, issue 22

Example – NLP Reconciliation of Model Elements

Model A	Model B
Verification Procedures	Verification Procedure
Quality Assurance Evaluation Results	Qualification Test Report
Quality Assurance Plan	Quality Management Plan
Configuration Record	Configuration Status Report
Survey	Service Plan
Complaints	Service Plan
Portfolio Evaluation Report	Evaluation Report
Needs Assessment	Product Need Assessment
Measurement Procedures	Measurement Procedure
Service Level Agreement	Service Management Plan
Use Case	Reuse Plan
Knowledge Management Records	Knowledge Management Record
Organizational Procedure	Operational Test Procedure
Project Life-Cycle Policies and Procedure	Life-Cycle Policy and Procedure
Other Plans	Service Plan
Operational Strategy	Operational Test Procedure
Test Procedure	Audit Procedure
Analysis of Metrics and Variations	Risk Management Policy and Plan
Test Procedures	Audit Procedure
Complaint	Contract
Release Records	Release Record
Organizational Procedure	Operational Test Procedure
Business Action Plan	Installation Plan
Quality Assurance Plan	Quality Management Plan
Disposal Records	Disposal Record
Measurement Results	Measurement Plan
Measurement Strategy	Measurement Procedure
Design Description	Database Design Description

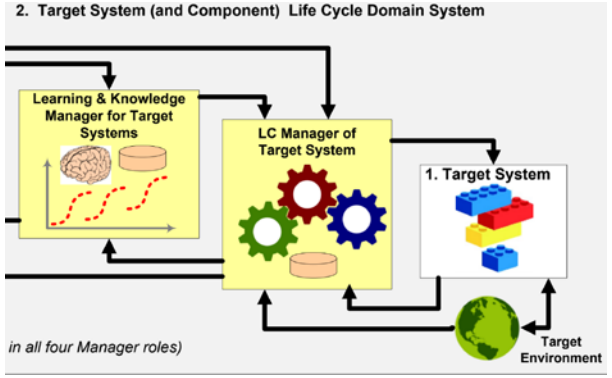
...

Model A	Score	Model B
Knowledge Management Records	0.96	Knowledge Management Record
Verification Procedures	0.96	Verification Procedure
Measurement Procedures	0.95	Measurement Procedure
Measurement Procedures	0.95	Measurement Procedure
Measurement Procedures	0.95	Measurement Procedure
Maintenance Procedures	0.95	Maintenance Procedure
Validation Procedures	0.95	Validation Procedure
Disposal Records	0.94	Disposal Record
Release Records	0.93	Release Record
Assessment Report	0.88	Assessment Record
Assessment Report	0.88	Assessment Record
Release Report	0.86	Release Record
Customer Satisfaction Report	0.86	Customer Satisfaction Survey
Customer Satisfaction Report	0.86	Customer Satisfaction Survey
Customer Satisfaction Report	0.86	Customer Satisfaction Survey
Information Security Plan	0.85	Information Security Policy
Other System Requirements Specification	0.85	System Requirements Specification
System Design Descriptions	0.81	Software Design Description
System Design Description	0.81	Software Design Description
Knowledge Management Policy	0.81	Knowledge Management Record
Measurement Data	0.81	Measurement Plan
Measurement Data	0.81	Measurement Plan

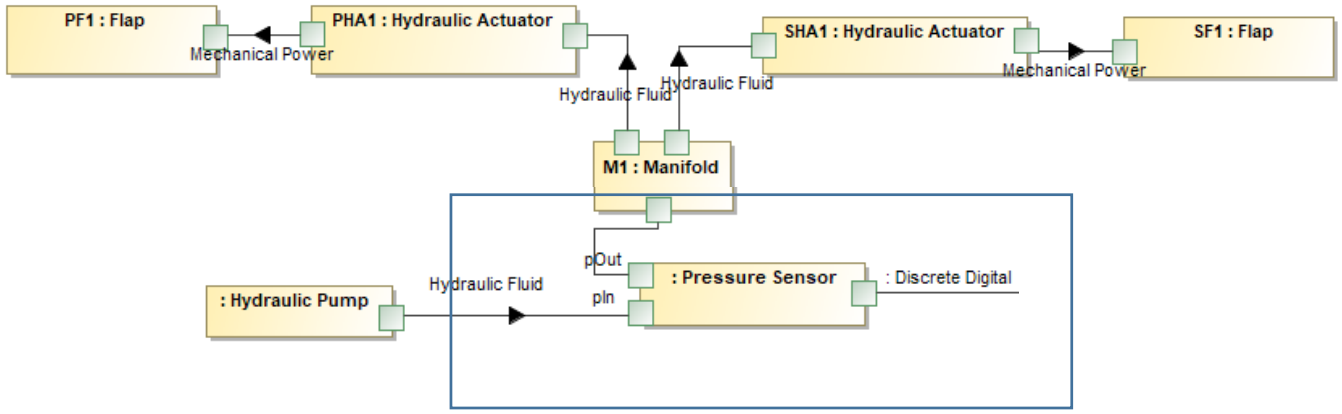
...

Survey	0.33	Service Plan
Budget	0.33	Audit Report
Standard	0.30	Audit Plan
Skills	0.26	Personnel Skills Record

Case Study – Applying AuI



ISO15288: Tech Process : Maintenance

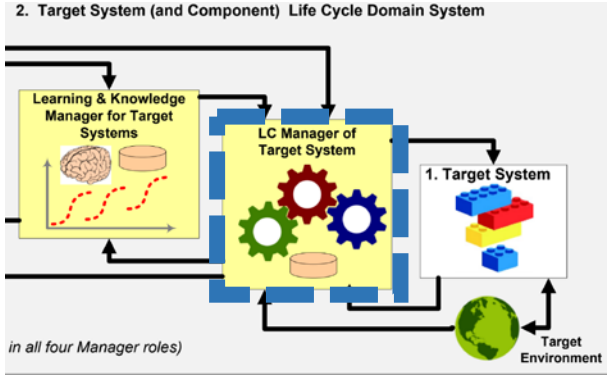


14% fault isolation

Performance requirement:
Achieve > 90% fault isolation

Constraints:
Sensors can be placed on hydraulic or mechanical connectors

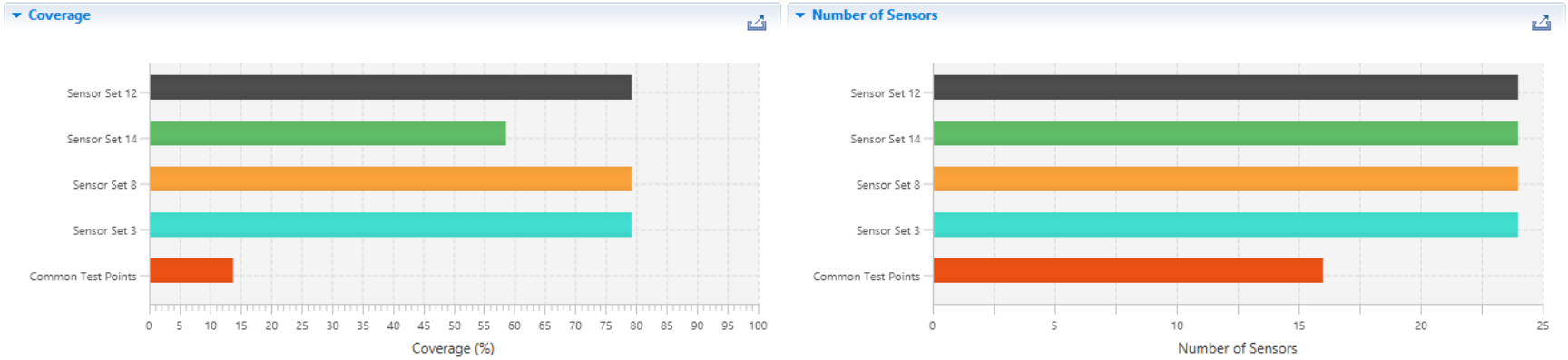
System 2 – Apply Maintenance Procedures



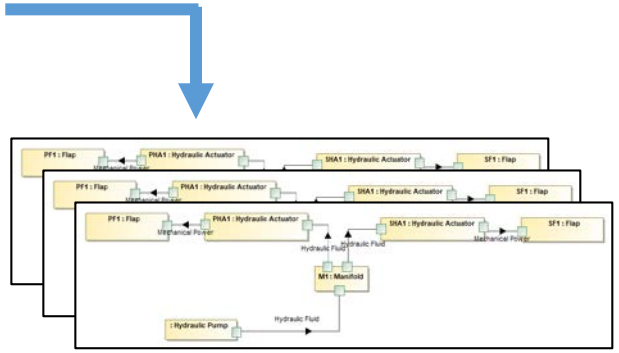
ISO15288: Tech Process : Maintenance

Fault Isolation

User: compare sensor sets parameters (coverage, size, weight, cost)



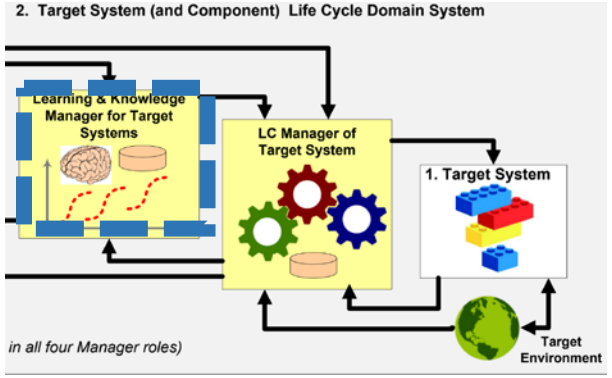
Apply Maintenance Design



Method: Genetic Algorithm

https://www.phmtechnology.com/made/what-made-does/case-studies/design-for-cbm.html

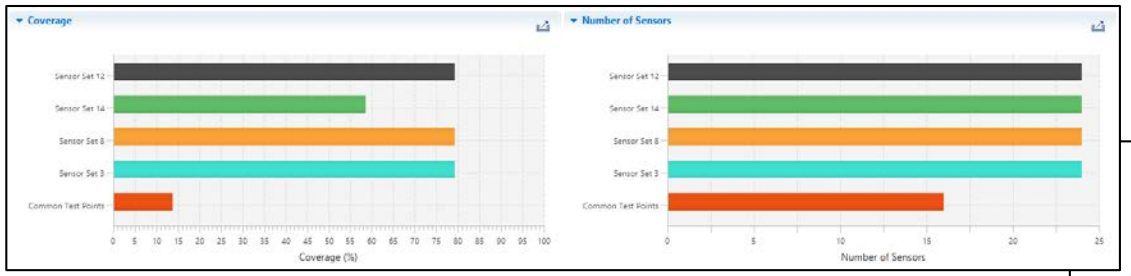
System 2 – Learn Maintenance Procedures

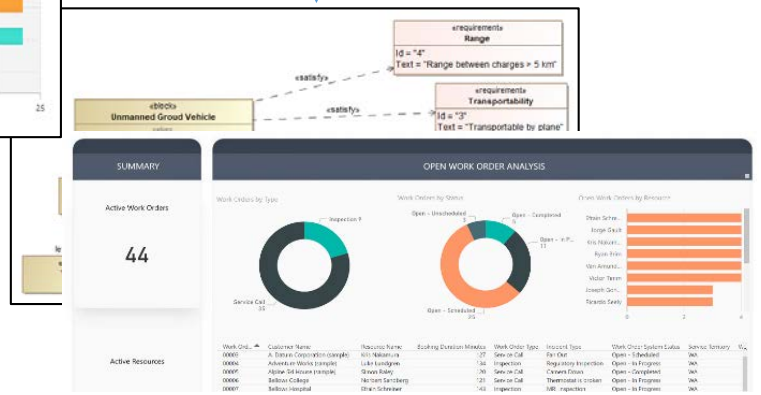


ISO15288: Tech Process : Maintenance

Apply
User: compare sensor sets parameters (coverage, size, weight, cost, reliability) → isolation %

Maintenance Learning System





Learn: Sensor count → Reliability

Observe: Increased failure modes from sensors

Service Reports

https://www.phmtechnology.com/made/what-made-does/case-studies/design-for-cbm.html

Conclusion

- AI winning narrow intelligence, humans winning general intelligence
- Kasperov's Law = Relationship key to human machine performance
- Kasperov's Law has held in all domains tested
- Effective teaming is itself a difficult design problem
- What does MBSE look like in a teaming relationship?

Less:
- Direct modeling
- Qualitative assessments

More:
- Problem space & constraint definition
- Formalization of domain knowledge
- Use of patterns
- Visualization of state space
- Option sets
- …

Q&A

"Many jobs will continue to be lost to intelligent automation. But if you're looking for a field that will be booming for many years, get into human-machine collaboration." -Kasperov, Deep Thinking

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PRINCIPAL

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