Artificial Intelligence and Machine Learning Technology Prediction Analysis Summary Report

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6/15/20

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Introduction:

This report is a summary of a groundbreaking analysis and report as to what future technological changes will be seen with artificial intelligence and machine learning. The source report, *Artificial Intelligence and Machine Learning Technology Forecast Report for the Milwaukee Development Corporation*[1], was delivered on March 31st, 2020.

In the first quarter of 2020, the Milwaukee Development Corporation executed a contract, supported by grant funding from the U.S. Economic Development Administration, with Innomation Corp. to forecast the future states of artificial intelligence (AI) and machine learning (ML). The technology trending subject matter expert (SME), David W. Conley, President and Principle of Innomation Corp (see Appendix One – Subject Matter Expert/Author Biography), was the systems analysis expert who performed the study. The primary methodology used to execute the study was a prerequisite 80 year study, of over four-million patents, that discovered and documented the universal changes that all engineering systems experience as they develop over time (see Appendix Two – Trends of Engineering System Evolution (TESE) Description[2]). This paper will not discuss details of the TESE, nor its specific application within the study, but rather summarize what the TESE reveal, in a mixture of abstraction and concretion, about the technological future of AI and ML.

Process/Methodology:

When analyzing technical systems it is necessary to either focus on, or rather model, a specific system in so far as how it works and what it does (i.e., functional output), or abstract a system by generalizing aspects of its design and output. Since the general system description of artificial intelligence (AI) and machine learning (ML) is somewhat nebulous and broad, the later method of utilizing a system generalization method was employed.

	AI/ML Constructs	
1 - Input/sensing	**2- Computation**	**3 - Output**
Data - Digitization Type	Optimization Goal Guidance	General Output
Data - Source	Analysis Progression Direction	Output Supervision
Data - Storage (could go in section 2 - Computation)	System Configuration	Output Relevance Testing (required after system changes - data, data sources, hosting IT system, new learning, etc.)
Data - Transition	System Improvement	Machine's Relative Level of Influence Over Super-system
Data - Structure	Accuracy Decision	Data Output Type
Data - Updates	Goal Pursuit	Signaling Output Target High level Categories
Data Retrieval Independence	Goal/Task Configuration	Output Target Types
Data Supervision	System Learning Design	
Sensing Field Types (if data must first be "created" by way of sensing)	Operational Transparency	
Sensing Target Source		
Sensing Target Direction		
Data + Target Direction		
Input Pathways		
Data Prep / Configuration (could be part of column 2 - Computation)		

Categories

Figure 1 - AI/ML Current State Constructs and Categories

As with any computing structure, within which AI and ML are subsets, the system requires three primary features: 1.) input, which is either directly entered data or sensing systems that converts their own input into data for subsequent entry into the system, 2.) logic processing (i.e., computational manipulation), and 3.) output, which of course also covers a wide range of categories to include data, images, control signals, and other modalities. The various constructs, and their categories, of AI and ML systems analyzed can be seen in Figure 1 – AI/ML Current State Constructs and Categories.

After identifying the various analysis target constructs, it was necessary to gather information regarding the current states of those targeted AI and ML system constructs. An example of the current state data gathering tool can be seen in Figure 2 – AI/ML Current State Trend Analysis Template Sample. Since a general AI/ML system was chosen as the analysis model, information was gathered as to the current state of a wide variety of AI/ML systems and then an empirical process was utilized to create the generalized system; an analogous average of the studied AI/ML systems.

AI/ML Current State Template for Trend Analysis Rev 10

check one or both

	Makers input			Overall Usage Case
Steps (input/logic/output)	**Users Input**			
2- Computation	Current State (check "X" if applicable)	Line Item Usage Case (if different than overall usage case)	**Constructs**	**examples/descriptions**
Analysis Progression Direction			initiation passively directed	*Initial one time process direction given to the system by human*
			initiation actively directed	*Initial process direction given to system by human followed by updates as human sees fit*
			initiation passively nondirected	*Initial one time process direction decided by the system*
			initiation actively nondirected	*Initial process direction decided by the system followed by updates as system sees fit*
			in-process passively directed (see **initiation passively directed** in this section)	*One time process direction update given to the system by human*
			in-process actively directed	*Process direction updates as human sees fit*
			in-process passively nondirected (see **initiation passively undirected** in this section)	*One time process direction update decided by the system*
			in-process actively nondirected	*Process direction updates decide by the system as system sees fit*
System Configuration			single engine (laptop/desktop or massively parallel contiguous system)	*laptop*
			multi-engine (local)	*desktop/workstation*
			multi-engine (virtual)	*company datacenter*
			multi-engine (dynamic-virtual)	*cluster compute server*
			multi-engine (same tasking)	*cloud computing*
			multi-engine (different tasking)	*cloud computing*
			multi-engine (series)	*cloud computing*
			multi-engine (parallel)	*cloud computing*
System Improvement			directed improvement during development and then static in operation	*directed - human driven*
			directed improvement during operation (periodic)	*directed - human driven*
			directed improvement during operation (continuous)	*directed - human driven*
			directed improvement during operation (dynamic)	*directed - human driven*
			undirected self-improving during development and then static in operation	*undirected - system driven*
			undirected self-improving during operation (periodic)	*undirected - system driven*
			undirected self-improving during operation (continuous)	*undirected - system driven*
			undirected self-improving during operation (dynamic)	*undirected - system driven*
Accuracy Decision			iteration decision by human	*the default*
			iteration decision by computer	*Totally autonomous learning systems could make decisions such as tasking a machine to increase or decrease accuracy for a ML algorithm -based on energy consumption/fit to achieve a different goal. Currently things are not here, but it is not too far e.g. with self-driving cars*
			iteration decision by system	
			hybrid iteration decision	

Figure 2 - AI/ML Current State Trend Analysis Template Sample

The general AI/ML system current state was then represented for each of the eleven TESE and their sub-trends (totaling some 24 unique trend continuums) across the categories of: Input/Sensing – Data, Input/Sensing – Field Types, Input/Sensing – Target Selection, Computation, Output – System to Machine, and Output – Ultimate Machine Output. One example of a single trend continuum current state analysis for a single AI/ML Construct/Category can be seen in Figure 3 – Trend of Increasing Coordination (current state) AI/ML input/sensing – Data Construct.

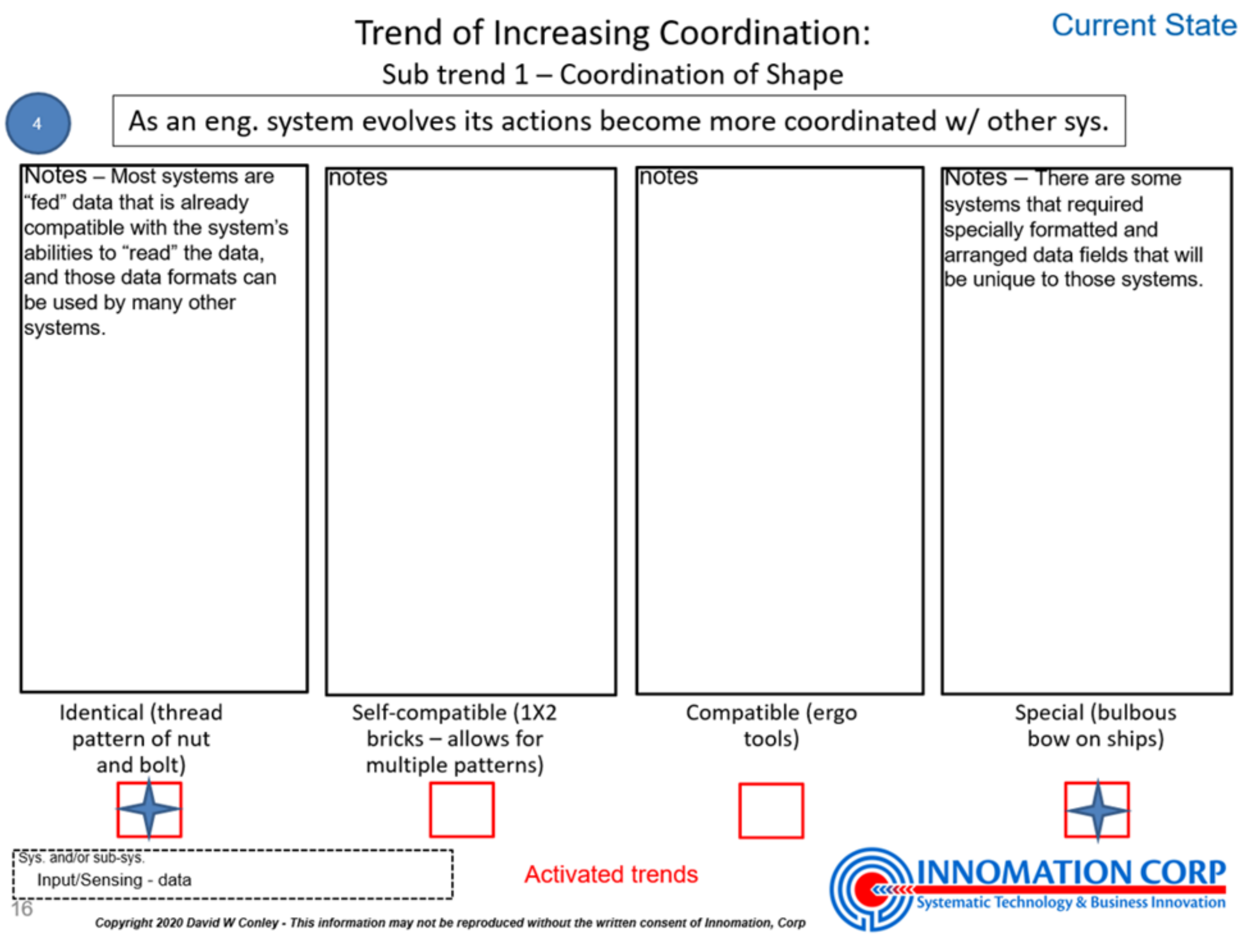

Figure 3 – Trend of Increasing Coordination (current state) – AI/ML Input/Sensing – Data Construct

Next, the generalized AI/ML system was hypothetically progressed down each of the 24 TESE continuums across the previously mentioned categories to predict the future states of each category. An example of future states, correlated to the current state show in Figure 3, can be seen in Figure 4 – Trend of Increasing Coordination (future state) AI/ML input/sensing – Data Construct. Finally, a summary was created which melds the trend continuum analyses (i.e., current and future states) across all the AI/ML constructs/categories which provides a textual representation of the insight gained from the analysis. A text only version of the entirety of the

177 trends / AI/ML categories / constructs analysis can be found in Appendix Three. In order to reduce mental inertia, the SME did not perform any forecasting research prior to executing the engineering system evolution study.

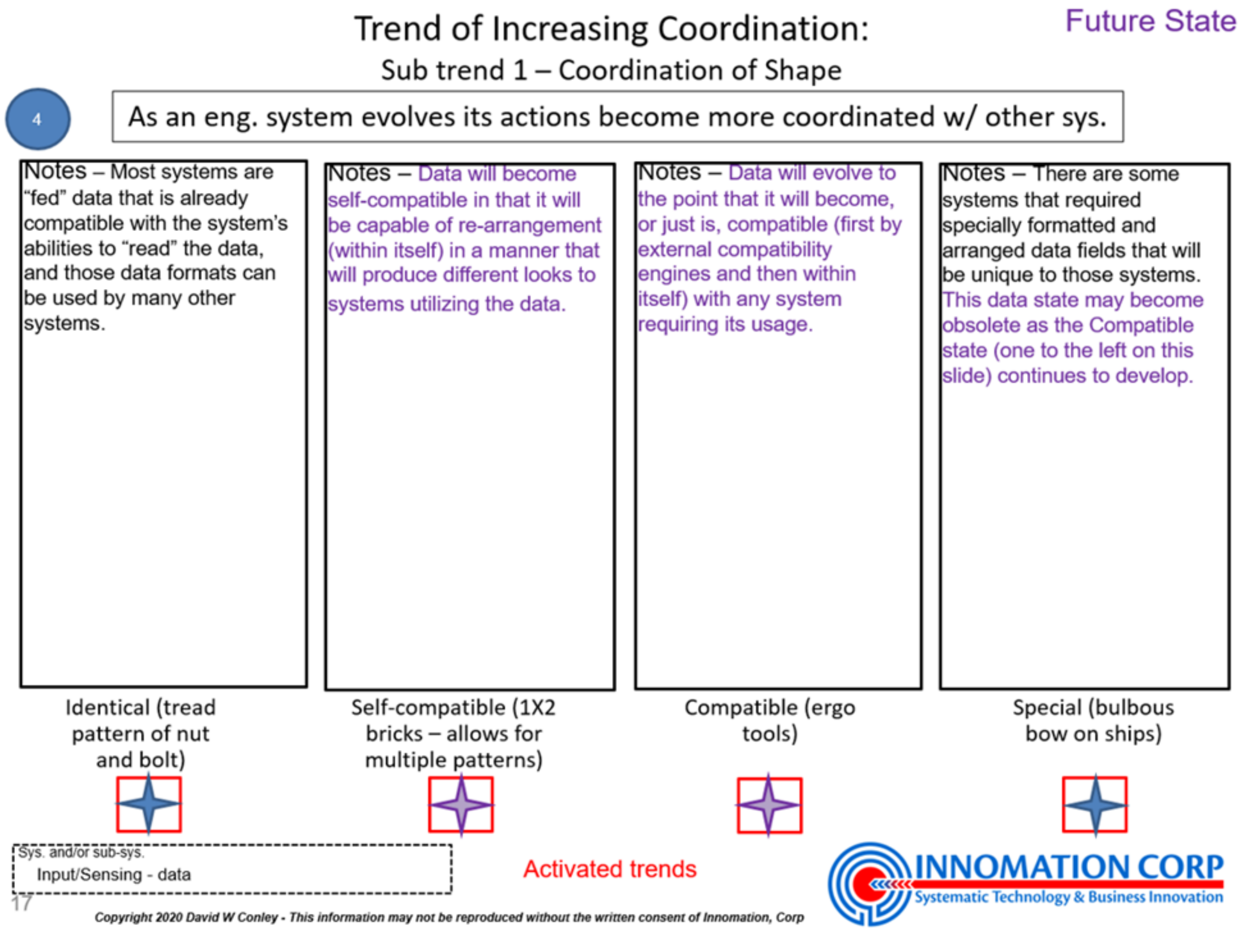

Figure 4 – Trend of Increasing Coordination (future state) – AI/ML Input/Sensing – Data Construct

As suggested by the title, the following is a high-level summary of the analysis and is meant to provide a universal, and admittedly abstract, description of what will likely manifest as AI/ML systems continue their evolutionary advancement into the near to medium-term future. The AI/ML Trend Analysis Summary is followed by an also generalized, but somewhat less abstracted, discussion of the associated next step research as suggested by the author.

It is important to understand that various combinations of the trends and the AI/ML constructs will often produce similar, or related, future state scenario abstractions. Therefore, when reviewing the AI/ML Trend Analysis Summary below, it will be noticed that themes repeat themselves throughout the summary. This is not only expected but also useful in establishing important focus areas for future analyses and research investigations. To understand what exact combinations of the TESE, with the various AI/ML constructs, produced the narrative below it will be necessary to review the full report found in Appendix Three – Full AI/ML Trend Analysis (Text Only).

AI/ML Trend Analysis Summary

Input/Sensing – Data
Input/Sensing – Sensing Field Types
Input/Sensing – Target Selection
Computation
Output - System to Machine & Ultimate Machine Output

Input/Sensing - Data

Internal and external data structure will become more dynamic, capable of carrying more information, available from a greater variety of sources, and able to carry heterogeneous signals and thus increase in its capability. This increase in capability of data will also be driven by the dynamics underlying its storage methods including location, category groupings, "virtualness", and other parameters.

Data will contain multi-parameter information at the lowest "unit" level including about its own variation in space, time, or other dimensionality and will be able to vary itself based on usage modes. Data will be capable of morphing to interface with all systems and to most effectively work within those systems.

Future data sets will first have common relative anchors but be capable of small relative individual dynamic variation (e.g., various parameters across packets, bits, etc.) in relationship to the whole. Future data sets will then have common relative attributes but be capable of relative individual dynamic variation (e.g., various parameters across packets, bits, etc.) in relationship to the whole.

Data sets will be multi-purpose both within a single system's functionality and between different systems. This multi-functionality will grow to the point of effectively being a universal data set. This could be a single data set for all purposes or rather that the data contains peripheral data, in relation to the primary analysis task, that at first glance may appear as unnecessary to that analysis.

The current static/human provided data will become system/data updated data, though designed by humans. Then the data will be updated /configured by supersystems, with no human involvement, and finally by the system itself, with no human involvement.

Data sets will become more universal in that they will contain wider and wider ranges of information and therefore become more heterogeneous. The specific information required for a specific analysis will be easy to pull from those universal data set by varying some data management parameters as needed.

Data will evolve to the point that it will become, or just is, compatible, first by external compatibility engines and then within itself, with any system requiring its usage.

Data itself will become more dynamic and "powerful," which could address limited storage and handling capabilities as well as computational power limitations.

System will do all data selection, cleaning, and tagging, opposed to humans doing that work in the current state. It is likely that all three of these attributes (i.e., selection, cleaning and tagging) will not evolve at the same rate or time.

Systems will handle data transmission, the energy required to transmit the data, and the control and decision making around the usage of the data. Systems will also become fully complete (i.e., transmission, energy source, control, and decision making) as far as data curation (i.e., selecting, cleaning, and tagging) is concerned. Though likely not in unison across all three constructs.

Data structure and dynamization described previously will accelerate the increase of conductivity of data. The advancement in the coordination of coding with the hardware it is run on and the job it is designed to do, as well as the development of specific AI/ML hardware, will drive the Improvement of flow utilization of data. The development of specialized sub-systems (i.e., internal controls) and/or supersystems (i.e., external controls) will reduce the availability of "bad" data to the systems. When "bad" data does slip through the barriers, future systems (i.e., hardware and software) will minimize the negative impacts of the "bad" data on the system output/effectiveness.

Data will become more valuable by way of pre-curation (i.e., selection, cleaning and tagging) by way of specialized human driven systems (i.e., external supersystems) at first then by way of non-human driven systems (i.e., external supersystem followed by internal sub-system driven) later. As the current data format/structuring maxes out in value a new principle of action for data will appear on the market.

As the current state of data moves through S-curve stage 2, (note - where all (90% plus) the money is made over the life of a system) the primary driver in relation to AI/ML systems data will be the value increase of that data due to curation (i.e., selection, cleaning and tagging). See Appendix Four – Trend of S-Curve Evolution.

Input/Sensing – Sensing Field Types

Outbound sensing fields (i.e., from the sensor or "activator" to the data target) will become more dynamic making them more effective at conditioning the target to give up its data.

All sensing fields will be represented across the attributes of gradient, pulsed, resonant, and interfering which will also support the dynamization concept making them more useful and effective.

All systems sensing fields will progress to being "self-controlled" as AI/ML systems become capable of doing so. This will first occur by the utilization of external (i.e., supersystem components) and then by way of internal (i.e., subsystem components) systems.

All electro-magnetic, mechanical-acoustic, thermal, and nuclear fields will continue to be the primary sensing fields in the short to medium term and then joined by mechanical-physical, chemical, olfactory, and biological as capabilities around those fields are further developed.

Sensing fields that move towards 0D (note - see Glossary for O, 1, 2 and 3D definitions) will also likely become matrixed to artificially and functionally represent a 2D or 3D application.

Sensors will begin transmitting their own fields across all field types. Then the energy required for the transmission, the control of those fields, and the decision making about the use of the fields will appear in that order, all from within the sensors or sensor sub-systems.

As the computational portion of the AI/ML systems and specialized sub-systems advance, at least those associated with sending and receiving and analyzing the sensor fields, then energy sources, control systems, and decision making will enter the sensing sub-systems of the overall AI/ML system.

Increase output of sensors for nonenergetic targets across all sensing fields will occur. Then improved sensor sensitivity will occur across all fields. Next sensors will be developed to "rule out" unwanted fields (e.g., frequencies) and field "data." And finally, signal correction for attenuating or distorting environments (e.g., astronomical observations from earth's surface), for all fields, will be developed.

Sensing systems for mechanical-physical, chemical olfactory, and biological will increase their functionality significantly and will therefore be more valued, or finally valued at all, by the market. Sensing systems for electro-magnetic, thermal, acoustic, and nuclear will raise their functionality in order to keep their price steady.

Currently, the most developed sensing fields are electro-magnetic, thermal, acoustic, and nuclear and they will continue to get better. Upcoming sensing fields will be mechanical-physical, chemical, olfactory, and biological.

Input/Sensing – Target Selection

As systems begin choosing their own data targets they will first apply a gradient in order to deemphasize some data, then become more sophisticated in target selection by varying a wide variety of selection criteria in a dynamic manner, then will change target selection on a periodic bases calculated to maximize quality of output, and finally will coordinates usage of selected targets to some natural frequency of the business, technical, or operational environment.

Data targets will grow in numbers as systems become more broad-based as far as combining various goals/variables into a single analysis or working multi-analyses in parallel for common or non-common ultimate outputs.

Systems will begin identifying their own targets and overseeing the target data acquisition but initially with human intervention and oversight. Supersystems will take over the identification of targets and or the oversight of target data acquisition. Then AI/ML systems themselves will begin performing all target identification and target data acquisition oversight internally with no external support, oversight, or intervention.

Targets will be chosen, and their data acquisition managed, in a 3D manner (note - at least in abstraction) whether by humans, other systems or the system itself. 3D could represent a 3D matrix representing three different parameter axes, thus giving substantial flexibility/dynamicity in so far as focus, functionality, and application. An example, 3D target selection might be choosing data targets throughout, and at all levels within, an ecosystem such as taking data from 1.) all corn crops throughout the US, 2.) from all plants within each corn crop, and 3.) at the molecular level within each plant within those crops.

Target types will become more and more diverse, for both single applications and for target groups meant to support multiple related or unrelated applications. For example, when studying human migration, target data for economic trends of countries, waste output of migrating humans, family histories, etc.

Target selection will become more automated according to pre-set rules and objectives. Ultimately, target selection will be fully automated with the system itself setting both targeting objectives, first based on human set goals and then later based on system set goals, and target selection rules.

Future systems will combine multiple "independent" systems to work in collaboration, and sometimes competitively, to select targets, then objectives and targets, and then goals, objectives and targets. Variable setting will also transition from human to system in some manner.

Human involvement in target selection will gradually disappear replaced by complete system-controlled target selection and direction.

Systems will, step by step, take over all functional requirements of target selection and direction.

Systems takes over target selection and curation (i.e., cleaning and tagging). System will then evolve to where there are no requirements for data curation and then to where there are no requirements for target selection. This later step is hard to visualize but will none the less occur probably by way of a completely different principle of action as to how the learning even occurs and what "information" it is based on.

Human driven data collection will be eliminated followed by the elimination of system driven data collection. Then, human driven data curation will be eliminated followed by the elimination of system driven data curation. Then data storage requirements will be eliminated.

Targets will become easier to find, and data easier to gather, as system internalizes these functions. Data will be easier to use as system internalizes data handling functions. Data will contribute to the improvement of results as system internalizes data curation functions. "Bad" data that "slips through" will have less of an impact on the results as the system internalize self-correcting functionality.

Supersystems will emerge, driven first by humans and then by the system itself, to set goals, objectives, and variables and to find targets, gather data and curate that data and will improve rapidly allowing substantial profits from those products and services.

Target identification and data gathering will improve rapidly and will first be human driven systems followed by machine drive systems.

Computation

Single processor, or single multi-processor, systems will be replaced by coordinated collaborative, competitive, or both, multi-systems. The new "systems" may be multi-system stand-alone systems (i.e., dedicated systems designed to work with each other) or multi-system independent systems (i.e., non-dedicated sperate systems (e.g., in space and/or functionality)) that are coordinated to work together, but not originally designed to do so.

The coordination of systems, both within those systems and between separate systems, will explore all of the field dynamization steps (i.e., constant, gradient, variable, pulsed, resonance, and interference) as far as their computational processes go. This is sperate from, though related to, data field dynamization but instead represents the overall system methodology of data handling, storage and logic processing and general machine operations methodologies. Consider interference fields as error correcting signals coming from separate systems/sub-systems which are either from within or without the system that needs correction.

Universally, the systems will become more real-time flexible in their abilities to function the same as or differently, within itself or between it and other systems. Multi-systems, whether separate or within the same system, will act in partial orchestration and in either functionally equivalent or closely functionally equivalent ways. Then multi-systems, whether separate systems or within the same system, will act in partial orchestration, or complete non-orchestration, and in either functionally equivalent or functionally non-equivalent ways. Finally, multi-systems, whether separate or within the same system, will be developed with capabilities to dynamically morph themselves real-time in both coordination and functionality.

Systems, whether contiguous or separate sub-systems, will develop more and more multi-functionality features and will be capable of more and more coordination within, or between, these different delineations of functionality, whether virtually, physically or both.

Currently, most AI systems require external human input. Current stand-alone AI/ML systems will first become virtual or physically distributed coordinated systems with substantial external control by other systems or humans. Next the virtual or physically distributed coordinated AI/ML systems will become self-controlled.

Systems will be multi-resourced in both the types of various computing platforms that are coordinated and the types of various functional components that are integrated (e.g., full systems: goal/objective setting, data target selection, sensing, data collection, computation, and output control). In the long-term imagine a handheld "advisor" that observes your environment, gathers information, from both local and global sources, and gives you advice or direction as it learns.

New AI/ML functionality (e.g., data curation) will begin development shortly in order to enter the market. Existing functionality (e.g., neural networks) will be improved to increasing their effectiveness. Existing model and older technology AI/ML systems will be developed in areas un-related to their main function (i.e., integration into an automobiles or refrigerators).

AI/ML systems will become more and more coordinated within themselves, between each other, and with other systems (i.e., non-AI/ML). AI/ML systems will become better at knowing when, and utilizing down-time, to do "other" activities including planning, future states scenario testing, maintenance, data corrections, etc.

The computational portion of AI/ML systems will become more highly integrated with, and connected to, other computational AI/ML systems as well as other non-computational systems (e.g., data stores, sensing systems, output controllers, etc.) and can be considered as 3D (i.e., volume action) systems. In this construct the computing resources can be considered as in excess, and the effect is desired to be strong, thus driving the evolution from 0D to 3D.

Coordination between partially different types of systems (e.g., data search and retrieval, data storage, computation, output management, etc.) will expand. Systems designed for competition or collaboration will be developed. These systems will not only compete but will be designed in different ways; possibly to include all aspects of purpose/functionality to include both the hardware and software designs.

AI/ML systems designed to compete with each other will appear for the purpose of improving output and accuracy. Allied AI/ML systems designed to collaborate with each other either as completely separate but functionally equal systems, or that are separate and not equal in that they are executing their "parallel functions" in different manners, will appear. Artificial stupidity systems will grow, such as disinformation bots. The use of artificial stupidity/disinformation systems for the benefit of society will be explored.

Collaborative or competitive AI/ML systems will appear. Series linked collaborative AI/ML systems will appear. Parallel linked collaborative and competitive AI/ML systems will appear. Functionally different integrated AI/ML systems will appear (e.g., data targeting, data gathering, data management, computation, iteration feedback and control, output management, output direction and sharing, etc.). This will occur first with human decision making followed by various aspects of decision-making being transfer to the machine and then all aspects of decision-making being transferred to the machine (i.e., Sky Net).

Multi-system AI/ML with both homogeneous and heterogeneous functionality will appear. Massively parallel AI/ML and competitive AI/ML, which can be localized or distributed systems, will appear.

AI/ML systems with various levels of internal decision-making will appear first and then followed by systems with almost complete internal decision-making authority.

Decision-making will slowly enter the system (note - the speed of uptake more determined by policy than by technology).

As systems begin to judge their own performance, they will be capable of making performance corrections and thus improve the utilization of the data flows. Supersystem components will be developed that are better equipped to identify and take "harmful" data out of the data flows. AI/ML systems will begin to be able to understand "bad" information and not allow it to impact the accuracy of their output or at least correct for the reduced level of accuracy.

Due to the probable inability of 0/1 processors to ever be truly capable of grey area decision making, true improvements with the current silicon-based microprocessor AI/ML systems will be mainly in the area of data curation. As the collection and curation of data improves (e.g., see third party specialist service providers), this will go a long way in improving the effectiveness of AI/ML output. Algorithms and methods improvement will help but not as much as dealing with the data end of things.

Expect AI/ML grey area decision-making to begin a transition out of S-curve stage one once vastly improved AI/ML data systems are developed (e.g., analogous to fuzzy logic but not based on 0/1 logic processing). Expect AI/ML black and white decision-making capabilities to grow rapidly as other improvements occur. (note – see glossary for grey area, and black and white, decision-making definitions)

Output - System to Machine & Ultimate Machine Output

Regardless of output level of the machine (i.e., informs, advises, requests, directs, or controls) the upstream output of the AI/ML system will be a field as that output will be by way of a digital signal (unless a major breakthrough in analogue signaling occurs (e.g., related to consistency of transmission and other send/receive performance parameters)). However, when considering the many types of possible downstream machine outputs, those outputs may or may not be a field, based on the specific output situation. See Outbound Fields below.

Outbound Fields (machine to supersystem)	Future Trend Progression
EM spectrum - radio	none - already at "Field"
EM spectrum - microwave	none - already at "Field"
EM spectrum - infrared	none - already at "Field"
EM spectrum - visible	none - already at "Field"
EM spectrum - ultraviolet	none - already at "Field"
EM spectrum - x-ray	none - already at "Field"
EM spectrum - gamma ray	none - already at "Field"
mechanical - physical	While all states are possible now most systems are likely low on trend progression (multi-joint and below). Expect to see all systems progress towards gaseous.
mechanical - acoustic	Will remain at gaseous
thermal	All states possible now though possibly not used, therefore rapid progression expected.
chemical	No progression expected from powder, liquid, and gas
olfactory	No progression from field (activation) or powder, liquid, and gas (delivery)
biological	All states in use now, therefore no progression expected
nuclear	While technically a monolithic wave-function can already be defined at field (no progression expected)

Variable fields will be used in cases where ultimate machine output is intended to appear, or act as, analogue systems. Digital signal pulsing, resonance, and interference will all be developed to help systems' signals to become better coordinated with their operational environment. The following examples are for where the ultimate machine output is within the electro-magnetic spectrum:

Constant field - Safety light
Gradient field - Range sensitive motion detector
Variable field – Electro-magnetically transmitted music

Pulsed field - Warning light or timing signal
Resonance field - Fusion activation laser
Interference field - Electro-magnetic disruption.

Expect AI/ML systems to affect a wide variety of other AI/ML systems where the "same" input for each would actually result in different functional effects onto those systems. Also expect the AI/ML systems to begin creating heterogeneous signal sets used to activate a variety of other AI/ML systems as well as a variety of machines. Expect AI/ML driven ultimate machine output to affect multiple supersystem components simultaneously (e.g., system to determine if a person gets a loan could: 1.) inform the person (note - ultimate output target is a person), 2.) complete their loan paperwork (note - ultimate output target is a loan processing system), 3.) inform the borrowers accountant (note - ultimate output target is an accountant/accounting system).

Currently, most AI/ML system's output will be a fixed program but where other inputs occasionally alter the fixed program (e.g., feed information to central control systems every hour on the hour unless instructed otherwise due to internal system decisions). Expect other coordinated systems to externally control what the AI/ML system does with its output and when. Ultimately, expect AI/ML systems to dynamically and real-time make their own decisions as to what they do with their output and when.

The number of controllable states of AI/ML system output will increase.
Single state - Set/single signal type with repetitive usage (e.g., traffic light control signal).
Multi-state discrete - Variable/heterogeneous signals with either repetitive usage or non-repetitive usage (e.g., temperature range forecasts).
Multi-state infinite - Greatly variable (i.e., approaching infinity) in so far as amplitude or parameter measure. (e.g., solar flare driven geomagnetic storm intensity/magnitude analysis).
Multi-state multi-resource - Expect AI/ML systems to provide a variety of different, yet coordinated, signaling to a variety of machines (e.g., signals emergency system due to aircraft crash (i.e., control function), signals FAA (i.e., reporting function), signals local control tower (i.e., control function), send information to airline to support customer communications (i.e., information function), etc.)
Dynamically stable - Expect AI/ML system signaling to support operation of dynamically stable systems (e.g., fighter aircraft).
Unstable - Expect AI/ML systems signaling to support operation of unstable systems (e.g., blasting at mining operations).
The number of controllable states of machine output will increase.
Multi-state discrete - Railroad crossing signal (i.e., up/ down) likely exists now.
Multi-state infinite - Laser output power (note - but since likely controlled with a digital signal would only appear infinite or analogue) likely exists now.
Multi-state multi-resource - Expect the ultimate output machines of individual AI/ML systems to affect multiple heterogenous supersystem components (e.g., human, auto controls, etc.).
Dynamically stable - Expect the ultimate output machines of AI/ML systems to affect dynamically stable systems such as a Segway or modern fighter jet (e.g., F35 Raptor).
Unstable - Expect the ultimate output machines of AI/ML systems to affect unstable system such as blasting system used in mining.

Expect the "quality" of AI/ML system signaling to improve in the near term first based on better input data curation and second on better algorithms/system to system coordination. Expect ultimate machine output, with less developed fields (e.g., chemical or biological fields), to move into its S-curve transition stage and then into its S-curve early stage two in the medium-term. Expect ultimate machine output, with better developed fields (e.g., mechanical, acoustic, thermal, electro-magnetic, and nuclear field), to continue improving at a somewhat constant rate.

Expect signaling output of AI/ML systems to begin performing alternative functions during "down time" of their downstream machinery (e.g., after triggering the Emergency Broadcast System, begin signaling emergency responders). Expect signaling output of AI/ML systems to become better at working and coordinating with other systems (e.g., learning from other AI/ML systems with different focus areas, sharing new data with systems that are working on different projects that could benefit from the new data, giving learnings to non-AI/ML systems as real-time updates, etc.).

Expect AI/L signaling to increase in its "dimensionality" to trigger "areas" of both homogeneous and heterogeneous machines (e.g., a network of systems). Expect AI/L signaling to increase in its "dimensionality" to trigger "volumes" of both homogeneous and heterogeneous machines (e.g., an ecosystem of systems). Expect ultimate machine output of AI/ML driven systems to move towards 0D (i.e., single point affect) output where beneficial (e.g., cancer treatment of individual cancer cells). Expect ultimate machine output of AI/ML driven systems to move towards 3D (i.e., volume affect) output where beneficial (e.g., manufacturing of components).

Expect systems to begin connecting with their ultimate output machines by way of multiple and competing systems (note - a competing system is a system with the same main function but that accomplishes that function in an alternative methodology, e.g., standard digital signaling vs. acoustic or pressure wave signaling).

As the outputs of both the AI/ML systems, and their subsequently controlled machines, transition to the supersystem there will be increasing differentiation in their main functions.

AI/ML signaling

Expect AI/ML systems to begin signaling other non-AI/ML decision systems (e.g., expert systems, decision tree systems, etc.). Then, followed by signaling other AI/ML systems with other "jobs to be done." (e.g., AI/ML system that forecasts future economic activity signals an allied AI/ML system that starts controlling the manufacture of products for next year's sales). Next, followed by signaling heterogeneous AI/ML systems (e.g., AI/ML system that forecasts future economic activity signals a heterogeneous system that compiles training material for schools – both based on same input data). Finally, followed by signaling inverse systems that are intended to counter the output of the initial system (e.g., Center for Disease Control AI system that sends warning signals to community health providers also sends a signal to an inverse system that is designed to send "no need to panic" messages to the public).

Machine output

Expect ultimate machine output of system to be by way of competing systems (e.g., storm signal through community warning sirens and simultaneously through smart phone direct text signaling). Then by way of allied systems (e.g., machine of a customer preference AI/ML system gathers ingredients for a meal and the allied machine cooks the meal). Then by way of heterogeneous systems (e.g., machine writes an economic activity report and the allied machine starts manufacturing products where both are based on same AI/ML input data). Then by way of inverse systems (e.g., machine of a national forest fire prediction AI/ML systems starts prescribed burn fires and the inverse machine controls/extinguishes those set fires).

Expect that the ultimate output machine will have AI/ML systems partially integrated into it and therefore most system to machine signaling will be integrated, while other signaling is not (e.g., self-driving car but where some signaling occurs from external sources such as lane marking magnets built into roadbed). Further, expect that the ultimate output machine will have AI/ML systems fully integrated into it. (e.g., planetary exploration robot that visits an unknow world and must sense, learn and do all tasks based on internal resources alone). Expect machine output to trigger machine output to trigger machine output (e.g., series of manufacturing processes). Then expect machine output to go from being external (e.g., an intersection traffic light) to being internal (e.g., in-vehicle warning system so that driver can safely navigate the intersection). Then expect machine output to go from being an internal support system (e.g., in-vehicle warning system so that driver can safely navigate the interjection) to an internal control system (e.g., in-vehicle control system that automatically takes over all automobiles' navigation at intersections, thus eliminating needs for traffic lights).

AI/ML systems will signal many homogeneous, and wide variety of heterogeneous machines (e.g., all traffic lights in downtown region and/or traffic lights, road maintenance crews, public transportation busses, etc.). AI/ML controlled machines will affect a large number of homogeneous, and wide variety of heterogeneous, supersystem components (e.g., a network of traffic lights (i.e., a distributed machine) signals all drivers in the downtown area and/or a network of associated AI/ML controlled machines will control traffic lights, delay/accelerate busses (i.e., adjust their schedules), mend pot hole, etc.).

Triggering signals will be fully self-contained including the AI/ML system that is creating the signals having decisions making built into its automated systems (i.e., no human driven decision making). Machine output will also contain decision making (e.g., a machine that informs its intended target (i.e., human) but where the machine itself decides when and how to do that informing).

System signaling output will be fully complete when the associated signaling decision making is internal to the associated AI/ML systems. Expect machines to also perform the decision making regarding their output (e.g., system of traffic lights is given overall guidance by AI/ML system but individually decide on their own when to change based on local activities).

Expect most machines to have their control systems trimmed driven by other trends such as the trend of increasing controllability (e.g., traffic lights controlled by central AI/ML system). Expect many machines' functionality to be replaced by related but unassociated functionality (e.g., traffic lights replaced by all vehicles in directed communication and coordination with each other where the vehicles navigate intersections automatically without the need for traffic lights).

Currently, signaling improvements are mainly focused on increasing conductivity (e.g., multiplexing, fiber optics, etc.). Expect machines to grow in their ability to better utilize the signals that are triggering/controlling them (e.g., signals containing more complex information and/or machines with improved internal signal processing). Expect AI/ML system to send less "bad signaling" based on advancements in their internal AI/ML functionality. Expect the associated downstream machines to be capable of filtering out "bad signaling" if received.

Expect to see future signaling have a principle of action change and therefore "start over" on a newly associated S-curve (e.g., gamma ray pulsing as a signal). The new principle of action will require significant development (i.e., functionality increase) and substantial cost reduction in order to leave stage one of its new S-curve.

Expect all machines to continue their advancement along their respective S-curves with the associated function versus cost ratios affecting the changes of those machines (i.e., always increasing in value).

Suggested Applied Research Directions

As the breadth and detail of this AI/ML trend analysis are wide and great there are dozens of focus areas where intelligence research could be beneficial. Every focus area, in and of itself, would require substantial resources to fully investigate. Therefore, it is obvious that the focus areas listed below should first be considered through the lens of what is most beneficial to the overall next-level analysis. In that way, a handful of specific focus areas can be moved forward allowing benefit to various researcher projects. It is important to note that there is an expected overlap between the following categories in both the research suggested and the ways in which the upcoming functionality can be harnessed.

Input/Sensing – Data

Specifics and details around the forthcoming changes to the data used as input to AI/ML systems.

The Features of Data

Specifically, execute data research and development (R&D) activities around data with multiple parameters or features, dynamic data, dynamic data gathering, and dynamic data storage, both in location and grouping/associations. Further, perform R&D around data with multi-parameter information at the lowest "unit" level including about its own variation in space, time, or other dimensionality and data that can vary itself based on usage mode and that can morph itself to effectively interfere where needed. Additionally, drive R&D around multi-purpose data sets leading to universal data sets. A detail of universal data sets is to execute R&D around providing data to AI/ML systems that may not intuitively be understood as required for those systems' objectives and goals.

Updating and Choosing Data
Perform R&D around systems that update their own data, or totally change their data focus, as required by the analysis and that is driven first by humans (i.e., external control), then by supersystem components (i.e., external control), and then by the systems themselves (i.e., internal control). Additionally, drive R&D focused on AI/ML systems making their own decisions (i.e., little to no human oversight) about data sources and usage.

Minimizing the Impacts of "Bad" Data
Execute research around the development of specialized sub-systems (i.e., internal controls) and/or supersystems (i.e., external controls) which reduce the availability (e.g., maybe filter or clean) of "bad" data to the systems. Further, drive R&D regarding minimizing the system output/effectiveness impacts of "bad" data when it does slip through the barriers.

Data Curation
A special analysis should understand the near-term to mid-term availability of human and/or system driven data pre-curation (i.e., selection, cleaning and tagging). The human driven processes will naturally be supersystem models (i.e., external to the AI/ML system), while the system driven processes could be either supersystem (i.e., external to the AI/ML system) or subsystem (i.e., internal to the AI/ML system) models. Then work towards R&D of moving the process of data selection, cleaning and tagging out of human hands and into the purview of the AI/ML systems themselves. This analysis is particularly import as it has the potential for a large short-term to long-term financial impact.

Input/Sensing – Sensing Field Types

Specifics and details around the forthcoming changes to the interaction fields (note - physics reference) utilized to gather the AI/ML system input data.

Use of ALL Interactions Fields for Data Gathering
Sensing fields are required to extract data from all data targets whether it is by way of acoustic and mechanical fields (e.g., humans interviewing humans and writing answers on a piece of paper) or electro-magnetic fields (e.g., gamma ray sensors gathering gamma ray spectrum data from the Milky Way) or any other of the sensing fields (i.e., interaction fields) or their combinations (i.e., Mechanical , Acoustic, Thermal, Chemical, Electro-magnetic, Olfactory, Biological, or Nuclear). Perform R&D around the utilization of all the various interaction fields used as activation fields (i.e., those that stimulate the target to give up its data), data gathering fields (i.e., those that deliver the data to the human or machine sensors), or both.

Data Field Design
Explore R&D around the utilization of gradient, pulsed, resonant, and interference fields in gathering data. Additionally, drive R&D around AI/ML data gathering fields which control themselves in some manner (e.g., strength, cross-section, focus, timing, period, etc.) useful to supporting the advancements in AI/ML capabilities. Further, perform R&D around exploring 0D (i.e., point), 1D (i.e., line), 2D (i.e., area) and 3D (i.e., volume) data gathering fields.

Some data targets will give up their own data (e.g., a star radiating electromagnetism) while other must be coaxed to do so (e.g., bouncing a radar field off an aircraft to determine its location, heading, and speed). The former can be considered an energetic target while the later can be considered a target in need of activation (i.e., static energy targets). R&D around outbound sensor fields (i.e., those required to activate their data targets) is most probably in process. Therefore, advance R&D around sensors transmitting their own fields, to include the control of those fields and the decision making around the use of those fields. Specifically, how can controlling the outbound “activation” sensor fields across various parameters (e.g., power, shape, dimensionality, wavelength, timing etc.) more effectively extract (i.e., activate) data from the targets?

Further, perform R&D around sensors, or sensor sub-systems, making their own decisions about target selection, activation field parameters, data gathering locations and times, and other variables of interest. Additionally, execute R&D around sensors being developed to “rule out” unwanted fields (e.g., frequencies) or field “data.” And finally, drive R&D around sensors, or sensor sub-systems, correcting the fields/data received from attenuating or distorting environments (e.g., astronomical observations from earth’s surface).

Elimination of Data Requirements

Push for R&D around the elimination of human data curation and then the elimination of the need for data curation all together. Then, perform R&D around the elimination of human driven data collection and then the need for data collection all together. Finally, drive R&D around the elimination of data storage requirements thus pushing the definition of what data storage really entails.

Input/Sensing – Target Selection

Specifics and details around the forthcoming changes to the ways in which targets are selected for the purpose of data acquisition.

The target options for AI/ML data are effectively infinite, especially when considering both the material targets themselves and the variety of parameters that can be measured from each. Therefore, the common direction in target selection is that methods to gather data from essentially every item on the planet will expand rapidly. This suggests that there are many connections and overlaps between the research suggested for the two constructs of Input/Sensing – Sensing Field Types and Input/Sensing – Target Selection.

Data Target Expansion

Perform R&D around the gathering of data, and more specifically the expansion of data targets, due to AI/ML systems combining various goals/variables into a single analysis or working multi-analyses in parallel for common or non-common ultimate outputs. Also, execute R&D regarding data targets becoming more diversified and heterogeneous, for both single applications and for target groups meant to support multiple related or unrelated applications.

Systems Select Their Own Data Targets
Explore R&D around AI/ML systems identifying their own targets and overseeing the target data acquisition. The early research will likely show substantial human intervention and oversight around the target selection but will transition to where humans are involved less and less in that process. Look for R&D around various supersystem components, that are human driven at first followed by system driven later, taking over the identification of targets and or the oversight of target data acquisition. Further, look for R&D around AI/ML systems themselves performing all target identification and target data acquisition oversight internally with no external support, oversight, or intervention.

Drive R&D regarding systems, both human and system driven, becoming more sophisticated in target selection by varying a wide variety of selection criteria in a dynamic manner, changing target selection on a periodic bases in order to maximize quality of output, and coordinating the usage of selected targets to some natural frequency of the business, technical, or operational environment. Therefore, initial R&D may be around the automated target selection being based on human created pre-set rules and objectives. Then, perform R&D around target selection being fully automated within the system itself, setting both targeting objectives, which will initially be based on human set goals and then later based on system set goals, and target selection rules.

Execute R&D around target selection moving towards a 3D model (note - at least in abstraction) whether by humans or other systems or the system itself. 3D could represent a 3D matrix representing three different parameter axes, thus giving substantial flexibility/dynamicity in so far as focus, functionality, and application. As an example, 3D target selection might be choosing data targets throughout, and at all levels within, an ecosystem such as taking data from 1.) all corn crops throughout the US, 2.) from all plants within each corn crop, and 3.) at the molecular level within each plant within those crops.

Multi-System Data Collection
Perform R&D around the use of multiple “independent” systems working in collaboration, and sometimes competitively, to select targets, then objectives and targets, and then goals, objectives and targets. Further, execute R&D around the setting of the AI/ML system analysis variables, that are directly associated with the input data, transitioning from human to system in some manner.

Computation
Specifics and details around the forthcoming changes to the ways in which AI/ML systems perform their computations for the purpose of producing their output.

Single Versus Multi-Systems & Functionality
Pursue R&D around the emergence of coordinated computational multi-systems. The new “systems” may be stand-alone multi-systems (i.e., dedicated systems designed to work with each other) or independent multi-systems (i.e., non-dedicated sperate systems (e.g., in space and/or functionality)) that are coordinated to work together, but not originally designed to do so).

Perform R&D around developing heterogeneous multi-functionality computing systems where the systems are comprised of complementary, yet different, sub-systems, each with its own unique contribution to the desired output. For example, learning sub-system, learning measurement sub-system, learning accuracy improvement sub-system, learning direction modification sub-system, and so forth. It is important to understand that these “separate” sub-systems may indeed be stand-alone, yet coordinated, systems or segmented functional sub-systems within an otherwise contiguous system.

Execute R&D around the computational portion of AI/ML systems becoming more highly integrated with, and connected to, other computational AI/ML systems as well as other non-computational systems (e.g., data stores, sensing systems, output controllers, etc.).

Coordination

It can be expected there will be, or already is, R&D related to:

- computational systems designed for real-time flexibility in their abilities to function the same as, or differently, within itself or between itself and other systems.
- computational multi-systems:
  - whether separate or within the same overall system, designed for partial orchestration in either functionally equivalent or closely functionally equivalent ways.
  - whether separate or within the same overall system, acting in partial orchestration, or complete non-orchestration, and in either functionally equivalent or functionally non-equivalent ways.
  - whether separate or within the same overall system, with capabilities to dynamically morph themselves real-time in both coordination and functionality.
- the development of systems, whether contiguous or separate sub-systems, with multi-functionality features that are capable of expanding coordination within, or between, these different delineations of functionality, whether virtually, physically, or both.
- AI/ML systems becoming better at knowing when, and utilizing down-time, to do other activities such as planning, future states scenario testing, maintenance, data corrections, etc.
- the use of various coordination attributes (i.e., constant, gradient, variable, pulsed, resonance, interference) to accelerate their ability to coordinate within themselves or between themselves and other systems. Consider interference fields as error correcting signals coming from separate systems/sub-systems, either from within or without the system that needs correction.
- the coordination of related but dissimilar system functionality (e.g., data search and retrieval, data storage, computation, output management, etc.).

Control and Decision Making
Pursue R&D around:

- stand-alone AI/ML systems becoming virtual or physically distributed coordinated systems with substantial external control by other systems or humans.
- virtual or physically distributed coordinated AI/ML systems becoming self-controlled.
- pushing internal decision making deeper into, and throughout, the AI/ML systems.

End to End Functionality
Pursue R&D pushing end-to-end functionality of AI/ML systems. More specifically, these systems will be multi-resourced in both the types of various computing platforms that are coordinated and the types of various functional components that are integrated (e.g., full systems: goal/objective setting, data target selection, sensing, data collection, computation, and output control). In the long-term imagine a handheld “advisor” that observes your environment, gathers both local and global information, and gives you advice or direction as it learns.

Seek out R&D around AI/ML systems that can judge their own performance, and therefore be capable of making performance corrections and thus improve the utilization of their data flows. Further, execute R&D for supersystem components that are better equipped to identify and take “harmful” data out of the data flows. Finally, drive R&D around AI/ML systems that can understand “bad” information and not allow it to impact the accuracy of their output or at least correct for the potentially reduced level of accuracy.

Perform R&D around the development of the inverse to AI systems (i.e., artificial stupidity). Understand how these systems (e.g., disinformation bots) can be used to harm and help society.

System Collaboration and Competition
Execute R&D around the development of AI/ML systems designed to compete with each other for the purpose of improving output and accuracy. Also, drive R&D around the development of allied AI/ML systems designed to collaborate with each other either as completely separate but functionally equal systems, or that are separate and not equal in that they are executing their “parallel functions” in different manners.

Pursue R&D around the development of:

- series and parallel collaborative AI/ML systems. It is likely that series collaborative AI/ML systems would be performing a series of related and sequenced process steps where each has its own specific output and that parallel collaborative AI/ML systems would likely perform the identical, or close to identical, analyses in parallel for the purpose of comparing outputs of each in order to maximize the effectiveness of the overall system.
- parallel competitive AI/ML systems. It is likely that parallel competitive AI/ML systems would likely perform vastly, or even minimally, different analyses in parallel for the purpose of competing for the “winning” (e.g., best, most efficient, most effective, most accurate, etc.) output in order to maximize the effectiveness of that chosen “winning” system’s output.

- collaboratively integrated, and functionally related but different, systems (e.g., data targeting, data gathering, data management, computation, iteration feedback and control, output management, output direction and sharing, etc.).

Some systems designed for competition or collaboration will not only compete/collaborate but will likely be designed in different ways; possibly to incorporate all aspects of purpose/functionality to include both the hardware and software designs. Other systems designed for competition or collaboration will not only compete/collaborate but may do so as identical systems, or close to identical systems, with one or more purposely design differences.

Performance Leaps

As the output of an AI/ML system, let alone any computational system, is dependent upon the quality of its input data, drive R&D focusing on AI/ML output effectiveness based on high quality data input.

Further, pursue R&D around computational systems that do not rely on 0/1 logic processing and will therefore be better suited to make grey area decisions (note – see glossary for grey area, and black and white, decision making definitions). These systems will likely utilize a different principle of action for their base computational processes (e.g., quantum, carbon chain, or other computing methodologies).

Output - System to Machine and Ultimate Machine Output

Specifics and details around the forthcoming changes to the output of AI/ML systems in so far as both 1.) their digital signal output to the machines they control, and 2.) the analogue/real-world output of those machines that those signals are fed into.

Regardless of output level of the machine (e.g., informs, advises, requests, directs, or controls) the upstream output of the AI/ML system will be a field as that output will be by way of a digital signal. However, when considering the many types of possible downstream machine outputs, those outputs may or may not be a field, based on the specific output situation. See Outbound Fields below (note- EM = electro-magnetic).

Outbound Fields (machine to supersystem)	Future Trend Progression
EM spectrum - radio	none - already at "Field"
EM spectrum - microwave	none - already at "Field"
EM spectrum - infrared	none - already at "Field"
EM spectrum - visible	none - already at "Field"
EM spectrum - ultraviolet	none - already at "Field"
EM spectrum - x-ray	none - already at "Field"
EM spectrum - gamma ray	none - already at "Field"
mechanical - physical	While all states are possible now most systems are likely low on trend progression (multi-joint and below). Expect to see all systems progress towards gaseous.
mechanical - acoustic	Will remain at gaseous
thermal	All states possible now though possibly not used, therefore rapid progression expected.
chemical	No progression expected from powder, liquid, and gas
olfactory	No progression from field (activation) or powder, liquid, and gas (delivery)
biological	All states in use now, therefore no progression expected
nuclear	While technically a monolithic wave-function can already be defined at field (no progression expected)

Variable fields will be used in cases where ultimate machine output is intended to appear, or act as, analogue systems. Digital signal pulsing, resonance, and interference will all be developed to help systems' signals to become better coordinated with their operational environment. The following examples are for where the ultimate machine output is within the electro-magnetic spectrum:

Constant field - Safety light
Gradient field - Range sensitive motion detector
Variable field – Electro-magnetically transmitted music
Pulsed field - Warning light or timing signal
Resonance field - Fusion activation laser
Interference field – Electro-magnetic disruption.

Heterogeneous Output Effects

Execute R&D:

- where AI/ML systems affect a wide variety of other AI/ML systems where the "same" input for each will results in different functional effects onto those systems. Additionally, look for R&D where AI/ML systems create heterogeneous signal sets used to activate a variety of other AI/ML systems as well as a variety of machines.

- where the AI/ML driven ultimate machine output affects multiple supersystem components simultaneously (e.g., system to determine if a person gets a loan could: 1.) inform the person (note - ultimate output target is the customer), 2.) complete customer's loan paperwork (note - ultimate output target is a loan processing system), 3.) inform the borrowers tax accountant (note - ultimate output target is an accountant/accounting system).

- organized around other coordinated systems externally controlling what the AI/ML system does with its output and when. And relatedly, look for R&D around AI/ML system that dynamically, and real-time, make their own decisions as to what they do with their output and when.
- around signaling output of AI/ML systems performing alternative functions during "down time" of the downstream machinery (e.g., after triggering the Emergency Broadcast System, begin signaling emergency responders). Further, look for R&D where signaling output of AI/ML systems become better at working and coordinating with other systems (e.g., learning from other AI/ML systems with different focus areas, sharing new data with systems that are working on different projects that could benefit from the new data, giving learnings to non-AI/ML systems as real-time updates, etc.).
- around AI/ML signaling "areas/volumes" of homogeneous and heterogeneous machines (e.g., a network of systems/an ecosystem of systems). Further, pursue R&D where the ultimate machine output of AI/ML driven systems move towards 0D output (e.g., single point effect) where beneficial (e.g., cancer treatment of individual cancer cells). Inversely, look for R&D where the ultimate machine output of AI/ML driven systems moves towards 3D output (e.g., volume effect) where beneficial (e.g., manufacturing of complex systems).

AI/ML systems will signal many homogeneous, and wide variety of heterogeneous, machines (e.g., all traffic lights in downtown region and/or traffic lights, road maintenance crews, public transportation busses, etc.). AI/ML controlled machines will affect a large number of homogeneous, and wide variety of heterogeneous, supersystem components (e.g., a network of traffic lights (i.e., a distributed machine) signals all drivers in the downtown area and/or a network of associated AI/ML controlled machines will control traffic lights, delay/accelerate busses (i.e., adjust their schedules), mend pot hole, etc.).

Controllable States

The number of controllable states of AI/ML system output (i.e., signaling) will increase.
Single state – Single set signal type with repetitive usage (e.g., traffic light control signal).
Multi-state discrete - Variable/heterogeneous signals with either repetitive usage or non-repetitive usage (e.g., temperature range forecasts).
Multi-state infinite - Greatly variable (i.e., approaching infinity) in so far as amplitude or parameter measured. (e.g., solar flare driven geomagnetic storm intensity/magnitude analysis).
Multi-state multi-resource - Expect AI/ML systems to provide a variety of different, yet coordinated, signaling to a variety of machines (e.g., signals emergency system due to aircraft crash (i.e., control function), signals FAA (i.e., reporting function), signals local control tower (i.e., control function), sends information to airline to support customer communications (i.e., information function), etc.)
Dynamically stable - Expect AI/ML system signaling to support operation of dynamically stable systems (e.g., fighter aircraft).
Unstable - Expect AI/ML systems signaling to support operation of unstable systems (e.g., blasting for miming operations).

Drive R&D pushing the signaling output of AI/ML systems down the controllable states trend line in so far as what type of machines they control (note - see content directly above).

The number of controllable states of AI/ML ultimate machine output (i.e., functional output affecting a real-world supersystem component) will increase.
Multi-state discrete - Railroad crossing signal (i.e., up/ down) likely exists now.
Multi-state infinite - Laser output power (note - but since likely controlled with a digital signal would only appear infinite or analogue) likely exists now.
Multi-state multi-resource - Expect the ultimate output machines of individual AI/ML systems to affect multiple heterogenous supersystem components (e.g., human, auto controls, etc.).
Dynamically stable - Expect the ultimate output machines of AI/ML systems to affect dynamically stable systems such as a Segway or modern fighter jet (e.g., F35 Raptor).
Unstable - Expect the ultimate output machines of AI/ML systems to affect unstable system such as blasting system used in mining.

Execute R&D pushing the supersystem effects of AI/ML ultimate machines' outputs down the controllable states trend line (note - see content directly above).

Output Interaction Fields
Perform R&D around improving the effectiveness of AI/ML ultimate machines output across mechanical, acoustic, thermal, electro-magnetic, and nuclear fields. Execute R&D around enabling AI/ML ultimate machines output across chemical and biological fields.

Drive R&D around systems connecting with their ultimate output machines by way of multiple and competing systems (note - a competing system is a system with the same main function but that accomplishes that function in an alternative methodology, (e.g., standard digital signaling vs. acoustic or pressure wave signaling)).

Differentiation of Main Function
As the outputs of both the AI/ML systems and their subsequently controlled machines transition to the supersystem, there will be increasing differentiation in their main functions.

AI/ML signaling
Pursue R&D where AI/ML systems signal other non-AI/ML decision systems (e.g., expert systems, decision tree systems, etc.). Next, drive R&D where AI/ML systems signal other AI/ML systems with other "jobs to be done." (e.g., AI/ML system that forecasts future economic activity signals an allied AI/ML system that starts controlling the manufacture of products for next year's sales). Additionally, consider R&D where AI/ML systems signal heterogeneous AI/ML systems (e.g., AI/ML system that forecasts future economic activity signals a heterogeneous system that compiles training material for schools, where both are based on the same input data). Further, look for R&D where AI/ML systems signal inverse systems that are intended to counter the output of the initial system (e.g., Center for Disease Control AI/ML system that sends warning signals to community health providers also sends a signal to an inverse system that is designed to send "no need to panic" messages to the public).

Machine output

Perform R&D where the ultimate machine output of the AI/ML system is focused on competing systems (e.g., storm signal through community warning sirens and simultaneously through smart phone direct text signaling). Next, drive R&D where the ultimate machine output of the AI/ML system is focused on allied systems (e.g., machine of a customer preference AI/ML system gathers ingredients for a meal and the allied machine prepares the meal). Then, consider R&D where the ultimate machine output of the AI/ML system is focused on heterogeneous systems (e.g., machine produces an economic activity report and the allied machine starts manufacturing products where both are based on the same AI/ML input data). Finally, scan for R&D where the ultimate machine output of the AI/ML system is focused on inverse systems (e.g., first, machine of a National Forest fire prediction AI/ML systems starts prescribed burn fires and the inverse machine controls / extinguishes those set fires).

AI/ML "Inside"

Drive R&D:

- where the ultimate output machine has an AI/ML system partially integrated into it and therefore most system to machine signaling will be integrated while other signaling is not (e.g., self-driving car but where some signaling occurs from external sources such as lane marking magnets built into roadbed). Also, consider R&D where the ultimate output machine has an AI/ML system fully integrated into it. (e.g., planetary exploration robot that visits an unknow world and must sense, learn, and do all tasks based on internal resources alone).
- where an AI/ML triggered machine output in turn triggers a subsequent machine's output which in turn triggers a subsequent machine's output … (e.g., series of manufacturing process steps).
- pushing an AI/ML ultimate machine output to go from being externally triggered (e.g., an intersection traffic light) to being internal triggered (e.g., in-vehicle warning system so that driver can safely navigate the intersection). Relatedly, drive for R&D pushing AI/ML ultimate output machines to go from being an internal support system (e.g., in-vehicle warning system so that driver can safely navigate the interjection) to being an internal control system (e.g., in-vehicle control system that automatically takes over all automobiles' navigation at intersections, thus eliminating needs for traffic lights).
- where ultimate machine output will also contain decision making (e.g., system of traffic lights is given overall guidance by an AI/ML traffic control system but where each light's internal control system (note – maybe also an AI/ML system) decide on its own when to specifically change based on immediately local activities/data).
- where downstream machines can better utilize the AI/ML signals triggering/controlling them (e.g., signals containing more complex information and/or machines with improved internal signal processing). Additionally, pursue R&D where the associated downstream machines can filter out "bad signaling" if received.

AI/ML Systems Replace Other Systems

Execute R&D investigating the removal of machines' control systems to be replaced by AI/ML control systems (e.g., traffic lights controlled by central AI/ML system). Further, pursue R&D focused on machines' functionality to be completely replaced by related but unassociated AI/ML functionality (e.g., traffic lights replaced by all vehicles in directed communication and coordination with each other where the vehicles navigate intersections automatically without the need for traffic lights).

Output Principle of Action Change

Perform R&D looking to find a principle of action change for signaling overall (e.g., electrical signaling replaced by gamma ray pulsing as a signal).

References

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Appendix One - Subject Matter Expert/Author Biography

David W Conley holds a BS in Nuclear Engineering from Texas A&M University ('83), an MBA with a concentration in Finance from the University of New Mexico ('89) and a Level 4 Specialist Certification ('09) in the Theory of Inventive Problem Solving (TRIZ – the science of systematic Innovation). His experience includes working as a commissioned officer in the US Air Force performing research in space nuclear propulsion and plasma physics including temporary positions at Brookhaven National Labs, Los Alamos National Labs, Sandia National Labs and NASA. After earning an honorable discharge from the Air Force, David work for Johnson and Johnson as a medical products and instruments sterilization engineer. He then worked as a facilities design engineer for Philips Semiconductor and then as a roboticist design, installation and qualification engineer for Lockwood Greene Engineers as a contractor for Intel Corp. Next, Intel hired him directly to manage their robotics engineering group. David worked for Intel for 17 years in a variety of engineering, business, and management roles where he managed and lead several poly-disciplinary teams and drove numerous projects requiring skills across manifold knowledge areas and the ability to coordinate and lead personnel from multiple cross-disciplinary functions and skill sets. He directly managed 100s of individuals (both corporate and contracted) in the areas of automated material handling, tool installation and qualification, payroll operations, industrial engineering, systems automation, coding development, and product test and sort. Many of his roles required the use of long-term forecasting and analyses in order to effectively design systems and processes considering continuously changing eco-systems and environments.

Most importantly, for his last seven years at Intel, David chaired Intel's world-wide innovation program where he lead the development and execution of Intel's innovation training curriculums, developed new applications for systematic innovation within Intel (technical, business, and computing) across the areas of product design, manufacturing systems and operations, facilities ops and design, business operations, and computing systems design and advancement. It was during these final years at Intel where he first began his focused study of the forecasting of engineering, business, and computational systems and began his journey as one of the few people worldwide to push the boundaries of utilizing the trends of engineering system evolution (TESE) to effectively forecast future changes of most any type of operational systems. All roles throughout his DoD and private sector career required that he understand both technical and business aspects of his environment and focus areas and that he orchestrates both technical and business knowledge, and human assets, in order to successfully execute various programs and contracts. As a result, David has become one of the premier worldwide experts in the fields of technology, business and computing system forecasting.

In the early 2000s, David left Intel to begin consulting in the discipline of systematic innovation. He has trained and performed innovation analyses and technical system forecasting for the likes of Samsung, Hewlett-Packard, Sandia National Labs, Ford Motors, Hyundai, Intel, Syngenta, Kohler, Presbyterian Hospital of New Mexico and many more. During that time he has developed, executed, and fine-tuned methods for applying systematic innovation to a wide variety of applications such as: engineering, technology and business forecasting, product design, computing systems analysis and evolution, business and operational systems advancements, development and advancement of chemical and biological systems and many others.

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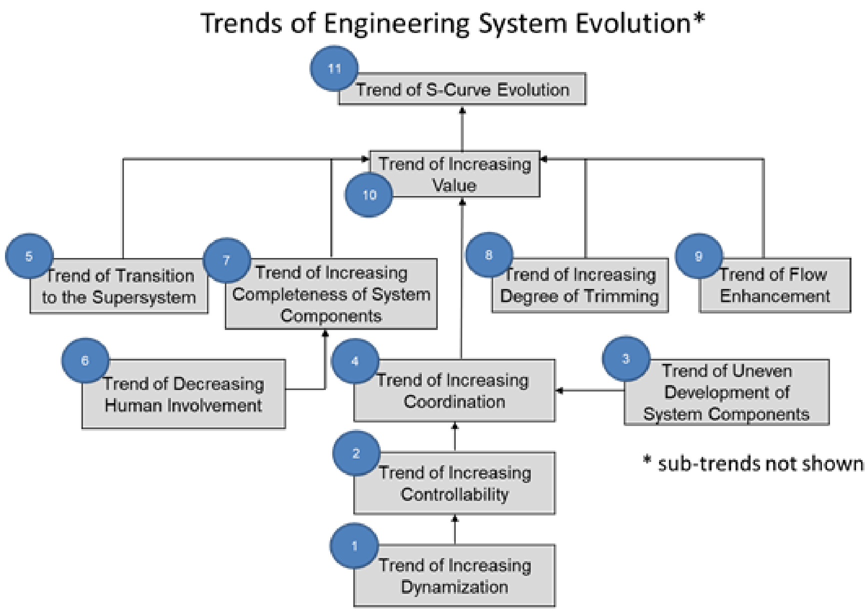
Appendix Two – Trends of Engineering System Evolution Description

The Trends of Engineering System Evolution are a hierarchically related set of eleven abstracted technology trends (note – there are a total of 24 trend continuums when considering all trends and their sub-trends) that were distilled from an analysis of over four million patents from the world-wide patent database over an 80-year period. The trends demonstrate the general evolutionary steps that all commercially successful engineering systems obey as they evolve. Any engineering system, or any/all of its separate yet coordinated sub-systems (i.e., components), can be initially placed on any, or all, of the 24 trend and sub-trend continuums and then hypothetically progressed down those trend continuums resulting in visibility to an abstraction of how the analyzed system/sub-system will successfully evolve in the near future. This analysis methodology, and tool set, therefore allows the accurate forecasting of what is to come next for any examined technical systems.



Appendix Three – Full AI/ML Trend Analysis (Text Only)

Input/Sensing – Data
Input/Sensing – Sensing Field Types
Input/Sensing – Target Selection
Computation
Output - System to Machine & Ultimate Machine Output

Input/Sensing - Data

Trend of Increasing Dynamization
Sub trend 1A – Design Dynamization - Substance

The design/structure of data can be expected to increase in dynamization or at least shift down the trend line with more and more data sets being more and more "capable." Expect data that carries multiple indicators with it at both the raw data level, and digitized bit level. Further expect data to be available from more and more sources, both in quality of homogenous sources and in categories of heterogeneous sources. Though also covered in other trends, data can be expected to become highly dynamic in its storage methods as far as in location, category groupings, "virtualness", and other parameters.

Trend of Increasing Dynamization
Sub trend 1B – Design Dynamization - Field

Expect data to be capable of containing multi-parameter information, not as data fields but rather as individual data "units." Data will contain information about its own variations in space, time, or other "dimensionality." Data will be internally capable of variability based on usage modes and this internal variability will be driven internally or from external sources. The "data packet" concept will be expanded to included variations that can all be abstracted to represent pulsing in so far as: frequency, size, type, groupings, sources, destinations, etc. Data will configure itself in such a way that it can "naturally" (e.g., more easily) interface with a wide variety of systems and in a wide variety of timings / "handshakes." New data concepts will include data that is either reconfigured, or self-configures to "interfere" with other data flows for various purposes such as: error correction, alternate data driven "viewpoints," representations of systems in alternative dimensionality constructs, and so on.

Trend of Increasing Dynamization
Sub trend 2 – Composite (structure) Dynamization

Currently, most data can be considered as monolithic in that it is a single operational unit. Groupings of various data sets could be considered as a system of plates in that they are similar data fields with one or more variations between the sets, but the entire set has the same general design/orientation. Future data sets will first have common relative anchors but be capable of small relative individual dynamic variation (e.g., various parameters of packets, bits, etc.) in relationship to the whole. Future data sets will then have common relative attributes but be capable of small or large relative individual dynamic variation (e.g., various parameters of packets, bits, etc.) in relationship to the whole. Then, relative variation within the data set can be large or small depending on the specific "location" within the data set.

Trend of Increasing Dynamization
Sub trend 4 – Functional Dynamization

It is assumed that most data sets are utilized for a single purpose, at least within a single system's functionality. Data sets will next be used for multiple purposes even within a single system's functionality. The multiple usages will grow both between various systems and within a single system. This "multi-functionality" of individual data sets will continue growing until some data sets can be considered as universal data sets (e.g., one manifestation of this concept might be that some data used within an AI/ML system, which would not be intuitively obvious as to how that data would even be used, such as with human subconscious thoughts, would partially represent this "universal data set" while another manifestation of this concept would indeed be one absolute and all-inclusive universal data set used in all systems).

Trend of Increasing Controllability
Sub trend 1 – Increase Level of Control

Most data sets are static and provided to the system by humans. The next step will be for the system, or the data itself, to update / configure the data in some limited, and human designed, way without real-time human intervention. Then the data will be updated / configured as needed or desired by way of external supersystems with no direct human oversight. Finally, the data will be updated / configured as needed or desired by way of the system itself with no direct human oversight.

Trend of Increasing Controllability
Sub trend 2 – Increase Number of Controllable States

Many systems utilize multiple sets of discrete data. All with some overriding common characteristic (e.g., human; ages, populations, gender, etc.). Next data sets will be able to represent a range of "infinitely" discrete sets by way of single or multiple parameter changes across a seemingly infinite range. Then, data sets will become even more heterogeneous, across "discreet" data sets, with their non-common features growing exponentially over time.

Trend of Increasing Coordination
Sub trend 1 – Coordination of Shape

Identical shape - Most systems are "fed" data that is already compatible with the system's abilities to "read" the data, and those data formats can be used by many other systems.
Self-compatible - Data will become self-compatible in that it will be capable of re-arrangement within itself in a manner that will produce different looks to systems utilizing the data.
Compatible - Data will evolve to the point that it will become, or just is, compatible with any system requiring its usage; first by external compatibility engines and then driven from within itself.
Special - There are some systems that require specially formatted and arranged data fields that will be unique to those systems. This "Special" data state may become obsolete as the "Compatible" state continues to develop.

Trend of Increasing Coordination
Sub trend 4 – Coordination of Action

This trend supports the common thread of data itself become more dynamic and "powerful," which could address limited storage and handling capabilities as well as computational power limitations. One manifestation could be that, like matrix manipulations of numbers, data matrices could be regularly manipulated to represent complex and wide-ranging data sets by way of much more condensed structures. This likely occurs at some level now even if only in limited applications.

Trend of Decreasing Human Involvement and Increasing System Completeness

Transmission, energy source, control - The system handles data transmission, the energy required to transmit the data, and the control of the usage of the data.
Transmission, energy source, control, decision making - The system will handle data transmission, the energy required to transmit the data, the control of the usage of the data and the decision making of how the data is used. There will first be limited usage of this "full system completeness" followed by accelerated usage across different system functional requirements. System will do all data selection, cleaning, and tagging, as opposed to humans executing these functions in the current state. Though it is likely that all three of these attributes (i.e., selection, cleaning and tagging) will not evolve at the same rate or time.

Trend of Increasing System Completeness

Data - Currently, the system handles data transmission, the energy required to transmit the data, and the control of the usage of the data. Then the system will handle data transmission, the energy required to transmit the data, and the control and decision making around the usage of the data.
Data – Selecting, Cleaning and Tagging
If computer support (e.g., data processing) is considered then humans do all except decision making, though control is shared between the hand and the keyboard. If computer support (e.g., data processing) is not considered, then humans do all. The system will become fully complete (i.e., transmission, energy source, control, and decision making) as far as data curation (i.e., selecting, cleaning and tagging) is concerned. Though likely not in unison across all three constructs.

Trend of Flow Enhancement

Data structure and dynamization described previously will accelerate the increasing of conductivity of data. The advancement in the coordination of coding with the hardware it is run on and the job it is designed to do, as well as the development of specific AI/ML hardware, will drive the Improvement of flow utilization of data. The development of specialized sub-systems (i.e., internal controls) and/or supersystems (i.e., external control) will reduce the availability of "bad" data to the systems. When "bad" data does slip through the barriers, future systems, both hardware and software, will minimize the negative impacts of the "bad" data on the system output/effectiveness.

Trend of Increasing Value

Data will become more valuable by way of pre-curation (i.e., selection, cleaning and tagging) by way of specialized systems which will be human driven at first then system driven later. When human driven, these specialized data curation systems will be supersystem components and when system driven, can be either sub-systems or supersystems to the system utilizing their output where supersystems are likely to come first. As the current data format/structuring maxes out in value a new principle of action for data will appear on the market driving the current format/structure into stage 4 of the S-curve. As the new data principle of action emerges, the existing format/structure will slip into stage four and be utilized with legacy system for sentimental (e.g., see ATARI) or economic reasons, such as it being too expensive to replace legacy AI/ML system and its infrastructure in some use cases.

Trend of S-curve Evolution

The new data principle of action itself, as eluded to previously, will of course be the primary driver for the next S-curve effectiveness increase. As the current state of data moves through stage 2 (note - where all (90% plus) the money is made over the life of a system) the primary driver in relation to AI/ML systems will be the value increase of that data due to curation (i.e., selection, cleaning and tagging).

Input/Sensing – Sensing Field Types (EM-electro-magnetic)

Trend of Increasing Dynamization

Sub trend 1A – Design Dynamization - Substance

Sensing Fields (outbound)	Future Trend Progression
EM spectrum - radio	none - already at "Field"
EM spectrum - microwave	none - already at "Field"
EM spectrum - infrared	none - already at "Field"
EM spectrum - visible	none - already at "Field"
EM spectrum - ultraviolet	none - already at "Field"
EM spectrum - x-ray	none - already at "Field"
EM spectrum - gamma ray	none - already at "Field"
mechanical - physical	While all states are possible now most systems are likely low on trend progression (multi-joint and below). Expect to see all systems progress towards gaseous.
mechanical - acoustic	Will remain at gaseous
thermal	All states possible now though possibly not used, therefore rapid progression expected.
chemical	No progression expected from powder, liquid, and gas
olfactory	No progression from field (activation) or powder, liquid, and gas (delivery)
biological	All states in use now, therefore no progression expected
nuclear	While technically a monolithic wave-function can already be defined at field (no progression expected)

Trend of Increasing Dynamization
Sub trend 1B – Design Dynamization – Field

Constant field - All electro-magnetic, mech.-physical, mechanical-acoustic, thermal, olfactory, biological, nuclear. **Gradient field** - All electro-magnetic, mechanical-acoustic, thermal, olfactory, nuclear. Variable field - All electro-magnetic, mechanical-acoustic, thermal.
Pulsed field - All electro-magnetic, mechanical-acoustic, thermal.
Resonance field - All electro-magnetic, mechanical-acoustic, nuclear.
Interference field - Mech.-physical, mechanical-acoustic, nuclear.
All electro-magnetic and nuclear can and will occupy all design states as necessary for application. Mechanical-physical, mechanical-acoustic, thermal, chemical, olfactory, and biological, will rise through pulsed.

Trend of Increasing Controllability
Sub trend 1 – Increase Level of Control

Uncontrolled System - All fields (i.e., all electro-magnetic, mech.-physical, mechanical-acoustic, thermal, olfactory, biological, nuclear) in native states.
Fixed program - All electro-magnetic, acoustic, and thermal (e.g., pre-set scanning across electro-magnetic spectrum, pre-set scanning across acoustic frequencies, pre-set scanning across thermal temperatures).
Fixed program w/ intervention - All electro-magnetic, acoustic, and thermal (e.g., pre-set scanning w/ internal intervention across electro-magnetic spectrum, pre-set scanning w/ internal intervention across acoustic frequencies, pre-set scanning w/ internal intervention across thermal temperatures).
Externally controlled - All electro-magnetic, acoustic, and thermal (e.g., pre-set scanning w/ external intervention across electro-magnetic spectrum, pre-set scanning w/ external intervention across acoustic frequencies, pre-set scanning w/ external intervention across thermal temperatures).
Self-controlled - All systems sensing fields will progress to self-controlled as AI systems become capable of doing so.

Trend of Uneven Development of System Components

S-curve early stage 2 - mechanical-physical, chemical, olfactory, biological. S-curve late stage 2 – All electro-magnetic, mechanical - acoustic, thermal, and nuclear.

Trend of Increasing Coordination
Sub trend 4 – Coordination of Action

Sensing fields can be assumed to be in deficit and the desired effect is to be strong. Therefore, the evolution direction will go from 3D to 0D. As sensing fields move towards 0D, they will also likely become matrixed to artificially and functionally represent a 2D or 3D application.

Trend of Decreasing Human Involvement and Increasing System Completeness

Transmission - Sensors will begin transmitting their own fields across all field types: electro-magnetic, thermal, acoustic and nuclear first followed by mechanical-physical, chemical, olfactory, biological, and portions of nuclear.
Transmission, energy source -This will include the energy required for the transmission coming from within the sensor. Same progression as with transmission.
Transmission, energy source, control - As the transmission and energy enter the sensors it will quickly follow that control systems will be developed for those systems.
Transmission, energy source, control, decision making - As the computational portion of the AI/ML systems advance, at least those associated with sending and receiving and analyzing the sensor fields, then decision making will enter the sensing sub-systems of the overall AI/ML system.

Trend of Increasing System Completeness

Operating Agent - Currently for electro-magnetic, acoustic, thermal, and portions of nuclear emanating targets. Sensors that activate the target by way of electro-magnetic, acoustic, thermal, and portions of nuclear fields have already been developed and will continue to be developed further.
Operating Agent+Transmission - The transmission of these fields will naturally accompany the operating agent.
Operating Agent+Transmission+Energy Source - Already provided by the target in the case of electro-magnetic, thermal and acoustic and portions of nuclear for self-emanating targets and fields and by the sensor where activation of the target is required. Mechanical, chemical, and biological, to follow.
Operating Agent+Transmission+Energy Source+Control System - Control systems will be quickly developed for all sensor emitting sensor fields.
Operating Agent+Transmission+Energy Source+Control System+Decision Making - As the computational portion of the AI/ML systems advance, at least those associated with sending and receiving and analyzing the sensor fields, then decision making will enter the sensing sub-systems of the overall AI/ML system.

Trend of Flow Enhancement

Increase output of sensors for nonenergetic targets across all sensing fields will occur. First for electro-magnetic, followed by acoustic and then thermal (note - maybe nuclear) and then followed, in no particular order, by mechanical, chemical and biological. Improved sensor sensitivity will occur across all fields with the following order: electro-magnetic, acoustic, thermal, and possibly nuclear and then in no particular order mechanical, chemical and biological. Sensors will be developed to “rule out” unwanted fields (e.g., frequencies) and field “data” (e.g., noise). Next signal correction for attenuating or distorting environments (e.g., astronomical observations from earth’s surface), for all fields, will be developed.

Trend of Increasing Value

Sensing systems for mechanical-physical, chemical olfactory, and biological will increase their functionality significantly and will therefore be more valued, or finally valued at all, by the market. Sensing systems for electro-magnetic, thermal, acoustic, and nuclear will raise their functionality in order to keep their price steady.

Trend of S-curve Evolution

S-curve stage1/early stage 2 - Mechanical-physical, Chemical, Olfactory, Biological
S-curve high stage 2 - Electro-magnetic, Thermal, Acoustic, portions of Nuclear

Input/Sensing – Target Selection

Trend of Increasing Dynamization
Sub trend 1B – Design Dynamization - Field

Constant field - System begins choosing targets with little to no discrimination between choices.
Gradient field - System applies a gradient to the selection process to choose targets (e.g., deemphasizes certain populations based on understanding about how those populations are already overrepresented).
Variable field - System becomes more sophisticated in target selection by varying a wide variety of selection criteria in a dynamic manner.
Pulsed field - System changes target selection on a periodic bases calculated to maximize quality of output.
Resonance field - System coordinates usage of selected targets to some natural frequency of the business, technical, or operational environment.

Trend of Increasing Dynamization
Sub trend 4 – Functional Dynamization

Data targets will grow in numbers as systems become more broad-based as far as combining various goals/variables into a single analysis or working multi-analyses in parallel for common or non-common ultimate outputs.

Trend of Increasing Controllability
Sub trend 1 – Increase Level of Control

System does little to no target ID or direction of target data acquisition. Systems will begin identifying their own targets and overseeing the target data acquisition but with human intervention and oversight. Supersystems will take over the identification of targets and or the oversight of target data acquisition. Theses supersystem components will either be 3rd party service providers, related yet separate operational systems or both. The system will begin performing all target identification and target data acquisition oversight internally with no external support, oversight, or intervention.

Trend of Increasing Coordination
Sub trend 4 – Coordination of Action

Targets chosen one at a time though some targets might be in groups which could be considered 1 or 2 D. Further, there is a deficit of resources available for target identification and acquisition and we want minimal effort, or rather a weak interaction, in interfacing with them therefore the trend is 0, 1, 2, 3D. Targets will be chosen, and their data acquisition managed, in a 3D manner (note - at least in abstraction) whether by humans or other systems or the system itself. 3D could represent a 3D matrix with of course three different parameters associated with the axes, thus giving substantial flexibility/dynamicity in so far as focus, functionality, and application.

Trend of Transition to the Supersystem
Sub trend 1 – Integrated Parameters Become Increasingly Differentiated from the Base System

Target types are probably mostly homogenous overall. Some target types will differ from each other in some number of parameters. Target types will become more and more diverse (for both single applications and for target groups meant to support multiple related or unrelated applications.)

Trend of Transition to the Supersystem
Sub trend 3 – Level of Integration Between Engineering System and Integrating System Becomes Deepest

Most target selection and direction are most likely chosen manually target by target. However, some target selection may be linked in some manner with other target selections, reducing the "custom" target by target requirements. Little to no automation in target selection or direction. Target selection will become more and more automated according to pre-set rules and objectives. Ultimately, target selection will be fully automated within the system itself setting both targeting objectives, based on human set goals and then later based on system set goals, and target selection rules.

Trend of Transition to the Supersystem
Sub trend 4 – Increased Integration of Number of Systems

Target linkages are likely low requiring more "work" by humans in selecting and acquiring target related data. Future systems will combine multiple "independent" systems to work in collaboration, and sometimes competitively, to select targets, then objectives and targets, and then goals, objectives and targets. Variable setting will also transition from human to system in some manner in relation to this transition.

Trend of Decreasing Human Involvement and Increasing System Completeness

Transmission, energy source, control, human decision making - Humans do most all target selection and direction.

Transmission, energy source, control, system decision making - Human involvement in target selection will gradually disappear replaced by complete system-controlled target selection and direction.

Trend of Increasing System Completeness

System does little to no target selection and self-direction. System will, step by step, take over all functional requirements of target selection and direction.

Trend of Increasing Degree of Trimming
Sub trend 2 – Trimming Operations

Humans perform all levels of operation with little to no process optimization such as eliminating of requirements or elimination of need for corrective actions. Systems takes over target curation (i.e., target selection and associated data curation (i.e., cleaning and tagging)). System evolves to where there are no requirements for data curation (i.e., cleaning and tagging) and then to where there are no requirements for target selection. This later step is hard to visualize but will none the less occur probably by way of a completely different principle of action as to how the learning even occurs and what "information" it is based on.

Trend of Increasing Degree of Trimming
Sub trend 3 – Trimming Components with the Lowest Value

Process of target selection and direction needs serious cost reduction by passing lower value, but time-consuming, functions off to system. I) elimination of human driven data collection followed by elimination of system driven data collection II) elimination of human driven data curation followed by elimination of system driven data curation (i.e., cleaning and tagging) III) elimination of data storage requirements.

Trend of Flow Enhancement

Substantial work is required to simply increase flow conductivity of target ID and acquisition let alone flow utilization. Targets will become easier to find and data easier to gather as system internalizes this function. Data will be easier to use as system internalizes data handling functions. Data will contribute to the improvement of better results as system internalizes data curation functions. "Bad" data that "slips through" will have less of an impact on the results as the system internalize self-correcting functionality.

Trend of Increasing Value

Systems to identify and acquire target data are likely rudimentary and need substantial improvement and cost reduction in order to enter the market. Supersystems, human driven first then system driven, to set goals, objectives, and variable and to find targets, gather data and curate data will improve rapidly allowing substantial profits from those products and services. These improvements may or may not happen in unison nor in the ordered implied above.

Trend of S-curve Evolution

Systems to identify and acquire target data are likely rudimentary and not very close to entering the market. However, there is much value in improving theses target identification and data gathering systems and therefore in the near-midterm human driven systems will indeed be improved and in the midterm, machine drive system will be developed and implemented. All focused on improving the effectiveness of the current processes.

Computation

Trend of Increasing Dynamization

Sub trend 1A – Design Dynamization – Substance

Monolithic single processor or single multi-processor systems will be replaced by “multi-joint” coordinated, whether collaborative or competitive or both, multi-systems. This suggests that the new “systems” may be multi-system stand-alone systems (i.e., dedicated systems designed to work with each other) or multi-system independent systems, which can be considered as non-dedicated separate (e.g., in space and/or functionality) systems coordinated to work together, but not initially designed to do so.

Trend of Increasing Dynamization

Sub trend 1B – Design Dynamization - Field

Variable field - Signals used to activate the system, whether coming from inside or outside the system, can be considered as variable in many cases.
Pulsed field - Some signals used to activate the system, whether coming from inside or outside the system, such as timing signals, can be considered as pulsed in many cases.
Resonance field - Other signals that are well tuned with the recipient sub-system “frequency” could be abstracted as being resonance.
Constant through resonant - The coordination of systems, both within those systems and between separate systems, will explore all of the field dynamization steps (i.e., constant, gradient, variable, pulsed, resonance, interference) in system to system, or inner system, triggering (i.e., signaling).
Interference field - Consider interference fields as error correcting signals coming from separate systems/sub-systems, either within or without the system that needs correction. These signals will be sent from a separate monitoring and correcting sub- or supersystem.

Trend of Increasing Dynamization

Sub trend 2 – Composite (structure) Dynamization

Stand alone or single systems can be considered monolithic at the system level even if that system has parallel processors at the sub-system level. Multi-systems, whether separate or within the same system, that act in direct orchestration and in functionally equivalent ways can be considered as a system of staked plates (e.g., think of an automobile struts that are staked plates that function in unison to accomplish the same goal). Multi-systems, whether separate or within the same system, that act in partial orchestration, and in either functionally equivalent or closely functionally equivalent ways, can be considered as a bristle system. Multi-systems, whether separate or within the same system, that act in partial orchestration or complete non-orchestration, and in either functionally equivalent or functionally non-equivalent ways, can be considered as a system of movable pins or balls. Universally, the systems will become more real-time flexible in their abilities to function the same as, or differently, within itself or between it and other systems. Multi-systems, whether separate or within the same system, will act in partial orchestration and in either functionally equivalent or closely functionally equivalent ways.

Then multi-systems, whether separate or within the same system, will act in partial orchestration, or complete non-orchestration, and in either functionally equivalent or functionally non-equivalent ways. Finally, multi-systems, whether separate or within the same system, will be developed with capabilities to dynamically morph themselves real-time in both coordination and functionality. Much like a sponge can be utilized in many scenarios, in different ways, torn apart, etc.

Trend of Increasing Dynamization
Sub trend 4 – Functional Dynamization

Systems, whether contiguous or separate sub-systems, will develop more and more multi-functionality features and will be capable of more and more coordination within, or between, these different delineations of functionality, whether virtually, physically or both.

Trend of Increasing Controllability
Sub trend 1 – Increase Level of Control

Currently, most AI systems require external human input. Current “stand-alone” AI/ML systems will first become virtual or physically distributed coordinated systems, having substantial external control by other systems or humans. Next the virtual or physically distributed coordinated AI/ML systems will become self-controlled.

Trend of Increasing Controllability
Sub trend 2 – Increase Number of Controllable States

All computation systems are multi-state discreet, even if the number of possible states is so numerous that it appears as infinitely variable. Systems will be multi-resourced in both the types of various computing platforms that are coordinated and the types of various functional components that are integrated (e.g., full systems: goal/objective setting, data target selection, sensing, data collection, computation, and output control). In the long-term imagine a handheld “advisor” that observes your environment, gathers information, both locally and globally/remotely, and gives you advice or direction as it learns. Though we are specifically looking at computation in this section this full system functionality will greatly enhance the computation ability of any system, and vice-versa.

Trend of Uneven Development of System Components

“New” AI/ML functionality, such the ability to curate its own data, will begin development shortly, if not already in development, in order that the functionality can enter the market. Existing functionality, such as performing as a neural network, will develop improved internal functionality for the purpose of increasing the effectiveness of these already existing systems. Existing model and older technology AI/ML systems, both in hardware and coding, that have reached the base functionality maximum effectiveness will be developed in areas un-related to their main function, such as the ability to be integrated into an automobile or refrigerator, or will slip out of S-curve stage 3 and into museum status.

Trend of Increasing Coordination
Sub trend 2 – Coordination of Rhythms

AI/ML systems will become more and more coordinated within themselves and between each other and with other non-AI/ML systems. AI/ML systems will become better at knowing when, and utilizing down-time, to do “other” activities including planning, future states scenario testing, maintenance, data corrections, etc. AI/ML systems will become better and better at working and coordinating with other systems (e.g., learning from other AI/ML systems with different focus areas, sharing new data with systems that are working on different projects that could benefit from the new data, giving learnings to non-AI/ML systems as real-time updates, etc.).

Trend of Increasing Coordination
Sub trend 4 – Coordination of Action

Stand-alone AI/ML systems (e.g., data storage and manipulation, logic engine, output to local report or video monitor, etc.) can be considered as 0D (i.e., point action) systems. AI/ML systems that coordinate with another AI/ML, or other functionality, system (e.g., AI/ML – data base system, AI/ML – statistical analysis/graphics platform, etc.) can be considered as a 1D (i.e., line action) system. AI/ML Multi-systems working in unison, usually collaboratively (note - see examples in 1D & neural networks, live sensing + data management, analysis) can be considered as 2D (i.e., area action) systems. The computational portion of AI/ML systems will become more highly integrated with, and connected to, other computational AI/ML systems as well as other non-computational systems (e.g., data stores, sensing systems, output controllers, etc.) and can be considered as 3D (i.e., volume action) systems. In this scenario the computing resources can be considered as in excess and the effect can be desired to be strong thus driving the evolution from 0D to 3D.

Trend of Transition to the Supersystem
Sub trend 1 – Integrated Parameters Become Increasingly Differentiated from the Base System

Parallel processing expansion, whether actual parallel processing or just growth in number of cores within the processors or both, will continue. Even after the switch to a new principle of action (e.g., quantum state computing). Coordination between partially different types of systems (e.g., data search and retrieval, data storage, computation, output management, etc.) will expand. Systems designed for competition, or collaboration will be developed. These systems will not only compete but will be designed in different ways; possibly to include all aspects of both the hardware and software designs.

Trend of Transition to the Supersystem
Sub trend 2 – Increasing Differentiation Between Main Functions

The base system is a stand-alone AI/ML system and currently many exist. AI/ML systems designed to compete with each other will appear, if they have not done so already, for the purpose of improving output and accuracy. Allied AI/ML systems designed to collaborate with each other either as completely separate but functionally equal systems that share progress and updates with each other to help the “team” (e.g., think best ball play in golf) or that are separate and not equal in that they are executing their “parallel functions” in different manners and then sharing the results to improve the output of the team (e.g., think multi-disciplined and skilled work groups) will appear. When will Artificial Stupidity system show up, or have they already? Are disinformation bots fulfilling that role now? Are there any utilizations of Artificial Stupidity/Disinformation systems that will be useful for society we need to anticipate?

Trend of Transition to the Supersystem
Sub trend 3 – Level of Integration Between Engineering System and Integrating System Becomes Deepest

Independent yet collaborative or competitive AI/ML systems will appear if not there already. Series collaborative AI/ML systems will appear if not there already. Highly integrated yet functionally different AI/ML systems will appear (e.g., data targeting, data gathering, data management, computation, iteration feedback and control, output management, output direction and sharing, etc.). Expect fully integrated systems, whether separate or truly integrated systems, that perform all aspects of AI/ML functional requirements. This will occur first with human decision making followed by various aspects of decision-making being transfer to the machine and then all aspects pf decision making being transferred to the machine (i.e., Sky Net).

Trend of Transition to the Supersystem
Sub trend 4 – Increased Integration of Number of Systems

Stand-alone AI/ML are mon-systems. Multi-system AI/ML with both homogeneous and heterogeneous functionality will appear. Massively parallel AI/ML or competitive AI/ML will appear and can be either localized or distributed systems.

Trend of Decreasing Human Involvement and Increasing System Completeness

Transmission, energy source, control - All AI/ML systems with regards to objectives.
Transmission, energy source, control, decision making - AI/ML systems with various levels of internal decision making will appear first and then followed by systems with almost complete decision-making authority, maybe with just a final decision override capability by human for fatally critical decisions. The message here is that AI/ML will become more and more independent.

Trend of Increasing System Completeness

Few if any AI/ML systems have any real decision-making authority as far as the AI/ML output is concerned (i.e., human led). Decision making will slowly enter the system where the speed of that uptake will be more determined by policy than by technology.

Trend of Flow Enhancement

AI/ML can process large volumes of data and make large number of computations but with limited "accuracy" and, without any ability to judge their own output relevance, are somewhat stuck here. As systems begin to judge their own performance, they will be capable of making performance corrections and thus improve the utilization of the data flows. Supersystem components will be developed that are better equipped to identify and take "harmful" data out of the data flows. This might also be built into the system opposed to outside of the system. AI/ML systems will begin to be able to understand "bad" information and not allow it to impact the accuracy of their output or at least correct for the reduced level of accuracy.

Trend of Increasing Value

AI/ML functionality must be raised substantially in order to raise their value in the consumers' eyes due to their fairly good black and white decision-making capabilities and almost no grey area decision-making capabilities. Due to the probable inability of 0/1 processors to ever be truly capable of grey area decision making, true improvements with the current silicon-based microprocessor AI/ML systems are mainly in the area of data curation. As the collection and curation of data improves (e.g., see third party specialist service providers) this will go a long way in improving the effectiveness of AI/ML output. Algorithms and methods improvement will help but not as much as dealing with the data end of things.

Trend of S-curve Evolution

Stage 1 - AI/ML grey area decision making. Expect AI/ML grey area decision making to begin a transition out of stage one once vastly improved AI/ML data systems are developed. Stage 2 - AI/ML black and white decision making. Expect AI/ML black and white decision-making capabilities to grow rapidly as other improvements occur (e.g., see computational design and configuration and data curation development).

Output - System to Machine & Ultimate Machine Output

Trend of Increasing Dynamization

Sub trend 1A – Design Dynamization - Substance

When considering the downstream machine output, that output could take many forms with a general abstraction being mechanical, acoustic, thermal, chemical, elector-magnetic, biological, or nuclear. Regardless of output level of the machine (i.e., informs, advises, requests, directs, or controls) the upstream output of the AI/ML system will be a field as that output will be by way of a digital signal. However, when considering the many types of possible downstream machine outputs, those outputs may or may not be a field, based on the specific output situation. See Outbound Fields below.

Outbound Fields (machine to supersystem)	Future Trend Progression
EM spectrum - radio	none - already at "Field"
EM spectrum - microwave	none - already at "Field"
EM spectrum - infrared	none - already at "Field"
EM spectrum - visible	none - already at "Field"
EM spectrum - ultraviolet	none - already at "Field"
EM spectrum - x-ray	none - already at "Field"
EM spectrum - gamma ray	none - already at "Field"
mechanical - physical	While all states are possible now most systems are likely low on trend progression (multi-joint and below). Expect to see all systems progress towards gaseous.
mechanical - acoustic	Will remain at gaseous
thermal	All states possible now though possibly not used, therefore rapid progression expected.
chemical	No progression expected from powder, liquid, and gas
olfactory	No progression from field (activation) or powder, liquid, and gas (delivery)
biological	All states in use now, therefore no progression expected
nuclear	While technically a monolithic wave-function can already be defined at field (no progression expected)

Trend of Increasing Dynamization
Sub trend 1B – Design Dynamization - Field
Variable field - Signals used to activate downstream non-AI/ML system (i.e., system to machine) can be considered as variable in many cases. Especially in cases where ultimate machine output is intended to appear, or act as, analogue systems. Pulsed field - As systems evolve expect signals to become better coordinated with their operational environment. One way to support this evolution is through digital signal pulsing. Resonance field - As systems evolve expect signals to become better coordinated with their operational environment. One way to support this evolution is through digital signal resonance. Interference field - As systems evolve expect signals to become better coordinated with their operational environment. One way to support this evolution is through digital signal interference.
The following examples are for where the ultimate machine output is within the electro-magnetic spectrum:
Constant field - Safety light
Gradient field - Range sensitive motion detector
Variable field – Electro-magnetic transmitted music
Pulsed field - Warning light or timing signal
Resonance field - Fusion activation laser
Interference field - Electro-magnetic disruption.

Trend of Increasing Dynamization
Sub trend 4 – Functional Dynamization
Most AI/ML outputs (i.e., system to machine) likely effect one type of machine assuming that output is a single or multiple homogenous signal. Expect AI/ML systems to affect a wide variety of other AI/ML systems where the "same" input for each actually results in different functional effects onto those systems. Also expect the AI/ML systems to begin creating heterogeneous signal sets used to activate a variety of other AI/ML systems as well as a variety of machines. Most ultimate machine output is likely aimed at a single target type (e.g., people, birds, rocks, etc.) and also probably has a single function. Expect AI/ML driven ultimate machine output to affect multiple supersystem components simultaneously (e.g., system to determine if a person gets a loan could 1.) inform the person (note - ultimate output target is a person), 2.) complete their loan paperwork (note - ultimate output target is a loan processing system), 3.) inform the borrowers accountant (note - ultimate output target is an accountant/accounting system).

Trend of Increasing Controllability
Sub trend 1 – Increase Level of Control
Once the AI/ML system is through with its AI/ML computation its output could be a fixed program (e.g., feed information to central "control systems" every hour on the hour). This is likely most system's current design. Once the AI/ML system is through with its AI/ML computation its output could be a fixed program but where other inputs occasionally alter the fixed program (e.g., feed information to central "control systems" every hour on the hour unless instructed otherwise due to internal system decisions). This likely exists within some systems now. Expect other coordinated systems to externally control what the AI/ML system does with its output and when. Ultimately, expect AI/ML system to dynamically and real-time make their own decisions as to what they do with their output and when.

Trend of Increasing Controllability
Sub trend 2 – Increase Number of Controllable States

Single state - Set/single signal type with repetitive usage (e.g., traffic light control signal). Multi-state discrete - Variable/heterogeneous signals with either repetitive usage or non-repetitive usage (e.g., temperature range forecasts). Multi-state infinite - Greatly variable (e.g., approaching infinity) in so far as amplitude or parameter measure. (e.g., solar flare driven geomagnetic storm intensity/magnitude analysis). Multi-state multi-resource - Expect AI/ML systems to provide a variety of different, yet coordinated, signaling to a variety of machines (e.g., signal emergency system because of aircraft crash (note – activation of system), signal FAA (note – activation of reporting), signal local control tower (note – activation of control), send information to airline to support customer communications (note – activation of information), etc. Dynamically stable - Expect AI/ML system signaling to support operation of dynamically stable systems (e.g., fighter aircraft). Unstable - Expect AI/ML systems signaling to support operation of unstable systems (e.g., blasting at miming operations). Multi-state discrete - Railroad crossing signal (i.e., up/ down) likely exists now. Multi-state infinite - Laser output power (note - but since likely controlled with a digital signal would only appear infinite or analogue) likely exists now. Multi-state multi-resource - Expect the ultimate output machines of AI/ML systems to affect multiple heterogenous supersystem components (e.g., human, auto controls, etc.). Dynamically stable - Expect the ultimate output machines of AI/ML systems to affect dynamically stable systems such as a Segway or modern fighter jet (i.e., F35 Raptor). Unstable - Expect the ultimate output machines of AI/ML systems to affect unstable system such as blasting system used in mining.

Trend of Uneven Development of System Components

Expect the "quality" of AI/ML system signaling to improve in the near term mainly based first on better input data curation and second on better algorithms/system to system coordination. Expect ultimate machine output of AI/ML systems, where that output is a chemical or biological field, to move into its S-curve transition stage and then into its S-curve early stage two in the medium-term. Expect ultimate machine output of AI/ML systems where that output is mechanical, acoustic, thermal, electro-magnetic, or nuclear field to continue improving at a somewhat constant rate, at least in comparison to their recent development rates.

Trend of Increasing Coordination
Sub trend 2 – Coordination of Rhythms

Machines are almost "always listening" and therefore system connects to, triggers, or activates machines that are on the same "handshaking" period. Expect signaling output of AI/ML systems to begin performing alternative functions during "down time" of their downstream machinery (e.g., after triggering the Emergency Broadcast System, begin signaling emergency responders). Expect signaling output of AI/ML systems to become better and better at working and coordinating with other systems (e.g., learning from other AI/ML systems with different focus areas, sharing new data with systems that are working on different projects that could benefit from the new data, giving learnings to non-AI/ML systems as real-time updates, etc.).

Trend of Increasing Coordination
Sub trend 4 – Coordination of Action

Most system "triggering" of down-stream machines will be by way of a line action connection (e.g., USB, co-axial, fiber optics, etc.). Expect AI/L signaling to increase in its "dimensionality" to trigger "areas" of both homogeneous and heterogeneous machines (e.g., a network of systems). Expect AI/L signaling to increase in its "dimensionality" to trigger "volumes" of both homogeneous and heterogeneous machines (e.g., an ecosystem of systems). Expect ultimate machine output of AI/ML driven systems to move towards 0D (i.e., single point affect) output where beneficial (e.g., cancer treatment of individual cancer cells). Expect ultimate machine output of AI/ML driven systems to move towards 3D (i.e., volume affect) output where beneficial (e.g., manufacturing of components).

Trend of Transition to the Supersystem
Sub trend 1 – Integrated Parameters Become Increasingly Differentiated from the Base System

If a system currently connects with (i.e., signals/controls) multiple homogeneous machines it is likely by way of homogeneous connections (e.g., network of coax cables). If a system currently connects with (i.e., signals/controls) multiple heterogeneous machines it is likely by way of heterogeneous connection methods (e.g., blue tooth, LAN, USB, etc.) Expect systems to begin connecting with their downstream ultimate output machines by way of multiple and competing systems (note - a competing system is a system with the same main function but that accomplishes that function in an alternative methodology, e.g., standard digital signaling vs acoustic or pressure wave signaling).

Trend of Transition to the Supersystem
Sub trend 2 – Increasing Differentiation Between Main Functions

Systems usually signal one type, or one set of machines (e.g., traffic lights or ambulance GPS, traffic lights, and broadcast emergency signal). Expect AI/ML systems to begin signaling other non-AI/ML decision systems (e.g., expert systems, decision tree systems, etc.). Expect AI/ML systems to begin signaling other AI/ML systems with other "jobs to be done." (e.g., AI/ML system that forecasts future economic activity signals an allied AI/ML system that starts controlling the manufacture of products for next year's sales). Expect AI/ML systems to begin signaling heterogeneous AI/ML systems (e.g., AI/ML system that forecasts future economic activity signals a heterogeneous system that compiles training material for schools – both based on same input data). Expect AI/ML systems to begin signaling inverse systems that are intended to counter the output of the initial system (e.g., CDC AI system that sends warning signals to community health providers also send a signal to an inverse system that is designed to send "no need to panic" messages to the public). Ultimate machine output of system is by way of competing systems (e.g., storm signal through community warning sirens and also through smart phone direct text signaling). Ultimate machine output of system is by way of allied systems (e.g., first, machine of a customer preference AI/ML system gathers ingredients for a meal and the allied machine cooks the meal). Ultimate machine output of system is by way of heterogeneous systems (e.g., first, machine writes an economic activity report and the allied machine starts manufacturing products where both are based on same AI/ML input data). Ultimate machine output is by way of inverse systems (e.g., first, machine of a National Forest fire prediction AI/ML systems starts prescribed burn fires and the inverse machine controls / extinguishes those set fires).

Trend of Transition to the Supersystem
Sub trend 3 – Level of Integration Between Engineering System and Integrating System Becomes Deepest

Currently, connectivity between system and machine is by way of an interfacing tool (e.g., wiring harness, digital to analogue converter hardware, etc.) or protocol (e.g., digital computer output to Programmable Logic Controller interface). Expect that the ultimate output machine will have AI/ML systems partially integrated into it and therefore most system to machine signaling will be integrated while other signaling is not (e.g., self-driving car but where some signaling occurs from external sources such as lane marking magnets built into roadbed). Further, expect that the ultimate output machine will have AI/ML systems fully integrated into it. (e.g., planetary exploration robot that visits an unknow world and must sense, learn and do all tasks based on internal resources alone). Expect machine output to trigger machine output to trigger machine output (e.g., series of manufacturing processes). Then expect machine output to go from being external (e.g., an intersection traffic light) to an internal (e.g., in-vehicle warning system so that driver can safely navigate the intersection). Then expect machine output to go from being an internal support system (e.g., in-vehicle warning system so that driver can safely navigate the interjection) to an internal control system (e.g., in-vehicle control system that automatically takes over all automobiles' navigation at intersections, thus eliminating needs for traffic lights).

Trend of Transition to the Supersystem
Sub trend 4 – Increased Integration of Number of Systems

Currently, it is likely that most AI/ML systems only affect one type of machine. AI/ML systems will signal a large number of homogeneous, and wide variety of heterogeneous, machines (e.g., all traffic lights in downtown region and/or traffic lights, road maintenance crews, public transportation busses, etc.). Most machines effect one, or one type, of supersystem component(s) and if not one type then all localized. AI/ML controlled machines will affect a large number of homogeneous, and wide variety of heterogeneous, supersystem components (e.g., a network of traffic lights (i.e., a distributed machine) signals all drivers in the downtown area and/or a network of associated AI/ML controlled machines will control traffic lights, delay/accelerate busses (i.e., schedules), mend pot hole, etc.).

Trend of Decreasing Human Involvement and Increasing System Completeness

Transmission, energy source, control - Triggering signals can be considered to contain transmission, energy and control only while decision making comes from upstream and likely human driven. Primarily, machine output can be considered to contain transmission, energy and control only while decision making comes from upstream and likely human driven.
Transmission, energy source, control, decision making - Trigger signals will be fully self-contained including the AI/ML system that is creating the signals having decisions making built into its automated systems (i.e., no human driven decision making). Machine output will also contain decision making (e.g., a machine that informs its intended target (i.e., human) but where the machine itself decides when and how to do that informing).

Trend of Increasing System Completeness

System signaling output can be considered to not contain decision making when that decision making is controlled by humans. System signaling output will be fully complete when the associated signaling decision making is internal to the associated AI/ML systems. In some cases, general machine output can be considered to not contain control systems or decision making (e.g., draw bridge motor servo). Most often, machine output can be considered to not contain overall decision making (e.g., robotic surgery system). Expect machines to also perform the decision making regarding their output (e.g., system of traffic lights is given overall guidance by AI/ML system but individually decide on their own when to change based on local activities).

Trend of Increasing Degree of Trimming

Sub trend 1 – Trimming Subsystems

Most machines will have only had their transmission and energy sources trimmed (e.g., traffic lights are not kerosene lamps but rather powered by external sources (i.e., electric power grid)). Expect most machines to have their control systems trimmed driven by other trends such as the trend of increasing controllability (e.g., traffic lights controlled by central AI/ML system). Expect many machines' functionality to be replaced by related but unassociated functionality (e.g., traffic lights replaced by all vehicles in directed communication and coordination with each other where the vehicles navigate intersections automatically without the need for traffic lights).

Trend of Flow Enhancement

Signaling mainly focused on conductivity increase (e.g., multiplexing, fiber optics, etc.). Expect machines to grow in their ability to better utilize the signals triggering/controlling them (e.g., signals containing more complex information and/or machines with improved internal signal processing). Expect AI/ML system to send less "bad signaling" based on advancements in their internal AI/ML functionality. Expect the associated downstream machines to be capable of filtering out "bad signaling" if received.

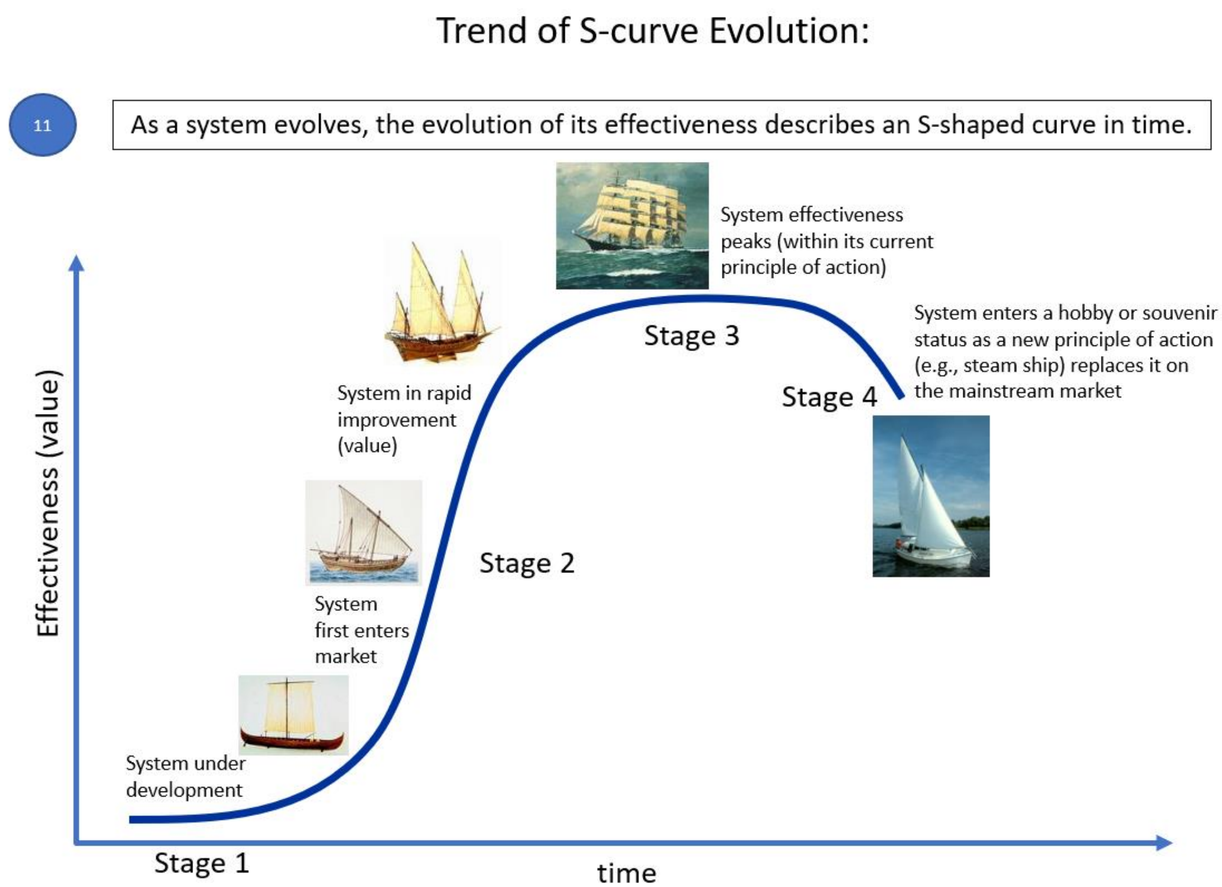
Trend of Increasing Value

Current machine signally likely towards top of S-curve stage two and therefore needs new functionality to stay relevant and to continue the current market pricing for the product/service and will therefore likely see a shift in principle of action. Expect to see future signaling have a principle of action change and therefore "start over" on a newly associated S-curve (e.g., gamma ray pulsing as a signal). The new principle of action will require significant development (i.e., functionality increase) and substantial cost reduction in order to leave stage one of its new S-curve. Expect all machines to continue their advancement along their respective S-curves with the associated function versus cost ratios affecting the changes of those machines (i.e., always increasing in value).

Trend of S-curve Evolution

Current machine signaling is likely towards top of stage two and therefore needs more functionality but that rise will be limited thus requiring an upcoming shift in principle of action. Expect to see future signaling have a principle of action change and therefore "start over" on the newly associated S-curve (e.g., gamma ray pulsing as a signal).

Appendix Four – Trend of S-Curve Evolution



Appendix Five – Glossary

0D – zero-dimensional system (i.e., a point (geometry))

1D – one- dimensional system (i.e., a line (geometry))

2D – two-dimensional system (i.e., an area (geometry))

3D – three-dimensional system (i.e., a volume (geometry))

AI – artificial intelligence

Application Expert Team - a team (note - minimum of three) of experts in the area of how AI and machine learning is utilized (note - not how the systems work but rather what the systems are being used for).

Black and white decision making – clear cut and easy to decide, such as with yes and no answers or zero/one logic processors. Easy for computers to navigate and utilize.

EM – Electro-magnetic

Data target – a thing that is chosen to collect data from for use in AI/ML system (e.g., human, star, virus, Chicago traffic, geological survey map (note - analog or digital), etc.)

Generalized AI/ML System – an overall description, or model, of an AI/ML system utilized to describe the initial states of such systems. An analogy might be the common description of an automobile to include a cabin to house passengers/driver, most usually four wheels to allow it to move, an engine, a way to connect the engine to the drive wheels where two to four of the wheels are utilized as drive wheels and two to four of the wheels are utilized to steer the automobile, etc.

Grey area decision making - not clear cut or easy to decide as there are no straight forward yes/no or zero/one logic pathways available. Very difficult (i.e., technically impossible) for computers to navigate and utilize without employing in-process and output assumptions.

Machine - In this analysis the “machine” is the end-of-line system that receives input from the “system” and does something by way of executing a *function*, for example - Subsequent AI/ML system (note – function of *computes* output), computer monitor (note – function of *informs* human), damn spillway valve (note – function of *stops* water), traffic light (note – function of *informs* human), or proton beam machine (note – function of *damages* cancer cells). The output of a machine is in the form of a function onto a supersystem component in the real-world (e.g., traffic light (machine) *informs (function)* human (supersystem component)).

ML – Machine learning

Signal – the output of a computational system that triggers a subsequent system or machine.

Signaling – the act of send a signal

SME – Subject matter expert / David W. Conley

Sub-system – The components that make up the system. For example, all the components that makeup an aircraft (e.g., fuselage, engines, avionics, etc.) are sub-systems of the aircraft, which is the system.

Supersystem – Everything outside of the system that interacts with the system but was not specifically designed as part of the system. The system is technically a sub-component of the supersystem. For example, an airport is the supersystem for an airliner (i.e., the system).

System - In this analysis the “system” is the AI/ML system, whether stand-alone independent system or a networked set of independent “parts” working together, and comprises: Sensors, Data (e.g., data sets), Computation engine(s), and Output (e.g., signal or signals). The output of the “system” will be by way of a signal (e.g., AI/ML system signals other “things” (e.g., other AI/ML systems or machines)). As used in this report the term “system” is flexible and can refer to any manifestation of any type of AI/ML “system” or other computing items (e.g., network storage, I/O controllers, etc.)

Target – used in two different manners in this report: 1.) as an all-purpose descriptor of a thing to pull data from (i.e., data target) and primarily utilized in sections labeled “Input/Sensing – Target Selection” and 2.) as an all-purpose descriptor of a thing that a machine will have its output applied to (e.g., human, air traffic control system, etc.) and primarily utilized in sections labeled “Output - System to Machine & Ultimate Machine Output”

Technology Forecast Report (note - this report) – report written by the SME summarizing the technology forecast (i.e., what will happen to the AI/ML technology, and downstream machines, in the future).

Trends of Engineering System Evolution (TESE) – an empirically validate study of the world-wide patent database that effectively captures fundamental changes that can be seen in all technical systems.

Technical Expert Team – a team (note - minimum of three) of experts in the area of how AI and machine learning actually operates (i.e., not what is done but rather how it is done).

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