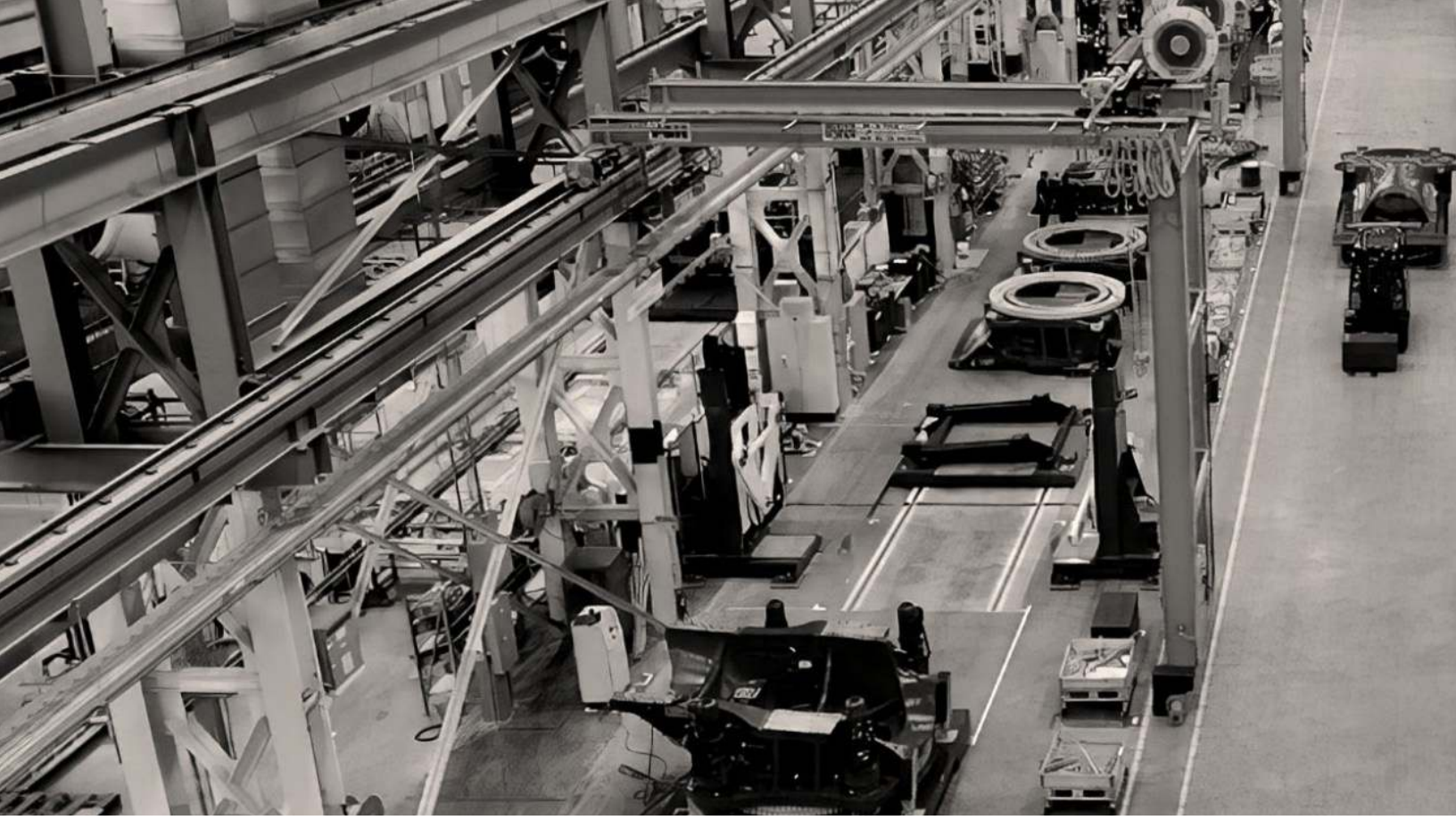
INDUSTRY 4.0 BUYERS GUIDE

JUNE 2020 | KCF TECHNOLOGIES, INC

TABLE OF CONTENTS

Industry 4.0 might seem simple when described in marketing hype—but the wide array of possible solutions and integrating them with the vast legacy infrastructure in manufacturing plants, is highly complex. The operational changes needed to practically achieve the value promised by Industry 4.0 increases that complexity. This guide seeks to help you sort through this jungle and arrive at the right solution for your organization. You will learn practical methods for not just picking the best products but also the right partners to optimally drive the improvement necessary to achieve your Industry 4.0 vision.



DEAD ON ARRIVAL

In this new age, technology progresses so fast that core technology is often obsolete by the time we have adopted a product (look no further than the roll-out of WiFi in plants just as a new superior technology using 5G or CBRS reaches maturity). Industry 4.0 is changing more than just how factories operate. It's changing how leading industrial companies look at technology and select the hardware, software, and IT technology that will give them a sustainable competitive edge. This guide takes you through the process of not just buying the latest factory tools but making the right long-term Industry 4.0 investments that will shape your company's future.

Typically, manufacturing investments have a life expectancy of 20-50 years. These investments are made with little need for a clear plan to optimally leverage the new equipment or maintain it over its lifespan. Historically, because technology evolved relatively slowly and the difference between products was relatively small, this approach worked. In the current context, this approach is no longer viable. Consider buying an Industry 4.0 sensor for your factory, for example. It may seem like a simple transaction, but in reality, the wireless backbone will need to be maintained, security patches deployed, and new capability added to support the latest edge computing. Wholesale replacement of electronics every few years may make sense to keep up with consumer technology trends, but not so in the industrial sector, where stripping out and replacing infrastructure is expensive and impractical. Rather, industrial buying criteria must consider how new technologies will grow and be supported over the next decade.

Because adopting its products requires workers and leaders to change how they do their jobs, Industry 4.0 buying is further complicated. Rather than performing unnecessary preventative maintenance, workers will now need to maintain based on equipment condition. They will need to proactively address chronic problems (such as cavitation) rather than watching failures develop. Reliability leaders will need to prioritize and organize maintenance based on data-driven expectations for machine failure as opposed to failures already in progress. Operators will need to adapt machine operating procedures on the fly to avoid damaging conditions like resonance. Plant leaders will need to make data-driven investments rather than relying only on experience.

All too often, buying decisions are made based on satisfying requirements at the lowest cost. This approach will mislead Industry 4.0 buying because achieving your vision requires much more than technology fit at the best price. Rather, it requires your organization to make a cultural shift. Enacting such change is not easy and usually doesn't come organically from within. Instead, it comes by way of partnerships that include pairing of a technical product with support from industry experts and enthusiastic individuals who thrive on improvement. Buying from a company that sees their Industry 4.0 product as a tool, not a solution, may leave you struggling to practically achieve the improvement essential to your success. In contrast, buying from an Industry 4.0 company that delivers a comprehensive whole product solution and Digital Transformation services will have upwards of an order of magnitude greater impact on your bottom line.

Rather than continuing to purchase technologies based on traditional buying methodologies and legacy vendor relationships, top manufacturing companies in oil and gas, wood products, automotive, metals, and pharmaceutical industries are finding fresh, growth-oriented products and transformative partnerships in the Industry 4.0 arena. This guide is an inside look into how they are doing it.

This guide presumes that you already have a vision for Industry 4.0 or Digital Transformation. It also presumes that you are ready to execute on your vision.

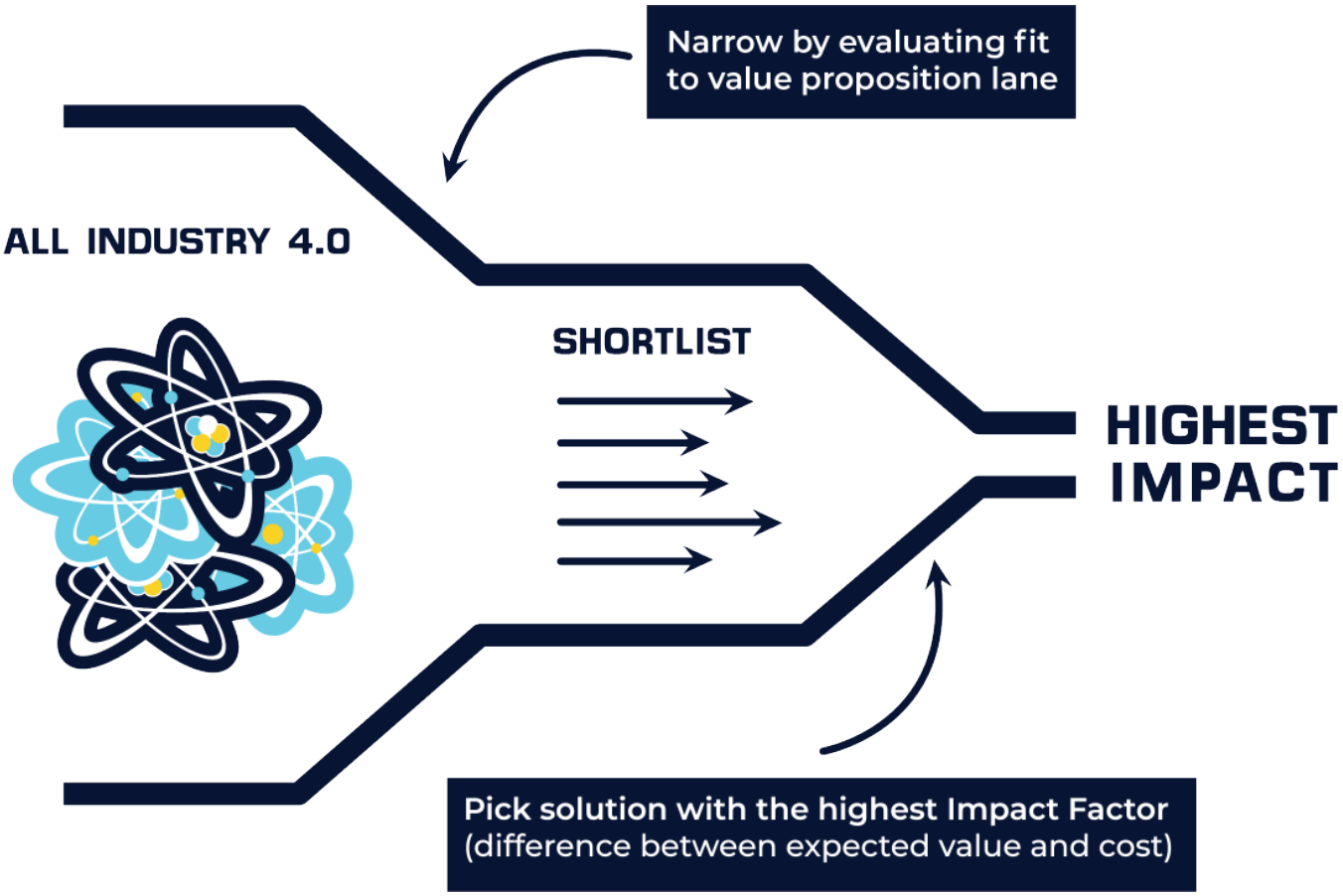
EXPECT TO LEARN

- Top Industry 4.0 value focus areas
- Strategies for fully addressing focus areas
- Key criteria for evaluating products in those areas
- Key criteria for evaluating partnerships
- Method for ranking solutions
- Practical example analyses
- Core elements of deals
- Common buying pitfalls

BUYING PROCESS

This guide helps you execute on your vision by taking you through the following six-step buying process:

Ultimately, this process offers a way to efficiently and diligently narrow the Industry 4.0 field of possible solutions to the ones that will deliver you the most value.

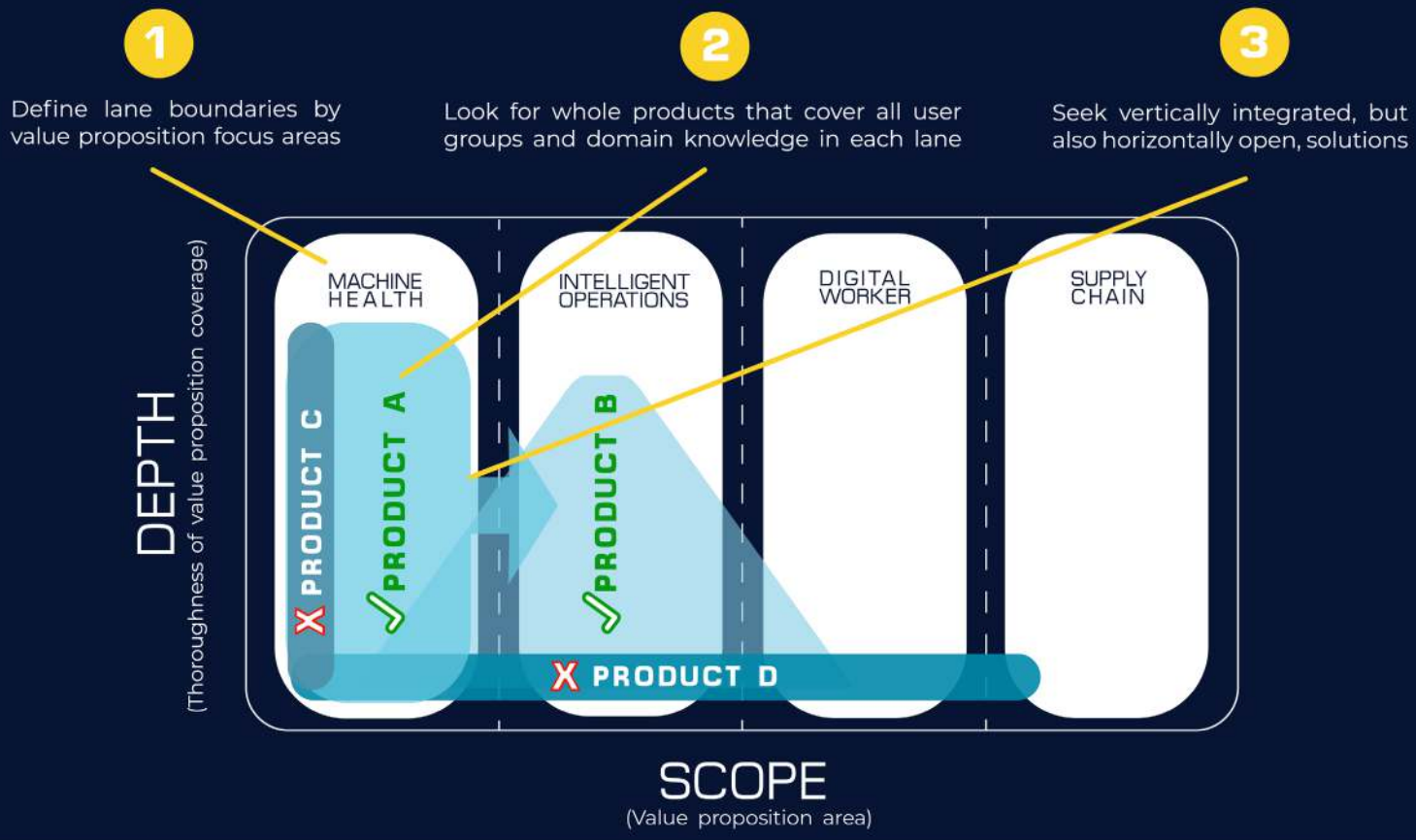


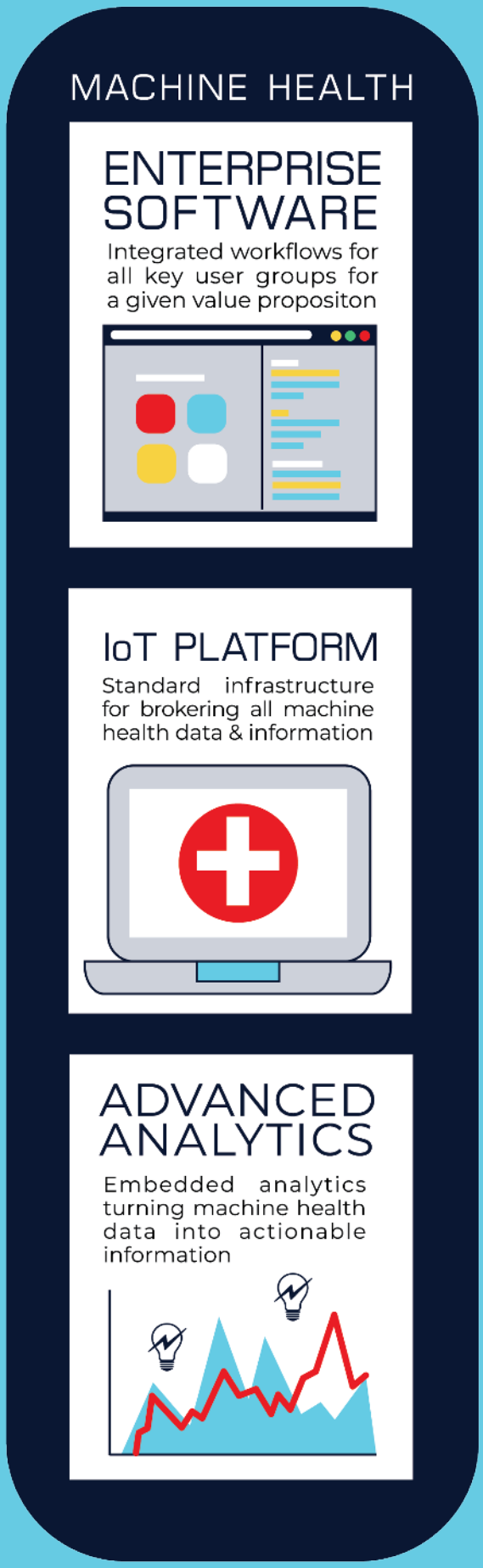
Buying Industry 4.0 products likely involves many facets of your business, from finance and corporate standards to business operations and IT. There may be many decision makers with different objectives involved in selecting products and partners. This guide doesn't target one specific audience, but instead seeks to align these audiences. It weighs both practical and technical requirements while keeping the focus oriented to actual business outcomes. This guide also recognizes that businesses leveraging it may be of vastly different size. Readers are encouraged to simplify or expand upon the framework offered, as required for their unique situations.

STEP 1: TARGET FOCUS AREAS

Tackling buying for an entire Industry 4.0 vision is daunting because, simply put, it's a big field. There are many different tools, technologies, and potential partners. To focus your Industry 4.0 pursuit, create several buying lanes defined by specific value propositions. Four Industry 4.0 value proposition lanes are: 1) machine health, 2) intelligent operations, 3) digital worker, and 4) connected supply chain. In a sense, Industry 4.0 intentionally blurs the lines between these areas, because its success is contingent on breaking down silos and achieving higher levels of interconnectivity of systems and processes.

However, implementing a single solution that fully addresses all four value proposition areas is not currently feasible (and by virtue of the market dynamics wouldn't be optimal anyway). Rather, the best strategy is to fill each focus area with whole products that mostly or entirely address the full value proposition within each lane. Look for solutions that are vertically integrated within the value proposition lanes and horizontally open, so that each solution can be bolstered by the next. For example, machine health information needs to be openly shared for designing real-time supply chain models, digital worker solutions will need to visualize machine health, and intelligent operations will need to make adjustments on the fly as machines degrade.





Using whole product solutions within each lane is an important strategy because it drives the cohesive and seamless workflows fundamental to ease of use, ultimately engaging your workers to embrace new Industry 4.0 products. In addition, whole products are designed with a target value proposition in mind and can be measured based on how well they deliver it. Keep in mind that the greatest barrier to achieving the full potential of Industry 4.0 is not the technology but rather use of the technology. Without your company's embrace of the technology and solutions that you choose, your Industry 4.0 plans will fall short. Whole product solutions recognize and address this reality.

The two key considerations that determine if a product is truly filling a lane and offering a whole product solution are domain knowledge and user groups. As an example, consider the machine health lane. Domain knowledge in this area includes vibration analysis, oil quality analysis, fluid dynamics and piping design, structural health monitoring, and electrical current signature analysis. User groups for this lane are reliability managers, maintenance leads, vibration analysis, schedulers, plant managers, equipment operators, and area leaders.

Whole product solutions in the machine health lane will offer comprehensive sensor systems, dashboards for plant managers, cohesive workflows for reliability managers, analysis tools for vibration analysts, and real time equipment displays for operators.

It's worth noting that there is a wealth of solutions similar to product C and product D in the Industry 4.0 market. For example, wireless predictive maintenance (PdM) tools are represented by product C in the machine health lane.

These are narrow and deep tools that seek to catch machine failures. They leave the vast majority of possible machine health improvements—including machine life extension, equipment performance optimization, machine-related quality improvement, root cause analysis, preventative maintenance task elimination, and capital decision-making support—unaddressed. Such narrow solutions also fall short in terms of application coverage including oil quality, steam traps, switchgear, intermittent operating equipment, and pump efficiency.

Alternatively, product D represents horizontal technology layers like sensors, wireless networks, device management tools, big data analysis, machine learning tools, cloud computing infrastructure, or mobile tools workflow software. While it is possible to piece several technologies together within in a lane to form a whole product solution, the reality is that standards are not yet well formed for putting them together (and even if they could readily be put together, integration of products is expensive, and at this early stage of Industry 4.0, requires custom development). Also, consider that those technologies do not deliver an ROI on their own. This means it's difficult to hold them accountable for their contribution to delivering value.

Products C and D are not whole product solutions and will therefore only address a small part of the value proposition within a lane. With this context, the right target set of solutions are products A and B, which previously might not have been considered. Product A covers the majority of the value proposition within the machine health lane, and while product B doesn't fit perfectly, it ultimately may be the best fit for the intelligent operations area. Overlap and use of a solution outside its core lane is acceptable. In this way, the boundaries are guidelines shaping the overall set of solutions rather than defining rigid boundaries that are not to be crossed. Also, lane boundaries do not define data silos. The solutions within each lane must be highly interconnected horizontally and, for example, share data at many levels in the technology stack, from factory floor to cloud.

A comprehensive machine health network gathers all relevant asset health data across the plant

Cloud-based analytics predict machine health and share actionable insights

User-friendly software connects with plant infrastructure, makes workflow suggestions to extend asset life, and automatically generates work orders

Whole product solutions for the machine health lane have three fully integrated core elements, creating a cohesive solution enterprise software, IoT platform, and advanced analytics. Although this guide's methodology applies to all four of the Industry 4.0 value proposition areas, it focuses on the machine health area, presenting this specific example in depth.

STEP 2: BUYING CRITERIA

Once your Industry 4.0 focus areas are identified, define both product and partner buying criteria for each lane. Product buying criteria should be broken into two categories: requirements and key metrics. Requirements characterize a baseline need in order to access the value proposition. Key metrics indicate the degree to which a solution will enable you to achieve your target value.

As previously emphasized, Industry 4.0 buying goes beyond evaluating products and extends to evaluating product providers as partners. Buying must weigh the capability of a partner to help you implement the product and use it to achieve its targeted ROI. Proper consideration of partnerships is what will determine if you get a 2X or 10X return on your investment.

Criteria for engaging in a partnership with an Industry 4.0 company should consider their capability and trajectory. Capability qualifies how well the partner will implement the technology, support you in adopting the technology, and drive practical Industry 4.0 results. The trajectory criteria evaluate a partner's likelihood of being around in several years. Leading indicators of a company's trajectory include product sales growth, and product installation base.

PRODUCT

REQUIREMENTS

Not all requirements carry the same weight or importance, and you may not be able to meet all requirements optimally. One way to manage this complication is to group requirements into two categories: required and advantageous. Also, keep in mind that your requirements need to be fluid, meaning that originally drafted requirements may change as you conduct detailed analyses of products. For example, you may require an equipment health vibration sensor to have a frequency resolution of 3200 lines. This may be valid, based on prior experience using a traditional route-based vibration analysis method. If an Industry 4.0 solution is taking measurements every few minutes rather than once per month on a route, the specification of each sample set is different. However, in general, to avoid such nuance, it is better to define requirements around achieving specific goals like equipment health assessment accuracy and frequency sufficient to diagnose pumps, fans (key faults: imbalance, misalignment, bearing faults, cavitation, start-up, intermittent resonance, and looseness).

It's worth noting that the fundamental technology enabling Industry 4.0 necessarily negates the need to use legacy automation systems and architecture where solutions are largely either siloed within departments or plants (like DCS or SCADA systems). Instead, Industry 4.0 solutions make it possible to tightly integrate vertically around specific value propositions, while also connecting horizontally to virtually any other system. Since new Industry 4.0 architectures largely skirt legacy systems and, in many cases, extend beyond plant walls, it's wise to leverage this. Without this architectural freedom, your industry 4.0 plans will be slow and incremental. Traditional architectures for DCS and SCADA may ultimately remain in place for decades. Rather than replace these completely, Industry 4.0 solutions are flexible enough to fit around and augment them.

KEY METRICS

A common practice in selecting products is to evaluate if they meet requirements, and then compare products based on price. This approach will mislead your Industry 4.0 buying because two products that each meet your requirements may have vast differences in their ability to deliver value. Key metrics seek to highlight characteristics such as ease of use and product performance. These are criteria that need to be measured on a scale rather than using binary evaluations.

Key metrics should highlight the product characteristics primarily responsible for driving value. They may overlap with requirements, but should go beyond them in terms of evaluating how the product will practically achieve your Industry 4.0 objectives.

PARTNER

TRAJECTORY

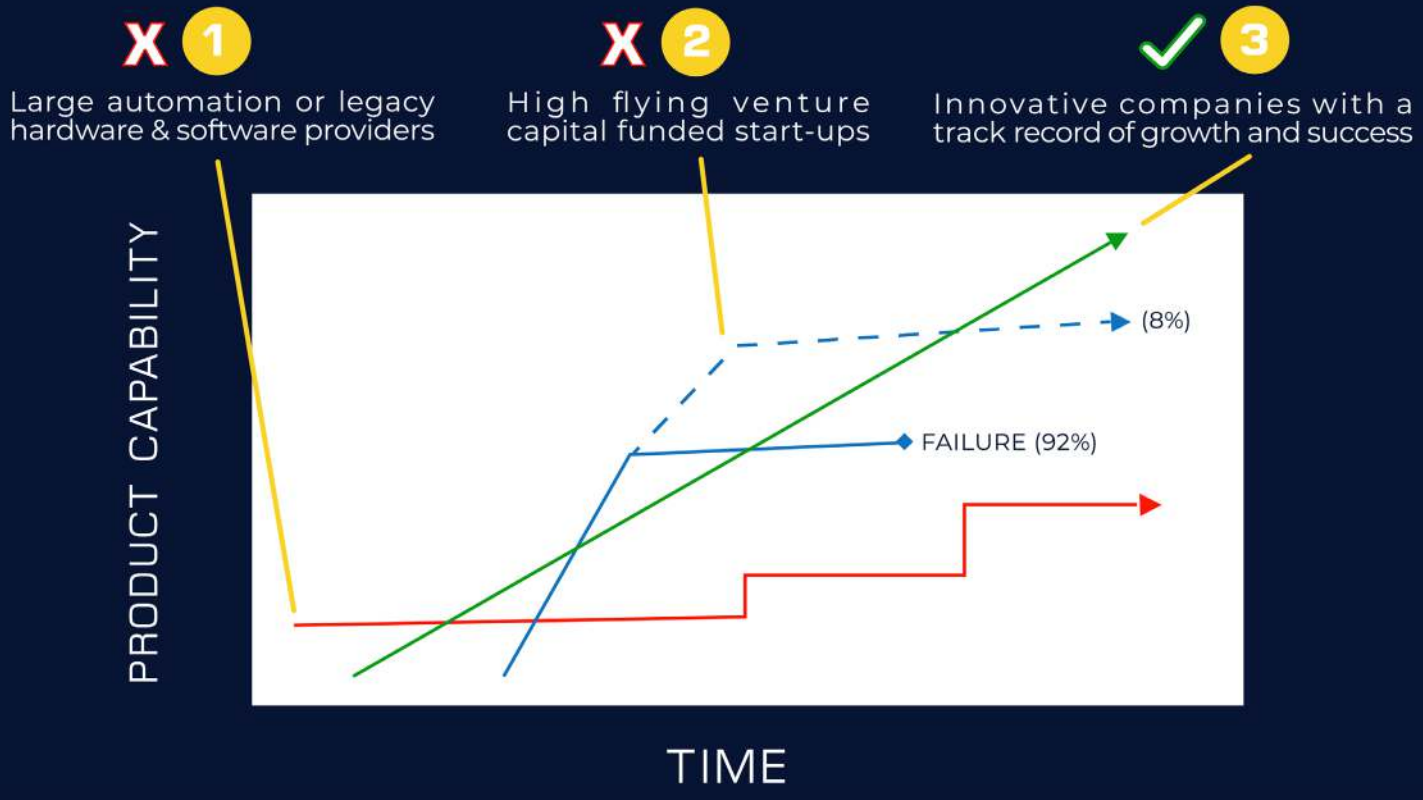
Unlike traditional manufacturing vendors, most of the Industry 4.0 software, analytics, and sensor companies are backed by aggressive venture capital investors. These investors expect rapid growth and a return in less than 5 years. Because only roughly 8% of such companies succeed, they are essentially gambling on a booming market. This creates a highly competitive landscape where most companies fail and few grow to full maturity. Ten years ago, the wireless sensor companies poised to take over the machinery health market were Ember and Crossbow. Now those companies are long gone.

Because winning often has to do with factors like product positioning in the market, timing, and business strategy, picking winners (i.e., the 8% that won't fail) is tricky. For example, consider the death of Corel's WordPerfect and IBM's Lotus 1-2-3 considering the growth of MS Office. In the 90's, IBM was the slow giant and Corel was setting the industry benchmark for word processing. MS Word didn't win the market by offering a better product; rather it dominated by offering wholly integrated products and aggressive partnering with the personal computer manufacturers. Notice, in this example, that while the safe bet might have been IBM's Lotus, in reality large companies generally struggle to compete with flexible and aggressive incumbents in new markets. Picking sluggish IBM back then is akin to picking Rockwell, GE, or Emerson today to support your Industry 4.0 vision.

To have picked MS Office from the outset, one would have needed to evaluate not just the product but also Microsoft in terms of its trajectory. Microsoft had a vision for a product that was highly integrated with their operating system, making it a faster and less buggy product. They had a track record of rapid growth, from a stock price of $1 in 1990 to $48 in 2000. Microsoft had an aggressive business mindset while IBM was looking to grow by using its legacy footprint and brand. Finally, Microsoft had a winning business strategy where they bundled their Office product with their operating system on all new computers. Microsoft exhibited a growth mindset with an eagerness for supporting the personal computing software market. This allowed them to best serve their customers and corner the market.

When evaluating companies to support your Industry 4.0 vision, look for companies like Microsoft which have a foundation and strong growth trajectory. Ensure they have a vision for the future and are eager to help you succeed. Avoid the extremes of slow legacy solutions and high-flying startups built on toothpick foundations. The tortoise (1) and hare (2) analogy applies except the winner is actually a fox (3) that knows the best path and pursues it consistently.

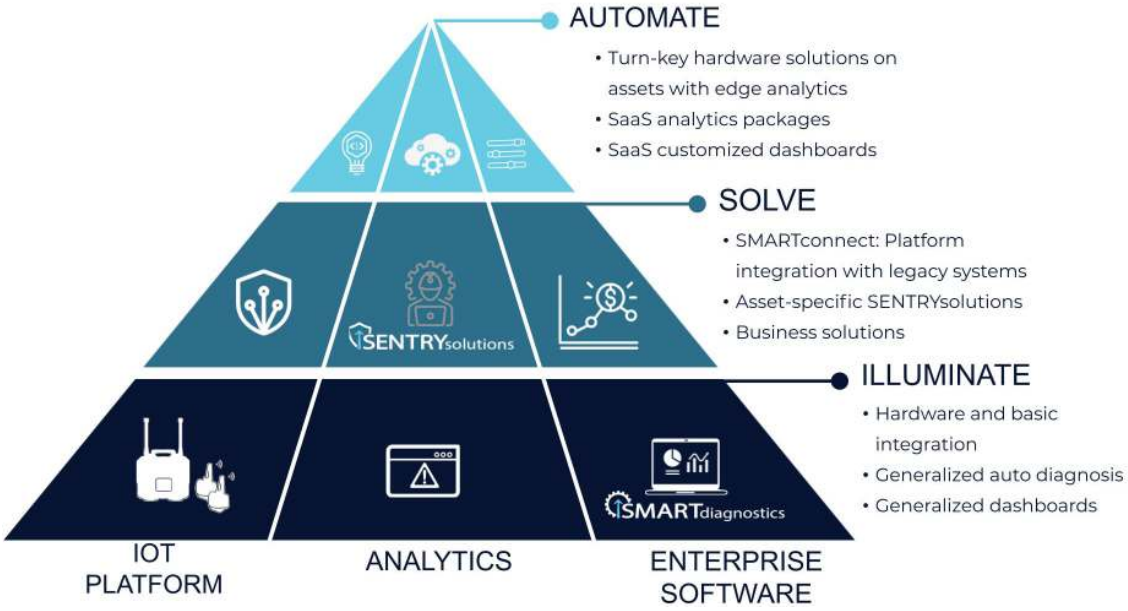
To quantify company trajectory, rank them based on their annual product sales growth for the specific product you are evaluating as well as metrics indicating the foundational strength of a company. Examples might include the number of years the product has been in the field and the size of the installed product base.



CAPABILITY

Look for evidence of a company's capability in five key areas: documented savings or value, ROI, Industry 4.0 value proposition coverage, Digital Transformation vision, and range of support services. Track records for delivering value and ROI are the most concrete metrics for evaluating a potential partner's likelihood of achieving the full value proposition promised by Industry 4.0. The best industry 4.0 companies will have customer verified savings and ROI. Savings for example, shows the scale of cost avoidance that a partner is capable of achieving, and the ROI indicates how cost efficiently they achieved it.

In addition to a company's record, value proposition coverage is an important measure of capability because it describes how well the company will be able to deliver on the entire Industry 4.0 value proposition within a lane. Companies that are mainly focused on predicting machine failure and catching them before they occur will only capture a small part of the overall potential value in the Industry 4.0 machine health lane. Companies that also focus on eliminating excessive preventative maintenance work, reducing spare parts inventory, and improving capital investment decision making will realize the entire machine health value proposition.



Because Digital Transformation is new manufacturers will often need to find their way as they go. This journey involves not just implementing the product but pursuing a holistic path to greater business automation (Industry 4.0 vision). The best partners are ones that can help you down this path. These rare partners are the ones that have already helped dozens of other companies transform. They are the ones that are aggressively seeking to transform American manufacturing because they are passionate about keeping it strong and in the US. They are the partners that build their own products in the US and don't outsource their software development to India.

You will find that the best partners to help you transform your business will have a transformation plan or vision like the one shown above. If a partner does not have their own vision for Digital Transformation articulated, it will not only lack the capability to help you transform but is also unlikely to be on a trajectory that will lead to a long-term position in the Industry 4.0 market. The most capable Industry 4.0 partners will not just have a vision for Digital Transformation but services that can support you in pursing that vision.

STEP 3: SHORTLIST

Industry 4.0 is one of the most marketed industrial technology areas. Coming up with a shortlist of products and partners requires cutting through the marketing spin to learn the essence of products. For example, “IoT platform” is a general term that covers many different types and depths of solutions. Most IoT platforms are a middleware software layer that enables device connectivity, device management, and data sharing. A machine health IoT platform should include much deeper capability, like integration into specific industrial infrastructure, wired and wireless network connectivity, edge computing, data acquisition tools, standard machine health sensors, and application-specific solutions. Avoid platforms that offer cobbled together technologies in lieu of cohesive and fully integrated systems.

A similar ambiguity exists around analytics platforms. Virtually all Industry 4.0 analytical solutions claim that they offer predictive maintenance capability. However, most lack key data features that are essential to accurately model equipment failure, like high frequency spectral sidebands. They also lack capability to deal with complex problems where equipment speed is changing, or operation is intermittent. As with the case of IoT platforms, analytics must focus on a particular lane, like machine health, rather than on a generalized tool set that could work in any lane.

One of the best ways to find solutions is to learn what your competitors are using in your market sector or adjacent sectors. Tradeshows can also be helpful; however, sometimes the showcased companies are more focused on what they are selling than learning how to best solve your problems. A good question to ask is: “Why should I buy your solution?” If the answer is because their product has the best accuracy or longest lifespan, etc., rule them out. If their answer is “we will take you on a journey to achieving 10X ROI,” then they are probably worth a closer look.

Keep your shortlist to no more than 10 products per lane so that you can dedicate sufficient time to analyze each. To end up with a true shortlist, look beyond webinars and demos to trialing the prospective technology. Trials are by far the best way to learn how well prospective solutions will work. Pay particular attention to how responsive the potential partner is and how easily their product is to set up. When trialing solutions, also keep in mind that there is a vast difference in the complexity and difficulty in setting up a 3000-sensor installation versus one with 10 sensors.

STEP 4: PRODUCT AND PARTNER ANALYSIS

PRODUCT ANALYSIS

Product analysis consists of evaluating each product on your shortlist relative to your requirements, and secondly rating them relative to your key metrics. This guide offers an analysis of products in the machine health focus area to illustrate concretely how to go about evaluating products and partners. While requirements and key metrics may be different for each buying lane, the process of evaluating them will be similar.

A shortlist of products in the machine health focus area is shown below.

INDUSTRY 4.0 MACHINE HEALTH SOLUTIONS	SMARTDiagnostics
WIRELESS VIBRATION MONITORING	Augury, Waites, PetaSense, Uptime Solutions
SOFTWARE INCLUDING ANALYTICS, CMMS & HISTORIANS	C3, OSIsoft (PI), IBM (Maximo)
DISTRIBUTED CONTROLS	Emerson, Baker Hughes (Bentley Nevada), Rockwell, ABB
TEST & MEASUREMENT	Fluke, National Instruments
EQUIPMENT/COMPONENT OEM	ITT (I-Alert), SKF
SYSTEM LEVEL OEM	Grob, Fanuc, Andritz, Schuler

Based on the methods described in Section 3 (shortlist), many of the products shown above should not have made it on a shortlist. These companies are included in this guide to show the diversity among the various products and companies sharing the machine health value proposition target.

Because so many are included in this shortlist, they are grouped by the background or approach that spurred their entry into the area of machinery health. In an actual analysis, the shortlist would consist of products, not product categories. For ease of presentation in this guide, each product group is rated as a collective. Because there are product differences within groups, some products will be over or under rated relative to the requirements or key criteria.

REQUIREMENTS

Requirements are assessed using the following designation.

Y = Meets product requirement
O = Does not currently meet, but is on a path to meeting requirement
N = Does not meet product requirement

Because the best Industry 4.0 solutions are ones that are growing or progressing quickly (as opposed to ones that have already peaked in terms of capability), it is important to include use of the "O" designation. Industry 4.0 is not a static target. The industry 4.0 requirements may look different in two years from now. This means that a dynamically changing product may well be relevant in the future. A small section of the machine health requirements is shown below with ratings for each product group. A more complete list of requirements is included in the appendix.

	INDUSTRY 4.0 MACHINE HEALTH SOLUTIONS	WIRELESS VIBRATION MONITORING	SOFTWARE (ANALYTICS, CMMS, HISTORIANS)	DISTRIBUTED CONTROLS	TEST & MEASUREMENT	EQUIPMENT/ COMPONENT OEM	SYSTEM LEVEL OEM
ACTIONABLE INFORMATION							
Automated Analysis							
Automated fault detection	Y	Y	Y	N	Y	O	O
Automated diagnosis	O	O	O	N	O	N	O
Email & text alarm alerts	Y	Y	Y	Y	Y	Y	Y
Auto-tracking run speed	Y	O	N	N	N	N	Y
Machine learning & algorithm training	O	O	O	N	N	N	N
Alarm workflow management	O	N	Y	N	N	N	Y
Hardware monitoring & analysis	Y	O	N	N	N	N	O
IOT PLATFORM							
Network							
Edge computing	Y	N	N	O	N	N	Y
Plant floor data visualization	Y	N	N	Y	N	N	Y
Over-the-air firmware updates	Y	N	N	O	N	N	O
Backhaul options (Wi-fi, Ethernet, Cell)	Y	Y	N	Y	Y	Y	O
Data I/O							
Waveform acquisition & transmission	Y	Y	N	Y	Y	Y	O
4 - 20 mA input, 0-10VDC input	O	N	N	Y	Y	N	N
IEPE accelerometer input	O	N	N	Y	Y	N	N
RS485, RS232 input	O	N	N	N	Y	N	N
Triggered acquisition	Y	N	N	N	Y	N	Y
Configurable timed acquisition	Y	N	N	N	Y	N	Y
ENTERPRISE SOFTWARE							
Interface Data & Sharing							
Python/C#/Typescript SDKs	Y	N	Y	N	N	N	N
Data sharing connections (MQTT, OPCUA, DA)	Y	O	N	O	N	N	Y
CMMS integration (Maximo, workorders)	Y	O	Y	Y	N	N	Y
Presentation							
Mobile friendly	O	Y	Y	Y	O	Y	Y
Powerful BI integration	O	N	Y	N	N	N	N
Dashboards	Y	Y	Y	Y	Y	Y	Y
Interactive maps	Y	Y	N	N	N	N	Y
Operators HMI displays	Y	N	N	Y	Y	N	Y
Gamification	O	N	N	N	N	N	N

KEY METRICS

When evaluating key metrics, consider that several focus areas of an Industry 4.0 plan may share a common need for an IoT platform, analytical solution, or enterprise software (i.e., machine health and intelligent operations. As previously pointed out, solutions that stretch across many focus areas generally offer compromised performance in relation to each value proposition. This is not to say that some IoT platforms couldn't practically serve multiple focus areas—they might—but it's worth considering them carefully within this context. The important point in relation to rating products is that analysis of key criteria must focus on how well products serve the targeted value proposition, even if analysis may point to using different solutions for each target focus area.

The key metrics for the enterprise software portion of a comprehensive machine health product are user group coverage, user interface tools, ease of deriving value, and data/information sharing. An example analysis is shown below. Complementary analysis of the two other parts of a comprehensive machine health solution, the IoT platform, and advanced analytics, are included in the appendix.

In the example analysis above, all features to the left of the product markers are covered by that particular product. For example, the SMARTDiagnostics product (blue dot) covers operator, plant supervisor, maintenance managers, and vibration analyst—but doesn't yet cover corporate SMEs, corporate reliability, or data scientist user groups.

User group coverage is a key criterion because it shows the degree to which the product is positioned to support the new workflows necessary to sustainably drive value. Baseline products in the machine health area may only target the vibration analyst. Best-in-class products extend capability to all user groups that can derive value from actionable information related to machine health. Each user group adds a potential path for increasing the value offered by the product, which drives the ROI up.

PARTNERSHIP ANALYSIS

In addition to meeting product buying criteria, the success of an Industry 4.0 solution depends on the company delivering the product. The two key criteria for evaluating partner companies are trajectory and capability. Interviewing references is one way you can quickly determine if the company you are evaluating can deliver value in a partnership. Questions to consider asking are: What ROI was achieved? What barriers to implementation were observed? How responsive were they? How buggy is their product?

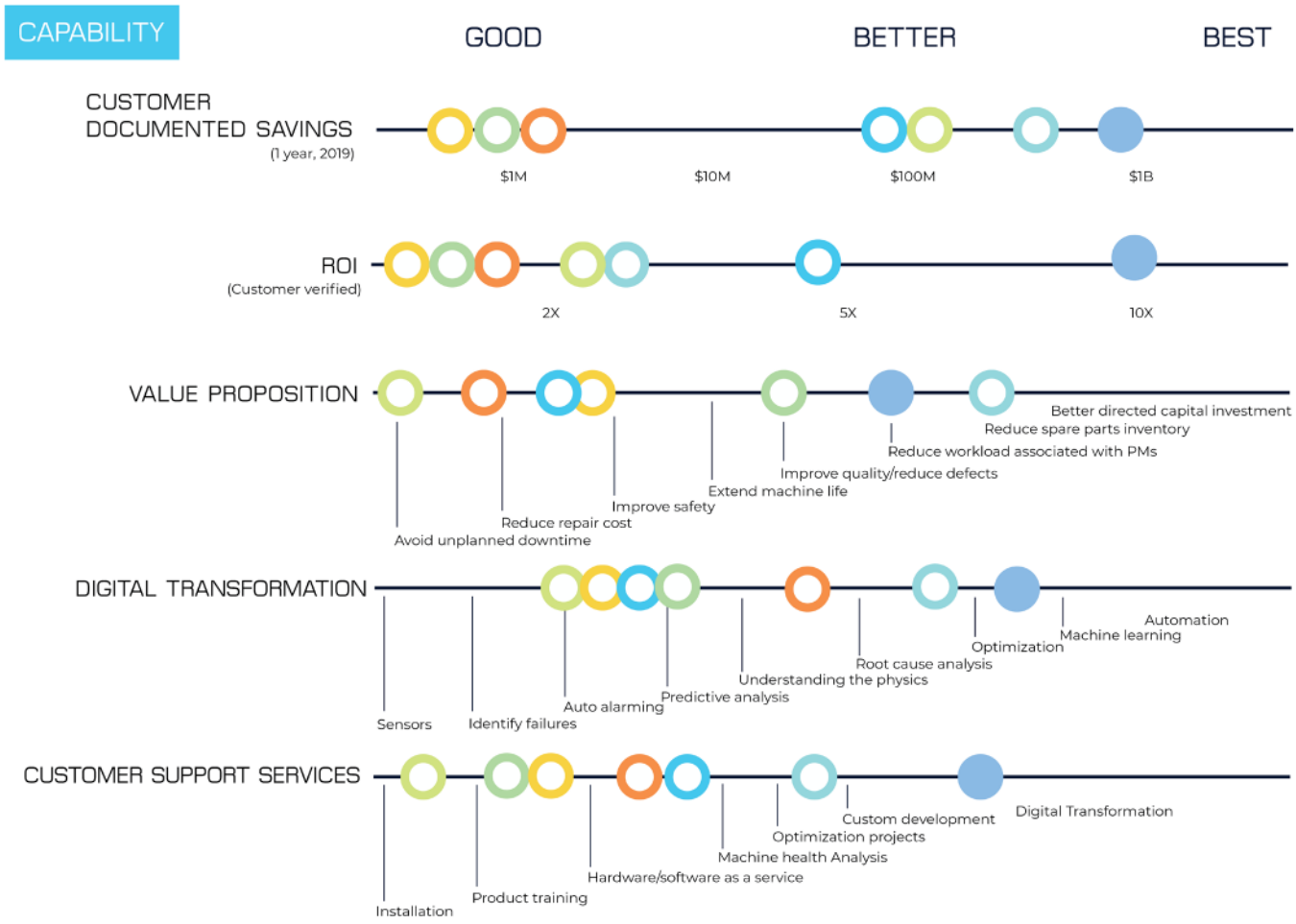
TRAJECTORY

To achieve a strong growth trajectory, companies need a strong foundation and few (if any) heavy anchors or limitations that will slow them down. For a machine health company, foundational strength is indicated by the number of years their product has been in the field (not the age of the company), the product installation base, and largest site installation size. The ability to leverage foundational strength and accelerate growth is often best indicated by annual product sales growth. Analysis of the machinery health market relative to these criteria is given below.

CAPABILITY

Having a strong growth position is important, but in the Industry 4.0 market, trajectory might mean that a company is leveraging a dominant strategic position, not that they will be a good partner. For your partnership to be sound, you need both a company on a successful trajectory and one with the capability to deliver the value you are targeting with your Industry 4.0 vision.

Partners with exceptional capability will have high marks in five key areas previously outlined: documented customer saving, ROI, scope of value propositions covered, ability to support Digital Transformation plans, and services coverage. While proven customer savings and ROI are important, it is possible to achieve high rankings by only focusing on one niche like catching bearing failures. Look for partners who fully understand Industry 4.0 and have a track record of executing on the broader vision as indicated by Digital Transformation capability. You will also want to look for companies who can deliver various levels of support services. Even if you don't need them now, it's important to consider that the retirement of large swaths of Subject Matter Experts (SMEs) in machinery health and analysis (vibration techs) will bring enormous change. Similarly, it's likely that you will need custom development work in the future as your IT infrastructure matures and products fit more closely together.

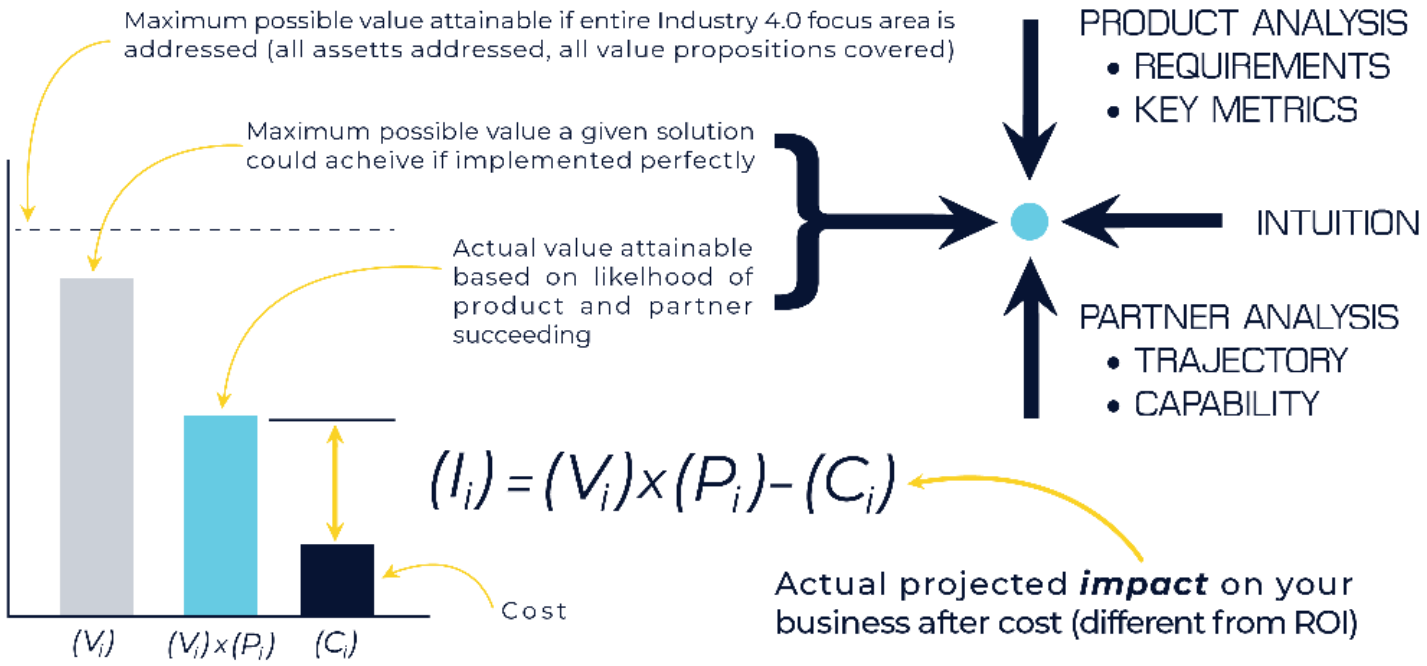


STEP 5: FINAL SELECTION

Using the product and partner analysis to arrive at a quantifiable winner could be done using decision matrices and mathematics weighting of the key factors, requirements, etc. This guide advocates for a simpler approach where solutions are ranked based on an Impact Factor. The Impact Factor requires decision makers to use their intuition and the analysis to 1) estimate the total maximum value that a solution could offer if implemented perfectly, and 2) the likelihood of successfully doing so. The Impact Factor is calculated as [total maximum value] times [likelihood of success] minus [solution cost].

Total maximum value (Vi) is determined based on the rating in the product analysis and your intuition. For example, total maximum value is strongly related to the scope of applications and failure modes that a system addresses: steam trap analysis, oil quality monitoring, intermittent running machines analysis, etc., in addition to standard rotating machinery vibration analysis. Total value also depends on robust CMMS connectors for seamless workflows, operator HMI screens for knowing when equipment is vibrating excessively, and plant manager level dashboards showing the current likelihood of downtime.

The likelihood of success (Pi) is determined by the partner analysis and your intuition. For example, if a company has not delivered a product at the scale you are expecting, then the likelihood of them succeeding in the implementation is low. Similarly, if a solution has already proven high ROI and value in a similar industry, then it is likely to offer a similar high success for your organization.

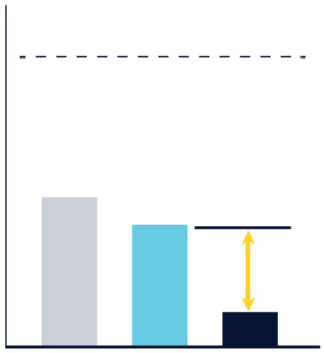


Please note that the Impact Factor is not ROI. Rather, it supersedes ROI by showing not just the cost efficiency of a solution but the net impact on your business after the system implementation cost (Ci). For an example of how the Impact Factor will help you pick the most impactful solution, consider the comparison of three products below (Solution A, Solution B, Solution C).

	Total possible savings	Value (savings using Industry 4.0 solutions)		
	CURRENT COST OF PROBLEM ($M)	SOLUTION A	SOLUTION B	SOLUTION C
Unplanned downtime	8.0	4.5	7.0	6.5
Excessive PM work	2.0	0.0	1.0	1.5
Equipment repair cost	5.0	3.0	4.0	3.5
Equipment/process performance	1.0	0.0	0.5	0.5
Spare parts inventory	0.5	0.0	0.5	0.2
Safety incidents	0.3	0.1	0.1	0.1
Total value (Vi)	16.8	7.6	13.1	12.3
Likelihood of succeeding (Pi)		80%	50%	80%
Product & Service cost (Ci)		1.0	2.0	2.0
Impact (Ii)		**5.1**	**4.6**	**7.8**

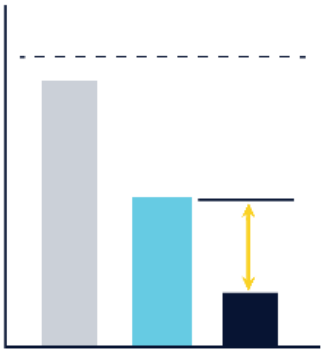
✗ SOLUTION A

- Low cost
- Narrow target value proposition
- High likelihood of succeeding
- High ROI
- **Low overall impact**



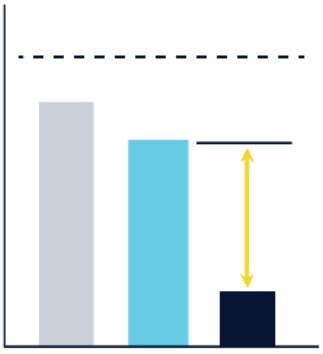
✗ SOLUTION B

- Moderate cost
- Large target value proposition
- Low likelihood of succeeding
- Moderate ROI
- **Low overall impact**



✓ SOLUTION C

- Moderate cost
- Large target value proposition
- Highlikelihood of succeeding
- High ROI
- **High overall impact**



Solution A is a PdM tool consisting of wireless vibration sensors and analysis software. It targets catching machine failures. The total value that can be attained by using the system and working with this partner is low relative to the total possible Industry 4.0 machine health value proposition. However, it is offered at a low cost which enables a high ROI.

Solution B has great promise for being comprehensive and integrated, but the partner offering the product is clumsy, offers little services or support, and is complicated to practically work with. When considering the likelihood for realizing the value target, both the ROI and actual value offered is low.

Solution C is offered by an aggressive partner that has a keen eye for helping you succeed. They offer a comprehensive machine health solution addressing machine life extension, machine health impact on quality, reducing costly and problematic preventative maintenance, and driving cultural change. This partner will deliver both a high ROI and much higher value even though their cost is more than Solution A.

STEP 6: DEAL

INCENTIVE

Deals can either reinforce value or undermine it. The deal structure can either grow a relationship with your Industry 4.0 partner or hold them at arm's length.

When structuring deals, the key questions are:

1. Does the deal encourage my team to leverage the solution and collaborate?
2. Does the deal encourage my partner to help me succeed?

Traditional software sales models, like pay-per-software-seat, discourage comprehensive user group coverage and undermine the scope of the value that could be attained. Similarly, pay-per-asset models encourage sites to instrument only the most critical parts of their plants. While this may drive high ROI, it ultimately limits the overall value that can be achieved. In contrast, fixed cost-per-site models encourage all potential participants to use the solution and coverage of all assets (including blind spots) that would otherwise be overlooked.

In high-performing partnerships, long-range success is dependent on not just successful implementation of the technology but also the success of both parties. Therefore, an objective should be to make sure that your relationship with your partner is helping rather than hindering their long-term growth. Large one-time purchases force both parties to absorb undulations in their budgets. Generally, reoccurring revenue models better support long-range partnerships.

Encouraging your partner to help you succeed is best achieved by tying pricing to the success that they help you achieve. In other words, your partner shares in the value that is uncovered. For example, reducing equipment failures and associated down-time might save you $10M in lost revenue. By basing the product cost on a fraction of that $10M, your partner is incentivized to not just deliver the product but to help you fully use it. From a contract management standpoint, complicated models for precisely managing the actual savings amount are not practical. However, a simpler model where success is measured in orders of magnitude, binned, and used progressively rather than retroactively is feasible. For example, an impact in the range of $1M-5M sets the product-as-a-service at a price of $300k the following year. Saving of $5-10M sets the contract cost to $700K, etc.

LEARNING AND OPENNESS

In markets where innovation is occurring rapidly, companies of any type, size, and industry stay at the forefront through an aggressive focus on learning. Industry 4.0 is just such an area. Learning can be achieved via many different venues, many of which are external to your business. Take for example two manufacturers who compete against each other in the manufacturing of plastic cups. Manufacturer A works openly with and Industry 4.0 solutions company. Manufacturer A rapidly learns from the experience and knowledge of the Industry 4.0 solutions company, who is also working with 200 other manufactures. Manufacturer A learns which assets to focus on, how to configure the system to derive the most value, how to go about tackling optimization projects, top Industry 4.0 investments that will drive the most value. Manufacturer A benefits from its own learning but also the latest Industry 4.0 trends based on the success of 200 other manufacturers using Industry 4.0 solutions.

Manufacturer B is highly protective about sharing information that is necessary to fully execute on using Industry 4.0 solution. For example, Manufacturer B doesn't share the failure rate of their assets by class, downtime cost, or problematic areas of their plants. Manufacturer B is confident in its ability to learn on its own. It believes that protecting what it learns (so as to reduce the likelihood that it could help unintentionally help Manufacturer A) while forgoing the learning of 200 other companies, is a winning strategy. Which manufacturer will come out on top?

Protectionism in aggressive and fast-moving markets has proven time and time again to be a failing strategy. However, protecting core trade secrets related to business strategy, process control, plant designs, etc., should remain tightly controlled, as these fall outside the scope of engagement required to successfully engage in an Industry 4.0 partnership. A general rule is that it is acceptable to share your plant leaders' common knowledge under a non-disclosure agreement with your partner. This is the type of knowledge that will enter the mainstream market when such employees leave, perhaps even to work for a competitor.

INTELLECTUAL PROPERTY

As a general rule, this guide encourages partnering to accelerate your Industry 4.0 plans rather than building internal capability to develop technologies and products on their own. While some IT integration work may be needed, becoming an expert in and building Industry 4.0 technologies is generally the wrong strategy for the reasons already stated. Within this context, Industry 4.0 partners should be asked to bring their own intellectual property to the table and seek to continuously grow it. Exclusive technology development partnerships are not feasible or practical for most Industry 4.0 companies.

1. Industry 4.0 solution providers should own technology that they develop and is integrated in their product, even if it was built to support a partnership.

   Example: The algorithms that convert vibration, temperature, etc. data into actionable machine health or behavior information

2. Manufactures should own implementations of the technology that are specific to their process or plant and outside of the core Industry 4.0 product offered by the partner.

   Example: Augmented processes that improve quality consistency based on machine health or behavior information

SERVICES

Software and more generally products-as-a-service are proving to be the correct models for solutions that are on a rapid growth or improvement trajectory and ones that need to be maintained on a regular basis. Industry 4.0 partnerships should look beyond one-time product sales transactions and consider five other types of service offerings:

- Installation and training
- Product-as-a-service (hardware, software monitoring and upkeep)
- Machine health analysis/monitoring
- Process or equipment optimization projects
- Custom technology development projects
- Digital Transformation

INSTALLATION AND TRAINING

Installing wireless Industry 4.0 products is easy—until the size scale becomes large. For example, many paper and pulp mills have outfitted their facilities with several thousand machinery health sensors. For an average Industry 4.0 PdM vendor, installing a sensor takes 20 minutes to place, commission in software, and validate operation. At this rate, 3000 sensors requires 1000 hours of labor to install. Best-in-class solutions with specialized mobile installation tools require a fraction of that.

Most if not all Industry 4.0 product companies provide product training, but there are big differences in its quality. You not only want your organization to learn how to use a product, but also how to derive the most value from it. For example, learning how to use a fishing rod is one thing and learning how to fish is another. Teaching your organization how to fish requires deep industry experience and domain expertise. Look to facilitate these types of deep engagements via your deal.

HARDWARE AND SOFTWARE MONITORING

Product-as-a-service is a model centered around ensuring that your new Industry 4.0 solutions are working properly and maintained. Batteries in wireless sensors will need to be changed and wireless networks will need to be tweaked as you add other wireless systems. It makes sense to outsource the sustainment of the product to the product developer, who can take responsibility for ensuring proper operation.

MACHINE HEALTH ANALYSIS

Machine health monitoring involves analyzing equipment symptoms and determining what corrective action is needed, and when. While parts of this can be automated, equipment health experts are still needed to validate the problem and to refine the estimate for when the work ultimately needs to be completed.

The best machine health monitoring programs extend beyond just analyzing equipment to proactively finding your machines' blind spots. For example, equipment may be accumulating damage at twice the rate during the first versus second shift. Or the plant in Plano TX, may run its pumps differently than the plant in Charleston, SC and therefore experience half the downtime. These assets may not be triggering alarms for corrective action, but rather offer insight into the root of what is prematurely wearing out equipment.

OPTIMIZATION PROJECTS

Optimization projects build on asset health monitoring programs by tackling large and complex problems without clear solutions. Oftentimes, these problems require process revisions, equipment redesign, or both. They may also offer large and ongoing improvements that extend equipment life, reduce ongoing maintenance and repair cost, and/or improve product quality. Optimization should be done via discrete projects but should be anticipated in the framework of a partner deal.

CUSTOM DEVELOPMENT

Building a complete Industry 4.0 solution set will require multiple interconnections with other solutions. Depending on the legacy of your existing infrastructure, these connection points may require custom development. Custom development may also include certain features to optimally use the Industry 4.0 solution. Generally, these are also discrete projects. To avoid messy intellectual property entanglements, establish ownership boundaries before work begins.

DIGITAL TRANSFORMATION

Digital Transformation services extend beyond traditional services by speeding transformation of your business into a best-in-class Industry 4.0 powerhouse. These services help you, for example, enact change needed to stop doing excessive PMs, adopt a long vision regarding asset health management, or proactively prioritize and tackle the biggest cost driver in your business. Digital Transformation engagements are opportunities for your business to learn how the best-in-class manufacturers are changing their operations around Industry 4.0. These services don't need to be a separate line item; rather, they can be a part of the broader agreement related to delivering the product-as-a-service.

COMMON PITFALLS

TOO CONSERVATIVE

By far the most common barrier to achieving Industry 4.0 success is complacency and bureaucratic sluggishness. The United States' manufacturing industry, and arguably the United States' status as world superpower, depend on how quickly it responds to Industry 4.0. China is already implementing against their Industry 4.0 plans at twice the rate of the US. The digital disruption descending on American manufacturing should be déjà vu. Kodak knew its industry was changing but couldn't pivot. The newspaper industry sat by and watched as its classified ad market revenue stream shifted to digital. Tom Siebel, former executive of Oracle Corporation, is right to characterize our time as "a mass extinction event," where we will see many Fortune 500 companies transform or fail. Now is the time to act quickly and execute the right plan.

TOO NEAR-TERM

Most large manufacturers have an Industry 4.0 vision. However, most of what is being purchased under the Industry 4.0 umbrella are tools like wireless vibration sensors and software analytics platforms. While those tools offer incremental improvement in asset monitoring, most are simply that—tools—and not solutions. The right machine health solution will be a whole product that covers not just continuous running rotating equipment but all machine health applications. The right long-term solution will connect horizontally to support the other three pillars of Industry 4.0. The solution will be paired with extensive services that drive value and are measured accordingly. Finally, keep a close eye on how well you are satisfying a long-range Industry 4.0 vision as opposed to an incremental near-term need.

TOO FOCUSED ON TECHNOLOGY

Most often, buying decisions are heavily influenced by the end users of the product (and rightly so, since they will be the ones executing on the value proposition). In the case of machine health monitoring solutions, the key individuals selecting solutions or heavily contributing to the decision making are often vibration analysts and maintenance supervisors. They know what has worked in the past and that forms a comforting reference point.

However, Industry 4.0 technology challenges end users to learn and adopt new ways of thinking and working. For example, vibration analysts may be set on using a bearing fault indicator like PeakVue. That may have made sense when you were taking monthly measurements, but does it still make sense when you are viewing your machine health every few minutes? Is it even the right question to be asking? In the case of Industry 4.0 buying, end user perspective needs to be balanced by that of business leaders, financial leaders, and Industry 4.0 visionaries. Remember you are investing in business outcomes and not technology.

TOO FOCUSED ON COST

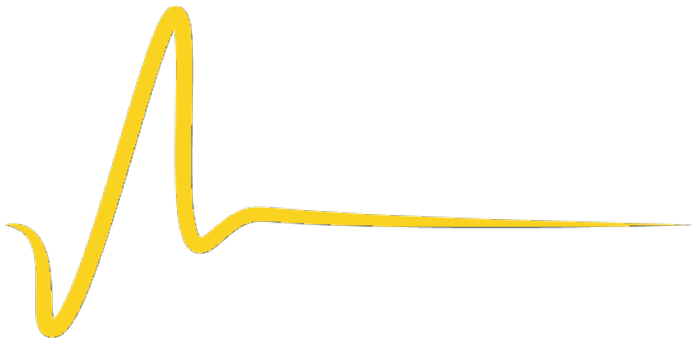
Of course, cost is an important factor in your buying decisions. However, it needs to be evaluated with a perspective shaped primarily by total opportunity and the likelihood of attaining the promised value. This guide has laid out a process that seeks to add diligence so that these factors are appropriately considered.

TAKE AWAYS

- Industry 4.0 requires much more than technology; it requires industrial companies to make fundamental changes to how they operate.
- Best-in-class manufactures are investing in whole product solutions that drive concrete and measurable business outcomes rather than only focusing on technology specifications.
- Succeeding in achieving target business outcomes requires a cohesive blend of both technical products and services that make it easy to achieve revolutionary improvement.
- Partnerships and products must be evaluated based on total value offered, not just cost and ROI. Ask: does this solution help address my big picture challenges like optimal capital investment decision-making in addition to predictive maintenance? Does this solution address all my machine health issues or just vibration?
- 92% of Industry 4.0 tech startup companies will fail. Legacy automation companies are lagging in the Industry 4.0 market. Look elsewhere for Industry 4.0 solutions that are on a strong and stable growth trajectory by considering product maturity, installation base, and sales growth.
- Form deals that both incentivize your organization and your partners to succeed.
- Avoid common Industry 4.0 buying pitfalls of being too conservative and slow, too focused on incremental and near-term objectives, too concerned about technology rather than business outcomes, and too focused on cost rather than total value.

ABOUT THE AUTHOR

Jacob Loverich, CTO and Vice President at KCF Technologies, has traversed the manufacturing ranks from machine operator to leading Industry 4.0 projects before the movement was coined, and is now shaping the field of industrial machinery health.



APPENDIX

EXAMPLE MACHINE HEALTH PRODUCT REQUIREMENTS

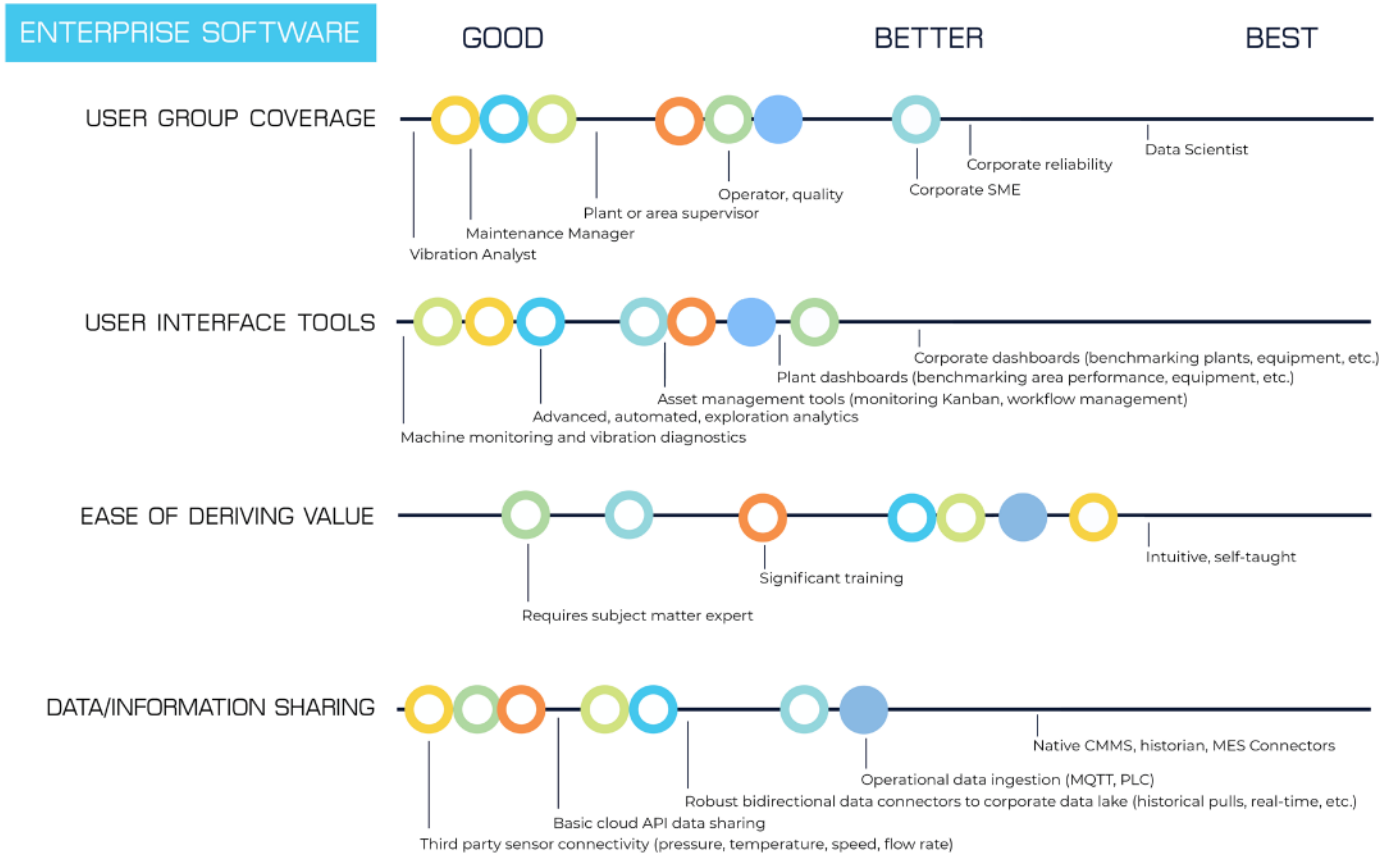
ENTERPRISE SOFTWARE
Presentation Responsive, mobile-friendly design Power BI integration Dashboards, option to share publicly Operators HMI displays Asset watchlist Heatmaps Interactive maps User statistics Gamification
Interface and Data Sharing Rest API Python/C#/Typescript SDKs Power BI Data Connector Data sharing, connections (MQTT, OPC UA, DA) PLC I/O Open data (meta, raw, config.) CMMS integration (Maximo, workorders) Power BI/Tableu integration through raw data mashup Excel and CSV on demand data export Customizable real-time integration through to a variety of instruments
Cloud Uptime (>99.9%) Server Redundancy Datacenter Redundancy Scaling of Storage Scaling of Performance Backups and Disaster Recovery Security Single-sign on Enterprise user access level control Data encrypted in flight Data encrypted at rest Firewall compatibility Security updates (servers and edge devices)

EXAMPLE MACHINE HEALTH PRODUCT REQUIREMENTS

ACTIONABLE INFORMATION
Automated Analysis Process-triggered vibration reading (IoT Hub) Automated fault detection Automated diagnosis Machine learning and algorithm training Alarm workflow management Auto pattern recognition (APR) Auto-tracking run speed Hardware monitoring and analysis Email and text alerts
General Purpose Data Analysis Tools Waveform data Frequency spectrum data Asset running speed Baseline setting & comparison Custom fault markers (frequency spectrum) Sidebands and harmonic frequency markers Spectrum measurement marker Waveform marker Asset Health indicator Custom analysis filters Adjustable sensor sampling frequency Adjustable sensor collection interval Data export Timeline of events Event Tagging Indicator Statistics table Alarm Severity Status (1-10)
Vibration Analysis Orbital analysis Envelope analysis Waterfall plots Machine vibration auditory playback Comprehensive bearing data base, with fault frequencies
Other Machine Health Analysis Oil analysis tools Electrical motor current signature analysis Steam trap analysis Pump efficiency analysis
Adhoc Analysis Root cauuse exploration via correlation, variable, interdependence) Asset monitization and capital decision making

EXAMPLE MACHINE HEALTH PRODUCT CRITERIAL

ENTERPRISE SOFTWARE



IOT PLATFORM

EXAMPLE MACHINE HEALTH PRODUCT CRITERIAL

ANALYTICS (ACTIONABLE INFORMATION)