An Evaluation Guide to **Industry 4.0** and **Smart Manufacturing**

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Introduction

The vision of a fully autonomous manufacturing enterprise, where every aspect of the value chain is optimized and everything is integrated together, providing automatic operations corrections at every step, is something we all long for. The reality is that every organization is at one of 5 levels of capability both from a technology and organizational readiness point of view. What is needed is wholistic material intelligence that will take a manufacturing business through the 5 stages needed to fully reach Smart Manufacturing status. This evaluation guide for Smart Manufacturing will help you asses where you are in the journey, considerations you should look at, and questions you should ask your solution vendor about how their solution meets the specific need level.

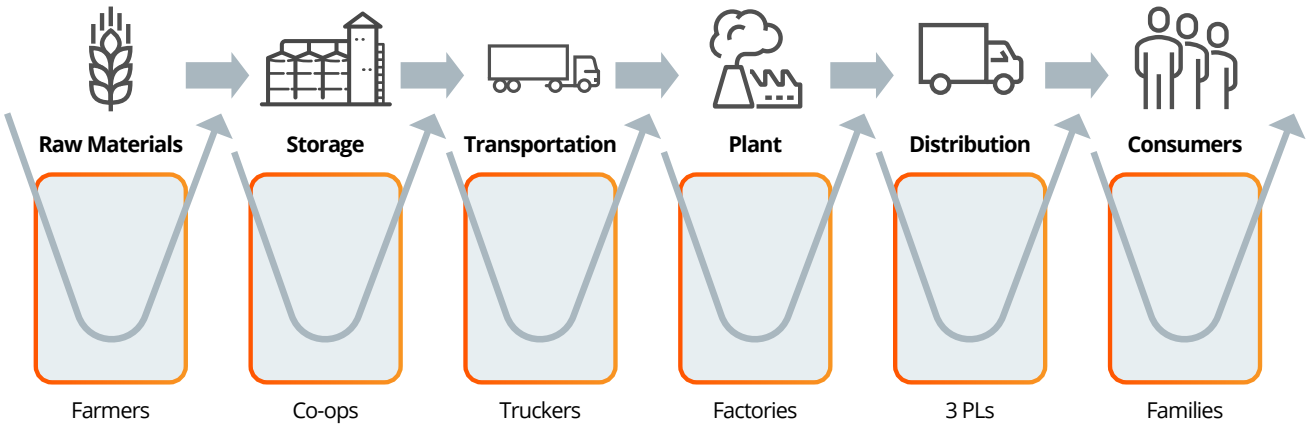
What is **Industry 4.0 Smart Manufacturing** and why do we need it?

The terms Industry 4.0 and Manufacturing 4.0 have been with us for a while now. The 4.0 representing the 4th revolution where the internet and AI makes the same step-change difference that the steam engine, electricity, and the computer made to industrial operations in the past. The essence of the Manufacturing 4.0 revolution is connectedness, where machines, people and processes can be connected across the supply chain to break down data silos. As this involves a lot more data, this data needs to be better managed. To interpret and analyze all the new data, it needs to be put into context and more efficient ways need to be developed to sort it, look for correlations and provide more advance prescription around what to do based on these timely insights. Enter Machine Learning and Artificial Intelligence to sift through this myriad of information and identify anomalies. As humans are always going to be in the loop, at least until or if we trust computers to completely run a business for us, the output of analytics need to be easily understood and provide human readable symbols that show opportunities for improvement. This capability needs to look across all the players in the manufacturing supply chain, including the raw material producer, the transporter, the warehouse, and the myriad of processors that convert these materials into products that are consumed. If we also consider the consumption of products and the disposal of waste generated by using the product, there are many components, events, state changes, mixtures and steps that need to be tracked.

The common element is **material**.

What is the digital thread that goes across this supply chain? What is the common element that stays with the process at every step? Of course, it is the material. So, if Industry 4.0 is about the internet, and the internet is all about connecting up every part of the supply chain, then material is the key element we need to track in order to reap the rewards of this next industrial revolution. It is material intelligence that is this key technology we need to reach Industry 4.0 Smart Manufacturing.

Supply Chain Systems with ThinkIQ

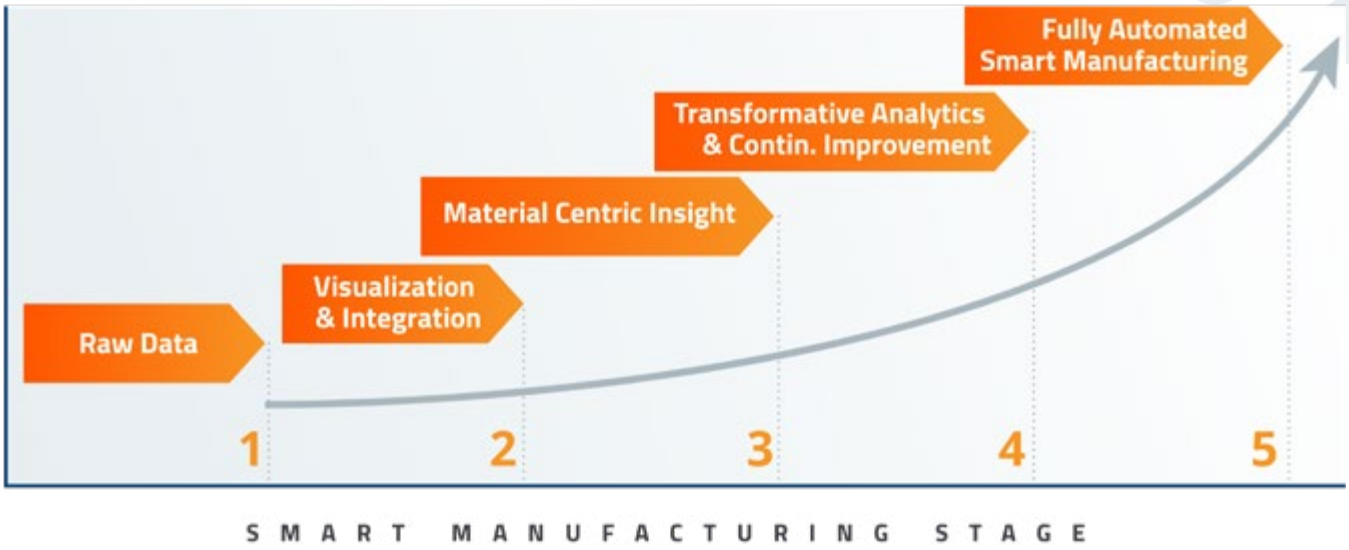


The reason this is so important is that material has a profound effect on all parts of the operation. For example, material coarseness or consistency directly affects machine performance and premature degradation. In the consumer-packaged goods industry, product freshness or ingredient makeup can cause quality problems or recalls due to contamination or mislabeling of allergy causing ingredients. Off spec material can result in the generation of waste or additional energy needed to process.

- **Enlightened**
- **Integrated**
- **Sensor Driven**
- **Granular**
- **Autonomous**
- **Trusted**
- **Multi Enterprise**

The 5 steps required to reach **Industrial 4.0** or **Smart Manufacturing**

At ThinkIQ, we have found that there are 5 stages to Industry 4.0 Smart Manufacturing as it applies to material traceability. Each new step builds on the previous one and there is no skipping. As you would expect, this progression follows the pattern of other digital transformation maturity models, but with a critical difference, that being the accounting of material information and the advanced computer science needed to connect the entire value chain to make sense of this material-based information.



Step 1: Data Capture

The first step in Smart Manufacturing is the ability to capture all the data needed to build a repository of information for the purpose of analytics. The more the better as machine learning was built to look at large data sets and extract insights that it would either take too long for a human to find (data does have a shelf life) or is so abstract that it would be missed by mortal eyes. Also, this data needs to come from many traditional silos, both within the enterprise and outside. Standalone IT systems deliver information for a specific activity through descriptive analytics. At this step, you can routinely measure performance and provide case-by-case problem solving. Operations run as a set of distinct processes or activities needing high coordination. This does however provide complete and trusted information for the job-at-hand. Below are the key elements of this step.

Attributes

- Manufacturing and plant data collected from HMIs, PLCs, ERPs, your CRM.
- Suppliers and partners transfer key material data and specifications.
- Includes material movements times and weights or volumes.

Considerations

- Types of data includes raw materials, processing parameters, quality test results, content, origin, delivery & distribution, transportation, blending information and customer information.
- Time series data, key events, certificates of analysis, movement times, % content.

Activities to Move On

- Data can be displayed on a wide variety of screens and in different data silos as dashboards.
- Start thinking about what can be aggregated together to provide a combined view.

Questions to ask your vendor:

1. Do you provide on-premises connectors to Automation, IoT, ERP, Quality and MES systems to collect and send data securely to the cloud?
2. Can you store both time series and event data in context?
3. Can you provide streaming data transformations?
4. Does your product provide an API that can be used with off the shelf UI development tools?
5. Can you store and curate data at the edge, datacenter, and cloud?

Step 2: Visualization & Integration

Once you have the data, the next step is to be able to see it. Not just looking at a list, but by leveraging graphs, dashboards, charts, dials, and visual indicators that give meaning and context. This information can be animated through graphics and updated in near real-time. In the previous step, the data was still in silos, but now it is navigable and searchable across the supply chain. This ability is, many times, an ah-ha moment for managers as now they can start to see cause and effect. This lets you continuously improve individual processes through descriptive data analytic methods.

Attributes

- Standardized metrics and views bring wide visibility and context to the data in an organization.
- Alerts and notifications bring problems to your attention, which begins to mitigate the risk of a recall, and often results in yield improvements.
- Facilitated by gateways, databases, cloud aggregation of data and single search and navigation.

Considerations

- Able to view all your data on one screen. This is often a revolutionary moment for production teams.
- Manufacturing and material data – including that from suppliers – available on one screen and across multiple geographic locations.

Activities to Move On

- Start thinking about the needs of data engineers and data scientists.
- How would you organize the data to give additional insights?

Questions to ask your vendor:

1. Do you provide a tool to create custom dashboards?
2. Do you have an alert and event subsystem that can publish data via common messaging services?
3. Do you have strong application security for sharing information via an internet connection?
4. Do you have the ability to share data on mobile devices?
5. Is your UI web browser-based?

Step 3: Material Centric Insight

In this step, we start to focus on the behavior of material in the supply chain, seen through the lens of all the other data you have collected. Unseen correlations are exposed through AI and ML. You start to manage your organization based on this new material-focused information. Relationships and questions are asked and answered around what upstream activity is causing problems further down the line. System optimization methods are employed leading to differential performance. Propagation of signal changes through the value chain provide feedback loops and inter-company collaboration.

Attributes

- Material-centric view of operations.
- Advanced AI and ML to correlate the data.
- A database that accommodates multiple data types, time series, pictures, geo-tags, etc.
- Organization can identify previously unseen correlations — even root issues — from their supply chain through the internal manufacturing process and outward towards the end-user.

Considerations

- Advanced visualizations of your manufacturing line (including supply chain), cause & effect identification, industry benchmark reporting, and cross-plant KPIs.
- Uses AI/ML to create associations that lead to cause-effect determinations, which are ultimately what lead to the most useful predictions, warnings, and suggestions.

Activities to Move On

- Building a linguistic and logical model ("semantic model") designed for manufacturing and able to "talk about" each different type of information.
- What additional data queries, along with additional algorithms, would give greater context.

Questions to ask your vendor:

1. Does your UI include graphics that provide overview and drill down of granular material movements including cause & effect identification and cross-plant KPIs?
2. Does your application use AI and ML to correlate data and identify anomalies?
3. Can your data historian handle petabytes of time series, event, and video data?
4. Does your application incorporate a linguistic and logical model ("semantic model") designed for manufacturing terminology to relate sensor data to physical plant equipment, manufacturing processes, raw materials, and finished goods?
5. Does your application incorporate an advanced query capability that allows sensor data to be queried using patterns identified by data science algorithms through the lens of a semantic model?

Step 4: Transformational Intelligence

In this next step, material starts to be accounted for in the same way cash and inventory is tracked. Every account is visible across the stream. Predictive and prescriptive methods and models can be employed. Forward looking business intelligence is provided through real-time data exchange across the value chain with data provenance and governance. Latency is minimized between events, decisions, actions and propagated across the value chain.

Attributes

- Ledger that allows for manufacturing data to digitally flow along the supply chain.
- For example, sensor data that a partner gathered needs to also flow along logistics pathways and through your manufacturing line, still digitally connected to the actual product itself.

Considerations

- Machine Learning to begin uncovering root causes and effects.
- Allows product tracing on a deeper level.
- Data points from suppliers through to customers are processed and related to your KPIs.

Activities to Move On

- Develop use cases to rapidly spot operational anomalies to address problems much earlier in the process — saving you both time and money.
- Example: See how a supplier's delay affects you, or where there were quality issues you were previously unaware of.

Questions to ask your vendor:

1. Can your application display root cause and effect through advanced AI and ML?
2. Can company KPIs be tracked and correlated to associated predictive values to see if operations are tracking to plan?
3. Is your application cloud agnostic?
4. Can your application provide views for different company and partner roles based on logon?
5. Does your application provide a material ledger enabling the tracing of materials and all accumulated information as they move through the manufacturing processes and supply chain?

Step 5: Industry 4.0 Smart Manufacturing

The final step is an operation run as a holistic system of people, physical assets, information, processes, and technology. Material information is integrated as part of an operational data model. Ubiquitous data access is provided and a frictionless flow of information travels along the entire order fulfillment chain. Scenario-based stress testing and simulation of disruption is provided across potential scenarios. Use of strategic dashboards or intelligent control towers guide the operation. The entire business is organized as an ecosystem with suppliers and customers that can reconfigure and adapt to changing scenarios, with material being the common element.

Attributes

- Cause & effect processing has begun, and continuous improvement procedures have been implemented.
- Fully autonomous Smart Manufacturing, your manufacturing process now includes traceability — from raw materials to product delivery — optimized supply chains, and fully transparent, real time contextualized data.

Considerations

- It can warn you of trouble, early on.
- It can surface numerous opportunities for improvement.
- It increases plant and product safety, and it can speed products to market.

Activities to Move On

- Establishes your company as a market leader.
- Smart Manufacturing companies are more profitable and more competitive.
- In addition, employees are happier — with better collaboration and connections — and are more empowered and able to make changes that support the organization's goals.

Questions to ask your vendor:

1. Does your application provide near real time traceability from raw materials to product delivery?
2. Does your application provide a collaboration capability through workflow and messaging subsystems?
3. Does your application provide time-series data presenting attributes at the individual equipment and unit of material level?
4. Does your application integration with common ERP and business systems?
5. Does your application's UI provide navigation based on material streams across the value chain vs just by plant, process, or equipment?

Benefits to be achieved

While many organizations deny the coming changes of Industry 4.0 — or consider it a marketing term — the benefits are vast and undeniable. Connected supply chains, sensors, and manufacturing lines can and do outperform "dumb manufacturing" in every instance.

Examples of Industry 4.0 Smart Manufacturing are many. But imagine it in your own manufacturing facility: you can see all the data, from supply chain source data to shipping, on one screen. That data has been AI connected to from cause & effect associations, which alert you, perhaps, that a temperature change at a grain silo may cause a manufacturing problem in the future, or that the way that you are cutting your product is inefficient.

In fact, an alliance of research & government labs and manufacturing organizations — the US Smart Manufacturing Leadership Coalition — has predicted that the benefits of Industry 4.0 Smart Manufacturing include a 10% overall improvement in operating efficiency, 10% faster time to market, and a 25% reduction in factory safety incidents.

So, how does one transform to the next generation of manufacturing efficiency?

The ThinkIQ **advantage**

ThinkIQ is the leader in Transformational Intelligence for Manufacturers, contextualizing data — both in-plant and across your supply chain — to improve yield, safety, quality, and compliance. ThinkIQ is an enterprise cloud-based software platform that combines existing disparate and siloed supply chain data with a unique modeling technology to detect material movements. It provides context for your data, and correlates events over time to enable end-to-end granular supply chain visibility. As a result, you can improve yield and quality like never before, while mitigating risk of recalls, saving cost and harmonizing operations.

Please contact us today to begin your journey to total material traceability.

info@thinkiq.com

Or visit us here to learn more about the ThinkIQ advantage.

Requirements Matrix to use on your next Smart Manufacturing Project:

Requirements:	ThinkIQ	Vendor A	Vendor B
Step 1- Data Capture			
Do you provide on-premises connectors to Automation, IoT, ERP, Quality and MES systems to collect and send data securely to the cloud?			
Can you store both time series and event data in context?			
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Step 3- Material Centric Insight			
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Does your application incorporate a linguistic and logical model ("semantic model") designed for manufacturing terminology to relate sensor data to physical plant equipment, manufacturing processes, raw materials, and finished goods?			
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