Authors
Dr. Max WINKLER
Ruediger HAGEDORN

Warehouse Automation

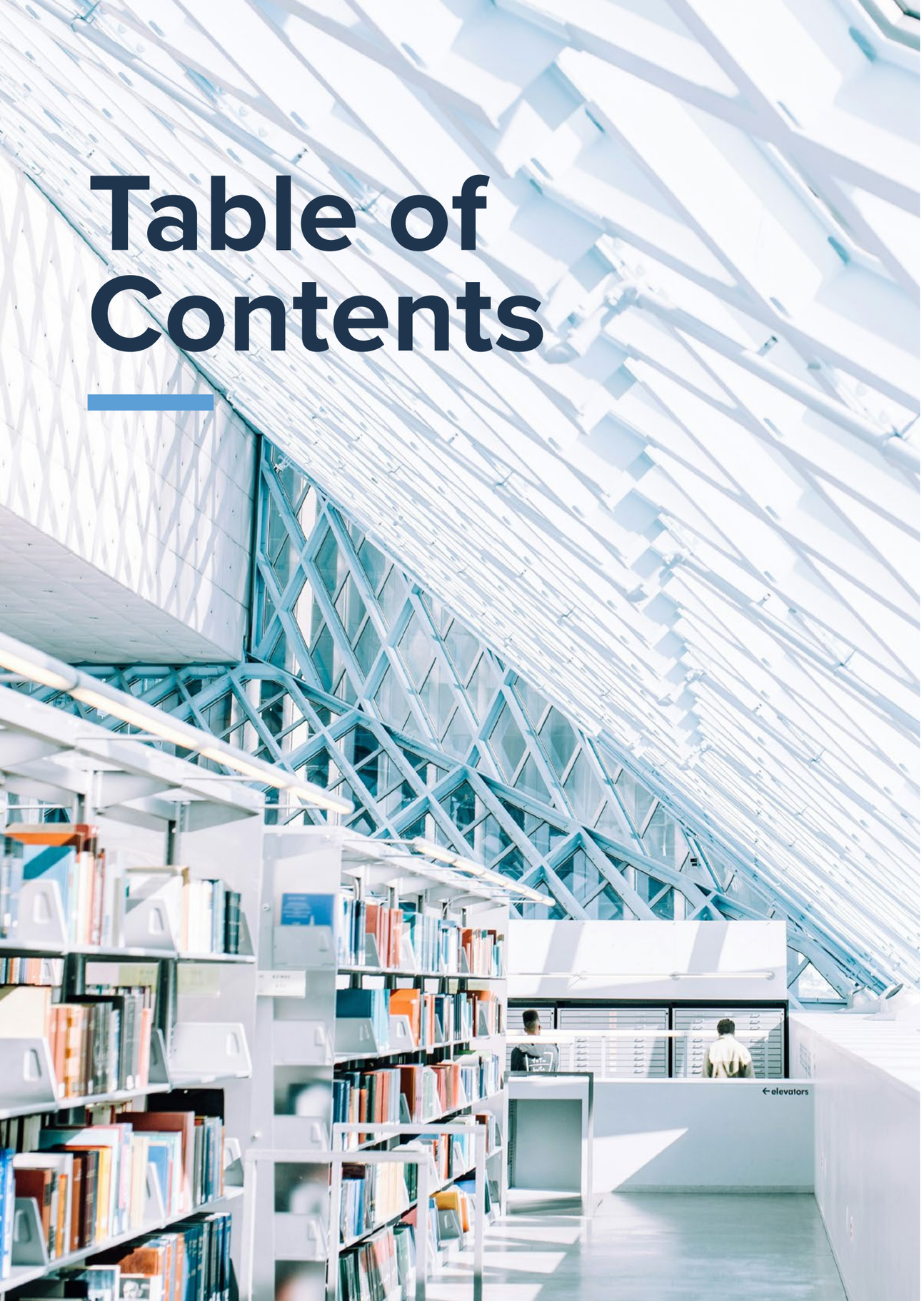
v 1.0

The do's and dont's for your path to automation

The Consumer Goods FORUM
End-to-End Value Chain

WINKLER TECHNOLOGY .com

Table of Contents



Intro

Okay, you want to go for automation in your warehousing and distribution activities.

But where to start and how to approach this?

Embark on Your Automation Journey with the CGF Whitepaper

Illuminate the Value: Gain crystal-clear insights into the tangible benefits and transformative impact automation can bring to your operations.

Navigate with Confidence: Ask the right questions upfront, ensuring a well-informed and strategic approach to your automation projects.

Mitigate Risks: Understand the potential limitations and challenges of automation, allowing you to proactively manage and mitigate risks.

Chart Your Course: Discover proven, step-by-step guidance for successful automation implementation, avoiding common pitfalls.

Build for Success: Access practical templates for structuring your automation project teams, ensuring efficient collaboration and execution.

Tap into real-world best practices for optimizing performance and maximizing ROI.

Speak the Language: Decipher the jargon of supply chain and automation with a comprehensive glossary, empowering you to confidently navigate vendor pitches and technical documentation.

Of course, you can study our whitepaper sequentially from start to finish.
But if you prefer an immediate deep dive into any specific topic, the following overview helps you with a quick jump to the respective section.

Why Automation?

Automation is expensive, requires a complex project to get there and sometimes (actually quite often) doesn't deliver the expected results.

Ultimately Automation is about ROI, like every business investment. But to find the right path to Automation for your specific business we need to dive a bit deeper.

Quite often – and rightfully so – the first and important approach to Automation is the increase of worker efficiency. Or in short, the total required FTE for a given supply chain operation before and after automation.

So why go there in the first place?

Metric	Current	(Semi-) Automated
FTE	Count & Costs (Skills for manual operation)	Count & Costs (Skills for automated operations)
Costs / efficiency	Costs per pick	Total operation and CAPEX financing costs divided by total picks

Although the above table is a much too simplified view, it already provides you with 2 important insights:

1. The total number of FTEs will most likely decrease with automation, but some of the FTEs will be more expensive than before because more specialists are required.

2. The automated 'machine' also produces new costs, way beyond an increased electricity bill. Think maintenance, spare parts or software license fees.
So a major ROI element of warehouse automation are reduced Costs, mainly achieved by a headcount reduction. The current – and likely ongoing – scarcity of labor obviously increases the importance of the FTE discussion. It actually introduces an additional ROI-element: the margin losses by unfulfilled customer orders due to lack of labor. In that sense automation can be seen as an opportunity to immunize a company partially from labor market developments, mitigating some risk.

? Are you currently experiencing or do you expect to suffer margin losses due to scarcity of labor in your warehousing and distribution processes?

Did you know that the forefront of warehouse and distribution automation was for decades with pharmaceutical wholesale? Not only because the handling of small and light pill boxes is relatively easy, but because speed is of essence for pharmaceutical wholesalers.

Only automated warehouses are capable of having thousands of orders every day ready for shipment within 20 min after launching the pick order. **Hence one important benefit of automation is the reduced cycle time or simply Speed within a warehouse or distribution center.** Would a tangible increase in speed have any impact on your business?

? How would a drastically reduced warehouse cycle time potentially influence your business, and if yes, how exactly?

Finally, all automation projects in the warehousing and distribution space lead to a **reduced error rate.** With automation items are misplaced less often, the transparency and quality of data about stock and orders is improved and most importantly, more often the right items are picked in the right quantity.

Hence automation always leads to increased quality.

In summary it can be said, **automation pays in to all three dimensions of business optimization:**

1
Costs & Margins

2
Speed

3
Quality

The respective importance of the individual business optimization dimensions will determine where the focus of your automation activities will be and how you should approach it.

Why Automation?

This deep-dive section helps you to better specify the benefits which are important for your concrete automation project or initiative. Remember, we previously explored the three core dimensions of these benefits:

- **Cost/Margins:** Enhancing profitability
- **Speed:** Accelerating processes
- **Quality:** Elevating standards

Have your pen and paper ready to take notes as we explore these dimensions in detail. By the end, you'll have a clear roadmap to harnessing automation's power to drive success.

Cost Savings

It is important, prior to starting an automation project or initiative in any way or form, to properly describe and document the expectations and envisaged business benefits.

Cost Savings are mainly driven by replacing manual process steps with automated equipment. It is important to understand what the real drivers are and also what the consequences will be.

Beyond the typical ROI calculation applied here, an increasingly important factor is the **scarcity of labor**. Indeed automation can be an answer to the growing difficulties of finding and retaining skilled labor - or >>> labor at all. Hence you might want to include as an additional element the effects of the scarcity of labor:

- **Missed customer orders or in general** limitations to the business growth.
- **Growing HR** efforts and costs.

While automation can be a powerful tool to address labor shortages, it's not a one-size-fits-all solution. In fact, it brings a new set of challenges.

- **Automated warehouses may need fewer workers overall**, but the remaining roles demand a different skillset. From managers overseeing the systems to technicians maintaining the equipment, everyone needs to adapt.
- **Automation also introduces new costs.** Just like any machine, automated warehouse equipment requires ongoing maintenance and occasional spare parts. These expenses typically range from 5% to 10% of the system's initial cost each year.

Remember to factor these additional costs into your return on investment (ROI) calculations to get a complete picture of automation's impact on your bottom line.

Speed

Speed is often not on the radar when engaging with warehouse automation. But practically all automated warehouse solutions translate into reduced order processing times. As there are too many variants of before and after solutions, it is impossible to provide a general calculation scheme. But the values provided in the table at the right might be useful for you to understand the potential of this warehouse automation aspect.

By analyzing order processing time, you can identify bottlenecks, streamline processes, and ultimately enhance the overall customer experience. At the end, reduced order processing time will translate into **increasing throughput**.

PRO-TIP

When you do a review of your current throughput and order processing times to define a base line, you should review the min, average and max times by order type to gauge what the drivers are and where your opportunities are.

Solution/Vertical	Automated Warehouse
Pharmaceutical Wholesale	20 - 30 min
Automotive Spare Parts	30 - 60 min
Grocery Wholesale	90 - 240 min (based on fully automated, aisle-ready mixed case palletizing operation)
Grocery E-Com	30 - 90 min

Please note: The table above illustrates a key performance indicator in warehouse operations: "Order Processing Time". This metric measures the duration between the moment a customer order is released by the ERP system to the warehouse, and when that order is fully prepared for shipping and arrives at the warehouse's designated shipping area.

Quality

Quality is an important positive effect of warehouse automation. Before we elaborate further, there is one thing to explain: an automated warehouse typically does not mean a lights-out operation without any people.

Actually, most automation solutions target at operators efficiency, by for example eliminating the requirement to walk and search within the warehouse or by providing guidance and checks to the operators for processes like picking, packing or replenishment.

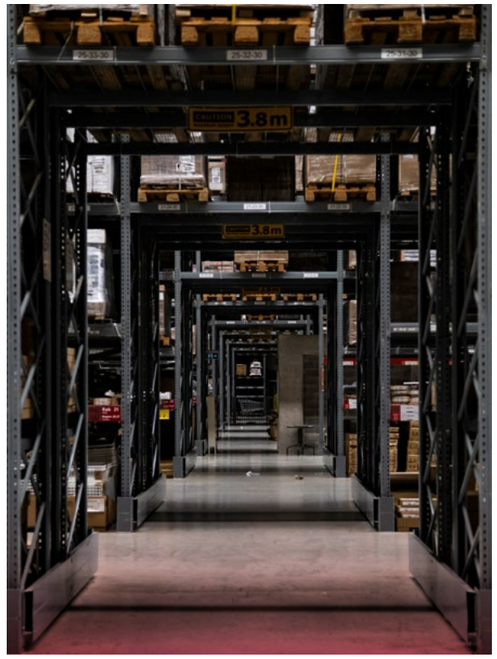
Quality in an automated warehouse is therefore a combination of increased accuracy of machines, e.g. for storage and retrieval or transport, and guided processes for the human operators. A typical, well managed automated warehouse achieves error rates of 0,1 to 0,3 %.

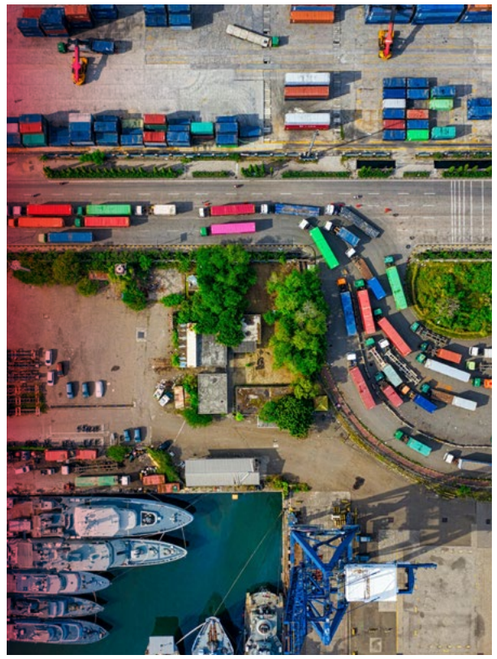
This error rate is measured at 'the end of the pipe' with completed orders ready for shipping. Hence only 1 to 3 out of 1000 orders will have an error like 'wrong quantity' of an item or 'wrong item'. **With additional quality measures like weight-checks or camera based inspections it is possible to improve the error rate by one magnitude to less than 0,1 %.**

To evaluate the importance of quality improvement through warehouse automation the following **two values might be helpful for you:**

- If a picking error can be detected before shipping of the customer order - so still within the warehouse -, then the typical processing costs for error handling and correction are in the area of 50-70 US$.
- If the picking error is detected by the recipient of the order and results in a customer complaint, then the typical processing costs for error handling and correction are in the area of 100 .. 150 US$. Additionally: The loss in customer trust is an intangible loss but needs to be added according to the companies' assessment.

Hence we propose that you add the effects of increased quality to the ROI calculation of your automation project.





Growth & Flexibility

Before we finalize this section, there are some additional aspects for you to document and specify early on: Growth and Flexibility.

Not every automated warehouse technology is easy to scale or ready to be adapted to different order structures or a new product range with changed characteristics. To be able to make the right choices later in the process it is important to analyze and describe your demands and expectations for growth and especially flexibility.

Growth is easy to describe and define, but what about flexibility? Here are some suggestions about what to look for in terms of flexibility:

Flexibility Aspect	Explanation	Possible Driver / Business Requirement
Order Structure	Distributing 1000 widgets @100 pieces each to 10 customers is a completely different warehouse operation as distributing the same 1000 widgets @1 piece each to 1000 customers.	• Change in customer behavior • Entering new distribution channels
Return Rate	Returns are a very inefficient form of goods-in. Therefore a change of just 5 or 10 percentage points of the return rate might have a huge impact on the warehouse operation.	• Change in customer behavior • Entering new markets (region and/or verticals) with different return rate levels • Providing new/ different services
SKU Range	A change in total count of SKUs but also a change of the SKU characteristics (size, weight, temperature requirements…) can have a major influence on the warehouse operations and equipment.	• Entering new markets (region and/ or verticals) with different SKU range • Change of the scope of supply

Important notice: in most cases automation of warehouse and distribution processes leads to reduced flexibility! A machine, a software algorithm is inherently less flexible than the corresponding human operation.

Therefore it is essential to ensure the future of your business by assessing your growth and flexibility requirements for the envisaged automation solution.

Bootstrapping your Project: How-To

Warehouse Automation is a broad topic and as such it is sometimes overwhelming, making it difficult to determine the best approach and starting point. This section aims at guiding you into the right direction and provide insights about the important first steps.

TIP: Make sure you have read and well understood the chapter **Deep-Dive "Why Automation?"** Have your notes at hand!

STEP 1 Documentation and analysis of your current warehouse operations

Your current warehousing and distribution operations are not only the obvious starting point. They actually provide valuable input for your automation project and most likely will also deliver the first wins in your project.
Create documentation of all your current warehouse and distribution processes. The emphasis is on **all**. You will quickly find out that there are many processes which happen every day but were never documented. The things that Jane or Joe do every day, but are not mapped in any process description or manual.
Please note: Only processes which are documented can be automated. Sometimes important activities which were never documented and hence are overlooked within the Automation project have the potential to break your new system and create a major disruption of your system ramp-up.

現場 Gemba!

How do you capture all activities, including the important, hitherto undocumented work by Jane or Joe? 'Gemba' (Japanese for "the actual place", "in situ") and a structured, diligent analyst who is not a business insider is your answer. Someone outside of warehousing and supply chain - who is not tempted to jump steps because he or she "already knows all this" - should follow real orders and processes step-by-step at the places where they actually happen ('gemba') and thus create a truthful documentation of all actual processes. Employ a person not too deep into the trenches of your current world of warehousing and supply chain, as immersing oneself in the actual processes is key to truly understanding them. The external analyst should resist the urge to skip steps, even if he/she thinks they've got it all figured out. Instead, they need to take the time to follow real orders from start to finish, observing each step as it happens on the warehouse floor. By documenting these real-world processes, they'll gain valuable insights and build a solid foundation for future analysis and improvement.

Think of it like an exciting detective story: the external analyst uncovering the hidden details of how a warehouse operates, and their detailed notes will be your most valuable clues.
While building that documentation you will already find the **first opportunities for process optimization:**

- Unnecessary activities
- Same activity performed twice (by different people / entities)
- Inefficient activities (using wrong tools or approaches)
- Repair activities for broken or missing processes

Although it is tempting to directly work on this goldmine of improvement opportunities you should restrict yourself to only:

a) Extremely important and high gain improvements.

b) Processes which you are sure will not be touched / modified by the future automation solution.

Chances are that some of the broken or inefficient processes will be either eliminated or drastically changed as a consequence of the new automation solution anyhow. Hence don't waste resources on fixing something which in some months might not even exist anymore.

STEP 2 Define Targets & Expectations

The section *Deep-Dive "Why Automation?* provided you with useful pointers where to look or what to expect when determining the targets.

But before defining your individual perspective on these different improvement vectors it is important to describe and define the plans and targets for your business. Don't think of automation, just think of how your business shall evolve in the next 3 to 7 years, e.g.:

- **Volume growth:** How much do you expect your sales and order volumes to increase in the coming years? Will it be gradual or a sudden spike?
- **Regional presence:** Are you expanding into new geographic markets? This can significantly impact your warehouse locations and transportation needs.
- **Type of services/offerings:** Are you planning to introduce new products or services that might require different storage or handling?
- **Change of verticals:** Are you considering venturing into new industries or customer segments? This might mean different order profiles and fulfillment requirements.
- **Availability of resources:** Will there be changes in labor availability or cost in your operating regions? This could be a major driver for automation.
- **Customer demands:** Are your customers expecting faster delivery times, more customization, or higher service levels?
- **Regulatory requirements:** Are there any upcoming changes in regulations or industry standards that you need to prepare for?

Now comes the difficult task: aligning and translating your business targets and planned developments with the specific targets and expectations for your warehouse automation initiative.

How do you translate "growth of the B2C E-Com share by 50%" or "introduction of a new product line for X" into warehouse characteristics and ultimately into the respective RfQ? Quite often your automation project will include the replacement and/or modification of existing warehouses and operations.

For this critical phase, it is highly advisable to engage the expertise of seasoned warehouse design and optimization professionals. Their specialized knowledge and experience will prove invaluable in translating your business objectives into actionable warehouse automation strategies.

To ensure effective collaboration with external experts, we have compiled a comprehensive guide in the "Deep-Dive" section dedicated to your first steps in automation see page 25 "Step 2".

Project Environment & Infrastructure

Every project, also your warehouse automation project, lives in an environment with its specific requirements and restrictions. Make sure to analyze and document:

- **The location, the property and building:** required or available size. Access and potential traffic restrictions. Required permits, future use of the area and connected areas, etc.
- **The available infrastructure,** especially when re-using or modifying an existing building: power supply, building loads, IT connectivity, Security, Labor Market, Social Developments, current and future legislation and regulation (global, regional, local), etc.
- **Global requirements with regard to sustainability.**
- **Situation and development of capital markets and/or company own resources to secure the long term capability of financing the project during all phases:** plan, build, run, maintain.

STEP 3 Get Some Quotes & Feedback

Based on the documents in Steps 1 & 2 above, reach out to potential suppliers and get some budget quotes. There are two very different approaches for this step and how to design the RfQ (Request for Quotes) and what it specifies:

1. **Solution-agnostic approach:** This approach involves defining the requirements and targets for the warehouse automation project in a general manner, without specifying a particular solution or technology. Thus allowing potential suppliers to propose a variety of solutions, potentially including innovative or niche approaches that may be more tailored to the specific needs of the organization.
2. **Solution-defined approach:** This approach involves specifying a detailed solution or technology stack in the request for quotation. While a solution-defined approach makes it easier to compare supplier offerings, it may limit the potential for innovative solutions. When you specify a detailed solution upfront, suppliers will likely base their proposals on meeting those exact specifications. Since the solution is already defined, there's less room for suppliers to offer unique or innovative approaches that might exceed your expectations. As a result, the main differentiator between proposals often becomes (sometimes only) the price.

Most industrial projects are based on a very specific and detailed RfQ. What is so special about warehouse and distribution automation that an RfQ shall actually just define targets and requirements without any specifications about the expected solution? Basically there is no science in designing the right solution for a given logistic request or targeted warehouse operation. Unlike applying the laws of thermodynamics and mechanics to design, for example, a combustion engine, the solution concept and dimensioning for warehouse automation is not based on defined engineering rules and approaches. This leads to many different solutions and concepts fulfilling the very same set of requirements and targets.

There might be a concept or technology which is only supported by very few vendors but which could be the perfect answer to your needs, much better than a generic design which can be supplied by many vendors.

Therefore let's dig a little deeper into these alternative approaches to design and define your RfQ.

Benefits of the solution-agnostic approach:

1. **Access to a wider range of solutions:** By not specifying a particular solution, you may be able to identify and evaluate more innovative or niche approaches that may be more suitable for your needs.
2. **Potential for better fit:** By allowing suppliers to propose tailored solutions, your organization is more likely to receive a solution that is specifically designed to address unique requirements and challenges.

Benefits of the solution-defined approach:

1. **Simplified comparison:** By specifying a detailed solution, offers can easily be compared based on the exact same criteria, making it easier for your organization to evaluate the different proposals.
2. **More potential suppliers and alternative sourcing:** a solution-defined approach tends to rely on well known building blocks which are typically provided by many different suppliers.

A middle way

A middle ground between these two approaches involves defining the requirements and targets in a more detailed manner than in the solution-agnostic approach, but still allowing some flexibility for suppliers to propose different solutions or technologies. This can help to balance the benefits of both approaches, providing a more structured process for evaluating proposals while still allowing for innovation and customization.

Here are some key considerations for determining the appropriate approach for a particular project:

1. **The complexity of the project:** More complex projects may benefit from a modularised approach to solution selection, by allowing and evaluating alternative solutions on a module basis. Such a module would typically be a functional area in the warehouse like "Goods-In" or "Manual Picking Zone" or "GtP (Goods-to-Person) Picking Module" or "Shipping".
2. **The organization's experience with warehouse automation:** Organizations with more experience may be more comfortable with a solution-agnostic approach, while organizations with less experience may prefer a more defined approach.
3. **The organization's willingness to rely on a vendor specific solution:** An organization that is willing to follow a vendor specific solution is increasing the dependence on that specific vendor and/or the capability to fully assess such an alternative solution.

Choosing the optimal path forward is a journey unique to your organization and project. Carefully evaluate the factors we've explored, and proactively engage with potential suppliers to gain a deeper understanding of their distinct approaches and capabilities.

The insights and perspectives gained from these discussions will be invaluable as you embark on the next phase of your automation journey, bringing you one step closer to achieving your vision.

STEP 4 Evaluation & Org Set-Up

The Symbiotic Relationship: Evaluation & Organizational Setup

Imagine you're building a house. You wouldn't finalize the blueprints (the organizational structure) without understanding the different types of materials and construction methods available (the evaluation). The same principle applies to warehouse automation.

1. **Quotes as a Learning Tool:** When you receive quotes for warehouse automation solutions, they're not just price lists. They're detailed proposals outlining different technologies, configurations, and workflows. Each quote is a potential roadmap for your warehouse's future.
2. **Impact Beyond Procurement:** Evaluating these quotes goes far beyond simple cost comparisons. It's about understanding the operational implications of each solution:
   - **Efficiency:** How much faster can you process orders?
   - **Storage Density:** Can you fit more inventory in the same space?
   - **Accuracy:** Will automation reduce errors and improve inventory management?
   - **Flexibility:** Can the system adapt as your business grows?
3. **Building the Right Team:** This in-depth evaluation requires a diverse set of skills. You'll need experts in:
   - **Warehouse Operations:** To assess how well each solution aligns with your existing processes.
   - **Engineering and Technology:** To understand the technical feasibility and potential challenges.
   - **Finance:** To analyze the return on investment and long-term costs.
   - **Project Management:** To oversee the implementation process.

Why Organizational Setup Can't Wait

1. **Informed Decision-Making:** By setting up your project team before the final evaluation, you ensure that the right people are involved in analyzing the quotes. Their expertise will lead to more informed decisions about which solution is the best fit for your specific needs**.**
2. **Smooth Transition:** Having your team in place early allows them to start building relationships with potential vendors, clarifying technical details, and preparing for a seamless implementation.
3. **Time Savings:** Delays in setting up your team can lead to bottlenecks later in the process. By starting early, you can avoid unnecessary hold-ups and keep the project on track.

The Bottom Line

In warehouse automation, evaluation and organizational setup are intertwined. Evaluating quotes is a critical learning opportunity that informs the structure and expertise needed within your project team. By aligning these steps, you'll set the stage for a successful automation project that delivers tangible benefits to your business.

Here is a brief overview of recommended team members:

Team member / Function	Remarks
Project lead	The project and hence the project lead should include the ramp-up phase of the automation solution for at least 6 months, better an entire year, after the formal hand-over by the supplier and start of the operational use. The candidate should have several years of relevant professional experience in warehouse automation with service providers, manufacturers or users of intralogistic systems. The candidate should have very good knowledge of logistics planning and technical intralogistics (materials handling, automation, planning of systems and equipment in intralogistics). The candidate should also have the ability to think in an analytical and logical way with a strong affinity for numbers and data.
Operations	As operating an automated warehouse or distribution center requires new skills and functions, Operations should be involved early. Recommended two project members from Operations are: • Manager or Deputy Manager of the new system. • Troubleshooter / error-station staff (many new, automation related features and procedures accumulate at error handling). Also Operations will play a vital role during system acceptance and ramp-up.
Human Resources	Operating an automated warehouse requires new skills on all levels, from warehouse manager to an order error station professional. Hence HR shall be involved early for recruitment or training programs.
IT	The most complex interfaces of an automation solution with your existing organization are with the IT systems. This includes all levels from networking and servers up to interfaces and modifications with the ERP system.
Procurement	No further explanation is probably necessary here.
Finance	Even if it may surprise you, the involvement of Finance is important especially for a warehouse automation project. To learn more about the specific tasks and responsibility of Finance in this context, please refer to the deep-dive section see page 33.

Before going into more details of evaluating the offers, you should be aware that you are not buying conveyors, stacker cranes or AGVs.

Your RfQ is for a solution.

It is through your solution / application glasses that you should look at the proposals and quotes received. The specifics of the types of equipment offered are of secondary importance. Obviously the quotes are a first opportunity to verify your ROI expectations. The next steps depend on your type of RfQ (solution agnostic or highly specified):

Analyze the proposed solution

Solution-agnostic approach	Solution-specified approach
Understand each specific solution and translate the solution elements with respect to your targets (“How does a module / function of the solution fulfill which of your targets?”).	Compare the offer with your RfQ and the specified solution. Is the offer within the scope of the specified solution (range)?
Do a conventional ROI calculation including the expected / guaranteed operation costs of all specific solutions offered.	Do a conventional ROI calculation including the expected/guaranteed operation costs offered.
Compare the offer with your RfQ using a check-list: which RfQ element is fulfilled, which is not?	Compare the offer with your RfQ using a check-list: which RfQ element is fulfilled, which is not?
Create an overall evaluation based on the three points above.	Create an overall evaluation based on the three points above.

Solution Simulation and Modeling

A solution simulation may be necessary to verify system performance, depending on the complexity of the solution. This is typically in the supplier’s interest and provides a valuable tool for evaluating alternatives and input parameter changes.

Analyze the potential supplier(s)

Equally important as the above described solution evaluation is the evaluation of the solution provider. Unlike the procurement of a widget or a bespoke machine the implementation of your warehouse solution requires scrutinizing the supplier at a much broader and deeper level.

QUESTIONS

Does the supplier’s long-term vision align with your company’s goals and values?

Will this supplier be the right partner for your key logistic processes and equipment for the next 5 to 15 years?

Are you feeling comfortable entering a long term collaboration and also dependency with this supplier?

How do they manage risks and unexpected challenges during implementation?

Do they have clear SLAs outlining response times and resolution procedures?

Trust your instincts. Do you feel comfortable communicating with the supplier’s representatives? Do they seem genuinely interested in your success?

First Steps

Make sure that you have read the introduction chapter for the First Steps before jumping into these deep-dive explanations.

STEP 1 Documentation & analysis of your current warehouse operations

The following is obvious and we will not spend a lot of text / your time for explanations: Before addressing the processes you should document the key numbers of your current warehousing operations (input-throughput-output flows).

Core Warehouse Processes & Associated Metrics

DISCLAIMER: Obviously the following is a proposal derived from a generic warehouse. Please evaluate before applying: does this specific data point makes sense in my current environment AND most likely also in the future, automated warehousing set-up?

1. Receiving (Goods-In)

Metrics

- **Cost of Receiving per Receiving Line:** Total cost (labor, equipment, etc.) per unit received.
- **Receiving Accuracy Percentage** of incoming shipments received without errors.
- **Receiving Cycle Time:** Average time from truck arrival to goods being available in the warehouse.

Purpose

Optimize labor allocation, identify cost drivers, ensure accuracy, and minimize delays in making goods available.

2. Putaway

Metrics

- **Putaway Cost per Line:** Total cost per item put away.
- **Putaway Productivity:** Units put away per labor hour.
- **Putaway Accuracy:** Percentage of items placed in the correct location.
- **Putaway Cycle Time:** Average time to put away a single unit.

Purpose

Improve efficiency, reduce errors, optimize space utilization, and ensure timely availability of goods for order fulfillment.

3. Storage

Metrics

- **Storage Density:** Cubic feet of storage space utilized per SKU.
- **Inventory Accuracy:** Percentage of inventory records matching physical counts.
- **Inventory Turnover:** Number of times inventory is sold or used in a period.
- **Carrying Cost of Inventory:** Total cost of holding inventory (storage, insurance, etc.).

Purpose

Maximize storage space, ensure accurate inventory records, minimize holding costs, and identify slow-moving or obsolete inventory.

4. Order Picking

Metrics

- **Picking Accuracy:** Percentage of orders picked without errors.
- **Picking Productivity:** Order lines or units picked per labor hour
- **Order Picking Cycle Time:** Average time to pick a single order
- **Order Fill Rate:** Percentage of orders.

Purpose

Improve accuracy, speed, and efficiency of order fulfillment, reduce labor costs, and enhance customer satisfaction.

5. Packing & Shipping

Metrics

- **Packing Productivity:** Orders packed per labor hour.
- **Shipping Accuracy:** Percentage of orders shipped without errors.
- **Shipping Cost per Order:** Total cost (labor, materials, etc.) per order shipped.
- **On-Time Shipment Rate:** Percentage of orders shipped by the promised date.

Purpose

Optimize packing and shipping processes, minimize errors, reduce costs, and meet customer delivery expectations.

Additional Considerations

- **Warehouse Layout:** Analyze travel distances and bottlenecks to optimize workflow.
- **Labor Utilization:** Measure labor productivity and identify areas for improvement.
- **Equipment Utilization:** Track equipment uptime and maintenance costs.
- **Safety:** Record incidents and implement measures to ensure a safe working environment.

By systematically tracking and analyzing these metrics, you'll gain valuable insights into your warehouse operations.

To ensure comprehensive system performance, it is essential to consider peak and unbalanced operational periods in addition to average values. Please document order profile variations, peak days/periods, and any deviations from average material flow values, such as goods-in peaks. Iterative simulations, where minimum and maximum values are adjusted, may be necessary to identify outliers and rare combinations that could unexpectedly disrupt or impede system performance.

More time and effort will be required to document all your processes. Please find in the following some pro-tips on how to attack this task.

1. **Document current processes:** walk along the process of receiving an order up to shipping. This includes also the documentation of the currently involved IT-systems and interfaces.

2. **Make sure to include all the parallel and also the non-standard processes** besides the straight forward process from goods-in to shipping. This includes:

- All replenishment activities
- Returns-handling
- All error cases and respective processing (you will be surprised how many there are, especially when using 'Gemba' and observing what actually is happening on the operational level)
- Handling of waste and also of damaged goods

Make sure to also **document some quantities and measurements** for the respective activities and processes:

- **Frequency of the process /activity**
- **Required FTE / time spent**

As your RfQ will also be based on the above, a good idea might be to ask potential suppliers for an evaluation of your documentation: is everything in there what is needed and with the right level of details and numbers?

STEP 2 Define targets & expectations

Please refer to the section "Bootstrapping your Project: How-To" for an overview of targets to specify. Obviously this document keeps it rather generic. Your business and your business-needs will provide the specifics.

So, how to find the right expert helping you to translate your targets and expectations into "warehouse and distribution language" and ultimately into a RfQ?

You should look for the following qualifications:

- **Experience with warehouse and distribution automation in your industry.**

  There is no such thing as a perfect automation project, especially not in warehousing. Processes are very diverse and often poorly documented - and sometimes also poorly understood. You don't want this to become unnecessarily complex by involving someone who does not know and understand the specific processes and requirements of your industry.

- **Someone who has been in your shoes before.**

  Even with a track record of several warehousing automation projects, don't rely on a consultant who never worked in the actual business of warehouse and distribution automation with direct operational line management responsibility.

  Your best option is a former head of warehouse operations or a former in-house project-lead for the same type of project. Your second best option is an experienced manager with an execution background from the other side of the business, from an integrator providing such solutions.

If that right expert does not come with the package offered by the logistic consulting company, you might want to consider a temporary engagement of the expert described above on your payroll. Don't forget, the project includes the ramp-up phase after hand-over of the new systems and hence represents a typical total duration of 15 to 30 months.

Please note: don't forget to also include the project environment aspects (see page 15) when defining and translating your targets into "warehouse and distribution language".

STEP 3 Get some quotes & feedback

The section "Bootstrapping your Project: How-To" provides you with some hints about the general approach. In essence:

Should you shop for either the best offers for a given solution / concept

or

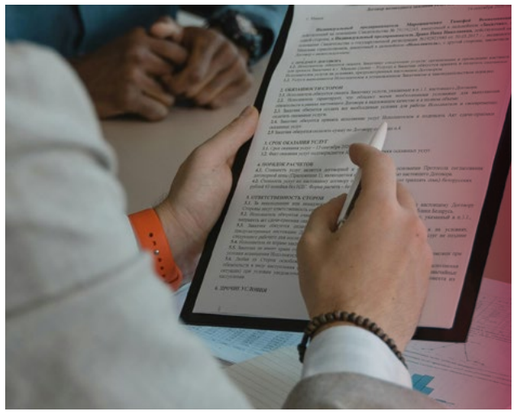
Should you shop for the best solution for given requirements / targets

After you made that decision and prepared your RfQ documents, the next question is "who should you invite to provide an offer?"

Warehouse Automation is a complex topic, hence the offers for an automated warehouse solution you receive will require substantial effort to analyze and evaluate. Therefore it is important to make a smart choice for the companies you invite to quote.

How to select companies to invite for a quote?

The first choice to make is: shall you go for one supplier offering both, the mechatronic equipment (the conveyors, storage/retrieval machines etc.) and the software (material flow controller, warehouse management and/or control system etc.) or should one supplier concentrate on software only, providing you also with more choices to split the mechatronics among different suppliers?



The following table provides you with some guidance for making this choice by looking at the different phases of your Automation initiative from start to sustained operations.

	Software & mechatronic equipment from the same (GC) supplier	Different suppliers for software & mechatronic equipment
Early project phase (definition of targets & solution types)	+ Less complex RfQ and offer evaluation	+ Broader choices + Different mechatronic solutions / suppliers can be combined
Project & implementation phase	+ Simple communication and project interfaces	- Much higher project managemen effort - Late scope or function changes are complicated (and more costly)
Ramp-up & sustained operations	- Dependency on the resources / capacity and deliveries of one supplier	- Longer and more complex ramp-up problems resolution - Long-term dependence on collaboration of different suppliers for upgrades and changes
Conclusion	If you find the right partner this is your perfect solution (very much like in a marriage)	You are less dependent on that one single supplier, but it comes with a price: the long-term management of different suppliers (in good and bad times)

Specific criteria to look for

The above table provides some generic criteria for the supplier set-up. Most likely your procurement organization will have additional supplier criteria to fulfill. Here are some warehouse automation specific criteria to look for with your potential supplier(s):

- **Most important:** references in your specific industry.
- **Is the supplier experienced with the requirements and processes relevant to your industry vertical?** Can peers in your industry provide positive feedback about the supplier, especially when it comes to long-term collaboration and support?
- **In case of the combination of several suppliers, e.g. one for software and one for mechatronic equipment: did these suppliers co-operate before?**
- **If you have existing systems (WMS, ERP), the criteria should include the supplier's ability to seamlessly integrate their solutions with your technology landscape.**
- **Is the top management team of the supplier stable or is the majority of the management team new to the company and/or new to warehouse automation?** Related to this: is there a fit between the culture and values of your company and of the potential supplier?
- You will rely on this supplier not only for the specific project but also for the sustained operation (e.g. maintenance) and optimization (change orders) of the automated warehouse. Hence we are talking about a partnership of typically 10 or more years.
- **How is the innovation track record of the supplier?** Is he demonstrating a continuous improvement of solutions and technologies?
- **Consider the supplier's commitment to sustainable practices, energy efficiency, and their overall environmental impact.** This aligns with growing corporate social responsibility trends.

Important advice: use the suppliers also as additional consultants. Ask them to challenge your assumptions and your targets. This will not only provide you with valuable input - free of charge - but also helps you evaluate the potential supplier: is the advice backed by relevant experience in your industry vertical, preferably demonstrated by an existing reference installation?

STEP 4 Evaluation & Org Set-Up

We have to start this deep-dive section with a "Never ever":

You should never ever take over the role of the integrator or general contractor (GC) yourself!

Never ever!

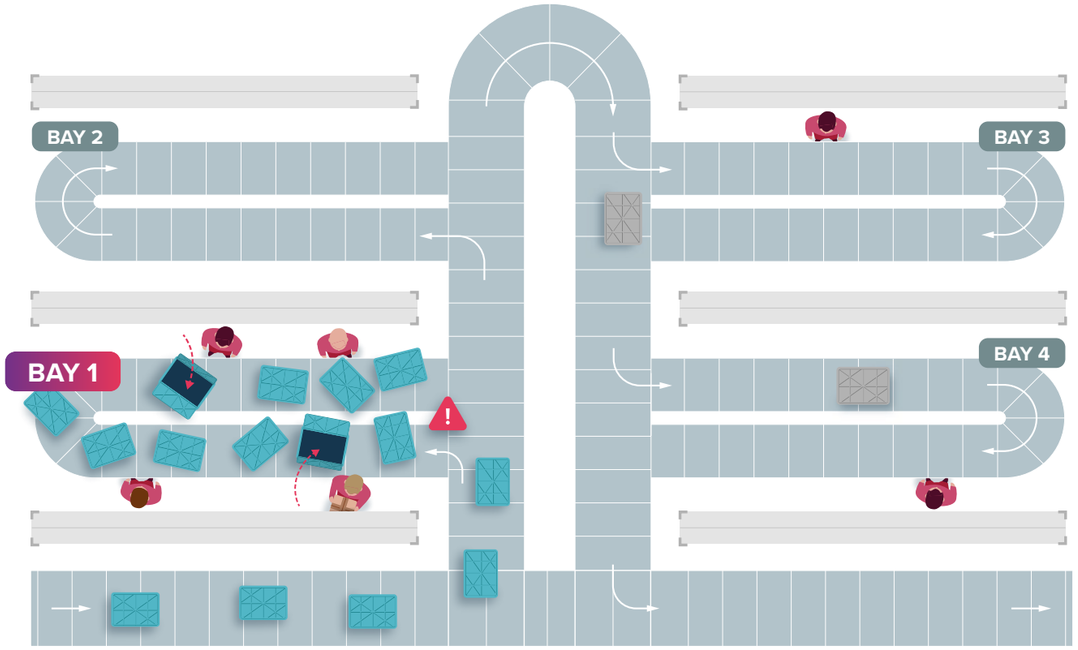
Often seen and very dangerous in this context is the triangle of **A) Logistic Consultant designing the overall concept, B) Software Provider delivering the solution specific WMS / WCS / MFC components** and **C) the Automation Equipment** provider delivering the automated equipment including the machine control level. You should never ever take over explicit or implicit integrator responsibility for such a triangle. Either the Software Provider or the Automation Equipment provider has to act as GC / integrator. **This includes also the final authority about the details of the solution and the solution design!**

The best way to illustrate why the GC needs the authority for defining the details of the solution let's use a real case:

The project was based on the mentioned triangle of A) Logistic Consultant designing the overall concept, B) Software Provider delivering WMS / WCS and C) the Automation Equipment provider delivering the automated equipment including material flow and machine control. This solution contains a manual picking zone with conveyors for transporting the order totes in and out of this zone (see drawing below). The main conveyor line and also the individual picking bays initially seemed well dimensioned for the calculated material flow and pick rates. Shortly after the real-live ramp-up of the system not even half of the designed system performance could be reached.

What happened? The operator of the system placed all fast mover SKUs in the racks at Bay 1 of the picking zone. As a consequence frequent overloads of this bay occurred with more order totes accumulating in this area than the pickers could process. This led to the backing up of totes not only within Bay 1 but also before this bay, waiting to enter. And in consequence even backing all the way up into the main conveyor line and blocking the entire material flow on the main line. As Bay 1 was closest to the goods-in / replenishment area the operator insisted that it shall be used for the fast movers. Nothing in the solution design documents of the Logistic Consultant, Software Provider or Automation Supplier mentioned anything about a required balanced distribution of SKUs between the 4 bays. The next steps in this project involved articulated finger-pointing between the parties, arguing that the other party would be responsible for considering this design detail and finally a costly litigation.

Hence either already with the initial RfQ or after the evaluation and refinement of the solution a clear definition of the roles / responsibilities and especially the GC / integrator shall be defined.



In chapter “Bootstrapping your Project” on page 12. we already looked at the evaluation process for the offers received to your RfQ. In this deep-dive section we want to emphasize the unique opportunities this project phase offers.

Often the negotiation phase with the 2 or 3 short-listed potential vendors is called the “honeymoon phase”. Actually correct would be the term “engagement phase” ending with a formal contract and the start of the project. Think of it like a prenup to prepare for bad weather or one-sided dependencies.

Make sure that the contract with the vendor(s) include the following safeguards for your system and your bottom-line:

1. TCO (Total Cost of Ownership)

For the cost-elements which are determined by the solution provider time and/or cost values shall be an integral part of the contract

a. **Energy consumption**

b. **Service effort (material and labor)**

c. **System availability and performance**

2. Guaranteed price level for future upgrades

Based on an agreed inflation factor / reference, price levels should be defined for

a. **Key mechatronic equipment components** (the list depends on your type of solution and equipment selections)

b. **Hourly rates for**

- Software engineering
- System engineering
- On-site works (mechanical and commissioning)

3. For the SCADA, MFC, WCS, WMS provider: guarantee that the experts who work on your project will also be involved for service / bug-fixing as well as potential future upgrades and modifications.

a. **The final system documentation** shall include the list of names for the respective key experts for the main software / solution modules.

b. **As these experts will be involved with other activities** after your project a reasonable reaction time and capacity - depending on the nature of your demand - shall be defined.

4. Support of the “train the trainer” - concept
Your operation team for the automated system will likely grow and sometimes also change more often than you anticipated. Therefore the training and respective documentation shall support you in doing in-house training including vendor accepted certifications.

The latter is important if the vendor requires certified technicians for some activities.

Please refer also to the section “Getting real” (see page 42) for further recommendations. Obviously the evaluation of the offers shall be based on the targets and environment conditions defined by your RfQ. At this point we will not repeat the evaluation criteria derived from the definitions explained in chapter “Bootstrapping your Project” above. Instead we would like to point your attention to some important additional deep-dive evaluation topics.

Focus area: software

All the processes, all the functionality of the new automated warehouse system are represented and concentrated at one place: the software. First, one should understand that “software” in this context means everything, from a machine level PLC (Programmable Logic Controller) type of code over sub-system and material flow control to overall warehouse management and control including all the interfaces to other software based systems and of course the human operators and managers.

Although it is everywhere and managing all the processes and automated activities, software is the most difficult part to evaluate. Practically every supplier claims that the offered software suite is modular, uses state-of-the-art technologies, is safe and flexible.

Depending on your type of solution and equipment your software stack will be different. Our recommendation is therefore to focus less on specific vendor defined modules but let your needs, your processes lead the evaluation. Think of a table with two columns:

- **Column 1** contains your processes, your targets and expectations. We recommend grouping this column by functional areas or domains like “Goods-In”, “Shipping” or “Replenishment”.
- **Column 2** represents the evaluation of the proposed software solution and components with respect to the requirements defined in column 1.

Here is an example. DISCLAIMER: your specific list most likely will look extremely different)

Functional Area/ Domain	Requirement/Target/Expectation	Proposed Solution Evaluation
Goods-In	Automated ASN (Advance Shipping Notice) processing Real-time visibility of incoming shipments Integration with existing WMS Mobile receiving capabilities	Module/feature: [Name/Description] Dashboard/reporting: [Details] Integration method: [API/EDI/etc.] Device compatibility: [Android/iOS]
Storage	Optimized putaway strategies (e.g., zone picking) Dynamic slotting based on demand/velocity Inventory tracking across multiple locations Cycle counting optimization	Algorithm/logic: [Description] Functionality: [Yes/No/Partial] System accuracy: [Percentage/SLA] Feature: [Name/Description]
Picking	Efficient picking routes/algorithms (e.g., batch picking) Wave planning optimization Real-time order status updates Integration with shipping carriers	Algorithm/logic: [Description] Functionality: [Yes/No/Partial] Dashboard/reporting: [Details] Integration method: [API/EDI/etc.]
Shipping	Automated packing list generation Shipping label printing and carrier integration Load optimization and truck scheduling Returns management and processing	Feature: [Name/Description] Integration method: [API/EDI/etc.] Functionality: [Yes/No/Partial] Module/feature: [Name/Description]
Reporting & Analytics	Customizable dashboards and reports Key performance indicator (KPI) tracking Real-time alerts and notifications Predictive analytics capabilities	Reporting engine: [Name/Capabilities] KPIs included: [List] Alert types: [Email/SMS/etc.] Functionality: [Yes/No/Partial]

Default Values/Comments

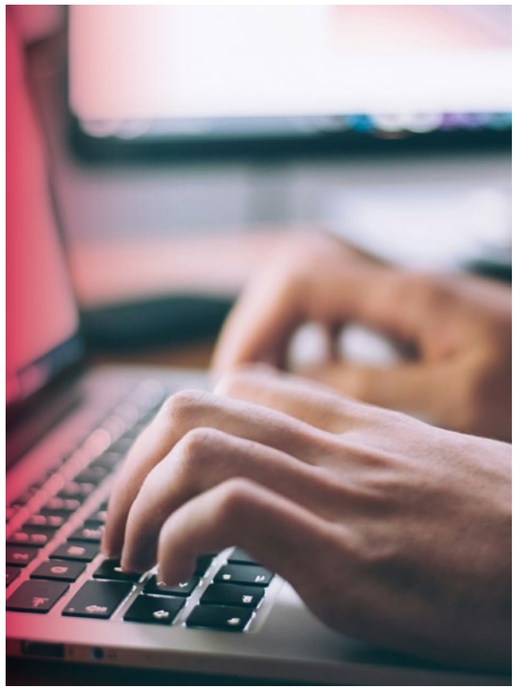
- In the “Proposed Solution Evaluation” column, start by entering the names/ descriptions of relevant modules or features offered by the vendor.
- For functionality questions, you can use “Yes,” “No,” or “Partial” (if the feature is partially present).
- For integration methods, specify the type (API, EDI, etc.) and any relevant details.
- For system accuracy and SLAs, include any percentages or guarantees provided by the vendor.

Customization:

- Feel free to add or remove rows as needed to reflect your specific warehouse processes and priorities.
- Consider adding columns for “Importance” (High, Medium, Low) and “Vendor Score” (1-5) to help prioritize requirements and compare different vendors.

At this point you might want to include a software architecture and technology expert into the evaluation process:

- With respect to the potential future additional or changed requirements: is the software architecture an enabler or a potential blocker for flexibility and scalability? Consider all levels from PLC/machine controls over SCADA / material flow up to general warehouse management and control including interfaces and communication.
- Maintenance and exception handling: which means are proposed and which means are potentially additionally possible? Again, consider all levels from PLC/machine controls over SCADA / material flow up to general warehouse management and control including interfaces and communication.
- Cyber Security and Data: Both are by nature moving targets. The security thread landscape is changing almost daily. Also your requirements and the requirements of your supplier(s) for access to data for analytics or also monetarization will evolve. The choices made for software architecture and technology will also determine what is covered already now and what could be included or considered in the future.



You will want to re-use all the intelligence and documentation created above when you have to evaluate the actual implementation of your automated warehouse solution. This should be driven by use cases derived from the above. More on this in the section “Getting Real”.

Additional important considerations for your check list:

- **User Interface (UI):** Intuitive and user-friendly interfaces for operators and managers to interact with the system, monitor operations, and access reports.
- **Data Security:** Robust security measures to protect sensitive data (inventory, customer information, financial transactions) from unauthorized access, breaches, or loss.
- **Scalability:** The ability of the software to adapt to changing business needs and growth, allowing for the addition of new equipment or functionalities without major disruptions.
- **Maintainability:** Clear documentation and modular software design to facilitate updates, modifications, and troubleshooting.

Either your in-house IT expert or an external expert, preferable with experience in software for automated intralogistic systems, shall help you look behind the glossy software sales brochures, e.g.:

Test the claimed modularity

- Is the logic and data layer really decoupled and could the database be changed to a different product?
- Which different HMIs (Human Machine Interfaces are supported? Is the same type of functionality / HMI available on different platforms and/or hardware devices, like touchscreens, keypads, mobile devices, voice commands?

Ask for detailed specifications and descriptions of the safety concepts:

- Is the safety specified / verified according to relevant norms? Which ones?
- Can the supplier show you the work process and regulations for managing access to your system and data?
- Which technology and which methods are used for remote access? Will you get access to remote access logs?

Challenge the claimed flexibility of the software:

- Create some realistic scenarios of future processes and use and ask for a rough assessment of feasibility and effort / costs. Preferable this should be scenarios which are already on your radar for the possible future.
- Do a late change in your specs / processes and ask for a revised quote. Is the effort reasonable and the delay acceptable? If not, you might want to dig-deeper into the claimed flexibility of the software architecture and technology.

And as always: ask your peers from your industry or customers of the potential supplier from other industries what they think about the suppliers software products. This shall include an assessment of the software team in terms of know-how, efficiency, flexibility and availability. Are there areas of the software which are only mastered by that one guru-type expert within the team?

A GENERAL ADVICE

When doing the final choice for the supplier(s) make sure that your eventually required access to the source code for all software on all levels (from machine up to WCS/WMS) is safeguarded against any potential supplier troubles by an escrow agreement.

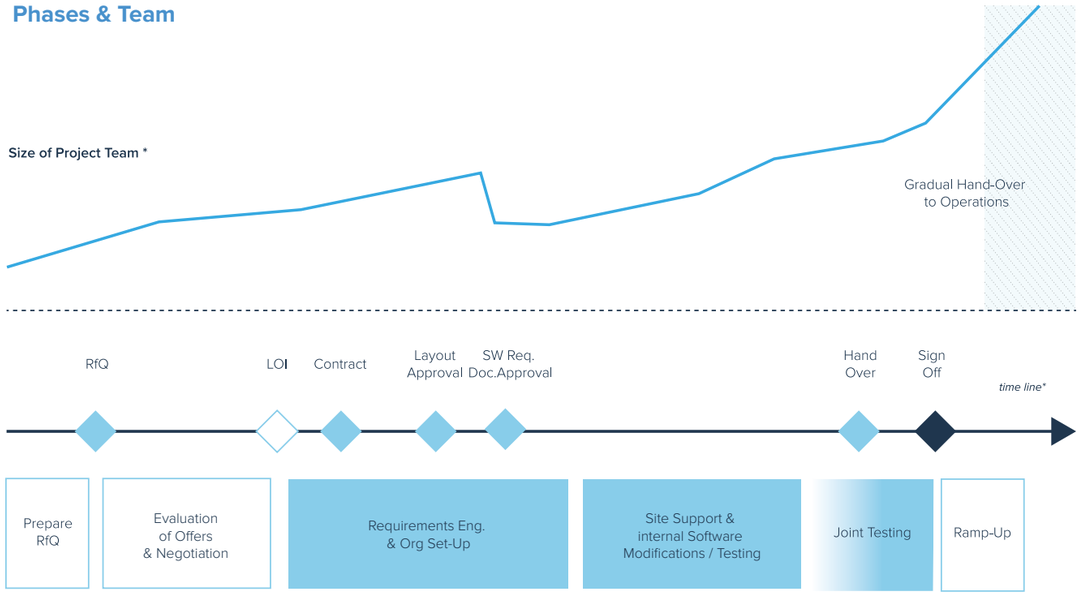
Beyond comparing offers with the defined targets and required material flow etc. think also about:

- Is the offer and the sizing of the solution derived from a systematic analysis and calculation - shown and explained to your team?
- Ergonomics / work environment
- Risk evaluation (what elements of the solution are critical and could potentially compromise your targets?)
- Digitalization and data access / ownership
- Flexibility and scalability of the proposed solution
- Also: what is not included in the offer, either not being mentioned at all or declared as an option?
- Project plan and team: does the offer include a sound presentation of the project execution plan and the team set-up? Is the role and responsibility of your organization and team clearly defined?

Which brings us to the deep-dive of your own organization Set-Up

The following graphic provides a summary of the activities and milestones described in this document. At the same time it also outlines the dynamic nature of your automation project team. Different phases of the project will not only require different experts but also the total headcount of the automation project team will vary considerably over time.

Warehouse Automation Project Phases & Team



*not to scale!

In the section Bootstrapping your Project: How-To and the respective Deep-Dive we already explained who is needed to get you to the RfQ milestone. Therefore in the following let's concentrate first on who is needed to reach the milestone "Contract" and the two design approval milestones.

From RfQ to Layout Approval: During this project phase the following three persons shall form a triumvirate for detailed planning and definition of your automation solution:

- **Project Lead**

  Ensuring that all aspects are considered and synchronized. With a special focus on topics not covered by the following two colleagues.

- **Operations Manager or Operations Expert**

  As the principal internal customer and user of the solution shall validate and determine all operations related decisions and definitions.

- **IT-Manager or IT-Expert**

  This role goes way beyond all interfacing and synchronization aspects with the IT environment. For example the incorporation of financial / accounting requirements (see also the box at the right). Also this person is your guardian for all Cyber Security aspects of the warehouse automation solution.

Why Include Finance/Accounting in Warehouse Automation Planning?

Warehouse automation is great for speeding up work and keeping track of everything digitally. But it can also cause problems if not planned carefully.

Imagine a worker puts a box in the wrong place. The computer system thinks the item is missing and stops anyone from ordering it. If this mistake isn't fixed, the (ERP) system might even tell the accounting department to remove the item from the company's records. This can mess up financial reports.

The Key Takeaway:

It's crucial to involve people from finance and accounting when planning your warehouse automation, for example when it comes to inventory error handling. They understand how the system affects money and record-keeping, so they can help prevent costly mistakes. By working together, you can create a system that's both efficient and financially accurate.

This triumvirate will then pull-in additional experts and stakeholders. Think of:

- Building and infrastructure
- Maintenance
- Human Resources for recruitment and training requirements
- Sales and Customer Service (new or changed processes and services offered to the customers)

Most organizations will also install a Steering Committee on top of the project organization. Depending on your company culture this might be an important tool to facilitate the conquering of potential obstacles or for the approval of change orders / scope enlargements.

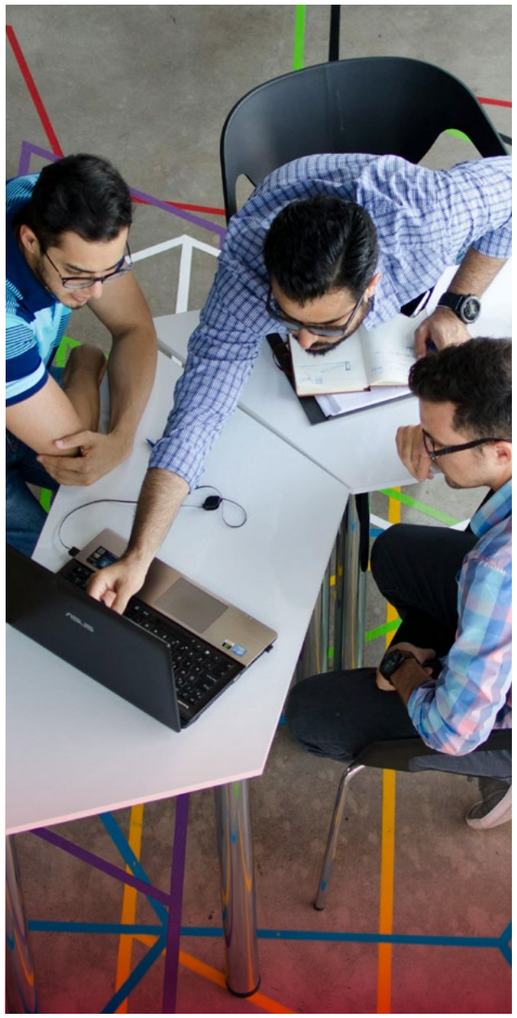
After the design approval milestones are passed a phase is reached where actually the project team is temporarily reduced. Depending on the size of the project and the lead-times of the supplier(s) this phase typically takes 3 to 6 months.

To be followed by a rapid and substantial increase of the project team and topics to be covered in parallel. Most suppliers will overlap the installation of physical equipment on your site with the implementation and testing of software interfaces. Both activities require involvement and support by your project team.

As soon as real warehouse processes are tested, both physical and virtual activities, many additional resources are required:

- Operators performing the tests
- BTW this requires these operators to be trained before-hand. Also auxiliary equipment which was not in the scope of the main supplier(s) has to be available, etc.
- Test material and test data
- Experts monitoring and documenting the tests

Be prepared for this phase being the start of many surprises and overlooks. Don't worry, this happens to everyone and to every warehouse automation project. Some more, and some less. The key is to be prepared for it: The above mentioned triumvirate shall be represented by the respective experts to quickly answer and resolve upcoming issues. Some of these resolutions will result in refinements of earlier design decisions. Make sure to properly document all issues and the respective resolutions. The further you progress towards



system hand-over and the start of actual customer orders, the more heated projects sometimes get.

The start of customer orders is typically accompanied by the hand-over or at least the transfer of perils for the system. Please note: this does not represent the formal sign-off for the system. The last section of this document, "Getting real", will provide you with some recommendations dedicated to this very important milestone.

At this stage, and coming back to the graph on the previous page, we want you to make aware of the continuing growth for the required project team.

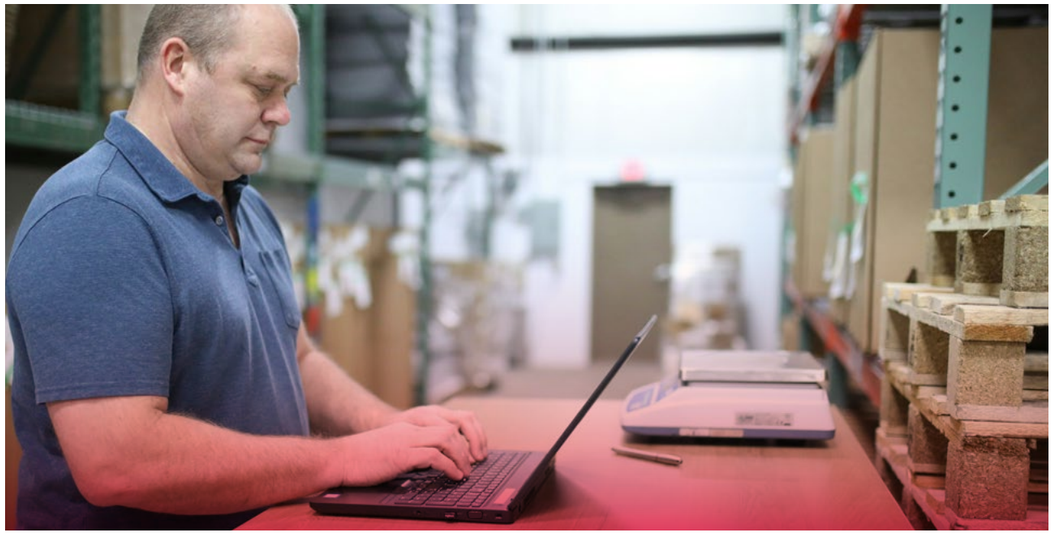
Quite often you will need, at least temporarily, even more people than with your previous non-automated warehousing solution

Not only during joint testing but also in the middle of your ramp-up you will encounter new exceptions and errors. For example an operator might wrongly assign a fast-moving item to a slow-mover picking area in the master data of your warehouse management system. A simple error which will manifest itself as an operational overload in that area. Most likely you will need several experts to detect the root-cause and a lot of feet on the ground to cope with the operational challenges until the root-cause is fixed.

Over time the training level of the operations team will increase, software bugs will be ironed out and mechatronic equipment issues will be fixed. Be prepared to begin on a bumpy road for your ramp-up and thoroughly monitor and fix issues for quickly getting on a smooth highway.

Not to forget that proper documentation is the basis for qualified claims with the supplier(s).

Experience from many automation projects actually has good news beyond just a smooth highway. More on this at the end of the section "Getting real".



Understanding Automation

This section provides an overview about the aspects and most common concepts for warehouse automation.

It is not meant as a “To Do”, rather as an overview to better understand the topic and especially be more educated for your interactions with industry experts / consultants as well as potential suppliers.

Automation for warehousing and distribution centers actually follows a rather simple logic. There are 4 areas of automation which build logically on top of each other:

LEVEL 1 Electronic Communication & Information

Replacement of paper based picking lists and stock checks and updates with electronic information transfer by means of e.g. WMS/WCS, wearable computers, pick-by-light, pick-by-voice or augmented reality.

The benefits of Level 1 automation:

- No time-consumed for paper printing / distribution
- Less errors
- Higher pick-rate
- Immediate picking feedback order update / alternatives
- Online inventory update

LEVEL 2 Transport Automation

The main objective of transport automation is the elimination or reduction of human operators walking. It is not possible to execute warehouse activities like picking, packing or counting items while the operator is walking. Hence walking is the No. 1 efficiency killer. That is why there are so many different automation solutions for transport, like conveyors, mono-rail tracks, overhead conveyors or self-propelled transport devices like automated guided vehicles (AGV) or autonomous mobile robots (AMR).

As a conveyor and an AGV/AMR basically fulfill the same task - transport from A to B - the following overview shall help you better understand the characteristics of these two concepts.

Conveyor or AGV/AMR?

Conveyor	Automated Guided Vehicle/ Autonomous Mobile Robot
+ Cost efficient	+ Scalable performance
+ High performance / throughput	+ Flexible *e.g. adaptable to different load-units,* *e.g. change of routing*
+ Easy to operate / maintain	+ Conveying path is free for other passages / transport devices
- Layout fixed	- Complex management of empty vehicles (where to hold AGV/AMR capacity when)
- Blocking of pass-ways / space	- Especially for high throughput applications more expensive than conveyor based transport
- Performance not scalable	

LEVEL 3 Automation Of Storage & Retrieval

An automated storage and retrieval system (ASRS or AS/RS) consists of computer-controlled machines for automatically placing and retrieving loads from defined storage locations. These machines and the corresponding solutions come in various forms and shapes.

Important: The choice of AS/RS concept / technology determines like nothing else what your warehouse will be able to do or not to do, now and in the future!

Why is this component of your warehouse solution such an important building block influencing many other processes and capabilities?

First off, obviously the type and dimension of the AS/RS machines and load handling devices determines the **range of load units which can be operated.** Think of everything from pallets or other bigger unit-loads over cartons of different sizes and weights to plastic boxes or even individual cases/crates or products.

Secondly, the type and technology of the AS/RS determines the **dynamics of the storage sub-system.** "Dynamics" simply means, how many load-units can you access in a given time? If your future process might require access to over 500 different items per hour, then obviously a technology which can not scale beyond 250 items/hour is not the right choice. For example a shuttle based AS/RS provides a higher dynamic than a stacker crane solution, but at higher costs per location.

Finally, some AS/RS solutions are more **flexible and scalable** than others. Basically this relates to the following criteria or parameter of the storage sub-system:

- Capacity in terms of number of storage locations
- Flexibility in terms of locations heights or location size (also relates to the capabilities of the load handling device of the AS/RS machine)
- Dynamics / Through-put: some solutions allow for the addition of machines to increase the performance, some don't.
- Layout / Access: some solutions allow for changing / adding interface locations to the storage sub-system, some don't.

Therefore the following list of criteria to look and ask for is essential.

Criterion	Explanation
Load unit flexibility	How many different load units can be stored? *Especially for mini-load: different tote sizes and cartons?*
Typical storage capacity	System dimensioning limitations (max. height, storage depth etc.) determine typical storage capacity
Throughput / dynamics	Measured in Double Cycles / hr / 1000 storage locations *The throughput has to match the ABC curve of your SKU access requirements (today and future)*
Applications	From overstock / slow-movers over goods-to-person (with low to high access frequency) up to shipping buffers
Flexibility / Scalability	Size, dynamics, application (see above)
Costs	Costs per storage location (fully installed incl. Controls, Software)

LEVEL 4 Automated item handling

The handling of SKUs by machines or robots for picking, packing, stacking, de-stacking, layering or de-layering, inspection, counting etc. is called automated item handling.

Currently the most common application extensively using automated item handling is the **mixed case palletizing** used for Grocery B2B distribution. Rather than handling one individual product item, like one bottle or one can, mixed case palletizing handles cases or trays containing multiple items.

Robotic piece picking grips individual product items, like one bottle or one shirt or one spare part. Obviously this task is much more complex than the above mentioned case picking as the variety of product characteristics is enormous, even within one industry vertical. Just think for example about the different shapes and sizes of shampoo bottles. And then add all the other product types and possible variants within each product type for this example which just addresses products of one industry vertical of FMCG (fast moving consumer goods). A typical warehouse / industry vertical comprises between 50 000 and 500 000 different items. In light of this broad variety of product or packaging characteristics, currently no robotic gripper, no machine vision solution can match the capabilities and flexibility of the combination of human hands, eyes and brain.

Goods-to-Person

Sometimes you will also read about “Goods-to-Person” or “Sorting / Buffering” as being one level of automation.

Goods-to-Person (GtP) is a warehouse automation solution that optimizes order fulfillment efficiency. This system leverages a combination of storage, retrieval, and transport automation technologies to deliver products directly to operators at dedicated workstations. By eliminating the need for manual item retrieval, GtP significantly reduces walking time and physical strain on workers, resulting in increased productivity and improved accuracy.

GtP is particularly effective for picking medium-velocity items, often categorized as the B-area in the ABC analysis of SKU access frequency. This system is ideal for handling small to medium-sized items that can be easily picked with one hand.

Key Advantages of GtP

- **Enhanced Productivity:** By eliminating non-value-added activities like walking and searching, operators can focus on picking and packing tasks, resulting in higher throughput.
- **Improved Accuracy:** Automated product delivery and guided picking processes minimize human error, leading to improved order accuracy and customer satisfaction.
- **Ergonomic Benefits:** Reduced walking and lifting contribute to a safer and healthier working environment for employees.

Implementation Considerations

Product Profile: GtP is best suited for warehouses with a significant proportion of medium-velocity SKUs and small to medium-sized items.

- **Warehouse Layout:** Implementing GtP may require adjustments to the warehouse layout to accommodate automation equipment and optimize workflows.
- **Technology Integration:** Effective GtP implementation relies on seamless integration of storage, retrieval, and transport systems with warehouse management software.

By strategically implementing GtP, businesses can achieve significant improvements in order fulfillment efficiency, accuracy, and employee well-being. It is a valuable tool for warehouses seeking to optimize their operations.

LEVEL 4+ Sorting / Buffering

There are many different solutions and technologies which are summarized as “Sorting and/or Buffering”. The most commonly sorting solution used is a cross-belt, tilt-tray or sliding-shoe diverter before the shipping area for typically cartons to different shipping areas or delivery routes. A sorter technology like the Pouch-System also works very nicely as a buffer and thus enables the usage for sorting as well as for returns processing.

Finally, sorters are a key enabler for two-stage picking solutions where the first stage represents a very efficient bulk pick (for different customers or targets in parallel) and in a second stage the sorting is used to distribute to individual orders.

Getting Real

This section addresses the phases happening after the supplier(s) is chosen, the contracts are signed and the actual implementation project kicks-off.

Obviously project management and project execution are the key topics to concentrate on when getting real. There is plenty of excellent advice out there for literally every aspect of project management and execution. We compiled a list of some really good industrial project management literature for you - see below. We will therefore concentrate here on the specific challenges and hints related to the warehouse automation aspects of your project.

RECOMMENDED PROJECT MANAGEMENT LITERATURE FOR YOU

GOLDRATT, Eliyahu M.: ***Critical Chain***

KERZNER, Harold: ***Project Management: A Systems Approach to Planning, Scheduling, and Controlling***

BERKUN, Scott: ***Making Things Happen: Mastering Project Management***

In the deep-dive section “First Steps” we already recommended the installation of a “triumvirat” representing

- Overall project management and coordination
- Operations
- IT and interfaces with other company stakeholders

Most likely overlapping with the final contract negotiations is the joint requirements engineering with the supplier(s) for two important deliverables:

1. The solution design, namely the layout of the system

The sign-off of the layout is the basis for the procurement and manufacturing activities of the suppliers. It always has to be based on a material flow analysis and calculation established by the supplier(s), derived from the target values provided by you (SKUs, orders, order structure etc.). Larger and especially more complex projects (e.g. automatic full-case picking with shop-ready shipping or solutions with multi-stage picking) typically also require a simulation to verify the physical dimensioning of the system. Make sure that your team fully understands the layout, the dimensioning and the calculations which were used. If the supplier(s) made any assumption about the system operation or its interfaces / boundaries, ask for a detailed documentation of such assumptions (remember the example from page #27: *The best way to illustrate why the GC needs the authority for...*).

2. The software requirements document

This document is the single most important deliverable for your warehouse automation solution. It defines both,

- all the processes implemented and available for the warehouse operation and the warehouse management and control
- all the functions, monitoring, interfacing etc. for the mechatronic equipment of the system

Therefore you will have to invest a lot of know-how and time of your best experts to ensure the quality and value of this document.

PRO-TIP

Don’t fall for the temptation to send the employee with the most available capacity instead of your best expert. As this document is such an important deliverable you would pay later for this short-cut.

As the software requirements document addresses many different aspects of your new system, it is recommended to include at least the following experts from your organization for the respective discussions with the supplier(s):

- **Maintenance and infrastructure** With a special focus on the mechatronic equipment and all functions and data for both, reactive and planned maintenance or optimization.
- **Operations** Covering all aspects and processes from goods-in over storage and replenishment to picking, packing, quality control, shipping and capacity planning including all error situations and exceptions.
- **IT** Addressing not only all the interfaces but also looking at the transition from legacy systems and data to the new solution. Also other aspects like Cyber Security, Data Protection and Backup as well as Access and Data Usage shall be covered with respect to specific software requirements definitions.

Acceptance Procedures

Both of these documents are the starting point for the preparation of the acceptance procedures. We recommend scanning both of the requirements documents topic per topic, paragraph per paragraph and deduce the respective use cases. This sounds a bit abstract, let’s illustrate with some examples:

Examples for System design/layout:

- Most likely there will be a safety fence around an automated storage and retrieval system (AS/RS). Obviously this implies one or more safety doors for access. In terms of acceptance you will then not only look for the physical equipment check as such, but also create one or more use cases for the functionality of the safety door, including interfacing and monitoring by the respective SCADA or system visualization tool.
- If the system includes equipment with a belt drive, then the acceptance procedures shall include use cases for the respective preventive and reactive maintenance of such belts (replacement, tensioning, belt tracking etc.)

PRO-TIP

In order to save time and costs, some of the above acceptance use cases can be conducted during and as part of training provided by the supplier(s).

Examples for Software Requirements:

- A PLC maintenance panel typically provides tools for error handling like resetting a fault or manual routing of a load-unit. The respective use cases will describe real world (error) scenarios and check the respective PLC maintenance panel software support.
- Every planned or unplanned status change of any pick-order, replenishment-order etc. of the warehouse represents a use case to be tested during acceptance.

Best-practice for use case design

Use cases shall be grouped by functional areas like “Goods-In”, “Shipping” and “Replenishment” or by a sub-system or tool like “Conveyors” or “Maintenance panel for AS/RS sub-system”.

A use case typically follows this structure:

- General (e.g. definition of the object(s) and the main task)
- Material Flow (e.g. for through-put checks)
- Preconditions
- Functionality
- Results
- Error handling

Some complex use cases will have multiple levels of definitions of each of the above lines.

The collection of all the use cases is the first step for preparing your system acceptance procedures. Although some of them might be rather complex, at the end they represent in essence a list of individual check-boxes. Hence the acceptance and test of the entire system as such is not covered by the use-cases.

As there are two excellent sources available for addressing the **entire system acceptance** we will not repeat the respective contents here but refer to these two important documents:

- FEM 9.222
- VDI 4486

We recommend reading and using both of these guidelines. Yes, both address the overall system acceptance. But they use different methods and also have a different scope. In short:

- FEM 9.222 is more comprehensive and provides guidance beyond the overall system performance and availability assessment. Also the FEM guideline allows for better drill-down, especially in case of performance deviations.
- VDI 4486 follows kind of an end-of-the-pipe approach for the (sub-) system performance measurement and is a great tool for the combined assessment of performance and availability.

This is the perfect opportunity for reminding you to be prepared for surprises and deviations. Basically a warehouse automation system addresses three dimensions: people, processes and technologies. Your people, on all levels, will require a learning curve to understand and master the new tool, the sometimes complex warehouse automation solution. You will end up in a situation where the system will not do or deliver what it is supposed to do. There are many reasons why this could happen and therefore you should be prepared for it to happen. The above is a selection of tools and procedures for addressing such deviations in a structured way.

IMPORTANT: Back-up and availability

One important aspect of surprises and deviations during the system acceptance and especially also during the operational ramp-up is not yet addressed: the back-up and availability of your legacy warehouse and distribution solution. Typically you don’t jump from nothing to a full-blown automated warehouse solution. Most warehouse automation projects represent an enhancement (performance, costs, quality) or replacement of existing manual operations and infrastructure. Don’t fall for the often seen overly optimistic time plan for switching from the legacy solution to your new automated solution. **Be prepared for having an overlap of both operations for 3 to 12 months.** The larger and more complex your new solution, the longer the planned overlap period shall be.

Hence be prepared for a temporary “overshoot” of required people for ramping up the new system while in parallel maintaining partially or entirely your legacy operations. Which brings us to two important Pro-Tips:

PRO-TIP

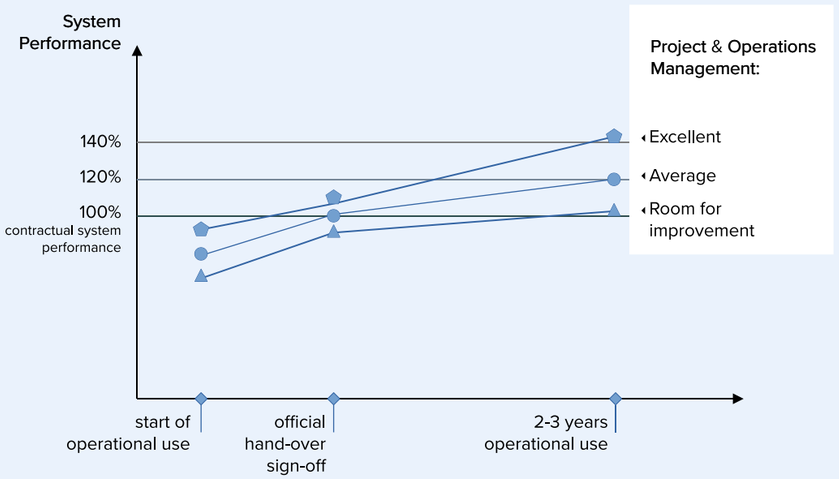
Get an early start for your mechatronic maintenance team by integrating them with the installation teams of the supplier(s). Not only is this a perfect first-hand opportunity for learning about the new equipment. The direct interfacing of mechatronic experts on the day-to-day operation level will provide your team access to insights and recommendations not found in the official documentation or training material. Even if you can’t reach an agreement with the supplier(s) for the compensation of these additional installation resources provided, it will be labor well spent!

PRO-TIP

Don’t fall for the temptation to entice experts from your supplier(s) to join your operations and company. Unless such a move is explicitly part of the deal and was negotiated and agreed up-front of the project realization with the supplier(s). Remember: you are in a long-term relationship with your automation solution provider(s). Don’t damage the relationship right at the start by stealing valuable resources.

One final positive aspect of your new automated warehouse: experience shows that the vast majority of warehouses achieve substantially higher performance and quality levels as specified for the system. At least for those users who maintain a continuous optimization process beyond the initial ramp-up period. Typically these users achieve 2 to 3 years after initial go-live performance levels of 110 to 130% compared to the contractual system specification.

Experience from numerous automation projects:
Good teams achieve > 130% of the contractual / as-sold system performance



Glossary

Some important warehouse automation “nerd terminology”

ABC curve

The ABC curve is a tool for categorizing your inventory.
In logistics the three categories are:

A-movers := ➜ SKUs with high turnover / frequent demand
B-movers := ➜ SKUs with medium turnover / medium demand
C-movers := ➜ SKUs with low turnover / low demand

AGV

Automated Guided Vehicle

A self-propelled transport device which follows predefined paths (refer also to -> AMR) to transport load-units or trailers (in case of automated tow tractors). AGV come in many different forms and shapes, e.g.

- automated forklift truck (allowing for also manual operation)
- AGV with lift and forks (like a forklift truck but without manual driver option)
- transport platform with or without a conveyor as load area
- tugger truck for pulling of trailers
- plus many SKU / vertical specific variants with special load-unit interfaces like paper-drum holders, integrated lifting tables or special workpiece fixtures etc.

AIV

Autonomous Intralogistic Vehicle

To overcome the overlapping and sometimes unclear distinction between an ➜AMR and an ➜AGV the industry association FEM (www.fem-eur.com) introduced the term AIV, representing any form of autonomous vehicle used in an ➜intralogistics environment regardless of the specific technology or form.

AMR

Autonomous Mobile Robot

A self-propelled transport device which navigates autonomously, typically using references marked on the floor or optical markers on columns or radio beacons. AMR come in many different forms and shapes, e.g.

- transport platform with or without a conveyor as load area
- transport platform with lift and forks (like a forklift truck but without manual driver option)
- tugger truck for pulling of trailers
- plus many SKU / vertical specific variants with special load-unit interfaces like paper-drum holders, integrated lifting tables or special workpiece fixtures etc.

AS/RS

Automated Storage and Retrieval System

A machine or sub-system which automatically stores and retrieves ➜ load-units

Intralogistics

The part of logistics (material and information) which happens within the boundaries of a company or within the boundaries of a physical site.

Load-unit

A Load-unit is any form of carrier used in the system holding one or typically several SKUs / items. Most common load-units used are:

- pallets (Euro-Pallet, CHEP-Pallet etc.)
- trays
- bins / totes
- cartons

with dimensions from something like 150x150 mm (small cartons) to 1200x800 mm (Euro-Pallet) and even beyond for large trays used for example in furniture warehouses.

MFC

Material Flow Controller

A software which plans and executes all automated transport tasks within an automated warehouse. It interfaces with the higher level management software levels like WMS / WCS and the equipment controls for the execution of the transport tasks

Negative picking

Negative picking is a means for picking efficiency when the required quantity is substantial (typically more than 1 digit) but slightly less than the available quantity within a (multiple pack) SKU or staging unit.
Example: a carton to be picked from contains 100 pcs of the required SKU, but the ordered quantity is 95 pcs. Then the most efficient solution is to take 5 pcs out and pick the entire carton with the remaining 95 pcs (provided that the warehouse processes and software allow to do so).

Overstock

Inventory which is not used for current picking operations within the warehouse.
For example if an ➜SKU is picked at a flow rack with a capacity of 5 cartons but your delivery to the warehouse was 20 cartons. Then the remaining 15 cartons are stored in a separate overstock area.

SCADA

Supervisory Control And Data Acquisition stands for software and hardware components of systems used for controlling, monitoring, and analyzing industrial devices and processes.

SLA

Service Level Agreement

A service-level agreement is a formal contract between a service provider and a customer that outlines specific aspects of the service, such as quality, availability, and responsibilities. The primary purpose of an SLA is to ensure that the service is delivered as agreed upon in the contract. These agreements typically include technical specifications like mean time between failures (MTBF), mean time to repair (MTTR), and mean time to recovery (MTTR). They also specify which party is responsible for reporting issues, paying fees, and maintaining various performance metrics.

SKU

Stock Keeping Unit

It is the unit of measure in which stock or material is handled within a warehouse or distribution center. It is different from an item or article as the same item or article can be translated into different SKUs, mainly by packs of multiple items. Hence a shrink wrapped pack of 6 widget represents a different SKU as one individual item of the same widget. Also it means that one SKU can be translated into another SKU, e.g. by breaking up a package (see also ➜negative picking).

WCS

Warehouse Control System

The WCS coordinates material handling sub-systems such as picking-zones, storage subsystems or carousels, scales and sorters. Facilities with automated material-handling hardware often have a warehouse control system (WCS) that integrates with a warehouse management system (WMS) to provide management with a comprehensive view of the warehouse.

WMS

Warehouse Management System

A Warehouse Management System (WMS) is a software tool designed to streamline and optimize the day-to-day functions of a warehouse or distribution center. This system enhances operational efficiency through a suite of features or applications, including goods receipt, storage optimization, precise inventory tracking, periodic stock verification, efficient task organization, strategic order preparation, task assignment, picking and packing processes, restocking, dispatching, workforce oversight, premises supervision, and integration with automated equipment for material handling.

Thank you!

Which brings us to the end of this whitepaper and our recommendations for your warehouse automation venture.

Can we please ask you for a favor? If there is any aspect or topic which you are missing and which should be part of this whitepaper or if there is anything which you feel different about, please let us know and drop us a quick message. We are eager to hear from you and improve this little document.

Max Winkler

max.winkler@winkler-technology.com

Ruediger Hagedorn

r.hagedorn@theconsumergoodsforum.com