LAYOUT PLANNING AND OPTIMIZATION WITH VISUAL COMPONENTS

How 3D manufacturing simulation can help you increase flexibility, reduce costs, and improve production performance.

V VISUAL
COMPONENTS

What Is Layout Planning?

Layout planning is the discipline of designing an effective facility layout that prioritizes worker safety and wellbeing, facilitates streamlined processes and ensures the production of high-quality products — all while simultaneously allowing for quick and easy modifications. It involves the optimal usage and placement of all resources including personnel, equipment, materials and storage space to facilitate a smooth workflow in the production process. Considering the savings that can be realized from a well-planned layout, and the heavy costs that can be incurred to address a poor facility design retrospectively, there's a strong incentive for manufacturers to implement sound layout planning from the beginning of a new project [1].

A well planned and optimized layout offers several benefits:

- It ensures the layout design is functional and achievable and prevents mistakes or surprises further along in the process.
- It streamlines the flow of materials through the plant, maximizing throughput while reducing material handling costs and capital bound in unfinished goods / inventories.
- It ensures the effective and efficient utilization of labor, equipment, and space, helping manufacturers to reduce both CapEx and OpEx while maximizing use of plant resources.

Layout planning can and should be used when planning both new production projects or changes to existing production systems.

[1] Okpala, C. and Chukwumuanya, E. (2016). Plant Layouts' Analysis and Design. ResearchGate.

The Layout Planning Process

There are many books, methodologies, and best practices on the subjects of layout, factory, and facility planning; this has been an area of interest by academics and practitioners since the 1950s. The methodology we present here is a simulation-based approach to layout planning, design, and optimization. It's based on existing approaches to layout planning and grounded in on our experience of having worked with and supported several manufacturers on projects throughout the years.

The methodology we've outlined in this guide consists of the following steps:

1. **Define the manufacturing program**
2. **Equipment selection**
3. **Initial layout design**
4. **Define the flow**
5. **Validate the model**
6. **Layout optimization**

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1 DEFINE THE MANUFACTURING PROGRAM

Defining the manufacturing program involves considering the key drivers for the project — such as customer requirements, sales expectations and product mix — in order to define the product portfolio and production requirements for the project, such as production volume and lead time.

The next step is to define the structure of the manufacturing system[2]. Here, planners determine the abstract and theoretical steps, as well as the resources that are required to assemble a product. This includes buffers, possible control strategies, the selection and definition of functional subsystems as well as the production principle.

The goal for this phase is to define the key elements of the layout: production principle and strategy, product and manufacturing requirements, and the production sectors. This will lay the groundwork for the next steps.

[2] Hawer, S., Sager, B., Braun, H. and Reinhart, G. (2017). An Adaptable Model for the Factory Planning Process: Analyzing Data Based Interdependencies. ScienceDirect.

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2 EQUIPMENT SELECTION

Oftentimes, the next step is equipment selection, at least for critical or high-value equipment. In addition to manufacturing and material handling requirements, equipment must meet the project's financial objectives, such as ROI and total cost of ownership. Operational Equipment Effectiveness (OEE) is another important and closely monitored metric tied to ROI.

Depending on your organization's budget and purchasing requirements, as well as the availability and diversity of equipment suppliers that cater to your applications, there may be a broad or narrow range of options available. Some projects have firm requirements for certain equipment brands or to use existing available equipment, while others offer more flexibility.

For projects with tight cycle time requirements or space constraints, it might be necessary to first virtually validate the layout and workflow with the equipment. If you're deciding between multiple equipment options, try to obtain the CAD models of the equipment that you're considering. You can also check if the equipment is available in the Visual Components eCatalog, or request CAD data from the equipment suppliers. This way you'll have accurately sized models when designing and analyzing the layout.

Next, the quantity of equipment is estimated. In general, the goal is to achieve the project goals without overspending on equipment. Planners should take into account operational considerations, such as production volumes, number of SKUs, station setup times, planned downtime and maintenance, and shift models, in order to make an initial estimate on the quantity of equipment needed. This can be validated when simulating the workflow.

Discover what's available in the
Visual Components eCatalog

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3 INITIAL LAYOUT DESIGN

One of the first steps in layout design is to develop an accurate model of the space or facility. 2D drawings and point cloud models are both good sources of data that can be imported directly into Visual Components. Alternatively, you can model your space using Visual Component's simple CAD modeling toolkit. If vertical clearance is a concern for the project, it's important to accurately model the space in 3D.

For larger projects, a next step might be to determine the space requirements for the production sections or areas. The size of production areas can be approximated via key figures for area estimation (e.g. for producing 200 parts per day, about 5,000 m^2 of space is necessary). These production areas should be designed and labeled in the layout.

When it comes to designing the initial layout, the goal is to come up with a functional and achievable layout of equipment and resources that accommodates the production flow. Equipment should be placed in the correct position and orientation, and stations, walkways, buffers, fixtures, and spacing requirements should all be factored into the design. If the project includes human workers, they should also be included in the layout.

With Visual Components, this initial layout can be designed using components from the eCatalog and/or CAD data, which you can import directly into software. It's common to use comparable components from the eCatalog to represent processes and equipment that won't have a material effect on validating the layout design but help to simulate the flow. CAD models can be used to represent fixtures and equipment, but they aren't simulation-ready until their behaviors and properties have been defined in Visual Components, so appear as static. It's common to use a combination of simulation-ready components and CAD geometry to design the initial layout.

For some projects, especially robot cells, it's often possible to design layouts using mostly components from the eCatalog.

The eCatalog includes more that 1,400 simulation-ready robot models from 40+ brands, as well as end effectors, parts positioners, etc. to design your cell

See what you can do with our eCatalog
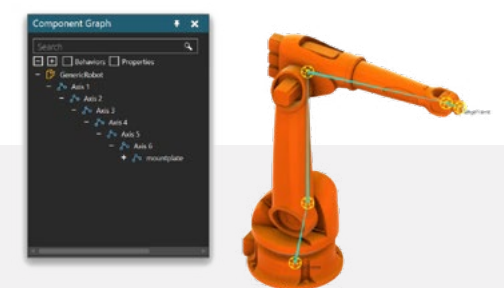
If the robot or peripheral you're looking for isn't in the eCatalog, you can model it in Visual Components

Modeling Robots with Visual Components

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4 DEFINE THE FLOW

In defining the production flow, planners must specify the production processes, the sequence of processes, and the capacity and availability of resources and spaces. Planners should also consider the following:

- Process times, batch sizes, control logic, shift models, equipment setup / down times, and scheduled maintenance should all be modeled in.

- Routings for people, forklifts, and AGVs should be defined.

- Feeder rates (or distributions) of parts entering the system and priority assignments for parts and / or resources should be checked.

- If there are processes with randomness or meaningful variability (i.e. arrival of parts, loading/unloading times, process times, etc.), this should also be factored into the model.

Another important consideration is the extent to which physics should be modeled into your simulation. The material properties of parts can influence important decisions such as batch sizes, equipment selection, handling procedures, and speeds / acceleration rates. If you believe the interactions of parts and resources in your model could have a meaningful influence on their kinematics or dynamics, then it's advisable to define their physical properties. Visual Components utilizes the NVIDIA PhysX physics engine, which allows users to simulate and visualize functionality affected by physical forces, such as collisions, gravity, and material properties.

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5 VALIDATE THE MODEL

To **validate the model** means that the assumptions, operating philosophy, process flow, operating and material handling specifications, input data analysis, and runtime parameters for the model have been accepted by the project stakeholders. It should account for the variables, logic, boundary conditions, and special cases that drive the model and outcomes. If the project is to replace an existing production system, it can also be used as a source to validate the new production system.

An important consideration is ensuring the model is focused on the correct level of detail. For example, if you're planning to expand a palletizing cell in a large packaging facility, you might create a model of only that cell and area, without including the upstream and downstream processes (unless you're also considering changes to the layout or operation of those processes).

For many robotics applications, it's helpful at this stage to perform reachability, collision, and cycle time analyses of the different robot models under consideration. If you're still deciding between different robots, ensure your model works with the different robot options. This includes using correctly sized end effectors and dimensioned cells and verifying the robot can perform the required tasks taking collision-free paths.

You'll likely have to iterate through several changes to the layout and / or production flow in order to arrive at a valid model. Especially for projects with more complex requirements, the final model can look very different from the initial estimate.

Find out how to intuitively teach tasks to a robot and validate the design of the robot work cell with the Visual Components

Simple Robotics Toolkit

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6 LAYOUT OPTIMIZATION

With the validated model, you can conduct experiments to identify optimizations. Layouts can be optimized to achieve a number of improvements, including:

- **Reduce use of space**
- **Reduce travel distance for parts and resources**
- **Reduce investment in resources (equipment, labor, etc.)**
- **Reduce non value-added work, waste, and material handling costs**
- **Reduce WIP and minimize inventories**
- **Improve line balancing**
- **Improve flexibility**
- **Improve safety**
- **Increase OEE**

The improvements that can be realized from layout optimization can be substantial, and there are many examples of manufacturers that have used simulation to achieve significant savings in new manufacturing projects. Here's a **case study** about a major white goods manufacturer that

used Visual Components to achieve impressive results in the design of a new a flexible assembly line, including:

- **15% reduction in total costs**
- **10% reduction in floor area**
- **45% reduction in labor**
- **20% improvement in line balancing**
- **10% increase in production capacity**
- **Reduced reject ratio from 1200 defects per million (dpm) to 120dpm**
- **20% reduction in construction schedule**

In some cases, typically projects with more flexible production requirements, it's useful to consider multiple layout options. Taking this **scenario-based approach**, planners test different production scenarios (e.g. fluctuation of customer demand, number of product variants, etc.) against different layout variants (e.g. low automation, medium automation, high automation), optimize each layout, then choose the best variant.

Summary

Layout planning is part-art and part-science. Good planners are able to draw from experience, best practices, and oftentimes past mistakes, in order to have some good ideas on where to start with a new project. Great planners know the limits of their experience; they take a disciplined approach to the planning process and use data to inform their decisions.

Using a combination of careful planning and simulation to design and optimize production layouts, manufacturers are able to achieve significant financial and operational benefits, including improved flexibility, reduced costs, and improved performance. Visual Components 3D manufacturing simulation software provides planners, engineers, and management with a powerful and easy-to-use platform on which to plan, design, optimize, and visualize production layouts.
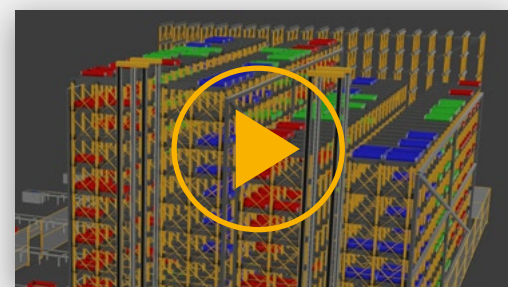
Design, Optimize, and Visualize New Production Solutions with Visual Components
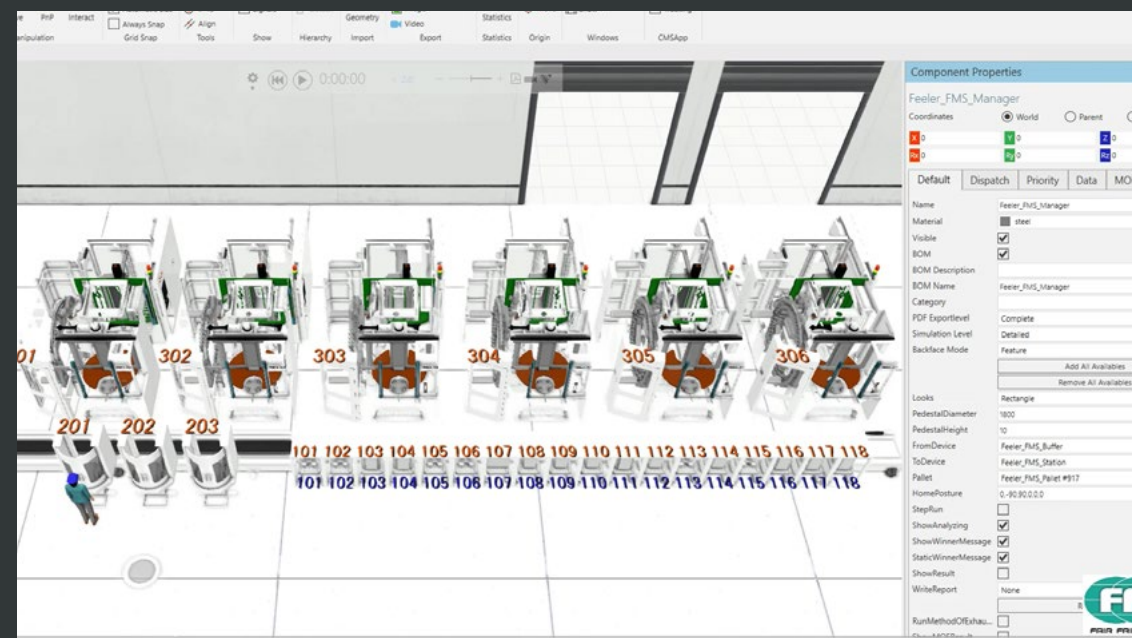
Demo Layouts Created with Visual Components
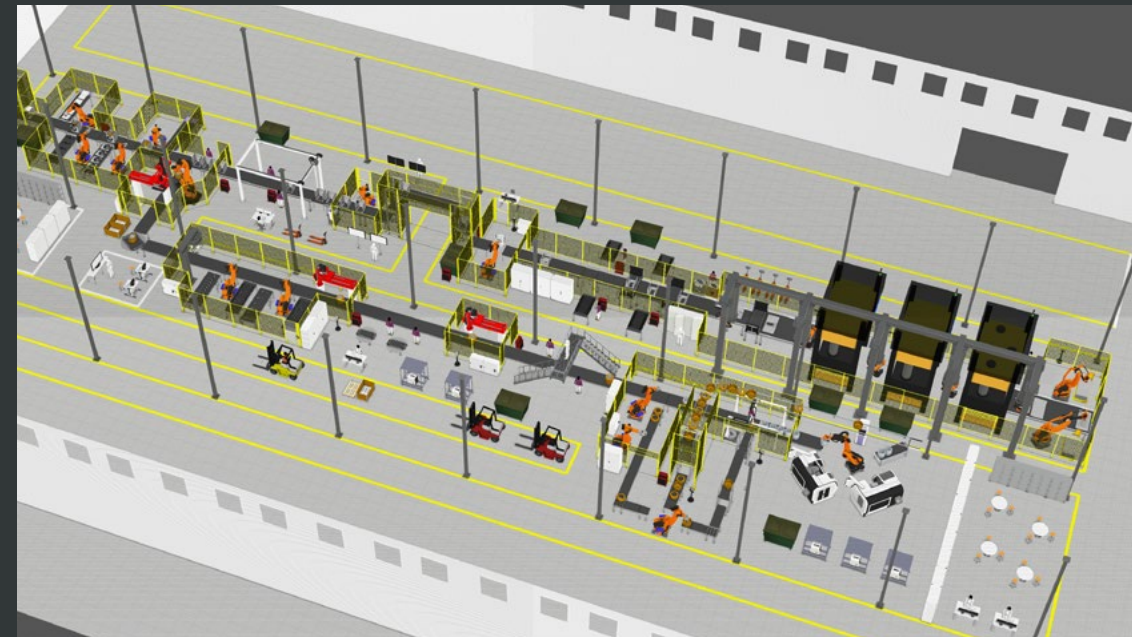
▶ Midea Group
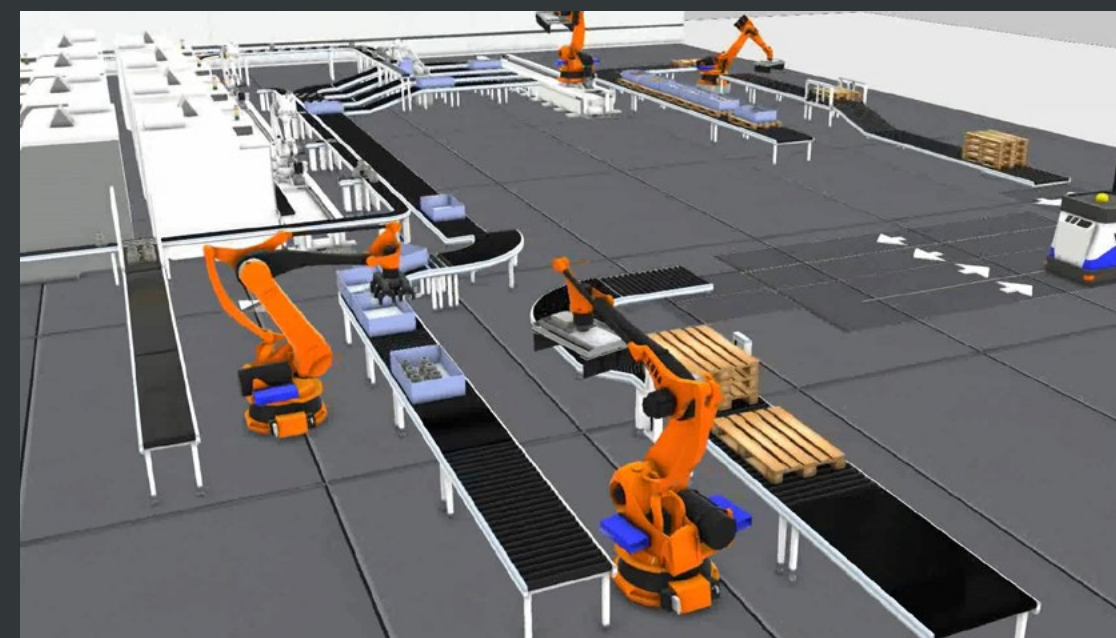Increasing the capacity and flexibility of a high-end washing machine assembly line

▶ Virtual Manufacturing
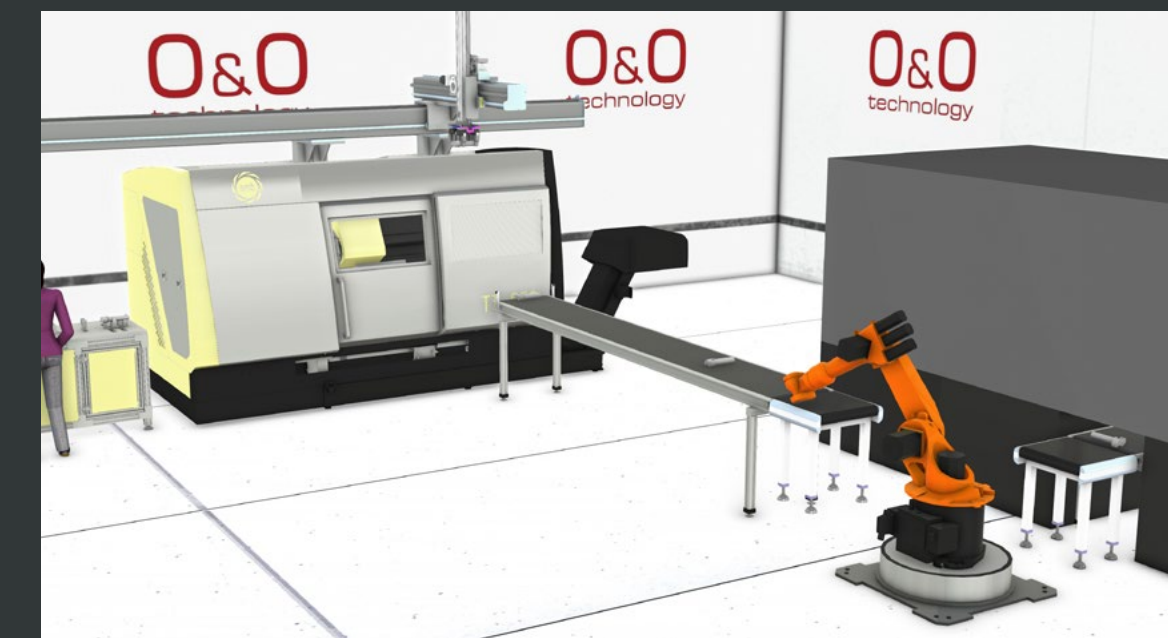Driving Sales of Lean Manufacturing Products with 3D Simulation
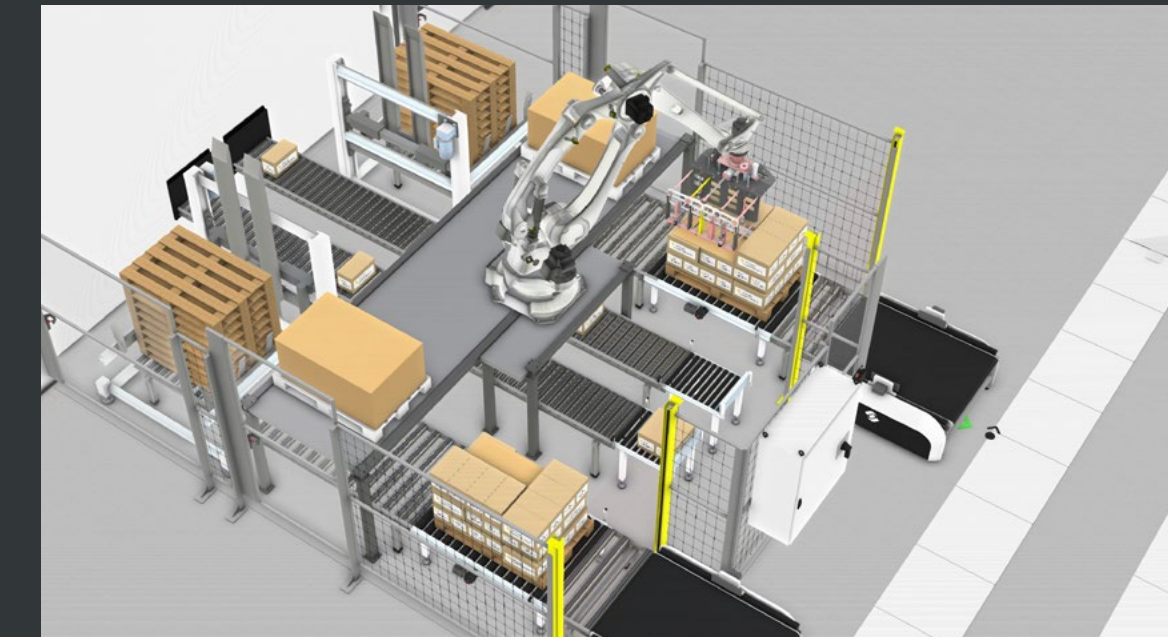
▶ JSC Savushkin Product and Concern R-Pro
Packaging Automation in the Dairy Industry

▶ FFG Feeler
Designing and optimizing a Flexible Manufacturing System

▶ Cambridge Automation Simulation
Simulate your production workflow

▶ O&O Technology and SMB Technic
A Winning Partnership Lands a Key Project with an Automotive Supplier

Want to find out how **Visual Components** 3D manufacturing simulation solutions can help you save time, reduce costs and improve production performance?

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