

Streamlining factory simulations with an intuitive factory layout tool

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Abstract. Complex factory layouts can be improved by performing optimization on the layout in discrete event simulation packages. Creating models of complex factories in these simulation packages can, however, be very time-consuming and generally requires a highly skilled operator. This work proposes an intuitive factory layout tool that greatly reduces the time required to create a factory layout in simulation packages, allowing optimization and simulations to be run with greater ease. By lowering the skills level required, the tool allows for the client to be part of the simulation loop, thus enabling faster iteration between different layout options.

1 Introduction and background

1.1 Introduction

Factories are complex environments where many different processes are integrated to produce products. Producing products as quickly and efficiently as possible is beneficial to any factory, so the industry goes to great lengths to optimize factory lines.

Factory line optimization is often achieved by creating a model of the factory in a discrete event simulation package, where various parameters can then be adjusted and optimized to achieve a superior factory design and/or layout. This process of creating a model of the factory is very time-consuming as the factory itself and each object in the factory must be created to scale and manually placed in the correct position in the 3D environment of the simulation package.

In this paper we present an intuitive web-based factory layout tool named Plananator, which simplifies and speeds up the creation process of a virtual factory, allowing simulations to be more readily performed. This factory layout tool allows users to import a floor plan, specify or calculate the scale, draw walls, and place machines to scale in 2D on the imported floor plan. A machine list, specifying the dimensions of different machines, is imported to ensure that machines are placed with the correct scale. Once the user is satisfied with the layout, this can be exported to a discrete event simulation package, in this case, Tecnomatix Plant Simulation [1], to perform the required simulations and execute “what if” scenarios.

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1.2 Background

The main objective of the Factory Layout Tool is to offer an easy-to-use, cloud-based, interactive tool that can support a "client-in-the-loop" functionality where clients with limited or no knowledge of discrete event simulation tools can collaborate and contribute to the creation of a digital twin representation of a factory layout. The software tool uses a Software-as-a-Service (SaaS) framework, and the cost depends on the available capabilities required for each contract. Siemens defines a digital twin as follows:

“A digital twin is a virtual representation of a physical product or process, used to understand and predict the physical counterpart’s performance characteristics. Digital twins are used throughout the product lifecycle to simulate, predict, and optimize the product and production system before investing in physical prototypes and assets” - Siemens [2]

A real-world and digital-world representation is illustrated in **Figure 1**. The digital twin representation captures elements of the real world and enables the optimisation of the real factory process. The core 'value add' of the Factory Layout Tool is to replicate the factory layout in the most efficient way and to capture the customer's domain knowledge during the creation process.

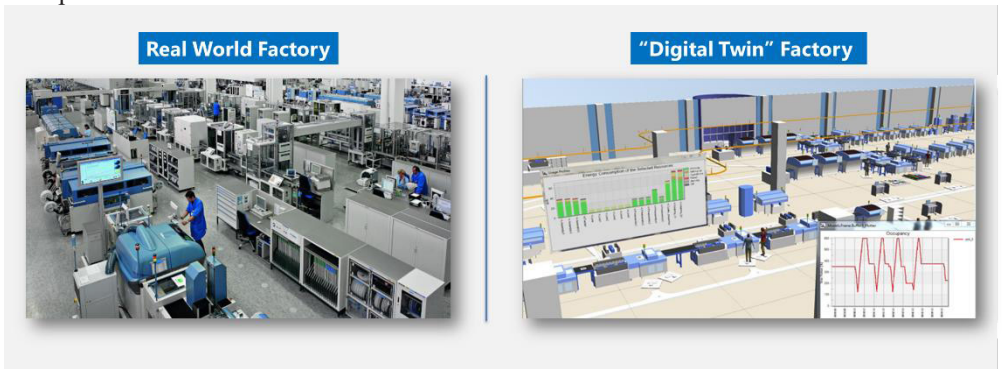


Figure 1: Real World Factory / Digital Twin of a Real World Factory [1]

The proposed software stack is illustrated in **Figure 2**, where the Factory Layout Tool user interface and data pre- and post-processing capabilities enable the customer to create 3D models, thereby extending the discrete event simulation tool’s current capabilities.

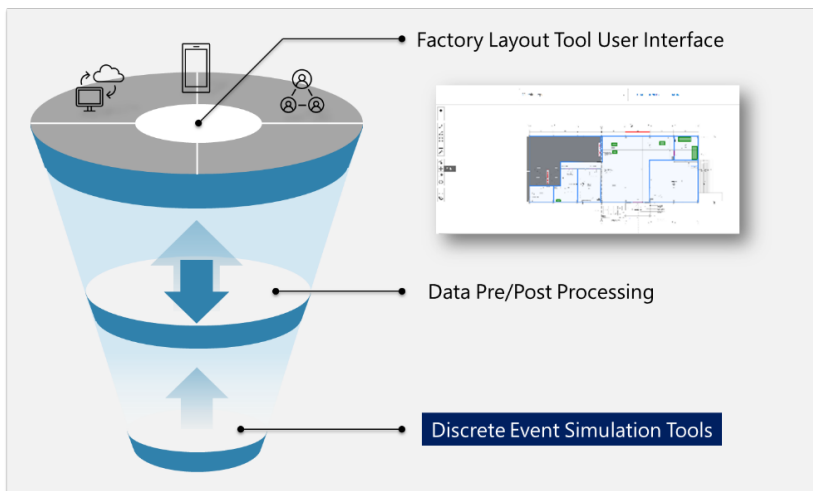


Figure 2: Factory Layout Tool Software Stack

Figure 3 illustrates the data exchange between the Factory Layout Tool user interface and the Siemens PlantSim discrete event simulation tool. The ability to simplify the usage model for the client/end-user of the discrete event simulation tool was an important design parameter during the development of the capability.

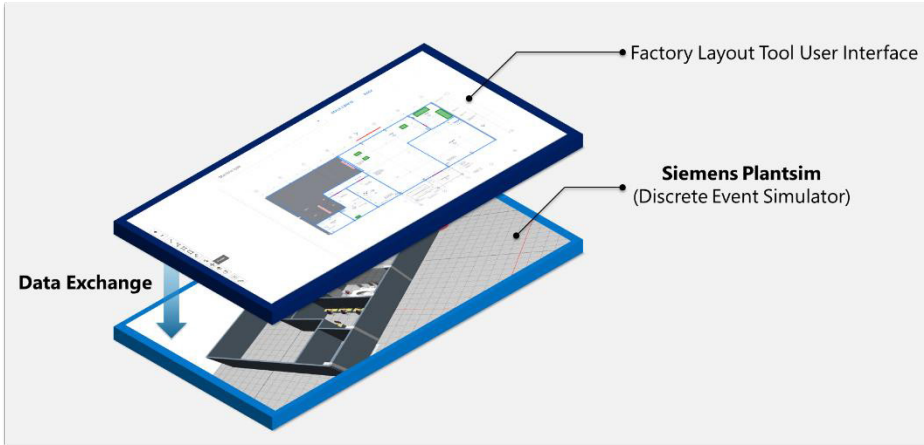


Figure 3: Factory Layout Tool User Interface Data Exchange Model

An illustration of the "client-in-the-loop" methodology is shown in **Figure 4**, where the client can iteratively interact with the discrete event simulation tools and continuously improve the factory layout design or explore different what-if scenarios regarding the layout. The factory layout tool will thereby abstract the core layout functionality of the discrete event simulator tool and simplify the usage model of these types of tools.

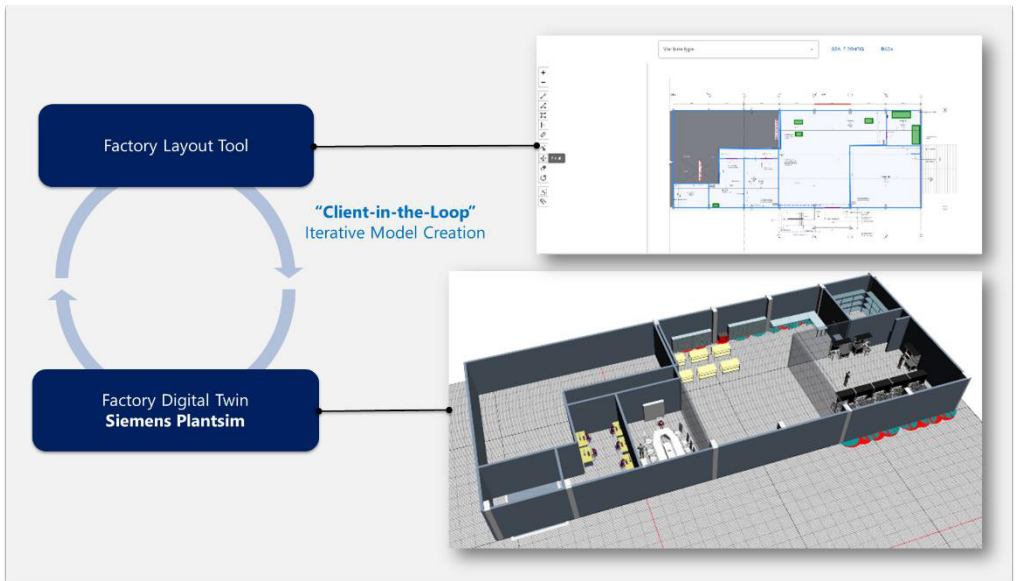


Figure 4 : Client-in-the-Loop Framework

Requirements for the factory layout tool were developed in-house based on self-imposed requirements and feedback from clients. Some key requirements are listed below:

- Ability to place walls and rooms on a PDF floor plan
- Placing of pre-defined machines on the floor plan
- Being able to move, rotate and delete machines already placed
- Integrating with discrete simulation programs

Value can be added to this tool through comparison with tools that offer similar functionalities, which also have the goal of being an intuitive factory layout tool that significantly decreases the time needed to create a layout in discrete event simulation packages. Such a comparison is important because, if such tools do exist, comparisons could provide a further and more thorough examination of how appropriate the Factory Layout Tool is and what it might be lacking.

In researching the capabilities of discrete event simulation tools to facilitate the creation of a digital twin factory layout [3, 4, 5], no third-party tools could be found with capabilities like the proposed factory layout tool. This search focused on several specific key features - such as the ability to import layouts in a way that increased productivity, reduced complexity, and an overall focus on ease of use.

1.3 Development

The following section describes the process and tools that were used to develop the layout tool, its integration into Tecnomatix Plant Simulation and how the tool functions.

The ReactJS [6] and LeafletJS [7] libraries were chosen in the creation of the factory layout tool, to present users with an intuitive interface. Using the layout tool, the users interactively create elements, such as walls and doors, and place pre-loaded machines on the imported floor plan. The developed tool was implemented using the TypeScript language and makes use of the NodeJS environment to integrate the imperative style LeafletJS library with the declarative style ReactJS library. Significant effort is expended to keep the two libraries in sync and provide a consistent and bug-free user experience.

Layouts created by the user can be exported to JSON save files and then imported again at a later stage. Users can also use the exporting and importing functionality to collaborate on a layout by sharing the JSON save files with one another and importing the saved layouts again. The objects that are placed onto the floor plan are serialized and stored as GeoJSON [8] objects, a standard format that many different tools can process. Serializing the objects to the GeoJSON format also allows the data to be manually viewed and edited since the format is text-based.

The factory layout tool does not require a backend server and performs all processing locally. This processing includes processing the floor plan in PDF format, importing, and exporting data. The fact that all data is processed locally makes the tool more accessible, only requiring internet connectivity when first opened and the users to have a web browser installed.

1.3.1 Integration with Tecnomatix Plant Simulation

To import the layout tool generated data into Tecnomatix Plant Simulation, comma-separated values (CSV) files are used. Tables containing all the fields needed to create the items were created. The simulation items were divided into two main categories, namely equipment and decorative (walls and doors) items. Custom methods, written in Simtalk [9], were then created to read these tables and create the corresponding items. Creation of the decorative items is done by setting the x, y position, length, height, and rotation of a cube.

The equipment creation is a bit more complex as they are created as stations that can be used for process flow. These items need to have unique names and some characters are not usable in the naming of them, so checks need to be completed to ensure that this happens without errors. After these checks have been completed the items are created in the class library and created to scale and placed in the correct location in relation to the decorative items. There are also custom methods to delete all the added items or to delete each type of item namely equipment, walls, and doors. The plan is to have the layout tool independent of discrete simulation service providers, so integration to other discrete simulation platforms will follow.

1.4 Functionality

The homepage of Plananator presents a user-friendly interface that offers a wide range of functionalities as seen below in **Figure 5**.

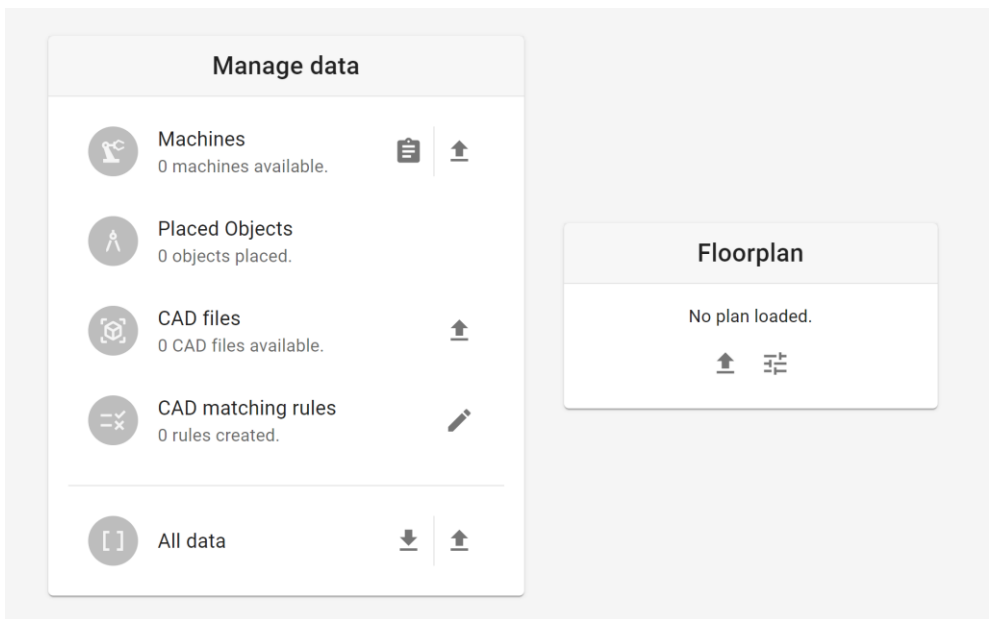


Figure 5: Home page of layout tool

After entering the homepage, users have the option to go on a guided tour that provides a comprehensive overview of these functionalities. However, even if the tour is not utilised, Plananator is highly intuitive and ensures ease of use for all users.

There are two primary sections on the homepage a “Manage data” section and a “Floorplan” section. The “Manage data” section includes an area where an Excel spreadsheet can be uploaded containing all the machines, and their relevant dimensions, that are present within the facility, an example can be seen in **Figure 6**.

Item Name	Serial Number	Size (LXWXH)(mm)
Jones mixer	4223	1150X600X40
Twin screw mixer	4242	1250X1800X400
High Power High-Speed mixer	1005-5VSF1	1450X1200X450
High Power granulator	1001-LCM12	1000X750X500
Capillary Rheometer	7042	1660X600X520
Arburg Allrounder Injection Moulding Machine	205425	1835X3035X1235
Mould temperature controller	TQ6D1B5B00-02-01	650X250X700
Granulator	5055	1300X450X600
Julabo Water Bath SW23	4552	260X350X700
MIM Furnace	335-M	2500X4300X4000
2 Drum polishing tumbler	3341	1450X750X600
Electropolisher	4567	1997X818X674
Particle size analyser	1142	1600X1800X750
Fume Cupboard	FC1	1500X1350X800
Heater (mixer)	187 6-87	1200X500X700
Chiller	1345	3000X700X1450

Figure 6: Example equipment importing table

CAD files in .STEP and .JT format can be uploaded here, with an additional option to create CAD matching rules that assign CAD files to machines. Furthermore, there is a separate “All data” sub-section where the user can import saved data from previous sessions in Plananator. There is also an export option, which allows the user to export data to Siemens Plant Simulation or save a file that can be reimported into Plananator again.

The “Floorplan” section of the homepage is dedicated to uploading a PDF version of the floorplan. Once the floorplan is uploaded, an additional “Place Objects” button becomes accessible which enables the user to move onto the next screen and start the layout optimisation process.

In the layout screen, the tool allows users to zoom and pan around on the floor plan, allowing them to place elements with greater precision than a paper-based setup allows. The tool further improves upon a paper-based system by allowing rotation, multiple selections and snapping of placed objects, as well as showing labels of machines. Since the tool displays everything to scale, users can realistically plan out their factory floor layout by moving placed machines around and spacing them out as they would in real life.

One of the main benefits of the tool is that all elements are to scale, allowing the user to accurately visualize the spacing and layout. The tool provides users with two options for setting the scale: they can manually enter the scale, or they can draw a line, usually corresponding to a line already on the floor plan and enter the length of that line. Using the length of the line in real life, read from the floor plan, and the length of the drawn line the scale is then automatically calculated by the layout tool. The scale needs to be set before any machines can be placed and cannot be changed after machine placement.

The configured scale is then used when exporting objects to generate objects of the correct sizes. The scale is also used when placing machines, along with the machines’ pre-configured size, to determine how big the machine should be on the interactive floor plan. An example layout generated in Plananator can be seen in **Figure 7**.

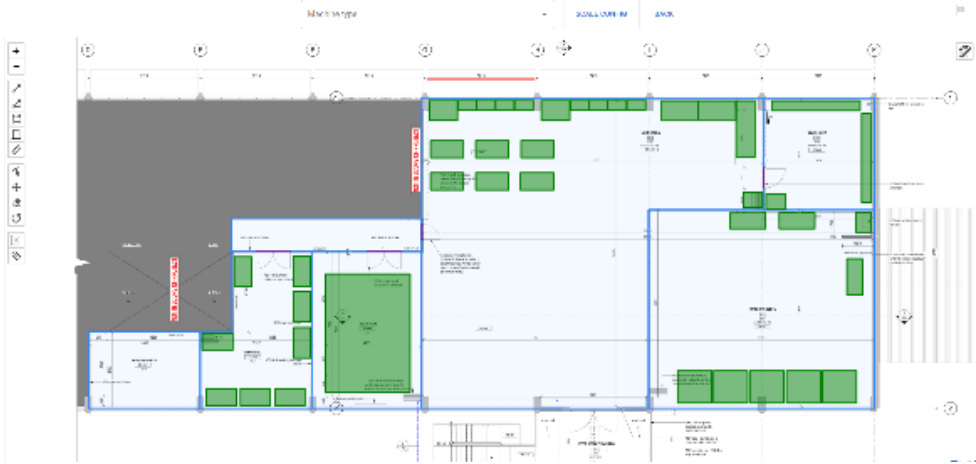


Figure 7: 2D Plananator layout of a facility

Once the user is satisfied, the tool allows for exporting the layout to a CSV representation, which can then be imported into Tecnomatix Plant Simulation. The import step can also create 3D objects that have the correct CAD model, as specified in the factory layout tool, further reducing the time required to create the 3D representation of the factory in the simulation package. The layout can also be exported to a 2D CAD format to assist in the implementation of the layout on the floor. An example 3D Plant Simulation layout generated from CSVs can be seen in **Figure 8**.

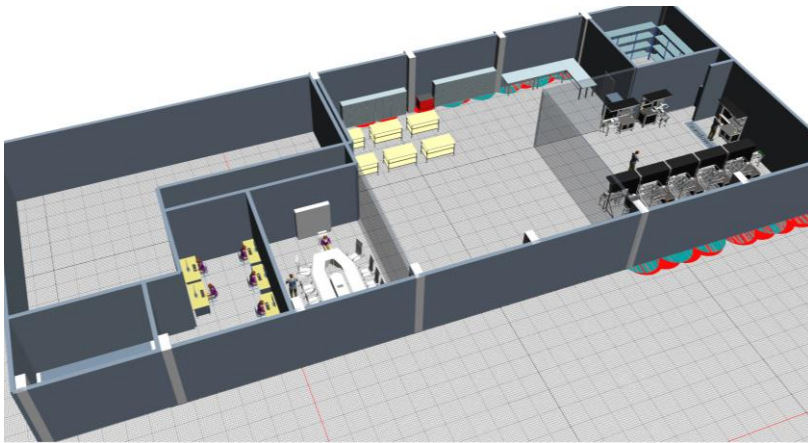


Figure 8: 3D Plant Simulation of a facility

2 Case Study

The Factory Layout Tool was used to support a manufacturing company that was moving its factory to a new premises and needed to visualise the layout options to optimise the space before physically moving into the new premises. One of the client layouts created using the Factory Layout tool is shown in **Figure 9**.

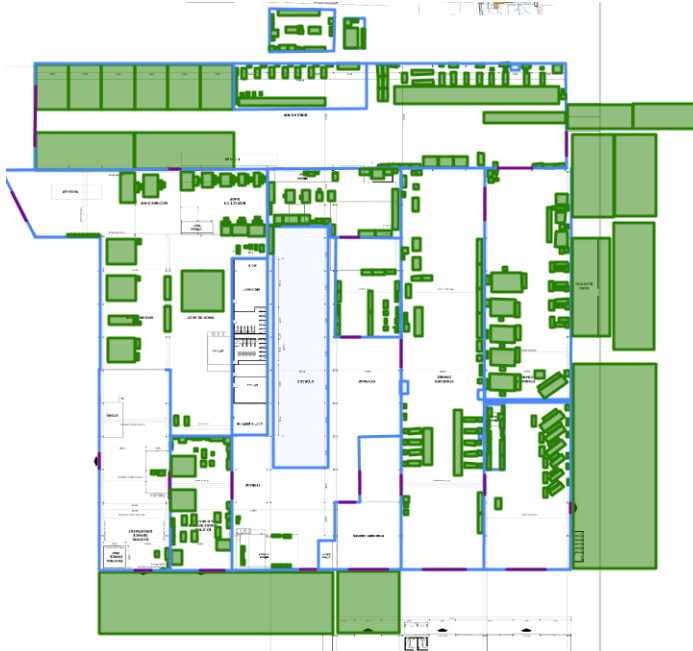


Figure 9: Plananator Layout of client site

Once the client completed the 2D layouts, these were converted into 3D by importing them into Tecnomatix Plant Simulation. The generated 3D layouts were shared with the client by means of video screen capture as well as a model executable that the client can open without license needs. The client was then able to engage the different stakeholders affected by the move to the new facility and plan accordingly., and the 3D layout can be seen in **Figure 10**.

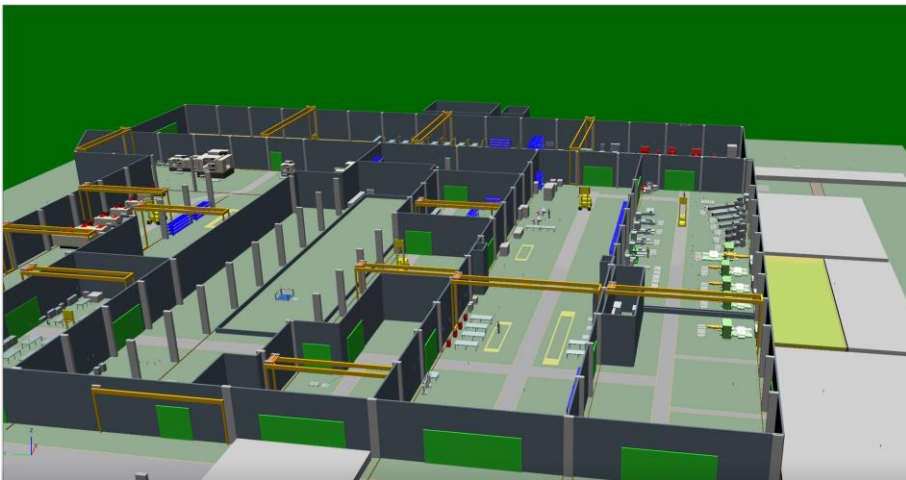


Figure 10: 3D Plant Simulation layout of client site

3 Future development

Currently, the tool mainly focuses on assisting with the layout of a facility. The tool will be expanded to also include the setup of machine parameters needed for simulations, as well as basic component flows. This will require product information to be linked in Plananator as well. This will greatly assist to speed up the initial setups of facility models. The end goal is to be able to run basic simulations by means of the cloud interface without the need for user interaction with the discrete simulation software. To achieve this more of the workflow components will be integrated into the Plananator tool to ensure a fluid process that requires fewer operator interventions between steps. Some effort will also be invested in using machine vision to generate the walls and doors automatically from the floor plan, in a format that the user can then edit. The tool is currently only integrated with Tecnomatix Plant Simulation, and as such more work needs to be done to integrate it with other discreet simulation packages.

4 Conclusion

The factory layout tool proposed in this paper greatly reduces the time required to create a factory layout, with the correct scale, in a simulation package. It also allows users to perform preliminary planning of their factory layout by quickly moving machines around and spacing them as they see fit, before importing the layout into the simulation package. The ease of use and low learning curve of the tool allows people without modelling and simulation experience to effectively perform basic factory layouts.

The first use of the Plananator tool in a real-world environment was by a client using it to plan a move to new premises, where it was used to plan the new building layout. The experience of the client was overwhelmingly positive, as much time was saved during both planning and the actual moving of equipment.

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