Go with the Flow: Using Material Flow Optimization in Autodesk® Factory Design Suite

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MA4496 - The Factory Utilities inside Factory Design Suite provide the means to define products that are to be manufactured in the facility, the stations where the processes occur, and the routes between the stations. Once you have a layout you can analyze the transportation costs, and machine utilization and power consumption. Reports of the results can be produced so that multiple scenarios can be compared and documented.

About the Speaker:
Mark has been using Autodesk® products since 1999 in many different manufacturing environments. He has implemented Autodesk products for many diverse industries. Autodesk® Inventor® has profoundly augmented Mark’s abilities, allowing him to bring 3D digital prototyping to the forefront of the industries with which he has interacted. Mark has extensive experience and a comprehensive understanding of the technical and practical business and human dimensions of implementation. His expertise has helped his clients maximize their project’s effectiveness and return on investment. He is an effective and skillful communicator, consulting with his clients to help achieve their business objectives. Mark provides training, support, and implementation on all Autodesk manufacturing solutions.

AutoCAD Factory Design Utilities Introduction

The Factory Design Utilities for AutoCAD provide an optimized environment and design tools for factory floor layout. They also allow you to open legacy DWG facility layouts and add factory intelligence to those drawings. Then, the factory drawings can be used to populate a 3D layout in Inventor Factory.

A 2D factory layout is a DWG model of a factory, warehouse, or office environment. The size and complexity can range from a work cell to an entire factory. The layout can contain building elements such as walls, columns, and utilities. You can layout individual pieces of equipment and create routing paths for each product.

Factory Design Utilities allow you to add intelligence to the factory layout. The intelligence can be added to a legacy facility layout or a new file. The additional data provides the needed information for analyzing layouts, generating reports, and automatically populating the factory layout with 3D assets in Inventor Factory.

It is also important to remember that the Material Flow portion of the Factory Design utilities is currently at best an estimating tool and not a full-fledged reporting tool to be used in complex studies but more to gain insight into what if situations and general flow of material in a factory.
Factory User Interface

The Factory Design Utilities user interface is located on the Factory tab and laid out with panels named Factory, Material Flow, Analysis, Learn about Factory, and Community. A blend of Factory and standard AutoCAD panels create the default Factory working environment.

There are three palettes associated with the Factory Design Utilities: the Asset Browser (1), the Material Flow Browser (2), and the Properties browser (3). The palettes share the browser area and can be adjusted using standard resizing methods. The browsers can be docked in different positions or left floating if pulled away from the application frame.

The Asset Browser provides access to the installed assets, user assets, and cloud based assets. Assets are components that, together, make up the content of a factory. They can include architectural features, equipment for material handling, processing equipment, and so on.

The Material Flow palette provides access to defined stations, products, and routings. From the browser you can manage the definitions of these factory objects. Context menus provide access to commonly used commands.

Tech Note: The palettes can be docked, anchored or chosen to Auto-hide based on the controls of the palette.
Factory Suite Layouts

Factory Tools provide the means to define products that are to be manufactured in the facility, the stations where the processes occur, and the routes between the stations.

A Station is an area where a manufacturing process is applied to material or a component to generate a product. Station properties provide a means of assigning cost to the station setup and operation. Properties participate in the analysis results. A station is defined using drawing geometry and can be simple or complex, depending on your preference.

A Product can be a single component or assembly that is produced as the output of the manufacturing process. Products can be nested within other products. For example, a sub-assembly (Sa1) can be part of a larger final assembly (Lg1) and a standalone product. Products do not have a geometric representation on the drawing.

Routing represent the transportation between manufacturing stations. The routes between stations display as straight lines with arrowheads spanning the distance between station connectors. The arrowheads denote the direction of flow the product takes between stations and not the physical path. The routing lines provide estimated distances for analysis purposes.

The Import tool allows you to bring in spreadsheet data generating variable related information pertinent to factory layout. The Export tool provides a means of storing and sharing layout variable information in spreadsheet format.
### Analysis

Once you have a layout you can analyze the transportation costs, and machine utilization and power consumption. Reports of the results can be produced so that multiple scenarios can be compared and documented. Once a layout meets your requirements, the layout can be sent to Inventor where it becomes a 2D overlay that is populated with 3D assets.

![Analysis](image1)

### Suite Workflow

Factory System assets are available in 2D for AutoCAD and 3D for Inventor. Assets placed in a 2D factory layout in AutoCAD can be populated in the 3D layout without you having to perform the entire pick and place steps ordinarily involved in making an assembly. It is easy and reduces the effort of pulling together a 3D version of a factory layout.

![Suite Workflow](image2)

Typically, you would have one of two different users. Those that perform the entire 2D/3D layout work who would push the layout to Inventor (Factory Suite Premium and Ultimate) and those that only perform the 2D layout work (Factory Suite Standard). Either type of user can use the Asset Library to make sure the content is identical to those two different personas.
Create Stations

Select station geometry and specify a station connector. Station geometry can include any drawing geometry and text you want to use. It can also include factory assets from your library.

To create a new station from within the browser, right click in empty browser space in the palette and click Create. A new station node is created and highlighted so you can immediately enter the station name.

1. Review the geometry that will make up the station definition. The geometry can include anything from a simple shape up to a detailed station layout.
2. On the Factory tab, in the Material Flow panel, click Station.
3. In the graphics display, select the geometry making up the station.
4. Specify the Station connector. We recommend a point nearest the center of the station so routing distances represent an average. The station is created and default properties assigned.
5. Optionally, in the Factory Object Properties panel, modify the station properties. Some default values are included.

The geometry for the Station can be that of a Factory Asset or can be simplistic block references as well.

Factory Suite Authored Asset from Library (above); Simplistic AutoCAD Blocks (below)
Create Products

The product is the item being manufactured. You can nest products within each other. These are represented hierarchically in the Material Flow Browser.

2. Optionally, change the name of the Product by slow-clicking in the product name text. Enter your product name.
3. With the product browser node selected, in the Factory tab > Factory panel, click Tools and then click Properties. Alternatively, right-click the product node and click Properties. The Factory Object Properties palette displays the product property.
4. Continue to add any products to be manufactured in the factory.

To nest a product within another product, do the following:

1. In the Material Flow Browser, on the Product tab, right click an existing product node and click **Add**.
2. Specify a name for the product either during this process or when convenient. A default name is provided.
Create Routings

A product routing displays the flow of the manufacturing process for the given product through the factory. The end product of a routing is a Job node with a list of assorted stations used to manufacture the product. The order of the stations should properly define the flow of the product through manufacturing. If stations are selected out of order, it is possible to reorder them.

1. On the Factory tab, in the Material Flow panel, click Routing. The Material Flow Browser changes to the Products tab and you are prompted to select a product.
2. Select the product to be routed. Next, you are prompted to select the stations used in manufacturing the product.
3. Select the stations used to manufacture the product. You can select them in their process sequence or independent of their process sequence.
4. If needed, rearrange route browser nodes using drag and drop.

After the Routing has been created it can be modified through the Factory palettes.

Notes about Routings –
• Routings cannot be copied for nearly identical Products/Jobs
• Routings can be overlapped over each other only during analysis

• Routes are explicit, products cannot route from two or more stations into the same station, use an average or adjust amounts accordingly to get accurate results from the analysis.
Analyze Transportation

You can analyze your factory layouts for transportation costs and machine utilization. Then, modify the layout and re-analyze in order to optimize the factory layout. You can open existing factory layouts and assign station, product, and routings to match your current processes. Then, analyze the layout, make modifications based on the analysis and note the improvements. It is also possible to generate before and after reports to document the improvements.

To analyze transportation costs:

1. On the Factory tab, in the Analysis panel, click **Transportation**. The Material Flow Browser displays the Routings tab with the list of Jobs.
2. All jobs are immediately analyzed and the results presented.
3. The Transportation and Total Cost indicators display the analysis results. Flags and connection lines provide additional feedback. Numbered red flags appear next to the stations. The flags indicate Station intensity, a measure of how much material flows through that station. The numbered flags can be used to guide you to the regions where changes can have the greatest impact. Between the stations are connection lines colored in red or green. Red indicates a high intensity or high material flow path. These can be used as indicators of regions in the network of stations and jobs that can have the greatest impact on the transportation cost.
4. To perform a discrete analysis of one or more jobs, right-click the analysis indicator and click Select Job. Then, in the Material Flow Browser select one or more jobs to analyze. After selecting the jobs to analyze, press <Enter>.
5. Reposition the stations, using click and drag, to see modify the impact.
Transportation Indicators

1. Transportation Cost = Travel Time x Cost Rate
2. Total Cost = Transportation Cost + Machining Cost
3. Display the Total Travel Time
4. Displays the Total Travel Distance

Access the indicator settings by clicking in the Transportation Cost Indicator. These settings help to identify areas where transportation costs are likely to be higher.

| Part Quantity | Relative to the number of parts moving along the path. |
| Part Quantity x Distribution | Relative to the number of parts moving along a path segment adjusted for the length of the segment. |
| Transport Cost | Relative to the transportation costs of each segment connected to a station. |
| Intensity Ratio | Adjusts the number of stations that are flagged with the color bar. |

Moving the Stations around will dynamically adjust the indicators to reflect the changes.

Moving the Sensitivity can more clearly identify bottlenecks in the Routing.
Analyse Machine Utilization and Power

To analyse machine utilization and power consumption:

On the Factory tab, in the Analysis panel, click **Machine**.

1. The Material Flow Browser displays the Routings tab with the list of Jobs.
2. All jobs are immediately analyzed and the results presented.
3. The Power Consumption indicator displays the analysis results. Flags display the utilization status for each station. The flag color is based upon the *Utilization Settings*. Yellow = under-utilized, green = well utilized, and red = over utilized.

4. To perform a discrete analysis of one or more jobs, right click the analysis indicator and click **Select Job**. Then, in the Material Flow Browser select one or more jobs to analyze. After selecting the jobs to analyze, press <Enter>.
5. To view the utilization for a specific station, pause the cursor over the station flag. A gauge displays the utilization value for that specific station.
6. To add a station gauge to the display, right-click the station flag and in **Optimization** click **Add meter to dashboard**. You can add multiple gauges to the dashboard.

7. To remove a gauge from the dashboard, right-click the gauge and in **Close Indicator**, click the name of the gauge to be removed.
Pausing the cursor over a utilization flag displays the individual station utilization indicator. The indicator displays the percentage of uptime based on the facts mentioned above. To add the indicator to the dashboard of other indicators, right click on the flag as previously mentioned.
Import and Export

Since the Asset Library does not retain Station information added to it when it is placed from the Library, it may be necessary to save already assigned information about Routings, Products, and Stations leaving only the actual geometry to be defined.

The Import/Export methodology is not a straight cut and dry procedure inside AutoCAD. The data actually needs massaging outside AutoCAD in Excel.

General Export and Import Procedure:

1. Export a complete routing to XML (FACT_EXPORTDATA)
2. Open the Factory.xlt template in Excel

3. Import the XML to the Factory template using the Developer Tab. If your Developer Tab is not shown by default, go to http://office.microsoft.com to see how to enable it for your version of Office.
4. Adjust any values of data in the spreadsheet and save it to a secure location as a template reference.
5. Open an empty Factory Layout and import the Excel spreadsheet (FACT_IMPORTDATA). All the data from the spreadsheet will import into the Factory palettes and generic footprint blocks will be placed onscreen based on the original export.

6. Place new station definitions that represent the asset instead of simplified blocks. At the very least use Text to denote on screen the different stations.
7. Redefine Stations to new Geometry if necessary by right clicking on the station and choosing Redefine.
Material Flow Reports

Another great aspect of Material Flow is to check multiple what if scenarios to see the best course of action to add new equipment, new personnel, more or less shifts and get that data in some easy to read communicable reports. To run a Report of your findings from Material Flow, use the Generate Report button located in the expanded section of the Analysis Panel of the Factory Tab.

Here we have adjusted the uptime percentages for our machines based on labor statistics as well as adjusting the shift times and conveyance methods between machines from Human to Fork Truck as well as adding conveyors to help automate the line. We can run more scenarios to see what increasing our daily output would entail as well. The most important factor for looking at any of these reports or indicators is if it actually makes sense. If you put garbage in you will get garbage out.
Summary

Material Flow analyzed through Transportation Cost and Machine Utilization in the Factory Design Suite product line has a wealth of advantages for determining planning for new assets or labor while not overly bogging down the experience with overly complex details. Conversely, this simplicity can also be said to be a downside to those that want the ultimate costing solution in the Autodesk product.

The AutoCAD Material Flow capabilities are best utilized in what if scenarios and overall planning diagrams used during communication with various teams and stakeholders in the project.

The easy to change settings and machine locations for these scenarios makes for a very dynamic tool during planning meetings and web conferences to aid in a visual layout as compared to simply laying down cardboard in the plant or using rudimentary visual aids.
Appendix: Setting Defaults

To reduce redundancy in the process of setting up new Material Flow layouts, considering adjusting the defaults of the Factory Utilities for AutoCAD Architecture or AutoCAD Mechanical. In either product the settings for the defaults are stored in the Application Options of the product on the Factory Tab. The Factory Assets tab controls how the Asset Browser brings in and references new assets as they are created or downloaded from Autodesk.

**Object Selection Preference:** Establishes the preferred method for selecting factory objects.

**Top Down:** Sets the selection preference to stations. All objects in the station are selected with the initial click. A second click, on an object grip, selects the individual object within the station. This is the default setting.

**Bottom Up:** Sets the selection preference to objects. The first click selects a single object. A second click selects the station.

**Send to Inventor**

You can automatically populate a 2D DWG overlay when you use the Send to Inventor command. To do so, check the box next to the label. The default is unchecked. If you have automatically populated a DWG overlay, and subsequently update it you can update the overlay from within Inventor. In Inventor, right-click the overlay browser node and click Update.

**Transportation Defaults**
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**Operation Defaults**

![Operation Defaults](image1)

**Station Defaults**

![Station Defaults](image2)

**Shift Defaults** — These values can only be adjusted here in the Application Options for the overall drawing.

![Shift Defaults](image3)

**Job Defaults**

![Job Defaults](image4)
Appendix: Glossary of Terms

Stations

The following commands are accessible from the context menu in the Material Flow Browser:

- **Redefine**: Removes the geometry from the station. Select the geometry that is to be included in the station. Right-click the background to end the selection process.
- **Reposition Connector**: Select the new location for the connector.
- **Copy**: Copies the selected station geometry, properties, and connector. The new station is in the same location as the copy host station. Use the standard Move command to relocate the station.
- **Rename**: Highlights the station name allowing you to immediately enter a new name.
- **Delete**: Deletes the selected station.
- **Properties**: Displays the Factory Object Properties palette with the selected station properties.

The following adjustments can be made on the Factory Object Properties:

- **Name**: Read-only field displaying the station name.
- **Identifier**: An asset tag value used to identify the station. It can be a corporate asset tag or departmental.
- **Setup Cost Rate (/hr)**: Assigns the hourly cost for preparing the station resource for use in a manufacturing operation.
- **Processing Cost Rate (/hr)**: Assigns the hourly cost for running manufacturing operations on the station.
- **Uptime Percent**: Assigns the amount of time the asset is expected to be in use or available for immediate use.
- **Energy Consumption Cost Rate (/hr)**: Assigns the hourly cost for energy required to operate the asset.
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**Products**

The following commands are accessible from the context menu in the Material Flow Browser:

- **Add**: Adds a new product to the list. The new product is the active selection.
- **Rename**: Highlights the product name so you can immediately enter a new name.
- **Delete**: Deletes the selected product from the list.
- **Create Routing**: Create a new routing for the selected product.
- **Properties**: Displays the selected product properties in the Factory Object Properties palette.

![Material Flow Browser](image)

**Routings**

The following commands are accessible from the context menu in the Material Flow Browser:

- **Job node**: Lists the product being manufactured as the job name and, as child nodes, the operations used in the process.
- **Operation node**: Specifies the manufacturing Operation: Station used in the process.
- **Include in Analysis**: Available only during an analysis. All jobs participating in the analysis are checked. To remove a job from an analysis, click Include in Analysis to uncheck it. Click it again to include the job in the analysis.
- **Append Station**: Adds a new station at the end of the current list. You are prompted to identify the station.
- **Rename**: Highlights the job name so you can immediately enter a new name.
- **Delete**: Deletes the selected job from the list of jobs.
- **Properties**: Displays the Factory Object Properties palette with the selected Job properties.
- **Rename**: Highlights the operation name so you can immediately enter a new name.

![Material Flow Browser](image)
The following adjustments can be made on the Factory Object Properties palette for **Job Nodes**:

- **Desired Production Rate**: Specifies the goal for parts completed in a job.
- **Part Quantity**: Specifies the number of parts completed in a job.
- **Batch Size**: Specifies the number of parts in a batch. A batch equals the number of parts times the number of jobs at a given station. For example, a job produces 10 parts which are put into a bin. The process allows for 10 bins to be placed on a palette before transferring to another station. The batch size would be 100 parts, 10 (parts) × 10 (jobs per batch) = 100 parts in the batch.

The following adjustments can be made on the Factory Object Properties palette for **Operations**:

- **Operation Type**: A list of several operation types is presented, select the applicable one.
- **Processing Time (min)**: 10 (default), specified the amount of time the process takes. The value is used in determining cost.
- **Setup Time (min)**: 5 (default), separate from process time, specifies the amount of time to setup the operation
- **Start**: Specifies the operation occurring at this sequence.
- **End**: Specifies the next operation to be performed.
- **Transportation Type**: Displays a list of transportation types to select from.
- **Travel Speed (ft / min)**: 100 (default) Specify the transportation travel speed at ft/min.
- **Cost Rate ( / min)**: 25 (default), specify the transportation cost rate per minute.
- **Load Time (min)**: 1 (default), specify the amount of time to load the product onto the transportation.
- **Unload Time (min)**: 1 (default), specify the amount of time to unload the product from the transportation.
- **Directionality**: Specifies how the material or product is allowed to flow. Select from either Bidirectional (default) or Unidirectional.
- **Flow Type**: Continuous- continuously flowing, as in a motorized conveyor system. This resource handles product batches continuously. Discrete- not continuously flowing, but intermittent based on the means of transportation. If Continuous, the transportation travel time for a single batch is compared with the station processing time and unload time to determine how many batches are active on the transportation segment at any one time. The transportation cost is then reduced relative to the number of active jobs on the transportation segment.