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MANAGING THE RAMP-UP AT **KMWE**

Lessons learned from the Tilburg University simulations

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AGENDA

15 min. Project & model introduction

20 min. Recommendations by winning student team

15 min. Testing additional scenarios

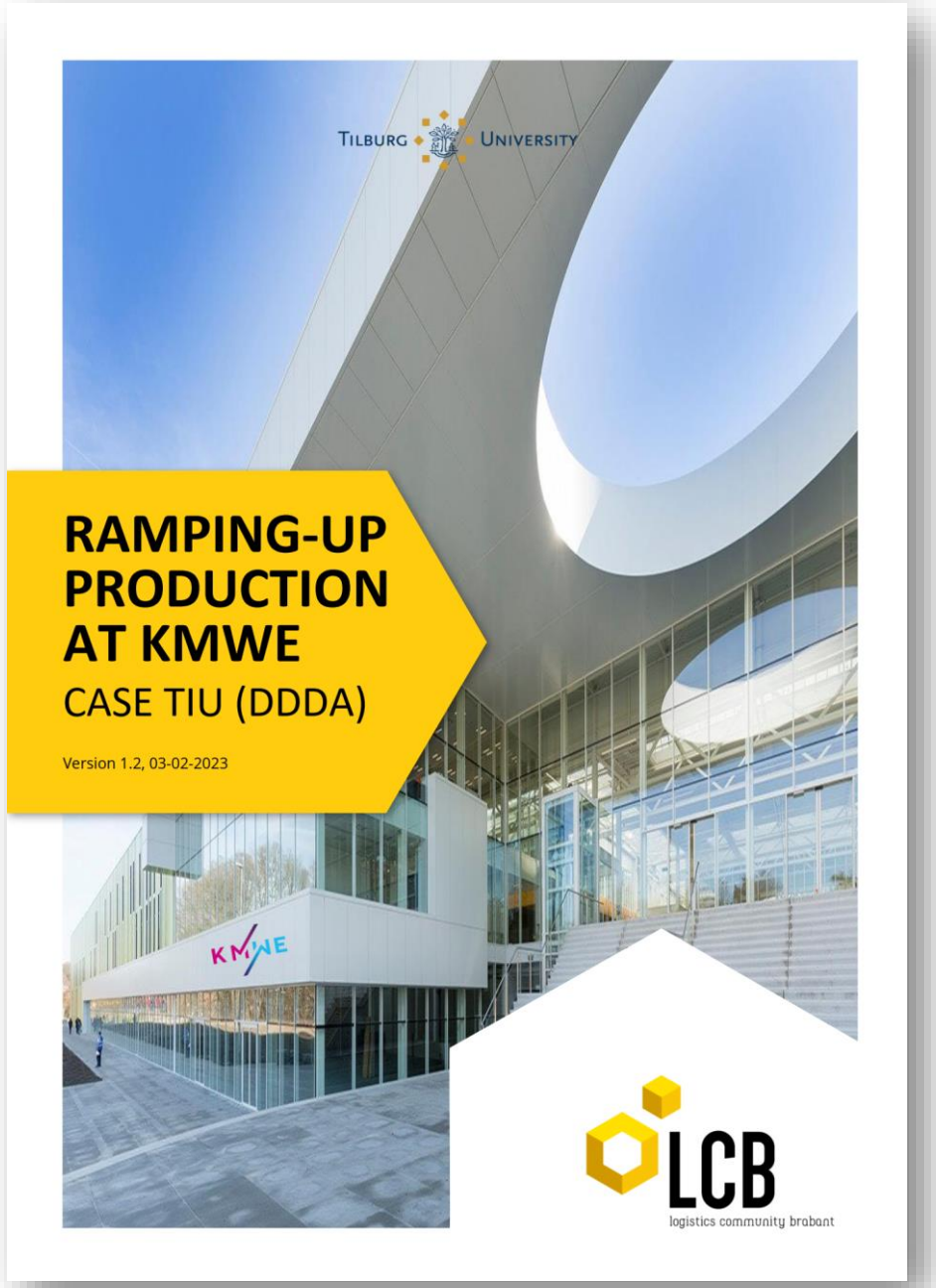
THE CASE

Main question
How can KMWE manage the production ramp-up of the **Unicom**, while keeping **inventories** low and managing the worsening **delivery performance** of its suppliers?

Simulation objective
Identify supply chain management strategies that enable KMWE:

- To increase production from 5 to 10 Unicoms per week
- To reduce the Cash Conversion Cycle (CCC) and increase the Inventory TurnOver (ITO)
- To retain a strong delivery reliability

Check the robustness of your recommendations. What if the speed of ramp-up changes, what if the forecast is biased, what if the lead time of suppliers worsen gradually/instantaneously, … Are your recommendations still optimal?



THE PROJECT

Setup
- Part of the course Data-Driven Design Approaches in Supply Chain Management
- 37 teams of 5 students
- Weekly coaching session with lecturer

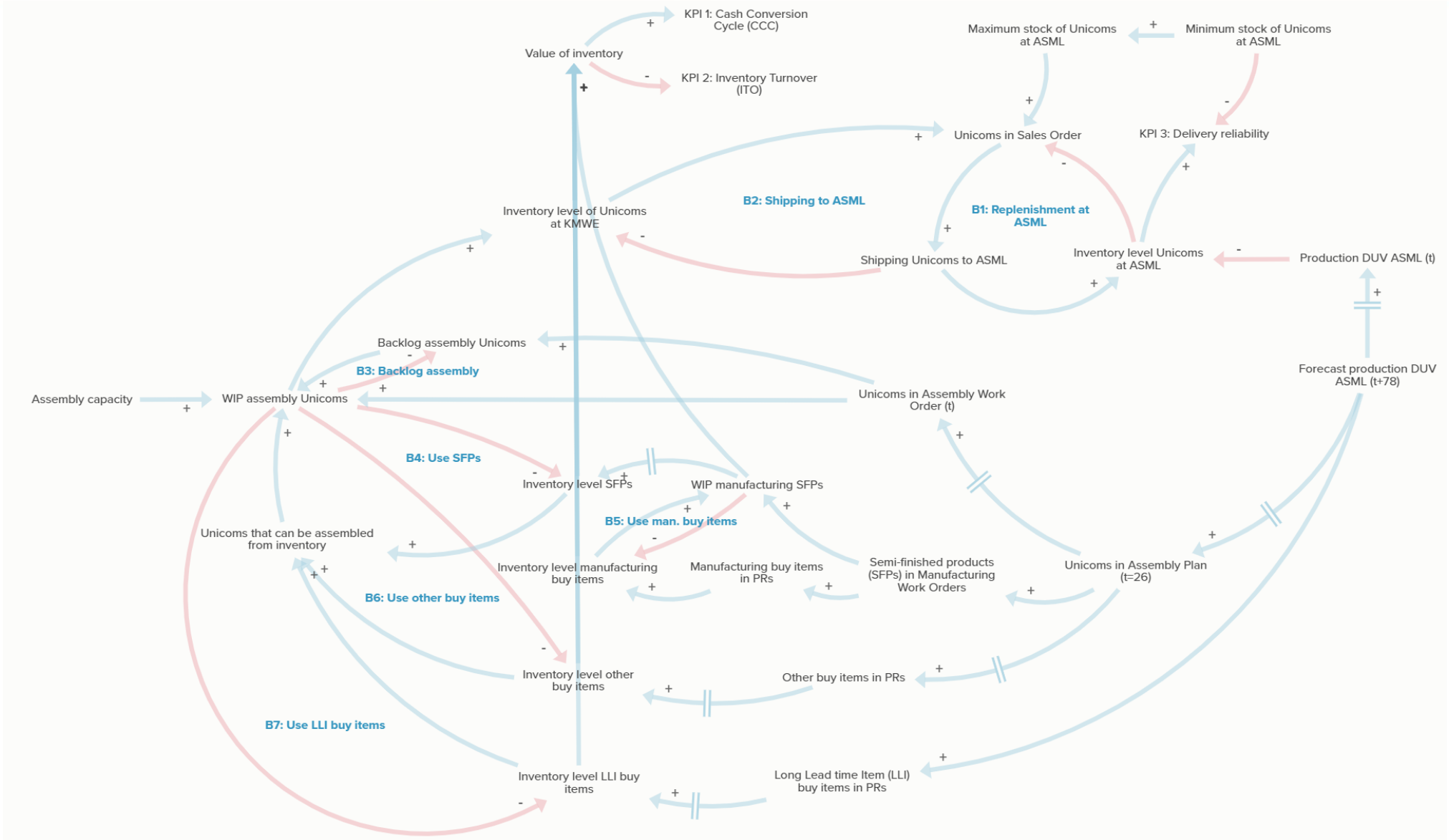
Four phases
The project took 8 weeks in total and consisted of 4 phases:

1. Problem understanding (2 weeks)
2. Model development (3 weeks)
3. Data analysis (1 week)
4. Scenario testing (2 weeks)

To keep all teams up to speed, teams received our version of the model after each phase.

Preparation
Many thanks go to Stijn Smulders, Anne Schoenmakers and Benny Carels for the preparation of the case.

Causal Loop Diagram (assignment 1)



Potential problems (assignment 1)

KMWE's current delivery reliability (60-70%)

- Structural bias in ASML's forecast (deviation between forecast and production)
- Demand smoothing (stable move rate) is based on nearest integer (instead of round-up)
- Delivery unreliability of suppliers
- Unreliability of manufacturing throughput time
- JIT backward planning of 115 items might result in frequently waiting for the last item to arrive
- Changing lead times of suppliers: if the lead time of a supplier increases from 10 to 20 weeks, for example, a 10-week gap arises
- Insufficient assembly capacity to recover (deplete the backlog)

Ramp-up in upcoming years

- Assembly (and manufacturing) capacity has to be increased
- Supplier capacity has to be increased, supplier lead times are expected to increase
- Stepwise increase of demand might lead to bullwhip

Potential solutions (assignment 1)

Potential solutions

- Higher maximum level at ASML (safety stock at ASML)
- Safety stock of Unicoms at KMWE
- Differentiate safety lead times based on reliability of suppliers (safety stock for items with unreliable suppliers)
- Reduce variability in supplier lead time
- Update supplier lead times frequently in master data
- Reduce MOQ (reduces average stock)
- Reduce variability in manufacturing throughput time
- Increase assembly capacity (to increase recovery capability)

To be precise, KMWE's main goals are:

- To increase the production of the Unicorn, from a stable move rate of 5 Unicorns per week to a stable move rate of 10 Unicorns per week.
- While reducing the Cash Conversion Cycle (CCC) and increasing the Inventory TurnOver (ITO).
- And retaining a strong delivery reliability. That is, KMWE should be:
  - Able to recover after one or multiple weeks in which fewer Unicorns could be assembled than planned.
  - Resilient to short-term deviations in customer demand and supplier deliveries and long-term changes in customer demand (upward trend) and increasing lead times of suppliers.

Contents are changing:
In order to identify whether your policies are indeed robust improvements for KMWE, it is recommended to test several contextual factors:

- The speed of ramp-up by ASML can differ: what if ASML wants to ramp up within 2 years, what if ASML wants to/can ramp up within 10 years? (AVAR) is dependent upon its suppliers capability to ramp up)
- No forecast is perfect. What if ASML's production forecast is structurally biased, what if the random error becomes higher?
- What if the lead time of suppliers gradually worsens (or improves) over time?
- What if the delivery performance of suppliers gradually worsens (or improves) over time?

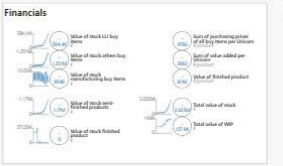
Finances

In order to calculate the financial KPIs, we have to keep track of several financials:

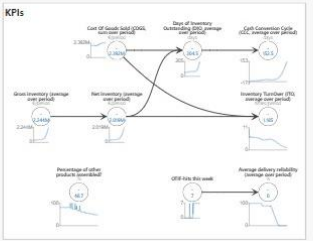
- The value of stock: the total value of KMWE's current stock. This consists of buy items, semi-finished products and end products. The value for each of these is calculated in a slightly different manner:
  - Buy items: the value of buy items is based on the purchasing price of the item to which 10% material overhead is added.
  - Semi-finished products: the value of semi-finished products is based on the value of manufacturing buy items, which is summed with the value added during the manufacturing process. For this model, we assume that KMWE utilizes a constant tariff of value added for each manufacturing hour spent. This tariff includes personnel and machine costs.
  - End products: the value of end products is based on the value of buy items and semi-finished products, which is summed with the value added during the assembly process.
- The value of WIP: since assembly takes one week (and the model runs in weeks), there's not a separate value calculation for the products during assembly. Manufacturing on the other hand takes several weeks on average, so here we do need to keep track of the value of the items in WIP. For the model, you can assume that the value added per week is roughly equal - on average - for all semi-finished products across the entire manufacturing process. That is, every week the same value is added to a semi-finished product that is still in the manufacturing WIP. A delay in manufacturing (due to waiting times) does not increase the total value added during manufacturing however.
- Cost of goods sold, per product: the direct costs of producing the goods sold by a company. This amount includes the cost of the materials, labor and machine costs directly used to create the good.

Note: The value of items in stock is calculated from the expected items that are in stock. Since most items arrive (on average) in time (some too early, some too late), this indicator is more accurate than the timing of the latest arriving item. Since we're waiting still for the last item to arrive at the expected time, this is a slight overestimation of the items in stock. Since the Unicorn is assembled from 115 unique items however, using the timing of the latest item leads to a serious underestimation of the items in stock.

Financials



KPIs



KPI 1: Cash Conversion Cycle (CCC)

A metric that expresses the time that it takes for a company to convert its investments in inventory and other resources into cash flows from sales. This metric takes into account how much time the company needs to sell its inventory (days sales of inventory), how much time it takes to collect receivables (days sales outstanding), and how much time it has to pay its bills (days payables outstanding).

- *Days sales outstanding (DSO)*: since November 2022, KMWE has made an agreement with ASML that the invoices (which are sent at the same time as the Unicorns are shipped) are paid within 7 day. This agreement makes use of Deutsche Bank (to which KMWE has to pay interest), but that is out of scope.
- *Days payables outstanding (DPO)*: when the buy items arrive at KMWE, KMWE receives the invoice from their suppliers. In 2022, these invoices were paid 53 days afterwards, on average.
- *Days of inventory outstanding (DIO)*, also known as Days sales of inventory: this can be calculated by dividing the average net inventory with the cost of goods sold over the last period. KMWE aggregates the cost of goods sold over the last year (52 weeks).
  - *Net inventory*: the net inventory is calculated by subtracting the provisions (for aged stock, wrongly purchased stock and stock with quality defects) from the gross inventory (value of current inventory). For simplicity reasons, we assume the provisions are a constant percentage of the gross inventory value.
  - *Cost of goods sold (COGS)*: the direct costs of producing the goods sold by a company. This amount includes the cost of the materials and labor directly used to create the good. It excludes indirect expenses, such as distribution costs and sales force costs.

KPI 2: Inventory TurnOver (ITO)

A financial ratio showing how many times a company turned over its inventory relative to its cost of goods sold (COGS) in a given period. The inventory turnover ratio can help businesses make better decisions on pricing, manufacturing, marketing, and purchasing. It is one of the efficiency ratios measuring how effectively a company uses its assets.

One of the ways to calculate the ITO is by dividing the total COGS over a certain period by the average net inventory during that period.

KPI 3: Delivery reliability

Percentage of days in which the stock of Unicorns is above the minimum stock level. That is, for each day the stock is below the minimum stock level, KMWE receives an OTIF-hit (On-Time-In-Full hit). ASML produces 7 days per week, we assume that the production is spread out evenly throughout the week. So, if ASML produces 7 DUVs in a week, that's 1 on Monday, 1 on Tuesday, etc. Since the assembly of Unicorns is typically finished on Friday, the shipments to ASML are typically scheduled on Friday (at the end of the day) as well.

Benchmark of financial KPIs

https://www.cleverlearners.com/en/industry/282

Warehouse

KMWE has an internal warehouse in which the buy items and semi-finished products are stored. If the stock of Unicorns at ASML is at the maximum, additional Unicorns can be stored in KMWE's warehouse as well.

Buy

In total 115 unique buy items are purchased for the Unicorn from 28 different suppliers. Part of these items are manufactured first (24 manufacturing buy items), the others can be directly used for assembly (91 assembly buy items). Out of the 91 assembly buy items, 3 have a very long leadtime (3 Long Leadtime Items (LLI): PCBs, spindles and motors PCA), so are handled differently by the planning department.

Purchase Requisitions (PRs):

- The timing of all purchase requisitions is based on the leadtime of the supplier and an internal handling time (door-to-stock time = 1 week). The LLIs have an additional 2 weeks of safety time.
- So, KMWE is purchasing the buy items just-in-time (JIT) and is not steering towards target stock levels.
- The PRs for the LLIs follow directly from the forecast of ASML. For example, PCBs have a leadtime of approximately 52 weeks. If the production forecast of ASML for 53 weeks from now indicates 5 Unicorns in that week, then a PR for 5 Unicorns is created this week (leadtime + door-to-stock time + safety time).
- The PRs for all other buy items is derived from KMWE's production plan, which works with a time horizon of 26 weeks. For example, if a buy item has a leadtime of 4 weeks, then a PR is created 5 weeks before assembly at KMWE is scheduled.

Minimum Order Quantities
Not all PRs result in a purchase order at the supplier due to minimum order quantities (MOQ). If the MOQ is 50 and the PR is 5, then you either order 50 or 0 buy items. Hence, the higher the MOQ, the more items are ordered ahead and the higher the inventory levels at KMWE will be.

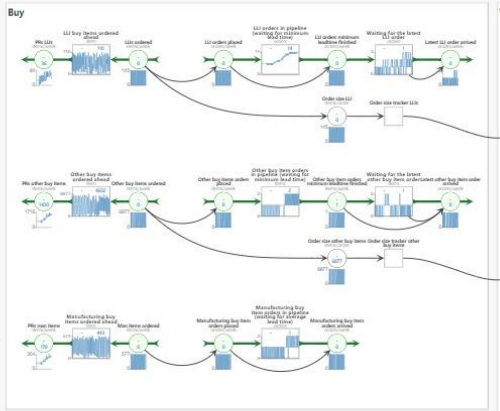
Note that KMWE can also choose to elevate the order quantity themselves. For some products, higher orders quantities receive a graduated price discount. For example, if you purchase 1 item, it costs €100 per item, if you purchase 100 items, it costs €90 per item. While negatively affecting the CCC and ITO (due to higher inventory levels), it might still be profitable for KMWE depending on the graduated price discount. This is not modelled explicitly, but can be tested in a scenario (in which you increase the item's MOQ) and decrease the item's purchasing price), if desired.

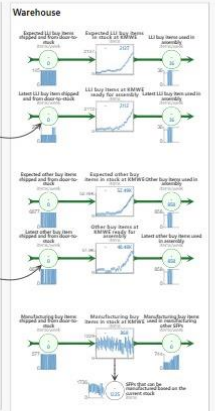
Supplier leadtimes
Unfortunately, due to world-wide supply chain challenges, not all suppliers are capable of delivering the items always in time - delivery performance has decreased. Therefore, in the model we take into account that leadtimes for some items (LLI and other buy items) are stochastic. In the model, we use 3 components:

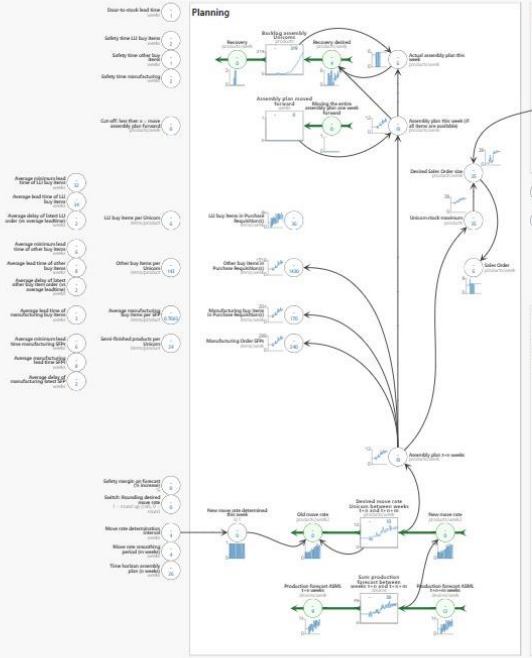
- A minimum leadtime: the supplier will never deliver the purchased items faster than the minimum leadtime.
- An average leadtime: on average, the supplier delivers the purchased items this amount of weeks after the purchase order has been shared. It's possible that the items arrive earlier, it's possible that the items arrive later. This average can be used to calculate the expected value of the stock.
- An average delay of the last item: since assembly can only start once all 115 items are present, the timing of the arrival of the latest item is relevant.

In the model we assume that the manufacturing buy items arrive at the desired time (most have a leadtime of 7 days and/or are in stock), such that manufacturing can always start at the desired time.

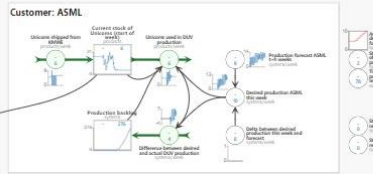
Note: a complicating factor for KMWE is that the leadtime for PCBs (an LLI) has increased from 26 weeks to 52 weeks, and is expected to increase even further in the upcoming years.







Customer: ASML



ASML

In the upcoming years, ASML is hoping to double the production of DUV systems, which also requires increasing the production of the Unicorn product.

Supplier managed inventory:
KMWE is allowed to manage the stock of Unicorns at ASML. In order to do so, KMWE receives the production forecast for the upcoming 13 months every week (rolling horizon) and receives insight in the current stock levels (of the products managed by KMWE) at ASML. Based on this information, KMWE is allowed to write sales orders and ship products when needed. This typically happens at Friday, after finishing the assembly of the Unicorns.

ASML and KMWE have agreed upon minimum and maximum levels of the Unicorn stock at ASML. The minimum is based on the delivery reliability of KMWE. For simplicity reasons, we assume here that the minimum is 10 and remains constant throughout the simulation. The maximum is calculated from the minimum desired stock level, summed with two times the smoothed demand and the optimized production quantity (which is currently 5 for the Unicorns).

ASML's production forecast
In this model, we assume that ASML's forecast is normally distributed. The mean is increasing over time (as ASML is ramping up the production of DUVs) and for now we assume that the standard deviation is constant.

However, no forecast is perfect. Therefore, in the model we'd like to test the impact of ASML's forecast inaccuracy. The easiest way to do this is by creating an additional variable. Delta between desired production this week and forecasted production this week. The forecast might have a structural bias (e.g., shortage gaming) and/or a random error. In our case, we assume the delta is normally distributed as well, in which the structural bias is the mean and the random error is the standard deviation.

Demand for other products
KMWE produces multiple products for ASML's DUV systems, as well as for other systems from ASML. Therefore, if the production of DUV systems is ramped up, the demand for other products will increase as well. In our now, we assume total demand for assembly will increase with increase with 50% and follows the increase in demand of the Unicorn. That is, if demand for Unicorn increases, demand for other products will increase simultaneously.

Data analysis forecast ASML

If you only take the forecasted weeks of 2022 into account and remove the large numbers (15, 28, 38), the average forecasted demand is 4.6 systems. Therefore, the average number of DUV devices in production forecast starts at 4.6 in the simulation. After the 1st of January 2023 (week 79 in the simulation), it's up to you to test different speeds and patterns of ramp-up.

If you remove the large numbers and calculate the standard deviation over all forecasts provided, the standard deviation is close to 2. Therefore, the simulation is initialized at 2.

Since no data is provided about the actual production at ASML, the bias in the realization is set initially at 0. You can test what would happen if there would be a structural or random bias.

Planning

KMWE primarily uses backward scheduling for planning assembly, manufacturing and purchasing. Based on the production forecast of ASML, KMWE derives (and agrees with ASML upon) an *Assembly Plan* for 26 weeks from now – aiming at a stable move rate. Based on this assembly plan, manufacturing and purchasing activities are started just-in-time, with the aim of having all 115 items available just before assembly takes place.

Thus, based on the information from ASML and KMWE, KMWE's planning department creates four types of orders:

- *Purchase Requisitions (PRs)*: these orders are sent to KMWE's purchasing department and are translated into purchase orders for KMWE's suppliers. Each order contains how many items are supposed to be ordered. For most items, the PR is derived from the Assembly Plan (and thus the Assembly Work Order or Manufacturing Work Order). For the Long Leadtime Items (LLI), the PR is derived directly from ASML's production forecast.
- *Manufacturing Work Orders*: these orders are sent to KMWE's manufacturing teams and contain how many semi-finished products need to be manufactured. The Manufacturing Work Orders are derived from the Assembly Work Orders: each assembly requires 24 semi-finished products. Manufacturing these semi-finished products is scheduled just-in-time: each of these semi-finished products (with different routing and manufacturing throughput times) is scheduled to be finished two weeks before assembly starts (safety time = 2 weeks). The detailed manufacturing planning (for each work station) is made by the manufacturing teams themselves and is out-of-scope.
- *Assembly Work Orders*: these orders are sent to KMWE's assembly team (in clean room ISO 7) and contain how many products need to be assembled. Every month (at the start of the month), an assembly plan is made for 7 months from now (t+25 weeks until t+32 weeks) and translated to Assembly Work Orders for 26 weeks from now. The production forecast of ASML 7 months from now is averaged over these 4 weeks to create a stable move rate (during these weeks). Since it's not possible to assemble 4.5 Unicorns in a week, the move rate is typically rounded to the nearest integer. How the assembly plan changes over time (with supply delays for example) is explained in more detail below).
- *Sales Orders*: these orders are created by KMWE and contain how many products will be shipped to ASML. KMWE and ASML are currently experimenting with Supplier Managed Inventory: the responsibility for managing the inventory is relocated to the supplier. It works as follows: ASML has specified the maximum and minimum stock levels per product, both organisations have created a shared environment in which KMWE has near real-time insight into the Unicorn stock at ASML (stock levels are updated every 15 minutes). Since KMWE aims to minimize their own stock, they aim to fill ASML's stock up to the maximum stock level. Sales Orders are sent every Friday, right after completion of assembly. These products are shipped typically on Friday as well.

Background information:

- The orders are created by KMWE's ERP system, GLOVIA, as recommendations (Computer Planned Orders, CPOs). The planners of KMWE check and finalize the orders.
- Assembly planning and Manufacturing planning occurs against infinite capacity. That is, in the planning process, infinite capacity is assumed.

Changes to the assembly plan

Assembly starts only for these products that can be assembled: the products for which all buy items and semi-finished products are present. If 114 out of 115 items are present, assembly will wait for the last item to arrive. Therefore, if KMWE has insufficient items in stock to assemble the desired number of Unicorns (according to the original assembly plan), they select either of two options:

- If KMWE can at least assemble x Unicorns this week, they assemble the number of Unicorns which they can assemble. The remaining Unicorns enter the backlog and are added to the assembly plan for this week whenever the items have arrived and there's spare capacity available.
- If KMWE is not able to produce x Unicorns, the entire assembly plan is moved one week forward. For now, we assume that the orders outstanding remain unchanged: the due date for suppliers and manufacturing remains the same. The orders that haven't been placed yet however are moved one week ahead. Effectively this results in:
  - This week no new orders are placed
  - Next week the supposed orders from this week are placed

Currently x = 1. That is, if KMWE is not able to produce any Unicorn this week, the entire assembly plan is moved one week forward.

Manufacturing

KMWE is manufacturing many components for the Unicorn (and for other products) themselves: out of the 115 items that are assembled into the Unicorn, 24 are manufactured by KMWE. In their factory hall, KMWE has 18 work centres, including CNC milling stations, CNC turning stations, sawing stations, bench working stations, heat treatment stations, and quality control stations. Not every step in the manufacturing process can be performed in-house though: KMWE works together with specialised suppliers for several activities, such as wire EDM, nickel plating, surface treatment and clean room cleaning.

Each semi-finished product (i.e., manufactured item) follows a specific path through the factory. The fastest semi-finished products need 28 workdays (slightly less than 6 weeks); the semi-finished products with the longest manufacturing processes take on average 65 workdays (13 weeks). Most of the semi-finished products visit a work centre once (±70% of 50 Ps), but there are some exceptions. To give you an idea about the manufacturing paths:

- The interface ring starts with CNC milling, followed by heat treatment, CNC turning, CNC milling, bench working, quality control, nickel plating and clean room cleaning.
- The fiber frame starts with CNC turning, followed by quality control, CNC milling, CNC milling (once more), bench working, quality control, wire EDM, surface treatment, clean room cleaning and bench working.
- The distribution BS starts with sawing, followed by CNC milling, bench working, quality control and clean room cleaning.
- Etc.

Since properly analysing the manufacturing process is a study by itself, in this model we treat the manufacturing process as a black box: we see what goes in and what comes out of manufacturing, but we don't keep track of what happens at the factory floor.

Manufacturing planning:
In its manufacturing process, KMWE typically works with a cycle time of 4 weeks. The batch size of each semi-finished product is therefore determined every 4 weeks and consists of the expected manufacturing orders in the upcoming 4 weeks. Once a batch is planned, the due date (and stop time) remain unchanged (also when the assembly plan moves forward).

Additional details of Manufacturing planning (out-of-scope)
KMWE is planning manufacturing backwards. That is, based on the desired due date of a semi-finished product (factory Planner (software package) determines when each step needs to be finished (stop time). In this, factory planner takes a production time (constant per item) and waiting time (constant per work centre) into account. Factory planner is planning with infinite capacity; the waiting times per work centre are considered to be constant (they are based on historical performance).

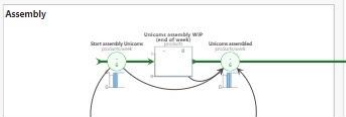
The production team leads are responsible for determining the sequence of activities at each work centre. Based on the stop times (and priority) of each S/P, they determine what S/Ps are handled first. In this, they are searching for efficiency gains: sometimes it makes sense waiting for the next batch of the same S/P to reduce the number of setups.

With the current data, it's hard to determine the throughput time of each work centre. The stop time is tracked, but not the time an item arrives at that work centre. Since it quite often happens that items are not directly transported to the next work centre upon finishing (this requires internal logistics), there might be quite a gap between the stop time at work centre n and the arrival time at work centre n+1.

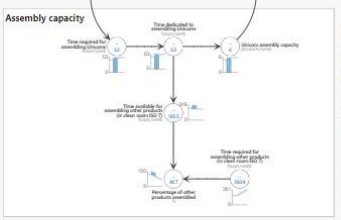
Assembly

The assembly process of the Unicorn is performed in a clean room (ISO 7) and consist of several steps. First, the pipes are glued to the base frame, after which the glue needs to dry for 24 hours. Then, the spindle and pipes are cleaned and assembly of the Unicorn starts. The cleaning and assembly process takes of five Unicorns takes approximately 2.5 days (with working days of 8 hours). After the Unicorn is assembled, it is tested (half a day) and packed, after which the technician can finalize the registration (together also half a day). Thereby the assembly process of five (or fewer) Unicorns always takes 5 days: it starts on Monday and is final-ized on Friday afternoon.

In this process, the set-up time per Unicorn is approximately 15 minutes. The handling time per Unicorn is 10 hours and 15 minutes, so that results in 10 hours and 30 minutes total per Unicorn.



Assembly capacity



Data analysis assembly capacity

Based on the historical assembly data, it can be deducted that it is possible to assemble 5 Unicorns in a week (this happened twice). Much more frequently however, 5 Unicorns were produced in a week (28 weeks). So the current assembly capacity is either 5 or 6.

For the simulation, you might want to test different capacities, either as fixed capacity (what if we can increase the capacity to x throughput the rum?) or as increasing over time. For this, you can test different patterns of stepwise increase as well (what if it increases in line with ASML's forecast? What if it increases earlier/later?).

Data analysis master data

For calculating the average lead times (and the MOQs), we assume that all items with a lead time of more than 20 weeks are long lead time items (LLIs). We make this assumption because we want to be able to test what happens if we increase the safety time of other buy items: if the assembly plan looks 26 weeks ahead and the door-to-stock lead time is 1 week, we can test (maximally) 4 weeks of safety time for other buy items.

While 6 items have a lead time of 20 weeks or more, one of them is a manufacturing buy item (lead time 20 weeks). In the model, the manufacturing buy item is treated as a manufacturing buy item, so in the model we work with 5 LLIs. The average lead time of these 5 LLIs is 24 weeks (rounded up). The average lead time of the other 68 buy items is 8 weeks (rounded up). The average leadtime of the 17 manufacturing buy items is 3 weeks (rounded up).

From the historical manufacturing data, we can calculate the average throughput time. In 2022, this was 8 weeks (rounded up) for the Unicorn semi-finished products.

Since there is no data available about the average minimum lead times and the average delay of the latest item, these are set in the base case to -2 and +2 of the average lead time.

To assemble a Unicorn, in total 6 LLI buy items are needed (one item is needed twice), as well as 143 other buy items (rounded up) and 24 semi-finished products. Since the quantitates of many manufacturing buy items are presented in measurement units (e.g., kg), we assume that all 17 manufacturing buy items are used once in the 24 semi-finished products. To calculate the values and the inventory of manufacturing buy items correctly, we do take the measurement units into account there.

Lastly, the MOQ of the LLIs is calculated by summing the MOQs for the 5 individual items, resulting in an aggregate MOQ of 145 items. For the other buy items that are used less than 1 in the Unicorn (due to their measurement units), we calculate the MOQ for this item by dividing the MOQ with the quantity (that is, if 0.05 of an item goes into the Unicorn, the MOQ of 50 results in the new MOQ of this item is 40). This calculation results in an aggregate MOQ for all other buy items of 6,0[illegible]. Lastly, the MOQ for manufacturing buy items is then 5/7 items (rounded up).

Capacity

In the model, we assume that manufacturing capacity is sufficient: we don't model manufacturing capacity explicitly and assume that the distribution of the throughput time is constant over time (even when the production of semi-finished products for the Unicorn is scaled up). In reality, this is not the case – of course –, but diving properly into the manufacturing process is a study by itself.

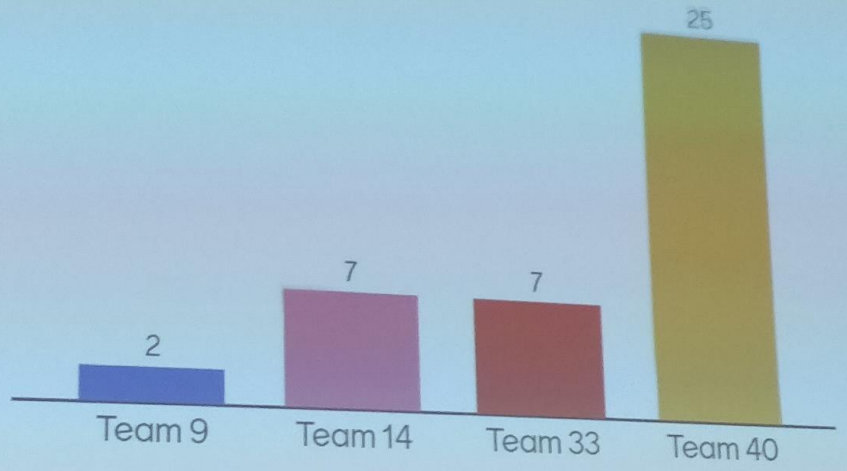
Assembly capacity on the other hand is limited in the model. Assembly capacity of the Unicorn is determined by:

- *Machines and tooling*: three machines (and corresponding tooling) are used in the assembly process of the

Go to www.menti.com and use the code 2292 0024

What group has the best recommendation for KMWE?

Mentimeter



Insights and recommendations (assignment 4)

A note before: the base run & assumptions

In the base run of the simulation, we test what happens if ASML is ramping up the production of DUVs (and therefore the demand of Unicoms) from 4.6 on average to 10 in the upcoming 3 years. In the base run, we assume that the lead times of suppliers are constant, that the delivery reliability of suppliers is constant, that the MOQs are constant, that the forecast of ASML is not structurally biased, that the prices are constant, and that the assembly capacity is constant at 6 Unicoms/week.

Insights and recommendations (assignment 4)

Main insights

Given these assumptions, the main insights are:

1. If the system has structural undercapacity, we observe that the system stops functioning: the backlog increases (demand is higher than capacity), the inventories rise (because the assembly plan is based on the forecast of ASML) and all KPIs become worse (by a lot). So, if ASML is ramping up capacity, KMWE needs to ramp up capacity as well (which makes sense). In the model we've tested how to link the assembly capacity to the demand/forecast of ASML. If you link it to the forecast, two elements are relevant: (a) the timing of capacity increase (earlier/later than the increase in demand of ASML) and (b) the buffer capacity. In the model we found that the delivery reliability stays close to perfect if you (a) increase the assembly capacity at the same time the production of ASML is increasing (it's not necessary to increase it months ahead) and (b) have a buffer capacity of 1 or 2 (to deal with fluctuations in the forecast and unreliability of suppliers of KMWE). If the unreliability of suppliers increases, a higher buffer capacity might be desirable.

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Main insights (cont'd)

2. With the current way of planning (backward planning), the lead time of suppliers is not that relevant. That is, for these KPIs it doesn't matter if the lead time of a supplier is 10 weeks or 20 weeks, as long as it is constant and delivering in time. What matters for assembly is the delivery reliability of suppliers. If one supplier delivers late (regardless of whether it is a LLI or other buy item), all other items cannot be used for assembly, thus both the inventory and the backlog increases simultaneously, which results in a higher CCC and lower delivery reliability of KMWE. There are several ways to deal with this:
   a. Increasing delivery reliability of suppliers, for example with (contractual) incentives, information sharing, …
   b. Increasing safety times for buy items (this increases the average inventory as well, since all items are ordered earlier. If this can be done in a targeted manner – only to those items with a high delivery unreliability – then it's optimal)
   c. Increasing the accuracy of the master data, by regularly updating the lead time of each buy item in the planning system (if lead times are changing over time, updating them accordingly reduces the variability in when items arrive)
   d. For items with a high delivery unreliability, consider manufacturing these items in-house or moving to a different supplier

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Main insights (cont'd)

3. The same can be said for the internal manufacturing process: throughput time by itself doesn't affect the KPIs, variability in throughput time does.
4. Repeatedly, we've observed the CCC and ITO worsening when the backlog is increasing. Typically, this increase in backlog is caused by unreliability of suppliers. The main way to recover from a backlog is by having some buffer capacity.

So, what to do? It depends upon the variability in lead times of suppliers whether policy 1 is sufficient to maintain a high delivery reliability. If the variability is too high, additional measures are needed, in which we think 2b and 2c are most effective. Please note that 2b does increase the average inventory at KMWE, so negatively affects the CCC and ITO. The more this can be done in a targeted manner, the fewer the inventory will increase (it might be possible this will actually lead to a net inventory decrease, if it also decreases the backlog).

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Additional insights

We have also tested what happens if you loosen some of the assumptions, which generated several additional insights:

- If the forecast of ASML is biased (that is, the actual production is structurally higher/lower than the forecast), then it's wise to include a safety margin when converting the forecast into the assembly plan. Trying to get the assembly plan as close to the actual desired products by ASML is good for all KPIs. If there is no structural bias, rounding the move rate to the nearest integer (which is done currently) is a better policy than always rounding it up.
- Changing the time horizon for the assembly plan (currently set at 26 weeks) – making it look further/shorter ahead – doesn't affect the KPIs.
- If the MOQ of buy items is reduced, the average inventory decreases, resulting in a better CCC and ITO. However, at the same time, we observe that a backlog might increase, since it happens more often that one of the items is delayed. If you order an item every week (instead of once every 10 weeks), there's a possibility every week that an item is delayed (instead of once every 10 weeks). Removing supplier unreliability from the model (completely) solves this problem. So, for items that have a very low delivery reliability, a high MOQ might be a blessing in disguise.
- Sudden changes in lead times (from 10 to 20 weeks, for example) can cause a large backlog and increase in overall inventory, if there is no safety stock (or stock left from the MOQ) at that time.

THANK YOU!

AND WE HOPE WE HAVE GENERATED SOME USEFUL INSIGHTS

If this also raises new questions, feel free to reach out
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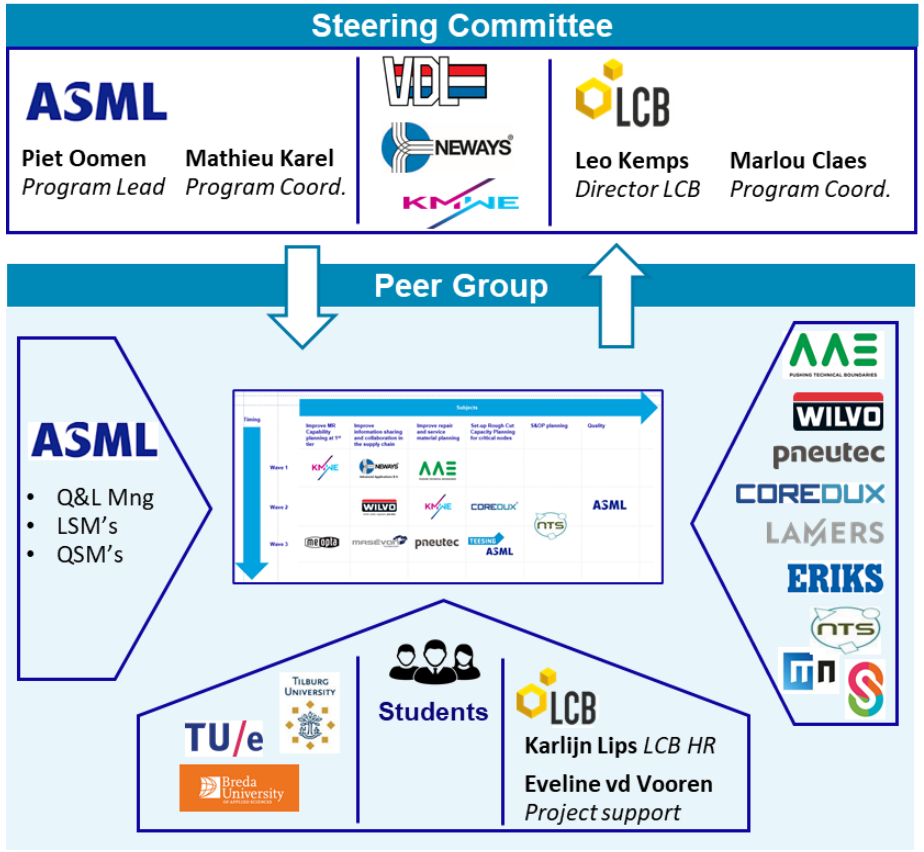
HTSC-E


Steering Committee
ASML
Piet Oomen
Program Lead
Mathieu Karel
Program Coord.
VDL
NEWAYS
KMWE
LCB
Leo Kemps
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LAMERS
ERIKS
NTS
TU/e
Tilburg University
Breda University
Students
LCB
Karlijn Lips LCB HR
Eveline vd Vooren
Project support


Subjects
Timing
Improve MR Capability planning at 1st tier
Improve information sharing and collaboration in the supply chain
Improve repair and service material planning
Set-up Rough Cut Capacity Planning
-S&OP Planning - Leadtime
Lot size & Inventory control
Wave 1
Wave 2
Wave 3
Wave 4
KMWE
NEWAYS
Advanced Applications B.V.
AAE
WILVO
COREDUX
NTS
ASML
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