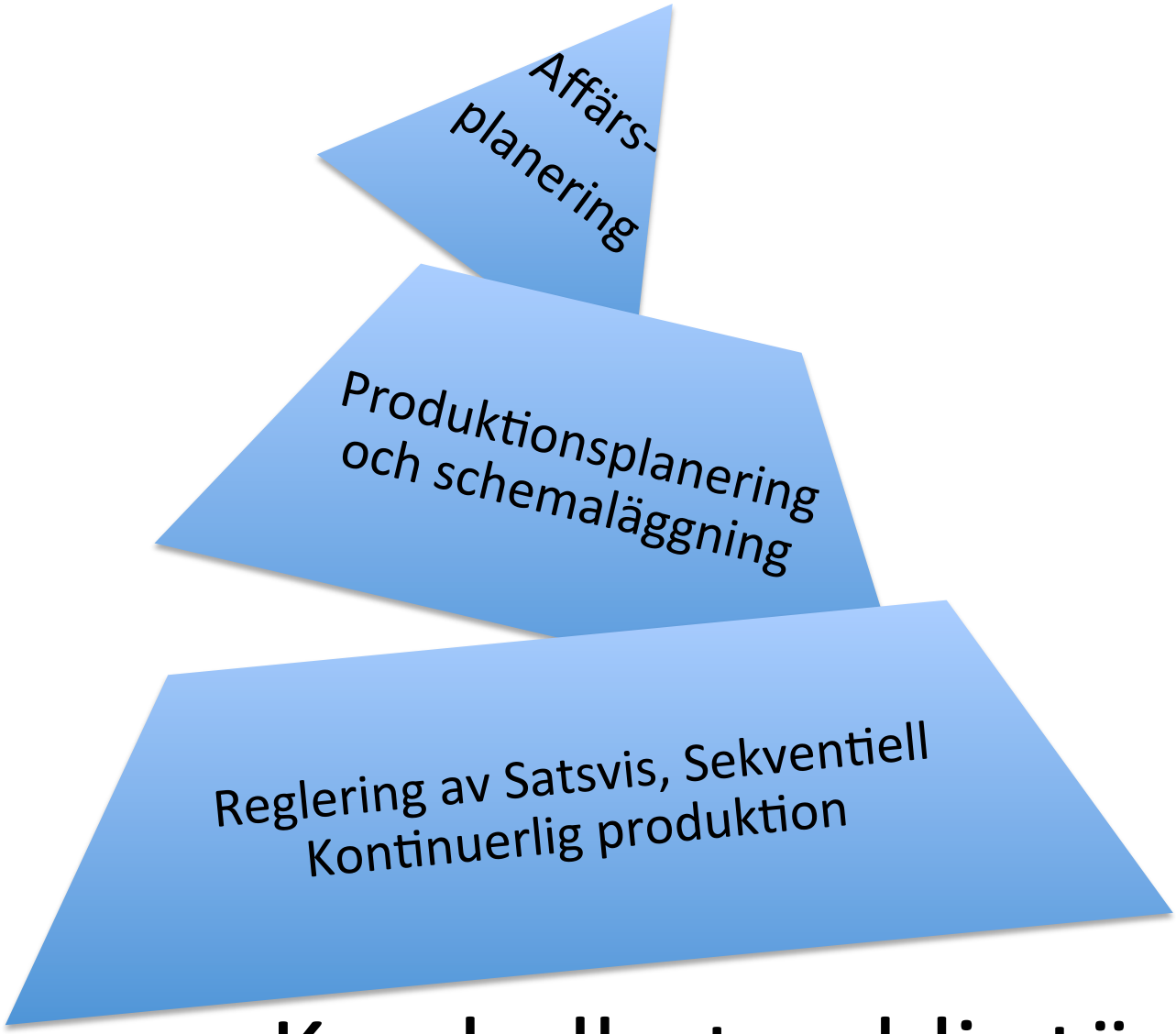
Lång och kort planeringshorisont från ett industriellt perspektiv

Krister Forsman

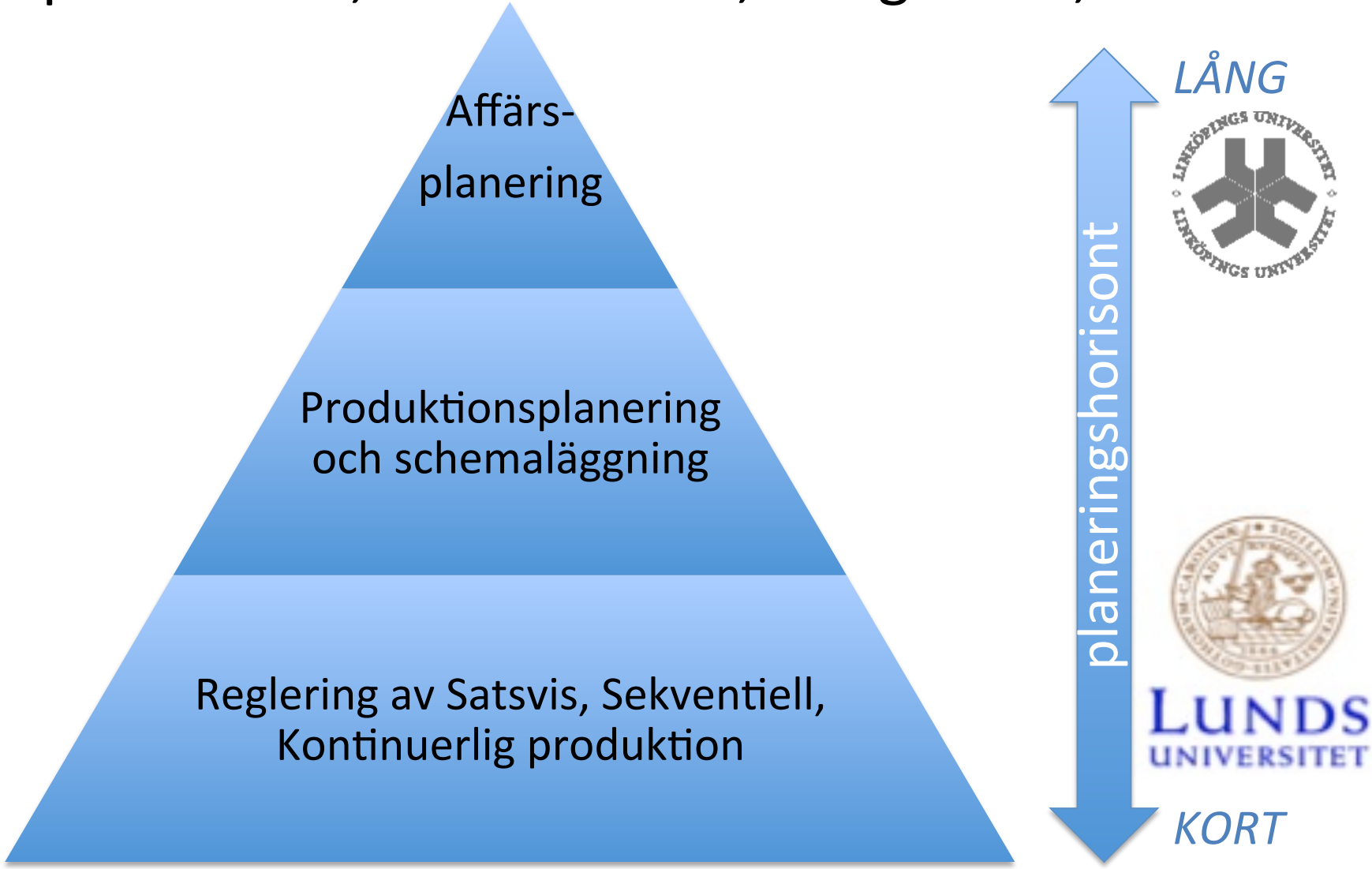
Charlotta Johnsson

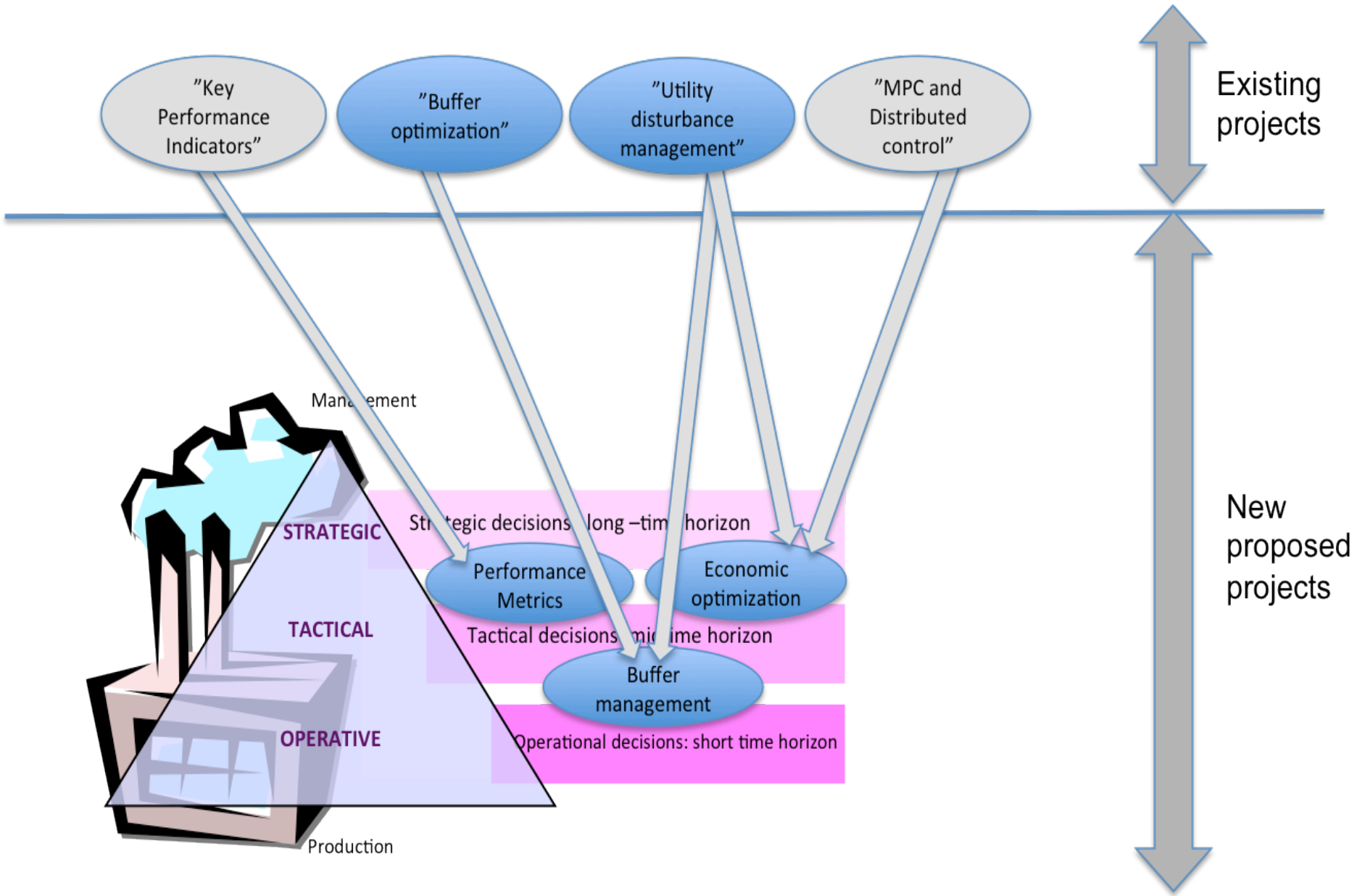


Kan helheten bli större än summan av delarna?

PIC-opic:

Optimization, Performance, Integration, Control




"Key Performance Indicators"
"Buffer optimization"
"Utility disturbance management"
"MPC and Distributed control"
Existing projects
New proposed projects
Management
STRATEGIC
TACTICAL
OPERATIVE
Production
Performance Metrics
Economic optimization
Buffer management
Operational decisions: short time horizon

Collaborating teams

Industrial Partner: Perstorp
Krister and Nils-Petter
+ Daniel Hansson, Anders Broberg

PIC-Linköping & PIC-Lund

Buffer Mgmnt and Inventories

- Ou Tang
- Tore Hägglund
- Daqin Wang
- Liu Weihua

Performance Metrics

- Charlotta Johnsson
- Joakim Wikner
- Sayeh Noroozi

Economic Optimization

- Helene Liedestam
- Anna Lindholm
- Nils-Hassan Quttineh
- Pontus Giselsson
- Mathias Henningsson
- Charlotta Johnsson
- Joakim Wikner

Planning, optimization, inventory control:

Challenges particular to the process industry

Krister Forsman

The Perstorp group – short facts

- Specialty chemicals company with focus on organic chemistry
  - 1500 employees; Turn-over 2012 = 10.5 GSEK
- Products: Mainly additives for other chemical industries, e.g. additives in paints and coatings, plastic-processing, food and feed, solvents.
- Main product groups: polyalcohols, esters, organic acids, polymers, aldehydes
- Nine production sites, in eight countries; Totally ~40 plants
- Typical plant characteristics:
  - Synthesis (reaction) followed by a large number of separation steps
  - Batch-wise reaction, continuous separation, e.g. distillations, evaporations, crystallization,
  - Many intermediate buffers
  - High value side streams (byproducts), gives many recycle loops

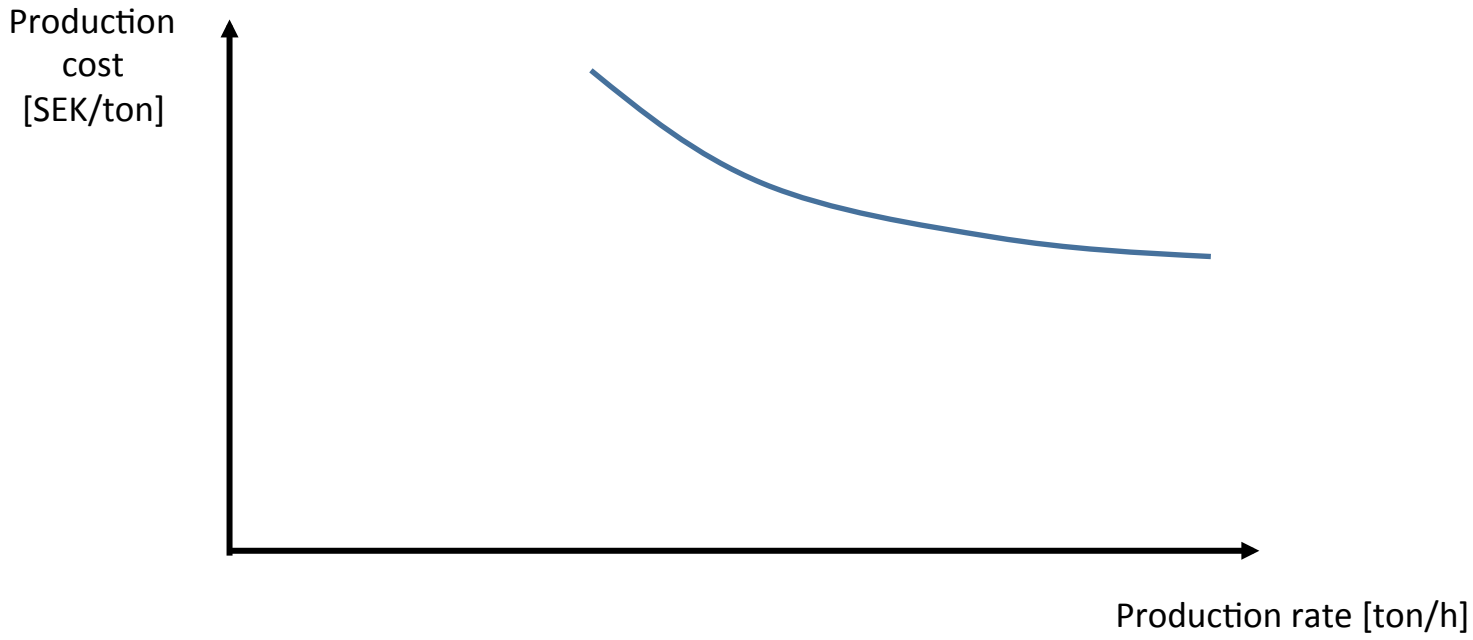
Characteristic of a process industry plant

- Some aspects of a typical chemical plant makes it very different from a discrete manufacturing plant. Examples:

- There is a **turn-down ratio**.
  - The plant cannot be run at a slower production rate than maybe 50-70%.
- Start-up time is significant
  - Not uncommon that it takes up to 24 h to go from shut down to full production (”cold start”)
- Start-up costs are signficant
  - Varies significantly from plant to plant, but ~100 k€ is not uncommon
- Variable cost per ton depend on production rate

Variable costs depend on production rate

- Almost always: production cost in SEK/ton decreases as production rate is increased.
- Primary reason: there is a “base load” for utilities, which is distributed on more tons when you run faster.
- In some cases, the raw material yield is also better at higher rates.



What is an “unplanned” shutdown?

- Two extreme cases:
  - Regular maintenance shutdown: planned months or years ahead. Typically lasts for two weeks or more
  - Immediate, out-of-the-blue, shutdown: with only minutes or seconds head warning. E.g. power outage, faulty trips, human error

- But most shutdowns are somewhere in between:
  - “The pump sounds strange and needs to be repaired within a week”.
    Check the list of pending maintenance work requiring shutdown, and try to plan the shutdown timing and duration, so as to optimize this.
  - Example: “Fixing the pump only takes 6 hours, but if we have a 12 hour shutdown and fix some other stuff as well, we can postpone the next planned shutdown and get better availability next month”.

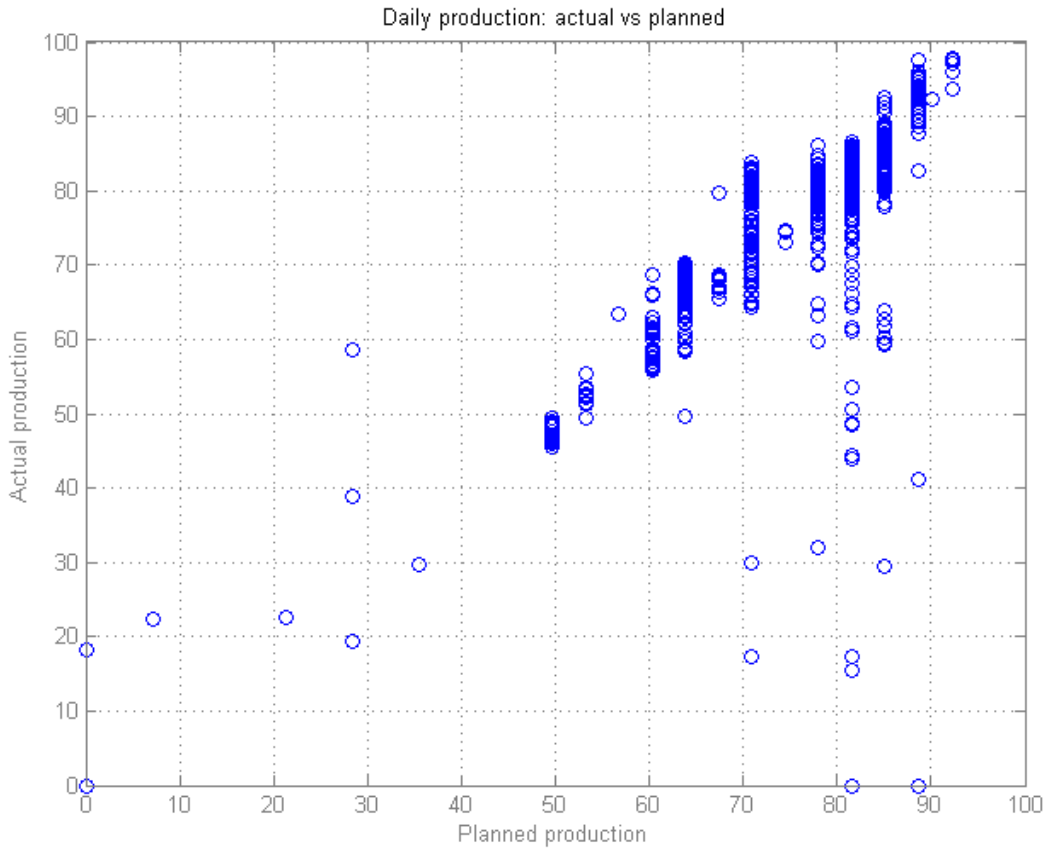
Hard to assign a value to availability

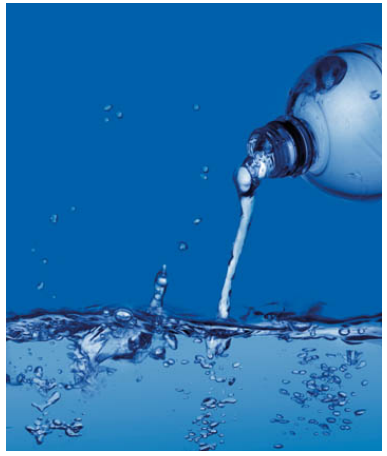
- An unplanned shutdown means lower produced volume than planned during a period.
- Suppose the planned volume was only 80% of available max capacity.
  - If we have a one day shut, we can catch up within five days.
  - Is there any cost associated to this? What is the loss?

- Always creates additional work for distribution planning / transports. Sometimes actual monetary costs.
- What is the effect on sales?
  - Very hard to model. There may be lost orders, but that is not always registered.
  - There may also be direct or indirect penalties associated to delays, but this is often subject to negotiation.
- Average stock levels can be decreased if production is more reliable.

Input to inventory planning discussion

Consider the production as a process which is not 100% reliable.
A probability distribution specifies how likely we are to get what we planned.
How do we calculate the optimum inventory levels given this pdf and specifications on delivery accuracy?





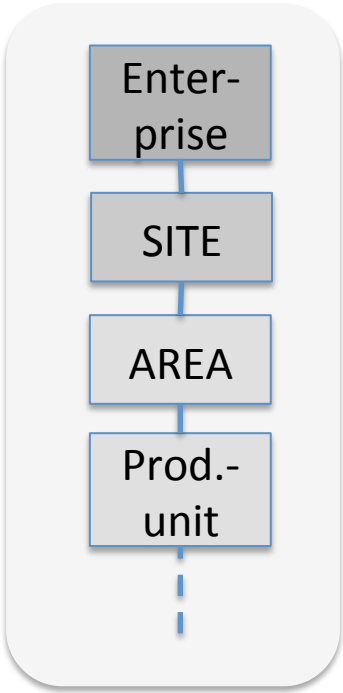
How did we address these challenges ?

Economic Optimization
Buffer and Inventory Management
Performance Metrics

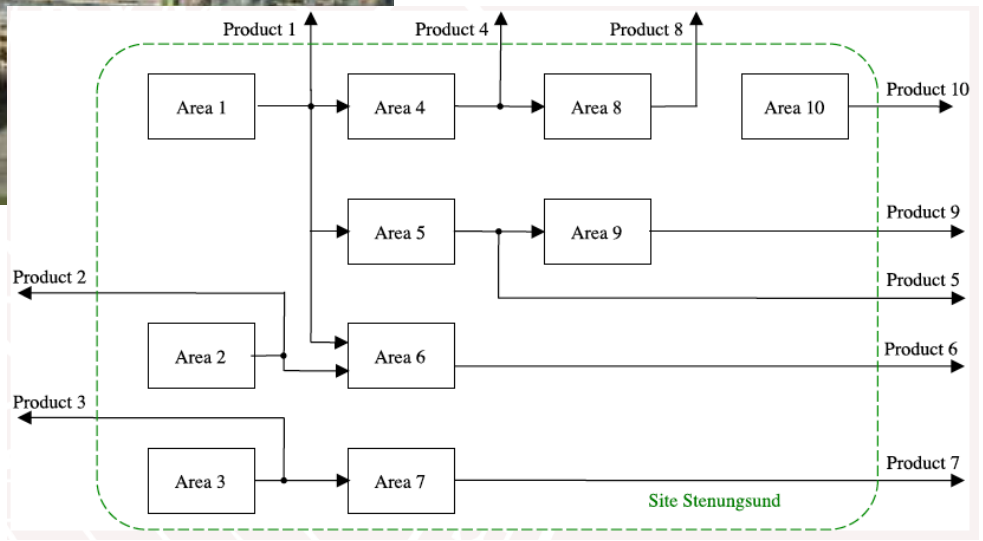
Charlotta Johnsson

Perstorp

Perstorp – 9 Produktionssiter runt om i världen – vardera site har flertalet Areor/Fabriker



Equipment hierarchy

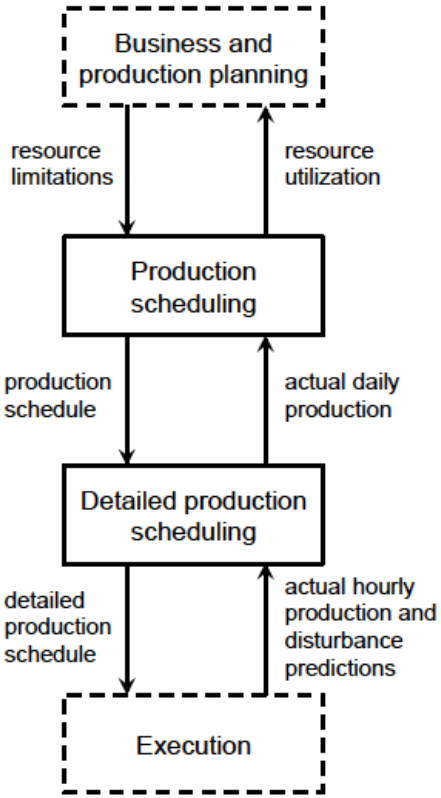


Economic Optimization

- Störningar i stöd-material (utilities) har en ekonomisk påverkan på företaget. Hur kan denna bli så liten som möjligt?
  - Pro-active disturbance handling
    - Titta på hur historisk data för störningar har sett ut. Vilken störning har genererat mest problem? Beslutsunderlag
  - Re-active disturbance handling
    - Vad kan göras i de korta planeringshorisonterna (control)
    - Vad kan göras i de långa planeringshorisonterna (scheduling)

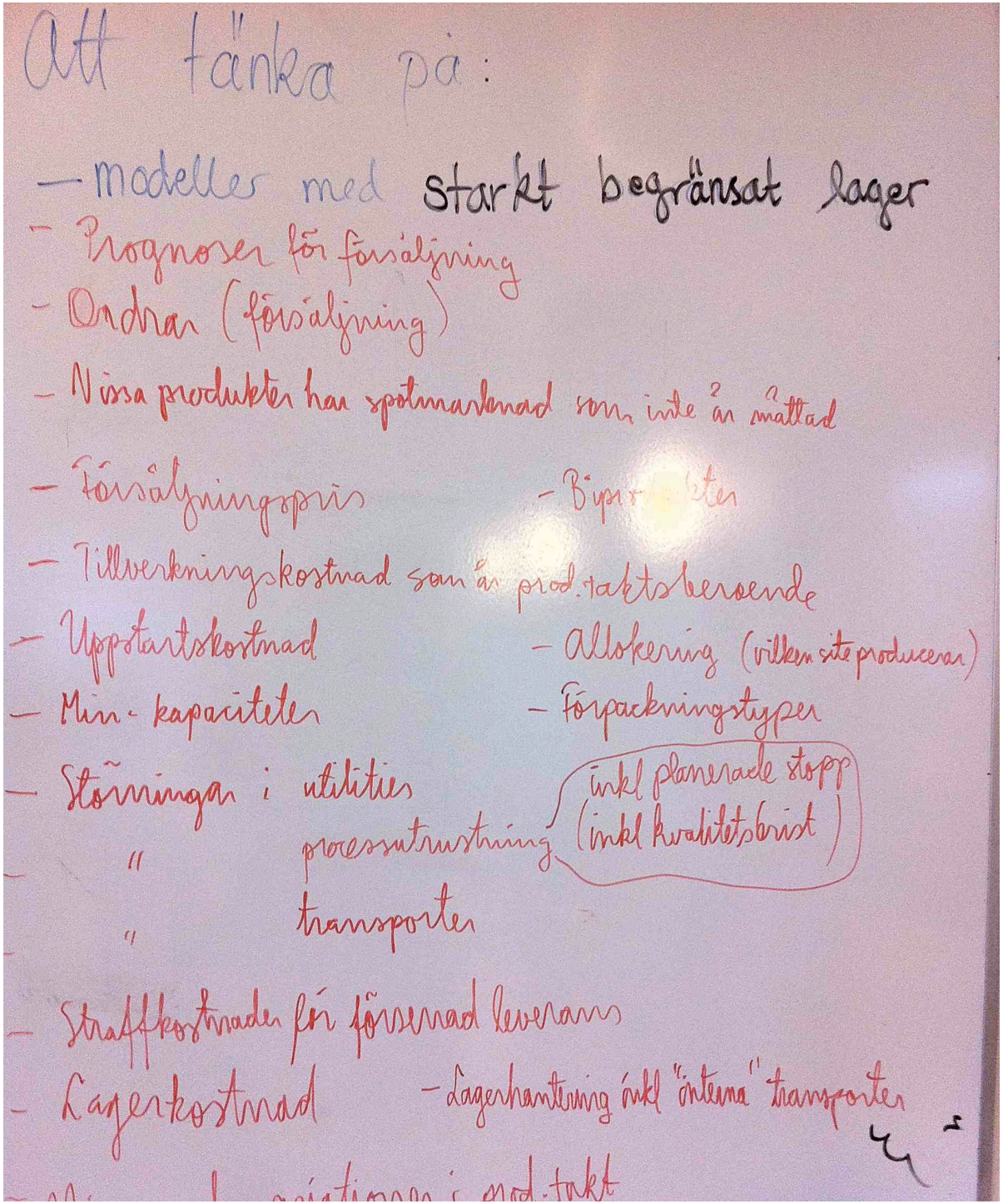
    => en optimeringsmodell delad i två delar

Economic optimizaton

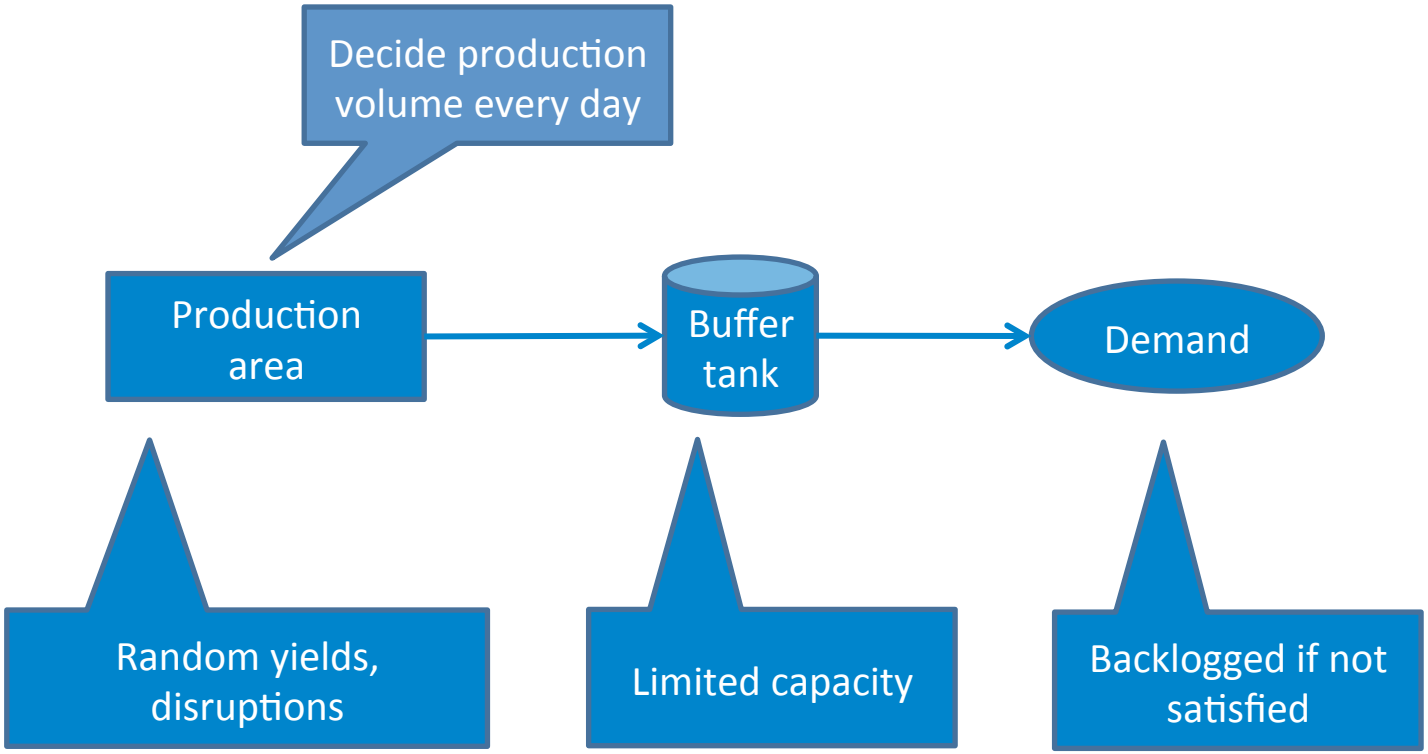


Formulation of optimization-problem for the schedules according to ”wish-list” from industry.

MPC as optimization technique



Buffer management



The project develops algorithms to estimate key parameters in the stochastics representations.

Buffer management – Stochastic dynamic programming

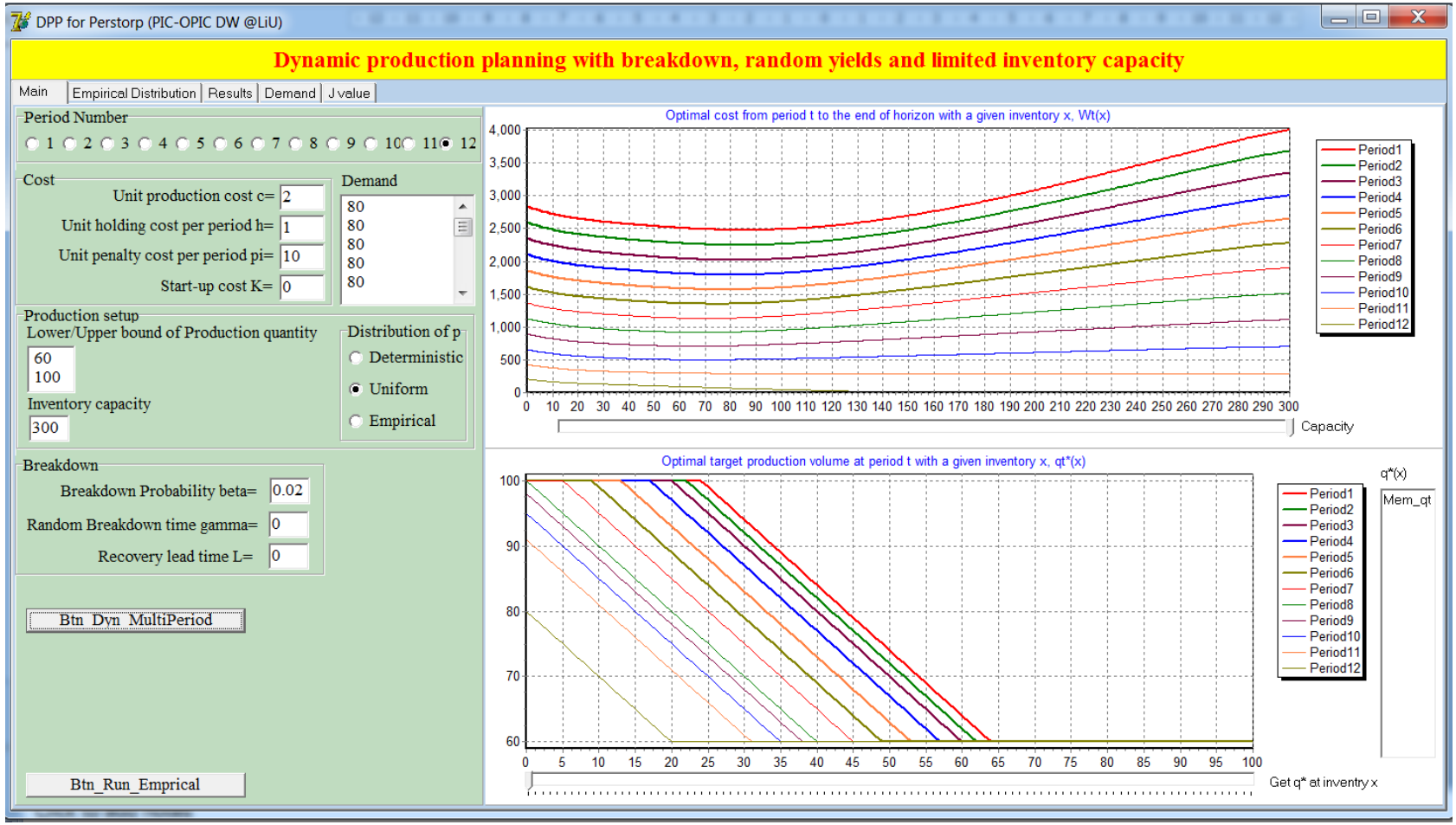
$$W_t(x,s) = \begin{cases} \min_{q\in[\underline{q},\bar{q}]} \left\{(1-\beta)J_t(x,q) + \beta I_t(x,q)\right\} + \beta K, & s = 0 \\ H(x-d) + \rho(s)W_{t+1}(x-d,0) + (1-\rho(s))W_{t+1}(x-d,s+1), & s > 0 \end{cases}$$

$$\begin{aligned} J_t(x,q) &= \mathbf{E}_P\left[c(P(q)) + H(x+P(q)-d) + W_{t+1}(x+P(q)-d,0)\right]\cdot I\{P(q) \le A+d-x\} \\ &\quad + \mathbf{E}_P\left[c(A+d-x) + H(A) + \rho(0)W_{t+1}(A,0) + (1-\rho(0))W_{t+1}(A,1) + K\right]\cdot I\{P(q) > A+d-x\} \\ I_t(x,q) &= \mathbf{E}_\gamma\mathbf{E}_P\left[c(\gamma P(q)) + H(x+\gamma P(q)-d) + W_{t+1}(x+\gamma P(q)-d,0)\right]\cdot I\{\gamma P(q) \le A+d-x\} \\ &\quad + \mathbf{E}_\gamma\mathbf{E}_P\left[c(A+d-x) + H(A) + \rho(0)W_{t+1}(A,0) + (1-\rho(0))W_{t+1}(A,1) + K\right]\cdot I\{\gamma P(q) > A+d-x\} \end{aligned}$$

Buffer management
- main results

- Develop exact and approximated models
  - production planning
- Analyse the effect of frozen periods
  - Cope frozen periods with the inventory capacity and disruption occurance.
- Analyse the effect of delayed transportations
  - Benefit of obtaining delay information early

Buffer management
- Simulation platform

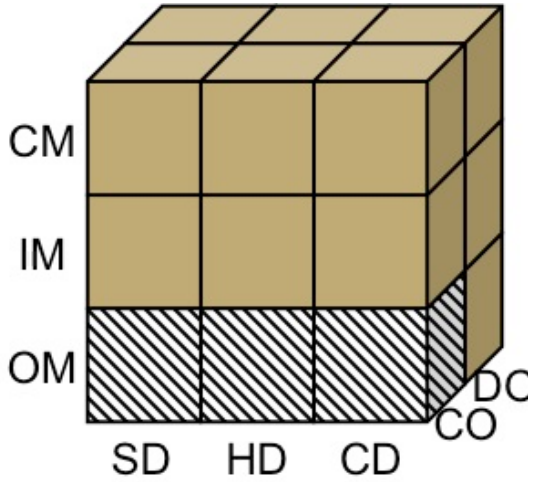


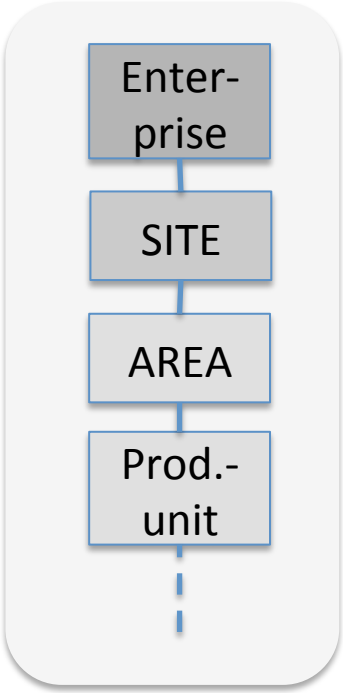
Performance Metrics

- Performance Metrics = mätetal lämpligt för utvärdering och mål.

- Vilka Performance Metrics kan användas i process industrin?
  - ISO 22400 och Studentrapporter
  - Exempel: Utilization ratio används oftare än Availability
- När är olika Performance Metrics lämpliga att använda?
  - Olika typer av kombination av produkt, produktion, drivare
  - En kub har plockats fram
  - ⇒ Ny ansökan där lämpliga nyckeltal skall sättas in i kuben
- Hur kan olika Performance Metrics visas för användare?
  - Physical equation
  - Physical relation
  - Logical equation
  - Logical relation
- Hur kan olika Performance Metrics implementeras i ett IT system?
  - XML är ett vanligt format för utbyte av information mellan IT system (jämför tex ISA95 scheman B2MML)

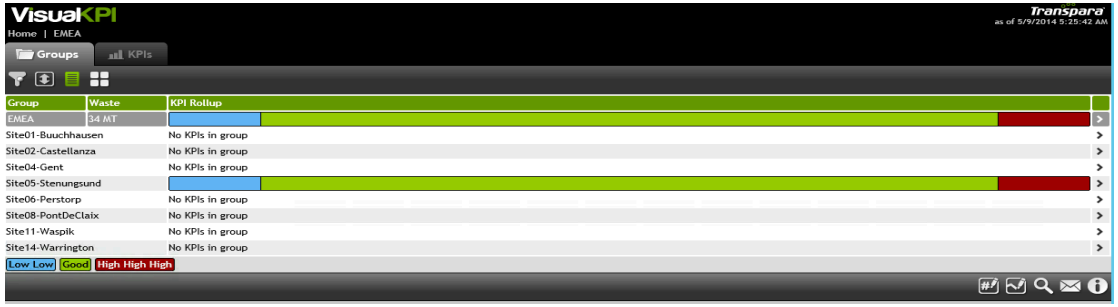
  => Ny ansökan om kpiML

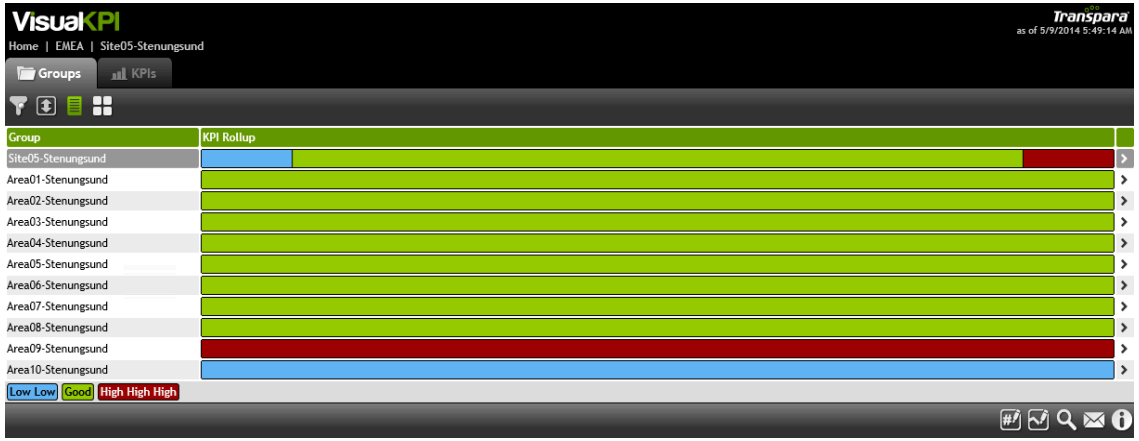


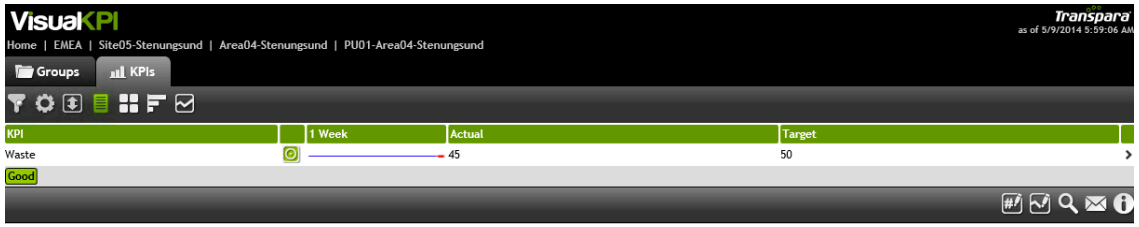


Equipment hierarchy

4 way to roll-up or drill-down







PIC-opic:

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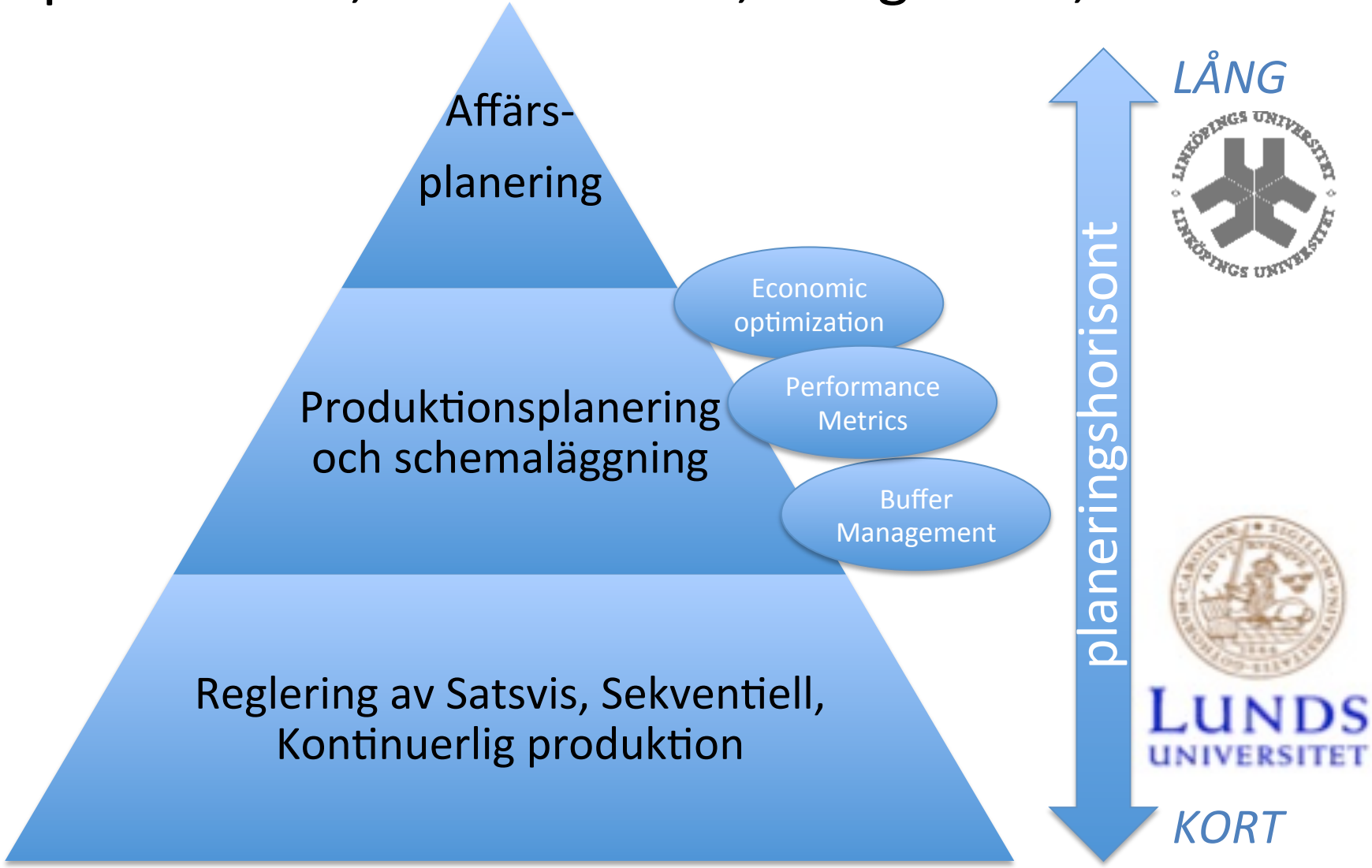

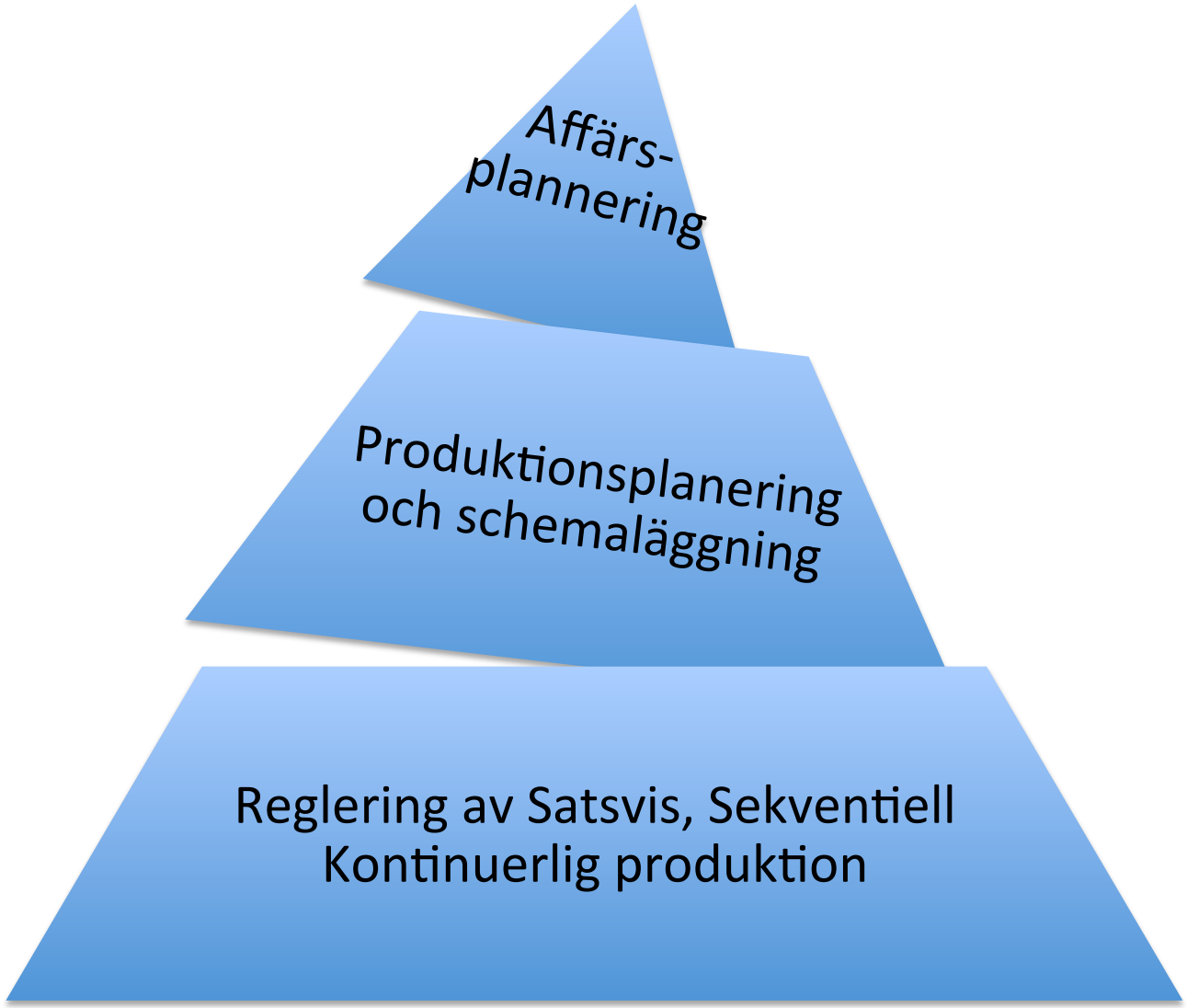

Vi tror att vi skapat lite mer ”helhet” bland delarna