Factory operations modelling / scheduling /implementation

An industrial case study

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Based on ESCAPE 17-18-19 contributions by Bakker & Bongers

Unilever in a glance!

You may not know “Unilever” …

But you know our products!

UNILEVER

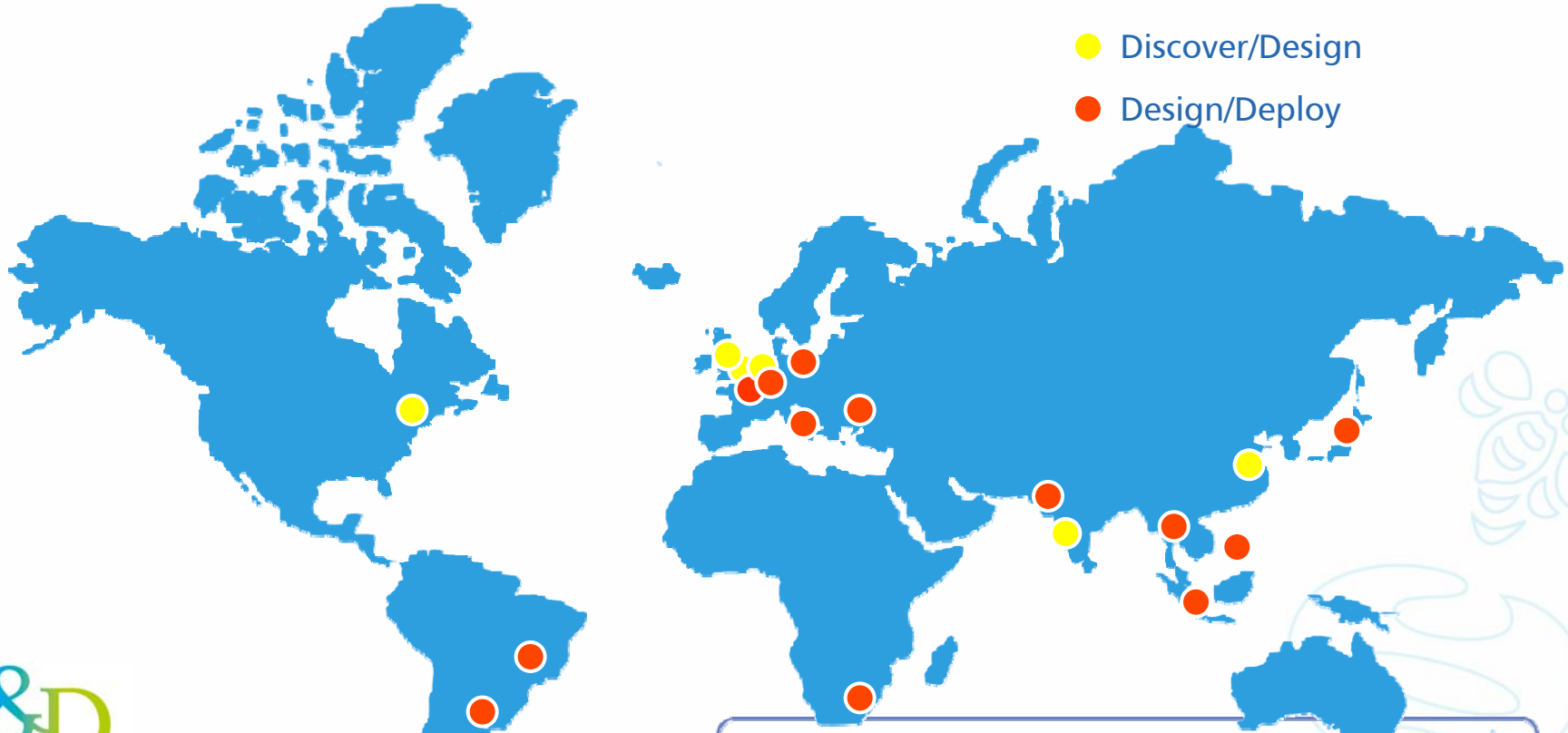
Our mission is to add vitality to life

We meet everyday needs for nutrition, hygiene, and personal care with brands that help people feel good, look good and get more out of life

Unilever – the Vitality Company!

- 150 million times a day, **in over** 150 countries, **people are using our products at key moments of their day… that's** 150 million opportunities **to make a positive difference to people's lives.**

Unilever R&D organisation



R&D brings great ideas to **life!**

- 6000 employees
- 900 million Euros (2.3% turnover; 2006)
- 6 Global Research centres
- 15 Global Product Development centres
- Regional & country centres

Agenda

- Motivation
- Classical process & challenges
- Scheduling Model design
  - Factory structure
  - Material flow
  - Constraints / change-overs
  - Multi-stage scheduling model
- Results and concluding remarks

Motivation

- Operational scheduling is
  - Production when needed

Motivation

- Operational scheduling is
  - Flexibility in production

Motivation

- Operational scheduling is
  - Choose when/where to produce

The GAP between theory and practice

- In spite of the fact that during this last decade many companies have made large investments in the development as well as in the implementation of scheduling systems, not that many systems appear to be used on a regular basis. Systems, after being implemented, often remain in use for only a limited amount of time; after a while they often are, for one reason or another, ignored altogether

- *Pinedo, M. (1992). Scheduling. In G. Salvendy (Ed.), Handbook of Industrial Engineering (2nd edition). Chichester: Wiley.Interscience.*

The GAP between theory and practice

- Complexity
  - The real world aspects/constraints/rules/assumptions that are relevant for the scheduling problem, and the relationships between those.
- Robustness
  - Robustness avoids nervousness in scheduling in situations with uncertainty. Nervousness should be avoided as much as possible
- Organizational embedding
  - Alignment of the scheduling decisions with the business
- Availability and accuracy of data
  - If this condition is not met, the scheduling model will be incorrect
- Interaction with human scheduler
  - It is recognized by many authors that the human scheduler will remain an indispensable factor in the scheduling process. However, many techniques do not account for interaction with the human scheduler.

Case study

Ice cream production plant

Complexity

- 12 packing lines
- Limited availability of staff
- Constraints on auxiliary equipment
  - Fruit feeders, secondary packers
- Buffer tanks per line vary in number and size
- Packing lines share buffers
- Two process lines to feed all packing lines
  - Different capabilities
- 146 SKUs
  - SKU's can be produced at multiple lines
- 150 recipes
  - Fresh dairy ingredients (shelf life)
  - In-house cone production (as well as bought-in)
- Stringent cleaning regime on process
  - Allergens
- Minimum <u>and</u> maximum standing time in buffers
- Mandatory Cleaning In Place
  - 24 hour cycle on process
  - 72 hour cycle on all other equipment

Why beyond engineering rules

Engineering rules or rules-of-thumb

Low (<50%) utilisation ↔ High (>70%) utilisation

Single stage production (dedicated resources) ↔ Multi stage production (shared resources)

Single product ↔ Complex product mix

Long (=1week) production runs ↔ Short (=1shift) production runs

large capacity margin for future growth ↔ De-bottle necking existing site OR rationalisation many plants into only one

"Guesstimate" inventory, storage & delivery ↔ Controlled inventory, storage & delivery

We want to be here

Minimize capital
Increased flexibility

Modelling (Multi-stage Scheduling)

Overview commercial scheduling software

	Vendor or Product Name	Comment	Web-page
1	SAP APO PP/DS	The Production Planning and Detailed scheduling component of the SAP Advanced Planning and Optimizer	http://help.sap.com/saphelp_apo/helpdata/en/7e/63fc37004d0a1ee10000009b38f8cf/frameset.htm
2	Manugistics	In 2006 acquired by the JDA software group	http://www.jda.com/company/manugistics-acquisition/
3	i2	In 2010 acquired by the JDA software group	http://www.jda.com/company/i2-acquisition/
4	Infor Advanced scheduler		http://www.infor.com/product_summary/scm/scheduler/
5	JD Edwards	In 2005 acquired by Oracle	http://www.oracle.com/us/products/applications/jd-edwards-enterpriseone/solution-manufacturing/index.html
6	SchedulePro		http://intelligen.com/schedulepro_overview.shtml
7	PIMS	AspenTech	http://www.aspentech.com/core/aspen-pims.aspx
8	Aspen Petroleum Scheduler	AspenTech	http://www.aspentech.com/core/aspen-orion-xt.aspx
9	GRTMPS	Haverly Systems	http://www.haverly.com/grtmps.htm
10	H/SCHED	Haverly Systems	http://www.haverly.com/hsched.htm
11	RMPS	Honeywell	http://hpsweb.honeywell.com/Cultures/en-US/Products/OperationsApplications/PlanningScheduling/RPMS/default.htm

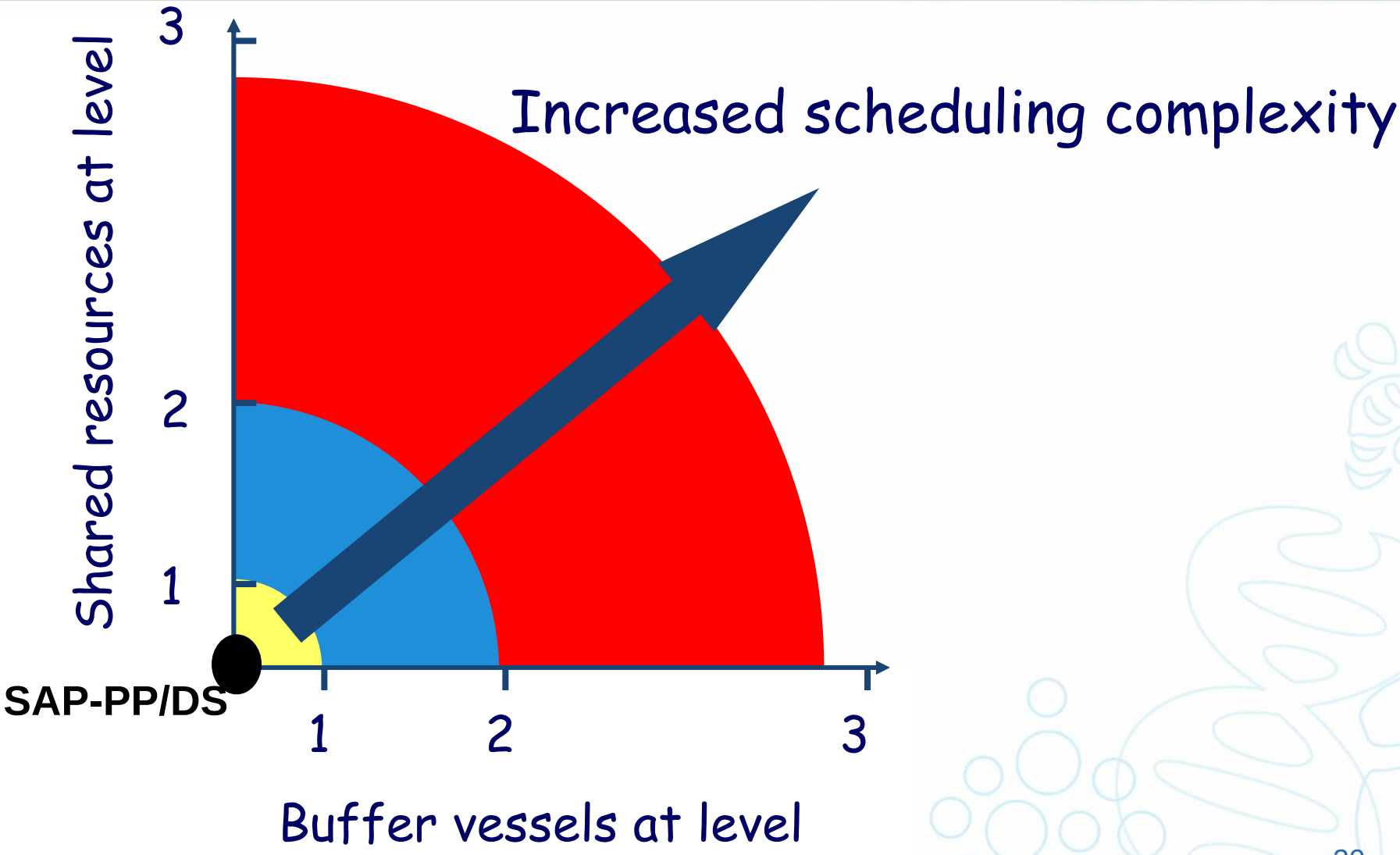
Necessary conditions to enable successful implementation

•	The model of the plant need to be a sufficient accurate representation of the real situation.
•	The graphical user interface for the plant scheduler needs to be intuitive and represent the plant.
•	The software should be usable by the plant scheduler, who, in general does not have an academic grade.
•	The solution, or schedule, need to be robust rather than optimal to the last decimal digit. One important item of the robustness is that the same schedule is generated even if there are small changes in the inputs.
•	The schedule of the complete plant need to be generated in a relative short period of time (faster than appr. 15 min. or one cup of coffee) in order to deal with decisions on the factory floor.
•	The software need to be able to deal with break-down of the equipment, and that buffer vessels might be partially full.
•	Communication with the other factory software, such that master data is only stored in one location to prevent errors. Master data contains information such as specific capacities, bill of materials, routing, alternatives, etc.

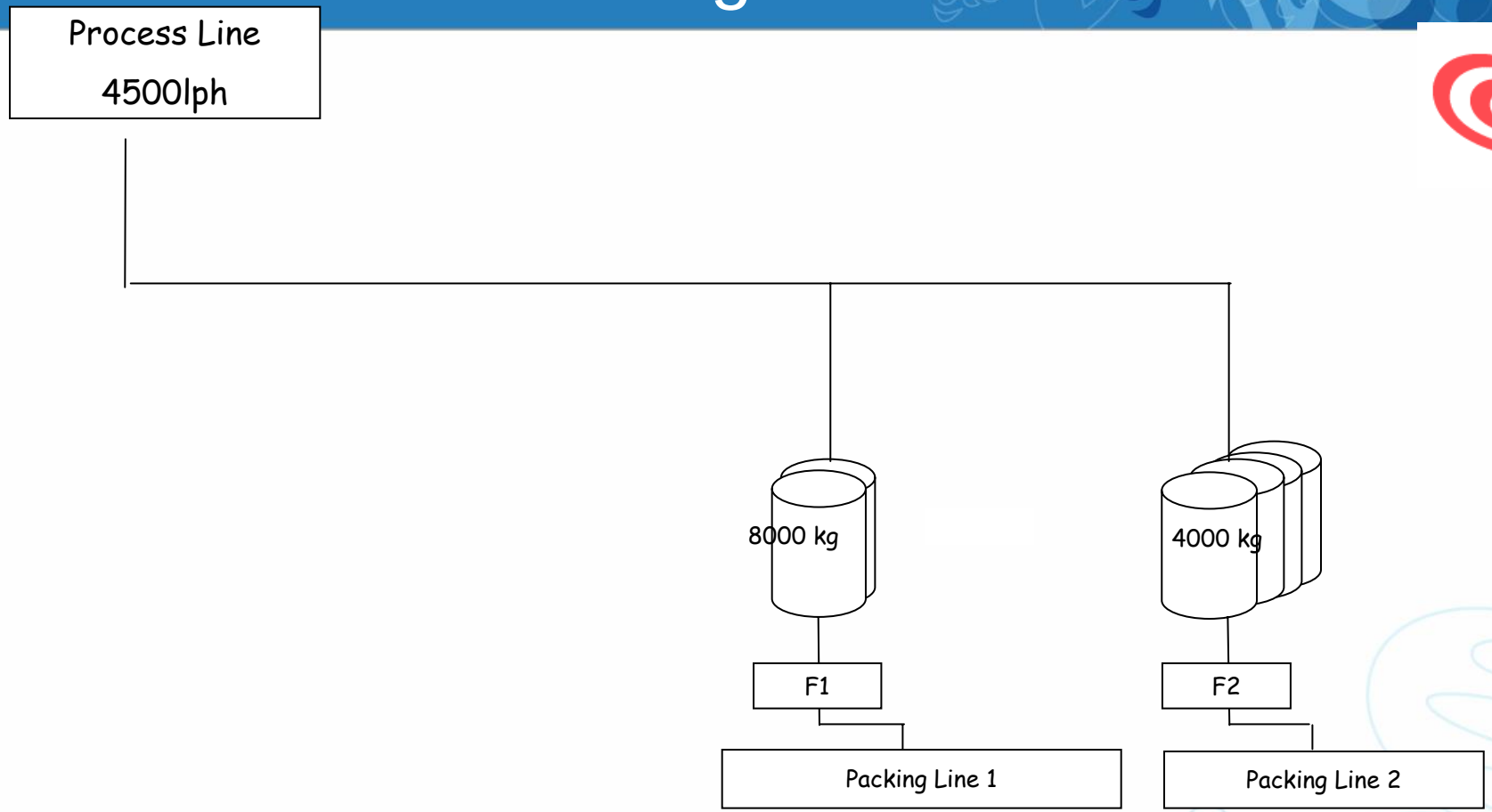
Why look outside SAP PP/DS

- SAP is leading and there is only ONE plan !
  - Everything that is critical within 24 hours has to be handled outside SAP PP/DS:
    - The material requirements in SAP are generated for a complete run OR 24 hours (which ever is the shortest should be selected)
  - Some processes are not suitable for SAP PP/DS:
    - Buffer vessels or intermediate buffers
    - Shared resources
      - » Retorts, mixers, mechanics, CIP, …
    - Multiple manufacturing levels
      - » Packing, ageing, pasteurising, pre-mixing, …
  - Everything that is non-operational has to be handled outside SAP
    - Scenario's, Change-of-plans

Scheduling complexity



Reduced complexity model to evaluate commercial scheduling software



Information

SKU information

product	composition	Packing rate [kg/hr]	packing Line
SKU A	mix A	1750	1
SKU B	mix B	1500	1
SKU C	mix C	1000	1
SKU D	mix D	1500	1
SKU E	mix E	1750	2
SKU F	mix F	2000	2
SKU G	mix G	2000	2
SKU H	mix H	2000	2

mix information

product	Minimum standing time [hr]	Maximum shelf-life [hr]
mix A	1	72
mix B	3	72
mix C	3	72
mix D	0	72
mix E	2	72
mix F	2	72
mix G	2	72
mix H	2	72

Production demand

product	Quantity [kg]
SKU A	80000
SKU B	48000
SKU C	32000
SKU D	8000
SKU E	112000
SKU F	12000
SKU G	48000
SKU H	24000

Change-over information

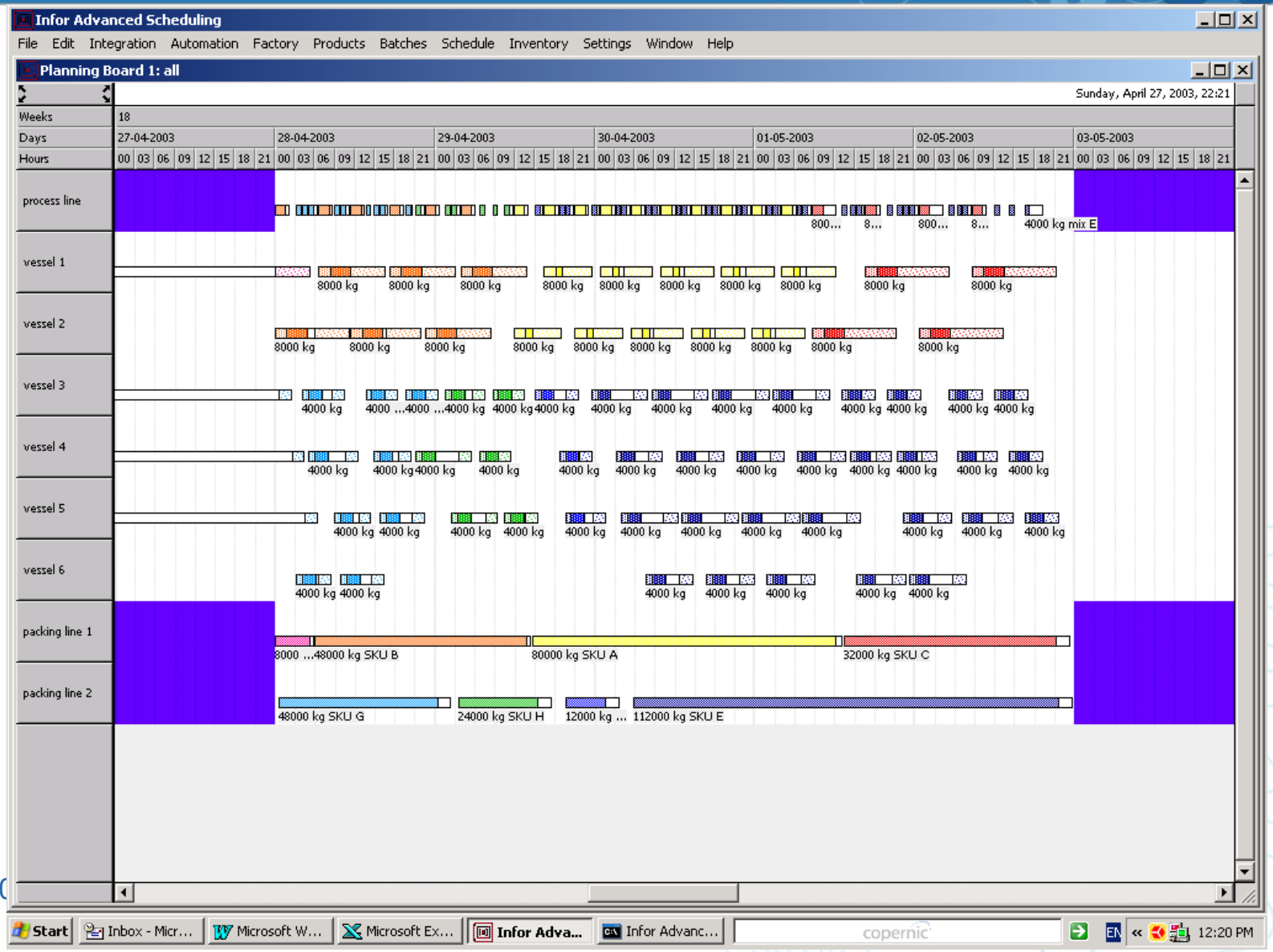
to from	idle	SKU A	SKU B	SKU C	SKU D	SKU E	SKU F	SKU G	SKU H
idle	0	120	120	120	120	120	120	120	120
SKU A	120	0	60	60	60	0	0	0	0
SKU B	120	30	0	60	60	0	0	0	0
SKU C	120	30	30	0	60	0	0	0	0
SKU D	120	30	30	30	0	0	0	0	0
SKU E	120	0	0	0	0	0	60	60	60
SKU F	120	0	0	0	0	30	0	60	60
SKU G	120	0	0	0	0	30	30	0	60
SKU H	120	0	0	0	0	30	30	30	0

Packing

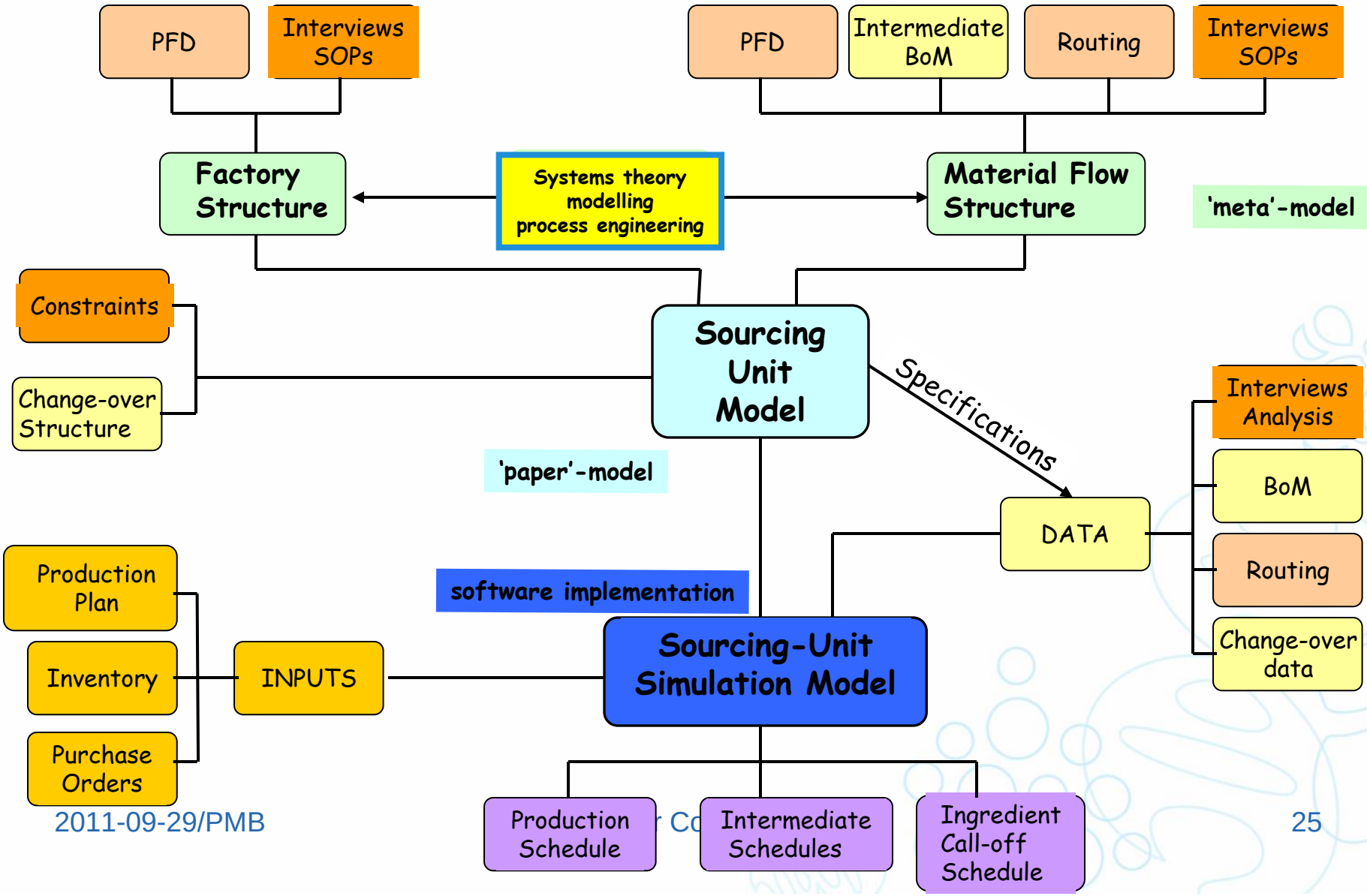
Process

to from	idle	Mix A	mix B	mix C	mix D	mix E	mix F	mix G	Mix H
idle	0	120	120	120	120	120	120	120	120
mix A	120	0	30	30	30	30	30	30	30
mix B	120	30	0	30	30	30	30	30	30
mix C	120	30	30	0	30	30	30	30	30
mix D	120	30	30	30	0	30	30	30	30
mix E	120	30	30	30	30	0	15	15	15
mix F	120	30	30	30	30	5	0	15	15
mix G	120	30	30	30	30	5	5	0	15
mix H	120	30	30	30	30	5	5	5	0

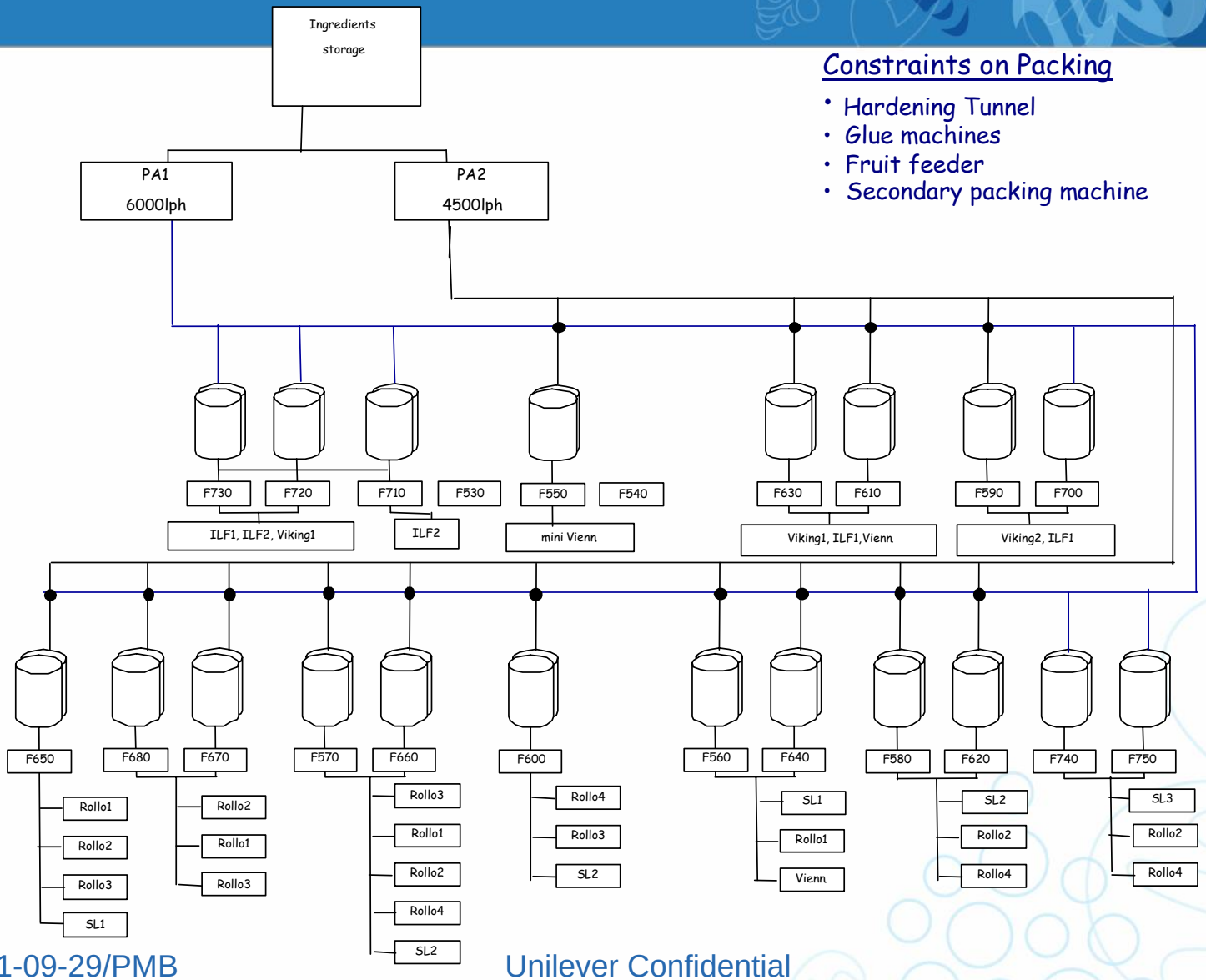
So far only INFOR could produce a feasible schedule



Methodology Multi-Stage Scheduling



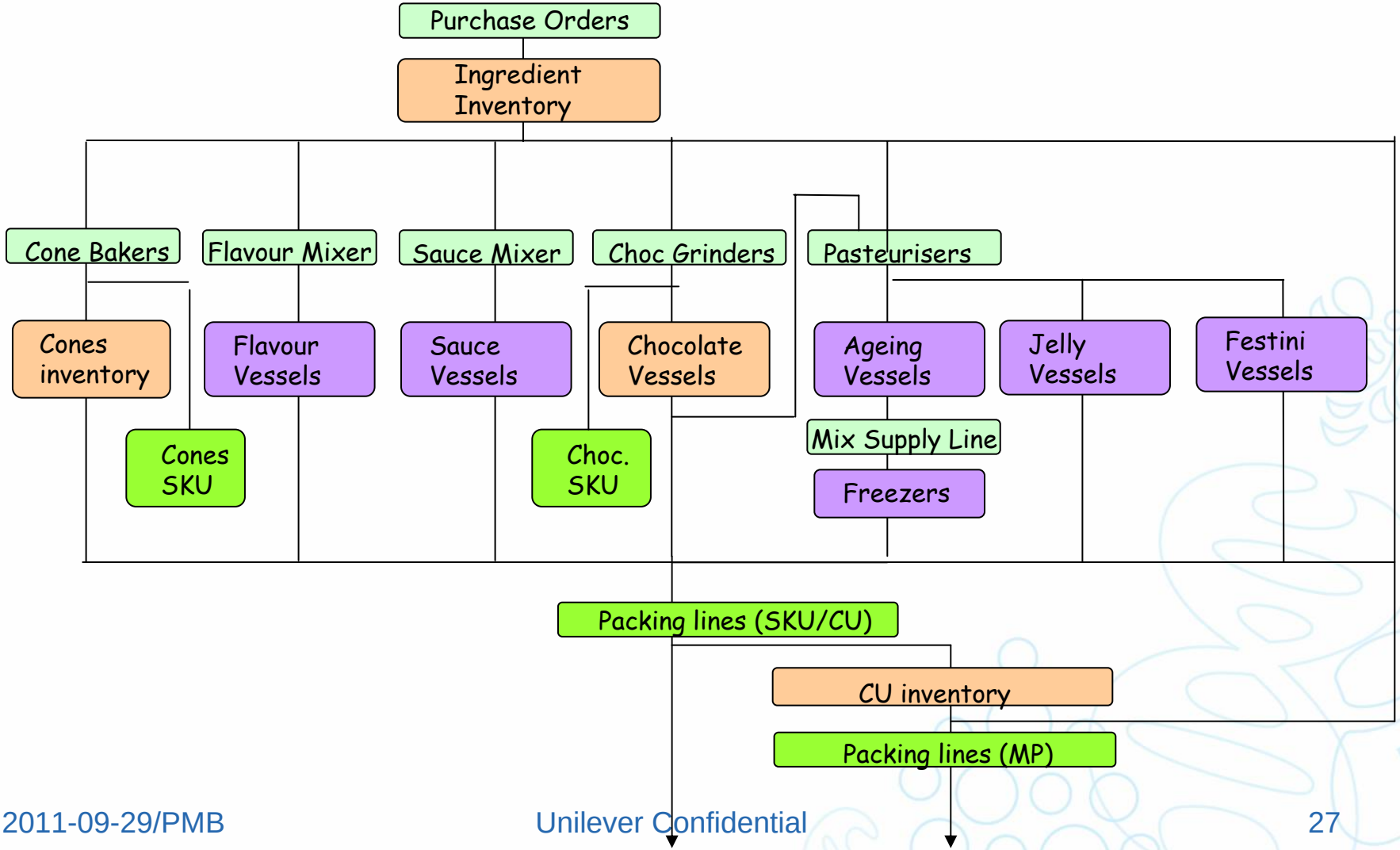
Factory structure



Constraints on Packing

- Hardening Tunnel
- Glue machines
- Fruit feeder
- Secondary packing machine

Material flow



Change-over information

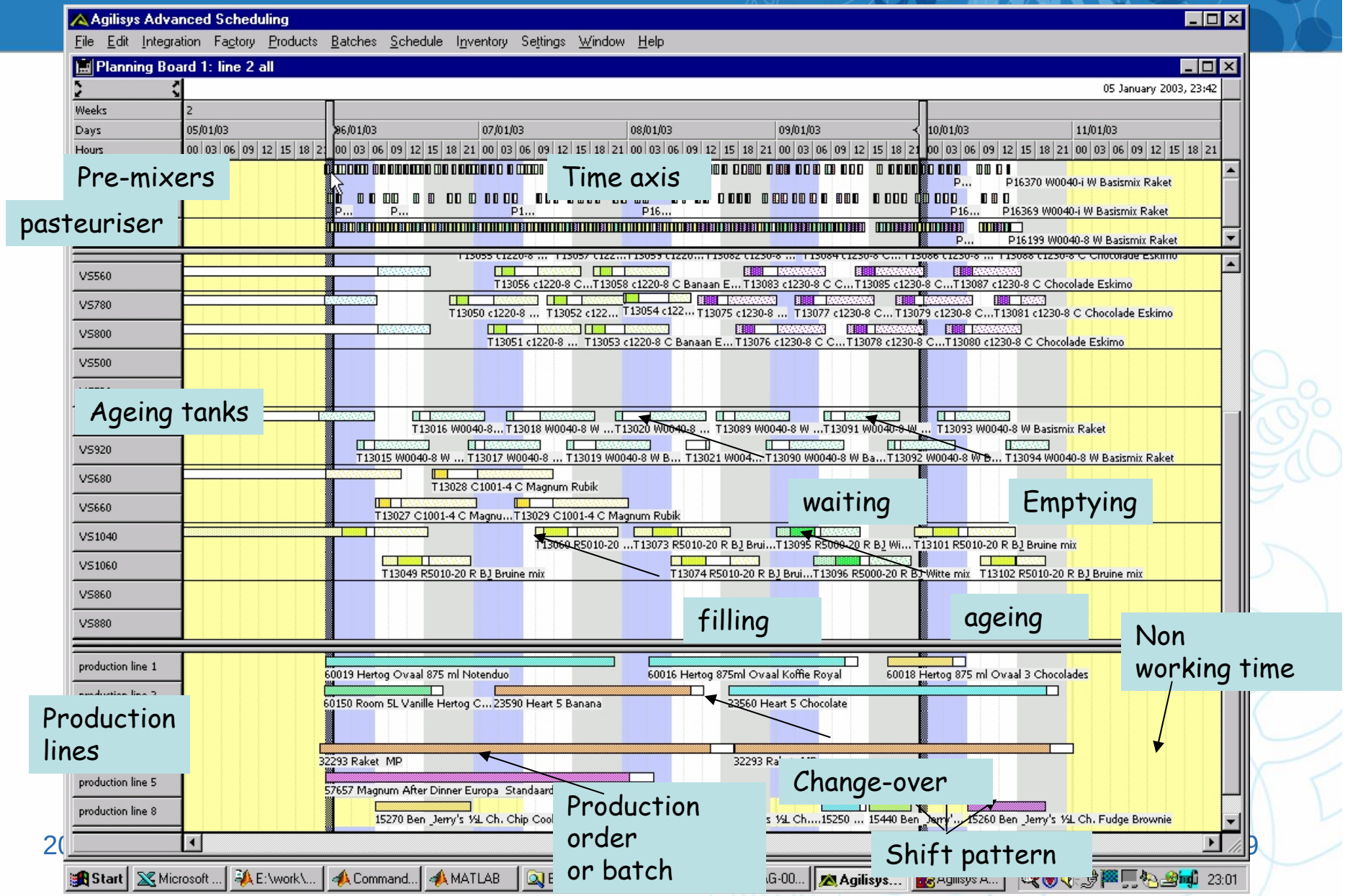
- Pasteuriser
  - Colour, allergens

to:	NONE	Clear	White	Yellow	Green	Red	Purple	Brown
from:								
NONE	~~120~~	120	120	120	120	120	120	120
Clear	120	~~20~~	20	20	20	20	20	20
White	120	20	~~20~~	20	20	20	20	20
Yellow	120	20	20	~~20~~	20	20	20	20
Green	120	20	20	20	~~20~~	20	20	20
Red	120	20	20	20	20	~~20~~	20	20
Purple	120	20	20	20	20	20	~~20~~	20
Brown	120	20	20	20	20	20	20	~~20~~

- Packing lines

to:	NONE	CTT.Mini	CTT.Classi	Yummy cu	Smiling Cup No	CTT.Swirl	Expert Nozzle	Tart Nozzle
from:								
NONE	0	240	240	240	240	240	240	240
CTT.Mini Nozzle	240	240	480	480	480	480	480	480
CTT.Classic Nozzle	240	480	240	480	480	480	480	480
Yummy cup Nozzle	240	480	480	240	480	480	480	480
Smiling Cup Nozzle	240	480	480	480	240	480	480	480
CTT.Swirl Nozzle	240	480	480	480	480	240	480	480
Expert Nozzle	240	480	480	480	480	480	240	480
Tart Nozzle	240	480	480	480	480	480	480	480

Factory model overview



Conclusions

- Implementation of operational multi-stage scheduling leads to:
  - Feasible route to reduced cost/tonnes manufactured products by:
    - raw material waste reduction
    - increased available capacity (upto 30% on factory level)
  - **In CONTROL of MAKE**

Barriers / challenges

- General
  - Problems occur at the interfaces
  - Factory data is not reliable, in-consistent, or not-existent
    - Specifications, Flow diagrams, line-speeds, shift variations, …
- Operational implementation
  - BSc level needed for running the system
  - Cultural change necessary
    - Packing line operators no longer “in charge”
    - Master data maintenance (also now in SAP)


Thanks!