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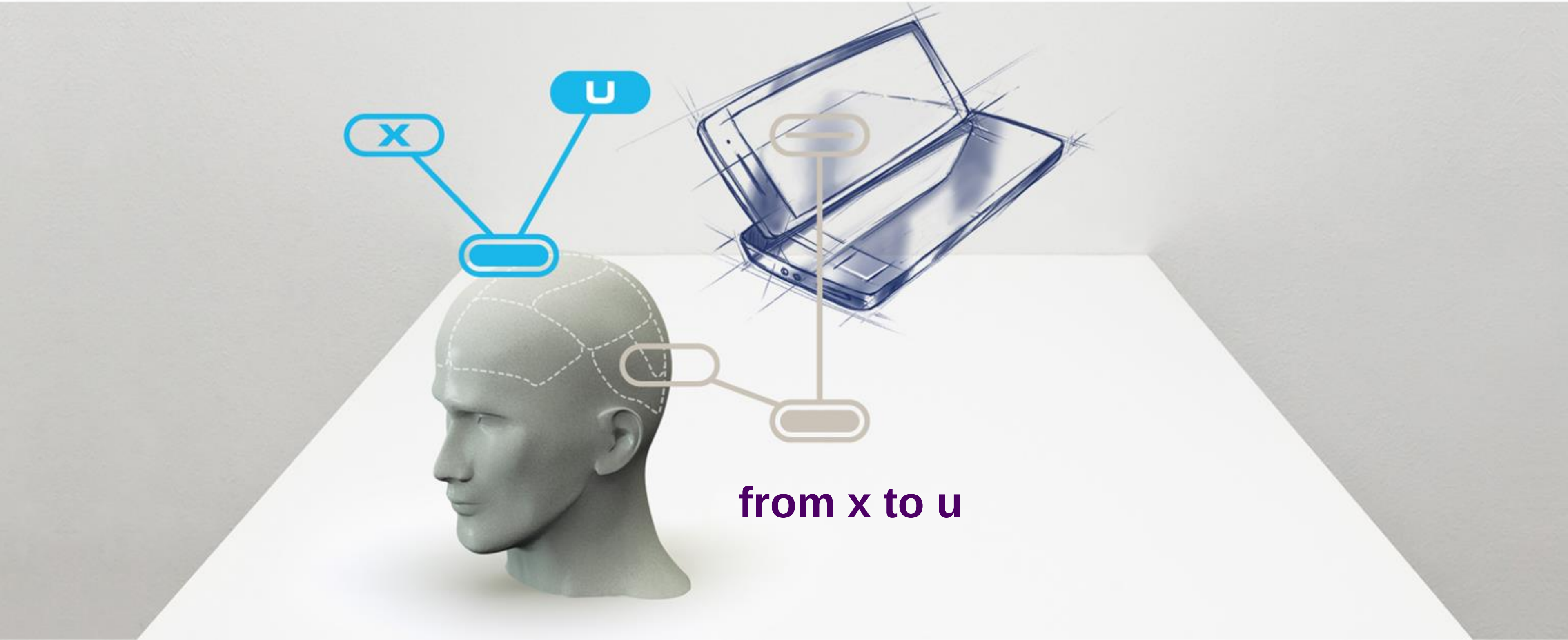
Supply Chain Analytics - OR in Action

Jan van Doremalen | January 14th, 2016 | Lunteren



A Practitioners View on Supply Chain Analytics

- This talk is about applying existing operations research techniques to real-life business questions in a creative and value adding way; this includes decision support, system and process design, and problem solving; it includes understanding the actual situation, predicting what will happen when we continue to work in the way we do and shaping the future by changing the way we work to the best of our interests.
- We tend to underestimate the power of simple models and messages; the more you know and have experienced, the easier it gets to use simple and effective models and to bring the conclusions and recommendations as a simple and clear message.
- Fortunately, there are many complex situations that require a deep analysis and advanced modeling skills; however, the two questions we must ask ourselves each time are (a) is the customer asking the right question and (b) how can we answer the right question with the least effort and complexity.
- This is what is called the art of modelling; it requires broad knowledge, a long experience and social skills. It is a beautiful profession with inspiring model building, gratifying results and hundreds of stimulating conversations and contacts.
- Some thoughts on inside-out and outside-in; research is very often about inside and trying to find instances in the world that might fight that inside; so, an extreme inside-out view; consultancy requires a more balanced approach; there is a world out there; we do a project in an environment with people; we assess the situation and formulate the question; we look for the best way to analyze and model that world in order to give an effective and satisfying answer to the question; the basic stance is outside-in.

About myself

Professional career

- I am a mathematician with a MSc in operations research and decision analysis and a PhD in queueing theory. After my PhD I started in 1986 as a consultant at CQM, then a staff department of Philips Electronics. In 1990 I moved to the Philips Labs in Briarcliff Manor, NY, and acted as an interface between research and business for 2 years. In 1993 we did a management and employee buy-out and I became partner, group leader and senior advisor.

Professional drive

- I strongly believe in the added value of mathematical modeling in decision making, system and process design and problem solving in complex environments. To be successful a strong people orientation is necessary to guarantee well-supported decisions and sustainable solutions.
- For me the key concepts are: use analytical skills, use intuition and creativity, collaborate, balance technology and people, strive for a sustainable world.

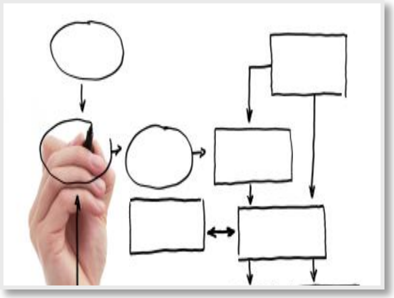
About CQM

Our bureau

- 1979: founded as staff department of Philips Electronics
- 1993: buy-out by management (60%) and employees (40%)
- 2016: 35 consultants

Focus

- Design and planning of supply networks
- Demand and inventory management
- Operational planning of transportation, manufacturing, personnel
- Product and process development



Our power

- High skill level: operations research, data science, software engineering
- Broad experience: 35 years, 350 clients, 3500 projects
- Dedication: each situation requires a tailored approach
- People orientation: only collaboration brings sustainable solutions

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About our customers

CQM
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Agenda

Strategic Network Design

Optimal Service of Professional Systems

Collaborative Planning in Global Supply Network

Robust Supply Chains

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Strategic Network Design

MIP using AIMMS and CPLEX

Goal Statement and Scope

Goal Statement

- Identify the best footprint for the physical distribution in Europe.
- Create feasible scenarios facilitating growth and generating savings and/or customer service improvements.

Ranking of improvements

- Potential savings
- Facilitation of growth
- Improvements in customer service
- Dependency on other projects
- Business urgency
- Implementation feasibility and costs

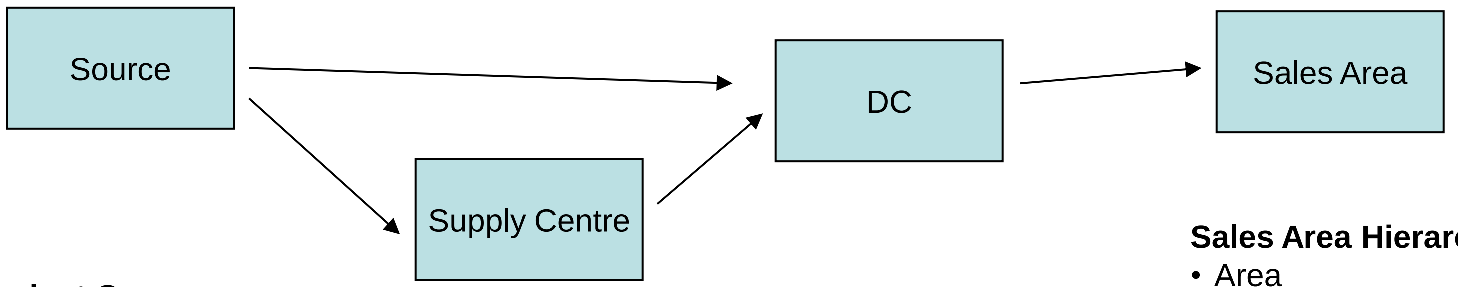
Scope

- Europe
- All business lines
- All customers

Developments

- Changes in industrial set-up
- Impact of recent acquisitions
- Customer requirements per sales channel
- Growth plans of business lines
- Changes in product characteristics

Network elements



Sales Area Hierarchy
- Area
- Country
- Region

Product Groups
- 11 groups

Flow level
- Source
- Product Group
- Area
- Channel

Flow parameters
- Volume in cbm
- Weight in kg
- Value in €
- Pallets in #
- Boxes in #
- OrderLines in #

Sales Channels
- 4 channels

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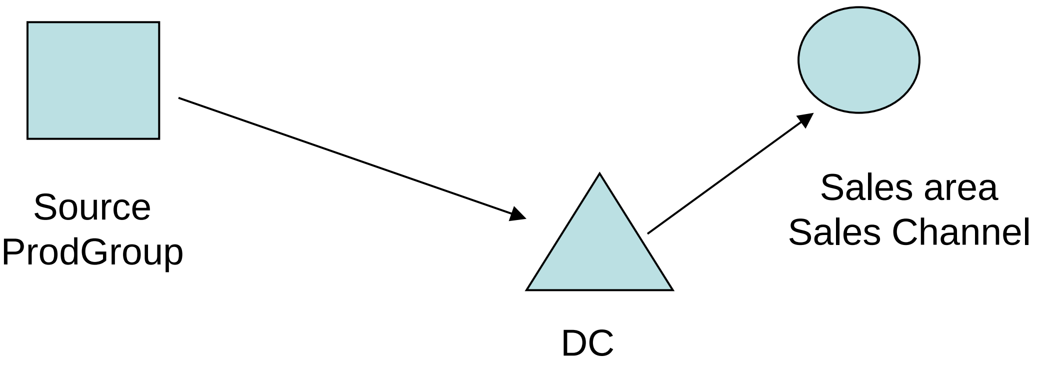
Two supply options: single-echelon and two-echelon

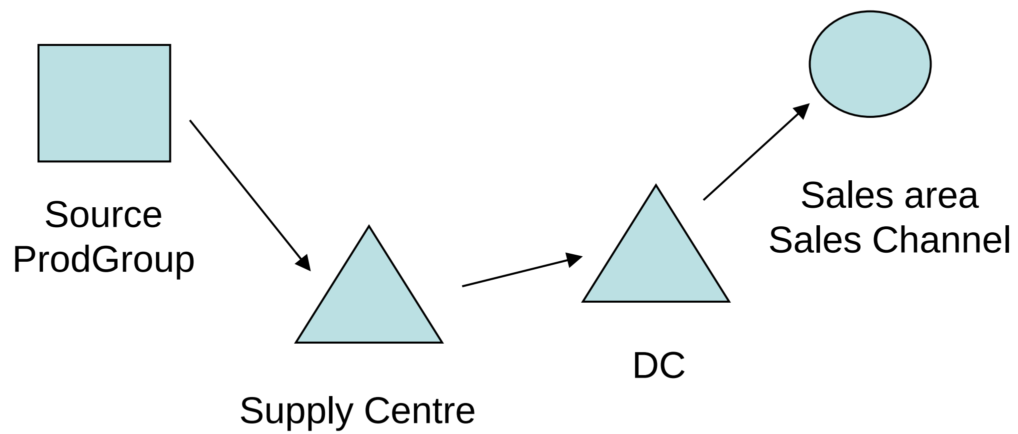
Single-echelon make to stock

- DCs replenished from Source
- Customers delivered from DC
- DC choice per Sales Area
- DC choice per Sales Channel



Two-echelon hub-and-spoke

- Supply Centre replenished from Source
- DCs replenished from Supply Centre
- Customers delivered from DC
- Supply Centre choice per Source
- Supply Centre choice per ProdGroup
- DC choice per Sales Area
- DC choice per Sales Channel



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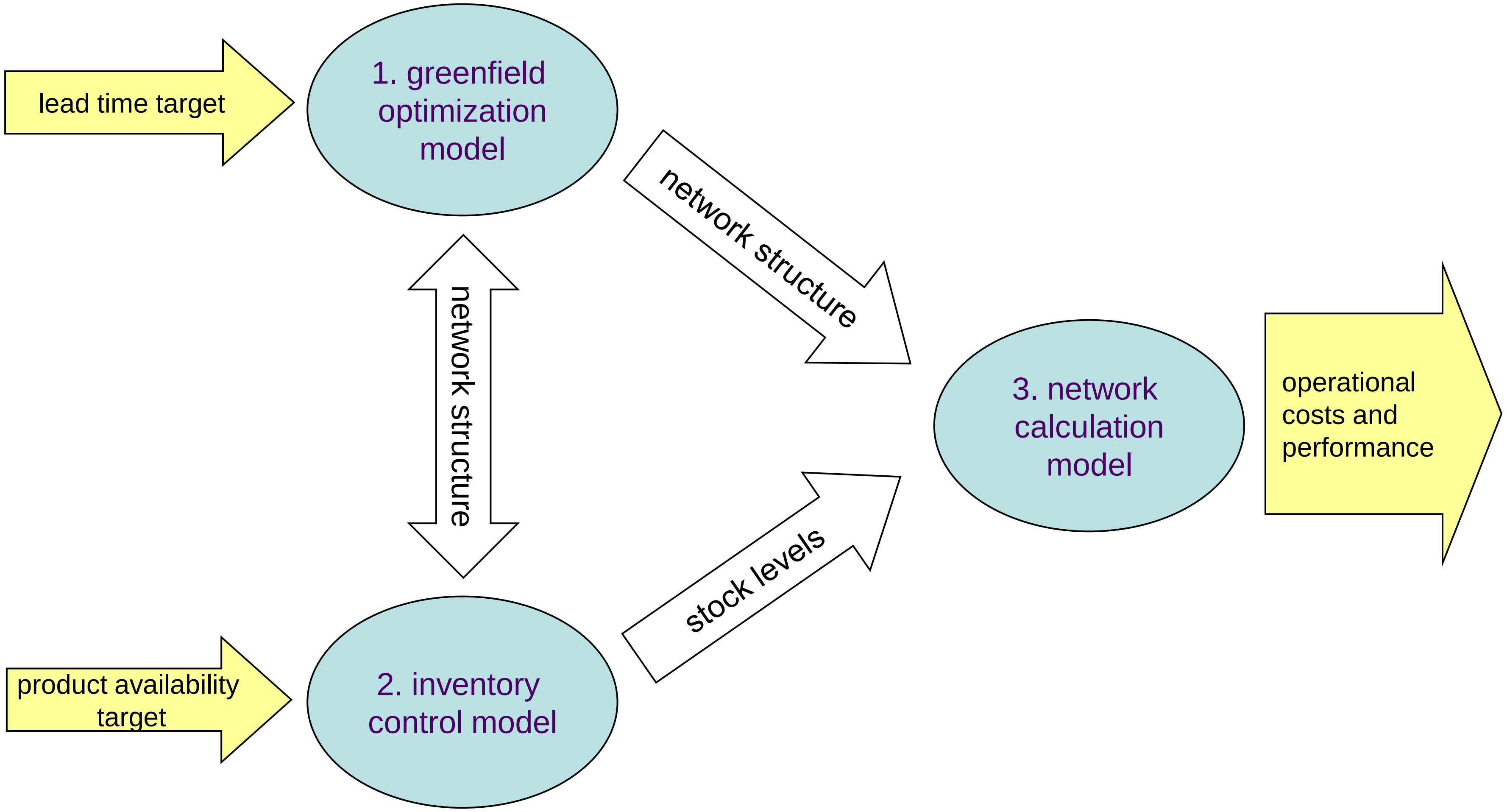
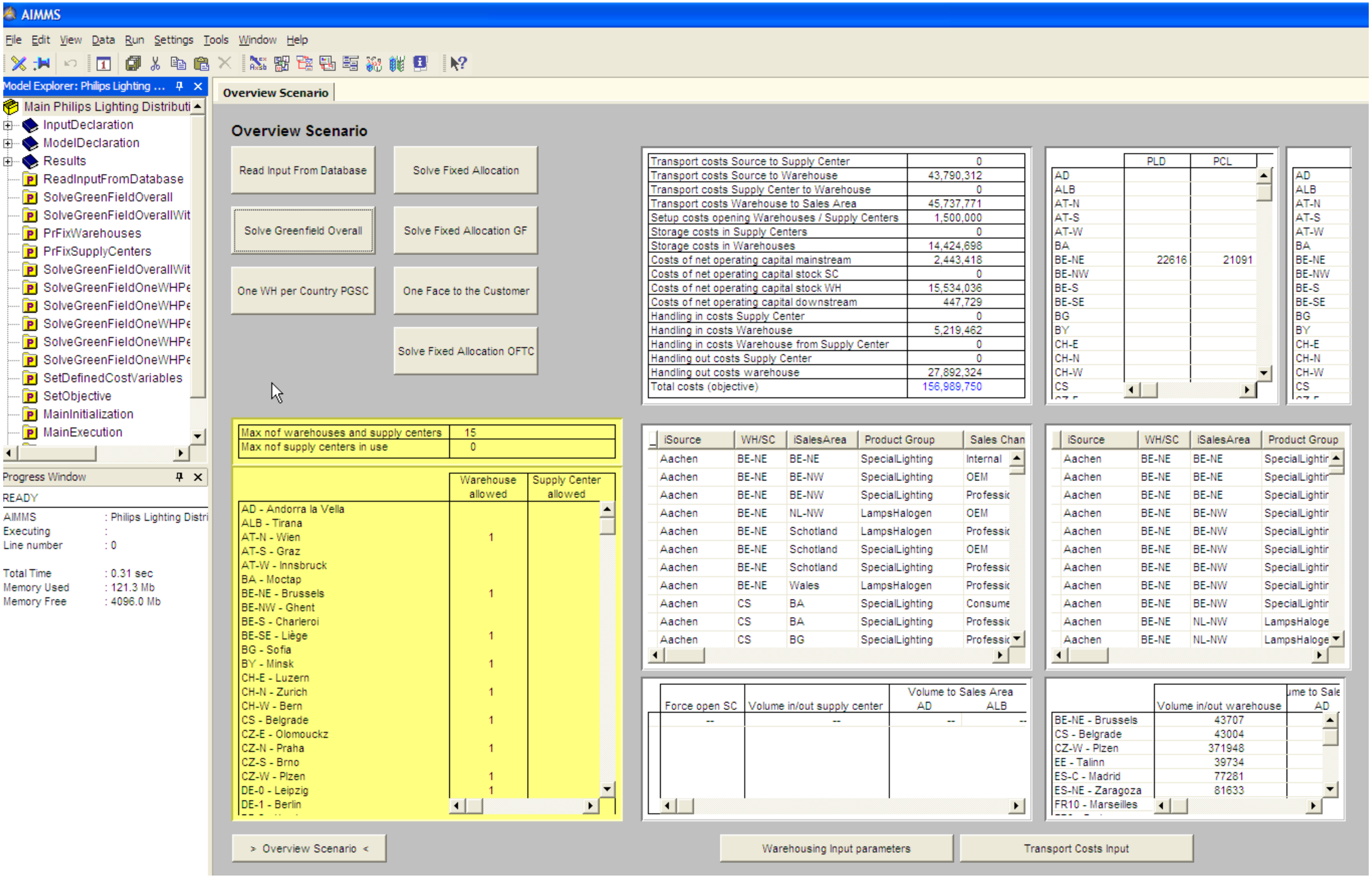
Supply Network Design Modeling Approach



AIMMS - Mixed Integer Linear Programming Model



AIMMS - Inventory Calculations for Supply Network

inp_01_sales : Table

Field Name	Data Type
12NC	Text
business	Text
state	Text
week	Text
qty	Number

inp_04_iplc_rdc : Table

Field Name	Data Type
iplc	Text
rdc	Text
class	Text
mean_lead_time	Number
stdv_lead_time	Number

inp_02_state_rdc : Table

Field Name	Data Type
Business	Text
State	Text
RDC	Text

inp_05_class : Table

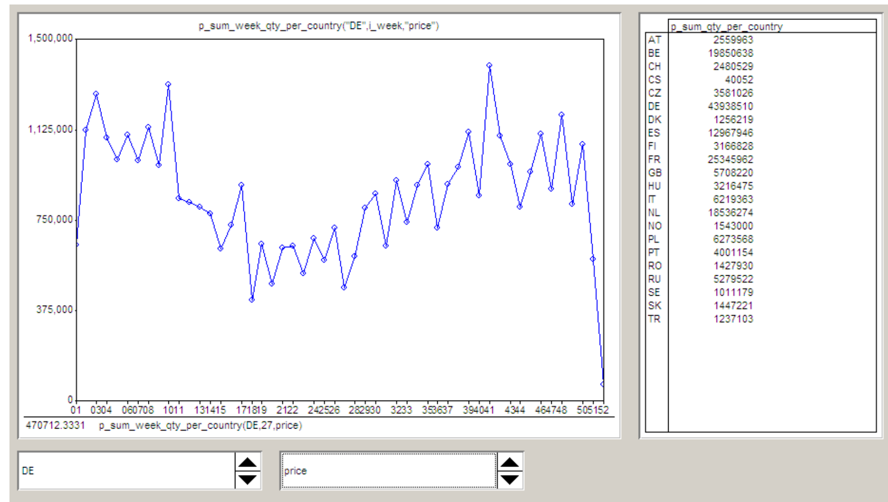
Field Name	Data Type
class	Text
production_frequency	Number
service_level	Number

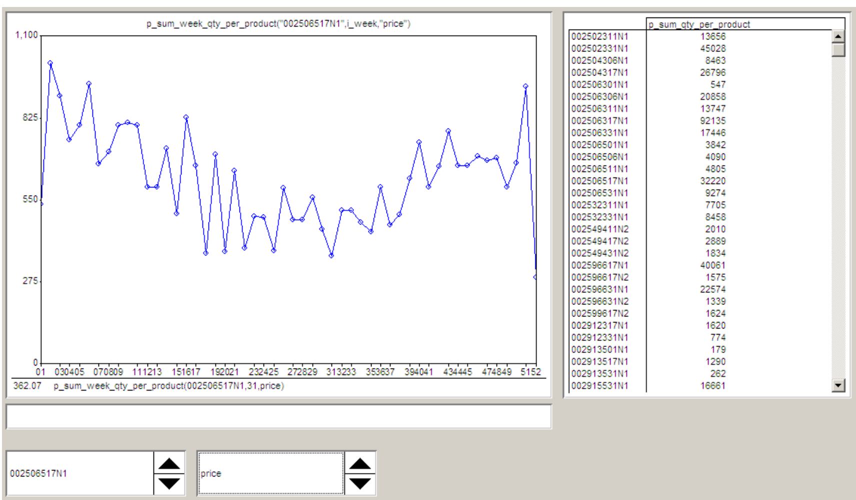
inp_03_products : Table

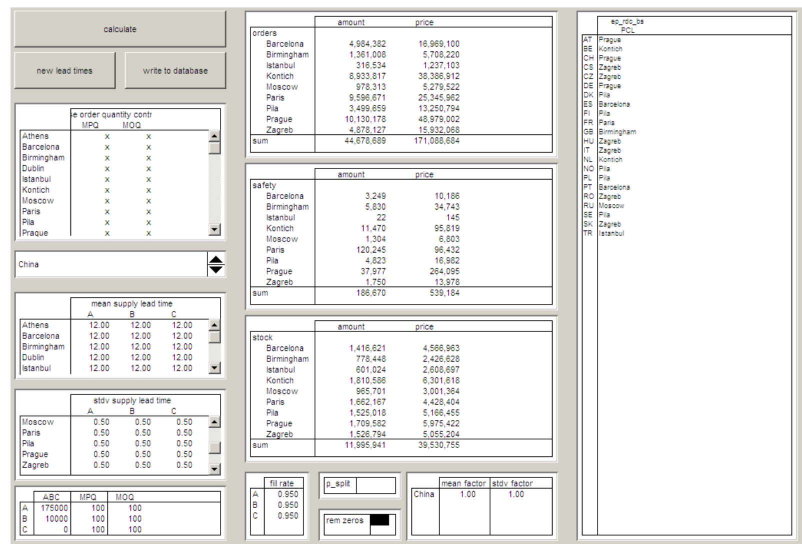
Field Name	Data Type
12NC	Text
IPLC	Text
Volume	Number
Price	Number
Pieces_per_box	Number
Pieces_per_pallet	Number

inp_06_active_rdcs : Table

Field Name	Data Type
rdc	Text
active	Number







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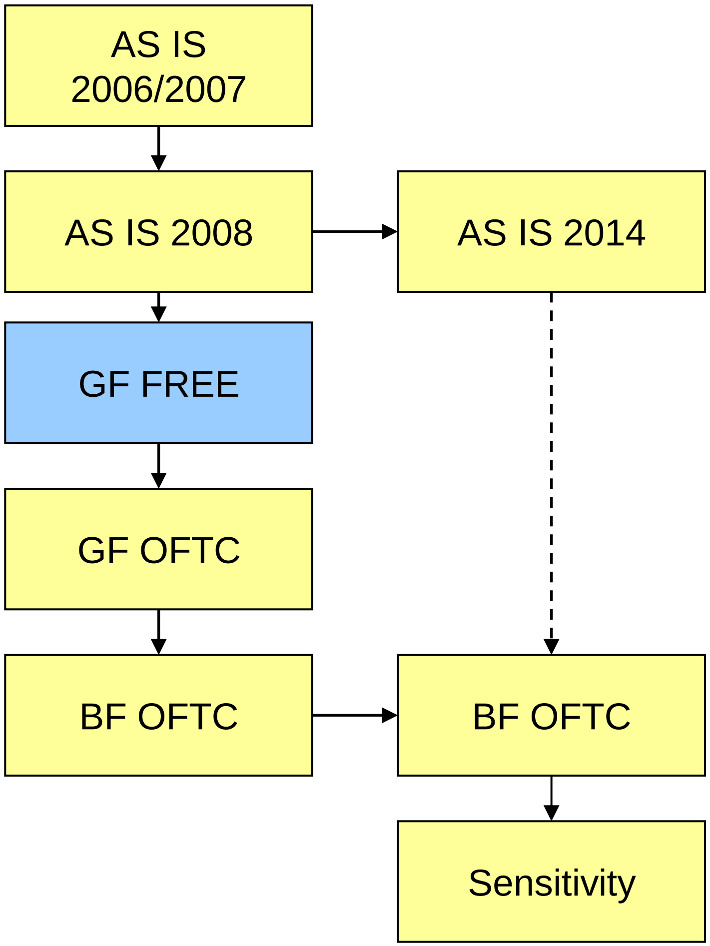
Line of argument: GreenField FREE



GF FREE

- Optimize under the constraint of a maximum lead time of 3 days to 99% of European market

Observations

- Optimal: 10 DCs
- Lead time: 60% in 2 days, 99% in 3 days
- Drop in costs: 40 mio€
- Most customers delivered from more DCs
- Closure of all major DCsin Western Europe
- Very large new DCs in Central Europe

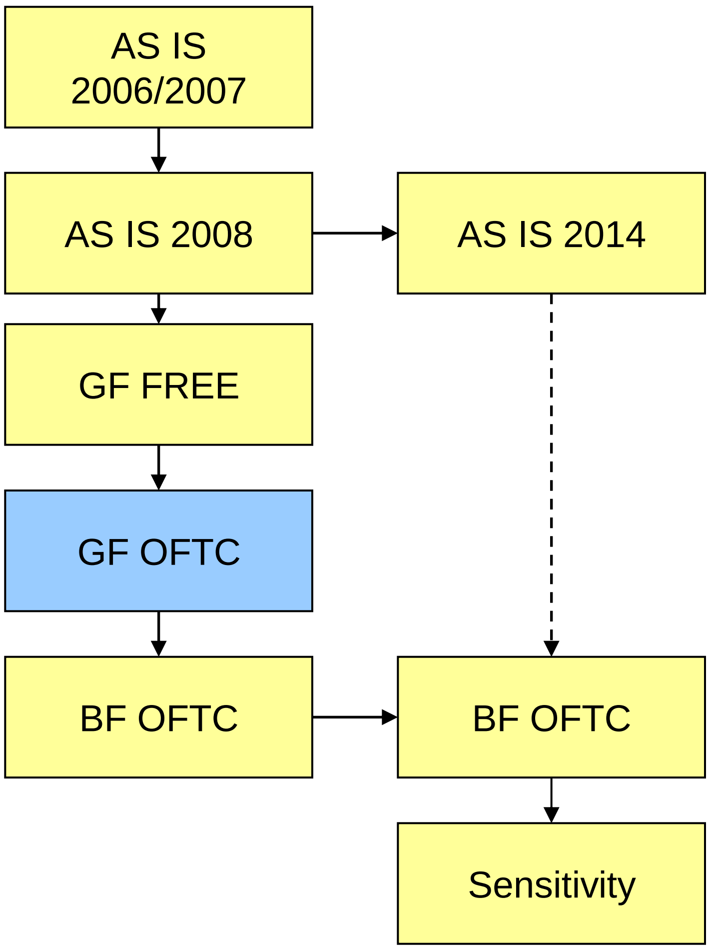
Conclusion

- Lowest operational cost solution does not give an attractive location (where are the DCs) and allocation (from where are customers delivered)

Next step

- Improve the allocation by adding extra constraint that customers of a specific sales channel in a country need to be served from a single DC

Line of argument: GreenField One-Face-To-Customer



GF OFTC

- Greenfield but with an extra constraint that a customer must be served from a single DC

Observations

- Optimal: 10 DCs
- Lead time performance: 55% within 1 day
- Increase in costs: 5 mio€
- Poor lead time performance in Western Europe
- Closure of all major DCs in Western Europe

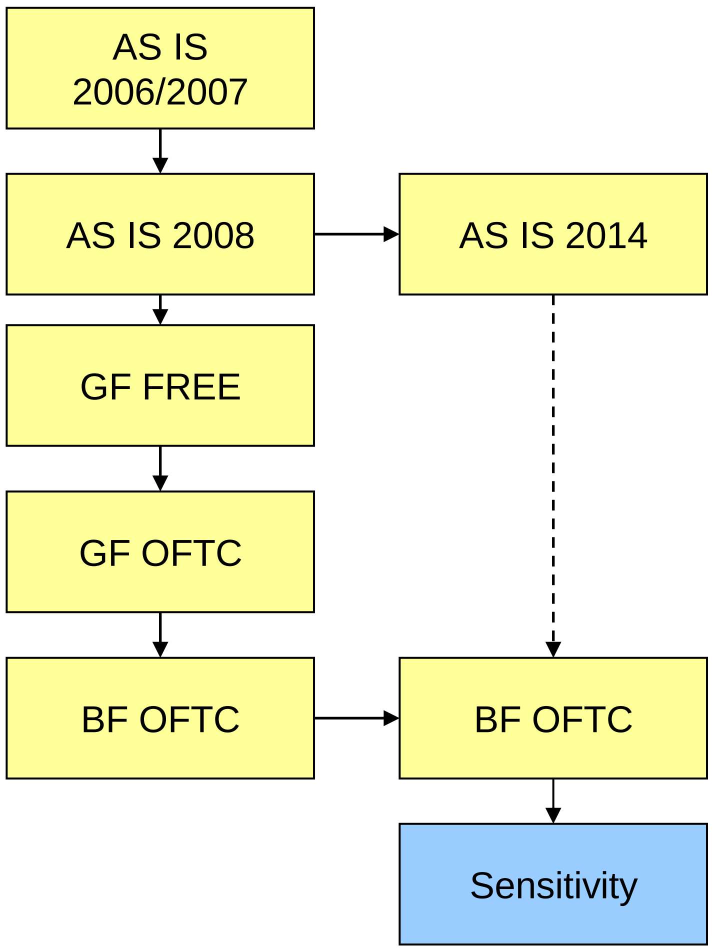
Conclusion

- Allocation has improved in line with requirements
- Issue of poor lead time performance in Western Europe and closure of all major DCs in Western Europe remains

Next step

- Introduce fixation of certain DCs and allocations

Line of argument: Sensitivity analysis



BF OFTC – Sensitivity analysis

Aim
- Analyse robustness of optimal solution to 2014 volumes and possible changes in tariffs and profiles

Scenarios
- Scenario 1: Increase warehouse tariffs in EE
- Scenario 2: Transportation tariffs plus 50%
- Scenario 3: Volumes minus 25%
- Scenario 4: Deliver customers once per week

Observations
- Minor impact on locations and allocation

Conclusion
- Preferred scenario is robust for volume, tariff and profile changes

Characteristics of optimal footprint

- Location
  - 8 larger plus 3 smaller warehouses
  - Integration of warehouses in several regions
  - New warehouses in Eastern and Central Europe
- Allocation
  - Customer served from single warehouse (one-face-to-the-customer)
  - Cluster of countries served from single warehouse (sales region orientation)
- Operational cost
  - 10% operational cost savings
- Lead time
  - 85% within 2 days (1 day warehousing and 1 day transport)
- Robustness
  - Footprint robust for changes in tariffs and volumes

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Optimal service of professional equipment

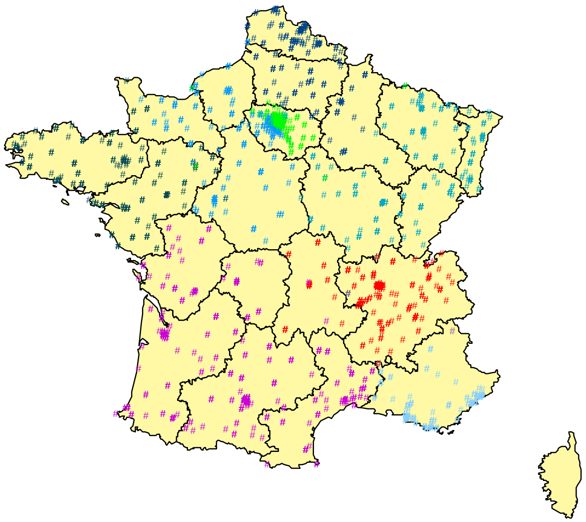
Heuristic Search Algorithm

Environment, goal and objectives

- Environment
  - Expensive medical equipment in hospitals
  - Tight service level agreements
  - Large number of service engineers and account managers
  - Long travel times, unbalanced groups, unbalanced customer contacts

- Goal
  - Develop model to support effective and efficient allocation of service engineers and account managers

- Objectives
  - Allocate service engineers to systems
  - Link service area managers to service engineers
  - Allocate account managers to customers
  - Link sales area managers to account managers
  - Observe relations between sales and service



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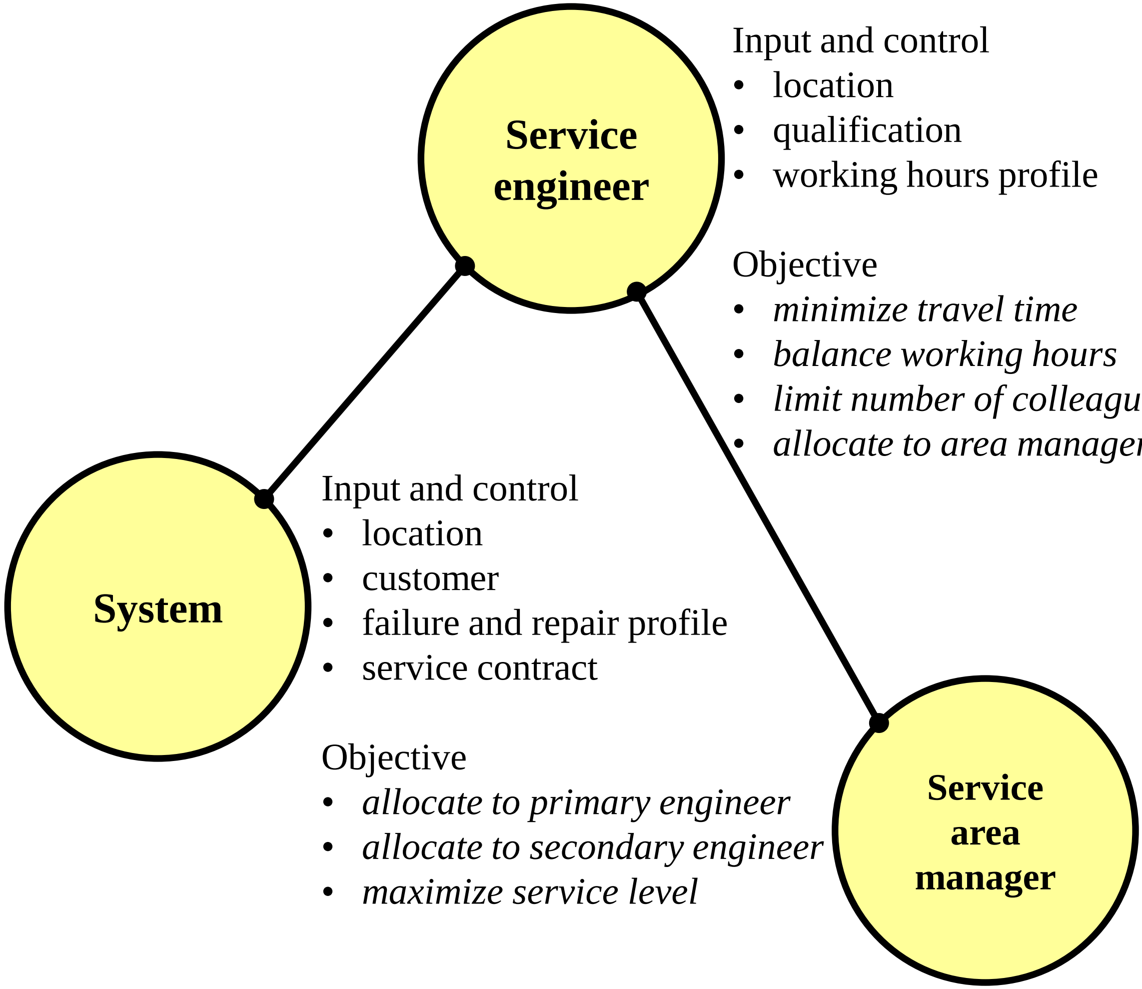
Allocation of service engineers



Service engineer

Input and control
- location
- qualification
- working hours profile

Objective
- *minimize travel time*
- *balance working hours*
- *limit number of colleagues*
- *allocate to area manager*

System

Input and control
- location
- customer
- failure and repair profile
- service contract

Objective
- *allocate to primary engineer*
- *allocate to secondary engineer*
- *maximize service level*

Service area manager

Input and control
- location

Objective
- *balance number of service engineers*
- *link with customers of service engineers*

Relation with current allocation
Being close to current allocation may be part of objective function.

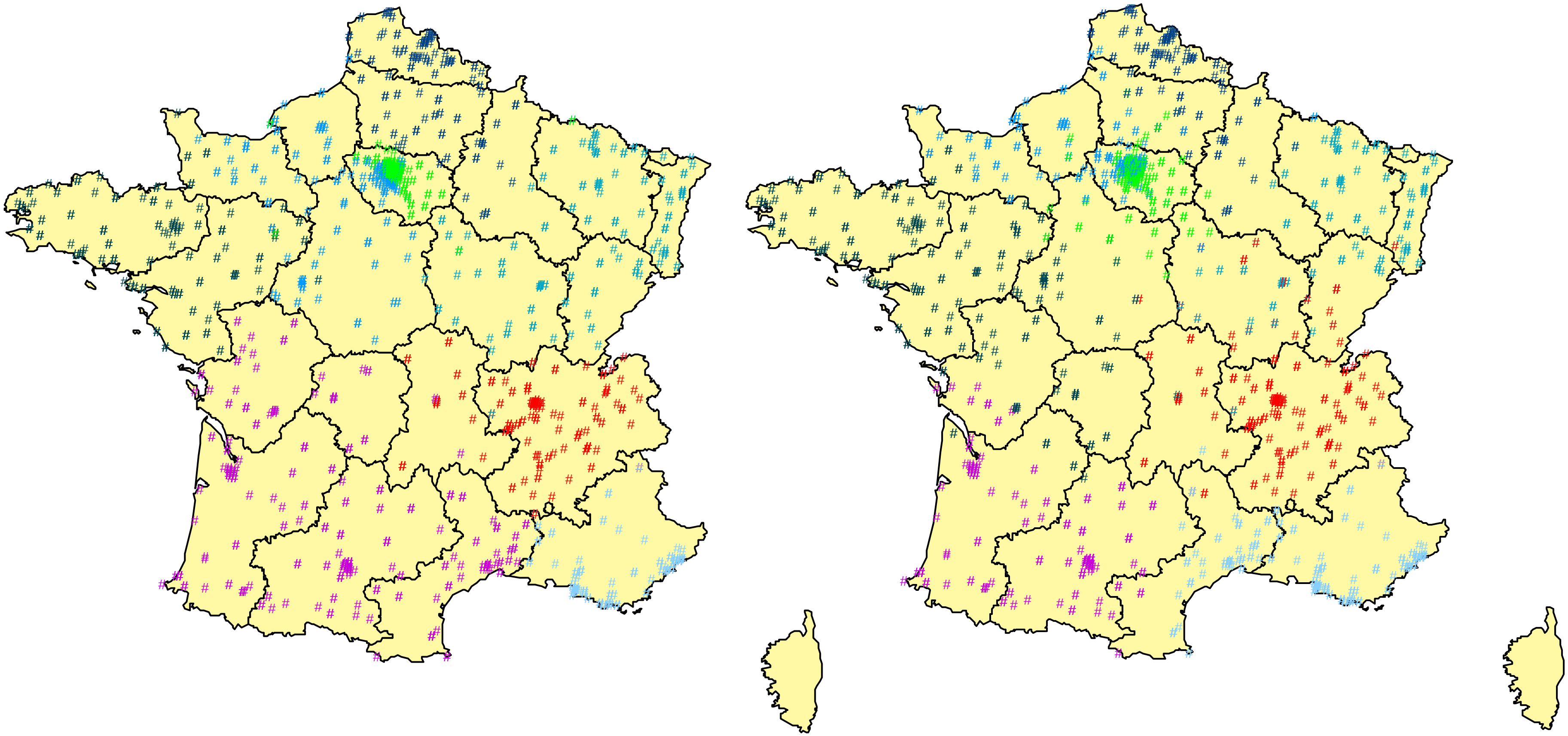
Improved qualifications
Consider consequences of improved qualification levels.

Improved locations
Consider consequences of improved location of service engineers.

Choice of algorithm

- Feels like a general assignment problem, however
  - Many and complex constraints
  - Size of problem is very large
  - Complex objectives
  - Many (soft) feasibility issues
- Model
  - Prioritize constraints (sequence) and penalize (squared) violation of constraints
- Construction heuristic
  - Use current relation or closest qualified
- Improve by using Local Search
  - Tabu search: intensification and diversification
  - Neighborhoods: move system to other engineer / move engineer to other manager

France Current and Optimal Allocation



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Results in words

- Current allocation
  - 10% relations by engineers that are not qualified
  - 30% relations by engineers that live too far away
  - Workload not balanced at all
  - Engineer groups of managers not balanced

- Greenfield Allocation:
  - Reduction in over all travel time by 7.5%
  - Reduction in over-hours by 40%
  - Reduction in individual excessive travel by 40%

  - Much more balanced workload
  - Balanced group sizes
  - More compact regions

  - More service area managers tightly linked with customers
  - More engineers tightly linked with customers

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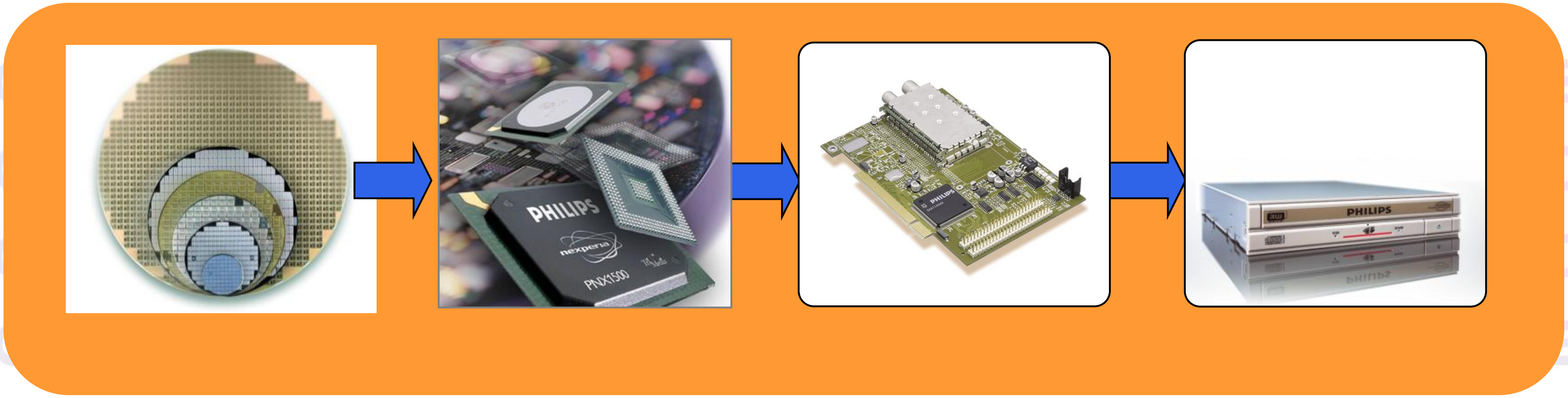
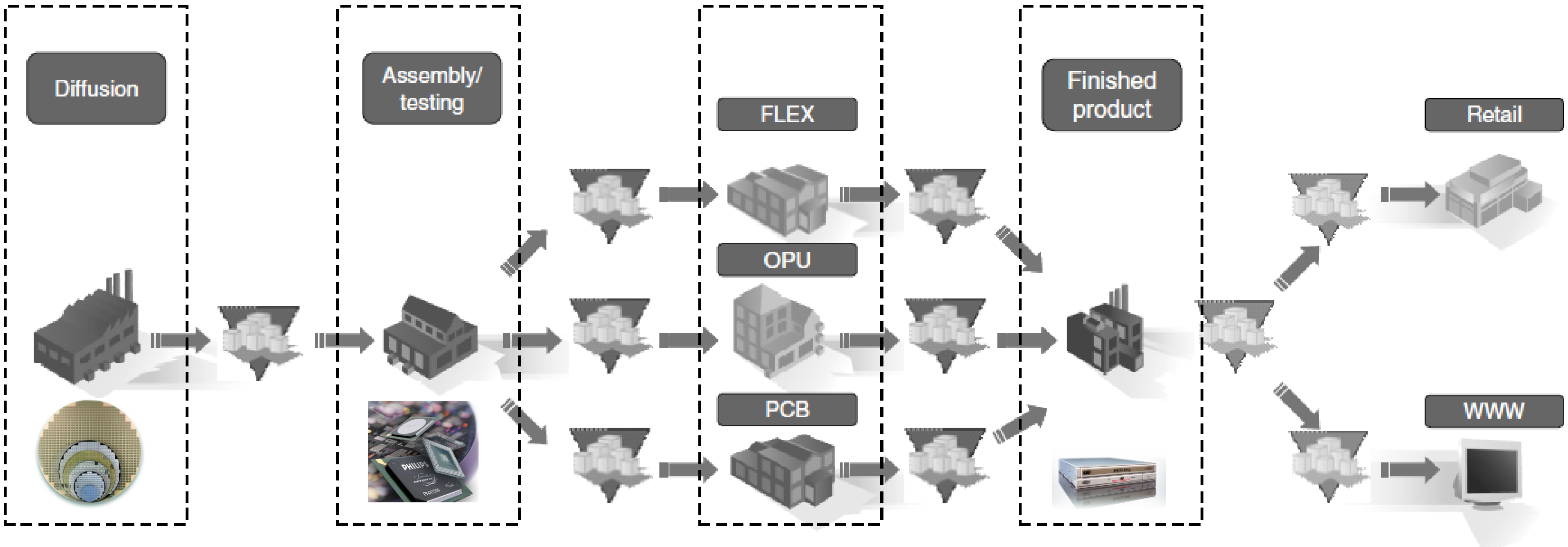
Collaborative Planning in Global Supply Network

Multi-Echelon Synchronized Base Stock Policies

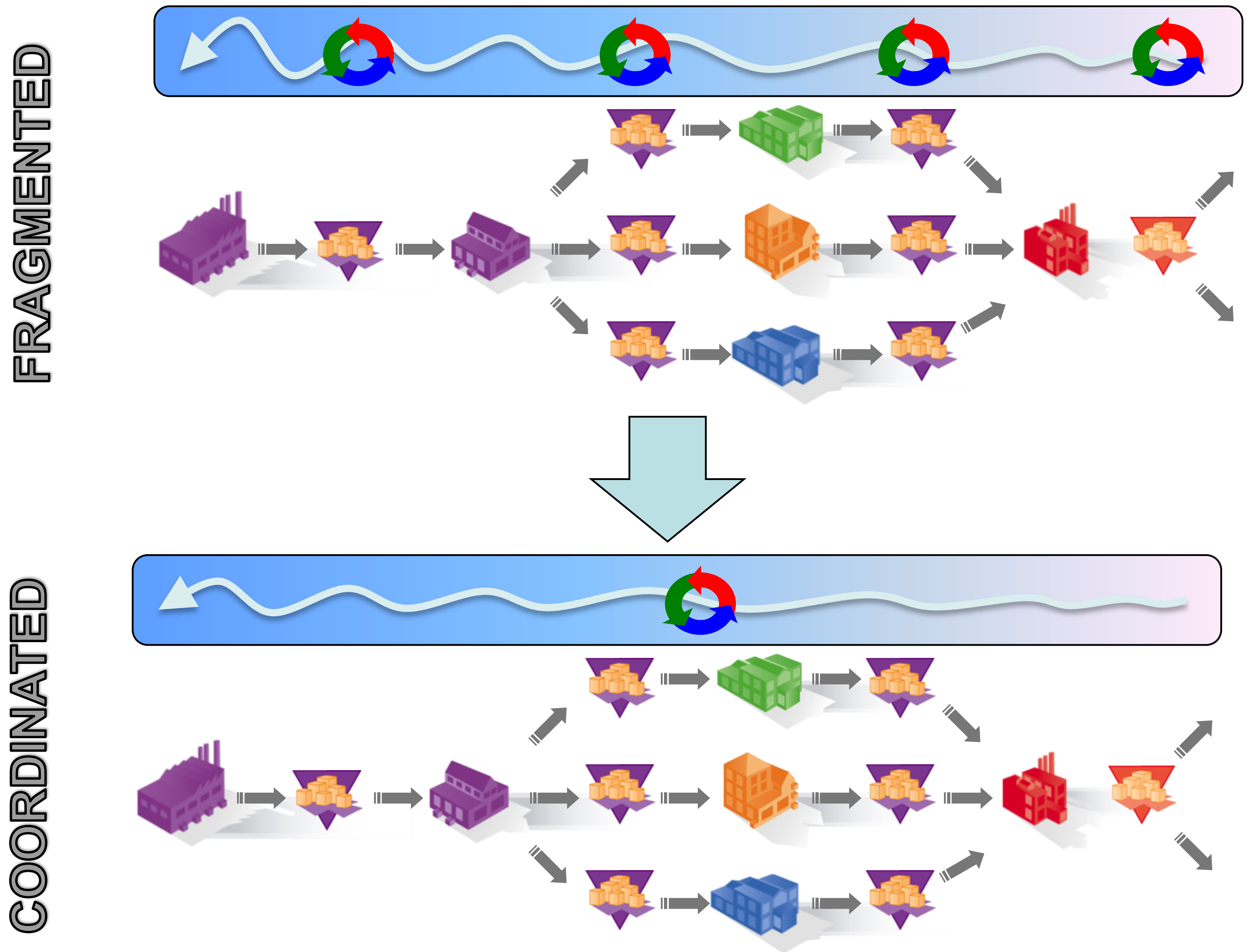


Complex Global Supply Network

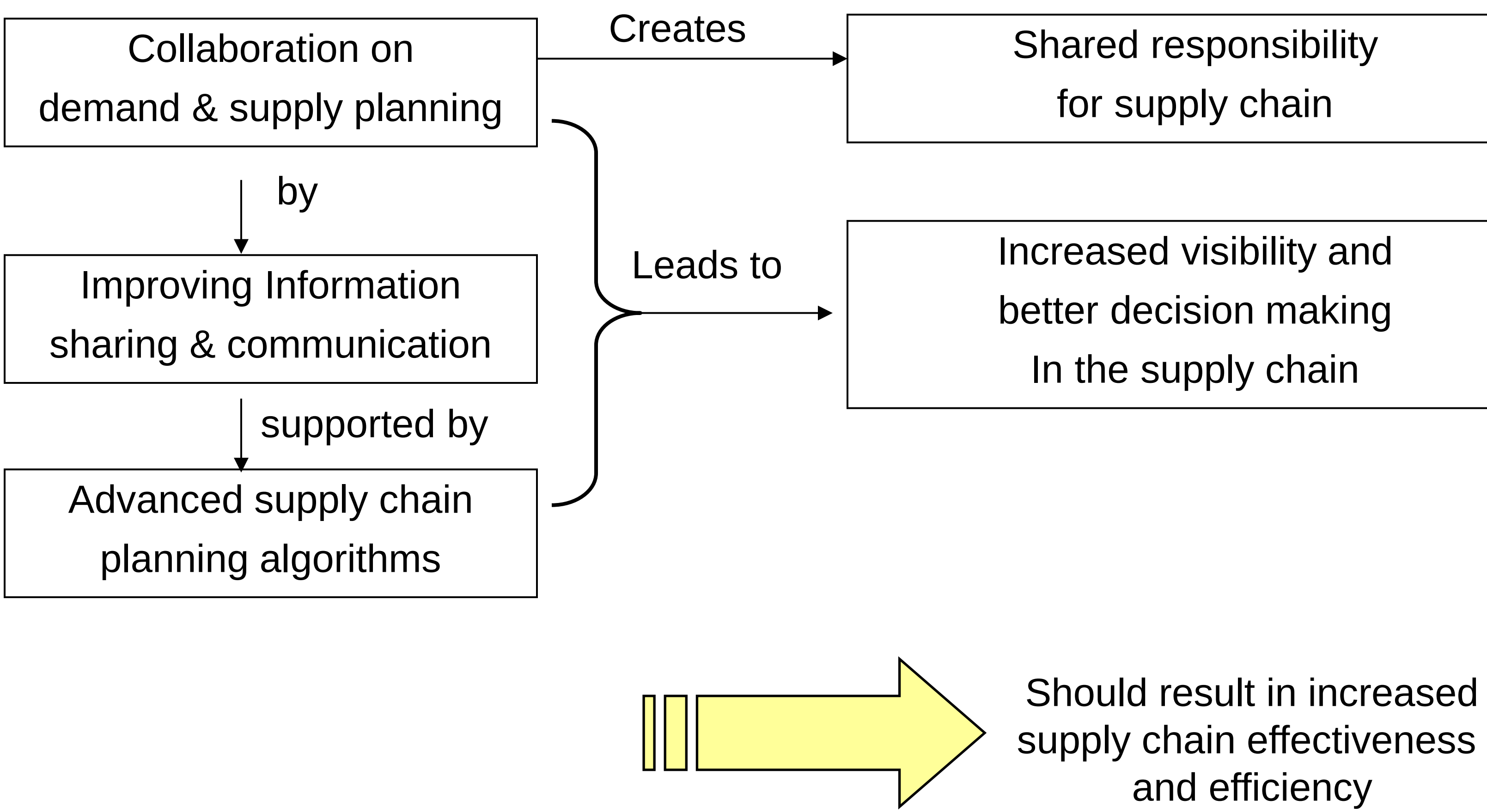


- Independent players
- Short life cycle versus long stacked lead time
- Very volatile market
- Strong bullwhip effect

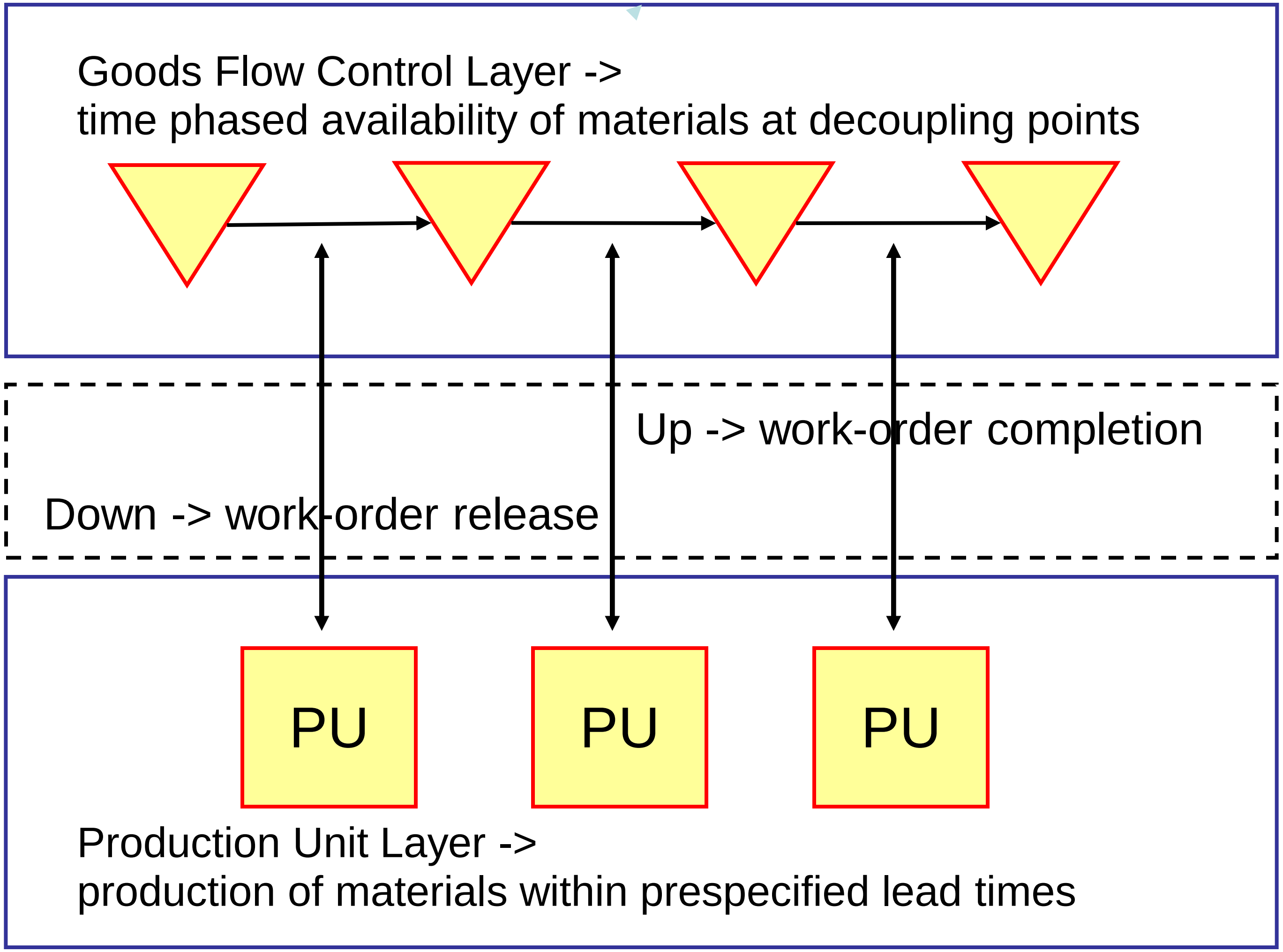
Challenge is to create coordinated supply chain



Expected benefits of supply chain collaboration



Background: Synchronized Goods Flow Control



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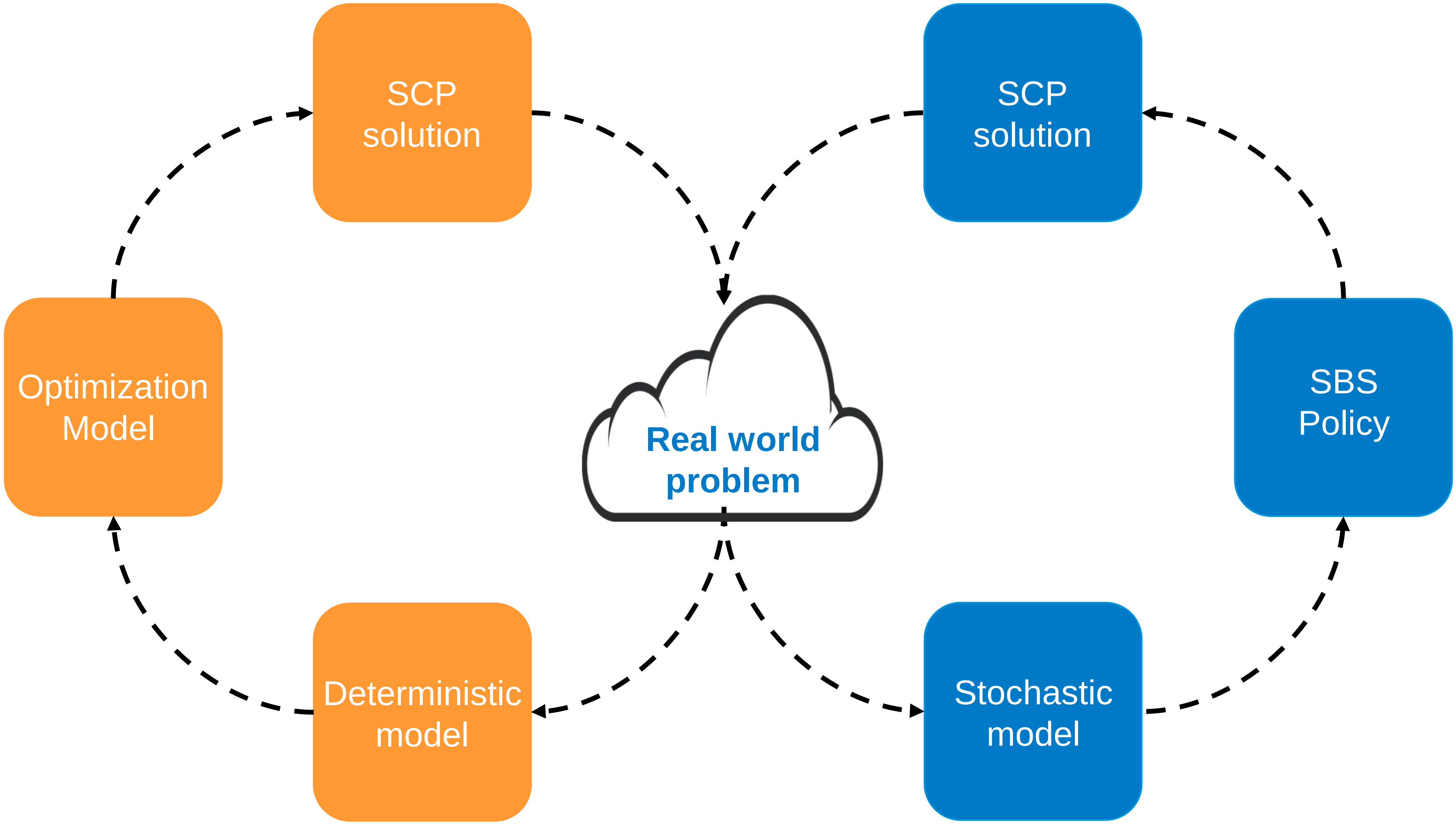
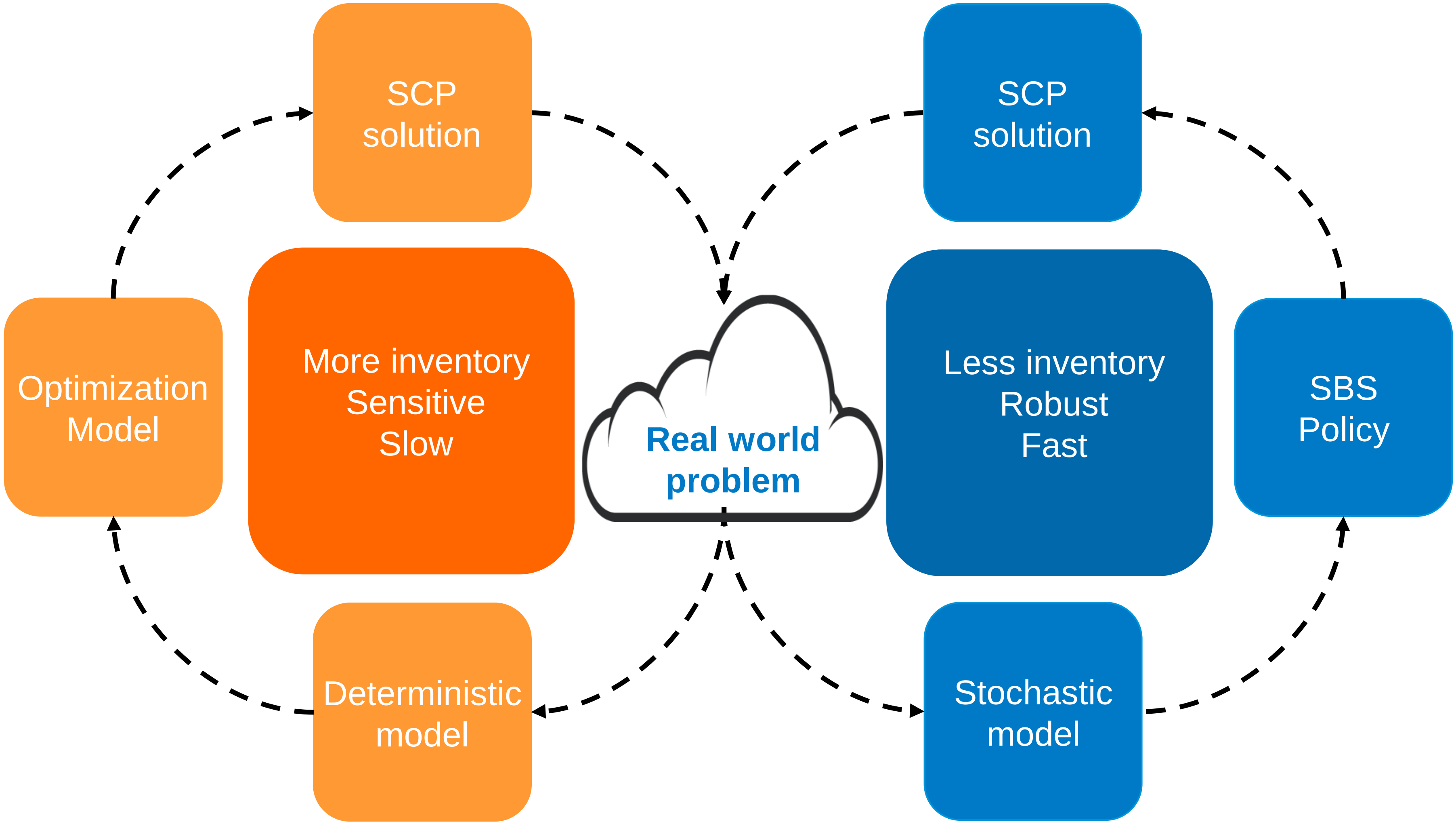
Two modelling routes towards APS



Two modelling routes towards APS



Synchronized Base Stock Policies 1/2

Dynamic base stock levels

$$S_i = \sum_{k \in F_i} \left\{ \sum_{s=1}^{L^*_{i,k} + ST^*_{i,k} + 1} D_k(s) \right\}, \; i \in \mathrm{M}$$

cumulative demand

Dynamic safety stocks

safety lead time

$$SS_i = \sum_{k \in F_i} \left\{ \sum_{s=1}^{L^*_{i,k} + ST^*_{i,k} + 1} D_k(s) \right\} - \sum_{k \in F_i} \left\{ \sum_{s=1}^{L^*_{i,k} + 1} D_k(s) \right\}, \; i \in \mathrm{M}$$

Allocation policies,
j parent of *i*

$$EIP^+_j = S_j - \frac{SS_j}{\sum_{m \in C_i} SS_m} \left(\sum_{m \in C_i} q_m - I_i \right)^+$$

rationing **shortage**

Synchronized Base Stock Policies 2/2

current echelon inventory position

Determine quantity of i allocated to parent j

$$Q_j^{(i)} = EIP_j^{+} - EIP_j^{-}$$

calculated echelon inventory position

Determine order release item *j*

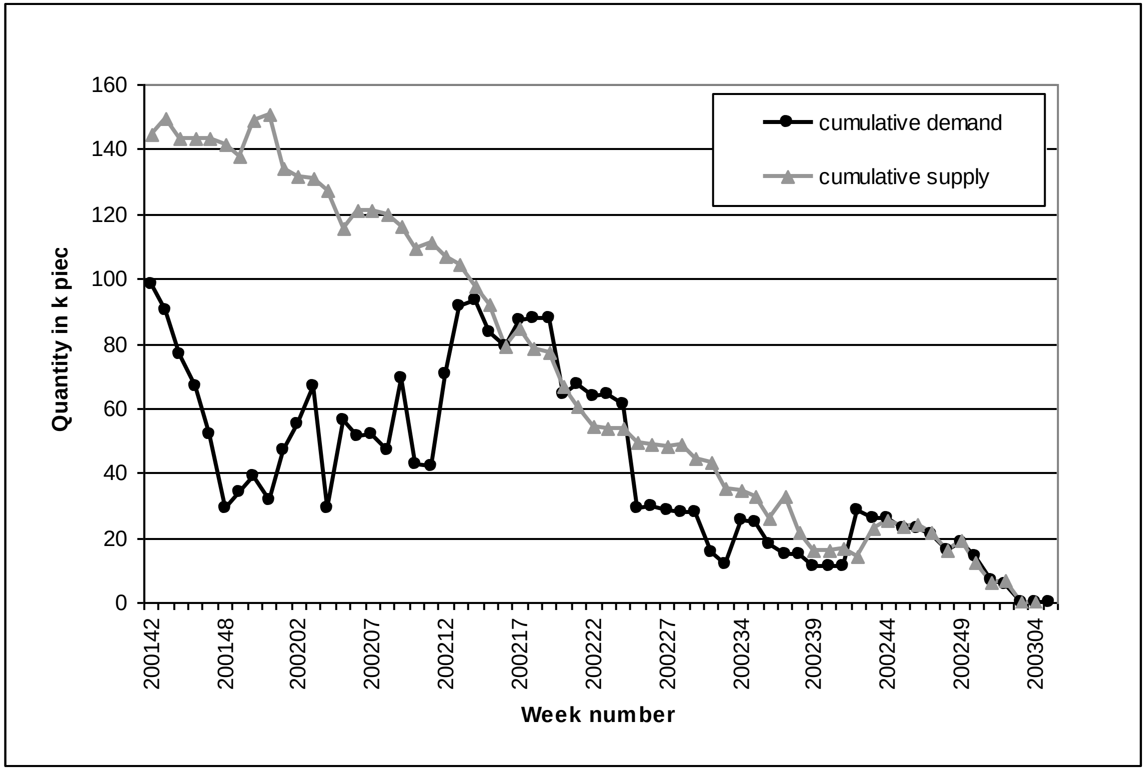
$$PO_j = \min_{n \in P_j} Q_j^{(n)}$$

Minimum allocations from children

Smart, flexible and user-friendly planning support tool

Interactive use	Robust solutions
Concentration on critical components and flows	Simple decision rules lead to robust divide and conquer solutions
Fast simulations and clear highlighting of planning issues	Takes into account intrinsic uncertainty in demand and supply
Team oriented to support dialogue and thereby collaboration	Mathematical model supports tactical optimization

Benefits -> successful reaction to end of life-cycle



Graph shows the life-line of an existing product in the new situation. The new CP process decreased the gap (first part of the graph) and then closely followed the graph (second part) with almost no obsolescence at the end of the life-cycle.

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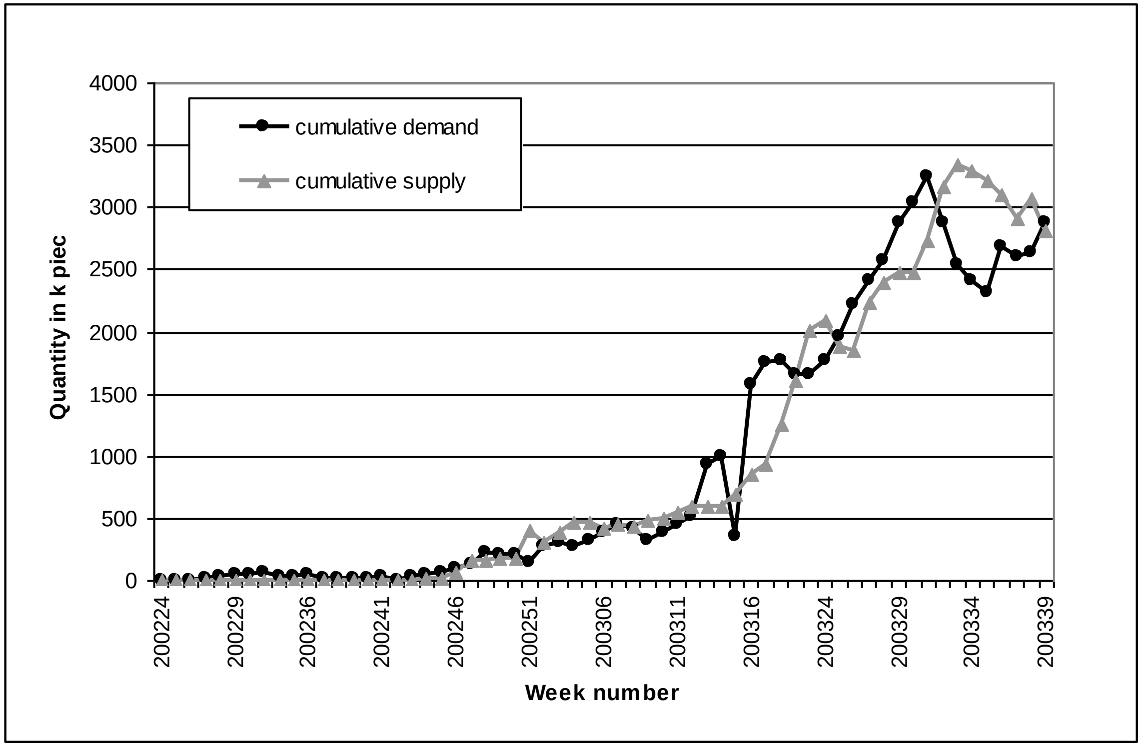
Benefits -> successful reaction to ramp-up



Graph shows a successful ramp-up, with the supply line closely following the demand line. Of course, there were some delivery lead time issues before the chain was balanced, but the new behaviour was a complete turn-around from previous ramp-ups.

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References

Interfaces
Vol. 35, No. 1, January–February 2005, pp. 37–48
ISSN 0092-2102 | EISSN 1526-551X | 05 | 3501 | 0037

DOI 10.1287/inte.1040.0116

Philips Electronics Synchronizes Its Supply Chain to End the Bullwhip Effect

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Demand variability increases as one moves up a supply chain. The demand for finished products is less variable than for subassemblies, which is less variable than for individual components. This phenomenon is known as the bullwhip or Forrester effect. It increases inventory unnecessarily and makes managing the capacity of equipment and personnel difficult. In 1999, Philips Semiconductors confirmed substantial bullwhip effects in some of its supply chains and began developing a collaborative-planning process and tool to reduce them. It sought to reduce inventory and increase customer-service levels by integrating its supply chain planning and control with those of its customers. By applying stochastic multiechelon inventory theory, it developed an advanced planning and scheduling system that supports weekly collaborative planning of operations by Philips Semiconductors and one of its customers, Philips Optical Storage. The project has brought substantial savings. A conservative estimate shows minimum yearly savings of around US$5 million from $300 million yearly turnover. More important, Philips Optical Storage now has a more flexible and reliable supplier that can virtually guarantee quantities and delivery times. Philips Semiconductor is rolling out its new approach to other customers.

Key words: supply-chain management; collaborative planning; bullwhip effect; multiechelon inventory theory.

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European Journal of Operational Research xxx (2003) xxx–xxx
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Travail, transparency and trust: A case study of computer-supported collaborative supply chain planning in high-tech electronics

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bstract

Describes a case study of supply chain collaboration facilitated by a decision support environment in a high-tech lectronics supply chain with multiple independent companies. In a business process called collaborative planning, epresentatives from these companies jointly take decisions regarding production and shipments for a large part of their ollective supply chain. Particular attention is given to the interactions between levels of partner trust and information ransparency on the one hand, and resulting improvements in supply chain performance on the other. The importance f hard work in developing the work flows necessary to support this joint planning process in starting a virtuous cycle of teadily increasing levels of all these aspects of supply chain collaboration is stressed. A theoretical model of the interactions between these aspects is presented, based upon a review in the literature. This model is then explored in an nalysis of the collaborative planning case. Contains suggestions for further research and managerial recommendations.

eywords: Supply chain management; Collaborative planning; Interorganisational trust; Group decision-making; Case study

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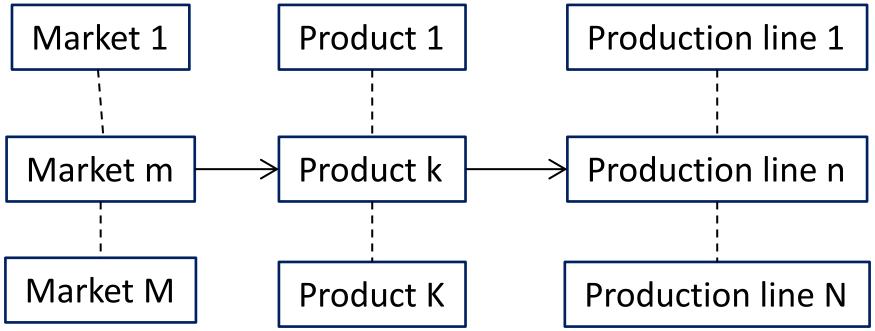
Robust Supply Chains

Queuing Theory and Supply Chain Planning

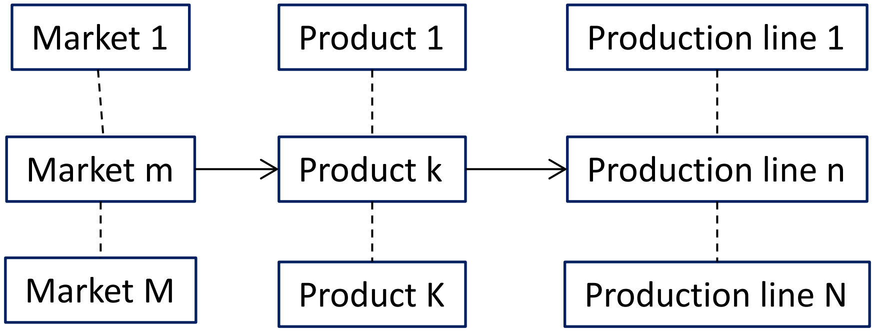
Description and base question



Description
- Markets require products which are be produced on production lines
- Not all products can be produced on all production lines
- Production lines and products are linked via switch over times and line speed
- Markets and production lines are linked via transportation costs
- Markets and products are linked via demand requirements
- Costs are for (a) waiting time, (b) capacity use and investment and (c) transportation

Base question
- How to make robust capacity decisions and allocations for a longer period taking into account all of the above plus information on expected demand and cost developments over the next years?

Research started in 2015



Research with Hugo Bink (master student), prof. Bert Zwart and prof. Onno Boxma

- One market, one product, one line, FCFS , two investment periods (queueing and optimization).
- Two products, one line, FCFS, two investment periods (queueing and optimization).
- One market, multiple products, one line, k-limited polling, single investment period (queueing).

Way forward

- Extend the polling model to situation with multiple markets, multiple lines and multiple periods step by step and combine queueing theory and optimization in a clever way.
- Assess the results in terms of robustness as compared with the more traditional approach using deterministic optimization models.

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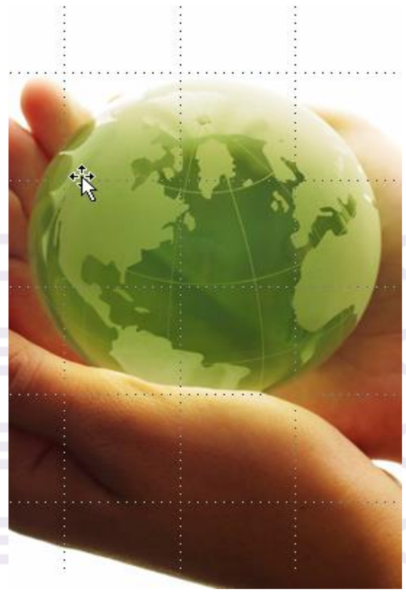

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