Application of Optimization Methods at OM Partners nv

October 2004

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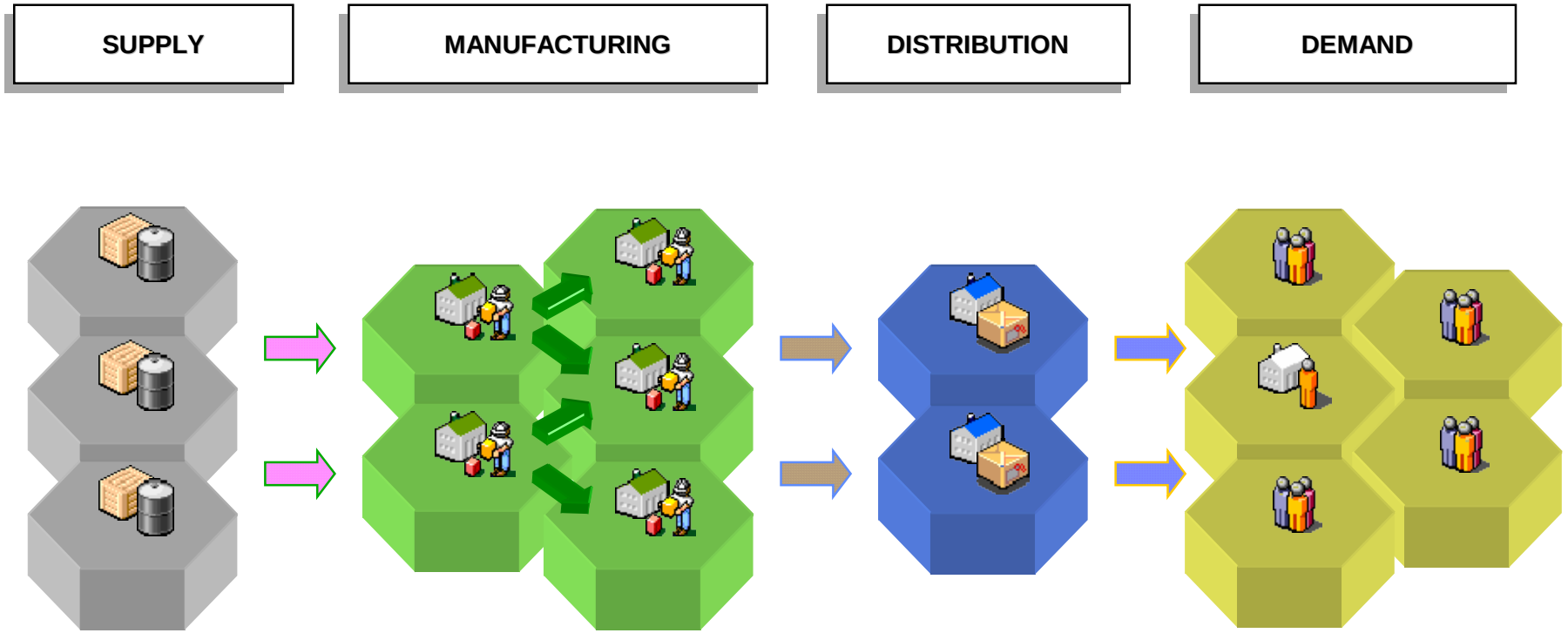
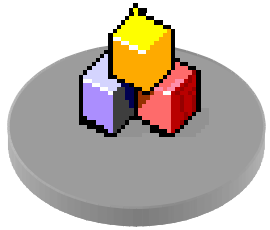
OM Partners = Provider of Demand and Supply Chain Planning Solutions



Activity: Focus on solutions

Solutions = Software Products + Services + Commitment



- **Software Products**
  - **Interactive : intuitive and easy to use**
  - **Intelligent : unique optimization expertise in Supply Chain Planning**
  - **Integrated : integration between planning modules (one data model) and with external systems**

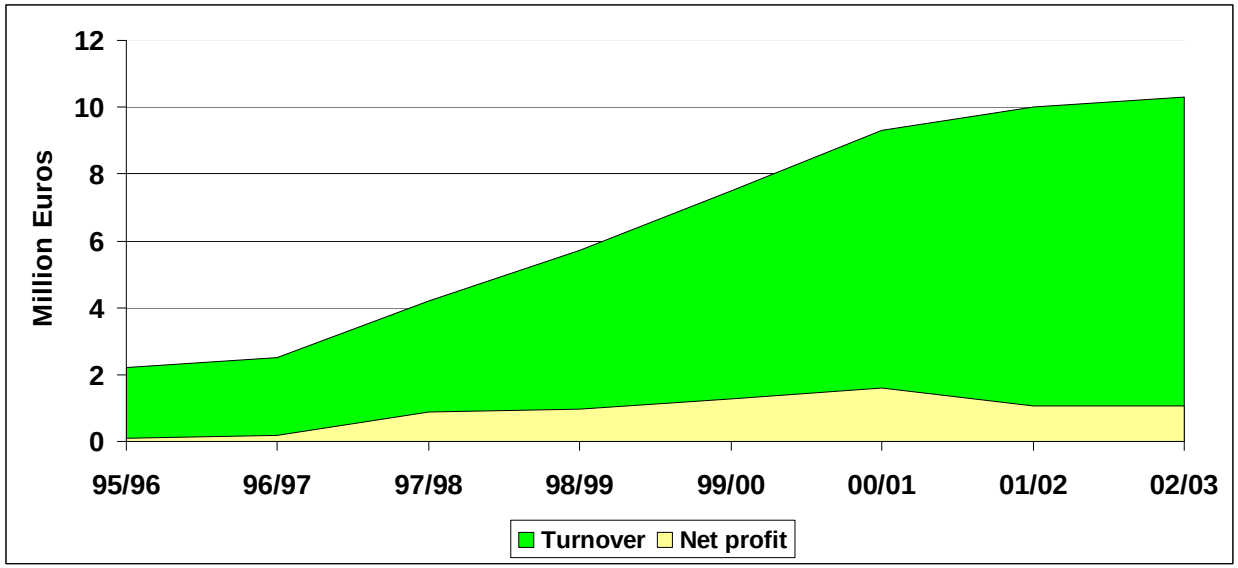
- **Services**
  - **Business consultancy : conceptual knowledge and sector expertise**
  - **Implementation : product knowledge and sector expertise**
  - **Support services : training, help desk**

- **Commitment**
  - **To make it work**
  - **To keep it running**

The OM Partners Group: History

- **Founded in 1985**
  - **Strong roots in Mathematical Optimization**
  - **Subsequent evolution towards Supply Chain Solutions**

- **Steady growth of key figures (resume past 5 years)**
  - **Personnel : growth from 40 to 80 employees**
  - **Turnover : rise from 5 to 10 mio €**
  - **Clients : over 150 clients and 300 implementations**



The OM Partners Group: International Structure

- **Headquarters** — **OM Partners (Antwerpen)**

- **Local offices** — **OM Partners Nederland**

  OM Partners France

  OM Partners UK

  OM Partners USA

- **Associated company** — **Aperia (Paris)**

The OM Partners Group: Research & Development

- **25 % of net sales reinvested in R&D**
- **European Esprit / IST projects**
  - **ICEP: integrated and concurrent enterprise planning and scheduling**
  - **HOPLICCS: planning and scheduling in horticulture**
  - **Chainfeed: planning and scheduling in animal feed**
  - **DiSCiPl: debugging in Constraint Programming**
  - **OMP/CAST: software testing tools**
- **Cooperation with academic experts**
- **Teaching assignments and seminars**

Sectors: Overview

▷ Flow Shop

Corrugated and solid board, paper

Metals, plastics, textiles, …

▷ Semi Process

Animal feed, chemicals, dairy, fertilizers, food and beverages, pharmaceutics, starch,…

Sectors: Flow Shop Characteristics

- **Long routings**
  - **Up to 15 operations**
  - **One or more bottlenecks (shifting)**
  - **Throughput varying from a few weeks (e.g. metals) to a few hours (e.g. corrugated board)**
- **Complex sequencing rules**
- **Continuous operation, limited intermediate stock (WIP – work-in-process)**

  e.g.: Blast furnace → hot rolling mill, paper machines
- **Optimize capacity, material and resource/tools usage**

  e.g.: Cutting optimization, blending optimization
- **Make-to-order (MTO) , make-to-stock (MTS), and combinations MTO – MTS**
- **Cycle and Campaign Planning**

Sectors: Semi Process Characteristics

- **Production on stock (continuous or on a lot-basis) followed by packaging**
- **Inventory policies**
- **Tank and silo allocation**
- **Co- and by-product planning**
- **Contamination rules**
- **Cycle and campaign planning**
- **Reactor planning, lot sizing constraints**
- **Pack-to-order (PTO)**
- **Shelf life, quarantine, maturation times, ...**

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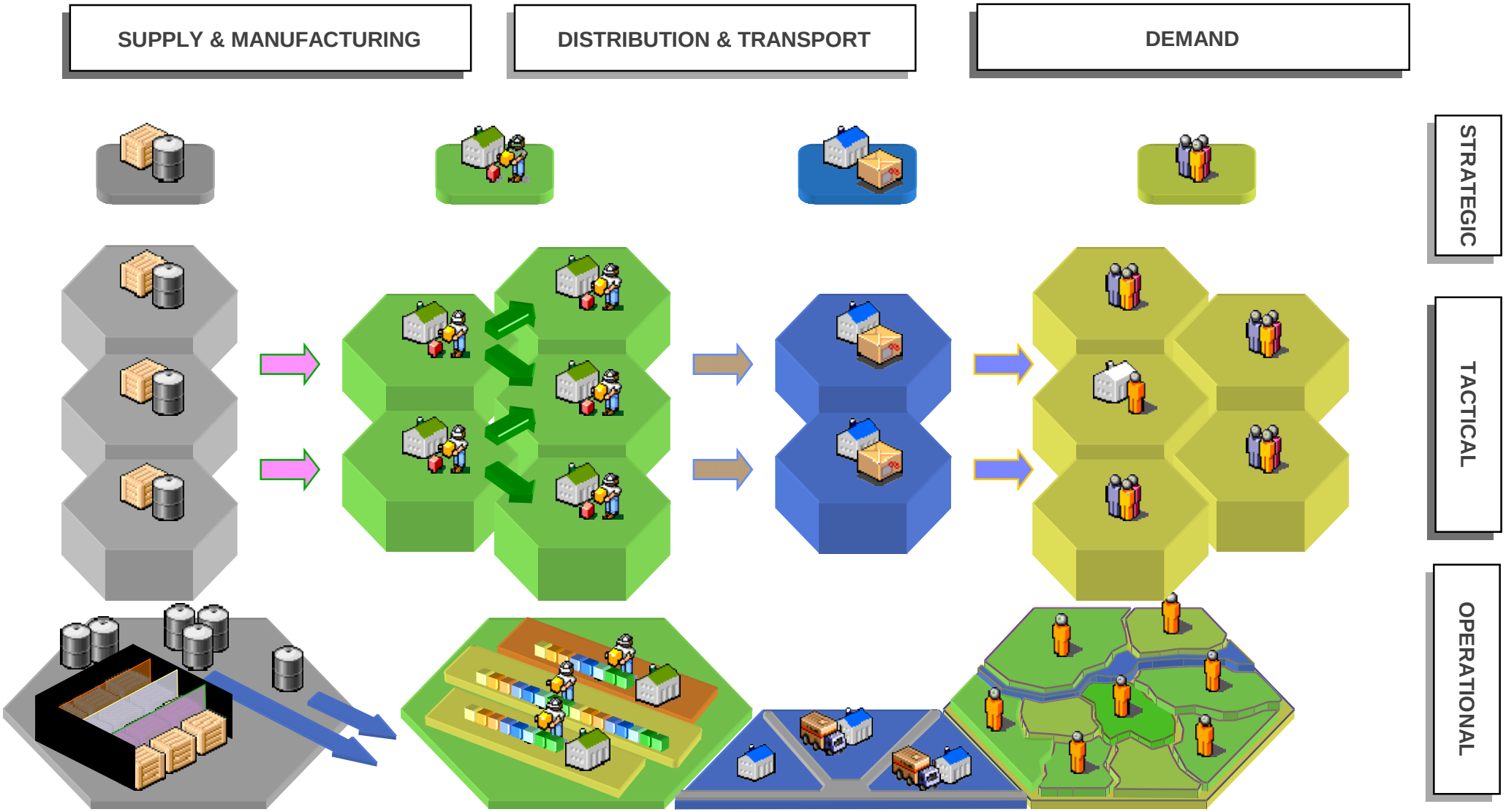
Planning Dimensions

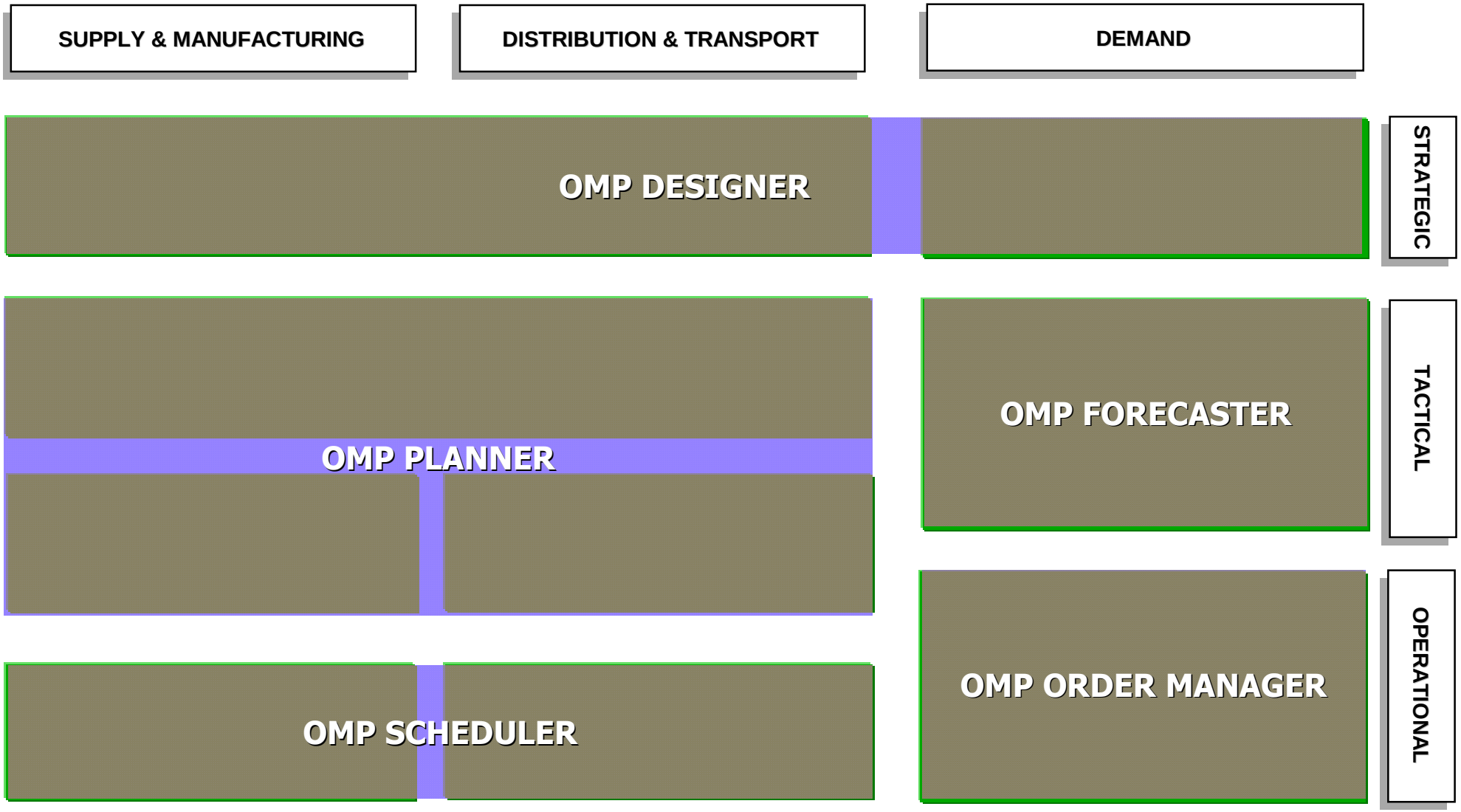


Approach

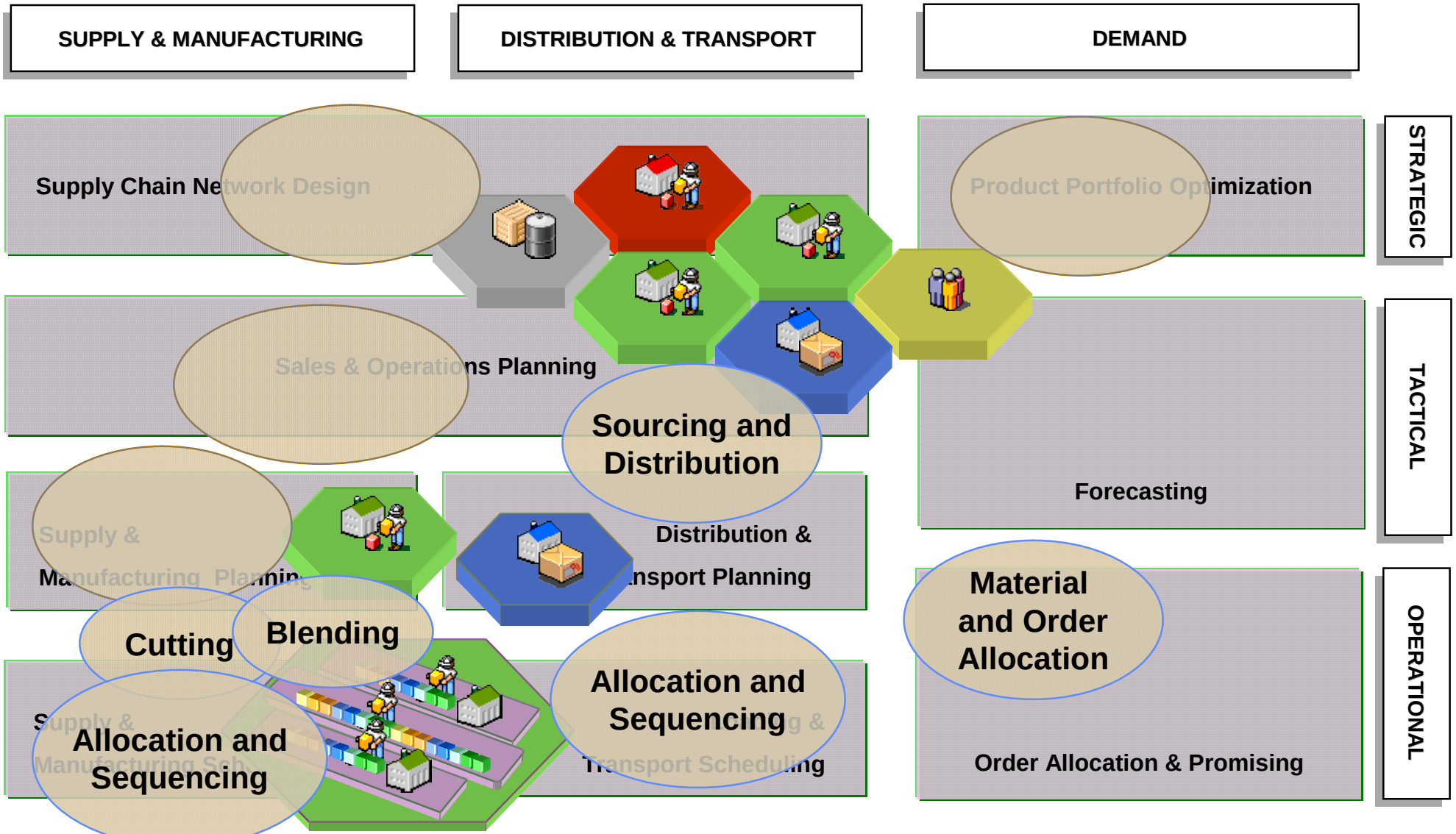
- **Utilization of highly interactive tools**
  - clear and concise reporting of problems in a plan
  - drill-down into problems and possible solutions
  - easy adaptation of all handles on the problem
  - instantaneous recalculation of all consequences

- **Supported by correctly chosen optimization algorithms**
  - preparation of a first version of the plan
  - application to entire problem or to part of the problem
  - utilization of the right technique for the problem!

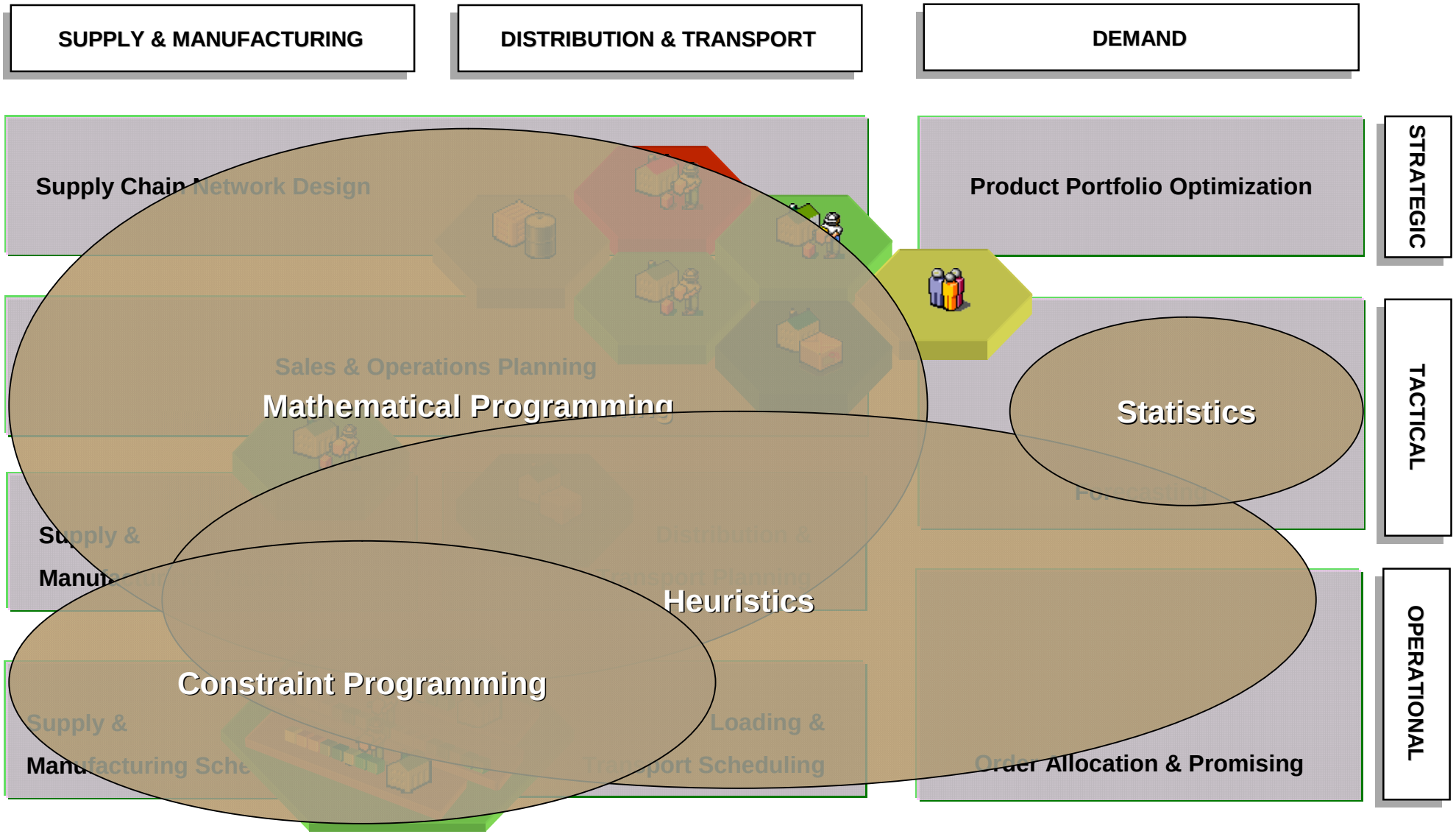
OMP Supply Chain Suite: Planning Modules



Solver Modules: Problem Types



Solver Modules: Solver Techniques



▷ OMP Optimizer

- **OMP Optimizer is developed by OM Partners**
  - . joint effort with Prof. F. Louveaux (FUNDP) since 1984
  - . interior point solver Mosek (2001) by Erling Andersen

- **state-of-the-art techniques for solving linear and mixed integer problems**

- **increasing sizes**
  - . 64-bit version

- **type of problems**
  - . blending optimization (animal feed, alloys, food, ..)
  - . product mix optimization (dairy, meat, …)
  - . cutting optimization (paper, steel, plastics, …)
  - . network design (SC network, utilities, …)
  - . multi-site, multi-period production and distribution planning

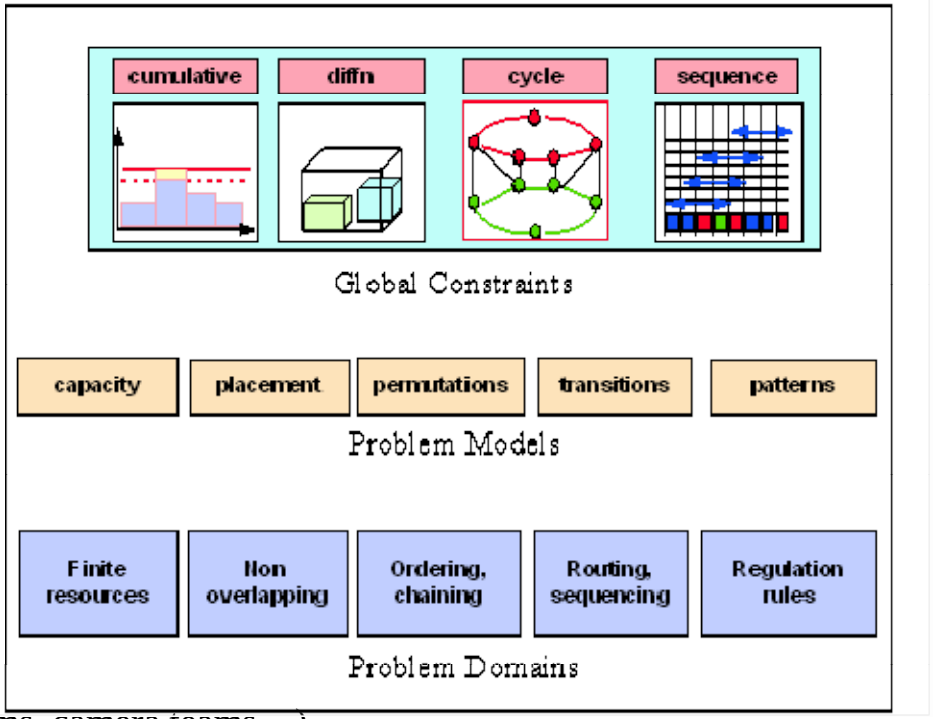
CHIP

▷ CHIP = Constraint Handling In Prolog

COSYTEC

- **product of COSYTEC (Paris)**
  - . research and implementation partner of OM Partners since 1992

- **constraint programming language**
  - . domain variables with integer domain
  - . dynamic propagation of knowledge via domain restriction
  - . backtracks are provoked as soon as possible
  - . CHIP global constraints : simple and powerful



- **type of problems**
  - . personnel roistering (schools, maintenance teams, camera teams, ..)
  - . transport schedules (flights, trains), tour assignment, crew scheduling
  - . production scheduling
    - **N tasks to be scheduled at finite capacity,**
    - **on M machines with product dependent capacity and setup times,**
    - **limited intermediate storage,**
    - **and precedence constraints, raw material constraints, resource constraints, …**

Heuristics - Types of problems

▷ Heuristics are a good technique if

- **"mathematical" optimization is not needed or not possible**
- **the solution to the problem can be described in a deterministic way**
- **constraints can be formulated as if - then - else rules**
- **the end user prefers to determine completely how the system will react**

▷ Type of problems

- **dispatching tasks**
  - . assignment of tasks to identical machines (FIFO)
  - . allocation of trucks to loading points
- **standard procedures**
  - . OMP Planner : set plan to requirements and reduce overloads
  - . OMP Scheduler : complex sorting/grouping rules, ALAP scheduling
- **customized procedures**
  - . OMP Planner : allocation of "unused" capacity following product priorities
  - . OMP Scheduler : adapt production orders in order to empty the tanks completely
- **problems too complex to model in LP/MIP or CLP**

Heuristics

▷ The technique

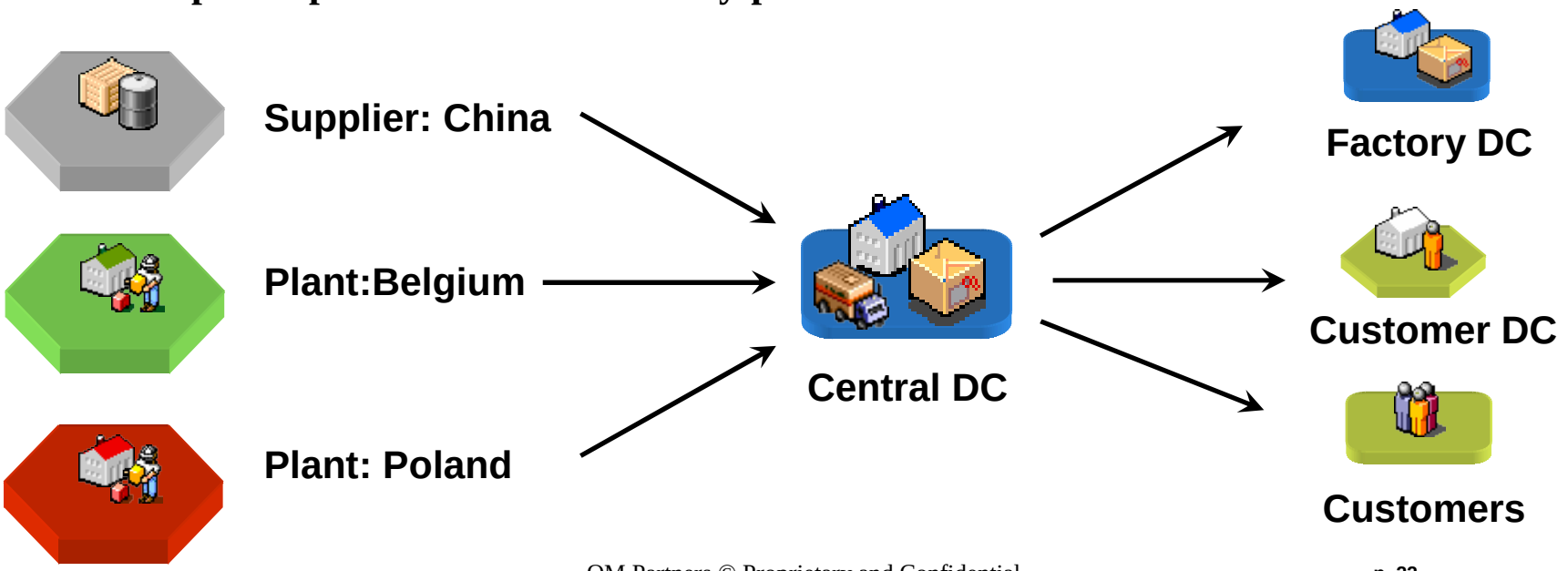
- **deterministic algorithms going from very simple to very complex**
  - . if – then – else … sorting … enumeration
- **reflecting human experience and/or way of working/thinking**
- **written in deterministic language : C++, OPAL, …**

▷ Heuristics in OMP Planner and OMP Scheduler

- **Built-in : Set Plan to, Reduce Overload heuristics, Replan heuristics, …**
- **Customized : OPAL Macros executed automatically or on demand**
- **OPAL : OM Partners Application Language**
  - . Visual Basic - like
  - . Can access all Objects and Attributes of the OM Partners Data Model
  - . Mix of customer-specific vs. generic programming: stored in OM Partners Knowledge base, communicated via internal OM Partners OPAL newsletter

OMP Designer - The Strategic Level

- **Developed by OM Partners since 1985**
  - based on OMP Optimizer
- **Package for Supply Chain Network Design:**
  - (re)location studies of plants and depots
  - determination of the number of machines/tools in which plant
  - make or buy/outsource decisions
  - investment studies
  - optimal product mix of co- and by-products

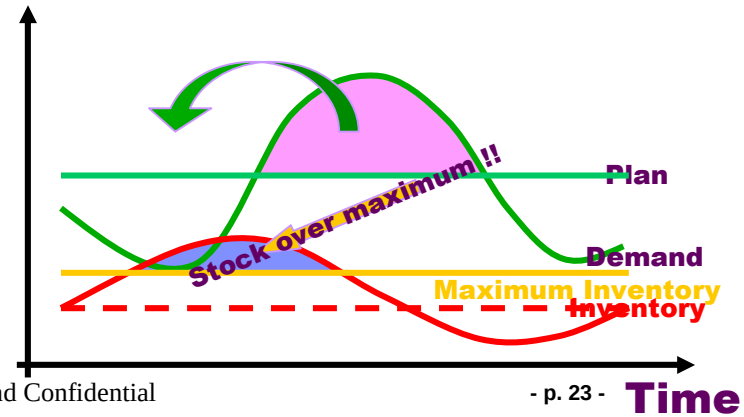


OMP Planner - The Tactical Level

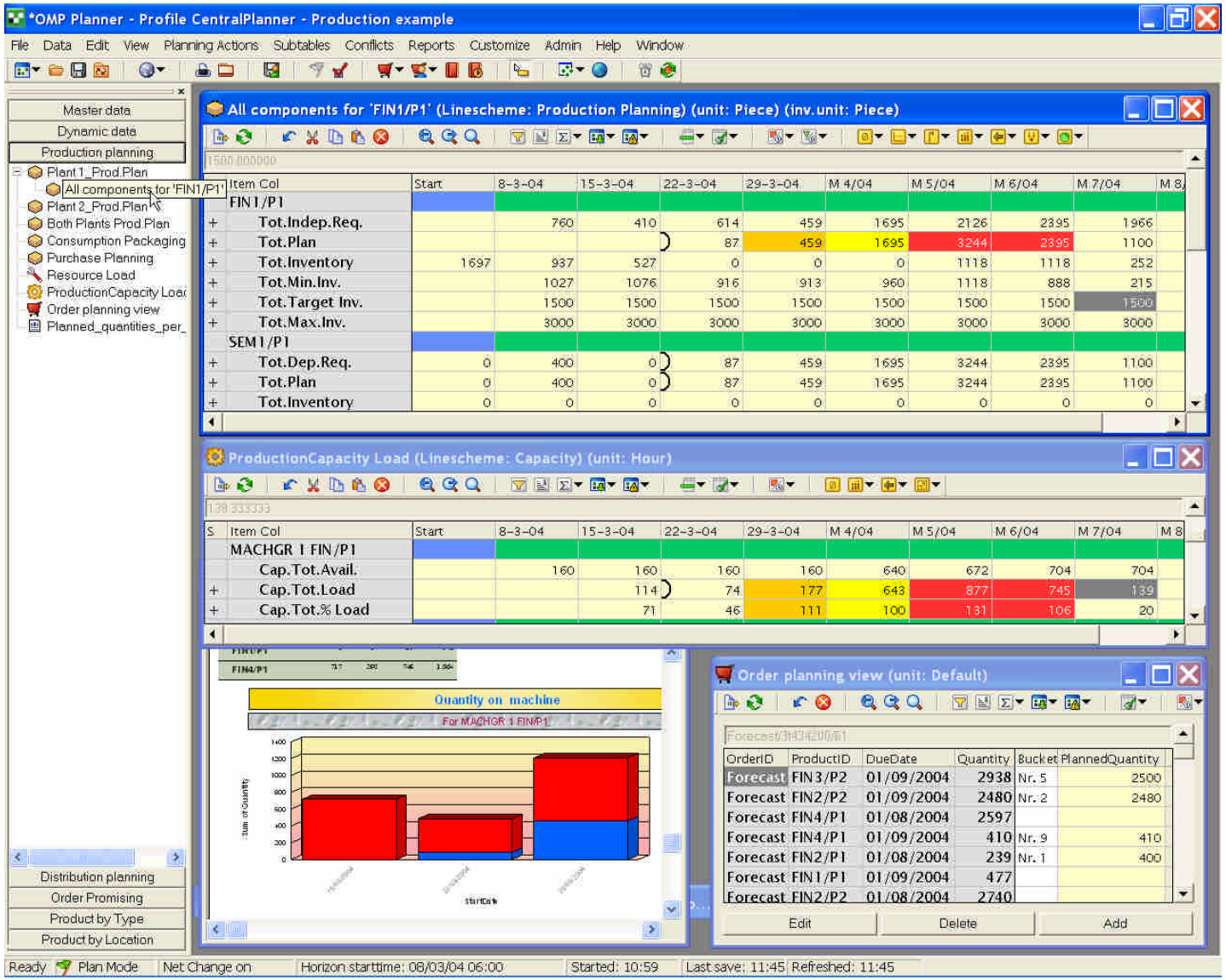
- **Developed by OM Partners since 1994**
- **Supply Chain Planning (mid- en long term planning)**
  - **(Collaborative) Sales & Operations Planning (S&OP) and budgeting**
  - **Master Planning**
  - **Distribution Requirements Planning and Vendor Managed Inventory Planning (VMI)**

- **Sales & Operations Planning (S&OP) and Master planning**
  - **Global matching of demand (different certainty levels) and capacity**
  - **Multi-site product-plant allocations (incl. Subcontracting) and distribution policy**
  - **Optimum service levels and procurement decisions**
  - **Cost or revenue optimization**
  - **Finite capacity planning of materials, machines, resources (e.g. manpower, tools) and warehouses**

- **Planning environment**
  - **Horizon: weeks, months, years**
  - **Buckets: days, weeks, months (+mixed)**
  - **Scenario management & comparison**
  - **Aggregations or detailed data**



Planning Modules: OMP Planner



A typical MPS optimization model

- **Objective function**
  - **Minimize costs of (over)production, inventory, backorders, …**

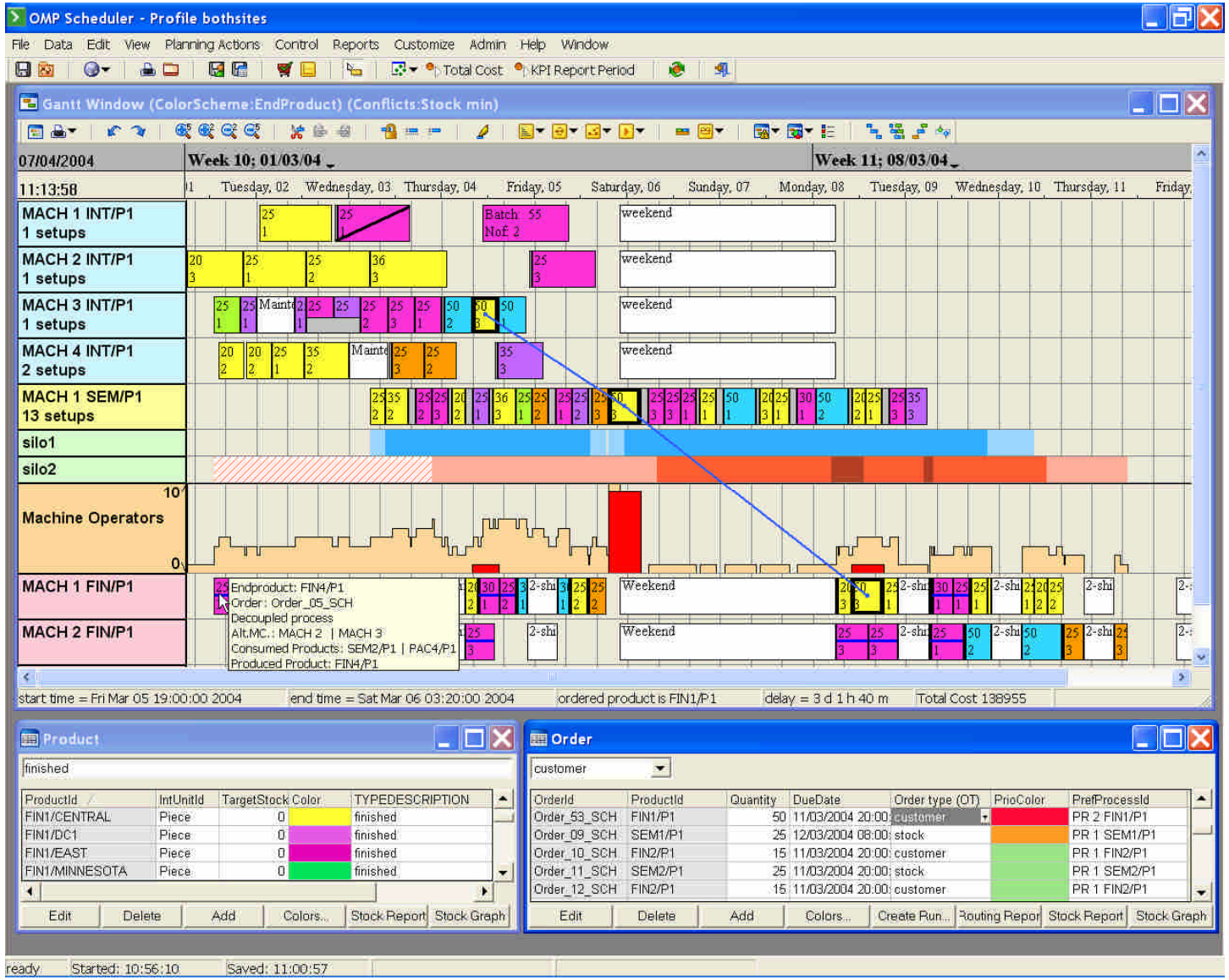
- **Variables**
  - **production/transportation variables**
    - alternative routings, BOMs, machines, manpower, utilities, …
  - **integrality due to minimum batch size and lot sizing, campaigns, cycles, …**

- **Constraints**
  - **Minimum and maximum**
    - machines capacity
    - resources capacity
    - production
    - stock levels
  - **Stock equilibrium**
  - **Reduce deviations from**
    - previous plan
    - target stock

OMP Scheduler - The Operational Level

- **Developed by OM Partners since 1992**
- **Short term scheduling**
  - **Finite capacity planning**
  - **Detailed process or routing consideration for each order**
  - **Assignment of operations or routing steps to individual machines (and tanks) and sequencing of these operations**
  - **Planning of warehouses, tanks, resources and materials**
  - **Integration of VMI (Vendor Managed Inventory), truck loading, …**
  - **Real-time integration of feedback events**
- **Planning environment**
  - **Horizon: hours, days, weeks**
  - **Continuous time horizon (no bucketing)**
  - **Detailed data**

Planning Modules: OMP Scheduler



Why Constraint Logic Programming?

- **Domain variables**
  - **are like integers**
  - **min/max**
  - **deduction algorithms can remove values from the domain**
    - e.g. [1,2, ,4, , , ,8,9,10]

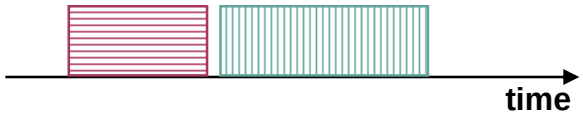
- **The "different" constraint is very powerful**
  - **X ≠ Y, hence instantiation of variable X removes value from domain of Y**

- **"Labeling"**
  - **≈ specification of the enumeration/branching**
  - **implementation of problem specific algorithms to explore the search tree**

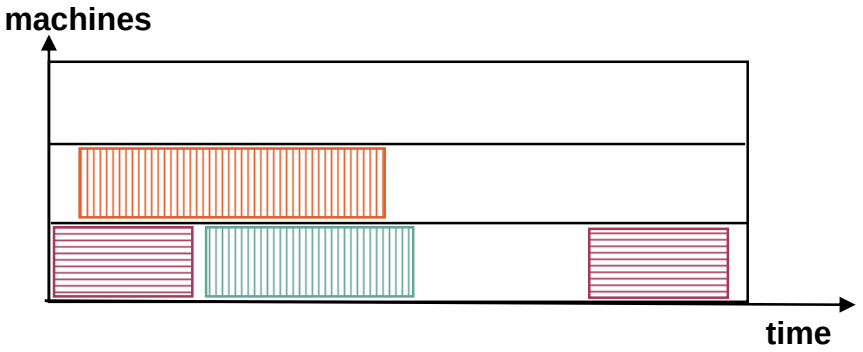
- **Global constraints with strong deduction algorithms**
  - **avoid backtracks**

CHIP Global Constraint : Multi Dimensional Rectangle Placement

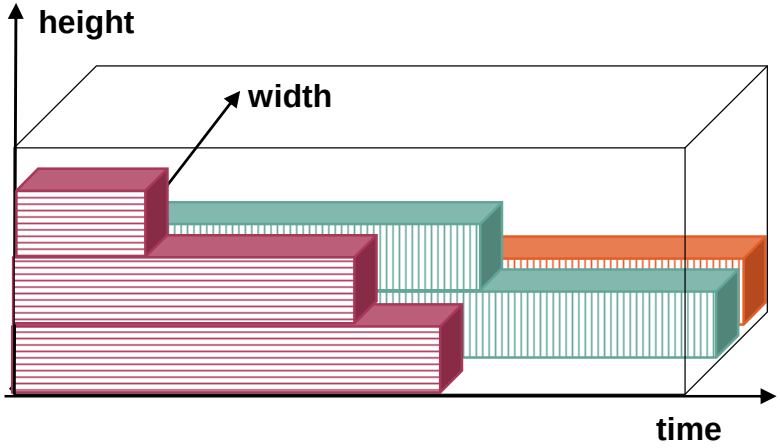
▷ **Non overlapping tasks on 1 machine**



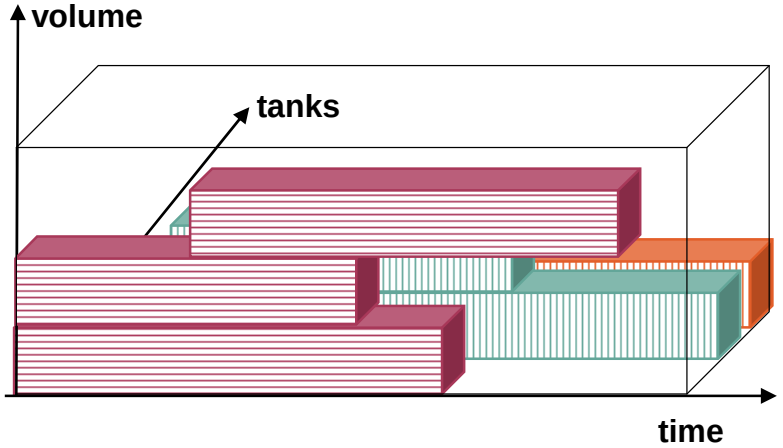
▷ **Non overlapping on multiple machines**



▷ **Non overlapping volumes in a truck**



▷ **Different products should be stored in different tanks**



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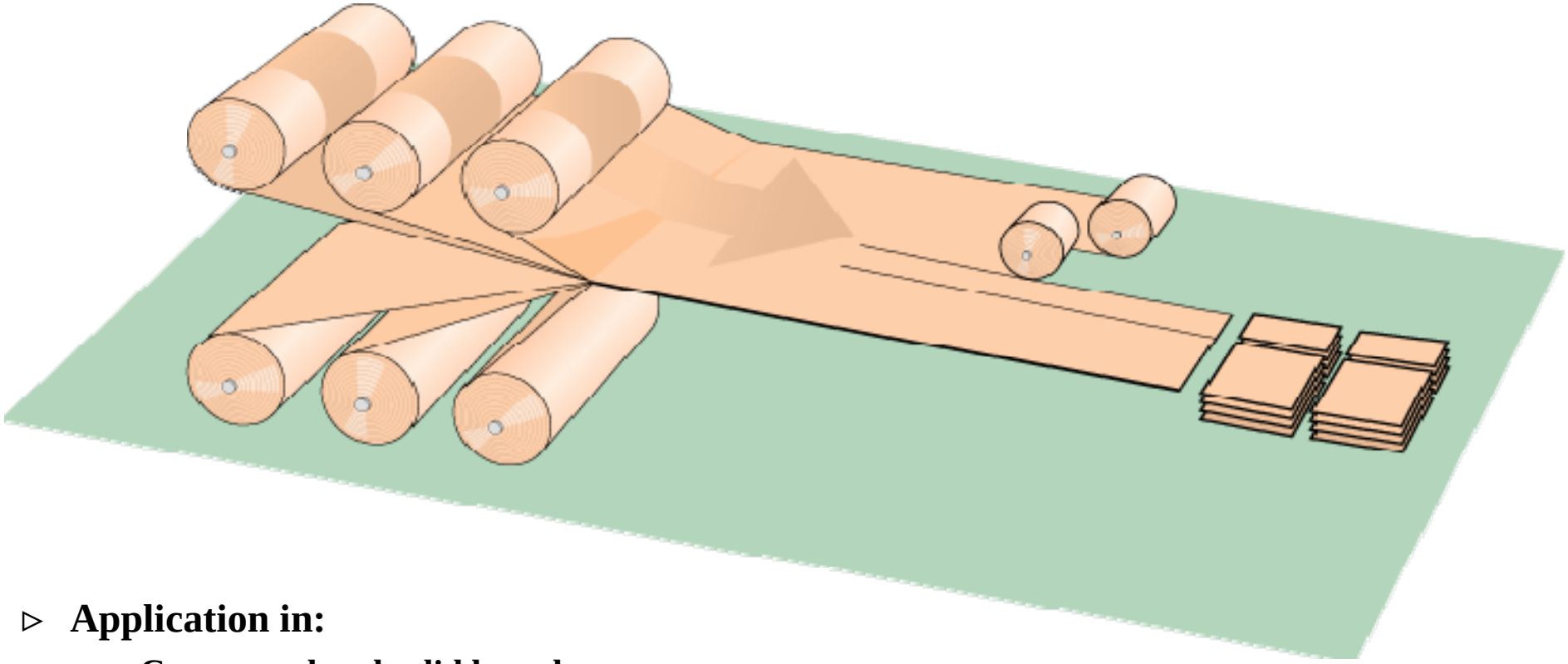
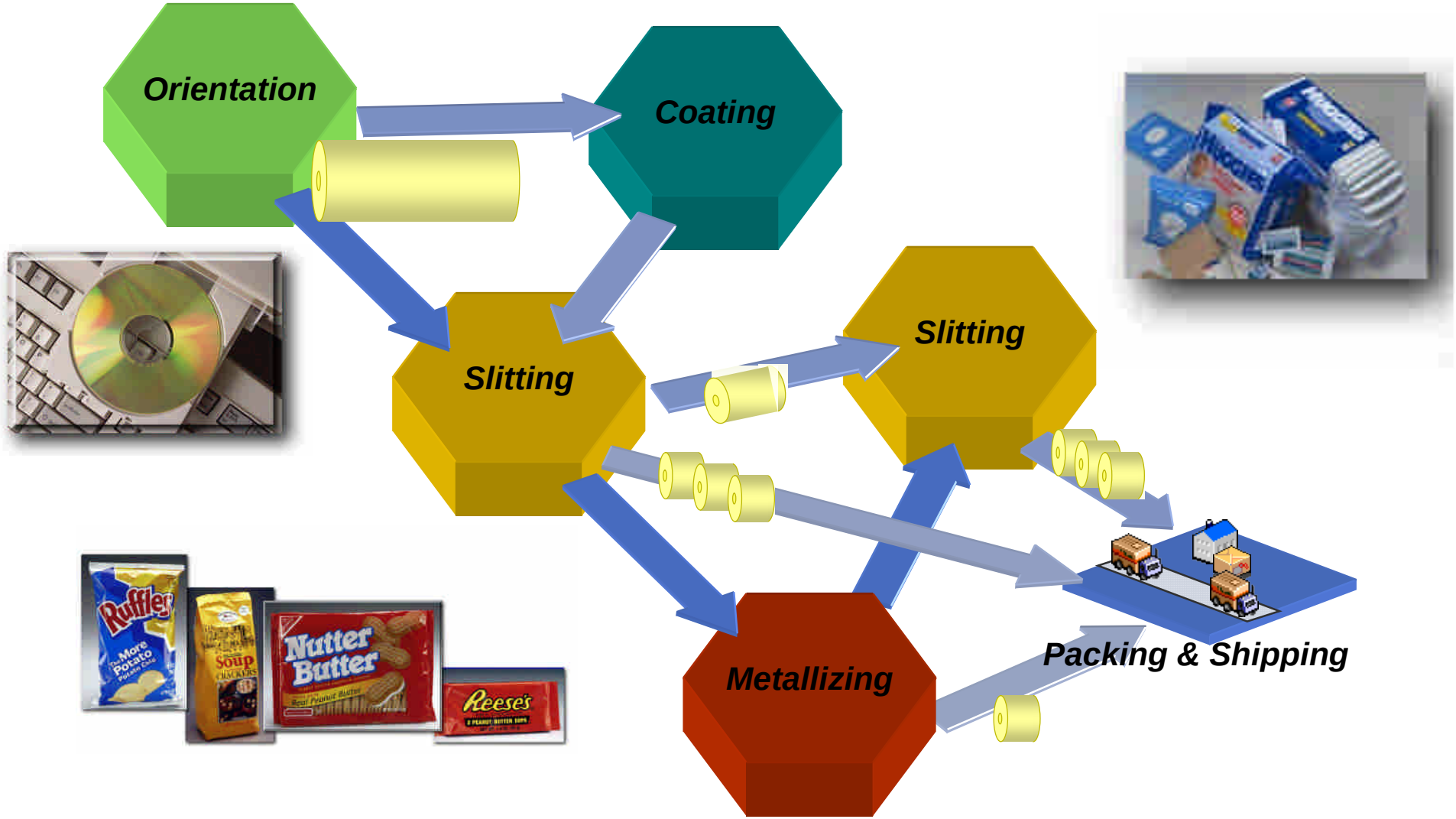
Cutting Stock Problems - Overview



- **Application in:**
  - **Corrugated and solid board**
  - **Paper**
  - **Plastics**
  - **Steel service centers**
  - **Textile**

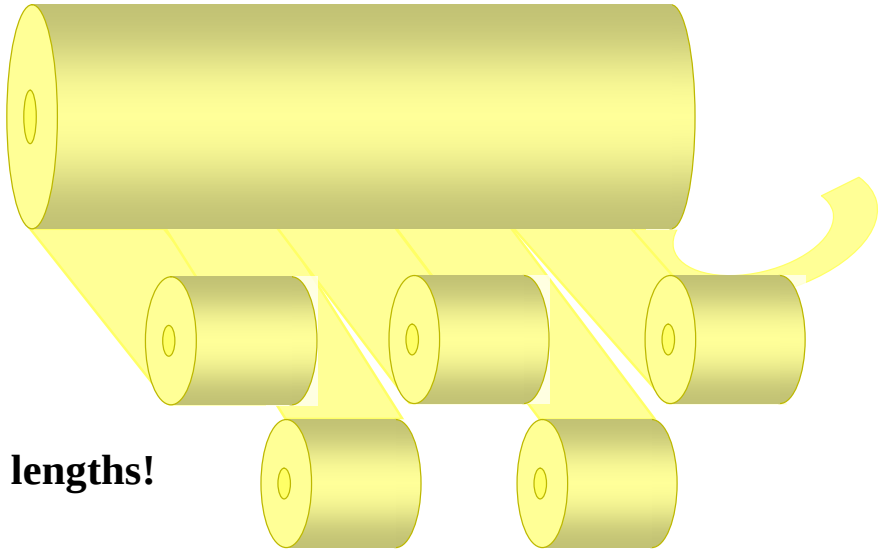
Plastic Film Industry



Slitters

Plastic Film Slitting – The Optimization Problem

- **Combine**
  - **a given set of orders (roll width and length, quantity and tolerances)**
    - order sizes vary from 1 roll to 1000 rolls
  - **on a number of alternative mill rolls (specified by width, length and defects)**
  - **on a number of alternative slitters**



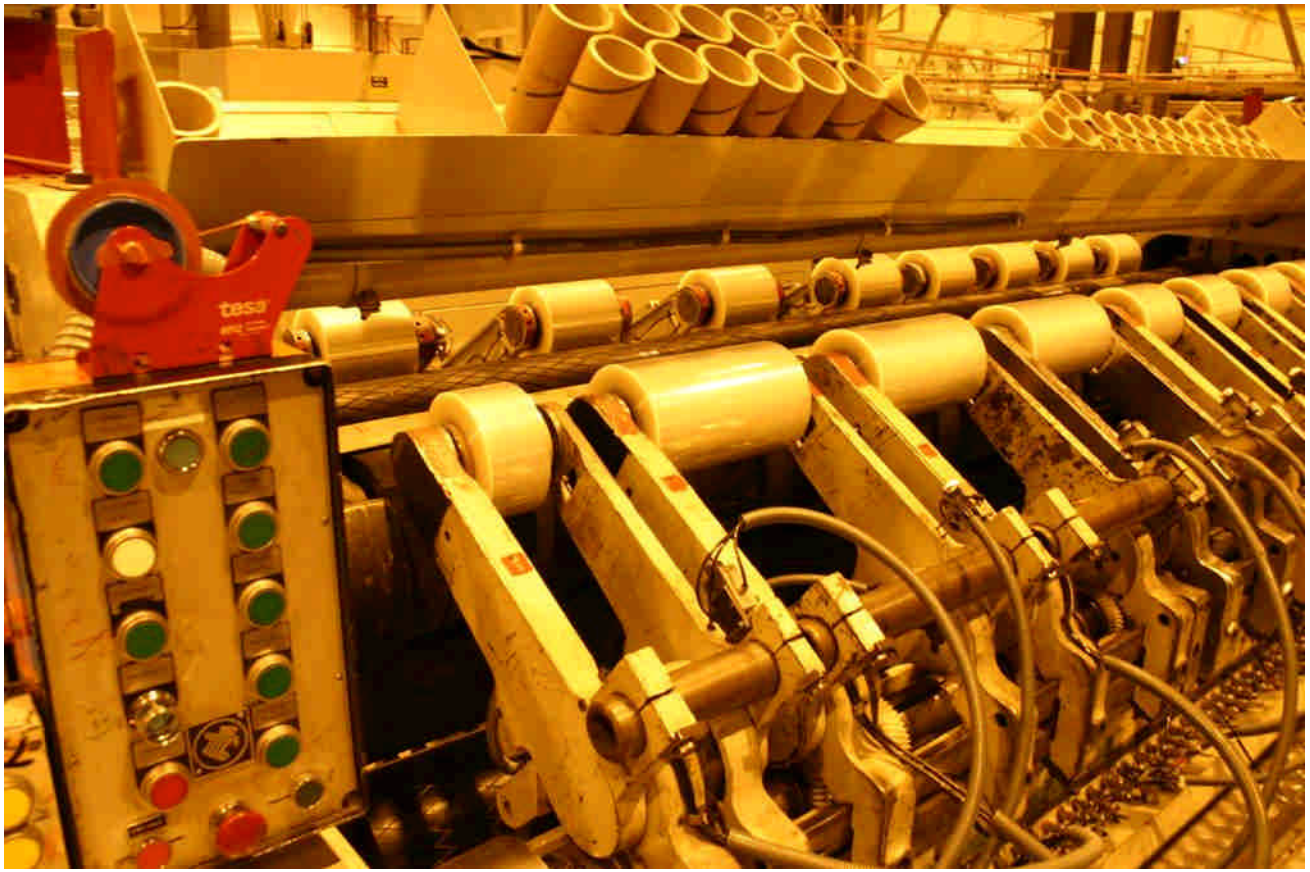
- **Minimizing**
  - **edge losses (trim)**
  - **change-over time**

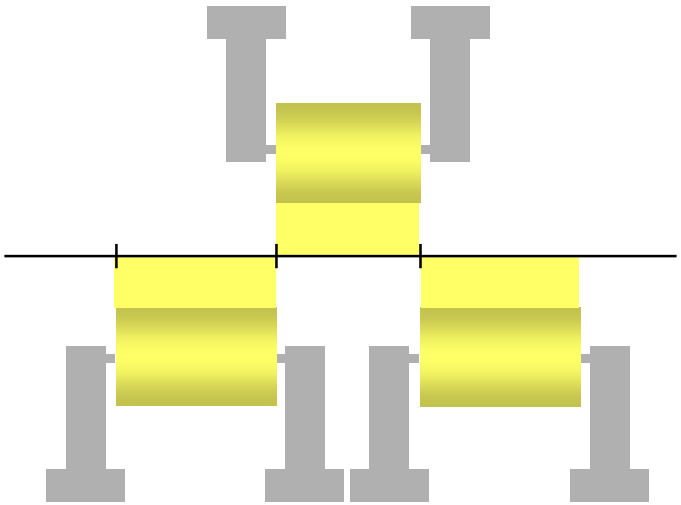
- **Taking into account**
  - **slitter restrictions**
  - **combinable order lengths - integer run lengths!**
  - **preferences in production practices**

- **Strong relationship with detailed scheduling**
  - **make building blocks for detailed scheduling (“programs”)**

Slitter restrictions

- **Winding stations**
  - **up to 30 rolls**
  - **physical limitations**
  - **sequence-dependent change-overs**



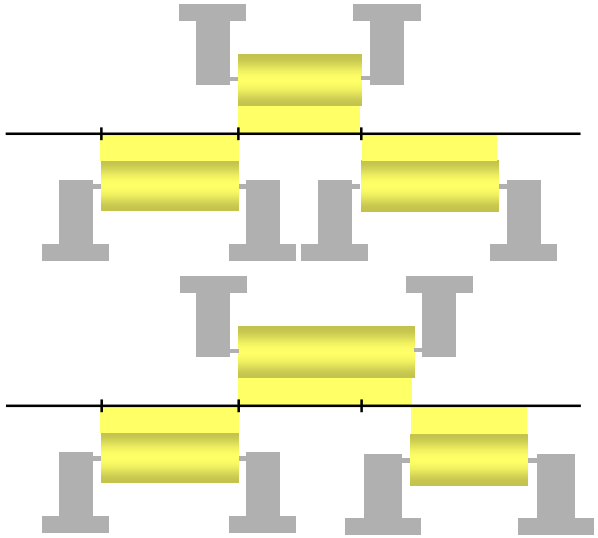


- **Strong relationship with detailed scheduling**
  - **make building blocks for detailed scheduling (“programs”)**
    - shortest sequence of set-ups in which each order that is started must finish

Plastic Film Slitting – Difficulties

▷ **Difficulties**

- **sequence-dependent change-overs**
  - . also determined by roll positions in a set-up
  - . AABBCCC is different from AACBBCC
- **time-intensive feasibility and cost evaluation of programs**




CAN YOU SUMMARIZE THIS ON ONE PAGE FOR OUR CEO?