SmarterCommerce

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IBM ILOG Optimization

Introduction and Overview

Optimization – The Science of Better Decisions

How to best allocate aircrafts and crews?

Inventory cost vs. customer satisfaction?

What to build, where and when?

Optimization helps businesses:

- *create the best possible plans*
- *explore alternatives and understand trade-off*
- *respond to changes in business operations*

Risk vs. potential reward?

Cost vs. carbon emission?

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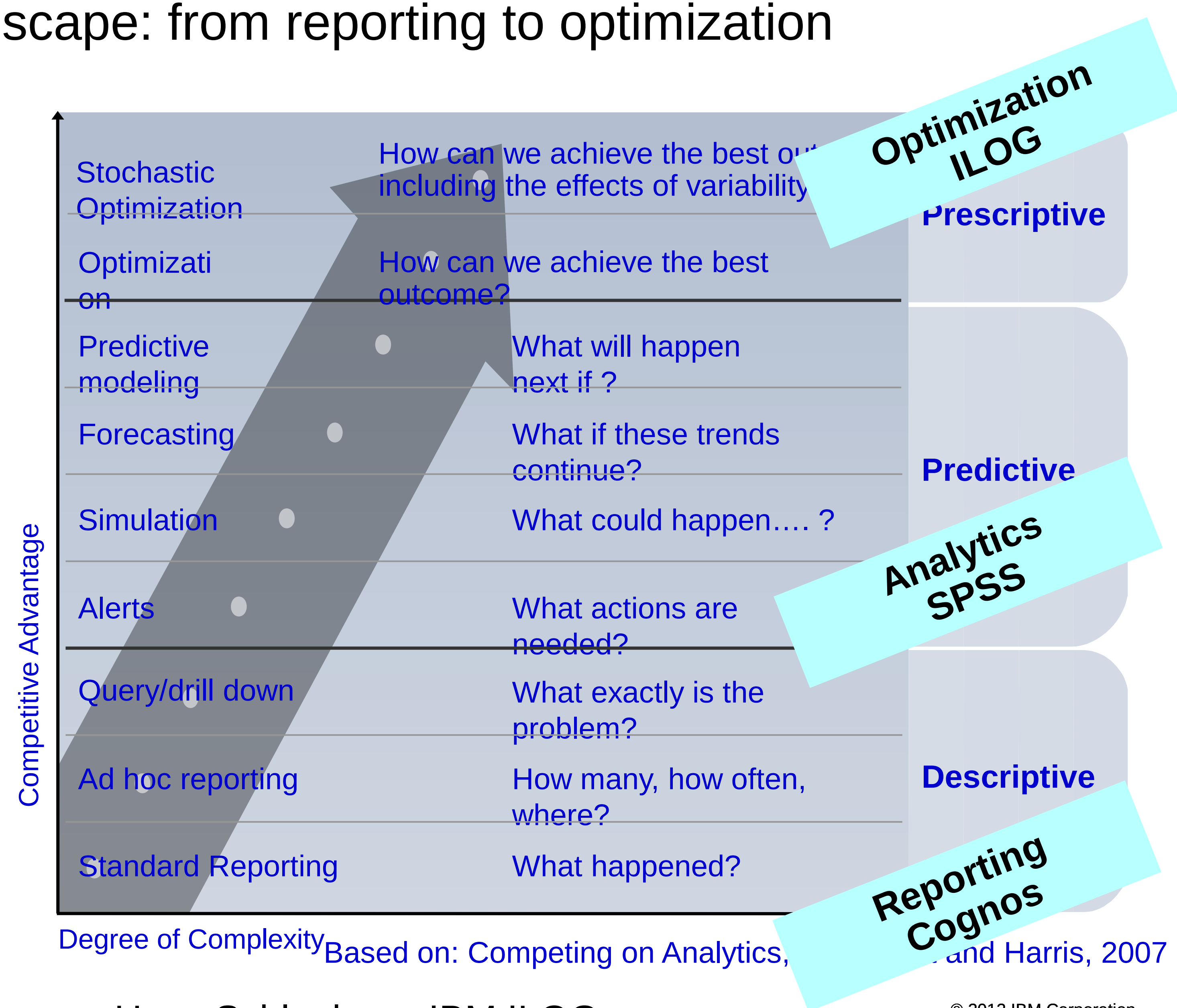
Analytics landscape: from reporting to optimization



Based on: Competing on Analytics, … and Harris, 2007

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What is optimization all about

- **Complex decision support**
- **Business value**

Projects and references

- Many different customers and application areas
- Huge ROI

Product portfolio

- CPLEX components, ODME platform, SCM packages

ILOG Optimization: **Complex Decision Support**

Optimization **solves business problems**!

- **Automated**
  - thru mathematical optimization
- **Planning**
  - or scheduling, dispatching, yield management, risk management, etc etc.

Business Value

- Cut operating costs
- Avoid capital expenses
- Shorten delivery times
- Offer flexible, precise customer service
- Provide personalized work schedules
- Manage risk
- Create better products
- Maximize profitability
- Etc etc etc

Optimization: What is so special about it.

- Scenario: create a timetable for a small school
  - 5 days, 6 hours each, 10 classes, 10 teachers, 10 courses
  - Possibilities for a plan: **10 ^ 600**
    - (10 * 10) ^ (5 * 6 * 10) = 100 ^ 300 = 10 ^ 600
  - Number of atoms in the universe: **10 ^ 80** (roughly)

- Deterministic heuristic would probably find you a good solution, but to find (one of) the optimal solution, you need a better approach!
- Optimization takes into account *the space of* all possible solutions
  - not each and every individual one!
  - and selects good ones or the best!

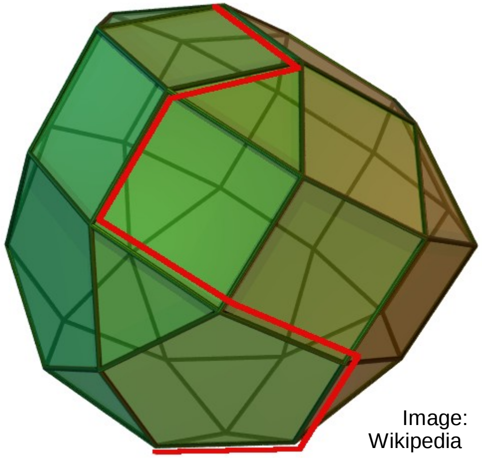
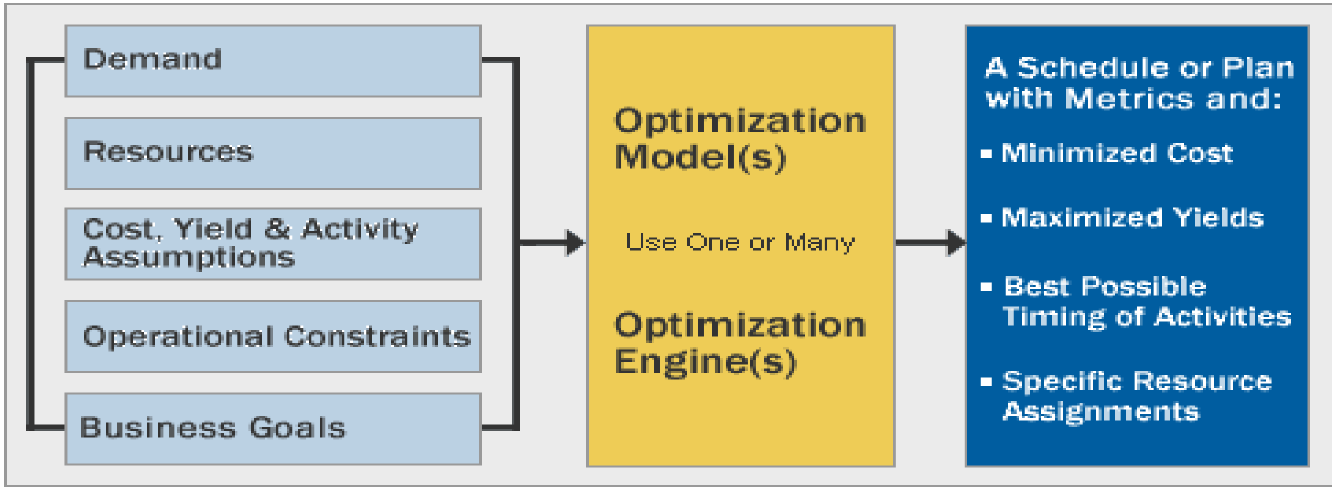


Image: Wikipedia

Optimization: What is so special about it.



- *Model* specifies the *problem*
  - variables, constraints, goals
  - generic model is filled with application data
- ILOG *engine* solves it with special algorithms
- *Solution*: a plan or schedule

Optimization basics: TLC+D

- TLC+D: Targets, Limits, Choices + Data
- Data (input)
  - demand, products, costs, lead time, production recipes
- Choices
  - What to produce, where, when, how to transport, to which customer
- Targets
  - Minimize costs, maximize plant throughput, maximize yield
- Limits
  - Production capacity, storage capacity, supplier capacity, physical constraints

Optimization example: Pasta production

- Data (input)

Products					Resources			Consumption		
Name	**Demand**	**InCost**	**OutCost**		**Name**	**Capacity**		**Prod \ Re**	flour	eggs
kluski	100	0.6	0.8		flour	80		kluski	0.5	0.2
capellini	200	0.8	0.9		eggs	50		capellini	0.4	0.4
fettucine	300	0.3	0.4					fettucine	0.3	0.6

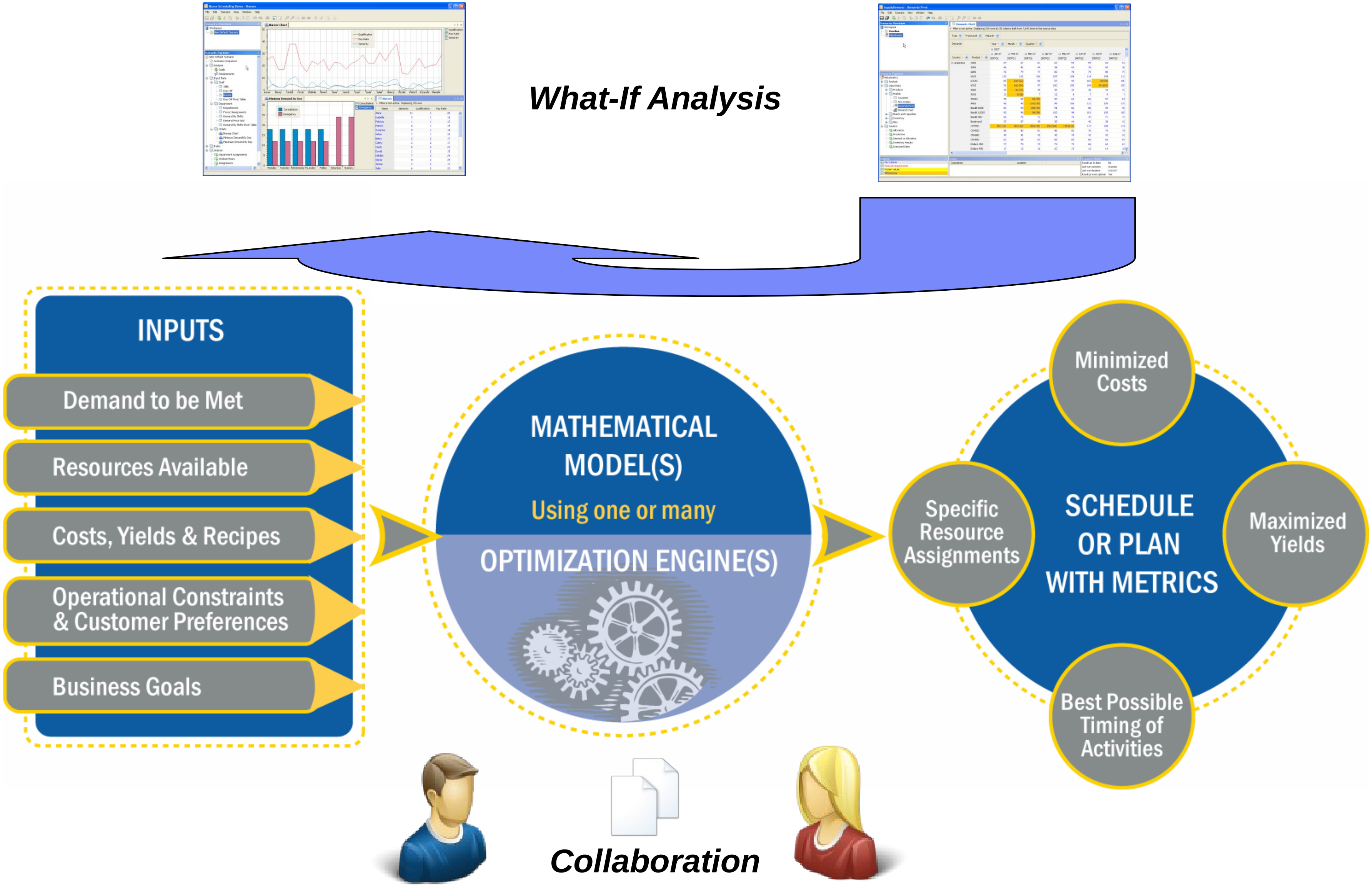
- Choices
  - What products to produce internally, what to buy from external supplier
- Target
  - Minimize costs: production+sourcing
- Limits
  - Resource capacity (here: raw material)
  - Recipe constraint
  - Demand fulfilment

Optimization example: OPL model

- Data (input)
- Choices
- Target
- Limits

```
tuple product {
      key string name;
      float demand;
      float insideCost;
      float outsideCost;
}
{product} Products = ...;
tuple resource {
      key string name;
      float capacity;
}
{resource} Resources = ...;
float Consumption[Products][Resources] = ...;

dvar float+ Inside[Products];
dvar float+ Outside[Products];

dexpr float InCost[p in Products] = p.insideCost * Inside[p];
dexpr float OutCost[p in Products] = p.outsideCost * Outside[p];
dexpr float OverallCost = sum( p in Products ) (InCost[p] + OutCost[p]);

minimize OverallCost;

subject to {
      forall( r in Resources )
            sum( p in Products )
                  Consumption[p][r] * Inside[p] <= r.capacity;

      forall( p in Products )
            Inside[p] + Outside[p] >= p.demand;
}
```

How does optimization support decision making?



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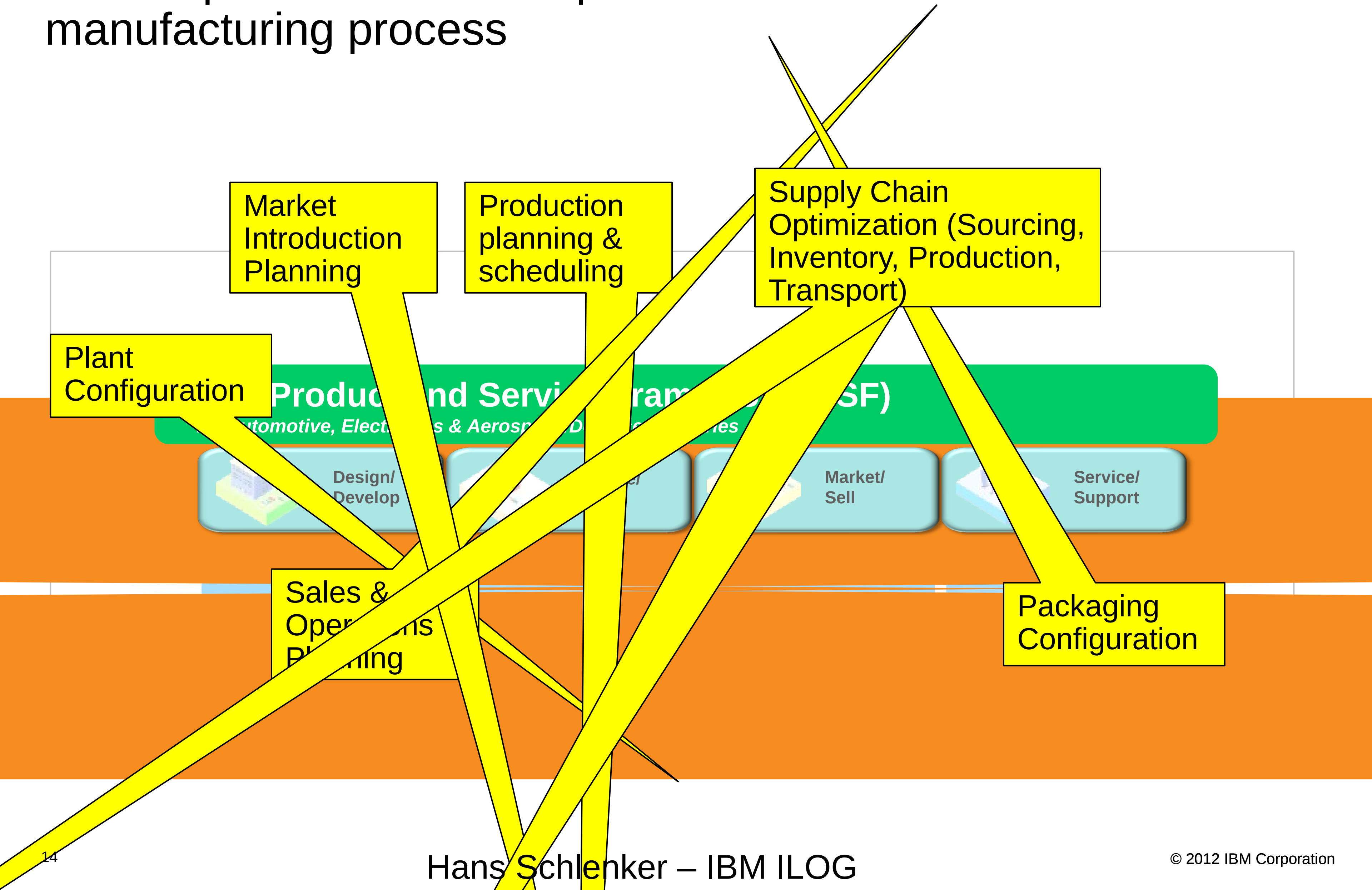
- **Huge ROI**

Product portfolio
- CPLEX components, ODME platform, SCM packages

Optimization applies everywhere

ILOG Optimization solves problems in the whole manufacturing process



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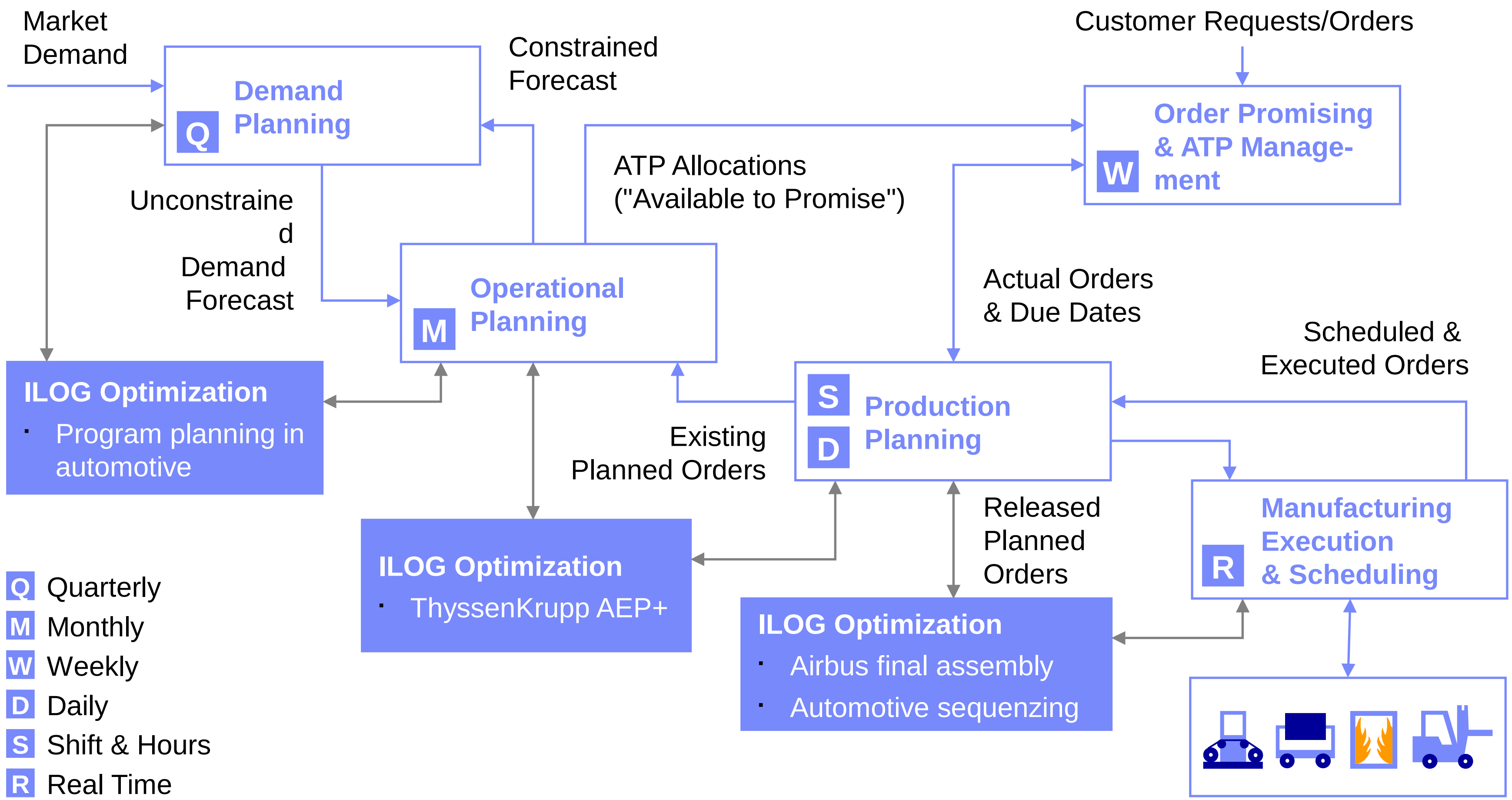
Optimization in production planning: ILOG supports all planning steps and horizons



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Automotive Sales & Operations Planning: Overview

2164
types

110
countries

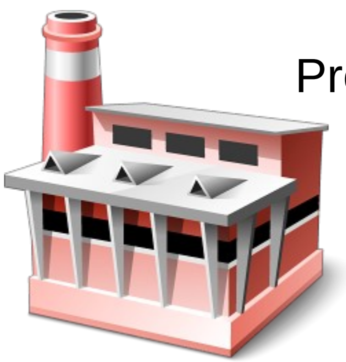
**Major Car
Manufacturer**

How many cars of
each type?

Delivered to what
market?

1000's critical decisions
… each month

10 collaborating planners



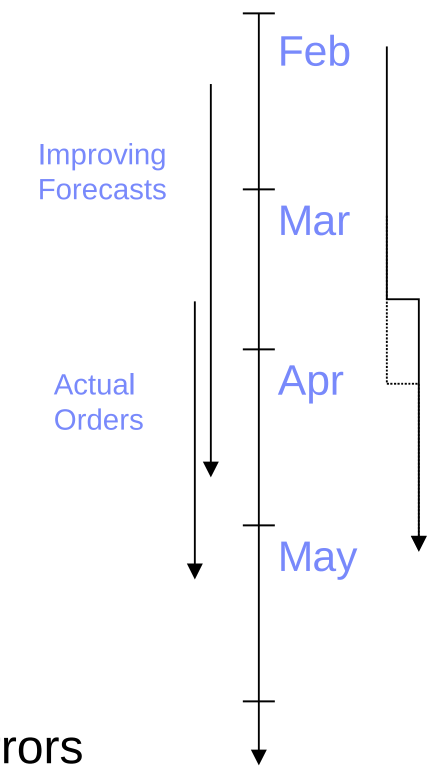
Produced where?

At what time?

12
plants

24
months

Automotive Sales & Operations Planning



- Business needs
  - Efficiently allocate production capacity to market demand
  - Make difficult supply-demand trade-offs
- Current issues
  - Lacks agility (planning 3 months in advance)
  - Continuous re-adjustments of plan
  - Planning was very inaccurate
    - very detailed forecast: on most detailed level
    - many small figures -> many errors

Example:

Before: planning on most detailed level, led to many planning errors

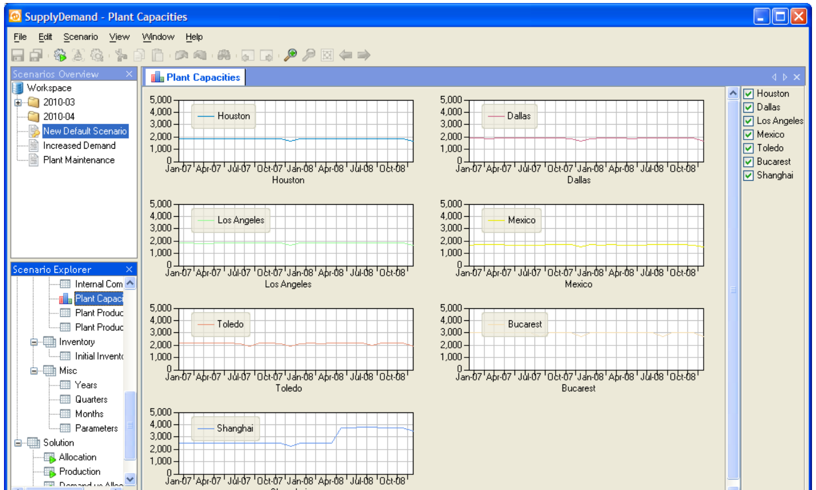
Belgium	E220 (car type)	Diesel	Oct 2011	+3%
Belgium	E230	Diesel	Oct 2011	+2%
Belgium	E230	Gasoline	Oct 2011	+4%

After: p

Europe	all car types	Diesel engine	2H 2011	+5%
France	E class	any engine	2H 2011	+8%
France	E220	Diesel	June 2011	+3%

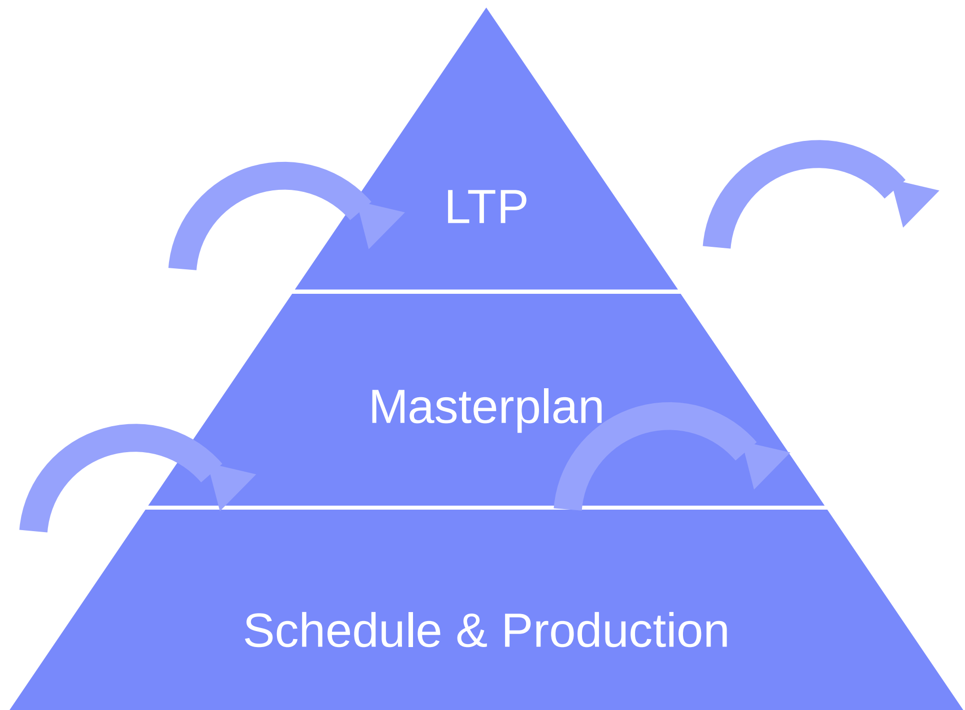
Automotive Sales & Operations Planning

- **Solution**
  - Solution based on IBM ILOG ODME optimization platform
  - Supports many collaborating planners
  - Optimization for efficient supply-demand balancing
- **Benefits**
  - Increased agility: saved 1 month planning time
  - Reduced planning effort: 75% less planning figures
  - Better planning accuracy: 50% less plan changes



Car tire production planning

- Customer:
  - 10000 products
  - 20 plants world wide
  - each ~10M tires / year

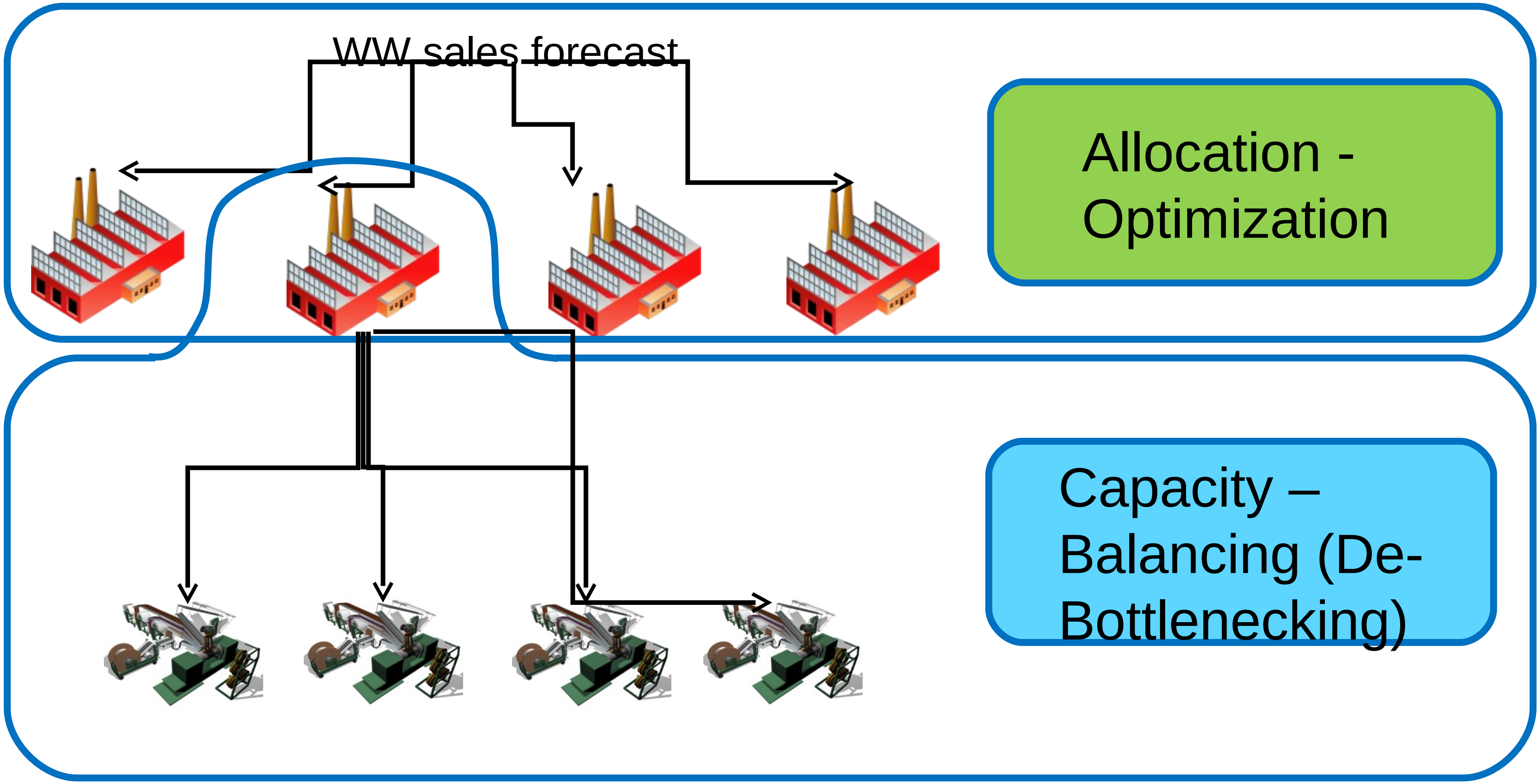


Long term planning (LTP)
1-5 years

12 month supply chain planning
incl production planning (i2)

Production scheduling,
sequencing and manufacturing
executing (SAP)

Car tire production planning: Allocation & Capacity Planning



Car tire production planning: One approach supports different planning goals

Allocation

- WW network
- 1 period
- All products
- Ressources
  - Plants (incl calendar)
  - Some others (like tire size)
- BOC
  - Wrt ressources
- Production complexity
  - Wrt different products
- Transportation

Capacity Planning

- Per plant
- 12 months
- Plant‘s products
- Ressources
  - Machines (incl calendar)
  - Many others
- BOM
  - Incl materials

Planning Process: Allocation first (centrally), then Capacity (distributed)

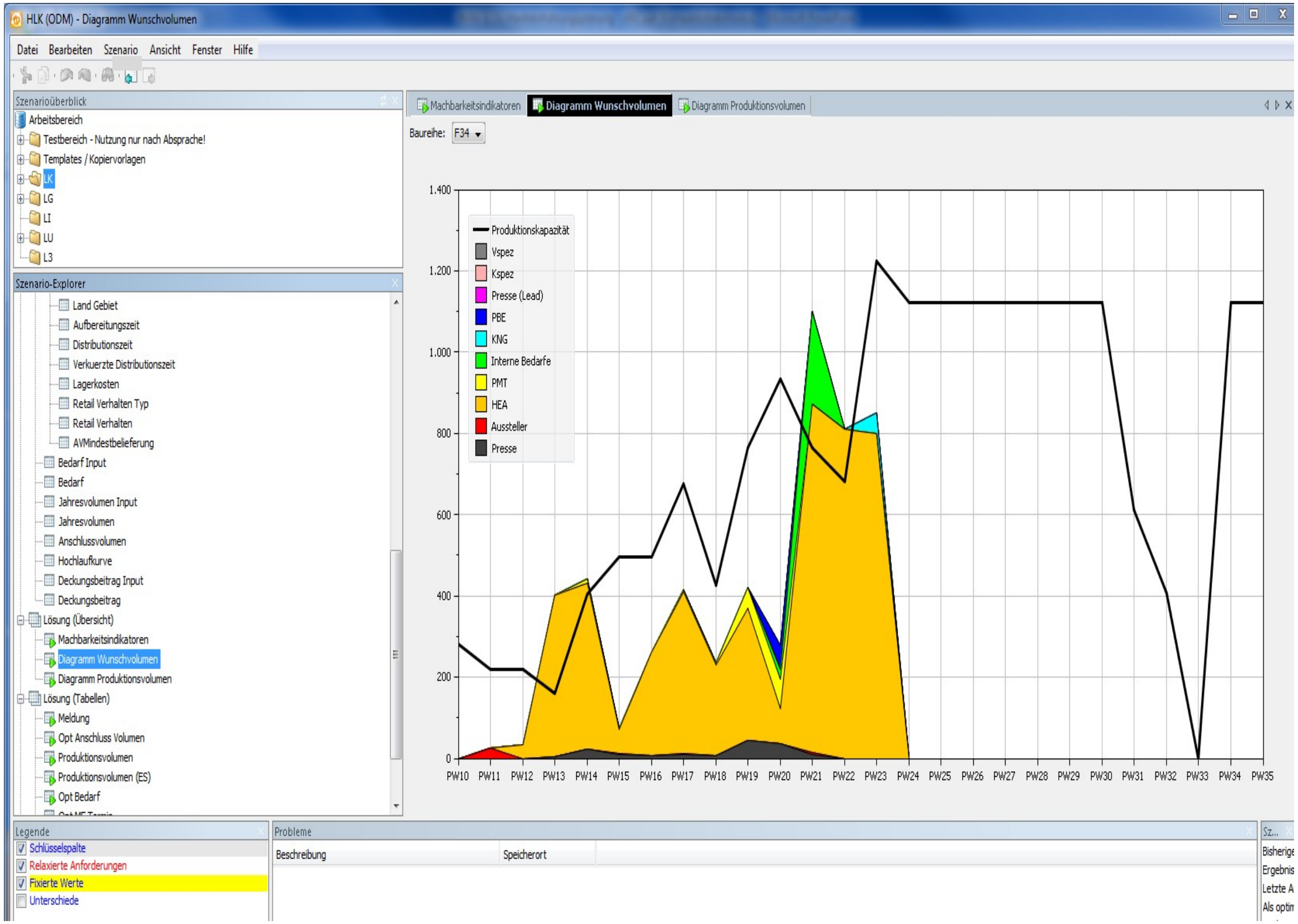
Market Introduction Planning

- **Situation**
  - Client seeks to improve market introduction planning for new car models
    - Some years before the introduction of a new model, initial production and introduction dates have to be planned
  - Solution has to take into account
    - Demands by

Markets	e.g. US, Asia, Europe
Car type	e.g. sedan, convertible, coupé
Category	e.g. for trade show, press, dealers

    - Different market introduction dates
    - Category specific production sequences
    - Type and market specific sales margins
  - Planning goals
    - Find earliest market introduction dates
    - Balance production costs / delivery costs / market specific profit
    - Maximize retail volume to produce after market introduction
  - No standard package exists that provides all required functionality

Market Introduction Planning: Manual planning



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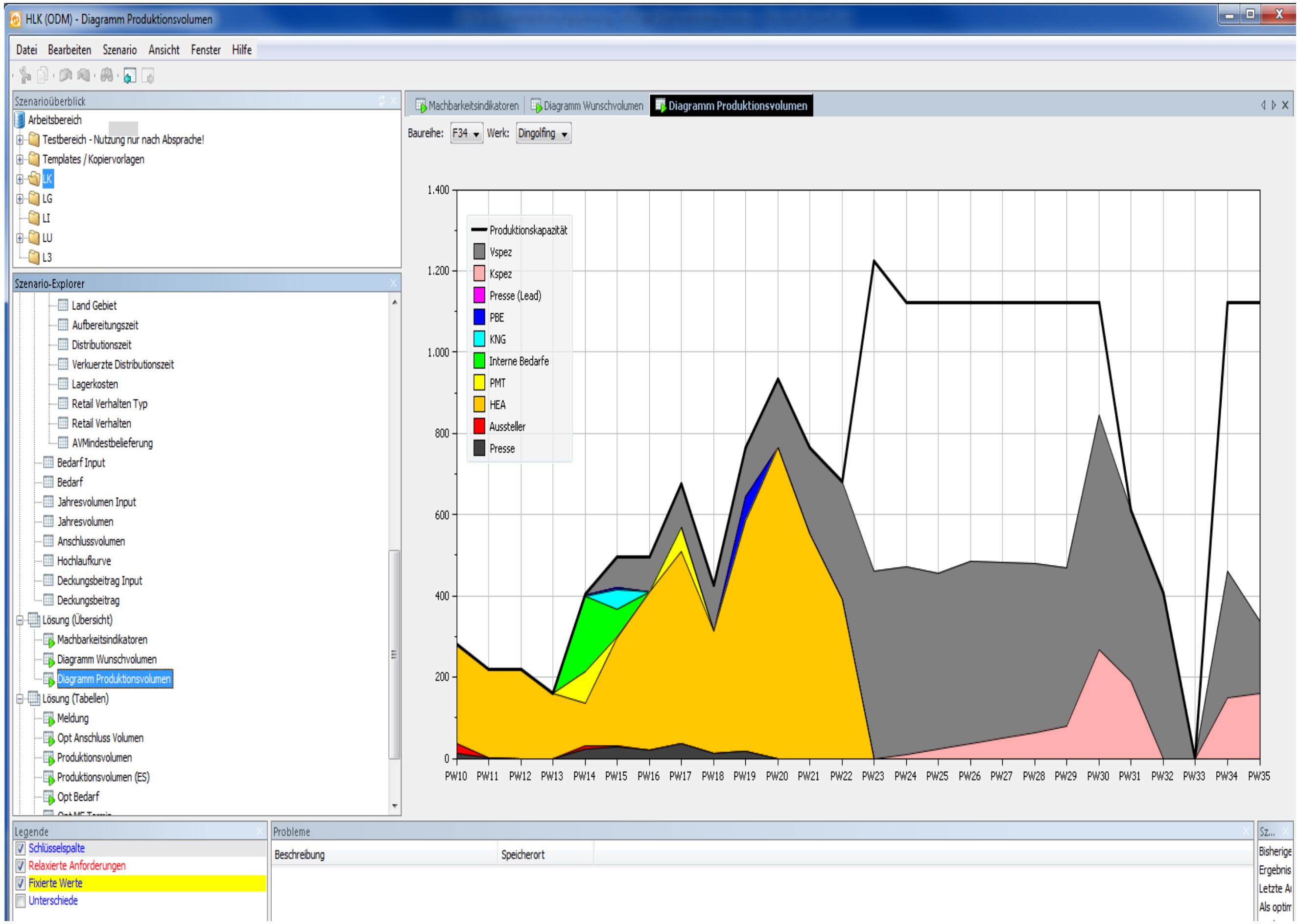
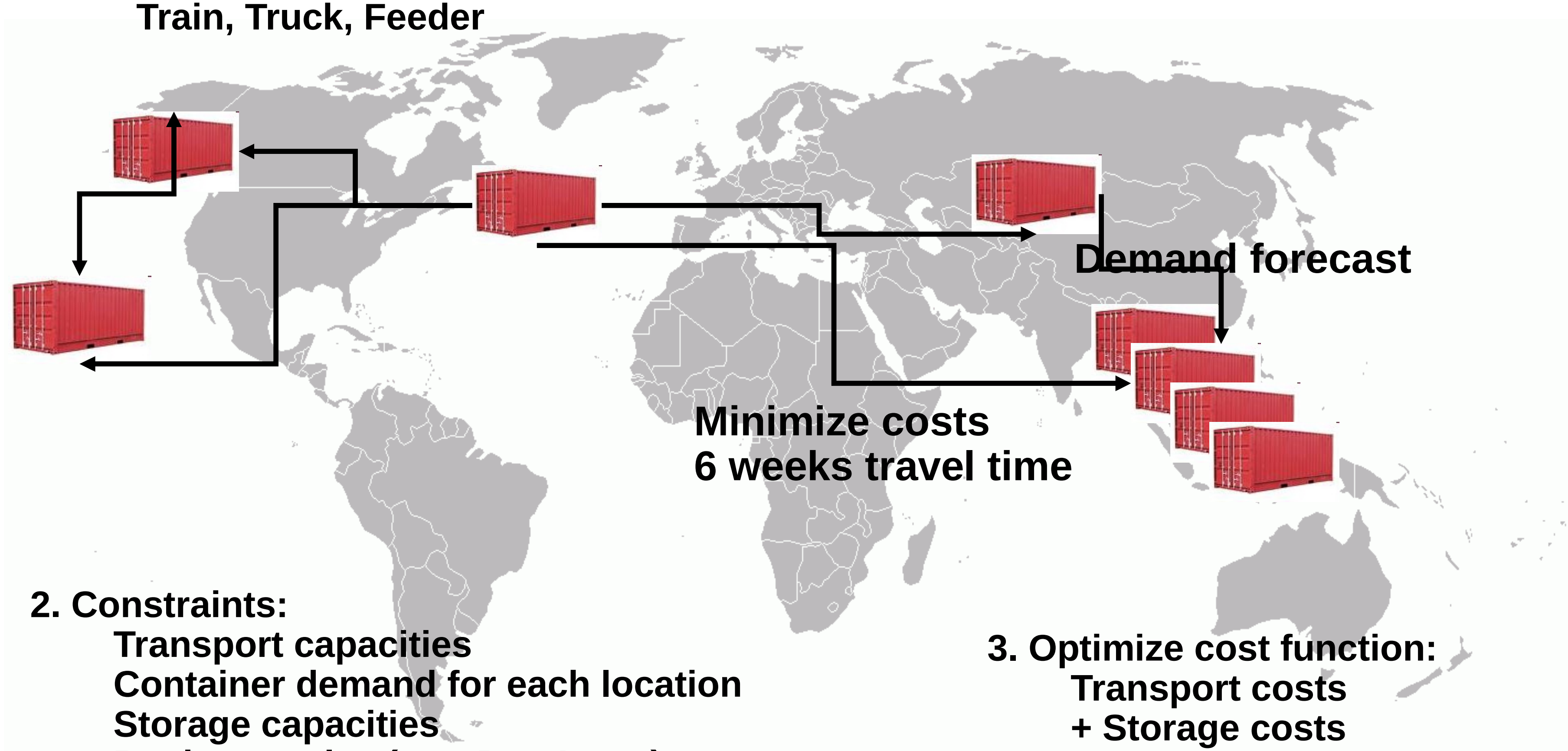
Market Introduction Planning: Automated optimization



Empty Container Re-Positioning System

2 Million Empty Container moves per year
Cost: ~ 500 M€

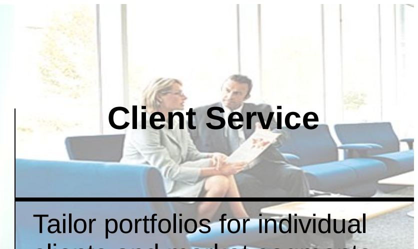
1. Decision variables:
- **Chose transport modes and time**
  - **Company vessel**
  - **Train, Truck, Feeder**



2. Constraints:
- **Transport capacities**
- **Container demand for each location**
- **Storage capacities**
- **Business rules (e.g. Jone's act)**

3. Optimize cost function:
- **Transport costs**
- **+ Storage costs**
- **+ On / Off hire**

Banking+Finance: How Optimization Addresses Hot Button Issues

	 **Risk Management**	 **Operational Efficiency**	 **Client Service**
Portfolio Optimization Investment Banking Retail Services	target return		Tailor portfolios for individual clients and market segments
Trade Matching Investment Banking		Reduce transactions costs	Efficiently manage large clients' portfolios
Settlement and Clearing Exchanges	Faster settlement, less exposure	Reduce carrying charges	
Managing Cash Retail Services		Reduce operations costs	Provide more flexibility for customers' accounts
Product Configuration Retail Services		Respond more quickly to customer requests	Provide more flexibility in customer offers

Some further applications in various areas

- Crew-Scheduling (Airlines, Rail, etc)
- Power Plant Scheduling
- Production Scheduling (Steel, Food/Beverage, Aerospace)
- Online Optimization (Car Service Personell)
- Transport Optimization (Banks)
- Network Optimization (Telco)
- Sports Scheduling
- TV Ads Scheduling

Selected projects in network optimization: Huge benefit / ROI

Customer	Industry	Application	Benefit (ROI)
Leading US local phone provider	Telecommunications	Network performance optimization	Savings of U.S. $1.5 million 2000 Wagner Prize for excellence in OR
Major retailer, USA	Retail	Inventory Optimization	U.S .$1.5 million inventory costs saving
Food supplier, USA	Wholesale Distribution	Post-Merger Network Optimization	Reduced transportation costs by U.S.$8 million
Supplier of printing systems, USA	Wholesale Distribution	Network Design and Planning	Over U.S. $5 million in annual savings
Computer parts manufacturer, Singapore	Wholesale Distribution	Optimized Distribution Strategy	Savings of up to U.S. $4 million annually
Electronics Supplier, USA	Wholesale Distribution	Supply Chain Redesign and Inventory Optimization	Reduced safety stock by 60%
Consumer packaged goods maker, USA	Consumer Products	Global Sourcing and Manufacturing Network Rationalization	Savings of U.S. $15 million
US Dairy Industry Leader	Consumer Products	Supply Chain Strategy and Network Optimization	Cost reduction by more than U.S. $300 million
Metal Parts Manufacturer, USA	Industrial Products	Global Inventory Positioning	Reduced inventory costs by 11%
Plastic Goods Maker, USA	Industrial Products	Production Planning	U.S.$ 6 million through dynamic reassignemt of customers among plants
Maker of Industrial and Farm Machinery	Industrial Products	Parts Distribution Network design	Cut distribution costs by U.S. $17 million annually
Two Chilean Firms	Industrial Products	Planning and Scheduling of Forestry Operations	U.S. $20 million annually + 30% fewer trucks
Leading Global Logistics Provider	Travel & Transportation	Shipment Consolidation and Routing	Save app. 3000$ per day for one of its customers

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  - Huge ROI
- **Product portfolio**
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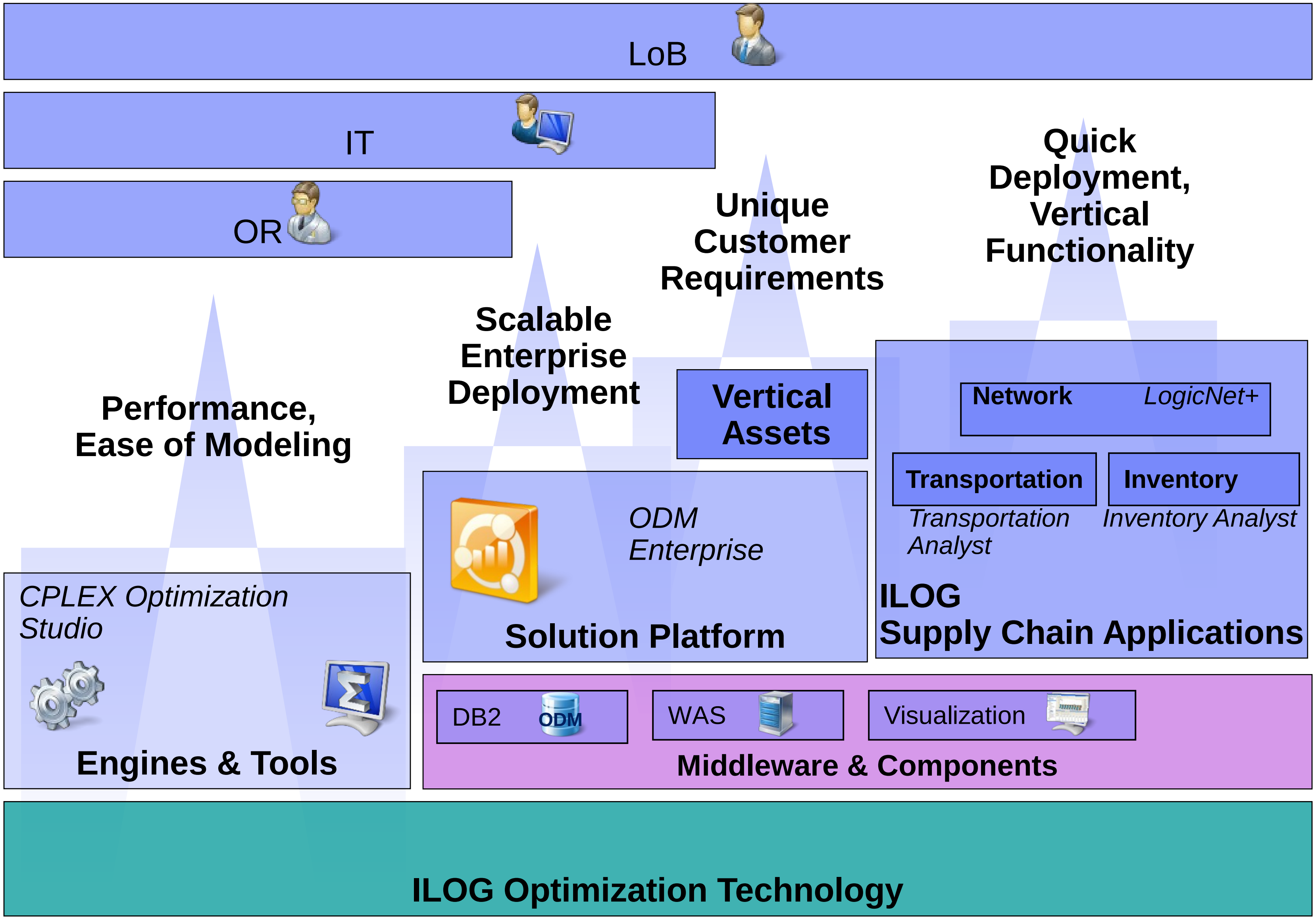
ILOG Optimization Product Portfolio: we offer the full range

the whole range

IBM ILOG Optimization and Supply Chain Products



CPLEX’s History of Performance Enhancement

CPLEX is the optimization core component of ODME

- CPLEX 7 (2000): 60% on “hard mixed integer problems”
- CPLEX 8 (2002): 40% overall, 70% on “difficult problems”
- CPLEX 9 (2003): 50% on “difficult customer models”
- CPLEX 10 (2006): 35% overall, 70% on “particularly difficult models”
- CPLEX 11 (2007): 15% under one minute, 3X on 1-60 minutes, 10X on one hour and up
- IBM ILOG CPLEX 12.0 (2009): 30% overall, 2X on 1000 seconds an
- IBM ILOG CPLEX 12.2 (2010): 50% overall, 2.7X on 1000 seconds a
- IBM ILOG CPLEX 12.3 (2011): 20% overall, 2X on 1000 seconds an
- IB[illegible]2.4 (2011): 15% overall, 1.4X on 1000 seconds and up
- **IB[illegible]PLEX 12.5 (2012): 1.6X on 100 secs, 2.8X on 100 secs and up**

- Drivers:
  - Improved heuristics
  - Improved cuts
  - Reduced parallel overhead
  - General software engineering

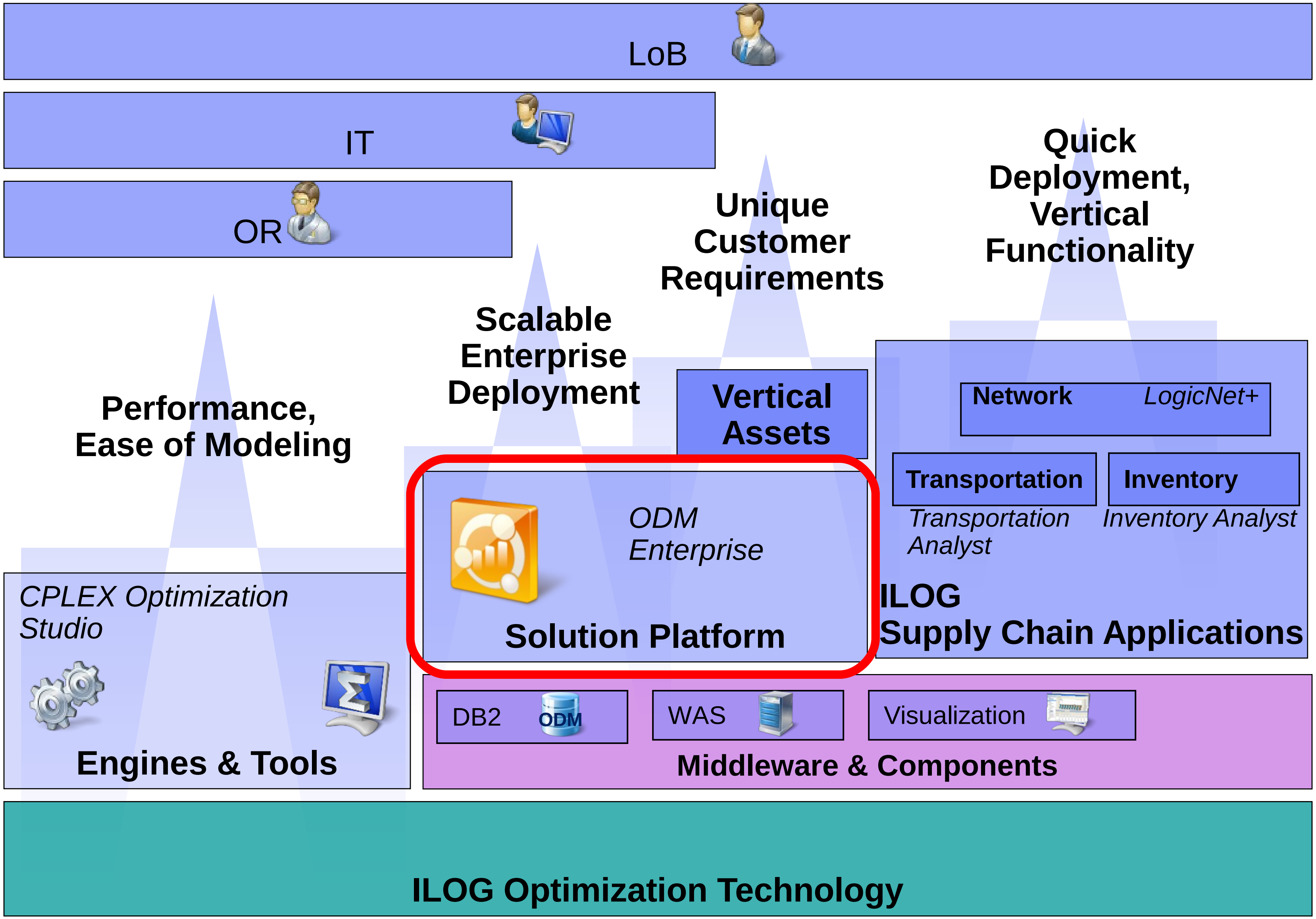
ODME 3.3

ODME 3.4

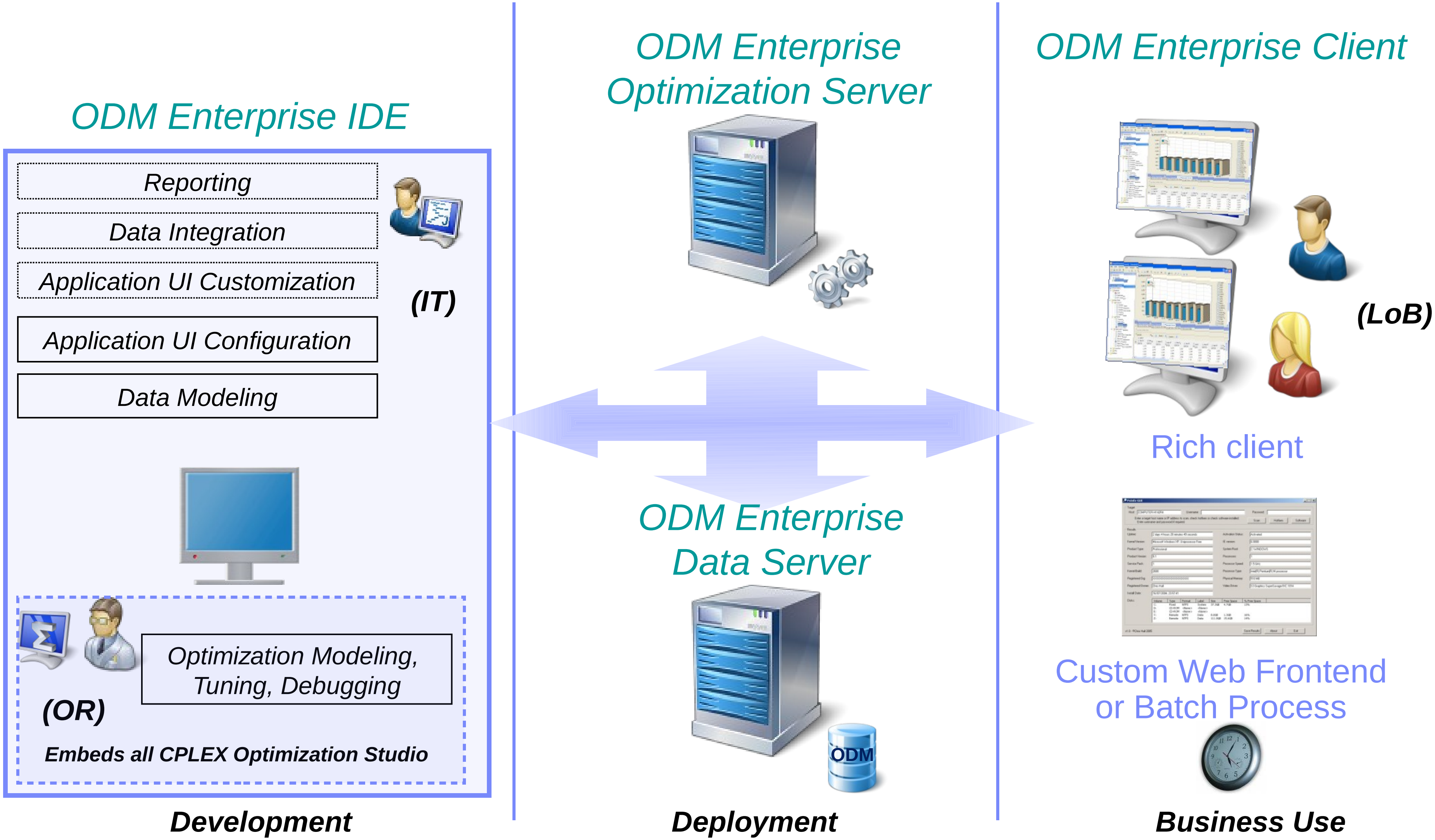
ODME 3.5

ODME 3.6

IBM ILOG Optimization and Supply Chain Products

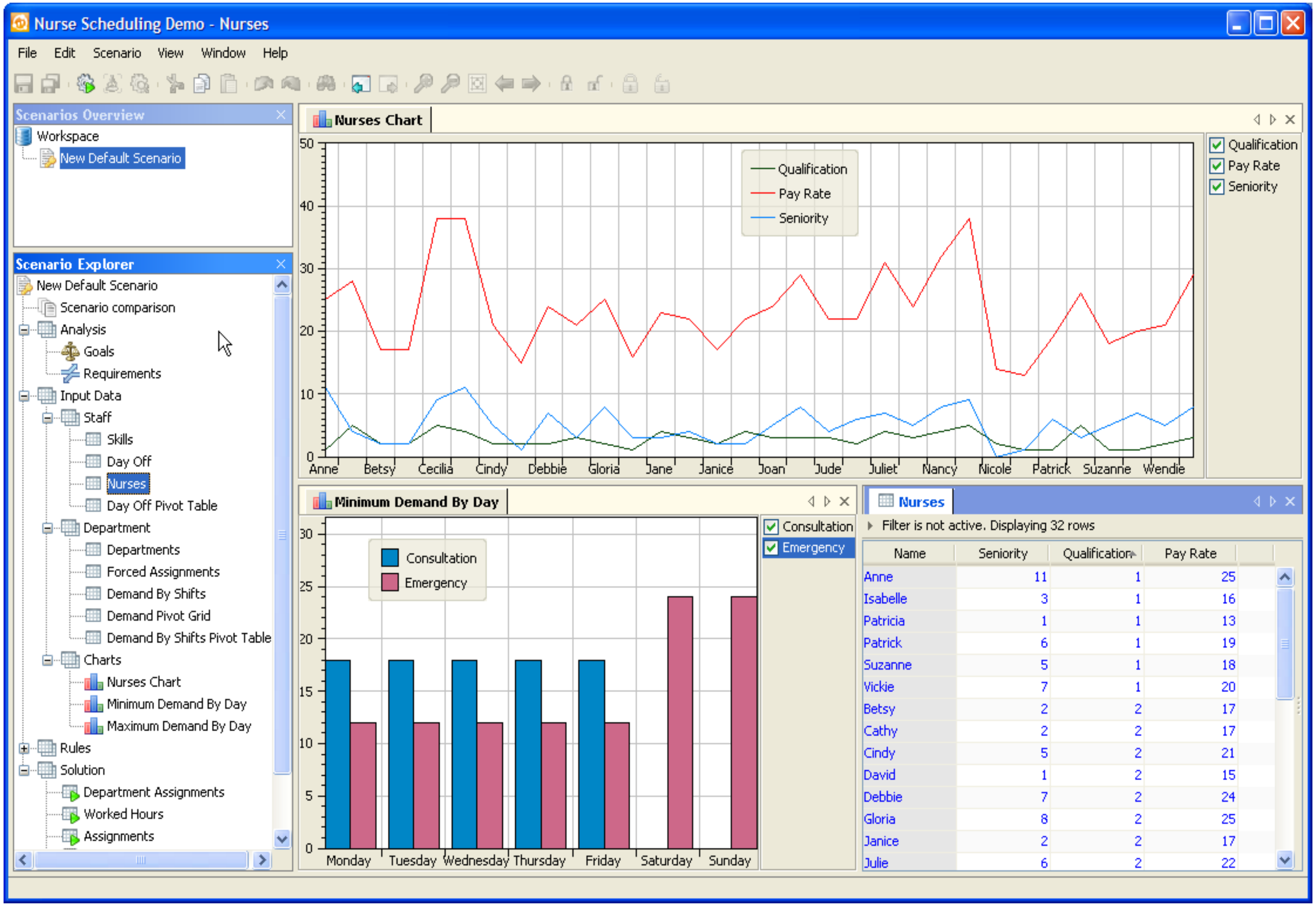


ODM Enterprise - Architecture



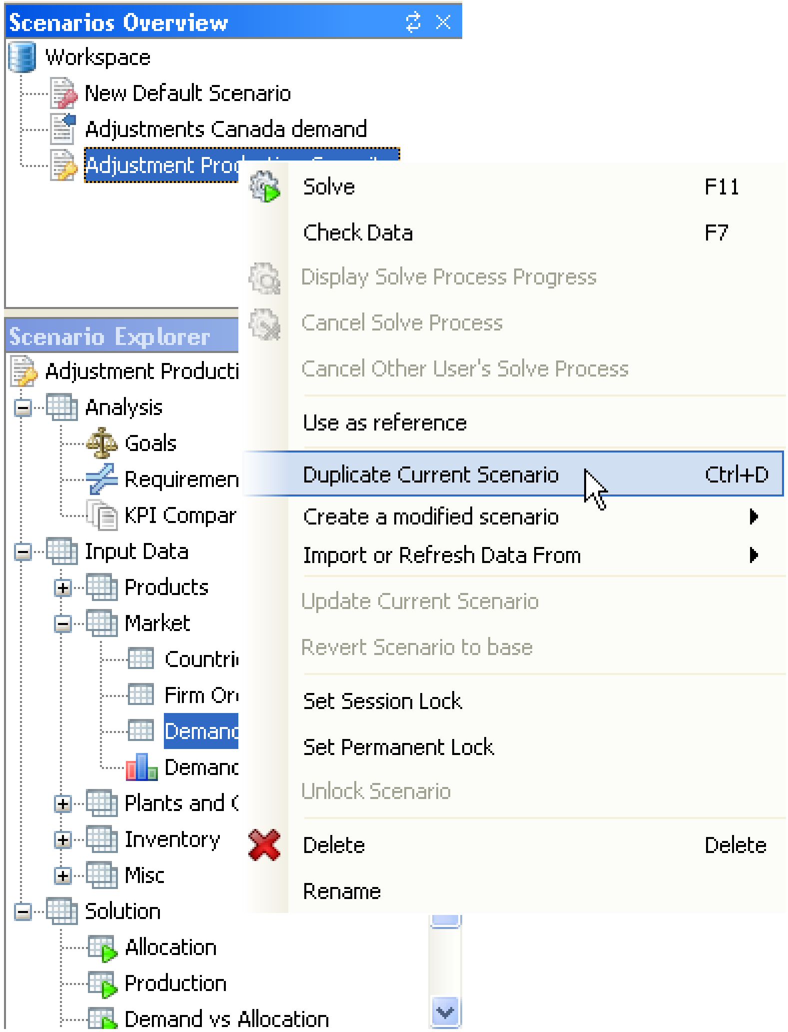
ODM Client – Generic Planning Cockpit

- Rich, configurable GUI



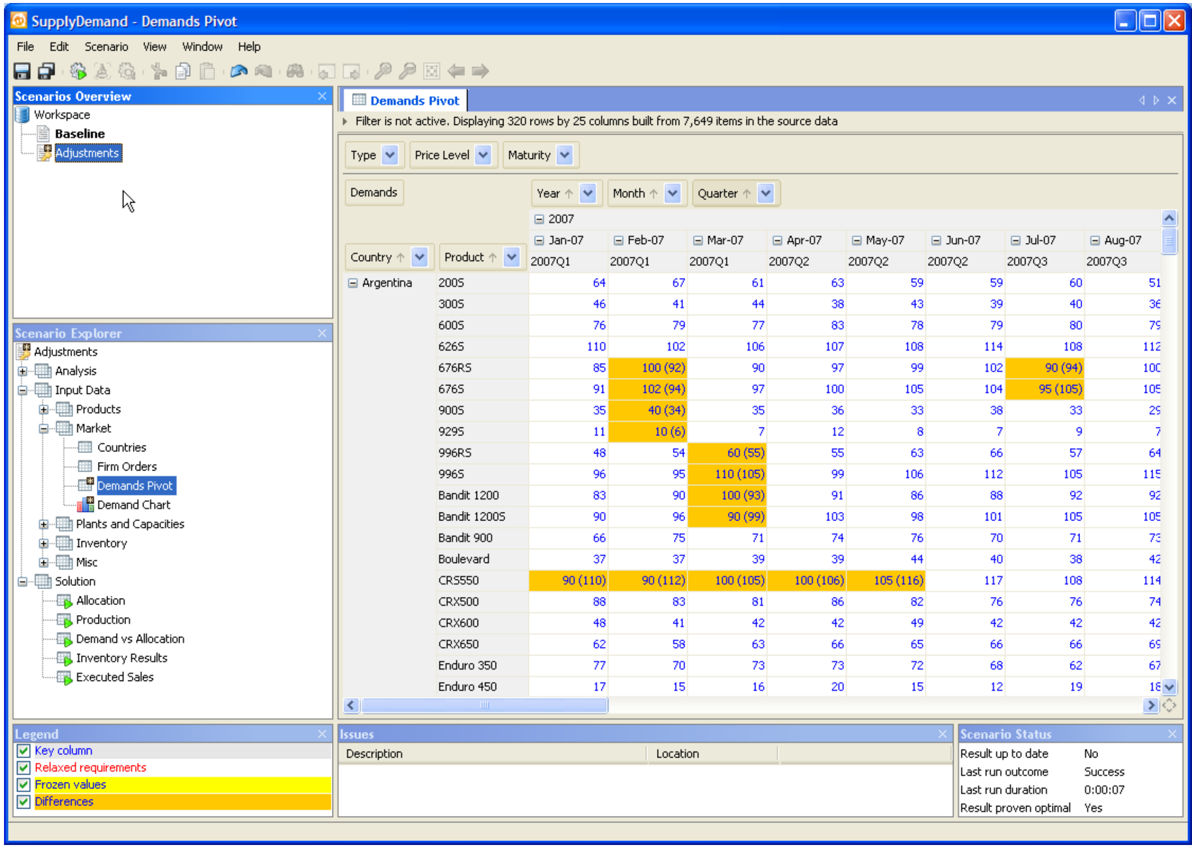
ODM Client – Generic Planning Cockpit

- Rich, configurable GUI
- Scenario-based planning, what-if simulation
  - Scenario:
    - master+transaction data
    - parameters
    - results



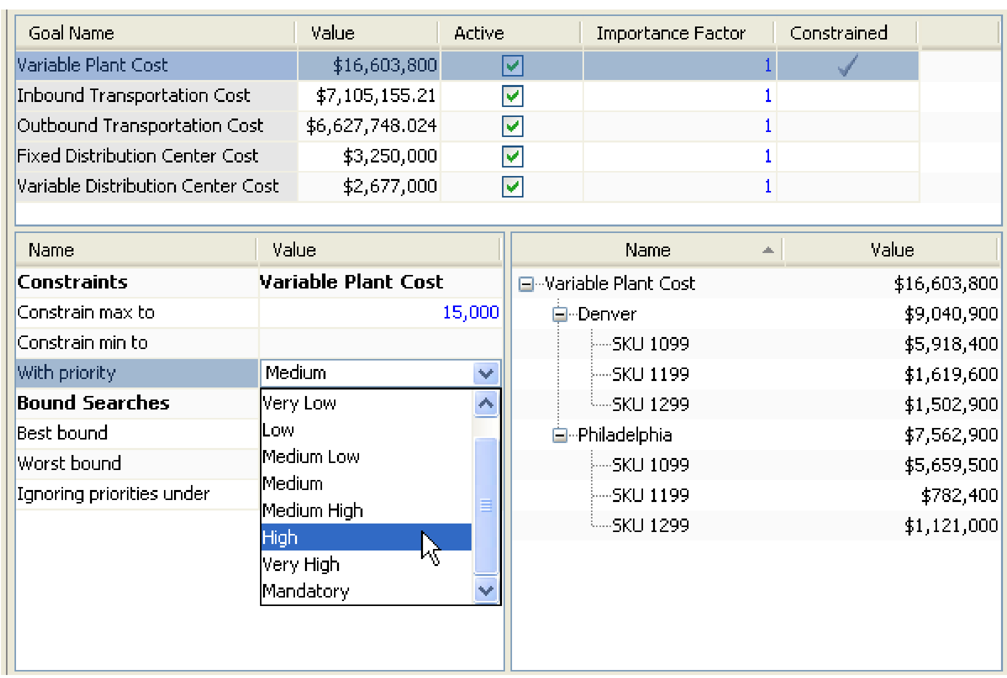
ODM Client – Generic Planning Cockpit

- Rich, configurable GUI
- Scenario-based planning, what-if simulation
- Data editing and analysis
  - E.g. simple tables, pivot tables
  - Scenario comparison: detailed highlighting



ODM Client – Generic Planning Cockpit

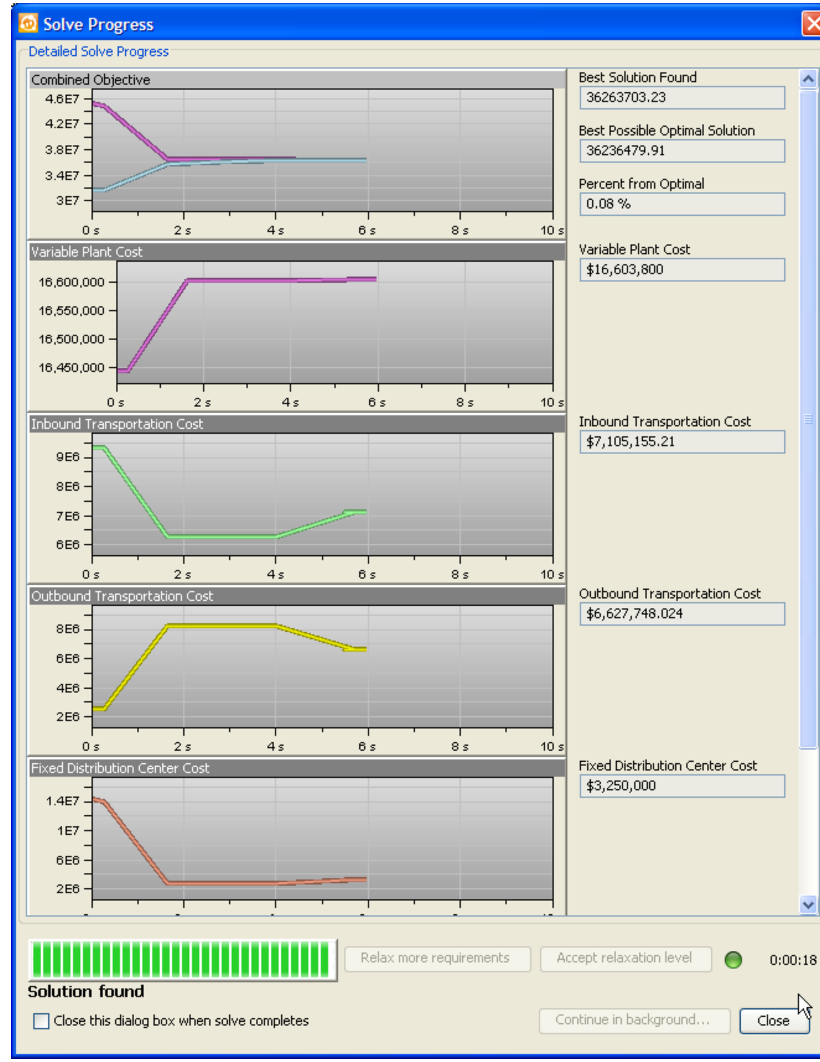
- Rich, configurable GUI
- Scenario-based planning, what-if simulation
- Data editing and analysis
- Optimization execution+control
  - Manage business goals
  - Detailed cost analysis



Goal Name	Value	Active	Importance Factor	Constrained
Variable Plant Cost	$16,603,800	✓	1	✓
Inbound Transportation Cost	$7,105,155.21	✓	1	
Outbound Transportation Cost	$6,627,748.024	✓	1	
Fixed Distribution Center Cost	$3,250,000	✓	1	
Variable Distribution Center Cost	$2,677,000	✓	1	

Name	Value
Constraints	**Variable Plant Cost**
Constrain max to	15,000
Constrain min to	
With priority	Medium
Bound Searches	
Best bound	
Worst bound	
Ignoring priorities under	

Name	Value
Variable Plant Cost	$16,603,800
Denver	$9,040,900
SKU 1099	$5,918,400
SKU 1199	$1,619,600
SKU 1299	$1,502,900
Philadelphia	$7,562,900
SKU 1099	$5,659,500
SKU 1199	$782,400
SKU 1299	$1,121,000



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- Rich, configurable GUI
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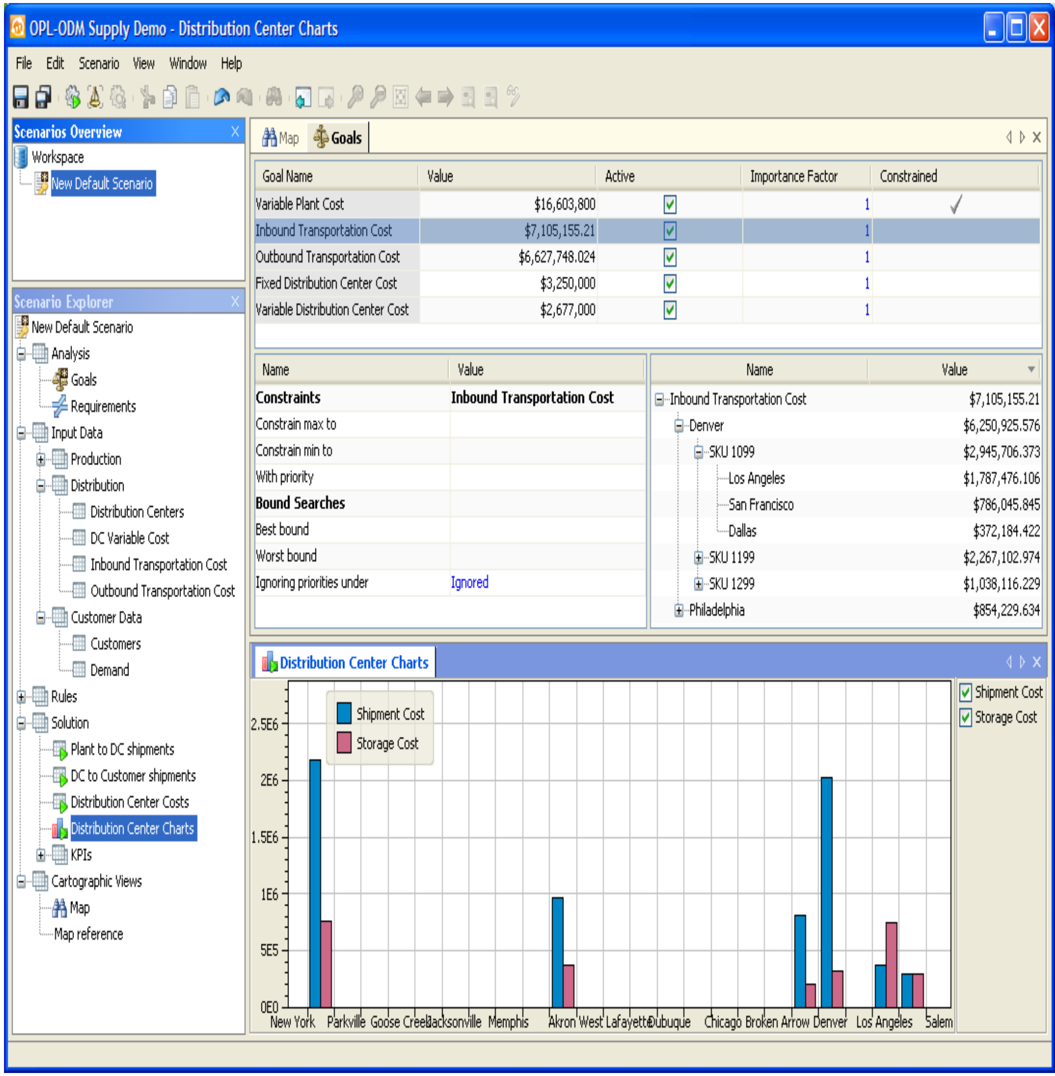
- Data editing and analysis
- Optimization execution+control
- Business goals and plan overview



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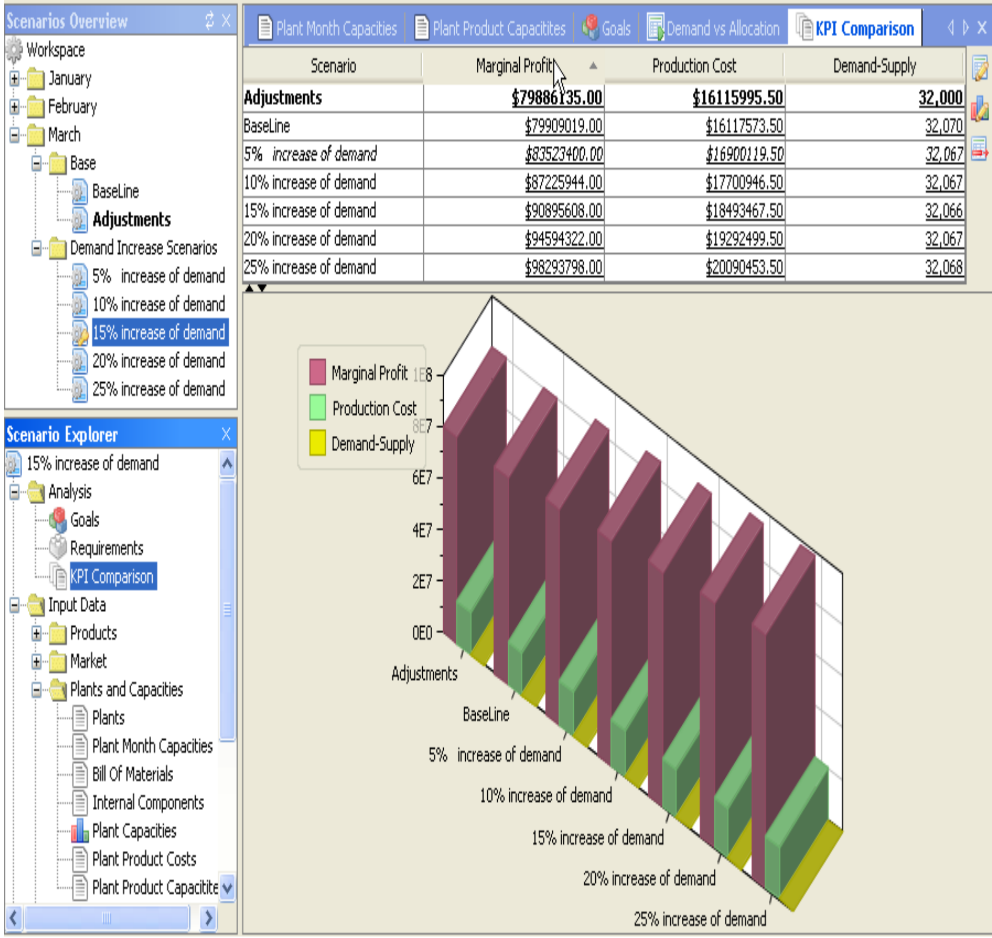
- What-if analysis: KPI comparison



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- Rich, configurable GUI
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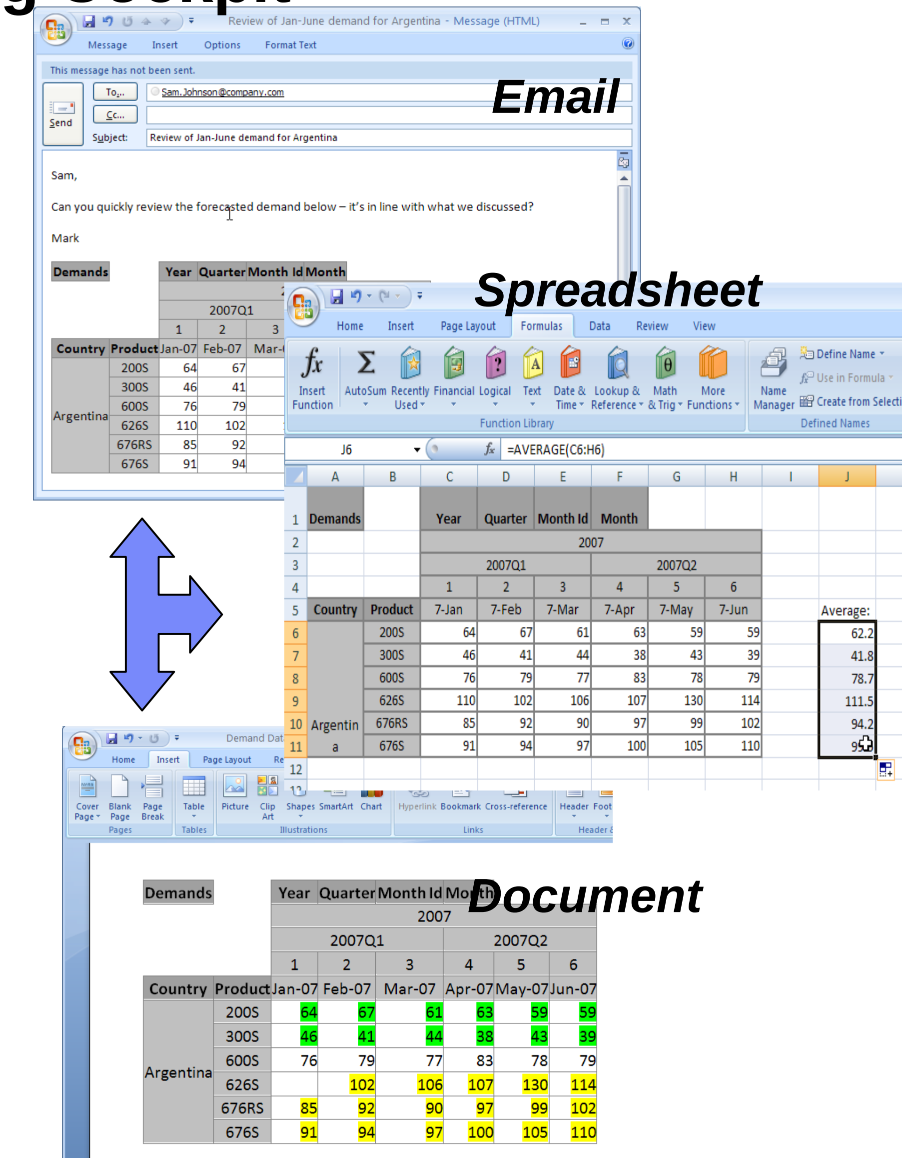
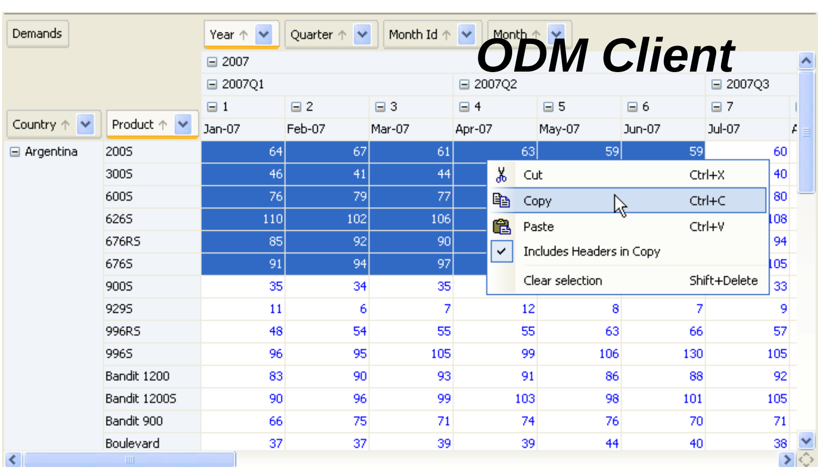
- What-if analysis: KPI comparison
- Office integration:
  - formatted Copy-n-Paste





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- Rich, configurable GUI
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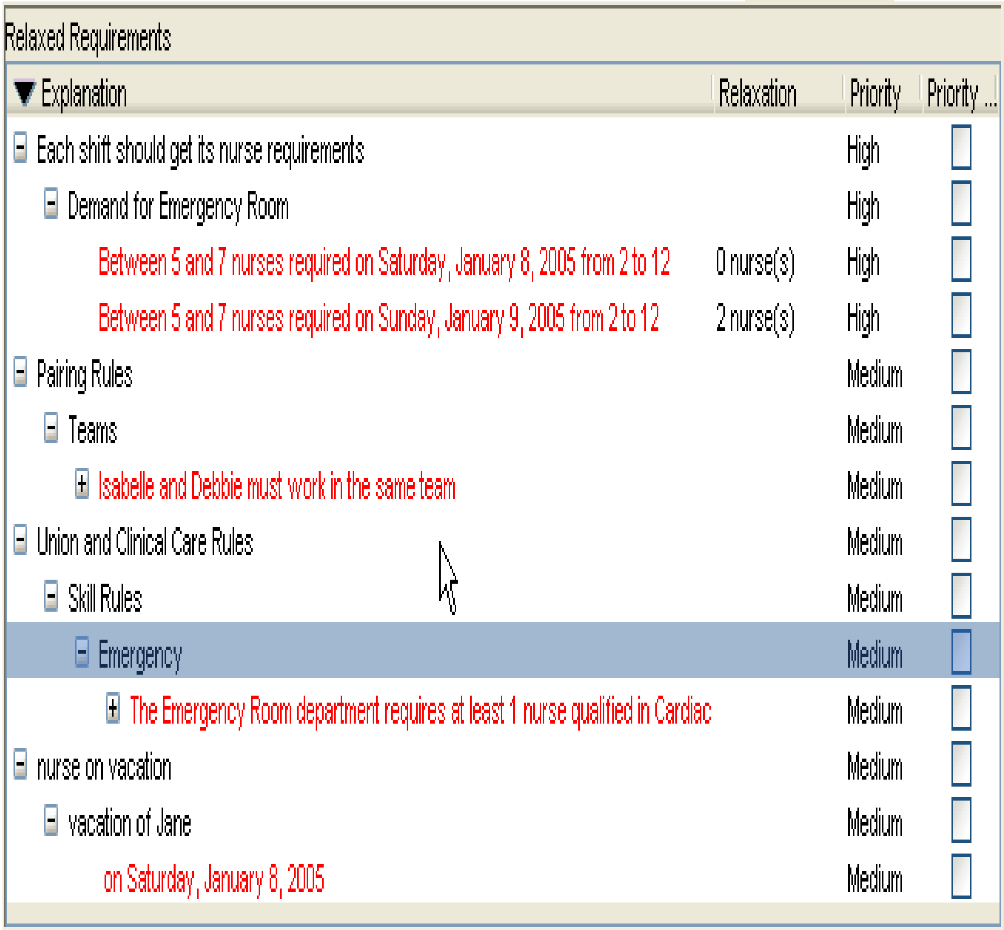
- Business goals and plan overview
- What-if analysis: KPI comparison
- Office integration
- Controlled constraint relaxation



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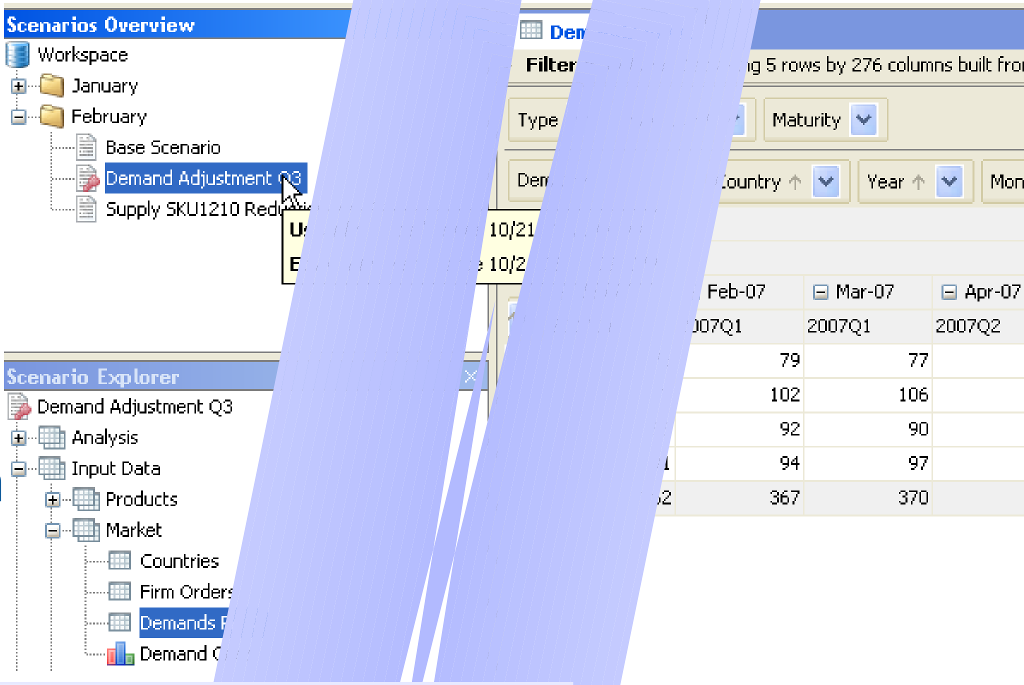
- Collaboration



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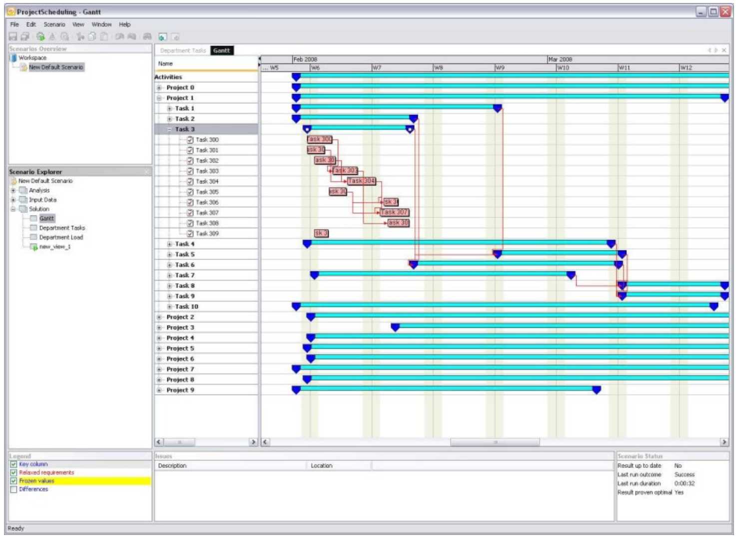
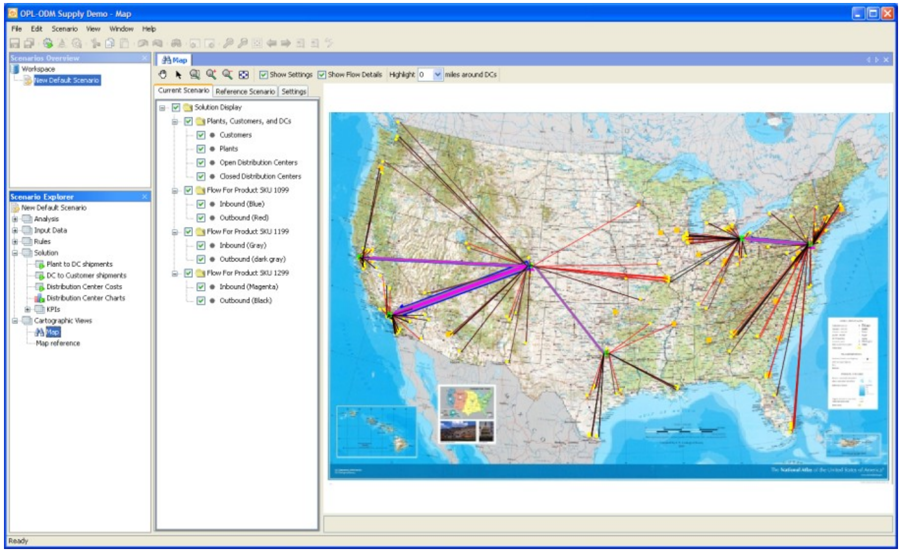
- Office integration
- Controlled constraint relaxation
- Collaboration
- Extensible platform
    - APIs for GUI, Server, Repository





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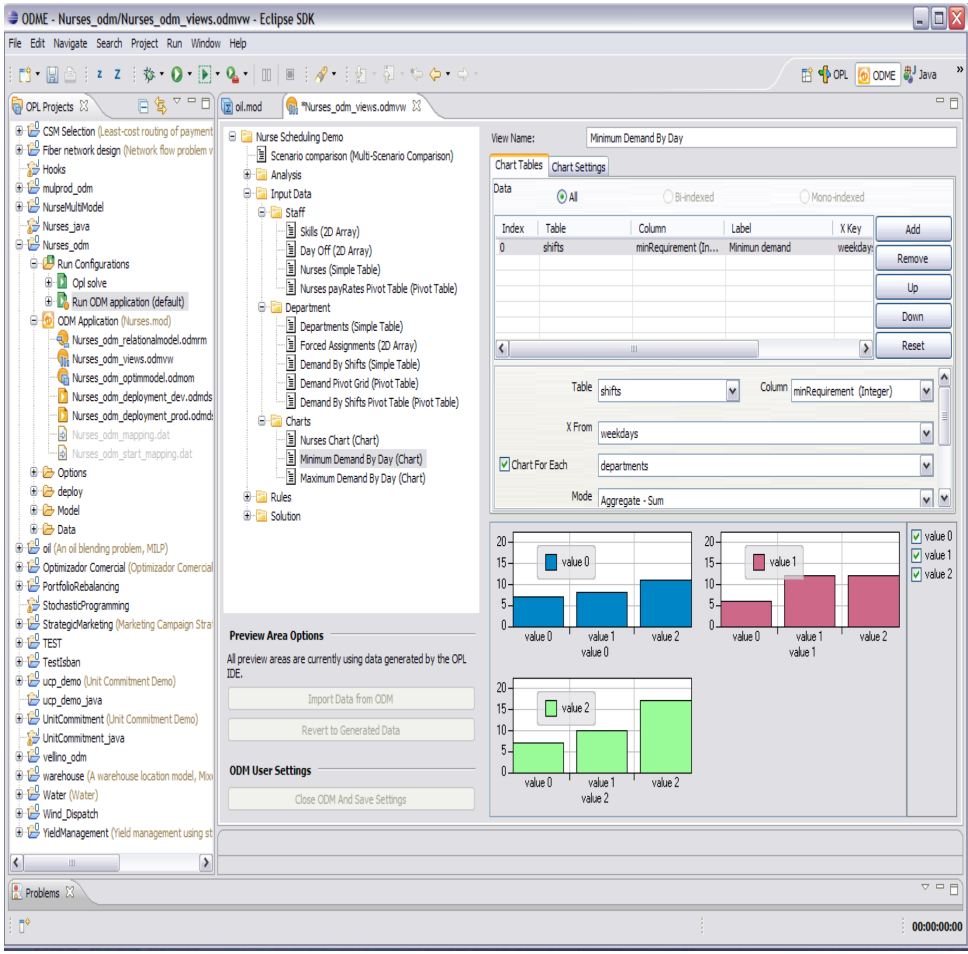
- Extensible platform
- Tight integration with optimization model development



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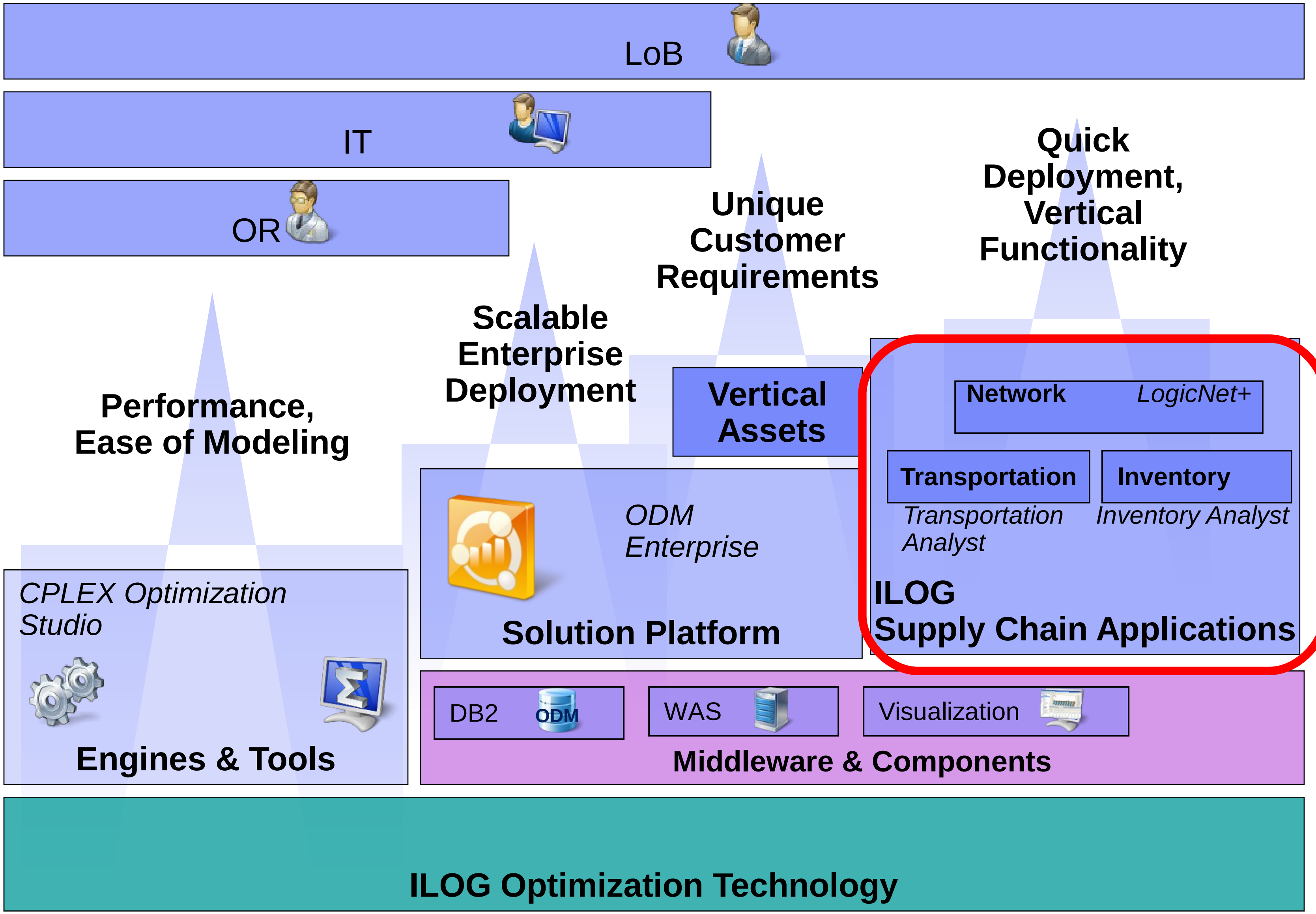
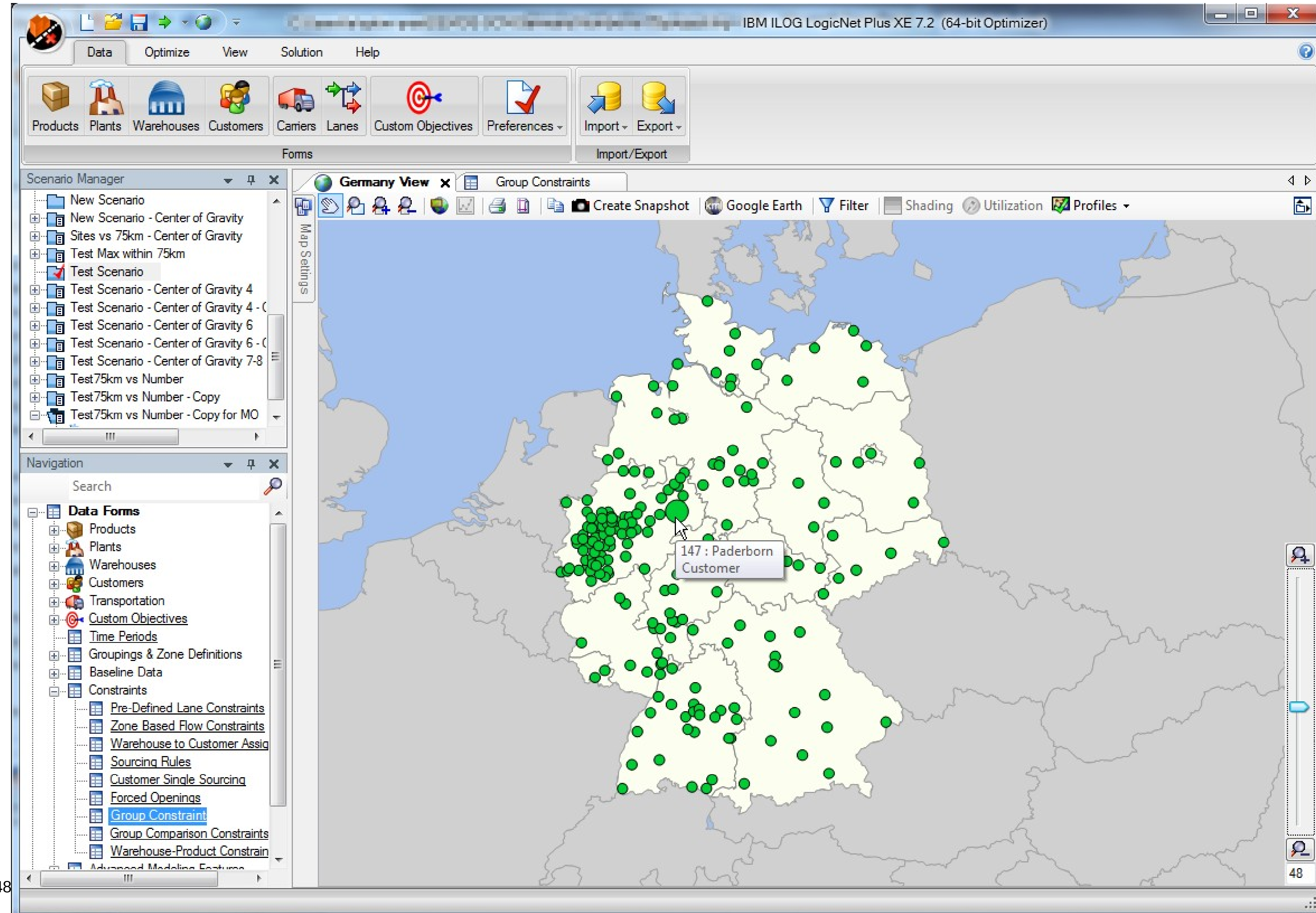
- **ODM Client**
- **90% configuration, 10% implementation**
- **Various applications**
  - **Small to large**
  - **Production, logistics, marketing, sports, energy, etc. etc.**

IBM ILOG Optimization and Supply Chain Products



Supply Chain Management: LogicNet Plus (LNP)

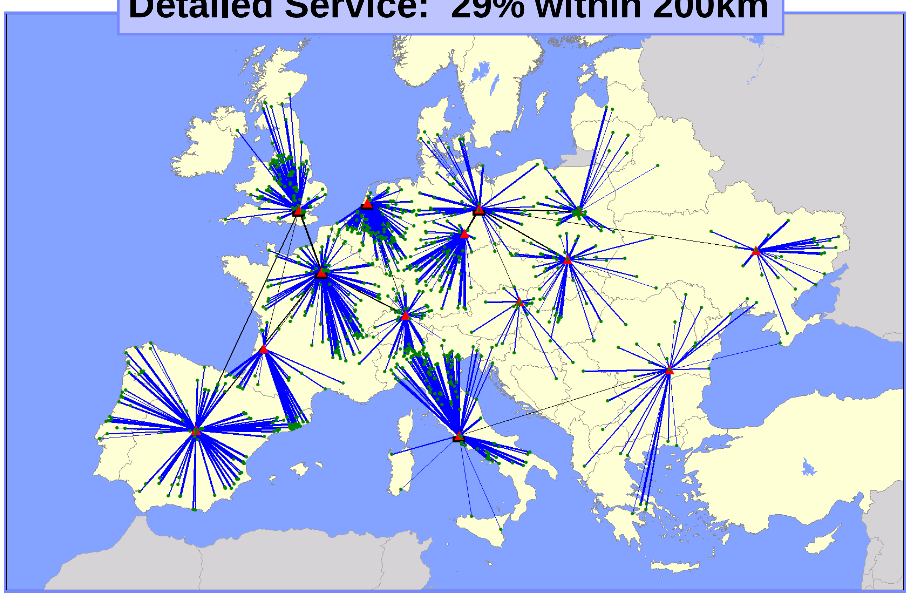


Supply Chain Management: LogicNet Plus (LNP) – A case study

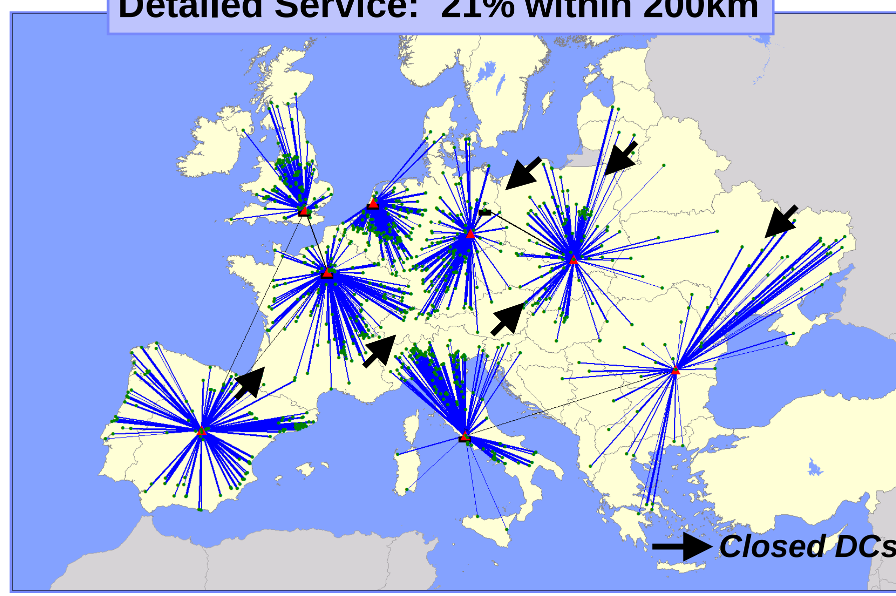
- **Business: A European based manufacturer with 5 production facilities and 14 DCs.**
- **Project Objective: Understand the optimal number and locations of DCs for the after-market business.**

Optimization Drivers
- **Demand to/from matrix**
- **Capacity by facility**
- **Cost by facility**
- **Transportation costs**
- **Service constraints**
- **Min flows for new lanes**
- **Carbon emissions**

Baseline Distribution: 14 DCs
Total Cost: €22.0 M
Avg. Service: 308 km
Detailed Service: 29% within 200km



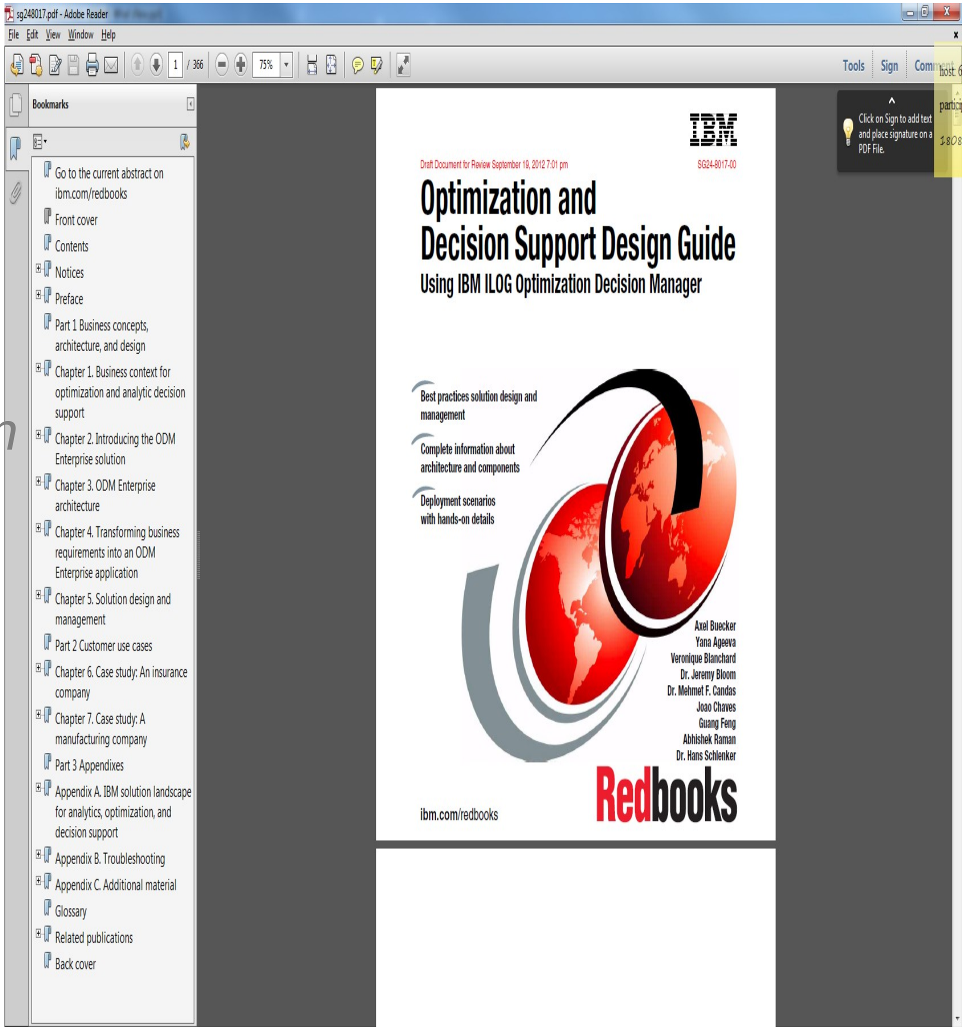
Cost Optimal Distribution: 8 DCs
Total Cost: €20.4 M
Avg. Service: 360 km
Detailed Service: 21% within 200km



Which one is better?

New Redbook

- Available at **http://tinyurl.com/ODMEredbook**
- *“Like an onion, the architecture of an ODM Enterprise application has many layers to it, and peeling them one at a time is the best way to understand how they are structured and work with each other.”*



धन्यवाद
Hindi

多謝
Traditional Chinese

Grazie
Italian

ขอบคุณ
Thai

Gracias
Spanish

Thank You

多谢
Simplified Chinese

Спасибо
Russian

Obrigado
Brazilian Portuguese

IBM

شكراً
Arabic

Danke
German

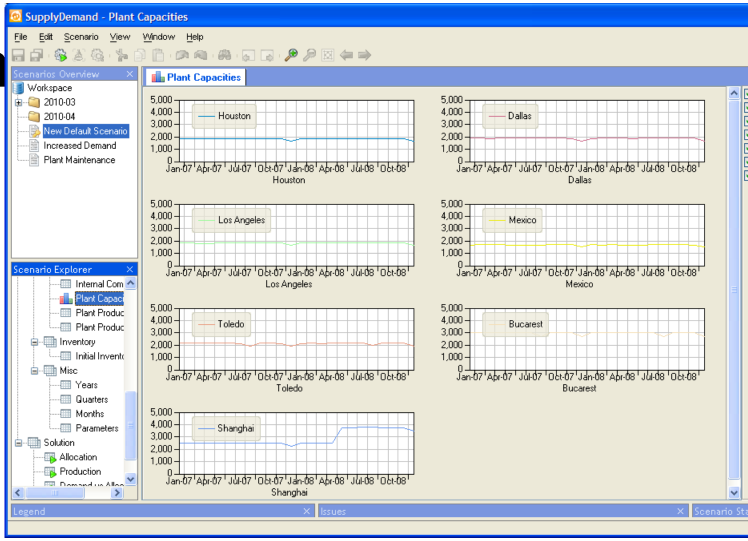
Merci
French

நன்றி
Tamil

ありがとうございました
Japanese

감사합니다

Automotive Sales & Operations Plannin



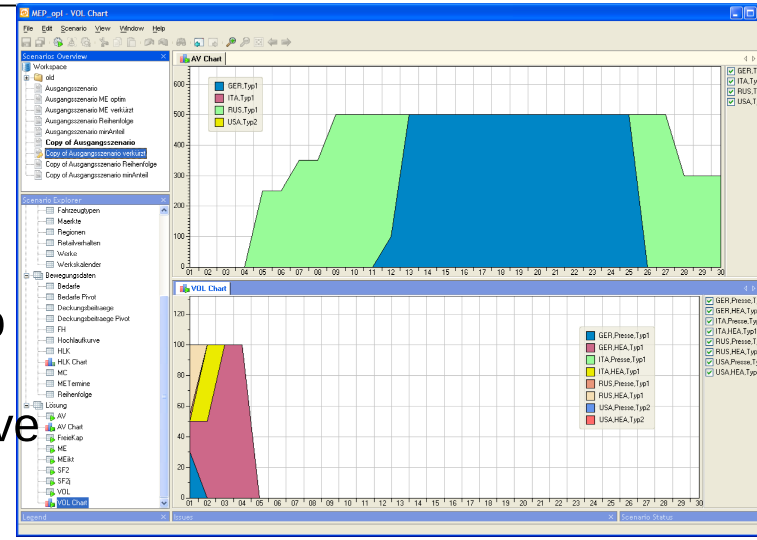
- **Solution**
  - Solution based on IBM ILOG ODME optimization platform
  - Supports many collaborating planners
  - Optimization for efficient supply-demand balancing
- **Benefits**
  - Increased agility: saved 1 month planning time
  - Reduced planning effort: 75% less planning figures
  - Better planning accuracy: 50% less plan changes

Prospect: whom to talk to
- WW sales planning
- WW distribution planning
- Supply Chain Management
- Production Management

Project: 500k€ lic, 1000+d serv

Prospect: questions to ask
- Is your central sales planning accurate and efficient?
- Are you sure that your worldwide distribution network operates at its cost minimum?
- How do you adjust your supply chain to market changes?
- Does your production allocaztion planning take into account margins and transport costs?

Market Introduction Planning



- **Solution**
  - Customized planning solution based on IBM ILOG ODME platform
    - Planning and optimization model tailored to customer’s requirements
    - Gives this car company a unique competitive advantage over its competitors
- **Benefit**
  - Fast, flexible, risk-less introduction, with very low effort
  - Business model can be changed by customer‘s experts during application‘s lifetime
  - Planning benefit from mathematical approach and world-class CPLEX library
    - Cost minimized / benefit maximized
  - Client expects **margin increase of several million Euros**
    - through earlier introduction and better assignment to high-margin markets

Prospect: whom to talk to
- WW sales planning
- WW distribution planning
- Supply Chain Management
- Production Management

Prospect: questions to ask
- How do organize the introduction of new car models?
- Are you still using spreadsheets?
- Are you aware that other car companies use mathematical optimization and gain millions of Euros?
- Can you imagine that this can be achieved with a small project?

Project: 300k€ lic + 80d service

Feedback Mark
- Focus more on output
- Show: this is initial computation, then the following scenarios show optimized ways and you can see that
- Presentation order
  - Change of results (from initial computed, to optimized)
  - Usability of the tool
  - Process (how to get the optimized results)
- Also change different parameters, and show consequences of these different changes
- Customer‘s prios
  - Is the end results better?
  - Can I really change all the variables that I can change in reality
  - How easy is it
- Mozy: „As-is vs. To-be“; this is what SAP focusses on
- Manual planning: the cust already has already an existing way to do it
  - He wants to see e.g. how to reduce external capacity usage

TODO OPL example

TODO
Simple OPL model that shows that requs are directly modelled here
The magics are behind the solve, (usually) not in the model
Thus, the optimization results can easily be proven to be correct