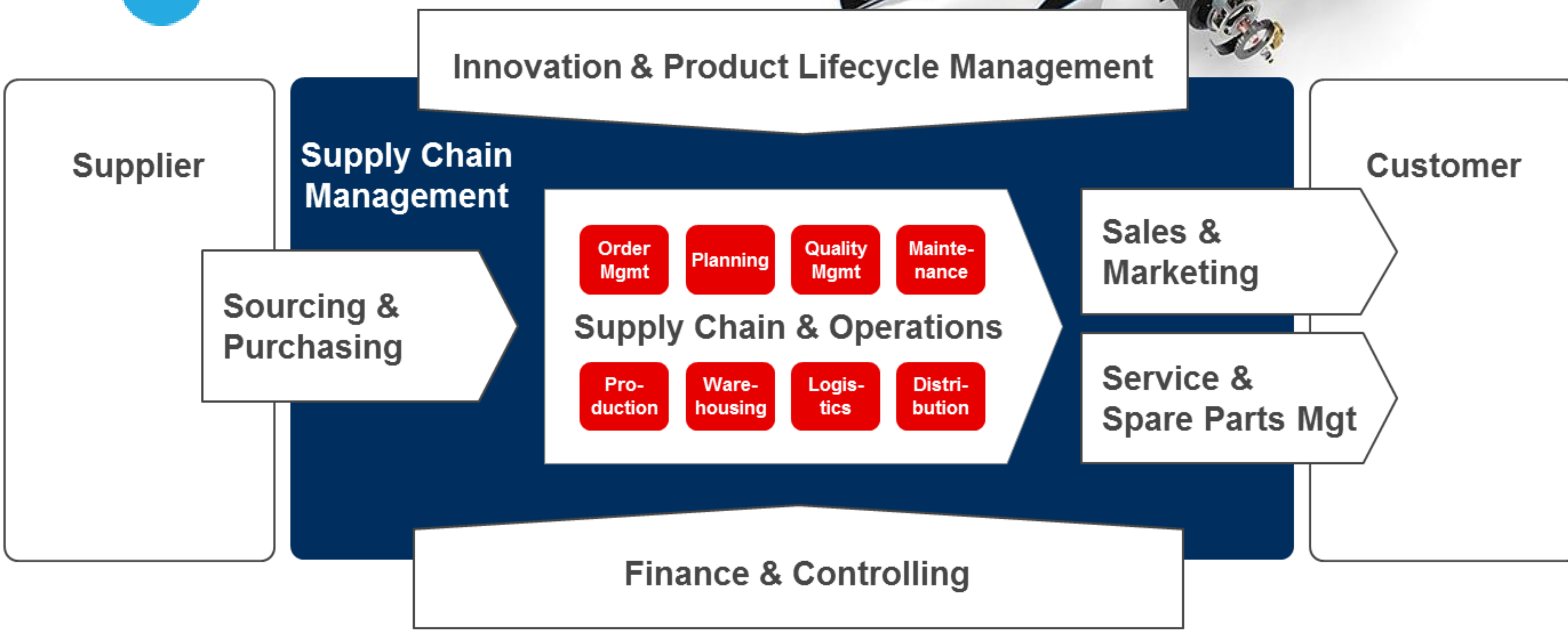
Automotive Supply Chain Management A2Z

RAHUL GUHATHAKURTA

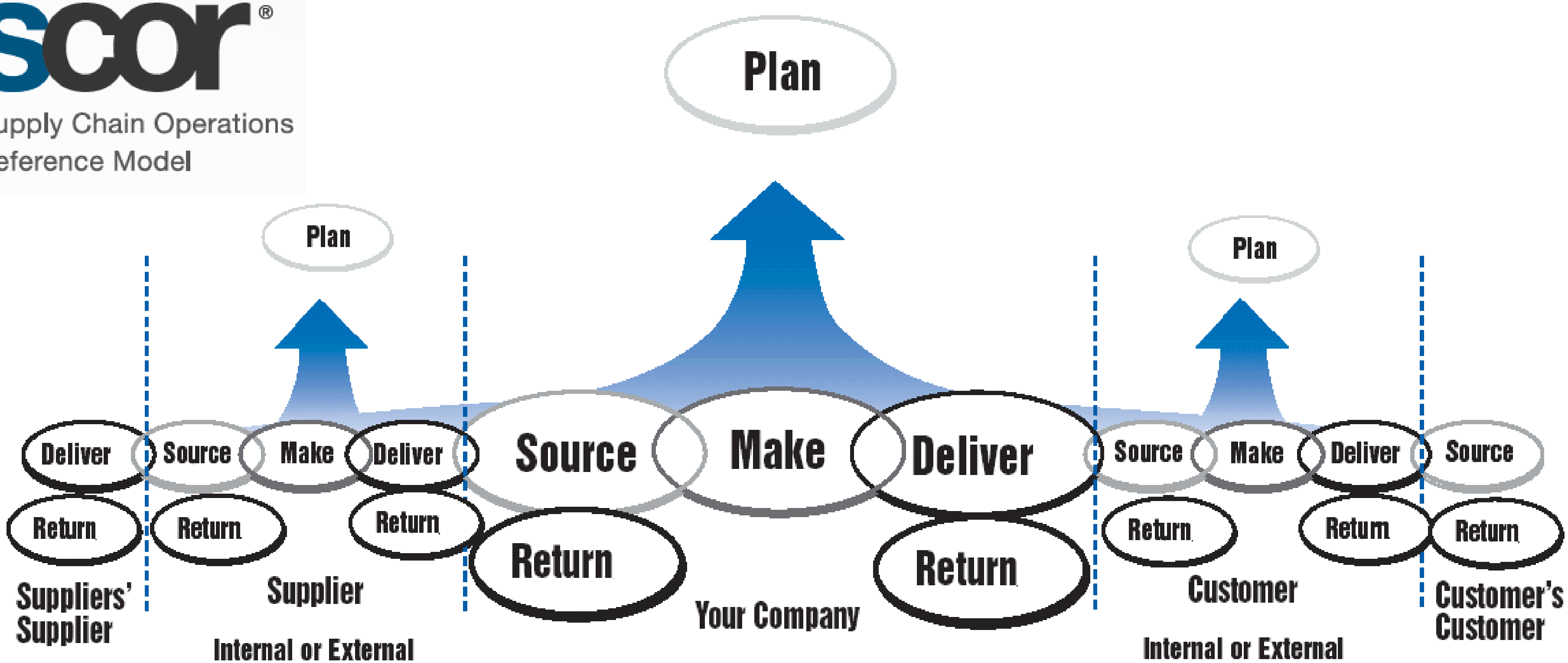
CONTENTS

SCORING WITH SCOR


Innovation & Product Lifecycle Management
Supplier
Supply Chain Management
Customer
Sourcing & Purchasing
Order Mgmt
Planning
Quality Mgmt
Mainte-nance
Supply Chain & Operations
Pro-duction
Ware-housing
Logis-tics
Distri-bution
Sales & Marketing
Service & Spare Parts Mgt
Finance & Controlling

Supply Chain Operations Reference Model

SCOR is Based on Five Distinct Management Processes



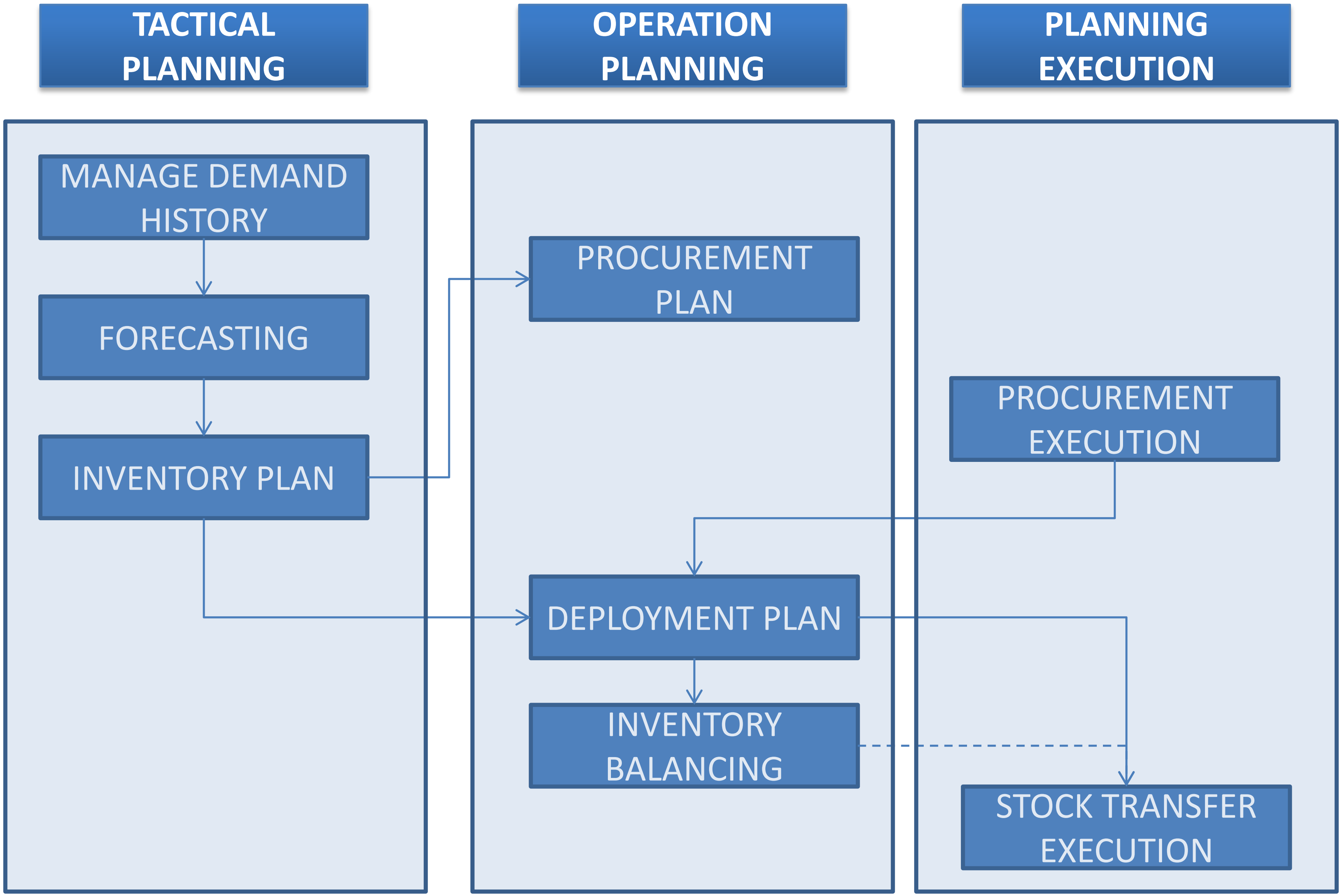
- The integrated processes of Plan, Source, Make, Deliver and Return
- Spanning your suppliers, supplier to your customers and customers
- Aligned with Operational Strategy, Material, Work & Information Flows.

PROCESS LEVELS OF SCOR Model

SCOR Contains Three Levels of Process Detail

Scope	Level	Application	Examples
In Scope Applicable Across Industries	1	Level 1 processes are used to describe the scope and high level configuration of a supply chain. SCOR has five level 1 processes.	Plan, Source, Make, Deliver, and Return
In Scope Applicable Across Industries	2	Level 2 processes differentiate the strategies of the level 1 processes. Both the level 2 processes themselves as well as their positioning in the supply chain determine the supply chain strategy. SCOR contains 26 level 2 processes.	Example Make level 2 processes: › Make-to-Stock › Make-to-Order › Engineer-to-Order
In Scope Applicable Across Industries	3	Level 3 processes describe the steps performed to execute the level 2 processes. The sequence in which these processes are executed influences the performance of the level 2 processes and the overall supply chain. SCOR contains 185 level 3 processes.	Example Make-to-Order level 3 processes: › Schedule Production Activities › Issue Product › Produce and Test › Package › Stage › Dispose Waste › Release Product
Not in Scope Industry Specific	4	Level 4 processes describe the industry specific activities required to perform level 3 processes. Level 4 processes describe the detailed implementation of a process. SCOR does not detail level 4 processes. Organizations and industries develop their own level 4 processes.	Example Issue Product level 4 processes for the electronics industry: › Print Pick List › Pick Items (Bin) › Deliver Bin to Production Cell › Return Empty Bins to Pick Area › Close Pick Order

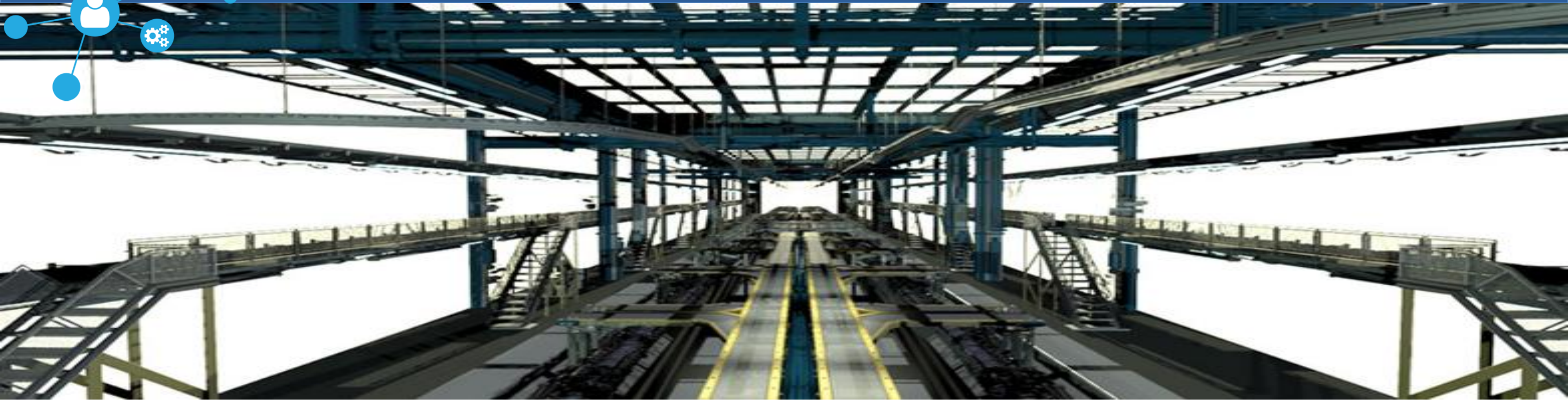
SUPPLY CHAIN PLANNING



At this level, you and your partners make joint decisions on strategic issues such as the following examples:

– *Production capacities*
– *Product design*
– *Production facility and fulfilment network expansion*
– *Portfolio joint marketing*
– *Pricing plans*

SUPPLY CHAIN PLANNING –TACTICAL



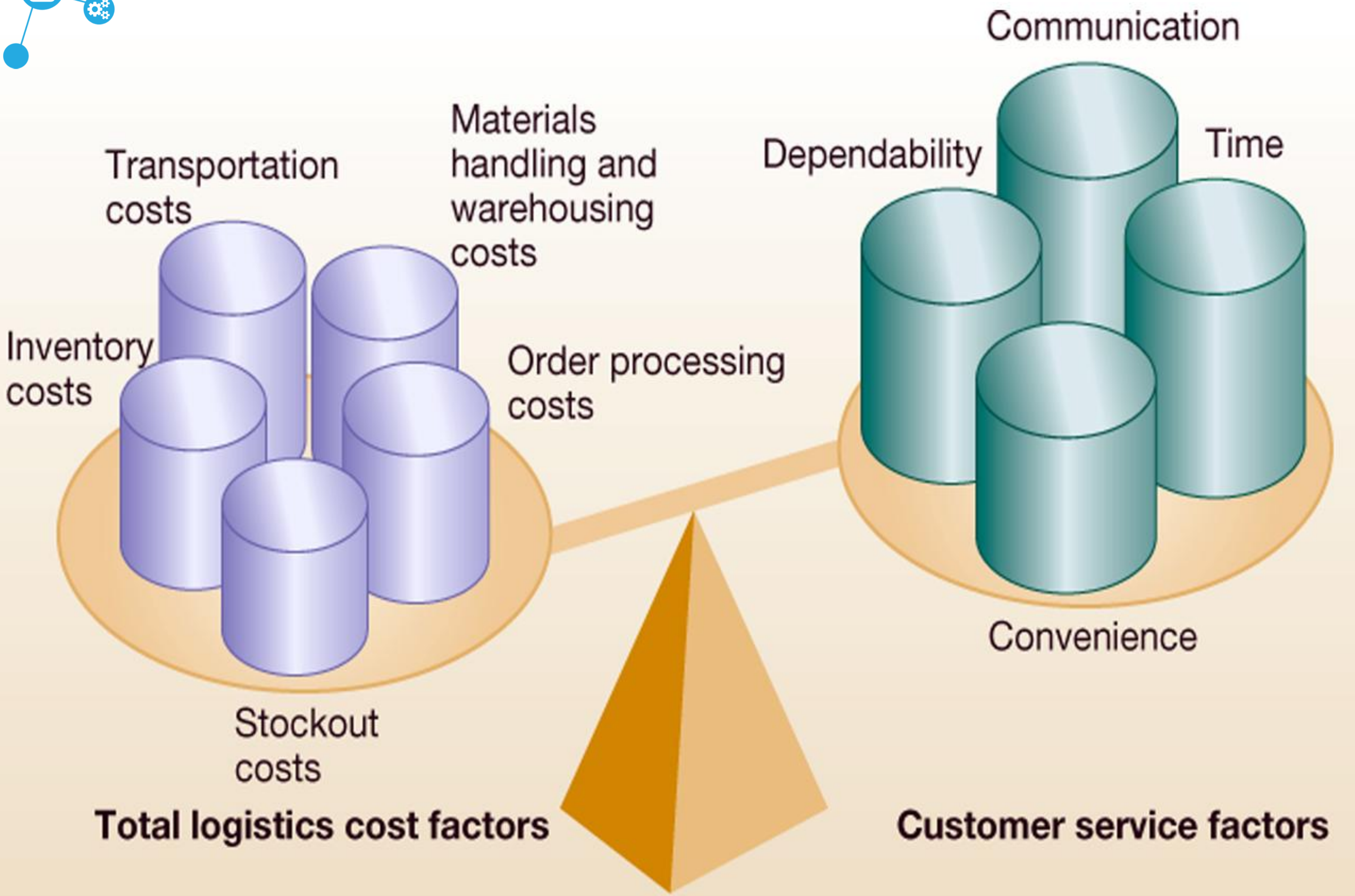
This level involves sharing information with your partners on topics such as the following:

– *Forecasts*
– *Production and transportation plans and capacities*
– *Bills of material (BOMs)*
– *Orders*
– *Product descriptions*
– *Prices and promotions*
– *Inventory*
– *Allocations*
– *Product and material availability*
– *Service levels*
– *Contract terms, such as supply capacity, inventory, and services*

At this level, you and your partners engage in an integrated exchange of key transactional data such as the following information:

– *Purchase orders*
– *Production/work orders*
– *Sales orders*
– *POS information*
– *Invoices*
– *Credit notes*
– *Debit notes*
– *Payments*

SUPPLY CHAIN MANAGER'S BALANCING ACT

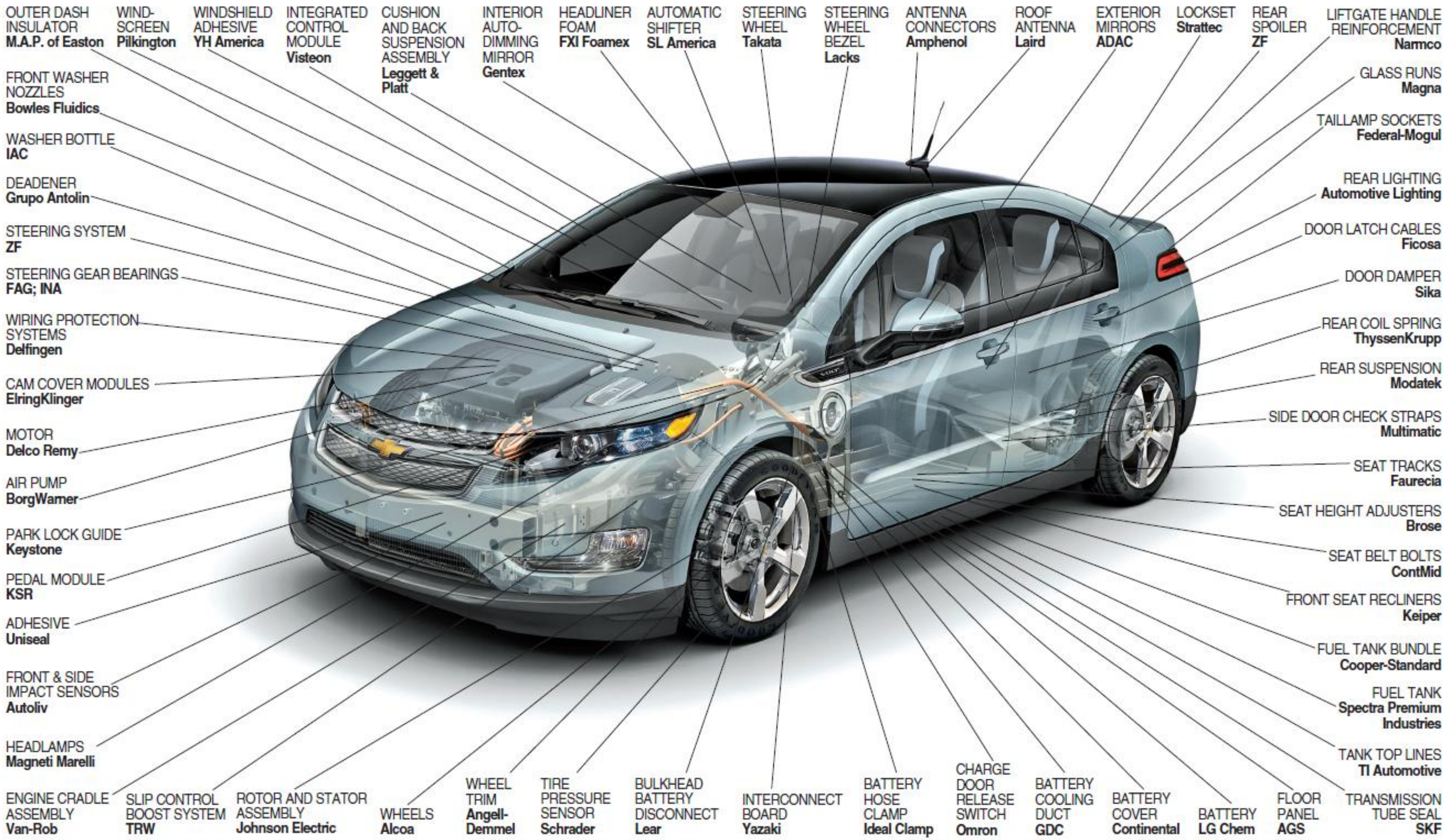


Source: 2006 (c) McGraw Hill/Irwin

Criteria ⇒ Types ⇓	Decision Maker	Inventory Ownership	New Skills Employed by vendors
Quick Response	Automotive Manufacturer	Automotive Manufacturer	Forecasting Skills
Continuous Replenishment	Contractually Agreed to Levels	Either Party	Forecasting & Inventory Control
Advanced Continuous Replenishment	Contractually agreed to & Continuously Improved Levels	Either Party	Forecasting & Inventory Control
VMI	Vendor/Supplier	Either Party	Distribution Management

Source: Simchi-Levi, Kaminsky & Simchi-Levi, Irwin McGraw Hill, 2000

Suppliers to the 2011 Chevrolet Volt

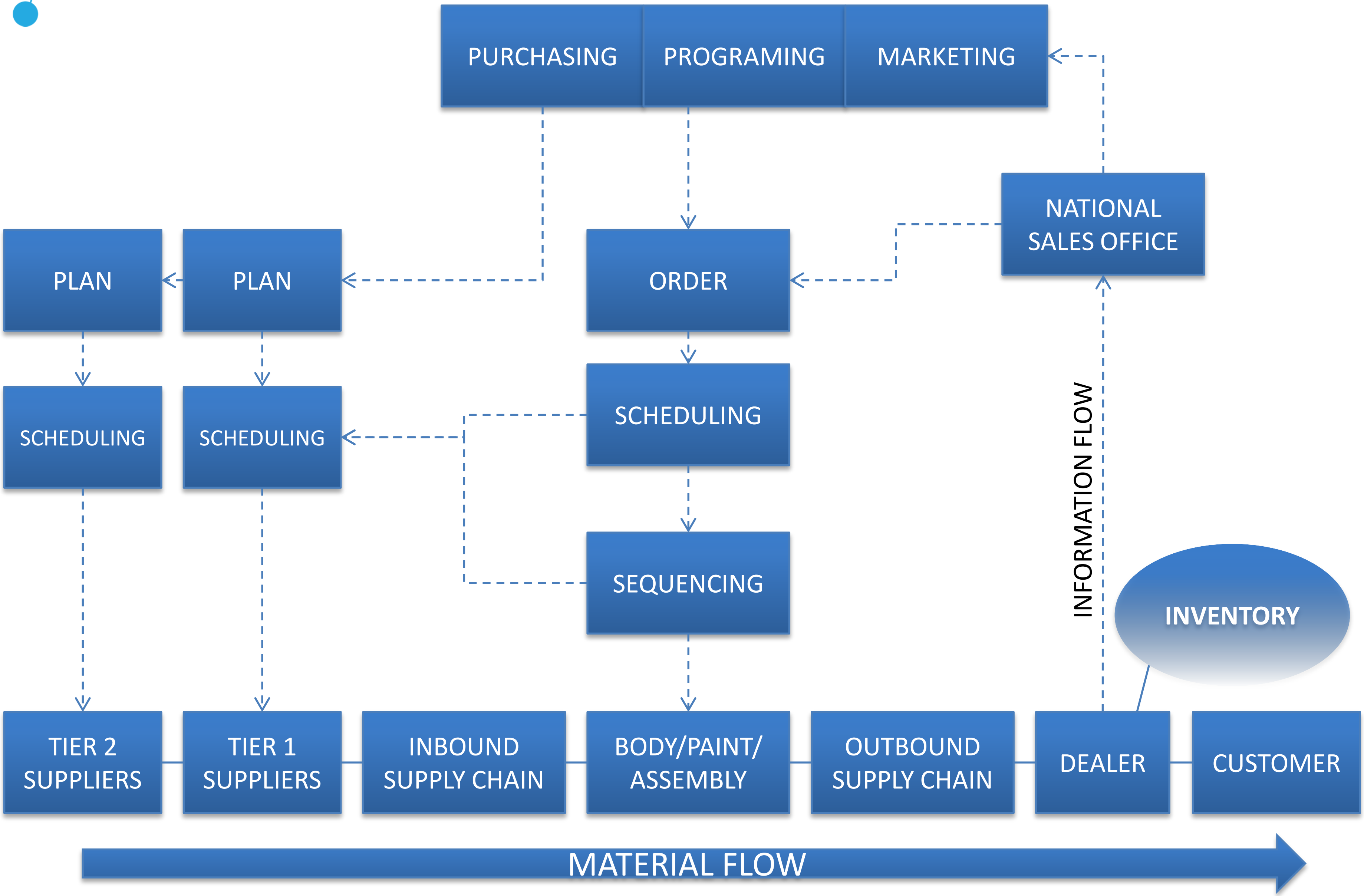


SUPPLIERS WANTED: If you are a supplier and have questions or want your information considered for our car cutaways, contact Steven Wingett at automotivenews@supplierbusiness.com

Source: SupplierBusiness

SupplierBusiness
An IHS Global Insight Company

BUILD TO FORECAST MODEL



BUILD TO FORECAST MODEL

•Sales Forecasting aggregates all dealers and national sales companies' forecasts and uses them as an input for production programming. The method is the bottom-up approach.

•Production programming is the process of consolidating forecast market demand to available production capacity to get the framework that defines how many vehicles will be built in each factory.

•Order entry is the stage in which orders are checked and entered into an order bank to await production scheduling.

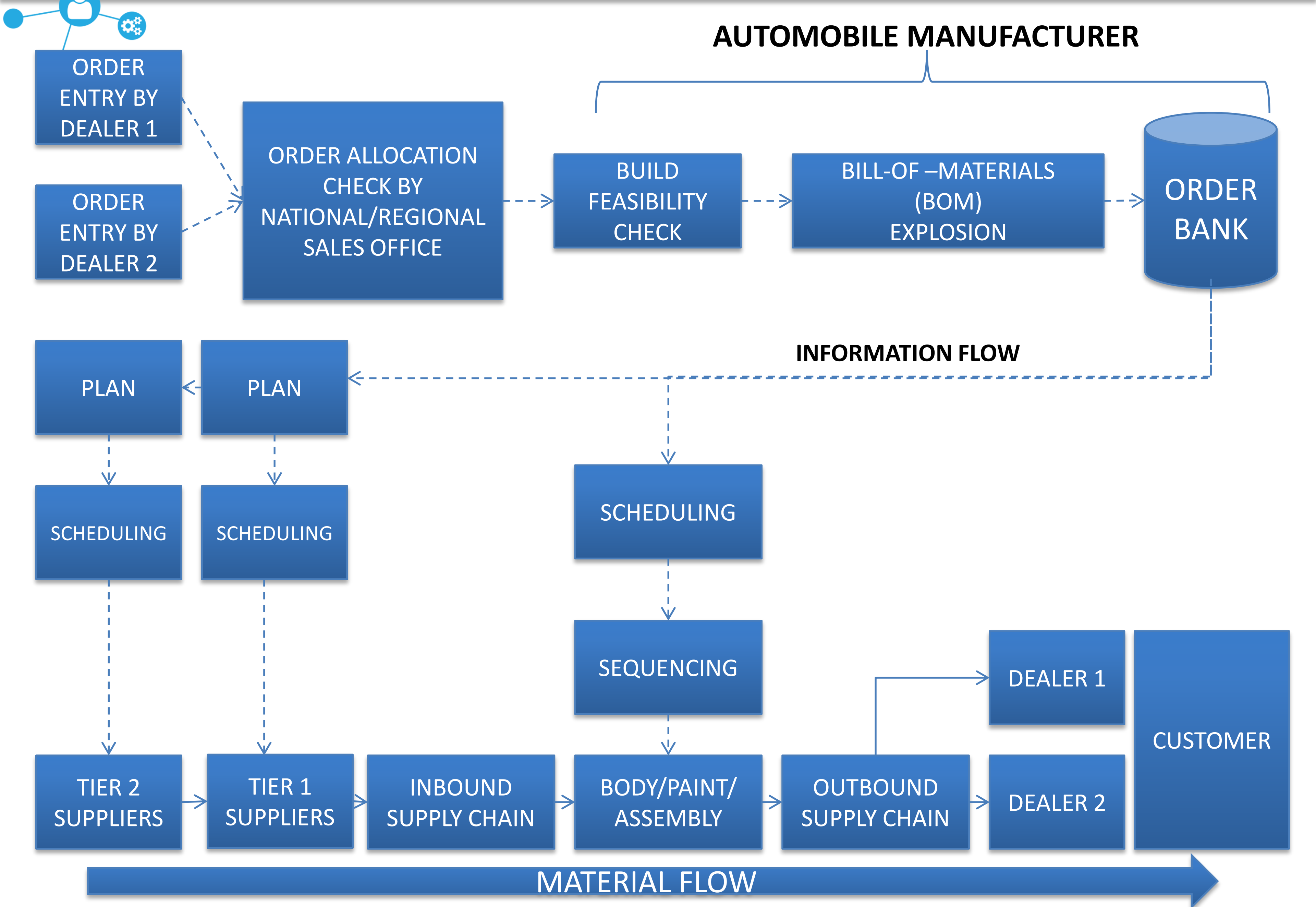
•Production scheduling and sequencing fit orders from the order banks into production schedules. These orders are used to develop the sequence of cars to be built on the scheduled date. Supplier scheduling is the process whereby suppliers receive forecasts at various times, actual schedules, and daily call-offs.

•Inbound logistics are the process of moving components and parts from supplier to assembly plant.

•Vehicle production is the process of welding, painting, and assembling the vehicle.

•Vehicle distribution is the stage at which the finished vehicle is shipped to dealers.

BUILD TO DELIVERY MODEL



BUILD TO DELIVERY MODEL

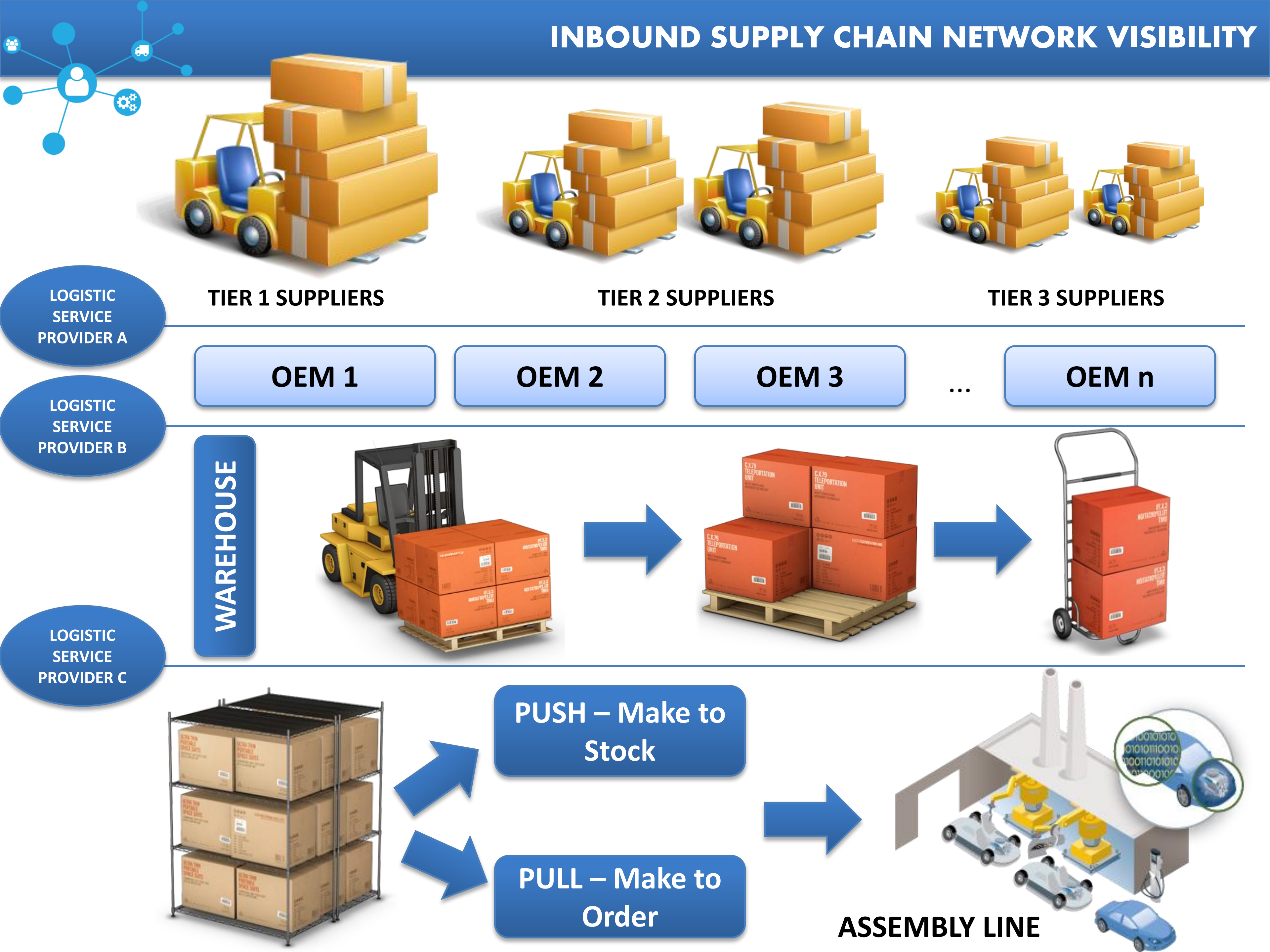
•Order entry begins when a salesperson enters a customer order into the system. Then, the order is passed on from the dealer to the national sales/regional sales office and subsequently to the manufacturer's headquarters.

•An allocation check is done at the national sales company to see if the desired vehicle is available or not for the dealer.

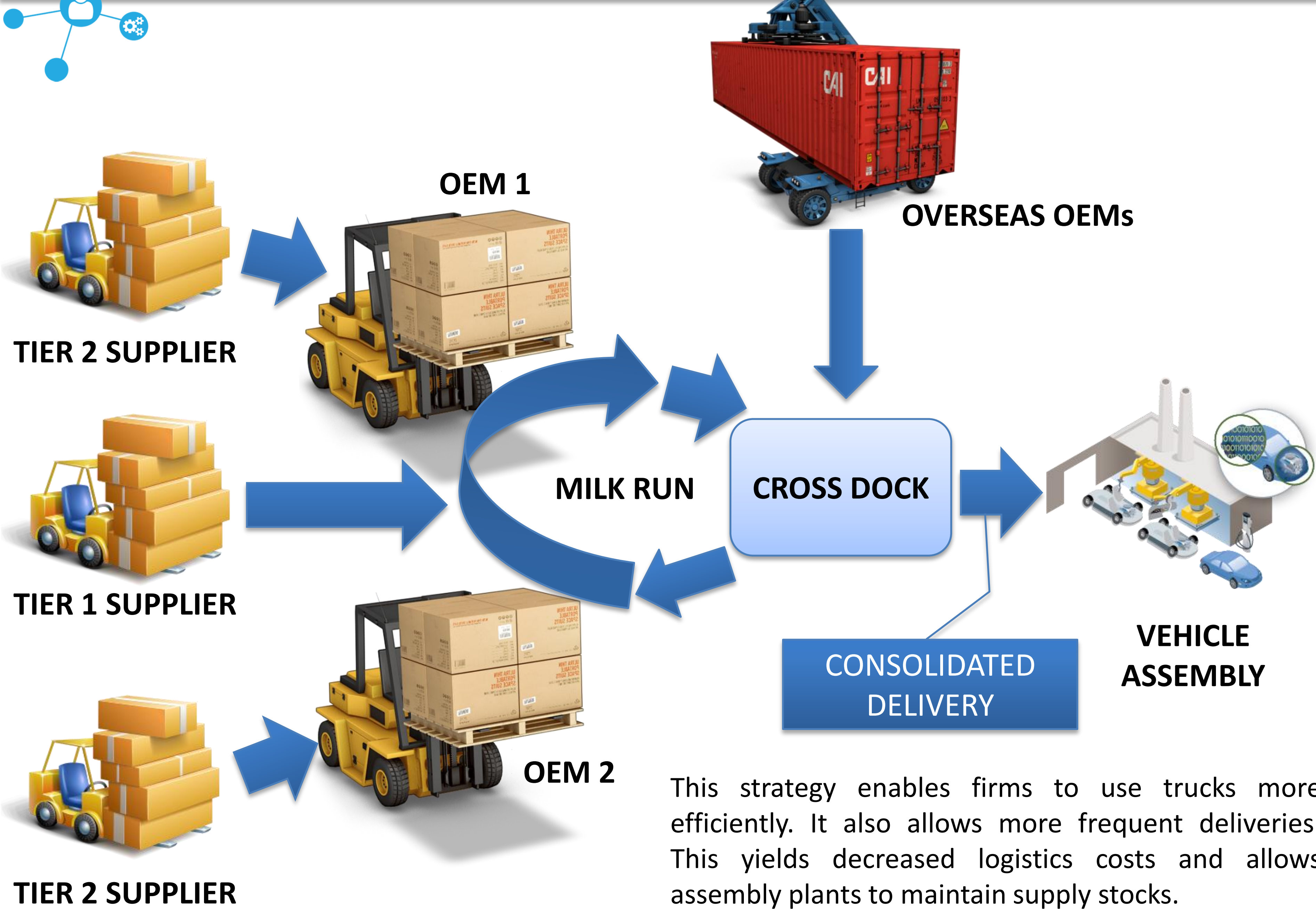
•Then, a build-feasibility check, which is the process of checking whether the special options and specifications are feasible for the production, follows to determine whether special options and specifications are available for that vehicle in the market. If not, the system rejects the order and the dealer must make the necessary order correction. Bill-Material-Conversion is the process of converting the orders received from the dealer to a bill of materials.

•Bill-of-Material-Conversion is the process of converting the orders received from the dealer to a bill of materials. This tells the manufacturers what kind of components they need to build the vehicle.

•The final stage in order entry is to transfer the order as a bill of material to the order bank. The order will stay in the order bank until the system transfers it into the
•plant's production schedule.

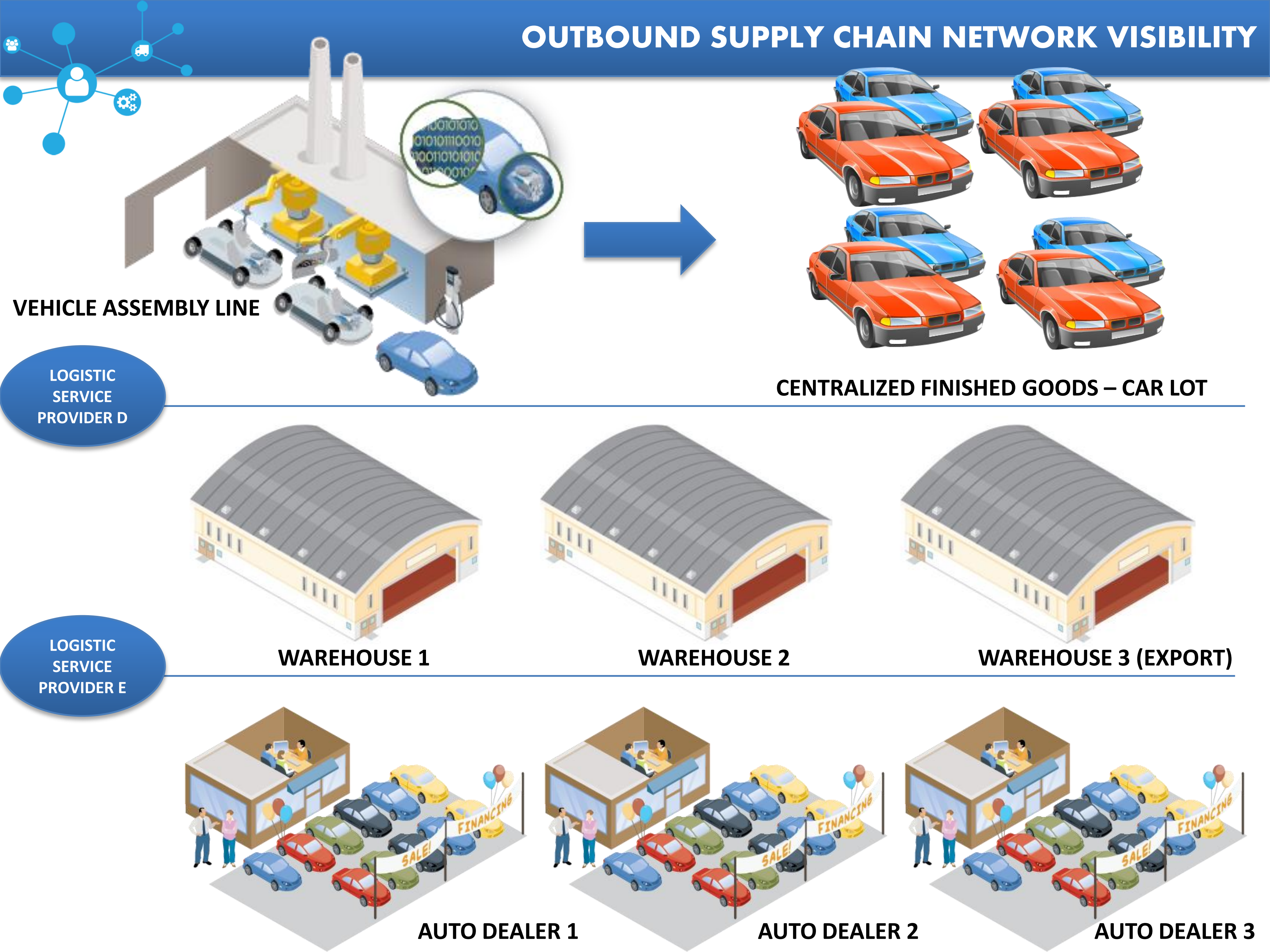

INBOUND SUPPLY CHAIN NETWORK VISIBILITY
LOGISTIC SERVICE PROVIDER A
LOGISTIC SERVICE PROVIDER B
LOGISTIC SERVICE PROVIDER C
TIER 1 SUPPLIERS
TIER 2 SUPPLIERS
TIER 3 SUPPLIERS
OEM 1
OEM 2
OEM 3
...
OEM n
WAREHOUSE
PUSH – Make to Stock
PULL – Make to Order
ASSEMBLY LINE

INBOUND SUPPLY CHAIN COST OPTIMIZATION BY CROSS DOCKING



This strategy enables firms to use trucks more efficiently. It also allows more frequent deliveries. This yields decreased logistics costs and allows assembly plants to maintain supply stocks.

OUTBOUND SUPPLY CHAIN NETWORK VISIBILITY

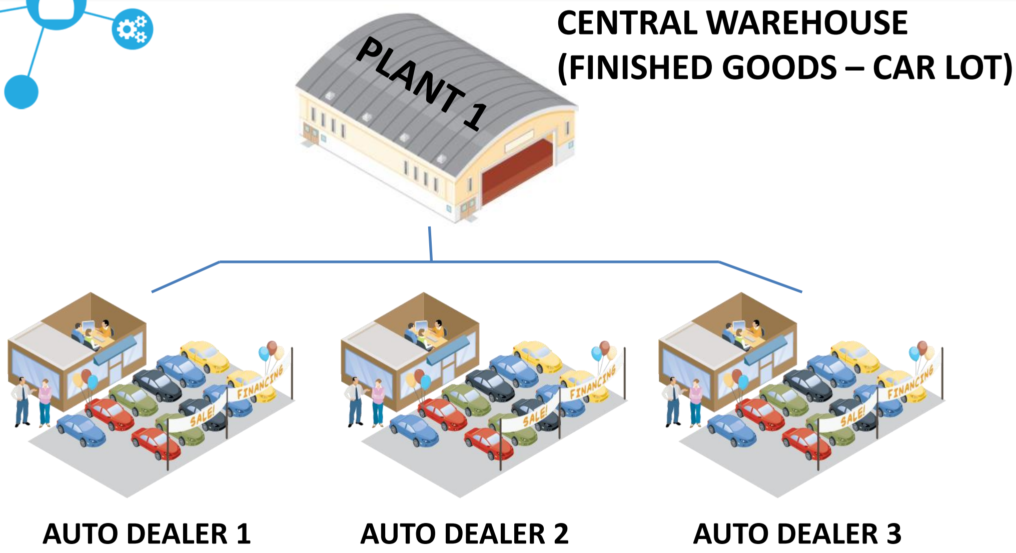


OUTBOUND SUPPLY CHAIN NETWORK LAYERS – AVAILABLE OPTIONS

OPTION A: 1 LAYER

Concept: Single Central Warehouse + Multiple Auto Dealers

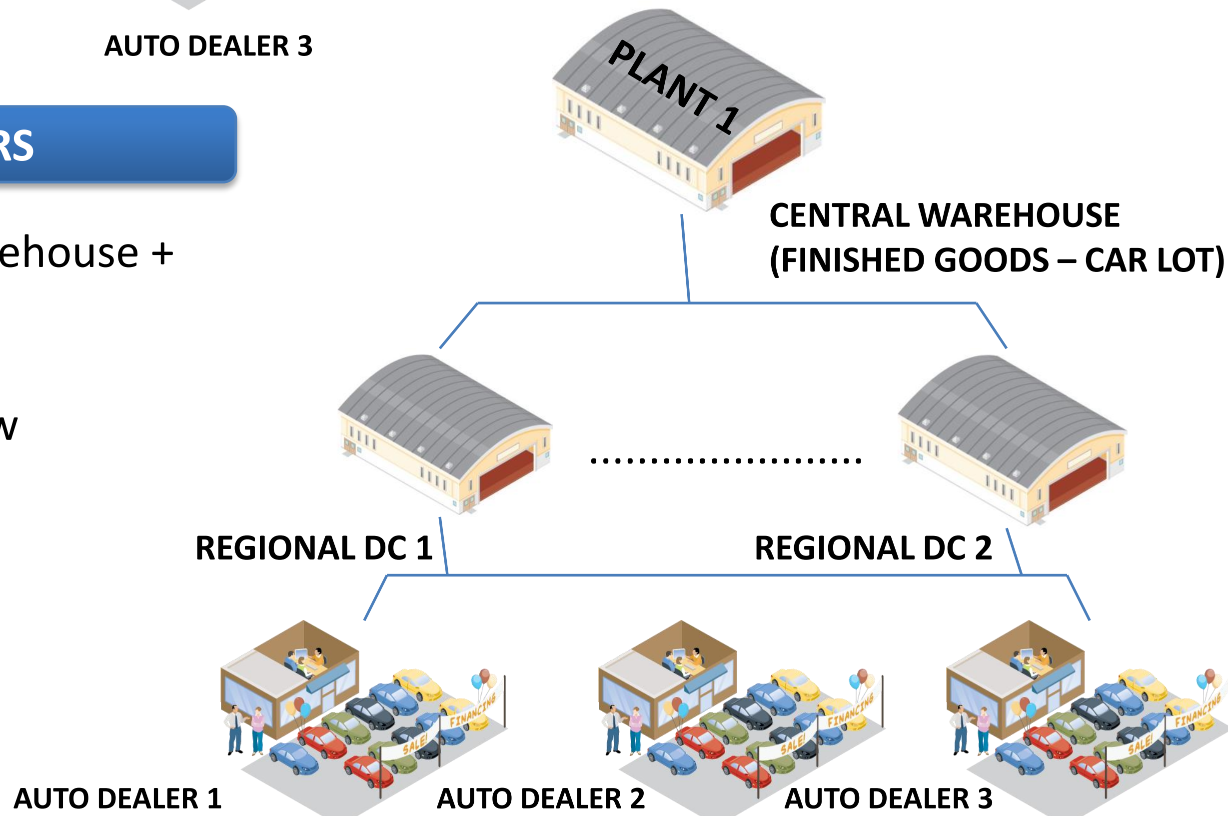
Product: Finished Brand New Automobile



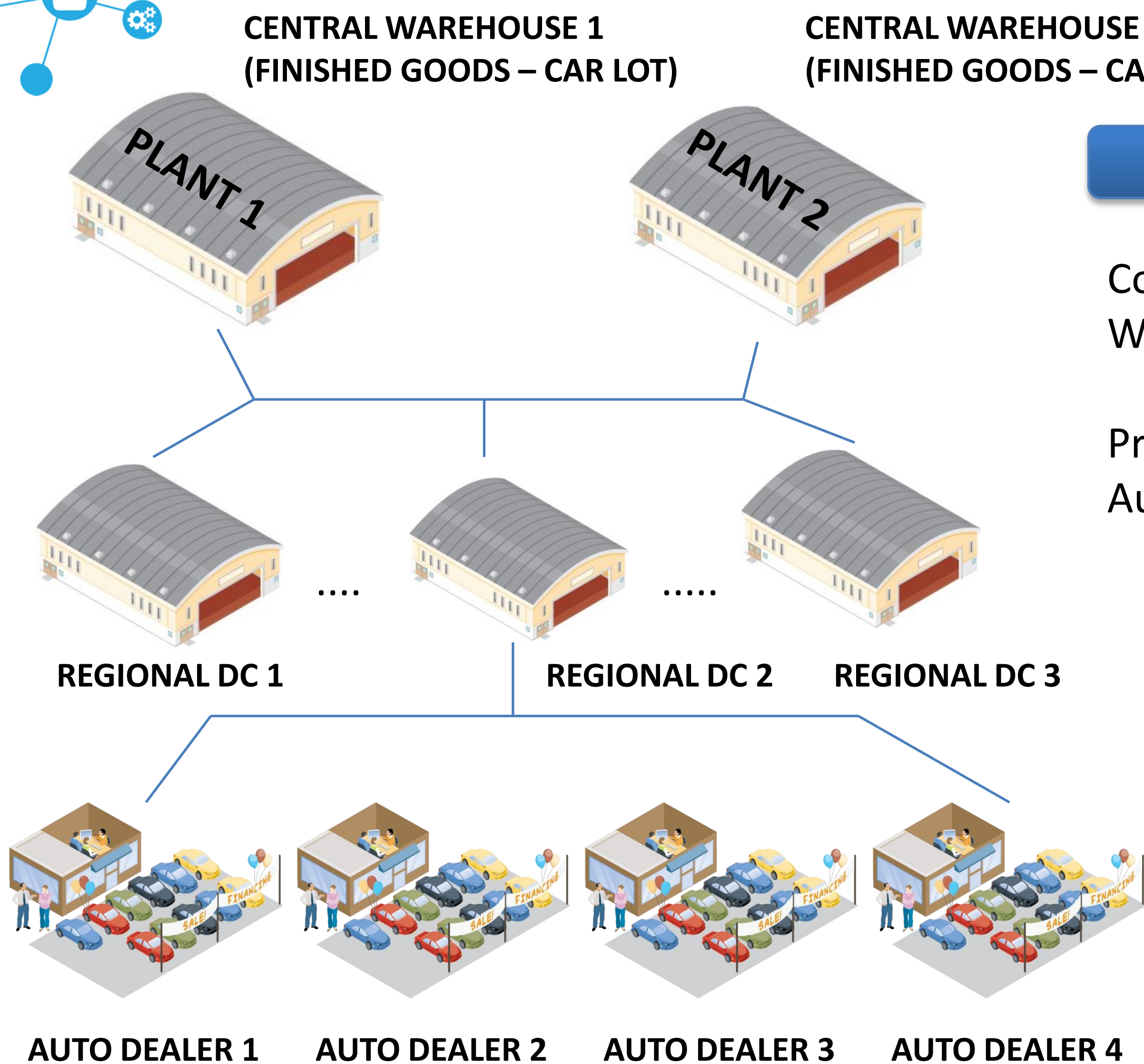
OPTION B: 2 LAYERS

Concept: Single Central Warehouse + Multiple RDCs

Product: Finished Brand New Automobile



OUTBOUND SUPPLY CHAIN NETWORK LAYERS – AVAILABLE OPTIONS



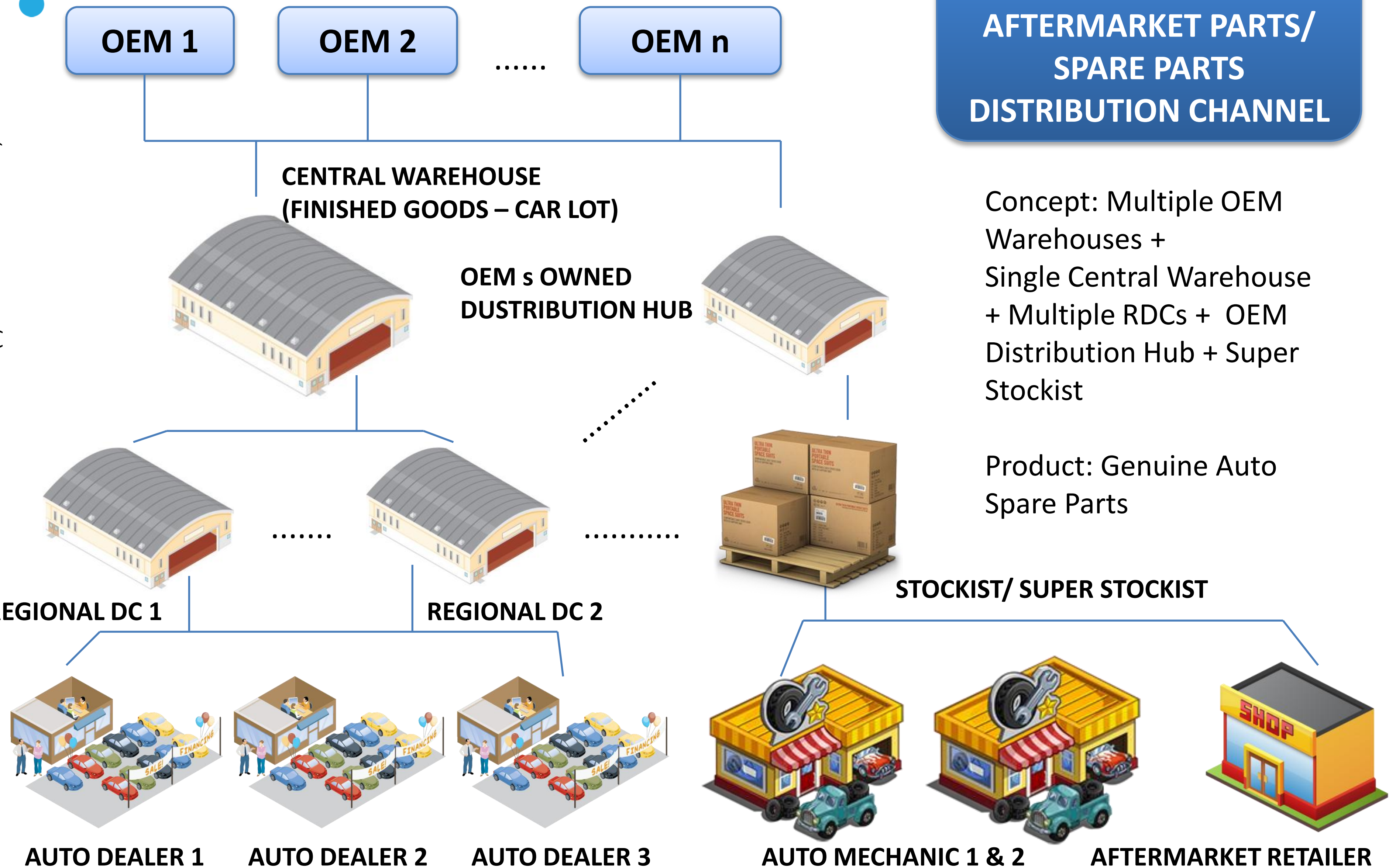
OPTION C : 2 LAYERS

Concept: Multiple Central Warehouses + Multiple RDCs

Product: Finished Brand New Automobile

OUTBOUND SUPPLY CHAIN NETWORK LAYERS – AVAILABLE OPTIONS

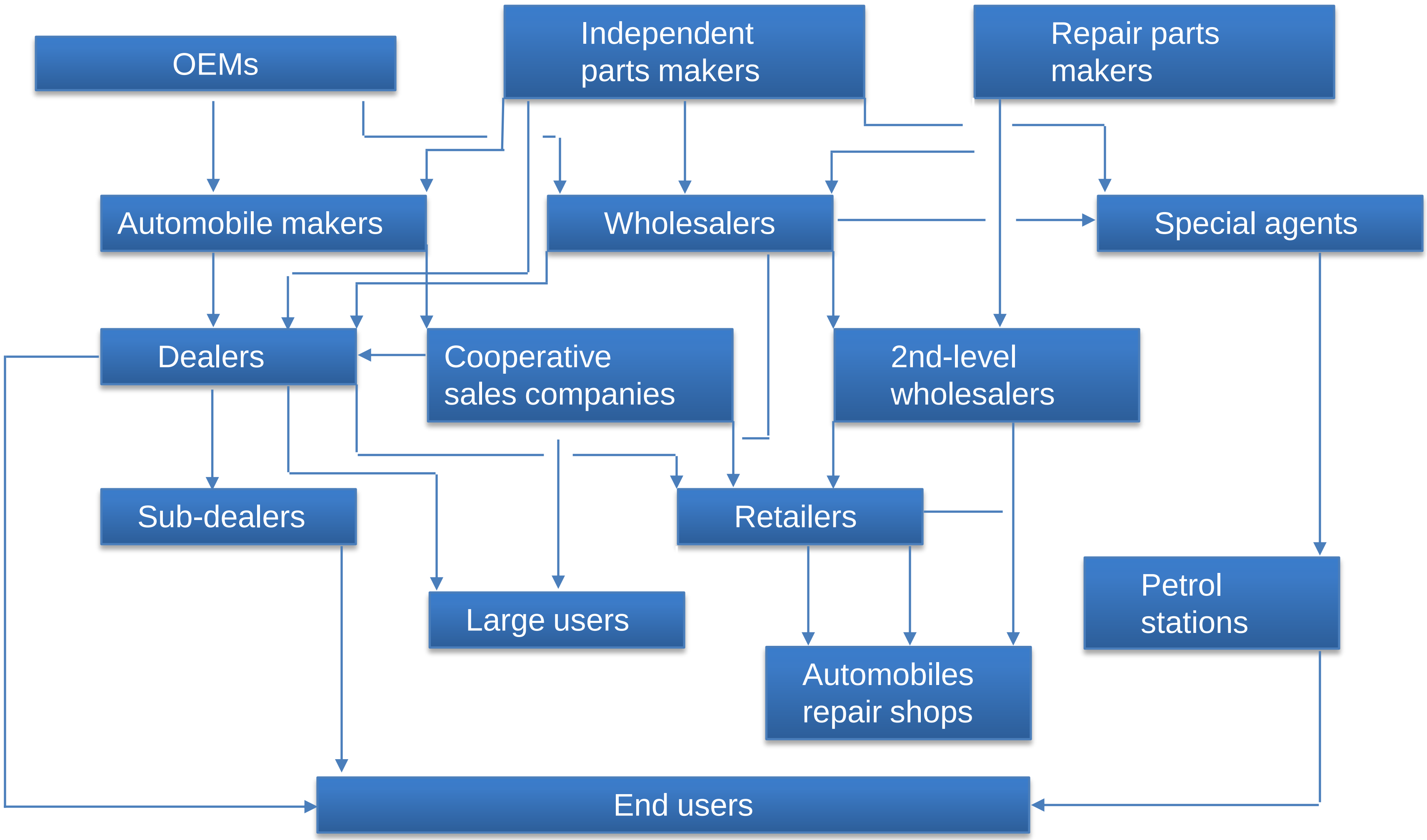
OPTION D: 3 LAYER OEM AFTERMARKET PARTS/ SPARE PARTS DISTRIBUTION CHANNEL



Concept: Multiple OEM Warehouses + Single Central Warehouse + Multiple RDCs + OEM Distribution Hub + Super Stockist

Product: Genuine Auto Spare Parts

AFTERMARKET/SPARE PARTS – SUPPLY CHAIN NETWORK



Source: McKinsey Industries Study

Three Stages of Spare Parts Business Management Mode

Spare Parts Management Capability

The Initial Stage: Basic Management Mode

- The most important target of the spare parts business is to guarantee the parts supply
- Due to limited business size, overall supply chain operations cannot achieve economies of scale and supply timeliness is hard to guarantee
- The companies' focus lies in building the basic spare parts operation structure
- Spare parts business is a cost center in this stage

Rapid Developing Stage: Network Management Mode

- As the client base expands, the spare parts business is undergoing exponential growth, and a network effect begins to emerge
- Through the establishment of a distribution network, the service level of spare parts business Stabilizes
- The focus of this stage is improvement of service quality and customer satisfaction
- Spare parts business is still a cost center but its revenue and profit become key performance indicator

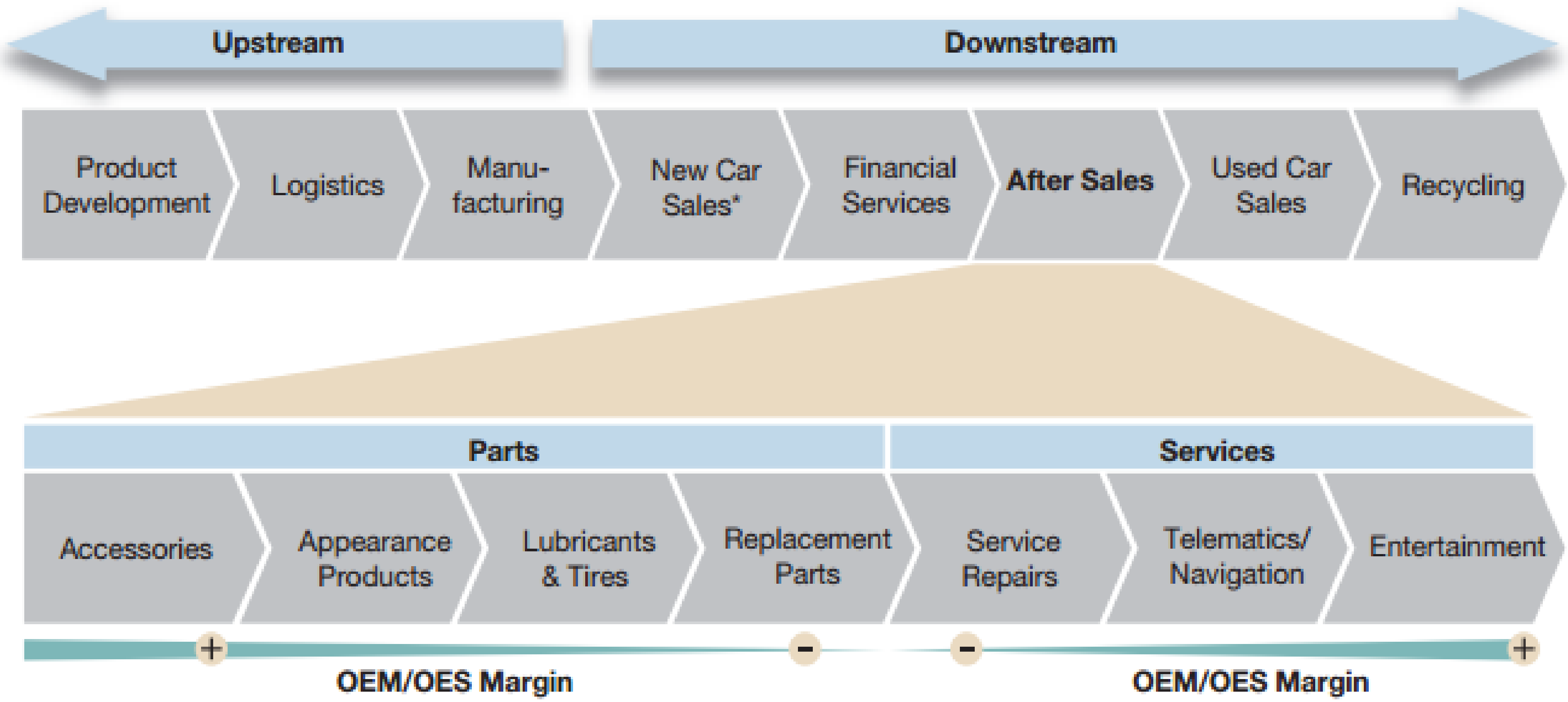
Mature Stage: Integration Management Mode

- Spare parts business becomes key source of revenues and profits; its positioning also begins to shift to that of a profit center
- As economies of scale has achieved, reducing operating costs and increasing revenues and profits become the main objectives in this stage
- Integration of global distribution network, improving lean management and agility of the supply chain, increasing collaboration of the entire supply chain become the key tasks at this stage

1 million units | **3 to 5 million units** | **Car Parc**

Source: Deolite Automotive Aftermarket Survey

Exhibit 2: Value Chain of OEM/OES and Focus of Study

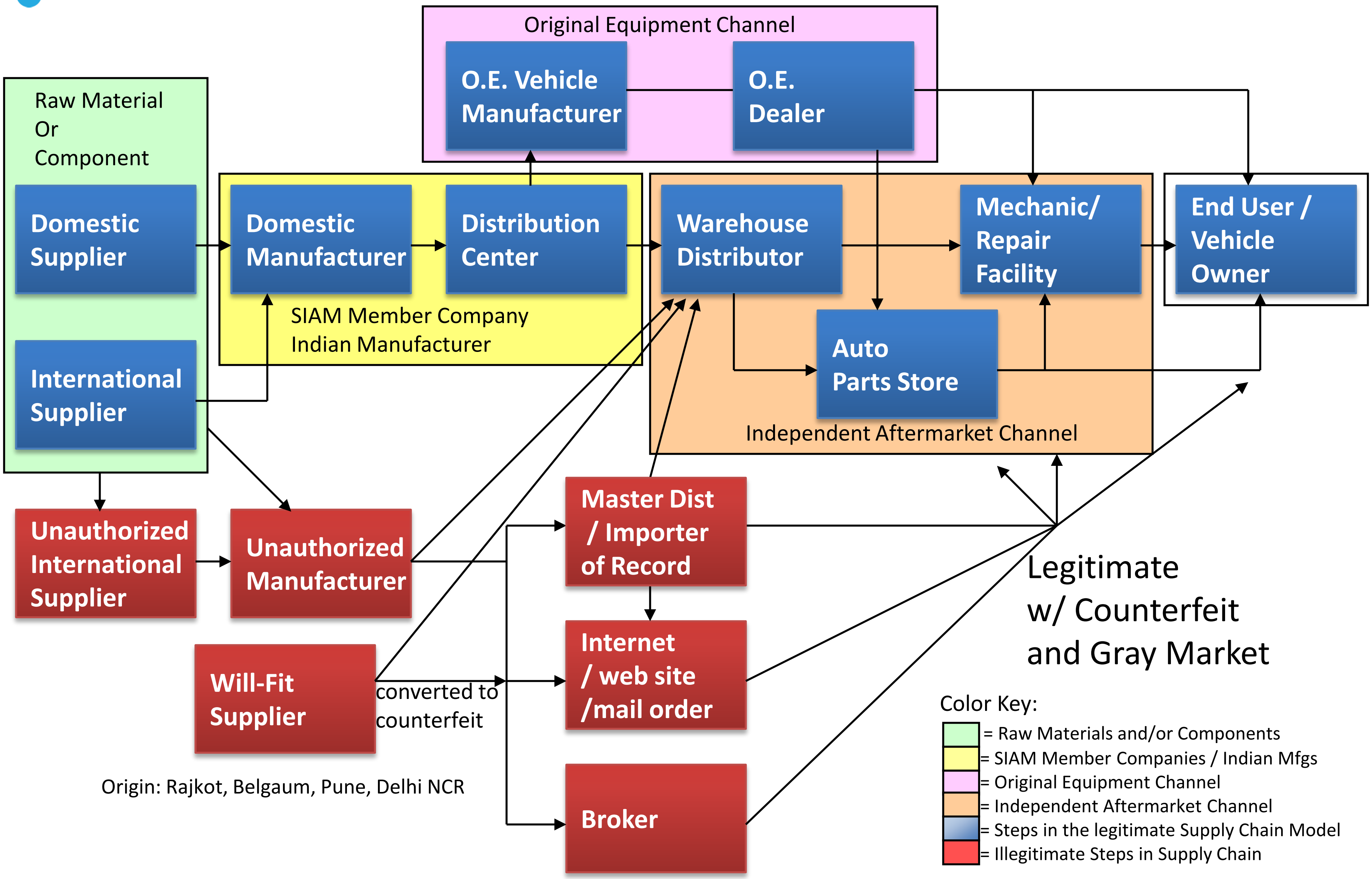


* New car sales is relevant for OEMs only. For OESs the equivalent is parts/components sales to OEMs

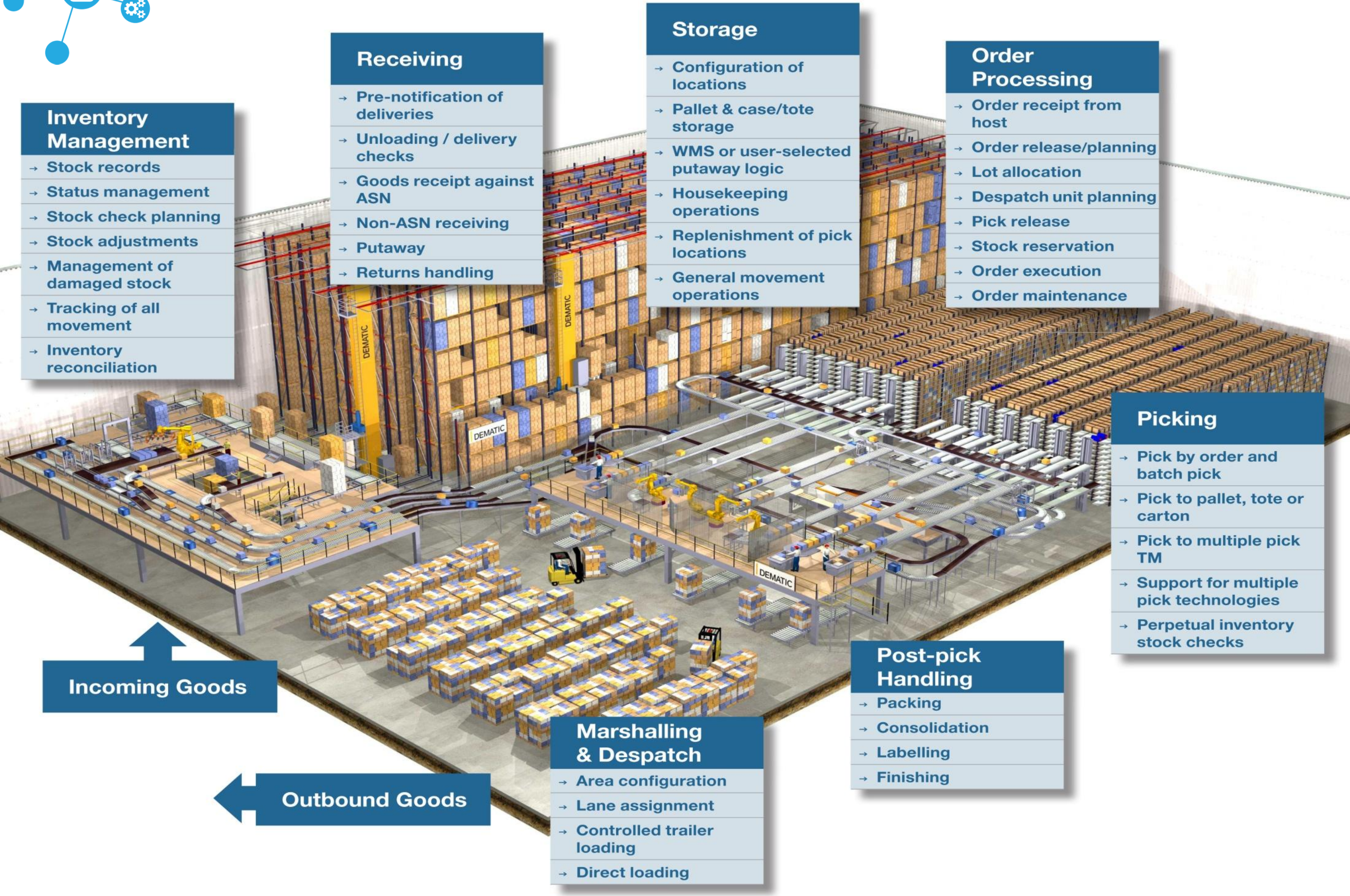
The relevancy of the different elements varies for OEMs/OESs due to the nature of their meaning

Capgemini Consulting

AFTERMARKET – COUNTERFIET/GRAY MARKET ELEMENTS IN SCM



INVENTORY AND WAREHOUSE MANAGEMENT


Inventory Management
Stock records
Status management
Stock check planning
Stock adjustments
Management of damaged stock
Tracking of all movement
Inventory reconciliation
Receiving
Pre-notification of deliveries
Unloading / delivery checks
Goods receipt against ASN
Non-ASN receiving
Putaway
Returns handling
Storage
Configuration of locations
Pallet & case/tote storage
WMS or user-selected putaway logic
Housekeeping operations
Replenishment of pick locations
General movement operations
Order Processing
Order receipt from host
Order release/planning
Lot allocation
Despatch unit planning
Pick release
Stock reservation
Order execution
Order maintenance
Picking
Pick by order and batch pick
Pick to pallet, tote or carton
Pick to multiple pick TM
Support for multiple pick technologies
Perpetual inventory stock checks
Post-pick Handling
Packing
Consolidation
Labelling
Finishing
Marshalling & Despatch
Area configuration
Lane assignment
Controlled trailer loading
Direct loading
Incoming Goods
Outbound Goods
DEMATIC

Inventory is the raw materials, component parts, work-in-process, or finished products that are held at a location in the supply chain.

Physical holding costs:

-Out of pocket expenses for storing inventory (insurance, security, warehouse rental, cooling)
- All costs that may be entailed before you sell it (obsolescence, spoilage, rework...)

Opportunity cost of inventory: foregone return on the funds invested.

Operational costs:

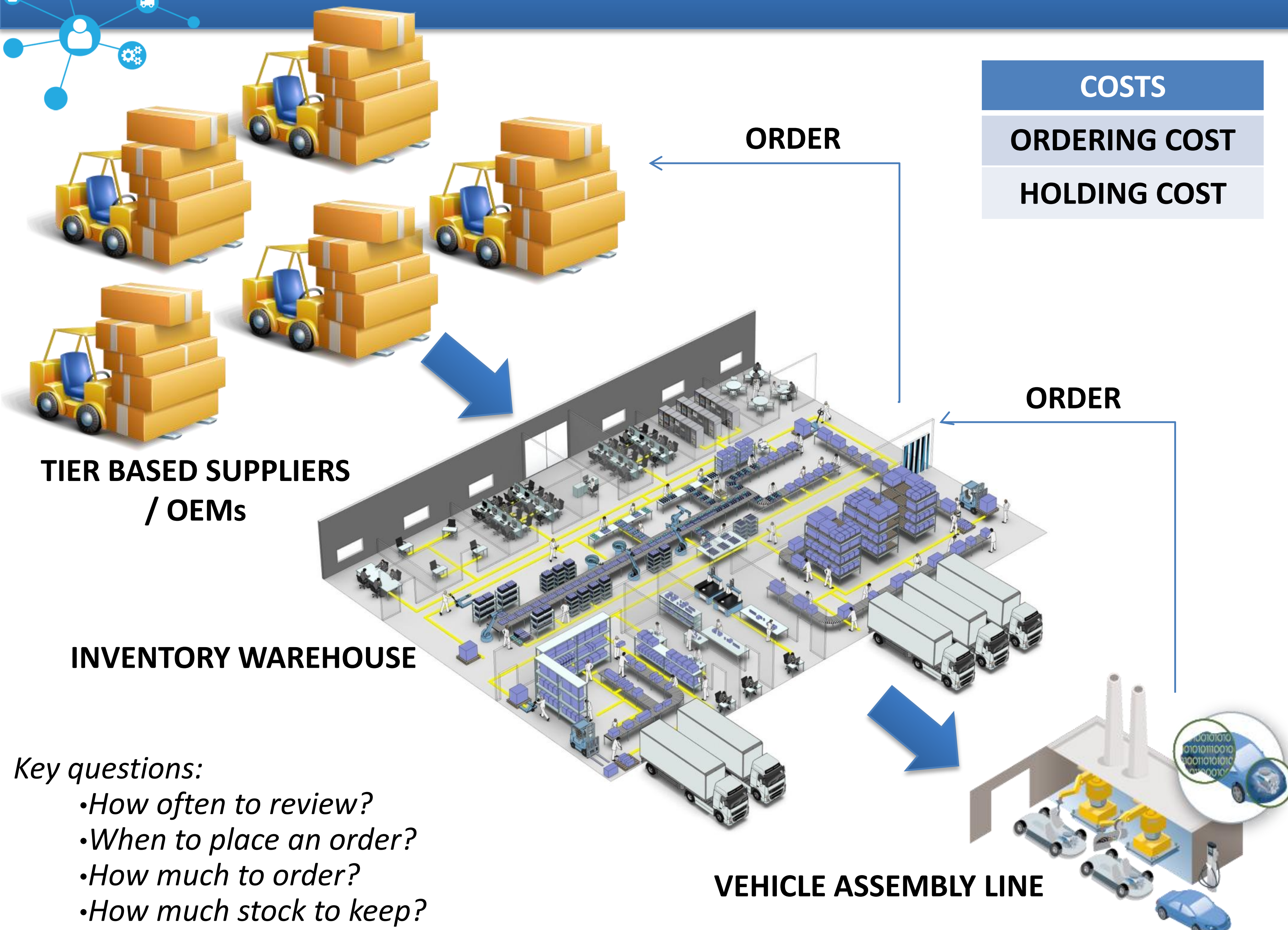
-Delay in detection of quality problems.

-Delay the introduction of new products.

-Increase throughput times.

COST OF INVENTORY - INBOUND

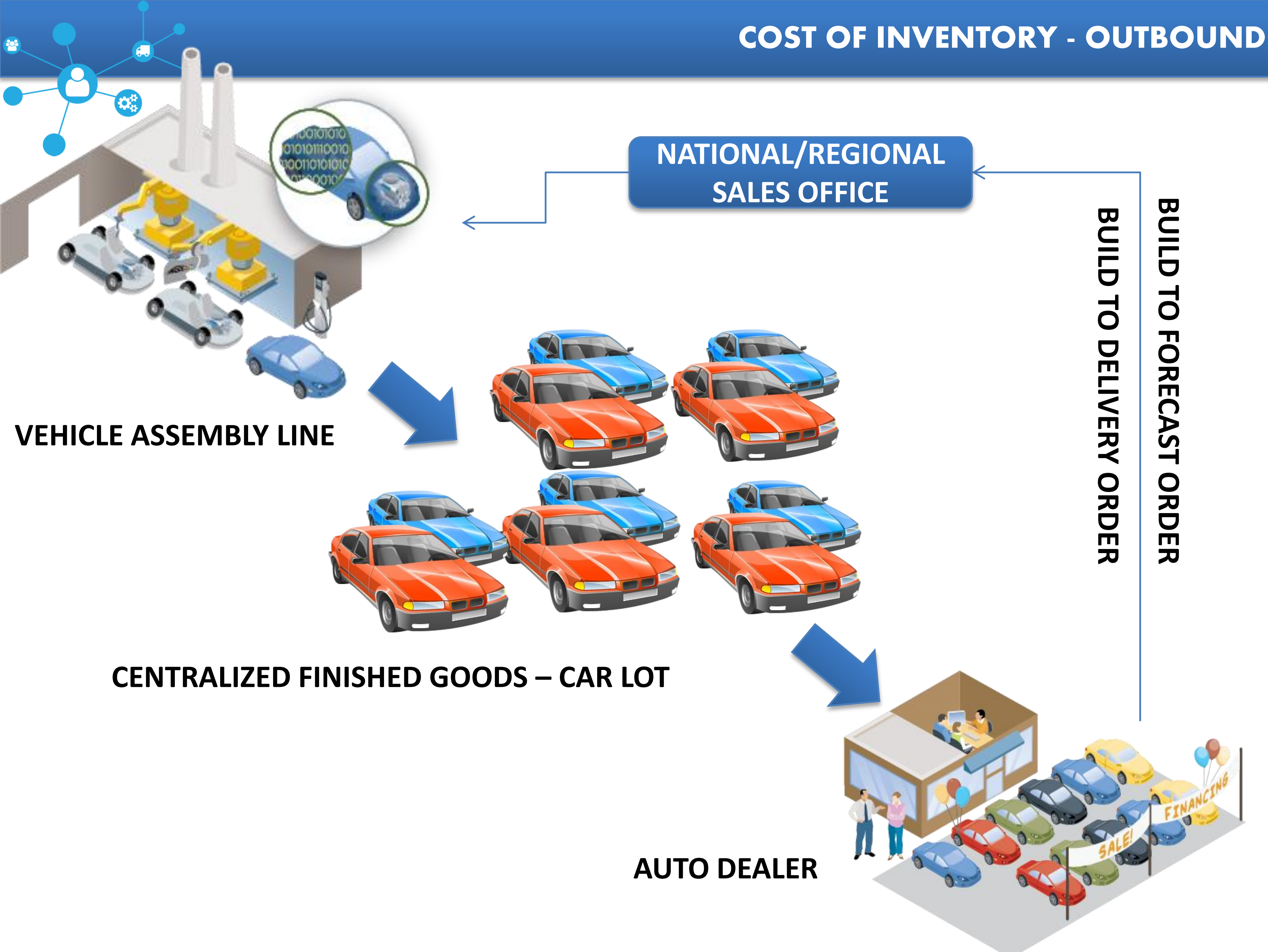
COSTS
ORDERING COST
HOLDING COST



Key questions:

- *How often to review?*
- *When to place an order?*
- *How much to order?*
- *How much stock to keep?*

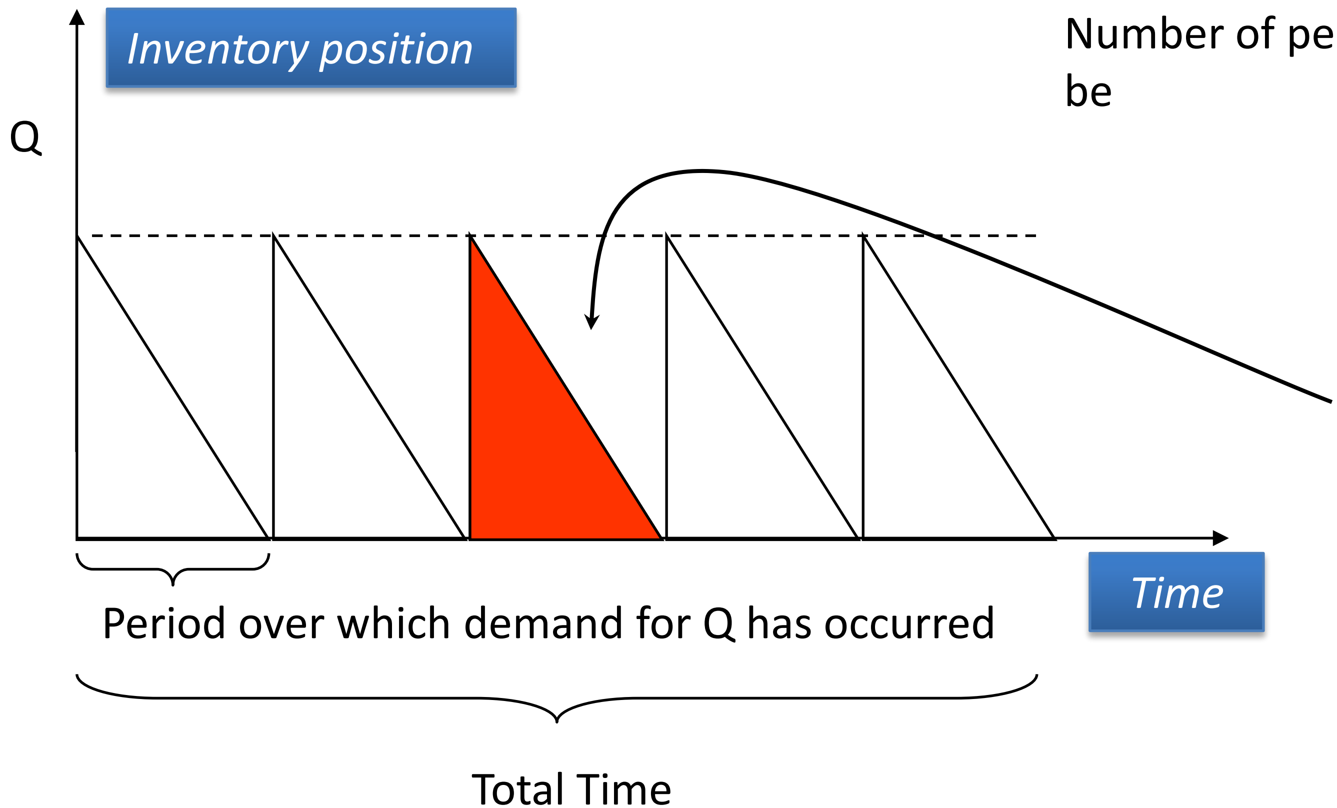
COST OF INVENTORY - OUTBOUND



NOTATIONS

- *<u>Demand</u> is known and deterministic: D units/year*
- *We have a known <u>ordering cost</u>, S, and immediate replenishment*
- *Annual <u>holding cost</u> of average inventory is H per unit*
- *<u>Purchasing cost</u> C per unit*

Let's say we decide to order in batches of Q…



Number of periods will be $= \frac{D}{Q}$

The average inventory for each period is… $= \frac{Q}{2}$

Total Cost = Purchasing Cost + Ordering Cost + Inventory Cost

Purchasing Cost = (total units) x (cost per unit) = D x C

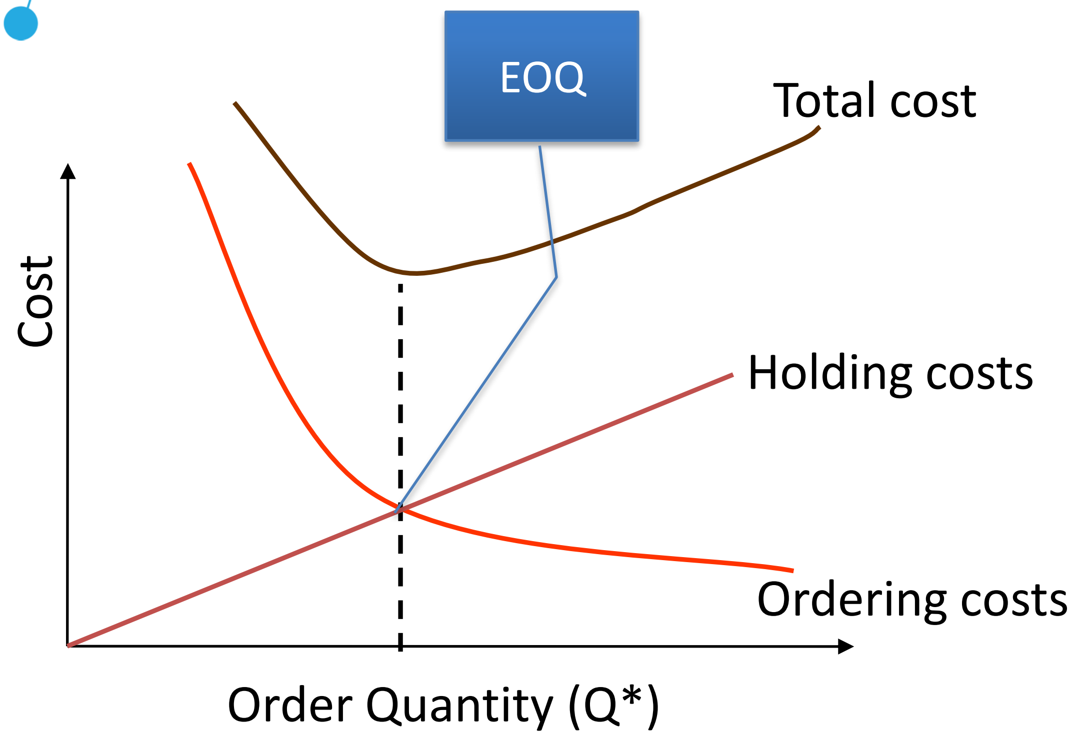
Ordering Cost = (number of orders) x (cost per order) = $\frac{D}{Q} \times S$

Inventory Cost = (average inventory) x (holding cost) = $\frac{Q}{2} \times H$

TOTAL COST = $D \times C + \frac{D}{Q} \times S + \frac{Q}{2} \times H$

NOTE: In order now to find the optimal quantity we need to optimize the total cost with respect to the decision variable (the variable we control)

COMPUTATION OF EOQ- ECONOMIC ORDER OF QUANTITY



Insight on EOQ: There is a tradeoff between holding costs and ordering costs

EOQ = Q*

$$Q^* = \sqrt{\frac{2SD}{H}}$$

EOQ applies only when demand for a product is constant over the year and each new order is delivered in full when inventory reaches zero.

There is a fixed cost for each order placed, regardless of the number of units ordered. There is also a cost for each unit held in storage, commonly known as holding cost, sometimes expressed as a percentage of the purchase cost of the item.

CASE STUDY:

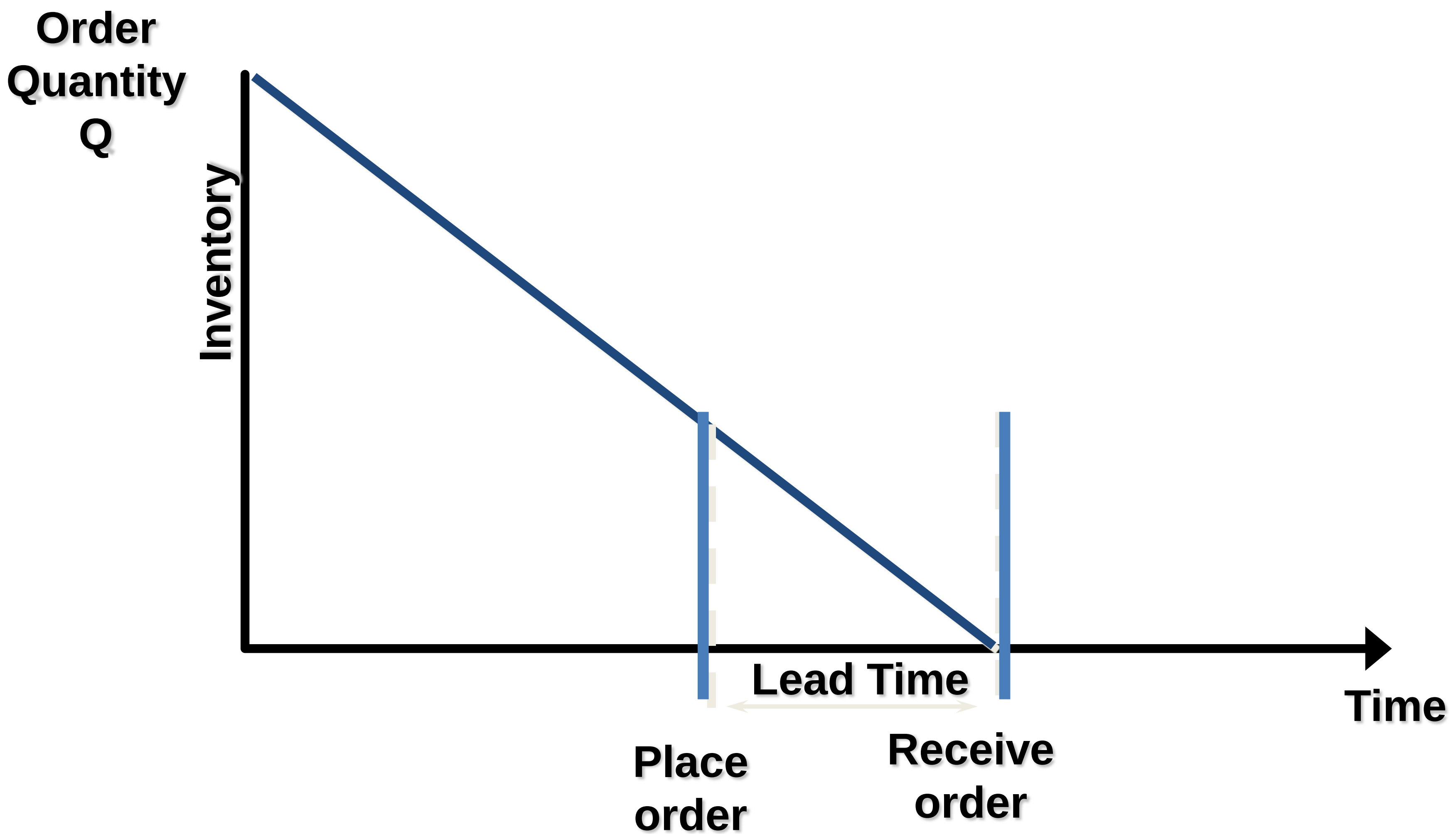
Assume a car dealer that faces demand for 5,000 cars per year, and that it costs INR 3,00,000 to have the cars shipped to the dealership. Holding cost is estimated at INR 10,000 per car per year. How many times should the dealer order, and what should be the order size?

$$Q^* = \sqrt{\frac{2(300000)(5,000)}{10000}} = 548$$

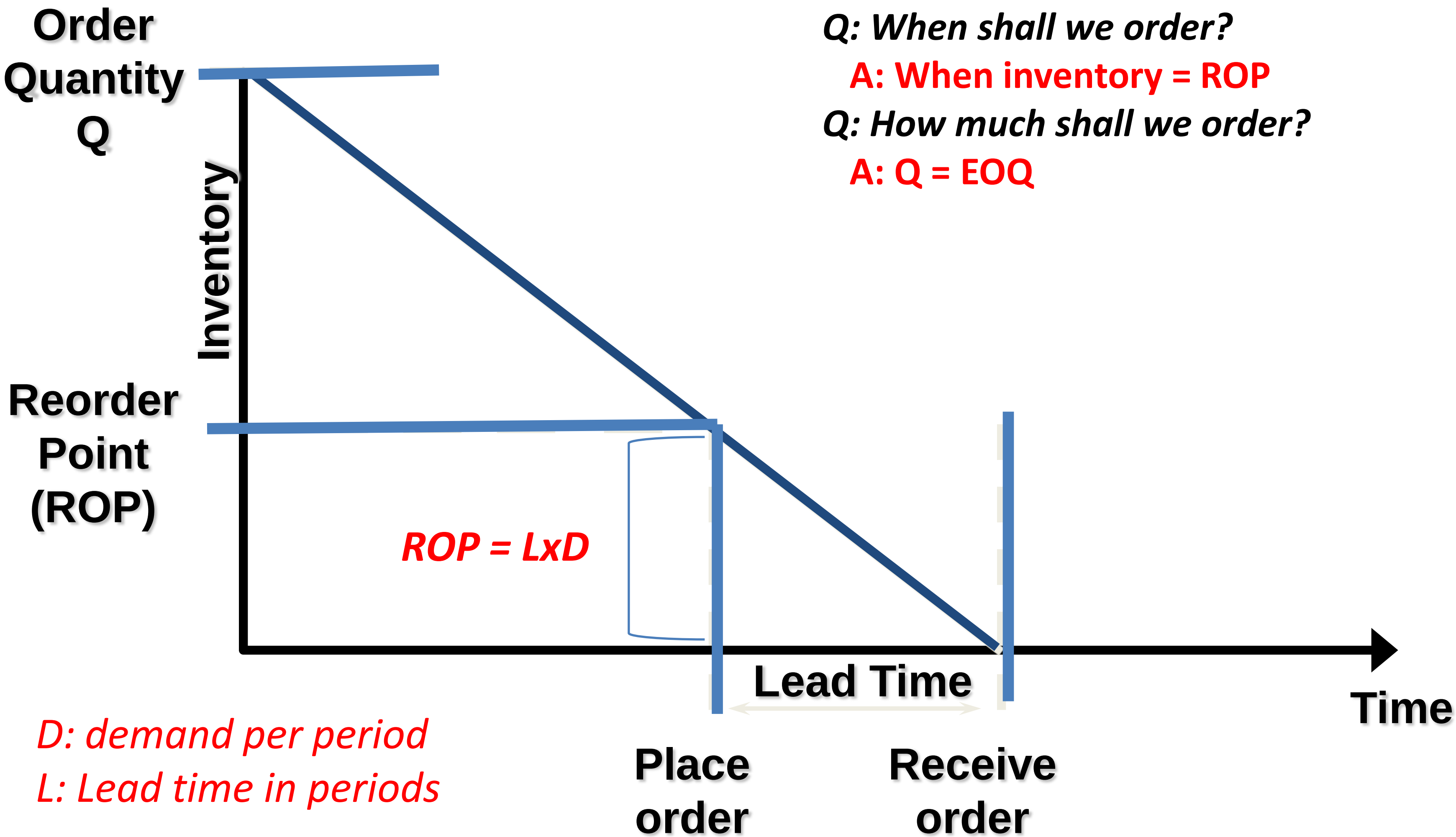
Therefore, optimum Economic Order Of Quantity is 548 Cars

If delivery is not instantaneous, but there is a lead time L:

When to order? How much to order?



If demand is known exactly, place an order when inventory equals demand during lead time.



Q: When shall we order?

A: When inventory = ROP

Q: How much shall we order?

A: Q = EOQ

D: demand per period

L: Lead time in periods

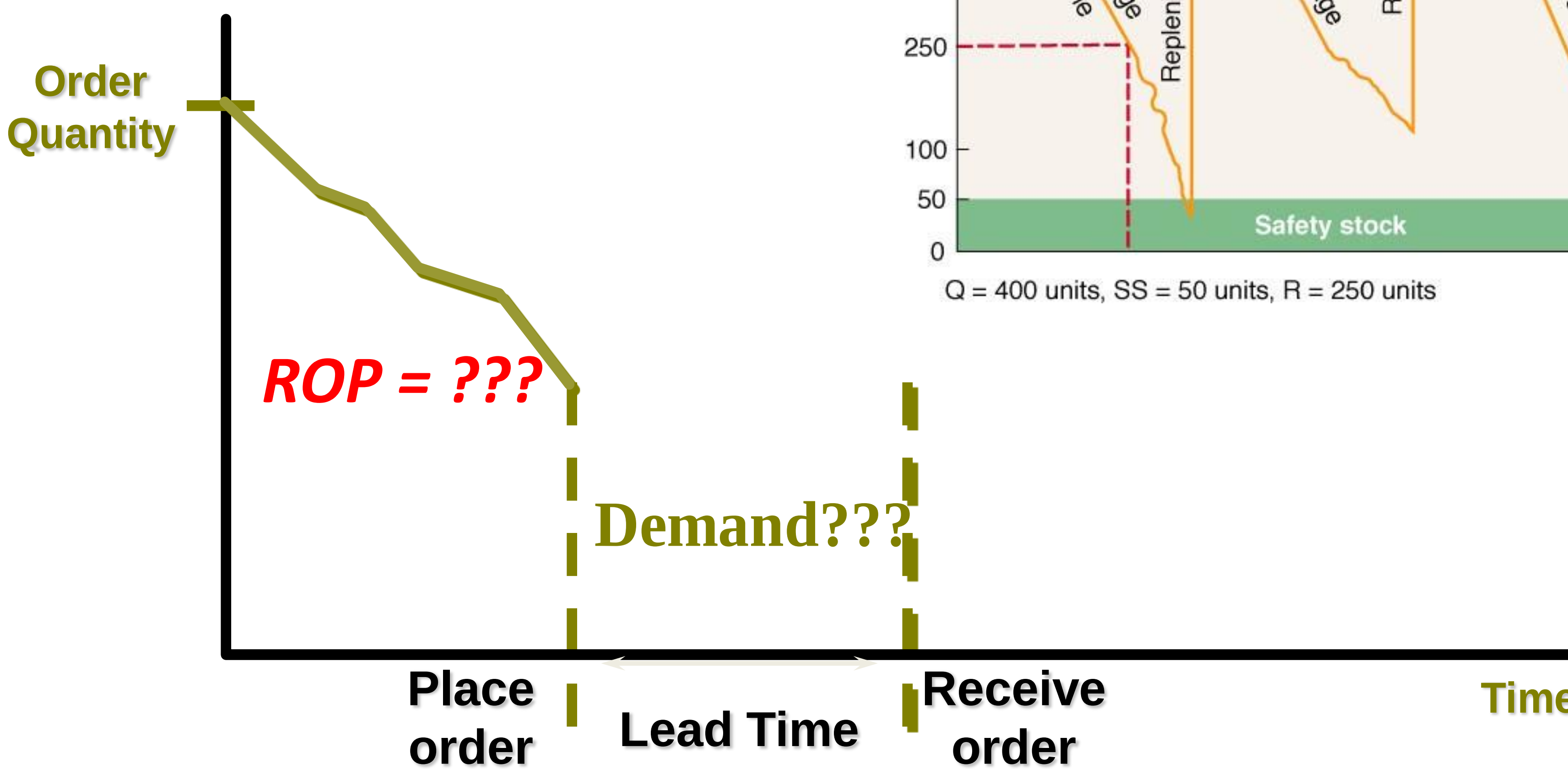
What if the lead time to receive cars is 10 days? (when should you place your order?)

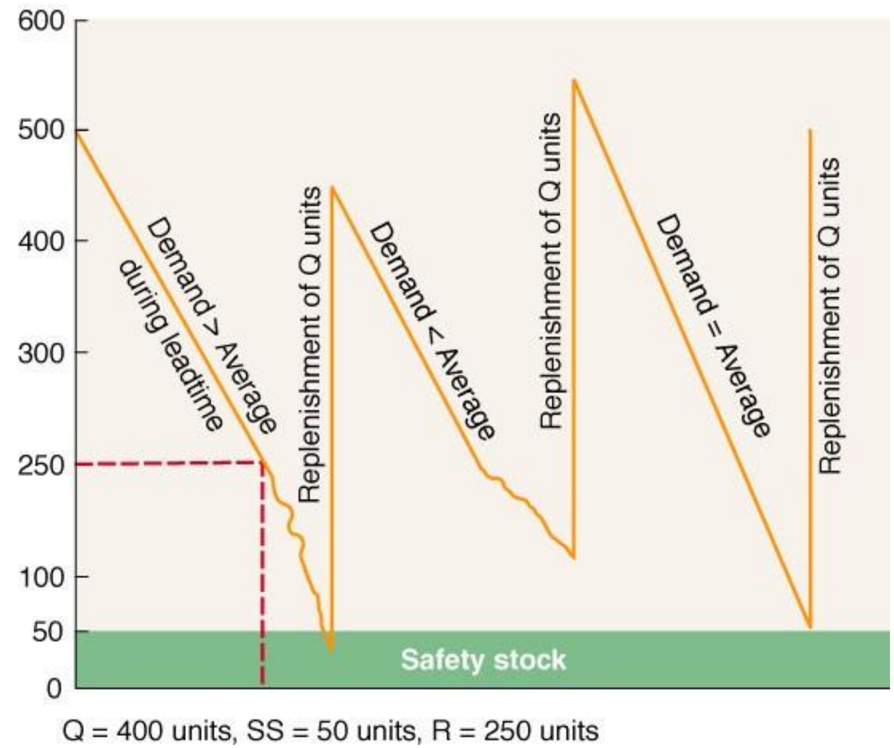
Since D is given in years, first convert: 10 days = 10/365yrs

$$R = \frac{10}{365} D = \frac{10}{365} 5000 = 137$$

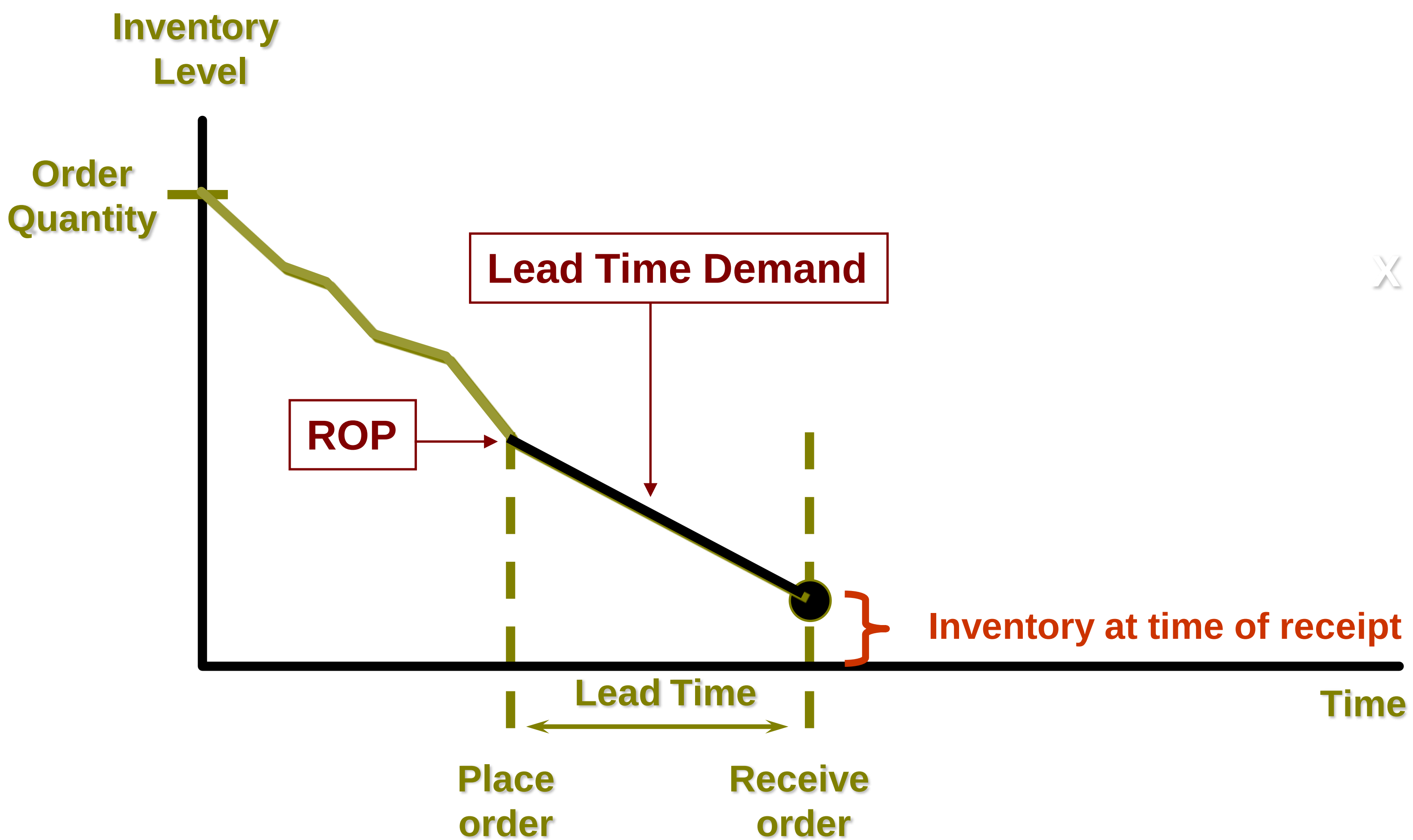
<u>So, when the number of cars on the lot reaches 137, order 548 more cars.</u>

PREDICTABILITY OF DEMAND

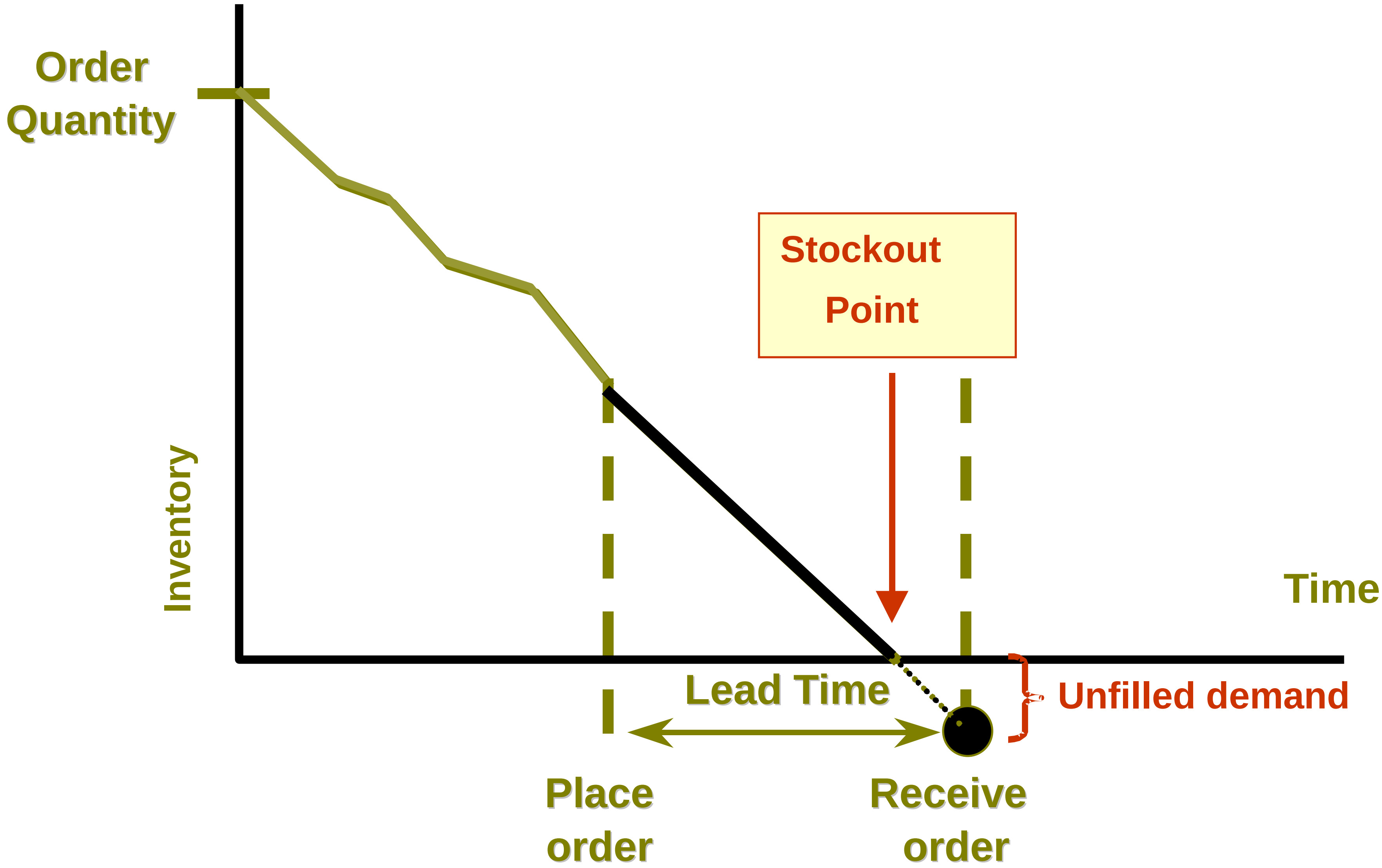




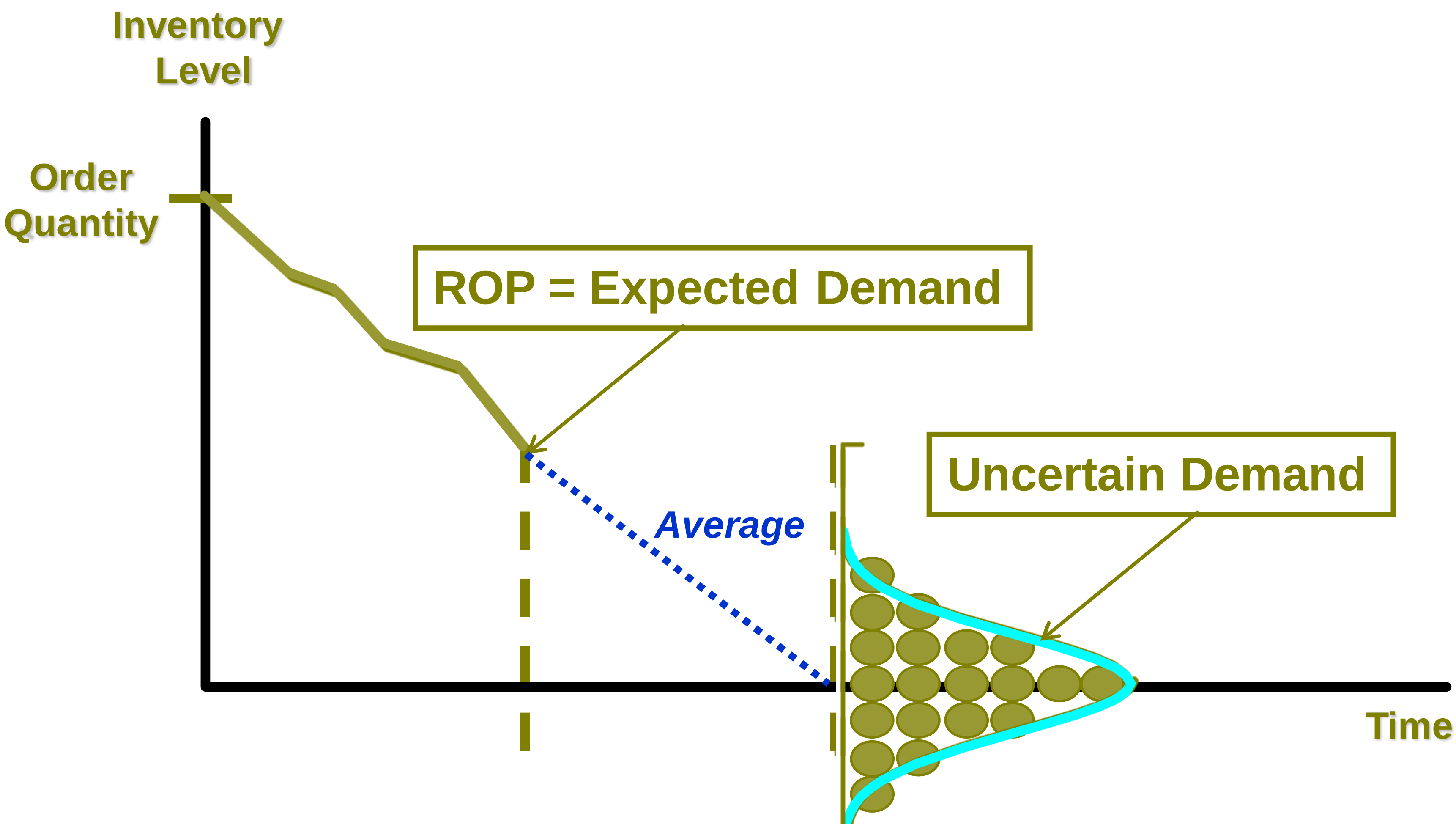
Actual Demand < Expected Demand



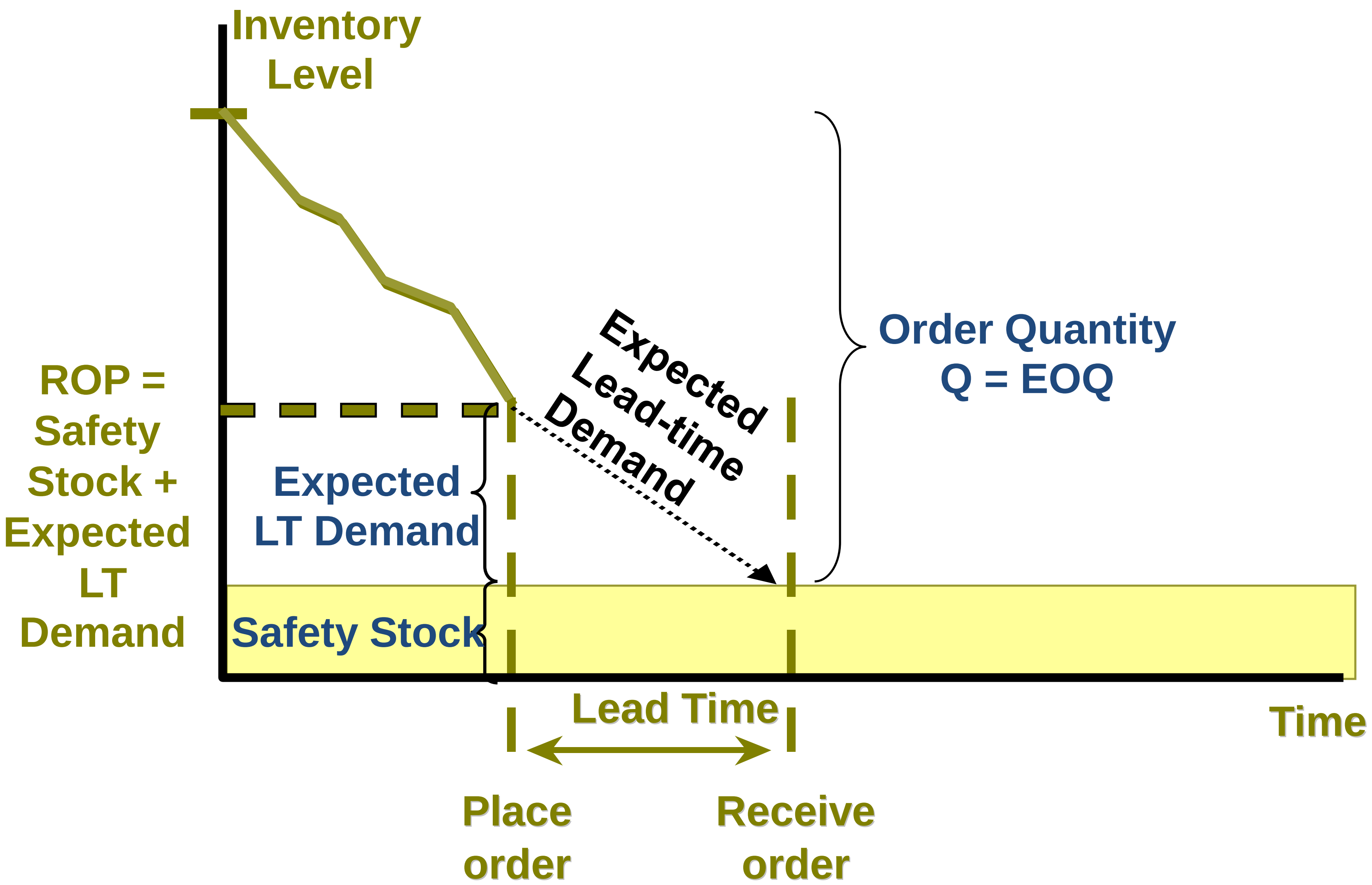
<u>**If Actual Demand > Expected, we Stock-Out**</u>



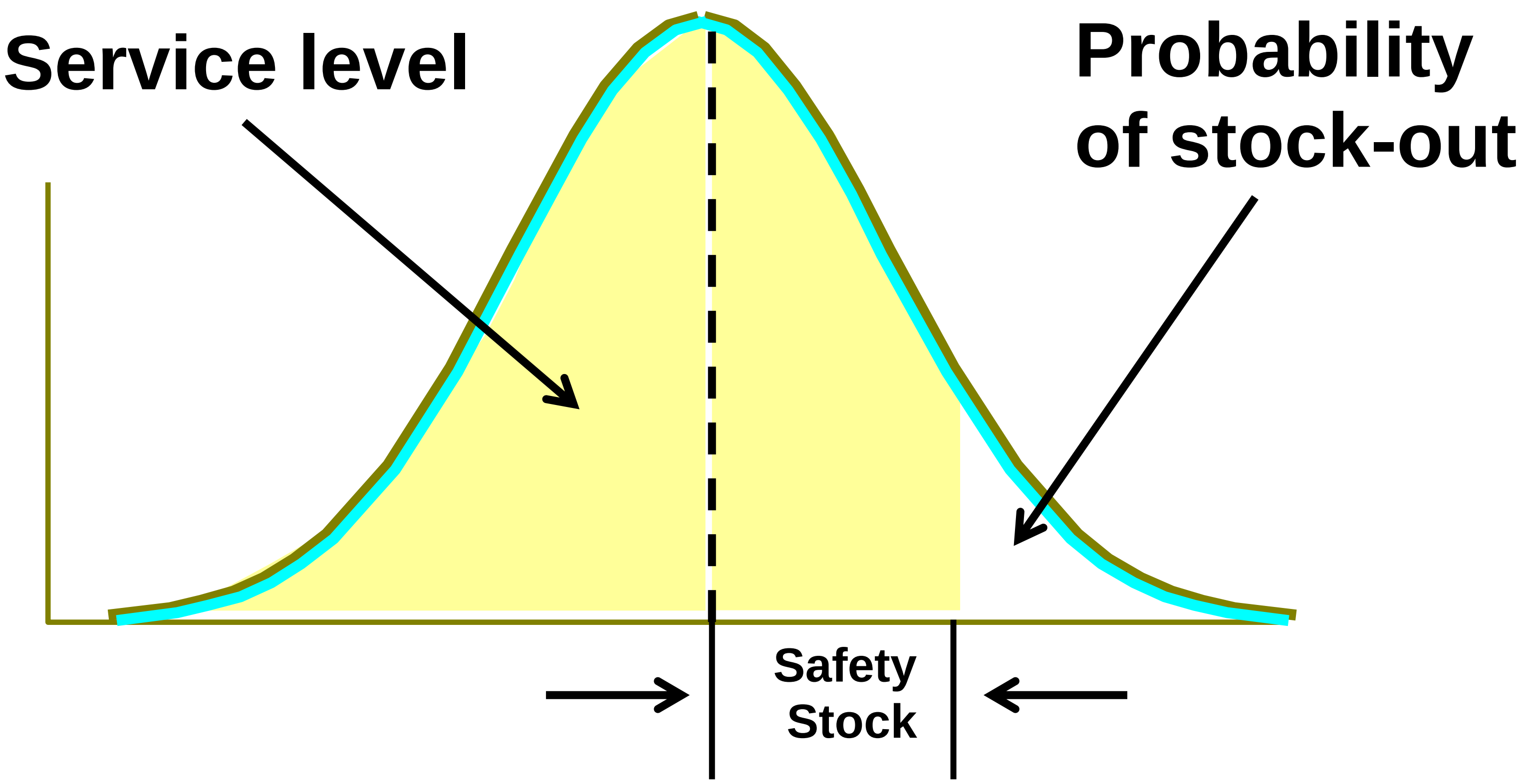
If ROP = expected demand, service level is 50%. Inventory left 50% of the time, stock outs 50% of the time.



To reduce stock-outs we add safety stock

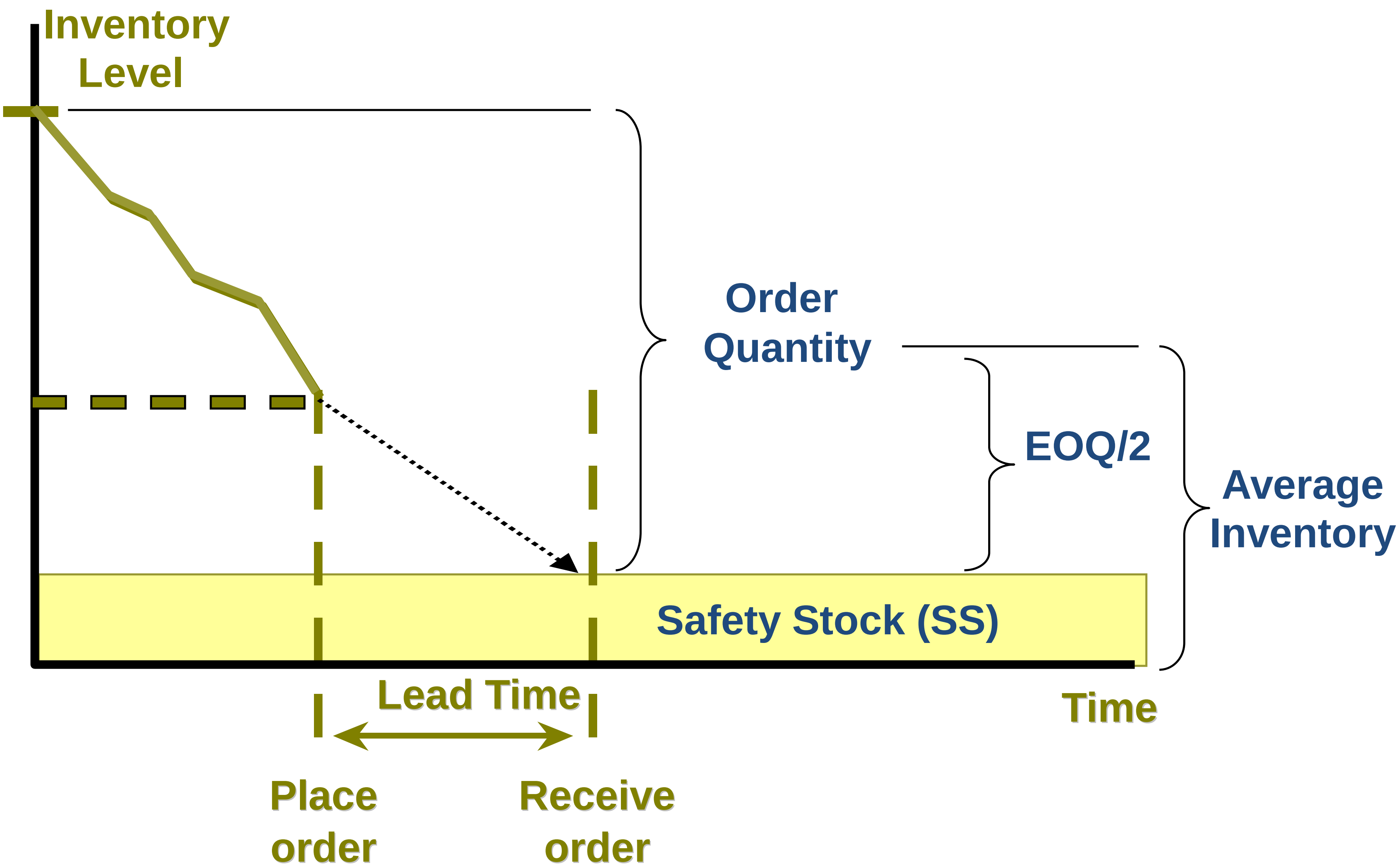


Decide what Service Level you want to provide
(Service level = probability of NOT stocking out)



Variance over multiple periods = the sum of the variances of each period (assuming independence) and ***Standard deviation over multiple periods is the square root of the sum of the variances, not the sum of the standard deviations!!!***

Average Inventory = (Order Qty)/2 + Safety Stock



Order quantity Q = $$EOQ = \sqrt{\frac{2SD}{H}}$$

To find ROP, determine the *service level* (i.e., the probability of NOT stocking out.)

- Find the *safety factor* from a *z*-table or from the graph.
- Find *std deviation in LT demand: square root law.*

$$std\ dev\ in\ LT\ demand = (std\ dev\ in\ daily\ demand)\sqrt{days\ in\ LT}$$

$$\sigma_{LT} = \sigma_D \sqrt{LT}$$

- Safety stock is given by: *SS = (safety factor)(std dev in LT demand)*
- Reorder point is: *ROP = Expected LT demand + SS*

Average Inventory is: *SS + EOQ/2*

COMPLETING THE CASE STUDY BY FINDING ROP – REORDER POINT

Back to the car lot… recall that the lead time is 10 days and the expected yearly demand is 5000. You estimate the standard deviation of daily demand to be $\sigma_d = 6$. When should you re-order if you want to be 95% sure you don't run out of cars?

Since the expected yearly demand is 5000, the expected demand over the lead time is 5000(10/365) = 137. The z-value corresponding to a service level of 0.95 is 1.65. So

$$ROP = 137 + 1.65\sqrt{10(36)} = 168$$

Order 548 cars when the inventory level drops to 168.

EOQ BASED QUANTITY DISCOUNT – AFTERMARKET VENDORS

$$TC_{QD} = \left(\frac{D}{Q}S\right) + \left(\frac{Q}{2}H\right) + PD$$

Same as the EOQ, except: Unit price depends upon the quantity ordered

Calculate the EOQ at the lowest price

Determine whether the EOQ is feasible at that price

- Will the vendor sell that quantity at that price?
- If yes, stop – if no, continue

Check the feasibility of EOQ at the next higher price

Continue until you identify a feasible EOQ

Calculate the total costs (including total item cost) for the feasible EOQ model

Calculate the total costs of buying at the minimum quantity required for each of the cheaper unit prices

Compare the total cost of each option & choose the lowest cost alternative

Any other issues to consider?

Annual Demand of Bearing Model TEX123 = 5000 units

Ordering cost = INR 49

Annual carrying charge = 20%

Unit price schedule:

Quantity	Unit Price
0 to 999	INR 5
1000 to 1999	INR 4.8
2000 and over	INR 4.75

QUANTITY DISCOUNT : STEP 1

$$Q_{P=INR4.75} = \sqrt{\frac{2\times 5{,}000\times 49}{0.2\times 4.75}} = 718 \;\; (not\ feasible)$$

$$Q_{P=INR4.80} = \sqrt{\frac{2\times 5{,}000\times 49}{0.2\times 4.80}} = 714 \;\; (not\ feasible)$$

$$Q_{P=INR5.00} = \sqrt{\frac{2\times 5{,}000\times 49}{0.2\times 5.00}} = 700 \;\; (feasible)$$

- Annual Demand of Bearing Model TEX123 = 5000 units

  Ordering cost = INR 49

  Annual carrying charge = 20%

Unit price schedule:

Quantity	Unit Price
0 to 999	INR 5
1000 to 1999	INR 4.8
2000 and over	INR 4.75

QUANTITY DISCOUNT : STEP 2

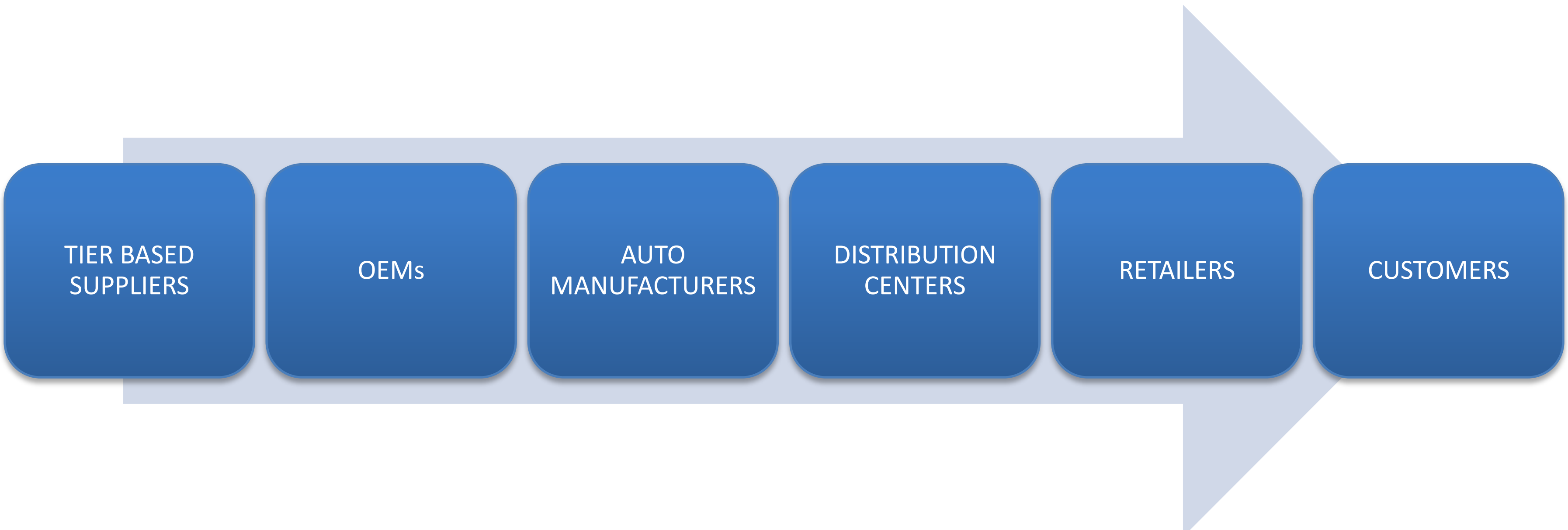
$$TC_{Q=700} = \frac{5,000}{700} \times 49 + \frac{700}{2} \times 0.2 \times 5.00 + 5.00 \times 5000 = INR\,25,700$$

$$TC_{Q=1000} = \frac{5,000}{1000} \times 49 + \frac{1000}{2} \times 0.2 \times 4.80 + 4.80 \times 5000 = \boxed{INR\,24,725}$$

FEASIBLE

$$TC_{Q=2000} = \frac{5,000}{2000} \times 49 + \frac{2000}{2} \times 0.2 \times 4.75 + 4.75 \times 5000 = INR\,24,822.50$$

The supply chain structure of the automobile industry under study consists of four echelons viz. Suppliers, Manufacturing plants, Distribution Centres (DCs) and Customers .



The strategic level modelling is the long term planning which decides the basic configuration of the supply chain and determine the optimum number of the suppliers out of the approved list, plants and distribution centres to keep under operation and the assignment of customers to distribution centres with an objective of minimizing the total cost of supply chain.

ROLE OF CORPORATE HQ/OFFICE IN MILP MODEL

The MILP strategic level modeling is the long term planning which decides the basic configuration of the supply chain and determine the optimum number of the suppliers out of the approved list, plants and distribution centres to keep under operation and the assignment of customers to distribution centres with an objective of minimizing the total cost of supply chain.

All the supply chain activities are controlled by the corporate office using a network of information flow between the corporate office and various echelons. The industry under investigation receives the customer orders at its corporate office. The customer orders primarily include the three key information i.e. the quantity required, delivery dates and penalty clause for late delivery.

All customers' demands are aggregated and the annual production distribution planning is done by the corporate office. At the strategic level decision, the corporate office decides the suppliers and the allocation of the quantities of the raw materials to the selected suppliers, optimum production quantity allocation to various manufacturing plants, the assignment of the distribution centres to the manufacturing plants and also the assignment of the customers to the distribution centres.

ASSUMPTIONS MADE IN THE MILP MODEL

- It has been assumed that production of one unit of a product requires one unit of plant capacity, regardless of type of product. The similar assumption is adopted for distribution centres also.

- The components/raw materials procurement and finished product inventory at stores follow a continuous-review inventory control policy.

- The demand for the finished products is deterministic and the demand rate is constant over time horizon under study. The model considers the demands generated at each distribution centre independently from each other.

- The processing time, which is the time to perform the operation, is a linear function of the quantity of the products produced.

- Transportation times of components/raw materials, subassemblies and finished products between the stages of the production cycle have been assumed to be same in the present model.

- A type of product can be produced in more than one plant, and each plant can produce at least one type of product.

- The transportation time, waiting time, setup time and production processing times have been assumed to be fixed.

- The plants usually hold raw material stock to maintain production.

MILP – Mixed Integer Linear Programing Model (NOTATIONS)

NOTATIONS	DESCRIPTION OF NOTATIONS
T	Index on product, where t = 1…….T, T is number of types of products produced
Z	Index on manufacturing plant, where z = 1…….Z, Z is the number of manufacturing plants
D	Index on distribution centre, where d = 1…….D, D is the number of distribution centres
C	Index on customer, where c = 1…….C, C is the number of customers
S	Index on supplier, where s = 1…….S, S is the number of suppliers
B (d)	Binary variable for distribution centre
B (dc)	Binary variable for distribution centre 'd' serving customer 'c'
B (z)	Binary variable for plant 'z'
CP (z)	Production capacity of plant 'z' (number of products/year)
D (tc)	Demand of customer 'c' for product 't' (number of products/year)

MILP – Mixed Integer Linear Programing Model (NOTATIONS)

NOTATIONS	DESCRIPTION OF NOTATIONS
F (d)	Fixed cost of distribution centre ‘d’ (Rupees/year)
F (z)	Fixed cost of plant ‘z’ (Rupees/year)
Max. PV (tz)	Maximum production capacity for product ‘t’ at plant ‘z’ (number of products/year)
Max. TP (d)	Maximum throughput capacity of distribution centre ‘d’ (number of products per year)
Min. PV (tz)	Minimum production volume required for product ‘t’ at plant ‘z’ to keep the plant operational (number of products/year)
Min. TP (d)	Minimum throughput required at distribution centre ‘d’ to keep the distribution centre operational (number of products/year)
PC (ms)	Unit cost of component/raw material ‘m’ of supplier ‘s’ (Rupees per component or Rupees per Kg)
Q (tz)	Quantity of product ‘t’ produced at plant ‘z’ (number of products per year)
Q (tzd)	Quantity of product ‘t’ shipped from plant ‘z’ to distribution centre ‘d’ (number of products/year)

MILP – Mixed Integer Linear Programing Model (NOTATIONS)

NOTATIONS	DESCRIPTION OF NOTATIONS
Q (msz)	Quantity of component/raw material 'm' shipped from supplier 's' to plant 'z' (number of products/year)
UCT (td)	Unit throughput cost (handling and inventory)of product 't' at distribution centre 'd' (Rupees/product)
UPC (tz)	Unit production cost for product 't' at plant 'z' (Rupees/product)
UTC (tdc)	Unit transportation cost of product 't' from distribution centre 'd' to customer 'c' (Rupees per product)
UTC (tzd)	Unit transportation cost of product 't' from plant 'z' to distribution centre 'd' (Rupees per product)
UTC (msz)	Unit transportation cost of component/raw material 'm' from supplier 's' to plant 'z'(Rupees per unit of component/raw material)
w(1), w(2)...	Weight factors for plant and distribution centre volume flexibility
X	Total cost of entire supply chain (Rupees/year)

MILP – Mixed Integer Linear Programing Model (EQUATIONS)

The objective function of the strategic model is to minimize the total cost of entire supply chain. The total cost of the supply chain includes the cost of raw materials, various transportation costs of components/raw materials and finished products between various echelons and various fixed and variable costs associated with the plants and distribution centres. The objective function which is the sum of various costs is represented in mathematical form as:

Min X = Cost 1+ Cost 2 + Cost 3 + Cost 4 + Cost 5 + Cost 6 + Cost 7 + Cost 8

COST 1 = *Total cost of components/raw materials supplied by suppliers*

= Σ { Unit cost of component/raw material 'm' of supplier 's' (Rupees per component or Rupees per Kg) **X** Quantity of component/raw material 'm' shipped from supplier 's' to plant 'z' (number of products/year) }

$$= \sum_{msz} \left(PC(ms) \times Q(msz) \right)$$

COST 2 = *Transportation cost of components/raw materials from suppliers to the manufacturing plants.*

= $\sum$ { Transportation cost of components/raw materials from suppliers to the manufacturing plants **X** Quantity of component/raw material 'm' shipped from supplier 's' to plant 'z' (number of products/year) }

$$= \sum_{msz} \left(UTC(msz) \times Q(msz) \right)$$

COST 3 = *Fixed cost associated with plant operations*

= $\sum$ { Fixed cost of plant 'z' (Rupees/year) **X** Binary variable for plant 'z' }

$$= \sum_{z} \left(F(z) \times B(z) \right)$$

MILP – Mixed Integer Linear Programing Model (EQUATIONS)

COST 4 = *Variable costs associated with plant operations*

= $\sum$ { Unit production cost for product ‘t’ at plant ‘z’ (Rupees/product) **X** Quantity of product ‘t’ produced at plant ‘z’ (number of products per year) }

$$= \sum_{tz} \left(UPC(tz) \times Q(tz) \right)$$

COST 5 = *Fixed cost associated with distribution centre operations*

= $\sum$ { Fixed cost of distribution centre ‘d’ (Rupees/year) **X** Binary variable for distribution centre }

$$= \sum_{d} \left(F(d) \times B(d) \right)$$

MILP – Mixed Integer Linear Programing Model (EQUATIONS)

COST 6 = *Variable cost associated with distribution centre operations*

= $\sum$ { Unit throughput cost (handling and inventory)of product 't' at distribution centre 'd' (Rupees/product) **X** Demand of customer 'c' for product 't' (number of products/year) **X** Binary variable for distribution centre 'd' serving customer 'c' }

$$= \sum_{tdc} \left(UCT(td) \times D(tc) \times B(dc) \right)$$

COST 7 = *Transportation cost of products from plants to the distribution centres*

= $\sum$ { Unit transportation cost of product 't' from plant 'z' to distribution centre 'd' (Rupees per product) **X** Quantity of product 't' shipped from plant 'z' to distribution centre 'd' (number of products/year) }

$$= \sum_{tzd} \left(UTC(tzd) \times Q(tzd) \right)$$

MILP – Mixed Integer Linear Programing Model (EQUATIONS)

COST 8 = *Transportation cost of products from distribution centres to customers*

$$= \sum \left\{ \text{Unit transportation cost of product 't' from distribution centre 'd' to customer 'c' (Rupees per product) } \mathbf{X} \text{ Demand of customer 'c' for product 't' (number of products/year) } \mathbf{X} \text{ Binary variable for distribution centre 'd' serving customer 'c'} \right\}$$

$$= \sum_{tdc} \left(UTC\,(tdc) \times D\,(tc) \times B(dc) \right)$$

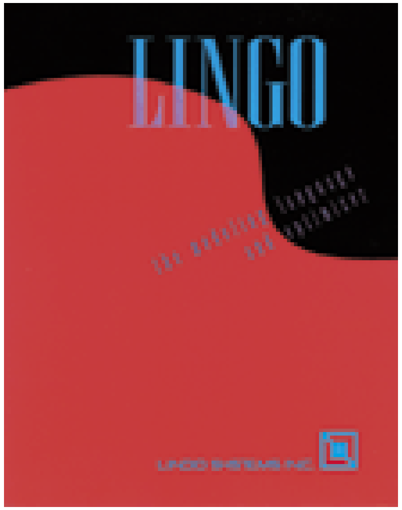
Min. X

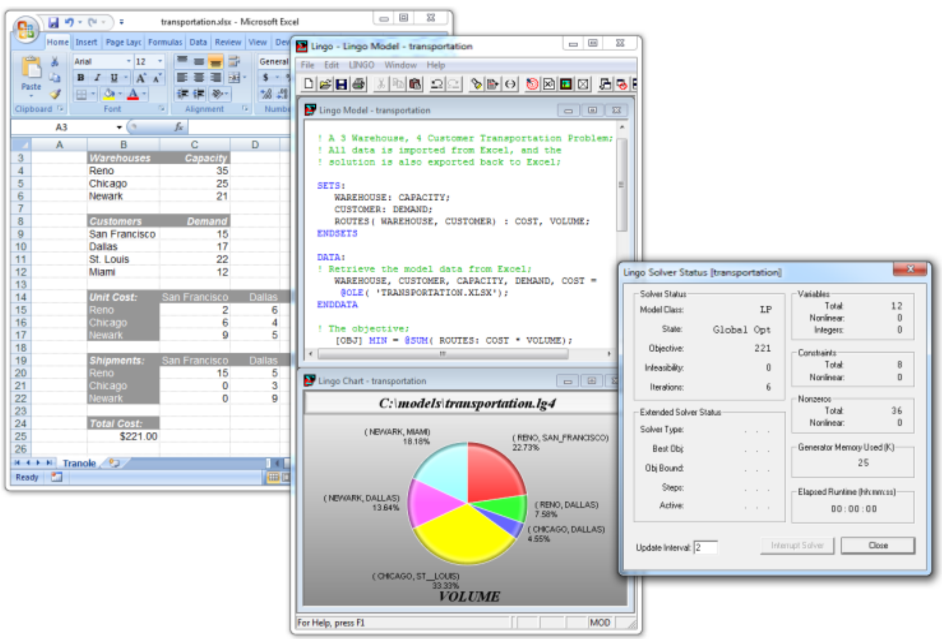
$$= \sum_{msz} \left(PC(ms) \times Q\,(msz) \right) + \sum_{msz} \left(UTC\,(msz) \times Q\,(msz) \right)$$

$$+ \sum_{z} \left(F(z) \times B(z) \right) + \sum_{tz} \left(UPC\,(tz) \times Q\,(tz) \right) + \sum_{d} \left(F\,(d) \times B\,(d) \right)$$

$$+ \sum_{tdc} \left(UCT(td) \times D(tc) \times B(dc) \right) + \sum_{tzd} \left(UTC\,(tzd) \times Q\,(tzd) \right) + \sum_{tdc} \left(UTC\,(tdc) \times D\,(tc) \times B(dc) \right)$$

MILP SOLUTION BY LINGO 14.0





The use of conventional tools for solving the MILP problem is limited due to the complexity of the problem and the large number of variables and constraints, particularly for realistically sized problems.

LINGO an Operations Research software tool is used to solve the strategic MILP model for supply chain of the said automobile industry. LINGO solves the problems by using branch and bound methodology.

The main purpose of LINGO is to allow a user to quickly input a model formulation, solve it, assess the correctness or appropriateness of the formulation based on the solution, quickly make minor modifications to the formulation, and repeat the process.

LINGO features a wide range of commands, any of which may be invoked at any time. LINGO optimization model has two attributes: objective function of problem and constraints of problem.

LIMITATIONS OF MILP MODEL

- The model has not considered the global considerations like import/export regulations, duty rates and exchange rates etc.

- The model will be applicable in supply chains involved in manufacturing and distribution industry – ONLY, because input factors changes from industries to industries.

- Modeling is not having the flexibility of supplying the finished products from manufacturing plants to the customers directly.

- Modeling is unable to handle the risk factors at various stages of the supply chains.

- Preference of various supply chain members have not been considered in the modeling.

FINAL OUTPUT OF MILP MODEL

$$\text{Min. X} = \sum_{msz} \left(PC(ms) \times Q(msz) \right) + \sum_{msz} \left(UTC(msz) \times Q(msz) \right) + \sum_{z} \left(F(z) \times B(z) \right) + \sum_{tz} \left(UPC(tz) \times Q(tz) \right) + \sum_{d} \left(F(d) \times B(d) \right) + \sum_{tdc} \left(UCT(td) \times D(tc) \times B(dc) \right) + \sum_{tzd} \left(UTC(tzd) \times Q(tzd) \right) + \sum_{tdc} \left(UTC(tdc) \times D(tc) \times B(dc) \right)$$

After giving the above as input, the strategic model, given by above equation is able to give the following outputs:

- Quantities of products produced at the plants.
- Quantities of raw materials shipped from the suppliers to the plants.
- Quantities of products shipped from plants to the distribution centers.
- Quantities of products shipped from the distribution centers to the customers.
- Total volume flexibility.
- Total cost of the entire supply chain.

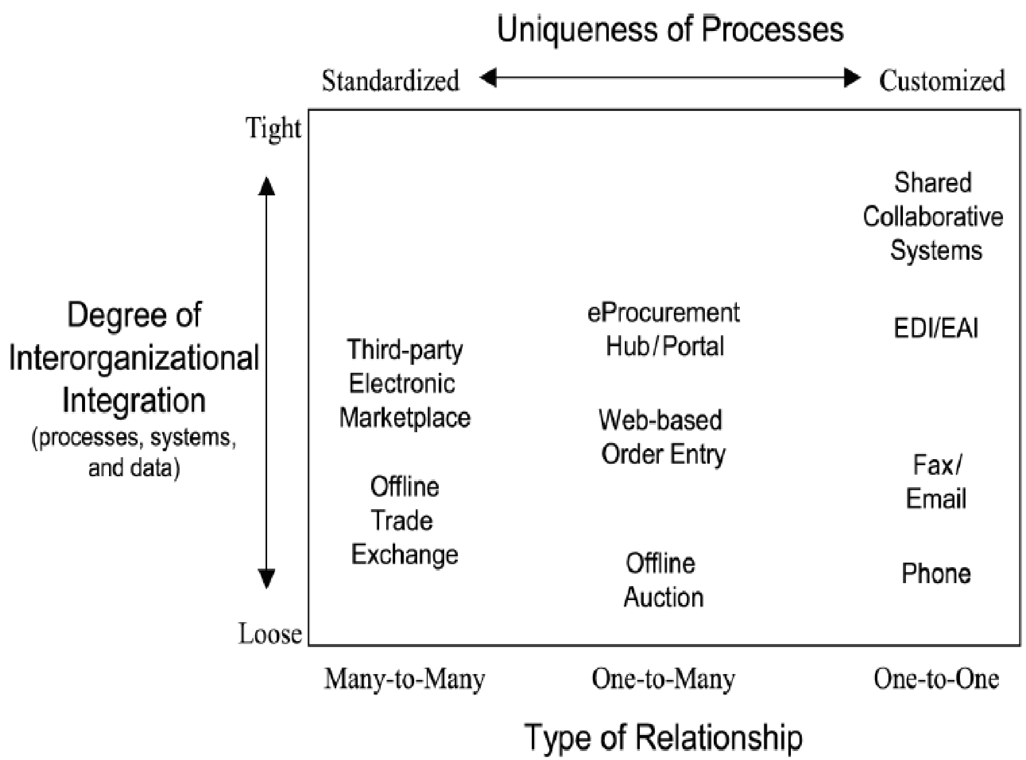
COLLABORATION IN SCM

Inter-organizational Systems for Supply Chain Collaboration can be classified into sub-systems that support varying degrees of supply chain co-ordination and collaboration into three major types:

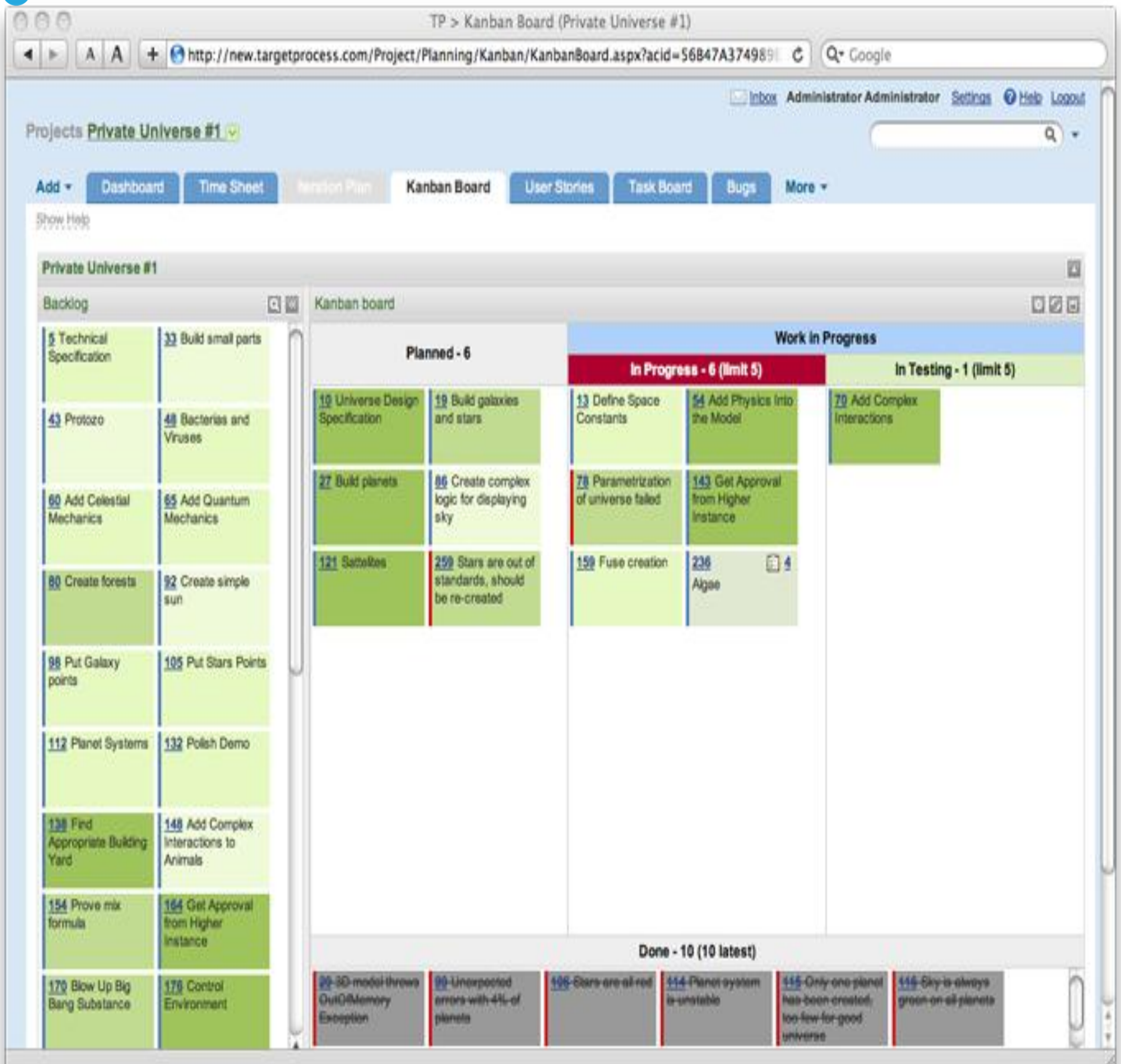
1. message-based systems that transmit information to partner applications using technologies such as fax, e-mail EDI or eXtensible Markup Language (XML) messages.

2. Electronic procurement hubs, portals or market places that facilitates purchasing of goods and services from electronic catalogues, tenders and auctions.

Figure 1 Interorganizational systems for supply chain collaboration



3. Shared collaborative SCM systems that include collaborative planning, forecasting and replenishment capabilities in addition to electronic procurement functionality.



看板 – Kanban literally means "visual card," "signboard," or "billboard."

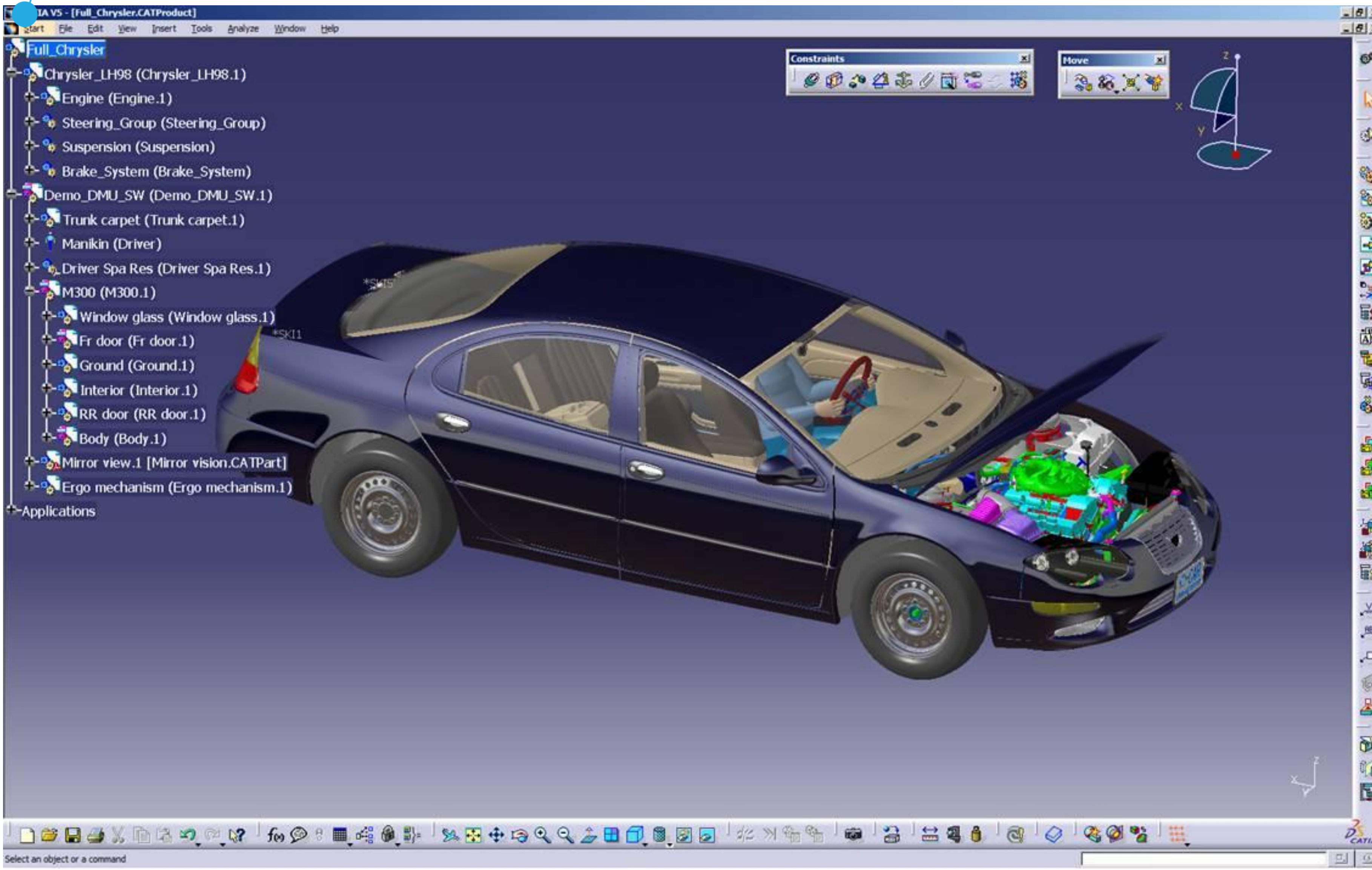
Toyota originally used Kanban cards to limit the amount of inventory tied up in "work in progress" on a manufacturing floor.

Not only is excess inventory waste, time spent producing it is time that could be expended elsewhere.

Kanban cards act as a form of "currency" representing how WIP is allowed in a system.

WORK FLOW – A TYPICAL KANBAN BOARD

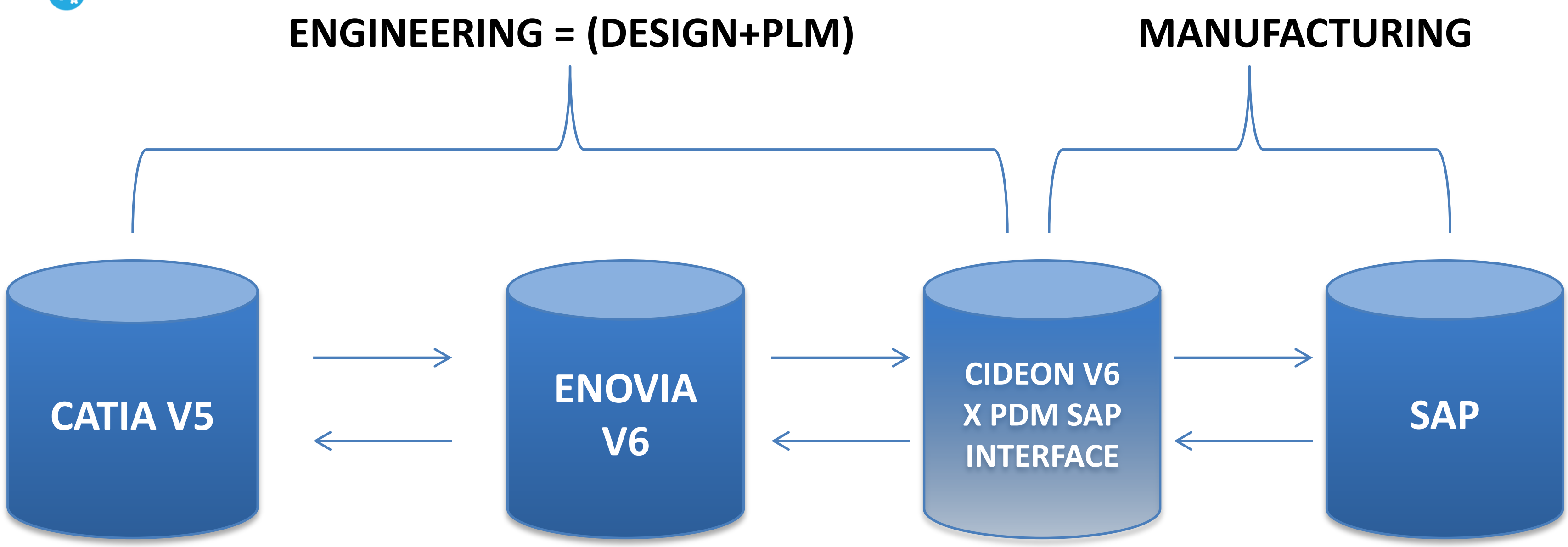
CATIA V5 – INTEGRATED DESIGN PLATFORM

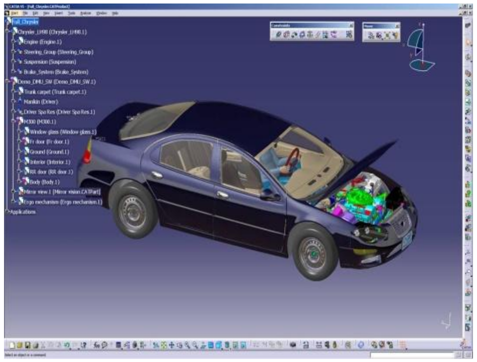


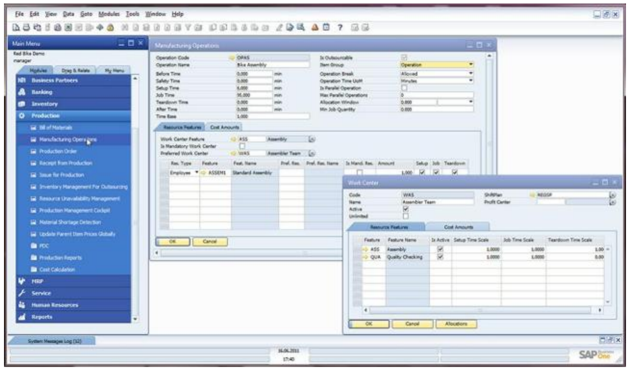
ENOVIA 3D Live: Virtual Product LifeCycle Management

ENOVIA is for collaborative management and global life cycle (PLM) with the historical VPM (Virtual Product Management) and its successor VPLM as well as DMU which came from the SmartTeam and MatrixOne acquisitions.

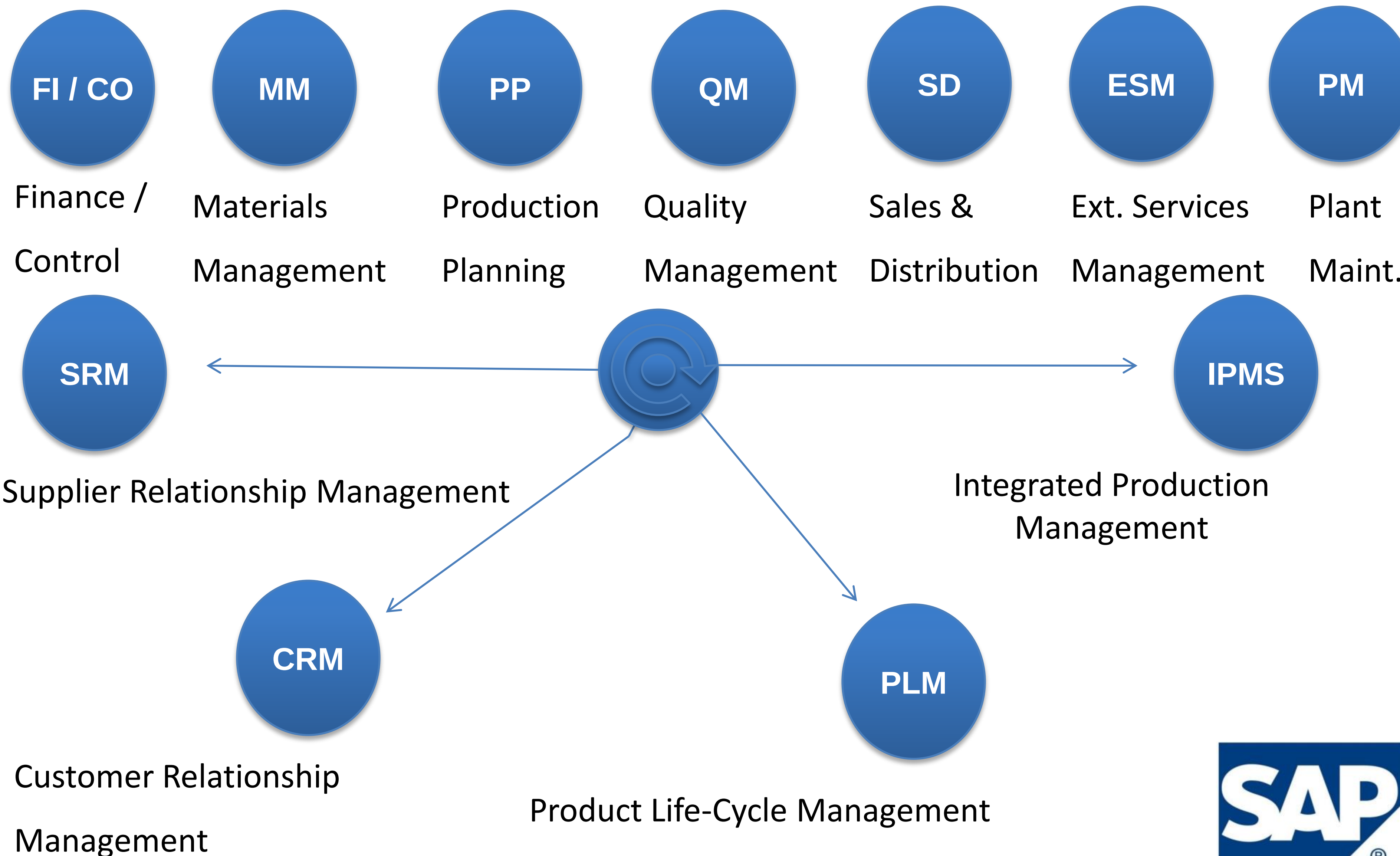
ENOVIA provides a framework for collaboration for Auto Company's PLM software. It is an online environment that involves creators, collaborators and consumers in the product lifecycle.


ENGINEERING = (DESIGN+PLM)
MANUFACTURING
CATIA V5
ENOVIA V6
CIDEON V6 X PDM SAP INTERFACE
SAP

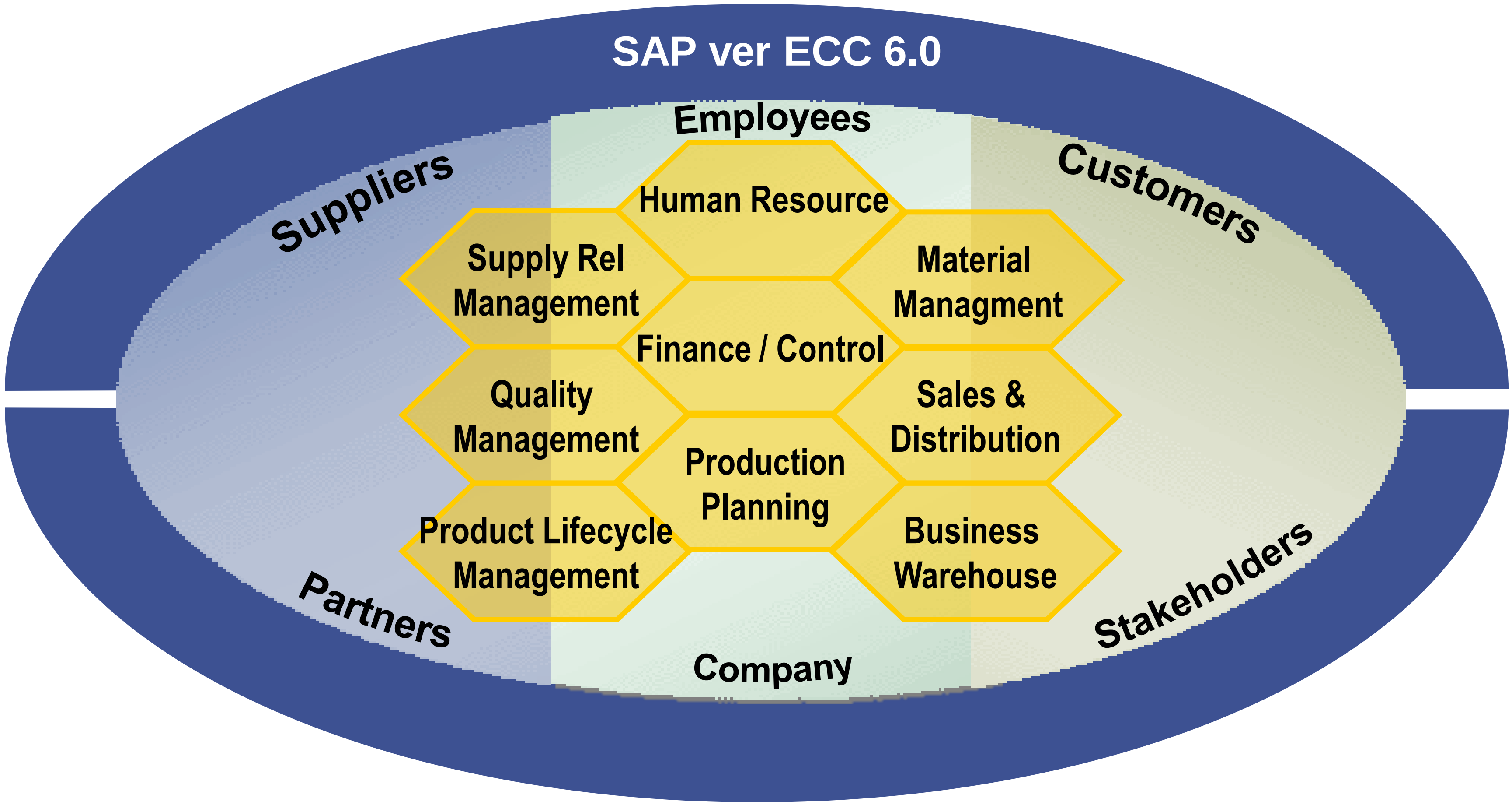




TYPICAL SAP MODULES IN AUTOMOTIVE ASSEMBLY PLANT



SAP ECOSYSTEM



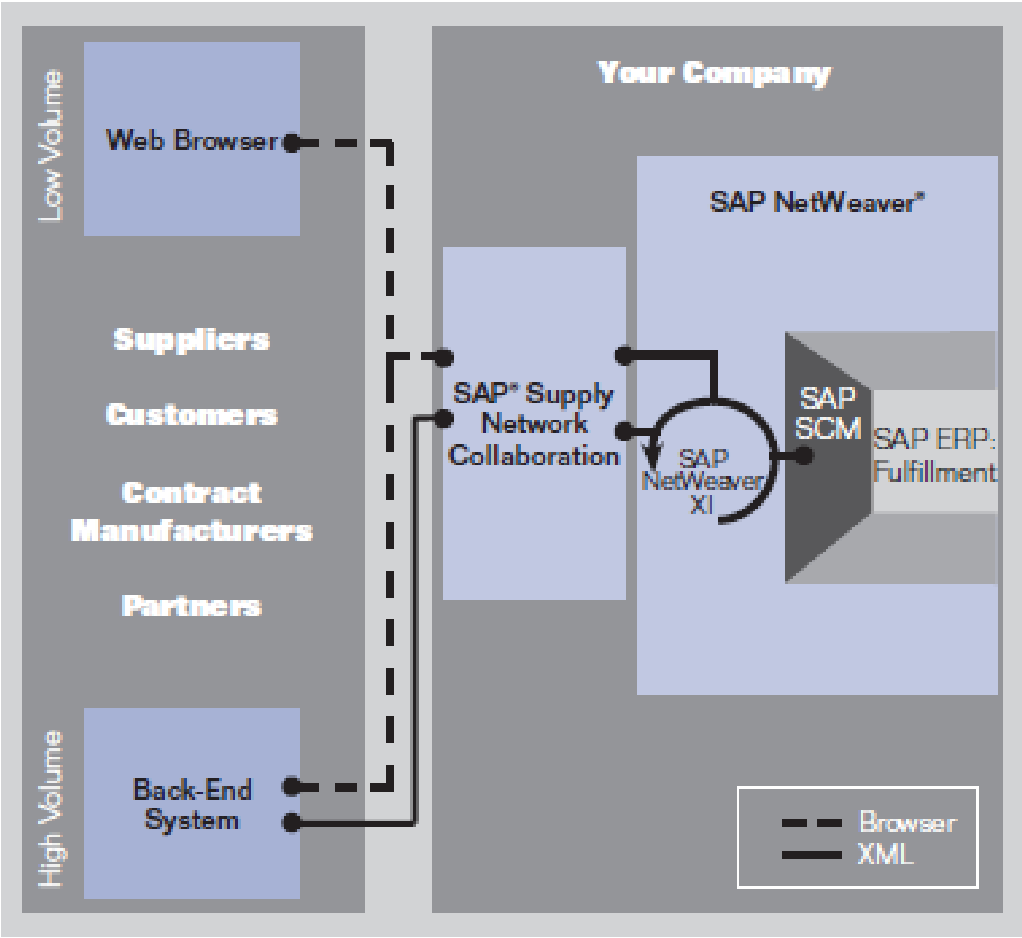


Figure 3: SAP Supply Network Collaboration Powered by the SAP NetWeaver Platform

The SAP NetWeaver® platform empowers the collaborative functionalities of SAP SCM. It allows you to flexibly and rapidly deploy, execute, monitor, and refine the software that enables your business processes and strategies. With SAP NetWeaver, you can deploy innovative business processes across the organization while making use of your existing software and systems.

SAP NetWeaver provides end-to-end process integration by enabling application-to-application processes and business to- business processes, performing business process management and business task management and enabling platform interoperability.

CONCLUSION

A supply chain is defined as a set of relationships among suppliers, manufacturers, distributors, and retailers that facilitates the transformation of raw materials into final products. Although the supply chain is comprised of a number of business components, the chain itself is viewed as a single entity.

In construction and identification of this integrated logistics model, we identified the primary processes as logistics processes concerning all the participants of the integrated value chain. It is reasonable to consider transfers and transaction of products and information as primary processes, when logistics functions are in focus

It shares operating and financial risks by having these suppliers build with their capital and operate their employees, facilities that are usually part of the OEM's span of control. They share the profits with Automotive Manufacturers when demand is strong because these suppliers receive a payment per unit that covers variable material and labor costs and contributes to overhead and profit. When demand is high, this relationship is profitable for all. When the economy is slumping, they share the loss with Automotive Manufacturers because Automotive Manufacturers buys only what it needs to meet consumer demand. Automotive Manufacturers has less invested capital and therefore lower fixed costs.

CONCLUSION

Even though Automotive Manufacturers is at the end of the assembly process, it coordinates the supply chain by providing demand information to not only first tier but second, third, and fourth tier suppliers. This process of spreading information about product demand often, quickly, and simultaneous provides the supply chain members with up-to-date information that greatly reduces/eliminates fluctuation in demand usually seen by suppliers, commonly known as the bullwhip effect .

Sequence Part Delivery and Pay As Built systems are commonly used by OEMs and their supply chains to simplify transactions, reduce transportation cost, slash inventory, and improve efficiency. These systems work very well when the components being shipped are bulky and take much inventory space, can be easily damaged, and are expensive to ship

Just In Time (JIT) concept can also be incorporated to improve further the integrated logistics model which can be considered as a future work.

ABOUT AUTHOR

Rahul Guhathakurta

Retail | FMCG | E-commerce | Automotive | SCM

Ahmedabad, Gujarat, India | Automotive

Current	TEXSPIN Bearings Limited
Previous	Claris LifeSciences Group Company - Dairy Division, Wagh Bakri Tea Group, Future Innoversity, Ahmedabad Campus
Education	GoG-AMA Centre for International Trade

Complete your profile   Edit Profile

500+ connections

Copyright Guidelines

DO

1. Make a copy of backups on your hard-drive or network
2. Use this presentation for personal, educational or professional purpose
3. Print as hand-outs for your audience or shared groups
4. Embed this power-point and integrate with your website
5. Use it to make your own presentation but do give due credit

DON'T

1. Resell or distribute my work as your own'
2. Make it available for download on a portal
3. Edit of modify this presentation and claim/pass off as your own work

Email: rahul.gt@aiesec.net / rahulogy@gmail.com

Cell Number/WhatsApp/Viber : +91-9978066443, **Skype**: rahul.gt

Webpage: http://about.me/rahul.guhathakurta, **SlideShare:** http://www.slideshare.com/rahulogy

- ***Supply Chain Collaboration: The Key to Success in a Global Economy*** *by SAP*
- ***Supply Chain Collaboration Alternatives: Understanding the expected costs and benefits*** *– Tim McLaren, Milena Head, Yufei Yuan*
- ***A Strategic Level Model for Supply Chain of an Automotive Industry: Formulation and Solution Approach*** *by Dr. Amit Kumar Gupta, Dr. O.P. Singh, Dr. R.K. Garg*
- ***A Structured Approach to Optimize Outbound Supply Chain Cost in an Automotive Industry*** *by C. P. Aruna Kumari , Y. Vijaya Kumar*
- ***Damien Power, titled, "Adoption of Supply Chain Management Enabling Technologies: Comparing Small, Medium and Larger Organizations***", *Journal of Operations and Supply Chain Management (1), Volume 1, Number 1, May 2008, pp 31-42.*
- ***Aguilar-Savén, R.S., 2004. Business Process Modelling: Review and Framework****. Int. J. Production Economics, 90, 129-149.*
- *Kejia Chen, Ping Ji* ***"A mixed integer programming model for advanced planning and sched****uling" European Journal of Operations Research, 181(2007), 515-522*
- *Aslam T., Ng A.H.C., 2010.* ***Multi-objective Optimization for Supply Chain Management: a Literature Review and New Development****. SCMIS 8th International Conference on Supply Chain Management and Information Systems, 6-9 October 2010, 1-8*
- ***Supply Chain Operations Reference (SCOR®) model 10.0*** *by SCC*
- ***Managing Supply Networks in the Automotive Industry: Integration of OEM, Suppliers and Logistic Service Providers*** *by Bernd Hellingrath*
- ***The Aftermarket in the Automotive Industry****-Capgemni Consulting*
- ***Supply Chain Design and Analysis: Models and Methods*** *by Benita M. Beamon, University of Washington*
- *Bhatnagar, Rohit, Chandra Pankaj, and Suresh K. Goyal, 1993.* ***Models for Multi-Plant Coordination****, European Journal of Operational Research, 67: 141-160.*
- *Chen, Fangruo, 1997.* ***Decentralized Supply Chains Subject to Information Delays (formerly The Stationary Beer Game),*** *Graduate School of Business, Columbia University, New York, NY.*
- *Clark, A.J. and H. Scarf, 1962.* ***Approximate Solutions to a Simple Multi- Echelon Inventory Problem****, in K.J. Arros, S. Karlin, and H. Scarf (eds.),* ***Studies in Applied Probability and Management Science****, pp. 88-110, Stanford, CA: Stanford University Press.*
- *Cohen, Morris A. and Sanqwon Moon, 1990.* ***Impact of Production Scale Economies, Manufacturing Complexity, and Transportation Costs on Supply Chain Facility Networks****, Journal of Manufacturing and Operations Management, 3: 269- 292.*
- ***North American automotive supplier supply chain performance study*** *BY PwC*
- ***An Analysis of Automobile Demand*** *by Øyvind Thomassen Exeter College University of Oxford MPhil thesis in Economics Trinity term*
- *Caplin, A., and B. Nalebuff (1991): "****Aggregation and Imperfect Competition: On the Existence of Equilibrium,"*** *Econometrica, 59(1), 25–59.*