Strategic Inventory Placement Model: Intent

- **Tactical model to determine the amount and positioning of safety stocks in supply chains**
- **Tactical model to support supply chain improvement teams**
- **Simple model, easily accessible, runs on PC, understandable inputs/outputs**
- **http://web.mit.edu/lfmrg3/www/**

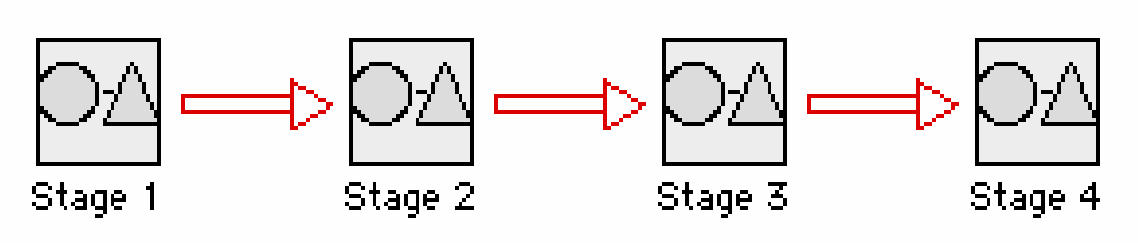
Assumptions

- **Supply chain modeled by an acyclic graph**
- **Deterministic processing time for each stage**
- **No capacity constraints**
- **Deterministic yield**
- **Periodic review, base stock control for each stage (no lot sizing)**

Assumptions

- **Fixed service time between stages where service time is the decision variable**
- **Each stage quotes same service time to all adjacent downstream stages**
- **Stationary, bounded demand process for each end item**
- **Each stage provides 100% service**

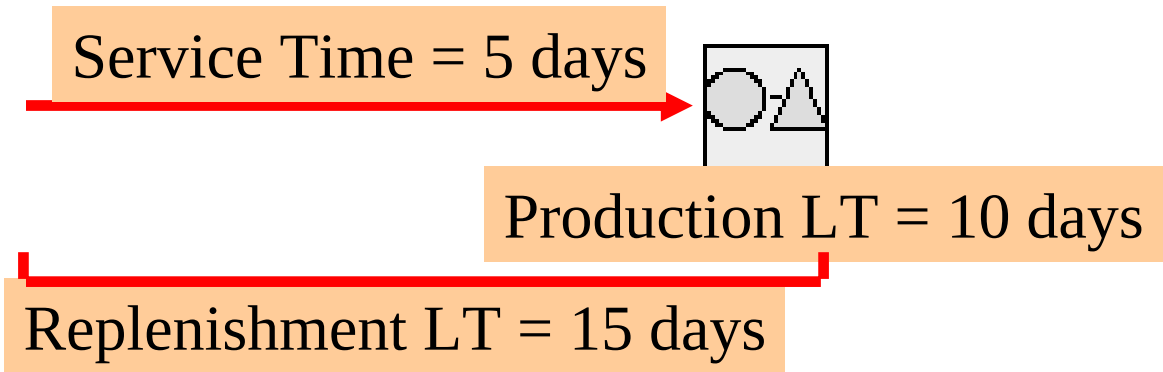
Model Inputs



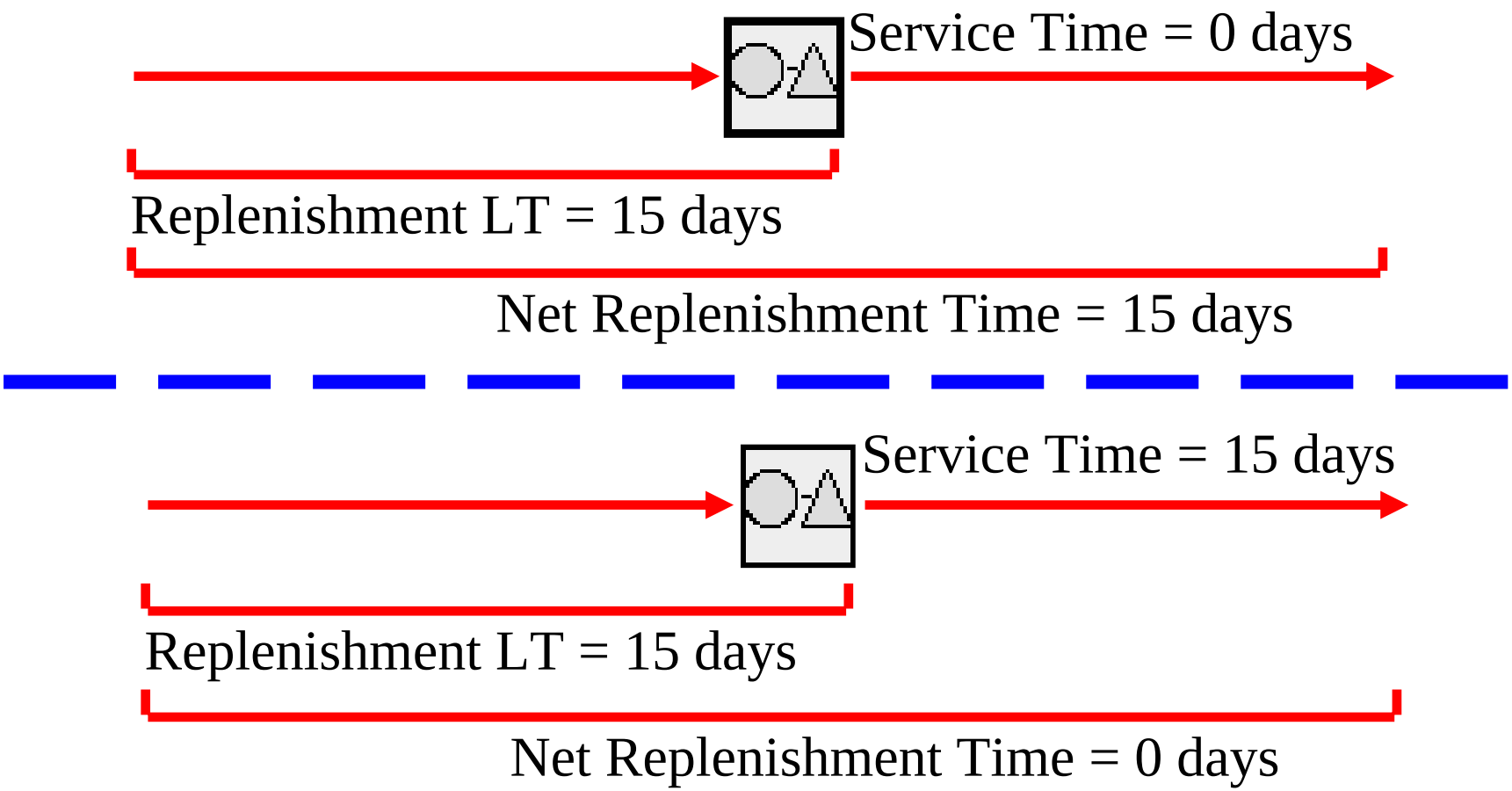
- **Production (procurement) lead-time**
  - **The time spent at a stage; this includes the processing time and waiting time**
- **Service-time (decision variable)**
  - **The delivery time that a stage quotes to its customer**
- **Cost added**

Replenishment Lead-Time

- **Time required to replenish a part once a production request has been made**
- **This equals the service-time quoted to the stage plus the stage's production lead-time**



Net Replenishment Time



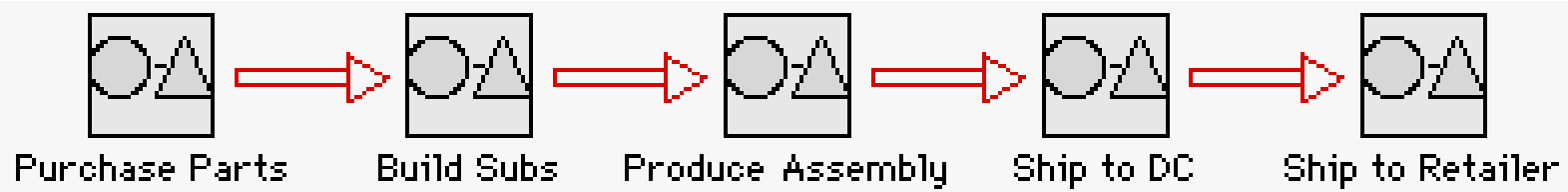
Net Replenishment Time

- **Net replenishment time equals the replenishment lead-time minus the service-time at stage**
- **Base stock at each stage set to the maximum demand over net replenishment time**
- **Safety stock equals base stock minus average demand over the net replenishment time**

Example Demand Data

Net Repl. Time	Maximum Demand	Expected Demand	Safety Stock
0	0	0	0
1	53	20	33
2	87	40	47
3	117	60	57
4	146	80	66
5	174	100	74
6	201	120	81
7	227	140	87
8	253	160	93
9	279	180	99
10	304	200	104
12	354	240	114
13	379	260	119
14	403	280	123
15	427	300	127
16	452	320	132
17	476	340	136
18	500	360	140
19	523	380	143
20	547	400	147

Example I - All Stages Stock



Prod LT	**20**	**5**	**3**	**1**	**3**
Cost Added	**20**	**25**	**45**	**10**	**10**
Service Time	**0**	**0**	**0**	**0**	**0**

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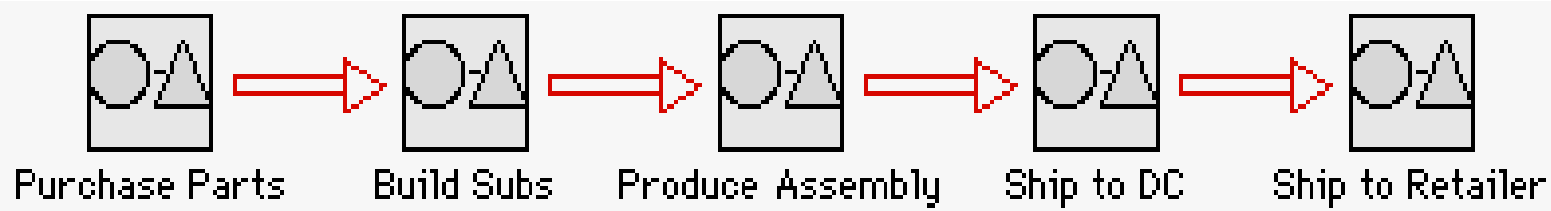

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Cost Added	**20**	**25**	**45**	**10**	**10**
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Replen LT	**20**	**5**	**3**	**1**	**3**
Net Rep LT	**20**	**5**	**3**	**1**	**3**

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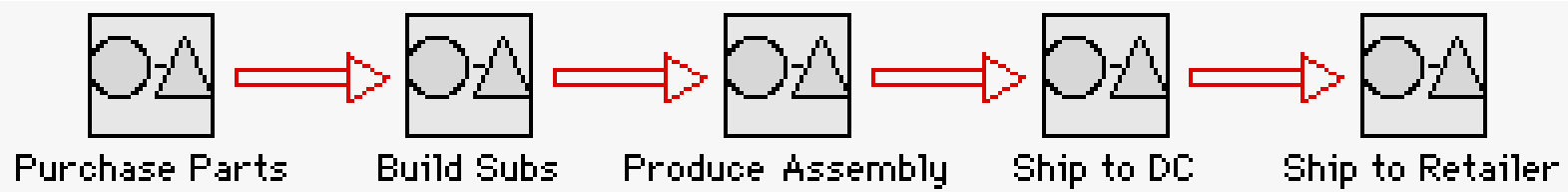

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Net Rep LT	**20**	**5**	**3**	**1**	**3**
Safety Stock	**147**	**74**	**57**	**33**	**57**

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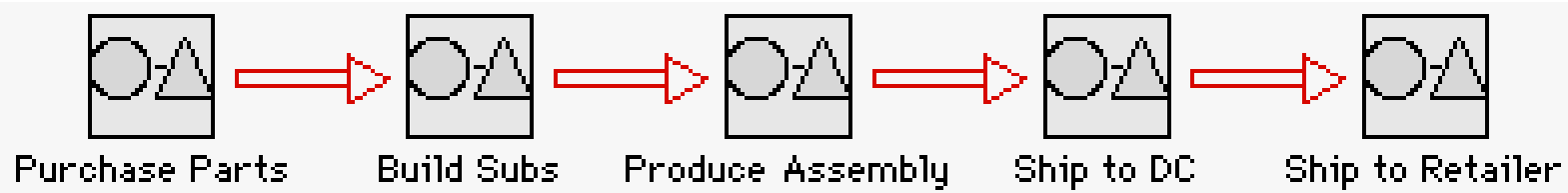
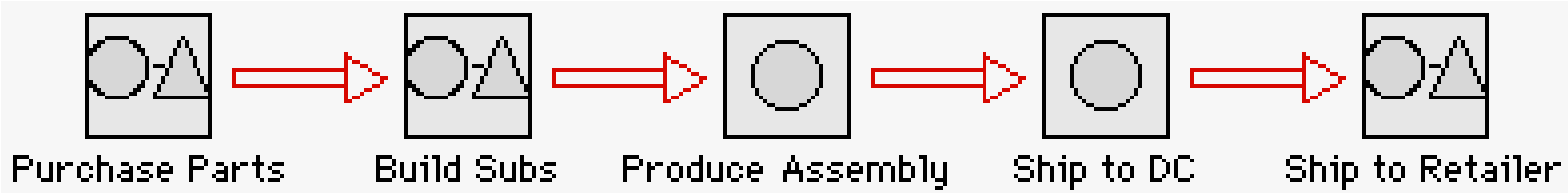


Prod LT	**20**	**5**	**3**	**1**	**3**
Cost Added	**20**	**25**	**45**	**10**	**10**
Service Time	**0**	**0**	**0**	**0**	**0**
Replen LT	**20**	**5**	**3**	**1**	**3**
Net Rep LT	**20**	**5**	**3**	**1**	**3**
Safety Stock	**147**	**74**	**57**	**33**	**57**
SS Cost	**$588**	**$666**	**$1026**	**$660**	**$1254**

(20% annual interest rate) The total safety stock cost for the supply chain is $4194

Some Stages Stock



Prod LT	**20**	**5**	**3**	**1**	**3**
Cost Added	**20**	**25**	**45**	**10**	**10**
Service Time	**0**	**0**	**3**	**4**	**0**
Replen LT	**20**	**5**	**3**	**4**	**7**
Net Rep LT	**20**	**5**	**0**	**0**	**7**
Safety Stock	**147**	**74**	**0**	**0**	**87**
SS Cost	**$588**	**$666**	**$0**	**$0**	**$1914**

(20% annual interest rate) The total safety stock cost for the supply chain is $3168

Model Intuition

- **Model considers all possible service-time combinations to determine the configuration that satisfies a customer delivery time constraint with the least inventory cost**

For n-stage serial system:

$$SS_i = z\sigma\sqrt{s_{i-1} + L_i - s_i}$$

Then optimization to find service times:

$$\text{Min} \sum_{i=1}^{n} h_i z\sigma\sqrt{s_{i-1} + L_i - s_i}$$

$$s.t. \quad 0 \le s_i \le s_{i-1} + L_i \qquad i = 1...n$$

and s_n *given*

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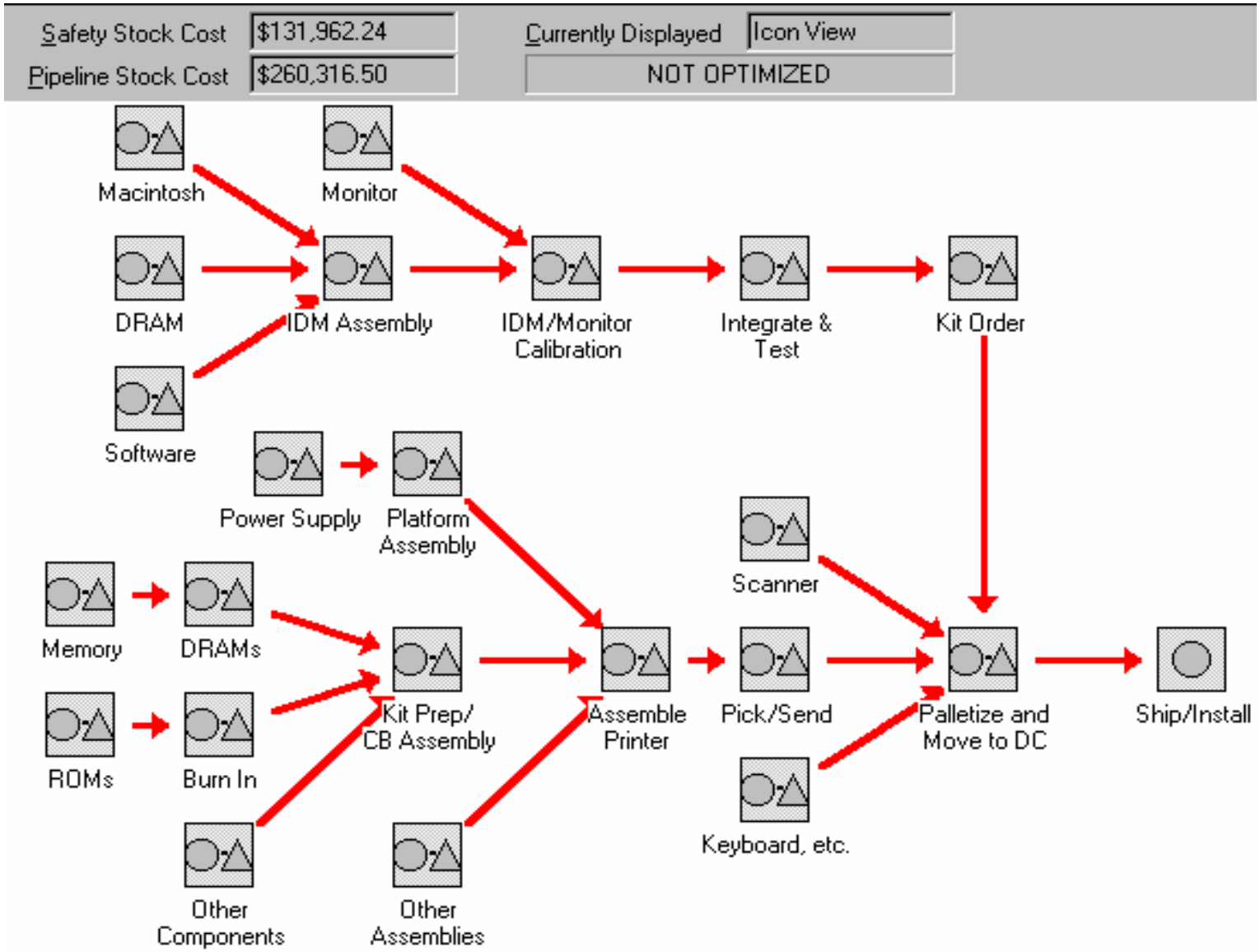
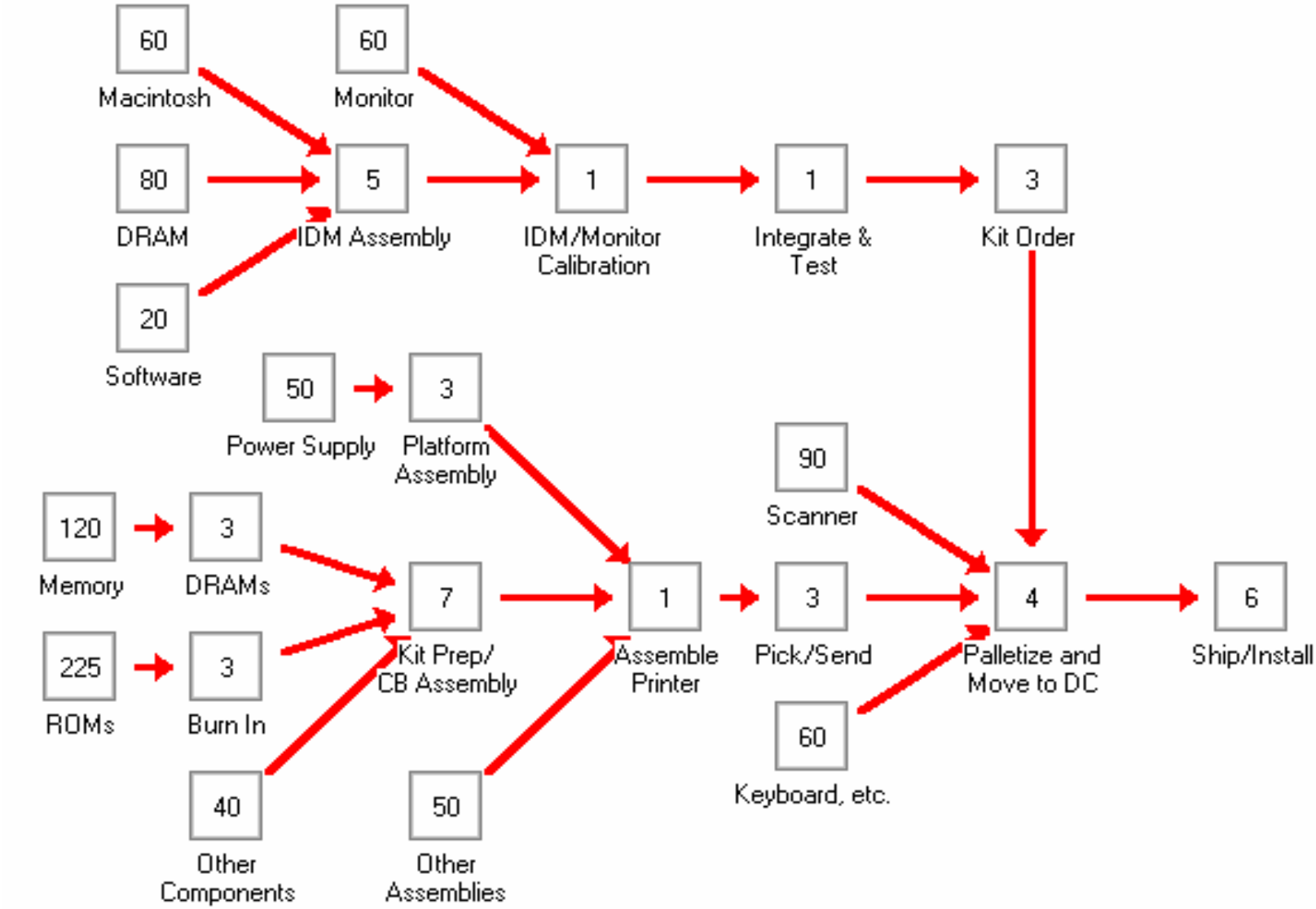
- **Characteristics**
  - **Large supply chain**
  - **Key components sourced internally and externally**
  - **Some parts are unique to the product, some are off-the-shelf components**

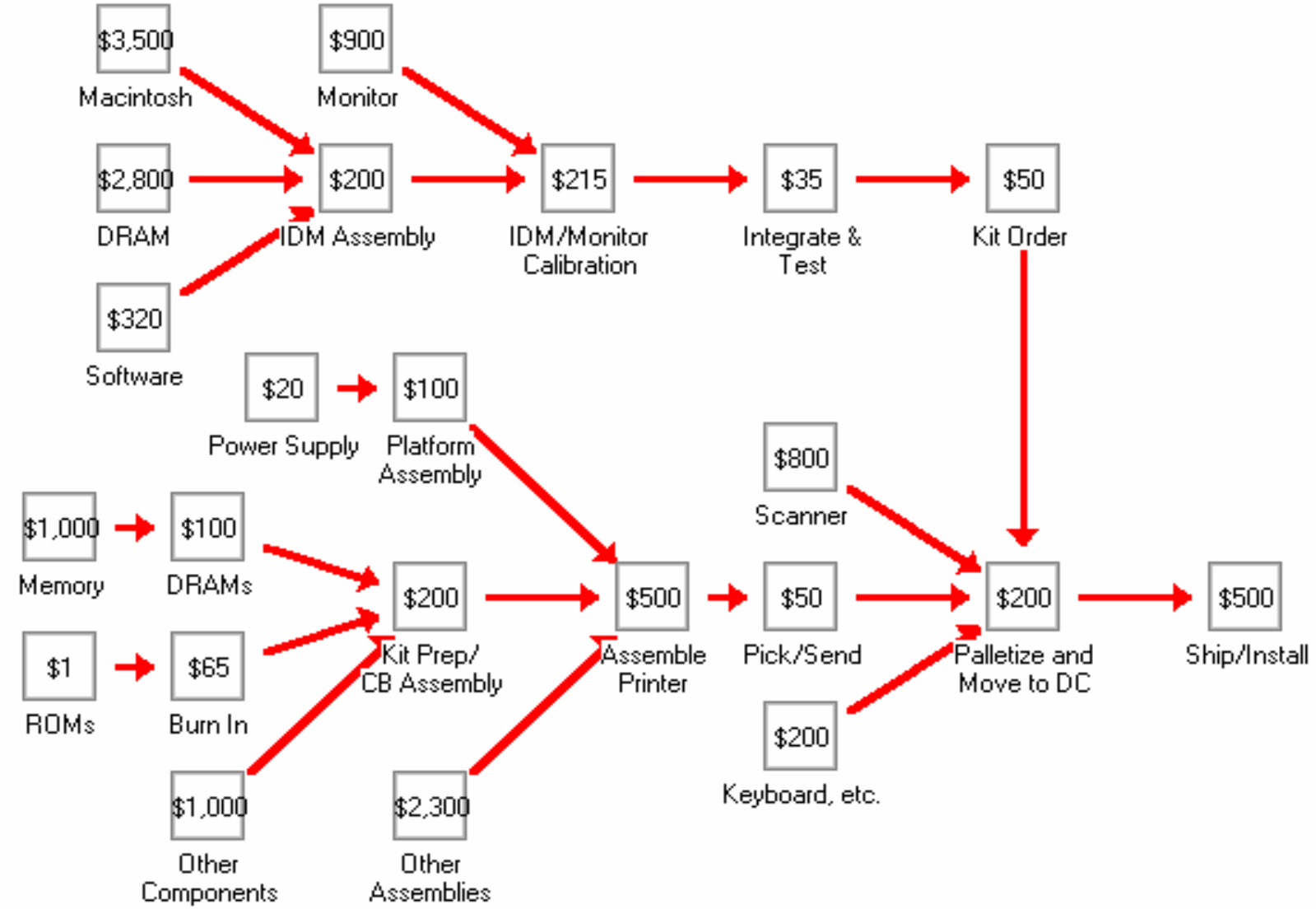
Supply Chain: Before



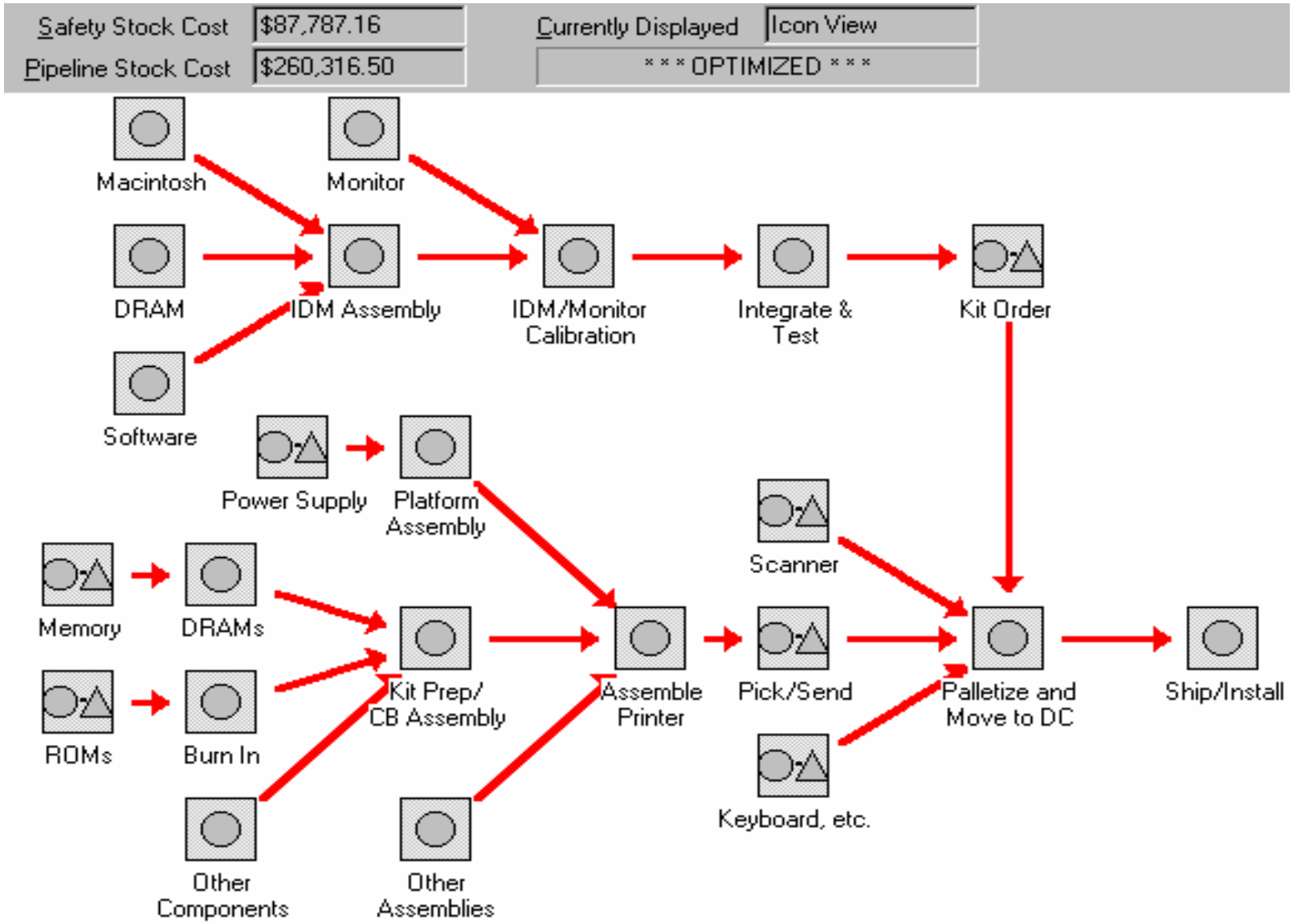
Supply Chain: Lead Times



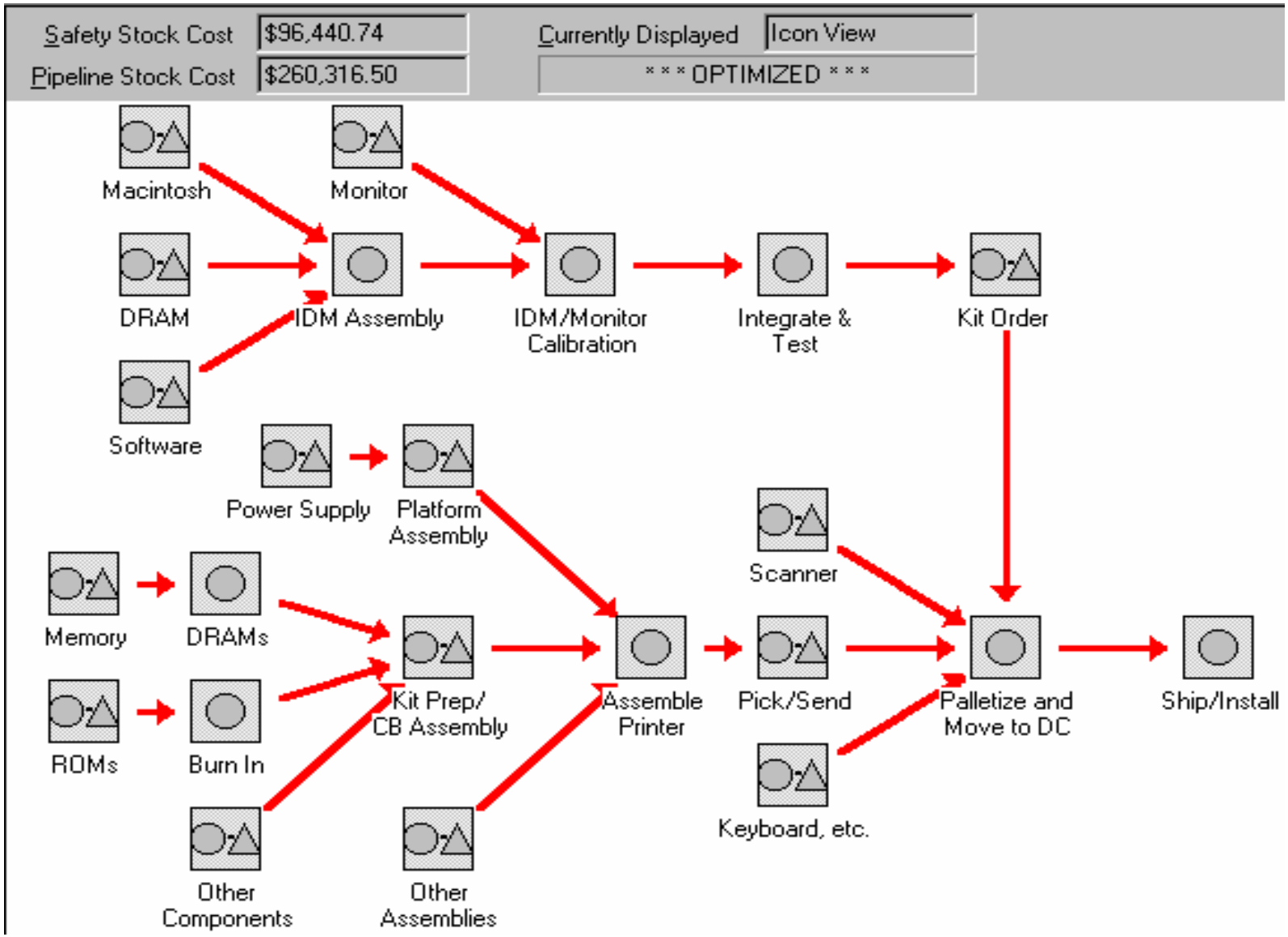
Supply Chain: Costs



Supply Chain: Optimized



Supply Chain: Implemented



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- **Project results**
  - **Sizing finished goods inventory**
  - **Assess where to target lead-time reduction efforts**
  - **Framework to work with suppliers on purchasing long lead-time parts**

Key Benefits

- **Shows value from "holistic" perspective**
- **Formalizes inventory-related supply chain costs, and provides an optimal benchmark**
- **Provides framework and terminology for cross-functional debate**
- **Shows the effectiveness of inventory, strategically positioned in a few places to de-couple the supply chain**

Key Learnings

- **De-couple supply chain prior to a high-cost added stage; and prior to product explosion**
- **Substitute information for inventory**
- **Postpone product differentiation step**
- **Win-win from optimizing multi-company supply chain**
- **Value of a standard terminology and a neutral tool**
- **Most leverage from lead time reduction**