Supply chains and variability

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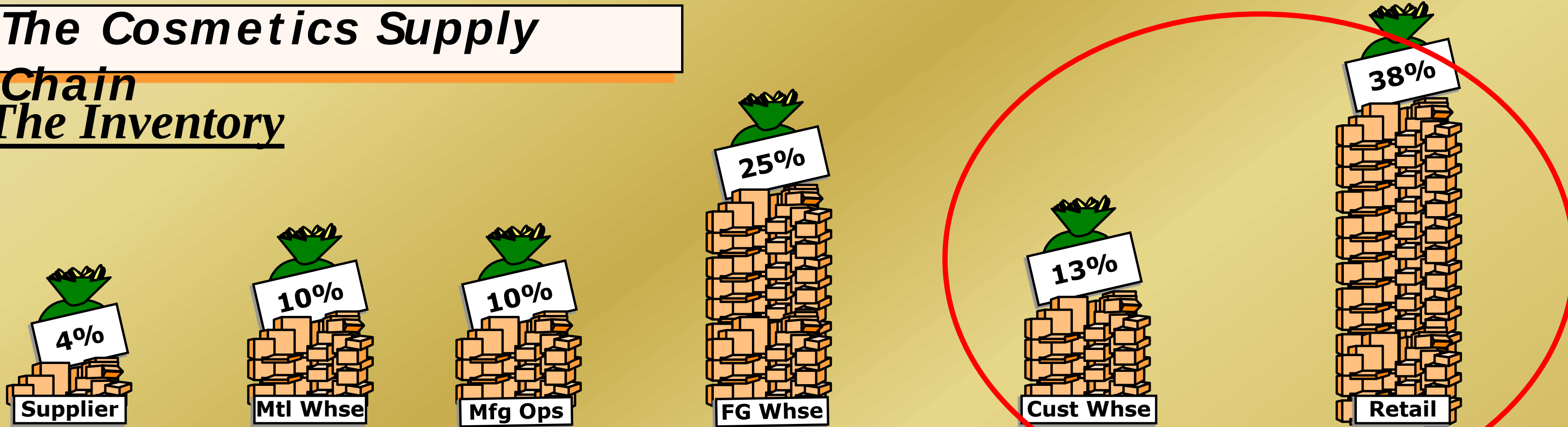
Supply Chain Management

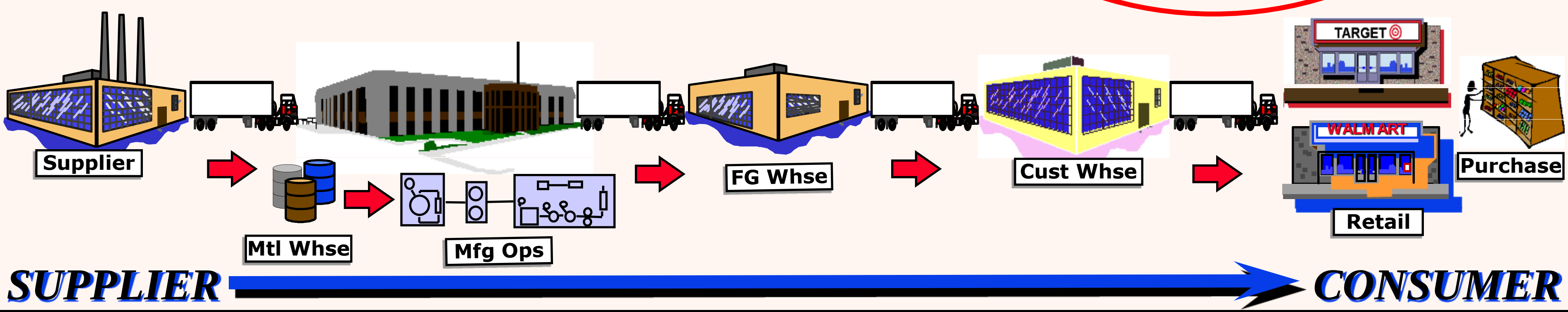
- SCM is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandize is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements

The Cosmetics Supply Chain

The Inventory

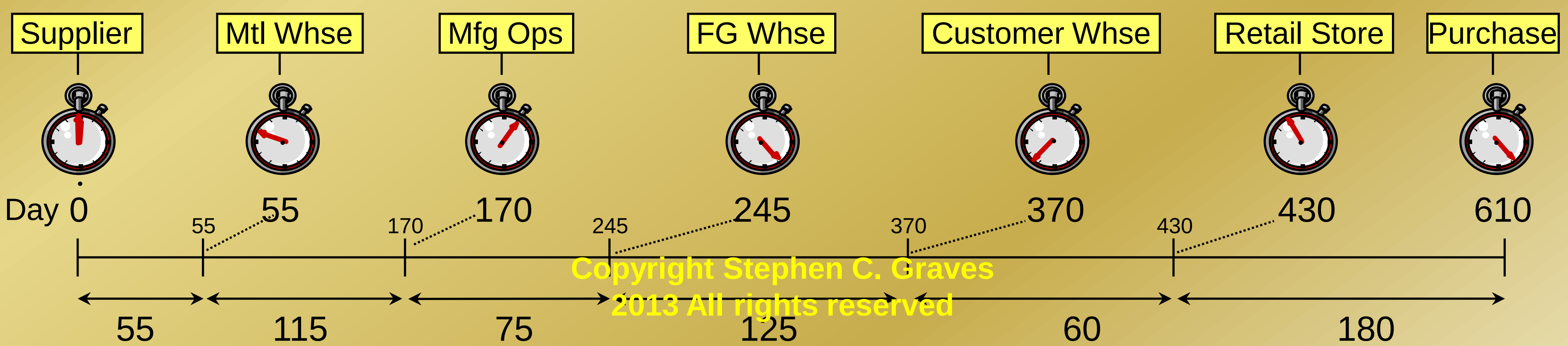


The Chain

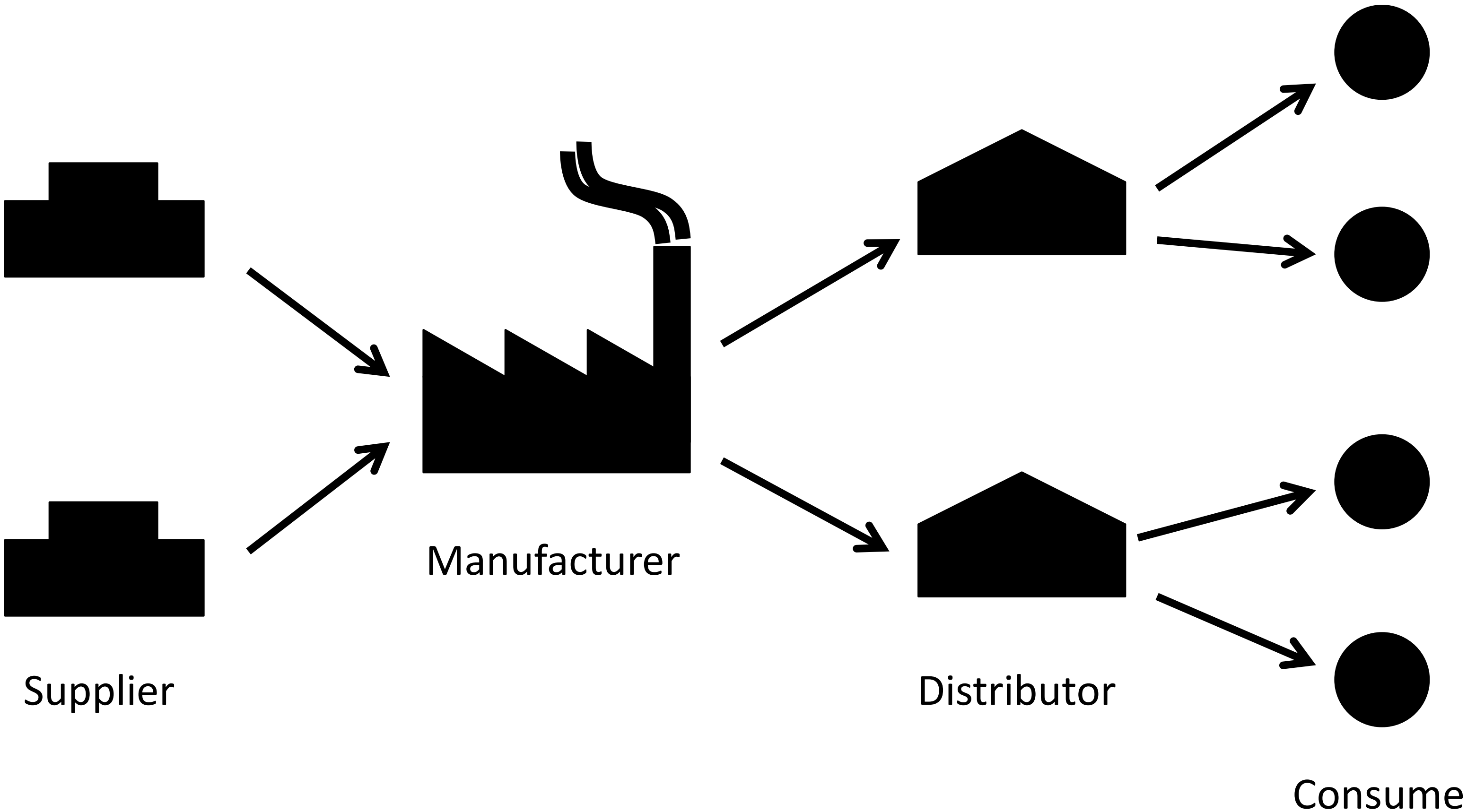


The Time

Total = 610 days



What makes SCM difficult?



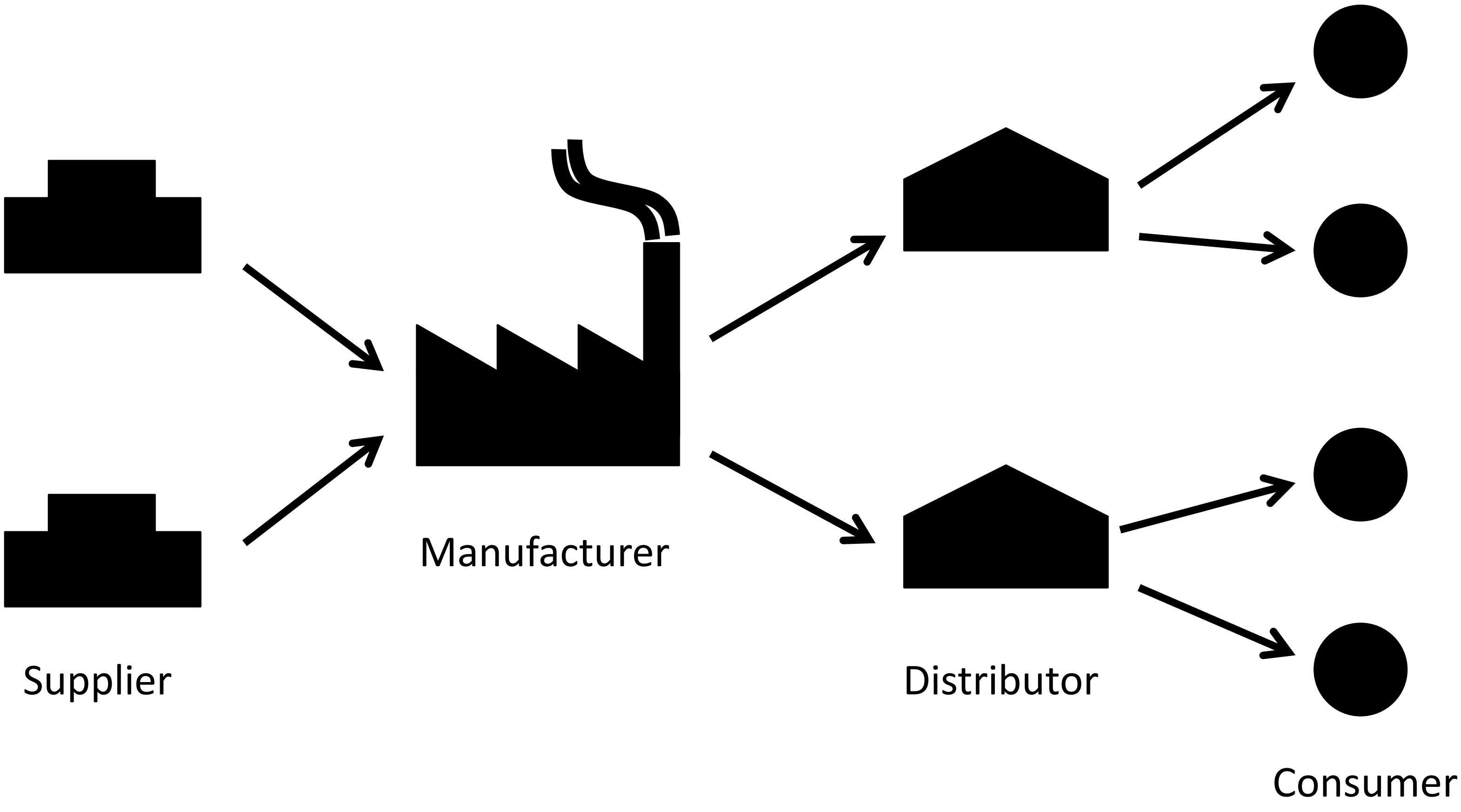
Types of variability

- Demand: volume, mix
- Process: yield, cycle time
- Procurement: yield, lead time, quality

Other types of variability

- Rare and disruptive events (versus nominal variability)
- "predictable" variability, eg, cyclic patterns (versus probabilistic variability)
- Self-induced variability, eg, demand amplification (versus exogenous)

How do SCs cope with variability?



Counter measures: Buffers

- Buffers: inventory, capacity, time
- Inventory can be held across SC
- Reserved or underutilized capacity provides response option
- Increased process flow time or customer service time creates time window to balance supply and demand

Counter measures: Tactics

- Product/process design to permit delayed differentiation
- Smoothing to dampen variability propagation
- Dual sourcing (& expedited shipping) to provide quick response options
- Inventory pooling
- Better forecasts, avoid distortions and delays.

Dealing with variability: examples

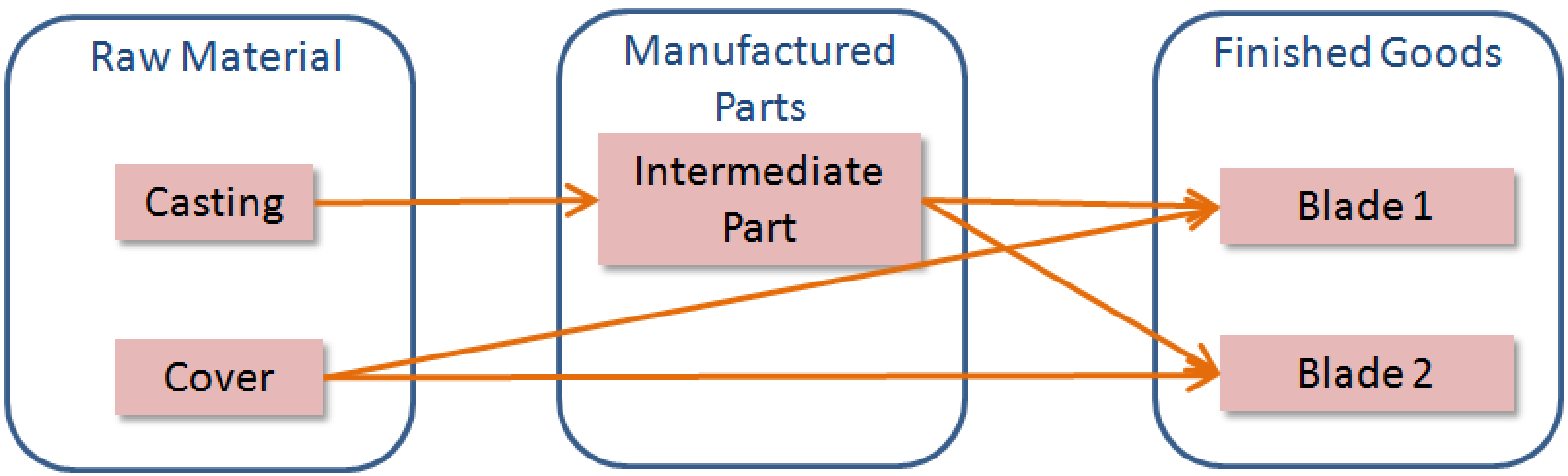
- Safety stock location in a SC
- Delayed differentiation in a SC
- Dual sourcing
- Better forecast
- Smoothing and line segmentation

Example

- Safety stock optimization in a supply chain
- Key concept:
  - Inventory depends on demand variability over replenishment lead-time LT
  - Demand variability over replenishment LT proportional to $\sqrt{LT}$

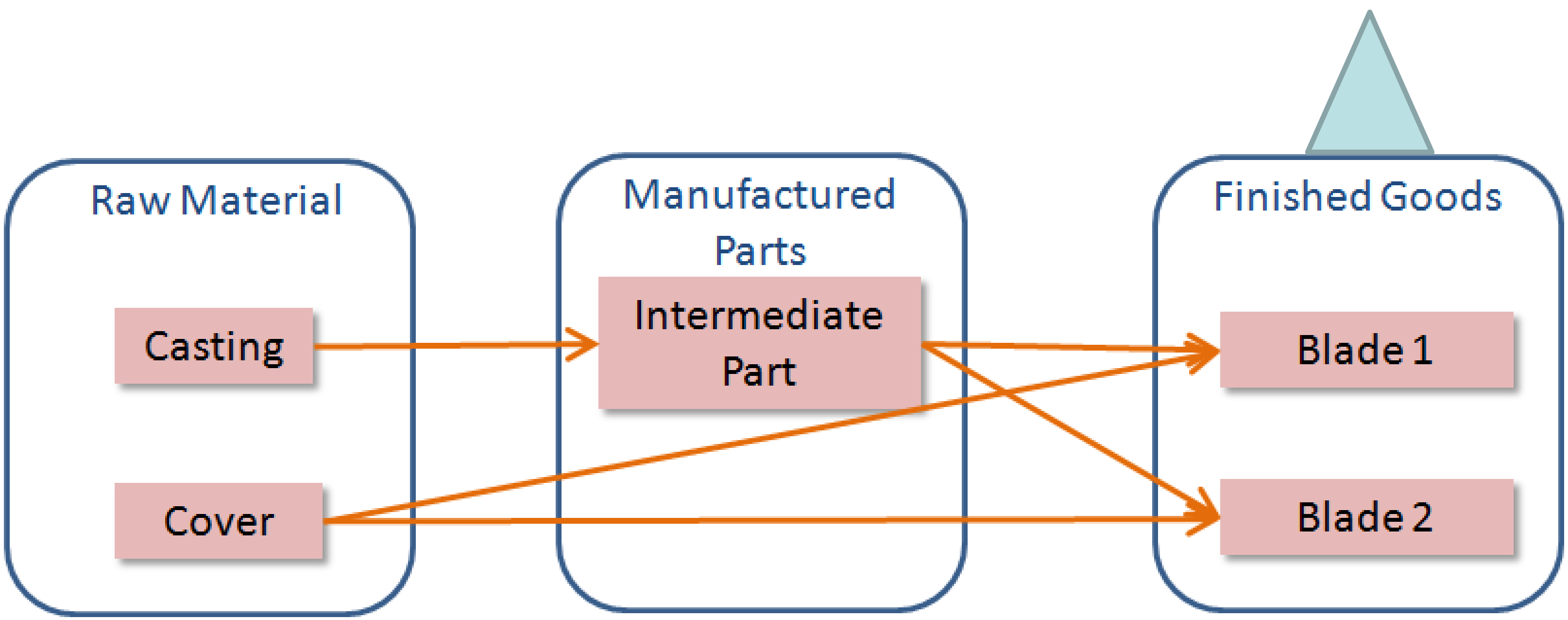
Supply Chain Example

Part	Part Value	Lead Time (weeks)
Blade 1	$400	4
Blade 2	$425	4.5
Intermediate Part	$250	2
Cover	$2	1
Casting	$75	8



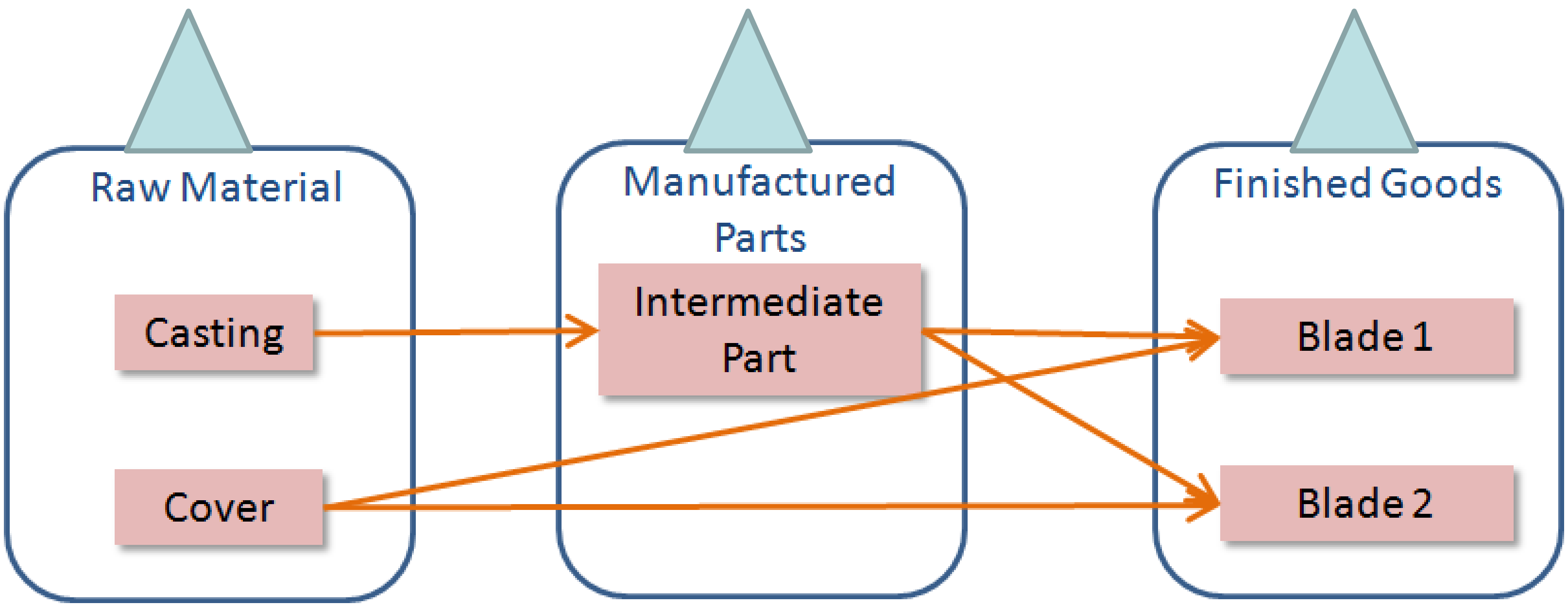
Hold only FGs; total inventory = $189,000

Part	Part Value ($)	Lead Time (weeks)	Service Time (weeks)	Safety Stock (units)	Safety Stock Value ($)
Blade 1	$400	4	0	150	60,000
Blade 2	$425	4.5	0	305	129.000
Intermediate Part	$250	2	10	0	0
Cover	$2	1	1	0	0
Casting	$75	8	8	0	0



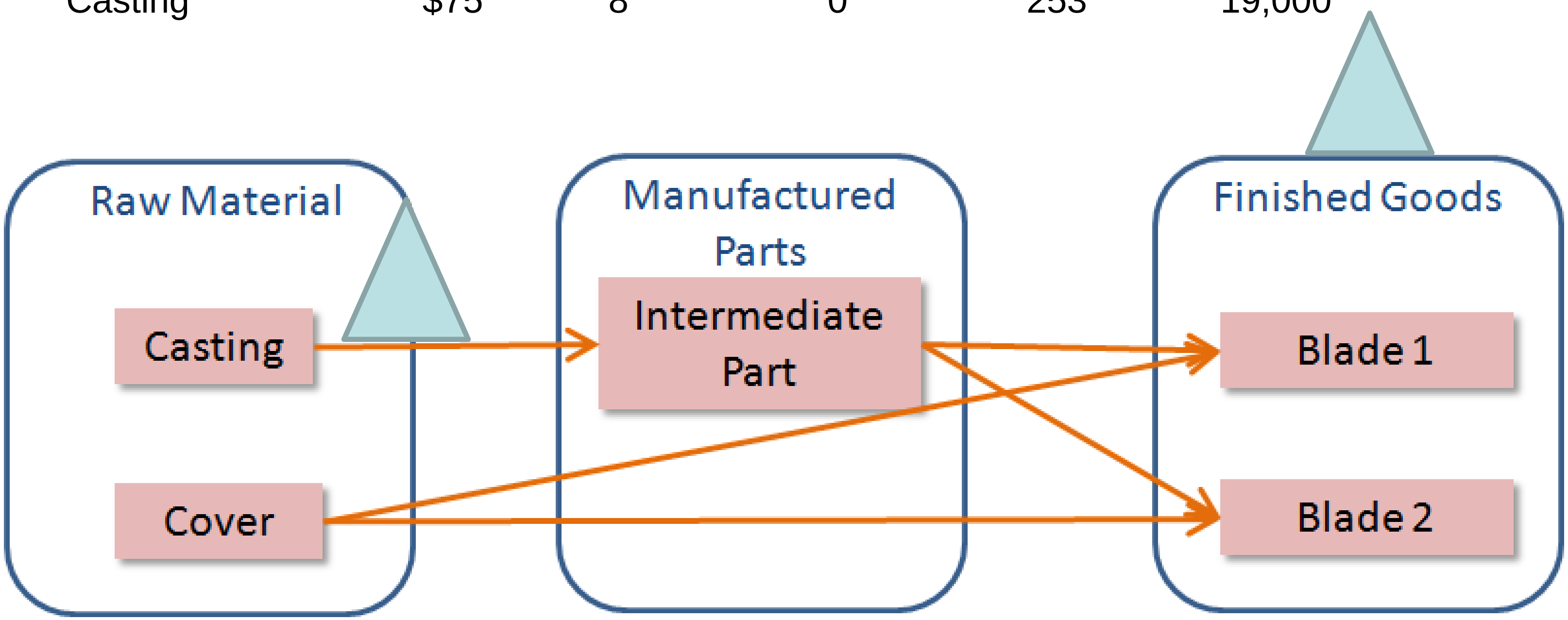
Hold SS at each stage; total inventory = $136,000

Part	Part Value ($)	Lead Time (weeks)	Service Time (weeks)	Safety Stock (units)	Safety Stock Value ($)
Blade 1	$400	4	0	80	32,000
Blade 2	$425	4.5	0	170	72.000
Intermediate Part	$250	2	0	126	32,000
Cover	$2	1	0	89	200
Casting	$75	8	0	253	19,000



Optimal SS strategy – hold castings; total inventory = $126,000

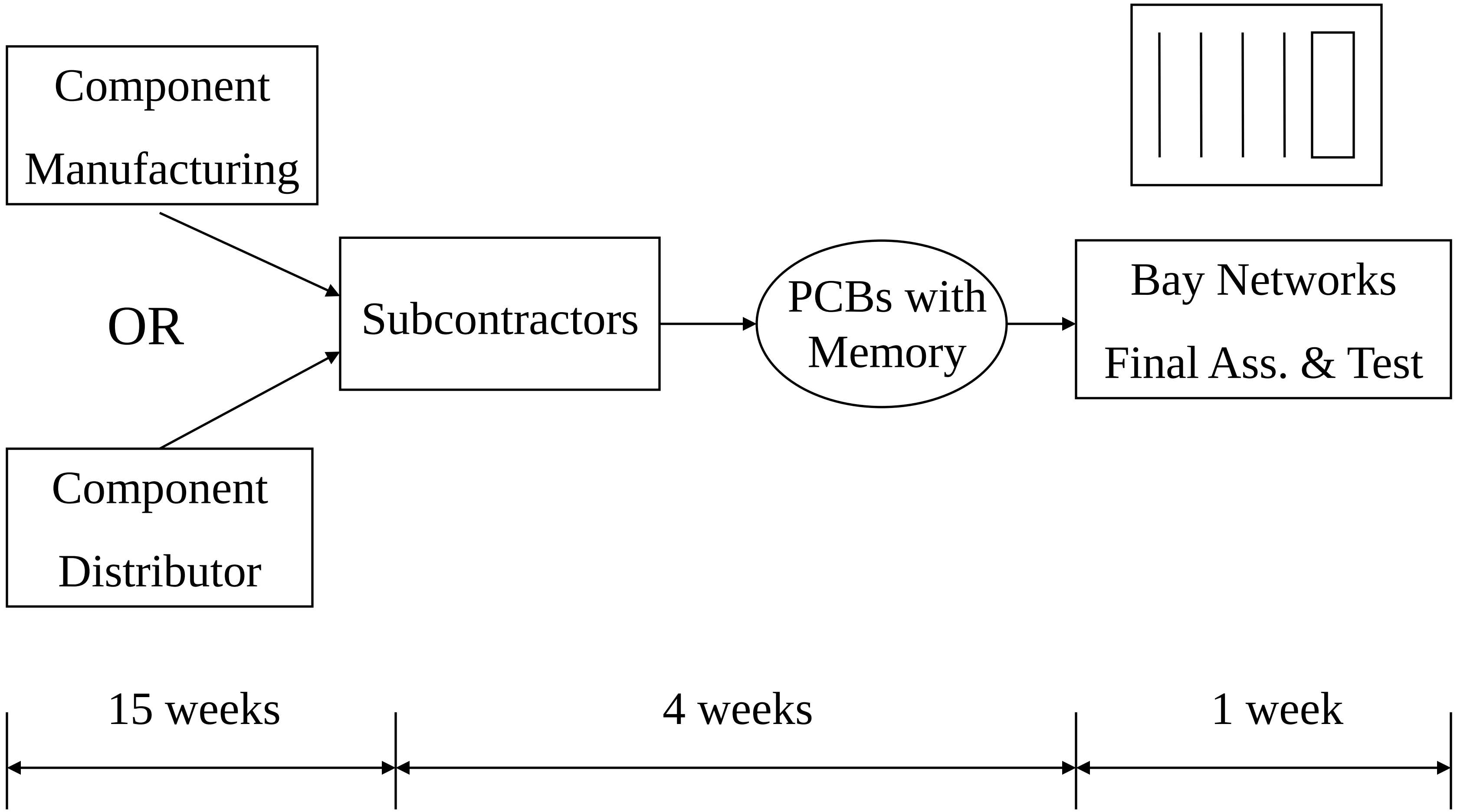
Part	Part Value ($)	Lead Time (weeks)	Service Time (weeks)	Safety Stock (units)	Safety Stock Value ($)
Blade 1	$400	4	0	98	39,000
Blade 2	$425	4.5	0	204	87.000
Intermediate Part	$250	2	2	0	0
Cover	$2	1	1	0	0
Casting	$75	8	0	253	19,000



Example

- Delayed product differentiation
- Key Concept
  - Pooling reduces variability
  - $$\sigma_{A+B} < \sigma_A + \sigma_B$$

Example: Bay Networks



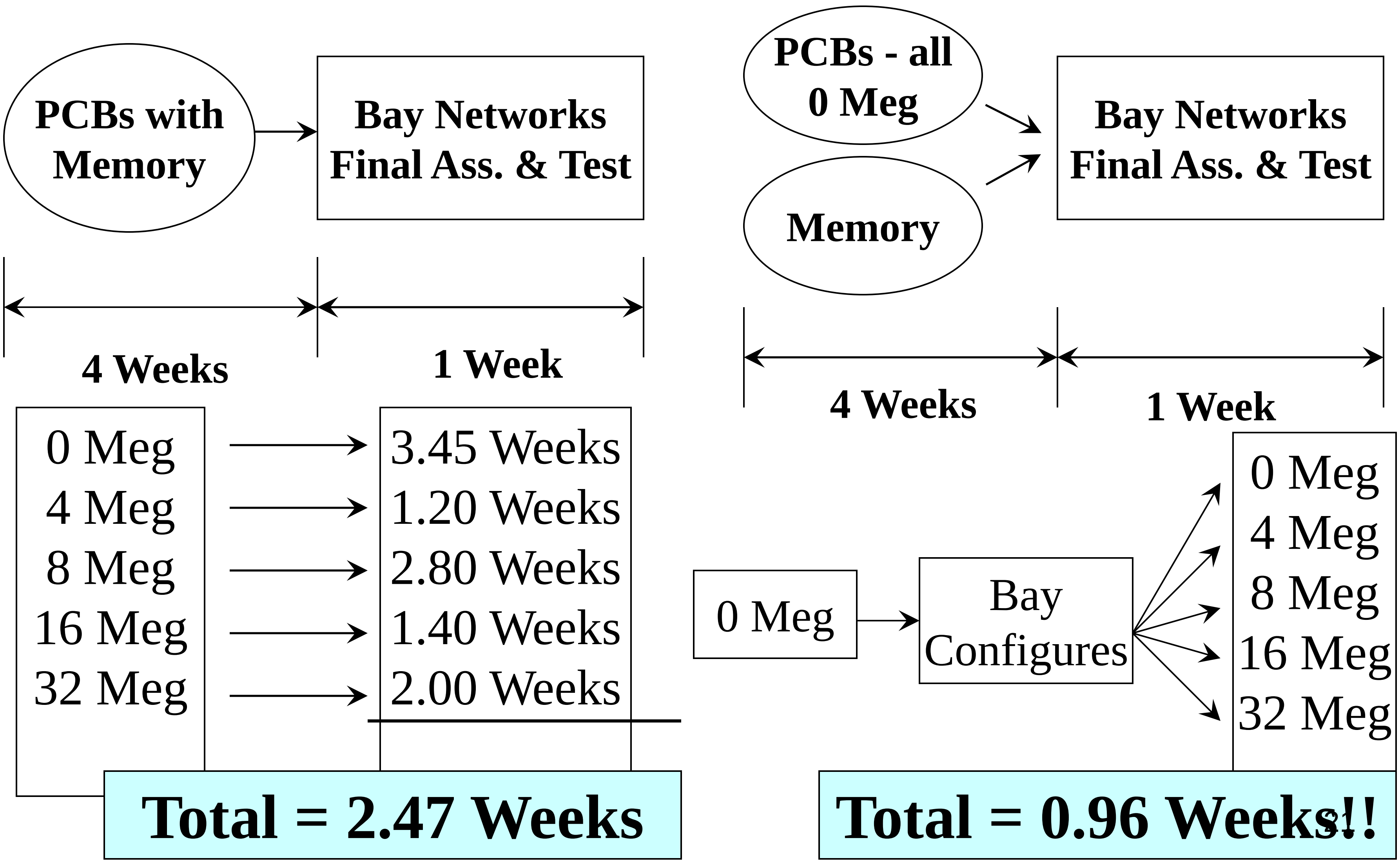
Risk Pooling of PCB's decreases demand uncertainty

Individual memory flavors are highly volatile as evidenced by the quarterly forecast error.

Aggregating or Risk-Pooling the PCB's by configuring memory later in the process decreases forecast error and required safety stock!

PCB Model	Ave. Forecast % Error	Next Qtr Forecast (Units)	Service Level Fraction from inventory	Material Safety Stock (Units)	Material Safety Stock (%)
ENET MTR 0	37%	730	.83	210	28.7
ENET MTR 4M	13%	500	.83	49	9.7
ENET MTR 8M	30%	6000	.83	1396	23.3
ENET MTR 16M	15%	1800	.83	204	11.4
ENET MTR 32M	21%	60	.83	10	16.4
AGGREGATE	**10%**	**9090**	**.83**	**730**	**8.0**

Bay Networks' new process



Substantial dollar value reduction

Original Scenario

Safety Stock for EACH configuration

Safety Stock = $934,500.00

With Delayed Differentiation

Safety Stock for GENERIC configuration

Safety Stock = $365,000.00

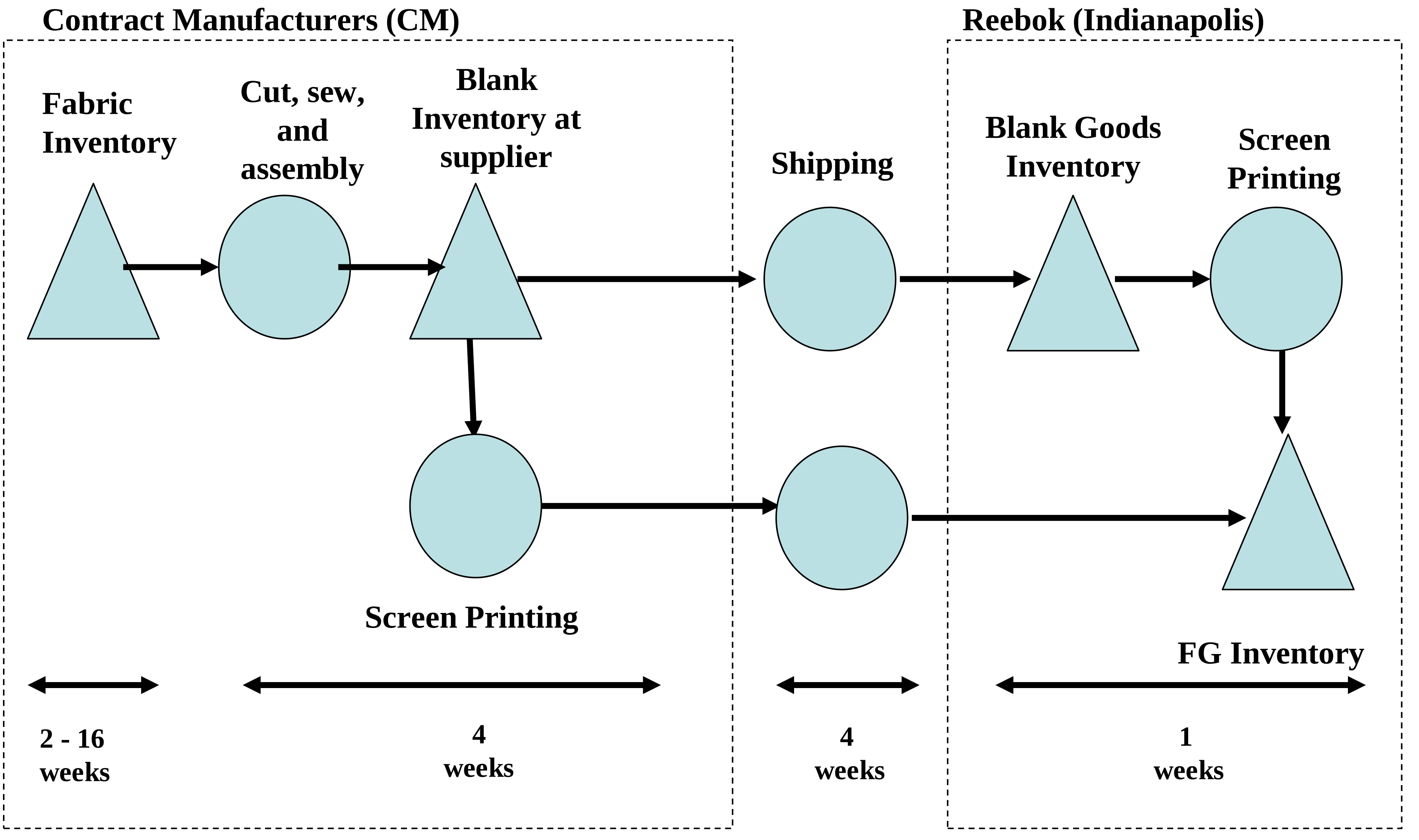
60% Reduction

This Methodology can be applied to 6 other multi-memory flavored motherboards for additional savings.

Planning Question

– How should Reebok plan and manage inventory to manage costs while providing the flexibility required to meet demand for NFL Replica jerseys?

Internal Supply Chain



Example

- Dual sourcing, e.g., via two transportation modes
- Key Concept
  - Option value from time-cost tradeoff

Background

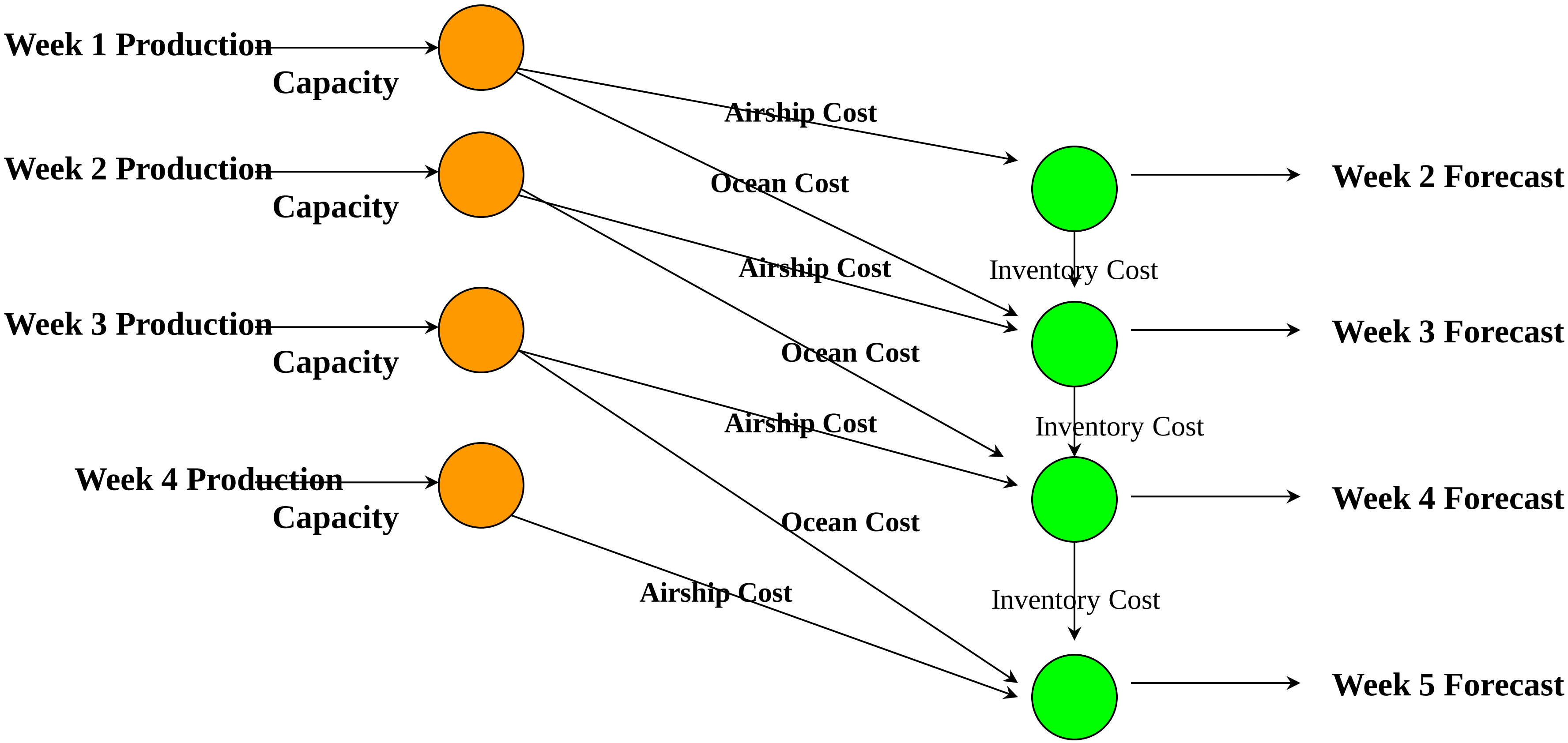
- Camera production moved to Asia, mostly to sub-contractors
- Long transit times – 5-7weeks by ocean, 1-2 weeks by air
- Primary customers are major retailers (e.g. Walmart); each has individual packaging requirements
- Product postponement occurs in US DC's

Background

- Large forecast errors for new products
- New products shipped by air initially to fill pipeline, to meet launch dates, to keep inventory low
- Production capacity constraints due to long lead times for tooling and components

Model Description

NETWORK STRUCTURE (Min-cost, Max-Flow)



Findings

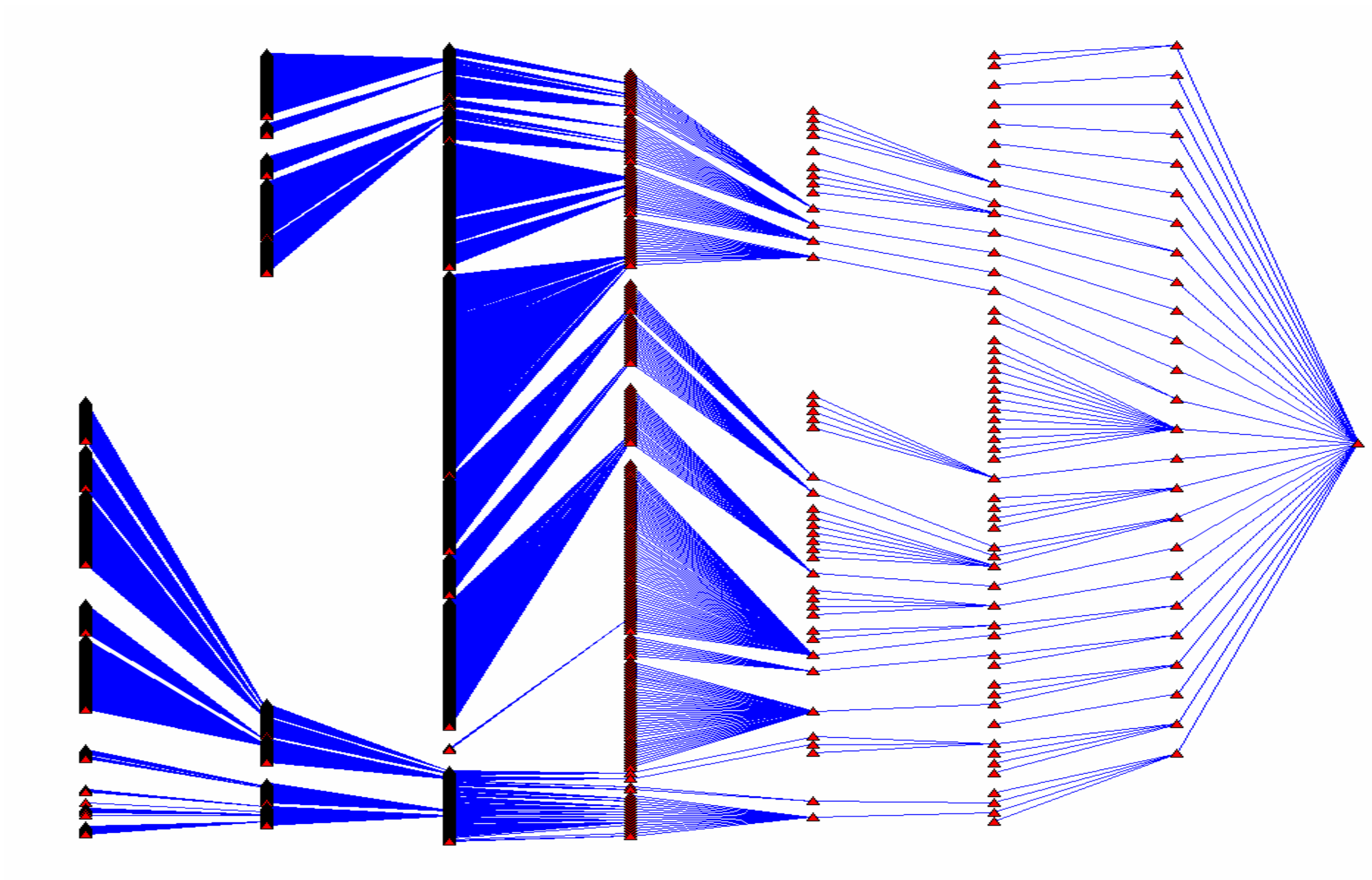
- Model can save transportation costs by increased use of ocean
- Most optimal policies use a mix of ocean and air
- ***Ocean shipments set to cover base demand; air used for quick response for variable demand***
- Simple network model is easy to implement, and can aid current planning process

Example

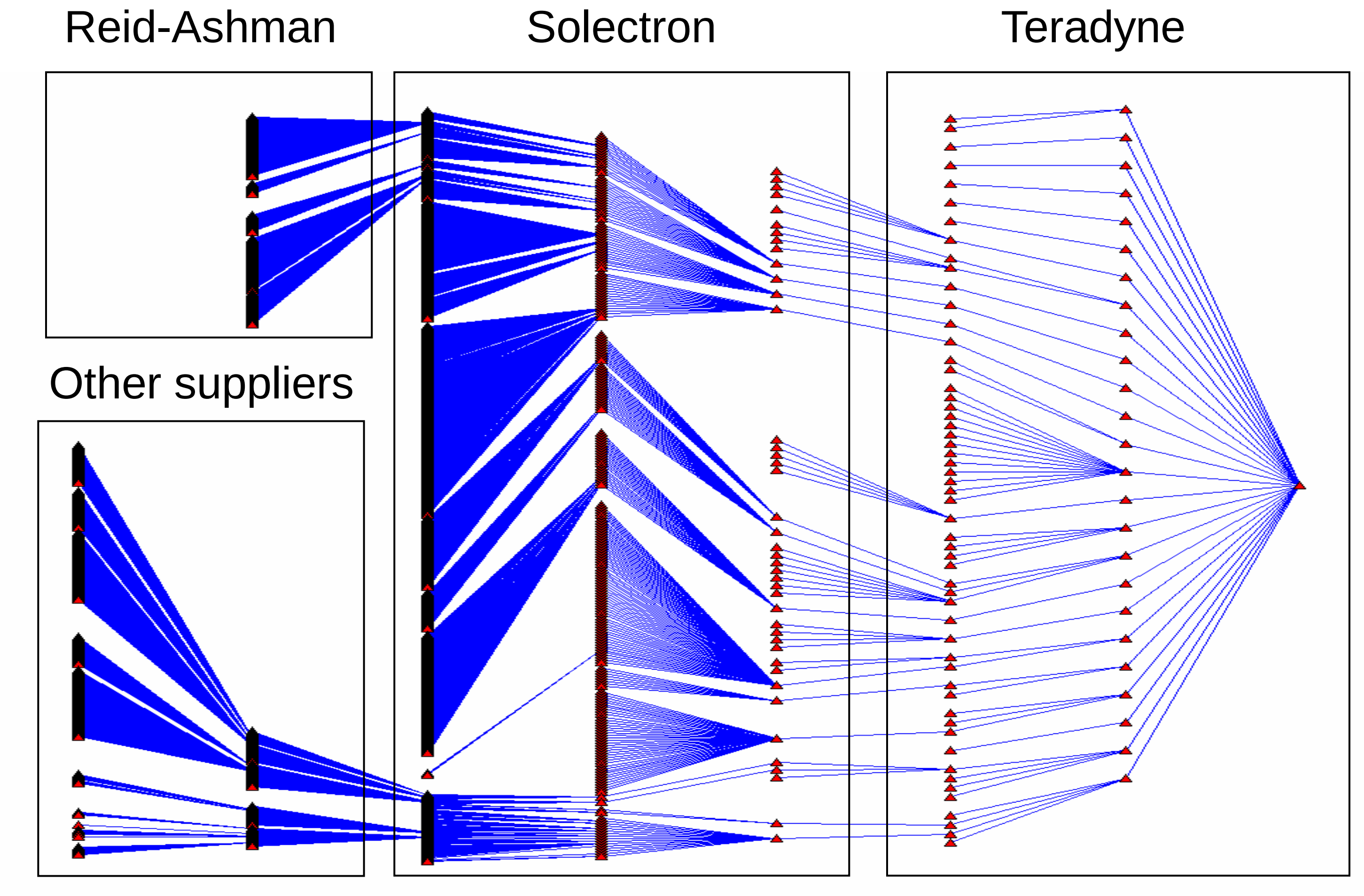
- Supply chain modeling, accounting for evolving forecast process
- Key Concept
  - Forecast accuracy improves as target date gets closer

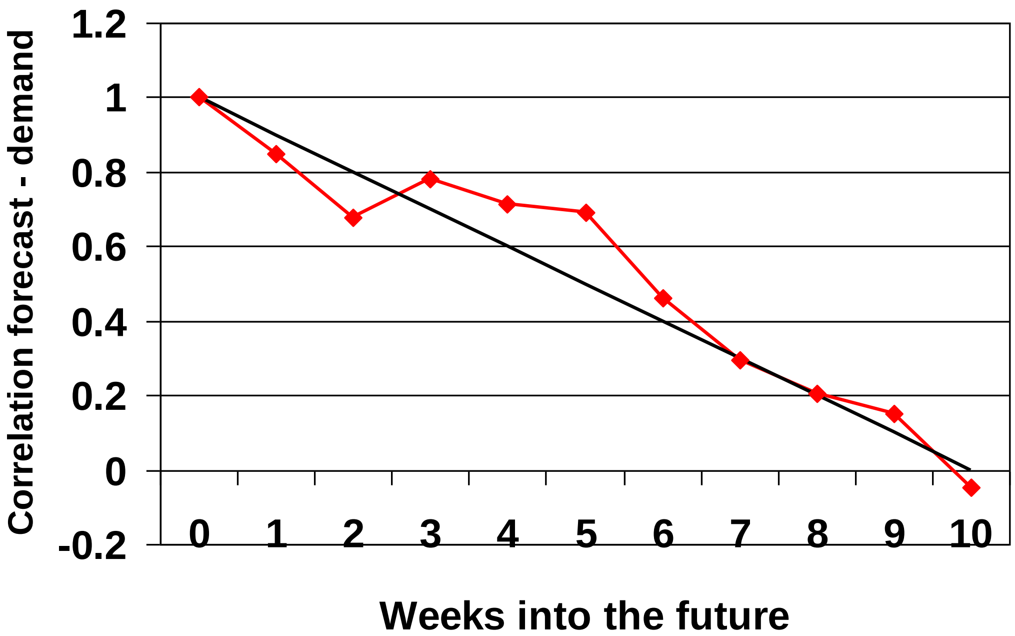
$$n \text{ week ahead } \sigma < (n+1) \text{ week ahead } \sigma$$

- Motivation:
  - Electronic test system manufactured by Teradyne, Inc.
  - Lack of global method to optimize inventory over the large (~4,000 part-locations) supply chain
  - Supply chain decisions driven by evolving master assembly schedules
  - Schedules quite accurate in the near term (~next few weeks), but virtually useless further out (>10 weeks)

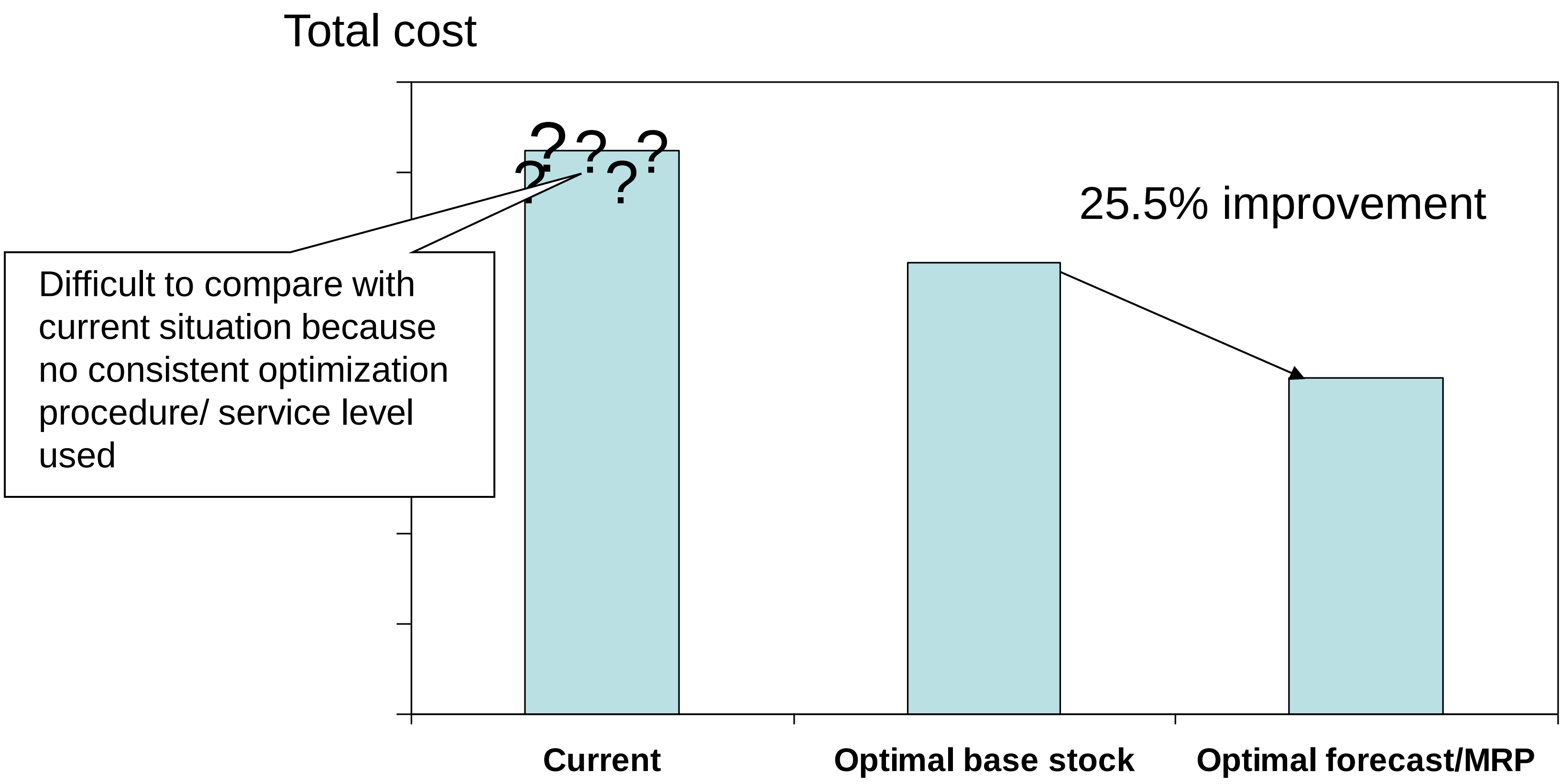


- Electronic test system manufactured by Teradyne, Inc.
- 3,866 part/locations
- Used real data on supply chain topology, lead times, costs of parts


Reid-Ashman
Solectron
Teradyne
Other suppliers



- Schedule contained booked and “preliminary” orders, and got increasingly locked down as the date of delivery approach
- The schedule was effectively a forecast, and we used data on past schedule changes to calculate *F(L)*
- As a forecast of actual demand, it was fairly accurate in the short term but useless >10 weeks out

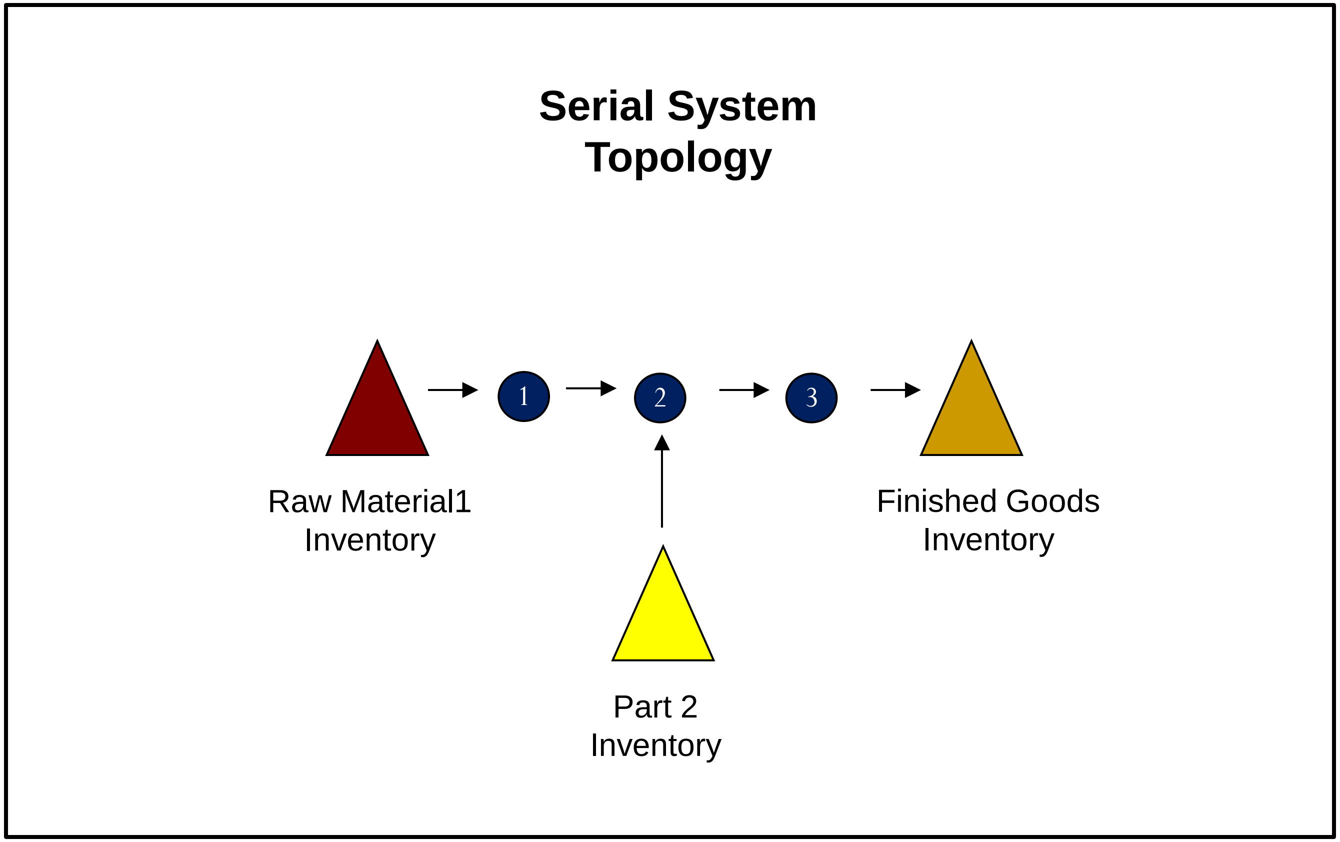


- **In the forecasted case, most savings were far downstream, where forecasts were accurate**
- Optimization time ~1 minute on a laptop computer

Example

- Smoothing and line segmentation
- Key Concept
  - Upstream variability depends on downstream actions
  - WIP inventory can act as a damper

Example: two products

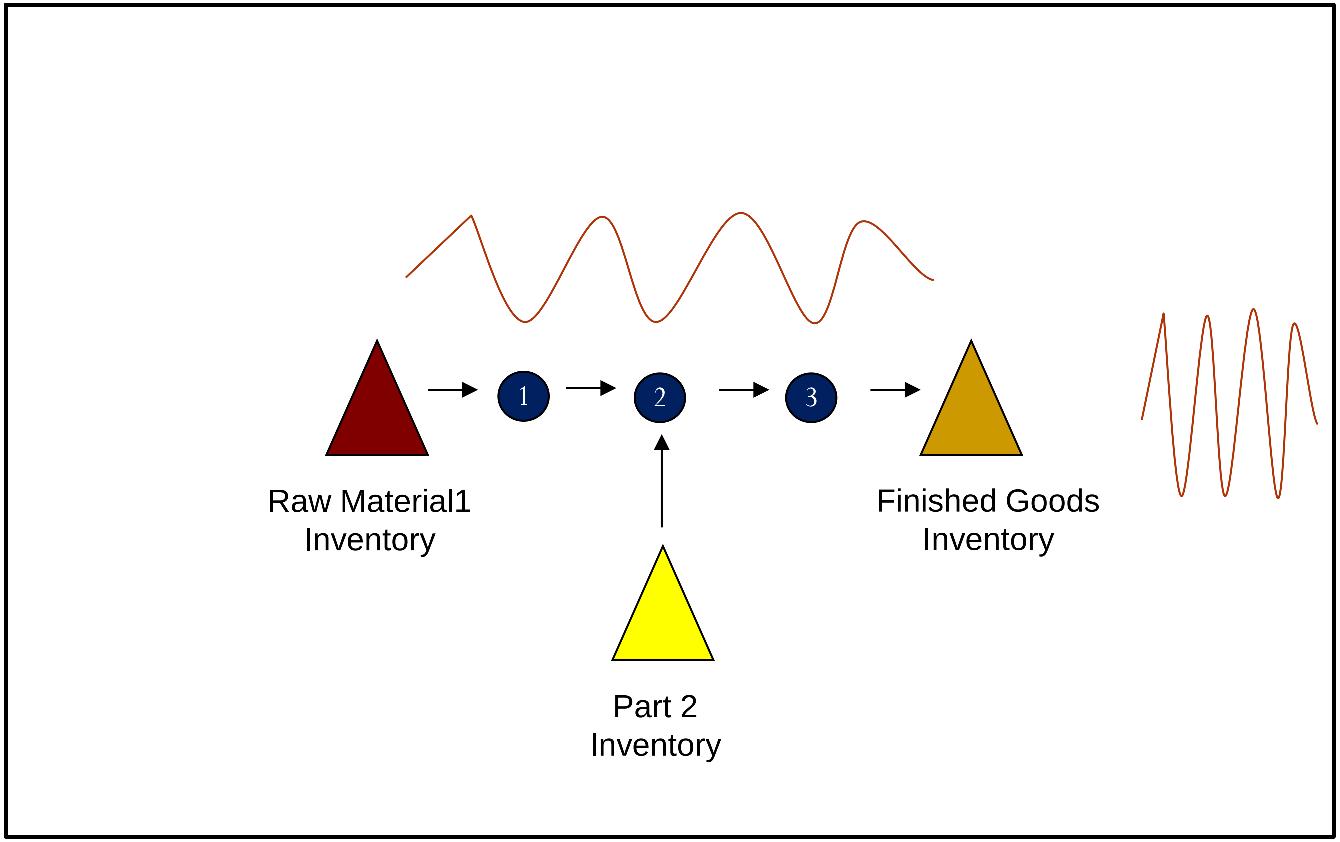


Stage 1: parts fabrication

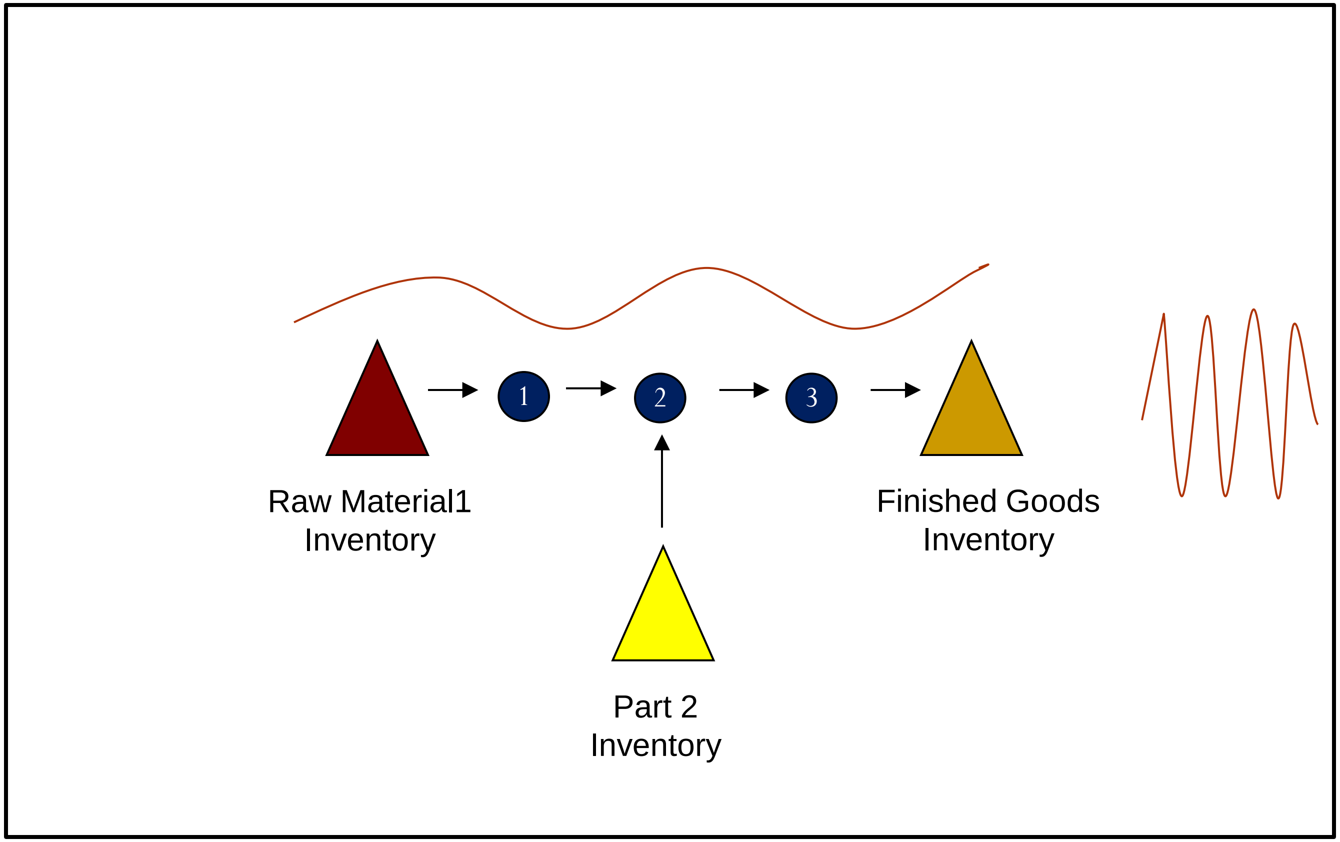
Stage 2: assembly

Stage 3: packaging and test

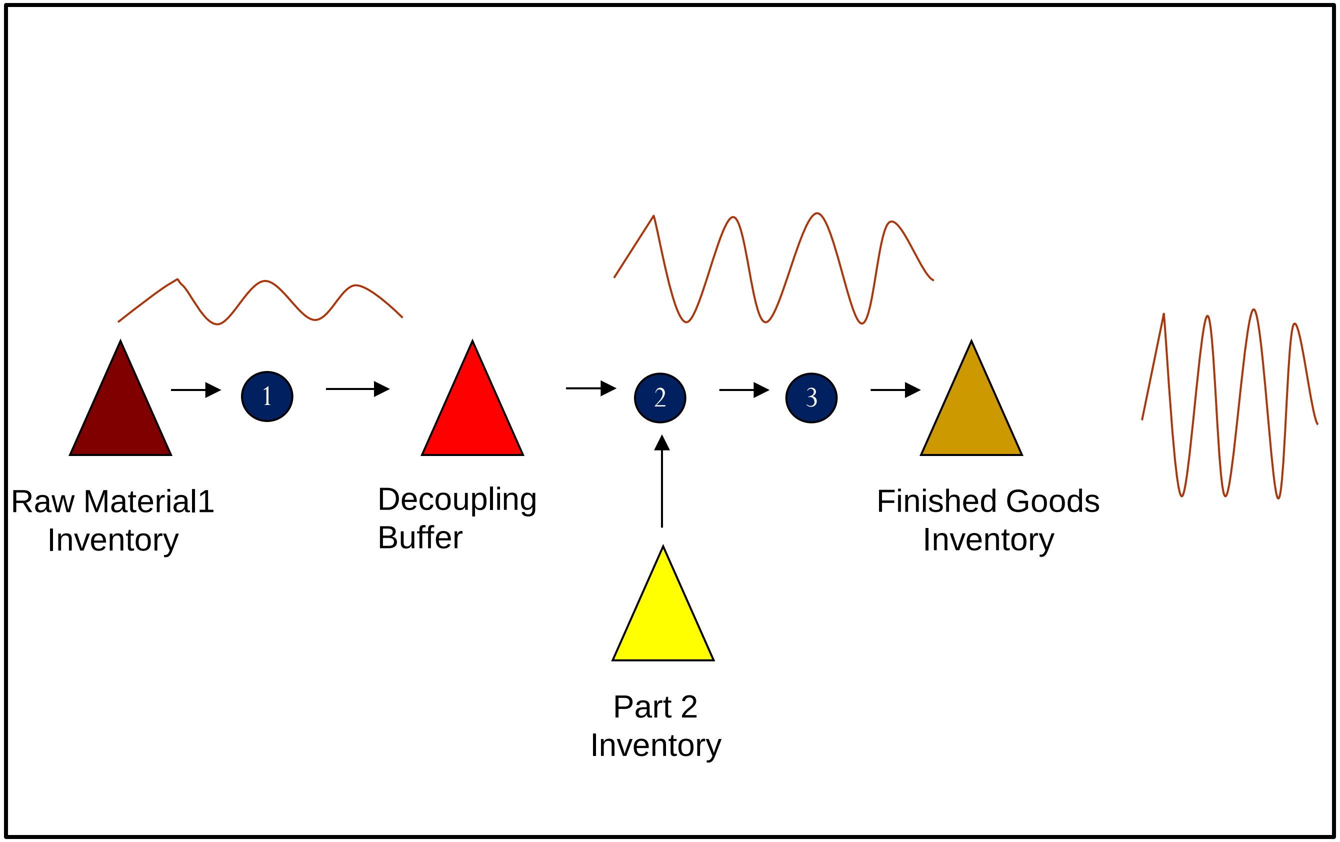
Example: moderate smoothing

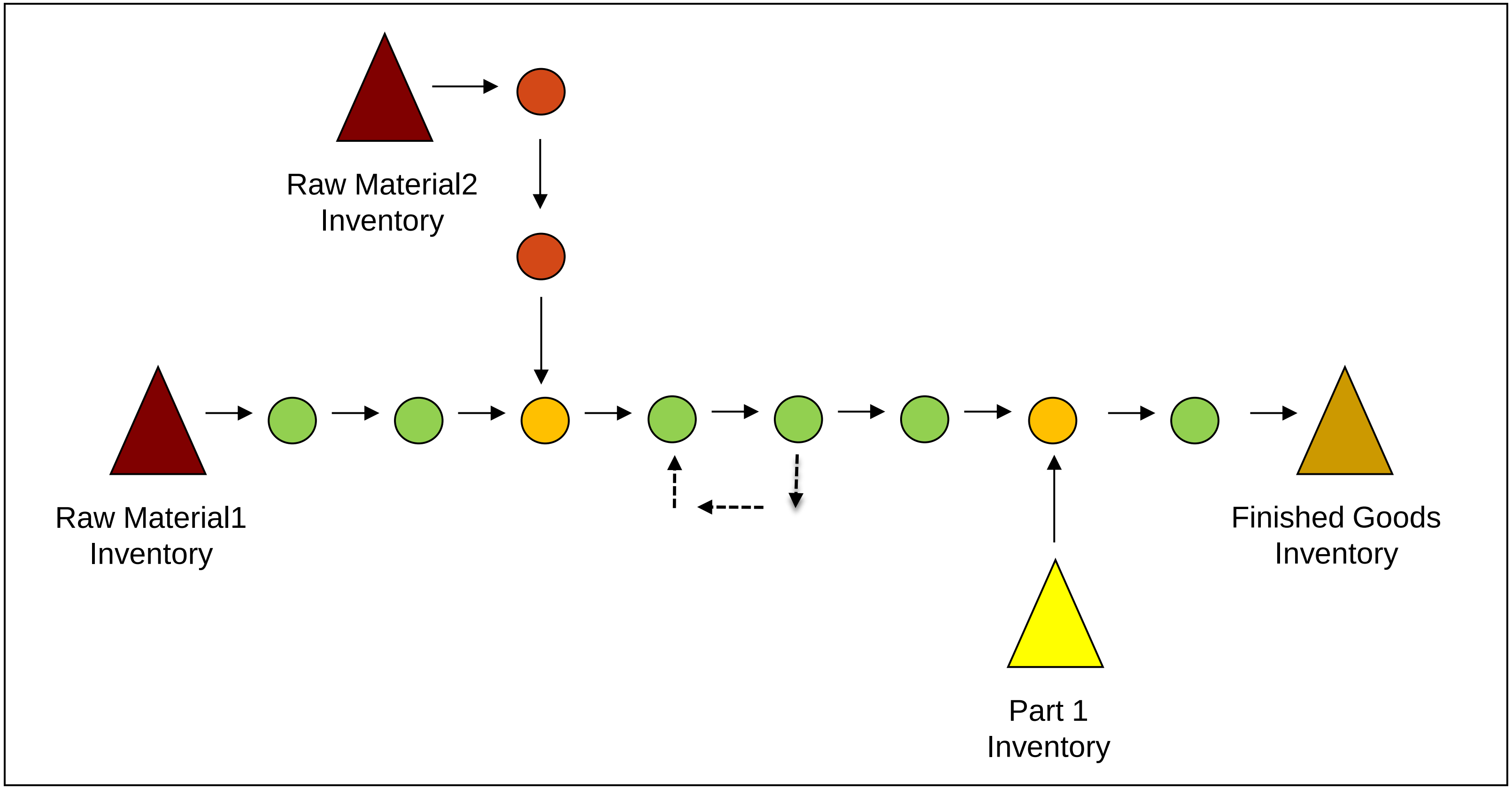


Example: extensive smoothing

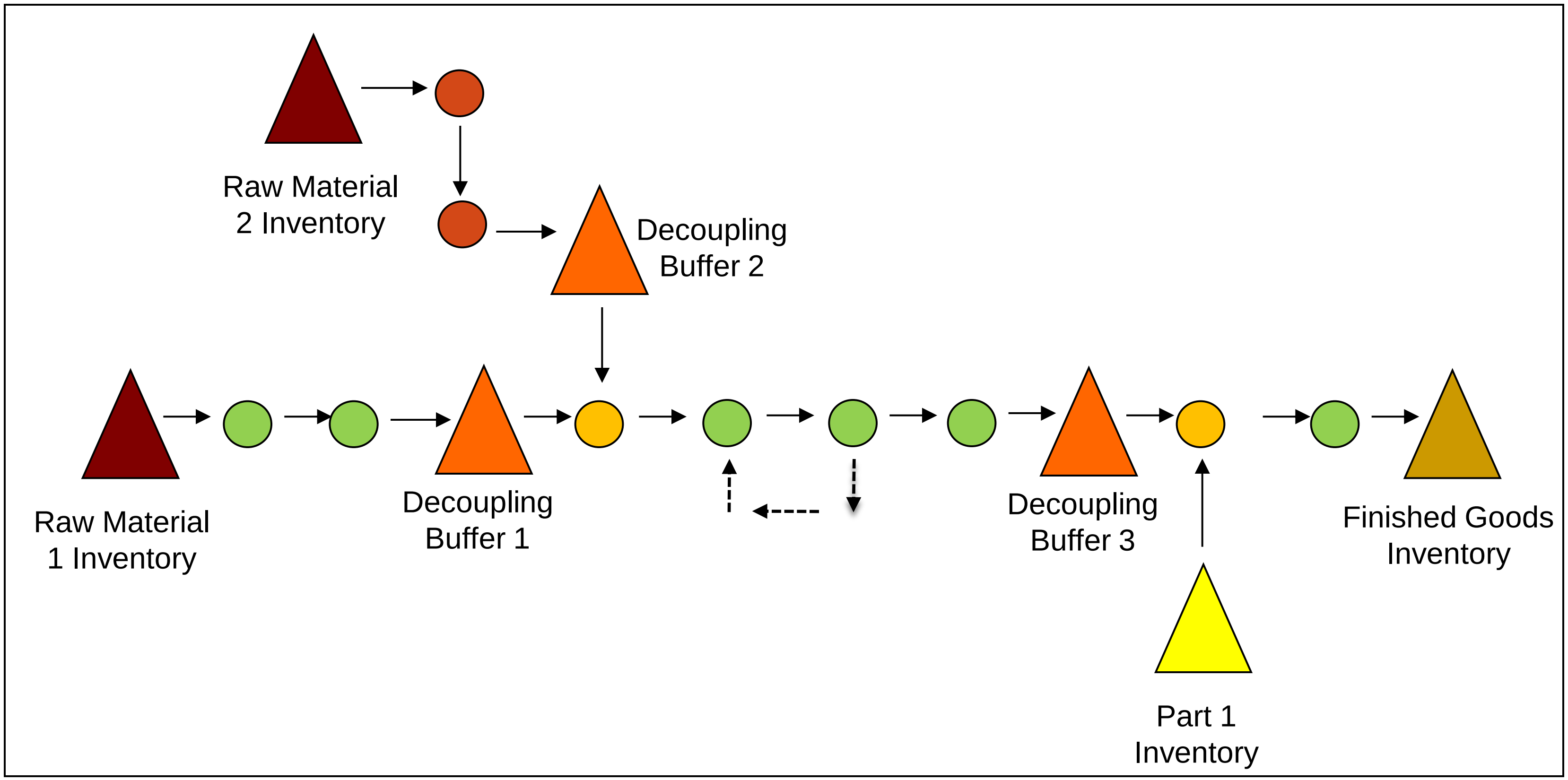


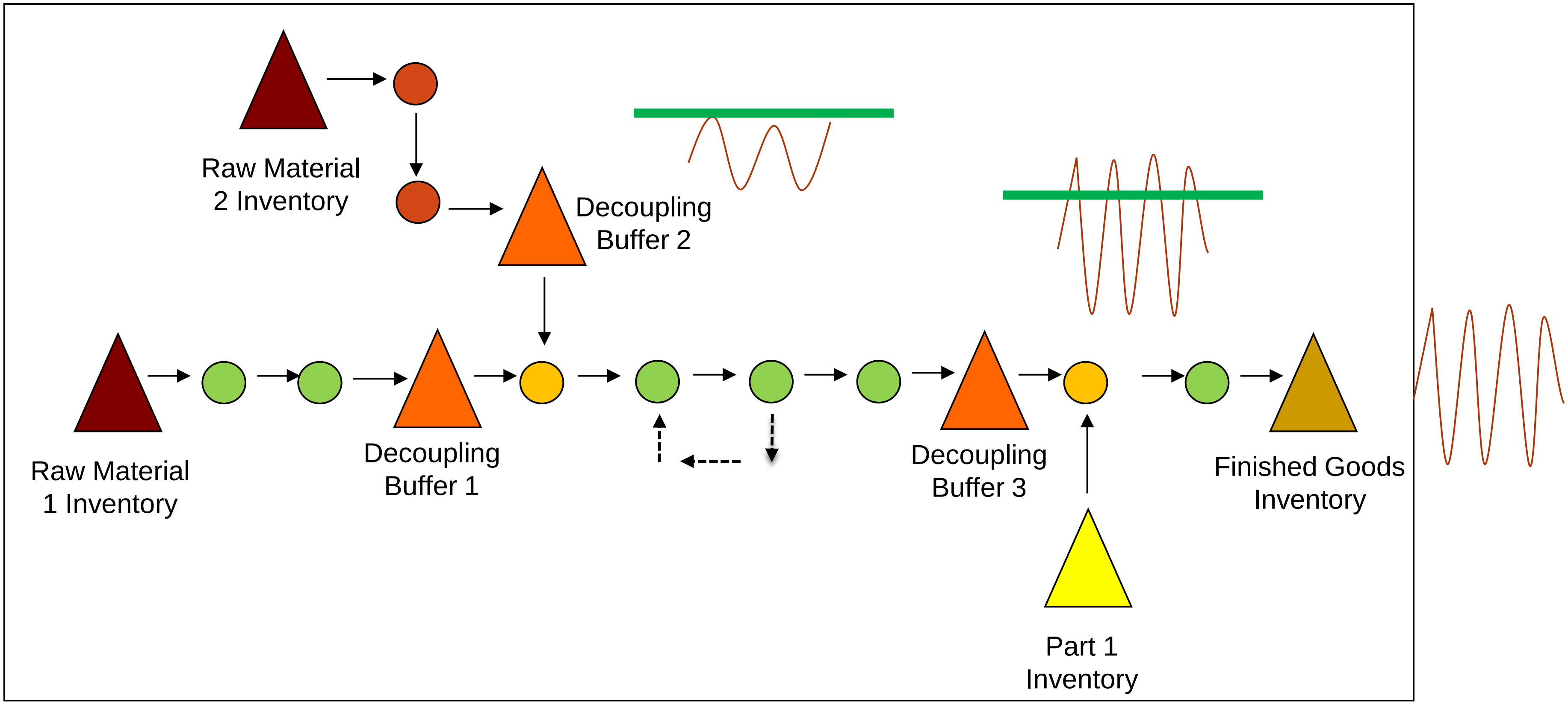
Example: multiple segments





Multiple products, similar flow paths


Raw Material
2 Inventory
Decoupling
Buffer 2
Raw Material
1 Inventory
Decoupling
Buffer 1
Decoupling
Buffer 3
Finished Goods
Inventory
Part 1
Inventory



Cycle Time = 2 days

Findings

- Higher level of smoothing is needed when:
  - OT cost is high relative to inventory cost
  - Process utilization is high
  - Forecast/Demand variance is high

- Decoupling buffers are needed:
  - To isolate bottleneck processes
  - Prior to high value-add processes
  - To separate operations with differing costs of flexibility (or OT)

Wrap-Up: Dealing with variability

- Safety stock location in a SC
- Delayed differentiation in a SC
- Dual sourcing
- Better forecast
- Smoothing and line segmentation