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A Resilience Assessment Case Study for a Munitions Supply Chain

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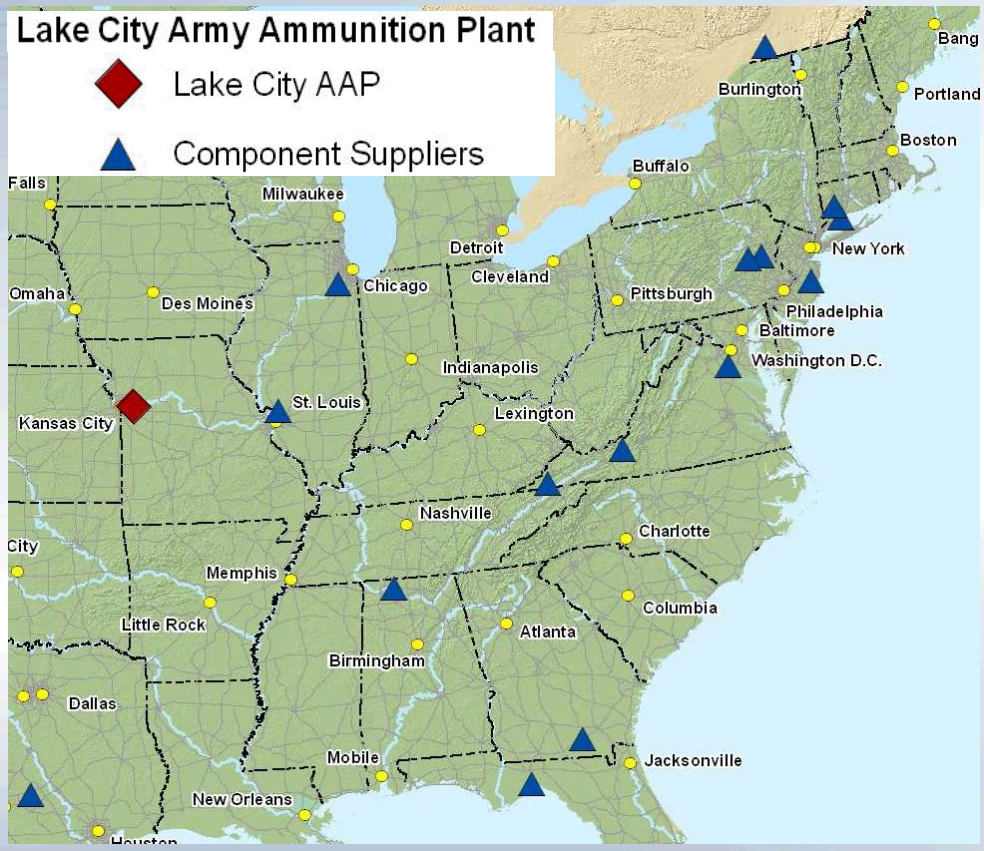
Munitions Component Suppliers

- **Lake City Army Ammunitions Plant is a primary producer of munitions for the military**
- **Component suppliers are dispersed across the country**
  - Two foreign suppliers



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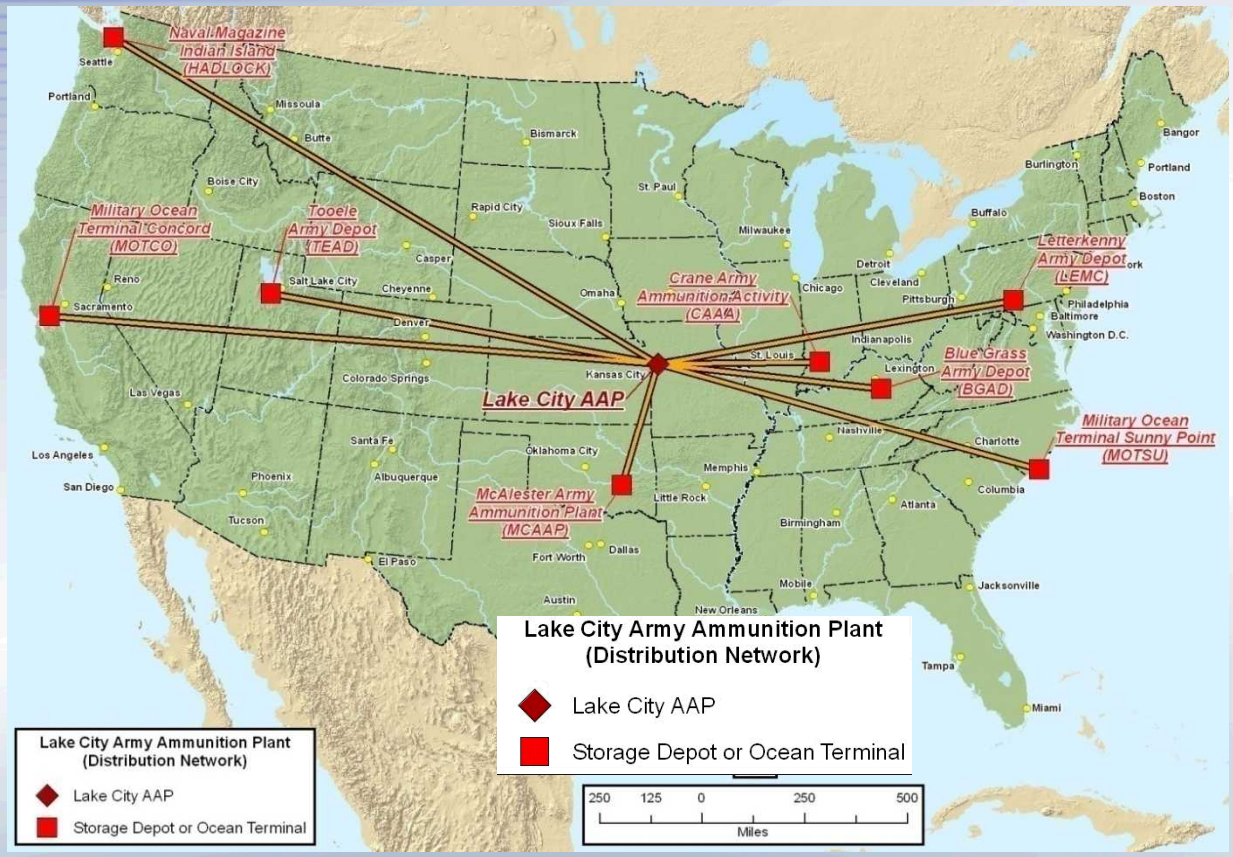
Distribution Points

- Storage depots and terminals are located across the country



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Resilience of Munitions Supply Chains

- **Analysis objectives:**
  - How might disruption of some stage in the supply chain (either production or transportation) affect the ability of the system to meet its mission objective?
  - How might the system be reconfigured to make it more resilient?
- **Solution Approach**
  - Develop dynamic simulation tool to represent supply chains for a set of munitions manufactured at Lake City AAP
  - Include production of raw materials, intermediate goods, production capacities, final assembly of multiple ammunition types, and transportation steps
  - Multiple locations and time steps

Following slides are results from a ~2 week effort that relied on data supplied from Program Executive Office for Ammunition (PEO Ammo).

Bill of Material (BOM) Data

Munitions Product X				
Component	Prod. Factor	Supplier	Location	Capacity (/month)
A	1	Acme Co.	Atl., Ga	30k
B	13.4	Apex Co.	NY, NY	400k
C	2.2	EDV Co.	Raleigh, NC	500k
D	1	Big Co.	Paris, France	5k

Component D

Component C

Component B

Component A				
Component	Prod. Factor	Supplier	Location	Capacity (/month)
A.1	5	BobCo.	Tempe, FL	10k
A.2	1	BenCo.	Savannah, Ga	35k
A.3	3	BillCo.	Raleigh, NC	89k

Component A.1				
Component	Prod. Factor	Supplier	Location	Capacity (/month)
A.1.1	8	DaleCo.	NY, NY	1k
A.1.2	11	DaveCo.	Radford, VA	5k
A.1.3	6	DenCo.	Las Vegas, NV	9k

- **Were provided BOM data for "critical" suppliers**
- **BOMs included**
  - Production recipes
  - Suppliers
  - Locations
  - Capacity constraints
- **High quality data enabled us to build supply chain models**

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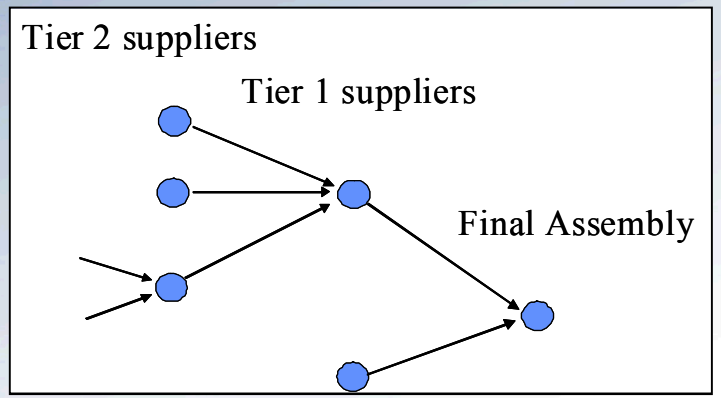
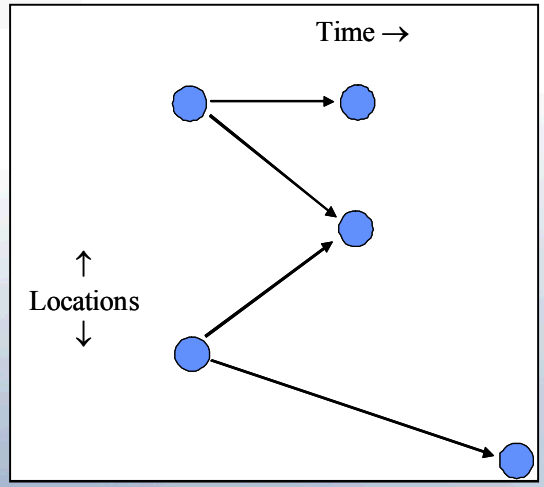
Model Details

- Allows input of disruptive events
  - Facility outage for some period
  - Inability to transport specific products
- Assess:
  - Can mission targets for delivery be met?
  - If not, how short, over what period?
- Design changes to improve resiliency of system



Multi-tiered Network from Bill-of-Materials Data



Multi-tiered Network from Bill-of-Materials Data

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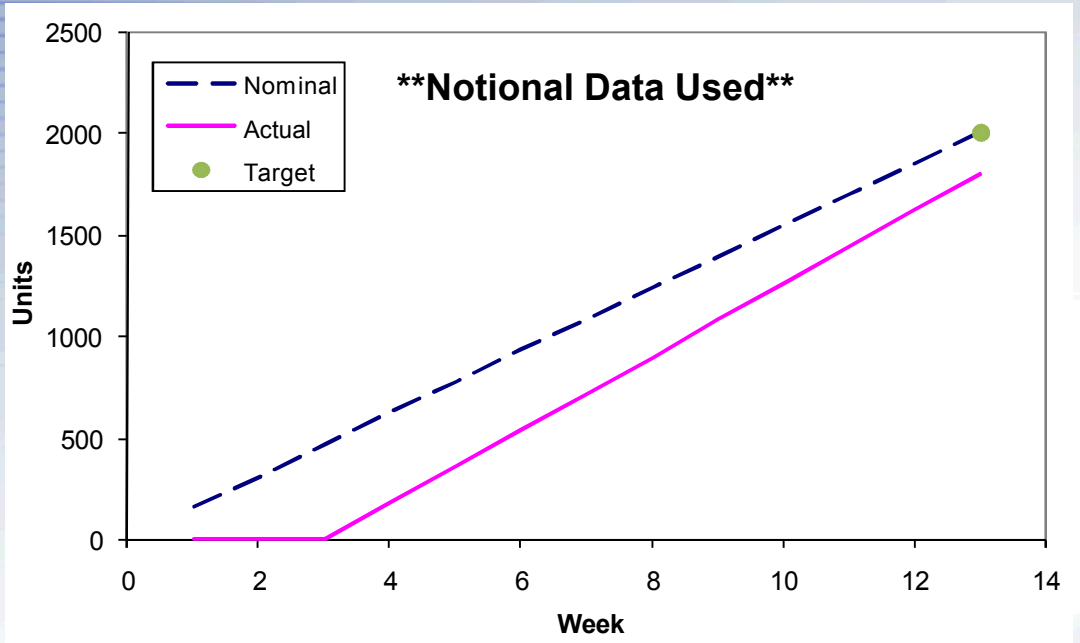
Scenario 1: Disrupt Final Assembly

- 3 week disruption for final assembly of Ammo Type 1 at Lake City AAP
- Production rate exceeds nominal rate in attempt to make up for disruption
- Production constraints prevent facility from meeting production goal
  - Short by 10%



Cumulative Production

- In this scenario, need to maintain excess inventory equal to 10% of target to meet production goals for Ammo Type 1

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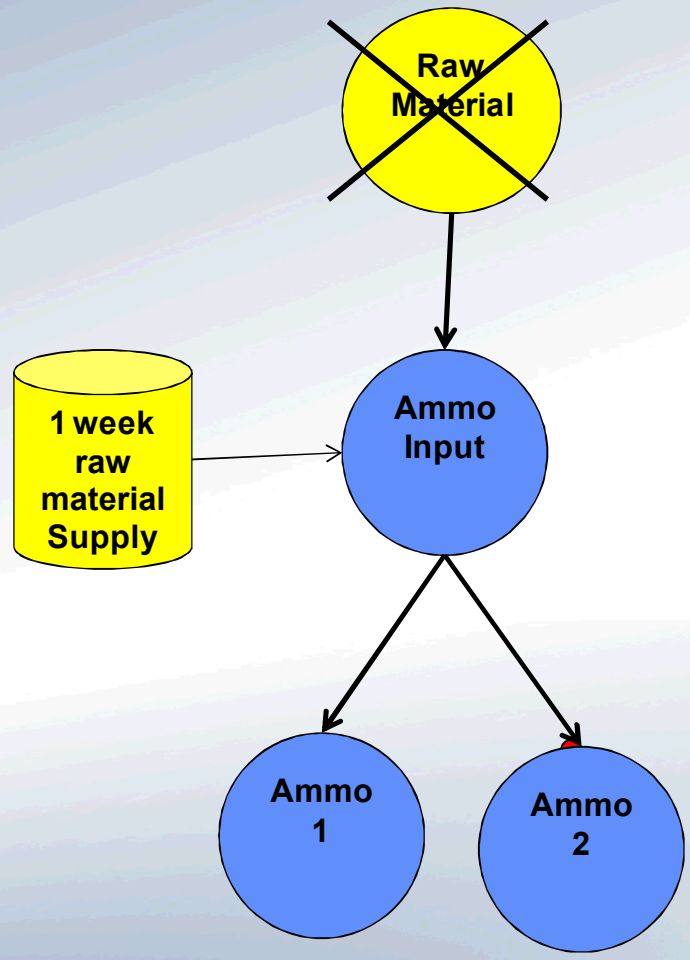
Scenario 2: Disrupt Raw Material Production

- Raw material production reduced by 2/3 for 4 weeks
- Propellant manufacturer has 1 week supply on hand
- 2 ammo types require propellant



Scenario Abstraction

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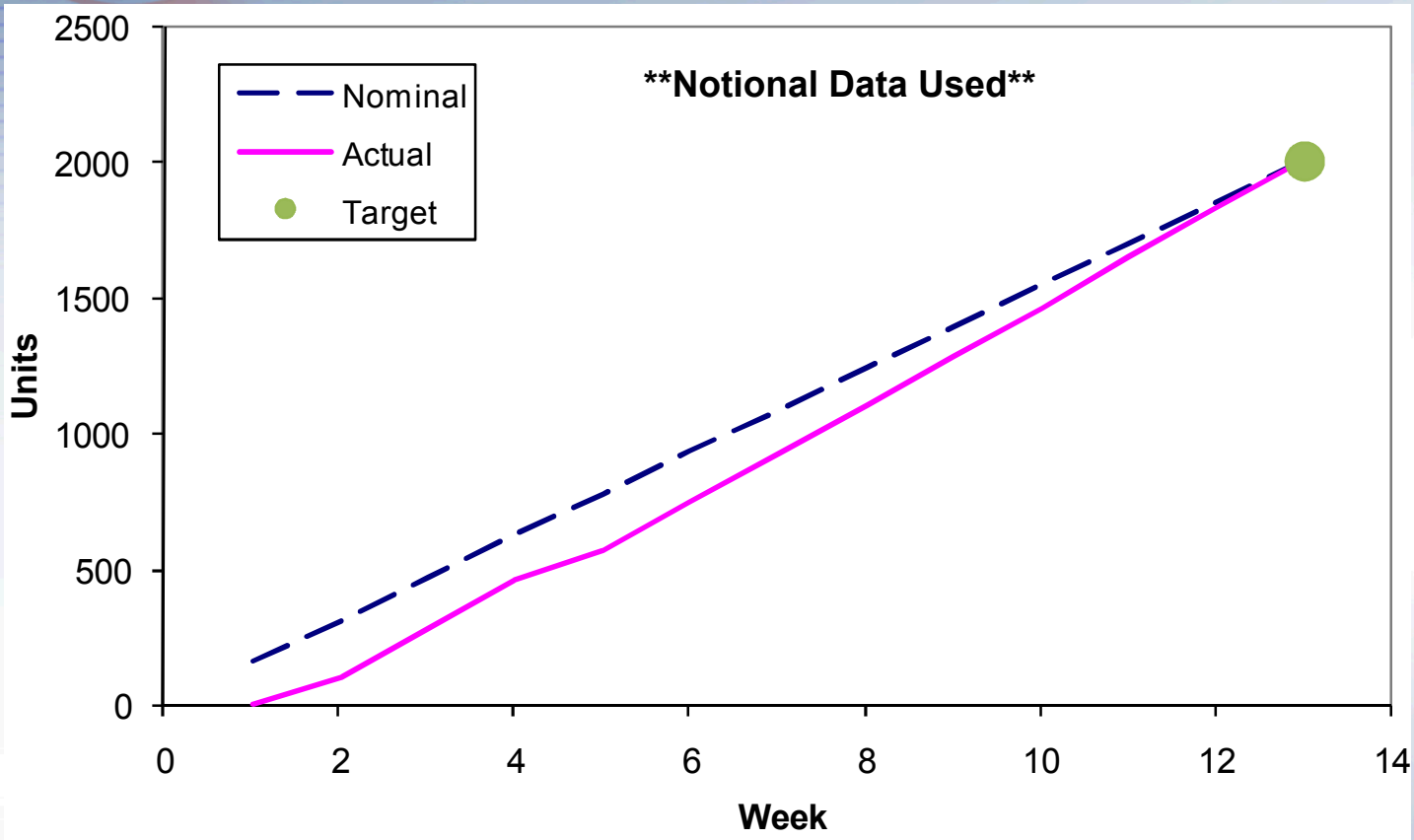
Scenario 2: Ammo 1 Cumulative Production



- **Disruption does not prevent meeting production goals for Ammo 1**

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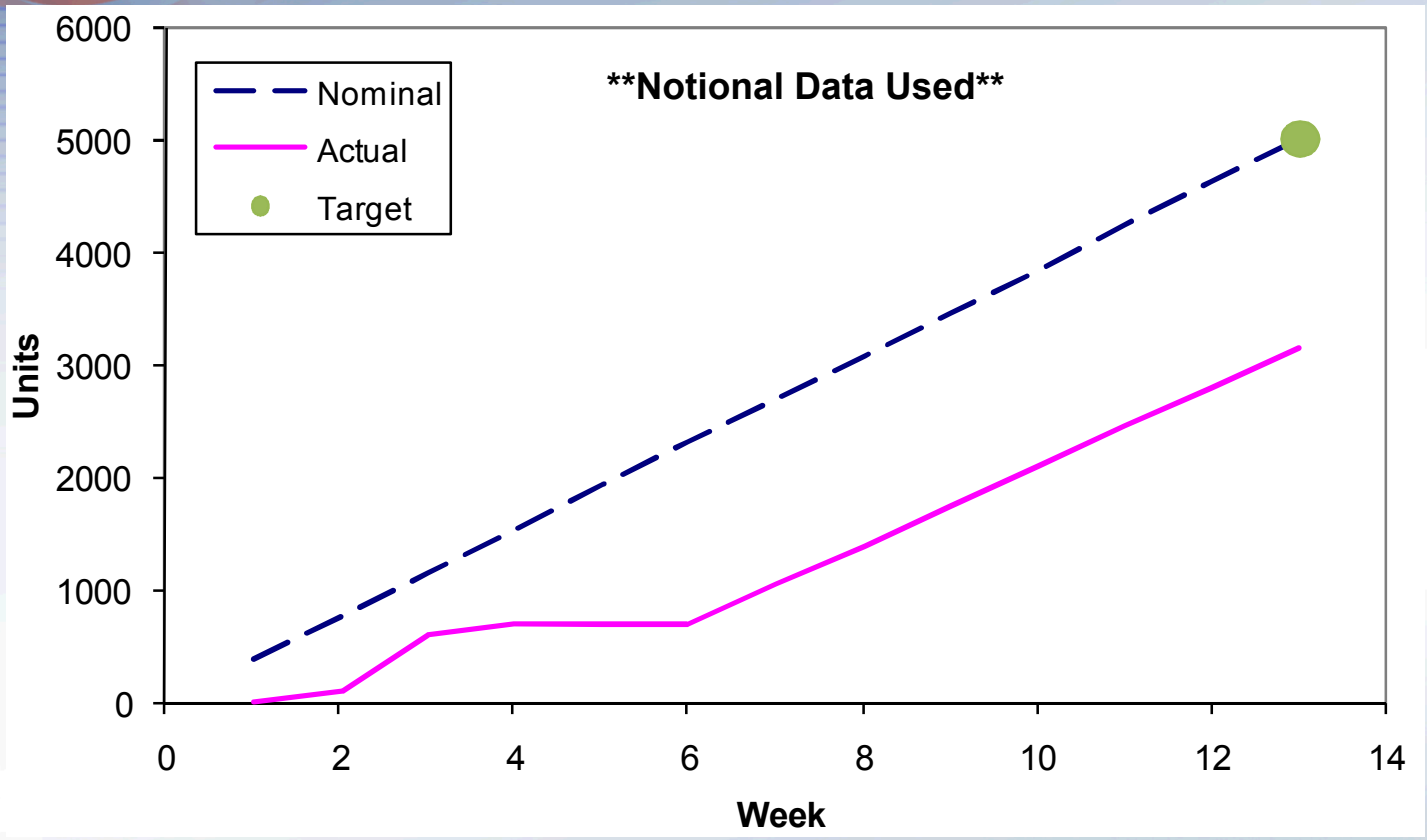
Scenario 2: Ammo 2 Production



- Impact of raw material disruption to Ammo 2 production is delayed due to extra inventory and "distance" of disruption from Ammo 2 production
- Ammo 2 production falls short of target by ~ 40%

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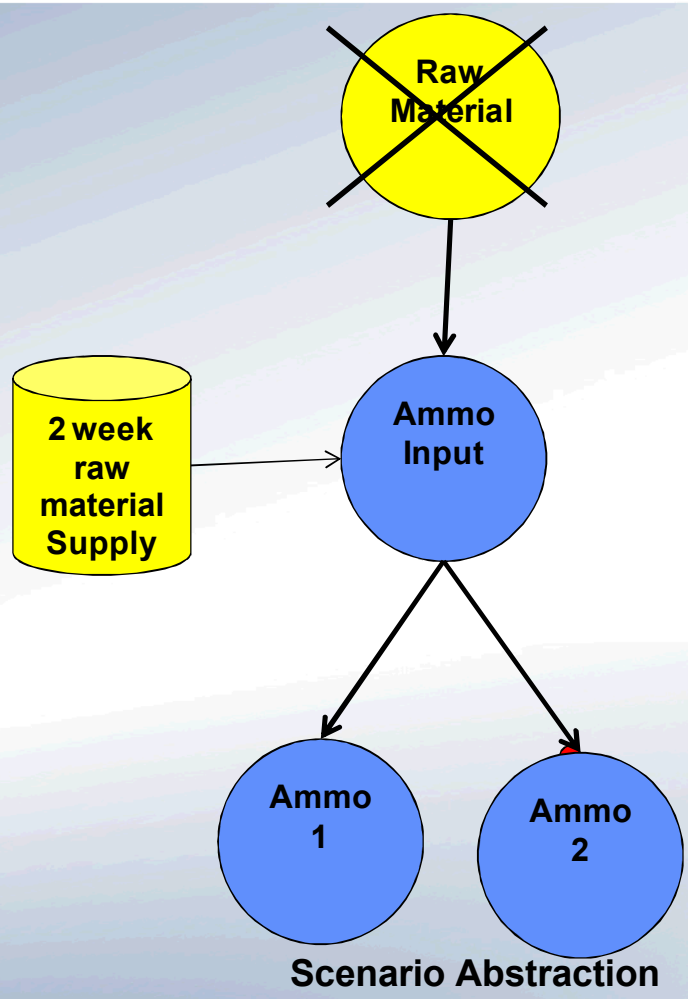
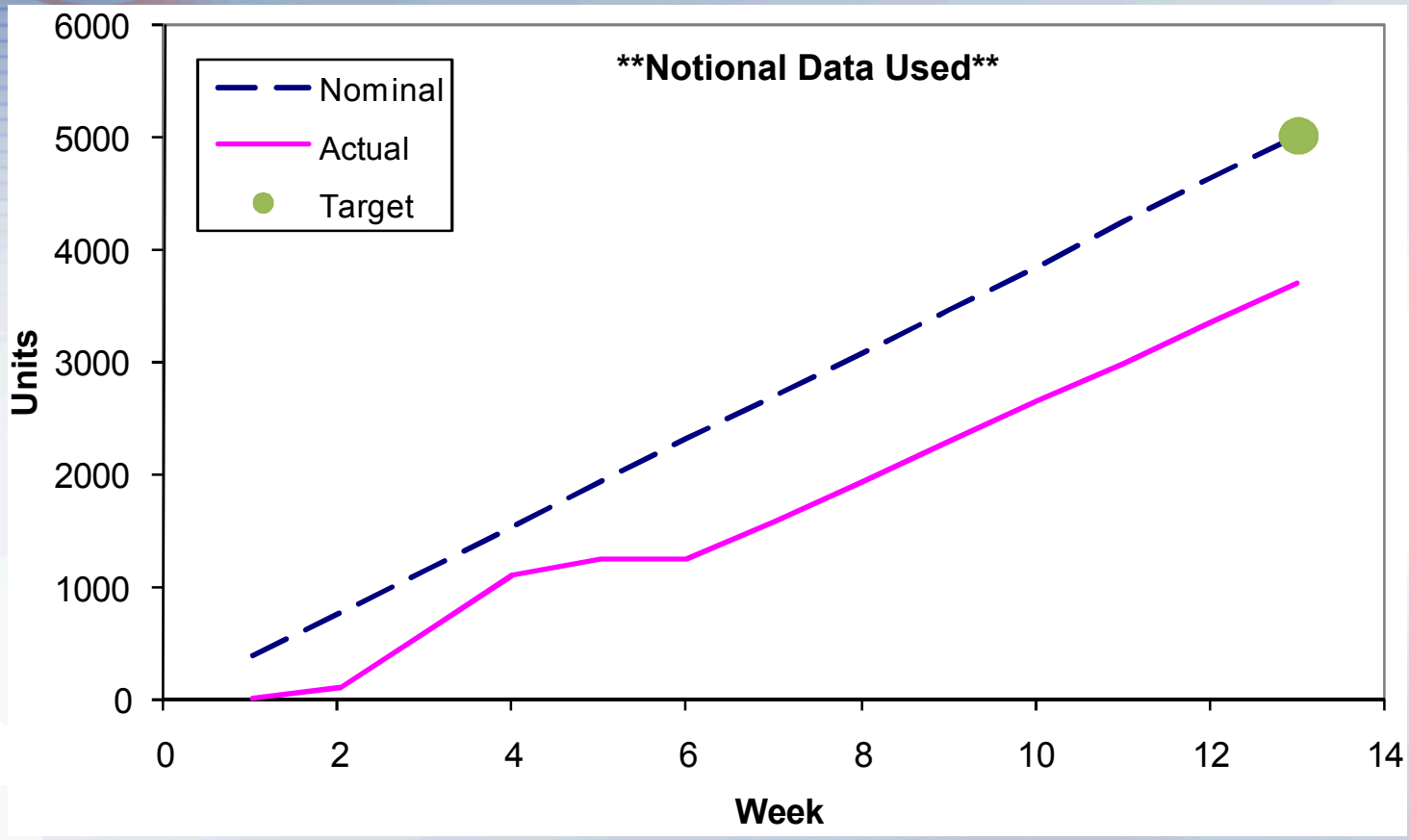
Scenario 3: Disrupt Raw Material Production

- Raw material production reduced by 2/3 for 4 weeks
- Propellant manufacturer has *2* week supply on hand
- 2 ammo types require propellant



Scenario Abstraction

Scenario 3: Ammo 2 Cumulative Production



- **Doubling excess inventory helps but result is not linear**
  - Double inventory results in ~30% shortfall

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Summary

- **High quality production data greatly facilitates supply chain model building**
- **For the munitions example, we used the model to perform quantitative contingency planning for a limited set of munitions**
- **Further expansion of the model could involve**
  - Including all ~50 munitions
  - Adding economic factors (such as cost of extra inventory, ability to ramp up production, etc.)
  - Linking potential shortages to ability to meet mission
  - A systematic evaluation of “non-critical” suppliers

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