Stress Testing of Supply Chains through Digital Twins

J. Chris White

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The new reality.

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. . . but the software tools and techniques that we use today are *insufficient* for analyzing and addressing these types of risks.

We need this.

We need this.

Harvard Business Review

Crisis Management

We Need a Stress Test for Critical Supply Chains

by David Simchi-Levi and Edith Simchi-Levi

April 28, 2020

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SCM SUPPLY CHAIN MOVEMENT

Exclusively in magazine, Trends | Friday | 24 February 2023 | 17:22h

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Stress testing uncovers supply chain vulnerabilities

Forbes

INNOVATION

Supply Chain Orchestration: Creating Harmony From Cacophony

Nov 28, 2023, 04:05pm EST

By, Dr. Anne Robinson, Chief Strategy Officer, Kinaxis

New rules, new tools

The supply chain game has changed. It's less about being a chain and more about being a network of networks. If your suppliers' suppliers' supplier is a small component manufacturer in Taiwan that was hit by an extreme weather event, you need to know. But just knowing isn't enough. You also responsible for a can act right awa whether you are call on to tide you

Legacy supply chain tools just weren't designed for this level of insight. As the supply chain landscape becomes ever more complex, a new approach is needed.

> Legacy supply chain tools just weren't designed for this level of insight…. *a new approach is needed.*

Real-world examples.

The Boeing Company is especially proud of its gi... ...bly plant here, 30 miles north of Seattle. Cranes ... ... in a high-technology ballet, piecing togethe... ... modern age: the jumbo jet. Last year, 135,0... factory, which, covering 98.3 acres, could co... Disneyland.

But in September, observant visitors glimpsed a surprising spectacle: the arrival of taxis dispatched by Boeing to pick up parts from local suppliers, parts desperately needed to move unfinished airplanes out the door.

Such not-in-time manufacturing was just one sign that Boeing's ==ambitious plan to more than double its monthly output,== to 43 planes from 18, had spun out of control. In early October, overwhelmed by thousands of foul-ups, Boeing temporarily halted production of the 747 as well as the smaller 737.

Then, a few weeks later, Boeing posted a $1.6 billion third-quarter charge and its first operating loss in 28 years. The problems will cost another $1 billion next year, the company said.

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The New York Times

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KFC **$300M**

Supply Chain Game Changer™

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KFC Ran Out of Chicken!

There's another unfortunate entry in the annals of Supply Chain failures that burst into the wider world of business and pop culture: More than half of the UK's Kentucky Fried Chicken stores recently closed because KFC ran out of chicken!

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CBS EVENING NEWS ›

Chip shortage cost U.S. economy billions in 2021

CBS EVENING NEWS

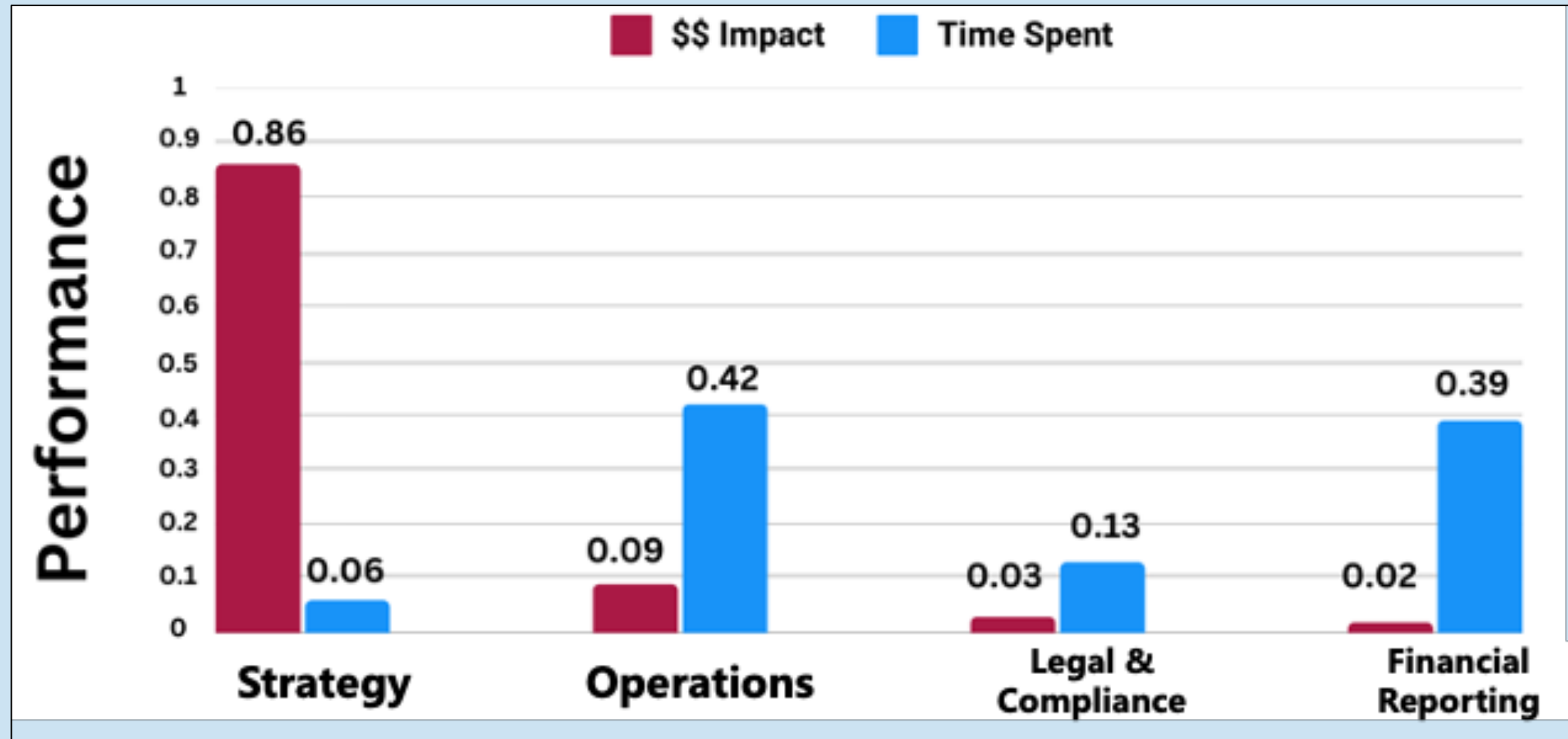BY OMAR VILLAFRANCA
JANUARY 28, 2022 / 9:16 PM EST / CBS NEWS
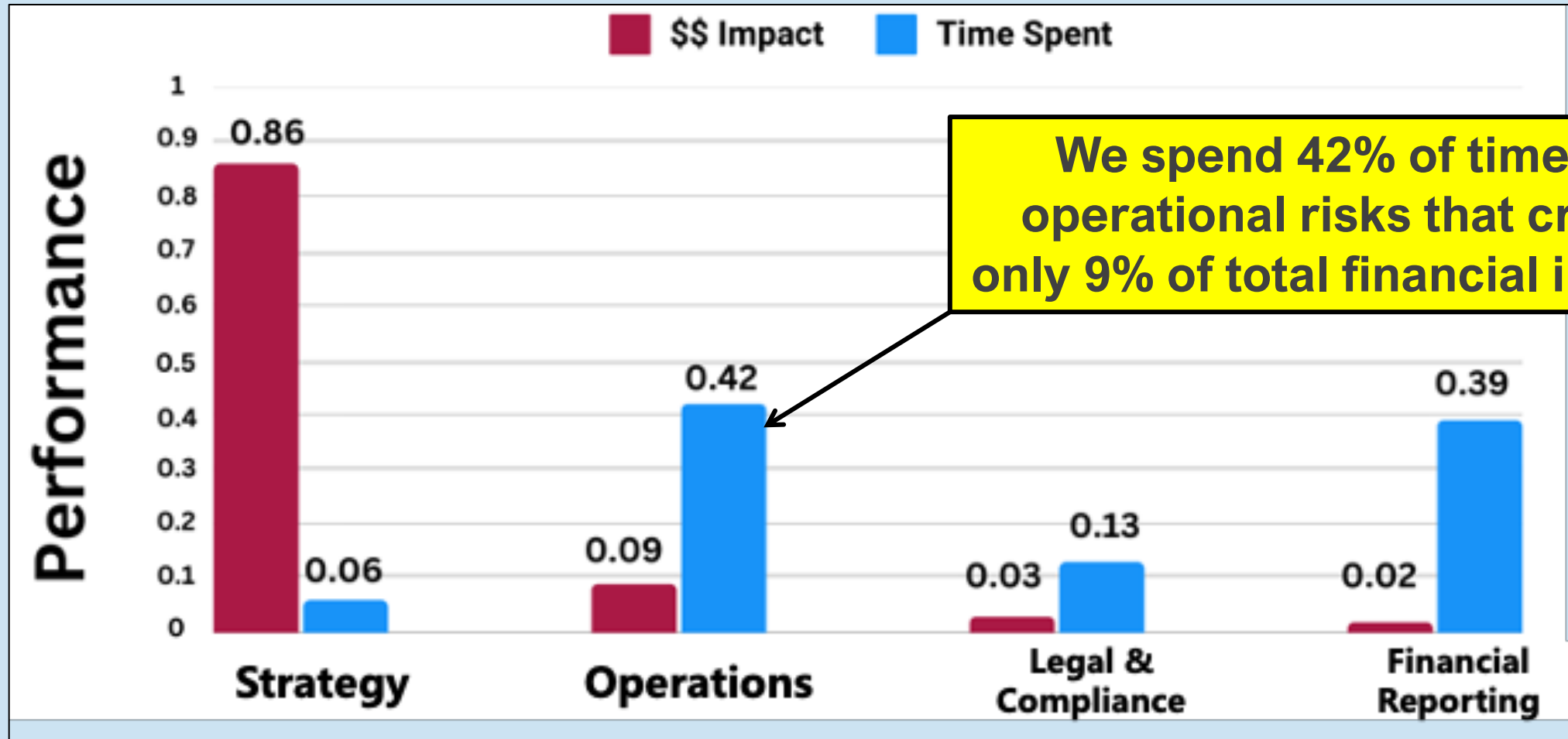
($240B)

We need to do something better.

However . . .

Strategic risk paradox.

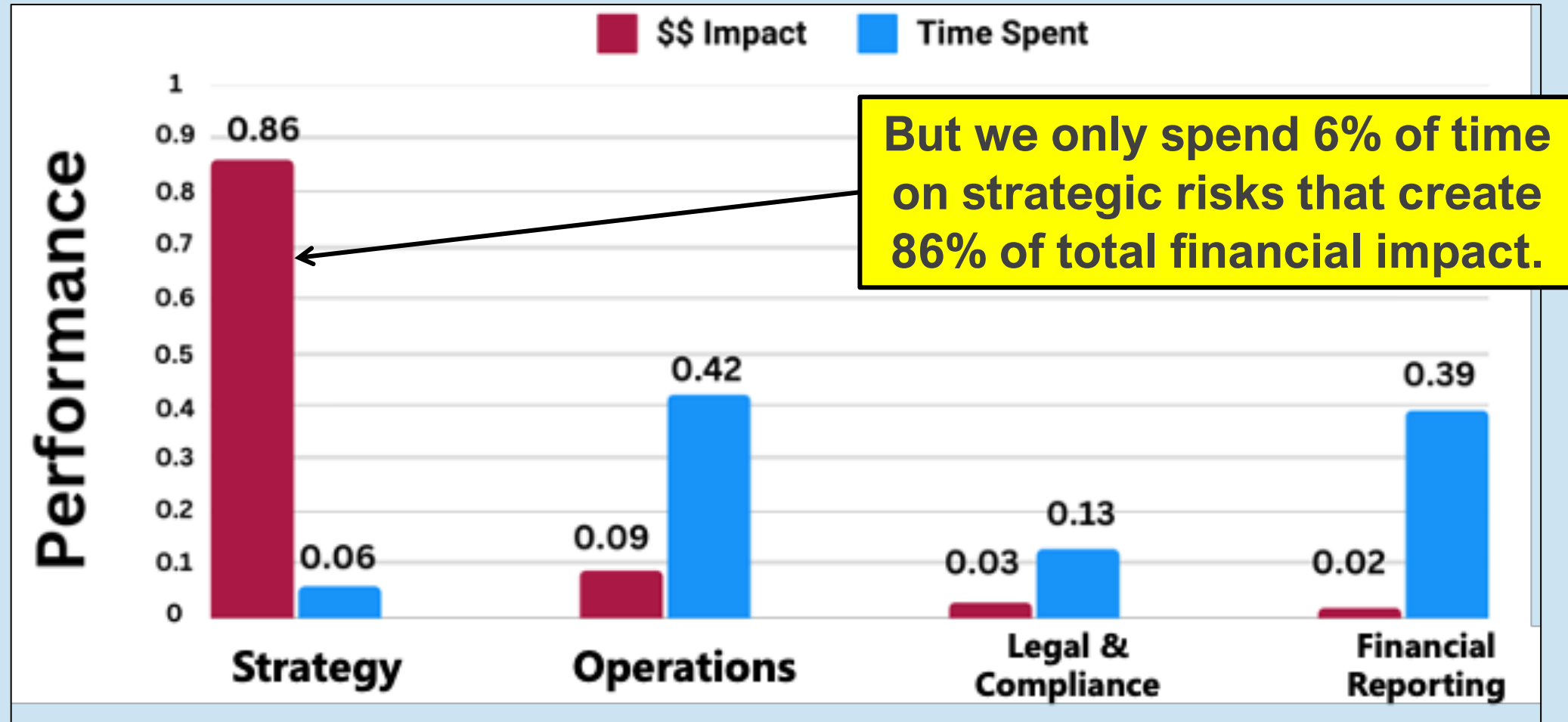# Strategic risk paradox.

Bar chart titled "Performance" with a legend showing **$$ Impact** (dark red) and **Time Spent** (blue).

Category	$$ Impact	Time Spent
Strategy	0.86	0.06
Operations	0.09	0.42
Legal & Compliance	0.03	0.13
Financial Reporting	0.02	0.39

Callout: **We spend 42% of time on operational risks that create only 9% of total financial impact.**

Strategic risk paradox.

But we only spend 6% of time on strategic risks that create 86% of total financial impact.

What tool do we use? A spreadsheet!

We use the simplest, least expensive tool to address major strategic risks and issues worth $Ms and even $Bs!

Spreadsheets remain the top method for supply-chain planning.

Top 6 planning IT systems in use,[1] % of respondents

Spreadsheets	SAP APO[2]	SAP IBP[3]	E2Open	Blue Yonder/JDA	In-house
73	53	20	17	13	13

[1]Respondents could choose more than one system; all other systems were named by 7% of respondents or less (n = 30).
[2]Advanced Planning and Optimization.
[3]Integrated Business Planning.
Source: McKinsey survey of global supply-chain leaders (May 6–June 3, 2021)

McKinsey & Company

We can't do that.

We don't have data.

INPUT   **ACTIVITIES**   **RESULTS**

INPUT **ACTIVITIES** **RESULTS**

Statistical modeling attempts to project future results by extrapolating historical process data into trends or patterns:

- Highly dependent on the quality of data.

- Focuses on results with no consideration for activities and decisions that occur.

- Does not forecast well when future conditions are different from the past.

INPUT **ACTIVITIES** **RESULTS**

RESULTS

ACTIVITIES

Statistical modeling attempts to project future results by extrapolating historical process data into trends or patterns:

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◦ Focuses on results with no consideration for activities and decisions that occur.

◦ Does not forecast well when future conditions are different from the past.

Structural modeling attempts to project future results by simulating the activities or operations that actually occur:

◦ Focuses on the flow of activities, which is independent of data.

◦ Data are good (if available), but it's only used to tailor and calibrate the model.

◦ Focuses on causal activities which generate the behavior and results.

Statistical vs. Structural Modeling

System "momentum" prevents significant changes from occurring within the time horizon for which forecast is **valid**.
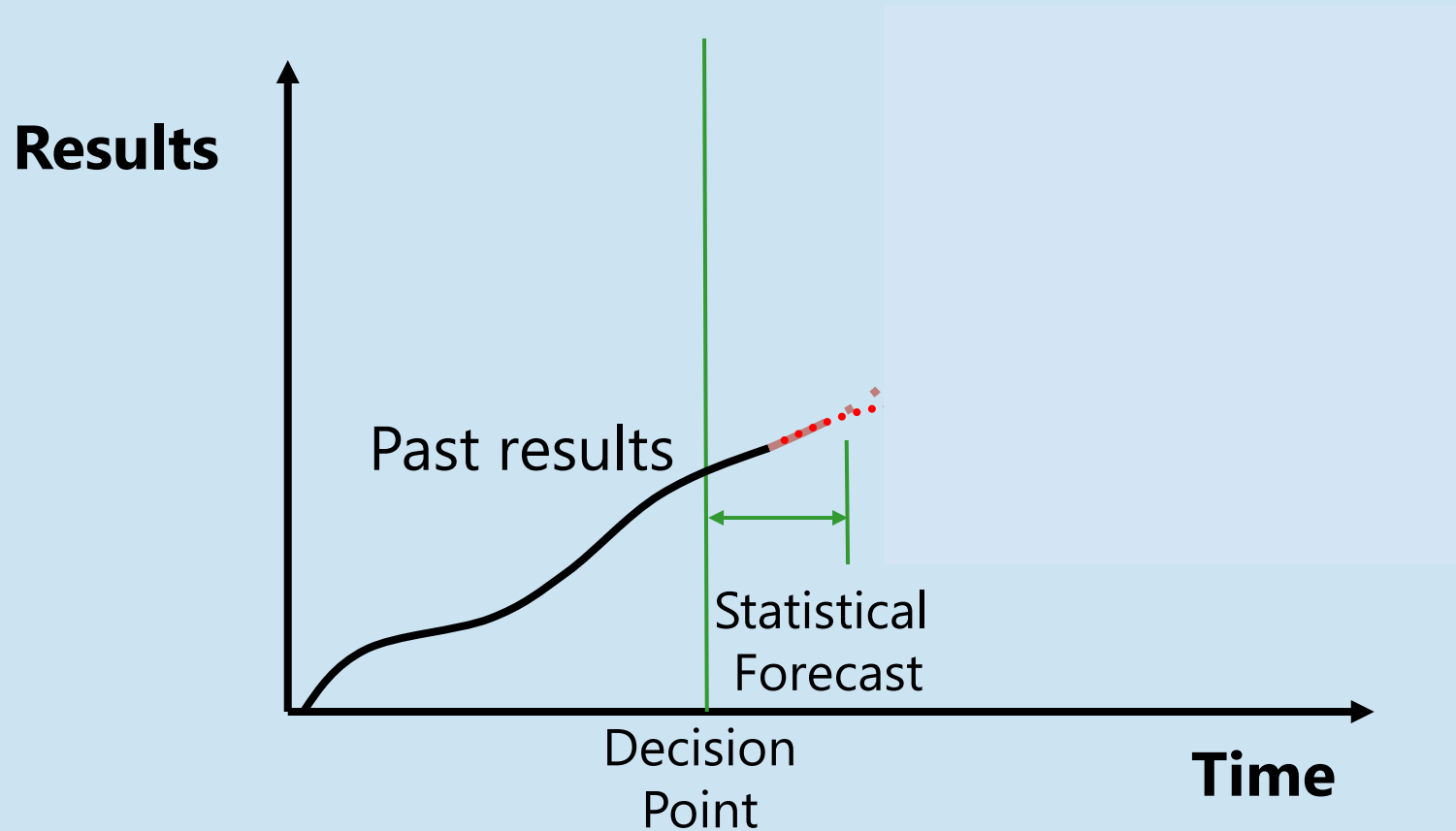
Statistical vs. Structural Modeling
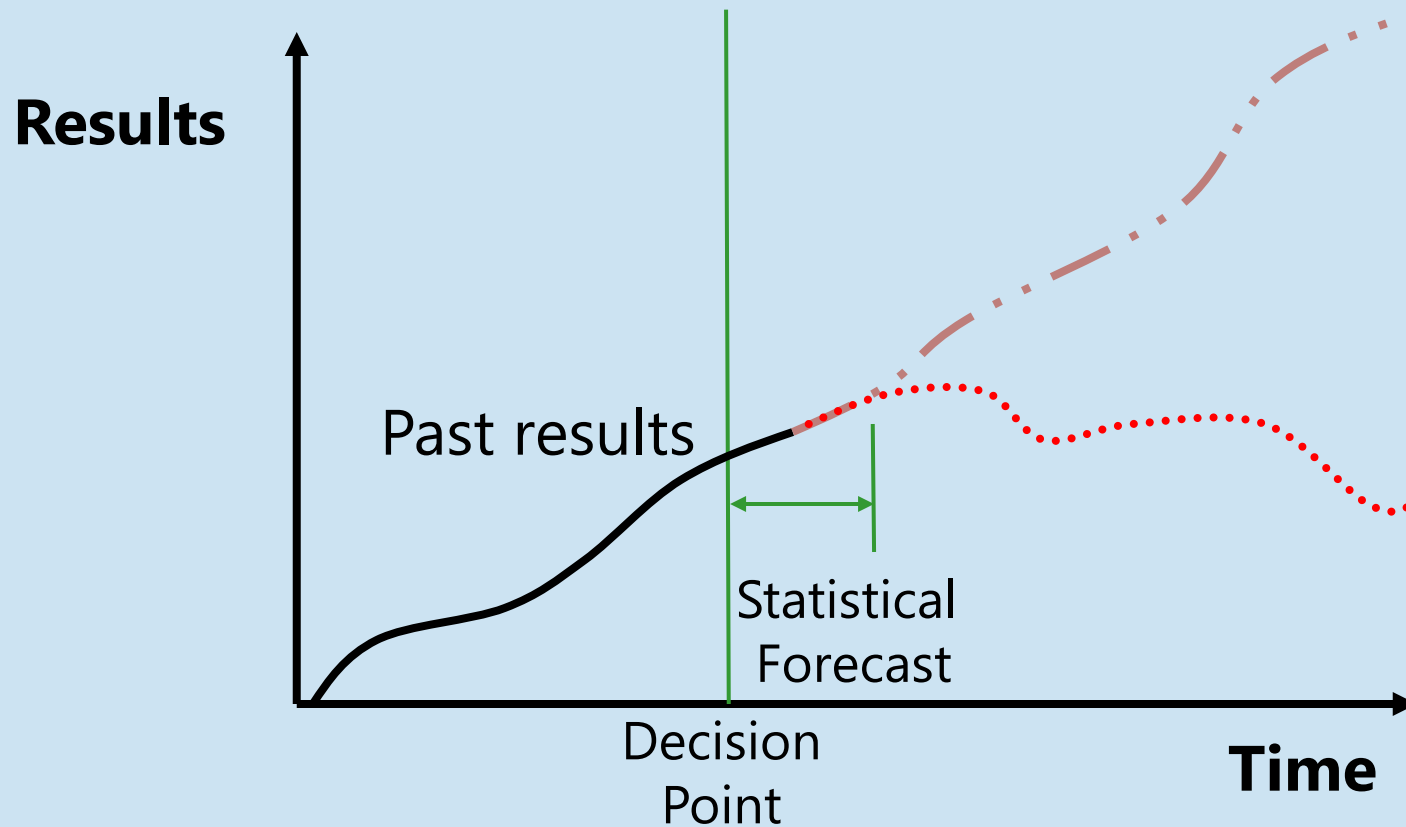
Decisions become effective and significant changes occur **beyond** the forecast horizon.

Statistical vs. Structural Modeling

Decisions become effective and significant changes occur **beyond** the forecast horizon.

Results

Structural forecast minimizes long-term forecast error

Past results

Statistical Forecast

Decision Point

Time
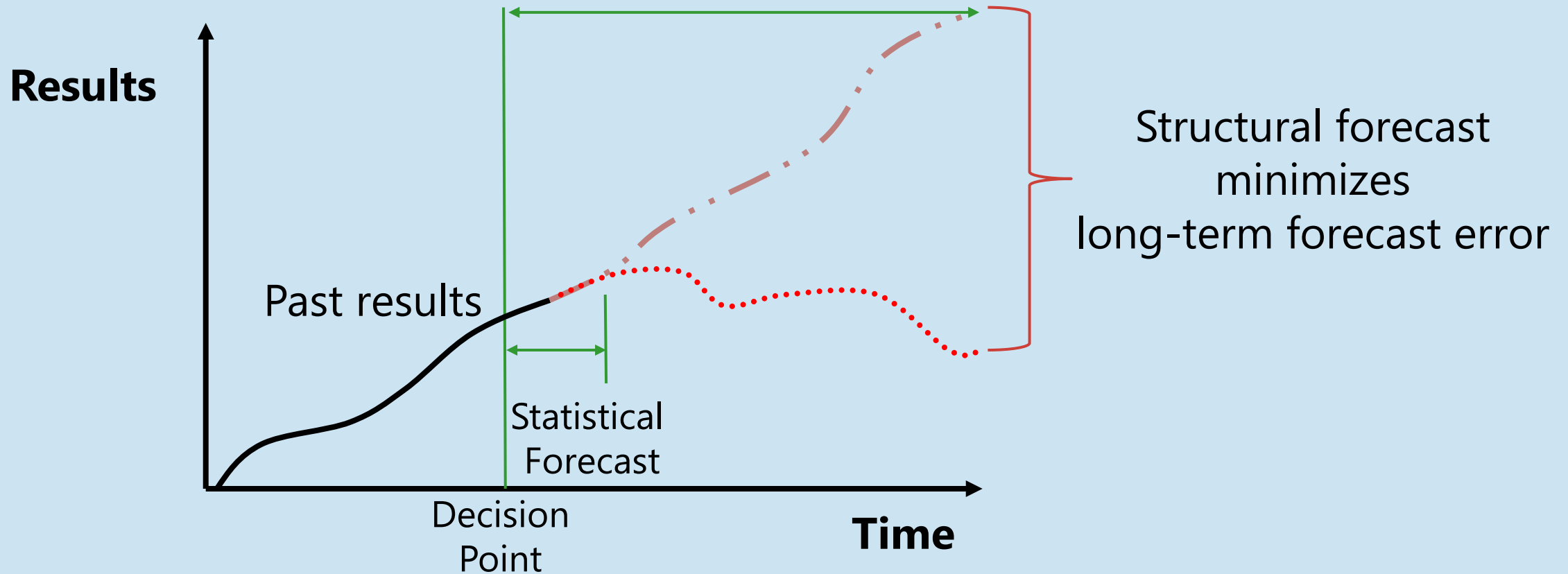
Statistical vs. Structural Modeling

STATISTICAL MODELING

Pros

- Can be useful for the short-term forecasts because conditions do not change much, so almost any forecast methodology is valid.

- Already built into ERP/SCM tools.

Cons

- Often requires "scrubbing" data or otherwise "cleansing" the data, which can add bias.

- Not effective for long-term forecasts, especially when conditions change because data used in the model is no longer valid.

- Does not include decision-making processes that can alter behavior based on reactions to conditions.

Statistical vs. Structural Modeling
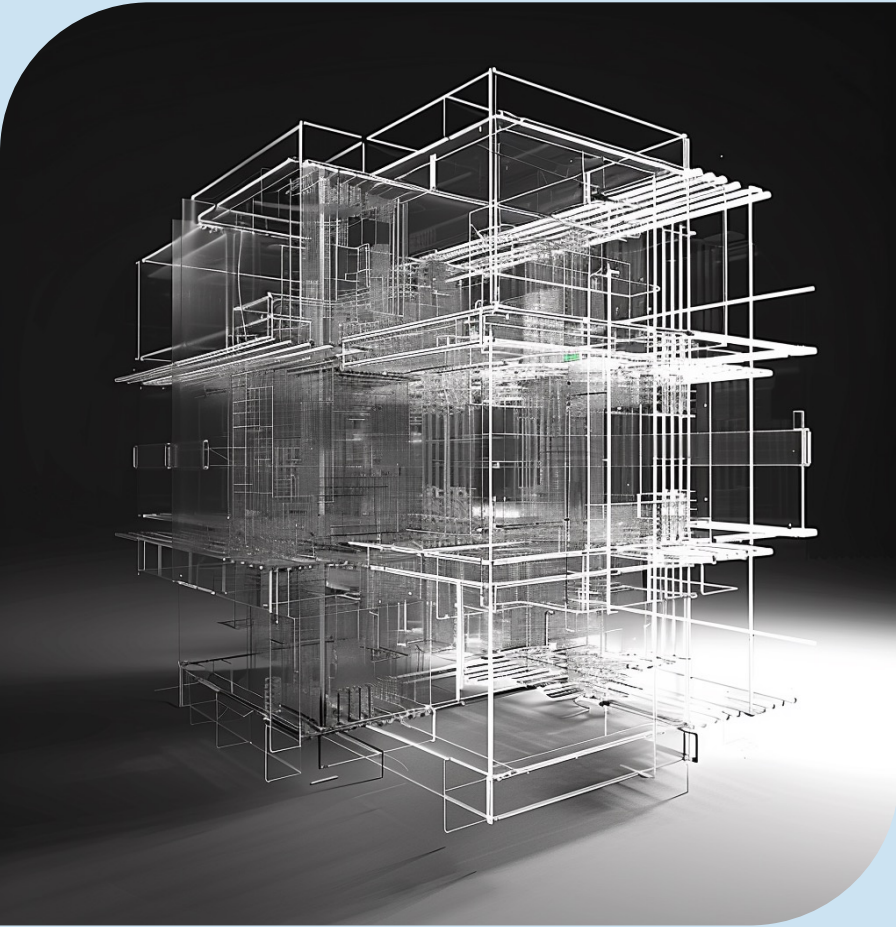
STRUCTURAL MODELING

Pros

- ○ Incorporates the causal activities that produce the observed behavior.
- ○ Includes management feedback loops and management policies that can alter the system based on reactions to conditions or changes experienced along the way.
- ○ Most effective for long-term forecasts.

Cons

- ○ Does not offer anything different from statistical modeling when doing very short-term forecasts.
- ○ Currently, not ERP/SCM tools contain this methodology, so it would need to be added.

What do we mean by a "stress test?"

And what does a structural model do?

Structure:
Wide and shallow
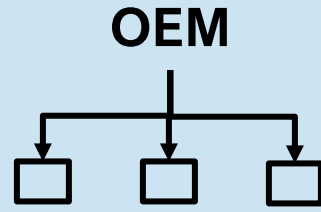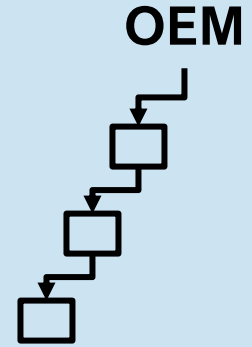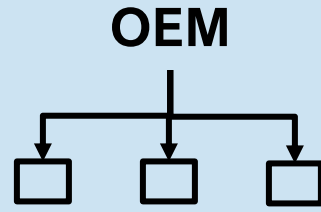
OEM

Structure:
Narrow and deep

OEM

Structure: Wide and shallow

OEM

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OEM Raw Material inventory grows by ~35% and it takes ~26 weeks to settle down

Structure: Wide and shallow

OEM

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OEM Raw Material inventory grows by ~35% and it takes ~26 weeks to settle down

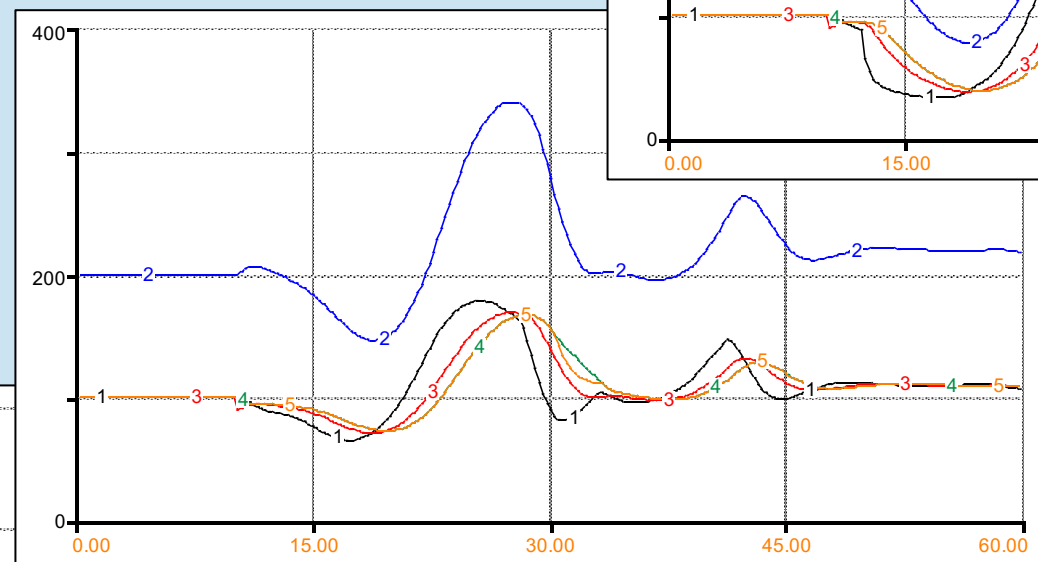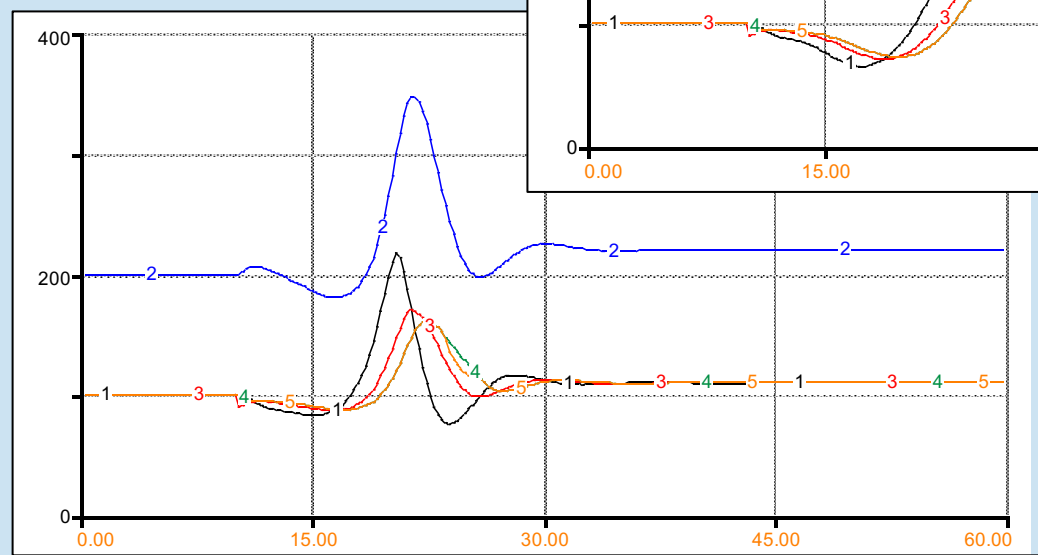**OEM Raw Material inventory grows by ~70% and it takes ~13 weeks to settle down**

What about a disruption?

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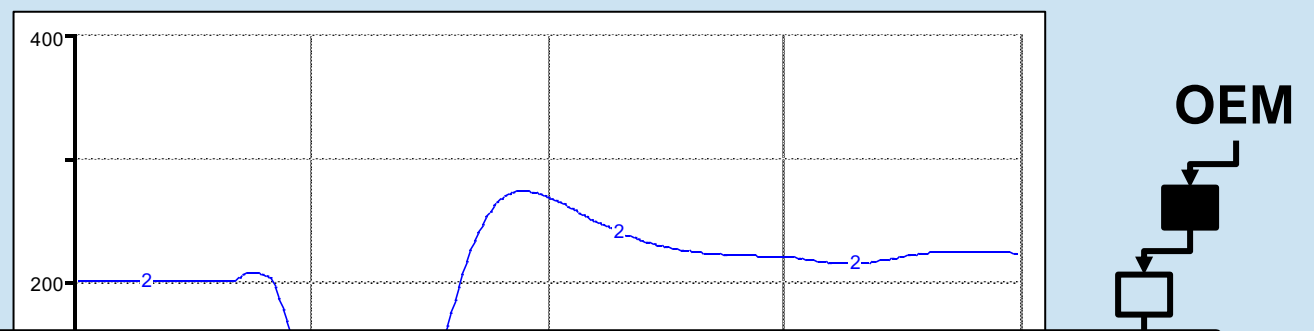

OEM

What about a disruption?
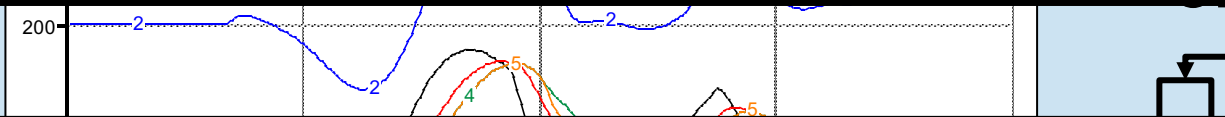
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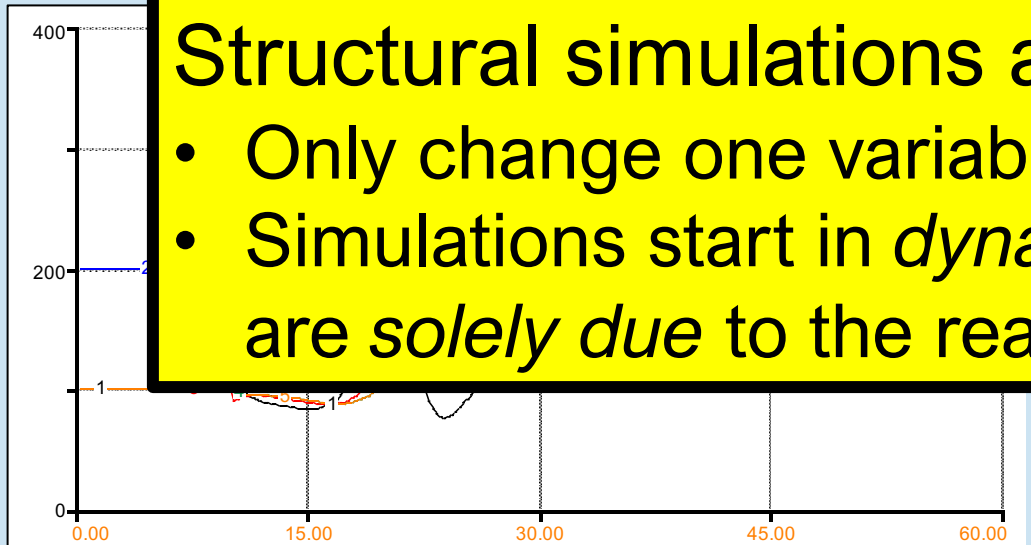
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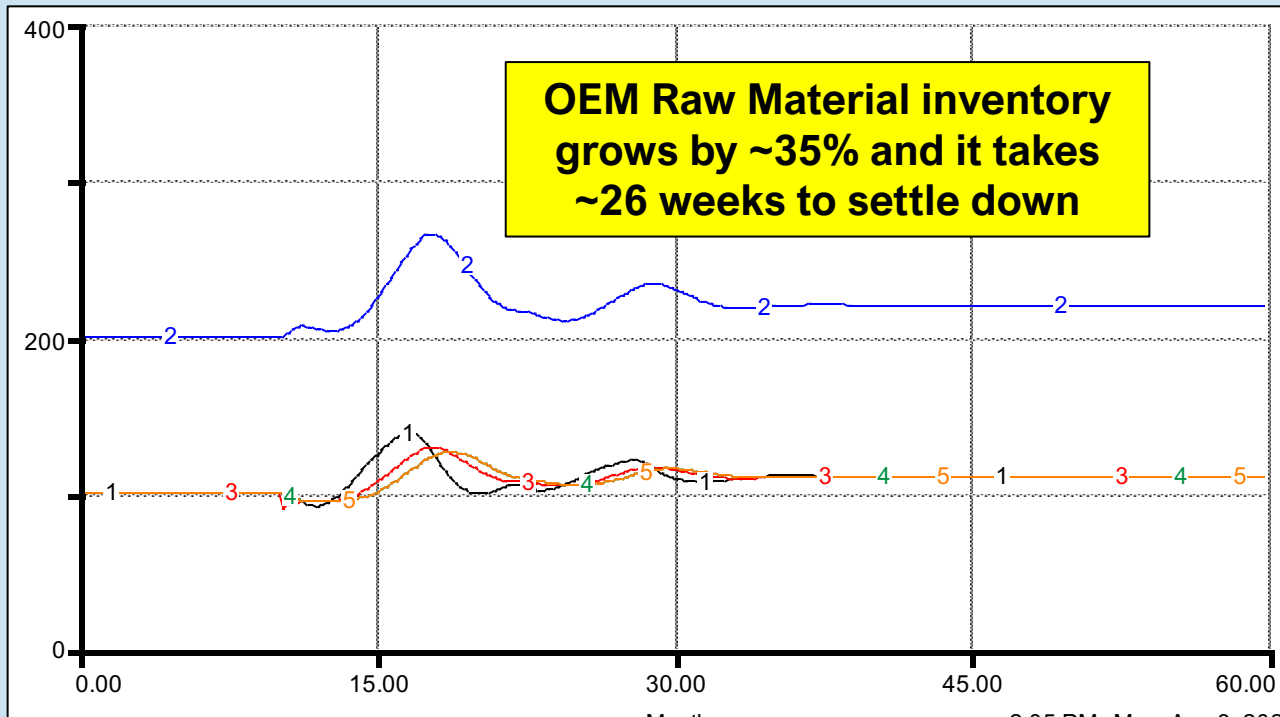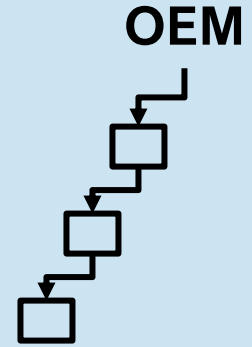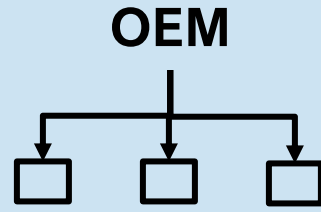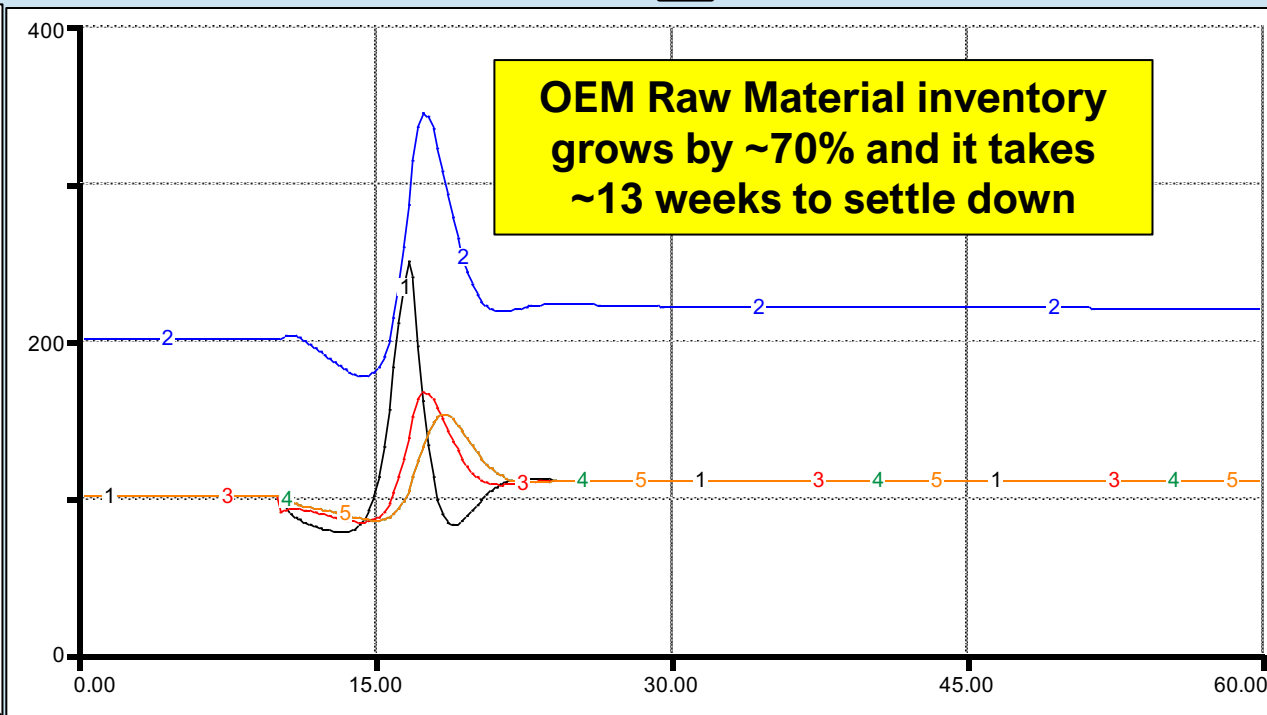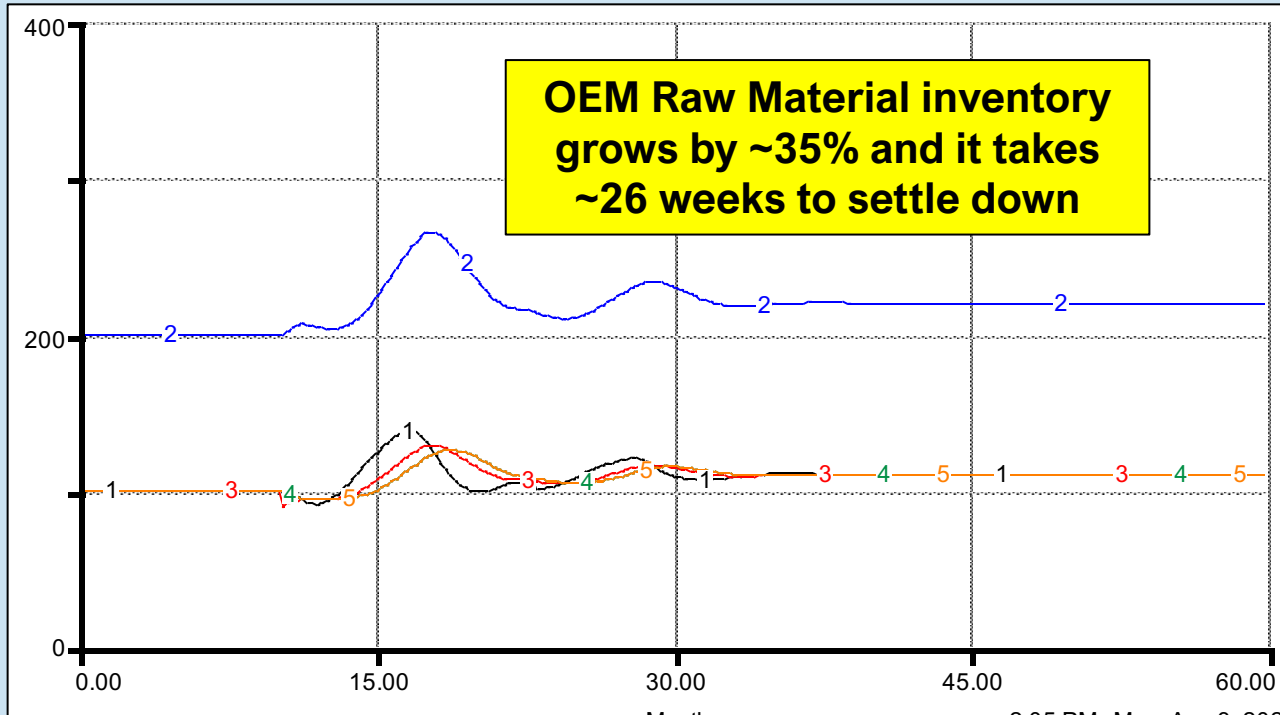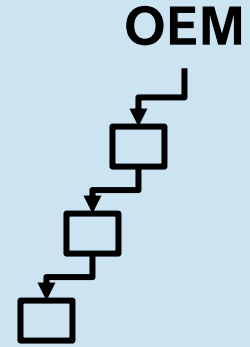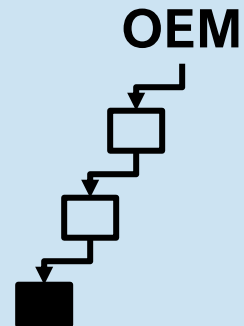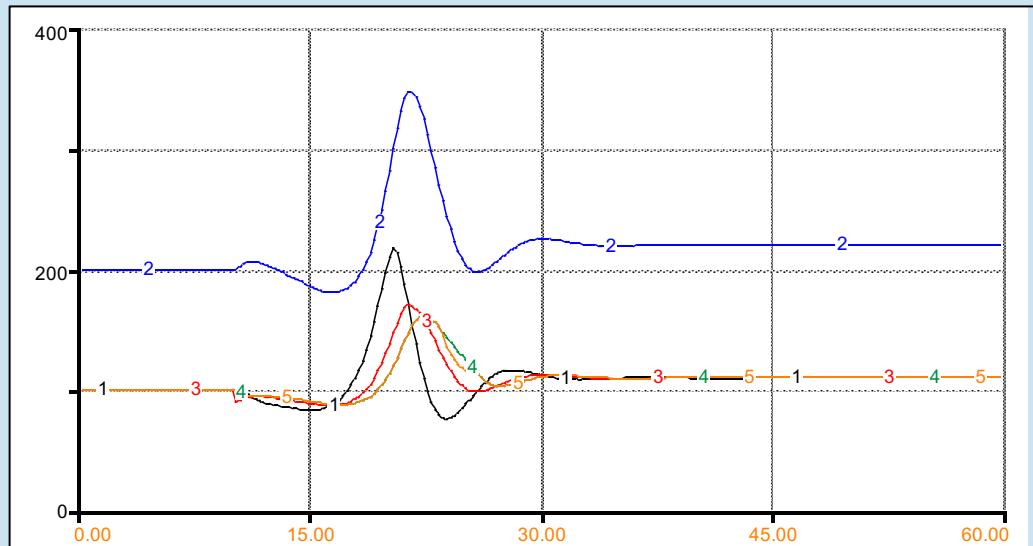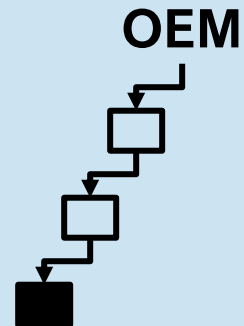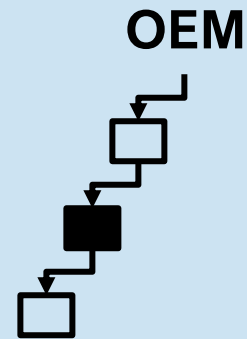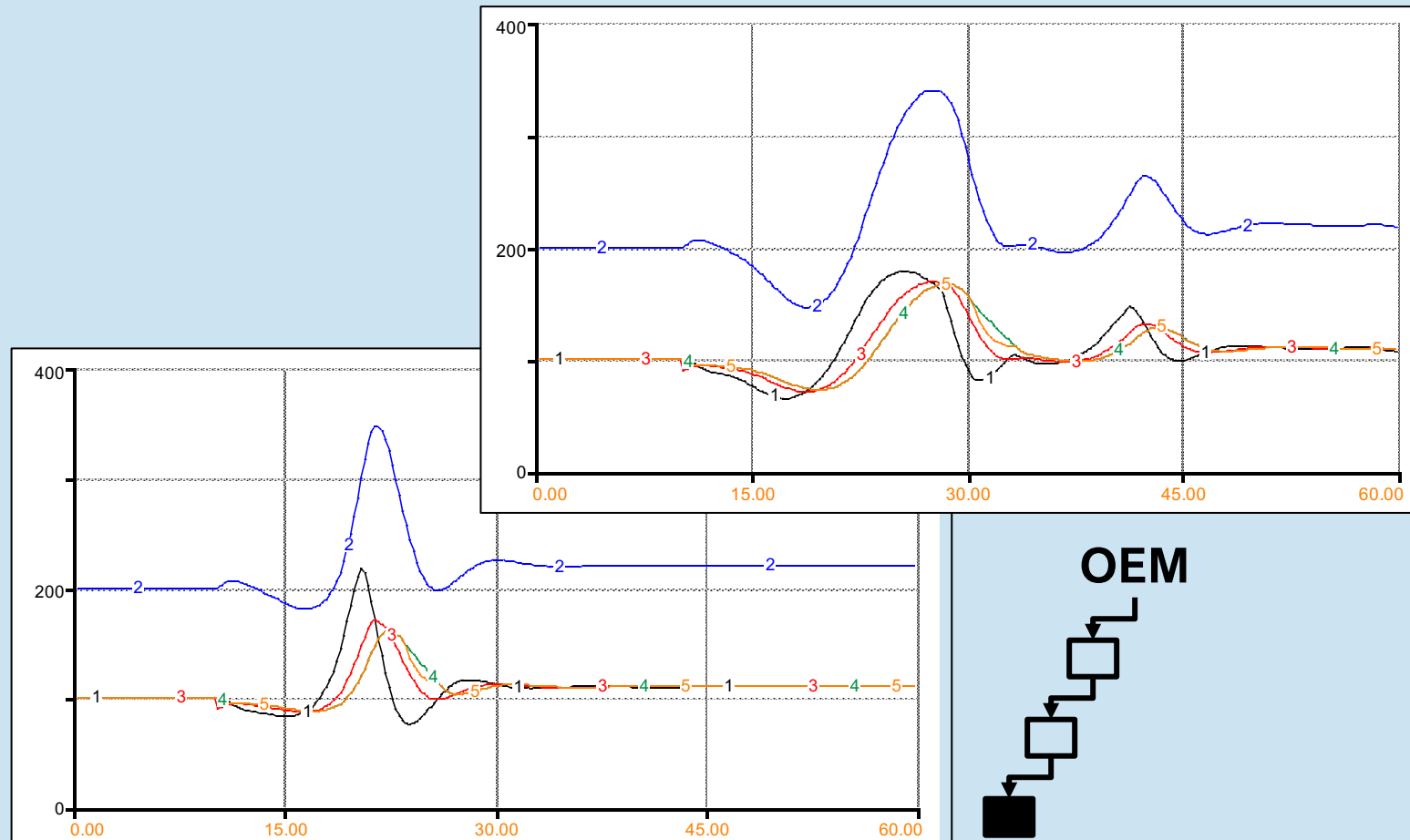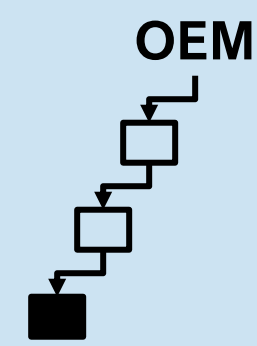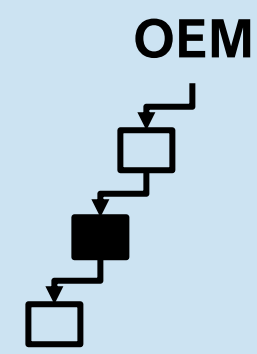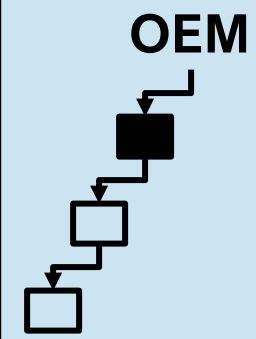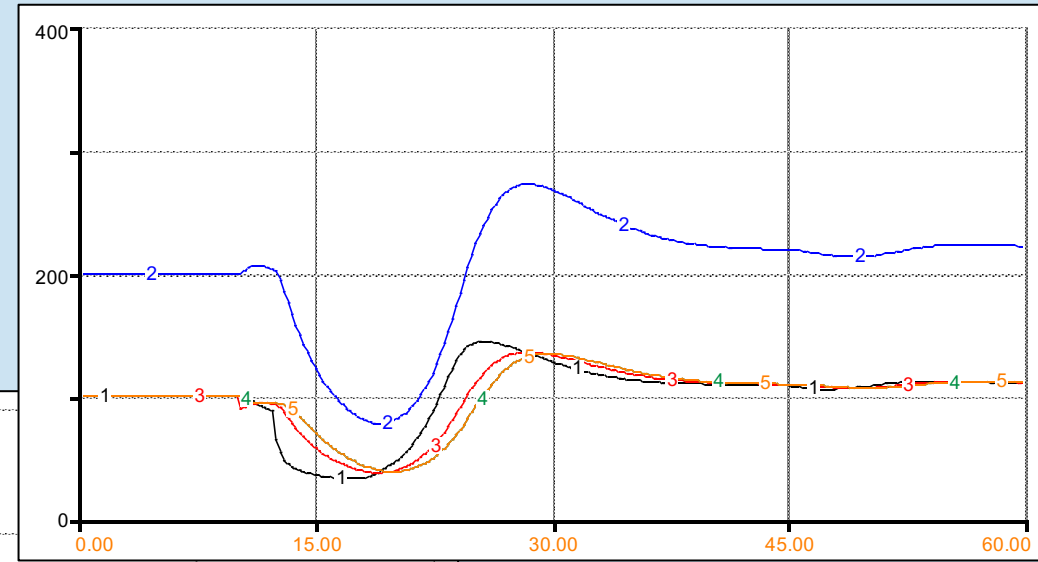
Notice that:
- No specific data are required.
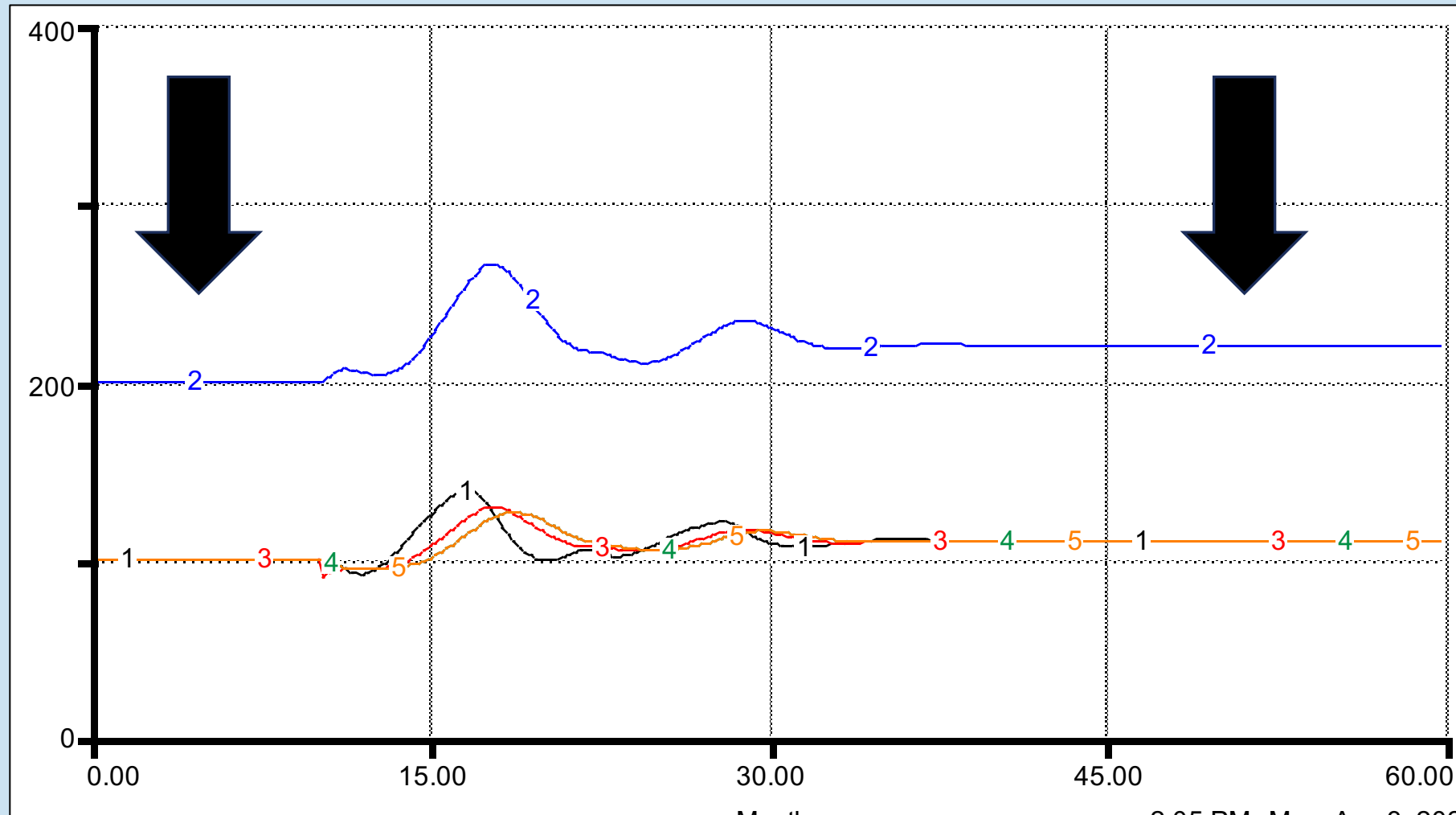- Relative "better" performance differences can be assessed.

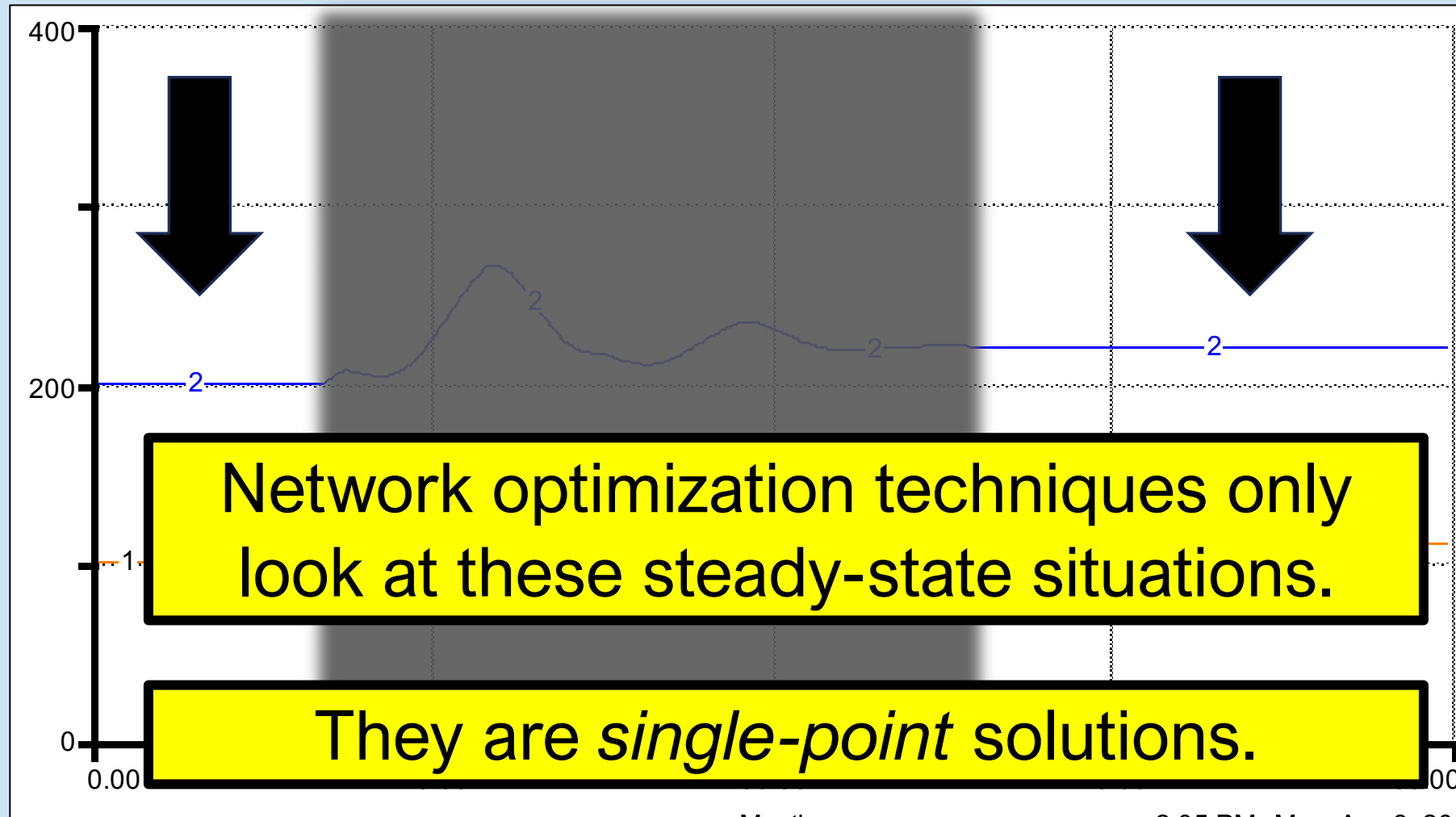**Structural simulations are scientifically rigorous:**
- Only change one variable at a time.
- Simulations start in *dynamic equilibrium* so that any changes are *solely due* to the reactions of the entities to the stimulus.
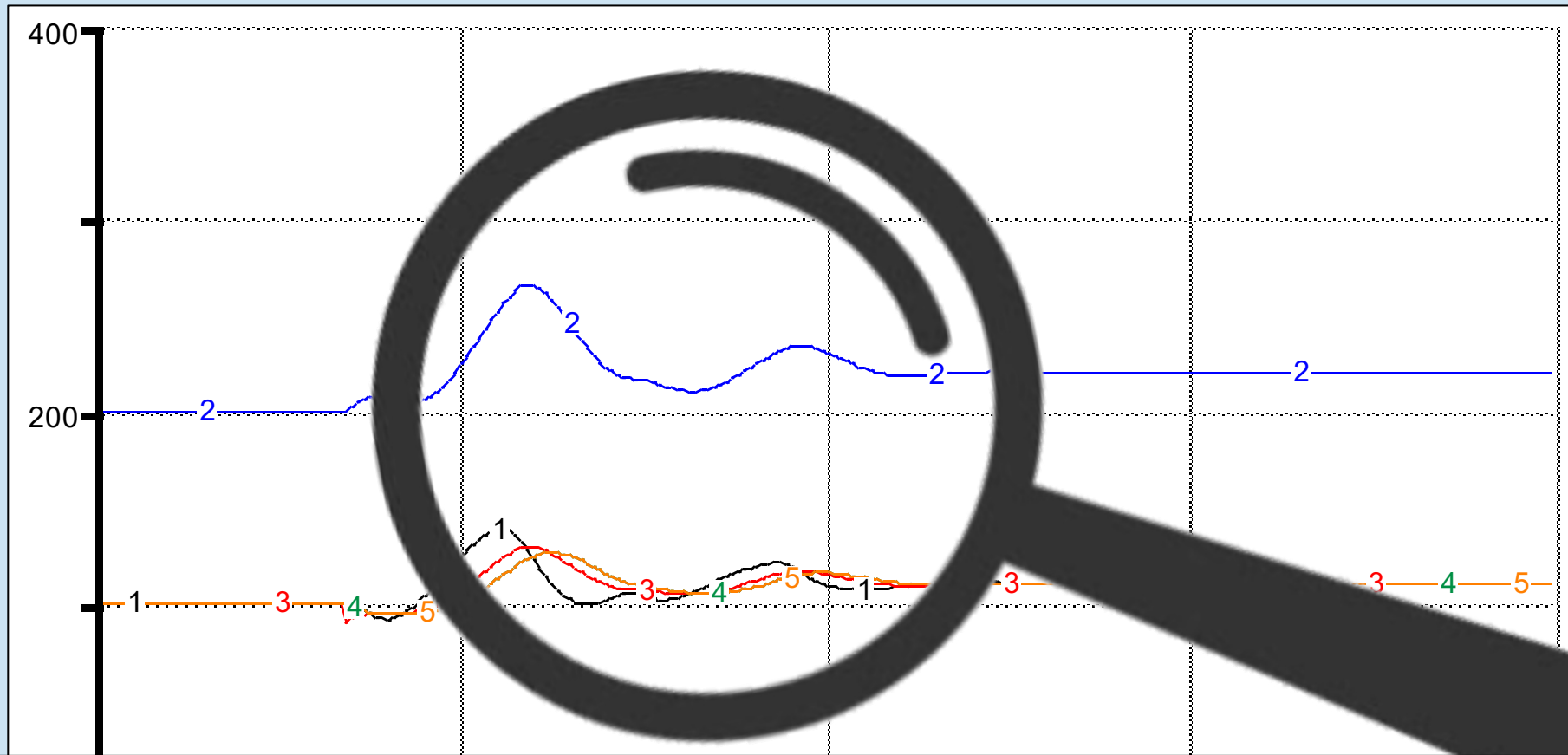
Current optimization methods are insufficient.

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Network optimization techniques only look at these steady-state situations.

They are *single-point* solutions.

Current optimization methods are insufficient.

Structural methods can look at the dynamic adjustments that occur *between* the steady-state situations.

We talk a lot about supply chain "resilience."

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Resilience is a system phenomenon.

The only way to understand and assess resilience is to treat the supply chain as a "system" and stress that system through a digital twin to see how it *reacts*, *responds*, and *recovers*.

"Supply chain management" is a misnomer.

Today's leaders do not manage "supply chains."
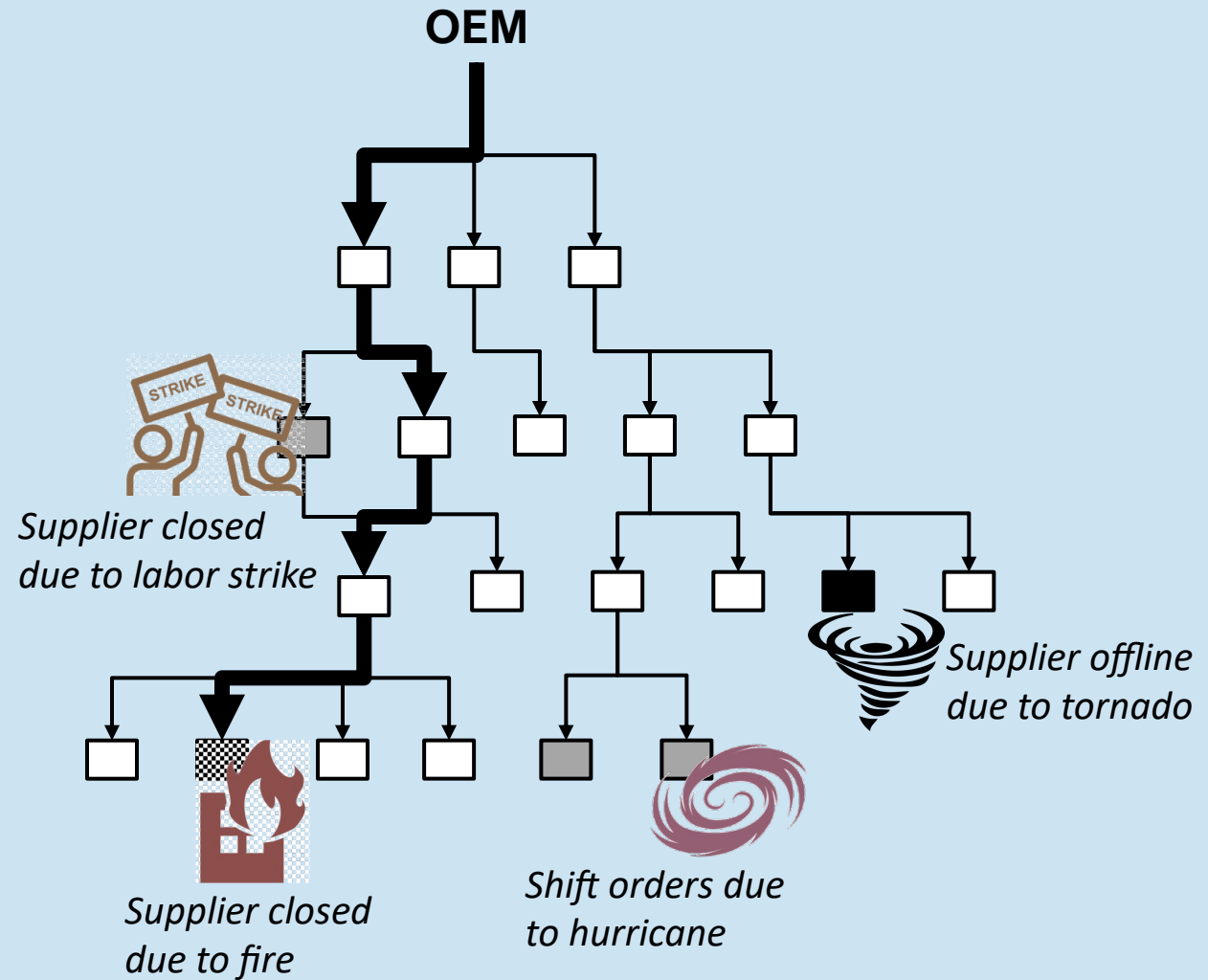
They manage *pieces* of the supply chain.

They manage suppliers, orders, inventory, etc.

They rarely look at the *entire* supply chain.

There is a critical need for this capability.

scmBLOX can stress-test supply chains.

OEM

Supplier closed due to labor strike

Supplier offline due to tornado

Supplier closed due to fire

Shift orders due to hurricane
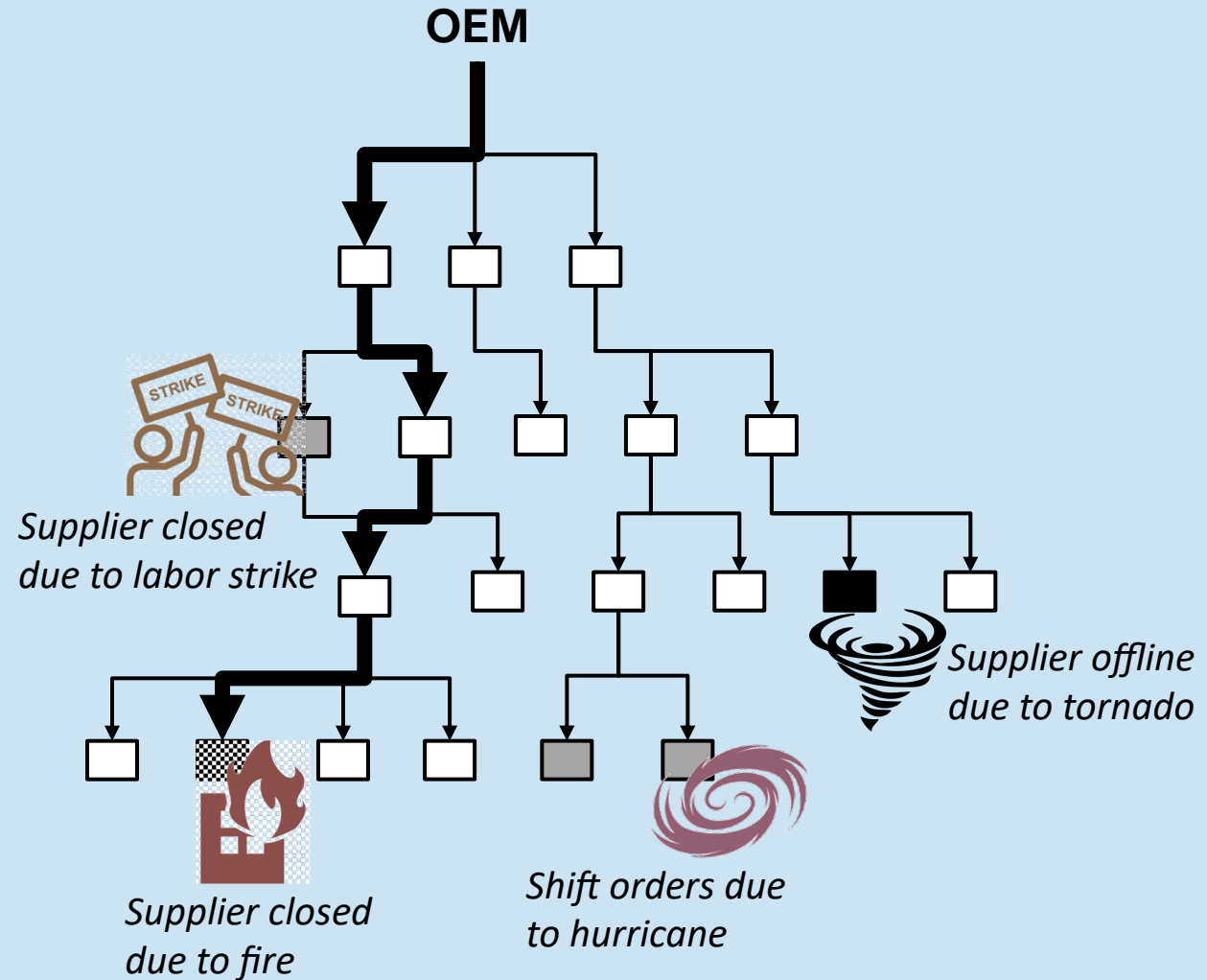
scmBLOX can stress-test supply chains.

Stress-test from *top-to-bottom-to-top*.

Check entities for their *vulnerability*.

**Test operational impacts of *disruptions* anywhere in the supply chain.**

Determine *weak points* and *adapting*.

Improve *resiliency* and *recovery times*.

OEM

Supplier closed due to labor strike

Supplier closed due to fire

Shift orders due to hurricane

Supplier offline due to tornado

Ex: DoD helicopter program

- Analyzed capacities at several "choke points".

- Validated ability of supply chain to withstand several shocks and survive.

- Results: $900M financial impact

Although Inventories Get Low, It Appears Possible to Live Off Overhaul
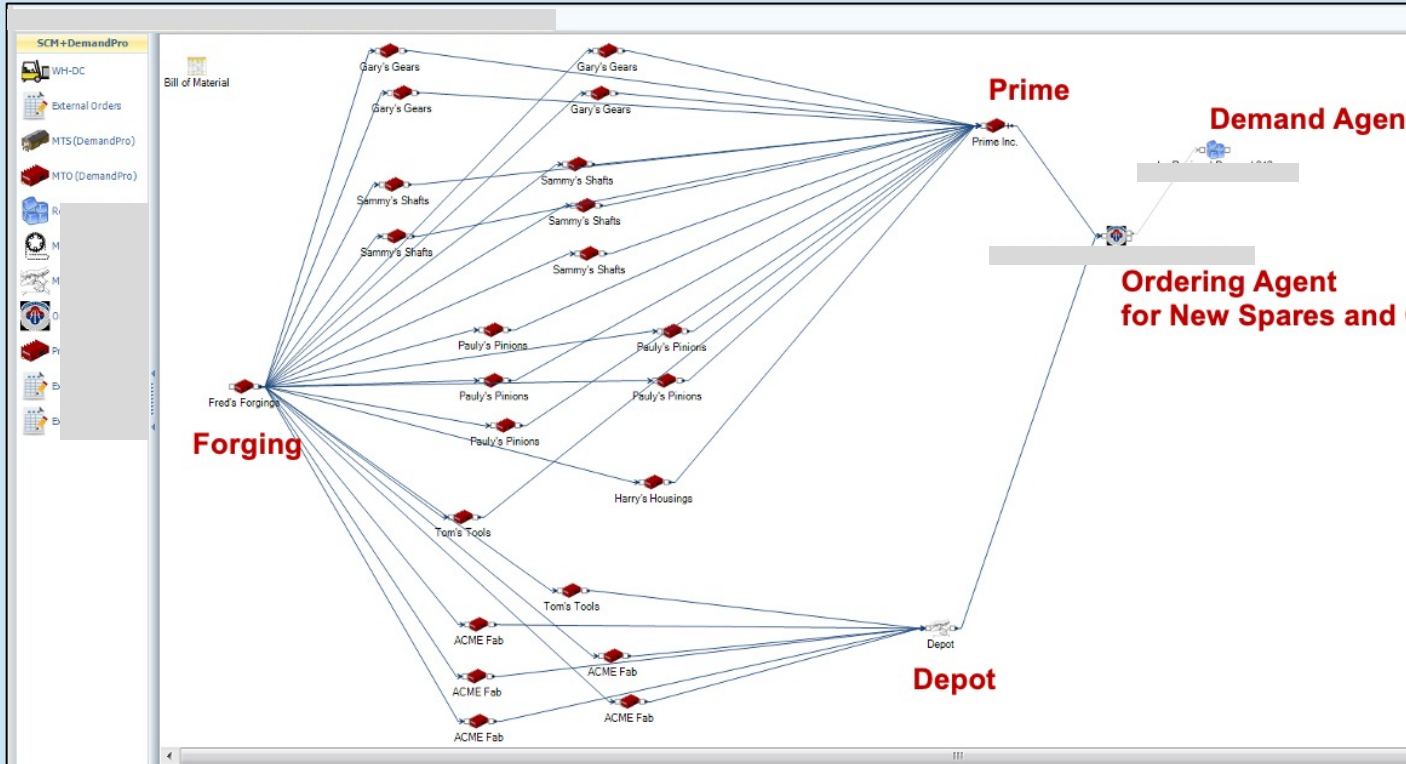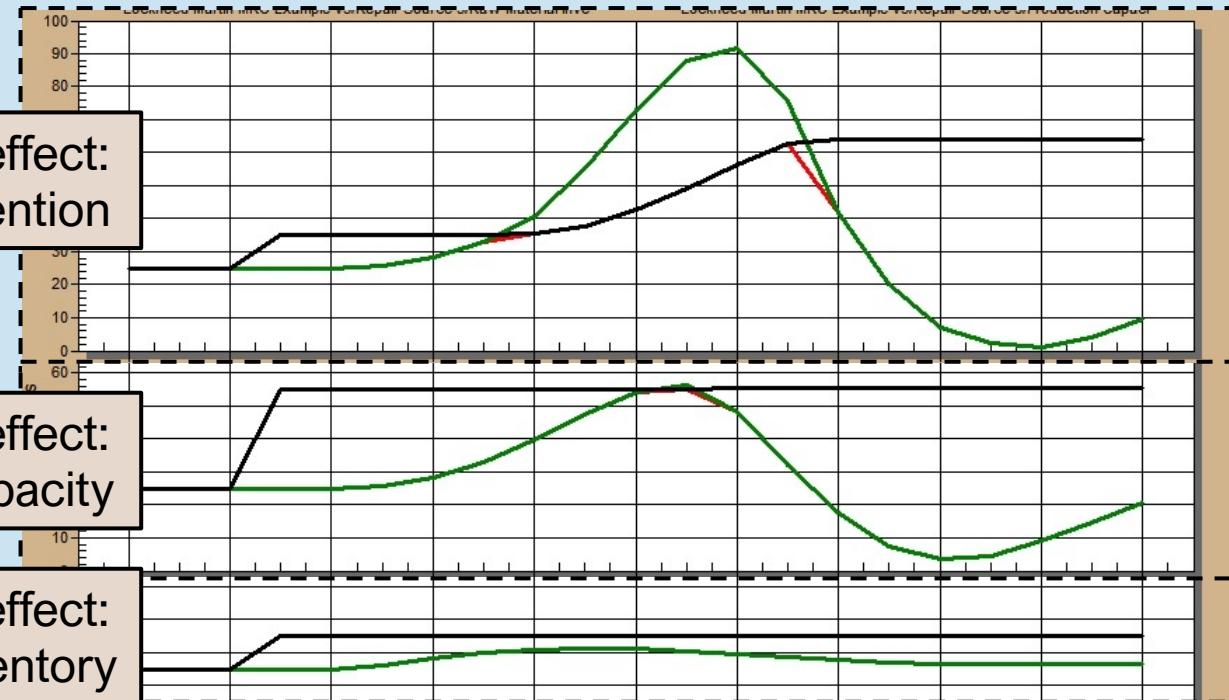
Ex: DoD aircraft program

- Analyzed trade-offs of capacity vs. inventory at multiple locations.
- Determined methods for minimizing bullwhip effect on operations.
- Results: $1.2B financial impact
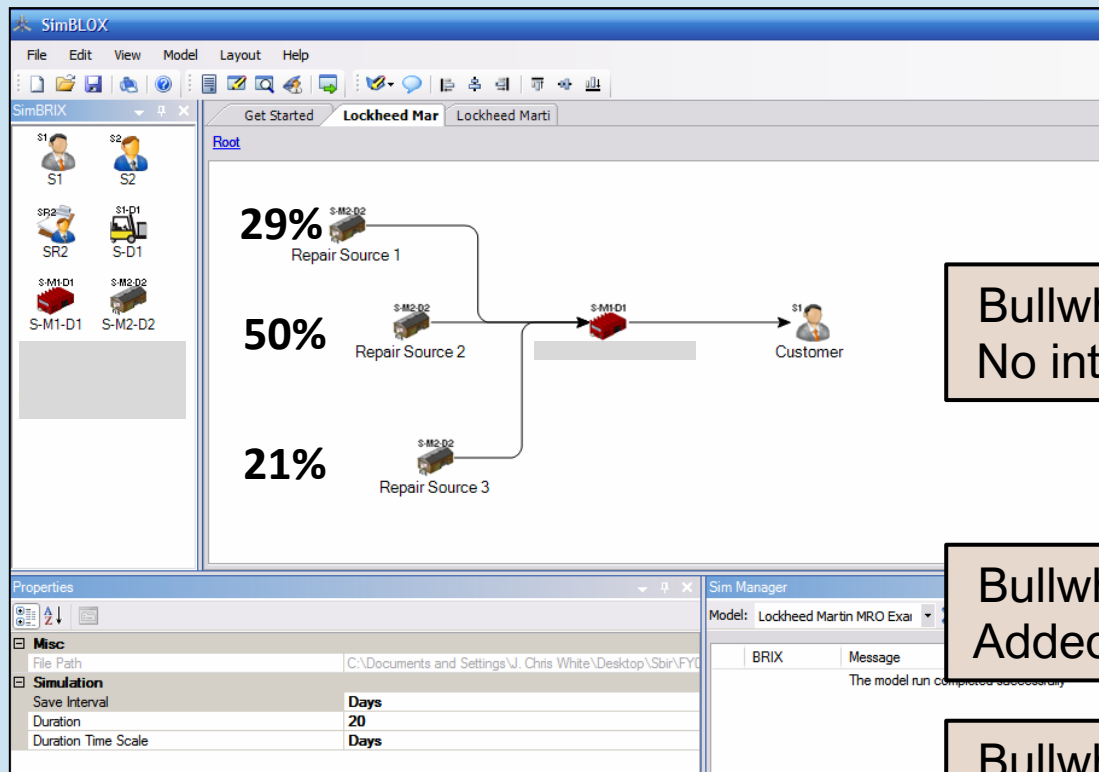
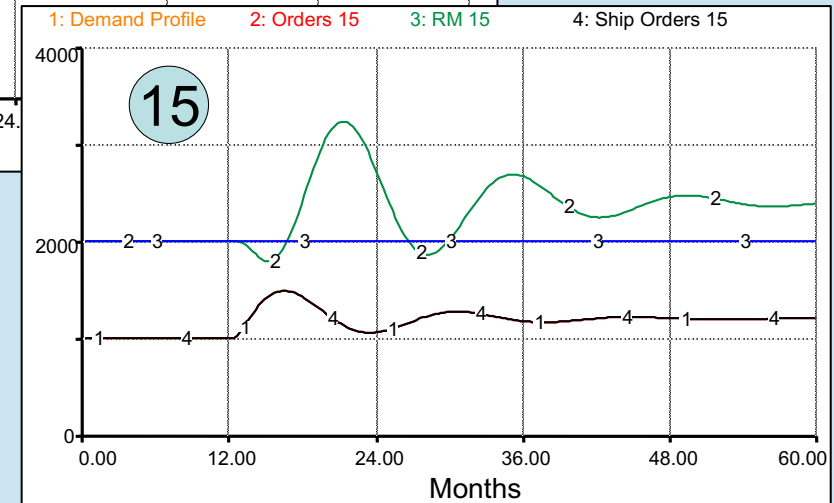

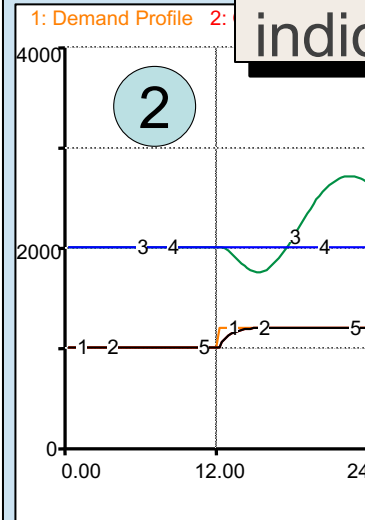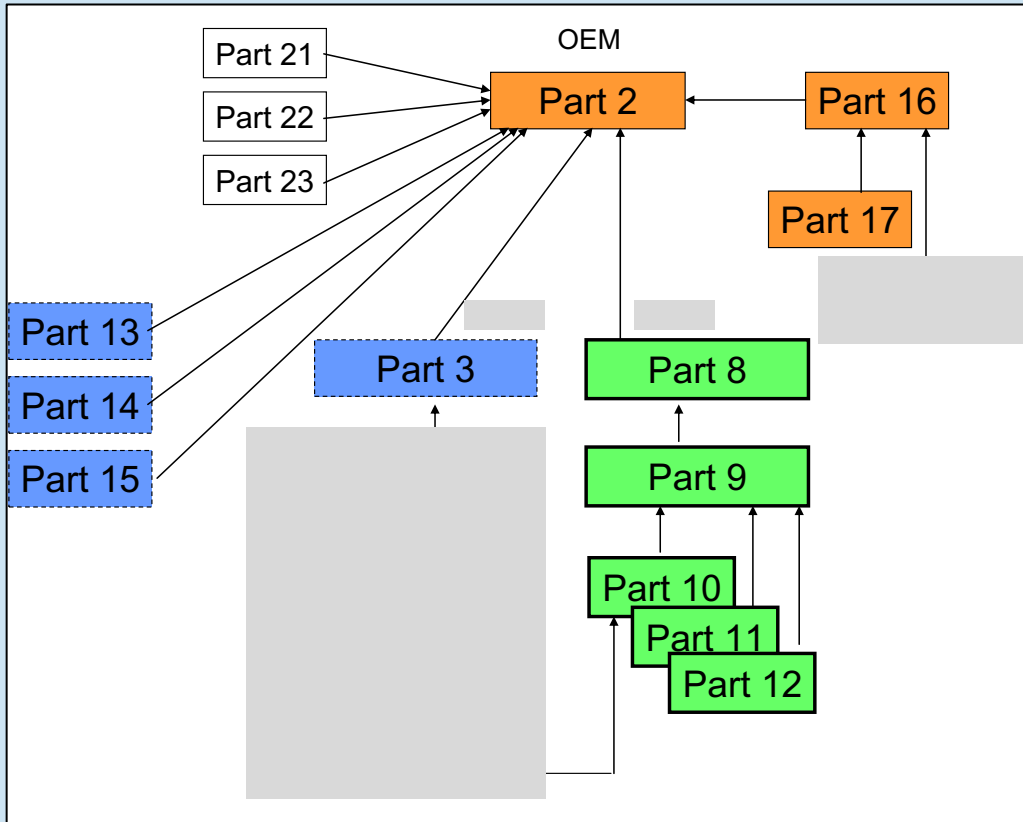Bullwhip effect: No intervention

Bullwhip effect: Added capacity

Bullwhip effect: Buffer inventory

Ex: DoD missile program

- Stress-tested to verify recoverability with acceptable limits.

- Identified the maximum survivable disruption.

- Results: Identified key early warning indicators and response plans.

scmBLOX can . . .

Understand *vulnerabilities* related to:
- Demand variability
- Sole sourcing vs. multiple sources
- Long lead times
- Disruptions or delays

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- Recovery speed to reach new demand levels
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Improve *performance* in terms of:
- Reallocation or movement of inventories
- Alterations of ordering patterns to minimize volatility
- Adding or removing suppliers for contingencies
- Investing in additional production capacity for surges

Questions?

scmBLOX

The foundation for building resilient supply chains.