moffatt & nichol

Bulk Terminal Planning Trends – Using Simulation

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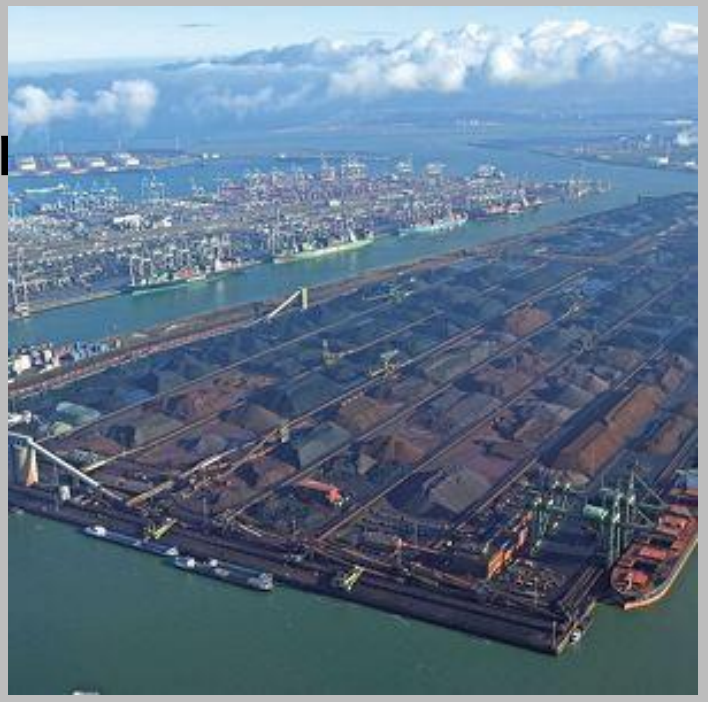
Outline

- Bulk Terminal Systems, Constraints, Operations
- Why Simulation
- Case Study – Bulk Terminal Rail Loader System
- Case Study Conclusion



Dry Bulk Terminals

- **Physical system constraints**
  - External rail system
  - Internal rail system
  - Dumping systems
    - *Bottom Dumper*
    - *Rotary Dumper*
  - Product storage
    - *Product segregation*
  - Ship loading system
  - Berths
  - Downtime delays

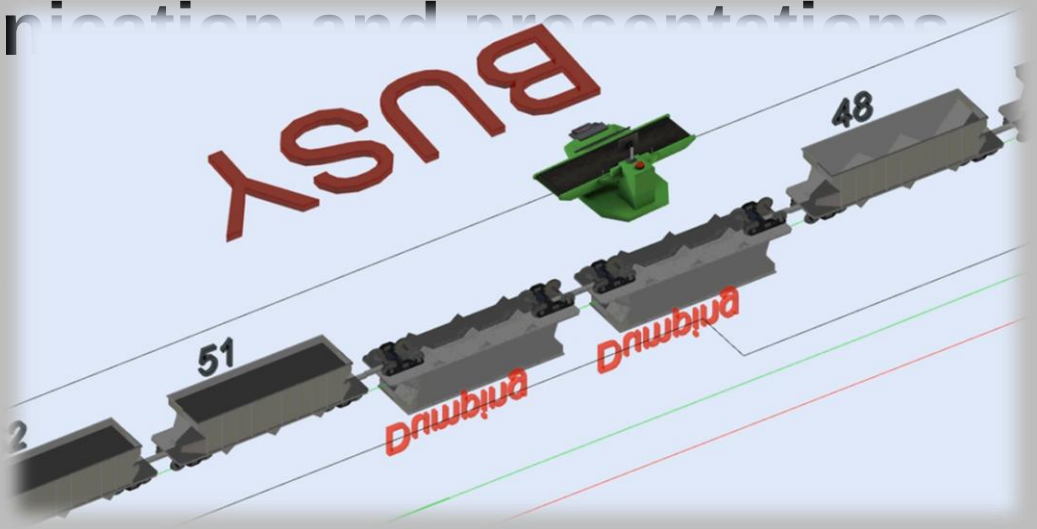
Dry Bulk Terminals

- **Operating procedure constraints**
  - External rail
    - *Schedule and reliability*
    - *System Delays*
  - Internal rail
    - *Switching and car movement*
  - Car inspection/repair
  - Days and hours of operation
  - Labor rules
    - *Adjacent Track Rule*
  - Safety rules

Why Simulation

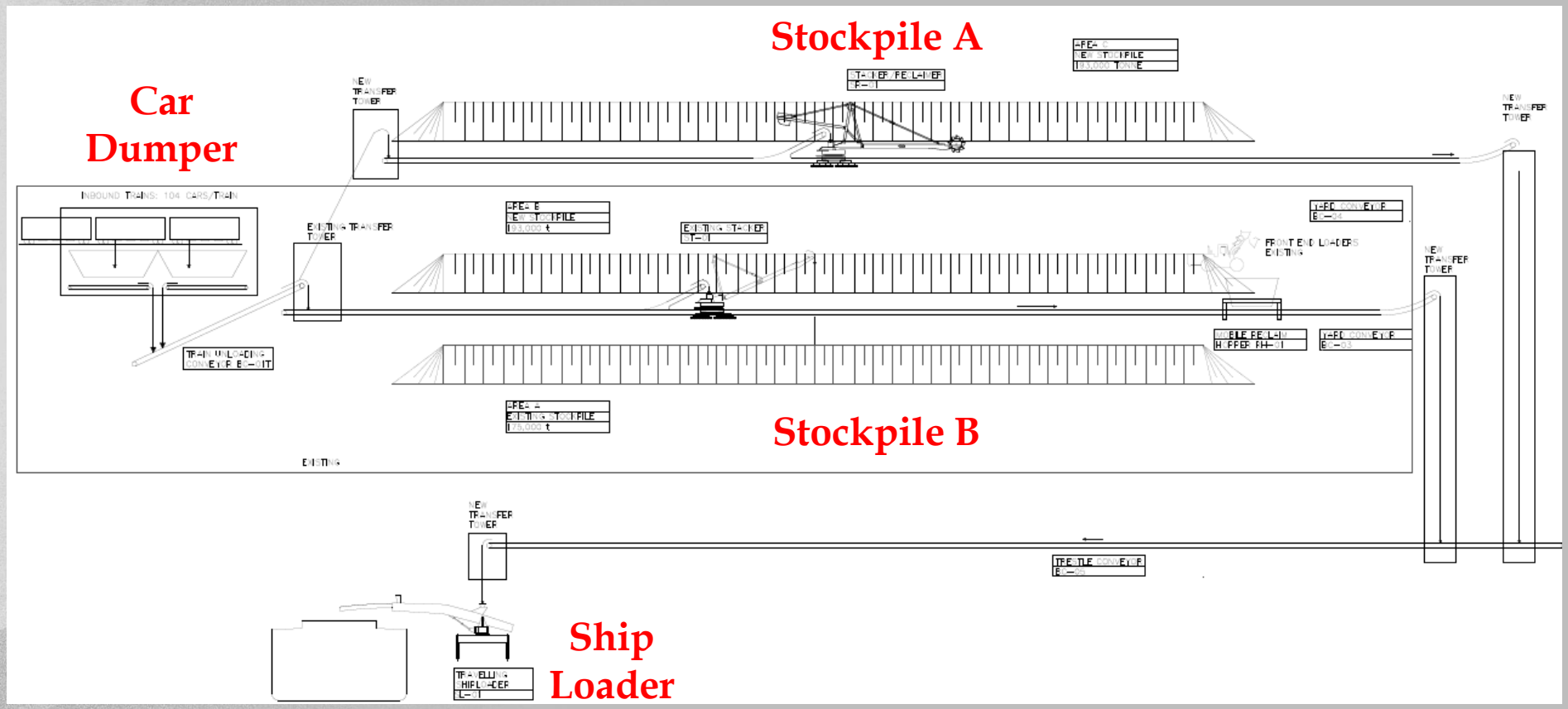
- **Analytic capabilities of other tools (spreadsheets) are limited and cant model Complex systems with many interdependencies**

- **Provides Visualization and Animation for better commun**



Why Simulation

- **Study system behavior without building the real system**

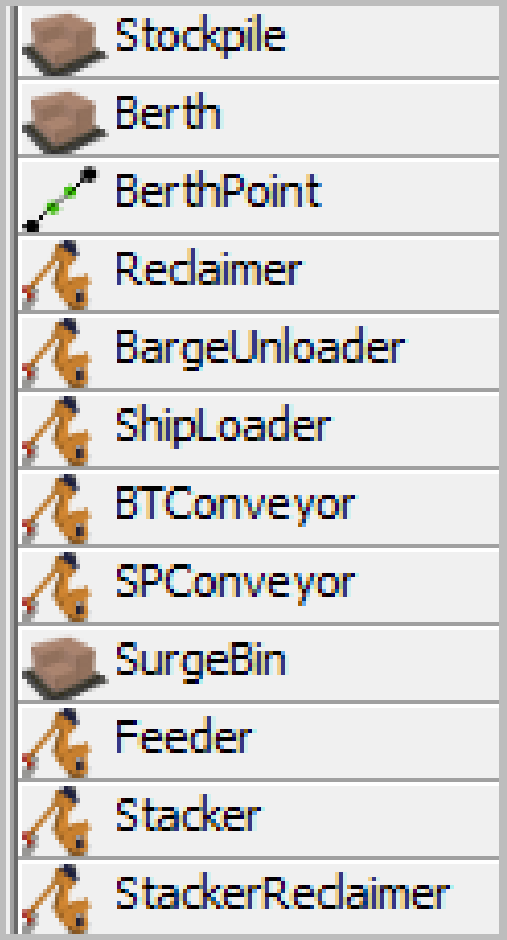


Why Simulation

- **Assess proposed impacts and changes before they are implemented**
- **Identify system modifications that provide the greatest benefit**
- **Cheaper and easier than before**

Simulation Tool

- **FlexTerm (previously FlexSim CT)**
  - General purpose discrete event simulation software
- **Extended from container terminal simulation to bulk terminal simulation**
- **Embedded objects such as train or barge unloaders, ship loaders, conveyors, stockpiles, etc. for fast model building**
- **C++ or FlexScript for customization**

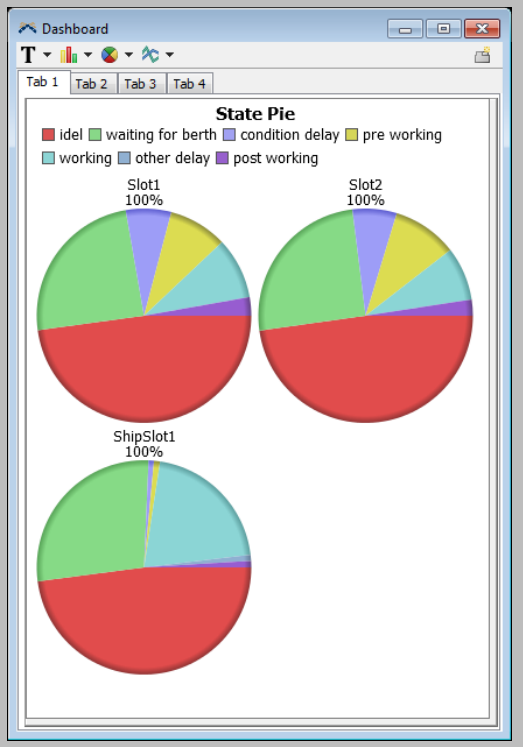


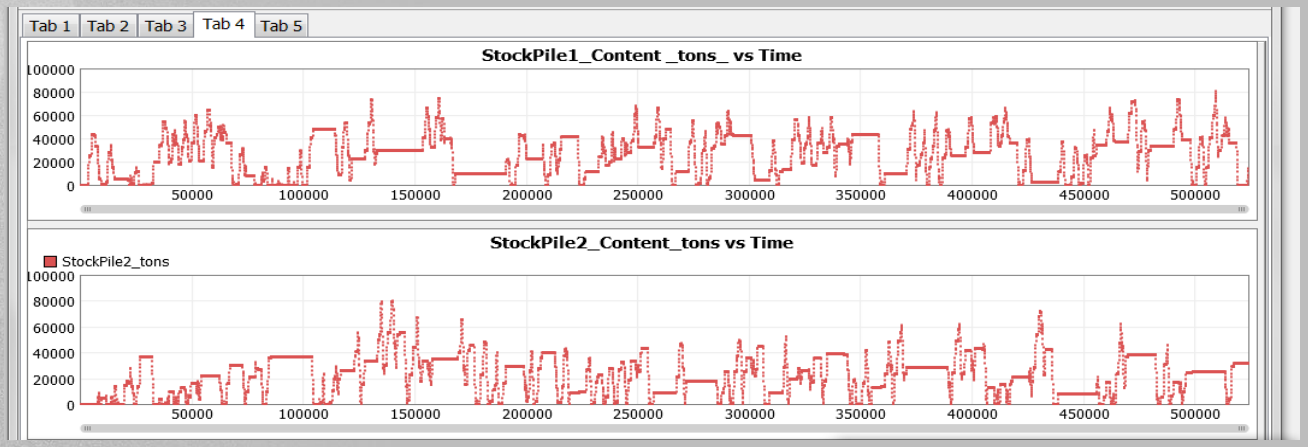
Simulation Tool

- Drag-and-Drop objects into model space
- Make connections between objects to define material flow according to Process Flow Diagram (PFM)
- Define mixing rules including direct-loading and stockpile logic
- Define events such as break-downs and other delays
- Typically run 10 years with 1 minute time interval

Typical Simulation Outputs

- **Typical outputs include:**
  - Throughput finished
  - Identification of System Delays
  - Equipment utilization
  - Unloading and loading rate
  - Berth time, port time and waiting time
  - Stockpile contents – average/maximum





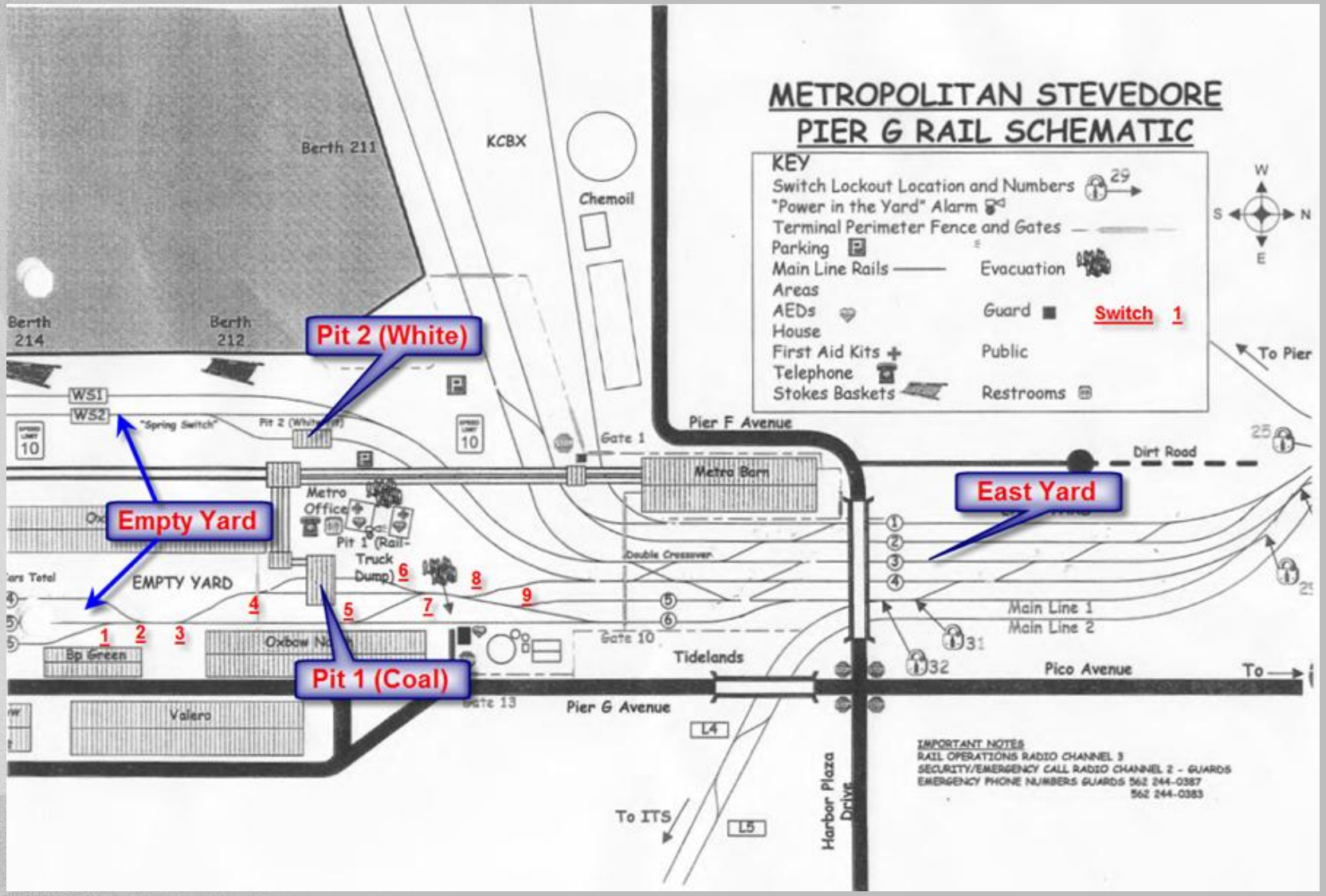
Case Study – Objective

- **Assess track improvements proposed by the Port and investigate operational changes they would allow**
- **Build simulation model that replicated the rail delivery system for an existing bulk loading operation**
- **Determine capacity**
  - Existing System
  - System with improvements
- **Identify any bottlenecks**
- **Assess opportunities and their relative benefits**

Case Study – Bulk Terminal Rail Simulation

- Black product operations
- White operations
- Shared rail storage yard

Rail System Schematic



Constraints and Assumptions

- **Black product is received by train and transferred to storage and vessels for export**
- **White product has no on-terminal storage**
  - Must be transferred directly to vessels upon dumping
- **Physical plant is very constrained**
  - Limited train length for both commodities prevented simultaneous black and white receiving

Constraints and Assumptions

- **There is no Storage tracks for bulk product near the Port**
- **Staging track for inbound trains is 12 hours away**
  - Train cannot be released from staging track until order has been sent to remove train from the port facility
  - Minimum gap between train finish and start is 12 hours
- **During white product loading, receipt of black product trains must be suspended**

Constraints and Assumptions

- **Terminals switch engines are not allowed to touch the mainline tracks**
  - Limiting train Length
  - Required one of the terminals two switch engines be buried on a storage track in order to dump maximum length train

- **After Dumping Cars must be inspected and bad order cars cut out before train can be removed**

Basic Assumptions – Black Product Dumper

- **Existing Single rotary dumper**
  - Typical cycle time 2 to 6 minutes
  - 3.5 minutes per car on average
- **Evaluate**
  - Faster rotary dumper
  - Replacement with bottom dumper

Black Train Dumping Process

- Cut 30 cars (Set 1) of half train on one track
- Pull Set 1 to Track 6 using Engine A
- Park Engine A at south end of Track 6
- Using Engine B, pull Set 1 from north, then push through dumper and unload all cars
- After finishing Set 1, use Engine B to pull remaining cars (Set 2) of half train from south
- Use tracks on white operation side to maneuver Engine B to north of Set 2
- Pull and then push Set 2 through dumper and unload all cars
- Engine B pulls empty cars of Set2, then connects Set 2 with Set 1
- Engine A pushes empty half train to an empty track
- Repeat the process for the second half train

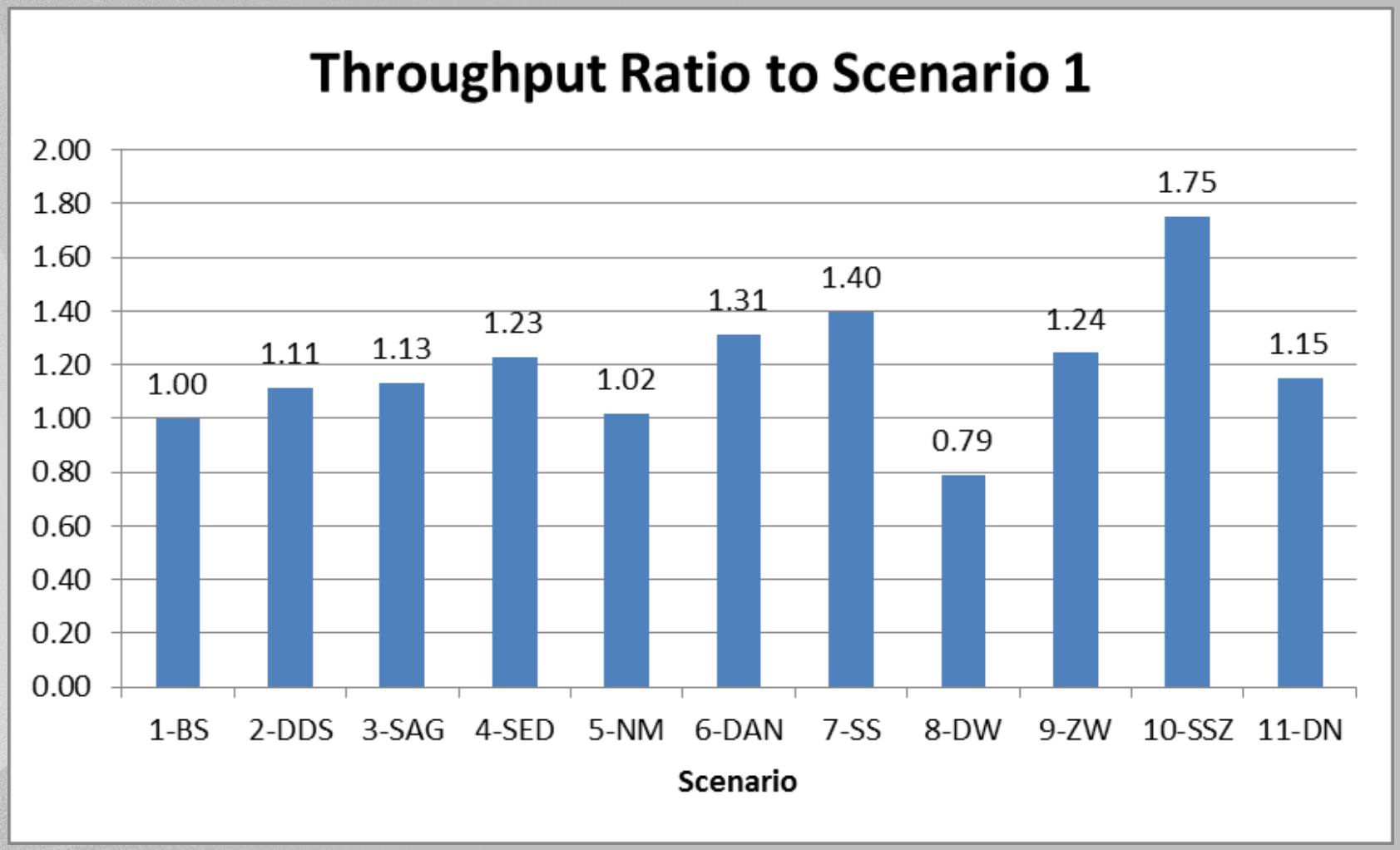
System Animation

Model output verified with known data

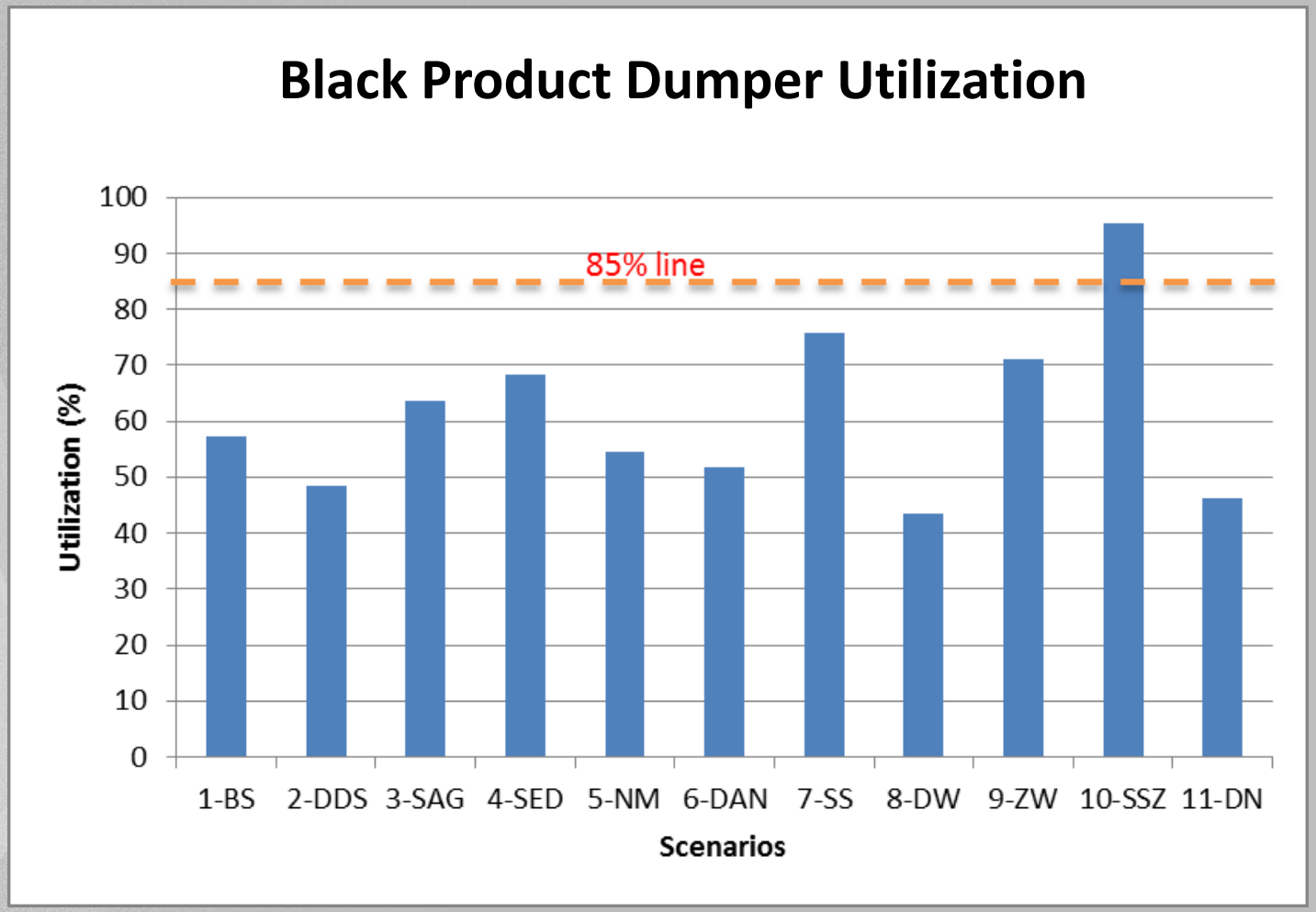
Simulation Scenario Summary

Scenario	Acronym	Description	Avg dumper	Train arrival gap (hr)	Empty train dwell (hr)	White Shifts
1	BS	Base scenario	3.5	8 to 12 hours	16 to 24 hours	3
2	DDS	Base scenario + double dumper speed	1.75	8 to 12 hours	16 to 24 hours	3
3	SAG	Base scenario + shorter train arrival gap	3.5	2 to 4 hours	16 to 24 hours	3
4	SED	Base scenario + shorter empty train dwell	3.5	8 to 12 hours	4 to 8 hours	3
5	NM	Base scenario + no "macarena" operation	3.5	8 to 12 hours	16 to 24 hours	3
6	DAN	Base scenario + double dumper speed + shorter arrival gap + no macarena	3.5	2 to 4 hours	4 to 8 hours	3
7	SS	Base scenario + shorter arrival gap + shorter empty dwell	3.5	2 to 4 hours	4 to 8 hours	3
8	DW	Base scenario + doubled white shifts	3.5	8 to 12 hours	16 to 24 hours	6
9	ZW	Base scenario + 0 white shifts	3.5	8 to 12 hours	16 to 24 hours	0
10	SSZ	Base scenario + shorter arrival gap + shorter empty dwell + 0 white	3.5	2 to 4 hours	4 to 8 hours	0
11	DN	Base scenario + double dumper speed + no "macarena"	1.75	8 to 12 hours	16 to 24 hours	3

Results – Comparison to Base Scenario

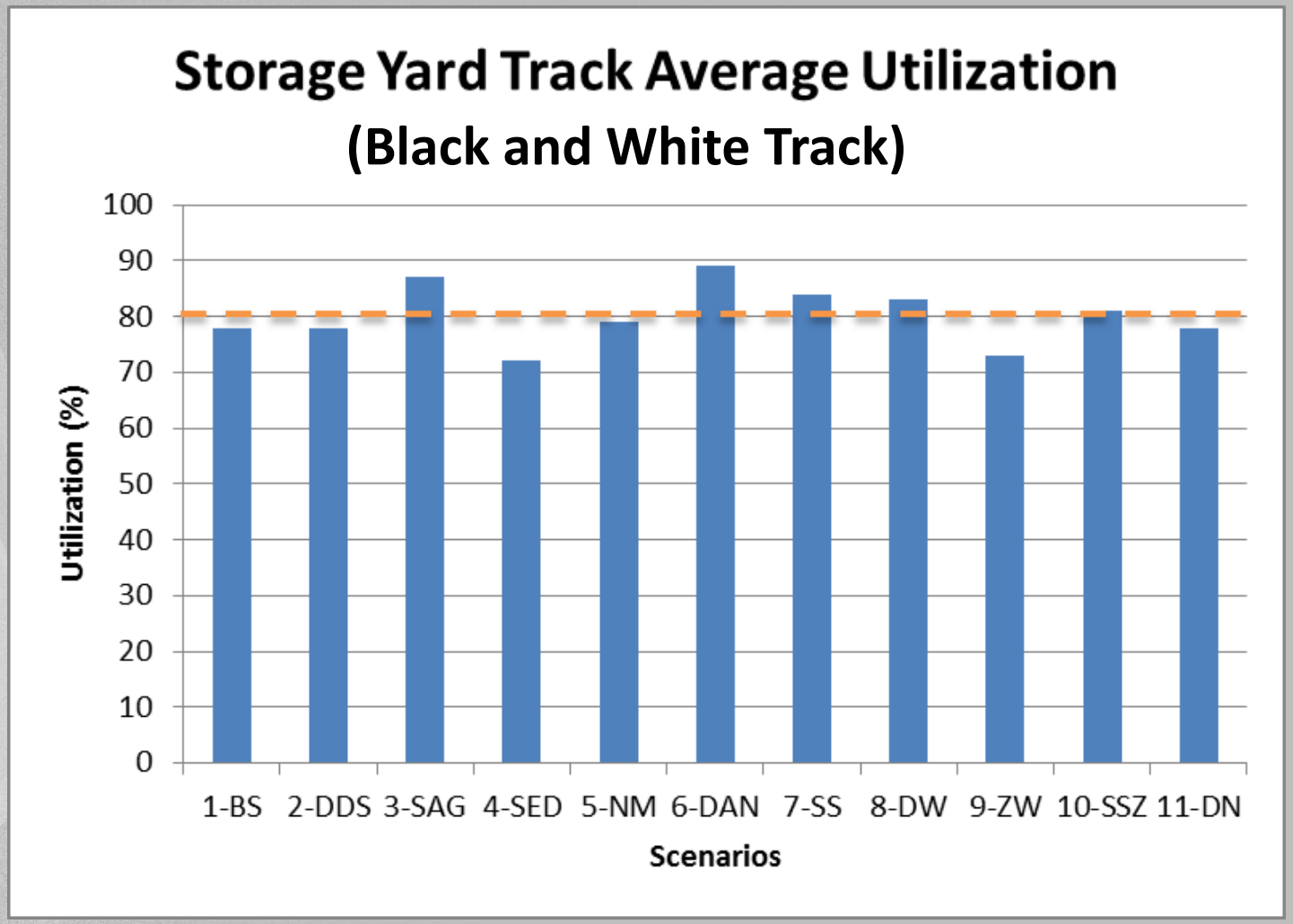


Results – Dumper Utilization



Base Scenario dumper utilization less than 60%, not at capacity. For Scenario 10, dumper becomes a constraint with utilization >85%.

Results – Storage Yard Track Utilization (Black + White)

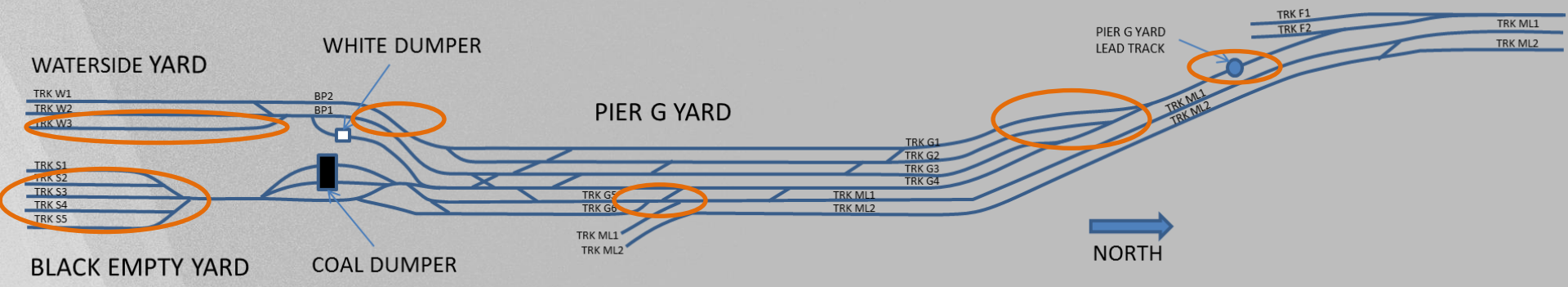


Average of Tracks 1, 2, 3, and 4; 80% track utilization considered at capacity

Simulation Conclusions

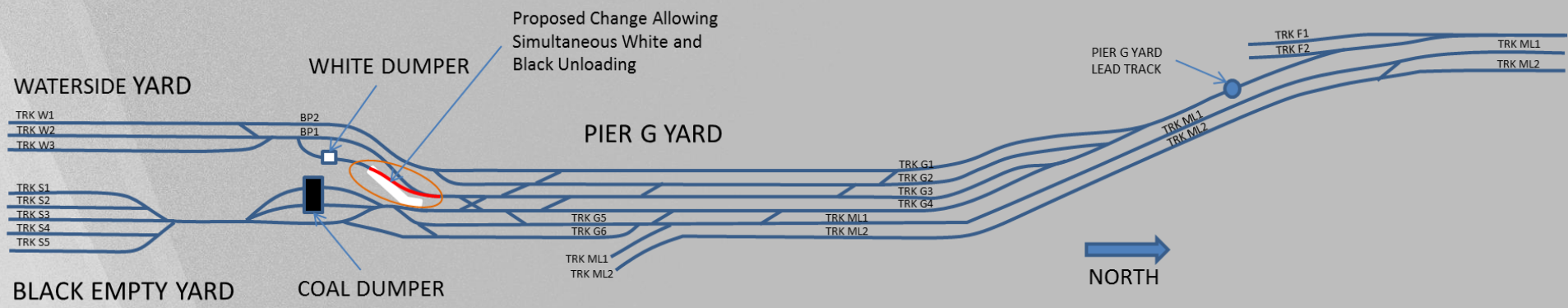
- **Black product capacity is about 283 trains per year, assuming on average 3 white product shifts per week**
- **Dumper was not a capacity bottleneck for black product operation, as indicated by its relatively low utilization**
- **Storage yard track is a capacity bottleneck as indicated by its high utilization**

Pier G Rail Schematic (Proposed Improvements)



1. 2 New tracks at black empty yard (each 14 coal cars capacity)
2. Reactivated WS3 and connectors (additional 23 coal cars capacity)
3. New bypass track 2 (20 white cars capacity)
4. New connector between tracks G6 and G5
5. New crossover between tracks G5 and G4
6. New Pier G lead track
7. New connections at north end
    1. Between G1 and G2
    2. Between G2 and G3
    3. Between G3 and G4

Proposed Improvement Allowing Simultaneous Unloading



- Add a connector between tracks G3 and G4 before white dumper
- Eliminate the conflict point between white and black unloading
  - Originally G4 and double crossover are needed to access white dumper
- Simultaneous unloading operation
  - Unload white trains on tracks G1 and G2
  - Unload black trains on tracks G3 and G4

Simulation Objectives

- What are potential operational benefits
- Opportunity for simultaneous black and white Operations
- Impact on capacity
- Are there potential bottlenecks

Black Product – Train Unloading Steps

1. Engine pulls Set 1 (~25 cars on G4) south
2. Engine maneuvers to north of Set 1, pushes and then pulls onto G5
3. Pushes to unload Set 1
4. Engine pulls Set 2 (remaining cars on G4) onto G5, then maneuvers to north
5. Pushes to unload Set 2
6. Engine maneuvers to north lead track, pulls and then pushes Set 3 (~23 cars on G3) onto G5
7. Pushes to unload Set 3
8. Engine pulls and pushes Set 4 (remaining cars on G3) onto G5
9. Pushes to unload Set 4
10. Pulls first half of empty train onto G3
11. Pulls second half of empty train onto G4

White Product – Train Unloading Steps

1. **Cars on each track divided into four sets, each about 10 to 11 cars**
    1. *Set 1, Set 2, Set 3 and Set 4 on G1*
    2. *Set 5, Set 6, Set 7 and Set 8 on G2*
2. **Engine pulls Set 1 and hooks to indexer**
3. **Unloads Set 1**
4. **Engine pulls Set 2 and hooks to indexer**
5. **Engine pushes Set 1 to WS1**
6. **Engine pulls Set 3 and hooks to indexer**
7. **Engine pushes and pulls Set 2 empty cars onto BP1**
8. **Engine pushes Set 4 and hooks to indexer**
9. **Engine pushes and then pulls Set 3 empty cars onto BP1, and pushes Set 2 empty car back to G1**
10. **Repeats steps 6 to 9 for remaining sets of cars**
11. **Pulls and then pushes Set 1 onto G2**

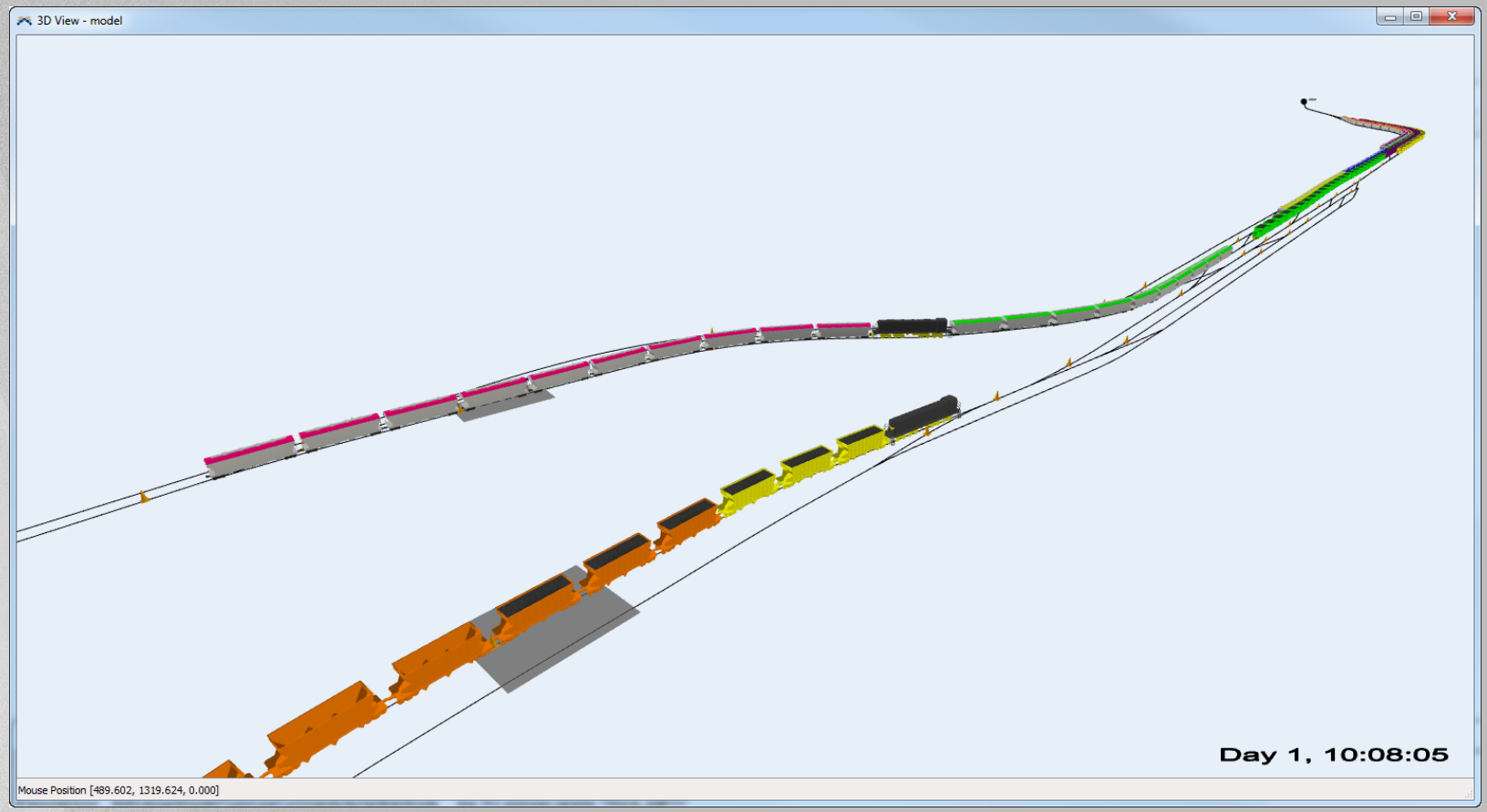
Simulation Settings

- **Include**
  - Dumper activity (cycle time per car)
  - Equipment breakdown
  - Labor meal and break times
  - Connecting/disconnecting cars/engines
  - Train arrival and departure delays
  - Train inter-arrival gap
  - On Terminal empty car dwell time

Base Case Scenario

- **Modeled both white and black operations**
- **White trains based on demand**
  - 60 trains per year on average
- **Continue sending black product trains based on space available to evaluate the capacity**
- **White trains arrive randomly on either tracks G1&G2 or G3&G4**
- **Existing black product train unloading sequence used by default**
- **When simultaneous unloading is possible, switch to revised sequence**

Proposed System



Visualization of proposed operations

Scenarios

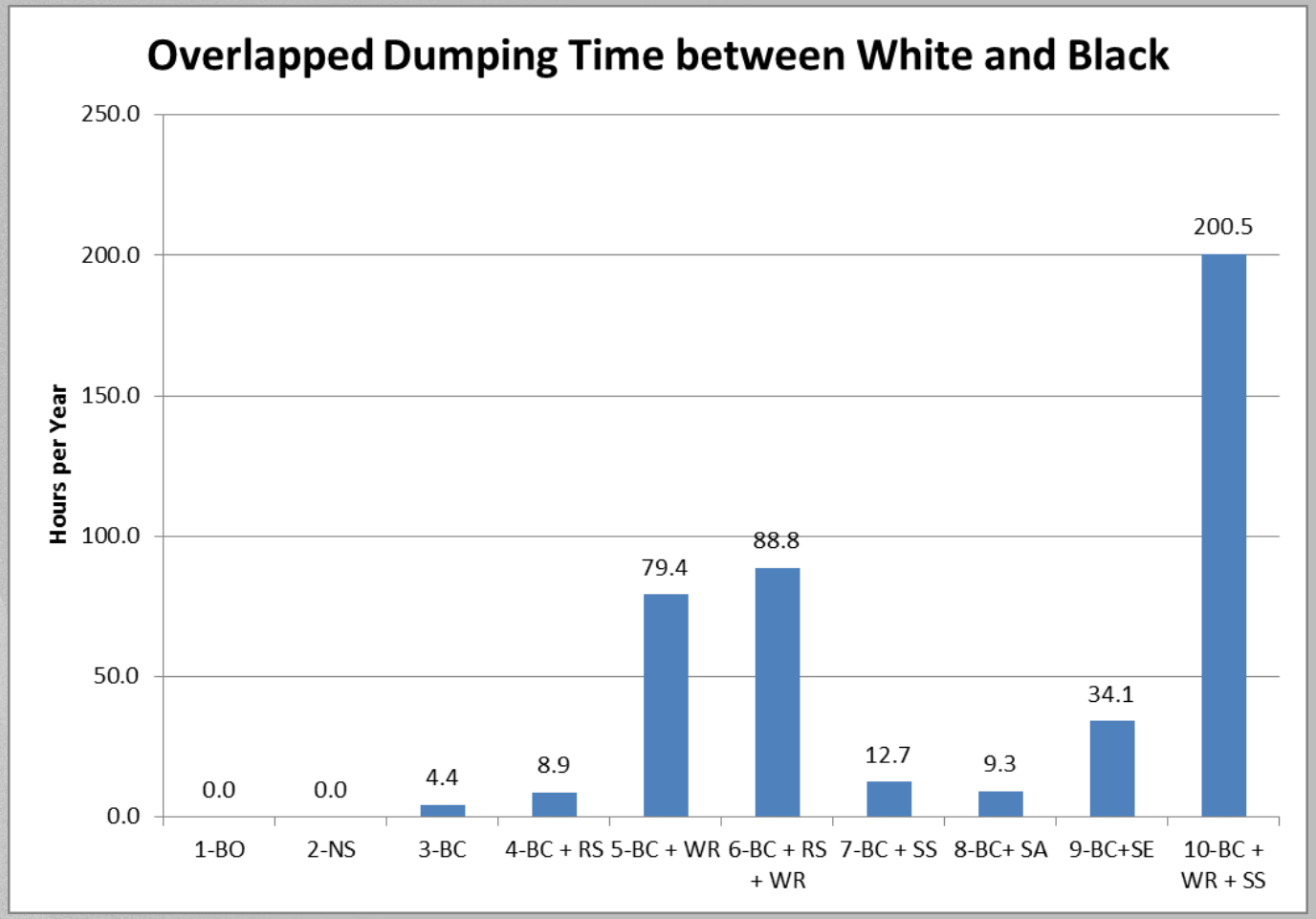
Scenario	Acronym	Description	Train arrival gap (hr)	Empty train dwell (hr)
1	BO	Black Only	8 to 12 hours	16 to 24 hours
2	NS	No Simultaneous Unloading of Black and White	8 to 12 hours	16 to 24 hours
3	BC	Base Case	8 to 12 hours	16 to 24 hours
4	BC + RS	Base Case + Revised Sequence	8 to 12 hours	16 to 24 hours
5	BC + WR	Base Case + White Restriction (Track 1 & 2 Only)	8 to 12 hours	16 to 24 hours
6	BC + RS + WR	Base Case + Revised Sequence + White Restriction (Track 1 & 2 Only)	8 to 12 hours	16 to 24 hours
7	BC + SS	Base Case + Shorter arrival gap + Shorter empty dwell	2 to 4 hours	4 to 8 hours
8	BC+ SA	Base Case + Shorter arrival gap	2 to 4 hours	16 to 24 hours
9	BC+SE	Base Case + Shorter empty dwell	8 to 12 hours	4 to 8 hours
10	BC + WR + SS	Base Case + White Restriction (Track 1 & 2 Only) + Shorter arrival gap + Shorter empty dwell	2 to 4 hours	4 to 8 hours

- **Revised Sequence (RS)**: Black trains will be unloaded by using the sequence that allows simultaneous unloading of white and black trains
- **White Restriction (WR)**: White train will always arrive and depart on Track G1 and G2
- **Shorter arrival gap + Shorter empty dwell (SS)**: The rail side operations are improved for arriving and departing trains

Model Results

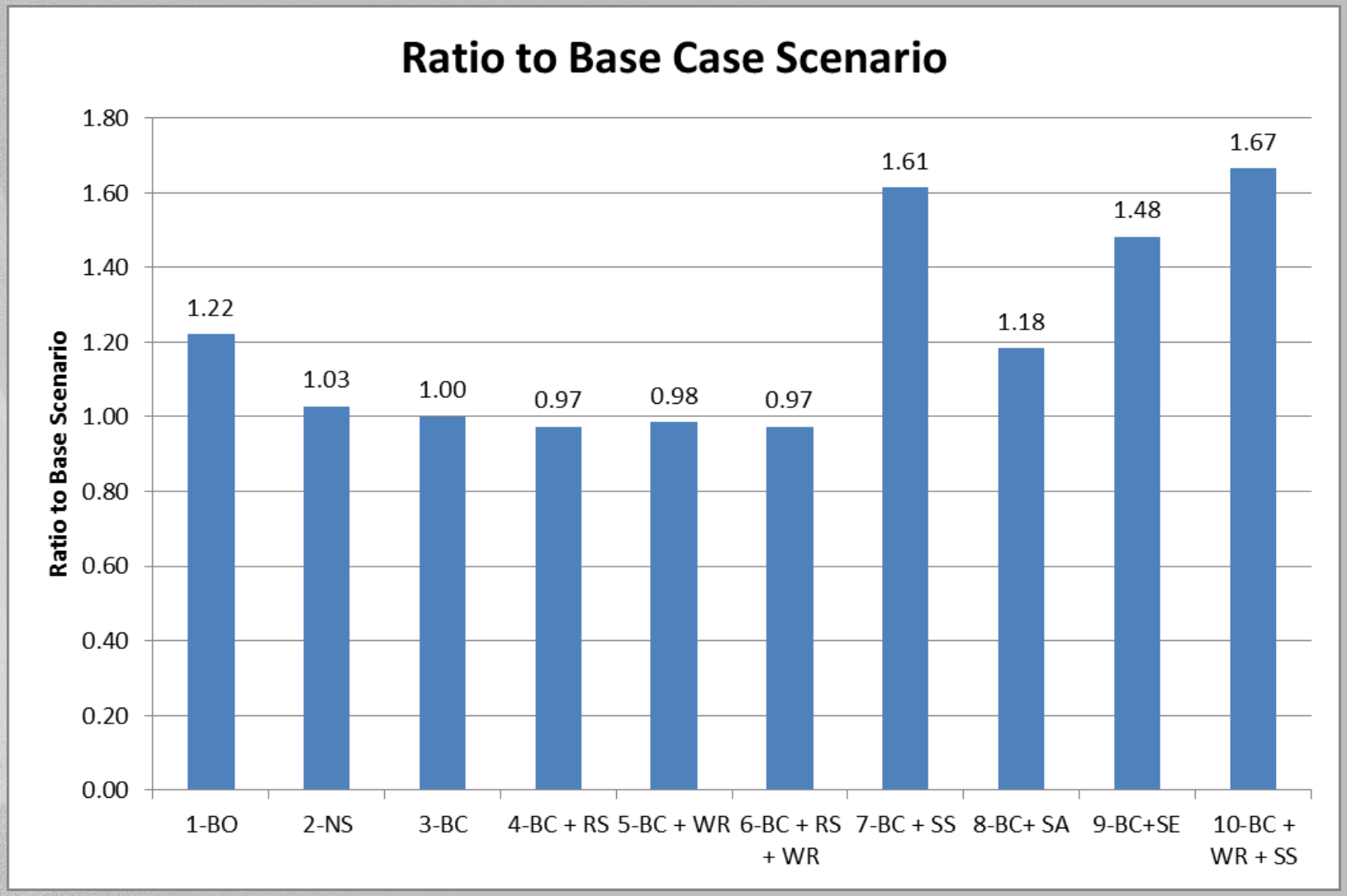
- Simultaneous unloading does not significantly help on increasing throughput (Scenario 3 vs. Scenario 2)

Model Results



- Time when both dumpers (white and black) are simultaneously unloading
- Base case indicates there is very little time when both dumpers are working

Model Results



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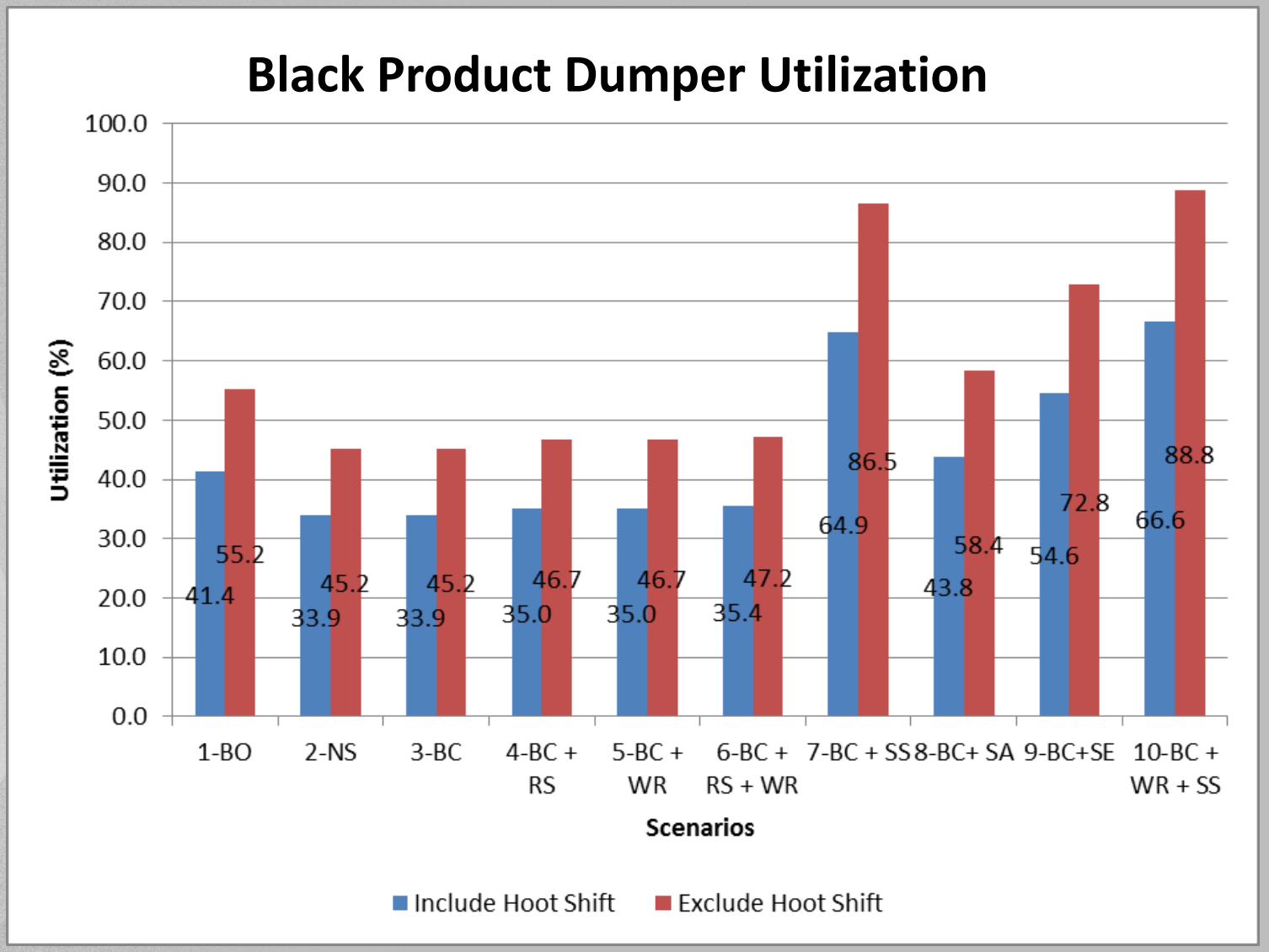
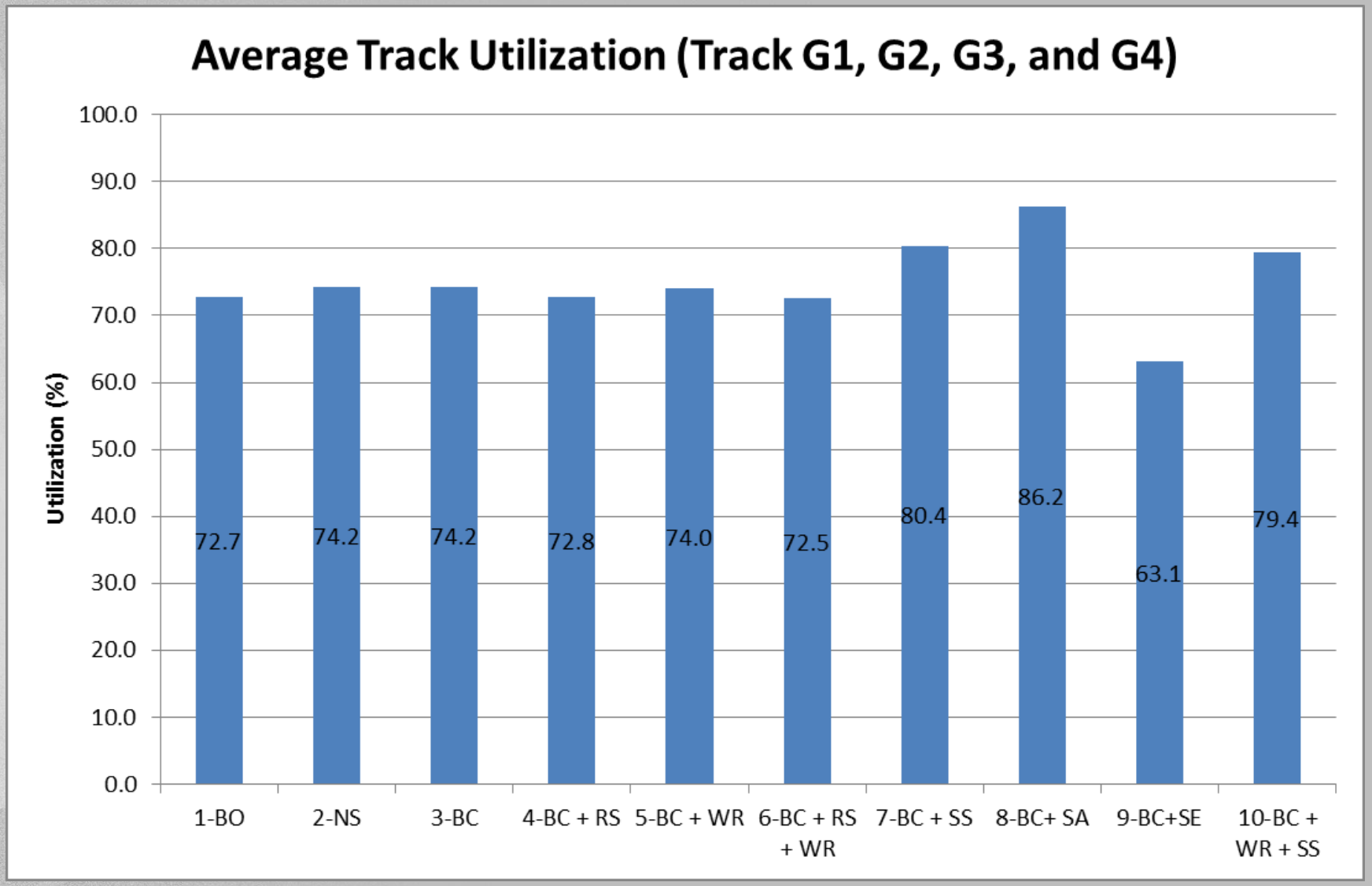


Model Results

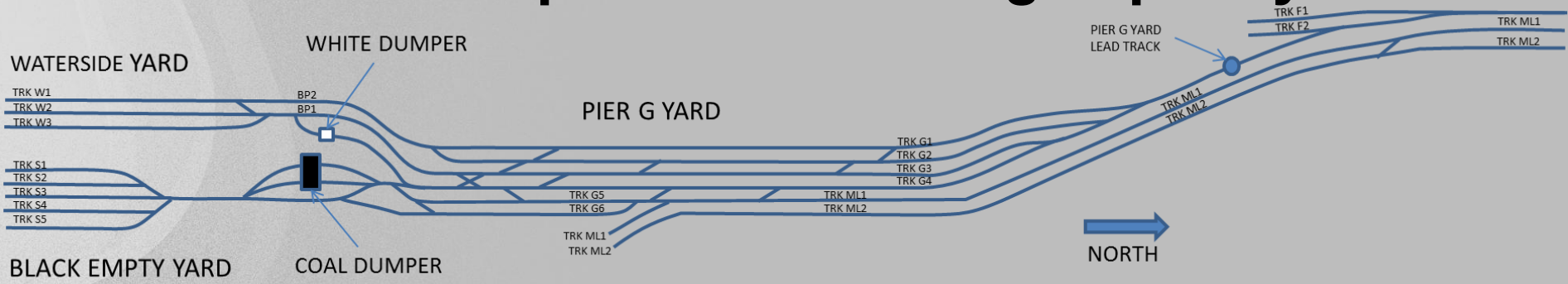


Conclusions

- **Proposed improvements :**
  - **Longer trains for arrival and departure**
    - *84 cars/white train, 5% increase*
    - *96 cars/black train), 4% increase*
  - **More capacity for holding empty cars, both white and black**
  - **Operational flexibility without impacting mainline traffic**
    - *Using any of G1, G2, G3, and G4 as bypass to access their north ends*
    - *Better use of track G5 and G6*
    - *One more by-pass track for white*
  - **Allows simultaneous black and white operation**
  - **Black and white simultaneous unloading gives operational flexibility, but not a significant increase in**

Conclusions (Continued)

- **Proposed system has potential to increase throughput capability by a significant percentage**
- **Improving rail side operation or getting near-terminal or more on-terminal rail storage should be the highest priority in terms of a strategy to increase black product handling capacity.**



Simulation Tool

- **Modeled existing complex operations and Proposed improvements providing a visual and analytical tool to study the terminal**
- **Identified**
  - Impacts on operations
  - Potential bottlenecks
- **Assessed opportunities and their relative benefits to facilitate decision making process**

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