

# Prevention of Berthing Pains: Flexibility in the Design of a Marine Dock for Bulk Liquid Chemicals Loading

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## Background

- \* Bulk marine shipping is the primary mode of transport
- \* Marine dock idle capacity and over capacity both carry large cost penalties
- \* Design can be componentized for adding flexibility



Image Source: [http://upload.wikimedia.org/wikipedia/commons/4/46/Marine>Loading\\_Arm\\_KLEa.jpg](http://upload.wikimedia.org/wikipedia/commons/4/46/Marine>Loading_Arm_KLEa.jpg)

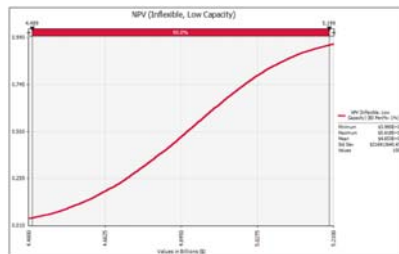
# Approach

- \* Four design scenarios
- \* Monte-Carlo simulation and decision rules
- \* Based on Master's thesis project with sponsor company
- \* Mix of stochastic and deterministic variables

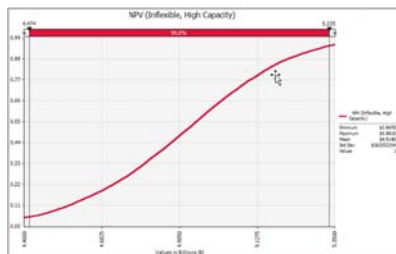
Stochastic Variables	Deterministic Variables
Demand Growth	Discount Rate
Panama Canal Expansion Project Completion Year	Starting Demand
Panama Canal Expansion Project Completion Factor	Starting Capacity
Asset Utilization	Expansion Capacity
Average Chemical Price per Ton Growth	Expansion Cost
	Starting Average Chemical Price per Ton

# Simulation Results

Inflexible, Low Capacity

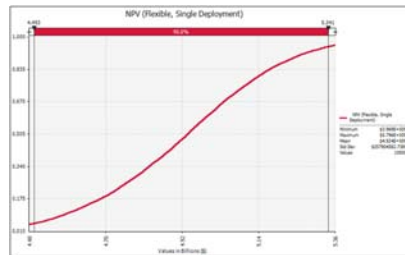


Inflexible, High Capacity

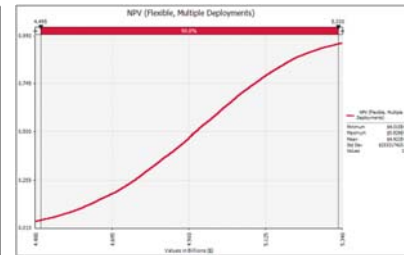


# Simulation Results

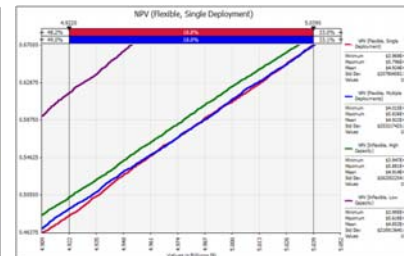
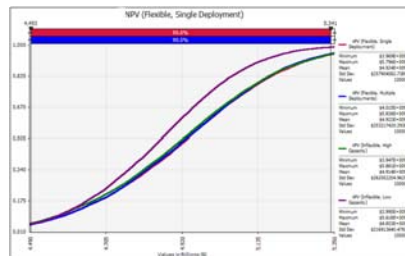
Flexible, Single Stage



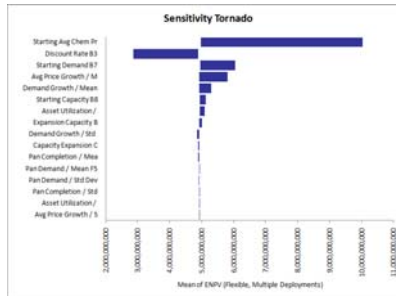
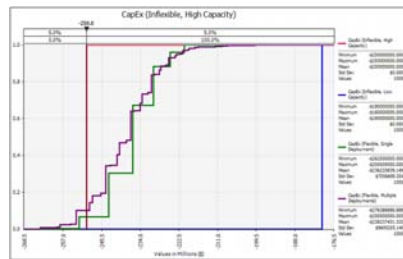
Flexible, Multiple Stages



# Comparison



# Additional Analysis



# Conclusions

- \* Flexible scenarios yield highest NPV and lowest PV Capital Expenditure
- \* Significant Capital Expenditure is delayed to later years with flexibility
- \* A hybrid of the multi-stage and single-stage models should be investigated



Image Source: [http://upload.wikimedia.org/wikipedia/commons/c/co/Marine\\_Loading\\_Arm\\_KLE.jpg](http://upload.wikimedia.org/wikipedia/commons/c/co/Marine_Loading_Arm_KLE.jpg)

## Works Cited

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