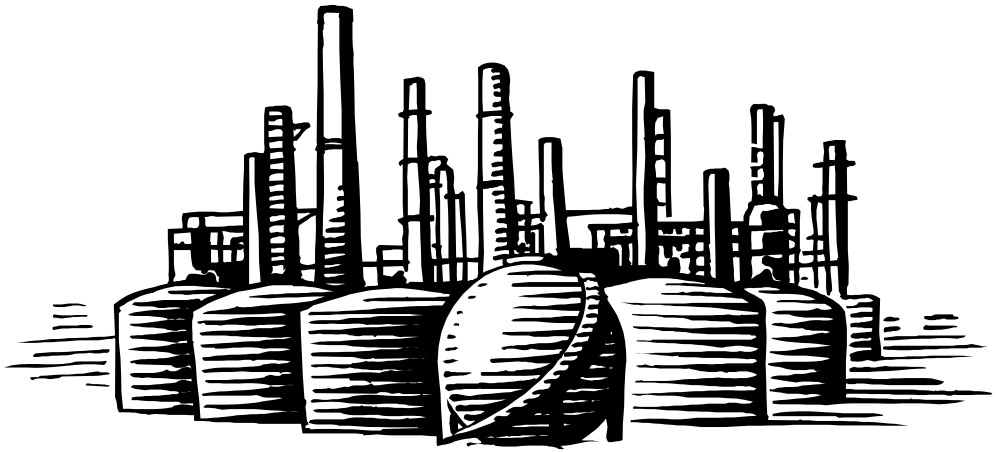
Challenges of Integrating Planning and Scheduling in Oil Industry

San Yip, Ph.D., P.Eng., CMA

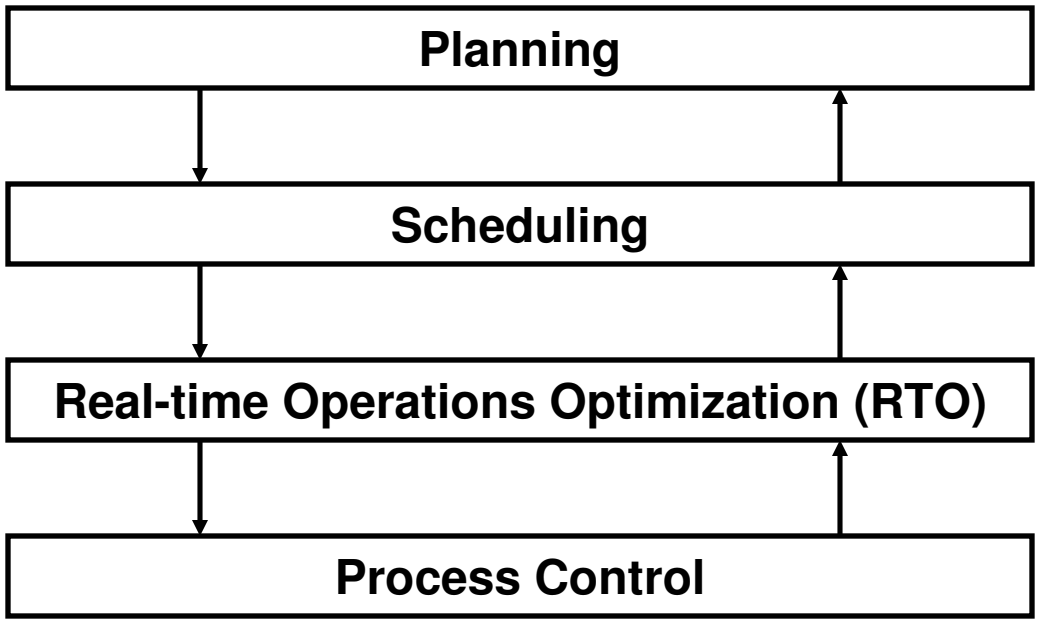
Suncor Energy Inc

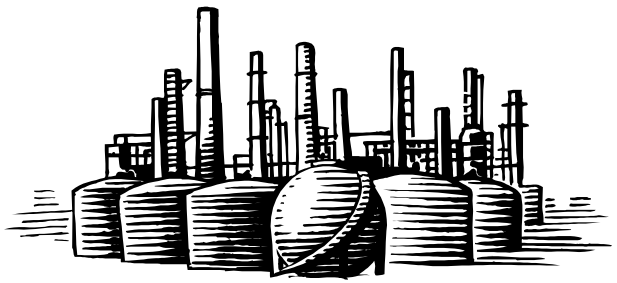


Outline

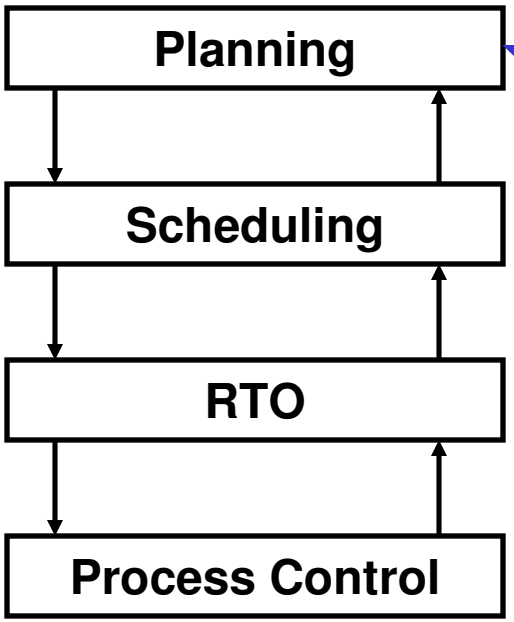
- Decision making hierarchy
- Ideal integrated planning and scheduling problem
- Current planning and scheduling practice
- Integration challenges
- Conclusion

Decision Making Hierarchy

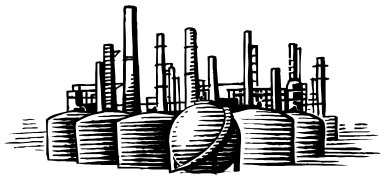




Decision Making Hierarchy



- Execute monthly
- Planning horizon of ~6 months
- Long-term economics
- Plant-wide model
- Simplified yield model
- Aggregate inventory
- Monthly average targets



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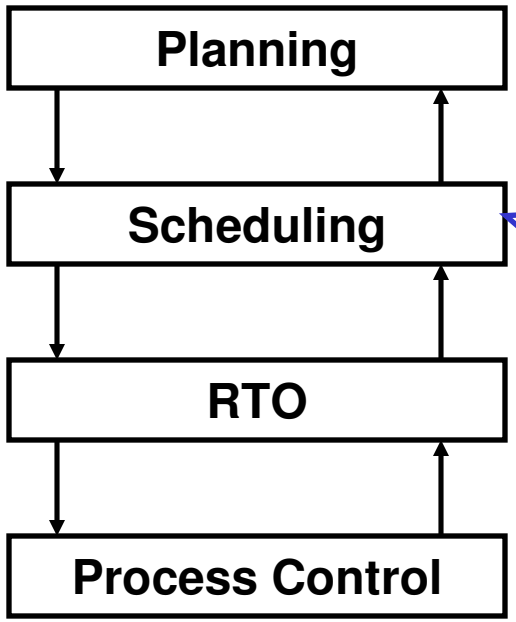
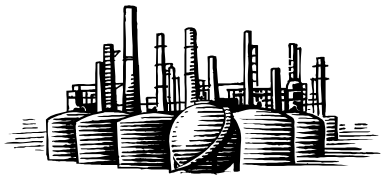


- Execute weekly
- Planning horizon of ~ 6 to 8 weeks
- Plant-wide model
- Simplified yield model
- Short-term feasibility
- Individual tanks
- Daily operations targets



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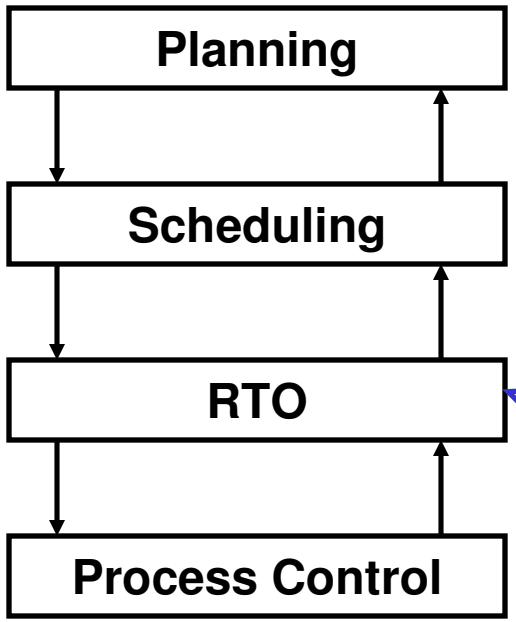
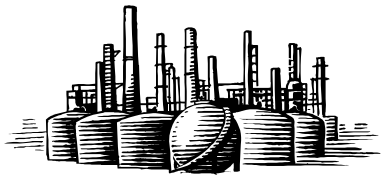
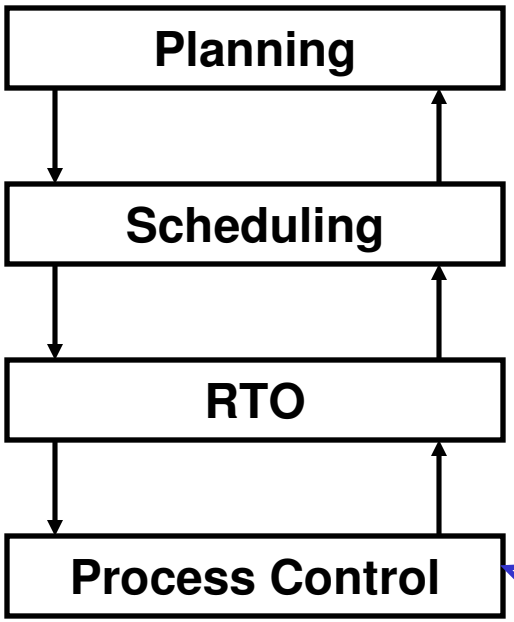


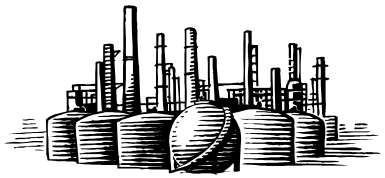
- Execute ~hourly
- Optimize current economics
- Unit based optimization
- Detailed nonlinear mathematical models (Steady-State)
- Real-time process unit operation targets



Decision Making Hierarchy



- Execute every minute
- Keep process units at RTO targets
- Dynamic model
- Control horizon long enough to capture process dynamics



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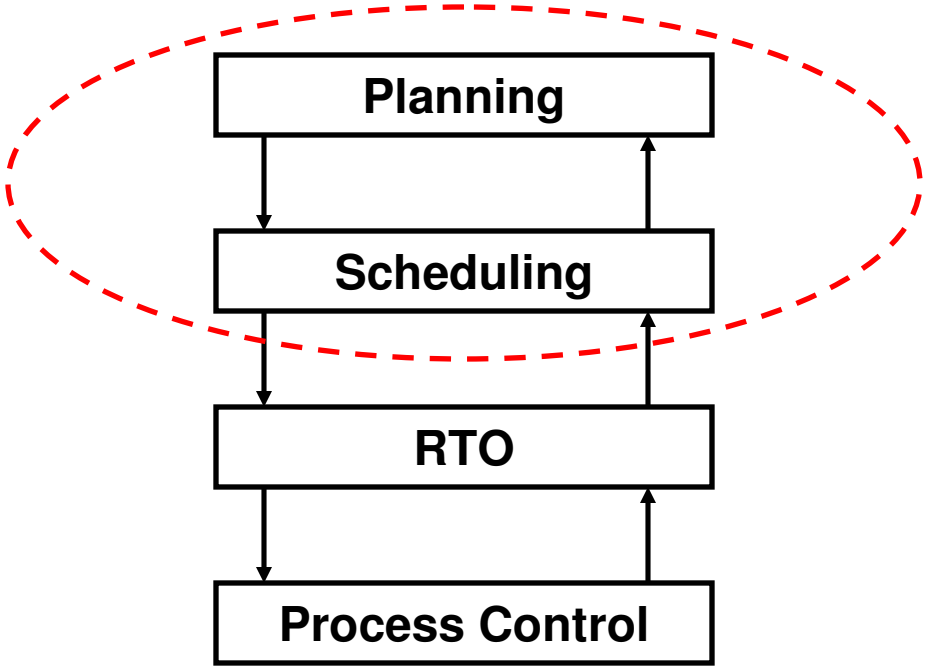
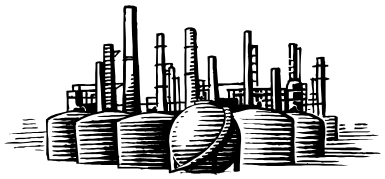
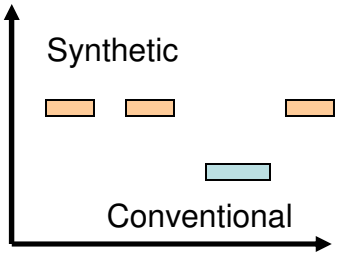


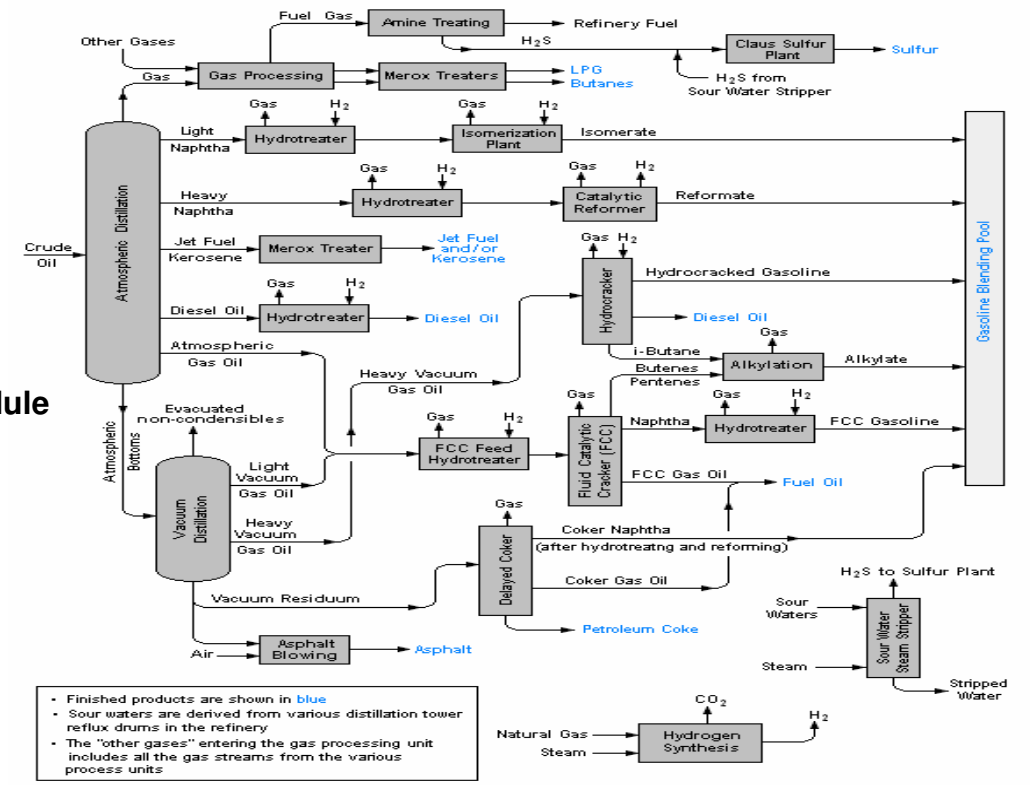
- Main Focus
- Current Practice
- Challenges of Integration

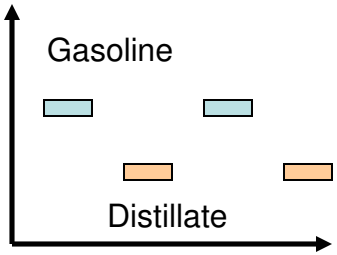


Ideal Integration Framework



Crude Delivery Schedule



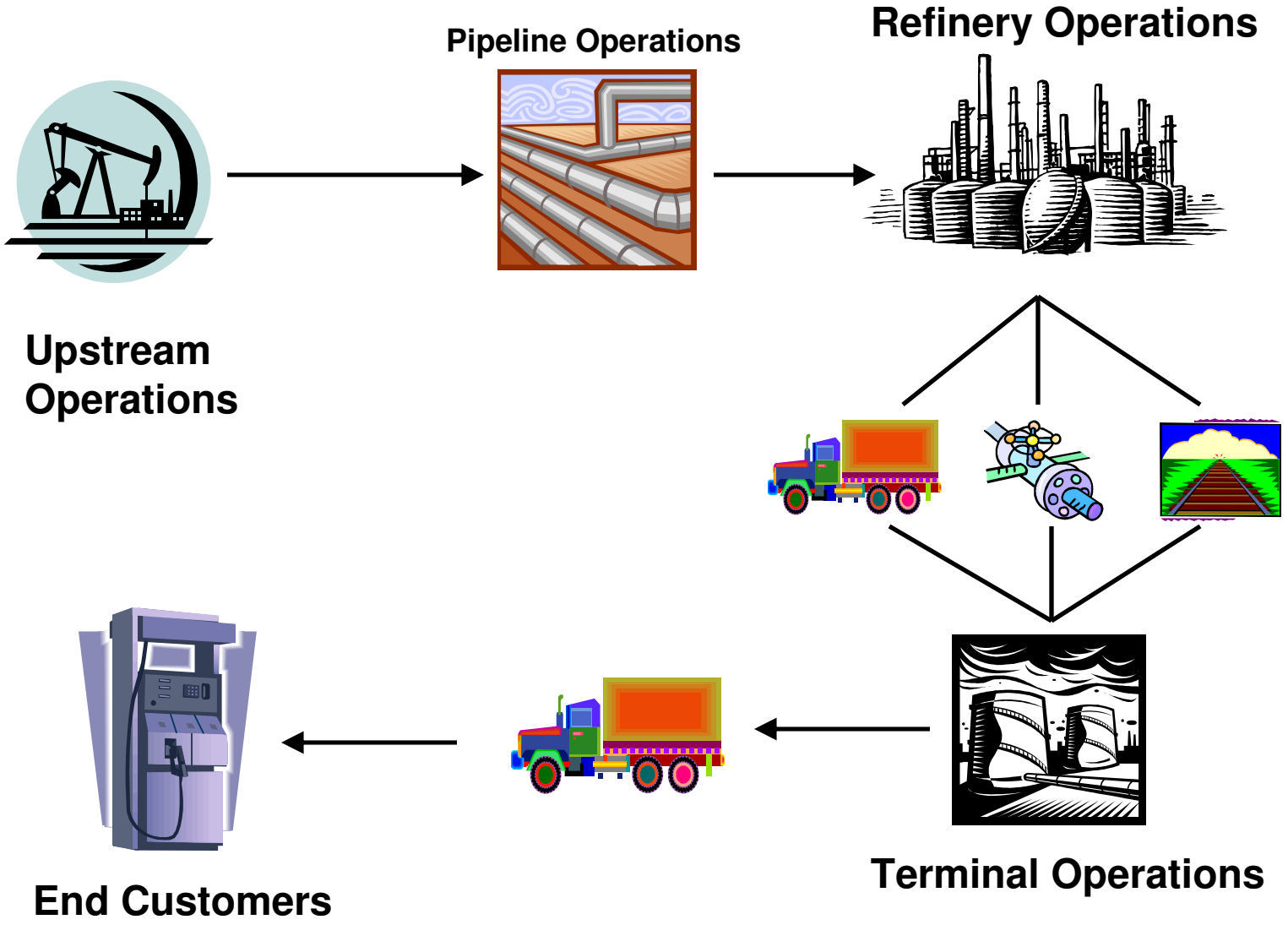


Product Lifting Schedule (At terminal)

Decisions:
What crude to buy?
Crude delivery schedule?
Process unit operations?
Inventory profile?
Product lifting schedule (at refinery)?

Lot of decision variables
Continuous and integer

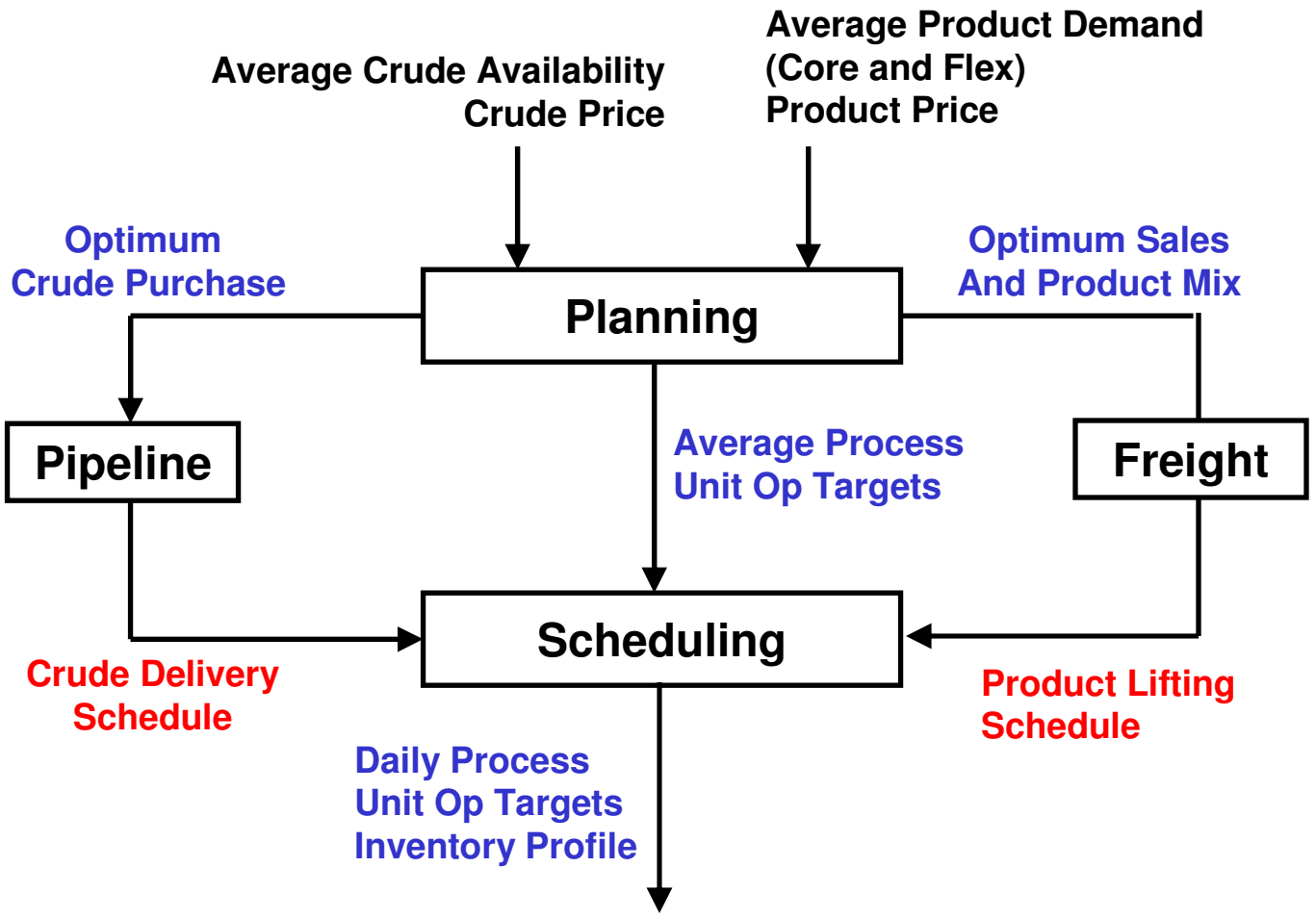
Industry Supply Chain



Industry Supply Chain

- **Not all decisions made by oil companies**
  - Crude delivery from pipeline company
  - Product delivery from pipeline and freight companies
  - Wholesalers can influence product delivery decision
- **Making optimum crude purchase and delivery decisions from an integrated planning scheduling problem not possible**
- **Industrial practice: Separate planning and scheduling optimization**

Current Industrial Practice



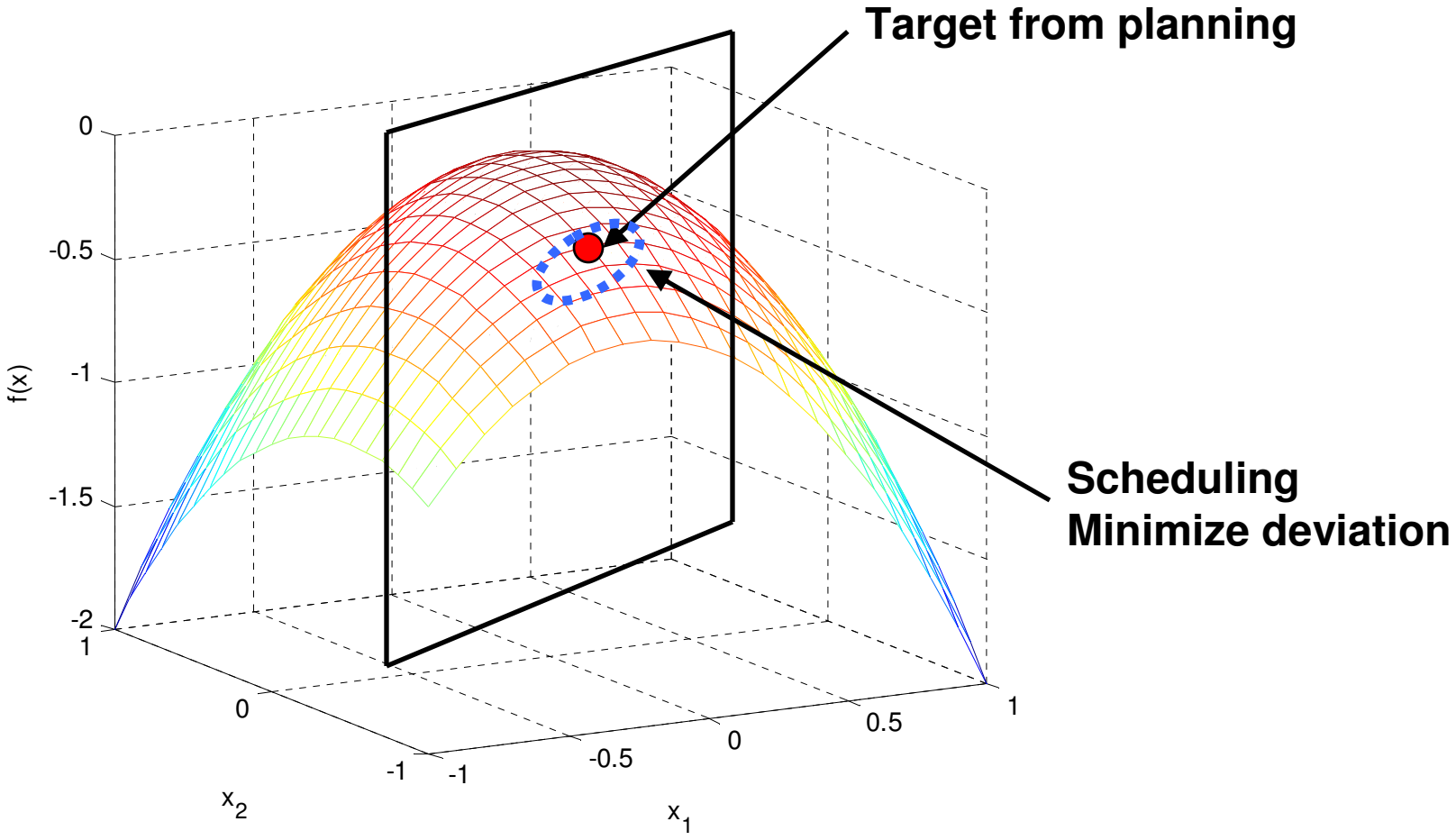
Planning Optimization Problem

- **Simplified Process Unit Models**
  - **Crude Assays**
  - **Linear Yield, Base-Delta, etc**
  - **Can be linked to nonlinear simulator**
  - **Nonlinear blending and quality calculations**
  - **Aggregate inventory**
- **Decisions implemented (first month)**
  - **Crude and product purchases**
  - **Sale volumes**
  - **Unit rates and other operating targets**
  - **Diesel and gasoline blending**

Scheduling Optimization Problem

- Process models – same as planning models
- Inventory – model all tanks
- Fixed decisions
  - Crude delivery schedule
  - Product lifting schedule
  - Monthly operating targets
- Optimization problem
  - Determine daily operating targets
  - Minimizing deviation from the monthly operating targets

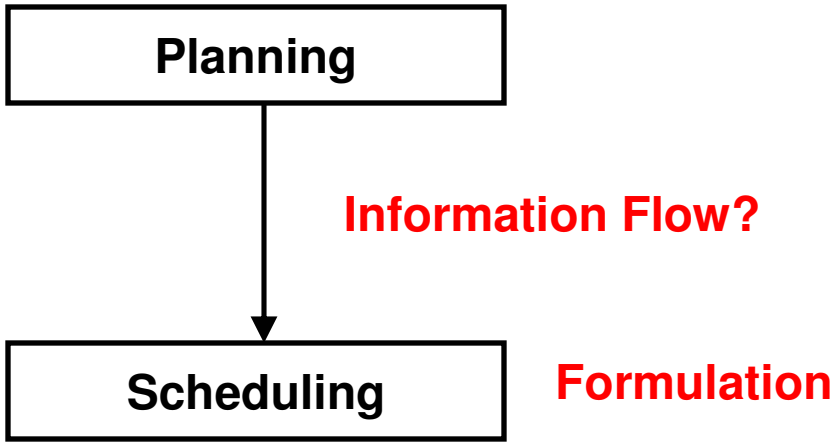
Planning/Scheduling Problem



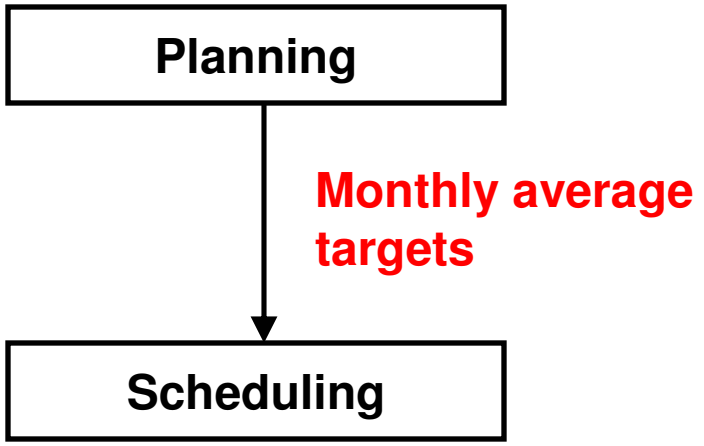
Current Practice

- **Planning Problem**
  - **Haverly GRTMPS**
  - **SLP**
  - **Economic optimization**
- **Scheduling Problem**
  - **Haverly H-Sched**
  - **Progressive LP**
  - **Economics not explicitly formulated**

Current Issues

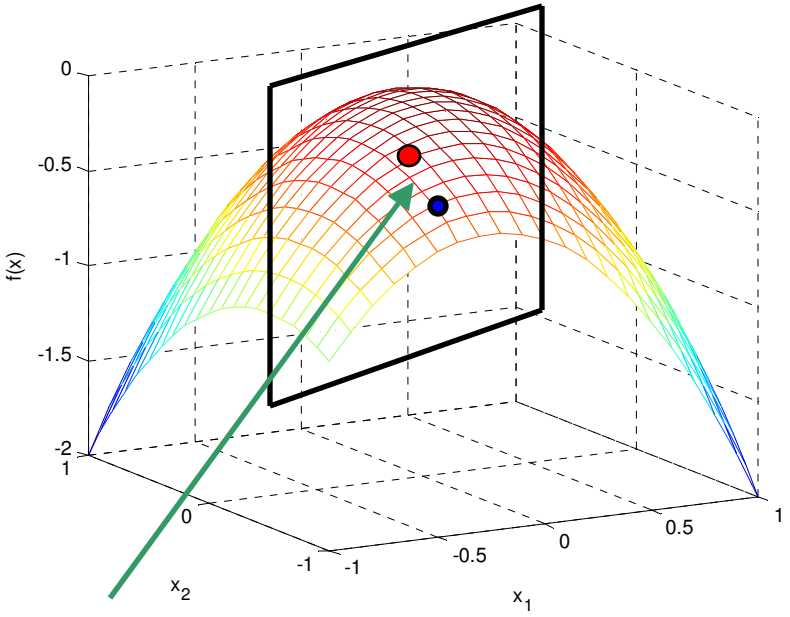


Current Issue – Economics



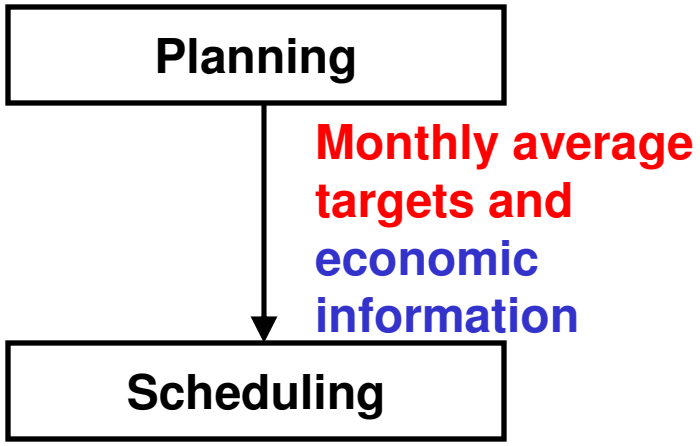
Monthly average targets

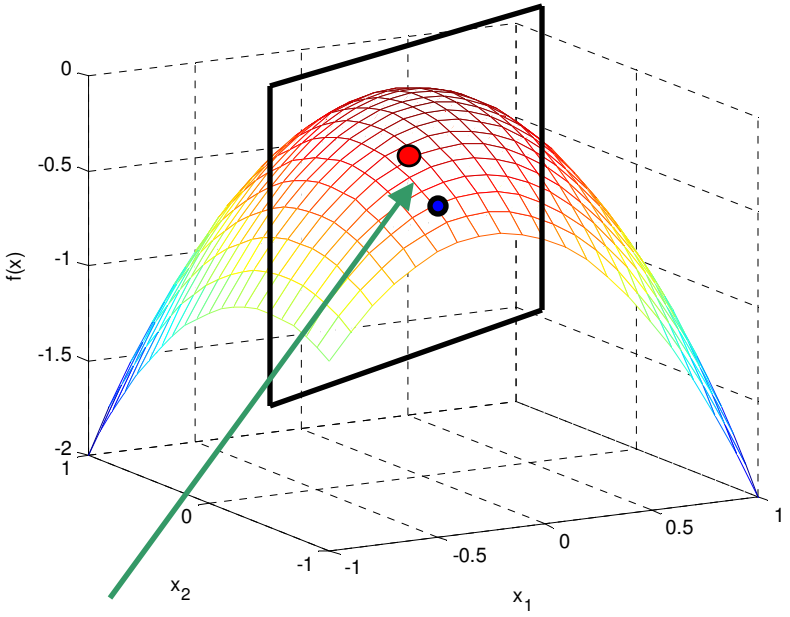
Penalty set by user to minimize deviation from the targets



Objective to minimize this deviation. Penalty parameter set arbitrarily

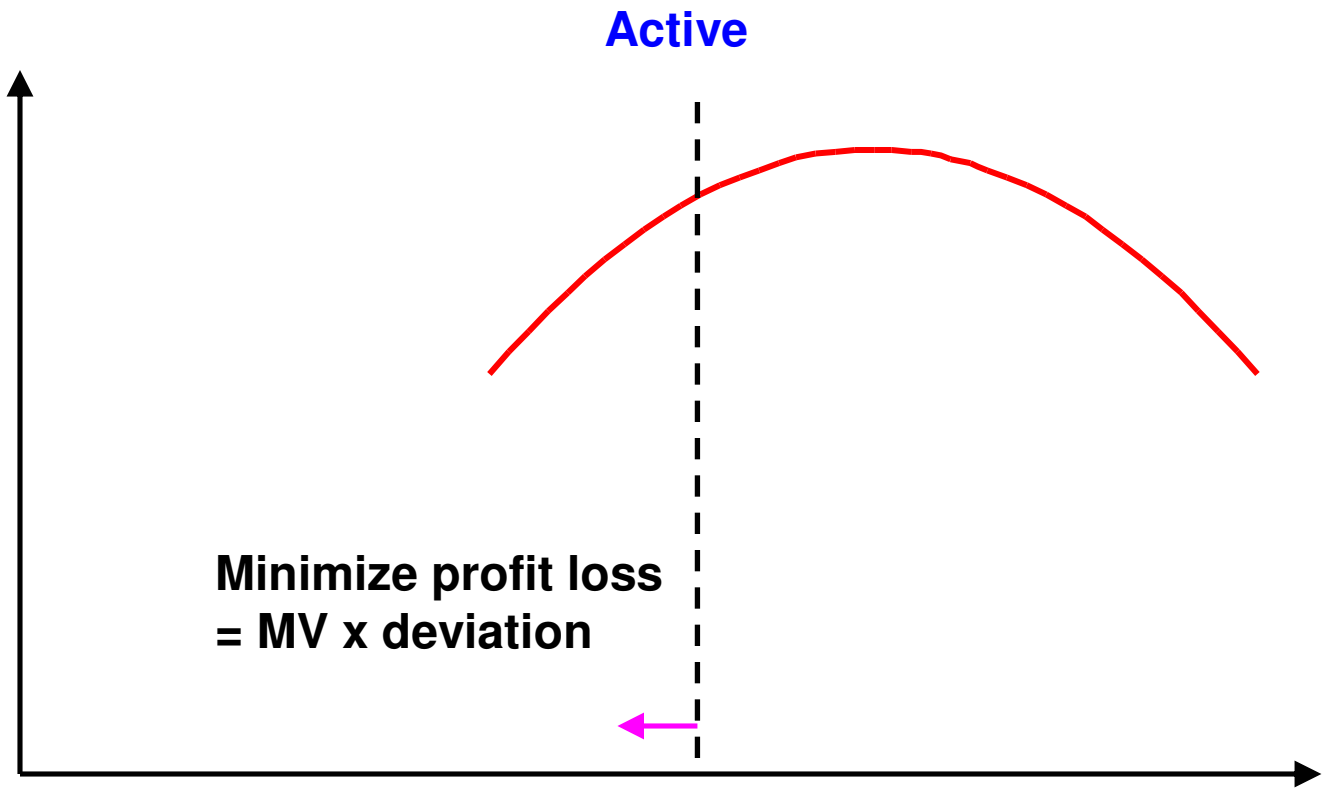
Current Issue – Economics





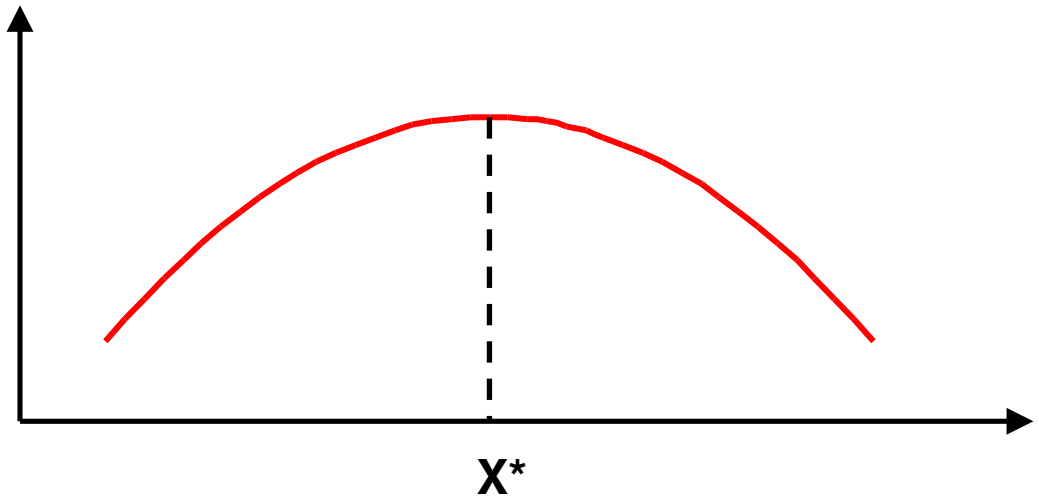
Penalty parameter can be set from economic Information from the planning problem

Current Issue – Economics



This formulation is possible in H-Sched

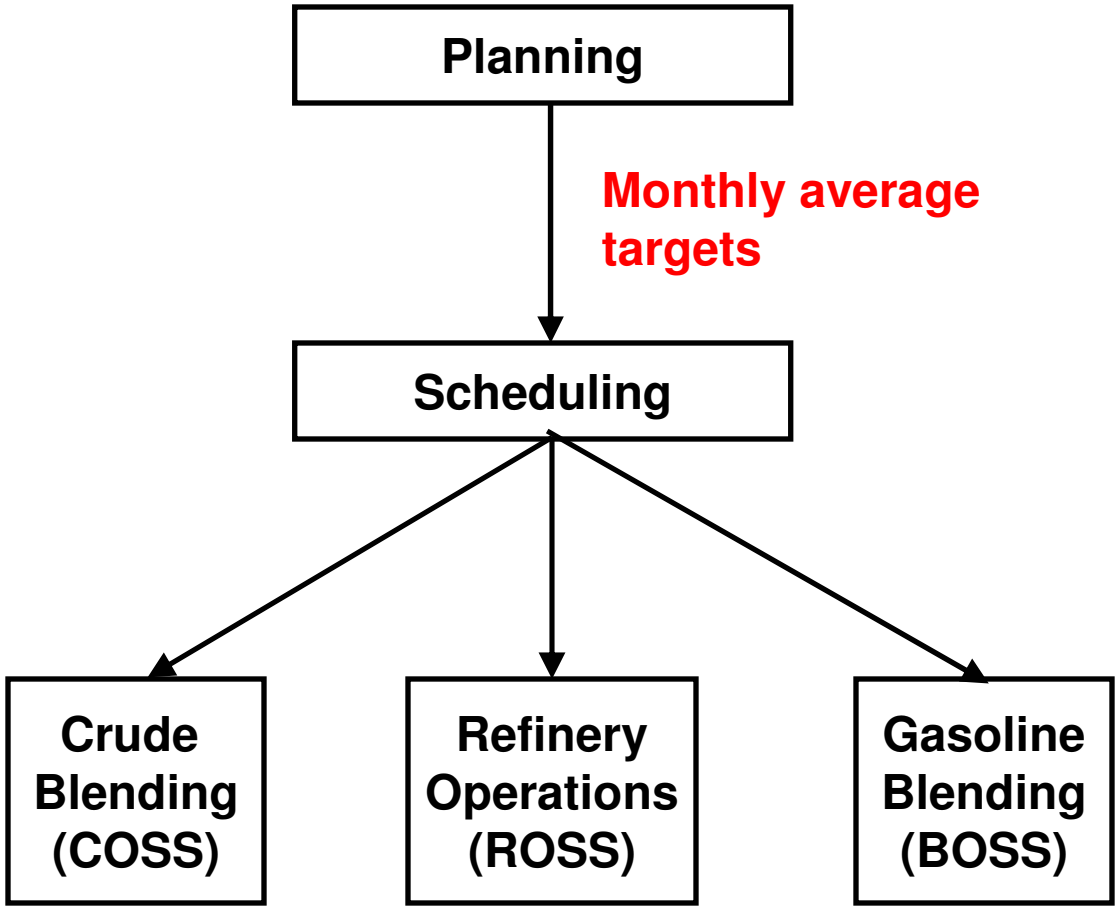
Current Issue – Economics



Minimize $P(x) - P(x^*) \approx \frac{1}{2}(x - x^*)^T \nabla_r^2 P\Big|_{x^*} (x - x^*)$

This formulation is not possible in H-Sched. Also changes in active set on a daily basis could limit this formulation.

Current Issue – Problem Decomposition



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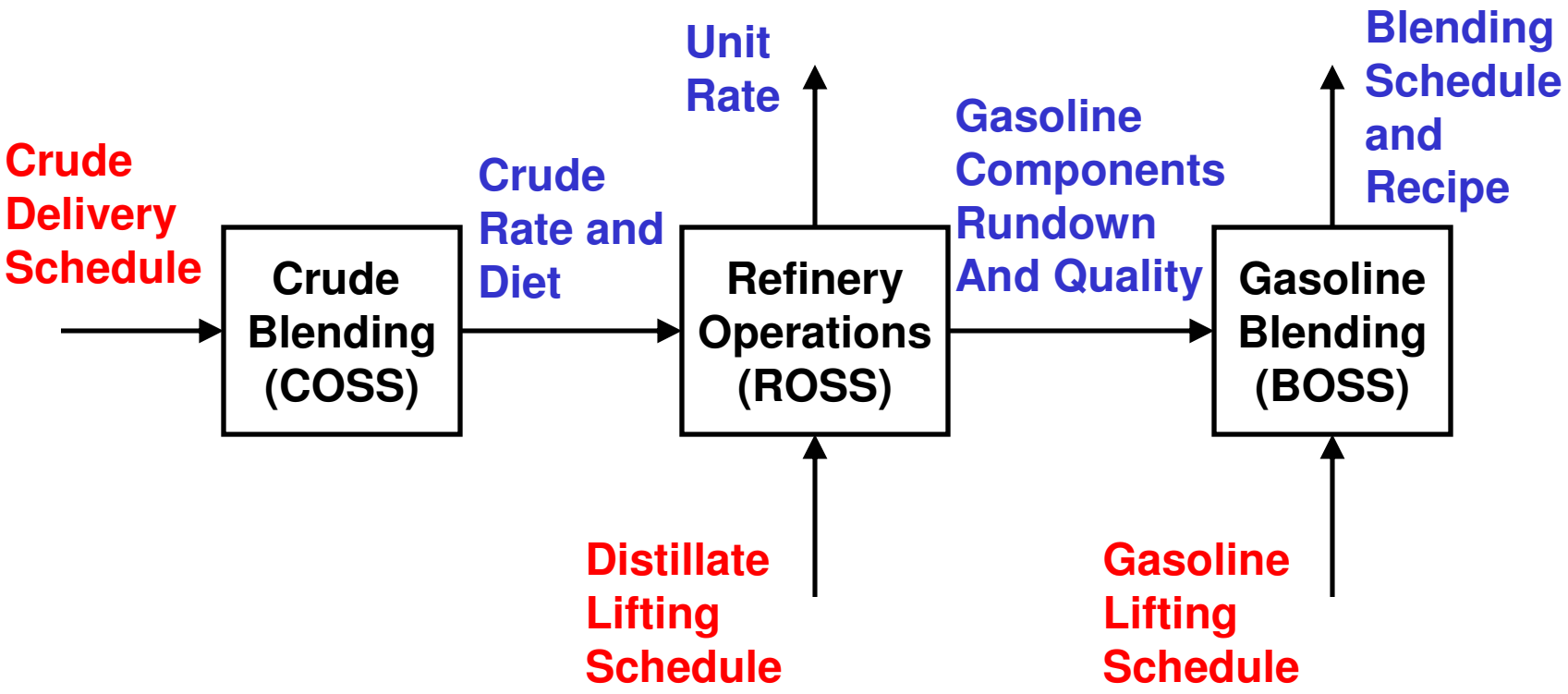
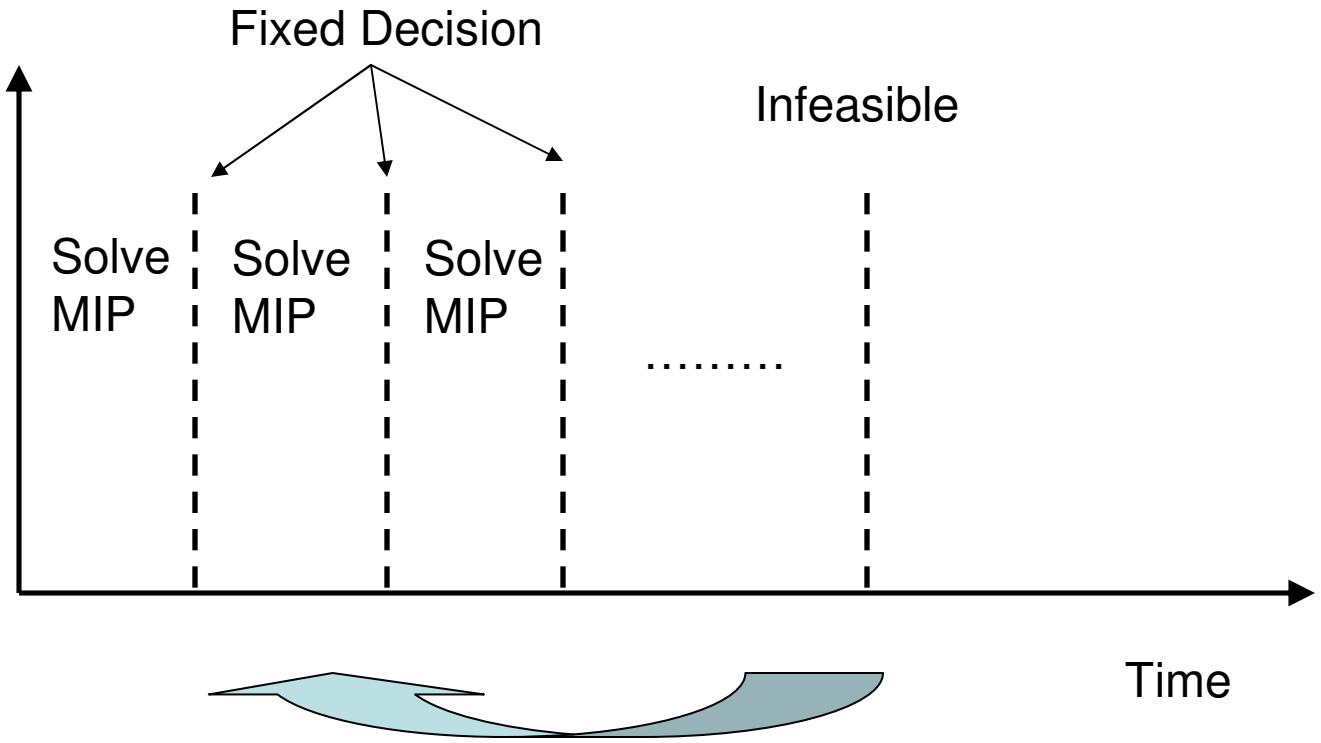


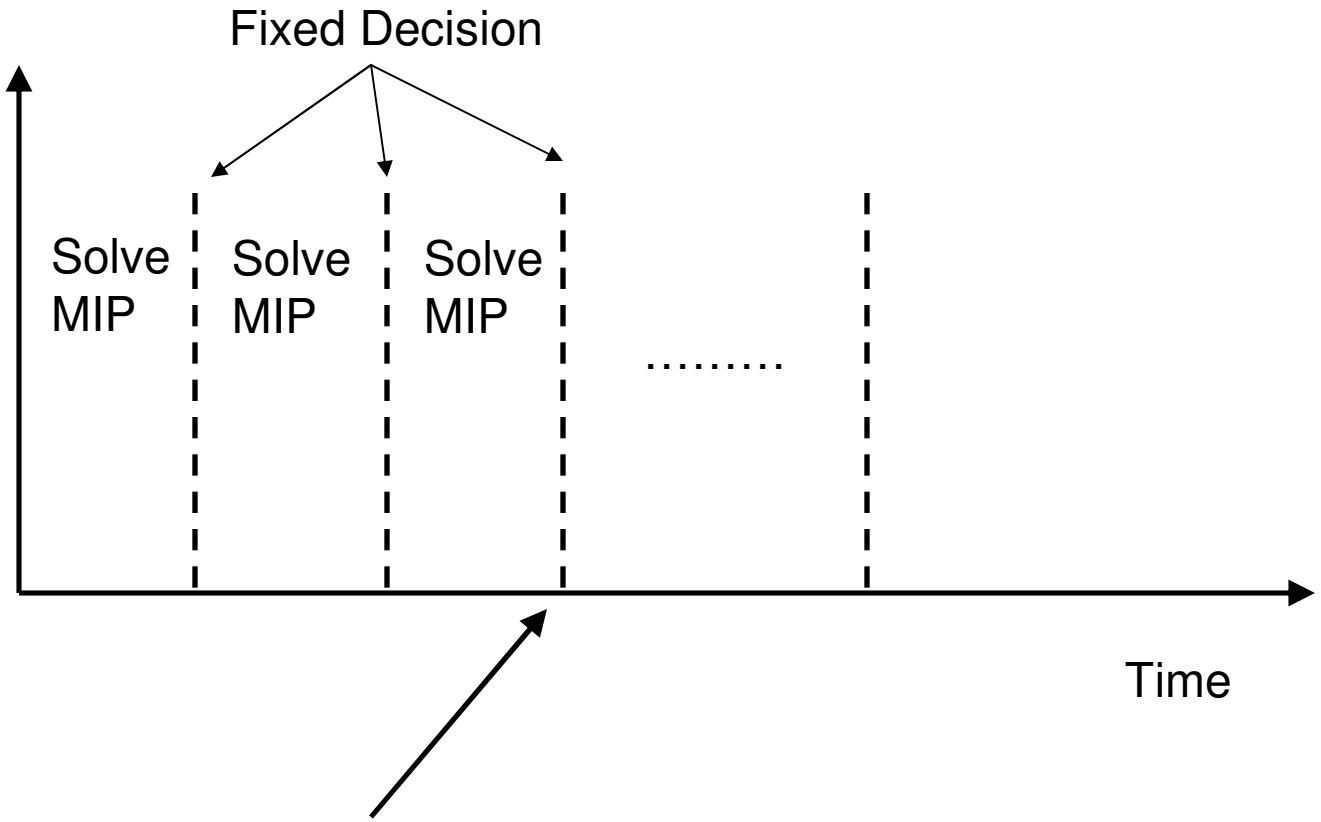
Sequential decision making process. Optimization of plantwide operations not considered.

Current Issue – Problem Decomposition



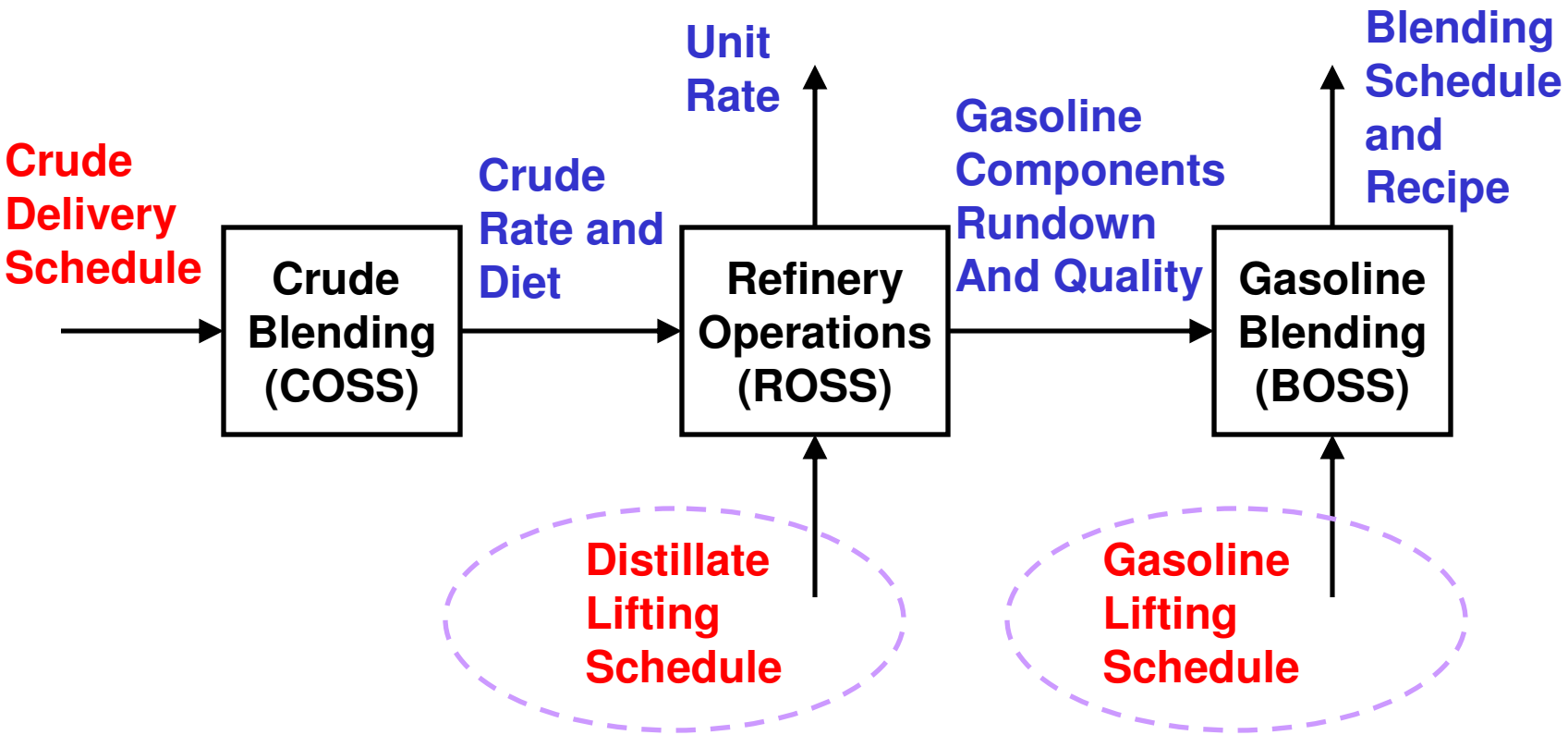
Progressive LP does not go back to adjust decisions in previous periods to ensure feasibility.

Current Issue – Problem Decomposition



Unable to set inventory targets at any period.

Current Issue – No Purchase Decision

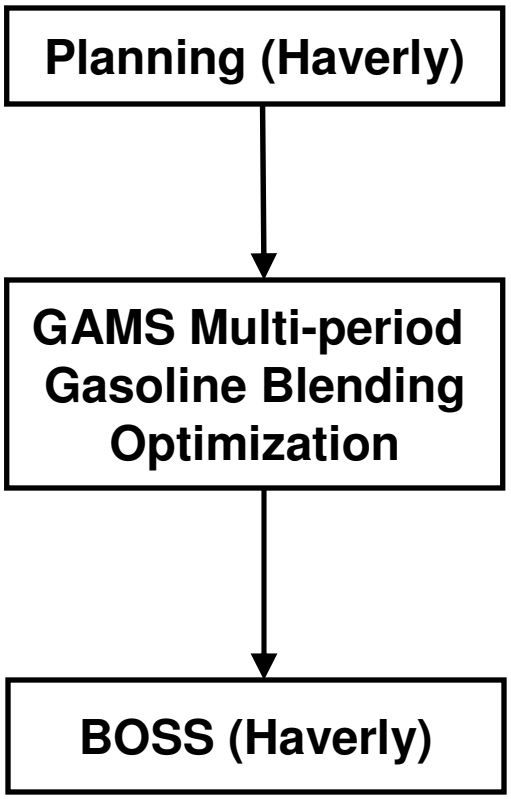


Unexpected upset may lower production and demands may not be met. Without purchase decision, H-Sched will not provide a feasible solution

Integration Framework for Gasoline Blending

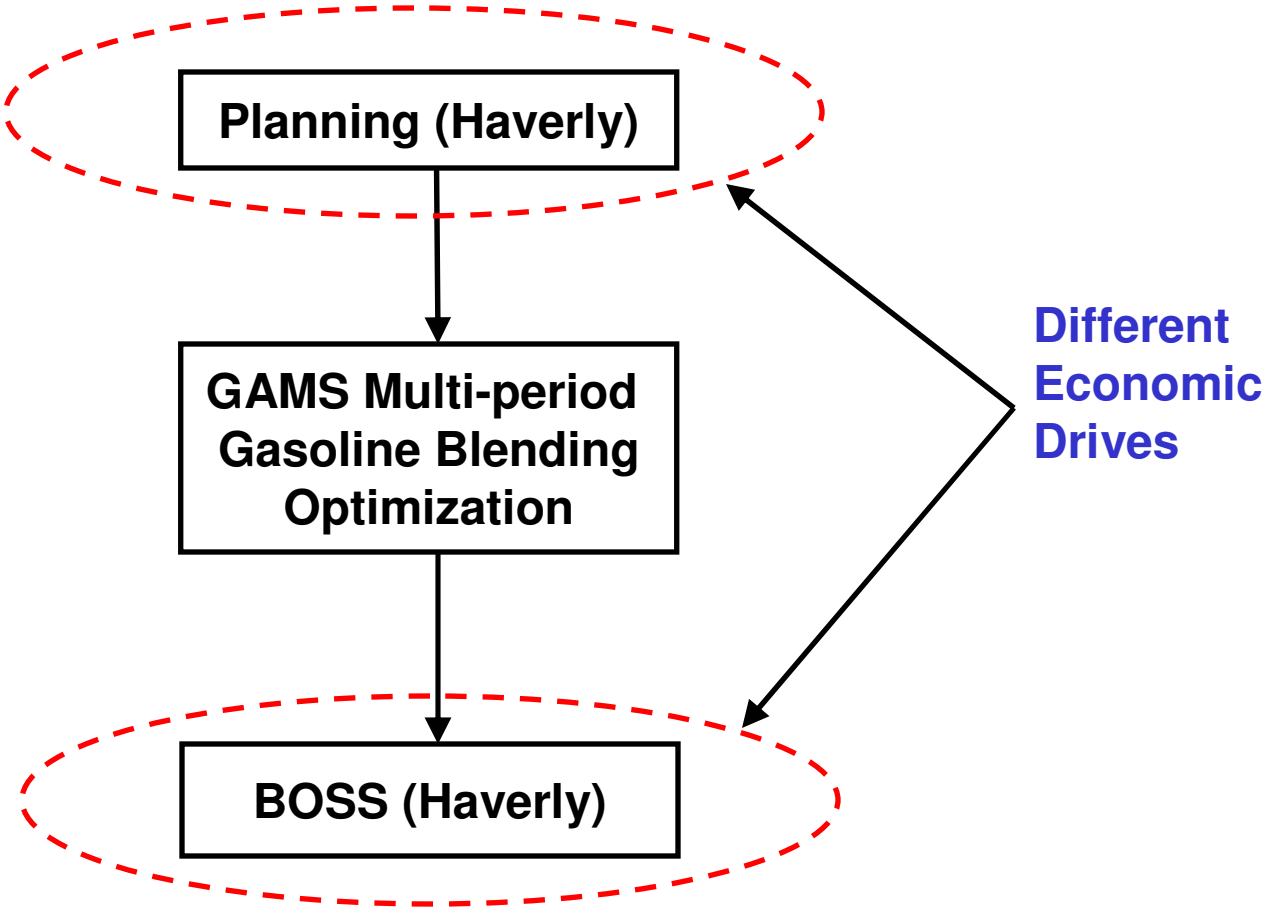
- Include some economics
- Determine the maximum gasoline production for any unplanned upset
- Able to set closing inventory targets
- Determine the optimum gasoline blending recipe for H-Sched implementation
  - Minimize the chance of getting an infeasible solution when solving progressive LP

Integration Framework for Gasoline Blending

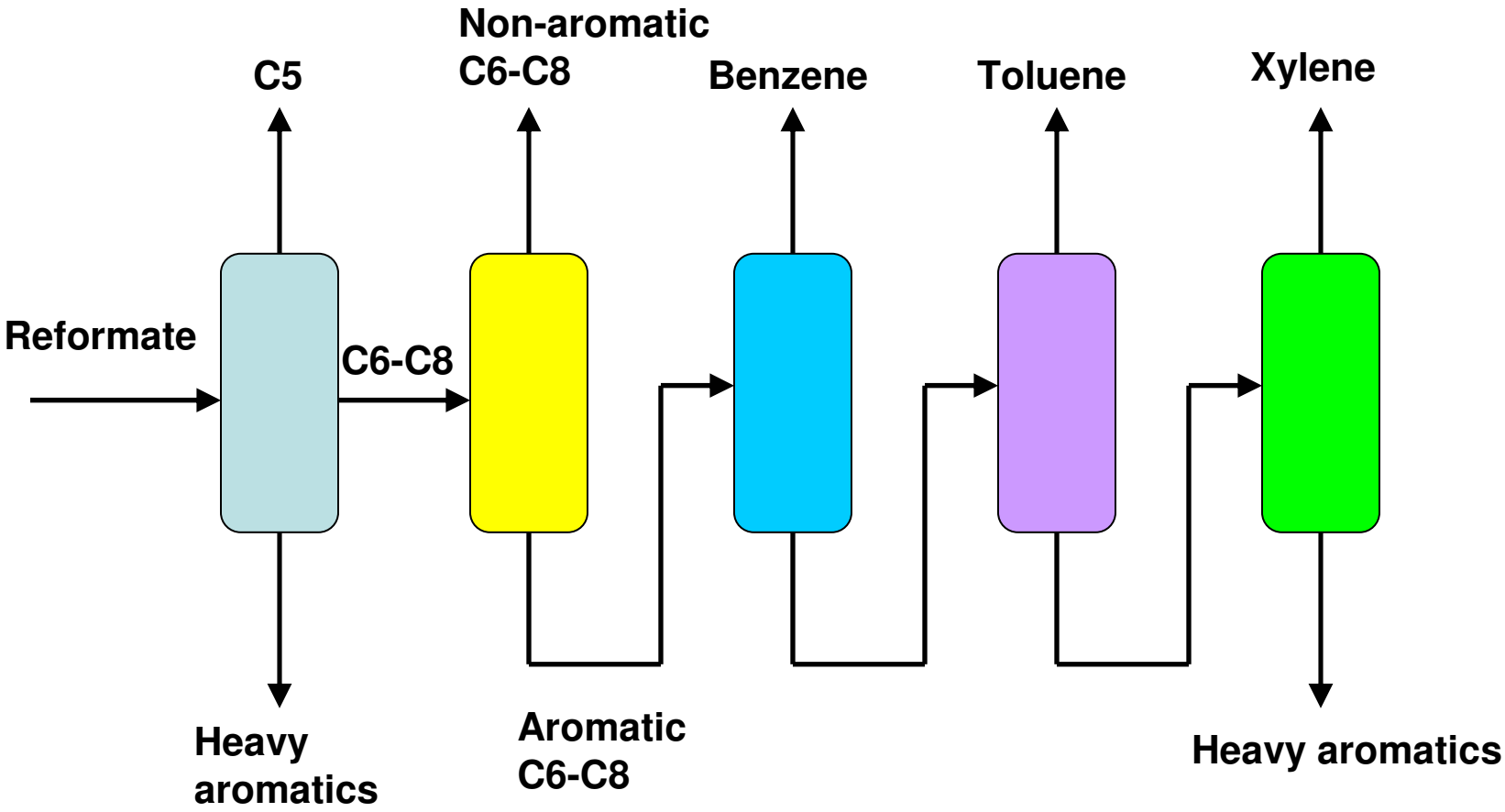


Why not implementing gasoline blending targets from planning directly to BOSS?

Integration Framework for Gasoline Blending

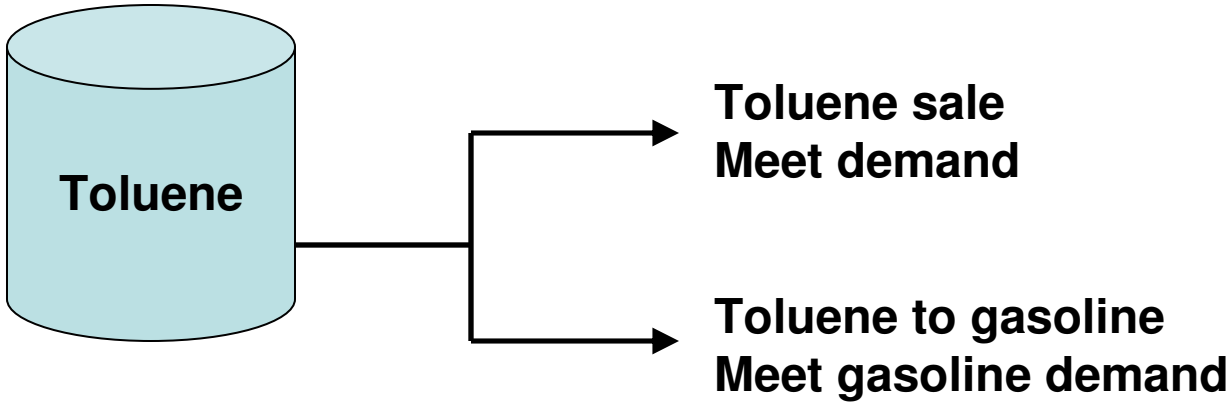


Integration Framework for Gasoline Blending



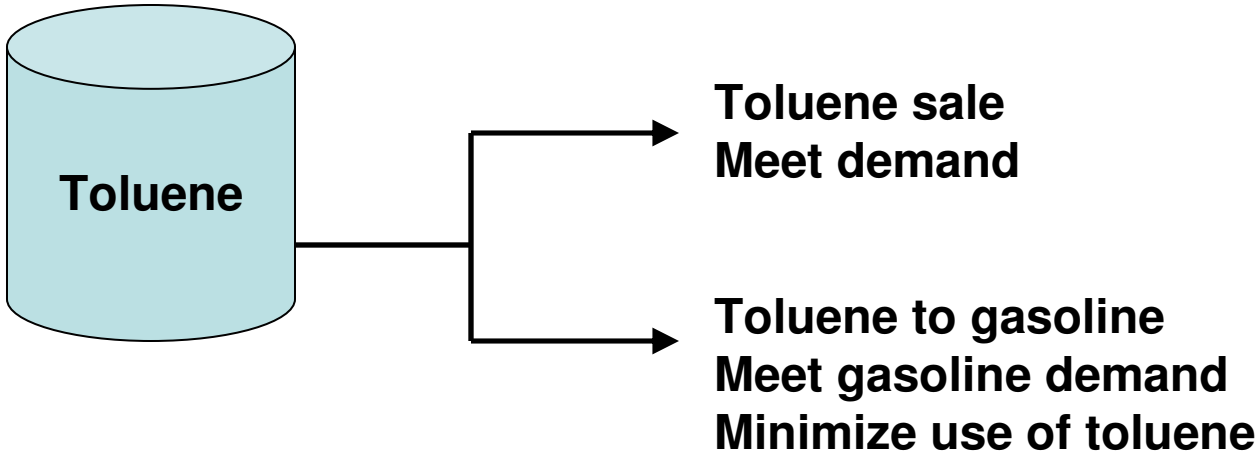
Marginal cost of heavy aromatics is higher than that of chemicals. Cost of making heavy aromatics is high but it can only go to gasoline blends. There is no market for heavy aromatics.

Integration Framework for Gasoline Blending



Once the toluene demand is met, toluene can go to gasoline only for making profit

Integration Framework for Gasoline Blending



Gasoline blender wants to minimize toluene to gasoline so that toluene can be used for future potential sale. This drive is different from that in the production planning model.

Integration Framework for Gasoline Blending

- Increase toluene cost in gasoline blend schedule optimization (i.e. change drive)
- For example, use toluene sale price instead of marginal cost from the planning optimization result
- Transfer price approach

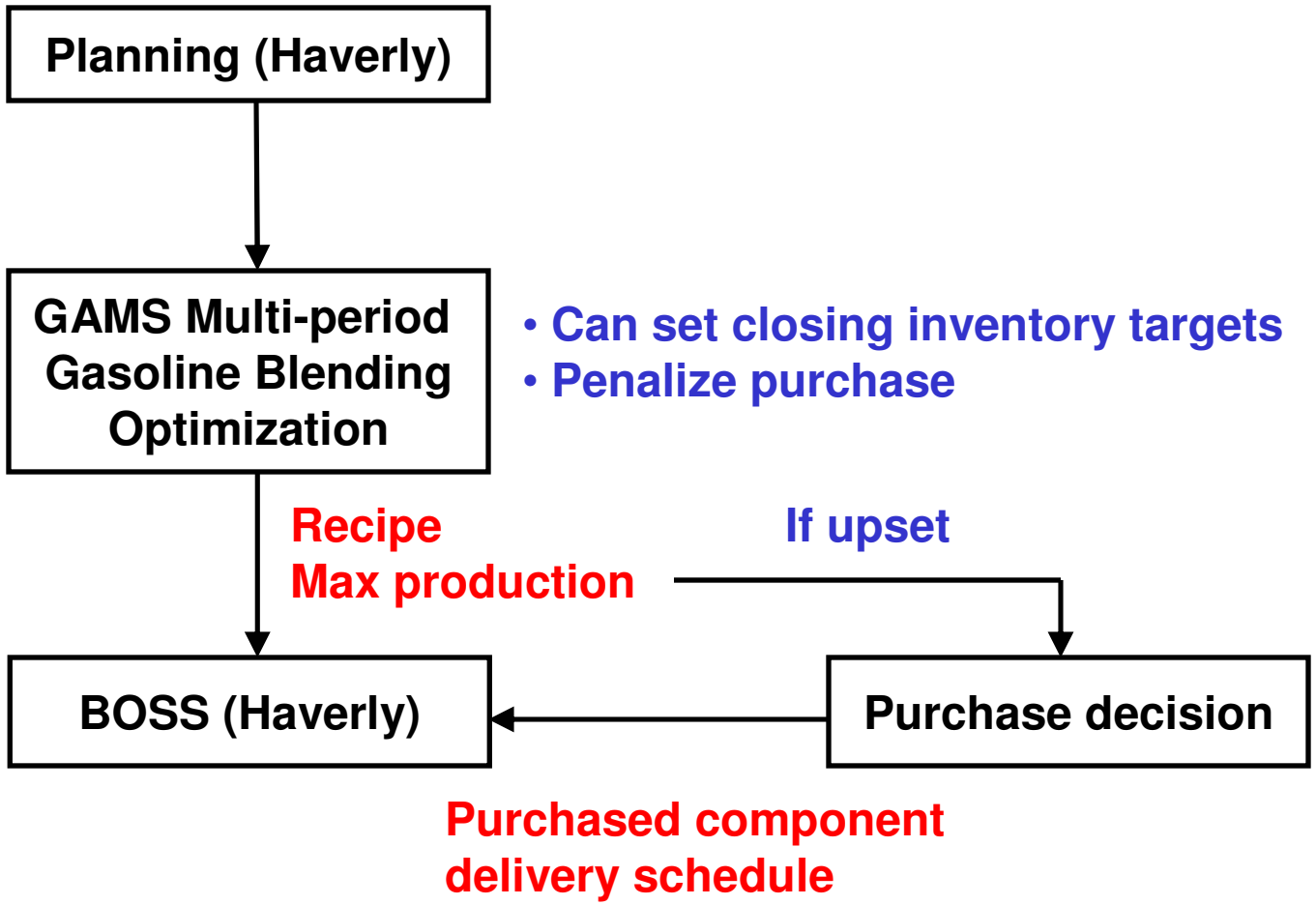
  Minimum transfer price = variable cost + opportunity loss

  Variable cost = Marginal cost

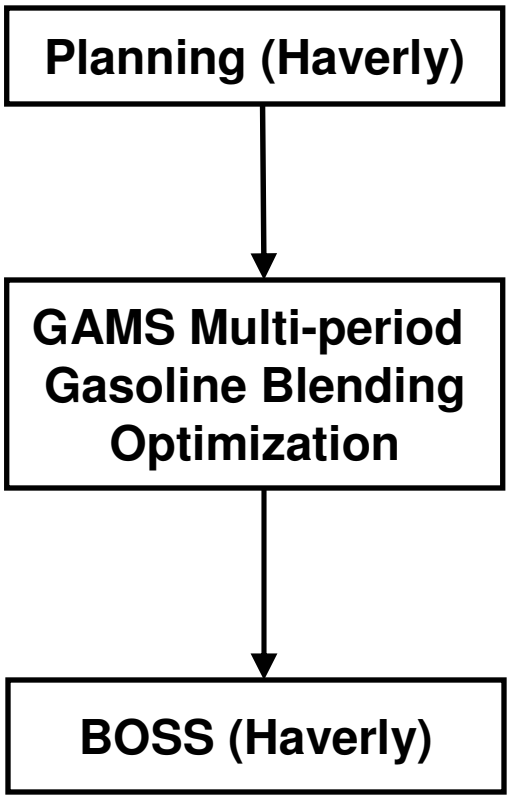
  Opportunity loss = Sale price – Marginal cost

  Minimum transfer price = Sale price
- Recipe determined by scheduler could be different from the recipe from the planning model

Integration Framework for Gasoline Blending



Integration Framework for Gasoline Blending



Fine Tuning Gasoline Blending Recipe before Implementation

This approach is successfully applied to generate weekly gasoline blending plan and daily recipe targets

Conclusions

- **Challenges of integrating planning and scheduling**
  - **Decisions**
  - **Mathematical formulation**
  - **Commercial tools**
- **Multi-period gasoline blending optimizer**
  - **Fine tune gasoline blend recipe**
  - **Facilitate decision making for unplanned upset**
  - **Minimize the chance of getting an infeasible solution from BOSS**