What does an Industrial Mathematician really do?

By

Dr. Francis J. Vasko
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He or she uses mathematics to formulate and solve real-world problems.
Most times, the size of these problems dictate the need for these solution procedures to be computer-based.
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Some major Career Paths for Industrial Mathematicians:

- Federal Government—NSA, CIA, etc.
- Statistician
- Actuary
- Operations Researcher
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What is Operations Research?

The use of mathematical (optimization) models to provide guidelines to managers for making effective decisions.
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Mathematical Optimization is everywhere
Finance
Marketing
E-business
Telecommunications
Production Planning
Transportation Planning
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Industrial Projects that I have been involved with
- Determining Continuous Caster Configurations
- Optimal Selection of Ingot Sizes
- Solving a Fuzzy Cutting Stock Problem
- Optimal Metallurgical Grade Assignment
- Dynamic Cold Ingot Substitution
- Planning Mother Plate Requirements
- Consolidating Product Sizes to Minimize Inventory Levels
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More Industrial Projects that I have been involved with

- Optimally Loading Structural Steel on Rail Cars
- Optimal Assignment of Slabs to Orders
- Optimally Determining Bloom Lengths
- Replenishing Rectangular Stock Sizes
- Optimizing Water Spray Settings on a CC
- Optimally Balancing Trim Loss and Setups
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Still More Industrial Projects that I have been involved with

- Real-Time Optimal Cutting of Steel Beams
- Optimal Coal Blending Models for Cokemaking
- Meltshop Scheduling in the Steel Industry
- Strategic Planning
- Optimizing Performance Funding
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Somewhat different applications of Operations Research

☐ Does Marilyn Know her Game Theory
☐ Math Programming and LL Baseball
☐ Math Programming takes the fun out of SUDOKU Puzzles
☐ OR and Women’s College Basketball
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My Background

- BS Mathematics Education (KU)
- MS Theoretical Mathematics (LU)
- Two Years Teaching Junior HS Mathematics
- MS Operations Research (LU)
- 25 Years Industrial Mathematician
- Ph.D. Operations Research (LU)—got while working fulltime in industry
- Math Professor/Industrial Consultant
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Strategic Planning: Operations Research to the Rescue

Work done by Dr. Ken Stott and Dr. Francis J. Vasko for a Strategic Planning Committee. The Goals were to evaluate alternative operating and marketing strategies.
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Strategic Planning Committee Membership
Corporate middle management

- Sales
- Marketing
- Accounting
- Operations
- Research
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Basic Strategic Planning Model

- Mill capacity constraints
- Market demand constraints
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Basic Strategic Planning Model Math Formulation
Maximize \( P = \sum (PHPi)(XHPi) + \sum (PLPi)(XLPi) \)
Subject to:
\( \sum (RHPi)(XHPi) \geq MIN\_HRS\_HM \)
\( \sum (RHPi)(XHPi) \leq MAX\_HRS\_HM \)
\( \sum (RLPi)(XLPi) \geq MIN\_HRS\_LM \)
\( \sum (RLPi)(XLPi) \leq MAX\_HRS\_LM \)
\( XHPi \leq DEMAND\_HPi \)
\( XLPi \leq DEMAND\_LPi \)
\( XHPi \geq 0 \)
\( XLPi \geq 0 \)
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Critique of Basic Model Results

- Sales department very unhappy—results totally unrealistic
- Sales claimed “We sell structural steel used to make complete buildings”.
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Sales “Complete Buildings” Constraints.

- Sample model produced 125,000 of the 340,000 market demand or about 37% of the market demand.
- Sales contended that each product in the model should have been produced about 37% of its market demand—within a 15% tolerance of that value.
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“Complete Buildings” Constraints.

\[ \sum X_{HPi} + \sum X_{LPi} = TPROD \]

\[ \frac{X_{HPi}}{TPROD} \leq \left( \frac{DEMAND_{HPi}}{TDEMAND} \right)(1+TOL) \]
\[ \frac{X_{HPi}}{TPROD} \geq \left( \frac{DEMAND_{HPi}}{TDEMAND} \right)(1-TOL) \]

\[ \frac{X_{LPi}}{TPROD} \leq \left( \frac{DEMAND_{LPi}}{TDEMAND} \right)(1+TOL) \]
\[ \frac{X_{LPi}}{TPROD} \geq \left( \frac{DEMAND_{LPi}}{TDEMAND} \right)(1-TOL) \]
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Refined Strategic Planning Model Critique

Sales felt the results were very realistic and endorsed the use of the refined model by the Strategic Planning Committee.
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Strategic Planning Model Uses

Over a period of several years, the Strategic Planning Committee made widespread use of the refined linear programming model for evaluating various marketing and operating scenarios.
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Strategic Planning Model Uses

- The confidence of the committee in the accuracy of the model results grew with each analysis that was performed.
- The “fun” part was explaining any counter intuitive model results to the committee members.
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Second Heavy Products Mill Scenario

Sales, based on calculations done by Accounting, wanted to open an idled second heavy products mill.
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Second Heavy Products Mill Scenario:
Sales Rationale

- Unmet heavy products demand of 160,378 tons (LP model)
- Heavy products mill operating at maximum capacity
- Operate second heavy products mill between 500 and 1000 hours
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Second Heavy Products Mill Scenario:
Accounting Calculations
- Operate second heavy products mill for 500 hours
- Expect to produce 19,968 tons of heavy product 1 at $180 profit/ton = $3,594,240 profit
- Expect to produce 11,154 tons of heavy product 2 at $100 profit/ton = $1,115,400 profit
- Expect to produce 3,690 tons of heavy product 3 at $60 profit/ton = $221,400 profit
- About 34,800 total additional tons
- About $4.9 million total additional profit
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Second Heavy Products Mill Scenario:  
Linear Programming Model Results

- About 5,000 total additional tons
- About $577,000 total additional profit
- Operating hours on 1\textsuperscript{st} heavy products mill reduced from 1000 to only 580
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Why the discrepancy?
- Accounting calculations did not account for Sales “complete buildings” constraints!
- The second heavy products mill only increased heavy products capacity—no increase in light products capacity.
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Second Heavy Products Mill Conclusions:  
After reviewing the linear programming model results, the Strategic Planning Committee unanimously decided NOT to recommend reopening the second heavy products mill.
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Overall Conclusions:

A linear programming model was developed and used extensively to evaluate alternative operating and marketing scenarios.
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