ECE 100 Introduction to Engineering Design, Spring 2003

Project No. 1: Improving Inventory Management in Supply Chains

Sparky Computer (SC) Inc., a diversified, global computer manufacturer based in Tempe, Arizona, has realized that it can significantly increase its profit margins and customer satisfaction by improving its inventory managment system.

Upper management at SC is well aware of your team's expertise in engineering modeling and simulation and has hired your services to study its current inventory management practices (based on the use of EOQ-style approaches) and advise on improvements and modifications. In particular, Sparky Computer is opting to license technology from two PID control system vendors (IMC, Inc. and ACME®) and wishes to determine the following:

- whether the replacement of the existing EOQ policies with PID ones has merit,
- which one of the two PID control vendors offers the most suitable technology, and
- which specific product model within that vendor's suite of offerings represents the best buy.

To this end, SC's management is interested in receiving *demonstrated* answers to the following questions:

1. *How do standard EOQ policies (tested under conditions that involve both stochastic and deterministic demand variations) compare with PID-type decision policies?*
2. *How can the design and adjustable parameters in the PID decision policies (e.g., λ and initial net stock) be "tuned" to minimize total costs over 60 days while avoiding the "bullwhip effect"?*
3. *How can the PID policies be modified to take advantage of a 5-day ahead demand forecast? The forecast consists of anticipated knowledge (five days prior) of the deterministic demand.*
4. *How robust are the decision policies per item 3 to erroneous information? Specifically consider the effect of error in the demand forecast.*

A summary of the PID tuning rules offered by IMC, Inc. is presented in Table 1. These tuning rules require only knowledge of the order fulfillment time (θ) and possess an adjustable parameter (λ) that can be specified for good stability, performance, and robustness properties. The IMC PID policy evaluated in Modeling Assignment No. 3 (not shown in Table 1) can be referred to as the Platinum (Level One) policy. IMC, Inc. offers the Gold, Silver, and Bronze controllers at increasing discounts compared to the Platinum (Level One) controller, but charges a 10% premium to customers who select the Platinum (Level Two) controller. ACME® is a discount technology provider whose control policies (listed in Table 2) can be licensed at fees that are 25% cheaper on average to the equivalent controller offered by IMC, Inc. ACME®-brand controllers also require knowledge of the order fulfillment time but do not have any adjustable parameters.

$$u(t) = K_c e(t) + \frac{K_c}{\tau_I}\int_0^t e(t')dt' + K_c \tau_D \frac{de}{dt} - \tau_F \frac{du}{dt}$$

Model		K_c	τ_I	τ_D	τ_F
BRONZE	$\beta = \theta/2$	$\frac{2\lambda+\beta}{(\lambda+\beta)^2}$	$2\lambda + \beta$	-	-
SILVER (Level I)	$\tau = \theta/2$	$\frac{2\lambda+\tau}{\lambda^2}$	$2\lambda + \tau$	$\frac{2\lambda\tau}{2\lambda+\tau}$	-
SILVER (Level II)	$\beta = \theta/2$ $\tau = \theta/2$	$\frac{\beta+2\lambda+\tau}{(\beta+\lambda)^2}$	$\beta + 2\lambda + \tau$	$\frac{\tau(\beta+2\lambda)}{\beta+2\lambda+\tau}$	-
GOLD	$\beta = \theta/2$	$\frac{2(\beta+\lambda)}{2\beta^2+4\beta\lambda+\lambda^2}$	$2(\beta + \lambda)$	-	$\frac{\beta\lambda^2}{2\beta^2+4\beta\lambda+\lambda^2}$
PLATINUM (Level Two)	$\beta = \theta/2$	$\frac{2(\beta+\lambda)}{2\beta^2+\lambda^2}$	$2(\beta + \lambda)$	$\frac{2\beta\lambda}{\beta+\lambda}$	$\frac{\beta\lambda^2+4\beta^2\lambda}{2\beta^2+\lambda^2}$

Table 1: IMC, Inc. PID Controller Tuning Rules. θ represents the order fulfillment time. The IMC Platinum Level I policy corresponds to the one evaluated in Modeling Assignment No. 3.

$$u(t) = K_c e(t) + \frac{K_c}{\tau_I}\int_0^t e(t')dt' + K_c \tau_D \frac{de}{dt}$$

Model	K_c	τ_I	τ_D	τ_F
BRONZE	0.2	20	-	-
SILVER (Level I)	$0.9/\theta$	3.3θ	-	-
SILVER (Level II)	$0.67/\theta$	6.0θ	-	-
GOLD	$(10 + \theta)/100$	$10 + \theta$	$10\theta/(10 + \theta)$	-
PLATINUM	$1.2/\theta$	3.3θ	0.5θ	-

Table 2: ACME® PID Controller Tuning Rules

Some specific activities include (*this is not a comprehensive list*):

1. Evaluate demand variation (both stochastic and deterministic) in your EOQ models and assess how these changes affect the performance of the decision policy.

2. Recommend systematic procedures for determining and visualizing optimal operating conditions in the PID inventory management policies.

3. Modify the PID-based policies to use take advantage of a five day ahead demand forecast. Simulate and evaluate what occurs when the modified policy is subject to 1) combined stochastic and deterministic demand changes and 2) forecast errors of various magnitudes. Compare this to a feedforward-only decision policy.

4. Search the literature to learn of ways to avoid the bullwhip effect, alternate control strategies that can be used to enhance the existing PID policies, etc.

You can use the various Excel spreadsheets that you developed for Modeling Assignments 2 and 3 to meet the requirements of the project. Additionally, the Graphical Policy Display Mark 1 simulator developed by Mike Pew and Dr. Rivera will be available to assist you in completing the project.

As with previous assignments, this project includes both individual and group responsibilities. As an individual, you must:

1. Evaluate the EOQ policy that was assigned to you in Modeling Assignment No. 2,

2. Evaluate two PID control policies, one from IMC, Inc. and one from ACME®.

If you have a team composed of three members, you may choose to ignore one level (e.g., bronze). As a team,

1. Work together to brainstorm the problem and its solution(s). I would suggest using the IMC Platinum (Level 1) policy as a common basis for testing and evaluating strategies.

2. Collectively discuss your observations, findings and conclusions to come up with a final recommendation to SC, Inc. management.

Project Deliverables.

Project deliverables include a final report (with one individual and one team component), a team presentation, and the corresponding Excel worksheets that were developed to come up with your findings. Each team member is responsible for submitting an individual report documenting the evaluation and results of the EOQ and PID decision policies assigned to him/her. *Reports are due at the beginning of class on Thursday, April 3.* Each report should be written in a concise, clear, and convincing manner according to the following general format:

- A one-page (maximum) *executive summary* with emphasis on main results, conclusions and recommendations,

- A brief *introduction* that states the purpose of the modeling exercise,

- A well-organized *discussion* section describing, interpreting, and comparing the results of the modeling and analysis exercise. This section should include the most relevant figures and tables (do not relegate all of these to the appendix).

- A *summary statement of conclusions and recommendations* that may be drawn from your results.

- A *bibliography* listing all references and resources used in the development of the analysis/design and the report (there should be at least two entries in this section),

- An *appendix* containing a team member *accountability statement* and any relevant project information not included in the body of the report.

Students are welcome to use the more formal technical report format described in Volland, Section 1.5.2 (pages 14-16). The guidelines described by Volland in Section 1.5.1. (pages 11-14) should be adhered to. The main body of the report (i.e., all sections excluding the executive summary and the appendix) should not exceed seven double-spaced pages (use 12 pt type or larger). Prudently use tables and resizing of figures to stay within this page requirement. You can go beyond the page limit to describe "wow" (extra credit) items, but please keep your discussion of these reasonable.

The *group* report consists of an executive summary (of no more than three pages, double-spaced) that presents an overall summary of conclusions and recommendations to SC management. The group report should be accompanied with a cover letter (addressed to Daniel E. Rivera, Ph.D., President and CEO of SC, Inc.) as shown in Volland, page 17. *Please note that I, the instructor, will read and grade all individual and group reports.*

Please avoid detailed descriptions of the tasks carried out in the project in favor of interpretation, analysis, and discussion of results. Pay attention to good grammar and readability of your report (the easier you make it for me to read your report, the better your chances for a good grade). Please avoid the following in your report:

1. first-person references (e.g., "I did this or that"),

2. figures or tables with no captions,

3. contractions (e.g. "can't", "won't")

4. statements such as "this is intuitively obvious," etc.

In addition to the written report, each team will be required to make a 10 minute (maximum) presentation on Tuesday, April 8, summarizing and demonstrating the project results to the class. The participation of *all* team members in the presentation will be required. Additional details on the presentation will be discussed during the March 27 class session. A team process check/evaluation will also be performed as part of the design project.

Students will earn points for the project based on the quality of the following: 1) technical content 2) discussion and interpretation of results 3) organization and report quality and Excel spreadsheet quality. The total number of points for all components of this project will correspond to 245 points (24.5% of your final course grade) The point breakdown is described in more detail in the course presentation corresponding to the design project overview.