

## Company Goal: Increase Productivity?

By Phil B Brubaker

### For CEOs of Technical Firms

We will introduce Calculus-based software for Engineers and Scientists to use in their Problem-Solving efforts. Such software has been shown to increase productivity by as much as 20 times. At the same time, we will try to increase the problem size from one unit to many units being solved; see Think-Outside-The-Box.

This book is for CEOs and should be coupled with “[Engineering Design Optimization using Calculus Level Methods: A Casebook Approach](#)” textbook. Once you are convinced, or at least want to find out more, we recommend that a dozen or so of your Engineers & Scientists, read the Engineering Design Optimization textbook and try the [FC-Compiler](#) software. Then get their opinions on whether they think the Compiler software would improve future solutions to in-house problems and help meet company goal (e.g. maximize Profit!). These employees should come from diverse parts of your Company so Problem-Solving capabilities will be well tested for your future teams.

Things we want you to learn from reading this textbook:

- What is your Company’s Goal/Objective?
- How to increase Engineering productivity by many orders of magnitude?
- Accelerate Math Model Understanding
- Think Outside-The-Box

Let’s begin with ‘How to build a Team to build an Optimal Solution for a given project?’ The project may be a simple Rubber Band Gun design to a complicated Military Fighter Jet design. The first step is setting your Company’s goal/objective. There are two example problems included in this book that will help illustrate a problem and it’s solutions.

‘How to increase Engineering productivity’ is achieved by using the FC-Compiler software. The 2 examples below will help one ‘see’ the benefits. Application 8.2 requires a Calculus-level language to solve it. The nesting of ‘find’ statements is a difficult task to be achieved.

‘Accelerate Math Model Understanding’ comes from being able to modify a projects program, execute it, and see the new results in minutes. For example, let’s say one needs to change a ‘234’ to ‘321’ in their code. In minutes, one would see the affects from the change. In today’s computer coding, a change request is often sent to the programming department. It can take a few days or a year or two to due. By the time a requested change is completed, the person requesting the change may have forgot all about it OR left the company.

This textbook tries to move today’s thinking from solving one problem at a time, to solving all of a project’s problems at once in order to achieve an optimum solution. This requires Calculus-level thinking. An analogy might be thinking in terms of Machine code, one bit at a time. Today, computer simulations have people thinking in terms of Algebraic code, one problem at a time. We are trying to move people to Calculus-level code, solving entire projects at a time. This will reduce development time and improve accuracy of their math models.

## Preface

Those that read and follow through on the concepts mentioned in this textbook, should find answers to the following:

- What is your Company's Goal/Objective?
- How to increase Engineering productivity by many orders of magnitude?
- Accelerate Math Model Understanding
- Think Outside-The-Box

This textbook should be used in conjunction with CEO: what's your Company Goal?. This textbook is for CEOs of technical firms. It includes success story examples, problem-solving applications, and other illustrations.

The 'Accelerate Math Model Understanding' is very important to one's future. Very important! It has to do with making a change and seeing the affect of the change in minutes. This can give Engineers & Scientists a good feeling for how well their math model is modeling the desired phenomenon.

This textbook tries to move today's thinking from solving one problem at a time, to solving all of their project's problems at once in order to achieve an optimum solution. This requires Calculus-level thinking. An analogy might be thinking in terms of Machine code, one bit at a time. Today, computer simulations have people thinking in terms of Algebraic code, one problem at a time. We are trying to move people to Calculus-level code, solving entire projects at a time. This will reduce development time and improve accuracy of their math models.

## Features that link concepts to the real world

### New Technologies:

- The calculus-based computer language, FortranCalculus, for PC usage is now available for Windows. (With or without software, students who learn the objective-driven solution methodology will increase productivity from their increased understanding, even if their solution is incorrect.) A calculus-based language requires an objective function as well as a math model to determine an optimal solution.

### Features:

- Clear Problem Definition
- **Accelerates Problem "Understanding"** ... Key feature ... in minutes, change one's program, run it, and see how changes effect solution!
- Decouples Models from Algorithms ... i.e., removes "noise" from the picture

## About

### Author: Phil B Brubaker Biography

Phil has been involved in industrial training on math modeling & optimization problems for over 30 years.

Co-authored 'Arbitrary Equalization with Simple LC Structures', IEEE Transaction on Magnetics, Vol. Mag-17, No. 6, Nov. 1981, pp. 3346-3348.

#### Abstract:

Intro to *Objective-driven Management*: Assume you're a dept. manager for the XYZ project, what would be your depts. goal/objective? How would you guide your dept. to meet its goal? Thinking green? Most presidents today may have goals but those goals are only known by a few people. How can your chief bottle washer help if he/she has no idea what your goal is? A company must work as a team in order to maximize their success. There will be several optimization examples to help tomorrow's leaders start thinking optimization.

#### Personal Accomplishments:

- Reducing circuit development time from 12 weeks to less than 1 week was another increased productivity example at Memorex Corp. Plus the solution was optimal. This circuit was called a Matched Filter where minimizing inter-symbol interference (ISI) was the goal. This was accomplished by using the Calculus-level Problem-Solving computer language, Prose.
- Increased productivity resulting from optimizing a software program that required 20 to 30 days per execution to less than 10 hours at Lockheed Missiles & Space Co. Received Presidents award. Saved Lockheed \$10 Million!



## Introduction to Calculus-level Programming

A 'find' statement is the work horse of a Calculus language. It is used in parameter estimation, boundary value problems, implicit equation problems, inverse problems, etc.. The find statement's solver varies parameters in ones model until the stated goal is achieved. The partial derivatives necessary for a solver are calculated using 'automatic differentiation' (AD) and thus are as exact as one's computer.

Models must be continuously differentiable for AD to work right and calculate the right step size for the next parameter values.

### Success Stories

The Aertech Industry of Sunnyvale, CA were developing black boxes that required a customized thermistor. A in-house technicians could use up to two weeks to solve for the right thermistors to build each customized thermistor. If the technicians ran out of time, the problem was given to an Engineer. The Engineer had 2 hours to solve such a problem. If they couldn't solve it either, the black box was half dismantled and reassembled with new parts. Now, the problem starts over with the technicians. When they learned about Calculus-based computer language, a software program was written to solve these thermistor problems. The problems were solved in minutes and saved up to two weeks on worst case problems.

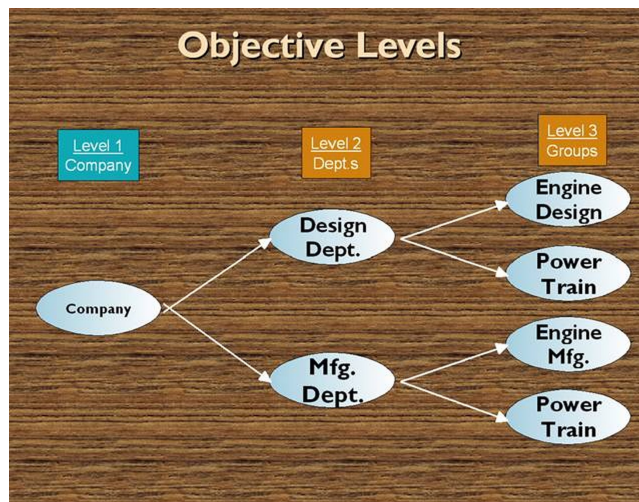
The Watkins-Johnson Co. of Palo Alto, CA were working on a government proposal to build a black box that would solve 10 specific things. 9 things were solved with their present design when they ran into a snag. After working on the problem for over a month, the Engineer in charge learned about PROSE. PROSE is a Calculus-based computer language. In one week, he learned the language, wrote a program, and solved the problem. Watkins-Johnson won the government bid! (Solving this problem, convinced them that they MUST redesign their black box in order to remove this snag problem. PROSE improved their understand of their black box.)

The Memorex Corp. of Santa Clara, CA was developing 14” Disc Drives that required a 3-month testing cycle for each new Read-Write circuit. A PROSE software program was written that found the optimal circuit design. This software dropped the building & testing time from 12 weeks to less than 1 week. (See Application 2.1 for more on the problem & solution.)

## What is your Company's Objective?

Most companies should have several levels of objectives as shown in the chart below. All Company level objectives must be known by all employees and clearly stated in order to achieve all goals/objectives. For example, a person sweeping the floor might change from a left-to-right movement to a right-to-left movement if they knew that some objective might be improved upon by such a change in their work. Get the word out, "Our company's goal is ooo".

Keep it simple, like a slogan, and easy to remember. Limit your Company level objective to one or two key words; i.e. maximize **profit** while minimizing **pollution**. The more confining the objective, the less freedom for creative solutions.



In the 1970s, a VIP at Memorex was asked, what is the company goal for the disc drive manufacturing industry. He replied 'minimize cost'. In this world of computers, minimize cost would be equivalent to minimize cost regardless of profit, quality, sales, etc. On the other hand, maximize profit as a goal/objective would minimize cost whenever possible and does NOT affect profit. Sales, quality, etc. would be affected ONLY IF they did not reduce profit. When explained this way, the VIP changed to 'maximize profit' as our goal. Pick your goal/objectives carefully! Get input from everyone to be sure you didn't overlook some important affect of your goal.

## What is *Your* Objective(s)?

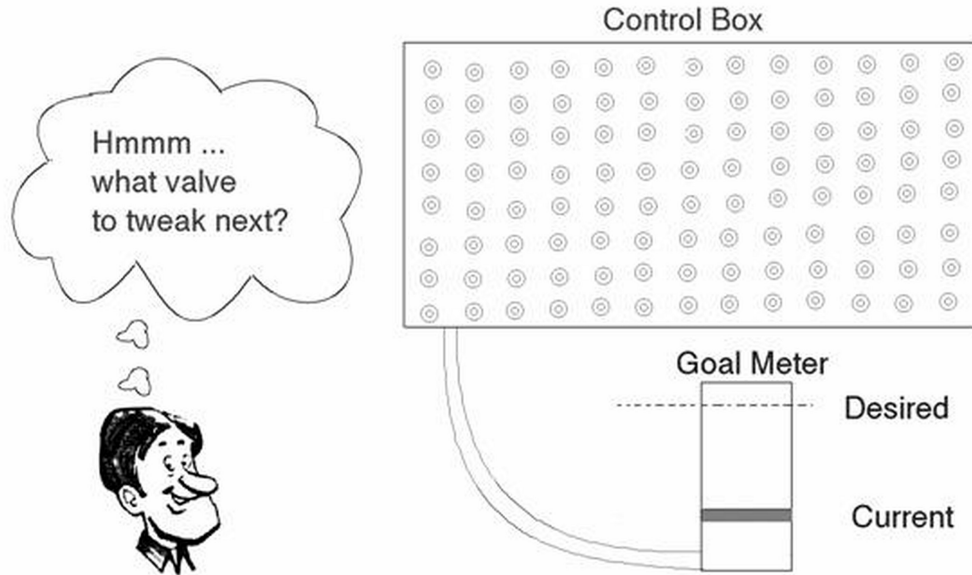
**Minimize cost**  
**Maximize Profit**  
**Minimize Pollution**  
**Maximize Productivity**  
**Minimize Weight of Products**  
**Maximize Green Energy Usage**  
**Minimize Customer Complaints**

**All The Above!**

## Application Problem 1.7

## Paper Bicycle Design

What's your present project's goal/objective?



Are you sure? Why?

What is the ideal or desired objective/goal? Are you sure? Why?

A class in Mechanical Engineering at Stanford University requires its students to design a “Paper” Bicycle. A student’s grade is dependent on their bicycles lap times, total weight, and a penalty when their non-paper parts weight is more than 10% of their total weight. The lower the score the better for ones grade!

A class is divided into small teams of 3 to 5 people. Each individual team gets together over a 2 week period to come up with their entry into the race. Imagine what they discuss, especially on their first meeting. They don’t know each other, so the first topic is probable, who will be their leader? After the race, each team gave a class presentation on building their “paper” bicycle. The two years when I was their as a coach, only one team mentioned their goal. They won their race! This is an example of what is called *Objective-Driven Engineering*. The other teams never had a real goal, and thus lacked direction in their design.

What would be the design objective given each 3 member team has (a time constraint of) 2 weeks to build a team, design, test, and race their “paper” bicycle?

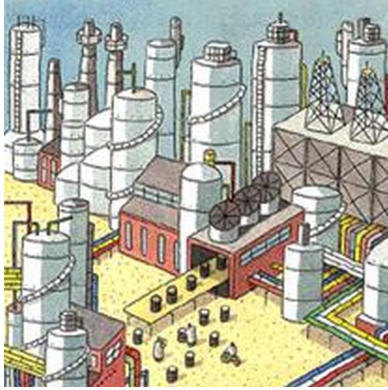
1. Minimize the design weight;
2. Maximize each individual's class grade;
3. Minimize the total lap times, i.e., win the race!
4. Minimize cost of design project;
5. Minimize time required for design
6. \_\_\_\_\_



## Application Problem 8.2

### Oil Refinery Production

#### Problem Description



An oil company may have many different distillation processes going on at each of its refineries at the same time. Each time new crude oil arrives at a refinery, or one distillation unit goes in or out of service, a new tweaking of all distillation parameters must be done in order to maximize the company's profit.

Here we will assume that the company has 'nDistUnits' at each refinery and 'nRefineries' for total number of refineries. The real issue will be agreeing on the company objective. Here we will use maximize profit while minimizing pollution.

**Marketing effects:** pollution is mainly seen as a cost item but it does not provide some profit to a company who's marketing group properly advertises the product as a 'green' product or has no detrimental chemicals in it. Check with your marketing group to create a math model showing some profit from products that have minimized pollution and add that model to this OilProduction program.

A monitor of present in stock inventories would be helpful for instant updating of ones model as used here.

**Refinery Buy/Sell Options:** Once one runs this OilProduction program a few times and is confident in its results, it would be time to start using it to play 'what if' games. For example, what if another 'B' refinery was up for sale and your company was trying to decide whether to buy it. Say this 'B' refinery is the same relative size with the same number of distillation units as your 'A' refinery, just a different location. Change your refinery 'A' location in this program and re-run it. The resulting increase or decrease in 'profit' will help your company decide to reject 'B' refinery or make an offer. Changing a refineries location will affect the distribution cost of your products. A new location might have a better grade of crude oil; another variable to test and see if the new value is worth it from a computer simulation view point.

Another use of this program would be deciding which refinery should get a new distillation unit first. Every one wants to have the latest gadgets in their backyard to show off but these can be very very expensive. So use this program to add a new unit to each refinery one at a time. This should give you some evidence to which site to start implementing new distillation units.

#### Computer Code

Our objective in the first level (or outer) find statement is to determine how much of the various products to produce at various refineries in order to maximize the companies profit.

**FIND totProdPrct IN refineries BY JUPITER  
MATCHING productErr TO MAXIMIZE profit**

The goal of this 2<sup>nd</sup> level find statement is to determine product quantities to manufacture at each refinery and minimize pollution in the process. Limits are added to insure that the quantities are above some set values and below other values. Setting the upper limit to the lower limit will stop production of that one product; e.g. low(3) equals hi(3) then product(3) will be zero. There is another constraint that needs to be added to the find statement here. The total crude oil processed at each refinery must equal the total crude oil available; no more, no less. 'Matching crudeErr' addition to this 2<sup>nd</sup> 'find' statement will ensure the variable 'crudeErr' is (near) zero.



**FIND qtyIn IN distillation BY JOVE;  
with UPPER hi and LOWER low  
MATCHING crudeErr TO MINIMIZE pollution**

The following is just a rough sketch of necessary code to solve such a problem. Calculating the cost of manufacturing and distribution, pollution, profits of each product, etc. are left to the user. Each of these variables may require a math model of their own and knowledgeable people to be accurate enough for this OilProduction program.

ooo

! find product percentages for all Refineries in order to maximize profit.

**find** totProdPrct in refineries by jupiter  
matching errsum to maximize profit

ooo

! finds qty production @ each refinery to minimize overall pollution

**find** sameProd in processing by Jove  
with upper hi and lower low  
matching crudeErr to minimize pollution

This example shows nesting of find statements that will help maximize productivity. Getting agreement on what a company's objective is or should be may take some time. It is hoped that this example will aid you on solving your problem with Calculus-level programming. Solve not just one equation but your entire problem/project in one program.

### Influential Parameters

Grade of crude oil, air quality, types of distillation units available, number of distillation units available, etc. at each refinery are important parameters that will be necessary for this program to find the optimum solution for each day it is executed. These parameters need to be included in one's math model. Such parameters (and their derivatives) will aid the built-in solvers in finding the amounts, locations, & distillation units at each refinery in order to maximize company's profit.

### Findings

A computer simulation may look good on paper but implementing the method may be a problem. In the 1960s or 70s, the Chevron refinery at Richmond, CA implemented a computerized monitoring system at each of their control rooms. It was found that the average employee started their eight hour shift by tweaking their controls to settings that they new were safe. For the rest of their shift they read books or did other things of self interest. Then the computer monitor was turned on along with the plant manager telling these controllers that they could earn gold or silver or red stars as rewards for doing a good job of improving oil production. The computer monitors would 'watch' their tweaking. If they went into an unsafe zone for any control, it would stop them. After a few weeks most controllers were tweaking their controls to maximize some oil production and thus were receiving some gold/silver/red stars.



This program built in-house competition that resulted in a huge increase in productivity. (I don't know prices of the 1960s or 70s. Let's use today's prices for this example.) Say that crude oil cost \$50 / barrel and after refinement, sold for \$100 / barrel. One element in the refining process was Black Gold. Say it



increased one once per barrel. Today, Gold is selling for above \$1,100 per ounce. Thus, this competition with computer monitoring, yielded a \$1,000 / barrel interest in profit; a ten fold increase!

We are not talking peanuts here. With the computer program discussed here, a ten fold increase would be a good increase on a bad day. Is your company going to be first or one of your competitors? Get a year or two head start on you competitors and it may be impossible for them to catch you.

### **Estimate Necessary Increase of Black Gold**

What increase in Black Gold production is necessary to justify a program that tweaks oil production parameters? You do the math. Here are some parameters to get an estimate:

P = Desired profit increase (in dollars) per day at a refinery

B = Number of barrels processed per day at a refinery

G = One ounce of Gold price today (\$ estimate, e.g. \$1,000)

Pg = Present Gold production per barrel of oil

Y = Yeild of Gold increase per barrel

Yp = Percent Yeild of Gold increase per barrel

$$Y = (P / B) / G \text{ (in ounces)}$$

$$Yp = (Y / Pg) * 100 \text{ (in percent)}$$

If Yp is less than 10%, you should implement a parameter tweaking program; otherwise, more calculations may be necessary to answer this question. Re-check your parameter values and calculations to insure your answers. A 1 to 10% increase in oil production profit could amount to a nice sum.

### **Future**

To implement such a software program, consider doing it in phases. As soon as one or more distillation units have a good math model, execute optimizing these units with an objective of Maximize BlackGold. This is simpler than Maximizing Profit where many things like inventory, cost of doing business, etc. must be defined in the computer code.

Execute these Maximize BlackGold programs until all distillation units have good math models. This may require a man year or more of time. During this time, have someone developing code to show expenses of refining crude to final products.

Next, execute entire refineries at various locations with Maximize BlackGold objective. Monitor increase in productivity.

Next to last, start small and try to Maximize Profit with a few refineries. This may take a few months.

Last, send me some of the resulting increase in profits! ☺

Keeping your distillation (math) models updated is essential. Each refinery must routinely verify that the models are correct for their refinery. Here is where you will spend most of your time for keeping this type program valid.

*Marketing:* increase your company sales by telling your marketing department that your refineries minimize pollution. They could put some comments in their ads that would result in increase sales by 5 to 10%.

### **College Training?**

Did or due colleges teach about Black Gold processing from crude oil? If not, how will future employees know about extracting Gold? Will Black Gold be in their math models? If Black Gold is not in ones math model, this would put them right back in the 1950s thinking! Somehow college professors need to be informed about Black Gold processing from crude oil.

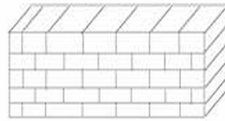
## 10.1 Future: Thinking Outside The Box

### One's Vision



Mr. Arithmetic

*Before Computers*



Mr. Algebra

*With Computer,  
Gained some vision*



Mr. Calculus

*Optimize the Whole  
Show in One Run*

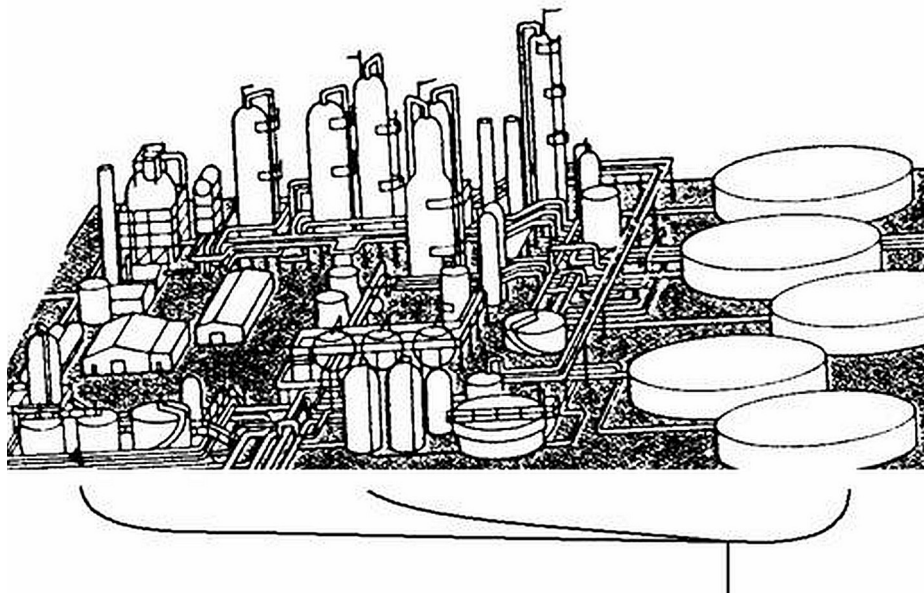
### Process Methodology:

One Step at a Time

Simulate Problem on  
Computer

Find Optimal Solution.  
Must 'See' Entire  
Problem & Objectives

Today, most individuals are working on getting their math model to provide an accurate description of one component of a project. We would suggest moving past that and on to considering all components of a project or site or company. For example, those working at an oil refinery, they may be modeling one distillation unit. Why not consider modeling the whole refinery? This is now possible with a Calculus-level compiler. Finding the right objective may be an issue for total project simulation. This may require input from engineers to president of company.



Where are you going?

## Conclusions

We hope you have answers and some understanding of their importance to:

- What is your Company's Goal/Objective?
- How to increase Engineering productivity by many orders of magnitude?

And some understanding of

- Accelerate Math Model *Understanding*; and,
- Think Outside-The-Box.

Please be sure to have your Engineers & Scientists test the Calculus-level software, [FortranCalculus](#). Hear is where you will see the gains in productivity.

Consider giving a copy of ' [Engineering Design Optimization using Calculus Level Methods: A Casebook Approach](#) ' textbook to a Professor or two at colleges where you constantly hire graduates from. Let the colleges do the future training.

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PS: **Guest [Speaker](#)**. To get help in the future, click [here](#) or ask for it on the [donationcoder.com/forum/](#) . It's called retirement! Hope others will learn and use this Calculus-level programming language. It's a great math tool. Enjoy ☺