Technical Due Diligence, Errors & Uncertainty©

James F. Wright, Ph.D.

January 20, 2001

(Rev: October 15, 2002)

***A new Book has been written by Dr. Wright and has been published by AMACOM (The Publishing arm of the American Management Association). The title is "Monte Carlo Risk Analysis and Due Diligence of New Business Ventures" and it is sold worldwide through major Book Sellers for US$99.95. More information can be found on my web site* (http://www.drjfwright.com/book.html)**

The purpose of this paper is to serve as a brief "**how-to guide**" for accomplishing *Technical Due Diligence*. The term *Technical Due Diligence* may seem mystical to many that are unfamiliar with the term *due diligence* - and/or the complex technologies that may be involved in their projects. The very nature of these *Technical Projects* increases their risk over that commonly seen in more traditional commerce. In order to help compensate for this increased risk, Technical Due Diligence should address whether a Technical Project will accomplish both its technical and economic goals. This is accomplished by not only providing a complete pro forma describing how the technology will be used in the business venture, but also including a quantitative measure of the pro forma's precision and accuracy.

Table of Contents

I. Introduction

In general, the process of *due diligence* has been used for many years to help determine whether or not a project either will accomplish, or has accomplished, specific predetermined goals. The process has historically been used to evaluate many types of scenarios and projects. These projects range from evaluating the economic viability (profitability) of proposed business ventures to determining the economic, regulatory or technical success of existing business and governmental projects (Quality Audit). The purpose of this paper is to briefly describe how Technical Due Diligence can be used to evaluate the economic viability of proposed risky business ventures. It should also be easy to visualize

All Right Reserved by James F. Wright, PhD

how to similarly apply this process to Quality Audits.

Consider the following three *due diligence* efforts on the same proposed technical business project. In each case the Business Plan appears to be thorough and the pro forma predicts the Present Value of the total profit after 3 years to be $3.4 million. This profit is 4 times the original capital investment for the project. The results of the three due diligence efforts (labeled A, B, and C) are identical except as noted below.

A. No quantitative uncertainty in the results is provided.
B. The report states that the uncertainty in the total profit of $3.4 million after 3 years is calculated to be $250,000.
C. The report states that the uncertainty in the total profit of $3.4 million after 3 years is calculated to be $1.5 million.

A quick evaluation of the final reports for these three efforts reveals the following. Report A is the least desirable of the three because it contains <u>no</u> measure of how much confidence the author has in the pro forma (i.e., no reported uncertainty in the profit!). Obviously, Report B provides the *most desirable* result (according to the author of the report) because of its relatively small uncertainty. Since Report B quotes a quantitative amount of uncertainty, it should also discuss how this uncertainty was determined. If the methodology is credible, this will truly be the *most desirable* result. Report C is also a good report because the reader at least knows how much confidence the author has in the calculated profit because of the reported uncertainty. The report would have to be closely read in order to determine the cause of this large uncertainty. This may simply be a reflection of the fact that the results are just preliminary.

It has been *historically required* to perform due diligence on all new business ventures that require additional capital or investment. It is *especially prudent* (at a minimum!) to perform due diligence on new business ventures, plants or processes that rely on the commercial application of <u>any</u> technologies. However, I believe that it is *imperative* to perform due diligence on all new plants or processes that utilize either *new* or *emerging* technologies. I call these ventures *Technical Projects* and their evaluation process *Technical Due Diligence*. In practical terms, Technical Due Diligence is simply a methodology to determine whether or not a Technical Project will accomplish the <u>technical and economic goal(s)</u> set forth in its business plan. It is important to realize that a technology may be "interesting" and "actually work" but it may *never* have the required <u>value and utility</u> so that it can be sold to customers in a manner that will create a profitable venture!

Further, this Technical Due Diligence process should always provide, at a minimum, *quantifiable and significant measures of the accuracy and precision of the results*! The eight Steps shown in Table 1 on the next page briefly describe the Technical Due Diligence process.

I have named the processes defined by the first five Steps in Table 1 *Technical Systems Analysis* and the last three Steps *Technical Risk Analysis*. Technical System Analysis is accomplished by <u>combining both technical and financial</u> investigative and analytical processes. In fact, this information should already exist in a Business Plan that truly de-

All Right Reserved by James F. Wright, PhD

Table 1 – The Steps of Technical Due Diligence

1	Determine if the technologies used in the Technical Project are valid and if their market as described in the business plan truly exist
2	Determine the validity of the proposed operational process to be used in the context of the business plan
3	Determine the status of relevant technologies used by existing and potential competition
4	Determine marketing and sales methods to be used to gain market penetration required by business plan
5	Determine pertinent legal issues (ownership of technologies, facilities, marketing aids, permits, etc.)
6	Create an operational model
7	Create a pro forma (the *scenario*)
8	Evaluate the *consequences of the scenario*

fines how the technology will be used as a basis for a profitable venture. However, it has been my experience that the business plan seldom contains all of the information required for a thorough Technical Systems Analysis.

If one recalls that *risk analysis* can be defined as first defining a scenario and then evaluating the consequences of the scenario you can see that the Technical Systems Analysis process gathers the information that will be required to define our scenario. Steps 6 and 7 of Table 1 require that estimations and future pro forma be developed (from the information gathered in the Technical Systems Analysis) in order to define a complete operational scenario for the project. Step 8 requires that the consequences of the scenario defined by the total process be determined. These last three Steps of Table 1 are the Technical Risk Analysis processes. This entire process will quantify the *uncertainty* in the Technical Project. This quantification is very important as it helps provide very important information for the investor(s) to use in their final evaluation of the proposed investment. I use Monte Carlo simulation with my Gaussangular™ distribution functions to provide the quantitative basis for my Technical Risk Analysis. On October 11, 2002, I applied for a US Patent to cover the methodology of Monte Carlo risk analysis of business scenarios used in Technical Due Diligence. One embodiment of this invention is presented in the software package MCGRA™ that the author uses to perform Monte Carlo Risk Analysis of business scenarios and ventures.

In cases where either a Business Plan does not exist, or it is simply inadequate, this Technical Due Diligence process will automatically develop new projections that are based on the results of the "investigations and analyses" presented in Steps 1 through 5 of Table 1. During this entire process, the adage of "garbage in – garbage out" is applicable in the sense that the first five Steps of Table 1 can be thought of as "input" and the last three as "output". It then follows that the most accurate and precise estimations and projections will come from the most accurate and precise input obtained in Steps 1 through 5. And therefore, the most valuable Technical Due Diligence product will come from the most accurate and precise estimations and projections from Steps 6 though 8.

Since the Technical Due Diligence process

All Right Reserved by James F. Wright, PhD
email: drjfw@drjfwright.com

can be very complex it sometimes requires expertise that usually can be found only on a *team* of highly qualified professionals. A Project Manager should always lead the Technical Due Diligence process. Depending on the size, estimated risk, location and complexity of the Technical Project being evaluated, the team may be expanded to include Lawyers, Certified Public Accountants, Marketing Experts, Scientists, Engineers, Writers, and Foreign Language Translators. Each would have different responsibilities and would be assigned specific tasks by the Project Manager.

It must be emphasized that the overall purpose of Technical Due Diligence is to use cost-effective methods to provide management with sufficient information to make a knowledgeable business decision.

II. Technical Due Diligence

In this discussion I have once again taken the liberty to arbitrarily divide the Technical Due Diligence process in to Technical Systems Analysis and Technical Risk Analysis.

A. Technical Systems Analysis

The heart of the **TSA** (Technical Systems Analysis) process starts with Steps 1 through 3 of Table 1. The first actual task in any **TSA** effort is to make sure that a precise definition of the proposed Technical Project can be made and exists. I call this precise definition the *Technical Scope of the Project* and its importance cannot be overestimated. This Technical Scope should briefly define how the technology is to be used to profitably produce the product or service to be sold to the target market and why the target market will purchase the product or service as priced in the business plan. More than a few ventures have failed in the past because they tried to sell “slick” new products to a target market that weren’t needed (the technology lacks utility), or were overpriced (the technology lacks value), or both.

The next step in the **TSA** process is to isolate and examine the “technologies” from the Technical Scope and verify that they will work in the new plant or process as advertised in the business plan. This usually requires a complex calculus of physics, chemistry, engineering, marketing, and finance. Will more R&D be required and at what cost? Can a plant be constructed that will produce the amount of product or services at the price required by the business plan? These are complex and difficult questions that are usually answered by first breaking the technologies into smaller “key” components that can more easily be evaluated. Next, it must be determined if these smaller “key” components will likely function in concert such that the entire “technical system” should perform as advertised. One of the principle goals of the **TSA** is to ensure that the technical process, first and foremost, obeys all of the known laws of science and that no unforeseen problems are caused as the technology is scaled to the final size required by the business plan. Oddly enough, a significant number of projects are terminated every year, and sometimes after significant cost, because they involved a variation of the infamous perpetual motion machine.

After it is determined that the technology will likely work in the new plant or process, a review should be made of existing and potentially competing technologies. This review should also include other competitive factors such as relative operating costs and the potential for competitors selling their product at a loss in order to protect their market share. Product market cycles are very important since they tend to become significantly compressed by desperate competitors when a new technology is introduced.

Special care should be given as to how the venture plans to penetrate the existing markets with this new or emerging technology. Experience says that many good projects are driven out of business because they did not have the cash required to live through the product introduction phase of the business plan.

Lastly, potential legal hurdles need to be addressed. This is especially true for Technical Projects and is becoming more important to all types of businesses as they operate in different countries around the world where each may have different laws that apply to the new venture.

B. Technical Risk Analysis

The purpose of the **TRA** (Technical Risk Analysis) is to define different business scenarios so that a Consequence, or Risk, Analysis can be performed on each. In the end, only a "best scenario" is usually presented for the investors.

Most risk in Technical Projects is due to added capital requirements and/or development costs of the technology to be used. In general, an increase in technical complexity doubles the increase in risk that might be expected from the technology alone. An increase in technical complexity not only increases risk due to the uncertainties in the technology, but also increases risk due to these aforementioned increased costs. Almost without exception, increases in capital costs due to increases in technology must be recovered through higher profits at the end of the process, and not through lower project construction costs. And if the product market cycles become too compressed then the second or third generation products must pay for the technology. All of this of course, gives some credibility to the KISS (Keep It Simple Stupid!) principle.

In addition, most companies view an equivalent amount of risk differently. This is due to the fact that a $100,000 capital risk is quite different to a company with $1 million/year in annual sales than it is to a company with $1 billion/year in sales.

The first step in the **TRA** is to combine the results from the **TSA** (Steps 1 through 3 of Table 1) with information obtained from addressing Steps 4 and 5 of Table 1. At this point, different operational scenarios are developed (Step 6) and pro forma prepared (Step 7). The best pro forma is selected and a Consequence Analysis is performed (Step 8). This is the final step of the **TRA**.

I use Monte Carlo Simulation techniques to "evaluate the consequences of the scenario." This process utilizes my previously mentioned Gaussangular distribution function to

All Right Reserved by James F. Wright, PhD
email: drjfw@drjfwright.com

calculate a metric commonly used by the investors. This metric can be discounted cash flow, or the profitability index or some other Risk-Based Investment Factor (**RBIF**). This **RBIF** is also selected by the Investor (or other person performing the Technical Due Diligence) for each particular project. The end result of the Monte Carlo Simulation of the metric is to provide the Investor with several unique pieces of information that are summarized below.

1. The average value of the metric.
2. The most likely value of the metric.
3. The uncertainty, in the form of an unsymmetrical standard deviation of the most likely value of the metric.
4. The probability that the metric will have a certain value (for example the investor's threshold) after a specific number of years.

In business, the goal of a **TRA** is to determine the chances that a particular Technical Project will be profitable. In other words, it should answer the following types of questions.

1. What is the probability that a new plant utilizing this new technical proprietary process will become profitable within a certain time frame?
2. What is the reward to risk ratio of this venture?
3. What is the uncertainty of the final pro forma?

Due diligence on government projects is similar except that profitability is not the key issue. The **TRA** for government projects should ask the following types of questions.

1. What is the probability that the project will meet the intended political goals?
2. What is the probability that the project can fit within the planned budget?
3. What are the key issues that would make the project over budget?
4. What is the uncertainty of the final pro forma?

III. The Due Diligence Team

As with all complex projects, one of the key ingredients for success is having the right personnel involved in each task.

The very first step of Technical Due Diligence is to hire a **PM** (Project Manager)! For a small project (without much risk) the **PM** may actually perform most of the work. For a large project (with significant risk) the **PM** is the key manager and driving force for the Technical Due Diligence effort. The **PM** should be a well-rounded professional with an experience base that is broad enough to cover the attributes listed below.

1. Be focused!
2. Have good presentation skills with skills to help sell the project to investors, if required.
3. Have good organization, people, and management skills.
4. Be familiar with the Technology involved in the project.
5. Be familiar with the technology used by the present and potential competition.
6. Be familiar with marketing and sales methodologies.
7. Be familiar with potential legal problems and their implications.
8. Be familiar with pro forma.

All Right Reserved by James F. Wright, PhD email: drjfw@drjfwright.com

9. Be familiar with statistics and risk analysis techniques

The first job a **PM** should perform is to prepare the Technical Scope of the Project and have it approved by senior management. If the size of the project warrants, the **PM** should next develop a Gantt Chart (or other planning chart) for the Technical Due Diligence Process. At this point the **PM** should also develop a list of professionals that will perform the different tasks in Table 1 and start the process.

Table 2 summarizes a possible range of requirements for the personnel that could be used to perform the Technical Due Diligence in each of the Steps shown in Table 1.

It is important to remember that as the project risk increases, the requirements for the experts hired to perform the Technical Due Diligence become more stringent. This is due to the fact that the infamous "**people that care**" (investors, bankers, Boards of Directors, shareholders, etc.) believe that resumes and experience are more important than actual capabilities. In other words, if you hired a BS engineer to perform a certain task you may be wasting your money! The infamous "**people that care**" will most likely not want to spend time trying to determine if this BS engineer is capable or not and therefore, they won't put their faith in his results ("their faith" really means "their confidence and money"!). Therefore, "heavier" resumes are required by the "**people that care**" to offset any increased risk!

Let's further illustrate this point. For a small project with little risk (small amount of capital required and the project does not "push" technology) a BS engineer with relevant experience may be the appropriate person to evaluate the operational processes (Steps 2, 3, 4, and 6 in Table 1). However, Ph.D.'s and large engineering firms are required for the more complex *higher-cost* projects.

Table 2 – Range of Requirements for Personnel

Step # of Table 1	Personnel to Perform Actions Described in Table 1
1	BS Scientist to R&D Firm
2	BS Engineer to Large Engineering Firm
3	BS Scientist or Engineer to Large Engineering Firm
4	Tech Consultant to Tech Marketing Firm
5	Attorney
6	Industrial Consultant to Large Engineering Firm
7	Accountant to Major Financial Firm
8	Risk Consultant

►An Expanded Report on Technical Due Diligence is available for US$25.00 at my Web site* <http://www.drjfwright.com>*. The Table of Contents and "cover sheet" for this Report are on the NEXT page of this Paper.

All Right Reserved by James F. Wright, PhD

The How & Why of Technical Due Diligence©

James F. Wright, Ph.D.
January 20, 2001

The purpose of this paper is to serve as a brief "**how-to guide",** with some examples, for accomplishing *Technical Due Diligence*. The term Technical Due Diligence may seem mystical to many that are unfamiliar with the term *due diligence* – and/or the complex *technologies* that may be involved in their projects. The application of any complex technology in a business venture increases the risk of the proposed projects over that commonly seen in more traditional commerce. In order to help compensate for this increased risk, Technical Due Diligence should address whether a Technical Project will accomplish both its technical and economic goals. This is accomplished by not only providing a pro forma, but also including a numerical measure of the pro forma's accuracy, reliability, and the probability that a specific investment will meet the goals of the investor.

Table of Contents

The first half of this Paper (Sections 1 through 4) was written for those with a business background and/or a non-technical college degree. These Sections provide a solid Primer for the subject of Technical Due Diligence.

Most of the concepts presented in Section 5 will be easily recognized by those readers familiar with elementary statistics. This Section contains several examples that are meant to illustrate how to actually apply these individual analytical techniques to a "real life" Technical Due Diligence project. Some mathematical equations are included to give the bases of the processes, but nothing is rigorously derived.

***** This Report May Not Be Copied or Otherwise Distributed *****
*****Without the Written Consent of the Author *****