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Technical Due Diligence for
ZControl Project

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TS-08/02-02b
August 9, 2002
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Table of Contents

I. Executive Summary

Project Summary.

The project being developed is called the ZControl systems. These systems are being proposed as compact revolutionary devices that quickly (< 5 μsec) filter infrared radiation as the temperature of the surroundings increase. Furthermore, they also quickly (< 7 μsec) return to the original state when the temperature of the surroundings cools. The technology was developed by URDL (a not-for-profit research and development company) and ZZZest and is based upon earlier work by URDL. URDL's work on the basic technology began in 1993 and has progressed significantly through a series of grants from the National Institute of Standards and Technology (NIST), the Defense Advanced Research Projects Agency (DARPA) and the Office of Naval Research (ONR). In technical projects like this, it is my opinion that time is truly money. In the current atmosphere of limitless communication capabilities in a global economy, we can never predict what new technology will be developed in the future. Therefore the time where ZZZest has a technical advantage may be limited to just a few years. Your competitors will vigorously work to develop ways to compete with the ZControl product systems. After all, it is a matter of survival for them! Therefore, it is my opinion that every effort must be made to either discard (for technical reasons), or commercialize, the technology as soon as possible. I have separated this project into three phases to help focus on, and mitigate areas of risk to the project. These three phases and their associated risk factors are summarized below.

Phase A – Proof of Principle.

There is a single key technology element that has yet to be proven. The question that needs to be immediately addressed is, "Will the *MEMS* (Micro-Electro-Mechanical System) controller work in temperatures of up to 800^{o} C (degrees Celsius)?" If this cannot be accomplished then the technology will most likely have to be scrapped and the project terminated. The calculated <u>Most Likely value</u> of US$285,000 in additional money is required to complete this Proof of Principle.

In order to facilitate this process, Dr. Scott Peterson of URDL needs to be focused on this project by URDL's management. Discussion should be immediately initiated to accomplish this, even by contract if required.

Phase B – Production Process Development.

Once the technology of Phase A is proven, the next step is to develop the production processes needed to manufacture the ZControl product systems as required by the business plan in Phase C. The primary steps that can be taken to lower ZZZest's risk is to ensure that certain key people from other companies are more readily and deeply involved in this process. These two technical people are Dr. Scott Peterson of URDL and John Wilson of AA Controllers Inc. There appears to be no substitute for Dr. Scott

Peterson or for John Wilson. I would immediately try to implement a contractual arrangement to compel their active participation in this development process as required by ZZZest.

Phase C – Exploiting the Market.

Phase C must start immediately after Phases A and B are successfully completed because the business plan for Phase C appears to be extremely promising. The successful introduction of radical new technologies such as this will immediately make your competitors feel threatened. The key risks seem to be:
1) how your competitors will react to your new pricing and marketing strategies that are causing them to rapidly lose their market share, and
2) how you will have to change your production and distribution methods to further facilitate your obtaining the maximum market share and optimum profits.

Some solutions to mitigate these risks for Phase C are listed below.
- Time is truly money. If this Phase C can be started in 2003 or 2004 it should be. Starting the plant as soon as possible will actually lower the risk (economic) of the project since the period of higher profits is never at the beginning of technical projects.
- You will be able to follow the Southwest Airline model of gaining new market share (you will make money selling a better product at prices at of below your competitors' cost) and will quickly make enemies among your competitors. In situations like this where a new revolutionary technology is being introduced, the potential exists for a larger competitor to react to this new technology in a ruthless manner and operate at a loss for some period of time until ZZZest is driven from the market. As with the introduction of all revolutionary business models or technologies, some competitors will be driven out of the market. The obvious solution to this is to form a JV with a large competitor to rapidly increase market share and for protection. The JV should be in a limited liability vehicle and require a significant cash payment up front plus significant sales and production quotas for all parties concerned. Further, I would immediately start the process of identifying the prospective JV partners so the contract negotiations could begin and be completed as soon as feasible.
- Market penetration is also enhanced if certain leaders in key markets are properly incentivized during the introduction phase of new products. One effective incentive is deep cuts in the selling price to create showcases for the market leaders. In west Texas, this process is colloquially known as the “Sell the ‘bell cow’ and the herd will follow” method.
- It <u>may</u> be desirable to construct new plants and/or facilities overseas to enhance your product distribution. However, it should be noted that high shipping costs and lengthy delivery times of large products usually drive the need for foreign production facilities. The inherent risks of such ventures stem from ZZZest’s potential loss of capital in the foreign country where the facility is envisioned, or by the loss of proprietary information. In most countries, the loss of capital usually occurs for any of a myriad of <u>political</u> reasons, and not economic or business reasons. Further, it

most always turns out to be much more expensive to place and operate facilities in foreign countries (especially less developed ones!) than initially envisioned. This set of risks can be mitigated by creating a vehicle that minimizes the amount of capital ZZZest ever places in the foreign country and by carefully selecting your international partners and plant sites. A few examples follow.

- ✓ Form a JV, or Equity JV (if such vehicles exist in the target country), with a business entity in the foreign country to increase production and enhance distribution. These JV's are much riskier than the JV whose purpose is to simply increase market share. In many countries where there is a significant and recognized risk to placing your capital, a vehicle called an Equity JV usually exists and is constructed to be similar to a United States limited liability company. However, these vehicles are seen by many, including myself, to illustrate the trade-off that the foreign manufacturing entity is making by trading hard currency for the in-hand possession of new technologies.
- ✓ Always think long and hard before placing proprietary equipment, processes, or information in another country. Industrial espionage is a serious problem in all countries, especially where patent laws are not apt to be enforced.
- ✓ Finance these plants and facilities using vehicles such as grants and no-recourse loans from both international banking groups (World Bank, etc.), the central bank of the target country, and financial institutions with international connections (both in and out of the target country).

- By having just a few production platforms (three or less), the warehouse is an ideal candidate for an automated "picker" system. This should be considered and implemented (if feasible) as soon as possible.

II. Key Business Assumptions

A new and revolutionary family of products can be created; both within the thermal control industry and in a wide variety of other national security markets, if ZZZest's ZControl technology can be made to function as the business plan requires. The products being developed in this venture are called the ZControl product systems and, if successfully developed, this technology can be revolutionary and enabling. The purpose of this Technical Due Diligence is to identify, isolate and determine how to mitigate the technical risks of commercializing this new technology.

The timeline used in this analysis is divided into three phases and they are described below.

A. **Proof of Principle** – This phase, as presently planned, will continue until the end of 2002. During this time period each of the requisite technologies required by the highest and lowest temperatures ZControl product systems will be demonstrated so that they can be integrated into the proposed systems in a manner required by the business plan. It should be added that even though the individual technologies work by themselves, the integration of these technologies into a ZControl product system has yet to be fully demonstrated. If this phase is not successful the project will be terminated.
B. **Production Process Development** – This phase will start when "Phase A" is successfully completed and is planned to proceed to the end of 2004. During this phase ZZZest will design, develop and integrate the final production processes for the ZControl product systems. The evaluation model is based solely upon the sales of infrared optical sensors and thermal controller systems that are organized into three separate manufacturing *platforms* to enhance projected profits. These three basic *platforms* have different filtering capabilities that can each be further configured into separate *models* designed to operate as either 3-filter, 4-filter or 5-filter controllers. It is anticipated that the true value of the ZControl product systems could greatly exceed that detailed in this report if properly exploited. It should very much be an Enabling Technology that will revolutionize the high-temperature thermal controller industry. Furthermore, once the base technology has been commercialized within the thermal controller industry, the team will be well positioned to utilize it in other markets.
C. **Exploiting the Market** – This is a five-year marketing plan that will aggressively market the ZControl product systems. It will start when Phase B is successfully completed.

This section of the Technical Due Diligence will discuss the assumptions that will be initially used in order to accomplish the three above-mentioned phases.

A. Proof of Principle

The base technology is fully licensed for ZZZest to exploit and includes the use of *MEMS* actuators to exercise thermal and spectral control with flexible polymer switches.

It is crucial for this device to be able to control remote systems in temperature environments of up to 800^{o} C at very fast rates. During the Proof of Principle phase the effort will focus on achieving at least 800^{o} C operation. If this level can be achieved, it is reasonable to assume that 1000^{o} C can be reached during the development process. Achieving a higher operating temperature is a function of cost (more filters), as there are no technical limitations to this goal.

There is a theoretical limit to the maximum filtering that the controller can effectively accomplish. This theoretical limit was derived when URDL developed earlier generations of the controller. This limit will be validated during the Proof of Principle phase and an appropriate safety factor will be applied to insure that the device functions correctly across all proposed models and platforms. From this data the team will determine the different filter media and maximum instruction rate per unit area of silicon at the high temperatures. Once the maximum limit is determined, this data will be employed as a design rule limitation for all future products. By increasing the number of instructions (i.e., filters to be inserted), one can increase the number of devices to virtually any level. While this is technically viable, there are costs associated with increasing the area of a single silicon device. The design team cost model is based upon a 4:1 safety factor applied to the theoretical limit.

Over the years, URDL has successfully developed several *MEMS* controllers based on electrostatically driven polymer gates. The *MEMS* device for this project is an extension of the original URDL development. ZZZest and URDL jointly developed this current device, configured as a thermal controller, under a DARPA grant with the first samples delivered to ZZZest for evaluation in June of 2002. The early *MEMS* devices have been demonstrated to work very well under ambient temperatures at a wide range of other operating conditions. However, this application requires the controlling several filters at significant operating temperatures of up to 1000^{o} C. ZZZest is currently in the process of testing the first generation DARPA (Defense Advanced Research Projects Agency) device, called G1, under conditions of up to 800^{o} C.

The assumptions for the Monte Carlo calculations are as follows.

- Minimum Cost scenario – If the G1 device will control multiple units at temperatures up to 800^{o} C it will be certified under a range of operating conditions on a test stand. If it passes all operating conditions the Proof of Principle will be demonstrated and the project will move to Phase B. If it does not pass all operating conditions the project will move to the Most Likely scenario.
- Most Likely Cost scenario – Since the G1 device did not control multiple units at temperatures up to 800^{o} C, ZZZest will work with URDL to design a new *MEMS* using the data acquired from the testing of the G1 device. The new G2 (Generation 2) device will be manufactured and then brought to ZZZest for testing. If this G2 device passes all operating conditions the Proof of Principle will be demonstrated and the project will move to Phase B. If it does not pass all operating conditions the project moves to the Maximum Cost scenario.

- Maximum Cost scenario – Since the G2 device did not control multiple units at temperatures up to 800^{o} C, ZZZest will work with URDL to design a new *MEMS* using the data acquired from the testing of the G2 device. The new G3 (Generation 3) device will be manufactured and then brought to ZZZest for testing. If this G3 device passes all operating conditions the Proof of Principle will be demonstrated and the project will move to Phase B.

Based on the measurements performed to date, it is assumed by URDL and ZZZest that further Generations will not be required for this Proof of Principle phase.

B. Production Process Development

The purpose of this phase is to develop and construct the manufacturing equipment required to produce the first set of ZControl product systems to be sold. Since this is a new application of existing similar *MEMS* technologies, the composition of the Project Production Process Development Team required for the design and implementation of the production process is crucial for success. ZZZest has extensive manufacturing, testing, engineering, and marketing expertise in the application of thermal controller controls and has taken the lead in the development and commercialization of this ZControl technology. ZZZest has identified and assembled a unique team that has extensive experience in each of the requisite technologies. The team members and their key area of expertise, as it is applied to the ZControl project, are listed below.

- ZZZest Manufacturing Company – Thermal control systems
- URDL – Design and application of *MEMS* technologies
- AA Controllers Inc. – System packaging and *ASIC* (Application Specific Integrated Circuit) design

Brief summaries of each of these team members are described below.

<u>ZZZest Manufacturing Company</u>

ZZZest Manufacturing Company was founded in 1957 when Charles Duke invented an inexpensive, non-repairable, thermal control system to replace existing thermocouple-based control units. The system Mr. Duke pioneered has now become a standard in the industry. ZZZest remains the market leader for this product and has a goal of being the undisputed leader in thermal and electro-magnetic controllers for the defense and space industry. ZZZest has ISO 9001 certification and is located in several facilities including: Corporate headquarters in Tulsa, Oklahoma; a manufacturing plant in Claremore, Oklahoma; a new products facility in Norman, Oklahoma; ZZZest Limited, in the UK; and TSI, a wholly owned subsidiary in Dallas, Texas. ZZZest's product line has expanded over the years to include a wide range of controllers in a variety of configurations. In addition to its broad line of standard catalog products, nearly 40% of ZZZest's business consists of "specials". “Specials” are products, custom designed for specific customers and their unique applications.

One of the trends in the industry is to develop smaller, more accurate products with increased functionality. ZZZest has concluded that the market leader of “tomorrow” in thermal controller systems must be able to develop these new systems by including electronics within the insulated cylinder. ZZZest envisions the day when the company will be able to offer its customers a

"Smart" insulated cylinder that is considerably cheaper, smaller and more versatile than existing products. This device will include a traditional cylinder, integral solid-state controllers, and would be programmable. ZZZest predicts the introduction of a whole series of increasingly advanced products (based on the successful development of a solid-state controller system), culminating with a smart cylinder system. The Project Leader for this effort will be Jerry Smith, a Project Engineer leading a new product development team at ZZZest's New Products Division in Tulsa, Oklahoma. Mr. Smith's past experiences includes leading R&D teams in the development of new solid-state sensors, *ASIC*s, and cylinders. In the past he has led R&D efforts for the National Aeronautics and Space Administration (NASA) - Johnson Space Center, Lockheed Engineering and Sciences Company, and most recently for ZZZest. Don Donaldson will also be an important member of the ZControl development team. As the ZControl Marketing Manager he will be responsible for all general management and marketing activities including the development of strategic alliances with global directional control valve manufacturers. Mr. Donaldson is currently the Marketing Manager for ZZZest's New Product Division and has past experience in developing and marketing technical products, direct sales, sales through distribution and management.

<u>URDL</u>

URDL is a not for profit, research and development company with strong efforts in microfabrication (this includes *MEMS*), wireless technology, and next generation Internet communications. URDL conducts contract research and brings promising technologies through the development process including limited production, to the point where they can be spun off into new companies. URDL has successfully spun off three companies in the past four years. The principal investigator, Dr. Scott Peterson is from the Sensors and Actuators Group of the Microfabrication Division. Dr. Peterson was the creative force behind the initial *IFA* (Integrated Functional Analysis) control system and the flexible film electrostatic high-energy switch. The fabrication work will be done in the URDL clean room and other associated labs, which have been recently upgraded with new equipment and more space to better support the ongoing and future projects at URDL. Due to the small size of URDL, close interactions occur between the process engineers in charge of the wafers being processed, and the sector engineers who are in charge of the processing equipment in the clean room. In this manner efficient processing and problem solving is accomplished.

<u>AA Controllers Inc.</u>

John Wilson, Chief Executive Officer of AA Controllers Incorporated (AACI) will lead the packaging effort. AACI manufacturers micro-machined controllers, including temperature sensors for use in the industrial marketplace. AACI offers foundry services in *MEMS* packaging and product commercialization. They will provide a complete solution for packaging from design, to prototyping, pilot creation and ultimately to high volume production. AACI will be responsible for all packaging issues including design, assembly and final product acceptance test efforts. A commercial *ASIC* company will be retained as a subcontractor to provide the application specific devices utilized in this project. Subcontractor selection will be based upon the low cost bidder in a competitive bidding process.

This Production Process Development Team will develop the production process by using the standard iterative methodology commonly used to develop new production lines and production trains. The development process is based on just two complete manufacturing runs because of the unique talent and experience level of this team that ZZZest has assembled. Lessons learned from the first effort will be utilized to improve the design during the second iteration. The steps for a single iteration are briefly outlined below.

1. Create a number of unique electrostatic actuator designs, which will be prototyped simultaneously, via the batch manufacturing process, on a single silicon wafer. All of these different designs will have the same size, shape and number/type of electrical interfaces. This will allow ZZZest to package all of the unique valve designs into a single housing design.
2. Design an *ASIC* to drive the controller, and to provide a communications channel.
3. Design all packaging components to complete the assembly of 3-filter, 4-filter, and 5-filter systems. These components will contain the controllers and *ASIC*, internally.
4. URDL has not yet developed computer models for the controllers. Said models would need to be developed, and optimized at the *packaged* level to accommodate the temperature transients typical in industrial, thermal controller systems and the potential for mechanical resonance as these devices are installed in environments that generates shock and or vibration during normal operation. The packaged controllers would be subjected to simulated, simultaneous, inputs from a wide variety of physical phenomena. Some of the modeling capabilities required of the simulation software package appears below:
   - Modeling the effects of airflow via Computational Thermal Fluid Dynamics (CTFD). The modeling software must include subsonic, laminar and turbulent flow and complete conservation of energy.
   - Model loading due to high acceleration and deceleration rates (g-forces)
   - Calculate heat and mass transfer.
5. Perform multi-input structural dynamic analysis, calculating the complex interactions of fluid, structural, thermal and electrostatic contributions. The technological approach will be to develop fundamental devices, based upon first order analysis, material properties and geometric shapes. The team will complete a silicon run and conduct experiments whereby the actuator will be subjected to input from a single phenomenon such as vibration, fluid flow, specific pressurization states, temperature, and humidity. Of particular concern will be resonance, fatigue and overstress issues. The Project Team will employ a transparent package; a high-speed digital camera and a number of high-speed Personal Computer (PC) based instruments to record the results. The data will be analyzed and the results forwarded to URDL where they will improve their models. Next the Project Team will subject the test article to multiple, simultaneous physical inputs and the models will be further refined. This process will be repeated until the models are determined to be accurate enough to make design decisions at the packaged level.
6. The lessons learned from this effort will be repeated in a second iteration, to refine the design and produce valves that will be utilized in an alpha-test site program with industrial end-users.

The following are the major milestones and task flow for this proposal.

Project Plan, Budget and Milestones		
Task	**Total Funds**	**Major Milestones**
Create Initial Computer Models	$240,049	Validate Multi-Physics, coupled with CTFD
Fabricate *MEMS* Structures	$301,961	Complete Silicon Fabrication Run #1
Develop Packaging	$262,000	Design, Fabricate & Test Packaging, Validate Sealing Techniques, Validate Wafer Dicing, Bonding & Processes
Design *ASIC*s	$127,000	Design, Fabricate & Test *ASIC*s
Integrate Components & Test Systems	$150,000	Integrate Components, Develop Assembly Processes, Develop Final Assembly Processes, Validate Assembly Processes, Validate In-Process Tests
Revise Models	$150,000	Validate Multi-Physics, coupled with CTFD
Fabricate New *MEMS* Structures	$301,961	Complete Silicon Fabrication Run #2
Revise Packaging	$102,000	Design, Fabricate & Test Packaging
Correct *ASIC*s	$127,000	Design, Fabricate & Test *ASIC*s
Integrate Components & Test Systems	$129,116	Integrate Components & Develop Assembly Processes, Complete Final Electronics Packaging, Test Final Electronics Packaging
Complete Alpha-Site Test Plan	$60,000	Compile Results & Draw Conclusions

C. Exploiting the Market

The data used in the evaluation for this Phase C of Exploiting the Market can be classified as generally conservative. Several steps were taken in the course of this analysis to identify and reduce the project risk for each and all phases. Further, the development of the marketing of this ZControl project was already a market driven process. The assumptions for the business plan to exploit the market are summarized in this section. Since this analysis will be using Monte Carlo risk analysis to quantify the results, ZZZest was required to provide Absolute Minimum, Most Likely, and Absolute Maximum values for each of the input parameters used in developing the business model (pro forma). I supplied standard deviation data. This requirement forces all participants to always think about a realistic range of values for these parameters rather than typical single-valued best guesses. The key assumptions are listed below.

Market Data

Don Donaldson performed an analysis where he isolated and identified an 80% segment of the worldwide thermal controller controls market as the total available target market for 2001. These sales numbers for 2001 are used for 2005 as the market expands from its current global recession. These base marketing numbers were inflated at a rate of ~5% per year up to 2009.

Production Data

It is assumed that the market penetration in the 5th year (2009) will range between 1%, 4% and 9% (Absolute Minimum, Most Likely, and Absolute Maximum values) of the total worldwide market by selling in the targeted “80%” market segment. This will be accomplished by introducing new and revolutionary product platforms that have high projected demand. Market penetration will be accomplished by the extensive use of incentives granted to select leaders in key markets and the formation of a JV through a fixed term limited liability vehicle. A powerful worldwide market leader will be selected as the JV partner because they want to participate in this new revolutionary technology.

The production will be geared to three different platforms that are each based on their number of filters. They will be low, moderate and high rate platforms with approximate rates of 4.5, 9.0, and 13.4 mips (million instructions per second), respectively. Each of the platforms will be able to function as 5-filter, 4-filter or 3-filter models. This manufacturing process using "platforms" is known to reduce manufacturing costs and increase efficiencies. Chrysler first used it in their K-car platforms in order to recover from their bankruptcy.

It is planned to contract the manufacture and packaging of all components of the ZControl product systems except the infrared sensors and accessories, which will be produced by ZZZest. The units will be warehoused at ZZZest where they can be programmed as required and then shipped. The location of manufacturing locations can always change as cash flow and production requirements change.

Since the projected cost to produce these ZControl product systems is considerably lower than existing systems, the target selling price structure will give ZZZest a considerable profit while still being priced at or below the average cost of all existing systems that are servicing the target markets. The ZControl product systems are priced so that the Absolute Minimum selling price is 20% below the market average selling price, the Most Likely selling price is 10% below the market average selling price, and the Absolute Maximum selling price is equal to the market average selling price.

Economic Data

Many of the key economic assumptions are driven by the production rate required by the size of the market and the ability of these revolutionary devices to garner market share. ZZZest has been a successful manufacturing company since 1957 and has extensive data on such matters such as:

- The Absolute Maximum selling price used in this model is equal to the current market average selling price. The Most Likely selling price of the integrated unit is 10% below the market average selling price. The Absolute Minimum value of the selling price of the integrated unit is 20% below the market average selling price.
- Number of CNC (Computer Numerical Control) machines required to produce a certain number of parts,
- Number of production employees (CNC operator, warehouse, shipping, and overhead) per part produced,
- Number of accessories produced per unit produced,
- Maintenance costs per CNC,
- QA/QC cost per part produced,
- Overhead required (office space, office equipment, insurance, hand tools, etc.) per part produced, and
- Employee salaries and benefits.

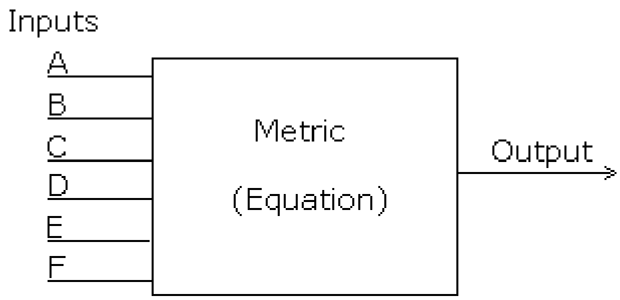
Other key parameters in the model are listed below.

- All sales are on account and collected within 45 days,
- Inventory is maintained at a level of 60-days of materials required for finished goods,
- All inventory items are purchased on account and paid in 30 days.
- The tax rate on income will be paid as 41% on profits.
- The costs for Phase A and Phase B are carried as a short-term loan.

III. Monte Carlo Risk Analysis

Monte Carlo risk analysis is a specialized form of Monte Carlo simulation where the “answer” provides a quantitative measure of risk for a proposed project. The following couple of paragraphs and a single diagram are an attempt to describe a relatively complex process in a few words. The history of Monte Carlo has been exemplary in that it has successfully been used to predict outcomes in projects as diverse as designing nuclear weapons and quantifying the reserves in offshore oil and gas plays.

The box in the figure below is a symbolic representation of a Monte Carlo simulation *engine* that takes a metric, or equation, and uses input data to create a realistic answer (the output).



The unique aspects of the Monte Carlo Simulation are as follows:

- The Monte Carlo engine assumes that the input data always contains errors and uncertainties, even though this fact is ignored in most other methodologies. Therefore, it requires that the data for each of the input variables be in the form of a frequency distribution function and it assumes that this (frequency) distribution function is representative of the real data.
- The Monte Carlo engine has a method that uses the metric to calculate the frequency distribution function of the “output” that reflects and contains all of the uncertainties that are in of each and every one of the input variables.

My experience with Monte Carlo simulation (and Monte Carlo risk analysis) is that the GIGO (Garbage In, Garbage Out) principle still holds and if there is a problem with the results, it is due to either the metric or the data. The Monte Carlo process works!

A more complete description of Technical Due Diligence and Monte Carlo Risk Analysis can be found in my book titled “Monte Carlo Risk Analysis and the Due Diligence of New Investments” which can be purchased at technical bookstores and on the Internet. It is divided into two sections with the first being less technical and oriented to those with a business background, The second part is very technical and discusses the mathematical techniques required by what I call the Technical Due Diligence process. This Technical Due Diligence process includes process analysis, discrete and continuous statistics and of course Monte Carlo Risk Analysis.

A. Proof of Principle

Phase A is the first risk milestone for the entire project. In other words, if we can't prove the technical principles required by the ZControl project then the project should be terminated.

The key risk item for Phase A is listed below.

- Can a *MEMS* system be constructed that will operate in temperatures of at least 800^o C? This is a critical milestone and if it can't be proven then the project must be re-evaluated and perhaps terminated. In order to facilitate this process, Dr. Scott Peterson of URDL needs to be focused on this project by URDL's management. Discussion should be immediately initiated to accomplish this.

The Monte Carlo Risk Analysis of the Proof of Principle (Phase A) indicates that the most likely amount remaining to be spent to determine if the relevant technical principles can either be proved or discounted is approximately US$285,000. The following is a list of Probabilities, *P* of the cost to prove or disprove the relevant technical principles.

- *P{Phase A Cost ≤ US$377,400}* = 0.90 = 90%
- *P{Phase A Cost ≤ US$342,200}* = 0.75 = 75%
- *P{Phase A Cost ≤ US$302,600}* = 0.50 = 50%
- *P{Phase A Cost ≤ US$271,800}* = 0.25 = 25%
- *P{Phase A Cost ≤ US$245,400}* = 0.10 = 10%

It was further calculated that there is a near-zero probability for the amount required for Phase A to be outside the range of US$126,600 to US$557,800. For review purposes, if the probability that an event will occur is 1.0 then it is certain. An event will never occur if its probability is 0.0.

B. Production Process Development

Once the technical Proof of Principle is demonstrated (Phase A) the Phase B should be addressed in an expeditious manner. The key risk items for Phase B are listed below.

- Special attention should be given to the final packaging of the new ZControl product systems. Packaging of *MEMS* systems has historically been a very expensive part of manufacturing these types of devices (up to 80% of the total cost of manufacturing). The price estimates in this pro forma are based on two quotes with one coming from AA Controllers Inc. I suggest placing John Wilson, the CEO of AA Controllers Inc., under some sort of contractual commitment since his expertise is so important in meeting the cost estimates of packaging these devices. If he is not amenable to such an agreement I would go after the key person at the other company that made a packaging bid for the ZControl product systems.
- Once again put Dr. Scott Peterson of URDL under contract to keep him focused on this project.

The Monte Carlo Risk Analysis of Phase B (Production Process Development) indicates that the most likely amount that will have to be spent in order to develop the production processes is approximately US$2,079,500. This is of course after the technical principles are determined to be valid (Phase A). The following is a list of probabilities, *P*, for the Cost of Phase B to be less than or equal to certain values.

- *P*{ *Phase B Cost* ≤ *US$2,396,000*} = 0.90 = 90%
- *P*{ *Phase B Cost* ≤ *US$2,253,600*} = 0.75 = 75%
- *P*{ *Phase B Cost* ≤ *US$2,111,200*} = 0.50 = 50%
- *P*{ *Phase B Cost* ≤ *US$1,984,500*} = 0.25 = 25%
- *P*{ *Phase B Cost* ≤ *US$1,873,700*} = 0.10 = 10%

It was further calculated that there is a near-zero probability for the cost of Phase B to be <u>outside the range</u> of US$1,446,400 to US$2,997,500. Once again, if the probability that an event will occur is 1.0 then it is certain. An event will never occur if its probability is 0.00.

It is important to note that at the completion of Phase B a new Monte Carlo analysis of the Phase C must be run to insure that the project is still economically feasible. The purpose of this Phase B is to narrow the range of these costs to be used in the production process of Phase C. Phase B could be "satisfactorily" completed and yet the newly determined production costs could make commercialization of the ZControl technology unprofitable and unworthy of further development. There are countless projects in the "graveyards of commerce" that are technically possible yet not economically feasible for commercial development. The purpose of this Technical Due Diligence process is to make this determination at the earliest possible time.

C. Exploiting the Market

Since you will be able to use the Southwest Airline model of gaining new market share (you will make money selling a better product at prices at or below your competitor's cost), you will quickly make your competitors feel threatened. Phase C must be started immediately after Phases A and B are successfully completed. The key risks seem to be:

1) how your competitors will react to your new pricing and marketing strategies (using a revolutionary technology), and
2) how you will have to change production and distribution methods to further facilitate your obtaining the maximum market share.

Some solutions to mitigate these risks for Phase C are listed below.

- Time is truly money. If this Phase C can be started in 2003 or 2004 it should be. Starting the plant as soon as possible will actually lower the risk (economic) of the project since the period of higher profits is never at the beginning of technical projects.
- In situations like this where a new revolutionary technology is being introduced, the potential exists for a larger competitor to react to this new technology in a ruthless

manner and operate at a loss for some period of time until ZZZest is driven from the market. As with the introduction of all revolutionary business models or technologies, some competitors will be driven out of the market. The obvious solution to this is to form a JV with a large competitor to rapidly increase market share and for protection. The JV should be in a limited liability vehicle and require a significant cash payment up front plus significant sales and production quotas for all parties concerned. Further, I would immediately start the process of identifying the prospective JV partners so the contract negotiations could begin and be completed as soon as feasible.

- Market penetration will follow if certain leaders in key markets are properly incentivized during the introduction phase of new products. One effective incentive is deep cuts in the selling price to create showcases for the market leaders. In west Texas, this process is colloquially known as the "Sell the 'bell cow' and the herd will follow" method.
- It <u>may</u> be desirable to construct new plants and/or facilities overseas to enhance your product distribution. However, it should be noted that high shipping costs and lengthy delivery times of large products usually drive the need for foreign production facilities. The inherent risks of such ventures stem from ZZZest's potential loss of capital in the foreign country where the facility is envisioned, or by the loss of proprietary information. In most countries, the loss of capital usually occurs for any of a myriad of <u>political</u> reasons, and not economic or business reasons. Further, it most always turns out to be much more expensive to place and operate facilities in foreign countries (especially less developed ones!) than initially envisioned. This set of risks can be mitigated by creating a vehicle that minimizes the amount of capital ZZZest <u>ever</u> places in the foreign country and by carefully selecting your international partners and plant sites. A few examples follow.
  - ✓ Form a JV or Equity JV (if such vehicles exist in the target country) with a business entity in the foreign country to increase production and enhance distribution. These JV's are much riskier than the JV whose purpose is to simply increase market share. In many countries where there is a significant and recognized risk to placing your capital, a vehicle called an Equity JV usually exists and is constructed to be similar to a United States limited liability company. However, these vehicles are seen by many, including myself, to illustrate the trade-off that the foreign manufacturing entity is making by trading hard currency for the in-hand possession of new technologies. If JV's, or Equity JV's are of interest to ZZZest, it is important to consult an international law firm that is knowledgeable about these matters in the specific county you are considering. One such law firm in Chicago that has some global reach is Suem & Weap. I am not personally familiar with this law firm but a large Venture Capital company that has used them successfully in several deals recommended them to me.
  - ✓ Always think long and hard before placing proprietary equipment, processes, or information in another country. Industrial espionage is a serious problem in all countries, especially where patent laws are not apt to be enforced.
  - ✓ Finance these plants and facilities using vehicles such as grants and no-recourse loans from both international banking groups (World Bank, etc.), the central bank

of the target country, and financial institutions with international connections (both in and out of the target country).

- By having just a few production platforms (three or less), the warehouse is an ideal candidate for an automated "picker" system. This should be considered and implemented (if feasible) as soon as possible.

Some additional product considerations (both within as well as outside of the thermal controllers industry) are shown below that have not been included in this analysis. They should add significantly to the product unit sales, profit and cash flow after market penetration of the thermal controller industry is established.

- Thermal controller units for use in both Process Control and Semiconductor Manufacturing industries.
- Electronic controls at high temperatures, to limit thermal degradation (estimated $94 million United States market).
- Voltage controlled proportional and servo valves to provide thermally stable motion control.
- Lower cost and improved electronic temperature regulators (estimated $74 million United States market).
- Smart cylinders. A cylinder with integral sensors and electronics.
- A high-speed pilot operator for both thermal controller & hydraulic valves (estimated $47 million market).
- High temperature voltage controlled variable capacitors.
- High-speed optical devices such as shutters and beam deflectors.
- Lightweight, low power relays.
- Active vibration damping systems.
- Large and small-scale robotic devices.
- Controllers for osmotic pumps, including both the Biomedical and Beverage industries.
- Position sensors.
- Tactile interface devices for virtual reality.
- Protective covers for optical sensors.
- Active control surfaces for aircraft including unmanned aerial vehicles.

In the course of this analysis I requested the Absolute Minimum, Most Likely, and Absolute Maximum values for <u>each</u> of the input parameters from ZZZest. In addition, I forced all production-related parameters to be expressed as a function of the quantity of units produced. ZZZest had already related the units produced (and sold) to the market analysis. I then supplied a parameter that caused the "effective" standard deviation of the input distributions to increase as the projections moved out in years. ZZZest personnel were continually asked to explain and justify their data. It is my opinion that the information ZZZest provided for this analysis was made using realistic scenarios and the best data available. Furthermore, the Monte Carlo methodology ensured that the data used in the calculations were conservative in nature because they were based on distribution functions and not just single values.

The Monte Carlo Risk Analysis of Phase C (Exploiting the Market) assumes that a loan of US$7,595,800 is made to the new venture of which US$5,000,000 is for working capital and the balance is to repay ZZZest for their initial investment. This loan is repaid by the end of year 3. The Monte Carlo analysis calculates that the Most Likely Value of the Before Tax Net Profit for the five years of this phase are as follows.

- Year 1 Before Tax Net Profit = US$11,500,000
- Year 2 Before Tax Net Profit = US$14,600,000
- Year 3 Before Tax Net Profit = US$15,800,000
- Year 4 Before Tax Net Profit = US$20,900,000
- Year 5 Before Tax Net Profit = US$25,900,000

The Monte Carlo Analysis also calculates that the Most Likely Values of the After Tax Cash Flow for the five years of this phase are as follows.

- Year 1 After Tax Cash Flow = US$7,100,000
- Year 2 After Tax Cash Flow = US$6,800,000
- Year 3 After Tax Cash Flow = US$7,300,000
- Year 4 After Tax Cash Flow = US$15,200,000
- Year 5 After Tax Cash Flow = US$24,500,000

The above cash flows are after the principal and interest for the US$7,595,800 loan are repaid. The Probability, *P*, that the After Tax Cash Flow for the entire project (after five years) will be at least certain amounts are also as follows.

- *P*{After tax Cash Flow after 5 Years ≥ US$5,546,700} = 0.75 = 75%
- *P*{After tax Cash Flow after 5 Years ≥ US$22,776,000} = 0.50 = 50%
- *P*{After tax Cash Flow after 5 Years ≥ US$40,364,000} = 0.25 = 25%
- *P*{After tax Cash Flow after 5 Years ≥ US$56,712,000} = 0.10 = 10%

The Most Likely value of the Profitability Index (*PI*) after 5 years is calculated to be 8.8 where the profitability Index is defined as the present values of cash flows divided by the US$7,595,800 initial investment. If we multiply the 8.8 times the initial Investment (US$7,595,800) we can see that the Most Likely "present value of cash flows after five years and the debt repayment (both principal and interest)" is US$66,843,040. It can also be determined that there is an 80% probability that the *PI* after 5 years ≥ 1.2. In other words, there is an 80% probability that the project will pay back the principle and interest on the loan plus another US$9,114,960 (1.2 x US$7,575,800). By examining the CDF of the *PI* distribution we can also determine that there is an 84% probability that <u>at least</u> the principal and interest will be repaid.

Therefore, this project (Phase C) is likely to be very profitable and contain relatively low risk if the Phases A and B can be satisfactorily addressed. At the completion of Phase B, the uncertainties in the manufacturing costs will be reduced and a Monte Carlo calculation using the new data derived from Phases A and B should yield much more reliable values of the Before Tax Profit, After Tax Cash Flows and the Profitability Index.

However, it should be remembered that even though the results from Phases A and B reduce the uncertainties, the commercialization of the ZControl technology might be less appealing. This could occur in a scenario where Phase A indicates the technology is feasible but Phase B indicates the production costs to be so high that the technology cannot be commercialized. This is close to the worst case scenario and further justification for my using accounting-type metrics rather than scientific ones!