ALGORITHMIC TRADING & INVESTING SYSTEM DEVELOPMENT

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TABLE OF CONTENTS

1 Introduction & Overview of Research 7
1.1 Statement of the Problem 7
1.2 Statement of Problem Importance 7
1.3 Summary of Literature & Statement of Creativity 8
1.4 Summary 9
2 Trading & Investing 11
2.1 Retail Trader vs. Investor 11
2.2 Introduction to Basic Macroeconomics 12
2.3 The 4 asset groups classes 13
2.3.1 Stocks 13
2.3.2 Currencies 13
2.3.3 Bonds and commodities 14
2.4 Inter-market Analysis 14
2.4.1 Stocks 14
2.4.2 Advantages and Disadvantages of Stocks 15
2.5 Breadth of the Market 16
3 Trading Systems 17
3.1 Trading Platforms 17
3.2 Strategies and Other Logic 17
3.2.1 Trend Following Systems 18
3.2.2 Volatility Expansion Systems 18
3.2.3 Support & Resistance Systems 19
3.3 Automatic v. Manual Trading 19
3.4 Fundamental v. Technical Trading 19
3.5 Rules for Trading Systems 21
3.5.1 Entry Rules 21
3.5.2 Exit Rules 21
3.5.3 Position Sizing Rules 22
3.6 Order Types 22
3.7 Trend Following Strategies 22

3.8 Gap Strategies 23
4 Optimizing and Analyzing Trading Systems 25
4.1 Optimization 25
4.2 Work-Forward Analysis 26
4.3 Expectancy, Expectunity, & System Quality 28
4.4 Monte Carlo Analysis 29
4.5 System of Systems 30
5 Literature Review 31
6 Fancher's Trading System 33
6.1 System Development 33
6.2 System Description 37
6.3 System Analysis 41
7 William's Trading System 52
7.1 System Development 52
7.2 System Description 53
7.3 System Analysis 55
8 Pepic's Trading Strategy 67
8.1 System Development 67
8.2 System Description 70
8.3 System Analysis 72
9 System of Systems 80
10 Summary & Conclusion 84
11 Works Cited 86
12 Appendices 88

TABLE OF FIGURES

Figure 1: Segmented Walk-Forward Optimizer Example 27

Figure 2: Example of Buy and Hold System 35

Figure 3: Example of Buy and Sell System 36

Figure 4: Market Trend and Momentum 38

Figure 5: Joe's Trading Chart 40

Figure 6: Joe's Trading Rules 41

Figure 7: Joe's TradeStation Summary Report 42

Figure 8: Joe's TradeStation Equity Curve 44

Figure 9: Joe's System Cluster Walk Forward Results 45

Figure 10: Joe's System Cluster Walk Forward Efficiency Results 45

Figure 11: Joe WFO Test Criterion 46

Figure 12: Walk-Forward Optimized Equity Curve 46

Figure 13: Monte Carlo Analysis 48

Figure 14: Monte Carlo Confidence Cone 49

Figure 15: Equity Curve Before Fixed Fractional Position Sizing 50

Figure 16: Equity Curve After Fixed Fractional Position Sizing 50

Figure 17: Joe's System Quality analysis 51

Figure 18: Mina's GOOGL Stock Chart 57

Figure 19: Mina's TradeStation Summary Report 58

Figure 20: Mina's TradeStation Equity Graph 59

Figure 21: Mina's Walk-Forward Analysis Results 60

Figure 22: Mina's Walk-Forward Efficiency Results 60

Figure 23: Mina's Confidence Cone 61

Figure 24: Mina's Monte Carlo Confidence Cone 62

Figure 25: Mina's Monte Carlo Analysis Results 63

Figure 26: Mina's GoogL Equity Curve 64

Figure 27: Mina's GOOGL Position Sizing 65

Figure 28: Mina's System Quality analysis 66

Figure 29: Gap Example 69

Figure 30: Dollar Trailing Example 70

Figure 31: Mladen's Trading Rules 71

Figure 32: Mladen's TradeStation Summary Results 73

Figure 33: Mladen's Walk Forward Analysis Results 74

Figure 34: Mladen's Walk Forward Efficiency Results 75

Figure 35: Mladen's Optimized Equity Curve 75

Figure 36: Mladen's Equity Curve 76

Figure 37: Mladen's Equity Curve After Position Sizing 77

Figure 38: Mladen's Monte Carlo Confidence Cone 78

Figure 39: Mladen's System Quality analysis 79

Figure 40: System of Systems Equity Curve 81

Figure 41: System Quality Comparison Table 82

Figure 42: System of Systems Monte Carlo Confidence Cone 82

Figure 43: System of Systems Monte Carlo Results 83

1 INTRODUCTION & OVERVIEW OF RESEARCH

1.1 STATEMENT OF THE PROBLEM

The purpose of this Interactive Qualifying Project (IQP) is to equip the team members with information and experience with stock market automatic trading. The project combined the work of three different trading strategies that were implemented into a system of systems to create a trading portfolio. Each system had its own parameters and time frames that collectively simulated trades with artificial money. This research paper describes, analyzes and tests each system separately, as well as the whole system of systems.

1.2 STATEMENT OF PROBLEM IMPORTANCE

Financial stability is the most common concern among citizens of any economical state. Learning and managing a financial portfolio is extremely important for one's future. The stock market is a great mean for individuals to start future investing, as long as they have the proper knowledge to secure their investments. The Internet provides investors and traders with the ability to trade from their home. There are many online trading platforms, which tends to hurt individuals who lack the proper training and strategizing skills for maintaining a profitable portfolio. It is estimated that "84% of all stocks are traded using high-frequency computers" (Washingtons Blog). Lack of knowledge induces risk, which has proven detrimental to one's assets; this as a result leads to troubled savings for many individuals out there.

Personal saving is a major key in one's retirement, leaving money in a bank alone is not as profitable as actively investing it. Knowing that, and with the help of electronic trading, trading popularity has increased and prospered. From the constant increase in active trading,

more programs for raising awareness on risks, teaching skills, and implementing strategies have risen.

The main goal of this IQP is to create a system of systems that would trade on a profitable margin within a specified time frame. Three systems were merged together to create a trading portfolio that users could start investing with. Each group member analyzed stock patterns, tested different strategies, and used different indicators. Once each system was proven to generate profit, it was combined with the others, and used for specific stocks that followed the general pattern of the system.

1.3 SUMMARY OF LITERATURE & STATEMENT OF CREATIVITY

Our team developed a profitable diversified system of systems that utilized the work of previous professional traders and investors. It contains a two moving average crossover strategy operating on daily bars, a one moving average crossover strategy operating on daily bars, and a gap up and down strategy operating on 60-minute bars. The derivation of the strategies will be explained in depth in the upcoming chapters. Of the many professional investors we acquired information from is Charlie Wright. In his book, *Trading as a Business*, he gives a deep understanding of trending markets; in which two systems utilizes them. He states that trending markets sustain a large increase/decrease in price over a considerable amount of bars. He also states that the price movement indicates the direction. Based on his explanation, the average moving strategies were modified to detect the direction of the market, and lock a position given information from previous data.

Our IQP team had little to no knowledge of trading at the beginning of the term. We were advised to use previous strategies to better advance our knowledge, as well as try to change parameters to give those strategies an edge in the market. For example, the two average moving crossover strategy was implemented from the previous work of Frederic Palmiden, a TradeStation expert and developer. The system was used on different stocks, with different parameters, as well as turning off the short-sell trigger in the system. It is advantageous to test and use other's systems, as long as one could improve on it and try to maximize its profit margin.

1.4 SUMMARY

The purpose of this IQP was to equip our group with financial knowledge about trading, investing, and portfolio management to create a systematic profit. At the beginning of this IQP, the team had little to no knowledge of the logistics of the market. But through the help and support for our advisors, we were able to gain insightful information that will benefit us far beyond this learning experience, as well as knowledge on how to build a profitable trading system. Over the course of the year, we were equipped with knowledge on how to read graphs, understand the market, and think systematically to prevent losses. After many attempts of trial and error, and complexity build up, we developed three systems: A Gap Strategy, A Moving Average Strategy, and a Crossover strategy. Our team developed a profitable diversified system of systems that utilized the work previous professional traders and investors. It contains a two moving average crossover strategy operating on daily bars, a one moving average crossover strategy operating on daily bars, and a gap up and down strategy operating on 60-minute bars. The derivation of the strategies will be explained in depth in the Strategy sections below. Of the many professional investors we acquired information from is Charlie Wright. In his book,

Trading as a Business, he gives a deep understanding of trending markets; in which two systems utilize them. He states that trending markets sustain a large increase/decrease in price over a considerable amount of bars; and the direction is indicated by price movement. Based on his explanation, the average moving strategies were modified to detect the direction of the market, and lock a position given information from previous data.

2 TRADING & INVESTING

2.1 RETAIL TRADER VS. INVESTOR

Investing is the idea of gradual build-up of wealth over longer extended period of times. This is achieved by buying and holding securities, such as futures, stocks and options. They are long-term profit seekers, in which they make most of their profits through compounding, and reinvesting their previous profits into additional securities. They hold their investment for years, and sometimes even decades. Taking stock as an example, these "investors view themselves as the partial owners of the company they are investing with," (Extension) as well as always predicting success of that company by following current news and other informative means. They are expected to be in the market through inevitable fluctuation, and "ride out" any waves in the market. The main advantage of investing is that it yields such higher profits on the long run, compared to trading. It requires less effort to be in the market, since they are consistent with the company of choice. However, if the company invested in did turn out to fail, they could potentially lose all their profit and their invested money as well. They tend to look for a 10% to 15% profit annually on investment.

Traders on the other hand, are frequent buyers and sellers of securities. They purchase those things as a mean to capitalize on a shorter-term fluctuation to generate a profit. They do not view themselves as owners of the companies they hold stocks with, however, they look for stocks that contain certain pre-set profiting characteristics. They exploit previous data, and watch for recurring signals, whether it is success or fail for the company. Compared to investors, who will wait out the periods of losses with the outlook that the market will rise again, traders will

identify the loss, reset their trading strategies and systems, and enter a different company/market. The main advantage for traders is that they are able to generate profits in shorter periods of time. They do not generate huge long-term profits, and usually look for 10 percent monthly profit.

2.2 INTRODUCTION TO BASIC MACROECONOMICS

In the study of macroeconomics, which is a field of economics that studies behavior of the aggregate economy and examines economy-wide structures such as unemployment national income, and price levels. In terms of business, two terms always arise, trend vs. cycle. A trend is a general direction that a variable is moving over time. In stocks for example, a market is described in terms of trends. A trend could either be upwards or downwards. On a related note, a business cycle is a period of economic growth, that is followed by an economic withdraw. It is defined as a cycle of it repeats over a period of time (Dollars and Sense).

In terms of equities, and future markets, a bid price is the highest price a buyer is willing to pay, while an ask price is the lowest price a seller is willing to accept. A spread is the difference between those two, which inversely relates to volume; the number of shares or contracts bought and sold. There are two methods to trade in stocks, long and short. A long stand means that the trader is buying a stock at a current price, and anticipating to sell it since the price will go higher. However, a trader could also short a trade, which means borrow stocks from a broker, and selling it for a lower price; making the profit due to the price difference. When a trader decides to sell a stock that has been longed, a trader can either place a limit or marker order. A limit order is a pre-set price that the shares should be sold on, where a marker order is immediate, and takes the trader out the market whenever decided. To aid in covering losses, a

trader will often use a stop loss, which is a price that is pre-set to close a position if a price falls under it. There are four asset classes: Equities (stocks), Bonds, Currencies, and Commodities.

2.3 THE 4 ASSET GROUPS CLASSES

2.3.1 STOCKS

Equities, or stocks, are a representation of a company's ownership. They are one of the main methods that a company can raise its capital. There are many different sectors of stocks including: technology, energy, housing, and many more. The market opens at 9:30 AM and closes at 4:00 PM Eastern Standard Time. ETFs, or Exchange Traded Funds, tracks a bond, index, currencies, or a group of stocks, and these traded in terms of a representation of a group of investments. As oppose to a mutual fund, ETFs trades as a normal stock without extra management fees. On the other hand, mutual funds are money-managers controlled, which is invested and moves assets around to make profit; requiring a fee to do so. In stocks, options are available, which are a financial asset to be traded in the market. It gives the trader the right, rather the obligation, to buy a stock at a pre-set price when the option was bought, also named a call option. A put option however, gives the power to the trader to sell the stock at a price previously set. There are two main equity markets, the NASDAQ and NYSE.

2.3.2 CURRENCIES

Currencies are traded in a global decentralized market, known as the forex, or foreign exchange market. They are placed in pairs, and they rise and decline in units of pips. A pip is a percentage in point, which denotes the smallest price a currency pair could potentially make. It is a change in price carried out to two-four decimal places in the exchange rate depending on the currencies. They could be traded at any time of day, unlike stocks. They are usually highly

leveraged, depending on the broker, which could lead the leverage to be as high as fifty to one. An example for a fifty to one leverage, if a trader has a $100, that means they could trade of up to $5000 of currency!

2.3.3 BONDS AND COMMODITIES

A Bond is a debt investment in which an investor loans money to an entity, allowing the funds to be borrowed for a defined period of time at a fixed or variable interest rate. They are used by companies and states to raise money and finance projects. They are defined to be as fixed-income securities. When a company needs to raise money, they issue bonds to investors, rather than borrowing a loan of a bank (Yale). This gives the investor a bond with an interest rate that will be paid for once the bond is returned. Commodities are basic commerce goods that are interchangeable with commodities of the same type. They are used as inputs in production of other goods and serves. Some examples of commodities are: Gold, Beef, and Oil. Their trades are usually placed through futures contracts on exchange that standardize the quantity and minimum quality a commodity is being traded.

2.4 INTER-MARKET ANALYSIS

2.4.1 STOCKS

The US economy is a large contributor to the market and it's movement. However, international affairs are also able to affect the stock market. Many variables are taken into consideration when understanding how the stock market changes. Unemployment news, Federal Reserve, and even terrorism, are able to shift the market up or down. The market is also highly influenced and controlled by humans, who are emotional, fearful, and easily manipulated. This could be harmful to investors and traders due to the concept that a company's stock can easily

change based on all these variables listed. Companies release an earning report that analyses the company's loss or profit per share every quarter, as well as important news that the public should be made aware of. These releases are detrimental to start up and new companies, they are the proof of the wellbeing of the company, as well as its advancements. A bad report will result in a decline of investing, which could ruin a company. Corporate news is also another variable that could greatly affect the market. If a pharmaceutical company were to release a new breakthrough in a medical advance, for example, their stocks would rise almost immediately.

2.4.2 Advantages and Disadvantages of Stocks

Liquidity is used to describe how easy it is converting an asset into cash, since cash can be used easily and immediately. However, stocks tend to have a different meaning of liquidity - the ability to convert a stock into cash. A stock is termed liquid if the shares can be sold without greatly impacting the stock's price. A way to analyze liquidity, is to look at a company's bid/ask spread, and is typically below 1%. This could be a potential way to measure the strength of a company, as well as make it easier for investors to decide their position. Stocks are traded on a margin requirement, which is a percentage of marginable securities that an investor must pay of his/her own cash. For example, if you have $1,000, and if a company requires a 50% margin requirement, you are only able to buy stocks of a maximum of $2,000. This puts a limit on how much an investor invests, which could hinder their profitability margin if the company's stock rises. When trading in the stock market, one must consider taxes. There are two possible ways taxes could affect one's stocks. If the stock pays a dividend, then those dividends will be taxed at a rate of up to 15% each year! Along that, an extra 15% is taken of every profit made over the year. When addressing stock trading, there is usually a commission that a broker collects on each

trade. This commission usually ranges from 7 to 12%. This is an important key aspect to keep in mind when building a trading strategy: it must trade at a rate in which it does not lose the majority of its profit on commissions.

2.5 BREADTH OF THE MARKET

A stock exchange is a well-regulated, organized financial market, in which securities are bold and sold at prices set by supply/demand. They serve as the primary markets where corporations, governments, and other incorporated bodies can raise capital. They help to maintain liquidity in the system by giving the opportunity for investors to buy/sell securities: aiding in cash flow. Currently, these trades are conducted via a telephone and/or internet network. The three largest exchanges in the world are the New York Stock Exchange (NYSE), London Stock Exchange (LSE), and Tokyo Stock Exchange (TSE).

3 TRADING SYSTEMS

Thanks to the advancement of trading platforms, people/firms associated with the financial world today no longer have to focus on manual trading – instead these platforms he financial world today is leading more and more to electronic/automatic trading. the manner in which trades are being done today has evolved exponentially in the recent years. Some traders use Trading Platforms while others have brokerage accounts.

3.1 TRADING PLATFORMS

Trading platforms are developed, computer programs that allow people to analyze and buy/sell different stocks, bonds and other financial assets. Tradestation and OptionsXpress are some examples of these platforms. Tradestation was used for this inter qualitative project. In Barron's 2015 Best Online Broker Ranking, Theresa W. Carey had nothing but approval for Tradestation – saying how it "offers terrific tools to those who want to develop a trading strategy based on technical and/or fundamental data, plus the ability to backtest it and improve it" (Carey).

Tradestation is a brokerage, and just like any other brokerage it comes with commissions and fees. However, these platforms are so rich and advanced they offer individuals all the tools needed to become successful traders in the financial market. As Theresa puts it, "the sky is the limit for Tradestation when it comes to trading tools" (Carey).

3.2 STRATEGIES AND OTHER LOGIC

Trading strategies are programs within programs that are developed to follow a specific cycle of steps in order to reach profitable gains. These steps, or better yet rules, will be discussed

later on in this chapter. Platforms such as Tradestation offer a great deal of different strategies to choose from. In this section, Charlie Wright's "Trading as a Business" will be referenced to talk about market types and patterns. Three market types exist out there: trending, volatile, and directionless. A trending market is characterized by a large, sustained increase or decrease in price. Up-trending markets make higher highs and higher lows, while down-trending markets make lower highs and lower lows. A volatile market is characterized by sharp jumps in price. And a directionless market is characterized by small, insignificant up/down movements in price with a general sideways movement (Wright).

3.2.1 TREND FOLLOWING SYSTEMS

A trend following system must always do one of the two things: be in the market or have a stop order resting above/below the market. That being said, an exit order for a long is accompanied by an entry order for a short and vice versa. They generate a low percentage of winning trades. Markets only tend to trend 15% of the time. Also, it is very hard to trade psychologically (Wright).

3.2.2 VOLATILITY EXPANSION SYSTEMS

In a volatility expansion, price suddenly leaps out of its low volatility trading range b/c something is up. Volatility expansion systems measure recent volatility and attempt to buy an abrupt upside breakout with increased volatility or sell an abrupt downside breakdown with increased volatility. Common volatility measures include gaps, ATR, and the spread between two EMAs. Volatility expansion systems do well in volatile markets. They have a high percentage of winning trades but generate a small amount of profit per trade. Also, they usually make relatively quick exists (Wright).

3.2.3 SUPPORT & RESISTANCE SYSTEMS

Sometimes called "over-bought/over-sold," these systems try to profit from swings in directionless markets. They try to capture price movements that are opposite to those captured by trend following systems. In fact, these systems lose money during trends because they keep shorting a market in an up-trend and buying a market in a down-trend. Generally speaking, support and resistance systems generate a higher percentage of winning trades relative to trend following systems but with a smaller amount of profit per trade (Wright).

3.3 AUTOMATIC V. MANUAL TRADING

Automatic or manual trading has been a consistent topic following the financial world for years now. Automatic trading is based on a fixed plan. It follows a fixed set of rules and then determines automatically when to enter and/or exit the market. A model will never drift away from these rules. As mentioned before, this can be helpful or detrimental to a system.

On the other hand, manual trading calls for human intervention and human decision when entering or exiting trade positions. No two people are the same when looking at categories such as character, individuality, interests, beliefs, etc. Some believe in computer models while others do not, some are open to experiment with new things while others are not, and the comparisons can go on and on. That being said, there is no way of choosing one investing strategy over the other. That decision depends solely on the individual and his or her preference.

3.4 FUNDAMENTAL V. TECHNICAL TRADING

In the world of finance, people use fundamental and technical analysis as tools to determine whether or not an investment is attractive. When making evaluations and determining

whether or not to invest, there are two ways to look at it from a fundamental or a technical standpoint. These two methods of analysis represent fundamentally different philosophies when it comes to making money, and are used under very different circumstances. Fundamental analysis refers to analyzing a financial instrument utilizing news stories, earnings, economic events, and any other resourceful information. On the other hand, technical analysis refers to analyzing a financial instrument utilizing market data, market indicators, and charts.

Fundamental analysis takes into account the most basic aspects of a company's financial strengths (WStreet). For example, if fundamental analysis is to be used to evaluate a company one might take into account the company's financial statements, management team, products, competitors, and industry. On the other hand, technical analysis takes into account past trends to predict how a company will do in the future. If using technical analysis to evaluate a company, one might take into account price, volume, and charts. Technical analysis typically utilizes different charts patterns, chart setups, and price movements to derive good entry and exit points.

Investors or long term traders focus more on fundamentals since they show up in long term price movements. And that involves looking closely into a company's earnings and the company's debt. Day or short term traders focus more on technical analysis since they show up on a day to day basis. Technical analysis involves looking solely at a stock's chart to predict where that chart is going to go in the short term. This is because company fundamentals are not always portrayed in the day-to-day price movement, however technical setups exist everyday. All in all, whether a person decides to evaluate something using fundamental or technical analysis solely depends on his or her preference and mentality.

3.5 RULES FOR TRADING SYSTEMS

Trading systems are collections of rules that are coordinated to work together. Such components that all trading systems must possess are entry rules, exit rules and position sizing rules.

3.5.1 ENTRY RULES

Before a strategy can enter the market, it must follow two sub-entry rules: set-ups and triggers. Strategies have specific set-up conditions that indicate whether or not a specific strategy is ready to be implemented for trading. Following that, trigger rules confirm the set-up; they indicate the ideal time to enter the market. Such detailed rules are created by traditional techniques, theory, world news, a great deal of fundamental and technical analyses, etc. Once these sub-entry rules are met, a strategy is ready to enter the market.

3.5.2 EXIT RULES

One of the most difficult concepts a trader can master is knowing how far he or she can, and should, go until pulling out of the market. Not exiting the market too early or too late is a crucial aspect that strongly depends on an individual's volatility level. Exit rules significantly influence the expectancy of a system. Rules exist for exiting with a profit, with a loss, or after inactivity. Exiting with a profit is based only on price, where the trader automatically exits the market once he or she has reached his or her intended profit margin. Similarly, an exit with a stop loss takes a position out of the market once it has reached a new, low value. This prevents traders from significant losses. Applying rules to positions that are non-performing is known as an inactivity exist. A position is considered non-performing when its generated threshold for the

profit/loss amount is proportional to the volatility of the asset being traded. As implied, exit rules with a profit and/or loss are crucial components in managing one's trading positions.

3.5.3 POSITION SIZING RULES

Some rules for exiting with a profit or stop loss are intertwined with position sizing. Position sizing rules specify how much money to place on each trade. This rule is very important as it offers traders a balance between not risking too much or too little money. Several techniques exist for specifying a position sizing rule, but it is known that Anti-Martingale techniques work best. This technique shuts down losing trades and doubles up on winning trades. As Steve Connell says, "Unlike forward Martingale it doesn't have 'fat tail' risks" (Connell).

3.6 ORDER TYPES

In the financial market, a trade is executed by the use of order types. There are different order types such as market orders, stop orders, and limit orders. A market order is an order to buy or sell a stock at the current bid ask price. It is used to take a position in the market without any restrictions on what the price should be. On the other hand, a limit order is set at a specific price. Limit buy is a target price that allows a person to buy low and sell high. Another type of order is a stop "loss" order. It triggers a market or limit order once a specific stock price is reached. Stop orders allow the trader to either enter or exit at a specific price.

3.7 TREND FOLLOWING STRATEGIES

One of the most common trading methods is Trend Following trading - the prediction of trends/patterns in the market utilizing previous data. The individual using this style of trading is thought of as an investor for the company; willing to stay in the market and bear the swings to

attain long term profit. An investor must use technical analysis, indicators, and entry/exit rules to minimize losses during the trend that a security is exhibiting. In a short book written by John Palatine, Master Trend Following, he states that "once we (the investors) get into a trade, we want to follow the trend until the market exits for us, because this is where the really big money is made. Trends last weeks and months if there is fundamental backup; trend following a stock means trading a story" (Palatine). When it comes to trends, there are two terms often used to describe the market: bullish and bearish. A bull market is a market with an upward trend, while a bear market is a market with a downward trend. Investors long-buy bullish markets if they see potential in the company, and willing to risk staying in for the swings, while other investors short-sell a bearish market if they know the company is failing and will not change direction into the positive for a while.

A Moving Average Strategy usually trades only a few times over a year period. The system is only designed to take advantages of big market swings. They risk the fact that over a large holding period major losses due to noise in the market might accumulate. Market noise is due to the volume/price fluctuations due to investor's confusion in terms of interpreting the direction of the market. That means that for a short time frame, there is an increased likelihood of difficulty to separate noise from quantifiable data in terms of market movements; leading to major losses compared to holding a position for a longer period of time and analyzing random fluctuation of the market.

3.8 GAP STRATEGIES

In the real world, a gap is defined as a hole in an object or between two objects. However, in trading, a gap is a zone defined by the prior day's open, high, low and close with a

potential that a big gap could actually open up the next day. Acute awareness has to be given into where the gap opens up the next day, as location is critical in these strategies. There are four types of gaps: full up and down gaps and partial up and down gaps. A full gap up is when the opening price is higher than prior day's high. A full gap down is when the opening price is lower than the prior day's low. Likewise, a partial gap up is when the opening is higher than the prior day's close, but lower than the prior high. While a partial gap down is when the opening is lower than the prior day's close, but higher than the prior low.

Gap strategies are an easy way to do some momentum investing. With rolling stop losses, the downside is pretty limited, while the upside is limitless. Full gaps are a safer bet, but partial gaps provide more profit potential. In all cases, first hour of trading is key. A trader who decides to study and implement this strategy has to be watchful of the way the stock seems to be headed, as this is the key to successful implementation of any gap trading strategy.

There are opening gap opportunities that occur just about every single day. And often the biggest move of the day is at the open. So that creates a tremendous opportunity to get in if you can use the leverage of futures, margins, or options, you can take advantage of that initial opening move.

4 OPTIMIZING AND ANALYZING TRADING SYSTEMS

4.1 OPTIMIZATION

The definition of the word *optimize*, according to the Merriam-Webster Dictionary, is "to make (something) as good or as effective as possible." In the context of trading and investing, the most effective strategy, or the ideal trading system, would be one that satisfies all user requirements. In the most general sense of satisfaction, the ideal strategy would be most effective at minimizing losses and maximizing profit while maintaining a low risk factor.

Over the course of history, the word optimization in trading has been interchanged with the word curve-fitting. Curve-fitting is a term that describes the statistical analysis of approximating or *fitting* a line or *curve* to a given set of data; in this context the market (Rice). *Overfitting* is when this is done extensively and the fitted curve essentially begins to be an exact fit. Again, this term is sometimes confused with curve-fitting.

Overfitting is a result of extensive curve-fitting, and is a statistical term for a curve-fitting model that is excessive in terms of fitting the data. This occurs in a trading system when there are so many rules and parameters added to the system that the strategy begins to fail by predicting optimistic-like data that most likely will not occur in the future market. It is important to know the difference between optimization and these statistical terms, and to fully understand the potential negative side effects of excessive data analysis to ensure the most beneficial results from a trading system.

Optimization is a technique used by investors and traders that deal with technical analysis. The act of optimizing one's trading system means that the trader or investor is adjusting

the system while keeping the goal of making it more effective in mind. Some adjustments may include, but are not limited to: altering the period used in moving averages, changing the amount of indicators used, or eliminating portions of the strategy that appear to negatively affect the strategy.

By changing some of the parameters in a trading system in an attempt to optimize the trading system the trader will obtain alternate profits, capital drawdowns and different risk patterns associated with the new system parameters. There is typically no right or wrong optimization, but in terms of the trader's personal preferences, optimization helps determine the optimal parameters to trade.

Overall, optimization is used to improve a trading system that is working, but still has some imperfections. These imperfections may include, but are not limited to: specific events that result in losses, rules that are too broad, or failure to maximize profits.

4.2 WORK-FORWARD ANALYSIS

The walk-forward analysis is determined by using the walk forward optimizer in TradeStation. It automates the complex and multi-step task of running statistical walk forward testing on two sets of data. One set of data is the in-sample data, and the other set of data is the out-of-sample data. This tool optimizes the system inputs for the data and then are applied to the out-of-sample data to measure performance. This allows for statistical performance analysis to see if the optimized system inputs perform well on the out-of-sample data. The walk-forward analysis provides useful information to measure if the strategy will perform well on live trading. The total data of the symbol being traded is divided into multiple segments. Each segment of

data is further divided into in-sample and out-of-sample data. The in-sample data is usually 80% and the out-of-sample data is 20%. The optimizer then performs optimization on the in-sample data while not seeing the out-of-sample data. Then the optimized inputs are tested on the out-of-sample data to simulate live trading. After this the optimizer moves to the next subsection of the symbols data to perform this test again. This is repeated until the entire data set for the symbol is tested and optimized. Below in Figure 1 is a visual representation of the segment analysis used by the optimizer.

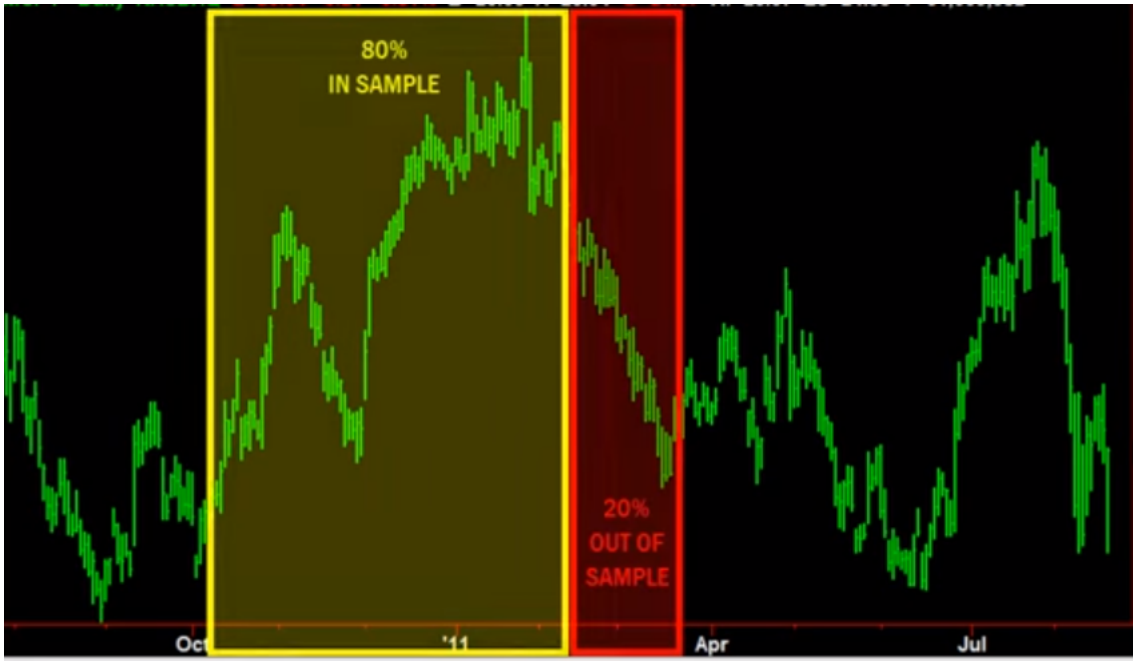

FIGURE 1: SEGMENTED WALK-FORWARD OPTIMIZER EXAMPLE

The Walk-Forward Analysis is a way of optimizing a trading strategy after you have already used a particular set of historical data to back test and optimize the strategy based on a specified time period. Thus, if a trading system passes a rigorous Walk-Forward Analysis, then it is suggested to be ready for live trading. In conclusion, the test will determine if the trading

model will make money, what rate it will make money at, and how the changes in market conditions affect performance (Pardo).

4.3 EXPECTANCY, EXPECTUNITY, & SYSTEM QUALITY

Expectancy measures the average profit/loss that a dollar risks per trade, while annualized expectancy is called expectunity. Those measurements are used to analyze the profitability of a system. The system is profitable if it exhibits a positive expectancy, and both expectancy and expectunity are important aspects to evaluate the system's long-term profits. Expectancy and expecunity are able to inform the investor about a system's profitability even if the investors observe multiple losing trades in a row. This allows the investor to evaluate the system as a whole and not just the "in a row" losing trades evaluation. When comparing different systems, it is important to evaluate them over a long period of time to get real quantifiable data. Expectunity is able to provide the annual analysis; allowing investors/traders to evaluate and compare systems in an analytical/profitable manner. In summary, expectancy and expectunity are able to inform the investor/trader if the system is profitable overtime, as well as aid the comparison process of analyzing different systems.

Van Tharp has explained the way expectancy and expectunity are measured. The way expectancy is calculated is using two conventional methods of summing R-multitudes (Risk to Ratio) intervals. The first method sums R-multitudes generated from each trade's profit/loss and divides them by the system's largest loss. The second approach sums the R-multitudes generated from each trade's profit/loss and divides them by the system's average loss. Based on the mathematics, the first approach that uses the largest loss yields a more conservative estimate compared to dividing by the average loss. This is beneficial because it gives the investor the

"worst case scenario" of the system; increasing the investors confidence. To calculate expectunity, simply multiply the opportunities of the system that is achieved in a year by the expectancy.

System quality is another analytical tool to evaluate systems. It calculates the ratio of the total profit/loss compared to the total variability of the profit/loss per dollar risked. This quantifiable measurement is obtained by multiplying the expectancy by the square-root of the trades together, and dividing the result by the R-Multitudes standard deviation. A system is said to have the upper "system quality" if the profits/losses are more consistent compared to another system that has high variance of profits/losses, even if both systems are equal in expectancy.

4.4 MONTE CARLO ANALYSIS

A Monte Carlo analysis is a simulation that is computerized to evaluate risk in quantitative analysis. It builds models of all the feasible results by inputting a maximum and minimum set of values, known as a probability distribution. It then recalculates the results multiple time while using a different set of random values to generate new values. In summary, it is a method to calculate uncertainty, as well as feasibility of a set of numbers using randomized data ranges. This analysis portrays confidence yields over an interval that tests the rates of return and maximum drawdowns. A Monte Carlo analysis is used to check the performance of a system. The trials generated by the program include a 95% confidence interval graph of the system's drawdown.

4.5 SYSTEM OF SYSTEMS

Many successful traders use more than one trading system. A system of systems is a way of comparing and contrasting different systems. It must leverage between the strengths and weaknesses of other individual systems. It must exhibit a form of stability that allows an investor/trader to take the risk given the trading portfolio. A strong system of systems must have a desired system quality, profit factor, and minimum drawdown so the risk is tolerable. A system of systems must work in a way that maximizes profit. It must work simultaneously to make sure it does not ruin an individual strategy. System quality, calculated using a specific formula, is a method used to compare multiple, different trading systems. Using system quality, each individual system could have a weighted percentage of how much it receives when executing trades from the total equity. One of the most important aspects of a system of systems is money allocation. This aspect is based on the performance of each individual system and is thus calculated based on profit, losses, drawdowns, etc. As important as it is to analyze each system individually, it is just as important to analyze the overall portfolio as a system of systems.

5 LITERATURE REVIEW

Before describing the details about the individual trading systems, a brief introduction to trend following systems in necessary. The definition of a trend can be described as the direction that the market is currently moving in. The three types of trends include the uptrend, downtrend and the sideways trend. An up-trend would be described as a period of time where the overall net price of the security is going up while ignoring the noise of small price fluctuations. These trends are used to develop systems that will signal market positions based on trading rules that are aimed to find bullish or bearish moving markets (Jankovsky).

Many traders have developed moving average crossover systems that involve fast and slow moving averages. In Charlie Wright's Book, *Trading as a Business*, he describes many moving average systems and the trading rules involved. Examples of system set-ups that many traders use include a fast moving average crossing a slow moving average, prices moving outside of a price channel, using the relative strength index indicator moving into overbought or oversold territory, using the stochastic indicator or using a moving average envelope for prices that reach specified upper and lower bounds (Wright).

Similarly, when it comes to gap strategies, a trader named Scott Andrews was closely studied. Andrews is the CEO and Co-Founder of the financial service company InvestiQuant. Known by many as the "Gap Guy," his keen analyses of gaps was closely examined and studied for the purpose of this project. Unlike trending markets, gaps fall under a volatile market. According to Andrews, full gaps are a safer bet, but partial gaps provide more profit potential. In all cases, first hour of trading is key. A trader who decides to study and implement this strategy

has to be watchful of the way the stock seems to be headed, as this is the key to successful implementation of any gap trading strategy.

According to Andrews, there are opening gap opportunities that occur just about every single day. And often the biggest move of the day is at the open. So that creates a tremendous opportunity to get in if you can use the leverage of futures, margins, or options, you can take advantage of that initial opening move. Gaps are an easy way to do some momentum investing. With rolling stop losses, the downside is pretty limited, while the upside is limitless. That being said are many different ways to trade gaps successfully (Andrews).

6 FANCHER'S TRADING SYSTEM

6.1 SYSTEM DEVELOPMENT

Before this project, I would have considered myself to be financially inexperienced. After spending A-term learning about the economic system and what governs the economy, I set myself up to be able to successfully produce a profitable automated trading and investing strategy. I continued my research into B-term, where I first started familiarizing myself with the TradeStation trading platform, EasyLanguage, and the different markets. After completing my research in B-term and becoming acquainted with the platform, I was able to begin exploring and testing strategies, stocks, and various parameters in C-term. I was naturally drawn to equities because of my young age, the potential for asset growth and the more aggressive nature to stocks. What I learned was that, if done right, trading and investing in stocks has the most potential to grow your money over time. This is appealing because a better retirement can come from trading and investing stocks by yielding in a significantly greater amount of money than you would have yielded otherwise. Another attraction to trading stocks is that you can take advantage of the volatile nature of certain stocks with day trading strategies or ride out the ups and downs of the stock to result in long term asset growth. This is where I began exploring types of day trading strategies.

After concluding my research I became more familiar with a financial analyst named John Murphy. John Murphy is a well-known financial analyst who started his first job as an assistant at CIT Financial Corporation and was later promoted to Director of Technical Analysis. Murphy went on to publish what is considered to be the standard reference of technical analysis,

the *Technical Analysis of the Futures Markets*, and laid the foundation of the *Ten Laws of Technical Trading*. When I was first starting out these laws were useful in developing a preliminary strategy. These ten laws include: map the trends, determine the trends, find the low and high, measure percentage retracements, draw trend lines, follow moving averages, track oscillators, know the warning signs, determine the market type, and know the confirming signals. These general laws allowed me to go through a detailed process for my system development, and also lead me to explore the power and simplicity of simple moving averages. To utilize a simple moving average and the indicators, it is necessary to determine which type of strategy you will use to trade with, so I explored buy and hold systems. Below, in figure 1, is an example of a 'buy and hold' system. Entry and exits shown by the blue and white arrows respectively, and profit shown by the blue dotted line.

FIGURE 2: EXAMPLE OF BUY AND HOLD SYSTEM

Buy and hold systems are great for making long term gains, but after reading about John Murphy's investment strategy I became more interested in trend following based on technical analysis of market prices. In figure 2 below, there is a depiction of a buy and short system. The chart shows a Buy with blue arrows and a Sell Short transaction with red arrows while the exits are shown with white arrows. Profit is shown by blue dotted lines.

FIGURE 3: EXAMPLE OF BUY AND SELL SYSTEM

These two examples are arbitrary and do not resemble any real trades. Through my research and experimental practice with trading systems, I have grown to agree with the fundamental rules of technical analysis set by John Murphy. It may be true that buying and holding will result in a statistically more significant amount of money over the long run.

However being a young adult, I am more interested in the intricacies that come with technical analysis of the market to create buy and sell systems that will yield in short term profits.

6.2 SYSTEM DESCRIPTION

Being a college student who has recently become acquainted with finance and the economy, I was directed toward the stock market due to the potential for large gains over short periods of time. My young age allows me to be more aggressive with my asset mix, and thus, equities are the perfect candidate for this. I explored stocks that I would be most interested in trading. My guidelines for determining the right type of stock include examining the performance of the stock to see if there are any recent breakouts, what the company is currently doing, how their performance has been in the last year, and how stable the stock is. A simple moving average (SMA) strategy is an equity market stock trading strategy that falls into a trend following category.

FIGURE 4: MARKET TREND AND MOMENTUM

A moving average uses x number of bars to look back on to calculate an average. The average is saved and recalculated every x number of bars to create an array of data points to create a curve. This curve is called a simple moving average. Other moving averages include exponential or weighted moving averages. The word simple indicates that there are no other extremities being used to calculate the average. The term cross-over indicates that when my simple moving average crosses a specified threshold, the system will trade long or short depending on the direction the trend is going (up or down). Going up will yield in a long trade, while a downtrend that breaks the threshold will sell short. Day traders have used trend following strategies like this one for decades and have yielded various results depending on the chosen

stock, time frame and parameters of the system. Due to this it is important to gain an edge to be successful.

I knew I wanted to be in the market at any given time, regardless of the direction of the trend; creating a Stop and Reverse system. A Stop and Reverse system is a system used to determine the direction of the security's trend; allocating position taking depending on the parameters entered in the system. For example, if a security is currently at $100.00 per share, and the price increases to $200.00 per share after 10 bars, the system should have detected an indication and placed a buy order before it fully reached the maximum price after 10 bars. The system should also indicate when the security decreases in price, for example if the $200.00 price starts showing indication of price drop, the strategy should exit the market to ensure maximum profit. The system is to apply the same methodology in terms of short-selling stocks as well; yielding in a system that is always in the market accumulating many trades and using price shifts as profit margins. Initially, my strategy was simple: I created a simple moving average, and set a mid line at 0 to utilize as a trigger. If the moving average crosses above the line, buy the stock. If the simple moving average crosses below the 0 line, short-sell the stock. However, this was a simple strategy that was not going to be profitable due to it's full dependability on just one indicator. After back testing with the strategy, I wanted to make it more unique with input values and include a more dynamic usage of indicators.

Below is the chart analysis, as well as the code used on Google from 2012-2016. My system utilizes two Simple Moving Averages and a midline, all intertwined to trigger trades. One moving average is a Slow Moving Average (shown by the red line in the figure below) and the other is a Fast moving average (shown by the yellow line in the figure below). The slow and fast

moving averages in my code are being calculated by twenty-five and five bars back, respectively. After determining these differences it averages them to create the curve. The mid-line trigger is set to zero (shown by the blue line).

FIGURE 5: JOE'S TRADING CHART

```
Inputs:
        SMA             ( 25),
        FMA             ( 5),
        Trigger         ( 0),
        ProfitTarget    (1000),
        TradeSize$      (100000);

Value1 = Average (Close - Open, SMA) ;
Value2 = Average (Close - Open, FMA) ;

If Value1 crosses over Trigger
    and (openpositionprofit > ProfitTarget) then
    Buy (TradeSize$ / close) shares next bar at market;

If Value1 crosses under Trigger then
    Sell Short (TradeSize$ / close) shares next bar at market;

If (MarketPosition = -1)
    and (Value2 crosses above Value1) then
    Buy next bar at market;
```

FIGURE 6: JOE'S TRADING RULES

6.3 SYSTEM ANALYSIS

To fully understand how the system works, a set of analytical tools must be used to verify the system and its operation. The system is analyzed based on: Back-testing, Walk-Forward analysis, Monte Carlos analysis, Expectancy, Expectunity, System Quality, and Position sizing.

This analysis uses a system strategy performance chart, which is used to calculate different parameters of data based on a system's performance over a selected period of time. This method gives a lot of insightful information at a quick access, Below is a figure of my system's profit chart used on GOOGL from 2012 until 2016.

TradeStation TradeManager Performance Report

! Real Body Long fifteen, GOOGL, 60 min., 5/9/2012 10:30:00 AM - 5/9/2016 2:30:00 PM

TradeStation Performance Summary

	All Trades	Long Trades	Short Trades
Total Net Profit	$71,381.07	$54,653.75	$16,727.32
Gross Profit	$252,302.04	$132,095.01	$120,207.03
Gross Loss	($180,920.97)	($77,441.26)	($103,479.71)
Profit Factor	1.39	1.71	1.16
Roll Over Credit	$0.00	$0.00	$0.00
Open Position P/L	$1,856.00	$1,856.00	$0.00
Select Total Net Profit	$63,974.47	$41,496.73	$22,477.74
Select Gross Profit	$214,794.23	$107,431.99	$107,362.24
Select Gross Loss	($150,819.76)	($65,935.26)	($84,884.50)
Select Profit Factor	1.42	1.63	1.26
Adjusted Total Net Profit	$43,672.58	$35,816.59	($3,577.36)
Adjusted Gross Profit	$235,665.74	$120,184.40	$108,586.18
Adjusted Gross Loss	($191,993.15)	($84,367.82)	($112,163.53)
Adjusted Profit Factor	1.23	1.42	0.97
Total Number of Trades	497	248	249
Percent Profitable	46.28%	49.60%	42.97%
Winning Trades	230	123	107
Losing Trades	267	125	142
Even Trades	0	0	0
Avg. Trade Net Profit	$143.62	$220.38	$67.18
Avg. Winning Trade	$1,096.97	$1,073.94	$1,123.43
Avg. Losing Trade	($677.61)	($619.53)	($728.73)
Ratio Avg. Win:Avg. Loss	1.62	1.73	1.54
Largest Winning Trade	$10,598.00	$10,598.00	$7,453.19
Largest Losing Trade	($4,687.00)	($4,687.00)	($4,241.56)
Largest Winner as % of Gross Profit	4.20%	8.02%	6.20%
Largest Loser as % of Gross Loss	2.59%	6.05%	4.10%
Net Profit as % of Largest Loss	1,522.96%	1,166.07%	394.37%
Select Net Profit as % of Largest Loss	1,364.93%	885.36%	529.94%
Adjusted Net Profit as % of Largest Loss	931.78%	764.17%	-84.34%
Max. Consecutive Winning Trades	12	8	8
Max. Consecutive Losing Trades	8	5	9
Avg. Bars in Total Trades	14.97	22.68	7.29
Avg. Bars in Winning Trades	18.97	28.03	8.56
Avg. Bars in Losing Trades	11.52	17.42	6.32
Avg. Bars in Even Trades	0.00	0.00	0.00

FIGURE 7: JOE'S TRADESTATION SUMMARY REPORT

In the market, my system had a total of 497 trades. My percent profitable based on the trades is 46.28%, which means that I have a less than 50% For my strategy, the total net profit is $71,381.07, with an overall price factor of 1.39. At first, my long trades have performed well at a profit factor of 1.71, however, my short trades had a price factor of 1.16; adversely affecting my overall profit factor. Given the low overall profit factor, the system needs adjustment; improving

on the performance of short trades in my strategy. A stop and reverse system should have a high number of trades due to its consistency chance of winning a trade, however, this doesn't mean the system cannot be profitable. It means that although I might be losing many trades, I am also winning a large enough number of trades that are higher in profit; making up for the different and reflecting on my positive price factor. The short trading is the main problem within my system, which if given enough time I would put an exit strategy to address the problem.

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Below is the equity curve generated in TradeStation for my system on GOOGL. It can be seen that the first 100 trades, the system dips; lacking to make profit. However, the system does overcome the losses, and exponentially increases over the trades; allowing certainty and hope that the system might have potential on the long run if modified and adjusted accordingly.

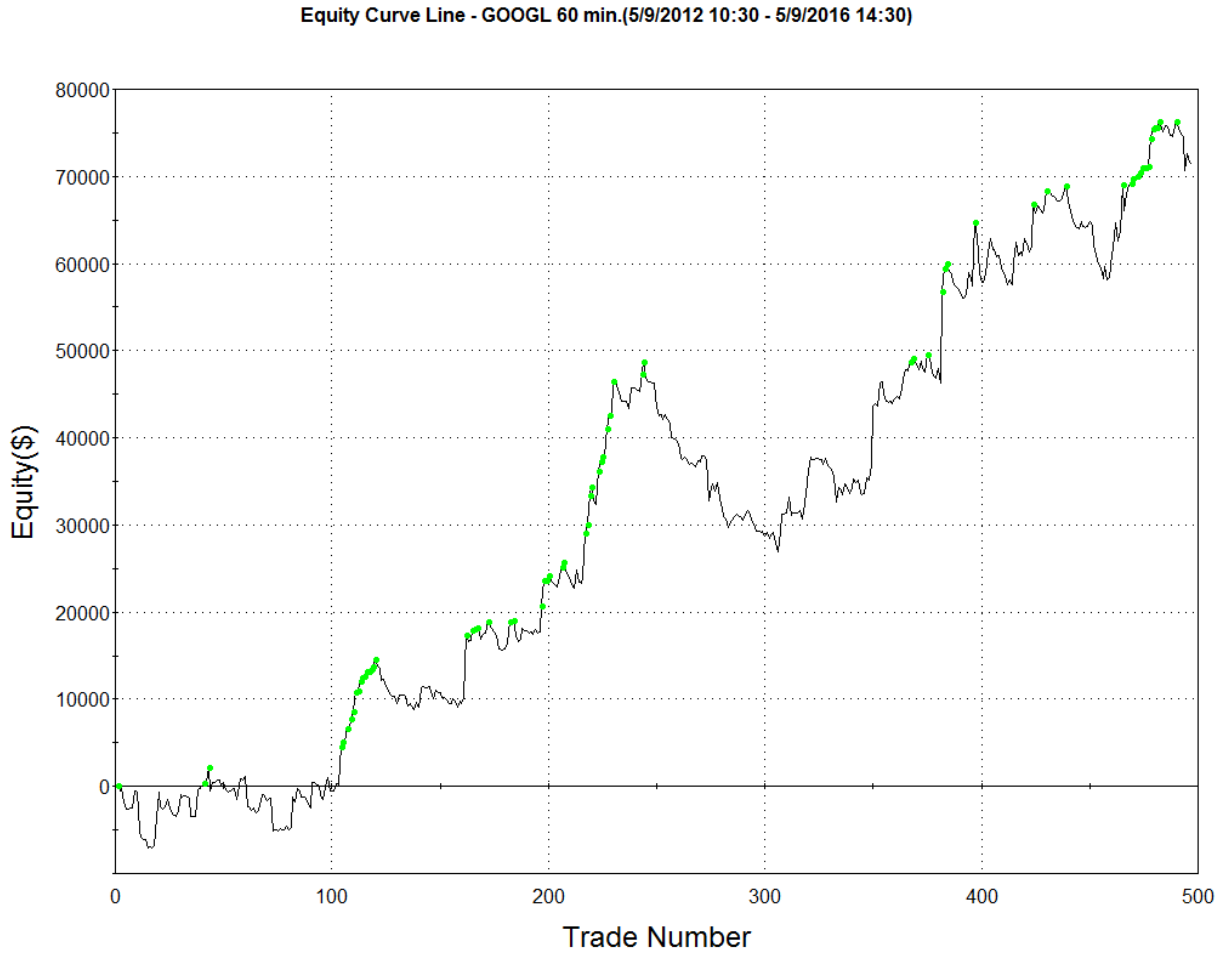

FIGURE 8: JOE'S TRADESTATION EQUITY CURVE

The Walk-Forward analysis is used to determine the best region of a historical data to use in terms of a trading system's parameters. A cluster analysis shown below, indicates my system's OOS% matrix. The green is the cluster that indicates the profitability in my system under the percentage of the historical data used. However, I also ran an efficiency test to see the extent to which the out of sample data is performing compared to the in sample data. This test is based on percentages, a 100% means that the system functions just as well on not-seen-yet data. Anything under a 100% means that it is performing worse. In my case, not one scenario achieved the 100%

zone indicating that my system might be overfit, however, it does only fail one scenario not achieving at least 50%. This shows that the system has the potential to be profitable with adjustments and that it has a high likelihood to not performing as profitable in the future compared to the past.

OOS% \ Runs	5	10	15	20	25	30
10	PASS	PASS	PASS	PASS	PASS	FAILED
15	FAILED	PASS	PASS	PASS	FAILED	FAILED
20	FAILED	PASS	PASS	FAILED	FAILED	FAILED
25	FAILED	FAILED	FAILED	FAILED	FAILED	FAILED
30	PASS	FAILED	FAILED	FAILED	FAILED	FAILED

FIGURE 9: JOE'S SYSTEM CLUSTER WALK FORWARD RESULTS

OOS% \ Runs	5	10	15	20	25	30
10	110.5%	72.0%	50.7%	87.7%	74.1%	35.6%
15	18.3%	50.7%	53.2%	64.8%	13.7%	27.6%
20	57.1%	68.4%	61.2%	45.2%	10.8%	9.1%
25	49.8%	43.7%	35.3%	26.1%	36.4%	31.6%
30	75.4%	35.4%	22.5%	33.4%	35.7%	25.6%

FIGURE 10: JOE'S SYSTEM CLUSTER WALK FORWARD EFFICIENCY RESULTS

	Test Criteria	Result	Comment
1	Overall Profitability	Pass	Total Profit > 0. System is likely
			to perform profitable on unseen data
2	Walk-Forward Efficiency	Pass	Walk-Forward Efficiency >= 50%. System is likely to perform in future
			at a rate between 50-100% of those achieved during optimization
3	Consistency of Profits	Pass **	80%+ of walk-forward runs were profitable.
			System is most likely to be successful in future.
4	Distribution of Profits	Pass	No individual time period contributed more than 50%
			of Profitable Run Total.
5	Maximum Drawdown	Pass	No individual run had a drawdown of more than 40%
			of initial capital.
	OVERALL RESULT	PASS	Walk-Forward Efficiency >= 0%. System is likely to perform in future

FIGURE 11: JOE WFO TEST CRITERION

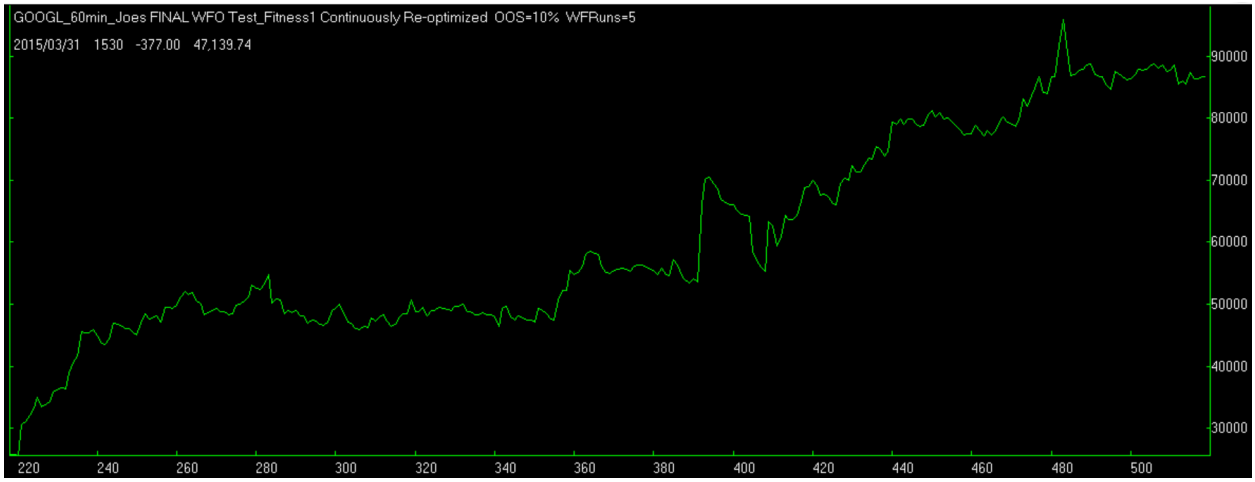

FIGURE 12: WALK-FORWARD OPTIMIZED EQUITY CURVE

The first thing to look at, is expectancy; a positive expectancy means a profitable system. It is an indication of how much the system profits per one dollar that is risked in the market (Tharp), meaning that the system is to make a profit over the trades it takes. However, relatively,

the expectancy is low; ideally a system should have high expectancy meaning that my system should implement improvements to better address the issue. From expectancy, you can measure expectuniy based on the number of oppertunites the system has over a trading period. Expectunity is the link of comparison to compare differnt systems that operate on different time frames (Tharp); meaning that a high expectunity indicates that a system frequently trades and has high opportunities in the market. To compare TSLA to GOOGL, expectancy and expectunity are higher on TSLA compared to APPL .This could be the result of flaws in my system, or that TSLA is not meating the system paramets well in terms of having it's trends detected well. Lastly, system quality is used to evaluate the allocation of money when analyzing a system of systems. System qualities will be compared all together in the System of System analysis to finalize monetary allocation between the team member's systems for maximum profit in the system.

I ran a Monte Carlo analysis, which is explained previously in the paper, on GOOGL due to it's better profitability and system expectancy/expectunity the analysis is used to analyze the perfomance of a system. The randomly generated trials produce a chart that contains a 95% confidence interval created for the system's drawdown. Below are the figures produced from the Monte Carlo analysis:

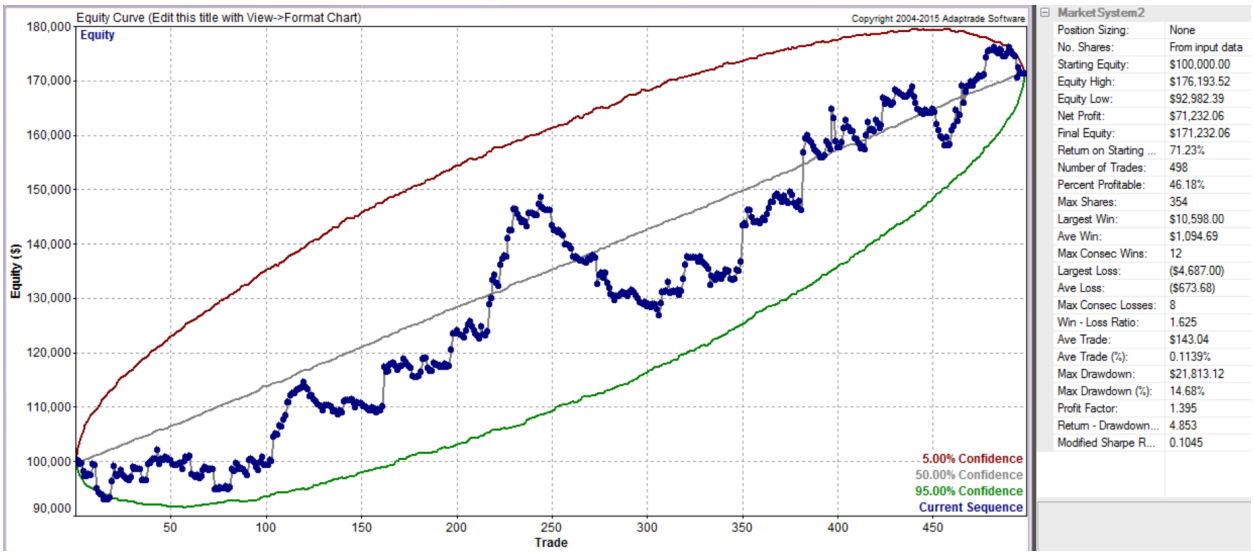

FIGURE 13: MONTE CARLO ANALYSIS

This graph depicts the 95% confidence intervals alongside the equity curve generated on the back-testing analysis. Based on the graph, the system does indeed profit over time. The system started with $100,000, and with a profit return percentage of 71.23% lead to an overall profit of $71,232.06. However, as promising as it may seem, this is just one scenario with optimized scenario.

Another graph is used to analyze future trades. The “Cone Prediction” is used to represent if future trades are within the 95% confidence zone (the green cone). My system does indeed fall within the “cone” region and that it is inside the projected confidence interval; indicating normal behavior of trades, as well as projecting positive future trades. If the future trades were outside the 95% confidence zone, it would be proven that the system needs to be adjusted or abandoned; it would not be ideal to keep trading the system if there is no confidence shown.

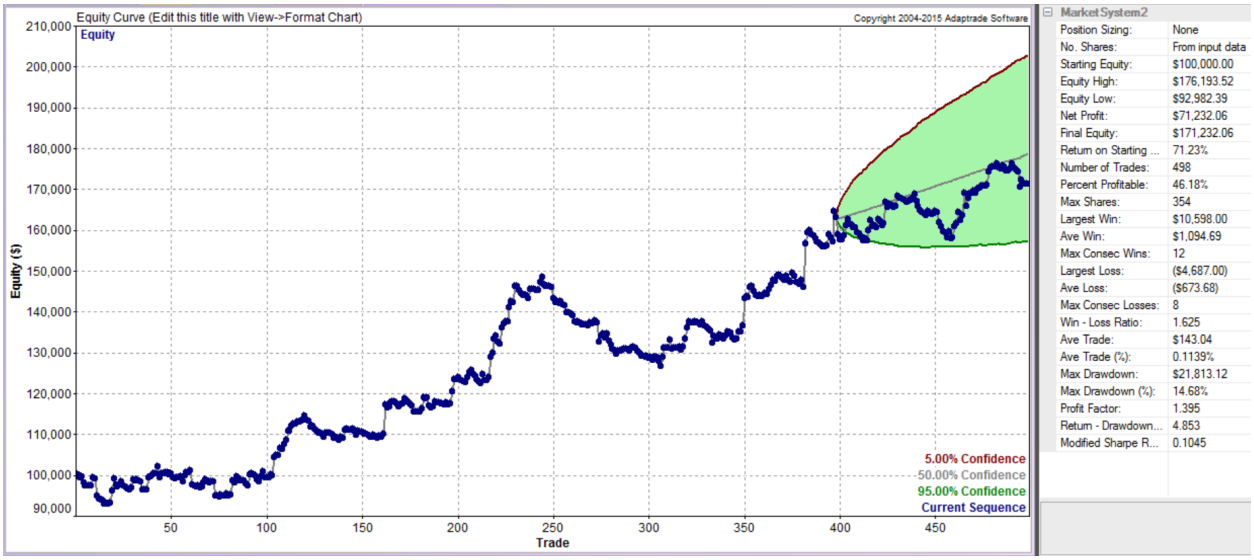

FIGURE 14: MONTE CARLO CONFIDENCE CONE

Another analysis used was position sizing strategizing. It exemplifies how large a position will be taken throughout the course of a trade. A fixed fractional position sizing is a position sizing methodology that limits the amount of money risked on a trade based on a percentage of the original account's monetary supply. It is a calculated percentage that tells the system how much to invest of the initial monetary supply. For example, if an account has $50,000 in it and the position sizing (a fixed fractional rate) is set to 10%, it means that the system is going to only risk $5,000 on the next trade. Position sizing is also able to scale-down if the account is losing money. Optimization is used with different fixed fractional rates each time; allowing for calculating the optimal fixed fraction.

I have already imputed a position sizing code in my system to allow more control in terms of a risk factor. In my code, I am using a specified dollar amount divided by the close price of the current bar to determine the size of the shares bought at the next bar. The reasoning behind this is that if the stock is trending upward for a long period of time, my code would prevent a

substantial loss of equity if for some reason the stock would drastically shift position. I ran an optimization position fixed fractional rate of 2%; the results were eye opening.

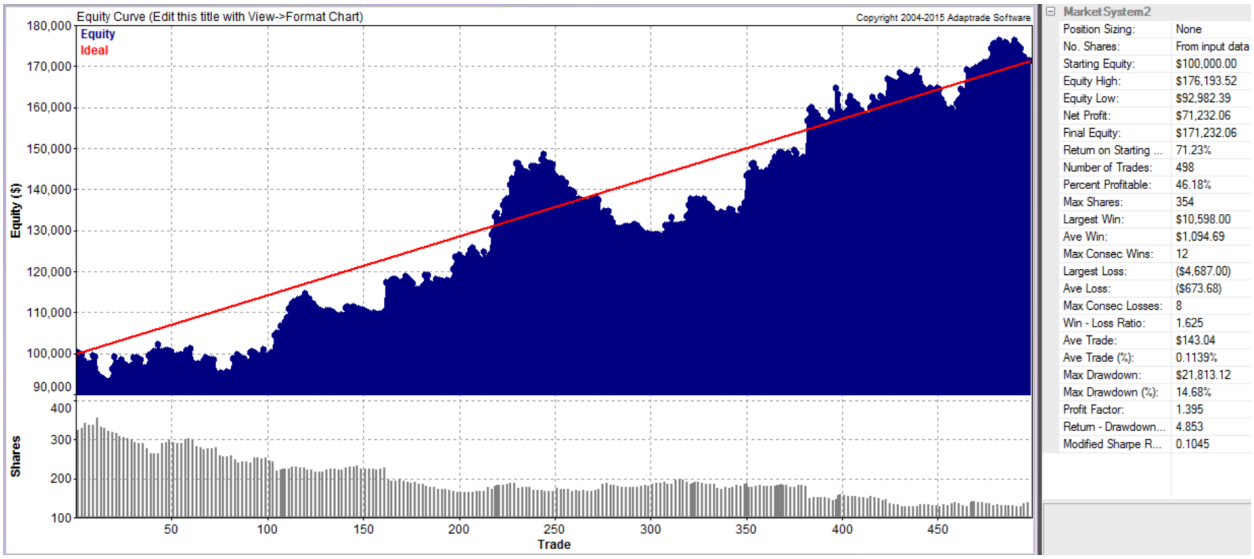

FIGURE 15: EQUITY CURVE BEFORE FIXED FRACTIONAL POSITION SIZING

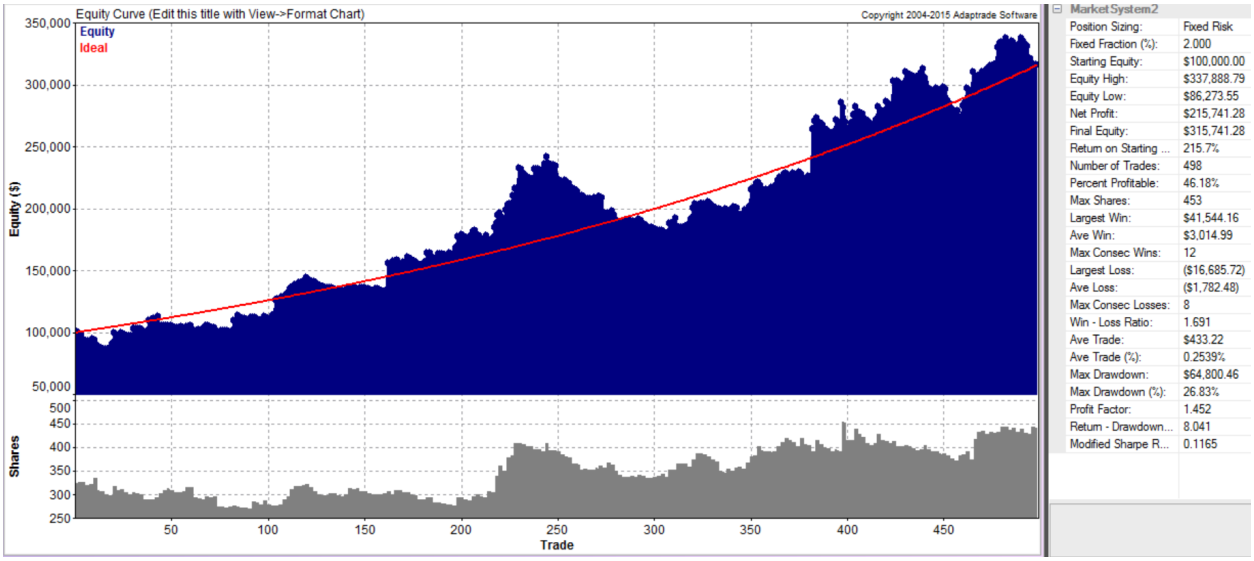

FIGURE 16: EQUITY CURVE AFTER FIXED FRACTIONAL POSITION SIZING

After testing with different fixed fraction values, a rate of 2% proved to be ideal for the profit, as

well as the risk I am willing to take as an investor. The net profit increased to $215,741.28, with a maximum drawdown of 26.83%.

Num Trades	498		Expectancy	0.211532	0.030581
Days/yr	365				
STDDEV R1	2.081284		Expectunity	26.5536	3.838894
Strat Calandı	1448.021				
Opportunitie	125.53				
			System quality	2.268085	

FIGURE 17: JOE'S SYSTEM QUALITY ANALYSIS

7 WILLIAM'S TRADING SYSTEM

7.1 SYSTEM DEVELOPMENT

When it comes to trends, there are two terms often used to describe the market: Bullish, and Bearish. A bull market is a market with an upward trend, while a bear market is a market with a downward trend. Investors long-buy bullish markets if they see potential in the company, and willing to risk staying in for the swings, while other investors short-sell a bearish market if they know the company is failing and will not change direction into the positive for a while.

Trend following styles are among the most used systems by investors and traders. They are particularly used by large trading firms because of their large capacity to support large amounts of equity. The system's rules are usually simple in terms of understanding, and could be used in many ways based on the investor's style. The system initiates based on triggers that are measured by the variation of price along different reference values. When a trend is said to be "detected", a position is taken based on the type of trend it is. The strategy is to maintain the position of the security until a detection of a change of price or movement is triggered; usually using a stop-loss system of a predetermined precedence.

Disadvantages of a trend following strategy, yet alone any strategy, is the amount of risk an investor is willing to take in terms of predicting a market. Investors are advised and usually pre-determine a potential maximum monetary value the investor is willing to lose on a single position. The market is ever-changing and primarily projects the expectations of traders world wide.

One form of a trend moving strategy is to use moving average crossovers. It is a type of indicator that allows the investor to get a better reading of the market by filtering out random noise due to price fluctuations. They are used to identify trend directions using a security's previous data. The strategy implements two moving averages: a slow moving average (covering a shorter period of time), and a fast moving average (covering a longer period of time). A crossover is said to occur when the fast moving average crosses the slow moving average, either above or below. As an indicator, when the fast moving average crosses over the slow moving average, the market is considered bull, and when the fast moving average crosses under the slow moving average, it is considered a bear market. To indicate trends, if the slow moving average is upward trending, that means the market is strong. Usually, a long position is taken when the fast moving average crosses over the slow moving average. On the opposite, a sell-short position is taken when the fast moving average crosses below the slow moving average. As though this could be simple to understand, it requires a long period of time of analyzing the market, and making sure the indicator is truly being represented by the market.

7.2 SYSTEM DESCRIPTION

During this IQP, I have learned many insightful information on the market, as well as the nation's economic state. Throughout the year, I have managed to figure out the type of investor I am; allowing me to finalize my decision of the type of strategy I use. I am an investor who firmly believes that I should only invest in companies that I see myself a part of. I have also learned that I am willing to take the risks of fluctuation because I believe the companies I chose will prove profitable and beneficial on a national level. After reading Trading as a Business, by Charlie Wright, a very important concept shaped my trading strategies. In creating trend following

strategies, the number one priority is that the strategy must never miss the big move. The easy way to accomplish this is to always be in the market, that is, to always be either short or long. If you always have a position, you will always be there when the big move takes place." (Wright).

I then started to test with different indicators and TradeStation built-in moving strategies to better understand trend in the market. While doing so, I figured out the crossing-over concept. I knew I wanted a system that uses cross-overs of a moving average; predicting the trend of the security. I googled TradeStation moving average strategies, and one system in particular stood out; designed by Frederic Palmiden. In general, a trend following strategy is made to detect trends and big swings, the system is supposed to trade a few times per year, in which it takes advantage of the big market swings; yielding to long term profits. Due to the idea mentioned earlier of fluctuations affecting market analysis, a trend following system must use moving averages to account of the fluctuations, as well as using crossovers to detect entry to market and holding positions. Palmiden's system seemed to be what I was looking for, but with different parameters to what I had in mind. The system also implements an indicator and an automated coded system to assist the trading; avoiding noise and trade more frequently over a long period of the position.

After extensive market research, I decided to finalize the list of stocks I would be interested in with my group, and reached two major stocks: Google (GOOGL) Tesla (TSLA). We chose those stocks because they have shown promising upward trends, as well as high customer expectation and trust. Both companies are dynamic, innovative, and always producing new technological advances that customers have trusted for many years. At the time of research, Tesla was on the verge of producing a new model, the S Model, a highly advanced fully electric

vehicle that was made to be very affordable. Their stocks were skyrocketing; making it a perfecting testing stock. Google also released many updates in terms of innovating Google Chrome, and their search engine; gaining favor from millions of customers over the year period. Google also came out with the new Nexus phone that implements Android/Google internal systems, which also gave Mina the confidence to invest in the company for a long period of time. Mina knew he was to ride the tides of the market, and take advantage of the company's big swings. He used intra-day intervals using data from two years ago to better understand both securities. While doing his research, he noticed that the original Google (GOOG) had split on March 26 of 2014, a 2-for-1 split. This means that the number of stocks each shareholder doubled, while the prices of each stock split in half; leading to more shares available for consumers to purchase. This allows the company to reach out to another class of consumers that only have limited amount of money, as well as increase the company's cash flow. Mina chose the splitted google, GOOGL, because it was slightly cheaper than GOOG. Mina's strategy traded over daily bars, which proved to be the most profitable trading interval during the time.

7.3 SYSTEM ANALYSIS

This strategy uses two moving averages that are designed to give signals when crossing over: a slow exponential moving average, and a fast exponential moving average. The width of each "river", or moving averages, is determined based on the standard deviation of the stock's price over the two specific intervals. The "small river", the fast exponential average, contains an upper and a lower boundary. The upper/lower bounds are defined by a set number of days (over a short period of time) that are preset to calculate exponential moving average with the option of entering a standard deviation value. The "big river", or the slow exponential moving average,

also contain an upper and lower bounds that are defined by a number of days (over a longer period of time), preset to also calculate an exponential moving average with the option of entering a standard deviation value. In order for the system to enter a long position, or buy a security, the lower bound of the fast exponential moving average must cross over the upper bound of the slow exponential moving average. On the other hand, the system is to sell-short if the upper bound of the fast exponential moving average crosses under the lower bound of the slow exponential moving average.

The automatic system also implements a dynamic exit strategy in which, a selected percentage is chosen of the security to be sold after holding for a pre-set number of days. Another mechanism is used of a longer pre-set number of holding days, to prevent further losses if necessary. The system exits the full position once the price of the security moves a third of the distance back into the big river.

The system is implemented with an indicator, which has 4 different inputs: number of standard deviation for the slow moving average, number of standard deviation for the fast moving average, the length of the fast moving average, and the length of the slow moving average. After testing the strategy with different systems, I determined to use the system for long only positions; turning off short-selling because of the type of investor I am. I see myself as a long time investor of the company I am pursuing, so I will "ride the tides" with my company, and truly support it at all its swings

Below is the trading chart of GOOGL, as seen, the system implements two moving averages depicted in the blue. The system is to buy when the "small river" crosses over the

"large river", and sell when it reverses cycles. As seen, the system buys a stock, holds it for a certain amount of days, and implements the position sizing as preset, shown below the trading

FIGURE 18: MINA'S GOOGL STOCK CHART

Below is the performance chart of GOOGLE from 2006-2016. It has a total net profit of $141,570.31, with a highly favored profit factor of 3.46. Since my strategy is a trend following hold-and-sell, I would expect a small amount of trades that are highly profitable, which are shown to be 36 trades. I have had 75% profitable trades, meaning that out of the 36 trades I had only 9 were losing trades. I had a maximum of six consecutive trades, and a maximum consecutive loss of 2 trades. This to me has proven to be a system that could potentially work with adjustments, as well as making sure it passes other analysis tests to formally conclude the result.

TradeStation Performance Summary

	All Trades	Long Trades	Short Trades
Total Net Profit	$141,570.31	$141,570.31	$0.00
Gross Profit	$199,161.72	$199,161.72	$0.00
Gross Loss	($57,591.41)	($57,591.41)	$0.00
Profit Factor	3.46	3.46	n/a
Roll Over Credit	$0.00	$0.00	$0.00
Open Position P/L	$0.00	$0.00	$0.00
Select Total Net Profit	$90,776.26	$90,776.26	$0.00
Select Gross Profit	$148,367.67	$148,367.67	$0.00
Select Gross Loss	($57,591.41)	($57,591.41)	$0.00
Select Profit Factor	2.58	2.58	n/a
Adjusted Total Net Profit	$84,044.48	$84,044.48	$0.00
Adjusted Gross Profit	$160,833.03	$160,833.03	$0.00
Adjusted Gross Loss	($76,788.55)	($76,788.55)	$0.00
Adjusted Profit Factor	2.09	2.09	n/a
Total Number of Trades	36	36	0
Percent Profitable	75.00%	75.00%	0.00%
Winning Trades	27	27	0
Losing Trades	9	9	0
Even Trades	0	0	0
Avg. Trade Net Profit	$3,932.51	$3,932.51	$0.00
Avg. Winning Trade	$7,376.36	$7,376.36	$0.00
Avg. Losing Trade	($6,399.05)	($6,399.05)	$0.00
Ratio Avg. Win:Avg. Loss	1.15	1.15	n/a
Largest Winning Trade	$50,794.05	$50,794.05	$0.00
Largest Losing Trade	($10,586.14)	($10,586.14)	$0.00
Largest Winner as % of Gross Profit	25.50%	25.50%	n/a
Largest Loser as % of Gross Loss	18.38%	18.38%	n/a
Net Profit as % of Largest Loss	1,337.32%	1,337.32%	n/a
Select Net Profit as % of Largest Loss	857.50%	857.50%	n/a
Adjusted Net Profit as % of Largest Loss	793.91%	793.91%	n/a
Max. Consecutive Winning Trades	6	6	0
Max. Consecutive Losing Trades	2	2	0
Avg. Bars in Total Trades	64.83	64.83	0.00
Avg. Bars in Winning Trades	76.00	76.00	0.00
Avg. Bars in Losing Trades	31.33	31.33	0.00
Avg. Bars in Even Trades	0.00	0.00	0.00

FIGURE 19: MINA'S TRADESTATION SUMMARY REPORT

Below is the equity curve for my strategy on GOOGL. An Ideal equity curve is a straight line; indicating that every trade is perfectly executed. A system that performs this well is highly unlikely and rather impossible. The concept is used to analyze systems based on this perfect straight linear line concept. My system had a down-pit for the first 10 trades, I'm assuming this was when Google initially started launching Google Chrome, and before all the exponential development they have achieved over the years. After 10 trades, my system does in fact surpass

the losses and increases the equity exponentially over time; giving assurance that the system still has hope to perform well after more analysis and modification concluded.

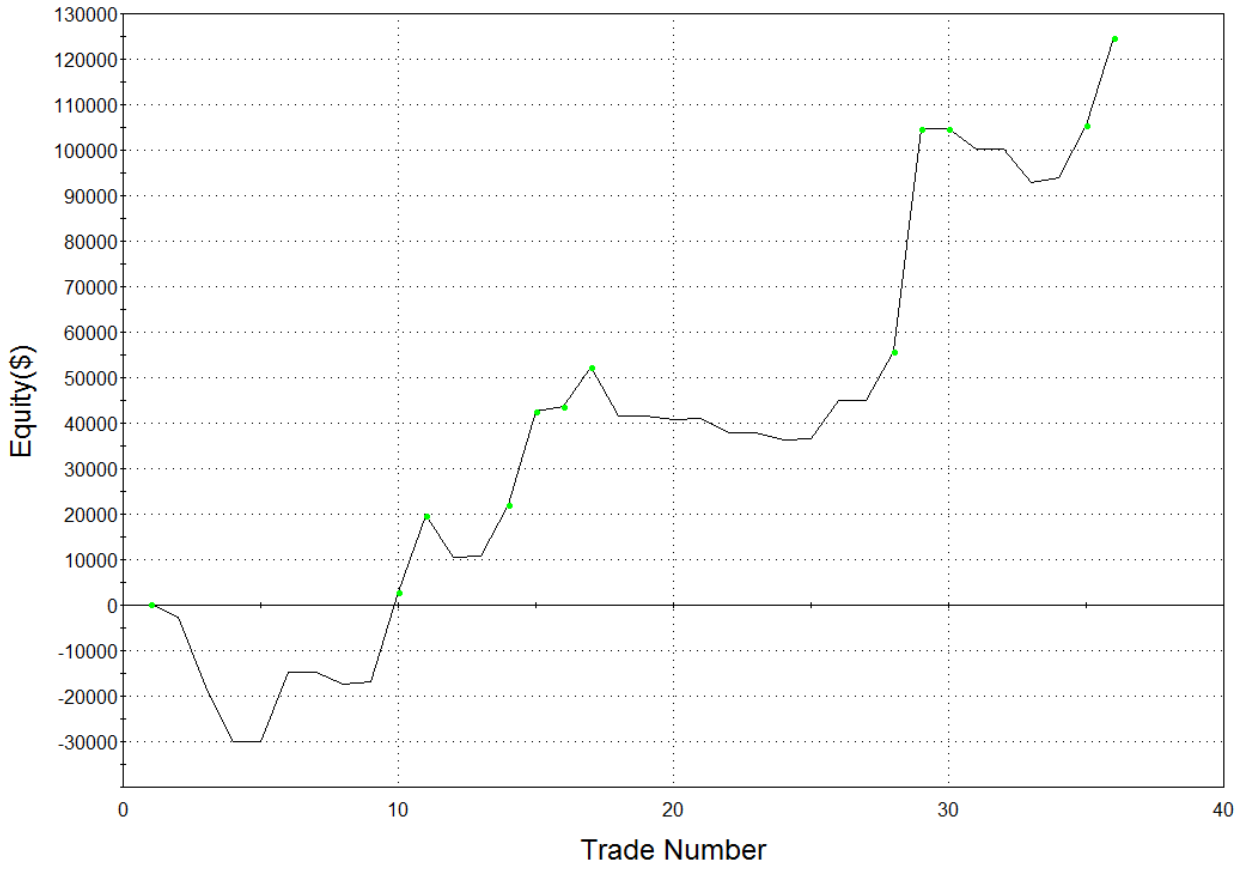

FIGURE 20: MINA'S TRADESTATION EQUITY GRAPH

I ran a Walk-Forward analysis to see how the system performs outside its own time frame. It is shown below, that there is a 3x3 array of pass between 5% and 15%. Ideally, there should be a 9x9 matrix of passing, while the middle one is the most viable. However, this is slightly devastating. This means that if there is a small/medium change of the market overtime, the system will not operate as well. This shows that the system does have flaws, and needs more

work in terms of development before it reaches maximum profit, however it does also conclude that the system is on track and hopeful in the future.

OOS% \ Runs	5	10	15	20	25	30
10	PASS	PASS	PASS	PASS	FAILED	FAILED
15	FAILED	PASS	FAILED	FAILED	FAILED	FAILED
20	PASS **	PASS	PASS	PASS	FAILED	PASS
25	PASS **	PASS	PASS	PASS	PASS	PASS
30	PASS **	PASS	PASS	PASS	PASS	PASS

FIGURE 21: MINA'S WALK-FORWARD ANALYSIS RESULTS

I also ran an efficiency Walk-Forward analysis. Ideally, a 100% rate means that the system performs equally well on out-sample-data compared to in-sample data; any value under concludes a lesser performance. My system only passed two scenarios where it attained 100% shown below. However, just because it did not achieve 100%, it doesn't mean it is hopeless. In all scenarios, it never went below 53.3% efficiency, which is favorable and promising. The analysis concludes that the system does indeed profit, however, it is risky, and doesn't perform as well in the future.

OOS% \ Runs	5	10	15	20	25	30
10	60.0%	60.0%	53.3%	50.0%	48.0%	43.3%
15	60.0%	70.0%	40.0%	40.0%	48.0%	46.7%
20	80.0%	60.0%	53.3%	50.0%	48.0%	50.0%
25	100.0%	60.0%	53.3%	55.0%	52.0%	53.3%
30	100.0%	70.0%	53.3%	50.0%	52.0%	60.0%

FIGURE 22: MINA'S WALK-FORWARD EFFICIENCY RESULTS

I also ran a Monte Carlo Analysis specified for all the trades to test future performance of my system; guiding me to better optimize it in the future. The figure below shows the Monte Carlo Analysis confidence projection. The red line means that the analysis is 5% confident that the trades will go above it, the gray line is 50% confident, and the green line is 95% confident that the trades would go above it. This analysis shows to be accurate because almost all of the trades are within the green bound (the 95% confidence line). The analysis does fail when looking at trades 30-36, as seen they are outside of the 95% confidence zone.

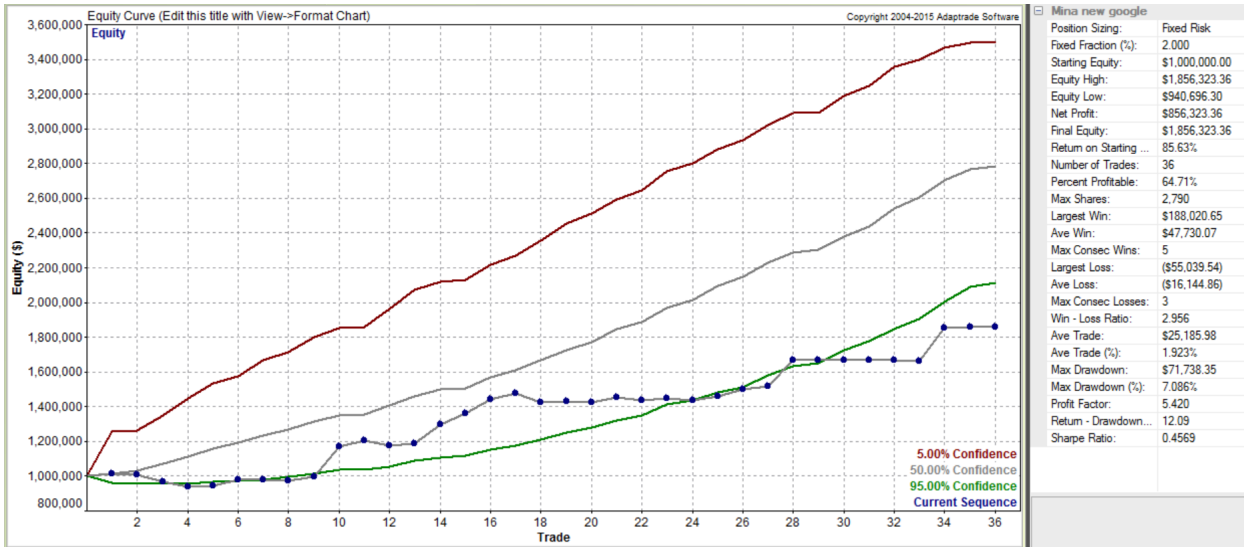

FIGURE 23: MINA'S CONFIDENCE CONE

Below, is the same graph moving forward with the system's most recent 15 trades. As seen, the green cone represents the projected trade regions of the strategy. If the trades do not fall in it, then the analysis fails to project future trades. In this case, the trades do indeed fall within the green cone (95% confidence), showing that the analysis was able to project the trades and that the strategy still has hope.

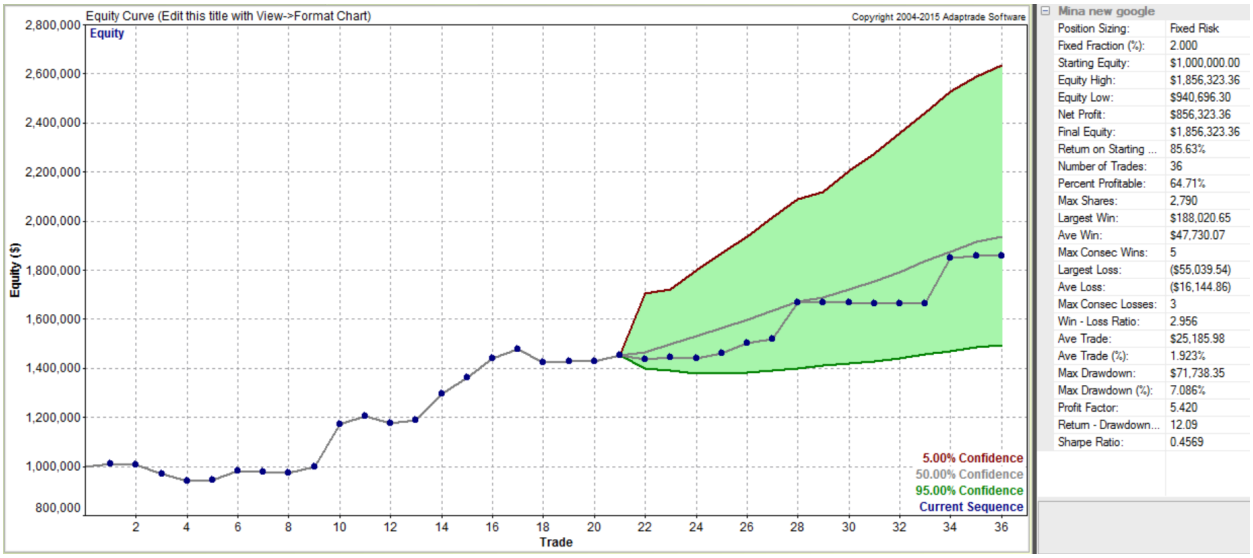

FIGURE 24: MINA'S MONTE CARLO CONFIDENCE CONE

Below is the table of numbers for the 95% confidence analysis. Of the most important numbers, maximum drawdown, profit factor, and win/loss ratio. The maximum drawdown was 10.76%, it is noticeably high but with optimization, this number could be reduced. The profit factor is 4.201, which is highly favored. The Win/Loss ratio is 2.120, which is also favorable g that my trades win to almost a 2:1 ratio.

Monte Carlo Results at 95.00% Confidence	
Total Net Profit: $1,114,053.44	Max Number of Shares: 3,224
Final Account Equity: $2,114,053.44	Minimum Number of Shares: 1
Return on Starting Equity: 111.4%	Average Number of Shares: 1,855
Profit Factor: 4.201	
Largest Winning Trade: $273,852.09	Largest Losing Trade: ($135,499.04)
Largest Winning Trade (%): 19.18%	Largest Losing Trade (%): -4.957%
Average Winning Trade: $62,012.10	Average Losing Trade: ($40,997.60)
Average Winning Trade (%): 4.431%	Average Losing Trade (%): -1.973%
Average Trade: $32,124.05	Win/Loss Ratio: 2.120
Average Trade (%): 2.334%	Win/Loss Ratio (%/%): 2.437
Trade Standard Deviation: $156,345.08	Max Consecutive Wins: 4
Trade Standard Deviation (%): 8.033%	Max Consecutive Losses: 4
Worst Case Drawdown: ($237,846.40)	Return/Drawdown Ratio: 12.97
Worst Case Drawdown (%): 10.76%	Modified Sharpe Ratio: 0.3856
Average Drawdown: ($81,460.90)	
Average Drawdown (%): 4.249%	

FIGURE 25: MINA'S MONTE CARLO ANALYSIS RESULTS

After running a Walk-Forward analysis, I extracted the trade file into Market System Analyzer. Below is the original equity curve without position sizing. It can be seen on the right size that the system had a net profit of $124,836.80, with a rate of return of 12.48%. This shows to be a slow progressing, yet a profitable system, with a maximum drawdown of $30,303.87; alarming. Given this to any individual to use would be rather hard, the drawdown is very high for someone to try the risk. However, the drawdown-to-profit ratio could be scaled down with position sizing and better implementation of system strategizing and parameter changes.

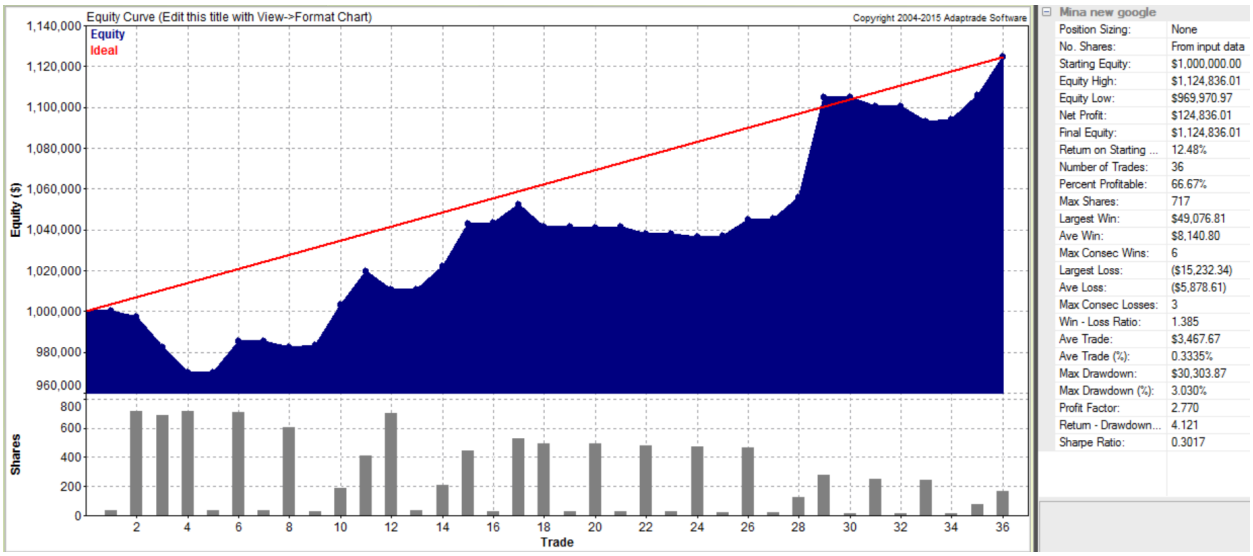

FIGURE 26: MINA'S GOOGL EQUITY CURVE

I then applied position sizing with a fixed fraction rate. This analysis takes into account the percentage of the equity in an account, and use that amount to be risked in trades. I set the fixed fraction rate at 2%, yielding much better results. My rate of return increased to 73.64%, with a total net profit of $73,642.45. Although the total net profit did decrease when applying the fixed fractional rate, a remarkable parameter did stand out: the large drop in the maximum drawdown. The maximum drawdown is now $8,110,39! Meaning that risk has reduced, and that it is more appealing for traders to utilize this system.

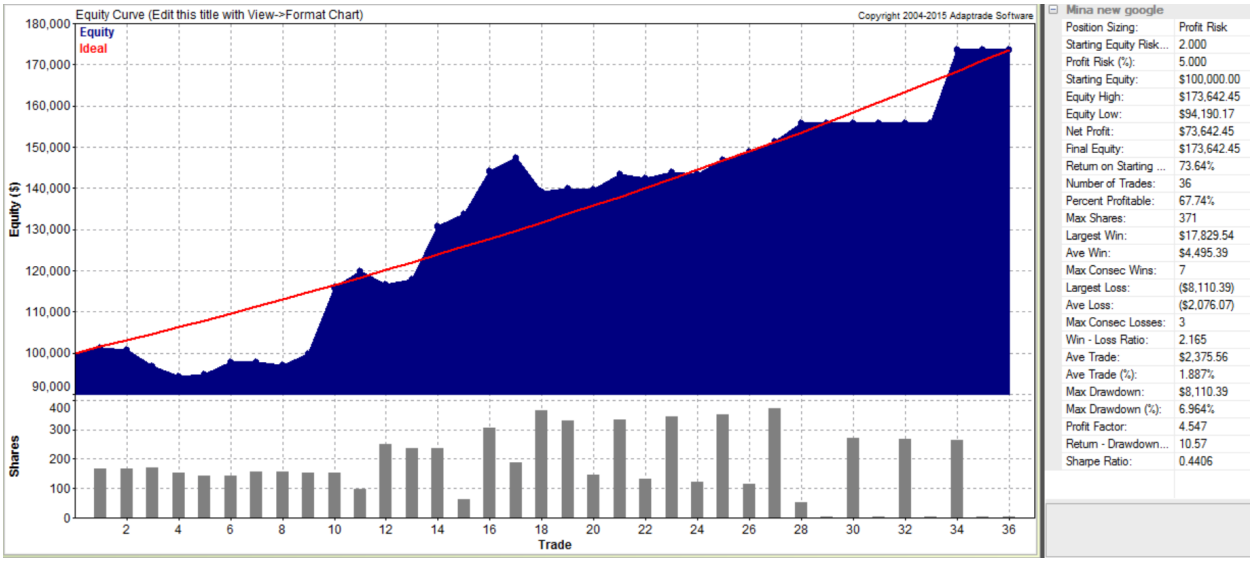

FIGURE 27: MINA'S GOOGL POSITION SIZING

Below is the last and one of the most important analytical tools to use, calculating: Expectancy, Expectunity, and System Quality. All these parameters are explained in details earlier in the report (see Chapter 4). My expectancy is 0.5898, low but still profitable since it is positive. My expectunity is 2.196, although I wished I had more opportunities to have higher expectunity, knowing that my system is a slow-progressing system that only had 36 trades the past 4 years makes me satisfied with the results. My overall system quality was 1.784, which was used to analyze money allocation in the System of Systems.

Num Trades	36		Expectancy	0.589879	0.227652
Days/yr	365				
STDDEV R1	1.982921		Expectunity	2.196999	0.847886
Strat Calandar Days	3528				
Opportunities	3.72449				
			System quality	1.784879	

FIGURE 28: MINA'S SYSTEM QUALITY ANALYSIS

8 PEPIC'S TRADING STRATEGY

Entering this IQP, I had little to no knowledge of the economy, let alone stocks. Over the course of the IQP, I have gained insightful information; benefiting me the rest of my life. It is obvious that many investors use trend-following strategies to minimize losses, as well as accumulate large number of profits over a long period of time. I wanted to do something different that is not a trend following strategy, I decided to implement a gap strategy. A stock gap occurs when there is a difference between one bar and a preceding bar in terms of a stock price that changes with respect to the close of the previous bar and the open of the next bar. This usually occurs during night time when the market closes and reopens, usually with a different open price than the previous day's close; leading to a gap. This gap is usually the result of the news/media, profit reports of companies that were released after a day's close, or even a change in the supply/demand of the security. Within a gap strategy, there are two ways to implement the strategy on: closing the gap or following the gap. Closing the gap means that the stock gaps, up/down, that then has a reverse of the trend during the day. Following the gap means that the stock gaps, up.down; continuing on the day's trend. Gaps are usually analyzed and defined by previous data, not indicators. Meaning that if a stock shows a pattern of gaps from previous data, I could potentially use those statistics to gather more information of the future; creating a gap strategy.

8.1 SYSTEM DEVELOPMENT

Entering this IQP my expectations were high. I am pleased to report the findings of my research and methodology. The steps that I took to develop and utilize automated trading strategies allowed me to produce a unique system to gain an edge over average day traders in the

equity market. My research informed me of many different types of trading strategies including, but not limited to, trend following and momentum trading, moving average systems, break-out systems, and counter-trend systems. I have learned that most common system is a trend following system. Naturally, I have tried to stay away from developing this type of strategy due to the overuse and lack of "edge-making" opportunities that come with popular trend following strategies. The biggest reason I chose not to go with a trend following or moving average system is due to the disadvantage created when what is called the "whipsaw" phenomenon occurs. The whipsaw effect is known to cause discrepancies with moving averages. The moving average can tend to enter a phase for a period of time that unexpectedly reverses direction, thus causing a false signal. When a whipsaw impact occurs, significant losses can amount from the event unless there is a successful implementation of stop-losses and other risk management procedures in the system. Additionally, when the market is trending sideways this type of strategy would be very inefficient and can suffer losses. Due to these discrepancies I decided to develop a system that would take advantage of gaps.

I wanted to do something different that is not a trend following strategy, I decided to implement a gap strategy. A stock gap occurs when there is a difference between one bar and a preceding bar in terms of a stock price that changes with respect to the close of the previous bar and the open of the next bar. This usually occurs during night time when the market closes and reopens, usually with a different open price than the previous day's close; leading to a gap. This gap is usually the result of the news/media, profit reports of companies that were released after a day's close, or even a change in the supply/demand of the security. Within a gap strategy, there are two ways to implement the strategy on: closing the gap or following the gap. Closing the gap

means that the stock gaps, up/down, that then has a reverse of the trend during the day. Following the gap means that the stock gaps, up/down; continuing on the day's trend. Gaps are usually analyzed and defined by previous data, not indicators. Meaning that if a stock shows a pattern of gaps from previous data, I could potentially use those statistics to gather more information of the future; creating a gap strategy. My research indicated the advantages and disadvantages of being a day trader, but after further research I determined that I would develop a system to utilize the advantages of trading both gap up and gap down systems as well as utilizing a dollar trailing strategy tactic. Below, in Figure 29, shows an example of a gap and the apparent motivation behind my methodology.

FIGURE 29: GAP EXAMPLE

My strategy development began with the idea of taking advantage of overnight market close and market open gaps. To add to my development and develop a more unique strategy I started developing a method to combine gap down and gap up strategies. This would mean that I

would always be in the market. This introduced risk but enables me to buy and sell short while staying in the market. Due to the risk of staying in the market I also included a dollar trailing tactic in my code to generate an exit depending on the inputted value. This inputted value can be changed to support a riskier or more conservative trading approach. In Figure 29 below, an example of a dollar trailing tactic is indicated by the red line. In this example the trail is set to four dollars and follows the increase of the stock price but stops for a reversal in price, in which an exit is generated when the stock price falls to the price of the dollar trailer.

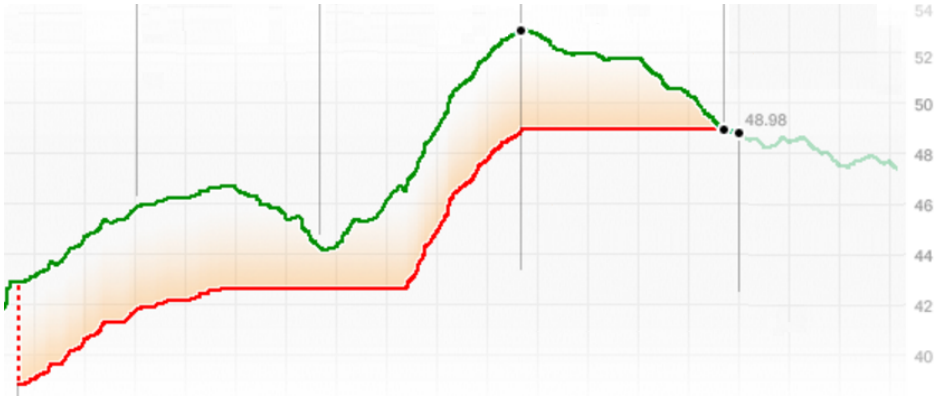

FIGURE 30: DOLLAR TRAILING EXAMPLE

To make the development of my system unique, the advantages of all three of these tactics are being used. This will generate trades more often and allow for intrabar exits by using specific inputs to gain an edge on other day traders.

8.2 SYSTEM DESCRIPTION

After determining the goals of my strategy and developing steps and methods to reach these goals, I used EasyLanguage to code the automated strategy. Below, Figure 30, shows my EasyLanguage code.

```
{ Trading system: Trading based on gaps going up and down}
[IntrabarOrderGeneration = false]
inputs: PositionBasis( false ),
      GapHi    ( 4),
      GapLo    ( 4),
      Amount   ( 1);

if PositionBasis then
    SetStopPosition
else
    SetStopShare ;

SetDollarTrailing( Amount ) ;

if Low > High[GAPHi] then
    Buy ( "GapUp" ) next bar at market ;

if High < Low[GAPLo] then
    Sell Short ( "GapDn" ) next bar at market ;
```

FIGURE 31: MLADEN'S TRADING RULES

In my code I utilized four inputs to allow for the later optimization of the inputs using the TradeStation functionality. PositionBasis is used to determine if whether you are using a percentage or a dollar amount by specifying True or False. If False is specified, then the amount entered in the input called "Amount" will be used to follow the highest position by a percentage. For example, if I buy 100 shares of Google at $500 per share, set PositionBasis to False, and specify the Amount as 1, then the trailing exit will be 100*500*(0.001) of the highest position. Using a very small Amount would cause quick in and out positions, which my strategy is designed to do in order to gain an edge.

My strategy can be seen as a scalping strategy because it exits so quickly after entering a position. This may cause discrepancy with commissions, but I have taken this into account and designed this strategy to buy and sell stocks with a specific criteria. The way I decided on this criteria was through the functionality of TradeStation and the "Research" option under the

TradingApps tab. Using Research I was able to test my strategy on stocks to determine which parameter would be most effective to correlate with my stock choice. After numerous stock and parameter correlation testing I determined that I would use this strategy on stocks with a Gross Profitability Margin of at least 50. This financial metric is important because it can be used to rate the financial health of the security by assessing the money left over from revenues versus the goods sold. It is a good metric to address future savings of the company, and therefore can be used as an indication if the company will have adequate funds for potential expansion or future development of the company. My system is very dynamic because it can generate intrabar market orders to close a position.

8.3 SYSTEM ANALYSIS

Below is the performance summary generated by TradeStation. As explained previously, it calculates different objectives based on previous data from a stock using an input strategy. This was run on daily bars on GOOGL from 2012 to 2016.

TradeStation Performance Summary

	All Trades	Long Trades	Short Trades
Total Net Profit	$54,855.00	$30,781.00	$24,074.00
Gross Profit	$79,741.00	$45,919.00	$33,822.00
Gross Loss	($24,886.00)	($15,138.00)	($9,748.00)
Profit Factor	3.20	3.03	3.47
Roll Over Credit	$0.00	$0.00	$0.00
Open Position P/L	$0.00	$0.00	$0.00
Select Total Net Profit	$45,787.00	$25,246.00	$20,541.00
Select Gross Profit	$70,673.00	$40,384.00	$30,289.00
Select Gross Loss	($24,886.00)	($15,138.00)	($9,748.00)
Select Profit Factor	2.84	2.67	3.11
Adjusted Total Net Profit	$48,009.45	$25,502.44	$19,712.09
Adjusted Gross Profit	$74,460.02	$41,860.30	$30,439.80
Adjusted Gross Loss	($26,450.57)	($16,357.85)	($10,727.71)
Adjusted Profit Factor	2.82	2.56	2.84
Total Number of Trades	481	282	199
Percent Profitable	47.40%	45.39%	50.25%
Winning Trades	228	128	100
Losing Trades	253	154	99
Even Trades	0	0	0
Avg. Trade Net Profit	$114.04	$109.15	$120.97
Avg. Winning Trade	$349.74	$358.74	$338.22
Avg. Losing Trade	($98.36)	($98.30)	($98.46)
Ratio Avg. Win:Avg. Loss	3.56	3.65	3.43
Largest Winning Trade	$2,008.00	$2,008.00	$1,837.00
Largest Losing Trade	($116.00)	($116.00)	($116.00)
Largest Winner as % of Gross Profit	2.52%	4.37%	5.43%
Largest Loser as % of Gross Loss	0.47%	0.77%	1.19%
Net Profit as % of Largest Loss	47,288.79%	26,535.34%	20,753.45%
Select Net Profit as % of Largest Loss	39,471.55%	21,763.79%	17,707.76%
Adjusted Net Profit as % of Largest Loss	41,387.46%	21,984.86%	16,993.18%
Max. Consecutive Winning Trades	7	6	8
Max. Consecutive Losing Trades	8	6	6
Avg. Bars in Total Trades	1.06	1.06	1.05
Avg. Bars in Winning Trades	1.12	1.14	1.09
Avg. Bars in Losing Trades	1.00	1.00	1.00
Avg. Bars in Even Trades	0.00	0.00	0.00

FIGURE 32: MLADEN'S TRADESTATION SUMMARY RESULTS

The strategy shows a total net profit of $54,855.00 with a strong profit factor of 3.2. It also indicates that both the long and short trades are very profitable with profit factors of 3.03 and 3.47, respectively. Since this is a gap strategy using small input values on a stock that meet my requirements, I am expecting a large number of trades which is demonstrated by the 481 total trades generated. Some traders are more conservative than others but for my strategy I determined that a profit factor over 3.00 would result in a strategy that would yield results that fit my preferences.

Walk-Forward analysis

To analyze my system performance further, I used a walk-forward optimizer, which is an advanced strategy optimization tool that automates multiple steps to carry out a statistical walk-forward test comparing the performance of a specified amount of in-sample data to a specified amount of out-of sample data. Below are two figures depicting the results of my walk-forward analysis. Figure 29 shows the total results based on the test criterion for the walk-forward analysis. A majority of the walk-forward tests passed, while only three failed. This may indicate that my strategy could be over fitted to the data. In Figure 30, the annual profit and losses are shown, and the dark green cell depicts the best overall test performance. My test criterion can be found in the appendix.

OOS% \ Runs	5	10	15	20	25	30
10	PASS	PASS	PASS	PASS	PASS	PASS
15	PASS	PASS	PASS	PASS	PASS	PASS
20	PASS **	PASS	PASS	PASS	PASS	PASS
25	PASS	PASS	PASS	PASS	FAILED	FAILED
30	PASS	PASS	PASS	FAILED	PASS	FAILED

FIGURE 33: MLADEN'S WALK FORWARD ANALYSIS RESULTS

OOS% \ Runs	5	10	15	20	25	30
10	20,261.19	19,160.76	19,278.44	20,196.54	19,754.64	17,484.78
15	20,265.09	21,135.99	19,485.24	18,894.22	19,589.74	17,658.69
20	24,313.71	18,153.46	16,007.04	16,266.81	17,486.03	20,193.35
25	20,237.32	18,040.44	16,780.42	19,126.98	16,310.58	17,126.56
30	21,642.56	18,758.56	17,770.65	17,187.20	18,454.72	15,067.79

FIGURE 34: MLADEN'S WALK FORWARD EFFICIENCY RESULTS

After running the walk-forward analysis and optimization the equity curve that was produced is shown below. This equity curve shows mostly a continuation of profitability with only a few losses.

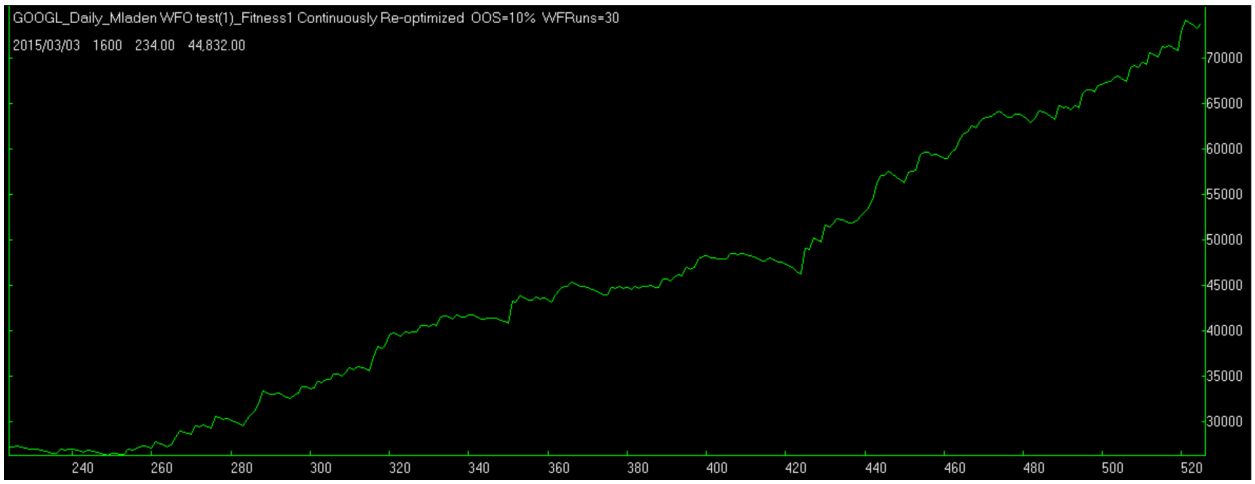

FIGURE 35: MLADEN'S OPTIMIZED EQUITY CURVE

After using TradeStation to analyze my strategy performance and optimize my input values using walk-forward tests, I exported my trade's list using the *writetrades32* function. This saved my trades in a .CSV format that enables the upload of my trades to the software called Market System Analyzer. I used this software to further analyze my system. Below in Figure 36,

shows my equity curve generated by all of the trades loaded. The software provides a list of results on the right side of the screen showing that these are indeed the same trades and results I saw in TradeStation. One of the first indicators I look at is the number of trades. Here my number of trades match the number of trades I yielded from back testing, a total of 481 trades. Other results that I look and determine if my preferences agree are the equity curve, which does show profitability with a rate of return of 54.55%, and a maximum drawdown of 0.896%.

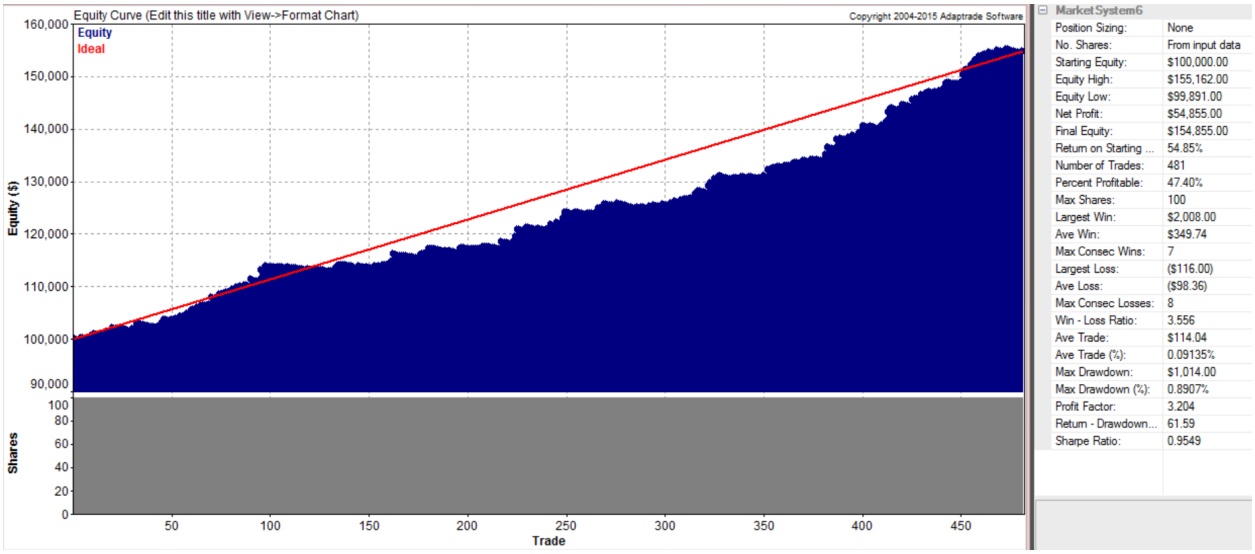

FIGURE 36: MLADEN'S EQUITY CURVE

After confirming the correct trades have been uploaded and displayed, I then utilized position sizing for my strategy. I used the fixed risk/fixed fractional method, which is used to specify a percent of the account equity to be risked on each trade. I specified 2% because with a strategy that trades frequently, I want to be a bit more conservative to fit my trading preferences. By utilizing position sizing my return on starting equity increased from 54.85% to 178.7%, yielding in preferable results. Below in Figure 33 is a chart of the equity curved produced after position sizing with this method.

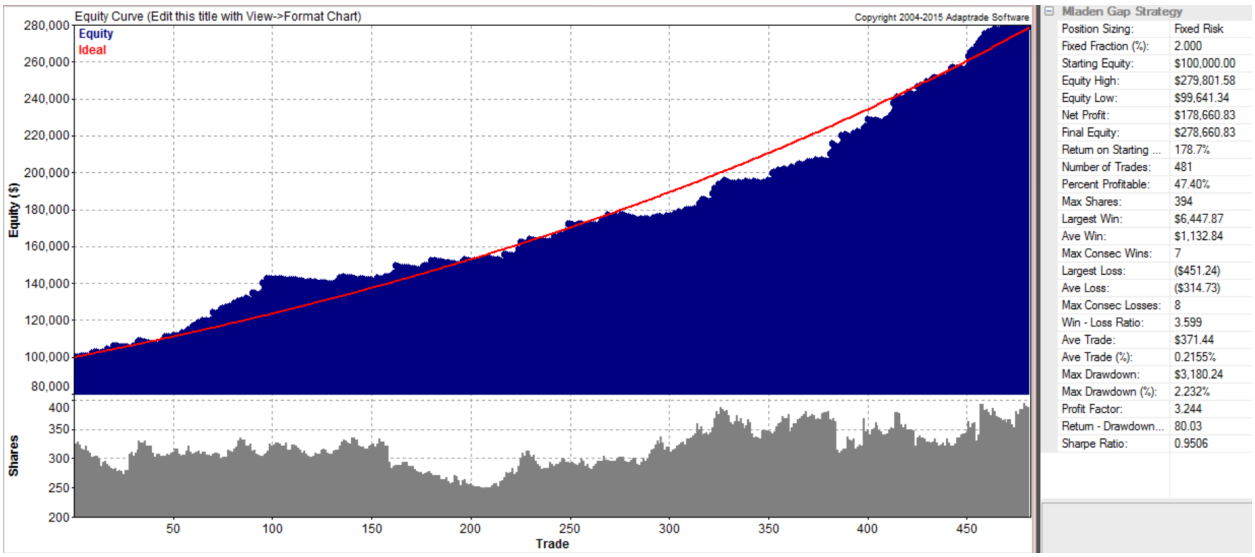

FIGURE 37: MLADEN'S EQUITY CURVE AFTER POSITION SIZING

The next analysis technique used was a Monte Carlo Analysis. I specified 200 trades back and the results showed a preferable projectory. The green shows all of the confidence cone which is projecting the likelihood of future trades. The results show that the system is 5% confident that the future trades will go above the red line, 50% confident that the trades will go over the grey line and 95% confident that the trades will stay above the green line.

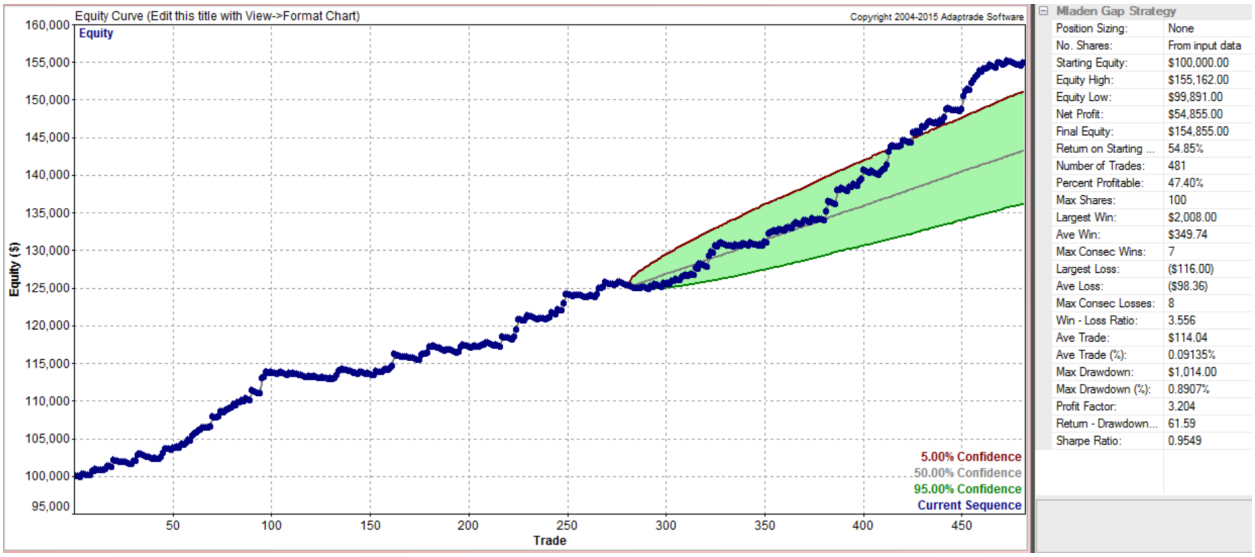

FIGURE 38: MLADEN'S MONTE CARLO CONFIDENCE CONE

If the trades do not follow the cone it means that the analysis was not able to successfully predict the future likelihood of trade results, thus making the analysis is more likely to be false. The chart shows that the analysis was mostly able to correctly predict the later trades, which confirms that the strategy is coherent. The Monte Carlo summary results (seen in the appendix) show that with 95% confidence that the average drawdown is 0.25185% which is highly preferable.

After all of the previous analysis techniques, the last one may be the most important to most traders. In excel, I used all of the trades to calculate the expectancy, expectunity, and system quality for my system. My results yielded an expectancy of 1.16, expectunity of 147.68 and an overall system quality of 7.15. Shown below in Figure 35 is a summary of the calculated results.

Num Trades	481		Expectancy	1.159409	0.983135
Days/yr	365				
STDDEV R1	3.555624		Expectunity	147.6081	125.1661
Strat Calandar Days	1379				
Opportunities	127.3133				
			System quality	7.151436	

FIGURE 39: MLADEN'S SYSTEM QUALITY ANALYSIS

9 SYSTEM OF SYSTEMS

Each system has proven to be profitable through the multiple analyses techniques used. In respect to each system, they are successful in their own way, but a truly successful system utilizes the strengths of multiple systems. By allocating a specific percentage of equity to each one we can maximize the gains. To conclude our IQP, we created a system of systems and then analyzed the System of Systems with emphasis on the equity return, max drawdown, Monte Carlo, and money allocation.

Below is the equity curve of the system of systems. It is observed that the system is much less volatile than any individual system. This is depicted by a more stable curve, rather an unstable one that was seen in individual systems. The return on starting of combined systems is 498.8%! This has increased dramatically compared with each individual system alone. The low volatility indicated in equity curve proves that the combination of systems is much safer in terms of risk, compared to single strategies. The maximum drawdown is 4.428%, which is $20,708.79. This is actually not as risky as it seems because it is calculated based on an initial equity of $300,000, if downscaled to $100,000, the maximum drawdown would be $6902.93; a very doable risk for many traders.

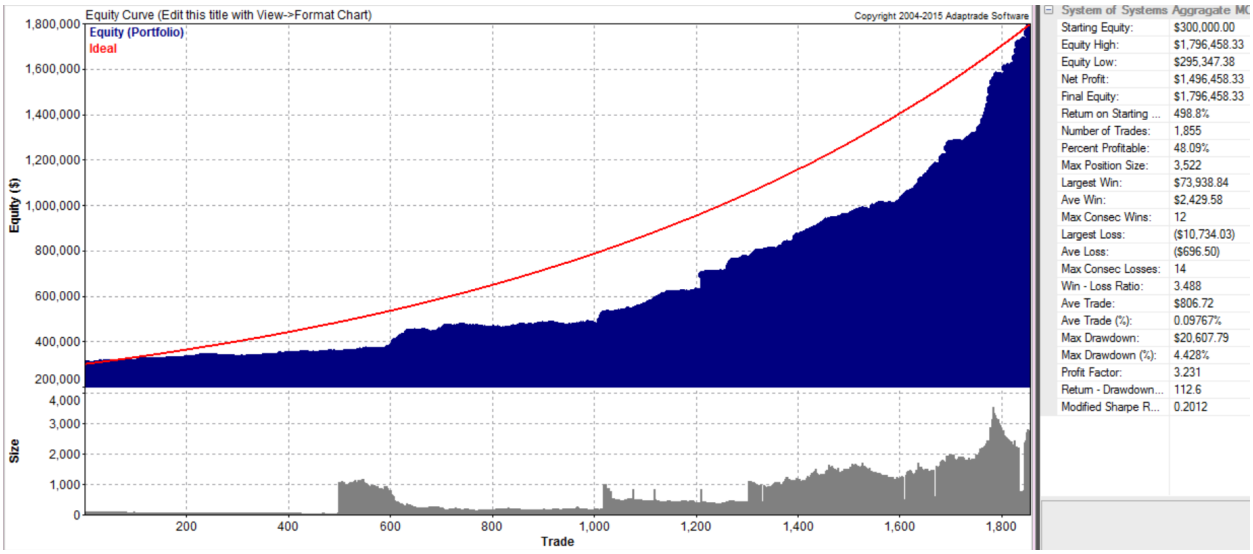

FIGURE 40: SYSTEM OF SYSTEMS EQUITY CURVE

The equity curve is highly optimized based on money allocation calculated from the system quality of each strategy used on two stocks. System quality is used to compare systems that operate on different time frames and parameters. It takes into account the winning size, as well as the consistency of the winning trades. System quality was used to determine the allocation of the equity for the three different strategies. For the calculations, a weighted average was taken of the system quality, and the individual percentage of the individual system's system quality was used to calculate the contribution to the overall stock. Shown below is a table highlighting the system qualities, percent allocations, and the allocation values.

	Joe's Moving Averages		Mina's 2 Rivers		Mladen's Gap	
	GOOGL	TSLA	GOOGL	TSLA	GOOGL	TSLA
Expectancy	0.2115	0.1993	0.5899	1.0477	1.1594	1.7169
Expectunity	26.5536	25.2850	2.1970	5.3016	147.6081	302.7965
System Quality	**2.2681**	**1.8962**	**1.7849**	**1.0301**	**7.1514**	**6.8113**
% Allocated	10.83%	9.05%	8.52%	4.92%	34.15%	32.52%
$ Allocated	$32,490.93	$27,164.09	$25,568.87	$14,755.79	$102,446.23	$97,574.09
Initial Equity	$300,000.00					

FIGURE 41: SYSTEM QUALITY COMPARISON TABLE

To conclude the analysis, the team ran a Monte Carlo analysis on the System of Systems. Below, it is seen that the trades do fall within the 95% confidence zone, and that the equity curve is much more stable; concluding that the System of Systems utilizes the individual system's strength, and minimizes the weakness.

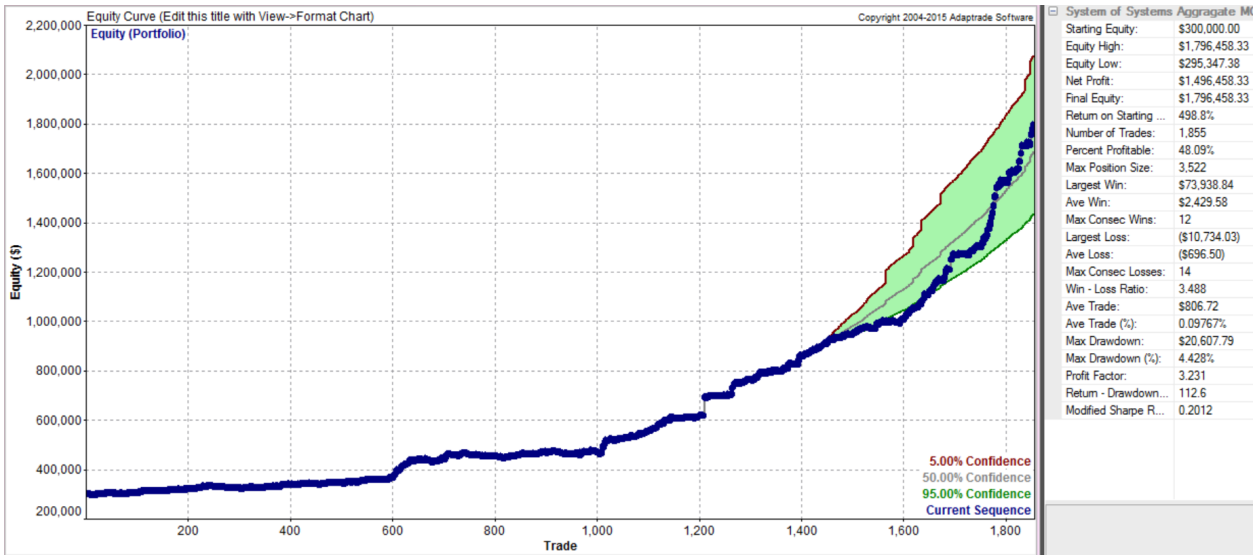

FIGURE 42: SYSTEM OF SYSTEMS MONTE CARLO CONFIDENCE CONE

Additionally, the Monte Carlo performance results, shown below in Figure 43, depict a maximum drawdown of only 4.428% and a return on starting equity of 378.2%. This return is greater than any individual system and therefore shows the success of the system of systems.

Monte Carlo Results at 95.00% Confidence	
Total Net Profit: $1,134,698.49	Maximum Position Size: 2,285
Final Account Equity: $1,434,698.49	Minimum Position Size: 46
Return on Starting Equity: 378.2%	Average Position Size: 525
Profit Factor: 2.711	
Largest Winning Trade: $73,938.84	Largest Losing Trade: ($9,725.60)
Largest Winning Trade (%): 11.98%	Largest Losing Trade (%): -1.165%
Average Winning Trade: $2,041.02	Average Losing Trade: ($722.55)
Average Winning Trade (%): 0.3070%	Average Losing Trade (%): -0.1162%
Average Trade: $611.70	Win/Loss Ratio: 3.017
Average Trade (%): 0.08544%	Win/Loss Ratio (%/%): 2.668
Trade Standard Deviation: $6,952.70	Max Consecutive Wins: 12
Trade Standard Deviation (%): 0.6374%	Max Consecutive Losses: 14
Worst Case Drawdown: ($23,816.76)	Return/Drawdown Ratio: 85.41
Worst Case Drawdown (%): 4.428%	Modified Sharpe Ratio: 0.1645
Average Drawdown: ($2,588.31)	
Average Drawdown (%): 0.3914%	

FIGURE 43: SYSTEM OF SYSTEMS MONTE CARLO RESULTS

10 SUMMARY & CONCLUSION

Based on the analysis of the individual systems, it can be concluded that each individual system is profitable. Each system has been proven to generate profits over long and short periods of time. No individual system was perfect, but after analyzing, optimizing and testing each system, it was determined that the systems would be profitable for live trading. Although we do have a profitable system of systems, we would prefer to do more testing and gain more certainty before using real money with our developed strategies.

This IQP has provided us with useful financial knowledge that will be utilized in the future. The information presented and learned throughout this process has helped us realize the importance of financial literacy. Unfortunately, a great deal of people are uneducated in this area and miss out on the opportunity to secure themselves financially for the future. The lack of knowledge alone, made the project seem impossible at first because initially we were one of these people. To address this, we met weekly to better ourselves with the information needed to complete the work. We came together as a team, and decided to test and try different methods to gain more knowledge. The goal was to develop three separate systems that could perform successfully on Google (GOOGL) and Tesla (TSLA). It is very difficult to develop three different strategies that are all profitable on restricted stocks. Overall, the goal was met and a system of systems was developed to trade on these stocks. System quality analyses were conducted to determine the percent of equity that we would allocate to each individual system. After doing this, the system of systems performed successfully and outperformed any individual system.

In conclusion, this project has proven to be not just another project but a life learning experience for us all. We plan on gaining even more knowledge from here on out and immediately taking action in trying to secure ourselves financially for the near future. Even Though our systems might be simple with their own advantages and disadvantages, we have gained enough resources to better utilize indicators, exit/enter strategies, and most importantly, picking the right stocks. Lastly, it is important to note that these strategies may not perform successfully on other stocks due to intricate market relationships and overall company performances.

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12 APPENDICES

Joe TSLA TradeStation Summary Report

	All Trades	Long Trades	Short Trades
Total Net Profit	$97,630.46	$35,774.84	$61,855.62
Gross Profit	$354,726.11	$101,629.37	$253,096.74
Gross Loss	($257,095.65)	($65,854.53)	($191,241.12)
Profit Factor	1.38	1.54	1.32
Roll Over Credit	$0.00	$0.00	$0.00
Open Position P/L	$2,108.75	$0.00	$2,108.75
Select Total Net Profit	$87,156.34	$14,155.79	$73,000.55
Select Gross Profit	$296,386.00	$80,010.32	$216,375.68
Select Gross Loss	($209,229.66)	($65,854.53)	($143,375.13)
Select Profit Factor	1.42	1.21	1.51
Adjusted Total Net Profit	$58,813.84	$20,818.04	$21,766.76
Adjusted Gross Profit	$331,732.63	$92,539.36	$229,287.40
Adjusted Gross Loss	($272,918.79)	($71,721.32)	($207,520.65)
Adjusted Profit Factor	1.22	1.29	1.10
Total Number of Trades	502	251	251
Percent Profitable	47.41%	49.80%	45.02%
Winning Trades	238	125	113
Losing Trades	264	126	138
Even Trades	0	0	0
Avg. Trade Net Profit	$194.48	$142.53	$246.44
Avg. Winning Trade	$1,490.45	$813.03	$2,239.79
Avg. Losing Trade	($973.85)	($522.66)	($1,385.81)
Ratio Avg. Win:Avg. Loss	1.53	1.56	1.62
Largest Winning Trade	$21,619.05	$21,619.05	$17,490.14
Largest Losing Trade	($11,960.02)	($3,147.52)	($11,960.02)
Largest Winner as % of Gross Profit	6.09%	21.27%	6.91%
Largest Loser as % of Gross Loss	4.65%	4.78%	6.25%

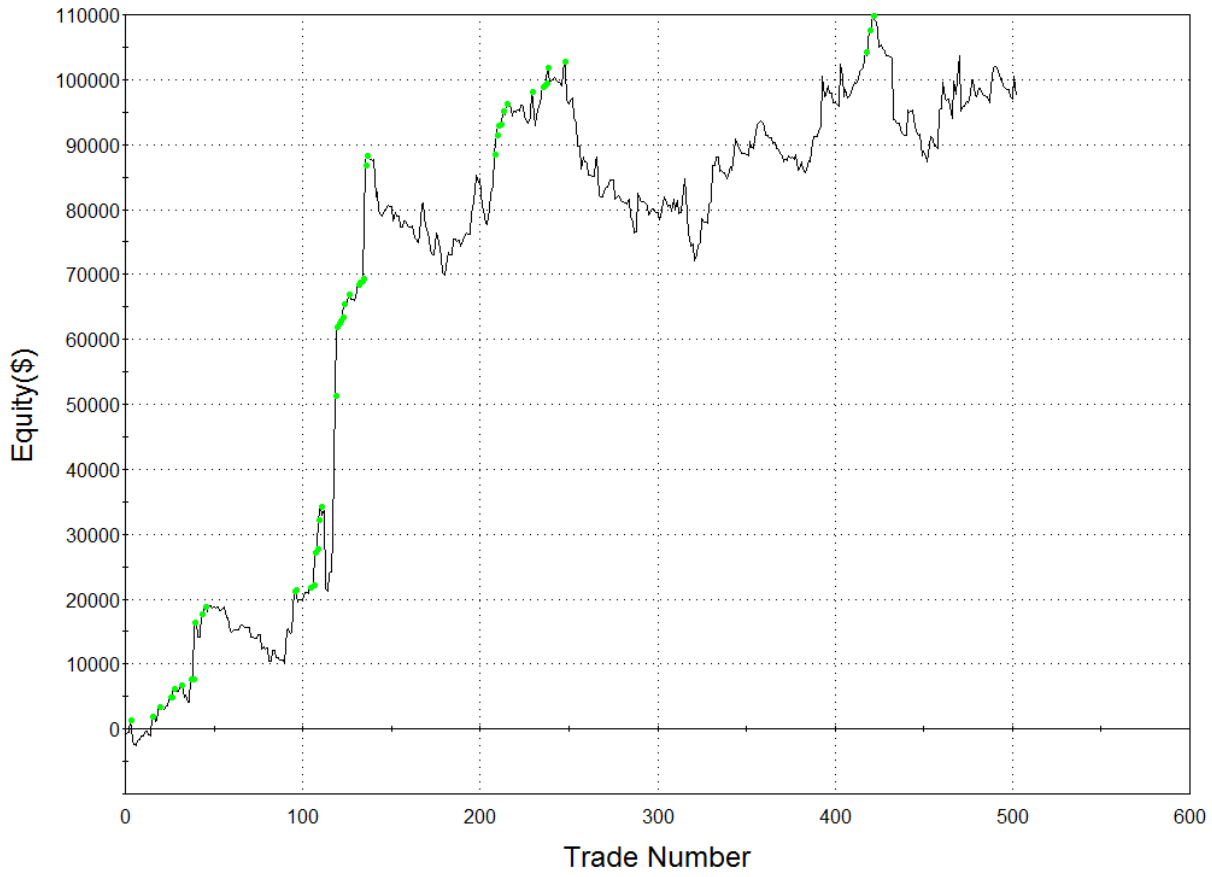
Joe WFO Pass or Fail

OOS% \ Runs	5	10	15	20	25	30
10	FAILED	FAILED	FAILED	FAILED	PASS	FAILED
15	FAILED	FAILED	FAILED	FAILED	PASS	FAILED
20	FAILED	PASS	FAILED	FAILED	FAILED	FAILED
25	FAILED	PASS	PASS	FAILED	FAILED	FAILED
30	FAILED	FAILED	FAILED	FAILED	FAILED	FAILED

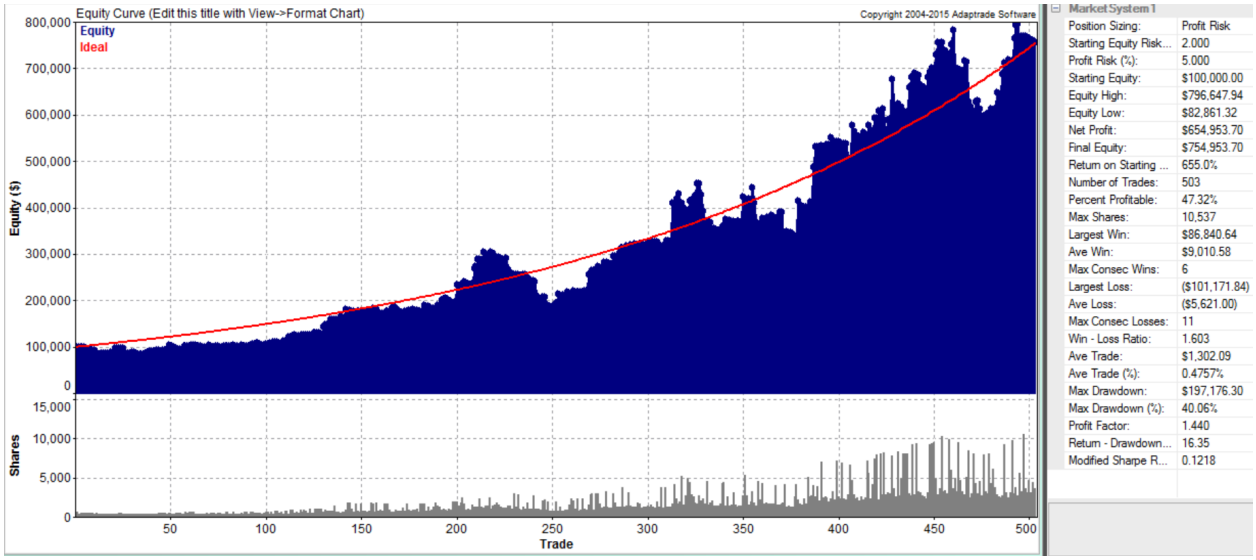
Joe WFO Consistency of Profits

OOS% \ Runs	5	10	15	20	25	30
10	60.0%	40.0%	60.0%	55.0%	76.0%	66.7%
15	80.0%	50.0%	80.0%	65.0%	72.0%	56.7%
20	40.0%	90.0%	73.3%	75.0%	48.0%	60.0%
25	60.0%	90.0%	93.3%	55.0%	48.0%	53.3%
30	60.0%	80.0%	73.3%	45.0%	52.0%	50.0%

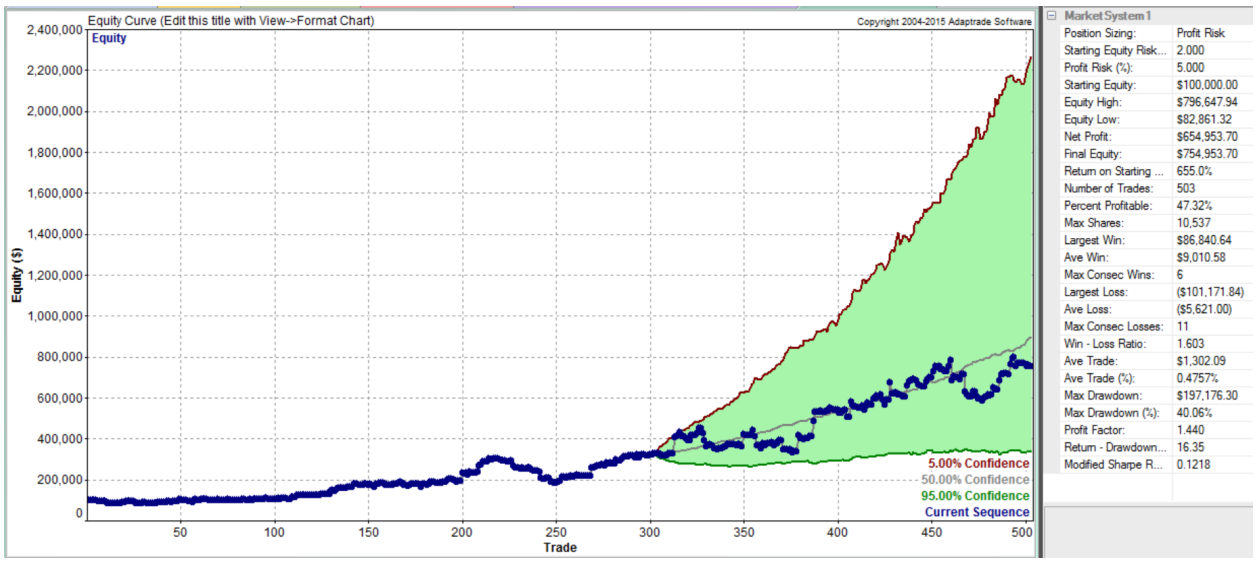
Joe TSLA TradeStation Equity Curve



Joe TSLA Equity Curve



Joe TSLA Monte Carlo Confidence Cone



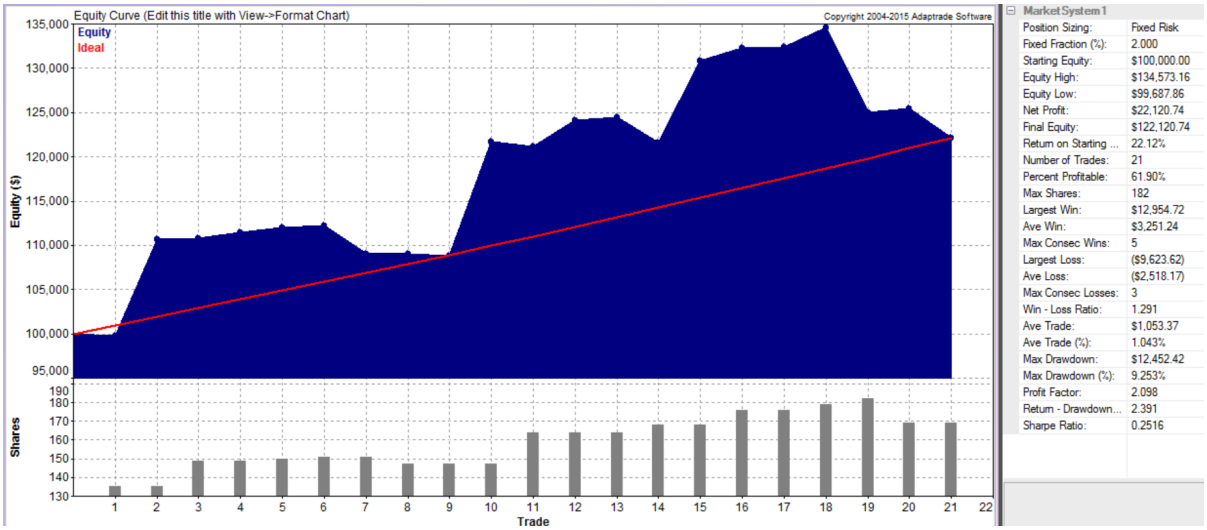
Mina TSLA TradeStation Summary Report

	All Trades	Long Trades	Short Trades
Total Net Profit	$281,470.67	$281,470.67	$0.00
Gross Profit	$380,049.64	$380,049.64	$0.00
Gross Loss	($98,578.97)	($98,578.97)	$0.00
Profit Factor	3.86	3.86	n/a
Roll Over Credit	$0.00	$0.00	$0.00
Open Position P/L	$0.00	$0.00	$0.00
Select Total Net Profit	$8,099.65	$8,099.65	$0.00
Select Gross Profit	$106,678.62	$106,678.62	$0.00
Select Gross Loss	($98,578.97)	($98,578.97)	$0.00
Select Profit Factor	1.08	1.08	n/a
Adjusted Total Net Profit	$141,210.94	$141,210.94	$0.00
Adjusted Gross Profit	$274,642.83	$274,642.83	$0.00
Adjusted Gross Loss	($133,431.90)	($133,431.90)	$0.00
Adjusted Profit Factor	2.06	2.06	n/a
Total Number of Trades	21	21	0
Percent Profitable	61.90%	61.90%	0.00%
Winning Trades	13	13	0
Losing Trades	8	8	0
Even Trades	0	0	0
Avg. Trade Net Profit	$13,403.37	$13,403.37	$0.00
Avg. Winning Trade	$29,234.59	$29,234.59	$0.00
Avg. Losing Trade	($12,322.37)	($12,322.37)	$0.00
Ratio Avg. Win:Avg. Loss	2.37	2.37	n/a
Largest Winning Trade	$273,371.02	$273,371.02	$0.00
Largest Losing Trade	($31,091.68)	($31,091.68)	$0.00
Largest Winner as % of Gross Profit	71.93%	71.93%	n/a
Largest Loser as % of Gross Loss	31.54%	31.54%	n/a

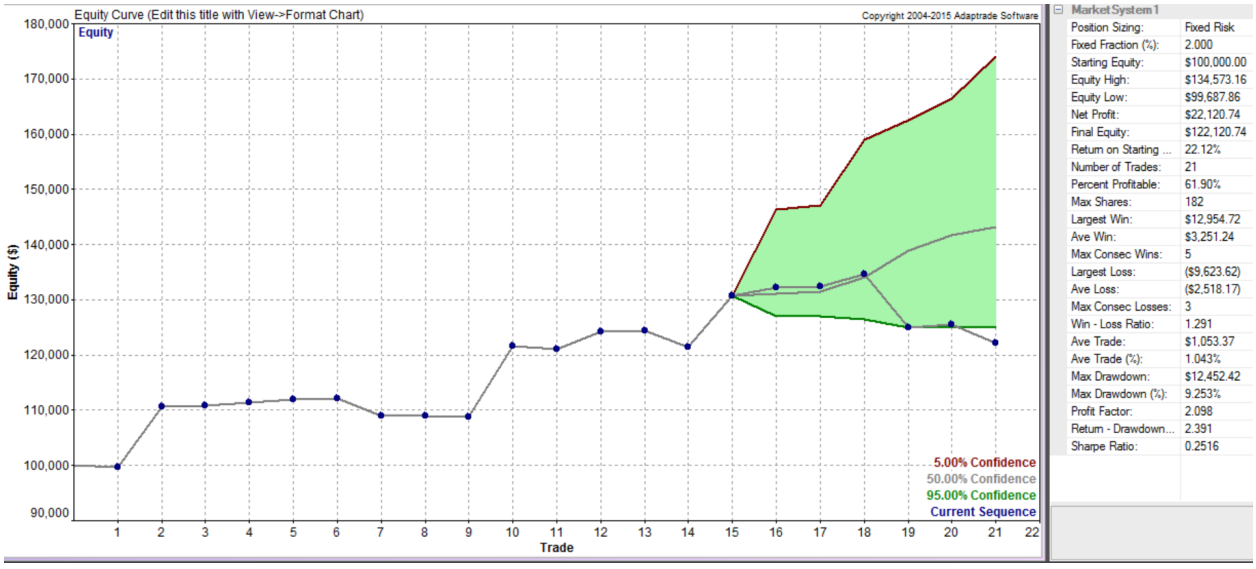
Mina WFO System Annual Return

OOS% \ Runs	5	10	15	20	25	30
10	13,123.70	17,974.93	13,428.33	18,364.44	85,724.16	92,870.76
15	14,910.88	111,458.67	90,717.54	86,308.21	71,535.57	6,307.65
20	102,321.58	15,252.21	85,640.83	-1,336.32	4,786.56	13,310.78
25	106,040.96	89,798.60	-5,043.48	4,786.56	56,085.55	34,739.99
30	8,892.32	86,770.57	4,841.73	60,987.73	29,652.34	24,547.26

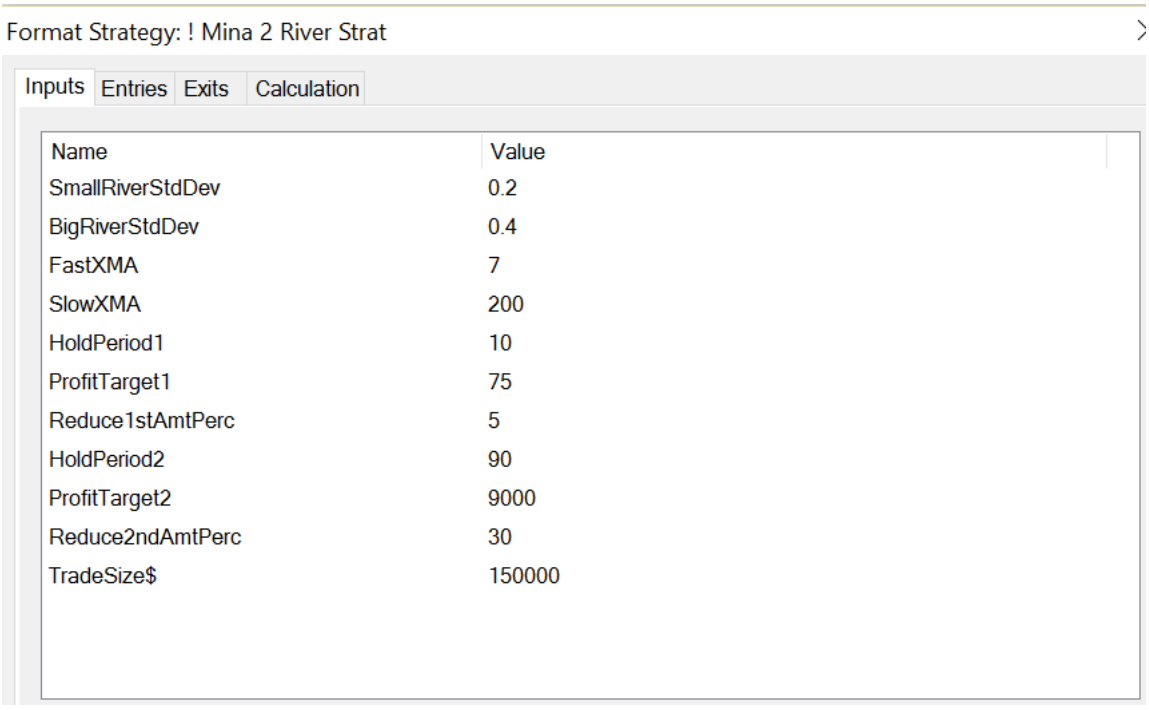
Mina TSLA Equity Curve



Mina TSLA Monte Carlo Confidence Cone



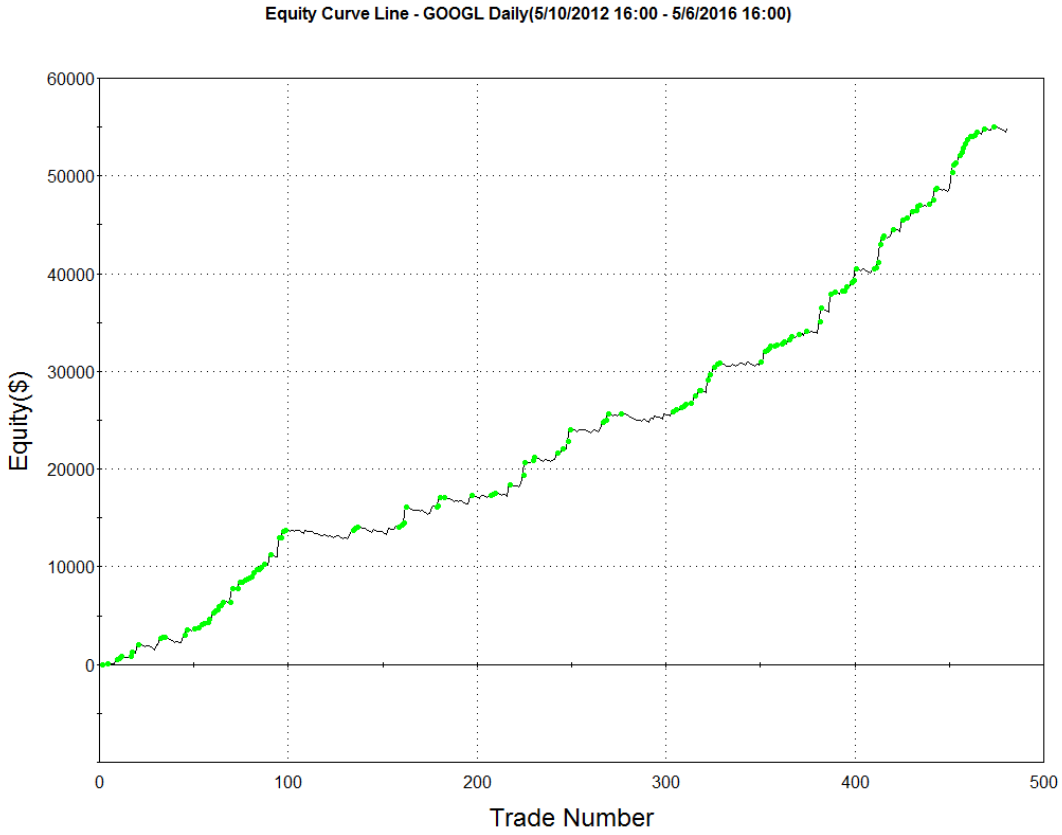
Mina's Strategy Input Parameters



Mina's Strategy Code

```
Inputs: SmallRiverStdDev ( 1),
        BigRiverStdDev   ( 1),
        FastXMA          ( 6),
        SlowXMA          ( 280),
        HoldPeriod1      ( 12),
        ProfitTarget1    ( 800),
        ReducelstAmtPerc ( 20),
        HoldPeriod2      ( 55),
        ProfitTarget2    ( 6400),
        Reduce2ndAmtPerc ( 20),
        TradeSize$       ( 100000);
vars: FastCorrection ( 0 ),
      FastUpMA       ( 0 ),
      FastDownMA     ( 0 ),
      SlowCorrection ( 0 ),
      SlowUpMA       ( 0 ),
      SlowDownMA     ( 0 );

FastCorrection = standardDev(Close, FastXMA, 2);
SlowCorrection = standardDev(Close, SlowXMA, 2);

FastUpMA   = xaverage(Close, FastXMA)
+ SmallRiverStdDev * FastCorrection;
FastDownMA = xaverage(Close, FastXMA)
- SmallRiverStdDev * FastCorrection;

SlowUpMA   = xaverage(Close,
SlowXMA) + BigRiverStdDev * SlowCorrection;
SlowDownMA = xaverage(Close,
SlowXMA) - BigRiverStdDev * SlowCorrection;

If FastDownMA crosses over SlowUpMA then
    Buy ( "2RiversLE" ) (TradeSize$
/ Close) shares next bar at market;

If FastUpMA crosses under SlowDownMA then
    SellShort ( "2RiversSE" ) (TradeSize$ / Cl
se) shares next bar at market;

If (Marketposition = 1) and (BarsSinceEntry >
HoldPeriod1) and (openpositionprofit > Prof
tTarget1) then
    Sell ( "2RivPartialLX1" ) (TradeSize$ /
entryprice / (100 / ReducelstAmtPerc)) shares n
xt bar at market;

If (Marketposition = -1) and (BarsSinceEntry >
HoldPeriod1) and (openpositionprofit > Prof
tTarget1) then
    Buy to Cover ( "2RivPartialSX1" ) (TradeSize$
entryprice / (100/ReducelstAmtPerc)) share
 next bar at market;

If (Marketposition = 1) and (BarsSinceEntry >
HoldPeriod2) and
(openpositionprofit > ProfitTarget2) then
    Sell ( "2RivPartialLX2" ) (TradeSize$ /
entryprice / (100 /
Reduce2ndAmtPerc)) shares next bar at market;

If (Marketposition = -1) and (BarsSinceEntry >
HoldPeriod2) and (openpositionprofit > Prof
tTarget2) then
    Buy to Cover ( "2RivPartialSX2" ) (TradeSize$ /
entryprice / (100 /
Reduce2ndAmtPerc)) shares next bar at market;

If (Marketposition = 1) and (Close < (SlowUpMA - (
SlowUpMA - SlowDownMA)/3))) then
    Sell ( "2RiversLX" ) next bar at market;

If (Marketposition = -1) and (Close > (SlowDo
nMA + ((SlowUpMA - SlowDownMA)/3))) then
    Buy to cover (
"2RiversSX" ) next bar at market;
```

Mladen's GOOGL Daily TradeStation Equity Curve



Mladen's GOOGL Monte Carlo Analysis Results

Monte Carlo Results at 95.00% Confidence	
Total Net Profit: $39,340.00	Max Number of Shares: 100
Final Account Equity: $139,340.00	Minimum Number of Shares: 100
Return on Starting Equity: 39.34%	Average Number of Shares: 100
Profit Factor: 2.569	
Largest Winning Trade: $2,008.00	Largest Losing Trade: ($116.00)
Largest Winning Trade (%): 1.808%	Largest Losing Trade (%): -0.1160%
Average Winning Trade: $288.23	Average Losing Trade: ($97.36)
Average Winning Trade (%): 0.2408%	Average Losing Trade (%): -0.07997%
Average Trade: $81.79	Win/Loss Ratio: 2.997
Average Trade (%): 0.06931%	Win/Loss Ratio (%/%): 3.039
Trade Standard Deviation: $331.41	Max Consecutive Wins: 6
Trade Standard Deviation (%): 0.2710%	Max Consecutive Losses: 10
Worst Case Drawdown: ($1,415.00)	Return/Drawdown Ratio: 40.74
Worst Case Drawdown (%): 1.017%	Modified Sharpe Ratio: 0.2722
Average Drawdown: ($305.17)	
Average Drawdown (%): 0.2518%	

Mladen's GOOGL Daily Walk Forward Criterion

	Test Criteria	Result	Comment
1	Overall Profitability	Pass	Total Profit > 0. System is likely
			to perform profitable on unseen data
2	Walk-Forward Efficiency	Pass	Walk-Forward Efficiency >= 50%. System is likely to perform in future
			at a rate between 50-100% of those achieved during optimization
3	Consistency of Profits	Pass **	80%+ of walk-forward runs were profitable.
			System is most likely to be successful in future.
4	Distribution of Profits	Pass	No individual time period contributed more than 50%
			of Profitable Run Total.
5	Maximum Drawdown	Pass	No individual run had a drawdown of more than 40%
			of initial capital.
	OVERALL RESULT	PASS	Walk-Forward Efficiency >= 0%. System is likely to perform in future

Mladen TSLA TradeStation Summary Report

TradeStation Performance Summary Collapse

	All Trades	Long Trades	Short Trades
Total Net Profit	$45,439.00	$14,642.00	$30,797.00
Gross Profit	$58,588.00	$21,976.00	$36,612.00
Gross Loss	($13,149.00)	($7,334.00)	($5,815.00)
Profit Factor	4.46	3.00	6.30
Roll Over Credit	$0.00	$0.00	$0.00
Open Position P/L	$0.00	$0.00	$0.00
Select Total Net Profit	$39,594.00	$14,642.00	$24,952.00
Select Gross Profit	$52,743.00	$21,976.00	$30,767.00
Select Gross Loss	($13,149.00)	($7,334.00)	($5,815.00)
Select Profit Factor	4.01	3.00	5.29
Adjusted Total Net Profit	$39,743.26	$11,250.74	$26,194.87
Adjusted Gross Profit	$53,941.67	$19,349.37	$32,731.14
Adjusted Gross Loss	($14,198.40)	($8,098.62)	($6,536.26)
Adjusted Profit Factor	3.80	2.39	5.01
Total Number of Trades	316	162	154
Percent Profitable	50.32%	43.21%	57.79%
Winning Trades	159	70	89
Losing Trades	157	92	65
Even Trades	0	0	0
Avg. Trade Net Profit	$143.79	$90.38	$199.98
Avg. Winning Trade	$368.48	$313.94	$411.37
Avg. Losing Trade	($83.75)	($79.72)	($89.46)
Ratio Avg. Win:Avg. Loss	4.40	3.94	4.60
Largest Winning Trade	$2,462.00	$1,509.00	$2,462.00
Largest Losing Trade	($110.00)	($110.00)	($110.00)
Largest Winner as % of Gross Profit	4.20%	6.87%	6.72%
Largest Loser as % of Gross Loss	0.84%	1.50%	1.89%

Mladen TSLA WFO Efficiency Results

OOS% \ Runs	5	10	15	20	25	30
10	143.9%	138.2%	87.1%	84.4%	89.5%	74.1%
15	156.5%	98.2%	93.7%	86.8%	76.0%	69.6%
20	133.1%	86.2%	85.7%	64.3%	64.4%	71.9%
25	91.9%	94.6%	70.1%	62.9%	61.7%	49.1%
30	85.5%	71.8%	62.7%	57.9%	35.2%	26.5%

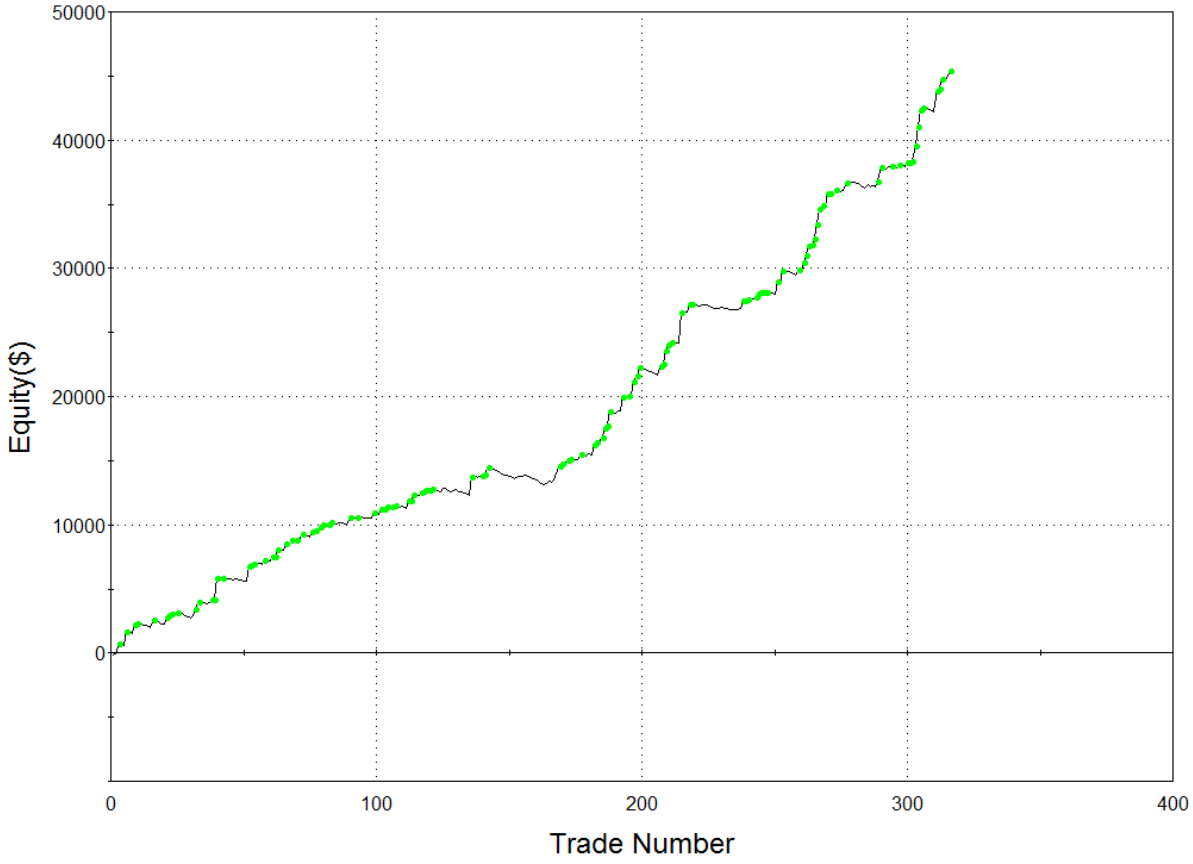
Mladen TSLA WFO Criterion

Walk-Forward Analysis Results : OOS=15% WFRuns=10

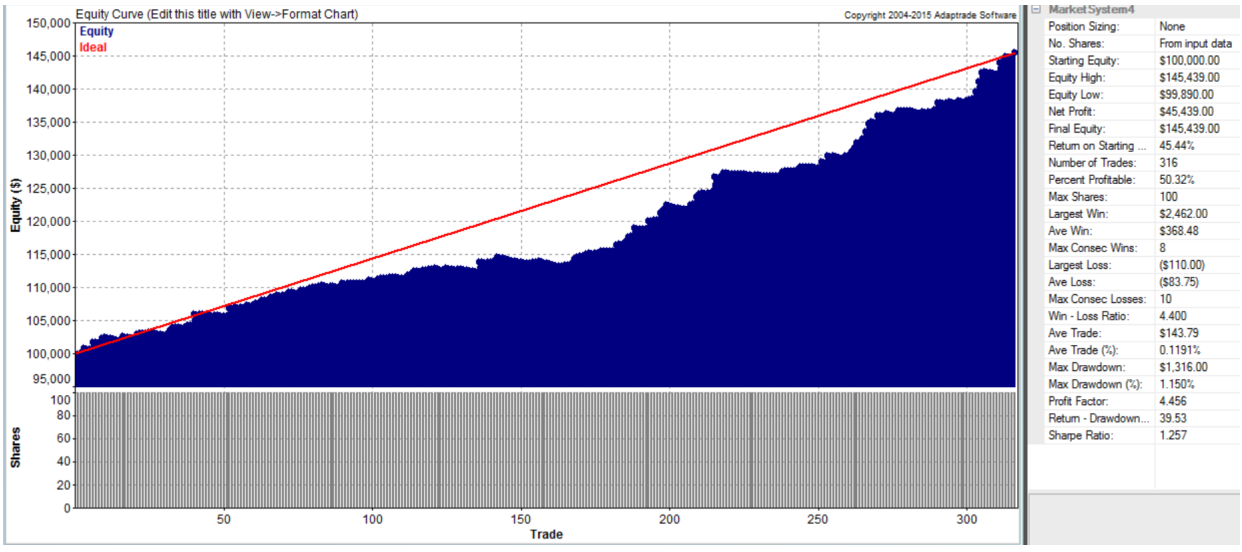
Symbol: TSLA_Daily Strategy: Mladen WFO1

	Test Criteria	Result	Comment
1	Overall Profitability	Pass	Total Profit > 0. System is likely
			to perform profitable on unseen data
2	Walk-Forward Efficiency	Pass	Walk-Forward Efficiency >= 50%. System is likely to perform in future
			at a rate between 50-100% of those achieved during optimization
3	Consistency of Profits	Pass **	80%+ of walk-forward runs were profitable.
			System is most likely to be successful in future.
4	Distribution of Profits	Pass	No individual time period contributed more than 50%
			of Profitable Run Total.
5	Maximum Drawdown	Pass	No individual run had a drawdown of more than 40%
			of initial capital.
	OVERALL RESULT	PASS	Walk-Forward Efficiency >= 0%. System is likely to perform in future

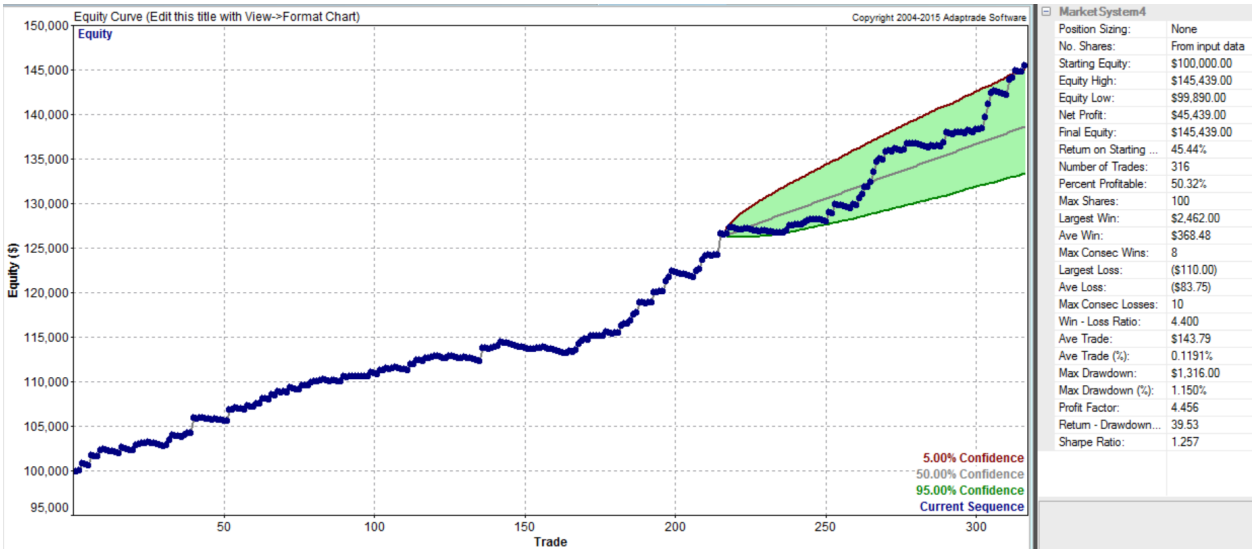
Mladen TSLA TradeStation Equity Curve



Mladen TSLA Equity Curve



Mladen TSLA Confidence Cone



Mladen TSLA Monte Carlo Results

Monte Carlo Results at 95.00% Confidence

Total Net Profit: $33,362.00	Max Number of Shares: 100
Final Account Equity: $133,362.00	Minimum Number of Shares: 100
Return on Starting Equity: 33.36%	Average Number of Shares: 100
Profit Factor: 3.389	
Largest Winning Trade: $2,462.00	Largest Losing Trade: ($110.00)
Largest Winning Trade (%): 1.983%	Largest Losing Trade (%): -0.1100%
Average Winning Trade: $321.39	Average Losing Trade: ($83.37)
Average Winning Trade (%): 0.2770%	Average Losing Trade (%): -0.07133%
Average Trade: $105.58	Win/Loss Ratio: 3.959
Average Trade (%): 0.09156%	Win/Loss Ratio (%/%): 3.961
Trade Standard Deviation: $390.80	Max Consecutive Wins: 5
Trade Standard Deviation (%): 0.3232%	Max Consecutive Losses: 10
Worst Case Drawdown: ($1,316.00)	Return/Drawdown Ratio: 28.96
Worst Case Drawdown (%): 1.150%	Modified Sharpe Ratio: 0.3169
Average Drawdown: ($227.81)	
Average Drawdown (%): 0.1955%	