# Investment Planning Group (IPG) Progress Report #1

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## Outline

- Background
- Problem Definition
- Technical Approach
- Task Breakdown and Status
- Progress Management
- Issues and Concerns
- Future Plans



# **Options Trading Definitions**

- **Derivatives**: financial instrument whose value depends on (or derives from) the values of other, more basic, underlying variables.
- **Options**: financial derivatives sold on exchanges that establishes a contract between two parties concerning the buying or selling of an asset
  - Call Option: affords the holder the *right, but not the obligation* to buy the underlying asset from the writer at the strike price, by the expiration date.
  - Put Option: affords the holder the *right* to sell the underlying asset to the writer at the strike price, by the expiration date.
  - Value of an option derives from the strike price, the spot price, interest rate, and the volatility



# **Definitions (cont'd)**

- Strike or Exercise Price: fixed price at which the holder can purchase (if call) or sell (if put) the underlying asset from/to the writer
- **Spot or Market Price**: the settlement price of the underlying asset when an option is exercised
- **Expiration Date**: date upon which the contract expires, after which it becomes worthless if it is out of money
- **Stop Loss Order**: order to buy back an option once the price of the asset has climbed above (or dropped below) a specified *stop price*. Used to minimize catastrophic loss.
- **Slippage:** the difference between estimated filled prices and the amount actually paid, typically due to market forces.
- **Short Strangle Strategy**: selling both a put and a call option with the same expiration date but with different strike prices



#### **Recap of Exchange and E-Mini S&P**

- Exchange: platform where assets such as commodities (pork bellies, cattle, sugar, wool, lumbar, copper, aluminum, gold, tin, ...) or financial assets (currencies, treasury bonds, stock indices, ...) are traded in standardized contracts.
  - Chicago Mercantile Exchange (CME)
    - E-Mini S&P is a stock market index futures contract traded on the Chicago Mercantile Exchange's Globex electronic trading platform.
    - The notional value of one E-Mini contract is US\$50 times the value of the S&P 500 index futures.
    - E-Mini S&P futures is the underlying asset upon which our group will write options to engineer an optimal investment strategy



## **Problem Definition**

#### Problem Definition

- Options investment strategies that are rigorously modeled are usually proprietary and are the efforts of many resources
  - Determine an optimal options investment strategy
  - Balance aggressive investment against catastrophic loss
- Sponsor's Primary Objectives
  - Extend the efforts of Fall 2009 and Spring 2010 project teams to develop a more realistic simulated trading process
  - Develop an analytical model to predict the risk reward ratio of an investment strategy and validate the strategy with our simulated trading process using real data
  - Submit technical paper for publication



# **Options Trading Clarification**

- We are not trading stocks or other commodities
- Effectively selling insurance on price changes of one commodity, the E-mini S&P
  - i.e. gambling
- Always buy back the option on expiration
- Useful tool for other traders to hedge against losses in other commodities



# **Options Trading Scenarios (1)**



- Sell a put with strike price of 1300 and sell a call with strike price of 1350
- Stop price is ±40pts (1390 for call, 1260 for put)
- Premium for each is 10pts (each point is \$50)
- If option never stops out and expiration price is between put and call price, collected option premium is pure profit



# **Options Trading Scenarios (2)**



- If an option stops out, which implies we buy it back to prevent further loss
  - At a cost of the difference in stop and strike price
- Both put and call stop out in this case
- Loss of 2 · 40pts 2 · 10pts (60pts)



# **Options Trading Scenarios (3)**



- No stop loss, final price is 1280
- Only put option has value, call expires worthless
- Call makes 10pts on premium
- Put loses 10pts (cost to buy option back minus premium)



#### **Methodology and Technical Approach**

- Extend existing Java simulated trading process GUI
  - Implement a more user-friendly front-end interface
- Improve existing simulated trading process:
  - Enumerate to find optimal Short Strangle Strategy
  - Use and improve realistic assumptions to prune search space
    - Model slippage as a function of size of trades
    - Use premium range as a parameter instead of strike price and put/call range
    - Reduce trade size when too large for market to handle
  - Use Kelly Criterion to determine optimal fractional allocation of investment
    - Marginal requirement on investment
- Implement performance prediction model(s) and recommend the optimal strategy with highest estimated profit
  - Estimate the distribution of asset prices at options expiration using Geometric Brownian Motion model
  - Estimate profit potential against feasible strategies using expected value of the asset price then select best strategy



## Task Breakdown

- Modify simulated trading process to use more realistic assumptions
  - Use Bear-Call/Bull-Put spread options strategy instead of stop-loss orders
  - Investigate and implement models for slippage
  - Determine optimum fractional allocation of current fund balance for writing new options contracts
  - Use premium (5-25 points) instead of strike prices to parameterize writing strategies
- Improve front-end user-interface (UI)
  - Allow user to more easily modify and prune trading strategy parameters
- Implement, analyze and validate a performance prediction model to recommend the optimal investment strategy that maximizes expected profit



# **Spread Options Strategies**

- Bear Call
  - Buy now and sell later at higher price
  - Useful in a bear market when the value of the E-Mini S&P index is increasing
- Bull Put
  - Sell now and buy back later for lower price
  - Useful in a bull market when the value of the E-Mini S&P index is decreasing
- Replaces stop-loss orders



# **Spread Strategies**

- Sell both put and call options and buy another pair at further out of the money.
- We collect the premium
- Four Ways
  - Long on call short on put
  - Short on call long on put
  - Long on call long on put
  - Short on call short on put



### **Spread Strategies**

#### Goal of model is to determine which spread is best to apply

Option	Trade	Strike	Strategy	Profitable				
Strategy	Setup	Order	Risk/Reward	Conditions				
Bull Put Spread	Sell Put/	Sell Higher/	Limited Loss/	Neutral; Bullish;				
	Buy Put	Buy Lower	Limited Profit	Moderately Bearish				
Bear Call Spread	Sell Call/	Sell Lower/	Limited Loss/	Neutral: Bearish:				
	Buy Call	Buy Higher	Limited Profit	Moderately Bullish				

Exhibit I



# **Slippage Model**

- More realistic model requirement
- Effect of instant market reaction is a narrow "bidask" spread
- Large trade size effects market depth resulting in slippage
- Combing the two methods:

$$S_{t+1} = u \cdot S_t \cdot e^{\lambda(1-\alpha)(H_{t+1}-H_t)}$$
  
$$S_{t+1} = d \cdot S_t \cdot e^{\lambda(1-\alpha)(H_{t+1}-H_t)}$$

• If price goes up:

$$u = e^{\left(\sigma/\sqrt{\Delta t}\right)}$$

• If price goes down: d

$$d = e^{\left(-\sigma/\sqrt{\Delta t}\right)}$$



#### **Optimum Fractional Allocation Model**

- Determine optimum fraction of capital to invest using Kelly Criterion
- Kelly % = Edge/Odds
  - Edge: how much expected to win
  - Odds: how much they would win if successful

• Kelly % = 
$$\frac{(bp)-(1-p)}{b}$$

- b = win/loss
- *p* = probability of winning



## **Software Development Status**

- Improved simulation speed
  - Parallelized to use all available CPU resources
  - Enhanced exception handling and serialization
  - Resulted in 10x faster simulation
- Trading simulation front end UI under development
- Use premium to parameterize trading strategies
  - Ashirvad has provided initial code to parameterize trading strategies by premium rather than strike price



#### **Front End UI Mock-up**

🚳 IPG : Optimal E-Mini S&P Options Trading Strategies	
File Help	
Trading Simulation Prediction Model Strategy Analysis	
CME Input Data Directory: ./data/input/ Browse	Spring 2010 Strategy Spring 2011 Strategy Adjusted Strategy Put Option:
Trading Year: Min: 2004 Max: 2009	Min: -50 Max: -5 Call Option:
Trading Days to Expiration:	Min: 5 Max: 50
	Strike Value Increment:     5       Stop-loss Values:     5, 10,
Initial Investment Amount: \$100,000	Max Volatilities: 30, 40, 50
Required Margin:     \$5,000       Ruin Fraction:     0.5	
Strategy Output Directory: ./data/output/ Browse	
Output Filename Prefix: strangleStrategy	Run Trading Simulation
	0

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## **Prediction Model Status**

- We have a basic understanding of the Performance Prediction Model but more research and analysis is required
  - Estimate the distribution of asset prices at options expiration using Geometric Brownian Motion model
  - Using expected value of the asset price, we will estimate profit potential against feasible strategies then recommend the best strategy
  - We will analyze the performance of our prediction model for each month and option expiration date.



### **Progress Management**

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D		Task Name	Duration	Start	Finish	Jan 23	Jan 30 F	eb 6 Feb 13	Feb 20	Feb 27 Mar	r6 Mar13	Mar 20	Mar 27	Apr 3 Apr 10	Apr 17	Apr 24	May 1	May 8 May
1	-	Management	70 days	Mon 1/31/11	Eri 5/6/11	3 1 1 5		5 I I S M V	v r 5 I f	S M VV F S	II ISMW		3 M W F	5       S M	w r s I T	S M W	-  <b>3</b>	S M W F S
-	-	Meetings	69 days	Tue 2/1/11	Eri 5/6/44													
2		Team Mastings	60 days	Tue 2/1/11	Eri 5/0/11													
3		Spanner Meetings	46 days	Eri 2/4/11	Eri 4/9/11				-	1 1		-						
4		Advisor Meetings	40 days	Eri 4/45/11	Thu 4/21/11		-											
6		Personal Activity Loop	70 days	Mon 1/31/11	Eri 5/8/11													
0	_	Problem Definition and Seene	70 days	Mon 4/24/44	Thu 2/40/44													
<u>'</u>	-	Problem Definition and Scope	9 uays	Mon 1/31/11	Thu 2/10/11													
•	×	Problem Definition and Scope Prep	9 udys	Thu 2/2/44	Thu 2/10/11		A 2/3											
9		Problem Definition Due	1 day	Thu 2/3/11	Thu 2/3/11			A 2/10										
10		Problem Definition and Scope Due	T day	Thu 2/10/11	Thu 2/10/11				_									
11		Project Proposal	5 days	Fri 2/11/11	Thu 2/17/11			¥-										
12	×	Project Proposal Prep	5 days	FR 2/11/11	Thu 2/17/11				A 2/47									
13		Project Proposal Due	1 day	Thu 2/17/11	Thu 2/17/11				• 2111									
14	_	Progress Reports	40 days	Fri 2/18/11	Thu 4/14/11													
15		Progress Report #1	15 days	Fri 2/18/11	Thu 3/10/11				+									
16	×	Progress Report #1 Prep	15 days	Fri 2/18/11	Thu 3/10/11													
17		Progress Report #1 Due	1 day	Thu 3/10/11	Thu 3/10/11						a 3/10							
18		Progress Report #2	25 days	Fri 3/11/11	Thu 4/14/11						<b>1</b>							
19		Progress Report #2 Prep	25 days	Fri 3/11/11	Thu 4/14/11							_						
20	<b>E</b>	Progress Report #2 Due	1 day	Thu 4/14/11	Thu 4/14/11										<b>4/14</b>			
21		Final Report	12 days	Fri 4/15/11	Mon 5/2/11													
22		Final Report Prep	12 days	Fri 4/15/11	Mon 5/2/11										4			
23		Final Report Due	1 day	Mon 5/2/11	Mon 5/2/11												♦ 5/2	
24		Project Website	15 days	Fri 4/15/11	Thu 5/5/11										4			
25		Project Website Prep	15 days	Fri 4/15/11	Thu 5/5/11											-		
26		Project Website Due	1 day	Thu 5/5/11	Thu 5/5/11												•	5/5
27		Final Presentation	16 days	Fri 4/15/11	Fri 5/6/11												<u> </u>	,
28		Final Presentation Prep	16 days	Fri 4/15/11	Fri 5/6/11													
29		Dry Run #1	1 day	Thu 4/28/11	Thu 4/28/11											•	4/28	
30		Dry Run #2	1 day	Thu 5/5/11	Thu 5/5/11												•	5/5
31		Final Presentation	1 day	Fri 5/6/11	Fri 5/6/11												4	5/6
32		Research	40 days?	Mon 1/31/11	Fri 3/25/11		Ç						,					
33		Background	40 days?	Mon 1/31/11	Fri 3/25/11		<b>Q</b>					$\rightarrow$	,					
34	×	Financial Investing	20 days	Mon 1/31/11	Fri 2/25/11			_										
35	×	Options Trading	20 days	Mon 1/31/11	Fri 2/25/11			_										
36	× .	Short Strangle Strategy	20 days	Mon 2/7/11	Fri 3/4/11													
37	×	Spread Options Strategies	16 days?	Fri 2/18/11	Fri 3/11/11													
38		Performance Prediction Models	20 days	Mon 2/28/11	Fri 3/25/11													
39	<ul> <li>Image: A second s</li></ul>	Review Previous Projects' Efforts	20 days	Mon 1/31/11	Fri 2/25/11				_									
40	×	Review Previous Project's Software	20 days	Mon 2/7/11	Fri 3/4/11				_									
41		Modeling and Simulation	55 days	Mon 2/7/11	Fri 4/22/11			-	_									
42	×.	Technical Approach	15 days	Mon 2/7/11	Fri 2/25/11													
43		Model Developtment	15 days	Mon 2/21/11	Fri 3/11/11													
44		Software Development	45 days	Mon 2/21/11	Fri 4/22/11				<b>—</b>									
45	×.	Improve Simulation Runtime	10 days	Mon 2/21/11	Fri 3/4/11													
46		Improve UI Front End	15 days	Mon 2/21/11	Fri 3/11/11													
47		Make Assumption More Realistic	20 days	Mon 2/28/11	Fri 3/25/11					<b></b>			,					
48		Parameterize Strategies by Premium	10 days	Mon 2/28/11	Fri 3/11/11													
49		Implement Slippage Model	10 days	Mon 3/7/11	Fri 3/18/11													
50	==	Implement Spread Options Strategies	10 days	Mon 3/14/11	Fri 3/25/11													
51		Implement Kelly Criterion	10 days	Mon 3/14/11	Fri 3/25/11													
52		Implement Prediction Model(s)	25 days	Mon 3/21/11	Fri 4/22/11													
53		Analysis	52 days	Mon 2/21/11	Tue 5/3/11				<b>~</b>			-		_		-		
54		Input Data Analysis	10 days	Mon 2/21/11	Fri 3/4/11													
55		Model Analysis	20 days	Mon 2/21/11	Fri 3/18/11													
56		Results Analysis	40 days	Mon 2/28/11	Fri 4/22/11							_		_		<b>V</b>		
57		Post-processing	40 days	Mon 2/28/11	Fri 4/22/11													
58		Visual Analysis in UI	35 days	Mon 3/7/11	Fri 4/22/11													
59	==	Compare to Previous Year's Results	15 days	Mon 3/7/11	Fri 3/25/11													
60		Validate New Results	25 days	Mon 3/21/11	Fri 4/22/11													
61		Recommendations	12 days	Mon 4/18/11	Tue 5/3/11													

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# **Future Tasking**

- Near-term Software Development
  - Finish front-end UI
  - Implement new spread options strategies
  - Implement model for slippage
  - Implement Kelly's Criterion
- Performance Prediction Model
  - Near-term: Create initial Excel spreadsheet to generate a distribution of expiration prices using a Monte Carlo simulation
  - Long-term: Implement prediction model component into trading simulation tool and recommend best trading strategy
- Analysis
  - Compare new trading strategy results against previous projects
  - Test prediction model with historical data and compare with actual future data



## **Issues and Concerns**

- New requirements added by sponsor
- Slippage model liquidity parameter has unclear definition
- Behind schedule on:
  - Software development
  - Performance prediction model development
  - Data and model analysis



#### References

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