WFATOOLBOX 1.1.0 USER'S GUIDE

CONTENTS

REVIEW

WFAToolbox is an application for MATLAB® intended to carry out Walk-Forward testing through graphic interface to create financial markets trading strategies.

MAIN PRINCIPLES OF WALK-FORWARD TESTING

Walk-Forward testing is based on the principle of optimization with data validation and it's realized in WFAToolbox through several different stages:

i. Loading dynamics of quotations of any desired financial asset (stocks, bonds, currencies, futures etc.);

ii. Loaded data are separated into several equal test periods;

iii. These periods are also divided into In-Sample (Optimization) period and Out-of-Sample (Backtesting) period - see **Image 1**

iv. During start of any selected trading strategy (or group of trading strategies) there are several stages:

   i. strategy is being optimized to the In-Sample period, e.g. best parameters are selected to maximize Sharp Ratio (as the main trading strategy efficiency criteria);

   ii. strategy is tested on the Out-of-Sample period and all data are saved as a trading strategy results for this interval;

   iii. strategy is being optimized again to next period (with an offset equal to the length of previous Out-of-Sample period) and so on.

v. After optimization and testing you can save all trading data with periods summary into separate file. Then it can be used for comprehensive analysis in XpressAnalyzer application for Excel.
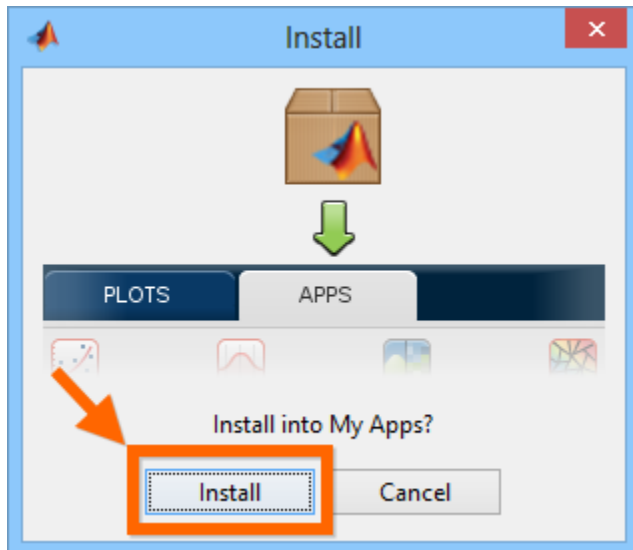
1. INSTALLATION

1.1. FIRST LAUNCH

To install the WFAToolbox application you need to execute file with ".mlappinstall" extension.

When you open installation file for the first time, MATLAB® will ask you to install application automatically. Just press "Install" button.

After first launch you will receive 30 days evaluation license, that will allow you to use all the features and services of the program during mentioned period.

After installation you will see WFAToolbox icon in the list of MATLAB application. Press it to start the application.
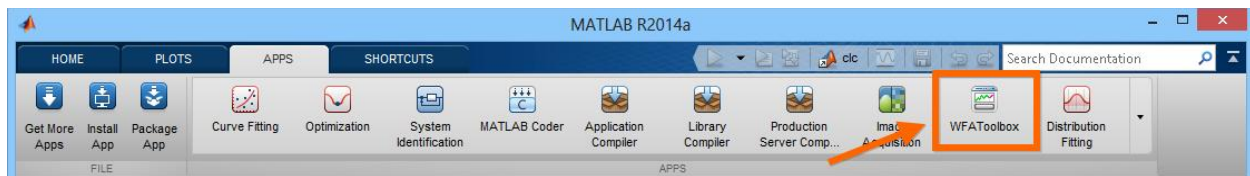
1.2. REINSTALLING OR INSTALLING NEW VERSION

If you want to reinstall application or install new version of it and you already have previous version of the WFAToolbox application, then MATLAB will offer you to reinstall the application. We recommend to back-up all the information from program folder "C:\Documents\MATLAB\WFAToolbox\" that contains all your changes, including all the files with strategies. You can then allow MATLAB to install new version, by pushing "Re-install" button. All the information from previous version is going to be saved and restored after.
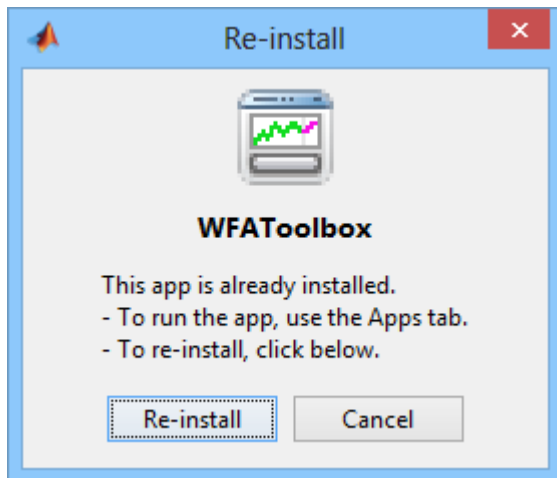
1.3. WFATOOLBOX ACTIVATION

After purchasing of the WFAToolbox application you will receive an e-mail containing your license number, which you need to enter to activate application.

To activate your application, firstly you need to start the WFAToolbox, and click on the "Activation" menu item in the upper left corner.

Then you need to enter license number, received in e-mail.
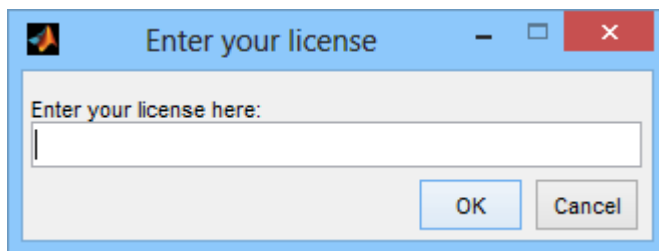
2. DATA LOADING

After loading off application you will see application interface. First of all you have to load data which are necessary for your work. Push "Load Data" button to load your information.
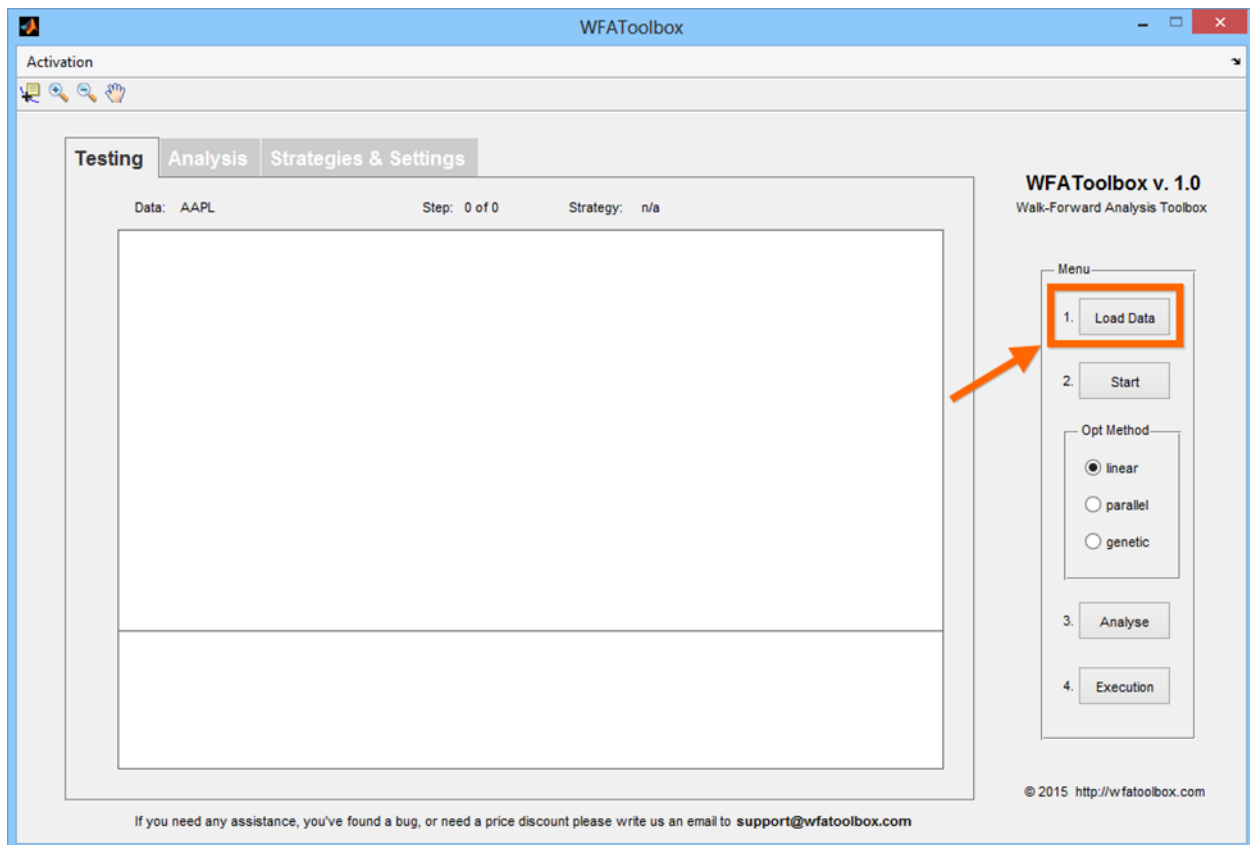
2.1. GOOGLE FINANCE

Using Google Finance tab you can download and update free daily and intraday historical data of stock prices of companies from North America, Europe and whole World.

Please note! Historic share prices from Google server may contain inaccurate data or gaps, and can be delivered with "delays", e.g. some "fresh" information about last periods may be missing. Furthermore some tickers may not contain intraday historical data or data download may be totally prohibited due to some reasons. As long as this information is free, nor Google, nor WFAToolbox have no liability, but we are really sure that this information can be good tool in addition to paid services to carry out preliminary testing and analysis of trading strategies.

Thus, to load data from Google Finance you have to complete next steps:

a. **Select type of asset, region and stock exchange**

In the upper part of the window you can select type of asset (only Stocks is available for today), the region and stock exchange from drop-down list.

Available Stock Exchanges List

North America

NYSE	New York Stock Exchange
NASDAQ	NASDAQ Stock Market
AMEX	NYSE AMEX
NYSEARCA	NYSE ARCA
NYSEMKT	NYSE MKT
CVE	TSX Ventures stocks
CNSX	Canadian National Stock Exchange
PINK	Pink Sheets

OTC	Over the Counter Stocks
OTCBB	FINRA OTC Bulletin Board
OTCMKTS	FINRA Other OTC Issues

Europe

VIE	Vienna Stock Exchange
CPH	Coppenhagen Stock Exchange
EBR	NYSE Euronext Brussels
ELI	NYSE Euronext Lisbon
FRA	Paris Stock Exchange
HEL	NASDAQ OMX Helsinki
ICE	NASDAQ OMX Iceland
FRAN	Deutsche Börse Frankfurt Stock Exchange
ETR	XETRA Stock Exchange
BIT	Milan Stock Exchange
AMS	Amsterdam Stock Exchange
STO	Stockholm Stock Exchange
VTX	Swiss Exchange
LON	London Stock Exchange
IST	Borsa Instanbul
MCX	Moscow Exchange
RSE	NASDAQ OMX Riga
TAL	NASDAQ OMX Tallinn
VSE	NASDAQ OMX Vilnius

World

ASX	Australian Stock Exchange
BVMF	BOVESPA - Sao Paolo Stock Exchange
SHE	Shenzhen Stock Exchange
HKG	Hong Kong Stock Exchange
BOM	Bombay Stock Exchange
NSE	National Stock Exchange of India
TLV	Tel Aviv Stock Exchange
NZE	New Zealand Stock Exchange
SGX	Singapore Stock Exchange
KRX	Korea Stock Exchange
KOSDAQ	Korean Securities Dealers Automated Quotations
TPE	Taiwan Stock Exchange
BKK	Thailand Stock Exchange
TYO	Tokyo Stock Exchange

b. **Enter keyword to search faster**

After selecting of necessary stock exchange, to facilitate the search and avoid continous scrolling you can enter any desired keyword into "Type a keyword for searching" field and press "Find" button. By doing so list is going to be limited with positions containing the keyword that you entered.
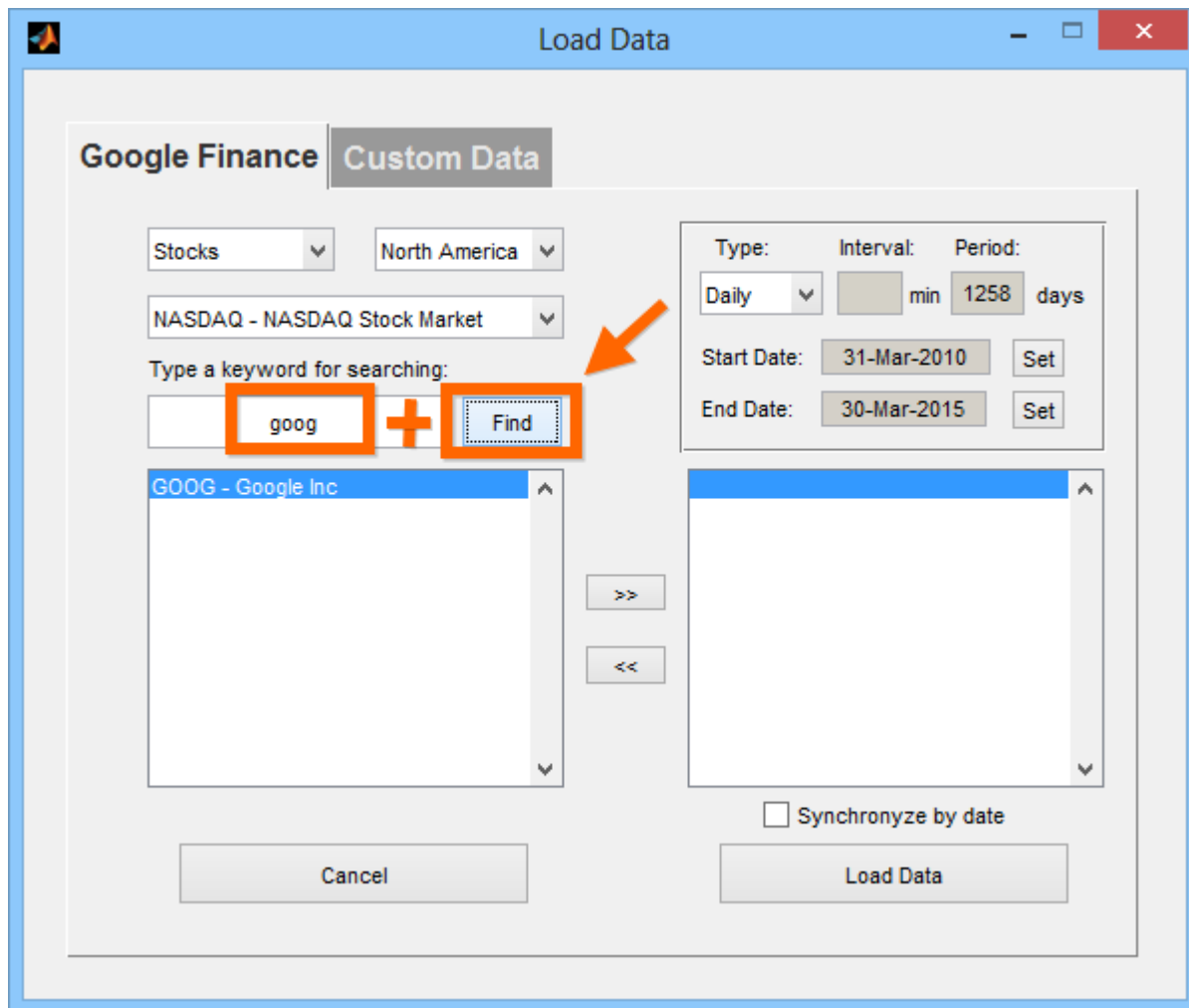
c. **Select ticker from the list**
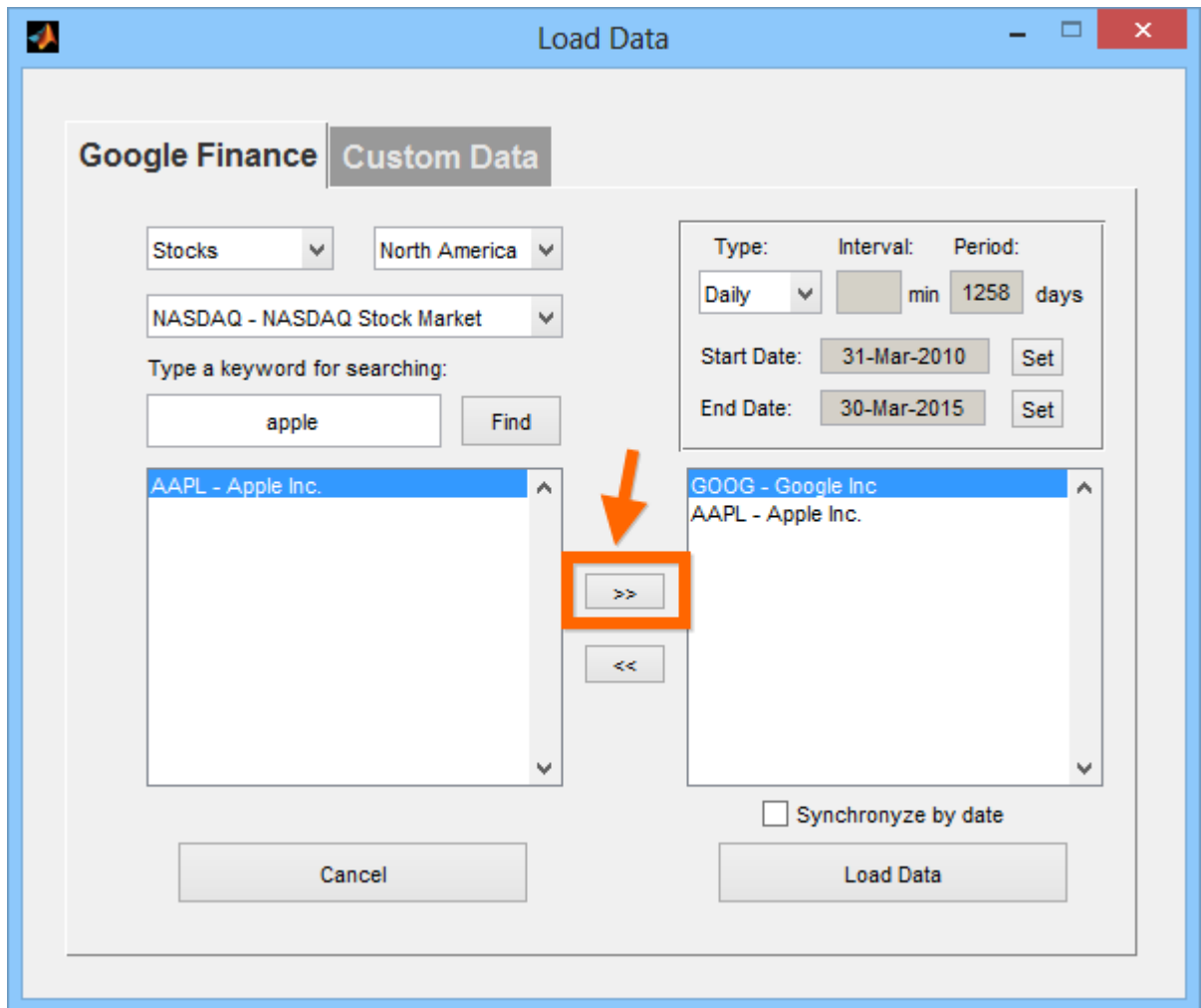
After clicking on any ticker in the list you can include it into the list of bootable tools by pressing ">>" button. This list may contain several tickers, added from the list of the same or different stock exchange.

d. Select data frequency and duration

You can select data frequency from the "Type:" drop-down list: it can be Daily or Intraday.

When you select *daily period,* you can chose the start and end time of the downloaded data period by pushing one of "Set" buttons.

When you select *intraday period,* you can select timeframe in minutes as well as quantity of days for loading.

e. Push "Load Data" button
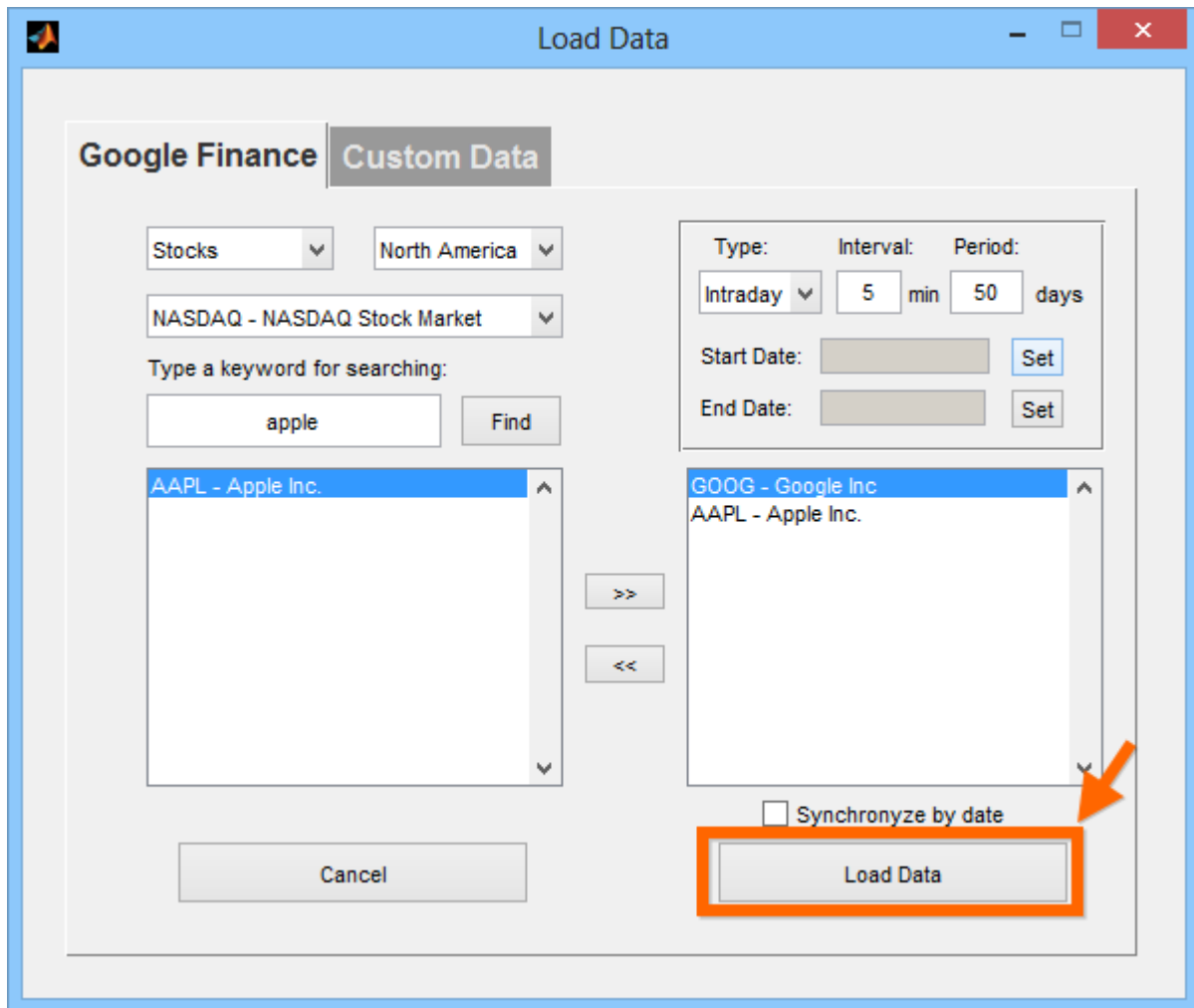
After selecting desired tickers and the period of time with data frequency, you can push "Load Data" button, which will load selected tickers into the MATLAB Workspace.

You can also use "Synchronyze by date" checkbox, which will synchronize all the data in time, e.g. timestamp for all the information about ABC company will correspond with all the information about XYZ company and all other. It can be vital during creation of strategies which involve several different assets, e.g. pairs trading or basket trading.
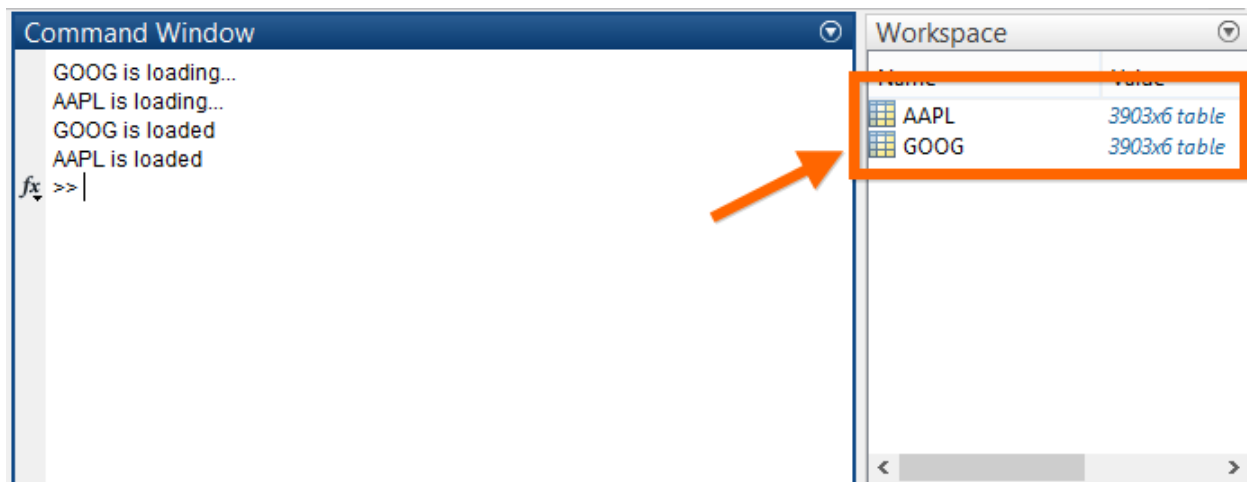
After data loading you should see loaded tickers in the upper left corner of WFAToolbox , which means that you can use loaded data during your testing.

2.2. CUSTOM DATA

You can also load your own data into the WFAToolbox. The only rule is that data must have proper formatting:

- Be in "table" or "dataset" format;

- Have at least 2 data columns, one of them should contain date and time, and second - information about "Close" bar closing;

- Columns must be named with one of these words: Date, Open, High, Low, Close, Volume.

In the list on "Custom Data" tab you can see all the variables from Workspace, which are shown in "table" or "dataset" format. If new variables appear in Workspace, you have to refresh variables list, by pressing "Update List" button.
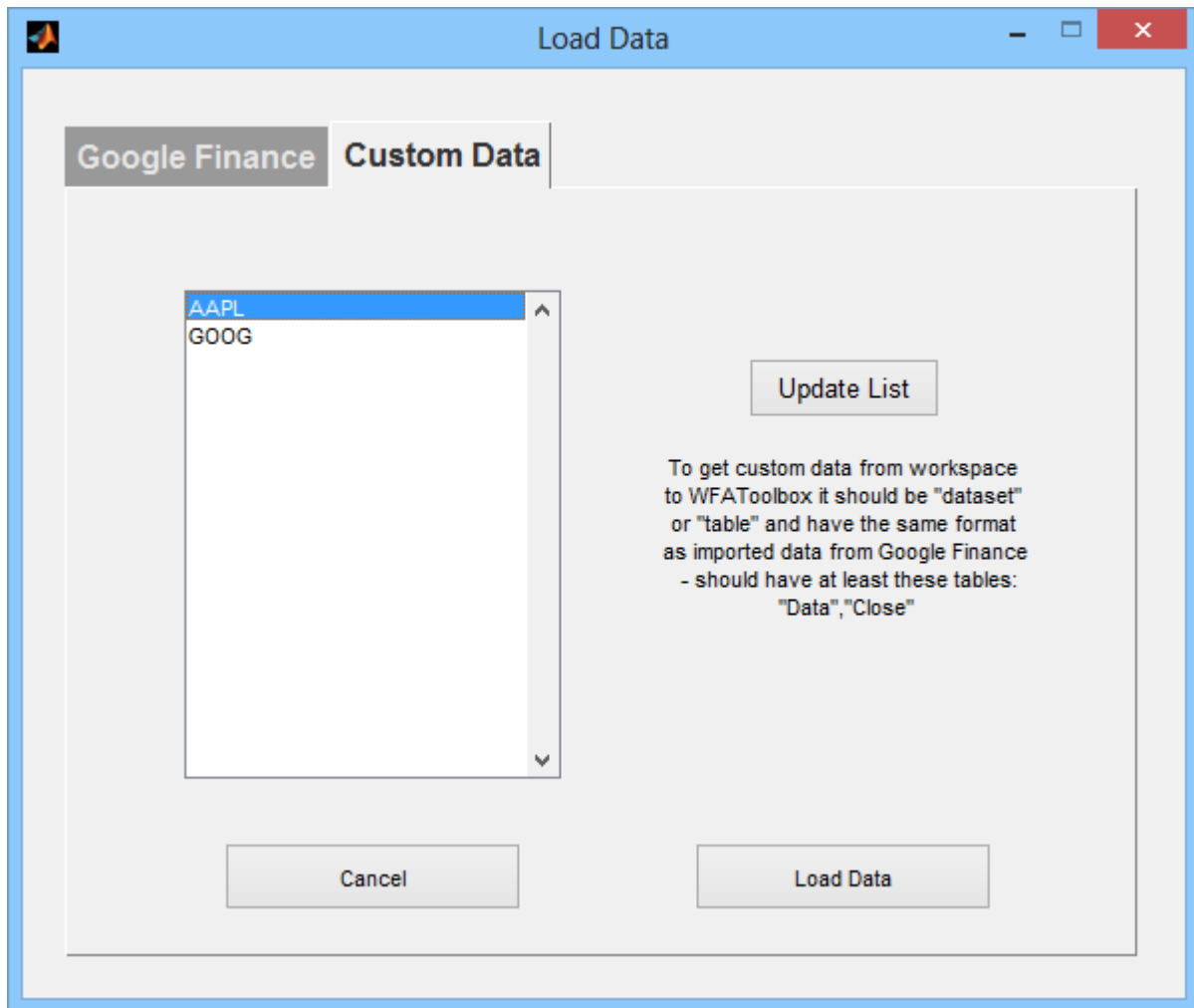
To load data from Workspace, just select desired tickers from the list (you can select several tickers, using SHIFT or CTRL button) and push Load Data button.

If there's no error in process, you will see names of loaded tickers in the upper left corner of the WFAToolbox application.
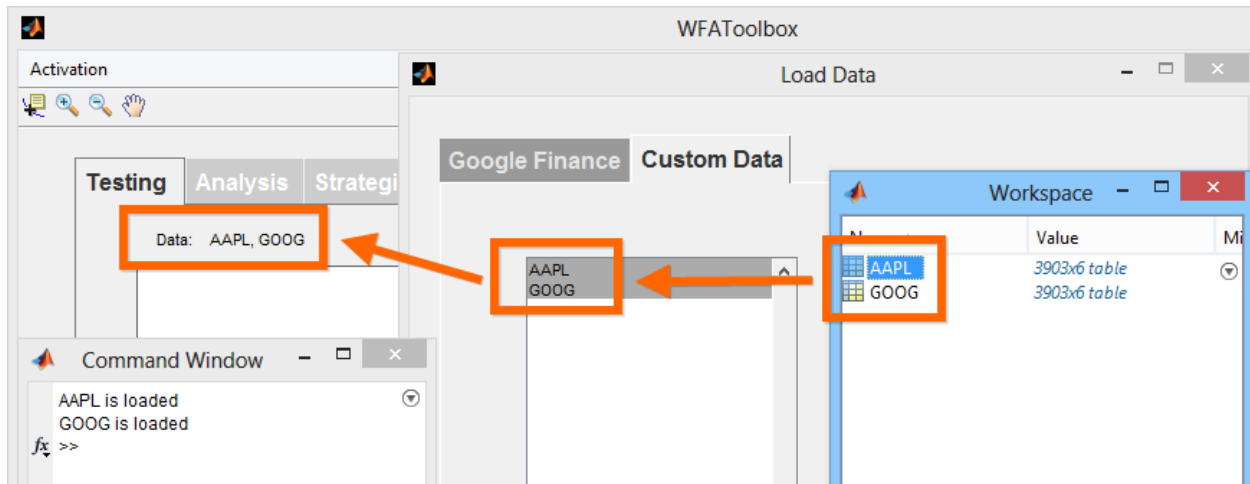
3. CREATING & EDITING OF STRATEGIES

Trading strategies in the WFAToolbox represent functions of the MATLAB, which describe algorithm that determines variable for optimization, indicators calculation formulas and some other calculations as well as converts initial data and describes rules of trading system itself.

Interaction with trading strategies can be done in two ways: using «Strategies & Settings» tab of the WFAToolbox application, or directly from «Current Folder» window of the MATLAB application.

Interacting with strategies through «Strategies & Settings» tab

In the left side of «Strategies & Settings» tab you can find strategies list, and some buttons above it, which allow various interactions with strategies files.
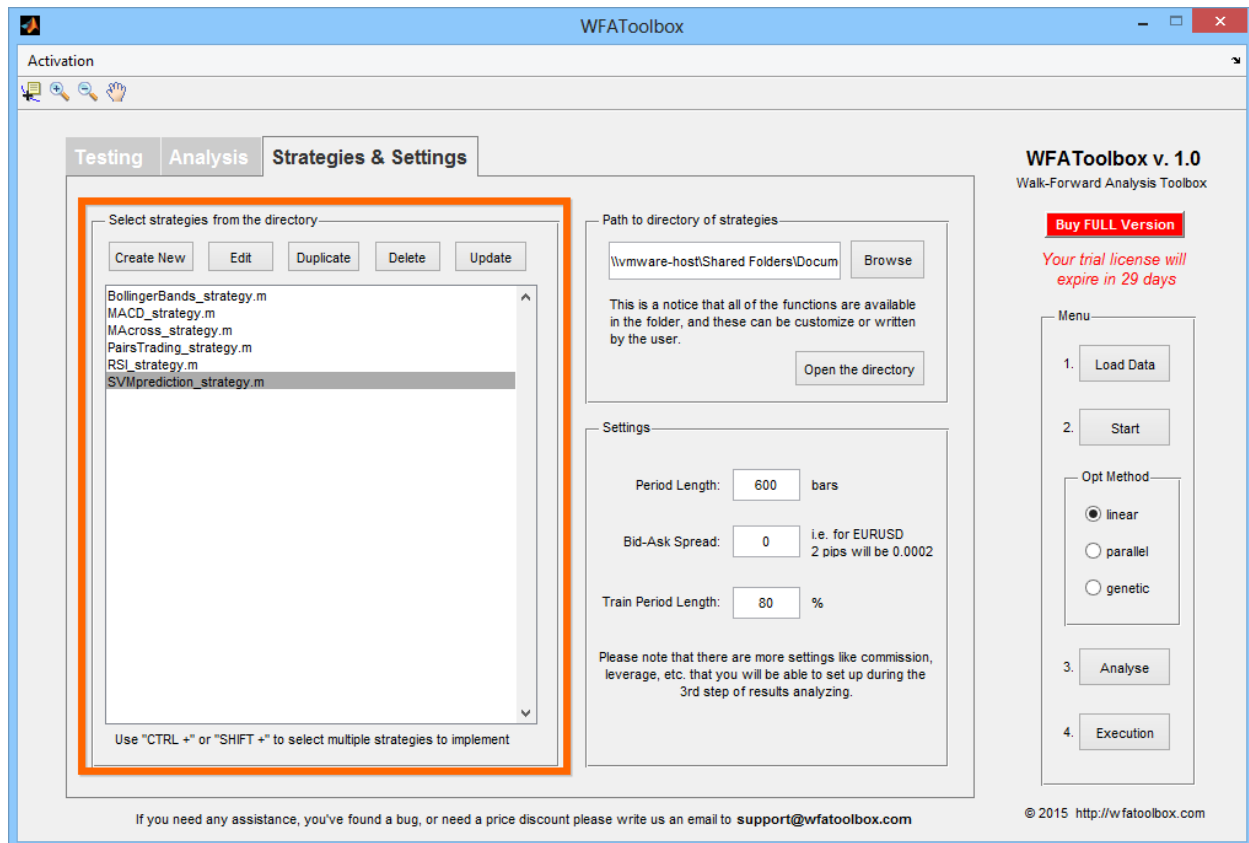
Creating new strategy

To create new strategy you can use «Create New» button, which is located above strategies list. When you push it, new trading strategy template is created. It's new file called «NewStrategy» and divided into «3 zones», which you have to fill in.

- Declare parameters and optimization range

- Processing

- Signals

Also there's a part of source code, which is necessary to provide stable work of the application. We will look more closely at each block in different sections.

When your strategy is created, you can select any desired name for it. To do so, you can just change the function in the very first row of source code, using «Editor – Save – Save As…» menu items, setting any name during file saving procedure.

```matlab
NewStrategy.m  ✕  +
1   function [params,sig,cost] = NewStrategy(x,price)
2       % Function for trading strategy optimisation
3
4       %% Declare parameters and optimization range
5       % Here you can define names of variables and range for optimization
6       % by setting PARAMS structure
7
8
9       %% Warning! Don't change this block of code
10      % You can skip this block of code
11      var_names = fieldnames(params);
12      for i = 1:length(var_names)
13      if ~isempty(x)
14          eval([var_names{i},'=',num2str(x(i)),';']);
15        else
16          eval([var_names{i},'=',num2str(params.(var_names{i})(1)),';']);
17        end
18      end
19      sig = zeros(length(price.Close),1);
20
21
22      %% Processing
23      % Here you can do any calculations for your strategy
24
25
26      %% Signals
27      % Here you can fill out signals variable SIG
28
29
```

In order to display new saved function in the list, you can just click «Update» button. If you wish to delete old function, just click «Delete» button.

Strategy duplication

If your strategy has common features with any existing strategy, you can avoid creation of strategy from the scratch, by using duplication of strategy and then editing only selected parts of source code.

Thus, to duplicate any strategy from the list you need to select it with mouse and click «Duplicate» button, which will result in the appearance of new strategy with the same name, but with «_copy» prefix, which then can be opened for editing with «Edit» button.

Interacting with strategies directly in «Current Folder» window of the MATLAB application

Another way to edit strategies - is to open strategies containing folder in the MATLAB. By default they are located in «C://Documents/MATLAB/WFAToolbox/Strategies» folder. But you can choose any desired folder location for your strategies. To do so you need to push «Browse» button in «Strategies & Settings» tab and select folder location.

In order to open selected folder with strategies more easy, you can push «Open the directory» button, and the MATLAB will open folder in «Current Folder» window.
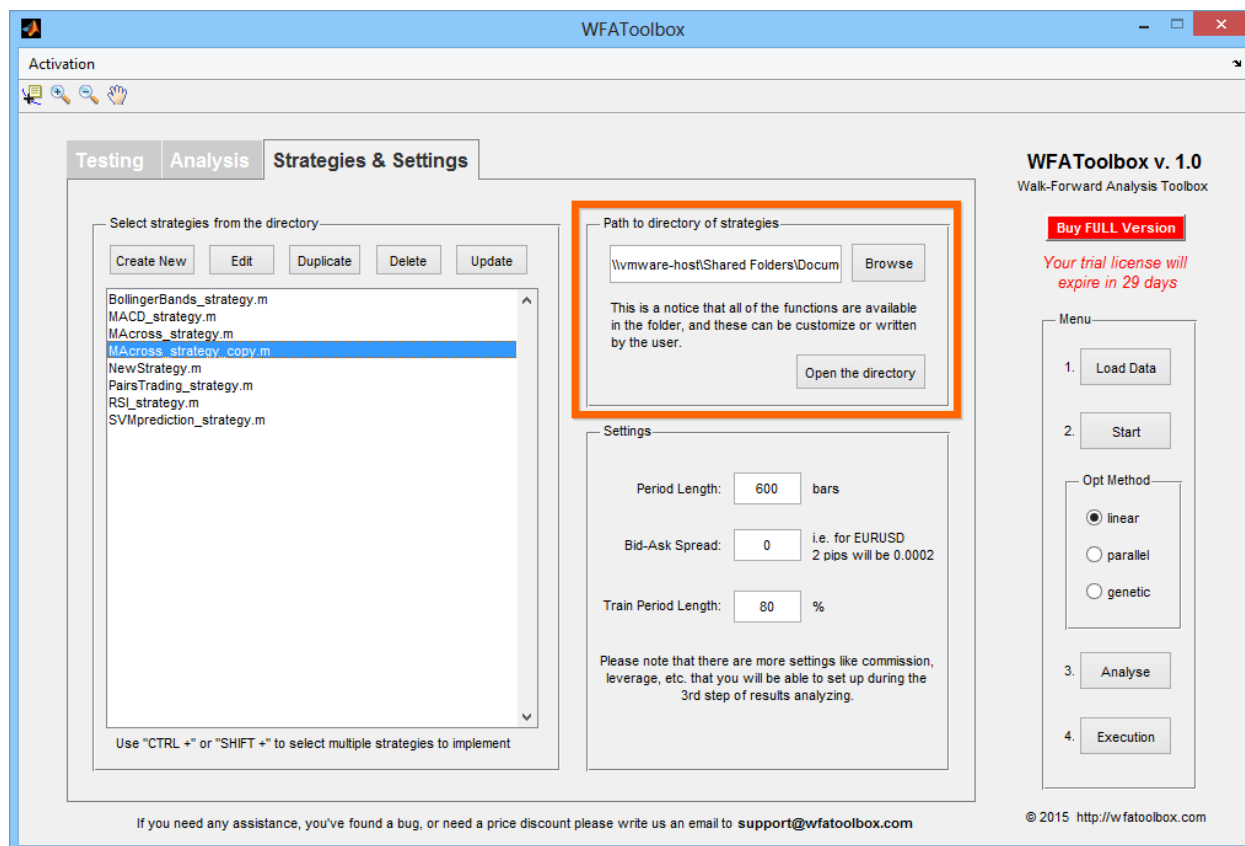
Using «Current Folder» window you can also edit strategy name, as well as open and delete any of them.

Setting period length

When your strategy is ready, it's the right time to move to strategy testing procedure, but before doing so you have to check if all settings are correct.
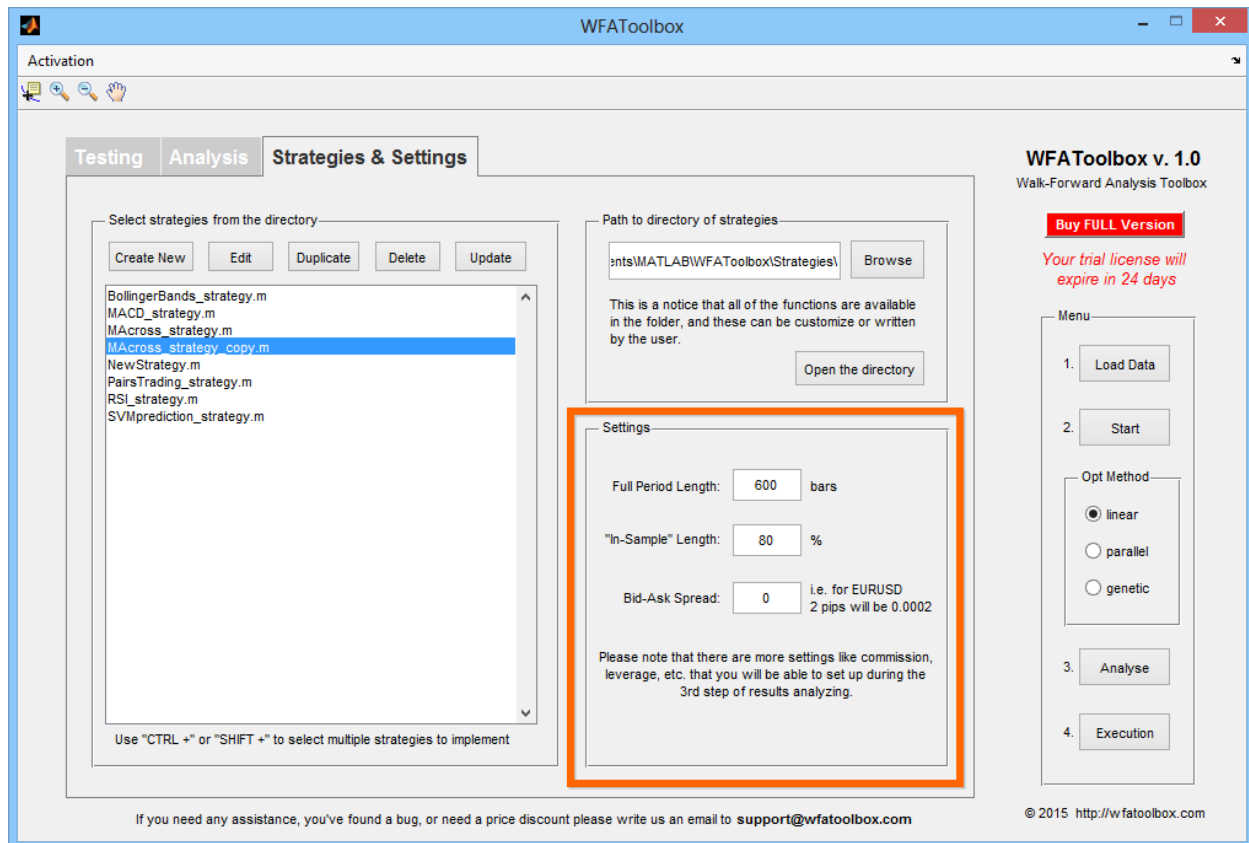
Thus, there are 2 field in «Strategies and Settings» tab, which are used to select period length:

Full Period Length – it's the length of whole data period, which is going to be shown in «Testing» tab. This parameters selects amount of bars for data period, which is taken for in-sample and out-of-sample testing.

«In-Sample» Period Length – this parameter selects percentage of total period for «in-sample» period.

Please note, that «In-sample Period Length» parameter can be really important for optimal strategy search, because it determines frequency of system optimal variables recalculation. The classical value, which is set by default is 80%, but you can make some experiments selecting, for example 90% and checking final result affection. Perhaps, your strategy would be really sensitive especially to this parameter.

Creation of trading strategies in the WFAToolbox can be divided into 3 parts:

1. Selection ranges for the optimization of variables
2. Calculation of indicators or data processing functions
3. Description of the rules of all the openings and closings of the positions

3.1. SELECTION RANGES FOR THE OPTIMIZATION OF VARIABLES

To select name and range of the variable, which is going to participate in your optimization process, you can use next formula:

params.param_name = start_num:step:end_num;

where

param_name – is the name of variable

start_num – the number of the beginning of the range

step – step of the range

end_num – the number of the end of the range

start_num:step:end_num – one of possible ways to select vector, using the MATLAB

Example for moving average crossover strategy:

```
36 -    params.lead = 2:2:25;    % period of lead moving average
37 -    params.lag = 5:5:200;    % period of lag moving average
```

If you don't want your parameter to participate in optimization process (to minimize calculation time), you can select fixed value for variable instead of selecting ranges.

Example:

```
13 -    params.thresh = 1;
```

Trick

If you want to set range in geometric progression, you can use generateSpacedInts function (it can be useful if your indicator or strategy is not changing significantly when optimized parameter's values are high). Right example of strategy where it can be helpful can also be moving average crossover strategy.

Example of generateSpacedInts implementation

```
15 -      params.per = generateSpacedInts(8, 250, 25);
```

To get more information about functions, you can enter next string in MATLAB's command prompt:

```
>> help generateSpacedInts
```

Part of the source code, which can be ignored

After parameters section you will see this source code part:

```
39          %% Warning! Don't change this block of code
40          % You may skip this block of code
41 -        var_names = fieldnames(params);
42 -        for i = 1:length(var_names)
43              % 'x' is a vector of optimising parameters
44 -            if ~isempty(x)
45 -                eval([var_names{i},'=',num2str(x(i)),';']);
46 -            else
47 -                eval([var_names{i},'=',num2str(params.(var_names{i})(1)),';']);
48 -            end
49 -        end
50 -        sig = zeros(length(price.Close),1);
```

It's intended to facilitate work with variables and select some parameters by default. You can just ignore this part of source code, making no changes in it. If you will try to create new strategy from the scratch, please note that you have to insert this part of source code right after variable parameters selection.

3.2. CALCULATION OF INDICATORS OR DATA PROCESSING FUNCTIONS

Next part after setting of parameters, is the indicator or data processing functions calculation block. This block is used for basic calculations, which are made in trading system: e.g. if our system is based on technical indicators, we have to calculate them in this block; if we are using, for example pairs trading strategy, we have to calculate cointegration coefficient first, continuing with spread calculation. The obtained results are necessary for further interpretation of the results to receive signals from our trading system.

Calling loaded data

The most important thing that you need to know to make successful calculation on this stage (excluding MATLAB rules for functions interpretation) - is the knowledge of how to call loaded data for one or more tools. This can be done in several ways:

a) Calling first tool data

This is the easiest way of data calling (especially if strategy involves only one tool at one time) - you only have to enter your request with «price.» structure variable and enter one of the columns of the first tool, that was loaded into application: High, Low, Open, Close, Volume etc. Most commonly we use Close column.

data = price.column_name;

where column_name – is the name of column in loaded data

Example:

```
58 -    data = price.Close;
```

Please note, that this data is only actual for the first tool in the list of loaded tickers. In our example this data belongs to the Google Company.

b) Calling data of selected ticker

You can also call desired columns of specified ticker from those, which were loaded into application. To do so, you have to enter next string after «price.»: «(» (bracket opens), «'» (apostrophe) then put the name of the ticker, again «'» (apostrophe), «)» (bracket closes). Then put «.» (dot) and data column name.

data = price.('ticker_name').column_name;

where
ticker_name – is the name of the ticker
column_name – is the column in selected ticker

Example:

```
44 -     data = price.('AAPL').Close;
```

Such way of specified ticker data calling can be helpful in you calculations if you need to use the same tool, that is prescribed in data calling independently to sequence and amount of loaded tickers. E.g., when we build strategy, based on basket arbitrage, tool basket may contain various tickers, but comparable tool will be the same, and you can set it using described way.

Trick

If you want to select ticker names with separate list, you can call them from data massive.

```
41 -     symbols = {'AAPL','GOOG'};
42 -     data1 = price.(symbols{1}).Close;
43 -     data2 = price.(symbols{2}).Close;
```

c) Calling anonymous ticker data

Another way of data calling - is using of such formula: «symbol» + tool number. So, instead of ticker name entering, which was used in previous ways, you can call any desired ticker from loaded tickers list by its number. Full formula looks like this:

data = price.symbolN. column_name;

where

N – ticker number in the list

column_name – column name of N ticker

Example:

```
47 -    data1 = price.symbol1.Close;
48 -    data2 = price.symbol2.Close;
```

Such way of data calling can be useful, when strategy involves several tools, but you don't need to call one of them separately, allowing usage of such strategy for various tools, without changing the source code of strategy.

Trick

If you want to set symbol number not using variable string (e.g. using some algorithm), you can do that with composing of variable name during data call

```
48 -    N = 3;
49 -    sym_num = cell2double(N);
50 -    dataN = price.(['symbol',sym_num]).Close;
```

3.3. TRADING SYSTEM RULES DESCRIPTION

All you have to do in third section trading system testing preparation, is to describe all the rules of your system, which are going to be used for opening and closing of positions.

Main principles of rules description

To describe rules using MATLAB language in the WFAToolbox application on your own, you have to understand 3 main principles of their formation:

a) **Signals at the input of trading system look like «sig» vector with zero values, the length of which is equal to the length of loaded data of related instrument**

sig = [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 … 0 0 0 0];

length(sig) = length(price.Close)

b) **Each value of «sig» variable is a command:**

0 – do nothing (or close previous position)

1 – buy long

-1 – sell short

Value can be equal not only to 1, but to any other number («2», «3.2324»). These values show us the value of the open position.

Therefore, at the output, «sig» variable must look like this:

sig = [0 0 0 1 1 1 1 1 1 1 1 -1-1-1-1-1-1-1-1-1-1 0 0 0 … 1 1 1 1];

or

sig = [1 1 1 2 2 2 2 2 2 1 1 1 0 0 0 -1 -1 -1 -1 -1 2 2 -3 -3 … 1 1 1];

and suchlike.

c) **If your system loads data from several tools, you have to use the very same rules for signals setting as for several tools data loading.**

Examples:

```
95 -    sig.symbol1 = s1;
96 -    sig.symbol2 = s2;
```

or

```
98 -    sig.('GOOG') = s1;
99 -    sig.('AAPL') = s2;
```

Ways of rules description

Now, when you know all the rules of signal formation mentioned above, you can set them using any desired way, but we would like to recommend you some of them and make a comparison.

For illustrative purposes we will use rules description for «moving average crossover» strategy.

Method #1: brute force

This is the easiest way that gives excellent possibilities in signals formation understanding. If you need to use more difficult rules (enter closing signals or increase position), you will more likely avoid any mistakes, which then is really difficult to find during testing.

Example:

```
71 -    for i = 1:length(data)
72 -        if lead_ma(i) >= lag_ma(i)
73 -           sig(i) = 1;
74 -        elseif lead_ma(i) < lag_ma(i)
75 -           sig(i) = -1;
76 -        end
77 -    end
```

This method has one disadvantage, which is that brute force requires higher amount of computational resources than Method #2, which can result in slow trading system optimization and can be critical in case if you use too many variables or their values.

Method #2: resource-saving

This method is more recommended in case if you use simple rules for trading system, and if high speed of optimization is vitally important. In such case you describe rules directly in parentheses of «sig» variable.

Example:

```
67 -    sig(lead_ma >= lag_ma) = 1; % buy 1 amount of asset
68 -    sig(lead_ma < lag_ma) = -1; % sell short 1 amount of asset
```

Method #3: walking method

This method is advanced one and requires experience in MATLAB function creation, but in other hand it allows to create really "heaped up" systems. So, by default in application you can find «SVMprediction_strategy» trading strategy, which is based on SVM (Support Vector Machine) prediction. We are going to look more closely at it during practical part. To calculate signals for this strategy we have to use separate function, which launches SVM learning process during first start-up, and shifts on a predetermined pitch then, calculating predictions for each interval, and signals for buying or selling.

Example:

```
40      % walking prediction
41 -    sig = wfa_walking_BKSVM_fun(price.Close,wind,0,0,opt_params);
```

3.4. EXPENSES SETTING (BID-ASK SPREAD)

Final (optional) stage of trading system description can be setting of expenses using «cost» variable. This variable includes expenses on position openings and represents the average bid-ask spread.

«Cost» variable does not have to include commission value and slippage, because these parameters can be given in Excel table during detailed analysis of the results of trading system.

«Cost» variable is necessary, because it can cut off those options of optimal variables, which can result in losses. It's really actual for intraday strategies and strategies with high-frequency. If

«cost» is equal to zero, it can show that there are no expenses and strategies with several deals may show good income (sometimes it can really impressive income), but when we involve «cost» variable, such income can disappear, because high amount of deal openings can result in big expenses.

«Cost» variable in strategy code

One way to set expenses for position openings, is to set «cost» variable at the end of strategy code, adding it as outgoing variable in the function header.

You always have to remember, that we don't use dollars (or any other account currency) to set it, but we use the value of an asset. E.g., for EURUSD currency pair, an average bid-ask spread can be equal to 2 pip, which results in 0.0002 EUR/USD in natural expression. That means we have to set «cost» variable for such case like this:

```
22 -     cost = 0.0002;
```

If you set «cost» variable in strategy code, don't forget to add variable into the strategy header, which selects variable for the output.

Example:

```
1     function [params,sig,cost] = NewStrategy(x,price)
```

Setting expenses parameter in "Strategies and Settings" tab

There's another way of «cost» parameter setting in addition to strategy code inclusion. To set it you have to enter any desired value into «Bid-Ask Spread» field of «Strategies & Settings» tab. But remember, that such method can be used only if your strategy involves data from only one financial instrument.
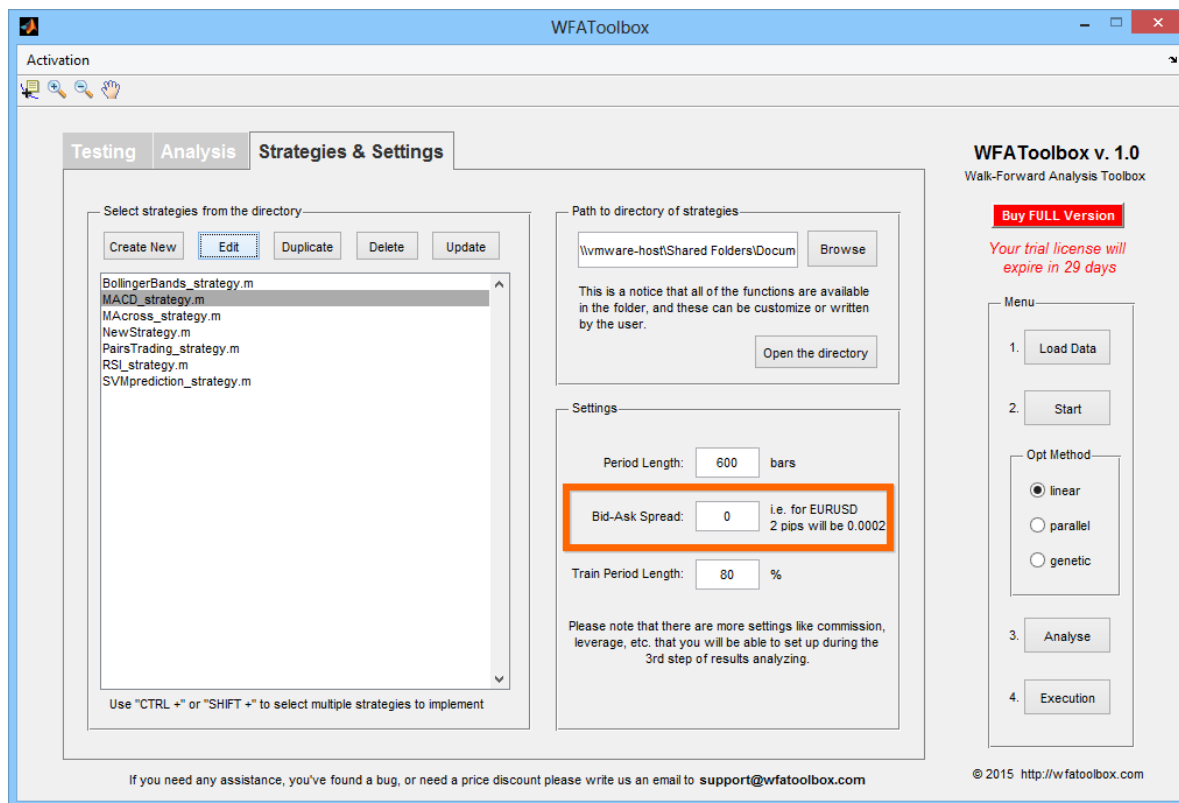
Please note that if you set «cost» parameter directly in the code of your strategy, software will use this value for optimization and not the one from «Bid-Ask Spread» field.

Setting cost parameter for a variety of data

If you want to set expenses value for position opening for several instruments, you can use the very same formula as for «sig» variable for various signals.

Example #1:

```
92 -    cost.symbol1 = 0.002;
93 -    cost.symbol2 = 0.03;
```

Example #2:

```
92 -    cost.('GOOG') = 0.002;
93 -    cost.('AAPL') = 0.03;
```

Trick

It can be really inconvenient to set expenses for every new instrument loaded, that's why you can use our advice about unification of expenses value setting procedure for any type of asset: for highly liquid platforms (e.g. New York Stock Exchange) you have to take one fifth of average value of the difference between High and Low prices.

Example:

```
97 -    cost.symbol1 = mean(price.symbol1.High-price.symbol1.Low)/5;
98 -    cost.symbol2 = mean(price.symbol2.High-price.symbol2.Low)/5;
```

If liquidity is low, instead of using coefficient equal to 5, you can use 4, 3 and so on.

4. SETTINGS & OPTIMIZATION

After creating of your own strategy and setting all the required parameters you can immediately start optimization process. To do so, you have to select necessary strategy from the list (you can also select several strategies by pressing CTRL or SHIFT buttons), and then just press Start button. In case when you select several strategies, they are going to be analyzed one by one and results are summed up and displayed in the Analysis tab as trading result for both strategies. However, as long as you are able to add several strategies to your portfolio during detailed analysis stage, we recommend you to select more than one strategy at the very beginning, only if you are sure in your actions and you understand real reason to do so.
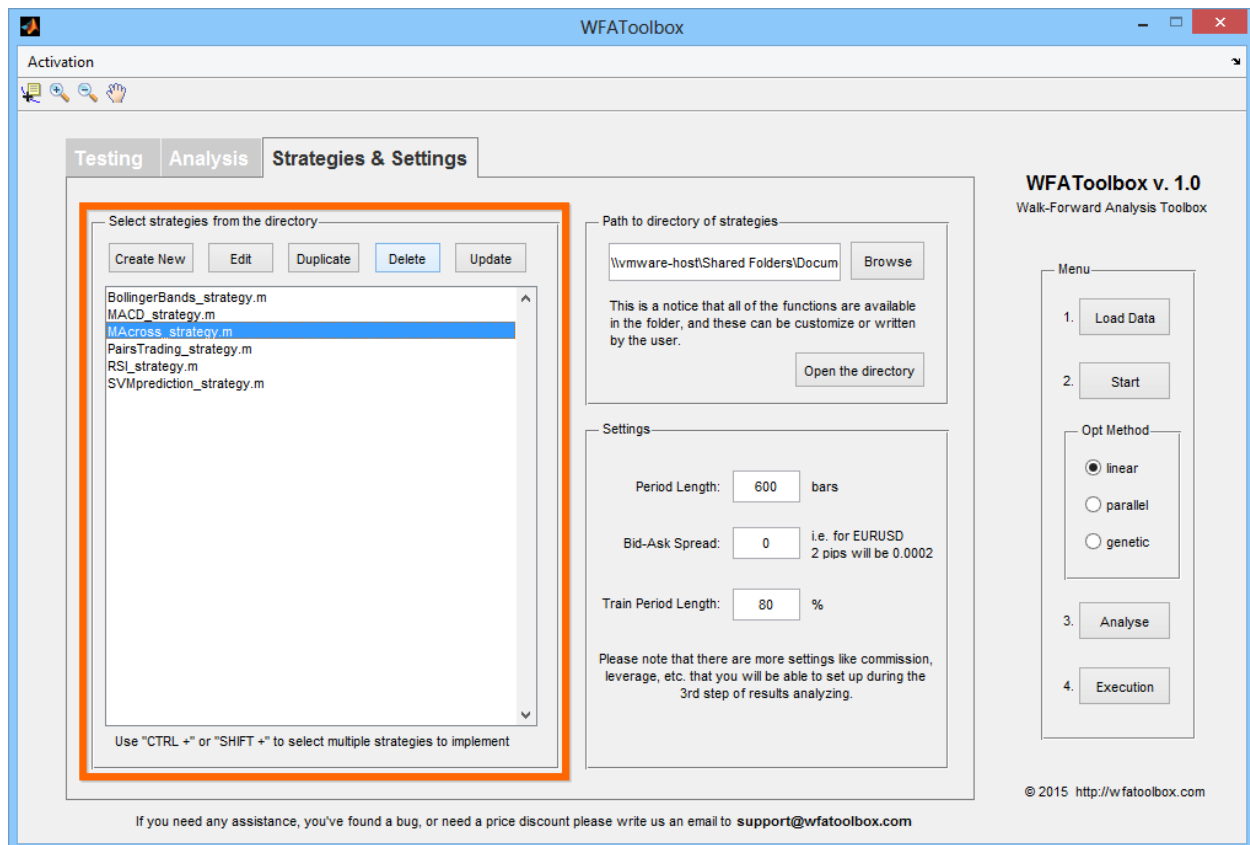
Before we start it, let's look around and see which optimization methods are available in the application.

Optimization methods

The WFAToolbox application allows to use 3 algorithms of trading system optimization:

1. **Linear method** – the easiest way of parameters bruteforce. This method is really convenient if you have small amount of variables, which need to be optimized and therefore you don't need massive computing power. This method allows to observe optimization process: each time when system finds best value for any variable, trading system result is going to be shown on the screen. This feature allows you to see and understand suboptimal values, which can be more convenient for you, for instance, because of signals quantity. It also allows you to edit optimization ranges, because when bruteforce doesn't bring you any result in a while, then it is likely that you can avoid them, decreasing total optimization time.

2. **Parallel method** – this method allows you to involve additional cores of your processor into calculation process using parallelization of process for all the cores. This method allows you to speed up calculation time, having the accuracy of the values at the same level as in linear method. One disadvantage in comparison with linear method is that you won't be able to see optimal values during optimization, but getting only final result;

therefore we recommend you to use this method only after linear optimization process and limitation of selection ranges.

3. **Method of genetic algorithms** – this method involves special mathematical model of evolutionary algorithms, which allows you to find optimal values, even from really huge data massive, making total process much more faster than when going through all the parameters. Therefore, we recommend you to use this method only when your system has huge amount of values to go through and find optimal one, because such process can take a lot of time. The main disadvantage of this method is that it can provide you values which are not really accurate, but really close to such values. That's why we strongly recommend you to use parallel or linear optimization before you continue to next stage of detailed analysis of strategy results.

5. ANALYSIS & EXECUTION

5.1. PRIMARY ANALYSIS

When you start optimization process, you can immediately see results shown by your strategy. You need to pay attention to the amount of signals, generated by your strategy - you can see it by the amount of blue arrows looking up (open long signals) and red arrows looking down (sell short signals) on the graph. Cross icon means the closure of position.

In the upper left corner optimized variables are shown. If you see that system is going through them, but there's no better value, you can usually narrow the range of your selection to reduce time of optimization.

The main criteria that you need to be guided by and which is used by optimization process is Sharp Ratio. To understand the idea of this indicator without using formula, we can tell that it shows how smooth equity line is, because namely its "roughness" means a risk for our strategy, therefore we have to minimize it as soon as we can. You may ask: "And what about equity line inclination? Because we also need to know how much will we earn in total - i.e. our profitability". The fact that the most important criteria, which should be guided by is the ratio of return to risk, which should strive to be more than 7. And equity inclination can be adjusted by reinvestment or money management, but we are going to discuss it later in the analysis section.

You also need to control the indicators of the Analysis tab during optimization process, because all the sectors of out-of-sample periods are combined into one range here. Exactly this range is

going to be analyzed in details during next stage.
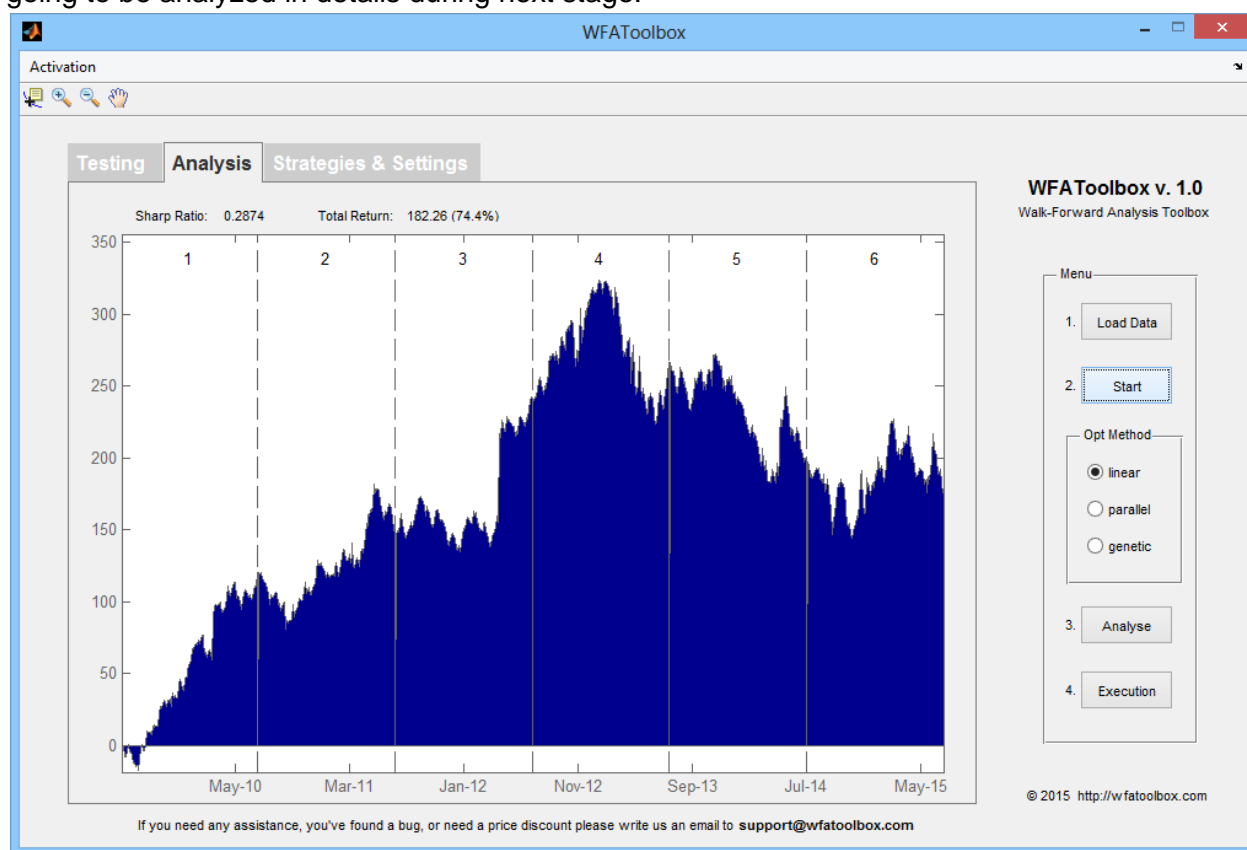
If you see that something goes wrong during your analysis, you can always stop it immediately, by pressing CTRL+C key combination.

5.2. DETAILED ANALYSIS

When the optimization of the entire range is done, we can continue with detailed analysis of trading strategy results. You can perform such analysis only when you clearly understand that trading strategies results are interesting and are worthy of detailed examination, in any other case you have to pay attention and change parameters range, strategy rules and other values, performing testing after that.

Loading data into the table

First, you have to push "Analyze" button.

In new window you are offered to enter name of file with trading strategy results. Let it be: «MA cross over». We are leaving the path to folder as it is. Press «Save» button, continue with "Yes" to confirm.
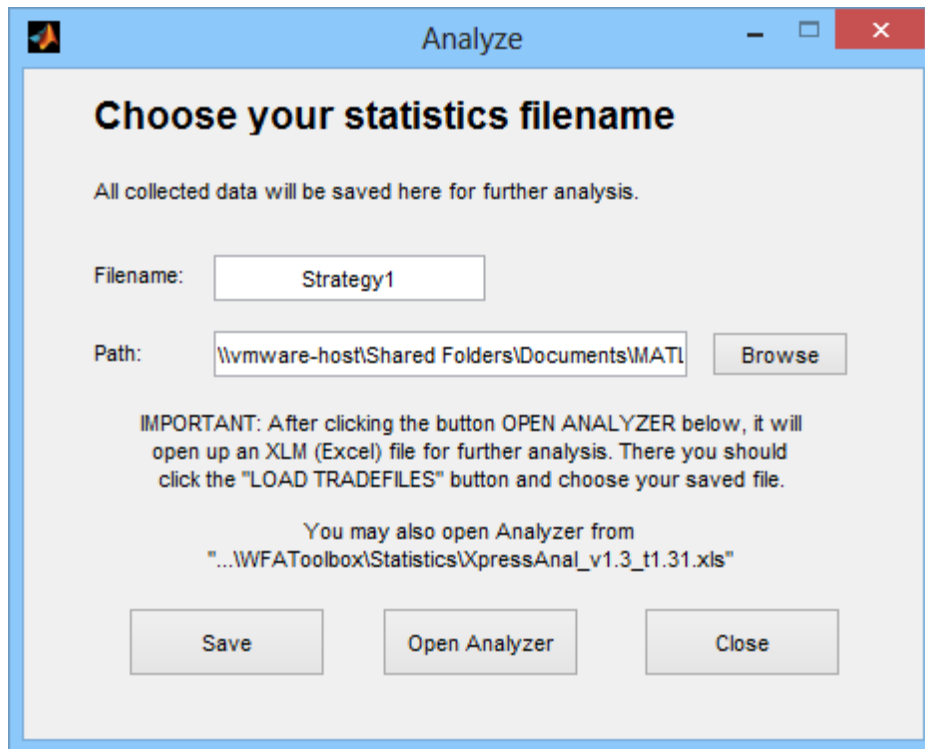
Now we need to open saved file in the analyzing table. First, let's open the analyzing table itself. It can be done directly from your current window, by pressing «Open Analyzer» button. You can also find this file in the Statistics folder of the application directory.

Excel table for detailed analysis of trading strategy results is opened then.
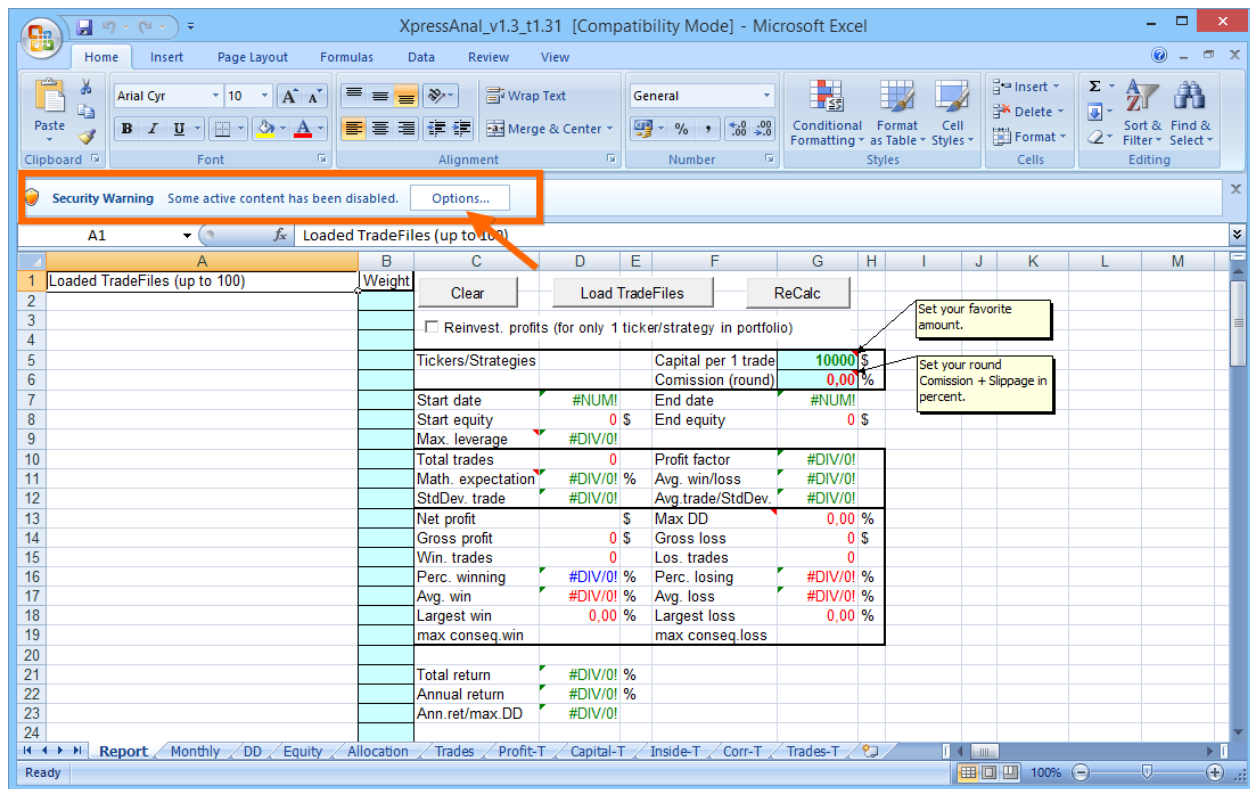
To provide correct work of the table you need to allow macros usage in Excel, by pressing Options button in the upper left corner, continuing with «Enable this content» and OK menu items.

Then we need to press "ReCalc" button, which allows us to recalculate all the values in the table.

Data analysis on the main page

First page of the table is the main mage for you. Here you are able to select all the parameters, and check main indicators of your system. Parameters can be set up in the fields, highlighted with cyan color. These parameters are:

- capital based on each strategy;

- your broker's commission in percent;

- weighting factors for each of the loaded strategies;
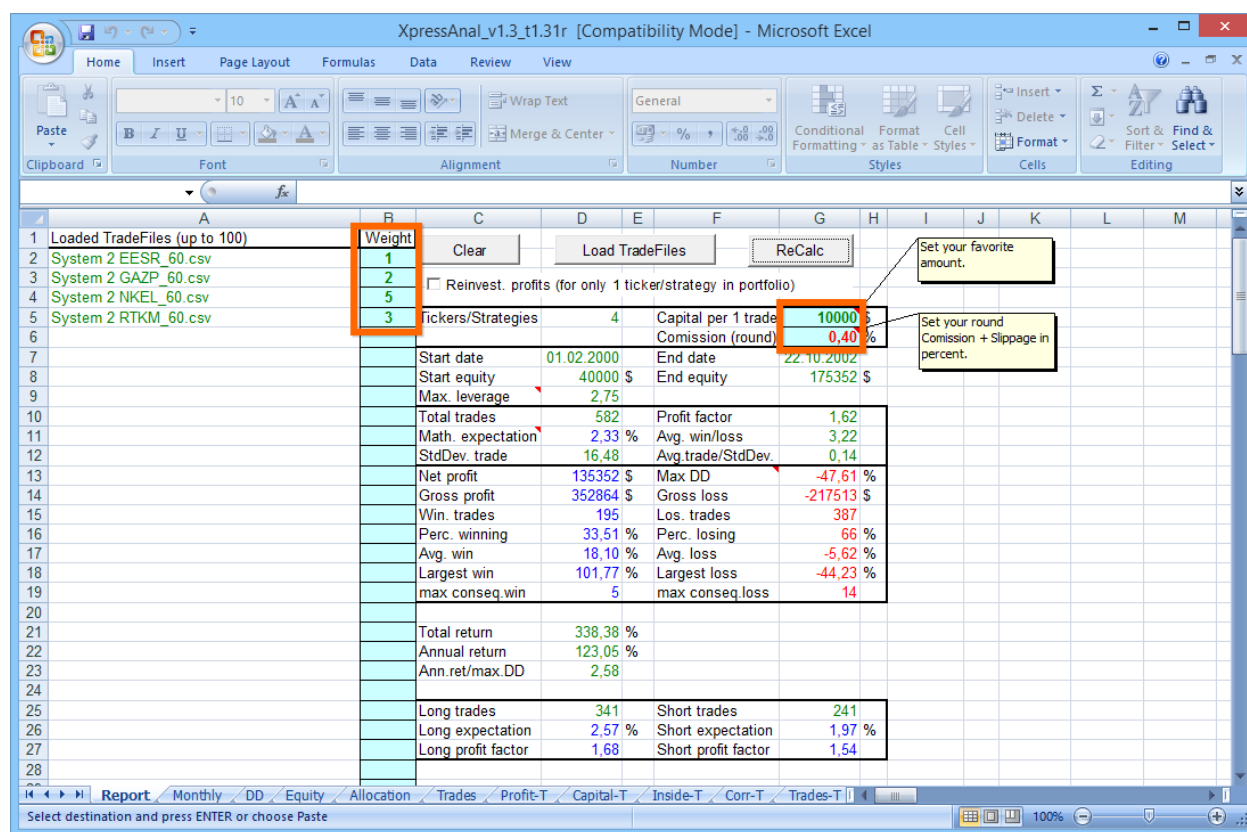
You can load several strategies into the table, and their names are going to be shown in the left part of your screen. You can also choose different weighting factors for each of them, thus making you "portfolio of strategies".

The main indicator, that should guide you, is the ratio of annual return to maximum drawdown. In fact, this indicator shows the ratio of return to risk. The higher - the better, but it is necessary to strive to 7, because this number is an unofficial reference point used by professional asset managers. But that doesn't mean that you have to limit all strategies or portfolios of strategies when such ratio is below 7, especially when you see that other parameters look really acceptable.

This value is important not only due to its obvious meaning (to maximize the return and minimize risk at the same time), but due to the possibility of leverage using by reinvestment of the portfolio, which allows you to grow your capital up to the skies!

Let's say that we have trading strategy results, which start from $10000 and creates more than $70000 during 4 years, which looks really impressive itself. Now we enable "Reinvest Profits" item and we can see how the very same system can bring up to $1460000 during 4 years! But how can it be possible? Yes, you are right! We reinvest profits, received on each stage of the strategy, making it that way to avoid losses, but increase our positions each time. There's no magic, or "blackboxes", just pure math. And exactly such effect of multiplying by reinvesting depends directly on the ratio of annual return to maximum drawdown, and that's why it's so important.

Furthermore, we can say that only realistic and reliable testing results, involving walk forward method and strategy algorithmization make it possible to calculate the position, which needs to be opened in order to obtain maximum reinvestment efficiency. In fact, you have only one rule for position opening - you have to make it such way that when maximum drawdown occurs(one we know about), there must be no margin call on our account and we must not go into losses.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Loaded TradeFiles (up to 100)	Weight											
2	kk(1_NRTR_Duble)EESR_H.CSV(60).csv	1	Clear		Load TradeFiles		ReCalc						
3			☐ Reinvest. profits (for only 1 ticker/strategy in portfolio)						Set your favorite amount.				
4													
5			Tickers/Strategies		1	Capital per 1 trade	10000 $		Set your round				
6						Comission (round)	0,00 %		Comission + Slippage in percent.				
7			Start date	13.01.1998		End date	11.03.2002						
8			Start equity	10000 $		End equity	70413 $						
9			Max. leverage	1									
10			Total trades	193		Profit factor	2,99						

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Loaded TradeFiles (up to 100)	Weight											
2	kk(1_NRTR_Duble)EESR_H.CSV(60).csv	1	Clear		Load TradeFiles		ReCalc						
3			☑ Reinvest. profits (for only 1 ticker/strategy in portfolio)						Set your favorite amount.				
4													
5			Tickers/Strategies		1	Capital per 1 trade	10000 $		Set your round				
6						Comission (round)	0,00 %		Comission + Slippage in percent.				
7			Start date	13.01.1998		End date	11.03.2002						
8			Start equity	10000 $		End equity	1461350 $						
9			Max. leverage	1									
10			Total trades	193		Profit factor	3,00						

Drawdown – is the value, which reflects the percentage by which deposit will go down after reaching of a new record level. Maximum Drawdown – is the maximum deviation in the testing history.

Please note that all the indicators in the system results are based on the history, and therefore they can't guarantee such results in future, but remember that if testing was carried out correctly using pretty large period of time with large number of transactions, you can use Maximum Drawdown indicator as your reference point in real trading, trying recreate the effect of the reinvestment. However, for greater safety of your money we recommend you to multiply the potential maximum drawdown at least by 2.
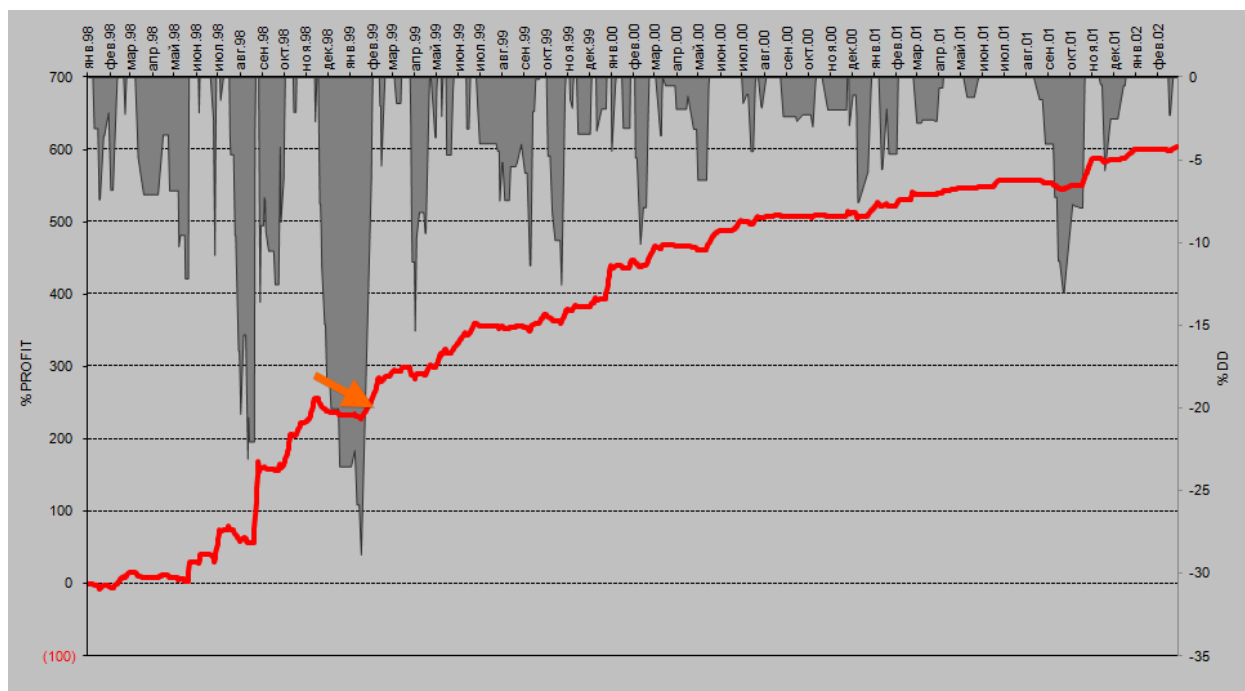
Detailed analysis on other sheets

Let's look and understand what information is represented in each sheet of file for trading strategy results analysis.

Monthly

Using "Monthly" sheet, you can get detailed information about trading system work results on a monthly basis, you can also analyze the amount of income and the number of trades per each month of testing. Profitability during month is always calculated without reinvestment.
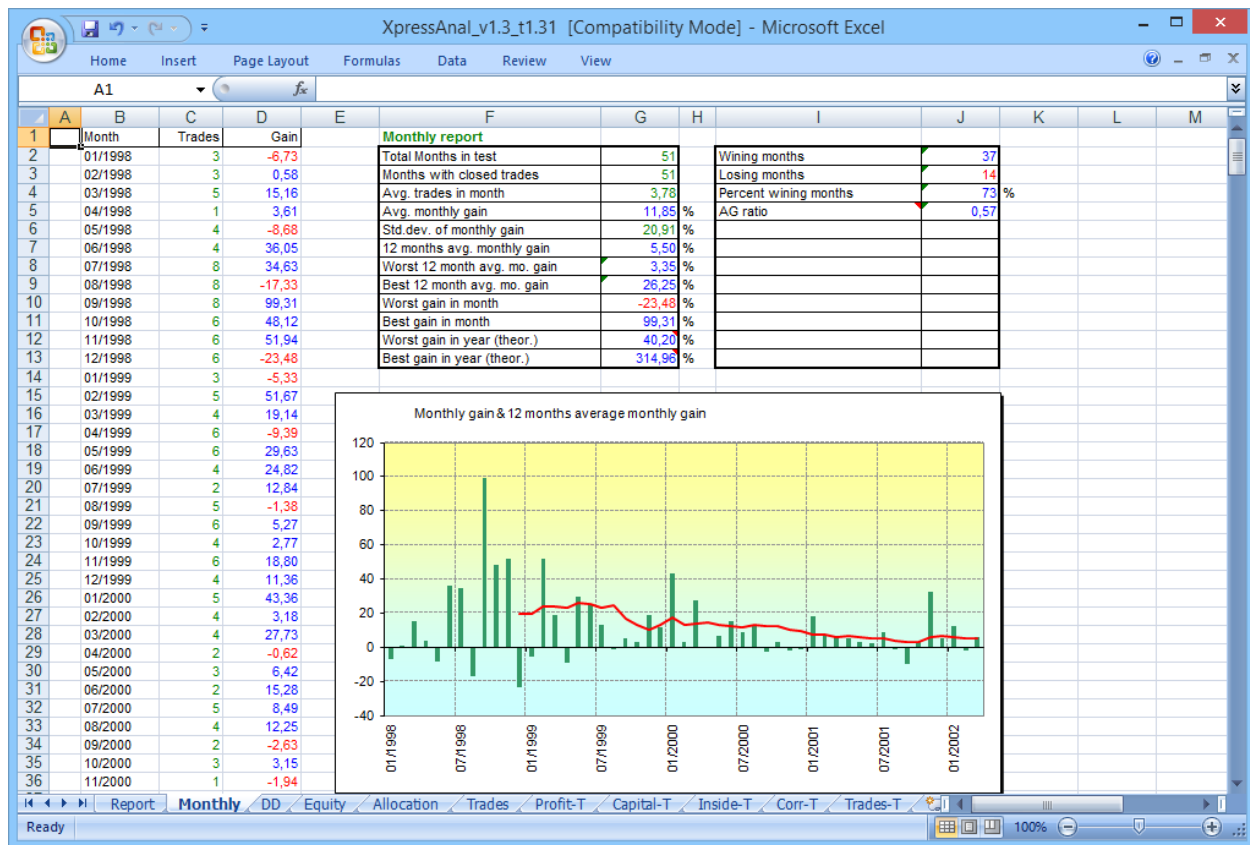
DD - Drawdowns

In fact, Drawdowns sheet shows trading system risks on a monthly basis. At the same time you are able to get information not only about drawdown percentage of achieved levels, but also about quantity of days while it will last. Agree that is not really easy just to wait, let's say 92 days, until your deposit reaches new income levels, especially when you are not sure about exact amount and type of reference points by maximum term which can be provided by your strategy.

Home | Insert | Page Layout | Formulas | Data | Review | View

E20   =IF(C20<>""; C20-B20;"")

	B	C	D	E	F	G	H	I	J	K
1	From date	To date	DD%	Days in DD		DrawDowns report				
2	21.01.1998	03.03.1998	-7,36	41			Value DD (%)	Days in DD (period)	from date	to date
3	05.03.1998	11.03.1998	-2,21	6		Worst value DD	-28,81	78	01.12.1998	17.02.1999
4	23.03.1998	03.06.1998	-12,13	72		Worst period DD	-11,34	92	12.07.1999	12.10.1999
5	16.06.1998	18.06.1998	-2,11	2						
6	06.07.1998	15.07.1998	-10,72	9						
7	16.07.1998	28.07.1998	-2,73	12			10 worst values DD	10 worst periods DD		
8	29.07.1998	07.09.1998	-25,52	40			-28,81	92		
9	08.09.1998	20.10.1998	-13,55	42			-25,52	78		
10	26.10.1998	03.11.1998	-2,08	8			-15,29	74		
11	25.11.1998	27.11.1998	-2,65	2			-13,55	72		
12	01.12.1998	17.02.1999	-28,81	78			-13,00	63		
13	23.02.1999	15.03.1999	-7,02	20			-12,51	48		
14	18.03.1999	26.03.1999	-1,54	8			-12,13	46		
15	08.04.1999	05.05.1999	-15,29	27			-11,34	42		
16	11.05.1999	19.05.1999	-3,62	8			-10,72	41		
17	25.05.1999	25.05.1999	-3,91	0			-10,05	40		
18	27.05.1999	15.06.1999	-4,66	19		Average	-15,29	60		
19	24.06.1999	07.07.1999	-3,08	13		Deviation	6,48	18,62		
20	12.07.1999	12.10.1999	-11,34	92						
21	15.10.1999	11.11.1999	-12,51	27						
22	15.11.1999	24.11.1999	-1,84	9						
23	26.11.1999	16.12.1999	-3,40	20		Start date	13.01.1998			
24	22.12.1999	11.01.2000	-3,21	20		End date	11.03.2002			
25	18.01.2000	18.01.2000	-5,25	0		Days in test	1518			
26	28.01.2000	09.02.2000	-3,04	12		Days in DD	1043			
27	14.02.2000	13.03.2000	-10,05	28		Days in largest DD	489	(10 worst values DD)		
28	20.03.2000	23.03.2000	-3,50	3		Time in DD	68,71	%		
29	27.03.2000	29.05.2000	-6,19	63		Time in largest DD	32,21	%		
30	13.07.2000	03.08.2000	-4,44	21						
31	08.08.2000	17.08.2000	-2,13	9						
32	07.09.2000	23.10.2000	-2,96	46						
33	08.11.2000	07.12.2000	-1,94	29						
34	13.12.2000	18.01.2001	-7,53	36						
35	22.01.2001	16.02.2001	-5,53	25						
36	12.03.2001	20.04.2001	-3,29	39						

Report | Monthly | DD | Equity | Allocation | Trades | Profit-T | Capital-T | Inside-T | Corr-T | Trades-T

Ready   100%

Equity

Using "Equity" sheet we can monitor graph of change your deposit in time, as well as Drawdown level in the upper part and its chart in the right part.
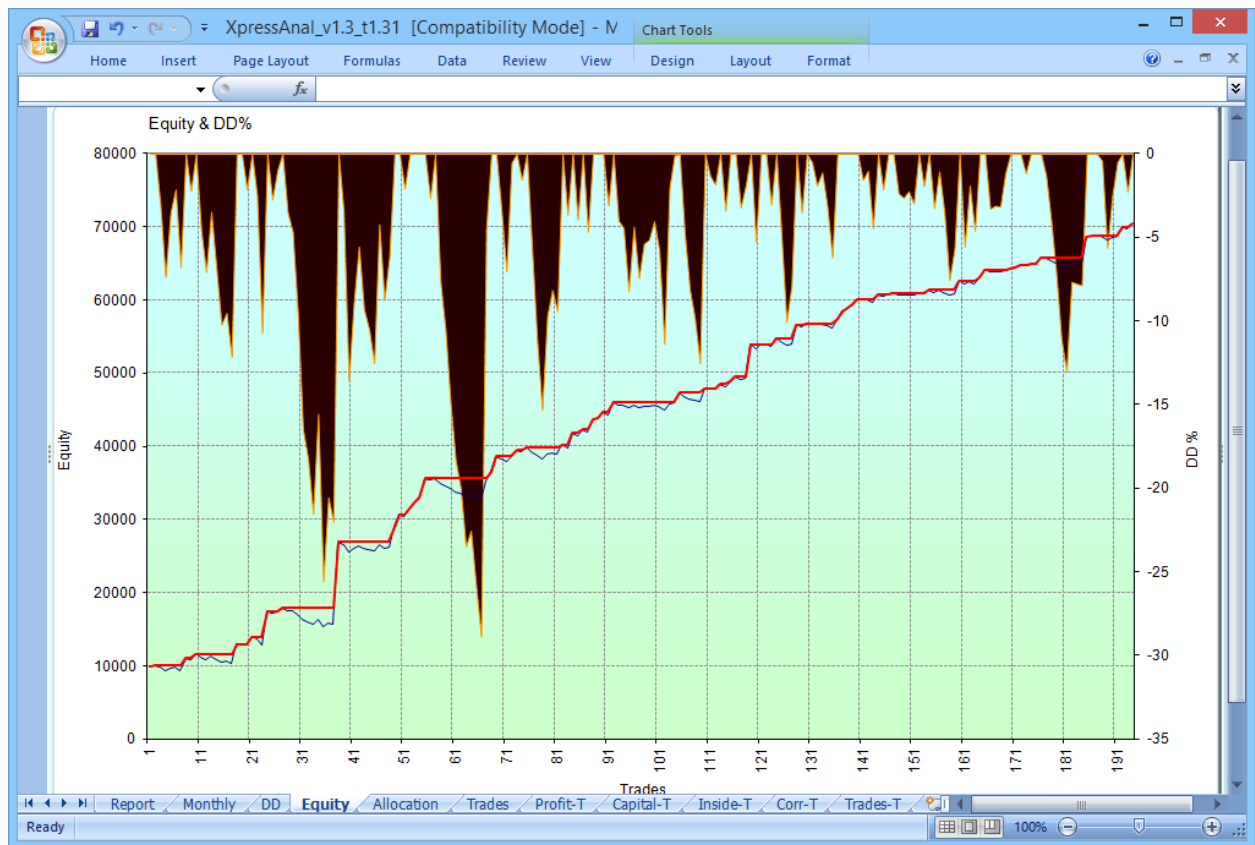
Allocation

When you push "Plot Diagram" button on the "Allocation" sheet, you will see your trading system signals spread in terms of assets which were selected during testing.
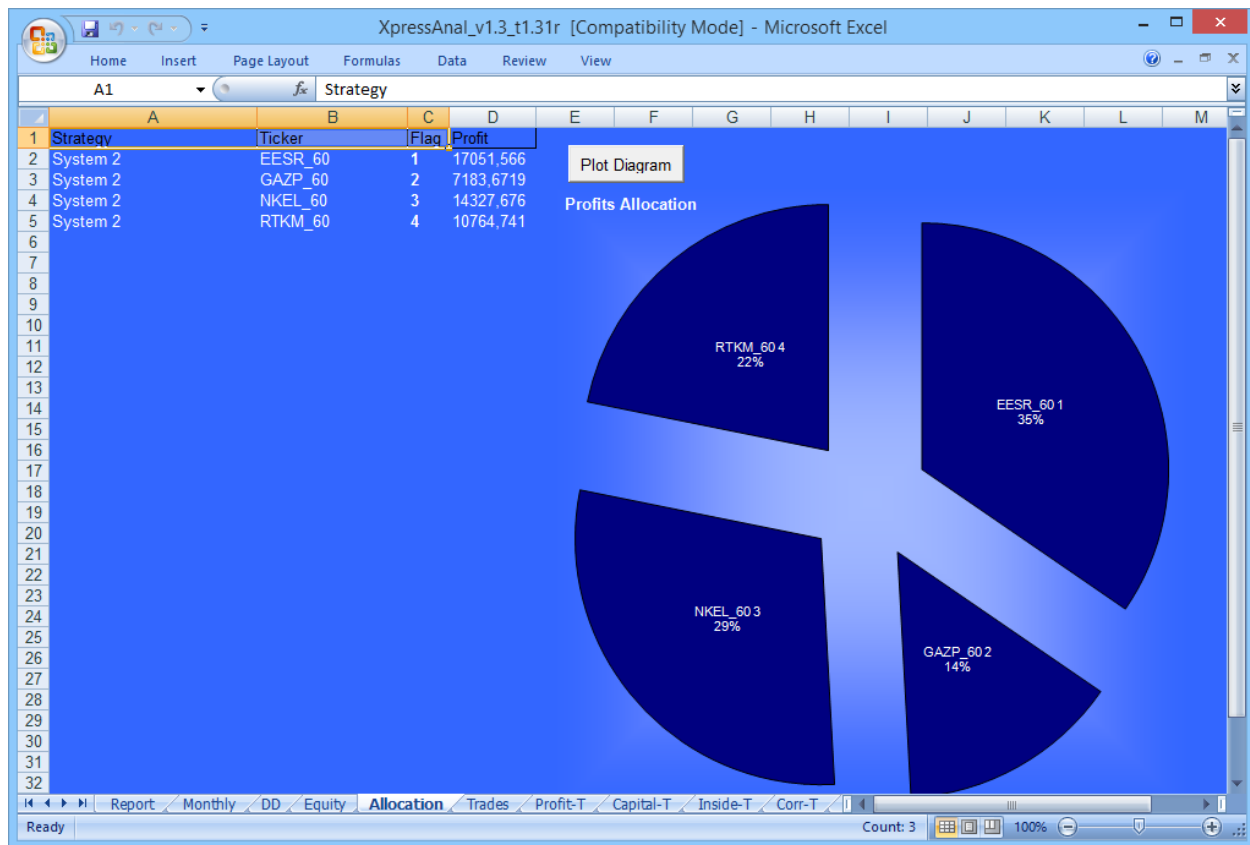
Trades

"Trades" sheet of the file contains all the source data loaded from the trading system table of results. In case if you want to carry out some additional calculations or create your own Excel sheets or tables, you can simply use all these data, because all the parameters and values on other pages are made basing on it.

|	A	B	C	D	E	F	M	N	Q	R	S	T	U	V
1	Strategy	Ticker	Position	EnterDate	ExitDate	Gain	Flag	Weight	Num	$Gain	40000	40000	%DD	%Gain
2	System 2	NKEL_60	1	20000201	20000207	0,1629	3	1	1	1589	41589	41589	0,00	15,89
3	System 2	NKEL_60	1	20000209	20000209	-0,0322	3	1	2	-362	41226	41589	-0,91	-3,62
4	System 2	EESR_60	-1	20000228	20000229	-0,0269	1	1	3	-309	40918	41589	-1,68	-3,09
5	System 2	NKEL_60	1	20000310	20000310	-0,0191	3	1	4	-231	40687	41589	-2,26	-2,31
6	System 2	NKEL_60	1	20000310	20000320	0,06694	3	1	5	629	41316	41589	-0,68	6,29
7	System 2	NKEL_60	1	20000323	20000323	-0,0417	3	1	6	-457	40859	41589	-1,83	-4,57
8	System 2	EESR_60	1	20000303	20000328	0,31823	1	1	7	3142	44001	44001	0,00	31,42
9	System 2	EESR_60	1	20000329	20000330	-0,0247	1	1	8	-287	43714	44001	-0,72	-2,87
10	System 2	EESR_60	1	20000331	20000403	-0,0286	1	1	9	-326	43388	44001	-1,53	-3,26
11	System 2	RTKM_60	-1	20000417	20000418	-0,0283	4	1	10	-323	43066	44001	-2,34	-3,23
12	System 2	EESR_60	1	20000421	20000424	-0,0172	1	1	11	-212	42853	44001	-2,87	-2,12
13	System 2	RTKM_60	-1	20000424	20000425	-0,043	4	1	12	-470	42383	44001	-4,04	-4,70
14	System 2	EESR_60	1	20000425	20000504	0,06563	1	1	13	616	42999	44001	-2,50	6,16
15	System 2	EESR_60	1	20000506	20000510	-0,0124	1	1	14	-164	42835	44001	-2,92	-1,64
16	System 2	RTKM_60	-1	20000428	20000517	0,12652	4	1	15	1225	44060	44060	0,00	12,25
17	System 2	RTKM_60	-1	20000518	20000518	-0,0199	4	1	16	-239	43821	44060	-0,60	-2,39
18	System 2	RTKM_60	-1	20000519	20000525	0,11076	4	1	17	1068	44889	44889	0,00	10,68
19	System 2	EESR_60	-1	20000510	20000526	0,29141	1	1	18	2874	47763	47763	0,00	28,74
20	System 2	EESR_60	1	20000529	20000529	-0,0271	1	1	19	-311	47452	47763	-0,78	-3,11
21	System 2	EESR_60	-1	20000529	20000530	-0,0243	1	1	20	-283	47169	47763	-1,48	-2,83
22	System 2	RTKM_60	1	20000605	20000606	-0,0425	4	1	21	-465	46704	47763	-2,65	-4,65
23	System 2	EESR_60	1	20000601	20000606	0,00753	1	1	22	35	46739	47763	-2,56	0,35
24	System 2	RTKM_60	-1	20000607	20000607	-0,0241	4	1	23	-281	46458	47763	-3,26	-2,81
25	System 2	RTKM_60	1	20000607	20000607	0,00139	4	1	24	-26	46432	47763	-3,33	-0,26
26	System 2	RTKM_60	-1	20000606	20000607	0,05011	4	1	25	461	46893	47763	-2,17	4,61
27	System 2	EESR_60	-1	20000606	20000608	-0,05	1	1	26	-540	46354	47763	-3,52	-5,40
28	System 2	RTKM_60	-1	20000613	20000613	-0,0182	4	1	27	-222	46131	47763	-4,08	-2,22
29	System 2	EESR_60	1	20000608	20000613	-0,0142	1	1	28	-182	45949	47763	-4,53	-1,82
30	System 2	RTKM_60	1	20000607	20000613	0,00073	4	1	29	-33	45916	47763	-4,62	-0,33
31	System 2	EESR_60	-1	20000614	20000614	-0,0197	1	1	30	-237	45679	47763	-5,21	-2,37
32	System 2	RTKM_60	1	20000614	20000614	-0,0085	4	1	31	-125	45553	47763	-5,52	-1,25

Sheet tabs: Report / Monthly / DD / Equity / Allocation / **Trades** / Profit-T / Capital-T / Inside-T / Corr-T

Profit-T

"Profit-T" sheet is one of the most important and illustrative , that's why we recommend you to pay additional attention to this sheet. Indicators of each strategy from your portfolio are shown here, so you can visually control which work they do in the overall dynamics of the deposit, as well as in drawdowns "smoothing", which are shown in the upper part and have their chart in the right part of the sheet. This chart can help you to take more balanced decision about removing of any strategy or redistribution of weighting factors.
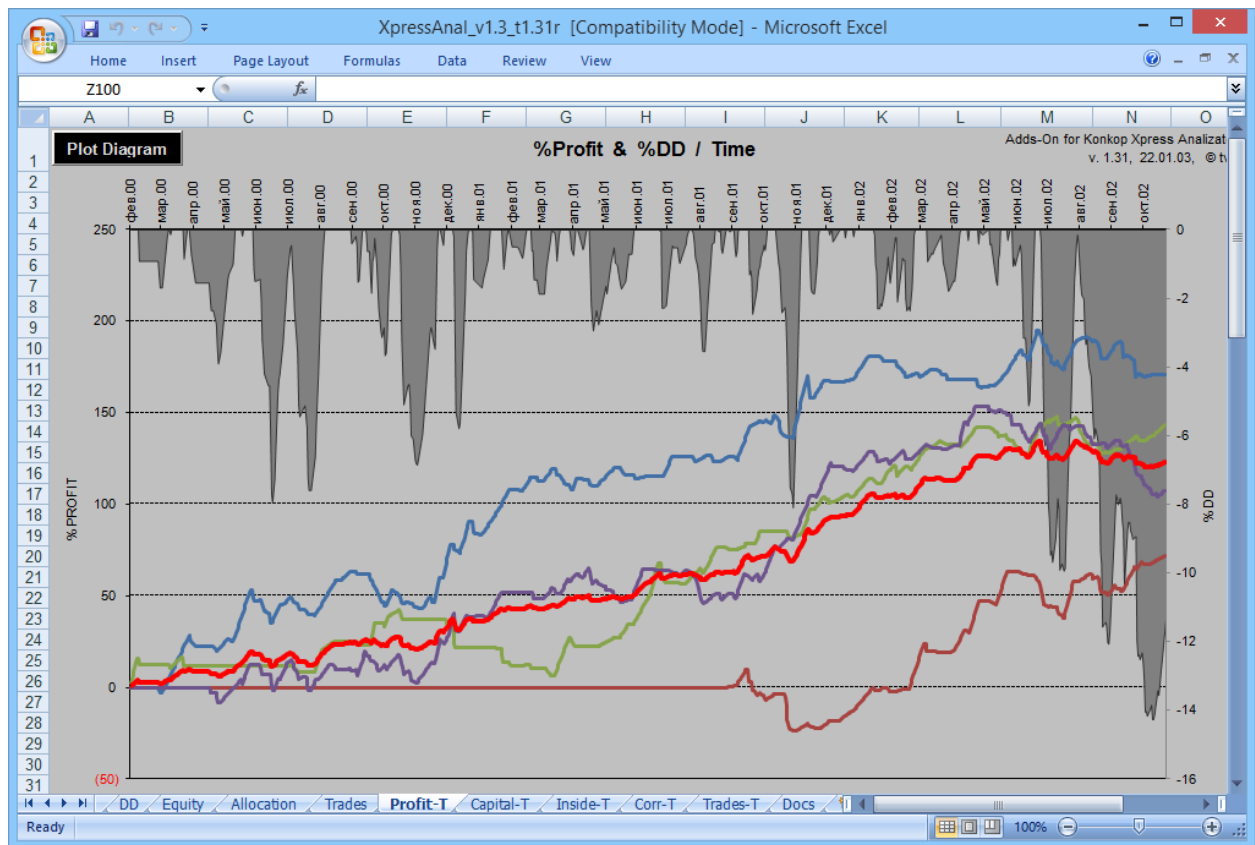
Capital-T

"Capital-T' sheet shows which part of capital is used by your portfolio of strategies.
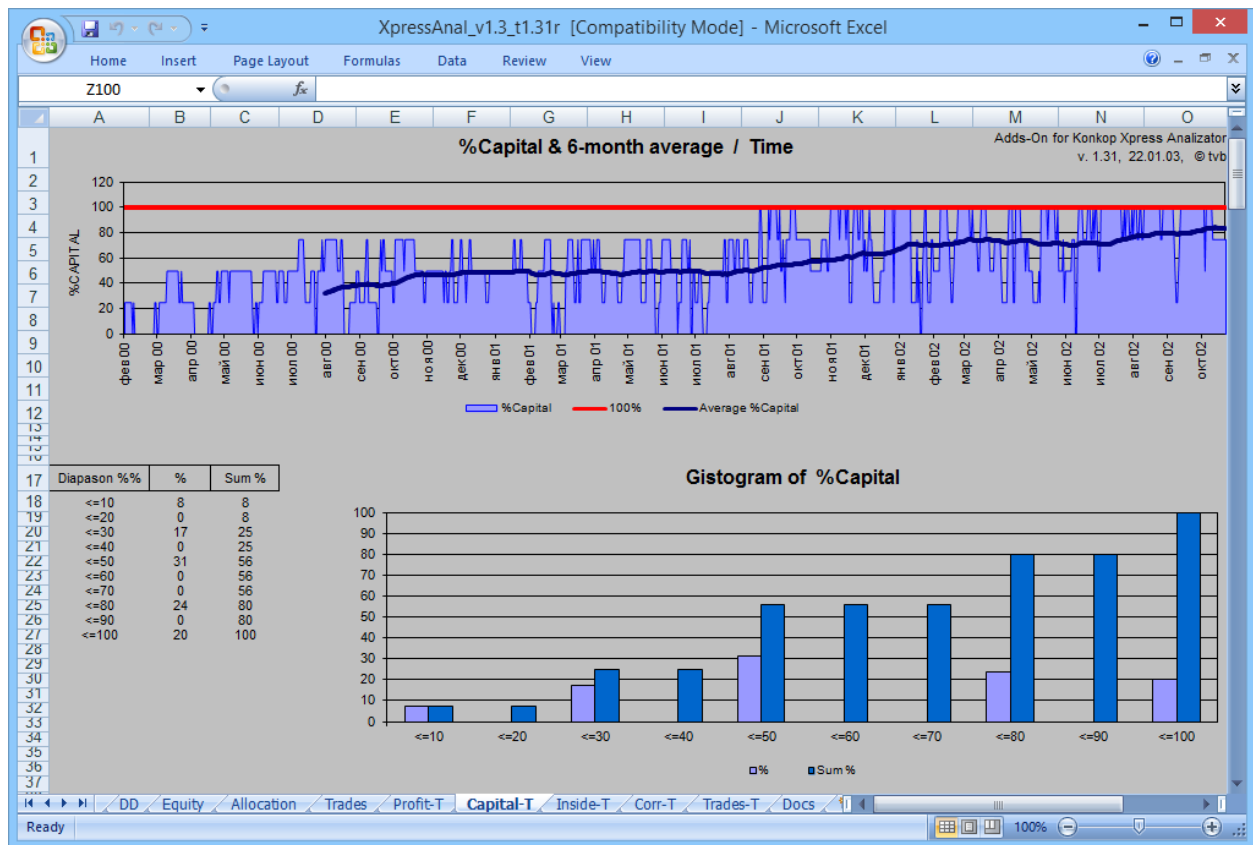
Inside-T

On "Inside-T" sheet you can check statistics for each strategy from your portfolio.

No.	Ticker - Strategy	Weight	Total Return (%)	Annual Ret.(%)	Max. DD (%)	Ann.Ret. / Max.DD	% In Market	Ret. / Day In Market (%)	Total Trades	Long	Short	% Pro-fitable	Avg. Win/Loss	Profit Factor	Average Trade (%)
0	Portfolio	1,00	123,3	45,2	14,2	3,18	58	0,219	582	341	241	34	3,18	1,60	0,8
1	EESR_60 - System 2	1,00	170,5	62,6	25,4	2,46	71	0,240	153	79	74	33	3,40	1,70	1,1
2	GAZP_60 - System 2	1,00	71,8	26,4	33,2	0,79	33	0,221	87	53	34	33	3,40	1,70	0,8
3	NKEL_60 - System 2	1,00	143,3	52,6	35,9	1,46	53	0,270	122	85	37	41	2,75	1,91	1,1
4	RTKM_60 - System 2	1,00	107,6	39,5	49,3	0,80	74	0,146	220	124	96	30	3,20	1,34	0,4

Corr-T

"Corr-T" sheet shows the correlation between trading systems. Correlation indicator can become your constant instrument, especially if you analyze many different strategies. Our advice is to select only best and low correlated strategies. The lower amount of strategies you have, the easier your work is going to be, because it's much more easier to monitor and debug them, but remember that when you have too low amount of them, there's a risk that your portfolio is going to be unstable - you always need to look for golden mean.
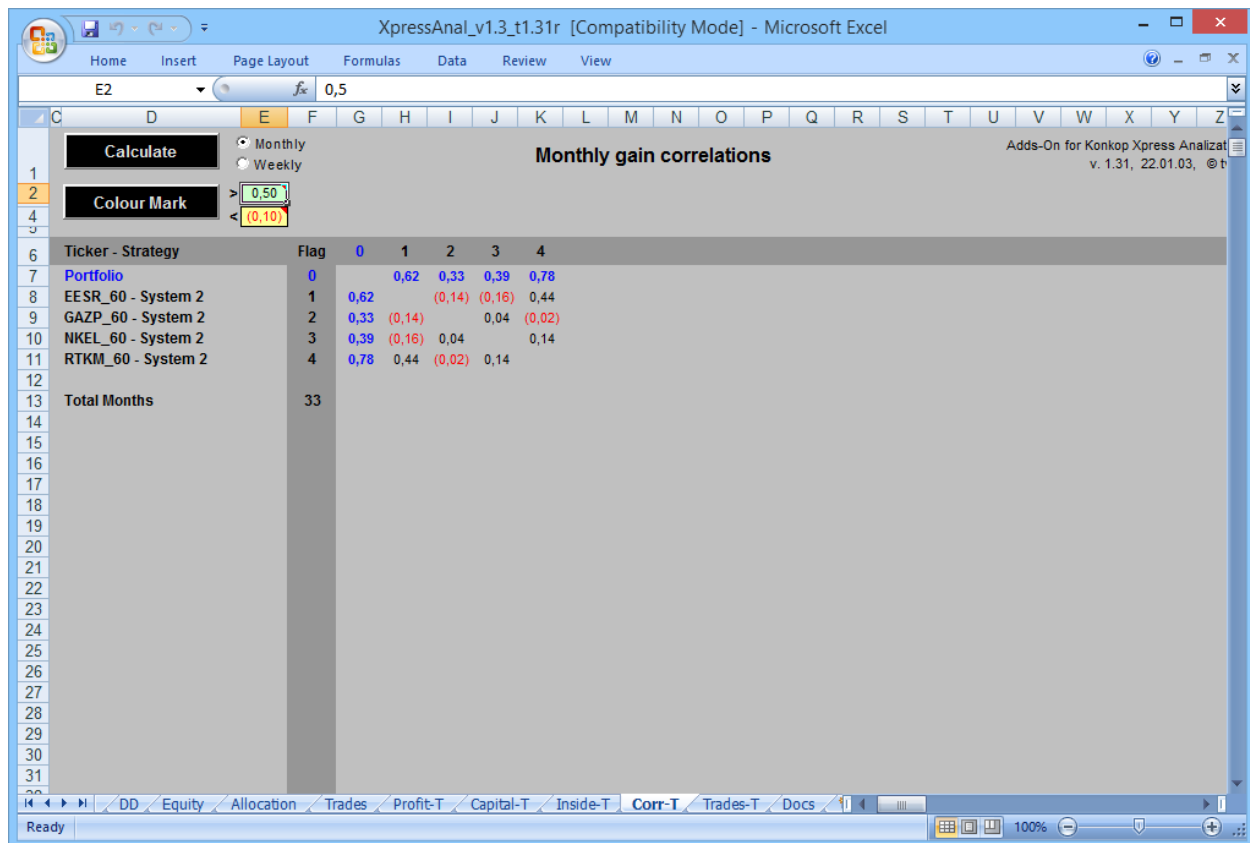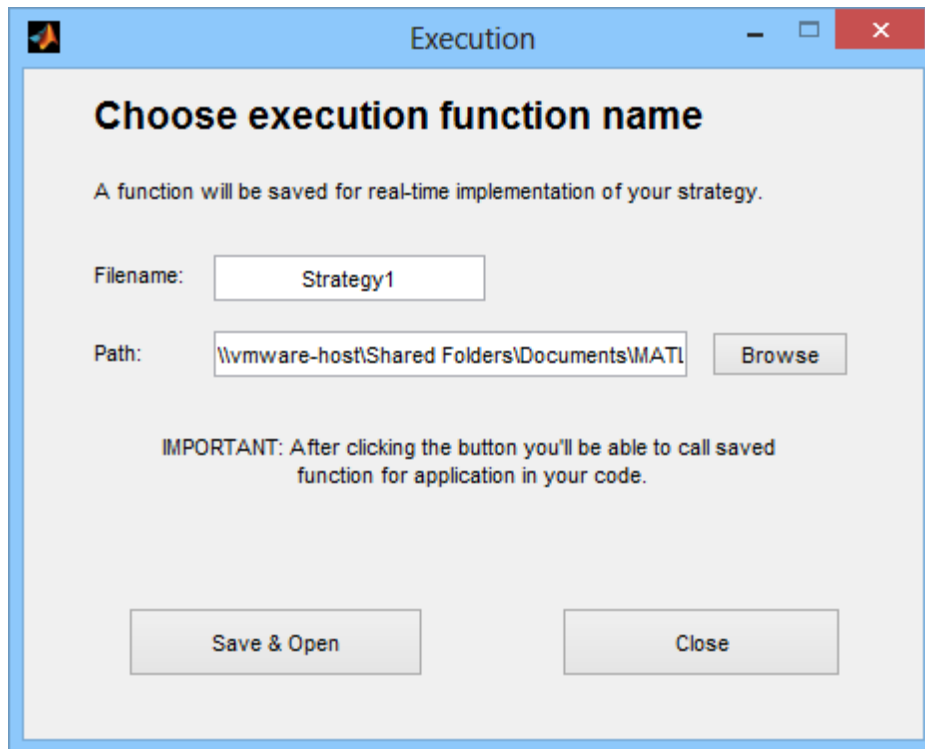
Trades-T

"Trades-T" sheet – it shows the very same data as the "Trades" sheet, but in more brutal form. It's necessary only as the base for the calculations for other pages.
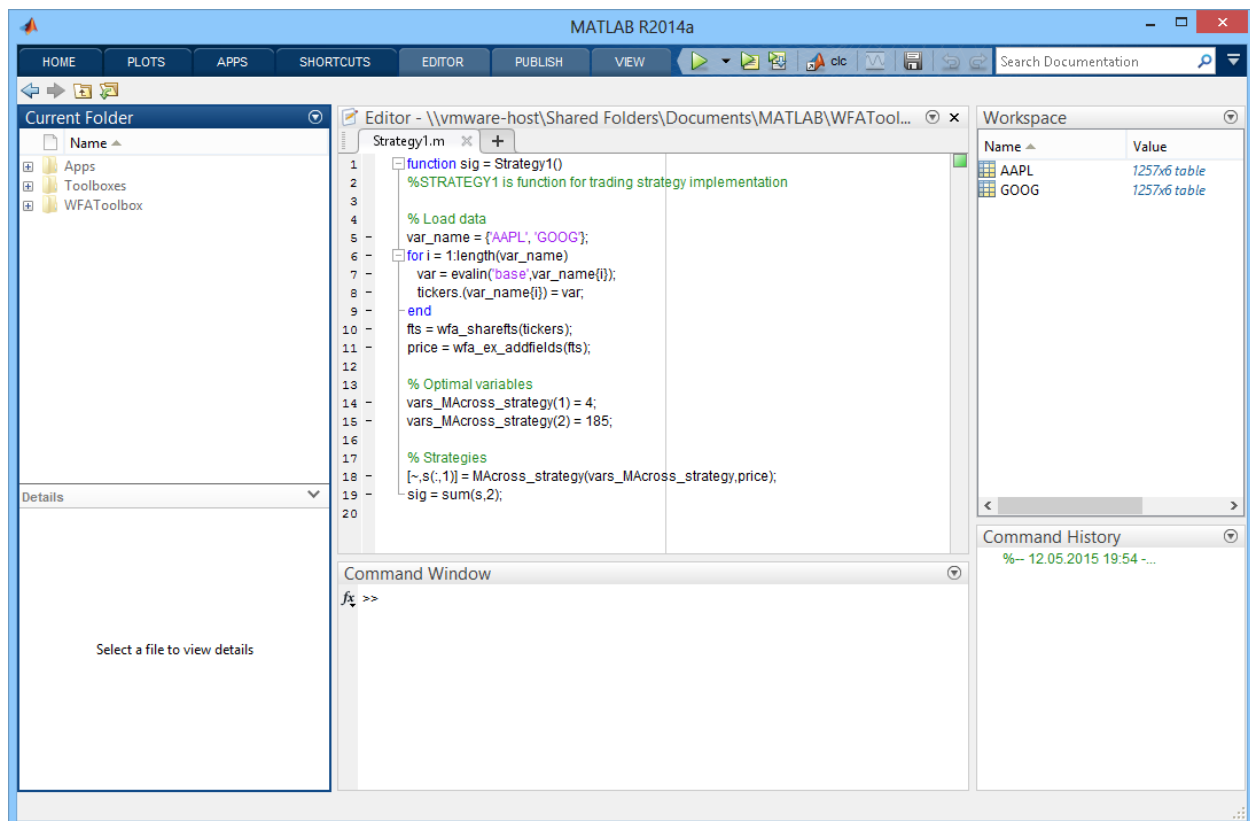
6. EXECUTION

When you are done with detailed analysis and you are sure that all the indicators are satisfying you, then you can go to next stage – execution.

To make realization of new and ready solution for automated trade possible, the WFAToolbox allows you to integrate generated functions, which are going to call necessary data from the MATLAB workspace and convert them into signals, using the algorithm of tested system with optimal parameters.

In order to generate function, you have to push the "Execution" button on the main panel. Then you need to select name and location of function file. Push "Save & Open" button to create new function.

New generated function is going to appear in the MATLAB. You can edit any function and integrate them into your automated trade solution.

In the nearest future we are planning to integrate complete module for execution of trading systems in various software applications, e.g. MetaTrader, Interactive Brokers terminal and many others.

7. CONTACTS

Please, do not hesitate to contact us if you have any questions.

support@wfatoolbox.com

We're always ready to help you.