General Motors FinTech

Software Requirements Specification

V3.0

Document Version History

Version	Date	Author	Reviewer	Approved by	Description
0.1	9/22/2019	Abdul Ahmad	N/A	N/A	Created the new document, formatted, updated
0.2	10/2/2019	Abdul Ahmad	N/A	N/A	Written up to functional requirements, edited, formatted
0.3	10/3/2019	Abdul Ahmad	John Gettel; Mohamad Saab; Aalem Singh;	John Gettel; Mohamad Saab; Aalem Singh; Abdul Ahmad;	Functional requirement and onwards, completion at 90%
0.4	10/4/2019	Abdul Ahmad	N/A	N/A	Material added, DFD, proofread
1.0	10/6/2019	Abdul Ahmad	John Gettel; Mohamad Saab; Aalem Singh;	John Gettel; Mohamad Saab; Aalem Singh; Abdul Ahmad;	Sequence diagram, ERD, proofread, formatting
2.0	10/12/2019	Abdul Ahmad	N/A	John Gettel; Mohamad Saab; Aalem Singh; Abdul Ahmad;	Edited and rewritten many sections. Rewrote purpose, assumptions. Added backward dependencies, forward dependencies, priority to all functional and non-functional requirements. Added error handling to functional requirements.
3.0	12/7/2019	Abdul Ahmad	N/A	John Gettel; Aalem Singh; Mohamad Saab;	Updated database diagram, TOC, hyperlinks, edited sections

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1. Introduction

This document will provide a detailed overview of the Software Requirements Specification agreed upon between the client and developers for the GM FinTech project. This project will use algorithm based directional close-price predictions, improved basis points calculations on a SQL and Python driven back-end with a Tableau front-end application.

1.1 Purpose

The purpose of this document is to provide a description of the requirements associated with the completion of the GM FinTech Tableau application. Information in this document will provide all the necessary guidelines to implement all the required features. It will also provide a glimpse of the application's design but not in detail. The document will detail and define the project requirements as agreed upon by the client and the developers. After the final iteration of this document is completed, it will be submitted to the client.

1.2 Scope

The scope of the GM FinTech application is to take existing financial data from a free data exchange server and prediction what future market trends will be for a financial instrument. By investigating historical market trends using adjusted close price value, viable buy/sell strategies, and implementing robust advanced algorithms, this scope can be achieved. All this data will be visually presented through Tableau. It will provide a detailed overview of market trends and indicate profitable buying and selling points.

Making profitable financial decisions requires understanding the direction of the market and ability to make decisions at the right time. The model will visualize the best times to buy and sell with the intent to maximize profit on a trade.

This application will require a connection to the internet as it needs to pull financial data from an online data source(YAHOO). This information is stored on a local server and can be used on any machine, given software/system requirements are met.

1.3 Definitions, Acronyms, and Abbreviations

Activity Point / Trading Data	Data of one-time interval and its associated information and activity.
ARIMA	Auto-Regressive Integrated Moving Average.
Back testing	Process of applying the applications trading strategy to historical data. The result will show how accurate the system is, as if it were trading in real time.
Client/User/Data Analyst	A user who interacts with the application.
CMA	Cross Moving Average.
EMA	Exponential Moving Average.
FRL	Fibonacci Retracement Line.
Financial Instrument	Financial instruments are monetary contracts between parties. They can be created, traded, modified and settled. They can be cash, evidence of an ownership interest in an entity, or a contractual right to receive or deliver cash.
IoT	Internet of Things.
Machine Learning	Algorithmic techniques for computer-based analysis and classification of data.
Random Forest Regression	An algorithm for making predictions on the data using the learning method of classification.
Tableau	Software used to visualize data.
Tooltip Window	The tooltip window is displayed when the user hovers the mouse pointer over a data point on a graph. The information contained in the tooltip window will be relevant to that point, and points related to it on the same date.

1.4 References

Microsoft SQL Server documentation
https://docs.microsoft.com/en-us/sql/sql-server/sql-server-technical-documentation?view=sql-server-2017

MySQL documentation
https://dev.mysql.com/doc/

YAHOO Finance
https://finance.yahoo.com/

1.5 Overview

This SRS document will guide developers through the requirements of the application and allow them to implement it on their own machines. The remaining 3 sections will be in the following order.

Section 2 will provide the users with details regarding the functions of the application and what its requirements are.

Section 3 will break down each specific requirement and discuss them in detail. It will assist the user in understanding the software design, how its implemented, and how it was tested.

Section 4 will include all pertinent diagrams and important documents that will provide references and support for the entire SRS document.

2. General Description

The following sections provide a general overview of the system from top to bottom. The system will be elaborated on its functionality, user-interaction, front-end interface and engineered features. It will be reviewed, how the forecasting, directional accuracy and buy/sell strategies come together. Then we will look at the constraints, dependencies and assumptions. Lastly, we will go over the functional and non-functional requirements.

2.1 Product Perspective

The system will consist of a user interface made available on a local server and accessed via a Tableau Dashboard. The visuals presented in the user interface will be supported by a database that obtains information from YAHOO financial data exchange. The user interface will offer informative interaction, users will be able to 'hover over' data points on the graphs to receive information pertaining to a data point. In addition, users will be able to zoom in and out. Tableau will connect to the database for visualization purposes, it will not directly have access to the database to write changes.

The data obtained from YAHOO will be stored in a local database with a potential port over to MySQL. Once the data has been stored, the financial algorithms implemented will make prediction and create signals that indicate if it's time to buy or sell depending on the trend that is observed in the pharmaceutical, automotive and other selected exchange traded instruments. The data sources available to the system administrator will be stored in this database as well. The database can be hosted on any machine if the settings have been adjusted and access granted.

2.2 Product Functions

With the data pulled from YAHOO finance, the product is going to show predictions in the automotive, S&P 500 and pharmaceutical markets. The strategies used in the application will be Auto-Regressive Integrated Moving Average(ARIMA), Random Forest Regression and a few more algorithms based on client's interest. Cross moving averages (CMA) and the Fibonacci retracement algorithm (FRA) already exist in the application.

Cross moving averages helps cut down on the distractions on a price chart. It mainly focuses on the slope of the market to see if the momentum is up or down. An overall benefit of this strategy is that the average time can be set by the developer from few days to 20 weeks. Fibonacci retracement is created by using the peak and the lowest point on a price chart and diving the vertical distance by key ratios. These points help identify rise and fall in the market.

With the implementation of these algorithms, the simulation will use the last three years' worth of data and varying parameters to create a profit while investing in the market. The data produced by these trading strategies will allow our system to automate the decision making and trading process. The algorithms will determine if the data presents a buy, sell, or hold action; based on this logic, a signal will be presented to the user.

All results will be displayed in Tableau. The graphs will indicate the trend of the stock market as it plots the data from YAHOO. Additionally, there will be lines for projecting forecasts using different models and signals for buy or sell along with other custom model-based calculations.

2.3 User Characteristics

The product is designed for a data analyst with knowledge of stocks and has the skillset to use a business intelligence application like Tableau. The analyst will have access to the Tableau dashboard application depending on the permission level. Accessing the application will allow the analyst to understand the calculations made using different strategies. Analyst can then invoke the human element to catch any discrepancies or outlier data points before taking any action. When the analyst accesses the application they will have all the raw data available to them. They can verify the data and data sources if needed. They will also have access to raw data pulled from YAHOO's financial data exchange.

2.4 General Constraints

To have the data be as up to date as possible will require an internet connection. The way the system is currently set up does not monitor the data in a dynamic way. The capacity of the database is another constraint that the product faces. If the historical data exceeds the limit, then to fit in the more current data from YAHOO the older data from the database must be purged out.

Another constraint imposed by obtaining the data is how the data source is accessed, and how the data is formatted. Any change in standards can cause errors in extracting the data, and ultimately affect the computations. Predetermined data sources will be configured in the application however additional sources will require a software update.

2.5 Dependencies

The foremost dependency is on the availability of free YAHOO's financial exchange data. A new exchange source will require minor software updates that can only be done by developers.

The setup of the system is very sensitive and requires troubleshooting if not executed correctly. It is assumed that the product will be used on a personal computer(Windows) with Tableau installed. Additionally, the use of PyCharm Professional edition is also a necessity for the Anaconda environment to download the necessary dependencies.

2.6 Assumptions

It is assumed, that the database and relevant code will be hosted locally or on a server accessible to the workstation. If the software requirements are not met, or there is an issue hosting the system on a server, the system will not function properly.

Furthermore, it is assumed that all viable data sources will have data configured with the following data columns, at minimum: Date and Adj. Close. Additionally, contain over 1000 rows of data (i.e. around 3 years of records)

3. Specific Requirements

3.1 External Interface Requirements

3.1.1 User Interface

General Layout of a Tableau Dashboard

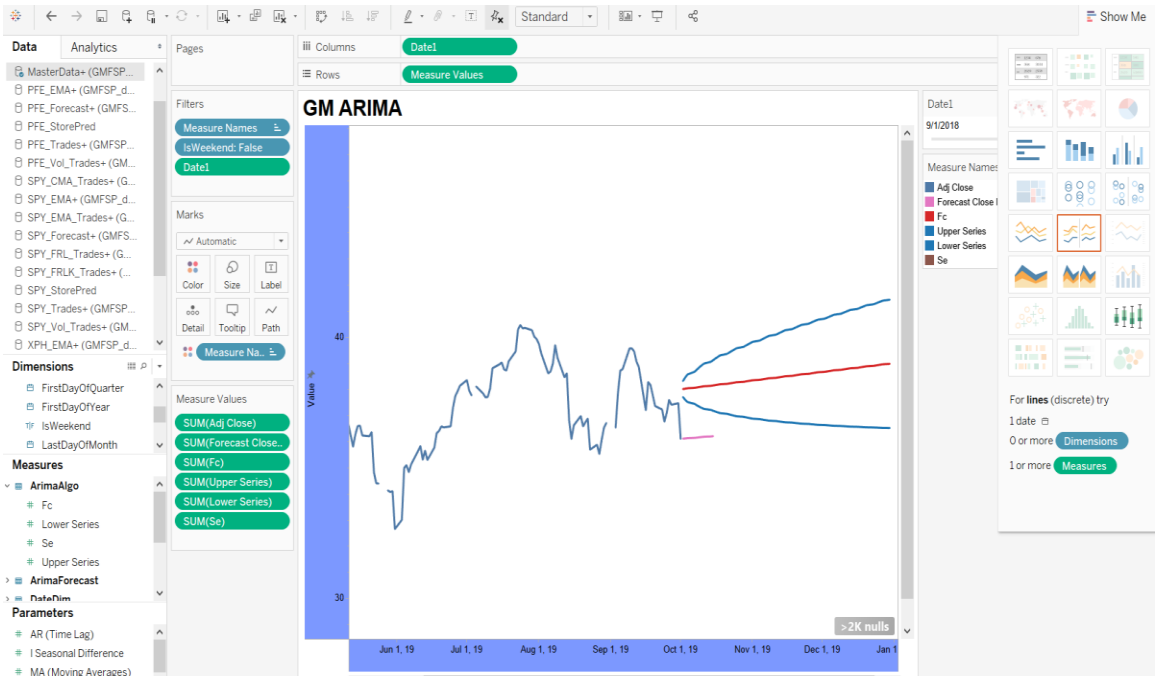
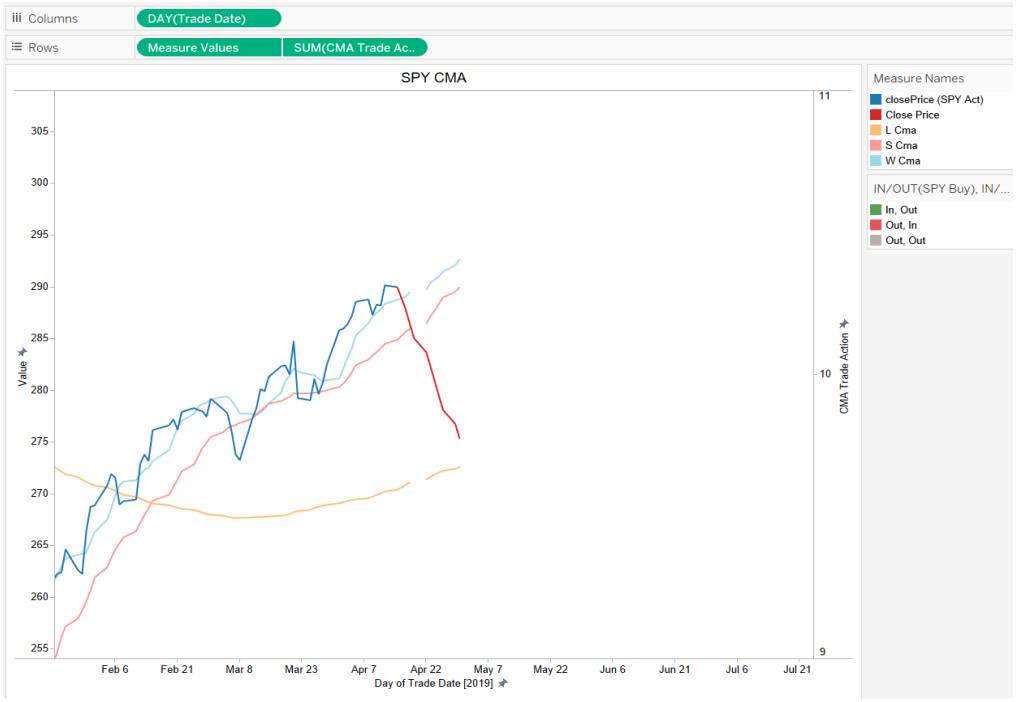
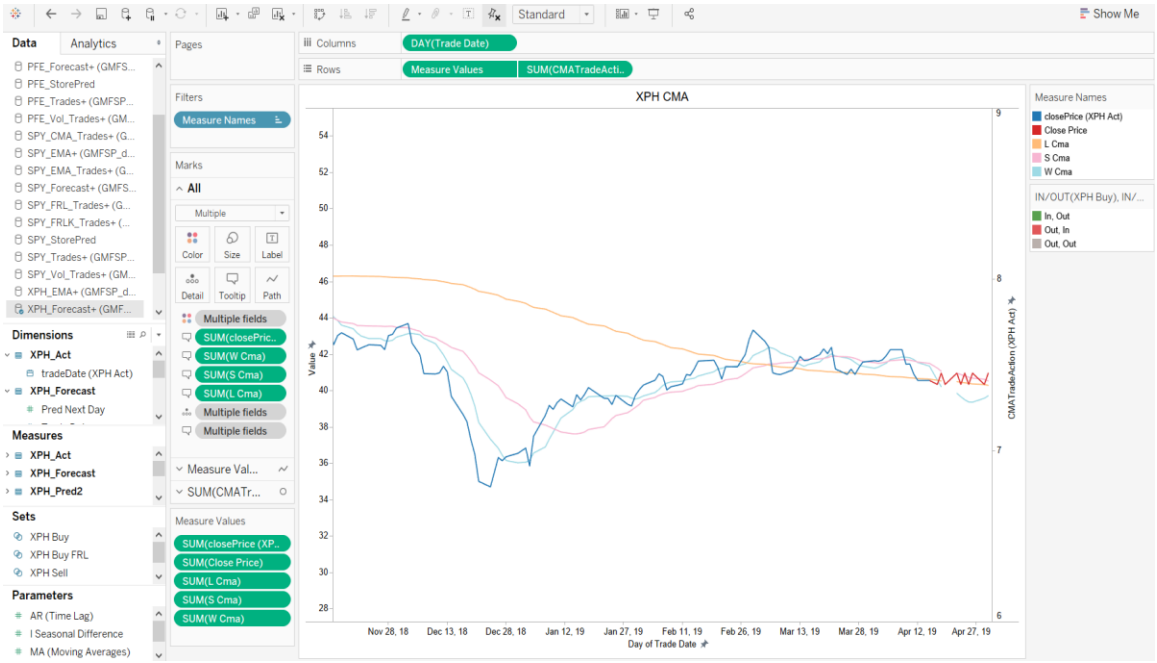


Tableau dashboard will be the user interface of the program. From this interface the user will be able to switch between the different workbooks or graphs using the tabs at the bottom of the Dashboard. Above is an ARIMA graph with forecast, upper and lower control limits.

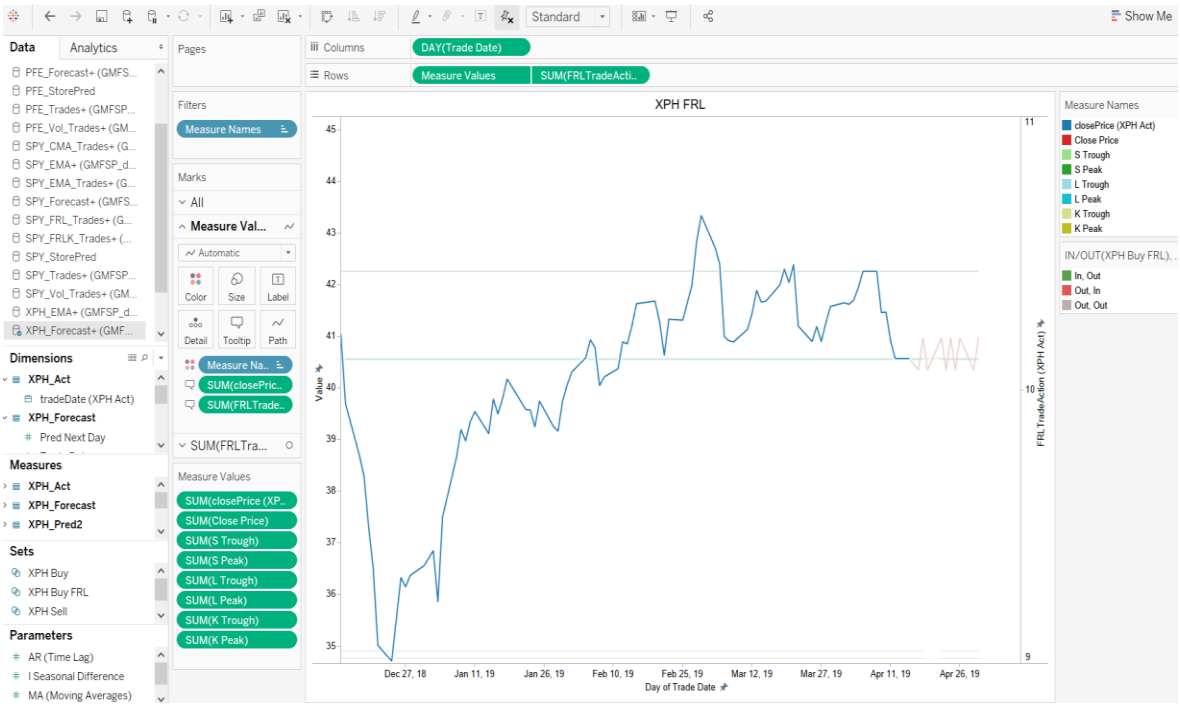


SPY CMA graph shows the trade date, closing price, and the CMA values for the SPY exchange-traded fund. The predicted change of the SPY according to the CMA algorithm is shown in red.

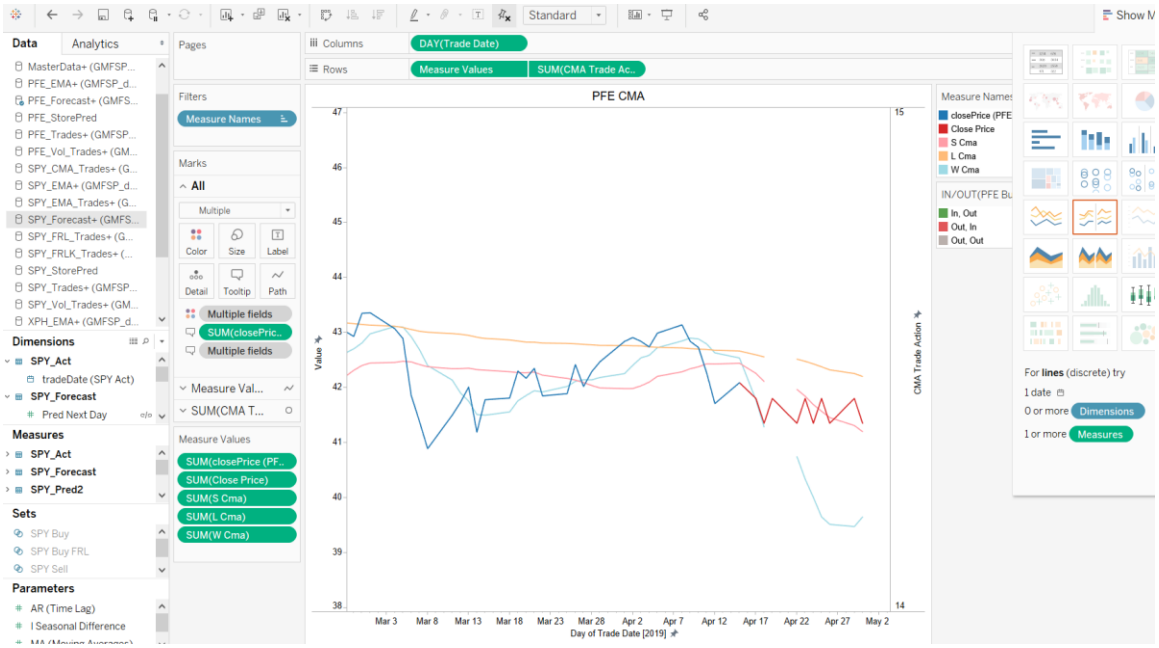
SPY FRL graph shows the trade date, closing price, and the FRL values for the SPY exchange-traded fund. The predicted change of the SPY according to the FRL algorithm is shown in red.



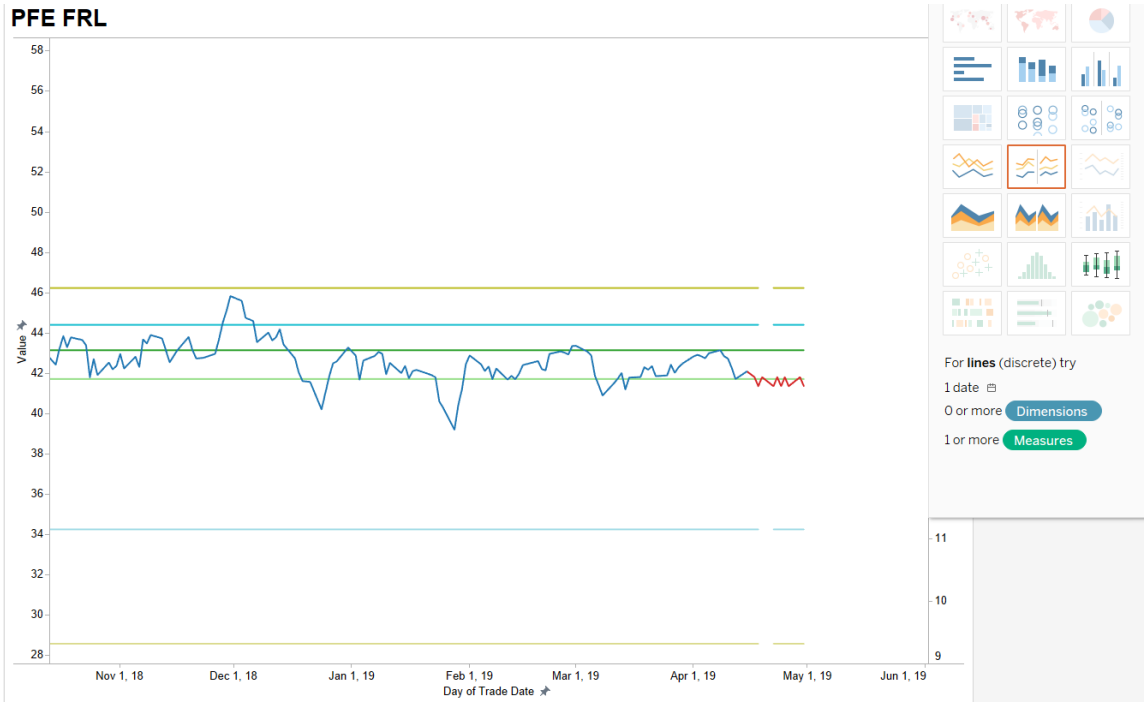
XPH CMA graph shows the trade date, closing price, and the CMA values for the XPH exchange-traded fund. The predicted change of the XPH according to the CMA algorithm is shown in red.



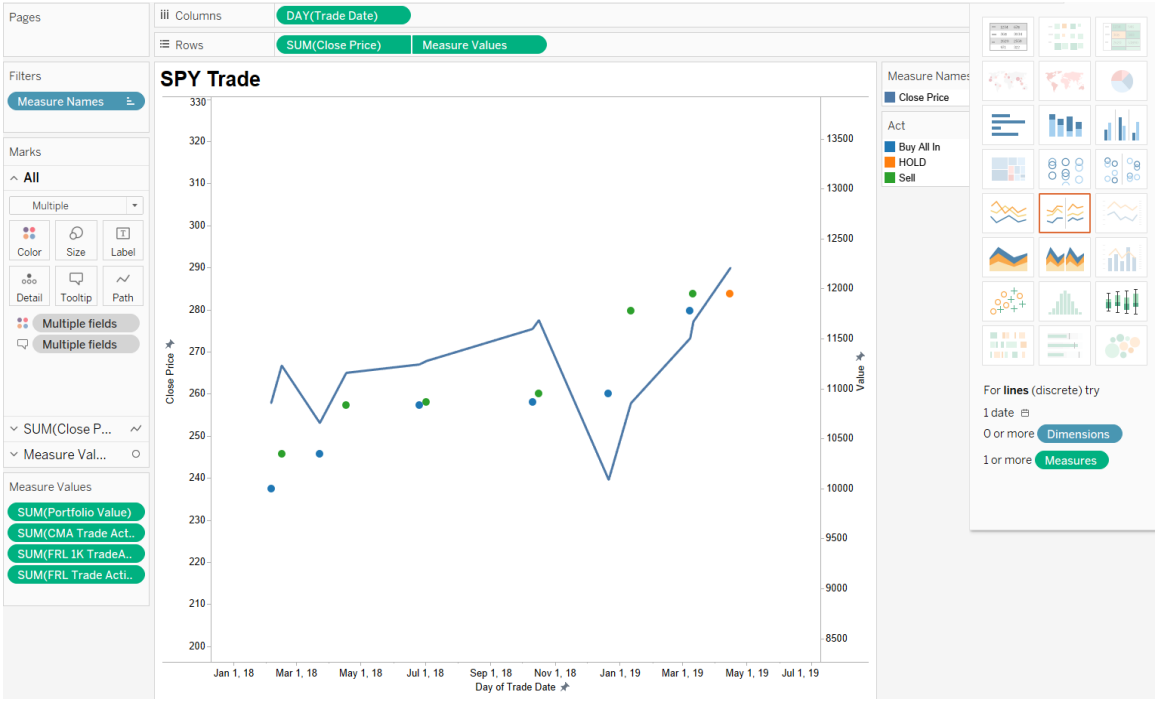
XPH FRL graph shows the trade date, closing price, and the FRL values for the XPH exchange-traded fund. The predicted change of the XPH according to the FRL algorithm is shown in red.



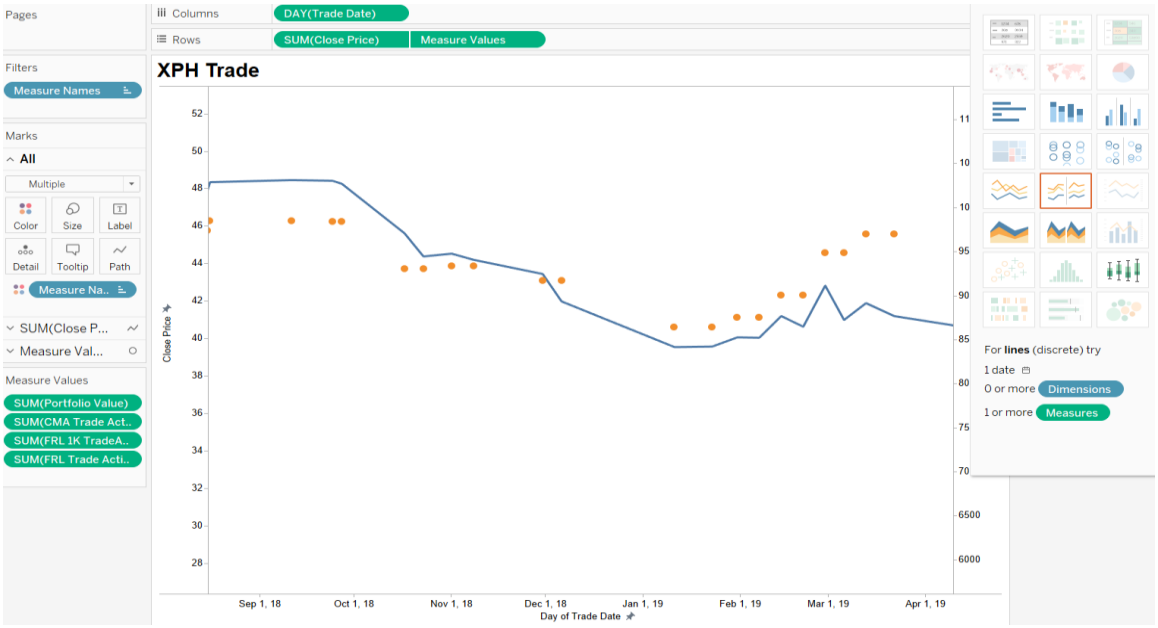
PFE CMA graph shows the trade date, closing price, and the CMA values for the PFE exchange-traded fund. The predicted change of the PFE according to the CMA algorithm is shown in red.



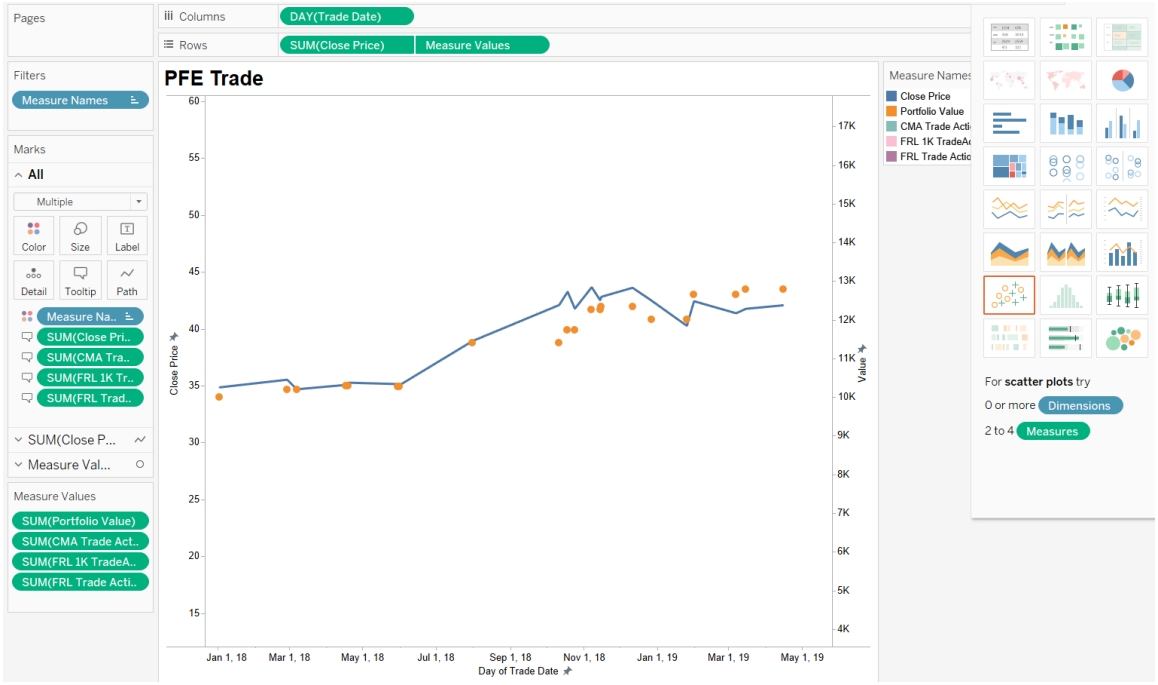
PFE FRL graph shows the trade date, closing price, and the FRL values for the PFE exchange-traded fund. The predicted change of the PFE according to the FRL algorithm is shown in red.



SPY Trade graph shows the stock price as well as the decisions that the algorithm made to either buy, sell, or hold.



XPH Trade graph shows the current value of the portfolio as well as the decisions that the algorithm made to either buy, sell, or hold according to the CMA and FRL algorithms.



PFE Trade graph shows the current value of the portfolio as well as the decisions that the algorithm made to either buy, sell, or hold.

3.1.2 Hardware Interface

GM FinTech application is designed in Tableau which can be easily integrated into any web browser for mass access. Tableau is mostly used in corporate environments within large organizations. No components of this application are intended for IoT.

GM FinTech is developed specifically for Windows machine with Intel 10^{th} or AMD 7^{th} generation processors or newer with a steady network connection in order to safely retrieve and manipulate stock data. The device will require around 5 gigabytes of free disk space and 4 GB of RAM.

The Windows platform provides access to all the services need to run the application, most importantly to retrieve and process stock information from the YAHOO finance.

3.1.3 Software Interface

The GM FinTech application will work using Python libraries, Pandas API, and YAHOO trader.

Trading data

- Trading data is fetched from Yahoo trader using pyodbc API and then processed in a Python program and then sent directly to the database server
- Incoming trading data consists of date and adjusted closing price for traded funds, SPY, XPH, PFE, GM, CARZ and more.

Algorithmic Manipulation and Decision

- Incoming trade data will be processed for ARIMA, Random Forest Regression, SVM and more advanced prediction techniques. Results of each calculation will be stored in a relational database.
- The CMA and FLR values for the preexisting data will stay in the existing tables in MS SQL Server
- A few calculations may be done using stored SQL procedures but most will be handled in Python's middle processing layer.

Data View

- The data from the server will be linked to a Tableau custom dashboard application. This data includes ARIMA, Random Forest Regression, CMA and FLR values, Adj. Close, Date, and the algorithm's decision to buy, sell, or trade.
- New database structure will also have tables to perform advanced analytics visualizations, i.e.; DateDim table.

3.1.4 Communications Interface

The GM FinTech application will have a network server that is running on the user's machine and has access to the database. The server exists to retrieve information collected through Yahoo trader and stored into the database. The product will then call the database system that stores the trade data and manipulate the trade data using many algorithms. The user's machine will run the Python code which will update and process the latest trade information and update that information and sync it to the database for Tableau to display the data for the user.

3.2 Functional Requirements

ID	FR_0.1		
Name	Login information		
Description	Login username and password to use the application		
Rationale	Provided the ability to use the system		
Input	Username = sa Password = Gmfintech18		
Output	Connection to the application		
Forward Dependency	Entire application		
Backward Dependency	None		
Priority	**High**	**Priority Reason**	**Large Scale**
Priority Sequence	**H-1**		
Error Handling	User will have to contact the system administrator to request the username and password as there is no functionality to request a new username/password or reset it. Username and password are hardcoded as this is an internal application.		

ID	FR_1.0		
Name	Database must be restructured with a completely new optimized design		
Description	Application must use the new database structure for storing the data, if possible. It will also be ported over to MySQL from MS SQL Server		
Rationale	To remove redundancy and provide ease in scalability		
Input	Financial data feed from YAHOO's data exchange, algorithms result outputs from Python scripts, inputs from SQL scripts and stored procedures.		
Output	Redundancy free storage of all the incoming data in a highly structured relational database.		
Forward Dependency	None		
Backward Dependency	YAHOO's data feed		
Priority	**High**	**Priority Reason**	**Large Scale**
Priority Sequence	**H-1**		
Error Handling	Contact the database administrator or the developers.		

ID	FR_2.0		
Name	Database Management System needs to be converted over to MySQL from currently locally deployed MS SQL Server		
Description	All existing data and structure to be migrated to MySQL, along with the existing records in all the tables. All new algorithms are to be implemented in the new data structure. The client would like us to continue in SQL Server until we are ready to migrate.		
Rationale	To increase accessibility		
Input	Previously created data tables with structure and data, newly created tables with new structure		
Output	Storage of all incoming data in a highly structured relational database		
Forward Dependency	FR_3.0		
Backward Dependency	FR_1.0		
Priority	**High**	**Priority Reason**	**High Cost**
Priority Sequence	**H-2**		
Error Handling	For any error in the new MySQL or current SQL Server database please contact the database administrator. If the issue is not resolved please contact th developers.		

ID	FR_3.0		
Name	Functionality of existing prediction techniques must be changed and improved		
Description	Output of previously implemented predictions must be recoded or reconfigured to show better results. Modify if possible otherwise re-write the existing scripts and show the results in a functional state on the front-end.		
Rationale	To improve the quality of existing predictive techniques		
Input	Algorithms and calculations in existing data structure		
Output	Improved output of forecasts and predictions, visualized in a Tableau application		
Forward Dependency	None		
Backward Dependency	FR_2.0, YAHOO's data exchange		
Priority	**High**	**Priority Reason**	**Large Scale**
Priority Sequence	**H-3**		
Error Handling	Python code would need to be corrected, possibly some parts in the stored procedures as well. Users will not be able to address the error on their own.		

ID	FR_4.0		
Name	Introduce new stock symbols such as GM, CARZ and more as needed by client with least amount of manual effort by the user		
Description	Expand the applications in terms of reviewing more stocks. Data loads for any instrument must be seamless, fully automated and controlled in the Python environment		
Rationale	To increase the depth of the application and increase the market share by employing buying and selling opportunities to more stocks		
Input	YAHOO exchange data with Date, Open, High, Low, Close, Adj Close, Volume columns. Date is in m/d/yyyy format, all other fields are float.		
Output	Data values to algorithms and other scripts as needed		
Forward Dependency	FR_5.0		
Backward Dependency	FR_1.0		
Priority	**Medium**	**Priority Reason**	**Low Cost**
Priority Sequence	**M-1**		
Error Handling	Python code would need to be updated. If the error is due to exchange connectivity then another free exchange would need to be configured, field names will be impacted. User will not be able to address any error.		

ID	FR_5.0		
Name	Introduce new algorithms for predictions using adjusted close price data label		
Description	Application must provide the user with options to analyze a stock using different advanced algorithms so they can confidently support business decisions		
Rationale	To increase the depth of the application		
Input	YAHOO exchange data		
Output	Predictions, engineered features, graphable data		
Forward Dependency	None		
Backward Dependency	FR_1.0		
Priority	**Medium**	**Priority Reason**	**Medium Scale**
Priority Sequence	**M-2**		
Error Handling	Python code would need to be updated. User will not be able to address any error. User can spot irregularities and report them to the system admin.		

ID	FR_6.0		
Name	Data in Tableau must be up to date		
Description	Application must display updated data when its opened **Steps:** 1) Open Python code in PyCharm 2) Install and set up Anaconda Environment 3) Install an instance of MS SQL Server running, will change to MySQL 4) Install Tableau and open Tableau file from the directory 5) Run dataMain.py in PyCharm 6) Recent data can be viewed in Tableau		
Rationale	To show the robustness and automation of the application. Also improve the user experience with the interface.		
Input	YAHOO exchange data		
Output	Update database tables and Tableau user interface		
Forward Dependency	FR_7.0, 8.0		
Backward Dependency	None		
Priority	**Medium**	**Priority Reason**	**Low Cost**
Priority Sequence	**M-3**		
Error Handling	Connection to exchange could cause an error. Software configurations or installation will need to be looked at. Developers will have to look at the application.		

ID	FR_7.0		
Name	Tableau shows all updated and relevant graphs		
Description	Tableau reads data from the tables in the database and displays it a dashboard. After the data is updated, these graphs will also update.		
Rationale	Valid data to be consumed by the data analyst using the application		
Input	Data feeds from the configured data sources		
Output	User interface graphs and measure values		
Forward Dependency	None		
Backward Dependency	FR_6.0		
Priority	**Medium**	**Priority Reason**	**Low Cost**
Priority Sequence	**M-4**		
Error Handling	Data table or calculations will need to be reviewed. Tableau visual could also have an issue. User can manipulate the front-end by changing visual settings or values. If error is still not resolved a developer will need to review.		

ID	FR_8.0		
Name	Tableau shows CMA, FRL and EMA(cross moving average and Fibonacci retracement, and exponential moving average) graphs.		
Description	Along the bottom of the Tableau dashboard, the graphs titles for the pricing data collected for each individual index will be displayed. Their labels will also indicate which algorithm each of them will show.		
Rationale	The user will be able to view the predictions of the algorithm of their choice by selecting the corresponding tab along the bottom of the Tableau Dashboard.		
Input	Data from database tables		
Output	Front End Tableau user interface		
Forward Dependency	None		
Backward Dependency	FR_3.0, 6.0		
Priority	**Low**	**Priority Reason**	**Low Scale**
Priority Sequence	**L-1**		
Error Handling	Data table or calculations will need to be reviewed. Tableau visual could also have an issue. User can manipulate the front-end by changing visual settings or values. If error is still not resolved a developer will need to review.		

ID	FR_9.0		
Name	User can view algorithm predictions within the graphs and select which specific algorithm would like to be viewed		
Description	The user will have the option of selecting which algorithms prediction will be visible on the graph		
Rationale	These algorithms have only one way of being visually indicated, and by looking at what trends they indicate, the user has trading information at their disposal		
Input	Data from database tables		
Output	Front End Tableau user interface		
Forward Dependency	None		
Backward Dependency	FR_3.0, 6.0, YAHOO exchange data		
Priority	**Low**	**Priority Reason**	**Low Scale**
Priority Sequence	**L-2**		
Error Handling	Front end graphs or measures would need to be corrected. User can try creating a new graph but if that does not work, developers would have to be contacted.		

ID	FR_10.0		
Name	Visual Representation of buying and selling in portfolio		
Description	The trade simulator shows all points of buying and selling and holding shares in an easy to view/color coordinated fashion		
Rationale	Via Tableau, the graph of the individual market of the corresponding data source (XPH, SPY, PFE) will be projected as well as the points where the algorithm indicates where buying and selling took place. These points will also come with a pop-up window when the user hovers over to see the date of trade, close price, CMA trade action, FRL trade action, and portfolio trade value.		
Input	Data from database tables		
Output	Front End Tableau user interface		
Forward Dependency	None		
Backward Dependency	FR_3.0, 6.0, YAHOO exchange data		
Priority	**Low**	**Priority Reason**	**Low Scale**
Priority Sequence	**L-3**		
Error Handling	If buy/sell signals don't seem valid to the user, Python code would need to be updated by the developers. If the error is on the front-end user can seek help from the system administrator.		

ID	FR_11.0		
Name	Display the variables in the CMA calculation and the trade signal		
Description	Hovering over CMA market indication lines show trade date, market value on that date, the trade indicator, week long CMA, short term CMA, and long-term CMA		
Rationale	The user can hover over any point on the close price projected by the graph and be able to understand what the calculations of the CMA based on week (7 business days), short (20 business days), and long (100 business days) including the trading signal at any given point		
Input	Data from database tables		
Output	Front End Tableau user interface		
Forward Dependency	None		
Backward Dependency	FR_6.0, 7.0, 8.0, 9.0		
Priority	**Low**	**Priority Reason**	**Low Scale**
Priority Sequence	**L-4**		
Error Handling	Any calculation error would need to be addressed by the developers. If there is any front-end error user can seek assistance from the system administrator.		

ID	FR_12.0		
Name	Display the projected calculation for week CMA, short-term CMA, and long-term CMA		
Description	Alongside the close price graph of the certain market (ex: SPY, XPH, PFE) there will be the calculated projections of week, short, and long CMA		
Rationale	To display the CMA algorithm being able to calculate the market values and distinguish the different periods of time that play a factor in the calculation.		
Input	Data from database tables		
Output	Front End Tableau user interface		
Forward Dependency	None		
Backward Dependency	FR_6.0, 7.0, 8.0, 9.0		
Priority	**Low**	**Priority Reason**	**Low Cost**
Priority Sequence	**L-5**		
Error Handling	Any calculation error would need to be addressed by the developers. If there is any front-end error user can seek assistance from the system administrator.		

ID	FR_13.0		
Name	Display the variables in the FRL calculation and the trade signal		
Description	Hovering over FRL market indication lines show trade date, market value on that date, the trade indicator.		
Rationale	The user can hover over any point on the close price projected by the graph and be able to understand what the trade signal at the given point is indicating		
Input	Data from database tables		
Output	Front End Tableau user interface		
Forward Dependency	None		
Backward Dependency	FR_6.0, 7.0, 8.0, 9.0		
Priority	**Low**	**Priority Reason**	**Low Cost**
Priority Sequence	**L-6**		
Error Handling	Last calculation is always Hold, it may seem like an error. Any error on ‘Sell’ or ‘Buy All In’ would need to be addressed by the developers. If there is any front-end error user can seek assistance from the system administrator.		

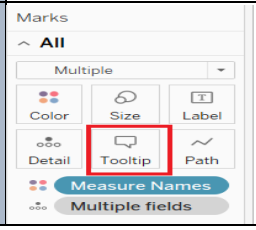
ID	FR_14.0		
Name	Display the projected calculation for FRL and the natural numbers in the formula (23%, 38.2%, 61.8%, 79.4%)		
Description	Alongside the close price graph of the certain market (ex: SPY, XPH, PFE) there will be the calculated projections of short-term peak and trough, long-term peak and trough, and thousand (k) day peak and trough		
Rationale	The graph will display close price graph of the selected market and there will be horizontal lines that intersect through the close price for the peaks and troughs for the different type of lengths in time		
Input	Data from database tables		
Output	Front End Tableau user interface		
Forward Dependency	None		
Backward Dependency	FR_6.0, 7.0, 8.0, 9.0		
Priority	**Low**	**Priority Reason**	**Low Cost**
Priority Sequence	**L-7**		
Error Handling	In, Out, Trough, Peak calculation errors will have to address by the developers. Any graph display errors can be addressed by the system administrator.		

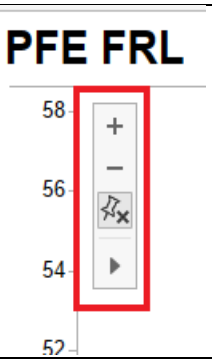
ID	FR_15.0		
Name	Display the variables in the EMA calculation and the trade signal		
Description	Hovering over CMA market indication lines show trade date, market value on that date, the trade indicator, week long EMA, short term EMA, and long-term EMA		
Rationale	The user can hover over any point on the close price projected by the graph and be able to understand what the calculations of the EMA based on week (7 business days), short (20 business days), and long (100 business days) including the trading signal at any given point		
Input	Data from database tables		
Output	Front End Tableau user interface		
Forward Dependency	None		
Backward Dependency	FR_6.0, 7.0, 8.0, 9.0		
Priority	**Low**	**Priority Reason**	**Low Cost**
Priority Sequence	**L-8**		
Error Handling	EMA Signal, L EMA, S EMA, M EMA, all need to be addressed by the developers. If the user encounters any graph display errors, they can contact the system administrator.		

ID	FR_16.0		
Name	Display the projected calculation for short EMA, medium EMA, and long term EMA		
Description	Alongside the close price graph of the certain market (ex: SPY, XPH, PFE) there will be the calculated projections of week, short, and long EMA		
Rationale	To display the EMA algorithm being able to calculate the market values and distinguish the different periods of time that play a factor in the calculation		
Input	Data from database tables		
Output	Front End Tableau user interface		
Forward Dependency	None		
Backward Dependency	FR_6.0, 7.0, 8.0, 9.0		
Priority	**Low**	**Priority Reason**	**Low Cost**
Priority Sequence	**L-9**		
Error Handling	All EMA calculations will need to be addressed by the developers. If the user encounters any graph display errors, they can contact the system administrator.		

ID	FR_17.0		
Name	Navigate through the different graphs (CMA, FRL, Trade) for the different markets		
Description	Bottom bar of tableau can allow the user to look at the specific metric measured and the target pharmaceutical market that the user requires		
Rationale	The user will be able to switch between the different graphs or view them all at once based on preference. This is to allow the user to gain a better understanding of each algorithm and its variables as well as the trading portfolio		
Input	Data from Tableau data-sources, existence of Tableau tabs		
Output	User Interface for the required symbol/instrument		
Forward Dependency	None		
Backward Dependency	FR_6.0, 7.0, 8.0, 9.0		
Priority	**Low**	**Priority Reason**	**Low Scale**
Priority Sequence	**L-10**		
Error Handling	Close the application and reopen it, the errors could be due to memory resources or heavy data load as the application executes and run scripts locally. If you still encounter errors please contact the system administrator.		

ID	FR_18.0		
Name	View data values on Tableau from the database		
Description	User can view the database values from within Tableau instead of Microsoft SQL Server Management Studio or MySQL		
Rationale	The user will be able to view the date, close price, algorithm calculations and the respective variable values in a table format		
Input	Tableau connected to data-sources		
Output	A table format view of the data. User can edit the number of rows in the top left corner of the table view.		
Forward Dependency	None		
Backward Dependency	FR_6.0, 7.0, 8.0, 9.0		
Priority	**Low**	**Priority Reason**	**Low Cost**
Priority Sequence	**L-11**		
Error Handling	If the values are not visible, database will have to be queried to see if they exist in the 'InstrumentStatistics' and other related source tables, this task can be performed by the system administrator.		

ID	FR_19.0		
Name	Tooltip Windows		
Description	Data points will be interactive as the user will be able to click on a point and details such as date, current index value, predictions will be provided		
Rationale	To verify system integrity and to get an up-close look at an individual data point		
Input	Data points, data values		
Output	Tooltip message		
Forward Dependency	None		
Backward Dependency	All FRs		
Priority	**Low**	**Priority Reason**	**Low Cost**
Priority Sequence	**L-12**		
Error Handling	 Click on the 'Tooltip' box under the measures in the 'Marks' section in the left side of the Tableau and make sure there are values listed in the dialog box that appears on the screen.		

ID	FR_20.0		
Name	Zoom Feature		
Description	The feature will be displayed when the user goes over the graph with the cursor or by double clicking at a certain part		
Rationale	To allow for easy access to investigate in closer detail		
Input	Tableau dashboard's canvas		
Output	Tableau canvas in zoomed-in or zoomed-out state		
Forward Dependency	None		
Backward Dependency	None		
Priority	**Low**	**Priority Reason**	**Low Cost**
Priority Sequence	**L-13**		
Error Handling	 If the mouse double-click is not working try using a pinch action on a touch-pad(if a touch-pad is available). Pinch is same action that we use on our mobile phone's touchscreen. User can also try to use the **'+'** and **'–'** buttons on each graph's top left section, when the user hovers on the graph this toolbar appears otherwise it stays hidden. If still no resolution, close and reopen the application or contact the system administrator.		

3.3 Non-Functional Requirements

3.3.1 Performance

ID	NFR_1.0		
Name	Notifications		
Description	Should be complete but concise, the application should wait for acknowledgement from the user		
Rationale	There will be no option for update or any notification, application data is updated as soon as it's opened each time. The application will never notify the user and require user information to proceed. Relaying the update notification will be rudimentary to informing the user is looking for.		
Input	None		
Output	None		
Forward Dependency	NFR_2.0		
Backward Dependency	None		
Priority	**High**	**Priority Reason**	**Large Scale**
Priority Sequence	**H-1**		

ID	NFR_2.0		
Name	Data Sources		
Description	Updating the data when the application is launched automatically		
Rationale	When the application starts the system should pull data from YAHOO and display it via Tableau. To keep the data current and ensure business standards are met, the data and visualizations will be current to the day. Data load time must be optimized to not take any longer than 1-3 minutes.		
Input	Data from configured data sources, database management system		
Output	Auto refresh of the application		
Forward Dependency	All NFRs		
Backward Dependency	None		
Priority	**High**	**Priority Reason**	**Large Scale**
Priority Sequence	**H-2**		

ID	NFR_3.0		
Name	Graphs & Visualizations		
Description	Every Graph and Visualization should be clean and easy to interpret. It should not be busy with too much information. The user should be able to view individual graphs and measurements. Information related to each graph i.e. legend, info box, tooltip window should be displayed clearly.		
Rationale	For the user to have full comprehension of the data being displayed it is necessary that there is nothing ambiguous on the user interface		
Input	Data from the data-sources, Tableau canvas and tabs		
Output	Graphs display		
Forward Dependency	None		
Backward Dependency	None		
Priority	**High**	**Priority Reason**	**Large Scale**
Priority Sequence	**H-3**		

ID	NFR_4.0		
Name	Information Box		
Description	The information box should remain in the same location for each view type but update to represent what is current being viewed		
Rationale	This information box will contain pertinent information to further verify system integrity; specifically, the current trading positions		
Input	None		
Output	Stable view of the Tableau canvas		
Forward Dependency	None		
Backward Dependency	None		
Priority	**Medium**	**Priority Reason**	**Medium Cost**
Priority Sequence	**M-1**		

ID	NFR_5.0		
Name	Dual Graphs		
Description	The two graphs on the data source trade charts will show how the previous algorithm is progressing and the other one will show how the new algorithm with volumetric trading will be progressing over a 100-day period		
Rationale	To visually represent how the two algorithms, buy and sell and to visualize how that volumetric trading is outperforming the “all in” strategy		
Input	Data from the data-sources configured in Tableau		
Output	Graphs with 2 or more lines and measures in the user interface of Tableau		
Forward Dependency	None		
Backward Dependency	None		
Priority	**Medium**	**Priority Reason**	**Medium Scale**
Priority Sequence	**M-2**		

3.3.2 Reliability

ID	NFR_6.0		
Name	System Reliability		
Description	When fully functioning, the system will collect the data and store it in the local database and output the data via Tableau		
Measurability	Daily operation for 30 days > 97%		
Input	None		
Output	None		
Forward Dependency	None		
Backward Dependency	None		
Ideal	100%		
Success	N/A		
Priority	**High**	**Priority Reason**	**Large Scale**
Priority Sequence	**H-1**		

3.3.3 Availability

ID	NFR_7.0		
Name	System Availability		
Description	The availability of the system when it is used		
Measurability	Daily operation for 30 days > 97%		
Input	None		
Output	None		
Forward Dependency	None		
Backward Dependency	None		
Ideal	100% fully functioning		
Success	N/A		
Priority	**High**	**Priority Reason**	**Large Scale**
Priority Sequence	**H-1**		

ID	NFR_8.0		
Name	Database connection		
Description	The computer system must have an established connection with the database for the application to store the data obtained from YAHOO Local Host : Local machine has the database connected locally on the hard-drive Server Host : The database is on the server and the machine is connected properly		
Measurability	Daily operation for 30 days > 97%		
Input	Existence of database in a DBMS with required structure		
Output	Entire User Interface in Tableau		
Forward Dependency	Entire Application		
Backward Dependency	Entire Application		
Ideal	100% connectivity		
Success	N/A		
Priority	**High**	**Priority Reason**	**High Cost**
Priority Sequence	**H-2**		

ID	NFR_9.0		
Name	Internet connection		
Description	For the application to obtain the current data there must be an internet connection		
Measurability	Daily operation for 30 days > 97%		
Input	None		
Output	Connection to YAHOO's financial data exchange		
Forward Dependency	Application updates, database updates with new data		
Backward Dependency	None		
Ideal	100% fully functioning		
Success	N/A		
Priority	**Medium**	**Priority Reason**	**Medium Scale**
Priority Sequence	**M-1**		

3.3.4 Security

ID	NFR_10.0		
Name	System Security		
Description	The security of the system comes from the architecture and all the individual components of the system		
Rationale	Single User : This case makes the user the main security administrator. This implies that the user will have full access to the application when fully installed. Multiple users : The user interface will be installed on all machines to view the data, however, only a few will have administrative rights to ensure security is handled appropriately.		
Input	None		
Output	None		
Forward Dependency	Security of transformed data		
Backward Dependency	None		
Ideal	100% secure connectivity		
Success	N/A		
Priority	**Medium**	**Priority Reason**	**Medium Scale**
Priority Sequence	**M-1**		

3.3.5 Maintainability

ID	NFR_11.0		
Name	System Maintainability		
Description	Platform design will be centered around the financial instruments		
Rationale	To allow the code to add more functionality and the ability to change the algorithms if needed		
Input	None		
Output	None		
Forward Dependency	Correct algorithm calculations		
Dependency	None		
Priority	**Medium**	**Priority Reason**	**Medium Cost**
Priority Sequence	**M-1**		

ID	NFR_12.0		
Name	Code Refactoring		
Description	Refactoring the code to make it more modular		
Rationale	The code right now is not user friendly and takes time to navigate through. By refactoring, some of the redundancies can be eliminated and can create better structure		
Input	Existing code		
Output	Modular code		
Forward Dependency	Entire Application		
Backward Dependency	All functional requirements		
Priority	**Medium**	**Priority Reason**	**Medium Scale**
Priority Sequence	**M-2**		

3.3.6 Portability

NFR ID	13.0		
Name	Application Portability		
Description	The application should be able to function on any Personal Computer with Windows 10 and all applicable web browsers that the dashboard is embedded into. With the correct versions of required software installed, the application can be reproduced without any issue.		
Rationale	These are trusted and established platforms and APIs		
Input	None		
Output	None		
Forward Dependency	Must work on all PCs when all the required software is installed		
Backward Dependency	None		
Priority	**High**	**Priority Reason**	**Large Scale**
Priority Sequence	**H-1**		

3.4 Design Constraints

- Database structure is setup per client's requirements
- The database is currently set up to only run on MS SQL Server 2017
- Database will also be converted over to MySQL DBMS
- Python 3.7 or later must be used for the back-end code execution
- Dependent libraries must be installed as required before any code execution
- GitLab must be used for the latest version of the code, documentation and readme
- Tableau Software and services must be used to provide a user interface
- Steady internet connection is required to update YAHOO's financial exchange data
- If source trading data is no longer available, data exchange switch may be required, current exchange has no cost associated with data pulls
- Size of data can impose a constraint on the database, physical storage limits cannot be exceeded
- Deciding on buy, sell or hold criteria, human input required

3.5 Logical Database Requirements

3.5.1 Data Labels

The system must store data retrieved from YAHOO daily trader into the database in 6 float values and one date value for each exchange traded fund. The data values include the Date, Open, High, Low, Close, Adj. Close and Volume for each trade date.

3.5.2 Database Tables

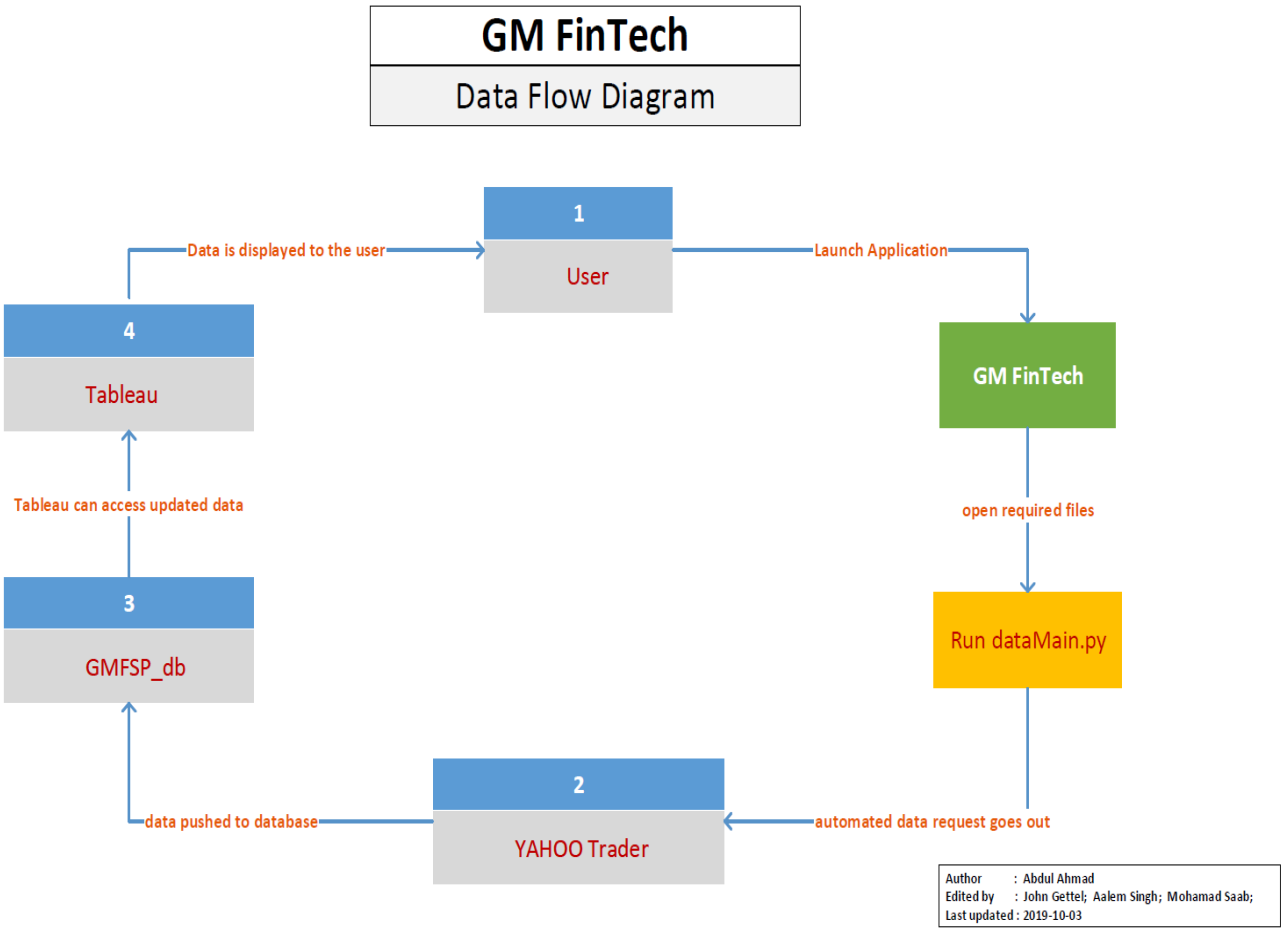
The new database structure will exponentially reduce the number of tables required to store the base instrument statistical data. Labels mentioned in 3.5.1.

Please see appendix A.1.2 for new database structure diagram.

4. Analysis Models

4.1 System Diagrams

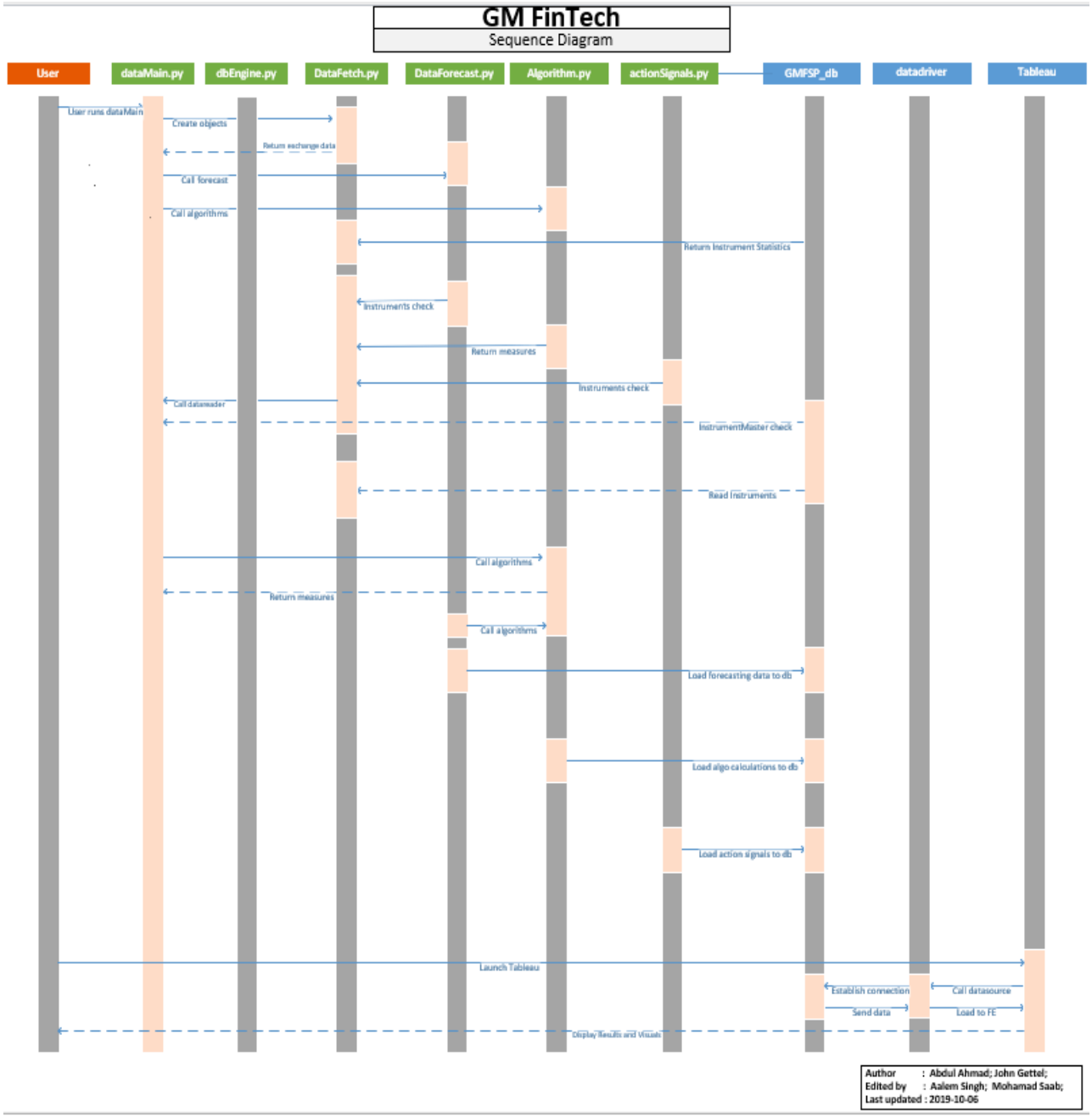
4.1.1 Data Flow Diagram



A. Appendices

A.1 Appendix 1

A.1.1 Sequence Diagram



A.1.2 Database Diagram (new structure)