Validation of Liquidity Model

A validation of the liquidity model used by Nasdaq Clearing

November 2015

Revision history:

Date	Version	Description	Author
2015-10-06	1.0	Initial draft	Jonas Schödin
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Validation of liquidity model

1. Background

1.1 General

Nasdaq Clearing AB ("Nasdaq" Clearing or "Nasdaq") provides clearing and Central Counterparty ("CCP") services. In order to prudently manage these services Nasdaq Clearing uses a large number of different models. This report is the validation of the liquidity model, called LaR (Liquidity at Risk).

The purpose of a validation of models is to ensure the theoretical and empirical soundness of the models used by the CCP. The validation report should ensure transparency on the models used by the CCP for the benefit of:

- Board of Directors, Nasdaq Clearing AB.
- Competent Authorities.
- Internal Audit and Audit Committee.
- Other stake holders.

1.2 Legal environment

Nasdaq Clearing was at the 19th of March 2014 authorised as Central Counterparty (CCP) to offer services and activities in the Union in accordance with Regulation (EU) No 648/2012 of the European Parliament and of the Council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories.

The legal framework that governs Nasdaq Clearing is therefore the EMIR framework, Regulation (EU) No 648/2012 and supporting delegated Regulations 148/2013, 149/2013, 150/2013, 151/2013, 152/2013, 153/2013, 285/2014, 667/2014, 876/2013, 1003/2013 and the implementing Regulations 484/2014, 1247/2012, 1249/2012.

The Regulation of particular interest for this validation is Article 33 in COMMISSION DELEGATED REGULATION (EU) No 153/2013, Article 34 and 42 in COMMISSION DELEGATED REGULATION (EU) No 153/2013 and article 44 in REGULATION (EU) No 648/2012 OF THE EUROPEAN PARALMENT AND THE COUNCIL of 4 July 2012.

2. Input to the validation

2.1 Documentation at Nasdaq Clearing

2.1.1 Previous validation of LaR

In Nasdaq Clearing's application for being an authorised CCP and to offer services and activities in the Union in accordance with Regulation (EU) No 648/2012 a validation of the LaR model was performed. This validation will act as an important building block for this new validation. The full document name is: "CCP liquidity framework review"

2.1.2 Addition to validation of LaR

In November 2014 an addition validation was made. This will act as one source of information for this validation. The full document name is: "Validation of liquidity model"

2.1.3 Validation of the LaR method amended for new functionality - cash optimization

In January 2015 a validation of a new functionality was made. This will act as one source of information for this validation. The full document name is: "Validation of liquidity cash optimization model".

2.1.4 Policy for liquidity risk

This policy is in line with Nasdaq Clearing's standard when it comes to documentation available for internal use. It is meant as a general policy and not necessarily as a technical document describing the actual model for handling of liquidity risk. The full document name is: "Nasdaq OMX Clearing AB Liquidity Policy"

This policy is approved by the Board of Directors of Nasdaq Clearing AB.

2.1.5 Liquidity stress test policy

This policy is in line with Nasdaq Clearing standard when it comes to documentation available in respect of model calibrations. This policy describes how the liabilities should be calculated by using a number of different stress test scenarios. The full document name is: "Liquidity at Risk Stress Test Policy"

This document has been approved by the Clearing Risk Committee.

2.1.6 LaR implementation

This document is in line with Nasdaq Clearing standard when it comes to internal documents describing the details of how the liquidity needs are calculated. This document was created by the Head of Risk Management Financial Products. The document name is: "LaR implementation – details"

2.2 Numerical analysis of LaR

Nasdaq Clearing has ongoing numerical procedures in place to deliver numerical output from the liquidity model that is in use. The numerical data can be roughly divided into three separate parts:

- Back testing data.
- Stress testing
- Reversed stress testing data.

2.3 Discussions

In any validation a large part of the information received must be thoroughly discussed with the personal at the Treasury department and personal at the CCP. The following persons are prime sources of information to this model validation:

- Maria Nehlin, Treasury Non-US.
- Tomas Thyblad, Chief Risk Officer, Nasdaq Clearing.

2.4 Special issues

LaR was validated in January 2015 before the implementation of the new cash optimization functionality. Since a model must, and should, be validated on a yearly basis each validation will be updated with new issues as:

- New added functionality to the LaR model.

- New types of instruments or markets added to the group of instruments and markets in which the LaR model is used.

- Changed financial environment as different volatility in the market.

- New distribution of counterparts as increased risk towards certain firms.

- New legislation that changes the rules thereby contradicts assumptions made in the model.

3. Theoretical framework of the model

3.1 Background on liquidity models

3.1.1 Basic liquidity risk methodologies

Liquidity risk is the risk of not being able to meet payment obligations on their due dates without the cost of obtaining the funds increasing considerably.

The basic idea behind a liquidity method is that a firm shall apply a forward-looking view to its liquidity risk and assess the structure of the balance sheet, cash flows, liquidity positions and risks in off-balance sheet items. Risk measurements and key ratios shall identify vulnerabilities in day-to-day operations and during periods of stress. The measurement methods, where applicable, shall distinguish between liquidity risks in different currencies.

A traditional method is based on that a firm shall calculate the cash flows expected to arise when total assets, liabilities and off-balance sheet items are settled. Cash flows shall be allocated to the various horizons in which they are normally expected to occur. The firm shall use daily horizons in its calculation. A firm shall calculate the net cash flow for each horizon as the sum of the expected cash outflows minus the sum of the expected cash inflows. The firm shall thereafter accumulate the net cash flow across all horizons in order to demonstrate how long it has a positive cash flow.

Liquidity methods are usually based on calculations where expected cash flows is distinguished between contracted cash flows with established payment dates and cash flows for which the payment dates and amounts are influenced by the firm's own decisions, customer behaviour or market developments.

3.2 Background to LaR calculations

3.2.1 Basic LaR definition/calculations

3.2.1.1 General

Nasdaq liquidity risk method differ in many ways from other financial institutions, this since Nasdaq acts as a CCP, where all essential cash flows (all cash flows are by definition matched in the CCP activities) emerge within a short time period, cash flows has to be forecasted as

they do not have any contracted cash flow amounts and most liabilities are off balance sheet. Because of this Nasdaq liquidity method is based on several different stress test scenarios, instead of matching contracted cash flow dates and amounts.

3.2.1.2 Assets

The assets that Nasdaq takes into consideration are assets which are held in Nasdaq's own name and are both on-balance sheet items and credit lines. Pledged collaterals are assumed not to be available for liquidity until realization.

3.2.1.3 Liquidity layer

Nasdaq has internally layered their liquidity resources into three different layers:

- Qualified liquidity resources ("QLR").

- Additional liquidity resources ("ALR").

- Other liquidity resources ("OLR").
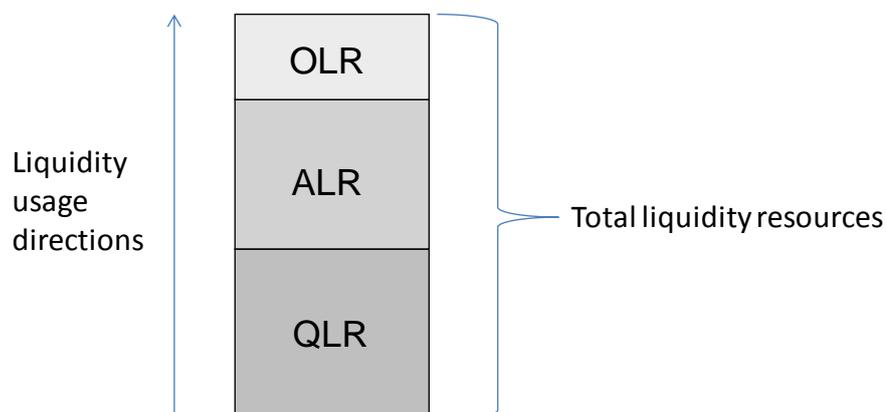
Figure 1: Liquidity layers

3.2.1.4 Qualified liquid resources

According to Nasdaq's liquidity policy the below assets are included:

1. Committed credit lines.
2. Cash.
3. Government Securities.

3.2.1.5 Committed credit lines

According to article 33 in COMMISSION DELEGATED REGULATION (EU) No 153/2013 committed lines of credit allowed to be included in the liquidity resources. Nasdaq has these preconditions for credit lines:

- Provided by banks rated A- (S&P) or A3 (Moody's) or higher.
- Refinanced at least one month before expiration.
- Should provide Nasdaq with at least 7 days credit.
- Should be fully committed.
- In the applicable currency.

However, being dependent on credit facilities in a stressed market is a risk that has to be taken into consideration. It could also be assumed that institutions issuing credit lines, with a lower credit rating, has a tendency to have a less honourable approach when it comes to committed credit facilities in a stressed market.

3.2.1.6   Cash

According to article 33 in COMMISSION DELEGATED REGULATION (EU) No 153/2013 cash is an approved asset that can be included in liquidity resources. The cash has to be deposited at a central bank or at an authorized credit institution. According to Nasdaq's liquidity policy should the cash held with commercial banks be available with same day value.

3.2.1.7   Government securities

According to article 33 in COMMISSION DELEGATED REGULATION (EU) No 153/2013 are Government securities classified as liquidity resource. Nasdaq's liquidity policy has these preconditions when it comes to Government securities:

- Eligible as collateral in the applicable central bank.

- Should be held in custody in own name.

- Issued in the applicable currency.

- Nasdaq holds Global Master Repurchase Agreement with at least two counterparties to ensure possibility to execute repo transactions.

- A haircut of 5% on the market value of securities should be applied.

- Any securities, which are needed as collateral in collateralized credit facilities should be deducted.

It should be clarified that Nasdaq do not have direct access to the central banks o/n liquidity set up for securities. Nasdaq would have to go through one of the major banks if the securities should be used as collateral at the central bank. However, the only securities that are preapproved as collateral at the central bank are the collaterals listed at the Swedish Central bank's web page (http://www.riksbank.se/sv/Finansiell-stabilitet/Betalningssystemet-RIX/Sakerheter/Godkanda-sakerheter/). All other securities have to be approved before they could be used as collateral at the central bank.

3.2.1.8   Other liquid resources

The liquidity layer OLR includes for example the internal group cash pool and other liquid resources that do not qualify as ALR.

3.2.2   Concentration risk limits

According to article 34 and 42 in COMMISSION DELEGATED REGULATION (EU) No 153/2013 and article 44 in REGULATION (EU) No 648/2012 OF THE EUROPEAN PARALMENT AND THE COUNCIL of 4 July 2012 shall a CCP closely monitor and control the concentration of its liquidity risk exposure. Nasdaq has in the liquidity policy the following limits when it comes to liquidity risk:

- The resources in the form of cash and committed credit facilities must minimum amount to 50 % of the QLR.

- The liquidity shortfall from the loss of a single liquidity provider, which is also a member of Nasdaq Clearing, can be a maximum of 25 % of the total estimated requirement.

- The liquidity shortfall from the loss of a single liquidity provider, which is not a member of Nasdaq Clearing can be a maximum of 100 % of the total estimated requirement in applicable currency if the requirement is below 150 MSEK (or equivalent amount in other currency).

- The liquidity shortfall from the loss of a single liquidity provider, which is not a member of Nasdaq can be a maximum of 50 % of the total estimated requirement in applicable currency if the requirement is above 150 MSEK (or equivalent amount in other currency).

- Exposure limits are defined for the sum or a single entity's aggregated highpoints for each individual liquidity risk in a specific currency.

  o Exposure limits towards single entity is 5,000 MSEK. This limit is more of the "soft kind" (indication relatively high concentrations risk). If the limit is exceeded should the situation be assessed and a proposal for reduction of the exposure should be presented in the quarterly report to the board of directors.

- Concentration risk limit is defined as a single entity's relative share of total aggregated exposure in a specific currency. The concentration limit should be calculated and monitored where the AR in the specific currency exceeds 400 MSEK.

  o Concentration limits in a specific currency towards single entity is 33 %, which is also a soft limit.

According to article 42 in COMMISSION DELEGATED REGULATION (EU) No 153/2013 a CCP shall establish and implement policies and procedures to ensure that the collateral remains sufficiently diversified to allow its liquidation within a defined holding period without a significant market impact. As Nasdaq liquidity method assumes that collateral is not available for liquidity relief this article is not applicable for Nasdaq's method.

3.2.3 Different liabilities

In general a firm shall apply a forward-looking view to its liquidity risk and assess the structure of the balance sheet, cash flows, liquidity positions and risks in off-balance sheet items. When it comes to a clearinghouse are most of the liabilities connected to the clearing operation and in proportion to these liabilities are the liabilities in CCP's own balance sheet quite insignificant.

3.2.4 Basic assumptions

Nasdaq assumes that it is only daily cash settled products that create liquidity pressures at default, for example are American call options not included.

Nasdaq has layered the liabilities into:

1. Minimum requirement ("MR")
2. Additional requirement ("AR")

MR should be equal to the largest need in any of the defined potential risk scenarios (see below).

The AR should be equal to the combination of the liquidity need in two stress scenarios. It should for example include if two participants with the largest exposures towards the CCP defaults simultaneously. For details regarding the calculation of MR and AR see figure 2 below.

3.2.5 On-balance minimum requirement

According to Nasdaq's liquidity policy a buffer of 20 MSEK should be held in case of stressed corporate situations. Nasdaq's argument is that the legal entity does not hold any financial debt and has a strong cash flow.

According to Nasdaq's liquidity policy QLR should always be larger than MR, the minimum requirement and ALR should always be larger than AR, both with a buffer of 10 %. The figure below describes the setup.

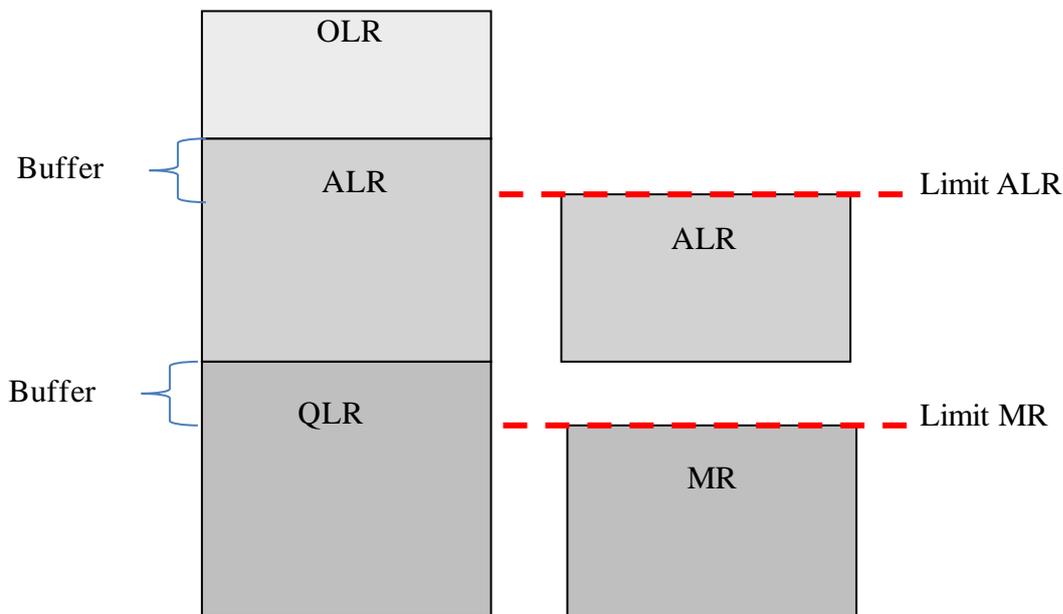**Figure 2: Liquidity model**

Excess liquidity within QLR could be used to cover the requirement under ALR, however, not the other way around.

3.2.5.1.1 Minimum requirement ("MR")

The minimum requirement is based on worst of four risk scenarios over a 12 month time period. The worst case for each risk factor could arise at different days. The figure below illustrates how MR is calculated.
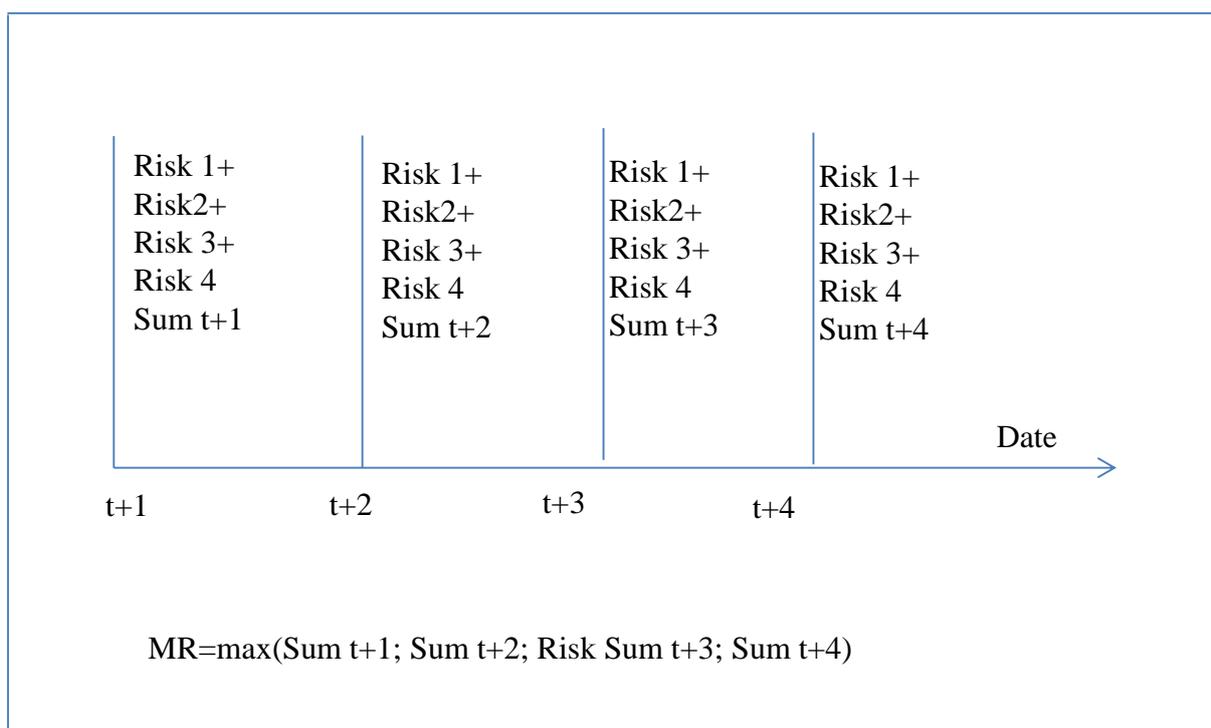
Risk 1   Risk 2   Risk 3   Risk 4

Date

t   t+1   t+20   t+40

MR=max(Risk 1; Risk 2; Risk 3; Risk 4)
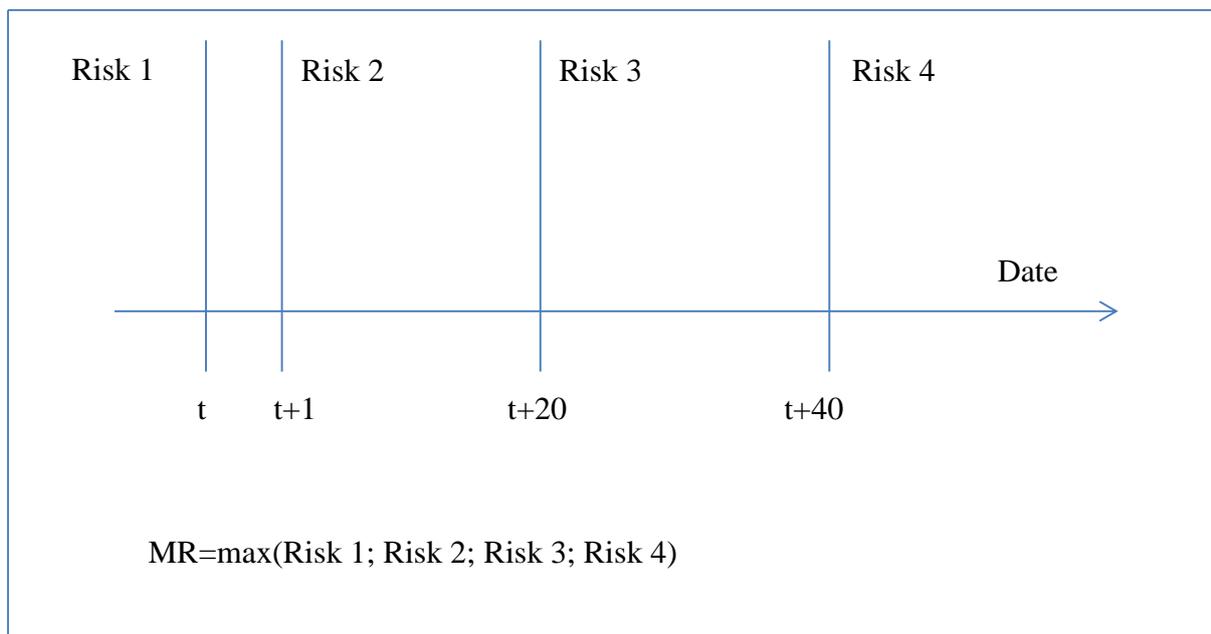
Figure 3: MR calculation

3.2.5.1.2 Additional requirement ("AR")

Additional requirement is calculated based on the same assumption as for MR. However, both the worst and the second worst scenario are added and the maximum of these represent AR.

3.2.6 Calculation issues

Instead of taking the maximum of one of the risk scenarios over a 12 month period, where it is assumed that these events could not occur at the same time, a maximum certain date for all risk scenarios could be used (with a correlation table). The figure below illustrates how this could be set up.

Risk 1+   Risk 1+   Risk 1+   Risk 1+
Risk2+   Risk2+   Risk2+   Risk2+
Risk 3+   Risk 3+   Risk 3+   Risk 3+
Risk 4   Risk 4   Risk 4   Risk 4
Sum t+1   Sum t+2   Sum t+3   Sum t+4

Date

t+1   t+2   t+3   t+4

MR=max(Sum t+1; Sum t+2; Risk Sum t+3; Sum t+4)

Figure 4: Alternative MR calculation

3.3 Purpose & Limitations

Nasdaq liquidity method is based on two core assumptions, i.e. that the only liquidity available are Nasdaq's own liquidity and committed credit lines and that the cash effects are mainly caused by cash settled products (future style) and delivery failures.

3.4 Statistical significance

The LaR model can be evaluated with back testing, stress testing and reversed stress testing techniques.

3.5 Risk Factors

When designing a model in general the key decision is to decide what factors that do, and should, affect the result of the model.

Nasdaq has identified a number of essential liquidity risks factors, which are all connected to the clearing operation:

- Default of participant – market movement
- Default of participant – settlement amount
- Settlement bank
- Delivery problems
- Liquidity providers
- Realization of collateral
- Cash collateral call back/Cash optimization call back

3.6 Academic and industry references

The academic references in this area are low.

3.7 Key assumptions

Using historical data as input to the model do imply that Nasdaq to some extent belief that historical data could be used to predict more turbulent periods.

4. Parameters

4.1 General

There are excellent explanations of how risk parameters are estimated within the LaR model. The two documents NASDAQ OMX Clearing AB Liquidity Policy and Liquidity at Risk Stress Test Policy can be read for this purpose.

In short there are some steps that must be done to calculate the parameters:

- Nasdaq should determine the Minimum Requirement (MR) in each applicable currency. This should be equal to the largest need in any of the defined potential risk scenarios estimated in the LaR-method. In the MR, the scenario where the participant with the largest exposure towards the CCP defaults should be included. In addition to the largest requirement under any of the defined scenarios, the minimum 20 MSEK buffer and the need for Cash Collateral/Optimization Call Back should be added to define the MR HighPoint in each currency.

- Nasdaq should determine the Additional Requirement (AR) in each applicable currency. This should be equal to the combination of the liquidity need in two stress scenarios defined in the Stress Test Policy. Defined combination of stress scenarios in the LaR method for AR should at least include the scenario where the two participants with the largest exposures towards the CCP defaults simultaneously (Top 1 + 2), the scenario where an extended lead time to realize collateral is required for the member with largest exposure towards the CCP (Top 1), and where the default of the participant with the largest exposure (Top 1) defaults at the same time as there is a 1) liquidity shortage due to delivery problem, 2) settlement bank problem, or 3) lacking settlement amount from a member.

  In addition to the largest requirement under any of the defined scenarios, the 20 MSEK buffer for corporate purposes and the need for Cash Collateral/Optimization Call Back should be added to define the MR HighPoint in each currency.

- A look-back period of 12 months should be applied to establish a high point for AR and MR. The high points define the amount for liquidity need which Nasdaq should hold as a minimum.

4.2   Cash optimization – an improved collateral management services

This functionality was implemented in March 2015. The functionality has been developed in order to improve the collateral management service and optimize capital utilization from a member perspective by avoid double funding but also reduce operational risk for the CCP by merging the settlement and margin flows into one. This means that cash collateral and daily cash settlement has to be recorded at the same account, excess cash collateral will be used to cover a negative cash settlement (only within the same currency) and positive cash settlements will be recorded on the account as collateral to cover the margin requirement.

Before the launch of cash optimization, cash settlement had no effect on the liquidity planning on a daily basis in terms of assets to be invested by Treasury as the cash settlement flows to and from participants was a zero-sum game. This is not the case with the cash optimization model as both cash settlement and cash collateral are merged into one flow.

Previous to the launch Nasdaq assumed that the deviations in cash flows due to that Treasury had not been informed beforehand, will increase i.e. increased volatility in the cash payment.

The volatility is a risk due to the uncertainty that Treasury receives its forecast each day at 15:00 CET, and the report with the actual cash flows will be received at 9:00 CET the next business day. Nasdaq adjust this uncertainty by multiplying the amount calculated above with a time parameter calculated as a function between 15:00 CET and the closing of the market i.e. the time where positions, prices etc could change.

It has proven that this report, which is received each day at 15:00 CET, has been of limited use when trying to predict the actual cash flow. Nasdaq has therefore decided to use the figures in the report in an indicative way and instead use the final report and make same day investments. It is also wise to remember that Nasdaq always has the possibility to postpone a payment stemming from cash collateral call back if Nasdaq suspect that it might put them into a liquidity squeeze, which means the inability to use the cash forecast report generates limited additional liquidity risk.

5. Monitoring process

5.1 General

The LaR monitoring process is divided into:

- Nasdaq Clearing Risk Management should measure the Top 1 and Top 2on a daily basis in each currency which are the drivers for MR and AR.
- Nasdaq Clearing Treasury should measure that size of QLR and ALR on a daily basis in each currency.

The QLR should always be higher than MR in each currency with a buffer. The ALR should always be higher than AR with a buffer. The buffers should be 10%.

6. Numerical data

6.1 The control frame work of the LaR model

For a model the numerical control frame work is instrumental in supervising the usage of the LaR model. It is very rare that a model is "wrong". That would be using assumptions in the model that are clearly not logical or against all financial experience.

What is important is that a model is used within an appropriate environment. This is the main task of a numerical control frame work. By investigate the outcome of the model against the actual behaviour it can be decided if the model can be used within the present financial environment.

The guiding policy framework regarding back testing, stress testing, reversed back testing will be used as sources of information in this investigation but will not be validated as individual processes.
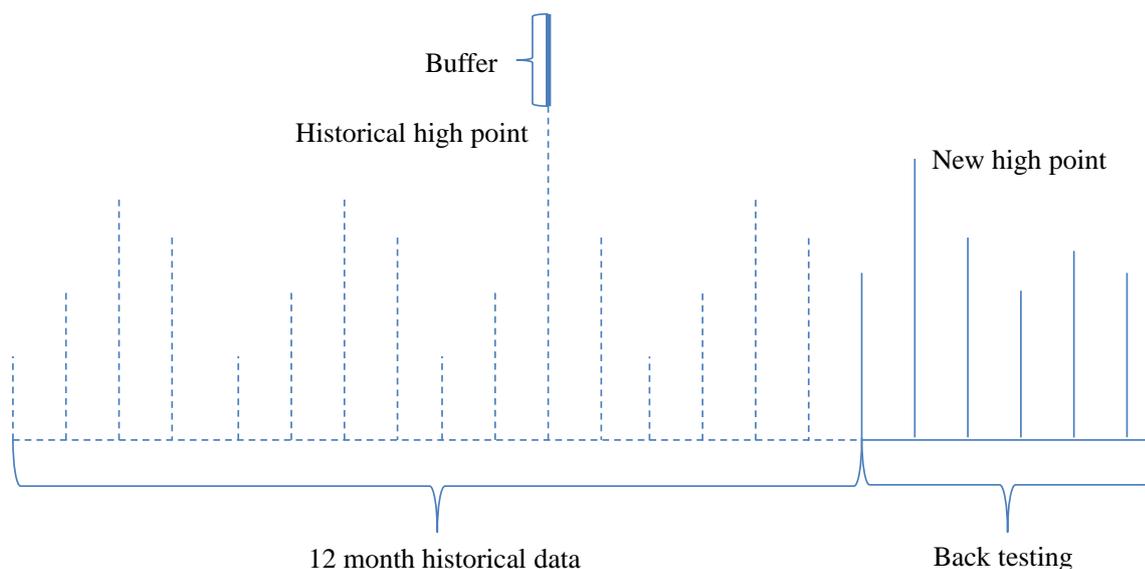
6.2 LaR back testing

6.2.1 General

Back testing is a technique that is used to control whether the behaviour of the LaR model behaves as expected/desired.

6.2.2 Model back testing

The back testing is done on a daily and quarterly basis. Having back testing that checks against the moments for a longer amount of history is a very useful tool in the risk management toolbox.

The back testing compares 12 month historical high points with the latest actual high points and checks if these are within the historical high point plus 25 %. The figure below describes the back testing process.

Figure 5: Back testing

The figure above shows that according to the back test the historical high point plus the buffer are sufficient to cover current high points.

An essential question when trying to predict the future by analyzing historical data is how long back in time the data should be collected. Too old data might not represent current situation and too new data might miss important information that this is still relevant to current operation. A rule of thumb is that the historical data should go back the same number of month as number of month in the future that the model tries to predict i.e. if you are trying to predict the high points the coming 12 months should the model be based on historical data going back 12 month (see figure below).
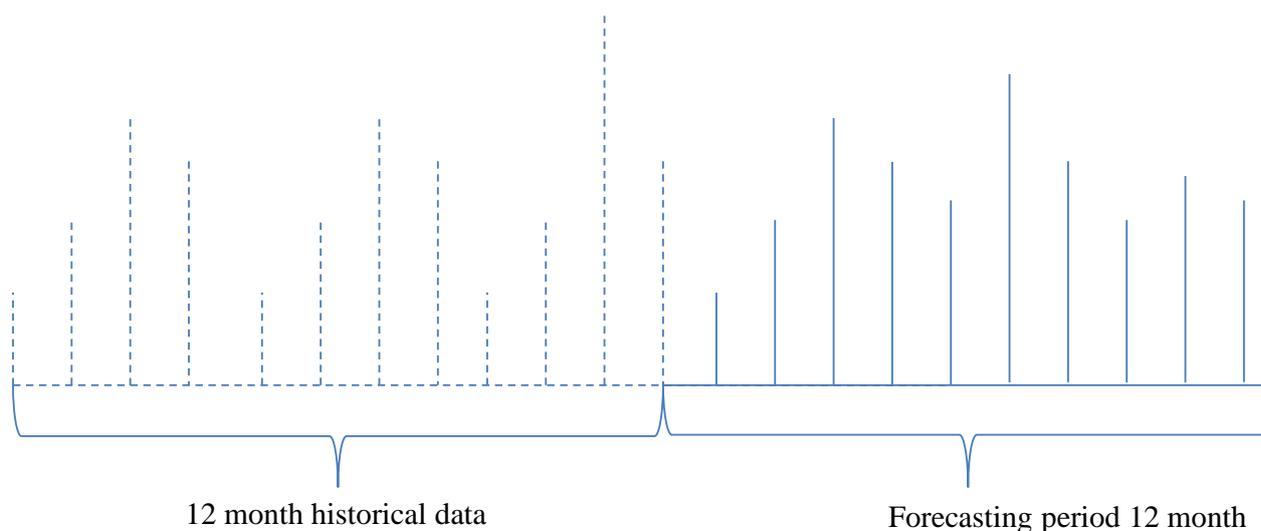
Figure 6: Back testing historical data

As the liquidity model tries to capture the effect of (among other things) the next quarterly mark to market cash flow, will a model have to be based on a sufficient number of historical mark to market dates. By going back 12 month in time will four quarterly the mark to market

activates can assumed be captured. This has to be seen as sufficient for this kind of liquidity model.

6.3 LaR stress testing

6.3.1 General

Stress testing (and reversed stress testing) is to test how a model behaves if "large" changes are made in the basic assumptions or parameters. There can be a lot of different stress tests done to investigate the behaviour of the model and the market which it is used in. In this additional validation two different stress tests will be used.

6.3.2 Stress testing

6.3.2.1 *Explanatory power of principal components for stressed markets*

The most common methods for stress testing of financial risks are various VAR methods, historical scenario analysis, ad hoc scenario analysis and parametric/simulated stress testing. The preferred method depends primarily on the type and magnitude of the risks to estimate, the availability of historical data and the cost for implementation. The frequency of tests and the lead time to adjust risk mitigating resources are also important factors to consider.

Since Nasdaq faces different types of liquidity risks the LaR method encompasses a combination of different methods for estimating risk. With respect to liquidity risks in true tail events such as member defaults in extreme but plausible market conditions a structured simulation approach is considered the most appropriate since tail events are hard to capture properly with other methods. Other liquidity risks, such as delivery or settlement failures, are estimated with historical analysis, i.e. the historically (within a certain look-back period) worst experienced exposure is used and then adjusted with an uncertainty factor that shall reflect the likelihood for potential future increases in exposures.

7. New products

7.1 New product approval process

The purpose with a new product approval process ("NPAP") is to set up the rules for the approval of new products and service offerings. Nasdaq's new product approval process applies to all new products offered to customers, but equally to new ventures, changes in organisational structure or existing products and services in order to identify changes.

By adhering to this process Nasdaq has a better protection against entering into ventures that may not immediately be manageable by the organisation. It also ascertains that no activities are taken without the possibility of risk assessment of new products.

It is the responsibility of the project manager that requires the new product or service to compile all relevant information necessary to perform the investigation. In the material there should also be clear indications as to how this will affect the operation and other material that could be of importance in the assessment of how the total risk profile may be affected by the proposed change.

The introduction of new markets, products or members within Nasdaq requires assessment of the potential impact of such activity on the High Points for the applicable currency. If the

new market / product are assessed to impact the High Point materially, a proposal should be presented to the Nasdaq's Board of Directors, Member Risk Committee and Clearing Risk Committee regarding how the liquidity requirement is impacted and how resources should be increased if needed.

Nasdaq has among other projects changed contract type for the Nordic power products from forward contracts to future contracts and launched steel and iron ore futures. These changes had to pass Nasdaq's new service assessment process before it could be implemented. The assessments have shown that the introduction of steel and iron ore will have limited effect on AR, MR and the liquidity situation. Further, the introduction of Nordic power futures will result in an increase of MR and AR but liquidity resources will be sufficient. The assessments also show that the process works as it is supposed to do. However, Nasdaq is recommended to update applicable policy with more detail requirements concerning the NPAP. This as current evaluation form open ups for questions regarding responsibilities, minimum requirements, documentation demands, approval level etc.

8. Conclusions

8.1 Changes from previous validation

The two previous validations of the LaR model were supported with a validation of the cash optimisation functionality. These three documents in combination are to be considered "previous validation" for the LaR model.

According to article 33 in COMMISSION DELEGATED REGULATION (EU) No 153/2013 is cash an approved asset that can be included in the liquidity resource. The cash has to be deposited at a central bank or at an authorized credit institution. According to Nasdaq's liquidity policy should the cash held with commercial banks be available with same day value.

The liquidity policy has been changed so that is does stipulate the allowed minimum credit rating of institution and the maximum cash exposure against a single institute.

8.2 Input to the validation

The key personnel do have a thorough understanding of the LaR model and its deficiencies therefore minimizing the operational risk of using the model in a less optimal way.

The documentation of the model, with the NASDAQ OMX Clearing AB Liquidity Policy and Liquidity at Risk Stress Test Policy as main reference material does its job with supplying information on the model.

The documentation is updated and of high quality.

8.3 Theoretical framework of the model

The LaR model has both pros and cons. On the positive side there is:

- Higher understanding due to the simplicity of the model.
- Easy to incorporate new instruments in the model.
- Small number of parameters to handle, which is good from operational point of view.

Challenges with the LaR model are:

- Collateral is not assumed to be available for liquidity relief. Nasdaq is recommended to develop the model and include analysis of the diversification of collaterals and how

these could be liquidated in a stressed market. However, the fact that collateral is no taken into consideration has to be seen as a very conservative approach.

Nasdaq's liquidity model is over all robust and well-constructed, it takes all significant risk scenarios into consideration, scenarios are stress tested, limits are monitored and back tested. The model is in compliance with the regulations and available liquidity compared to possible liabilities is estimated to be sufficient.

Nasdaq liquidity method is based on two core assumptions, i.e. that the only liquidity available are Nasdaq's own liquidity and committed credit lines and that the cash effects are mainly caused by cash settled products (and delivery failures). The figure below illustrates the basics in Nasdaq's liquidity method. The figure below describes Nasdaq's model.
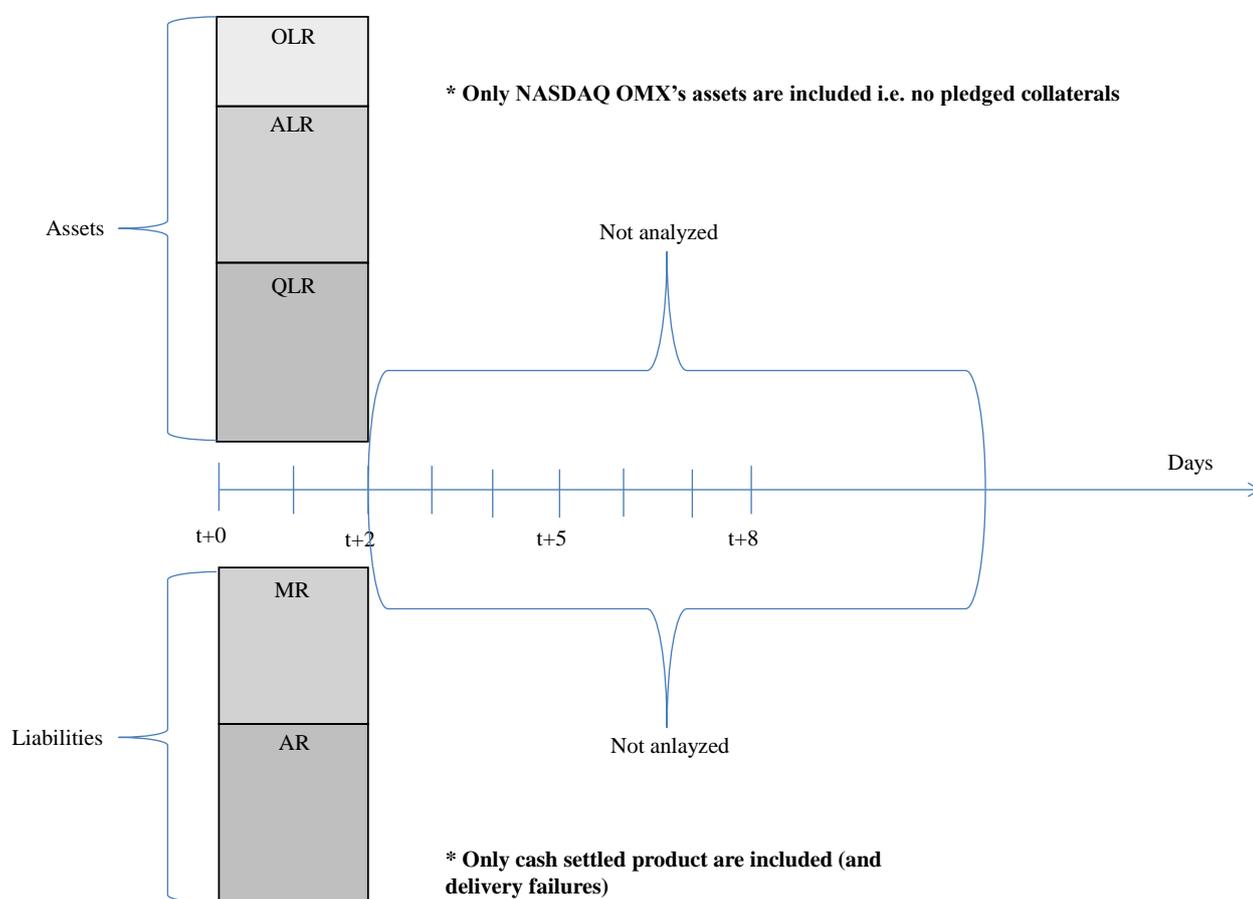

Figure 7: Back testing historical data

These preconditions has probably very limited effect on the reality as all collaterals are highly liquid and could be realized in the same rate as the none cash settled products has to be closed. However, in the further development of the model Nasdaq could include analysis of the diversification of collaterals and how these could be liquidated in a stressed market. This should be compared to the estimated cash flows when closing all none cash settled products. As Nasdaq's collateral model is very robust and allowed collaterals are only very liquid assets, this analysis will most likely show that this is not an issue.

The model has parts and details that can be directly related to academic and industry references.

8.4 Parameters

Nasdaq uses a fixed 25 % buffer on some of the worst of case scenarios. Instead of using a fixed buffer could a confidence level be calculated and the percentage buffer according to the calculations could be added to the high point. This means the following steps:

1. Calculate the standard deviation:

$$\sqrt{\frac{\sum_{i=0}^{n}(x_i - \bar{x})^2}{n}}$$

2. With 99,5 % one side confidence interval is the change from one time period to the next calculated:

$$\Phi^{-1}(\,0{,}995) \times \text{Std}$$

   where Φ^{-1} is the quantile function for the normal distribution.

3. Add this to the high point

8.5 Monitoring process

Nasdaq Clearing has an ambitious testing program at place which facilitates the monitoring of the model. Changes in the way the model behave or changes in the surrounding environment would quickly be discovered.

8.6 Recommendations

There are no new material recommendations from previous validations. These are the recommendations from previous validations:

- Nasdaq current liquidity method is based on that only own liquidity resources and credit lines are available. Given the strict collateral concentration rules (according to the clearing rules and regulations), applicable both on member level and aggregated over the entire collateral mass, and the conservative collateral haircuts, it is considered that this is a very conservative treatment of collateral as a liquidity resource. However, as the method is further refined it is recommended that Nasdaq starts to take pledged collateral into account as a liquidity resource, with prudent modelling of securities realization in stressed market conditions.

- The buffer of 20 MSEK seems to be a fixed parameter set on historical high point i.e. current tests does not include the investigation if there has been a new high point. However, as this has a minimum effect on the overall picture will this simplification not have any material impact on the liquidity risk handling.

- A general approach is that all risk limits should be connected to the company's approved risk appetite. This means that a limit could be set by analyzing all possible events that could occur and which would generate a cash flow. It is recommended that the limit should set according to identified liquidity risk drivers. This could be implemented once the model is further developed.

- Instead of taking the maximum of one of the risk scenarios over a 12 month time period, where it is assumed that these events could not occur at the same time, could a maximum a certain date for all risk scenarios be used (with a correlation table).

- Nasdaq uses a fixed 25 % buffer on some of the worst of case scenarios. Instead of using a fixed buffer could a confidence level be calculated and the percentage buffer according to the calculations could be added to the high point.