Vendor Spotlight

Vendor Spotlight: Numerix

Front Office Risk Management Technology 2018

Chartis

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- Credit risk
- Operational risk and governance, risk and compliance (GRC)
- Market risk
- Asset and liability management (ALM) and liquidity risk
- Energy and commodity trading risk
- Financial crime, including trader surveillance, anti-fraud and anti-money laundering
- Cyber risk management
- Insurance risk
- Regulatory requirements including Basel 2 and 3, Dodd-Frank, MiFID II and Solvency II

Chartis is solely focused on risk and compliance technology, which gives it a significant advantage over generic market analysts.

The firm has brought together a leading team of analysts and advisors from the risk management and financial services industries. This team has hands-on experience of implementing and developing risk management systems and programs for Fortune 500 companies and leading consulting houses.

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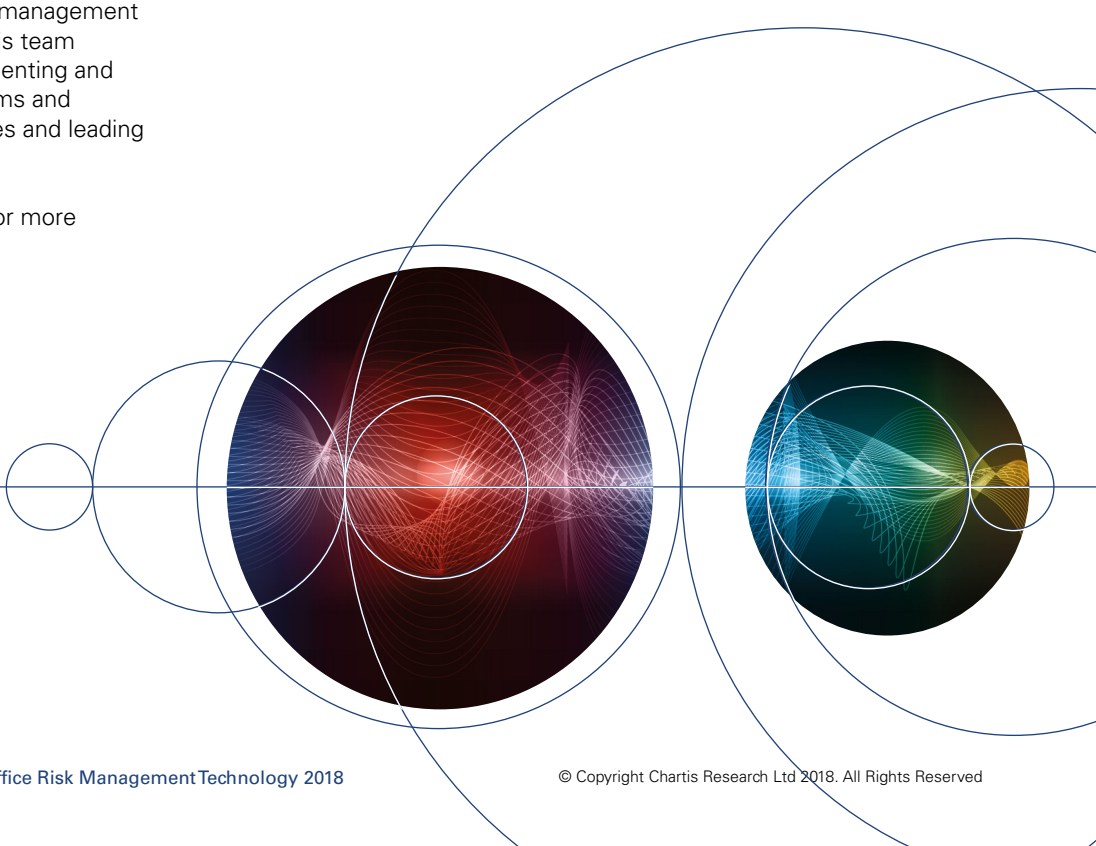

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1. Report context

This Vendor Spotlight is based on the Chartis quadrant report *Front Office Risk Management Technology 2018* (published in June 2018). This section summarizes the key theses in that report; subsequent sections take a detailed look at Numerix's quadrant positioning and scoring, and Chartis' underlying opinion and analysis.

Key thesis

A complex tangle of embedded components

Over the past three decades, Front Office Risk Management (FORM) has developed in a piecemeal way. As a result of historical business drivers and the varying needs of teams focused on different products within banks, FORM systems were created for individual business silos, products and trading desks. Typically, different risk components and systems were entwined and embedded within trading systems and transaction processing platforms, and ran on different analytics, trade capture and data management technology. As a result, many banks now have multiple, varied and overlapping FORM systems.

Increasingly, however, FORM systems are emerging as a fully fledged risk solution category, rather than remaining as embedded components inside trading systems or transactional platforms (although those components still exist).

For many institutions FORM, along with the front-office operating environment, has fundamentally changed following the global financial crisis of 2008. Banks are now dealing with a wider environment of systemically reduced profitability in which cluttered and inefficient operating models are no longer sustainable, and there are strong cost pressures for them to simplify their houses.

Equally, a more stringent and prescriptive regulatory environment is having significant direct and indirect impacts on front-office risk technology. Because of regulators' intense scrutiny of banks' capital management, the front office is continuously and far more acutely aware of its capital usage (and cost), and this is having a fundamental impact on the way the systems it uses are evolving. The imperative for risk-adjusted pricing means that traditional trading systems are struggling to cope with the growing importance of and demand for Valuation Adjustment (xVA) systems at scale. Meanwhile, regulations such as the Fundamental Review of the Trading Book (FRTB) will have profound implications for front-office risk systems.

As a result of these direct and indirect regulatory pressures, several factors are changing the front-office risk technology landscape:

- The scale and complexity involved in data management.
- Requirements for more computational power.
- The imperative for integration and consistency with middle-office risk systems.

Evolving to survive

As banks recognize the need for change, FORM is slowly but steadily evolving. Banks can no longer put off upgrades to systems that were built for a different era, and consensus around the need for a flexible, cross-asset, externalized[1] front-office risk system has emerged.

Over the past few years, most Tier 1 and Tier 2 banks have started working toward the difficult goal of standardizing, consolidating and externalizing their risk systems, extracting them from trading and transaction processing platforms (if that's where they existed). These efforts are complicated by the nature of FORM – specifically that it cuts across several functional areas.

Vendors, meanwhile, are struggling with the challenges of meeting the often contradictory nature of front-office demands (such as the need for flexibility vs. scalability). As the front-office risk landscape shifts under the weight of all these demand-side changes, many leading vendors have been slow to adapt to the significant competitive challenges. Not only are they dealing with competition from new market entrants with different business models, in many instances they are also playing catch-up with more innovative Tier 1 banks. What's more, the willingness to experiment and innovate with front-office risk systems is now filtering down to Tier 2s and smaller institutions across the board. Chartis is seeing an increase in 'build and buy' hybrid

[1] *From trading and transaction management platforms.*

solutions that leverage open-source and open-HPC[2] infrastructure.

The rapid development of new technologies is radically altering the dynamics of the market, following several developments:

- A wave of new, more focused tools.
- Platforms that leverage popular computational paradigms.
- Software as a Service (SaaS) risk systems.

More often than not, incumbent vendors are failing to harness the opportunities that these technologies and new open-source languages bring, increasing the risk that they could become irrelevant within the FORM sector.

Chartis contends that, as the market develops, the future landscape will be dominated by a combination of agile new entrants and existing players that can successfully transform their current offerings. Vendors have many different strategies in evidence, but the evolution required for them to survive and flourish has only just begun.

With that in mind, we have outlined several recommendations for vendors seeking to stay relevant in the new front-office risk environment:

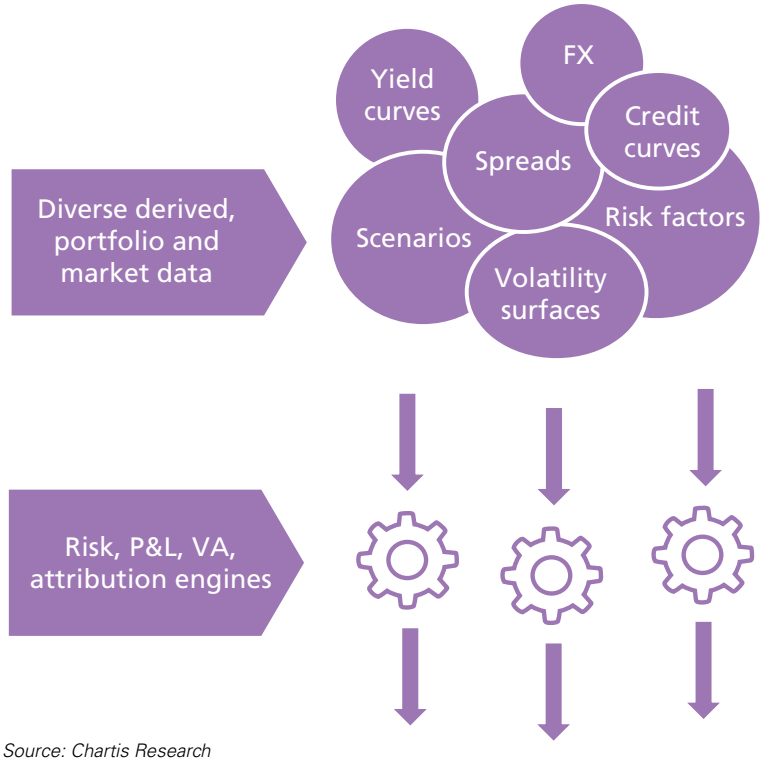
- Above all, focus on an open, flexible environment.
- Create consistent risk data and risk factor frameworks.
- Develop highly standardized interfaces.
- Develop matrices and arrays as 'first-class constructs'.
- Embrace open-source languages and ecosystems.
- Consider options such as partnerships and acquisitions to acquire the requisite new skills and technology capabilities in a relatively short period of time.

Demand-side takeaways

The history of FORM: a complex spaghetti of solutions, and little appetite for change

The development of FORM systems since the late 1990s has been highly fragmented. Traditionally FORM tended to be embedded within numerous different trading systems and transaction processing platforms. Individual product lines and trading desks developed their own risk systems incrementally. In addition, the significant variance in pricing and risk models across different asset classes (Foreign Exchange [FX] vs. credit, for example, or interest rate derivatives vs. equity derivatives) meant that it was often easier to keep systems separate and embedded within individual transaction processing silos. Finally, and crucially, the data requirements of front-office systems were – and still are – highly diverse (see Figure 1).

Figure 1: FORM's data requirements are varied



Source: Chartis Research

As a result, separate FORM systems were created for different business silos and products. As the scale and complexity of trading increased during the early to mid-2000s, and as banks kept adding more trading systems to their already burgeoning numbers, the spread of individualized risk systems accelerated.

[2] *High-Performance Computing.*

The need for something new

Banks' attitudes to transforming their risk system architectures have changed, largely due to the dramatic impact of several recent developments:

- Radical changes in the operating environment following the financial crisis.
- The new business models adopted by sell-side institutions.
- The direct and indirect impacts of regulation.
- The availability of new technology.

For banks, the process of adapting their existing transaction lifecycle management systems to meet their new requirements could be a long and near impossible task, given the complexity, the costs and the number of vendors involved with these legacy systems. Adding new risk features to existing transaction lifecycle management systems can also be a lengthy and tortuous process. This further underlines the limitations of existing systems, many of which were built for a different time, and which struggle to cope with new, more demanding requirements.

Banks are now seeking to standardize, structure and order their front-office systems and, most importantly, extract risk management from their trading systems. For a significant group of banks with relatively simple (or well-defined and/or narrow) footprints or business models, consolidating around a transaction system can be an alternative.

Working toward the goal

In the last few years it has become clear that it is not just Tier 1 banks that have recognized the need for change. All big global and national banks are now seeking to free their risk systems from the constraints and silos of their trading systems. As a result, we are seeing a slow but steady move toward cross-silo, cross-functional infrastructure[3].

In particular, banks have focused on reducing the number of risk systems they operate. A few institutions even began the process early (before the financial crisis) and have now achieved relatively low numbers of risk systems. Most of those in the front line of change, however, started work in 2010-11, and currently we estimate that just 5-10 Tier 1 institutions are operating with single-digit numbers of risk systems. Most banks are still grappling with these issues, and there is a huge discrepancy in performance across the market. Several large institutions still have more than 40 front-office risk systems, while some have hundreds. Smaller institutions are also now making efforts to consolidate their systems, or at least to create consistent frameworks that link and rationalize them.

Experience shows that integrating risk systems across the many divisions within a bank is hard, and should be carried out incrementally. Best practices are starting to emerge, however, thanks to the development of new technologies and the experience of Tier 1 organizations, where iterative system consolidation/changes have been taking place.

What's more, banks are getting bolder in their approach. They are more willing to experiment and be creative with their own databases, using new database technologies such as MongoDB and SciDB for different components of their operational stack. While Tier 1s have been experimenting for some time, architectural changes are now filtering down to Tier 2s and smaller institutions everywhere. These institutions, like Tier 1s, are moving away from a front-to-back focus toward a more open architecture. Chartis is also seeing an increase in 'build and buy' hybrid systems that use open-source and parallel-computing infrastructure. These efforts are gradually ensuring that the process of building externalized and integrated front-office risk infrastructure is no longer the stuff of magic – but a practical and effective advancement.

Supply-side takeaways

Developing an effective FORM solution

Most of the dominant vendors' applications were built for an environment that existed before the global financial crisis, and are still embedded in transactional lifecycle management and trading systems.

Vendors are struggling with the challenges of meeting banks' new and more complex front-office needs. While transaction processing platforms are designed to rapidly process and handle complex datasets, risk systems, by contrast, are designed to handle very large, but relatively simple, data

[3] *It's important to emphasize, however, that cross-silo, cross-functional and cross-asset-class risk management is unlikely to form a single integrated 'monolith' to replace complex platforms.*

sets that only need to be processed relatively slowly.

We believe that, in attempting to address the complex requirements of FORM systems, vendors will have to deal with a dichotomy: managing the complex functionality necessary for an effective system, and ensuring ease of use. The FORM engine can maximize performance by leveraging every aspect of the infrastructure and data stack (such as Storage-Attached Networks [SAN], Network-Attached Storage [NAS], network, grid infrastructure and special-purpose compute capabilities). If not undertaken carefully, however, that optimization can restrict flexibility.

SaaS suppliers of application-specific capabilities[4] marry data and analytics in a single integrated stack that they make available over the web. Growth for these types of narrow vertical vendors, which supply very specific risk analytics, has been significant, further necessitating the need for openness and flexibility.

Harnessing new technologies

The dominant vendor offerings are generally built on technology one generation old, which can compound the problem. In stark contrast, new technology trends have enabled more choice, broadening the horizons for front-office risk systems and shifting the 'build and buy' equation. Banks themselves are harnessing many of these new technologies, and vendors are lagging behind in adopting them.

In particular, technology advances have led to:

- Radically reduced memory costs and changes in compute costs, as a result of the increased availability of HPC through the use of Big Data and cloud computing.

- Greater programmability of both software and hardware, allowing for more flexibility and efficient customization.

A wide variety of commercial and open-source languages, such as Python, Julia, OCAML, R, and Scilab, are now available, with full ecosystems behind them that include multi-dimensional array stores, workflow components, and array management components. Vendors have yet to truly harness the opportunities that these new technologies bring, and could risk becoming irrelevant within the evolving FORM marketplace if they don't explore these options.

Different vendor strategies are in evidence, at an early stage

To respond to their competitive challenges, and equipped with an understanding of the emerging needs of the front office, many vendors are changing and adapting their strategies to develop effective externalized front-office risk systems.

A variety of strategies are in evidence, and the winning approaches are yet to play out. Some vendors will choose to exit the analytics space entirely, working with analytics partners instead and focusing more on a platform or infrastructure play, using Application Programming Interfaces (APIs). Other vendors, meanwhile, will shift to a pure analytics focus. Several examples of these vendors are already present in the market today. However, Chartis believes that occupying the middle ground, providing both analytics and APIs, will be very hard to achieve successfully in the long term.

We have also observed that vendors' efforts to adapt their offerings to solve problems in one area can open up a different set of issues in another. Solving issues of scalability, for example, may open up a new set of problems around integrating with existing trade processing environments – integrating a brand new xVA system with older existing systems is not a simple task.

Chartis therefore believes that the current dominant vendors face difficult and existential challenges ahead, and that it may be two to four years before the winning strategies emerge. However, it is clear that the evolution required for survival has only just begun. As the market evolves, the future landscape will be dominated by a combination of new entrants and existing players that can successfully transform their current offerings.

[4] Such as relative value in Residential Mortgage-Backed Security (RMBS) markets, or calculating Credit Valuation Adjustment (CVA) or Margin Valuation Adjustment (MVA).

2. Quadrant context

Introducing the Chartis RiskTech Quadrant®

This section of the report contains:

- The Chartis RiskTech Quadrant® for FORM technology solutions for 2018.
- An examination of Numerix's positioning and its scores as part of Chartis' analysis.
- A consideration of how the quadrant reflects the broader vendor landscape.

Summary information

What does the Chartis quadrant show?

The RiskTech Quadrant® uses a comprehensive methodology that involves in-depth independent research and a clear scoring system to explain which technology solutions meet an organization's needs. The RiskTech Quadrant® does not simply describe one technology option as the best FORM solution; rather it has a sophisticated ranking methodology to explain which solutions are best for specific buyers, depending on their implementation strategies.

The RiskTech Quadrant® is a proprietary methodology developed specifically for the risk technology marketplace. It takes into account vendors' product, technology and organizational capabilities. Section 4 sets out the generic methodology and criteria used for the RiskTech Quadrant®.

How are quadrants used by technology buyers?

Chartis' RiskTech and FinTech quadrants provide a view of the vendor landscape in a specific area of risk, financial and/or regulatory technology. We monitor the market to identify the strengths and weaknesses of different solutions, and track the post-sales performance of companies selling and implementing these systems. Users and buyers can consult the quadrants as part of their wider research when considering the most appropriate solution for their needs.

Note, however, that Chartis Research does not endorse any vendor, product or service depicted in its research publications, and does not advise technology users to select only those vendors with the highest ratings or other designation. Chartis Research's publications consist of the opinions of its research analysts and should not be construed as statements of fact.

How are quadrants used by technology vendors?

Technology vendors can use Chartis' quadrants to achieve several goals:

- Gain an independent analysis and view of the provider landscape in a specific area of risk, financial and/or regulatory technology.
- Assess their capabilities and market positioning against their competitors and other players in the space.
- Enhance their positioning with actual and potential clients, and develop their go-to-market strategies.

In addition, the Chartis Vendor Spotlight report offers detailed insight into specific vendors and their capabilities, with further analysis of their quadrant positioning and scoring.

Chartis Research RiskTech Quadrant® for FORM technology solutions, 2018

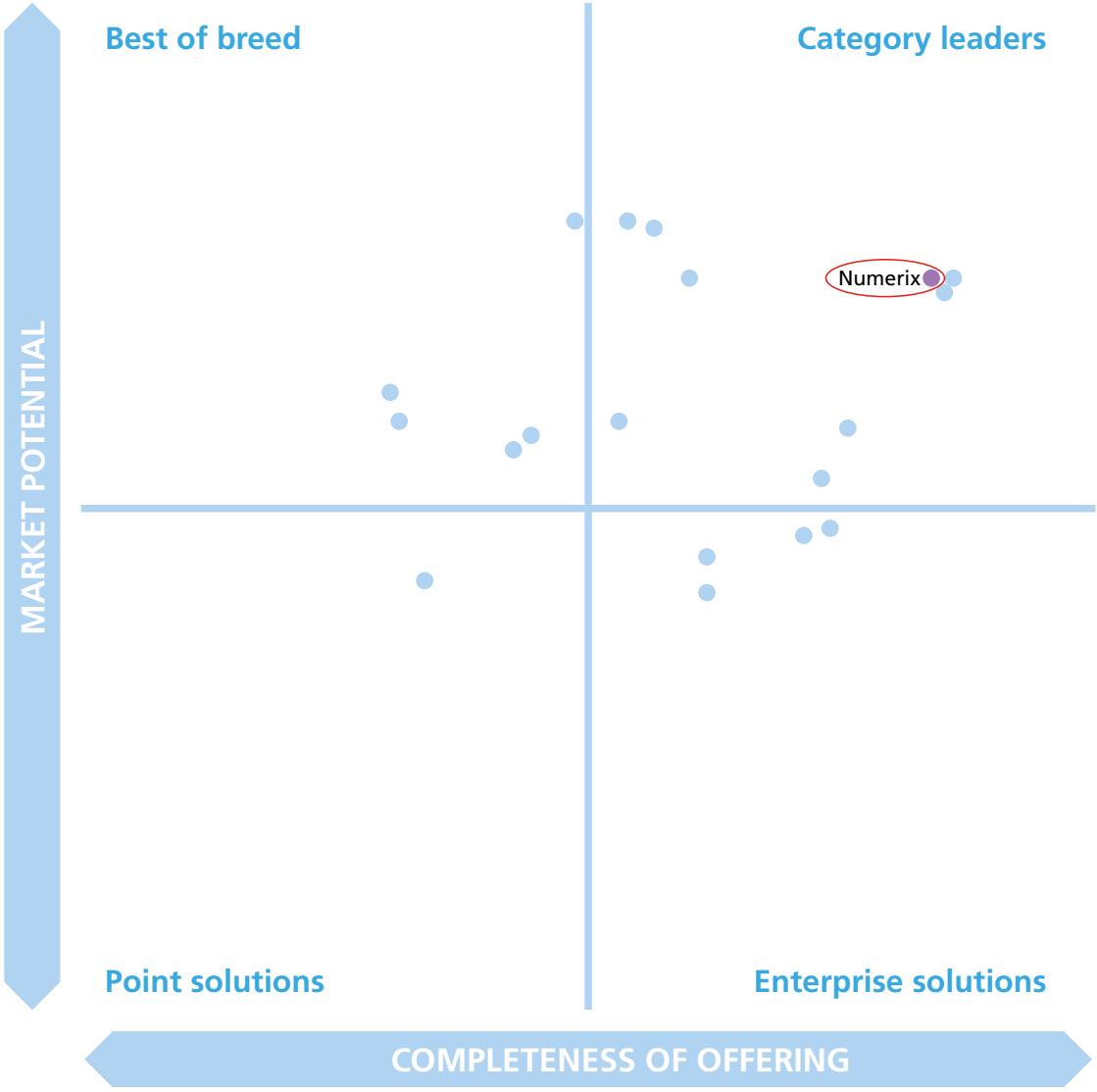
Figure 2 illustrates Chartis' view of the FORM vendor landscape, spotlighting Numerix's position.

Quadrant dynamics

General quadrant takeaways

The fragmentation seen in FORM systems is common to all but the strongest of solution providers – which is to be expected considering the history and development of front office risk systems. We see the current leaders in the space as those that have made progress toward aggregating their systems, although this is certainly not the only criterion for the dominant vendors. Many of the other vendors in the quadrant are simply a little further behind on the path to a unified FORM system, and their offerings will tend to consist of components that can communicate and function together, but which are still essentially separate.

Figure 2: RiskTech Quadrant® for FORM technology solutions, 2018



Source: Chartis Research

Many vendors in this space – even those with strong completeness of offering scores – provide solutions that are based on architectures developed for the historic front office environment (i.e., built for multiple independent components). While this is popular with existing clients, it can leave them with less flexibility than is ideal – a potential detriment in a rapidly changing landscape. With this in mind, vendors with strong functionality in addition to a modern, open architecture are currently well placed in the FORM space.

Smaller vendors are also prevalent in this space, often providing more niche libraries and tools. These vendors – though relatively small – fill an important role in the vendor landscape, supporting larger vendors' broader coverage. Their existence allows firms to specialize in niche areas and still have access to the functionality they require.

Vendor positioning in context – completeness of offering

Numerix scored well for completeness of offering, in part due to its modern underlying architecture, which is uncommon in this particular space (for vendors of Numerix's size, at least). That Numerix does not have to rely on legacy architecture gives it the opportunity to be more flexible and react to change more efficiently. Similarly, the single-platform nature of Numerix's offerings optimizes the interaction between components, facilitating

good communication and simplifying the integration of external software. The use of Rest APIs on backend services enables the Numerix front end to offer a high degree of customization to different client workflows (which may vary considerably depending on client type and focus) using modern web interfaces.

In terms of functionality, Numerix offers broad functional coverage across multiple asset classes, and strong support for a wide range of xVAs, providing pre-trade analytics, stress testing and market sensitivity capture (including xVA sensitivity calculation for dynamic hedging purposes). Real-time functionality is also a core strength of Numerix's offering, and the Oneview pricing and risk management platform now contains integrated real-time, distributed, event-driven processing capabilities. Numerix's 2017 acquisition of TFG Financial Systems further added to its real-time capabilities, as TFG's flagship product was a platform that calculates P&L and risk in real-time.

Table 1 shows Chartis' rankings for Numerix's coverage against each of the completeness of offering criteria.

Table 1: Completeness of offering – Numerix (FORM Technology, 2018)

Completeness of offering criterion	Coverage
Asset coverage, pricing and model support	High
xVA	High
P&L	Medium/High
Statistical risk	High
Mathematical and computational framework	High
Workflow and visualization	High
Data management	Medium
Data and event model capabilities	Medium

Source: Chartis Research

Vendor positioning in context – market potential

Numerix provides software to a wide range of client types and sizes, including banks, insurance firms, asset managers and hedge funds. Software openness is a core aspect of Numerix's coverage. This benefits clients not only by simplifying and speeding up the development of new functionality, but also by enabling the vendor to adapt the solution to different client use cases.

This openness also provides flexibility: the solution can be adapted to meet changing conditions, helping to simplify the move toward system consolidation that we are seeing in the front office space. Numerix's modern platform and architecture mean that it is not constrained in the same way as some other firms, which are in the process of consolidating their FORM systems using architectures designed for multiple discrete components.

Table 2 shows Chartis' rankings for Numerix's coverage against each of the market potential criteria.

Table 2: Market potential – Numerix (FORM Technology, 2018)

Market potential criterion	Coverage
Customer satisfaction	High
Market penetration	Medium
Growth strategy	High
Financials	Medium
Business model	High

Source: Chartis Research

3. Vendor context

Overview of relevant vendor solutions/capabilities

Table 3 gives an overview of Numerix and its FORM solution.

Summary of Oneview's front office risk capabilities

- Mark-to-Market (MTM) pricing and comprehensive Greeks, including xVA Greeks and cross Greeks.
- Strong xVA coverage of CVA, DVA, FVA, FCA, FBA, KVA and ColVA[5] (pre-trade and post-trade).
  - Margin Valuation Adjustment (MVA) is in development.
- Counterparty credit risk exposures, including PFE, EPE, ENE and EE[6].
- Support for Value at Risk (VaR)/Expected Shortfall: historical, scenario, Monte Carlo.
- Support for Standard Initial Margin Model (SIMM) initial margin calculations.
  - SIMM 'what-if' analysis in development.
- Credit Support Annex (CSA)/counterparty hierarchy support, plus CSA scripting to support complex CSAs.
- Flexible scenario/stress framework, supported by a scenario scripting language.
- P&L calculations, including xVA P&L.
- Regulatory capital calculations, including SA-CCR[7] and Basel III SA-CVA.
- Real-time pre-deal checks for xVAs and counterparty exposures, including:
  - xVA 'what-if' analysis – calculating the potential impact of new trades on xVAs and counterparty exposures.
  - Cheapest-to-trade analytics – determining which counterparty to conduct a trade with to get the most xVA benefit.

Table 3: Numerix – company information

Company	Numerix
Headquarters	New York
Other offices	Bogota, Charlotte, Chicago, Mexico City, Miami, Rochester, Santa Fe, Vancouver, Dubai, Dublin, Frankfurt, Helsinki, London, Milan, Paris, Beijing, Hong Kong, Mumbai, Seoul, Singapore, Sydney, Taipei City, Tokyo
Description	Numerix is a FinTech company providing trading and risk solutions to capital markets firms (both sell-side and buy-side). Originating as a pricing library provider, it has since diversified, and now provides front-to-back coverage of risk, enabling its customers to view their risk exposure from a single platform.
Solution	Numerix offers products and services through its Oneview Platform, a platform for pricing, risk, analytics and trade management for capital markets. Oneview is a real-time, cross-asset platform which allows components and modules to communicate with each other. Oneview covers trading and risk, economic scenario generation, model validation and xVA.

Source: Numerix

[5] *Credit Valuation Adjustment, Debit Valuation Adjustment, Funding Valuation Adjustment, Funding Cost Adjustment, Funding Benefit Adjustment, Capital Valuation Adjustment, and Collateral Valuation Adjustment.*
[6] *Potential Future Exposure, Expected Positive Exposure, Expected Negative Exposure, and Expected Exposure.*
[7] *Standardised Approach for Measuring Counterparty Credit Risk Exposures.*

- Cancellation/novation analysis – calculating the impact of cancellation or novation on xVAs.

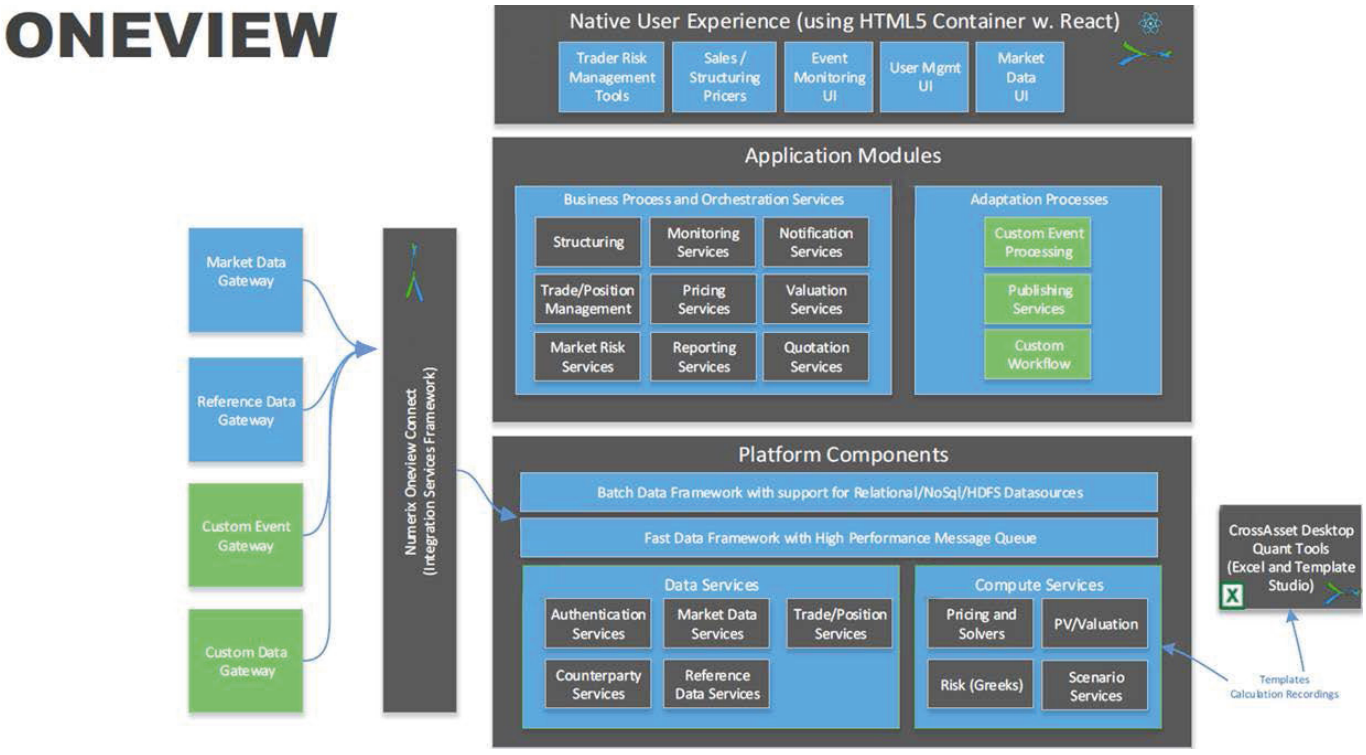
- Tools for curve and surface visualization and analysis.
- Model validation tools for automated model validation runs.
- Partner extensions for:
  - Limits.
  - Time-series/tick-data/market-making statistics.
  - FRTB-SA/Internal Models Approach (IMA).

Additional features of note

- Broad asset class coverage: rates, FX, credit, equity, commodity, inflation, volatility, life, hybrids.
- Depth of instrument/payoff support via scripting.
- Model coverage for every instrument/asset class.
- Multi-asset-class hybrid model for exposure simulations.
- High-performance simulations via American Monte Carlo.
- User-configurable stress/scenario engine.
- CSA configurability, via modeling of collateral, ratings and other CSA features.
- Automated model validation tools.
- Support for sales, trading, risk and automated market-making workflows.

Planned features include the adoption of reactive microservices to enable faster, event-driven calculations (see Figure 3).

Figure 3: Key components of Numerix's Oneview platform



Source: Numerix

Client leading practices

The following sections provide an outline of Oneview's key features, as well as Numerix's evolution roadmaps for these solution elements.

xVA features

- Comprehensive xVA measures: CVA, DVA, FVA, FCA, FBA, KVA, ColVA, pre-trade and post-trade.
- Real-time integration of xVAs into pricing and valuations.
- xVA visualization tools.
- xVA Greeks, cross-Greeks and Ladder reports.
- Pre- and post-trade xVA analysis.
    - Pre- and post-margin xVAs.
    - Standalone and incremental xVAs.
    - Trade-level back allocation of xVAs.
- Greeks-based xVA explain.
- Flexible CSA modeling using CSA scripting.
    - For example, break clauses, rating triggers, multi-asset collateral options.

Roadmap:

- Complete SIMM coverage.
    - SIMM job manager.
    - Market data normalization.
    - CRIF reports.
    - SIMM calculator.
    - UI for SIMM setup and results display.
    - SIMM 'what-if' calculations.
- MVA functionality.
    - Ability to calculate MVA based on SIMM or other Initial Margin methodologies.
    - Ability to integrate MVA into pre-deal checks and other xVA analyses.
- Configurable workflows for different roles.
    - Ability to design bespoke workflows for roles in sales/trading/xVA desks/risk/treasury.
    - Ability to customize multi-role/user workflows for xVA pricing, pre-trade checks, 'what-ifs'.

Interface and delivery options

- Delivery options:
    - On-premise.
    - Private cloud.
    - Public cloud – Microsoft Azure, Amazon Web Services, Google Cloud.
    - Hybrid (on-premise/cloud).
    - Managed service via private or public cloud.
- Application interface options:
    - HTML5 containerization with React JS (OpenFin interface).
    - Web browser.
- Platform (calculation engine) API options:
    - REST, Java, Python SDK.

Mathematical, methodological and technical elements to help the front office

- American Monte Carlo.
    - Oneview leverages Numerix's AMC algorithms for xVA and Potential Future Exposure (PFE) calculations, helping to minimize compute time and enable near real-time capabilities.
- GPU.
    - Monte Carlo simulations can be offloaded/parallelized on GPU instead of CPU, helping to decrease simulation time.
- xVA sensitivities.
    - Currently calculated using the Risk Scenario Framework (further details below), with AAD/Backward Differentiation (BD) on the roadmap to increase speed.

Roadmap:

- MVA calculations for pricing initial margin into trade prices.

Technology options for more flexible and efficient consumption of analytics and results

UI innovation:

- App containerization (OpenFin interface).
  - Oneview's different sections (e.g. trade entry, trade blotter, risk, pre-deal checks, market data) become separate 'apps' that can be independently moved, resized, docked/pinned, or snapped together.
  - Provides users with a customizable workspace, so they can see all the information they need and interact with the apps they use frequently.

In-memory Online Analytical Processing (OLAP) cube:

- Enables multi-dimensional, flexible views of risk measures and xVA calculations.
- Provides real-time 'slice and dice' and drill-down into data, so users can analyze large volumes of data in any dimension.

'Open data' environment via REST API:

- Users can utilize a Python SDK to submit calculation requests and then extract results (including intermediate data such as trade exposures, model calibrations, and collateral utilization) for further analysis and visualization.
- Data is available/exposed via REST API calls; the Python SDK helps customers construct the REST calls.

Reactive microservices (currently in development):

- Oneview is being migrated to a new architecture based on apps, APIs and reactive microservices, to support clients' increasing need for agility and scalability.
- Provides a more responsive user experience that accommodates fast (streaming/event-driven, real-time) data and slow (batch) data.
- The goal is to enhance performance, resilience, reliability, elasticity, and the availability of the system.

Domain-specific languages to enable the customization and tailoring of applications

- Payoff scripting via Numerix's proprietary scripting language:
  - This easy to learn scripting language is loosely based on VB.
  - Allows users to describe the mechanics of a deal.
  - Users can specify all the details of an instrument's payoff and cash flows.
  - Enables users to price any type of deal.
- Creating new product types using trade templates:
  - If clients trade new products that aren't currently available in Oneview, they can create new trade templates and upload them into Oneview's trade repository.
  - Trade templates enable full specification and customization of a trade payoff structure.
  - Once created and uploaded into Oneview's trade repository, the new deal type will be available for calculations and analysis within Oneview.
  - Trade templating enables rapid time-to-market for new product types.
- Scenario generation and customization via Risk Scenario Framework (RSF):
  - RSF is the scenario engine that underlies all scenario analysis and stress testing done in Oneview.
  - Out-of-the-box scenarios in Oneview can be modified within the Oneview UI, without any scripting knowledge required.
  - The underlying RSF script can be modified to specify any market scenario desired.
- Flexible handling of CSAs via CSA scripting:
  - Enables the pricing of deals with complex CSAs.

  - CSA scripting language helps users incorporate all of a deal's CSA terms, so CSA optionality can be priced accurately.
  - Handles CSA terms such as: single collateral vs. multi-collateral; cash vs. non-cash collateral (e.g., bonds); cheapest-to-deliver collateral; Minimum Threshold Amount, rounding, haircuts, etc.; various triggers or thresholds.

- Flexible xVA scripting for 'future proof' xVA capabilities:
  - Transparent methodology.
  - Enables customers to add to existing sets of xVAs and/or modify the methodologies of existing xVAs.

- Flexible pricing policies and market data policies:
  - Pricing policy: for selecting and assigning valuation models, simulation methods, and custom model calibration routines to different trade types.
  - Market data policy: for defining curve and surface construction for different purposes.

4. Methodology

Overview

Chartis is a research and advisory firm that provides technology and business advice to the global financial services industry. Chartis provides independent market intelligence regarding market dynamics, regulatory trends, technology trends, best practices, competitive landscapes, market sizes, expenditure priorities, and mergers and acquisitions. Chartis' RiskTech and FinTech Quadrant reports are written by experienced analysts with hands-on experience of selecting, developing and implementing financial technology solutions for a variety of international companies in a range of industries including banking, insurance and capital markets. The findings and analyses in our quadrant reports reflect our analysts' considered opinions, along with research into market trends, participants, expenditure patterns, and best practices.

Chartis seeks to include RiskTech and FinTech vendors that have a significant presence in a given target market. The significance may be due to market penetration (e.g., a large client base) or innovative solutions. Chartis uses detailed 'vendor evaluation forms' and briefing sessions to collect information about each vendor. If a vendor chooses not to respond to a Chartis request for information, Chartis may still include the vendor in the report. Should this happen, Chartis will base its opinion on direct data collated from technology buyers and users, and from publicly available sources.

Chartis' research clients include leading financial services firms and Fortune 500 companies, leading consulting firms and financial technology vendors. The vendors evaluated in our quadrant reports can be Chartis clients or firms with whom Chartis has no relationship.

Chartis evaluates all vendors using consistent and objective criteria, regardless of whether or not they are Chartis clients. Chartis does not give preference to its own clients and does not request compensation for inclusion in a quadrant report, nor can vendors influence Chartis' opinion.

Selection criteria

As previously explored, FORM is operationally very complex. Its analytical requirements are sophisticated, and its underlying technical and computational geometry varies across systems. Its exact nature also varies from enterprise to enterprise, compounding the complexity. The fragmentation in the market, and vendors' ongoing adaptation of their strategies to develop effective externalized front-office risk systems, means that the FORM space is still evolving, and we believe it may be several years before winning strategies emerge. To reflect this we selected a range of vendors with a variety of strategies and approaches, covering the key elements of FORM: asset coverage, data management, xVA and the mathematical framework underpinning the solution.

Briefing process

We conducted face-to-face and/or web-based briefings with each vendor[8]. During these sessions, Chartis experts asked in-depth, challenging questions to establish the real strengths and weaknesses of each vendor. Vendors provided Chartis with:

- A business update – an overview of solution sales and client satisfaction.
- A product update – an overview of relevant solutions and R&D roadmaps.
- A product demonstration – key differentiators of their solutions relative to those of their competitors.

In addition to briefings, Chartis used other third-party sources of data, such as conferences, academic and regulatory studies, and publicly available information.

Evaluation criteria

The generic evaluation criteria for each dimension are set out below. In addition to these generic criteria, Chartis utilizes domain-specific criteria relevant to each individual risk. This ensures total transparency in our methodology and allows readers to fully appreciate the rationale for our analysis. The specific criteria used for FORM are shown in Table 4.

[8] *Note that vendors do not always respond to requests for briefings; they may also choose not to participate in the briefings for a particular report.*

Table 4: Evaluation criteria for Chartis' FORM report

Completeness of offering	Market potential
• Asset coverage, pricing and model support	• Customer satisfaction
• xVA	• Market penetration
• P&L	• Growth strategy
• Statistical risk	• Financials
• Mathematical and computational framework	• Business model
• Workflow and visualization	
• Data management	
• Data and event model capabilities	

Source: Chartis Research

Completeness of offering

- **Depth of functionality**. The level of sophistication and amount of detailed features in the software product (e.g., advanced risk models, detailed and flexible workflow, domain-specific content). Aspects assessed include: innovative functionality, practical relevance of features, user-friendliness, flexibility, and embedded intellectual property. High scores are given to those firms that achieve an appropriate balance between sophistication and user-friendliness. In addition, functionality linking risk to performance is given a positive score.

- **Breadth of functionality**. The spectrum of requirements covered as part of an enterprise risk management system. This will vary for each subject area, but special attention will be given to functionality covering regulatory requirements, multiple risk classes, multiple asset classes, multiple business lines, and multiple user types (e.g., risk analyst, business manager, CRO, CFO, Compliance Officer). Functionality within risk management systems and integration between front-office (customer-facing) and middle/back office (compliance, supervisory and governance) risk management systems are also considered.

- **Data management and technology infrastructure**. The ability of risk management systems to interact with other systems and handle large volumes of data is considered to be very important. Data quality is often cited as a critical success factor and ease of data access, data integration, data storage, and data movement capabilities are all important factors. Particular attention is given to the use of modern data management technologies, architectures and delivery methods relevant to risk management (e.g., in-memory databases, complex event processing, component-based architectures, cloud technology, and Software as a Service). Performance, scalability, security and data governance are also important factors.

- **Risk analytics**. The computational power of the core system, the ability to analyze large amounts of complex data in a timely manner (where relevant in real time), and the ability to improve analytical performance are all important factors. Particular attention is given to the difference between 'risk' analytics and standard 'business' analytics. Risk analysis requires such capabilities as non-linear calculations, predictive modeling, simulations, scenario analysis, etc.

- **Reporting and presentation layer**. The ability to present information in a timely manner, the quality and flexibility of reporting tools, and ease of use, are important for all risk management systems. Particular attention is given to the ability to do ad-hoc 'on-the-fly' queries (e.g., 'what-if' analysis), as well as the range of 'out of the box' risk reports and dashboards.

Market potential

- **Market penetration**. Both volume (i.e., number of customers) and value (i.e., average deal size) are considered important. Also, rates of growth relative to sector growth rates are evaluated.

- **Brand**. Brand awareness, reputation, and the ability to leverage current market position to expand horizontally (with new offerings) or vertically (into new sectors) are evaluated.

- **Momentum**. Performance over the previous 12 months is evaluated, including financial performance, new product releases, quantity and quality of contract wins, and market expansion moves.

- **Innovation**. New ideas, functionality and technologies to solve specific risk management problems are evaluated. Developing new products is only the first step in generating success. Speed to market, positioning and translation into incremental revenues are critical success factors for exploiting the new product. Chartis also evaluates business model or organizational innovation (i.e., not just product innovation).

- **Customer satisfaction**. Feedback from customers regarding after-sales support and service (e.g., training and ease of implementation), value for money (e.g., price to functionality ratio) and product updates (e.g., speed and process for keeping up to date with regulatory changes) is evaluated.

- **Sales execution**. The size and quality of the vendor's sales force, and its sales distribution channels, global presence, focus on risk management, messaging and positioning are all important factors.

- **Implementation and support**. Important factors include size and quality of implementation team, approach to software implementation, and post-sales support and training. Particular attention is given to 'rapid' implementation methodologies and 'packaged' services offerings.

- **Thought leadership**. Business insight and understanding, new thinking, formulation and execution of best practices, and intellectual rigor are considered important by end users.

- **Financial strength and stability**. Revenue growth, profitability, sustainability and financial backing (e.g., the ratio of license to consulting revenues) are considered key to the scalability of the business model for risk technology vendors.

Quadrant construction process

Chartis constructs its quadrants after assigning scores to vendors for each component of the Completeness of Offering and Market Potential criteria. By aggregating these values, we produce total scores for each vendor on both axes, which are used to place the vendor on the quadrant.

Definition of quadrant boxes

Chartis' quadrant reports do not simply describe one technology option as the best solution in a particular area. Our ranking methodology is designed to highlight which solutions are best for specific buyers, depending on the technology they need and the implementation strategy they plan to adopt. Vendors that appear in each quadrant have characteristics and strengths that make them especially suited to that particular category, and by extension to particular users' needs.

Point solutions

- Point solutions providers focus on a small number of component technology capabilities, meeting a critical need in the risk technology market by solving specific risk management problems with domain-specific software applications and technologies.

- They are often strong engines for innovation, as their deep focus on a relatively narrow area generates thought leadership and intellectual capital.

- By growing their enterprise functionality and utilizing integrated data management, analytics and Business Intelligence (BI) capabilities, vendors in the point solutions category can expand their completeness of offering, market potential and market share.

Best-of-breed

- Best-of-breed providers have best-in-class point solutions and the ability to capture significant market share in their chosen markets.

- They are often distinguished by a growing client base, superior sales and marketing execution, and a clear strategy for sustainable, profitable growth. High performers also have a

demonstrable track record of R&D investment, together with specific product or 'go-to-market' capabilities needed to deliver a competitive advantage.

- Because of their focused functionality, best-of-breed solutions will often be packaged together as part of a comprehensive enterprise risk technology architecture, co-existing with other solutions.

Enterprise solutions

- Enterprise solution providers typically offer risk management technology platforms, combining functionally rich risk applications with comprehensive data management, analytics and BI.

- A key differentiator in this category is the openness and flexibility of the technology architecture and a 'toolkit' approach to risk analytics and reporting, which attracts larger clients.

- Enterprise solutions are typically supported with comprehensive infrastructure and service capabilities, and best-in-class technology delivery. They also combine risk management content, data and software to provide an integrated 'one stop shop' for buyers.

Category leaders

- Category leaders combine depth and breadth of functionality, technology and content with the required organizational characteristics to capture significant share in their market.

- They demonstrate a clear strategy for sustainable, profitable growth, matched with best-in-class solutions and the range and diversity of offerings, sector coverage and financial strength to absorb demand volatility in specific industry sectors or geographic regions.

- They will typically benefit from strong brand awareness, a global reach, and strong alliance strategies with leading consulting firms and systems integrators.

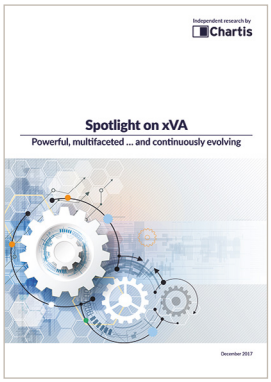
5. Further reading

Front Office Risk Management Technology 2018

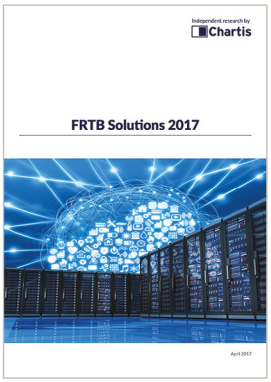
Data Integrity and Control in Financial Services: Market Update 2018

Open Source in Capital Markets 2018

Hedge Fund Risk Management Technology 2018



Spotlight on xVA



FRTB Solutions 2017

RiskTech100® 2018

For all these reports, see **www.chartis-research.com**