All investors need to better understand the risks of their investments and the liabilities of their plans. Good risk management can only be based on sound judgment, effective governance, and a comprehensive risk measurement system, including good risk tools (Curwood 2007, 2010). This article focuses solely on the choice of a quantitative risk tool or system. Due to the complexity of the task and the differing positions of investors, this article may raise as many questions as it provides answers.

Many investors have the internal resources required to feed, run, and make use of a risk system's output. Investors who wish to take this step alone are faced with a bewildering array of choices of risk systems to monitor investment, liquidity, and counterparty risk of portfolios. All systems do some asset classes well, some asset classes poorly, and many not at all. Some systems are designed for short-term risk analysis, some for long-term risk analysis (a concept that is poorly defined). Most systems can be easily loaded with listed equity portfolios but become more complex when populating other asset classes. Many systems produce a plethora of colored graphs as output, but do they satisfy the investor's requirements?

We have our most favorite risk systems, our least favorite risk systems, and our own share of horror stories using risk systems. But this article is not about any of that. It is more about the process and what to expect rather than ABC system does a better job than DEF system of estimating risk for XYZ asset class. The bad news for readers is there is not one best system; you can't jump to the conclusion, see which system is at the top of the list, and give the local representative a ring.

This article provides guidance to investors trying to navigate the minefield of choosing an investment risk system and to turn the considerable effort required into a productive tool for the investment process. Potential users of these tools need to be cognizant of three key points:

1. A risk tool is a part of a broader risk governance framework.
2. Not all risk tools are the same—all have different features to meet different needs. What are your needs?
3. Measuring the risk of a diverse fund covering different asset classes is a significant project that has direct costs, indirect costs, and often an implementation timetable in years. Successful implementation requires management time; technology resources to feed the system with data and create reporting platforms; and lastly risk specialists to run the process, ensure accuracy of the analysis, and interpret the output.

Requirements for an Effective Risk Process

For any investor, a significant part of any risk process is the risk system used to quantify the investment risks, among others, taken by the investor and delivered to the members, plan sponsor, or client. The current and future requirements for a risk process must dictate the selection of the risk system. This section discusses some of the issues to consider before a search for an investor embarks on choosing a risk system. The information garnered in this process will help define what is to be accomplished and the right sort of risk system that may assist in the process.

Relativity between different classes of risk. Funds face many risks—investment/market, liquidity, counterparty, operational, and the like. Some of these risks can be quantified by a risk system and some as operational risk.

Figure 1 shows a typical implementation.
require a battery of different approaches, including a sound due diligence process. It is crucial to understand which risks will be measured by a system and which risks will not.

**Board/director/trustee requirements.** An early understanding of all the board’s requirements (guidelines, timing, reporting, etc.) is important. But often of greater importance is getting buy-in at the board level for a significant and often expensive project. What will a new risk system do for us? What won’t the system do for us? What sort of information can we expect? How do we make sense of it? What do we do with the information? Why and when do we need it? These and many other common questions must be addressed early to ensure a successful project.

**Investment team requirements.** Introducing a new risk system will change work flows for any investment team and introduce new perspectives on the assets and liabilities. As with the board, early buy-in by the investment team is essential to success.

**Regulatory reporting.** Depending upon the nature and type of fund as well as regulatory requirements for a particular jurisdiction, regulatory reporting may be required from a risk system. The nature, complexity, and detail of this reporting will vary widely and an up-front understanding of these requirements will be essential. In a period of increasing regulatory requirements for investors, it is prudent to understand as best as possible the existing regulatory requirements and proposed changes. On a similar note, it also is worth considering the requirements for any new jurisdictions if there are organizational plans to expand.

**Divergent reporting requirements.** Boards probably will want broad reporting on overall risk, its decomposition into investment asset classes or factors, and a few key stress tests. Investment teams will require vastly more granular detail on individual asset classes/sectors/investments. These will vary from asset class to asset class; a fixed-interest investor will want to know about duration of a portfolio and an equity investor will want to know about beta. Key to balancing these divergent needs is the acknowledgement that overall risk reporting can be done only if each and every part is modeled correctly. For example, fixed-interest portfolios are usually vastly less risky than equity portfolios but require significantly more effort to model correctly due to the custom securities/derivatives in typical portfolios—but both asset classes must be modeled correctly to have a sound basis to make this judgment about relative magnitudes of overall risk.

**Risk reporting needs/system capabilities.** How are the results expected to be consumed? Does the risk system itself need to produce final risk reports? If yes, what are the desired formats? If reporting is done outside the risk system, which system will produce the reports and how should they be delivered?

**Constraints.** Are there any investment constraints that need to be adhered to by the plan sponsor, board, or regulator? What are the constraints, how are they to be measured, how often are they to be monitored, and what steps need be taken and by whom if they are breached?

**Liabilities.** Does the fund have an explicit liability side or are the risks of the assets to be measured and monitored in isolation? Does the fund follow a liability-driven investment strategy? Is there a benchmark for the whole fund as well as for individual asset classes and individual portfolios that must be monitored?

**Asset class only or individual investments.** Investors can choose to base a risk analysis on actual individual holdings or use the asset class groupings and common benchmarks to characterize the risk of actual holdings. This decision usually will be made on the basis of cost, requirements, and fund composition. Asset class only is cheaper but will miss a lot of risk data such as the risk of the active portfolio for managers, style/size/factor/sector/individual holding risk analysis. Does the fund have a lot of alpha risk (very active managers, hedge funds, and the like)? Is it expected that one asset class or factor will dominate the fund’s risk profile?

**Sourcing the holdings data.** Where will the holdings data come from—internal systems, custodian, or other sources? What about some asset holdings that are private securities (hedge funds, direct property, infrastructure, unlisted equity, and the like)—where will risk data be sourced for these assets and what information needs to be fed into the system? In what form will the data be delivered? How can the data be reconciled with other accounting/risk information on the fund? Is there a need to send data via separate files (e.g., by geography, instrument type, etc.)? Can the risk system handle this?

**Fund structure.** How will the fund’s structure be represented in the risk system so that reporting is in a form that makes sense? This may be simply a matter of tagging each holding with the asset class and manager name, but often a richer set of tags is required. Where will the data come from, how will it be merged with holdings data when populating a risk system, and how will it be maintained?

**How long-term is long term?** Over what risk horizon are statistics to be calculated? One day, one month, one year, or 10 years? How do the selections fit with the objective of the fund members or plan sponsor? How realistic are some of the longer-term horizons for very active, alpha-intensive asset classes such as hedge funds? Is it appropriate to extrapolate one-year risk statistics from the current holdings of a statistical arbitrage long-short fund with an average holding period measured in hours not months?

**Frequency of analysis.** How frequently does the analysis need to be run? Daily, weekly, monthly, quarterly,
or just ad hoc? For higher frequencies, where can valid and reconcilable holdings data be sourced and how stale is that data?

**Benchmark and other data licensing.** What market data will be needed for risk measurement? Does the risk system have appropriate access to the necessary data? Is constituent-level benchmark data necessary? If yes, who is responsible for getting that data to the risk system?

**Over-the-counter derivatives data.** What are the types of over-the-counter (OTC) securities that need to be modeled? Will counterparty risk need to be analyzed? If yes, is the data on netting and counterparties readily available?

**Cost.** What are the budgets for the implementation project and ongoing running of the process? How are these costs split between direct costs (system license fees, data costs, benchmark costs, risk team head count, etc.) and indirect costs (management time, technology costs, etc.)?

**Key Features of Risk Systems**

What do you need to look for in a risk system? This section discusses some of the different features of risk systems and issues to consider when planning how a system will be used to measure the risk of a particular investor’s assets and liabilities. Figure 2 shows some common features.

Risk systems all do some core analysis but they do it in different ways, and then each one does different analysis that none of the others do. What is important and what is simply pretty flashing lights? Choose wisely, because risk systems are expensive to implement and take a considerable amount of management/risk staff/information technology staff time. A key part of hiring a new risk system is to do thorough due diligence that includes the following:

**Contract.** Before we get to the mathematical detail the contractual side needs to be considered. What is included in the contract and what is an extra cost service? Is the provision of benchmark indexes included in the contract or are extra subscriptions required for both the index providers and the system provider? Does the service level agreement offer enough protection? Under what conditions can the contract be broken and what are the terms? How long will the contract run for and what are the restrictions around price rises? What are the maintenance and system upgrade fees?

**Understand the support team structure.** Risk systems are complex and large computer systems and a local/knowledgable vendor support team is essential to smooth operation and getting the best out of the system. Where is the support team located? Does the team offer 24-hour service? How knowledgable are the team members?

**Information-technology (IT) requirements to run the system.**

What is required to run the system? Is the system web-based/ASP (application service provider) requiring a simple web browser? Is it a local installation that can be loaded onto most Windows systems? Or does the system require specialist database servers and calculation servers that must be priced, bought, installed, and maintained by in-house technology staff? How fast is the ASP solution and is the Internet connection adequate? For an ASP solution, how much capacity is there at the data center? Will the ASP solution work with current firewalls and security measures? How is the locally installed system updated with new models and market data? Are there addi-

**FIGURE 2: COMMON FEATURES OF RISK SYSTEMS**

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<th>Feature</th>
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<td>Factor-Based Proxy</td>
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<td>Counterparty Risk</td>
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<td>Multi-Period Analysis</td>
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tional data services that must be fit into the budget? Is there enough processing power on the hardware to run large-scale Monte Carlo analyses?

**Security of Web-based systems.** If the system is web-based, then how much holdings data is sent outside the organization? What are the security measures that the vendor has employed to ensure the safety of the data? Who operates the data center? Is the data center audited regularly? What is the business continuity plan for the data center? And the entire web solution?

**User access control.** Will there be different user access levels across users of the risk system? If yes, how complex is the user permissioning and can the risk system accommodate this?

**Input file formats.** Most systems can be operated by manual input of positions, but this is unsustainable for regular use of a typical fund with thousands of individual holdings. The key to getting fund data (holdings information, fund structure information, historical time series for private securities, and the like) is to automate the process as much as possible. This is a nontrivial exercise for a holdings-based risk analysis and usually requires dedicated IT staff and risk personnel for oversight. A key bit of advice is to start thinking early about data transfer and format issues.

**Types of Value-at-Risk (VaR).** Systems employ two different broad types of VaR calculations, historic and parametric. Historic uses historical data to directly calculate risk statistics such as VaR. Parametric uses the same history but calculates covariance matrices and the like, from which the risk statistics are calculated. For longer risk horizons the historic method breaks down because many securities in the portfolio may not have been in the data. Parametric models can accommodate more directly different historic periods for the securities in the portfolio and better proxy the risk to other assets when the data have not been available. Parametric models also provide some desirable smoothing of data. How can a one-year 95-percent VaR be calculated directly from only 10 years of data? If 100 years were available, it would be a simple matter to compute the fifth-worst annual return, but with shorter periods some form of smoothing is required and desirable. Is the smoothing sensible, or has the vendor let a bunch of mathematicians go crazy (well, as crazy as mathematicians can get)? Many systems also offer Monte Carlo VaR, which is a form of parametric that allows the correct risk measurement of nonlinear securities such as options. Are options and derivatives with optionality a big part of the risk profile?

**Risk horizon.** Most risk analysis and techniques such as VaR have emerged out of the needs of investment banks over the past 20 years where risk horizons are typically 1–10 days. For short risk horizons such as this, the projection of risk based upon current holdings is a reasonable assumption. As noted above, the projection of risk based upon current holdings for longer risk horizons such as one year is a more tenuous assumption that needs care. Users need to understand the turnover feature of the different alpha strategies in the fund.

**Factor model or full statistical model.** All risk systems require something like a covariance matrix to calculate parametric risk statistics. This covariance matrix can be either a full statistical one or a reduced form derived from a factor model. The factor model approach is appealing in that factor loading and decompositions of risk are a natural by-product of the calculation that adds a significant amount of detail to the understanding of the risks in the portfolio. But the factor model will need to be appropriately chosen to match the fund’s investments; for example, the risk analysis for a fund of emerging market debt that is derived from a factor model tuned to U.S. equities will be next to useless. Users of factor models will need to evaluate, through direct testing, the ability of a particular factor model to measure and differentiate the risk of a particular portfolio. The nature of the investments is also of importance when evaluating factor models. Does the factor model adequately capture a strategy’s active risk, including long-short exposure? Factor models are relatively rigid techniques; how often are models reviewed and potential new factors added? Deriving the desirable factor analysis from a full statistical model is difficult, but some progress can be made with a battery of sensitivity analyses.

**Custom modeling.** Is there a desire and capacity to custom-tune the risk-model settings (e.g., time horizon, observation weighting)? Is there a need for custom definitions of the stress tests and sensitivity measures? Is there a need for custom defined risk statistics (e.g., VaR 98 percent)? Can the system be augmented with user-programmed models?

**Risk by asset classes.** Most systems have grown from the specific needs of one particular asset class or another. Many of these systems have not evolved much and are simply an equity system glued to a fixed-interest system glued to another system, etc. The ability of such systems to span all asset classes comprehensively and consistently is questionable. Most systems will measure the risk profile of listed equities fairly well. While this is probably a fair proportion of the risk in any 60-percent growth/40-percent defensive fund, there is little point in adopting an enterprise investment risk system unless it can cover, in some form or another, the entire portfolio. How are over-the-counter derivative transactions entered and can the risk system model all the types of transactions of interest? How can the system profile and model private investments such as hedge funds and direct property investments? Can the risk system cover commodities and other asset classes that may be in the liability representation, asset portfolio, or planned future portfolios?
Proxy decomposition of private securities. For some systems, the only way of incorporating the risk of private securities is to decompose the observed returns into a portfolio of proxy securities modeled by the system. For example, unlisted property often is decomposed into listed property funds and nominal and real inflation-based derivatives. This process will never fully capture the risks of these investments and will need to be regularly reviewed for accuracy and goodness of fit. For some assets such as private equity, this is a reasonable approach if care is taken to capture the correct leverage of investments vs. listed market proxies as well as differing sector exposures.

Appraisal-based asset classes. Care is required in modeling appraisal-based asset classes because the returns often are smoothed. Statistical techniques exist to de-smooth the returns to capture the inherent risk rather than the observed risk.

Hedge fund transparency. Of the difficult asset classes (hedge funds, direct property, infrastructure, etc.), hedge funds are often the asset class with the most potential risk where the risk system’s transparency is invaluable. Despite the demand for increased transparency from investors, hedge funds continue to be sensitive to leakage of position information that may adversely impact the manager’s future returns. While we are not shying away from encouraging investors to continue to demand transparency from their managers, the reality of many large and successful hedge funds is that extracting position-based information continues to be difficult. A number of vendors offer hedge fund transparency services where hedge funds submit position-based information to the system vendor and these are then uploaded into special secure portfolios. Subscribers to the system then can access the risk of these special secure portfolios without the ability to see the actual holdings.

Nonlinear securities. These are derivatives that have some form of optionality; their upside risk is different from that of their downside risk. Portfolios with exposure to these types of securities, and longer risk horizons, will require a Monte-Carlo technique or the like to measure the downside risk accurately. Other techniques, such as closed-form parametric, will approximate the exposure with a linear approximation that misrepresents the risk over longer horizons.

Single-period vs. multi-period analysis. Many risk systems will produce risk analysis for a single period or a single as-of date. To answer questions such as, “How has the risk changed over the past month?” often requires post-processing the risk system reports in Microsoft Excel or one of the common reporting tools.

Absolute and relative risk analysis. Measuring the absolute risks of the asset only and measuring the relative risks of the assets against the liabilities or a benchmark is often a key requirement. The same is true for manager portfolios, where these measurements help illustrate how much absolute risk a manager is taking and provide a way to monitor mandate restrictions involving tracking error and the like. For example, two managers may have the same tracking error of 5 percent, but one manager may have an absolute volatility of 17 percent and the other may score 23 percent (vs. a benchmark of 20 percent). These managers have vastly different risk characteristics that are not captured by tracking error alone.

Decomposition of risk. A key part of understanding risk is to understand where the risk comes from—asset class, manager, investment type, investment sector, currency, country, by rating, and the like. Custom tags that represent the fund’s structure as well as automated tags that can be applied as part of the upload process are key features of most systems.

Stress tests. Stress tests are a powerful tool for understanding a portfolio’s risks and overcoming the prevalence of statistical outliers observed in times of market stress. There are two types of stress tests—historical and scenario-based. Historical stress tests explain potential future events by testing the portfolio over a specific historical market event, e.g., the 1987 market crash. Scenario tests are based upon possible future market events, e.g., equity market falls by 10 percent. Actual tests will vary depending on investment types and interests.

What-if analysis. Can changes to portfolios be easily road tested? How would risk change if the weight in ABC asset class increased by X percent?

Counterparty risk. Counterparty risk pertains to the potential default of the issuer of a derivative. Investors typically do not get compensated for taking counterparty risk. This is distinct from credit risk in a bond, where the buyer of the bond is compensated by a higher yield/lower purchase price. Credit risk is considered one form of market risk. How does the system represent the counterparty risk of derivatives? Are data available on counterparties for each transaction? Can the system measure the counterparty risk in a stress environment such as currency rates moving by X percent?

Liquidity risk. Liquidity risk can manifest in two forms. First, what is the liquidity of the asset portfolio and how would a lack of liquidity adversely impact the risk statistics? Second, what is the liquidity of the entire fund, which investments deplete the cash position, and what market scenarios deplete the cash position? Understanding both aspects is part of good management of a fund.

Automation and batch processing. Can the uploading of data and running of reports be automated? Most of the presentations that prospective customers sit through concentrate on a nice-looking system front end. But for
regular users, the goal must be to automate as much of the process as possible. Most system providers will offer this feature in some form or another, but it would be prudent to understand exactly what is required because it may be complex from an IT perspective. Can we create the XML input files? Can we post-processing is required to generate what is required because it may be complex from an IT perspective. Can we create the XML input files? Can we read the output files and upload them into our database? Does it require a lot of programming?

Implementing a Risk System as Part of a Risk Process

Once the risk system is chosen, the hard work begins. Below are issues to consider when planning to implement a risk system. Figure 3 shows an overview of a typical risk system.

Some of the key issues of implementing a risk system include the following:

Complete front-to-back test. Ask the vendor for a complete test of any risk system with a representative fund structure and investments. Ask for a copy of the input files. How hard will it be to feed the system on a regular basis? How many manual steps are required on a regular basis? Can the system perform the required analysis? How much post-processing is required to generate the types of reporting required?

Speak to other users. Nothing replaces first-hand experience, and you can learn a lot from others’ first-hand experience. Speak with other users from a similar sort of organization with similar types of investments and similar in-house resources. Moreover, now is the time to join forces with similar users because the collective voice of a number of users is louder than that of individual users and is more likely to be heard. What issues were encountered feeding the system? How much work is required to get data into the system on a regular basis and how much manual work is required? How are data coming out of the system reconciled to other sources? Does the system adequately model all the investments, and if not, which ones? How much work is required to generate reports for the board/investment team/regulators, etc.? What has the user’s experience been of the service team? Can they answer basic questions or does it take days to get an answer? Is the system stable or have there been significant outages?

Budget. Implementing a risk system is a large task. Direct costs include the base risk system, add-on modules, additional data services, computer hardware, extra network bandwidth, index subscriptions, external audit, and the like. Indirect costs include risk team members’ time, investment staff time, management staff time, and so forth.

Plan and timetable. As with the budget, now is the time to start thinking about the plan and timetable, so that the team and management know what and when units of the final system will be released and how they will fit together.

Contract. Before we get to the main task of loading the system it is important to make sure the contractual side of using a risk system is squared away.

Specification creep. The number-one reason why risk systems sour is specification creep, i.e., extra specifications being added halfway through the life of implementation. Specification creep creates a project where nothing is ever delivered or timetables are significantly overrun. Risk systems must adapt to new market environments and new types of investments. But it is also crucial to follow the plan and get the system functional before considering add-ons and new functionality.

IT staff. IT staff are key to creating the automated processes to get data into the system, run reports, and extract results. Have you enough resources? Do they need any training in risk or system specifics?
Testing. Each step will need to be thoroughly tested. Each security and each type of analysis will need to be tested and retested. Is it possible to create a complete front-to-back test bed so future evolutions of the system can be checked?

Reporting. The requirements you have laid out for an effective risk process will guide the content of your reporting. Reporting, as well as the usual post-processing of reports and storage of data, needs to be planned and implemented.

Reconciliation. In the ongoing operation of the system how can the data and results be reconciled back to other key systems?

Automation. Have as many manual steps as possible been automated?

Documentation. How does the risk process work? How has it been implemented? What critical decisions have been made implementing the system? Documentation is an important audit requirement and will help future users to understand your original logic and decisions.

Review and audit. An internal review of the risk system implementation will ensure that requirements were met and the system was efficiently implemented. Now is also the time to consider the development plan for the future enhancements and suggestions you have put off. Is an independent audit required by a regulator, the board, or plan sponsor?

Maintenance. Ongoing maintenance is key to keeping a system updated—even for an ASP solution. Data that need to be updated regularly should be sourced and documented.

Review and renewal. Consider the timetable for a formal review of the risk process, system provider, and requirements in the future.

Conclusions
This article is intended to provide guidance to clients who are choosing a risk system to measure and monitor investment risk. Although comprehensive, it is not meant to be all-inclusive. The choice of a system will be driven by the type and size of fund; requirements, sophistication, and ability to internalize the variety of skills required; budget; types of investments, and so forth. For two similar-sized funds with similar investments, the right risk system may be very different for a multitude of reasons. In fact, this article may have raised more questions than it answers.

The next step for any investor will vary depending upon the answers to some of the questions posed here. But the right choice for all investors will be governed by the system requirements and the ability to implement a large and complex system. Investors who have considered and answered many of the questions posed here will be well-prepared for the hard work of implementation.

Remember, however, that choosing a risk tool is just one aspect of creating a good risk measurement system, and good risk management depends on good risk measurement. To be successful, the risk tool should be utilized within a culture of risk-adjusted decision-making.

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