2018 Annual Risk Management Review
The Risk Management Function

Dimitry Shishkoff, Director of Risk Management
Melissa Jerkins, Ph.D., Quantitative Risk Analyst II
Agenda

I. Governance & Resources: Overview

II. Delivery & Operation: What do we deliver and how do we do it?
   A. Risk Analysis, Monitoring and Reporting
   B. Data Management
   C. Research

III. Conclusion

IV. Appendices
Section I

GOVERNANCE & RESOURCES:
OVERVIEW
TMRS IPS Language Regarding the Risk Management Function

VII. ROLES AND RESPONSIBILITIES

E. The non-CIO Investment Staff report to the CIO.

Investment staff responsible for risk management supports the investment program at the strategic and operational levels through the establishment of appropriate policies and procedures as well as implementation and maintenance of analytical tools to measure and monitor risk as further described in the IPS and procedures documents.

XIII. INVESTMENT RISK MANAGEMENT

A. Risk Management

2. 2nd Line of Defense: The CIO establishes and oversees risk management and compliance functions to ensure the first line of defense is properly designed, in place, and operating as intended, including by ensuring that policies and procedures are documented and followed regarding risk identification, evaluation and management within the investment department.

D. Investment Risk Reporting

Investment risk reporting is the responsibility of the risk management function. The reporting will be done at least quarterly to senior management and the Board through implementation of internal analytical resources and are expected to address the following areas at a minimum:

Range of risk implied by IPS Asset Class Guidelines and the risk in the current Asset Class implementations. Holdings based estimate of asset class total market risk and relative to risk expectations used in Asset Allocation studies.
Development of the Risk Management Function

Key Milestones

"Overview of the Investment Risk Management Program for TMRS" is presented to the Board

- "Investment Risk Reporting" is presented to the Board
- State Street Associates reviews Risk Management Program and presents a summary to the Board
- Risk Management Process Components (Framework) is presented to the Board
- Risk Governance and Risk Guidance Policy is recommended to the Board

- Initial version of Oracle Investment Data Warehouse goes live
- Performance Attribution System (FactSet) goes live for Public Equities and Public Fixed Income
- Ortec Capital Markets Simulation System is purchased

- New Data Analyst is hired
- Work begins on Oracle Investment Data Warehouse
- "Three Lines of Defense" Governance model is presented
- Risk guidance is recommended in place of risk budgeting
- Both are formalized in December changes to IPS

- Global Capital Market simulation system that allows proper incorporation of observed market risk behaviors, economic cycles and long term trends.

Strong planning, execution & data management has allowed us to implement a best practice risk management framework with the necessary governance and resources to sustain it.
**Risk Management Staff Resources**

**Risk Management Team Experience**

**Dimitry Shishkoff**
- 30 years experience

**Melissa Jerkins, Ph.D.**
- 7 years experience
- High Energy Particle Physics, Capital Market Models & Investment Risk Management

**Ryan Conner**
- 1 Year Experience
- Oracle software, Data Warehouse Development & Portfolio Data Management

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**Private Equity**
- Chris Schelling
- Peter Teneriello

**Absolute Return**
- Mark Leavitt
- Kevin Notaro

**Real Assets**
- Tom Masthay
- Eddie Schultz
- Rachel Cleak

**Operations**
- Sally Case
- Geldon Vluha
- Susan Jaques

**Fixed Income**
- Jason Weiner
- German Gaymer
- TBD

**Compliance**
- Kurt Cressotti

**Public Equity**
- Kristin Qualls
- Carol Leung

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**CIO**
- TJ Carlson

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**Admin. Support**
- Cindy Morse
- Debbie Farahmandi
Additional Information

- 82 meetings held in 2017

Service provider relationships managed

- **Analytics Systems**
  - MSCI BarraOne (Risk System)
  - FactSet (Performance Attribution System)
  - ORTEC (Capital Market Simulation System)

- **Index constituent data**
  - MSCI Global Equity
  - JP Morgan Emerging Market Debt
  - Russell Equity
  - Bloomberg (formerly Barclays) Fixed Income
  - BAML US High Yield
  - S&P Equity and Leveraged Loan
  - Burgiss Private Equity Funds data and index

- **Other information sources/systems used**
  - Albourne Castle
  - Blackstone Hedgehog
  - Bloomberg
  - eVestment
Data Management is by far the largest allocation.

In the coming year we expect implementation of the public market Performance Attribution system to be complete and related time demands to decline.

Increases in available time will be allocated to research.

**Allocation of Time**

- Data Management: 43%
- Holdings-Based Risk: 13%
- Research: 17%
- Performance Attribution: 17%
- Admin & Other: 10%
Section II A.

DELIVERY & OPERATION:
RISK ANALYSIS, MONITORING AND REPORTING
Holdings–Based Risk System: Independent and Objective Short Term Risk Monitoring

System Input

TMRS
- Separate account security holdings
- Hedge fund market risk exposures
- Private market Fund holdings

Benchmark Providers
- Benchmark holdings

Risk System

Models
- Global Capital Market (securities, rates and currencies)
- Global Private Equity
- Global Private Real Estate

Facts
- 3,000 global risk factors
- Over 100,000 securities
- Calibrated from recent market behavior

System Output

- Risk (volatility) estimates meaningful for next several months
- Very granular (over 1400 Excel files of output each month)

TMRS
Aggregate risk the way we need for reporting and analyze results

Benefits

Objective and independent view of actual investments

Disciplined representation of global capital market risks and their interrelationships

Independent monitoring of market exposure risk relative to objectives:
- Policy Index (Total Fund Benchmark)
- Policy Benchmarks (Asset Classes)
- Manager Benchmarks or Expectations

1. We develop customized solutions for hedge funds and certain private funds where sufficient holdings information is unavailable
# Holdings-Based Risk System: Attainable Precision of Short Term Risk Declines Together With Transparency and Liquidity

<table>
<thead>
<tr>
<th>Characteristics of investments held in portfolios</th>
<th>Stock and/or Bond Portfolios</th>
<th>Alternative Strategy Portfolios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transparent Funds</td>
<td>Limited Transparency Funds</td>
</tr>
<tr>
<td></td>
<td>Private Market Funds</td>
<td></td>
</tr>
<tr>
<td>Information</td>
<td>Abundant, publicly available and cheap</td>
<td>Expensive and/or highly complex</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only market segment exposures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not publicly available and expensive</td>
</tr>
<tr>
<td>Liquidity</td>
<td>High liquidity (securities trade daily in large volume)</td>
<td>Medium to low liquidity (securities trade once in a few months or less)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can vary from low to high liquidity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No liquidity (trade once in a few years or less)</td>
</tr>
<tr>
<td>Price Behavior Information</td>
<td>Large amount of meaningful data</td>
<td>Moderate to small amount of often not meaningful data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>We only know the market segment allocation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pricing more an art than a science</td>
</tr>
<tr>
<td>Volatility of Annual Return</td>
<td>Measurable</td>
<td>Somewhat measurable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Measurable for the market segments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Educated guess</td>
</tr>
<tr>
<td>Precision of Risk Measurement</td>
<td>High</td>
<td>Medium to low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium to low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very low</td>
</tr>
<tr>
<td>Value of Holdings Based Analysis</td>
<td>Detailed active risk analysis</td>
<td>Market risk exposure</td>
</tr>
</tbody>
</table>
Risk ranges implied by asset class guidelines (black bars)

Risk of the current implementation (red)

RVK risk assumptions used in asset allocation (blue)
Distinguishing Luck From Skill By Attributing Performance to Public Market Manager Decisions

**System Input**

**TMRS**
- 20 data fields per security
- Daily data
- Combined from 5 different State Street reports and fully reconciled
- Over 80,000 records per month

**Benchmark Providers**
- Same information for Benchmark portfolios

**Performance Attribution System**

Daily transaction based return attribution system

Analyzes return contribution due to differences from benchmark in:
- Industry allocations
- Country allocations
- Currency allocations
- Bond duration exposures
- Security selection

**System Output**

- Very granular output with over 230 Excel files each month
- Active return contribution from different decisions both cumulative and monthly

**TMRS**

Aggregate attribution the way we need for internal evaluation

**Benefits**

- Identifies a manager’s patterns of good or bad decision making
- Allows dialog in which managers must account for outcomes of their decisions
- Provides independent and detailed monitoring of return from active risk
Currently Performance Attribution Can Be Done Only For Stock and Bond Portfolios

<table>
<thead>
<tr>
<th>Characteristics of Portfolio Holdings</th>
<th>Stock and Bond Portfolios</th>
<th>Private Market portfolios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>Public and cheap</td>
<td>Not public and expensive</td>
</tr>
<tr>
<td>Liquidity</td>
<td>High</td>
<td>Virtually none</td>
</tr>
<tr>
<td>Pricing</td>
<td>Transaction based</td>
<td>More art than science</td>
</tr>
<tr>
<td>Benchmark</td>
<td>Cheap passive solutions</td>
<td>No passive solutions</td>
</tr>
<tr>
<td>Every Manager Decision</td>
<td>Can be identified and evaluated based on portfolio and market data</td>
<td>Cannot be identified or evaluated based on portfolio data; market data does not exist</td>
</tr>
</tbody>
</table>
Section II B.

DELIVERY & OPERATION: DATA MANAGEMENT
Evolution of Data Management Needs

Data feed (input) requirements of public market Performance Attribution System

- Daily security level transactions, holdings, and prices
- Requires merging five different reports from State Street
- 22 accounts with over 4,000 securities
- Data quality required for this analysis is much higher than for accounting or performance reporting

Rapid growth in number of accounts and administrative reports

- From 2011 to 2017 the number of accounts grew from 6 to 134
- Number of administrative and management reports required also grew
- Over 50 administrative data items maintained per account
- Rapidly growing inefficiency and risk of error from maintaining data on spreadsheets updated by manual entry

Rapid growth in raw analytical reports

- Over 1,400 raw risk reports from Holdings Based Risk system
- Over 200 raw reports from Performance Attribution system
- Holdings based risk reports are done bottom up where granular analytics are aggregated across risk sources and accounts to asset classes and then total fund
- Likewise transaction based performance attribution is done bottom up and aggregated

Large Number and Variation in Fund Documents

- Over 1,400 raw risk reports from Holdings Based Risk system
- Over 200 raw reports from Performance Attribution system

Dozens of documents per account per year, including:
- Contracts
- Financial statements
- Capital call letters
- Disbursement letters
- Regulatory Filings
Investment Department Data Management Needs

- **Investment Data Highlights** – There is a lot of very different data we need to keep track of
  - 134 investment accounts
    - Over 50 administrative data items per account
    - Full accounting and transaction history for each account
    - Over 4,000 securities in 22 Separately Managed Accounts
  - 63 countries, 33 currencies, 7 asset classes and more than 30 sub-asset classes
  - Dozens of market sector and industry classifications and multiple classification systems
  - Over 1,400 raw risk system reports used in production of Board and internal Risk Reports
  - Over 200 raw performance attribution system reports used in performance attribution analysis

- **Data Usage Needs** – Each function has its own specific set of data and reporting needs
  - Management and Administrative
  - Operational
  - Risk Management and Analytics
  - Investment Opportunity and Evaluation

- **Data Management Needs** – All the above translates into well-known data management requirements
  - Single (authoritative) version of every data item
  - Accurate
  - Searchable
  - Scalable
Volume and Types of Data We Need To Manage Will Continue to Grow Rapidly

- Growth in accounts (should reach stable level around 150)
- Growth in years (time span) of data history
- Potential growth in responsibilities like internal stock and bond portfolio management
- Increase in transparency and data availability of fund holdings
- Increase in market data available
  - Evaluating relative performance of our investments
  - Better understanding investment risks
Investment Department Data Management Program

- **Framework Components**
  - Data Governance (directs and controls the Investment Department regarding data policy and objectives)
  - Responsibilities and procedures
  - System
    - Internally developed Data Warehouse
    - Oracle Data Base and Business Intelligence (BI) platform

- **Conceptual Organization** (of Investment Data Warehouse)
  - Current
    - Account Related Data (administrative and performance data)
    - Portfolio transaction and holdings data (input to risk and performance analysis systems)
    - Analytics Output Data
  - Planned
    - Documents (aka Records) management
    - Fund holdings descriptive and analytical data
    - Other needs that may emerge

- **Resources**
  - Overall Program management – Director of Risk Management
  - Software Development and management of Data Warehouse – Data Analyst
  - Platform and technical support – IT Department, Data Base Administrator (DBA)
Section II C.

DELIVERY & OPERATION: RESEARCH
Research

Research is essential for achieving and maintaining best practice

- The one constant about Capital Markets is change
  - Change in market behavior and opportunities
  - Change in our understanding of the markets and analytical abilities
  - Growth in data availability and transparency

- Risk Management conducts research to:
  - Remain current
  - Address questions that arise in the department

Examples:

- **Capital Market Behavior and Investment Strategies:**
  - Factor Investing: white paper, monitoring for potential use
  - Volatility Capture Strategies: led discussion at two conferences, monitoring
  - Risk Parity Investing: presented at a conference, set aside
  - Tail Risk Strategies: presented at a conference, set aside
  - Order of Diversification & Reality of Non-US Equity: CIO presented at conference, monitoring
  - Implied path risk of private market investments: incorporated in assumption setting
  - Currency trade execution: summary Paper, internal procedures and manager guidelines
  - Return to rebalancing: internal presentation

- **Research on Risk Measures & Analytical Methods:**
  - VaR and Within Period VaR: write up and internal calculation resource
  - Expected Max Draw Down: internal presentation and calculation resource
Section III

CONCLUSION
Conclusion

- Risk Management is developing necessary systems and resources to meet data management needs
  - Data is the foundation of everything we do
  - Data availability varies greatly across asset classes
  - Transparency and data technology will continue to advance rapidly

- Research is essential to maintaining best practice in Risk Management

- Resources for measuring, monitoring, and communicating risk have been established and will continue to evolve based on data availability and research advancements
Section IV

APPENDICES
TMRS Investment Data Warehouse Conceptual Schematic

Data Sources
- Current
  - State Street
    - Accounting
    - Performance & Analytics
    - Alternative Investment Services
  - TMRS Investment Department
- Planned
  - OP and other HF Risk Reports
  - Private Fund Holdings - External Data
  - Bloomberg security level descriptive data

Data Warehouse
- Current
  - Accounting Book of Record (ABOR)
    - Holdings
    - Transactions
    - Market Values
    - Returns
  - Unlagged Book of Record (UBOR) for Funds with monthly or quarterly Pricing. UBOR and ABOR are the same for SMA's and Funds with daily pricing
  - Monthly Return History
    - Accounts
    - Performance Composites
    - Benchmarks
  - Other Account Related Data
    - Account descriptive information
    - Unfunded Capital Commitments
    - Over commitment model data
    - Etc.

Analytics Systems
- Current
  - Portfolio Risk System (BarraOne)
  - Portfolio Performance Attribution System (FactSet)

Data Uses
- Current
  - Rebalancing Projection Report
  - Quarterly Staff Report
  - Operations Resource
  - Investment Support Resource
  - Ad-hoc Queries

- Planned
  - Risk Analysis and Reports
  - Performance Attribution Analysis and Reports
  - Specialized Internal Performance Reports
  - Compliance System Input?

ETL's
- Raw Output from Analytics Systems
- Private Fund Holdings - Descriptive Data and Operating Metrics
- Contract Management

ETL's
- Report Writing System
  - Report Delivery
Global Industry Standards Organizations

Risk Management

- **COSO (Committee of Sponsoring Organizations of the Treadway Commission)** is a joint initiative of five private sector organizations (listed below) and is dedicated to providing thought leadership through the development of frameworks and guidance on enterprise risk management, internal control and fraud deterrence.
  - American Accounting Association
  - American Institute of Certified Public Accountants
  - Financial Executives International
  - The Association of Accountants and Financial Professionals in Business
  - The Institute of Internal Auditors

- **IIA (The Institute of Internal Auditors)** is an international professional association. It is the internal audit profession's recognized authority and principal educator. Generally, members work in internal auditing, risk management, governance, internal control, information technology audit, education, and security.

Data Management

- **ARMA International** is a not-for-profit professional association and the authority on governing information as a strategic asset. Originally, ARMA was the acronym for the Association of Records Managers and Administrators, established in 1955. Its members include records and information managers, information governance professionals, archivists, corporate librarians, imaging specialists, legal professionals, IT managers, consultants, and educators, all of whom work in a wide variety of industries, including government, legal, healthcare, financial services, and petroleum in the United States, Canada, and more than 30 other countries around the globe.

- **ISO (Internal Organization of Standardization)** is an independent, non-governmental international organization with a membership of 162 national standards bodies. Through its members, it brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International Standards.

- **ANSI (American National Standards Institute)** is a 501(c)3 private, not-for-profit organization that facilitates the development of American National Standards (ANS) by accrediting the procedures of standards developing organizations (SDOs). ANSI is the official U.S. representative to the International Organization for Standardization (ISO) and, via the U.S. National Committee, the International Electrotechnical Commission (IEC)
Definitions

- **Data terminology**: Data, Records, Documents, Information, Content, and possibly others are all used in the industry to refer to information created or consumed in the operation of an enterprise. To avoid confusion, the TMRS Investment Department has adopted the following terms and definitions:
  - **Data Management** to refer to the most comprehensive scope of information created or used in the operation of the Department
  - **Records** to refer to any information, including documents, that serves an evidentiary role in operating activities of the Investment Department. (Note: There are numerous other data categories necessary for supporting the operating activities of the Investment Department ranging from contact information to analytical systems feeds and outputs.)
  - **Metadata** to refer to information used to indicate context and apply appropriate rules for managing records.

- **Data Warehouse (DW)**, is a system used for reporting and data analysis, and is considered a core component of business intelligence. DWs are central repositories of integrated data from one or more disparate sources. They store current and historical data in one single place and are used for input to analytical systems and creating analytical reports. The typical Extract, Transform, Load (ETL)-based data warehouse uses staging, data integration, and access layers to house its key functions. The staging layer or staging database stores raw data extracted from each of the disparate source data systems. The integration layer integrates the disparate data sets by transforming the data from the staging layer often storing this transformed data in an operational data store database. The integrated data are then moved to yet another database, often called the data warehouse database.

- **State Street Associates (SSA)** is a partnership between State Street and renowned academics at Harvard Business School and MIT's Sloan School of Management. Since 1999, it has bridged the academic and practitioner worlds of finance, drawing on State Street’s deep information resources. SSA research directors and staff have published more than 120 articles in peer-reviewed finance journals and provided advisory services to hundreds of large institutional investors around the world, focusing on topics including asset allocation, risk management, manager evaluation and hedging.

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1. Data Management was chosen over the currently prevalent term Content Management because, in our case, we feel it more directly communicates intended meaning to stakeholders.